NASM – The Netwide Assembler

version 3.02



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Chapter 1: Introduction

1.1 What Is NASM?

The Netwide Assembler, NASM, is an 80x86 and x86-64 assembler designed for portability and modularity. It supports a range of object file formats, including Linux and BSD `a.out`, ELF, Mach-O, 16-bit and 32-bit `.obj` (OMF) format, COFF (including its Win32 and Win64 variants.) It can also output plain binary files, Intel hex and Motorola S-Record formats. Its syntax is designed to be simple and easy to understand, similar to the syntax in the Intel Software Developer Manual with minimal complexity. It supports all currently known x86 architectural extensions, and has strong support for macros.

1.1.1 License

NASM is under the so-called 2-clause BSD license, also known as the simplified BSD license:

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Chapter 2: Running NASM

2.1 NASM Command-Line Syntax

To assemble a file, you issue a command of the form

```
nasm -f <format> <filename> [-o <output>]
```

For example,

```
nasm -f elf myfile.asm
```

will assemble `myfile.asm` into an 32-bit ELF object file `myfile.o`. And

```
nasm -f bin myfile.asm -o myfile.com
```

will assemble `myfile.asm` into a raw binary file `myfile.com`.

To produce a listing file, with the hex codes output from NASM displayed on the left of the original sources, use the `-l` option to give a listing file name, for example:

```
nasm -f coff myfile.asm -l myfile.lst
```

To get further usage instructions from NASM, try typing

```
nasm -h
```

The option `--help` is an alias for the `-h` option.

Like Unix compilers and assemblers, NASM is silent unless it goes wrong: you won't see any output at all, unless it gives error messages.

2.1.1 The `-o` Option: Output File Name

NASM will normally choose the name of your output file for you; precisely how it does this is dependent on the object file format. For Microsoft object file formats (`obj`, `win32` and `win64`), it will remove the `.asm` extension (or whatever extension you like to use – NASM doesn't care) from your source file name and substitute `.obj`. For Unix object file formats (`aout`, `as86`, `coff`, `elf32`, `elf64`, `elfx32`, `ieee`, `macho32` and `macho64`) it will substitute `.o`. For `dbg`, `ith` and `srec`, it will use `.dbg`, `.ith` and `.srec`, respectively, and for the `bin` format it will simply remove the extension, so that `myfile.asm` produces the output file `myfile`.

If the output file already exists, NASM will overwrite it, unless it has the same name as the input file, in which case it will give a warning and use `nasm.out` as the output file name instead.

For situations in which this behaviour is unacceptable, NASM provides the `-o` command-line option, which allows you to specify your desired output file name. You invoke `-o` by following it with the name you wish for the output file, either with or without an intervening space. For example:

```
nasm -f bin program.asm -o program.com
nasm -f bin driver.asm -odriver.sys
```

Note that this is a small o, and is different from a capital O , which is used to specify the number of optimization passes required. See section 2.1.24.

2.1.2 The `-f` Option: Output File Format

If you do not supply the `-f` option to NASM, it will choose an output file format for you itself. In the distribution versions of NASM, the default is always `bin`; if you've compiled your own copy of NASM, you can redefine `OF_DEFAULT` at compile time and choose what you want the default to be.

Like `-o`, the intervening space between `-f` and the output file format is optional; so `-f elf` and `-felf` are both valid.

A complete list of the available output file formats can be given by issuing the command `nasm -h`.

2.1.3 The `-l` Option: Generating a Listing File

If you supply the `-l` option to NASM, followed (with the usual optional space) by a file name, NASM will generate a source-listing file for you, in which addresses and generated code are listed on the left, and the actual source code, with expansions of multi-line macros (except those which specifically request no expansion in source listings: see section 5.6.11) on the right. For example:

```
nasm -f elf myfile.asm -l myfile.lst
```

If a list file is selected, you may turn off listing for a section of your source with `[list -]`, and turn it back on with `[list +]`, (the default, obviously). There is no "user form" (without the brackets). This can be used to list only sections of interest, avoiding excessively long listings.

2.1.4 The `-L` Option: Additional or Modified Listing Info

Use this option to specify listing output details.

`-L` options for general use are:

- `-Lb` show builtin macro packages (standard and `%use`, see section 5.9.4)
- `-Lc` list the data from `INCBIN` files (see section 3.2.3)
- `-Ld` show byte and repeat counts in decimal, not hex
- `-Le` show the preprocessed output
- `-Lf` ignore `.nolist` (force output) (see section 5.6.11)
- `-LF` ignore `[LIST -]` directives (force output) (see section 8.15)
- `-Lm` show multi-line macro calls with expanded parameters
- `-Lp` output a list file every pass, in case of errors
- `-Ls` show all single-line macro definitions
- `-Lt` list the full output from `TIMES` and `ALIGN` directives
- `-L+` equivalent to `-LbdefFmps`
- `-L++` equivalent to `-L+ -Lct`

`-L` options intended for the debugging of NASM itself (including bug reporting), and not likely to be otherwise useful:

- `-Lw` flush the output after every line (very slow!)
- `-LX` list instruction pattern line numbers from `insns.xda`
- `-L!` enable *all* listing options including debugging ones

For forward compatility reasons, an undefined flag will be ignored. Thus, a new flag introduced in a newer version of NASM can be specified without breaking older versions. Listing flags will always be a single alphanumeric character and are case sensitive.

These options can be enabled or disabled at runtime using the `%pragma list options` directive:

```
%pragma list options [+|-|*]{!|flags}...
```

`+`, `-` and `*` adds, removes, or restores to the command-line default the flags that follow.

For example, to turn on the `d` and `m` flags but disable the `s` flag:

```
%pragma list options +dm -s
```

The `+` and `++` shorthands available in on the command line are not available when using `%pragma list options`; each listing option needs to be specified explicitly, or `!` can be used to specify all options.

Spaces, quotation marks, and commas in the argument are explicitly ignored; thus, specifying the options as one or more quoted strings is valid.

The built-in macros `__?LIST_OPTIONS?__` and `__?LIST_OPTIONS_DEFAULT?__` contain the currently active and the command-line default listing options, respectively, as quoted strings.

To save and restore the listing options, one can use:

```
%macro ...
%define %%saved_list_options __?LIST_OPTIONS?__
; ... do stuff with special listing options ...
%pragma list options -! +%%saved_list_options
%endmacro
```

The statement:

```
%pragma list options -! +__?LIST_OPTIONS_DEFAULT?__
```

... is exactly equivalent to ...

```
%pragma list options *!
```

2.1.5 The `-M` Option: Generate Makefile Dependencies

This option can be used to generate makefile dependencies on stdout. This can be redirected to a file for further processing. For example:

```
nasm -M myfile.asm > myfile.dep
```

2.1.6 The `-MG` Option: Generate Makefile Dependencies

This option can be used to generate makefile dependencies on stdout. This differs from the `-M` option in that if a nonexisting file is encountered, it is assumed to be a generated file and is added to the dependency list without a prefix.

2.1.7 The `-MF` Option: Set Makefile Dependency File

This option can be used with the `-M` or `-MG` options to send the output to a file, rather than to stdout. For example:

```
nasm -M -MF myfile.dep myfile.asm
```

2.1.8 The `-MD` Option: Assemble and Generate Dependencies

The `-MD` option acts as the combination of the `-M` and `-MF` options (i.e. a filename has to be specified.) However, unlike the `-M` or `-MG` options, `-MD` does *not* inhibit the normal operation of the assembler. Use this to automatically generate updated dependencies with every assembly session. For example:

```
nasm -f elf -o myfile.o -MD myfile.dep myfile.asm
```

If the argument after `-MD` is an option rather than a filename, then the output filename is the first applicable one of:

- the filename set in the `-MF` option;
- the output filename from the `-o` option with `.d` appended;
- the input filename with the extension set to `.d`.

2.1.9 The `-MT` Option: Dependency Target Name

The `-MT` option can be used to override the default name of the dependency target. This is normally the same as the output filename, specified by the `-o` option.

2.1.10 The `-MQ` Option: Dependency Target Name (Quoted)

The `-MQ` option acts as the `-MT` option, except it tries to quote characters that have special meaning in Makefile syntax. This is not foolproof, as not all characters with special meaning are quotable in `make`. The default output (if no `-MT` or `-MQ` option is specified) is automatically quoted.

2.1.11 The `-MP` Option: Emit Phony Makefile Targets

When used with any of the dependency generation options, the `-MP` option causes NASM to emit a phony target without dependencies for each header file. This prevents `make` from complaining if a header file has been removed.

2.1.12 The `-MW` Option: Watcom `make` quoting style

This option causes NASM to attempt to quote dependencies according to Watcom `make` conventions rather than POSIX `make` conventions (also used by most other `make` variants.) This quotes `#` as `$#` rather than `\#`, uses `&` rather than `\` for continuation lines, and encloses filenames containing whitespace in double quotes.

2.1.13 The `-F` Option: Debug Information Format

This option is used to select the format of the debug information emitted into the output file, to be used by a debugger (or *will* be). Prior to version 2.03.01, the use of this switch did *not* enable output of the selected debug info format. Use `-g`, see section 2.1.14, to enable output. Versions 2.03.01 and later automatically enable `-g` if `-F` is specified.

A complete list of the available debug file formats for an output format can be seen by issuing the command `nasm -h`. Not all output formats currently support debugging output.

This should not be confused with the `-f dbg` output format option, see section 9.14.

2.1.14 The `-g` Option: Enabling Debug Information.

This option can be used to generate debugging information in the specified format. See section 2.1.13. Using `-g` without `-F` results in emitting debug info in the default format, if any, for the selected output format. If no debug information is currently implemented in the selected output format, `-g` is *silently ignored*.

2.1.15 The `-X` Option: Selecting an Error Reporting Format

This option can be used to select an error reporting format for any error messages that might be produced by NASM.

Currently, two error reporting formats may be selected. They are the `-Xvc` option and the `-Xgnu` option. The GNU format is the default and looks like this:

```
filename.asm:65: error: specific error message
```

where `filename.asm` is the name of the source file in which the error was detected, `65` is the source file line number on which the error was detected, `error` is the severity of the error (this could be `warning`), and `specific error message` is a more detailed text message which should help pinpoint the exact problem.

The other format, specified by `-Xvc` is the style used by Microsoft Visual C++ and some other programs. It looks like this:

```
filename.asm(65) : error: specific error message
```

where the only difference is that the line number is in parentheses instead of being delimited by colons.

See also the `Visual C++` output format, section 9.6.

2.1.16 The -z Option: Send Errors to a File

Under MS-DOS it can be difficult (though there are ways) to redirect the standard-error output of a program to a file. Since NASM usually produces its warning and error messages on `stderr`, this can make it hard to capture the errors if (for example) you want to load them into an editor.

NASM therefore provides the `-Z` option, taking a filename argument which causes errors to be sent to the specified files rather than standard error. Therefore you can redirect the errors into a file by typing

```
nasm -Z myfile.err -f obj myfile.asm
```

In earlier versions of NASM, this option was called `-E`, but it was changed since `-E` is an option conventionally used for preprocessing only, with disastrous results. See section 2.1.22.

2.1.17 The -s Option: Send Errors to `stdout`

The `-s` option redirects error messages to `stdout` rather than `stderr`, so it can be redirected under MS-DOS. To assemble the file `myfile.asm` and pipe its output to the `more` program, you can type:

```
nasm -s -f obj myfile.asm | more
```

See also the `-Z` option, section 2.1.16.

2.1.18 The -i Option: Include File Search Directories

When NASM sees the `%include` or `%pathsearch` directive in a source file (see section 5.9.1, section 5.9.2 or section 3.2.3), it will search for the given file not only in the current directory, but also in any directories specified on the command line by the use of the `-i` option. Therefore you can include files from a macro library, for example, by typing

```
nasm -ic:\macrolib\ -f obj myfile.asm
```

(As usual, a space between `-i` and the path name is allowed, and optional).

Prior NASM 2.14 a path provided in the option has been considered as a verbatim copy and providing a path separator been up to a caller. One could implicitly concatenate a search path together with a filename. Still this was rather a trick than something useful. Now the trailing path separator is made to always present, thus `-ifoo` will be considered as the `-ifoo/` directory.

If you want to define a *standard* include search path, similar to `/usr/include` on Unix systems, you should place one or more `-i` directives in the `NASMENV` environment variable (see section 2.1.36).

For Makefile compatibility with many C compilers, this option can also be specified as `-I`.

2.1.19 The -p Option: Pre-Include a File

NASM allows you to specify files to be *pre-included* into your source file, by the use of the `-p` option. So running

```
nasm myfile.asm -p myinc.inc
```

is equivalent to running `nasm myfile.asm` and placing the directive `%include "myinc.inc"` at the start of the file.

`--include` option is also accepted.

For consistency with the `-I`, `-D` and `-U` options, this option can also be specified as `-P`.

2.1.20 The -d Option: Pre-Define a Macro

Just as the `-p` option gives an alternative to placing `%include` directives at the start of a source file, the `-d` option gives an alternative to placing a `%define` directive. You could code

```
nasm myfile.asm -dFOO=100
```

as an alternative to placing the directive

```
%define FOO 100
```

at the start of the file. You can miss off the macro value, as well: the option `-dFOO` is equivalent to coding `%define FOO`. This form of the directive may be useful for selecting assembly-time options which are then tested using `%ifdef`, for example `-dDEBUG`.

For Makefile compatibility with many C compilers, this option can also be specified as `-D`.

2.1.21 The -u Option: Undefine a Macro

The `-u` option undefines a macro that would otherwise have been pre-defined, either automatically or by a `-p` or `-d` option specified earlier on the command lines.

For example, the following command line:

```
nasm myfile.asm -dFOO=100 -uFOO
```

would result in `FOO` *not* being a predefined macro in the program. This is useful to override options specified at a different point in a Makefile.

For Makefile compatibility with many C compilers, this option can also be specified as `-U`.

2.1.22 The -E Option: Preprocess Only

NASM allows the preprocessor to be run on its own, up to a point. Using the `-E` option (which requires no arguments) will cause NASM to preprocess its input file, expand all the macro references, remove all the comments and preprocessor directives, and print the resulting file on standard output (or save it to a file, if the `-o` option is also used).

This option cannot be applied to programs which require the preprocessor to evaluate expressions which depend on the values of symbols: so code such as

```
%assign tablesize ($-tablestart)
```

will cause an error in preprocess-only mode.

For compatibility with older version of NASM, this option can also be written `-e`. `-E` in older versions of NASM was the equivalent of the current `-Z` option, section 2.1.16.

2.1.23 The -a Option: Suppress Preprocessing

If NASM is being used as the back end to a compiler, it might be desirable to suppress preprocessing completely and assume the compiler has already done it, to save time and increase compilation speeds. The `-a` option, requiring no argument, instructs NASM to replace its powerful preprocessor with a stub preprocessor which does nothing.

2.1.24 The -O Option: Multipass Optimization

Using the `-O` option, you can tell NASM to carry out different levels of optimization. Multiple flags can be specified after the `-O` options, some of which can be combined in a single option, e.g. `-Oxv`.

- `-O0`: No optimization. All operands take their long forms, if a short form is not specified, except conditional jumps. This is intended to match NASM 0.98 behavior.
- `-O1`: Minimal optimization. As above, but immediate operands which will fit in a signed byte are optimized, unless the long form is specified. Conditional jumps default to the long form unless otherwise specified.
- `-Ox` (where `x` is the actual letter `x`): Multipass optimization. Minimize branch offsets and signed immediate bytes, overriding size specification unless the `strict` keyword has been used (see section 3.7). For compatibility with earlier releases, the letter `x` may also be any number greater than one. This number has no effect on the actual number of passes.
- `-Ov`: At the end of assembly, print the number of passes actually executed.

The `-Ox` mode is recommended for most uses, and is the default since NASM 2.09. *Any other mode will generate worse quality output.* Use `-O0` or `-O1` only if you need the finer programmer-level control of output and `strict` is not suitable for your use case.

Note that this is a capital `O`, and is different from a small `o`, which is used to specify the output file name. See section 2.1.1.

2.1.25 The `-t` Option: TASM Compatibility Mode

NASM includes a limited form of compatibility with Borland's TASM. When NASM's `-t` option is used, the following changes are made:

- local labels may be prefixed with `@@` instead of `.`
- size override is supported within brackets. In TASM compatible mode, a size override inside square brackets changes the size of the operand, and not the address type of the operand as it does in NASM syntax. E.g. `mov eax,[DWORD val]` is valid syntax in TASM compatibility mode. Note that you lose the ability to override the default address type for the instruction.
- unprefixed forms of some directives supported (`arg`, `elif`, `else`, `endif`, `if`, `ifdef`, `ifdifi`, `ifndef`, `include`, `local`)

2.1.26 The `-w` and `-W` Options: Enable or Disable Assembly Warnings

NASM can observe many conditions during the course of assembly which are worth mentioning to the user, but not a sufficiently severe error to justify NASM refusing to generate an output file. These conditions are reported like errors, but come up with the word 'warning' before the message. Warnings do not prevent NASM from generating an output file and returning a success status to the operating system.

Some conditions are even less severe than that: they are only sometimes worth mentioning to the user. Therefore NASM supports the `-w` command-line option, which enables or disables certain classes of assembly warning. Such warning classes are described by a name, for example `label-orphan`; you can enable warnings of this class by the command-line option `-w+label-orphan` and disable it by `-w-label-orphan`.

Since version 2.15, NASM has group aliases for all prefixed warnings, so they can be used to enable or disable all warnings in the group. For example, -w+float enables all warnings with names starting with float-*.

Since version 2.00, NASM has also supported the `gcc`–like syntax `-Wwarning-class` and `-Wno-warning-class` instead of `-w+warning-class` and `-w-warning-class`, respectively; both syntaxes work identically.

The option `-w+error` or `-Werror` can be used to treat warnings as errors. This can be controlled on a per warning class basis (`-w+error=`*warning-class* or `-Werror=`*warning-class*); if no *warning-class* is specified NASM treats it as `-w+error=all`; the same applies to `-w-error` or `-Wno-error`, of course.

In addition, you can control warnings in the source code itself, using the `[WARNING]` directive. See section 8.14.

See appendix A for the complete list of warning classes.

2.1.27 The `-v` Option: Display Version Info

Typing `NASM -v` will display the version of NASM which you are using, and the date on which it was compiled.

You will need the version number if you report a bug.

For command-line compatibility with Yasm, the form `--v` is also accepted for this option starting in NASM version 2.11.05.

2.1.28 The `--[gl]prefix` and `--[gl]postfix` Options

The `--gprefix` option prepends the given argument to all `extern`, `common`, `static`, and `global` symbols, and the `--lprefix` option prepends to all other symbols. Similarly, `--gpostfix` and `--lpostfix` options append the argument, in a manner similar to the `--[gl]prefix` options.

Running this:

```
nasm -f macho --gprefix _
```

is equivalent to placing the directive `%pragma macho gprefix _` at the start of the file (section 8.10). It will prepend the underscore to all global and external variables, as C requires it in some, but not all, system calling conventions.

`--prefix` is an alias for `--gprefix`.

See section 8.10 for the equivalent directives and pragmas.

Earlier versions of NASM called the pragmas `suffix` and the options `--postfix`, and did not implement directives at all despite being so documented. Since NASM 3.01, the directive forms are implemented, and directives, pragmas and options all support all spellings.

2.1.29 The `--pragma` Option

NASM accepts an argument as `%pragma` option, which is like placing a `%pragma` preprocess statement at the beginning of the source. Running this:

```
nasm -f macho --pragma "macho gprefix _"
```

is equivalent to the example in section 2.1.28. See section 5.13.

2.1.30 The `--before` Option

Insert a statement (usually, but not necessarily) a preprocess statement before the input file. The example shown in section 2.1.29 is the same as running this:

```
nasm -f macho --before "%pragma macho gprefix _"
```

2.1.31 The `--bits` Option

Set the processor mode by inserting a `BITS` directive (kee section 8.1) before the input file. The following two statements are exactly equivalent:

```
nasm -f bin --bits 16 file.asm
nasm -f bin --before "BITS 16" file.asm
```

The `--bits` option was introduced in NASM 3.01; the `--before` form can be used for compatibility with older versions of NASM.

2.1.32 The `--limit-` Options

These options allows user to setup various maximum values after which NASM will terminate with a fatal error rather than consume arbitrary amount of compute time. Each limit can be set to a positive number, `unlimited`, `maximum`, or `default`.

- `--limit-passes`: Number of maximum allowed passes. Default is `unlimited`.
- `--limit-stalled-passes`: Maximum number of allowed unfinished passes. Default is 1000.
- `--limit-macro-levels`: Define maximum depth of macro expansion (in preprocess). Default is 10000
- `--limit-macro-tokens`: Maximum number of tokens processed during single-line macro expansion. Default is 10000000.
- `--limit-mmacros`: Maximum number of multi-line macros processed before returning to the top-level input. Default is 100000.

- `--limit-rep`: Maximum number of allowed preprocessor loop, defined under `%rep`. Default is 1000000.
- `--limit-eval`: This number sets the maximum allowed expression length. Default is 8192 on most systems.
- `--limit-lines`: Total number of source lines allowed to be processed. Default is 2000000000.
- `--limit-params`: Maximum number of multi-line macro parameters. Default is 16383.

For example, set the maximum line count to 1000:

```
nasm --limit-lines 1000
```

Limits can also be set via the directive `%pragma limit`, for example:

```
%pragma limit lines 1000
```

Specifying the limit value as `*` or `reset` resets the limit to the value specified on the command line or the default value, undoing any previous `%pragma limit`.

See also the `%limit()` preprocessor function (section 5.5.13) and the `__?NASM_LIMITS?__` standard macro (section 6.8).

2.1.33 The `--keep-all` Option

This option prevents NASM from deleting any output files even if an error happens.

2.1.34 The `--no-line` Option

If this option is given, all `%line` directives in the source code are ignored. This can be useful for debugging already preprocessed code. See section 5.14.1.

2.1.35 The `--reproducible` Option

If this option is given, NASM will not emit information that is inherently dependent on the NASM version or different from run to run (such as timestamps) into the output file.

2.1.36 The `NASMENV` Environment Variable

If you define an environment variable called `NASMENV`, the program will interpret it as a list of extra command-line options, which are processed before the real command line. You can use this to define standard search directories for include files, by putting `-i` options in the `NASMENV` variable.

The value of the variable is split up at white space, so that the value `-s -ic:\nasmlib\` will be treated as two separate options. However, that means that the value `-dNAME="my name"` won't do what you might want, because it will be split at the space and the NASM command-line processing will get confused by the two nonsensical words `-dNAME="my` and `name"`.

To get round this, NASM provides a feature whereby, if you begin the `NASMENV` environment variable with some character that isn't a minus sign, then NASM will treat this character as the separator character for options. So setting the `NASMENV` variable to the value `!-s!-ic:\nasmlib\` is equivalent to setting it to `-s -ic:\nasmlib\`, but `!-dNAME="my name"` will work.

This environment variable was previously called `NASM`. This was changed with version 0.98.31.

2.2 Quick Start for MASM Users

If you're used to writing programs with MASM, or with TASM in MASM-compatible (non-Ideal) mode, or with `a86`, this section attempts to outline the major differences between MASM's syntax and NASM's. If you're not already used to MASM, it's probably worth skipping this section.

2.2.1 NASM Is Case-Sensitive

One simple difference is that NASM is case-sensitive. It makes a difference whether you call your label `foo`, `Foo` or `FOO`. If you're assembling to `DOS` or `OS/2 .OBJ` files, you can invoke the `UPPERCASE` directive (documented in section 9.4) to ensure that all symbols exported to other code modules are forced to be upper case; but even then, *within* a single module, NASM will distinguish between labels differing only in case.

2.2.2 NASM Requires Square Brackets For Memory References

NASM was designed with simplicity of syntax in mind. One of the design goals of NASM is that it should be possible, as far as is practical, for the user to look at a single line of NASM code and tell what opcode is generated by it. You can't do this in MASM: if you declare, for example,

```
foo     equ     1
bar     dw      2
```

then the two lines of code

```
        mov     ax,foo
        mov     ax,bar
```

generate completely different opcodes, despite having identical-looking syntaxes.

NASM avoids this undesirable situation by having a much simpler syntax for memory references. The rule is simply that any access to the *contents* of a memory location requires square brackets around the address, and any access to the *address* of a variable doesn't. So an instruction of the form `mov ax,foo` will *always* refer to a compile-time constant, whether it's an `EQU` or the address of a variable; and to access the *contents* of the variable `bar`, you must code `mov ax,[bar]`.

This also means that NASM has no need for MASM's `OFFSET` keyword, since the MASM code `mov ax,offset bar` means exactly the same thing as NASM's `mov ax,bar`. If you're trying to get large amounts of MASM code to assemble sensibly under NASM, you can always code `%idefine offset` to make the preprocessor treat the `OFFSET` keyword as a no-op.

This issue is even more confusing in `a86`, where declaring a label with a trailing colon defines it to be a 'label' as opposed to a 'variable' and causes `a86` to adopt NASM-style semantics; so in `a86`, `mov ax,var` has different behaviour depending on whether `var` was declared as `var: dw 0` (a label) or `var dw 0` (a word-size variable). NASM is very simple by comparison: *everything* is a label.

NASM, in the interests of simplicity, also does not support the hybrid syntaxes supported by MASM and its clones, such as `mov ax,table[bx]`, where a memory reference is denoted by one portion outside square brackets and another portion inside. The correct syntax for the above is `mov ax,[table+bx]`. Likewise, `mov ax,es:[di]` is wrong and `mov ax,[es:di]` is right.

2.2.3 NASM Doesn't Store Variable Types

NASM, by design, chooses not to remember the types of variables you declare. Whereas MASM will remember, on seeing `var dw 0`, that you declared `var` as a word-size variable, and will then be able to fill in the ambiguity in the size of the instruction `mov var,2`, NASM will deliberately remember nothing about the symbol `var` except where it begins, and so you must explicitly code `mov word [var],2`.

For this reason, NASM doesn't support the `LODS`, `MOVS`, `STOS`, `SCAS`, `CMPS`, `INS`, or `OUTS` instructions, but only supports the forms such as `LODSB`, `MOVSW`, and `SCASD`, which explicitly specify the size of the components of the strings being manipulated.

2.2.4 NASM Doesn't `ASSUME`

As part of NASM's drive for simplicity, it also does not support the `ASSUME` directive. NASM will not keep track of what values you choose to put in your segment registers, and will never *automatically* generate a segment override prefix.

2.2.5 NASM Doesn't Support Memory Models

NASM also does not have any directives to support different 16-bit memory models. The programmer has to keep track of which functions are supposed to be called with a far call and which with a near call, and is responsible for putting the correct form of RET instruction (RETN or RETF; NASM accepts RET itself as an alternate form for RETN); in addition, the programmer is responsible for coding CALL FAR instructions where necessary when calling *external* functions, and must also keep track of which external variable definitions are far and which are near.

2.2.6 Floating-Point Differences

NASM uses different names to refer to floating-point registers from MASM: where MASM would call them `ST(0)`, `ST(1)` and so on, and `a86` would call them simply `0`, `1` and so on, NASM chooses to call them `st0`, `st1` etc.

2.2.7 Other Differences

For historical reasons, NASM uses the keyword TWORD where MASM and compatible assemblers use TBYTE.

Historically, NASM does not declare uninitialized storage in the same way as MASM: where a MASM programmer might use `stack db 64 dup (?)`, NASM requires `stack resb 64`, intended to be read as 'reserve 64 bytes'. As of NASM 2.15, the MASM syntax is also supported.

In addition to all of this, macros and directives work completely differently to MASM. See chapter 5 and chapter 8 for further details.

2.2.8 MASM compatibility package

The MASM compatibility macro package can be used to improve MASM compatibility. See section 7.5.

Chapter 3: The NASM Language

3.1 Layout of a NASM Source Line

Like most assemblers, each NASM source line contains (unless it is a macro, a preprocessor directive or an assembler directive: see chapter 5 and chapter 8) some combination of the four fields

```
label:    instruction operands        ; comment
```

As usual, most of these fields are optional; the presence or absence of any combination of a label, an instruction and a comment is allowed. Of course, the operand field is either required or forbidden by the presence and nature of the instruction field.

NASM uses backslash (\) as the line continuation character; if a line ends with backslash, the next line is considered to be a part of the backslash-ended line.

NASM places no restrictions on white space within a line: labels may have white space before them, or instructions may have no space before them, or anything. The colon after a label is also optional. (Note that this means that if you intend to code `lodsb` alone on a line, and type `lodab` by accident, then that's still a valid source line which does nothing but define a label. Running NASM with the command-line option `-w+orphan-labels` will cause it to warn you if you define a label alone on a line without a trailing colon.)

Valid characters in labels are letters, numbers, `_`, `$`, `#`, `@`, `~`, `.`, and `?`. The only characters which may be used as the *first* character of an identifier are letters, `.` (with special meaning: see section 3.9), `_` and `?`. An identifier may also be prefixed with a `$` to indicate that it is intended to be read as an identifier and not a reserved word; thus, if some other module you are linking with defines a symbol called `eax`, you can refer to `$eax` in NASM code to distinguish the symbol from the register. Maximum length of an identifier is 4095 characters.

The instruction field may contain any machine instruction: Pentium and P6 instructions, FPU instructions, MMX instructions and even undocumented instructions are all supported. The instruction may be prefixed by `LOCK`, `REP`, `REPE`/`REPZ`, `REPNE`/`REPNZ`, `XACQUIRE`/`XRELEASE` or `BND`/`NOBND`, in the usual way. Explicit address-size and operand-size prefixes `A16`, `A32`, `A64`, `O16` and `O32`, `O64` are provided – one example of their use is given in chapter 12. You can also use the name of a segment register as an instruction prefix: coding `es mov [bx],ax` is equivalent to coding `mov [es:bx],ax`. We recommend the latter syntax, since it is consistent with other syntactic features of the language, but for instructions such as `LODSB`, which has no operands and yet can require a segment override, there is no clean syntactic way to proceed apart from `es lodsb`.

An instruction is not required to use a prefix: prefixes such as `CS`, `A32`, `LOCK` or `REPE` can appear on a line by themselves, and NASM will just generate the prefix bytes.

In addition to actual machine instructions, NASM also supports a number of pseudo-instructions, described in section 3.2.

Instruction operands may take a number of forms: they can be registers, described simply by the register name (e.g. `ax`, `bp`, `ebx`, `cr0`: NASM does not use the `gas`–style syntax in which register names must be prefixed by a `%` sign), or they can be effective addresses (see section 3.3), constants (section 3.4) or expressions (section 3.5).

For x87 floating-point instructions, NASM accepts a wide range of syntaxes: you can use two-operand forms like MASM supports, or you can use NASM's native single-operand forms in most cases. For example, you can code:

```
fadd    st1             ; this sets st0 := st0 + st1
fadd    st0,st1         ; so does this
```

```
fadd    st1,st0         ; this sets st1 := st1 + st0
fadd    to st1          ; so does this
```

Almost any x87 floating-point instruction that references memory must use one of the prefixes DWORD, QWORD or TWORD to indicate what size of memory operand it refers to.

3.2 Pseudo-Instructions

Pseudo-instructions are things which, though not real x86 machine instructions, are used in the instruction field anyway because that's the most convenient place to put them. The current pseudo-instructions are DB, DW, DD, DQ, DT, DO, DY and DZ; their uninitialized counterparts RESB, RESW, RESD, RESQ, REST, RESO, RESY and RESZ; the INCBIN command, the EQU command, and the TIMES prefix.

In this documentation, the notation "D*x*" and "RES*x*" is used to indicate all the DB and RESB type directives, respectively.

3.2.1 D*x*: Declaring Initialized Data

DB, DW, DD, DQ, DT, DO, DY and DZ (collectively "D*x*" in this documentation) are used, much as in MASM, to declare initialized data in the output file. They can be invoked in a wide range of ways:

```
db    0x55                ; just the byte 0x55
db    0x55,0x56,0x57      ; three bytes in succession
db    'a',0x55            ; character constants are OK
db    'hello',13,10,'$'   ; so are string constants
dw    0x1234              ; 0x34 0x12
dw    'a'                 ; 0x61 0x00 (it's just a number)
dw    'ab'                ; 0x61 0x62 (character constant)
dw    'abc'               ; 0x61 0x62 0x63 0x00 (string)
dd    0x12345678          ; 0x78 0x56 0x34 0x12
dd    1.234567e20         ; floating-point constant
dq    0x123456789abcdef0  ; eight byte constant
dq    1.234567e20         ; double-precision float
dt    1.234567e20         ; extended-precision float
```

DT, DO, DY and DZ do not accept integer numeric constants as operands.

Starting in NASM 2.15, a the following MASM–like features have been implemented:

- A ? argument to declare uninitialized storage:

```
db    ?                   ; uninitialized
```

- A superset of the DUP syntax. The NASM version of this has the following syntax specification; capital letters indicate literal keywords:

```
dx      := DB | DW | DD | DQ | DT | DO | DY | DZ
type    := BYTE | WORD | DWORD | QWORD | TWORD | OWORD | YWORD | ZWORD
atom    := expression | string | float | '?'
parlist := '(' value [',' value ...] ')'
duplist := expression DUP [type] ['%'] parlist
list    := duplist | '%' parlist | type ['%'] parlist
value   := [type] atom | list

stmt    := dx value [',' value ...]
```

  Note that a *list* needs to be prefixed with a % sign unless prefixed by either DUP or a *type* in order to avoid confusing it with a parenthesis starting an expression. The following expressions are all valid:

```
  db 33
  db (44)               ; Integer expression
; db (44,55)            ; Invalid - error
  db %(44,55)
  db %('XX','YY')
  db ('AA')             ; Integer expression - outputs single byte
  db %('BB')            ; List, containing a string
  db ?
```

```
db 6 dup (33)
db 6 dup (33, 34)
db 6 dup (33, 34), 35
db 7 dup (99)
db 7 dup dword (?, word ?, ?)
dw byte (?,44)
dw 3 dup (0xcc, 4 dup byte ('PQR'), ?), 0xabcd
dd 16 dup (0xaaaa, ?, 0xbbbbbb)
dd 64 dup (?)
```

The use of `$` (current address) in a D*x* statement is undefined in the current version of NASM, *except in the following cases*:

- For the first expression in the statement, either a `DUP` or a data item.
- An expression of the form "*value* `-` `$`", which is converted to a self-relative relocation.

Future versions of NASM is likely to produce a different result or issue an error this case.

There is no such restriction on using `$$` or section-relative symbols.

3.2.2 `RESB` and Friends: Declaring Uninitialized Data

`RESB`, `RESW`, `RESD`, `RESQ`, `REST`, `RESO`, `RESY` and `RESZ` are designed to be used in the BSS section of a module: they declare *uninitialized* storage space. Each takes a single operand, which is the number of bytes, words, doublewords or whatever to reserve. The operand to a `RESB`–type pseudo-instruction *would* be a *critical expression* (see section 3.8), except that for legacy compatibility reasons forward references are permitted, however *the code will be extremely fragile and this should be considered a severe programming error.* A warning will be issued; code generating this warning should be remedied as quickly as possible (see the `forward` class in appendix A.)

For example:

```
buffer:         resb    64              ; reserve 64 bytes
wordvar:        resw    1               ; reserve a word
realarray       resq    10              ; array of ten reals
ymmval:         resy    1               ; one YMM register
zmmvals:        resz    32              ; 32 ZMM registers
```

Since NASM 2.15, the MASM syntax of using `?` and `DUP` in the D*x* directives is also supported. Thus, the above example could also be written:

```
buffer:         db      64 dup (?)      ; reserve 64 bytes
wordvar:        dw      ?               ; reserve a word
realarray       dq      10 dup (?)      ; array of ten reals
ymmval:         dy      ?               ; one YMM register
zmmvals:        dz      32 dup (?)      ; 32 ZMM registers
```

3.2.3 `INCBIN`: Including External Binary Files

`INCBIN` includes binary file data verbatim into the output file. This can be handy for (for example) including graphics and sound data directly into a game executable file. It can be called in one of these three ways:

```
    incbin  "file.dat"              ; include the whole file
    incbin  "file.dat",1024         ; skip the first 1024 bytes
    incbin  "file.dat",1024,512     ; skip the first 1024, and
                                    ; actually include at most 512
```

`INCBIN` is both a directive and a standard macro; the standard macro version searches for the file in the include file search path and adds the file to the dependency lists. This macro can be overridden if desired.

3.2.4 EQU: Defining Constants

EQU defines a symbol to a given constant value: when EQU is used, the source line must contain a label. The action of EQU is to define the given label name to the value of its (only) operand. This definition is absolute, and cannot change later. So, for example,

```
message         db      'hello, world'
msglen          equ     $-message
```

defines msglen to be the constant 12. msglen may not then be redefined later. This is not a preprocessor definition either: the value of msglen is evaluated *once*, using the value of $ (see section 3.5 for an explanation of $) at the point of definition, rather than being evaluated wherever it is referenced and using the value of $ at the point of reference.

3.2.5 TIMES: Repeating Instructions or Data

The TIMES prefix causes the instruction to be assembled multiple times. This is partly present as NASM's equivalent of the DUP syntax supported by MASM–compatible assemblers, in that you can code

```
zerobuf:        times 64 db 0
```

or similar things; but TIMES is more versatile than that. The argument to TIMES is not just a numeric constant, but a numeric *expression*, so you can do things like

```
buffer: db      'hello, world'
        times 64-$+buffer db ' '
```

which will store exactly enough spaces to make the total length of buffer up to 64. Finally, TIMES can be applied to ordinary instructions, so you can code trivial unrolled loops in it:

```
        times 100 movsb
```

Note that there is no effective difference between times 100 resb 1 and resb 100, except that the latter will be assembled about 100 times faster due to the internal structure of the assembler.

The operand to TIMES is a critical expression (section 3.8).

Note also that TIMES can't be applied to macros: the reason for this is that TIMES is processed after the macro phase, which allows the argument to TIMES to contain expressions such as 64-$+buffer as above. To repeat more than one line of code, or a complex macro, use the preprocessor %rep directive.

3.3 Effective Addresses

An effective address is any operand to an instruction which references memory. Effective addresses, in NASM, have a very simple syntax: they consist of an expression evaluating to the desired address, enclosed in square brackets. For example:

```
wordvar dw      123
        mov     ax,[wordvar]
        mov     ax,[wordvar+1]
        mov     ax,[es:wordvar+bx]
```

Anything not conforming to this simple system is not a valid memory reference in NASM, for example es:wordvar[bx].

More complicated effective addresses, such as those involving more than one register, work in exactly the same way:

```
        mov     eax,[ebx*2+ecx+offset]
        mov     ax,[bp+di+8]
```

NASM is capable of doing algebra on these effective addresses, so that things which don't necessarily *look* legal are perfectly all right:

```
    mov     eax,[ebx*5]             ; assembles as [ebx*4+ebx]
    mov     eax,[label1*2-label2]   ; ie [label1+(label1-label2)]
```

Some forms of effective address have more than one assembled form; in most such cases NASM will generate the smallest form it can. For example, there are distinct assembled forms for the 32-bit effective addresses `[eax*2+0]` and `[eax+eax]`, and NASM will generally generate the latter on the grounds that the former requires four bytes to store a zero offset.

NASM has a hinting mechanism which will cause `[eax+ebx]` and `[ebx+eax]` to generate different opcodes; this is occasionally useful because `[esi+ebp]` and `[ebp+esi]` have different default segment registers.

However, you can force NASM to generate an effective address in a particular form by the use of the keywords `BYTE`, `WORD`, `DWORD` and `NOSPLIT`. If you need `[eax+3]` to be assembled using a double-word offset field instead of the one byte NASM will normally generate, you can code `[dword eax+3]`. Similarly, you can force NASM to use a byte offset for a small value which it hasn't seen on the first pass (see section 3.8 for an example of such a code fragment) by using `[byte eax+offset]`. As special cases, `[byte eax]` will code `[eax+0]` with a byte offset of zero, and `[dword eax]` will code it with a double-word offset of zero. The normal form, `[eax]`, will be coded with no offset field.

The form described in the previous paragraph is also useful if you are trying to access data in a 32-bit segment from within 16 bit code. For more information on this see the section on mixed-size addressing (section 12.2). In particular, if you need to access data with a known offset that is larger than will fit in a 16-bit value, if you don't specify that it is a dword offset, nasm will cause the high word of the offset to be lost.

Similarly, NASM will split `[eax*2]` into `[eax+eax]` because that allows the offset field to be absent and space to be saved; in fact, it will also split `[eax*2+offset]` into `[eax+eax+offset]`. You can combat this behaviour by the use of the `NOSPLIT` keyword: `[nosplit eax*2]` will force `[eax*2+0]` to be generated literally. `[nosplit eax*1]` also has the same effect. In another way, a split EA form `[0, eax*2]` can be used, too. However, `NOSPLIT` in `[nosplit eax+eax]` will be ignored because user's intention here is considered as `[eax+eax]`.

In 64-bit mode, NASM will by default generate absolute addresses. The `REL` keyword makes it produce `RIP`–relative addresses. Since this is frequently the normally desired behaviour, see the `DEFAULT` directive (section 8.2). The keyword `ABS` overrides `REL`.

A new syntax for split EA (effective addressing) is also supported in NASM. It's mainly intended for MPX instructions that use the MIB operands, but it can be used for any memory reference. It's described in more detail in section 4.4.

When broadcasting decorator is used, the opsize keyword should match the size of each element.

```
VDIVPS zmm4, zmm5, dword [rbx]{1to16}   ; single-precision float
VDIVPS zmm4, zmm5, zword [rbx]          ; packed 512 bit memory
```

3.4 Constants

NASM understands four different types of constant: numeric, character, string and floating-point.

3.4.1 Numeric Constants

A numeric constant is simply a number. NASM allows you to specify numbers in a variety of number bases, in a variety of ways: you can suffix `H` or `X`, `D` or `T`, `Q` or `O`, and `B` or `Y` for hexadecimal, decimal, octal and binary respectively, or you can prefix `0h` or `0x`, `0d` or `0t`, `0q` or `0o`, and `0b` or `0y`) in the style of C. Please note that unlike C, a `0` prefix by itself does *not* imply an octal constant (this is deprecated in C23.)

Previous versions of NASM allowed prefixing `$` for hexadecimal in the style of Borland Pascal or Motorola Assemblers. Unfortunately though, the `$` prefix does double duty as a prefix on identifiers (see section 3.1), so a hex number prefixed with a `$` sign would have to have a digit after the `$` rather than a letter, which is *not* what users would typically expect. This syntax is strongly deprecated, and can be disabled entirely with the `[DOLLARHEX]` directive, see section 8.12.

Numeric constants can have underscores (_) interspersed to break up long strings.

Some examples (all producing exactly the same code):

```
mov     ax,200          ; decimal
mov     ax,0200         ; still decimal
mov     ax,0200d        ; explicitly decimal
mov     ax,0d200        ; also decimal
mov     ax,0c8h         ; hex
mov     ax,0xc8         ; hex yet again
mov     ax,0hc8         ; still hex
mov     ax,310q         ; octal
mov     ax,310o         ; octal again
mov     ax,0o310        ; octal yet again
mov     ax,0q310        ; octal yet again
mov     ax,11001000b    ; binary
mov     ax,1100_1000b   ; same binary constant
mov     ax,1100_1000y   ; same binary constant once more
mov     ax,0b1100_1000  ; same binary constant yet again
mov     ax,0y1100_1000  ; same binary constant yet again

; Deprecated syntax:
mov     ax,$0c8         ; hex again: the 0 is required
```

3.4.2 Character Strings

A character string consists of up to eight characters enclosed in either single quotes (`'...'`), double quotes (`"..."`) or backquotes (`‘...‘`). Single or double quotes are equivalent in NASM (except of course that surrounding the constant with single quotes allows double quotes to appear within it and vice versa); the contents of those are represented verbatim. Strings enclosed in backquotes support C-style `\`–escapes for special characters.

The following escape sequences are recognized by backquoted strings:

```
\'          single quote (')
\"          double quote (")
\‘          backquote (‘)
\\          backslash (\)
\?          question mark (?)
\a          BEL (ASCII 7)
\b          BS  (ASCII 8)
\t          TAB (ASCII 9)
\n          LF  (ASCII 10)
\v          VT  (ASCII 11)
\f          FF  (ASCII 12)
\r          CR  (ASCII 13)
\e          ESC (ASCII 27)
\377        Up to 3 octal digits - literal byte
\xFF        Up to 2 hexadecimal digits - literal byte
\u1234      4 hexadecimal digits - Unicode character
\U12345678  8 hexadecimal digits - Unicode character
```

NASM 3.02 added the following additional sequences:

```
\o377       Up to 3 octal digits - literal byte (from C2y)
\d255       Up to 3 decimal digits - literal byte (NASM extension)
\^?         ASCII DEL (\d127, \177)
\^X         Convert X to a control character (e.g.
```

Since NASM 3.02, the numeric escape sequences starting with `\x`, `\o`, `\d` or `\u` can have their argument enclosed in curly braces to delimit their length, instead of terminating after a certain number of digits or a non-digit another character:

```
\x{FF}      Hexadecimal, literal byte
\o{377}     Octal, literal byte
\d{255}     Decimal, literal byte
```

```
\u{1234}    Unicode character
\u{12345}   Unicode character
```

All other escape sequences are reserved. Note that `\0`, meaning a `NUL` character (ASCII 0), is a special case of the octal escape sequence.

Unicode characters specified with `\u` or `\U` are converted to UTF-8. For example, the following lines are all equivalent:

```
db ‘\u263a‘            ; UTF-8 smiley face
db ‘\U0000263a‘        ; UTF-8 smiley face
db ‘\u{263a}‘          ; UTF-8 smiley face
db ‘\xe2\x98\xba‘      ; UTF-8 smiley face
db 0E2h, 098h, 0BAh    ; UTF-8 smiley face
```

3.4.3 Character Constants

A character constant consists of a string up to eight bytes long, used in an expression context. It is treated as if it was an integer.

A character constant with more than one byte will be arranged with little-endian order in mind: if you code

```
    mov eax,’abcd’
```

then the constant generated is not `0x61626364`, but `0x64636261`, so that if you were then to store the value into memory, it would read `abcd` rather than `dcba`. This is also the sense of character constants understood by the Pentium’s `CPUID` instruction.

3.4.4 String Constants

String constants are character strings used in the context of some pseudo-instructions, namely the `DB` family and `INCBIN` (where it represents a filename). They are also used in certain preprocessor directives.

A string constant looks like a character constant, only longer. It is treated as a concatenation of maximum-size character constants for the conditions. So the following are equivalent:

```
db    ’hello’               ; string constant
db    ’h’,’e’,’l’,’l’,’o’   ; equivalent character constants
```

And the following are also equivalent:

```
dd    ’ninechars’           ; doubleword string constant
dd    ’nine’,’char’,’s’     ; becomes three doublewords
db    ’ninechars’,0,0,0     ; and really looks like this
```

Note that when used in a string-supporting context, quoted strings are treated as a string constants even if they are short enough to be a character constant, because otherwise `db ’ab’` would have the same effect as `db ’a’`, which would be silly. Similarly, three-character or four-character constants are treated as strings when they are operands to `DW`, and so forth.

3.4.5 Unicode Strings

The special operators `__?utf16?__`, `__?utf16le?__`, `__?utf16be?__`, `__?utf32?__`, `__?utf32le?__` and `__?utf32be?__` allows definition of Unicode strings. They take a string in UTF-8 format and converts it to UTF-16 or UTF-32, respectively. Unless the `be` forms are specified, the output is little endian.

For example:

```
%define u(x) __?utf16?__(x)
%define w(x) __?utf32?__(x)

      dw u(’C:\WINDOWS’), 0       ; Pathname in UTF-16
      dd w(‘A + B = \u206a‘), 0   ; String in UTF-32
```

The UTF operators can be applied either to strings passed to the DB family instructions, or to character constants in an expression context.

3.4.6 Floating-Point Constants

Floating-point constants are acceptable only as arguments to DB, DW, DD, DQ, DT, and DO, or as arguments to the special operators __?float8?__, __?float16?__, __?bfloat16?__, __?float32?__, __?float64?__, __?float80m?__, __?float80e?__, __?float128l?__, and __?float128h?__. See also section 7.3.

Floating-point constants are expressed in the traditional form: digits, then a period, then optionally more digits, then optionally an E followed by an exponent. The period is mandatory, so that NASM can distinguish between dd 1, which declares an integer constant, and dd 1.0 which declares a floating-point constant.

NASM also support C99-style hexadecimal floating-point: 0x, hexadecimal digits, period, optionally more hexadeximal digits, then optionally a P followed by a *binary* (not hexadecimal) exponent in decimal notation. As an extension, NASM additionally supports the 0h and $ prefixes for hexadecimal, as well binary and octal floating-point, using the 0b or 0y and 0o or 0q prefixes, respectively. As with integers, the $ prefix for hexadecimal is deprecated.

Underscores to break up groups of digits are permitted in floating-point constants as well.

Some examples:

```
db    -0.2                    ; "Quarter precision"
dw    -0.5                    ; IEEE 754r/SSE5 half precision
dd    1.2                     ; an easy one
dd    1.222_222_222           ; underscores are permitted
dd    0x1p+2                  ; 1.0x2^2 = 4.0
dq    0x1p+32                 ; 1.0x2^32 = 4 294 967 296.0
dq    1.e10                   ; 10 000 000 000.0
dq    1.e+10                  ; synonymous with 1.e10
dq    1.e-10                  ; 0.000 000 000 1
dt    3.14159265358979238462 ; pi
do    1.e+4000                ; IEEE 754r quad precision
```

The 8-bit "quarter-precision" floating-point format is sign:exponent:mantissa = 1:4:3 with an exponent bias of 7. This appears to be the most frequently used 8-bit floating-point format, although it is not covered by any formal standard. This is sometimes called a "minifloat."

The bfloat16 format is effectively a compressed version of the 32-bit single precision format, with a reduced mantissa. It is effectively the same as truncating the 32-bit format to the upper 16 bits, except for rounding. There is no D*x* directive that corresponds to bfloat16 as it obviously has the same size as the IEEE standard 16-bit half precision format, see however section 7.3.

The special operators are used to produce floating-point numbers in other contexts. They produce the binary representation of a specific floating-point number as an integer, and can use anywhere integer constants are used in an expression. __?float80m?__ and __?float80e?__ produce the 64-bit mantissa and 16-bit exponent of an 80-bit floating-point number, and __?float128l?__ and __?float128h?__ produce the lower and upper 64-bit halves of a 128-bit floating-point number, respectively.

For example:

```
mov    rax,__?float64?__(3.14159265358979238462)
```

... would assign the binary representation of pi as a 64-bit floating point number into RAX. This is exactly equivalent to:

```
mov    rax,0x400921fb54442d18
```

NASM cannot do compile-time arithmetic on floating-point constants. This is because NASM is designed to be portable – although it always generates code to run on x86 processors, the assembler itself can

run on any system with an ANSI C compiler. Therefore, the assembler cannot guarantee the presence of a floating-point unit capable of handling the Intel number formats, and so for NASM to be able to do floating arithmetic it would have to include its own complete set of floating-point routines, which would significantly increase the size of the assembler for very little benefit.

The special tokens `__?Infinity?__`, `__?QNaN?__` (or `__?NaN?__`) and `__?SNaN?__` can be used to generate infinities, quiet NaNs, and signalling NaNs, respectively. These are normally used as macros:

```
%define Inf __?Infinity?__
%define NaN __?QNaN?__

      dq    +1.5, -Inf, NaN         ; Double-precision constants
```

The `%use fp` standard macro package contains a set of convenience macros. See section 7.3.

3.4.7 Packed BCD Constants

x87-style packed BCD constants can be used in the same contexts as 80-bit floating-point numbers. They are suffixed with `p` or prefixed with `0p`, and can include up to 18 decimal digits.

As with other numeric constants, underscores can be used to separate digits.

For example:

```
dt 12_345_678_901_245_678p
dt -12_345_678_901_245_678p
dt +0p33
dt 33p
```

3.5 Expressions

Expressions in NASM are similar in syntax to those in C. Expressions are evaluated as 64-bit integers which are then adjusted to the appropriate size.

NASM supports two special tokens in expressions, allowing calculations to involve the current assembly position: the `$` and `$$` tokens. `$` evaluates to the assembly position at the beginning of the line containing the expression; so you can code an infinite loop using `JMP $`. `$$` evaluates to the beginning of the current section; so you can tell how far into the section you are by using `($-$$)`.

The arithmetic operators provided by NASM are listed here, in increasing order of precedence.

A *boolean* value is true if nonzero and false if zero. The operators which return a boolean value always return 1 for true and 0 for false.

3.5.1 `?` ... `:`: Conditional Operator

The syntax of this operator, similar to the C conditional operator, is:

boolean `?` *trueval* `:` *falseval*

This operator evaluates to *trueval* if *boolean* is true, otherwise to *falseval*.

Note that NASM allows `?` characters in symbol names. Therefore, it is highly advisable to always put spaces around the `?` and `:` characters.

3.5.2 `|`|: Boolean OR Operator

The `||` operator gives a boolean OR: it evaluates to 1 if either side of the expression is nonzero, otherwise 0.

3.5.3 `^^`: Boolean XOR Operator

The `^^` operator gives a boolean XOR: it evaluates to 1 if exactly one side of the expression is nonzero, otherwise 0.

3.5.4 : &&: Boolean AND Operator

The && operator gives a boolean AND: it evaluates to 1 if both sides of the expression is nonzero, otherwise 0.

3.5.5 : Comparison Operators

NASM supports the following comparison operators:

- = or == compare for equality.
- != or <> compare for inequality.
- < compares signed less than.
- <= compares signed less than or equal.
- > compares signed greater than.
- >= compares signed greater than or equal.

These operators evaluate to 0 for false or 1 for true.

- <=> does a signed comparison, and evaluates to –1 for less than, 0 for equal, and 1 for greater than.

At this time, NASM does not provide unsigned comparison operators.

3.5.6 |: Bitwise OR Operator

The | operator gives a bitwise OR, exactly as performed by the OR machine instruction.

3.5.7 ^: Bitwise XOR Operator

^ provides the bitwise XOR operation.

3.5.8 &: Bitwise AND Operator

& provides the bitwise AND operation.

3.5.9 Bit Shift Operators

<< gives a bit-shift to the left, just as it does in C. So 5<<3 evaluates to 5 times 8, or 40. >> gives an *unsigned* (logical) bit-shift to the right; the bits shifted in from the left are set to zero.

<<< gives a bit-shift to the left, exactly equivalent to the << operator; it is included for completeness. >>> gives an *signed* (arithmetic) bit-shift to the right; the bits shifted in from the left are filled with copies of the most significant (sign) bit.

3.5.10 + and –: Addition and Subtraction Operators

The + and – operators do perfectly ordinary addition and subtraction.

3.5.11 Multiplication, Division and Modulo

* is the multiplication operator.

/ and // are both division operators: / is unsigned division and // is signed division.

Similarly, % and %% provide unsigned and signed modulo operators respectively.

Since the % character is used extensively by the macro preprocessor, you should ensure that both the signed and unsigned modulo operators are followed by white space wherever they appear.

NASM, like ANSI C, provides no guarantees about the sensible operation of the signed modulo operator. On most systems it will match the signed division operator, such that:

```
b * (a // b) + (a %% b) = a        (b != 0)
```

3.5.12 Unary Operators

The highest-priority operators in NASM's expression grammar are those which only apply to one argument. These are:

- `-` negates (2's complement) its operand.
- `+` does nothing; it's provided for symmetry with `-`.
- `~` computes the bitwise negation (1's complement) of its operand.
- `!` is the boolean negation operator. It evaluates to 1 if the argument is 0, otherwise 0.
- `SEG` provides the segment address of its operand (explained in more detail in section 3.6).
- A set of additional operators with leading and trailing double underscores are used to implement the `integer functions` of the `ifunc` macro package, see section 7.4.

3.6 `SEG` and `WRT`

When writing large 16-bit programs, which must be split into multiple segments, it is often necessary to be able to refer to the segment part of the address of a symbol. NASM supports the `SEG` operator to perform this function.

The `SEG` operator evaluates to the *preferred* segment base of a symbol, defined as the segment base relative to which the offset of the symbol makes sense. So the code

```
mov     ax,seg symbol
mov     es,ax
mov     bx,symbol
```

will load `ES:BX` with a valid pointer to the symbol `symbol`.

Things can be more complex than this: since 16-bit segments and groups may overlap, you might occasionally want to refer to some symbol using a different segment base from the preferred one. NASM lets you do this, by the use of the `WRT` (With Reference To) keyword. So you can do things like

```
mov     ax,weird_seg        ; weird_seg is a segment base
mov     es,ax
mov     bx,symbol wrt weird_seg
```

to load `ES:BX` with a different, but functionally equivalent, pointer to the symbol `symbol`.

The `WRT` keyword is also used in far (inter-segment) calls and jumps. It's synonymous to the

```
call far procedure
```

syntax which is documented in section 4.1.5.

3.7 `STRICT`: Inhibiting Optimization

When assembling with the optimizer set to level 2 or higher (see section 2.1.24), NASM will use size specifiers (`BYTE`, `WORD`, `DWORD`, `QWORD`, `TWORD`, `OWORD`, `YWORD` or `ZWORD`), but will give them the smallest possible size. The keyword `STRICT` can be used to inhibit optimization and force a particular operand to be emitted in the specified size. For example, with the optimizer on, and in `BITS 16` mode,

```
push dword 33
```

is encoded in three bytes `66 6A 21`, whereas

```
push strict dword 33
```

is encoded in six bytes, with a full dword immediate operand `66 68 21 00 00 00`.

With the optimizer off, the same code (six bytes) is generated whether the `STRICT` keyword was used or not.

3.8 Critical Expressions

Although NASM has an optional multi-pass optimizer, there are some expressions which must be resolvable on the first pass. These are called *Critical Expressions*.

The first pass is used to determine the size of all the assembled code and data, so that the second pass, when generating all the code, knows all the symbol addresses the code refers to. So one thing NASM can't handle is code whose size depends on the value of a symbol declared after the code in question. For example,

```
        times (label-$) db 0
label:  db      'Where am I?'
```

The argument to `TIMES` in this case could equally legally evaluate to anything at all; NASM will reject this example because it cannot tell the size of the `TIMES` line when it first sees it. It will just as firmly reject the slightly paradoxical code

```
        times (label-$+1) db 0
label:  db      'NOW where am I?'
```

in which *any* value for the `TIMES` argument is by definition wrong!

NASM rejects these examples by means of a concept called a *critical expression*, which is defined to be an expression whose value is required to be computable in the first pass, and which must therefore depend only on symbols defined before it. The argument to the `TIMES` prefix is a critical expression.

3.9 Local Labels

NASM gives special treatment to symbols beginning with a period. A label beginning with a single period is treated as a *local* label, which means that it is associated with the previous non-local label. So, for example:

```
label1  ; some code

.loop
        ; some more code

        jne     .loop
        ret

label2  ; some code

.loop
        ; some more code

        jne     .loop
        ret
```

In the above code fragment, each `JNE` instruction jumps to the line immediately before it, because the two definitions of `.loop` are kept separate by virtue of each being associated with the previous non-local label.

This form of local label handling is borrowed from the old Amiga assembler DevPac; however, NASM goes one step further, in allowing access to local labels from other parts of the code. This is achieved by means of *defining* a local label in terms of the previous non-local label: the first definition of `.loop` above is really defining a symbol called `label1.loop`, and the second defines a symbol called `label2.loop`. So, if you really needed to, you could write

```
label3  ; some more code
        ; and some more

        jmp label1.loop
```

Sometimes it is useful – in a macro, for instance – to be able to define a label which can be referenced from anywhere but which doesn't interfere with the normal local-label mechanism. Such a label can't be non-local because it would interfere with subsequent definitions of, and references to, local labels; and it can't be local because the macro that defined it wouldn't know the label's full name. NASM therefore introduces a third type of label, which is probably only useful in macro definitions: if a label begins with the special prefix `..@`, then it does nothing to the local label mechanism. So you could code

```
label1:                         ; a non-local label
.local:                         ; this is really label1.local
..@foo:                         ; this is a special symbol
label2:                         ; another non-local label
.local:                         ; this is really label2.local

        jmp     ..@foo          ; this will jump three lines up
```

NASM has the capacity to define other special symbols beginning with a double period: for example, `..start` is used to specify the entry point in the `obj` output format (see section 9.4.6), `..imagebase` is used to find out the offset from a base address of the current image in the `win64` output format (see section 9.7.1), `..symtab` is used to emit the COFF symbol table index (see section 9.6.3). So just keep in mind that symbols beginning with a double period are special.

Chapter 4: Syntax Quirks and Summaries

4.1 Summary of the JMP and CALL Syntax

The JMP and CALL instructions support a variety of syntaxes to simplify their specific use cases. Some of the following chapters explain how these two instructions interact with various special symbols that NASM uses and some document non-obvious scenarios regarding differently sized modes of operation.

4.1.1 Near Jumps

Near jumps are jumps within a single segment. Probably the most common way to use them is through labels, as explained in section 3.9. APX added a near jump instruction – JMPABS, that allows jumps to any 64-bit address specified with an immediate operand. The instruction works with absolute addresses and the syntax options are shown in section 4.1.6.

4.1.2 Infinite Loop Trick

One of the ways to quickly implement an infinite loop is using the `$` token which evaluates to the current position in the code. So a one line infinite loop can simply look like:

```
jmp $
```

4.1.3 Jumps and Mixed Sizes

In some special circumstances one might need to jump between 16-bit mode and 32-bit mode. A similar issue is addressing between 16 and 32 bit segments. The possible cases and the relevant syntax for both problems are explained in section 12.1 and section 12.2 respectively.

4.1.4 Calling Procedures Outside of a Shared Library

When writing shared libraries it's often necessary to call external code. In the ELF format the keyword takes on a different meaning than normally when it helps reference a segment – it's used to refer to some special symbols (more about it can be found in section 9.7.1). In the case described here, "`wrt ..plt`" references a PLT (procedure linkage table) entry. It can be used to call external routines in a way explained in section 11.2.5.

4.1.5 FAR Calls and Jumps

NASM supports FAR (inter-segment) calls and jumps by means of the syntax `call segment:offset`, where `segment` and `offset` both represent immediate values. So to call a far procedure, you could code either of

```
call    (seg procedure):procedure
call    weird_seg:(procedure wrt weird_seg)
```

(The parentheses are included for clarity, to show the intended parsing of the above instructions. They are not necessary in practice.)

NASM also supports the syntax `call far procedure` as a synonym for the first of the above usages. JMP works identically to CALL in these examples.

To declare a far pointer to a data item in a data segment, you must code

```
dw symbol, seg symbol                ; 16 bit
dd symbol, word seg symbol           ; 32 bit
```

NASM supports no convenient synonym for this, though you can always invent one using the macro processor.

4.1.6 64-bit absolute jump (JMPABS)

Defined as part of the APX specification, JMPABS is a new near jump instruction takes a 64-bit *absolute* address immediate. It is the only *direct* jump instruction that can jump anywhere in the address space in 64-bit mode.

NASM allows this instruction to be specified either as:

```
jmpabs target
```

... or:

```
jmp abs target
```

The generated code is identical. The ABS is required regardless of the DEFAULT setting.

4.1.7 Optimizing jump lengths and sizes

JMP lengths can be specified using keywords such as SHORT and NEAR. The keyword used also has consequences in how many bytes will be emitted in the final assembled instruction. It's worth to note the behavior of SHORT and NEAR for example in 16 bit mode. If it's specifically required to emit a 3 byte encoding of the jump instruction, then the NEAR version shall always fulfill this requirement, even if the jump is made within a SHORT distance (so up to a byte away). If the optimized version is expected then it's best to not use a length specifier at all and let the assembler pick the relevant version by itself.

Using size specifiers with jumps (and therefore with labels which are just immediates) will be optimized down to the shortest possible encoding since the size specifier is relevant to the operation size and not to the jump length.

```
00000000 EB09                   jmp label
00000002 EB07                   jmp SHORT label
00000004 E90400                 jmp NEAR label
00000007 EB02                   jmp BYTE label
00000009 EB00                   jmp WORD label

                                label:
```

4.2 Compact NDS/NDD Operands

Some instructions that use the VEX prefix, mainly AVX ones, use NDS (Non-Destructive Source) or NDD (New Data Destination) operands. Semantically it works by passing another operand to the instruction so that none of the source operands are modified as a result of the operation.

Syntactically NASM allows both the obvious format mentioned above and a compact format – compact meaning that if a user passes two operands instead of three, one of them is simply copied to be used as the source or destination. Thereby these instructions have exactly the same encoding:

```
vaddpd xmm0, xmm0, xmm1
vaddpd xmm0, xmm1
```

Here the XMM0 register is used as the "non-destructive source" even though in this case it will of course be modified.

4.3 64-bit *moffs*

The *moffs* operand can be used with the MOV instruction, only using the "A" register (AL, AX, EAX, or RAX), and for non-64-bit operand size means to address memory at an offset from a segment. For 64-bit operands it simply accesses memory at a specified offset (since segment based addressing is mostly unavailable in 64-bit mode). Syntax to use 64-bit offsets to address memory is showcased in section 13.2.2.

4.4 Split EA Addressing Syntax

Instructions that use the mib operand, (that is memory addressed with a base register, with some offset, with an added index register that's multiplied by some scale factor) can also utilize the split EA (effective addressing). The new form is mainly intended for MPX instructions that use the mib operands, but can be used for any memory reference. The basic concept of this form is splitting base and index:

```
mov eax,[ebx+8,ecx*4]   ; ebx=base, ecx=index, 4=scale, 8=disp
```

NASM supports all currently possible forms of the mib syntax:

```
; bndstx
; next 5 lines are parsed same
; base=rax, index=rbx, scale=1, displacement=3
bndstx [rax+0x3,rbx], bnd0      ; NASM - split EA
bndstx [rbx*1+rax+0x3], bnd0    ; GAS - '*1' indecates an index reg
bndstx [rax+rbx+3], bnd0        ; GAS - without hints
bndstx [rax+0x3], bnd0, rbx     ; ICC-1
bndstx [rax+0x3], rbx, bnd0     ; ICC-2
```

4.5 No Syntax for Ternary Logic Instruction

`VPTERNLOGD` and `VPTERNLOGQ` are instructions that implement an arbitrary logic function for three inputs. They take three register operands and one immediate value that determines what logic function the instruction shall implement on execution. Specifically the output of the desired logic function is encoded in the immediate 8-bit operand. 3 binary inputs can be configured in 8 possible ways giving 8 output bits that could implement any one of 256 possible logic functions. Therefore it's not practical to have any syntax around different possible logic functions.

However there are some macro solutions that can help avoid writing out truth tables in order to use the ternary logic instructions. The simple, more manual way is to calculate the logic operation encoding on the fly with a few lines of arithmetic directives:

```
a equ 0xaa
b equ 0xcc
c equ 0xf0
imm equ a | b & c
```

Here, values for "a", "b" and "c" together are all possible bit configurations that a 3 input function can take ("a" being the least significant bit and "c" being the most significant one). Then the "imm" variable is calculated by evaluating the desired logic function, in this case "a or b and c", thereby getting the function's output column that one would get when writing out the truth tables.

Note that only the expression must be written using the bitwise operators `&`, `|`, `^`, and `~`. Using the boolean operators `&&`, `||`, `^^`, `!` and `? :` will not work correctly.

The `vtern` standard macro package, section 7.6, allows for these kinds of expressions without introducing the symbols `a`, `b` and `c` into the global namespace:

```
%use vtern
     vpternlogd xmm1, xmm2, xmm3, a | b & c
     vpternlogq ymm4, ymm5, xmm6, (b ^ c) & ~a
     ; a, b, and c are not defined as symbols elsewhere
```

4.6 APX Instruction Syntax

Intel APX (Advanced Performance Extensions) introduces multiple new features, mostly to existing instructions. APX is only available in 64-bit mode.

- There are 16 new general purpose registers, `R16` to `R31`.
- Many instructions now support a non-destructive destination operand.
- The ability to suppress the setting of the arithmetic flags.

- The ability to zero the upper parts of a full 64-bit register for 8- and 16-bit operation size instructions. (This zeroing is always performed for 32-bit operations; this has been the case since 64-bit mode was first introduced.)
- New instructions to conditionally set the arithmetic flags to a user-specified value.
- Performance-enhanced versions of the PUSH and POP instructions.
- A 64-bit absolute jump instruction.
- A new REX2 prefix.

See `https://www.nasm.us/specs/apx` for a link to the APX technical documentation. NASM generally follows the syntax specified in the *Assembly Syntax Recommendations for Intel APX* document although some syntax is relaxed, see below.

4.6.1 Extended General Purpose Registers (EGPRs)

When it comes to register size, the new registers (R16–R31) work the same way as registers R8–R15 (see also section 13.1):

- R31 is the 64-bit form of register 31,
- R31D is the 32-bit form,
- R31W is the 16-bit form, and
- R31B is the 8-bit form. The form R31L can also be used if the `altreg` macro package is used (`%use altreg`), see section 7.1.

Extended registers require that either a REX2 prefix (the default, if possible) or an EVEX prefix is used.

There are some instructions that don't support EGPRs. In that case, NASM will generate an error if they are used.

4.6.2 New Data Destination (NDD)

Using the new data destination register (when supported) is specified by adding an additional register in place of the first operand. For example an ADD instruction:

```
add rax, rbx, rcx
```

... which would add RBX and RCX and store the result in RAX, without modifying neither RBX nor RCX.

4.6.3 Suppress Modifying Flags (NF)

The `{nf}` prefix on a supported instruction inhibits the update of the flags, for example:

```
{nf} add rax, rbx
```

... will add RAX and RBX together, storing the result in RAX, while leaving the flags register unchanged.

NASM also allows the `{nf}` prefix (or any other curly-brace prefix) to be specified *after* the instruction mnemonic. Spaces around curly-brace prefixes are optional:

```
{nf} add rax, rbx       ; Standard syntax
{nf}add  rax, rbx       ; Prefix without space
add {nf} rax, rbx       ; Suffix syntax
add{nf}  rax, rbx       ; Suffix without space
```

4.6.4 Zero Upper (ZU)

The `{zu}` prefix can be used meaning – "zero-upper", which disables retaining the upper parts of the registers and instead zero-extends the value into the full 64-bit register when the operand size is 8 or 16 bits (this is always done when the operand size is 32 bits, even without APX). For example:

```
{zu} setb al
```

... zeroes out bits [63:8] of the RAX register. For this specific instruction, NASM also eccepts these alternate syntaxes:

```
{zu} setb ax
setb {zu} al
setb {zu} ax
setb {zu} eax
setb {zu} rax
setb eax
setb rax
```

4.6.5 Source Condition Code (S*cc*) and Default Flags Value (DFV)

The source condition code (S*cc*) instructions, CCMPS*cc* and CTESTS*cc*, perform a test which if successful set the arithmetic flags to a user specfied value and otherwise leave them unchanged.

NASM allows the resulting *default flags value* to be specified either using the `{dfv=}...}` syntax, containing a comma-separated list of zero or more of the CPU flags OF, SF, ZF or CF or simply as a numeric immediate (with OF, SF, ZF and CF being represented by bits 3 to 0 in that order.)

The PF flag is always set to the same value as the CF flag, and the AF flag is always cleared. NASM allows `{dfv=pf}` as an alias for `{dfv=cf}`, but do note that it still affects both flags.

NASM allows, but does not require, a comma after the `{dfv=}` value; when using the immediate syntax a comma is required; these examples all produce the same instruction:

```
ccmpl {dfv=of,cf} rdx, r30
ccmpl {dfv=of,cf}, rdx, r30
ccmpl 0x9, rdx, r30                     ; Comma required
```

The immediate syntax also allows for the `{dfv=}` values to be stored in a symbol, or having arithmetic done on them. Note that when used in an expression, or in contexts other than EQU or one of the S*cc* instructions, parenteses are required; this is a safety measure (programmer needs to explicitly indicate that use as an expression is what is intended):

```
     ccmpl ({dfv=of}|{dfv=cf}), rdx, r30     ; Parens, comma required
ocf1 equ {dfv=of,cf}                         ; Parens not required
     ccmpl ocf1, rdx, r30                    ; Comma required
ofcf equ ({dfv=of,sf,cf} & ~{dfv=sf})        ; Parens required
     ccmpl ofcf2, rdx, r30                   ; Comma required
```

4.6.6 PUSH and POP Extensions

APX adds variations of the PUSH and POP instructions that:

- informs the CPU that a specific PUSH and POP constitute a matched pair, allowing the hardware to optimize for this common use case: PUSHP and POPP;
- operates on two registers at the same time: PUSH2 and POP2, with paired variants PUSH2P and POP2P.

These extensions only apply to register forms; they are not supported for memory or immediate operands.

The standard syntax for (P)PUSH2 and (P)POP2 specify the registers in the order they are to be pushed and popped on the stack:

```
push2p rax, rbx
; rax in [rsp+8]
; rbx is [rsp+0]
pop2p rbx, rax
```

... would be the equivalent of:

```
push rax
push rbx
; rax in [rsp+8]
; rbx is [rsp+0]
```

```
pop rbx
pop rax
```

NASM also allows the registers to be specified as a *register pair* separated by a colon, in which case the order is always specified in the order *high*:*low* and thus is the same for PUSH2 and POP2. This means the order of the operands in the POP2 instruction is different:

```
push2p rax:rbx
; rax in [rsp+8]
; rbx is [rsp+0]
pop2p rax:rbx
```

4.6.7 APX and the NASM optimizer

When the optimizer is enabled (see section 2.1.24), NASM may apply a number of optimizations, some of which may apply non-APX instructions to what otherwise would be APX forms. Some examples are:

- The `{nf}` prefix may be ignored on instructions that already don't modify the arithmetic flags.
- When the `{nf}` prefix is specified, NASM may generate another instruction which would not modify the flags register. For example, `{nf} ror rax, rcx, 3` can be translated into `rorx rax, rcx, 3`.
- The `{zu}` prefix may be ignored on instruction that already zero the upper parts of the destination register.
- When the `{zu}` prefix is specified, NASM may generate another instruction which would zero the upper part of the register. For example, `{zu} mov ax, cs` can be translated into `mov eax, cs`.
- New data destination or nondestructive source operands may be contracted if they are the same (and the semantics are otherwise identical). For example, `add eax, eax, edx` could be encoded as `add eax, edx` using legacy encoding. *NASM does not perform this optimization as of version 3.00, but it probably will in the future.*

4.6.8 Force APX Encoding

APX encoding, using REX2 and EVEX, respectively, can be forced by using the `{rex2}` or `{evex}` instruction prefixes.

Chapter 5: The NASM Preprocessor

NASM contains a powerful macro processor, which supports conditional assembly, multi-level file inclusion, two forms of macro (single-line and multi-line), and a 'context stack' mechanism for extra macro power. Preprocessor directives all begin with a `%` sign. As a result, some care needs to be taken when using the `%` arithmetic operator to avoid it being confused with a preprocessor directive; it is recommended that it always be surrounded by whitespace.

The NASM preprocessor borrows concepts from both the C preprocessor and the macro facilities of many other assemblers.

5.1 Preprocessor Expansions

The input to the preprocessor is expanded in the following ways in the order specified here.

5.1.1 Continuation Line Collapsing

The preprocessor first collapses all lines which end with a backslash (`\`) character into a single line. Thus:

```
%define THIS_VERY_LONG_MACRO_NAME_IS_DEFINED_TO \
        THIS_VALUE
```

will work like a single-line macro without the backslash-newline sequence.

5.1.2 Comment Removal

After concatenation, comments are removed. Comments begin with the character `;` unless contained inside a quoted string or a handful of other special contexts.

Note that this is applied *after* continuation lines are collapsed. This means that

```
add al,'\'     ; Add the ASCII code for \
mov [ecx],al   ; Save the character
```

will probably not do what you expect, as the second line will be considered part of the preceeding comment. Although this behavior is sometimes confusing, it is both the behavior of NASM since the very first version as well as the behavior of the C preprocessor.

5.1.3 `%line` directives

In this step, `%line` directives are processed. See section 5.14.1.

5.1.4 Conditionals, Loops and Multi-Line Macro Definitions

In this step, the following preprocessor directives are processed:

- Multi-line macro definitions, specified by the `%macro` and `%imacro` directives. The body of a multi-line macro is stored and is not further expanded at this time. See section 5.6.
- Conditional assembly, specified by the `%if` family of preprocessor directives. Disabled part of the source code are discarded and are not futher expanded. See section 5.7.
- Preprocessor loops, specified by the `%rep` preprocessor directive. A preprocessor loop is very similar to a multi-line macro and as such the body is stored and is not futher expanded at this time. See section 5.8.

These constructs are required to be balanced, so that the ending of a block can be detected, but no further processing is done at this time; stored blocks will be inserted at this step when they are expanded (see below.)

It is specific to each directive to what extent inline expansions and detokenization are performed for the arguments of the directives.

5.1.5 Directives processing

Remaining preprocessor directives are processed. It is specific to each directive to what extend the above expansions or the ones specified in section 5.1.8 are performed on their arguments.

It is specific to each directive to what extent inline expansions and detokenization are performed for the arguments of the directives.

5.1.6 Inline expansions and other directives

In this step, the following expansions are performed on each line:

- Single-line macros are expanded. See section 5.3.
- Preprocessor functions are expanded. See section 5.5.
- If this line is the result of multi-line macro expansions (see below), the parameters to that macro are expanded at this time. See section 5.6.
- Macro indirection, using the `%[...]` construct, is expanded. See section 5.3.3.
- Token concatenation using either the `%+` operator (see section 5.3.4) or implicitly (see section 5.3.3 and section 5.6.9.)
- Macro-local labels are converted into unique strings, see section 5.6.2.

5.1.7 Multi-Line Macro Expansion

In this step, multi-line macros are expanded into new lines of source, like the typical macro feature of many other assemblers. See section 5.6.

After expansion, the newly injected lines of source are processed starting with the step defined in section 5.1.4.

5.1.8 Detokenization

In this step, the final line of source code is produced. It performs the following operations:

- Environment variables specified using the `%!` construct are expanded. See section 5.10.2.
- Context-local labels are expanded into unique strings. See section 5.10.2.
- All tokens are converted to their text representation. Unlike the C preprocessor, the NASM preprocessor does not insert whitespace between adjacent tokens unless present in the source code. See section 5.6.9.

The resulting line of text either is sent to the assembler, or, if running in preprocessor-only mode, to the output file (see section 2.1.22); if necessary prefixed by a newly inserted `%line` directive.

5.2 Preprocessor caveats

5.2.1 Case Insensitivity

The NASM preprocessor allows the user to create case-insensitive macros using directives prefixed with `%i` for 'insensitive' (`%idefine`, `%imacro`, etc.) However, this is limited by NASM inherently not being aware of the character set used in either the source code nor the output object code.

The primary intended use for case-insensitive macros is to override NASM keywords or instructions. Therefore, *NASM case insensitivity is limited to the ASCII character range only.* NASM does permit non-ASCII characters (bytes with values above 127) in macros (and labels), but treats them as opaque bytes that can only be matched exactly.

In general, it is recommended to avoid using case insensitive macros unless you have specific reasons to need them.

The same caveat applies to any other case-insensitive matching: the `%ifidni` and `%elifidni` directives and the `%isidni()` and `%findi()` functions.

5.3 Single-Line Macros

Single-line macros are expanded inline, much like macros in the C preprocessor.

5.3.1 The Normal Way: `%define`

Single-line macros are defined using the `%define` preprocessor directive. The definitions work in a similar way to C; so you can do things like

```
%define ctrl    0x1F &
%define param(a,b) ((a)+(a)*(b))

        mov     byte [param(2,ebx)], ctrl 'D'
```

which will expand to

```
        mov     byte [(2)+(2)*(ebx)], 0x1F & 'D'
```

When the expansion of a single-line macro contains tokens which invoke another macro, the expansion is performed at invocation time, not at definition time. Thus the code

```
%define a(x)    1+b(x)
%define b(x)    2*x

        mov     ax,a(8)
```

will evaluate in the expected way to `mov ax,1+2*8`, even though the macro `b` wasn't defined at the time of definition of `a`.

Note that single-line macro argument list cannot be preceded by whitespace. Otherwise it will be treated as an expansion. For example:

```
   %define foo (a,b)              ; no arguments, (a,b) is the expansion
   %define bar(a,b)               ; two arguments, empty expansion
```

Macros defined with `%define` are case sensitive: after `%define foo bar`, only `foo` will expand to `bar`: `Foo` or `FOO` will not. By using `%idefine` instead of `%define` (the 'i' stands for 'insensitive') you can define all the case variants of a macro at once, so that `%idefine foo bar` would cause `foo`, `Foo`, `FOO`, `fOO` and so on all to expand to `bar`. See however section 5.2.1.

There is a mechanism which detects when a macro call has occurred as a result of a previous expansion of the same macro, to guard against circular references and infinite loops. If this happens, the preprocessor will only expand the first occurrence of the macro. Hence, if you code

```
%define a(x)    1+a(x)

        mov     ax,a(3)
```

the macro `a(3)` will expand once, becoming `1+a(3)`, and will then expand no further. This behaviour can be useful: see section 11.1 for an example of its use.

You can overload single-line macros: if you write

```
%define foo(x)   1+x
%define foo(x,y) 1+x*y
```

the preprocessor will be able to handle both types of macro call, by counting the parameters you pass; so `foo(3)` will become `1+3` whereas `foo(ebx,2)` will become `1+ebx*2`. However, if you define

```
%define foo bar
```

then no other definition of `foo` will be accepted: a macro with no parameters prohibits the definition of the same name as a macro *with* parameters, and vice versa.

This doesn't prevent single-line macros being *redefined*: you can perfectly well define a macro with

```
%define foo bar
```

and then re-define it later in the same source file with

```
%define foo baz
```

Then everywhere the macro `foo` is invoked, it will be expanded according to the most recent definition. This is particularly useful when defining single-line macros with `%assign` (see section 5.3.8).

The following additional features were added in NASM 2.15:

It is possible to define an empty string instead of an argument name if the argument is never used. For example:

```
%define ereg(foo,) e %+ foo
  mov eax,ereg(dx,cx)
```

A single pair of parentheses is a subcase of a single, unused argument:

```
%define myreg() eax
  mov edx,myreg()
```

This is similar to the behavior of the C preprocessor.

- If declared with an `=`, NASM will expand the argument and then evaluate it as a numeric expression. The name of the argument may optionally be followed by `/` followed by a numeric radix character (`b`, `y`, `o`, `q`, `d`, `t`, `h` or `x`) and/or the letters `u` (unsigned) or `s` (signed), in which the number is formatted accordingly, with a radix prefix if a radix letter is specified. For the case of hexadecimal, if the radix letter is in upper case, alphabetic hex digits will be in upper case.
- If declared with an `&`, NASM will expand the argument and then turn into a quoted string; if the argument already *is* a quoted string, it will be quoted again.
- If declared with `&&`, NASM will expand the argument and then turn it into a quoted string, but if the argument already is a quoted string, it will *not* be re-quoted.
- If declared with a `+`, it is a greedy or variadic parameter; it will include any subsequent commas and parameters.
- If declared with an `!`, NASM will not strip whitespace and braces (potentially useful in conjunction with `&` or `&&`.)

For example:

```
%define xyzzy(=expr,&val,=hex/x) expr, str, hex
%define plugh(x) xyzzy(x,x,x)
db plugh(13+5), ‘\0‘ ; Expands to: db 18, "13+5", 0x12, ‘\0‘
```

You can pre-define single-line macros using the '-d' option on the NASM command line: see section 2.1.20.

5.3.2 Resolving `%define`: `%xdefine`

To have a reference to an embedded single-line macro resolved at the time that the embedding macro is *defined*, as opposed to when the embedding macro is *expanded*, you need a different mechanism to the one offered by `%define`. The solution is to use `%xdefine`, or it's case-insensitive counterpart `%ixdefine`.

Suppose you have the following code:

```
%define  isTrue  1
%define  isFalse isTrue
```

```
%define  isTrue  0

val1:    db      isFalse

%define  isTrue  1

val2:    db      isFalse
```

In this case, `val1` is equal to 0, and `val2` is equal to 1. This is because, when a single-line macro is defined using `%define`, it is expanded only when it is called. As `isFalse` expands to `isTrue`, the expansion will be the current value of `isTrue`. The first time it is called that is 0, and the second time it is 1.

If you wanted `isFalse` to expand to the value assigned to the embedded macro `isTrue` at the time that `isFalse` was defined, you need to change the above code to use `%xdefine`.

```
%xdefine isTrue  1
%xdefine isFalse isTrue
%xdefine isTrue  0

val1:    db      isFalse

%xdefine isTrue  1

val2:    db      isFalse
```

Now, each time that `isFalse` is called, it expands to 1, as that is what the embedded macro `isTrue` expanded to at the time that `isFalse` was defined.

`%xdefine` and `%ixdefine` supports argument expansion exactly the same way that `%define` and `%idefine` does.

5.3.3 Macro Indirection: `%[...]`

The `%[...]` construct can be used to expand macros in contexts where macro expansion would otherwise not occur, including in the names other macros. For example, if you have a set of macros named `Foo16`, `Foo32` and `Foo64`, you could write:

```
     mov ax,Foo%[__?BITS?__] ; The Foo value
```

to use the builtin macro `__?BITS?__` (see section 6.3) to automatically select between them. Similarly, the two statements:

```
%xdefine Bar         Quux    ; Expands due to %xdefine
%define  Bar         %[Quux] ; Expands due to %[...]
```

have, in fact, exactly the same effect.

`%[...]` concatenates to adjacent tokens in the same way that multi-line macro parameters do, see section 5.6.9 for details.

5.3.4 Concatenating Single Line Macro Tokens: `%+`

Individual tokens in single line macros can be concatenated, to produce longer tokens for later processing. This can be useful if there are several similar macros that perform similar functions.

Please note that a space is required after `%+`, in order to disambiguate it from the syntax `%+1` used in multiline macros.

As an example, consider the following:

```
%define BDASTART 400h                ; Start of BIOS data area

struc   tBIOSDA                      ; its structure
        .COM1addr       RESW    1
        .COM2addr       RESW    1
```

```
        ; ..and so on
endstruc
```

Now, if we need to access the elements of tBIOSDA in different places, we can end up with:

```
        mov     ax,BDASTART + tBIOSDA.COM1addr
        mov     bx,BDASTART + tBIOSDA.COM2addr
```

This will become pretty ugly (and tedious) if used in many places, and can be reduced in size significantly by using the following macro:

```
; Macro to access BIOS variables by their names (from tBDA):

%define BDA(x)  BDASTART + tBIOSDA. %+ x
```

Now the above code can be written as:

```
        mov     ax,BDA(COM1addr)
        mov     bx,BDA(COM2addr)
```

Using this feature, we can simplify references to a lot of macros (and, in turn, reduce typing errors).

5.3.5 The Macro Name Itself: `%?` and `%??`

The special symbols `%?` and `%??` can be used to reference the macro name itself inside a macro expansion, this is supported for both single-and multi-line macros. `%?` refers to the macro name as *invoked*, whereas `%??` refers to the macro name as *declared*. The two are always the same for case-sensitive macros, but for case-insensitive macros, they can differ.

For example:

```
%imacro Foo 0
        mov %?,%??
%endmacro

        foo
        FOO
```

will expand to:

```
        mov foo,Foo
        mov FOO,Foo
```

These tokens can be used for single-line macros *if defined outside any multi-line macros.* See below.

5.3.6 The Single-Line Macro Name: `%*?` and `%*??`

If the tokens `%?` and `%??` are used inside a multi-line macro, they are expanded before any directives are processed. As a result,

```
%imacro Foo 0
      %idefine Bar _%?
      mov BAR,bAr
%endmacro

      foo
      mov eax,bar
```

will expand to:

```
      mov _foo,_foo
      mov eax,_foo
```

which may or may not be what you expected. The tokens `%*?` and `%*??` behave like `%?` and `%??` but are only expanded inside single-line macros. Thus:

```
%imacro Foo 0
      %idefine Bar _%*?
      mov BAR,bAr
%endmacro
```

```
foo
mov eax,bar
```

will expand to:

```
mov _BAR,_bAr
mov eax,_bar
```

The `%*?` can be used to make a keyword "disappear", for example in case a new instruction has been used as a label in older code. For example:

```
%idefine pause $%*?                ; Hide the PAUSE instruction
```

`%*?` and `%*??` were introduced in NASM 2.15.04.

5.3.7 Undefining Single-Line Macros: `%undef`

Single-line macros can be removed with the `%undef` directive. For example, the following sequence:

```
%define foo bar
%undef  foo

        mov     eax, foo
```

will expand to the instruction `mov eax, foo`, since after `%undef` the macro `foo` is no longer defined.

Macros that would otherwise be pre-defined can be undefined on the command-line using the '-u' option on the NASM command line: see section 2.1.21.

5.3.8 Preprocessor Variables: `%assign`

An alternative way to define single-line macros is by means of the `%assign` command (and its case-insensitive counterpart `%iassign`, which differs from `%assign` in exactly the same way that `%idefine` differs from `%define`).

`%assign` is used to define single-line macros which take no parameters and have a numeric value. This value can be specified in the form of an expression, and it will be evaluated once, when the `%assign` directive is processed.

Like `%define`, macros defined using `%assign` can be re-defined later, so you can do things like

```
%assign i i+1
```

to increment the numeric value of a macro.

`%assign` is useful for controlling the termination of `%rep` preprocessor loops: see section 5.8 for an example of this. Another use for `%assign` is given in section 10.4 and section 11.1.

The expression passed to `%assign` is a critical expression (see section 3.8), and must also evaluate to a pure number (rather than a relocatable reference such as a code or data address, or anything involving a register).

See also the `%eval()` preprocessor function, section 5.5.8.

5.3.9 Defining Strings: `%defstr`

`%defstr`, and its case-insensitive counterpart `%idefstr`, define or redefine a single-line macro without parameters but converts the entire right-hand side, after macro expansion, to a quoted string before definition.

For example:

```
%defstr test TEST
```

is equivalent to

```
%define test 'TEST'
```

This can be used, for example, with the `%!` construct (see section 5.14.2):

```
%defstr PATH %!PATH          ; The operating system PATH variable
```

See also the `%str()` preprocessor function, section 5.5.22.

5.3.10 Defining Tokens: `%deftok`

`%deftok`, and its case-insensitive counterpart `%ideftok`, define or redefine a single-line macro without parameters but converts the second parameter, after string conversion, to a sequence of tokens.

For example:

```
%deftok test 'TEST'
```

is equivalent to

```
%define test TEST
```

See also the `%tok()` preprocessor function, section 5.5.26.

5.3.11 Defining Aliases: `%defalias`

`%defalias`, and its case-insensitive counterpart `%idefalias`, define an alias to a macro, i.e. equivalent of a symbolic link.

When used with various macro defining and undefining directives, it affects the aliased macro. This functionality is intended for being able to rename macros while retaining the legacy names.

When an alias is defined, but the aliased macro is then undefined, the aliases can legitimately point to nonexistent macros.

The alias can be undefined using the `%undefalias` directive. *All* aliases can be undefined using the `%clear defalias` directive. This includes backwards compatibility aliases defined by NASM itself.

To disable aliases without undefining them, use the `%aliases off` directive.

To check whether an alias is defined, regardless of the existence of the aliased macro, use `%ifdefalias`.

For example:

```
%defalias OLD NEW
   ; OLD and NEW both undefined
%define NEW 123
   ; OLD and NEW both 123
%undef OLD
   ; OLD and NEW both undefined
%define OLD 456
   ; OLD and NEW both 456
%undefalias OLD
   ; OLD undefined, NEW defined to 456
```

5.3.12 Conditional Comma Operator: `%,`

As of version 2.15, NASM has a conditional comma operator `%,` that expands to a comma *unless* followed by a null expansion, which allows suppressing the comma before an empty argument. This is especially useful with greedy single-line macros.

For example, all the expressions below are valid:

```
%define greedy(a,b,c+) a + 66 %, b * 3 %, c

       db greedy(1,2)          ; db 1 + 66, 2 * 3
       db greedy(1,2,3)        ; db 1 + 66, 2 * 3, 3
       db greedy(1,2,3,4)      ; db 1 + 66, 2 * 3, 3, 4
       db greedy(1,2,3,4,5)    ; db 1 + 66, 2 * 3, 3, 4, 5
```

5.4 String Manipulation in Macros

It's often useful to be able to handle strings in macros. NASM supports a few simple string handling macro operators from which more complex operations can be constructed.

All the string operators define or redefine a single-line macro to some value (either a string or a numeric value). When producing a string value, it may change the style of quoting of the input string or strings, and possibly use `\`–escapes inside `‘`–quoted strings.

These directives are also available as preprocessor functions, see section 5.5.

5.4.1 Concatenating Strings: `%strcat`

The `%strcat` operator concatenates quoted strings and assign them to a single-line macro.

For example:

```
%strcat alpha "Alpha: ", '12" screen'
```

... would assign the value `'Alpha: 12" screen'` to `alpha`. Similarly:

```
%strcat beta '"foo"\', "'bar'"
```

... would assign the value `‘"foo"\\'bar'‘` to `beta`.

The use of commas to separate strings is permitted but optional.

The corresponding preprocessor function is `%strcat()`, see section 5.5.23.

5.4.2 String Length: `%strlen`

The `%strlen` operator assigns the length of a string to a macro. For example:

```
%strlen charcnt 'my string'
```

In this example, `charcnt` would receive the value 9, just as if an `%assign` had been used. In this example, `'my string'` was a literal string but it could also have been a single-line macro that expands to a string, as in the following example:

```
%define sometext 'my string'
%strlen charcnt sometext
```

As in the first case, this would result in `charcnt` being assigned the value of 9.

The corresponding preprocessor function is `%strlen()`, see section 5.5.24.

5.4.3 Extracting Substrings: `%substr`

Individual letters or substrings in strings can be extracted using the `%substr` operator. An example of its use is probably more useful than the description:

```
%substr mychar 'xyzw' 1       ; equivalent to %define mychar 'x'
%substr mychar 'xyzw' 2       ; equivalent to %define mychar 'y'
%substr mychar 'xyzw' 3       ; equivalent to %define mychar 'z'
%substr mychar 'xyzw' 2,2     ; equivalent to %define mychar 'yz'
%substr mychar 'xyzw' 2,-1    ; equivalent to %define mychar 'yzw'
%substr mychar 'xyzw' 2,-2    ; equivalent to %define mychar 'yz'
```

As with `%strlen` (see section 5.4.2), the first parameter is the single-line macro to be created and the second is the string. The third parameter specifies the first character to be selected, and the optional fourth parameter (preceded by comma) is the length. Note that the first index is 1, not 0 and the last index is equal to the value that `%strlen` would assign given the same string. Index values out of range result in an empty string. A negative length means "until N-1 characters before the end of string", i.e. `-1` means until end of string, `-2` until one character before, etc.

The corresponding preprocessor function is `%substr()`, see section 5.5.25, however please note that the default value for the length parameter, if omitted, is `-1` rather than `1` for `%substr()`.

5.5 Preprocessor Functions

Preprocessor functions are, fundamentally, a kind of built-in single-line macros. They expand to a string depending on its arguments, and can be used in any context where single-line macro expansion would be performed. Preprocessor functions were introduced in NASM 2.16.

Starting with NASM 3.00, the `%ifdef` directive or `%isdef()` function can also test for the availability of preprocessor functions. They cannot, however, be undefined, aliased or redefined.

5.5.1 `%abs()` Function

The `%abs()` function evaluates its first argument as an expression, and then emits the absolute value. This will always be emitted as a single token containing a decimal number; no minus sign will be emitted even if the input value is the maximum negative number.

5.5.2 `%b2hs()` Function

The `%b2hs()` functin takes a quoted string and an optional separator string, and expands to a quoted string containing a packed hexadecimal form of the bytes of the first string, separated by the separator string if applicable. This is the inverse of the `%hs2b()` function, see section 5.5.11.

5.5.3 `%chr()` Function

The `%chr()` function evaluates its arguments as integers, then creates a quoted string out of these integers (mod 256) as bytes.

5.5.4 `%cond()` Function

The `%cond()` function evaluates its first argument as an expression, then expands to its second argument if true (nonzero), and the third, if present, if false (zero). This is in effect a specialized version of the `%sel()` function; `%cond(x,y,z)` is equivalent to `%sel(1+!(x),y,z)`.

```
%define a 1
%xdefine astr %cond(a,"true","false") ; %define astr "true"
```

The argument not selected is never expanded.

5.5.5 `%count()` Function

The `%count()` function expands to the number of argments passed to the macro. Note that just as for single-line macros, `%count()` treats an empty argument list as a single empty argument.

```
%xdefine empty %count()        ; %define empty 1
%xdefine one   %count(1)       ; %define one 1
%xdefine two   %count(5,q)     ; %define two 2
%define  list  a,b,46
%xdefine lc1   %count(list)    ; %define lc 1 (just one argument)
%xdefine lc2   %count(%[list]) ; %define lc 3 (indirection expands)
```

5.5.6 `%depend()` Function

The `%depend()` function takes a quoted string as argument, adds it to the output dependency list generated by the `-M` options (see section 2.1.5), and evaluates to the unchanged string.

This is the function equivalent of the `%depend` directive, see section 5.9.3.

See also the `%pathsearch()` function (section 5.5.18).

5.5.7 `%env()` Function

The `%env()` function takes an optionally quoted string as its first argument, and if an environment variable with that name exists, expands to a quoted string with the value of that environment variable. If the environment variable does *not* exist, expands to any additional arguments given, or to an empty quoted string if no additional arguments are provided.

```
; This example assumes USER=nasmuser and MISSING is undefined

db %env(USER)                   ; db 'nasmuser'
db %env("USER")                 ; db 'nasmuser'
db %env("USER",0)               ; db 'nasmuser'
db %env(MISSING)                ; db ''
db %env("MISSING",0xff)         ; db 0xff
db %env("MISSING",1,"2",3)      ; db 1,"2",3

; This line generates a warning for "db" without data:
db %env("MISSING",)             ; db
```

See also the `%ifenv` directive (section 5.7.13) and the `%!` construct (section 5.14.2).

5.5.8 `%eval()` Function

The `%eval()` function evaluates its argument as a numeric expression and expands to the result as an integer constant in much the same way the `%assign` directive would, see section 5.3.8. Unlike `%assign`, `%eval()` supports more than one argument; if more than one argument is specified, it is expanded to a comma-separated list of values.

```
%assign a    2
%assign b    3
%defstr what %eval(a+b,a*b)  ; equivalent to %define what "5,6"
```

The expressions passed to `%eval()` are critical expressions, see section 3.8.

5.5.9 `%find()` and `%findi()` Functions

The `%find()` and `%findi()` functions take an argument followed by an optional list. These are turned into quoted strings if necessary, and then compared as if by the `%isidn()` or `%isidni()` functions, respectively (see section 5.7.6) – the `%find()` function compares case sensitively, and `%findi()` case insensitively; see however section 5.2.1.

The functions then expand to `0` if none of the strings in the list match the first string, or the position in the list where the first string was found, where `1` is the first argument in the list, i.e. not including the first argument to the function.

Once a matching argument has been found, no further arguments are expanded.

For example:

```
db %find(a,b,c,d)                       ; 0
db %find(a,b,a,c)                       ; 2
db %find(a)                             ; 0 (empty list)
```

5.5.10 `%hex()` Function

Equivalent to `%eval()`, except that the results generated are given as unsigned hexadecimal, with a `0x` prefix.

5.5.11 `%hs2b()` Function

The `%hs2b()` function takes one or more quoted strings containing hexadecimal numbers and optional separators (any character that is not a valid hexadecimal digit is considered a separator) and expands to a quoted string containing the bytes encoded in the hexadecimal string. Every pair of hexadecimal digits encodes a byte, but a separator will always terminate the encoding of a byte. Thus, these two statements will produce the same output:

```
db 0x00, 0x01, 0x02, 0x03, 0x04, 0x05, 0x06, 0x07, 0x08, 0x09
db %hs2b("00010203 4 0506 07 8","9")
```

This can be used to compactly encode long strings of binary data in source code.

5.5.12 `%is()` Family Functions

Each `%if` conditional assembly family directive (see section 5.7) has an equivalent `%is()` family function, that expands to `1` if the equivalent `%if` directive would process as true, and `0` if the equivalent `%if` directive would process as false.

This includes the `%ifn` forms of these directives, which become `%isn()`.

```
; Instead of !%isidn() could have used %isnidn()
%if %isdef(foo) && !%isidn(foo,bar)
      db "foo is defined, but not as 'bar'"
%endif
```

Note that, being functions, the arguments (before expansion) will always need to have balanced parentheses so that the end of the argument list can be defined. This means that the syntax of e.g. `%istoken()` and `%isidn()` is somewhat stricter than their corresponding `%if` directives; it may be necessary to escape the argument to the conditional using `{}`:

```
; Instead of !%isidn() could have used %isnidn()
%if %isdef(foo) && !%isidn({foo,)})
      db "foo is defined, but not as ')'"
%endif
```

Unlike the C `defined()` preprocessor construct, these functions are valid anywhere in the source code, not just in `%if` expressions.

5.5.13 `%limit()` Function

The `%limit()` function takes as its first argument an optionally quoted string which is matched against a resource limit as defined by the `--limit-` command line option or the `%pragma limit` directive (see section 2.1.32). The macro then expands to the value of that limit, or `0` if no limit with that name is known in the current version of NASM.

An optional second argument can be set to one of the following optionally quoted strings:

- `current`: the current value for the limit. This is also the result if no second argument is specified.
- *reset*: the initial value for the limit, set on the command line or the default value if no such value is set; this is the value that `%pragma limit` *limit-name* `reset` would set the limit to.
- *default*: the default value for the limit. This is the value that `%pragma limit` *limit-name* `default` would set the limit to.
- *maximum*: the maximum permitted value for the limit. This is the value that `%pragma limit` *limit-name* `maximum` would set the limit to.

The value `unlimited` is represented by a very large positive number. If the limit name is the empty string or `unlimited`, `%limit()` returns this value for comparison purposes.

The standard macro `__?NASM_LIMITS?__` expands to a comma-separated list of quoted strings representing all limits defined in the current version of NASM, see section 6.8.

The `%limit()` function was introduced in NASM 3.02.

5.5.14 `%map()` Function

The `%map()` function takes as its first parameter the name of a single-line macro, followed by up to two optional colon-separated subparameters:

- The first subparameter, if present, should be a list of macro parameters enclosed in parentheses. Note that `()` represents a one-argument list containing an empty parameter; omit the parentheses to specify no parameters.
- The second subparameter, if present, represent the number of group size for additional parameters to the macro (default 1).

Further parameters, if any, are then passed as additional parameters to the given macro for expansion, in sets given by the specified group size, and the results turned into a comma-separated list. If no additional parameters are given, `%map()` expands to nothing.

For example:

```
%define alpha(&x)     x
%define alpha(&x,y)   y dup (x)
%define alpha(s,&x,y) y dup (x,s)
; 0 fixed + 1 grouped parameters per call, calls alpha(&x)
      db %map(alpha,foo,bar,baz,quux)
; 0 fixed + 2 grouped parameters per call, calls alpha(&x,y)
      db %map(alpha::2,foo,bar,baz,quux)
; 1 fixed + 2 grouped parameters per call, calls alpha(s,&x,y)
      db %map(alpha:("!"):2,foo,bar,baz,quux)
```

... expands to:

```
      db 'foo','bar','baz','quux'
      db bar dup ('foo'),quux dup ('baz')
      db bar dup ('foo',"!"),quux dup ('baz',"!")
```

As a more complex example, a macro that joins quoted strings together with a user-specified delimiter string:

```
%define join(sep)        ''      ; handle the case of zero strings
%define _join(sep,str)   sep,str ; helper macro
%define join(sep,s1,sn+) %strcat(s1, %map(_join:(sep) %, sn))

      db join(':')
      db join(':','a')
      db join(':','a','b')
      db join(':','a','b','c')
      db join(':','a','b','c','d')
```

... expands to:

```
      db ''
      db 'a'
      db 'a:b'
      db 'a:b:c'
      db 'a:b:c:d'
```

5.5.15 `%null()` Function

The `%null()` function ignores its arguments without expanding them, and expands to nothing.

5.5.16 `%num()` Function

The `%num()` function evaluates its arguments as expressions, and then produces a quoted string encoding the first argument as an *unsigned* 64-bit integer.

The second argument is the desired number of digits (max 255, default –1).

The third argument is the encoding base (from 2 to 64, default 10); if the base is given as –2, –8, –10, or –16, then `0b`, `0q`, `0d` or `0x` is prepended, respectively; all other negative values are disallowed.

Only the first argument is required.

If the number of digits is negative, NASM will add additional digits if needed; if positive the string is truncated to the number of digits specified. 0 is treated as –1, except that the input number 0 always generates an empty string (thus, the first digit will never be zero), even if the base given is negative.

The full 64-symbol set used is, in order:

```
0123456789abcdefghijklmnopqrstuvwxyzABCDEFGHIJKLMNOPQRSTUVWXYZ@_
```

If a *signed* number needs to be converted to a string, use `%abs()`, `%cond()`, and `%strcat()` to format the signed number string to your specific output requirements.

5.5.17 `%ord()` Function

The `%ord()` function takes a quoted string, and (like `%substr()`, see section 5.5.25) an optional starting index and length, and expands to a comma-separated list of integers corresponding to the bytes of the quoted string. Note that unlike `%substr()` the length argument defaults to `1`, so if it is not given only a single byte value is expanded.

5.5.18 `%pathsearch()` Function

The `%pathsearch()` function takes a quoted string as argument, and searches for a file with that name in the include path, then expands to the pathname located, if found, otherwise to the unmodified string.

This is the function equivalent of the `%pathsearch` directive, see section 5.9.2.

See also the `%depend()` function (section 5.5.6).

5.5.19 `%realpath()` Function

The `%realpath()` function takes a quoted string as argument, and attempts to convert it to a fully qualified absolute path name if supported by the underlying host operating system.

If successful, it expands to a quoted string with the resulting path name, otherwise to the unmodified string.

The include path is *not* searched; to search for the file using the include path, use the `%pathsearch()` function in conjunction with this function, for example:

```
%define SOMEREALPATH %realpath(%pathsearch("somefile.asm"))
```

5.5.20 `%sel()` Function

The `%sel()` function evaluates its first argument as an expression, then expands to its second argument if 1, the third argument if 2, and so on. If the value is less than 1 or larger than the number of arguments minus one, then the `%sel()` function expands to nothing.

```
%define b 2
%xdefine bstr %sel(b,"one","two","three") ; %define bstr "two"
```

The arguments not selected are never expanded.

5.5.21 `%selbits()` Function

The `%selbits()` function returns its first, second, or third argument depending on if the current mode is 16, 32 or 64 bits. If less than three arguments are given, the last argument is considered repeated. Like `%cond()`, this is a specialized version of the `%sel()` function.

For example:

```
     BITS 64

%define breg %selbits(bx,ebx,rbx)
%define vreg %selbits(ax,eax)

     mov vreg,[breg]         ; mov eax,[rbx]
```

5.5.22 `%str()` Function

The `%str()` function converts its argument, including any commas, to a quoted string, similar to the way the `%defstr` directive would, see section 5.3.9.

Being a function, the argument will need to have balanced parentheses or be escaped using `{}`.

```
; The following lines are all equivalent
%define  test 'TEST'
%defstr  test TEST
%xdefine test %str(TEST)
```

5.5.23 `%strcat()` Function

The `%strcat()` function concatenates a list of quoted strings, in the same way the `%strcat` directive would, see section 5.4.1.

```
; The following lines are all equivalent
%define  alpha 'Alpha: 12" screen'
%strcat  alpha "Alpha: ", '12" screen'
%xdefine alpha %strcat("Alpha: ", '12" screen')
```

5.5.24 `%strlen()` Function

The `%strlen()` function expands to the length of a quoted string, in the same way the `%strlen` directive would, see section 5.4.2.

```
; The following lines are all equivalent
%define  charcnt 9
%strlen  charcnt 'my string'
%xdefine charcnt %strlen('my string')
```

5.5.25 `%substr()` Function

The `%substr()` function extracts a substring of a quoted string, in the same way the `%substr` directive would, see section 5.4.3. Note that unlike the `%substr` directive, commas are required between all parameters, is required after the string argument, and that the default for the length argument, if omitted, is `-1` (i.e. the remainder of the string) rather than `1`.

```
; The following lines are all equivalent
%define  mychar 'yzw'
%substr  mychar 'xyzw' 2,-1
%xdefine mychar %substr('xyzw',2,3)
%xdefine mychar %substr('xyzw',2,-1)
%xdefine mychar %substr('xyzw',2)
```

5.5.26 `%tok()` function

The `%tok()` function converts a quoted string into a sequence of tokens, in the same way the `%deftok` directive would, see section 5.3.10.

```
; The following lines are all equivalent
%define test TEST
%deftok test 'TEST'
%define test %tok('TEST')
```

5.6 Multi-Line Macros: `%macro`

Multi-line macros much like the type of macro seen in MASM and TASM, and expand to a new set of lines of source code. A multi-line macro definition in NASM looks something like this.

```
%macro  prologue 1

        push    ebp
        mov     ebp,esp
        sub     esp,%1

%endmacro
```

This defines a C-like function prologue as a macro: so you would invoke the macro with a call such as:

```
myfunc:   prologue 12
```

which would expand to the three lines of code

```
myfunc: push    ebp
        mov     ebp,esp
        sub     esp,12
```

The number `1` after the macro name in the `%macro` line defines the number of parameters the macro `prologue` expects to receive. The use of `%1` inside the macro definition refers to the first parameter to the macro call. With a macro taking more than one parameter, subsequent parameters would be referred to as `%2`, `%3` and so on.

Multi-line macros, like single-line macros, are case-sensitive, unless you define them using the alternative directive `%imacro`.

If you need to pass a comma as *part* of a parameter to a multi-line macro, you can do that by enclosing the entire parameter in braces. So you could code things like:

```
%macro  silly 2

    %2: db      %1

%endmacro

        silly 'a', letter_a             ; letter_a:  db 'a'
        silly 'ab', string_ab           ; string_ab: db 'ab'
        silly {13,10}, crlf             ; crlf:      db 13,10
```

The behavior with regards to empty arguments at the end of multi-line macros before NASM 2.15 was often very strange. For backwards compatibility, NASM attempts to recognize cases where the legacy behavior would give unexpected results, and issues a warning, but largely tries to match the legacy behavior. This can be disabled with the `%pragma` (see section 5.13.1):

```
%pragma preproc sane_empty_expansion
```

5.6.1 Overloading Multi-Line Macros

As with single-line macros, multi-line macros can be overloaded by defining the same macro name several times with different numbers of parameters. This time, no exception is made for macros with no parameters at all. So you could define

```
%macro  prologue 0

        push    ebp
        mov     ebp,esp

%endmacro
```

to define an alternative form of the function prologue which allocates no local stack space.

Sometimes, however, you might want to 'overload' a machine instruction; for example, you might want to define

```
%macro  push 2

        push    %1
        push    %2

%endmacro
```

so that you could code

```
        push    ebx             ; this line is not a macro call
        push    eax,ecx         ; but this one is
```

Ordinarily, NASM will give a warning for the first of the above two lines, since `push` is now defined to be a macro, and is being invoked with a number of parameters for which no definition has been given. The correct code will still be generated, but the assembler will give a warning. This warning can be disabled by the use of the `-w-macro-params` command-line option (see section 2.1.26).

5.6.2 Macro-Local Labels

NASM allows you to define labels within a multi-line macro definition in such a way as to make them local to the macro call: so calling the same macro multiple times will use a different label each time. You do this by prefixing `%%` to the label name. So you can invent an instruction which executes a RET if the Z flag is set by doing this:

```
%macro  retz 0

        jnz     %%skip
        ret
    %%skip:

%endmacro
```

You can call this macro as many times as you want, and every time you call it NASM will make up a different 'real' name to substitute for the label `%%skip`. The names NASM invents are of the form `..@2345.skip`, where the number 2345 changes with every macro call. The `..@` prefix prevents macro-local labels from interfering with the local label mechanism, as described in section 3.9. You should avoid defining your own labels in this form (the `..@` prefix, then a number, then another period) in case they interfere with macro-local labels.

These labels are really macro-local *tokens*, and can be used for other purposes where a token unique to each macro invocation is desired, e.g. to name single-line macros without using the context feature (section 5.10.2).

5.6.3 Greedy Macro Parameters

Occasionally it is useful to define a macro which lumps its entire command line into one parameter definition, possibly after extracting one or two smaller parameters from the front. An example might be a macro to write a text string to a file in MS-DOS, where you might want to be able to write

```
        writefile [filehandle],"hello, world",13,10
```

NASM allows you to define the last parameter of a macro to be *greedy*, meaning that if you invoke the macro with more parameters than it expects, all the spare parameters get lumped into the last defined one along with the separating commas. So if you code:

```
%macro  writefile 2+

        jmp     %%endstr
  %%str:        db      %2
  %%endstr:
        mov     dx,%%str
        mov     cx,%%endstr-%%str
        mov     bx,%1
        mov     ah,0x40
        int     0x21

%endmacro
```

then the example call to `writefile` above will work as expected: the text before the first comma, `[filehandle]`, is used as the first macro parameter and expanded when `%1` is referred to, and all the subsequent text is lumped into `%2` and placed after the `db`.

The greedy nature of the macro is indicated to NASM by the use of the `+` sign after the parameter count on the `%macro` line.

If you define a greedy macro, you are effectively telling NASM how it should expand the macro given *any* number of parameters from the actual number specified up to infinity; in this case, for example, NASM now knows what to do when it sees a call to `writefile` with 2, 3, 4 or more parameters. NASM will take this into account when overloading macros, and will not allow you to define another form of `writefile` taking 4 parameters (for example).

Of course, the above macro could have been implemented as a non-greedy macro, in which case the call to it would have had to look like

```
writefile [filehandle], {"hello, world",13,10}
```

NASM provides both mechanisms for putting commas in macro parameters, and you choose which one you prefer for each macro definition.

See section 8.3.1 for a better way to write the above macro.

5.6.4 Macro Parameters Range

NASM allows you to expand parameters via special construction `%{x:y}` where `x` is the first parameter index and `y` is the last. Any index can be either negative or positive but must never be zero.

For example

```
%macro mpar 1-*
     db %{3:5}
%endmacro

mpar 1,2,3,4,5,6
```

expands to `3,4,5` range.

Even more, the parameters can be reversed so that

```
%macro mpar 1-*
     db %{5:3}
%endmacro

mpar 1,2,3,4,5,6
```

expands to `5,4,3` range.

But even this is not the last. The parameters can be addressed via negative indices so NASM will count them reversed. The ones who know Python may see the analogue here.

```
%macro mpar 1-*
     db %{-1:-3}
%endmacro

mpar 1,2,3,4,5,6
```

expands to `6,5,4` range.

Note that NASM uses comma to separate parameters being expanded.

By the way, here is a trick – you might use the index `%{-1:-1}` which gives you the last argument passed to a macro.

5.6.5 Default Macro Parameters

NASM also allows you to define a multi-line macro with a *range* of allowable parameter counts. If you do this, you can specify defaults for omitted parameters. So, for example:

```
%macro  die 0-1 "Painful program death has occurred."

        writefile 2,%1
        mov     ax,0x4c01
        int     0x21

%endmacro
```

This macro (which makes use of the `writefile` macro defined in section 5.6.3) can be called with an explicit error message, which it will display on the error output stream before exiting, or it can be called with no parameters, in which case it will use the default error message supplied in the macro definition.

In general, you supply a minimum and maximum number of parameters for a macro of this type; the minimum number of parameters are then required in the macro call, and then you provide defaults for the optional ones. So if a macro definition began with the line

```
%macro foobar 1-3 eax,[ebx+2]
```

then it could be called with between one and three parameters, and `%1` would always be taken from the macro call. `%2`, if not specified by the macro call, would default to `eax`, and `%3` if not specified would default to `[ebx+2]`.

You can provide extra information to a macro by providing too many default parameters:

```
%macro quux 1 something
```

This will trigger a warning by default; see section 2.1.26 for more information. When `quux` is invoked, it receives not one but two parameters. `something` can be referred to as `%2`. The difference between passing `something` this way and writing `something` in the macro body is that with this way `something` is evaluated when the macro is defined, not when it is expanded.

You may omit parameter defaults from the macro definition, in which case the parameter default is taken to be blank. This can be useful for macros which can take a variable number of parameters, since the `%0` token (see section 5.6.6) allows you to determine how many parameters were really passed to the macro call.

This defaulting mechanism can be combined with the greedy-parameter mechanism; so the `die` macro above could be made more powerful, and more useful, by changing the first line of the definition to

```
%macro die 0-1+ "Painful program death has occurred.",13,10
```

The maximum parameter count can be infinite, denoted by `*`. In this case, of course, it is impossible to provide a *full* set of default parameters. Examples of this usage are shown in section 5.6.8.

5.6.6 `%0`: Macro Parameter Counter

The parameter reference `%0` will return a numeric constant giving the number of parameters received, that is, if `%0` is n then `%`n is the last parameter. `%0` is mostly useful for macros that can take a variable number of parameters. It can be used as an argument to `%rep` (see section 5.8) in order to iterate through all the parameters of a macro. Examples are given in section 5.6.8.

5.6.7 `%00`: Label Preceding Macro

`%00` will return the label preceding the macro invocation, if any. The label must be on the same line as the macro invocation, may be a local label (see section 3.9), and need not end in a colon.

If `%00` is present anywhere in the macro body, the label itself will not be emitted by NASM. You can, of course, put `%00:` explicitly at the beginning of your macro.

5.6.8 `%rotate`: Rotating Macro Parameters

Unix shell programmers will be familiar with the `shift` shell command, which allows the arguments passed to a shell script (referenced as `$1`, `$2` and so on) to be moved left by one place, so that the argument previously referenced as `$2` becomes available as `$1`, and the argument previously referenced as `$1` is no longer available at all.

NASM provides a similar mechanism, in the form of `%rotate`. As its name suggests, it differs from the Unix `shift` in that no parameters are lost: parameters rotated off the left end of the argument list reappear on the right, and vice versa.

`%rotate` is invoked with a single numeric argument (which may be an expression). The macro parameters are rotated to the left by that many places. If the argument to `%rotate` is negative, the macro parameters are rotated to the right.

So a pair of macros to save and restore a set of registers might work as follows:

```
%macro  multipush 1-*

  %rep  %0
        push    %1
  %rotate 1
  %endrep

%endmacro
```

This macro invokes the PUSH instruction on each of its arguments in turn, from left to right. It begins by pushing its first argument, `%1`, then invokes `%rotate` to move all the arguments one place to the left, so that the original second argument is now available as `%1`. Repeating this procedure as many times as there were arguments (achieved by supplying `%0` as the argument to `%rep`) causes each argument in turn to be pushed.

Note also the use of `*` as the maximum parameter count, indicating that there is no upper limit on the number of parameters you may supply to the `multipush` macro.

It would be convenient, when using this macro, to have a POP equivalent, which *didn't* require the arguments to be given in reverse order. Ideally, you would write the `multipush` macro call, then cut-and-paste the line to where the pop needed to be done, and change the name of the called macro to `multipop`, and the macro would take care of popping the registers in the opposite order from the one in which they were pushed.

This can be done by the following definition:

```
%macro  multipop 1-*

  %rep %0
  %rotate -1
        pop     %1
  %endrep

%endmacro
```

This macro begins by rotating its arguments one place to the *right*, so that the original *last* argument appears as `%1`. This is then popped, and the arguments are rotated right again, so the second-to-last argument becomes `%1`. Thus the arguments are iterated through in reverse order.

5.6.9 Concatenating Macro Parameters

NASM can concatenate macro parameters and macro indirection constructs with other surrounding text. This allows you to declare a family of symbols, for example, in a macro definition. If, for example, you wanted to generate a table of key codes along with offsets into the table, you could code something like

```
%macro keytab_entry 2

    keypos%1    equ     $-keytab
                db      %2

%endmacro

keytab:
          keytab_entry F1,128+1
          keytab_entry F2,128+2
          keytab_entry Return,13
```

which would expand to

```
keytab:
keyposF1        equ     $-keytab
                db     128+1
keyposF2        equ     $-keytab
                db      128+2
```

```
keyposReturn    equ     $-keytab
                db      13
```

You can just as easily concatenate text on to the other end of a macro parameter, by writing `%1foo`.

If you need to append a *digit* to a macro parameter, for example defining labels `foo1` and `foo2` when passed the parameter `foo`, you can't code `%11` because that would be taken as the eleventh macro parameter. Instead, you must code `%{1}1`, which will separate the first `1` (giving the number of the macro parameter) from the second (literal text to be concatenated to the parameter).

This concatenation can also be applied to other preprocessor in-line objects, such as macro-local labels (section 5.6.2) and context-local labels (section 5.10.2). In all cases, ambiguities in syntax can be resolved by enclosing everything after the `%` sign and before the literal text in braces: so `%{%foo}bar` concatenates the text `bar` to the end of the real name of the macro-local label `%%foo`. (This is unnecessary, since the form NASM uses for the real names of macro-local labels means that the two usages `%{%foo}bar` and `%%foobar` would both expand to the same thing anyway; nevertheless, the capability is there.)

The single-line macro indirection construct, `%[...]` (section 5.3.3), behaves the same way as macro parameters for the purpose of concatenation.

See also the `%+` operator, section 5.3.4.

5.6.10 Condition Codes as Macro Parameters

NASM can give special treatment to a macro parameter which contains a condition code. For a start, you can refer to the macro parameter `%1` by means of the alternative syntax `%+1`, which informs NASM that this macro parameter is supposed to contain a condition code, and will cause the preprocessor to report an error message if the macro is called with a parameter which is *not* a valid condition code.

Far more usefully, though, you can refer to the macro parameter by means of `%-1`, which NASM will expand as the *inverse* condition code. So the `retz` macro defined in section 5.6.2 can be replaced by a general conditional-return macro like this:

```
%macro  retc 1

        j%-1    %%skip
        ret
  %%skip:

%endmacro
```

This macro can now be invoked using calls like `retc ne`, which will cause the conditional-jump instruction in the macro expansion to come out as `JE`, or `retc po` which will make the jump a `JPE`.

The `%+1` macro-parameter reference is quite happy to interpret the arguments `CXZ` and `ECXZ` as valid condition codes; however, `%-1` will report an error if passed either of these, because no inverse condition code exists.

5.6.11 Disabling Listing Expansion `.nolist`

When NASM is generating a listing file from your program, it will generally expand multi-line macros by means of writing the macro call and then listing each line of the expansion. This allows you to see which instructions in the macro expansion are generating what code; however, for some macros this clutters the listing up unnecessarily.

NASM therefore provides the `.nolist` qualifier, which you can include in a macro definition to inhibit the expansion of the macro in the listing file. The `.nolist` qualifier comes directly after the number of parameters, like this:

```
%macro foo 1.nolist
```

Or like this:

```
%macro bar 1-5+.nolist a,b,c,d,e,f,g,h
```

5.6.12 Undefining Multi-Line Macros: `%unmacro`, `%unimacro`

Multi-line macros can be removed with the `%unmacro` or `%unimacro` directives.

Unlike the `%undef` directive, however, these directives take an argument specification, and will only remove exact matches with that argument specification. Furthermore, case sensitive macros have match the directive: a case-sensitive macro has to be removed with `%unmacro`, and a case-insensitive one with `%unimacro`. This ensures that only the specific macro intended is removed.

For example:

```
%macro foo 1-3
        ; Do something
%endmacro
%unmacro foo 1-3
```

removes the previously defined macro `foo`, but

```
%macro bar 1-3
        ; Do something
%endmacro
%unmacro bar 1
```

does *not* remove the macro `bar`, since the argument specification does not match exactly.

5.6.13 `%exitmacro`: Stop Expanding a Multi-Line Macro

If a `%exitmacro` directive is encountered, NASM will immediately stop expanding the current multiline macro. This can, for example, be used to avoid unnecessarily deep `%if` trees in the case of error conditions, such as:

```
%macro count_something 2
 %if %1 < 0
   %warning %?: negative count
   %exitmacro
 %endif
 ; ... do the thing, knowing that %1 >= 0 ...
%endmacro
```

Compare with the `%exitrep` directive, section 5.8.

5.7 Conditional Assembly

Similarly to the C preprocessor, NASM allows sections of a source file to be assembled only if certain conditions are met. The general syntax of this feature looks like this:

```
%if<condition>
    ; some code which only appears if <condition> is met
%elif<condition2>
    ; only appears if <condition> is not met but <condition2> is
%else
    ; this appears if neither <condition> nor <condition2> was met
%endif
```

The inverse forms `%ifn` and `%elifn` are also supported.

You can have multiple `%elif` clauses, or none. The `%else` clause is likewise optional.

There are a number of variants of the `%if` directive. Each has its corresponding `%elif`, `%ifn`, and `%elifn` directives; for example, the equivalents to the `%ifdef` directive are `%elifdef`, `%ifndef`, and `%elifndef`.

Futhermore, each variant of the `%if` directive (including `%ifn` forms) has a corresponding `%is()` preprocessor function (see section 5.5.12.) These are particularly useful for testing multiple conditions at the same time. Unlike the C `defined()` preprocessor construct, these functions are valid anywhere in the source code, not just in `%if` expressions.

The following descriptions of tests all imply the existence of these alternate forms.

5.7.1 `%if`: Testing Arbitrary Numeric Expressions

The conditional-assembly construct `%if expr` will cause the subsequent code to be assembled if and only if the value of the numeric expression `expr` is non-zero. An example of the use of this feature is in deciding when to break out of a `%rep` preprocessor loop: see section 5.8 for a detailed example.

The expression given to `%if` is a critical expression (see section 3.8).

5.7.2 `%ifdef`: Testing Single-Line Macro Existence

Beginning a conditional-assembly block with the line `%ifdef MACRO` will assemble the subsequent code if, and only if, a single-line macro called `MACRO` is defined.

For example, when debugging a program, you might want to write code such as

```
          ; perform some function
%ifdef DEBUG
          writefile 2,"Function performed successfully",13,10
%endif
          ; go and do something else
```

Then you could use the command-line option `-dDEBUG` to create a version of the program which produced debugging messages, and remove the option to generate the final release version of the program.

From NASM 3.00 onward, `%ifdef` can also test for the availability of a preprocessor function, for example:

```
%ifdef %newfunc
  db %newfunc(99)     ; Generates something magic
%else
  %warning "This version of NASM doesn't support %newfunc()"
  db -1               ; Feature not supported
%endif
```

or, if the warning is not needed, using the function form:

```
  db %cond(%isdef(%newfunc),%newfunc(99),-1)
```

It is strongly recommended to use this test instead of relying on NASM version numbers. To make it possible to test that this use of `%ifdef` is valid, the macro `__?NASM_HAS_IFDIRECTIVE?__` is defined on versions of NASM that support `%ifdirective`, `%ifusable`, `%ifusing` and using `%ifdef` to test for preprocessor functions. See section 6.9.

5.7.3 `%ifdefalias`: Testing Single-Line Macro Alias Existence

The `%ifdefalias` directive operates in the same was as the `%ifdef` directive, except it tests for the definition of a single-line macro *alias*, as defined by `%defalias`.

5.7.4 `%ifmacro`: Testing Multi-Line Macro Existence

The `%ifmacro` directive operates in the same way as the `%ifdef` directive, except that it checks for the existence of a multi-line macro.

For example, you may be working with a large project and not have control over the macros in a library. You may want to create a macro with one name if it doesn't already exist, and another name if one with that name does exist.

The `%ifmacro` is considered true if defining a macro with the given name and number of arguments would cause a definitions conflict. For example:

```
%ifmacro MyMacro 1-3

     %error "MyMacro 1-3" causes a conflict with an existing macro.
```

```
%else

     %macro MyMacro 1-3

             ; insert code to define the macro

     %endmacro

%endif
```

This will create the macro "MyMacro 1-3" if no macro already exists which would conflict with it, and emits a warning if there would be a definition conflict.

5.7.5 `%ifctx`: Testing the Context Stack

The conditional-assembly construct `%ifctx` will cause the subsequent code to be assembled if and only if the top context on the preprocessor's context stack has the same name as one of the arguments.

For more details of the context stack, see section 5.10. For a sample use of `%ifctx`, see section 5.10.6.

5.7.6 `%ifidn` and `%ifidni`: Testing Exact Text Identity

The construct `%ifidn text1,text2` will cause the subsequent code to be assembled if and only if `text1` and `text2`, after expanding single-line macros, are identical pieces of text. Differences in white space are not counted.

`%ifidni` is similar to `%ifidn`, but is case-insensitive; see however section 5.2.1.

For example, the following macro pushes a register or number on the stack, and allows you to treat `IP` as a real register:

```
%macro  pushparam 1

  %ifidni %1,ip
        call    %%label
  %%label:
  %else
        push    %1
  %endif

%endmacro
```

5.7.7 `%ifid`, `%ifnum`, `%ifstr`: Testing Token Types

Some macros will want to perform different tasks depending on whether they are passed a number, a string, or an identifier. For example, a string output macro might want to be able to cope with being passed either a string constant or a pointer to an existing string.

The conditional assembly construct `%ifid`, taking one parameter (which may be blank), assembles the subsequent code if and only if *the first token* in the parameter exists and is an identifier. `$` and `$$` are *not* considered identifiers by `%ifid`.

`%ifnum` works similarly, but tests for the token being an integer numeric constant (not an expression!) possibly preceded by `+` or `-`; `%ifstr` tests for it being a quoted string.

For example, the `writefile` macro defined in section 5.6.3 can be extended to take advantage of `%ifstr` in the following fashion:

```
%macro writefile 2-3+

  %ifstr %2
        jmp     %%endstr
    %if %0 = 3
      %%str:    db      %2,%3
    %else
```

```
      %%str:    db      %2
    %endif
      %%endstr: mov     dx,%%str
                mov     cx,%%endstr-%%str
  %else
                mov     dx,%2
                mov     cx,%3
  %endif
                mov     bx,%1
                mov     ah,0x40
                int     0x21

%endmacro
```

Then the `writefile` macro can cope with being called in either of the following two ways:

```
        writefile [file], strpointer, length
        writefile [file], "hello", 13, 10
```

In the first, `strpointer` is used as the address of an already-declared string, and `length` is used as its length; in the second, a string is given to the macro, which therefore declares it itself and works out the address and length for itself.

Note the use of `%if` inside the `%ifstr`: this is to detect whether the macro was passed two arguments (so the string would be a single string constant, and `db %2` would be adequate) or more (in which case, all but the first two would be lumped together into `%3`, and `db %2,%3` would be required).

5.7.8 `%iftoken`: Test for a Single Token

Some macros will want to do different things depending on if it is passed a single token (e.g. paste it to something else using `%+`) versus a multi-token sequence.

The conditional assembly construct `%iftoken` assembles the subsequent code if and only if the expanded parameters consist of exactly one token, possibly surrounded by whitespace.

For example:

```
%iftoken 1
```

will assemble the subsequent code, but

```
%iftoken -1
```

will not, since `-1` contains two tokens: the unary minus operator `-`, and the number `1`.

5.7.9 `%ifempty`: Test for Empty Expansion

The conditional assembly construct `%ifempty` assembles the subsequent code if and only if the expanded parameters do not contain any tokens at all, whitespace excepted.

5.7.10 `%ifdirective`: Test If a Directive Is Supported

The conditional assembly construct `%ifdirective` assembles the subsequent code if and only if followed by a token that corresponds to a preprocessor directive, assembler directive (see chapter 8) or a pseudo-instruction (see section 3.2) supported in the current version of NASM.

The argument can be a quoted string to prevent macro expansion, in which case it is unquoted before the test, that is, these two lines do the same thing:

```
%ifdirective %ifndef
%ifdirective "%ifndef"
```

Preprocessor directives must be specified with a leading `%` sign (except for certain directives in TASM mode); assembler directives *may* be specified with surrounding brackets `[]`, but those are not required.

Some assembly directives can be supported in some contexts and not others, for example, most output formats do not support the ORG directive, therefore the result of `%ifdirective` may depend on more than just the current version of NASM.

`%ifdirective` was introduced in NASM 3.00. It is strongly recommended to use this test instead of relying on NASM version numbers. To make it possible to probe for the existence of this test itself, the macro `__?NASM_HAS_IFDIRECTIVE?__` is defined on versions of NASM that support `%ifdirective`, `%ifusable`, `%ifusing` and using `%ifdef` to test for preprocessor functions. See section 6.9.

5.7.11 `%ifusable` and `%ifusing`: Test For Standard Macro Packages

The conditional assembly construct `%ifusable` assembles the subsequent code if and only if the following argument would be valid as the argument to `%use` (see section 5.9.4), in other words, that a standard macro package with that name is available in the current version of NASM.

The conditional assembly construct `%ifusing` assembles the subsequent code if and only if the following argument would be valid as the argument to `%use`. It is more or less equivalent to the `__?USE_`*package*`?__` standard macros (see section 6.10) but is potentially more robust.

`%ifusing` and `%ifusable` were introduced in NASM 3.00. It is strongly recommended to use this test instead of relying on NASM version numbers. To make it possible to probe for the existence of this test itself, the macro `__?NASM_HAS_IFDIRECTIVE?__` is defined on versions of NASM that support `%ifdirective`, `%ifusable`, `%ifusing` and using `%ifdef` to test for preprocessor functions. See section 6.9.

5.7.12 `%iffile`: Test If a File Exists

The conditional assembly construct `%iffile` assembles the subsequent code if and only if a quoted string is specified which contains the name of a file that is available for NASM to read.

The include path is *not* searched; to search for the file using the include path, use the `%pathsearch()` function in conjunction with this test, for example:

```
%define MYFILE "file.asm"
%iffile %pathsearch(MYFILE)
     ; ...
%endif
```

5.7.13 `%ifenv`: Test If Environment Variable Exists

The conditional assembly construct `%ifenv` assembles the subsequent code if and only if the environment variable referenced by the `%!`*variable* construct exists.

Just as for `%!`*variable* the variable name must be written as a quoted string if it contains characters that would not be legal in an identifier. See section 5.14.2.

See also the the `%env()` function (section 5.5.7).

5.7.14 Backwards Compatibility Caveat

Note that NASM before version 3.00 would not handle an unknown `%if`–type directive for the purpose of `%if`...`%endif` balancing. Therefore, something like this would not work:

```
%ifdef __?NASM_HAS_IFDIRECTIVE?__        ; NASM 3.00 or later
  %ifdirective %iffile                   ; Test for directive
    %iffile MYFILE
       incbin MYFILE
    %endif
  %endif
%endif
```

This can be worked around by using the `%is()` series functions and plain `%if` instead:

```
%ifdef __?NASM_HAS_IFDIRECTIVE?__        ; NASM 3.00 or later
  %if %isdef(%isfile)                    ; Test for function
```

```
    %if %isfile(MYFILE)
       incbin MYFILE
    %endif
  %endif
%endif
```

NASM 3.00 and later treats an unknown preprocessor directive beginning with `%if` or `%elif` as if it were a known conditional directive for the purpose of `%if`...`%endif` balancing.

5.8 Preprocessor Loops: `%rep`

NASM's `TIMES` prefix, though useful, cannot be used to invoke a multi-line macro multiple times, because it is processed by NASM after macros have already been expanded. Therefore NASM provides another form of loop, this time at the preprocessor level: `%rep`.

The directives `%rep` and `%endrep` (`%rep` takes a numeric argument, which can be an expression; `%endrep` takes no arguments) can be used to enclose a chunk of code, which is then replicated as many times as specified by the preprocessor:

```
%assign i 0
%rep    64
        inc     word [table+2*i]
%assign i i+1
%endrep
```

This will generate a sequence of 64 `INC` instructions, incrementing every word of memory from `[table]` to `[table+126]`.

For more complex termination conditions, or to break out of a repeat loop part way along, you can use the `%exitrep` directive to terminate the loop, like this:

```
fibonacci:
%assign i 0
%assign j 1
%rep 100
%if j > 65535
    %exitrep
%endif
        dw j
%assign k j+i
%assign i j
%assign j k
%endrep

fib_number equ ($-fibonacci)/2
```

This produces a list of all the Fibonacci numbers that will fit in 16 bits. Note that a maximum repeat count must still be given to `%rep`. This is to prevent the possibility of NASM getting into an infinite loop in the preprocessor, which (on multitasking or multi-user systems) would typically cause all the system memory to be gradually used up and other applications to start crashing.

Note the maximum repeat count is limited to the value specified by the `--limit-rep` option or `%pragma limit rep`, see section 2.1.32.

5.9 Source Files and Dependencies

These commands allow you to split your sources into multiple files.

5.9.1 `%include`: Including Other Files

Using, once again, a very similar syntax to the C preprocessor, NASM's preprocessor lets you include other source files into your code. This is done by the use of the `%include` directive:

```
%include "macros.mac"
```

will include the contents of the file `macros.mac` into the source file containing the `%include` directive.

Include files are searched for in the current directory (the directory you're in when you run NASM, as opposed to the location of the NASM executable or the location of the source file), plus any directories specified on the NASM command line using the `-i` option.

The standard C idiom for preventing a file being included more than once is just as applicable in NASM: if the file `macros.mac` has the form

```
%ifndef MACROS_MAC
    %define MACROS_MAC
    ; now define some macros
%endif
```

then including the file more than once will not cause errors, because the second time the file is included nothing will happen because the macro `MACROS_MAC` will already be defined.

You can force a file to be included even if there is no `%include` directive that explicitly includes it, by using the `-p` option on the NASM command line (see section 2.1.19).

5.9.2 `%pathsearch`: Search the Include Path

The `%pathsearch` directive takes a single-line macro name and a filename, and declare or redefines the specified single-line macro to be the include-path-resolved version of the filename, if the file exists (otherwise, it is passed unchanged.)

For example,

```
%pathsearch MyFoo "foo.bin"
```

... with `-Ibins/` in the include path may end up defining the macro `MyFoo` to be `"bins/foo.bin"`.

See also the `%pathsearch()` function (section 5.5.18).

5.9.3 `%depend`: Add Dependent Files

The `%depend` directive takes a filename and adds it to the list of files to be emitted as dependency generation when the `-M` options and its relatives (see section 2.1.5) are used. It produces no output.

This is generally used in conjunction with `%pathsearch`. For example, a simplified version of the standard macro wrapper for the `INCBIN` directive looks like:

```
%imacro incbin 1-2+ 0
%pathsearch dep %1
%depend dep
        incbin dep,%2
%endmacro
```

This first resolves the location of the file into the macro `dep`, then adds it to the dependency lists, and finally issues the assembler-level `INCBIN` directive.

See also the `%depend()` function (section 5.5.6).

5.9.4 `%use`: Include Standard Macro Package

The `%use` directive is similar to `%include`, but rather than including the contents of a file, it includes a named standard macro package. The standard macro packages are part of NASM, and are described in chapter 7.

Unlike the `%include` directive, package names for the `%use` directive do not require quotes, but quotes are permitted. In NASM 2.04 and 2.05 the unquoted form would be macro-expanded; this is no longer true. Thus, the following lines are equivalent:

```
%use altreg
%use 'altreg'
```

Standard macro packages are protected from multiple inclusion. When a standard macro package is used, a testable single-line macro of the form `__?USE_`*package*`?__` is also defined, see section 6.10.

The `%ifusable` and `%ifusing` directives can be used for the existence and inclusion of a specific standard macro package, see `ifusing`.

5.10 The Context Stack

Having labels that are local to a macro definition is sometimes not quite powerful enough: sometimes you want to be able to share labels between several macro calls. An example might be a `REPEAT` ... `UNTIL` loop, in which the expansion of the `UNTIL` macro would need to be able to refer to a label which the `REPEAT` macro had defined. However, for such a macro you would also want to be able to nest these loops.

NASM provides this level of power by means of a *context stack*. The preprocessor maintains a stack of *contexts*, each of which is characterized by a name. You add a new context to the stack using the `%push` directive, and remove one using `%pop`. You can define labels that are local to a particular context on the stack.

5.10.1 `%push` and `%pop`: Creating and Removing Contexts

The `%push` directive is used to create a new context and place it on the top of the context stack. `%push` takes an optional argument, which is the name of the context. For example:

```
%push     foobar
```

This pushes a new context called `foobar` on the stack. You can have several contexts on the stack with the same name: they can still be distinguished. If no name is given, the context is unnamed (this is normally used when both the `%push` and the `%pop` are inside a single macro definition).

The directive `%pop`, taking one optional argument, removes the top context from the context stack and destroys it, along with any labels associated with it. If an argument is given, it must match the name of the current context, otherwise it will issue an error.

5.10.2 Context-Local Labels

Just as the usage `%%foo` defines a label which is local to the particular macro call in which it is used, the usage `%$foo` is used to define a label which is local to the context on the top of the context stack. So the `REPEAT` and `UNTIL` example given above could be implemented by means of:

```
%macro repeat 0

    %push   repeat
    %$begin:

%endmacro

%macro until 1

        j%-1    %$begin
    %pop

%endmacro
```

and invoked by means of, for example,

```
        mov     di,string
        repeat
        add     di,3
        scasb
        until   e
```

which would scan every fourth byte of a string in search of the byte in `AL`.

If you need to define, or access, labels local to the context *below* the top one on the stack, you can use `%$$foo`, or `%$$$foo` for the context below that, and so on.

5.10.3 Context-Local Single-Line Macros

NASM also allows you to define single-line macros which are local to a particular context, in just the same way:

```
%define %$localmac 3
```

will define the single-line macro `%$localmac` to be local to the top context on the stack. Of course, after a subsequent `%push`, it can then still be accessed by the name `%$$localmac`.

5.10.4 Context Fall-Through Lookup *(deprecated)*

Context fall-through lookup (automatic searching of outer contexts) is a feature that was added in NASM version 0.98.03. Unfortunately, this feature is unintuitive and can result in buggy code that would have otherwise been prevented by NASM's error reporting. As a result, this feature has been *deprecated*. NASM version 2.09 will issue a warning when usage of this *deprecated* feature is detected. Starting with NASM version 2.10, usage of this *deprecated* feature will simply result in an *expression syntax error*.

An example usage of this *deprecated* feature follows:

```
%macro ctxthru 0
%push ctx1
    %assign %$external 1
        %push ctx2
            %assign %$internal 1
            mov eax, %$external
            mov eax, %$internal
        %pop
%pop
%endmacro
```

As demonstrated, `%$external` is being defined in the `ctx1` context and referenced within the `ctx2` context. With context fall-through lookup, referencing an undefined context-local macro like this implicitly searches through all outer contexts until a match is made or isn't found in any context. As a result, `%$external` referenced within the `ctx2` context would implicitly use `%$external` as defined in `ctx1`. Most people would expect NASM to issue an error in this situation because `%$external` was never defined within `ctx2` and also isn't qualified with the proper context depth, `%$$external`.

Here is a revision of the above example with proper context depth:

```
%macro ctxthru 0
%push ctx1
    %assign %$external 1
        %push ctx2
            %assign %$internal 1
            mov eax, %$$external
            mov eax, %$internal
        %pop
%pop
%endmacro
```

As demonstrated, `%$external` is still being defined in the `ctx1` context and referenced within the `ctx2` context. However, the reference to `%$external` within `ctx2` has been fully qualified with the proper context depth, `%$$external`, and thus is no longer ambiguous, unintuitive or erroneous.

5.10.5 `%repl`: Renaming a Context

If you need to change the name of the top context on the stack (in order, for example, to have it respond differently to `%ifctx`), you can execute a `%pop` followed by a `%push`; but this will have the side

effect of destroying all context-local labels and macros associated with the context that was just popped.

NASM provides the directive `%repl`, which *replaces* a context with a different name, without touching the associated macros and labels. So you could replace the destructive code

```
%pop
%push   newname
```

with the non-destructive version `%repl newname`.

5.10.6 Example Use of the Context Stack: Block IFs

This example makes use of almost all the context-stack features, including the conditional-assembly construct `%ifctx`, to implement a block IF statement as a set of macros.

```
%macro if 1

    %push if
    j%-1  %$ifnot

%endmacro

%macro else 0

  %ifctx if
        %repl   else
        jmp     %$ifend
        %$ifnot:
  %else
        %error  "expected `if' before `else'"
  %endif

%endmacro

%macro endif 0

  %ifctx if
        %$ifnot:
        %pop
  %elifctx      else
        %$ifend:
        %pop
  %else
        %error  "expected `if' or `else' before `endif'"
  %endif

%endmacro
```

This code is more robust than the `REPEAT` and `UNTIL` macros given in section 5.10.2, because it uses conditional assembly to check that the macros are issued in the right order (for example, not calling `endif` before `if`) and issues an `%error` if they're not.

In addition, the `endif` macro has to be able to cope with the two distinct cases of either directly following an `if`, or following an `else`. It achieves this, again, by using conditional assembly to do different things depending on whether the context on top of the stack is `if` or `else`.

The `else` macro has to preserve the context on the stack, in order to have the `%$ifnot` referred to by the `if` macro be the same as the one defined by the `endif` macro, but has to change the context's name so that `endif` will know there was an intervening `else`. It does this by the use of `%repl`.

A sample usage of these macros might look like:

```
        cmp     ax,bx

        if ae
```

```
        cmp     bx,cx

        if ae
                mov     ax,cx
        else
                mov     ax,bx
        endif

else
        cmp     ax,cx

        if ae
                mov     ax,cx
        endif

endif
```

The block-`IF` macros handle nesting quite happily, by means of pushing another context, describing the inner `if`, on top of the one describing the outer `if`; thus `else` and `endif` always refer to the last unmatched `if` or `else`.

5.11 Stack Relative Preprocessor Directives

The following preprocessor directives provide a way to use labels to refer to local variables allocated on the stack.

- `%arg` (see section 5.11.1)
- `%stacksize` (see section 5.11.2)
- `%local` (see section 5.11.3)

5.11.1 `%arg` Directive

The `%arg` directive is used to simplify the handling of parameters passed on the stack. Stack based parameter passing is used by many high level languages, including C, C++ and Pascal.

While NASM has macros which attempt to duplicate this functionality (see section 10.4.5), the syntax is not particularly convenient to use and is not TASM compatible. Here is an example which shows the use of `%arg` without any external macros:

```
some_function:

    %push     mycontext        ; save the current context
    %stacksize large           ; tell NASM to use bp
    %arg      i:word, j_ptr:word

        mov     ax,[i]
        mov     bx,[j_ptr]
        add     ax,[bx]
        ret

    %pop                       ; restore original context
```

This is similar to the procedure defined in section 10.4.5 and adds the value in i to the value pointed to by j_ptr and returns the sum in the ax register. See section 5.10.1 for an explanation of `push` and `pop` and the use of context stacks.

5.11.2 `%stacksize` Directive

The `%stacksize` directive is used in conjunction with the `%arg` (see section 5.11.1) and the `%local` (see section 5.11.3) directives. It tells NASM the default size to use for subsequent `%arg` and `%local` directives. The `%stacksize` directive takes one required argument which is one of `flat`, `flat64`, `large` or `small`.

`%stacksize flat`

This form causes NASM to use stack-based parameter addressing relative to `ebp` and it assumes that a near form of call was used to get to this label (i.e. that `eip` is on the stack).

`%stacksize flat64`

This form causes NASM to use stack-based parameter addressing relative to `rbp` and it assumes that a near form of call was used to get to this label (i.e. that `rip` is on the stack).

`%stacksize large`

This form uses `bp` to do stack-based parameter addressing and assumes that a far form of call was used to get to this address (i.e. that `ip` and `cs` are on the stack).

`%stacksize small`

This form also uses `bp` to address stack parameters, but it is different from `large` because it also assumes that the old value of bp is pushed onto the stack (i.e. it expects an `ENTER` instruction). In other words, it expects that `bp`, `ip` and `cs` are on the top of the stack, underneath any local space which may have been allocated by `ENTER`. This form is probably most useful when used in combination with the `%local` directive (see section 5.11.3).

5.11.3 `%local` Directive

The `%local` directive is used to simplify the use of local temporary stack variables allocated in a stack frame. Automatic local variables in C are an example of this kind of variable. The `%local` directive is most useful when used with the `%stacksize` (see section 5.11.2 and is also compatible with the `%arg` directive (see section 5.11.1). It allows simplified reference to variables on the stack which have been allocated typically by using the `ENTER` instruction. An example of its use is the following:

```
silly_swap:

    %push mycontext             ; save the current context
    %stacksize small            ; tell NASM to use bp
    %assign %$localsize 0       ; see text for explanation
    %local old_ax:word, old_dx:word

        enter   %$localsize,0   ; see text for explanation
        mov     [old_ax],ax     ; swap ax & bx
        mov     [old_dx],dx     ; and swap dx & cx
        mov     ax,bx
        mov     dx,cx
        mov     bx,[old_ax]
        mov     cx,[old_dx]
        leave                   ; restore old bp
        ret                     ;

    %pop                        ; restore original context
```

The `%$localsize` variable is used internally by the `%local` directive and *must* be defined within the current context before the `%local` directive may be used. Failure to do so will result in one expression syntax error for each `%local` variable declared. It then may be used in the construction of an appropriately sized `ENTER` instruction as shown in the example.

5.12 Reporting User-generated Diagnostics: `%error`, `%warning`, `%fatal`, `%note`

The preprocessor directive `%error` will cause NASM to report an error if it occurs in assembled code. So if other users are going to try to assemble your source files, you can ensure that they define the right macros by means of code like this:

```
%ifdef F1
    ; do some setup
%elifdef F2
    ; do some different setup
```

```
%else
    %error "Neither F1 nor F2 was defined."
%endif
```

Then any user who fails to understand the way your code is supposed to be assembled will be quickly warned of their mistake, rather than having to wait until the program crashes on being run and then not knowing what went wrong.

Similarly, `%warning` issues a warning, but allows assembly to continue:

```
%ifdef F1
    ; do some setup
%elifdef F2
    ; do some different setup
%else
    %warning "Neither F1 nor F2 was defined, assuming F1."
    %define F1
%endif
```

User-defined error messages can be suppressed with the `-w-user` option, and promoted to errors with `-w+error=user`.

`%error` and `%warning` are issued only on the final assembly pass. This makes them safe to use in conjunction with tests that depend on symbol values.

`%fatal` terminates assembly immediately, regardless of pass. This is useful when there is no point in continuing the assembly further, and doing so is likely just going to cause a spew of confusing error messages.

`%note` adds an output line to the list file; it does not output anything on the console or error file.

It is optional for the message string after `%error`, `%warning`, `%fatal`, or `%note` to be quoted. If it is *not*, then single-line macros are expanded in it, which can be used to display more information to the user. For example:

```
%if foo > 64
    %assign foo_over foo-64
    %error foo is foo_over bytes too large
%endif
```

5.13 `%pragma`: Setting Options

The `%pragma` directive controls a number of options in NASM. Pragmas are intended to remain backwards compatible, and therefore an unknown `%pragma` directive is not an error.

The various pragmas are documented with the options they affect.

The general structure of a NASM pragma is:

`%pragma` *namespace directive* [*arguments...*]

Currently defined namespaces are:

- `ignore`: this `%pragma` is unconditionally ignored.
- `preproc`: preprocessor, see section 5.13.1.
- `limit`: resource limits, see section 2.1.32.
- `asm`: the parser and assembler proper. Currently no such pragmas are defined.
- `list`: listing options, see section 2.1.4.
- `file`: general file handling options. Currently no such pragmas are defined.
- `input`: input file handling options. Currently no such pragmas are defined.
- `output`: output format options.

- `debug`: debug format options.

In addition, the name of any output or debug format, and sometimes groups thereof, also constitute `%pragma` namespaces. The namespaces `output` and `debug` simply refer to *any* output or debug format, respectively.

For example, to prepend an underscore to global symbols regardless of the output format (see section 8.10):

```
%pragma output gprefix _
```

... whereas to prepend an underscore to global symbols only when the output is either `win32` or `win64`:

```
%pragma win gprefix _
```

5.13.1 Preprocessor Pragmas

The only preprocessor `%pragma` defined as the current version of NASM is:

- `%pragma preproc sane_empty_expansion`: disables legacy compatibility handling of braceless empty arguments to multi-line macros. See section 5.6 and section 2.1.26.

5.14 Other Preprocessor Directives

5.14.1 `%line` Directive

The `%line` directive is used to notify NASM that the input line corresponds to a specific line number in another file. Typically this other file would be an original source file, with the current NASM input being the output of a pre-processor. The `%line` directive allows NASM to output messages which indicate the line number of the original source file, instead of the file that is being read by NASM.

This preprocessor directive is not generally used directly by programmers, but may be of interest to preprocessor authors. The usage of the `%line` preprocessor directive is as follows:

```
%line nnn[+mmm] [filename]
```

In this directive, `nnn` identifies the line of the original source file which this line corresponds to. `mmm` is an optional parameter which specifies a line increment value; each line of the input file read in is considered to correspond to `mmm` lines of the original source file. Finally, `filename` is an optional parameter which specifies the file name of the original source file. It may be a quoted string, in which case any additional argument after the quoted string will be ignored.

After reading a `%line` preprocessor directive, NASM will report all file name and line numbers relative to the values specified therein.

If the command line option `--no-line` is given, all `%line` directives are ignored. This may be useful for debugging preprocessed code. See section 2.1.34.

Starting in NASM 2.15, `%line` directives are processed before any other processing takes place.

For compatibility with the output from some other preprocessors, including many C preprocessors, a `#` character followed by whitespace *at the very beginning of a line* is also treated as a `%line` directive, except that double quotes surrounding the filename are treated like NASM backquotes, with `\`-escaped sequences decoded.

5.14.2 `%!`*variable*: Read an Environment Variable.

The `%!`*variable* directive makes it possible to read the value of an environment variable at assembly time. This could, for example, be used to store the contents of an environment variable into a string, which could be used at some other point in your code.

For example, suppose that you have an environment variable `FOO`, and you want the contents of `FOO` to be embedded in your program as a quoted string. You could do that as follows:

```
%defstr FOO          %!FOO
```

See section 5.3.9 for notes on the `%defstr` directive.

If the name of the environment variable contains non-identifier characters, you can use string quotes to surround the name of the variable, for example:

```
%defstr C_colon      %!'C:'
```

See also the `%ifenv` directive (section 5.7.13) and the `%env()` function (section 5.5.7).

5.14.3 `%clear`: Clear All Macro Definitions

The directive `%clear` clears all definitions of a certain type, *including the ones defined by NASM itself.* This can be useful when preprocessing non-NASM code, or to drop backwards compatibility aliases.

The syntax is:

```
%clear [global|context] type...
```

... where `context` indicates that this applies to context-local macros only; the default is `global`.

`type` can be one or more of:

- `define` single-line macros
- `defalias` single-line macro aliases (useful to remove backwards compatibility aliases)
- `alldefine` same as `define defalias`
- `macro` multi-line macros
- `all` same as `alldefine macro` (default)

In NASM 2.14 and earlier, only the single syntax `%clear` was supported, which is equivalent to `%clear global all`.

Chapter 6: Standard Macros

NASM defines a set of standard macros, which are already defined when it starts to process any source file. If you really need a program to be assembled with no pre-defined macros, you can use the `%clear` directive to empty the preprocessor of everything but context-local preprocessor variables and single-line macros, see section 5.14.3.

Most user-level directives (see chapter 8) are implemented as macros which invoke primitive directives; these are described in chapter 8. The rest of the standard macro set is described here.

For compatibility with NASM versions before NASM 2.15, most standard macros of the form `__?foo?__` have aliases of form `__foo__` (see section 5.3.11). These can be removed with the directive `%clear defalias`.

6.1 NASM Version Macros

The single-line macros `__?NASM_MAJOR?__`, `__?NASM_MINOR?__`, `__?NASM_SUBMINOR?__` and `__?NASM_PATCHLEVEL?__` expand to the major, minor, subminor and patch level parts of the version number of NASM being used. So, under NASM 0.98.32p1 for example, `__?NASM_MAJOR?__` would be defined to be 0, `__?NASM_MINOR?__` would be defined as 98, `__?NASM_SUBMINOR?__` would be defined to 32, and `__?NASM_PATCHLEVEL?__` would be defined as 1.

Additionally, the macro `__?NASM_SNAPSHOT?__` is defined for automatically generated snapshot releases *only*.

6.1.1 `__?NASM_VERSION_ID?__`: NASM Version ID

The single-line macro `__?NASM_VERSION_ID?__` expands to a dword integer representing the full version number of the version of nasm being used. The value is the equivalent to `__?NASM_MAJOR?__`, `__?NASM_MINOR?__`, `__?NASM_SUBMINOR?__` and `__?NASM_PATCHLEVEL?__` concatenated to produce a single doubleword. Hence, for 0.98.32p1, the returned number would be equivalent to:

```
dd      0x00622001
```

or

```
db      1,32,98,0
```

Note that the above lines generate exactly the same code, the second line is used just to give an indication of the order that the separate values will be present in memory.

6.1.2 `__?NASM_VER?__`: NASM Version String

The single-line macro `__?NASM_VER?__` expands to a string which defines the version number of nasm being used. So, under NASM 0.98.32 for example,

```
db      __?NASM_VER?__
```

would expand to

```
db      "0.98.32"
```

6.2 `__?FILE?__` and `__?LINE?__`: File Name and Line Number

Like the C preprocessor, NASM allows the user to find out the file name and line number containing the current instruction. The macro `__?FILE?__` expands to a string constant giving the name of the current input file (which may change through the course of assembly if `%include` directives are used), and `__?LINE?__` expands to a numeric constant giving the current line number in the input file.

These macros could be used, for example, to communicate debugging information to a macro, since invoking `__?LINE?__` inside a macro definition (either single-line or multi-line) will return the line

number of the macro *call*, rather than *definition*. So to determine where in a piece of code a crash is occurring, for example, one could write a routine `stillhere`, which is passed a line number in `EAX` and outputs something like `line 155: still here`. You could then write a macro:

```
%macro  notdeadyet 0

        push    eax
        mov     eax,__?LINE?__
        call    stillhere
        pop     eax

%endmacro
```

and then pepper your code with calls to `notdeadyet` until you find the crash point.

6.3 `__?BITS?__`: Current Code Generation Mode

The `__?BITS?__` standard macro is updated every time that the BITS mode is set using the `BITS XX` or `[BITS XX]` directive, where XX is a valid mode number of 16, 32 or 64. `__?BITS?__` receives the specified mode number and makes it globally available. This can be very useful for those who utilize mode-dependent macros.

6.4 `__?DEFAULT?__`: `DEFAULT` directive settings

The `__?DEFAULT?__` standard macro contains a comma-separated list of all possible settings of the `DEFAULT` directive (see section 8.2), including ones which are set as NASM defaults. For example, after:

```
default rel, fs:rel
```

... the `__?DEFAULT?__` macro might expand to:

```
rel,fs:rel,gs:abs,nobnd
```

6.5 `__?OUTPUT_FORMAT?__`: Current Output Format

The `__?OUTPUT_FORMAT?__` standard macro holds the current output format name, as given by the `-f` option or NASM's default. Type `nasm -h` for a list.

```
%ifidn __?OUTPUT_FORMAT?__, win32
 %define NEWLINE 13, 10
%elifidn __?OUTPUT_FORMAT?__, elf32
 %define NEWLINE 10
%endif
```

6.6 `__?DEBUG_FORMAT?__`: Current Debug Format

If debugging information generation is enabled, The `__?DEBUG_FORMAT?__` standard macro holds the current debug format name as specified by the `-F` or `-g` option or the output format default. Type `nasm -f` *output* `y` for a list.

`__?DEBUG_FORMAT?__` is not defined if debugging is not enabled, or if the debug format specified is `null`.

6.7 Assembly Date and Time Macros

NASM provides a variety of macros that represent the timestamp of the assembly session.

- The `__?DATE?__` and `__?TIME?__` macros give the assembly date and time as strings, in ISO 8601 format (`"YYYY-MM-DD"` and `"HH:MM:SS"`, respectively.)
- The `__?DATE_NUM?__` and `__?TIME_NUM?__` macros give the assembly date and time in numeric form; in the format `YYYYMMDD` and `HHMMSS` respectively.

- The `__?UTC_DATE?__` and `__?UTC_TIME?__` macros give the assembly date and time in universal time (UTC) as strings, in ISO 8601 format (`"YYYY-MM-DD"` and `"HH:MM:SS"`, respectively.) If the host platform doesn't provide UTC time, these macros are undefined.
- The `__?UTC_DATE_NUM?__` and `__?UTC_TIME_NUM?__` macros give the assembly date and time universal time (UTC) in numeric form; in the format `YYYYMMDD` and `HHMMSS` respectively. If the host platform doesn't provide UTC time, these macros are undefined.
- The `__?POSIX_TIME?__` macro is defined as a number containing the number of seconds since the POSIX epoch, 1 January 1970 00:00:00 UTC; excluding any leap seconds. This is computed using UTC time if available on the host platform, otherwise it is computed using the local time as if it was UTC.

All instances of time and date macros in the same assembly session produce consistent output. For example, in an assembly session started at 42 seconds after midnight on January 1, 2010 in Moscow (timezone UTC+3) these macros would have the following values, assuming, of course, a properly configured environment with a correct clock:

```
__?DATE?__              "2010-01-01"
__?TIME?__              "00:00:42"
__?DATE_NUM?__          20100101
__?TIME_NUM?__          000042
__?UTC_DATE?__          "2009-12-31"
__?UTC_TIME?__          "21:00:42"
__?UTC_DATE_NUM?__      20091231
__?UTC_TIME_NUM?__      210042
__?POSIX_TIME?__        1262293242
```

6.8 `__?NASM_LIMITS?__`: List of Resource Limits

The standard macro `__?NASM_LIMITS?__` is defined as a comma-separated list of quoted strings corresponding to all resource limits defined in the current version of NASM. It also indicates the availability of the `%limit()` function and the keywords `default`, `maximum`, and `reset` for `%pragma limit`.

See section 2.1.32 and `f_limit`.

`__?NASM_LIMITS?__` is defined since NASM 3.02.

6.9 `__?NASM_HAS_IFDIRECTIVE?__`: Directive Probing Support

The standard macro `__?NASM_HAS_IFDIRECTIVE?__` is defined if this version of NASM supports the preprocessor tests `%ifdirective`, `%ifusable` and `%ifusing`, and supports using `%ifdef` to test for the presence of preprocessor functions. See section 5.7.2, section 5.7.10, and section 5.7.11.

It is strongly suggested to test for the presence of this macro and, if present, relying on the corresponding tests instead of relying on NASM version number tests.

However, see section 5.7.14 for an important caveat.

6.10 `__?USE_`*package*`?__`: Package Include Test

When a standard macro package (see chapter 7) is included with the `%use` directive (see section 5.9.4), a single-line macro of the form `__?USE_`*package*`?__` is automatically defined. This allows testing if a particular package is invoked or not.

For example, if the `altreg` package is included (see section 7.1), then the macro `__?USE_ALTREG?__` is defined.

See also the `%ifusable` and `%ifusing` directives, section 5.7.11.

6.11 `__?LIST_OPTIONS?__`: Current Listing Options

Contains a quoted string with the listing options currently in effect. See section 2.1.4.

6.12 __?LIST_OPTIONS_DEFAULT?__: Default Listing Options

Contains a quoted string with the listing options originally specified by the user on the command line. See section 2.1.4.

6.13 __?PASS?__: Assembly Pass

The macro `__?PASS?__` is defined to be `1` on preparatory passes, and `2` on the final pass. In preprocess-only mode, it is set to `3`, and when running only to generate dependencies (due to the `-M` or `-MG` option, see section 2.1.5) it is set to `0`.

Avoid using this macro if at all possible. It is tremendously easy to generate very strange errors by misusing it, and the semantics may change in future versions of NASM.

6.14 Structure Data Types

6.14.1 STRUC and ENDSTRUC: Declaring Structure Data Types

The core of NASM contains no intrinsic means of defining data structures; instead, the preprocessor is sufficiently powerful that data structures can be implemented as a set of macros. The macros STRUC and ENDSTRUC are used to define a structure data type.

STRUC takes one or two parameters. The first parameter is the name of the data type. The second, optional parameter is the base offset of the structure. The name of the data type is defined as a symbol with the value of the base offset, and the name of the data type with the suffix `_size` appended to it is defined as an EQU giving the size of the structure. Once STRUC has been issued, you are defining the structure, and should define fields using the RESB family of pseudo-instructions, and then invoke ENDSTRUC to finish the definition.

For example, to define a structure called `mytype` containing a longword, a word, a byte and a string of bytes, you might code

```
struc   mytype

  mt_long:      resd    1
  mt_word:      resw    1
  mt_byte:      resb    1
  mt_str:       resb    32

endstruc
```

The above code defines six symbols: `mt_long` as 0 (the offset from the beginning of a `mytype` structure to the longword field), `mt_word` as 4, `mt_byte` as 6, `mt_str` as 7, `mytype_size` as 39, and `mytype` itself as zero.

The reason why the structure type name is defined at zero by default is a side effect of allowing structures to work with the local label mechanism: if your structure members tend to have the same names in more than one structure, you can define the above structure like this:

```
struc mytype

  .long:        resd    1
  .word:        resw    1
  .byte:        resb    1
  .str:         resb    32

endstruc
```

This defines the offsets to the structure fields as `mytype.long`, `mytype.word`, `mytype.byte` and `mytype.str`.

NASM, since it has no *intrinsic* structure support, does not support any form of period notation to refer to the elements of a structure once you have one (except the above local-label notation), so code such

as `mov ax,[mystruc.mt_word]` is not valid. `mt_word` is a constant just like any other constant, so the correct syntax is `mov ax,[mystruc+mt_word]` or `mov ax,[mystruc+mytype.word]`.

Sometimes you only have the address of the structure displaced by an offset. For example, consider this standard stack frame setup:

```
push ebp
mov ebp, esp
sub esp, 40
```

In this case, you could access an element by subtracting the offset:

```
mov [ebp - 40 + mytype.word], ax
```

However, if you do not want to repeat this offset, you can use –40 as a base offset:

```
struc mytype, -40
```

And access an element this way:

```
mov [ebp + mytype.word], ax
```

6.14.2 ISTRUC, AT and IEND: Declaring Instances of Structures

Having defined a structure type, the next thing you typically want to do is to declare instances of that structure in your data segment. NASM provides an easy way to do this in the ISTRUC mechanism. To declare a structure of type `mytype` in a program, you code something like this:

```
mystruc:
    istruc mytype

        at mt_long, dd      123456
        at mt_word, dw      1024
        at mt_byte, db      'x'
        at mt_str,  db      'hello, world', 13, 10, 0

    iend
```

The function of the AT macro is to make use of the TIMES prefix to advance the assembly position to the correct point for the specified structure field, and then to declare the specified data. Therefore the structure fields must be declared in the same order as they were specified in the structure definition.

If the data to go in a structure field requires more than one source line to specify, the remaining source lines can easily come after the AT line. For example:

```
        at mt_str,  db      123,134,145,156,167,178,189
                    db      190,100,0
```

Depending on personal taste, you can also omit the code part of the AT line completely, and start the structure field on the next line:

```
        at mt_str
                db      'hello, world'
                db      13,10,0
```

6.15 Alignment Control

6.15.1 ALIGN and ALIGNB: Code and Data Alignment

The ALIGN and ALIGNB macros provides a convenient way to align code or data on a word, longword, paragraph or other boundary. (Some assemblers call this directive EVEN.) The syntax of the ALIGN and ALIGNB macros is

```
        align   4               ; align on 4-byte boundary
        align   16              ; align on 16-byte boundary
        align   8,db 0          ; pad with 0s rather than NOPs
        align   4,resb 1        ; align to 4 in the BSS
        alignb  4               ; equivalent to previous line
```

Both macros require their first argument to be a power of two; they both compute the number of additional bytes required to bring the length of the current section up to a multiple of that power of two, and then apply the TIMES prefix to their second argument to perform the alignment.

If the second argument is not specified, the default for ALIGN is NOP, and the default for ALIGNB is RESB 1. So if the second argument is specified, the two macros are equivalent. Normally, you can just use ALIGN in code and data sections and ALIGNB in BSS sections, and never need the second argument except for special purposes.

ALIGN and ALIGNB, being simple macros, perform no error checking: they cannot warn you if their first argument fails to be a power of two, or if their second argument generates more than one byte of code. In each of these cases they will silently do the wrong thing.

ALIGNB (or ALIGN with a second argument of RESB 1) can be used within structure definitions:

```
struc mytype2

  mt_byte:
        resb 1
        alignb 2
  mt_word:
        resw 1
        alignb 4
  mt_long:
        resd 1
  mt_str:
        resb 32

endstruc
```

This will ensure that the structure members are sensibly aligned relative to the base of the structure.

A final caveat: ALIGN and ALIGNB work relative to the beginning of the *section*, not the beginning of the address space in the final executable. Aligning to a 16-byte boundary when the section you're in is only guaranteed to be aligned to a 4-byte boundary, for example, is a waste of effort. Again, NASM does not check that the section's alignment characteristics are sensible for the use of ALIGN or ALIGNB.

Both ALIGN and ALIGNB do call SECTALIGN macro implicitly. See section 6.15.2 for details.

See also the smartalign standard macro package, section 7.2.

6.15.2 SECTALIGN: Section Alignment

The SECTALIGN macros provides a way to modify alignment attribute of output file section. Unlike the align= attribute (which is allowed at section definition only) the SECTALIGN macro may be used at any time.

For example the directive

```
SECTALIGN 16
```

sets the section alignment requirements to 16 bytes. Once increased it can not be decreased, the magnitude may grow only.

Note that ALIGN (see section 6.15.1) calls the SECTALIGN macro implicitly so the active section alignment requirements may be updated. This is by default behaviour, if for some reason you want the ALIGN do not call SECTALIGN at all use the directive

```
SECTALIGN OFF
```

It is still possible to turn in on again by

```
SECTALIGN ON
```

Note that SECTALIGN <ON|OFF> affects only the ALIGN/ALIGNB directives, not an explicit SECTALIGN directive.

Chapter 7: Standard Macro Packages

The %use directive (see section 5.9.4) includes one of the standard macro packages included with the NASM distribution and compiled into the NASM binary. It operates like the %include directive (see section 5.9.1), but the included contents is provided by NASM itself.

The names of standard macro packages are case insensitive and can be quoted or not.

As of version 2.15, NASM has %ifusable and %ifusing directives to help the user understand whether an individual package available in this version of NASM (%ifusable) or a particular package already loaded (%ifusing).

7.1 altreg: Alternate Register Names

The altreg standard macro package provides alternate register names. It provides numeric register names for all registers (not just R8–R31), the Intel-defined aliases R8L–R31L for the low bytes of registers (as opposed to the NASM/AMD standard names R8B–R31B), and the names R0H–R3H (by analogy with R0L–R3L) for AH, CH, DH, and BH.

Example use:

```
%use altreg

proc:
      mov r0l,r3h                   ; mov al,bh
      ret
```

See also section 13.1 and section 4.6.1.

7.2 smartalign: Smart ALIGN Macro

The smartalign standard macro package provides an ALIGN macro which is more powerful than the default (and backwards-compatible) one (see section 6.15.1). When the smartalign package is enabled, when ALIGN is used without a second argument, NASM will generate a sequence of instructions more efficient than a series of NOP. Furthermore, if the padding exceeds a specific threshold, then NASM will generate a jump over the entire padding sequence.

The specific instructions generated can be controlled with the new ALIGNMODE macro. This macro takes two parameters: one mode, and an optional jump threshold override. If (for any reason) you need to turn off the jump completely just set jump threshold value to −1 (or set it to nojmp). The following modes are possible:

- generic: Works on all x86 CPUs and should have reasonable performance. The default jump threshold is 8. This is the default.
- nop: Pad out with NOP instructions. The only difference compared to the standard ALIGN macro is that NASM can still jump over a large padding area. The default jump threshold is 16.
- k7: Optimize for the AMD K7 (Athlon/Althon XP). These instructions should still work on all x86 CPUs. The default jump threshold is 16.
- k8: Optimize for the AMD K8 (Opteron/Althon 64). These instructions should still work on all x86 CPUs. The default jump threshold is 16.
- p6: Optimize for Intel CPUs. This uses the long NOP instructions first introduced in Pentium Pro. This is incompatible with all CPUs of family 5 or lower, as well as some VIA CPUs and several virtualization solutions. The default jump threshold is 16.

The macro __?ALIGNMODE?__ is defined to contain the current alignment mode. A number of other macros beginning with __?ALIGN_ are used internally by this macro package.

7.3 `fp`: Floating-point macros

This packages contains the following floating-point convenience macros:

```
%define Inf             __?Infinity?__
%define NaN             __?QNaN?__
%define QNaN            __?QNaN?__
%define SNaN            __?SNaN?__

%define float8(x)       __?float8?__(x)
%define float16(x)      __?float16?__(x)
%define bfloat16(x)     __?bfloat16?__(x)
%define float32(x)      __?float32?__(x)
%define float64(x)      __?float64?__(x)
%define float80m(x)     __?float80m?__(x)
%define float80e(x)     __?float80e?__(x)
%define float128l(x)    __?float128l?__(x)
%define float128h(x)    __?float128h?__(x)
```

It also defines the a multi-line macro `bf16` that can be used in a similar way to the D*x* directives for the other floating-point numbers:

```
bf16 -3.1415, NaN, 2000.0, +Inf
```

7.4 `ifunc`: Integer functions

This package contains a set of macros which implement integer functions. These are actually implemented as special operators, but are most conveniently accessed via this macro package.

The macros provided are:

7.4.1 Integer logarithms

These functions calculate the integer logarithm base 2 of their argument, considered as an unsigned integer. The only differences between the functions is their respective behavior if the argument provided is not a power of two.

The function `ilog2e()` (alias `ilog2()`) generates an error if the argument is not a power of two.

The function `ilog2f()` rounds the argument down to the nearest power of two; if the argument is zero it returns zero.

The function `ilog2c()` rounds the argument up to the nearest power of two.

The functions `ilog2fw()` (alias `ilog2w()`) and `ilog2cw()` generate a warning if the argument is not a power of two, but otherwise behaves like `ilog2f()` and `ilog2c()`, respectively.

7.5 `masm`: MASM compatibility

Since version 2.15, NASM has a MASM compatibility package with minimal functionality, as intended to be used primarily with machine-generated code. It does not include any "programmer-friendly" shortcuts, nor does it in any way support ASSUME, symbol typing, or MASM-style structures.

To enable the package, use the directive:

```
%use masm
```

Currently, the MASM compatibility package emulates:

- The `FLAT` and `OFFSET` keywords are recognized and ignored.
- The `PTR` keyword signifies a memory reference, as if the argument had been put in square brackets:

```
mov eax,[foo]               ; memory reference
mov eax,dword ptr foo       ; memory reference
mov eax,dword ptr flat:foo  ; memory reference
```

```
mov eax,offset foo          ; address
mov eax,foo                 ; address (ambiguous syntax in MASM)
```

- The SEGMENT ... ENDS syntax:

```
segname SEGMENT
    ...
segname ENDS
```

- The PROC ... ENDP syntax:

```
procname PROC [FAR]
     ...
procname ENDP
```

  PROC will also define RET as a macro expanding to either RETF if FAR is specified and RETN otherwise. Any keyword after PROC other than FAR is ignored.

- The TBYTE keyword as an alias for TWORD (see section 2.2.7).
- The END directive is ignored.
- In 64-bit mode relative addressing is the default (DEFAULT REL, see section 8.2.1).
- A macro is defined to allow using the syntax ST(0) instead of ST0 (and so on) for the x87 stack registers.

In addition, NASM now natively supports, regardless of whether this package is used or not:

- ? and DUP syntax for the DB etc data declaration directives (see section 3.2.1).
- displacement[base+index] syntax for memory operations, instead of [base+index+displacement].
- seg:[addr] instead of [seg:addr] syntax.
- A pure offset can be given to LEA without square brackets:

```
lea rax,[foo]               ; standard syntax
lea rax,foo                 ; also accepted
```

7.6 vtern: Ternary Logic Assist

The vtern macro package allows for a simple and clear way of defining the immediate operand to the VPTERNLOGD and VPTERNLOGQ instructions. See section 4.5 for a description.

Chapter 8: Assembler Directives

NASM, though it attempts to avoid the bureaucracy of assemblers like MASM and TASM, is nevertheless forced to support a *few* directives. These are described in this chapter.

NASM's directives come in two types: *user-level* directives and *primitive* directives. Typically, each directive has a user-level form and a primitive form. In almost all cases, we recommend that users use the user-level forms of the directives, which are implemented as macros which call the primitive forms.

Primitive directives are enclosed in square brackets; user-level directives are not.

In addition to the universal directives described in this chapter, each object file format can optionally supply extra directives in order to control particular features of that file format. These *format-specific* directives are documented along with the formats that implement them, in chapter 9.

8.1 `BITS`: Target Processor Mode

The `BITS` directive specifies whether NASM should generate code designed to run on a processor operating in 16-bit mode, 32-bit mode or 64-bit mode. The syntax is `BITS XX`, where XX is 16, 32 or 64.

In most cases, you should not need to use `BITS` explicitly. The `aout`, `coff`, `elf*`, `macho`, `win32` and `win64` object formats, which are designed for use in 32-bit or 64-bit operating systems, all cause NASM to select 32-bit or 64-bit mode, respectively, by default. The `obj` object format allows you to specify each segment you define as either `USE16` or `USE32`, and NASM will set its operating mode accordingly, so the use of the `BITS` directive is once again unnecessary.

The most likely reason for using the `BITS` directive is to write 32-bit or 64-bit code in a flat binary file; this is because the `bin` output format defaults to 16-bit mode in anticipation of it being used most frequently to write DOS `.COM` programs, DOS `.SYS` device drivers and boot loader software.

The `BITS` directive can also be used to generate code for a different mode than the standard one for the output format.

You do *not* need to specify `BITS 32` merely in order to use 32-bit instructions in a 16-bit DOS program; if you do, the assembler will generate incorrect code because it will be writing code targeted at a 32-bit platform, to be run on a 16-bit one.

When NASM is in `BITS 16` mode, instructions which use 32-bit data are prefixed with an 0x66 byte, and those referring to 32-bit addresses have an 0x67 prefix. In `BITS 32` mode, the reverse is true: 32-bit instructions require no prefixes, whereas instructions using 16-bit data need an 0x66 and those working on 16-bit addresses need an 0x67.

When NASM is in `BITS 64` mode, most instructions operate the same as they do for `BITS 32` mode. However, there are 8 more general and SSE registers, and 16-bit addressing is no longer supported.

The default address size is 64 bits; 32-bit addressing can be selected with the 0x67 prefix. The default operand size is still 32 bits, however, and the 0x66 prefix selects 16-bit operand size. The `REX` prefix is used both to select 64-bit operand size, and to access the new registers. NASM automatically inserts REX prefixes when necessary.

When the `REX` prefix is used, the processor does not know how to address the AH, BH, CH or DH (high 8-bit legacy) registers. Instead, it is possible to access the the low 8-bits of the SP, BP, SI and DI registers as SPL, BPL, SIL and DIL, respectively; but only when the REX prefix is used.

The `BITS` directive has an exactly equivalent primitive form, `[BITS 16]`, `[BITS 32]` and `[BITS 64]`. The user-level form is a macro which has no function other than to call the primitive form.

Note that the space is necessary, e.g. `BITS32` will *not* work!

8.1.1 USE16 & USE32: Aliases for BITS

The 'USE16' and 'USE32' directives can be used in place of 'BITS 16' and 'BITS 32', for compatibility with other assemblers.

8.2 DEFAULT: Change the assembler defaults

The DEFAULT directive changes the assembler defaults. Normally, NASM defaults to a mode where the programmer is expected to explicitly specify most features directly. However, this is occasionally obnoxious, as the explicit form is pretty much the only one one wishes to use.

Currently, DEFAULT can be used to select RIP–relative (REL) or absolute (ABS) addressing in 64-bit mode, and the use of MPX BND prefixes.

8.2.1 REL, ABS: RIP-relative addressing

This sets whether registerless instructions in 64-bit mode are RIP–relative or not. By default, they are absolute unless overridden with the REL specifier (see section 3.3). However, if DEFAULT REL is specified, REL is default, unless overridden with the ABS specifier, *except when used with an FS or GS segment override*.

DEFAULT REL is disabled with DEFAULT ABS.

The special handling of FS and GS overrides are due to the fact that these registers are generally used as thread pointers or other special functions in 64-bit mode, and generating RIP–relative addresses is not desired on most platforms.

To specify that FS– or GS–relative addresses *should* also be generated as RIP–relative, specify the ABS or REL keyword with an FS: or GS: prefix:

```
DEFAULT REL, FS:ABS, GS:REL
```

... will make FS–relative references default to absolute, but all others, including GS–relative references, RIP–relative.

DEFAULT REL is likely to become the default setting in a future version of NASM. Specify DEFAULT ABS explicitly if you need your code to avoid relative offsets.

8.2.2 BND, NOBND: BND prefix

If DEFAULT BND is set, all bnd-prefix available instructions following this directive are prefixed with bnd. To override it, NOBND prefix can be used.

```
DEFAULT BND
    call foo            ; BND will be prefixed
    nobnd call foo      ; BND will NOT be prefixed
```

DEFAULT NOBND can disable DEFAULT BND and then BND prefix will be added only when explicitly specified in code.

DEFAULT BND is expected to be the normal configuration for writing MPX-enabled code.

8.3 SECTION or SEGMENT: Changing and Defining Sections

The SECTION directive (SEGMENT is an exactly equivalent synonym) changes which section of the output file the code you write will be assembled into. In some object file formats, the number and names of sections are fixed; in others, the user may make up as many as they wish. Hence SECTION may sometimes give an error message, or may define a new section, if you try to switch to a section that does not (yet) exist.

The Unix object formats, and the bin object format (but see section 9.1.3), all support the standardized section names .text, .data and .bss for the code, data and uninitialized-data sections. The obj format,

by contrast, does not recognize these section names as being special, and indeed will strip off the leading period of any section name that has one.

8.3.1 The __?SECT?__ Macro

The SECTION directive is unusual in that its user-level form functions differently from its primitive form. The primitive form, [SECTION xyz], simply switches the current target section to the one given. The user-level form, SECTION xyz, however, first defines the single-line macro __?SECT?__ to be the primitive [SECTION] directive which it is about to issue, and then issues it. So the user-level directive

```
        SECTION .text
```

expands to the two lines

```
%define __?SECT?__        [SECTION .text]
        [SECTION .text]
```

Users may find it useful to make use of this in their own macros. For example, the writefile macro defined in section 5.6.3 can be usefully rewritten in the following more sophisticated form:

```
%macro  writefile 2+

        [section .data]

  %%str:        db      %2
  %%endstr:

        __?SECT?__

        mov     dx,%%str
        mov     cx,%%endstr-%%str
        mov     bx,%1
        mov     ah,0x40
        int     0x21

%endmacro
```

This form of the macro, once passed a string to output, first switches temporarily to the data section of the file, using the primitive form of the SECTION directive so as not to modify __?SECT?__. It then declares its string in the data section, and then invokes __?SECT?__ to switch back to *whichever* section the user was previously working in. It thus avoids the need, in the previous version of the macro, to include a JMP instruction to jump over the data, and also does not fail if, in a complicated OBJ format module, the user could potentially be assembling the code in any of several separate code sections.

8.4 ABSOLUTE: Defining Absolute Labels

The ABSOLUTE directive can be thought of as an alternative form of SECTION: it causes the subsequent code to be directed at no physical section, but at the hypothetical section starting at the given absolute address. The only instructions you can use in this mode are the RESB family.

ABSOLUTE is used as follows:

```
absolute 0x1A

    kbuf_chr    resw    1
    kbuf_free   resw    1
    kbuf        resw    16
```

This example describes a section of the PC BIOS data area, at segment address 0x40: the above code defines kbuf_chr to be 0x1A, kbuf_free to be 0x1C, and kbuf to be 0x1E.

The user-level form of ABSOLUTE, like that of SECTION, redefines the __?SECT?__ macro when it is invoked.

STRUC and ENDSTRUC are defined as macros which use ABSOLUTE (and also __?SECT?__).

ABSOLUTE doesn't have to take an absolute constant as an argument: it can take an expression (actually, a critical expression: see section 3.8) and it can be a value in a segment. For example, a TSR can re-use its setup code as run-time BSS like this:

```
        org     100h                ; it's a .COM program

        jmp     setup               ; setup code comes last

        ; the resident part of the TSR goes here
setup:
        ; now write the code that installs the TSR here

absolute setup

runtimevar1     resw    1
runtimevar2     resd    20

tsr_end:
```

This defines some variables 'on top of' the setup code, so that after the setup has finished running, the space it took up can be re-used as data storage for the running TSR. The symbol 'tsr_end' can be used to calculate the total size of the part of the TSR that needs to be made resident.

8.5 EXTERN: Importing Symbols from Other Modules

EXTERN is similar to the MASM directive EXTRN and the C keyword `extern`: it is used to declare a symbol which is not defined anywhere in the module being assembled, but is assumed to be defined in some other module and needs to be referred to by this one. Not every object-file format can support external variables: the `bin` format cannot.

The EXTERN directive takes as many arguments as you like. Each argument is the name of a symbol:

```
extern  _printf
extern  _sscanf,_fscanf
```

Some object-file formats provide extra features to the EXTERN directive. In all cases, the extra features are used by suffixing a colon to the symbol name followed by object-format specific text. For example, the `obj` format allows you to declare that the default segment base of an external should be the group `dgroup` by means of the directive

```
extern  _variable:wrt dgroup
```

The primitive form of EXTERN differs from the user-level form only in that it can take only one argument at a time: the support for multiple arguments is implemented at the preprocessor level.

You can declare the same variable as EXTERN more than once: NASM will quietly ignore the second and later redeclarations.

If a variable is declared both GLOBAL and EXTERN, or if it is declared as EXTERN and then defined, it will be treated as GLOBAL. If a variable is declared both as COMMON and EXTERN, it will be treated as COMMON.

Since NASM version 2.15, the EXTERN keyword (since version 2.15) does not request import of symbols that are never actually referenced in the code, as that prevents using common header files, as it might cause the linker to pull in a bunch of unnecessary modules. To unconditionally request import of external symbols, use the REQUIRED directive instead (see section 8.6).

If the old behavior is required, rather than changing the source code, one can override the user macro definition:

```
%ifmacro required      ; Test for NASM new enough to support REQUIRED
  %unimacro extern 1-*
  %imacro extern 1+.nolist
     required %1
  %endmacro
%endif
```

8.6 REQUIRED: Unconditionally Importing Symbols from Other Modules

The REQUIRED keyword is similar to EXTERN one. The difference is that the EXTERN keyword (since version 2.15) does not request import of symbols that are never actually referenced in the code, as that prevents using common header files, as it might cause the linker to pull in a bunch of unnecessary modules.

8.7 GLOBAL: Exporting Symbols to Other Modules

GLOBAL is the other end of EXTERN: if one module declares a symbol as EXTERN and refers to it, then in order to prevent linker errors, some other module must actually *define* the symbol and declare it as GLOBAL. Some assemblers use the name PUBLIC for this purpose.

GLOBAL uses the same syntax as EXTERN, except that it must refer to symbols which *are* defined in the same module as the GLOBAL directive. For example:

```
global _main
_main:
        ; some code
```

GLOBAL, like EXTERN, allows object formats to define private extensions by means of a colon. The ELF object format, for example, lets you specify whether global data items are functions or data:

```
global  hashlookup:function, hashtable:data
```

Like EXTERN, the primitive form of GLOBAL differs from the user-level form only in that it can take only one argument at a time.

8.8 COMMON: Defining Common Data Areas

The COMMON directive is used to declare *common variables*. A common variable is much like a global variable declared in the uninitialized data section, so that

```
common  intvar  4
```

is similar in function to

```
global  intvar
section .bss

intvar  resd    1
```

The difference is that if more than one module defines the same common variable, then at link time those variables will be *merged*, and references to `intvar` in all modules will point at the same piece of memory.

Like GLOBAL and EXTERN, COMMON supports object-format specific extensions. For example, the `obj` format allows common variables to be NEAR or FAR, and the ELF format allows you to specify the alignment requirements of a common variable:

```
common  commvar  4:near  ; works in OBJ
common  intarray 100:4   ; works in ELF: 4 byte aligned
```

Once again, like EXTERN and GLOBAL, the primitive form of COMMON differs from the user-level form only in that it can take only one argument at a time.

8.9 STATIC: Local Symbols within Modules

Opposite to EXTERN and GLOBAL, STATIC is local symbol, but should be named according to the global mangling rules (named by analogy with the C keyword `static` as applied to functions or global variables).

```
static foo
foo:
         ; codes
```

Unlike GLOBAL, STATIC does not allow object formats to accept private extensions mentioned in section 8.7.

8.10 [[GL]PREFIX], [[GL]SUFFIX]: Mangling Symbols

[PREFIX], [GPREFIX], [LPREFIX], [SUFFIX], [GSUFFIX], and [LSUFFIX] directives can prepend or append a string to a certain type of symbols, normally to fit specific ABI conventions

- [PREFIX], [GPREFIX]: Prepend the argument to all EXTERN, COMMON, STATIC, and GLOBAL symbols.
- [LPREFIX: Prepend the argument to all other symbols such as local labels and backend defined symbols.
- [SUFFIX], [GSUFFIX], [POSTFIX], [GPOSTFIX]: Append the argument to all EXTERN, COMMON, STATIC, and GLOBAL symbols.
- [LSUFFIX], [LPOSTFIX]: Append the argument to all other symbols such as local labels and backend defined symbols.

These directives are also implemented as pragmas, and using %pragma syntax can be restricted to specific backends (see section 5.13):

```
%pragma macho lprefix L_
```

Command line options are also available. See also section 2.1.28.

One example which supports many ABIs:

```
; The most common conventions
%pragma output gprefix _
%pragma output lprefix L_
; ELF uses a different convention
%pragma elf    gprefix                      ; empty
%pragma elf    lprefix .L
```

Some toolchains is aware of a particular prefix for its own optimization options, such as dead code elimination. For instance, the Mach-O binary format has a linker convention that uses a simplistic naming scheme to chunk up sections into smaller subsections, each of which may be eliminated. When the subsections_via_symbols directive (section 9.9.4) is declared, each symbol is the start of a separate block. The subsection is, then, defined to include sections before the one that starts with a 'L'. [LPREFIX] is useful here to mark all local symbols with the 'L' prefix to be excluded to the meta section. It converts local symbols compatible with the particular toolchain. Note that local symbols declared with STATIC (section 8.9) are excluded from the symbol mangling and also not marked as global.

Earlier versions of NASM called the pragmas suffix and the options --postfix, and did not implement directives at all despite being so documented. Since NASM 3.01, the directive forms are implemented, and directives, pragmas and options all support all spellings.

8.11 CPU: Defining CPU Dependencies

The CPU directive restricts assembly to those instructions which are available on the specified CPU. At the moment, it is primarily used to enforce unavailable *encodings* of instructions, such as 5-byte jumps on the 8080.

(If someone would volunteer to work through the database and add proper annotations to each instruction, this could be greatly improved. Please contact the developers to volunteer, see appendix E.)

Current CPU keywords are:

- CPU 8086 – Assemble only 8086 instruction set
- CPU 186 – Assemble instructions up to the 80186 instruction set
- CPU 286 – Assemble instructions up to the 286 instruction set

- `CPU 386` – Assemble instructions up to the 386 instruction set
- `CPU 486` – 486 instruction set
- `CPU 586` – Pentium instruction set
- `CPU PENTIUM` – Same as 586
- `CPU 686` – P6 instruction set
- `CPU PPRO` – Same as 686
- `CPU P2` – Same as 686
- `CPU P3` – Pentium III (Katmai) instruction sets
- `CPU KATMAI` – Same as P3
- `CPU P4` – Pentium 4 (Willamette) instruction set
- `CPU WILLAMETTE` – Same as P4
- `CPU PRESCOTT` – Prescott instruction set
- `CPU X64` – x86-64 (x64/AMD64/Intel 64) instruction set
- `CPU IA64` – IA64 CPU (in x86 mode) instruction set
- `CPU DEFAULT` – All available instructions
- `CPU ALL` – All available instructions *and flags*

All options are case insensitive.

In addition, optional flags can be specified to modify the instruction selections. These can be combined with a CPU declaration or specified alone. They can be prefixed by `+` (add flag, default), `-` (remove flag) or `*` (set flag to default); these prefixes are "sticky", so:

```
cpu -foo,bar
```

means remove both the `foo` and `bar` options.

If prefixed with `no`, it inverts the meaning of the flag, but this is not sticky, so:

```
cpu nofoo,bar
```

means remove the `foo` flag but add the `bar` flag.

Currently available flags are:

- `EVEX` – Enable generation of EVEX (AVX-512) encoded instructions without an explicit `{evex}` prefix. Default on.
- `VEX` – Enable generation of VEX (AVX) or XOP encoded instructions without an explict `{vex}` prefix. Default on.
- `LATEVEX` – Enable generation of VEX (AVX) encoding of instructions where the VEX instructions forms were introduced *after* the corresponding EVEX (AVX-512) instruction forms without requiring an explicit `{vex}` prefix. This is implicit if the `EVEX` flag is disabled and the `VEX` flag is enabled. Default off.

8.12 `[DOLLARHEX]`: Enable or disable $ hexadecimal syntax

Using a `$` prefix for hexadecimal numbers is deprecated, as it conflicts with the use of `$` for escaping symbols (see section 3.4.1 and section 3.1). The `[DOLLARHEX]` directive can be used to disable it completely:

```
[dollarhex off]
```

When disabled, symbols beginning with digits can be escaped as well, e.g. `$3` would define a symbol `3`.

No "user form" (without the brackets) currently exists.

8.13 `FLOAT`: Handling of floating-point constants

By default, floating-point constants are rounded to nearest, and IEEE denormals are supported. The following options can be set to alter this behaviour:

- `FLOAT DAZ` – Flush denormals to zero
- `FLOAT NODAZ` – Do not flush denormals to zero (default)
- `FLOAT NEAR` – Round to nearest (default)
- `FLOAT UP` – Round up (toward +Infinity)
- `FLOAT DOWN` – Round down (toward –Infinity)
- `FLOAT ZERO` – Round toward zero
- `FLOAT DEFAULT` – Restore default settings

The standard macros `__?FLOAT_DAZ?__`, `__?FLOAT_ROUND?__`, and `__?FLOAT?__` contain the current state, as long as the programmer has avoided the use of the bracketed primitive form, (`[FLOAT]`).

`__?FLOAT?__` contains the full set of floating-point settings; this value can be saved away and invoked later to restore the setting.

8.14 `[WARNING]`: Enable or disable warnings

The `[WARNING]` directive can be used to enable or disable classes of warnings in the same way as the `-w` option, see appendix A for more details about warning classes.

- `[warning +`*warning-class*`]` enables warnings for *warning-class*.
- `[warning -`*warning-class*`]` disables warnings for *warning-class*.
- `[warning *`*warning-class*`]` restores *warning-class* to the original value, either the default value or as specified on the command line.
- `[warning push]` saves the current warning state on a stack.
- `[warning pop]` restores the current warning state from the stack.

The `[WARNING]` directive also accepts the `all`, `error` and `error=`*warning-class* specifiers, see section 2.1.26.

No "user form" (without the brackets) currently exists.

8.15 `[LIST]`: Locally disable list file output

The `[LIST]` directive disables or re-enables list file output.

- `[list -]` disables list file output.
- `[list +]` re-enables list file output.

The `[LIST]` directive can be overridden with the `-LF` command-line option, see section 2.1.4.

Chapter 9: Output Formats

NASM is a portable assembler, designed to be able to compile on any ANSI C-supporting platform and produce output to run on a variety of Intel x86 operating systems. For this reason, it has a large number of available output formats, selected using the `-f` option on the NASM command line. Each of these formats, along with its extensions to the base NASM syntax, is detailed in this chapter.

As stated in section 2.1.1, NASM chooses a default name for your output file based on the input file name and the chosen output format. This will be generated by removing the filename extension (`.asm`, `.s`, or whatever you like to use) from the input file name, and substituting an extension defined by the output format. The extensions are given with each format below.

9.1 `bin`: Flat-Form Binary Output

The `bin` format does not produce object files: it generates nothing in the output file except the code you wrote. Such 'pure binary' files are used by MS-DOS: `.COM` executables and `.SYS` device drivers are pure binary files. Pure binary output is also useful for operating system and boot loader development.

The `bin` format supports multiple section names. For details of how NASM handles sections in the `bin` format, see section 9.1.3.

Using the `bin` format puts NASM by default into 16-bit mode (see section 8.1). In order to use `bin` to write 32-bit or 64-bit code, such as an OS kernel, you need to explicitly issue the `BITS 32` or `BITS 64` directive.

`bin` has no default output file name extension: instead, it leaves your file name as it is once the original extension has been removed. Thus, the default is for NASM to assemble `binprog.asm` into a binary file called `binprog`.

It is extremely important to understand that the binary output format is simply nothing other than *a linker built into the NASM executable.* As such, NASM behaves just as it does when producing any other output format: notably the list file reflects the code output *before* relocation, and the addresses in the list file are addresses relative to the start of the current output section.

9.1.1 `ORG`: Binary File Program Origin

The `bin` format provides an additional directive to the list given in chapter 8: `ORG`. The function of the `ORG` directive is to specify the origin address which NASM will assume the program begins at when it is loaded into memory.

For example, the following code will generate the longword `0x00000104`:

```
        org     0x100
        dd      label
label:
```

Unlike the `ORG` directive provided by MASM-compatible assemblers, which allows you to jump around in the object file and overwrite code you have already generated, NASM's `ORG` does exactly what the directive says: *origin*. Its sole function is to specify one offset which is added to all internal address references within the section; it does not permit any of the trickery that MASM's version does. See section 14.1.3 for further comments.

9.1.2 `bin` Extensions to the `SECTION` Directive

The `bin` output format extends the `SECTION` (or `SEGMENT`) directive to allow you to specify the alignment requirements of segments. This is done by appending the `ALIGN` qualifier to the end of the section-definition line. For example,

```
section .data   align=16
```

switches to the section `.data` and also specifies that it must be aligned on a 16-byte boundary.

The parameter to `ALIGN` specifies how many low bits of the section start address must be forced to zero. The alignment value given may be any power of two.

9.1.3 Multisection Support for the `bin` Format

The `bin` format allows the use of multiple sections, of arbitrary names, besides the "known" `.text`, `.data`, and `.bss` names.

- Sections may be designated `progbits` or `nobits`. Default is `progbits` (except `.bss`, which defaults to `nobits`, of course).
- Sections can be aligned at a specified boundary following the previous section with `align=`, or at an arbitrary byte-granular position with `start=`.
- Sections can be given a virtual start address, which will be used for the calculation of all memory references within that section with `vstart=`.
- Sections can be ordered using `follows=<section>` or `vfollows=<section>` as an alternative to specifying an explicit start address.
- Arguments to `org`, `start`, `vstart`, and `align=` are critical expressions. See section 3.8. For example, in the case of `align=(1 << ALIGN_SHIFT)`, `ALIGN_SHIFT` must be defined before it is used here.
- Any code which comes before an explicit `SECTION` directive is directed by default into the `.text` section.
- If an `ORG` statement is not given, `ORG 0` is used by default.
- The `.bss` section will be placed after the last `progbits` section, unless `start=`, `vstart=`, `follows=`, or `vfollows=` has been specified.
- All sections are aligned on dword boundaries, unless a different alignment has been specified.
- Sections may not overlap.
- NASM creates the `section.<secname>.start` for each section, which may be used in your code.

9.1.4 Map Files

Map files can be generated in `-f bin` format by means of the `[map]` option. Map types of `all` (default), `brief`, `sections`, `segments`, or `symbols` may be specified. Output may be directed to `stdout` (default), `stderr`, or a specified file. E.g. `[map symbols myfile.map]`. No "user form" exists, the square brackets must be used.

9.2 `ith`: Intel Hex Output

The `ith` file format produces Intel hex-format files. Just as the `bin` format, this is a flat memory image format with no support for further relocation or linking. It is usually used with ROM programmers and similar utilities.

From a programmer point of view, this behaves identically to the `.bin` format; the only difference is the encoding of the output. All extensions supported by the `bin` file format is also supported by the `ith` file format.

`ith` provides a default output file-name extension of `.ith`.

9.3 `srec`: Motorola S-Records Output

The `srec` file format produces Motorola S-records files. Just as the `bin` format, this is a flat memory image format with no support for relocation or linking. It is usually used with ROM programmers and similar utilities.

From a programmer point of view, this behaves identically to the `.bin` format; the only difference is the encoding of the output. All extensions supported by the `bin` file format is also supported by the `srec` file format.

`srec` provides a default output file-name extension of `.srec`.

9.4 `obj`: Microsoft OMF Object Files

The `obj` file format (NASM calls it `obj` rather than `omf` for historical reasons) is the one produced by MASM and TASM, which is typically fed to 16-bit DOS linkers to produce `.EXE` files. It is also the format used by OS/2.

`obj` provides a default output file-name extension of `.obj`.

`obj` is not exclusively a 16-bit format, though; NASM has full support for the 32-bit extensions to the format. In particular, 32-bit `obj` format files are used by Borland's Win32 compilers, instead of using Microsoft's newer `win32` object file format.

The `obj` format does not define any special segment names: you can call your segments anything you like. Typical names for segments in `obj` format files are `CODE`, `DATA` and `BSS`.

If your source file contains code before specifying an explicit `SEGMENT` directive, then NASM will invent its own segment called `__NASMDEFSEG` for you.

When you define a segment in an `obj` file, NASM defines the segment name as a symbol as well, so that you can access the segment address of the segment. So, for example:

```
segment data

dvar:   dw      1234

segment code

function:
        mov     ax,data         ; get segment address of data
        mov     ds,ax           ; and move it into DS
        inc     word [dvar]     ; now this reference will work
        ret
```

The `obj` format also enables the use of the `SEG` and `WRT` operators, so that you can write code which does things like

```
extern  foo

      mov   ax,seg foo            ; get preferred segment of foo
      mov   ds,ax
      mov   ax,data               ; a different segment
      mov   es,ax
      mov   ax,[ds:foo]           ; this accesses 'foo'
      mov   [es:foo wrt data],bx  ; so does this
```

9.4.1 `obj` Extensions to the `SEGMENT` Directive

The `obj` output format extends the `SEGMENT` (or `SECTION`) directive to allow you to specify various properties of the segment you are defining. This is done by appending extra qualifiers to the end of the segment-definition line. For example,

```
segment code private align=16
```

defines the segment `code`, but also declares it to be a private segment, and requires that the portion of it described in this code module must be aligned on a 16-byte boundary.

The available qualifiers are:

- `PRIVATE`, `PUBLIC`, `COMMON` and `STACK` specify the combination characteristics of the segment. `PRIVATE` segments do not get combined with any others by the linker; `PUBLIC` and `STACK` segments get concatenated together at link time; and `COMMON` segments all get overlaid on top of each other rather than stuck end-to-end.
- `ALIGN` is used, as shown above, to specify how many low bits of the segment start address must be forced to zero. The alignment value given may be any power of two from 1 to 4096; in reality, the only values supported are 1, 2, 4, 16, 256 and 4096, so if 8 is specified it will be rounded up to 16, and 32, 64 and 128 will all be rounded up to 256, and so on. Note that alignment to 4096-byte boundaries is a PharLap extension to the format and may not be supported by all linkers.
- `CLASS` can be used to specify the segment class; this feature indicates to the linker that segments of the same class should be placed near each other in the output file. The class name can be any word, e.g. `CLASS=CODE`.
- `OVERLAY`, like `CLASS`, is specified with an arbitrary word as an argument, and provides overlay information to an overlay-capable linker.
- Segments can be declared as `USE16` or `USE32`, which has the effect of recording the choice in the object file and also ensuring that NASM's default assembly mode when assembling in that segment is 16-bit or 32-bit respectively.
- When writing OS/2 object files, you should declare 32-bit segments as `FLAT`, which causes the default segment base for anything in the segment to be the special group `FLAT`, and also defines the group if it is not already defined.
- The `obj` file format also allows segments to be declared as having a pre-defined absolute segment address, although no linkers are currently known to make sensible use of this feature; nevertheless, NASM allows you to declare a segment such as `SEGMENT SCREEN ABSOLUTE=0xB800` if you need to. The `ABSOLUTE` and `ALIGN` keywords are mutually exclusive.

NASM's default segment attributes are `PUBLIC`, `ALIGN=1`, no class, no overlay, and `USE16`.

9.4.2 `GROUP`: Defining Groups of Segments

The `obj` format also allows segments to be grouped, so that a single segment register can be used to refer to all the segments in a group. NASM therefore supplies the `GROUP` directive, whereby you can code

```
segment data

        ; some data

segment bss

        ; some uninitialized data

group dgroup data bss
```

which will define a group called `dgroup` to contain the segments `data` and `bss`. Like `SEGMENT`, `GROUP` causes the group name to be defined as a symbol, so that you can refer to a variable `var` in the `data` segment as `var wrt data` or as `var wrt dgroup`, depending on which segment value is currently in your segment register.

If you just refer to `var`, however, and `var` is declared in a segment which is part of a group, then NASM will default to giving you the offset of `var` from the beginning of the *group*, not the *segment*. Therefore `SEG var`, also, will return the group base rather than the segment base.

NASM will allow a segment to be part of more than one group, but will generate a warning if you do this. Variables declared in a segment which is part of more than one group will default to being relative to the first group that was defined to contain the segment.

A group does not have to contain any segments; you can still make WRT references to a group which does not contain the variable you are referring to. OS/2, for example, defines the special group FLAT with no segments in it.

GROUP is cumulative. The above example can be done like this:

```
group dgroup data
group dgroup bss
```

9.4.3 UPPERCASE: Disabling Case Sensitivity in Output

Although NASM itself is case sensitive, some OMF linkers are not; therefore it can be useful for NASM to output single-case object files. The UPPERCASE format-specific directive causes all segment, group and symbol names that are written to the object file to be forced to upper case just before being written. Within a source file, NASM is still case-sensitive; but the object file can be written entirely in upper case if desired.

UPPERCASE is used alone on a line; it requires no parameters.

9.4.4 IMPORT: Importing DLL Symbols

The IMPORT format-specific directive defines a symbol to be imported from a DLL, for use if you are writing a DLL's import library in NASM. You still need to declare the symbol as EXTERN as well as using the IMPORT directive.

The IMPORT directive takes two required parameters, separated by white space, which are (respectively) the name of the symbol you wish to import and the name of the library you wish to import it from. For example:

```
import  WSAStartup wsock32.dll
```

A third optional parameter gives the name by which the symbol is known in the library you are importing it from, in case this is not the same as the name you wish the symbol to be known by to your code once you have imported it. For example:

```
import  asyncsel wsock32.dll WSAAsyncSelect
```

9.4.5 EXPORT: Exporting DLL Symbols

The EXPORT format-specific directive defines a global symbol to be exported as a DLL symbol, for use if you are writing a DLL in NASM. You still need to declare the symbol as GLOBAL as well as using the EXPORT directive.

EXPORT takes one required parameter, which is the name of the symbol you wish to export, as it was defined in your source file. An optional second parameter (separated by white space from the first) gives the *external* name of the symbol: the name by which you wish the symbol to be known to programs using the DLL. If this name is the same as the internal name, you may leave the second parameter off.

Further parameters can be given to define attributes of the exported symbol. These parameters, like the second, are separated by white space. If further parameters are given, the external name must also be specified, even if it is the same as the internal name. The available attributes are:

- `resident` indicates that the exported name is to be kept resident by the system loader. This is an optimization for frequently used symbols imported by name.
- `nodata` indicates that the exported symbol is a function which does not make use of any initialized data.
- `parm=NNN`, where NNN is an integer, sets the number of parameter words for the case in which the symbol is a call gate between 32-bit and 16-bit segments.

- An attribute which is just a number indicates that the symbol should be exported with an identifying number (ordinal), and gives the desired number.

For example:

```
export  myfunc
export  myfunc TheRealMoreFormalLookingFunctionName
export  myfunc myfunc 1234  ; export by ordinal
export  myfunc myfunc resident parm=23 nodata
```

9.4.6 `..start`: Defining the Program Entry Point

OMF linkers require exactly one of the object files being linked to define the program entry point, where execution will begin when the program is run. If the object file that defines the entry point is assembled using NASM, you specify the entry point by declaring the special symbol `..start` at the point where you wish execution to begin.

9.4.7 `obj` Extensions to the `EXTERN` Directive

If you declare an external symbol with the directive

```
extern  foo
```

then references such as `mov ax,foo` will give you the offset of `foo` from its preferred segment base (as specified in whichever module `foo` is actually defined in). So to access the contents of `foo` you will usually need to do something like

```
mov     ax,seg foo      ; get preferred segment base
mov     es,ax           ; move it into ES
mov     ax,[es:foo]     ; and use offset 'foo' from it
```

This is a little unwieldy, particularly if you know that an external is going to be accessible from a given segment or group, say `dgroup`. So if DS already contained `dgroup`, you could simply code

```
mov     ax,[foo wrt dgroup]
```

However, having to type this every time you want to access `foo` can be a pain; so NASM allows you to declare `foo` in the alternative form

```
extern  foo:wrt dgroup
```

This form causes NASM to pretend that the preferred segment base of `foo` is in fact `dgroup`; so the expression `seg foo` will now return `dgroup`, and the expression `foo` is equivalent to `foo wrt dgroup`.

This default-`WRT` mechanism can be used to make externals appear to be relative to any group or segment in your program. It can also be applied to common variables: see section 9.4.8.

9.4.8 `obj` Extensions to the `COMMON` Directive

The `obj` format allows common variables to be either near or far; NASM allows you to specify which your variables should be by the use of the syntax

```
common  nearvar 2:near   ; 'nearvar' is a near common
common  farvar  10:far   ; and 'farvar' is far
```

Far common variables may be greater in size than 64Kb, and so the OMF specification says that they are declared as a number of *elements* of a given size. So a 10-byte far common variable could be declared as ten one-byte elements, five two-byte elements, two five-byte elements or one ten-byte element.

Some OMF linkers require the element size, as well as the variable size, to match when resolving common variables declared in more than one module. Therefore NASM must allow you to specify the element size on your far common variables. This is done by the following syntax:

```
common  c_5by2  10:far 5        ; two five-byte elements
common  c_2by5  10:far 2        ; five two-byte elements
```

If no element size is specified, the default is 1. Also, the FAR keyword is not required when an element size is specified, since only far commons may have element sizes at all. So the above declarations could equivalently be

```
common  c_5by2  10:5            ; two five-byte elements
common  c_2by5  10:2            ; five two-byte elements
```

In addition to these extensions, the COMMON directive in obj also supports default-WRT specification like EXTERN does (explained in section 9.4.7). So you can also declare things like

```
common  foo     10:wrt dgroup
common  bar     16:far 2:wrt data
common  baz     24:wrt data:6
```

9.4.9 Embedded File Dependency Information

Since NASM 2.13.02, obj files contain embedded dependency file information. To suppress the generation of dependencies, use

```
%pragma obj nodepend
```

9.5 obj2: OS/2 32-bit OMF Object Files

The obj2 output format is the same as obj except:

- Default attributes for a segment are ALIGN=16 and USE32.
- All 32-bit segment is added to FLAT group implicitly.
- Support Unix sections such as .text, .rodata, .data and .bss for compatibility with other Unix platforms. And they are aliased to TEXT32, CONST32, DATA32, BSS32, respectively.
- Set default classes implicitly for known segments such as TEXT32, CONST32, DATA32, BSS32 and so on.

The defaults assumed by NASM if you do not specify the qualifiers are:

```
SECTION .text    ALIGN=16 USE32 CLASS=CODE  FLAT
SECTION .rodata  ALIGN=16 USE32 CLASS=CONST FLAT
SECTION .data    ALIGN=16 USE32 CLASS=DATA  FLAT
SECTION .bss     ALIGN=16 USE32 CLASS=BSS   FLAT
SECTION CODE     ALIGN=16 USE32 CLASS=CODE  FLAT
SECTION TEXT     ALIGN=16 USE32 CLASS=CODE  FLAT
SECTION CONST    ALIGN=16 USE32 CLASS=CONST FLAT
SECTION DATA     ALIGN=16 USE32 CLASS=DATA  FLAT
SECTION BSS      ALIGN=16 USE32 CLASS=BSS   FLAT
SECTION STACK    ALIGN=16 USE32 CLASS=STACK FLAT
SECTION CODE32   ALIGN=16 USE32 CLASS=CODE  FLAT
SECTION TEXT32   ALIGN=16 USE32 CLASS=CODE  FLAT
SECTION CONST32  ALIGN=16 USE32 CLASS=CONST FLAT
SECTION DATA32   ALIGN=16 USE32 CLASS=DATA  FLAT
SECTION BSS32    ALIGN=16 USE32 CLASS=BSS   FLAT
SECTION STACK32  ALIGN=16 USE32 CLASS=STACK FLAT
```

9.6 win32: Microsoft Win32 Object Files

The win32 output format generates Microsoft Win32 object files, suitable for passing to Microsoft linkers such as Visual C++. Note that Borland Win32 compilers do not use this format, but use obj instead (see section 9.4).

win32 provides a default output file-name extension of .obj.

Note that although Microsoft say that Win32 object files follow the COFF (Common Object File Format) standard, the object files produced by Microsoft Win32 compilers are not compatible with COFF linkers such as DJGPP's, and vice versa. This is due to a difference of opinion over the precise semantics of PC-relative relocations. To produce COFF files suitable for DJGPP, use NASM's coff output format;

conversely, the `coff` format does not produce object files that Win32 linkers can generate correct output from.

9.6.1 `win32` Extensions to the `SECTION` Directive

Like the `obj` format, `win32` allows you to specify additional information on the `SECTION` directive line, to control the type and properties of sections you declare. Section types and properties are generated automatically by NASM for the standard section names `.text`, `.data` and `.bss`, but may still be overridden by these qualifiers.

The available qualifiers are:

- `code`, or equivalently `text`, defines the section to be a code section. This marks the section as readable and executable, but not writable, and also indicates to the linker that the type of the section is code.
- `data` and `bss` define the section to be a data section, analogously to `code`. Data sections are marked as readable and writable, but not executable. `data` declares an initialized data section, whereas `bss` declares an uninitialized data section.
- `rdata` declares an initialized data section that is readable but not writable. Microsoft compilers use this section to place constants in it.
- `info` defines the section to be an informational section, which is not included in the executable file by the linker, but may (for example) pass information *to* the linker. For example, declaring an `info`–type section called `.drectve` causes the linker to interpret the contents of the section as command-line options.
- `align=`, used with a trailing number as in `obj`, gives the alignment requirements of the section. The maximum you may specify is 64: the Win32 object file format contains no means to request a greater section alignment than this. If alignment is not explicitly specified, the defaults are 16-byte alignment for code sections, 8-byte alignment for rdata sections and 4-byte alignment for data (and BSS) sections. Informational sections get a default alignment of 1 byte (no alignment), though the value does not matter.
- `comdat=`, followed by a number ("selection"), colon (acting as a separator) and a name, marks the section as a "COMDAT section". It allows Microsoft linkers to perform function-level linking, to deal with multiply defined symbols, to eliminate dead code/data.

The "selection" number should be one of the `IMAGE_COMDAT_SELECT_*` constants from `COFF format specification`; this value controls if the linker allows multiply defined symbols and how it handles them.

The name is the "COMDAT symbol" – basically a new name for the section. So even though you have one section given by the main name (e.g. `.text`), it can actually consist of hundreds of COMDAT sections having their own name (and alignment).

When the "selection" is IMAGE_COMDAT_SELECT_ASSOCIATIVE (5), the following name is the "COMDAT symbol" of the associated COMDAT section; this way you can link a piece of code or data only when another piece of code or data gets actually linked.

So, when linking a NASM-compiled file with some C code, the source may be structured as follows. Note that the default `.text` section in handled in a special way and it doesn't work well with `comdat`; you may want to append a `$` character and an arbitrary suffix to the section name. It will get linked into the `.text` section anyway – see the info on `Grouped Sections`.

```
section .text$1 align=16 comdat=1:FirstFnc
   ...            ; Code linked only if referenced from C

section .text$1 align=16 comdat=1:SecondFnc
   ...            ; Code linked only if referenced from C
```

```
section .rdata align=32 comdat=5:FirstFnc
   ...            ; Data linked onlyif the related code
                  ; (FirstFnc) is linked
```

The defaults assumed by NASM if you do not specify the above qualifiers are:

```
section .text    code  align=16
section .data    data  align=4
section .rdata   rdata align=8
section .bss     bss   align=4
```

The `win64` format also adds:

```
section .pdata   rdata align=4
section .xdata   rdata align=8
```

Any other section name is treated by default like `.text`.

9.6.2 `win32`: Safe Structured Exception Handling

Among other improvements in Windows XP SP2 and Windows Server 2003, Microsoft has introduced the concept of "safe structured exception handling." The general idea is to collect handlers' entry points in a designated read-only table and have SEH entry points verified against this table before exception control is passed to the corresponding handler. In order for an executable module to be equipped with this read-only table, all object modules on linker command line have to comply with certain criteria. If even a single module among them does not, then the table in question is omitted and above mentioned run-time checks will not be performed for the application in question. Table omission is silent by default and therefore can be easily missed. One can instruct the linker to refuse to produce binary without such table by passing the `/safeseh` command line option.

Without regard to this run-time check, it's natural to expect NASM to be capable of generating modules suitable for `/safeseh` linking. From the developer's viewpoint the problem is two-fold:

- how to adapt modules not deploying exception handlers of their own;
- how to adapt/develop modules utilizing custom exception handling;

The former can be easily achieved with any NASM version by adding the following line to the source code:

```
$@feat.00 equ 1
```

As of version 2.03 NASM adds this absolute symbol automatically, if it is not already present (in which case the developer can choose to assign another value, if desired, for whatever reason).

Registering a custom exception handler on the other hand requires certain "magic." As of version 2.03, an additional `safeseh` directive is implemented, which instructs the assembler to produce appropriately formatted input data for the above-mentioned "safe exception handler table." Its typical use would be:

```
section .text
extern  _MessageBoxA@16
%if     __?NASM_VERSION_ID?__ >= 0x02030000
safeseh handler         ; register handler as "safe handler"
%endif
handler:
        push    DWORD 1 ; MB_OKCANCEL
        push    DWORD caption
        push    DWORD text
        push    DWORD 0
        call    _MessageBoxA@16
        sub     eax,1   ; incidentally suits as return value
                        ; for exception handler
        ret
global  _main
```

```
_main:
        push    DWORD handler
        push    DWORD [fs:0]
        mov     DWORD [fs:0],esp ; engage exception handler
        xor     eax,eax
        mov     eax,DWORD[eax]   ; cause exception
        pop     DWORD [fs:0]     ; disengage exception handler
        add     esp,4
        ret
text:   db      'OK to rethrow, CANCEL to generate core dump',0
caption:db      'SEGV',0

section .drectve info
        db      '/defaultlib:user32.lib /defaultlib:msvcrt.lib '
```

As you might imagine, it's perfectly possible to produce an .exe binary with the "safe exception handler table" and yet invoke an unregistered exception handler. A handler is invoked by manipulating `[fs:0]` at run-time, something the linker has no power over. It is therefore important to note that such failure to register a handler's entry point with the `safeseh` directive will have undesired side effects at run-time. If an exception is raised and an unregistered handler is to be executed, the application is abruptly terminated without any notification whatsoever. One can argue that the system should at least log some kind of "non-safe exception handler in x.exe at address n" message in the event log, but unfortunately the user is left without any clue as to what might have caused the crash.

Finally, all mentions of linker in this paragraph refer to Microsoft linker version 7.x and later. Presence of `@feat.00` symbol and input data for "safe exception handler table" causes no backward incompatibilities and "safeseh" modules generated by NASM 2.03 and later can still be linked by earlier versions or non-Microsoft linkers.

9.6.3 `win32`: Special Symbol and WRT

The Microsoft linker may require symbol table indexes instead of absolute or image relative addresses in some more modern structures, like those used for exception handler control flow guard metadata (ehcont). This can be accomplished by getting the symbol address with respect to the special `..symtab` symbol. For instance:

```
__guard_ehcont_main: dd main.cont wrt ..symtab
```

9.6.4 `win32` Extensions to the `GLOBAL`, `EXTERN` and `STATIC` Directives

You can specify whether a symbol is a function by suffixing the name with a colon and the word `function`. For example:

```
global   hashlookup:function
static   localfunc:function
extern   extfunc:function
```

The linker may use this extra symbol information when generating tables of valid indirect branch targets and such.

9.6.5 Debugging formats for Windows

The `win32` and `win64` formats support the Microsoft CodeView debugging format. Currently CodeView version 8 format is supported (`cv8`), but newer versions of the CodeView debugger should be able to handle this format as well.

9.7 `win64`: Microsoft Win64 Object Files

The `win64` output format generates Microsoft Win64 object files, which is nearly 100% identical to the `win32` object format (section 9.6) with the exception that it is meant to target 64-bit code and the x86-64 platform altogether. This object file is used exactly the same as the `win32` object format (section 9.6), in NASM, with regard to this exception.

9.7.1 win64: Writing Position-Independent Code

While REL takes good care of RIP-relative addressing, there is one aspect that is easy to overlook for a Win64 programmer: indirect references. Consider a switch dispatch table:

```
        jmp     qword [dsptch+rax*8]
        ...
dsptch: dq      case0
        dq      case1
        ...
```

Even a novice Win64 assembler programmer will soon realize that the code is not 64-bit savvy. Most notably the linker will refuse to link it, showing:

```
'ADDR32' relocation to '.text' invalid without /LARGEADDRESSAWARE:NO
```

So [s]he will have to split jmp instruction as following:

```
        lea     rbx,[rel dsptch]
        jmp     qword [rbx+rax*8]
```

What happens behind the scenes is that the effective address in `lea` is encoded relative to instruction pointer, in a perfectly position-independent manner. But this is only part of the problem! The issue is that in a .dll context, the `caseN` relocations will make their way to the final module and might have to be adjusted at .dll load time (specifically, when it can't be loaded at the preferred address). When this occurs, pages with such relocations will be rendered private to current process, which kind of undermines the idea of a shared .dll. But not to worry, it's trivial to fix:

```
        lea     rbx,[rel dsptch]
        add     rbx,[rbx+rax*8]
        jmp     rbx
        ...
dsptch: dq      case0-dsptch
        dq      case1-dsptch
        ...
```

NASM version 2.03 and later provides another alternative, `wrt ..imagebase` operator, which returns an offset from base address of the current image, be it .exe or .dll module, hence the name. For those acquainted with PE-COFF format, this base address denotes the start of the IMAGE_DOS_HEADER structure. Here is how to implement a switch statement with these image-relative references:

```
        lea     rbx,[rel dsptch]
        mov     eax,[rbx+rax*4]
        sub     rbx,dsptch wrt ..imagebase
        add     rbx,rax
        jmp     rbx
        ...
dsptch: dd      case0 wrt ..imagebase
        dd      case1 wrt ..imagebase
```

That said, the snippet before last works just fine with any NASM version and is not even Windows specific, which makes this operator unnecessary in this case. The real reason for the `wrt ..imagebase` operator will become apparent in the next section.

It should be noted that `wrt ..imagebase` is defined as 32-bit operand only:

```
        dd      label wrt ..imagebase           ; ok
        dq      label wrt ..imagebase           ; bad
        mov     eax,label wrt ..imagebase       ; ok
        mov     rax,label wrt ..imagebase       ; bad
```

9.7.2 win64: Structured Exception Handling

Structured exception handing in Win64 is completely different compared to Win32. When an exception occurs, the program counter is noted, and a linker-generated table containing start and end addresses of all the functions (in a given executable module) is traversed and compared to the saved program

counter. This is used to identify the corresponding `UNWIND_INFO` structure. If missing, then the offending subroutine is assumed to be "leaf" and this lookup procedure is instead attempted for its caller. In Win64, a leaf function is a function that does not call any other functions *nor* modifies any Win64 non-volatile registers, including the stack pointer. The latter ensures that it's possible to identify a leaf function's caller by simply pulling the value from the top of the stack.

While the majority of subroutines written in assembler are not calling any other functions, they may not qualify as "leaf" functions in the Win64 sense. The requirement for non-volatile registers to be unchanged leaves the developer with not more than 7 registers and no stack frame, which is not necessarily what they counted on. Customarily one would meet this requirement by saving non-volatile registers on stack and restoring them upon return. However, if (and only if) an exception is raised at run-time and no `UNWIND_INFO` structure is associated with such a "leaf" function, the stack unwind procedure will expect to find the caller's return address on the top of the stack immediately followed by its frame. Given that the developer pushed the caller's non-volatile registers onto the stack, the value on top will no longer point to the right place. The developer can attempt to copy the caller's return address to the top of stack, which would work in some very specific circumstances. But unless the developer can guarantee that these circumstances are always met, it's more appropriate to assume the worst, i.e. the stack unwind procedure goes berserk, abruptly terminating without any notification whatsoever (just like in the the Win32 case).

Now that we understand significance of the `UNWIND_INFO` structure, let us discuss what is in it and how it is processed. First, it is checked for the presence of a reference to a custom language-specific exception handler. If there is one, then it is invoked. Depending on the return value, execution flow is resumed (exception is said to be "handled"), *or* the rest of the `UNWIND_INFO` structure is processed as follows. Aside from an optional reference to a custom handler, it carries information about the current callee's stack frame and where non-volatile registers are saved. The information is detailed enough to be able to reconstruct the contents of the caller's non-volatile registers on entry to the current callee. And so the caller's context is reconstructed, at which point the unwind procedure is repeated, using the `UNWIND_INFO` structure associated with the caller's instruction pointer. The procedure is repeated recursively until the exception is handled. As a last resort, the system "handles" it by generating a memory dump and terminating the application.

As of this writing, NASM unfortunately does not facilitate generation of above mentioned detailed information about stack frame layout. But as of version 2.03, it implements building blocks for generating structures involved in stack unwinding. Here is a simple example showing how to deploy a custom exception handler for a leaf function:

```
default rel
section .text
extern  MessageBoxA
handler:
        sub     rsp,40
        mov     rcx,0
        lea     rdx,[text]
        lea     r8,[caption]
        mov     r9,1    ; MB_OKCANCEL
        call    MessageBoxA
        sub     eax,1   ; incidentally suits as return value
                        ; for exception handler
        add     rsp,40
        ret
global  main
main:
        xor     rax,rax
        mov     rax,QWORD[rax]  ; cause exception
        ret
main_end:
text:   db      'OK to rethrow, CANCEL to generate core dump',0
caption:db      'SEGV',0
```

```
section .pdata  rdata align=4
        dd      main wrt ..imagebase
        dd      main_end wrt ..imagebase
        dd      xmain wrt ..imagebase
section .xdata  rdata align=8
xmain:  db      9,0,0,0
        dd      handler wrt ..imagebase
section .drectve info
        db      '/defaultlib:user32.lib /defaultlib:msvcrt.lib '
```

What you see is that the `.pdata` section contains a single-element table, containing function start and end addresses, along with references to associated `UNWIND_INFO` structures (only one in this case). The `.xdata` section contains the referenced `UNWIND_INFO` structure, describing a function with no frame, but with a designated exception handler. These references are *required* to be image-relative, which is the real reason for implementing the `wrt ..imagebase` operator). It should be noted that `rdata align=n`, as well as `wrt ..imagebase`, are actually optional in the context of these two segments (they apply even when omitted); *all* 32-bit references placed into these two segments will be image-relative. This is important to understand, as the developer is allowed to append handler-specific data to the `UNWIND_INFO` structure, and any 32-bit references that are added may require adjustment to obtain the real pointer.

As already mentioned, in Win64 terms, a leaf function is one that neither calls any other function *nor* modifies any non-volatile registers, including the stack pointer. But it is not uncommon for the programmer to intend to utilize every single register and sometimes even have a variable stack frame, requiring a more complicated `UNWIND_INFO` structure than in the example above. Is there anything one can do with these simpler building blocks, and avoid manually composing fully-fledged `UNWIND_INFO` structures, which would surely be considered error-prone? Yes, there is. Recall that an exception handler is called first, before the stack layout is analyzed. As it turns out, it is perfectly possible to manipulate current callee's context in a custom handler in a manner that permits further stack unwinding. The general idea is that handler would not actually "handle" the exception, but instead restore the callee's context (restore to state at entry point) and thus mimic a Win64 leaf function. In other words, the handler would effectively undertake part of the unwinding procedure. Consider the following example:

```
function:
        mov     rax,rsp         ; copy rsp to volatile register
        push    r15             ; save non-volatile registers
        push    rbx
        push    rbp
        mov     r11,rsp         ; prepare variable stack frame
        sub     r11,rcx
        and     r11,-64
        mov     QWORD[r11],rax  ; check for exceptions
        mov     rsp,r11         ; allocate stack frame
        mov     QWORD[rsp],rax  ; save original rsp value
magic_point:
        ...
        mov     r11,QWORD[rsp]  ; pull original rsp value
        mov     rbp,QWORD[r11-24]
        mov     rbx,QWORD[r11-16]
        mov     r15,QWORD[r11-8]
        mov     rsp,r11         ; destroy frame
        ret
```

The key is that until `magic_point`, the original `rsp` value remains in the chosen volatile register, and no non-volatile register except for `rsp` is modified. After `magic_point`, `rsp` remains constant till the very end of the `function`. In this case a custom language-specific exception handler would look like this:

```
EXCEPTION_DISPOSITION handler (EXCEPTION_RECORD *rec,ULONG64 frame,
        CONTEXT *context,DISPATCHER_CONTEXT *disp)
{   ULONG64 *rsp;
    if (context->Rip<(ULONG64)magic_point)
        rsp = (ULONG64 *)context->Rax;
```

```
    else
    {   rsp = ((ULONG64 **)context->Rsp)[0];
        context->Rbp = rsp[-3];
        context->Rbx = rsp[-2];
        context->R15 = rsp[-1];
    }
    context->Rsp = (ULONG64)rsp;

    memcpy (disp->ContextRecord,context,sizeof(CONTEXT));
    RtlVirtualUnwind(UNW_FLAG_NHANDLER,disp->ImageBase,
        dips->ControlPc,disp->FunctionEntry,disp->ContextRecord,
        &disp->HandlerData,&disp->EstablisherFrame,NULL);
    return ExceptionContinueSearch;
}
```

As this custom handler allows the example function to mimic a Win64 leaf function, the corresponding `UNWIND_INFO` structure does not need to contain any information about the stack frame and its layout.

9.8 `coff`: Common Object File Format

The `coff` output type produces `COFF` object files suitable for linking with the DJGPP linker.

`coff` provides a default output file-name extension of `.o`.

The `coff` format supports the same extensions to the `SECTION` directive as `win32` does, except that the `align` qualifier and the `info` section type are not supported.

9.9 `macho32` and `macho64`: Mach Object File Format

The `macho32` and `macho64` output formts produces Mach-O object files suitable for linking with the MacOS X linker. `macho` is a synonym for `macho32`.

`macho` provides a default output file-name extension of `.o`.

9.9.1 `macho` extensions to the `SECTION` Directive

The `macho` output format specifies section names in the format "*segment*,*section*". No spaces are allowed around the comma. The following flags can also be specified:

- `data` – this section contains initialized data items
- `code` – this section contains code exclusively
- `mixed` – this section contains both code and data
- `bss` – this section is uninitialized and filled with zero
- `zerofill` – same as `bss`
- `no_dead_strip` – inhibit dead code stripping for this section
- `live_support` – set the live support flag for this section
- `strip_static_syms` – strip static symbols for this section
- `debug` – this section contains debugging information
- `align=`*alignment* – specify section alignment

The default is `data`, unless the section name is `__text` or `__bss` in which case the default is `text` or `bss`, respectively.

For compatibility with other Unix platforms, the following standard names are also supported:

```
.text    = __TEXT,__text  text
.rodata  = __DATA,__const data
.data    = __DATA,__data  data
.bss     = __DATA,__bss   bss
```

If the `.rodata` section contains no relocations, it is instead put into the `__TEXT,__const` section unless this section has already been specified explicitly. However, it is probably better to specify `__TEXT,__const` and `__DATA,__const` explicitly as appropriate.

9.9.2 Thread Local Storage in Mach-O: `macho` special symbols and `WRT`

Mach-O defines the following special symbols that can be used on the right-hand side of the `WRT` operator:

- `..tlvp` is used to specify access to thread-local storage.
- `..gotpcrel` is used to specify references to the Global Offset Table. The GOT is supported in the `macho64` format only.

9.9.3 `macho` specific directive `subsections_via_symbols`

The directive `subsections_via_symbols` sets the `MH_SUBSECTIONS_VIA_SYMBOLS` flag in the Mach-O header, that effectively separates a block (or a subsection) based on a symbol. It is often used for eliminating dead codes by a linker.

This directive takes no arguments.

This is a macro implemented as a `%pragma`. It can also be specified in its `%pragma` form, in which case it will not affect non-Mach-O builds of the same source code:

```
%pragma macho subsections_via_symbols
```

9.9.4 `macho` specific directive `no_dead_strip`

The directive `no_dead_strip` sets the Mach-O `SH_NO_DEAD_STRIP` section flag on the section containing a a specific symbol. This directive takes a list of symbols as its arguments.

This is a macro implemented as a `%pragma`. It can also be specified in its `%pragma` form, in which case it will not affect non-Mach-O builds of the same source code:

```
%pragma macho no_dead_strip symbol...
```

9.9.5 `macho` specific extensions to the `GLOBAL` Directive: `private_extern`

The directive extension to `GLOBAL` marks the symbol with limited global scope. For example, you can specify the global symbol with this extension:

```
global foo:private_extern
foo:
        ; codes
```

Using with static linker will clear the private extern attribute. But linker option like `-keep_private_externs` can avoid it.

9.9.6 `macho` specific directive `build_version`

The directive `build_version` generates a `LC_BUILD_VERSION` load command in the Mach-O header, which allows specifying a target platform, minimum OS version and optionally SDK version. Newer Xcode linker versions warn if this is not present in object files.

This directive takes the target platform name and minimum OS version as arguments, in this form:

```
build_version macos,10,7
```

Platform names that make sense for x86 code are `macos`, `iossimulator`, `tvossimulator` and `watchossimulator`.

Optionally, a trailing version number and minimum SDK version can also be specified with this syntax:

```
build_version macos, 10, 14, 0 sdk_version 10, 14, 0
```

This is a macro implemented as a `%pragma`. It can also be specified in its `%pragma` form, in which case it will not affect non-Mach-O builds of the same source code:

```
%pragma macho build_version ...
```

This latter form is also useful on the command line when using the `--pragma` command-line switch:

```
nasm -f macho64 --pragma "macho build_version macos,10,9" ...
```

9.10 `elf32`, `elf64`, `elfx32`: Executable and Linkable Format Object Files

The `elf32`, `elf64` and `elfx32` output formats generate `ELF32` and `ELF64` (Executable and Linkable Format) object files, as used by Linux as well as Unix System V, including Solaris x86, UnixWare and SCO Unix. ELF provides a default output file-name extension of `.o`. `elf` is a synonym for `elf32`.

The `elfx32` file format is an ELF32 file containing 64-bit x86 code, and is used for the x32 ABI, which runs the CPU in 64-bit mode while using 32-bit values for pointers to reduce memory footprint. Thus, code intended to be used with the x32 ABI should be assembled with `BITS 64`.

9.10.1 ELF specific directive `osabi`

The ELF header specifies the application binary interface for the target operating system (OSABI). This field can be set by using the `osabi` directive with the numeric value (0-255) of the target system. If this directive is not used, the default value will be "UNIX System V ABI" (0) which will work on most systems which support ELF.

9.10.2 ELF extensions to the `SECTION` Directive

Like the `obj` format, `elf` allows you to specify additional information on the `SECTION` directive line, to control the type and properties of sections you declare. Section types and properties are generated automatically by NASM for the standard section names, but may still be overridden by these qualifiers.

The available qualifiers are:

- `alloc` defines the section to be one which is loaded into memory when the program is run. `noalloc` defines it to be one which is not, such as an informational or comment section.
- `exec` defines the section to be one which should have execute permission when the program is run. `noexec` defines it as one which should not.
- `write` defines the section to be one which should be writable when the program is run. `nowrite` defines it as one which should not.
- `progbits` defines the section to be one with explicit contents stored in the object file: an ordinary code or data section, for example.
- `nobits` defines the section to be one with no explicit contents given, such as a BSS section.
- `note` indicates that this section contains ELF notes. The content of ELF notes are specified using normal assembly instructions; it is up to the programmer to ensure these are valid ELF notes.
- `preinit_array` indicates that this section contains function addresses to be called before any other initialization has happened.
- `init_array` indicates that this section contains function addresses to be called during initialization.
- `fini_array` indicates that this section contains function pointers to be called during termination.
- `align=`, used with a trailing number as in `obj`, gives the alignment requirements of the section.
- `byte`, `word`, `dword`, `qword`, `tword`, `oword`, `yword`, or `zword` with an optional `*`multiplier specify the fundamental data item size for a section which contains either fixed-sized data structures or strings; it also sets a default alignment. This is generally used with the `strings` and `merge` attributes (see below.) For example `byte*4` defines a unit size of 4 bytes, with a default alignment of 1; `dword` also

defines a unit size of 4 bytes, but with a default alignment of 4. The `align=` attribute, if specified, overrides this default alignment.

- `pointer` is equivalent to `dword` for `elf32` or `elfx32`, and `qword` for `elf64`.
- `strings` indicate that this section contains exclusively null-terminated strings. By default these are assumed to be byte strings, but a size specifier can be used to override that.
- `merge` indicates that duplicate data elements in this section should be merged with data elements from other object files. Data elements can be either fixed-sized objects or null-terminated strings (with the `strings` attribute). A size specifier is required unless `strings` is specified, in which case the size defaults to `byte`.
- `tls` defines the section to be one which contains thread local variables.

The defaults assumed by NASM if you do not specify the above qualifiers are:

```
section .text          progbits      alloc   exec    nowrite  align=16
section .rodata        progbits      alloc   noexec  nowrite  align=4
section .lrodata       progbits      alloc   noexec  nowrite  align=4
section .data          progbits      alloc   noexec  write    align=4
section .ldata         progbits      alloc   noexec  write    align=4
section .bss           nobits        alloc   noexec  write    align=4
section .lbss          nobits        alloc   noexec  write    align=4
section .tdata         progbits      alloc   noexec  write    align=4   tls
section .tbss          nobits        alloc   noexec  write    align=4   tls
section .comment       progbits      noalloc noexec  nowrite  align=1
section .preinit_array preinit_array alloc   noexec  nowrite  pointer
section .init_array    init_array    alloc   noexec  nowrite  pointer
section .fini_array    fini_array    alloc   noexec  nowrite  pointer
section .note          note          noalloc noexec  nowrite  align=4
section other          progbits      alloc   noexec  nowrite  align=1
```

(Any section name other than those in the above table is treated by default like `other` in the above table. Please note that section names are case sensitive.)

9.10.3 Position-Independent Code: ELF Special Symbols and `WRT`

Since `ELF` does not support segment-base references, the `WRT` operator is not used for its normal purpose; therefore NASM's `elf` output format makes use of `WRT` for a different purpose, namely the PIC-specific relocation types.

`elf` defines five special symbols which you can use as the right-hand side of the `WRT` operator to obtain PIC relocation types. They are `..gotpc`, `..gotoff`, `..got`, `..plt` and `..sym`. Their functions are summarized here:

- Referring to the symbol marking the global offset table base using `wrt ..gotpc` will end up giving the distance from the beginning of the current section to the global offset table. (`_GLOBAL_OFFSET_TABLE_` is the standard symbol name used to refer to the GOT.) So you would then need to add `$$` to the result to get the real address of the GOT.
- Referring to a location in one of your own sections using `wrt ..gotoff` will give the distance from the beginning of the GOT to the specified location, so that adding on the address of the GOT would give the real address of the location you wanted.
- Referring to an external or global symbol using `wrt ..got` causes the linker to build an entry *in* the GOT containing the address of the symbol, and the reference gives the distance from the beginning of the GOT to the entry; so you can add on the address of the GOT, load from the resulting address, and end up with the address of the symbol.
- Referring to a procedure name using `wrt ..plt` causes the linker to build a procedure linkage table entry for the symbol, and the reference gives the address of the PLT entry. You can only use this in

contexts which would generate a PC-relative relocation normally (i.e. as the destination for `CALL` or `JMP`), since ELF contains no relocation type to refer to PLT entries absolutely.

- Referring to a symbol name using `wrt ..sym` causes NASM to write an ordinary relocation, but instead of making the relocation relative to the start of the section and then adding on the offset to the symbol, it will write a relocation record aimed directly at the symbol in question. The distinction is a necessary one due to a peculiarity of the dynamic linker.

A fuller explanation of how to use these relocation types to write shared libraries entirely in NASM is given in section 11.2.

9.10.4 Thread Local Storage in ELF: `elf` Special Symbols and `WRT`

- In ELF32 mode, referring to an external or global symbol using `wrt ..tlsie` causes the linker to build an entry *in* the GOT containing the offset of the symbol within the TLS block, so you can access the value of the symbol with code such as:

```
mov  eax,[tid wrt ..tlsie]
mov  [gs:eax],ebx
```

- In ELF64 or ELFx32 mode, referring to an external or global symbol using `wrt ..gottpoff` causes the linker to build an entry *in* the GOT containing the offset of the symbol within the TLS block, so you can access the value of the symbol with code such as:

```
mov   rax,[rel tid wrt ..gottpoff]
mov   rcx,[fs:rax]
```

9.10.5 `elf` Extensions to the `GLOBAL` Directive

`ELF` object files can contain more information about a global symbol than just its address: they can contain the size of the symbol and its type as well. These are not merely debugger conveniences, but are actually necessary when the program being written is a shared library. NASM therefore supports some extensions to the `GLOBAL` directive, allowing you to specify these features.

You can specify whether a global variable is a function or a data object by suffixing the name with a colon and the word `function` or `data`. (`object` is a synonym for `data`.) For example:

```
global   hashlookup:function, hashtable:data
```

exports the global symbol `hashlookup` as a function and `hashtable` as a data object.

Optionally, you can control the ELF visibility of the symbol. Just add one of the visibility keywords: `default`, `internal`, `hidden`, or `protected`. The default is `default` of course. For example, to make `hashlookup` hidden:

```
global   hashlookup:function hidden
```

Since version 2.15, it is possible to specify symbols binding. The keywords are: `weak` to generate weak symbol or `strong`. The default is `strong`.

You can also specify the size of the data associated with the symbol, as a numeric expression (which may involve labels, and even forward references) after the type specifier. Like this:

```
global  hashtable:data (hashtable.end - hashtable)

hashtable:
        db this,that,theother  ; some data here
.end:
```

This makes NASM automatically calculate the length of the table and place that information into the `ELF` symbol table.

Declaring the type and size of global symbols is necessary when writing shared library code. For more information, see section 11.2.4.

NASM supports the GNU indirect function symbol type using the keyword `gnu_ifunc`. This marks the symbol as `STT_GNU_IFUNC` and causes the dynamic loader to call the symbol as a resolver at runtime. For example:

```
global  func_ifunc:function

global  func:gnu_ifunc
func    equ func_ifunc
```

9.10.6 `elf` Extensions to the `EXTERN` Directive

Since version 2.15 it is possible to specify keyword `weak` to generate weak external reference. Example:

```
extern weak_ref:weak
```

9.10.7 `elf` Extensions to the `COMMON` Directive

`ELF` also allows you to specify alignment requirements on common variables. This is done by putting a number (which must be a power of two) after the name and size of the common variable, separated (as usual) by a colon. For example, an array of doublewords would benefit from 4-byte alignment:

```
common  dwordarray 128:4
```

This declares the total size of the array to be 128 bytes, and requires that it be aligned on a 4-byte boundary.

9.10.8 16-bit code and ELF

Older versions of the `ELF32` specification did not provide relocations for 8- and 16-bit values. It is now part of the formal specification, and any new enough linker should support them.

ELF has currently no support for segmented programming.

9.10.9 Debug formats and ELF

ELF provides debug information in `STABS` and `DWARF` formats. Line number information is generated for all executable sections, but please note that only the ".text" section is executable by default.

9.11 `aout`: Linux `a.out` Object Files

The `aout` format generates `a.out` object files, in the form used by early Linux systems (current Linux systems use ELF, see section 9.10.) These differ from other `a.out` object files in that the magic number in the first four bytes of the file is different; also, some implementations of `a.out`, for example NetBSD's, support position-independent code, which Linux's implementation does not.

`a.out` provides a default output file-name extension of `.o`.

`a.out` is a very simple object format. It supports no special directives, no special symbols, no use of `SEG` or `WRT`, and no extensions to any standard directives. It supports only the three standard section names `.text`, `.data` and `.bss`.

9.12 `aoutb`: NetBSD/FreeBSD/OpenBSD `a.out` Object Files

The `aoutb` format generates `a.out` object files, in the form used by the various free `BSD Unix` clones, `NetBSD`, `FreeBSD` and `OpenBSD`. For simple object files, this object format is exactly the same as `aout` except for the magic number in the first four bytes of the file. However, the `aoutb` format supports position-independent code in the same way as the `elf` format, so you can use it to write `BSD` shared libraries.

`aoutb` provides a default output file-name extension of `.o`.

`aoutb` supports no special directives, no special symbols, and only the three standard section names `.text`, `.data` and `.bss`. However, it also supports the same use of `WRT` as `elf` does, to provide position-independent code relocation types. See section 9.10.3 for full documentation of this feature.

aoutb also supports the same extensions to the GLOBAL directive as elf does: see section 9.10.5 for documentation of this.

9.13 as86: Minix/Linux as86 Object Files

The Minix/Linux 16-bit assembler as86 has its own non-standard object file format. Although its companion linker ld86 produces something close to ordinary a.out binaries as output, the object file format used to communicate between as86 and ld86 is not itself a.out.

NASM supports this format, just in case it is useful, as as86. as86 provides a default output file-name extension of .o.

as86 is a very simple object format (from the NASM user's point of view). It supports no special directives, no use of SEG or WRT, and no extensions to any standard directives. It supports only the three standard section names .text, .data and .bss. The only special symbol supported is ..start.

9.14 dbg: Debugging Format

The dbg format does not output an object file as such; instead, it outputs a text file which contains a complete list of all the transactions between the main body of NASM and the output-format back end module. It is primarily intended to aid people who want to write their own output drivers, so that they can get a clearer idea of the various requests the main program makes of the output driver, and in what order they happen.

For simple files, one can easily use the dbg format like this:

```
nasm -f dbg filename.asm
```

which will generate a diagnostic file called filename.dbg. However, this will not work well on files which were designed for a different object format, because each object format defines its own macros (usually user-level forms of directives), and those macros will not be defined in the dbg format. Therefore it can be useful to run NASM twice, in order to do the preprocessing with the native object format selected:

```
nasm -e -f elf32 -o elfprog.i elfprog.asm
nasm -a -f dbg elfprog.i
```

This preprocesses elfprog.asm into elfprog.i, keeping the elf32 object format selected in order to make sure ELF special directives are converted into primitive form correctly. Then the preprocessed source is fed through the dbg format to generate the final diagnostic output.

This workaround will still typically not work for programs intended for obj format, because the obj SEGMENT and GROUP directives have side effects of defining the segment and group names as symbols; dbg will not do this, so the program will not assemble. You will have to work around that by defining the symbols yourself (using EXTERN, for example) if you really need to get a dbg trace of an obj-specific source file.

dbg accepts any section name and any directives at all, and logs them all to its output file.

dbg accepts and logs any %pragma, but the specific %pragma:

```
%pragma dbg maxdump <size>
```

where <size> is either a number or unlimited, can be used to control the maximum size for dumping the full contents of a rawdata output object.

Chapter 10: Writing 16-bit Code (DOS, Windows 3/3.1)

This chapter attempts to cover some of the common issues encountered when writing 16-bit code to run under MS-DOS or Windows 3.x. It covers how to link programs to produce `.EXE` or `.COM` files, how to write `.SYS` device drivers, and how to interface assembly language code with 16-bit C compilers and with Borland Pascal.

10.1 Producing `.EXE` Files

Any large program written under DOS needs to be built as a `.EXE` file: only `.EXE` files have the necessary internal structure required to span more than one 64K segment. Windows programs, also, have to be built as `.EXE` files, since Windows does not support the `.COM` format.

In general, you generate `.EXE` files by using the `obj` output format to produce one or more `.obj` files, and then linking them together using a linker. However, NASM also supports the direct generation of simple DOS `.EXE` files using the `bin` output format (by using `DB` and `DW` to construct the `.EXE` file header), and a macro package is supplied to do this. Thanks to Yann Guidon for contributing the code for this.

NASM may also support `.EXE` natively as another output format in future releases.

10.1.1 Using the `obj` Format To Generate `.EXE` Files

This section describes the usual method of generating `.EXE` files by linking `.OBJ` files together.

Most 16-bit programming language packages come with a suitable linker; if you have none of these, there is a free linker called VAL, available in `LZH` archive format from `x2ftp.oulu.fi`. An LZH archiver can be found at `ftp.simtel.net`. There is another 'free' linker (though this one doesn't come with sources) called FREELINK, available from `www.pcorner.com`. A third, `djlink`, written by DJ Delorie, is available at `www.delorie.com`. A fourth linker, `ALINK`, written by Anthony A.J. Williams, is available at `alink.sourceforge.net`.

When linking several `.OBJ` files into a `.EXE` file, you should ensure that exactly one of them has a start point defined (using the `..start` special symbol defined by the `obj` format: see section 9.4.6). If no module defines a start point, the linker will not know what value to give the entry-point field in the output file header; if more than one defines a start point, the linker will not know *which* value to use.

An example of a NASM source file which can be assembled to a `.OBJ` file and linked on its own to a `.EXE` is given here. It demonstrates the basic principles of defining a stack, initialising the segment registers, and declaring a start point. This file is also provided in the `test` subdirectory of the NASM archives, under the name `objexe.asm`.

```
segment code

..start:
        mov     ax,data
        mov     ds,ax
        mov     ax,stack
        mov     ss,ax
        mov     sp,stacktop
```

This initial piece of code sets up `DS` to point to the data segment, and initializes `SS` and `SP` to point to the top of the provided stack. Notice that interrupts are implicitly disabled for one instruction after a move into `SS`, precisely for this situation, so that there's no chance of an interrupt occurring between the loads of `SS` and `SP` and not having a stack to execute on.

Note also that the special symbol `..start` is defined at the beginning of this code, which means that will be the entry point into the resulting executable file.

```
        mov     dx,hello
        mov     ah,9
        int     0x21
```

The above is the main program: load DS:DX with a pointer to the greeting message (hello is implicitly relative to the segment data, which was loaded into DS in the setup code, so the full pointer is valid), and call the DOS print-string function.

```
        mov     ax,0x4c00
        int     0x21
```

This terminates the program using another DOS system call.

```
segment data

hello:  db      'hello, world', 13, 10, '$'
```

The data segment contains the string we want to display.

```
segment stack stack
        resb 64
stacktop:
```

The above code declares a stack segment containing 64 bytes of uninitialized stack space, and points stacktop at the top of it. The directive segment stack stack defines a segment *called* stack, and also of *type* STACK. The latter is not necessary to the correct running of the program, but linkers are likely to issue warnings or errors if your program has no segment of type STACK.

The above file, when assembled into a .OBJ file, will link on its own to a valid .EXE file, which when run will print 'hello, world' and then exit.

10.1.2 Using the bin Format To Generate .EXE Files

The .EXE file format is simple enough that it's possible to build a .EXE file by writing a pure-binary program and sticking a 32-byte header on the front. This header is simple enough that it can be generated using DB and DW commands by NASM itself, so that you can use the bin output format to directly generate .EXE files.

Included in the NASM archives, in the misc subdirectory, is a file exebin.mac of macros. It defines three macros: EXE_begin, EXE_stack and EXE_end.

To produce a .EXE file using this method, you should start by using %include to load the exebin.mac macro package into your source file. You should then issue the EXE_begin macro call (which takes no arguments) to generate the file header data. Then write code as normal for the bin format – you can use all three standard sections .text, .data and .bss. At the end of the file you should call the EXE_end macro (again, no arguments), which defines some symbols to mark section sizes, and these symbols are referred to in the header code generated by EXE_begin.

In this model, the code you end up writing starts at 0x100, just like a .COM file – in fact, if you strip off the 32-byte header from the resulting .EXE file, you will have a valid .COM program. All the segment bases are the same, so you are limited to a 64K program, again just like a .COM file. Note that an ORG directive is issued by the EXE_begin macro, so you should not explicitly issue one of your own.

You can't directly refer to your segment base value, unfortunately, since this would require a relocation in the header, and things would get a lot more complicated. So you should get your segment base by copying it out of CS instead.

On entry to your .EXE file, SS:SP are already set up to point to the top of a 2Kb stack. You can adjust the default stack size of 2Kb by calling the EXE_stack macro. For example, to change the stack size of your program to 64 bytes, you would call EXE_stack 64.

A sample program which generates a .EXE file in this way is given in the test subdirectory of the NASM archive, as binexe.asm.

10.2 Producing .COM Files

While large DOS programs must be written as .EXE files, small ones are often better written as .COM files. .COM files are pure binary, and therefore most easily produced using the bin output format.

10.2.1 Using the bin Format To Generate .COM Files

.COM files expect to be loaded at offset 100h into their segment (though the segment may change). Execution then begins at 100h, i.e. right at the start of the program. So to write a .COM program, you would create a source file looking like

```
        org 100h

section .text

start:
        ; put your code here

section .data

        ; put data items here

section .bss

        ; put uninitialized data here
```

The bin format puts the .text section first in the file, so you can declare data or BSS items before beginning to write code if you want to and the code will still end up at the front of the file where it belongs.

The BSS (uninitialized data) section does not take up space in the .COM file itself: instead, addresses of BSS items are resolved to point at space beyond the end of the file, on the grounds that this will be free memory when the program is run. Therefore you should not rely on your BSS being initialized to all zeros when you run.

To assemble the above program, you should use a command line like

```
nasm myprog.asm -fbin -o myprog.com
```

The bin format would produce a file called myprog if no explicit output file name were specified, so you have to override it and give the desired file name.

10.2.2 Using the obj Format To Generate .COM Files

If you are writing a .COM program as more than one module, you may wish to assemble several .OBJ files and link them together into a .COM program. You can do this, provided you have a linker capable of outputting .COM files directly (TLINK does this), or alternatively a converter program such as EXE2BIN to transform the .EXE file output from the linker into a .COM file.

If you do this, you need to take care of several things:

- The first object file containing code should start its code segment with a line like RESB 100h. This is to ensure that the code begins at offset 100h relative to the beginning of the code segment, so that the linker or converter program does not have to adjust address references within the file when generating the .COM file. Other assemblers use an ORG directive for this purpose, but ORG in NASM is a format-specific directive to the bin output format, and does not mean the same thing as it does in MASM-compatible assemblers.
- You don't need to define a stack segment.
- All your segments should be in the same group, so that every time your code or data references a symbol offset, all offsets are relative to the same segment base. This is because, when a .COM file is loaded, all the segment registers contain the same value.

10.3 Producing .SYS Files

MS-DOS device drivers – .SYS files – are pure binary files, similar to .COM files, except that they start at origin zero rather than 100h. Therefore, if you are writing a device driver using the bin format, you do not need the ORG directive, since the default origin for bin is zero. Similarly, if you are using obj, you do not need the RESB 100h at the start of your code segment.

.SYS files start with a header structure, containing pointers to the various routines inside the driver which do the work. This structure should be defined at the start of the code segment, even though it is not actually code.

For more information on the format of .SYS files, and the data which has to go in the header structure, a list of books is given in the Frequently Asked Questions list for the newsgroup comp.os.msdos.programmer.

10.4 Interfacing to 16-bit C Programs

This section covers the basics of writing assembly routines that call, or are called from, C programs. To do this, you would typically write an assembly module as a .OBJ file, and link it with your C modules to produce a mixed-language program.

10.4.1 External Symbol Names

C compilers have the convention that the names of all global symbols (functions or data) they define are formed by prefixing an underscore to the name as it appears in the C program. So, for example, the function a C programmer thinks of as printf appears to an assembly language programmer as _printf. This means that in your assembly programs, you can define symbols without a leading underscore, and not have to worry about name clashes with C symbols.

If you find the underscores inconvenient, you can define macros to replace the GLOBAL and EXTERN directives as follows:

```
%macro  cglobal 1

  global  _%1
  %define %1 _%1

%endmacro

%macro  cextern 1

  extern  _%1
  %define %1 _%1

%endmacro
```

(These forms of the macros only take one argument at a time; a %rep construct could solve this.)

If you then declare an external like this:

```
cextern printf
```

then the macro will expand it as

```
extern  _printf
%define printf _printf
```

Thereafter, you can reference printf as if it was a symbol, and the preprocessor will put the leading underscore on where necessary.

The cglobal macro works similarly. You must use cglobal before defining the symbol in question, but you would have had to do that anyway if you used GLOBAL.

Also see section 2.1.28.

10.4.2 Memory Models

NASM contains no mechanism to support the various C memory models directly; you have to keep track yourself of which one you are writing for. This means you have to keep track of the following things:

- In models using a single code segment (tiny, small and compact), functions are near. This means that function pointers, when stored in data segments or pushed on the stack as function arguments, are 16 bits long and contain only an offset field (the CS register never changes its value, and always gives the segment part of the full function address), and that functions are called using ordinary near CALL instructions and return using RETN (which, in NASM, is synonymous with RET anyway). This means both that you should write your own routines to return with RETN, and that you should call external C routines with near CALL instructions.
- In models using more than one code segment (medium, large and huge), functions are far. This means that function pointers are 32 bits long (consisting of a 16-bit offset followed by a 16-bit segment), and that functions are called using CALL FAR (or CALL seg:offset) and return using RETF. Again, you should therefore write your own routines to return with RETF and use CALL FAR to call external routines.
- In models using a single data segment (tiny, small and medium), data pointers are 16 bits long, containing only an offset field (the DS register doesn't change its value, and always gives the segment part of the full data item address).
- In models using more than one data segment (compact, large and huge), data pointers are 32 bits long, consisting of a 16-bit offset followed by a 16-bit segment. You should still be careful not to modify DS in your routines without restoring it afterwards, but ES is free for you to use to access the contents of 32-bit data pointers you are passed.
- The huge memory model allows single data items to exceed 64K in size. In all other memory models, you can access the whole of a data item just by doing arithmetic on the offset field of the pointer you are given, whether a segment field is present or not; in huge model, you have to be more careful of your pointer arithmetic.
- In most memory models, there is a *default* data segment, whose segment address is kept in DS throughout the program. This data segment is typically the same segment as the stack, kept in SS, so that functions' local variables (which are stored on the stack) and global data items can both be accessed easily without changing DS. Particularly large data items are typically stored in other segments. However, some memory models (though not the standard ones, usually) allow the assumption that SS and DS hold the same value to be removed. Be careful about functions' local variables in this latter case.

In models with a single code segment, the segment is called _TEXT, so your code segment must also go by this name in order to be linked into the same place as the main code segment. In models with a single data segment, or with a default data segment, it is called _DATA.

10.4.3 Function Definitions and Function Calls

The C calling convention in 16-bit programs is as follows. In the following description, the words *caller* and *callee* are used to denote the function doing the calling and the function which gets called.

- The caller pushes the function's parameters on the stack, one after another, in reverse order (right to left, so that the first argument specified to the function is pushed last).
- The caller then executes a CALL instruction to pass control to the callee. This CALL is either near or far depending on the memory model.
- The callee receives control, and typically (although this is not actually necessary, in functions which do not need to access their parameters) starts by saving the value of SP in BP so as to be able to use BP as a base pointer to find its parameters on the stack. However, the caller was probably doing this

too, so part of the calling convention states that BP must be preserved by any C function. Hence the callee, if it is going to set up BP as a *frame pointer*, must push the previous value first.

- The callee may then access its parameters relative to BP. The word at [BP] holds the previous value of BP as it was pushed; the next word, at [BP+2], holds the offset part of the return address, pushed implicitly by CALL. In a small-model (near) function, the parameters start after that, at [BP+4]; in a large-model (far) function, the segment part of the return address lives at [BP+4], and the parameters begin at [BP+6]. The leftmost parameter of the function, since it was pushed last, is accessible at this offset from BP; the others follow, at successively greater offsets. Thus, in a function such as `printf` which takes a variable number of parameters, the pushing of the parameters in reverse order means that the function knows where to find its first parameter, which tells it the number and type of the remaining ones.
- The callee may also wish to decrease SP further, so as to allocate space on the stack for local variables, which will then be accessible at negative offsets from BP.
- The callee, if it wishes to return a value to the caller, should leave the value in AL, AX or DX:AX depending on the size of the value. Floating-point results are sometimes (depending on the compiler) returned in ST0.
- Once the callee has finished processing, it restores SP from BP if it had allocated local stack space, then pops the previous value of BP, and returns via RETN or RETF depending on memory model.
- When the caller regains control from the callee, the function parameters are still on the stack, so it typically adds an immediate constant to SP to remove them (instead of executing a number of slow POP instructions). Thus, if a function is accidentally called with the wrong number of parameters due to a prototype mismatch, the stack will still be returned to a sensible state since the caller, which *knows* how many parameters it pushed, does the removing.

It is instructive to compare this calling convention with that for Pascal programs (described in section 10.5.1). Pascal has a simpler convention, since no functions have variable numbers of parameters. Therefore the callee knows how many parameters it should have been passed, and is able to deallocate them from the stack itself by passing an immediate argument to the RET or RETF instruction, so the caller does not have to do it. Also, the parameters are pushed in left-to-right order, not right-to-left, which means that a compiler can give better guarantees about sequence points without performance suffering.

Thus, you would define a function in C style in the following way. The following example is for small model:

```
global  _myfunc

_myfunc:
        push    bp
        mov     bp,sp
        sub     sp,0x40         ; 64 bytes of local stack space
        mov     bx,[bp+4]       ; first parameter to function

        ; some more code

        mov     sp,bp           ; undo "sub sp,0x40" above
        pop     bp
        ret
```

For a large-model function, you would replace RET by RETF, and look for the first parameter at [BP+6] instead of [BP+4]. Of course, if one of the parameters is a pointer, then the offsets of *subsequent* parameters will change depending on the memory model as well: far pointers take up four bytes on the stack when passed as a parameter, whereas near pointers take up two.

At the other end of the process, to call a C function from your assembly code, you would do something like this:

```
extern  _printf

      ; and then, further down...

      push    word [myint]        ; one of my integer variables
      push    word mystring       ; pointer into my data segment
      call    _printf
      add     sp,byte 4           ; 'byte' saves space

      ; then those data items...

segment _DATA

myint         dw    1234
mystring      db    'This number -> %d <- should be 1234',10,0
```

This piece of code is the small-model assembly equivalent of the C code

```
int myint = 1234;
printf("This number -> %d <- should be 1234\n", myint);
```

In large model, the function-call code might look more like this. In this example, it is assumed that DS already holds the segment base of the segment _DATA. If not, you would have to initialize it first.

```
      push    word [myint]
      push    word seg mystring   ; Now push the segment, and...
      push    word mystring       ; ... offset of "mystring"
      call    far _printf
      add    sp,byte 6
```

The integer value still takes up one word on the stack, since large model does not affect the size of the `int` data type. The first argument (pushed last) to `printf`, however, is a data pointer, and therefore has to contain a segment and offset part. The segment should be stored second in memory, and therefore must be pushed first. (Of course, `PUSH DS` would have been a shorter instruction than `PUSH WORD SEG mystring`, if DS was set up as the above example assumed.) Then the actual call becomes a far call, since functions expect far calls in large model; and SP has to be increased by 6 rather than 4 afterwards to make up for the extra word of parameters.

10.4.4 Accessing Data Items

To get at the contents of C variables, or to declare variables which C can access, you need only declare the names as GLOBAL or EXTERN. (Again, the names require leading underscores, as stated in section 10.4.1.) Thus, a C variable declared as `int i` can be accessed from assembler as

```
extern _i

        mov ax,[_i]
```

And to declare your own integer variable which C programs can access as `extern int j`, you do this (making sure you are assembling in the _DATA segment, if necessary):

```
global  _j

_j      dw      0
```

To access a C array, you need to know the size of the components of the array. For example, `int` variables are two bytes long, so if a C program declares an array as `int a[10]`, you can access `a[3]` by coding `mov ax,[_a+6]`. (The byte offset 6 is obtained by multiplying the desired array index, 3, by the size of the array element, 2.) The sizes of the C base types in 16-bit compilers are: 1 for `char`, 2 for `short` and `int`, 4 for `long` and `float`, and 8 for `double`.

To access a C data structure, you need to know the offset from the base of the structure to the field you are interested in. You can either do this by converting the C structure definition into a NASM structure definition (using STRUC), or by calculating the one offset and using just that.

To do either of these, you should read your C compiler's manual to find out how it organizes data structures. NASM gives no special alignment to structure members in its own STRUC macro, so you have to specify alignment yourself if the C compiler generates it. Typically, you might find that a structure like

```
struct {
    char c;
    int i;
} foo;
```

might be four bytes long rather than three, since the `int` field would be aligned to a two-byte boundary. However, this sort of feature tends to be a configurable option in the C compiler, either using command-line options or `#pragma` lines, so you have to find out how your own compiler does it.

10.4.5 `c16.mac`: Helper Macros for the 16-bit C Interface

Included in the NASM archives, in the `misc` directory, is a file `c16.mac` of macros. It defines three macros: `proc`, `arg` and `endproc`. These are intended to be used for C-style procedure definitions, and they automate a lot of the work involved in keeping track of the calling convention.

(An alternative, TASM compatible form of `arg` is also now built into NASM's preprocessor. See section 5.11 for details.)

An example of an assembly function using the macro set is given here:

```
proc    _nearproc

%$i     arg
%$j     arg
        mov     ax,[bp + %$i]
        mov     bx,[bp + %$j]
        add     ax,[bx]

endproc
```

This defines `_nearproc` to be a procedure taking two arguments, the first (`i`) an integer and the second (`j`) a pointer to an integer. It returns `i + *j`.

Note that the `arg` macro has an `EQU` as the first line of its expansion, and since the label before the macro call gets prepended to the first line of the expanded macro, the `EQU` works, defining `%$i` to be an offset from `BP`. A context-local variable is used, local to the context pushed by the `proc` macro and popped by the `endproc` macro, so that the same argument name can be used in later procedures. Of course, you don't *have* to do that.

The macro set produces code for near functions (tiny, small and compact-model code) by default. You can have it generate far functions (medium, large and huge-model code) by means of coding `%define FARCODE`. This changes the kind of return instruction generated by `endproc`, and also changes the starting point for the argument offsets. The macro set contains no intrinsic dependency on whether data pointers are far or not.

`arg` can take an optional parameter, giving the size of the argument. If no size is given, 2 is assumed, since it is likely that many function parameters will be of type `int`.

The large-model equivalent of the above function would look like this:

```
%define FARCODE

proc    _farproc

%$i     arg
%$j     arg     4
        mov     ax,[bp + %$i]
        mov     bx,[bp + %$j]
        mov     es,[bp + %$j + 2]
        add     ax,[bx]
```

```
endproc
```

This makes use of the argument to the `arg` macro to define a parameter of size 4, because `j` is now a far pointer. When we load from `j`, we must load a segment and an offset.

10.5 Interfacing to Borland Pascal Programs

Interfacing to Borland Pascal programs is similar in concept to interfacing to 16-bit C programs. The differences are:

- The leading underscore required for interfacing to C programs is not required for Pascal.
- The memory model is always large: functions are far, data pointers are far, and no data item can be more than 64K long. (Actually, some functions are near, but only those functions that are local to a Pascal unit and never called from outside it. All assembly functions that Pascal calls, and all Pascal functions that assembly routines are able to call, are far.) However, all static data declared in a Pascal program goes into the default data segment, which is the one whose segment address will be in DS when control is passed to your assembly code. The only things that do not live in the default data segment are local variables (they live in the stack segment) and dynamically allocated variables. All data *pointers*, however, are far.
- The function calling convention is different – described below.
- Some data types, such as strings, are stored differently.
- There are restrictions on the segment names you are allowed to use – Borland Pascal will ignore code or data declared in a segment it doesn't like the name of. The restrictions are described below.

10.5.1 The Pascal Calling Convention

The 16-bit Pascal calling convention is as follows. In the following description, the words *caller* and *callee* are used to denote the function doing the calling and the function which gets called.

- The caller pushes the function's parameters on the stack, one after another, in normal order (left to right, so that the first argument specified to the function is pushed first).
- The caller then executes a far CALL instruction to pass control to the callee.
- The callee receives control, and typically (although this is not actually necessary, in functions which do not need to access their parameters) starts by saving the value of SP in BP so as to be able to use BP as a base pointer to find its parameters on the stack. However, the caller was probably doing this too, so part of the calling convention states that BP must be preserved by any function. Hence the callee, if it is going to set up BP as a frame pointer, must push the previous value first.
- The callee may then access its parameters relative to BP. The word at `[BP]` holds the previous value of BP as it was pushed. The next word, at `[BP+2]`, holds the offset part of the return address, and the next one at `[BP+4]` the segment part. The parameters begin at `[BP+6]`. The rightmost parameter of the function, since it was pushed last, is accessible at this offset from BP; the others follow, at successively greater offsets.
- The callee may also wish to decrease SP further, so as to allocate space on the stack for local variables, which will then be accessible at negative offsets from BP.
- The callee, if it wishes to return a value to the caller, should leave the value in AL, AX or DX:AX depending on the size of the value. Floating-point results are returned in ST0. Results of type `Real` (Borland's own custom floating-point data type, not handled directly by the FPU) are returned in DX:BX:AX. To return a result of type `String`, the caller pushes a pointer to a temporary string before pushing the parameters, and the callee places the returned string value at that location. The pointer is not a parameter, and should not be removed from the stack by the RETF instruction.

- Once the callee has finished processing, it restores SP from BP if it had allocated local stack space, then pops the previous value of BP, and returns via RETF. It uses the form of RETF with an immediate parameter, giving the number of bytes taken up by the parameters on the stack. This causes the parameters to be removed from the stack as a side effect of the return instruction.
- When the caller regains control from the callee, the function parameters have already been removed from the stack, so it needs to do nothing further.

Thus, you would define a function in Pascal style, taking two `Integer`–type parameters, in the following way:

```
global  myfunc

myfunc: push    bp
        mov     bp,sp
        sub     sp,0x40         ; 64 bytes of local stack space
        mov     bx,[bp+8]       ; first parameter to function
        mov     bx,[bp+6]       ; second parameter to function

        ; some more code

        mov     sp,bp           ; undo "sub sp,0x40" above
        pop     bp
        retf    4               ; total size of params is 4
```

At the other end of the process, to call a Pascal function from your assembly code, you would do something like this:

```
extern  SomeFunc

       ; and then, further down...

       push   word seg mystring   ; Now push the segment, and...
       push   word mystring       ; ... offset of "mystring"
       push   word [myint]        ; one of my variables
       call   far SomeFunc
```

This is equivalent to the Pascal code

```
procedure SomeFunc(String: PChar; Int: Integer);
    SomeFunc(@mystring, myint);
```

10.5.2 Borland Pascal Segment Name Restrictions

Since Borland Pascal's internal unit file format is completely different from OBJ, it only makes a very sketchy job of actually reading and understanding the various information contained in a real OBJ file when it links that in. Therefore an object file intended to be linked to a Pascal program must obey a number of restrictions:

- Procedures and functions must be in a segment whose name is either CODE, CSEG, or something ending in _TEXT.
- initialized data must be in a segment whose name is either CONST or something ending in _DATA.
- Uninitialized data must be in a segment whose name is either DATA, DSEG, or something ending in _BSS.
- Any other segments in the object file are completely ignored. GROUP directives and segment attributes are also ignored.

10.5.3 Using `c16.mac` With Pascal Programs

The `c16.mac` macro package, described in section 10.4.5, can also be used to simplify writing functions to be called from Pascal programs, if you code `%define PASCAL`. This definition ensures that functions

are far (it implies FARCODE), and also causes procedure return instructions to be generated with an operand.

Defining PASCAL does not change the code which calculates the argument offsets; you must declare your function's arguments in reverse order. For example:

```
%define PASCAL

proc    _pascalproc

%$j     arg 4
%$i     arg
        mov     ax,[bp + %$i]
        mov     bx,[bp + %$j]
        mov     es,[bp + %$j + 2]
        add     ax,[bx]

endproc
```

This defines the same routine, conceptually, as the example in section 10.4.5: it defines a function taking two arguments, an integer and a pointer to an integer, which returns the sum of the integer and the contents of the pointer. The only difference between this code and the large-model C version is that PASCAL is defined instead of FARCODE, and that the arguments are declared in reverse order.

Chapter 11: Writing 32-bit Code (Unix, Win32, DJGPP)

This chapter attempts to cover some of the common issues involved when writing 32-bit code, to run under Win32 or Unix, or to be linked with C code generated by a Unix-style C compiler such as DJGPP. It covers how to write assembly code to interface with 32-bit C routines, and how to write position-independent code for shared libraries.

Almost all 32-bit code, and in particular all code running under `Win32`, `DJGPP` or any of the PC Unix variants, runs in *flat* memory model. This means that the segment registers and paging have already been set up to give you the same 32-bit 4Gb address space no matter what segment you work relative to, and that you should ignore all segment registers completely. When writing flat-model application code, you never need to use a segment override or modify any segment register, and the code-section addresses you pass to `CALL` and `JMP` live in the same address space as the data-section addresses you access your variables by and the stack-section addresses you access local variables and procedure parameters by. Every address is 32 bits long and contains only an offset part.

11.1 Interfacing to 32-bit C Programs

A lot of the discussion in section 10.4, about interfacing to 16-bit C programs, still applies when working in 32 bits. The absence of memory models or segmentation worries simplifies things a lot.

11.1.1 External Symbol Names

Most 32-bit C compilers share the convention used by 16-bit compilers, that the names of all global symbols (functions or data) they define are formed by prefixing an underscore to the name as it appears in the C program. However, not all of them do: the `ELF` specification states that C symbols do *not* have a leading underscore on their assembly-language names.

The older Linux `a.out` C compiler, all `Win32` compilers, `DJGPP`, and `NetBSD` and `FreeBSD`, all use the leading underscore; for these compilers, the macros `cextern` and `cglobal`, as given in section 10.4.1, will still work. For `ELF`, though, the leading underscore should not be used.

See also section 2.1.28.

11.1.2 Function Definitions and Function Calls

The C calling convention in 32-bit programs is as follows. In the following description, the words *caller* and *callee* are used to denote the function doing the calling and the function which gets called.

- The caller pushes the function's parameters on the stack, one after another, in reverse order (right to left, so that the first argument specified to the function is pushed last).
- The caller then executes a near `CALL` instruction to pass control to the callee.
- The callee receives control, and typically (although this is not actually necessary, in functions which do not need to access their parameters) starts by saving the value of `ESP` in `EBP` so as to be able to use `EBP` as a base pointer to find its parameters on the stack. However, the caller was probably doing this too, so part of the calling convention states that `EBP` must be preserved by any C function. Hence the callee, if it is going to set up `EBP` as a frame pointer, must push the previous value first.
- The callee may then access its parameters relative to `EBP`. The doubleword at `[EBP]` holds the previous value of `EBP` as it was pushed; the next doubleword, at `[EBP+4]`, holds the return address, pushed implicitly by `CALL`. The parameters start after that, at `[EBP+8]`. The leftmost parameter of the function, since it was pushed last, is accessible at this offset from `EBP`; the others follow, at successively greater offsets. Thus, in a function such as `printf` which takes a variable number of parameters, the pushing of the parameters in reverse order means that the function knows where to find its first parameter, which tells it the number and type of the remaining ones.

- The callee may also wish to decrease ESP further, so as to allocate space on the stack for local variables, which will then be accessible at negative offsets from EBP.
- The callee, if it wishes to return a value to the caller, should leave the value in AL, AX or EAX depending on the size of the value. Floating-point results are typically returned in ST0.
- Once the callee has finished processing, it restores ESP from EBP if it had allocated local stack space, then pops the previous value of EBP, and returns via RET (equivalently, RETN).
- When the caller regains control from the callee, the function parameters are still on the stack, so it typically adds an immediate constant to ESP to remove them (instead of executing a number of slow POP instructions). Thus, if a function is accidentally called with the wrong number of parameters due to a prototype mismatch, the stack will still be returned to a sensible state since the caller, which *knows* how many parameters it pushed, does the removing.

There is an alternative calling convention used by Win32 programs for Windows API calls, and also for functions called *by* the Windows API such as window procedures: they follow what Microsoft calls the `__stdcall` convention. This is slightly closer to the Pascal convention, in that the callee clears the stack by passing a parameter to the RET instruction. However, the parameters are still pushed in right-to-left order.

Thus, you would define a function in C style in the following way:

```
global  _myfunc

_myfunc:
        push    ebp
        mov     ebp,esp
        sub     esp,0x40        ; 64 bytes of local stack space
        mov     ebx,[ebp+8]     ; first parameter to function

        ; some more code

        leave                   ; mov esp,ebp / pop ebp
        ret
```

At the other end of the process, to call a C function from your assembly code, you would do something like this:

```
extern  _printf

        ; and then, further down...

        push    dword [myint]   ; one of my integer variables
        push    dword mystring  ; pointer into my data segment
        call    _printf
        add     esp,byte 8      ; ‘byte’ saves space

        ; then those data items...

segment _DATA

myint       dd   1234
mystring    db   'This number -> %d <- should be 1234',10,0
```

This piece of code is the assembly equivalent of the C code

```
    int myint = 1234;
    printf("This number -> %d <- should be 1234\n", myint);
```

11.1.3 Accessing Data Items

To get at the contents of C variables, or to declare variables which C can access, you need only declare the names as GLOBAL or EXTERN. (Again, the names require leading underscores, as stated in section 11.1.1.) Thus, a C variable declared as `int i` can be accessed from assembler as

```
        extern _i
        mov eax,[_i]
```

And to declare your own integer variable which C programs can access as `extern int j`, you do this (making sure you are assembling in the `_DATA` segment, if necessary):

```
        global _j
_j      dd 0
```

To access a C array, you need to know the size of the components of the array. For example, `int` variables are four bytes long, so if a C program declares an array as `int a[10]`, you can access `a[3]` by coding `mov ax,[_a+12]`. (The byte offset 12 is obtained by multiplying the desired array index, 3, by the size of the array element, 4.) The sizes of the C base types in 32-bit compilers are: 1 for `char`, 2 for `short`, 4 for `int`, `long` and `float`, and 8 for `double`. Pointers, being 32-bit addresses, are also 4 bytes long.

To access a C data structure, you need to know the offset from the base of the structure to the field you are interested in. You can either do this by converting the C structure definition into a NASM structure definition (using `STRUC`), or by calculating the one offset and using just that.

To do either of these, you should read your C compiler's manual to find out how it organizes data structures. NASM gives no special alignment to structure members in its own `STRUC` macro, so you have to specify alignment yourself if the C compiler generates it. Typically, you might find that a structure like

```
struct {
    char c;
    int i;
} foo;
```

might be eight bytes long rather than five, since the `int` field would be aligned to a four-byte boundary. However, this sort of feature is sometimes a configurable option in the C compiler, either using command-line options or `#pragma` lines, so you have to find out how your own compiler does it.

11.1.4 `c32.mac`: Helper Macros for the 32-bit C Interface

Included in the NASM archives, in the `misc` directory, is a file `c32.mac` of macros. It defines three macros: `proc`, `arg` and `endproc`. These are intended to be used for C-style procedure definitions, and they automate a lot of the work involved in keeping track of the calling convention.

An example of an assembly function using the macro set is given here:

```
proc    _proc32

%$i     arg
%$j     arg
        mov     eax,[ebp + %$i]
        mov     ebx,[ebp + %$j]
        add     eax,[ebx]

endproc
```

This defines `_proc32` to be a procedure taking two arguments, the first (`i`) an integer and the second (`j`) a pointer to an integer. It returns `i + *j`.

Note that the `arg` macro has an `EQU` as the first line of its expansion, and since the label before the macro call gets prepended to the first line of the expanded macro, the `EQU` works, defining `%$i` to be an offset from `BP`. A context-local variable is used, local to the context pushed by the `proc` macro and popped by the `endproc` macro, so that the same argument name can be used in later procedures. Of course, you don't *have* to do that.

`arg` can take an optional parameter, giving the size of the argument. If no size is given, 4 is assumed, since it is likely that many function parameters will be of type `int` or pointers.

11.2 Writing NetBSD/FreeBSD/OpenBSD and Linux/ELF Shared Libraries

ELF replaced the older `a.out` object file format under Linux because it contains support for position-independent code (PIC), which makes writing shared libraries much easier. NASM supports the `ELF` position-independent code features, so you can write Linux `ELF` shared libraries in NASM.

NetBSD, and its close cousins FreeBSD and OpenBSD, take a different approach by hacking PIC support into the `a.out` format. NASM supports this as the `aoutb` output format, so you can write BSD shared libraries in NASM too.

The operating system loads a PIC shared library by memory-mapping the library file at an arbitrarily chosen point in the address space of the running process. The contents of the library's code section must therefore not depend on where it is loaded in memory.

Therefore, you cannot get at your variables by writing code like this:

```
        mov     eax,[myvar]             ; WRONG
```

Instead, the linker provides an area of memory called the *global offset table*, or GOT; the GOT is situated at a constant distance from your library's code, so if you can find out where your library is loaded (which is typically done using a `CALL` and `POP` combination), you can obtain the address of the GOT, and you can then load the addresses of your variables out of linker-generated entries in the GOT.

The *data* section of a PIC shared library does not have these restrictions: since the data section is writable, it has to be copied into memory anyway rather than just paged in from the library file, so as long as it's being copied it can be relocated too. So you can put ordinary types of relocation in the data section without too much worry (but see section 11.2.4 for a caveat).

11.2.1 Obtaining the Address of the GOT

Each code module in your shared library should define the GOT as an external symbol:

```
extern  _GLOBAL_OFFSET_TABLE_   ; in ELF
extern  __GLOBAL_OFFSET_TABLE_  ; in BSD a.out
```

At the beginning of any function in your shared library which plans to access your data or BSS sections, you must first calculate the address of the GOT. This is typically done by writing the function in this form:

```
func:   push    ebp
        mov     ebp,esp
        push    ebx
        call    .get_GOT
.get_GOT:
        pop     ebx
        add     ebx,_GLOBAL_OFFSET_TABLE_+$$-.get_GOT wrt ..gotpc

        ; the function body comes here

        mov     ebx,[ebp-4]
        mov     esp,ebp
        pop     ebp
        ret
```

(For BSD, again, the symbol `_GLOBAL_OFFSET_TABLE` requires a second leading underscore.)

The first two lines of this function are simply the standard C prologue to set up a stack frame, and the last three lines are standard C function epilogue. The third line, and the fourth to last line, save and restore the `EBX` register, because PIC shared libraries use this register to store the address of the GOT.

The interesting bit is the `CALL` instruction and the following two lines. The `CALL` and `POP` combination obtains the address of the label `.get_GOT`, without having to know in advance where the program was loaded (since the `CALL` instruction is encoded relative to the current position). The `ADD` instruction makes use of one of the special PIC relocation types: GOTPC relocation. With the `WRT ..gotpc` qualifier

specified, the symbol referenced (here _GLOBAL_OFFSET_TABLE_, the special symbol assigned to the GOT) is given as an offset from the beginning of the section. (Actually, ELF encodes it as the offset from the operand field of the ADD instruction, but NASM simplifies this deliberately, so you do things the same way for both ELF and BSD.) So the instruction then *adds* the beginning of the section, to get the real address of the GOT, and subtracts the value of .get_GOT which it knows is in EBX. Therefore, by the time that instruction has finished, EBX contains the address of the GOT.

If you didn't follow that, don't worry: it's never necessary to obtain the address of the GOT by any other means, so you can put those three instructions into a macro and safely ignore them:

```
%macro  get_GOT 0

        call    %%getgot
  %%getgot:
        pop     ebx
        add     ebx,_GLOBAL_OFFSET_TABLE_+$$-%%getgot wrt ..gotpc

%endmacro
```

11.2.2 Finding Your Local Data Items

Having got the GOT, you can then use it to obtain the addresses of your data items. Most variables will reside in the sections you have declared; they can be accessed using the ..gotoff special WRT type. The way this works is like this:

```
        lea     eax,[ebx+myvar wrt ..gotoff]
```

The expression myvar wrt ..gotoff is calculated, when the shared library is linked, to be the offset to the local variable myvar from the beginning of the GOT. Therefore, adding it to EBX as above will place the real address of myvar in EAX.

If you declare variables as GLOBAL without specifying a size for them, they are shared between code modules in the library, but do not get exported from the library to the program that loaded it. They will still be in your ordinary data and BSS sections, so you can access them in the same way as local variables, using the above ..gotoff mechanism.

Note that due to a peculiarity of the way BSD a.out format handles this relocation type, there must be at least one non-local symbol in the same section as the address you're trying to access.

11.2.3 Finding External and Common Data Items

If your library needs to get at an external variable (external to the *library*, not just to one of the modules within it), you must use the ..got type to get at it. The ..got type, instead of giving you the offset from the GOT base to the variable, gives you the offset from the GOT base to a GOT *entry* containing the address of the variable. The linker will set up this GOT entry when it builds the library, and the dynamic linker will place the correct address in it at load time. So to obtain the address of an external variable extvar in EAX, you would code

```
        mov     eax,[ebx+extvar wrt ..got]
```

This loads the address of extvar out of an entry in the GOT. The linker, when it builds the shared library, collects together every relocation of type ..got, and builds the GOT so as to ensure it has every necessary entry present.

Common variables must also be accessed in this way.

11.2.4 Exporting Symbols to the Library User

If you want to export symbols to the user of the library, you have to declare whether they are functions or data, and if they are data, you have to give the size of the data item. This is because the dynamic linker has to build *procedure linkage table* entries for any exported functions, and also moves exported data items away from the library's data section in which they were declared.

So to export a function to users of the library, you must use

```
global  func:function           ; declare it as a function

func:   push    ebp

        ; etc.
```

And to export a data item such as an array, you would have to code

```
global  array:data array.end-array      ; give the size too

array:  resd    128
.end:
```

Be careful: If you export a variable to the library user, by declaring it as `GLOBAL` and supplying a size, the variable will end up living in the data section of the main program, rather than in your library's data section, where you declared it. So you will have to access your own global variable with the `..got` mechanism rather than `..gotoff`, as if it were external (which, effectively, it has become).

Equally, if you need to store the address of an exported global in one of your data sections, you can't do it by means of the standard sort of code:

```
dataptr:        dd      global_data_item        ; WRONG
```

NASM will interpret this code as an ordinary relocation, in which `global_data_item` is merely an offset from the beginning of the `.data` section (or whatever); so this reference will end up pointing at your data section instead of at the exported global which resides elsewhere.

Instead of the above code, then, you must write

```
dataptr:        dd      global_data_item wrt ..sym
```

which makes use of the special `WRT` type `..sym` to instruct NASM to search the symbol table for a particular symbol at that address, rather than just relocating by section base.

Either method will work for functions: referring to one of your functions by means of

```
funcptr:        dd      my_function
```

will give the user the address of the code you wrote, whereas

```
funcptr:        dd      my_function wrt ..sym
```

will give the address of the procedure linkage table for the function, which is where the calling program will *believe* the function lives. Either address is a valid way to call the function.

11.2.5 Calling Procedures Outside the Library

Calling procedures outside your shared library has to be done by means of a *procedure linkage table*, or PLT. The PLT is placed at a known offset from where the library is loaded, so the library code can make calls to the PLT in a position-independent way. Within the PLT there is code to jump to offsets contained in the GOT, so function calls to other shared libraries or to routines in the main program can be transparently passed off to their real destinations.

To call an external routine, you must use another special PIC relocation type, `WRT ..plt`. This is much easier than the GOT-based ones: you simply replace calls such as `CALL printf` with the PLT-relative version `CALL printf WRT ..plt`.

11.2.6 Generating the Library File

Having written some code modules and assembled them to `.o` files, you then generate your shared library with a command such as

```
ld -shared -o library.so module1.o module2.o       # for ELF
ld -Bshareable -o library.so module1.o module2.o   # for BSD
```

For ELF, if your shared library is going to reside in system directories such as `/usr/lib` or `/lib`, it is usually worth using the `-soname` flag to the linker, to store the final library file name, with a version number, into the library:

```
ld -shared -soname library.so.1 -o library.so.1.2 *.o
```

You would then copy `library.so.1.2` into the library directory, and create `library.so.1` as a symbolic link to it.

Chapter 12: Mixing 16- and 32-bit Code

This chapter tries to cover some of the issues, largely related to unusual forms of addressing and jump instructions, encountered when writing operating system code such as protected-mode initialization routines, which require code that operates in mixed segment sizes, such as code in a 16-bit segment trying to modify data in a 32-bit one, or jumps between different-size segments.

12.1 Mixed-Size Jumps

The most common form of mixed-size instruction is the one used when writing a 32-bit OS: having done your setup in 16-bit mode, such as loading the kernel, you then have to boot it by switching into protected mode and jumping to the 32-bit kernel start address. In a fully 32-bit OS, this tends to be the *only* mixed-size instruction you need, since everything before it can be done in pure 16-bit code, and everything after it can be pure 32-bit.

This jump must specify a 48-bit far address, since the target segment is a 32-bit one. However, it must be assembled in a 16-bit segment, so just coding, for example,

```
jmp     0x1234:0x56789ABC       ; wrong!
```

will not work, since the offset part of the address will be truncated to `0x9ABC` and the jump will be an ordinary 16-bit far one.

The Linux kernel setup code gets round the inability of `as86` to generate the required instruction by coding it manually, using `DB` instructions. NASM can go one better than that, by actually generating the right instruction itself. Here's how to do it right:

```
jmp     dword 0x1234:0x56789ABC         ; right
```

The `DWORD` prefix (strictly speaking, it should come *after* the colon, since it is declaring the *offset* field to be a doubleword; but NASM will accept either form, since both are unambiguous) forces the offset part to be treated as far, in the assumption that you are deliberately writing a jump from a 16-bit segment to a 32-bit one.

You can do the reverse operation, jumping from a 32-bit segment to a 16-bit one, by means of the `WORD` prefix:

```
jmp     word 0x8765:0x4321      ; 32 to 16 bit
```

If the `WORD` prefix is specified in 16-bit mode, or the `DWORD` prefix in 32-bit mode, they will be ignored, since each is explicitly forcing NASM into a mode it was in anyway.

12.2 Addressing Between Different-Size Segments

If your OS is mixed 16 and 32-bit, or if you are writing a DOS extender, you are likely to have to deal with some 16-bit segments and some 32-bit ones. At some point, you will probably end up writing code in a 16-bit segment which has to access data in a 32-bit segment, or vice versa.

If the data you are trying to access in a 32-bit segment lies within the first 64K of the segment, you may be able to get away with using an ordinary 16-bit addressing operation for the purpose; but sooner or later, you will want to do 32-bit addressing from 16-bit mode.

The easiest way to do this is to make sure you use a register for the address, since any effective address containing a 32-bit register is forced to be a 32-bit address. So you can do

```
mov     eax,offset_into_32_bit_segment_specified_by_fs
mov     dword [fs:eax],0x11223344
```

This is fine, but slightly cumbersome (since it wastes an instruction and a register) if you already know the precise offset you are aiming at. The x86 architecture does allow 32-bit effective addresses to

specify nothing but a 4-byte offset, so why shouldn't NASM be able to generate the best instruction for the purpose?

It can. As in section 12.1, you need only prefix the address with the DWORD keyword, and it will be forced to be a 32-bit address:

```
mov     dword [fs:dword my_offset],0x11223344
```

Also as in section 12.1, NASM is not fussy about whether the DWORD prefix comes before or after the segment override, so arguably a nicer-looking way to code the above instruction is

```
mov     dword [dword fs:my_offset],0x11223344
```

Don't confuse the DWORD prefix *outside* the square brackets, which controls the size of the data stored at the address, with the one inside the square brackets which controls the length of the address itself. The two can quite easily be different:

```
mov     word [dword 0x12345678],0x9ABC
```

This moves 16 bits of data to an address specified by a 32-bit offset.

You can also specify WORD or DWORD prefixes along with the FAR prefix to indirect far jumps or calls. For example:

```
call    dword far [fs:word 0x4321]
```

This instruction contains an address specified by a 16-bit offset; it loads a 48-bit far pointer from that (16-bit segment and 32-bit offset), and calls that address.

12.3 Other Mixed-Size Instructions

The other way you might want to access data might be using the string instructions (LODSx, STOSx and so on) or the XLATB instruction. These instructions, since they take no parameters, might seem to have no easy way to make them perform 32-bit addressing when assembled in a 16-bit segment.

This is the purpose of NASM's a16, a32 and a64 prefixes. If you are coding LODSB in a 16-bit segment but it is supposed to be accessing a string in a 32-bit segment, you should load the desired address into ESI and then code

```
a32     lodsb
```

The prefix forces the addressing size to 32 bits, meaning that LODSB loads from [DS:ESI] instead of [DS:SI]. To access a string in a 16-bit segment when coding in a 32-bit one, the corresponding a16 prefix can be used.

The a16, a32 and a64 prefixes can be applied to any instruction in NASM's instruction table, but most of them can generate all the useful forms without them. The prefixes are necessary only for instructions with implicit addressing: CMPSx, SCASx, LODSx, STOSx, MOVSx, INSx, OUTSx, and XLATB. Also, the various push and pop instructions (PUSHA and POPF as well as the more usual PUSH and POP) can accept a16, a32 or a64 prefixes to force a particular one of SP, ESP or RSP to be used as a stack pointer, in case the stack segment in use is a different size from the code segment.

PUSH and POP, when applied to segment registers in 32-bit mode, also have the slightly odd behaviour that they push and pop 4 bytes at a time, of which the top two are ignored and the bottom two give the value of the segment register being manipulated. To force the 16-bit behaviour of segment-register push and pop instructions, you can use the operand-size prefix o16:

```
o16 push    ss
o16 push    ds
```

This code saves a doubleword of stack space by fitting two segment registers into the space which would normally be consumed by pushing one.

(You can also use the o32 prefix to force the 32-bit behaviour when in 16-bit mode, but this seems less useful.)

Chapter 13: Writing 64-bit Code (Unix, Win64)

This chapter attempts to cover some of the common issues involved when writing 64-bit code, to run under Win64 or Unix. It covers how to write assembly code to interface with 64-bit C routines, and how to write position-independent code for shared libraries.

All 64-bit code uses a flat memory model, since segmentation is not available in 64-bit mode. The one exception is the FS and GS registers, which still add their bases.

Position independence in 64-bit mode is significantly simpler, since the processor supports RIP–relative addressing directly; see the REL keyword (section 3.3). On most 64-bit platforms, it is probably desirable to make that the default, using the directive DEFAULT REL (section 8.2).

DEFAULT REL is likely to become the default in a future version of NASM.

64-bit programming is relatively similar to 32-bit programming, but of course pointers are 64 bits long; additionally, all existing platforms pass arguments in registers rather than on the stack. Furthermore, 64-bit platforms use SSE2 by default for floating point. Please see the ABI documentation for your platform.

64-bit platforms differ in the sizes of the C/C++ fundamental datatypes, not just from 32-bit platforms but from each other. If a specific size data type is desired, it is probably best to use the types defined in the standard C header <inttypes.h>.

All known 64-bit platforms except some embedded platforms require that the stack is 16-byte aligned at the entry to a function. Specifically, the stack pointer (RSP) needs to be 16-byte aligned just before the CALL instruction.

In 64-bit mode, the default instruction size is still 32 bits. When loading a value into a 32-bit register (but not an 8- or 16-bit register), the upper 32 bits of the corresponding 64-bit register are set to zero.

13.1 Register Names in 64-bit Mode

NASM uses the following names for general-purpose registers in 64-bit mode, for 8-, 16-, 32- and 64-bit references, respectively:

```
AL/AH, CL/CH, DL/DH, BL/BH, SPL, BPL, SIL, DIL, R8B-R15B
AX, CX, DX, BX, SP, BP, SI, DI, R8W-R15W
EAX, ECX, EDX, EBX, ESP, EBP, ESI, EDI, R8D-R15D
RAX, RCX, RDX, RBX, RSP, RBP, RSI, RDI, R8-R15
```

This is consistent with the AMD documentation and most other assemblers. The Intel documentation, however, uses the names R8L–R15L for 8-bit references to the higher registers. It is possible to use those names by defining them as macros; similarly, if one wants to use numeric names for the low 8 registers, define them as macros. The standard macro package altreg (see section 7.1) can be used for this purpose.

13.2 Immediates and Displacements in 64-bit Mode

In 64-bit mode, immediates and displacements are generally only 32 bits wide. NASM will therefore truncate most displacements and immediates to 32 bits.

13.2.1 Immediate 64-bit Operands

The only instruction which takes a full 64-bit immediate is:

```
MOV reg64,imm64
```

NASM will produce this instruction whenever the programmer uses MOV with an immediate into a 64-bit register. If this is not desirable, simply specify the equivalent 32-bit register, which will be automatically zero-extended by the processor, or specify the immediate as DWORD:

```
mov rax,foo             ; 64-bit immediate
mov rax,qword foo       ; (identical)
mov eax,foo             ; 32-bit immediate, zero-extended
mov rax,dword foo       ; 32-bit immediate, sign-extended
```

The length of these instructions are 10, 5 and 7 bytes, respectively.

If optimization is enabled and NASM can determine at assembly time that a shorter instruction will suffice, the shorter instruction will be emitted unless of course STRICT QWORD or STRICT DWORD is specified (see section 3.7):

```
mov rax,1               ; Assembles as "mov eax,1" (5 bytes)
mov rax,strict qword 1  ; Full 10-byte instruction
mov rax,strict dword 1  ; 7-byte instruction
mov rax,symbol          ; 10 bytes, not known at assembly time
lea rax,[rel symbol]    ; 7 bytes, usually preferred by the ABI
```

Note that `lea rax,[rel symbol]` is position-independent, whereas `mov rax,symbol` is not. Most ABIs prefer or even require position-independent code in 64-bit mode. However, the MOV instruction is able to reference a symbol anywhere in the 64-bit address space, whereas LEA is only able to access a symbol within within 2 GB of the instruction itself (see below).

13.2.2 64-bit Displacements

The only instructions which take a full 64-bit *displacement* is loading or storing, using MOV, AL, AX, EAX or RAX (but no other registers) to an absolute 64-bit address. Since this is a relatively rarely used instruction (64-bit code generally uses relative addressing), the programmer has to explicitly declare the displacement size as ABS QWORD:

```
default abs

mov eax,[foo]           ; 32-bit absolute disp, sign-extended
mov eax,[a32 foo]       ; 32-bit absolute disp, zero-extended
mov eax,[qword foo]     ; 64-bit absolute disp

default rel

mov eax,[foo]           ; 32-bit relative disp
mov eax,[a32 foo]       ; d:o, address truncated to 32 bits(!)
mov eax,[qword foo]     ; error
mov eax,[abs qword foo] ; 64-bit absolute disp
```

A sign-extended absolute displacement can access from −2 GB to +2 GB; a zero-extended absolute displacement can access from 0 to 4 GB.

13.3 Interfacing to 64-bit C Programs (Unix)

On Unix, the 64-bit ABI as well as the x32 ABI (32-bit ABI with the CPU in 64-bit mode) is defined by the documents at:

`https://www.nasm.us/abi/unix64`

Although written for AT&T-syntax assembly, the concepts apply equally well for NASM-style assembly. What follows is a simplified summary.

The first six integer arguments (from the left) are passed in RDI, RSI, RDX, RCX, R8, and R9, in that order. Additional integer arguments are passed on the stack. These registers, plus RAX, R10 and R11 are destroyed by function calls, and thus are available for use by the function without saving.

Integer return values are passed in RAX and RDX, in that order.

Floating point is done using SSE registers, except for `long double`, which is 80 bits (`TWORD`) on most platforms (Android is one exception; there `long double` is 64 bits and treated the same as `double`.) Floating-point arguments are passed in `XMM0` to `XMM7`; return is `XMM0` and `XMM1`. `long double` are passed on the stack, and returned in `ST0` and `ST1`.

All SSE and x87 registers are destroyed by function calls.

On 64-bit Unix, `long` is 64 bits.

Integer and SSE register arguments are counted separately, so for the case of

```
void foo(long a, double b, int c)
```

`a` is passed in `RDI`, `b` in `XMM0`, and `c` in `ESI`.

13.4 Interfacing to 64-bit C Programs (Win64)

The Win64 ABI is described by the document at:

`https://www.nasm.us/abi/win64`

What follows is a simplified summary.

The first four integer arguments are passed in `RCX`, `RDX`, `R8` and `R9`, in that order. Additional integer arguments are passed on the stack. These registers, plus `RAX`, `R10` and `R11` are destroyed by function calls, and thus are available for use by the function without saving.

Integer return values are passed in `RAX` only.

Floating point is done using SSE registers, except for `long double`. Floating-point arguments are passed in `XMM0` to `XMM3`; return is `XMM0` only.

On Win64, `long` is 32 bits; `long long` or `_int64` is 64 bits.

Integer and SSE register arguments are counted together, so for the case of

```
void foo(long long a, double b, int c)
```

`a` is passed in `RCX`, `b` in `XMM1`, and `c` in `R8D`.

There is a requirement for functions to allocate a "shadow space" for callees, prior to calling them, that is owned by the callee. This is for the callee to (optionally) store the arguments that are passed in via registers (e.g. for debugging purposes), or in fact any other desired values. This 32-byte shadow space must be allocated just before the stack space used for non-register arguments (5th and beyond, if any).

Before a function call, 16-byte stack alignment is required.

Regarding shadow space and stack alignment, an exception is made for leaf functions, which in Win64 terms means no modification to `RSP` at all (not just having no function calls).

Chapter 14: Troubleshooting

This chapter describes some of the common problems that users have been known to encounter with NASM, and answers them. If you think you have found a bug in NASM, please see section E.2.

14.1 Common Problems

14.1.1 NASM Generates Inefficient Code

We sometimes get 'bug' reports about NASM generating inefficient, or even 'wrong', code on instructions such as `ADD ESP,8`. This is a deliberate design feature, connected to predictability of output: NASM, on seeing `ADD ESP,8`, will generate the form of the instruction which leaves room for a 32-bit offset. You need to code `ADD ESP,BYTE 8` if you want the space-efficient form of the instruction. This isn't a bug, it's user error: if you prefer to have NASM produce the more efficient code automatically enable optimization with the `-O` option (see section 2.1.24).

14.1.2 My Jumps are Out of Range

Similarly, people complain that when they issue conditional jumps (which are `SHORT` by default) that try to jump too far, NASM reports 'short jump out of range' instead of making the jumps longer.

This, again, is partly a predictability issue, but in fact has a more practical reason as well. NASM has no means of being told what type of processor the code it is generating will be run on; so it cannot decide for itself that it should generate `Jcc NEAR` type instructions, because it doesn't know that it's working for a 386 or above. Alternatively, it could replace the out-of-range short `JNE` instruction with a very short `JE` instruction that jumps over a `JMP NEAR`; this is a sensible solution for processors below a 386, but hardly efficient on processors which have good branch prediction *and* could have used `JNE NEAR` instead. So, once again, it's up to the user, not the assembler, to decide what instructions should be generated. See section 2.1.24.

14.1.3 `ORG` Doesn't Work

People writing boot sector programs in the `bin` format often complain that `ORG` doesn't work the way they'd like: in order to place the `0xAA55` signature word at the end of a 512-byte boot sector, people who are used to MASM tend to code

```
ORG 0

; some boot sector code

ORG 510
DW 0xAA55
```

This is not the intended use of the `ORG` directive in NASM, and will not work. The correct way to solve this problem in NASM is to use the `TIMES` directive, like this:

```
ORG 0

; some boot sector code

TIMES 510-($-$$) DB 0
DW 0xAA55
```

The `TIMES` directive will insert exactly enough zero bytes into the output to move the assembly point up to 510. This method also has the advantage that if you accidentally fill your boot sector too full, NASM will catch the problem at assembly time and report it, so you won't end up with a boot sector that you have to disassemble to find out what's wrong with it.

14.1.4 `TIMES` Doesn't Work

The other common problem with the above code is people who write the `TIMES` line as

```
TIMES 510-$ DB 0
```

by reasoning that `$` should be a pure number, just like 510, so the difference between them is also a pure number and can happily be fed to `TIMES`.

NASM is a *modular* assembler: the various component parts are designed to be easily separable for re-use, so they don't exchange information unnecessarily. In consequence, the `bin` output format, even though it has been told by the `ORG` directive that the `.text` section should start at 0, does not pass that information back to the expression evaluator. So from the evaluator's point of view, `$` isn't a pure number: it's an offset from a section base. Therefore the difference between `$` and 510 is also not a pure number, but involves a section base. Values involving section bases cannot be passed as arguments to `TIMES`.

The solution, as in the previous section, is to code the `TIMES` line in the form

```
TIMES 510-($-$$) DB 0
```

in which `$` and `$$` are offsets from the same section base, and so their difference is a pure number. This will solve the problem and generate sensible code.

Appendix A: List of Warning Classes

These are the warning classes currently defined by NASM for the purpose of enabling, disabling and promoting to error. See section 2.1.26 and section 8.14.

A.1 Warning Classes

This list shows each warning class that can be enabled or disabled individually. Each warning containing a `-` character in the name can also be enabled or disabled as part of a group, named by removing one or more `--`-delimited suffixes.

A.1.1 Enabled by default

- `db-empty`: no operand for data declaration

  Warns about a `D`*x* declaration with no operands, producing no output. This is permitted, but often indicative of an error. See section 3.2.1.

- `ea-absolute`: absolute address cannot be RIP-relative

  Warns that an address that is inherently absolute cannot be generated with RIP-relative encoding using `REL`, see section 8.2.1.

- `ea-dispsize`: displacement size ignored on absolute address

  Warns that NASM does not support generating displacements for inherently absolute addresses that do not match the address size of the instruction.

- `float-overflow`: floating point overflow

  Warns about floating point underflow.

- `float-toolong`: too many digits in floating-point number

  Warns about too many digits in floating-point numbers.

- `forward`: forward reference may have unpredictable results

  Warns that a forward reference is used which may have unpredictable results, notably in a `RESB`–type pseudo-instruction. These would be *critical expressions* (see section 3.8) but are permitted in a handful of cases for compatibility with older versions of NASM. This warning should be treated as a severe programming error as the code could break at any time for any number of reasons.

- `implicit-abs-deprecated`: implicit DEFAULT ABS is deprecated

  Warns that in a future version of NASM, the 64-bit default addressing form is likely to change from `DEFAULT ABS` to `DEFAULT REL`. If absolute addressing is indeed intended, it is strongly recommended to specify `DEFAULT ABS` explicitly.

- `label-orphan`: labels alone on lines without trailing `:`

  Warns about source lines which contain no instruction but define a label without a trailing colon. This is most likely indicative of a typo, but is technically correct NASM syntax (see section 3.1.)

- `number-deprecated-hex`: $ prefix for hexadecimal is deprecated

  Warns that the `$` prefix for hexadecimal numbers is deprecated, due to the syntactic conflict with `$` used as a symbol escape prefix. This syntax may be disabled by default in a future version of NASM. Replace `$` with `0x` to ensure compatibility with future versions.

- `number-overflow`: numeric constant does not fit

Covers warnings about numeric constants which don't fit in 64 bits.

- `obsolete-nop`: instruction obsolete and is a noop on the target CPU

  Warns for an instruction which has been removed from the architecture, but has been architecturally defined to be a noop for future CPUs.

- `obsolete-removed`: instruction obsolete and removed on the target CPU

  Warns for an instruction which has been removed from the architecture, and is no longer included in the CPU definition given in the `[CPU]` directive, for example `POP CS`, the opcode for which, `0Fh`, instead is an opcode prefix on CPUs newer than the first generation 8086.

- `obsolete-valid`: instruction obsolete but valid on the target CPU

  Warns for an instruction which has been removed from the architecture, but is still valid on the specific CPU given in the `CPU` directive. Code using these instructions is most likely not forward compatible.

- `other`: any warning not assigned to a specific warning class

  Specifies any warning not included in any specific warning class.

- `pp-else-elif`: `%elif` after `%else`

  Warns that an `%elif`–type directive was encountered after `%else` has already been encounted. As a result, the content of the `%elif` will never be expanded.

- `pp-else-else`: `%else` after `%else`

  Warns that a second `%else` clause was found for the same `%if` statement. The content of this `%else` clause will never be expanded.

- `pp-empty-braces`: empty `%{}` construct

  Warns that an empty `%{}` was encountered. This expands to a single `%` character, which is normally the `%` arithmetic operator.

- `pp-environment`: nonexistent environment variable

  Warns if a nonexistent environment variable is accessed using the `%!` preprocessor construct (see section 5.14.2.) Such environment variables are treated as empty (with this warning issued) starting in NASM 2.15; earlier versions of NASM would treat this as an error.

- `pp-macro-def-case-single`: single-line macro defined both case sensitive and insensitive

  Warns when a single-line macro is defined both case sensitive and case insensitive. The new macro definition will override (shadow) the original one, although the original macro is not deleted, and will be re-exposed if the new macro is deleted with `%undef`, or, if the original macro is the case insensitive one, the macro call is done with a different case.

- `pp-macro-def-greedy-single`: single-line macro

  Warns that a single-line macro is defined which would match a previously existing greedy definition. The new macro definition will override (shadow) the original one, although the original macro is not deleted, and will be re-exposed if the new macro is deleted with `%undef`, and will be invoked if called with a parameter count that does not match the new definition.

- `pp-macro-defaults`: macros with more default than optional parameters

  Warns when a macro has more default parameters than optional parameters. See section 5.6.5 for why one might want to disable this warning.

- `pp-macro-params-legacy`: improperly calling multi-line macro for legacy support

Warns about multi-line macros being invoked with the wrong number of parameters, but for bug-compatibility with NASM versions older than 2.15, NASM tried to fix up the parameters to match the legacy behavior and call the macro anyway. This can happen in certain cases where there are empty arguments without braces, sometimes as a result of macro expansion.

The legacy behavior is quite strange and highly context-dependent, and can be disabled with:

```
%pragma preproc sane_empty_expansion true
```

It is highly recommended to use this option in new code.

- `pp-macro-params-multi`: multi-line macro calls with wrong parameter count

  Warns about multi-line macros being invoked with the wrong number of parameters. See section 5.6.1 for an example of why you might want to disable this warning.

- `pp-macro-params-single`: single-line macro calls with wrong parameter count

  Warns about single-line macros being invoked with the wrong number of parameters.

- `pp-macro-redef-multi`: redefining multi-line macro

  Warns that a multi-line macro is being redefined, without first removing the old definition with `%unmacro`.

- `pp-open-braces`: unterminated `%{...}`

  Warns that a preprocessor parameter enclosed in braces `%{...}` lacks the terminating `}` character.

- `pp-open-brackets`: unterminated `%[...]`

  Warns that a preprocessor `%[...]` construct lacks the terminating `]` character.

- `pp-open-string`: unterminated string

  Warns that a quoted string without a closing quotation mark was encountered during preprocessing.

- `pp-rep-negative`: negative `%rep` count

  Warns about a negative count given to the `%rep` preprocessor directive.

- `pp-reserved`: reserved unimplemented preprocessor directive

  Warns that a preprocessor directive which was inadvertently permitted in earlier versions of NASM without having been properly implemented was seen in the source code. This currently applies to the `%rmacro` (treated as `%macro`) and `%irmacro` (treated as `%imacro`) directives. These directive names are reserved and may be properly implemented in the future, changing the meaning of the source code. directive is

- `pp-sel-range`: `%sel()` argument out of range

  Warns that the `%sel()` preprocessor function was passed a value less than 1 or larger than the number of available arguments.

- `pp-trailing`: trailing garbage ignored

  Warns that the preprocessor encountered additional text where no such text was expected. This can sometimes be the result of an incorrectly written expression, or arguments that are inadvertently separated.

- `prefix-bnd`: invalid `BND` prefix

  Warns about ineffective use of the `BND` prefix when the `JMP` instruction is converted to the `SHORT` form. This should be extremely rare since the short `JMP` only is applicable to jumps inside the same module, but if it is legitimate, it may be necessary to use `bnd jmp dword`.

- `prefix-hint-dropped`: invalid branch hint prefix dropped

Warns that the {PT} (predict taken) or {PN} (predict not taken) branch prediction hint prefixes are specified on an instruction that does not take these prefixes. As these prefixes alias the segment override prefixes, this may be a very serious error, and therefore NASM will not generate these prefixes. To force these prefixes to be emitted, use DS or CS, instead, respectively.

- `prefix-hle`: invalid HLE prefix

  Warns about invalid use of the HLE XACQUIRE or XRELEASE prefixes.

- `prefix-invalid`: invalid prefix for instruction

  Warns about an instruction which is only valid with certain combinations of prefixes. The prefix will still be generated as requested, but the result may be a completely different instruction or result in a #UD trap.

- `prefix-lock-error`: LOCK prefix on unlockable instruction

  Warns about LOCK prefixes specified on unlockable instructions.

- `prefix-lock-xchg`: superfluous LOCK prefix on XCHG instruction

  Warns about a LOCK prefix added to an XCHG instruction. The XCHG instruction is *always* locking, and so this prefix is not necessary; however, NASM will generate it if explicitly provided by the user, so this warning indicates that suboptimal code is being generated.

- `prefix-opsize`: invalid operand size prefix

  Warns that an operand prefix (`o16`, `o32`, `o64`, `osp`) is invalid for the specified instruction has been specified. The operand prefix will be ignored by the assembler.

- `prefix-seg`: segment prefix ignored in 64-bit mode

  Warns that an `es`, `cs`, `ss` or `ds` segment override prefix has no effect in 64-bit mode. The prefix will still be generated as requested.

- `ptr`: non-NASM keyword used in other assemblers

  Warns about keywords used in other assemblers that might indicate a mistake in the source code. Currently only the MASM PTR keyword is recognized. If (limited) MASM compatibility is desired, the `%use masm` macro package is available, see section 7.5; however, carefully note the caveats listed.

- `regsize`: register size specification ignored

  Warns about a register with implicit size (such as EAX, which is always 32 bits) been given an explicit size specification which is inconsistent with the size of the named register, e.g. `WORD EAX`. `DWORD EAX` or `WORD AX` are permitted, and do not trigger this warning. Some registers which *do not* imply a specific size, such as K0, may need this specification unless the instruction itself implies the instruction size:

```
KMOVW K0,[foo]          ; OK: KMOVW = 16 bits
KMOV  WORD K0,[foo]     ; OK: WORD K0 = 16 bits
KMOV  K0,WORD [foo]     ; OK: WORD [foo] = 16 bits
KMOV  K0,[foo]          ; Error: unknown size
```

- `section-alignment-rounded`: section alignment rounded up

  Warn if a section alignment is specified which is not supported by the underlying object format, but can be rounded up to a supported value.

- `user`: `%warning` directives

  Controls output of `%warning` directives (see section 5.12).

- `warn-stack-empty`: warning stack empty

A `[WARNING POP]` directive was executed when the warning stack is empty. This is treated as a `[WARNING *all]` directive.

- `zeroing`: RES*x* in initialized section becomes zero

  A RES*x* directive was used in a section which contains initialized data, and the output format does not support this. Instead, this will be replaced with explicit zero content, which may produce a large output file.

- `zext-reloc`: relocation zero-extended to match output format

  Warns that a relocation has been zero-extended due to limitations in the output format.

A.1.2 Enabled and promoted to error by default

- `directive-garbage-eol`: garbage after directive

  Text was found after a directive. This is a warning so it can be suppressed, because previous versions of NASM did not check for this condition.

- `label-redef-late`: label (re)defined during code generation

  The value of a label changed during the final, code-generation pass. This may be the result of strange use of the preprocessor. This is very likely to produce incorrect code and may end up being an unconditional error in a future version of NASM.

- `pp-macro-def-param-single`: single-line macro defined with and without parameters

  Warns if the same single-line macro is defined with and without parameters. The new macro definition will override (shadow) the original one, although the original macro is not deleted, and will be re-exposed if the new macro is deleted with `%undef`.

- `prefix-badmode-o64`: o64 prefix invalid in 16/32-bit mode

  Warns that an `a64` prefix was specified in 16- or 32-bit mode. If the error is demoted to a warning or suppressed, the prefix is ignored by the assembler, but is likely to trigger futher errors.

A.1.3 Disabled by default

- `float-denorm`: floating point denormal

  Warns about denormal floating point constants.

- `float-underflow`: floating point underflow

  Warns about floating point underflow (a nonzero constant rounded to zero.)

- `label-redef`: label redefined to an identical value

  Warns if a label is defined more than once, but the value is identical. It is an unconditional error to define the same label more than once to *different* values.

- `phase`: phase error during stabilization

  Warns about symbols having changed values during the second-to-last assembly pass. This is not inherently fatal, but may be a source of bugs.

- `pragma-bad`: malformed `%pragma`

  Warns about a malformed or otherwise unparsable `%pragma` directive.

- `pragma-empty`: empty `%pragma` directive

  Warns about a `%pragma` directive containing nothing. This is treated identically to `%pragma ignore` except for this optional warning.

- `pragma-na`: `%pragma` not applicable to this compilation

Warns about a `%pragma` directive which is not applicable to this particular assembly session. This is not yet implemented.

- `pragma-unknown`: unknown `%pragma` facility or directive

  Warns about an unknown `%pragma` directive. This is not yet implemented for most cases.

- `reloc-abs-byte`: 8-bit absolute section-crossing relocation

  Warns that an 8-bit absolute relocation that could not be resolved at assembly time was generated in the output format.

  This is usually normal, but may not be handled by all possible target environments

- `reloc-abs-dword`: 32-bit absolute section-crossing relocation

  Warns that a 32-bit absolute relocation that could not be resolved at assembly time was generated in the output format.

  This is usually normal, but may not be handled by all possible target environments

- `reloc-abs-qword`: 64-bit absolute section-crossing relocation

  Warns that a 64-bit absolute relocation that could not be resolved at assembly time was generated in the output format.

  This is usually normal, but may not be handled by all possible target environments

- `reloc-abs-word`: 16-bit absolute section-crossing relocation

  Warns that a 16-bit absolute relocation that could not be resolved at assembly time was generated in the output format.

  This is usually normal, but may not be handled by all possible target environments

- `reloc-rel-byte`: 8-bit relative section-crossing relocation

  Warns that an 8-bit relative relocation that could not be resolved at assembly time was generated in the output format.

  This is usually normal, but may not be handled by all possible target environments

- `reloc-rel-dword`: 32-bit relative section-crossing relocation

  Warns that a 32-bit relative relocation that could not be resolved at assembly time was generated in the output format.

  This is usually normal, but may not be handled by all possible target environments

- `reloc-rel-qword`: 64-bit relative section-crossing relocation

  Warns that an 64-bit relative relocation that could not be resolved at assembly time was generated in the output format.

  This is usually normal, but may not be handled by all possible target environments

- `reloc-rel-word`: 16-bit relative section-crossing relocation

  Warns that a 16-bit relative relocation that could not be resolved at assembly time was generated in the output format.

  This is usually normal, but may not be handled by all possible target environments

- `unknown-warning`: unknown warning in `-W`/`-w` or warning directive

  Warns about a `-w` or `-W` option or a `[WARNING]` directive that contains an unknown warning name or is otherwise not possible to process.

A.2 Warning Class Groups

Warning class groups are aliases for all warning classes with a common prefix. This list shows the warnings that are currently included in specific warning groups.

- `all`: all possible warnings

  `all` is an group alias for *all* warning classes. Thus, `-w+all` enables all available warnings, and `-w-all` disables warnings entirely (since NASM 2.13).

- `ea`: group alias for:

  ```
  ea-absolute
  ea-dispsize
  ```

- `float`: group alias for:

  ```
  float-denorm
  float-overflow
  float-toolong
  float-underflow
  ```

- `label`: group alias for:

  ```
  label-orphan
  label-redef
  label-redef-late
  ```

- `number`: group alias for:

  ```
  number-deprecated-hex
  number-overflow
  ```

- `obsolete`: group alias for:

  ```
  obsolete-nop
  obsolete-removed
  obsolete-valid
  ```

- `pp`: group alias for:

  ```
  pp-else-elif
  pp-else-else
  pp-empty-braces
  pp-environment
  pp-macro-def-case-single
  pp-macro-def-greedy-single
  pp-macro-def-param-single
  pp-macro-defaults
  pp-macro-params-legacy
  pp-macro-params-multi
  pp-macro-params-single
  pp-macro-redef-multi
  pp-open-braces
  pp-open-brackets
  pp-open-string
  pp-rep-negative
  pp-reserved
  pp-sel-range
  pp-trailing
  ```

- `pp-else`: group alias for:

  ```
  pp-else-elif
  pp-else-else
  ```

- `pp-macro`: group alias for:

  ```
  pp-macro-def-case-single
  pp-macro-def-greedy-single
  ```

```
pp-macro-def-param-single
pp-macro-defaults
pp-macro-params-legacy
pp-macro-params-multi
pp-macro-params-single
pp-macro-redef-multi
```

- `pp-macro-def`: group alias for:

```
pp-macro-def-case-single
pp-macro-def-greedy-single
pp-macro-def-param-single
```

- `pp-macro-params`: group alias for:

```
pp-macro-params-legacy
pp-macro-params-multi
pp-macro-params-single
```

- `pp-open`: group alias for:

```
pp-open-braces
pp-open-brackets
pp-open-string
```

- `pragma`: group alias for:

```
pragma-bad
pragma-empty
pragma-na
pragma-unknown
```

- `prefix`: group alias for:

```
prefix-badmode-o64
prefix-bnd
prefix-hint-dropped
prefix-hle
prefix-invalid
prefix-lock-error
prefix-lock-xchg
prefix-opsize
prefix-seg
```

- `prefix-lock`: group alias for:

```
prefix-lock-error
prefix-lock-xchg
```

- `reloc`: group alias for:

```
reloc-abs-byte
reloc-abs-dword
reloc-abs-qword
reloc-abs-word
reloc-rel-byte
reloc-rel-dword
reloc-rel-qword
reloc-rel-word
```

- `reloc-abs`: group alias for:

```
reloc-abs-byte
reloc-abs-dword
reloc-abs-qword
reloc-abs-word
```

- `reloc-rel`: group alias for:

```
reloc-rel-byte
reloc-rel-dword
```

```
reloc-rel-qword
reloc-rel-word
```

A.3 Warning Class Aliases for Backward Compatiblity

These aliases are defined for compatibility with earlier versions of NASM.

- `bad-pragma`: malformed `%pragma`

  Alias for `pragma-bad`.

- `bnd`: invalid `BND` prefix

  Alias for `prefix-bnd`.

- `environment`: nonexistent environment variable

  Alias for `pp-environment`.

- `hle`: invalid HLE prefix

  Alias for `prefix-hle`.

- `lock`: `LOCK` prefix on unlockable instruction

  Alias for `prefix-lock-error`.

- `macro-def-case-single`: single-line macro defined both case sensitive and insensitive

  Alias for `pp-macro-def-case-single`.

- `macro-def-greedy-single`: single-line macro

  Alias for `pp-macro-def-greedy-single`.

- `macro-def-param-single`: single-line macro defined with and without parameters

  Alias for `pp-macro-def-param-single`.

- `macro-defaults`: macros with more default than optional parameters

  Alias for `pp-macro-defaults`.

- `macro-params-legacy`: improperly calling multi-line macro for legacy support

  Alias for `pp-macro-params-legacy`.

- `macro-params-multi`: multi-line macro calls with wrong parameter count

  Alias for `pp-macro-params-multi`.

- `macro-params-single`: single-line macro calls with wrong parameter count

  Alias for `pp-macro-params-single`.

- `negative-rep`: negative `%rep` count

  Alias for `pp-rep-negative`.

- `not-my-pragma`: `%pragma` not applicable to this compilation

  Alias for `pragma-na`.

- `orphan-labels`: labels alone on lines without trailing `:`

  Alias for `label-orphan`.

- `unknown-pragma`: unknown `%pragma` facility or directive

  Alias for `pragma-unknown`.

Appendix B: Ndisasm

The Netwide Disassembler, NDISASM

B.1 Introduction

The Netwide Disassembler is a small companion program to the Netwide Assembler, NASM. It seemed a shame to have an x86 assembler, complete with a full instruction table, and not make as much use of it as possible, so here's a disassembler which shares the instruction table (and some other bits of code) with NASM.

The Netwide Disassembler does nothing except to produce disassemblies of *binary* source files. NDISASM does not have any understanding of object file formats, like `objdump`, and it will not understand DOS `.EXE` files like `debug` will. It just disassembles.

B.2 Running NDISASM

To disassemble a file, you will typically use a command of the form

```
ndisasm -b {16|32|64} filename
```

NDISASM can disassemble 16-, 32- or 64-bit code equally easily, provided of course that you remember to specify which it is to work with. If no `-b` switch is present, NDISASM works in 16-bit mode by default. The `-u` switch (for USE32) also invokes 32-bit mode.

Two more command line options are `-r` which reports the version number of NDISASM you are running, and `-h` which gives a short summary of command line options.

B.2.1 Specifying the Input Origin

To disassemble a `DOS .COM` file correctly, a disassembler must assume that the first instruction in the file is loaded at address `0x100`, rather than at zero. NDISASM, which assumes by default that any file you give it is loaded at zero, will therefore need to be informed of this.

The `-o` option allows you to declare a different origin for the file you are disassembling. Its argument may be expressed in any of the NASM numeric formats: decimal by default, if it begins with '`$`' or '`0x`' or ends in '`H`' it's `hex`, if it ends in '`Q`' it's `octal`, and if it ends in '`B`' it's `binary`.

Hence, to disassemble a `.COM` file:

```
ndisasm -o100h filename.com
```

will do the trick.

B.2.2 Code Following Data: Synchronization

Suppose you are disassembling a file which contains some data which isn't machine code, and *then* contains some machine code. NDISASM will faithfully plough through the data section, producing machine instructions wherever it can (although most of them will look bizarre, and some may have unusual prefixes, e.g. '`FS OR AX,0x240A`'), and generating 'DB' instructions ever so often if it's totally stumped. Then it will reach the code section.

Supposing NDISASM has just finished generating a strange machine instruction from part of the data section, and its file position is now one byte *before* the beginning of the code section. It's entirely possible that another spurious instruction will get generated, starting with the final byte of the data section, and then the correct first instruction in the code section will not be seen because the starting point skipped over it. This isn't really ideal.

To avoid this, you can specify a 'synchronization' point, or indeed as many synchronization points as you like (although NDISASM can only handle 2147483647 sync points internally). The definition of a sync point is this: NDISASM guarantees to hit sync points exactly during disassembly. If it is thinking about generating an instruction which would cause it to jump over a sync point, it will discard that instruction and output a '`db`' instead. So it *will* start disassembly exactly from the sync point, and so you *will* see all the instructions in your code section.

Sync points are specified using the `-s` option: they are measured in terms of the program origin, not the file position. So if you want to synchronize after 32 bytes of a `.COM` file, you would have to do

```
ndisasm -o100h -s120h file.com
```

rather than

```
ndisasm -o100h -s20h file.com
```

As stated above, you can specify multiple sync markers if you need to, just by repeating the `-s` option.

B.2.3 Mixed Code and Data: Automatic (Intelligent) Synchronization

Suppose you are disassembling the boot sector of a DOS floppy (maybe it has a virus, and you need to understand the virus so that you know what kinds of damage it might have done you). Typically, this will contain a `JMP` instruction, then some data, then the rest of the code. So there is a very good chance of NDISASM being *misaligned* when the data ends and the code begins. Hence a sync point is needed.

On the other hand, why should you have to specify the sync point manually? What you'd do in order to find where the sync point would be, surely, would be to read the `JMP` instruction, and then to use its target address as a sync point. So can NDISASM do that for you?

The answer, of course, is yes: using either of the synonymous switches `-a` (for automatic sync) or `-i` (for intelligent sync) will enable `auto-sync` mode. Auto-sync mode automatically generates a sync point for any forward-referring PC-relative jump or call instruction that NDISASM encounters. (Since NDISASM is one-pass, if it encounters a PC-relative jump whose target has already been processed, there isn't much it can do about it...)

Only PC-relative jumps are processed, since an absolute jump is either through a register (in which case NDISASM doesn't know what the register contains) or involves a segment address (in which case the target code isn't in the same segment that NDISASM is working in, and so the sync point can't be placed anywhere useful).

For some kinds of file, this mechanism will automatically put sync points in all the right places, and save you from having to place any sync points manually. However, it should be stressed that auto-sync mode is *not* guaranteed to catch all the sync points, and you may still have to place some manually.

Auto-sync mode doesn't prevent you from declaring manual sync points: it just adds automatically generated ones to the ones you provide. It's perfectly feasible to specify `-i` *and* some `-s` options.

Another caveat with auto-sync mode is that if, by some unpleasant fluke, something in your data section should disassemble to a PC-relative call or jump instruction, NDISASM may obediently place a sync point in a totally random place, for example in the middle of one of the instructions in your code section. So you may end up with a wrong disassembly even if you use auto-sync. Again, there isn't much I can do about this. If you have problems, you'll have to use manual sync points, or use the `-k` option (documented below) to suppress disassembly of the data area.

B.2.4 Other Options

The `-e` option skips a header on the file, by ignoring the first N bytes. This means that the header is *not* counted towards the disassembly offset: if you give `-e10 -o10`, disassembly will start at byte 10 in the file, and this will be given offset 10, not 20.

The `-k` option is provided with two comma-separated numeric arguments, the first of which is an assembly offset and the second is a number of bytes to skip. This *will* count the skipped bytes towards

the assembly offset: its use is to suppress disassembly of a data section which wouldn't contain anything you wanted to see anyway.

Appendix C: NASM Version History

C.1 NASM 3 Series

The NASM 3 series added support for the APX instruction encodings (extended GPRs), as well as preprocessor enhancements meant to make evolving code simpler.

It is the production version of NASM since 2025.

C.1.1 Version 3.02

- Fix build problems on C23 compilers using a pre-C23 version of `<stdbool.h>` which defines `bool` as a macro in violation of the C23 specification.
- The immediate form of the `JMPE` instruction (opcode `0F B8`) has been changed to an absolute address, as in the Itanium Architecture Software Developer's Manual, version 2.3, Volume 4, page 4:249. Hopefully this won't break whatever virtual environments use `JMPE`, but it is the closest thing there is to an official specification for this opcode.

  Being an *absolute* address, treat it equivalent to a `FAR` jump and do not default to 64 bits in 64-bit mode.

  That `JMPE` has apparently been wrong all these years is probably as good of a hint as any how much it has been actually used, but it *does* have the possibility of breaking virtual environments. In that case, please file a bug report to `https://bugs.nasm.us` with details about the virtual environment, and we will figure out a suitable solution.
- Various build fixes. Fix the documentation not building on MacOS because of the `cp` utility lacking `-u` there. Also fix not building generally due to wrong link formatting. Another fix was a typo in `compiler.h` related to a C++ check.
- Corrections to assembling encodings:

  Fix `CMP` allowing `LOCK` which is illegal.

  Correct multiple `AVX512` instructions such as `VCVTSD2SI`, `VCVTSD2USI`, `VCVTSS2SI`, `VCVTSS2USI`, `VCVTTSD2SI`, `VCVTTSD2USI`, `VCVTTSS2SI`, `VCVTTSS2USI`, `VGETEXPSH`, `VGETMANTSH`, `MOVDDUP`, `VMOVDDUP`.

  Fixed other encodings or instruction formats for instructions `UWRMSR`, `CMPSD`, `VCMPSS`, `V4FMADDSS`, `V4FNMADDSS`, `VCVTDQ2PH`, `VCVTPD2PH`, `VCVTPH2UDQ`, `VCVTQQ2PH`, `VCVTUDQ2PH`, `VCVTUQQ2PH`, `VGETEXPSH`, `VGETMANTSH`, `VRCPPH`, `VRSQRTPH`, `VCVTPH2BF8`, `VCVTPH2BF8S`, `VCVTPH2HF8`, `VCVTPH2HF8S`.

  Fixed typos in `VP4DPWSSD` mnemonic.

  Fixed `BYTE` and `WORD` operands getting the same encoding on arithmetic instructions such as `CMP`.

  Fixed `PUSH` not assembling when used with a `DWORD` in 64-bit mode. This is not a recommended syntax as the operand size is still 64 bits, but was permitted by earlier versions of NASM.

  Fix parsing of `$`–escaped symbols in directives (`GLOBAL`, `STATIC`, `EXTERN`, `REQUIRED`, `COMMON`).
- Corrections to disassembling:

  Shift instructions with the unity operand were getting disassembled to a zero operand instead of one.

  `JMP`, `CALL` and `JMPE` disassembled incorrectly with the register operands.
- Whole bunch of minor fixes to operand sizes, operand size prefixes. Changes mostly return the behavior known from 2.16.03.

`MOV [mem], label` would be accepted without size specifiers which could cause unintended consequences. Raise an error if no size was specified and one of the operands is a memory reference and another operands is a label.

`JMP NEAR` is now the same as `JMP STRICT NEAR` as the `STRICT` is redundant here. `JMP WORD` on the other hand is up for optimization as `NEAR` and `WORD` relate to different things – jump lengths and operation sizes respectively.

Using redundant (or not) but valid operands size prefixes was fixed on instructions such as `IRET`, `PUSHF`, `POPF`, `PUSH` and `POP`.

Using an operand size prefix on a `JMP` or `CALL` instruction could generate an invalid instruction. This appears to have been a long-standing bug. Specifying the operand size by specifying the size of the immediate explicitly (e.g. `JMP DWORD label`) has always worked correctly, however.

- Add support for C2y-style `\o` escape sequences, braced escape sequences, and as NASM extensions, decimal escape sequences (`\d`) and control-character escape sequences (`\^`). See section 3.4.2.
- Fix generation of the short opcodes for `ADD`, `OR`, `ADC`, `SBB`, `AND`, `SUB`, `XOR`, and `CMP AL,imm8`.
- Fix truncation of the generated constant to 63 bits when invoking a single-line macro when an argument is defined as `=/b` or `=/ub`.
- Add an `%env()` preprocessor function as a more robust and flexible alternative to the `%!` construct. See section 5.5.7.
- The maximum number of multi-line macro parameters is now a configurable limit. See section 2.1.32.
- The `--limit-` options and `%pragma limit` now accept the keywords `default`, `maximum`, and `reset`. See section 2.1.32.
- Fix parsing of `seg:offs`-style `FAR` pointers in `EQU`.
- Fix the `%clear` preprocessor directive hanging when given parameters.
- The never properly implemented (or documented) preprocessor directives `%rmacro` and `%irmacro` are now properly disabled; to avoid breaking existing code, they fall back to `%macro` and `%imacro` with a suitable warning.

  Programmers should *not* rely on this behavior: in the future, these directives might actually be (properly) implemented.
- Fix a crash when `-M` directives were used in response files.
- New listing option `-Lc` to include the contents of `INCBIN` files, see section 2.1.4.
- New listing option `-Lt` to include the output from every iteration of `TIMES` and `ALIGN` directives, see section 2.1.4.
- The `%pragma list options` directive now support resetting options to their command-line default, see section 2.1.4.
- New predefined macros `__?LIST_OPTIONS?__` and `__?LIST_OPTIONS_DEFAULT?__` to query the active and command-line default listing options. See section 2.1.4.

C.1.2 Version 3.01

- A new `obj2` version of the `obj` output format, intended for use on OS/2. See section 9.5.
- The condition after `%if` or `%elif` would be evaluated while output is suppressed after `%exitrep` or `%exitmacro`. Although no output would be generated in either case, assembly would fail if evaluating the expression triggered an error.

- Fix encoding of `TCVTROWPS2PHL`, correct multiple AVX512-BF16 instructions' operand formats and typoed mnemonics.
- The unofficial but obvious alternate form `TEST reg,mem` was not accepted by NASM 3.00; corrected.
- For the `obj` output format, multiple `GROUP` directives can now be specified for the same group; the resulting group includes all sections specified in all `GROUP` directives for the group.
- A new `%selbits()` preprocessor function. See section 5.5.21.
- A new `--bits` option as convenience shorthand for `--before "BITS ..."`. See section 2.1.31.
- The options and pragmas for configuring external label mangling were inconsistent, the former using the spelling `postfix` and the latter `suffix`. Furthermore, these were also documented as *directives* in addition to pragmas. Implement the already documented directives (bracketed forms only) and allow both `postfix` and `suffix` in all cases.

  See section 2.1.28 and section 8.10.
- Define additional permissive patterns and fix several opcode bugs.
- Fix parsing of two-operand forms of x87 instructions.
- Fix bogus "absolute address can not be RIP-relative" warning.
- Hopefully fix building with OpenWatcom.
- Generate a warning, promoted to error by default, on the use of `o64` prefixes in 16- or 32-bit mode. If demoted to a warning or suppressed the prefix is ignored, but likely will trigger subsequent, harder to debug, error messages.
- More consistent handling of jump and call instructions with specified operand sizes.
- Fix an operand size handling bug in the `CMPXCHG` instruction.

C.1.3 Version 3.00

- Improve the documentation for building from source (appendix D).
- Add support for the APX and AVX10 instruction sets, and various miscellaneous new instructions.
- Add new preprocessor functions: `%b2hs()`, `%chr()`, `%depend()`, `%find()`, `%findi()`, `%hs2b()`, `%null()`, `%ord()`, `%pathsearch()`, and `%realpath()`. See section 5.5.
- New preprocessor directive `%note` to insert a note in the list file, without issuing an external diagnosic. Unlike a comment, it is optionally macro-expanded, see section 5.12.
- New preprocessor directive `%iffile` (and corresponding function `%isfile()`) to test for the existence of a file. See section 5.7.12.
- New preprocessor directive `%ifdirective` to test for the existence of a preprocessor directive, assembly directive, or pseudo-instruction; see section 5.7.10.
- Fix a number of invalid memory references (usually causing crashes) on various invalid inputs.
- Fix multiple bugs in the handling of `$`–escaped symbols.
- The use of `$` as a prefix for hexadecimal numbers has been deprecated, and will now issue a warning. A new directive `[DOLLARHEX]` can be used to disable this syntax entirely, see section 8.12.
- Fix the generation of segment selector references (mainly used in the `obj` output format.)
- Fix crash in the `obj` backend when code was emitted into the default segment, without any labels having been defined.

- Clean up the command-line help text (`-h`) and break it down into individual topics, as the previous output was just too verbose to be practical as a quick reference.
- The implicit `DEFAULT ABS` in 64-bit mode is deprecated and may be changed to `REL` in the future. See section 8.2. A warning is now emitted for this condition.
- It is now possible to set the `REL`/`ABS` default for memory accesses using `FS:` or `GS:`, see section 8.2.
- The `__?DEFAULT?__` standard macro now reflects the settings of the `DEFAULT` directive. See section 6.4.
- The NASM preprocessor now assumes that an unknown directive starting with `%if` or `%elif` is a misspelled or not yet implemented conditional directive, and tries to match it with a corresponding `%endif`. See section 5.7.14.
- The `masm` macro package now defines a macro for x87 register syntax. See section 7.5.
- A new macro package, `vtern`, to simplify generation of the control immediates for the `VPTERNLOGD` and `VPTERNLOGQ` instructions. See section 7.6.
- A new command line option `-LF` allows overriding `[LIST -]` directives.
- In the `obj` output format, allow a segment in the `FLAT` pseudo-group to also belong to another (real) group. Used on OS/2.
- Add a new `build_version` directive to the Mach-O backend. See section 9.9.6.
- Fix a spec violation in the generation of DWARF debugging information on ELF.
- Response files can now be nested.
- Many documentation improvements.

C.2 NASM 2 Series

The NASM 2 series added support for x86-64, and was the production versions of NASM from 2007 to 2025.

C.2.1 Version 2.16.03

This is a source build machinery and documentation update only. There are no functionality changes.

- Fix building from `git` in a separate directory from the source.
- Remove some irrelevant files from the source distribution.
- Make the documentation stronger that `-O0` or `-O1` are probably not what the user wants. See section 2.1.24.
- Fix `configure --enable-lto` build option.
- Update the included RPM `.spec` file.

C.2.2 Version 2.16.02

- Fix building from the source distribution in a separate directory from the source.
- Fix a number of issues when building from source, mostly involving `configure` or dependency generation.

  In particular, more aggressively avoid cross-compilation problems on Unix/Linux systems automatically invoking WINE. We could end up invoking WINE even when we didn't want to, making `configure` think it was running native when in fact cross-compiling.
- Hopefully fix compiling with the latest versions of MSVC/nmake.

- Windows host: add embedded manifest file. Without a manifest, Windows applications force a fixed PATH_MAX limit to any pathname; this is unnecessary.
- Add support VEX-encoded SM4-NI instructions.
- Add support for VEX-encoded SM3-NI instructions.
- Add support for VEX-encoded SHA512-NI instructions.
- PTWRITE opcode corrected (F3 prefix required.)
- Disassembler: the SMAP instructions are NP; notably the prefixed versions of CLAC are ERETU/ERETS.
- Add support for Flexible Return and Exception Delivery (FRED): the LKGS, ERETS and ERETU instructions.
- Fix external references to segments in the obj (OMF) and possibly other output formats.
- Always support up to 8 characters, i.e. 64 bits, in a string-to-numeric conversion.
- Preprocessor: add %map() function to expand a macro from a list of arguments, see section 5.5.14.
- Preprocessor: allow the user to specify the desired radix for an evaluated parameter. It doesn't make any direct difference, but can be nice for debugging or turning into strings. See the = modifier in section 5.3.1.
- Update documentation: __USE_*package*__ is now __?USE_*package*?__.
- Documentation: correct a minor problem in the expression grammar for D*x* statements, see section 3.2.1.
- Preprocessor: correctly handle empty %rep blocks.
- Preprocessor: add options for a base prefix to %num(), see section 5.5.16.
- Preprocessor: add a %hex() function, equivalent to %eval() except that it producess hexadecimal values that are nevertheless valid NASM numeric constants, see section 5.5.10.
- Preprocessor: fix the parameter number in error messages (should be 1-based, like %*num* references to multi-line macro arguments.)
- Documentation: be more clear than the bin format is simply a linker built into NASM. See section 9.1.
- Adjust the LOCK prefix warning for XCHG.

  LOCK XCHG *reg*,*mem* would issue a warning for being unlockable, which is incorrect. In this case the *reg*,*mem* encoding is simply an alias for the *mem*,*reg* encoding. However, XCHG is *always* locked, so create a new warning (-w+prefix-lock-xchg) to explicitly flag a user-specified LOCK XCHG; default off. Future versions of NASM may remove the LOCK prefix when optimization is enabled.
- Fix broken dependency-list generation.
- Add optional warnings for specific relocation types (-w+reloc-*, see appendix A), default off.

  Some target environments may have specific restrictions on what kinds of relocations are possible or allowed.
- Error out on certain bad syntax in D*x* statements, such as db 1 2. See section 3.2.1.

C.2.3 Version 2.16.01

This is a documentation update release only. There are no functionality changes.

- Fix the creation of the table of contents in the HTML version of the documentation.

C.2.4 Version 2.16

- Support for the `rdf` format has been discontinued and all the RDOFF utilities has been removed.
- The `--reproducible` option now leaves the filename field in the COFF object format blank. This was always rather useless since it is only 18 characters long; as such debug formats have to carry their own filename information anyway.
- Fix handling of MASM-syntax reserved memory (e.g. `dw ?`) when used in structure definitions.
- The preprocessor now supports functions, which can be less verbose and more convenient than the equivalent code implemented using directives. See section 5.5.
- Fix the handling of `%00` in the preprocessor.
- Fix incorrect handling of path names affecting error messages, dependency generation, and debug format output.
- Support for the RDOFF output format and the RDOFF tools have been removed. The RDOFF tools had already been broken since at least NASM 2.14. For flat code the ELF output format recommended; for segmented code the `obj` (OMF) output format.
- New facility: preprocessor functions. Preprocessor functions, which are expanded similarly to single-line macros, can greatly simplify code that in the past would have required a lengthy list of directives and intermediate macros. See section 5.5.
- Single-line macros can now declare parameters (using a `&&` prefix) that creates a quoted string, but does *not* requote an already quoted string. See section 5.3.1.
- Instruction table updated per public information available as of November 2022.
- All warnings in the preprocessor have now been assigned warning classes. See appendix A.
- Fix the invalid use of `RELA`–type relocations instead of `REL`–type relocations when generating DWARF debug information for the `elf32` output format.
- Fix the handling `at` in `istruc` when the structure contains local labels. See section 6.14.2.
- When assembling with `--reproducible`, don't encode the filename in the COFF header for the `coff`, `win32` or `win64` output formats. The COFF header only has space for an 18-character filename, which makes this field rather useless in the first place. Debug output data, if enabled, is not affected.
- Fix incorrect size calculation when using MASM syntax for non-byte reservations (e.g. `dw ?`.)
- Allow forcing an instruction in 64-bit mode to have a (possibly redundant) REX prefix, using the syntax `{rex}` as a prefix.
- Add a `{vex}` prefix to enforce VEX (AVX) encoding of an instruction, either using the 2- or 3-byte VEX prefixes.
- The `CPU` directive has been augmented to allow control of generation of VEX (AVX) versus EVEX (AVX-512) instruction formats, see section 8.11.
- Some recent instructions that previously have been only available using EVEX encodings are now also encodable using VEX (AVX) encodings. For backwards compatibility these encodings are not enabled by default, but can be generated either via an explicit `{vex}` prefix or by specifying either `CPU LATEVEX` or `CPU NOEVEX`; see section 8.11.
- Document the already existing `%unimacro` directive. See section 5.6.12.
- Fix a code range generation bug in the DWARF debug format (incorrect information in the `DW_AT_high_pc` field) for the ELF output formats. This bug happened to cancel out with a bug in older versions of the GNU binutils linker, but breaks with other linkers and updated or other linkers that expect the spec to be followed.

- Fix segment symbols with addends, e.g. `jmp _TEXT+10h:0` in output formats that support segment relocations, e.g. the `obj` format.
- Fix various crashes and hangs on invalid input.

C.2.5 Version 2.15.05

- Fix `%ifid $` and `%ifid $$` incorrectly being treated as true. See section 5.7.7.
- Add `--reproducible` option to suppress NASM version numbers and timestamps in output files. See section 2.1.35.

C.2.6 Version 2.15.04

- More sensible handling of the case where one single-line macro definition will shadow another. A warning will be issued, but the additional definition will be allowed. For the existing error case where both a parameterless and parametered macro are created, that warning is promoted to an error by default.
- Add special preprocessor tokens `%*?` and `%*??` that expand like `%?` and `%??` in single-line macros only. See section 5.3.6.
- Correct the encoding of the `ENQCMDS` and `TILELOADT1` instructions.
- Fix case where the COFF backend (the `coff`, `win32` and `win64` output formats) would add padding bytes in the middle of a section if a `SECTION`/`SEGMENT` directive was provided which repeated an `ALIGN=` attribute. This neither matched legacy behavior, other backends, or user expectations.
- Fix SSE instructions not being recognized with an explicit memory operation size (e.g. `movsd qword [eax],xmm0`).
- The `-L+` option no longer enables `-Lw`, which is mainly useful to debug NASM crashes. See section 2.1.4.
- Document long-standing hazards in the use of `$` in D*x* statements, see section 3.2.1.
- The NASM-only RDOFF output format backend, which has been broken since at least NASM 2.14, has been disabled. The RDOFF tools are scheduled to be removed from the NASM distribution in NASM 2.16. If you have a concrete use case for RDOFF, please file a NASM bug report at `https://bugs.nasm.us/` as soon as possible.

C.2.7 Version 2.15.03

- Add instructions from the Intel Instruction Set Extensions and Future Features Programming Reference, June 2020. This includes AVX5512 `bfloat16`, AVX512 mask intersect, and Intel Advanced Matrix Extensions (AMX).
- Support for `bfloat16` floating-point constants. See section 3.4.6 and section 7.3.
- Properly display warnings in preprocess-only mode.
- Fix copy-and-paste of examples from the PDF documentation.
- Debug information now properly reflect the line numbers of macro invocations (unless declared `.nolist`).
- Fix excessive alignment of sections in the `coff`/`win32`/`win64` output formats when the user-specified alignment is less than the default alignment for the section or section type.
- Fix explicit token pasting (`%+`, section 5.3.4) for the cases where one or more parts result from empty token expansion, resulting in `%+` tokens at the beginning or end, or multiple ones in a row.
- Fix macro label capture (`%00`, section 5.6.7).

- Much better documentation for the MASM compatibility package, `%use masm` (see section 7.5).
- Fix `LEA` without square brackets, for MASM compatibility.
- Portability fixes.

C.2.8 Version 2.15.02

- Fix miscompilation when building with `clang`.
- Add `db-empty` warning class, see section 2.1.26.
- Fix the dependencies in the MSVC NMAKE makefile (`Mkfiles/msvc.mak`).
- Some documentation improvements and cleanups.
- Fix the handling of macro parameter ranges (`%{:}`), including with brace-enclosed original arguments.

C.2.9 Version 2.15.01

- Fix building the documentation from the release archive. For 2.15, the user has to do `make warnings` manually in the main directory in order to be able to build the documentation, which means Perl needs to be installed on the system.
- Add instructions for Intel Control Flow Enforcement Technology (CET).

C.2.10 Version 2.15

- The comparison and booleanizing operators can now be used in any expression context, not just `%if`. See section 3.5.
- New operator `?` ... `:`. See section 3.5.1.
- Signed shift operators <<< and >>>. See section 3.5.9.
- The MASM `DUP` syntax for data definitions is now supported, in a somewhat enhanced form. See section 3.2.1.
- Warn for strange legacy behavior regarding empty arguments in multi-line macro expansion, but try to match legacy behavior in most cases. Legacy behavior can be disabled with the directive `%pragma preproc sane_empty_expansion`, see section 5.6 and section 5.13.1.
- A much more sensible limit to expression evaluation depth. The previously defined limit would rarely trigger before NASM died with a stack overrun error on most systems. See section 2.1.32.
- The state of warnings can now be saved and restored via the `[WARNING PUSH]` and `[WARNING POP]` directives. See section 8.14.
- The `sectalign on|off` switch does not affect an explicit directive. See section 6.15.2.
- Added `configure` option to enable building with profiling (`--enable-profiling`).
- Attempt to support of long path names, up to 32767 of UTF-16 characters, on Windows.
- Fixed 'mismatch in operand sizes' error in the `MOVDDUP`, `CMPXCHG8B` and `CMPXCHG16B` instructions.
- Improved error messages in the string transformation routine.
- Removed obsolete `gnu-elf-extensions` warning about 8- and 16-bit relocation generation. See section 9.10.8
- Added group aliases for all prefixed warnings. See section 2.1.26.
- Allowed building with MSVC versions older than 1700.

- Added implicitly sized versions of the `K...` instructions, which allows the `K...` instructions to be specified without a size suffix as long as the operands are sized.
- Added `-L` option for additional listing information. See section 2.1.4.
- Added some warnings for obsolete instructions for a specified CPU.
- Deprecated `-hf` and `-y` options. Use `-h` instead.
- Made DWARF as the default debug format for ELF.
- Added `%pragma list` *options...* to set or clear listing options (see `opt-L`).
- Allowed immediate syntax for `LEA` instruction (ignore operand size completely).
- Added limited functionality MASM compatibility package. See section 7.5.
- Add single-line macros aliases using `%defalias` or `%idefalias`. These behave like a kind of "symbolic links" for single-line macros. See section 5.3.11 and `clear`.
- Added support for stringify, nostrip, evaluating, and greedy single-line macro arguments. See section 5.3.1.
- Unused single-line macro arguments no longer need to have a specified name. See section 5.3.1.
- Added conditional comma operator `%,`. See section 5.3.12.
- Changed private namespace from `__foo__` to `__?foo?__`, so a user namespace starting from underscore is now clean from symbols. For backwards compatibility, the previous names are defined as aliases; see section 5.3.11, section 5.14.3 and chapter 6.
- Added support of ELF weak symbols and external references. See section 9.10.5.
- Changed the behavior of the EXTERN keyword and introduced REQUIRED keyword. See section 8.6.
- Added `%ifusable` and `%ifusing` directives. See chapter 7.
- Made various performance improvements and stability fixes in macro preprocessor engine.
- Improved NASM error handling and cleaned up error messages.
- Many, many bug fixes.

C.2.11 Version 2.14.03

- Suppress nuisance "`label changed during code generation`" messages after a real error.
- Add support for the `merge` and `strings` attributes on ELF sections. See section 9.10.2.
- Add support for the `note`, `preinit_array`, `init_array`, and `fini_array` sections type in ELF. See section 9.10.2.
- Handle more than 32,633 sections in ELF.

C.2.12 Version 2.14.02

- Fix crash due to multiple errors or warnings during the code generation pass if a list file is specified.

C.2.13 Version 2.14.01

- Create all system-defined macros before processing command-line given preprocessing directives (`-p`, `-d`, `-u`, `--pragma`, `--before`).
- If debugging is enabled, define a `__DEBUG_FORMAT__` predefined macro. See section 6.6.
- Fix an assert for the case in the `obj` format when a `SEG` operator refers to an `EXTERN` symbol declared further down in the code.

- Fix a corner case in the floating-point code where a binary, octal or hexadecimal floating-point having at least 32, 11, or 8 mantissa digits could produce slightly incorrect results under very specific conditions.
- Support `-MD` without a filename, for `gcc` compatibility. `-MF` can be used to set the dependencies output filename. See section 2.1.8.
- Fix `-E` in combination with `-MD`. See section 2.1.22.
- Fix missing errors on redefined labels; would cause convergence failure instead which is very slow and not easy to debug.
- Duplicate definitions of the same label *with the same value* is now explicitly permitted (2.14 would allow it in some circumstances.)
- Add the option `--no-line` to ignore `%line` directives in the source. See section 2.1.34 and section 5.14.1.

C.2.14 Version 2.14

- Changed `-I` option semantics by adding a trailing path separator unconditionally.
- Fixed null dereference in corrupted invalid single line macros.
- Fixed division by zero which may happen if source code is malformed.
- Fixed out of bound access in processing of malformed segment override.
- Fixed out of bound access in certain `EQU` parsing.
- Fixed buffer underflow in float parsing.
- Added SGX (Intel Software Guard Extensions) instructions.
- Added `+n` syntax for multiple contiguous registers.
- Fixed `subsections_via_symbols` for `macho` object format.
- Added the `--gprefix`, `--gpostfix`, `--lprefix`, and `--lpostfix` command line options, to allow command line base symbol renaming. See section 2.1.28.
- Allow label renaming to be specified by `%pragma` in addition to from the command line. See section 8.10.
- Supported generic `%pragma` namespaces, `output` and `debug`. See section 5.13.
- Added the `--pragma` command line option to inject a `%pragma` directive. See section 2.1.29.
- Added the `--before` command line option to accept preprocess statement before input. See section 2.1.30.
- Added `AVX512 VBMI2` (Additional Bit Manipulation), `VNNI` (Vector Neural Network), `BITALG` (Bit Algorithm), and `GFNI` (Galois Field New Instruction) instructions.
- Added the `STATIC` directive for local symbols that should be renamed using global-symbol rules. See section 8.9.
- Allow a symbol to be defined as `EXTERN` and then later overridden as `GLOBAL` or `COMMON`. Furthermore, a symbol declared `EXTERN` and then defined will be treated as `GLOBAL`. See section 8.5.
- The `GLOBAL` directive no longer is required to precede the definition of the symbol.
- Support `private_extern` as `macho` specific extension to the `GLOBAL` directive. See section 9.9.5.
- Updated `UD0` encoding to match with the specification
- Added the `--limit-X` command line option to set execution limits. See section 2.1.32.

- Updated the `Codeview` version number to be aligned with `MASM`.
- Added the `--keep-all` command line option to preserve output files. See section 2.1.33.
- Added the `--include` command line option, an alias to `-P` (section 2.1.19).
- Added the `--help` command line option as an alias to `-h` (section 3.1).
- Added `-W`, `-D`, and `-Q` suffix aliases for `RET` instructions so the operand sizes of these instructions can be encoded without using `o16`, `o32` or `o64`.

C.2.15 Version 2.13.03

- Added AVX and AVX512 `VAES*` and `VPCLMULQDQ` instructions.
- Fixed missing dwarf record in x32 ELF output format.

C.2.16 Version 2.13.02

- Fix false positive in testing of numeric overflows.
- Fix generation of `PEXTRW` instruction.
- Fix `smartalign` package which could trigger an error during optimization if the alignment code expanded too much due to optimization of the previous code.
- Fix a case where negative value in `TIMES` directive causes panic instead of an error.
- Always finalize `.debug_abbrev` section with a null in `dwarf` output format.
- Support `debug` flag in section attributes for `macho` output format. See section 9.9.1.
- Support up to 16 characters in section names for `macho` output format.
- Fix missing update of global `BITS` setting if `SECTION` directive specified a bit size using output format-specific extensions (e.g. `USE32` for the `obj` output format.)
- Fix the incorrect generation of VEX-encoded instruction when static mode decorators are specified on scalar instructions, losing the decorators as they require EVEX encoding.
- Option `-MW` to quote dependency outputs according to Watcom Make conventions instead of POSIX Make conventions. See section 2.1.12.
- The `obj` output format now contains embedded dependency file information, unless disabled with `%pragma obj nodepend`. See section 9.4.9.
- Fix generation of dependency lists.
- Fix a number of null pointer reference and memory allocation errors.
- Always generate symbol-relative relocations for the `macho64` output format; at least some versions of the XCode/LLVM linker fails for section-relative relocations.

C.2.17 Version 2.13.01

- Fix incorrect output for some types of `FAR` or `SEG` references in the `obj` output format, and possibly other 16-bit output formats.
- Fix the address in the list file for an instruction containing a `TIMES` directive.
- Fix error with `TIMES` used together with an instruction which can vary in size, e.g. `JMP`.
- Fix breakage on some uses of the `DZ` pseudo-op.

C.2.18 Version 2.13

- Support the official forms of the `UD0` and `UD1` instructions.

- Allow self-segment-relative expressions in immediates and displacements, even when combined with an external or otherwise out-of-segment special symbol, e.g.:

```
extern foo
mov eax,[foo - $ + ebx]              ; Now legal
```

- Handle a 64-bit origin in NDISASM.
- NASM can now generate sparse output files for relevant output formats, if the underlying operating system supports them.
- The `macho` object format now supports the `subsections_via_symbols` and `no_dead_strip` directives, see section 9.9.4.
- The `macho` object format now supports the `no_dead_strip`, `live_support` and `strip_static_syms` section flags, see section 9.9.1.
- The `macho` object format now supports the `dwarf` debugging format, as required by newer toolchains.
- All warnings can now be suppressed if desired; warnings not otherwise part of any warning class are now considered its own warning class called `other` (e.g. `-w-other`). Furthermore, warning-as-error can now be controlled on a per warning class basis, using the syntax `-w+error=`*warning-class* and its equivalent for all other warning control options. See section 2.1.26 for the command-line options and warning classes and section 8.14 for the `[WARNING]` directive.
- Fix a number of bugs related to AVX-512 decorators.
- Significant improvements to building NASM with Microsoft Visual Studio via `Mkfiles/msvc.mak`. It is now possible to build the full Windows installer binary as long as the necessary prerequisites are installed; see `Mkfiles/README`
- To build NASM with custom modifications (table changes) or from the git tree now requires Perl 5.8 at the very minimum, quite possibly a higher version (Perl 5.24.1 tested.) There is no requirement to have Perl on your system at all if all you want to do is build unmodified NASM from source archives.
- Fix the `{z}` decorator on AVX-512 `VMOVDQ*` instructions.
- Add new warnings for certain dangerous constructs which never ought to have been allowed. In particular, the `RES`*x* family of instructions should have been taking a critical expression all along.
- Fix the EVEX (AVX-512) versions of the `VPBROADCAST`, `VPEXTR`, and `VPINSR` instructions.
- Support contracted forms of additional instructions. As a general rule, if an instruction has a non-destructive source immediately after a destination register that isn't used as an input, NASM supports omitting that source register, using the destination register as that value. This among other things makes it easier to convert SSE code to the equivalent AVX code:

```
addps xmm1,xmm0                      ; SSE instruction
vaddps ymm1,ymm1,ymm0                ; AVX official long form
vaddps ymm1,ymm0                     ; AVX contracted form
```

- Fix Codeview malformed compiler version record.
- Add the `CLWB` and `PCOMMIT` instructions. Note that the `PCOMMIT` instruction has been deprecated and will never be included in a shipping product; it is included for completeness only.
- Add the `%pragma` preprocessor directive for soft-error directives.
- Add the `RDPID` instruction.

C.2.19 Version 2.12.02

- Fix preprocessor errors, especially `%error` and `%warning`, inside `%if` statements.
- Fix relative relocations in 32-bit Mach-O.

- More Codeview debug format fixes.
- If the MASM `PTR` keyword is encountered, issue a warning. This is much more likely to indicate a MASM-ism encountered in NASM than it is a valid label. This warning can be suppressed with `-w-ptr`, the `[warning]` directive (see section 2.1.26) or by the macro definition `%idefine ptr $%?` (see section 5.3.5).
- When an error or a warning comes from the expansion of a multi-line macro, display the file and line numbers for the expanded macros. Macros defined with `.nolist` do not get displayed.
- Add macros `ilog2fw()` and `ilog2cw()` to the `ifunc` macro package. See section 7.4.1.

C.2.20 Version 2.12.01

- Portability fixes for some platforms.
- Fix error when not specifying a list file.
- Correct the handling of macro-local labels in the Codeview debugging format.
- Add `CLZERO`, `MONITORX` and `MWAITX` instructions.

C.2.21 Version 2.12

- Major fixes to the `macho` backend (section 9.9); earlier versions would produce invalid symbols and relocations on a regular basis.
- Support for thread-local storage in Mach-O.
- Support for arbitrary sections in Mach-O.
- Fix wrong negative size treated as a big positive value passed into backend causing NASM to crash.
- Fix handling of zero-extending unsigned relocations, we have been printing wrong message and forgot to assign segment with predefined value before passing it into output format.
- Fix potential write of oversized (with size greater than allowed in output format) relative relocations.
- Portability fixes for building NASM with the LLVM compiler.
- Add support of Codeview version 8 (`cv8`) debug format for `win32` and `win64` formats in the `COFF` backend, see section 9.6.5.
- Allow 64-bit outputs in 16/32-bit only backends. Unsigned 64-bit relocations are zero-extended from 32-bits with a warning (suppressible via `-w-zext-reloc`); signed 64-bit relocations are an error.
- Line numbers in list files now correspond to the lines in the source files, instead of simply being sequential.
- There is now an official 64-bit (x64 a.k.a. x86-64) build for Windows.

C.2.22 Version 2.11.09

- Fix potential stack overwrite in `macho32` backend.
- Fix relocation records in `macho64` backend.
- Fix symbol lookup computation in `macho64` backend.
- Adjust `.symtab` and `.rela.text` sections alignments to 8 bytes in `elf64` backed.
- Fix section length computation in `bin` backend which leaded in incorrect relocation records.

C.2.23 Version 2.11.08

- Fix section length computation in `bin` backend which leaded in incorrect relocation records.

- Add a warning for numeric preprocessor definitions passed via command line which might have unexpected results otherwise.
- Add ability to specify a module name record in `rdoff` linker with `-mn` option.
- Increase label length capacity up to 256 bytes in `rdoff` backend for FreePascal sake, which tends to generate very long labels for procedures.
- Fix segmentation failure when rip addressing is used in `macho64` backend.
- Fix access on out of memory when handling strings with a single grave. We have sixed similar problem in previous release but not all cases were covered.
- Fix NULL dereference in disassembled on `BND` instruction.

C.2.24 Version 2.11.07

- Fix 256 bit `VMOVNTPS` instruction.
- Fix `-MD` option handling, which was rather broken in previous release changing command line api.
- Fix access to uninitialized space when handling strings with a single grave.
- Fix nil dereference in handling memory reference parsing.

C.2.25 Version 2.11.06

- Update AVX512 instructions based on the Extension Reference (319433-021 Sept 2014).
- Fix the behavior of `-MF` and `-MD` options (Bugzilla 3392280)
- Updated Win32 Makefile to fix issue with build

C.2.26 Version 2.11.05

- Add `--v` as an alias for `-v` (see section 2.1.27), for command-line compatibility with Yasm.
- Fix a bug introduced in 2.11.03 whereby certain instructions would contain multiple REX prefixes, and thus be corrupt.

C.2.27 Version 2.11.04

- Removed an invalid error checking code. Sometimes a memref only with a displacement can also set an evex flag. For example:

```
vmovdqu32 [0xabcd]{k1}, zmm0
```

- Fixed a bug in disassembler that EVEX.L'L vector length was not matched when EVEX.b was set because it was simply considered as EVEC.RC. Separated EVEX.L'L case from EVEX.RC which is ignored in matching.

C.2.28 Version 2.11.03

- Fix a bug there REX prefixes were missing on instructions inside a `TIMES` statement.

C.2.29 Version 2.11.02

- Add the `XSAVEC`, `XSAVES` and `XRSTORS` family instructions.
- Add the `CLFLUSHOPT` instruction.

C.2.30 Version 2.11.01

- Allow instructions which implicitly uses `XMM0` (`VBLENDVPD`, `VBLENDVPS`, `PBLENDVB` and `SHA256RNDS2`) to be specified without an explicit `xmm0` on the assembly line. In other words, the following two lines produce the same output:

```
vblendvpd xmm2,xmm1,xmm0      ; Last operand is fixed xmm0
vblendvpd xmm2,xmm1           ; Implicit xmm0 omitted
```

- In the ELF backends, don't crash the assembler if `section align` is specified without a value.

C.2.31 Version 2.11

- Add support for the Intel AVX-512 instruction set:
- 16 new, 512-bit SIMD registers. Total 32 (`ZMM0 ~ ZMM31`)
- 8 new opmask registers (`K0 ~ K7`). One of 7 registers (`K1 ~ K7`) can be used as an opmask for conditional execution.
- A new EVEX encoding prefix. EVEX is based on VEX and provides more capabilities: opmasks, broadcasting, embedded rounding and compressed displacements.

```
- opmask
    VDIVPD zmm0{k1}{z}, zmm1, zmm3  ; conditional vector operation
                                    ; using opmask k1.
                                    ; {z} is for zero-masking
- broadcasting
    VDIVPS zmm4, zmm5, [rbx]{1to16} ; load single-precision float and
                                    ; replicate it 16 times. 32 * 16 = 512
- embedded rounding
    VCVTSI2SD xmm6, xmm7, {rz-sae}, rax ; round toward zero. note that it
                                     ; is used as if a separate operand.
                                     ; it comes after the last SIMD operand
```

- Add support for `ZWORD` (512 bits), `DZ` and `RESZ`.
- Add support for the MPX and SHA instruction sets.
- Better handling of section redefinition.
- Generate manpages when running `'make dist'`.
- Handle all token chains in mmacro params range.
- Support split [base,index] effective address:

```
mov eax,[eax+8,ecx*4]   ; eax=base, ecx=index, 4=scale, 8=disp
```

This is expected to be most useful for the MPX instructions.

- Support `BND` prefix for branch instructions (for MPX).
- The `DEFAULT` directive can now take `BND` and `NOBND` options to indicate whether all relevant branches should be getting `BND` prefixes. This is expected to be the normal for use in MPX code.
- Add `{evex}`, `{vex3}` and `{vex2}` instruction prefixes to have NASM encode the corresponding instruction, if possible, with an EVEX, 3-byte VEX, or 2-byte VEX prefix, respectively.
- Support for section names longer than 8 bytes in Win32/Win64 COFF.
- The `NOSPLIT` directive by itself no longer forces a single register to become an index register, unless it has an explicit multiplier.

```
mov eax,[nosplit eax]       ; eax as base register
mov eax,[nosplit eax*1]     ; eax as index register
```

C.2.32 Version 2.10.09

- Pregenerate man pages.

C.2.33 Version 2.10.08

- Fix `VMOVNTDQA`, `MOVNTDQA` and `MOVLPD` instructions.

- Fix collision for VGATHERQPS, VPGATHERQD instructions.
- Fix VPMOVSXBQ, VGATHERQPD, VSPLLW instructions.
- Add a bunch of AMD TBM instructions.
- Fix potential stack overwrite in numbers conversion.
- Allow byte size in PREFETCHTx instructions.
- Make manual pages up to date.
- Make F3 and F2 SSE prefixes to override 66.
- Support of AMD SVM instructions in 32 bit mode.
- Fix near offsets code generation for JMP, CALL instrictions in long mode.
- Fix preprocessor parse regression when id is expanding to a whitespace.

C.2.34 Version 2.10.07

- Fix line continuation parsing being broken in previous version.

C.2.35 Version 2.10.06

- Always quote the dependency source names when using the automatic dependency generation options.
- If no dependency target name is specified via the -MT or -MQ options, quote the default output name.
- Fix assembly of shift operations in CPU 8086 mode.
- Fix incorrect generation of explicit immediate byte for shift by 1 under certain circumstances.
- Fix assembly of the VPCMPGTQ instruction.
- Fix RIP-relative relocations in the macho64 backend.

C.2.36 Version 2.10.05

- Add the CLAC and STAC instructions.

C.2.37 Version 2.10.04

- Add back the inadvertently deleted 256-bit version of the VORPD instruction.
- Correct disassembly of instructions starting with byte 82 hex.
- Fix corner cases in token pasting, for example:

```
%define N 1e%++%+ 5
        dd N, 1e+5
```

C.2.38 Version 2.10.03

- Correct the assembly of the instruction:

```
XRELEASE MOV [absolute],AL
```

  Previous versions would incorrectly generate F3 A2 for this instruction and issue a warning; correct behavior is to emit F3 88 05.

C.2.39 Version 2.10.02

- Add the ifunc macro package with integer functions, currently only integer logarithms. See section 7.4.
- Add the RDSEED, ADCX and ADOX instructions.

C.2.40 Version 2.10.01

- Add missing VPMOVMSKB instruction with reg32, ymmreg operands.

C.2.41 Version 2.10

- When optimization is enabled, `mov r64,imm` now optimizes to the shortest form possible between:

  ```
  mov r32,imm32                  ;  5 bytes
  mov r64,imm32                  ;  7 bytes
  mov r64,imm64                  ; 10 bytes
  ```

  To force a specific form, use the `STRICT` keyword, see section 3.7.
- Add support for the Intel AVX2 instruction set.
- Add support for Bit Manipulation Instructions 1 and 2.
- Add support for Intel Transactional Synchronization Extensions (TSX).
- Add support for x32 ELF (32-bit ELF with the CPU in 64-bit mode.) See section 9.10.
- Add support for bigendian UTF-16 and UTF-32. See section 3.4.5.

C.2.42 Version 2.09.10

- Fix up NSIS script to protect uninstaller against registry keys absence or corruption. It brings in a few additional questions to a user during deinstallation procedure but still it is better than unpredictable file removal.

C.2.43 Version 2.09.09

- Fix initialization of section attributes of `bin` output format.
- Fix `mach64` output format bug that crashes NASM due to NULL symbols.

C.2.44 Version 2.09.08

- Fix `__OUTPUT_FORMAT__` assignment when output driver alias is used. For example when `-f elf` is used `__OUTPUT_FORMAT__` must be set to `elf`, if `-f elf32` is used `__OUTPUT_FORMAT__` must be assigned accordingly, i.e. to `elf32`. The rule applies to all output driver aliases. See section 6.5.

C.2.45 Version 2.09.07

- Fix attempts to close same file several times when `-a` option is used.
- Fixes for VEXTRACTF128, VMASKMOVPS encoding.

C.2.46 Version 2.09.06

- Fix missed section attribute initialization in `bin` output target.

C.2.47 Version 2.09.05

- Fix arguments encoding for VPEXTRW instruction.
- Remove invalid form of VPEXTRW instruction.
- Add `VLDDQU` as alias for `VLDQQU` to match specification.

C.2.48 Version 2.09.04

- Fix incorrect labels offset for VEX instructions.
- Eliminate bogus warning on implicit operand size override.
- `%if` term could not handle 64 bit numbers.

- The COFF backend was limiting relocations number to 16 bits even if in real there were a way more relocations.

C.2.49 Version 2.09.03

- Print `%macro` name inside `%rep` blocks on error.
- Fix preprocessor expansion behaviour. It happened sometime too early and sometime simply wrong. Move behaviour back to the origins (down to NASM 2.05.01).
- Fix uninitialized data dereference on OMF output format.
- Issue warning on unterminated `%{` construct.
- Fix for documentation typo.

C.2.50 Version 2.09.02

- Fix reversed tokens when `%deftok` produces more than one output token.
- Fix segmentation fault on disassembling some VEX instructions.
- Missing `%endif` did not always cause error.
- Fix typo in documentation.
- Compound context local preprocessor single line macro identifiers were not expanded early enough and as result lead to unresolved symbols.

C.2.51 Version 2.09.01

- Fix NULL dereference on missed %deftok second parameter.
- Fix NULL dereference on invalid %substr parameters.

C.2.52 Version 2.09

- Fixed assignment the magnitude of `%rep` counter. It is limited to 62 bits now.
- Fixed NULL dereference if argument of `%strlen` resolves to whitespace. For example if nonexistent macro parameter is used.
- `%ifenv`, `%elifenv`, `%ifnenv`, and `%elifnenv` directives introduced. See section 5.7.13.
- Fixed NULL dereference if environment variable is missed.
- Updates of new AVX v7 Intel instructions.
- `PUSH imm32` is now officially documented.
- Fix for encoding the LFS, LGS and LSS in 64-bit mode.
- Fixes for compatibility with OpenWatcom compiler and DOS 8.3 file format limitation.
- Macros parameters range expansion introduced. See section 5.6.4.
- Backward compatibility on expanging of local single macros restored.
- 8 bit relocations for `elf` and `bin` output formats are introduced.
- Short intersegment jumps are permitted now.
- An alignment more than 64 bytes are allowed for `win32`, `win64` output formats.
- `SECTALIGN` directive introduced. See section 6.15.2.
- `nojmp` option introduced in `smartalign` package. See section 7.2.

- Short aliases `win`, `elf` and `macho` for output formats are introduced. Each stands for `win32`, `elf32` and `macho32` accordingly.
- Faster handling of missing directives implemented.
- Various small improvements in documentation.
- No hang anymore if unable to open malloc.log file.
- The environments without vsnprintf function are able to build nasm again.
- AMD LWP instructions updated.
- Tighten EA checks. We warn a user if there overflow in EA addressing.
- Make `-Ox` the default optimization level. For the legacy behavior, specify `-O0` explicitly. See section 2.1.24.
- Environment variables read with `%!` or tested with `%ifenv` can now contain non-identifier characters if surrounded by quotes. See section 5.14.2.
- Add a new standard macro package `%use fp` for floating-point convenience macros. See section 7.3.

C.2.53 Version 2.08.02

- Fix crash under certain circumstances when using the `%+` operator.

C.2.54 Version 2.08.01

- Fix the `%use` statement, which was broken in 2.08.

C.2.55 Version 2.08

- A number of enhancements/fixes in macros area.
- Support for converting strings to tokens. See section 5.3.10.
- Fuzzy operand size logic introduced.
- Fix COFF stack overrun on too long export identifiers.
- Fix Macho-O alignment bug.
- Fix crashes with –fwin32 on file with many exports.
- Fix stack overrun for too long [DEBUG id].
- Fix incorrect sbyte usage in IMUL (hit only if optimization flag passed).
- Append ending token for `.stabs` records in the ELF output format.
- New NSIS script which uses ModernUI and MultiUser approach.
- Visual Studio 2008 NASM integration (rules file).
- Warn a user if a constant is too long (and as result will be stripped).
- The obsoleted pre-XOP AMD SSE5 instruction set which was never actualized was removed.
- Fix stack overrun on too long error file name passed from the command line.
- Bind symbols to the .text section by default (ie in case if SECTION directive was omitted) in the ELF output format.
- Fix sync points array index wrapping.
- A few fixes for FMA4 and XOP instruction templates.
- Add AMD Lightweight Profiling (LWP) instructions.

- Fix the offset for `%arg` in 64-bit mode.
- An undefined local macro (`%$`) no longer matches a global macro with the same name.
- Fix NULL dereference on too long local labels.

C.2.56 Version 2.07

- NASM is now under the 2-clause BSD license. See section 1.1.1.
- Fix the section type for the `.strtab` section in the `elf64` output format.
- Fix the handling of `COMMON` directives in the `obj` output format.
- New `ith` and `srec` output formats; these are variants of the `bin` output format which output Intel hex and Motorola S-records, respectively. See section 9.2 and section 9.3.
- `rdf2ihx` replaced with an enhanced `rdf2bin`, which can output binary, COM, Intel hex or Motorola S-records.
- The Windows installer now puts the NASM directory first in the `PATH` of the "NASM Shell".
- Revert the early expansion behavior of `%+` to pre-2.06 behavior: `%+` is only expanded late.
- Yet another Mach-O alignment fix.
- Don't delete the list file on errors. Also, include error and warning information in the list file.
- Support for 64-bit Mach-O output, see section 9.9.
- Fix assert failure on certain operations that involve strings with high-bit bytes.

C.2.57 Version 2.06

- This release is dedicated to the memory of Charles A. Crayne, long time NASM developer as well as moderator of `comp.lang.asm.x86` and author of the book *Serious Assembler*. We miss you, Chuck.
- Support for indirect macro expansion (`%[...]`). See section 5.3.3.
- `%pop` can now take an argument, see section 5.10.1.
- The argument to `%use` is no longer macro-expanded. Use `%[...]` if macro expansion is desired.
- Support for thread-local storage in ELF32 and ELF64. See section 9.10.4.
- Fix crash on `%ifmacro` without an argument.
- Correct the arguments to the `POPCNT` instruction.
- Fix section alignment in the Mach-O format.
- Update AVX support to version 5 of the Intel specification.
- Fix the handling of accesses to context-local macros from higher levels in the context stack.
- Treat `WAIT` as a prefix rather than as an instruction, thereby allowing constructs like `o16 FSAVE` to work correctly.
- Support for structures with a non-zero base offset. See section 6.14.1.
- Correctly handle preprocessor token concatenation (see section 5.6.9) involving floating-point numbers.
- The `PINSR` series of instructions have been corrected and rationalized.
- Removed AMD SSE5, replaced with the new XOP/FMA4/CVT16 (rev 3.03) spec.
- The ELF backends no longer automatically generate a `.comment` section.

- Add additional "well-known" ELF sections with default attributes. See section 9.10.2.

C.2.58 Version 2.05.01

- Fix the `-w`/`-W` option parsing, which was broken in NASM 2.05.

C.2.59 Version 2.05

- Fix redundant REX.W prefix on `JMP reg64`.
- Make the behaviour of `-O0` match NASM 0.98 legacy behavior. See section 2.1.24.
- `-w-user` can be used to suppress the output of `%warning` directives. See section 2.1.26.
- Fix bug where `ALIGN` would issue a full alignment datum instead of zero bytes.
- Fix offsets in list files.
- Fix `%include` inside multi-line macros or loops.
- Fix error where NASM would generate a spurious warning on valid optimizations of immediate values.
- Fix arguments to a number of the `CVT` SSE instructions.
- Fix RIP-relative offsets when the instruction carries an immediate.
- Massive overhaul of the ELF64 backend for spec compliance.
- Fix the Geode `PFRCPV` and `PFRSQRTV` instruction.
- Fix the SSE 4.2 `CRC32` instruction.

C.2.60 Version 2.04

- Sanitize macro handing in the `%error` directive.
- New `%warning` directive to issue user-controlled warnings.
- `%error` directives are now deferred to the final assembly phase.
- New `%fatal` directive to immediately terminate assembly.
- New `%strcat` directive to join quoted strings together.
- New `%use` macro directive to support standard macro directives. See section 5.9.4.
- Excess default parameters to `%macro` now issues a warning by default. See section 5.6.
- Fix `%ifn` and `%elifn`.
- Fix nested `%else` clauses.
- Correct the handling of nested `%rep`s.
- New `%unmacro` directive to undeclare a multi-line macro. See section 5.6.12.
- Builtin macro `__PASS__` which expands to the current assembly pass. See section 6.13.
- `__utf16__` and `__utf32__` operators to generate UTF-16 and UTF-32 strings. See section 3.4.5.
- Fix bug in case-insensitive matching when compiled on platforms that don't use the `configure` script. Of the official release binaries, that only affected the OS/2 binary.
- Support for x87 packed BCD constants. See section 3.4.7.
- Correct the `LTR` and `SLDT` instructions in 64-bit mode.
- Fix unnecessary REX.W prefix on indirect jumps in 64-bit mode.

- Add AVX versions of the AES instructions (`VAES`...).
- Fix the 256-bit FMA instructions.
- Add 256-bit AVX stores per the latest AVX spec.
- VIA XCRYPT instructions can now be written either with or without `REP`, apparently different versions of the VIA spec wrote them differently.
- Add missing 64-bit `MOVNTI` instruction.
- Fix the operand size of `VMREAD` and `VMWRITE`.
- Numerous bug fixes, especially to the AES, AVX and VTX instructions.
- The optimizer now always runs until it converges. It also runs even when disabled, but doesn't optimize. This allows most forward references to be resolved properly.
- `%push` no longer needs a context identifier; omitting the context identifier results in an anonymous context.

C.2.61 Version 2.03.01

- Fix buffer overflow in the listing module.
- Fix the handling of hexadecimal escape codes in `...` strings.
- The Postscript/PDF documentation has been reformatted.
- The `-F` option now implies `-g`.

C.2.62 Version 2.03

- Add support for Intel AVX, CLMUL and FMA instructions, including YMM registers.
- `dy`, `resy` and `yword` for 32-byte operands.
- Fix some SSE5 instructions.
- Intel `INVEPT`, `INVVPID` and `MOVBE` instructions.
- Fix checking for critical expressions when the optimizer is enabled.
- Support the DWARF debugging format for ELF targets.
- Fix optimizations of signed bytes.
- Fix operation on bigendian machines.
- Fix buffer overflow in the preprocessor.
- `SAFESEH` support for Win32, `IMAGEREL` for Win64 (SEH).
- `%?` and `%??` to refer to the name of a macro itself. In particular, `%idefine keyword $%?` can be used to make a keyword "disappear".
- New options for dependency generation: `-MD`, `-MF`, `-MP`, `-MT`, `-MQ`.
- New preprocessor directives `%pathsearch` and `%depend`; INCBIN reimplemented as a macro.
- `%include` now resolves macros in a sane manner.
- `%substr` can now be used to get other than one-character substrings.
- New type of character/string constants, using backquotes (`` `...` ``), which support C-style escape sequences.
- `%defstr` and `%idefstr` to stringize macro definitions before creation.

- Fix forward references used in `EQU` statements.

C.2.63 Version 2.02

- Additional fixes for MMX operands with explicit `qword`, as well as (hopefully) SSE operands with `oword`.
- Fix handling of truncated strings with `DO`.
- Fix segfaults due to memory overwrites when floating-point constants were used.
- Fix segfaults due to missing include files.
- Fix OpenWatcom Makefiles for DOS and OS/2.
- Add autogenerated instruction list back into the documentation.
- ELF: Fix segfault when generating stabs, and no symbols have been defined.
- ELF: Experimental support for DWARF debugging information.
- New compile date and time standard macros.
- `%ifnum` now returns true for negative numbers.
- New `%iftoken` test for a single token.
- New `%ifempty` test for empty expansion.
- Add support for the `XSAVE` instruction group.
- Makefile for Netware/gcc.
- Fix issue with some warnings getting emitted way too many times.
- Autogenerated instruction list added to the documentation.

C.2.64 Version 2.01

- Fix the handling of MMX registers with explicit `qword` tags on memory (broken in 2.00 due to 64-bit changes.)
- Fix the PREFETCH instructions.
- Fix the documentation.
- Fix debugging info when using `-f elf` (backwards compatibility alias for `-f elf32`).
- Man pages for rdoff tools (from the Debian project.)
- ELF: handle large numbers of sections.
- Fix corrupt output when the optimizer runs out of passes.

C.2.65 Version 2.00

- Added c99 data-type compliance.
- Added general x86-64 support.
- Added win64 (x86-64 COFF) output format.
- Added `__BITS__` standard macro.
- Renamed the `elf` output format to `elf32` for clarity.
- Added `elf64` and `macho` (MacOS X) output formats.
- Added Numeric constants in `dq` directive.
- Added `oword`, `do` and `reso` pseudo operands.

- Allow underscores in numbers.
- Added 8-, 16- and 128-bit floating-point formats.
- Added binary, octal and hexadecimal floating-point.
- Correct the generation of floating-point constants.
- Added floating-point option control.
- Added Infinity and NaN floating point support.
- Added ELF Symbol Visibility support.
- Added setting OSABI value in ELF header directive.
- Added Generate Makefile Dependencies option.
- Added Unlimited Optimization Passes option.
- Added `%IFN` and `%ELIFN` support.
- Added Logical Negation Operator.
- Enhanced Stack Relative Preprocessor Directives.
- Enhanced ELF Debug Formats.
- Enhanced Send Errors to a File option.
- Added SSSE3, SSE4.1, SSE4.2, SSE5 support.
- Added a large number of additional instructions.
- Significant performance improvements.
- `-w+warning` and `-w-warning` can now be written as –Wwarning and –Wno-warning, respectively. See section 2.1.26.
- Add `-w+error` to treat warnings as errors. See section 2.1.26.
- Add `-w+all` and `-w-all` to enable or disable all suppressible warnings. See section 2.1.26.

C.3 NASM 0.98 Series

The 0.98 series was the production versions of NASM from 1999 to 2007.

C.3.1 Version 0.98.39

- fix buffer overflow
- fix outas86's `.bss` handling
- "make spotless" no longer deletes config.h.in.
- `%(el)if(n)idn` insensitivity to string quotes difference (#809300).
- (nasm.c)`__OUTPUT_FORMAT__` changed to string value instead of symbol.

C.3.2 Version 0.98.38

- Add Makefile for 16-bit DOS binaries under OpenWatcom, and modify `mkdep.pl` to be able to generate completely pathless dependencies, as required by OpenWatcom wmake (it supports path searches, but not explicit paths.)
- Fix the `STR` instruction.
- Fix the ELF output format, which was broken under certain circumstances due to the addition of stabs support.

- Quick-fix Borland format debug-info for `-f obj`
- Fix for `%rep` with no arguments (#560568)
- Fix concatenation of preprocessor function call (#794686)
- Fix long label causes coredump (#677841)
- Use autoheader as well as autoconf to keep configure from generating ridiculously long command lines.
- Make sure that all of the formats which support debugging output actually will suppress debugging output when `-g` not specified.

C.3.3 Version 0.98.37

- Paths given in `-I` switch searched for `incbin`–ed as well as `%include`–ed files.
- Added stabs debugging for the ELF output format, patch from Martin Wawro.
- Fix `output/outbin.c` to allow origin > 80000000h.
- Make `-U` switch work.
- Fix the use of relative offsets with explicit prefixes, e.g. `a32 loop foo`.
- Remove `backslash()`.
- Fix the `SMSW` and `SLDT` instructions.
- `-O2` and `-O3` are no longer aliases for `-O10` and `-O15`. If you mean the latter, please say so! :)

C.3.4 Version 0.98.36

- Update rdoff – librarian/archiver – common rec – docs!
- Fix signed/unsigned problems.
- Fix `JMP FAR label` and `CALL FAR label`.
- Add new multisection support – map files – fix align bug
- Fix sysexit, movhps/movlps reg,reg bugs in insns.dat
- `Q` or `O` suffixes indicate octal
- Support Prescott new instructions (PNI).
- Cyrix `XSTORE` instruction.

C.3.5 Version 0.98.35

- Fix build failure on 16-bit DOS (Makefile.bc3 workaround for compiler bug.)
- Fix dependencies and compiler warnings.
- Add "const" in a number of places.
- Add –X option to specify error reporting format (use –Xvc to integrate with Microsoft Visual Studio.)
- Minor changes for code legibility.
- Drop use of tmpnam() in rdoff (security fix.)

C.3.6 Version 0.98.34

- Correct additional address-size vs. operand-size confusions.
- Generate dependencies for all Makefiles automatically.

- Add support for unimplemented (but theoretically available) registers such as tr0 and cr5. Segment registers 6 and 7 are called segr6 and segr7 for the operations which they can be represented.
- Correct some disassembler bugs related to redundant address-size prefixes. Some work still remains in this area.
- Correctly generate an error for things like "SEG eax".
- Add the JMPE instruction, enabled by "CPU IA64".
- Correct compilation on newer gcc/glibc platforms.
- Issue an error on things like "jmp far eax".

C.3.7 Version 0.98.33

- New __NASM_PATCHLEVEL__ and __NASM_VERSION_ID__ standard macros to round out the version-query macros. version.pl now understands X.YYplWW or X.YY.ZZplWW as a version number, equivalent to X.YY.ZZ.WW (or X.YY.0.WW, as appropriate).
- New keyword "strict" to disable the optimization of specific operands.
- Fix the handing of size overrides with JMP instructions (instructions such as "jmp dword foo".)
- Fix the handling of "ABSOLUTE label", where "label" points into a relocatable segment.
- Fix OBJ output format with lots of externs.
- More documentation updates.
- Add –Ov option to get verbose information about optimizations.
- Undo a braindead change which broke `%elif` directives.
- Makefile updates.

C.3.8 Version 0.98.32

- Fix NASM crashing when `%macro` directives were left unterminated.
- Lots of documentation updates.
- Complete rewrite of the PostScript/PDF documentation generator.
- The MS Visual C++ Makefile was updated and corrected.
- Recognize .rodata as a standard section name in ELF.
- Fix some obsolete Perl4-isms in Perl scripts.
- Fix configure.in to work with autoconf 2.5x.
- Fix a couple of "make cleaner" misses.
- Make the normal "./configure && make" work with Cygwin.

C.3.9 Version 0.98.31

- Correctly build in a separate object directory again.
- Derive all references to the version number from the version file.
- New standard macros __NASM_SUBMINOR__ and __NASM_VER__ macros.
- Lots of Makefile updates and bug fixes.
- New `%ifmacro` directive to test for multiline macros.
- Documentation updates.

- Fixes for 16-bit OBJ format output.
- Changed the NASM environment variable to NASMENV.

C.3.10 Version 0.98.30

- Changed doc files a lot: completely removed old READMExx and Wishlist files, incorporating all information in CHANGES and TODO.
- I waited a long time to rename zoutieee.c to (original) outieee.c
- moved all output modules to output/ subdirectory.
- Added 'make strip' target to strip debug info from nasm & ndisasm.
- Added INSTALL file with installation instructions.
- Added –v option description to nasm man.
- Added dist makefile target to produce source distributions.
- 16-bit support for ELF output format (GNU extension, but useful.)

C.3.11 Version 0.98.28

- Fastcooked this for Debian's Woody release: Frank applied the INCBIN bug patch to 0.98.25alt and called it 0.98.28 to not confuse poor little apt-get.

C.3.12 Version 0.98.26

- Reorganised files even better from 0.98.25alt

C.3.13 Version 0.98.25alt

- Prettified the source tree. Moved files to more reasonable places.
- Added findleak.pl script to misc/ directory.
- Attempted to fix doc.

C.3.14 Version 0.98.25

- Line continuation character \.
- Docs inadvertently reverted – "dos packaging".

C.3.15 Version 0.98.24p1

- FIXME: Someone, document this please.

C.3.16 Version 0.98.24

- Documentation – Ndisasm doc added to Nasm.doc.

C.3.17 Version 0.98.23

- Attempted to remove rdoff version1
- Lino Mastrodomenico's patches to preproc.c (%$$ bug?).

C.3.18 Version 0.98.22

- Update rdoff2 – attempt to remove v1.

C.3.19 Version 0.98.21

- Optimization fixes.

C.3.20 Version 0.98.20

- Optimization fixes.

C.3.21 Version 0.98.19

- H. J. Lu's patch back out.

C.3.22 Version 0.98.18

- Added ".rdata" to "-f win32".

C.3.23 Version 0.98.17

- H. J. Lu's "bogus elf" patch. (Red Hat problem?)

C.3.24 Version 0.98.16

- Fix whitespace before "[section ..." bug.

C.3.25 Version 0.98.15

- Rdoff changes (?).
- Fix fixes to memory leaks.

C.3.26 Version 0.98.14

- Fix memory leaks.

C.3.27 Version 0.98.13

- There was no 0.98.13

C.3.28 Version 0.98.12

- Update optimization (new function of "-O1")
- Changes to test/bintest.asm (?).

C.3.29 Version 0.98.11

- Optimization changes.
- Ndisasm fixed.

C.3.30 Version 0.98.10

- There was no 0.98.10

C.3.31 Version 0.98.09

- Add multiple sections support to "-f bin".
- Changed GLOBAL_TEMP_BASE in outelf.c from 6 to 15.
- Add "-v" as an alias to the "-r" switch.
- Remove "#ifdef" from Tasm compatibility options.
- Remove redundant size-overrides on "mov ds, ex", etc.
- Fixes to SSE2, other insns.dat (?).
- Enable uppercase "I" and "P" switches.
- Case insinsitive "seg" and "wrt".

- Update install.sh (?).
- Allocate tokens in blocks.
- Improve "invalid effective address" messages.

C.3.32 Version 0.98.08

- Add "`%strlen`" and "`%substr`" macro operators
- Fixed broken c16.mac.
- Unterminated string error reported.
- Fixed bugs as per 0.98bf

C.3.33 Version 0.98.09b with John Coffman patches released 28-Oct-2001

Changes from 0.98.07 release to 98.09b as of 28-Oct-2001

- More closely compatible with 0.98 when –O0 is implied or specified. Not strictly identical, since backward branches in range of short offsets are recognized, and signed byte values with no explicit size specification will be assembled as a single byte.
- More forgiving with the PUSH instruction. 0.98 requires a size to be specified always. 0.98.09b will imply the size from the current BITS setting (16 or 32).
- Changed definition of the optimization flag:

```
-O0     strict two-pass assembly, JMP and Jcc are
        handled more like 0.98, except that back-
        ward JMPs are short, if possible.

-O1     strict two-pass assembly, but forward
        branches are assembled with code guaranteed
        to reach; may produce larger code than
        -O0, but will produce successful assembly
        more often if branch offset sizes are not
        specified.

-O2     multi-pass optimization, minimize branch
        offsets; also will minimize signed immed-
        iate bytes, overriding size specification.

-O3     like -O2, but more passes taken, if needed
```

C.3.34 Version 0.98.07 released 01/28/01

- Added Stepane Denis' SSE2 instructions to a *working* version of the code – some earlier versions were based on broken code – sorry 'bout that. version "0.98.07"
- Cosmetic modifications to nasm.c, nasm.h, AUTHORS, MODIFIED

C.3.35 Version 0.98.06f released 01/18/01

- Add "metalbrain"s jecxz bug fix in insns.dat
- Alter nasmdoc.src to match – version "0.98.06f"

C.3.36 Version 0.98.06e released 01/09/01

- Removed the "outforms.h" file – it appears to be someone's old backup of "outform.h". version "0.98.06e"
- fbk – finally added the fix for the "multiple %includes bug", known since 7/27/99 – reported originally (?) and sent to us by Austin Lunnen – he reports that John Fine had a fix within the day. Here it is...

- Nelson Rush resigns from the group. Big thanks to Nelson for his leadership and enthusiasm in getting these changes incorporated into Nasm!
- fbk – [list +], [list –] directives – ineptly implemented, should be re-written or removed, perhaps.
- Brian Raiter / fbk – "elfso bug" fix – applied to aoutb format as well – testing might be desirable...
- James Seter – –postfix, –prefix command line switches.
- Yuri Zaporozhets – rdoff utility changes.

C.3.37 Version 0.98p1

- GAS-like palign (Panos Minos)
- FIXME: Someone, fill this in with details

C.3.38 Version 0.98bf (bug-fixed)

- Fixed – elf and aoutb bug – shared libraries – multiple "%include" bug in "-f obj" – jcxz, jecxz bug – unrecognized option bug in ndisasm

C.3.39 Version 0.98.03 with John Coffman's changes released 27-Jul-2000

- Added signed byte optimizations for the 0x81/0x83 class of instructions: ADC, ADD, AND, CMP, OR, SBB, SUB, XOR: when used as 'ADD reg16,imm' or 'ADD reg32,imm.' Also optimization of signed byte form of 'PUSH imm' and 'IMUL reg,imm'/'IMUL reg,reg,imm.' No size specification is needed.
- Added multi-pass JMP and Jcc offset optimization. Offsets on forward references will preferentially use the short form, without the need to code a specific size (short or near) for the branch. Added instructions for 'Jcc label' to use the form 'Jnotcc $+3/JMP label', in cases where a short offset is out of bounds. If compiling for a 386 or higher CPU, then the 386 form of Jcc will be used instead.

  This feature is controlled by a new command-line switch: "O", (upper case letter O). "-O0" reverts the assembler to no extra optimization passes, "-O1" allows up to 5 extra passes, and "-O2"(default), allows up to 10 extra optimization passes.
- Added a new directive: 'cpu XXX', where XXX is any of: 8086, 186, 286, 386, 486, 586, pentium, 686, PPro, P2, P3 or Katmai. All are case insensitive. All instructions will be selected only if they apply to the selected cpu or lower. Corrected a couple of bugs in cpu-dependence in 'insns.dat'.
- Added to 'standard.mac', the "use16" and "use32" forms of the "bits 16/32" directive. This is nothing new, just conforms to a lot of other assemblers. (minor)
- Changed label allocation from 320/32 (10000 labels @ 200K+) to 32/37 (1000 labels); makes running under DOS much easier. Since additional label space is allocated dynamically, this should have no effect on large programs with lots of labels. The 37 is a prime, believed to be better for hashing. (minor)

C.3.40 Version 0.98.03

"Integrated patchfile 0.98-0.98.01. I call this version 0.98.03 for historical reasons: 0.98.02 was trashed." ––John Coffman <johninsd@san.rr.com>, 27-Jul-2000

- Kendall Bennett's SciTech MGL changes
- Note that you must define "TASM_COMPAT" at compile-time to get the Tasm Ideal Mode compatibility.
- All changes can be compiled in and out using the TASM_COMPAT macros, and when compiled without TASM_COMPAT defined we get the exact same binary as the unmodified 0.98 sources.
- standard.mac, macros.c: Added macros to ignore TASM directives before first include

- nasm.h: Added extern declaration for tasm_compatible_mode
- nasm.c: Added global variable tasm_compatible_mode
- Added command line switch for TASM compatible mode (-t)
- Changed version command line to reflect when compiled with TASM additions
- Added response file processing to allow all arguments on a single line (response file is @resp rather than –@resp for NASM format).
- labels.c: Changes islocal() macro to support TASM style @@local labels.
- Added islocalchar() macro to support TASM style @@local labels.
- parser.c: Added support for TASM style memory references (ie: mov [DWORD eax],10 rather than the NASM style mov DWORD [eax],10).
- preproc.c: Added new directives, `%arg`, `%local`, `%stacksize` to directives table
- Added support for TASM style directives without a leading % symbol.
- Integrated a block of changes from Andrew Zabolotny <bit@eltech.ru>:
- A new keyword `%xdefine` and its case-insensitive counterpart `%ixdefine`. They work almost the same way as `%define` and `%idefine` but expand the definition immediately, not on the invocation. Something like a cross between `%define` and `%assign`. The "x" suffix stands for "eXpand", so "xdefine" can be deciphered as "expand-and-define". Thus you can do things like this:

```
%assign ofs     0

%macro  arg     1
        %xdefine %1 dword [esp+ofs]
        %assign ofs ofs+4
%endmacro
```

- Changed the place where the expansion of %$name macros are expanded. Now they are converted into ..@ctxnum.name form when detokenizing, so there are no quirks as before when using %$name arguments to macros, in macros etc. For example:

```
%macro  abc     1
        %define %1 hello
%endm

abc     %$here
%$here
```

  Now last line will be expanded into "hello" as expected. This also allows for lots of goodies, a good example are extended "proc" macros included in this archive.

- Added a check for "cstk" in smacro_defined() before calling get_ctx() – this allows for things like:

```
%ifdef %$abc
%endif
```

  to work without warnings even in no context.

- Added a check for "cstk" in %if*ctx and %elif*ctx directives – this allows to use `%ifctx` without excessive warnings. If there is no active context, `%ifctx` goes through "false" branch.
- Removed "user error: " prefix with `%error` directive: it just clobbers the output and has absolutely no functionality. Besides, this allows to write macros that does not differ from built-in functions in any way.
- Added expansion of string that is output by `%error` directive. Now you can do things like:

```
%define hello(x) Hello, x!
```

```
%define %$name andy
%error "hello(%$name)"
```

Same happened with `%include` directive.

- Now all directives that expect an identifier will try to expand and concatenate everything without whitespaces in between before usage. For example, with "unfixed" nasm the commands

  ```
  %define %$abc hello
  %define __%$abc goodbye
  __%$abc
  ```

  would produce "incorrect" output: last line will expand to

  ```
  hello goodbyehello
  ```

  Not quite what you expected, eh? :-) The answer is that preprocessor treats the `%define` construct as if it would be

  ```
  %define __ %$abc goodbye
  ```

  (note the white space between __ and %$abc). After my "fix" it will "correctly" expand into

  ```
  goodbye
  ```

  as expected. Note that I use quotes around words "correct", "incorrect" etc because this is rather a feature not a bug; however current behaviour is more logical (and allows more advanced macro usage :-).

Same change was applied to: `%push`,`%macro`,`%imacro`,`%define`,`%idefine`,`%xdefine`,`%ixdefine`, `%assign`,`%iassign`,`%undef`

- A new directive [WARNING {+|-}warning-id] have been added. It works only if the assembly phase is enabled (i.e. it doesn't work with nasm –e).
- A new warning type: macro-selfref. By default this warning is disabled; when enabled NASM warns when a macro self-references itself; for example the following source:

  ```
  [WARNING macro-selfref]

  %macro          push    1-*
          %rep    %0
                  push    %1
                  %rotate 1
          %endrep
  %endmacro

                  push    eax,ebx,ecx
  ```

  will produce a warning, but if we remove the first line we won't see it anymore (which is The Right Thing To Do {tm} IMHO since C preprocessor eats such constructs without warnings at all).
- Added a "error" routine to preprocessor which always will set ERR_PASS1 bit in severity_code. This removes annoying repeated errors on first and second passes from preprocessor.
- Added the %+ operator in single-line macros for concatenating two identifiers. Usage example:

  ```
  %define _myfunc _otherfunc
  %define cextern(x) _ %+ x
  cextern (myfunc)
  ```

  After first expansion, third line will become "_myfunc". After this expansion is performed again so it becomes "_otherunc".
- Now if preprocessor is in a non-emitting state, no warning or error will be emitted. Example:

  ```
  %if 1
          mov     eax,ebx
  %else
  ```

```
        put anything you want between these two brackets,
        even macro-parameter references %1 or local
        labels %$zz or macro-local labels %%zz - no
        warning will be emitted.
%endif
```

- Context-local variables on expansion as a last resort are looked up in outer contexts. For example, the following piece:

```
%push   outer
%define %$a [esp]

        %push   inner
        %$a
        %pop
%pop
```

  will expand correctly the fourth line to [esp]; if we'll define another %$a inside the "inner" context, it will take precedence over outer definition. However, this modification has been applied only to expand_smacro and not to smacro_define: as a consequence expansion looks in outer contexts, but `%ifdef` won't look in outer contexts.

  This behaviour is needed because we don't want nested contexts to act on already defined local macros. Example:

```
%define %$arg1  [esp+4]
test    eax,eax
if      nz
        mov     eax,%$arg1
endif
```

  In this example the "if" mmacro enters into the "if" context, so %$arg1 is not valid anymore inside "if". Of course it could be worked around by using explicitly %$$arg1 but this is ugly IMHO.

- Fixed memory leak in `%undef`. The origline wasn't freed before exiting on success.
- Fixed trap in preprocessor when line expanded to empty set of tokens. This happens, for example, in the following case:

```
#define SOMETHING
SOMETHING
```

C.3.41 Version 0.98

All changes since NASM 0.98p3 have been produced by H. Peter Anvin <hpa@zytor.com>.

- The documentation comment delimiter is
- Allow EQU definitions to refer to external labels; reported by Pedro Gimeno.
- Re-enable support for RDOFF v1; reported by Pedro Gimeno.
- Updated License file per OK from Simon and Julian.

C.3.42 Version 0.98p9

- Update documentation (although the instruction set reference will have to wait; I don't want to hold up the 0.98 release for it.)
- Verified that the NASM implementation of the PEXTRW and PMOVMSKB instructions is correct. The encoding differs from what the Intel manuals document, but the Pentium III behaviour matches NASM, not the Intel manuals.
- Fix handling of implicit sizes in PSHUFW and PINSRW, reported by Stefan Hoffmeister.
- Resurrect the –s option, which was removed when changing the diagnostic output to stdout.

C.3.43 Version 0.98p8

- Fix for "DB" when NASM is running on a bigendian machine.
- Invoke insns.pl once for each output script, making Makefile.in legal for "make –j".
- Improve the Unix configure-based makefiles to make package creation easier.
- Included an RPM .spec file for building RPM (RedHat Package Manager) packages on Linux or Unix systems.
- Fix Makefile dependency problems.
- Change src/rdsrc.pl to include sectioning information in info output; required for install-info to work.
- Updated the RDOFF distribution to version 2 from Jules; minor massaging to make it compile in my environment.
- Split doc files that can be built by anyone with a Perl interpreter off into a separate archive.
- "Dress rehearsal" release!

C.3.44 Version 0.98p7

- Fixed opcodes with a third byte-sized immediate argument to not complain if given "byte" on the immediate.
- Allow `%undef` to remove single-line macros with arguments. This matches the behaviour of #undef in the C preprocessor.
- Allow –d, –u, –i and –p to be specified as –D, –U, –I and –P for compatibility with most C compilers and preprocessors. This allows Makefile options to be shared between cc and nasm, for example.
- Minor cleanups.
- Went through the list of Katmai instructions and hopefully fixed the (rather few) mistakes in it.
- (Hopefully) fixed a number of disassembler bugs related to ambiguous instructions (disambiguated by –p) and SSE instructions with REP.
- Fix for bug reported by Mark Junger: "call dword 0x12345678" should work and may add an OSP (affected CALL, JMP, Jcc).
- Fix for environments when "stderr" isn't a compile-time constant.

C.3.45 Version 0.98p6

- Took officially over coordination of the 0.98 release; so drop the p3.x notation. Skipped p4 and p5 to avoid confusion with John Fine's J4 and J5 releases.
- Update the documentation; however, it still doesn't include documentation for the various new instructions. I somehow wonder if it makes sense to have an instruction set reference in the assembler manual when Intel et al have PDF versions of their manuals online.
- Recognize "idt" or "centaur" for the –p option to ndisasm.
- Changed error messages back to stderr where they belong, but add an –E option to redirect them elsewhere (the DOS shell cannot redirect stderr.)
- –M option to generate Makefile dependencies (based on code from Alex Verstak.)
- `%undef` preprocessor directive, and –u option, that undefines a single-line macro.
- OS/2 Makefile (Mkfiles/Makefile.os2) for Borland under OS/2; from Chuck Crayne.
- Various minor bugfixes (reported by): – Dangling `%s` in preproc.c (Martin Junker)

- THERE ARE KNOWN BUGS IN SSE AND THE OTHER KATMAI INSTRUCTIONS. I am on a trip and didn't bring the Katmai instruction reference, so I can't work on them right now.
- Updated the License file per agreement with Simon and Jules to include a GPL distribution clause.

C.3.46 Version 0.98p3.7

- (Hopefully) fixed the canned Makefiles to include the outrdf2 and zoutieee modules.
- Renamed changes.asm to changed.asm.

C.3.47 Version 0.98p3.6

- Fixed a bunch of instructions that were added in 0.98p3.5 which had memory operands, and the address-size prefix was missing from the instruction pattern.

C.3.48 Version 0.98p3.5

- Merged in changes from John S. Fine's 0.98-J5 release. John's based 0.98-J5 on my 0.98p3.3 release; this merges the changes.
- Expanded the instructions flag field to a long so we can fit more flags; mark SSE (KNI) and AMD or Katmai-specific instructions as such.
- Fix the "PRIV" flag on a bunch of instructions, and create new "PROT" flag for protected-mode-only instructions (orthogonal to if the instruction is privileged!) and new "SMM" flag for SMM-only instructions.
- Added AMD-only SYSCALL and SYSRET instructions.
- Make SSE actually work, and add new Katmai MMX instructions.
- Added a –p (preferred vendor) option to ndisasm so that it can distinguish e.g. Cyrix opcodes also used in SSE. For example:

```
ndisasm -p cyrix aliased.bin
00000000  670F514310        paddsiw mm0,[ebx+0x10]
00000005  670F514320        paddsiw mm0,[ebx+0x20]
ndisasm -p intel aliased.bin
00000000  670F514310        sqrtps xmm0,[ebx+0x10]
00000005  670F514320        sqrtps xmm0,[ebx+0x20]
```

- Added a bunch of Cyrix-specific instructions.

C.3.49 Version 0.98p3.4

- Made at least an attempt to modify all the additional Makefiles (in the Mkfiles directory). I can't test it, but this was the best I could do.
- DOS DJGPP+"Opus Make" Makefile from John S. Fine.
- changes.asm changes from John S. Fine.

C.3.50 Version 0.98p3.3

- Patch from Conan Brink to allow nesting of `%rep` directives.
- If we're going to allow INT01 as an alias for INT1/ICEBP (one of Jules 0.98p3 changes), then we should allow INT03 as an alias for INT3 as well.
- Updated changes.asm to include the latest changes.
- Tried to clean up the <CR>s that had snuck in from a DOS/Windows environment into my Unix environment, and try to make sure than DOS/Windows users get them back.

- We would silently generate broken tools if insns.dat wasn't sorted properly. Change insns.pl so that the order doesn't matter.
- Fix bug in insns.pl (introduced by me) which would cause conditional instructions to have an extra "cc" in disassembly, e.g. "jnz" disassembled as "jccnz".

C.3.51 Version 0.98p3.2

- Merged in John S. Fine's changes from his 0.98-J4 prerelease; see http://www.csoft.net/cz/johnfine/
- Changed previous "spotless" Makefile target (appropriate for distribution) to "distclean", and added "cleaner" target which is same as "clean" except deletes files generated by Perl scripts; "spotless" is union.
- Removed BASIC programs from distribution. Get a Perl interpreter instead (see below.)
- Calling this "pre-release 3.2" rather than "p3-hpa2" because of John's contributions.
- Actually link in the IEEE output format (zoutieee.c); fix a bunch of compiler warnings in that file. Note I don't know what IEEE output is supposed to look like, so these changes were made "blind".

C.3.52 Version 0.98p3-hpa

- Merged nasm098p3.zip with nasm-0.97.tar.gz to create a fully buildable version for Unix systems (Makefile.in updates, etc.)
- Changed insns.pl to create the instruction tables in nasm.h and names.c, so that a new instruction can be added by adding it *only* to insns.dat.
- Added the following new instructions: SYSENTER, SYSEXIT, FXSAVE, FXRSTOR, UD1, UD2 (the latter two are two opcodes that Intel guarantee will never be used; one of them is documented as UD2 in Intel documentation, the other one just as "Undefined Opcode" -- calling it UD1 seemed to make sense.)
- MAX_SYMBOL was defined to be 9, but LOADALL286 and LOADALL386 are 10 characters long. Now MAX_SYMBOL is derived from insns.dat.
- A note on the BASIC programs included: forget them. insns.bas is already out of date. Get yourself a Perl interpreter for your platform of choice at http://www.cpan.org/ports/index.html.

C.3.53 Version 0.98 pre-release 3

- added response file support, improved command line handling, new layout help screen
- fixed limit checking bug, 'OUT byte nn, reg' bug, and a couple of rdoff related bugs, updated Wishlist; 0.98 Prerelease 3.

C.3.54 Version 0.98 pre-release 2

- fixed bug in outcoff.c to do with truncating section names longer than 8 characters, referencing beyond end of string; 0.98 pre-release 2

C.3.55 Version 0.98 pre-release 1

- Fixed a bug whereby STRUC didn't work at all in RDF.
- Fixed a problem with group specification in PUBDEFs in OBJ.
- Improved ease of adding new output formats. Contribution due to Fox Cutter.
- Fixed a bug in relocations in the 'bin' format: was showing up when a relocatable reference crossed an 8192-byte boundary in any output section.

- Fixed a bug in local labels: local-label lookups were inconsistent between passes one and two if an EQU occurred between the definition of a global label and the subsequent use of a local label local to that global.
- Fixed a seg-fault in the preprocessor (again) which happened when you use a blank line as the first line of a multi-line macro definition and then defined a label on the same line as a call to that macro.
- Fixed a stale-pointer bug in the handling of the NASM environment variable. Thanks to Thomas McWilliams.
- ELF had a hard limit on the number of sections which caused segfaults when transgressed. Fixed.
- Added ability for ndisasm to read from stdin by using '-' as the filename.
- ndisasm wasn't outputting the TO keyword. Fixed.
- Fixed error cascade on bogus expression in `%if` – an error in evaluation was causing the entire `%if` to be discarded, thus creating trouble later when the `%else` or `%endif` was encountered.
- Forward reference tracking was instruction-granular not operand- granular, which was causing 286-specific code to be generated needlessly on code of the form 'shr word [forwardref],1'. Thanks to Jim Hague for sending a patch.
- All messages now appear on stdout, as sending them to stderr serves no useful purpose other than to make redirection difficult.
- Fixed the problem with EQUs pointing to an external symbol – this now generates an error message.
- Allowed multiple size prefixes to an operand, of which only the first is taken into account.
- Incorporated John Fine's changes, including fixes of a large number of preprocessor bugs, some small problems in OBJ, and a reworking of label handling to define labels before their line is assembled, rather than after.
- Reformatted a lot of the source code to be more readable. Included 'coding.txt' as a guideline for how to format code for contributors.
- Stopped nested `%reps` causing a panic – they now cause a slightly more friendly error message instead.
- Fixed floating point constant problems (patch by Pedro Gimeno)
- Fixed the return value of insn_size() not being checked for –1, indicating an error.
- Incorporated 3Dnow! instructions.
- Fixed the 'mov eax, eax + ebx' bug.
- Fixed the GLOBAL EQU bug in ELF. Released developers release 3.
- Incorporated John Fine's command line parsing changes
- Incorporated David Lindauer's OMF debug support
- Made changes for LCC 4.0 support (`__NASM_CDecl__`, removed register size specification warning when sizes agree).

C.4 NASM 0.90-0.97

Revisions before 0.98.

C.4.1 Version 0.97 released December 1997

- This was entirely a bug-fix release to 0.96, which seems to have got cursed. Silly me.

- Fixed stupid mistake in OBJ which caused ‘MOV EAX,<constant>’ to fail. Caused by an error in the ‘MOV EAX,’ support.
- ndisasm hung at EOF when compiled with lcc on Linux because lcc on Linux somehow breaks feof(). ndisasm now does not rely on feof().
- A heading in the documentation was missing due to a markup error in the indexing. Fixed.
- Fixed failure to update all pointers on realloc() within extended- operand code in parser.c. Was causing wrong behaviour and seg faults on lines such as ‘dd 0.0,0.0,0.0,0.0,...’
- Fixed a subtle preprocessor bug whereby invoking one multi-line macro on the first line of the expansion of another, when the second had been invoked with a label defined before it, didn’t expand the inner macro.
- Added internal.doc back in to the distribution archives – it was missing in 0.96 *blush*
- Fixed bug causing 0.96 to be unable to assemble its own test files, specifically objtest.asm. *blush again*
- Fixed seg-faults and bogus error messages caused by mismatching `%rep` and `%endrep` within multi-line macro definitions.
- Fixed a problem with buffer overrun in OBJ, which was causing corruption at ends of long PUBDEF records.
- Separated DOS archives into main-program and documentation to reduce download size.

C.4.2 Version 0.96 released November 1997

- Fixed a bug whereby, if ‘nasm sourcefile’ would cause a filename collision warning and put output into ‘nasm.out’, then ‘nasm sourcefile –o outputfile’ still gave the warning even though the ‘-o’ was honoured. Fixed name pollution under Digital UNIX: one of its header files defined R_SP, which broke the enum in nasm.h.
- Fixed minor instruction table problems: FUCOM and FUCOMP didn’t have two-operand forms; NDISASM didn’t recognise the longer register forms of PUSH and POP (eg FF F3 for PUSH BX); TEST mem,imm32 was flagged as undocumented; the 32-bit forms of CMOV had 16-bit operand size prefixes; ‘AAD imm’ and ‘AAM imm’ are no longer flagged as undocumented because the Intel Architecture reference documents them.
- Fixed a problem with the local-label mechanism, whereby strange types of symbol (EQUs, auto-defined OBJ segment base symbols) interfered with the ‘previous global label’ value and screwed up local labels.
- Fixed a bug whereby the stub preprocessor didn’t communicate with the listing file generator, so that the –a and –l options in conjunction would produce a useless listing file.
- Merged ‘os2’ object file format back into ‘obj’, after discovering that ‘obj’ _also_ shouldn’t have a link pass separator in a module containing a non-trivial MODEND. Flat segments are now declared using the FLAT attribute. ‘os2’ is no longer a valid object format name: use ‘obj’.
- Removed the fixed-size temporary storage in the evaluator. Very very long expressions (like ‘mov ax,1+1+1+1+...’ for two hundred 1s or so) should now no longer crash NASM.
- Fixed a bug involving segfaults on disassembly of MMX instructions, by changing the meaning of one of the operand-type flags in nasm.h. This may cause other apparently unrelated MMX problems; it needs to be tested thoroughly.
- Fixed some buffer overrun problems with large OBJ output files. Thanks to DJ Delorie for the bug report and fix.

- Made preprocess-only mode actually listen to the `%line` markers as it prints them, so that it can report errors more sanely.
- Re-designed the evaluator to keep more sensible track of expressions involving forward references: can now cope with previously-nightmare situations such as:

```
mov ax,foo | bar
foo equ 1
bar equ 2
```

- Added the ALIGN and ALIGNB standard macros.
- Added PIC support in ELF: use of WRT to obtain the four extra relocation types needed.
- Added the ability for output file formats to define their own extensions to the GLOBAL, COMMON and EXTERN directives.
- Implemented common-variable alignment, and global-symbol type and size declarations, in ELF.
- Implemented NEAR and FAR keywords for common variables, plus far-common element size specification, in OBJ.
- Added a feature whereby EXTERNs and COMMONs in OBJ can be given a default WRT specification (either a segment or a group).
- Transformed the Unix NASM archive into an auto-configuring package.
- Added a sanity-check for people applying SEG to things which are already segment bases: this previously went unnoticed by the SEG processing and caused OBJ-driver panics later.
- Added the ability, in OBJ format, to deal with 'MOV EAX,' type references: OBJ doesn't directly support dword-size segment base fixups, but as long as the low two bytes of the constant term are zero, a word-size fixup can be generated instead and it will work.
- Added the ability to specify sections' alignment requirements in Win32 object files and pure binary files.
- Added preprocess-time expression evaluation: the `%assign` (and `%iassign`) directive and the bare `%if` (and `%elif`) conditional. Added relational operators to the evaluator, for use only in `%if` constructs: the standard relationals = < > <= >= <> (and C-like synonyms == and !=) plus low-precedence logical operators &&, ^^ and ||.
- Added a preprocessor repeat construct: `%rep` / `%exitrep` / `%endrep`.
- Added the __FILE__ and __LINE__ standard macros.
- Added a sanity check for number constants being greater than 0xFFFFFFFF. The warning can be disabled.
- Added the %0 token whereby a variadic multi-line macro can tell how many parameters it's been given in a specific invocation.
- Added `%rotate`, allowing multi-line macro parameters to be cycled.
- Added the '*' option for the maximum parameter count on multi-line macros, allowing them to take arbitrarily many parameters.
- Added the ability for the user-level forms of EXTERN, GLOBAL and COMMON to take more than one argument.
- Added the IMPORT and EXPORT directives in OBJ format, to deal with Windows DLLs.
- Added some more preprocessor `%if` constructs: `%ifidn` / `%ifidni` (exact textual identity), and `%ifid` / `%ifnum` / `%ifstr` (token type testing).

- Added the ability to distinguish SHL AX,1 (the 8086 version) from SHL AX,BYTE 1 (the 286-and-upwards version whose constant happens to be 1).
- Added NetBSD/FreeBSD/OpenBSD's variant of a.out format, complete with PIC shared library features.
- Changed NASM's idiosyncratic handling of FCLEX, FDISI, FENI, FINIT, FSAVE, FSTCW, FSTENV, and FSTSW to bring it into line with the otherwise accepted standard. The previous behaviour, though it was a deliberate feature, was a deliberate feature based on a misunderstanding. Apologies for the inconvenience.
- Improved the flexibility of ABSOLUTE: you can now give it an expression rather than being restricted to a constant, and it can take relocatable arguments as well.
- Added the ability for a variable to be declared as EXTERN multiple times, and the subsequent definitions are just ignored.
- We now allow instruction prefixes (CS, DS, LOCK, REPZ etc) to be alone on a line (without a following instruction).
- Improved sanity checks on whether the arguments to EXTERN, GLOBAL and COMMON are valid identifiers.
- Added misc/exebin.mac to allow direct generation of .EXE files by hacking up an EXE header using DB and DW; also added test/binexe.asm to demonstrate the use of this. Thanks to Yann Guidon for contributing the EXE header code.
- ndisasm forgot to check whether the input file had been successfully opened. Now it does. Doh!
- Added the Cyrix extensions to the MMX instruction set.
- Added a hinting mechanism to allow [EAX+EBX] and [EBX+EAX] to be assembled differently. This is important since [ESI+EBP] and [EBP+ESI] have different default base segment registers.
- Added support for the PharLap OMF extension for 4096-byte segment alignment.

C.4.3 Version 0.95 released July 1997

- Fixed yet another ELF bug. This one manifested if the user relied on the default segment, and attempted to define global symbols without first explicitly declaring the target segment.
- Added makefiles (for NASM and the RDF tools) to build Win32 console apps under Symantec C++. Donated by Mark Junker.
- Added 'macros.bas' and 'insns.bas', QBasic versions of the Perl scripts that convert 'standard.mac' to 'macros.c' and convert 'insns.dat' to 'insnsa.c' and 'insnsd.c'. Also thanks to Mark Junker.
- Changed the diassembled forms of the conditional instructions so that JB is now emitted as JC, and other similar changes. Suggested list by Ulrich Doewich.
- Added '@' to the list of valid characters to begin an identifier with.
- Documentary changes, notably the addition of the 'Common Problems' section in nasm.doc.
- Fixed a bug relating to 32-bit PC-relative fixups in OBJ.
- Fixed a bug in perm_copy() in labels.c which was causing exceptions in cleanup_labels() on some systems.
- Positivity sanity check in TIMES argument changed from a warning to an error following a further complaint.
- Changed the acceptable limits on byte and word operands to allow things like '~10111001b' to work.

- Fixed a major problem in the preprocessor which caused seg-faults if macro definitions contained blank lines or comment-only lines.
- Fixed inadequate error checking on the commas separating the arguments to ‘db’, ‘dw’ etc.
- Fixed a crippling bug in the handling of macros with operand counts defined with a ‘+’ modifier.
- Fixed a bug whereby object file formats which stored the input file name in the output file (such as OBJ and COFF) weren’t doing so correctly when the output file name was specified on the command line.
- Removed [INC] and [INCLUDE] support for good, since they were obsolete anyway.
- Fixed a bug in OBJ which caused all fixups to be output in 16-bit (old-format) FIXUPP records, rather than putting the 32-bit ones in FIXUPP32 (new-format) records.
- Added, tentatively, OS/2 object file support (as a minor variant on OBJ).
- Updates to Fox Cutter’s Borland C makefile, Makefile.bc2.
- Removed a spurious second fclose() on the output file.
- Added the ‘-s’ command line option to redirect all messages which would go to stderr (errors, help text) to stdout instead.
- Added the ‘-w’ command line option to selectively suppress some classes of assembly warning messages.
- Added the ‘-p’ pre-include and ‘-d’ pre-define command-line options.
- Added an include file search path: the ‘-i’ command line option.
- Fixed a silly little preprocessor bug whereby starting a line with a ‘%!’ environment-variable reference caused an ‘unknown directive’ error.
- Added the long-awaited listing file support: the ‘-l’ command line option.
- Fixed a problem with OBJ format whereby, in the absence of any explicit segment definition, non-global symbols declared in the implicit default segment generated spurious EXTDEF records in the output.
- Added the NASM environment variable.
- From this version forward, Win32 console-mode binaries will be included in the DOS distribution in addition to the 16-bit binaries. Added Makefile.vc for this purpose.
- Added ‘return 0;’ to test/objlink.c to prevent compiler warnings.
- Added the __NASM_MAJOR__ and __NASM_MINOR__ standard defines.
- Added an alternative memory-reference syntax in which prefixing an operand with ‘&’ is equivalent to enclosing it in square brackets, at the request of Fox Cutter.
- Errors in pass two now cause the program to return a non-zero error code, which they didn’t before.
- Fixed the single-line macro cycle detection, which didn’t work at all on macros with no parameters (caused an infinite loop). Also changed the behaviour of single-line macro cycle detection to work like cpp, so that macros like ‘extrn’ as given in the documentation can be implemented.
- Fixed the implementation of WRT, which was too restrictive in that you couldn’t do ‘mov ax,[di+abc wrt dgroup]’ because (di+abc) wasn’t a relocatable reference.

C.4.4 Version 0.94 released April 1997

- Major item: added the macro processor.

- Added undocumented instructions SMI, IBTS, XBTS and LOADALL286. Also reorganised CMPXCHG instruction into early-486 and Pentium forms. Thanks to Thobias Jones for the information.
- Fixed two more stupid bugs in ELF, which were causing 'ld' to continue to seg-fault in a lot of non-trivial cases.
- Fixed a seg-fault in the label manager.
- Stopped FBLD and FBSTP from _requiring_ the TWORD keyword, which is the only option for BCD loads/stores in any case.
- Ensured FLDCW, FSTCW and FSTSW can cope with the WORD keyword, if anyone bothers to provide it. Previously they complained unless no keyword at all was present.
- Some forms of FDIV/FDIVR and FSUB/FSUBR were still inverted: a vestige of a bug that I thought had been fixed in 0.92. This was fixed, hopefully for good this time...
- Another minor phase error (insofar as a phase error can _ever_ be minor) fixed, this one occurring in code of the form

```
rol ax,forward_reference
forward_reference equ 1
```

- The number supplied to TIMES is now sanity-checked for positivity, and also may be greater than 64K (which previously didn't work on 16-bit systems).
- Added Watcom C makefiles, and misc/pmw.bat, donated by Dominik Behr.
- Added the INCBIN pseudo-opcode.
- Due to the advent of the preprocessor, the [INCLUDE] and [INC] directives have become obsolete. They are still supported in this version, with a warning, but won't be in the next.
- Fixed a bug in OBJ format, which caused incorrect object records to be output when absolute labels were made global.
- Updates to RDOFF subdirectory, and changes to outrdf.c.

C.4.5 Version 0.93 released January 1997

This release went out in a great hurry after semi-crippling bugs were found in 0.92.

- Really *did* fix the stack overflows this time. *blush*
- Had problems with EA instruction sizes changing between passes, when an offset contained a forward reference and so 4 bytes were allocated for the offset in pass one; by pass two the symbol had been defined and happened to be a small absolute value, so only 1 byte got allocated, causing instruction size mismatch between passes and hence incorrect address calculations. Fixed.
- Stupid bug in the revised ELF section generation fixed (associated string-table section for .symtab was hard-coded as 7, even when this didn't fit with the real section table). Was causing 'ld' to seg-fault under Linux.
- Included a new Borland C makefile, Makefile.bc2, donated by Fox Cutter <lmb@comtch.iea.com>.

C.4.6 Version 0.92 released January 1997

- The FDIVP/FDIVRP and FSUBP/FSUBRP pairs had been inverted: this was fixed. This also affected the LCC driver.
- Fixed a bug regarding 32-bit effective addresses of the form `[other_register+ESP]`.
- Documentary changes, notably documentation of the fact that Borland Win32 compilers use 'obj' rather than 'win32' object format.
- Fixed the COMENT record in OBJ files, which was formatted incorrectly.

- Fixed a bug causing segfaults in large RDF files.
- OBJ format now strips initial periods from segment and group definitions, in order to avoid complications with the local label syntax.
- Fixed a bug in disassembling far calls and jumps in NDISASM.
- Added support for user-defined sections in COFF and ELF files.
- Compiled the DOS binaries with a sensible amount of stack, to prevent stack overflows on any arithmetic expression containing parentheses.
- Fixed a bug in handling of files that do not terminate in a newline.

C.4.7 Version 0.91 released November 1996

- Loads of bug fixes.
- Support for RDF added.
- Support for DBG debugging format added.
- Support for 32-bit extensions to Microsoft OBJ format added.
- Revised for Borland C: some variable names changed, makefile added.
- LCC support revised to actually work.
- JMP/CALL NEAR/FAR notation added.
- 'a16', 'o16', 'a32' and 'o32' prefixes added.
- Range checking on short jumps implemented.
- MMX instruction support added.
- Negative floating point constant support added.
- Memory handling improved to bypass 64K barrier under DOS.
- `$` prefix to force treatment of reserved words as identifiers added.
- Default-size mechanism for object formats added.
- Compile-time configurability added.
- `#`, `@`, `~` and `c{?}` are now valid characters in labels.
- `-e` and `-k` options in NDISASM added.

C.4.8 Version 0.90 released October 1996

First release version. First support for object file output. Other changes from previous version (0.3x) too numerous to document.

Appendix D: Building NASM from Source

The source code for NASM is available from our website, https://www.nasm.us/, see section E.1.

D.1 Building from a Source Archive

The source archives available on the web site should be capable of building on a number of platforms. This is the recommended method for building NASM to support platforms for which executables are not available, if you do not require changing the source code.

The preferred build platforms are development environments which support POSIX (Unix)-style tools (a "POSIX environment"). For Windows, MSYS2 (https://www.msys2.org/) is such a development environment. Normally either gcc or clang is used as the compiler, but it is also possible to use MSVC with a POSIX wrapper like cccl from the SWIG project.

In a POSIX environment, run:

```
sh configure
make
```

A number of options can be passed to configure; see sh configure --help. In particular, the --host option can be used to cross-compile NASM to run on another host system.

For non-POSIX environments, a set of makefiles for a handful of other environments are also available; please see the file Mkfiles/README. These makefiles are generally considered unreliable, as we have very little ability to test them.

The .zip version of the source archive has DOS/Windows line endings (CR LF), which many Unix/POSIX systems will not recognize. To extract the .zip version on such a system, use unzip -a. The .tar versions of the source archive has POSIX line endings (LF).

D.2 Optional Build Tools

The following additional tools are required to build specific subsystems, to build from the git repository, or if the sources are modified.

Note that some of these tools will have their own dependencies.

Make sure all tools are available in your PATH (or equivalent.)

To build the installer for the Windows platform:

- The Nullsoft Scriptable Installer (NSIS, https://nsis-dev.github.io/).

To modify the sources, *or* to build the documentation:

- A Perl interpreter (https://www.perl.org/).
- Modules from CPAN (https://www.cpan.org/). The following Perl modules are currently required, some of which will be bundled with the Perl interpreter or into larger CPAN packages:

```
Compress::Zlib
Fcntl
File::Basename
File::Compare
File::Copy
File::Find
File::Path
File::Spec
File::Temp
Font::TTF::Cmap
Font::TTF::Font
```

```
Font::TTF::Head
Font::TTF::Hmtx
Font::TTF::Maxp
Font::TTF::PSNames
Font::TTF::Post
Getopt::Long
JSON
Pod::Usage
Sort::Versions
Win32 (if building on Windows only)
```

To build the documentation:

- Either Ghostscript (`https://www.ghostscript.com/`) or Adobe Acrobat Distiller (untested.)
- The Google *Roboto* and *Roboto Mono* fonts, which are freely available under the SIL Open Font License (`https://github.com/google/roboto`).

To build the Unix man pages:

- AsciiDoc (`https://asciidoc.org/`).
- xmlto (`https://pagure.io/xmlto/`).

To build from the `git` repository on a POSIX platform:

- GNU `m4`, `autoconf` and `autoheader` (`https://www.gnu.org/`).

D.3 Building Optional Components

Install the required tools for the subsystem in question as described in section D.2.

To build the documentation:

```
make doc
```

Building the documentation may not work in a non-POSIX environment.

To build the Windows installer:

```
make nsis
```

To build the Unix man pages:

```
make manpages
```

To build everything available on the current platform:

```
make everything
```

D.4 Building from the `git` Repository

The NASM development tree is kept in a source code repository using the `git` distributed source control system. The link is available on the website. This is recommended only to participate in the development of NASM or to assist with testing the development code.

Install the required tools as described in section section D.2.

In a POSIX environment:

Run:

```
sh autogen.sh
```

to create the `configure` script and then build as described in section D.1.

In a non-POSIX environment, use the tool-specific Makefiles as described in section D.1.

D.5 Modifying the Sources

To build modified sources, you will need the tools described in section D.2.

Some build system changes might not be possible without a POSIX environment.

If you have modified the sources to change the embedded declarations of warning classes, you may have to manually re-build the warning catalog:

```
make warnings
```

This is not done automatically, as the tools do not have the ability to automatically detect when it is necessary to do so.

Appendix E: Contact Information

E.1 Website

NASM has a website at `https://www.nasm.us/`.

New releases, release candidates, and daily development snapshots of NASM are available from the official web site in source form as well as binaries for a number of common platforms.

E.1.1 User Forums

Users of NASM may find the Forums on the website useful. These are, however, not frequented much by the developers of NASM, so they are not suitable for reporting bugs.

E.1.2 Development Community

The development of NASM is coordinated primarily though the `nasm-devel` mailing list. If you wish to participate in development of NASM, please join this mailing list. Subscription links and archives of past posts are available on the website.

E.2 Reporting Bugs

To report bugs in NASM, please use the bug tracker at `https://www.nasm.us/` (click on "Bug Tracker"), or if that fails then through one of the contacts in section E.1.

Please read section 2.2 first, and don't report the bug if it's listed in there as a deliberate feature. (If you think the feature is badly thought out, feel free to send us reasons why you think it should be changed, but don't just send us mail saying 'This is a bug' if the documentation says we did it on purpose.) Then read section 14.1, and don't bother reporting the bug if it's listed there.

If you do report a bug, *please* make sure your bug report includes the following information:

- What operating system you're running NASM under: Linux, FreeBSD, NetBSD, MacOS X, Win16, Win32, Win64, MS-DOS, OS/2, VMS, whatever.
- If you compiled your own executable from a source archive, compiled your own executable from `git`, used the standard distribution binaries from the website, or got an executable from somewhere else (e.g. a Linux distribution.) If you were using a locally built executable, try to reproduce the problem using one of the standard binaries, as this will make it easier for us to reproduce your problem prior to fixing it.
- Which version of NASM you're using, and exactly how you invoked it. Give us the precise command line, and the contents of the `NASMENV` environment variable if any.
- Which versions of any supplementary programs you're using, and how you invoked them. If the problem only becomes visible at link time, tell us what linker you're using, what version of it you've got, and the exact linker command line. If the problem involves linking against object files generated by a compiler, tell us what compiler, what version, and what command line or options you used. (If you're compiling in an IDE, please try to reproduce the problem with the command-line version of the compiler.)
- If at all possible, send us a NASM source file which exhibits the problem. If this causes copyright problems (e.g. you can only reproduce the bug in restricted-distribution code) then bear in mind the following two points: firstly, we guarantee that any source code sent to us for the purposes of debugging NASM will be used *only* for the purposes of debugging NASM, and that we will delete all our copies of it as soon as we have found and fixed the bug or bugs in question; and secondly, we would prefer *not* to be mailed large chunks of code anyway. The smaller the file, the better. A three-line sample file that does nothing useful *except* demonstrate the problem is much easier to

work with than a fully fledged ten-thousand-line program. (Of course, some errors *do* only crop up in large files, so this may not be possible.)

- A description of what the problem actually *is*. 'It doesn't work' is *not* a helpful description! Please describe exactly what is happening that shouldn't be, or what isn't happening that should. Examples might be: 'NASM generates an error message saying Line 3 for an error that's actually on Line 5'; 'NASM generates an error message that I believe it shouldn't be generating at all'; 'NASM fails to generate an error message that I believe it *should* be generating'; 'the object file produced from this source code crashes my linker'; 'the ninth byte of the output file is 66 and I think it should be 77 instead'.
- If you believe the output file from NASM to be faulty, send it to us. That allows us to determine whether our own copy of NASM generates the same file, or whether the problem is related to portability issues between our development platforms and yours. We can handle binary files mailed to us as MIME attachments, uuencoded, and even BinHex. Alternatively, we may be able to provide an FTP site you can upload the suspect files to; but mailing them is easier for us.
- Any other information or data files that might be helpful. If, for example, the problem involves NASM failing to generate an object file while TASM can generate an equivalent file without trouble, then send us *both* object files, so we can see what TASM is doing differently from us.

Appendix F: Instruction List

F.1 Introduction

The following sections show the instructions which NASM currently supports. For each instruction, there is a separate entry for each supported addressing mode. The third column shows the processor type in which the instruction was introduced and, when appropriate, one or more usage flags.

F.1.1 Special instructions (pseudo-ops)

```
DB                              PSEUDO
DW                              PSEUDO
DD                              PSEUDO
DQ                              PSEUDO
DT                              PSEUDO
DO                              PSEUDO
DY                              PSEUDO
DZ                              PSEUDO
RESB            imm             PSEUDO
RESW            imm             PSEUDO
RESD            imm             PSEUDO
RESQ            imm             PSEUDO
REST            imm             PSEUDO
RESO            imm             PSEUDO
RESY            imm             PSEUDO
RESZ            imm             PSEUDO
INCBIN                          PSEUDO
EQU             imm             PSEUDO
EQU             imm:imm         PSEUDO
EQU             spec4           PSEUDO,DFV
```

F.1.2 No operation

```
NOP                             BESTDIS,8086
NOP2                            ND,386
NOP             rm16            BESTDIS,P6
NOP             rm32            BESTDIS,P6
NOP             rm64            LONG,BESTDIS,PROT,X86_64
```

F.1.3 Integer data move instructions

```
MOV             reg_al,mem_offs         SM0-1,NOAPX,8086
MOV             reg_ax,mem_offs         SM0-1,NOAPX,8086
MOV             reg_eax,mem_offs        SM0-1,NOAPX,ZU,386
MOV             reg_rax,mem_offs        SM0-1,NOAPX,ZU,LONG,PROT,X86_64
MOV             mem_offs,reg_al         SM0-1,NOAPX,NOHLE,8086
MOV             mem_offs,reg_ax         SM0-1,NOAPX,NOHLE,8086
MOV             mem_offs,reg_eax        SM0-1,NOAPX,NOHLE,386
MOV             mem_offs,reg_rax        SM0-1,NOAPX,LONG,NOHLE,PROT,X86_64
MOVABS          reg_al,mem_offs         ND,SM0-1,NOAPX,8086
MOVABS          reg_ax,mem_offs         ND,SM0-1,NOAPX,8086
MOVABS          reg_eax,mem_offs        ND,SM0-1,NOAPX,ZU,386
MOVABS          reg_rax,mem_offs        SM0,ND,SM1,NOAPX,ZU,LONG,PROT,X86_64
MOVABS          mem_offs,reg_al         SM0,ND,SM1,NOAPX,NOHLE,8086
MOVABS          mem_offs,reg_ax         SM0,ND,SM1,NOAPX,NOHLE,8086
MOVABS          mem_offs,reg_eax        SM0,ND,SM1,NOAPX,NOHLE,386
MOVABS          mem_offs,reg_rax        ND,SM0-1,NOAPX,LONG,NOHLE,PROT,X86_64
MOV             rm8,reg8                SM0-1,8086
MOV             rm16,reg16              SM0-1,8086
MOV             rm32,reg32              SM0-1,386
MOV             rm64,reg64              SM0-1,LONG,PROT,X86_64
MOV             reg8,rm8                SM0-1,8086
MOV             reg16,rm16              SM0-1,8086
```

```
MOV             reg32,rm32              SM0-1,386
MOV             reg64,rm64              SM0-1,LONG,PROT,X86_64
MOV             reg64,udword64          ND,SM0-1,OPT,LONG,PROT,X86_64
MOV             reg64,sdword64          SM0,ND,SM1,SDWORD,OPT,LONG,PROT,X86_64
MOV             reg8,imm8               SM0-1,8086
MOV             reg16,imm16             SM0-1,8086
MOV             reg32,imm32             SM0-1,386
MOV             reg64,imm64             SM0-1,LONG,PROT,X86_64
MOV             reg8,imm8|abs           SM0,ND,SM1,8086
MOV             reg16,imm16|abs         SM0,ND,SM1,8086
MOV             reg32,imm32|abs         SM0,ND,SM1,386
MOV             reg64,imm64|abs         ND,SM0-1,LONG,PROT,X86_64
MOVABS          reg8,imm8               SM0,ND,SM1,8086
MOVABS          reg16,imm16             SM0,ND,SM1,8086
MOVABS          reg32,imm32             ND,SM0-1,386
MOVABS          reg64,imm64             ND,SM0-1,LONG,PROT,X86_64
MOV             rm8,imm8                SM0-1,8086
MOV             rm16,imm16              SM0-1,8086
MOV             rm32,imm32              SM0-1,386
MOV             rm64,sdword64           SM0-1,LONG,PROT,X86_64
MOVRS           reg8,mem8               SM0-1
MOVRS           reg16,mem16             SM0-1
MOVRS           reg32,mem32             SM0-1
MOVRS           reg64,mem64             SM0-1,LONG,PROT,X86_64
MOVRS           reg8,mem8               SM0-1
MOVRS           reg16,mem16             SM0-1
MOVRS           reg32,mem32             SM0-1
MOVRS           reg64,mem64             SM0-1,LONG,PROT,X86_64
```

F.1.4 Load effective address

```
LEA             reg16,mem               8086
LEA             reg32,mem               386
LEA             reg64,mem               LONG,PROT,X86_64
LEA             reg16,imm16             ND,8086
LEA             reg32,imm32             ND,386
LEA             reg64,sdword64          ND,LONG,PROT,X86_64
```

F.1.5 The basic 8 arithmetic operations

```
ADD             rm8,reg8                SM0-1,LOCK,FL,8086
ADD             rm16,reg16              SM0-1,LOCK,FL,8086
ADD             rm32,reg32              SM0-1,LOCK,FL,386
ADD             rm64,reg64              SM0-1,LOCK,LONG,FL,PROT,X86_64
ADD             reg8,rm8                SM0-1,FL,8086
ADD             reg16,rm16              SM0-1,FL,8086
ADD             reg32,rm32              SM0-1,FL,386
ADD             reg64,rm64              SM0-1,LONG,FL,PROT,X86_64
ADD             reg_al,imm8             SM0-1,FL,8086
ADD             rm8,imm8                SM0-1,LOCK,FL,8086
ADD             rm16,sbyteword16        SM0-1,LOCK,FL,8086
ADD             reg_ax,imm16            SM0-1,FL,8086
ADD             rm16,imm16              SM0-1,LOCK,FL,8086
ADD             rm32,sbytedword32       SM0-1,ZU,LOCK,FL,386
ADD             reg_eax,imm32           SM0-1,ZU,FL,386
ADD             rm32,imm32              SM0-1,ZU,LOCK,FL,386
ADD             rm64,sbytedword64       SM0-1,ZU,LOCK,LONG,FL,PROT,X86_64
ADD             reg_rax,sdword64        SM0-1,ZU,LONG,FL,PROT,X86_64
ADD             rm64,sdword64           SM0-1,ZU,LOCK,LONG,FL,PROT,X86_64
ADD             reg8?,reg8,rm8          SM0-2,NF,LONG,FL,EVEX,PROT,APX,X86_64
ADD             reg16?,reg16,rm16       SM0-2,NF,LONG,FL,EVEX,PROT,APX,X86_64
ADD             reg32?,reg32,rm32       SM0-2,NF,LONG,FL,EVEX,PROT,APX,X86_64
ADD             reg64?,reg64,rm64       SM0-2,NF,LONG,FL,EVEX,PROT,APX,X86_64
ADD             reg8?,rm8,reg8          SM0-2,NF,LONG,FL,EVEX,PROT,APX,X86_64
ADD             reg16?,rm16,reg16       SM0-2,NF,LONG,FL,EVEX,PROT,APX,X86_64
ADD             reg32?,rm32,reg32       SM0-2,NF,LONG,FL,EVEX,PROT,APX,X86_64
ADD             reg64?,rm64,reg64       SM0-2,NF,LONG,FL,EVEX,PROT,APX,X86_64
```

```
ADD             reg16?,rm16,sbyteword16  SM0-2,NF,LONG,FL,EVEX,PROT,APX,X86_64
ADD             reg32?,rm32,sbytedword32 SM0-2,NF,LONG,FL,EVEX,PROT,APX,X86_64
ADD             reg64?,rm64,sbytedword64 SM0-2,NF,LONG,FL,EVEX,PROT,APX,X86_64
ADD             reg8?,rm8,imm8           SM0-2,NF,LONG,FL,EVEX,PROT,APX,X86_64
ADD             reg16?,rm16,imm16        SM0-2,NF,LONG,FL,EVEX,PROT,APX,X86_64
ADD             reg32?,rm32,imm32        SM0-2,NF,LONG,FL,EVEX,PROT,APX,X86_64
ADD             reg64?,rm64,sdword64     SM0-2,NF,LONG,FL,EVEX,PROT,APX,X86_64
OR              rm8,reg8                 SM0-1,LOCK,FL,8086
OR              rm16,reg16               SM0-1,LOCK,FL,8086
OR              rm32,reg32               SM0-1,LOCK,FL,386
OR              rm64,reg64               SM0-1,LOCK,LONG,FL,PROT,X86_64
OR              reg8,rm8                 SM0-1,FL,8086
OR              reg16,rm16               SM0-1,FL,8086
OR              reg32,rm32               SM0-1,FL,386
OR              reg64,rm64               SM0-1,LONG,FL,PROT,X86_64
OR              reg_al,imm8              SM0-1,FL,8086
OR              rm8,imm8                 SM0-1,LOCK,FL,8086
OR              rm16,sbyteword16         SM0-1,LOCK,FL,8086
OR              reg_ax,imm16             SM0-1,FL,8086
OR              rm16,imm16               SM0-1,LOCK,FL,8086
OR              rm32,sbytedword32        SM0-1,ZU,LOCK,FL,386
OR              reg_eax,imm32            SM0-1,ZU,FL,386
OR              rm32,imm32               SM0-1,ZU,LOCK,FL,386
OR              rm64,sbytedword64        SM0-1,ZU,LOCK,LONG,FL,PROT,X86_64
OR              reg_rax,sdword64         SM0-1,ZU,LONG,FL,PROT,X86_64
OR              rm64,sdword64            SM0-1,ZU,LOCK,LONG,FL,PROT,X86_64
OR              reg8?,reg8,rm8           SM0-2,NF,LONG,FL,EVEX,PROT,APX,X86_64
OR              reg16?,reg16,rm16        SM0-2,NF,LONG,FL,EVEX,PROT,APX,X86_64
OR              reg32?,reg32,rm32        SM0-2,NF,LONG,FL,EVEX,PROT,APX,X86_64
OR              reg64?,reg64,rm64        SM0-2,NF,LONG,FL,EVEX,PROT,APX,X86_64
OR              reg8?,rm8,reg8           SM0-2,NF,LONG,FL,EVEX,PROT,APX,X86_64
OR              reg16?,rm16,reg16        SM0-2,NF,LONG,FL,EVEX,PROT,APX,X86_64
OR              reg32?,rm32,reg32        SM0-2,NF,LONG,FL,EVEX,PROT,APX,X86_64
OR              reg64?,rm64,reg64        SM0-2,NF,LONG,FL,EVEX,PROT,APX,X86_64
OR              reg16?,rm16,sbyteword16  SM0-2,NF,LONG,FL,EVEX,PROT,APX,X86_64
OR              reg32?,rm32,sbytedword32 SM0-2,NF,LONG,FL,EVEX,PROT,APX,X86_64
OR              reg64?,rm64,sbytedword64 SM0-2,NF,LONG,FL,EVEX,PROT,APX,X86_64
OR              reg8?,rm8,imm8           SM0-2,NF,LONG,FL,EVEX,PROT,APX,X86_64
OR              reg16?,rm16,imm16        SM0-2,NF,LONG,FL,EVEX,PROT,APX,X86_64
OR              reg32?,rm32,imm32        SM0-2,NF,LONG,FL,EVEX,PROT,APX,X86_64
OR              reg64?,rm64,sdword64     SM0-2,NF,LONG,FL,EVEX,PROT,APX,X86_64
ADC             rm8,reg8                 SM0-1,LOCK,FL,8086
ADC             rm16,reg16               SM0-1,LOCK,FL,8086
ADC             rm32,reg32               SM0-1,LOCK,FL,386
ADC             rm64,reg64               SM0-1,LOCK,LONG,FL,PROT,X86_64
ADC             reg8,rm8                 SM0-1,FL,8086
ADC             reg16,rm16               SM0-1,FL,8086
ADC             reg32,rm32               SM0-1,FL,386
ADC             reg64,rm64               SM0-1,LONG,FL,PROT,X86_64
ADC             reg_al,imm8              SM0-1,FL,8086
ADC             rm8,imm8                 SM0-1,LOCK,FL,8086
ADC             rm16,sbyteword16         SM0-1,LOCK,FL,8086
ADC             reg_ax,imm16             SM0-1,FL,8086
ADC             rm16,imm16               SM0-1,LOCK,FL,8086
ADC             rm32,sbytedword32        SM0-1,ZU,LOCK,FL,386
ADC             reg_eax,imm32            SM0-1,ZU,FL,386
ADC             rm32,imm32               SM0-1,ZU,LOCK,FL,386
ADC             rm64,sbytedword64        SM0-1,ZU,LOCK,LONG,FL,PROT,X86_64
ADC             reg_rax,sdword64         SM0-1,ZU,LONG,FL,PROT,X86_64
ADC             rm64,sdword64            SM0-1,ZU,LOCK,LONG,FL,PROT,X86_64
ADC             reg8?,reg8,rm8           SM0-2,LONG,FL,EVEX,PROT,APX,X86_64
ADC             reg16?,reg16,rm16        SM0-2,LONG,FL,EVEX,PROT,APX,X86_64
ADC             reg32?,reg32,rm32        SM0-2,LONG,FL,EVEX,PROT,APX,X86_64
ADC             reg64?,reg64,rm64        SM0-2,LONG,FL,EVEX,PROT,APX,X86_64
ADC             reg8?,rm8,reg8           SM0-2,LONG,FL,EVEX,PROT,APX,X86_64
ADC             reg16?,rm16,reg16        SM0-2,LONG,FL,EVEX,PROT,APX,X86_64
ADC             reg32?,rm32,reg32        SM0-2,LONG,FL,EVEX,PROT,APX,X86_64
```

```
ADC             reg64?,rm64,reg64         SM0-2,LONG,FL,EVEX,PROT,APX,X86_64
ADC             reg16?,rm16,sbyteword16   SM0-2,LONG,FL,EVEX,PROT,APX,X86_64
ADC             reg32?,rm32,sbytedword32  SM0-2,LONG,FL,EVEX,PROT,APX,X86_64
ADC             reg64?,rm64,sbytedword64  SM0-2,LONG,FL,EVEX,PROT,APX,X86_64
ADC             reg8?,rm8,imm8            SM0-2,LONG,FL,EVEX,PROT,APX,X86_64
ADC             reg16?,rm16,imm16         SM0-2,LONG,FL,EVEX,PROT,APX,X86_64
ADC             reg32?,rm32,imm32         SM0-2,LONG,FL,EVEX,PROT,APX,X86_64
ADC             reg64?,rm64,sdword64      SM0-2,LONG,FL,EVEX,PROT,APX,X86_64
SBB             rm8,reg8                  SM0-1,LOCK,FL,8086
SBB             rm16,reg16                SM0-1,LOCK,FL,8086
SBB             rm32,reg32                SM0-1,LOCK,FL,386
SBB             rm64,reg64                SM0-1,LOCK,LONG,FL,PROT,X86_64
SBB             reg8,rm8                  SM0-1,FL,8086
SBB             reg16,rm16                SM0-1,FL,8086
SBB             reg32,rm32                SM0-1,FL,386
SBB             reg64,rm64                SM0-1,LONG,FL,PROT,X86_64
SBB             reg_al,imm8               SM0-1,FL,8086
SBB             rm8,imm8                  SM0-1,LOCK,FL,8086
SBB             rm16,sbyteword16          SM0-1,LOCK,FL,8086
SBB             reg_ax,imm16              SM0-1,FL,8086
SBB             rm16,imm16                SM0-1,LOCK,FL,8086
SBB             rm32,sbytedword32         SM0-1,ZU,LOCK,FL,386
SBB             reg_eax,imm32             SM0-1,ZU,FL,386
SBB             rm32,imm32                SM0-1,ZU,LOCK,FL,386
SBB             rm64,sbytedword64         SM0-1,ZU,LOCK,LONG,FL,PROT,X86_64
SBB             reg_rax,sdword64          SM0-1,ZU,LONG,FL,PROT,X86_64
SBB             rm64,sdword64             SM0-1,ZU,LOCK,LONG,FL,PROT,X86_64
SBB             reg8?,reg8,rm8            SM0-2,LONG,FL,EVEX,PROT,APX,X86_64
SBB             reg16?,reg16,rm16         SM0-2,LONG,FL,EVEX,PROT,APX,X86_64
SBB             reg32?,reg32,rm32         SM0-2,LONG,FL,EVEX,PROT,APX,X86_64
SBB             reg64?,reg64,rm64         SM0-2,LONG,FL,EVEX,PROT,APX,X86_64
SBB             reg8?,rm8,reg8            SM0-2,LONG,FL,EVEX,PROT,APX,X86_64
SBB             reg16?,rm16,reg16         SM0-2,LONG,FL,EVEX,PROT,APX,X86_64
SBB             reg32?,rm32,reg32         SM0-2,LONG,FL,EVEX,PROT,APX,X86_64
SBB             reg64?,rm64,reg64         SM0-2,LONG,FL,EVEX,PROT,APX,X86_64
SBB             reg16?,rm16,sbyteword16   SM0-2,LONG,FL,EVEX,PROT,APX,X86_64
SBB             reg32?,rm32,sbytedword32  SM0-2,LONG,FL,EVEX,PROT,APX,X86_64
SBB             reg64?,rm64,sbytedword64  SM0-2,LONG,FL,EVEX,PROT,APX,X86_64
SBB             reg8?,rm8,imm8            SM0-2,LONG,FL,EVEX,PROT,APX,X86_64
SBB             reg16?,rm16,imm16         SM0-2,LONG,FL,EVEX,PROT,APX,X86_64
SBB             reg32?,rm32,imm32         SM0-2,LONG,FL,EVEX,PROT,APX,X86_64
SBB             reg64?,rm64,sdword64      SM0-2,LONG,FL,EVEX,PROT,APX,X86_64
AND             rm8,reg8                  SM0-1,LOCK,FL,8086
AND             rm16,reg16                SM0-1,LOCK,FL,8086
AND             rm32,reg32                SM0-1,LOCK,FL,386
AND             rm64,reg64                SM0-1,LOCK,LONG,FL,PROT,X86_64
AND             reg8,rm8                  SM0-1,FL,8086
AND             reg16,rm16                SM0-1,FL,8086
AND             reg32,rm32                SM0-1,FL,386
AND             reg64,rm64                SM0-1,LONG,FL,PROT,X86_64
AND             reg_al,imm8               SM0-1,FL,8086
AND             rm8,imm8                  SM0-1,LOCK,FL,8086
AND             rm16,sbyteword16          SM0-1,LOCK,FL,8086
AND             reg_ax,imm16              SM0-1,FL,8086
AND             rm16,imm16                SM0-1,LOCK,FL,8086
AND             rm32,sbytedword32         SM0-1,ZU,LOCK,FL,386
AND             reg_eax,imm32             SM0-1,ZU,FL,386
AND             rm32,imm32                SM0-1,ZU,LOCK,FL,386
AND             rm64,sbytedword64         SM0-1,ZU,LOCK,LONG,FL,PROT,X86_64
AND             reg_rax,sdword64          SM0-1,ZU,LONG,FL,PROT,X86_64
AND             rm64,sdword64             SM0-1,ZU,LOCK,LONG,FL,PROT,X86_64
AND             reg8?,reg8,rm8            SM0-2,NF,LONG,FL,EVEX,PROT,APX,X86_64
AND             reg16?,reg16,rm16         SM0-2,NF,LONG,FL,EVEX,PROT,APX,X86_64
AND             reg32?,reg32,rm32         SM0-2,NF,LONG,FL,EVEX,PROT,APX,X86_64
AND             reg64?,reg64,rm64         SM0-2,NF,LONG,FL,EVEX,PROT,APX,X86_64
AND             reg8?,rm8,reg8            SM0-2,NF,LONG,FL,EVEX,PROT,APX,X86_64
AND             reg16?,rm16,reg16         SM0-2,NF,LONG,FL,EVEX,PROT,APX,X86_64
```

```
AND             reg32?,rm32,reg32         SM0-2,NF,LONG,FL,EVEX,PROT,APX,X86_64
AND             reg64?,rm64,reg64         SM0-2,NF,LONG,FL,EVEX,PROT,APX,X86_64
AND             reg16?,rm16,sbyteword16   SM0-2,NF,LONG,FL,EVEX,PROT,APX,X86_64
AND             reg32?,rm32,sbytedword32  SM0-2,NF,LONG,FL,EVEX,PROT,APX,X86_64
AND             reg64?,rm64,sbytedword64  SM0-2,NF,LONG,FL,EVEX,PROT,APX,X86_64
AND             reg8?,rm8,imm8            SM0-2,NF,LONG,FL,EVEX,PROT,APX,X86_64
AND             reg16?,rm16,imm16         SM0-2,NF,LONG,FL,EVEX,PROT,APX,X86_64
AND             reg32?,rm32,imm32         SM0-2,NF,LONG,FL,EVEX,PROT,APX,X86_64
AND             reg64?,rm64,sdword64      SM0-2,NF,LONG,FL,EVEX,PROT,APX,X86_64
SUB             rm8,reg8                  SM0-1,LOCK,FL,8086
SUB             rm16,reg16                SM0-1,LOCK,FL,8086
SUB             rm32,reg32                SM0-1,LOCK,FL,386
SUB             rm64,reg64                SM0-1,LOCK,LONG,FL,PROT,X86_64
SUB             reg8,rm8                  SM0-1,FL,8086
SUB             reg16,rm16                SM0-1,FL,8086
SUB             reg32,rm32                SM0-1,FL,386
SUB             reg64,rm64                SM0-1,LONG,FL,PROT,X86_64
SUB             reg_al,imm8               SM0-1,FL,8086
SUB             rm8,imm8                  SM0-1,LOCK,FL,8086
SUB             rm16,sbyteword16          SM0-1,LOCK,FL,8086
SUB             reg_ax,imm16              SM0-1,FL,8086
SUB             rm16,imm16                SM0-1,LOCK,FL,8086
SUB             rm32,sbytedword32         SM0-1,ZU,LOCK,FL,386
SUB             reg_eax,imm32             SM0-1,ZU,FL,386
SUB             rm32,imm32                SM0-1,ZU,LOCK,FL,386
SUB             rm64,sbytedword64         SM0-1,ZU,LOCK,LONG,FL,PROT,X86_64
SUB             reg_rax,sdword64          SM0-1,ZU,LONG,FL,PROT,X86_64
SUB             rm64,sdword64             SM0-1,ZU,LOCK,LONG,FL,PROT,X86_64
SUB             reg8?,reg8,rm8            SM0-2,NF,LONG,FL,EVEX,PROT,APX,X86_64
SUB             reg16?,reg16,rm16         SM0-2,NF,LONG,FL,EVEX,PROT,APX,X86_64
SUB             reg32?,reg32,rm32         SM0-2,NF,LONG,FL,EVEX,PROT,APX,X86_64
SUB             reg64?,reg64,rm64         SM0-2,NF,LONG,FL,EVEX,PROT,APX,X86_64
SUB             reg8?,rm8,reg8            SM0-2,NF,LONG,FL,EVEX,PROT,APX,X86_64
SUB             reg16?,rm16,reg16         SM0-2,NF,LONG,FL,EVEX,PROT,APX,X86_64
SUB             reg32?,rm32,reg32         SM0-2,NF,LONG,FL,EVEX,PROT,APX,X86_64
SUB             reg64?,rm64,reg64         SM0-2,NF,LONG,FL,EVEX,PROT,APX,X86_64
SUB             reg16?,rm16,sbyteword16   SM0-2,NF,LONG,FL,EVEX,PROT,APX,X86_64
SUB             reg32?,rm32,sbytedword32  SM0-2,NF,LONG,FL,EVEX,PROT,APX,X86_64
SUB             reg64?,rm64,sbytedword64  SM0-2,NF,LONG,FL,EVEX,PROT,APX,X86_64
SUB             reg8?,rm8,imm8            SM0-2,NF,LONG,FL,EVEX,PROT,APX,X86_64
SUB             reg16?,rm16,imm16         SM0-2,NF,LONG,FL,EVEX,PROT,APX,X86_64
SUB             reg32?,rm32,imm32         SM0-2,NF,LONG,FL,EVEX,PROT,APX,X86_64
SUB             reg64?,rm64,sdword64      SM0-2,NF,LONG,FL,EVEX,PROT,APX,X86_64
XOR             rm8,reg8                  SM0-1,LOCK,FL,8086
XOR             rm16,reg16                SM0-1,LOCK,FL,8086
XOR             rm32,reg32                SM0-1,LOCK,FL,386
XOR             rm64,reg64                SM0-1,LOCK,LONG,FL,PROT,X86_64
XOR             reg8,rm8                  SM0-1,FL,8086
XOR             reg16,rm16                SM0-1,FL,8086
XOR             reg32,rm32                SM0-1,FL,386
XOR             reg64,rm64                SM0-1,LONG,FL,PROT,X86_64
XOR             reg_al,imm8               SM0-1,FL,8086
XOR             rm8,imm8                  SM0-1,LOCK,FL,8086
XOR             rm16,sbyteword16          SM0-1,LOCK,FL,8086
XOR             reg_ax,imm16              SM0-1,FL,8086
XOR             rm16,imm16                SM0-1,LOCK,FL,8086
XOR             rm32,sbytedword32         SM0-1,ZU,LOCK,FL,386
XOR             reg_eax,imm32             SM0-1,ZU,FL,386
XOR             rm32,imm32                SM0-1,ZU,LOCK,FL,386
XOR             rm64,sbytedword64         SM0-1,ZU,LOCK,LONG,FL,PROT,X86_64
XOR             reg_rax,sdword64          SM0-1,ZU,LONG,FL,PROT,X86_64
XOR             rm64,sdword64             SM0-1,ZU,LOCK,LONG,FL,PROT,X86_64
XOR             reg8?,reg8,rm8            SM0-2,NF,LONG,FL,EVEX,PROT,APX,X86_64
XOR             reg16?,reg16,rm16         SM0-2,NF,LONG,FL,EVEX,PROT,APX,X86_64
XOR             reg32?,reg32,rm32         SM0-2,NF,LONG,FL,EVEX,PROT,APX,X86_64
XOR             reg64?,reg64,rm64         SM0-2,NF,LONG,FL,EVEX,PROT,APX,X86_64
XOR             reg8?,rm8,reg8            SM0-2,NF,LONG,FL,EVEX,PROT,APX,X86_64
```

```
XOR             reg16?,rm16,reg16         SM0-2,NF,LONG,FL,EVEX,PROT,APX,X86_64
XOR             reg32?,rm32,reg32         SM0-2,NF,LONG,FL,EVEX,PROT,APX,X86_64
XOR             reg64?,rm64,reg64         SM0-2,NF,LONG,FL,EVEX,PROT,APX,X86_64
XOR             reg16?,rm16,sbyteword16   SM0-2,NF,LONG,FL,EVEX,PROT,APX,X86_64
XOR             reg32?,rm32,sbytedword32  SM0-2,NF,LONG,FL,EVEX,PROT,APX,X86_64
XOR             reg64?,rm64,sbytedword64  SM0-2,NF,LONG,FL,EVEX,PROT,APX,X86_64
XOR             reg8?,rm8,imm8            SM0-2,NF,LONG,FL,EVEX,PROT,APX,X86_64
XOR             reg16?,rm16,imm16         SM0-2,NF,LONG,FL,EVEX,PROT,APX,X86_64
XOR             reg32?,rm32,imm32         SM0-2,NF,LONG,FL,EVEX,PROT,APX,X86_64
XOR             reg64?,rm64,sdword64      SM0-2,NF,LONG,FL,EVEX,PROT,APX,X86_64
CMP             rm8,reg8                  SM0-1,FL,8086
CMP             rm16,reg16                SM0-1,FL,8086
CMP             rm32,reg32                SM0-1,FL,386
CMP             rm64,reg64                SM0-1,LONG,FL,PROT,X86_64
CMP             reg8,rm8                  SM0-1,FL,8086
CMP             reg16,rm16                SM0-1,FL,8086
CMP             reg32,rm32                SM0-1,FL,386
CMP             reg64,rm64                SM0-1,LONG,FL,PROT,X86_64
CMP             reg_al,imm8               SM0-1,FL,8086
CMP             rm8,imm8                  SM0-1,FL,8086
CMP             rm16,sbyteword16          SM0-1,FL,8086
CMP             reg_ax,imm16              SM0-1,FL,8086
CMP             rm16,imm16                SM0-1,FL,8086
CMP             rm32,sbytedword32         SM0-1,ZU,FL,386
CMP             reg_eax,imm32             SM0-1,ZU,FL,386
CMP             rm32,imm32                SM0-1,ZU,FL,386
CMP             rm64,sbytedword64         SM0-1,ZU,LONG,FL,PROT,X86_64
CMP             reg_rax,sdword64          SM0-1,ZU,LONG,FL,PROT,X86_64
CMP             rm64,sdword64             SM0-1,ZU,LONG,FL,PROT,X86_64
```

F.1.6 Bitwise testing

```
TEST            rm8,reg8                  SM0-1,FL,8086
TEST            rm16,reg16                SM0-1,FL,8086
TEST            rm32,reg32                SM0-1,FL,386
TEST            rm64,reg64                SM0-1,LONG,FL,PROT,X86_64
TEST            reg8,mem8                 SM0,ND,SM1,FL,8086
TEST            reg16,mem16               SM0,ND,SM1,FL,8086
TEST            reg32,mem32               ND,SM0-1,FL,386
TEST            reg64,mem64               SM0,ND,SM1,LONG,FL,PROT,X86_64
TEST            reg_al,imm8               SM0-1,NOAPX,FL,8086
TEST            reg_ax,imm16              SM0-1,NOAPX,FL,8086
TEST            reg_eax,imm32             SM0-1,NOAPX,FL,386
TEST            reg_rax,sdword64          SM0-1,NOAPX,LONG,FL,PROT,X86_64
TEST            rm8,imm8                  SM0-1,FL,8086
TEST            rm16,imm16                SM0-1,FL,8086
TEST            rm32,imm32                SM0-1,FL,386
TEST            rm64,sdword64             SM0-1,LONG,FL,PROT,X86_64
```

F.1.7 The basic shift and rotate operations

```
ROL             rm8,unity                 FL,8086
ROL             rm16,unity                FL,8086
ROL             rm32,unity                FL,386
ROL             rm64,unity                LONG,FL,PROT,X86_64
ROL             rm8,reg_cl                FL,8086
ROL             rm16,reg_cl               FL,8086
ROL             rm32,reg_cl               FL,386
ROL             rm64,reg_cl               LONG,FL,PROT,X86_64
ROL             rm8,reg_cx                ND,FL,8086
ROL             rm16,reg_cx               ND,FL,8086
ROL             rm32,reg_cx               ND,FL,386
ROL             rm64,reg_cx               ND,LONG,FL,PROT,X86_64
ROL             rm8,reg_ecx               ND,FL,8086
ROL             rm16,reg_ecx              ND,FL,8086
ROL             rm32,reg_ecx              ND,FL,386
ROL             rm64,reg_ecx              ND,LONG,FL,PROT,X86_64
```

```
ROL             rm8,reg_rcx             ND,FL,8086
ROL             rm16,reg_rcx            ND,FL,8086
ROL             rm32,reg_rcx            ND,FL,386
ROL             rm64,reg_rcx            ND,LONG,FL,PROT,X86_64
ROL             rm8,imm8                FL,186
ROL             rm16,imm8               FL,186
ROL             rm32,imm8               FL,386
ROL             rm64,imm8               LONG,FL,PROT,X86_64
ROR             rm8,unity               FL,8086
ROR             rm16,unity              FL,8086
ROR             rm32,unity              FL,386
ROR             rm64,unity              LONG,FL,PROT,X86_64
ROR             rm8,reg_cl              FL,8086
ROR             rm16,reg_cl             FL,8086
ROR             rm32,reg_cl             FL,386
ROR             rm64,reg_cl             LONG,FL,PROT,X86_64
ROR             rm8,reg_cx              ND,FL,8086
ROR             rm16,reg_cx             ND,FL,8086
ROR             rm32,reg_cx             ND,FL,386
ROR             rm64,reg_cx             ND,LONG,FL,PROT,X86_64
ROR             rm8,reg_ecx             ND,FL,8086
ROR             rm16,reg_ecx            ND,FL,8086
ROR             rm32,reg_ecx            ND,FL,386
ROR             rm64,reg_ecx            ND,LONG,FL,PROT,X86_64
ROR             rm8,reg_rcx             ND,FL,8086
ROR             rm16,reg_rcx            ND,FL,8086
ROR             rm32,reg_rcx            ND,FL,386
ROR             rm64,reg_rcx            ND,LONG,FL,PROT,X86_64
ROR             rm8,imm8                FL,186
ROR             rm16,imm8               FL,186
ROR             rm32,imm8               FL,386
ROR             rm64,imm8               LONG,FL,PROT,X86_64
RCL             rm8,unity               FL,8086
RCL             rm16,unity              FL,8086
RCL             rm32,unity              FL,386
RCL             rm64,unity              LONG,FL,PROT,X86_64
RCL             rm8,reg_cl              FL,8086
RCL             rm16,reg_cl             FL,8086
RCL             rm32,reg_cl             FL,386
RCL             rm64,reg_cl             LONG,FL,PROT,X86_64
RCL             rm8,reg_cx              ND,FL,8086
RCL             rm16,reg_cx             ND,FL,8086
RCL             rm32,reg_cx             ND,FL,386
RCL             rm64,reg_cx             ND,LONG,FL,PROT,X86_64
RCL             rm8,reg_ecx             ND,FL,8086
RCL             rm16,reg_ecx            ND,FL,8086
RCL             rm32,reg_ecx            ND,FL,386
RCL             rm64,reg_ecx            ND,LONG,FL,PROT,X86_64
RCL             rm8,reg_rcx             ND,FL,8086
RCL             rm16,reg_rcx            ND,FL,8086
RCL             rm32,reg_rcx            ND,FL,386
RCL             rm64,reg_rcx            ND,LONG,FL,PROT,X86_64
RCL             rm8,imm8                FL,186
RCL             rm16,imm8               FL,186
RCL             rm32,imm8               FL,386
RCL             rm64,imm8               LONG,FL,PROT,X86_64
RCR             rm8,unity               FL,8086
RCR             rm16,unity              FL,8086
RCR             rm32,unity              FL,386
RCR             rm64,unity              LONG,FL,PROT,X86_64
RCR             rm8,reg_cl              FL,8086
RCR             rm16,reg_cl             FL,8086
RCR             rm32,reg_cl             FL,386
RCR             rm64,reg_cl             LONG,FL,PROT,X86_64
RCR             rm8,reg_cx              ND,FL,8086
RCR             rm16,reg_cx             ND,FL,8086
RCR             rm32,reg_cx             ND,FL,386
```

```
RCR             rm64,reg_cx             ND,LONG,FL,PROT,X86_64
RCR             rm8,reg_ecx             ND,FL,8086
RCR             rm16,reg_ecx            ND,FL,8086
RCR             rm32,reg_ecx            ND,FL,386
RCR             rm64,reg_ecx            ND,LONG,FL,PROT,X86_64
RCR             rm8,reg_rcx             ND,FL,8086
RCR             rm16,reg_rcx            ND,FL,8086
RCR             rm32,reg_rcx            ND,FL,386
RCR             rm64,reg_rcx            ND,LONG,FL,PROT,X86_64
RCR             rm8,imm8                FL,186
RCR             rm16,imm8               FL,186
RCR             rm32,imm8               FL,386
RCR             rm64,imm8               LONG,FL,PROT,X86_64
SHL             rm8,unity               FL,8086
SHL             rm16,unity              FL,8086
SHL             rm32,unity              FL,386
SHL             rm64,unity              LONG,FL,PROT,X86_64
SHL             rm8,reg_cl              FL,8086
SHL             rm16,reg_cl             FL,8086
SHL             rm32,reg_cl             FL,386
SHL             rm64,reg_cl             LONG,FL,PROT,X86_64
SHL             rm8,reg_cx              ND,FL,8086
SHL             rm16,reg_cx             ND,FL,8086
SHL             rm32,reg_cx             ND,FL,386
SHL             rm64,reg_cx             ND,LONG,FL,PROT,X86_64
SHL             rm8,reg_ecx             ND,FL,8086
SHL             rm16,reg_ecx            ND,FL,8086
SHL             rm32,reg_ecx            ND,FL,386
SHL             rm64,reg_ecx            ND,LONG,FL,PROT,X86_64
SHL             rm8,reg_rcx             ND,FL,8086
SHL             rm16,reg_rcx            ND,FL,8086
SHL             rm32,reg_rcx            ND,FL,386
SHL             rm64,reg_rcx            ND,LONG,FL,PROT,X86_64
SHL             rm8,imm8                FL,186
SHL             rm16,imm8               FL,186
SHL             rm32,imm8               FL,386
SHL             rm64,imm8               LONG,FL,PROT,X86_64
SAL             rm8,unity               FL,8086
SAL             rm16,unity              FL,8086
SAL             rm32,unity              FL,386
SAL             rm64,unity              LONG,FL,PROT,X86_64
SAL             rm8,reg_cl              FL,8086
SAL             rm16,reg_cl             FL,8086
SAL             rm32,reg_cl             FL,386
SAL             rm64,reg_cl             LONG,FL,PROT,X86_64
SAL             rm8,reg_cx              ND,FL,8086
SAL             rm16,reg_cx             ND,FL,8086
SAL             rm32,reg_cx             ND,FL,386
SAL             rm64,reg_cx             ND,LONG,FL,PROT,X86_64
SAL             rm8,reg_ecx             ND,FL,8086
SAL             rm16,reg_ecx            ND,FL,8086
SAL             rm32,reg_ecx            ND,FL,386
SAL             rm64,reg_ecx            ND,LONG,FL,PROT,X86_64
SAL             rm8,reg_rcx             ND,FL,8086
SAL             rm16,reg_rcx            ND,FL,8086
SAL             rm32,reg_rcx            ND,FL,386
SAL             rm64,reg_rcx            ND,LONG,FL,PROT,X86_64
SAL             rm8,imm8                FL,186
SAL             rm16,imm8               FL,186
SAL             rm32,imm8               FL,386
SAL             rm64,imm8               LONG,FL,PROT,X86_64
SHR             rm8,unity               FL,8086
SHR             rm16,unity              FL,8086
SHR             rm32,unity              FL,386
SHR             rm64,unity              LONG,FL,PROT,X86_64
SHR             rm8,reg_cl              FL,8086
SHR             rm16,reg_cl             FL,8086
```

```
SHR             rm32,reg_cl             FL,386
SHR             rm64,reg_cl             LONG,FL,PROT,X86_64
SHR             rm8,reg_cx              ND,FL,8086
SHR             rm16,reg_cx             ND,FL,8086
SHR             rm32,reg_cx             ND,FL,386
SHR             rm64,reg_cx             ND,LONG,FL,PROT,X86_64
SHR             rm8,reg_ecx             ND,FL,8086
SHR             rm16,reg_ecx            ND,FL,8086
SHR             rm32,reg_ecx            ND,FL,386
SHR             rm64,reg_ecx            ND,LONG,FL,PROT,X86_64
SHR             rm8,reg_rcx             ND,FL,8086
SHR             rm16,reg_rcx            ND,FL,8086
SHR             rm32,reg_rcx            ND,FL,386
SHR             rm64,reg_rcx            ND,LONG,FL,PROT,X86_64
SHR             rm8,imm8                FL,186
SHR             rm16,imm8               FL,186
SHR             rm32,imm8               FL,386
SHR             rm64,imm8               LONG,FL,PROT,X86_64
SAR             rm8,unity               FL,8086
SAR             rm16,unity              FL,8086
SAR             rm32,unity              FL,386
SAR             rm64,unity              LONG,FL,PROT,X86_64
SAR             rm8,reg_cl              FL,8086
SAR             rm16,reg_cl             FL,8086
SAR             rm32,reg_cl             FL,386
SAR             rm64,reg_cl             LONG,FL,PROT,X86_64
SAR             rm8,reg_cx              ND,FL,8086
SAR             rm16,reg_cx             ND,FL,8086
SAR             rm32,reg_cx             ND,FL,386
SAR             rm64,reg_cx             ND,LONG,FL,PROT,X86_64
SAR             rm8,reg_ecx             ND,FL,8086
SAR             rm16,reg_ecx            ND,FL,8086
SAR             rm32,reg_ecx            ND,FL,386
SAR             rm64,reg_ecx            ND,LONG,FL,PROT,X86_64
SAR             rm8,reg_rcx             ND,FL,8086
SAR             rm16,reg_rcx            ND,FL,8086
SAR             rm32,reg_rcx            ND,FL,386
SAR             rm64,reg_rcx            ND,LONG,FL,PROT,X86_64
SAR             rm8,imm8                FL,186
SAR             rm16,imm8               FL,186
SAR             rm32,imm8               FL,386
SAR             rm64,imm8               LONG,FL,PROT,X86_64
RORX            reg32,rm32,imm8         SM0-1,BMI2
ROLX            reg32,rm32,imm_known8   SM0-1,BMI2
SHLX            reg32,rm32*,reg8        ND,SM0-1,BMI2
SALX            reg32,rm32*,reg8        SM0,ND,SM1,BMI2
SARX            reg32,rm32*,reg8        ND,SM0-1,BMI2
SHRX            reg32,rm32*,reg8        SM0,ND,SM1,BMI2
SHLX            reg32,rm32*,reg16       SM0,ND,SM1,BMI2
SALX            reg32,rm32*,reg16       SM0,ND,SM1,BMI2
SARX            reg32,rm32*,reg16       ND,SM0-1,BMI2
SHRX            reg32,rm32*,reg16       ND,SM0-1,BMI2
SHLX            reg32,rm32*,reg32       SM0-1,BMI2
SALX            reg32,rm32*,reg32       ND,SM0-1,BMI2
SARX            reg32,rm32*,reg32       SM0-1,BMI2
SHRX            reg32,rm32*,reg32       SM0-1,BMI2
SHLX            reg32,rm32*,reg64       SM0,ND,SM1,BMI2
SALX            reg32,rm32*,reg64       SM0,ND,SM1,BMI2
SARX            reg32,rm32*,reg64       SM0,ND,SM1,BMI2
SHRX            reg32,rm32*,reg64       SM0,ND,SM1,BMI2
RORX            reg64,rm64,imm8         SM0-1,BMI2
ROLX            reg64,rm64,imm_known8   SM0-1,BMI2
SHLX            reg64,rm64*,reg8        ND,SM0-1,BMI2
SALX            reg64,rm64*,reg8        SM0,ND,SM1,BMI2
SARX            reg64,rm64*,reg8        ND,SM0-1,BMI2
SHRX            reg64,rm64*,reg8        ND,SM0-1,BMI2
SHLX            reg64,rm64*,reg16       SM0,ND,SM1,BMI2
```

```
SALX            reg64,rm64*,reg16       SM0,ND,SM1,BMI2
SARX            reg64,rm64*,reg16       SM0,ND,SM1,BMI2
SHRX            reg64,rm64*,reg16       SM0,ND,SM1,BMI2
SHLX            reg64,rm64*,reg32       SM0,ND,SM1,BMI2
SALX            reg64,rm64*,reg32       ND,SM0-1,BMI2
SARX            reg64,rm64*,reg32       ND,SM0-1,BMI2
SHRX            reg64,rm64*,reg32       SM0,ND,SM1,BMI2
SHLX            reg64,rm64*,reg64       SM0-1,BMI2
SALX            reg64,rm64*,reg64       ND,SM0-1,BMI2
SARX            reg64,rm64*,reg64       SM0-1,BMI2
SHRX            reg64,rm64*,reg64       SM0-1,BMI2
ROR             reg32,rm32,imm8         ND,SM0-1,OPT,NF,NF_R,BMI2
ROL             reg32,rm32,imm_known8   SM0,ND,SM1,OPT,NF,NF_R,BMI2
SHL             reg32,rm32*,reg8        ND,SM0-1,OPT,NF,NF_R,BMI2
SAL             reg32,rm32*,reg8        SM0,ND,SM1,OPT,NF,NF_R,BMI2
SAR             reg32,rm32*,reg8        SM0,ND,SM1,OPT,NF,NF_R,BMI2
SHR             reg32,rm32*,reg8        SM0,ND,SM1,OPT,NF,NF_R,BMI2
SHL             reg32,rm32*,reg16       SM0,ND,SM1,OPT,NF,NF_R,BMI2
SAL             reg32,rm32*,reg16       ND,SM0-1,OPT,NF,NF_R,BMI2
SAR             reg32,rm32*,reg16       ND,SM0-1,OPT,NF,NF_R,BMI2
SHR             reg32,rm32*,reg16       SM0,ND,SM1,OPT,NF,NF_R,BMI2
SHL             reg32,rm32*,reg32       ND,SM0-1,OPT,NF,NF_R,BMI2
SAL             reg32,rm32*,reg32       SM0,ND,SM1,OPT,NF,NF_R,BMI2
SAR             reg32,rm32*,reg32       ND,SM0-1,OPT,NF,NF_R,BMI2
SHR             reg32,rm32*,reg32       SM0,ND,SM1,OPT,NF,NF_R,BMI2
SHL             reg32,rm32*,reg64       SM0,ND,SM1,OPT,NF,NF_R,BMI2
SAL             reg32,rm32*,reg64       ND,SM0-1,OPT,NF,NF_R,BMI2
SAR             reg32,rm32*,reg64       ND,SM0-1,OPT,NF,NF_R,BMI2
SHR             reg32,rm32*,reg64       SM0,ND,SM1,OPT,NF,NF_R,BMI2
ROR             reg64,rm64,imm8         ND,SM0-1,OPT,NF,NF_R,BMI2
ROL             reg64,rm64,imm_known8   ND,SM0-1,OPT,NF,NF_R,BMI2
SHL             reg64,rm64*,reg8        ND,SM0-1,OPT,NF,NF_R,BMI2
SAL             reg64,rm64*,reg8        ND,SM0-1,OPT,NF,NF_R,BMI2
SAR             reg64,rm64*,reg8        ND,SM0-1,OPT,NF,NF_R,BMI2
SHR             reg64,rm64*,reg8        ND,SM0-1,OPT,NF,NF_R,BMI2
SHL             reg64,rm64*,reg16       ND,SM0-1,OPT,NF,NF_R,BMI2
SAL             reg64,rm64*,reg16       SM0,ND,SM1,OPT,NF,NF_R,BMI2
SAR             reg64,rm64*,reg16       SM0,ND,SM1,OPT,NF,NF_R,BMI2
SHR             reg64,rm64*,reg16       ND,SM0-1,OPT,NF,NF_R,BMI2
SHL             reg64,rm64*,reg32       SM0,ND,SM1,OPT,NF,NF_R,BMI2
SAL             reg64,rm64*,reg32       SM0,ND,SM1,OPT,NF,NF_R,BMI2
SAR             reg64,rm64*,reg32       SM0,ND,SM1,OPT,NF,NF_R,BMI2
SHR             reg64,rm64*,reg32       SM0,ND,SM1,OPT,NF,NF_R,BMI2
SHL             reg64,rm64*,reg64       ND,SM0-1,OPT,NF,NF_R,BMI2
SAL             reg64,rm64*,reg64       ND,SM0-1,OPT,NF,NF_R,BMI2
SAR             reg64,rm64*,reg64       SM0,ND,SM1,OPT,NF,NF_R,BMI2
SHR             reg64,rm64*,reg64       SM0,ND,SM1,OPT,NF,NF_R,BMI2
```

F.1.8 APX EVEX versions

```
ROL             reg8?,rm8,unity         SM0-1,NF,LONG,FL,PROT,APX,X86_64
ROL             reg16?,rm16,unity       SM0-1,NF,LONG,FL,PROT,APX,X86_64
ROL             reg32?,rm32,unity       SM0-1,NF,LONG,FL,PROT,APX,X86_64
ROL             reg64?,rm64,unity       SM0-1,NF,LONG,FL,PROT,APX,X86_64
ROL             reg8?,rm8,reg_cl        SM0-1,NF,LONG,FL,PROT,APX,X86_64
ROL             reg16?,rm16,reg_cl      SM0-1,NF,LONG,FL,PROT,APX,X86_64
ROL             reg32?,rm32,reg_cl      SM0-1,NF,LONG,FL,PROT,APX,X86_64
ROL             reg64?,rm64,reg_cl      SM0-1,NF,LONG,FL,PROT,APX,X86_64
ROL             reg8?,rm8,reg_cx        SM0,ND,SM1,NF,LONG,FL,PROT,APX,X86_64
ROL             reg16?,rm16,reg_cx      SM0,ND,SM1,NF,LONG,FL,PROT,APX,X86_64
ROL             reg32?,rm32,reg_cx      SM0,ND,SM1,NF,LONG,FL,PROT,APX,X86_64
ROL             reg64?,rm64,reg_cx      SM0,ND,SM1,NF,LONG,FL,PROT,APX,X86_64
ROL             reg8?,rm8,reg_ecx       SM0,ND,SM1,NF,LONG,FL,PROT,APX,X86_64
ROL             reg16?,rm16,reg_ecx     ND,SM0-1,NF,LONG,FL,PROT,APX,X86_64
ROL             reg32?,rm32,reg_ecx     SM0,ND,SM1,NF,LONG,FL,PROT,APX,X86_64
ROL             reg64?,rm64,reg_ecx     ND,SM0-1,NF,LONG,FL,PROT,APX,X86_64
ROL             reg8?,rm8,reg_rcx       SM0,ND,SM1,NF,LONG,FL,PROT,APX,X86_64
```

```
ROL             reg16?,rm16,reg_rcx     SM0,ND,SM1,NF,LONG,FL,PROT,APX,X86_64
ROL             reg32?,rm32,reg_rcx     SM0,ND,SM1,NF,LONG,FL,PROT,APX,X86_64
ROL             reg64?,rm64,reg_rcx     ND,SM0-1,NF,LONG,FL,PROT,APX,X86_64
ROL             reg8?,rm8,imm8          SM0-1,NF,LONG,FL,PROT,APX,X86_64
ROL             reg16?,rm16,imm8        SM0-1,NF,LONG,FL,PROT,APX,X86_64
ROL             reg32?,rm32,imm8        SM0-1,NF,LONG,FL,PROT,APX,X86_64
ROL             reg64?,rm64,imm8        SM0-1,NF,LONG,FL,PROT,APX,X86_64
ROR             reg8?,rm8,unity         SM0-1,NF,LONG,FL,PROT,APX,X86_64
ROR             reg16?,rm16,unity       SM0-1,NF,LONG,FL,PROT,APX,X86_64
ROR             reg32?,rm32,unity       SM0-1,NF,LONG,FL,PROT,APX,X86_64
ROR             reg64?,rm64,unity       SM0-1,NF,LONG,FL,PROT,APX,X86_64
ROR             reg8?,rm8,reg_cl        SM0-1,NF,LONG,FL,PROT,APX,X86_64
ROR             reg16?,rm16,reg_cl      SM0-1,NF,LONG,FL,PROT,APX,X86_64
ROR             reg32?,rm32,reg_cl      SM0-1,NF,LONG,FL,PROT,APX,X86_64
ROR             reg64?,rm64,reg_cl      SM0-1,NF,LONG,FL,PROT,APX,X86_64
ROR             reg8?,rm8,reg_cx        ND,SM0-1,NF,LONG,FL,PROT,APX,X86_64
ROR             reg16?,rm16,reg_cx      ND,SM0-1,NF,LONG,FL,PROT,APX,X86_64
ROR             reg32?,rm32,reg_cx      SM0,ND,SM1,NF,LONG,FL,PROT,APX,X86_64
ROR             reg64?,rm64,reg_cx      ND,SM0-1,NF,LONG,FL,PROT,APX,X86_64
ROR             reg8?,rm8,reg_ecx       SM0,ND,SM1,NF,LONG,FL,PROT,APX,X86_64
ROR             reg16?,rm16,reg_ecx     ND,SM0-1,NF,LONG,FL,PROT,APX,X86_64
ROR             reg32?,rm32,reg_ecx     SM0,ND,SM1,NF,LONG,FL,PROT,APX,X86_64
ROR             reg64?,rm64,reg_ecx     ND,SM0-1,NF,LONG,FL,PROT,APX,X86_64
ROR             reg8?,rm8,reg_rcx       SM0,ND,SM1,NF,LONG,FL,PROT,APX,X86_64
ROR             reg16?,rm16,reg_rcx     ND,SM0-1,NF,LONG,FL,PROT,APX,X86_64
ROR             reg32?,rm32,reg_rcx     SM0,ND,SM1,NF,LONG,FL,PROT,APX,X86_64
ROR             reg64?,rm64,reg_rcx     ND,SM0-1,NF,LONG,FL,PROT,APX,X86_64
ROR             reg8?,rm8,imm8          SM0-1,NF,LONG,FL,PROT,APX,X86_64
ROR             reg16?,rm16,imm8        SM0-1,NF,LONG,FL,PROT,APX,X86_64
ROR             reg32?,rm32,imm8        SM0-1,NF,LONG,FL,PROT,APX,X86_64
ROR             reg64?,rm64,imm8        SM0-1,NF,LONG,FL,PROT,APX,X86_64
RCL             reg8?,rm8,unity         SM0-1,NF,LONG,FL,PROT,APX,X86_64
RCL             reg16?,rm16,unity       SM0-1,NF,LONG,FL,PROT,APX,X86_64
RCL             reg32?,rm32,unity       SM0-1,NF,LONG,FL,PROT,APX,X86_64
RCL             reg64?,rm64,unity       SM0-1,NF,LONG,FL,PROT,APX,X86_64
RCL             reg8?,rm8,reg_cl        SM0-1,NF,LONG,FL,PROT,APX,X86_64
RCL             reg16?,rm16,reg_cl      SM0-1,NF,LONG,FL,PROT,APX,X86_64
RCL             reg32?,rm32,reg_cl      SM0-1,NF,LONG,FL,PROT,APX,X86_64
RCL             reg64?,rm64,reg_cl      SM0-1,NF,LONG,FL,PROT,APX,X86_64
RCL             reg8?,rm8,reg_cx        SM0,ND,SM1,NF,LONG,FL,PROT,APX,X86_64
RCL             reg16?,rm16,reg_cx      ND,SM0-1,NF,LONG,FL,PROT,APX,X86_64
RCL             reg32?,rm32,reg_cx      SM0,ND,SM1,NF,LONG,FL,PROT,APX,X86_64
RCL             reg64?,rm64,reg_cx      SM0,ND,SM1,NF,LONG,FL,PROT,APX,X86_64
RCL             reg8?,rm8,reg_ecx       ND,SM0-1,NF,LONG,FL,PROT,APX,X86_64
RCL             reg16?,rm16,reg_ecx     SM0,ND,SM1,NF,LONG,FL,PROT,APX,X86_64
RCL             reg32?,rm32,reg_ecx     SM0,ND,SM1,NF,LONG,FL,PROT,APX,X86_64
RCL             reg64?,rm64,reg_ecx     ND,SM0-1,NF,LONG,FL,PROT,APX,X86_64
RCL             reg8?,rm8,reg_rcx       SM0,ND,SM1,NF,LONG,FL,PROT,APX,X86_64
RCL             reg16?,rm16,reg_rcx     SM0,ND,SM1,NF,LONG,FL,PROT,APX,X86_64
RCL             reg32?,rm32,reg_rcx     SM0,ND,SM1,NF,LONG,FL,PROT,APX,X86_64
RCL             reg64?,rm64,reg_rcx     ND,SM0-1,NF,LONG,FL,PROT,APX,X86_64
RCL             reg8?,rm8,imm8          SM0-1,NF,LONG,FL,PROT,APX,X86_64
RCL             reg16?,rm16,imm8        SM0-1,NF,LONG,FL,PROT,APX,X86_64
RCL             reg32?,rm32,imm8        SM0-1,NF,LONG,FL,PROT,APX,X86_64
RCL             reg64?,rm64,imm8        SM0-1,NF,LONG,FL,PROT,APX,X86_64
RCR             reg8?,rm8,unity         SM0-1,NF,LONG,FL,PROT,APX,X86_64
RCR             reg16?,rm16,unity       SM0-1,NF,LONG,FL,PROT,APX,X86_64
RCR             reg32?,rm32,unity       SM0-1,NF,LONG,FL,PROT,APX,X86_64
RCR             reg64?,rm64,unity       SM0-1,NF,LONG,FL,PROT,APX,X86_64
RCR             reg8?,rm8,reg_cl        SM0-1,NF,LONG,FL,PROT,APX,X86_64
RCR             reg16?,rm16,reg_cl      SM0-1,NF,LONG,FL,PROT,APX,X86_64
RCR             reg32?,rm32,reg_cl      SM0-1,NF,LONG,FL,PROT,APX,X86_64
RCR             reg64?,rm64,reg_cl      SM0-1,NF,LONG,FL,PROT,APX,X86_64
RCR             reg8?,rm8,reg_cx        SM0,ND,SM1,NF,LONG,FL,PROT,APX,X86_64
RCR             reg16?,rm16,reg_cx      ND,SM0-1,NF,LONG,FL,PROT,APX,X86_64
RCR             reg32?,rm32,reg_cx      ND,SM0-1,NF,LONG,FL,PROT,APX,X86_64
RCR             reg64?,rm64,reg_cx      ND,SM0-1,NF,LONG,FL,PROT,APX,X86_64
```

```
RCR             reg8?,rm8,reg_ecx       SM0,ND,SM1,NF,LONG,FL,PROT,APX,X86_64
RCR             reg16?,rm16,reg_ecx     ND,SM0-1,NF,LONG,FL,PROT,APX,X86_64
RCR             reg32?,rm32,reg_ecx     ND,SM0-1,NF,LONG,FL,PROT,APX,X86_64
RCR             reg64?,rm64,reg_ecx     SM0,ND,SM1,NF,LONG,FL,PROT,APX,X86_64
RCR             reg8?,rm8,reg_rcx       SM0,ND,SM1,NF,LONG,FL,PROT,APX,X86_64
RCR             reg16?,rm16,reg_rcx     SM0,ND,SM1,NF,LONG,FL,PROT,APX,X86_64
RCR             reg32?,rm32,reg_rcx     ND,SM0-1,NF,LONG,FL,PROT,APX,X86_64
RCR             reg64?,rm64,reg_rcx     ND,SM0-1,NF,LONG,FL,PROT,APX,X86_64
RCR             reg8?,rm8,imm8          SM0-1,NF,LONG,FL,PROT,APX,X86_64
RCR             reg16?,rm16,imm8        SM0-1,NF,LONG,FL,PROT,APX,X86_64
RCR             reg32?,rm32,imm8        SM0-1,NF,LONG,FL,PROT,APX,X86_64
RCR             reg64?,rm64,imm8        SM0-1,NF,LONG,FL,PROT,APX,X86_64
SHL             reg8?,rm8,unity         SM0-1,NF,LONG,FL,PROT,APX,X86_64
SHL             reg16?,rm16,unity       SM0-1,NF,LONG,FL,PROT,APX,X86_64
SHL             reg32?,rm32,unity       SM0-1,NF,LONG,FL,PROT,APX,X86_64
SHL             reg64?,rm64,unity       SM0-1,NF,LONG,FL,PROT,APX,X86_64
SHL             reg8?,rm8,reg_cl        SM0-1,NF,LONG,FL,PROT,APX,X86_64
SHL             reg16?,rm16,reg_cl      SM0-1,NF,LONG,FL,PROT,APX,X86_64
SHL             reg32?,rm32,reg_cl      SM0-1,NF,LONG,FL,PROT,APX,X86_64
SHL             reg64?,rm64,reg_cl      SM0-1,NF,LONG,FL,PROT,APX,X86_64
SHL             reg8?,rm8,reg_cx        SM0,ND,SM1,NF,LONG,FL,PROT,APX,X86_64
SHL             reg16?,rm16,reg_cx      SM0,ND,SM1,NF,LONG,FL,PROT,APX,X86_64
SHL             reg32?,rm32,reg_cx      ND,SM0-1,NF,LONG,FL,PROT,APX,X86_64
SHL             reg64?,rm64,reg_cx      ND,SM0-1,NF,LONG,FL,PROT,APX,X86_64
SHL             reg8?,rm8,reg_ecx       ND,SM0-1,NF,LONG,FL,PROT,APX,X86_64
SHL             reg16?,rm16,reg_ecx     ND,SM0-1,NF,LONG,FL,PROT,APX,X86_64
SHL             reg32?,rm32,reg_ecx     ND,SM0-1,NF,LONG,FL,PROT,APX,X86_64
SHL             reg64?,rm64,reg_ecx     ND,SM0-1,NF,LONG,FL,PROT,APX,X86_64
SHL             reg8?,rm8,reg_rcx       ND,SM0-1,NF,LONG,FL,PROT,APX,X86_64
SHL             reg16?,rm16,reg_rcx     ND,SM0-1,NF,LONG,FL,PROT,APX,X86_64
SHL             reg32?,rm32,reg_rcx     ND,SM0-1,NF,LONG,FL,PROT,APX,X86_64
SHL             reg64?,rm64,reg_rcx     ND,SM0-1,NF,LONG,FL,PROT,APX,X86_64
SHL             reg8?,rm8,imm8          SM0-1,NF,LONG,FL,PROT,APX,X86_64
SHL             reg16?,rm16,imm8        SM0-1,NF,LONG,FL,PROT,APX,X86_64
SHL             reg32?,rm32,imm8        SM0-1,NF,LONG,FL,PROT,APX,X86_64
SHL             reg64?,rm64,imm8        SM0-1,NF,LONG,FL,PROT,APX,X86_64
SAL             reg8?,rm8,unity         SM0-1,NF,LONG,FL,PROT,APX,X86_64
SAL             reg16?,rm16,unity       SM0-1,NF,LONG,FL,PROT,APX,X86_64
SAL             reg32?,rm32,unity       SM0-1,NF,LONG,FL,PROT,APX,X86_64
SAL             reg64?,rm64,unity       SM0-1,NF,LONG,FL,PROT,APX,X86_64
SAL             reg8?,rm8,reg_cl        SM0-1,NF,LONG,FL,PROT,APX,X86_64
SAL             reg16?,rm16,reg_cl      SM0-1,NF,LONG,FL,PROT,APX,X86_64
SAL             reg32?,rm32,reg_cl      SM0-1,NF,LONG,FL,PROT,APX,X86_64
SAL             reg64?,rm64,reg_cl      SM0-1,NF,LONG,FL,PROT,APX,X86_64
SAL             reg8?,rm8,reg_cx        ND,SM0-1,NF,LONG,FL,PROT,APX,X86_64
SAL             reg16?,rm16,reg_cx      SM0,ND,SM1,NF,LONG,FL,PROT,APX,X86_64
SAL             reg32?,rm32,reg_cx      ND,SM0-1,NF,LONG,FL,PROT,APX,X86_64
SAL             reg64?,rm64,reg_cx      ND,SM0-1,NF,LONG,FL,PROT,APX,X86_64
SAL             reg8?,rm8,reg_ecx       ND,SM0-1,NF,LONG,FL,PROT,APX,X86_64
SAL             reg16?,rm16,reg_ecx     SM0,ND,SM1,NF,LONG,FL,PROT,APX,X86_64
SAL             reg32?,rm32,reg_ecx     ND,SM0-1,NF,LONG,FL,PROT,APX,X86_64
SAL             reg64?,rm64,reg_ecx     SM0,ND,SM1,NF,LONG,FL,PROT,APX,X86_64
SAL             reg8?,rm8,reg_rcx       ND,SM0-1,NF,LONG,FL,PROT,APX,X86_64
SAL             reg16?,rm16,reg_rcx     SM0,ND,SM1,NF,LONG,FL,PROT,APX,X86_64
SAL             reg32?,rm32,reg_rcx     ND,SM0-1,NF,LONG,FL,PROT,APX,X86_64
SAL             reg64?,rm64,reg_rcx     ND,SM0-1,NF,LONG,FL,PROT,APX,X86_64
SAL             reg8?,rm8,imm8          SM0-1,NF,LONG,FL,PROT,APX,X86_64
SAL             reg16?,rm16,imm8        SM0-1,NF,LONG,FL,PROT,APX,X86_64
SAL             reg32?,rm32,imm8        SM0-1,NF,LONG,FL,PROT,APX,X86_64
SAL             reg64?,rm64,imm8        SM0-1,NF,LONG,FL,PROT,APX,X86_64
SHR             reg8?,rm8,unity         SM0-1,NF,LONG,FL,PROT,APX,X86_64
SHR             reg16?,rm16,unity       SM0-1,NF,LONG,FL,PROT,APX,X86_64
SHR             reg32?,rm32,unity       SM0-1,NF,LONG,FL,PROT,APX,X86_64
SHR             reg64?,rm64,unity       SM0-1,NF,LONG,FL,PROT,APX,X86_64
SHR             reg8?,rm8,reg_cl        SM0-1,NF,LONG,FL,PROT,APX,X86_64
SHR             reg16?,rm16,reg_cl      SM0-1,NF,LONG,FL,PROT,APX,X86_64
SHR             reg32?,rm32,reg_cl      SM0-1,NF,LONG,FL,PROT,APX,X86_64
```

```
SHR             reg64?,rm64,reg_cl      SM0-1,NF,LONG,FL,PROT,APX,X86_64
SHR             reg8?,rm8,reg_cx        SM0,ND,SM1,NF,LONG,FL,PROT,APX,X86_64
SHR             reg16?,rm16,reg_cx      ND,SM0-1,NF,LONG,FL,PROT,APX,X86_64
SHR             reg32?,rm32,reg_cx      SM0,ND,SM1,NF,LONG,FL,PROT,APX,X86_64
SHR             reg64?,rm64,reg_cx      SM0,ND,SM1,NF,LONG,FL,PROT,APX,X86_64
SHR             reg8?,rm8,reg_ecx       SM0,ND,SM1,NF,LONG,FL,PROT,APX,X86_64
SHR             reg16?,rm16,reg_ecx     SM0,ND,SM1,NF,LONG,FL,PROT,APX,X86_64
SHR             reg32?,rm32,reg_ecx     ND,SM0-1,NF,LONG,FL,PROT,APX,X86_64
SHR             reg64?,rm64,reg_ecx     ND,SM0-1,NF,LONG,FL,PROT,APX,X86_64
SHR             reg8?,rm8,reg_rcx       ND,SM0-1,NF,LONG,FL,PROT,APX,X86_64
SHR             reg16?,rm16,reg_rcx     ND,SM0-1,NF,LONG,FL,PROT,APX,X86_64
SHR             reg32?,rm32,reg_rcx     SM0,ND,SM1,NF,LONG,FL,PROT,APX,X86_64
SHR             reg64?,rm64,reg_rcx     ND,SM0-1,NF,LONG,FL,PROT,APX,X86_64
SHR             reg8?,rm8,imm8          SM0-1,NF,LONG,FL,PROT,APX,X86_64
SHR             reg16?,rm16,imm8        SM0-1,NF,LONG,FL,PROT,APX,X86_64
SHR             reg32?,rm32,imm8        SM0-1,NF,LONG,FL,PROT,APX,X86_64
SHR             reg64?,rm64,imm8        SM0-1,NF,LONG,FL,PROT,APX,X86_64
SAR             reg8?,rm8,unity         SM0-1,NF,LONG,FL,PROT,APX,X86_64
SAR             reg16?,rm16,unity       SM0-1,NF,LONG,FL,PROT,APX,X86_64
SAR             reg32?,rm32,unity       SM0-1,NF,LONG,FL,PROT,APX,X86_64
SAR             reg64?,rm64,unity       SM0-1,NF,LONG,FL,PROT,APX,X86_64
SAR             reg8?,rm8,reg_cl        SM0-1,NF,LONG,FL,PROT,APX,X86_64
SAR             reg16?,rm16,reg_cl      SM0-1,NF,LONG,FL,PROT,APX,X86_64
SAR             reg32?,rm32,reg_cl      SM0-1,NF,LONG,FL,PROT,APX,X86_64
SAR             reg64?,rm64,reg_cl      SM0-1,NF,LONG,FL,PROT,APX,X86_64
SAR             reg8?,rm8,reg_cx        SM0,ND,SM1,NF,LONG,FL,PROT,APX,X86_64
SAR             reg16?,rm16,reg_cx      SM0,ND,SM1,NF,LONG,FL,PROT,APX,X86_64
SAR             reg32?,rm32,reg_cx      SM0,ND,SM1,NF,LONG,FL,PROT,APX,X86_64
SAR             reg64?,rm64,reg_cx      ND,SM0-1,NF,LONG,FL,PROT,APX,X86_64
SAR             reg8?,rm8,reg_ecx       SM0,ND,SM1,NF,LONG,FL,PROT,APX,X86_64
SAR             reg16?,rm16,reg_ecx     ND,SM0-1,NF,LONG,FL,PROT,APX,X86_64
SAR             reg32?,rm32,reg_ecx     SM0,ND,SM1,NF,LONG,FL,PROT,APX,X86_64
SAR             reg64?,rm64,reg_ecx     ND,SM0-1,NF,LONG,FL,PROT,APX,X86_64
SAR             reg8?,rm8,reg_rcx       SM0,ND,SM1,NF,LONG,FL,PROT,APX,X86_64
SAR             reg16?,rm16,reg_rcx     ND,SM0-1,NF,LONG,FL,PROT,APX,X86_64
SAR             reg32?,rm32,reg_rcx     SM0,ND,SM1,NF,LONG,FL,PROT,APX,X86_64
SAR             reg64?,rm64,reg_rcx     SM0,ND,SM1,NF,LONG,FL,PROT,APX,X86_64
SAR             reg8?,rm8,imm8          SM0-1,NF,LONG,FL,PROT,APX,X86_64
SAR             reg16?,rm16,imm8        SM0-1,NF,LONG,FL,PROT,APX,X86_64
SAR             reg32?,rm32,imm8        SM0-1,NF,LONG,FL,PROT,APX,X86_64
SAR             reg64?,rm64,imm8        SM0-1,NF,LONG,FL,PROT,APX,X86_64
RORX            reg32,rm32,imm8         SM0-1,LONG,PROT,BMI2,APX,X86_64
ROLX            reg32,rm32,imm_known8   SM0-1,LONG,PROT,BMI2,APX,X86_64
SHLX            reg32,rm32*,reg8        SM0,ND,SM1,LONG,PROT,BMI2,APX,X86_64
SALX            reg32,rm32*,reg8        SM0,ND,SM1,LONG,PROT,BMI2,APX,X86_64
SARX            reg32,rm32*,reg8        ND,SM0-1,LONG,PROT,BMI2,APX,X86_64
SHRX            reg32,rm32*,reg8        SM0,ND,SM1,LONG,PROT,BMI2,APX,X86_64
SHLX            reg32,rm32*,reg16       SM0,ND,SM1,LONG,PROT,BMI2,APX,X86_64
SALX            reg32,rm32*,reg16       ND,SM0-1,LONG,PROT,BMI2,APX,X86_64
SARX            reg32,rm32*,reg16       SM0,ND,SM1,LONG,PROT,BMI2,APX,X86_64
SHRX            reg32,rm32*,reg16       ND,SM0-1,LONG,PROT,BMI2,APX,X86_64
SHLX            reg32,rm32*,reg32       SM0-1,LONG,PROT,BMI2,APX,X86_64
SALX            reg32,rm32*,reg32       SM0,ND,SM1,LONG,PROT,BMI2,APX,X86_64
SARX            reg32,rm32*,reg32       SM0-1,LONG,PROT,BMI2,APX,X86_64
SHRX            reg32,rm32*,reg32       SM0-1,LONG,PROT,BMI2,APX,X86_64
SHLX            reg32,rm32*,reg64       SM0,ND,SM1,LONG,PROT,BMI2,APX,X86_64
SALX            reg32,rm32*,reg64       SM0,ND,SM1,LONG,PROT,BMI2,APX,X86_64
SARX            reg32,rm32*,reg64       SM0,ND,SM1,LONG,PROT,BMI2,APX,X86_64
SHRX            reg32,rm32*,reg64       ND,SM0-1,LONG,PROT,BMI2,APX,X86_64
RORX            reg64,rm64,imm8         SM0-1,LONG,PROT,BMI2,APX,X86_64
ROLX            reg64,rm64,imm_known8   SM0-1,LONG,PROT,BMI2,APX,X86_64
SHLX            reg64,rm64*,reg8        SM0,ND,SM1,LONG,PROT,BMI2,APX,X86_64
SALX            reg64,rm64*,reg8        SM0,ND,SM1,LONG,PROT,BMI2,APX,X86_64
SARX            reg64,rm64*,reg8        SM0,ND,SM1,LONG,PROT,BMI2,APX,X86_64
SHRX            reg64,rm64*,reg8        ND,SM0-1,LONG,PROT,BMI2,APX,X86_64
SHLX            reg64,rm64*,reg16       SM0,ND,SM1,LONG,PROT,BMI2,APX,X86_64
SALX            reg64,rm64*,reg16       SM0,ND,SM1,LONG,PROT,BMI2,APX,X86_64
```

```
SARX            reg64,rm64*,reg16       SM0,ND,SM1,LONG,PROT,BMI2,APX,X86_64
SHRX            reg64,rm64*,reg16       ND,SM0-1,LONG,PROT,BMI2,APX,X86_64
SHLX            reg64,rm64*,reg32       SM0,ND,SM1,LONG,PROT,BMI2,APX,X86_64
SALX            reg64,rm64*,reg32       ND,SM0-1,LONG,PROT,BMI2,APX,X86_64
SARX            reg64,rm64*,reg32       ND,SM0-1,LONG,PROT,BMI2,APX,X86_64
SHRX            reg64,rm64*,reg32       SM0,ND,SM1,LONG,PROT,BMI2,APX,X86_64
SHLX            reg64,rm64*,reg64       SM0-1,LONG,PROT,BMI2,APX,X86_64
SALX            reg64,rm64*,reg64       ND,SM0-1,LONG,PROT,BMI2,APX,X86_64
SARX            reg64,rm64*,reg64       SM0-1,LONG,PROT,BMI2,APX,X86_64
SHRX            reg64,rm64*,reg64       SM0-1,LONG,PROT,BMI2,APX,X86_64
ROR             reg32,rm32,imm8         ND,SM0-1,OPT,NF,NF_R,LONG,PROT,BMI2,APX,X86_64
ROL             reg32,rm32,imm_known8   SM0,ND,SM1,OPT,NF,NF_R,LONG,PROT,BMI2,APX,X86_64
SHL             reg32,rm32*,reg8        ND,SM0-1,OPT,NF,NF_R,LONG,PROT,BMI2,APX,X86_64
SAL             reg32,rm32*,reg8        ND,SM0-1,OPT,NF,NF_R,LONG,PROT,BMI2,APX,X86_64
SAR             reg32,rm32*,reg8        ND,SM0-1,OPT,NF,NF_R,LONG,PROT,BMI2,APX,X86_64
SHR             reg32,rm32*,reg8        ND,SM0-1,OPT,NF,NF_R,LONG,PROT,BMI2,APX,X86_64
SHL             reg32,rm32*,reg16       ND,SM0-1,OPT,NF,NF_R,LONG,PROT,BMI2,APX,X86_64
SAL             reg32,rm32*,reg16       ND,SM0-1,OPT,NF,NF_R,LONG,PROT,BMI2,APX,X86_64
SAR             reg32,rm32*,reg16       ND,SM0-1,OPT,NF,NF_R,LONG,PROT,BMI2,APX,X86_64
SHR             reg32,rm32*,reg16       ND,SM0-1,OPT,NF,NF_R,LONG,PROT,BMI2,APX,X86_64
SHL             reg32,rm32*,reg32       ND,SM0-1,OPT,NF,NF_R,LONG,PROT,BMI2,APX,X86_64
SAL             reg32,rm32*,reg32       ND,SM0-1,OPT,NF,NF_R,LONG,PROT,BMI2,APX,X86_64
SAR             reg32,rm32*,reg32       ND,SM0-1,OPT,NF,NF_R,LONG,PROT,BMI2,APX,X86_64
SHR             reg32,rm32*,reg32       ND,SM0-1,OPT,NF,NF_R,LONG,PROT,BMI2,APX,X86_64
SHL             reg32,rm32*,reg64       ND,SM0-1,OPT,NF,NF_R,LONG,PROT,BMI2,APX,X86_64
SAL             reg32,rm32*,reg64       ND,SM0-1,OPT,NF,NF_R,LONG,PROT,BMI2,APX,X86_64
SAR             reg32,rm32*,reg64       ND,SM0-1,OPT,NF,NF_R,LONG,PROT,BMI2,APX,X86_64
SHR             reg32,rm32*,reg64       ND,SM0-1,OPT,NF,NF_R,LONG,PROT,BMI2,APX,X86_64
ROR             reg64,rm64,imm8         SM0,ND,SM1,OPT,NF,NF_R,LONG,PROT,BMI2,APX,X86_64
ROL             reg64,rm64,imm_known8   SM0,ND,SM1,OPT,NF,NF_R,LONG,PROT,BMI2,APX,X86_64
SHL             reg64,rm64*,reg8        ND,SM0-1,OPT,NF,NF_R,LONG,PROT,BMI2,APX,X86_64
SAL             reg64,rm64*,reg8        SM0,ND,SM1,OPT,NF,NF_R,LONG,PROT,BMI2,APX,X86_64
SAR             reg64,rm64*,reg8        ND,SM0-1,OPT,NF,NF_R,LONG,PROT,BMI2,APX,X86_64
SHR             reg64,rm64*,reg8        SM0,ND,SM1,OPT,NF,NF_R,LONG,PROT,BMI2,APX,X86_64
SHL             reg64,rm64*,reg16       SM0,ND,SM1,OPT,NF,NF_R,LONG,PROT,BMI2,APX,X86_64
SAL             reg64,rm64*,reg16       ND,SM0-1,OPT,NF,NF_R,LONG,PROT,BMI2,APX,X86_64
SAR             reg64,rm64*,reg16       SM0,ND,SM1,OPT,NF,NF_R,LONG,PROT,BMI2,APX,X86_64
SHR             reg64,rm64*,reg16       SM0,ND,SM1,OPT,NF,NF_R,LONG,PROT,BMI2,APX,X86_64
SHL             reg64,rm64*,reg32       ND,SM0-1,OPT,NF,NF_R,LONG,PROT,BMI2,APX,X86_64
SAL             reg64,rm64*,reg32       SM0,ND,SM1,OPT,NF,NF_R,LONG,PROT,BMI2,APX,X86_64
SAR             reg64,rm64*,reg32       SM0,ND,SM1,OPT,NF,NF_R,LONG,PROT,BMI2,APX,X86_64
SHR             reg64,rm64*,reg32       SM0,ND,SM1,OPT,NF,NF_R,LONG,PROT,BMI2,APX,X86_64
SHL             reg64,rm64*,reg64       ND,SM0-1,OPT,NF,NF_R,LONG,PROT,BMI2,APX,X86_64
SAL             reg64,rm64*,reg64       SM0,ND,SM1,OPT,NF,NF_R,LONG,PROT,BMI2,APX,X86_64
SAR             reg64,rm64*,reg64       SM0,ND,SM1,OPT,NF,NF_R,LONG,PROT,BMI2,APX,X86_64
SHR             reg64,rm64*,reg64       ND,SM0-1,OPT,NF,NF_R,LONG,PROT,BMI2,APX,X86_64
```

F.1.9 Other basic integer arithmetic

```
INC             reg16                   NOREX,NOAPX,NOLONG,FL,8086
INC             reg32                   NOREX,NOAPX,NOLONG,FL,386
INC             rm8                     LOCK,FL,8086
INC             rm16                    LOCK,FL,8086
INC             rm32                    LOCK,FL,386
INC             rm64                    LOCK,LONG,FL,PROT,X86_64
INC             reg8?,rm8               NF,LOCK,LONG,PROT,APX,X86_64
INC             reg16?,rm16             NF,LOCK,LONG,PROT,APX,X86_64
INC             reg32?,rm32             NF,LOCK,LONG,PROT,APX,X86_64
INC             reg64?,rm64             NF,LOCK,LONG,PROT,APX,X86_64
DEC             reg16                   NOREX,NOAPX,NOLONG,FL,8086
DEC             reg32                   NOREX,NOAPX,NOLONG,FL,386
DEC             rm8                     LOCK,FL,8086
DEC             rm16                    LOCK,FL,8086
DEC             rm32                    LOCK,FL,386
DEC             rm64                    LOCK,LONG,FL,PROT,X86_64
DEC             reg8?,rm8               NF,LOCK,LONG,PROT,APX,X86_64
DEC             reg16?,rm16             NF,LOCK,LONG,PROT,APX,X86_64
```

```
DEC             reg32?,rm32             NF,LOCK,LONG,PROT,APX,X86_64
DEC             reg64?,rm64             NF,LOCK,LONG,PROT,APX,X86_64
IMUL            rm8                     FL,8086
IMUL            rm16                    FL,8086
IMUL            rm32                    FL,386
IMUL            rm64                    LONG,FL,PROT,X86_64
IMUL            rm8                     SM0,NF,LONG,PROT,APX,X86_64
IMUL            rm16                    SM0,NF,LONG,PROT,APX,X86_64
IMUL            rm32                    SM0,NF,LONG,PROT,APX,X86_64
IMUL            rm64                    SM0,NF,LONG,PROT,APX,X86_64
IMUL            reg16,rm16              SM0-1,FL,386
IMUL            reg32,rm32              SM0-1,FL,386
IMUL            reg64,rm64              SM0-1,LONG,FL,PROT,X86_64
IMUL            reg16,rm16*,sbyteword16 SM0-2,FL,186
IMUL            reg32,rm32*,sbytedword32 SM0-2,FL,386
IMUL            reg64,rm64*,sbytedword64 SM0-2,LONG,FL,PROT,X86_64
IMUL            reg16,rm16*,imm16       SM0-2,FL,186
IMUL            reg32,rm32*,imm32       SM0-2,FL,386
IMUL            reg64,rm64*,sdword64    SM0-2,LONG,FL,PROT,X86_64
IMUL            reg16?,reg16,rm16       SM0-2,NF,LONG,PROT,APX,X86_64
IMUL            reg32?,reg32,rm32       SM0-2,NF,LONG,PROT,APX,X86_64
IMUL            reg64?,reg64,rm64       SM0-2,NF,LONG,PROT,APX,X86_64
IMUL            reg16,rm16,sbyteword16  SM0-2,NF,LONG,PROT,APX,X86_64
IMUL            reg32,rm32,sbytedword32 SM0-2,NF,LONG,PROT,APX,X86_64
IMUL            reg64,rm64,sbytedword64 SM0-2,NF,LONG,PROT,APX,X86_64
IMUL            reg16,rm16,imm16        SM0-2,NF,LONG,PROT,APX,X86_64
IMUL            reg32,rm32,imm32        SM0-2,NF,LONG,PROT,APX,X86_64
IMUL            reg64,rm64,sdword64     SM0-2,NF,LONG,PROT,APX,X86_64
MUL             rm8                     FL,8086
MUL             rm16                    FL,8086
MUL             rm32                    FL,386
MUL             rm64                    LONG,FL,PROT,X86_64
MULX            reg32,reg32*,rm32       BMI2
MULX            reg64,reg64*,rm64       LONG,PROT,BMI2,X86_64
MUL             reg32,reg32*,rm32       ND,OPT,NF,NF_R,BMI2
MUL             reg64,reg64*,rm64       ND,OPT,NF,NF_R,LONG,PROT,BMI2,X86_64
MUL             rm8                     SM0,NF,LONG,PROT,APX,X86_64
MUL             rm16                    SM0,NF,LONG,PROT,APX,X86_64
MUL             rm32                    SM0,NF,LONG,PROT,APX,X86_64
MUL             rm64                    SM0,NF,LONG,PROT,APX,X86_64
MUL             reg16,rm16              ND,SM0-1,FL,386
MUL             reg32,rm32              ND,SM0-1,FL,386
MUL             reg64,rm64              ND,SM0-1,LONG,FL,PROT,X86_64
MUL             reg16,rm16*,sbyteword16 ND,SM0-2,FL,186
MUL             reg32,rm32*,sbytedword32 ND,SM0-2,FL,386
MUL             reg64,rm64*,sbytedword64 SM0,ND,SM1-2,LONG,FL,PROT,X86_64
MUL             reg16,rm16*,imm16       ND,SM0-2,FL,186
MUL             reg32,rm32*,imm32       SM0,ND,SM1-2,FL,386
MUL             reg64,rm64*,sdword64    SM0,ND,SM1-2,LONG,FL,PROT,X86_64
MUL             reg16?,reg16,rm16       SM0,ND,SM1-2,NF,LONG,PROT,APX,X86_64
MUL             reg32?,reg32,rm32       ND,SM0-2,NF,LONG,PROT,APX,X86_64
MUL             reg64?,reg64,rm64       SM0,ND,SM1-2,NF,LONG,PROT,APX,X86_64
MUL             reg16,rm16,sbyteword16  SM0,ND,SM1-2,NF,LONG,PROT,APX,X86_64
MUL             reg32,rm32,sbytedword32 ND,SM0-2,NF,LONG,PROT,APX,X86_64
MUL             reg64,rm64,sbytedword64 ND,SM0-2,NF,LONG,PROT,APX,X86_64
MUL             reg16,rm16,imm16        ND,SM0-2,NF,LONG,PROT,APX,X86_64
MUL             reg32,rm32,imm32        SM0,ND,SM1-2,NF,LONG,PROT,APX,X86_64
MUL             reg64,rm64,sdword64     ND,SM0-2,NF,LONG,PROT,APX,X86_64
IDIV            rm8                     FL,8086
IDIV            rm16                    FL,8086
IDIV            rm32                    FL,386
IDIV            rm64                    LONG,FL,PROT,X86_64
IDIV            rm8                     NF,LONG,PROT,APX,X86_64
IDIV            rm16                    NF,LONG,PROT,APX,X86_64
IDIV            rm32                    NF,LONG,PROT,APX,X86_64
IDIV            rm64                    NF,LONG,PROT,APX,X86_64
DIV             rm8                     FL,8086
```

```
DIV             rm16                    FL,8086
DIV             rm32                    FL,386
DIV             rm64                    LONG,FL,PROT,X86_64
DIV             rm8                     NF,LONG,PROT,APX,X86_64
DIV             rm16                    NF,LONG,PROT,APX,X86_64
DIV             rm32                    NF,LONG,PROT,APX,X86_64
DIV             rm64                    NF,LONG,PROT,APX,X86_64
NEG             rm8                     LOCK,FL,8086
NEG             rm16                    LOCK,FL,8086
NEG             rm32                    LOCK,FL,386
NEG             rm64                    LOCK,LONG,FL,PROT,X86_64
NEG             reg8?,rm8               NF,LOCK,LONG,PROT,APX,X86_64
NEG             reg16?,rm16             NF,LOCK,LONG,PROT,APX,X86_64
NEG             reg32?,rm32             NF,LOCK,LONG,PROT,APX,X86_64
NEG             reg64?,rm64             NF,LOCK,LONG,PROT,APX,X86_64
NOT             rm8                     LOCK,8086
NOT             rm16                    LOCK,8086
NOT             rm32                    LOCK,386
NOT             rm64                    LOCK,LONG,PROT,X86_64
NOT             reg8?,rm8               LOCK,LONG,PROT,APX,X86_64
NOT             reg16?,rm16             LOCK,LONG,PROT,APX,X86_64
NOT             reg32?,rm32             LOCK,LONG,PROT,APX,X86_64
NOT             reg64?,rm64             LOCK,LONG,PROT,APX,X86_64
```

F.1.10 Interleaved flags arithmetic

```
ADCX            reg32,rm32              ZU,FL,ADX
ADCX            reg64,rm64              ZU,LONG,FL,PROT,ADX,X86_64
ADCX            reg32?,reg32,rm32       ZU,LONG,FL,PROT,APX,ADX,X86_64
ADCX            reg64?,reg64,rm64       ZU,LONG,FL,PROT,APX,ADX,X86_64
ADOX            reg32,rm32              ZU,FL,ADX
ADOX            reg64,rm64              ZU,LONG,FL,PROT,ADX,X86_64
ADOX            reg32?,reg32,rm32       ZU,LONG,FL,PROT,APX,ADX,X86_64
ADOX            reg64?,reg64,rm64       ZU,LONG,FL,PROT,APX,ADX,X86_64
```

F.1.11 Double width shift

```
SHLD            rm16,reg16,imm8         SM0-1,FL,386
SHLD            rm32,reg32,imm8         SM0-1,FL,386
SHLD            rm64,reg64,imm8         SM0-1,LONG,FL,PROT,X86_64
SHLD            rm16,reg16,reg_cl       SM0-1,FL,386
SHLD            rm32,reg32,reg_cl       SM0-1,FL,386
SHLD            rm64,reg64,reg_cl       SM0-1,LONG,FL,PROT,X86_64
SHLD            reg16?,rm16,reg16,imm8  SM0-1,NF,LONG,PROT,APX,X86_64
SHLD            reg32?,rm32,reg32,imm8  SM0-1,NF,LONG,PROT,APX,X86_64
SHLD            reg64?,rm64,reg64,imm8  SM0-1,NF,LONG,PROT,APX,X86_64
SHLD            reg16?,rm16,reg16,reg_cl SM0-1,NF,LONG,PROT,APX,X86_64
SHLD            reg32?,rm32,reg32,reg_cl SM0-1,NF,LONG,PROT,APX,X86_64
SHLD            reg64?,rm64,reg64,reg_cl SM0-1,NF,LONG,PROT,APX,X86_64
SHRD            rm16,reg16,imm8         SM0-1,FL,386
SHRD            rm32,reg32,imm8         SM0-1,FL,386
SHRD            rm64,reg64,imm8         SM0-1,LONG,FL,PROT,X86_64
SHRD            rm16,reg16,reg_cl       SM0-1,FL,386
SHRD            rm32,reg32,reg_cl       SM0-1,FL,386
SHRD            rm64,reg64,reg_cl       SM0-1,LONG,FL,PROT,X86_64
SHRD            reg16?,rm16,reg16,imm8  SM0-1,NF,LONG,PROT,APX,X86_64
SHRD            reg32?,rm32,reg32,imm8  SM0-1,NF,LONG,PROT,APX,X86_64
SHRD            reg64?,rm64,reg64,imm8  SM0-1,NF,LONG,PROT,APX,X86_64
SHRD            reg16?,rm16,reg16,reg_cl SM0-1,NF,LONG,PROT,APX,X86_64
SHRD            reg32?,rm32,reg32,reg_cl SM0-1,NF,LONG,PROT,APX,X86_64
SHRD            reg64?,rm64,reg64,reg_cl SM0-1,NF,LONG,PROT,APX,X86_64
```

F.1.12 Bit operations

```
BT              rm16,reg16              SM0-1,FL,386
BT              rm32,reg32              SM0-1,FL,386
BT              rm64,reg64              SM0-1,LONG,FL,PROT,X86_64
BT              rm16,imm8               FL,386
```

```
BT              rm32,imm8               FL,386
BT              rm64,imm8               LONG,FL,PROT,X86_64
BTC             rm16,reg16              SM0-1,LOCK,FL,386
BTC             rm32,reg32              SM0-1,LOCK,FL,386
BTC             rm64,reg64              SM0-1,LOCK,LONG,FL,PROT,X86_64
BTC             rm16,imm8               LOCK,FL,386
BTC             rm32,imm8               LOCK,FL,386
BTC             rm64,imm8               LOCK,LONG,FL,PROT,X86_64
BTR             rm16,reg16              SM0-1,LOCK,FL,386
BTR             rm32,reg32              SM0-1,LOCK,FL,386
BTR             rm64,reg64              SM0-1,LOCK,LONG,FL,PROT,X86_64
BTR             rm16,imm8               LOCK,FL,386
BTR             rm32,imm8               LOCK,FL,386
BTR             rm64,imm8               LOCK,LONG,FL,PROT,X86_64
BTS             rm16,reg16              SM0-1,LOCK,FL,386
BTS             rm32,reg32              SM0-1,LOCK,FL,386
BTS             rm64,reg64              SM0-1,LOCK,LONG,FL,PROT,X86_64
BTS             rm16,imm8               LOCK,FL,386
BTS             rm32,imm8               LOCK,FL,386
BTS             rm64,imm8               LOCK,LONG,FL,PROT,X86_64
BSF             reg16,rm16              SM0-1,386
BSF             reg32,rm32              SM0-1,386
BSF             reg64,rm64              SM0-1,LONG,PROT,X86_64
BSR             reg16,rm16              SM0-1,386
BSR             reg32,rm32              SM0-1,386
BSR             reg64,rm64              SM0-1,LONG,PROT,X86_64
IBTS            rm16,reg16              ND,NOREX,NOAPX,NOLONG,UNDOC,OBSOLETE,386
IBTS            rm32,reg32              ND,NOREX,NOAPX,NOLONG,UNDOC,OBSOLETE,386
XBTS            rm16,reg16              ND,NOREX,NOAPX,NOLONG,UNDOC,OBSOLETE,386
XBTS            rm32,reg32              ND,NOREX,NOAPX,NOLONG,UNDOC,OBSOLETE,386
```

F.1.13 BMI1 and BMI2 bit operations

```
LZCNT           reg16,rm16              SM0-1,FL,LZCNT
LZCNT           reg32,rm32              SM0-1,FL,LZCNT
LZCNT           reg64,rm64              SM0-1,LONG,FL,PROT,LZCNT,X86_64
LZCNT           reg16,rm16              SM0-1,NF,LONG,PROT,APX,LZCNT,X86_64
LZCNT           reg32,rm32              SM0-1,NF,LONG,PROT,APX,LZCNT,X86_64
LZCNT           reg64,rm64              SM0-1,NF,LONG,PROT,APX,LZCNT,X86_64
TZCNT           reg16,rm16              SM0-1,FL,BMI1
TZCNT           reg32,rm32              SM0-1,FL,BMI1
TZCNT           reg64,rm64              SM0-1,LONG,FL,PROT,BMI1,X86_64
TZCNT           reg16,rm16              SM0-1,NF,LONG,PROT,BMI1,APX,X86_64
TZCNT           reg32,rm32              SM0-1,NF,LONG,PROT,BMI1,APX,X86_64
TZCNT           reg64,rm64              SM0-1,NF,LONG,PROT,BMI1,APX,X86_64
ANDN            reg32,reg32*,rm32       SM0-2,FL,BMI1
ANDN            reg64,reg64*,rm64       SM0-2,LONG,FL,PROT,BMI1,X86_64
ANDN            reg32,reg32*,rm32       SM0-2,NF,LONG,PROT,BMI1,APX,X86_64
ANDN            reg64,reg64*,rm64       SM0-2,NF,LONG,PROT,BMI1,APX,X86_64
BEXTR           reg32,rm32*,reg32       SM0-2,FL,BMI1
BEXTR           reg64,rm64*,reg64       SM0-2,LONG,FL,PROT,BMI1,X86_64
BEXTR           reg32,rm32*,reg32       SM0-2,NF,LONG,PROT,BMI1,APX,X86_64
BEXTR           reg64,rm64*,reg64       SM0-2,NF,LONG,PROT,BMI1,APX,X86_64
BLSMSK          reg32,rm32              SM0-1,FL,BMI1
BLSMSK          reg64,rm64              SM0-1,LONG,FL,PROT,BMI1,X86_64
BLSMSK          reg32,rm32              SM0-1,NF,LONG,PROT,BMI1,APX,X86_64
BLSMSK          reg64,rm64              SM0-1,NF,LONG,PROT,BMI1,APX,X86_64
BLSR            reg32,rm32              SM0-1,FL,BMI1
BLSR            reg64,rm64              SM0-1,LONG,FL,PROT,BMI1,X86_64
BLSR            reg32,rm32              SM0-1,NF,LONG,PROT,BMI1,APX,X86_64
BLSR            reg64,rm64              SM0-1,NF,LONG,PROT,BMI1,APX,X86_64
BLSI            reg32,rm32              SM0-1,FL,BMI1
BLSI            reg64,rm64              SM0-1,LONG,FL,PROT,BMI1,X86_64
BLSI            reg32,rm32              SM0-1,NF,LONG,PROT,BMI1,APX,X86_64
BLSI            reg64,rm64              SM0-1,NF,LONG,PROT,BMI1,APX,X86_64
BZHI            reg32,rm32*,reg32       SM0-2,FL,BMI2
BZHI            reg64,rm64*,reg64       SM0-2,LONG,FL,PROT,BMI2,X86_64
```

```
BZHI            reg32,rm32*,reg32       SM0-2,NF,LONG,PROT,BMI1,APX,X86_64
BZHI            reg64,rm64*,reg64       SM0-2,NF,LONG,PROT,BMI1,APX,X86_64
PDEP            reg32,reg32*,rm32       SM0-2,BMI2
PDEP            reg64,reg64*,rm64       SM0-2,LONG,PROT,BMI2,X86_64
PEXT            reg32,reg32*,rm32       SM0-2,BMI2
PEXT            reg64,reg64*,rm64       SM0-2,LONG,PROT,BMI2,X86_64
```

F.1.14 AMD XOP bit operations

```
BEXTR           reg32,rm32*,imm32       SM0-1,FL,TBM,OBSOLETE,AMD
BEXTR           reg64,rm64*,imm32       SM0-1,LONG,FL,PROT,TBM,OBSOLETE,X86_64,AMD
BLCI            reg32,rm32              SM0-1,FL,TBM,OBSOLETE,AMD
BLCI            reg64,rm64              SM0-1,LONG,FL,PROT,TBM,OBSOLETE,X86_64,AMD
BLCIC           reg32,rm32              SM0-1,FL,TBM,OBSOLETE,AMD
BLCIC           reg64,rm64              SM0-1,LONG,FL,PROT,TBM,OBSOLETE,X86_64,AMD
BLSIC           reg32,rm32              SM0-1,FL,TBM,OBSOLETE,AMD
BLSIC           reg64,rm64              SM0-1,LONG,FL,PROT,TBM,OBSOLETE,X86_64,AMD
BLCFILL         reg32,rm32              SM0-1,TBM,OBSOLETE,AMD
BLCFILL         reg64,rm64              SM0-1,LONG,PROT,TBM,OBSOLETE,X86_64,AMD
BLSFILL         reg32,rm32              TBM,OBSOLETE,AMD
BLSFILL         reg64,rm64              LONG,PROT,TBM,OBSOLETE,X86_64,AMD
BLCMSK          reg32,rm32              FL,TBM,OBSOLETE,AMD
BLCMSK          reg64,rm64              LONG,FL,PROT,TBM,OBSOLETE,X86_64,AMD
BLCS            reg32,rm32              TBM,OBSOLETE,AMD
BLCS            reg64,rm64              LONG,PROT,TBM,OBSOLETE,X86_64,AMD
TZMSK           reg32,rm32              TBM,OBSOLETE,AMD
TZMSK           reg64,rm64              LONG,PROT,TBM,OBSOLETE,X86_64,AMD
T1MSKC          reg32,rm32              TBM,OBSOLETE,AMD
T1MSKC          reg64,rm64              LONG,PROT,TBM,OBSOLETE,X86_64,AMD
```

F.1.15 Decimal arithmetic

```
AAA                                     NOREX,NOAPX,NOLONG,FL,8086
AAD                                     NOREX,NOAPX,NOLONG,FL,8086
AAD             imm8                    AR0,NOREX,NOAPX,NOLONG,FL,8086
AAM                                     NOREX,NOAPX,NOLONG,FL,8086
AAM             imm8                    AR0,NOREX,NOAPX,NOLONG,FL,8086
AAS                                     NOREX,NOAPX,NOLONG,FL,8086
DAA                                     NOREX,NOAPX,NOLONG,FL,8086
DAS                                     NOREX,NOAPX,NOLONG,FL,8086
```

F.1.16 Endianness handling

```
BSWAP           reg32                   486
BSWAP           reg64                   LONG,PROT,X86_64
BSWAP           reg_ax                  ND,OPT,NOREX,NOAPX,8086
BSWAP           reg_cx                  ND,OPT,NOREX,NOAPX,8086
BSWAP           reg_dx                  ND,OPT,NOREX,NOAPX,8086
BSWAP           reg_bx                  ND,OPT,NOREX,NOAPX,8086
MOVBE           reg16,mem16             SM0-1,MOVBE,NEHALEM
MOVBE           reg32,mem32             SM0-1,MOVBE,NEHALEM
MOVBE           reg64,mem64             SM0-1,LONG,PROT,MOVBE,X86_64,NEHALEM
MOVBE           mem16,reg16             SM0-1,MOVBE,NEHALEM
MOVBE           mem32,reg32             SM0-1,MOVBE,NEHALEM
MOVBE           mem64,reg64             SM0-1,LONG,PROT,MOVBE,X86_64,NEHALEM
MOVBE           reg16,mem16             SM0-1,LONG,PROT,APX,MOVBE,X86_64,NEHALEM
MOVBE           reg32,mem32             SM0-1,LONG,PROT,APX,MOVBE,X86_64,NEHALEM
MOVBE           reg64,mem64             SM0-1,LONG,PROT,APX,MOVBE,X86_64,NEHALEM
MOVBE           mem16,reg16             SM0-1,LONG,PROT,APX,MOVBE,X86_64,NEHALEM
MOVBE           mem32,reg32             SM0-1,LONG,PROT,APX,MOVBE,X86_64,NEHALEM
MOVBE           mem64,reg64             SM0-1,LONG,PROT,APX,MOVBE,X86_64,NEHALEM
```

F.1.17 Sign and zero extension

```
CBW                                     8086
CDQ                                     386
CDQE                                    LONG,PROT,X86_64
CQO                                     LONG,PROT,X86_64
```

```
CWD                             8086
CWDE                            386
MOVSX           reg_ax,reg_al   ND,OPT,8086
MOVSXB          reg_ax,reg_al   ND,OPT,8086
MOVSX           reg_eax,reg_ax  ND,OPT,ZU,386
MOVSXW          reg_eax,reg_ax  ND,OPT,ZU,386
MOVSX           reg_rax,reg_eax ND,OPT,ZU,LONG,PROT,X86_64
MOVSXD          reg_rax,reg_eax ND,OPT,ZU,LONG,PROT,X86_64
MOVSX           reg16,rm8       AR0-1,SX,386
MOVSX           reg32,rm8       AR0-1,SX,386
MOVSX           reg64,rm8       AR0-1,SX,LONG,PROT,X86_64
MOVSXB          reg16,rm8       ND,386
MOVSXB          reg32,rm8       ND,386
MOVSXB          reg64,rm8       ND,LONG,PROT,X86_64
MOVSX           reg16,rm16      AR0-1,SX,386
MOVSX           reg32,rm16      AR0-1,SX,386
MOVSX           reg64,rm16      AR0-1,SX,LONG,PROT,X86_64
MOVSXW          reg16,rm16      ND,386
MOVSXW          reg32,rm16      ND,386
MOVSXW          reg64,rm16      ND,LONG,PROT,X86_64
MOVSX           reg16,rm32      ND,AR0-1,SX,LONG,PROT,X86_64
MOVSX           reg32,rm32      ND,AR0-1,SX,LONG,PROT,X86_64
MOVSX           reg64,rm32      ND,AR0-1,SX,LONG,PROT,X86_64
MOVSXD          reg16,rm32      LONG,PROT,X86_64
MOVSXD          reg32,rm32      LONG,PROT,X86_64
MOVSXD          reg64,rm32      LONG,PROT,X86_64
MOVZX           reg16,rm8       AR0-1,SX,386
MOVZX           reg32,rm8       AR0-1,SX,386
MOVZX           reg64,rm8       AR0-1,SX,LONG,PROT,X86_64
MOVZXB          reg16,rm8       ND,386
MOVZXB          reg32,rm8       ND,386
MOVZXB          reg64,rm8       ND,LONG,PROT,X86_64
MOVZX           reg16,rm16      AR0-1,SX,386
MOVZX           reg32,rm16      AR0-1,SX,386
MOVZX           reg64,rm16      AR0-1,SX,LONG,PROT,X86_64
MOVZXW          reg16,rm16      ND,386
MOVZXW          reg32,rm16      ND,386
MOVZXW          reg64,rm16      ND,LONG,PROT,X86_64
MOVZX           reg16,rm32      ND,AR0-1,SX,OPT,8086
MOVZX           reg32,rm32      ND,AR0-1,SX,OPT,386
MOVZX           reg64,rm32      ND,AR0-1,SX,OPT,LONG,PROT,X86_64
MOVZXD          reg16,rm32      ND,OPT,8086
MOVZXD          reg32,rm32      ND,OPT,386
MOVZXD          reg64,rm32      ND,OPT,LONG,PROT,X86_64
```

F.1.18 Atomic operations

```
CMPXCHG         rm8,reg8        SM0-1,LOCK,FL,PENT
CMPXCHG         rm16,reg16      SM0-1,LOCK,FL,PENT
CMPXCHG         rm32,reg32      SM0-1,LOCK,FL,PENT
CMPXCHG         rm64,reg64      SM0-1,LOCK,LONG,FL,PROT,X86_64
CMPXCHG8B       mem64           LOCK,FL,PENT
CMPXCHG16B      mem128          LOCK,LONG,FL,PROT,X86_64
XADD            rm8,reg8        SM0-1,LOCK,FL,486
XADD            rm16,reg16      SM0-1,LOCK,FL,486
XADD            rm32,reg32      SM0-1,LOCK,FL,486
XADD            rm64,reg64      SM0-1,LOCK,LONG,FL,PROT,X86_64
XCHG            reg_ax,reg16    8086
XCHG            reg_rax,reg64   ZU,LONG,PROT,X86_64
XCHG            reg16,reg_ax    ND,8086
XCHG            reg64,reg_rax   ND,LONG,PROT,X86_64
XCHG            reg_eax,reg32na ZU,386
XCHG            reg32na,reg_eax ND,386
XCHG            reg_eax,reg_eax ND,NOREX,NOAPX,ZU,NOLONG,386
XCHG            reg8,rm8        SM0-1,LOCK1,8086
XCHG            reg16,rm16      SM0-1,LOCK1,8086
XCHG            reg32,rm32      SM0-1,LOCK1,386
```

```
XCHG            reg64,rm64              SM0-1,LOCK1,LONG,PROT,X86_64
XCHG            rm8,reg8                ND,SM0-1,LOCK,8086
XCHG            rm16,reg16              SM0,ND,SM1,LOCK,8086
XCHG            rm32,reg32              SM0,ND,SM1,LOCK,386
XCHG            rm64,reg64              ND,SM0-1,LOCK,LONG,PROT,X86_64
CMPXCHG486      rm8,reg8                SM0,ND,SM1,NOREX,NOAPX,LOCK,NOLONG,FL,UNDOC,OBSOLETE,486
CMPXCHG486      rm16,reg16              SM0,ND,SM1,NOREX,NOAPX,LOCK,NOLONG,FL,UNDOC,OBSOLETE,486
CMPXCHG486      rm32,reg32              SM0,ND,SM1,NOREX,NOAPX,LOCK,NOLONG,FL,UNDOC,OBSOLETE,486
```

F.1.19 Jumps

```
JMPABS          imm64|near              LONG,PROT,APX,X86_64
JMP             imm64|abs|near          ND,LONG,PROT,APX,X86_64
JMPABS          imm64|abs|near          ND,LONG,PROT,APX,X86_64
JMP             imm16|short             ND,AR0,OSIZE,NOREX,NOAPX,NOLONG,8086
JMP             imm32|short             ND,AR0,OSIZE,NOREX,NOAPX,NOLONG,8086
JMP             imm64|short             ND,AR0,OSIZE,NOAPX,LONG,PROT,X86_64
JMP             imm16|near              AR0,OSIZE,JMP_RELAX,NOREX,NOAPX,NOLONG,8086
JMP             imm32|near              AR0,OSIZE,JMP_RELAX,NOREX,NOAPX,NOLONG,8086
JMP             imm64|near              AR0,OSIZE,JMP_RELAX,NOAPX,LONG,PROT,X86_64
JMP             imm32|near              ND,AR0,SX,JMP_RELAX,NOAPX,LONG,PROT,X86_64
JMP             imm16|near              AR0,OSIZE,NOREX,NOAPX,NOLONG,BND,8086
JMP             imm32|near              AR0,OSIZE,NOREX,NOAPX,NOLONG,BND,8086
JMP             imm64|near              AR0,OSIZE,LONG,BND,PROT,X86_64
JMP             imm32|near              ND,AR0,SX,LONG,BND,PROT,X86_64
JMP             rm16|near               AR0,OSIZE,NOREX,NOAPX,NOLONG,BND,8086
JMP             rm32|near               AR0,OSIZE,NOREX,NOAPX,NOLONG,BND,386
JMP             rm64|near               AR0,OSIZE,LONG,BND,PROT,X86_64
JMP             imm16|far               ND,AR0,OSIZE,NOREX,NOAPX,NOLONG,8086
JMP             imm32|far               ND,AR0,OSIZE,NOREX,NOAPX,NOLONG,386
JMP             imm16:imm16             ND,SM0-1,AR0,SX,NOREX,NOAPX,NOLONG,8086
JMP             imm32:imm32             ND,SM0-1,AR0,SX,NOREX,NOAPX,NOLONG,386
JMP             imm16:imm16|far         ND,SM0-1,AR0,SX,NOREX,NOAPX,NOLONG,8086
JMP             imm32:imm32|far         SM0,ND,SM1,AR0,SX,NOREX,NOAPX,NOLONG,386
JMP             imm16:imm16             AR1,OSIZE,NOREX,NOAPX,NOLONG,8086
JMP             imm16:imm32             AR1,OSIZE,NOREX,NOAPX,NOLONG,386
JMP             imm16:imm16|far         ND,AR1,OSIZE,NOREX,NOAPX,NOLONG,8086
JMP             imm16:imm32|far         ND,AR1,OSIZE,NOREX,NOAPX,NOLONG,386
JMP             mem16|far               AR0,NWSIZE,OSIZE,NOREX,NOAPX,NOLONG,8086
JMP             mem32|far               AR0,NWSIZE,OSIZE,386
JMP             mem64|far               AR0,NWSIZE,OSIZE,LONG,386,X86_64
JMP             rm16                    AR0,OSIZE,NOREX,NOAPX,NOLONG,BND,8086
JMP             rm32                    AR0,OSIZE,NOREX,NOAPX,NOLONG,BND,386
JMP             rm64                    AR0,OSIZE,LONG,BND,PROT,X86_64
Jcc             imm16|short             ND,AR0,OSIZE,JCC_HINT,NOREX,NOAPX,NOLONG,BND,8086
Jcc             imm32|short             ND,AR0,OSIZE,JCC_HINT,NOREX,NOAPX,NOLONG,BND,8086
Jcc             imm64|short             ND,AR0,OSIZE,JCC_HINT,NOAPX,LONG,BND,PROT,X86_64
Jcc             imm16|near              AR0,OSIZE,JMP_RELAX,JCC_HINT,NOREX,NOAPX,NOLONG,BND,8086
Jcc             imm32|near              AR0,OSIZE,JMP_RELAX,JCC_HINT,NOREX,NOAPX,NOLONG,BND,8086
Jcc             imm64|near              AR0,OSIZE,JMP_RELAX,JCC_HINT,NOAPX,LONG,BND,PROT,X86_64
Jcc             imm32|near              ND,AR0,SX,JMP_RELAX,JCC_HINT,NOAPX,LONG,BND,PROT,X86_64
Jcc             imm16|near              AR0,OSIZE,JCC_HINT,NOREX,NOAPX,NOLONG,BND,386
Jcc             imm32|near              AR0,OSIZE,JCC_HINT,NOREX,NOAPX,NOLONG,BND,386
Jcc             imm64|near              AR0,OSIZE,JCC_HINT,NOAPX,LONG,BND,PROT,X86_64
Jcc             imm32|near              ND,AR0,SX,JCC_HINT,NOAPX,LONG,BND,PROT,X86_64
Jcc             imm                     ND,AR0,OSIZE,NOAPX,8086
JCXZ            imm16|near|short        AR0,OSIZE,NOREX,NOAPX,NOLONG,8086
JECXZ           imm16|near|short        AR0,OSIZE,NOREX,NOAPX,NOLONG,386
JCXZ            imm32|near|short        AR0,OSIZE,NOREX,NOAPX,NOLONG,8086
JECXZ           imm32|near|short        AR0,OSIZE,NOREX,NOAPX,NOLONG,386
JECXZ           imm64|near|short        AR0,OSIZE,NOAPX,LONG,PROT,X86_64
JRCXZ           imm64|near|short        AR0,OSIZE,NOAPX,LONG,PROT,X86_64
JCXZ            imm16|near|short,reg_cx  ND,AR0-1,OSIZE,NOREX,NOAPX,NOLONG,8086
JCXZ            imm16|near|short,reg_ecx ND,AR0-1,OSIZE,NOREX,NOAPX,NOLONG,386
JCXZ            imm32|near|short,reg_cx  ND,AR0-1,OSIZE,NOREX,NOAPX,NOLONG,8086
JCXZ            imm32|near|short,reg_ecx ND,AR0-1,OSIZE,NOREX,NOAPX,NOLONG,386
JCXZ            imm64|near|short,reg_ecx ND,AR0-1,OSIZE,NOAPX,LONG,PROT,X86_64
```

```
JCXZ            imm64|near|short,reg_rcx ND,AR0-1,OSIZE,NOAPX,LONG,PROT,X86_64
LOOP            imm16|near|short         AR0,OSIZE,NOREX,NOAPX,NOLONG,8086
LOOPW           imm16|near|short         ND,AR0,OSIZE,NOREX,NOAPX,NOLONG,8086
LOOPD           imm16|near|short         ND,AR0,OSIZE,NOREX,NOAPX,NOLONG,386
LOOP            imm32|near|short         AR0,OSIZE,NOREX,NOAPX,NOLONG,8086
LOOPW           imm32|near|short         ND,AR0,OSIZE,NOREX,NOAPX,NOLONG,8086
LOOPD           imm32|near|short         ND,AR0,OSIZE,NOREX,NOAPX,NOLONG,386
LOOP            imm64|near|short         AR0,OSIZE,NOAPX,LONG,PROT,X86_64
LOOPD           imm64|near|short         ND,AR0,OSIZE,NOAPX,LONG,PROT,X86_64
LOOPQ           imm64|near|short         ND,AR0,OSIZE,NOAPX,LONG,PROT,X86_64
LOOPE           imm16|near|short         AR0,OSIZE,NOREX,NOAPX,NOLONG,8086
LOOPEW          imm16|near|short         ND,AR0,OSIZE,NOREX,NOAPX,NOLONG,8086
LOOPED          imm16|near|short         ND,AR0,OSIZE,NOREX,NOAPX,NOLONG,386
LOOPE           imm32|near|short         AR0,OSIZE,NOREX,NOAPX,NOLONG,8086
LOOPEW          imm32|near|short         ND,AR0,OSIZE,NOREX,NOAPX,NOLONG,8086
LOOPED          imm32|near|short         ND,AR0,OSIZE,NOREX,NOAPX,NOLONG,386
LOOPE           imm64|near|short         AR0,OSIZE,NOAPX,LONG,PROT,X86_64
LOOPED          imm64|near|short         ND,AR0,OSIZE,NOAPX,LONG,PROT,X86_64
LOOPEQ          imm64|near|short         ND,AR0,OSIZE,NOAPX,LONG,PROT,X86_64
LOOPNE          imm16|near|short         AR0,OSIZE,NOREX,NOAPX,NOLONG,8086
LOOPNEW         imm16|near|short         ND,AR0,OSIZE,NOREX,NOAPX,NOLONG,8086
LOOPNED         imm16|near|short         ND,AR0,OSIZE,NOREX,NOAPX,NOLONG,386
LOOPNE          imm32|near|short         AR0,OSIZE,NOREX,NOAPX,NOLONG,8086
LOOPNEW         imm32|near|short         ND,AR0,OSIZE,NOREX,NOAPX,NOLONG,8086
LOOPNED         imm32|near|short         ND,AR0,OSIZE,NOREX,NOAPX,NOLONG,386
LOOPNE          imm64|near|short         AR0,OSIZE,NOAPX,LONG,PROT,X86_64
LOOPNED         imm64|near|short         ND,AR0,OSIZE,NOAPX,LONG,PROT,X86_64
LOOPNEQ         imm64|near|short         ND,AR0,OSIZE,NOAPX,LONG,PROT,X86_64
LOOPZ           imm16|near|short         ND,AR0,OSIZE,NOREX,NOAPX,NOLONG,8086
LOOPZW          imm16|near|short         ND,AR0,OSIZE,NOREX,NOAPX,NOLONG,8086
LOOPZD          imm16|near|short         ND,AR0,OSIZE,NOREX,NOAPX,NOLONG,386
LOOPZ           imm32|near|short         ND,AR0,OSIZE,NOREX,NOAPX,NOLONG,8086
LOOPZW          imm32|near|short         ND,AR0,OSIZE,NOREX,NOAPX,NOLONG,8086
LOOPZD          imm32|near|short         ND,AR0,OSIZE,NOREX,NOAPX,NOLONG,386
LOOPZ           imm64|near|short         ND,AR0,OSIZE,NOAPX,LONG,PROT,X86_64
LOOPZD          imm64|near|short         ND,AR0,OSIZE,NOAPX,LONG,PROT,X86_64
LOOPZQ          imm64|near|short         ND,AR0,OSIZE,NOAPX,LONG,PROT,X86_64
LOOPNZ          imm16|near|short         ND,AR0,OSIZE,NOREX,NOAPX,NOLONG,8086
LOOPNZW         imm16|near|short         ND,AR0,OSIZE,NOREX,NOAPX,NOLONG,8086
LOOPNZD         imm16|near|short         ND,AR0,OSIZE,NOREX,NOAPX,NOLONG,386
LOOPNZ          imm32|near|short         ND,AR0,OSIZE,NOREX,NOAPX,NOLONG,8086
LOOPNZW         imm32|near|short         ND,AR0,OSIZE,NOREX,NOAPX,NOLONG,8086
LOOPNZD         imm32|near|short         ND,AR0,OSIZE,NOREX,NOAPX,NOLONG,386
LOOPNZ          imm64|near|short         ND,AR0,OSIZE,NOAPX,LONG,PROT,X86_64
LOOPNZD         imm64|near|short         ND,AR0,OSIZE,NOAPX,LONG,PROT,X86_64
LOOPNZQ         imm64|near|short         ND,AR0,OSIZE,NOAPX,LONG,PROT,X86_64
LOOP            imm16|near|short,reg_cx  AR0-1,OSIZE,NOREX,NOAPX,NOLONG,8086
LOOP            imm16|near|short,reg_ecx AR0-1,OSIZE,NOREX,NOAPX,NOLONG,386
LOOP            imm32|near|short,reg_cx  AR0-1,OSIZE,NOREX,NOAPX,NOLONG,8086
LOOP            imm32|near|short,reg_ecx AR0-1,OSIZE,NOREX,NOAPX,NOLONG,386
LOOP            imm64|near|short,reg_ecx AR0-1,OSIZE,NOAPX,LONG,PROT,X86_64
LOOP            imm64|near|short,reg_rcx AR0-1,OSIZE,NOAPX,LONG,PROT,X86_64
LOOPE           imm16|near|short,reg_cx  AR0-1,OSIZE,NOREX,NOAPX,NOLONG,8086
LOOPE           imm16|near|short,reg_ecx AR0-1,OSIZE,NOREX,NOAPX,NOLONG,386
LOOPE           imm32|near|short,reg_cx  AR0-1,OSIZE,NOREX,NOAPX,NOLONG,8086
LOOPE           imm32|near|short,reg_ecx AR0-1,OSIZE,NOREX,NOAPX,NOLONG,386
LOOPE           imm64|near|short,reg_ecx AR0-1,OSIZE,NOAPX,LONG,PROT,X86_64
LOOPE           imm64|near|short,reg_rcx AR0-1,OSIZE,NOAPX,LONG,PROT,X86_64
LOOPNE          imm16|near|short,reg_cx  AR0-1,OSIZE,NOREX,NOAPX,NOLONG,8086
LOOPNE          imm16|near|short,reg_ecx AR0-1,OSIZE,NOREX,NOAPX,NOLONG,386
LOOPNE          imm32|near|short,reg_cx  AR0-1,OSIZE,NOREX,NOAPX,NOLONG,8086
LOOPNE          imm32|near|short,reg_ecx AR0-1,OSIZE,NOREX,NOAPX,NOLONG,386
LOOPNE          imm64|near|short,reg_ecx AR0-1,OSIZE,NOAPX,LONG,PROT,X86_64
LOOPNE          imm64|near|short,reg_rcx AR0-1,OSIZE,NOAPX,LONG,PROT,X86_64
LOOPZ           imm16|near|short,reg_cx  AR0-1,OSIZE,NOREX,NOAPX,NOLONG,8086
LOOPZ           imm16|near|short,reg_ecx AR0-1,OSIZE,NOREX,NOAPX,NOLONG,386
LOOPZ           imm32|near|short,reg_cx  AR0-1,OSIZE,NOREX,NOAPX,NOLONG,8086
```

```
LOOPZ           imm32|near|short,reg_ecx AR0-1,OSIZE,NOREX,NOAPX,NOLONG,386
LOOPZ           imm64|near|short,reg_ecx AR0-1,OSIZE,NOAPX,LONG,PROT,X86_64
LOOPZ           imm64|near|short,reg_rcx AR0-1,OSIZE,NOAPX,LONG,PROT,X86_64
LOOPNZ          imm16|near|short,reg_cx  AR0-1,OSIZE,NOREX,NOAPX,NOLONG,8086
LOOPNZ          imm16|near|short,reg_ecx AR0-1,OSIZE,NOREX,NOAPX,NOLONG,386
LOOPNZ          imm32|near|short,reg_cx  AR0-1,OSIZE,NOREX,NOAPX,NOLONG,8086
LOOPNZ          imm32|near|short,reg_ecx AR0-1,OSIZE,NOREX,NOAPX,NOLONG,386
LOOPNZ          imm64|near|short,reg_ecx AR0-1,OSIZE,NOAPX,LONG,PROT,X86_64
LOOPNZ          imm64|near|short,reg_rcx AR0-1,OSIZE,NOAPX,LONG,PROT,X86_64
JMPE            imm16|near               AR0,OSIZE,IA64
JMPE            imm32|near               AR0,OSIZE,IA64
JMPE            sdword64|near            AR0,OSIZE,LONG,IA64,X86_64
JMPE            rm16|near                AR0,OSIZE,IA64
JMPE            rm32|near                AR0,OSIZE,IA64
JMPE            rm64|near                AR0,OSIZE,LONG,PROT,X86_64
JMPE            rm16                     AR0,OSIZE,IA64
JMPE            rm32                     AR0,OSIZE,IA64
JMPE            rm64                     AR0,OSIZE,LONG,PROT,X86_64
```

F.1.20 Call and return

```
CALL            imm16|near               AR0,OSIZE,NOREX,NOAPX,NOLONG,BND,8086
CALL            imm32|near               AR0,OSIZE,NOREX,NOAPX,NOLONG,BND,8086
CALL            imm64|near               AR0,OSIZE,NOAPX,LONG,BND,PROT,X86_64
CALL            imm32|near               ND,AR0,SX,NOAPX,LONG,BND,PROT,X86_64
CALL            rm16|near                AR0,OSIZE,NOREX,NOAPX,NOLONG,BND,8086
CALL            rm32|near                AR0,OSIZE,NOREX,NOAPX,NOLONG,BND,386
CALL            rm64|near                LONG,BND,PROT,X86_64
CALL            imm16|far                ND,AR0,OSIZE,NOREX,NOAPX,NOLONG,8086
CALL            imm32|far                ND,AR0,OSIZE,NOREX,NOAPX,NOLONG,386
CALL            imm16:imm16              SM0,ND,SM1,AR0,SX,NOREX,NOAPX,NOLONG,8086
CALL            imm32:imm32              SM0,ND,SM1,AR0,SX,NOREX,NOAPX,NOLONG,386
CALL            imm16:imm16|far          SM0,ND,SM1,AR0,SX,NOREX,NOAPX,NOLONG,8086
CALL            imm32:imm32|far          SM0,ND,SM1,AR0,SX,NOREX,NOAPX,NOLONG,386
CALL            imm16:imm16              AR1,OSIZE,NOREX,NOAPX,NOLONG,8086
CALL            imm16:imm32              AR1,OSIZE,NOREX,NOAPX,NOLONG,386
CALL            imm16:imm16|far          ND,AR1,OSIZE,NOREX,NOAPX,NOLONG,8086
CALL            imm16:imm32|far          ND,AR1,OSIZE,NOREX,NOAPX,NOLONG,386
CALL            mem16|far                AR0,NWSIZE,OSIZE,NOREX,NOAPX,NOLONG,8086
CALL            mem32|far                AR0,NWSIZE,OSIZE,386
CALL            mem64|far                AR0,NWSIZE,OSIZE,LONG,386,X86_64
CALL            rm16                     AR0,OSIZE,NOREX,NOAPX,NOLONG,BND,8086
CALL            rm32                     AR0,OSIZE,NOREX,NOAPX,NOLONG,BND,386
CALL            rm64                     LONG,BND,PROT,X86_64
RET                                      BND,8086
RETW                                     BND,8086
RETD                                     NOREX,NOAPX,NOLONG,BND,386
RETQ                                     LONG,BND,386,X86_64
RET             imm16                    BND,8086
RETW            imm16                    BND,8086
RETD            imm16                    NOREX,NOAPX,NOLONG,BND,386
RETQ            imm16                    LONG,BND,386,X86_64
RETF                                     8086
RETFW                                    8086
RETFD                                    386
RETFQ                                    LONG,386,X86_64
RETF            imm16                    8086
RETFW           imm16                    8086
RETFD           imm16                    386
RETFQ           imm16                    LONG,386,X86_64
RETN                                     ND,BND,8086
RETNW                                    ND,BND,8086
RETND                                    ND,NOREX,NOAPX,NOLONG,BND,386
RETNQ                                    ND,LONG,BND,386,X86_64
RETN            imm16                    ND,BND,8086
RETNW           imm16                    ND,BND,8086
```

```
RETND           imm16                   ND,NOREX,NOAPX,NOLONG,BND,386
RETNQ           imm16                   ND,LONG,BND,386,X86_64
```

F.1.21 Interrupts, system calls, and returns

```
INT             imm8                    8086
INT1                                    386
INT01                                   ND,386
ICEBP                                   ND,386
INT3                                    8086
INT03                                   ND,8086
BRKPT                                   ND,8086
INTO                                    NOREX,NOAPX,NOLONG,8086
SYSCALL                                 P6,AMD
SYSENTER                                NOAPX,P6
SYSEXIT                                 NOAPX,PRIV,P6
SYSRET                                  PRIV,P6,AMD
IRET                                    FL,8086
IRETW                                   FL,8086
IRETD                                   FL,386
IRETQ                                   LONG,FL,386,X86_64
ERETS                                   LONG,PRIV,PROT,FRED,X86_64
ERETU                                   LONG,PRIV,PROT,FRED,X86_64
```

F.1.22 Flag register instructions

```
CLC                                     FL,8086
CLD                                     FL,8086
CLI                                     FL,8086
CLAC                                    FL,PRIV,SMAP
STC                                     FL,8086
STD                                     FL,8086
STI                                     FL,8086
STAC                                    FL,PRIV,SMAP
CMC                                     FL,8086
LAHF                                    8086
SAHF                                    FL,8086
SALC                                    NOREX,NOAPX,NOLONG,UNDOC,8086
PUSHF                                   8086
PUSHFW                                  8086
PUSHFD                                  386
PUSHFQ                                  LONG,386,X86_64
POPF                                    FL,8086
POPFW                                   FL,8086
POPFD                                   FL,386
POPFQ                                   LONG,FL,386,X86_64
```

F.1.23 String instructions

```
CMPSB                                   NOAPX,FL,8086
CMPSW                                   NOAPX,FL,8086
CMPSD                                   NOAPX,FL,386
CMPSQ                                   NOAPX,LONG,FL,386,X86_64
LODSB                                   NOAPX,8086
LODSW                                   NOAPX,8086
LODSD                                   NOAPX,386
LODSQ                                   NOAPX,LONG,386,X86_64
MOVSB                                   NOAPX,8086
MOVSW                                   NOAPX,8086
MOVSD                                   NOAPX,386
MOVSQ                                   NOAPX,LONG,386,X86_64
STOSB                                   NOAPX,8086
STOSW                                   NOAPX,8086
STOSD                                   NOAPX,386
STOSQ                                   NOAPX,LONG,386,X86_64
SCASB                                   NOAPX,FL,8086
SCASW                                   NOAPX,FL,8086
SCASD                                   NOAPX,FL,386
```

```
SCASQ                                   NOAPX,LONG,FL,386,X86_64
INSB                                    186
INSW                                    186
INSD                                    386
OUTSB                                   186
OUTSW                                   186
OUTSD                                   386
```

F.1.24 Synchronization and fencing

```
LFENCE                                  LONG,PROT,X86_64,AMD
MFENCE                                  LONG,PROT,X86_64,AMD
SFENCE                                  LONG,PROT,X86_64,AMD
SERIALIZE                               SERIALIZE
```

F.1.25 Memory management and control

```
CLFLUSH         mem                     SSE2,WILLAMETTE
CLFLUSHOPT      mem                     CLFLUSHOPT
CLWB            mem                     CLWB
PCOMMIT                                 OBSOLETE,NEVER,NOP
CLZERO          reg_ax                  NOLONG,CLZERO,AMD
CLZERO          reg_eax                 CLZERO,AMD
CLZERO          reg_rax                 LONG,PROT,CLZERO,X86_64,AMD
CLZERO                                  ND,CLZERO,AMD
INVD                                    PRIV,486
WBINVD                                  PRIV,486
WBNOINVD                                PRIV,WBNOINVD
INVPCID         reg32,mem128            NOREX,NOAPX,NOLONG,PRIV,INVPCID
INVPCID         reg64,mem128            LONG,PRIV,PROT,INVPCID,X86_64
INVPCID         reg64,mem128            LONG,PRIV,PROT,APX,INVPCID,X86_64
INVLPG          mem                     PRIV,486
INVLPGA         reg_ax,reg_ecx          NOLONG,X86_64,AMD
INVLPGA         reg_eax,reg_ecx         X86_64,AMD
INVLPGA         reg_rax,reg_ecx         LONG,PROT,X86_64,AMD
INVLPGA                                 ND,X86_64,AMD
```

F.1.26 Special reads: timestamp, CPU number, performance counters, randomness

```
RDPMC                                   NOAPX,P6
RDTSC                                   NOAPX,PENT
RDTSCP                                  X86_64
RDRAND          reg16                   FL,RDRAND
RDRAND          reg32                   FL,RDRAND
RDRAND          reg64                   LONG,FL,PROT,RDRAND,X86_64
RDSEED          reg16                   FL,RDSEED
RDSEED          reg32                   FL,RDSEED
RDSEED          reg64                   LONG,FL,PROT,RDSEED,X86_64
RDPID           reg64                   ND,OPT,LONG,PROT,RDPID,X86_64
RDPID           reg32                   RDPID
RDPID           reg64                   LONG,PROT,RDPID,X86_64
```

F.1.27 Machine control and management instructions

```
CLTS                                    PRIV,286
CPUID                                   PENT
LMSW            rm16                    PRIV,286
SMSW            rm16                    286
SMSW            reg64                   ND,LONG,PROT,X86_64
SMSW            reg16                   286
SMSW            reg32                   386
SMSW            reg64                   LONG,PROT,X86_64
MOV             reg32,reg_creg          NOREX,NOAPX,NOLONG,PRIV,386
MOV             reg_creg,reg32          NOREX,NOAPX,NOLONG,PRIV,386
MOV             reg64,reg_creg          LONG,PRIV,PROT,X86_64
MOV             reg_creg,reg64          LONG,PRIV,PROT,X86_64
MOV             reg32,reg_dreg          NOREX,NOAPX,NOLONG,PRIV,386
MOV             reg_dreg,reg32          NOREX,NOAPX,NOLONG,PRIV,386
```

```
MOV             reg64,reg_dreg          LONG,PRIV,PROT,X86_64
MOV             reg_dreg,reg64          LONG,PRIV,PROT,X86_64
MOV             reg32,reg_treg          ND,NOREX,NOAPX,NOLONG,OBSOLETE,386
MOV             reg_treg,reg32          ND,NOREX,NOAPX,NOLONG,OBSOLETE,386
WRMSR                                   NOAPX,PRIV,PENT
RDMSR                                   NOAPX,PRIV,PENT
RDMSR           reg64,imm32             LONG,PRIV,PROT,MSR_IMM,X86_64
WRMSRNS                                 PRIV,WRMSRNS
WRMSRNS         imm32,reg64             LONG,PRIV,PROT,MSR_IMM,X86_64
RDMSRLIST                               LONG,PRIV,PROT,MSRLIST,X86_64
WRMSRLIST                               LONG,PRIV,PROT,MSRLIST,X86_64
URDMSR          reg64,reg64             NOAPX
URDMSR          reg64,reg64             LONG,PROT,APX,X86_64
URDMSR          reg64,imm32
UWRMSR          reg64,reg64             NOAPX
UWRMSR          reg64,reg64             LONG,PROT,APX,X86_64
UWRMSR          imm32,reg64
UMOV            rm8,reg8                SM0,ND,SM1,NOREX,NOAPX,NOLONG,UNDOC,OBSOLETE,386
UMOV            rm16,reg16              SM0,ND,SM1,NOREX,NOAPX,NOLONG,UNDOC,OBSOLETE,386
UMOV            rm32,reg32              ND,SM0-1,NOREX,NOAPX,NOLONG,UNDOC,OBSOLETE,386
UMOV            reg8,rm8                ND,SM0-1,NOREX,NOAPX,NOLONG,UNDOC,OBSOLETE,386
UMOV            reg16,rm16              ND,SM0-1,NOREX,NOAPX,NOLONG,UNDOC,OBSOLETE,386
UMOV            reg32,rm32              ND,SM0-1,NOREX,NOAPX,NOLONG,UNDOC,OBSOLETE,386
BB0_RESET                               ND,NOREX,NOAPX,NOLONG,OBSOLETE,PENT,CYRIX
BB1_RESET                               ND,NOREX,NOAPX,NOLONG,OBSOLETE,PENT,CYRIX
CPU_READ                                ND,NOREX,NOAPX,NOLONG,OBSOLETE,PENT,CYRIX
CPU_WRITE                               ND,NOREX,NOAPX,NOLONG,OBSOLETE,PENT,CYRIX
DMINT                                   ND,NOREX,NOAPX,NOLONG,OBSOLETE,P6,CYRIX
RDM                                     ND,NOREX,NOAPX,NOLONG,OBSOLETE,P6,CYRIX
SMINT                                   ND,NOREX,NOAPX,NOLONG,OBSOLETE,P6,CYRIX
SMINTOLD                                ND,NOREX,NOAPX,NOLONG,OBSOLETE,486,CYRIX
```

F.1.28 System management mode

```
RSM                                     FL,SMM,PENT
WRSHR           rm32                    ND,NOREX,NOAPX,NOLONG,SMM,OBSOLETE,P6,CYRIX
RDSHR           rm32                    ND,NOREX,NOAPX,NOLONG,SMM,OBSOLETE,P6,CYRIX
RSDC            reg_sreg,mem80          ND,NOREX,NOAPX,NOLONG,SMM,OBSOLETE,486,CYRIX
RSLDT           mem80                   ND,NOREX,NOAPX,NOLONG,SMM,OBSOLETE,486,CYRIX
RSTS            mem80                   ND,NOREX,NOAPX,NOLONG,SMM,OBSOLETE,486,CYRIX
SVDC            mem80,reg_sreg          ND,NOREX,NOAPX,NOLONG,SMM,OBSOLETE,486,CYRIX
SVLDT           mem80                   ND,NOREX,NOAPX,NOLONG,SMM,OBSOLETE,486,CYRIX
SVTS            mem80                   ND,NOREX,NOAPX,NOLONG,SMM,OBSOLETE,486,CYRIX
```

F.1.29 Power management

```
HLT                                     PRIV,8086
PAUSE                                   8086
MONITOR                                 MONITOR,PRESCOTT
MONITORW                                NOLONG,MONITOR,PRESCOTT
MONITORD                                MONITOR,PRESCOTT
MONITORQ                                LONG,MONITOR,PRESCOTT,X86_64
MONITOR         reg_ax,reg_ecx,reg_edx  ND,NOLONG,MONITOR,PRESCOTT
MONITOR         reg_eax,reg_ecx,reg_edx ND,MONITOR,PRESCOTT
MONITOR         reg_rax,reg_ecx,reg_edx ND,LONG,PROT,MONITOR,X86_64
MWAIT                                   MONITOR,PRESCOTT
MWAIT           reg_eax,reg_ecx         ND,MONITOR,PRESCOTT
MONITORX                                MONITORX,AMD
MONITORX                                NOLONG,MONITORX,AMD
MONITORX                                MONITORX,AMD
MONITORX                                LONG,MONITORX,X86_64,AMD
MONITORX        reg_ax,reg_ecx,reg_edx  ND,NOLONG,MONITORX,AMD
MONITORX        reg_eax,reg_ecx,reg_edx ND,MONITORX,AMD
MONITORX        reg_rax,reg_ecx,reg_edx ND,LONG,PROT,MONITORX,X86_64,AMD
MWAITX                                  MONITORX,AMD
MWAITX          reg_eax,reg_ecx         ND,MONITORX,AMD
TPAUSE          reg32                   FL,WAITPKG
```

```
TPAUSE          reg32,reg_edx,reg_eax   ND,FL,WAITPKG
UMONITOR        reg16                   NOLONG,WAITPKG
UMONITOR        reg32                   WAITPKG
UMONITOR        reg64                   LONG,PROT,WAITPKG,X86_64
UMWAIT          reg32                   WAITPKG
UMWAIT          reg32,reg_edx,reg_eax   ND,WAITPKG
```

F.1.30 I/O instructions

```
IN              reg_al,imm8             NOAPX,8086
IN              reg_ax,imm8             NOAPX,8086
IN              reg_eax,imm8            NOAPX,ZU,386
IN              reg_al,reg_dx           NOAPX,8086
IN              reg_ax,reg_dx           NOAPX,8086
IN              reg_eax,reg_dx          NOAPX,ZU,386
OUT             imm8,reg_al             NOAPX,8086
OUT             imm8,reg_ax             NOAPX,8086
OUT             imm8,reg_eax            NOAPX,386
OUT             reg_dx,reg_al           NOAPX,8086
OUT             reg_dx,reg_ax           NOAPX,8086
OUT             reg_dx,reg_eax          NOAPX,386
```

F.1.31 Segment handling instructions

```
MOV             mem16,reg_sreg          8086
MOV             reg16,reg_sreg          8086
MOV             reg32,reg_sreg          386
MOV             reg64,reg_sreg          LONG,386,X86_64
MOV             reg_sreg,mem16          8086
MOV             reg_sreg,reg16          8086
MOV             reg_sreg,reg32          386
MOV             reg_sreg,reg64          LONG,386,X86_64
LDS             reg16,mem16             NOREX,NOAPX,NOLONG,8086
LDS             reg32,mem32             NOREX,NOAPX,NOLONG,386
LES             reg16,mem16             NOREX,NOAPX,NOLONG,8086
LES             reg32,mem32             NOREX,NOAPX,NOLONG,386
LFS             reg16,mem16             SM0-1,386
LFS             reg32,mem32             SM0-1,386
LFS             reg64,mem64             SM0-1,LONG,PROT,X86_64
LGS             reg16,mem16             SM0-1,386
LGS             reg32,mem32             SM0-1,386
LGS             reg64,mem64             SM0-1,LONG,PROT,X86_64
LSS             reg16,mem16             SM0-1,386
LSS             reg32,mem32             SM0-1,386
LSS             reg64,mem64             SM0-1,LONG,PROT,X86_64
PUSH            reg_es                  NOREX,NOAPX,NOLONG,8086
PUSH            reg_cs                  NOREX,NOAPX,NOLONG,8086
PUSH            reg_ss                  NOREX,NOAPX,NOLONG,8086
PUSH            reg_ds                  NOREX,NOAPX,NOLONG,8086
PUSH            reg_fs                  386
PUSH            reg_gs                  386
POP             reg_es                  NOREX,NOAPX,NOLONG,8086
POP             reg_cs                  ND,NOREX,NOAPX,NOLONG,UNDOC,OBSOLETE,8086
POP             reg_ss                  NOREX,NOAPX,NOLONG,8086
POP             reg_ds                  NOREX,NOAPX,NOLONG,8086
POP             reg_fs                  386
POP             reg_gs                  386
RDFSBASE        reg32                   LONG,PROT,X86_64
RDFSBASE        reg64                   LONG,PROT,X86_64
RDGSBASE        reg32                   LONG,PROT,X86_64
RDGSBASE        reg64                   LONG,PROT,X86_64
WRFSBASE        reg32                   LONG,PROT,X86_64
WRFSBASE        reg64                   LONG,PROT,X86_64
WRGSBASE        reg32                   LONG,PROT,X86_64
WRGSBASE        reg64                   LONG,PROT,X86_64
ARPL            rm16,reg16              SM0-1,NOREX,NOAPX,NOLONG,FL,PROT,286
ARPL            rm16,reg32              SM0-1,NOREX,NOAPX,NOLONG,FL,PROT,386
```

```
LAR             reg16,rm_sel            FL,PROT,286
LAR             reg32,rm_sel            FL,PROT,386
LAR             reg64,rm_sel            LONG,FL,PROT,X86_64
LSL             reg16,rm_sel            PROT,286
LSL             reg32,rm_sel            PROT,386
LSL             reg64,rm_sel            LONG,PROT,X86_64
VERR            rm_sel                  FL,PROT,286
VERW            rm_sel                  FL,PROT,286
SWAPGS                                  LONG,PROT,X86_64
LKGS            rm_sel                  LONG,PRIV,PROT,LKGS,X86_64
LGDT            mem16                   AR0,OSIZE,PRIV,286
LGDT            mem32                   AR0,OSIZE,PRIV,386
LGDT            mem64                   AR0,OSIZE,LONG,PRIV,386,X86_64
LIDT            mem16                   AR0,OSIZE,PRIV,286
LIDT            mem32                   AR0,OSIZE,PRIV,386
LIDT            mem64                   AR0,OSIZE,LONG,PRIV,386,X86_64
LLDT            mem16                   PRIV,PROT,286
LLDT            reg16                   PRIV,PROT,286
LLDT            reg32                   PRIV,PROT,386
LLDT            reg64                   LONG,PRIV,PROT,386,X86_64
LTR             mem16                   PRIV,PROT,286
LTR             reg16                   PRIV,PROT,286
LTR             reg32                   PRIV,PROT,386
LTR             reg64                   LONG,PRIV,PROT,386,X86_64
SGDT            mem16                   AR0,OSIZE,286
SGDT            mem32                   AR0,OSIZE,386
SGDT            mem64                   AR0,OSIZE,LONG,386,X86_64
SIDT            mem16                   AR0,OSIZE,286
SIDT            mem32                   AR0,OSIZE,386
SIDT            mem64                   AR0,OSIZE,LONG,386,X86_64
SLDT            mem16                   PROT,286
SLDT            reg16                   PROT,286
SLDT            reg32                   PROT,386
SLDT            reg64                   LONG,PROT,386,X86_64
STR             mem16                   PROT,286
STR             reg16                   PROT,286
STR             reg32                   PROT,386
STR             reg64                   LONG,PROT,386,X86_64
LOADALL                                 ND,UNDOC,OBSOLETE,386
LOADALL286                              ND,UNDOC,OBSOLETE,286
```

F.1.32 x87 floating point

```
F2XM1                                   FPU,8086
FABS                                    FPU,8086
FADD            mem32                   FPU,8086
FADD            mem64                   FPU,8086
FADD            fpureg|to               FPU,8086
FADD            fpureg                  FPU,8086
FADD            fpureg,fpu0             FPU,8086
FADD            fpu0,fpureg             FPU,8086
FADD                                    ND,FPU,8086
FADDP           fpureg                  FPU,8086
FADDP           fpureg,fpu0             FPU,8086
FADDP                                   ND,FPU,8086
FBLD            mem80                   FPU,8086
FBLD            mem                     FPU,8086
FBSTP           mem80                   FPU,8086
FBSTP           mem                     FPU,8086
FCHS                                    FPU,8086
FCLEX                                   FPU,8086
FCMOVB          fpureg                  FPU,P6
FCMOVB          fpu0,fpureg             FPU,P6
FCMOVB                                  ND,FPU,P6
FCMOVBE         fpureg                  FPU,P6
FCMOVBE         fpu0,fpureg             FPU,P6
FCMOVBE                                 ND,FPU,P6
```

```
FCMOVE          fpureg                  FPU,P6
FCMOVE          fpu0,fpureg             FPU,P6
FCMOVE                                  ND,FPU,P6
FCMOVNB         fpureg                  FPU,P6
FCMOVNB         fpu0,fpureg             FPU,P6
FCMOVNB                                 ND,FPU,P6
FCMOVNBE        fpureg                  FPU,P6
FCMOVNBE        fpu0,fpureg             FPU,P6
FCMOVNBE                                ND,FPU,P6
FCMOVNE         fpureg                  FPU,P6
FCMOVNE         fpu0,fpureg             FPU,P6
FCMOVNE                                 ND,FPU,P6
FCMOVNU         fpureg                  FPU,P6
FCMOVNU         fpu0,fpureg             FPU,P6
FCMOVNU                                 ND,FPU,P6
FCMOVU          fpureg                  FPU,P6
FCMOVU          fpu0,fpureg             FPU,P6
FCMOVU                                  ND,FPU,P6
FCOM            mem32                   FPU,8086
FCOM            mem64                   FPU,8086
FCOM            fpureg                  FPU,8086
FCOM            fpu0,fpureg             FPU,8086
FCOM                                    ND,FPU,8086
FCOMI           fpureg                  FL,FPU,P6
FCOMI           fpu0,fpureg             FL,FPU,P6
FCOMI                                   ND,FL,FPU,P6
FCOMIP          fpureg                  FL,FPU,P6
FCOMIP          fpu0,fpureg             FL,FPU,P6
FCOMIP                                  ND,FL,FPU,P6
FCOMP           mem32                   FPU,8086
FCOMP           mem64                   FPU,8086
FCOMP           fpureg                  FPU,8086
FCOMP           fpu0,fpureg             FPU,8086
FCOMP                                   ND,FPU,8086
FCOMPP                                  FPU,8086
FCOS                                    FPU,386
FDECSTP                                 FPU,8086
FDISI                                   FPU,8086
FDIV            mem32                   FPU,8086
FDIV            mem64                   FPU,8086
FDIV            fpureg|to               FPU,8086
FDIV            fpureg                  FPU,8086
FDIV            fpureg,fpu0             FPU,8086
FDIV            fpu0,fpureg             FPU,8086
FDIV                                    ND,FPU,8086
FDIVP           fpureg                  FPU,8086
FDIVP           fpureg,fpu0             FPU,8086
FDIVP                                   ND,FPU,8086
FDIVR           mem32                   FPU,8086
FDIVR           mem64                   FPU,8086
FDIVR           fpureg|to               FPU,8086
FDIVR           fpureg,fpu0             FPU,8086
FDIVR           fpureg                  FPU,8086
FDIVR           fpu0,fpureg             FPU,8086
FDIVR                                   ND,FPU,8086
FDIVRP          fpureg                  FPU,8086
FDIVRP          fpureg,fpu0             FPU,8086
FDIVRP                                  ND,FPU,8086
FEMMS                                   3DNOW,PENT
FENI                                    FPU,8086
FFREE           fpureg                  FPU,8086
FFREE                                   FPU,8086
FFREEP          fpureg                  UNDOC,FPU,286
FFREEP                                  UNDOC,FPU,286
FIADD           mem32                   FPU,8086
FIADD           mem16                   FPU,8086
FICOM           mem32                   FPU,8086
```

```
FICOM           mem16                   FPU,8086
FICOMP          mem32                   FPU,8086
FICOMP          mem16                   FPU,8086
FIDIV           mem32                   FPU,8086
FIDIV           mem16                   FPU,8086
FIDIVR          mem32                   FPU,8086
FIDIVR          mem16                   FPU,8086
FILD            mem32                   FPU,8086
FILD            mem16                   FPU,8086
FILD            mem64                   FPU,8086
FIMUL           mem32                   FPU,8086
FIMUL           mem16                   FPU,8086
FINCSTP                                 FPU,8086
FINIT                                   FPU,8086
FIST            mem32                   FPU,8086
FIST            mem16                   FPU,8086
FISTP           mem32                   FPU,8086
FISTP           mem16                   FPU,8086
FISTP           mem64                   FPU,8086
FISTTP          mem16                   FPU,PRESCOTT
FISTTP          mem32                   FPU,PRESCOTT
FISTTP          mem64                   FPU,PRESCOTT
FISUB           mem32                   FPU,8086
FISUB           mem16                   FPU,8086
FISUBR          mem32                   FPU,8086
FISUBR          mem16                   FPU,8086
FLD             mem32                   FPU,8086
FLD             mem64                   FPU,8086
FLD             mem80                   FPU,8086
FLD             fpureg                  FPU,8086
FLD                                     ND,FPU,8086
FLD1                                    FPU,8086
FLDCW           mem                     AR0,SW,FPU,8086
FLDENV          mem                     FPU,8086
FLDL2E                                  FPU,8086
FLDL2T                                  FPU,8086
FLDLG2                                  FPU,8086
FLDLN2                                  FPU,8086
FLDPI                                   FPU,8086
FLDZ                                    FPU,8086
FMUL            mem32                   FPU,8086
FMUL            mem64                   FPU,8086
FMUL            fpureg|to               FPU,8086
FMUL            fpureg,fpu0             FPU,8086
FMUL            fpureg                  FPU,8086
FMUL            fpu0,fpureg             FPU,8086
FMUL                                    ND,FPU,8086
FMULP           fpureg                  FPU,8086
FMULP           fpureg,fpu0             FPU,8086
FMULP                                   ND,FPU,8086
FNCLEX                                  FPU,8086
FNDISI                                  FPU,8086
FNENI                                   FPU,8086
FNINIT                                  FPU,8086
FNOP                                    FPU,8086
FNSAVE          mem                     FPU,8086
FNSTCW          mem                     AR0,SW,FPU,8086
FNSTENV         mem                     FPU,8086
FNSTSW          mem                     AR0,SW,FPU,8086
FNSTSW          reg_ax                  FPU,286
FPATAN                                  FPU,8086
FPREM                                   FPU,8086
FPREM1                                  FPU,386
FPTAN                                   FPU,8086
FRNDINT                                 FPU,8086
FRSTOR          mem                     FPU,8086
FSAVE           mem                     FPU,8086
```

```
FSCALE                                  FPU,8086
FSETPM                                  FPU,286
FSIN                                    FPU,386
FSINCOS                                 FPU,386
FSQRT                                   FPU,8086
FST             mem32                   FPU,8086
FST             mem64                   FPU,8086
FST             fpureg                  FPU,8086
FST                                     ND,FPU,8086
FSTCW           mem                     AR0,SW,FPU,8086
FSTENV          mem                     FPU,8086
FSTP            mem32                   FPU,8086
FSTP            mem64                   FPU,8086
FSTP            mem80                   FPU,8086
FSTP            fpureg                  FPU,8086
FSTP                                    ND,FPU,8086
FSTSW           mem                     AR0,SW,FPU,8086
FSTSW           reg_ax                  FPU,286
FSUB            mem32                   FPU,8086
FSUB            mem64                   FPU,8086
FSUB            fpureg|to               FPU,8086
FSUB            fpureg,fpu0             FPU,8086
FSUB            fpureg                  FPU,8086
FSUB            fpu0,fpureg             FPU,8086
FSUB                                    ND,FPU,8086
FSUBP           fpureg                  FPU,8086
FSUBP           fpureg,fpu0             FPU,8086
FSUBP                                   ND,FPU,8086
FSUBR           mem32                   FPU,8086
FSUBR           mem64                   FPU,8086
FSUBR           fpureg|to               FPU,8086
FSUBR           fpureg,fpu0             FPU,8086
FSUBR           fpureg                  FPU,8086
FSUBR           fpu0,fpureg             FPU,8086
FSUBR                                   ND,FPU,8086
FSUBRP          fpureg                  FPU,8086
FSUBRP          fpureg,fpu0             FPU,8086
FSUBRP                                  ND,FPU,8086
FTST                                    FPU,8086
FUCOM           fpureg                  FPU,386
FUCOM           fpu0,fpureg             FPU,386
FUCOM                                   ND,FPU,386
FUCOMI          fpureg                  FL,FPU,P6
FUCOMI          fpu0,fpureg             FL,FPU,P6
FUCOMI                                  ND,FL,FPU,P6
FUCOMIP         fpureg                  FL,FPU,P6
FUCOMIP         fpu0,fpureg             FL,FPU,P6
FUCOMIP                                 ND,FL,FPU,P6
FUCOMP          fpureg                  FPU,386
FUCOMP          fpu0,fpureg             FPU,386
FUCOMP                                  ND,FPU,386
FUCOMPP                                 FPU,386
FXAM                                    FPU,8086
FXCH            fpureg                  FPU,8086
FXCH            fpureg,fpu0             FPU,8086
FXCH            fpu0,fpureg             FPU,8086
FXCH                                    ND,FPU,8086
FXTRACT                                 FPU,8086
FYL2X                                   FPU,8086
FYL2XP1                                 FPU,8086
```

F.1.33 MMX (SIMD using the x87 register file)

```
EMMS                                    MMX,PENT
MOVD            mmxreg,rm32             MMX,PENT
MOVD            rm32,mmxreg             MMX,PENT
MOVD            mmxreg,rm64             ND,LONG,PROT,MMX,X86_64
```

```
MOVD            rm64,mmxreg             ND,LONG,PROT,MMX,X86_64
MOVQ            mmxreg,mmxrm64          MMX,PENT
MOVQ            mmxrm64,mmxreg          MMX,PENT
MOVQ            mmxreg,rm64             LONG,PROT,MMX,X86_64
MOVQ            rm64,mmxreg             LONG,PROT,MMX,X86_64
PACKSSDW        mmxreg,mmxrm            AR0-1,MMX,PENT
PACKSSWB        mmxreg,mmxrm            AR0-1,MMX,PENT
PACKUSWB        mmxreg,mmxrm            AR0-1,MMX,PENT
PADDB           mmxreg,mmxrm            AR0-1,MMX,PENT
PADDD           mmxreg,mmxrm            AR0-1,MMX,PENT
PADDSB          mmxreg,mmxrm            AR0-1,MMX,PENT
PADDSIW         mmxreg,mmxrm            AR0-1,MMX,PENT,CYRIX
PADDSW          mmxreg,mmxrm            AR0-1,MMX,PENT
PADDUSB         mmxreg,mmxrm            AR0-1,MMX,PENT
PADDUSW         mmxreg,mmxrm            AR0-1,MMX,PENT
PADDW           mmxreg,mmxrm            AR0-1,MMX,PENT
PAND            mmxreg,mmxrm            AR0-1,MMX,PENT
PANDN           mmxreg,mmxrm            AR0-1,MMX,PENT
PAVEB           mmxreg,mmxrm            AR0-1,MMX,PENT,CYRIX
PAVGUSB         mmxreg,mmxrm            AR0-1,3DNOW,PENT
PCMPEQB         mmxreg,mmxrm            AR0-1,MMX,PENT
PCMPEQD         mmxreg,mmxrm            AR0-1,MMX,PENT
PCMPEQW         mmxreg,mmxrm            AR0-1,MMX,PENT
PCMPGTB         mmxreg,mmxrm            AR0-1,MMX,PENT
PCMPGTD         mmxreg,mmxrm            AR0-1,MMX,PENT
PCMPGTW         mmxreg,mmxrm            AR0-1,MMX,PENT
PDISTIB         mmxreg,mem              AR0-1,MMX,PENT,CYRIX
PF2ID           mmxreg,mmxrm            AR0-1,3DNOW,PENT
PFACC           mmxreg,mmxrm            AR0-1,3DNOW,PENT
PFADD           mmxreg,mmxrm            AR0-1,3DNOW,PENT
PFCMPEQ         mmxreg,mmxrm            AR0-1,3DNOW,PENT
PFCMPGE         mmxreg,mmxrm            AR0-1,3DNOW,PENT
PFCMPGT         mmxreg,mmxrm            AR0-1,3DNOW,PENT
PFMAX           mmxreg,mmxrm            AR0-1,3DNOW,PENT
PFMIN           mmxreg,mmxrm            AR0-1,3DNOW,PENT
PFMUL           mmxreg,mmxrm            AR0-1,3DNOW,PENT
PFRCP           mmxreg,mmxrm            AR0-1,3DNOW,PENT
PFRCPIT1        mmxreg,mmxrm            AR0-1,3DNOW,PENT
PFRCPIT2        mmxreg,mmxrm            AR0-1,3DNOW,PENT
PFRSQIT1        mmxreg,mmxrm            AR0-1,3DNOW,PENT
PFRSQRT         mmxreg,mmxrm            AR0-1,3DNOW,PENT
PFSUB           mmxreg,mmxrm            AR0-1,3DNOW,PENT
PFSUBR          mmxreg,mmxrm            AR0-1,3DNOW,PENT
PI2FD           mmxreg,mmxrm            AR0-1,3DNOW,PENT
PMACHRIW        mmxreg,mem              AR0-1,MMX,PENT,CYRIX
PMADDWD         mmxreg,mmxrm            AR0-1,MMX,PENT
PMAGW           mmxreg,mmxrm            AR0-1,MMX,PENT,CYRIX
PMULHRIW        mmxreg,mmxrm            AR0-1,MMX,PENT,CYRIX
PMULHRWA        mmxreg,mmxrm            AR0-1,3DNOW,PENT
PMULHRWC        mmxreg,mmxrm            AR0-1,MMX,PENT,CYRIX
PMULHW          mmxreg,mmxrm            AR0-1,MMX,PENT
PMULLW          mmxreg,mmxrm            AR0-1,MMX,PENT
PMVGEZB         mmxreg,mem              AR0-1,MMX,PENT,CYRIX
PMVLZB          mmxreg,mem              AR0-1,MMX,PENT,CYRIX
PMVNZB          mmxreg,mem              AR0-1,MMX,PENT,CYRIX
PMVZB           mmxreg,mem              AR0-1,MMX,PENT,CYRIX
POR             mmxreg,mmxrm            AR0-1,MMX,PENT
PREFETCH        mem                     AR0,3DNOW,PENT
PREFETCHW       mem                     AR0,3DNOW,PENT
PSLLD           mmxreg,mmxrm            AR0-1,MMX,PENT
PSLLD           mmxreg,imm              MMX,PENT
PSLLQ           mmxreg,mmxrm            AR0-1,MMX,PENT
PSLLQ           mmxreg,imm              MMX,PENT
PSLLW           mmxreg,mmxrm            AR0-1,MMX,PENT
PSLLW           mmxreg,imm              MMX,PENT
PSRAD           mmxreg,mmxrm            AR0-1,MMX,PENT
PSRAD           mmxreg,imm              MMX,PENT
```

```
PSRAW           mmxreg,mmxrm            AR0-1,MMX,PENT
PSRAW           mmxreg,imm              MMX,PENT
PSRLD           mmxreg,mmxrm            AR0-1,MMX,PENT
PSRLD           mmxreg,imm              MMX,PENT
PSRLQ           mmxreg,mmxrm            AR0-1,MMX,PENT
PSRLQ           mmxreg,imm              MMX,PENT
PSRLW           mmxreg,mmxrm            AR0-1,MMX,PENT
PSRLW           mmxreg,imm              MMX,PENT
PSUBB           mmxreg,mmxrm            AR0-1,MMX,PENT
PSUBD           mmxreg,mmxrm            AR0-1,MMX,PENT
PSUBSB          mmxreg,mmxrm            AR0-1,MMX,PENT
PSUBSIW         mmxreg,mmxrm            AR0-1,MMX,PENT,CYRIX
PSUBSW          mmxreg,mmxrm            AR0-1,MMX,PENT
PSUBUSB         mmxreg,mmxrm            AR0-1,MMX,PENT
PSUBUSW         mmxreg,mmxrm            AR0-1,MMX,PENT
PSUBW           mmxreg,mmxrm            AR0-1,MMX,PENT
PUNPCKHBW       mmxreg,mmxrm            AR0-1,MMX,PENT
PUNPCKHDQ       mmxreg,mmxrm            AR0-1,MMX,PENT
PUNPCKHWD       mmxreg,mmxrm            AR0-1,MMX,PENT
PUNPCKLBW       mmxreg,mmxrm            AR0-1,MMX,PENT
PUNPCKLDQ       mmxreg,mmxrm            AR0-1,MMX,PENT
PUNPCKLWD       mmxreg,mmxrm            AR0-1,MMX,PENT
```

F.1.34 Stack operations

```
PUSH            reg16                   8086
PUSH            reg32                   386
PUSH            reg64                   LONG,PROT,X86_64
PUSH            rm16                    AR0,OSIZE,8086
PUSH            rm32                    AR0,OSIZE,386
PUSH            rm64                    AR0,OSIZE,LONG,PROT,X86_64
PUSH            imm8                    ND,AR0,SX,186
PUSH            sbyteword16             AR0,OSIZE,186
PUSH            sbytedword32            AR0,OSIZE,386
PUSH            sbytedword64            AR0,OSIZE,LONG,386,X86_64
PUSH            imm16                   AR0,OSIZE,186
PUSH            imm32                   AR0,OSIZE,NOREX,NOAPX,NOLONG,386
PUSH            sdword64                AR0,OSIZE,LONG,386,X86_64
POP             reg16                   8086
POP             reg32                   386
POP             reg64                   LONG,PROT,X86_64
POP             rm16                    AR0,OSIZE,8086
POP             rm32                    AR0,OSIZE,386
POP             rm64                    AR0,OSIZE,LONG,PROT,X86_64
PUSHA                                   NOREX,NOAPX,NOLONG,186
PUSHAW                                  NOREX,NOAPX,NOLONG,186
PUSHAD                                  NOREX,NOAPX,NOLONG,386
POPA                                    NOREX,NOAPX,NOLONG,186
POPAW                                   NOREX,NOAPX,NOLONG,186
POPAD                                   NOREX,NOAPX,NOLONG,386
ENTER           imm16,imm8              186
ENTERW          imm16,imm8              186
ENTERD          imm16,imm8              386
ENTERQ          imm16,imm8              LONG,386,X86_64
ENTER           imm16                   ND,186
ENTERW          imm16                   ND,186
ENTERD          imm16                   ND,386
ENTERQ          imm16                   ND,LONG,386,X86_64
LEAVE                                   186
LEAVEW                                  186
LEAVED                                  386
LEAVEQ                                  LONG,386,X86_64
BOUND           reg16,mem               NOREX,NOAPX,NOLONG,186
BOUND           reg32,mem               NOREX,NOAPX,NOLONG,386
PUSHP           reg64                   LONG,PROT,APX,X86_64
POPP            reg64                   LONG,PROT,APX,X86_64
PUSH            reg64,reg64             ND,LONG,PROT,APX,X86_64
```

```
PUSH            reg64:reg64             ND,LONG,PROT,APX,X86_64
PUSHP           reg64,reg64             ND,LONG,PROT,APX,X86_64
PUSHP           reg64:reg64             ND,LONG,PROT,APX,X86_64
PUSH2           reg64,reg64             LONG,PROT,APX,X86_64
PUSH2           reg64:reg64             ND,LONG,PROT,APX,X86_64
PUSH2P          reg64,reg64             LONG,PROT,APX,X86_64
PUSH2P          reg64:reg64             ND,LONG,PROT,APX,X86_64
POP             reg64,reg64             ND,LONG,PROT,APX,X86_64
POP             reg64:reg64             ND,LONG,PROT,APX,X86_64
POPP            reg64,reg64             ND,LONG,PROT,APX,X86_64
POPP            reg64:reg64             ND,LONG,PROT,APX,X86_64
POP2            reg64,reg64             LONG,PROT,APX,X86_64
POP2            reg64:reg64             ND,LONG,PROT,APX,X86_64
POP2P           reg64,reg64             LONG,PROT,APX,X86_64
POP2P           reg64:reg64             ND,LONG,PROT,APX,X86_64
```

F.1.35 MMX instructions

```
PXOR            mmxreg,mmxrm            AR0-1,MMX,PENT
SKINIT                                  LONG,PROT,X86_64
```

F.1.36 Permanently undefined instructions

```
UD0             reg16,rm16              SM0-1,186
UD0             reg32,rm32              SM0-1,386
UD0             reg64,rm64              SM0-1,LONG,PROT,X86_64
UD0                                     186
UD1             reg16,rm16              SM0-1,186
UD1             reg32,rm32              SM0-1,386
UD1             reg64,rm64              SM0-1,LONG,PROT,X86_64
UD1                                     186
UD2B            reg16,rm16              SM0,ND,SM1,186
UD2B            reg32,rm32              ND,SM0-1,386
UD2B            reg64,rm64              SM0,ND,SM1,LONG,PROT,X86_64
UD2B                                    ND,186
UD2                                     186
UD2             reg16,rm16              SM0,ND,SM1,186
UD2             reg32,rm32              SM0,ND,SM1,386
UD2             reg64,rm64              SM0,ND,SM1,LONG,PROT,X86_64
UD2A                                    ND,186
UD2A            reg16,rm16              ND,186
UD2A            reg32,rm32              ND,386
UD2A            reg64,rm64              ND,LONG,PROT,X86_64
UDB                                     LONG,PROT,X86_64
UDW                                     UNDOC,186
FWAIT                                   8086
XLATB                                   8086
XLAT                                    ND,8086
CCMPscc         spec4,rm8,reg8          SM1-2,LONG,PROT,APX,X86_64
CCMPscc         spec4,rm16,reg16        SM1-2,LONG,PROT,APX,X86_64
CCMPscc         spec4,rm32,reg32        SM1-2,LONG,PROT,APX,X86_64
CCMPscc         spec4,rm64,reg64        SM1-2,LONG,PROT,APX,X86_64
CCMPscc         spec4,reg8,rm8          SM1-2,LONG,PROT,APX,X86_64
CCMPscc         spec4,reg16,rm16        SM1-2,LONG,PROT,APX,X86_64
CCMPscc         spec4,reg32,rm32        SM1-2,LONG,PROT,APX,X86_64
CCMPscc         spec4,reg64,rm64        SM1-2,LONG,PROT,APX,X86_64
CCMPscc         spec4,rm16,sbyteword16  SM1-2,LONG,PROT,APX,X86_64
CCMPscc         spec4,rm32,sbytedword32 SM1-2,LONG,PROT,APX,X86_64
CCMPscc         spec4,rm64,sbytedword64 SM1-2,LONG,PROT,APX,X86_64
CCMPscc         spec4,rm8,imm8          SM1-2,LONG,PROT,APX,X86_64
CCMPscc         spec4,rm16,imm16        SM1-2,LONG,PROT,APX,X86_64
CCMPscc         spec4,rm32,imm32        SM1-2,LONG,PROT,APX,X86_64
CCMPscc         spec4,rm64,sdword64     SM1-2,LONG,PROT,APX,X86_64
CTESTscc        spec4,rm8,reg8          SM1-2,LONG,PROT,APX,X86_64
CTESTscc        spec4,rm16,reg16        SM1-2,LONG,PROT,APX,X86_64
CTESTscc        spec4,rm32,reg32        SM1-2,LONG,PROT,APX,X86_64
CTESTscc        spec4,rm64,reg64        SM1-2,LONG,PROT,APX,X86_64
```

```
CTESTscc        spec4,rm8,imm8          SM1-2,LONG,PROT,APX,X86_64
CTESTscc        spec4,rm16,imm16        SM1-2,LONG,PROT,APX,X86_64
CTESTscc        spec4,rm32,imm32        SM1-2,LONG,PROT,APX,X86_64
CTESTscc        spec4,rm64,sdword64     SM1-2,LONG,PROT,APX,X86_64
CTESTscc        spec4,rm8,imm8          SM1-2,LONG,PROT,APX,X86_64
CTESTscc        spec4,rm16,imm16        SM1-2,LONG,PROT,APX,X86_64
CTESTscc        spec4,rm32,imm32        SM1-2,LONG,PROT,APX,X86_64
CTESTscc        spec4,rm64,sdword64     SM1-2,LONG,PROT,APX,X86_64
```

F.1.37 Conditional instructions

```
CMOVcc          reg16,rm16              SM0-1,P6
CMOVcc          reg32,rm32              SM0-1,P6
CMOVcc          reg64,rm64              SM0-1,LONG,PROT,X86_64
CMOVcc          reg16,reg16,rm16        SM0-2,LONG,PROT,APX,X86_64
CMOVcc          reg32,reg32,rm32        SM0-2,LONG,PROT,APX,X86_64
CMOVcc          reg64,reg64,rm64        SM0-2,LONG,PROT,APX,X86_64
CFCMOVcc        rm16,reg16              SM0-1,LONG,PROT,APX,X86_64
CFCMOVcc        rm32,reg32              SM0-1,LONG,PROT,APX,X86_64
CFCMOVcc        rm64,reg64              SM0-1,LONG,PROT,APX,X86_64
CFCMOVcc        reg16,rm16              SM0-1,LONG,PROT,APX,X86_64
CFCMOVcc        reg32,rm32              SM0-1,LONG,PROT,APX,X86_64
CFCMOVcc        reg64,rm64              SM0-1,LONG,PROT,APX,X86_64
CFCMOVcc        reg16?,reg16,rm16       SM0-2,LONG,PROT,APX,X86_64
CFCMOVcc        reg32?,reg32,rm32       SM0-2,LONG,PROT,APX,X86_64
CFCMOVcc        reg64?,reg64,rm64       SM0-2,LONG,PROT,APX,X86_64
SETcc           rm8                     AR0,386
SETcc           reg64                   ZU,LONG,PROT,APX,X86_64
SETcc           reg32                   ND,ZU,LONG,PROT,APX,X86_64
SETccZU         reg64                   ND,ZU,LONG,PROT,APX,X86_64
SETccZU         reg32                   ND,ZU,LONG,PROT,APX,X86_64
SETcc           rm8                     LONG,PROT,APX,X86_64
SETccZU         rm8                     ND,ZU,LONG,PROT,APX,X86_64
CMPccXADD       mem32,reg32,reg32       SM0-2,LONG,PROT,CMPCCXADD,X86_64
CMPccXADD       mem64,reg64,reg64       SM0-2,LONG,PROT,CMPCCXADD,X86_64
CMPccXADD       mem32,reg32,reg32       SM0-2,LONG,PROT,CMPCCXADD,APX,X86_64
CMPccXADD       mem64,reg64,reg64       SM0-2,LONG,PROT,CMPCCXADD,APX,X86_64
```

F.1.38 Katmai Streaming SIMD instructions (SSE -- a.k.a. KNI, XMM, MMX2)

```
ADDPS           xmmreg,xmmrm128         SSE,KATMAI
ADDSS           xmmreg,xmmrm32          SSE,KATMAI
ANDNPS          xmmreg,xmmrm128         SSE,KATMAI
ANDPS           xmmreg,xmmrm128         SSE,KATMAI
CMPEQPS         xmmreg,xmmrm128         SSE,KATMAI
CMPEQSS         xmmreg,xmmrm32          SSE,KATMAI
CMPLEPS         xmmreg,xmmrm128         SSE,KATMAI
CMPLESS         xmmreg,xmmrm32          SSE,KATMAI
CMPLTPS         xmmreg,xmmrm128         SSE,KATMAI
CMPLTSS         xmmreg,xmmrm32          SSE,KATMAI
CMPNEQPS        xmmreg,xmmrm128         SSE,KATMAI
CMPNEQSS        xmmreg,xmmrm32          SSE,KATMAI
CMPNLEPS        xmmreg,xmmrm128         SSE,KATMAI
CMPNLESS        xmmreg,xmmrm32          SSE,KATMAI
CMPNLTPS        xmmreg,xmmrm128         SSE,KATMAI
CMPNLTSS        xmmreg,xmmrm32          SSE,KATMAI
CMPORDPS        xmmreg,xmmrm128         SSE,KATMAI
CMPORDSS        xmmreg,xmmrm32          SSE,KATMAI
CMPUNORDPS      xmmreg,xmmrm128         SSE,KATMAI
CMPUNORDSS      xmmreg,xmmrm32          SSE,KATMAI
CMPPS           xmmreg,xmmrm128,imm8    SSE,KATMAI
CMPSS           xmmreg,xmmrm32,imm8     SSE,KATMAI
COMISS          xmmreg,xmmrm32          FL,SSE,KATMAI
CVTPI2PS        xmmreg,mmxrm64          MMX,SSE,KATMAI
CVTPS2PI        mmxreg,xmmrm64          MMX,SSE,KATMAI
CVTSI2SS        xmmreg,rm32             SSE,KATMAI
CVTSI2SS        xmmreg,rm64             AR1,SX,LONG,PROT,SSE,X86_64
```

```
CVTSS2SI        reg32,xmmrm32           SSE,KATMAI
CVTSS2SI        reg64,xmmrm32           LONG,PROT,SSE,X86_64
CVTTPS2PI       mmxreg,xmmrm64          MMX,SSE,KATMAI
CVTTSS2SI       reg32,xmmrm32           SSE,KATMAI
CVTTSS2SI       reg64,xmmrm32           LONG,PROT,SSE,X86_64
DIVPS           xmmreg,xmmrm128         SSE,KATMAI
DIVSS           xmmreg,xmmrm32          SSE,KATMAI
LDMXCSR         mem32                   SSE,KATMAI
MAXPS           xmmreg,xmmrm128         SSE,KATMAI
MAXSS           xmmreg,xmmrm32          SSE,KATMAI
MINPS           xmmreg,xmmrm128         SSE,KATMAI
MINSS           xmmreg,xmmrm32          SSE,KATMAI
MOVAPS          xmmreg,xmmrm128         SSE,KATMAI
MOVAPS          xmmrm128,xmmreg         SSE,KATMAI
MOVHPS          xmmreg,mem64            SSE,KATMAI
MOVHPS          mem64,xmmreg            SSE,KATMAI
MOVLHPS         xmmreg,xmmreg           SSE,KATMAI
MOVLPS          xmmreg,mem64            SSE,KATMAI
MOVLPS          mem64,xmmreg            SSE,KATMAI
MOVHLPS         xmmreg,xmmreg           SSE,KATMAI
MOVMSKPS        reg32,xmmreg            SSE,KATMAI
MOVMSKPS        reg64,xmmreg            LONG,PROT,SSE,X86_64
MOVNTPS         mem128,xmmreg           SSE,KATMAI
MOVSS           xmmreg,xmmrm32          SSE,KATMAI
MOVSS           xmmrm32,xmmreg          SSE,KATMAI
MOVUPS          xmmreg,xmmrm128         SSE,KATMAI
MOVUPS          xmmrm128,xmmreg         SSE,KATMAI
MULPS           xmmreg,xmmrm128         SSE,KATMAI
MULSS           xmmreg,xmmrm32          SSE,KATMAI
ORPS            xmmreg,xmmrm128         SSE,KATMAI
RCPPS           xmmreg,xmmrm128         SSE,KATMAI
RCPSS           xmmreg,xmmrm32          SSE,KATMAI
RSQRTPS         xmmreg,xmmrm128         SSE,KATMAI
RSQRTSS         xmmreg,xmmrm32          SSE,KATMAI
SHUFPS          xmmreg,xmmrm128,imm8    SSE,KATMAI
SQRTPS          xmmreg,xmmrm128         SSE,KATMAI
SQRTSS          xmmreg,xmmrm32          SSE,KATMAI
STMXCSR         mem32                   SSE,KATMAI
SUBPS           xmmreg,xmmrm128         SSE,KATMAI
SUBSS           xmmreg,xmmrm32          SSE,KATMAI
UCOMISS         xmmreg,xmmrm32          FL,SSE,KATMAI
UNPCKHPS        xmmreg,xmmrm128         SSE,KATMAI
UNPCKLPS        xmmreg,xmmrm128         SSE,KATMAI
XORPS           xmmreg,xmmrm128         SSE,KATMAI
```

F.1.39 Introduced in Deschutes but necessary for SSE support

```
FXRSTOR         mem                     FPU,SSE,P6
FXRSTOR64       mem                     LONG,PROT,FPU,SSE,X86_64
FXSAVE          mem                     FPU,SSE,P6
FXSAVE64        mem                     LONG,PROT,FPU,SSE,X86_64
```

F.1.40 XSAVE group (AVX and extended state)

```
XGETBV                                  NEHALEM
XSETBV                                  PRIV,NEHALEM
XSAVE           mem                     NOAPX,NEHALEM
XSAVE64         mem                     NOAPX,LONG,PROT,X86_64,NEHALEM
XSAVEC          mem                     NOAPX
XSAVEC64        mem                     NOAPX,LONG,PROT,X86_64
XSAVEOPT        mem                     NOAPX
XSAVEOPT64      mem                     NOAPX,LONG,PROT,X86_64
XSAVES          mem                     NOAPX
XSAVES64        mem                     NOAPX,LONG,PROT,X86_64
XRSTOR          mem                     NOAPX,NEHALEM
XRSTOR64        mem                     NOAPX,LONG,PROT,X86_64,NEHALEM
```

```
XRSTORS         mem                     NOAPX
XRSTORS64       mem                     NOAPX,LONG,PROT,X86_64
```

F.1.41 Generic memory operations

```
PREFETCHNTA     mem8                    AR0,KATMAI
PREFETCHT0      mem8                    AR0,KATMAI
PREFETCHT1      mem8                    AR0,KATMAI
PREFETCHT2      mem8                    AR0,KATMAI
PREFETCHIT0     mem8                    AR0,PREFETCHI
PREFETCHIT1     mem8                    AR0,PREFETCHI
SFENCE                                  KATMAI
```

F.1.42 New MMX instructions introduced in Katmai

```
MASKMOVQ        mmxreg,mmxreg           MMX,KATMAI
MOVNTQ          mem,mmxreg              AR0-1,MMX,KATMAI
PAVGB           mmxreg,mmxrm            AR0-1,MMX,KATMAI
PAVGW           mmxreg,mmxrm            AR0-1,MMX,KATMAI
PEXTRW          reg32,mmxreg,imm        MMX,KATMAI
PINSRW          mmxreg,mem,imm          MMX,KATMAI
PINSRW          mmxreg,rm16,imm         MMX,KATMAI
PINSRW          mmxreg,reg32,imm        MMX,KATMAI
PMAXSW          mmxreg,mmxrm            AR0-1,MMX,KATMAI
PMAXUB          mmxreg,mmxrm            AR0-1,MMX,KATMAI
PMINSW          mmxreg,mmxrm            AR0-1,MMX,KATMAI
PMINUB          mmxreg,mmxrm            AR0-1,MMX,KATMAI
PMOVMSKB        reg32,mmxreg            MMX,KATMAI
PMULHUW         mmxreg,mmxrm            AR0-1,MMX,KATMAI
PSADBW          mmxreg,mmxrm            AR0-1,MMX,KATMAI
PSHUFW          mmxreg,mmxrm,imm        MMX,KATMAI
```

F.1.43 AMD Enhanced 3DNow! (Athlon) instructions

```
PF2IW           mmxreg,mmxrm            AR0-1,3DNOW,PENT
PFNACC          mmxreg,mmxrm            AR0-1,3DNOW,PENT
PFPNACC         mmxreg,mmxrm            AR0-1,3DNOW,PENT
PI2FW           mmxreg,mmxrm            AR0-1,3DNOW,PENT
PSWAPD          mmxreg,mmxrm            AR0-1,3DNOW,PENT
```

F.1.44 Willamette SSE2 Cacheability Instructions

```
MASKMOVDQU      xmmreg,xmmreg           SSE2,WILLAMETTE
MOVNTDQ         mem,xmmreg              AR0-1,SO,SSE2,WILLAMETTE
MOVNTI          mem,reg32               AR0-1,SD,WILLAMETTE
MOVNTI          mem,reg64               AR0-1,LONG,PROT,X86_64
MOVNTPD         mem,xmmreg              AR0-1,SO,SSE2,WILLAMETTE
LFENCE                                  SSE2,WILLAMETTE
MFENCE                                  SSE2,WILLAMETTE
```

F.1.45 Willamette MMX instructions (SSE2 SIMD Integer Instructions)

```
MOVD            mem,xmmreg              AR0-1,SD,SSE2,WILLAMETTE
MOVD            xmmreg,mem              AR0-1,SD,SSE2,WILLAMETTE
MOVD            xmmreg,rm32             SSE2,WILLAMETTE
MOVD            rm32,xmmreg             SSE2,WILLAMETTE
MOVDQA          xmmreg,xmmrm128         AR0-1,SO,SSE2,WILLAMETTE
MOVDQA          xmmrm128,xmmreg         AR0-1,SO,SSE2,WILLAMETTE
MOVDQU          xmmreg,xmmrm128         AR0-1,SO,SSE2,WILLAMETTE
MOVDQU          xmmrm128,xmmreg         AR0-1,SO,SSE2,WILLAMETTE
MOVDQ2Q         mmxreg,xmmreg           SSE2,WILLAMETTE
MOVQ            xmmreg,xmmreg           SSE2,WILLAMETTE
MOVQ            xmmreg,xmmreg           SSE2,WILLAMETTE
MOVQ            mem,xmmreg              AR0-1,SSE2,WILLAMETTE
MOVQ            xmmreg,mem              AR0-1,SSE2,WILLAMETTE
MOVQ            xmmreg,rm64             LONG,PROT,SSE2,X86_64
MOVQ            rm64,xmmreg             LONG,PROT,SSE2,X86_64
MOVQ2DQ         xmmreg,mmxreg           SSE2,WILLAMETTE
```

```
PACKSSWB        xmmreg,xmmrm            AR0-1,SO,SSE2,WILLAMETTE
PACKSSDW        xmmreg,xmmrm            AR0-1,SO,SSE2,WILLAMETTE
PACKUSWB        xmmreg,xmmrm            AR0-1,SO,SSE2,WILLAMETTE
PADDB           xmmreg,xmmrm            AR0-1,SO,SSE2,WILLAMETTE
PADDW           xmmreg,xmmrm            AR0-1,SO,SSE2,WILLAMETTE
PADDD           xmmreg,xmmrm            AR0-1,SO,SSE2,WILLAMETTE
PADDQ           mmxreg,mmxrm            AR0-1,MMX,WILLAMETTE
PADDQ           xmmreg,xmmrm            AR0-1,SO,SSE2,WILLAMETTE
PADDSB          xmmreg,xmmrm            AR0-1,SO,SSE2,WILLAMETTE
PADDSW          xmmreg,xmmrm            AR0-1,SO,SSE2,WILLAMETTE
PADDUSB         xmmreg,xmmrm            AR0-1,SO,SSE2,WILLAMETTE
PADDUSW         xmmreg,xmmrm            AR0-1,SO,SSE2,WILLAMETTE
PAND            xmmreg,xmmrm            AR0-1,SO,SSE2,WILLAMETTE
PANDN           xmmreg,xmmrm            AR0-1,SO,SSE2,WILLAMETTE
PAVGB           xmmreg,xmmrm            AR0-1,SO,SSE2,WILLAMETTE
PAVGW           xmmreg,xmmrm            AR0-1,SO,SSE2,WILLAMETTE
PCMPEQB         xmmreg,xmmrm            AR0-1,SO,SSE2,WILLAMETTE
PCMPEQW         xmmreg,xmmrm            AR0-1,SO,SSE2,WILLAMETTE
PCMPEQD         xmmreg,xmmrm            AR0-1,SO,SSE2,WILLAMETTE
PCMPGTB         xmmreg,xmmrm            AR0-1,SO,SSE2,WILLAMETTE
PCMPGTW         xmmreg,xmmrm            AR0-1,SO,SSE2,WILLAMETTE
PCMPGTD         xmmreg,xmmrm            AR0-1,SO,SSE2,WILLAMETTE
PEXTRW          reg32,xmmreg,imm        SSE2,WILLAMETTE
PEXTRW          reg64,xmmreg,imm        ND,LONG,PROT,SSE2,X86_64
PINSRW          xmmreg,reg16,imm        SSE2,WILLAMETTE
PINSRW          xmmreg,reg32,imm        ND,SSE2,WILLAMETTE
PINSRW          xmmreg,reg64,imm        ND,LONG,PROT,SSE2,X86_64
PINSRW          xmmreg,mem,imm          SSE2,WILLAMETTE
PINSRW          xmmreg,mem16,imm        SSE2,WILLAMETTE
PMADDWD         xmmreg,xmmrm            AR0-1,SO,SSE2,WILLAMETTE
PMAXSW          xmmreg,xmmrm            AR0-1,SO,SSE2,WILLAMETTE
PMAXUB          xmmreg,xmmrm            AR0-1,SO,SSE2,WILLAMETTE
PMINSW          xmmreg,xmmrm            AR0-1,SO,SSE2,WILLAMETTE
PMINUB          xmmreg,xmmrm            AR0-1,SO,SSE2,WILLAMETTE
PMOVMSKB        reg32,xmmreg            SSE2,WILLAMETTE
PMULHUW         xmmreg,xmmrm            AR0-1,SO,SSE2,WILLAMETTE
PMULHW          xmmreg,xmmrm            AR0-1,SO,SSE2,WILLAMETTE
PMULLW          xmmreg,xmmrm            AR0-1,SO,SSE2,WILLAMETTE
PMULUDQ         mmxreg,mmxrm            AR0-1,SO,SSE2,WILLAMETTE
PMULUDQ         xmmreg,xmmrm            AR0-1,SO,SSE2,WILLAMETTE
POR             xmmreg,xmmrm            AR0-1,SO,SSE2,WILLAMETTE
PSADBW          xmmreg,xmmrm            AR0-1,SO,SSE2,WILLAMETTE
PSHUFD          xmmreg,xmmreg,imm       SSE2,WILLAMETTE
PSHUFD          xmmreg,mem,imm          SSE2,WILLAMETTE
PSHUFHW         xmmreg,xmmreg,imm       SSE2,WILLAMETTE
PSHUFHW         xmmreg,mem,imm          SSE2,WILLAMETTE
PSHUFLW         xmmreg,xmmreg,imm       SSE2,WILLAMETTE
PSHUFLW         xmmreg,mem,imm          SSE2,WILLAMETTE
PSLLDQ          xmmreg,imm              AR1,SSE2,WILLAMETTE
PSLLW           xmmreg,xmmrm            AR0-1,SO,SSE2,WILLAMETTE
PSLLW           xmmreg,imm              AR1,SSE2,WILLAMETTE
PSLLD           xmmreg,xmmrm            AR0-1,SO,SSE2,WILLAMETTE
PSLLD           xmmreg,imm              AR1,SSE2,WILLAMETTE
PSLLQ           xmmreg,xmmrm            AR0-1,SO,SSE2,WILLAMETTE
PSLLQ           xmmreg,imm              AR1,SSE2,WILLAMETTE
PSRAW           xmmreg,xmmrm            AR0-1,SO,SSE2,WILLAMETTE
PSRAW           xmmreg,imm              AR1,SSE2,WILLAMETTE
PSRAD           xmmreg,xmmrm            AR0-1,SO,SSE2,WILLAMETTE
PSRAD           xmmreg,imm              AR1,SSE2,WILLAMETTE
PSRLDQ          xmmreg,imm              AR1,SSE2,WILLAMETTE
PSRLW           xmmreg,xmmrm            AR0-1,SO,SSE2,WILLAMETTE
PSRLW           xmmreg,imm              AR1,SSE2,WILLAMETTE
PSRLD           xmmreg,xmmrm            AR0-1,SO,SSE2,WILLAMETTE
PSRLD           xmmreg,imm              AR1,SSE2,WILLAMETTE
PSRLQ           xmmreg,xmmrm            AR0-1,SO,SSE2,WILLAMETTE
PSRLQ           xmmreg,imm              AR1,SSE2,WILLAMETTE
PSUBB           xmmreg,xmmrm            AR0-1,SO,SSE2,WILLAMETTE
```

```
PSUBW           xmmreg,xmmrm            AR0-1,SO,SSE2,WILLAMETTE
PSUBD           xmmreg,xmmrm            AR0-1,SO,SSE2,WILLAMETTE
PSUBQ           mmxreg,mmxrm            AR0-1,SO,SSE2,WILLAMETTE
PSUBQ           xmmreg,xmmrm            AR0-1,SO,SSE2,WILLAMETTE
PSUBSB          xmmreg,xmmrm            AR0-1,SO,SSE2,WILLAMETTE
PSUBSW          xmmreg,xmmrm            AR0-1,SO,SSE2,WILLAMETTE
PSUBUSB         xmmreg,xmmrm            AR0-1,SO,SSE2,WILLAMETTE
PSUBUSW         xmmreg,xmmrm            AR0-1,SO,SSE2,WILLAMETTE
PUNPCKHBW       xmmreg,xmmrm            AR0-1,SO,SSE2,WILLAMETTE
PUNPCKHWD       xmmreg,xmmrm            AR0-1,SO,SSE2,WILLAMETTE
PUNPCKHDQ       xmmreg,xmmrm            AR0-1,SO,SSE2,WILLAMETTE
PUNPCKHQDQ      xmmreg,xmmrm            AR0-1,SO,SSE2,WILLAMETTE
PUNPCKLBW       xmmreg,xmmrm            AR0-1,SO,SSE2,WILLAMETTE
PUNPCKLWD       xmmreg,xmmrm            AR0-1,SO,SSE2,WILLAMETTE
PUNPCKLDQ       xmmreg,xmmrm            AR0-1,SO,SSE2,WILLAMETTE
PUNPCKLQDQ      xmmreg,xmmrm            AR0-1,SO,SSE2,WILLAMETTE
PXOR            xmmreg,xmmrm            AR0-1,SO,SSE2,WILLAMETTE
```

F.1.46 Willamette Streaming SIMD instructions (SSE2)

```
ADDPD           xmmreg,xmmrm            AR0-1,SO,SSE2,WILLAMETTE
ADDSD           xmmreg,xmmrm            AR0-1,SSE2,WILLAMETTE
ANDNPD          xmmreg,xmmrm            AR0-1,SO,SSE2,WILLAMETTE
ANDPD           xmmreg,xmmrm            AR0-1,SO,SSE2,WILLAMETTE
CMPEQPD         xmmreg,xmmrm            AR0-1,SO,SSE2,WILLAMETTE
CMPEQSD         xmmreg,xmmrm            AR0-1,SSE2,WILLAMETTE
CMPLEPD         xmmreg,xmmrm            AR0-1,SO,SSE2,WILLAMETTE
CMPLESD         xmmreg,xmmrm            AR0-1,SSE2,WILLAMETTE
CMPLTPD         xmmreg,xmmrm            AR0-1,SO,SSE2,WILLAMETTE
CMPLTSD         xmmreg,xmmrm            AR0-1,SSE2,WILLAMETTE
CMPNEQPD        xmmreg,xmmrm            AR0-1,SO,SSE2,WILLAMETTE
CMPNEQSD        xmmreg,xmmrm            AR0-1,SSE2,WILLAMETTE
CMPNLEPD        xmmreg,xmmrm            AR0-1,SO,SSE2,WILLAMETTE
CMPNLESD        xmmreg,xmmrm            AR0-1,SSE2,WILLAMETTE
CMPNLTPD        xmmreg,xmmrm            AR0-1,SO,SSE2,WILLAMETTE
CMPNLTSD        xmmreg,xmmrm            AR0-1,SSE2,WILLAMETTE
CMPORDPD        xmmreg,xmmrm            AR0-1,SO,SSE2,WILLAMETTE
CMPORDSD        xmmreg,xmmrm            AR0-1,SSE2,WILLAMETTE
CMPUNORDPD      xmmreg,xmmrm            AR0-1,SO,SSE2,WILLAMETTE
CMPUNORDSD      xmmreg,xmmrm            AR0-1,SSE2,WILLAMETTE
CMPPD           xmmreg,xmmrm128,imm8    SSE2,WILLAMETTE
CMPSD           xmmreg,xmmrm64,imm8     FL,SSE2,WILLAMETTE
COMISD          xmmreg,xmmrm64          FL,SSE2,WILLAMETTE
CVTDQ2PD        xmmreg,xmmrm            AR0-1,SSE2,WILLAMETTE
CVTDQ2PS        xmmreg,xmmrm            AR0-1,SO,SSE2,WILLAMETTE
CVTPD2DQ        xmmreg,xmmrm            AR0-1,SO,SSE2,WILLAMETTE
CVTPD2PI        mmxreg,xmmrm            AR0-1,SO,SSE2,WILLAMETTE
CVTPD2PS        xmmreg,xmmrm            AR0-1,SO,SSE2,WILLAMETTE
CVTPI2PD        xmmreg,mmxrm            AR0-1,SSE2,WILLAMETTE
CVTPS2DQ        xmmreg,xmmrm            AR0-1,SO,SSE2,WILLAMETTE
CVTPS2PD        xmmreg,xmmrm            AR0-1,SSE2,WILLAMETTE
CVTSD2SI        reg32,xmmrm64           SSE2,WILLAMETTE
CVTSD2SI        reg64,xmmrm64           LONG,PROT,SSE2,X86_64
CVTSD2SS        xmmreg,xmmrm64          AR0-1,SSE2,WILLAMETTE
CVTSI2SD        xmmreg,rm32             SSE2,WILLAMETTE
CVTSI2SD        xmmreg,rm64             AR1,SX,LONG,PROT,SSE2,X86_64
CVTSS2SD        xmmreg,xmmrm            AR0-1,SD,SSE2,WILLAMETTE
CVTTPD2PI       mmxreg,xmmrm            AR0-1,SO,SSE2,WILLAMETTE
CVTTPD2DQ       xmmreg,xmmrm            AR0-1,SO,SSE2,WILLAMETTE
CVTTPS2DQ       xmmreg,xmmrm            AR0-1,SO,SSE2,WILLAMETTE
CVTTSD2SI       reg32,xmmrm64           SSE2,WILLAMETTE
CVTTSD2SI       reg64,xmmrm64           LONG,PROT,SSE2,X86_64
DIVPD           xmmreg,xmmrm            AR0-1,SO,SSE2,WILLAMETTE
DIVSD           xmmreg,xmmrm            AR0-1,SSE2,WILLAMETTE
MAXPD           xmmreg,xmmrm            AR0-1,SO,SSE2,WILLAMETTE
MAXSD           xmmreg,xmmrm            AR0-1,SSE2,WILLAMETTE
MINPD           xmmreg,xmmrm            AR0-1,SO,SSE2,WILLAMETTE
```

```
MINSD           xmmreg,xmmrm            AR0-1,SSE2,WILLAMETTE
MOVAPD          xmmreg,xmmrm128         SSE2,WILLAMETTE
MOVAPD          xmmrm128,xmmreg         SSE2,WILLAMETTE
MOVHPD          mem64,xmmreg            SSE2,WILLAMETTE
MOVHPD          xmmreg,mem64            SSE2,WILLAMETTE
MOVLPD          mem64,xmmreg            SSE2,WILLAMETTE
MOVLPD          xmmreg,mem64            SSE2,WILLAMETTE
MOVMSKPD        reg32,xmmreg            SSE2,WILLAMETTE
MOVMSKPD        reg64,xmmreg            LONG,PROT,SSE2,X86_64
MOVSD           xmmreg,xmmrm64          SSE2,WILLAMETTE
MOVSD           xmmrm64,xmmreg          SSE2,WILLAMETTE
MOVUPD          xmmreg,xmmrm128         SSE2,WILLAMETTE
MOVUPD          xmmrm128,xmmreg         SSE2,WILLAMETTE
MULPD           xmmreg,xmmrm128         AR0-1,SO,SSE2,WILLAMETTE
MULSD           xmmreg,xmmrm64          AR0-1,SSE2,WILLAMETTE
ORPD            xmmreg,xmmrm128         AR0-1,SO,SSE2,WILLAMETTE
SHUFPD          xmmreg,xmmrm128,imm8    SSE2,WILLAMETTE
SQRTPD          xmmreg,xmmrm128         AR0-1,SO,SSE2,WILLAMETTE
SQRTSD          xmmreg,xmmrm64          SSE2,WILLAMETTE
SUBPD           xmmreg,xmmrm128         AR0-1,SO,SSE2,WILLAMETTE
SUBSD           xmmreg,xmmrm64          SSE2,WILLAMETTE
UCOMISD         xmmreg,xmmrm64          FL,SSE2,WILLAMETTE
UNPCKHPD        xmmreg,xmmrm128         SSE2,WILLAMETTE
UNPCKLPD        xmmreg,xmmrm128         SSE2,WILLAMETTE
XORPD           xmmreg,xmmrm128         SSE2,WILLAMETTE
```

F.1.47 Prescott New Instructions (SSE3)

```
ADDSUBPD        xmmreg,xmmrm128         AR0-1,SO,SSE3,PRESCOTT
ADDSUBPS        xmmreg,xmmrm128         AR0-1,SO,SSE3,PRESCOTT
HADDPD          xmmreg,xmmrm128         AR0-1,SO,SSE3,PRESCOTT
HADDPS          xmmreg,xmmrm128         AR0-1,SO,SSE3,PRESCOTT
HSUBPD          xmmreg,xmmrm128         AR0-1,SO,SSE3,PRESCOTT
HSUBPS          xmmreg,xmmrm128         AR0-1,SO,SSE3,PRESCOTT
LDDQU           xmmreg,mem128           AR0-1,SO,SSE3,PRESCOTT
MOVDDUP         xmmreg,xmmrm64          AR0-1,SSE3,PRESCOTT
MOVSHDUP        xmmreg,xmmrm128         SSE3,PRESCOTT
MOVSLDUP        xmmreg,xmmrm128         SSE3,PRESCOTT
```

F.1.48 VMX/SVM Instructions

```
CLGI                                    VMX,AMD
STGI                                    VMX,AMD
VMCALL                                  VMX
VMCLEAR         mem                     VMX
VMFUNC                                  VMX
VMLAUNCH                                VMX
VMLOAD                                  VMX,AMD
VMMCALL                                 VMX,AMD
VMPTRLD         mem                     VMX
VMPTRST         mem                     VMX
VMREAD          rm32,reg32              AR0-1,SD,NOREX,NOAPX,NOLONG,VMX
VMREAD          rm64,reg64              AR0-1,LONG,PROT,VMX,X86_64
VMRESUME                                VMX
VMRUN                                   VMX,AMD
VMSAVE                                  VMX,AMD
VMWRITE         reg32,rm32              AR0-1,SD,NOREX,NOAPX,NOLONG,VMX
VMWRITE         reg64,rm64              AR0-1,LONG,PROT,VMX,X86_64
VMXOFF                                  VMX
VMXON           mem                     VMX
```

F.1.49 Extended Page Tables VMX instructions

```
INVEPT          reg32,mem               AR0-1,SO,NOREX,NOAPX,NOLONG,VMX
INVEPT          reg64,mem               AR0-1,SO,LONG,PROT,VMX,X86_64
INVEPT          reg64,mem128            AR0-1,SO,LONG,PROT,VMX,APX,X86_64
INVVPID         reg32,mem               AR0-1,SO,NOREX,NOAPX,NOLONG,VMX
```

```
INVVPID         reg64,mem               AR0-1,SO,LONG,PROT,VMX,X86_64
INVVPID         reg64,mem128            AR0-1,SO,LONG,PROT,VMX,APX,X86_64
```

F.1.50 SEV-SNP AMD instructions

```
PVALIDATE                               VMX,AMD
RMPADJUST                               VMX,AMD
VMGEXIT                                 VMX,AMD
VMGEXIT                                 VMX,AMD
```

F.1.51 Tejas New Instructions (SSSE3)

```
PABSB           mmxreg,mmxrm            AR0-1,MMX,SSSE3
PABSB           xmmreg,xmmrm128         SSSE3
PABSW           mmxreg,mmxrm            AR0-1,MMX,SSSE3
PABSW           xmmreg,xmmrm128         SSSE3
PABSD           mmxreg,mmxrm            AR0-1,MMX,SSSE3
PABSD           xmmreg,xmmrm128         SSSE3
PALIGNR         mmxreg,mmxrm,imm        AR0-2,MMX,SSSE3
PALIGNR         xmmreg,xmmrm,imm        SSSE3
PHADDW          mmxreg,mmxrm            AR0-1,MMX,SSSE3
PHADDW          xmmreg,xmmrm128         SSSE3
PHADDD          mmxreg,mmxrm            AR0-1,MMX,SSSE3
PHADDD          xmmreg,xmmrm128         SSSE3
PHADDSW         mmxreg,mmxrm            AR0-1,MMX,SSSE3
PHADDSW         xmmreg,xmmrm128         SSSE3
PHSUBW          mmxreg,mmxrm            AR0-1,MMX,SSSE3
PHSUBW          xmmreg,xmmrm128         SSSE3
PHSUBD          mmxreg,mmxrm            AR0-1,MMX,SSSE3
PHSUBD          xmmreg,xmmrm128         SSSE3
PHSUBSW         mmxreg,mmxrm            AR0-1,MMX,SSSE3
PHSUBSW         xmmreg,xmmrm128         SSSE3
PMADDUBSW       mmxreg,mmxrm            AR0-1,MMX,SSSE3
PMADDUBSW       xmmreg,xmmrm128         SSSE3
PMULHRSW        mmxreg,mmxrm            AR0-1,MMX,SSSE3
PMULHRSW        xmmreg,xmmrm128         SSSE3
PSHUFB          mmxreg,mmxrm            AR0-1,MMX,SSSE3
PSHUFB          xmmreg,xmmrm128         SSSE3
PSIGNB          mmxreg,mmxrm            AR0-1,MMX,SSSE3
PSIGNB          xmmreg,xmmrm128         SSSE3
PSIGNW          mmxreg,mmxrm            AR0-1,MMX,SSSE3
PSIGNW          xmmreg,xmmrm128         SSSE3
PSIGND          mmxreg,mmxrm            AR0-1,MMX,SSSE3
PSIGND          xmmreg,xmmrm128         SSSE3
```

F.1.52 AMD SSE4A

```
EXTRQ           xmmreg,imm,imm          SSE4A,AMD
EXTRQ           xmmreg,xmmreg           SSE4A,AMD
INSERTQ         xmmreg,xmmreg,imm,imm   SSE4A,AMD
INSERTQ         xmmreg,xmmreg           SSE4A,AMD
MOVNTSD         mem64,xmmreg            AR0-1,SSE4A,AMD
MOVNTSS         mem32,xmmreg            AR0-1,SD,SSE4A,AMD
```

F.1.53 New instructions in Barcelona

F.1.54 Penryn New Instructions (SSE4.1)

```
BLENDPD         xmmreg,xmmrm128,imm8    SSE41
BLENDPS         xmmreg,xmmrm128,imm8    SSE41
BLENDVPD        xmmreg,xmmrm128,xmm0    SSE41
BLENDVPD        xmmreg,xmmrm128         SSE41
BLENDVPS        xmmreg,xmmrm128,xmm0    SSE41
BLENDVPS        xmmreg,xmmrm128         SSE41
DPPD            xmmreg,xmmrm128,imm8    SSE41
DPPS            xmmreg,xmmrm128,imm8    SSE41
EXTRACTPS       rm32,xmmreg,imm8        SSE41
EXTRACTPS       reg64,xmmreg,imm8       LONG,PROT,SSE41,X86_64
```

```
INSERTPS        xmmreg,xmmrm32,imm8     SSE41
MOVNTDQA        xmmreg,mem128           SSE41
MPSADBW         xmmreg,xmmrm128,imm8    SSE41
PACKUSDW        xmmreg,xmmrm128         SSE41
PBLENDVB        xmmreg,xmmrm,xmm0       SSE41
PBLENDVB        xmmreg,xmmrm128         SSE41
PBLENDW         xmmreg,xmmrm128,imm8    SSE41
PCMPEQQ         xmmreg,xmmrm128         SSE41
PEXTRB          reg32,xmmreg,imm8       SSE41
PEXTRB          mem8,xmmreg,imm8        SSE41
PEXTRB          reg64,xmmreg,imm8       LONG,PROT,SSE41,X86_64
PEXTRD          rm32,xmmreg,imm8        SSE41
PEXTRQ          rm64,xmmreg,imm8        LONG,PROT,SSE41,X86_64
PEXTRW          reg32,xmmreg,imm8       SSE41
PEXTRW          mem16,xmmreg,imm8       SSE41
PEXTRW          reg64,xmmreg,imm8       LONG,PROT,SSE41,X86_64
PHMINPOSUW      xmmreg,xmmrm128         SSE41
PINSRB          xmmreg,mem,imm8         SSE41
PINSRB          xmmreg,rm8,imm8         SSE41
PINSRB          xmmreg,reg32,imm8       SSE41
PINSRD          xmmreg,rm32,imm8        SSE41
PINSRQ          xmmreg,rm64,imm8        LONG,PROT,SSE41,X86_64
PMAXSB          xmmreg,xmmrm128         SSE41
PMAXSD          xmmreg,xmmrm128         SSE41
PMAXUD          xmmreg,xmmrm128         SSE41
PMAXUW          xmmreg,xmmrm128         SSE41
PMINSB          xmmreg,xmmrm128         SSE41
PMINSD          xmmreg,xmmrm128         SSE41
PMINUD          xmmreg,xmmrm128         SSE41
PMINUW          xmmreg,xmmrm128         SSE41
PMOVSXBW        xmmreg,xmmrm64          AR0-1,SSE41
PMOVSXBD        xmmreg,xmmrm32          AR0-1,SD,SSE41
PMOVSXBQ        xmmreg,xmmrm16          AR0-1,SW,SSE41
PMOVSXWD        xmmreg,xmmrm64          AR0-1,SSE41
PMOVSXWQ        xmmreg,xmmrm32          AR0-1,SD,SSE41
PMOVSXDQ        xmmreg,xmmrm64          AR0-1,SSE41
PMOVZXBW        xmmreg,xmmrm64          AR0-1,SSE41
PMOVZXBD        xmmreg,xmmrm32          AR0-1,SD,SSE41
PMOVZXBQ        xmmreg,xmmrm16          AR0-1,SW,SSE41
PMOVZXWD        xmmreg,xmmrm64          AR0-1,SSE41
PMOVZXWQ        xmmreg,xmmrm32          AR0-1,SD,SSE41
PMOVZXDQ        xmmreg,xmmrm64          AR0-1,SSE41
PMULDQ          xmmreg,xmmrm128         SSE41
PMULLD          xmmreg,xmmrm128         SSE41
PTEST           xmmreg,xmmrm128         SSE41
ROUNDPD         xmmreg,xmmrm128,imm8    SSE41
ROUNDPS         xmmreg,xmmrm128,imm8    SSE41
ROUNDSD         xmmreg,xmmrm64,imm8     SSE41
ROUNDSS         xmmreg,xmmrm32,imm8     SSE41
```

F.1.55 Nehalem New Instructions (SSE4.2)

```
CRC32           reg32,rm8               SSE42
CRC32           reg32,rm16              SSE42
CRC32           reg32,rm32              SSE42
CRC32           reg32,rm64              ND,LONG,PROT,SSE42,X86_64
CRC32           reg32,rm8               LONG,PROT,SSE42,APX,X86_64
CRC32           reg32,rm16              LONG,PROT,SSE42,APX,X86_64
CRC32           reg32,rm32              LONG,PROT,SSE42,APX,X86_64
CRC32           reg32,rm64              ND,LONG,PROT,SSE42,APX,X86_64
CRC32           reg64,rm8               OPT,LONG,PROT,SSE42,X86_64
CRC32           reg64,rm16              LONG,PROT,SSE42,X86_64
CRC32           reg64,rm32              LONG,PROT,SSE42,X86_64
CRC32           reg64,rm64              LONG,PROT,SSE42,X86_64
CRC32           reg64,rm8               OPT,LONG,PROT,SSE42,APX,X86_64
CRC32           reg64,rm16              LONG,PROT,SSE42,APX,X86_64
CRC32           reg64,rm32              LONG,PROT,SSE42,APX,X86_64
```

```
CRC32           reg64,rm64              LONG,PROT,SSE42,APX,X86_64
CRC32           reg64,rm8               LONG,SSE42,X86_64
CRC32           reg64,rm8               LONG,PROT,SSE42,APX,X86_64
PCMPESTRI       xmmreg,xmmrm128,imm8    SSE42
PCMPESTRM       xmmreg,xmmrm128,imm8    SSE42
PCMPISTRI       xmmreg,xmmrm128,imm8    SSE42
PCMPISTRM       xmmreg,xmmrm128,imm8    SSE42
PCMPGTQ         xmmreg,xmmrm128         SSE42
POPCNT          reg16,rm16              AR0-1,SW,FL,NEHALEM
POPCNT          reg32,rm32              AR0-1,SD,FL,NEHALEM
POPCNT          reg64,rm64              AR0-1,LONG,FL,PROT,X86_64,NEHALEM
POPCNT          reg16,rm16              SM0-1,NF,LONG,PROT,APX,X86_64,NEHALEM
POPCNT          reg32,rm32              SM0-1,NF,LONG,PROT,APX,X86_64,NEHALEM
POPCNT          reg64,rm64              SM0-1,NF,LONG,PROT,APX,X86_64,NEHALEM
```

F.1.56 Intel SMX

```
GETSEC                                  NOAPX,FL,KATMAI
```

F.1.57 Geode (Cyrix) 3DNow! additions

```
PFRCPV          mmxreg,mmxrm            AR0-1,3DNOW,PENT,CYRIX
PFRSQRTV        mmxreg,mmxrm            AR0-1,3DNOW,PENT,CYRIX
```

F.1.58 Intel new instructions in ???

F.1.59 Intel AES instructions

```
AESENC          xmmreg,xmmrm128         SSE,WESTMERE
AESENCLAST      xmmreg,xmmrm128         SSE,WESTMERE
AESDEC          xmmreg,xmmrm128         SSE,WESTMERE
AESDECLAST      xmmreg,xmmrm128         SSE,WESTMERE
AESIMC          xmmreg,xmmrm128         SSE,WESTMERE
AESKEYGENASSIST xmmreg,xmmrm128,imm8    SSE,WESTMERE
```

F.1.60 Intel AVX AES instructions

```
VAESENC         xmmreg,xmmreg*,xmmrm128 AVX,SANDYBRIDGE
VAESENCLAST     xmmreg,xmmreg*,xmmrm128 AVX,SANDYBRIDGE
VAESDEC         xmmreg,xmmreg*,xmmrm128 AVX,SANDYBRIDGE
VAESDECLAST     xmmreg,xmmreg*,xmmrm128 AVX,SANDYBRIDGE
VAESIMC         xmmreg,xmmrm128         AVX,SANDYBRIDGE
VAESKEYGENASSIST xmmreg,xmmrm128,imm8   AVX,SANDYBRIDGE
```

F.1.61 Intel AES Key Locker

```
AESDEC128KL     xmmreg,mem              FL,AESKLE
AESDEC256KL     xmmreg,mem512           FL,AESKLE
AESENC128KL     xmmreg,mem              FL,AESKLE
AESENC256KL     xmmreg,mem512           FL,AESKLE
ENCODEKEY128    reg32,reg32             AESKLE
ENCODEKEY256    reg32,reg32             AESKLE
LOADIWKEY       xmmreg,xmmreg           FL,AESKLE
AESDECWIDE128KL mem                     FL,AESKLEWIDE_KL
AESDECWIDE256KL mem512                  FL,AESKLEWIDE_KL
AESENCWIDE128KL mem                     FL,AESKLEWIDE_KL
AESENCWIDE256KL mem512                  FL,AESKLEWIDE_KL
```

F.1.62 Intel instruction extension based on pub number 319433-030 dated October 2017

```
VAESENC         ymmreg,ymmreg*,ymmrm256 VAES
VAESENCLAST     ymmreg,ymmreg*,ymmrm256 VAES
VAESDEC         ymmreg,ymmreg*,ymmrm256 VAES
VAESDECLAST     ymmreg,ymmreg*,ymmrm256 VAES
VAESENC         xmmreg,xmmreg*,xmmrm128 AVX512VL,VAES
VAESENC         ymmreg,ymmreg*,ymmrm256 AVX512VL,VAES
VAESENCLAST     xmmreg,xmmreg*,xmmrm128 AVX512VL,VAES
VAESENCLAST     ymmreg,ymmreg*,ymmrm256 AVX512VL,VAES
```

```
VAESDEC          xmmreg,xmmreg*,xmmrm128  AVX512VL,VAES
VAESDEC          ymmreg,ymmreg*,ymmrm256  AVX512VL,VAES
VAESDECLAST      xmmreg,xmmreg*,xmmrm128  AVX512VL,VAES
VAESDECLAST      ymmreg,ymmreg*,ymmrm256  AVX512VL,VAES
VAESENC          zmmreg,zmmreg*,zmmrm512  AVX512,VAES
VAESENCLAST      zmmreg,zmmreg*,zmmrm512  AVX512,VAES
VAESDEC          zmmreg,zmmreg*,zmmrm512  AVX512,VAES
VAESDECLAST      zmmreg,zmmreg*,zmmrm512  AVX512,VAES
```

F.1.63 Intel AVX instructions

```
VADDPD           xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VADDPD           ymmreg,ymmreg*,ymmrm256  AVX,SANDYBRIDGE
VADDPS           xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VADDPS           ymmreg,ymmreg*,ymmrm256  AVX,SANDYBRIDGE
VADDSD           xmmreg,xmmreg*,xmmrm64   AVX,SANDYBRIDGE
VADDSS           xmmreg,xmmreg*,xmmrm32   AVX,SANDYBRIDGE
VADDSUBPD        xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VADDSUBPD        ymmreg,ymmreg*,ymmrm256  AVX,SANDYBRIDGE
VADDSUBPS        xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VADDSUBPS        ymmreg,ymmreg*,ymmrm256  AVX,SANDYBRIDGE
VANDPD           xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VANDPD           ymmreg,ymmreg*,ymmrm256  AVX,SANDYBRIDGE
VANDPS           xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VANDPS           ymmreg,ymmreg*,ymmrm256  AVX,SANDYBRIDGE
VANDNPD          xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VANDNPD          ymmreg,ymmreg*,ymmrm256  AVX,SANDYBRIDGE
VANDNPS          xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VANDNPS          ymmreg,ymmreg*,ymmrm256  AVX,SANDYBRIDGE
VBLENDPD         xmmreg,xmmreg*,xmmrm128,imm8 AVX,SANDYBRIDGE
VBLENDPD         ymmreg,ymmreg*,ymmrm256,imm8 AVX,SANDYBRIDGE
VBLENDPS         xmmreg,xmmreg*,xmmrm128,imm8 AVX,SANDYBRIDGE
VBLENDPS         ymmreg,ymmreg*,ymmrm256,imm8 AVX,SANDYBRIDGE
VBLENDVPD        xmmreg,xmmreg*,xmmrm128,xmmreg AVX,SANDYBRIDGE
VBLENDVPD        ymmreg,ymmreg*,ymmrm256,ymmreg AVX,SANDYBRIDGE
VBLENDVPS        xmmreg,xmmreg*,xmmrm128,xmmreg AVX,SANDYBRIDGE
VBLENDVPS        ymmreg,ymmreg*,ymmrm256,ymmreg AVX,SANDYBRIDGE
VBROADCASTSS     xmmreg,mem32             AVX,SANDYBRIDGE
VBROADCASTSS     ymmreg,mem32             AVX,SANDYBRIDGE
VBROADCASTSD     ymmreg,mem64             AVX,SANDYBRIDGE
VBROADCASTF128   ymmreg,mem128            AVX,SANDYBRIDGE
VCMPEQ_OSPD      xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VCMPEQ_OSPD      ymmreg,ymmreg*,ymmrm256  AVX,SANDYBRIDGE
VCMPEQPD         xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VCMPEQPD         ymmreg,ymmreg*,ymmrm256  AVX,SANDYBRIDGE
VCMPLT_OSPD      xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VCMPLT_OSPD      ymmreg,ymmreg*,ymmrm256  AVX,SANDYBRIDGE
VCMPLTPD         xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VCMPLTPD         ymmreg,ymmreg*,ymmrm256  AVX,SANDYBRIDGE
VCMPLE_OSPD      xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VCMPLE_OSPD      ymmreg,ymmreg*,ymmrm256  AVX,SANDYBRIDGE
VCMPLEPD         xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VCMPLEPD         ymmreg,ymmreg*,ymmrm256  AVX,SANDYBRIDGE
VCMPUNORD_QPD    xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VCMPUNORD_QPD    ymmreg,ymmreg*,ymmrm256  AVX,SANDYBRIDGE
VCMPUNORDPD      xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VCMPUNORDPD      ymmreg,ymmreg*,ymmrm256  AVX,SANDYBRIDGE
VCMPNEQ_UQPD     xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VCMPNEQ_UQPD     ymmreg,ymmreg*,ymmrm256  AVX,SANDYBRIDGE
VCMPNEQPD        xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VCMPNEQPD        ymmreg,ymmreg*,ymmrm256  AVX,SANDYBRIDGE
VCMPNLT_USPD     xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VCMPNLT_USPD     ymmreg,ymmreg*,ymmrm256  AVX,SANDYBRIDGE
VCMPNLTPD        xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VCMPNLTPD        ymmreg,ymmreg*,ymmrm256  AVX,SANDYBRIDGE
VCMPNLE_USPD     xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VCMPNLE_USPD     ymmreg,ymmreg*,ymmrm256  AVX,SANDYBRIDGE
```

```
VCMPNLEPD        xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VCMPNLEPD        ymmreg,ymmreg*,ymmrm256  AVX,SANDYBRIDGE
VCMPORD_QPD      xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VCMPORD_QPD      ymmreg,ymmreg*,ymmrm256  AVX,SANDYBRIDGE
VCMPORDPD        xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VCMPORDPD        ymmreg,ymmreg*,ymmrm256  AVX,SANDYBRIDGE
VCMPEQ_UQPD      xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VCMPEQ_UQPD      ymmreg,ymmreg*,ymmrm256  AVX,SANDYBRIDGE
VCMPNGE_USPD     xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VCMPNGE_USPD     ymmreg,ymmreg*,ymmrm256  AVX,SANDYBRIDGE
VCMPNGEPD        xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VCMPNGEPD        ymmreg,ymmreg*,ymmrm256  AVX,SANDYBRIDGE
VCMPNGT_USPD     xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VCMPNGT_USPD     ymmreg,ymmreg*,ymmrm256  AVX,SANDYBRIDGE
VCMPNGTPD        xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VCMPNGTPD        ymmreg,ymmreg*,ymmrm256  AVX,SANDYBRIDGE
VCMPFALSE_OQPD   xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VCMPFALSE_OQPD   ymmreg,ymmreg*,ymmrm256  AVX,SANDYBRIDGE
VCMPFALSEPD      xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VCMPFALSEPD      ymmreg,ymmreg*,ymmrm256  AVX,SANDYBRIDGE
VCMPNEQ_OQPD     xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VCMPNEQ_OQPD     ymmreg,ymmreg*,ymmrm256  AVX,SANDYBRIDGE
VCMPGE_OSPD      xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VCMPGE_OSPD      ymmreg,ymmreg*,ymmrm256  AVX,SANDYBRIDGE
VCMPGEPD         xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VCMPGEPD         ymmreg,ymmreg*,ymmrm256  AVX,SANDYBRIDGE
VCMPGT_OSPD      xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VCMPGT_OSPD      ymmreg,ymmreg*,ymmrm256  AVX,SANDYBRIDGE
VCMPGTPD         xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VCMPGTPD         ymmreg,ymmreg*,ymmrm256  AVX,SANDYBRIDGE
VCMPTRUE_UQPD    xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VCMPTRUE_UQPD    ymmreg,ymmreg*,ymmrm256  AVX,SANDYBRIDGE
VCMPTRUEPD       xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VCMPTRUEPD       ymmreg,ymmreg*,ymmrm256  AVX,SANDYBRIDGE
VCMPEQ_OSPD      xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VCMPEQ_OSPD      ymmreg,ymmreg*,ymmrm256  AVX,SANDYBRIDGE
VCMPLT_OQPD      xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VCMPLT_OQPD      ymmreg,ymmreg*,ymmrm256  AVX,SANDYBRIDGE
VCMPLE_OQPD      xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VCMPLE_OQPD      ymmreg,ymmreg*,ymmrm256  AVX,SANDYBRIDGE
VCMPUNORD_SPD    xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VCMPUNORD_SPD    ymmreg,ymmreg*,ymmrm256  AVX,SANDYBRIDGE
VCMPNEQ_USPD     xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VCMPNEQ_USPD     ymmreg,ymmreg*,ymmrm256  AVX,SANDYBRIDGE
VCMPNLT_UQPD     xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VCMPNLT_UQPD     ymmreg,ymmreg*,ymmrm256  AVX,SANDYBRIDGE
VCMPNLE_UQPD     xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VCMPNLE_UQPD     ymmreg,ymmreg*,ymmrm256  AVX,SANDYBRIDGE
VCMPORD_SPD      xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VCMPORD_SPD      ymmreg,ymmreg*,ymmrm256  AVX,SANDYBRIDGE
VCMPEQ_USPD      xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VCMPEQ_USPD      ymmreg,ymmreg*,ymmrm256  AVX,SANDYBRIDGE
VCMPNGE_UQPD     xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VCMPNGE_UQPD     ymmreg,ymmreg*,ymmrm256  AVX,SANDYBRIDGE
VCMPNGT_UQPD     xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VCMPNGT_UQPD     ymmreg,ymmreg*,ymmrm256  AVX,SANDYBRIDGE
VCMPFALSE_OSPD   xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VCMPFALSE_OSPD   ymmreg,ymmreg*,ymmrm256  AVX,SANDYBRIDGE
VCMPNEQ_OSPD     xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VCMPNEQ_OSPD     ymmreg,ymmreg*,ymmrm256  AVX,SANDYBRIDGE
VCMPGE_OQPD      xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VCMPGE_OQPD      ymmreg,ymmreg*,ymmrm256  AVX,SANDYBRIDGE
VCMPGT_OQPD      xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VCMPGT_OQPD      ymmreg,ymmreg*,ymmrm256  AVX,SANDYBRIDGE
VCMPTRUE_USPD    xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VCMPTRUE_USPD    ymmreg,ymmreg*,ymmrm256  AVX,SANDYBRIDGE
VCMPPD           xmmreg,xmmreg*,xmmrm128,imm8 AVX,SANDYBRIDGE
```

```
VCMPPD           ymmreg,ymmreg*,ymmrm256,imm8 AVX,SANDYBRIDGE
VCMPEQ_OSPS      xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VCMPEQ_OSPS      ymmreg,ymmreg*,ymmrm256  AVX,SANDYBRIDGE
VCMPEQPS         xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VCMPEQPS         ymmreg,ymmreg*,ymmrm256  AVX,SANDYBRIDGE
VCMPLT_OSPS      xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VCMPLT_OSPS      ymmreg,ymmreg*,ymmrm256  AVX,SANDYBRIDGE
VCMPLTPS         xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VCMPLTPS         ymmreg,ymmreg*,ymmrm256  AVX,SANDYBRIDGE
VCMPLE_OSPS      xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VCMPLE_OSPS      ymmreg,ymmreg*,ymmrm256  AVX,SANDYBRIDGE
VCMPLEPS         xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VCMPLEPS         ymmreg,ymmreg*,ymmrm256  AVX,SANDYBRIDGE
VCMPUNORD_QPS    xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VCMPUNORD_QPS    ymmreg,ymmreg*,ymmrm256  AVX,SANDYBRIDGE
VCMPUNORDPS      xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VCMPUNORDPS      ymmreg,ymmreg*,ymmrm256  AVX,SANDYBRIDGE
VCMPNEQ_UQPS     xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VCMPNEQ_UQPS     ymmreg,ymmreg*,ymmrm256  AVX,SANDYBRIDGE
VCMPNEQPS        xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VCMPNEQPS        ymmreg,ymmreg*,ymmrm256  AVX,SANDYBRIDGE
VCMPNLT_USPS     xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VCMPNLT_USPS     ymmreg,ymmreg*,ymmrm256  AVX,SANDYBRIDGE
VCMPNLTPS        xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VCMPNLTPS        ymmreg,ymmreg*,ymmrm256  AVX,SANDYBRIDGE
VCMPNLE_USPS     xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VCMPNLE_USPS     ymmreg,ymmreg*,ymmrm256  AVX,SANDYBRIDGE
VCMPNLEPS        xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VCMPNLEPS        ymmreg,ymmreg*,ymmrm256  AVX,SANDYBRIDGE
VCMPORD_QPS      xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VCMPORD_QPS      ymmreg,ymmreg*,ymmrm256  AVX,SANDYBRIDGE
VCMPORDPS        xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VCMPORDPS        ymmreg,ymmreg*,ymmrm256  AVX,SANDYBRIDGE
VCMPEQ_UQPS      xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VCMPEQ_UQPS      ymmreg,ymmreg*,ymmrm256  AVX,SANDYBRIDGE
VCMPNGE_USPS     xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VCMPNGE_USPS     ymmreg,ymmreg*,ymmrm256  AVX,SANDYBRIDGE
VCMPNGEPS        xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VCMPNGEPS        ymmreg,ymmreg*,ymmrm256  AVX,SANDYBRIDGE
VCMPNGT_USPS     xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VCMPNGT_USPS     ymmreg,ymmreg*,ymmrm256  AVX,SANDYBRIDGE
VCMPNGTPS        xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VCMPNGTPS        ymmreg,ymmreg*,ymmrm256  AVX,SANDYBRIDGE
VCMPFALSE_OQPS   xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VCMPFALSE_OQPS   ymmreg,ymmreg*,ymmrm256  AVX,SANDYBRIDGE
VCMPFALSEPS      xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VCMPFALSEPS      ymmreg,ymmreg*,ymmrm256  AVX,SANDYBRIDGE
VCMPNEQ_OQPS     xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VCMPNEQ_OQPS     ymmreg,ymmreg*,ymmrm256  AVX,SANDYBRIDGE
VCMPGE_OSPS      xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VCMPGE_OSPS      ymmreg,ymmreg*,ymmrm256  AVX,SANDYBRIDGE
VCMPGEPS         xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VCMPGEPS         ymmreg,ymmreg*,ymmrm256  AVX,SANDYBRIDGE
VCMPGT_OSPS      xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VCMPGT_OSPS      ymmreg,ymmreg*,ymmrm256  AVX,SANDYBRIDGE
VCMPGTPS         xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VCMPGTPS         ymmreg,ymmreg*,ymmrm256  AVX,SANDYBRIDGE
VCMPTRUE_UQPS    xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VCMPTRUE_UQPS    ymmreg,ymmreg*,ymmrm256  AVX,SANDYBRIDGE
VCMPTRUEPS       xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VCMPTRUEPS       ymmreg,ymmreg*,ymmrm256  AVX,SANDYBRIDGE
VCMPEQ_OSPS      xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VCMPEQ_OSPS      ymmreg,ymmreg*,ymmrm256  AVX,SANDYBRIDGE
VCMPLT_OQPS      xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VCMPLT_OQPS      ymmreg,ymmreg*,ymmrm256  AVX,SANDYBRIDGE
VCMPLE_OQPS      xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VCMPLE_OQPS      ymmreg,ymmreg*,ymmrm256  AVX,SANDYBRIDGE
```

```
VCMPUNORD_SPS    xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VCMPUNORD_SPS    ymmreg,ymmreg*,ymmrm256  AVX,SANDYBRIDGE
VCMPNEQ_USPS     xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VCMPNEQ_USPS     ymmreg,ymmreg*,ymmrm256  AVX,SANDYBRIDGE
VCMPNLT_UQPS     xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VCMPNLT_UQPS     ymmreg,ymmreg*,ymmrm256  AVX,SANDYBRIDGE
VCMPNLE_UQPS     xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VCMPNLE_UQPS     ymmreg,ymmreg*,ymmrm256  AVX,SANDYBRIDGE
VCMPORD_SPS      xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VCMPORD_SPS      ymmreg,ymmreg*,ymmrm256  AVX,SANDYBRIDGE
VCMPEQ_USPS      xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VCMPEQ_USPS      ymmreg,ymmreg*,ymmrm256  AVX,SANDYBRIDGE
VCMPNGE_UQPS     xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VCMPNGE_UQPS     ymmreg,ymmreg*,ymmrm256  AVX,SANDYBRIDGE
VCMPNGT_UQPS     xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VCMPNGT_UQPS     ymmreg,ymmreg*,ymmrm256  AVX,SANDYBRIDGE
VCMPFALSE_OSPS   xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VCMPFALSE_OSPS   ymmreg,ymmreg*,ymmrm256  AVX,SANDYBRIDGE
VCMPNEQ_OSPS     xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VCMPNEQ_OSPS     ymmreg,ymmreg*,ymmrm256  AVX,SANDYBRIDGE
VCMPGE_OQPS      xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VCMPGE_OQPS      ymmreg,ymmreg*,ymmrm256  AVX,SANDYBRIDGE
VCMPGT_OQPS      xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VCMPGT_OQPS      ymmreg,ymmreg*,ymmrm256  AVX,SANDYBRIDGE
VCMPTRUE_USPS    xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VCMPTRUE_USPS    ymmreg,ymmreg*,ymmrm256  AVX,SANDYBRIDGE
VCMPPS           xmmreg,xmmreg*,xmmrm128,imm8 AVX,SANDYBRIDGE
VCMPPS           ymmreg,ymmreg*,ymmrm256,imm8 AVX,SANDYBRIDGE
VCMPEQ_OSSD      xmmreg,xmmreg*,xmmrm64   AVX,SANDYBRIDGE
VCMPEQSD         xmmreg,xmmreg*,xmmrm64   AVX,SANDYBRIDGE
VCMPLT_OSSD      xmmreg,xmmreg*,xmmrm64   AVX,SANDYBRIDGE
VCMPLTSD         xmmreg,xmmreg*,xmmrm64   AVX,SANDYBRIDGE
VCMPLE_OSSD      xmmreg,xmmreg*,xmmrm64   AVX,SANDYBRIDGE
VCMPLESD         xmmreg,xmmreg*,xmmrm64   AVX,SANDYBRIDGE
VCMPUNORD_QSD    xmmreg,xmmreg*,xmmrm64   AVX,SANDYBRIDGE
VCMPUNORDSD      xmmreg,xmmreg*,xmmrm64   AVX,SANDYBRIDGE
VCMPNEQ_UQSD     xmmreg,xmmreg*,xmmrm64   AVX,SANDYBRIDGE
VCMPNEQSD        xmmreg,xmmreg*,xmmrm64   AVX,SANDYBRIDGE
VCMPNLT_USSD     xmmreg,xmmreg*,xmmrm64   AVX,SANDYBRIDGE
VCMPNLTSD        xmmreg,xmmreg*,xmmrm64   AVX,SANDYBRIDGE
VCMPNLE_USSD     xmmreg,xmmreg*,xmmrm64   AVX,SANDYBRIDGE
VCMPNLESD        xmmreg,xmmreg*,xmmrm64   AVX,SANDYBRIDGE
VCMPORD_QSD      xmmreg,xmmreg*,xmmrm64   AVX,SANDYBRIDGE
VCMPORDSD        xmmreg,xmmreg*,xmmrm64   AVX,SANDYBRIDGE
VCMPEQ_UQSD      xmmreg,xmmreg*,xmmrm64   AVX,SANDYBRIDGE
VCMPNGE_USSD     xmmreg,xmmreg*,xmmrm64   AVX,SANDYBRIDGE
VCMPNGESD        xmmreg,xmmreg*,xmmrm64   AVX,SANDYBRIDGE
VCMPNGT_USSD     xmmreg,xmmreg*,xmmrm64   AVX,SANDYBRIDGE
VCMPNGTSD        xmmreg,xmmreg*,xmmrm64   AVX,SANDYBRIDGE
VCMPFALSE_OQSD   xmmreg,xmmreg*,xmmrm64   AVX,SANDYBRIDGE
VCMPFALSESD      xmmreg,xmmreg*,xmmrm64   AVX,SANDYBRIDGE
VCMPNEQ_OQSD     xmmreg,xmmreg*,xmmrm64   AVX,SANDYBRIDGE
VCMPGE_OSSD      xmmreg,xmmreg*,xmmrm64   AVX,SANDYBRIDGE
VCMPGESD         xmmreg,xmmreg*,xmmrm64   AVX,SANDYBRIDGE
VCMPGT_OSSD      xmmreg,xmmreg*,xmmrm64   AVX,SANDYBRIDGE
VCMPGTSD         xmmreg,xmmreg*,xmmrm64   AVX,SANDYBRIDGE
VCMPTRUE_UQSD    xmmreg,xmmreg*,xmmrm64   AVX,SANDYBRIDGE
VCMPTRUESD       xmmreg,xmmreg*,xmmrm64   AVX,SANDYBRIDGE
VCMPEQ_OSSD      xmmreg,xmmreg*,xmmrm64   AVX,SANDYBRIDGE
VCMPLT_OQSD      xmmreg,xmmreg*,xmmrm64   AVX,SANDYBRIDGE
VCMPLE_OQSD      xmmreg,xmmreg*,xmmrm64   AVX,SANDYBRIDGE
VCMPUNORD_SSD    xmmreg,xmmreg*,xmmrm64   AVX,SANDYBRIDGE
VCMPNEQ_USSD     xmmreg,xmmreg*,xmmrm64   AVX,SANDYBRIDGE
VCMPNLT_UQSD     xmmreg,xmmreg*,xmmrm64   AVX,SANDYBRIDGE
VCMPNLE_UQSD     xmmreg,xmmreg*,xmmrm64   AVX,SANDYBRIDGE
VCMPORD_SSD      xmmreg,xmmreg*,xmmrm64   AVX,SANDYBRIDGE
VCMPEQ_USSD      xmmreg,xmmreg*,xmmrm64   AVX,SANDYBRIDGE
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VCMPNGE_UQSD     xmmreg,xmmreg*,xmmrm64   AVX,SANDYBRIDGE
VCMPNGT_UQSD     xmmreg,xmmreg*,xmmrm64   AVX,SANDYBRIDGE
VCMPFALSE_OSSD   xmmreg,xmmreg*,xmmrm64   AVX,SANDYBRIDGE
VCMPNEQ_OSSD     xmmreg,xmmreg*,xmmrm64   AVX,SANDYBRIDGE
VCMPGE_OQSD      xmmreg,xmmreg*,xmmrm64   AVX,SANDYBRIDGE
VCMPGT_OQSD      xmmreg,xmmreg*,xmmrm64   AVX,SANDYBRIDGE
VCMPTRUE_USSD    xmmreg,xmmreg*,xmmrm64   AVX,SANDYBRIDGE
VCMPSD           xmmreg,xmmreg*,xmmrm64,imm8 AVX,SANDYBRIDGE
VCMPEQ_OSSS      xmmreg,xmmreg*,xmmrm64   AVX,SANDYBRIDGE
VCMPEQSS         xmmreg,xmmreg*,xmmrm64   AVX,SANDYBRIDGE
VCMPLT_OSSS      xmmreg,xmmreg*,xmmrm64   AVX,SANDYBRIDGE
VCMPLTSS         xmmreg,xmmreg*,xmmrm64   AVX,SANDYBRIDGE
VCMPLE_OSSS      xmmreg,xmmreg*,xmmrm64   AVX,SANDYBRIDGE
VCMPLESS         xmmreg,xmmreg*,xmmrm64   AVX,SANDYBRIDGE
VCMPUNORD_QSS    xmmreg,xmmreg*,xmmrm64   AVX,SANDYBRIDGE
VCMPUNORDSS      xmmreg,xmmreg*,xmmrm64   AVX,SANDYBRIDGE
VCMPNEQ_UQSS     xmmreg,xmmreg*,xmmrm64   AVX,SANDYBRIDGE
VCMPNEQSS        xmmreg,xmmreg*,xmmrm64   AVX,SANDYBRIDGE
VCMPNLT_USSS     xmmreg,xmmreg*,xmmrm64   AVX,SANDYBRIDGE
VCMPNLTSS        xmmreg,xmmreg*,xmmrm64   AVX,SANDYBRIDGE
VCMPNLE_USSS     xmmreg,xmmreg*,xmmrm64   AVX,SANDYBRIDGE
VCMPNLESS        xmmreg,xmmreg*,xmmrm64   AVX,SANDYBRIDGE
VCMPORD_QSS      xmmreg,xmmreg*,xmmrm64   AVX,SANDYBRIDGE
VCMPORDSS        xmmreg,xmmreg*,xmmrm64   AVX,SANDYBRIDGE
VCMPEQ_UQSS      xmmreg,xmmreg*,xmmrm64   AVX,SANDYBRIDGE
VCMPNGE_USSS     xmmreg,xmmreg*,xmmrm64   AVX,SANDYBRIDGE
VCMPNGESS        xmmreg,xmmreg*,xmmrm64   AVX,SANDYBRIDGE
VCMPNGT_USSS     xmmreg,xmmreg*,xmmrm64   AVX,SANDYBRIDGE
VCMPNGTSS        xmmreg,xmmreg*,xmmrm64   AVX,SANDYBRIDGE
VCMPFALSE_OQSS   xmmreg,xmmreg*,xmmrm64   AVX,SANDYBRIDGE
VCMPFALSESS      xmmreg,xmmreg*,xmmrm64   AVX,SANDYBRIDGE
VCMPNEQ_OQSS     xmmreg,xmmreg*,xmmrm64   AVX,SANDYBRIDGE
VCMPGE_OSSS      xmmreg,xmmreg*,xmmrm64   AVX,SANDYBRIDGE
VCMPGESS         xmmreg,xmmreg*,xmmrm64   AVX,SANDYBRIDGE
VCMPGT_OSSS      xmmreg,xmmreg*,xmmrm64   AVX,SANDYBRIDGE
VCMPGTSS         xmmreg,xmmreg*,xmmrm64   AVX,SANDYBRIDGE
VCMPTRUE_UQSS    xmmreg,xmmreg*,xmmrm64   AVX,SANDYBRIDGE
VCMPTRUESS       xmmreg,xmmreg*,xmmrm64   AVX,SANDYBRIDGE
VCMPEQ_OSSS      xmmreg,xmmreg*,xmmrm64   AVX,SANDYBRIDGE
VCMPLT_OQSS      xmmreg,xmmreg*,xmmrm64   AVX,SANDYBRIDGE
VCMPLE_OQSS      xmmreg,xmmreg*,xmmrm64   AVX,SANDYBRIDGE
VCMPUNORD_SSS    xmmreg,xmmreg*,xmmrm64   AVX,SANDYBRIDGE
VCMPNEQ_USSS     xmmreg,xmmreg*,xmmrm64   AVX,SANDYBRIDGE
VCMPNLT_UQSS     xmmreg,xmmreg*,xmmrm64   AVX,SANDYBRIDGE
VCMPNLE_UQSS     xmmreg,xmmreg*,xmmrm64   AVX,SANDYBRIDGE
VCMPORD_SSS      xmmreg,xmmreg*,xmmrm64   AVX,SANDYBRIDGE
VCMPEQ_USSS      xmmreg,xmmreg*,xmmrm64   AVX,SANDYBRIDGE
VCMPNGE_UQSS     xmmreg,xmmreg*,xmmrm64   AVX,SANDYBRIDGE
VCMPNGT_UQSS     xmmreg,xmmreg*,xmmrm64   AVX,SANDYBRIDGE
VCMPFALSE_OSSS   xmmreg,xmmreg*,xmmrm64   AVX,SANDYBRIDGE
VCMPNEQ_OSSS     xmmreg,xmmreg*,xmmrm64   AVX,SANDYBRIDGE
VCMPGE_OQSS      xmmreg,xmmreg*,xmmrm64   AVX,SANDYBRIDGE
VCMPGT_OQSS      xmmreg,xmmreg*,xmmrm64   AVX,SANDYBRIDGE
VCMPTRUE_USSS    xmmreg,xmmreg*,xmmrm64   AVX,SANDYBRIDGE
VCMPSS           xmmreg,xmmreg*,xmmrm32,imm8 AVX,SANDYBRIDGE
VCOMISD          xmmreg,xmmrm64           FL,AVX,SANDYBRIDGE
VCOMISS          xmmreg,xmmrm32           FL,AVX,SANDYBRIDGE
VCVTDQ2PD        xmmreg,xmmrm64           AVX,SANDYBRIDGE
VCVTDQ2PD        ymmreg,xmmrm128          AVX,SANDYBRIDGE
VCVTDQ2PS        xmmreg,xmmrm128          AVX,SANDYBRIDGE
VCVTDQ2PS        ymmreg,ymmrm256          AVX,SANDYBRIDGE
VCVTPD2DQ        xmmreg,xmmreg            AVX,SANDYBRIDGE
VCVTPD2DQ        xmmreg,mem128            AR0-1,SO,AVX,SANDYBRIDGE
VCVTPD2DQ        xmmreg,ymmreg            AVX,SANDYBRIDGE
VCVTPD2DQ        xmmreg,mem256            AR0-1,SY,AVX,SANDYBRIDGE
VCVTPD2PS        xmmreg,xmmreg            AVX,SANDYBRIDGE
VCVTPD2PS        xmmreg,mem128            AR0-1,SO,AVX,SANDYBRIDGE
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VCVTPD2PS       xmmreg,ymmreg             AVX,SANDYBRIDGE
VCVTPD2PS       xmmreg,mem256             AR0-1,SY,AVX,SANDYBRIDGE
VCVTPS2DQ       xmmreg,xmmrm128           AVX,SANDYBRIDGE
VCVTPS2DQ       ymmreg,ymmrm256           AVX,SANDYBRIDGE
VCVTPS2PD       xmmreg,xmmrm64            AVX,SANDYBRIDGE
VCVTPS2PD       ymmreg,xmmrm128           AVX,SANDYBRIDGE
VCVTSD2SI       reg32,xmmrm64             AVX,SANDYBRIDGE
VCVTSD2SI       reg64,xmmrm64             LONG,PROT,AVX,X86_64,SANDYBRIDGE
VCVTSD2SS       xmmreg,xmmreg*,xmmrm64    AVX,SANDYBRIDGE
VCVTSI2SD       xmmreg,xmmreg*,rm32       AR0-2,SD,AVX,SANDYBRIDGE
VCVTSI2SD       xmmreg,xmmreg*,mem32      ND,AR0-2,SD,AVX,SANDYBRIDGE
VCVTSI2SD       xmmreg,xmmreg*,rm64       AR0-2,LONG,PROT,AVX,X86_64,SANDYBRIDGE
VCVTSI2SS       xmmreg,xmmreg*,rm32       AR0-2,SD,AVX,SANDYBRIDGE
VCVTSI2SS       xmmreg,xmmreg*,mem32      ND,AR0-2,SD,AVX,SANDYBRIDGE
VCVTSI2SS       xmmreg,xmmreg*,rm64       AR0-2,LONG,PROT,AVX,X86_64,SANDYBRIDGE
VCVTSS2SD       xmmreg,xmmreg*,xmmrm32    AVX,SANDYBRIDGE
VCVTSS2SI       reg32,xmmrm32             AVX,SANDYBRIDGE
VCVTSS2SI       reg64,xmmrm32             LONG,PROT,AVX,X86_64,SANDYBRIDGE
VCVTTPD2DQ      xmmreg,xmmreg             AVX,SANDYBRIDGE
VCVTTPD2DQ      xmmreg,mem128             AR0-1,SO,AVX,SANDYBRIDGE
VCVTTPD2DQ      xmmreg,ymmreg             AVX,SANDYBRIDGE
VCVTTPD2DQ      xmmreg,mem256             AR0-1,SY,AVX,SANDYBRIDGE
VCVTTPS2DQ      xmmreg,xmmrm128           AVX,SANDYBRIDGE
VCVTTPS2DQ      ymmreg,ymmrm256           AVX,SANDYBRIDGE
VCVTTSD2SI      reg32,xmmrm64             AVX,SANDYBRIDGE
VCVTTSD2SI      reg64,xmmrm64             LONG,PROT,AVX,X86_64,SANDYBRIDGE
VCVTTSS2SI      reg32,xmmrm32             AVX,SANDYBRIDGE
VCVTTSS2SI      reg64,xmmrm32             LONG,PROT,AVX,X86_64,SANDYBRIDGE
VDIVPD          xmmreg,xmmreg*,xmmrm128   AVX,SANDYBRIDGE
VDIVPD          ymmreg,ymmreg*,ymmrm256   AVX,SANDYBRIDGE
VDIVPS          xmmreg,xmmreg*,xmmrm128   AVX,SANDYBRIDGE
VDIVPS          ymmreg,ymmreg*,ymmrm256   AVX,SANDYBRIDGE
VDIVSD          xmmreg,xmmreg*,xmmrm64    AVX,SANDYBRIDGE
VDIVSS          xmmreg,xmmreg*,xmmrm32    AVX,SANDYBRIDGE
VDPPD           xmmreg,xmmreg*,xmmrm128,imm8 AVX,SANDYBRIDGE
VDPPS           xmmreg,xmmreg*,xmmrm128,imm8 AVX,SANDYBRIDGE
VDPPS           ymmreg,ymmreg*,ymmrm256,imm8 AVX,SANDYBRIDGE
VEXTRACTF128    xmmrm128,ymmreg,imm8      AVX,SANDYBRIDGE
VEXTRACTPS      rm32,xmmreg,imm8          AVX,SANDYBRIDGE
VHADDPD         xmmreg,xmmreg*,xmmrm128   AVX,SANDYBRIDGE
VHADDPD         ymmreg,ymmreg*,ymmrm256   AVX,SANDYBRIDGE
VHADDPS         xmmreg,xmmreg*,xmmrm128   AVX,SANDYBRIDGE
VHADDPS         ymmreg,ymmreg*,ymmrm256   AVX,SANDYBRIDGE
VHSUBPD         xmmreg,xmmreg*,xmmrm128   AVX,SANDYBRIDGE
VHSUBPD         ymmreg,ymmreg*,ymmrm256   AVX,SANDYBRIDGE
VHSUBPS         xmmreg,xmmreg*,xmmrm128   AVX,SANDYBRIDGE
VHSUBPS         ymmreg,ymmreg*,ymmrm256   AVX,SANDYBRIDGE
VINSERTF128     ymmreg,ymmreg*,xmmrm128,imm8 AVX,SANDYBRIDGE
VINSERTPS       xmmreg,xmmreg*,xmmrm32,imm8 AVX,SANDYBRIDGE
VLDDQU          xmmreg,mem128             AVX,SANDYBRIDGE
VLDQQU          ymmreg,mem256             AVX,SANDYBRIDGE
VLDDQU          ymmreg,mem256             AVX,SANDYBRIDGE
VLDMXCSR        mem32                     AVX,SANDYBRIDGE
VMASKMOVDQU     xmmreg,xmmreg             AVX,SANDYBRIDGE
VMASKMOVPS      xmmreg,xmmreg,mem128      AVX,SANDYBRIDGE
VMASKMOVPS      ymmreg,ymmreg,mem256      AVX,SANDYBRIDGE
VMASKMOVPS      mem128,xmmreg,xmmreg      AR0-2,SO,AVX,SANDYBRIDGE
VMASKMOVPS      mem256,ymmreg,ymmreg      AR0-2,SY,AVX,SANDYBRIDGE
VMASKMOVPD      xmmreg,xmmreg,mem128      AVX,SANDYBRIDGE
VMASKMOVPD      ymmreg,ymmreg,mem256      AVX,SANDYBRIDGE
VMASKMOVPD      mem128,xmmreg,xmmreg      AVX,SANDYBRIDGE
VMASKMOVPD      mem256,ymmreg,ymmreg      AVX,SANDYBRIDGE
VMAXPD          xmmreg,xmmreg*,xmmrm128   AVX,SANDYBRIDGE
VMAXPD          ymmreg,ymmreg*,ymmrm256   AVX,SANDYBRIDGE
VMAXPS          xmmreg,xmmreg*,xmmrm128   AVX,SANDYBRIDGE
VMAXPS          ymmreg,ymmreg*,ymmrm256   AVX,SANDYBRIDGE
VMAXSD          xmmreg,xmmreg*,xmmrm64    AVX,SANDYBRIDGE
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VMAXSS          xmmreg,xmmreg*,xmmrm32   AVX,SANDYBRIDGE
VMINPD          xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VMINPD          ymmreg,ymmreg*,ymmrm256  AVX,SANDYBRIDGE
VMINPS          xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VMINPS          ymmreg,ymmreg*,ymmrm256  AVX,SANDYBRIDGE
VMINSD          xmmreg,xmmreg*,xmmrm64   AVX,SANDYBRIDGE
VMINSS          xmmreg,xmmreg*,xmmrm32   AVX,SANDYBRIDGE
VMOVAPD         xmmreg,xmmrm128          AVX,SANDYBRIDGE
VMOVAPD         xmmrm128,xmmreg          AVX,SANDYBRIDGE
VMOVAPD         ymmreg,ymmrm256          AVX,SANDYBRIDGE
VMOVAPD         ymmrm256,ymmreg          AVX,SANDYBRIDGE
VMOVAPS         xmmreg,xmmrm128          AVX,SANDYBRIDGE
VMOVAPS         xmmrm128,xmmreg          AVX,SANDYBRIDGE
VMOVAPS         ymmreg,ymmrm256          AVX,SANDYBRIDGE
VMOVAPS         ymmrm256,ymmreg          AVX,SANDYBRIDGE
VMOVD           xmmreg,rm32              AVX,SANDYBRIDGE
VMOVD           rm32,xmmreg              AVX,SANDYBRIDGE
VMOVQ           xmmreg,xmmrm64           AR0-1,AVX,SANDYBRIDGE
VMOVQ           xmmrm64,xmmreg           AR0-1,AVX,SANDYBRIDGE
VMOVQ           xmmreg,rm64              AR0-1,LONG,PROT,AVX,X86_64,SANDYBRIDGE
VMOVQ           rm64,xmmreg              AR0-1,LONG,PROT,AVX,X86_64,SANDYBRIDGE
VMOVDDUP        xmmreg,xmmrm64           AVX,SANDYBRIDGE
VMOVDDUP        ymmreg,ymmrm256          AVX,SANDYBRIDGE
VMOVDQA         xmmreg,xmmrm128          AVX,SANDYBRIDGE
VMOVDQA         xmmrm128,xmmreg          AVX,SANDYBRIDGE
VMOVQQA         ymmreg,ymmrm256          AVX,SANDYBRIDGE
VMOVQQA         ymmrm256,ymmreg          AVX,SANDYBRIDGE
VMOVDQA         ymmreg,ymmrm256          AVX,SANDYBRIDGE
VMOVDQA         ymmrm256,ymmreg          AVX,SANDYBRIDGE
VMOVDQU         xmmreg,xmmrm128          AVX,SANDYBRIDGE
VMOVDQU         xmmrm128,xmmreg          AVX,SANDYBRIDGE
VMOVQQU         ymmreg,ymmrm256          AVX,SANDYBRIDGE
VMOVQQU         ymmrm256,ymmreg          AVX,SANDYBRIDGE
VMOVDQU         ymmreg,ymmrm256          AVX,SANDYBRIDGE
VMOVDQU         ymmrm256,ymmreg          AVX,SANDYBRIDGE
VMOVHLPS        xmmreg,xmmreg*,xmmreg    AVX,SANDYBRIDGE
VMOVHPD         xmmreg,xmmreg*,mem64     AVX,SANDYBRIDGE
VMOVHPD         mem64,xmmreg             AVX,SANDYBRIDGE
VMOVHPS         xmmreg,xmmreg*,mem64     AVX,SANDYBRIDGE
VMOVHPS         mem64,xmmreg             AVX,SANDYBRIDGE
VMOVLHPS        xmmreg,xmmreg*,xmmreg    AVX,SANDYBRIDGE
VMOVLPD         xmmreg,xmmreg*,mem64     AVX,SANDYBRIDGE
VMOVLPD         mem64,xmmreg             AVX,SANDYBRIDGE
VMOVLPS         xmmreg,xmmreg*,mem64     AVX,SANDYBRIDGE
VMOVLPS         mem64,xmmreg             AVX,SANDYBRIDGE
VMOVMSKPD       reg64,xmmreg             LONG,PROT,AVX,X86_64,SANDYBRIDGE
VMOVMSKPD       reg32,xmmreg             AVX,SANDYBRIDGE
VMOVMSKPD       reg64,ymmreg             LONG,PROT,AVX,X86_64,SANDYBRIDGE
VMOVMSKPD       reg32,ymmreg             AVX,SANDYBRIDGE
VMOVMSKPS       reg64,xmmreg             LONG,PROT,AVX,X86_64,SANDYBRIDGE
VMOVMSKPS       reg32,xmmreg             AVX,SANDYBRIDGE
VMOVMSKPS       reg64,ymmreg             LONG,PROT,AVX,X86_64,SANDYBRIDGE
VMOVMSKPS       reg32,ymmreg             AVX,SANDYBRIDGE
VMOVNTDQ        mem128,xmmreg            AVX,SANDYBRIDGE
VMOVNTQQ        mem256,ymmreg            AVX,SANDYBRIDGE
VMOVNTDQ        mem256,ymmreg            AVX,SANDYBRIDGE
VMOVNTDQA       xmmreg,mem128            AVX,SANDYBRIDGE
VMOVNTPD        mem128,xmmreg            AVX,SANDYBRIDGE
VMOVNTPD        mem256,ymmreg            AVX,SANDYBRIDGE
VMOVNTPS        mem128,xmmreg            AVX,SANDYBRIDGE
VMOVNTPS        mem256,ymmreg            AVX,SANDYBRIDGE
VMOVSD          xmmreg,xmmreg*,xmmreg    AVX,SANDYBRIDGE
VMOVSD          xmmreg,mem64             AVX,SANDYBRIDGE
VMOVSD          xmmreg,xmmreg*,xmmreg    AVX,SANDYBRIDGE
VMOVSD          mem64,xmmreg             AVX,SANDYBRIDGE
VMOVSHDUP       xmmreg,xmmrm128          AVX,SANDYBRIDGE
VMOVSHDUP       ymmreg,ymmrm256          AVX,SANDYBRIDGE
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VMOVSLDUP       xmmreg,xmmrm128          AVX,SANDYBRIDGE
VMOVSLDUP       ymmreg,ymmrm256          AVX,SANDYBRIDGE
VMOVSS          xmmreg,xmmreg*,xmmreg    AVX,SANDYBRIDGE
VMOVSS          xmmreg,mem32             AVX,SANDYBRIDGE
VMOVSS          xmmreg,xmmreg*,xmmreg    AVX,SANDYBRIDGE
VMOVSS          mem32,xmmreg             AVX,SANDYBRIDGE
VMOVUPD         xmmreg,xmmrm128          AVX,SANDYBRIDGE
VMOVUPD         xmmrm128,xmmreg          AVX,SANDYBRIDGE
VMOVUPD         ymmreg,ymmrm256          AVX,SANDYBRIDGE
VMOVUPD         ymmrm256,ymmreg          AVX,SANDYBRIDGE
VMOVUPS         xmmreg,xmmrm128          AVX,SANDYBRIDGE
VMOVUPS         xmmrm128,xmmreg          AVX,SANDYBRIDGE
VMOVUPS         ymmreg,ymmrm256          AVX,SANDYBRIDGE
VMOVUPS         ymmrm256,ymmreg          AVX,SANDYBRIDGE
VMPSADBW        xmmreg,xmmreg*,xmmrm128,imm8 AVX,SANDYBRIDGE
VMULPD          xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VMULPD          ymmreg,ymmreg*,ymmrm256  AVX,SANDYBRIDGE
VMULPS          xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VMULPS          ymmreg,ymmreg*,ymmrm256  AVX,SANDYBRIDGE
VMULSD          xmmreg,xmmreg*,xmmrm64   AVX,SANDYBRIDGE
VMULSS          xmmreg,xmmreg*,xmmrm32   AVX,SANDYBRIDGE
VORPD           xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VORPD           ymmreg,ymmreg*,ymmrm256  AVX,SANDYBRIDGE
VORPS           xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VORPS           ymmreg,ymmreg*,ymmrm256  AVX,SANDYBRIDGE
VPABSB          xmmreg,xmmrm128          AVX,SANDYBRIDGE
VPABSW          xmmreg,xmmrm128          AVX,SANDYBRIDGE
VPABSD          xmmreg,xmmrm128          AVX,SANDYBRIDGE
VPACKSSWB       xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VPACKSSDW       xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VPACKUSWB       xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VPACKUSDW       xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VPADDB          xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VPADDW          xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VPADDD          xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VPADDQ          xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VPADDSB         xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VPADDSW         xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VPADDUSB        xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VPADDUSW        xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VPALIGNR        xmmreg,xmmreg*,xmmrm128,imm8 AVX,SANDYBRIDGE
VPAND           xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VPANDN          xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VPAVGB          xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VPAVGW          xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VPBLENDVB       xmmreg,xmmreg*,xmmrm128,xmmreg AVX,SANDYBRIDGE
VPBLENDW        xmmreg,xmmreg*,xmmrm128,imm8 AVX,SANDYBRIDGE
VPCMPESTRI      xmmreg,xmmrm128,imm8     AVX,SANDYBRIDGE
VPCMPESTRM      xmmreg,xmmrm128,imm8     AVX,SANDYBRIDGE
VPCMPISTRI      xmmreg,xmmrm128,imm8     AVX,SANDYBRIDGE
VPCMPISTRM      xmmreg,xmmrm128,imm8     AVX,SANDYBRIDGE
VPCMPEQB        xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VPCMPEQW        xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VPCMPEQD        xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VPCMPEQQ        xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VPCMPGTB        xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VPCMPGTW        xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VPCMPGTD        xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VPCMPGTQ        xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VPERMILPD       xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VPERMILPD       ymmreg,ymmreg*,ymmrm256  AVX,SANDYBRIDGE
VPERMILPD       xmmreg,xmmrm128,imm8     AVX,SANDYBRIDGE
VPERMILPD       ymmreg,ymmrm256,imm8     AVX,SANDYBRIDGE
VPERMILPS       xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VPERMILPS       ymmreg,ymmreg*,ymmrm256  AVX,SANDYBRIDGE
VPERMILPS       xmmreg,xmmrm128,imm8     AVX,SANDYBRIDGE
VPERMILPS       ymmreg,ymmrm256,imm8     AVX,SANDYBRIDGE
```

```
VPERM2F128      ymmreg,ymmreg*,ymmrm256,imm8 AVX,SANDYBRIDGE
VPEXTRB         reg64,xmmreg,imm8        LONG,PROT,AVX,X86_64,SANDYBRIDGE
VPEXTRB         reg32,xmmreg,imm8        AVX,SANDYBRIDGE
VPEXTRB         mem8,xmmreg,imm8         AVX,SANDYBRIDGE
VPEXTRW         reg64,xmmreg,imm8        LONG,PROT,AVX,X86_64,SANDYBRIDGE
VPEXTRW         reg32,xmmreg,imm8        AVX,SANDYBRIDGE
VPEXTRW         reg64,xmmreg,imm8        LONG,PROT,AVX,X86_64,SANDYBRIDGE
VPEXTRW         reg32,xmmreg,imm8        AVX,SANDYBRIDGE
VPEXTRW         mem16,xmmreg,imm8        AVX,SANDYBRIDGE
VPEXTRD         reg64,xmmreg,imm8        LONG,PROT,AVX,X86_64,SANDYBRIDGE
VPEXTRD         rm32,xmmreg,imm8         AVX,SANDYBRIDGE
VPEXTRQ         rm64,xmmreg,imm8         LONG,PROT,AVX,X86_64,SANDYBRIDGE
VPHADDW         xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VPHADDD         xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VPHADDSW        xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VPHMINPOSUW     xmmreg,xmmrm128          AVX,SANDYBRIDGE
VPHSUBW         xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VPHSUBD         xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VPHSUBSW        xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VPINSRB         xmmreg,xmmreg*,mem8,imm8 AVX,SANDYBRIDGE
VPINSRB         xmmreg,xmmreg*,rm8,imm8  AVX,SANDYBRIDGE
VPINSRB         xmmreg,xmmreg*,reg32,imm8 AVX,SANDYBRIDGE
VPINSRW         xmmreg,xmmreg*,mem16,imm8 AVX,SANDYBRIDGE
VPINSRW         xmmreg,xmmreg*,rm16,imm8 AVX,SANDYBRIDGE
VPINSRW         xmmreg,xmmreg*,reg32,imm8 AVX,SANDYBRIDGE
VPINSRD         xmmreg,xmmreg*,mem32,imm8 AVX,SANDYBRIDGE
VPINSRD         xmmreg,xmmreg*,rm32,imm8 AVX,SANDYBRIDGE
VPINSRQ         xmmreg,xmmreg*,mem64,imm8 LONG,PROT,AVX,X86_64,SANDYBRIDGE
VPINSRQ         xmmreg,xmmreg*,rm64,imm8 LONG,PROT,AVX,X86_64,SANDYBRIDGE
VPMADDWD        xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VPMADDUBSW      xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VPMAXSB         xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VPMAXSW         xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VPMAXSD         xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VPMAXUB         xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VPMAXUW         xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VPMAXUD         xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VPMINSB         xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VPMINSW         xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VPMINSD         xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VPMINUB         xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VPMINUW         xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VPMINUD         xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VPMOVMSKB       reg64,xmmreg             LONG,PROT,AVX,X86_64,SANDYBRIDGE
VPMOVMSKB       reg32,xmmreg             AVX,SANDYBRIDGE
VPMOVSXBW       xmmreg,xmmrm64           AVX,SANDYBRIDGE
VPMOVSXBD       xmmreg,xmmrm32           AVX,SANDYBRIDGE
VPMOVSXBQ       xmmreg,xmmrm16           AVX,SANDYBRIDGE
VPMOVSXWD       xmmreg,xmmrm64           AVX,SANDYBRIDGE
VPMOVSXWQ       xmmreg,xmmrm32           AVX,SANDYBRIDGE
VPMOVSXDQ       xmmreg,xmmrm64           AVX,SANDYBRIDGE
VPMOVZXBW       xmmreg,xmmrm64           AVX,SANDYBRIDGE
VPMOVZXBD       xmmreg,xmmrm32           AVX,SANDYBRIDGE
VPMOVZXBQ       xmmreg,xmmrm16           AVX,SANDYBRIDGE
VPMOVZXWD       xmmreg,xmmrm64           AVX,SANDYBRIDGE
VPMOVZXWQ       xmmreg,xmmrm32           AVX,SANDYBRIDGE
VPMOVZXDQ       xmmreg,xmmrm64           AVX,SANDYBRIDGE
VPMULHUW        xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VPMULHRSW       xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VPMULHW         xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VPMULLW         xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VPMULLD         xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VPMULUDQ        xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VPMULDQ         xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VPOR            xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VPSADBW         xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VPSHUFB         xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
```

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VPSHUFD         xmmreg,xmmrm128,imm8     AVX,SANDYBRIDGE
VPSHUFHW        xmmreg,xmmrm128,imm8     AVX,SANDYBRIDGE
VPSHUFLW        xmmreg,xmmrm128,imm8     AVX,SANDYBRIDGE
VPSIGNB         xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VPSIGNW         xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VPSIGND         xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VPSLLDQ         xmmreg,xmmreg*,imm8      AVX,SANDYBRIDGE
VPSRLDQ         xmmreg,xmmreg*,imm8      AVX,SANDYBRIDGE
VPSLLW          xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VPSLLW          xmmreg,xmmreg*,imm8      AVX,SANDYBRIDGE
VPSLLD          xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VPSLLD          xmmreg,xmmreg*,imm8      AVX,SANDYBRIDGE
VPSLLQ          xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VPSLLQ          xmmreg,xmmreg*,imm8      AVX,SANDYBRIDGE
VPSRAW          xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VPSRAW          xmmreg,xmmreg*,imm8      AVX,SANDYBRIDGE
VPSRAD          xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VPSRAD          xmmreg,xmmreg*,imm8      AVX,SANDYBRIDGE
VPSRLW          xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VPSRLW          xmmreg,xmmreg*,imm8      AVX,SANDYBRIDGE
VPSRLD          xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VPSRLD          xmmreg,xmmreg*,imm8      AVX,SANDYBRIDGE
VPSRLQ          xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VPSRLQ          xmmreg,xmmreg*,imm8      AVX,SANDYBRIDGE
VPTEST          xmmreg,xmmrm128          AVX,SANDYBRIDGE
VPTEST          ymmreg,ymmrm256          AVX,SANDYBRIDGE
VPSUBB          xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VPSUBW          xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VPSUBD          xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VPSUBQ          xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VPSUBSB         xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VPSUBSW         xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VPSUBUSB        xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VPSUBUSW        xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VPUNPCKHBW      xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VPUNPCKHWD      xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VPUNPCKHDQ      xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VPUNPCKHQDQ     xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VPUNPCKLBW      xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VPUNPCKLWD      xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VPUNPCKLDQ      xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VPUNPCKLQDQ     xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VPXOR           xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VRCPPS          xmmreg,xmmrm128          AVX,SANDYBRIDGE
VRCPPS          ymmreg,ymmrm256          AVX,SANDYBRIDGE
VRCPSS          xmmreg,xmmreg*,xmmrm32   AVX,SANDYBRIDGE
VRSQRTPS        xmmreg,xmmrm128          AVX,SANDYBRIDGE
VRSQRTPS        ymmreg,ymmrm256          AVX,SANDYBRIDGE
VRSQRTSS        xmmreg,xmmreg*,xmmrm32   AVX,SANDYBRIDGE
VROUNDPD        xmmreg,xmmrm128,imm8     AVX,SANDYBRIDGE
VROUNDPD        ymmreg,ymmrm256,imm8     AVX,SANDYBRIDGE
VROUNDPS        xmmreg,xmmrm128,imm8     AVX,SANDYBRIDGE
VROUNDPS        ymmreg,ymmrm256,imm8     AVX,SANDYBRIDGE
VROUNDSD        xmmreg,xmmreg*,xmmrm64,imm8 AVX,SANDYBRIDGE
VROUNDSS        xmmreg,xmmreg*,xmmrm32,imm8 AVX,SANDYBRIDGE
VSHUFPD         xmmreg,xmmreg*,xmmrm128,imm8 AVX,SANDYBRIDGE
VSHUFPD         ymmreg,ymmreg*,ymmrm256,imm8 AVX,SANDYBRIDGE
VSHUFPS         xmmreg,xmmreg*,xmmrm128,imm8 AVX,SANDYBRIDGE
VSHUFPS         ymmreg,ymmreg*,ymmrm256,imm8 AVX,SANDYBRIDGE
VSQRTPD         xmmreg,xmmrm128          AVX,SANDYBRIDGE
VSQRTPD         ymmreg,ymmrm256          AVX,SANDYBRIDGE
VSQRTPS         xmmreg,xmmrm128          AVX,SANDYBRIDGE
VSQRTPS         ymmreg,ymmrm256          AVX,SANDYBRIDGE
VSQRTSD         xmmreg,xmmreg*,xmmrm64   AVX,SANDYBRIDGE
VSQRTSS         xmmreg,xmmreg*,xmmrm32   AVX,SANDYBRIDGE
VSTMXCSR        mem32                    AVX,SANDYBRIDGE
VSUBPD          xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
```

```
VSUBPD          ymmreg,ymmreg*,ymmrm256  AVX,SANDYBRIDGE
VSUBPS          xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VSUBPS          ymmreg,ymmreg*,ymmrm256  AVX,SANDYBRIDGE
VSUBSD          xmmreg,xmmreg*,xmmrm64   AVX,SANDYBRIDGE
VSUBSS          xmmreg,xmmreg*,xmmrm32   AVX,SANDYBRIDGE
VTESTPS         xmmreg,xmmrm128          FL,AVX,SANDYBRIDGE
VTESTPS         ymmreg,ymmrm256          FL,AVX,SANDYBRIDGE
VTESTPD         xmmreg,xmmrm128          AVX,SANDYBRIDGE
VTESTPD         ymmreg,ymmrm256          AVX,SANDYBRIDGE
VUCOMISD        xmmreg,xmmrm64           FL,AVX,SANDYBRIDGE
VUCOMISS        xmmreg,xmmrm32           FL,AVX,SANDYBRIDGE
VUNPCKHPD       xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VUNPCKHPD       ymmreg,ymmreg*,ymmrm256  AVX,SANDYBRIDGE
VUNPCKHPS       xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VUNPCKHPS       ymmreg,ymmreg*,ymmrm256  AVX,SANDYBRIDGE
VUNPCKLPD       xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VUNPCKLPD       ymmreg,ymmreg*,ymmrm256  AVX,SANDYBRIDGE
VUNPCKLPS       xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VUNPCKLPS       ymmreg,ymmreg*,ymmrm256  AVX,SANDYBRIDGE
VXORPD          xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VXORPD          ymmreg,ymmreg*,ymmrm256  AVX,SANDYBRIDGE
VXORPS          xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VXORPS          ymmreg,ymmreg*,ymmrm256  AVX,SANDYBRIDGE
VZEROALL                                 AVX,SANDYBRIDGE
VZEROUPPER                               AVX,SANDYBRIDGE
```

F.1.64 Intel Carry-Less Multiplication instructions (CLMUL)

```
PCLMULLQLQDQ    xmmreg,xmmrm128          SSE,WESTMERE
PCLMULHQLQDQ    xmmreg,xmmrm128          SSE,WESTMERE
PCLMULLQHQDQ    xmmreg,xmmrm128          SSE,WESTMERE
PCLMULHQHQDQ    xmmreg,xmmrm128          SSE,WESTMERE
PCLMULQDQ       xmmreg,xmmrm128,imm8     SSE,WESTMERE
```

F.1.65 Intel AVX Carry-Less Multiplication instructions (CLMUL)

```
VPCLMULLQLQDQ   xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VPCLMULHQLQDQ   xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VPCLMULLQHQDQ   xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VPCLMULHQHQDQ   xmmreg,xmmreg*,xmmrm128  AVX,SANDYBRIDGE
VPCLMULQDQ      xmmreg,xmmreg*,xmmrm128,imm8 AVX,SANDYBRIDGE
VPCLMULLQLQDQ   ymmreg,ymmreg*,ymmrm256  VPCLMULQDQ
VPCLMULHQLQDQ   ymmreg,ymmreg*,ymmrm256  VPCLMULQDQ
VPCLMULLQHQDQ   ymmreg,ymmreg*,ymmrm256  VPCLMULQDQ
VPCLMULHQHQDQ   ymmreg,ymmreg*,ymmrm256  VPCLMULQDQ
VPCLMULQDQ      ymmreg,ymmreg*,ymmrm256,imm8 VPCLMULQDQ
VPCLMULLQLQDQ   xmmreg,xmmreg*,xmmrm128  AVX512VL,VPCLMULQDQ
VPCLMULHQLQDQ   xmmreg,xmmreg*,xmmrm128  AVX512VL,VPCLMULQDQ
VPCLMULLQHQDQ   xmmreg,xmmreg*,xmmrm128  AVX512VL,VPCLMULQDQ
VPCLMULHQHQDQ   xmmreg,xmmreg*,xmmrm128  AVX512VL,VPCLMULQDQ
VPCLMULQDQ      xmmreg,xmmreg*,xmmrm128,imm8 AVX512VL,VPCLMULQDQ
VPCLMULLQLQDQ   ymmreg,ymmreg*,ymmrm256  AVX512VL,VPCLMULQDQ
VPCLMULHQLQDQ   ymmreg,ymmreg*,ymmrm256  AVX512VL,VPCLMULQDQ
VPCLMULLQHQDQ   ymmreg,ymmreg*,ymmrm256  AVX512VL,VPCLMULQDQ
VPCLMULHQHQDQ   ymmreg,ymmreg*,ymmrm256  AVX512VL,VPCLMULQDQ
VPCLMULQDQ      ymmreg,ymmreg*,ymmrm256,imm8 AVX512VL,VPCLMULQDQ
VPCLMULLQLQDQ   zmmreg,zmmreg*,zmmrm512  AVX512,VPCLMULQDQ
VPCLMULHQLQDQ   zmmreg,zmmreg*,zmmrm512  AVX512,VPCLMULQDQ
VPCLMULLQHQDQ   zmmreg,zmmreg*,zmmrm512  AVX512,VPCLMULQDQ
VPCLMULHQHQDQ   zmmreg,zmmreg*,zmmrm512  AVX512,VPCLMULQDQ
VPCLMULQDQ      zmmreg,zmmreg*,zmmrm512,imm8 AVX512,VPCLMULQDQ
```

F.1.66 Intel Fused Multiply-Add instructions (FMA)

```
VFMADD132PS     xmmreg,xmmreg,xmmrm128   FMA
VFMADD132PS     ymmreg,ymmreg,ymmrm256   FMA
VFMADD132PD     xmmreg,xmmreg,xmmrm128   FMA
VFMADD132PD     ymmreg,ymmreg,ymmrm256   FMA
```

```
VFMADD312PS      xmmreg,xmmreg,xmmrm128   FMA
VFMADD312PS      ymmreg,ymmreg,ymmrm256   FMA
VFMADD312PD      xmmreg,xmmreg,xmmrm128   FMA
VFMADD312PD      ymmreg,ymmreg,ymmrm256   FMA
VFMADD213PS      xmmreg,xmmreg,xmmrm128   FMA
VFMADD213PS      ymmreg,ymmreg,ymmrm256   FMA
VFMADD213PD      xmmreg,xmmreg,xmmrm128   FMA
VFMADD213PD      ymmreg,ymmreg,ymmrm256   FMA
VFMADD123PS      xmmreg,xmmreg,xmmrm128   FMA
VFMADD123PS      ymmreg,ymmreg,ymmrm256   FMA
VFMADD123PD      xmmreg,xmmreg,xmmrm128   FMA
VFMADD123PD      ymmreg,ymmreg,ymmrm256   FMA
VFMADD231PS      xmmreg,xmmreg,xmmrm128   FMA
VFMADD231PS      ymmreg,ymmreg,ymmrm256   FMA
VFMADD231PD      xmmreg,xmmreg,xmmrm128   FMA
VFMADD231PD      ymmreg,ymmreg,ymmrm256   FMA
VFMADD321PS      xmmreg,xmmreg,xmmrm128   FMA
VFMADD321PS      ymmreg,ymmreg,ymmrm256   FMA
VFMADD321PD      xmmreg,xmmreg,xmmrm128   FMA
VFMADD321PD      ymmreg,ymmreg,ymmrm256   FMA
VFMADDSUB132PS   xmmreg,xmmreg,xmmrm128   FMA
VFMADDSUB132PS   ymmreg,ymmreg,ymmrm256   FMA
VFMADDSUB132PD   xmmreg,xmmreg,xmmrm128   FMA
VFMADDSUB132PD   ymmreg,ymmreg,ymmrm256   FMA
VFMADDSUB312PS   xmmreg,xmmreg,xmmrm128   FMA
VFMADDSUB312PS   ymmreg,ymmreg,ymmrm256   FMA
VFMADDSUB312PD   xmmreg,xmmreg,xmmrm128   FMA
VFMADDSUB312PD   ymmreg,ymmreg,ymmrm256   FMA
VFMADDSUB213PS   xmmreg,xmmreg,xmmrm128   FMA
VFMADDSUB213PS   ymmreg,ymmreg,ymmrm256   FMA
VFMADDSUB213PD   xmmreg,xmmreg,xmmrm128   FMA
VFMADDSUB213PD   ymmreg,ymmreg,ymmrm256   FMA
VFMADDSUB123PS   xmmreg,xmmreg,xmmrm128   FMA
VFMADDSUB123PS   ymmreg,ymmreg,ymmrm256   FMA
VFMADDSUB123PD   xmmreg,xmmreg,xmmrm128   FMA
VFMADDSUB123PD   ymmreg,ymmreg,ymmrm256   FMA
VFMADDSUB231PS   xmmreg,xmmreg,xmmrm128   FMA
VFMADDSUB231PS   ymmreg,ymmreg,ymmrm256   FMA
VFMADDSUB231PD   xmmreg,xmmreg,xmmrm128   FMA
VFMADDSUB231PD   ymmreg,ymmreg,ymmrm256   FMA
VFMADDSUB321PS   xmmreg,xmmreg,xmmrm128   FMA
VFMADDSUB321PS   ymmreg,ymmreg,ymmrm256   FMA
VFMADDSUB321PD   xmmreg,xmmreg,xmmrm128   FMA
VFMADDSUB321PD   ymmreg,ymmreg,ymmrm256   FMA
VFMSUB132PS      xmmreg,xmmreg,xmmrm128   FMA
VFMSUB132PS      ymmreg,ymmreg,ymmrm256   FMA
VFMSUB132PD      xmmreg,xmmreg,xmmrm128   FMA
VFMSUB132PD      ymmreg,ymmreg,ymmrm256   FMA
VFMSUB312PS      xmmreg,xmmreg,xmmrm128   FMA
VFMSUB312PS      ymmreg,ymmreg,ymmrm256   FMA
VFMSUB312PD      xmmreg,xmmreg,xmmrm128   FMA
VFMSUB312PD      ymmreg,ymmreg,ymmrm256   FMA
VFMSUB213PS      xmmreg,xmmreg,xmmrm128   FMA
VFMSUB213PS      ymmreg,ymmreg,ymmrm256   FMA
VFMSUB213PD      xmmreg,xmmreg,xmmrm128   FMA
VFMSUB213PD      ymmreg,ymmreg,ymmrm256   FMA
VFMSUB123PS      xmmreg,xmmreg,xmmrm128   FMA
VFMSUB123PS      ymmreg,ymmreg,ymmrm256   FMA
VFMSUB123PD      xmmreg,xmmreg,xmmrm128   FMA
VFMSUB123PD      ymmreg,ymmreg,ymmrm256   FMA
VFMSUB231PS      xmmreg,xmmreg,xmmrm128   FMA
VFMSUB231PS      ymmreg,ymmreg,ymmrm256   FMA
VFMSUB231PD      xmmreg,xmmreg,xmmrm128   FMA
VFMSUB231PD      ymmreg,ymmreg,ymmrm256   FMA
VFMSUB321PS      xmmreg,xmmreg,xmmrm128   FMA
VFMSUB321PS      ymmreg,ymmreg,ymmrm256   FMA
VFMSUB321PD      xmmreg,xmmreg,xmmrm128   FMA
```

```
VFMSUB321PD      ymmreg,ymmreg,ymmrm256   FMA
VFMSUBADD132PS   xmmreg,xmmreg,xmmrm128   FMA
VFMSUBADD132PS   ymmreg,ymmreg,ymmrm256   FMA
VFMSUBADD132PD   xmmreg,xmmreg,xmmrm128   FMA
VFMSUBADD132PD   ymmreg,ymmreg,ymmrm256   FMA
VFMSUBADD312PS   xmmreg,xmmreg,xmmrm128   FMA
VFMSUBADD312PS   ymmreg,ymmreg,ymmrm256   FMA
VFMSUBADD312PD   xmmreg,xmmreg,xmmrm128   FMA
VFMSUBADD312PD   ymmreg,ymmreg,ymmrm256   FMA
VFMSUBADD213PS   xmmreg,xmmreg,xmmrm128   FMA
VFMSUBADD213PS   ymmreg,ymmreg,ymmrm256   FMA
VFMSUBADD213PD   xmmreg,xmmreg,xmmrm128   FMA
VFMSUBADD213PD   ymmreg,ymmreg,ymmrm256   FMA
VFMSUBADD123PS   xmmreg,xmmreg,xmmrm128   FMA
VFMSUBADD123PS   ymmreg,ymmreg,ymmrm256   FMA
VFMSUBADD123PD   xmmreg,xmmreg,xmmrm128   FMA
VFMSUBADD123PD   ymmreg,ymmreg,ymmrm256   FMA
VFMSUBADD231PS   xmmreg,xmmreg,xmmrm128   FMA
VFMSUBADD231PS   ymmreg,ymmreg,ymmrm256   FMA
VFMSUBADD231PD   xmmreg,xmmreg,xmmrm128   FMA
VFMSUBADD231PD   ymmreg,ymmreg,ymmrm256   FMA
VFMSUBADD321PS   xmmreg,xmmreg,xmmrm128   FMA
VFMSUBADD321PS   ymmreg,ymmreg,ymmrm256   FMA
VFMSUBADD321PD   xmmreg,xmmreg,xmmrm128   FMA
VFMSUBADD321PD   ymmreg,ymmreg,ymmrm256   FMA
VFNMADD132PS     xmmreg,xmmreg,xmmrm128   FMA
VFNMADD132PS     ymmreg,ymmreg,ymmrm256   FMA
VFNMADD132PD     xmmreg,xmmreg,xmmrm128   FMA
VFNMADD132PD     ymmreg,ymmreg,ymmrm256   FMA
VFNMADD312PS     xmmreg,xmmreg,xmmrm128   FMA
VFNMADD312PS     ymmreg,ymmreg,ymmrm256   FMA
VFNMADD312PD     xmmreg,xmmreg,xmmrm128   FMA
VFNMADD312PD     ymmreg,ymmreg,ymmrm256   FMA
VFNMADD213PS     xmmreg,xmmreg,xmmrm128   FMA
VFNMADD213PS     ymmreg,ymmreg,ymmrm256   FMA
VFNMADD213PD     xmmreg,xmmreg,xmmrm128   FMA
VFNMADD213PD     ymmreg,ymmreg,ymmrm256   FMA
VFNMADD123PS     xmmreg,xmmreg,xmmrm128   FMA
VFNMADD123PS     ymmreg,ymmreg,ymmrm256   FMA
VFNMADD123PD     xmmreg,xmmreg,xmmrm128   FMA
VFNMADD123PD     ymmreg,ymmreg,ymmrm256   FMA
VFNMADD231PS     xmmreg,xmmreg,xmmrm128   FMA
VFNMADD231PS     ymmreg,ymmreg,ymmrm256   FMA
VFNMADD231PD     xmmreg,xmmreg,xmmrm128   FMA
VFNMADD231PD     ymmreg,ymmreg,ymmrm256   FMA
VFNMADD321PS     xmmreg,xmmreg,xmmrm128   FMA
VFNMADD321PS     ymmreg,ymmreg,ymmrm256   FMA
VFNMADD321PD     xmmreg,xmmreg,xmmrm128   FMA
VFNMADD321PD     ymmreg,ymmreg,ymmrm256   FMA
VFNMSUB132PS     xmmreg,xmmreg,xmmrm128   FMA
VFNMSUB132PS     ymmreg,ymmreg,ymmrm256   FMA
VFNMSUB132PD     xmmreg,xmmreg,xmmrm128   FMA
VFNMSUB132PD     ymmreg,ymmreg,ymmrm256   FMA
VFNMSUB312PS     xmmreg,xmmreg,xmmrm128   FMA
VFNMSUB312PS     ymmreg,ymmreg,ymmrm256   FMA
VFNMSUB312PD     xmmreg,xmmreg,xmmrm128   FMA
VFNMSUB312PD     ymmreg,ymmreg,ymmrm256   FMA
VFNMSUB213PS     xmmreg,xmmreg,xmmrm128   FMA
VFNMSUB213PS     ymmreg,ymmreg,ymmrm256   FMA
VFNMSUB213PD     xmmreg,xmmreg,xmmrm128   FMA
VFNMSUB213PD     ymmreg,ymmreg,ymmrm256   FMA
VFNMSUB123PS     xmmreg,xmmreg,xmmrm128   FMA
VFNMSUB123PS     ymmreg,ymmreg,ymmrm256   FMA
VFNMSUB123PD     xmmreg,xmmreg,xmmrm128   FMA
VFNMSUB123PD     ymmreg,ymmreg,ymmrm256   FMA
VFNMSUB231PS     xmmreg,xmmreg,xmmrm128   FMA
VFNMSUB231PS     ymmreg,ymmreg,ymmrm256   FMA
```

```
VFNMSUB231PD    xmmreg,xmmreg,xmmrm128   FMA
VFNMSUB231PD    ymmreg,ymmreg,ymmrm256   FMA
VFNMSUB321PS    xmmreg,xmmreg,xmmrm128   FMA
VFNMSUB321PS    ymmreg,ymmreg,ymmrm256   FMA
VFNMSUB321PD    xmmreg,xmmreg,xmmrm128   FMA
VFNMSUB321PD    ymmreg,ymmreg,ymmrm256   FMA
VFMADD132SS     xmmreg,xmmreg,xmmrm32    FMA
VFMADD132SD     xmmreg,xmmreg,xmmrm64    FMA
VFMADD312SS     xmmreg,xmmreg,xmmrm32    FMA
VFMADD312SD     xmmreg,xmmreg,xmmrm64    FMA
VFMADD213SS     xmmreg,xmmreg,xmmrm32    FMA
VFMADD213SD     xmmreg,xmmreg,xmmrm64    FMA
VFMADD123SS     xmmreg,xmmreg,xmmrm32    FMA
VFMADD123SD     xmmreg,xmmreg,xmmrm64    FMA
VFMADD231SS     xmmreg,xmmreg,xmmrm32    FMA
VFMADD231SD     xmmreg,xmmreg,xmmrm64    FMA
VFMADD321SS     xmmreg,xmmreg,xmmrm32    FMA
VFMADD321SD     xmmreg,xmmreg,xmmrm64    FMA
VFMSUB132SS     xmmreg,xmmreg,xmmrm32    FMA
VFMSUB132SD     xmmreg,xmmreg,xmmrm64    FMA
VFMSUB312SS     xmmreg,xmmreg,xmmrm32    FMA
VFMSUB312SD     xmmreg,xmmreg,xmmrm64    FMA
VFMSUB213SS     xmmreg,xmmreg,xmmrm32    FMA
VFMSUB213SD     xmmreg,xmmreg,xmmrm64    FMA
VFMSUB123SS     xmmreg,xmmreg,xmmrm32    FMA
VFMSUB123SD     xmmreg,xmmreg,xmmrm64    FMA
VFMSUB231SS     xmmreg,xmmreg,xmmrm32    FMA
VFMSUB231SD     xmmreg,xmmreg,xmmrm64    FMA
VFMSUB321SS     xmmreg,xmmreg,xmmrm32    FMA
VFMSUB321SD     xmmreg,xmmreg,xmmrm64    FMA
VFNMADD132SS    xmmreg,xmmreg,xmmrm32    FMA
VFNMADD132SD    xmmreg,xmmreg,xmmrm64    FMA
VFNMADD312SS    xmmreg,xmmreg,xmmrm32    FMA
VFNMADD312SD    xmmreg,xmmreg,xmmrm64    FMA
VFNMADD213SS    xmmreg,xmmreg,xmmrm32    FMA
VFNMADD213SD    xmmreg,xmmreg,xmmrm64    FMA
VFNMADD123SS    xmmreg,xmmreg,xmmrm32    FMA
VFNMADD123SD    xmmreg,xmmreg,xmmrm64    FMA
VFNMADD231SS    xmmreg,xmmreg,xmmrm32    FMA
VFNMADD231SD    xmmreg,xmmreg,xmmrm64    FMA
VFNMADD321SS    xmmreg,xmmreg,xmmrm32    FMA
VFNMADD321SD    xmmreg,xmmreg,xmmrm64    FMA
VFNMSUB132SS    xmmreg,xmmreg,xmmrm32    FMA
VFNMSUB132SD    xmmreg,xmmreg,xmmrm64    FMA
VFNMSUB312SS    xmmreg,xmmreg,xmmrm32    FMA
VFNMSUB312SD    xmmreg,xmmreg,xmmrm64    FMA
VFNMSUB213SS    xmmreg,xmmreg,xmmrm32    FMA
VFNMSUB213SD    xmmreg,xmmreg,xmmrm64    FMA
VFNMSUB123SS    xmmreg,xmmreg,xmmrm32    FMA
VFNMSUB123SD    xmmreg,xmmreg,xmmrm64    FMA
VFNMSUB231SS    xmmreg,xmmreg,xmmrm32    FMA
VFNMSUB231SD    xmmreg,xmmreg,xmmrm64    FMA
VFNMSUB321SS    xmmreg,xmmreg,xmmrm32    FMA
VFNMSUB321SD    xmmreg,xmmreg,xmmrm64    FMA
```

F.1.67 Intel post-32 nm processor instructions

```
VCVTPH2PS       ymmreg,xmmrm128          F16C
VCVTPH2PS       xmmreg,xmmrm64           F16C
VCVTPS2PH       xmmrm128,ymmreg,imm8     F16C
VCVTPS2PH       xmmrm64,xmmreg,imm8      F16C
```

F.1.68 Supervisor Mode Access Prevention (SMAP)

F.1.69 VIA (Centaur) security instructions

```
XSTORE                                  PENT,CYRIX
XCRYPTECB                               PENT,CYRIX
XCRYPTCBC                               PENT,CYRIX
XCRYPTCTR                               PENT,CYRIX
XCRYPTCFB                               PENT,CYRIX
XCRYPTOFB                               PENT,CYRIX
MONTMUL                                 PENT,CYRIX
XSHA1                                   PENT,CYRIX
XSHA256                                 PENT,CYRIX
```

F.1.70 AMD Lightweight Profiling (LWP) instructions

```
LLWPCB          reg32                   386,AMD
LLWPCB          reg64                   LONG,PROT,X86_64,AMD
SLWPCB          reg32                   386,AMD
SLWPCB          reg64                   LONG,PROT,X86_64,AMD
LWPVAL          reg32,rm32,imm32        386,AMD
LWPVAL          reg64,rm32,imm32        LONG,PROT,X86_64,AMD
LWPINS          reg32,rm32,imm32        386,AMD
LWPINS          reg64,rm32,imm32        LONG,PROT,X86_64,AMD
```

F.1.71 AMD XOP and FMA4 instructions (SSE5)

```
VFMADDPD        xmmreg,xmmreg*,xmmrm128,xmmreg SSE5,AMD
VFMADDPD        ymmreg,ymmreg*,ymmrm256,ymmreg SSE5,AMD
VFMADDPD        xmmreg,xmmreg*,xmmreg,xmmrm128 SSE5,AMD
VFMADDPD        ymmreg,ymmreg*,ymmreg,ymmrm256 SSE5,AMD
VFMADDPS        xmmreg,xmmreg*,xmmrm128,xmmreg SSE5,AMD
VFMADDPS        ymmreg,ymmreg*,ymmrm256,ymmreg SSE5,AMD
VFMADDPS        xmmreg,xmmreg*,xmmreg,xmmrm128 SSE5,AMD
VFMADDPS        ymmreg,ymmreg*,ymmreg,ymmrm256 SSE5,AMD
VFMADDSD        xmmreg,xmmreg*,xmmrm64,xmmreg SSE5,AMD
VFMADDSD        xmmreg,xmmreg*,xmmreg,xmmrm64 SSE5,AMD
VFMADDSS        xmmreg,xmmreg*,xmmrm32,xmmreg SSE5,AMD
VFMADDSS        xmmreg,xmmreg*,xmmreg,xmmrm32 SSE5,AMD
VFMADDSUBPD     xmmreg,xmmreg*,xmmrm128,xmmreg SSE5,AMD
VFMADDSUBPD     ymmreg,ymmreg*,ymmrm256,ymmreg SSE5,AMD
VFMADDSUBPD     xmmreg,xmmreg*,xmmreg,xmmrm128 SSE5,AMD
VFMADDSUBPD     ymmreg,ymmreg*,ymmreg,ymmrm256 SSE5,AMD
VFMADDSUBPS     xmmreg,xmmreg*,xmmrm128,xmmreg SSE5,AMD
VFMADDSUBPS     ymmreg,ymmreg*,ymmrm256,ymmreg SSE5,AMD
VFMADDSUBPS     xmmreg,xmmreg*,xmmreg,xmmrm128 SSE5,AMD
VFMADDSUBPS     ymmreg,ymmreg*,ymmreg,ymmrm256 SSE5,AMD
VFMSUBADDPD     xmmreg,xmmreg*,xmmrm128,xmmreg SSE5,AMD
VFMSUBADDPD     ymmreg,ymmreg*,ymmrm256,ymmreg SSE5,AMD
VFMSUBADDPD     xmmreg,xmmreg*,xmmreg,xmmrm128 SSE5,AMD
VFMSUBADDPD     ymmreg,ymmreg*,ymmreg,ymmrm256 SSE5,AMD
VFMSUBADDPS     xmmreg,xmmreg*,xmmrm128,xmmreg SSE5,AMD
VFMSUBADDPS     ymmreg,ymmreg*,ymmrm256,ymmreg SSE5,AMD
VFMSUBADDPS     xmmreg,xmmreg*,xmmreg,xmmrm128 SSE5,AMD
VFMSUBADDPS     ymmreg,ymmreg*,ymmreg,ymmrm256 SSE5,AMD
VFMSUBPD        xmmreg,xmmreg*,xmmrm128,xmmreg SSE5,AMD
VFMSUBPD        ymmreg,ymmreg*,ymmrm256,ymmreg SSE5,AMD
VFMSUBPD        xmmreg,xmmreg*,xmmreg,xmmrm128 SSE5,AMD
VFMSUBPD        ymmreg,ymmreg*,ymmreg,ymmrm256 SSE5,AMD
VFMSUBPS        xmmreg,xmmreg*,xmmrm128,xmmreg SSE5,AMD
VFMSUBPS        ymmreg,ymmreg*,ymmrm256,ymmreg SSE5,AMD
VFMSUBPS        xmmreg,xmmreg*,xmmreg,xmmrm128 SSE5,AMD
VFMSUBPS        ymmreg,ymmreg*,ymmreg,ymmrm256 SSE5,AMD
VFMSUBSD        xmmreg,xmmreg*,xmmrm64,xmmreg SSE5,AMD
VFMSUBSD        xmmreg,xmmreg*,xmmreg,xmmrm64 SSE5,AMD
VFMSUBSS        xmmreg,xmmreg*,xmmrm32,xmmreg SSE5,AMD
VFMSUBSS        xmmreg,xmmreg*,xmmreg,xmmrm32 SSE5,AMD
```

```
VFNMADDPD       xmmreg,xmmreg*,xmmrm128,xmmreg SSE5,AMD
VFNMADDPD       ymmreg,ymmreg*,ymmrm256,ymmreg SSE5,AMD
VFNMADDPD       xmmreg,xmmreg*,xmmreg,xmmrm128 SSE5,AMD
VFNMADDPD       ymmreg,ymmreg*,ymmreg,ymmrm256 SSE5,AMD
VFNMADDPS       xmmreg,xmmreg*,xmmrm128,xmmreg SSE5,AMD
VFNMADDPS       ymmreg,ymmreg*,ymmrm256,ymmreg SSE5,AMD
VFNMADDPS       xmmreg,xmmreg*,xmmreg,xmmrm128 SSE5,AMD
VFNMADDPS       ymmreg,ymmreg*,ymmreg,ymmrm256 SSE5,AMD
VFNMADDSD       xmmreg,xmmreg*,xmmrm64,xmmreg SSE5,AMD
VFNMADDSD       xmmreg,xmmreg*,xmmreg,xmmrm64 SSE5,AMD
VFNMADDSS       xmmreg,xmmreg*,xmmrm32,xmmreg SSE5,AMD
VFNMADDSS       xmmreg,xmmreg*,xmmreg,xmmrm32 SSE5,AMD
VFNMSUBPD       xmmreg,xmmreg*,xmmrm128,xmmreg SSE5,AMD
VFNMSUBPD       ymmreg,ymmreg*,ymmrm256,ymmreg SSE5,AMD
VFNMSUBPD       xmmreg,xmmreg*,xmmreg,xmmrm128 SSE5,AMD
VFNMSUBPD       ymmreg,ymmreg*,ymmreg,ymmrm256 SSE5,AMD
VFNMSUBPS       xmmreg,xmmreg*,xmmrm128,xmmreg SSE5,AMD
VFNMSUBPS       ymmreg,ymmreg*,ymmrm256,ymmreg SSE5,AMD
VFNMSUBPS       xmmreg,xmmreg*,xmmreg,xmmrm128 SSE5,AMD
VFNMSUBPS       ymmreg,ymmreg*,ymmreg,ymmrm256 SSE5,AMD
VFNMSUBSD       xmmreg,xmmreg*,xmmrm64,xmmreg SSE5,AMD
VFNMSUBSD       xmmreg,xmmreg*,xmmreg,xmmrm64 SSE5,AMD
VFNMSUBSS       xmmreg,xmmreg*,xmmrm32,xmmreg SSE5,AMD
VFNMSUBSS       xmmreg,xmmreg*,xmmreg,xmmrm32 SSE5,AMD
VFRCZPD         xmmreg,xmmrm128*         SSE5,AMD
VFRCZPD         ymmreg,ymmrm256*         SSE5,AMD
VFRCZPS         xmmreg,xmmrm128*         SSE5,AMD
VFRCZPS         ymmreg,ymmrm256*         SSE5,AMD
VFRCZSD         xmmreg,xmmrm64*          SSE5,AMD
VFRCZSS         xmmreg,xmmrm32*          SSE5,AMD
VPCMOV          xmmreg,xmmreg*,xmmrm128,xmmreg SSE5,AMD
VPCMOV          ymmreg,ymmreg*,ymmrm256,ymmreg SSE5,AMD
VPCMOV          xmmreg,xmmreg*,xmmreg,xmmrm128 SSE5,AMD
VPCMOV          ymmreg,ymmreg*,ymmreg,ymmrm256 SSE5,AMD
VPCOMB          xmmreg,xmmreg*,xmmrm128,imm8 SSE5,AMD
VPCOMD          xmmreg,xmmreg*,xmmrm128,imm8 SSE5,AMD
VPCOMQ          xmmreg,xmmreg*,xmmrm128,imm8 SSE5,AMD
VPCOMUB         xmmreg,xmmreg*,xmmrm128,imm8 SSE5,AMD
VPCOMUD         xmmreg,xmmreg*,xmmrm128,imm8 SSE5,AMD
VPCOMUQ         xmmreg,xmmreg*,xmmrm128,imm8 SSE5,AMD
VPCOMUW         xmmreg,xmmreg*,xmmrm128,imm8 SSE5,AMD
VPCOMW          xmmreg,xmmreg*,xmmrm128,imm8 SSE5,AMD
VPHADDBD        xmmreg,xmmrm128*         SSE5,AMD
VPHADDBQ        xmmreg,xmmrm128*         SSE5,AMD
VPHADDBW        xmmreg,xmmrm128*         SSE5,AMD
VPHADDDQ        xmmreg,xmmrm128*         SSE5,AMD
VPHADDUBD       xmmreg,xmmrm128*         SSE5,AMD
VPHADDUBQ       xmmreg,xmmrm128*         SSE5,AMD
VPHADDUBW       xmmreg,xmmrm128*         SSE5,AMD
VPHADDUDQ       xmmreg,xmmrm128*         SSE5,AMD
VPHADDUWD       xmmreg,xmmrm128*         SSE5,AMD
VPHADDUWQ       xmmreg,xmmrm128*         SSE5,AMD
VPHADDWD        xmmreg,xmmrm128*         SSE5,AMD
VPHADDWQ        xmmreg,xmmrm128*         SSE5,AMD
VPHSUBBW        xmmreg,xmmrm128*         SSE5,AMD
VPHSUBDQ        xmmreg,xmmrm128*         SSE5,AMD
VPHSUBWD        xmmreg,xmmrm128*         SSE5,AMD
VPMACSDD        xmmreg,xmmreg*,xmmrm128,xmmreg SSE5,AMD
VPMACSDQH       xmmreg,xmmreg*,xmmrm128,xmmreg SSE5,AMD
VPMACSDQL       xmmreg,xmmreg*,xmmrm128,xmmreg SSE5,AMD
VPMACSSDD       xmmreg,xmmreg*,xmmrm128,xmmreg SSE5,AMD
VPMACSSDQH      xmmreg,xmmreg*,xmmrm128,xmmreg SSE5,AMD
VPMACSSDQL      xmmreg,xmmreg*,xmmrm128,xmmreg SSE5,AMD
VPMACSSWD       xmmreg,xmmreg*,xmmrm128,xmmreg SSE5,AMD
VPMACSSWW       xmmreg,xmmreg*,xmmrm128,xmmreg SSE5,AMD
VPMACSWD        xmmreg,xmmreg*,xmmrm128,xmmreg SSE5,AMD
VPMACSWW        xmmreg,xmmreg*,xmmrm128,xmmreg SSE5,AMD
```

```
VPMADCSSWD      xmmreg,xmmreg*,xmmrm128,xmmreg SSE5,AMD
VPMADCSWD       xmmreg,xmmreg*,xmmrm128,xmmreg SSE5,AMD
VPPERM          xmmreg,xmmreg*,xmmreg,xmmrm128 SSE5,AMD
VPPERM          xmmreg,xmmreg*,xmmrm128,xmmreg SSE5,AMD
VPROTB          xmmreg,xmmrm128*,xmmreg  SSE5,AMD
VPROTB          xmmreg,xmmreg*,xmmrm128  SSE5,AMD
VPROTB          xmmreg,xmmrm128*,imm8    SSE5,AMD
VPROTD          xmmreg,xmmrm128*,xmmreg  SSE5,AMD
VPROTD          xmmreg,xmmreg*,xmmrm128  SSE5,AMD
VPROTD          xmmreg,xmmrm128*,imm8    SSE5,AMD
VPROTQ          xmmreg,xmmrm128*,xmmreg  SSE5,AMD
VPROTQ          xmmreg,xmmreg*,xmmrm128  SSE5,AMD
VPROTQ          xmmreg,xmmrm128*,imm8    SSE5,AMD
VPROTW          xmmreg,xmmrm128*,xmmreg  SSE5,AMD
VPROTW          xmmreg,xmmreg*,xmmrm128  SSE5,AMD
VPROTW          xmmreg,xmmrm128*,imm8    SSE5,AMD
VPSHAB          xmmreg,xmmrm128*,xmmreg  SSE5,AMD
VPSHAB          xmmreg,xmmreg*,xmmrm128  SSE5,AMD
VPSHAD          xmmreg,xmmrm128*,xmmreg  SSE5,AMD
VPSHAD          xmmreg,xmmreg*,xmmrm128  SSE5,AMD
VPSHAQ          xmmreg,xmmrm128*,xmmreg  SSE5,AMD
VPSHAQ          xmmreg,xmmreg*,xmmrm128  SSE5,AMD
VPSHAW          xmmreg,xmmrm128*,xmmreg  SSE5,AMD
VPSHAW          xmmreg,xmmreg*,xmmrm128  SSE5,AMD
VPSHLB          xmmreg,xmmrm128*,xmmreg  SSE5,AMD
VPSHLB          xmmreg,xmmreg*,xmmrm128  SSE5,AMD
VPSHLD          xmmreg,xmmrm128*,xmmreg  SSE5,AMD
VPSHLD          xmmreg,xmmreg*,xmmrm128  SSE5,AMD
VPSHLQ          xmmreg,xmmrm128*,xmmreg  SSE5,AMD
VPSHLQ          xmmreg,xmmreg*,xmmrm128  SSE5,AMD
VPSHLW          xmmreg,xmmrm128*,xmmreg  SSE5,AMD
VPSHLW          xmmreg,xmmreg*,xmmrm128  SSE5,AMD
```

F.1.72 Intel AVX2 instructions

```
VMPSADBW        ymmreg,ymmreg*,ymmrm256,imm8 AVX2
VPABSB          ymmreg,ymmrm256          AVX2
VPABSW          ymmreg,ymmrm256          AVX2
VPABSD          ymmreg,ymmrm256          AVX2
VPACKSSWB       ymmreg,ymmreg*,ymmrm256  AVX2
VPACKSSDW       ymmreg,ymmreg*,ymmrm256  AVX2
VPACKUSDW       ymmreg,ymmreg*,ymmrm256  AVX2
VPACKUSWB       ymmreg,ymmreg*,ymmrm256  AVX2
VPADDB          ymmreg,ymmreg*,ymmrm256  AVX2
VPADDW          ymmreg,ymmreg*,ymmrm256  AVX2
VPADDD          ymmreg,ymmreg*,ymmrm256  AVX2
VPADDQ          ymmreg,ymmreg*,ymmrm256  AVX2
VPADDSB         ymmreg,ymmreg*,ymmrm256  AVX2
VPADDSW         ymmreg,ymmreg*,ymmrm256  AVX2
VPADDUSB        ymmreg,ymmreg*,ymmrm256  AVX2
VPADDUSW        ymmreg,ymmreg*,ymmrm256  AVX2
VPALIGNR        ymmreg,ymmreg*,ymmrm256,imm8 AVX2
VPAND           ymmreg,ymmreg*,ymmrm256  AVX2
VPANDN          ymmreg,ymmreg*,ymmrm256  AVX2
VPAVGB          ymmreg,ymmreg*,ymmrm256  AVX2
VPAVGW          ymmreg,ymmreg*,ymmrm256  AVX2
VPBLENDVB       ymmreg,ymmreg*,ymmrm256,ymmreg AVX2
VPBLENDW        ymmreg,ymmreg*,ymmrm256,imm8 AVX2
VPCMPEQB        ymmreg,ymmreg*,ymmrm256  AVX2
VPCMPEQW        ymmreg,ymmreg*,ymmrm256  AVX2
VPCMPEQD        ymmreg,ymmreg*,ymmrm256  AVX2
VPCMPEQQ        ymmreg,ymmreg*,ymmrm256  AVX2
VPCMPGTB        ymmreg,ymmreg*,ymmrm256  AVX2
VPCMPGTW        ymmreg,ymmreg*,ymmrm256  AVX2
VPCMPGTD        ymmreg,ymmreg*,ymmrm256  AVX2
VPCMPGTQ        ymmreg,ymmreg*,ymmrm256  AVX2
VPHADDW         ymmreg,ymmreg*,ymmrm256  AVX2
```

```
VPHADDD          ymmreg,ymmreg*,ymmrm256  AVX2
VPHADDSW         ymmreg,ymmreg*,ymmrm256  AVX2
VPHSUBW          ymmreg,ymmreg*,ymmrm256  AVX2
VPHSUBD          ymmreg,ymmreg*,ymmrm256  AVX2
VPHSUBSW         ymmreg,ymmreg*,ymmrm256  AVX2
VPMADDUBSW       ymmreg,ymmreg*,ymmrm256  AVX2
VPMADDWD         ymmreg,ymmreg*,ymmrm256  AVX2
VPMAXSB          ymmreg,ymmreg*,ymmrm256  AVX2
VPMAXSW          ymmreg,ymmreg*,ymmrm256  AVX2
VPMAXSD          ymmreg,ymmreg*,ymmrm256  AVX2
VPMAXUB          ymmreg,ymmreg*,ymmrm256  AVX2
VPMAXUW          ymmreg,ymmreg*,ymmrm256  AVX2
VPMAXUD          ymmreg,ymmreg*,ymmrm256  AVX2
VPMINSB          ymmreg,ymmreg*,ymmrm256  AVX2
VPMINSW          ymmreg,ymmreg*,ymmrm256  AVX2
VPMINSD          ymmreg,ymmreg*,ymmrm256  AVX2
VPMINUB          ymmreg,ymmreg*,ymmrm256  AVX2
VPMINUW          ymmreg,ymmreg*,ymmrm256  AVX2
VPMINUD          ymmreg,ymmreg*,ymmrm256  AVX2
VPMOVMSKB        reg32,ymmreg             AVX2
VPMOVMSKB        reg64,ymmreg             AVX2
VPMOVSXBW        ymmreg,xmmrm128          AVX2
VPMOVSXBD        ymmreg,mem64             AVX2
VPMOVSXBD        ymmreg,xmmreg            AVX2
VPMOVSXBQ        ymmreg,mem32             AVX2
VPMOVSXBQ        ymmreg,xmmreg            AVX2
VPMOVSXWD        ymmreg,xmmrm128          AVX2
VPMOVSXWQ        ymmreg,mem64             AVX2
VPMOVSXWQ        ymmreg,xmmreg            AVX2
VPMOVSXDQ        ymmreg,xmmrm128          AVX2
VPMOVZXBW        ymmreg,xmmrm128          AVX2
VPMOVZXBD        ymmreg,mem64             AVX2
VPMOVZXBD        ymmreg,xmmreg            AVX2
VPMOVZXBQ        ymmreg,mem32             AVX2
VPMOVZXBQ        ymmreg,xmmreg            AVX2
VPMOVZXWD        ymmreg,xmmrm128          AVX2
VPMOVZXWQ        ymmreg,mem64             AVX2
VPMOVZXWQ        ymmreg,xmmreg            AVX2
VPMOVZXDQ        ymmreg,xmmrm128          AVX2
VPMULDQ          ymmreg,ymmreg*,ymmrm256  AVX2
VPMULHRSW        ymmreg,ymmreg*,ymmrm256  AVX2
VPMULHUW         ymmreg,ymmreg*,ymmrm256  AVX2
VPMULHW          ymmreg,ymmreg*,ymmrm256  AVX2
VPMULLW          ymmreg,ymmreg*,ymmrm256  AVX2
VPMULLD          ymmreg,ymmreg*,ymmrm256  AVX2
VPMULUDQ         ymmreg,ymmreg*,ymmrm256  AVX2
VPOR             ymmreg,ymmreg*,ymmrm256  AVX2
VPSADBW          ymmreg,ymmreg*,ymmrm256  AVX2
VPSHUFB          ymmreg,ymmreg*,ymmrm256  AVX2
VPSHUFD          ymmreg,ymmrm256,imm8     AVX2
VPSHUFHW         ymmreg,ymmrm256,imm8     AVX2
VPSHUFLW         ymmreg,ymmrm256,imm8     AVX2
VPSIGNB          ymmreg,ymmreg*,ymmrm256  AVX2
VPSIGNW          ymmreg,ymmreg*,ymmrm256  AVX2
VPSIGND          ymmreg,ymmreg*,ymmrm256  AVX2
VPSLLDQ          ymmreg,ymmreg*,imm8      AVX2
VPSLLW           ymmreg,ymmreg*,xmmrm128  AVX2
VPSLLW           ymmreg,ymmreg*,imm8      AVX2
VPSLLD           ymmreg,ymmreg*,xmmrm128  AVX2
VPSLLD           ymmreg,ymmreg*,imm8      AVX2
VPSLLQ           ymmreg,ymmreg*,xmmrm128  AVX2
VPSLLQ           ymmreg,ymmreg*,imm8      AVX2
VPSRAW           ymmreg,ymmreg*,xmmrm128  AVX2
VPSRAW           ymmreg,ymmreg*,imm8      AVX2
VPSRAD           ymmreg,ymmreg*,xmmrm128  AVX2
VPSRAD           ymmreg,ymmreg*,imm8      AVX2
VPSRLDQ          ymmreg,ymmreg*,imm8      AVX2
```

```
VPSRLW          ymmreg,ymmreg*,xmmrm128  AVX2
VPSRLW          ymmreg,ymmreg*,imm8      AVX2
VPSRLD          ymmreg,ymmreg*,xmmrm128  AVX2
VPSRLD          ymmreg,ymmreg*,imm8      AVX2
VPSRLQ          ymmreg,ymmreg*,xmmrm128  AVX2
VPSRLQ          ymmreg,ymmreg*,imm8      AVX2
VPSUBB          ymmreg,ymmreg*,ymmrm256  AVX2
VPSUBW          ymmreg,ymmreg*,ymmrm256  AVX2
VPSUBD          ymmreg,ymmreg*,ymmrm256  AVX2
VPSUBQ          ymmreg,ymmreg*,ymmrm256  AVX2
VPSUBSB         ymmreg,ymmreg*,ymmrm256  AVX2
VPSUBSW         ymmreg,ymmreg*,ymmrm256  AVX2
VPSUBUSB        ymmreg,ymmreg*,ymmrm256  AVX2
VPSUBUSW        ymmreg,ymmreg*,ymmrm256  AVX2
VPUNPCKHBW      ymmreg,ymmreg*,ymmrm256  AVX2
VPUNPCKHWD      ymmreg,ymmreg*,ymmrm256  AVX2
VPUNPCKHDQ      ymmreg,ymmreg*,ymmrm256  AVX2
VPUNPCKHQDQ     ymmreg,ymmreg*,ymmrm256  AVX2
VPUNPCKLBW      ymmreg,ymmreg*,ymmrm256  AVX2
VPUNPCKLWD      ymmreg,ymmreg*,ymmrm256  AVX2
VPUNPCKLDQ      ymmreg,ymmreg*,ymmrm256  AVX2
VPUNPCKLQDQ     ymmreg,ymmreg*,ymmrm256  AVX2
VPXOR           ymmreg,ymmreg*,ymmrm256  AVX2
VMOVNTDQA       ymmreg,mem256            AVX2
VBROADCASTSS    xmmreg,xmmreg            AVX2
VBROADCASTSS    ymmreg,xmmreg            AVX2
VBROADCASTSD    ymmreg,xmmreg            AVX2
VBROADCASTI128  ymmreg,mem128            AVX2
VPBLENDD        xmmreg,xmmreg*,xmmrm128,imm8 AVX2
VPBLENDD        ymmreg,ymmreg*,ymmrm256,imm8 AVX2
VPBROADCASTB    xmmreg,mem8              AVX2
VPBROADCASTB    xmmreg,xmmreg            AVX2
VPBROADCASTB    ymmreg,mem8              AVX2
VPBROADCASTB    ymmreg,xmmreg            AVX2
VPBROADCASTW    xmmreg,mem16             AVX2
VPBROADCASTW    xmmreg,xmmreg            AVX2
VPBROADCASTW    ymmreg,mem16             AVX2
VPBROADCASTW    ymmreg,xmmreg            AVX2
VPBROADCASTD    xmmreg,mem32             AVX2
VPBROADCASTD    xmmreg,xmmreg            AVX2
VPBROADCASTD    ymmreg,mem32             AVX2
VPBROADCASTD    ymmreg,xmmreg            AVX2
VPBROADCASTQ    xmmreg,mem64             AVX2
VPBROADCASTQ    xmmreg,xmmreg            AVX2
VPBROADCASTQ    ymmreg,mem64             AVX2
VPBROADCASTQ    ymmreg,xmmreg            AVX2
VPERMD          ymmreg,ymmreg*,ymmrm256  AVX2
VPERMPD         ymmreg,ymmrm256,imm8     AVX2
VPERMPS         ymmreg,ymmreg*,ymmrm256  AVX2
VPERMQ          ymmreg,ymmrm256,imm8     AVX2
VPERM2I128      ymmreg,ymmreg*,ymmrm256,imm8 AVX2
VEXTRACTI128    xmmrm128,ymmreg,imm8     AVX2
VINSERTI128     ymmreg,ymmreg*,xmmrm128,imm8 AVX2
VPMASKMOVD      xmmreg,xmmreg*,mem128    AVX2
VPMASKMOVD      ymmreg,ymmreg*,mem256    AVX2
VPMASKMOVQ      xmmreg,xmmreg*,mem128    AVX2
VPMASKMOVQ      ymmreg,ymmreg*,mem256    AVX2
VPMASKMOVD      mem128,xmmreg,xmmreg     AVX2
VPMASKMOVD      mem256,ymmreg,ymmreg     AVX2
VPMASKMOVQ      mem128,xmmreg,xmmreg     AVX2
VPMASKMOVQ      mem256,ymmreg,ymmreg     AVX2
VPSLLVD         xmmreg,xmmreg*,xmmrm128  AVX2
VPSLLVQ         xmmreg,xmmreg*,xmmrm128  AVX2
VPSLLVD         ymmreg,ymmreg*,ymmrm256  AVX2
VPSLLVQ         ymmreg,ymmreg*,ymmrm256  AVX2
VPSRAVD         xmmreg,xmmreg*,xmmrm128  AVX2
VPSRAVD         ymmreg,ymmreg*,ymmrm256  AVX2
```

```
VPSRLVD         xmmreg,xmmreg*,xmmrm128  AVX2
VPSRLVQ         xmmreg,xmmreg*,xmmrm128  AVX2
VPSRLVD         ymmreg,ymmreg*,ymmrm256  AVX2
VPSRLVQ         ymmreg,ymmreg*,ymmrm256  AVX2
VGATHERDPD      xmmreg,xmem64,xmmreg     AVX2
VGATHERQPD      xmmreg,xmem64,xmmreg     AVX2
VGATHERDPD      ymmreg,xmem64,ymmreg     AVX2
VGATHERQPD      ymmreg,ymem64,ymmreg     AVX2
VGATHERDPS      xmmreg,xmem32,xmmreg     AVX2
VGATHERQPS      xmmreg,xmem32,xmmreg     AVX2
VGATHERDPS      ymmreg,ymem32,ymmreg     AVX2
VGATHERQPS      xmmreg,ymem32,xmmreg     AVX2
VPGATHERDD      xmmreg,xmem32,xmmreg     AVX2
VPGATHERQD      xmmreg,xmem32,xmmreg     AVX2
VPGATHERDD      ymmreg,ymem32,ymmreg     AVX2
VPGATHERQD      xmmreg,ymem32,xmmreg     AVX2
VPGATHERDQ      xmmreg,xmem64,xmmreg     AVX2
VPGATHERQQ      xmmreg,xmem64,xmmreg     AVX2
VPGATHERDQ      ymmreg,xmem64,ymmreg     AVX2
VPGATHERQQ      ymmreg,ymem64,ymmreg     AVX2
```

F.1.73 Intel Transactional Synchronization Extensions (TSX)

```
XABORT          imm8                     RTM
XBEGIN          imm16|near               AR0,OSIZE,NOREX,NOAPX,NOLONG,RTM
XBEGIN          imm32|near               AR0,OSIZE,NOREX,NOAPX,NOLONG,RTM
XBEGIN          imm64|near               AR0,OSIZE,LONG,PROT,RTM,X86_64
XBEGIN          imm32|near               ND,AR0,SX,LONG,PROT,RTM,X86_64
XEND                                     RTM
XTEST                                    HLE,FL,RTM
PREFETCHWT1     mem8                     PREFETCHWT1
```

F.1.74 Intel Memory Protection Extensions (MPX)

```
BNDMK           bndreg,mem               MIB,MPX
BNDCL           bndreg,mem               MPX
BNDCL           bndreg,reg32             NOREX,NOAPX,NOLONG,MPX
BNDCL           bndreg,reg64             LONG,PROT,MPX,X86_64
BNDCU           bndreg,mem               MPX
BNDCU           bndreg,reg32             NOREX,NOAPX,NOLONG,MPX
BNDCU           bndreg,reg64             LONG,PROT,MPX,X86_64
BNDCN           bndreg,mem               MPX
BNDCN           bndreg,reg32             NOREX,NOAPX,NOLONG,MPX
BNDCN           bndreg,reg64             LONG,PROT,MPX,X86_64
BNDMOV          bndreg,bndreg            MPX
BNDMOV          bndreg,mem               MPX
BNDMOV          bndreg,bndreg            MPX
BNDMOV          mem,bndreg               MPX
BNDLDX          bndreg,mem               MIB,MPX
BNDLDX          bndreg,mem,reg32         NOREX,NOAPX,NOLONG,MIB,MPX
BNDLDX          bndreg,mem,reg64         LONG,MIB,PROT,MPX,X86_64
BNDSTX          mem,bndreg               MIB,MPX
BNDSTX          mem,reg32,bndreg         NOREX,NOAPX,NOLONG,MIB,MPX
BNDSTX          mem,reg64,bndreg         LONG,MIB,PROT,MPX,X86_64
BNDSTX          mem,bndreg,reg32         NOREX,NOAPX,NOLONG,MIB,MPX
BNDSTX          mem,bndreg,reg64         LONG,MIB,PROT,MPX,X86_64
```

F.1.75 Intel SHA acceleration instructions

```
SHA1MSG1        xmmreg,xmmrm128          SHA
SHA1MSG2        xmmreg,xmmrm128          SHA
SHA1NEXTE       xmmreg,xmmrm128          SHA
SHA1RNDS4       xmmreg,xmmrm128,imm8     SHA
SHA256MSG1      xmmreg,xmmrm128          SHA
SHA256MSG2      xmmreg,xmmrm128          SHA
SHA256RNDS2     xmmreg,xmmrm128,xmm0     SHA
SHA256RNDS2     xmmreg,xmmrm128          SHA
VSHA512MSG1     ymmreg,xmmreg            AVX,SHA512
```

```
VSHA512MSG2     ymmreg,ymmreg           AVX,SHA512
VSHA512RNDS2    ymmreg,ymmreg,xmmreg    AVX,SHA512
```

F.1.76 S3M hash instructions

```
VSM3MSG1        xmmreg,xmmreg,xmmreg    AVX,HSM3
VSM3MSG2        xmmreg,xmmreg,xmmreg    AVX,HSM3
VSM3RNDS2       xmmreg,xmmreg,xmmreg,imm8 AVX,HSM3
```

F.1.77 SM4 hash instructions

```
VSM4KEY4        xmmreg,xmmreg,xmmrm128  AVX,HSM4
VSM4KEY4        ymmreg,ymmreg,ymmrm256  AVX,HSM4
VSM4KEY4        xmmreg,xmmreg,xmmrm128  AVX,HSM4
VSM4KEY4        ymmreg,ymmreg,ymmrm256  AVX,HSM4
VSM4KEY4        zmmreg,zmmreg,zmmrm512  AVX,HSM4
VSM4RNDS4       xmmreg,xmmreg,xmmrm128  AVX,HSM4
VSM4RNDS4       ymmreg,ymmreg,ymmrm256  AVX,HSM4
VSM4RNDS4       xmmreg,xmmreg,xmmrm128  AVX,HSM4
VSM4RNDS4       ymmreg,ymmreg,ymmrm256  AVX,HSM4
VSM4RNDS4       zmmreg,zmmreg,zmmrm512  AVX,HSM4
```

F.1.78 AVX no exception conversions

```
VBCSTNEBF16PS   xmmreg,mem16            AR0-1,SW,AVXNECONVERT
VBCSTNEBF16PS   ymmreg,mem16            AR0-1,SW,AVXNECONVERT
VBCSTNEBF162PS  xmmreg,mem16            AR0-1,SW,AVXNECONVERT
VBCSTNEBF162PS  ymmreg,mem16            AR0-1,SW,AVXNECONVERT
VBCSTNESH2PS    xmmreg,mem16            AR0-1,SW,AVXNECONVERT
VBCSTNESH2PS    ymmreg,mem16            AR0-1,SW,AVXNECONVERT
VCVTNEEBF162PS  xmmreg,mem128           AR0-1,SO,AVXNECONVERT
VCVTNEEBF162PS  ymmreg,mem256           AR0-1,SY,AVXNECONVERT
VCVTNEEPH2PS    xmmreg,mem128           AR0-1,SO,AVXNECONVERT
VCVTNEEPH2PS    ymmreg,mem256           AR0-1,SY,AVXNECONVERT
VCVTNEOBF162PS  xmmreg,mem128           AR0-1,SO,AVXNECONVERT
VCVTNEOBF162PS  ymmreg,mem256           AR0-1,SY,AVXNECONVERT
VCVTNEOPH2PS    xmmreg,mem128           AR0-1,SO,AVXNECONVERT
VCVTNEOPH2PS    ymmreg,mem256           AR0-1,SY,AVXNECONVERT
VCVTNEPS2BF16   xmmreg,xmmrm128         AR0-1,SO,LATEVEX,AVXNECONVERT
VCVTNEPS2BF16   xmmreg,ymmrm256         AR0-1,SY,LATEVEX,AVXNECONVERT
```

F.1.79 AVX Vector Neural Network Instructions

```
VPDPBUSD        xmmreg,xmmreg,xmmrm128  AR0-2,SO,LATEVEX,AVXVNNI
VPDPBUSD        ymmreg,ymmreg,ymmrm256  AR0-2,SY,LATEVEX,AVXVNNI
VPDPBUSDS       xmmreg,xmmreg,xmmrm128  AR0-2,SO,LATEVEX,AVXVNNI
VPDPBUSDS       ymmreg,ymmreg,ymmrm256  AR0-2,SY,LATEVEX,AVXVNNI
VPDPWSSD        xmmreg,xmmreg,xmmrm128  AR0-2,SO,LATEVEX,AVXVNNI
VPDPWSSD        ymmreg,ymmreg,ymmrm256  AR0-2,SY,LATEVEX,AVXVNNI
VPDPWSSDS       xmmreg,xmmreg,xmmrm128  AR0-2,SO,LATEVEX,AVXVNNI
VPDPWSSDS       ymmreg,ymmreg,ymmrm256  AR0-2,SY,LATEVEX,AVXVNNI
```

F.1.80 AVX Vector Neural Network Instructions INT8

```
VPDPBSSD        xmmreg,xmmreg,xmmrm128  AR0-2,SO,LATEVEX,AVX,AVXVNNIINT8
VPDPBSSD        ymmreg,ymmreg,ymmrm256  AR0-2,SY,LATEVEX,AVX,AVXVNNIINT8
VPDPBSSDS       xmmreg,xmmreg,xmmrm128  AR0-2,SO,LATEVEX,AVX,AVXVNNIINT8
VPDPBSSDS       ymmreg,ymmreg,ymmrm256  AR0-2,SY,LATEVEX,AVX,AVXVNNIINT8
VPDPBSUD        xmmreg,xmmreg,xmmrm128  AR0-2,SO,LATEVEX,AVX,AVXVNNIINT8
VPDPBSUD        ymmreg,ymmreg,ymmrm256  AR0-2,SY,LATEVEX,AVX,AVXVNNIINT8
VPDPBSUDS       xmmreg,xmmreg,xmmrm128  AR0-2,SO,LATEVEX,AVX,AVXVNNIINT8
VPDPBSUDS       ymmreg,ymmreg,ymmrm256  AR0-2,SY,LATEVEX,AVX,AVXVNNIINT8
VPDPBUUD        xmmreg,xmmreg,xmmrm128  AR0-2,SO,LATEVEX,AVX,AVXVNNIINT8
VPDPBUUD        ymmreg,ymmreg,ymmrm256  AR0-2,SY,LATEVEX,AVX,AVXVNNIINT8
VPDPBUUDS       xmmreg,xmmreg,xmmrm128  AR0-2,SO,LATEVEX,AVX,AVXVNNIINT8
VPDPBUUDS       ymmreg,ymmreg,ymmrm256  AR0-2,SY,LATEVEX,AVX,AVXVNNIINT8
```

F.1.81 AVX Vector Neural Network Instructions INT16

```
VPDPWSUD        xmmreg,xmmreg,xmmrm128   AR0-2,SO,LATEVEX,AVX,AVXVNNIINT16
VPDPWSUD        ymmreg,ymmreg,ymmrm256   AR0-2,SY,LATEVEX,AVX,AVXVNNIINT16
VPDPWSUDS       xmmreg,xmmreg,xmmrm128   AR0-2,SO,LATEVEX,AVX,AVXVNNIINT16
VPDPWSUDS       ymmreg,ymmreg,ymmrm256   AR0-2,SY,LATEVEX,AVX,AVXVNNIINT16
VPDPWUSD        xmmreg,xmmreg,xmmrm128   AR0-2,SO,LATEVEX,AVX,AVXVNNIINT16
VPDPWUSD        ymmreg,ymmreg,ymmrm256   AR0-2,SY,LATEVEX,AVX,AVXVNNIINT16
VPDPWUSDS       xmmreg,xmmreg,xmmrm128   AR0-2,SO,LATEVEX,AVX,AVXVNNIINT16
VPDPWUSDS       ymmreg,ymmreg,ymmrm256   AR0-2,SY,LATEVEX,AVX,AVXVNNIINT16
VPDPWUUD        xmmreg,xmmreg,xmmrm128   AR0-2,SO,LATEVEX,AVX,AVXVNNIINT16
VPDPWUUD        ymmreg,ymmreg,ymmrm256   AR0-2,SY,LATEVEX,AVX,AVXVNNIINT16
VPDPWUUDS       xmmreg,xmmreg,xmmrm128   AR0-2,SO,LATEVEX,AVX,AVXVNNIINT16
VPDPWUUDS       ymmreg,ymmreg,ymmrm256   AR0-2,SY,LATEVEX,AVX,AVXVNNIINT16
```

F.1.82 AVX Integer Fused Multiply-Add

```
VPMADD52HUQ     xmmreg,xmmreg,xmmrm128   AR0-2,SO,LATEVEX,AVXIFMA
VPMADD52HUQ     ymmreg,ymmreg,ymmrm256   AR0-2,SY,LATEVEX,AVXIFMA
VPMADD52LUQ     xmmreg,xmmreg,xmmrm128   AR0-2,SO,LATEVEX,AVXIFMA
VPMADD52LUQ     ymmreg,ymmreg,ymmrm256   AR0-2,SY,LATEVEX,AVXIFMA
```

F.1.83 AVX-512 mask register instructions

```
KMOVB           kreg8,krm8               AVX512DQ,ZU
KMOVW           kreg16,krm16             AVX512F,ZU
KMOVD           kreg32,krm32             AVX512BW,ZU
KMOVQ           kreg64,krm64             AVX512BW,ZU
KMOV            kreg8,krm8               AVX512DQ,ND,ZU
KMOV            kreg16,krm16             AVX512F,ND,ZU
KMOV            kreg32,krm32             AVX512BW,ND,ZU
KMOV            kreg64,krm64             AVX512BW,ND,ZU
MOVB            kreg8,krm8               AVX512DQ,ND,ZU
MOVW            kreg16,krm16             AVX512F,ND,ZU
MOVD            kreg32,krm32             AVX512BW,ND,ZU
MOVQ            kreg64,krm64             AVX512BW,ND,ZU
MOV             kreg8,krm8               AVX512DQ,ND,ZU
MOV             kreg16,krm16             AVX512F,ND,ZU
MOV             kreg32,krm32             AVX512BW,ND,ZU
MOV             kreg64,krm64             AVX512BW,ND,ZU
KMOVB           mem8,kreg8               AVX512DQ,ZU
KMOVW           mem16,kreg16             AVX512DQ,ZU
KMOVD           mem32,kreg32             AVX512BW,ZU
KMOVQ           mem64,kreg64             AVX512BW,ZU
KMOV            mem8,kreg8               AVX512DQ,ND,ZU
KMOV            mem16,kreg16             AVX512DQ,ND,ZU
KMOV            mem32,kreg32             AVX512BW,ND,ZU
KMOV            mem64,kreg64             AVX512BW,ND,ZU
MOVB            mem8,kreg8               AVX512DQ,ND,ZU
MOVW            mem16,kreg16             AVX512DQ,ND,ZU
MOVD            mem32,kreg32             AVX512BW,ND,ZU
MOVQ            mem64,kreg64             AVX512BW,ND,ZU
MOV             mem8,kreg8               AVX512DQ,ND,ZU
MOV             mem16,kreg16             AVX512DQ,ND,ZU
MOV             mem32,kreg32             AVX512BW,ND,ZU
MOV             mem64,kreg64             AVX512BW,ND,ZU
KMOVD           kreg32,reg32             AVX512BW,ZU
KMOVQ           kreg64,reg64             AVX512BW,ZU,LONG,PROT,X86_64
KMOV            kreg32,reg32             AVX512BW,ND,ZU
KMOV            kreg64,reg64             AVX512BW,ND,ZU,LONG,PROT,X86_64
MOVD            kreg32,reg32             AVX512BW,ND,ZU
MOVQ            kreg64,reg64             AVX512BW,ND,ZU,LONG,PROT,X86_64
MOV             kreg32,reg32             AVX512BW,ND,ZU
MOV             kreg64,reg64             AVX512BW,ND,ZU,LONG,PROT,X86_64
KMOVD           reg32,kreg32             AVX512BW,ZU
KMOVQ           reg64,kreg64             AVX512BW,ZU,LONG,PROT,X86_64
KMOV            reg32,kreg32             AVX512BW,ND,ZU
```

```
KMOV            reg64,kreg64            AVX512BW,ND,ZU,LONG,PROT,X86_64
MOVD            reg32,kreg32            AVX512BW,ND,ZU
MOVQ            reg64,kreg64            AVX512BW,ND,ZU,LONG,PROT,X86_64
MOV             reg32,kreg32            AVX512BW,ND,ZU
MOV             reg64,kreg64            AVX512BW,ND,ZU,LONG,PROT,X86_64
KMOVB           kreg8,reg32             AVX512DQ,ZU
KMOV            kreg8,reg32             AVX512DQ,ND,ZU
MOVB            kreg8,reg32             AVX512DQ,ND,ZU
MOV             kreg8,reg32             AVX512DQ,ND,ZU
KMOVB           kreg8,reg8              AVX512DQ,ND,ZU
KMOV            kreg8,reg8              AVX512DQ,ND,ZU
MOVB            kreg8,reg8              AVX512DQ,ND,ZU
MOV             kreg8,reg8              AVX512DQ,ND,ZU
KMOVW           kreg16,reg32            AVX512F,ZU
KMOV            kreg16,reg32            AVX512F,ND,ZU
MOVW            kreg16,reg32            AVX512F,ND,ZU
MOV             kreg16,reg32            AVX512F,ND,ZU
KMOVW           kreg16,reg16            AVX512F,ND,ZU
KMOV            kreg16,reg16            AVX512F,ND,ZU
MOVW            kreg16,reg16            AVX512F,ND,ZU
MOV             kreg16,reg16            AVX512F,ND,ZU
KMOVB           reg32,kreg8             AVX512DQ,ZU
KMOV            reg32,kreg8             AVX512DQ,ND,ZU
MOVB            reg32,kreg8             AVX512DQ,ND,ZU
MOV             reg32,kreg8             AVX512DQ,ND,ZU
KMOVW           reg32,kreg16            AVX512F,ZU
KMOV            reg32,kreg16            AVX512F,ND,ZU
MOVW            reg32,kreg16            AVX512F,ND,ZU
MOV             reg32,kreg16            AVX512F,ND,ZU
KADDB           kreg8,kreg8*,kreg8      AVX512DQ,ZU
KADDW           kreg16,kreg16*,kreg16   AVX512DQ,ZU
KADDD           kreg32,kreg32*,kreg32   AVX512BW,ZU
KADDQ           kreg64,kreg64*,kreg64   AVX512BW,ZU
KADD            kreg8,kreg8*,kreg8      AVX512DQ,SM0,ND,SM1-2,ZU
KADD            kreg16,kreg16*,kreg16   AVX512DQ,ND,SM0-2,ZU
KADD            kreg32,kreg32*,kreg32   AVX512BW,SM0,ND,SM1-2,ZU
KADD            kreg64,kreg64*,kreg64   AVX512BW,SM0,ND,SM1-2,ZU
ADDB            kreg8,kreg8*,kreg8      AVX512DQ,ND,ZU
ADDW            kreg16,kreg16*,kreg16   AVX512DQ,ND,ZU
ADDD            kreg32,kreg32*,kreg32   AVX512BW,ND,ZU
ADDQ            kreg64,kreg64*,kreg64   AVX512BW,ND,ZU
ADD             kreg8,kreg8*,kreg8      AVX512DQ,SM0,ND,SM1-2,ZU,FL
ADD             kreg16,kreg16*,kreg16   AVX512DQ,ND,SM0-2,ZU,FL
ADD             kreg32,kreg32*,kreg32   AVX512BW,ND,SM0-2,ZU,FL
ADD             kreg64,kreg64*,kreg64   AVX512BW,ND,SM0-2,ZU,FL
KANDB           kreg8,kreg8*,kreg8      AVX512DQ,ZU
KANDW           kreg16,kreg16*,kreg16   AVX512F,ZU
KANDD           kreg32,kreg32*,kreg32   AVX512BW,ZU
KANDQ           kreg64,kreg64*,kreg64   AVX512BW,ZU
KAND            kreg8,kreg8*,kreg8      AVX512DQ,ND,SM0-2,ZU
KAND            kreg16,kreg16*,kreg16   AVX512F,ND,SM0-2,ZU
KAND            kreg32,kreg32*,kreg32   AVX512BW,SM0,ND,SM1-2,ZU
KAND            kreg64,kreg64*,kreg64   AVX512BW,ND,SM0-2,ZU
ANDB            kreg8,kreg8*,kreg8      AVX512DQ,ND,ZU
ANDW            kreg16,kreg16*,kreg16   AVX512F,ND,ZU
ANDD            kreg32,kreg32*,kreg32   AVX512BW,ND,ZU
ANDQ            kreg64,kreg64*,kreg64   AVX512BW,ND,ZU
AND             kreg8,kreg8*,kreg8      AVX512DQ,SM0,ND,SM1-2,ZU,FL
AND             kreg16,kreg16*,kreg16   AVX512F,SM0,ND,SM1-2,ZU,FL
AND             kreg32,kreg32*,kreg32   AVX512BW,SM0,ND,SM1-2,ZU,FL
AND             kreg64,kreg64*,kreg64   AVX512BW,ND,SM0-2,ZU,FL
KANDNB          kreg8,kreg8*,kreg8      AVX512DQ,ZU
KANDNW          kreg16,kreg16*,kreg16   AVX512F,ZU
KANDND          kreg32,kreg32*,kreg32   AVX512BW,ZU
KANDNQ          kreg64,kreg64*,kreg64   AVX512BW,ZU
KANDN           kreg8,kreg8*,kreg8      AVX512DQ,ND,SM0-2,ZU
KANDN           kreg16,kreg16*,kreg16   AVX512F,SM0,ND,SM1-2,ZU
```

```
KANDN           kreg32,kreg32*,kreg32    AVX512BW,SM0,ND,SM1-2,ZU
KANDN           kreg64,kreg64*,kreg64    AVX512BW,ND,SM0-2,ZU
ANDNB           kreg8,kreg8*,kreg8       AVX512DQ,ND,ZU
ANDNW           kreg16,kreg16*,kreg16    AVX512F,ND,ZU
ANDND           kreg32,kreg32*,kreg32    AVX512BW,ND,ZU
ANDNQ           kreg64,kreg64*,kreg64    AVX512BW,ND,ZU
ANDN            kreg8,kreg8*,kreg8       AVX512DQ,SM0,ND,SM1-2,ZU,FL
ANDN            kreg16,kreg16*,kreg16    AVX512F,SM0,ND,SM1-2,ZU,FL
ANDN            kreg32,kreg32*,kreg32    AVX512BW,SM0,ND,SM1-2,ZU,FL
ANDN            kreg64,kreg64*,kreg64    AVX512BW,SM0,ND,SM1-2,ZU,FL
KNOTB           kreg8,kreg8*             AVX512DQ,ZU
KNOTW           kreg16,kreg16*           AVX512F,ZU
KNOTD           kreg32,kreg32*           AVX512BW,ZU
KNOTQ           kreg64,kreg64*           AVX512BW,ZU
KNOT            kreg8,kreg8*             AVX512DQ,SM0,ND,SM1,ZU
KNOT            kreg16,kreg16*           AVX512F,ND,SM0-1,ZU
KNOT            kreg32,kreg32*           AVX512BW,SM0,ND,SM1,ZU
KNOT            kreg64,kreg64*           AVX512BW,SM0,ND,SM1,ZU
NOTB            kreg8,kreg8*             AVX512DQ,ND,ZU
NOTW            kreg16,kreg16*           AVX512F,ND,ZU
NOTD            kreg32,kreg32*           AVX512BW,ND,ZU
NOTQ            kreg64,kreg64*           AVX512BW,ND,ZU
NOT             kreg8,kreg8*             AVX512DQ,ND,SM0-1,ZU
NOT             kreg16,kreg16*           AVX512F,ND,SM0-1,ZU
NOT             kreg32,kreg32*           AVX512BW,SM0,ND,SM1,ZU
NOT             kreg64,kreg64*           AVX512BW,SM0,ND,SM1,ZU
KORB            kreg8,kreg8*,kreg8       AVX512DQ,ZU
KORW            kreg16,kreg16*,kreg16    AVX512F,ZU
KORD            kreg32,kreg32*,kreg32    AVX512BW,ZU
KORQ            kreg64,kreg64*,kreg64    AVX512BW,ZU
KOR             kreg8,kreg8*,kreg8       AVX512DQ,SM0,ND,SM1-2,ZU
KOR             kreg16,kreg16*,kreg16    AVX512F,SM0,ND,SM1-2,ZU
KOR             kreg32,kreg32*,kreg32    AVX512BW,SM0,ND,SM1-2,ZU
KOR             kreg64,kreg64*,kreg64    AVX512BW,ND,SM0-2,ZU
ORB             kreg8,kreg8*,kreg8       AVX512DQ,ND,ZU
ORW             kreg16,kreg16*,kreg16    AVX512F,ND,ZU
ORD             kreg32,kreg32*,kreg32    AVX512BW,ND,ZU
ORQ             kreg64,kreg64*,kreg64    AVX512BW,ND,ZU
OR              kreg8,kreg8*,kreg8       AVX512DQ,SM0,ND,SM1-2,ZU,FL
OR              kreg16,kreg16*,kreg16    AVX512F,ND,SM0-2,ZU,FL
OR              kreg32,kreg32*,kreg32    AVX512BW,ND,SM0-2,ZU,FL
OR              kreg64,kreg64*,kreg64    AVX512BW,ND,SM0-2,ZU,FL
KORTESTB        kreg8,kreg8              AVX512DQ,ZU,FL
KORTESTW        kreg16,kreg16            AVX512F,ZU,FL
KORTESTD        kreg32,kreg32            AVX512BW,ZU,FL
KORTESTQ        kreg64,kreg64            AVX512BW,ZU,FL
KORTEST         kreg8,kreg8              AVX512DQ,ND,SM0-1,ZU,FL
KORTEST         kreg16,kreg16            AVX512F,SM0,ND,SM1,ZU,FL
KORTEST         kreg32,kreg32            AVX512BW,ND,SM0-1,ZU,FL
KORTEST         kreg64,kreg64            AVX512BW,SM0,ND,SM1,ZU,FL
ORTESTB         kreg8,kreg8              AVX512DQ,ND,ZU,FL
ORTESTW         kreg16,kreg16            AVX512F,ND,ZU,FL
ORTESTD         kreg32,kreg32            AVX512BW,ND,ZU,FL
ORTESTQ         kreg64,kreg64            AVX512BW,ND,ZU,FL
ORTEST          kreg8,kreg8              AVX512DQ,SM0,ND,SM1,ZU,FL
ORTEST          kreg16,kreg16            AVX512F,ND,SM0-1,ZU,FL
ORTEST          kreg32,kreg32            AVX512BW,SM0,ND,SM1,ZU,FL
ORTEST          kreg64,kreg64            AVX512BW,SM0,ND,SM1,ZU,FL
KSHIFTLB        kreg8,kreg8,imm8         AVX512DQ,ZU
KSHIFTLW        kreg16,kreg16,imm8       AVX512F,ZU
KSHIFTLD        kreg32,kreg32,imm8       AVX512BW,ZU
KSHIFTLQ        kreg64,kreg64,imm8       AVX512BW,ZU
KSHIFTL         kreg8,kreg8,imm8         AVX512DQ,ND,SM0-1,ZU
KSHIFTL         kreg16,kreg16,imm8       AVX512F,ND,SM0-1,ZU
KSHIFTL         kreg32,kreg32,imm8       AVX512BW,SM0,ND,SM1,ZU
KSHIFTL         kreg64,kreg64,imm8       AVX512BW,ND,SM0-1,ZU
SHIFTLB         kreg8,kreg8,imm8         AVX512DQ,ND,ZU
```

```
SHIFTLW         kreg16,kreg16,imm8      AVX512F,ND,ZU
SHIFTLD         kreg32,kreg32,imm8      AVX512BW,ND,ZU
SHIFTLQ         kreg64,kreg64,imm8      AVX512BW,ND,ZU
SHIFTL          kreg8,kreg8,imm8        AVX512DQ,SM0,ND,SM1,ZU
SHIFTL          kreg16,kreg16,imm8      AVX512F,ND,SM0-1,ZU
SHIFTL          kreg32,kreg32,imm8      AVX512BW,SM0,ND,SM1,ZU
SHIFTL          kreg64,kreg64,imm8      AVX512BW,ND,SM0-1,ZU
KSHLB           kreg8,kreg8,imm8        AVX512DQ,ND,ZU
KSHLW           kreg16,kreg16,imm8      AVX512F,ND,ZU
KSHLD           kreg32,kreg32,imm8      AVX512BW,ND,ZU
KSHLQ           kreg64,kreg64,imm8      AVX512BW,ND,ZU
KSHL            kreg8,kreg8,imm8        AVX512DQ,ND,SM0-1,ZU
KSHL            kreg16,kreg16,imm8      AVX512F,ND,SM0-1,ZU
KSHL            kreg32,kreg32,imm8      AVX512BW,ND,SM0-1,ZU
KSHL            kreg64,kreg64,imm8      AVX512BW,ND,SM0-1,ZU
SHLB            kreg8,kreg8,imm8        AVX512DQ,ND,ZU
SHLW            kreg16,kreg16,imm8      AVX512F,ND,ZU
SHLD            kreg32,kreg32,imm8      AVX512BW,ND,ZU,FL
SHLQ            kreg64,kreg64,imm8      AVX512BW,ND,ZU
SHL             kreg8,kreg8,imm8        AVX512DQ,ND,SM0-1,ZU,FL
SHL             kreg16,kreg16,imm8      AVX512F,SM0,ND,SM1,ZU,FL
SHL             kreg32,kreg32,imm8      AVX512BW,SM0,ND,SM1,ZU,FL
SHL             kreg64,kreg64,imm8      AVX512BW,SM0,ND,SM1,ZU,FL
KSHIFTRB        kreg8,kreg8,imm8        AVX512DQ,ZU
KSHIFTRW        kreg16,kreg16,imm8      AVX512F,ZU
KSHIFTRD        kreg32,kreg32,imm8      AVX512BW,ZU
KSHIFTRQ        kreg64,kreg64,imm8      AVX512BW,ZU
KSHIFTR         kreg8,kreg8,imm8        AVX512DQ,SM0,ND,SM1,ZU
KSHIFTR         kreg16,kreg16,imm8      AVX512F,SM0,ND,SM1,ZU
KSHIFTR         kreg32,kreg32,imm8      AVX512BW,SM0,ND,SM1,ZU
KSHIFTR         kreg64,kreg64,imm8      AVX512BW,ND,SM0-1,ZU
SHIFTRB         kreg8,kreg8,imm8        AVX512DQ,ND,ZU
SHIFTRW         kreg16,kreg16,imm8      AVX512F,ND,ZU
SHIFTRD         kreg32,kreg32,imm8      AVX512BW,ND,ZU
SHIFTRQ         kreg64,kreg64,imm8      AVX512BW,ND,ZU
SHIFTR          kreg8,kreg8,imm8        AVX512DQ,SM0,ND,SM1,ZU
SHIFTR          kreg16,kreg16,imm8      AVX512F,ND,SM0-1,ZU
SHIFTR          kreg32,kreg32,imm8      AVX512BW,ND,SM0-1,ZU
SHIFTR          kreg64,kreg64,imm8      AVX512BW,ND,SM0-1,ZU
KSHRB           kreg8,kreg8,imm8        AVX512DQ,ND,ZU
KSHRW           kreg16,kreg16,imm8      AVX512F,ND,ZU
KSHRD           kreg32,kreg32,imm8      AVX512BW,ND,ZU
KSHRQ           kreg64,kreg64,imm8      AVX512BW,ND,ZU
KSHR            kreg8,kreg8,imm8        AVX512DQ,ND,SM0-1,ZU
KSHR            kreg16,kreg16,imm8      AVX512F,SM0,ND,SM1,ZU
KSHR            kreg32,kreg32,imm8      AVX512BW,ND,SM0-1,ZU
KSHR            kreg64,kreg64,imm8      AVX512BW,SM0,ND,SM1,ZU
SHRB            kreg8,kreg8,imm8        AVX512DQ,ND,ZU
SHRW            kreg16,kreg16,imm8      AVX512F,ND,ZU
SHRD            kreg32,kreg32,imm8      AVX512BW,ND,ZU,FL
SHRQ            kreg64,kreg64,imm8      AVX512BW,ND,ZU
SHR             kreg8,kreg8,imm8        AVX512DQ,SM0,ND,SM1,ZU,FL
SHR             kreg16,kreg16,imm8      AVX512F,SM0,ND,SM1,ZU,FL
SHR             kreg32,kreg32,imm8      AVX512BW,ND,SM0-1,ZU,FL
SHR             kreg64,kreg64,imm8      AVX512BW,ND,SM0-1,ZU,FL
KTESTB          kreg8,kreg8             AVX512DQ,ZU,FL
KTESTW          kreg16,kreg16           AVX512DQ,ZU,FL
KTESTD          kreg32,kreg32           AVX512BW,ZU,FL
KTESTQ          kreg64,kreg64           AVX512BW,ZU,FL
KTEST           kreg8,kreg8             AVX512DQ,ND,SM0-1,ZU,FL
KTEST           kreg16,kreg16           AVX512DQ,SM0,ND,SM1,ZU,FL
KTEST           kreg32,kreg32           AVX512BW,SM0,ND,SM1,ZU,FL
KTEST           kreg64,kreg64           AVX512BW,SM0,ND,SM1,ZU,FL
TESTB           kreg8,kreg8             AVX512DQ,ND,ZU,FL
TESTW           kreg16,kreg16           AVX512DQ,ND,ZU,FL
TESTD           kreg32,kreg32           AVX512BW,ND,ZU,FL
TESTQ           kreg64,kreg64           AVX512BW,ND,ZU,FL
```

```
TEST            kreg8,kreg8             AVX512DQ,ND,SM0-1,ZU,FL
TEST            kreg16,kreg16           AVX512DQ,ND,SM0-1,ZU,FL
TEST            kreg32,kreg32           AVX512BW,SM0,ND,SM1,ZU,FL
TEST            kreg64,kreg64           AVX512BW,ND,SM0-1,ZU,FL
KUNPCKBW        kreg16,kreg8*,kreg8     AVX512F,ZU
KUNPCKW         kreg16,kreg8*,kreg8     AVX512F,ND,ZU
KUNPCK          kreg16,kreg8*,kreg8     AVX512F,ND,ZU
UNPCKBW         kreg16,kreg8*,kreg8     AVX512F,ND,ZU
UNPCKW          kreg16,kreg8*,kreg8     AVX512F,ND,ZU
UNPCK           kreg16,kreg8*,kreg8     AVX512F,ND,ZU
KUNPCKWD        kreg32,kreg16*,kreg16   AVX512BW,ZU
KUNPCKD         kreg32,kreg16*,kreg16   AVX512BW,ND,ZU
KUNPCK          kreg32,kreg16*,kreg16   AVX512BW,ND,ZU
UNPCKWD         kreg32,kreg16*,kreg16   AVX512BW,ND,ZU
UNPCKD          kreg32,kreg16*,kreg16   AVX512BW,ND,ZU
UNPCK           kreg32,kreg16*,kreg16   AVX512BW,ND,ZU
KUNPCKDQ        kreg64,kreg32*,kreg32   AVX512BW,ZU
KUNPCKQ         kreg64,kreg32*,kreg32   AVX512BW,ND,ZU
KUNPCK          kreg64,kreg32*,kreg32   AVX512BW,ND,ZU
UNPCKDQ         kreg64,kreg32*,kreg32   AVX512BW,ND,ZU
UNPCKQ          kreg64,kreg32*,kreg32   AVX512BW,ND,ZU
UNPCK           kreg64,kreg32*,kreg32   AVX512BW,ND,ZU
KXNORB          kreg8,kreg8*,kreg8      AVX512DQ,ZU
KXNORW          kreg16,kreg16*,kreg16   AVX512F,ZU
KXNORD          kreg32,kreg32*,kreg32   AVX512BW,ZU
KXNORQ          kreg64,kreg64*,kreg64   AVX512BW,ZU
KXNOR           kreg8,kreg8*,kreg8      AVX512DQ,ND,SM0-2,ZU
KXNOR           kreg16,kreg16*,kreg16   AVX512F,SM0,ND,SM1-2,ZU
KXNOR           kreg32,kreg32*,kreg32   AVX512BW,SM0,ND,SM1-2,ZU
KXNOR           kreg64,kreg64*,kreg64   AVX512BW,ND,SM0-2,ZU
XNORB           kreg8,kreg8*,kreg8      AVX512DQ,ND,ZU
XNORW           kreg16,kreg16*,kreg16   AVX512F,ND,ZU
XNORD           kreg32,kreg32*,kreg32   AVX512BW,ND,ZU
XNORQ           kreg64,kreg64*,kreg64   AVX512BW,ND,ZU
XNOR            kreg8,kreg8*,kreg8      AVX512DQ,ND,SM0-2,ZU
XNOR            kreg16,kreg16*,kreg16   AVX512F,ND,SM0-2,ZU
XNOR            kreg32,kreg32*,kreg32   AVX512BW,SM0,ND,SM1-2,ZU
XNOR            kreg64,kreg64*,kreg64   AVX512BW,SM0,ND,SM1-2,ZU
KXORB           kreg8,kreg8*,kreg8      AVX512DQ,ZU
KXORW           kreg16,kreg16*,kreg16   AVX512F,ZU
KXORD           kreg32,kreg32*,kreg32   AVX512BW,ZU
KXORQ           kreg64,kreg64*,kreg64   AVX512BW,ZU
KXOR            kreg8,kreg8*,kreg8      AVX512DQ,SM0,ND,SM1-2,ZU
KXOR            kreg16,kreg16*,kreg16   AVX512F,SM0,ND,SM1-2,ZU
KXOR            kreg32,kreg32*,kreg32   AVX512BW,SM0,ND,SM1-2,ZU
KXOR            kreg64,kreg64*,kreg64   AVX512BW,ND,SM0-2,ZU
XORB            kreg8,kreg8*,kreg8      AVX512DQ,ND,ZU
XORW            kreg16,kreg16*,kreg16   AVX512F,ND,ZU
XORD            kreg32,kreg32*,kreg32   AVX512BW,ND,ZU
XORQ            kreg64,kreg64*,kreg64   AVX512BW,ND,ZU
XOR             kreg8,kreg8*,kreg8      AVX512DQ,SM0,ND,SM1-2,ZU,FL
XOR             kreg16,kreg16*,kreg16   AVX512F,SM0,ND,SM1-2,ZU,FL
XOR             kreg32,kreg32*,kreg32   AVX512BW,SM0,ND,SM1-2,ZU,FL
XOR             kreg64,kreg64*,kreg64   AVX512BW,ND,SM0-2,ZU,FL
```

F.1.84 AVX-512 instructions

```
VADDPD          xmmreg|mask|z,xmmreg*,xmmrm128|b64 AVX512VL
VADDPD          ymmreg|mask|z,ymmreg*,ymmrm256|b64 AVX512VL
VADDPD          zmmreg|mask|z,zmmreg*,zmmrm512|b64|er AVX512
VADDPS          xmmreg|mask|z,xmmreg*,xmmrm128|b32 AVX512VL
VADDPS          ymmreg|mask|z,ymmreg*,ymmrm256|b32 AVX512VL
VADDPS          zmmreg|mask|z,zmmreg*,zmmrm512|b32|er AVX512
VADDSD          xmmreg|mask|z,xmmreg*,xmmrm64|er AVX512
VADDSS          xmmreg|mask|z,xmmreg*,xmmrm32|er AVX512
VALIGND         xmmreg|mask|z,xmmreg*,xmmrm128|b32,imm8 AVX512VL
VALIGND         ymmreg|mask|z,ymmreg*,ymmrm256|b32,imm8 AVX512VL
```

```
VALIGND          zmmreg|mask|z,zmmreg*,zmmrm512|b32,imm8 AVX512
VALIGNQ          xmmreg|mask|z,xmmreg*,xmmrm128|b64,imm8 AVX512VL
VALIGNQ          ymmreg|mask|z,ymmreg*,ymmrm256|b64,imm8 AVX512VL
VALIGNQ          zmmreg|mask|z,zmmreg*,zmmrm512|b64,imm8 AVX512
VANDNPD          xmmreg|mask|z,xmmreg*,xmmrm128|b64 AVX512VL/DQ
VANDNPD          ymmreg|mask|z,ymmreg*,ymmrm256|b64 AVX512VL/DQ
VANDNPD          zmmreg|mask|z,zmmreg*,zmmrm512|b64 AVX512DQ
VANDNPS          xmmreg|mask|z,xmmreg*,xmmrm128|b32 AVX512VL/DQ
VANDNPS          ymmreg|mask|z,ymmreg*,ymmrm256|b32 AVX512VL/DQ
VANDNPS          zmmreg|mask|z,zmmreg*,zmmrm512|b32 AVX512DQ
VANDPD           xmmreg|mask|z,xmmreg*,xmmrm128|b64 AVX512VL/DQ
VANDPD           ymmreg|mask|z,ymmreg*,ymmrm256|b64 AVX512VL/DQ
VANDPD           zmmreg|mask|z,zmmreg*,zmmrm512|b64 AVX512DQ
VANDPS           xmmreg|mask|z,xmmreg*,xmmrm128|b32 AVX512VL/DQ
VANDPS           ymmreg|mask|z,ymmreg*,ymmrm256|b32 AVX512VL/DQ
VANDPS           zmmreg|mask|z,zmmreg*,zmmrm512|b32 AVX512DQ
VBLENDMPD        xmmreg|mask|z,xmmreg,xmmrm128|b64 AVX512VL
VBLENDMPD        ymmreg|mask|z,ymmreg,ymmrm256|b64 AVX512VL
VBLENDMPD        zmmreg|mask|z,zmmreg,zmmrm512|b64 AVX512
VBLENDMPS        xmmreg|mask|z,xmmreg,xmmrm128|b32 AVX512VL
VBLENDMPS        ymmreg|mask|z,ymmreg,ymmrm256|b32 AVX512VL
VBLENDMPS        zmmreg|mask|z,zmmreg,zmmrm512|b32 AVX512
VBROADCASTF32X2  ymmreg|mask|z,xmmrm64    AVX512VL/DQ
VBROADCASTF32X2  zmmreg|mask|z,xmmrm64    AVX512DQ
VBROADCASTF32X4  ymmreg|mask|z,mem128     AVX512VL
VBROADCASTF32X4  zmmreg|mask|z,mem128     AVX512
VBROADCASTF32X8  zmmreg|mask|z,mem256     AVX512DQ
VBROADCASTF64X2  ymmreg|mask|z,mem128     AVX512VL/DQ
VBROADCASTF64X2  zmmreg|mask|z,mem128     AVX512DQ
VBROADCASTF64X4  zmmreg|mask|z,mem256     AVX512
VBROADCASTI32X2  xmmreg|mask|z,xmmrm64    AVX512VL/DQ
VBROADCASTI32X2  ymmreg|mask|z,xmmrm64    AVX512VL/DQ
VBROADCASTI32X2  zmmreg|mask|z,xmmrm64    AVX512DQ
VBROADCASTI32X4  ymmreg|mask|z,mem128     AVX512VL
VBROADCASTI32X4  zmmreg|mask|z,mem128     AVX512
VBROADCASTI32X8  zmmreg|mask|z,mem256     AVX512DQ
VBROADCASTI64X2  ymmreg|mask|z,mem128     AVX512VL/DQ
VBROADCASTI64X2  zmmreg|mask|z,mem128     AVX512DQ
VBROADCASTI64X4  zmmreg|mask|z,mem256     AVX512
VBROADCASTSD     ymmreg|mask|z,mem64      AVX512VL
VBROADCASTSD     zmmreg|mask|z,mem64      AVX512
VBROADCASTSD     ymmreg|mask|z,xmmreg     AVX512VL
VBROADCASTSD     zmmreg|mask|z,xmmreg     AVX512
VBROADCASTSS     xmmreg|mask|z,mem32      AVX512VL
VBROADCASTSS     ymmreg|mask|z,mem32      AVX512VL
VBROADCASTSS     zmmreg|mask|z,mem32      AVX512
VBROADCASTSS     xmmreg|mask|z,xmmreg     AVX512VL
VBROADCASTSS     ymmreg|mask|z,xmmreg     AVX512VL
VBROADCASTSS     zmmreg|mask|z,xmmreg     AVX512
VCMPEQPD         kreg|mask,xmmreg,xmmrm128|b64 AVX512VL
VCMPEQPD         kreg|mask,ymmreg,ymmrm256|b64 AVX512VL
VCMPEQPD         kreg|mask,zmmreg,zmmrm512|b64|sae AVX512
VCMPEQPS         kreg|mask,xmmreg,xmmrm128|b32 AVX512VL
VCMPEQPS         kreg|mask,ymmreg,ymmrm256|b32 AVX512VL
VCMPEQPS         kreg|mask,zmmreg,zmmrm512|b32|sae AVX512
VCMPEQSD         kreg|mask,xmmreg,xmmrm64|sae AVX512
VCMPEQSS         kreg|mask,xmmreg,xmmrm32|sae AVX512
VCMPEQ_OQPD      kreg|mask,xmmreg,xmmrm128|b64 AVX512VL
VCMPEQ_OQPD      kreg|mask,ymmreg,ymmrm256|b64 AVX512VL
VCMPEQ_OQPD      kreg|mask,zmmreg,zmmrm512|b64|sae AVX512
VCMPEQ_OQPS      kreg|mask,xmmreg,xmmrm128|b32 AVX512VL
VCMPEQ_OQPS      kreg|mask,ymmreg,ymmrm256|b32 AVX512VL
VCMPEQ_OQPS      kreg|mask,zmmreg,zmmrm512|b32|sae AVX512
VCMPEQ_OQSD      kreg|mask,xmmreg,xmmrm64|sae AVX512
VCMPEQ_OQSS      kreg|mask,xmmreg,xmmrm32|sae AVX512
VCMPLTPD         kreg|mask,xmmreg,xmmrm128|b64 AVX512VL
VCMPLTPD         kreg|mask,ymmreg,ymmrm256|b64 AVX512VL
```

```
VCMPLTPD        kreg|mask,zmmreg,zmmrm512|b64|sae AVX512
VCMPLTPS        kreg|mask,xmmreg,xmmrm128|b32 AVX512VL
VCMPLTPS        kreg|mask,ymmreg,ymmrm256|b32 AVX512VL
VCMPLTPS        kreg|mask,zmmreg,zmmrm512|b32|sae AVX512
VCMPLTSD        kreg|mask,xmmreg,xmmrm64|sae AVX512
VCMPLTSS        kreg|mask,xmmreg,xmmrm32|sae AVX512
VCMPLT_OSPD     kreg|mask,xmmreg,xmmrm128|b64 AVX512VL
VCMPLT_OSPD     kreg|mask,ymmreg,ymmrm256|b64 AVX512VL
VCMPLT_OSPD     kreg|mask,zmmreg,zmmrm512|b64|sae AVX512
VCMPLT_OSPS     kreg|mask,xmmreg,xmmrm128|b32 AVX512VL
VCMPLT_OSPS     kreg|mask,ymmreg,ymmrm256|b32 AVX512VL
VCMPLT_OSPS     kreg|mask,zmmreg,zmmrm512|b32|sae AVX512
VCMPLT_OSSD     kreg|mask,xmmreg,xmmrm64|sae AVX512
VCMPLT_OSSS     kreg|mask,xmmreg,xmmrm32|sae AVX512
VCMPLEPD        kreg|mask,xmmreg,xmmrm128|b64 AVX512VL
VCMPLEPD        kreg|mask,ymmreg,ymmrm256|b64 AVX512VL
VCMPLEPD        kreg|mask,zmmreg,zmmrm512|b64|sae AVX512
VCMPLEPS        kreg|mask,xmmreg,xmmrm128|b32 AVX512VL
VCMPLEPS        kreg|mask,ymmreg,ymmrm256|b32 AVX512VL
VCMPLEPS        kreg|mask,zmmreg,zmmrm512|b32|sae AVX512
VCMPLESD        kreg|mask,xmmreg,xmmrm64|sae AVX512
VCMPLESS        kreg|mask,xmmreg,xmmrm32|sae AVX512
VCMPLE_OSPD     kreg|mask,xmmreg,xmmrm128|b64 AVX512VL
VCMPLE_OSPD     kreg|mask,ymmreg,ymmrm256|b64 AVX512VL
VCMPLE_OSPD     kreg|mask,zmmreg,zmmrm512|b64|sae AVX512
VCMPLE_OSPS     kreg|mask,xmmreg,xmmrm128|b32 AVX512VL
VCMPLE_OSPS     kreg|mask,ymmreg,ymmrm256|b32 AVX512VL
VCMPLE_OSPS     kreg|mask,zmmreg,zmmrm512|b32|sae AVX512
VCMPLE_OSSD     kreg|mask,xmmreg,xmmrm64|sae AVX512
VCMPLE_OSSS     kreg|mask,xmmreg,xmmrm32|sae AVX512
VCMPUNORDPD     kreg|mask,xmmreg,xmmrm128|b64 AVX512VL
VCMPUNORDPD     kreg|mask,ymmreg,ymmrm256|b64 AVX512VL
VCMPUNORDPD     kreg|mask,zmmreg,zmmrm512|b64|sae AVX512
VCMPUNORDPS     kreg|mask,xmmreg,xmmrm128|b32 AVX512VL
VCMPUNORDPS     kreg|mask,ymmreg,ymmrm256|b32 AVX512VL
VCMPUNORDPS     kreg|mask,zmmreg,zmmrm512|b32|sae AVX512
VCMPUNORDSD     kreg|mask,xmmreg,xmmrm64|sae AVX512
VCMPUNORDSS     kreg|mask,xmmreg,xmmrm32|sae AVX512
VCMPUNORD_QPD   kreg|mask,xmmreg,xmmrm128|b64 AVX512VL
VCMPUNORD_QPD   kreg|mask,ymmreg,ymmrm256|b64 AVX512VL
VCMPUNORD_QPD   kreg|mask,zmmreg,zmmrm512|b64|sae AVX512
VCMPUNORD_QPS   kreg|mask,xmmreg,xmmrm128|b32 AVX512VL
VCMPUNORD_QPS   kreg|mask,ymmreg,ymmrm256|b32 AVX512VL
VCMPUNORD_QPS   kreg|mask,zmmreg,zmmrm512|b32|sae AVX512
VCMPUNORD_QSD   kreg|mask,xmmreg,xmmrm64|sae AVX512
VCMPUNORD_QSS   kreg|mask,xmmreg,xmmrm32|sae AVX512
VCMPNEQPD       kreg|mask,xmmreg,xmmrm128|b64 AVX512VL
VCMPNEQPD       kreg|mask,ymmreg,ymmrm256|b64 AVX512VL
VCMPNEQPD       kreg|mask,zmmreg,zmmrm512|b64|sae AVX512
VCMPNEQPS       kreg|mask,xmmreg,xmmrm128|b32 AVX512VL
VCMPNEQPS       kreg|mask,ymmreg,ymmrm256|b32 AVX512VL
VCMPNEQPS       kreg|mask,zmmreg,zmmrm512|b32|sae AVX512
VCMPNEQSD       kreg|mask,xmmreg,xmmrm64|sae AVX512
VCMPNEQSS       kreg|mask,xmmreg,xmmrm32|sae AVX512
VCMPNEQ_UQPD    kreg|mask,xmmreg,xmmrm128|b64 AVX512VL
VCMPNEQ_UQPD    kreg|mask,ymmreg,ymmrm256|b64 AVX512VL
VCMPNEQ_UQPD    kreg|mask,zmmreg,zmmrm512|b64|sae AVX512
VCMPNEQ_UQPS    kreg|mask,xmmreg,xmmrm128|b32 AVX512VL
VCMPNEQ_UQPS    kreg|mask,ymmreg,ymmrm256|b32 AVX512VL
VCMPNEQ_UQPS    kreg|mask,zmmreg,zmmrm512|b32|sae AVX512
VCMPNEQ_UQSD    kreg|mask,xmmreg,xmmrm64|sae AVX512
VCMPNEQ_UQSS    kreg|mask,xmmreg,xmmrm32|sae AVX512
VCMPNLTPD       kreg|mask,xmmreg,xmmrm128|b64 AVX512VL
VCMPNLTPD       kreg|mask,ymmreg,ymmrm256|b64 AVX512VL
VCMPNLTPD       kreg|mask,zmmreg,zmmrm512|b64|sae AVX512
VCMPNLTPS       kreg|mask,xmmreg,xmmrm128|b32 AVX512VL
VCMPNLTPS       kreg|mask,ymmreg,ymmrm256|b32 AVX512VL
```

```
VCMPNLTPS       kreg|mask,zmmreg,zmmrm512|b32|sae AVX512
VCMPNLTSD       kreg|mask,xmmreg,xmmrm64|sae AVX512
VCMPNLTSS       kreg|mask,xmmreg,xmmrm32|sae AVX512
VCMPNLT_USPD    kreg|mask,xmmreg,xmmrm128|b64 AVX512VL
VCMPNLT_USPD    kreg|mask,ymmreg,ymmrm256|b64 AVX512VL
VCMPNLT_USPD    kreg|mask,zmmreg,zmmrm512|b64|sae AVX512
VCMPNLT_USPS    kreg|mask,xmmreg,xmmrm128|b32 AVX512VL
VCMPNLT_USPS    kreg|mask,ymmreg,ymmrm256|b32 AVX512VL
VCMPNLT_USPS    kreg|mask,zmmreg,zmmrm512|b32|sae AVX512
VCMPNLT_USSD    kreg|mask,xmmreg,xmmrm64|sae AVX512
VCMPNLT_USSS    kreg|mask,xmmreg,xmmrm32|sae AVX512
VCMPNLEPD       kreg|mask,xmmreg,xmmrm128|b64 AVX512VL
VCMPNLEPD       kreg|mask,ymmreg,ymmrm256|b64 AVX512VL
VCMPNLEPD       kreg|mask,zmmreg,zmmrm512|b64|sae AVX512
VCMPNLEPS       kreg|mask,xmmreg,xmmrm128|b32 AVX512VL
VCMPNLEPS       kreg|mask,ymmreg,ymmrm256|b32 AVX512VL
VCMPNLEPS       kreg|mask,zmmreg,zmmrm512|b32|sae AVX512
VCMPNLESD       kreg|mask,xmmreg,xmmrm64|sae AVX512
VCMPNLESS       kreg|mask,xmmreg,xmmrm32|sae AVX512
VCMPNLE_USPD    kreg|mask,xmmreg,xmmrm128|b64 AVX512VL
VCMPNLE_USPD    kreg|mask,ymmreg,ymmrm256|b64 AVX512VL
VCMPNLE_USPD    kreg|mask,zmmreg,zmmrm512|b64|sae AVX512
VCMPNLE_USPS    kreg|mask,xmmreg,xmmrm128|b32 AVX512VL
VCMPNLE_USPS    kreg|mask,ymmreg,ymmrm256|b32 AVX512VL
VCMPNLE_USPS    kreg|mask,zmmreg,zmmrm512|b32|sae AVX512
VCMPNLE_USSD    kreg|mask,xmmreg,xmmrm64|sae AVX512
VCMPNLE_USSS    kreg|mask,xmmreg,xmmrm32|sae AVX512
VCMPORDPD       kreg|mask,xmmreg,xmmrm128|b64 AVX512VL
VCMPORDPD       kreg|mask,ymmreg,ymmrm256|b64 AVX512VL
VCMPORDPD       kreg|mask,zmmreg,zmmrm512|b64|sae AVX512
VCMPORDPS       kreg|mask,xmmreg,xmmrm128|b32 AVX512VL
VCMPORDPS       kreg|mask,ymmreg,ymmrm256|b32 AVX512VL
VCMPORDPS       kreg|mask,zmmreg,zmmrm512|b32|sae AVX512
VCMPORDSD       kreg|mask,xmmreg,xmmrm64|sae AVX512
VCMPORDSS       kreg|mask,xmmreg,xmmrm32|sae AVX512
VCMPORD_QPD     kreg|mask,xmmreg,xmmrm128|b64 AVX512VL
VCMPORD_QPD     kreg|mask,ymmreg,ymmrm256|b64 AVX512VL
VCMPORD_QPD     kreg|mask,zmmreg,zmmrm512|b64|sae AVX512
VCMPORD_QPS     kreg|mask,xmmreg,xmmrm128|b32 AVX512VL
VCMPORD_QPS     kreg|mask,ymmreg,ymmrm256|b32 AVX512VL
VCMPORD_QPS     kreg|mask,zmmreg,zmmrm512|b32|sae AVX512
VCMPORD_QSD     kreg|mask,xmmreg,xmmrm64|sae AVX512
VCMPORD_QSS     kreg|mask,xmmreg,xmmrm32|sae AVX512
VCMPEQ_UQPD     kreg|mask,xmmreg,xmmrm128|b64 AVX512VL
VCMPEQ_UQPD     kreg|mask,ymmreg,ymmrm256|b64 AVX512VL
VCMPEQ_UQPD     kreg|mask,zmmreg,zmmrm512|b64|sae AVX512
VCMPEQ_UQPS     kreg|mask,xmmreg,xmmrm128|b32 AVX512VL
VCMPEQ_UQPS     kreg|mask,ymmreg,ymmrm256|b32 AVX512VL
VCMPEQ_UQPS     kreg|mask,zmmreg,zmmrm512|b32|sae AVX512
VCMPEQ_UQSD     kreg|mask,xmmreg,xmmrm64|sae AVX512
VCMPEQ_UQSS     kreg|mask,xmmreg,xmmrm32|sae AVX512
VCMPNGEPD       kreg|mask,xmmreg,xmmrm128|b64 AVX512VL
VCMPNGEPD       kreg|mask,ymmreg,ymmrm256|b64 AVX512VL
VCMPNGEPD       kreg|mask,zmmreg,zmmrm512|b64|sae AVX512
VCMPNGEPS       kreg|mask,xmmreg,xmmrm128|b32 AVX512VL
VCMPNGEPS       kreg|mask,ymmreg,ymmrm256|b32 AVX512VL
VCMPNGEPS       kreg|mask,zmmreg,zmmrm512|b32|sae AVX512
VCMPNGESD       kreg|mask,xmmreg,xmmrm64|sae AVX512
VCMPNGESS       kreg|mask,xmmreg,xmmrm32|sae AVX512
VCMPNGE_USPD    kreg|mask,xmmreg,xmmrm128|b64 AVX512VL
VCMPNGE_USPD    kreg|mask,ymmreg,ymmrm256|b64 AVX512VL
VCMPNGE_USPD    kreg|mask,zmmreg,zmmrm512|b64|sae AVX512
VCMPNGE_USPS    kreg|mask,xmmreg,xmmrm128|b32 AVX512VL
VCMPNGE_USPS    kreg|mask,ymmreg,ymmrm256|b32 AVX512VL
VCMPNGE_USPS    kreg|mask,zmmreg,zmmrm512|b32|sae AVX512
VCMPNGE_USSD    kreg|mask,xmmreg,xmmrm64|sae AVX512
VCMPNGE_USSS    kreg|mask,xmmreg,xmmrm32|sae AVX512
```

```
VCMPNGTPD        kreg|mask,xmmreg,xmmrm128|b64 AVX512VL
VCMPNGTPD        kreg|mask,ymmreg,ymmrm256|b64 AVX512VL
VCMPNGTPD        kreg|mask,zmmreg,zmmrm512|b64|sae AVX512
VCMPNGTPS        kreg|mask,xmmreg,xmmrm128|b32 AVX512VL
VCMPNGTPS        kreg|mask,ymmreg,ymmrm256|b32 AVX512VL
VCMPNGTPS        kreg|mask,zmmreg,zmmrm512|b32|sae AVX512
VCMPNGTSD        kreg|mask,xmmreg,xmmrm64|sae AVX512
VCMPNGTSS        kreg|mask,xmmreg,xmmrm32|sae AVX512
VCMPNGT_USPD     kreg|mask,xmmreg,xmmrm128|b64 AVX512VL
VCMPNGT_USPD     kreg|mask,ymmreg,ymmrm256|b64 AVX512VL
VCMPNGT_USPD     kreg|mask,zmmreg,zmmrm512|b64|sae AVX512
VCMPNGT_USPS     kreg|mask,xmmreg,xmmrm128|b32 AVX512VL
VCMPNGT_USPS     kreg|mask,ymmreg,ymmrm256|b32 AVX512VL
VCMPNGT_USPS     kreg|mask,zmmreg,zmmrm512|b32|sae AVX512
VCMPNGT_USSD     kreg|mask,xmmreg,xmmrm64|sae AVX512
VCMPNGT_USSS     kreg|mask,xmmreg,xmmrm32|sae AVX512
VCMPFALSEPD      kreg|mask,xmmreg,xmmrm128|b64 AVX512VL
VCMPFALSEPD      kreg|mask,ymmreg,ymmrm256|b64 AVX512VL
VCMPFALSEPD      kreg|mask,zmmreg,zmmrm512|b64|sae AVX512
VCMPFALSEPS      kreg|mask,xmmreg,xmmrm128|b32 AVX512VL
VCMPFALSEPS      kreg|mask,ymmreg,ymmrm256|b32 AVX512VL
VCMPFALSEPS      kreg|mask,zmmreg,zmmrm512|b32|sae AVX512
VCMPFALSESD      kreg|mask,xmmreg,xmmrm64|sae AVX512
VCMPFALSESS      kreg|mask,xmmreg,xmmrm32|sae AVX512
VCMPFALSE_OQPD   kreg|mask,xmmreg,xmmrm128|b64 AVX512VL
VCMPFALSE_OQPD   kreg|mask,ymmreg,ymmrm256|b64 AVX512VL
VCMPFALSE_OQPD   kreg|mask,zmmreg,zmmrm512|b64|sae AVX512
VCMPFALSE_OQPS   kreg|mask,xmmreg,xmmrm128|b32 AVX512VL
VCMPFALSE_OQPS   kreg|mask,ymmreg,ymmrm256|b32 AVX512VL
VCMPFALSE_OQPS   kreg|mask,zmmreg,zmmrm512|b32|sae AVX512
VCMPFALSE_OQSD   kreg|mask,xmmreg,xmmrm64|sae AVX512
VCMPFALSE_OQSS   kreg|mask,xmmreg,xmmrm32|sae AVX512
VCMPNEQ_OQPD     kreg|mask,xmmreg,xmmrm128|b64 AVX512VL
VCMPNEQ_OQPD     kreg|mask,ymmreg,ymmrm256|b64 AVX512VL
VCMPNEQ_OQPD     kreg|mask,zmmreg,zmmrm512|b64|sae AVX512
VCMPNEQ_OQPS     kreg|mask,xmmreg,xmmrm128|b32 AVX512VL
VCMPNEQ_OQPS     kreg|mask,ymmreg,ymmrm256|b32 AVX512VL
VCMPNEQ_OQPS     kreg|mask,zmmreg,zmmrm512|b32|sae AVX512
VCMPNEQ_OQSD     kreg|mask,xmmreg,xmmrm64|sae AVX512
VCMPNEQ_OQSS     kreg|mask,xmmreg,xmmrm32|sae AVX512
VCMPGEPD         kreg|mask,xmmreg,xmmrm128|b64 AVX512VL
VCMPGEPD         kreg|mask,ymmreg,ymmrm256|b64 AVX512VL
VCMPGEPD         kreg|mask,zmmreg,zmmrm512|b64|sae AVX512
VCMPGEPS         kreg|mask,xmmreg,xmmrm128|b32 AVX512VL
VCMPGEPS         kreg|mask,ymmreg,ymmrm256|b32 AVX512VL
VCMPGEPS         kreg|mask,zmmreg,zmmrm512|b32|sae AVX512
VCMPGESD         kreg|mask,xmmreg,xmmrm64|sae AVX512
VCMPGESS         kreg|mask,xmmreg,xmmrm32|sae AVX512
VCMPGE_OSPD      kreg|mask,xmmreg,xmmrm128|b64 AVX512VL
VCMPGE_OSPD      kreg|mask,ymmreg,ymmrm256|b64 AVX512VL
VCMPGE_OSPD      kreg|mask,zmmreg,zmmrm512|b64|sae AVX512
VCMPGE_OSPS      kreg|mask,xmmreg,xmmrm128|b32 AVX512VL
VCMPGE_OSPS      kreg|mask,ymmreg,ymmrm256|b32 AVX512VL
VCMPGE_OSPS      kreg|mask,zmmreg,zmmrm512|b32|sae AVX512
VCMPGE_OSSD      kreg|mask,xmmreg,xmmrm64|sae AVX512
VCMPGE_OSSS      kreg|mask,xmmreg,xmmrm32|sae AVX512
VCMPGTPD         kreg|mask,xmmreg,xmmrm128|b64 AVX512VL
VCMPGTPD         kreg|mask,ymmreg,ymmrm256|b64 AVX512VL
VCMPGTPD         kreg|mask,zmmreg,zmmrm512|b64|sae AVX512
VCMPGTPS         kreg|mask,xmmreg,xmmrm128|b32 AVX512VL
VCMPGTPS         kreg|mask,ymmreg,ymmrm256|b32 AVX512VL
VCMPGTPS         kreg|mask,zmmreg,zmmrm512|b32|sae AVX512
VCMPGTSD         kreg|mask,xmmreg,xmmrm64|sae AVX512
VCMPGTSS         kreg|mask,xmmreg,xmmrm32|sae AVX512
VCMPGT_OSPD      kreg|mask,xmmreg,xmmrm128|b64 AVX512VL
VCMPGT_OSPD      kreg|mask,ymmreg,ymmrm256|b64 AVX512VL
VCMPGT_OSPD      kreg|mask,zmmreg,zmmrm512|b64|sae AVX512
```

```
VCMPGT_OSPS      kreg|mask,xmmreg,xmmrm128|b32 AVX512VL
VCMPGT_OSPS      kreg|mask,ymmreg,ymmrm256|b32 AVX512VL
VCMPGT_OSPS      kreg|mask,zmmreg,zmmrm512|b32|sae AVX512
VCMPGT_OSSD      kreg|mask,xmmreg,xmmrm64|sae AVX512
VCMPGT_OSSS      kreg|mask,xmmreg,xmmrm32|sae AVX512
VCMPTRUEPD       kreg|mask,xmmreg,xmmrm128|b64 AVX512VL
VCMPTRUEPD       kreg|mask,ymmreg,ymmrm256|b64 AVX512VL
VCMPTRUEPD       kreg|mask,zmmreg,zmmrm512|b64|sae AVX512
VCMPTRUEPS       kreg|mask,xmmreg,xmmrm128|b32 AVX512VL
VCMPTRUEPS       kreg|mask,ymmreg,ymmrm256|b32 AVX512VL
VCMPTRUEPS       kreg|mask,zmmreg,zmmrm512|b32|sae AVX512
VCMPTRUESD       kreg|mask,xmmreg,xmmrm64|sae AVX512
VCMPTRUESS       kreg|mask,xmmreg,xmmrm32|sae AVX512
VCMPTRUE_UQPD    kreg|mask,xmmreg,xmmrm128|b64 AVX512VL
VCMPTRUE_UQPD    kreg|mask,ymmreg,ymmrm256|b64 AVX512VL
VCMPTRUE_UQPD    kreg|mask,zmmreg,zmmrm512|b64|sae AVX512
VCMPTRUE_UQPS    kreg|mask,xmmreg,xmmrm128|b32 AVX512VL
VCMPTRUE_UQPS    kreg|mask,ymmreg,ymmrm256|b32 AVX512VL
VCMPTRUE_UQPS    kreg|mask,zmmreg,zmmrm512|b32|sae AVX512
VCMPTRUE_UQSD    kreg|mask,xmmreg,xmmrm64|sae AVX512
VCMPTRUE_UQSS    kreg|mask,xmmreg,xmmrm32|sae AVX512
VCMPEQ_OSPD      kreg|mask,xmmreg,xmmrm128|b64 AVX512VL
VCMPEQ_OSPD      kreg|mask,ymmreg,ymmrm256|b64 AVX512VL
VCMPEQ_OSPD      kreg|mask,zmmreg,zmmrm512|b64|sae AVX512
VCMPEQ_OSPS      kreg|mask,xmmreg,xmmrm128|b32 AVX512VL
VCMPEQ_OSPS      kreg|mask,ymmreg,ymmrm256|b32 AVX512VL
VCMPEQ_OSPS      kreg|mask,zmmreg,zmmrm512|b32|sae AVX512
VCMPEQ_OSSD      kreg|mask,xmmreg,xmmrm64|sae AVX512
VCMPEQ_OSSS      kreg|mask,xmmreg,xmmrm32|sae AVX512
VCMPLT_OQPD      kreg|mask,xmmreg,xmmrm128|b64 AVX512VL
VCMPLT_OQPD      kreg|mask,ymmreg,ymmrm256|b64 AVX512VL
VCMPLT_OQPD      kreg|mask,zmmreg,zmmrm512|b64|sae AVX512
VCMPLT_OQPS      kreg|mask,xmmreg,xmmrm128|b32 AVX512VL
VCMPLT_OQPS      kreg|mask,ymmreg,ymmrm256|b32 AVX512VL
VCMPLT_OQPS      kreg|mask,zmmreg,zmmrm512|b32|sae AVX512
VCMPLT_OQSD      kreg|mask,xmmreg,xmmrm64|sae AVX512
VCMPLT_OQSS      kreg|mask,xmmreg,xmmrm32|sae AVX512
VCMPLE_OQPD      kreg|mask,xmmreg,xmmrm128|b64 AVX512VL
VCMPLE_OQPD      kreg|mask,ymmreg,ymmrm256|b64 AVX512VL
VCMPLE_OQPD      kreg|mask,zmmreg,zmmrm512|b64|sae AVX512
VCMPLE_OQPS      kreg|mask,xmmreg,xmmrm128|b32 AVX512VL
VCMPLE_OQPS      kreg|mask,ymmreg,ymmrm256|b32 AVX512VL
VCMPLE_OQPS      kreg|mask,zmmreg,zmmrm512|b32|sae AVX512
VCMPLE_OQSD      kreg|mask,xmmreg,xmmrm64|sae AVX512
VCMPLE_OQSS      kreg|mask,xmmreg,xmmrm32|sae AVX512
VCMPUNORD_SPD    kreg|mask,xmmreg,xmmrm128|b64 AVX512VL
VCMPUNORD_SPD    kreg|mask,ymmreg,ymmrm256|b64 AVX512VL
VCMPUNORD_SPD    kreg|mask,zmmreg,zmmrm512|b64|sae AVX512
VCMPUNORD_SPS    kreg|mask,xmmreg,xmmrm128|b32 AVX512VL
VCMPUNORD_SPS    kreg|mask,ymmreg,ymmrm256|b32 AVX512VL
VCMPUNORD_SPS    kreg|mask,zmmreg,zmmrm512|b32|sae AVX512
VCMPUNORD_SSD    kreg|mask,xmmreg,xmmrm64|sae AVX512
VCMPUNORD_SSS    kreg|mask,xmmreg,xmmrm32|sae AVX512
VCMPNEQ_USPD     kreg|mask,xmmreg,xmmrm128|b64 AVX512VL
VCMPNEQ_USPD     kreg|mask,ymmreg,ymmrm256|b64 AVX512VL
VCMPNEQ_USPD     kreg|mask,zmmreg,zmmrm512|b64|sae AVX512
VCMPNEQ_USPS     kreg|mask,xmmreg,xmmrm128|b32 AVX512VL
VCMPNEQ_USPS     kreg|mask,ymmreg,ymmrm256|b32 AVX512VL
VCMPNEQ_USPS     kreg|mask,zmmreg,zmmrm512|b32|sae AVX512
VCMPNEQ_USSD     kreg|mask,xmmreg,xmmrm64|sae AVX512
VCMPNEQ_USSS     kreg|mask,xmmreg,xmmrm32|sae AVX512
VCMPNLT_UQPD     kreg|mask,xmmreg,xmmrm128|b64 AVX512VL
VCMPNLT_UQPD     kreg|mask,ymmreg,ymmrm256|b64 AVX512VL
VCMPNLT_UQPD     kreg|mask,zmmreg,zmmrm512|b64|sae AVX512
VCMPNLT_UQPS     kreg|mask,xmmreg,xmmrm128|b32 AVX512VL
VCMPNLT_UQPS     kreg|mask,ymmreg,ymmrm256|b32 AVX512VL
VCMPNLT_UQPS     kreg|mask,zmmreg,zmmrm512|b32|sae AVX512
```

```
VCMPNLT_UQSD     kreg|mask,xmmreg,xmmrm64|sae AVX512
VCMPNLT_UQSS     kreg|mask,xmmreg,xmmrm32|sae AVX512
VCMPNLE_UQPD     kreg|mask,xmmreg,xmmrm128|b64 AVX512VL
VCMPNLE_UQPD     kreg|mask,ymmreg,ymmrm256|b64 AVX512VL
VCMPNLE_UQPD     kreg|mask,zmmreg,zmmrm512|b64|sae AVX512
VCMPNLE_UQPS     kreg|mask,xmmreg,xmmrm128|b32 AVX512VL
VCMPNLE_UQPS     kreg|mask,ymmreg,ymmrm256|b32 AVX512VL
VCMPNLE_UQPS     kreg|mask,zmmreg,zmmrm512|b32|sae AVX512
VCMPNLE_UQSD     kreg|mask,xmmreg,xmmrm64|sae AVX512
VCMPNLE_UQSS     kreg|mask,xmmreg,xmmrm32|sae AVX512
VCMPORD_SPD      kreg|mask,xmmreg,xmmrm128|b64 AVX512VL
VCMPORD_SPD      kreg|mask,ymmreg,ymmrm256|b64 AVX512VL
VCMPORD_SPD      kreg|mask,zmmreg,zmmrm512|b64|sae AVX512
VCMPORD_SPS      kreg|mask,xmmreg,xmmrm128|b32 AVX512VL
VCMPORD_SPS      kreg|mask,ymmreg,ymmrm256|b32 AVX512VL
VCMPORD_SPS      kreg|mask,zmmreg,zmmrm512|b32|sae AVX512
VCMPORD_SSD      kreg|mask,xmmreg,xmmrm64|sae AVX512
VCMPORD_SSS      kreg|mask,xmmreg,xmmrm32|sae AVX512
VCMPEQ_USPD      kreg|mask,xmmreg,xmmrm128|b64 AVX512VL
VCMPEQ_USPD      kreg|mask,ymmreg,ymmrm256|b64 AVX512VL
VCMPEQ_USPD      kreg|mask,zmmreg,zmmrm512|b64|sae AVX512
VCMPEQ_USPS      kreg|mask,xmmreg,xmmrm128|b32 AVX512VL
VCMPEQ_USPS      kreg|mask,ymmreg,ymmrm256|b32 AVX512VL
VCMPEQ_USPS      kreg|mask,zmmreg,zmmrm512|b32|sae AVX512
VCMPEQ_USSD      kreg|mask,xmmreg,xmmrm64|sae AVX512
VCMPEQ_USSS      kreg|mask,xmmreg,xmmrm32|sae AVX512
VCMPNGE_UQPD     kreg|mask,xmmreg,xmmrm128|b64 AVX512VL
VCMPNGE_UQPD     kreg|mask,ymmreg,ymmrm256|b64 AVX512VL
VCMPNGE_UQPD     kreg|mask,zmmreg,zmmrm512|b64|sae AVX512
VCMPNGE_UQPS     kreg|mask,xmmreg,xmmrm128|b32 AVX512VL
VCMPNGE_UQPS     kreg|mask,ymmreg,ymmrm256|b32 AVX512VL
VCMPNGE_UQPS     kreg|mask,zmmreg,zmmrm512|b32|sae AVX512
VCMPNGE_UQSD     kreg|mask,xmmreg,xmmrm64|sae AVX512
VCMPNGE_UQSS     kreg|mask,xmmreg,xmmrm32|sae AVX512
VCMPNGT_UQPD     kreg|mask,xmmreg,xmmrm128|b64 AVX512VL
VCMPNGT_UQPD     kreg|mask,ymmreg,ymmrm256|b64 AVX512VL
VCMPNGT_UQPD     kreg|mask,zmmreg,zmmrm512|b64|sae AVX512
VCMPNGT_UQPS     kreg|mask,xmmreg,xmmrm128|b32 AVX512VL
VCMPNGT_UQPS     kreg|mask,ymmreg,ymmrm256|b32 AVX512VL
VCMPNGT_UQPS     kreg|mask,zmmreg,zmmrm512|b32|sae AVX512
VCMPNGT_UQSD     kreg|mask,xmmreg,xmmrm64|sae AVX512
VCMPNGT_UQSS     kreg|mask,xmmreg,xmmrm32|sae AVX512
VCMPFALSE_OSPD   kreg|mask,xmmreg,xmmrm128|b64 AVX512VL
VCMPFALSE_OSPD   kreg|mask,ymmreg,ymmrm256|b64 AVX512VL
VCMPFALSE_OSPD   kreg|mask,zmmreg,zmmrm512|b64|sae AVX512
VCMPFALSE_OSPS   kreg|mask,xmmreg,xmmrm128|b32 AVX512VL
VCMPFALSE_OSPS   kreg|mask,ymmreg,ymmrm256|b32 AVX512VL
VCMPFALSE_OSPS   kreg|mask,zmmreg,zmmrm512|b32|sae AVX512
VCMPFALSE_OSSD   kreg|mask,xmmreg,xmmrm64|sae AVX512
VCMPFALSE_OSSS   kreg|mask,xmmreg,xmmrm32|sae AVX512
VCMPNEQ_OSPD     kreg|mask,xmmreg,xmmrm128|b64 AVX512VL
VCMPNEQ_OSPD     kreg|mask,ymmreg,ymmrm256|b64 AVX512VL
VCMPNEQ_OSPD     kreg|mask,zmmreg,zmmrm512|b64|sae AVX512
VCMPNEQ_OSPS     kreg|mask,xmmreg,xmmrm128|b32 AVX512VL
VCMPNEQ_OSPS     kreg|mask,ymmreg,ymmrm256|b32 AVX512VL
VCMPNEQ_OSPS     kreg|mask,zmmreg,zmmrm512|b32|sae AVX512
VCMPNEQ_OSSD     kreg|mask,xmmreg,xmmrm64|sae AVX512
VCMPNEQ_OSSS     kreg|mask,xmmreg,xmmrm32|sae AVX512
VCMPGE_OQPD      kreg|mask,xmmreg,xmmrm128|b64 AVX512VL
VCMPGE_OQPD      kreg|mask,ymmreg,ymmrm256|b64 AVX512VL
VCMPGE_OQPD      kreg|mask,zmmreg,zmmrm512|b64|sae AVX512
VCMPGE_OQPS      kreg|mask,xmmreg,xmmrm128|b32 AVX512VL
VCMPGE_OQPS      kreg|mask,ymmreg,ymmrm256|b32 AVX512VL
VCMPGE_OQPS      kreg|mask,zmmreg,zmmrm512|b32|sae AVX512
VCMPGE_OQSD      kreg|mask,xmmreg,xmmrm64|sae AVX512
VCMPGE_OQSS      kreg|mask,xmmreg,xmmrm32|sae AVX512
VCMPGT_OQPD      kreg|mask,xmmreg,xmmrm128|b64 AVX512VL
```

```
VCMPGT_OQPD      kreg|mask,ymmreg,ymmrm256|b64 AVX512VL
VCMPGT_OQPD      kreg|mask,zmmreg,zmmrm512|b64|sae AVX512
VCMPGT_OQPS      kreg|mask,xmmreg,xmmrm128|b32 AVX512VL
VCMPGT_OQPS      kreg|mask,ymmreg,ymmrm256|b32 AVX512VL
VCMPGT_OQPS      kreg|mask,zmmreg,zmmrm512|b32|sae AVX512
VCMPGT_OQSD      kreg|mask,xmmreg,xmmrm64|sae AVX512
VCMPGT_OQSS      kreg|mask,xmmreg,xmmrm32|sae AVX512
VCMPTRUE_USPD    kreg|mask,xmmreg,xmmrm128|b64 AVX512VL
VCMPTRUE_USPD    kreg|mask,ymmreg,ymmrm256|b64 AVX512VL
VCMPTRUE_USPD    kreg|mask,zmmreg,zmmrm512|b64|sae AVX512
VCMPTRUE_USPS    kreg|mask,xmmreg,xmmrm128|b32 AVX512VL
VCMPTRUE_USPS    kreg|mask,ymmreg,ymmrm256|b32 AVX512VL
VCMPTRUE_USPS    kreg|mask,zmmreg,zmmrm512|b32|sae AVX512
VCMPTRUE_USSD    kreg|mask,xmmreg,xmmrm64|sae AVX512
VCMPTRUE_USSS    kreg|mask,xmmreg,xmmrm32|sae AVX512
VCMPPD           kreg|mask,xmmreg,xmmrm128|b64,imm8 AVX512VL
VCMPPD           kreg|mask,ymmreg,ymmrm256|b64,imm8 AVX512VL
VCMPPD           kreg|mask,zmmreg,zmmrm512|b64|sae,imm8 AVX512
VCMPPS           kreg|mask,xmmreg,xmmrm128|b32,imm8 AVX512VL
VCMPPS           kreg|mask,ymmreg,ymmrm256|b32,imm8 AVX512VL
VCMPPS           kreg|mask,zmmreg,zmmrm512|b32|sae,imm8 AVX512
VCMPSD           kreg|mask,xmmreg,xmmrm64|sae,imm8 AVX512
VCMPSS           kreg|mask,xmmreg,xmmrm32|sae,imm8 AVX512
VCOMISD          xmmreg,xmmrm64|sae       AVX512,FL
VCOMISS          xmmreg,xmmrm32|sae       AVX512,FL
VCOMPRESSPD      mem128|mask,xmmreg       AVX512VL
VCOMPRESSPD      mem256|mask,ymmreg       AVX512VL
VCOMPRESSPD      mem512|mask,zmmreg       AVX512
VCOMPRESSPD      xmmreg|mask|z,xmmreg     AVX512VL
VCOMPRESSPD      ymmreg|mask|z,ymmreg     AVX512VL
VCOMPRESSPD      zmmreg|mask|z,zmmreg     AVX512
VCOMPRESSPS      mem128|mask,xmmreg       AVX512VL
VCOMPRESSPS      mem256|mask,ymmreg       AVX512VL
VCOMPRESSPS      mem512|mask,zmmreg       AVX512
VCOMPRESSPS      xmmreg|mask|z,xmmreg     AVX512VL
VCOMPRESSPS      ymmreg|mask|z,ymmreg     AVX512VL
VCOMPRESSPS      zmmreg|mask|z,zmmreg     AVX512
VCVTDQ2PD        xmmreg|mask|z,xmmrm64|b32 AVX512VL
VCVTDQ2PD        ymmreg|mask|z,xmmrm128|b32 AVX512VL
VCVTDQ2PD        zmmreg|mask|z,ymmrm256|b32|er AVX512
VCVTDQ2PS        xmmreg|mask|z,xmmrm128|b32 AVX512VL
VCVTDQ2PS        ymmreg|mask|z,ymmrm256|b32 AVX512VL
VCVTDQ2PS        zmmreg|mask|z,zmmrm512|b32|er AVX512
VCVTPD2DQ        xmmreg|mask|z,xmmrm128|b64 AVX512VL
VCVTPD2DQ        xmmreg|mask|z,ymmrm256|b64 AVX512VL
VCVTPD2DQ        ymmreg|mask|z,zmmrm512|b64|er AVX512
VCVTPD2PS        xmmreg|mask|z,xmmrm128|b64 AVX512VL
VCVTPD2PS        xmmreg|mask|z,ymmrm256|b64 AVX512VL
VCVTPD2PS        ymmreg|mask|z,zmmrm512|b64|er AVX512
VCVTPD2QQ        xmmreg|mask|z,xmmrm128|b64 AVX512VL/DQ
VCVTPD2QQ        ymmreg|mask|z,ymmrm256|b64 AVX512VL/DQ
VCVTPD2QQ        zmmreg|mask|z,zmmrm512|b64|er AVX512DQ
VCVTPD2UDQ       xmmreg|mask|z,xmmrm128|b64 AVX512VL
VCVTPD2UDQ       xmmreg|mask|z,ymmrm256|b64 AVX512VL
VCVTPD2UDQ       ymmreg|mask|z,zmmrm512|b64|er AVX512
VCVTPD2UQQ       xmmreg|mask|z,xmmrm128|b64 AVX512VL/DQ
VCVTPD2UQQ       ymmreg|mask|z,ymmrm256|b64 AVX512VL/DQ
VCVTPD2UQQ       zmmreg|mask|z,zmmrm512|b64|er AVX512DQ
VCVTPH2PS        xmmreg|mask|z,xmmrm64    AVX512VL
VCVTPH2PS        ymmreg|mask|z,xmmrm128   AVX512VL
VCVTPH2PS        zmmreg|mask|z,ymmrm256|sae AVX512
VCVTPS2DQ        xmmreg|mask|z,xmmrm128|b32 AVX512VL
VCVTPS2DQ        ymmreg|mask|z,ymmrm256|b32 AVX512VL
VCVTPS2DQ        zmmreg|mask|z,zmmrm512|b32|er AVX512
VCVTPS2PD        xmmreg|mask|z,xmmrm64|b32 AVX512VL
VCVTPS2PD        ymmreg|mask|z,xmmrm128|b32 AVX512VL
VCVTPS2PD        zmmreg|mask|z,ymmrm256|b32|sae AVX512
```

```
VCVTPS2PH       xmmreg|mask|z,xmmreg,imm8 AVX512VL
VCVTPS2PH       xmmreg|mask|z,ymmreg,imm8 AVX512VL
VCVTPS2PH       ymmreg|mask|z,zmmreg|sae,imm8 AVX512
VCVTPS2PH       mem64|mask,xmmreg,imm8   AVX512VL
VCVTPS2PH       mem128|mask,ymmreg,imm8  AVX512VL
VCVTPS2PH       mem256|mask,zmmreg|sae,imm8 AVX512
VCVTPS2QQ       xmmreg|mask|z,xmmrm64|b32 AVX512VL/DQ
VCVTPS2QQ       ymmreg|mask|z,xmmrm128|b32 AVX512VL/DQ
VCVTPS2QQ       zmmreg|mask|z,ymmrm256|b32|er AVX512DQ
VCVTPS2UDQ      xmmreg|mask|z,xmmrm128|b32 AVX512VL
VCVTPS2UDQ      ymmreg|mask|z,ymmrm256|b32 AVX512VL
VCVTPS2UDQ      zmmreg|mask|z,zmmrm512|b32|er AVX512
VCVTPS2UQQ      xmmreg|mask|z,xmmrm64|b32 AVX512VL/DQ
VCVTPS2UQQ      ymmreg|mask|z,xmmrm128|b32 AVX512VL/DQ
VCVTPS2UQQ      zmmreg|mask|z,ymmrm256|b32|er AVX512DQ
VCVTQQ2PD       xmmreg|mask|z,xmmrm128|b64 AVX512VL/DQ
VCVTQQ2PD       ymmreg|mask|z,ymmrm256|b64 AVX512VL/DQ
VCVTQQ2PD       zmmreg|mask|z,zmmrm512|b64|er AVX512DQ
VCVTQQ2PS       xmmreg|mask|z,xmmrm128|b64 AVX512VL/DQ
VCVTQQ2PS       xmmreg|mask|z,ymmrm256|b64 AVX512VL/DQ
VCVTQQ2PS       ymmreg|mask|z,zmmrm512|b64|er AVX512DQ
VCVTSD2SI       reg32,xmmrm64|er         AVX512
VCVTSD2SI       reg64,xmmrm64|er         AVX512
VCVTSD2SS       xmmreg|mask|z,xmmreg*,xmmrm64|er AVX512
VCVTSD2USI      reg32,xmmrm64|er         AVX512
VCVTSD2USI      reg64,xmmrm64|er         AVX512
VCVTSI2SD       xmmreg,xmmreg*,rm32      AVX512
VCVTSI2SD       xmmreg,xmmreg*,rm64|er   AVX512
VCVTSI2SS       xmmreg,xmmreg*,rm32|er   AVX512
VCVTSI2SS       xmmreg,xmmreg*,rm64|er   AVX512
VCVTSS2SD       xmmreg|mask|z,xmmreg*,xmmrm32|sae AVX512
VCVTSS2SI       reg32,xmmrm32|er         AVX512
VCVTSS2SI       reg64,xmmrm32|er         AVX512
VCVTSS2USI      reg32,xmmrm32|er         AVX512
VCVTSS2USI      reg64,xmmrm32|er         AVX512
VCVTTPD2DQ      xmmreg|mask|z,xmmrm128|b64 AVX512VL
VCVTTPD2DQ      xmmreg|mask|z,ymmrm256|b64 AVX512VL
VCVTTPD2DQ      ymmreg|mask|z,zmmrm512|b64|sae AVX512
VCVTTPD2QQ      xmmreg|mask|z,xmmrm128|b64 AVX512VL/DQ
VCVTTPD2QQ      ymmreg|mask|z,ymmrm256|b64 AVX512VL/DQ
VCVTTPD2QQ      zmmreg|mask|z,zmmrm512|b64|sae AVX512DQ
VCVTTPD2UDQ     xmmreg|mask|z,xmmrm128|b64 AVX512VL
VCVTTPD2UDQ     xmmreg|mask|z,ymmrm256|b64 AVX512VL
VCVTTPD2UDQ     ymmreg|mask|z,zmmrm512|b64|sae AVX512
VCVTTPD2UQQ     xmmreg|mask|z,xmmrm128|b64 AVX512VL/DQ
VCVTTPD2UQQ     ymmreg|mask|z,ymmrm256|b64 AVX512VL/DQ
VCVTTPD2UQQ     zmmreg|mask|z,zmmrm512|b64|sae AVX512DQ
VCVTTPS2DQ      xmmreg|mask|z,xmmrm128|b32 AVX512VL
VCVTTPS2DQ      ymmreg|mask|z,ymmrm256|b32 AVX512VL
VCVTTPS2DQ      zmmreg|mask|z,zmmrm512|b32|sae AVX512
VCVTTPS2QQ      xmmreg|mask|z,xmmrm64|b32 AVX512VL/DQ
VCVTTPS2QQ      ymmreg|mask|z,xmmrm128|b32 AVX512VL/DQ
VCVTTPS2QQ      zmmreg|mask|z,ymmrm256|b32|sae AVX512DQ
VCVTTPS2UDQ     xmmreg|mask|z,xmmrm128|b32 AVX512VL
VCVTTPS2UDQ     ymmreg|mask|z,ymmrm256|b32 AVX512VL
VCVTTPS2UDQ     zmmreg|mask|z,zmmrm512|b32|sae AVX512
VCVTTPS2UQQ     xmmreg|mask|z,xmmrm64|b32 AVX512VL/DQ
VCVTTPS2UQQ     ymmreg|mask|z,xmmrm128|b32 AVX512VL/DQ
VCVTTPS2UQQ     zmmreg|mask|z,ymmrm256|b32|sae AVX512DQ
VCVTTSD2SI      reg32,xmmrm64|sae        AVX512
VCVTTSD2SI      reg64,xmmrm64|sae        AVX512
VCVTTSD2USI     reg32,xmmrm64|sae        AVX512
VCVTTSD2USI     reg64,xmmrm64|sae        AVX512
VCVTTSS2SI      reg32,xmmrm32|sae        AVX512
VCVTTSS2SI      reg64,xmmrm32|sae        AVX512
VCVTTSS2USI     reg32,xmmrm32|sae        AVX512
VCVTTSS2USI     reg64,xmmrm32|sae        AVX512
```

```
VCVTUDQ2PD       xmmreg|mask|z,xmmrm64|b32 AVX512VL
VCVTUDQ2PD       ymmreg|mask|z,xmmrm128|b32 AVX512VL
VCVTUDQ2PD       zmmreg|mask|z,ymmrm256|b32|er AVX512
VCVTUDQ2PS       xmmreg|mask|z,xmmrm128|b32 AVX512VL
VCVTUDQ2PS       ymmreg|mask|z,ymmrm256|b32 AVX512VL
VCVTUDQ2PS       zmmreg|mask|z,zmmrm512|b32|er AVX512
VCVTUQQ2PD       xmmreg|mask|z,xmmrm128|b64 AVX512VL/DQ
VCVTUQQ2PD       ymmreg|mask|z,ymmrm256|b64 AVX512VL/DQ
VCVTUQQ2PD       zmmreg|mask|z,zmmrm512|b64|er AVX512DQ
VCVTUQQ2PS       xmmreg|mask|z,xmmrm128|b64 AVX512VL/DQ
VCVTUQQ2PS       xmmreg|mask|z,ymmrm256|b64 AVX512VL/DQ
VCVTUQQ2PS       ymmreg|mask|z,zmmrm512|b64|er AVX512DQ
VCVTUSI2SD       xmmreg,xmmreg*,rm32|er   AVX512
VCVTUSI2SD       xmmreg,xmmreg*,rm64|er   AVX512
VCVTUSI2SS       xmmreg,xmmreg*,rm32|er   AVX512
VCVTUSI2SS       xmmreg,xmmreg*,rm64|er   AVX512
VDBPSADBW        xmmreg|mask|z,xmmreg*,xmmrm128,imm8 AVX512VL/BW
VDBPSADBW        ymmreg|mask|z,ymmreg*,ymmrm256,imm8 AVX512VL/BW
VDBPSADBW        zmmreg|mask|z,zmmreg*,zmmrm512,imm8 AVX512BW
VDIVPD           xmmreg|mask|z,xmmreg*,xmmrm128|b64 AVX512VL
VDIVPD           ymmreg|mask|z,ymmreg*,ymmrm256|b64 AVX512VL
VDIVPD           zmmreg|mask|z,zmmreg*,zmmrm512|b64|er AVX512
VDIVPS           xmmreg|mask|z,xmmreg*,xmmrm128|b32 AVX512VL
VDIVPS           ymmreg|mask|z,ymmreg*,ymmrm256|b32 AVX512VL
VDIVPS           zmmreg|mask|z,zmmreg*,zmmrm512|b32|er AVX512
VDIVSD           xmmreg|mask|z,xmmreg*,xmmrm64|er AVX512
VDIVSS           xmmreg|mask|z,xmmreg*,xmmrm32|er AVX512
VEXP2PD          zmmreg|mask|z,zmmrm512|b64|sae AVX512ER
VEXP2PS          zmmreg|mask|z,zmmrm512|b32|sae AVX512ER
VEXPANDPD        xmmreg|mask|z,mem128     AVX512VL
VEXPANDPD        ymmreg|mask|z,mem256     AVX512VL
VEXPANDPD        zmmreg|mask|z,mem512     AVX512
VEXPANDPD        xmmreg|mask|z,xmmreg     AVX512VL
VEXPANDPD        ymmreg|mask|z,ymmreg     AVX512VL
VEXPANDPD        zmmreg|mask|z,zmmreg     AVX512
VEXPANDPS        xmmreg|mask|z,mem128     AVX512VL
VEXPANDPS        ymmreg|mask|z,mem256     AVX512VL
VEXPANDPS        zmmreg|mask|z,mem512     AVX512
VEXPANDPS        xmmreg|mask|z,xmmreg     AVX512VL
VEXPANDPS        ymmreg|mask|z,ymmreg     AVX512VL
VEXPANDPS        zmmreg|mask|z,zmmreg     AVX512
VEXTRACTF32X4    xmmreg|mask|z,ymmreg,imm8 AVX512VL
VEXTRACTF32X4    xmmreg|mask|z,zmmreg,imm8 AVX512
VEXTRACTF32X4    mem128|mask,ymmreg,imm8  AVX512VL
VEXTRACTF32X4    mem128|mask,zmmreg,imm8  AVX512
VEXTRACTF32X8    ymmreg|mask|z,zmmreg,imm8 AVX512DQ
VEXTRACTF32X8    mem256|mask,zmmreg,imm8  AVX512DQ
VEXTRACTF64X2    xmmreg|mask|z,ymmreg,imm8 AVX512VL/DQ
VEXTRACTF64X2    xmmreg|mask|z,zmmreg,imm8 AVX512DQ
VEXTRACTF64X2    mem128|mask,ymmreg,imm8  AVX512VL/DQ
VEXTRACTF64X2    mem128|mask,zmmreg,imm8  AVX512DQ
VEXTRACTF64X4    ymmreg|mask|z,zmmreg,imm8 AVX512
VEXTRACTF64X4    mem256|mask,zmmreg,imm8  AVX512
VEXTRACTI32X4    xmmreg|mask|z,ymmreg,imm8 AVX512VL
VEXTRACTI32X4    xmmreg|mask|z,zmmreg,imm8 AVX512
VEXTRACTI32X4    mem128|mask,ymmreg,imm8  AVX512VL
VEXTRACTI32X4    mem128|mask,zmmreg,imm8  AVX512
VEXTRACTI32X8    ymmreg|mask|z,zmmreg,imm8 AVX512DQ
VEXTRACTI32X8    mem256|mask,zmmreg,imm8  AVX512DQ
VEXTRACTI64X2    xmmreg|mask|z,ymmreg,imm8 AVX512VL/DQ
VEXTRACTI64X2    xmmreg|mask|z,zmmreg,imm8 AVX512DQ
VEXTRACTI64X2    mem128|mask,ymmreg,imm8  AVX512VL/DQ
VEXTRACTI64X2    mem128|mask,zmmreg,imm8  AVX512DQ
VEXTRACTI64X4    ymmreg|mask|z,zmmreg,imm8 AVX512
VEXTRACTI64X4    mem256|mask,zmmreg,imm8  AVX512
VEXTRACTPS       reg32,xmmreg,imm8        AVX512
VEXTRACTPS       reg64,xmmreg,imm8        AVX512
```

```
VEXTRACTPS       mem32,xmmreg,imm8        AVX512
VFIXUPIMMPD      xmmreg|mask|z,xmmreg*,xmmrm128|b64,imm8 AVX512VL
VFIXUPIMMPD      ymmreg|mask|z,ymmreg*,ymmrm256|b64,imm8 AVX512VL
VFIXUPIMMPD      zmmreg|mask|z,zmmreg*,zmmrm512|b64|sae,imm8 AVX512
VFIXUPIMMPS      xmmreg|mask|z,xmmreg*,xmmrm128|b32,imm8 AVX512VL
VFIXUPIMMPS      ymmreg|mask|z,ymmreg*,ymmrm256|b32,imm8 AVX512VL
VFIXUPIMMPS      zmmreg|mask|z,zmmreg*,zmmrm512|b32|sae,imm8 AVX512
VFIXUPIMMSD      xmmreg|mask|z,xmmreg*,xmmrm64|sae,imm8 AVX512
VFIXUPIMMSS      xmmreg|mask|z,xmmreg*,xmmrm32|sae,imm8 AVX512
VFMADD132PD      xmmreg|mask|z,xmmreg,xmmrm128|b64 AVX512VL
VFMADD132PD      ymmreg|mask|z,ymmreg,ymmrm256|b64 AVX512VL
VFMADD132PD      zmmreg|mask|z,zmmreg,zmmrm512|b64|er AVX512
VFMADD132PS      xmmreg|mask|z,xmmreg,xmmrm128|b32 AVX512VL
VFMADD132PS      ymmreg|mask|z,ymmreg,ymmrm256|b32 AVX512VL
VFMADD132PS      zmmreg|mask|z,zmmreg,zmmrm512|b32|er AVX512
VFMADD132SD      xmmreg|mask|z,xmmreg,xmmrm64|er AVX512
VFMADD132SS      xmmreg|mask|z,xmmreg,xmmrm32|er AVX512
VFMADD213PD      xmmreg|mask|z,xmmreg,xmmrm128|b64 AVX512VL
VFMADD213PD      ymmreg|mask|z,ymmreg,ymmrm256|b64 AVX512VL
VFMADD213PD      zmmreg|mask|z,zmmreg,zmmrm512|b64|er AVX512
VFMADD213PS      xmmreg|mask|z,xmmreg,xmmrm128|b32 AVX512VL
VFMADD213PS      ymmreg|mask|z,ymmreg,ymmrm256|b32 AVX512VL
VFMADD213PS      zmmreg|mask|z,zmmreg,zmmrm512|b32|er AVX512
VFMADD213SD      xmmreg|mask|z,xmmreg,xmmrm64|er AVX512
VFMADD213SS      xmmreg|mask|z,xmmreg,xmmrm32|er AVX512
VFMADD231PD      xmmreg|mask|z,xmmreg,xmmrm128|b64 AVX512VL
VFMADD231PD      ymmreg|mask|z,ymmreg,ymmrm256|b64 AVX512VL
VFMADD231PD      zmmreg|mask|z,zmmreg,zmmrm512|b64|er AVX512
VFMADD231PS      xmmreg|mask|z,xmmreg,xmmrm128|b32 AVX512VL
VFMADD231PS      ymmreg|mask|z,ymmreg,ymmrm256|b32 AVX512VL
VFMADD231PS      zmmreg|mask|z,zmmreg,zmmrm512|b32|er AVX512
VFMADD231SD      xmmreg|mask|z,xmmreg,xmmrm64|er AVX512
VFMADD231SS      xmmreg|mask|z,xmmreg,xmmrm32|er AVX512
VFMADDSUB132PD   xmmreg|mask|z,xmmreg,xmmrm128|b64 AVX512VL
VFMADDSUB132PD   ymmreg|mask|z,ymmreg,ymmrm256|b64 AVX512VL
VFMADDSUB132PD   zmmreg|mask|z,zmmreg,zmmrm512|b64|er AVX512
VFMADDSUB132PS   xmmreg|mask|z,xmmreg,xmmrm128|b32 AVX512VL
VFMADDSUB132PS   ymmreg|mask|z,ymmreg,ymmrm256|b32 AVX512VL
VFMADDSUB132PS   zmmreg|mask|z,zmmreg,zmmrm512|b32|er AVX512
VFMADDSUB213PD   xmmreg|mask|z,xmmreg,xmmrm128|b64 AVX512VL
VFMADDSUB213PD   ymmreg|mask|z,ymmreg,ymmrm256|b64 AVX512VL
VFMADDSUB213PD   zmmreg|mask|z,zmmreg,zmmrm512|b64|er AVX512
VFMADDSUB213PS   xmmreg|mask|z,xmmreg,xmmrm128|b32 AVX512VL
VFMADDSUB213PS   ymmreg|mask|z,ymmreg,ymmrm256|b32 AVX512VL
VFMADDSUB213PS   zmmreg|mask|z,zmmreg,zmmrm512|b32|er AVX512
VFMADDSUB231PD   xmmreg|mask|z,xmmreg,xmmrm128|b64 AVX512VL
VFMADDSUB231PD   ymmreg|mask|z,ymmreg,ymmrm256|b64 AVX512VL
VFMADDSUB231PD   zmmreg|mask|z,zmmreg,zmmrm512|b64|er AVX512
VFMADDSUB231PS   xmmreg|mask|z,xmmreg,xmmrm128|b32 AVX512VL
VFMADDSUB231PS   ymmreg|mask|z,ymmreg,ymmrm256|b32 AVX512VL
VFMADDSUB231PS   zmmreg|mask|z,zmmreg,zmmrm512|b32|er AVX512
VFMSUB132PD      xmmreg|mask|z,xmmreg,xmmrm128|b64 AVX512VL
VFMSUB132PD      ymmreg|mask|z,ymmreg,ymmrm256|b64 AVX512VL
VFMSUB132PD      zmmreg|mask|z,zmmreg,zmmrm512|b64|er AVX512
VFMSUB132PS      xmmreg|mask|z,xmmreg,xmmrm128|b32 AVX512VL
VFMSUB132PS      ymmreg|mask|z,ymmreg,ymmrm256|b32 AVX512VL
VFMSUB132PS      zmmreg|mask|z,zmmreg,zmmrm512|b32|er AVX512
VFMSUB132SD      xmmreg|mask|z,xmmreg,xmmrm64|er AVX512
VFMSUB132SS      xmmreg|mask|z,xmmreg,xmmrm32|er AVX512
VFMSUB213PD      xmmreg|mask|z,xmmreg,xmmrm128|b64 AVX512VL
VFMSUB213PD      ymmreg|mask|z,ymmreg,ymmrm256|b64 AVX512VL
VFMSUB213PD      zmmreg|mask|z,zmmreg,zmmrm512|b64|er AVX512
VFMSUB213PS      xmmreg|mask|z,xmmreg,xmmrm128|b32 AVX512VL
VFMSUB213PS      ymmreg|mask|z,ymmreg,ymmrm256|b32 AVX512VL
VFMSUB213PS      zmmreg|mask|z,zmmreg,zmmrm512|b32|er AVX512
VFMSUB213SD      xmmreg|mask|z,xmmreg,xmmrm64|er AVX512
VFMSUB213SS      xmmreg|mask|z,xmmreg,xmmrm32|er AVX512
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VFMSUB231PD      xmmreg|mask|z,xmmreg,xmmrm128|b64 AVX512VL
VFMSUB231PD      ymmreg|mask|z,ymmreg,ymmrm256|b64 AVX512VL
VFMSUB231PD      zmmreg|mask|z,zmmreg,zmmrm512|b64|er AVX512
VFMSUB231PS      xmmreg|mask|z,xmmreg,xmmrm128|b32 AVX512VL
VFMSUB231PS      ymmreg|mask|z,ymmreg,ymmrm256|b32 AVX512VL
VFMSUB231PS      zmmreg|mask|z,zmmreg,zmmrm512|b32|er AVX512
VFMSUB231SD      xmmreg|mask|z,xmmreg,xmmrm64|er AVX512
VFMSUB231SS      xmmreg|mask|z,xmmreg,xmmrm32|er AVX512
VFMSUBADD132PD   xmmreg|mask|z,xmmreg,xmmrm128|b64 AVX512VL
VFMSUBADD132PD   ymmreg|mask|z,ymmreg,ymmrm256|b64 AVX512VL
VFMSUBADD132PD   zmmreg|mask|z,zmmreg,zmmrm512|b64|er AVX512
VFMSUBADD132PS   xmmreg|mask|z,xmmreg,xmmrm128|b32 AVX512VL
VFMSUBADD132PS   ymmreg|mask|z,ymmreg,ymmrm256|b32 AVX512VL
VFMSUBADD132PS   zmmreg|mask|z,zmmreg,zmmrm512|b32|er AVX512
VFMSUBADD213PD   xmmreg|mask|z,xmmreg,xmmrm128|b64 AVX512VL
VFMSUBADD213PD   ymmreg|mask|z,ymmreg,ymmrm256|b64 AVX512VL
VFMSUBADD213PD   zmmreg|mask|z,zmmreg,zmmrm512|b64|er AVX512
VFMSUBADD213PS   xmmreg|mask|z,xmmreg,xmmrm128|b32 AVX512VL
VFMSUBADD213PS   ymmreg|mask|z,ymmreg,ymmrm256|b32 AVX512VL
VFMSUBADD213PS   zmmreg|mask|z,zmmreg,zmmrm512|b32|er AVX512
VFMSUBADD231PD   xmmreg|mask|z,xmmreg,xmmrm128|b64 AVX512VL
VFMSUBADD231PD   ymmreg|mask|z,ymmreg,ymmrm256|b64 AVX512VL
VFMSUBADD231PD   zmmreg|mask|z,zmmreg,zmmrm512|b64|er AVX512
VFMSUBADD231PS   xmmreg|mask|z,xmmreg,xmmrm128|b32 AVX512VL
VFMSUBADD231PS   ymmreg|mask|z,ymmreg,ymmrm256|b32 AVX512VL
VFMSUBADD231PS   zmmreg|mask|z,zmmreg,zmmrm512|b32|er AVX512
VFNMADD132PD     xmmreg|mask|z,xmmreg,xmmrm128|b64 AVX512VL
VFNMADD132PD     ymmreg|mask|z,ymmreg,ymmrm256|b64 AVX512VL
VFNMADD132PD     zmmreg|mask|z,zmmreg,zmmrm512|b64|er AVX512
VFNMADD132PS     xmmreg|mask|z,xmmreg,xmmrm128|b32 AVX512VL
VFNMADD132PS     ymmreg|mask|z,ymmreg,ymmrm256|b32 AVX512VL
VFNMADD132PS     zmmreg|mask|z,zmmreg,zmmrm512|b32|er AVX512
VFNMADD132SD     xmmreg|mask|z,xmmreg,xmmrm64|er AVX512
VFNMADD132SS     xmmreg|mask|z,xmmreg,xmmrm32|er AVX512
VFNMADD213PD     xmmreg|mask|z,xmmreg,xmmrm128|b64 AVX512VL
VFNMADD213PD     ymmreg|mask|z,ymmreg,ymmrm256|b64 AVX512VL
VFNMADD213PD     zmmreg|mask|z,zmmreg,zmmrm512|b64|er AVX512
VFNMADD213PS     xmmreg|mask|z,xmmreg,xmmrm128|b32 AVX512VL
VFNMADD213PS     ymmreg|mask|z,ymmreg,ymmrm256|b32 AVX512VL
VFNMADD213PS     zmmreg|mask|z,zmmreg,zmmrm512|b32|er AVX512
VFNMADD213SD     xmmreg|mask|z,xmmreg,xmmrm64|er AVX512
VFNMADD213SS     xmmreg|mask|z,xmmreg,xmmrm32|er AVX512
VFNMADD231PD     xmmreg|mask|z,xmmreg,xmmrm128|b64 AVX512VL
VFNMADD231PD     ymmreg|mask|z,ymmreg,ymmrm256|b64 AVX512VL
VFNMADD231PD     zmmreg|mask|z,zmmreg,zmmrm512|b64|er AVX512
VFNMADD231PS     xmmreg|mask|z,xmmreg,xmmrm128|b32 AVX512VL
VFNMADD231PS     ymmreg|mask|z,ymmreg,ymmrm256|b32 AVX512VL
VFNMADD231PS     zmmreg|mask|z,zmmreg,zmmrm512|b32|er AVX512
VFNMADD231SD     xmmreg|mask|z,xmmreg,xmmrm64|er AVX512
VFNMADD231SS     xmmreg|mask|z,xmmreg,xmmrm32|er AVX512
VFNMSUB132PD     xmmreg|mask|z,xmmreg,xmmrm128|b64 AVX512VL
VFNMSUB132PD     ymmreg|mask|z,ymmreg,ymmrm256|b64 AVX512VL
VFNMSUB132PD     zmmreg|mask|z,zmmreg,zmmrm512|b64|er AVX512
VFNMSUB132PS     xmmreg|mask|z,xmmreg,xmmrm128|b32 AVX512VL
VFNMSUB132PS     ymmreg|mask|z,ymmreg,ymmrm256|b32 AVX512VL
VFNMSUB132PS     zmmreg|mask|z,zmmreg,zmmrm512|b32|er AVX512
VFNMSUB132SD     xmmreg|mask|z,xmmreg,xmmrm64|er AVX512
VFNMSUB132SS     xmmreg|mask|z,xmmreg,xmmrm32|er AVX512
VFNMSUB213PD     xmmreg|mask|z,xmmreg,xmmrm128|b64 AVX512VL
VFNMSUB213PD     ymmreg|mask|z,ymmreg,ymmrm256|b64 AVX512VL
VFNMSUB213PD     zmmreg|mask|z,zmmreg,zmmrm512|b64|er AVX512
VFNMSUB213PS     xmmreg|mask|z,xmmreg,xmmrm128|b32 AVX512VL
VFNMSUB213PS     ymmreg|mask|z,ymmreg,ymmrm256|b32 AVX512VL
VFNMSUB213PS     zmmreg|mask|z,zmmreg,zmmrm512|b32|er AVX512
VFNMSUB213SD     xmmreg|mask|z,xmmreg,xmmrm64|er AVX512
VFNMSUB213SS     xmmreg|mask|z,xmmreg,xmmrm32|er AVX512
VFNMSUB231PD     xmmreg|mask|z,xmmreg,xmmrm128|b64 AVX512VL
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VFNMSUB231PD     ymmreg|mask|z,ymmreg,ymmrm256|b64 AVX512VL
VFNMSUB231PD     zmmreg|mask|z,zmmreg,zmmrm512|b64|er AVX512
VFNMSUB231PS     xmmreg|mask|z,xmmreg,xmmrm128|b32 AVX512VL
VFNMSUB231PS     ymmreg|mask|z,ymmreg,ymmrm256|b32 AVX512VL
VFNMSUB231PS     zmmreg|mask|z,zmmreg,zmmrm512|b32|er AVX512
VFNMSUB231SD     xmmreg|mask|z,xmmreg,xmmrm64|er AVX512
VFNMSUB231SS     xmmreg|mask|z,xmmreg,xmmrm32|er AVX512
VFPCLASSPD       kreg|mask,xmmrm128|b64,imm8 AVX512VL/DQ
VFPCLASSPD       kreg|mask,ymmrm256|b64,imm8 AVX512VL/DQ
VFPCLASSPD       kreg|mask,zmmrm512|b64,imm8 AVX512DQ
VFPCLASSPS       kreg|mask,xmmrm128|b32,imm8 AVX512VL/DQ
VFPCLASSPS       kreg|mask,ymmrm256|b32,imm8 AVX512VL/DQ
VFPCLASSPS       kreg|mask,zmmrm512|b32,imm8 AVX512DQ
VFPCLASSSD       kreg|mask,xmmrm64,imm8   AVX512DQ
VFPCLASSSS       kreg|mask,xmmrm32,imm8   AVX512DQ
VGATHERDPD       xmmreg|mask,xmem64       AVX512VL
VGATHERDPD       ymmreg|mask,xmem64       AVX512VL
VGATHERDPD       zmmreg|mask,ymem64       AVX512
VGATHERDPS       xmmreg|mask,xmem32       AVX512VL
VGATHERDPS       ymmreg|mask,ymem32       AVX512VL
VGATHERDPS       zmmreg|mask,zmem32       AVX512
VGATHERPF0DPD    ymem64|mask              AVX512PF
VGATHERPF0DPS    zmem32|mask              AVX512PF
VGATHERPF0QPD    zmem64|mask              AVX512PF
VGATHERPF0QPS    zmem32|mask              AVX512PF
VGATHERPF1DPD    ymem64|mask              AVX512PF
VGATHERPF1DPS    zmem32|mask              AVX512PF
VGATHERPF1QPD    zmem64|mask              AVX512PF
VGATHERPF1QPS    zmem32|mask              AVX512PF
VGATHERQPD       xmmreg|mask,xmem64       AVX512VL
VGATHERQPD       ymmreg|mask,ymem64       AVX512VL
VGATHERQPD       zmmreg|mask,zmem64       AVX512
VGATHERQPS       xmmreg|mask,xmem32       AVX512VL
VGATHERQPS       xmmreg|mask,ymem32       AVX512VL
VGATHERQPS       ymmreg|mask,zmem32       AVX512
VGETEXPPD        xmmreg|mask|z,xmmrm128|b64 AVX512VL
VGETEXPPD        ymmreg|mask|z,ymmrm256|b64 AVX512VL
VGETEXPPD        zmmreg|mask|z,zmmrm512|b64|sae AVX512
VGETEXPPS        xmmreg|mask|z,xmmrm128|b32 AVX512VL
VGETEXPPS        ymmreg|mask|z,ymmrm256|b32 AVX512VL
VGETEXPPS        zmmreg|mask|z,zmmrm512|b32|sae AVX512
VGETEXPSD        xmmreg|mask|z,xmmreg,xmmrm64|sae AVX512
VGETEXPSS        xmmreg|mask|z,xmmreg,xmmrm32|sae AVX512
VGETMANTPD       xmmreg|mask|z,xmmrm128|b64,imm8 AVX512VL
VGETMANTPD       ymmreg|mask|z,ymmrm256|b64,imm8 AVX512VL
VGETMANTPD       zmmreg|mask|z,zmmrm512|b64|sae,imm8 AVX512
VGETMANTPS       xmmreg|mask|z,xmmrm128|b32,imm8 AVX512VL
VGETMANTPS       ymmreg|mask|z,ymmrm256|b32,imm8 AVX512VL
VGETMANTPS       zmmreg|mask|z,zmmrm512|b32|sae,imm8 AVX512
VGETMANTSD       xmmreg|mask|z,xmmreg,xmmrm64|sae,imm8 AVX512
VGETMANTSS       xmmreg|mask|z,xmmreg,xmmrm32|sae,imm8 AVX512
VINSERTF32X4     ymmreg|mask|z,ymmreg*,xmmrm128,imm8 AVX512VL
VINSERTF32X4     zmmreg|mask|z,zmmreg*,xmmrm128,imm8 AVX512
VINSERTF32X8     zmmreg|mask|z,zmmreg*,ymmrm256,imm8 AVX512DQ
VINSERTF64X2     ymmreg|mask|z,ymmreg*,xmmrm128,imm8 AVX512VL/DQ
VINSERTF64X2     zmmreg|mask|z,zmmreg*,xmmrm128,imm8 AVX512DQ
VINSERTF64X4     zmmreg|mask|z,zmmreg*,ymmrm256,imm8 AVX512
VINSERTI32X4     ymmreg|mask|z,ymmreg*,xmmrm128,imm8 AVX512VL
VINSERTI32X4     zmmreg|mask|z,zmmreg*,xmmrm128,imm8 AVX512
VINSERTI32X8     zmmreg|mask|z,zmmreg*,ymmrm256,imm8 AVX512DQ
VINSERTI64X2     ymmreg|mask|z,ymmreg*,xmmrm128,imm8 AVX512VL/DQ
VINSERTI64X2     zmmreg|mask|z,zmmreg*,xmmrm128,imm8 AVX512DQ
VINSERTI64X4     zmmreg|mask|z,zmmreg*,ymmrm256,imm8 AVX512
VINSERTPS        xmmreg,xmmreg*,xmmrm32,imm8 AVX512
VMAXPD           xmmreg|mask|z,xmmreg*,xmmrm128|b64 AVX512VL
VMAXPD           ymmreg|mask|z,ymmreg*,ymmrm256|b64 AVX512VL
VMAXPD           zmmreg|mask|z,zmmreg*,zmmrm512|b64|sae AVX512
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VMAXPS          xmmreg|mask|z,xmmreg*,xmmrm128|b32 AVX512VL
VMAXPS          ymmreg|mask|z,ymmreg*,ymmrm256|b32 AVX512VL
VMAXPS          zmmreg|mask|z,zmmreg*,zmmrm512|b32|sae AVX512
VMAXSD          xmmreg|mask|z,xmmreg*,xmmrm64|sae AVX512
VMAXSS          xmmreg|mask|z,xmmreg*,xmmrm32|sae AVX512
VMINPD          xmmreg|mask|z,xmmreg*,xmmrm128|b64 AVX512VL
VMINPD          ymmreg|mask|z,ymmreg*,ymmrm256|b64 AVX512VL
VMINPD          zmmreg|mask|z,zmmreg*,zmmrm512|b64|sae AVX512
VMINPS          xmmreg|mask|z,xmmreg*,xmmrm128|b32 AVX512VL
VMINPS          ymmreg|mask|z,ymmreg*,ymmrm256|b32 AVX512VL
VMINPS          zmmreg|mask|z,zmmreg*,zmmrm512|b32|sae AVX512
VMINSD          xmmreg|mask|z,xmmreg*,xmmrm64|sae AVX512
VMINSS          xmmreg|mask|z,xmmreg*,xmmrm32|sae AVX512
VMOVAPD         xmmreg|mask|z,xmmrm128   AVX512VL
VMOVAPD         ymmreg|mask|z,ymmrm256   AVX512VL
VMOVAPD         zmmreg|mask|z,zmmrm512   AVX512
VMOVAPD         xmmreg|mask|z,xmmreg     AVX512VL
VMOVAPD         ymmreg|mask|z,ymmreg     AVX512VL
VMOVAPD         zmmreg|mask|z,zmmreg     AVX512
VMOVAPD         mem128|mask,xmmreg       AVX512VL
VMOVAPD         mem256|mask,ymmreg       AVX512VL
VMOVAPD         mem512|mask,zmmreg       AVX512
VMOVAPS         xmmreg|mask|z,xmmrm128   AVX512VL
VMOVAPS         ymmreg|mask|z,ymmrm256   AVX512VL
VMOVAPS         zmmreg|mask|z,zmmrm512   AVX512
VMOVAPS         xmmreg|mask|z,xmmreg     AVX512VL
VMOVAPS         ymmreg|mask|z,ymmreg     AVX512VL
VMOVAPS         zmmreg|mask|z,zmmreg     AVX512
VMOVAPS         mem128|mask,xmmreg       AVX512VL
VMOVAPS         mem256|mask,ymmreg       AVX512VL
VMOVAPS         mem512|mask,zmmreg       AVX512
VMOVD           xmmreg,rm32              AVX512
VMOVD           rm32,xmmreg              AVX512
VMOVDDUP        xmmreg|mask|z,xmmrm64    AVX512VL
VMOVDDUP        ymmreg|mask|z,ymmrm256   AVX512VL
VMOVDDUP        zmmreg|mask|z,zmmrm512   AVX512
VMOVDQA32       xmmreg|mask|z,xmmrm128   AVX512VL
VMOVDQA32       ymmreg|mask|z,ymmrm256   AVX512VL
VMOVDQA32       zmmreg|mask|z,zmmrm512   AVX512
VMOVDQA32       xmmrm128|mask|z,xmmreg   AVX512VL
VMOVDQA32       ymmrm256|mask|z,ymmreg   AVX512VL
VMOVDQA32       zmmrm512|mask|z,zmmreg   AVX512
VMOVDQA64       xmmreg|mask|z,xmmrm128   AVX512VL
VMOVDQA64       ymmreg|mask|z,ymmrm256   AVX512VL
VMOVDQA64       zmmreg|mask|z,zmmrm512   AVX512
VMOVDQA64       xmmrm128|mask|z,xmmreg   AVX512VL
VMOVDQA64       ymmrm256|mask|z,ymmreg   AVX512VL
VMOVDQA64       zmmrm512|mask|z,zmmreg   AVX512
VMOVDQU16       xmmreg|mask|z,xmmrm128   AVX512VL/BW
VMOVDQU16       ymmreg|mask|z,ymmrm256   AVX512VL/BW
VMOVDQU16       zmmreg|mask|z,zmmrm512   AVX512BW
VMOVDQU16       xmmrm128|mask|z,xmmreg   AVX512VL/BW
VMOVDQU16       ymmrm256|mask|z,ymmreg   AVX512VL/BW
VMOVDQU16       zmmrm512|mask|z,zmmreg   AVX512BW
VMOVDQU32       xmmreg|mask|z,xmmrm128   AVX512VL
VMOVDQU32       ymmreg|mask|z,ymmrm256   AVX512VL
VMOVDQU32       zmmreg|mask|z,zmmrm512   AVX512
VMOVDQU32       xmmrm128|mask|z,xmmreg   AVX512VL
VMOVDQU32       ymmrm256|mask|z,ymmreg   AVX512VL
VMOVDQU32       zmmrm512|mask|z,zmmreg   AVX512
VMOVDQU64       xmmreg|mask|z,xmmrm128   AVX512VL
VMOVDQU64       ymmreg|mask|z,ymmrm256   AVX512VL
VMOVDQU64       zmmreg|mask|z,zmmrm512   AVX512
VMOVDQU64       xmmrm128|mask|z,xmmreg   AVX512VL
VMOVDQU64       ymmrm256|mask|z,ymmreg   AVX512VL
VMOVDQU64       zmmrm512|mask|z,zmmreg   AVX512
VMOVDQU8        xmmreg|mask|z,xmmrm128   AVX512VL/BW
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VMOVDQU8        ymmreg|mask|z,ymmrm256   AVX512VL/BW
VMOVDQU8        zmmreg|mask|z,zmmrm512   AVX512BW
VMOVDQU8        xmmrm128|mask|z,xmmreg   AVX512VL/BW
VMOVDQU8        ymmrm256|mask|z,ymmreg   AVX512VL/BW
VMOVDQU8        zmmrm512|mask|z,zmmreg   AVX512BW
VMOVHLPS        xmmreg,xmmreg*,xmmreg    AVX512
VMOVHPD         xmmreg,xmmreg*,mem64     AVX512
VMOVHPD         mem64,xmmreg             AVX512
VMOVHPS         xmmreg,xmmreg*,mem64     AVX512
VMOVHPS         mem64,xmmreg             AVX512
VMOVLHPS        xmmreg,xmmreg*,xmmreg    AVX512
VMOVLPD         xmmreg,xmmreg*,mem64     AVX512
VMOVLPD         mem64,xmmreg             AVX512
VMOVLPS         xmmreg,xmmreg*,mem64     AVX512
VMOVLPS         mem64,xmmreg             AVX512
VMOVNTDQ        mem128,xmmreg            AVX512VL
VMOVNTDQ        mem256,ymmreg            AVX512VL
VMOVNTDQ        mem512,zmmreg            AVX512
VMOVNTDQA       xmmreg,mem128            AVX512VL
VMOVNTDQA       ymmreg,mem256            AVX512VL
VMOVNTDQA       zmmreg,mem512            AVX512
VMOVNTPD        mem128,xmmreg            AVX512VL
VMOVNTPD        mem256,ymmreg            AVX512VL
VMOVNTPD        mem512,zmmreg            AVX512
VMOVNTPS        mem128,xmmreg            AVX512VL
VMOVNTPS        mem256,ymmreg            AVX512VL
VMOVNTPS        mem512,zmmreg            AVX512
VMOVQ           xmmreg,rm64              AVX512
VMOVQ           rm64,xmmreg              AVX512
VMOVQ           xmmreg,xmmrm64           AVX512
VMOVQ           xmmrm64,xmmreg           AVX512
VMOVSD          xmmreg|mask|z,mem64      AVX512
VMOVSD          mem64|mask,xmmreg        AVX512
VMOVSD          xmmreg|mask|z,xmmreg*,xmmreg AVX512
VMOVSD          xmmreg|mask|z,xmmreg*,xmmreg AVX512
VMOVSHDUP       xmmreg|mask|z,xmmrm128   AVX512VL
VMOVSHDUP       ymmreg|mask|z,ymmrm256   AVX512VL
VMOVSHDUP       zmmreg|mask|z,zmmrm512   AVX512
VMOVSLDUP       xmmreg|mask|z,xmmrm128   AVX512VL
VMOVSLDUP       ymmreg|mask|z,ymmrm256   AVX512VL
VMOVSLDUP       zmmreg|mask|z,zmmrm512   AVX512
VMOVSS          xmmreg|mask|z,mem32      AVX512
VMOVSS          mem32|mask,xmmreg        AVX512
VMOVSS          xmmreg|mask|z,xmmreg*,xmmreg AVX512
VMOVSS          xmmreg|mask|z,xmmreg*,xmmreg AVX512
VMOVUPD         xmmreg|mask|z,xmmrm128   AVX512VL
VMOVUPD         ymmreg|mask|z,ymmrm256   AVX512VL
VMOVUPD         zmmreg|mask|z,zmmrm512   AVX512
VMOVUPD         xmmreg|mask|z,xmmreg     AVX512VL
VMOVUPD         ymmreg|mask|z,ymmreg     AVX512VL
VMOVUPD         zmmreg|mask|z,zmmreg     AVX512
VMOVUPD         mem128|mask,xmmreg       AVX512VL
VMOVUPD         mem256|mask,ymmreg       AVX512VL
VMOVUPD         mem512|mask,zmmreg       AVX512
VMOVUPS         xmmreg|mask|z,xmmrm128   AVX512VL
VMOVUPS         ymmreg|mask|z,ymmrm256   AVX512VL
VMOVUPS         zmmreg|mask|z,zmmrm512   AVX512
VMOVUPS         xmmreg|mask|z,xmmreg     AVX512VL
VMOVUPS         ymmreg|mask|z,ymmreg     AVX512VL
VMOVUPS         zmmreg|mask|z,zmmreg     AVX512
VMOVUPS         mem128|mask,xmmreg       AVX512VL
VMOVUPS         mem256|mask,ymmreg       AVX512VL
VMOVUPS         mem512|mask,zmmreg       AVX512
VMULPD          xmmreg|mask|z,xmmreg*,xmmrm128|b64 AVX512VL
VMULPD          ymmreg|mask|z,ymmreg*,ymmrm256|b64 AVX512VL
VMULPD          zmmreg|mask|z,zmmreg*,zmmrm512|b64|er AVX512
VMULPS          xmmreg|mask|z,xmmreg*,xmmrm128|b32 AVX512VL
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VMULPS          ymmreg|mask|z,ymmreg*,ymmrm256|b32 AVX512VL
VMULPS          zmmreg|mask|z,zmmreg*,zmmrm512|b32|er AVX512
VMULSD          xmmreg|mask|z,xmmreg*,xmmrm64|er AVX512
VMULSS          xmmreg|mask|z,xmmreg*,xmmrm32|er AVX512
VORPD           xmmreg|mask|z,xmmreg*,xmmrm128|b64 AVX512VL/DQ
VORPD           ymmreg|mask|z,ymmreg*,ymmrm256|b64 AVX512VL/DQ
VORPD           zmmreg|mask|z,zmmreg*,zmmrm512|b64 AVX512DQ
VORPS           xmmreg|mask|z,xmmreg*,xmmrm128|b32 AVX512VL/DQ
VORPS           ymmreg|mask|z,ymmreg*,ymmrm256|b32 AVX512VL/DQ
VORPS           zmmreg|mask|z,zmmreg*,zmmrm512|b32 AVX512DQ
VPABSB          xmmreg|mask|z,xmmrm128   AVX512VL/BW
VPABSB          ymmreg|mask|z,ymmrm256   AVX512VL/BW
VPABSB          zmmreg|mask|z,zmmrm512   AVX512BW
VPABSD          xmmreg|mask|z,xmmrm128|b32 AVX512VL
VPABSD          ymmreg|mask|z,ymmrm256|b32 AVX512VL
VPABSD          zmmreg|mask|z,zmmrm512|b32 AVX512
VPABSQ          xmmreg|mask|z,xmmrm128|b64 AVX512VL
VPABSQ          ymmreg|mask|z,ymmrm256|b64 AVX512VL
VPABSQ          zmmreg|mask|z,zmmrm512|b64 AVX512
VPABSW          xmmreg|mask|z,xmmrm128   AVX512VL/BW
VPABSW          ymmreg|mask|z,ymmrm256   AVX512VL/BW
VPABSW          zmmreg|mask|z,zmmrm512   AVX512BW
VPACKSSDW       xmmreg|mask|z,xmmreg*,xmmrm128|b32 AVX512VL/BW
VPACKSSDW       ymmreg|mask|z,ymmreg*,ymmrm256|b32 AVX512VL/BW
VPACKSSDW       zmmreg|mask|z,zmmreg*,zmmrm512|b32 AVX512BW
VPACKSSWB       xmmreg|mask|z,xmmreg*,xmmrm128 AVX512VL/BW
VPACKSSWB       ymmreg|mask|z,ymmreg*,ymmrm256 AVX512VL/BW
VPACKSSWB       zmmreg|mask|z,zmmreg*,zmmrm512 AVX512BW
VPACKUSDW       xmmreg|mask|z,xmmreg*,xmmrm128|b32 AVX512VL/BW
VPACKUSDW       ymmreg|mask|z,ymmreg*,ymmrm256|b32 AVX512VL/BW
VPACKUSDW       zmmreg|mask|z,zmmreg*,zmmrm512|b32 AVX512BW
VPACKUSWB       xmmreg|mask|z,xmmreg*,xmmrm128 AVX512VL/BW
VPACKUSWB       ymmreg|mask|z,ymmreg*,ymmrm256 AVX512VL/BW
VPACKUSWB       zmmreg|mask|z,zmmreg*,zmmrm512 AVX512BW
VPADDB          xmmreg|mask|z,xmmreg*,xmmrm128 AVX512VL/BW
VPADDB          ymmreg|mask|z,ymmreg*,ymmrm256 AVX512VL/BW
VPADDB          zmmreg|mask|z,zmmreg*,zmmrm512 AVX512BW
VPADDD          xmmreg|mask|z,xmmreg*,xmmrm128|b32 AVX512VL
VPADDD          ymmreg|mask|z,ymmreg*,ymmrm256|b32 AVX512VL
VPADDD          zmmreg|mask|z,zmmreg*,zmmrm512|b32 AVX512
VPADDQ          xmmreg|mask|z,xmmreg*,xmmrm128|b64 AVX512VL
VPADDQ          ymmreg|mask|z,ymmreg*,ymmrm256|b64 AVX512VL
VPADDQ          zmmreg|mask|z,zmmreg*,zmmrm512|b64 AVX512
VPADDSB         xmmreg|mask|z,xmmreg*,xmmrm128 AVX512VL/BW
VPADDSB         ymmreg|mask|z,ymmreg*,ymmrm256 AVX512VL/BW
VPADDSB         zmmreg|mask|z,zmmreg*,zmmrm512 AVX512BW
VPADDSW         xmmreg|mask|z,xmmreg*,xmmrm128 AVX512VL/BW
VPADDSW         ymmreg|mask|z,ymmreg*,ymmrm256 AVX512VL/BW
VPADDSW         zmmreg|mask|z,zmmreg*,zmmrm512 AVX512BW
VPADDUSB        xmmreg|mask|z,xmmreg*,xmmrm128 AVX512VL/BW
VPADDUSB        ymmreg|mask|z,ymmreg*,ymmrm256 AVX512VL/BW
VPADDUSB        zmmreg|mask|z,zmmreg*,zmmrm512 AVX512BW
VPADDUSW        xmmreg|mask|z,xmmreg*,xmmrm128 AVX512VL/BW
VPADDUSW        ymmreg|mask|z,ymmreg*,ymmrm256 AVX512VL/BW
VPADDUSW        zmmreg|mask|z,zmmreg*,zmmrm512 AVX512BW
VPADDW          xmmreg|mask|z,xmmreg*,xmmrm128 AVX512VL/BW
VPADDW          ymmreg|mask|z,ymmreg*,ymmrm256 AVX512VL/BW
VPADDW          zmmreg|mask|z,zmmreg*,zmmrm512 AVX512BW
VPALIGNR        xmmreg|mask|z,xmmreg*,xmmrm128,imm8 AVX512VL/BW
VPALIGNR        ymmreg|mask|z,ymmreg*,ymmrm256,imm8 AVX512VL/BW
VPALIGNR        zmmreg|mask|z,zmmreg*,zmmrm512,imm8 AVX512BW
VPANDD          xmmreg|mask|z,xmmreg*,xmmrm128|b32 AVX512VL
VPANDD          ymmreg|mask|z,ymmreg*,ymmrm256|b32 AVX512VL
VPANDD          zmmreg|mask|z,zmmreg*,zmmrm512|b32 AVX512
VPANDND         xmmreg|mask|z,xmmreg*,xmmrm128|b32 AVX512VL
VPANDND         ymmreg|mask|z,ymmreg*,ymmrm256|b32 AVX512VL
VPANDND         zmmreg|mask|z,zmmreg*,zmmrm512|b32 AVX512
```

```
VPANDNQ          xmmreg|mask|z,xmmreg*,xmmrm128|b64 AVX512VL
VPANDNQ          ymmreg|mask|z,ymmreg*,ymmrm256|b64 AVX512VL
VPANDNQ          zmmreg|mask|z,zmmreg*,zmmrm512|b64 AVX512
VPANDQ           xmmreg|mask|z,xmmreg*,xmmrm128|b64 AVX512VL
VPANDQ           ymmreg|mask|z,ymmreg*,ymmrm256|b64 AVX512VL
VPANDQ           zmmreg|mask|z,zmmreg*,zmmrm512|b64 AVX512
VPAVGB           xmmreg|mask|z,xmmreg*,xmmrm128 AVX512VL/BW
VPAVGB           ymmreg|mask|z,ymmreg*,ymmrm256 AVX512VL/BW
VPAVGB           zmmreg|mask|z,zmmreg*,zmmrm512 AVX512BW
VPAVGW           xmmreg|mask|z,xmmreg*,xmmrm128 AVX512VL/BW
VPAVGW           ymmreg|mask|z,ymmreg*,ymmrm256 AVX512VL/BW
VPAVGW           zmmreg|mask|z,zmmreg*,zmmrm512 AVX512BW
VPBLENDMB        xmmreg|mask|z,xmmreg,xmmrm128 AVX512VL/BW
VPBLENDMB        ymmreg|mask|z,ymmreg,ymmrm256 AVX512VL/BW
VPBLENDMB        zmmreg|mask|z,zmmreg,zmmrm512 AVX512BW
VPBLENDMD        xmmreg|mask|z,xmmreg,xmmrm128|b32 AVX512VL
VPBLENDMD        ymmreg|mask|z,ymmreg,ymmrm256|b32 AVX512VL
VPBLENDMD        zmmreg|mask|z,zmmreg,zmmrm512|b32 AVX512
VPBLENDMQ        xmmreg|mask|z,xmmreg,xmmrm128|b64 AVX512VL
VPBLENDMQ        ymmreg|mask|z,ymmreg,ymmrm256|b64 AVX512VL
VPBLENDMQ        zmmreg|mask|z,zmmreg,zmmrm512|b64 AVX512
VPBLENDMW        xmmreg|mask|z,xmmreg,xmmrm128 AVX512VL/BW
VPBLENDMW        ymmreg|mask|z,ymmreg,ymmrm256 AVX512VL/BW
VPBLENDMW        zmmreg|mask|z,zmmreg,zmmrm512 AVX512BW
VPBROADCASTB     xmmreg|mask|z,xmmrm8     AVX512VL/BW
VPBROADCASTB     ymmreg|mask|z,xmmrm8     AVX512VL/BW
VPBROADCASTB     zmmreg|mask|z,xmmrm8     AVX512BW
VPBROADCASTB     xmmreg|mask|z,reg8       AVX512VL/BW
VPBROADCASTB     xmmreg|mask|z,reg16      AVX512VL/BW
VPBROADCASTB     xmmreg|mask|z,reg32      AVX512VL/BW
VPBROADCASTB     xmmreg|mask|z,reg64      AVX512VL/BW
VPBROADCASTB     ymmreg|mask|z,reg8       AVX512VL/BW
VPBROADCASTB     ymmreg|mask|z,reg16      AVX512VL/BW
VPBROADCASTB     ymmreg|mask|z,reg32      AVX512VL/BW
VPBROADCASTB     ymmreg|mask|z,reg64      AVX512VL/BW
VPBROADCASTB     zmmreg|mask|z,reg8       AVX512BW
VPBROADCASTB     zmmreg|mask|z,reg16      AVX512BW
VPBROADCASTB     zmmreg|mask|z,reg32      AVX512BW
VPBROADCASTB     zmmreg|mask|z,reg64      AVX512BW
VPBROADCASTD     xmmreg|mask|z,mem32      AVX512VL
VPBROADCASTD     ymmreg|mask|z,mem32      AVX512VL
VPBROADCASTD     zmmreg|mask|z,mem32      AVX512
VPBROADCASTD     xmmreg|mask|z,xmmreg     AVX512VL
VPBROADCASTD     ymmreg|mask|z,xmmreg     AVX512VL
VPBROADCASTD     zmmreg|mask|z,xmmreg     AVX512
VPBROADCASTD     xmmreg|mask|z,reg32      AVX512VL
VPBROADCASTD     ymmreg|mask|z,reg32      AVX512VL
VPBROADCASTD     zmmreg|mask|z,reg32      AVX512
VPBROADCASTMB2Q  xmmreg,kreg              AVX512CD/VL
VPBROADCASTMB2Q  ymmreg,kreg              AVX512CD/VL
VPBROADCASTMB2Q  zmmreg,kreg              AVX512CD
VPBROADCASTMW2D  xmmreg,kreg              AVX512CD/VL
VPBROADCASTMW2D  ymmreg,kreg              AVX512CD/VL
VPBROADCASTMW2D  zmmreg,kreg              AVX512CD
VPBROADCASTQ     xmmreg|mask|z,mem64      AVX512VL
VPBROADCASTQ     ymmreg|mask|z,mem64      AVX512VL
VPBROADCASTQ     zmmreg|mask|z,mem64      AVX512
VPBROADCASTQ     xmmreg|mask|z,xmmreg     AVX512VL
VPBROADCASTQ     ymmreg|mask|z,xmmreg     AVX512VL
VPBROADCASTQ     zmmreg|mask|z,xmmreg     AVX512
VPBROADCASTQ     xmmreg|mask|z,reg64      AVX512VL
VPBROADCASTQ     ymmreg|mask|z,reg64      AVX512VL
VPBROADCASTQ     zmmreg|mask|z,reg64      AVX512
VPBROADCASTW     xmmreg|mask|z,xmmrm16    AVX512VL/BW
VPBROADCASTW     ymmreg|mask|z,xmmrm16    AVX512VL/BW
VPBROADCASTW     zmmreg|mask|z,xmmrm16    AVX512BW
VPBROADCASTW     xmmreg|mask|z,reg16      AVX512VL/BW
```

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VPBROADCASTW     xmmreg|mask|z,reg32      AVX512VL/BW
VPBROADCASTW     xmmreg|mask|z,reg64      AVX512VL/BW
VPBROADCASTW     ymmreg|mask|z,reg16      AVX512VL/BW
VPBROADCASTW     ymmreg|mask|z,reg32      AVX512VL/BW
VPBROADCASTW     ymmreg|mask|z,reg64      AVX512VL/BW
VPBROADCASTW     zmmreg|mask|z,reg16      AVX512BW
VPBROADCASTW     zmmreg|mask|z,reg32      AVX512BW
VPBROADCASTW     zmmreg|mask|z,reg64      AVX512BW
VPCMPEQB         kreg|mask,xmmreg,xmmrm128 AVX512VL/BW
VPCMPEQB         kreg|mask,ymmreg,ymmrm256 AVX512VL/BW
VPCMPEQB         kreg|mask,zmmreg,zmmrm512 AVX512BW
VPCMPEQD         kreg|mask,xmmreg,xmmrm128|b32 AVX512VL
VPCMPEQD         kreg|mask,ymmreg,ymmrm256|b32 AVX512VL
VPCMPEQD         kreg|mask,zmmreg,zmmrm512|b32 AVX512
VPCMPEQQ         kreg|mask,xmmreg,xmmrm128|b64 AVX512VL
VPCMPEQQ         kreg|mask,ymmreg,ymmrm256|b64 AVX512VL
VPCMPEQQ         kreg|mask,zmmreg,zmmrm512|b64 AVX512
VPCMPEQW         kreg|mask,xmmreg,xmmrm128 AVX512VL/BW
VPCMPEQW         kreg|mask,ymmreg,ymmrm256 AVX512VL/BW
VPCMPEQW         kreg|mask,zmmreg,zmmrm512 AVX512BW
VPCMPGTB         kreg|mask,xmmreg,xmmrm128 AVX512VL/BW
VPCMPGTB         kreg|mask,ymmreg,ymmrm256 AVX512VL/BW
VPCMPGTB         kreg|mask,zmmreg,zmmrm512 AVX512BW
VPCMPGTD         kreg|mask,xmmreg,xmmrm128|b32 AVX512VL
VPCMPGTD         kreg|mask,ymmreg,ymmrm256|b32 AVX512VL
VPCMPGTD         kreg|mask,zmmreg,zmmrm512|b32 AVX512
VPCMPGTQ         kreg|mask,xmmreg,xmmrm128|b64 AVX512VL
VPCMPGTQ         kreg|mask,ymmreg,ymmrm256|b64 AVX512VL
VPCMPGTQ         kreg|mask,zmmreg,zmmrm512|b64 AVX512
VPCMPGTW         kreg|mask,xmmreg,xmmrm128 AVX512VL/BW
VPCMPGTW         kreg|mask,ymmreg,ymmrm256 AVX512VL/BW
VPCMPGTW         kreg|mask,zmmreg,zmmrm512 AVX512BW
VPCMPEQB         kreg|mask,xmmreg,xmmrm128 AVX512VL/BW
VPCMPEQB         kreg|mask,ymmreg,ymmrm256 AVX512VL/BW
VPCMPEQB         kreg|mask,zmmreg,zmmrm512 AVX512BW
VPCMPEQD         kreg|mask,xmmreg,xmmrm128|b32 AVX512VL
VPCMPEQD         kreg|mask,ymmreg,ymmrm256|b32 AVX512VL
VPCMPEQD         kreg|mask,zmmreg,zmmrm512|b32 AVX512
VPCMPEQQ         kreg|mask,xmmreg,xmmrm128|b64 AVX512VL
VPCMPEQQ         kreg|mask,ymmreg,ymmrm256|b64 AVX512VL
VPCMPEQQ         kreg|mask,zmmreg,zmmrm512|b64 AVX512
VPCMPEQUB        kreg|mask,xmmreg,xmmrm128 AVX512VL/BW
VPCMPEQUB        kreg|mask,ymmreg,ymmrm256 AVX512VL/BW
VPCMPEQUB        kreg|mask,zmmreg,zmmrm512 AVX512BW
VPCMPEQUD        kreg|mask,xmmreg,xmmrm128|b32 AVX512VL
VPCMPEQUD        kreg|mask,ymmreg,ymmrm256|b32 AVX512VL
VPCMPEQUD        kreg|mask,zmmreg,zmmrm512|b32 AVX512
VPCMPEQUQ        kreg|mask,xmmreg,xmmrm128|b64 AVX512VL
VPCMPEQUQ        kreg|mask,ymmreg,ymmrm256|b64 AVX512VL
VPCMPEQUQ        kreg|mask,zmmreg,zmmrm512|b64 AVX512
VPCMPEQUW        kreg|mask,xmmreg,xmmrm128 AVX512VL/BW
VPCMPEQUW        kreg|mask,ymmreg,ymmrm256 AVX512VL/BW
VPCMPEQUW        kreg|mask,zmmreg,zmmrm512 AVX512BW
VPCMPEQW         kreg|mask,xmmreg,xmmrm128 AVX512VL/BW
VPCMPEQW         kreg|mask,ymmreg,ymmrm256 AVX512VL/BW
VPCMPEQW         kreg|mask,zmmreg,zmmrm512 AVX512BW
VPCMPGEB         kreg|mask,xmmreg,xmmrm128 AVX512VL/BW
VPCMPGEB         kreg|mask,ymmreg,ymmrm256 AVX512VL/BW
VPCMPGEB         kreg|mask,zmmreg,zmmrm512 AVX512BW
VPCMPGED         kreg|mask,xmmreg,xmmrm128|b32 AVX512VL
VPCMPGED         kreg|mask,ymmreg,ymmrm256|b32 AVX512VL
VPCMPGED         kreg|mask,zmmreg,zmmrm512|b32 AVX512
VPCMPGEQ         kreg|mask,xmmreg,xmmrm128|b64 AVX512VL
VPCMPGEQ         kreg|mask,ymmreg,ymmrm256|b64 AVX512VL
VPCMPGEQ         kreg|mask,zmmreg,zmmrm512|b64 AVX512
VPCMPGEUB        kreg|mask,xmmreg,xmmrm128 AVX512VL/BW
VPCMPGEUB        kreg|mask,ymmreg,ymmrm256 AVX512VL/BW
```

```
VPCMPGEUB       kreg|mask,zmmreg,zmmrm512 AVX512BW
VPCMPGEUD       kreg|mask,xmmreg,xmmrm128|b32 AVX512VL
VPCMPGEUD       kreg|mask,ymmreg,ymmrm256|b32 AVX512VL
VPCMPGEUD       kreg|mask,zmmreg,zmmrm512|b32 AVX512
VPCMPGEUQ       kreg|mask,xmmreg,xmmrm128|b64 AVX512VL
VPCMPGEUQ       kreg|mask,ymmreg,ymmrm256|b64 AVX512VL
VPCMPGEUQ       kreg|mask,zmmreg,zmmrm512|b64 AVX512
VPCMPGEUW       kreg|mask,xmmreg,xmmrm128 AVX512VL/BW
VPCMPGEUW       kreg|mask,ymmreg,ymmrm256 AVX512VL/BW
VPCMPGEUW       kreg|mask,zmmreg,zmmrm512 AVX512BW
VPCMPGEW        kreg|mask,xmmreg,xmmrm128 AVX512VL/BW
VPCMPGEW        kreg|mask,ymmreg,ymmrm256 AVX512VL/BW
VPCMPGEW        kreg|mask,zmmreg,zmmrm512 AVX512BW
VPCMPGTB        kreg|mask,xmmreg,xmmrm128 AVX512VL/BW
VPCMPGTB        kreg|mask,ymmreg,ymmrm256 AVX512VL/BW
VPCMPGTB        kreg|mask,zmmreg,zmmrm512 AVX512BW
VPCMPGTD        kreg|mask,xmmreg,xmmrm128|b32 AVX512VL
VPCMPGTD        kreg|mask,ymmreg,ymmrm256|b32 AVX512VL
VPCMPGTD        kreg|mask,zmmreg,zmmrm512|b32 AVX512
VPCMPGTQ        kreg|mask,xmmreg,xmmrm128|b64 AVX512VL
VPCMPGTQ        kreg|mask,ymmreg,ymmrm256|b64 AVX512VL
VPCMPGTQ        kreg|mask,zmmreg,zmmrm512|b64 AVX512
VPCMPGTUB       kreg|mask,xmmreg,xmmrm128 AVX512VL/BW
VPCMPGTUB       kreg|mask,ymmreg,ymmrm256 AVX512VL/BW
VPCMPGTUB       kreg|mask,zmmreg,zmmrm512 AVX512BW
VPCMPGTUD       kreg|mask,xmmreg,xmmrm128|b32 AVX512VL
VPCMPGTUD       kreg|mask,ymmreg,ymmrm256|b32 AVX512VL
VPCMPGTUD       kreg|mask,zmmreg,zmmrm512|b32 AVX512
VPCMPGTUQ       kreg|mask,xmmreg,xmmrm128|b64 AVX512VL
VPCMPGTUQ       kreg|mask,ymmreg,ymmrm256|b64 AVX512VL
VPCMPGTUQ       kreg|mask,zmmreg,zmmrm512|b64 AVX512
VPCMPGTUW       kreg|mask,xmmreg,xmmrm128 AVX512VL/BW
VPCMPGTUW       kreg|mask,ymmreg,ymmrm256 AVX512VL/BW
VPCMPGTUW       kreg|mask,zmmreg,zmmrm512 AVX512BW
VPCMPGTW        kreg|mask,xmmreg,xmmrm128 AVX512VL/BW
VPCMPGTW        kreg|mask,ymmreg,ymmrm256 AVX512VL/BW
VPCMPGTW        kreg|mask,zmmreg,zmmrm512 AVX512BW
VPCMPLEB        kreg|mask,xmmreg,xmmrm128 AVX512VL/BW
VPCMPLEB        kreg|mask,ymmreg,ymmrm256 AVX512VL/BW
VPCMPLEB        kreg|mask,zmmreg,zmmrm512 AVX512BW
VPCMPLED        kreg|mask,xmmreg,xmmrm128|b32 AVX512VL
VPCMPLED        kreg|mask,ymmreg,ymmrm256|b32 AVX512VL
VPCMPLED        kreg|mask,zmmreg,zmmrm512|b32 AVX512
VPCMPLEQ        kreg|mask,xmmreg,xmmrm128|b64 AVX512VL
VPCMPLEQ        kreg|mask,ymmreg,ymmrm256|b64 AVX512VL
VPCMPLEQ        kreg|mask,zmmreg,zmmrm512|b64 AVX512
VPCMPLEUB       kreg|mask,xmmreg,xmmrm128 AVX512VL/BW
VPCMPLEUB       kreg|mask,ymmreg,ymmrm256 AVX512VL/BW
VPCMPLEUB       kreg|mask,zmmreg,zmmrm512 AVX512BW
VPCMPLEUD       kreg|mask,xmmreg,xmmrm128|b32 AVX512VL
VPCMPLEUD       kreg|mask,ymmreg,ymmrm256|b32 AVX512VL
VPCMPLEUD       kreg|mask,zmmreg,zmmrm512|b32 AVX512
VPCMPLEUQ       kreg|mask,xmmreg,xmmrm128|b64 AVX512VL
VPCMPLEUQ       kreg|mask,ymmreg,ymmrm256|b64 AVX512VL
VPCMPLEUQ       kreg|mask,zmmreg,zmmrm512|b64 AVX512
VPCMPLEUW       kreg|mask,xmmreg,xmmrm128 AVX512VL/BW
VPCMPLEUW       kreg|mask,ymmreg,ymmrm256 AVX512VL/BW
VPCMPLEUW       kreg|mask,zmmreg,zmmrm512 AVX512BW
VPCMPLEW        kreg|mask,xmmreg,xmmrm128 AVX512VL/BW
VPCMPLEW        kreg|mask,ymmreg,ymmrm256 AVX512VL/BW
VPCMPLEW        kreg|mask,zmmreg,zmmrm512 AVX512BW
VPCMPLTB        kreg|mask,xmmreg,xmmrm128 AVX512VL/BW
VPCMPLTB        kreg|mask,ymmreg,ymmrm256 AVX512VL/BW
VPCMPLTB        kreg|mask,zmmreg,zmmrm512 AVX512BW
VPCMPLTD        kreg|mask,xmmreg,xmmrm128|b32 AVX512VL
VPCMPLTD        kreg|mask,ymmreg,ymmrm256|b32 AVX512VL
VPCMPLTD        kreg|mask,zmmreg,zmmrm512|b32 AVX512
```

```
VPCMPLTQ        kreg|mask,xmmreg,xmmrm128|b64 AVX512VL
VPCMPLTQ        kreg|mask,ymmreg,ymmrm256|b64 AVX512VL
VPCMPLTQ        kreg|mask,zmmreg,zmmrm512|b64 AVX512
VPCMPLTUB       kreg|mask,xmmreg,xmmrm128 AVX512VL/BW
VPCMPLTUB       kreg|mask,ymmreg,ymmrm256 AVX512VL/BW
VPCMPLTUB       kreg|mask,zmmreg,zmmrm512 AVX512BW
VPCMPLTUD       kreg|mask,xmmreg,xmmrm128|b32 AVX512VL
VPCMPLTUD       kreg|mask,ymmreg,ymmrm256|b32 AVX512VL
VPCMPLTUD       kreg|mask,zmmreg,zmmrm512|b32 AVX512
VPCMPLTUQ       kreg|mask,xmmreg,xmmrm128|b64 AVX512VL
VPCMPLTUQ       kreg|mask,ymmreg,ymmrm256|b64 AVX512VL
VPCMPLTUQ       kreg|mask,zmmreg,zmmrm512|b64 AVX512
VPCMPLTUW       kreg|mask,xmmreg,xmmrm128 AVX512VL/BW
VPCMPLTUW       kreg|mask,ymmreg,ymmrm256 AVX512VL/BW
VPCMPLTUW       kreg|mask,zmmreg,zmmrm512 AVX512BW
VPCMPLTW        kreg|mask,xmmreg,xmmrm128 AVX512VL/BW
VPCMPLTW        kreg|mask,ymmreg,ymmrm256 AVX512VL/BW
VPCMPLTW        kreg|mask,zmmreg,zmmrm512 AVX512BW
VPCMPNEQB       kreg|mask,xmmreg,xmmrm128 AVX512VL/BW
VPCMPNEQB       kreg|mask,ymmreg,ymmrm256 AVX512VL/BW
VPCMPNEQB       kreg|mask,zmmreg,zmmrm512 AVX512BW
VPCMPNEQD       kreg|mask,xmmreg,xmmrm128|b32 AVX512VL
VPCMPNEQD       kreg|mask,ymmreg,ymmrm256|b32 AVX512VL
VPCMPNEQD       kreg|mask,zmmreg,zmmrm512|b32 AVX512
VPCMPNEQQ       kreg|mask,xmmreg,xmmrm128|b64 AVX512VL
VPCMPNEQQ       kreg|mask,ymmreg,ymmrm256|b64 AVX512VL
VPCMPNEQQ       kreg|mask,zmmreg,zmmrm512|b64 AVX512
VPCMPNEQUB      kreg|mask,xmmreg,xmmrm128 AVX512VL/BW
VPCMPNEQUB      kreg|mask,ymmreg,ymmrm256 AVX512VL/BW
VPCMPNEQUB      kreg|mask,zmmreg,zmmrm512 AVX512BW
VPCMPNEQUD      kreg|mask,xmmreg,xmmrm128|b32 AVX512VL
VPCMPNEQUD      kreg|mask,ymmreg,ymmrm256|b32 AVX512VL
VPCMPNEQUD      kreg|mask,zmmreg,zmmrm512|b32 AVX512
VPCMPNEQUQ      kreg|mask,xmmreg,xmmrm128|b64 AVX512VL
VPCMPNEQUQ      kreg|mask,ymmreg,ymmrm256|b64 AVX512VL
VPCMPNEQUQ      kreg|mask,zmmreg,zmmrm512|b64 AVX512
VPCMPNEQUW      kreg|mask,xmmreg,xmmrm128 AVX512VL/BW
VPCMPNEQUW      kreg|mask,ymmreg,ymmrm256 AVX512VL/BW
VPCMPNEQUW      kreg|mask,zmmreg,zmmrm512 AVX512BW
VPCMPNEQW       kreg|mask,xmmreg,xmmrm128 AVX512VL/BW
VPCMPNEQW       kreg|mask,ymmreg,ymmrm256 AVX512VL/BW
VPCMPNEQW       kreg|mask,zmmreg,zmmrm512 AVX512BW
VPCMPNGTB       kreg|mask,xmmreg,xmmrm128 AVX512VL/BW
VPCMPNGTB       kreg|mask,ymmreg,ymmrm256 AVX512VL/BW
VPCMPNGTB       kreg|mask,zmmreg,zmmrm512 AVX512BW
VPCMPNGTD       kreg|mask,xmmreg,xmmrm128|b32 AVX512VL
VPCMPNGTD       kreg|mask,ymmreg,ymmrm256|b32 AVX512VL
VPCMPNGTD       kreg|mask,zmmreg,zmmrm512|b32 AVX512
VPCMPNGTQ       kreg|mask,xmmreg,xmmrm128|b64 AVX512VL
VPCMPNGTQ       kreg|mask,ymmreg,ymmrm256|b64 AVX512VL
VPCMPNGTQ       kreg|mask,zmmreg,zmmrm512|b64 AVX512
VPCMPNGTUB      kreg|mask,xmmreg,xmmrm128 AVX512VL/BW
VPCMPNGTUB      kreg|mask,ymmreg,ymmrm256 AVX512VL/BW
VPCMPNGTUB      kreg|mask,zmmreg,zmmrm512 AVX512BW
VPCMPNGTUD      kreg|mask,xmmreg,xmmrm128|b32 AVX512VL
VPCMPNGTUD      kreg|mask,ymmreg,ymmrm256|b32 AVX512VL
VPCMPNGTUD      kreg|mask,zmmreg,zmmrm512|b32 AVX512
VPCMPNGTUQ      kreg|mask,xmmreg,xmmrm128|b64 AVX512VL
VPCMPNGTUQ      kreg|mask,ymmreg,ymmrm256|b64 AVX512VL
VPCMPNGTUQ      kreg|mask,zmmreg,zmmrm512|b64 AVX512
VPCMPNGTUW      kreg|mask,xmmreg,xmmrm128 AVX512VL/BW
VPCMPNGTUW      kreg|mask,ymmreg,ymmrm256 AVX512VL/BW
VPCMPNGTUW      kreg|mask,zmmreg,zmmrm512 AVX512BW
VPCMPNGTW       kreg|mask,xmmreg,xmmrm128 AVX512VL/BW
VPCMPNGTW       kreg|mask,ymmreg,ymmrm256 AVX512VL/BW
VPCMPNGTW       kreg|mask,zmmreg,zmmrm512 AVX512BW
VPCMPNLEB       kreg|mask,xmmreg,xmmrm128 AVX512VL/BW
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VPCMPNLEB       kreg|mask,ymmreg,ymmrm256 AVX512VL/BW
VPCMPNLEB       kreg|mask,zmmreg,zmmrm512 AVX512BW
VPCMPNLED       kreg|mask,xmmreg,xmmrm128|b32 AVX512VL
VPCMPNLED       kreg|mask,ymmreg,ymmrm256|b32 AVX512VL
VPCMPNLED       kreg|mask,zmmreg,zmmrm512|b32 AVX512
VPCMPNLEQ       kreg|mask,xmmreg,xmmrm128|b64 AVX512VL
VPCMPNLEQ       kreg|mask,ymmreg,ymmrm256|b64 AVX512VL
VPCMPNLEQ       kreg|mask,zmmreg,zmmrm512|b64 AVX512
VPCMPNLEUB      kreg|mask,xmmreg,xmmrm128 AVX512VL/BW
VPCMPNLEUB      kreg|mask,ymmreg,ymmrm256 AVX512VL/BW
VPCMPNLEUB      kreg|mask,zmmreg,zmmrm512 AVX512BW
VPCMPNLEUD      kreg|mask,xmmreg,xmmrm128|b32 AVX512VL
VPCMPNLEUD      kreg|mask,ymmreg,ymmrm256|b32 AVX512VL
VPCMPNLEUD      kreg|mask,zmmreg,zmmrm512|b32 AVX512
VPCMPNLEUQ      kreg|mask,xmmreg,xmmrm128|b64 AVX512VL
VPCMPNLEUQ      kreg|mask,ymmreg,ymmrm256|b64 AVX512VL
VPCMPNLEUQ      kreg|mask,zmmreg,zmmrm512|b64 AVX512
VPCMPNLEUW      kreg|mask,xmmreg,xmmrm128 AVX512VL/BW
VPCMPNLEUW      kreg|mask,ymmreg,ymmrm256 AVX512VL/BW
VPCMPNLEUW      kreg|mask,zmmreg,zmmrm512 AVX512BW
VPCMPNLEW       kreg|mask,xmmreg,xmmrm128 AVX512VL/BW
VPCMPNLEW       kreg|mask,ymmreg,ymmrm256 AVX512VL/BW
VPCMPNLEW       kreg|mask,zmmreg,zmmrm512 AVX512BW
VPCMPNLTB       kreg|mask,xmmreg,xmmrm128 AVX512VL/BW
VPCMPNLTB       kreg|mask,ymmreg,ymmrm256 AVX512VL/BW
VPCMPNLTB       kreg|mask,zmmreg,zmmrm512 AVX512BW
VPCMPNLTD       kreg|mask,xmmreg,xmmrm128|b32 AVX512VL
VPCMPNLTD       kreg|mask,ymmreg,ymmrm256|b32 AVX512VL
VPCMPNLTD       kreg|mask,zmmreg,zmmrm512|b32 AVX512
VPCMPNLTQ       kreg|mask,xmmreg,xmmrm128|b64 AVX512VL
VPCMPNLTQ       kreg|mask,ymmreg,ymmrm256|b64 AVX512VL
VPCMPNLTQ       kreg|mask,zmmreg,zmmrm512|b64 AVX512
VPCMPNLTUB      kreg|mask,xmmreg,xmmrm128 AVX512VL/BW
VPCMPNLTUB      kreg|mask,ymmreg,ymmrm256 AVX512VL/BW
VPCMPNLTUB      kreg|mask,zmmreg,zmmrm512 AVX512BW
VPCMPNLTUD      kreg|mask,xmmreg,xmmrm128|b32 AVX512VL
VPCMPNLTUD      kreg|mask,ymmreg,ymmrm256|b32 AVX512VL
VPCMPNLTUD      kreg|mask,zmmreg,zmmrm512|b32 AVX512
VPCMPNLTUQ      kreg|mask,xmmreg,xmmrm128|b64 AVX512VL
VPCMPNLTUQ      kreg|mask,ymmreg,ymmrm256|b64 AVX512VL
VPCMPNLTUQ      kreg|mask,zmmreg,zmmrm512|b64 AVX512
VPCMPNLTUW      kreg|mask,xmmreg,xmmrm128 AVX512VL/BW
VPCMPNLTUW      kreg|mask,ymmreg,ymmrm256 AVX512VL/BW
VPCMPNLTUW      kreg|mask,zmmreg,zmmrm512 AVX512BW
VPCMPNLTW       kreg|mask,xmmreg,xmmrm128 AVX512VL/BW
VPCMPNLTW       kreg|mask,ymmreg,ymmrm256 AVX512VL/BW
VPCMPNLTW       kreg|mask,zmmreg,zmmrm512 AVX512BW
VPCMPB          kreg|mask,xmmreg,xmmrm128,imm8 AVX512VL/BW
VPCMPB          kreg|mask,ymmreg,ymmrm256,imm8 AVX512VL/BW
VPCMPB          kreg|mask,zmmreg,zmmrm512,imm8 AVX512BW
VPCMPD          kreg|mask,xmmreg,xmmrm128|b32,imm8 AVX512VL
VPCMPD          kreg|mask,ymmreg,ymmrm256|b32,imm8 AVX512VL
VPCMPD          kreg|mask,zmmreg,zmmrm512|b32,imm8 AVX512
VPCMPQ          kreg|mask,xmmreg,xmmrm128|b64,imm8 AVX512VL
VPCMPQ          kreg|mask,ymmreg,ymmrm256|b64,imm8 AVX512VL
VPCMPQ          kreg|mask,zmmreg,zmmrm512|b64,imm8 AVX512
VPCMPUB         kreg|mask,xmmreg,xmmrm128,imm8 AVX512VL/BW
VPCMPUB         kreg|mask,ymmreg,ymmrm256,imm8 AVX512VL/BW
VPCMPUB         kreg|mask,zmmreg,zmmrm512,imm8 AVX512BW
VPCMPUD         kreg|mask,xmmreg,xmmrm128|b32,imm8 AVX512VL
VPCMPUD         kreg|mask,ymmreg,ymmrm256|b32,imm8 AVX512VL
VPCMPUD         kreg|mask,zmmreg,zmmrm512|b32,imm8 AVX512
VPCMPUQ         kreg|mask,xmmreg,xmmrm128|b64,imm8 AVX512VL
VPCMPUQ         kreg|mask,ymmreg,ymmrm256|b64,imm8 AVX512VL
VPCMPUQ         kreg|mask,zmmreg,zmmrm512|b64,imm8 AVX512
VPCMPUW         kreg|mask,xmmreg,xmmrm128,imm8 AVX512VL/BW
VPCMPUW         kreg|mask,ymmreg,ymmrm256,imm8 AVX512VL/BW
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VPCMPUW         kreg|mask,zmmreg,zmmrm512,imm8 AVX512BW
VPCMPW          kreg|mask,xmmreg,xmmrm128,imm8 AVX512VL/BW
VPCMPW          kreg|mask,ymmreg,ymmrm256,imm8 AVX512VL/BW
VPCMPW          kreg|mask,zmmreg,zmmrm512,imm8 AVX512BW
VPCOMPRESSD     mem128|mask,xmmreg       AVX512VL
VPCOMPRESSD     mem256|mask,ymmreg       AVX512VL
VPCOMPRESSD     mem512|mask,zmmreg       AVX512
VPCOMPRESSD     xmmreg|mask|z,xmmreg     AVX512VL
VPCOMPRESSD     ymmreg|mask|z,ymmreg     AVX512VL
VPCOMPRESSD     zmmreg|mask|z,zmmreg     AVX512
VPCOMPRESSQ     mem128|mask,xmmreg       AVX512VL
VPCOMPRESSQ     mem256|mask,ymmreg       AVX512VL
VPCOMPRESSQ     mem512|mask,zmmreg       AVX512
VPCOMPRESSQ     xmmreg|mask|z,xmmreg     AVX512VL
VPCOMPRESSQ     ymmreg|mask|z,ymmreg     AVX512VL
VPCOMPRESSQ     zmmreg|mask|z,zmmreg     AVX512
VPCONFLICTD     xmmreg|mask|z,xmmrm128|b32 AVX512CD/VL
VPCONFLICTD     ymmreg|mask|z,ymmrm256|b32 AVX512CD/VL
VPCONFLICTD     zmmreg|mask|z,zmmrm512|b32 AVX512CD
VPCONFLICTQ     xmmreg|mask|z,xmmrm128|b64 AVX512CD/VL
VPCONFLICTQ     ymmreg|mask|z,ymmrm256|b64 AVX512CD/VL
VPCONFLICTQ     zmmreg|mask|z,zmmrm512|b64 AVX512CD
VPERMB          xmmreg|mask|z,xmmreg*,xmmrm128 AVX512VL/VBMI
VPERMB          ymmreg|mask|z,ymmreg*,ymmrm256 AVX512VL/VBMI
VPERMB          zmmreg|mask|z,zmmreg*,zmmrm512 AVX512VBMI
VPERMD          ymmreg|mask|z,ymmreg*,ymmrm256|b32 AVX512VL
VPERMD          zmmreg|mask|z,zmmreg*,zmmrm512|b32 AVX512
VPERMI2B        xmmreg|mask|z,xmmreg,xmmrm128 AVX512VL/VBMI
VPERMI2B        ymmreg|mask|z,ymmreg,ymmrm256 AVX512VL/VBMI
VPERMI2B        zmmreg|mask|z,zmmreg,zmmrm512 AVX512VBMI
VPERMI2D        xmmreg|mask|z,xmmreg,xmmrm128|b32 AVX512VL
VPERMI2D        ymmreg|mask|z,ymmreg,ymmrm256|b32 AVX512VL
VPERMI2D        zmmreg|mask|z,zmmreg,zmmrm512|b32 AVX512
VPERMI2PD       xmmreg|mask|z,xmmreg,xmmrm128|b64 AVX512VL
VPERMI2PD       ymmreg|mask|z,ymmreg,ymmrm256|b64 AVX512VL
VPERMI2PD       zmmreg|mask|z,zmmreg,zmmrm512|b64 AVX512
VPERMI2PS       xmmreg|mask|z,xmmreg,xmmrm128|b32 AVX512VL
VPERMI2PS       ymmreg|mask|z,ymmreg,ymmrm256|b32 AVX512VL
VPERMI2PS       zmmreg|mask|z,zmmreg,zmmrm512|b32 AVX512
VPERMI2Q        xmmreg|mask|z,xmmreg,xmmrm128|b64 AVX512VL
VPERMI2Q        ymmreg|mask|z,ymmreg,ymmrm256|b64 AVX512VL
VPERMI2Q        zmmreg|mask|z,zmmreg,zmmrm512|b64 AVX512
VPERMI2W        xmmreg|mask|z,xmmreg,xmmrm128 AVX512VL/BW
VPERMI2W        ymmreg|mask|z,ymmreg,ymmrm256 AVX512VL/BW
VPERMI2W        zmmreg|mask|z,zmmreg,zmmrm512 AVX512BW
VPERMILPD       xmmreg|mask|z,xmmrm128|b64,imm8 AVX512VL
VPERMILPD       ymmreg|mask|z,ymmrm256|b64,imm8 AVX512VL
VPERMILPD       zmmreg|mask|z,zmmrm512|b64,imm8 AVX512
VPERMILPD       xmmreg|mask|z,xmmreg*,xmmrm128|b64 AVX512VL
VPERMILPD       ymmreg|mask|z,ymmreg*,ymmrm256|b64 AVX512VL
VPERMILPD       zmmreg|mask|z,zmmreg*,zmmrm512|b64 AVX512
VPERMILPS       xmmreg|mask|z,xmmrm128|b32,imm8 AVX512VL
VPERMILPS       ymmreg|mask|z,ymmrm256|b32,imm8 AVX512VL
VPERMILPS       zmmreg|mask|z,zmmrm512|b32,imm8 AVX512
VPERMILPS       xmmreg|mask|z,xmmreg*,xmmrm128|b32 AVX512VL
VPERMILPS       ymmreg|mask|z,ymmreg*,ymmrm256|b32 AVX512VL
VPERMILPS       zmmreg|mask|z,zmmreg*,zmmrm512|b32 AVX512
VPERMPD         ymmreg|mask|z,ymmrm256|b64,imm8 AVX512VL
VPERMPD         zmmreg|mask|z,zmmrm512|b64,imm8 AVX512
VPERMPD         ymmreg|mask|z,ymmreg*,ymmrm256|b64 AVX512VL
VPERMPD         zmmreg|mask|z,zmmreg*,zmmrm512|b64 AVX512
VPERMPS         ymmreg|mask|z,ymmreg*,ymmrm256|b32 AVX512VL
VPERMPS         zmmreg|mask|z,zmmreg*,zmmrm512|b32 AVX512
VPERMQ          ymmreg|mask|z,ymmrm256|b64,imm8 AVX512VL
VPERMQ          zmmreg|mask|z,zmmrm512|b64,imm8 AVX512
VPERMQ          ymmreg|mask|z,ymmreg*,ymmrm256|b64 AVX512VL
VPERMQ          zmmreg|mask|z,zmmreg*,zmmrm512|b64 AVX512
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VPERMT2B        xmmreg|mask|z,xmmreg,xmmrm128 AVX512VL/VBMI
VPERMT2B        ymmreg|mask|z,ymmreg,ymmrm256 AVX512VL/VBMI
VPERMT2B        zmmreg|mask|z,zmmreg,zmmrm512 AVX512VBMI
VPERMT2D        xmmreg|mask|z,xmmreg,xmmrm128|b32 AVX512VL
VPERMT2D        ymmreg|mask|z,ymmreg,ymmrm256|b32 AVX512VL
VPERMT2D        zmmreg|mask|z,zmmreg,zmmrm512|b32 AVX512
VPERMT2PD       xmmreg|mask|z,xmmreg,xmmrm128|b64 AVX512VL
VPERMT2PD       ymmreg|mask|z,ymmreg,ymmrm256|b64 AVX512VL
VPERMT2PD       zmmreg|mask|z,zmmreg,zmmrm512|b64 AVX512
VPERMT2PS       xmmreg|mask|z,xmmreg,xmmrm128|b32 AVX512VL
VPERMT2PS       ymmreg|mask|z,ymmreg,ymmrm256|b32 AVX512VL
VPERMT2PS       zmmreg|mask|z,zmmreg,zmmrm512|b32 AVX512
VPERMT2Q        xmmreg|mask|z,xmmreg,xmmrm128|b64 AVX512VL
VPERMT2Q        ymmreg|mask|z,ymmreg,ymmrm256|b64 AVX512VL
VPERMT2Q        zmmreg|mask|z,zmmreg,zmmrm512|b64 AVX512
VPERMT2W        xmmreg|mask|z,xmmreg,xmmrm128 AVX512VL/BW
VPERMT2W        ymmreg|mask|z,ymmreg,ymmrm256 AVX512VL/BW
VPERMT2W        zmmreg|mask|z,zmmreg,zmmrm512 AVX512BW
VPERMW          xmmreg|mask|z,xmmreg*,xmmrm128 AVX512VL/BW
VPERMW          ymmreg|mask|z,ymmreg*,ymmrm256 AVX512VL/BW
VPERMW          zmmreg|mask|z,zmmreg*,zmmrm512 AVX512BW
VPEXPANDD       xmmreg|mask|z,mem128     AVX512VL
VPEXPANDD       ymmreg|mask|z,mem256     AVX512VL
VPEXPANDD       zmmreg|mask|z,mem512     AVX512
VPEXPANDD       xmmreg|mask|z,xmmreg     AVX512VL
VPEXPANDD       ymmreg|mask|z,ymmreg     AVX512VL
VPEXPANDD       zmmreg|mask|z,zmmreg     AVX512
VPEXPANDQ       xmmreg|mask|z,mem128     AVX512VL
VPEXPANDQ       ymmreg|mask|z,mem256     AVX512VL
VPEXPANDQ       zmmreg|mask|z,mem512     AVX512
VPEXPANDQ       xmmreg|mask|z,xmmreg     AVX512VL
VPEXPANDQ       ymmreg|mask|z,ymmreg     AVX512VL
VPEXPANDQ       zmmreg|mask|z,zmmreg     AVX512
VPEXTRB         reg8,xmmreg,imm8         AVX512BW
VPEXTRB         reg16,xmmreg,imm8        AVX512BW
VPEXTRB         reg32,xmmreg,imm8        AVX512BW
VPEXTRB         reg64,xmmreg,imm8        AVX512BW
VPEXTRB         mem8,xmmreg,imm8         AVX512BW
VPEXTRD         rm32,xmmreg,imm8         AVX512DQ
VPEXTRQ         rm64,xmmreg,imm8         AVX512DQ
VPEXTRW         reg16,xmmreg,imm8        AVX512BW
VPEXTRW         reg32,xmmreg,imm8        AVX512BW
VPEXTRW         reg64,xmmreg,imm8        AVX512BW
VPEXTRW         mem16,xmmreg,imm8        AVX512BW
VPEXTRW         reg16,xmmreg,imm8        AVX512BW
VPEXTRW         reg32,xmmreg,imm8        AVX512BW
VPEXTRW         reg64,xmmreg,imm8        AVX512BW
VPGATHERDD      xmmreg|mask,xmem32       AVX512VL
VPGATHERDD      ymmreg|mask,ymem32       AVX512VL
VPGATHERDD      zmmreg|mask,zmem32       AVX512
VPGATHERDQ      xmmreg|mask,xmem64       AVX512VL
VPGATHERDQ      ymmreg|mask,xmem64       AVX512VL
VPGATHERDQ      zmmreg|mask,ymem64       AVX512
VPGATHERQD      xmmreg|mask,xmem32       AVX512VL
VPGATHERQD      xmmreg|mask,ymem32       AVX512VL
VPGATHERQD      ymmreg|mask,zmem32       AVX512
VPGATHERQQ      xmmreg|mask,xmem64       AVX512VL
VPGATHERQQ      ymmreg|mask,ymem64       AVX512VL
VPGATHERQQ      zmmreg|mask,zmem64       AVX512
VPINSRB         xmmreg,xmmreg*,reg32,imm8 AVX512BW
VPINSRB         xmmreg,xmmreg*,mem8,imm8 AVX512BW
VPINSRD         xmmreg,xmmreg*,rm32,imm8 AVX512DQ
VPINSRQ         xmmreg,xmmreg*,rm64,imm8 AVX512DQ
VPINSRW         xmmreg,xmmreg*,reg32,imm8 AVX512BW
VPINSRW         xmmreg,xmmreg*,mem16,imm8 AVX512BW
VPLZCNTD        xmmreg|mask|z,xmmrm128|b32 AVX512CD/VL
VPLZCNTD        ymmreg|mask|z,ymmrm256|b32 AVX512CD/VL
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VPLZCNTD        zmmreg|mask|z,zmmrm512|b32 AVX512CD
VPLZCNTQ        xmmreg|mask|z,xmmrm128|b64 AVX512CD/VL
VPLZCNTQ        ymmreg|mask|z,ymmrm256|b64 AVX512CD/VL
VPLZCNTQ        zmmreg|mask|z,zmmrm512|b64 AVX512CD
VPMADD52HUQ     xmmreg|mask|z,xmmreg,xmmrm128|b64 AVX512VL/IFMA
VPMADD52HUQ     ymmreg|mask|z,ymmreg,ymmrm256|b64 AVX512VL/IFMA
VPMADD52HUQ     zmmreg|mask|z,zmmreg,zmmrm512|b64 AVX512IFMA
VPMADD52LUQ     xmmreg|mask|z,xmmreg,xmmrm128|b64 AVX512VL/IFMA
VPMADD52LUQ     ymmreg|mask|z,ymmreg,ymmrm256|b64 AVX512VL/IFMA
VPMADD52LUQ     zmmreg|mask|z,zmmreg,zmmrm512|b64 AVX512IFMA
VPMADDUBSW      xmmreg|mask|z,xmmreg*,xmmrm128 AVX512VL/BW
VPMADDUBSW      ymmreg|mask|z,ymmreg*,ymmrm256 AVX512VL/BW
VPMADDUBSW      zmmreg|mask|z,zmmreg*,zmmrm512 AVX512BW
VPMADDWD        xmmreg|mask|z,xmmreg*,xmmrm128 AVX512VL/BW
VPMADDWD        ymmreg|mask|z,ymmreg*,ymmrm256 AVX512VL/BW
VPMADDWD        zmmreg|mask|z,zmmreg*,zmmrm512 AVX512BW
VPMAXSB         xmmreg|mask|z,xmmreg*,xmmrm128 AVX512VL/BW
VPMAXSB         ymmreg|mask|z,ymmreg*,ymmrm256 AVX512VL/BW
VPMAXSB         zmmreg|mask|z,zmmreg*,zmmrm512 AVX512BW
VPMAXSD         xmmreg|mask|z,xmmreg*,xmmrm128|b32 AVX512VL
VPMAXSD         ymmreg|mask|z,ymmreg*,ymmrm256|b32 AVX512VL
VPMAXSD         zmmreg|mask|z,zmmreg*,zmmrm512|b32 AVX512
VPMAXSQ         xmmreg|mask|z,xmmreg*,xmmrm128|b64 AVX512VL
VPMAXSQ         ymmreg|mask|z,ymmreg*,ymmrm256|b64 AVX512VL
VPMAXSQ         zmmreg|mask|z,zmmreg*,zmmrm512|b64 AVX512
VPMAXSW         xmmreg|mask|z,xmmreg*,xmmrm128 AVX512VL/BW
VPMAXSW         ymmreg|mask|z,ymmreg*,ymmrm256 AVX512VL/BW
VPMAXSW         zmmreg|mask|z,zmmreg*,zmmrm512 AVX512BW
VPMAXUB         xmmreg|mask|z,xmmreg*,xmmrm128 AVX512VL/BW
VPMAXUB         ymmreg|mask|z,ymmreg*,ymmrm256 AVX512VL/BW
VPMAXUB         zmmreg|mask|z,zmmreg*,zmmrm512 AVX512BW
VPMAXUD         xmmreg|mask|z,xmmreg*,xmmrm128|b32 AVX512VL
VPMAXUD         ymmreg|mask|z,ymmreg*,ymmrm256|b32 AVX512VL
VPMAXUD         zmmreg|mask|z,zmmreg*,zmmrm512|b32 AVX512
VPMAXUQ         xmmreg|mask|z,xmmreg*,xmmrm128|b64 AVX512VL
VPMAXUQ         ymmreg|mask|z,ymmreg*,ymmrm256|b64 AVX512VL
VPMAXUQ         zmmreg|mask|z,zmmreg*,zmmrm512|b64 AVX512
VPMAXUW         xmmreg|mask|z,xmmreg*,xmmrm128 AVX512VL/BW
VPMAXUW         ymmreg|mask|z,ymmreg*,ymmrm256 AVX512VL/BW
VPMAXUW         zmmreg|mask|z,zmmreg*,zmmrm512 AVX512BW
VPMINSB         xmmreg|mask|z,xmmreg*,xmmrm128 AVX512VL/BW
VPMINSB         ymmreg|mask|z,ymmreg*,ymmrm256 AVX512VL/BW
VPMINSB         zmmreg|mask|z,zmmreg*,zmmrm512 AVX512BW
VPMINSD         xmmreg|mask|z,xmmreg*,xmmrm128|b32 AVX512VL
VPMINSD         ymmreg|mask|z,ymmreg*,ymmrm256|b32 AVX512VL
VPMINSD         zmmreg|mask|z,zmmreg*,zmmrm512|b32 AVX512
VPMINSQ         xmmreg|mask|z,xmmreg*,xmmrm128|b64 AVX512VL
VPMINSQ         ymmreg|mask|z,ymmreg*,ymmrm256|b64 AVX512VL
VPMINSQ         zmmreg|mask|z,zmmreg*,zmmrm512|b64 AVX512
VPMINSW         xmmreg|mask|z,xmmreg*,xmmrm128 AVX512VL/BW
VPMINSW         ymmreg|mask|z,ymmreg*,ymmrm256 AVX512VL/BW
VPMINSW         zmmreg|mask|z,zmmreg*,zmmrm512 AVX512BW
VPMINUB         xmmreg|mask|z,xmmreg*,xmmrm128 AVX512VL/BW
VPMINUB         ymmreg|mask|z,ymmreg*,ymmrm256 AVX512VL/BW
VPMINUB         zmmreg|mask|z,zmmreg*,zmmrm512 AVX512BW
VPMINUD         xmmreg|mask|z,xmmreg*,xmmrm128|b32 AVX512VL
VPMINUD         ymmreg|mask|z,ymmreg*,ymmrm256|b32 AVX512VL
VPMINUD         zmmreg|mask|z,zmmreg*,zmmrm512|b32 AVX512
VPMINUQ         xmmreg|mask|z,xmmreg*,xmmrm128|b64 AVX512VL
VPMINUQ         ymmreg|mask|z,ymmreg*,ymmrm256|b64 AVX512VL
VPMINUQ         zmmreg|mask|z,zmmreg*,zmmrm512|b64 AVX512
VPMINUW         xmmreg|mask|z,xmmreg*,xmmrm128 AVX512VL/BW
VPMINUW         ymmreg|mask|z,ymmreg*,ymmrm256 AVX512VL/BW
VPMINUW         zmmreg|mask|z,zmmreg*,zmmrm512 AVX512BW
VPMOVB2M        kreg,xmmreg             AVX512VL/BW
VPMOVB2M        kreg,ymmreg             AVX512VL/BW
VPMOVB2M        kreg,zmmreg             AVX512BW
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VPMOVD2M        kreg,xmmreg             AVX512VL/DQ
VPMOVD2M        kreg,ymmreg             AVX512VL/DQ
VPMOVD2M        kreg,zmmreg             AVX512DQ
VPMOVDB         xmmreg|mask|z,xmmreg    AVX512VL
VPMOVDB         xmmreg|mask|z,ymmreg    AVX512VL
VPMOVDB         xmmreg|mask|z,zmmreg    AVX512
VPMOVDB         mem32|mask,xmmreg       AVX512VL
VPMOVDB         mem64|mask,ymmreg       AVX512VL
VPMOVDB         mem128|mask,zmmreg      AVX512
VPMOVDW         xmmreg|mask|z,xmmreg    AVX512VL
VPMOVDW         xmmreg|mask|z,ymmreg    AVX512VL
VPMOVDW         ymmreg|mask|z,zmmreg    AVX512
VPMOVDW         mem64|mask,xmmreg       AVX512VL
VPMOVDW         mem128|mask,ymmreg      AVX512VL
VPMOVDW         mem256|mask,zmmreg      AVX512
VPMOVM2B        xmmreg,kreg             AVX512VL/BW
VPMOVM2B        ymmreg,kreg             AVX512VL/BW
VPMOVM2B        zmmreg,kreg             AVX512BW
VPMOVM2D        xmmreg,kreg             AVX512VL/DQ
VPMOVM2D        ymmreg,kreg             AVX512VL/DQ
VPMOVM2D        zmmreg,kreg             AVX512DQ
VPMOVM2Q        xmmreg,kreg             AVX512VL/DQ
VPMOVM2Q        ymmreg,kreg             AVX512VL/DQ
VPMOVM2Q        zmmreg,kreg             AVX512DQ
VPMOVM2W        xmmreg,kreg             AVX512VL/BW
VPMOVM2W        ymmreg,kreg             AVX512VL/BW
VPMOVM2W        zmmreg,kreg             AVX512BW
VPMOVQ2M        kreg,xmmreg             AVX512VL/DQ
VPMOVQ2M        kreg,ymmreg             AVX512VL/DQ
VPMOVQ2M        kreg,zmmreg             AVX512DQ
VPMOVQB         xmmreg|mask|z,xmmreg    AVX512VL
VPMOVQB         xmmreg|mask|z,ymmreg    AVX512VL
VPMOVQB         xmmreg|mask|z,zmmreg    AVX512
VPMOVQB         mem16|mask,xmmreg       AVX512VL
VPMOVQB         mem32|mask,ymmreg       AVX512VL
VPMOVQB         mem64|mask,zmmreg       AVX512
VPMOVQD         xmmreg|mask|z,xmmreg    AVX512VL
VPMOVQD         xmmreg|mask|z,ymmreg    AVX512VL
VPMOVQD         ymmreg|mask|z,zmmreg    AVX512
VPMOVQD         mem64|mask,xmmreg       AVX512VL
VPMOVQD         mem128|mask,ymmreg      AVX512VL
VPMOVQD         mem256|mask,zmmreg      AVX512
VPMOVQW         xmmreg|mask|z,xmmreg    AVX512VL
VPMOVQW         xmmreg|mask|z,ymmreg    AVX512VL
VPMOVQW         xmmreg|mask|z,zmmreg    AVX512
VPMOVQW         mem32|mask,xmmreg       AVX512VL
VPMOVQW         mem64|mask,ymmreg       AVX512VL
VPMOVQW         mem128|mask,zmmreg      AVX512
VPMOVSDB        xmmreg|mask|z,xmmreg    AVX512VL
VPMOVSDB        xmmreg|mask|z,ymmreg    AVX512VL
VPMOVSDB        xmmreg|mask|z,zmmreg    AVX512
VPMOVSDB        mem32|mask,xmmreg       AVX512VL
VPMOVSDB        mem64|mask,ymmreg       AVX512VL
VPMOVSDB        mem128|mask,zmmreg      AVX512
VPMOVSDW        xmmreg|mask|z,xmmreg    AVX512VL
VPMOVSDW        xmmreg|mask|z,ymmreg    AVX512VL
VPMOVSDW        ymmreg|mask|z,zmmreg    AVX512
VPMOVSDW        mem64|mask,xmmreg       AVX512VL
VPMOVSDW        mem128|mask,ymmreg      AVX512VL
VPMOVSDW        mem256|mask,zmmreg      AVX512
VPMOVSQB        xmmreg|mask|z,xmmreg    AVX512VL
VPMOVSQB        xmmreg|mask|z,ymmreg    AVX512VL
VPMOVSQB        xmmreg|mask|z,zmmreg    AVX512
VPMOVSQB        mem16|mask,xmmreg       AVX512VL
VPMOVSQB        mem32|mask,ymmreg       AVX512VL
VPMOVSQB        mem64|mask,zmmreg       AVX512
VPMOVSQD        xmmreg|mask|z,xmmreg    AVX512VL
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VPMOVSQD        xmmreg|mask|z,ymmreg     AVX512VL
VPMOVSQD        ymmreg|mask|z,zmmreg     AVX512
VPMOVSQD        mem64|mask,xmmreg        AVX512VL
VPMOVSQD        mem128|mask,ymmreg       AVX512VL
VPMOVSQD        mem256|mask,zmmreg       AVX512
VPMOVSQW        xmmreg|mask|z,xmmreg     AVX512VL
VPMOVSQW        xmmreg|mask|z,ymmreg     AVX512VL
VPMOVSQW        xmmreg|mask|z,zmmreg     AVX512
VPMOVSQW        mem32|mask,xmmreg        AVX512VL
VPMOVSQW        mem64|mask,ymmreg        AVX512VL
VPMOVSQW        mem128|mask,zmmreg       AVX512
VPMOVSWB        xmmreg|mask|z,xmmreg     AVX512VL/BW
VPMOVSWB        xmmreg|mask|z,ymmreg     AVX512VL/BW
VPMOVSWB        ymmreg|mask|z,zmmreg     AVX512BW
VPMOVSWB        mem64|mask,xmmreg        AVX512VL/BW
VPMOVSWB        mem128|mask,ymmreg       AVX512VL/BW
VPMOVSWB        mem256|mask,zmmreg       AVX512BW
VPMOVSXBD       xmmreg|mask|z,xmmrm32    AVX512VL
VPMOVSXBD       ymmreg|mask|z,xmmrm64    AVX512VL
VPMOVSXBD       zmmreg|mask|z,xmmrm128   AVX512
VPMOVSXBQ       xmmreg|mask|z,xmmrm16    AVX512VL
VPMOVSXBQ       ymmreg|mask|z,xmmrm32    AVX512VL
VPMOVSXBQ       zmmreg|mask|z,xmmrm64    AVX512
VPMOVSXBW       xmmreg|mask|z,xmmrm64    AVX512VL/BW
VPMOVSXBW       ymmreg|mask|z,xmmrm128   AVX512VL/BW
VPMOVSXBW       zmmreg|mask|z,ymmrm256   AVX512BW
VPMOVSXDQ       xmmreg|mask|z,xmmrm64    AVX512VL
VPMOVSXDQ       ymmreg|mask|z,xmmrm128   AVX512VL
VPMOVSXDQ       zmmreg|mask|z,ymmrm256   AVX512
VPMOVSXWD       xmmreg|mask|z,xmmrm64    AVX512VL
VPMOVSXWD       ymmreg|mask|z,xmmrm128   AVX512VL
VPMOVSXWD       zmmreg|mask|z,ymmrm256   AVX512
VPMOVSXWQ       xmmreg|mask|z,xmmrm32    AVX512VL
VPMOVSXWQ       ymmreg|mask|z,xmmrm64    AVX512VL
VPMOVSXWQ       zmmreg|mask|z,xmmrm128   AVX512
VPMOVUSDB       xmmreg|mask|z,xmmreg     AVX512VL
VPMOVUSDB       xmmreg|mask|z,ymmreg     AVX512VL
VPMOVUSDB       xmmreg|mask|z,zmmreg     AVX512
VPMOVUSDB       mem32|mask,xmmreg        AVX512VL
VPMOVUSDB       mem64|mask,ymmreg        AVX512VL
VPMOVUSDB       mem128|mask,zmmreg       AVX512
VPMOVUSDW       xmmreg|mask|z,xmmreg     AVX512VL
VPMOVUSDW       xmmreg|mask|z,ymmreg     AVX512VL
VPMOVUSDW       ymmreg|mask|z,zmmreg     AVX512
VPMOVUSDW       mem64|mask,xmmreg        AVX512VL
VPMOVUSDW       mem128|mask,ymmreg       AVX512VL
VPMOVUSDW       mem256|mask,zmmreg       AVX512
VPMOVUSQB       xmmreg|mask|z,xmmreg     AVX512VL
VPMOVUSQB       xmmreg|mask|z,ymmreg     AVX512VL
VPMOVUSQB       xmmreg|mask|z,zmmreg     AVX512
VPMOVUSQB       mem16|mask,xmmreg        AVX512VL
VPMOVUSQB       mem32|mask,ymmreg        AVX512VL
VPMOVUSQB       mem64|mask,zmmreg        AVX512
VPMOVUSQD       xmmreg|mask|z,xmmreg     AVX512VL
VPMOVUSQD       xmmreg|mask|z,ymmreg     AVX512VL
VPMOVUSQD       ymmreg|mask|z,zmmreg     AVX512
VPMOVUSQD       mem64|mask,xmmreg        AVX512VL
VPMOVUSQD       mem128|mask,ymmreg       AVX512VL
VPMOVUSQD       mem256|mask,zmmreg       AVX512
VPMOVUSQW       xmmreg|mask|z,xmmreg     AVX512VL
VPMOVUSQW       xmmreg|mask|z,ymmreg     AVX512VL
VPMOVUSQW       xmmreg|mask|z,zmmreg     AVX512
VPMOVUSQW       mem32|mask,xmmreg        AVX512VL
VPMOVUSQW       mem64|mask,ymmreg        AVX512VL
VPMOVUSQW       mem128|mask,zmmreg       AVX512
VPMOVUSWB       xmmreg|mask|z,xmmreg     AVX512VL/BW
VPMOVUSWB       xmmreg|mask|z,ymmreg     AVX512VL/BW
```

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VPMOVUSWB       ymmreg|mask|z,zmmreg     AVX512BW
VPMOVUSWB       mem64|mask,xmmreg        AVX512VL/BW
VPMOVUSWB       mem128|mask,ymmreg       AVX512VL/BW
VPMOVUSWB       mem256|mask,zmmreg       AVX512BW
VPMOVW2M        kreg,xmmreg              AVX512VL/BW
VPMOVW2M        kreg,ymmreg              AVX512VL/BW
VPMOVW2M        kreg,zmmreg              AVX512BW
VPMOVWB         xmmreg|mask|z,xmmreg     AVX512VL/BW
VPMOVWB         xmmreg|mask|z,ymmreg     AVX512VL/BW
VPMOVWB         ymmreg|mask|z,zmmreg     AVX512BW
VPMOVWB         mem64|mask,xmmreg        AVX512VL/BW
VPMOVWB         mem128|mask,ymmreg       AVX512VL/BW
VPMOVWB         mem256|mask,zmmreg       AVX512BW
VPMOVZXBD       xmmreg|mask|z,xmmrm32    AVX512VL
VPMOVZXBD       ymmreg|mask|z,xmmrm64    AVX512VL
VPMOVZXBD       zmmreg|mask|z,xmmrm128   AVX512
VPMOVZXBQ       xmmreg|mask|z,xmmrm16    AVX512VL
VPMOVZXBQ       ymmreg|mask|z,xmmrm32    AVX512VL
VPMOVZXBQ       zmmreg|mask|z,xmmrm64    AVX512
VPMOVZXBW       xmmreg|mask|z,xmmrm64    AVX512VL/BW
VPMOVZXBW       ymmreg|mask|z,xmmrm128   AVX512VL/BW
VPMOVZXBW       zmmreg|mask|z,ymmrm256   AVX512BW
VPMOVZXDQ       xmmreg|mask|z,xmmrm64    AVX512VL
VPMOVZXDQ       ymmreg|mask|z,xmmrm128   AVX512VL
VPMOVZXDQ       zmmreg|mask|z,ymmrm256   AVX512
VPMOVZXWD       xmmreg|mask|z,xmmrm64    AVX512VL
VPMOVZXWD       ymmreg|mask|z,xmmrm128   AVX512VL
VPMOVZXWD       zmmreg|mask|z,ymmrm256   AVX512
VPMOVZXWQ       xmmreg|mask|z,xmmrm32    AVX512VL
VPMOVZXWQ       ymmreg|mask|z,xmmrm64    AVX512VL
VPMOVZXWQ       zmmreg|mask|z,xmmrm128   AVX512
VPMULDQ         xmmreg|mask|z,xmmreg*,xmmrm128|b64 AVX512VL
VPMULDQ         ymmreg|mask|z,ymmreg*,ymmrm256|b64 AVX512VL
VPMULDQ         zmmreg|mask|z,zmmreg*,zmmrm512|b64 AVX512
VPMULHRSW       xmmreg|mask|z,xmmreg*,xmmrm128 AVX512VL/BW
VPMULHRSW       ymmreg|mask|z,ymmreg*,ymmrm256 AVX512VL/BW
VPMULHRSW       zmmreg|mask|z,zmmreg*,zmmrm512 AVX512BW
VPMULHUW        xmmreg|mask|z,xmmreg*,xmmrm128 AVX512VL/BW
VPMULHUW        ymmreg|mask|z,ymmreg*,ymmrm256 AVX512VL/BW
VPMULHUW        zmmreg|mask|z,zmmreg*,zmmrm512 AVX512BW
VPMULHW         xmmreg|mask|z,xmmreg*,xmmrm128 AVX512VL/BW
VPMULHW         ymmreg|mask|z,ymmreg*,ymmrm256 AVX512VL/BW
VPMULHW         zmmreg|mask|z,zmmreg*,zmmrm512 AVX512BW
VPMULLD         xmmreg|mask|z,xmmreg*,xmmrm128|b32 AVX512VL
VPMULLD         ymmreg|mask|z,ymmreg*,ymmrm256|b32 AVX512VL
VPMULLD         zmmreg|mask|z,zmmreg*,zmmrm512|b32 AVX512
VPMULLQ         xmmreg|mask|z,xmmreg*,xmmrm128|b64 AVX512VL/DQ
VPMULLQ         ymmreg|mask|z,ymmreg*,ymmrm256|b64 AVX512VL/DQ
VPMULLQ         zmmreg|mask|z,zmmreg*,zmmrm512|b64 AVX512DQ
VPMULLW         xmmreg|mask|z,xmmreg*,xmmrm128 AVX512VL/BW
VPMULLW         ymmreg|mask|z,ymmreg*,ymmrm256 AVX512VL/BW
VPMULLW         zmmreg|mask|z,zmmreg*,zmmrm512 AVX512BW
VPMULTISHIFTQB  xmmreg|mask|z,xmmreg*,xmmrm128|b64 AVX512VL/VBMI
VPMULTISHIFTQB  ymmreg|mask|z,ymmreg*,ymmrm256|b64 AVX512VL/VBMI
VPMULTISHIFTQB  zmmreg|mask|z,zmmreg*,zmmrm512|b64 AVX512VBMI
VPMULUDQ        xmmreg|mask|z,xmmreg*,xmmrm128|b64 AVX512VL
VPMULUDQ        ymmreg|mask|z,ymmreg*,ymmrm256|b64 AVX512VL
VPMULUDQ        zmmreg|mask|z,zmmreg*,zmmrm512|b64 AVX512
VPORD           xmmreg|mask|z,xmmreg*,xmmrm128|b32 AVX512VL
VPORD           ymmreg|mask|z,ymmreg*,ymmrm256|b32 AVX512VL
VPORD           zmmreg|mask|z,zmmreg*,zmmrm512|b32 AVX512
VPORQ           xmmreg|mask|z,xmmreg*,xmmrm128|b64 AVX512VL
VPORQ           ymmreg|mask|z,ymmreg*,ymmrm256|b64 AVX512VL
VPORQ           zmmreg|mask|z,zmmreg*,zmmrm512|b64 AVX512
VPROLD          xmmreg|mask|z,xmmrm128|b32*,imm8 AVX512VL
VPROLD          ymmreg|mask|z,ymmrm256|b32*,imm8 AVX512VL
VPROLD          zmmreg|mask|z,zmmrm512|b32*,imm8 AVX512
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VPROLQ          xmmreg|mask|z,xmmrm128|b64*,imm8 AVX512VL
VPROLQ          ymmreg|mask|z,ymmrm256|b64*,imm8 AVX512VL
VPROLQ          zmmreg|mask|z,zmmrm512|b64*,imm8 AVX512
VPROLVD         xmmreg|mask|z,xmmreg*,xmmrm128|b32 AVX512VL
VPROLVD         ymmreg|mask|z,ymmreg*,ymmrm256|b32 AVX512VL
VPROLVD         zmmreg|mask|z,zmmreg*,zmmrm512|b32 AVX512
VPROLVQ         xmmreg|mask|z,xmmreg*,xmmrm128|b64 AVX512VL
VPROLVQ         ymmreg|mask|z,ymmreg*,ymmrm256|b64 AVX512VL
VPROLVQ         zmmreg|mask|z,zmmreg*,zmmrm512|b64 AVX512
VPRORD          xmmreg|mask|z,xmmrm128|b32*,imm8 AVX512VL
VPRORD          ymmreg|mask|z,ymmrm256|b32*,imm8 AVX512VL
VPRORD          zmmreg|mask|z,zmmrm512|b32*,imm8 AVX512
VPRORQ          xmmreg|mask|z,xmmrm128|b64*,imm8 AVX512VL
VPRORQ          ymmreg|mask|z,ymmrm256|b64*,imm8 AVX512VL
VPRORQ          zmmreg|mask|z,zmmrm512|b64*,imm8 AVX512
VPRORVD         xmmreg|mask|z,xmmreg*,xmmrm128|b32 AVX512VL
VPRORVD         ymmreg|mask|z,ymmreg*,ymmrm256|b32 AVX512VL
VPRORVD         zmmreg|mask|z,zmmreg*,zmmrm512|b32 AVX512
VPRORVQ         xmmreg|mask|z,xmmreg*,xmmrm128|b64 AVX512VL
VPRORVQ         ymmreg|mask|z,ymmreg*,ymmrm256|b64 AVX512VL
VPRORVQ         zmmreg|mask|z,zmmreg*,zmmrm512|b64 AVX512
VPSADBW         xmmreg,xmmreg*,xmmrm128  AVX512VL/BW
VPSADBW         ymmreg,ymmreg*,ymmrm256  AVX512VL/BW
VPSADBW         zmmreg,zmmreg*,zmmrm512  AVX512BW
VPSCATTERDD     xmem32|mask,xmmreg       AVX512VL
VPSCATTERDD     ymem32|mask,ymmreg       AVX512VL
VPSCATTERDD     zmem32|mask,zmmreg       AVX512
VPSCATTERDQ     xmem64|mask,xmmreg       AVX512VL
VPSCATTERDQ     xmem64|mask,ymmreg       AVX512VL
VPSCATTERDQ     ymem64|mask,zmmreg       AVX512
VPSCATTERQD     xmem32|mask,xmmreg       AVX512VL
VPSCATTERQD     ymem32|mask,xmmreg       AVX512VL
VPSCATTERQD     zmem32|mask,ymmreg       AVX512
VPSCATTERQQ     xmem64|mask,xmmreg       AVX512VL
VPSCATTERQQ     ymem64|mask,ymmreg       AVX512VL
VPSCATTERQQ     zmem64|mask,zmmreg       AVX512
VPSHUFB         xmmreg|mask|z,xmmreg*,xmmrm128 AVX512VL/BW
VPSHUFB         ymmreg|mask|z,ymmreg*,ymmrm256 AVX512VL/BW
VPSHUFB         zmmreg|mask|z,zmmreg*,zmmrm512 AVX512BW
VPSHUFD         xmmreg|mask|z,xmmrm128|b32,imm8 AVX512VL
VPSHUFD         ymmreg|mask|z,ymmrm256|b32,imm8 AVX512VL
VPSHUFD         zmmreg|mask|z,zmmrm512|b32,imm8 AVX512
VPSHUFHW        xmmreg|mask|z,xmmrm128,imm8 AVX512VL/BW
VPSHUFHW        ymmreg|mask|z,ymmrm256,imm8 AVX512VL/BW
VPSHUFHW        zmmreg|mask|z,zmmrm512,imm8 AVX512BW
VPSHUFLW        xmmreg|mask|z,xmmrm128,imm8 AVX512VL/BW
VPSHUFLW        ymmreg|mask|z,ymmrm256,imm8 AVX512VL/BW
VPSHUFLW        zmmreg|mask|z,zmmrm512,imm8 AVX512BW
VPSLLD          xmmreg|mask|z,xmmreg*,xmmrm128 AVX512VL
VPSLLD          ymmreg|mask|z,ymmreg*,xmmrm128 AVX512VL
VPSLLD          zmmreg|mask|z,zmmreg*,xmmrm128 AVX512
VPSLLD          xmmreg|mask|z,xmmrm128|b32*,imm8 AVX512VL
VPSLLD          ymmreg|mask|z,ymmrm256|b32*,imm8 AVX512VL
VPSLLD          zmmreg|mask|z,zmmrm512|b32*,imm8 AVX512
VPSLLDQ         xmmreg,xmmrm128*,imm8    AVX512VL/BW
VPSLLDQ         ymmreg,ymmrm256*,imm8    AVX512VL/BW
VPSLLDQ         zmmreg,zmmrm512*,imm8    AVX512BW
VPSLLQ          xmmreg|mask|z,xmmreg*,xmmrm128 AVX512VL
VPSLLQ          ymmreg|mask|z,ymmreg*,xmmrm128 AVX512VL
VPSLLQ          zmmreg|mask|z,zmmreg*,xmmrm128 AVX512
VPSLLQ          xmmreg|mask|z,xmmrm128|b64*,imm8 AVX512VL
VPSLLQ          ymmreg|mask|z,ymmrm256|b64*,imm8 AVX512VL
VPSLLQ          zmmreg|mask|z,zmmrm512|b64*,imm8 AVX512
VPSLLVD         xmmreg|mask|z,xmmreg*,xmmrm128|b32 AVX512VL
VPSLLVD         ymmreg|mask|z,ymmreg*,ymmrm256|b32 AVX512VL
VPSLLVD         zmmreg|mask|z,zmmreg*,zmmrm512|b32 AVX512
VPSLLVQ         xmmreg|mask|z,xmmreg*,xmmrm128|b64 AVX512VL
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VPSLLVQ         ymmreg|mask|z,ymmreg*,ymmrm256|b64 AVX512VL
VPSLLVQ         zmmreg|mask|z,zmmreg*,zmmrm512|b64 AVX512
VPSLLVW         xmmreg|mask|z,xmmreg*,xmmrm128 AVX512VL/BW
VPSLLVW         ymmreg|mask|z,ymmreg*,ymmrm256 AVX512VL/BW
VPSLLVW         zmmreg|mask|z,zmmreg*,zmmrm512 AVX512BW
VPSLLW          xmmreg|mask|z,xmmreg*,xmmrm128 AVX512VL/BW
VPSLLW          ymmreg|mask|z,ymmreg*,xmmrm128 AVX512VL/BW
VPSLLW          zmmreg|mask|z,zmmreg*,xmmrm128 AVX512BW
VPSLLW          xmmreg|mask|z,xmmrm128*,imm8 AVX512VL/BW
VPSLLW          ymmreg|mask|z,ymmrm256*,imm8 AVX512VL/BW
VPSLLW          zmmreg|mask|z,zmmrm512*,imm8 AVX512BW
VPSRAD          xmmreg|mask|z,xmmreg*,xmmrm128 AVX512VL
VPSRAD          ymmreg|mask|z,ymmreg*,xmmrm128 AVX512VL
VPSRAD          zmmreg|mask|z,zmmreg*,xmmrm128 AVX512
VPSRAD          xmmreg|mask|z,xmmrm128|b32*,imm8 AVX512VL
VPSRAD          ymmreg|mask|z,ymmrm256|b32*,imm8 AVX512VL
VPSRAD          zmmreg|mask|z,zmmrm512|b32*,imm8 AVX512
VPSRAQ          xmmreg|mask|z,xmmreg*,xmmrm128 AVX512VL
VPSRAQ          ymmreg|mask|z,ymmreg*,xmmrm128 AVX512VL
VPSRAQ          zmmreg|mask|z,zmmreg*,xmmrm128 AVX512
VPSRAQ          xmmreg|mask|z,xmmrm128|b64*,imm8 AVX512VL
VPSRAQ          ymmreg|mask|z,ymmrm256|b64*,imm8 AVX512VL
VPSRAQ          zmmreg|mask|z,zmmrm512|b64*,imm8 AVX512
VPSRAVD         xmmreg|mask|z,xmmreg*,xmmrm128|b32 AVX512VL
VPSRAVD         ymmreg|mask|z,ymmreg*,ymmrm256|b32 AVX512VL
VPSRAVD         zmmreg|mask|z,zmmreg*,zmmrm512|b32 AVX512
VPSRAVQ         xmmreg|mask|z,xmmreg*,xmmrm128|b64 AVX512VL
VPSRAVQ         ymmreg|mask|z,ymmreg*,ymmrm256|b64 AVX512VL
VPSRAVQ         zmmreg|mask|z,zmmreg*,zmmrm512|b64 AVX512
VPSRAVW         xmmreg|mask|z,xmmreg*,xmmrm128 AVX512VL/BW
VPSRAVW         ymmreg|mask|z,ymmreg*,ymmrm256 AVX512VL/BW
VPSRAVW         zmmreg|mask|z,zmmreg*,zmmrm512 AVX512BW
VPSRAW          xmmreg|mask|z,xmmreg*,xmmrm128 AVX512VL/BW
VPSRAW          ymmreg|mask|z,ymmreg*,xmmrm128 AVX512VL/BW
VPSRAW          zmmreg|mask|z,zmmreg*,xmmrm128 AVX512BW
VPSRAW          xmmreg|mask|z,xmmrm128*,imm8 AVX512VL/BW
VPSRAW          ymmreg|mask|z,ymmrm256*,imm8 AVX512VL/BW
VPSRAW          zmmreg|mask|z,zmmrm512*,imm8 AVX512BW
VPSRLD          xmmreg|mask|z,xmmreg*,xmmrm128 AVX512VL
VPSRLD          ymmreg|mask|z,ymmreg*,xmmrm128 AVX512VL
VPSRLD          zmmreg|mask|z,zmmreg*,xmmrm128 AVX512
VPSRLD          xmmreg|mask|z,xmmrm128|b32*,imm8 AVX512VL
VPSRLD          ymmreg|mask|z,ymmrm256|b32*,imm8 AVX512VL
VPSRLD          zmmreg|mask|z,zmmrm512|b32*,imm8 AVX512
VPSRLDQ         xmmreg,xmmrm128*,imm8    AVX512VL/BW
VPSRLDQ         ymmreg,ymmrm256*,imm8    AVX512VL/BW
VPSRLDQ         zmmreg,zmmrm512*,imm8    AVX512BW
VPSRLQ          xmmreg|mask|z,xmmreg*,xmmrm128 AVX512VL
VPSRLQ          ymmreg|mask|z,ymmreg*,xmmrm128 AVX512VL
VPSRLQ          zmmreg|mask|z,zmmreg*,xmmrm128 AVX512
VPSRLQ          xmmreg|mask|z,xmmrm128|b64*,imm8 AVX512VL
VPSRLQ          ymmreg|mask|z,ymmrm256|b64*,imm8 AVX512VL
VPSRLQ          zmmreg|mask|z,zmmrm512|b64*,imm8 AVX512
VPSRLVD         xmmreg|mask|z,xmmreg*,xmmrm128|b32 AVX512VL
VPSRLVD         ymmreg|mask|z,ymmreg*,ymmrm256|b32 AVX512VL
VPSRLVD         zmmreg|mask|z,zmmreg*,zmmrm512|b32 AVX512
VPSRLVQ         xmmreg|mask|z,xmmreg*,xmmrm128|b64 AVX512VL
VPSRLVQ         ymmreg|mask|z,ymmreg*,ymmrm256|b64 AVX512VL
VPSRLVQ         zmmreg|mask|z,zmmreg*,zmmrm512|b64 AVX512
VPSRLVW         xmmreg|mask|z,xmmreg*,xmmrm128 AVX512VL/BW
VPSRLVW         ymmreg|mask|z,ymmreg*,ymmrm256 AVX512VL/BW
VPSRLVW         zmmreg|mask|z,zmmreg*,zmmrm512 AVX512BW
VPSRLW          xmmreg|mask|z,xmmreg*,xmmrm128 AVX512VL/BW
VPSRLW          ymmreg|mask|z,ymmreg*,xmmrm128 AVX512VL/BW
VPSRLW          zmmreg|mask|z,zmmreg*,xmmrm128 AVX512BW
VPSRLW          xmmreg|mask|z,xmmrm128*,imm8 AVX512VL/BW
VPSRLW          ymmreg|mask|z,ymmrm256*,imm8 AVX512VL/BW
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VPSRLW          zmmreg|mask|z,zmmrm512*,imm8 AVX512BW
VPSUBB          xmmreg|mask|z,xmmreg*,xmmrm128 AVX512VL/BW
VPSUBB          ymmreg|mask|z,ymmreg*,ymmrm256 AVX512VL/BW
VPSUBB          zmmreg|mask|z,zmmreg*,zmmrm512 AVX512BW
VPSUBD          xmmreg|mask|z,xmmreg*,xmmrm128|b32 AVX512VL
VPSUBD          ymmreg|mask|z,ymmreg*,ymmrm256|b32 AVX512VL
VPSUBD          zmmreg|mask|z,zmmreg*,zmmrm512|b32 AVX512
VPSUBQ          xmmreg|mask|z,xmmreg*,xmmrm128|b64 AVX512VL
VPSUBQ          ymmreg|mask|z,ymmreg*,ymmrm256|b64 AVX512VL
VPSUBQ          zmmreg|mask|z,zmmreg*,zmmrm512|b64 AVX512
VPSUBSB         xmmreg|mask|z,xmmreg*,xmmrm128 AVX512VL/BW
VPSUBSB         ymmreg|mask|z,ymmreg*,ymmrm256 AVX512VL/BW
VPSUBSB         zmmreg|mask|z,zmmreg*,zmmrm512 AVX512BW
VPSUBSW         xmmreg|mask|z,xmmreg*,xmmrm128 AVX512VL/BW
VPSUBSW         ymmreg|mask|z,ymmreg*,ymmrm256 AVX512VL/BW
VPSUBSW         zmmreg|mask|z,zmmreg*,zmmrm512 AVX512BW
VPSUBUSB        xmmreg|mask|z,xmmreg*,xmmrm128 AVX512VL/BW
VPSUBUSB        ymmreg|mask|z,ymmreg*,ymmrm256 AVX512VL/BW
VPSUBUSB        zmmreg|mask|z,zmmreg*,zmmrm512 AVX512BW
VPSUBUSW        xmmreg|mask|z,xmmreg*,xmmrm128 AVX512VL/BW
VPSUBUSW        ymmreg|mask|z,ymmreg*,ymmrm256 AVX512VL/BW
VPSUBUSW        zmmreg|mask|z,zmmreg*,zmmrm512 AVX512BW
VPSUBW          xmmreg|mask|z,xmmreg*,xmmrm128 AVX512VL/BW
VPSUBW          ymmreg|mask|z,ymmreg*,ymmrm256 AVX512VL/BW
VPSUBW          zmmreg|mask|z,zmmreg*,zmmrm512 AVX512BW
VPTERNLOGD      xmmreg|mask|z,xmmreg,xmmrm128|b32,imm8 AVX512VL
VPTERNLOGD      ymmreg|mask|z,ymmreg,ymmrm256|b32,imm8 AVX512VL
VPTERNLOGD      zmmreg|mask|z,zmmreg,zmmrm512|b32,imm8 AVX512
VPTERNLOGQ      xmmreg|mask|z,xmmreg,xmmrm128|b64,imm8 AVX512VL
VPTERNLOGQ      ymmreg|mask|z,ymmreg,ymmrm256|b64,imm8 AVX512VL
VPTERNLOGQ      zmmreg|mask|z,zmmreg,zmmrm512|b64,imm8 AVX512
VPTESTMB        kreg|mask,xmmreg,xmmrm128 AVX512VL/BW
VPTESTMB        kreg|mask,ymmreg,ymmrm256 AVX512VL/BW
VPTESTMB        kreg|mask,zmmreg,zmmrm512 AVX512BW
VPTESTMD        kreg|mask,xmmreg,xmmrm128|b32 AVX512VL
VPTESTMD        kreg|mask,ymmreg,ymmrm256|b32 AVX512VL
VPTESTMD        kreg|mask,zmmreg,zmmrm512|b32 AVX512
VPTESTMQ        kreg|mask,xmmreg,xmmrm128|b64 AVX512VL
VPTESTMQ        kreg|mask,ymmreg,ymmrm256|b64 AVX512VL
VPTESTMQ        kreg|mask,zmmreg,zmmrm512|b64 AVX512
VPTESTMW        kreg|mask,xmmreg,xmmrm128 AVX512VL/BW
VPTESTMW        kreg|mask,ymmreg,ymmrm256 AVX512VL/BW
VPTESTMW        kreg|mask,zmmreg,zmmrm512 AVX512BW
VPTESTNMB       kreg|mask,xmmreg,xmmrm128 AVX512VL/BW
VPTESTNMB       kreg|mask,ymmreg,ymmrm256 AVX512VL/BW
VPTESTNMB       kreg|mask,zmmreg,zmmrm512 AVX512BW
VPTESTNMD       kreg|mask,xmmreg,xmmrm128|b32 AVX512VL
VPTESTNMD       kreg|mask,ymmreg,ymmrm256|b32 AVX512VL
VPTESTNMD       kreg|mask,zmmreg,zmmrm512|b32 AVX512
VPTESTNMQ       kreg|mask,xmmreg,xmmrm128|b64 AVX512VL
VPTESTNMQ       kreg|mask,ymmreg,ymmrm256|b64 AVX512VL
VPTESTNMQ       kreg|mask,zmmreg,zmmrm512|b64 AVX512
VPTESTNMW       kreg|mask,xmmreg,xmmrm128 AVX512VL/BW
VPTESTNMW       kreg|mask,ymmreg,ymmrm256 AVX512VL/BW
VPTESTNMW       kreg|mask,zmmreg,zmmrm512 AVX512BW
VPUNPCKHBW      xmmreg|mask|z,xmmreg*,xmmrm128 AVX512VL/BW
VPUNPCKHBW      ymmreg|mask|z,ymmreg*,ymmrm256 AVX512VL/BW
VPUNPCKHBW      zmmreg|mask|z,zmmreg*,zmmrm512 AVX512BW
VPUNPCKHDQ      xmmreg|mask|z,xmmreg*,xmmrm128|b32 AVX512VL
VPUNPCKHDQ      ymmreg|mask|z,ymmreg*,ymmrm256|b32 AVX512VL
VPUNPCKHDQ      zmmreg|mask|z,zmmreg*,zmmrm512|b32 AVX512
VPUNPCKHQDQ     xmmreg|mask|z,xmmreg*,xmmrm128|b64 AVX512VL
VPUNPCKHQDQ     ymmreg|mask|z,ymmreg*,ymmrm256|b64 AVX512VL
VPUNPCKHQDQ     zmmreg|mask|z,zmmreg*,zmmrm512|b64 AVX512
VPUNPCKHWD      xmmreg|mask|z,xmmreg*,xmmrm128 AVX512VL/BW
VPUNPCKHWD      ymmreg|mask|z,ymmreg*,ymmrm256 AVX512VL/BW
VPUNPCKHWD      zmmreg|mask|z,zmmreg*,zmmrm512 AVX512BW
```

```
VPUNPCKLBW      xmmreg|mask|z,xmmreg*,xmmrm128 AVX512VL/BW
VPUNPCKLBW      ymmreg|mask|z,ymmreg*,ymmrm256 AVX512VL/BW
VPUNPCKLBW      zmmreg|mask|z,zmmreg*,zmmrm512 AVX512BW
VPUNPCKLDQ      xmmreg|mask|z,xmmreg*,xmmrm128|b32 AVX512VL
VPUNPCKLDQ      ymmreg|mask|z,ymmreg*,ymmrm256|b32 AVX512VL
VPUNPCKLDQ      zmmreg|mask|z,zmmreg*,zmmrm512|b32 AVX512
VPUNPCKLQDQ     xmmreg|mask|z,xmmreg*,xmmrm128|b64 AVX512VL
VPUNPCKLQDQ     ymmreg|mask|z,ymmreg*,ymmrm256|b64 AVX512VL
VPUNPCKLQDQ     zmmreg|mask|z,zmmreg*,zmmrm512|b64 AVX512
VPUNPCKLWD      xmmreg|mask|z,xmmreg*,xmmrm128 AVX512VL/BW
VPUNPCKLWD      ymmreg|mask|z,ymmreg*,ymmrm256 AVX512VL/BW
VPUNPCKLWD      zmmreg|mask|z,zmmreg*,zmmrm512 AVX512BW
VPXORD          xmmreg|mask|z,xmmreg*,xmmrm128|b32 AVX512VL
VPXORD          ymmreg|mask|z,ymmreg*,ymmrm256|b32 AVX512VL
VPXORD          zmmreg|mask|z,zmmreg*,zmmrm512|b32 AVX512
VPXORQ          xmmreg|mask|z,xmmreg*,xmmrm128|b64 AVX512VL
VPXORQ          ymmreg|mask|z,ymmreg*,ymmrm256|b64 AVX512VL
VPXORQ          zmmreg|mask|z,zmmreg*,zmmrm512|b64 AVX512
VRANGEPD        xmmreg|mask|z,xmmreg*,xmmrm128|b64,imm8 AVX512VL/DQ
VRANGEPD        ymmreg|mask|z,ymmreg*,ymmrm256|b64,imm8 AVX512VL/DQ
VRANGEPD        zmmreg|mask|z,zmmreg*,zmmrm512|b64|sae,imm8 AVX512DQ
VRANGEPS        xmmreg|mask|z,xmmreg*,xmmrm128|b32,imm8 AVX512VL/DQ
VRANGEPS        ymmreg|mask|z,ymmreg*,ymmrm256|b32,imm8 AVX512VL/DQ
VRANGEPS        zmmreg|mask|z,zmmreg*,zmmrm512|b32|sae,imm8 AVX512DQ
VRANGESD        xmmreg|mask|z,xmmreg*,xmmrm64|sae,imm8 AVX512DQ
VRANGESS        xmmreg|mask|z,xmmreg*,xmmrm32|sae,imm8 AVX512DQ
VRCP14PD        xmmreg|mask|z,xmmrm128|b64 AVX512VL
VRCP14PD        ymmreg|mask|z,ymmrm256|b64 AVX512VL
VRCP14PD        zmmreg|mask|z,zmmrm512|b64 AVX512
VRCP14PS        xmmreg|mask|z,xmmrm128|b32 AVX512VL
VRCP14PS        ymmreg|mask|z,ymmrm256|b32 AVX512VL
VRCP14PS        zmmreg|mask|z,zmmrm512|b32 AVX512
VRCP14SD        xmmreg|mask|z,xmmreg*,xmmrm64 AVX512
VRCP14SS        xmmreg|mask|z,xmmreg*,xmmrm32 AVX512
VRCP28PD        zmmreg|mask|z,zmmrm512|b64|sae AVX512ER
VRCP28PS        zmmreg|mask|z,zmmrm512|b32|sae AVX512ER
VRCP28SD        xmmreg|mask|z,xmmreg*,xmmrm64|sae AVX512ER
VRCP28SS        xmmreg|mask|z,xmmreg*,xmmrm32|sae AVX512ER
VREDUCEPD       xmmreg|mask|z,xmmrm128|b64,imm8 AVX512VL/DQ
VREDUCEPD       ymmreg|mask|z,ymmrm256|b64,imm8 AVX512VL/DQ
VREDUCEPD       zmmreg|mask|z,zmmrm512|b64|sae,imm8 AVX512DQ
VREDUCEPS       xmmreg|mask|z,xmmrm128|b32,imm8 AVX512VL/DQ
VREDUCEPS       ymmreg|mask|z,ymmrm256|b32,imm8 AVX512VL/DQ
VREDUCEPS       zmmreg|mask|z,zmmrm512|b32|sae,imm8 AVX512DQ
VREDUCESD       xmmreg|mask|z,xmmreg*,xmmrm64|sae,imm8 AVX512DQ
VREDUCESS       xmmreg|mask|z,xmmreg*,xmmrm32|sae,imm8 AVX512DQ
VRNDSCALEPD     xmmreg|mask|z,xmmrm128|b64,imm8 AVX512VL
VRNDSCALEPD     ymmreg|mask|z,ymmrm256|b64,imm8 AVX512VL
VRNDSCALEPD     zmmreg|mask|z,zmmrm512|b64|sae,imm8 AVX512
VRNDSCALEPH     xmmreg|mask|z,xmmrm128|b16,imm8 AVX512VL/FP16
VRNDSCALEPH     ymmreg|mask|z,ymmrm256|b16,imm8 AVX512VL/FP16
VRNDSCALEPH     zmmreg|mask|z,zmmrm512|b16|sae,imm8 AVX512FP16
VRNDSCALEPS     xmmreg|mask|z,xmmrm128|b32,imm8 AVX512VL
VRNDSCALEPS     ymmreg|mask|z,ymmrm256|b32,imm8 AVX512VL
VRNDSCALEPS     zmmreg|mask|z,zmmrm512|b32|sae,imm8 AVX512
VRNDSCALESD     xmmreg|mask|z,xmmreg*,xmmrm64|sae,imm8 AVX512
VRNDSCALESH     xmmreg|mask|z,xmmreg*,xmmrm16|sae,imm8 AVX512FP16
VRNDSCALESS     xmmreg|mask|z,xmmreg*,xmmrm32|sae,imm8 AVX512
VRSQRT14PD      xmmreg|mask|z,xmmrm128|b64 AVX512VL
VRSQRT14PD      ymmreg|mask|z,ymmrm256|b64 AVX512VL
VRSQRT14PD      zmmreg|mask|z,zmmrm512|b64 AVX512
VRSQRT14PS      xmmreg|mask|z,xmmrm128|b32 AVX512VL
VRSQRT14PS      ymmreg|mask|z,ymmrm256|b32 AVX512VL
VRSQRT14PS      zmmreg|mask|z,zmmrm512|b32 AVX512
VRSQRT14SD      xmmreg|mask|z,xmmreg*,xmmrm64 AVX512
VRSQRT14SS      xmmreg|mask|z,xmmreg*,xmmrm32 AVX512
VRSQRT28PD      zmmreg|mask|z,zmmrm512|b64|sae AVX512ER
```

```
VRSQRT28PS      zmmreg|mask|z,zmmrm512|b32|sae AVX512ER
VRSQRT28SD      xmmreg|mask|z,xmmreg*,xmmrm64|sae AVX512ER
VRSQRT28SS      xmmreg|mask|z,xmmreg*,xmmrm32|sae AVX512ER
VSCALEFPD       xmmreg|mask|z,xmmreg*,xmmrm128|b64 AVX512VL
VSCALEFPD       ymmreg|mask|z,ymmreg*,ymmrm256|b64 AVX512VL
VSCALEFPD       zmmreg|mask|z,zmmreg*,zmmrm512|b64|er AVX512
VSCALEFPS       xmmreg|mask|z,xmmreg*,xmmrm128|b32 AVX512VL
VSCALEFPS       ymmreg|mask|z,ymmreg*,ymmrm256|b32 AVX512VL
VSCALEFPS       zmmreg|mask|z,zmmreg*,zmmrm512|b32|er AVX512
VSCALEFSD       xmmreg|mask|z,xmmreg*,xmmrm64|er AVX512
VSCALEFSS       xmmreg|mask|z,xmmreg*,xmmrm32|er AVX512
VSCATTERDPD     xmem64|mask,xmmreg      AVX512VL
VSCATTERDPD     xmem64|mask,ymmreg      AVX512VL
VSCATTERDPD     ymem64|mask,zmmreg      AVX512
VSCATTERDPS     xmem32|mask,xmmreg      AVX512VL
VSCATTERDPS     ymem32|mask,ymmreg      AVX512VL
VSCATTERDPS     zmem32|mask,zmmreg      AVX512
VSCATTERPF0DPD  ymem64|mask             AVX512PF
VSCATTERPF0DPS  zmem32|mask             AVX512PF
VSCATTERPF0QPD  zmem64|mask             AVX512PF
VSCATTERPF0QPS  zmem32|mask             AVX512PF
VSCATTERPF1DPD  ymem64|mask             AVX512PF
VSCATTERPF1DPS  zmem32|mask             AVX512PF
VSCATTERPF1QPD  zmem64|mask             AVX512PF
VSCATTERPF1QPS  zmem32|mask             AVX512PF
VSCATTERQPD     xmem64|mask,xmmreg      AVX512VL
VSCATTERQPD     ymem64|mask,ymmreg      AVX512VL
VSCATTERQPD     zmem64|mask,zmmreg      AVX512
VSCATTERQPS     xmem32|mask,xmmreg      AVX512VL
VSCATTERQPS     ymem32|mask,xmmreg      AVX512VL
VSCATTERQPS     zmem32|mask,ymmreg      AVX512
VSHUFF32X4      ymmreg|mask|z,ymmreg*,ymmrm256|b32,imm8 AVX512VL
VSHUFF32X4      zmmreg|mask|z,zmmreg*,zmmrm512|b32,imm8 AVX512
VSHUFF64X2      ymmreg|mask|z,ymmreg*,ymmrm256|b64,imm8 AVX512VL
VSHUFF64X2      zmmreg|mask|z,zmmreg*,zmmrm512|b64,imm8 AVX512
VSHUFI32X4      ymmreg|mask|z,ymmreg*,ymmrm256|b32,imm8 AVX512VL
VSHUFI32X4      zmmreg|mask|z,zmmreg*,zmmrm512|b32,imm8 AVX512
VSHUFI64X2      ymmreg|mask|z,ymmreg*,ymmrm256|b64,imm8 AVX512VL
VSHUFI64X2      zmmreg|mask|z,zmmreg*,zmmrm512|b64,imm8 AVX512
VSHUFPD         xmmreg|mask|z,xmmreg*,xmmrm128|b64,imm8 AVX512VL
VSHUFPD         ymmreg|mask|z,ymmreg*,ymmrm256|b64,imm8 AVX512VL
VSHUFPD         zmmreg|mask|z,zmmreg*,zmmrm512|b64,imm8 AVX512
VSHUFPS         xmmreg|mask|z,xmmreg*,xmmrm128|b32,imm8 AVX512VL
VSHUFPS         ymmreg|mask|z,ymmreg*,ymmrm256|b32,imm8 AVX512VL
VSHUFPS         zmmreg|mask|z,zmmreg*,zmmrm512|b32,imm8 AVX512
VSQRTPD         xmmreg|mask|z,xmmrm128|b64 AVX512VL
VSQRTPD         ymmreg|mask|z,ymmrm256|b64 AVX512VL
VSQRTPD         zmmreg|mask|z,zmmrm512|b64|er AVX512
VSQRTPS         xmmreg|mask|z,xmmrm128|b32 AVX512VL
VSQRTPS         ymmreg|mask|z,ymmrm256|b32 AVX512VL
VSQRTPS         zmmreg|mask|z,zmmrm512|b32|er AVX512
VSQRTSD         xmmreg|mask|z,xmmreg*,xmmrm64|er AVX512
VSQRTSS         xmmreg|mask|z,xmmreg*,xmmrm32|er AVX512
VSUBPD          xmmreg|mask|z,xmmreg*,xmmrm128|b64 AVX512VL
VSUBPD          ymmreg|mask|z,ymmreg*,ymmrm256|b64 AVX512VL
VSUBPD          zmmreg|mask|z,zmmreg*,zmmrm512|b64|er AVX512
VSUBPS          xmmreg|mask|z,xmmreg*,xmmrm128|b32 AVX512VL
VSUBPS          ymmreg|mask|z,ymmreg*,ymmrm256|b32 AVX512VL
VSUBPS          zmmreg|mask|z,zmmreg*,zmmrm512|b32|er AVX512
VSUBSD          xmmreg|mask|z,xmmreg*,xmmrm64|er AVX512
VSUBSS          xmmreg|mask|z,xmmreg*,xmmrm32|er AVX512
VUCOMISD        xmmreg,xmmrm64|sae      AVX512,FL
VUCOMISS        xmmreg,xmmrm32|sae      AVX512,FL
VUNPCKHPD       xmmreg|mask|z,xmmreg*,xmmrm128|b64 AVX512VL
VUNPCKHPD       ymmreg|mask|z,ymmreg*,ymmrm256|b64 AVX512VL
VUNPCKHPD       zmmreg|mask|z,zmmreg*,zmmrm512|b64 AVX512
VUNPCKHPS       xmmreg|mask|z,xmmreg*,xmmrm128|b32 AVX512VL
```

```
VUNPCKHPS       ymmreg|mask|z,ymmreg*,ymmrm256|b32 AVX512VL
VUNPCKHPS       zmmreg|mask|z,zmmreg*,zmmrm512|b32 AVX512
VUNPCKLPD       xmmreg|mask|z,xmmreg*,xmmrm128|b64 AVX512VL
VUNPCKLPD       ymmreg|mask|z,ymmreg*,ymmrm256|b64 AVX512VL
VUNPCKLPD       zmmreg|mask|z,zmmreg*,zmmrm512|b64 AVX512
VUNPCKLPS       xmmreg|mask|z,xmmreg*,xmmrm128|b32 AVX512VL
VUNPCKLPS       ymmreg|mask|z,ymmreg*,ymmrm256|b32 AVX512VL
VUNPCKLPS       zmmreg|mask|z,zmmreg*,zmmrm512|b32 AVX512
VXORPD          xmmreg|mask|z,xmmreg*,xmmrm128|b64 AVX512VL/DQ
VXORPD          ymmreg|mask|z,ymmreg*,ymmrm256|b64 AVX512VL/DQ
VXORPD          zmmreg|mask|z,zmmreg*,zmmrm512|b64 AVX512DQ
VXORPS          xmmreg|mask|z,xmmreg*,xmmrm128|b32 AVX512VL/DQ
VXORPS          ymmreg|mask|z,ymmreg*,ymmrm256|b32 AVX512VL/DQ
VXORPS          zmmreg|mask|z,zmmreg*,zmmrm512|b32 AVX512DQ
```

F.1.85 Intel memory protection keys for userspace (PKU aka PKEYs)

```
RDPKRU                                  LONG,PROT,PKU,X86_64
WRPKRU                                  LONG,PROT,PKU,X86_64
```

F.1.86 Read Processor ID

F.1.87 Processor trace write

```
PTWRITE         rm32                    PTWRITE
PTWRITE         rm64                    AR0,SX,LONG,PROT,PTWRITE,X86_64
```

F.1.88 Instructions from the Intel Instruction Set Extensions,

F.1.89 doc 319433-034 May 2018

```
CLDEMOTE        mem                     CLDEMOTE
MOVDIRI         mem32,reg32             MOVDIRI
MOVDIRI         mem64,reg64             LONG,PROT,MOVDIRI,X86_64
MOVDIRI         mem32,reg32             LONG,PROT,APX,MOVDIRI,X86_64
MOVDIRI         mem64,reg64             LONG,PROT,APX,MOVDIRI,X86_64
MOVDIR64B       reg16,mem512            NOLONG,MOVDIR64B
MOVDIR64B       reg32,mem512            MOVDIR64B
MOVDIR64B       reg64,mem512            LONG,PROT,MOVDIR64B,X86_64
MOVDIR64B       reg64,mem512            LONG,PROT,APX,MOVDIR64B,X86_64
PCONFIG                                 FL,PCONFIG
```

F.1.90 doc 319433-058 June 2025

```
PBNDKB                                  PBNDKB
PREFETCHRST2    mem8                    MOVRS
```

F.1.91 Galois field operations (GFNI)

```
GF2P8AFFINEINVQB xmmreg,xmmrm128,imm8     SSE,GFNI
VGF2P8AFFINEINVQB xmmreg,xmmreg*,xmmrm128,imm8 AVX,GFNI
VGF2P8AFFINEINVQB ymmreg,ymmreg*,ymmrm256,imm8 AVX,GFNI
VGF2P8AFFINEINVQB xmmreg|mask|z,xmmreg*,xmmrm128|b64,imm8 AVX512VL,GFNI
VGF2P8AFFINEINVQB ymmreg|mask|z,ymmreg*,ymmrm256|b64,imm8 AVX512VL,GFNI
VGF2P8AFFINEINVQB zmmreg|mask|z,zmmreg*,zmmrm512|b64,imm8 AVX512,GFNI
GF2P8AFFINEQB    xmmreg,xmmrm128,imm8     SSE,GFNI
VGF2P8AFFINEQB   xmmreg,xmmreg*,xmmrm128,imm8 AVX,GFNI
VGF2P8AFFINEQB   ymmreg,ymmreg*,ymmrm256,imm8 AVX,GFNI
VGF2P8AFFINEQB   xmmreg|mask|z,xmmreg*,xmmrm128|b64,imm8 AVX512VL,GFNI
VGF2P8AFFINEQB   ymmreg|mask|z,ymmreg*,ymmrm256|b64,imm8 AVX512VL,GFNI
VGF2P8AFFINEQB   zmmreg|mask|z,zmmreg*,zmmrm512|b64,imm8 AVX512,GFNI
GF2P8MULB        xmmreg,xmmrm128          SSE,GFNI
VGF2P8MULB       xmmreg,xmmreg*,xmmrm128  AVX,GFNI
VGF2P8MULB       ymmreg,ymmreg*,ymmrm256  AVX,GFNI
VGF2P8MULB       xmmreg|mask|z,xmmreg*,xmmrm128 AVX512VL,GFNI
VGF2P8MULB       ymmreg|mask|z,ymmreg*,ymmrm256 AVX512VL,GFNI
VGF2P8MULB       zmmreg|mask|z,zmmreg*,zmmrm512 AVX512,GFNI
```

F.1.92 AVX512 Vector Bit Manipulation Instructions 2

```
VPCOMPRESSB     mem128|mask,xmmreg       AVX512VL/VBMI2
VPCOMPRESSB     mem256|mask,ymmreg       AVX512VL/VBMI2
VPCOMPRESSB     mem512|mask,zmmreg       AVX512VBMI2
VPCOMPRESSB     xmmreg|mask|z,xmmreg     AVX512VL/VBMI2
VPCOMPRESSB     ymmreg|mask|z,ymmreg     AVX512VL/VBMI2
VPCOMPRESSB     zmmreg|mask|z,zmmreg     AVX512VBMI2
VPCOMPRESSW     mem128|mask,xmmreg       AVX512VL/VBMI2
VPCOMPRESSW     mem256|mask,ymmreg       AVX512VL/VBMI2
VPCOMPRESSW     mem512|mask,zmmreg       AVX512VBMI2
VPCOMPRESSW     xmmreg|mask|z,xmmreg     AVX512VL/VBMI2
VPCOMPRESSW     ymmreg|mask|z,ymmreg     AVX512VL/VBMI2
VPCOMPRESSW     zmmreg|mask|z,zmmreg     AVX512VBMI2
VPEXPANDB       xmmreg|mask|z,xmmrm128   AVX512VL/VBMI2
VPEXPANDB       ymmreg|mask|z,ymmrm256   AVX512VL/VBMI2
VPEXPANDB       zmmreg|mask|z,zmmrm512   AVX512VBMI2
VPEXPANDW       xmmreg|mask|z,xmmrm128   AVX512VL/VBMI2
VPEXPANDW       ymmreg|mask|z,ymmrm256   AVX512VL/VBMI2
VPEXPANDW       zmmreg|mask|z,zmmrm512   AVX512VBMI2
VPSHLDW         xmmreg|mask|z,xmmreg*,xmmrm128,imm8 AVX512VL/VBMI2
VPSHLDW         ymmreg|mask|z,ymmreg*,ymmrm256,imm8 AVX512VL/VBMI2
VPSHLDW         zmmreg|mask|z,zmmreg*,zmmrm512,imm8 AVX512VBMI2
VPSHLDD         xmmreg|mask|z,xmmreg*,xmmrm128|b32,imm8 AVX512VL/VBMI2
VPSHLDD         ymmreg|mask|z,ymmreg*,ymmrm256|b32,imm8 AVX512VL/VBMI2
VPSHLDD         zmmreg|mask|z,zmmreg*,zmmrm512|b32,imm8 AVX512VBMI2
VPSHLDQ         xmmreg|mask|z,xmmreg*,xmmrm128|b64,imm8 AVX512VL/VBMI2
VPSHLDQ         ymmreg|mask|z,ymmreg*,ymmrm256|b64,imm8 AVX512VL/VBMI2
VPSHLDQ         zmmreg|mask|z,zmmreg*,zmmrm512|b64,imm8 AVX512VBMI2
VPSHLDVW        xmmreg|mask|z,xmmreg*,xmmrm128 AVX512VL/VBMI2
VPSHLDVW        ymmreg|mask|z,ymmreg*,ymmrm256 AVX512VL/VBMI2
VPSHLDVW        zmmreg|mask|z,zmmreg*,zmmrm512 AVX512VBMI2
VPSHLDVD        xmmreg|mask|z,xmmreg*,xmmrm128|b32 AVX512VL/VBMI2
VPSHLDVD        ymmreg|mask|z,ymmreg*,ymmrm256|b32 AVX512VL/VBMI2
VPSHLDVD        zmmreg|mask|z,zmmreg*,zmmrm512|b32 AVX512VBMI2
VPSHLDVQ        xmmreg|mask|z,xmmreg*,xmmrm128|b64 AVX512VL/VBMI2
VPSHLDVQ        ymmreg|mask|z,ymmreg*,ymmrm256|b64 AVX512VL/VBMI2
VPSHLDVQ        zmmreg|mask|z,zmmreg*,zmmrm512|b64 AVX512VBMI2
VPSHRDW         xmmreg|mask|z,xmmreg*,xmmrm128,imm8 AVX512VL/VBMI2
VPSHRDW         ymmreg|mask|z,ymmreg*,ymmrm256,imm8 AVX512VL/VBMI2
VPSHRDW         zmmreg|mask|z,zmmreg*,zmmrm512,imm8 AVX512VBMI2
VPSHRDD         xmmreg|mask|z,xmmreg*,xmmrm128|b32,imm8 AVX512VL/VBMI2
VPSHRDD         ymmreg|mask|z,ymmreg*,ymmrm256|b32,imm8 AVX512VL/VBMI2
VPSHRDD         zmmreg|mask|z,zmmreg*,zmmrm512|b32,imm8 AVX512VBMI2
VPSHRDQ         xmmreg|mask|z,xmmreg*,xmmrm128|b64,imm8 AVX512VL/VBMI2
VPSHRDQ         ymmreg|mask|z,ymmreg*,ymmrm256|b64,imm8 AVX512VL/VBMI2
VPSHRDQ         zmmreg|mask|z,zmmreg*,zmmrm512|b64,imm8 AVX512VBMI2
VPSHRDVW        xmmreg|mask|z,xmmreg*,xmmrm128 AVX512VL/VBMI2
VPSHRDVW        ymmreg|mask|z,ymmreg*,ymmrm256 AVX512VL/VBMI2
VPSHRDVW        zmmreg|mask|z,zmmreg*,zmmrm512 AVX512VBMI2
VPSHRDVD        xmmreg|mask|z,xmmreg*,xmmrm128|b32 AVX512VL/VBMI2
VPSHRDVD        ymmreg|mask|z,ymmreg*,ymmrm256|b32 AVX512VL/VBMI2
VPSHRDVD        zmmreg|mask|z,zmmreg*,zmmrm512|b32 AVX512VBMI2
VPSHRDVQ        xmmreg|mask|z,xmmreg*,xmmrm128|b64 AVX512VL/VBMI2
VPSHRDVQ        ymmreg|mask|z,ymmreg*,ymmrm256|b64 AVX512VL/VBMI2
VPSHRDVQ        zmmreg|mask|z,zmmreg*,zmmrm512|b64 AVX512VBMI2
```

F.1.93 AVX512 VNNI

```
VPDPBUSD        xmmreg|mask|z,xmmreg*,xmmrm128|b32 AVX512VL/VNNI
VPDPBUSD        ymmreg|mask|z,ymmreg*,ymmrm256|b32 AVX512VL/VNNI
VPDPBUSD        zmmreg|mask|z,zmmreg*,zmmrm512|b32 AVX512VNNI
VPDPBUSDS       xmmreg|mask|z,xmmreg*,xmmrm128|b32 AVX512VL/VNNI
VPDPBUSDS       ymmreg|mask|z,ymmreg*,ymmrm256|b32 AVX512VL/VNNI
VPDPBUSDS       zmmreg|mask|z,zmmreg*,zmmrm512|b32 AVX512VNNI
VPDPWSSD        xmmreg|mask|z,xmmreg*,xmmrm128|b32 AVX512VL/VNNI
VPDPWSSD        ymmreg|mask|z,ymmreg*,ymmrm256|b32 AVX512VL/VNNI
```

```
VPDPWSSD        zmmreg|mask|z,zmmreg*,zmmrm512|b32 AVX512VNNI
VPDPWSSDS       xmmreg|mask|z,xmmreg*,xmmrm128|b32 AVX512VL/VNNI
VPDPWSSDS       ymmreg|mask|z,ymmreg*,ymmrm256|b32 AVX512VL/VNNI
VPDPWSSDS       zmmreg|mask|z,zmmreg*,zmmrm512|b32 AVX512VNNI
```

F.1.94 AVX512 Bit Algorithms

```
VPOPCNTB        xmmreg|mask|z,xmmrm128   AVX512VL/BITALG
VPOPCNTB        ymmreg|mask|z,ymmrm256   AVX512VL/BITALG
VPOPCNTB        zmmreg|mask|z,zmmrm512   AVX512BITALG
VPOPCNTW        xmmreg|mask|z,xmmrm128   AVX512VL/BITALG
VPOPCNTW        ymmreg|mask|z,ymmrm256   AVX512VL/BITALG
VPOPCNTW        zmmreg|mask|z,zmmrm512   AVX512BITALG
VPOPCNTD        xmmreg|mask|z,xmmrm128   AVX512VL/VPOPCNTDQ
VPOPCNTD        ymmreg|mask|z,ymmrm256   AVX512VL/VPOPCNTDQ
VPOPCNTD        zmmreg|mask|z,zmmrm512   AVX512VPOPCNTDQ
VPOPCNTQ        xmmreg|mask|z,xmmrm128   AVX512VL/VPOPCNTDQ
VPOPCNTQ        ymmreg|mask|z,ymmrm256   AVX512VL/VPOPCNTDQ
VPOPCNTQ        zmmreg|mask|z,zmmrm512   AVX512VPOPCNTDQ
VPSHUFBITQMB    kreg|mask,xmmreg,xmmrm128 AVX512VL/BITALG
VPSHUFBITQMB    kreg|mask,ymmreg,ymmrm256 AVX512VL/BITALG
VPSHUFBITQMB    kreg|mask,zmmreg,zmmrm512 AVX512BITALG
```

F.1.95 AVX512 4-iteration Multiply-Add

```
V4FMADDPS       zmmreg|mask|z,zmmreg|rs4,mem AVX5124FMAPS,AR0-2,SO
V4FNMADDPS      zmmreg|mask|z,zmmreg|rs4,mem AVX5124FMAPS,AR0-2,SO
V4FMADDSS       xmmreg|mask|z,xmmreg|rs4,mem AVX5124FMAPS,AR0-2,SO
V4FNMADDSS      xmmreg|mask|z,xmmreg|rs4,mem AVX5124FMAPS,AR0-2,SO
```

F.1.96 AVX512 4-iteration Dot Product

```
VP4DPWSSDS      zmmreg|mask|z,zmmreg|rs4,mem AVX5124VNNIW,AR0-2,SO
VP4DPWSSD       zmmreg|mask|z,zmmreg|rs4,mem AVX5124VNNIW,AR0-2,SO
```

F.1.97 Intel Software Guard Extensions (SGX)

```
ENCLS                                SGX
ENCLU                                SGX
ENCLV                                SGX
```

F.1.98 Intel Control-Flow Enforcement Technology (CET)

```
CLRSSBSY        mem64                FL,CET
ENDBR32                              CET
ENDBR64                              CET
INCSSPD         reg32                CET
INCSSPQ         reg64                LONG,PROT,CET,X86_64
RDSSPD          reg32                CET
RDSSPQ          reg64                LONG,PROT,CET,X86_64
RSTORSSP        mem64                CET
SAVEPREVSSP                          CET
SETSSBSY                             CET
WRUSSD          mem32,reg32          CET
WRUSSD          mem32,reg32          LONG,PROT,CET,APX,X86_64
WRUSSQ          mem64,reg64          LONG,PROT,CET,X86_64
WRUSSQ          mem64,reg64          LONG,PROT,CET,APX,X86_64
WRSSD           mem32,reg32          CET
WRSSD           mem32,reg32          LONG,PROT,CET,APX,X86_64
WRSSQ           mem64,reg64          LONG,PROT,CET,X86_64
WRSSQ           mem64,reg64          LONG,PROT,CET,APX,X86_64
```

F.1.99 Instructions from ISE doc 319433-040, June 2020

```
ENQCMD          reg16,mem512         AR0-1,SZ,NOREX,NOAPX,NOLONG,FL,ENQCMD
ENQCMD          reg32,mem512         ND,AR0-1,SZ,NOREX,NOAPX,NOLONG,FL,ENQCMD
ENQCMD          reg32,mem512         AR0-1,SZ,FL,ENQCMD
ENQCMD          reg64,mem512         AR0-1,SZ,LONG,FL,PROT,ENQCMD,X86_64
```

```
ENQCMD          reg64,mem512            AR0-1,SZ,LONG,FL,PRIV,PROT,ENQCMD,APX,X86_64
ENQCMDS         reg16,mem512            AR0-1,SZ,NOREX,NOAPX,NOLONG,FL,PRIV,ENQCMD
ENQCMDS         reg32,mem512            ND,AR0-1,SZ,NOREX,NOAPX,NOLONG,FL,PRIV,ENQCMD
ENQCMDS         reg32,mem512            AR0-1,SZ,FL,PRIV,ENQCMD
ENQCMDS         reg64,mem512            AR0-1,SZ,LONG,FL,PRIV,PROT,ENQCMD,X86_64
ENQCMDS         reg64,mem512            AR0-1,SZ,LONG,FL,PRIV,PROT,ENQCMD,APX,X86_64
PCONFIG                                 FL,PRIV,PCONFIG
XRESLDTRK                               TSXLDTRK
XSUSLDTRK                               TSXLDTRK
```

F.1.100 AVX512 Bfloat16 instructions

```
VCVTNE2PS2BF16  xmmreg|mask|z,xmmreg*,xmmrm128|b32 AVX512VL/BF16
VCVTNE2PS2BF16  ymmreg|mask|z,ymmreg*,ymmrm256|b32 AVX512VL/BF16
VCVTNE2PS2BF16  zmmreg|mask|z,zmmreg*,zmmrm512|b32 AVX512BF16
VCVTNEPS2BF16   xmmreg|mask|z,xmmrm128|b32 AVX512VL/BF16
VCVTNEPS2BF16   xmmreg|mask|z,ymmrm256|b32 AVX512VL/BF16
VCVTNEPS2BF16   ymmreg|mask|z,zmmrm512|b32 AVX512BF16
VDPBF16PS       xmmreg|mask|z,xmmreg*,xmmrm128|b32 AVX512VL/BF16
VDPBF16PS       ymmreg|mask|z,ymmreg*,ymmrm256|b32 AVX512VL/BF16
VDPBF16PS       zmmreg|mask|z,zmmreg*,zmmrm512|b32 AVX512BF16
```

F.1.101 AVX512 mask intersect instructions

```
VP2INTERSECTD   kreg|rs2,xmmreg,xmmrm128|b32 AVX512VL/VP2INTERSECT
VP2INTERSECTD   kreg|rs2,ymmreg,ymmrm256|b32 AVX512VL/VP2INTERSECT
VP2INTERSECTD   kreg|rs2,zmmreg,zmmrm512|b32 AVX512F/VP2INTERSECT
VP2INTERSECTQ   kreg|rs2,xmmreg,xmmrm128|b64 AVX512VL/VP2INTERSECT
VP2INTERSECTQ   kreg|rs2,ymmreg,ymmrm256|b64 AVX512VL/VP2INTERSECT
VP2INTERSECTQ   kreg|rs2,zmmreg,zmmrm512|b64 AVX512F/VP2INTERSECT
```

F.1.102 Intel Advanced Matrix Extensions (AMX)

```
LDTILECFG       mem512                  AR0,SZ,LONG,PROT,AMXTILE,X86_64
STTILECFG       mem512                  AR0,SZ,LONG,PROT,AMXTILE,X86_64
TDPBF16PS       tmmreg,tmmreg,tmmreg    LONG,PROT,AMXBF16,X86_64
TDPFP16PS       tmmreg,tmmreg,tmmreg    LONG,PROT,AMXFP16,X86_64
TCMMIMFP16PS    tmmreg,tmmreg,tmmreg    LONG,PROT,AMXCOMPLEX,X86_64
TCMMRLFP16PS    tmmreg,tmmreg,tmmreg    LONG,PROT,AMXCOMPLEX,X86_64
TDPBSSD         tmmreg,tmmreg,tmmreg    LONG,PROT,AMXINT8,X86_64
TDPBSUD         tmmreg,tmmreg,tmmreg    LONG,PROT,AMXINT8,X86_64
TDPBUSD         tmmreg,tmmreg,tmmreg    LONG,PROT,AMXINT8,X86_64
TDPBUUD         tmmreg,tmmreg,tmmreg    LONG,PROT,AMXINT8,X86_64
TILELOADD       tmmreg,mem              AR1,ANYSIZE,SIB,LONG,MIB,PROT,AMXTILE,APX,X86_64
TILELOADDT1     tmmreg,mem              AR1,ANYSIZE,SIB,LONG,MIB,PROT,AMXTILE,APX,X86_64
TILERELEASE                             LONG,PROT,AMXTILE,X86_64
TILESTORED      mem,tmmreg              AR0,ANYSIZE,SIB,LONG,MIB,PROT,AMXTILE,APX,X86_64
TILEZERO        tmmreg                  LONG,PROT,AMXTILE,X86_64
TILELOADDRS     tmmreg,mem              AR1,ANYSIZE,SIB,LONG,MIB,PROT,AMXTILE,AMXMOVRS,APX,X86_64
TILELOADDRST1   tmmreg,mem              AR1,ANYSIZE,SIB,LONG,MIB,PROT,AMXTILE,AMXMOVRS,APX,X86_64
T2RPNTLVWZ0     tmmreg,mem              SIB,AMXTRANSPOSE,OBSOLETE,NEVER
T2RPNTLVWZ0T1   tmmreg,mem              SIB,AMXTRANSPOSE,OBSOLETE,NEVER
T2RPNTLVWZ1     tmmreg,mem              SIB,AMXTRANSPOSE,OBSOLETE,NEVER
T2RPNTLVWZ1T1   tmmreg,mem              SIB,AMXTRANSPOSE,OBSOLETE,NEVER
T2RPNTLVWZ0RS   tmmreg,mem              SIB,AMXTRANSPOSE,OBSOLETE,NEVER
T2RPNTLVWZ0RST1 tmmreg,mem              SIB,AMXTRANSPOSE,OBSOLETE,NEVER
T2RPNTLVWZ1RS   tmmreg,mem              SIB,AMXTRANSPOSE,OBSOLETE,NEVER
T2RPNTLVWZ1RST1 tmmreg,mem              SIB,AMXTRANSPOSE,OBSOLETE,NEVER
TCONJTCMMIMFP16PS tmmreg,tmmreg,tmmreg   AMXTRANSPOSE,OBSOLETE,NEVER
TCONJTFP16      tmmreg,tmmreg           AMXTRANSPOSE,OBSOLETE,NEVER
TCVTROWD2PS     zmmreg,tmmreg,reg32     AMXAVX512
TCVTROWD2PS     zmmreg,tmmreg,imm8      AMXAVX512
TCVTROWPS2BF16H zmmreg,tmmreg,reg32     AMXAVX512
TCVTROWPS2BF16H zmmreg,tmmreg,imm8      AMXAVX512
TCVTROWPS2BF16L zmmreg,tmmreg,reg32     AMXAVX512
TCVTROWPS2BF16L zmmreg,tmmreg,imm8      AMXAVX512
TCVTROWPS2PHH   zmmreg,tmmreg,reg32     AMXAVX512
TCVTROWPS2PHH   zmmreg,tmmreg,imm8      AMXAVX512
```

```
TCVTROWPS2PHL    zmmreg,tmmreg,reg32      AMXAVX512
TCVTROWPS2PHL    zmmreg,tmmreg,imm8       AMXAVX512
TDPBF8PS         tmmreg,tmmreg,tmmreg     AMXFP8
TDPBHF8PS        tmmreg,tmmreg,tmmreg     AMXFP8
TDPHBF8PS        tmmreg,tmmreg,tmmreg     AMXFP8
TDPHF8PS         tmmreg,tmmreg,tmmreg     AMXFP8
TILEMOVROW       zmmreg,tmmreg,imm8       AMXAVX512
TILEMOVROW       zmmreg,tmmreg,reg32      AMXAVX512
TMMULTF32PS      tmmreg,tmmreg,tmmreg     AMXTF32
TTCMMIMFP16PS    tmmreg,tmmreg,tmmreg     AMXTRANSPOSE,OBSOLETE,NEVER
TTCMMRLFP16PS    tmmreg,tmmreg,tmmreg     AMXTRANSPOSE,OBSOLETE,NEVER
TTDPBF16PS       tmmreg,tmmreg,tmmreg     AMXTRANSPOSE,OBSOLETE,NEVER
TTDPFP16PS       tmmreg,tmmreg,tmmreg     AMXTRANSPOSE,OBSOLETE,NEVER
TTMMULTF32PS     tmmreg,tmmreg,tmmreg     AMXTRANSPOSE,OBSOLETE,NEVER
TTRANSPOSED      tmmreg,tmmreg            AMXTRANSPOSE,OBSOLETE,NEVER
```

F.1.103 Intel AVX512-FP16 instructions

```
VADDPH           xmmreg|mask|z,xmmreg*,xmmrm128|b16 AVX512VL/FP16
VADDPH           ymmreg|mask|z,ymmreg*,ymmrm256|b16 AVX512VL/FP16
VADDPH           zmmreg|mask|z,zmmreg*,zmmrm512|b16|er AVX512FP16
VADDSH           xmmreg|mask|z,xmmreg*,xmmrm16|er AVX512FP16
VCMPPH           kreg|mask,xmmreg*,xmmrm128|b16,imm8 AVX512VL/FP16
VCMPPH           kreg|mask,ymmreg*,ymmrm256|b16,imm8 AVX512VL/FP16
VCMPPH           kreg|mask,zmmreg*,zmmrm512|b16|sae,imm8 AVX512FP16
VCMPSH           kreg|mask,xmmreg*,xmmrm16|sae,imm8 AVX512FP16
VCOMISH          xmmreg,xmmrm16|sae       AVX512FP16,FL
VCVTDQ2PH        xmmreg|mask|z,xmmrm128|b32 AVX512VL/FP16
VCVTDQ2PH        xmmreg|mask|z,ymmrm256|b32 AVX512VL/FP16
VCVTDQ2PH        ymmreg|mask|z,zmmrm512|b32|er AVX512FP16
VCVTPD2PH        xmmreg|mask|z,xmmrm128|b64 AVX512VL/FP16
VCVTPD2PH        xmmreg|mask|z,ymmrm256|b64 AVX512VL/FP16
VCVTPD2PH        xmmreg|mask|z,zmmrm512|b64|er AVX512FP16
VCVTPH2DQ        xmmreg|mask|z,xmmrm64|b16 AVX512VL/FP16
VCVTPH2DQ        ymmreg|mask|z,xmmrm128|b16 AVX512VL/FP16
VCVTPH2DQ        zmmreg|mask|z,ymmrm256|b16|er AVX512FP16
VCVTPH2PD        xmmreg|mask|z,xmmrm32|b16 AVX512VL/FP16
VCVTPH2PD        ymmreg|mask|z,xmmrm64|b16 AVX512VL/FP16
VCVTPH2PD        zmmreg|mask|z,xmmrm128|b16|sae AVX512FP16
VCVTPH2PS        xmmreg|mask|z,xmmrm64    AVX512VL
VCVTPH2PS        ymmreg|mask|z,xmmrm128   AVX512VL
VCVTPH2PS        zmmreg|mask|z,ymmrm256|sae AVX512
VCVTPH2PSX       xmmreg|mask|z,xmmrm64|b16 AVX512VL/FP16
VCVTPH2PSX       ymmreg|mask|z,xmmrm128|b16 AVX512VL/FP16
VCVTPH2PSX       zmmreg|mask|z,ymmrm256|b16|sae AVX512FP16
VCVTPH2QQ        xmmreg|mask|z,xmmrm32|b16 AVX512VL/FP16
VCVTPH2QQ        ymmreg|mask|z,xmmrm64|b16 AVX512VL/FP16
VCVTPH2QQ        zmmreg|mask|z,xmmrm128|b16|er AVX512FP16
VCVTPH2UDQ       xmmreg|mask|z,xmmrm64|b16 AVX512VL/FP16
VCVTPH2UDQ       ymmreg|mask|z,xmmrm128|b16 AVX512VL/FP16
VCVTPH2UDQ       zmmreg|mask|z,ymmrm256|b16|er AVX512FP16
VCVTPH2UQQ       xmmreg|mask|z,xmmrm32|b16 AVX512VL/FP16
VCVTPH2UQQ       ymmreg|mask|z,xmmrm64|b16 AVX512VL/FP16
VCVTPH2UQQ       zmmreg|mask|z,xmmrm128|b16|er AVX512FP16
VCVTPH2UW        xmmreg|mask|z,xmmrm128|b16 AVX512VL/FP16
VCVTPH2UW        ymmreg|mask|z,ymmrm256|b16 AVX512VL/FP16
VCVTPH2UW        zmmreg|mask|z,zmmrm512|b16|er AVX512FP16
VCVTPH2W         xmmreg|mask|z,xmmrm128|b16 AVX512VL/FP16
VCVTPH2W         ymmreg|mask|z,ymmrm256|b16 AVX512VL/FP16
VCVTPH2W         zmmreg|mask|z,zmmrm512|b16|er AVX512FP16
VCVTPS2PH        xmmreg|mask|z,xmmreg,imm8 AVX512VL
VCVTPS2PH        mem64|mask,xmmreg,imm8   AVX512VL
VCVTPS2PH        xmmreg|mask|z,ymmreg,imm8 AVX512VL
VCVTPS2PH        mem128|mask,ymmreg,imm8  AVX512VL
VCVTPS2PH        ymmreg|mask|z,zmmreg|sae,imm8 AVX512
VCVTPS2PH        mem256|mask,zmmreg|sae,imm8 AVX512
VCVTPS2PHX       xmmreg|mask|z,xmmrm128|b32 AVX512VL/FP16
```

```
VCVTPS2PHX      xmmreg|mask|z,ymmrm256|b32 AVX512VL/FP16
VCVTPS2PHX      ymmreg|mask|z,zmmrm512|b32|er AVX512FP16
VCVTQQ2PH       xmmreg|mask|z,xmmrm128|b64 AVX512VL/FP16
VCVTQQ2PH       xmmreg|mask|z,ymmrm256|b64 AVX512VL/FP16
VCVTQQ2PH       xmmreg|mask|z,zmmrm512|b64|er AVX512VL/FP16
VCVTSD2SH       xmmreg|mask|z,xmmreg*,xmmrm64|er AVX512FP16
VCVTSH2SD       xmmreg,xmmreg*,xmmrm16|sae AVX512FP16
VCVTSH2SI       reg32,xmmrm16|er         AVX512FP16
VCVTSH2SI       reg64,xmmrm16|er         AVX512FP16
VCVTSH2SS       xmmreg|mask|z,xmmreg*,xmmrm16|sae AVX512FP16
VCVTSH2USI      reg32,xmmrm16|er         AVX512FP16
VCVTSH2USI      reg64,xmmrm16|er         AVX512FP16
VCVTSI2SH       xmmreg,xmmreg*,rm32|er   AVX512FP16
VCVTSI2SH       xmmreg,xmmreg*,rm64|er   AVX512FP16
VCVTSS2SH       xmmreg,xmmreg*,xmmrm32|er AVX512FP16
VCVTTPH2DQ      xmmreg|mask|z,xmmrm64|b16 AVX512VL/FP16
VCVTTPH2DQ      ymmreg|mask|z,xmmrm128|b16 AVX512VL/FP16
VCVTTPH2DQ      zmmreg|mask|z,ymmrm256|b16|sae AVX512FP16
VCVTTPH2QQ      xmmreg|mask|z,xmmrm32|b16 AVX512VL/FP16
VCVTTPH2QQ      ymmreg|mask|z,xmmrm64|b16 AVX512VL/FP16
VCVTTPH2QQ      zmmreg|mask|z,xmmrm128|b16|sae AVX512FP16
VCVTTPH2UDQ     xmmreg|mask|z,xmmrm64|b16 AVX512VL/FP16
VCVTTPH2UDQ     ymmreg|mask|z,xmmrm128|b16 AVX512VL/FP16
VCVTTPH2UDQ     zmmreg|mask|z,ymmrm256|b16|sae AVX512FP16
VCVTTPH2UQQ     xmmreg|mask|z,xmmrm32|b16 AVX512VL/FP16
VCVTTPH2UQQ     ymmreg|mask|z,xmmrm64|b16 AVX512VL/FP16
VCVTTPH2UQQ     zmmreg|mask|z,xmmrm128|b16|sae AVX512FP16
VCVTTPH2UW      xmmreg|mask|z,xmmrm128|b16 AVX512VL/FP16
VCVTTPH2UW      ymmreg|mask|z,ymmrm256|b16 AVX512VL/FP16
VCVTTPH2UW      zmmreg|mask|z,zmmrm512|b16|sae AVX512FP16
VCVTTPH2W       xmmreg|mask|z,xmmrm128|b16 AVX512VL/FP16
VCVTTPH2W       ymmreg|mask|z,ymmrm256|b16 AVX512VL/FP16
VCVTTPH2W       zmmreg|mask|z,zmmrm512|b16|sae AVX512FP16
VCVTTSH2SI      reg32,xmmrm16|sae        AVX512FP16
VCVTTSH2SI      reg64,xmmrm16|sae        AVX512FP16
VCVTTSH2USI     reg32,xmmrm16|sae        AVX512FP16
VCVTTSH2USI     reg64,xmmrm16|sae        AVX512FP16
VCVTUDQ2PH      xmmreg|mask|z,xmmrm128|b32 AVX512VL/FP16
VCVTUDQ2PH      xmmreg|mask|z,ymmrm256|b32 AVX512VL/FP16
VCVTUDQ2PH      ymmreg|mask|z,zmmrm512|b32 AVX512FP16
VCVTUQQ2PH      xmmreg|mask|z,xmmrm128|b32 AVX512VL/FP16
VCVTUQQ2PH      xmmreg|mask|z,ymmrm256|b32 AVX512VL/FP16
VCVTUQQ2PH      xmmreg|mask|z,zmmrm512|b32 AVX512FP16
VCVTUSI2SH      xmmreg,xmmreg*,rm32|er   AVX512FP16
VCVTUSI2SH      xmmreg,xmmreg*,rm64|er   AVX512FP16
VCVTUW2PH       xmmreg|mask|z,xmmrm128|b16 AVX512VL/FP16
VCVTUW2PH       ymmreg|mask|z,ymmrm256|b16 AVX512VL/FP16
VCVTUW2PH       zmmreg|mask|z,zmmrm512|b16|er AVX512FP16
VCVTW2PH        xmmreg|mask|z,xmmrm128|b16 AVX512VL/FP16
VCVTW2PH        ymmreg|mask|z,ymmrm256|b16 AVX512VL/FP16
VCVTW2PH        zmmreg|mask|z,zmmrm512|b16|er AVX512FP16
VDIVPH          xmmreg|mask|z,xmmreg*,xmmrm128|b16 AVX512VL/FP16
VDIVPH          ymmreg|mask|z,ymmreg*,ymmrm256|b16 AVX512VL/FP16
VDIVPH          zmmreg|mask|z,zmmreg*,zmmrm512|b16|er AVX512FP16
VDIVSH          xmmreg|mask|z,xmmreg*,xmmrm16|er AVX512FP16
VFCMADDCPH      xmmreg|mask|z,xmmreg*,xmmrm128|b32 AVX512VL/FP16
VFCMADDCPH      ymmreg|mask|z,ymmreg*,ymmrm256|b32 AVX512VL/FP16
VFCMADDCPH      zmmreg|mask|z,zmmreg*,zmmrm512|b32|er AVX512VL/FP16
VFMADDCPH       xmmreg|mask|z,xmmreg*,xmmrm128|b32 AVX512VL/FP16
VFMADDCPH       ymmreg|mask|z,ymmreg*,ymmrm256|b32 AVX512VL/FP16
VFMADDCPH       zmmreg|mask|z,zmmreg*,zmmrm512|b32|er AVX512VL/FP16
VFCMADDCSH      xmmreg|mask|z,xmmreg*,xmmrm32|er AVX512FP16
VFMADDCSH       xmmreg|mask|z,xmmreg*,xmmrm32|er AVX512FP16
VFCMULCPH       xmmreg|mask|z,xmmreg*,xmmrm128|b32 AVX512VL/FP16
VFCMULCPH       ymmreg|mask|z,ymmreg*,ymmrm256|b32 AVX512VL/FP16
VFCMULCPH       zmmreg|mask|z,zmmreg*,zmmrm512|b32|er AVX512FP16
VFMULCPH        xmmreg|mask|z,xmmreg*,xmmrm128|b32 AVX512VL/FP16
```

```
VFMULCPH         ymmreg|mask|z,ymmreg*,ymmrm256|b32 AVX512VL/FP16
VFMULCPH         zmmreg|mask|z,zmmreg*,zmmrm512|b32|er AVX512FP16
VFCMULCSH        xmmreg|mask|z,xmmreg*,xmmrm32|er AVX512FP16
VFMULCSH         xmmreg|mask|z,xmmreg*,xmmrm32|er AVX512FP16
VFMADDSUB132PH   xmmreg|mask|z,xmmreg*,xmmrm128|b16 AVX512VL/FP16
VFMADDSUB132PH   ymmreg|mask|z,ymmreg*,ymmrm256|b16 AVX512VL/FP16
VFMADDSUB132PH   zmmreg|mask|z,zmmreg*,zmmrm512|b16|er AVX512FP16
VFMADDSUB213PH   xmmreg|mask|z,xmmreg*,xmmrm128|b16 AVX512VL/FP16
VFMADDSUB213PH   ymmreg|mask|z,ymmreg*,ymmrm256|b16 AVX512VL/FP16
VFMADDSUB213PH   zmmreg|mask|z,zmmreg*,zmmrm512|b16|er AVX512FP16
VFMADDSUB231PH   xmmreg|mask|z,xmmreg*,xmmrm128|b16 AVX512VL/FP16
VFMADDSUB231PH   ymmreg|mask|z,ymmreg*,ymmrm256|b16 AVX512VL/FP16
VFMADDSUB231PH   zmmreg|mask|z,zmmreg*,zmmrm512|b16|er AVX512FP16
VFMSUBADD132PH   xmmreg|mask|z,xmmreg*,xmmrm128|b16 AVX512VL/FP16
VFMSUBADD132PH   ymmreg|mask|z,ymmreg*,ymmrm256|b16 AVX512VL/FP16
VFMSUBADD132PH   zmmreg|mask|z,zmmreg*,zmmrm512|b16|er AVX512FP16
VFMSUBADD213PH   xmmreg|mask|z,xmmreg*,xmmrm128|b16 AVX512VL/FP16
VFMSUBADD213PH   ymmreg|mask|z,ymmreg*,ymmrm256|b16 AVX512VL/FP16
VFMSUBADD213PH   zmmreg|mask|z,zmmreg*,zmmrm512|b16|er AVX512FP16
VFMSUBADD231PH   xmmreg|mask|z,xmmreg*,xmmrm128|b16 AVX512VL/FP16
VFMSUBADD231PH   ymmreg|mask|z,ymmreg*,ymmrm256|b16 AVX512VL/FP16
VFMSUBADD231PH   zmmreg|mask|z,zmmreg*,zmmrm512|b16|er AVX512FP16
VFMADD132PH      xmmreg|mask|z,xmmreg*,xmmrm128|b16 AVX512VL/FP16
VFMADD132PH      ymmreg|mask|z,ymmreg*,ymmrm256|b16 AVX512VL/FP16
VFMADD132PH      zmmreg|mask|z,zmmreg*,zmmrm512|b16|er AVX512FP16
VFMADD213PH      xmmreg|mask|z,xmmreg*,xmmrm128|b16 AVX512VL/FP16
VFMADD213PH      ymmreg|mask|z,ymmreg*,ymmrm256|b16 AVX512VL/FP16
VFMADD213PH      zmmreg|mask|z,zmmreg*,zmmrm512|b16|er AVX512FP16
VFMADD231PH      xmmreg|mask|z,xmmreg*,xmmrm128|b16 AVX512VL/FP16
VFMADD231PH      ymmreg|mask|z,ymmreg*,ymmrm256|b16 AVX512VL/FP16
VFMADD231PH      zmmreg|mask|z,zmmreg*,zmmrm512|b16|er AVX512FP16
VFNMADD132PH     xmmreg|mask|z,xmmreg*,xmmrm128|b16 AVX512VL/FP16
VFNMADD132PH     ymmreg|mask|z,ymmreg*,ymmrm256|b16 AVX512VL/FP16
VFNMADD132PH     zmmreg|mask|z,zmmreg*,zmmrm512|b16|er AVX512FP16
VFNMADD213PH     xmmreg|mask|z,xmmreg*,xmmrm128|b16 AVX512VL/FP16
VFNMADD213PH     ymmreg|mask|z,ymmreg*,ymmrm256|b16 AVX512VL/FP16
VFNMADD213PH     zmmreg|mask|z,zmmreg*,zmmrm512|b16|er AVX512FP16
VFNMADD231PH     xmmreg|mask|z,xmmreg*,xmmrm128|b16 AVX512VL/FP16
VFNMADD231PH     ymmreg|mask|z,ymmreg*,ymmrm256|b16 AVX512VL/FP16
VFNMADD231PH     zmmreg|mask|z,zmmreg*,zmmrm512|b16|er AVX512FP16
VFMADD132SH      xmmreg|mask|z,xmmreg*,xmmrm16|er AVX512FP16
VFMADD213SH      xmmreg|mask|z,xmmreg*,xmmrm16|er AVX512FP16
VFMADD231SH      xmmreg|mask|z,xmmreg*,xmmrm16|er AVX512FP16
VFNMADD132SH     xmmreg|mask|z,xmmreg*,xmmrm16|er AVX512FP16
VFNMADD213SH     xmmreg|mask|z,xmmreg*,xmmrm16|er AVX512FP16
VFNMADD231SH     xmmreg|mask|z,xmmreg*,xmmrm16|er AVX512FP16
VFMSUB132PH      xmmreg|mask|z,xmmreg*,xmmrm128|b16 AVX512VL/FP16
VFMSUB132PH      ymmreg|mask|z,ymmreg*,ymmrm256|b16 AVX512VL/FP16
VFMSUB132PH      zmmreg|mask|z,zmmreg*,zmmrm512|b16|er AVX512FP16
VFMSUB213PH      xmmreg|mask|z,xmmreg*,xmmrm128|b16 AVX512VL/FP16
VFMSUB213PH      ymmreg|mask|z,ymmreg*,ymmrm256|b16 AVX512VL/FP16
VFMSUB213PH      zmmreg|mask|z,zmmreg*,zmmrm512|b16|er AVX512FP16
VFMSUB231PH      xmmreg|mask|z,xmmreg*,xmmrm128|b16 AVX512VL/FP16
VFMSUB231PH      ymmreg|mask|z,ymmreg*,ymmrm256|b16 AVX512VL/FP16
VFMSUB231PH      zmmreg|mask|z,zmmreg*,zmmrm512|b16|er AVX512FP16
VFNMSUB132PH     xmmreg|mask|z,xmmreg*,xmmrm128|b16 AVX512VL/FP16
VFNMSUB132PH     ymmreg|mask|z,ymmreg*,ymmrm256|b16 AVX512VL/FP16
VFNMSUB132PH     zmmreg|mask|z,zmmreg*,zmmrm512|b16|er AVX512FP16
VFNMSUB213PH     xmmreg|mask|z,xmmreg*,xmmrm128|b16 AVX512VL/FP16
VFNMSUB213PH     ymmreg|mask|z,ymmreg*,ymmrm256|b16 AVX512VL/FP16
VFNMSUB213PH     zmmreg|mask|z,zmmreg*,zmmrm512|b16|er AVX512FP16
VFNMSUB231PH     xmmreg|mask|z,xmmreg*,xmmrm128|b16 AVX512VL/FP16
VFNMSUB231PH     ymmreg|mask|z,ymmreg*,ymmrm256|b16 AVX512VL/FP16
VFNMSUB231PH     zmmreg|mask|z,zmmreg*,zmmrm512|b16|er AVX512FP16
VFMSUB132SH      xmmreg|mask|z,xmmreg*,xmmrm16|er AVX512FP16
VFMSUB213SH      xmmreg|mask|z,xmmreg*,xmmrm16|er AVX512FP16
VFMSUB231SH      xmmreg|mask|z,xmmreg*,xmmrm16|er AVX512FP16
```

```
VFNMSUB132SH     xmmreg|mask|z,xmmreg*,xmmrm16|er AVX512FP16
VFNMSUB213SH     xmmreg|mask|z,xmmreg*,xmmrm16|er AVX512FP16
VFNMSUB231SH     xmmreg|mask|z,xmmreg*,xmmrm16|er AVX512FP16
VFPCLASSPH       kreg|mask,xmmrm128|b16,imm8 AVX512VL/FP16
VFPCLASSPH       kreg|mask,ymmrm256|b16,imm8 AVX512VL/FP16
VFPCLASSPH       kreg|mask,zmmrm512|b16,imm8 AVX512FP16
VFPCLASSSH       kreg|mask,xmmrm16,imm8   AVX512FP16
VGETEXPPH        xmmreg|mask|z,xmmrm128|b16 AVX512VL/FP16
VGETEXPPH        ymmreg|mask|z,ymmrm256|b16 AVX512VL/FP16
VGETEXPPH        zmmreg|mask|z,zmmrm512|b16|sae AVX512FP16
VGETEXPSH        xmmreg|mask|z,xmmreg,xmmrm16|sae AVX512FP16
VGETMANTPH       xmmreg|mask|z,xmmrm128|b16,imm8 AVX512VL/FP16
VGETMANTPH       ymmreg|mask|z,ymmrm256|b16,imm8 AVX512VL/FP16
VGETMANTPH       zmmreg|mask|z,zmmrm512|b16|sae,imm8 AVX512FP16
VGETMANTSH       xmmreg|mask|z,xmmreg,xmmrm16|sae,imm8 AVX512FP16
VMAXPH           xmmreg|mask|z,xmmreg*,xmmrm128|b16 AVX512VL/FP16
VMAXPH           ymmreg|mask|z,ymmreg*,ymmrm256|b16 AVX512VL/FP16
VMAXPH           zmmreg|mask|z,zmmreg*,zmmrm512|b16|sae AVX512FP16
VMAXSH           xmmreg|mask|z,xmmreg,xmmrm16|sae AVX512FP16
VMINPH           xmmreg|mask|z,xmmreg*,xmmrm128|b16 AVX512VL/FP16
VMINPH           ymmreg|mask|z,ymmreg*,ymmrm256|b16 AVX512VL/FP16
VMINPH           zmmreg|mask|z,zmmreg*,zmmrm512|b16|sae AVX512FP16
VMINSH           xmmreg|mask|z,xmmreg,xmmrm16|sae AVX512FP16
VMOVSH           xmmreg|mask|z,mem16      AVX512FP16
VMOVSH           mem16|mask,xmmreg        AVX512FP16
VMOVSH           xmmreg|mask|z,xmmreg*,xmmreg AVX512FP16
VMOVSH           xmmreg|mask|z,xmmreg*,xmmreg AVX512FP16
VMOVW            xmmreg|mask|z,rm16       AVX512FP16
VMOVW            rm16,xmmreg              AVX512FP16
VMULPH           xmmreg|mask|z,xmmreg*,xmmrm128|b16 AVX512VL/FP16
VMULPH           ymmreg|mask|z,ymmreg*,ymmrm256|b16 AVX512VL/FP16
VMULPH           zmmreg|mask|z,zmmreg*,zmmrm512|b16 AVX512FP16
VMULSH           xmmreg|mask|z,xmmreg*,xmmrm16|er AVX512FP16
VRCPPH           xmmreg|mask|z,xmmrm128|b16 AVX512VL/FP16
VRCPPH           ymmreg|mask|z,ymmrm256|b16 AVX512VL/FP16
VRCPPH           zmmreg|mask|z,zmmrm512|b16 AVX512FP16
VRCPSH           xmmreg|mask|z,xmmreg*,xmmrm16|sae AVX512FP16
VREDUCEPH        xmmreg|mask|z,xmmrm128|b16,imm8 AVX512VL/FP16
VREDUCEPH        ymmreg|mask|z,ymmrm256|b16,imm8 AVX512VL/FP16
VREDUCEPH        zmmreg|mask|z,zmmrm512|b16|sae,imm8 AVX512FP16
VREDUCESH        xmmreg|mask|z,xmmreg*,xmmrm16|sae,imm8 AVX512FP16
VENDSCALEPH      xmmreg|mask|z,xmmrm128|b16,imm8 AVX512VL/FP16
VENDSCALEPH      ymmreg|mask|z,ymmrm256|b16,imm8 AVX512VL/FP16
VENDSCALEPH      zmmreg|mask|z,zmmrm512|b16|sae,imm8 AVX512FP16
VENDSCALESH      xmmreg|mask|z,xmmreg*,xmmrm16|sae,imm8 AVX512FP16
VRSQRTPH         xmmreg|mask|z,xmmrm128|b16 AVX512VL/FP16
VRSQRTPH         ymmreg|mask|z,ymmrm256|b16 AVX512VL/FP16
VRSQRTPH         zmmreg|mask|z,zmmrm512|b16|sae AVX512FP16
VRSQRTSH         xmmreg|mask|z,xmmreg*,xmmrm16|sae AVX512FP16
VSCALEFPH        xmmreg|mask|z,xmmreg*,xmmrm128|b16 AVX512VL/FP16
VSCALEFPH        ymmreg|mask|z,ymmreg*,ymmrm256|b16 AVX512VL/FP16
VSCALEFPH        zmmreg|mask|z,zmmreg*,zmmrm512|b16|er AVX512FP16
VSCALEFSH        xmmreg|mask|z,xmmreg*,xmmrm16|er AVX512FP16
VSQRTPH          xmmreg|mask|z,xmmrm128|b16 AVX512VL/FP16
VSQRTPH          ymmreg|mask|z,ymmrm256|b16 AVX512VL/FP16
VSQRTPH          zmmreg|mask|z,zmmrm512|b16|er AVX512FP16
VSQRTSH          xmmreg|mask|z,xmmreg*,xmmrm16|er AVX512FP16
VSUBPH           xmmreg|mask|z,xmmreg*,xmmrm128|b16 AVX512VL/FP16
VSUBPH           ymmreg|mask|z,ymmreg*,ymmrm256|b16 AVX512VL/FP16
VSUBPH           zmmreg|mask|z,zmmreg*,zmmrm512|b16|er AVX512FP16
VSUBSH           xmmreg|mask|z,xmmreg*,xmmrm16|er AVX512FP16
VUCOMISH         xmmreg,xmmrm16|sae       AVX512FP16,FL
VMINPH           xmmreg|mask|z,xmmreg*,xmmrm128|b16 AVX512VL/FP16
VMINPH           ymmreg|mask|z,ymmreg*,ymmrm256|b16 AVX512VL/FP16
VMINPH           zmmreg|mask|z,zmmreg*,zmmrm512|b16|sae AVX512FP16
VMINSH           xmmreg|mask|z,xmmreg*,xmmrm16|sae AVX512FP16
VMAXPH           xmmreg|mask|z,xmmreg*,xmmrm128|b16 AVX512VL/FP16
```

```
VMAXPH          ymmreg|mask|z,ymmreg*,ymmrm256|b16 AVX512VL/FP16
VMAXPH          zmmreg|mask|z,zmmreg*,zmmrm512|b16|sae AVX512FP16
VMAXSH          xmmreg|mask|z,xmmreg*,xmmrm16|sae AVX512FP16
```

F.1.104 RAO-INT weakly ordered atomic operations

```
AADD            mem32,reg32             AR0-1,LONG,PROT,RAOINT,X86_64
AADD            mem64,reg64             AR0-1,LONG,PROT,RAOINT,X86_64
AADD            mem32,reg32             AR0-1,LONG,PROT,RAOINT,APX,X86_64
AADD            mem64,reg64             AR0-1,LONG,PROT,RAOINT,APX,X86_64
AAND            mem32,reg32             AR0-1,LONG,PROT,RAOINT,X86_64
AAND            mem64,reg64             AR0-1,LONG,PROT,RAOINT,X86_64
AAND            mem32,reg32             AR0-1,LONG,PROT,RAOINT,APX,X86_64
AAND            mem64,reg64             AR0-1,LONG,PROT,RAOINT,APX,X86_64
AOR             mem32,reg32             AR0-1,LONG,PROT,RAOINT,X86_64
AOR             mem64,reg64             AR0-1,LONG,PROT,RAOINT,X86_64
AOR             mem32,reg32             AR0-1,LONG,PROT,RAOINT,APX,X86_64
AOR             mem64,reg64             AR0-1,LONG,PROT,RAOINT,APX,X86_64
AXOR            mem32,reg32             AR0-1,LONG,PROT,RAOINT,X86_64
AXOR            mem64,reg64             AR0-1,LONG,PROT,RAOINT,X86_64
AXOR            mem32,reg32             AR0-1,LONG,PROT,RAOINT,APX,X86_64
AXOR            mem64,reg64             AR0-1,LONG,PROT,RAOINT,APX,X86_64
```

F.1.105 User interrupts

```
CLUI                                    LONG,PROT,UINTR,X86_64
SENDUIPI        reg64                   LONG,PROT,UINTR,X86_64
STUI                                    LONG,PROT,UINTR,X86_64
TESTUI                                  LONG,FL,PROT,UINTR,X86_64
UIRET                                   LONG,FL,PROT,UINTR,X86_64
```

F.1.106 Flexible Return and Exception Delivery

F.1.107 History reset

```
HRESET          imm,reg_eax             AR0-1,PRIV,HRESET
HRESET          imm                     ND,AR0,PRIV,HRESET
```

F.1.108 AVX10.2 BF16 instructions

```
VADDBF16        xmmreg|mask|z,xmmreg,xmmrm128|b16 AVX10_2
VADDBF16        ymmreg|mask|z,ymmreg,ymmrm256|b16 AVX10_2
VADDBF16        zmmreg|mask|z,zmmreg,zmmrm512|b16 AVX10_2
VCMPBF16        kreg|mask,xmmreg,xmmrm128|b16,imm8 AVX10_2
VCMPBF16        kreg|mask,ymmreg,ymmrm256|b16,imm8 AVX10_2
VCMPBF16        kreg|mask,zmmreg,zmmrm512|b16,imm8 AVX10_2
VCOMISBF16      xmmreg,xmmrm16          AVX10_2
VDIVBF16        xmmreg|mask|z,xmmreg,xmmrm128|b16 AVX10_2
VDIVBF16        ymmreg|mask|z,ymmreg,ymmrm256|b16 AVX10_2
VDIVBF16        zmmreg|mask|z,zmmreg,zmmrm512|b16 AVX10_2
VFMADD132BF16   xmmreg|mask|z,xmmreg,xmmrm128|b16 AVX10_2
VFMADD132BF16   ymmreg|mask|z,ymmreg,ymmrm256|b16 AVX10_2
VFMADD132BF16   zmmreg|mask|z,zmmreg,zmmrm512|b16 AVX10_2
VFMADD213BF16   xmmreg|mask|z,xmmreg,xmmrm128|b16 AVX10_2
VFMADD213BF16   ymmreg|mask|z,ymmreg,ymmrm256|b16 AVX10_2
VFMADD213BF16   zmmreg|mask|z,zmmreg,zmmrm512|b16 AVX10_2
VFMADD231BF16   xmmreg|mask|z,xmmreg,xmmrm128|b16 AVX10_2
VFMADD231BF16   ymmreg|mask|z,ymmreg,ymmrm256|b16 AVX10_2
VFMADD231BF16   zmmreg|mask|z,zmmreg,zmmrm512|b16 AVX10_2
VFMSUB132BF16   xmmreg|mask|z,xmmreg,xmmrm128|b16 AVX10_2
VFMSUB132BF16   ymmreg|mask|z,ymmreg,ymmrm256|b16 AVX10_2
VFMSUB132BF16   zmmreg|mask|z,zmmreg,zmmrm512|b16 AVX10_2
VFMSUB213BF16   xmmreg|mask|z,xmmreg,xmmrm128|b16 AVX10_2
VFMSUB213BF16   ymmreg|mask|z,ymmreg,ymmrm256|b16 AVX10_2
VFMSUB213BF16   zmmreg|mask|z,zmmreg,zmmrm512|b16 AVX10_2
VFMSUB231BF16   xmmreg|mask|z,xmmreg,xmmrm128|b16 AVX10_2
VFMSUB231BF16   ymmreg|mask|z,ymmreg,ymmrm256|b16 AVX10_2
VFMSUB231BF16   zmmreg|mask|z,zmmreg,zmmrm512|b16 AVX10_2
```

```
VFNMADD132BF16   xmmreg|mask|z,xmmreg,xmmrm128|b16 AVX10_2
VFNMADD132BF16   ymmreg|mask|z,ymmreg,ymmrm256|b16 AVX10_2
VFNMADD132BF16   zmmreg|mask|z,zmmreg,zmmrm512|b16 AVX10_2
VFNMADD213BF16   xmmreg|mask|z,xmmreg,xmmrm128|b16 AVX10_2
VFNMADD213BF16   ymmreg|mask|z,ymmreg,ymmrm256|b16 AVX10_2
VFNMADD213BF16   zmmreg|mask|z,zmmreg,zmmrm512|b16 AVX10_2
VFNMADD231BF16   xmmreg|mask|z,xmmreg,xmmrm128|b16 AVX10_2
VFNMADD231BF16   ymmreg|mask|z,ymmreg,ymmrm256|b16 AVX10_2
VFNMADD231BF16   zmmreg|mask|z,zmmreg,zmmrm512|b16 AVX10_2
VFNMSUB132BF16   xmmreg|mask|z,xmmreg,xmmrm128|b16 AVX10_2
VFNMSUB132BF16   ymmreg|mask|z,ymmreg,ymmrm256|b16 AVX10_2
VFNMSUB132BF16   zmmreg|mask|z,zmmreg,zmmrm512|b16 AVX10_2
VFNMSUB213BF16   xmmreg|mask|z,xmmreg,xmmrm128|b16 AVX10_2
VFNMSUB213BF16   ymmreg|mask|z,ymmreg,ymmrm256|b16 AVX10_2
VFNMSUB213BF16   zmmreg|mask|z,zmmreg,zmmrm512|b16 AVX10_2
VFNMSUB231BF16   xmmreg|mask|z,xmmreg,xmmrm128|b16 AVX10_2
VFNMSUB231BF16   ymmreg|mask|z,ymmreg,ymmrm256|b16 AVX10_2
VFNMSUB231BF16   zmmreg|mask|z,zmmreg,zmmrm512|b16 AVX10_2
VFPCLASSBF16     kreg|mask,xmmrm128|b16,imm8 AVX10_2
VFPCLASSBF16     kreg|mask,ymmrm256|b16,imm8 AVX10_2
VFPCLASSBF16     kreg|mask,zmmrm512|b16,imm8 AVX10_2
VGETEXPBF16      xmmreg|mask|z,xmmrm128|b16 AVX10_2
VGETEXPBF16      ymmreg|mask|z,ymmrm256|b16 AVX10_2
VGETEXPBF16      zmmreg|mask|z,zmmrm512|b16 AVX10_2
VGETMANTBF16     xmmreg|mask|z,xmmrm128|b16,imm8 AVX10_2
VGETMANTBF16     ymmreg|mask|z,ymmrm256|b16,imm8 AVX10_2
VGETMANTBF16     zmmreg|mask|z,zmmrm512|b16,imm8 AVX10_2
VMAXBF16         xmmreg|mask|z,xmmreg,xmmrm128|b16 AVX10_2
VMAXBF16         ymmreg|mask|z,ymmreg,ymmrm256|b16 AVX10_2
VMAXBF16         zmmreg|mask|z,zmmreg,zmmrm512|b16 AVX10_2
VMINBF16         xmmreg|mask|z,xmmreg,xmmrm128|b16 AVX10_2
VMINBF16         ymmreg|mask|z,ymmreg,ymmrm256|b16 AVX10_2
VMINBF16         zmmreg|mask|z,zmmreg,zmmrm512|b16 AVX10_2
VMULBF16         xmmreg|mask|z,xmmreg,xmmrm128|b16 AVX10_2
VMULBF16         ymmreg|mask|z,ymmreg,ymmrm256|b16 AVX10_2
VMULBF16         zmmreg|mask|z,zmmreg,zmmrm512|b16 AVX10_2
VRCPBF16         xmmreg|mask|z,xmmrm128|b16 AVX10_2
VRCPBF16         ymmreg|mask|z,ymmrm256|b16 AVX10_2
VRCPBF16         zmmreg|mask|z,zmmrm512|b16 AVX10_2
VREDUCEBF16      xmmreg|mask|z,xmmrm128|b16,imm8 AVX10_2
VREDUCEBF16      ymmreg|mask|z,ymmrm256|b16,imm8 AVX10_2
VREDUCEBF16      zmmreg|mask|z,zmmrm512|b16,imm8 AVX10_2
VRNDSCALEBF16    xmmreg|mask|z,xmmrm128|b16,imm8 AVX10_2
VRNDSCALEBF16    ymmreg|mask|z,ymmrm256|b16,imm8 AVX10_2
VRNDSCALEBF16    zmmreg|mask|z,zmmrm512|b16,imm8 AVX10_2
VRSQRTBF16       xmmreg|mask|z,xmmrm128|b16 AVX10_2
VRSQRTBF16       ymmreg|mask|z,ymmrm256|b16 AVX10_2
VRSQRTBF16       zmmreg|mask|z,zmmrm512|b16 AVX10_2
VSCALEFBF16      xmmreg|mask|z,xmmreg,xmmrm128|b16 AVX10_2
VSCALEFBF16      ymmreg|mask|z,ymmreg,ymmrm256|b16 AVX10_2
VSCALEFBF16      zmmreg|mask|z,zmmreg,zmmrm512|b16 AVX10_2
VSQRTBF16        xmmreg|mask|z,xmmrm128|b16 AVX10_2
VSQRTBF16        ymmreg|mask|z,ymmrm256|b16 AVX10_2
VSQRTBF16        zmmreg|mask|z,zmmrm512|b16 AVX10_2
VSUBBF16         xmmreg|mask|z,xmmreg,xmmrm128|b16 AVX10_2
VSUBBF16         ymmreg|mask|z,ymmreg,ymmrm256|b16 AVX10_2
VSUBBF16         zmmreg|mask|z,zmmreg,zmmrm512|b16 AVX10_2
```

F.1.109 AVX10.2 Compare scalar fp with enhanced eflags instructions

```
VCOMXSD          xmmreg,xmmrm64|sae       AVX10_2
VCOMXSH          xmmreg,xmmrm16|sae       AVX10_2
VCOMXSS          xmmreg,xmmrm32|sae       AVX10_2
VUCOMXSD         xmmreg,xmmrm64|sae       AVX10_2
VUCOMXSH         xmmreg,xmmrm16|sae       AVX10_2
VUCOMXSS         xmmreg,xmmrm32|sae       AVX10_2
```

F.1.110 AVX10.2 Convert instructions

```
VCVT2PH2BF8      xmmreg|mask|z,xmmreg,xmmrm128|b16 AVX10_2
VCVT2PH2BF8      ymmreg|mask|z,ymmreg,ymmrm256|b16 AVX10_2
VCVT2PH2BF8      zmmreg|mask|z,zmmreg,zmmrm512|b16 AVX10_2
VCVT2PH2BF8S     xmmreg|mask|z,xmmreg,xmmrm128|b16 AVX10_2
VCVT2PH2BF8S     ymmreg|mask|z,ymmreg,ymmrm256|b16 AVX10_2
VCVT2PH2BF8S     zmmreg|mask|z,zmmreg,zmmrm512|b16 AVX10_2
VCVT2PH2HF8      xmmreg|mask|z,xmmreg,xmmrm128|b16 AVX10_2
VCVT2PH2HF8      ymmreg|mask|z,ymmreg,ymmrm256|b16 AVX10_2
VCVT2PH2HF8      zmmreg|mask|z,zmmreg,zmmrm512|b16 AVX10_2
VCVT2PH2HF8S     xmmreg|mask|z,xmmreg,xmmrm128|b16 AVX10_2
VCVT2PH2HF8S     ymmreg|mask|z,ymmreg,ymmrm256|b16 AVX10_2
VCVT2PH2HF8S     zmmreg|mask|z,zmmreg,zmmrm512|b16 AVX10_2
VCVTPH2BF8       xmmreg|mask|z,xmmrm128|b16 AVX10_2
VCVTPH2BF8       xmmreg|mask|z,ymmrm256|b16 AVX10_2
VCVTPH2BF8       ymmreg|mask|z,zmmrm512|b16 AVX10_2
VCVTPH2BF8S      xmmreg|mask|z,xmmrm128|b16 AVX10_2
VCVTPH2BF8S      xmmreg|mask|z,ymmrm256|b16 AVX10_2
VCVTPH2BF8S      ymmreg|mask|z,zmmrm512|b16 AVX10_2
VCVTPH2HF8       xmmreg|mask|z,xmmrm128|b16 AVX10_2
VCVTPH2HF8       xmmreg|mask|z,ymmrm256|b16 AVX10_2
VCVTPH2HF8       ymmreg|mask|z,zmmrm512|b16 AVX10_2
VCVTPH2HF8S      xmmreg|mask|z,xmmrm128|b16 AVX10_2
VCVTPH2HF8S      xmmreg|mask|z,ymmrm256|b16 AVX10_2
VCVTPH2HF8S      ymmreg|mask|z,zmmrm512|b16 AVX10_2
VCVT2PS2PHX      xmmreg|mask|z,xmmreg,xmmrm128|b32 AVX10_2
VCVT2PS2PHX      ymmreg|mask|z,ymmreg,ymmrm256|b32 AVX10_2
VCVT2PS2PHX      zmmreg|mask|z,zmmreg,zmmrm512|b32 AVX10_2
VCVTBIASPH2BF8   xmmreg|mask|z,xmmreg,xmmrm128|b16 AVX10_2
VCVTBIASPH2BF8   xmmreg|mask|z,ymmreg,ymmrm256|b16 AVX10_2
VCVTBIASPH2BF8   ymmreg|mask|z,zmmreg,zmmrm512|b16 AVX10_2
VCVTBIASPH2BF8S  xmmreg|mask|z,xmmreg,xmmrm128|b16 AVX10_2
VCVTBIASPH2BF8S  xmmreg|mask|z,ymmreg,ymmrm256|b16 AVX10_2
VCVTBIASPH2BF8S  ymmreg|mask|z,zmmreg,zmmrm512|b16 AVX10_2
VCVTBIASPH2HF8   xmmreg|mask|z,xmmreg,xmmrm128|b16 AVX10_2
VCVTBIASPH2HF8   xmmreg|mask|z,ymmreg,ymmrm256|b16 AVX10_2
VCVTBIASPH2HF8   ymmreg|mask|z,zmmreg,zmmrm512|b16 AVX10_2
VCVTBIASPH2HF8S  xmmreg|mask|z,xmmreg,xmmrm128|b16 AVX10_2
VCVTBIASPH2HF8S  xmmreg|mask|z,ymmreg,ymmrm256|b16 AVX10_2
VCVTBIASPH2HF8S  ymmreg|mask|z,zmmreg,zmmrm512|b16 AVX10_2
VCVTHF82PH       xmmreg|mask|z,xmmrm64    AVX10_2
VCVTHF82PH       ymmreg|mask|z,xmmrm128   AVX10_2
VCVTHF82PH       zmmreg|mask|z,ymmrm256   AVX10_2
```

F.1.111 AVX10.2 Integer and FP16 VNNI, media new instructions

```
VDPPHPS          xmmreg|mask|z,xmmreg,xmmrm128|b32 AVX10_2
VDPPHPS          ymmreg|mask|z,ymmreg,ymmrm256|b32 AVX10_2
VDPPHPS          zmmreg|mask|z,zmmreg,zmmrm512|b32 AVX10_2
VMPSADBW         xmmreg|mask|z,xmmreg,xmmrm128,imm8 AVX10_2
VMPSADBW         ymmreg|mask|z,ymmreg,ymmrm256,imm8 AVX10_2
VMPSADBW         zmmreg|mask|z,zmmreg,zmmrm512,imm8 AVX10_2
VPDPBSSD         xmmreg|mask|z,xmmreg,xmmrm128|b32 AVX10_2,AVX10_VNNIINT
VPDPBSSD         ymmreg|mask|z,ymmreg,ymmrm256|b32 AVX10_2,AVX10_VNNIINT
VPDPBSSD         zmmreg|mask|z,zmmreg,zmmrm512|b32 AVX10_2,AVX10_VNNIINT
VPDPBSSDS        xmmreg|mask|z,xmmreg,xmmrm128|b32 AVX10_2,AVX10_VNNIINT
VPDPBSSDS        ymmreg|mask|z,ymmreg,ymmrm256|b32 AVX10_2,AVX10_VNNIINT
VPDPBSSDS        zmmreg|mask|z,zmmreg,zmmrm512|b32 AVX10_2,AVX10_VNNIINT
VPDPBSUD         xmmreg|mask|z,xmmreg,xmmrm128|b32 AVX10_2,AVX10_VNNIINT
VPDPBSUD         ymmreg|mask|z,ymmreg,ymmrm256|b32 AVX10_2,AVX10_VNNIINT
VPDPBSUD         zmmreg|mask|z,zmmreg,zmmrm512|b32 AVX10_2,AVX10_VNNIINT
VPDPBSUDS        xmmreg|mask|z,xmmreg,xmmrm128|b32 AVX10_2,AVX10_VNNIINT
VPDPBSUDS        ymmreg|mask|z,ymmreg,ymmrm256|b32 AVX10_2,AVX10_VNNIINT
VPDPBSUDS        zmmreg|mask|z,zmmreg,zmmrm512|b32 AVX10_2,AVX10_VNNIINT
VPDPBUUD         xmmreg|mask|z,xmmreg,xmmrm128|b32 AVX10_2,AVX10_VNNIINT
VPDPBUUD         ymmreg|mask|z,ymmreg,ymmrm256|b32 AVX10_2,AVX10_VNNIINT
```

```
VPDPBUUD        zmmreg|mask|z,zmmreg,zmmrm512|b32 AVX10_2,AVX10_VNNIINT
VPDPBUUDS       xmmreg|mask|z,xmmreg,xmmrm128|b32 AVX10_2,AVX10_VNNIINT
VPDPBUUDS       ymmreg|mask|z,ymmreg,ymmrm256|b32 AVX10_2,AVX10_VNNIINT
VPDPBUUDS       zmmreg|mask|z,zmmreg,zmmrm512|b32 AVX10_2,AVX10_VNNIINT
VPDPWSUD        xmmreg|mask|z,xmmreg,xmmrm128|b32 AVX10_2,AVX10_VNNIINT
VPDPWSUD        ymmreg|mask|z,ymmreg,ymmrm256|b32 AVX10_2,AVX10_VNNIINT
VPDPWSUD        zmmreg|mask|z,zmmreg,zmmrm512|b32 AVX10_2,AVX10_VNNIINT
VPDPWSUDS       xmmreg|mask|z,xmmreg,xmmrm128|b32 AVX10_2,AVX10_VNNIINT
VPDPWSUDS       ymmreg|mask|z,ymmreg,ymmrm256|b32 AVX10_2,AVX10_VNNIINT
VPDPWSUDS       zmmreg|mask|z,zmmreg,zmmrm512|b32 AVX10_2,AVX10_VNNIINT
VPDPWUSD        xmmreg|mask|z,xmmreg,xmmrm128|b32 AVX10_2,AVX10_VNNIINT
VPDPWUSD        ymmreg|mask|z,ymmreg,ymmrm256|b32 AVX10_2,AVX10_VNNIINT
VPDPWUSD        zmmreg|mask|z,zmmreg,zmmrm512|b32 AVX10_2,AVX10_VNNIINT
VPDPWUSDS       xmmreg|mask|z,xmmreg,xmmrm128|b32 AVX10_2,AVX10_VNNIINT
VPDPWUSDS       ymmreg|mask|z,ymmreg,ymmrm256|b32 AVX10_2,AVX10_VNNIINT
VPDPWUSDS       zmmreg|mask|z,zmmreg,zmmrm512|b32 AVX10_2,AVX10_VNNIINT
VPDPWUUD        xmmreg|mask|z,xmmreg,xmmrm128|b32 AVX10_2,AVX10_VNNIINT
VPDPWUUD        ymmreg|mask|z,ymmreg,ymmrm256|b32 AVX10_2,AVX10_VNNIINT
VPDPWUUD        zmmreg|mask|z,zmmreg,zmmrm512|b32 AVX10_2,AVX10_VNNIINT
VPDPWUUDS       xmmreg|mask|z,xmmreg,xmmrm128|b32 AVX10_2,AVX10_VNNIINT
VPDPWUUDS       ymmreg|mask|z,ymmreg,ymmrm256|b32 AVX10_2,AVX10_VNNIINT
VPDPWUUDS       zmmreg|mask|z,zmmreg,zmmrm512|b32 AVX10_2,AVX10_VNNIINT
```

F.1.112 AVX10.2 MINMAX instructions

```
VMINMAXBF16     xmmreg|mask|z,xmmreg,xmmrm128|b16,imm8 AVX10_2
VMINMAXBF16     ymmreg|mask|z,ymmreg,ymmrm256|b16,imm8 AVX10_2
VMINMAXBF16     zmmreg|mask|z,zmmreg,zmmrm512|b16,imm8 AVX10_2
VMINMAXPD       xmmreg|mask|z,xmmreg,xmmrm128|b64,imm8 AVX10_2
VMINMAXPD       ymmreg|mask|z,ymmreg,ymmrm256|b64,imm8 AVX10_2
VMINMAXPD       zmmreg|mask|z,zmmreg,zmmrm512|b64|sae,imm8 AVX10_2
VMINMAXPH       xmmreg|mask|z,xmmreg,xmmrm128|b16,imm8 AVX10_2
VMINMAXPH       ymmreg|mask|z,ymmreg,ymmrm256|b16,imm8 AVX10_2
VMINMAXPH       zmmreg|mask|z,zmmreg,zmmrm512|b16|sae,imm8 AVX10_2
VMINMAXPS       xmmreg|mask|z,xmmreg,xmmrm128|b32,imm8 AVX10_2
VMINMAXPS       ymmreg|mask|z,ymmreg,ymmrm256|b32,imm8 AVX10_2
VMINMAXPS       zmmreg|mask|z,zmmreg,zmmrm512|b32|sae,imm8 AVX10_2
VMINMAXSD       xmmreg|mask|z,xmmreg,xmmrm64|sae,imm8 AVX10_2
VMINMAXSH       xmmreg|mask|z,xmmreg,xmmrm16|sae,imm8 AVX10_2
VMINMAXSS       xmmreg|mask|z,xmmreg,xmmrm32|sae,imm8 AVX10_2
```

F.1.113 AVX10.2 Saturating convert instructions

```
VCVTBF162IBS    xmmreg|mask|z,xmmrm128|b16 AVX10_2
VCVTBF162IBS    ymmreg|mask|z,ymmrm256|b16 AVX10_2
VCVTBF162IBS    zmmreg|mask|z,zmmrm512|b16 AVX10_2
VCVTBF162IUBS   xmmreg|mask|z,xmmrm128|b16 AVX10_2
VCVTBF162IUBS   ymmreg|mask|z,ymmrm256|b16 AVX10_2
VCVTBF162IUBS   zmmreg|mask|z,zmmrm512|b16 AVX10_2
VCVTTBF162IBS   xmmreg|mask|z,xmmrm128|b16 AVX10_2
VCVTTBF162IBS   ymmreg|mask|z,ymmrm256|b16 AVX10_2
VCVTTBF162IBS   zmmreg|mask|z,zmmrm512|b16 AVX10_2
VCVTTBF162IUBS  xmmreg|mask|z,xmmrm128|b16 AVX10_2
VCVTTBF162IUBS  ymmreg|mask|z,ymmrm256|b16 AVX10_2
VCVTTBF162IUBS  zmmreg|mask|z,zmmrm512|b16 AVX10_2
VCVTTPD2DQS     xmmreg|mask|z,xmmrm128|b64 AVX10_2
VCVTTPD2DQS     xmmreg|mask|z,ymmrm256|b64 AVX10_2
VCVTTPD2DQS     ymmreg|mask|z,zmmrm512|b64|sae AVX10_2
VCVTTPD2QQS     xmmreg|mask|z,xmmrm128|b64 AVX10_2
VCVTTPD2QQS     ymmreg|mask|z,ymmrm256|b64 AVX10_2
VCVTTPD2QQS     zmmreg|mask|z,zmmrm512|b64|sae AVX10_2
VCVTTPD2UDQS    xmmreg|mask|z,xmmrm128|b64 AVX10_2
VCVTTPD2UDQS    xmmreg|mask|z,ymmrm256|b64 AVX10_2
VCVTTPD2UDQS    ymmreg|mask|z,zmmrm512|b64|sae AVX10_2
VCVTTPD2UQQS    xmmreg|mask|z,xmmrm128|b64 AVX10_2
VCVTTPD2UQQS    ymmreg|mask|z,ymmrm256|b64 AVX10_2
VCVTTPD2UQQS    zmmreg|mask|z,zmmrm512|b64|sae AVX10_2
```

```
VCVTPH2IBS      xmmreg|mask|z,xmmrm128|b16 AVX10_2
VCVTPH2IBS      ymmreg|mask|z,ymmrm256|b16 AVX10_2
VCVTPH2IBS      zmmreg|mask|z,zmmrm512|b16|er AVX10_2
VCVTPH2IUBS     xmmreg|mask|z,xmmrm128|b16 AVX10_2
VCVTPH2IUBS     ymmreg|mask|z,ymmrm256|b16 AVX10_2
VCVTPH2IUBS     zmmreg|mask|z,zmmrm512|b16|er AVX10_2
VCVTTPH2IBS     xmmreg|mask|z,xmmrm128|b16 AVX10_2
VCVTTPH2IBS     ymmreg|mask|z,ymmrm256|b16 AVX10_2
VCVTTPH2IBS     zmmreg|mask|z,zmmrm512|b16|sae AVX10_2
VCVTTPH2IUBS    xmmreg|mask|z,xmmrm128|b16 AVX10_2
VCVTTPH2IUBS    ymmreg|mask|z,ymmrm256|b16 AVX10_2
VCVTTPH2IUBS    zmmreg|mask|z,zmmrm512|b16|sae AVX10_2
VCVTTPS2DQS     xmmreg|mask|z,xmmrm128|b32 AVX10_2
VCVTTPS2DQS     ymmreg|mask|z,ymmrm256|b32 AVX10_2
VCVTTPS2DQS     zmmreg|mask|z,zmmrm512|b32|sae AVX10_2
VCVTPS2IBS      xmmreg|mask|z,xmmrm128|b32 AVX10_2
VCVTPS2IBS      ymmreg|mask|z,ymmrm256|b32 AVX10_2
VCVTPS2IBS      zmmreg|mask|z,zmmrm512|b32|er AVX10_2
VCVTPS2IUBS     xmmreg|mask|z,xmmrm128|b32 AVX10_2
VCVTPS2IUBS     ymmreg|mask|z,ymmrm256|b32 AVX10_2
VCVTPS2IUBS     zmmreg|mask|z,zmmrm512|b32|er AVX10_2
VCVTTPS2IBS     xmmreg|mask|z,xmmrm128|b32 AVX10_2
VCVTTPS2IBS     ymmreg|mask|z,ymmrm256|b32 AVX10_2
VCVTTPS2IBS     zmmreg|mask|z,zmmrm512|b32|sae AVX10_2
VCVTTPS2IUBS    xmmreg|mask|z,xmmrm128|b32 AVX10_2
VCVTTPS2IUBS    ymmreg|mask|z,ymmrm256|b32 AVX10_2
VCVTTPS2IUBS    zmmreg|mask|z,zmmrm512|b32|sae AVX10_2
VCVTTPS2QQS     xmmreg|mask|z,xmmrm64|b32 AVX10_2
VCVTTPS2QQS     ymmreg|mask|z,xmmrm128|b32 AVX10_2
VCVTTPS2QQS     zmmreg|mask|z,ymmrm256|b32|sae AVX10_2
VCVTTPS2UDQS    xmmreg|mask|z,xmmrm128|b32 AVX10_2
VCVTTPS2UDQS    ymmreg|mask|z,ymmrm256|b32 AVX10_2
VCVTTPS2UDQS    zmmreg|mask|z,zmmrm512|b32|sae AVX10_2
VCVTTPS2UQQS    xmmreg|mask|z,xmmrm64|b32 AVX10_2
VCVTTPS2UQQS    ymmreg|mask|z,xmmrm128|b32 AVX10_2
VCVTTPS2UQQS    zmmreg|mask|z,ymmrm256|b32|sae AVX10_2
VCVTTSD2SIS     reg32,xmmrm64|sae       AVX10_2
VCVTTSD2SIS     reg64,xmmrm64|sae       LONG,PROT,AVX10_2,X86_64
VCVTTSD2USIS    reg32,xmmrm64|sae       AVX10_2
VCVTTSD2USIS    reg64,xmmrm64|sae       LONG,PROT,AVX10_2,X86_64
VCVTTSS2SIS     reg32,xmmrm32|sae       AVX10_2
VCVTTSS2SIS     reg64,xmmrm32|sae       LONG,PROT,AVX10_2,X86_64
VCVTTSS2USIS    reg32,xmmrm32|sae       AVX10_2
VCVTTSS2USIS    reg64,xmmrm32|sae       LONG,PROT,AVX10_2,X86_64
```

F.1.114 AVX10.2 Zero-extending partial vector copy instructions

```
VMOVD           xmmreg,xmmrm32          AVX10_2
VMOVD           xmmrm32,xmmreg          AVX10_2
VMOVW           xmmreg,xmmrm16          AVX10_2
VMOVW           xmmrm16,xmmreg          AVX10_2
```

F.1.115 AVX512BMM

```
VBMACOR16X16X16  ymmreg,ymmreg,ymmrm256   AVX512BMM
VBMACOR16X16X16  zmmreg,zmmreg,zmmrm512   AVX512BMM
VBMACXOR16X16X16 ymmreg,ymmreg,ymmrm256   AVX512BMM
VBMACXOR16X16X16 zmmreg,zmmreg,zmmrm512   AVX512BMM
VBITREV          xmmreg|mask|z,xmmrm128   AVX512BMM
VBITREV          ymmreg|mask|z,ymmrm256   AVX512BMM
VBITREV          zmmreg|mask|z,zmmrm512   AVX512BMM
```

F.1.116 Systematic names for the hinting nop instructions

```
NOP             imm,reg16,rm16          SM1-2,UNDOC,P6
NOP             imm,reg32,rm32          SM1-2,UNDOC,P6
NOP             imm,reg64,rm64          SM1-2,LONG,PROT,UNDOC,X86_64
HINT_NOP        imm,reg16,rm16          ND,SM1-2,FL,UNDOC,P6
```

```
HINT_NOP         imm,reg32,rm32          ND,SM1-2,FL,UNDOC,P6
HINT_NOP         imm,reg64,rm64          ND,SM1-2,LONG,FL,PROT,UNDOC,X86_64
HINT_NOP0        rm16                    ND,FL,UNDOC,P6
HINT_NOP0        rm32                    ND,FL,UNDOC,P6
HINT_NOP0        rm64                    ND,LONG,FL,PROT,UNDOC,X86_64
HINT_NOP1        rm16                    ND,FL,UNDOC,P6
HINT_NOP1        rm32                    ND,FL,UNDOC,P6
HINT_NOP1        rm64                    ND,LONG,FL,PROT,UNDOC,X86_64
HINT_NOP2        rm16                    ND,FL,UNDOC,P6
HINT_NOP2        rm32                    ND,FL,UNDOC,P6
HINT_NOP2        rm64                    ND,LONG,FL,PROT,UNDOC,X86_64
HINT_NOP3        rm16                    ND,FL,UNDOC,P6
HINT_NOP3        rm32                    ND,FL,UNDOC,P6
HINT_NOP3        rm64                    ND,LONG,FL,PROT,UNDOC,X86_64
HINT_NOP4        rm16                    ND,FL,UNDOC,P6
HINT_NOP4        rm32                    ND,FL,UNDOC,P6
HINT_NOP4        rm64                    ND,LONG,FL,PROT,UNDOC,X86_64
HINT_NOP5        rm16                    ND,FL,UNDOC,P6
HINT_NOP5        rm32                    ND,FL,UNDOC,P6
HINT_NOP5        rm64                    ND,LONG,FL,PROT,UNDOC,X86_64
HINT_NOP6        rm16                    ND,FL,UNDOC,P6
HINT_NOP6        rm32                    ND,FL,UNDOC,P6
HINT_NOP6        rm64                    ND,LONG,FL,PROT,UNDOC,X86_64
HINT_NOP7        rm16                    ND,FL,UNDOC,P6
HINT_NOP7        rm32                    ND,FL,UNDOC,P6
HINT_NOP7        rm64                    ND,LONG,FL,PROT,UNDOC,X86_64
HINT_NOP8        rm16                    ND,FL,UNDOC,P6
HINT_NOP8        rm32                    ND,FL,UNDOC,P6
HINT_NOP8        rm64                    ND,LONG,FL,PROT,UNDOC,X86_64
HINT_NOP9        rm16                    ND,FL,UNDOC,P6
HINT_NOP9        rm32                    ND,FL,UNDOC,P6
HINT_NOP9        rm64                    ND,LONG,FL,PROT,UNDOC,X86_64
HINT_NOP10       rm16                    ND,FL,UNDOC,P6
HINT_NOP10       rm32                    ND,FL,UNDOC,P6
HINT_NOP10       rm64                    ND,LONG,FL,PROT,UNDOC,X86_64
HINT_NOP11       rm16                    ND,FL,UNDOC,P6
HINT_NOP11       rm32                    ND,FL,UNDOC,P6
HINT_NOP11       rm64                    ND,LONG,FL,PROT,UNDOC,X86_64
HINT_NOP12       rm16                    ND,FL,UNDOC,P6
HINT_NOP12       rm32                    ND,FL,UNDOC,P6
HINT_NOP12       rm64                    ND,LONG,FL,PROT,UNDOC,X86_64
HINT_NOP13       rm16                    ND,FL,UNDOC,P6
HINT_NOP13       rm32                    ND,FL,UNDOC,P6
HINT_NOP13       rm64                    ND,LONG,FL,PROT,UNDOC,X86_64
HINT_NOP14       rm16                    ND,FL,UNDOC,P6
HINT_NOP14       rm32                    ND,FL,UNDOC,P6
HINT_NOP14       rm64                    ND,LONG,FL,PROT,UNDOC,X86_64
HINT_NOP15       rm16                    ND,FL,UNDOC,P6
HINT_NOP15       rm32                    ND,FL,UNDOC,P6
HINT_NOP15       rm64                    ND,LONG,FL,PROT,UNDOC,X86_64
HINT_NOP16       rm16                    ND,FL,UNDOC,P6
HINT_NOP16       rm32                    ND,FL,UNDOC,P6
HINT_NOP16       rm64                    ND,LONG,FL,PROT,UNDOC,X86_64
HINT_NOP17       rm16                    ND,FL,UNDOC,P6
HINT_NOP17       rm32                    ND,FL,UNDOC,P6
HINT_NOP17       rm64                    ND,LONG,FL,PROT,UNDOC,X86_64
HINT_NOP18       rm16                    ND,FL,UNDOC,P6
HINT_NOP18       rm32                    ND,FL,UNDOC,P6
HINT_NOP18       rm64                    ND,LONG,FL,PROT,UNDOC,X86_64
HINT_NOP19       rm16                    ND,FL,UNDOC,P6
HINT_NOP19       rm32                    ND,FL,UNDOC,P6
HINT_NOP19       rm64                    ND,LONG,FL,PROT,UNDOC,X86_64
HINT_NOP20       rm16                    ND,FL,UNDOC,P6
HINT_NOP20       rm32                    ND,FL,UNDOC,P6
HINT_NOP20       rm64                    ND,LONG,FL,PROT,UNDOC,X86_64
HINT_NOP21       rm16                    ND,FL,UNDOC,P6
HINT_NOP21       rm32                    ND,FL,UNDOC,P6
```

```
HINT_NOP21      rm64                    ND,LONG,FL,PROT,UNDOC,X86_64
HINT_NOP22      rm16                    ND,FL,UNDOC,P6
HINT_NOP22      rm32                    ND,FL,UNDOC,P6
HINT_NOP22      rm64                    ND,LONG,FL,PROT,UNDOC,X86_64
HINT_NOP23      rm16                    ND,FL,UNDOC,P6
HINT_NOP23      rm32                    ND,FL,UNDOC,P6
HINT_NOP23      rm64                    ND,LONG,FL,PROT,UNDOC,X86_64
HINT_NOP24      rm16                    ND,FL,UNDOC,P6
HINT_NOP24      rm32                    ND,FL,UNDOC,P6
HINT_NOP24      rm64                    ND,LONG,FL,PROT,UNDOC,X86_64
HINT_NOP25      rm16                    ND,FL,UNDOC,P6
HINT_NOP25      rm32                    ND,FL,UNDOC,P6
HINT_NOP25      rm64                    ND,LONG,FL,PROT,UNDOC,X86_64
HINT_NOP26      rm16                    ND,FL,UNDOC,P6
HINT_NOP26      rm32                    ND,FL,UNDOC,P6
HINT_NOP26      rm64                    ND,LONG,FL,PROT,UNDOC,X86_64
HINT_NOP27      rm16                    ND,FL,UNDOC,P6
HINT_NOP27      rm32                    ND,FL,UNDOC,P6
HINT_NOP27      rm64                    ND,LONG,FL,PROT,UNDOC,X86_64
HINT_NOP28      rm16                    ND,FL,UNDOC,P6
HINT_NOP28      rm32                    ND,FL,UNDOC,P6
HINT_NOP28      rm64                    ND,LONG,FL,PROT,UNDOC,X86_64
HINT_NOP29      rm16                    ND,FL,UNDOC,P6
HINT_NOP29      rm32                    ND,FL,UNDOC,P6
HINT_NOP29      rm64                    ND,LONG,FL,PROT,UNDOC,X86_64
HINT_NOP30      rm16                    ND,FL,UNDOC,P6
HINT_NOP30      rm32                    ND,FL,UNDOC,P6
HINT_NOP30      rm64                    ND,LONG,FL,PROT,UNDOC,X86_64
HINT_NOP31      rm16                    ND,FL,UNDOC,P6
HINT_NOP31      rm32                    ND,FL,UNDOC,P6
HINT_NOP31      rm64                    ND,LONG,FL,PROT,UNDOC,X86_64
HINT_NOP32      rm16                    ND,FL,UNDOC,P6
HINT_NOP32      rm32                    ND,FL,UNDOC,P6
HINT_NOP32      rm64                    ND,LONG,FL,PROT,UNDOC,X86_64
HINT_NOP33      rm16                    ND,FL,UNDOC,P6
HINT_NOP33      rm32                    ND,FL,UNDOC,P6
HINT_NOP33      rm64                    ND,LONG,FL,PROT,UNDOC,X86_64
HINT_NOP34      rm16                    ND,FL,UNDOC,P6
HINT_NOP34      rm32                    ND,FL,UNDOC,P6
HINT_NOP34      rm64                    ND,LONG,FL,PROT,UNDOC,X86_64
HINT_NOP35      rm16                    ND,FL,UNDOC,P6
HINT_NOP35      rm32                    ND,FL,UNDOC,P6
HINT_NOP35      rm64                    ND,LONG,FL,PROT,UNDOC,X86_64
HINT_NOP36      rm16                    ND,FL,UNDOC,P6
HINT_NOP36      rm32                    ND,FL,UNDOC,P6
HINT_NOP36      rm64                    ND,LONG,FL,PROT,UNDOC,X86_64
HINT_NOP37      rm16                    ND,FL,UNDOC,P6
HINT_NOP37      rm32                    ND,FL,UNDOC,P6
HINT_NOP37      rm64                    ND,LONG,FL,PROT,UNDOC,X86_64
HINT_NOP38      rm16                    ND,FL,UNDOC,P6
HINT_NOP38      rm32                    ND,FL,UNDOC,P6
HINT_NOP38      rm64                    ND,LONG,FL,PROT,UNDOC,X86_64
HINT_NOP39      rm16                    ND,FL,UNDOC,P6
HINT_NOP39      rm32                    ND,FL,UNDOC,P6
HINT_NOP39      rm64                    ND,LONG,FL,PROT,UNDOC,X86_64
HINT_NOP40      rm16                    ND,FL,UNDOC,P6
HINT_NOP40      rm32                    ND,FL,UNDOC,P6
HINT_NOP40      rm64                    ND,LONG,FL,PROT,UNDOC,X86_64
HINT_NOP41      rm16                    ND,FL,UNDOC,P6
HINT_NOP41      rm32                    ND,FL,UNDOC,P6
HINT_NOP41      rm64                    ND,LONG,FL,PROT,UNDOC,X86_64
HINT_NOP42      rm16                    ND,FL,UNDOC,P6
HINT_NOP42      rm32                    ND,FL,UNDOC,P6
HINT_NOP42      rm64                    ND,LONG,FL,PROT,UNDOC,X86_64
HINT_NOP43      rm16                    ND,FL,UNDOC,P6
HINT_NOP43      rm32                    ND,FL,UNDOC,P6
HINT_NOP43      rm64                    ND,LONG,FL,PROT,UNDOC,X86_64
```

```
HINT_NOP44       rm16                ND,FL,UNDOC,P6
HINT_NOP44       rm32                ND,FL,UNDOC,P6
HINT_NOP44       rm64                ND,LONG,FL,PROT,UNDOC,X86_64
HINT_NOP45       rm16                ND,FL,UNDOC,P6
HINT_NOP45       rm32                ND,FL,UNDOC,P6
HINT_NOP45       rm64                ND,LONG,FL,PROT,UNDOC,X86_64
HINT_NOP46       rm16                ND,FL,UNDOC,P6
HINT_NOP46       rm32                ND,FL,UNDOC,P6
HINT_NOP46       rm64                ND,LONG,FL,PROT,UNDOC,X86_64
HINT_NOP47       rm16                ND,FL,UNDOC,P6
HINT_NOP47       rm32                ND,FL,UNDOC,P6
HINT_NOP47       rm64                ND,LONG,FL,PROT,UNDOC,X86_64
HINT_NOP48       rm16                ND,FL,UNDOC,P6
HINT_NOP48       rm32                ND,FL,UNDOC,P6
HINT_NOP48       rm64                ND,LONG,FL,PROT,UNDOC,X86_64
HINT_NOP49       rm16                ND,FL,UNDOC,P6
HINT_NOP49       rm32                ND,FL,UNDOC,P6
HINT_NOP49       rm64                ND,LONG,FL,PROT,UNDOC,X86_64
HINT_NOP50       rm16                ND,FL,UNDOC,P6
HINT_NOP50       rm32                ND,FL,UNDOC,P6
HINT_NOP50       rm64                ND,LONG,FL,PROT,UNDOC,X86_64
HINT_NOP51       rm16                ND,FL,UNDOC,P6
HINT_NOP51       rm32                ND,FL,UNDOC,P6
HINT_NOP51       rm64                ND,LONG,FL,PROT,UNDOC,X86_64
HINT_NOP52       rm16                ND,FL,UNDOC,P6
HINT_NOP52       rm32                ND,FL,UNDOC,P6
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