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MICROCOMPUTER MN1030

# MN1030 Series Cross Assembler User's Manual

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Panasonic

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# About This Manual

This manual describes the functions and operation of the cross assembler for this series of microcomputers.

## • Manual Features

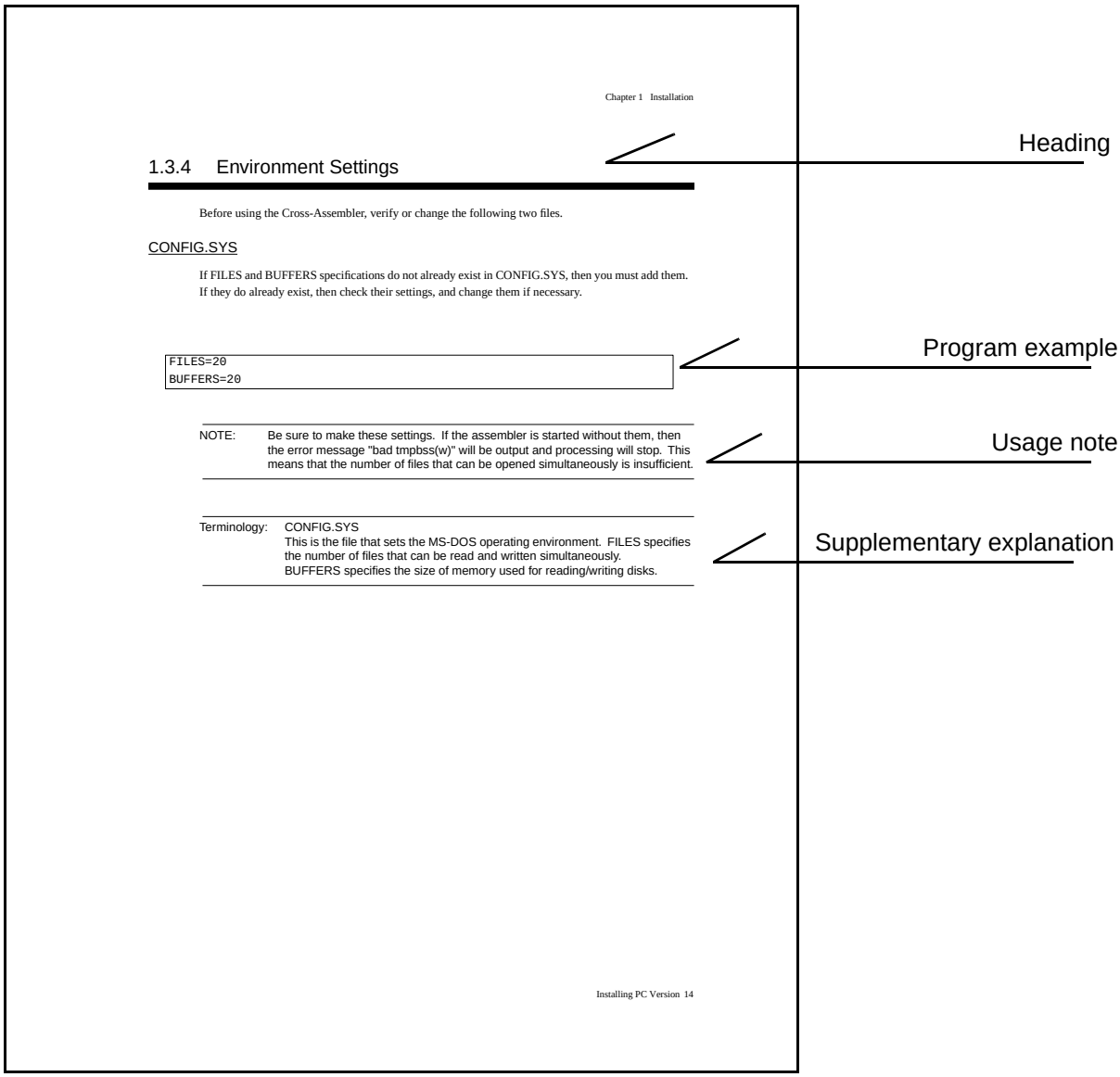
- Chapters on installation, program development flow, and introductory operation are provided, so first-time users can quickly get an overview and easily master operation.
- Optimization, a special feature of the cross assembler, is explained in its own chapter.
- Explanations of how to operate the assembler and linker and how to write programs are made mostly through the use of examples.
- Syntax, usage notes, and examples are given for each assembler directive, assembler control statement, and macro control statement.
- Use of the library manager, a tool for managing library files, is also explained.
- For users of engineering workstations (EWS), a separate chapter describes differences from the MS-DOS version.
- Chapters provides listings of machine-language instructions and error messages, as well as sample programs that demonstrate usage.

## • Reference Techniques

This document supports four techniques for quickly finding the required information.

1. Use the index at the front of the document to find the beginnings of chapters.
2. Use the table of contents at the front of the document to find subsection headings.
3. The chapter name and the subsection heading are listed at the top and bottom edges, respectively, on each page. Thus the contents of each page can be seen at a glance.
4. Use the index at the end of the document to find technical terms.

- How to read




- Heading
  Chapter titles are shown here on each page, so the reader can get a quick idea of contents while flipping through the pages.
- Program example
  These are actual examples of command options and instructions used by the assembler. First-time users should refer to these examples when trying to use the assembler.
- Usage note
  These give important information. Usage note provide cautions about usage, so they should always be read.
- Supplementary explanation
  These are hints and terminology definitions that can help the reader use the assembler.

## • Related Manuals

The following related manuals are available. Please contact our sales representative for more details.

- MN1030/MN103S Series Instruction Manual
  <Describes the instruction set>
- MN1030 Series C Compiler User's Manual: Usage Guide
  <Describes the installation, the commands, and options of the C Compiler>
- MN1030/MN103S/MN103E Series C Compiler User's Manual: Language Description
  <Describes the syntax of the C Compiler>
- MN1030/MN103S/MN103E Series C Compiler User's Manual: Library Reference
  <Describes the standard library of the C Compiler>
- MN1030 Series C Source Code Debugger for Windows® User's Manual
  <Describes the use of the C source code debugger for Windows®>
- MN1030/MN103S/MN103E Series Onboard Debug Unit Setup Manual
  <Describes the connection of the Debug Unit and explains about initial settings of the Onboard Debugger>
- MN1030/MN103S Series Installation Manual
  <Describes the installation of the C compiler, cross-assembler and C source code debugger and the procedure for bringing up the in-circuit emulator>

# Table of Contents

## Chapter 1 Getting Started



## Chapter 2 Program Development Flow



## Chapter 3 Introduction to Operation



## Chapter 4 Optimization



## Chapter 5 Using Assembler



## Chapter 6 Using Linker

## Chapter 7 Types of Source Statements



## Chapter 8 Writing Source Statements



## Chapter 9 Writing Machine Language Instruction Statements and Directive Statements

## Chapter 10 Writing Assembler Control Statements



## Chapter 11 Writing Macro Control Statements



## Chapter 12 List of Machine Language Instructions

## Chapter 13 Error Messages



## Chapter 14 Readinig List Files



## Chapter 15 Using Library Manager



## Chapter 16 Notes on Operating Environment

# Chapter 17 Appendix

# Chapter 1 Getting Started

# 1.1 Purpose of This Chapter

This chapter describes the operating environment for this system and the usage of the file conversion tool.

# 1.2 Operating Environment

This system runs on the following workstations, personal computers and compatibles.

| Host machine | Operating system | Version of OS |
|---|---|---|
| Sun/Sparc | Solaris | 2.6 or later |
| PC/AT | Windows | 98/Me/2000/XP |
| DOS/V | Windows | 98/Me/2000/XP |

For the PC/AT and compatibles, because of such differences as the ability to display Japanese, this Manual indicates a machine running the English-only operating system as a PC/AT and one running the Japanese operating system as a DOS/V machine.

Refer to the Release Notes for other restrictions.

# 1.3 File Organization

The installation media for this system contain the following files.

### as103 (assembler)

as103 is the assembler. For a description, see Chapter 5 "Using Assembler."

### ld103 (linker)

ld103 is the linker. For a description, see Chapter 6 "Using Linker."

### slib103 (library manager)

slib103 is the library manager, a utility for creating library files. For a description, see Chapter 15 "Using Library Manager."

### excv103 (file conversion utility)

This utility converts an executable produced by the linker into a file in Motorola S format, Intel HEX format, or Matsushita format.

In addition to the above files, the installation media may contain a README or README.DOC file containing late-breaking news missing from this Manual. Please read this file carefully before proceeding.

# 1.4 Installation

For the installation media, installation procedures, and notes on installation, see the Installation Manual.

# 1.5 Setup

These procedures are for setting up this system when it has just been installed or for altering basic settings.

## Setting command path

Unix uses the environment variable PATH when searching for executable files. Setting up this variable properly allows users to omit the directory name for commands and run them using their base names only.

If this system has been installed in /usr/local/bin, for example, adding the directory /usr/local/bin to the PATH environment variable permits the use of the command name only for the commands in this system.

Under Unix, most users initialize environment variables via a start-up file named .cshrc and located in the user's home directory. If this is the case, use an editor to modify the PATH variable setting in this start-up file.

To put the changes into effect, either log out and then log in again or use the source command to execute the contents of .cshrc.

## Start-up files

The assembler and linker start by reading start-up files which contain statements for initializing start-up variables.

The assembler start-up file (.as103rc) contains statements specifying the following three items.

1. The default language and character coding scheme for messages from the assembler
2. The radix notation used for numbers
3. The default toggle switch setting for optimization

The linker start-up file (.ld103rc) contains statements specifying the following eight items.

1. The language and character coding scheme for messages from the linker
2. A toggle controlling output of debugging information to the executable file
3. A toggle controlling output of the symbol table to the executable file
4. A toggle controlling output of DATA sections to the executable file
5. A toggle controlling output of a map file
6. A toggle controlling output of an executable file when there are errors
7. A library file
8. A directory searching for a library file

The assembler and linker search directories for these start-up files in the following order: the current directory, the user's home directory, and the directory containing the executable. If they find such a file, they use the contents to initialize their starting parameters. Otherwise, they set the parameters to their default values. These default values are given in the section "Start-up file format."

NOTE: Note that the command line is preceded when specifying the option which can be set in an environmental setting file with the command line at starting the assembler and the linker. Refer to the Chapter 5 “Using Assembler” for the assembler and to the Chapter 6 “Using Linker” for the linker. The order of precedence is as follows.
1) Specify by Command
2) Specify in Environmental setting file

## Start-up file format

The start-up files contain statements using the following format.

```
keyword                parameter
```

The first field is a keyword giving the name of the start-up parameter. The second field specifies the value to assign to that parameter. The two fields must be separated by at least one tab or space.

A sharp (#) may be used to incorporate comments into these start-up files. The assembler and linker then ignore all text from the sharp through to the end of the line.

NOTE: Each specification must end with a carriage return. In particular, make sure that the last line ends with a carriage return. Some editors allow users to end the last line with an end-of-file mark instead of a carriage return.

NOTE: There is no way to specify multiple parameters on the same line.

The start-up file .as103rc supports the following keywords.

| Keyword | Description |
|---|---|
| message | This entry specifies the language and coding scheme for messages from the assembler. One of the parameters ENGLISH, EUC, SJIS, or JIS comes after the keyword “message” followed by a blank space. These parameters have the following meanings.<br>message ENGLISH Outputs messages in English<br>message EUC Outputs messages in Japanese using EUC encoding<br>message SJIS Outputs messages in Japanese using Shift JIS encoding<br>message JIS Outputs messages in Japanese using JIS encoding<br>The default setting depends on the host machine and operating system.<br>Sun/Sparc ENGLISH<br>DOS/V SJIS<br>PC/AT ENGLISH |
| notation | This entry specifies the notation used for numbers in assembly language programs. One of the parameters PANA, CLANG, or INTEL comes after the keyword “notation” followed by a blank space. These parameters have the following meanings.<br>notation PANA Use Panasonic notation<br>notation CLANG Use C language notation<br>notation INTEL Use Intel notation<br>The default setting is in extended C language format. |
| O-OPTION | This entry controls optimization. Either ON or OFF of the parameters comes after the keyword O-OPTION followed by a blank space. These parameters have the following meanings.<br>O-OPTION ON Enable optimization<br>O-OPTION OFF Disable optimization<br>The default setting is to disable optimization. |

The start-up file .ld103rc supports the following keyboards.

| Keyword | Description |
|---|---|
| message | This entry specifies the language and coding scheme for messages from the linker. One of the parameters ENGLISH, EUC, SJIS, or JIS comes after the keyword “message” followed by a blank space. These parameters have the following meanings.<br>message ENGLISH Outputs messages in English<br>message EUC Outputs messages in Japanese using EUC encoding<br>message SJIS Outputs messages in Japanese using Shift JIS encoding<br>message JIS Outputs messages in Japanese using JIS encoding<br>The default setting depends on the host machine and operating system.<br>Sun/Sparc ENGLISH<br>DOS/V SJIS<br>PC/AT ENGLISH |
| g-OPTION | This entry controls the output of debugging information. Either ON or OFF of the parameters comes after the keyword g-OPTION followed by a blank space. These parameters have the following meanings.<br>g-OPTION ON Enable output of debugging information<br>g-OPTION OFF Disable output of debugging information<br>The default setting is to disable output of debugging information. |

| Keyword | Description |
|---|---|
| En-OPTION | This entry controls the output of debugging of the symbol table to the executable file. Either ON or OFF of the parameters comes after the keyword En-OPTION followed by a blank space. These parameters have the following meanings.<br>En-OPTION ON Disable output of the symbol table to the executable file.<br>En-OPTION OFF Enable output of the symbol table to the executable file.<br>The default setting is to disable output of the symbol table to the executable file. |
| Ed-OPTION | This entry controls the output of DATA sections to the executable file. Either ON or OFF of the parameters comes after the keyword Ed-OPTION followed by a blank space. These parameters have the following meanings.<br>Ed-OPTION ON Enable output of DATA section to the executable file.<br>O-OPTION OFF Disable output of DATA section to the executable file.<br>The default setting is to disable output of DATA section to the executable file. |
| m-OPTION | This entry controls the output of the map file. Either ON or OFF of the parameters comes after the keyword m-OPTION followed by a blank space. These parameters have the following meanings.<br>m-OPTION ON Enable output of the map file.<br>m-OPTION OFF Disable output of the map file.<br>The default setting is to disable output of the map file. |
| r-OPTION | This entry controls the output of the executable file when there are assembler errors. Either ON or OFF of the parameters comes after the keyword r-OPTION followed by a blank space. These parameters have the following meanings.<br>r-OPTION ON Enable output of the executable file when there are assembler errors.<br>r-OPTION OFF Disable output of the executable file when there are assembler errors.<br>The default setting is to disable output of executable file when there are assembler errors. |
| stdlib | This entry specifies the library file. The library file name comes after the keyword stdlib followed by a blank space.<br>Two or more stdlib descriptions are allowed. The default setting is no specification. |
| libdir | This entry specifies the directory for searching library files. The library file name comes after the keyword libdir followed by a blank space.<br>Two or more libdir descriptions are allowed. The default setting is no specification. |

# 1.6 File Conversion Utility

This file conversion utility converts an EX format file produced by the linker into a file in Intel HEX format, or Motorola S format.

## General command format

The general command format used to start the file conversion utility is shown below.

```
excv103 [options] EX format file name
```

Contents of brackets [ ]may be omitted.

## Options

| Option | Description |
|---|---|
| -j | Displays error and warning messages in Japanese. *1 |
| -e | Displays error and warning messages in English. *2 |
| -h | Displays help information regarding file conversion utility options to the screen. |
| -w | Perform conversion using a work file during execution. This enables a large amount of data to be converted even if the personal computer has little memory. However, conversion speed will be slower. |
| -i | Output the execution file in Intel HEX format. |
| -S3 | Output the execution file in Motorola S3 format. |
| -S2 | Output the execution file in Motorola S2 format. |
| S1 | Output the execution file in Motorola S1 format. |
| -ofile | Specify the file name to output |
| -p | No padding. |
| -P | Padding. |
| -R start address, end address | Converts the addresses within the specified range.<br>If omitting the end address, a conversion is performed until the last address of the execution module. |
| -A start address | Perform conversion for the starting address of EX format file into the specified address. |

*1 Option for UNIX version.

*2 Option for DOS/V version

## Default specification

See the default settings for the following operations.

| Operation | Default Setting |
|---|---|
| Message to output | UNIX and PC/AT versions: English<br>DOS/V version: Japanese |
| Conversion method | Not with a work file |
| Output format | Intel HEX format |
| Padding | No padding |
| Output file name | The same file name as EX format file but with ".hex" or ".rom" extensions. |
| Conversion range | From the start to the end address in EX format file. |

## Rules of output file name

Based on input file name or the file name specified with "o" option, change the extension. It is an output file name. The rules are different from each option specified.

| Option | Extension |
|---|---|
| i | .hex |
| S3, S2, S1 | .mot |
| default | .hex |

In addition, a file with ".rom" extension is output with them. The file contains its tool information.

## Example of specifying options

1. Specify the range of data conversion. (-R)
   ```
   excv103 -R1000, 1020 sample.ex
   ```
   Converts the data between the address 1000 and the address 1020 in the file of sample.ex.
2. Specify the start address upon format conversion. (-A)
   ```
   excv103 -A1000 sample.ex
   ```
   In the file of sample.ex, the information of start address specified when linking has been set. It will be needed when changing the start address for the format conversion.
   The example above, conversion has performed as the start address for the address 1000.
   ```
   excv103 -A4000, 8000 -A1000 sample.ex
   ```
   Converts the data between the address 4000 and the address 8000 in the file of sample.ex into the data of the address 1000.
3. Convert into a file in Intel HEX format.
   ```
   excv103 -i sample.ex
   ```
   Perform conversion a file into a file in Intel HEX format.
4. Convert into a file in Motorola S format.
   ```
   excv103 -S1 sample.ex
   excv103 -S2 sample.ex
   excv103 -S3 sample.ex
   ```
   Perform conversion a file into a file in Motorola format.
   -S1: 16-bit address format
   -S2: 24-bit address format
   -S3: 32-bit address format
5. Convert without padding.
   ```
   excv103 -p sample.ex
   ```
   Do not pad (0xff) when converting.
6. Convert with padding.
   ```
   excv103 -P sample.ex
   ```
   Do pad (0xff) when converting.

# Chapter 2 Program Development Flow

2

# 2.1 Purpose of This Chapter

Programs can be developed with a compiler or an assembler.

Currently most program development is done with a compiler, but an assembler is where compact code generation or faster processing speed is required.

This chapter gives an overview of development with the assembler, and explains the flow of development through completion.

# 2.2 Program Development Flow

## Main development flow

The microcomputers are used in such diverse applications as AV equipment, household electronics, information equipment, automobiles, robots, portable phones, computer peripherals, etc. Programs developed with the Cross-Assembler are ultimately incorporated into these products.

The software is developed using a source code debugger running the software on a target board which differs from the operating environment for the final application.

## Assembler and compiler

Both the assembler and C compiler can be used to develop programs for the microcomputers. Compared to assembly language, C language is a more productive language. Programs coded using a high-level language also offer superior ability for documentation.

On the other hand, microcomputer operations can be directly coded by programming with assembly language. Compared to high-level languages, programs can be created with more compact code size, less redundancy, and faster processing.

Given the features of both languages, the main body of a program can be coded using C language, while parts that require fast processing can be coded using assembly language.

When developing a program, the programmer must first consider which language to use, program structure, processing speed required to meet the target performance of the end product, ROM size of the device, and several other related factors.

## Source code debugger

The software developed on a workstation or personal computer must be checked using a hardware environment similar to that used by the final product.

Nearly all of this series microcomputers will ultimately be incorporated within end products. Therefore, program debugging must also be performed under the same conditions as the end product. This is why a source code debugger and in-circuit emulator are provided.

The probe of the in-circuit emulator can operate in place of the microcomputer by connecting it through the microcomputer socket in the product.

The source code debugger is a program for controlling the in-circuit emulator's hardware. The debugger downloads the application developed on a workstation or personal computer to the emulator's memory to create an environment in which the application runs as if it were in the microcomputer's ROM. It can start program execution as the address of any source statement, and can temporarily stop execution. Also, when execution is stopped, the source code debugger can display values of internal registers and memory and can be used to verify desired operation of programs by changing those values. It also enables more detailed operation checks with step operation, whereby execution proceeds one instruction at a time.

Using this development environment, the developer can prove programs in the same state as when finally incorporated into the microprocessor.

# 2.3 Programming with Assembler

Before creating programs using the assembler, you must understand the following items.

## Required knowledge

- Machine-language instructions
- Device operation
- Editor use
- C compiler use
- Assembler and linker use (in this manual)
- Debugger use

Program development is an iterative process of editing, assembling, linking, and debugging many times until finished. Therefore, you should as much as possible automate assembler and linker commands, debugger calls, and error correction.

## MAKE

When a program is divided into multiple files for joint development efforts by several programmers, a control system must be created for assembly and linking without error.

If this is not done, an old undebugged program could be linked within the iterative development process.

The solution lies with the following program which runs on the workstation or personal computer.

- MAKE

With MAKE the programmer defines the dependency relationships of the files needed to generate the final executable file and list files. Afterwards MAKE will automatically assemble and link only those files that have been modified.

## Program format

The Cross-Assembler utilizes a program format called section address format.

Section address format specifies the start addresses of programs for each section linked. Even when the program is divided between multiple files, or when a file is divided into multiple sections, identical sections are linked together with the same attributes. Therefore, the programmer must create programs such that addresses do not overlap.

[Reference: Chapter 6, "Using Linker", for details]

## Programming style

It is important to use a consistent style for program coding from start to finish. When several people are to create a program, they should meet in advance to decide on a common style.

You should consider the following points regarding the fixed style of the Cross Assembler.

- Header files
  Constants and variables used in all files and define identifiers used in common should be gathered into a single header file. As a result, changes can be made at just one location in the header file.
- Library files
  Subroutine programs frequently used by different files should be gathered by function as library files to make programs easier to use.
- Declaration position global directives
  Use one position for global directive declarations. The global directive can be declared anywhere within a program, but confusion will result if the declaration positions differ across source files.
- Unify radix and notation directives
  Choose a common default radix for coding numbers, constant values, strings, etc.
- Comment statements
  Comments reveal program algorithms and processing details within a program. Choose a common format for coding comment statements.

## Optimization

This Series' optimizations apply to unconditional branches, data transfer instructions, arithmetic instructions, logical instructions, bit manipulation instructions, and user-defined instructions.

- Unconditional branches that undergo optimization
- Data transfer, arithmetic, logical, bit manipulation, and user-defined instructions that undergo optimization

Coding is not a simple task if the programmer must always select the optimal instruction from the above instructions. In particular, it is nearly impossible to select the optimal instructions when coding a program divided between files in section format.

The optimization functions provide a solution to these problems. The assembler and linker use them to produce the optimal code no matter what the source code.

The assembler evaluates the source statement notation. It evaluates the immediate data, memory specifications, and displacement data appearing as operands to a data transfer, arithmetic, logical, bit manipulation, and user-defined instructions and selects the shortest version of the instruction.

The assembler also examines unconditional branches, choosing the shortest versions for the CALL, CALLS, JMP, and JSR instructions.

The linker evaluates instructions that were the object of optimization, and selects the optimal codes.

As a result, the programmer must be aware that the generated code will differ from the source statements coded in the list file.

## Conditional assembly

If a program for product A is to be created by partially modifying a program for product B, both can be combined into a single program by using conditional assembler control instructions.

Conditional assembly is done by defining a single symbol at the start of the program using a define control directive.

Here is an example.

```
#define                    TYPE                          A
```

Using TYPE and conditional assembler control directives to process different parts of the program, the programmer writes code in the format below.

```
                .
                .
                .           TYPE
                Program of product A
#else
                Program of product B
#endif
                .
                .
                .
```

TYPE has been defined with define, so in this case the program for product A will be assembled. If the statement

```
#define      TYPE      A
```

is omitted, the program for product B will be assembled.

By using conditional assembler control directives in this manner, different versions of programs can be managed in a single source file.

[Reference: Chapter 10, "Writing Assembler Control Statements", for details]

## Macros

Macros are an important function of the assembler. A macro assigns a name to a process, thereby simplifying the coding of that process. By assigning an appropriate macro name to a block of multiple machine language instructions, the programmer can create custom instructions.

## Debugging

When performing final program debugging, the programmer must verify whether the intended operations are being performed or not. A source code debugger is provided for this. The programmer uses the debugger to download generated and linked object code and verify operation.

The g option of the assembler and linker generates information that allows the debugger to work with symbols. This allows symbols to be used for specifying debugger start addresses, breakpoint settings, memory references and changes, etc.

# Chapter 3 Introduction to Operation

3

# 3.1 Purpose of This Chapter

Many options are provided with the Cross-Assembler and Linker, but you can use the assembler and linker without knowing all of them. This chapter explains how to use the most useful options while demonstrating actual operation.

This chapter first uses an example to show how to run the assembler and linker. Next, it explains assembler and linker use when assembler control statements and macro instructions are included for high-level operations.

After reading this chapter once through and trying actual operation, you will have mastered basic assembler and linker operation.

# 3.2 Files Used by Assembler and Linker

Figure 3-1 shows the inter-relationships of the files used by the assembler and linker.

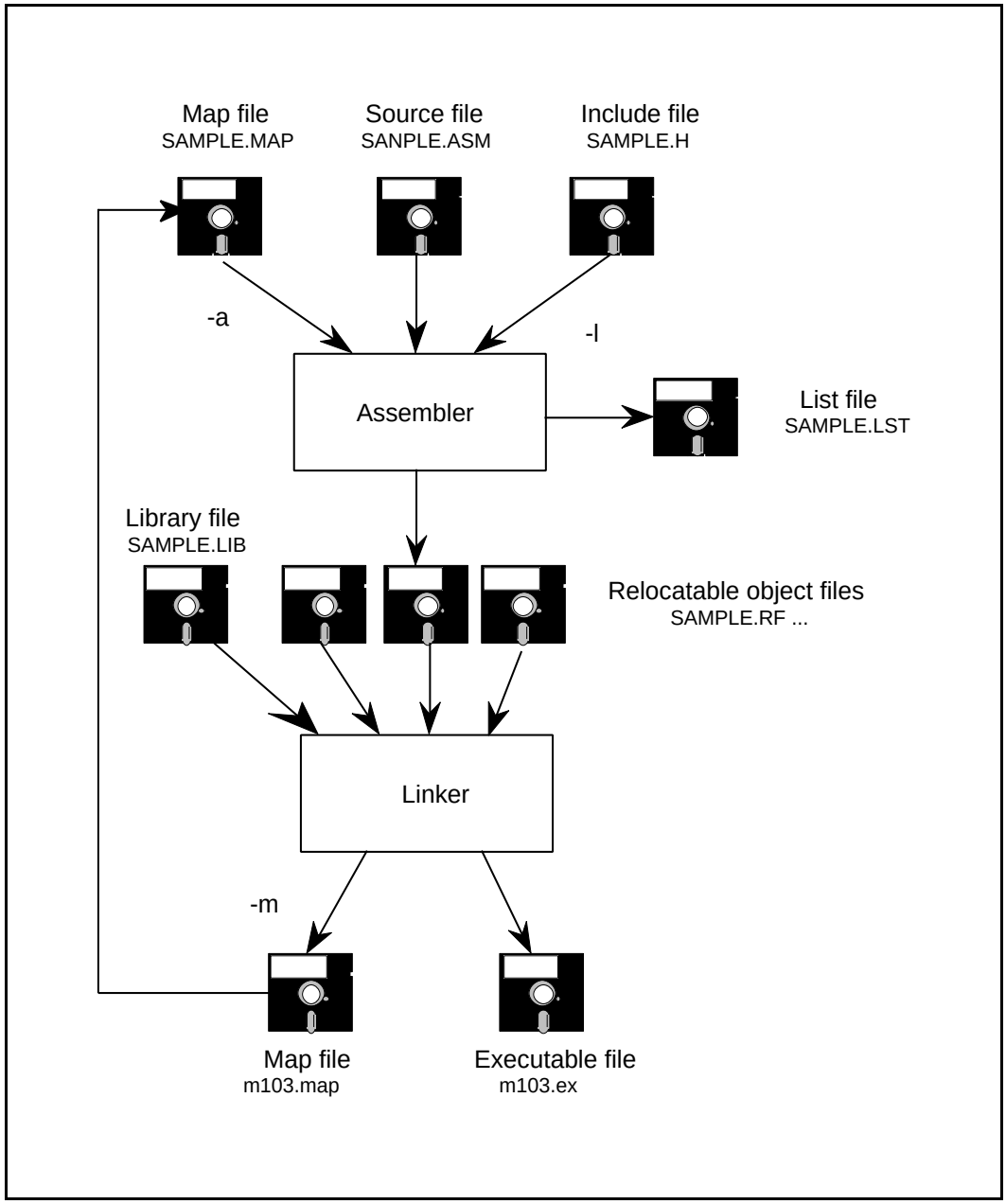



Figure: 3-1 Files Used

The assembler inputs source files and include files, and outputs relocatable object files.

Include files are not special files, but are just files that comprise parts of the source file. They are incorporated into assembly at the location of include directives defined within source statements.

Depending on the option specifications input for the source file and map file, a list file will be output with fully resolved addresses.

The map file is used to output a list file with fully resolved addresses.

The linker inputs relocatable object files output by the assembler and, depending on option specifications, library files. It generates an executable format file and, depending on option specifications, a map file.

Library files are collections of relocatable object files of frequently used programs and hardware interface programs. Only needed modules are specified to have the linker extract the appropriate relocatable object files from library files and load them into the executable format file. Several library files are provided, but you can maintain them or newly create them yourself. Refer to chapter 15, "Using The Library Manager", for details.

You cannot force different extensions for map files and list files. You can only specify whether or not to output these files. However, the extensions of relocatable object files and the executable format file can be changed with assembler and linker option specifications. In this case, the file specification must include the extension.

# 3.3 Basic Operation of Assembler and Linker

The Cross-Assembler uses a section address format, in which the start address for each section as defined with the section directive corresponds to its start address when linked. This allows the programmer to freely change the order of linking files.

The following explanation illustrates a simple example of only one section. In this example you will assemble and link two source files, program1.asm and program2.asm.

These two files have related external references and external definitions, where the subroutine of program2.asm is called from program1.asm. Therefore the final list files cannot be created just by assembling program1.asm. In this example, you will generate with the linker a map file and generate the final list files.

## Create source files

First, create the source files. Using an editor, create the two programs shown below (program1.asm and program2.asm).

The contents of program1.asm are as follows.

```
                global          data_set
__CODE          section         CODE, PUBLIC, 1
main
                mov             0, A0
                mov             0xff, D0
                mov             0x80, D1
                jsr             data_set
                bra             main
_DATA           section         DATA, PUBLIC, 4
data1           ds              4
                end
```

program1.asm consists of a section called _CODE (attribute CODE, link type PUBLIC) and a section called _DATA (attribute DATA, link type PUBLIC).

The contents of program2.asm are as follows.

```
                global          data_set
__CODE          section         CODE, PUBLIC, 1
data_set
                mov             0, D2
data_set_loop
                cmp             D1, D2
                bcc             data_set_end

                mov             D0, (A00
                add             1, D2
                add             2, A0
                bra             data_set_loop

data_set_end
                rts
                end
```

program2.asm also consists of a section called _CODE (attribute CODE, link type PUBLIC), and it makes an external declaration of data_set.

## Assemble

Assemble the two programs that you created to generate relocatable object files.

```
as103 program1.asm
as103 program2.asm
```

This will generate two relocatable object files (program1.rf and program2.rf). List files cannot be generated at this stage. These files will be generated after linking when the relationships of external references and external definitions are resolved.

## Link

Link the two relocatable object files to generate an executable format file. A map file will be generated along with the executable format file at this time.

```
ld103 -m -T_CODE=40000000 program1.rf program2.rf
m option    Option to output map file.
T option    Option to specify section address.
```

The above command line links two relocatable object files (program1.rf and program2.rf) and creates an executable file (m103.ex) and a map file (m103.map) in the current directory.

---

Supplemental Explanation:

The -o option is also available for specifying a different output file name and directory for the executable file. Omitting this option results in the use of the default name m103 and the extension .ex. There is no option for specifying the name of the map file. It uses the same default name as the executable file, m103, and the extension .map. The output directory is the same as that used for the executable file.

---

## Generate final list files

After link processing is complete, generate the final list files using the map file (m103.map).

```
as103 -l -a m103.map program1.asm
as103 -l -a m103.map program2.asm
```

| | |
|---|---|
| l option | Option to output a list file. |
| a option | Option to read a map file. Specify the map file name after it. |

This operation will generate the final list files (program1.lst and program2.lst) in the current directory.

With the above operations, you can generate an executable format file and final list files in the current directory.

You must generate the final list files using the map file after linking. This is because linking determines the start addresses of sections following the T option for files in section address format. In addition, there may be addresses unresolved until after link processing due to forward references, optimization, etc. (Refer to chapter 4, "Optimization".)

The contents of the final list file program1.lst are as follows.

```
                          program1.lst Page 1
               *** PanaX Series MN1030 Cross Assembler ***
Loc         Object          Line    Source
                            1                   global   data_set
                            2
                            3       _CODE       section  CODE, PUBLIC, 1
40000000                    4       main
40000000    9000            5                   mov      0, A0
40000002    2CFF00          6                   mov      0xff, D0
40000005    2D8000          7                   mov      0x80, D1
40000008    F8FEFCFCFF0C0000 8                  jsr      data_set
40000010    00F8FE04        8
40000014    CAF2            9                   bra      main
                            10
                            11      _DATA       section  DATA, PUBLIC, 4
40000024    00000000        12      data1       ds       4
                            13                  end
                          program1.lst Page 2
***         Table  ***
Symbol
            40000016        T       data_set
            40000000        T       main
            40000024        D       data1
```

The contents of the final list file program2.lst are as follows.

```
                          program2.lst Page 1
               *** PanaX Series MN1030 Cross Assembler ***
Loc           Object        Line    Source
                            1                  global   data_set
                            2
                            3       _CODE      section  CODE, PUBLIC, 1
40000016                    4       data_set
40000016      8A00          5                  mov      0, D2
                            6
40000018                    7       data_set_  loop
40000018      A6            8                  cmp      D1, D2
40000019      C60A          9                  bcc      data_set_end
                            10
4000001b      60            11                 mov      D0, (A0)
4000001c      2A01          12                 add      1, D2
4000001e      2002          13                 add      2, A0
40000020      CAF8          14                 bra      data_set_loop
                            15
40000022                    16      data_set__ end
40000022      F0FC          17                 rts
                            18                 end
                           program2.lst Page 2
***  Symbol   Table  ***
              40000016            T data_set
              40000018            T data_set_  loop
              40000022            T data_set_  end
```

Here is a simple explanation of how to read the list files. A list file shows four items of information.

Source statements and machine language code

- Source statements and machine language code
- Symbol table

Source statements and their corresponding machine language code are further divided into Loc, Object, Line, and Source headings.

The Loc heading gives location counter values, which show execution addresses in the final list files. program1.lst starts from location 40000000 (hex.), and program2.lst starts from location 40000016 (hex.).

The Object heading shows the codes of instructions converted to machine language by the assembler. Instructions consist of one to four bytes (1 byte=8 bits), shown as two to eight hex digits. After some machine language code, the symbol 'M' will be added. The 'M' indicates an instruction that was expanded from a macro instruction.

The Line heading shows line numbers added by the assembler. The Source heading shows the source statements as coded.

# 3.4 Assembling and Linking Multiple Sections

In section 3.3, "Basic Operation of the Assembler and Linker", source files each comprising one section were assigned to the same section as a basic example. However, normally a program will be divided into multiple sections to clearly divide programs by function and type.

The start addresses of a program in section format are set for each section during linking. Therefore, when a program divided into multiple files is developed, work can proceed without the programmer staying aware of the code size of each file. The programmer an also freely change the order in which files are linked.

The following explanation illustrates a simple example dividing two source files into sections for each routine, allocated to two sections.

## Create source files

Using an editor, create the two programs shown below (program3.asm and program4.asm).
The contents of program3.asm are as follows.

```
                global          main
                global          data_set, time_filler
_CODE_00        section         CODE, PUBLIC, 1
main
                mov             0, A0
                mov             0xff, D0
                mov             0x80, D1
                jsr             data_set
                jsr             time_filler
                bra             main

_DATA           section         DATA, PUBLIC, 4
data1           ds              4
                end
```

The contents of program4.asm are as follows.

```
               global         data_set, time_filler

_CODE_01       section        CODE, PUBLIC, 1
data_set
               mov            0, D2

data_set_      loop
               cmp            D1, D2
               bcc            data_set_end

               mov            D0, (A0)
               add            1, D2
               add            2, A0
               bra            data_set_loop

data_set_end
               rts
_CODE_00       section        CODE, PUBLIC,1
time_filler
               mov            0, D2
Time_filler    _loop
               cmp            D1, D0
               bcc            time_filler_end
               bra            time_filler_loop
time_filler    _end
               rts
               end
```

As can be seen from the above two files, these programs are divided as follows.

- main, time_filler ..._CODE_00
- data_set ..._CODE_01
- data1 ..._DATA

## Assemble and generate list files

Next assemble the two programs. Assemble with the option for output of list files in order to see what the list file is like when final addresses are not resolved.

```
as103 -l -g program3.asm
as103 -l -g program4.asm
```

| | |
|---|---|
| g option | Option to output debug information in the relocatable object file. |
| l option | Option to output list file (not normally specified at this stage before linking, but specify it here to see intermediate values). |

This will assemble the two source files (program3.asm and program4.asm) in the current directory. It will add debug information (g option) to the relocatable object files (program3.rf and program4.rf), and

generate list files (program3.lst and program4.lst) respectively in the current directory (l option). Adding debug information (g option) enables symbols to be used during debugging.

Let's take a look at the list files that were created.

The contents of the list file program3.lst are as follows.

Note that the symbol table is not displayed.

```
                              program3.lst Page 1
                 *** PanaX series Series MN1030 Cross Assembler ***
Loc               Object          Line    Source
                                  1                   global    main
                                  2                   global    data_set,
                                                                time_filler
                                  3
                                  4       _CODE_00    section   CODE, PUBLIC, 1
00000000                          5       main
00000000          9000            6                   mov       0, A0
00000002          2CFF00          7                   mov       0xff, D0
00000005          2D8000          8                   mov       0x80, D1
00000008          F8FEFCFCFF00000 +9                  jsr       data_set
00000010          00F8FE04        9
00000014          F8FEFCFCFF000000 +10                jsr       time_filler
0000001c          00F8FE04        10
00000020          CA00            +11                 bra       main
                                  12
                                  13      _DATA       section   DATA, PUBLIC,4
00000000          00000000        14      data1       ds        4
                                  15                  end
```

There is a plus sign '+' before line numbers 9 and 10. This indicates that the object code does not have final values. This is because the two functions data_set and time_filler do not exist in this program, so the call addresses will not be resolved unless linked. That further means that this list file is not the final list file.

Line number 11 also has a plus sign. This indicator warns that the line contains a symbol that is not assigned a final value until linking.

Finally, notice that the list begins from location 000000. The start addresses of section format programs are specified with the linker. Here the assembler uses relative values beginning from 000000 as location counter values.

The contents of the list file program4.lst are as follows.

Note that the symbol table is not displayed.

```
                          program4.lst Page 1
             *** PanaX series Series MN1030 Cross Assembler ***
Loc           Object    Line  Source
                        1                   global  data_Set, time_filler
                        2                   global  data_set, time_filler
                        3     _CODE_01              section CODE, PUBLIC, 1
00000000                4     data_set
00000000      8A00      5                   mov     0, D2
                        6
00000002                7     data_set_loo
                              p
00000002      A6        8                   cmp     D1, D2
00000003      C600      +9                  bcc     data_set_end
                        10
00000005      60        11                  mov     D0, (A0)
00000006      2A01      12                  add     1, D2
00000008      2002      13                  add     2, A0
0000000a      CA00      +14                 bra     data_set_loop
                        15
                        16    data_set_end
0000000c      F0FC      17                  rts
0000000c                18
                        19    _CODE_00      section CODE, PUBLIC, 1
                        20
00000000                21    time_filler
00000000      8A00      22                  mov     0, D2
                        23
00000002                24    time_filler_  loop
00000002      A4        25                  cmp     D1, D0
00000003      C600      +26                 bcc     time_filler_end
00000005      CA00      +27                 bra     time_filler_loop
                        28
00000007                29    Time_filler_  end
00000007      F0FC      30                  rts
                        31                  end
                        32
```

This file is defined as two sections. The addresses of the starting locations of both sections is assumed 00000000.

The plus signs in lines 14 and 27 have the same meaning that they had in program3.lst--namely, that the line contains a symbol that is not assigned a final value until linking.

## Link

Link the two relocatable object files to generate an executable format file. Specify the g option to add debug information to the executable format file.

A>ld103 -m -g -T_CODE_00=800000000 -T_CODE_01=80005000 program3.rf program4.rf

| | |
|---|---|
| m option | Option to output map file. |
| g option | Option to add debug information to the executable format file. |
| T option | Option to specify section address. |

The above command line links two relocatable object files (program3.rf and program4.rf) in the current directory, assigning the starting address 80000000 (hex.) to section _CODE_00 and the starting address 80005000 (hex.) to section _CODE_01, and creates an executable file (m103.ex) including debugging information and a map file (m103.map) in the current directory.

## Parameter file during linking

The following command was input to link.

```
A>ld103 -m -g -T_CODE_00=800000000 -T_CODE_01=80005000
program3.rf program4.rf
```

Repeated input of lines like this is tedious and prone to errors. For this reason the very convenient @ option is provided with the linker. With an editor create a file PFILE (the name can be freely chosen) with the following contents.

The contents of pfile are as follows.

```
-m
-g
-T_CODE_00        =80000000
-T_CODE_01        =80005000
program3.rf       program4.rf
```

This file is called a parameter file. If the @ option is specified when linking, the linker will read a parameter file, and will interpret its contents as command options for execution.

The two specifications below will be equivalent.

```
ld103 @PFILE
```

```
ld103 -m -g -T_CODE_00=80000000 -T_CODE_01=80005000 program3.rf
program4.rf
```

## Generate final list files

After link processing is complete, generate the final list files using the map file (program3.MAP). This will show what happens to the previous '+' and 'R' marks.

```
as103 -l -a m103.map program3.asm
as103 -l -a m103.map program4.asm

l option    Option to output a list file.
a option    Option to use a map file.
```

Specify the map file name after the a option, followed by the source file name. Based on the link information written in the map file, the assembler will reassemble the source file and generate a final list file.

Let's look at the final list files with all addresses resolved.

The contents of the final list file program3.lst are as follows.

Note that the symbol table is not displayed.

```
                          program3.lst Page 1
             *** PanaX series Series MN1030 Cross Assembler ***
Loc            Object         Line  Source
                              1                 global   main
                              2                 global   data_set,
                                                         time_filler
                              3
                              4     _CODE_00    section  CODE, PUBLIC, 1
8000000                       5     main
8000000        9000           6                 mov      0, A0
8000002        2CFF00         7                 mov      0xff, D0
8000005        2D8000         8                 mov      0x80, D1
8000008        F8FEFCFCFFF44F00 9                jsr      data_set
8000010        00F8FE04       9
8000014        F8FEFCFCFF0C0000 10               jsr      time_filler
800001c        00F8FE04       10
8000020        CAE0           11                bra      main
                              12
                              13    _DATA       section  DATA, PUBLIC, 4
8000500e       00000000       14    data1       ds       4
                              15                end
```

Compare this listing file to the one with indeterminate addresses. Note how the plus signs have disappeared from lines 9-11 and how the addresses start from 80000000 (hex.), the number specified with the -T option.

The contents of the final list file program4.lst are as follows.

Note that the symbol table is not displayed.

```
                            program4.lst Page 1
              *** PanaX series Series MN1030 Cross Assembler ***
Loc             Object        Line  Source
                              1                 global    data_set, time_filler
                              2
                              3     _CODE_01    section   CODE, PUBLIC, 1
80005000                      4     data_set
80005000        8A00          5                 mov       0, D2
                              6
80005002                      7     data_set_   loop
80005002        A6            8                 cmp       D1, D2
80005003        C60A          9                 bcc       data_set_end
                              10
80005005        60            11                mov       D0, (A0)
80005006        2A01          12                add       1, D2
80005008        2002          13                add       2, A0
8000500a        CAF8          14                bra       data_set_loop
                              15
8000500c                      16    data_set_   end
8000500c        F0FC          17                rts
                              18
                              19    _CODE_00    section   CODE, PUBLIC,1
                              20
80000022                      21    time_filler
80000022        8A00          22                mov       0, D2
                              23
80000024                      24    time_filler loop
                                    _
80000024        A4            25                cmp       D1, D0
80000025        C605          26                bcc       time_filler_end
80000027        CA03          27                bra       time_filler_loop
                              28
8000002a                      29    time_filler end
                                    _
8000002a        F0FC          30                rts
                              31                end
                              32
```

In this file the '+' on line numbers 14 and 27 have disappeared, and the start address of the first section _CODE_01 has been changed to address 80005000 (hex.) as specified by the T option. However, the start address of section _CODE_00 is address 80000022 (hex.). This shows that it has been linked after the same section existing in program3.

## program locations after linking

program locations in the executable file after linking as above are shown below.

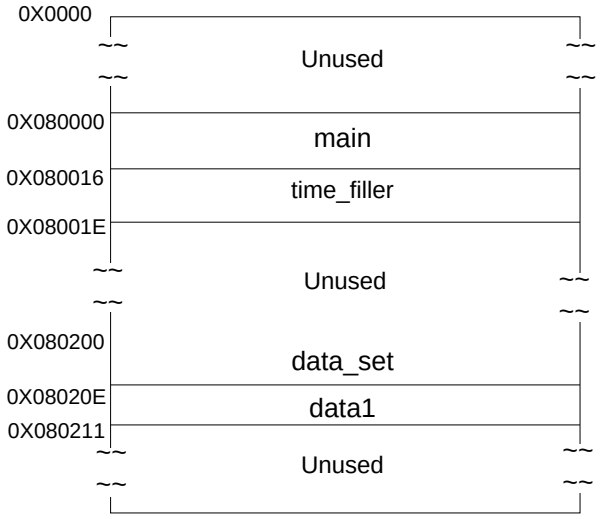



Figure: 3-2 program Location

If the program contains multiple sections, it is laid out using the following rules.

- Each section is assigned the starting address specified to the linker.
- Sections with the same section name and section attributes are merged in the order specified to the linker--that is, in the order in which they appear in the object file names following the linker options.
- Rules for joining sections

1. Join in the order in which the sections appear during linking.
2. Join sections for which both name and attribute match.
3. Join sections for which either name or attribute match.

For further details, see Chapter 6 "Using the Linker" Section 6.3 "Command Options" Section 6.3.3 "Program Generation Options."

# 3.5 Conditional Assembly and Linking

The Cross-Assembler provides many assembler directives. Assembler directives are not converted directly to machine language, but are used to control how the assembler processes.

For example, during the development stage a programmer may want to include a special program only for debugging. This program must be deleted when the product is complete. That can be accomplished by editing the source file, but if that editing is spread throughout the program, mistakes will be easy to make.

It is convenient to use assembler directives in such cases. The conditions for assembly are defined at the start of the program, and programs to be assembled when the conditions are satisfied or not satisfied are written in the source file.

## Create source file

Using an editor, create the program program5.asm shown below.
The contents of program5.asm are as follows.

```
#define                         DEBUG
*
dat_set                         macro                   adr, dat
                                mov                     adr, A0
                                mov                     dat, D0
                                mov                     D0, (A0)
                                endm
*
_CODE                           section CODE, PUBLIC,2
main                            DEBUG
#ifdef                          dat_set                 data1, 0x11
#else
#endif                          dat_set                 data1, 0x22

_DATA                           section DATA, PUBLIC, 2
data1                           dw                      0
data2                           dw                      0
                                end
```

The operation of this program is meaningless. The program will be used instead to explain program structure as it pertains to conditional assembly.The define DEBUG on the first line selects DEBUG as a condition by defining the identifier DEBUG. In the assembly control block starting with #ifdef DEBUG on line 13, the instructions between #ifdef to #else will be assembled if DEBUG has been defined, and the instructions between #else to #endif will be assembled if DEBUG is undefined. In this example DEBUG was defined on line 1, so the instructions in the defined block will be assembled.

This program also uses a macro control directive. Lines 4 to 8 are the macro definition. The macro's name is dat_set, and it has two parameters (adr, dat).

## Assemble and link

Assemble and link the program that you have created.

```
as103 program5.asm
ld103 -m -T_CODE=400000000 program5.rf
as103 -l -a m103. program5.asm
```

The first assembly generates the relocatable object file program5.rf. The second assembly generates the final list file program5.lst.

See the contents of the list file that was generated.

The contents of the final list file program5.lst are as follows.

Note that the symbol table is not displayed.

```
                          program5.lst Page 1
             *** PanaX series Series MN1030 Cross Assembler ***
Loc            Object        Line    Source
                             1       #define     DEBUG
                             2
                             3       *
                             M4      dat_set     macro    adr, dat
                             5                   mov      adr, A0
                             6                   mov      dat, D0
                             7                   mov      D0, (A0)
                             8                   endm
                             9       *
                             10
                             11      _CODE       section  CODE, PUBLIC, 1
40000000                     12      main
                             13      #ifdef      DEBUG
                             M14                 dat_set  data1, 0x11
40000000       FCDC0C000040  14+                 mov      data1, A0
40000006       8011          14+                 mov      0x11, D0
40000008       60            14+                 mov      D0, (A0)
                             15      #else
                             16X                 dat_set  data1, 0x22
                             17      #endif
                             18
                             19      _DATA       section  DATA, PUBLIC, 4
4000000C       00000000      20      data1       dd       0
40000010       00000000      21      data2       dd       0
                             22                  end
```

Line number 14 extends over four lines. This indicates lines where macro expansion has been performed. An 'M' is added before the line number where the macro instruction statement is shown, and a '+' is added after the line numbers where the instruction statements from macro expansion are shown.DEBUG has been defined, so the block between #ifdef to #else was assembled. Line number 16 has an X after the line number. This indicates a statement that was not assembled because a condition was not fulfilled.

## Select false condition, assemble, and link

Make the define source statement line into a comment line, or just delete it. Then assemble and link with the same procedure as before.

```
as103 program5.asm
ld103 -m -T_CODE=40000000 program5.rf
as103 -l -a m103.map program5.asm
```

The contents of the final list file program5.lst are as follows.

Note that the symbol table is not displayed.

```
                          program5.lst Page 1
             *** PanaX series Series MN1030 Cross Assembler ***
Loc           Object        Line   Source
                            1      #define      DEBUG
                            2
                            3      *
                            M4     dat_set      macro    adr, dat
                            5                   mov      adr, A0
                            6                   mov      dat, D0
                            7                   mov      D0, (A0)
                            8                   endm
                            9      *
                            10
                            11     _CODE        section  CODE, PUBLIC, 1
40000000                    12     main
                            13     #ifdef       DEBUG
                            14X                 dat_set  data1, 0x11
                            15     #else
                            M16                 dat_set  data1, 0x22
40000000      FCDC0C000040  16+                 mov      data1, A0
40000006      8022          16+                 mov      0x22, D0
40000008      60            16+                 mov      D0, (A0)
                            17     #endif
                            18
                            19     _DATA        section  DATA, PUBLIC, 4
4000000C      00000000      20     data1        dd       0
40000010      00000000      21     data2        dd       0
                            22                  end
```

Note how line number 14 is not assembled because the condition fails and how line number 16 is assembled instead.

## Specify assembly conditions in the command

Until this point the condition has been specified by define in the source file, but it has been bothersome to edit the source file each time. The explanation below describes how to directly specify conditions with command options. This operation is valid only with regards to #ifdef.

In the previous file, you either deleted the define line or made it into a comment, so you can use it to once again select the true condition.

```
as103 -D DEBUG program5.asm
ld103 -m -T_CODE=40000000 program5.rf
as103 -l -a m103.map -D DEBUG program5.asm
```

D option Option to specify an identifier (DEBUG), having the same effect as specifying define DEBUG in the source file.

The contents of the final list file program5.lst are as follows.

Note that the symbol table is not displayed.

```
                          program5.lst Page 1
             *** PanaX series Series MN1030 Cross Assembler ***
Loc           Object        Line    Source
                            1       #define      DEBUG
                            2
                            3       *
                            M4      dat_set      macro    adr, dat
                            5                    mov      adr, A0
                            6                    mov      dat, D0
                            7                    mov      D0, (A0)
                            8                    endm
                            9       *
                            10
                            11      _CODE        section  CODE, PUBLIC, 1
40000000                    12      main
                            13      #ifdef       DEBUG
                            M14                  dat_set  data1, 0x11
40000000      FCDC0CC000040 14+                  mov      data1, A0
40000006      8011          14+                  mov      0x11, D0
40000008      60            14+                  mov      D0, (A0)
                            15      #else
                            16X                  dat_set  data1, 0x22
                            17      #endif
                            18
                            19      _DATA        section  DATA, PUBLIC, 4
4000000c      00000000      20      data1        dd       0
40000010      00000000      21      data2        dd       0
                            22                   end
```

Line number 14 was assembled. Check for yourself that omitting -D DEBUG will assemble line number 16 instead. This technique enables the programmer to freely choose assembly conditions with command option specifications.

There is also an assembler option for suppressing the source code lines not selected during conditional assembly. For further details, see Chapter 5 "Using the Assembler" and Chapter 6 "Using the Linker."

# Chapter 4 Optimization

4

# 4.1 Purpose of This Chapter

The assembler and linker examine source statements containing conditional branches, unconditional branches, subroutine calls, data transfer instructions, arithmetic instructions, logical instructions, bit manipulation instructions, and user-defined instructions to determine the shortest possible machine language instruction corresponding to the instruction.

This chapter uses examples to explain what optimization is.

NOTE: The assembler and linker make changes to object code, not instruction mnemonics. Pay close attention to this point when viewing list files. When an @ is displayed before a line number in the list file, it indicates that the statement has been optimized.

## 4.2 Rules of Usage

To use the optimization function, optimization must be turned on by using the O option or by placing an opt directive at the start of the source file.

```
opt         on
```

NOTE: Optimization is off by default.

# 4.3 Usage Example

## Optimization Instructions

Optimization covers the following conditional branches, unconditional branches, subroutine calls, data transfer instructions, arithmetic instructions, logical instructions, bit manipulation instructions, and user-defined instructions.

Table 4-1 Optimized Conditional Branch Instructions

| Instruction | Type | Branch Range |
|---|---|---|
| BLT label | Relative branch instruction | Branch within -128 to +127 bytes of the PC. |
| BGT label | | |
| BGE label | | |
| BLE label | | |
| BCS label | | |
| BHI label | | |
| BCC label | | |
| BLS label | | |
| BEQ label | | |
| BNE label | | |
| BVC label | | |
| BVS label | | |
| BNC label | | |
| BNS label | | |

Table 4-2 Unconditional Branches and Subroutine Calls Subject to Optimization

| Instruction | Type | Branch Range |
|---|---|---|
| BRA label | Relative branch instruction | Branch within -128 to +127 bytes of the PC |
| CALL label | Branch instruction | Branch within the 4-gigabyte memory space. |
| CALLS label | | |
| JMP label | | |
| JSR label | | |

Table 4-3 Data Transfer Instructions Subject To Optimization

| Instruction | Type | Branch Range |
|---|---|---|
| MOV (abs), An | Absolute addressing | 16M-byte memory space |
| MOV (abs), Dn | | |
| MOV An, (abs) | | |
| MOV Dn, (abs) | | |
| MOVBU (abs), Dn | | |
| MOVBU Dn, (abs) | | |
| MOVB (abs), Dn | | |
| MOVB Dn, (abs) | | |
| MOVHU (abs), Dn | | |
| MOVHU Dn, (abs) | | |
| MOVH (abs), Dn | | |
| MOVH Dn, (abs) | | |
| MOV (d, An), An | Register relative indirect addressing | Branches possible to anywhere in the 4-gigabyte memory space |
| MOV (d, An), Dn | | |
| MOV (d, SP), An | | |
| MOV (d, SP), Dn | | |
| MOV An, (d, An) | | |
| MOV An,(d, SP) | | |
| MOV Dn, (d, An) | | |
| MOV Dn, (d, SP) | | |
| MOVBU (d, An), Dn | | |
| MOVBU (d, SP), Dn | | |
| MOVBU Dn,(d, An) | | |
| MOVBU Dn, (d, SP) | | |
| MOVB (d, An), Dn | | |
| MOVB (d, SP), Dn | | |
| MOVB Dn, (d, An) | | |
| MOVB Dn, (d, SP) | | |
| MOVHU (d, An), Dn | | |
| MOVHU (d, SP), Dn | | |
| MOVHU Dn, (d, An) | | |
| MOVHU Dn, (d, SP) | | |
| MOVH (d, An), Dn | | |
| MOVH (d, SP), Dn | | |
| MOVH Dn, (d, An) | | |
| MOVH Dn, (d, SP) | | |
| MOV imm, An | Immediate addressing | 32-bit immediate data. |
| MOV imm, Dn | | |

Table 4-4 Arithmetic Instructions Subject To Optimization

| Instruction | Type | Branch Range |
|---|---|---|
| ADD imm, An | Immediate addressing | 32-bit immediate data |
| ADD imm, Dn | | |
| ADD imm, SP | | |
| AND imm, Dn | | |
| CMP imm, An | | |
| CMP imm, Dn | | |

Table 4-5 Logical Instructions Subject To Optimization

| Instruction | Type | Branch Range |
|---|---|---|
| OR imm, Dn | Immediate addressing | 32-bit immediate data. |
| XOR imm, Dn | | |

Table 4-6 Logical Instructions Subject To Optimization

| Instruction | Type | Branch Range |
|---|---|---|
| BTST imm, Dn | Immediate addressing | 32-bit immediate data. |

Table 4-7 Data Transfer Instructions Subject To Optimization

| Instruction | Type | Branch Range |
|---|---|---|
| UDF00 imm, Dn | Immediate addressing | 32-bit immediate data |
| UDF01 imm, Dn | | |
| UDF02 imm, Dn | | |
| UDF03 imm, Dn | | |
| UDF04 imm, Dn | | |
| UDF05 imm, Dn | | |
| UDF06 imm, Dn | | |
| UDF07 imm, Dn | | |
| UDF08 imm, Dn | | |
| UDF09 imm, Dn | | |
| UDF10 imm, Dn | | |
| UDF11 imm, Dn | | |
| UDF12 imm, Dn | | |
| UDF13 imm, Dn | | |
| UDF14 imm, Dn | | |
| UDF15 imm, Dn | | |
| UDFU00 imm, Dn | | |
| UDFU01 imm, Dn | | |
| UDFU02 imm, Dn | | |
| UDFU03 imm, Dn | | |
| UDFU04 imm, Dn | | |
| UDFU05 imm, Dn | | |
| UDFU06 imm, dn | | |
| UDFU07 imm, Dn | | |
| UDFU08 imm, Dn | | |
| UDFU09 imm, dn | | |
| UDFU10 imm, Dn | | |
| UDFU11 imm, Dn | | |
| UDFU12 imm, Dn | | |
| UDFU13 imm, Dn | | |
| UDFU14 imm, Dn | | |
| UDFU15 imm, Dn | | |

## Optimization processing

The assembler informs the linker about all instructions to be optimized. Based on the information from the assembler, the linker outputs instruction codes with the smallest code size.

## Optimization processing of conditional branch instructions

The linker resolves address values for labels when linking multiple files. In the example below, the linker will determine whether or not the label coded as an operand is within the allowable range of the current instruction. If not in range, the linker will replace it with instructions for a wider branch range.

Take the BEQ instruction for example.

```
        BEQ         LABEL
        ......
LABEL
```

The destination label of the BEQ instructions must be in the range -128 to +127. However, the assembler cannot make that determination, so the following determinations are made during assembly and linking.

### Assembler processing

The assembler outputs information about instructions to be optimized to the linker.

### Linker processing

1. The linker inputs information from the assembler.
2. The linker determines if the branch destinations of conditional branches are in range.
3. If determined to be in range, the linker generates the normal code.
4. If determined to be not in range, the linker will substitute code that can branch correctly.

The substitution for the above example would be as follows.

```
        BNE         *+5
        JMP         LABEL
        ......
LABEL
```

## Optimization of function calls

This section describes the optimization of function calls by the linker.

The assembler provides advanced processing for function calls. This processing uses a combination of the call and ret instructions and the global and funcinfo directives. The following is an example.

```
            global              _0func
_TEXT       section             CODE, PUBLIC, 1
            :
            call                _0func              (1)
            :

            global              _0func, _func
_TEXT       section             CODE, PUBLIC, 1
_func
            movm                [D2], (SP)          (2)
            add                 -4, SP
_0func      funcinfo            _func, 8, [D2]
            :
            :                                       (3)
            ret
```

(1) gives the call to the function _0func. (3) is the body of the function. (2) the section between the labels _func and _0func, saves a register and sets up the stack frame.

When this source file is assembled and linked, the linker eliminates section (2). This section is preserved when the symbol _func is referred.

For further details on machine instructions and directives, see the Instruction Manual and Section 9.4 "Writing Directives."

NOTE: This optimization of function calls is always carried out regardless of the state of the optimization option (-O). It is suppressed throughout if even one of the source files to be linked contains a calls instruction with the operand (An).

Table 4-8 Substituted Instructions For Out-Of Range Conditional Branch Instructions

| Source Instruction | Candidate instruction 1 | Candidate instruction 2 | Candidate instruction 3 |
|---|---|---|---|
| BLT LABEL | BRA LABEL | BGE *+5<br>JMP LABEL | BGE *+7<br>JMP LABEL |
| BGT LABEL | BGT LABEL | BLE *+5<br>JMP LABEL | BLE *+7<br>JMP LABEL |
| BGE LABEL | BGE LABEL | BLT *+5<br>JMP LABEL | BLT *+7<br>JMP LABEL |
| BLE LABEL | BLE LABEL | BGT * +5<br>JMP LABEL | BGT *+7<br>JMP LABEL |
| BCS LABEL | BCS LABEL | BCC *+5<br>JMP LABEL | BCC *+7<br>JMP LABEL |
| BHI LABEL | BHI LABEL | BLS *+5<br>JMP LABEL | BLS *+7<br>JMP LABEL |
| BCC LABEL | BCC LABEL | BCS *+5<br>JMP LABEL | BCS *+7<br>JMP LABEL |
| BLS LABEL | BLS LABEL | BHI *+5<br>JMP LABEL | BHI *+7<br>JMP LABEL |
| BEQ LABEL | BEQ LABEL | BNE *+5<br>JMP LABEL | BNE *+7<br>JMP LABEL |
| BNE LABEL | BNE LABEL | BEQ *+5<br>JMP LABEL | BEQ *+7<br>JMP LABEL |
| BVC LABEL | BVC LABEL | BVS *+6<br>JMP LABEL | BVS *+8<br>JMP LABEL |
| BVS LABEL | BVS LABEL | BVC *+6<br>JMP LABEL | BVC *+8<br>JMP LABEL |
| BNC LABEL | BNC LABEL | BNS *+6<br>JMP LABEL | BNS *+8<br>JMP LABEL |
| BNS LABEL | BNS LABEL | BNC *+6<br>JMP LABEL | BNC *+8<br>JMP LABEL |

## Optimization of branches

For unconditional branch instructions, a JMP label instruction is replaced by a BRA label instruction if the jump target is within the range available for the shorter, relative branch instruction BRA. Similarly, a CALL label, CALLS label, or JSR label instruction is replaced by the shorter version with a 16-bit displacement (d16,PC) instead of the one with the 32-bit displacement (d32,PC).

The following table shows the possibilities for optimizing the unconditional branch instructions and the subroutine call instructions.

Table 4-9 Optimization of branches

| Source Instruction | First Candidate | Second Candidate | Third Candidate |
|---|---|---|---|
| BRA label | BRA label | JMP label | JMP label |
| JMP label | BRA label | JMP label | JMP label |
| CALL label | CALL label | CALL label | |
| CALLS label | CALLS label | CALLS label | |
| JSR label | JSR label | JSR label | |

## Optimization of data transfer, arithmetic, logical, bit manipulation and user-defined instructions

For data transfer, arithmetic, logical, bit manipulation, and user-defined instructions, the assembler uses the shortest instruction available for expressing the specified immediate data, memory address, or displacement data. The user thus obtains optimal code size without having to worry about instruction variants.

The following table shows the possibilities for optimizing data transfer, arithmetic, logical, bit manipulation, and user-defined instructions.

Table 4-10 optimization of data transfer, arithmetic, logical bit manipulation...

| Source instruction | First Candidate | Second Candidate | Third Candidate |
|---|---|---|---|
| MOV(abs), An | MOV(abs16), An | MOV (abs32), An | |
| MOV (abs), Dn | MOV(abs16), Dn | MOV (abs32), Dn | |
| MOV(d,An), An | MOV(d8, An), An | MOV(d16,An), An | MOV (d32, An), An |
| MOV (d, An), Dn | MOV (d8, An), Dn | MOV (d16, An), Dn | MOV (d32, An), Dn |
| MOV (d, SP), An | MOV(d8, SP), An | MOV(d16, SP), An | MOV (d32, SP), An |
| MOV (d, SP), Dn | MOV (d8, SP), Dn | MOV (d16, SP), Dn | MOV (d32, SP), Dn |
| MOV An, (abs) | MOV An,(abs16) | MOV An, (abs32) | |
| MOV An, (d, An) | MOV An, (d8, An) | MOV An, (d16, An) | MOV An, (d32, An) |
| MOV An, (d, SP) | MOV An, (d8, SP) | MOV An, (d16, SP) | MOV An, (d32, SP) |
| MOV Dn (abs) | MOV Dn (abs 16) | MOV Dn, (abs32) | |
| MOV Dn, (d, An) | MOV Dn, (d8, An) | MOV Dn, (d16, An) | MOV Dn, (d32, An) |
| MOV Dn, (d, SP) | MOV Dn, (d8, SP) | MOV Dn, (d16, SP) | MOV Dn, (d32, SP) |
| MOV imm, An | MOV imm8, An | MOV imm16, An | MOV imm32, An |
| MOV imm, Dn | MOV imm8, Dn | MOV imm16, Dn | MOV imm32, Dn |
| MOVBU (abs),Dn | MOVBU (abs16),Dn | MOVBU (abs32),Dn | |
| MOVBU (d,An),Dn | MOVBU (d8,An),Dn | MOVBU (d16,An),Dn | MOVBU (d32,An),Dn |
| MOVBU (d,SP),Dn | MOVBU (d8,SP),Dn | MOVBU (d16,SP),Dn | MOVBU (d32,SP),Dn |
| MOVBU Dn,(abs) | MOVBU Dn,(abs16) | MOVBU Dn,(abs32) | |
| MOVBU Dn,(d,An) | MOVBU Dn,(d8,An) | MOVBU Dn,(d16,An) | MOVBU Dn,(d32,An) |
| MOVBU Dn,(d,SP) | MOVBU Dn,(d8,SP) | MOVBU Dn,(d16,SP) | MOVBU Dn,(d32,SP) |
| MOVB (abs),Dn | MOVB (abs16),Dn | MOVB (abs32),Dn | |
| MOVB (d,An),Dn | MOVB (d8,An),Dn | MOVB (d16,An),Dn | MOVB (d32,An),Dn |
| MOVB (d,SP),Dn | MOVB (d8,SP),Dn | MOVB (d16,SP),Dn | MOVB (d32,SP),Dn |
| MOVB Dn,(abs) | MOVB Dn,(abs16) | MOVB Dn,(abs32) | |
| MOVB Dn,(d,An) | MOVB Dn,(d8,An) | MOVB Dn,(d16,An) | MOVB Dn,(d32,An) |
| MOVB Dn,(d,SP) | MOVB Dn,(d8,SP) | MOVB Dn,(d16,SP) | MOVB Dn,(d32,SP) |
| MOVHU (abs),Dn | MOVHU (abs16),Dn | MOVHU (abs32),Dn | |
| MOVHU (d,An),Dn | MOVHU (d8,An),Dn | MOVHU (d16,An),Dn | MOVHU (d32,An),Dn |
| MOVHU (d,SP),Dn | MOVHU (d8,SP),Dn | MOVHU (d16,SP),Dn | MOVHU (d32,SP),Dn |
| MOVHU Dn,(abs) | MOVHU Dn,(abs16) | MOVHU Dn,(abs32) | |
| MOVHU Dn,(d,An) | MOVHU Dn,(d8,An) | MOVHU Dn,(d16,An) | MOVHU Dn,(d32,An) |
| MOVHU Dn,(d,SP) | MOVHU Dn,(d8,SP) | MOVHU Dn,(d16,SP) | MOVHU Dn,(d32,SP) |
| MOVH (abs),Dn | MOVH (abs16),Dn | MOVH (abs32),Dn | |
| MOVH (d,An),Dn | MOVH (d8,An),Dn | MOVH (d16,An),Dn | MOVH (d32,An),Dn |

Table 4-10 optimization of data transfer, arithmetic, logical bit manipulation...

| Source instruction | First Candidate | Second Candidate | Third Candidate |
|---|---|---|---|
| MOVH (d,SP),Dn | MOVH (d8,SP),Dn | MOVH (d16,SP),Dn | MOVH (d32,SP),Dn |
| MOVH Dn,(abs) | MOVH Dn,(abs16) | MOVH Dn,(abs32) | |
| MOVH Dn,(d,An) | MOVH Dn,(d8,An) | MOVH Dn,(d16,An) | MOVH Dn,(d32,An) |
| MOVH Dn,(d,SP) | MOVH Dn,(d8,SP) | MOVH Dn,(d16,SP) | MOVH Dn,(d32,SP) |
| ADD imm,An | ADD imm8,An | ADD imm16,An | ADD imm32,An |
| ADD imm,Dn | ADD imm8,Dn | ADD imm16,Dn | ADD imm32,Dn |
| ADD imm,SP | ADD imm8,SP | ADD imm16,SP | ADD imm32,SP |
| AND imm,Dn | AND imm8,Dn | AND imm16,Dn | AND imm32,Dn |
| CMP imm,An | CMP imm8,An | CMP imm16,An | CMP imm32,An |
| CMP imm,Dn | CMP imm8,Dn | CMP imm16,Dn | CMP imm32,Dn |
| OR imm,Dn | OR imm8,Dn | OR imm16,Dn | OR imm32,Dn |
| XOR imm,Dn | XOR imm16,Dn | XOR imm32,Dn | |
| BTST imm,Dn | BTST imm8,Dn | BTST imm16,Dn | BTST imm32,Dn |
| UDF00 imm,Dn | UDF00 imm8,Dn | UDF00 imm16,Dn | UDF00 imm32,Dn |
| UDF01 imm,Dn | UDF01 imm8,Dn | UDF01 imm16,Dn | UDF01 imm32,Dn |
| UDF02 imm,Dn | UDF02 imm8,Dn | UDF02 imm16,Dn | UDF02 imm32,Dn |
| UDF03 imm,Dn | UDF03 imm8,Dn | UDF03 imm16,Dn | UDF03 imm32,Dn |
| UDF04 imm,Dn | UDF04 imm8,Dn | UDF04 imm16,Dn | UDF04 imm32,Dn |
| UDF05 imm,Dn | UDF05 imm8,Dn | UDF05 imm16,Dn | UDF05 imm32,Dn |
| UDF06 imm,Dn | UDF06 imm8,Dn | UDF06 imm16,Dn | UDF06 imm32,Dn |
| UDF07 imm,Dn | UDF07 imm8,Dn | UDF07 imm16,Dn | UDF07 imm32,Dn |
| UDF08 imm,Dn | UDF08 imm8,Dn | UDF08 imm16,Dn | UDF08 imm32,Dn |
| UDF09 imm,Dn | UDF09 imm8,Dn | UDF09 imm16,Dn | UDF09 imm32,Dn |
| UDF10 imm,Dn | UDF10 imm8,Dn | UDF10 imm16,Dn | UDF10 imm32,Dn |
| UDF11 imm,Dn | UDF11 imm8,Dn | UDF11 imm16,Dn | UDF11 imm32,Dn |
| UDF12 imm,Dn | UDF12 imm8,Dn | UDF12 imm16,Dn | UDF12 imm32,Dn |
| UDF13 imm,Dn | UDF13 imm8,Dn | UDF13 imm16,Dn | UDF13 imm32,Dn |
| UDF14 imm,Dn | UDF14 imm8,Dn | UDF14 imm16,Dn | UDF14 imm32,Dn |
| UDF15 imm,Dn | UDF15 imm8,Dn | UDF15 imm16,Dn | UDF15 imm32,Dn |
| UDFU00 imm,Dn | UDFU00 imm8,Dn | UDFU00 imm16,Dn | UDFU00 imm32,Dn |
| UDFU01 imm,Dn | UDFU01 imm8,Dn | UDFU01 imm16,Dn | UDFU01 imm32,Dn |
| UDFU02 imm,Dn | UDFU02 imm8,Dn | UDFU02 imm16,Dn | UDFU02 imm32,Dn |
| UDFU03 imm,Dn | UDFU03 imm8,Dn | UDFU03 imm16,Dn | UDFU03 imm32,Dn |
| UDFU04 imm,Dn | UDFU04 imm8,Dn | UDFU04 imm16,Dn | UDFU04 imm32,Dn |
| UDFU05 imm,Dn | UDFU05 imm8,Dn | UDFU05 imm16,Dn | UDFU05 imm32,Dn |
| UDFU06 imm,Dn | UDFU06 imm8,Dn | UDFU06 imm16,Dn | UDFU06 imm32,Dn |
| UDFU07 imm,Dn | UDFU07 imm8,Dn | UDFU07 imm16,Dn | UDFU07 imm32,Dn |
| UDFU08 imm,Dn | UDFU08 imm8,Dn | UDFU08 imm16,Dn | UDFU08 imm32,Dn |
| UDFU09 imm,Dn | UDFU09 imm8,Dn | UDFU09 imm16,Dn | UDFU09 imm32,Dn |
| UDFU10 imm,Dn | UDFU10 imm8,Dn | UDFU10 imm16,Dn | UDFU10 imm32,Dn |
| UDFU11 imm,Dn | UDFU11 imm8,Dn | UDFU11 imm16,Dn | UDFU11 imm32,Dn |
| UDFU12 imm,Dn | UDFU12 imm8,Dn | UDFU12 imm16,Dn | UDFU12 imm32,Dn |
| UDFU13 imm,Dn | UDFU13 imm8,Dn | UDFU13 imm16,Dn | UDFU13 imm32,Dn |
| UDFU14 imm,Dn | UDFU14 imm8,Dn | UDFU14 imm16,Dn | UDFU14 imm32,Dn |
| UDFU15 imm,Dn | UDFU15 imm8,Dn | UDFU15 imm16,Dn | UDFU15 imm32,Dn |

## Example: branch destination of conditional branch instruction within range

This example shows a branch in the permitted range (-128 to 127 of PC) of a BCC LABEL conditional branch instruction.

The source list is as follows.

```
                    opt                 on
_TEXT               section             CODE, PUBLIC,1
sub_func
                    mov                 0, D2
                    cmp                 D1, D2
addr_set            bcc                 func_end
                    org                 addr_set+127
func_end
                    rts
                    end
```

The final list file after assembly is shown next. The start address during linking is assumed to be 40000000 (hex.). The @ mark on line number 6 indicates that the instruction was the object of optimization. Since the target address is within the range of a relative jump, the assembler generates a BCC LABEL instruction.

```
                              opt1.lst Page 1
            ***  PanaX series Series MN1030 Cross Assembler  ***
Loc         Object    Line  Source
                      1                   opt     on
                      2     _TEXT                 section CODE, PUBLIC, 1
40000000              3     sub_func
40000000    8A00      4                   mov     0, D2
40000002    A6        5                   cmp     D1, D2
40000003    C67F      @6    addr_set      bcc     func_end
                      7
                      8                   org     addr_set+127
40000082              9     func_end
40000082    F0FC      10                  rts
                      11                  end
                               opt1.lst Page 2



***  Symbol  Table     ***

            40000000  T     sub_func
            40000003  T     addr_set
            40000082  T     func_end
```

## Example: branch destination of conditional branch instruction out of range

This example shows a branch outside the permitted range (-128 to +127 of PC) of a BCC LABEL conditional branch instruction.

The source list is as follows.

```
                    opt                 on
_TEXT               section             CODE, PUBLIC,1
sub_func
                    mov                 0, D2
                    cmp                 D1, D2
addr_set            bcc                 func_end
                    org                 addr_set+128
func_end
                    rts
                    end
```

The final list file after assembly is shown next. LABEL exceeds the permitted branch range of BCC LABEL, so the code has been converted to BCS *+5, JMP LABEL. Note that the mnemonics and object code are different.

```
                              opt2.lst Page 1
            ***  PanaX series Series MN1030 Cross Assembler  ***
Loc          Object       Line  Source
                          1                opt    on
                          2     _TEXT              section CODE, PUBLIC, 1
40000000                  3     sub_func
40000000     8A00         4                mov    0, D2
40000002     A6           5                cmp    D1, D2
40000003     C405CC0080   @6    addr_set   bcc    func_end
                          7
                          8                org    addr_set+128
40000083                  9     func_end
40000083     F0FC         10               rts
                          11               end
                          12
                              opt2.lst Page 2



***  Symbol  Table        ***

             40000000     T     sub_func
             40000003     T     addr_set
             40000083     T     func_end
```

## Example: unconditional branch instruction converted to relative branch

This example shows the branch destination of a JMP LABEL unconditional branch instruction within the permitted range (-128 to +127 of PC) for relative branching.

The source list is as follows.

```
                    opt                 on
_TEXT               section             CODE, PUBLIC,1
sub_func
addr_set            jmp                 func_end

                    org                 addr_set+127
fun_end
                    end
```

The final list file after assembly is shown next. The branch destination of the JMP LABEL instruction on line number 4 is in the permitted range for relative branching, so it has been converted to BRA LABEL. Note that the mnemonics and object code are different.

```
                              opt3.lst Page 1
            ***  PanaX series Series MN1030 Cross Assembler  ***
Loc          Object    Line  Source
                       1                   opt     on
                       2     _TEXT         section CODE, PUBLIC, 1
40000000               3     sub_func
40000000     CA7F      @4    addr_set      jmp     func_end
                       5
                       6                   org     addr_set+127
4000007f               7     func_end
4000007f     F0FC      8                   rts
                       9                   end
                               opt3.lst Page 2



***  Symbol  Table     ***

             40000000  T     sub_func
             40000000  T     addr_set
             4000007f  T     func_end
```

## Example: subroutine call converted to a relative branch

This section gives an example of a CALLS LABEL instruction with a target address within the range of a relative jump--that is, between -32,768 and +32,767 from the current program counter.

The source list is as follows.

```
                    opt                 on
_TEXT               section             CODE, PUBLIC,1
sub_func
addr_set            calls               func_end

                    org                 addr_set+128
func_end            rts
                    end
```

The final list file after assembly is shown next. Since the CALLS LABEL instruction in line four contains a target address that may be expressed with a 2-byte relative branch, the assembler replaces it with the CALLS LABEL variant with a 2-byte address field. Note that the mnemonics and object code are different.

```
                            opt4.lst Page 1
            ***  PanaX series Series MN1030 Cross Assembler  ***
Loc          Object       Line  Source
                          1                opt     on
                          2     _TEXT      section CODE, PUBLIC, 1
40000000                  3     sub_func
40000000     FAFF8000     @4    addr_set   Calls   func_end
                          5
                          6                org     addr_set+128
40000080                  7     func_end
40000080     F0FC         8                rts
                          9                end
                              opt4.lst Page 2
***  Symbol  Table        ***

             40000000     T     sub_func
             40000000     T     addr_set
             40000080     T     func_end
```

# Chapter 5 Using Assembler

# 5.1 Purpose of This Chapter

This Chapter describes assembler operating procedures. Chapter 3 "Introduction to Operation" described the basic operation of the assembler and linker, but this one describes the many options available with the assembler and gives examples.

# 5.2 Starting Assembler

The assembler is started by entering the command name and the desired parameters. The command name differs depending on the device being used. This chapter uses the terminology of as103 as its general format.

## General format of commands

Below is the general format of the command to use when starting the assembler.

```
as103 [options] source_filename
```

Contents of brackets [ ] may be omitted.

## Specifying options

An option starts with a hyphen (-) as the options specifier, followed by a character that indicate the particular option.

```
-l
```

Option specifications are case sensitive, so upper case and lower case letters must be specified correctly.

```
-Lc
```

Single-character options not accompanied by parameters can be specified as multiple characters following the hyphen (-) option specifier. The order is optional.

```
-gl
```

When an option is accompanied by a parameter and other options are to follow, add a space after the parameter, and follow with the hyphen (-) option specifier.

```
-I/user/source -Li -Lc
```

Parameters can be specified right after the option character or separated by one space.

```
-I/user/source or -I /user/source
```

When options are omitted, assembly will be perform in accordance with the default interpretations built in to the assembler. Refer to section 5.3, "Command Options", for default interpretations.

---

NOTE: Omitting the path specifies that the source file is in the current directory. Specifying a path for the source file does not affect the listing file and relocatable object file. They are always created in the current directory. Note, however, that the -o option is available for creating the relocatable object file in another directory.

---

## Summary of options

The following Table lists the available command line options.

Table 5-1 Assembler Options

| Option Type | Symbol | Description |
|---|---|---|
| Output file | o file_name | Specify the relocatable object file name to be output. |
| | l | Output a list file. |
| | Li | Do not output files included by include to the list file. |
| | Lm | Do not output assembler source created by macro expansion using macro or irp to the list file. Output only the machine language code. |
| | Ls | Do not output a symbol table to the list file. |
| | Lc | Do not output source statements that were not assembled due to unfulfilled conditions of conditional assembly to the list file |
| | a map_file name | Read the map file to output a list file with resolved addresses. |
| Error message options | j | Output error and warning messages in Japanese. Output will be to the screen and when a list file is specified, to the list file |
| | Je | Output error and warning messages in Japanese using EUC encoding to the console and, if specified, the listing file. |
| | Js | Output error and warning messages in Japanese using Shift JIS encoding to the console and, if specified, the listing file. |
| | Jj | Output error and warning messages in Japanese using JIS encoding to the console and, if specified, the listing file. |
| | e | Output error and warning messages in English. Output will be to the screen and, when a list file is specified, to the list file. |
| | W number | Do not output warning messages of the specified number. Output will not be performed to either the screen or list file. Refer to chapter 13, "Error Messages", for warning messages and their corresponding numbers |
| | Wall | Do not output any warning messages. |
| Preprocessor options | I path_name | Specify the path name of the directory that contains files specified by include. |
| | D identifier | Specify an identifier to be used by ifdef during conditional assembly. |
| Program generation options | g | Output debug information to the relocatable object file. |
| | Od | Turn off optimization. |
| | O | Turn on optimization. |
| Others | h | Display a listing of available assembler options on the console. |
| | v | Display the assembler's version number on the console. |

# 5.3 Command Options

This section describes the options available for the assembler. The assembler has an abundance of options for controlling assembler processing and output files.

Not all options are available at the same time. Certain options have default values that are used when the option is not specified. These defaults have been chosen to reflect the most frequently used settings. As long as the default settings are acceptable, it is possible to omit most options. For the details of the interpretation when an option is omitted, see the description below for that option.

## 5.3.1 Output File Options

| | |
|---|---|
| o file_name | Specify the relocatable object file name to be output |

### Functional description

This option specifies the relocatable object file name to be output by the assembler. If the specified file already exists, its previous contents will be erased. If a path name that does not exist is specified, the assembler will display an error message and suspend processing.

NOTE: Because the @ symbol is used as the character for specifying parameter files, it cannot be used as the first character of file names.

### Rules of Use

This option is specified with the hyphen (-) option specification character, followed by the lower-case letter 'o', then either immediately followed by the file name or a space and the file name. If the file is to be output to the current directory, only the file name needs to be specified. If the file is to be output to a different directory, both a path name and a file name must be specified.

```
as103 -o /user/obj/test.rf main.asm
```

### Default Specification

The assembler creates a file with the same name as the input file, but with the extension changed to .rf in the current directory.

### Operation Example

The following command line assembles the source file samp1.asm in the current directory and creates the relocatable object file /user/obj/samp1.rf. It does not create a listing file.

```
as103 -o/user/obj/sampl.rf sampl.asm
```

| | |
|---|---|
| l | Output a list file |

## Functional Description

This option outputs a list file. The file name of the list file will be the source file name with the extension .lst. The list file will be generated in the same directory as the source file.

If any assembler errors are detected, error information will also be written to the list file.

## Rules of Use

This option is specified with the hyphen (-) option specification character, followed by the lower-case letter 'l'.

```
as103 -l sample.asm
```

## Default Specification

No list file will be output.

| | |
|---|---|
| Li | Do not output files included by include to the list file |

## Functional Description

This option suppresses output of source file contents included by assembler directive (include) to the list file. However, the machine language code will be written to the relocatable object file.

This option is convenient when you need a listing only for a particular source file while debugging.

The Li option specification will be ignored for source files that do not have any include statements.

## Rules of Use

This option is specified with the hyphen (-) option specification character, followed by the upper-case letter 'L' and lower-case letter 'i'. The pair of characters of Li are handled as a single option.

```
as103 -Li -l sample.asm
```

NOTE: This option is used in conjunction with the l option (lower-case 'l', list output).

## Default Specification

Source files included by include will be output to the list file.

## Operation Example

The following command line assembles the source file samp1.asm and creates a listing file samp1.lst that suppresses all text merged with the assembler directive include.

```
as103 -l -Li sampl.asm
```

NOTE: Files included with include must not terminate with the end directive.

| | |
|---|---|
| Lm | Do not output files included by include to the list file |

## Functional Description

This option suppresses output of assembler source created by macro expansion using macro directives macro and irp to the list file. Only display of machine language instruction mnemonics will be suppressed; machine language code will be output.

By using names that represent their processing actions, macro names can make listings easier to read. In such cases, listings without expanded mnemonics will be easier to look at. This is why the Lm option is provided.

If the l option is not specified, the Lm option will be ignored even if specified. Source files with no macro expansion will be assembled normally even if assembled with the Lm option.

## Rules of Use

This option is specified with the hyphen (-) option specification character, followed by the upper-case letter 'L' and lower-case letter 'm'. The pair of characters of Lm are handled as a single option.

```
as103 -Lm -l sample.asm
```

NOTE: The Lm option is specified with the hyphen (-) option specification character

## Default Specification

Source statements expanded from macros will be output to the list file.

## Operation Example

The following command line assembles the source file samp1.asm and creates a listing file samp1.lst that suppresses all text generated by the expansion of macros.

```
as103 -l -Lm sampl.asm
```

| | |
|---|---|
| Lc | Do not output source statements that were not assembled due to unfulfilled conditions of conditional assembly to the list file |

## Functional Description

This option suppresses output of blocks of unsatisfied conditions with conditional assembly to the list file. It also suppresses source statements of conditional directives.

## Rules of Use

This option is specified with the hyphen (-) option specification character, followed by the upper-case letter 'L' and lower-case letter 'c'. The pair of characters of Lc are handled as a single option.

```
as103 -Lc -l sample.asm
```

NOTE: This option is used in conjunction with the l option (lower-case 'l', list output).

## Default Specification

Blocks of unsatisfied conditions will be output to the list file.

## Operation Example

The following command line assembles the source file samp1.asm and creates a listing file samp1.lst that suppresses all text from conditional assembly blocks for which the condition is not satisfied.

```
as103 -l -Lc sampl.asm
```

| | |
|---|---|
| Ls | Do not output a symbol table to the list file |

## Functional Description

This directive suppresses output of a symbol table when the list file is output.

## Rules of Use

This option is specified with the hyphen (-) option specification character, followed by the upper-case letter 'L' and lower-case letter 's'. The pair of characters of Ls are handled as a single option.

```
as103 -Ls -l sample.asm
```

NOTE: This option is used in conjunction with the l option (lower-case 'l', list output

## Default Specification

A symbol table will be output.

| | |
|---|---|
| a map_filename | Read the map file to output a list file with resolved address |

## Functional Description

This option is used to generate a final list file with resolved addresses.

First you must have generated a map file (.map) by specifying the m option with the linker. Then using this map file, reassemble with the a option to generate the final list file.

Specifying the wrong map file or specifying the different option from the one assembled at first results in an error.

## Rules of Use

This option is specified with the hyphen (-) option specification character, followed by the lower-case letter 'a', then followed by the map file name.

```
as103 -a sample.map -l sample.asm
```

NOTE: When specifying the a option, always specify the l option to output a list file. No list file will be generated if only the a option is specified. Specify a option and 1 option adding to the first assembled option for the final list file.

## Default Specification

The assembler will not generate a final list file with addresses resolved by a map file.

## 5.3.2 Error Message Options

| | |
|---|---|
| j | Output error and warning messages in Japanese |

### Functional Description

This option causes all error and warning messages and help screens sent to the console or the listing file to appear in Japanese.

The character coding depends on the host machine and the operating system.

| Host machine | Character coding |
|---|---|
| Sun/Sparc | EUC |
| DOS/V | Shift JIS |
| PC/AT | not supported |

### Rules of Use

To specify the option, enter the hyphen (-) followed by the lower case letter 'j'.

```
as103 -j sample.asm
```

NOTE: This option is not available on PC/AT machines.

### Default Specification

The default language used depends on the host machine and the operating system

| Host machine | Message Language |
|---|---|
| Sun/Sparc | English |
| DOS/V | Japanese in Shift JIS |
| PC/AT | English |

It is also possible to change the default message specification with an entry in the assembler's start-up file. See Chapter 1 "Getting Started" Section 1.5 "Setup."

| | |
|---|---|
| Je | Output error and warning messages in Japanese using EUC encoding |

## Functional Description

This option causes all error and warning messages and help screens sent to the console or the listing file to appear in Japanese using EUC coding.

## Rules of Use

To specify the option, enter the hyphen (-) followed by the upper case letter 'J' and the lower case letter 'e'. The two letters together function as a single option.

```
as103 -Je sample.asm
```

NOTE: This option is not available on DOS/V or PC/AT machines.

## Default Specification

The default language used depends on the host machine and the operating system.

| Host machine | Message language |
|---|---|
| Sun/Sparc | English |
| DOS/V | Japanese in Shift JIS |
| PC/AT | English |

It is also possible to change the default message specification with an entry in the assembler's start-up file. See Chapter 1 "Getting Started" Section 1.5 "Setup."

| | |
|---|---|
| Js | Output error and warning messages in Japanese using Shift JIS encoding |

## Functional Description

This option causes all error and warning messages and help screens sent to the console or the listing file to appear in Japanese using Shift JIS coding.

## Rules of Use

To specify the option, enter the hyphen (-) followed by the upper case letter 'J' and the lower case letter 's'. The two letters together function as a single option.

```
as103 -Js sample.asm
```

NOTE: This option is not available on PC/AT machines.

## Default Specification

The default language used depends on the host machine and the operating system.

| Host machine | Message language |
|---|---|
| Sun/Sparc | English |
| DOS/V | Japanese in Shift JIS |
| PC/AT | English |

It is also possible to change the default message specification with an entry in the assembler's start-up file. See Chapter 1 "Getting Started" Section 1.5 "Setup."

| | |
|---|---|
| Jj | Output error and warning messages in Japanese using JIS encoding |

## Functional Description

This option causes all error and warning messages and help screens sent to the console or the listing file to appear in Japanese using JIS coding.

## Rules of Use

To specify the option, enter the hyphen (-) followed by the upper case letter 'J' and the lower case letter 'j'. The two letters together function as a single option.

```
as103 -Jj sample.asm
```

NOTE: This option is not available on DOS/V or PC/AT machines.

## Default Specification

The default language used depends on the host machine and the operating system.

| Host machine | Message language |
|---|---|
| Sun/Sparc | English |
| DOS/V | Japanese in Shift JIS |
| PC/AT | English |

It is also possible to change the default message specification with an entry in the assembler's start-up file. See Chapter 1 "Getting Started" Section 1.5 "Setup."

| | |
|---|---|
| e | Output error and warning messages in English |

## Functional Description

This option causes all error and warning messages and help screens sent to the console or the listing file to appear in English.

## Rules of Use

To specify the option, enter the hyphen (-) followed by the lower case letter 'e'.

```
as103 -e sample.asm
```

## Default Specification

The default language used depends on the host machine and the operating system.

| Host machine | Message language |
|---|---|
| Sun/Sparc | English |
| DOS/V | Japanese in Shift JIS |
| PC/AT | English |

It is also possible to change the default message specification with an entry in the assembler's start-up file. See Chapter 1 "Getting Started" Section 1.5 "Setup."

| | |
|---|---|
| W number | Do not output warning messages of the specified number |

## Functional Description

This option suppresses output of warning messages generated during assembler operation. For a list of warning messages and their numbers, see Chapter 13 "Error Messages."

The assembler ignores specifications for warning numbers that do not have messages assigned to them.

## Rules of Use

To specify the option, enter the hyphen (-) followed by the upper case letter 'W' and the number.

```
as103 -W 2001 sample.asm
```

## Default Specification

The default is to display all warning messages.

| | |
|---|---|
| Wall | Do not output any warning messages |

## Functional Description

This option suppresses output of all warning messages generated during assembler operation.

## Rules of Use

To specify the option, enter the hyphen (-) followed by the letters 'Wall'.

```
as103 -Wall sample.asm
```

## Default Specification

The default is to display all warning messages.

## 5.3.3 Preprocessor Options

| | |
|---|---|
| I path_name | Specify the trace directory of the include file. |

### Functional Description

Trace from the directory that specifies the include file in the assembler source file. If the absolute path starting with “/” is written, tis option is invalid. Assembler traces the include file from the directory as follows.

1. Directory contains assembler source file
2. Directory specified with -I option.

### Rules of Use

This option is specified with the hyphen(-) option specification character, followed by the upper-case letter ‘I’, then either immediately followed by the path name or a space and the path name.

```
as103 -I/user/defs main.asm
```

### Default Specification

If not specifying this option, the assembler traces the directory (1) written above.

| | |
|---|---|
| D identifier | Specify an identifier to be used by ifdef during conditional assembly |

## Functional Description

The assembler directives #ifdef, #else, and #endif select which source statements are to be assembled depending on whether an identifier has been defined by a define directive. The D option has the same function as the define directive, but with direct specification from the command line.

Identifier specifications by define directives in source statements may be omitted. The statements to be assembled can instead be selected by specifying identifiers with the D option as needed.

Thus, the D option allows conditions to be set freely at the assembly stage without fixing the conditions with define directives in source statements.

There are two conditional assembly directives that can make use of the D option.

ifdef, ifndef

No error will occur if identifiers specified by the D option are not used in the source file. Assembly will process as though conditions are unfulfilled.

## Rules of Use

This option is specified with the hyphen (-) option specification character, followed by the upper-case letter 'D', then followed by the identifier. A space can be inserted between D and the identifier. The identifier must exactly match the string specified by #ifdef. Characters are case-sensitive.

```
as103 -D VERSION sample.asm
```

## Default Specification

Unfulfilled conditions will be selected. The #else to #endif blocks will be assembled.

## 5.3.4 Program Generation Options

| | |
|---|---|
| g | Output debug information to the relocatable object file |

### Functional Description

This option causes the assembler to include in the relocatable object file information for use in debugging at the source code level.

This information includes the following:

- Names and addresses of variables
- Detailed information on variables
- Correspondences between line numbers and code addresses

With this information, debugging is much easier since the user can specify variables by name instead of by address.

NOTE: This option must also be specified when linking. If the g option is not specified for either the assembler or linker, debug information will not be output to the executable format file (.EX).

NOTE: If the number of lines per source file exceeds 65535, some part of the debug information will not be output. Make sure when you debug programs, one source file can contain up to 65535 lines. Divide a file with more than 65535 lines to avoid errors. Note that the file names or line numbers in error messages will not be shown if the linker generates error or warning messages after the line 65535.

### Rules of Use

This option is specified with the hyphen (-) option specification character, followed by the lower-case letter 'g'.

```
as103 -g sample.asm
```

### Default Specification

Debug information will not be output.

| | |
|---|---|
| O | Turn on optimization |

## Functional Description

This option enables optimization of instructions by the assembler and linker. For the instructions subject to optimization, see Chapter 4 "Optimization Functions."

## Rules of Use

To specify the option, enter the hyphen (-) followed by the upper case letter 'O'.

```
as103 -O sample.asm
```

## Default Specification

The default is to suppress optimization.

It is also possible to change the optimization default with an entry in the assembler's start-up file. See Chapter 1 "Getting Started" Section 1.5 "Setup."

| | |
|---|---|
| Od | Turn off optimization |

## Functional Description

This option disables optimization of instructions by the assembler and linker. For the instructions subject to optimization, see Chapter 4 "Optimization Functions."

This option overrides any opt on directives included in the source files. For further details on the opt on directive, see Chapter 9 "Writing Machine Language Instructions and Directives" Section 9.4 "Writing Directives" Section 9.4 "opt."

## Rules of Use

To specify the option, enter the hyphen (-) followed by the upper case letter 'O' and the lower case letter 'd'. The two letters together function as a single option.

```
as103 -Od sample.asm
```

## Default Specification

The default is to suppress optimization.

It is also possible to change the optimization default with an entry in the assembler's start-up file. See Chapter 1 "Getting Started" Section 1.5 "Setup."

## 5.3.5 Other Options

| | |
|---|---|
| h | Display listing of available assembler option on the console |

### Functional Description

This option displays assembler command options and their descriptions to the screen.

The -j, -Je, -Js, -Jj, and -e options, if they appear, control the language and the coding scheme used to display this information.

### Rules of Use

To specify the option, enter the hyphen (-) followed by the lower case letter 'h'.

```
as103 -h
```

NOTE: Even if the h option is not specified, input of AS103 alone will also display the help screen. When displaying help information, version number is also displayed on the screen.

### Default Specification

Help information will not be displayed to the screen.

| | |
|---|---|
| v | Display the assembler's version number on the console |

### Functional Description

This option displays the assembler's version number on the console.

### Rules of Use

To specify the option, enter the hyphen (-) followed by the lower case letter 'v'.

```
as103 -v
```

### Default Specification

The default is to not display the version number.

NOTE: Even if the v option is not specified, input of as103 alone will also display the help screen. When displaying help information, version number is also displayed on the screen.

# 5.4 Operation Examples

There are three steps to perform when you need a final list file with resolved addresses.

1. With the assembler, generate a relocatable object file (.rf).
2. With the linker, generate an executable format file (.ex) and map file (.map).
3. With the assembler again, use the map file to generate a final list file (.lst) with addresses resolved by the linker.

## Program assembly

Generation of a list file with the l option on the first assembly will not resolve addresses, so you would not do so unless you have some special purpose. For the same reason, the Li, Lm, and Lc options are also not used.

```
as103 -g sample.asm
```

The above command assembles the source file (sample.asm) in the current directory, and generates a relocatable object file (sample.rf) with debug information in the current directory.

```
as103 -g -D VERSION -o test.rf /user/source/main.asm
```

The above command assembles the source file (main.asm) in the /user/source directory. For conditional assembly of the source file, assembly will proceed as though VERSION were defined.

The above command also generates a relocatable object file named test.rf with debug information in the current directory.

```
as103 -g -o test.rf -I /user/lib sample.asm
```

The above example assembles the source file (sample.asm) in the current directory. Files specified by include will be read from the /user/lib directory.

The above command also generates a relocatable object file named test.rf with debug information in the current directory.

```
as103 -I/user/defs -o /user/src/sample.rf -D TYPE file.asm
```

The above example assembles the source file (file.asm) in the current directory. For conditional assembly (ifdef), assembly will proceed as though TYPE were declared. The assembler reads files specified with the include directive from the directory /user/defs.

The above example will store the relocatable object file with name sample.rf in the /user/src directory.

## Generation of final list file with resolved program addresses

The final list file is generated as follows.

1. First use the assembler to generate a relocatable object file. Valid options at this stage are o, I, D, g, and the optimization options (O, Od).
2. Next use the linker to generate an executable format file by specifying the start address of each section and linking multiple files. Specify the linker's m option to generate the map file. Refer to chapter 6, "Using The Linker", for details.
3. Use the assembler once more to assemble the source file. This time read the map file generated by the linker with the assembler's a option. If the I or D options are specified, the parameters at this stage must be the same as those of the first assembly.

The following descriptions assume that a map file has already been generated.

```
as103 -l -a main.map sub.asm
```

In the above example all files exist in or are output to the current directory. The source file (sub.asm) is assembled using a map file (main.map), generating a list file (sub.lst).

```
as103 -l -Lc -Lm -a main.map -D MODE prog1.asm
```

The above example assembles the source file (prog1.asm) in the current directory using a map file (main.map), generating a list file (prog.lst). Assembly will be performed assuming that the identifier MODE has been defined for conditional assembly directives (ifdef). Source statements of unfulfilled conditions and macro expansion source will not be output.

# Chapter 6 Using Linker

# 6.1 Purpose of This Chapter

This chapter explains how to use all the options provided by the linker. The linker reads relocatable object files output by the assembler, outputs an executable format file, and if specified by option outputs a map file containing link information. If optimization was specified at the assembly stage, the linker will also adjust code such that it outputs optimal code for conditional and unconditional branch instructions. In addition, the linker also resolves forward references.

For programs in section address format, the start address of each section is specified when linking. The linker links relocatable object files by section in the order specified by the link command, and outputs an executable format file.

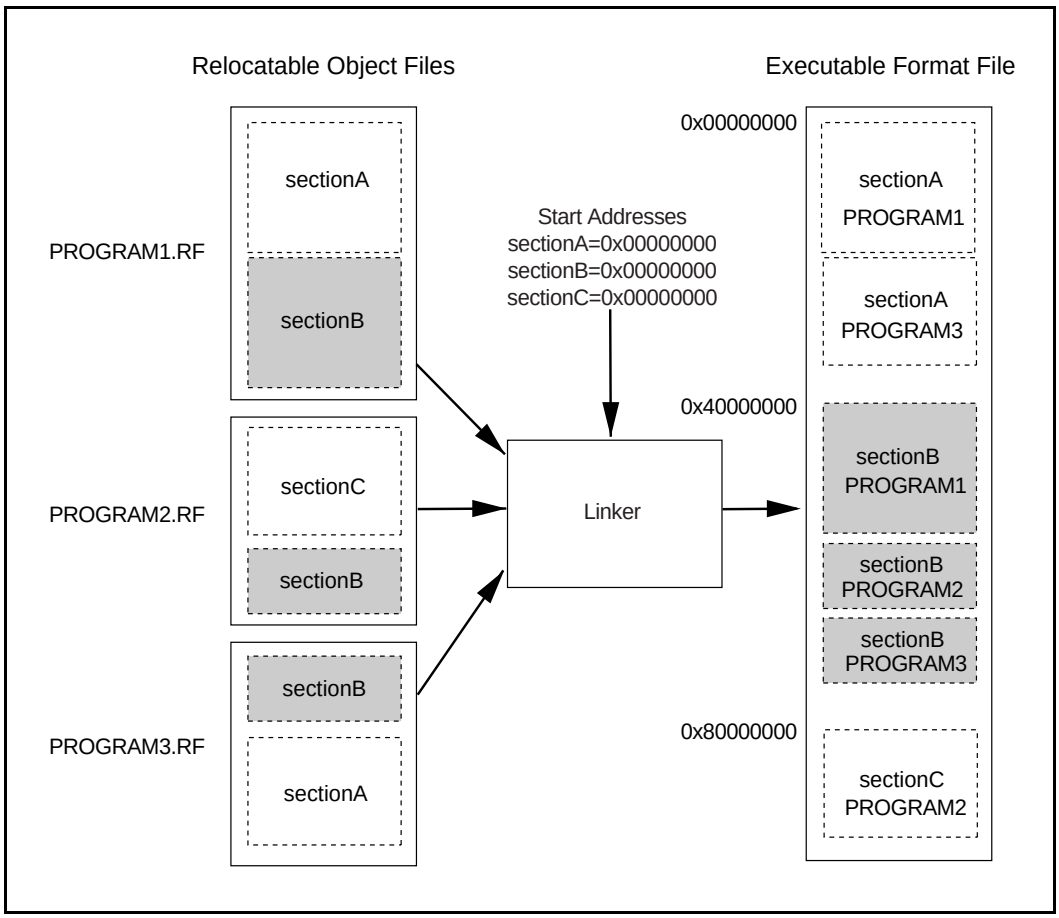



Figure: 6-1 Link Model of Section Address Format

# 6.2 Starting Linker

The linker is started by entering a command name and parameters, just as for other MS-DOS external commands. The parameters are linker options and names of files to be linked.

The command name differs depending on the device being used. This chapter uses the terminology of ld103 as is general format.

## General format of commands

Below is the general format of the command to use when starting the linker.

```
ld103 [options] relocatable_object_filename ...
[library_filename]
```

Contents of brackets [ ] may be omitted.

Ellipses (...) indicate item may be repeated.

## Specifying options

Except for the @ option, an option starts with a hyphen (-) as the options specifier, followed by a character that indicate the particular option.

```
-g
```

The @ option is not preceded by hyphen.

Option specifications are case sensitive, so upper case and lower case letters must be specified correctly.

```
-Ed
```

Single-character options not accompanied by parameters can be specified as multiple characters following the slash (/) or hyphen (-) option specifier. The order is optional.

```
-jmg
```

If you want to separate multiple options, delimit them with spaces.

```
-j -m -g
```

When an option is accompanied by a parameter and other options are to follow, add a space after the parameter, and follow with the slash (/) or hyphen (-) option specifier.

```
-o main.ex -gm
```

Parameters can be specified right after the option character or separated by one space.

```
-T@CODE=80000000 or -T @CODE=80000000
```

When options are omitted, assembly will be performed in accordance with the default interpretations built in to the assembler. Refer to section 6.3, "Command Options," for default interpretations

---

NOTE: When specifying multiple files, separate them with spaces. Files without path specifications are assumed to be in the current directory. The map file and executable file are always generated in the current directory regardless of any path specifications on the relocatable object files.
The default names for the executable file and the map file are m103.ex and m103.map, respectively.
The o option is available for creating the executable file in a directory other than the current directory. The map file is created in the same directory as the executable file.

---

## Summary of Options

Table 6-1 Linker options

| Option Type | Symbol | Description |
|---|---|---|
| Output file options | o filename | Specify the path name and file name of the executable format file to be output. |
| | m | Output a map file |
| Error message options | j | Output error and warning messages in Japanese. |
| | Je | Output error and warning messages in English. |
| | Js | Output error and warning messages in Japanese using Shift JIS encoding. |
| | Jj | Output error and warning messages in Japanese using JIS encoding. |
| | e | Output error and warning messages in English |
| | W number | Do not output warning messages of the specified number. Refer to chapter 10, "Error Messages," for warning messages and their corresponding numbers. |
| | Wall | Do not output any warning messages. |
| Program generation options | g | Output debug information to the executable format file. |
| | T section=address | Specify the start/end addresses of a start address [,end address]section (section group). |
| | r | Output an executable format file even if errors are detected. |
| | En | Do not output symbol table within the executable format file. |
| | Ed | Enable output of DATA sections to the executable format file. |
| Library file options | l library_filename | Specify a library file. |
| | L path_name | Specify a path name for library files. |
| Instruction RAM options | OVL ID_number section=address | Specify starting address for section in instruction RAM. |
| | PUT extra_symbol=address | Specify address for extra symbol. |
| Other | @filename | Specify a parameter file. |
| | h | Output help information to the screen. |
| | v | Display the linker’s version number on the console. |

# 6.3 Command Options

This section describes the options used by the linker. The linker has many options for controlling output file specifications and the information written to files. The linker reads multiple relocatable object files, links them into one, and creates an executable format file.

If optimization was selected at the assembly stage, the linker will output the optimal machine language code for conditional and unconditional branch instructions, regardless of the mnemonics defined in the source file.

In addition, the linker resolves the values of forward-referenced symbols and undefined operands.

## 6.3.1 Output File Options

| | |
|---|---|
| o filename | Specify the path name and file name of the executable format file to be output |

### Functional description

This option specifies the directory and file name of the executable format file to be output by the linker.

If the directory is omitted, the file will be output to the current directory. If a file name that already exists is specified, that file will be overwritten with new contents.

If just a path name is specified, or if a directory that does not exist is specified, an error message will be displayed.

NOTE: Because the @ symbol is used as the character for specifying parameter files, it cannot be used as the first character of file names

### Rules of use

This option is specified with the hyphen (-) option specification character, followed by the lower-case letter 'o', then either immediately followed by the file name or a space and the file name.

```
ld103 -o /usr/tmp/test.ex main.rf sub.rf
```

### Default specification

The executable format file named m103.ex will be output to the current directory.

| | |
|---|---|
| m | Output a map file |

## Functional description

The map file lists the addresses and sizes of all sections linked by the linker plus identifying information and values for local and global symbols.

For all programs, the addresses assigned to sections and symbols are not determined until linking.

To create a final list file, reassemble the source file using the map file.

## Rules of use

This option is specified with hyphen (-) option specification character, followed by the lower-case letter 'm'. The map file name will be the name of the first file specified in the link command with the extension .MAP. The map file will be output to the same directory as the directory where the executable format file is generated.

```
ld103 -m main.rf sub.rf
```

## Default specification

A map file will not be output.

The default can be changed to output a map file by using customization. Refer to section 1.5, "User Customization".

## Operation example

```
ld103 -o /user/obj/main.ex -m -T@CODE=80000000 prog1.rf prog2.rf
```

The above command line links two relocatable object files (prog1.rf and prog2.rf) located in the current directory, locates the resulting CODE section starting at the address 80000000 (hex.), and generates an executable file (main.ex) and map file (main.map) in the directory /user/obj.

```
ld103 -m -T_TEXT=80000000 -T_CONST=80005000 prog1.rf prog2.rf
```

The above command line links two relocatable object files (prog1.rf and prog2.rf) located in the current directory, locates the resulting _TEXT and _CONST sections starting at the addresses 80000000 (hex.) and 80005000 (hex.), respectively, and generates an executable file (m103.ex) and map file (m103.map) in the current directory.

## 6.3.2 Error Message Options

| | |
|---|---|
| j | Output error and warning messages in Japanese |

### Functional description

This option causes all error and warning messages and help screens sent to the console or the listing file to appear in Japanese.

The character coding depends on the host machine and the operating system.

| Host machine | Character coding |
|---|---|
| Sun/Parc | EUC |
| DOS/V | Shift JIS |
| PC/AT | not supported |

### Rules of use

This option is specified with the hyphen (-) option specification character, followed by the lower-case letter “j”.

```
ld103 -j sample.rf
```

NOTE: This option is not available on PC/AT machines.

### Default specification

The default language used depends on the host machine and the operating system.

| Host machine | Character coding |
|---|---|
| Sun/Parc | English |
| DOS/V | Japanese in Shift JIS |
| PC/AT | English |

It is also possible to change the default message specification with an entry in the linker’s start-up file. See Chapter 1 “Getting Started” Section 1.5 “Setup”.

| | |
|---|---|
| Je | Output error and warning messages in Japanese using EUC coding |

## Functional description

This option causes all error and warning messages and help screens sent to the console or the listing file to appear in Japanese using EUC coding.

## Rules of use

This option is specified with the hyphen (-) option specification character, followed by the upper-case letter “J” and the lower case letter “e”. The two letters together function as a single option.

```
ld103 -Je sample.rf
```

NOTE: This option is not available on DOS/V or PC/AT machines.

## Default specification

The default language used depends on the host machine and the operating system.

| Host machine | Character coding |
|---|---|
| Sun/Parc | English |
| DOS/V | Japanese in Shift JIS |
| PC/AT | English |

It is also possible to change the default message specification with an entry in the linker’s start-up file. See Chapter 1 “Getting Started” Section 1.5 “Setup”.

| | |
|---|---|
| Js | Output error and warning messages in Japanese using Shift JIS coding |

## Functional description

This option causes all error and warning messages and help screens sent to the console or the listing file to appear in Japanese using Shift JIS coding.

## Rules of use

This option is specified with the hyphen (-) option specification character, followed by the upper-case letter “J” and the lower case letter “e”. The two letters together function as a single option.

```
ld103 -Js sample.rf
```

NOTE: This option is not available on PC/AT machines.

## Default specification

The default language used depends on the host machine and the operating system.

| Host machine | Character coding |
|---|---|
| Sun/Parc | English |
| DOS/V | Japanese in Shift JIS |
| PC/AT | English |

It is also possible to change the default message specification with an entry in the linker’s start-up file. See Chapter 1 “Getting Started” Section 1.5 “Setup”.

| | |
|---|---|
| Jj | Output error and warning messages in Japanese using JIS coding |

## Functional description

This option causes all error and warning messages and help screens sent to the console or the listing file to appear in Japanese using JIS coding.

## Rules of use

This option is specified with the hyphen (-) option specification character, followed by the upper-case letter “J” and the lower case letter “e”. The two letters together function as a single option.

```
ld103 -Jj sample.rf
```

NOTE: This option is not available on DOS/V or PC/AT machines.

## Default specification

The default language used depends on the host machine and the operating system.

| Host machine | Character coding |
|---|---|
| Sun/Parc | English |
| DOS/V | Japanese in Shift JIS |
| PC/AT | English |

It is also possible to change the default message specification with an entry in the linker’s start-up file. See Chapter 1 “Getting Started” Section 1.5 “Setup”.

| | |
|---|---|
| e | Output error and warning messages in English. |

## Functional description

This option displays messages for errors and warnings detected in link commands and link processing to the screen and list file in English.

## Rules of use

This option is specified with the slash (/) or hyphen (-) option specification character, followed by the lower-case letter 'e'.

```
ld103 -e sample.rf
```

## Default specification

The default language used depends on the host machine and the operating system.

| Host machine | Character coding |
|---|---|
| Sun/Parc | English |
| DOS/V | Japanese in Shift JIS |
| PC/AT | English |

It is also possible to change the default message specification with an entry in the linker’s start-up file. See Chapter 1 “Getting Started” Section 1.5 “Setup”.

| | |
|---|---|
| W number | Do not output warning messages of the specified number |

## Functional description

This option suppresses output of specified warnings detected during linking. Unlike errors, warnings are not fatal, so the W option is used when you understand their meanings sufficiently and need to suppress their output. Specifying Wall will suppress output of all warnings. Refer to chapter 13, "Error Messages", for warning numbers and their corresponding messages.

## Rules of use

This option is specified with the hyphen (-) option specification character, followed by the upper-case letter 'W', and followed by the warning number specification.

```
ld103 -W3001 progr1.rf prog2.rf
```

## Default specification

Warning messages are output.

| | |
|---|---|
| Wall | Do not output any warning messages |

## Function description

This option suppresses output of all warnings detected during linking.

## Rules of use

This option is specified with the slash (/) or hyphen (-) option specification character, followed by the letters 'Wall'.

```
ld103 -Wall main.rf sub.rf
```

## Default specification

Warning messages are output.

## 6.3.3 Program Generation Options

| | |
|---|---|
| g | Output debug information to the executable format file |

### Functional description

This option causes the linker to include in the executable file information for use in debugging at the source code level.

This information includes the following;

- Names and addresses of variables
- Detailed information on variables
- Correspondences between line numbers and code addresses

With this information, debugging is much easier since the user can specify variables by name instead of by address.

NOTE: The g option must also be specified when assembling. If the g option is not specified for either the assembler or linker, debug information will not be output to the executable format file (.EX). If files assembled with the g option and files not assembled with the g option are linked with the g option, debug information will be output only for the files assembled with the g option.

### Rules of use

This option is specified with the hyphen (-) option specification character, followed by the lower-case letter 'g'.

```
ld103 -g main.rf sub.rf
```

### Default specification

Debug information will not be output.

It is also possible to change the default with an entry in the linker's start-up file. See Chapter 1 "Getting Started" section 1.5 "Setup".

| | |
|---|---|
| T section =addresses | Specify starting address for a section |

## Functional description

This option specifies the starting address for the specified section. It changes the starting address for all sections in all relocatable object files specified to the right of this option.

The linker checks these specifications for overlap between sections.

## Rules of use

This option is specified with the hyphen (-) option specification character, followed by the upper-case letter 'T'.

Section may be specified by section name, section attribute or both. To specify a section attribute, precede the name of the attribute with the character @. Multiple sections may be specified together as a comma-delimited list.

The starting address is given in hexadecimal. In -T@CODE=abc, ABC is a hexadecimal number.

```
ld103 -T@CODE=80000000 -T@DATA=0 prog1.rf prog2.rf
ld103 -T_TEXT,_CONST=80000000 main.rf -T_TEXT, _CONST=80002000
sub.rf
ld103 -T_TEXT@CODE=80000000 test1.rf test2.rf
```

Be careful with the specification order for files since that order is the order in which the linker merges sections.

## Section layout rules

The sections are merged according to the following rules.

1. Sections appearing with -T option specifications are assigned to the specified addresses.
2. The remaining sections with no such specifications are arranged with the CODE sections proceeding the DATA sections using the following rules.
   a Sections with the same name and same attribute are merged after the sections with the highest address.
   b Sections with the same attribute are merged after the sections with the highest address.
   c Remaining sections are merged after the sections with the highest address.

Figure 6-2 illustrates the process.

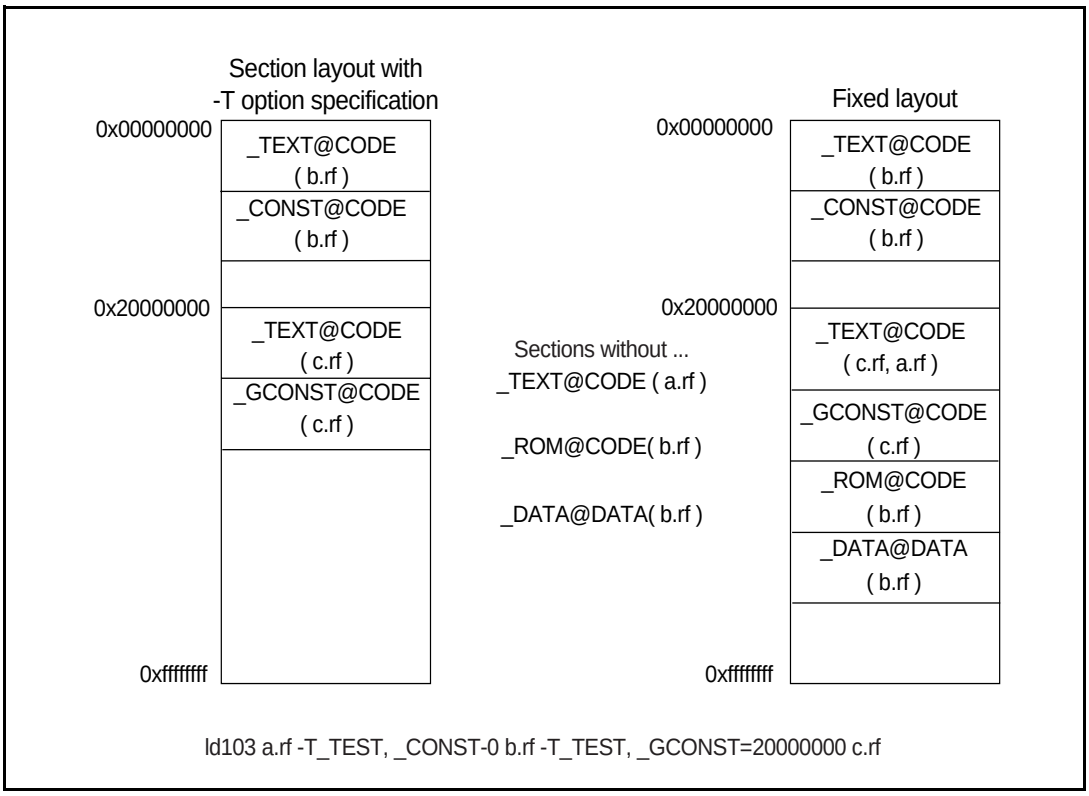



Figure: 6-2 Memory Space Layout

## Default specification

When there are no address specifications whatsoever, the first section in the first file is assigned to address 0. The remaining sections are assigned using the rule 2 mentioned above.

NOTE: If a section has been divided into two or more parts (sections), a starting address of the lowest section is referred to the section name.

## Operation example

The following are examples of section layout for two files, main.rf and sub.rf, in the current directory. Both files contain multiple CODE and DATA sections.

```
ld103 main.rf sub.rf
```

The linker merges the CODE sections in the order that they appear in the input files, starting at address 0. It merges the DATA sections in the order in which they appear, starting at address 0. It merges the DATA sections in the order in which they appear.

```
ld103  -T @CODE=80000000   -T@DATA=0 main.rf  sub.rf
```

The linker merges the DATA sections in the order that they appear in the input files, starting at address 0. It merges the CODE sections in the order in which they appear, starting at address 80000000(hex).

```
ld103 -T @CODE = 80000000 main.rf -T@DATA=0 sub.rf
```

The linker merges the CODE sections from the input files, starting at address 80000000 (hex). It merges the DATA sections from the file sub.rf, starting at address 0. The DATA section from main.rf do not have an address specification, so are merged following the DATA section from sub.rf.

NOTE: For specifying a parameter of _T option, a parameter file can not be used because the character @ would not be considered as an attribute specifying letter.
In addition, the description should include the _T option in order to use a parameter file.

| | |
|---|---|
| r | Output an executable format file even if errors are detected |

## Functional description

The linker normally suppresses the creation of an executable file if it detects errors during linking. This option forces file creation even if there are errors.

NOTE: An executable created with known linker errors will not execute properly. The r option is only a temporary measure. Do not run the executable that results.

## Rules of use

This option is specified with the hyphen (-) option specification character, followed by the lower-case letter 'r'.

```
ld103 -r prog1.rf
```

## Default specification

An executable format file will not be generated.

It is also possible to force creation of executable file by default with an entry in the linker's start-up file. See Chapter 1 "Getting Started" Section 1.5 "Setup".

| | |
|---|---|
| En | Do not output symbol table within the executable format file |

## Functional description

This option suppresses output of a symbol table in the executable format file. Only executable code will be output to the executable format file.

## Rules of use

This option is specified with the hyphen (-) option specification character, followed by the upper-case letter 'E' and lower-case letter 'n'. The pair of characters of En are handled as a single option.

```
ld103 -En main.rf sub.rf
```

NOTE: The En option cannot be used in conjunction with the g option.

## Default specification

The entire symbol table will be output.

It is also possible to disable symbol table output by default with an entry in the linker's Start-up file. See Chapter 1 "Getting Started" Section 1.5 "Setup".

| | |
|---|---|
| Ed | Output the DATA section to the executable file |

## Functional description

This option causes the linker to write sections with the DATA attribute to the executable.

## Rules of use

This option is specified with the hyphen (-) option specification character, followed by the upper-case letter 'E' and lower-case letter 'd'. The pair of characters of En are handled as a single option.

```
ld103 -Ed main.rf sub.rf
```

## Default specification

The default is not to output DATA sections to the executable.

It is also possible to enable DATA section output by default with an entry in the linker's start-up file. See Chapter 1 "Getting Started" Section 1.5 "Setup".

## 6.3.4 Library File Options

| | |
|---|---|
| l library_filename | Specify a library file |

### Functional description

This option specifies a library file.

### Rules of use

This option is specified with the hyphen (-) option specification character, followed by the lower-case letter 'l', then either immediately followed by the path name and file name or a space and the path name and file name. The l option must be coded end of the command line.

```
ld103 -l /usr/lib/sample.lib main.rf sub.rf
```

### Default specification

No library files will be read.

NOTE: The linker will search for a library file one time only in order to solve the problem of the undefined symbols. For instance, if an undefined symbol has defined in the former library file, the linker could never solve the problem, and a error message will be appeared.
Be sure to specify the library file at the end of the command line of the undefined symbol.
Object files would not limit any restriction.

| | |
|---|---|
| L path_name | Specify a directory containing library files |

## Functional description

This option specifies a directory that contains library files.

Library files following the L option specification will be searched for in the specified directory. First, the current directory is searched. And then, the specified directory is searched. When the L option is used multiple times, the search will be performed in the order of definition.

If any library file is not found, the linker outputs an error message to terminate operation.

## Rules of use

This option is specified with the hyphen (-) option specification character, followed by the upper-case letter 'L', then either immediately followed by the path name or a space and the path name.

```
ld103 -L/usr/lib -lsample.lib -sample2.lib prog1.rf prog2.rf
```

The files sample.lib and sample2.lib will be searched for in the directory /usr/lib.

## Default specification

Library files specified by the l option will be read.

## 6.3.5 Other Options

| | |
|---|---|
| @filename | Specify a parameter file |

### Functional description

By writing various option used by the linker in a file, the @ option lets you specify just that file during execution, and the linker will replace it with the option specifications.

All options other than the @ option can be written in a parameter file.

If a parameter file that does not exist is specified, the linker will display an error message.

### Rules of use

This option does not use the slash (/) or hyphen (-) option specification character. It specified alone, followed by the parameter file name.

```
ld103 @pfile
```

NOTE: Comments may be inserted into parameter files by starting them with a sharp (#). The linker ignores everything from the sharp to the end of the line.

### Default specification

Not applicable.

### Operational example

Assume the following contents for pfile.

```
-o main.ex
-gm
-T@CODE=80000000 prog1.rf
-T@DATA=f0000000 prog2.rf
```

Then specifying the following two commands is equivalent.

```
ld103 @pfile
```

```
ld103 -o main.ex -gm -T@CODE=80000000 prog1.rf -T@DATA=f0000000
prog2.rf
```

| | |
|---|---|
| h | Output help information to the screen |

## Functional description

This option displays linker command options and their descriptions to the screen. The h option is used alone.

## Rules of use

This option is specified with the hyphen (-) option specification character, followed by the lower-case letter 'h'.

```
ld103 -h
```

NOTE: Even if the h option is not specified, input of ld103 alone will also display the help screen. When displaying help information, version number is also displayed on the screen.

## Default specification

Help information will not be displayed to the screen.

| | |
|---|---|
| v | Display the linker’s version number on the console |

## Functional description

This option displays the linker’s version number on the console.

## Rules of use

This option is specified with the hyphen (-) option specification character, followed by the lower-case letter 'v'.

```
ld103 -v
```

## Default specification

Version number will not be displayed on the console.

NOTE: If not specifying v option and input “ld103”, a version number is displayed. In this case, the help information is also displayed.

# 6.4 Instruction RAM Support

This series includes members with instruction RAM for use in copying program portions to RAM for execution there.

The linker therefore supports special options for creating executable files with support for instruction RAM.

This section gives the particulars of the instruction RAM format for executable files and the procedures for creating them.

## 6.4.1 Structure of IRAM Support Executable File

### Structural Elements of an IRAM Support Executable

(A) Fixed program portion

This portion resides in external memory and runs using addresses as is in the normal fashion. Normal executable files contain only this portion.

(B) Instruction RAM program

This portion resides in external memory, but only works properly when transferred to the instruction RAM. This is automatically assigned to the external memory immediately following the fixed program portion.

(C) Instruction RAM program management table

When the program contains instruction RAM portions, the linker automatically generates this table in the executable file. Each entry for the transfer units contains the following information.

| | |
|---|---|
| ID number | 2 bytes |
| Program size | 2 bytes |
| External memory address | 4 bytes |
| Instruction RAM address | 4 bytes |

NOTE: The linker indicates the last entry in this table by setting the highest bit in the ID number field to 1.

The linker creates a extra symbol, __overlay_table, indicating the location of this table.

(D) Transfer program

This portion copies the instruction RAM program from the external memory to the instruction RAM. It refers to the instruction RAM program management table in the process. The developer must create this portion and add it to the fixed program portion.

(E) Instruction RAM status management table

During execution, this table keeps track of which portions are currently in the instruction RAM. Since this is for use by the debugger in identifying the portions currently in the instruction RAM, it is not necessary for a program that merely runs in instruction RAM. The contents and usage of this table is determined by the debugger.

The linker creates an extra symbol, __iram_manage, indicating the location of this table.

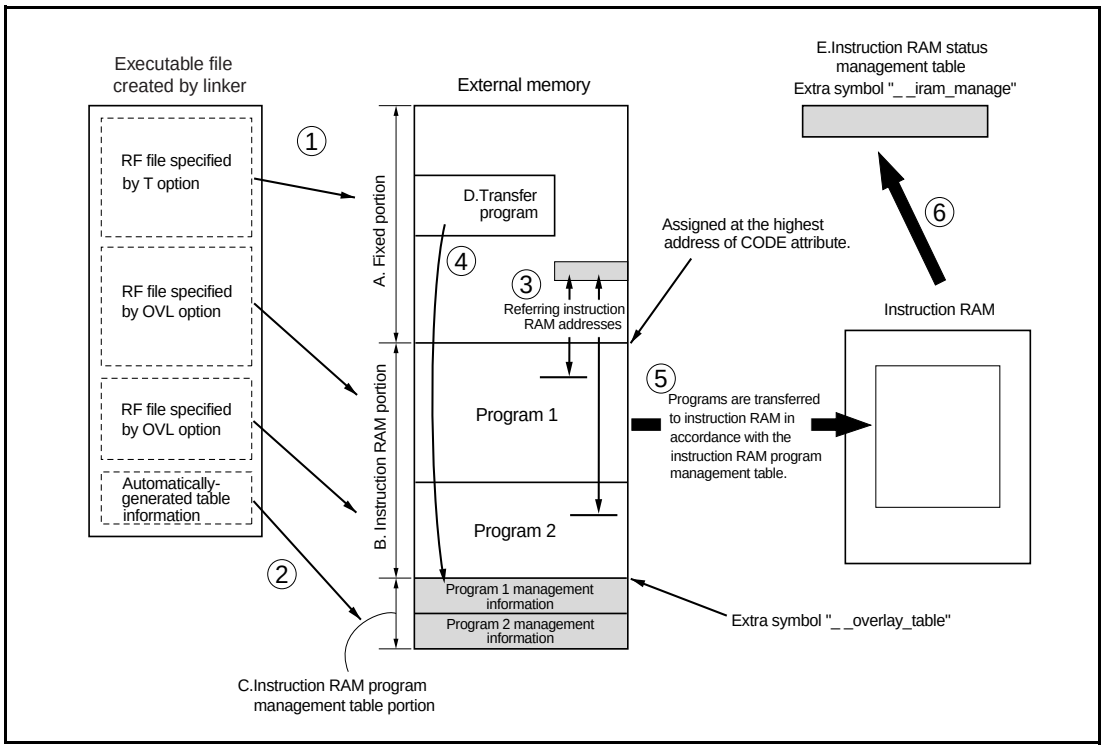



Figure: 6-3 Layout Image for Instruction RAM and External Memory

NOTE: When the instruction RAM function is in use, the linker reserves the extra symbol names __overlay_table and __iram_manage for its own use, so do not use these names for ordinary symbols

## File layout and transfer operations for an instruction RAM executable file

1. Use the linker's T and OVL layout options to divide the program into a fixed portion (A) and an instruction RAM portion (B). The linker assigns the latter to a location in external memory immediately following the former.
2. The linker automatically generates the instruction RAM program management table (C) at the address specified with the PUT option. If there is no specification, the table immediately follows the instruction RAM portion.
3. The linker resolves address references to other portions of the program assuming that the instruction RAM portions are running at the specified addresses in instruction RAM.
4. The linker creates an instruction RAM transfer unit for each -OVL option, making entry for each one in the instruction RAM program management table. The transfer program (D) obtains its parameters from this table during actual transfers.
5. When the program runs, the actual code for an instruction RAM portion referenced must be in the instruction RAM. The software must call upon the transfer routine to copy the necessary code into the instruction RAM immediately before it is referenced.
6. The instruction RAM status management table is for use by the debugger in determining how the instruction RAM is currently being used.

## 6.4.2 IRAM Support Options

Using the following options creates an executable file supporting instruction RAM operation.

| | |
|---|---|
| OVL ID_number: section=address | Specify address in instruction RAM for a section |

### Functional description

This option assigns an address in instruction RAM for the specified section. The linker resolves all addresses to assume that the relocatable object file following the option is running in instruction RAM. Note that this processing applies only to those relocatable object files between the current OVL option to the next T or OVL option or end of line.

Sections without OVL specifications are processed in accordance with the T specifications.

The linker merges all sections matching the OVL specification and places the result in the external memory starting immediately after the highest section with the CODE attribute.

NOTE: The linker produces an error message if the relevant object files do not contain the specified section. Specifying an -OVL option without a following file produces the same result

### Rules of use

This option is specified with the hyphen (-) option specification character, followed by the upper case letters 'OVL', the ID number, a colon, the section specification, an equals sign, and the address in instruction RAM. A space between the OVL option letters and the ID number is optional.

The ID number identifies a set of sections extracted from the corresponding object files and is used to reference that set during program operation. It can be any number between 1 and 255.

Sections may be specified by section name, section attribute, or both. To specify a section attribute, precede the name of the attribute with the character @. Multiple sections may be specified together as a comma-delimited list.

The starting address in instruction RAM is given in hexadecimal.

```
ld103 -T @CODE=80000000 main.rf sub.rf -OVL 1:@CODE=40000000
seg1.rf
-OVL 2:@CODE=40000000 seg2.rf
ld103 -T @CODE=80000000 main.rf sub.rf -OVL
1:_TEXT,_CONST=40000000
seg1.rf -OVL 2:_TEXT,_CONST=40000000 seg2.rf
ld103 -T @CODE=80000000 main.rf sub.rf -OVL
1:_TEXT@CODE=40000000
seg1.rf -OVL 2:_TEXT@CODE=40000000 seg2.rf
```

## Default specification

If there are no OVL options, the instruction RAM function is not used, and linking proceeds in the normal fashion.

| | |
|---|---|
| PUT symbol=address | Specify address for extra symbol |

## Functional description

This option is used to specify addresses for the extra symbols used by the instruction RAM function.

NOTE: A PUT option is only valid when there are one or more -OVL options.

## Rules of use

This option is specified with the hyphen (-) option specification character, followed by the upper case letters 'PUT', the name of an extra symbol, an equals sign, and the address for that symbol. There are two extra symbols:

```
__overlay_table
```

and

```
__iram_manage.
```

The address is in hexadecimal.

```
ld103 -T @CODE=80000000 main.rf sub.rf -OVL 1:_TEXT=40000000
seg1.rf
-PUT __overlay_table=a0000000 -PUT __iram_manage=30000000
```

## Default specification

The default for the extra symbol __iram_manage is the address 0; that for __overlay_table, the address following the last section in the external memory.

## 6.4.3 Operation Examples

The following are examples of section layouts using the OVL option for the five relocatable object files, main.rf, sub.rf, prog1.rf, prog2.rf, and prog3.rf, in the current directory. All files contain multiple CODE and DATA sections.

### Assigning to different addresses in instruction RAM

```
ld103 -T @CODE=80000000 -T @DATA=1000 main.rf sub.rf
-OVL 1:_TEXT=40001000 prog1.rf -OVL 2:_TEXT=40002000 prog2.rf
-OVL 3:_TEXT=40003000 prog3.rf
```

The linker first places all sections with the CODE attribute from main.rf and sub.rf in the order that they appear in the input files, beginning at the address 80000000 (hex.). It places all sections with the DATA attribute from all input files beginning at the address 1000 (hex.).

The linker places all sections other than those named _TEXT after the same sections in main.rf and sub.rf according to the -T option placement rules. (See Section 6.3.3.)

The linker resolves all internal references within the _TEXT sections of prog1.rf, prog2.rf, and prog3.rf so that the sections are ready to run in the specified instruction RAM addresses above 40000000 (hex.), but places the sections in the order that they appear in the input files, beginning at the address following the end of the sections with the CODE attribute as placed with the T option.

Finally, at the address following the end of all segments in external memory with the CODE option, the linker creates the instruction RAM program management table used by the routine for copying sections to instruction RAM.

### Assignment to the same address in instruction RAM

```
ld103 -T @CODE=80000000 -T@DATA=1000 main.rf sub.rf
-OVL 1:_TEXT=40000000 prog1.rf -OVL 2:_TEXT=40000000 prog2.rf
-OVL 3:_TEXT=40000000 prog3.rf
```

The linker first places all sections with the CODE attribute from main.rf and sub.rf in the order that they appear in the input files, beginning at the address 80000000 (hex.). It places all sections with the DATA attribute from all input files beginning at the address 1000 (hex.).

The linker places all sections other than those named _TEXT after the same sections in main.rf and sub.rf according to the T option placement rules. (See Section 6.3.3.)

The linker resolves all internal references within the _TEXT sections of prog1.rf, prog2.rf, and prog3.rf so that the sections are ready to run at the instruction RAM address 40000000 (hex.), but places the sections in the order that they appear in the input files, beginning at the address following the end of the sections with the CODE attribute as placed with the T option.

Finally, at the address following the end of all segments in external memory with the CODE option, the linker creates the instruction RAM program management table used by the routine for copying sections to instruction RAM.

NOTE: If multiple sections share the same or overlapping regions in instruction RAM, their code must be mutually exclusive. In other words, in the above example, the files prog1.rf, prog2.rf, and prog3.rf must not contain references to each other's symbols because that would require that they both be in instruction RAM at the same time—a physical impossibility. The linker automatically detects such conflicts and suppresses executable file output.

## Specifying an address for the instruction RAM program management table

```
ld103 -T @CODE=80000000 -T@DATA=1000 main.rf sub.rf
-OVL 1:_TEXT=40000000 prog1.rf -OVL 2:_TEXT=40000000 prog2.rf
-OVL 3:_TEXT=40000000 prog3.rf -PUT __overlay_table=a0000000
```

The section layout is the same as the previous example. The only difference is that the linker moves the instruction RAM program management table to the address a0000000 (hex.).

NOTE: The developer must be careful not assign this table to an address where it overlaps with actual code.

# Chapter 7 Types of Source Statements

# 7.1 Purpose of This Chapter

Programs used by the Cross Assembler are collections of source statements. There are five types of source statements, classified by their purpose.

- Machine language instruction statements and directive statements
- Assembler control statements
- Macro control statements
- Comment statements
- Blank statements

This chapter describes these five types of statements, and at the same time explains their position and use when constructing a program.

# 7.2 Program Format

A program is text created to assemble as machine language instructions in order to operate a microprocessor. The assembler translates the text into machine language code, while the linker joins that code to make an executable format file.

One line of text is called a source statement. There are five types of source statements, with the type determining how a source statement is written.

Basic program format is shown below.

| | |
|---|---|
| * Comment statement | Write comments as needed |
| #include | #include specifications |
| #define | Define #define identifiers |
| definitions of constants, macros, globals | Statements to define constants and macros and to declare and define globals |
| section name section | Declare start of section |
| . | |
| . | |
| . | |
| program body | Machine language instructions, conditional assembly directives, macro expansions |
| . | |
| . | |
| . | |
| end | End of program |

There are several points to be aware of when writing programs.

- Always declare an attribute and link type for a section name the first time it appears in a file.The same section name cannot be set to a different attribute or link type.
- The effective scope of a directive coding rule section is until the line preceding the next directive coding rule section
- Ignore all text after the directive coding rule instruction.

Below is an example source file.

```
;  SAMPLE PROGRAM                       ; comment
#include    "FILE1.H                     ;include a file
#define                                  ;define identifier for conditional assembly
KEYBORD     equ         0x32             ;define a constant

data_set    macro       data             ;define a macro
            movw        data, A0
            mov         0x12,  D0
            mov         D0, (A0)
            endm                         ;end of macro
_CODE       section     CODE, PUBLIC,1
                                         ;blank statement
main                                     ;statement with label only
            mov         0x10,  D1        ;machine language instruction statement
#ifdef      TYPE                         ;conditional assembly directive
            data_set    KEYBORD          ;expand macro
#else
            mov         0,  D1
#endif
            end                          ;end of program
```

# 7.3 Machine Language Instruction Statements and Directive Statements

## Machine language instruction statements

Machine language instructions are instructions that the microprocessor directly executes on its own hardware. Each machine language code has a corresponding mnemonic.

Machine language instruction statements are statements that code these mnemonics. The assembler will convert them into machine language code (called object code). After the program has been converted to ROM, these statements will be executed by the microprocessor.

The instructions have the following features.

- Memory-oriented instruction set (all calculations performed throughout memory)
- Single and double-operand instructions
- Minimized instruction set and instruction codes
- Six addressing formats

The example below shows machine language instruction statements.

```
    mov         0xff, D0
    mov         data1,  A0
    mov         D0,  (A0)
    add         1, D0
    rts
```

## Directive statements

Directive statements are not converted to machine language code. Within programs they specify assembler attributes to modify program structure and addresses, select radices, define constants, and control list file style.

The example below shows directive statements.

```
                global          save
CONST           equ             0x12
_TEXT           section         CODE, PUBLIC, 1
                org             100
MESG            dc              'S'
                end
```

# 7.4 Assembler Control Statements

Assembler control statements are source statements that control how the assembler processes.

The assembler provides include directives that include files and conditional assembly directives that specify conditions for changing which instructions are assembled.

The example below shows assembler control statements.

```
#include    “FILE1.ASM              ;include a file
#define     MODE                    ;define an identifier
            .
            .
            .
#ifdef      MODE                    ;begin conditional assembly
            mov       0x22, D0      ;block to assemble if condition is fulfilled
#else
            mov       0x11, D0      ;block to assemble if unfulfilled
#endif
            .
            .
            .
```

# 7.5 Macro Control Statements

Macro control statements reduce coding effort by replacing strings coded in source statements with other strings. This enables low-level assembly language for a program block to be abstracted as a macro name.

Macros are coded in two formats: macro definitions and macro calls.

A macro definition defines a macro name and macro body. The macro body uses multiple machine language instructions to construct a single program process.

A macro call is just a macro name coded as a source statement. The assembler will replace it with all the machine language instructions coded in the macro body. This process is called macro expansion.

The basic difference between a macro call and a subroutine call is that a macro call actually outputs machine language instructions as source statements, with arguments used to output different machine language instructions for each call.

The example below shows macro control statements.

```
*macro definition------------------------------
adr_set           macro  data, reg
                  mov    reg, A0
                  mov    data, D0
                  mov    D0, (A0)
                  endm
                  .
                  .
                  .
*macro call-----------------------------------
                  adr_set          data1, reg1
                  .
                  .
                  .
                  adr_set          data2, reg2
                  .
                  .
                  .
```

# 7.6 Comment Statements

The comment statements start from:

1) an asterisk (*) in the beginning of the line

2) a semicolon (;) in the beginning or middle of the line

If you find an asterisk (*) in a line, the whole line is the comment statement.

If you find a semicolon (;) in a line, the sentence after the semicolon is the comment statement.

No matter what a comment is, it will not affect program operation of function. Comments are used to explain data structures, program algorithms, etc.

Comment statements are an important structural element of documentation. You should add comments that are detailed as possible to enhance program maintenance.

The example below shows comment statements.

```
************************************************
*       MN1030 Series Cross-Assembler          *
*       Sample Program                         *
************************************************
#include                “ram.h”          ;RAM definition file
#include                “macro.h”        ;macro definition file
#define                 VERSION          ;conditional assembly definition
*   Program Start
main
                        .
                        .
```

# 7.7 Blank Statements

A blank statement consists of a single carriage return. Blank statements are used to make printed lists easier to read.

# Chapter 8 Writing Source Statements

8

# 8.1 Purpose of This Chapter

This chapter explains common information for writing source statements. Source statements include machine language instruction statements, assembler control statements, and macro control statements.

This chapter explains how to code the characters and numbers that can be used when writing source statements, and it describes how to write character constants, address constants, location counters, and expressions.

# 8.2 Permitted Characters

There are three types of characters that can be coded in source statements for the cross assembler of this series.

### Digits

0 1 2 3 4 5 6 7 8 9

### Letters

Upper-case

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

Lower-case

a b c d e f g h i j k l m n o p q r s t u v w x y z

### Control characters

space

tab

carriage return

line feed

! ” # $ % & ’ ( ) * + – . , / ; : < = > ? @ \ ^ [ ] – _

# 8.3 Numbers

The cross assembler provides three coding formats for use in numbers and (single) character constants (refer to section 8.4, "Character Constants").

- Extended C language format
- Intel format
- Matsushita format

One of these formats is selected by using the notation directive. The default is extended C language format.

Four radices can be used.

- Radix 2 (binary)
- Radix 8 (octal)
- Radix 10 (decimal)
- Radix 16 (hexadecimal)

Any radix can be selected by using the radix directive (but only decimal is allowed in extended C language format). The default is decimal, regardless of coding format.

To code numbers with a radix other than the default, a fixed suffix indicating the radix is appended to the digits.

## Radices and allowed digits

| | |
|---|---|
| Radix 2(binary) | `0 1` |
| Radix 8(octal) | `0 1 2 3 4 5 6 7` |
| Radix 10(decimal) | `0 1 2 3 4 5 6 7 8 9` |
| Radix 16(hexadecimal) | `0 1 2 3 4 5 6 7 8 9 A B C D E F` or `A B C D E F` are hexadecimal digits that correspond to decimal `10 11 12 13 14 15.` Lower case letters can also be used. |

The next page shows how the various radices and formats are coded.

## Extended C language format

| Radix | Current default radix | | | |
|---|---|---|---|---|
| | Binary | Octal | Decimal | Hexadecimal |
| Binary | -- | -- | 0B101 | -- |
| Octal | -- | -- | 0765 | -- |
| Decimal | -- | -- | 789 | -- |
| Hexadecimal | -- | -- | 0XDEF | -- |

Coding rules:

| | |
|---|---|
| Binary | Start with '0' (zero) and letter 'B' (or 'b'), followed by binary digits. |
| Octal | Start with '0' (zero), followed by octal digits. |
| Decimal | Code decimal number as is. |
| Hexadecimal | Start with '0' and letter 'X' (or 'x'), followed by hexadecimal digits. |

## Intel format

| Radix | Current default radix | | | |
|---|---|---|---|---|
| | Binary | Octal | Decimal | Hexadecimal |
| Binary | 101B<br>101 | 101B | 101B | 101B |
| Octal | 567O<br>567Q | 567O<br>567Q<br>567 | 567O<br>567Q | 567O<br>567Q |
| Decimal | 789D | 789D | 789D<br>789 | 789D |
| Hexadecimal | 0defH | 0defH | 0defH | 0defH<br>0def |

Coding rules:

| | |
|---|---|
| Binary | Follow binary digits with letter 'B' (or 'b'). When the default is binary, the suffix 'B' may be omitted. |
| Octal | Follow octal digits with letter 'O' (or 'o') or 'Q' (or 'q'). When the default is octal, the suffix 'O' or 'Q' may be omitted. |
| Decimal | Follow decimal digits with letter 'D' (or 'd'). When the default is decimal, the suffix 'D' may be omitted. |
| Hexadecimal | Follow hexadecimal digits with letter 'H' (or 'h'). If the digits begin with a letter A – F, they must be prefixed with the digit '0' (zero). When the default is hexadecimal, the suffix 'H' may be omitted. |

## Matsushita format

| Radix | Current default radix | | | |
|---|---|---|---|---|
| | Binary | Octal | Decimal | Hexadecimal |
| Binary | B’101’<br>101 | B’101’ | B’101’ | B’101’ |
| Octal | O’567’ | O’567’<br>567 | O’567’ | O’567’ |
| Decimal | F’789’ | F’789’ | F’789’<br>789 | F’789’ |
| Hexadecimal | X7’def’ | X’def’ | X’def’ | X’def’<br>0def |

Coding rules:

| | |
|---|---|
| Binary | Start with letter 'B' (or 'b'), and enclose binary digits in single quotation marks ( ' ). When the default is binary, code the binary number as is. |
| Octal | Start with letter 'O' (or 'o'), and enclose octal digits in single quotation marks ( ' ). When the default is octal, code the octal number as is. |
| Decimal | Start with letter 'F' (or 'f'), and enclose decimal digits in single quotation marks ( ' ). When the default is decimal, code the decimal number as is. |
| Hexadecimal | Start with letter 'X' (or 'x'), and enclose hexadecimal digits in single quotation marks ( ' ). When the default is hexadecimal, code the hexadecimal number as is. When the number begins with a letter, prefix it with '0' (zero). |

# 8.4 Character Constants

ASCII characters ,which can be displayed, can be coded as character constants or string constants. The characters that can be used for constants are as follows.

- Digits
- Letters (upper or lower cases)
- Blank letters
- Special characters

NOTE: “\” letters make the following letters valid.
Example: ‘\”, ‘\\’, “\””, “\\”

## Character constants

A character constant is stored as an ASCII code in the space of a single character. The method for specifying character constants differs depending on the coding format.

The coding format is selected using the notation directive. The default is extended C language format.

NOTE: The coding format also applies to numbers. Refer to section 8.3, "Numbers", for details.

Coding rules:

In extended C format and Intel format, character constants are specified just with the character enclosed in single quotation marks ( ' ). In Matsushita format, the enclosed character is preceded by the letter 'C' (or 'c').

The character 'A' (ASCII code 042) is specified in each coding format as follows.

| Coding Format | Character Constant |
|---|---|
| Extended C language format | ‘A’ |
| Matsushita format | C’A’ or c’A’ |
| Intel format | ‘A’ |

Specifying more than one character (such as C’FEDCBA’ or ’FEDCBA’) will cause an error.

NOTE: To specify a single quotation mark or a backslash for a character constant, a backslash (\) precedes the character.

## String constants

String constants are strings of one or more characters stored as ASCII code. When a string constant is one character it will be the same as a character constant.

Coding rules:

String constants are specified by enclosing the string in double quotation marks ( " ).

"ABCDEFG" Specifies the string ABCDEFG as ASCII code.

"+-[&%$#@!,.;:'" Specifies the string +-[&%$#@!,.;:' as ASCII code.

NOTE: To specify a double quotation mark or a backslash in a character constant, a backslash (\) precedes the character

NOTE: Note that string constants are specified the same regardless of coding format. The coding format has no effect even when a single-character string constant is specified.

# 8.5 Address Constants

Address constants return particular bits from expressions that can be evaluated as addresses.

They are written as follows.

address_specifier (expression)

An address constant is written as an expression enclosed in parentheses following an address specifier. An expression consists of names, self-reference address symbols, and constants linked by operators, with the result representing a single value (refer to section 8.7, "Expressions", for details).

The address specifiers are shown below.

```
A  or  a  Return the lower 32 bits of the expression value (bits
0 to 31)).
```

Example:

Assume that the following address is assigned to the label with the name MESSAGE.

address= 00000000001110010101011011101001(binary)

a(MESSAGE) represents 00000000001110010101011011101001

The values expressed by MESSAGE and a(MESSAGE) are the same. In a context calling for the address value associated with a symbol, it is more common to use the symbol itself alone instead of adding the address specifier.

# 8.6 Location Counter

The assembler contains an variable for counting addresses of instructions. This variable is called the location counter. Each time the assembler converts an instruction to machine language, it increments the location counter by the number of words in that instruction.

Location counter values are first set during linking for each section defined by the section directive, so location counter values during assembly will not necessarily match the addresses assigned to instructions during execution. Location counter values during execution will be offset values from the start of each section.

The address of the current instruction can be coded as an asterisk (*). This asterisk is called the self-reference address symbol. By using a self-reference address symbol in the operand field of a source statement, you can reference the address assigned to that statement during execution.

# 8.7 Expressions

Expressions are symbols, self-reference address symbols, and constants linked by operators, with the result representing a single value. When an expression is coded as an operand, its result will be a number or an address depending on the type of instruction.

When a symbol or self-reference address included in an expression is a forward referenced symbol, a relocatable symbol, or an undefined symbol, the result of the expression cannot be resolved by the assembler. It will then be resolved by the linker.

---

NOTE: If a section name in the expression was used as a symbol, declaration with the section directive must be done in the file. Without doing this would lead an error in the assembler or linker.

Example:

```
sec     section CODE,PUBLIC,1
_TEXT   section CODE,PUBLIC,1
        mov      sec, A0
```

---

# 8.7.1 Operators

There are three types of operators.

- Arithmetic operators
- Shift operators
- Logical operators

## Arithmetic operators

Arithmetic operators perform the four standard arithmetic calculations.

| Operator | Meaning |
|---|---|
| * | Multiplication |
| / | Division |
| % | Modulo operator (remainder) |
| + | Addition |
| - | Subtraction |
| + | Unary plus (positive) |
| ~ | Unary minus (negative) |

| Formats: | Example: | | |
|---|---|---|---|
| operand1 | * | operand2 | 123 * LABEL |
| operand1 | / | operand2 | 123 / 10 |
| operand1 | % | operand2 | COUNT % 4 |
| operand1 | + | operand2 | SATRT + 0x10 |
| operand1 | – | operand2 | STACK – 16 |
| + operand | | | +SIGN |
| ~operand | | | -SIGN |

## Shift operators

The shift operators shift to the left or right in bit units.

| Operator | Meaning |
|---|---|
| >> | Logical right shift |
| << | Logical left shift |

Formats:

operand>>countADDRESS >> 3 3-bit right shift

operand<<countADDRESS << 4 4-bit left shift

Binary 0 (zero) will be shifted in. Shifted out bits will be lost.

## Logical operators

Logical operators perform calculation in bit units.

| Operator | Meaning |
|---|---|
| & | Logical AND |
| ^ | Exclusive OR |
| \| | Logical OR |
| - | Unary negation (1's complement) |

| Formats: | | Example: | |
|---|---|---|---|
| operand1 | & | operand2 | ADDRESS & MASK |
| operand1 | ^ | operand2 | CONST ^ 0b0011110000 |
| operand1 | \| | operand2 | VECT \| 0b0011110000 |
| ~operand | | | -MAIN |

## 8.7.2 Expression Evaluation

There are seven levels of operator precedence. The order of precedence can be changed using parentheses ( ). Operators with the same precedence are evaluated in order from left to right.

| Precedence | Operator | Description |
|---|---|---|
| Highest | ~ + - | Unary negation, unary plus, unary minus |
| | * / % | Multiplication, division, remainder |
| ↑ | + - | Addition, subtraction |
| ↑ | << >> | Left shift, right shift |
| ↑ | & | Logical AND |
| | ^ | Exclusive OR |
| Lowest | \| | Logical OR |

An example of operator is shown below.

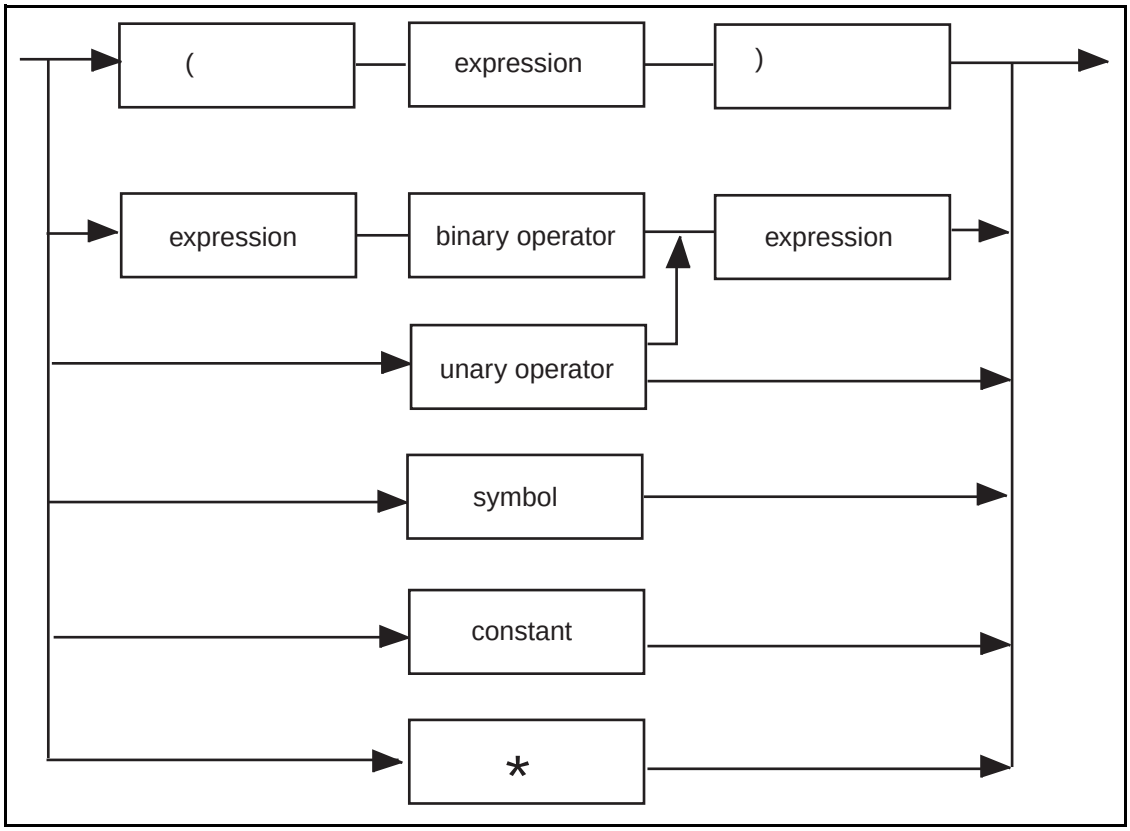
```
c1              equ             10
c2              equ             0b01101110

_CODE           section         CODE, PUBLIC, 1
data1           dc              c1/3*(3+4)
data2           dc              c1%3*(3+4)
data3           dc              -c2
data4           dc              ~c2
data5           dc              c2>>2
data6           dc              c1<<2
data7           dc              main>>2
data8           dc              c2>>2^0b00001111)>>2
data9           dc              (c2&0b00001111)
data10          dc              c2|0b00001111
                org             0x100
main            mov             c2 & 0b00001111, D0
                end
```

An asterisk * is used as both the self-reference address symbol and the multiplication operator, so take care in its use. The expression *** will be multiplication of the self-reference address symbol by itself.

## 8.7.3 Expression Syntax

Below is an expression syntax diagram




Expression Syntax

NOTE: When the expressions starting with parenthesis are coded to the operands of Machine language instructions, it will be regarded as an address-reference. To be proceeded as expressions, put 0+ before the parenthesis and distinguish them from others.

```
mov     (10+5), d0          ; move the value of address 15 to d0
                            ; equal to mov(15), d0
mov     (0+(10+5), d0       ; move the value of constant 15 to d0 equal to mov 15, d0
mov     (10+5)+2, d0        ; Error. "(10+5)" is regarded as an  address-reference.
                            ; It causes syntax error.
```

## 8.7.4 Expression Attributes

When expression operands are connected by an operator, the calculated result of the expression will have attributes of the operands and the operator.

The most important attributes for expression evaluation are as follows.

- Undefined (undefined-UND)
- Absolute (absolute-ABS)
- External (external-EXT)
- Relative (relocate-REL)

### Operation result attributes

The operation result attributes for the label itself or the labels are following four.

- UND: undefined attributes
  The label is undefined at the reference.
- ABS: absolute attributes
  The label is undefined with equ pseudo instruction. The value is not changed. The constant value written directly will be regarded as an absolute attribute.
- REL: relative attributes
  The label is already defined in the same file at the reference (the label referring forward).
- EXT: external reference attributes
  The label is declared with global pseudo instruction and defined by another file.

The rules for connecting attributes are as follows.

### For ~, +, – (unary) operators

| Attribute of Operand | Attribute of Result |
|---|---|
| UND | UND |
| ABS | ABS |
| REL | REL |
| EXT | EXT |

## For + (addition) operator

| + (addition) | | Operand 2 | | | |
|---|---|---|---|---|---|
| | | UND | ABS | REL | EXT |
| Operand 1 | UND | UND | UND | UND | UND |
| | ABS | UND | ABS | REL | EXT |
| | REL | UND | REL | REL | EXT |
| | EXT | UND | EXT | EXT | EXT |

## For - (subtraction) operator

operand1 - operand2

| -(SUBTRACTION) | | Operand 2 | | | |
|---|---|---|---|---|---|
| | | UND | ABS | REL | EXT |
| Operand 1 | UND | UND | UND | UND | UND |
| | ABS | UND | ABS | REL | EXT |
| | REL | UND | REL | REL | EXT |
| | EXT | UND | EXT | EXT | EXT |

## For *, /, %, <<, >>, &, ^ , | operators

operand1 operator operand2

| *, /, %, <<, >>, &, ^, \| | | Operand 2 | | | |
|---|---|---|---|---|---|
| | | UND | ABS | REL | EXT |
| Operand 1 | UND | UND | UND | UND | UND |
| | ABS | UND | ABS | REL | EXT |
| | REL | UND | REL | REL | EXT |
| | EXT | UND | EXT | EXT | EXT |

NOTE: The expressions writing in directive coding instructions and assembler control instruction must result in absolute attributes(ABS).

# 8.8 Reserved Words

The assembler gives special meanings to the symbols listed below, so they cannot be used for other purposes. These symbols are called reserved words.

Either all upper-case or all lower-case letters may be used to code reserved words, but they cannot be mixed within one reserved word.

- Machine language instruction mnemonics
- Port names
- Register names
- Address constants
- Directives
- Assembler control instructions
- Macro control instructions

Except for machine language instruction mnemonics and port names, the reserved words are listed below.

| | |
|---|---|
| Register name | `d0, d1, d2, d3, a0, a1,a2, a3, PSW, mdr, sp` |
| Address constants | `a` |
| Directives | `align, dc, ds, dw, end, equ, global, listoff, liston, xlistoff, xliston, notation, org, opt, page, radix, section, tit, funcinfo, assign` |
| Assembler control instructions | `define, if, ifb, ifdef, ifeq, ifge, ifgt, ifle, iflt, ifn, ifnb, ifndef, ifneq, include, undef` |
| Macro control instructions | `endm, exitm, irp, irpc, local, macro, purg, rept` |

# Chapter 9 Writing Machine Language Instruction Statements and Directive Statements

9

# 9.1 Purpose of This Chapter

This chapter explains how to write machine language instructions and directives.
There are five source statement formats

- Instruction statements that code machine language instructions and directives.
- Assembler control statements that code assembler control instructions
- Macro control statements that code macro control instructions
- Comment statements
- Blank statements

Each is coded differently.

This chapter explains in detail the code syntax and usage examples of machine language instructions and directives.

Refer to Chapter 8, "Writing Source Statements", regarding address constants, numeric constants, expressions, and the syntax rules for numbers and characters.

Refer to the "Instruction Manual" for detailed descriptions of machine language instructions.

# 9.2 Instruction Statement Fields

Source statements that code machine language instructions and directives are built from four fields.

[label] [operation [operand [, operand]]] [comment]
Contents of brackets [ ] can be omitted.

## Coding rules

Source statements may contain a label field only.
Depending on the operation, source statements may contain no operand.
Fields are delimited by at least one space or tab. Two operands are delimited by a comma (,).
A statement with an LF only, omitting all fields, is a blank statement.
Statements are terminated by the LF character (line feed = 0x0A).
The maximum number of characters on one line is 255.

## 9.2.1 Writing Label Field

Labels are called both symbols and names. The assembler assigns a label the value of the location counter at the point it is defined.

### Coding rules

Labels can use upper-case and lower-case letters, digits, underscores (_).

Labels are coded in the first column.

The first character of a label must not be a digit.

Labels are case sensitive.

The same label name cannot be defined twice.

When the label is omitted, it must be replaced with at least one space or tab.

Terminology: * Column
This is a column on the display or printer paper. One character takes one column. Columns are counted from the left as column 1, 2, etc.

### Coding examples

```
LABEL
LONGLABELLONGLABELLONGLABELLONGLAB
main
start_cont
```

The following examples are incorrect.

```
1LABEL          ; Starts with a digit
@START          ; Uses a prohibited character
 START          ; Does not start from the first column
```

## 9.2.2 Writing Operation Field

The operation field is written with a machine language instruction or directive.

### Coding rules

Machine language instructions cannot mix case. They must use either upper or lower case throughout.

### Coding examples

```
CONST1          equ             10
_CODE           section         CODE, PUBLIC, 2
start           mov             CONST1, D0
                rts
```

## 9.2.3 Writing Operand Field

The operand field coding is determined by the machine language instruction or directive in the operation field. Refer to the "Instruction Manual" for details on coding machine language instructions.

### Coding rules

Operands are written with expressions and reserved words (register names, etc.).

Operands cannot include spaces, except for character constants and string constants.

When two operands are coded, they must be delimited by a comma (,).

### Coding examples

```
        ROL     D0              ;One operand
        mov     CONST+3, D0     ;Operands are register and expression
        jsr     PRINT           ;Operand is an address
```

## 9.2.4 Writing Comment Field

The field that starts from a semicolon (;) after the operands is called the comment field. Comments coded in this position are called end-of-line comments, as opposed to comment statements where the entire line is a comment.

### Coding rules

Comments being with a semicolon (;) and end with a line feed (LF).

Comment fields may be written with letters, digits, special characters, and control characters other than carriage return and line feed.

### Coding examples

```
                mov             0x10, D0        ;Set count value
```

# 9.3 Writing Machine Language Instruction Statements

Each machine language instruction is defined by specific mnemonics. Mnemonics are formed from operations and operands accurately coded in the statement fields previously described.

Both upper-case and lower-case letters may be used.

Refer to the "Instruction Manual" for details of machine language instructions.

## Coding rules

When coding a label, insert at least one space or tab between it and the operation field.

When the label field is omitted, replace it with at least one space or tab.

Both upper-case and lower-case letters may be used.

Insert at least one space or tab between the operation field and operand field.

The assembler and linker optimization function will adjust conditional and unconditional branch instructions to generate the optimal code.

When a relative address is specified in an operand and only labels with specific addresses are coded, the assembler will calculate and set the relative values.

## Coding examples

```
START       mov       D0, (A0)     ;src=register, dst=register indirect
            mov       0x11, D0     ;src=immediate data, dst=register
            not       D0           ;negate
            rol       D0           ;rotate left
            ror       D0           ;rotate right
            and       0x0f, D0     ;logical AND
            or        0x30, D0     ;logical OR
            xor       D0, D1       ;exclusive OR
            add       D1, D0       ;addition
            sub       D1, D0       ;subtraction
            mul       D1, D0       ;multiplication
            divu      D1, D0       ;division
            cmp       0x05, D0     ;comparison
            bra       SUBR         ;unconditional branch
            jmp       (A0)         ;unconditional branch(register indirect)
            jsr       SUBR         ;subroutine call
            rts                    ;return from subroutine
```

# 9.4 Writing Directive Statements

Directives differ from machine language instructions in that they only have effect on the assembler. Directives specify program structure and start addresses, set constants and radices, and specify options and label attributes.

## List of directives

Below is a list of directives.

| Directive | Function |
|---|---|
| section | Specifies a section |
| align | Aligns the location counter value to a multiple of an expression. |
| end | Indicates the end of the program. |
| listoff | Stops list output from the line following this directive. |
| liston | Starts list output from this directive. |
| notation | Selects the coding format for numbers. |
| org | Changes the program address. |
| opt | Enables/disables optimization functions. |
| page | Specifies the number of columns and rows on one page of the list file. |
| radix | Selects the radix to be specified by default. |
| dc | Stores an 8-bit constant in a memory area. |
| ds | Reserves an 8-bit data area in a memory area. |
| dw | Stores a 16-bit constant in a memory area. |
| dd | Stores a 32-bit constant in a memory area. |
| equ | Defines a name as the value of an operand expression. |
| global | Declares external references with external declarations. |
| tit | Specifies the header name of the list file. |
| xlistoff | Stops list output including this directive. |
| xliston | Starts list output from the line following this directive. |
| funcinfo | Specifies additional information for a function. |
| assign | Defines a name as the value of an operand expression. |

## Document conventions

Symbols used in this chapter have the following meanings.

| | |
|---|---|
| [ ] | Contents of brackets [ ] may be omitted. |
| ( )... | Contents of parentheses ( ) may be repeated. |
| \| | Specify one or the other of the terms delimited by a vertical bar \|. |

## 9.4.1 section

### Syntax

| label | operation | operand |
|---|---|---|
| section_name | section | [definition1 [,definition2 [,expression]]] |

definition1 Section attribute (CODE or DATA)

definition2 Link type (PUBLIC)

(Note that the words PRIVATE and COMMON are reserved for use in expansion. However, they are treated as PUBLIC for now.)

expression Alignment factor for the location counter (2 to the specified power)

### Default settings

If the section name appears for the first time in the file, the following defaults are used.

definition1 CODE

definition2 PUBLIC

expression 1

For subsequent appearances of the section name, the section inherits the values from previous appearances.

### Functional description

The section directive specifies a section name, as well as its attribute, link type, and location boundary. During linking the linker gathers sections with the same name and links them together by attribute. The order of linking is determined by the link type and the order in which the linker encounters the sections.

### Section linking rules

1. Link sections in order of appearance.
2. Link by attribute.
3. Link by link type.

PUBLIC Link across all linked files.

## Operand coding rules

Only specific strings can be defined for definition1 and definition2. If some other string is defined, the assembler will generate an error and ignore this directive.

The value of expression must be a power of 2 between 1 and 32768, or 0. If its value is outside this range, the assembler will assume the closest valid value instead.

The attribute, link type, and location boundary of sections with the same name must be either identical or omitted. If a different attribute, link type, or location boundary is defined, actual value will be inherited from the setting of the very first section.

If there is the same section name in a file with a different attribute, link type, or location boundary, the linker warns.

## Directive coding rules

The section directive has no restrictions on where in the source file it can be defined.

## Usage example

Below is an example use of the section directive.

```
_CODE       section          CODE, PUBLIC, 2
main
            jsr        INIT
            .
            .
            .
```

NOTE: Assembler instructions and dc, dw, ds and dd directives must be coded after a section has been defined. If used before a section has been defined, the assembler will generate an error and ignore that assembler instruction or directive.

NOTE: The value for the section name will be the starting address in the same section after link. If separating the sections, the starting address of the lowest section will be used.

## 9.4.2 align

### Syntax

| label | operation | operand |
|---|---|---|
| | align | expression |

### Default settings

The current location counter value will be inherited.

### Functional description

The align directive adjusts the location counter to be a multiple of the value indicated by expression. The expression must be a power of 2 in the range 1 to $2^{15}$.

When the expression value is 4, the multiples of 4 will be the following series.

4, 8, 12, 16, 20, 24, 28, 32, ...

When the location counter value is 13, the statement after align 4 will have its location counter changed to 16. When the location counter is 23, the statement will have its location counter changed to 24. When the location counter is 30, the statement counter will have its location counter changed to 32.

Thus, the align directive rounds up the current location counter value up to the next greater multiple of the expression value.

### Operand coding rules

The attribute of the calculated result of the expression coded in the operand must be abs (absolute). For a discussion of expression attributes, see Chapter 8 “Writing Source Statements” Section 8.7 “Expressions”, 8.7.4 ”Expression Attributes”.

The expression value must be a power of 2 in the range 1 to $2^{15}$.

2, 4, 8, 16, 32, 64, 128, 256, ...

If the expression value is not a power of 2, the assembler will generate an error and round up to the next greater power of 2. In such a case, if the assembler's r option has been specified, the assembler will generate a relocatable object file even with the error.

When the expression value is between 5 to 7, it can be round up to 8. Also, when the expression value is between 17to 31,it can be round up to 32.

## Usage example

Below is an example use of the align directive.

```
                          align.lst Page 1
            ***  PanaX Series MN1030 Cross Assembler  ***
Loc         Object        Line     Source
                          1        _DATA   section  ,DATA, PUBLIC, 4
00000000                  2        TABLE
00000000    01            3                dc       0x01
00000001    02            4                dc       0x02
00000002    03            5                dc       0x03
                          6                align    6
align.asm(6) :Warning 2002: Illegal operand value.
00000008    04            7                dc       0x04
00000009    05            8                dc       0x05
0000000a    06            9                dc       0x06
                          10               align    8
00000010    07            11               dc       0x07
00000011    08            12               dc       0x08
                          13               align    16
00000020    09            14               dc       0x09
00000021    0A            15               dc       0x0a

                Errors:  0 Warnings: 1   (align.asm)
```

In the align 6 directive on line 6, the expression value 6 is not a power of 2, so the assembler will convert it to align 8.

The series of multiples of 8 is shown below. Numbers in parentheses are hexadecimal.

8(8) 16(10) 24(18) 32(20) 40(28) 48(30) 56(38) 64(40)

The location counter value at the line of align 6 is 0003 (hex.), which is between 0000 and 0008 (hex.).

Therefore the next line will start from location 0008 (hex.).

The same series applies to the align 8 on line 10. The location counter there is 000B (hex.), which is between 0008 and 0010 (hex.). Therefore the next line will start from location 0010 (hex.).

Similarly, the align 16 on line 13 uses the series 16 (10), 32 (20), 48 (30)... The location counter there is 0012 (hex.), which is between 0010 and 0020 (hex.). Therefore the next line will start from location 0020 (hex.).

## 9.4.3 end

### Syntax

```
label       operation operand
[name]      end
```

### Default settings

If the end directive is omitted, the assembler file will assume that the end of the file is the end of the program.

### Functional description

This directive is coded once at the end of a program. All text coded after the end directive will be ignored by the assembler (but it will be output to the source list).

When a name is coded in the label field, the current location counter value will be assigned to it.

### Operand coding rules

The end directive takes no operands. If operands are coded, they will cause an assembler syntax error.

### Usage example

Below is an example use of the end directive.

```
_CODE          section        CODE, PUBLIC, 2
main
               jsr            data_move
               mov            0, D0
               .
               .
               end
```

## 9.4.4 listoff, liston

### Syntax

| label | operation | operand |
|---|---|---|
| [name] | listoff | |
| | . | |
| | . | |
| | . | |
| [name] | liston | |

### Functional description

The listoff and liston directives are used in pairs. Statements from the statement following the listoff directive until the statement preceding the liston directive will not be output to the list file. These directives are used when you do not want to output an already debugged program to the list file.

NOTE: The listoff and liston directives themselves are output.

Only output to the list file will be suppressed. Output of object code will not be suppressed at all.

### Operand coding rules

These directives take no operands.

### Usage example

Below is an example use of the listoff and liston directives. The mov 0x22,D0 is a statement that should not be output to the list file.

```
_CODE           section         CODE, PUBLIC, 2
main
                mov             0x11, D0
                listoff
                mov             0x22, D0
                liston
                mov             0x33, D0
                end
```

# 9.4.5 notation

## Syntax

| label | operation | operand |
|---|---|---|
| | notation | CLANG \| INTE \| PANA |

## Default settings

CLANG will be selected.

## Functional description

This directive selects the format of numbers and character constants (single character).

The Cross-Assembler provides three numeric formats.

- Extended C language format
- Intel format
- Matsushita format

Each format gives a specific way to represent binary, octal, decimal, and hexadecimal numbers, as well as character constants.

The notation directive selects which format numbers and character constants will be coded with. This directive can be coded any number of times in a program.

Refer to Chapter 8 “Writing Source Statements”, section 8.7, "Expressions”, section 8.7.4 “Expression Attributes”.

## Operand coding rules

The strings that can be specified in the operand and the format that they select are listed below.

| operand | Format |
|---|---|
| CLANG | Extended C language format |
| INTEL | Intel format |
| PANA | Matsushita format |

If other strings are specified, the assembler will generate an error and ignore this directive.

## Usage example

Below is an example use of the notation directive.

```
                        notation.lst page 1
            ***  PanaX Series MN1030 Cross Assembler  ***
Loc         Object       Line      Source
                         1         _DATA    section  CODE, PUBLIC, 4
                         2                  notation INTEL
00000000    FF           3                  dc       11111111b
00000001    FF           4                  dc       377q
00000002    FF           5                  dc       377o
00000003    FF           6                  dc       255d
00000004    FF           7                  dc       0ffh
                         8                  notation CLANG
00000005    FF           9                  dc       0b11111111
00000006    FF           10                 dc       0377
00000007    FF           11                 dc       255
00000008    FF           12                 dc       0xff
                         13                 notation PANA
00000009    FF           14                 dc       b'11111111'
0000000a    FF           15                 dc       o'377'
0000000b    FF           16                 dc       f'255'
0000000c    FF           17                 dc       x'ff'
```

# 9.4.6 org

## Syntax

| label | operation | operand |
|---|---|---|
| | org | expression |

## Default settings

The current location counter value will be inherited.

## Functional description

This directive sets the location counter to the address value specified by expression.

## Operand coding rules

For the expression coded in the operand, the attribute of the calculation result must be abs(absolute).

For a discussion of attributes of expressions, see Chapter 8 “Writing Source Statements” Section 8.7 “Expressions” Section 8.7.4 “Expression Attributes”.

If the expression value is less than the current location counter, it causes an error.

## Usage example

Below is an example use of the org directive.

```
_CODE          section        CODE, PUBLIC, 2
sec_adr
               .
               instructions
               .
               org            0x20
sec_fnc
               .
               instructions
               .
               org            0x100
               .
               .
               .
               end
```

# 9.4.7 opt

## Syntax

| label | operation | operand |
|---|---|---|
| | opt | on \| off |

## Default settings

If omitted, opt off will be assumed.

## Functional description

This directive enables and disables the optimization functions of the assembler and linker.

The optimization applies only to conditional and unconditional branch instructions. The optimization function evaluates how the source statements are coded, and converts them to the optimal code with the linker.

While the linker is linking multiple files, it outputs the instructions with the smallest possible code size for the instructions subject to optimization.

Refer to chapter 4, "Optimization", for details.

NOTE: The -Od assembler option disables the optimization function, however, optimization will be enabled if opt on is coded in the source file

## Operand coding rules

The strings that can be coded for the operand and their meanings are as follows.

| | |
|---|---|
| opt on | Enables optimization. |
| opt off | Disables optimization. |

## Usage example

Below is an example use of the opt directive.

```
        opt         on
        opt         off
```

# 9.4.8 page

## Syntax

| label | operation | operand |
|---|---|---|
| | page | lines_expression [,columns_expression] |

## Default settings

Number of lines = 60

Number of columns = 132

## Functional description

This directive specifies the number of lines and columns per page. At the line where the page directive itself is specified the assembler will output a carriage return and apply the newly set values.

## Operand coding rules

The expressions coded in the operand must result in the attribute abs (absolute). Refer to section 8.7.4, "Expression Attributes", regarding attributes of expressions.

Specify the number of lines in the range 10 – 255. Specify the number of columns in the range 60 – 255.

If a value outside the allowable range is specified, the assembler will generate an error and ignore this directive.

## Usage example

Below is an example use of the page directive.

```
page        24, 80
page        LINE_NO, COLUMN_NO
```

# 9.4.9 radix

## Syntax

| label | operation | operand |
|---|---|---|
| | radix | expression |

## Default settings

Radix 10 (decimal).

## Functional description

This directive specifies the radix that will be used by default. The Cross-Assembler provides three coding formats for numbers.

- Extended C language format
- Intel format
- Matsushita format

The format is selected with the notation directive. Refer to the description of the notation directive. The default is extended C language format.

The radix directive specifies the default radix for numbers in these coding formats by the expression in the operand. Select one from radix 2 (binary), radix 8 (octal), radix 10 (decimal), and radix 16 (hexadecimal).

NOTE: In extended C language format, the default radix cannot be specified by the radix directive. The default is fixed as radix 10 (decimal), and it cannot be changed to another radix

## Operand coding rules

The expression coded in the operand must result in the attribute abs (absolute). Refer to section 8.7.4, "Expression Attributes", regarding attributes of expressions.

The calculated result of the expression coded in the operand must be either 2, 8, 10, or 16. The radix of the expression in the operand is always 10 (decimal), regardless of the current default radix. If the expression results in a number that does not specify a radix, the assembler will generate an error and ignore this directive.

## Usage example

Below is an example use of the radix directive.

```
        radix   16
        radix   BINARY
```

# 9.4.10 dc

## Syntax

| label | operation | operand |
|---|---|---|
| [name] | dc | constant \| expression (, constant \| expression )... |

## Functional description

This directive is used to define constants in a memory area. The 8-bit constant specified by the operand will be stored at the location of the statement specifying this directive.

When a name is coded for the label, the assembler will assign the current location counter value to that name.

## Operand coding rules

The expression coded in the operand must result in the attribute abs(absolute).

Refer to section 8.7.4 “Expression Attributes”, regafding attributes of expressions.

Specify one of the following constants or the operand.

- character constant
- string constant

The operands are delimited with commas (,). Any number of operands can be coded.

If data that exceeds 8 bits is specified, the lower 8 bits will be valid, and the upper bits will be lost. The assembler will output a warning message in such cases.

When the specified data has fewer than 8 bits, those bits will fill the lower bits, and the upper bits will be padded with zeroes.

## Usage example

Below is an example use of the dc directive.

```
                                        DC.LST    Page 1
            ***  PanaX Series MN1030 Cross Assembler  ***
Loc         Object      Line  Source
                        1     _DATA       section   DATA,PUBLIC,4
00000000    41          2     cd0  dc               'A'
00000001    414243      3     cd1  dc               "ABC"
00000004    3F          4     cd2  dc               255 >> 2
00000005    0E          5     cd3  dc               (12+3)/2*2
00000006    FF          6     cd4  dc               0b11111111
00000007    FFFE        7     cd5  dc               0377, 0376
00000009    FF          8     cd6  dc               255
```

# 9.4.11 ds

## Syntax

| label | operation | operand |
|---|---|---|
| [name] | ds | expression1 [, expression2 [, expression3]] |

| | |
|---|---|
| expression1 | Number of bytes of memory to reserve |
| expression2 | Initial value |
| expression3 | Number of iterations |

## Default settings

expression2 (initial value) If omitted, the assembler will assume 0.

expression3 (iterations) If omitted, the assembler will assume 1.

## Functional description

This directive reserves a memory area of the number of bytes specified by expression1 of the operand. When expression2 (initial value) is specified, that memory area will be filled with the initial value. Note that expression2 can be specified only when the value of expression1 is 4 or less. When expression3 (iterations) is specified, the same specification will be repeated for the number of iterations. For example, if the operand is 4, 0, 3, a 4-byte area will be filled with 0 three times. Thus, a 12-byte area will be reserved.

When a name is coded for the label, the assembler will assign the current location counter value to that name.

## Operand coding rules

The expression1 (bytes), expression2 (initial value), and expression3 (iterations) coded in the operand must result in the attribute abs (absolute). Refer to section 8.7.4, "Expression Attributes", regarding attributes of expressions.

NOTE: When expression2 is omitted, expression3 cannot be specified.

## Usage example

Below is an example use of the ds directive.

```
                                          DC.LST    Page 1
            ***  PanaX Series MN1030 Cross Assembler  ***
Loc       Object           Line  Source
                           1     _DATA      section   DATA, PUBLIC, 4
00000000  00               2     ds0  ds            1
00000001  1122             3          ds            2, 0x1122
00000003  3344556633445566 4     ds1  ds            4, 0x33445566,2
```

# 9.4.12 dw

## Syntax

| label | operation | operand |
|---|---|---|
| [name] | dw | expression (, expression )... |

## Functional description

This directive is used to define 16-bit constants in a memory area. The 16-bit constant specified by the operand will be stored at the location of the statement specifying this directive.

When a name is coded for the label, the assembler will assign the current location counter value to that name.

## Operand coding rules

The operands are delimited with commas (,). Any number of operands can be coded.

If data that exceeds 16 bits is specified, the lower 16 bits will be valid, and the upper bits will be lost. The assembler will output a warning message in such cases.

When the specified data has fewer than 16 bits, those bits will fill the lower bits, and the upper bits will be padded with zeroes.

## Usage example

Below is an example use of the dw directive.

```
                                dw.lst     Page 1
             ***  PanaX Series MN1030 Cross Assembler  ***
Loc         Object        Line  Source
                          1     _DATA      section   DATA, PUBLIC, 4
00000000    3930          2     dw0 dw               12345
00000002    34127856      3     dw1 dw               0x1234, 0x5678
00000006    0000          4     dw2 dw               0
```

# 9.4.13 dd

## Syntax

| label | operation | operand |
|---|---|---|
| [name] | dd | expression(, expression)... |

## Functional description

This directive is used to define 32-bit constants in a memory area. The 32-bit constant specified by the operand will be stored at the location of the statement specifying this directive.

When a name is coded for the label, the assembler will assign the current location counter value to that name.

## Operand coding rules

The operands are delimited with commas(,). Any number of operands can be coded.

When the specified data has fewer than 24 bits, those bits will fill the lower bits and the upper bits will be padded with zeros.

## Usage example

Below is an example use of the dw directive.

```
                              dd.LST     Page 1
            ***  PanaX Series MN1030 Cross Assembler  ***
Loc         Object       Line  Source
                         1                global   dd0, dd1, g_dd0
                         2       ;
                         3     _DATA      section  DATA, PUBLIC, 4
00000000    78563412     4     dd0        dd       0x12345678
00000004    00000000     +5                dd       dd0
00000008    00000000     +6    dd1        dd       g_dd0
```

# 9.4.14 equ

## Syntax

| label | operation | operand |
|---|---|---|
| name | equ | expression |

## Functional description

This directive defines the name to be the value of the expression coded in the operand. When that name is coded in the operand of machine language instructions or directive instructions, the assembler will reference the name's value.

System constants often used in programs (memory size, clock frequency, etc.) can be assigned to names that describe those values.

```
MEMORY    equ    0x20
MOTOR     equ    10
STOP      equ    0b00001000
BASE      equ    0x1000
```

This allows numbers used in programs to be coded as descriptive names instead, making programs easier to read. Furthermore, values can be changed just by modifying the equ directive, which in turn changes the data wherever it is used. This makes programs easier to maintain.

## Operand coding rules

The expression coded in the operand must result in the attribute abs (absolute). Refer to Section 8.7.4, "Expression Attributes", regarding attributes of expressions.

If the attributes of expressions are not the attribute abs (absolute), #define of the assembler control statement should be used, instead of the equ of the directive statement..

Names defined in other programs cannot be specified within expression.

Names defined once with the equ directive cannot be defined again.

No memory area is reserved when an equ directive statement is executed.

---

NOTE: Symbols with unresolved values cannot be coded in the operand. In the following example, the value of ram1 is not resolved at the point where the value of ram2 is to be resolved, so the assembler will generate an error.

Error example:

```
ram2    equ    ram1+0x1
ram1    equ    0x10
```

By changing the order such that the value of ram1 is resolved first, no error will occur.

No error example:

```
ram1    equ    0x10
ram2    equ    ram1+0x1
```

---

## Usage example

Below is an example use of the equ directive.

```
                              equ.lst     Page 1
            ***  PanaX Series MN1030 Cross Assembler  ***
Loc         Object        Line  Source
                          1     MEMORY      equ     0x20
                          2     MOTOR       equ     10
                          3     STOP        equ     0b00001000
                          4     BASE        equ     0x1000
                          5       ;
                          6     _TEXT       section CODE, PUBLIC, 1
00000000    8020          7                 mov     MEMORY, D0
00000002    800A          8                 mov     MOTOR, D0
00000004    8008          9                 mov     STOP, D0
00000006    2C0010        10                mov     BASE, D0
```

# 9.4.15 global

## Syntax

| label | operation | operand |
|---|---|---|
| [name] | global | name(, name)... |

## Default settings

External reference when omitted = undefined label error

External declaration when omitted = undefined label error during linking

## Functional description

This directive declares external references and external declarations.

For external references, the global directive declares that the names coded in the operand are from other files.

For external declarations, the global directive declares that the names coded in the operand can be referenced externally.

The global directive can be coded anywhere in a source programs.

## Operand coding rules

Write the name coded in the label field as an operand. Generally this will be a program name.

The names are delimited with commas (,). Any number of operands can be coded.

When a specified name has been coded in a label field within the program, it will be considered an external declaration. When it has been coded as operands, it will be considered an external reference.

## Usage example

Below is an example use of the global directive.

```
            global      SUB1          ;external declaration
            global      READ,         ;external reference
                        WRITE
main        jsr         READ
            .
            .
            jsr         WRITE
            .
            .
SUB1        mov         0x11, D0
            .
            .
            rts
            end
```

NOTE: If a section name was referred as an external label, declaration with the section directive, not with the global directive, is necessary.
Example:

```
sec     section CODE,PUBLIC,1
_TEXT   section CODE,PUBLIC,1
        mov      sec, A0
```

# 9.4.16 tit

## Syntax

| label | operation | operand |
|---|---|---|
| | tit | ["string"] |

## Functional description

This directive specifies that the string coded as its operand is to be output as the header of the list file. Typically the string is written with the program name, function, author, version, company, date, etc.

## Operand coding rules

The operand is written with any string enclosed by double quotation marks ("). A double quotation mark itself cannot be included in the string.

## Usage example

Below is an example use of the tit directive.

```
                                TIT.LST  Page 1
***  TEST PROGRAM  ***
Loc         Object    Line      Source

                      1         tit      “*** TEST PROGRAM***
000000      54        2         dc       0x54
                      3         end
                      4
```

# 9.4.17 xlistoff, xliston

## Syntax

```
label       operation       operand
[name]      xlistoff
              .
              .
              .
            xliston
```

## Functional description

The xlistoff and xliston directives are used in pairs. Statements from the xlistoff directive until the xliston directive will not be output to the list file. These directives are used when you do not want to output an already debugged program to the list file.

NOTE: The xlistoff and xliston directives themselves are not output.

Only output to the list file will be suppressed. Output of object code will not be suppressed at all.

## Operand coding rules

These directives take no operand.

## Usage example

Below is an example use of the xlistoff and xliston directives. The range from xlistoff to xliston will be suppressed.

```
_CODE       section     CODE, PUBLIC, 2
main
            mov         0x11, D0
            xlistoff
            mov         0x22, D0
            xliston
            mov         0x33, D0
            end
```

# 9.4.18 funcinfo

## Syntax

| label | operation | operand |
|---|---|---|
| function_name | funcinfo | label_name, expression, register list |
| where | expression: Stack frame size | |

## Functional description

This directive provides additional information about a function name specified as the operand to a call instruction. The call instruction branches to the function after saving registers to the stack and setting up the stack frame. To use call instructions, the program must define the stack frame size and the registers to be saved using a special format in the function's declaration section. This special format takes the form of the funcinfo directive.l

The linker uses the specified stack size and register list to automatically set up the proper calling sequences for calls to the function.

## Operand coding rules

The label_name gives the branch target used by instructions other than the call instruction--the call instruction, for example. This label_name is necessary even if no other instructions call it. In that case, assign a label to any empty statement immediately preceding the funcinfo directive and use the name of that label. The label_name must be defined prior to the funcinfo directive. Otherwise, an error results. The expression gives the size of the stack frame used by the function. It must evaluate to a value between 0 and255. A value outside this range results in an error. The register list gives a list of registers to be saved to the stack before entering the function proper. Enclose the list in square brackets ([ ]) and separate the registers in the list with commas. The registers that can appear in the list are D2, D3, A2, A3 and OTHER, where OTHER indicates D0, D1, A0, A1, MDR, LIR. A register specification other than these five results in an error.

NOTE: When writing directive statements in between the function and label_name, it may not link properly or it may create a bad execution format.

NOTE: Optimization can be performed for the instructions between label_name and the function name. For details, see Chapter 4 "Optimization Functions" Section 4.3 "Usage Examples", "Optimization of function calls".

## Directive Specification Rules

The funcinfo directive must always define a branch target label for use with the call instruction.

## Usage Example

The following gives an example of funcinfo usage.

```
                global          _0func
_TEXT           section         CODE, PUBLIC, 1
                  :
                call            _0func
                  :
                global          _0func, _func
_TEXT           section         CODE, PUBLIC, 1
_func
                movm            [D2], (SP)
                add             -4, SP
_0func          funcinfo        _func, 8, [D2]
                  :
                  :
                ret
```

NOTE: The ret and retf instructions free the stack frame and restore registers from the stack.
The assembler bases this code on the information provided by the funcinfo directive. For this reason, the ret and retf instructions cannot precede the funcinfo directive.

# 9.4.19 assign

## Syntax

| label | operation | operand |
|---|---|---|
| name | assign | expression |

## Functional description

This directive defines the name to be the value of the expression coded in the operand. When that name is coded in the operand of machine language instructions or directive instructions, the assembler will refer the name's value.

## Operand coding rules

The expression coded in the operand must result in the attribute abs (absolute).

Refer to Chapter 8, "Writing Source Statements", section 8.7, "Expressions", section 8.7.4, "Expression Attributes", regarding attributes of expression.

Names defined with the assign directive can be defined again with the assign directive.

Names defined with the assign directive cannot be declared external references or external declarations.

No memory ares is reserved when an assign directive statement is executed.

## Usage examples

The example below is a use of the assign directive.

```
                                          assign.lst        Page 1
            ***  PanaX Series MN1030 Cross Assembler  ***
Loc         Object       Line  Source
                         1     _TEXT       section  CODE, PUBLIC, 1
                         2     NUM         assign   0x01
00000000    8001         3                 mov      NUM, D0
                         4
                         5     NUM         assign   0x02
00000002    8002         6                 mov      NUM, D0
```

NOTE: If a name defined with this directive is used, you must define the value before the statement.

# Chapter 10 Writing Assembler Control Statements

10

# 10.1 Purpose of This Chapter

Assembler control statements are statements that control assembler processing. They specify include files and refinement of the identifier and control conditional assembly.

Include files are used to place definitions of constants, memory areas, I/O ports, and bit assignments common to the entire program in separate files. They read in during assembly.

Identifier definement names a variable or a set of steps, and replace the name (the identifier) to the string that has been defined.

Conditional assembly allows the assembler to evaluate conditions, and then to select a block of statements to assemble depending on whether the conditions are fulfilled or not.

This chapter describes these functions and how to code them, and provides examples of actual use.

Many directives used in conditional assembly are used only within macro definitions. Refer to chapter 11, "Writing Macro Statements", as needed.

## Common coding rules

Here are some rules common to coding of all assembly control statements.

The assembler directive should be coded from the first column of its statement. Both upper and lower case letters can be used.

The characters that can be used as identifiers are upper and lower case letter, digits, and underscores ( _ ). However, the first character must not be a digit.

Further conditional assembly directives can be used within a block of conditional assembly directives. Up to 255 nesting levels are allowed.

The #else directive and the second block can be omitted. Refer to section 10.4, "Conditional Assembly", for details about the second block.

An expression combines symbols, self-reference address symbols, and constants with operators into an equation that returns a single value as its result. The value must have the attribute abs (absolute). Refer to section 8.7, "Expressions", regarding attributes of expressions.

## Document conventions

Symbols used in this chapter have the following meanings.

| | |
|---|---|
| [ ] | Contents of brackets [ ] may be omitted. |

# 10.2 File Inclusion

The file inclusion is an assembler control instruction that reads the specific file to the source file. It is used for the following purpose.

- Using same macro or same declarations variables in several source files

## 10.2.1 #include

### Syntax

#include ”filename”

### Functional description

This directive causes the assembler to read in the source file with the specified name at the location of the directive.

NOTE: The included file will be assembled and output to the relocatable object file and list file. In order for the list file to show that lines were included as part of an include file, a period (.) will be prefixed before the line number.

By specifying the assembler's Li option, you can suppress output of include files to the list file.

### Coding rules

The file is specified by the file name enclosed in double quotation marks ("). If the file is in a different directory, the file name specification must include the path name. The assembler will assume an .ASM extension if the extension is omitted.

NOTE: By adding the I option when starting the assembler, you can specify a path name for include files. However, even in this case the option will be ignored if a specific path name is coded within "filename".

NOTE: As the assembler ignores all text after the directive coding rules, end directive coding rules should not be written in a file captured with “include”.

## Usage example

The following example illustrates the use of an include file.

The file inc.h consists of the following statement.

```
data        equ         0x12
```

The file to be assembled consists of the following statements.

```
#include    “inc.h”
_TEXT       section     CODE, PUBLIC, 1
main
            mov         data, A0
            mov         0x34, D0
            mov         D0, (A0)
            end
```

The above file is assembled with the file inc.h included. For this reason, at points after the #include statement, the operand data is interpreted as the numerical value 0x12.

# 10.3 Identifier Definement

Identifier definement names a variable or a set of steps, and replace the name (the identifier) in the source code to the string that has been defined.

It is used for the following purposes.

- If the same process or the same variable has been used several times
- To make clear of the meaning of the process or the variable

# 10.3.1 #define

## Syntax

#define [replacement_string] [; comment]

## Functional description

This directive causes the assembler to replace the identifier with the replacement_string on all further lines.

The #define directive differs from the #equ directive in that a string can be specified. Furthermore, when used in conjunction with the #undef directive, redefinition is possible.

## Coding rules

Any string can be coded for the replacement_string. The string can include spaces and tabs. If the replacement_string is omitted, the identifier will be defined as a null character.

Everything after a semicolon (;) is considered a comment. Therefore semicolons cannot be included in the replacement_string.

The same identifier cannot just be redefined with another #define directive. When used in conjunction with the #undef directive, redefinition is possible. Refer to section 10.4, "#undef", for details.

If the replacement_string is omitted, the identifier will be defined as a null character.

## Usage example

Source file contents are shown below. The first line replaces data with the character 5. The next line is an example of changing a mnemonic, so mov data,D0 can be coded as load.

```
#define     data        5
#define     load        mov             data, D0

_CODE       section     CODE, PUBLIC,2
main
                        mov             data, D0
            load
                        end
```

## 10.3.2 #undef

### Syntax

```
#undef          identifier
```

### Functional description

This directive deletes an identifier defined by a #define directive. The effective range of an identifier is from the line following #define until the line before #undef.

To redefine the replacement string of an identifier, redefine it with #define after performing an #undef.

### Coding rules

The identifier for an #undef directive must be the same string as the identifier for the corresponding #define directive. The string is case sensitive.

### Usage example

A source file that uses #undef is shown below.

```
#define       data1         0x11
#define       data2         0x22
_CODE         section       CODE, PUBLIC, 2
              mov           data1, D0
              mov           data2, D1
#undef        data1
              mov           data1, D0
#undef        data2
#define                     data1     0x33
#define                     data2     0x44
              mov           data1, D0
              mov           data2, D1
              end
```

# 10.4 Conditional Assembly

The cross assembler provides conditional assembly capabilities. The directives explained in this section are provided for this purpose.

By coding conditional assembly directives in a program, the assembler will select which block to assemble by judging the specified conditions at the time of assembly.

Many conditional assembly directives are used only within macro definitions.

The actual program structure of conditional assembly is shown below.

```
#if                     expression, identifier, parameter, etc.
            block1 to be    assembled if condition is true
[#else
            block 2 to be   assembled if condition is false]
#endif
```

NOTE: The contents of brackets [ ] from #else on can be omitted.

The basic function of conditional assembly directives are for the assembler to evaluate the condition specified by #if, and then to select the block to assemble based on the result.

Conditional assembly directives are used for the following purposes.

- Different object code for different versions can be output with a single source program.
- Machine language instructions differ depending on the device type.
- Conditional assembly directives can be included in programs being debugged.

The table below lists the conditional assembly directives.

| Directive | Condition for selecting block1 | Condition for selecting block2 |
|---|---|---|
| #ifdef | Identifier has been defined by #define. | Identifier has not been defined. |
| #ifndef | Identifier has not been defined by #define. | Identifier has been defined. |
| #if | Expression value is not 0. | Expression value is 0. |
| #ifn | Expression value is 0. | Expression value is not 0. |
| #ifeq (see note) | Parameters 1 and 2 are the same string. | Parameters 1 and 2 are not the same string. |
| #ifneq (see note) | Parameters 1 and 2 are not the same string. | Parameters 1 and 2 are the same string. |
| #iflt | Expression value is negative. | Expression value is not negative. |
| #ifle | Expression value is 0 or negative. | Expression value is not 0 and not negative. |
| #ifgt | Expression value is positive. | Expression value is not positive. |
| #ifge | Expression value is 0 or positive. | Expression value is not 0 and not positive. |
| #ifb (see note) | Parameter is the null character. | Parameter is not the null character. |
| #ifnb (see note) | Parameter is not the null character. | Parameter is the null character. |

NOTE: These directives can be used only within macro definitions

# 10.4.1 #ifdef, #ifndef

## Syntax

Syntax for #ifdef

```
#ifdef    identifier
          block1
[#else
          block2]
#endif
```

Syntax for #ifndef

```
#ifndef   identifier
          block1
[#else
          block2]
#endif
```

## Functional description

#ifdef

If the identifier has been defined by a #define directive before the #ifdef statement, block1 will be assembled. If it has not been defined and an #else directive has been coded, block2 will be assembled.

#ifndef

If the identifier has not been defined by a #define directive before the #ifndef statement, block1 will be assembled. If it has been defined and an #else directive has been coded, block2 will be assembled.

## Coding rules

These directives can be used within macro definitions and wherever machine language instructions can be coded.

If an identifier is defined after #ifdef or #ifndef, it will be considered undefined.

Identifiers can be specified by the D option when the assembler is started, even if they are not defined with #define directives.

## Usage example

A source file that uses #ifdef and #ifndef is shown below.

```
#define       VERSION
_TEXT         section       CODE, PUBLIC,1
#ifdef        VERSION
              mov           0x01, D0
#else
              mov           0x02, D0
#endif
#ifndef       VERSION
              mov           0x03, D1
#else
              mov           0x04, D1
#endif
```

The assembled list file is shown below.

```
                                    ifdef.lst   Page 1
           ***   PanaX Series MN1030 Cross Assembler    **
Loc       Object    Line   Source
                    1      #define     VERSION
                    2
                    3      _TEXT       section     CODE, PUBLIC, 1
                    4      #ifdef      VERSION
00000000  8001      5                  mov         0x01, D0
                    6      #else
                    7x                 mov         0x02, D0
                    8      #endif
                    9      #ifndef     VERSION
                    10X                mov         0x03, D1
                    11     #else
00000002  8504      12                 mov         0x04, D1
                    13     #endif
```

The identifier VERSION is defined in line number 1. The replacement string is a null character. Since VERSION has been defined, the #ifdef starting from line number 4 will assemble block 1 (line number 5 here), and will not assemble block 2 (shown as line number X).

The #ifndef directive inverts the condition, so block 2 (line number 12) will be assembled.

## 10.4.2 #if, #ifn

### Syntax

Syntax for #if

```
#if         expression
            block1
[#else
            block2]
#endif
```

Syntax for #ifn

```
#ifn        expression
            block1
[#else
            block2]
#endif
```

### Functional description

#if

If the value of expression is not 0, block1 will be assembled. If it is 0 and an #else directive has been coded, block2 will be assembled.

#ifn

If the value of expression is 0, block1 will be assembled. If it is not 0 and an #else directive has been coded, block2 will be assembled.

### Coding rules

These directives can be used within macro definitions and wherever machine language instructions can be coded.

## Usage example

A source file that uses #if and #ifn is shown below.

```
DEVICE          equ             1
_TEXT           section         CODE, PUBLIC, 1
#if             DEVICE-1
                mov             0x01, D0
#else
                mov             0x02, D0
#endif
#ifn            DEVICE-1
                mov             0x03, D0
#else
                mov             0x04, D0
#endif
```

The assembled list file is shown below. The program first sets DEVICE to 1. Therefore the expression DEVICE-1 will be 0, so the #if directive causes line number 7 to be assembled and the #ifn directive causes line number 10 to be assembled.

```
                                        if.lst      Page 1
          ***   PanaX Series MN1030 Cross Assembler     ***
Loc       Object    Line   Source
          =00000001 1      DEVICE      equ         1
                    2
                    3      _TEXT       section     CODE, PUBLIC, 1
                    4      #if         DEVICE-1
                    5X                 mov         0x01, D0
                    6      #else
00000000  8002      7                  mov         0x02, D0
                    8      #endif
                    9      #ifn        DEVICE-1
00000002  8503      10                 mov         0x03, D1
                    11     #else
                    12X                mov         0x04, D1
                    13     #endif
```

## 10.4.3 #ifeq, #ifneq

### Syntax

Syntax for #ifeq

```
#ifeq     parameter1, parameter2
          block1
[#else
          block2]
#endif
```

Syntax for #ifneq

```
#ifneq    parameter1, parameter2
          block1
[#else
          block2]
#endif
```

### Functional description

#ifeq

If parameter1 and parameter2 are the same string, block1 will be assembled. If they are different and an #else directive has been coded, block2 will be assembled.

#ifneq

If parameter1 and parameter2 are different strings, block1 will be assembled. If they are the same and an #else directive has been coded, block2 will be assembled.

### Coding rules

These directives can only be used within macro definitions.

Either or both of parameter1 and parameter2 may be dummy parameters set up during macro definition.

## Usage example

A source file that uses #ifeq and #ifneq is shown below. The macro named compare uses two dummy parameters(data1,data2). Within the macro it compares the strings of those dummy parameters. If they match, an instruction that sets the A register to 1 will be assembled. If they do not match, an instruction that sets the A register to 0 will be assembled. The macro is called by specifying strings to be passed to the dummy parameters.

```
compare     macro           data1, data2
#ifeq       data1, data2
            mov             0x01, D0
#else
            mov             0x02, D0
#endif
            endm
;
_TEXT       section         CODE, PUBLIC, 1
            compare         abc, abc
            compare         abc, acb
```

The assembled list file is shown below. Line number 11 assembles the statements for a match, and line number 12 assembles the statements for a mismatch.

```
                                    ifeq.lst      Page 1
          ***   PanaX Series MN1030 Cross Assembler     ***
Loc       Object    Line   Source
                    1      compare     macro         data1, data2
                    2      #ifeq       data1,data2
                    3                  mov           0x01, D0
                    4      #else
                    5                  mov           0x02, D0
                    6      #endif
                    7                  endm
                    8      ;
                    9      _TEXT       section       CODE, PUBLIC, 1
                    M10                compare       abc, abc
                    10+    #ifeq       abc, abc
00000000  8001      10+                mov           0x01, D0
                    10+    #else
                    10X                mov           0x02, D0
                    10+    #endif
                    M11                compare       abc, acb
                    11+    #ifeq       abc, acb
                    11X                mov           0x01, D0
                    11+    #else
00000002  8002      11+                mov           0x02, D0
                    11+    #endif
```

# 10.4.4 #iflt, #ifle

## Syntax

Syntax for #iflt

```
#iflt       expression
            block1
[#else
            block2]
#endif
```

Syntax for #ifle

```
#ifle       expression
            block1
[#else
            block2]
#endif
```

## Functional description

#iflt

If the value of expression is negative, block1 will be assembled. If it is not negative and an #else directive has been coded, block2 will be assembled.

#ifle

If the value of expression is 0 or negative, block1 will be assembled. If it is positive and an #else directive has been coded, block2 will be assembled.

## Usage example

The first example will be of #iflt. A source file is shown below. The "size-16" expression of the #iflt is not negative, so block 2 is assembled

```
MNXXX       equ             32
;
dsize       macro           size
#iflt       size-           32
            mov             0x01, D0
#else
            mov             0x02, D0
#endif
            endm
_TEXT       section         CODE, PUBLIC, 1
            dsize           MNXXX
```

The assembled list file is shown below.

```
                                        iflt.lst    Page 1
          ***   PanaX Series MN1030 Cross Assembler     ***
Loc       Object       Line   Source
                       1      MNXXX     equ         32
                       2      ;
                       M3     dsize     macro       size
                       4      #iflt     size-       32
                       5                mov         0x01, D0
                       6      #else
                       7                mov         0x02, D0
                       8      #endif
                       9                endm
                       10     ;
                       11     _TEXT     section     CODE, PUBLIC, 1
                       M12              dsize       MNXXX
                       12+    #iflt     MNXXX-      32
                       12X              mov         0x01, D0
                       12+    #else
00000000  8002         12+              mov         0x02, D0
                       12+    #endif
```

# 10.4.5 #ifgt, #ifge

## Syntax

Syntax for #ifgt

```
#ifgt    expression
         block1
[#else
         block2]
#endif
```

Syntax for #ifge

```
#ifge    expression
         block1
[#else
         block2]
#endif
```

## Coding rules

#ifgt

If the value of expression is positive, block1 will be assembled. If it is not positive and an #else directive has been coded, block2 will be assembled.

#ifge

If the value of expression is 0 or positive, block1 will be assembled. If it is negative and an #else directive has been coded, block2 will be assembled.

Note that 0 is not included in positive numbers.

## Usage example

A source file that uses #ifgt is shown below.

```
DEVICE      equ         1
_TEXT       section     CODE, PUBLIC, 1
#ifgt       DEVICE-1
            mov         0x01, D0
#else
            mov         0x02, D0
#endif
#ifge       DEVICE-1
            mov         0x03, D1
#else
            mov         0x04, D1
#endif
```

The assembled list file is shown below. You can see that the expression's value is 0, so block 2 was assembled.

```
                                        ifgt.lst    Page 1
          ***   PanaX Series MN1030 Cross Assembler     ***
Loc       Object       Line   Source
                       1      DEVICE     equ         1
                       2      ;
                       3      _TEXT      section     CODE, PUBLIC, 1
                       4      #ifgt      DEVICE-1
                       5                 mov         0x01, D0
                       6      #else
00000000  8002         7                 mov         0x02, D0
                       8      #endif
                       9      #ifge      DEVICE-1
00000002  8503         10                mov         0x03, D1
                       11     #else
                       12X               mov         0x04, D1
                       13     #endif
```

# 10.4.6 #ifb, #ifnb

## Syntax

Syntax for #ifb

```
#ifb        dummy_parameter
            block1
[#else
            block2]
#endif
```

Syntax for #ifnb

```
#ifnb       dummy_parameter
            block1
[#else
            block2]
#endif
```

## Functional description

#ifb

If the dummy_parameter is a null character, block1 will be assembled. If it is not a null character and an #else directive has been coded, block2 will be assembled.

#ifnb

If the value of expression is not a null character, block1 will be assembled. If it is a null character and an #else directive has been coded, block2 will be assembled.

## Coding rules

These directives can only be used within macro definitions.

The parameter must be a dummy parameter.

## Usage example

A source file that uses #ifb is shown below. If the dummy parameter para to the macro debug is a null character, the program will execute next_cycle. If it is not a null character, the program will execute test and then execute next_cycle. In this example, the identifier MODE is passed to the macro debug. When a replacement string has been specified, the call is without a null character.

```
            global      check           proc
;
debug       macro       string
#ifb        string
            jsr         check
            jsr         proc
#else
            jsr         proc
#endif
            endm
;
_TEXT       section     CODE, PUBLIC,
                        1
#define     MODE        debug_on
            debug       MODE
#undef      MODE
#define     MODE
            debug       MODE
```

The assembled list file is shown below. Where the characters debug_on have been specified, block 2 is assembled. Where the null character has been specified, block 1 is assembled.

```
                                          ifb.lst    Page 1
          ***   PanaX Series MN1030 Cross Assembler     ***
Loc       Object            Line   Source
                            1              global     check,proc
                            2      ;
                            M3     debug     macro      string
                            4      #ifb      string
                            5              jsr        check
                            6              jsr        proc
                            7      #else
                            8              jsr        proc
                            9      #endif
                            10             endm
                            11     ;
                            12     _TEXT     section    CODE, PUBLIC, 1
                            13     #define   MODE       debug_on
                            M14            debug      MODE
                            14+    #ifb      debug_on
                            14X            jsr        check
                            14X            jsr        proc
                            14+    #else
00000000  F8FEFCFCFF000000  +14+           jsr        proc
00000008  00F8FE04          14+
                            14+    #endif
                            15     #undef    MODE
                            16     #define   MODE
                            M17            debug      MODE
                            17+    #ifb
0000000c  F8FEFCFCFF000000  +17+           jsr        check
00000014  00F8FE04          17+
00000018  F8FEFCFCFF000000  +17+           jsr        proc
00000020  00F8FE04          17+
                            17+    #else
                            17X            jsr        proc
                            17+    #endif
```

# Chapter 11 Writing Macro Control Statements

11

# 11.1 Purpose of This Chapter

Macros consist of two parts: macro definitions and macro calls. A macro that has been defined can be coded as a macro call in any source statement after that.

When a macro without parameters is called, it becomes a simple text substitution. When a macro with parameters is called, part of the text to be substituted will be modified by the strings specified as the parameters.

This chapter explains how define and call macros. It also describes the directives used for macros.

## Common coding rules

The characters that can be used for macro names, dummy parameters, parameters, and identifiers are upper and lower case letters, digits, and underscores (_). The first character must not be a digit.

Symbols used in expressions must have been previously defined.

The following directives cannot be coded within macro blocks.

```
#include directive
macro definitions
```

Refer to section 11.2, "Macro Definitions", regarding macro definitions and blocks.

The rept and irp directives and macro calls can be coded within macro blocks. Up to 20 nesting levels are allowed.

A dummy parameter appearing in a string or character constant inside the macro is not expanded.

## Document conventions

Symbols used in this chapter have the following meanings.

| | |
|---|---|
| [ ] | Contents of brackets [ ] may be omitted. |
| ( ) | Contents of parentheses ( ) may be repeated. |

# 11.2 Macro Definitions (macro, endm)

## Syntax

```
macro_name    macro      [dummy_parameter (, dummy_parameter)...]
              macro_body
              endm
```

NOTE: Up to 10 dummy parameters can be specified.

## Functional description

A macro assigns a name to a single process that is used repeatedly in a program, simplifying the coding of source statements. Macros must be defined before they are called.

The macro body is coded with multiple machine language instructions, directives, macro control instructions, and conditional assembly control instructions. A macro definition is the assignment of a name to the single process in the macro body.

A macro is called by coding its name in the operation field of a source statement. The assembler then inserts the text of the macro body at that position. This is called macro expansion.

Macro definitions can have up to 10 dummy parameters. Dummy parameters are used within the macro body to allow the caller to modify some of the expanded text.

Reference:

Subroutines have similar functions, but macros and subroutines differ on the following points.
1) Macro expansion actually writes the macro body's machine language code in the object file each time the macro is called at that call's position. For subroutines, the subroutine body exists at one location in the program.
2) By using parameters, macro expansion allows the programmer to change the expanded machine language instructions each time the macro is called. For subroutines, the process cannot be changed.

## Coding rules

The following instructions cannot be used within macro definitions.

- include directive
- macro directive — within a macro definition another different macro cannot be defined
- purge directive — within a macro definition macros cannot be purged

The symbols used in the label fields within a macro definition must be declared with the local directive or passed from the outside using dummy parameters. Refer to section 11.5, "Local Symbol Declaration (local)", for details.

A macro can be redefined. The new definition will be effective from the following line on.

The purge directive can purge a macro definition. The macro will be recognized as an instruction or symbol from the following line on.

The macro name cannot be the same as a machine language mnemonic.

The assembler does not perform syntax checks when a macro is defined. If there are errors or warnings, they will be output when the macro is expanded.

## Usage example

An example macro definition is shown below.

```
xchg        macro
            mov         D2, D0
            mov         D1, D2
            mov         D0, D1
            endm
```

# 11.3 Macro Calls and Expansion

## Syntax

macro_name [parameter (, parameter)... ]

NOTE: Up to10 dummy parameters can be specified.

## Functional description

A macro is called by coding its name in the operation field of a source statement. The assembler then inserts the text of the macro body at that position.

When parameters are specified, their values are passed in the same order as the dummy parameter when the macro was defined.

```
mac1    macro       para1, para2, para3        ;macro definition
        .
        .
        endm
main    mac1        address, data, count       ;macro call
```

In this example para1, para2, and para3 are dummy parameters. The parameters of the macro call are passed to the dummy parameters as follows.

para1 = address

para2 = data

para3 = count

## Coding rules

Any string can be specified as a parameter. To specify a string that includes commas or spaces, use the macro operator <>. Refer to section 11.4 "Macro Operators", for details.

If there are more parameters than there were dummy parameters in the macro definition, an error will occur.

If there are fewer parameters than there were dummy parameters in the macro definition, the assembler will process the remaining parameters as though null characters were specified.

In the list file, the line numbers of source statements with macro calls will be prefixed by the letter 'M'. The source statements resulting from macro expansion will have a '+' appended to the line number.

## Usage example

A source file is shown below. The macro add_adr has one dummy parameter. The dummy parameter is used as the operand of an add machine language instruction within the macro body. Take note whether a macro name is the same as a machine language instruction.

The macro is called with var1 and var2 as parameters.

```
var1        equ         0x10
var2        equ         var1+2
add_adr     macro       adr
            add         adr, A0
            endm
_CODE       section     CODE, PUBLIC, 2
main
            add_adr     var1
            add_adr     var2
            end
```

---

Reference:

By adding the Lm option when the assembler is started, you can suppress the output of mnemonics of macros expanded by the assembler.

---

# 11.4 Macro Operators

Macro operators are used in macro bodies to operate on parameters of macro calls. Macro operators are listed below.

<table>
<tr><th>Operator</th><th colspan="3">Description</th></tr>
<tr><td rowspan="3">&</td><td colspan="3">Concatenates strings.</td></tr>
<tr><td>Macro definition dummy parameters</td><td>Macro call</td><td>Macro expansion</td></tr>
<tr><td>p1&p2&p3 → <br>p1&p2&p3 →</td><td>abc, def,ghi →<br>data, 1, 3 →</td><td>abcdefghi<br>data13</td></tr>
<tr><td rowspan="3">\</td><td colspan="3">Escape characters for including normally unusable characters (<, >, &, \) in parameters of macro calls.</td></tr>
<tr><td>Macro definition dummy parameters</td><td>Macro call</td><td>Macro expansion</td></tr>
<tr><td>p1&p2&\>\>&p3\&0x0f →</td><td>var. 3. 2 →</td><td>var3>>2&0x0f</td></tr>
<tr><td rowspan="3">< ></td><td colspan="3">Passes the enclosed string as a single parameter of a macro call.</td></tr>
<tr><td>Macro parameters</td><td>Macro call</td><td>Macro expansion</td></tr>
<tr><td>p1 →</td><td><“abc”, 1> →</td><td>“abc”, 1</td></tr>
</table>

## Usage example

The following example uses the operators \, <>, and &. The & characters in the body of macro mac1 are used with two different meanings. The & before the dummy parameters is a macro operator. The & before the hexadecimal 0x0f indicates a logical AND.

```
mac1            macro           p1, p2, p3
                mov             p1&p2\>\>&p3\&0x0f, D0
                endm
mac2            macro           p1, p2
                p1              p2
                endm
_TEXT           section         CODE, PUBLIC, 1
                mac1            1,2,3
                mac2            <add>, <1, D0>
                end
```

The assembled list file is shown below.

```
                                macexp.lst       Page 1
               ***  Panax Series MN1030 Cross Assembler  ***
Loc       Object        Line    Source
                        M1      mac1        macro       p1,p2,p3
                        2                   mov         p1&p2\>\>&p3\&0x0f,D0
                        3                   endm
                        4
                        M5      mac2        macro       p1,p2
                        6                   p1          p2
                        7                   endm
                        8
                        9       _TEXT       SECTION     CODE,PUBLIC,1
                        M10                 mac1        1, 2, 3
00000000  8001          10+                 mov         12>>3&0x0f, D0
                        M11                 mac2        <add>, <1, D0>
00000002  2801          11+                 add         1, D0
                        12                  end
```

# 11.5 Local Symbol Declaration (local)

## Syntax

| | | |
|---|---|---|
| macro_name | `macro` | parameter |
| | `local` | symbol (, symbol)... |
| symbol | . | |
| | . | |
| | . | |
| | `endm` | |

NOTE: Up to 30 symbols can be specified.

## Functional description

The local directive declares local symbols used in a macro body. When local symbols are expanded, they will be expanded in the form ??XXXXX, where XXXXX is in the range starting 00001 to 99999.

## Coding rules

Symbols specified with the local directive should not be used outside the macro definition.

The local directive can be used only within macro definitions.

Local symbols should be used after they have been declared by the local directive.

If the local symbol ??XXXXX used by the local directive is undefined, an error will occur.

## Usage example

An example using the local directive is shown below.

```
loc             macro           p1
                local           lab1, lab2
                mov             p1, D0
lab1            cmp             0, D0
                jmp             lab2
                mov             1, A1
lab2            mov             0, A0
                endm
;
_TEXT           section         CODE, PUBLIC, 1
                loc             0
                loc             1
```

The assembled list file is shown next. You can see that each time the local symbol is expanded, it is changed to ??00001, ??00002, ...

```
                                    local.lst       Page 1
                ***  Panax Series MN1030 Cross Assembler  ***
Loc       Object        Line    Source
                        M1      loc         macro       p1
                        2                   local       lab1, lab2
                        3                   mov         p1, D0
                        4       lab1        cmp         0, D0
                        5                   jmp         lab2
                        6                   mov         1, A1
                        7       lab2        mov         0, A0
                        8                   endm
                        9       ;
                        10      _TEXT       section     CODE, PUBLIC, 1
                        M11                 loc         0
                        M11+                local       lab1, lab2
00000000  8000          11+                 mov         0, D0
00000002  A000          11+     ??00001     cmp         0, D0
00000004  DC00000000    +11+                jmp         ??00002
00000009  9501          11+                 mov         1, A1
0000000b  9000          11+     ??00002     mov         0, A0
                        M12                 loc         1
                        M12+                local       lab1, lab2
0000000d  8001          12+                 mov         1, D0
0000000f  A000          12+     ??00003     cmp         0, D0
00000011  DC00000000    +12+                jmp         ??00004
00000016  9501          12+                 mov         1, A1
00000018  9000          12+     ??00004     mov         0, A0
```

# 11.6 Forced Termination of Macro Expansion (exitm)

## Syntax

```
macro_name      macro           parameter
#ifndef         identifier
                exitm
#endif
                .
                .
                .
                endm
```

## Functional description

The exitm directive forcibly terminates macro expansion at the point it appears. Used in conjunction with an #ifndef directive, it can end macro expansion if an identifier is undefined. If the identifier has been defined, expansion beyond #endif will be performed. (The conditions are reversed when #ifdef is used.)

## Coding rules

In addition to #ifdef–#endif, all directives listed in chapter 10 "Writing Assembler Control Statements" section 10.5, “Conditional Assembly”, can be used.

The exitm directive can be used at any location. The assembler will terminate macro expansion after it appears.

The exitm directive can only be used within macro definitions.

## Usage example

Usage example with #ifb directive

A source file is shown below. The identifier TEST is used for the condition. In main the first macro call is made with TEST undefined. This causes exitm to be executed, so jsr debug will not be expanded.

TEST is defined before the second macro call, so here the statements after #endif will be assembled.

```
                global          debug
;
extml           macro
                mov             1, D0
#ifndef         TEST
                exitm
#endif
                jsr             debug
                endm
;
_TEXT           section         CODE, PUBLIC, 1
                extm1
#define         TEST
                extm1
```

The list file is shown below. The second macro call has been expanded after #endif.

```
                                exitm.lst               Page 1
                ***  Panax Series MN1030 Cross Assembler** *
Loc       Object           Line   Source
                           1                  global     debug
                           2      ;
                           M3     extm1       macro
                           4                  mov        1, D0
                           5      #ifndef     TEST
                           6                  exitm
                           7      #endif
                           8                  jsr        debug
                           9                  endm
                           10     ;
                           11     _TEXT       section    CODE, PUBLIC, 1
                           M12                extm1
00000000  8001             12+                mov        1, D0
                           12+    #ifndef     TEST
                           M12+               exitm
                           13     #define     TEST
                           M14                extm1
00000002  8001             14+                mov        1, D0
                           14+    #itndef     TEST
                           14x                exitm
                           14+    #endif
00000004  F8FEFCFCFF000000 +14+               jsr        debug
0000000c  00F8FE04         14+
```

# 11.7 Purging Macro Definitions (purge)

## Syntax

`purge` macro_name (, macro_name)...

## Functional description

The purge directive purges the definitions of the specified macro names.

## Coding rules

The macro names specified with the purge directive are valid for previously defined macro names.

After the purge directive, purged macros will not be expanded even if they are called. They will be processed as instructions or symbols.

The purge directive cannot be used within macro definitions.

When multiple macro names are specified, they are delimited by commas (,).

## Usage example

The following example illustrates the use of the purge control statement.

The above example contains two definitions for the same macro name. The first instance of mac1 expands to a mov instruction. After the purge control statement, the second definition for mac1 takes effect.

```
mac1        macro       p1, p2
            mov         p1, p2
            endm
_TEXT       section     CODE, PUBLIC, 1
            mac1        0, A1
            purge       mac1
mac1        macro       p1, p2
            add         p1, p2
            endm
            mac1        1, A1
```

# 11.8 rept

## Syntax

```
rept        expression
block
endm
```

## Functional description

The rept directive repeatedly expands the specified block the specified number of times. It is used for simple repeating without parameters. The rept directive can be coded anywhere in a program or even within a macro definition.

## Coding rules

Symbols cannot be used within a block. If used, a double definition error will occur. The local directive cannot be used either.

Further rept and irp directives and macro calls can be coded within a block. Up to 20 nesting levels are allowed.

## Usage example

In the following example, the rept directive is in a macro definition that is used twice in the program main.

```
repeat      macro       p1
            rept        p1
            add         1, D0
            endm
            endm
;
_TEXT       section     CODE, PUBLIC,1
            repeat      2
            rept        3
            add         1, D1
            endm
```

The assembled list file is shown below.

```
                                    rept.lst        Page 1
               ***   Panax Series MN1030 Cross Assembler   ***
Loc       Object        Line    Source
                        M1      repeat      macro       p1
                        2                   rept        p1
                        3                   add         1, D0
                        4                   endm
                        5                   endm
                        6       ;
                        7       _TEXT       section     CODE, PUBLIC, 1
                        M8                  repeat      2
                        M8+                 rept        2
                        8+                  add         1, D0
                        8+                  endm
00000000  2801          8+                  add         1, D0
00000002  2801          8+                  add         1, D0
                        M9                  rept        3
                        10                  add         1, D0
                        11                  endm
00000004  2901          11+                 add         1, D0
00000006  2901          11+                 add         1, D0
00000008  2901          11+                 add         1, D0
```

# 11.9 irp

## Syntax

```
irp         dummy_parameter, parameter (, parameter) ...
block
endm
```

NOTE: Up to10 dummy parameters can be specified.

## Functional description

The irp directive repeatedly expands the specified block the specified number of times. The dummy parameter is used within the block. The macro expansion replaces the dummy parameter with each parameter in turn, repeated for the number of parameters.

## Coding rules

Symbols cannot be used within a block. If used, a double definition error will occur. The local directive cannot be used either.

If a comma (,) delimiters in a row are specified, the corresponding parameter will be processed as though a null character had been specified.

To specify strings that include commas and spaces, use the macro operator <>.

## Usage example

In the following example, the irp directive is in a macro definition that is used twice in the program.

```
init            macro           p1
                irp             opr, <pl\& 0x0f>
                mov             opr, D0
                endm
                endm
;
_TEXT           section         CODE, PUBLIC, 1
                init            1
                irp             reg, D2, D3
                mov             0, reg
                endm
```

The assembled list file is shown below.

```
                                        irp.lst             Page 1
                 ***  Panax Series MN1030 Cross Assembler ***
Loc       Object      Line    Source
                      M1      init        macro               p1
                      2                   irp                 opr,<p1\&0x0f>
                      3                   mov                 opr, D0
                      4                   endm
                      5                   endm
                      6       ;
                      7       _TEXT       section             CODE, PUBLIC, 1
                      M8                  init                1
                      M8+                 irp                 opr,<1\&0x0f>
                      8+                  mov                 opr, D0
                      8+                  endm
00000000  8001        8+                  mov                 1&0x0f, D0
                      M9                  irp                 reg, D2, D3
                      10                  mov                 0, reg
                      11                  endm
00000002  8A00        11+                 mov                 0, D2
00000004  8F00        11+                 mov                 0, D3
```

# 11.10 irpc

## Syntax

```
irpc        dummy_parameter, "string"
block
endm
```

## Functional description

The irpc description repeatedly replaces the dummy parameter with each character in the specified string one at a time. The dummy parameter can be used in the block. The macro expansion replaces the dummy parameter with each character in turn, repeated for the number of characters.

## Coding rules

The string cannot include the characters &, \, ', and ".

Symbols cannot be used within a block. If used, a double definition error will occur. The local directive cannot be used either.

A dummy parameter appearing in a string or character constant inside the irpc block is not expanded.

## Usage example

The following example uses the irpc directive.

```
_DATA           section         CODE, PUBLIC, 1
                irpc            dummy, “0123456789”
                dc              dummy
                endm
                end
```

The assembled list file is shown below.

```
                                    irpc.lst            Page 1
                  *** Panax Series MN1030 Cross Assembler ***
Loc       Object      Line    Source
                      1       _DATA     section           DATA, PUBLIC, 1
                      M2                irpc              dummy, “0123456789”
                      3                 dc                dummy
                      4                 endm
00000000  00          4+                dc                0
00000001  01          4+                dc                1
00000002  02          4+                dc                2
00000003  03          4+                dc                3
00000004  04          4+                dc                4
00000005  05          4+                dc                5
00000006  06          4+                dc                6
00000007  07          4+                dc                7
00000008  08          4+                dc                8
00000009  09          4+                dc                9
```

# Chapter 12 List of Machine Language Instructions

12

# 12.1 Purpose of This Chapter

The chapter lists machine language instructions of this series microcomputers.

This comprehensive list of addressing modes and mnemonics for every instruction can be quite useful when you are coding machine language instruction statements.

If you need to know about the detailed operation of individual instructions, refer to the “MN1030/MN103S Series Instruction Manual”.

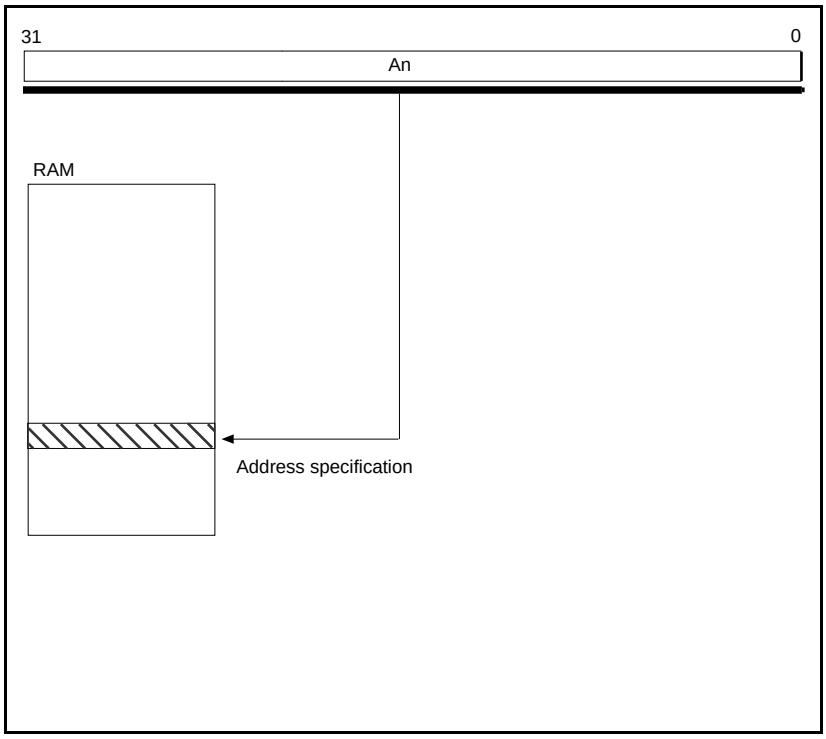
# 12.2 Addressing Modes

This series of the microcomputers supports four addressing modes for memory accesses.
The following four address formats are methods for accessing an address specified as an address register's contents or as the sum of an address register's contents and a displacement.

- Register indirect addressing
- Register relative indirect addressing
- Absolute addressing
- Index addressing

## Register indirect addressing

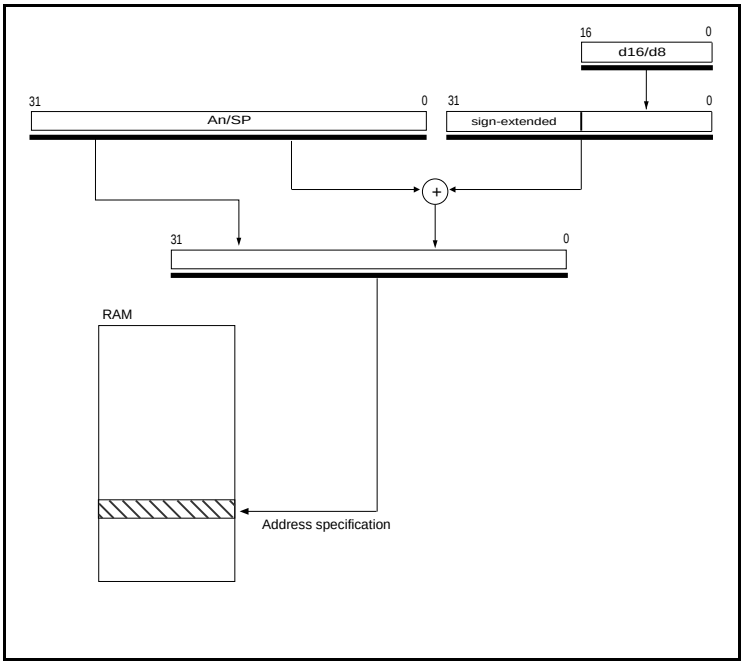
Register indirect addressing specifies the address to access with the address register An.



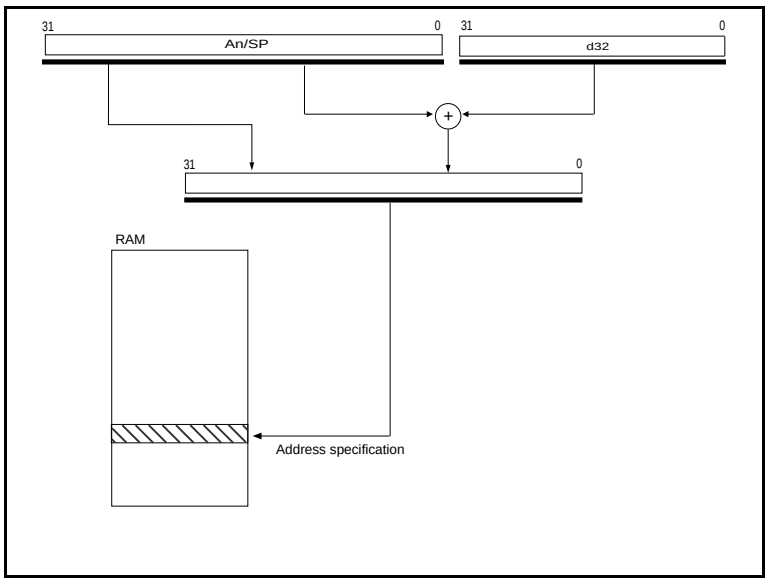
## Register relative indirect addressing

Register relative indirect addressing determines the address to access using the following three combinations.

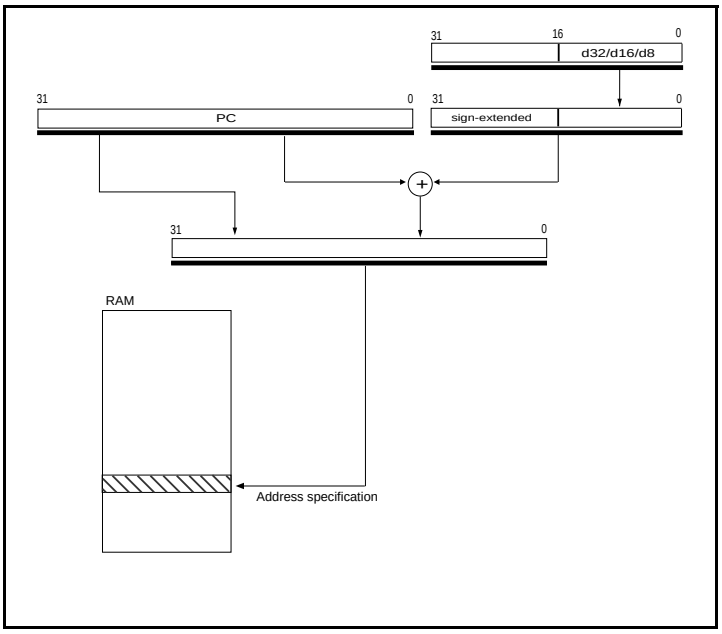
1. An address register, An, plus a sign-extended 8-bit or 16-bit displacement or the stack pointer register, SP, plus a zero-extended 8-bit or 16-bit displacement.




2. An address register, An, or the stack pointer register, SP, plus a 32-bit displacement.

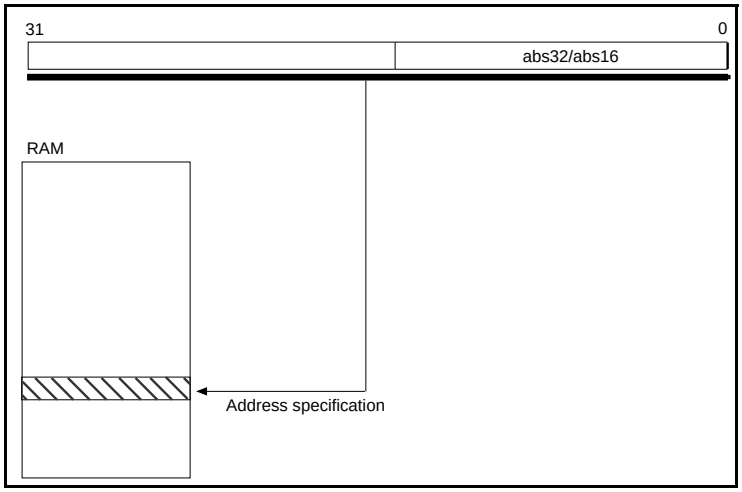


3. The program counter, PC, plus a sign-extended 8-bit or 16-bit displacement or a 32-bit displacement.



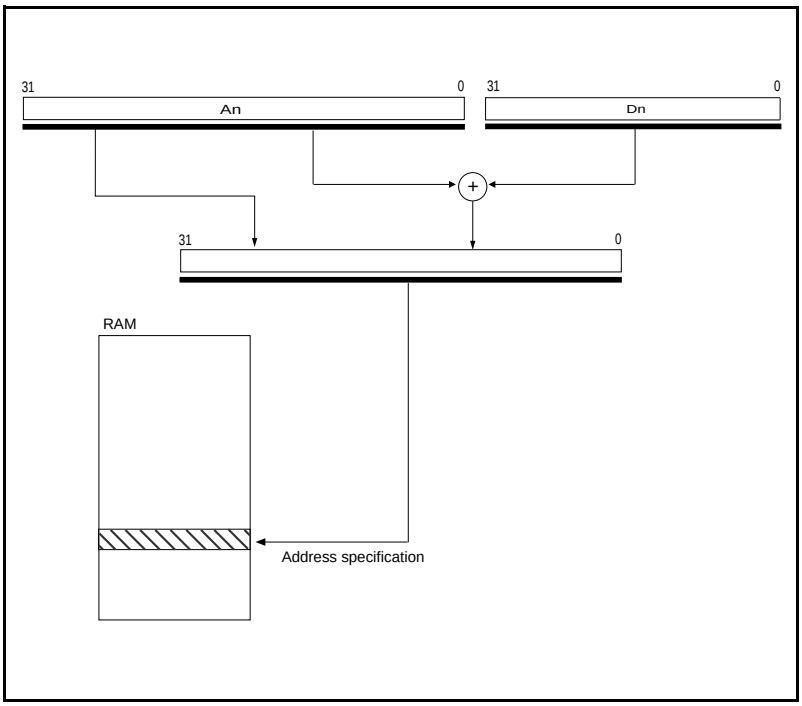

## Absolute addressing

Absolute addressing specifies the address to be accessed as a 16-bit or 32-bit displacement.



## Index addressing

Index addressing adds the contents of an address register, An, and a data register, Dn, to yield a displacement.



# 12.3 List of Machine Language Instructions

| Symbol | Description |
|---|---|
| An, Am | Address register (n, m=3 to 0) |
| Dn, Dm | Data register (n, m = 3 to 0) |
| Di | Index, a data register (i=0,1,2,3) |
| SP | Stack pointer register |
| imm | Immediate data |
| imm8 | 8-bit immediate data specified with an instruction |
| imm16 | 16-bit immediate data specified with an instruction |
| imm32 | 32-bit immediate data specified with an instruction |
| abs16 | A 16-bit absolute address specified by the instruction |
| abs32 | A 32-bit absolute address specified by the instruction |
| d | Displacement data |
| d8 | 8-bit offset data specified with an instruction |
| d16 | 16-bit offset data specified with an instruction |
| d32 | 32-bit offset data specified with an instruction |
| MDR | Multiply/divide register |
| LIR | Loop instruction register |
| LAW | Instruction fetch address register |
| PSW | Program status word |
| CF | Carry flag |
| ZF | Zero flag |
| NF | Negative flag |
| VF | Overflow flag |
| PC | Program counter |
| regs | Specification of multiple registers |
| ( ) | Indicates an indirect address |

## 12.3.1 Data Move Instructions

### MOVE source to destination

| | Mnemonic | Description of operation |
|---|---|---|
| Register Direct | MOV Dm, Dn | Transfers the contents of Dm to Dn. |
| | MOV Dm, An | Transfers the contents of Dm to An. |
| | MOV Am, Dn | Transfers the contents of Am to Dn. |
| | MOV Am, An | Transfers the contents of Am to An. |
| | MOV SP, An | Transfers the contents of SP to An. |
| | MOV Am, SP | Transfers the contents of Am to SP. |
| | MOV PSW, Dn | Transfers the contents of PSW to Dn. |
| | MOV Dm, PSW | Transfers the contents of Dm to PSW. |
| | MOV MDR, Dn | Transfers the contents of MDR to Dn. |
| | MOV Dm, MDR | Transfers the contents of Dm to MDR. |
| Immediate Value | MOV imm, Dn | Transfers the sign-extended imm8, sign-extended imm16, or imm32 to Dn. |
| | MOV imm, An | Transfers the zero-extended imm8, zero-extended imm16, or imm32 to An. |
| Register Indirect | MOV (Am),Dn | Transfers the contents of the memory location specified by Am to Dn. |
| | MOV (Am), An | Transfers the contents of the memory location specified by Am to An. |
| | MOV Dm, (An) | Transfers the contents of Dm to the memory location specified by An. |
| | MOV Am, (An) | Transfers the contents of Am to the memory location specified by An. |
| | MOVBU (Am), Dn | Transfers, with zero extension, the 8-bit contents of the memory location specified by Am to Dn. |
| | MOVBU Dm,(An) | Transfers the lowest 8 bits of Dm to the memory location specified by An. |
| | MOVB (Am), Dn | Transfers, with sign extension, the 8-bit contents of the memory location specified by Am to Dn. |
| | MOVB Dm, (An) | Transfers the lowest 8 bits of Dm to the memory location specified by An. |
| | MOVHU (Am), Dn | Transfers, with zero extension, the 16-bit contents of the memory location specified by Am to Dn. |
| | MOVHU Dm, (An) | Transfers the lowest 16 bits of Dm to the memory location specified by An. |
| | MOVH (Am), Dn | Transfers, with sign extension, the 16-bit contents of the memory location specified by Am to Dn. |
| | MOVH Dm, (An) | Transfers the lowest 16 bits of Dm to the memory location specified by An. |
| Register Relative Indirect | MOV (d, Am), Dn | Transfers the contents of the memory location specified by Am and displacement d to Dn.<br>8- and 16-bit displacements are sign-extended. |
| | MOV (d, SP), Dn | Transfers the contents of the memory location specified by SP and displacement d to Dn.<br>8- and 16-bit displacements are zero-extended. |

| | Mnemonic | Description of operation |
|---|---|---|
| Register Relative Indirect | MOV (d, Am), An | Transfers the contents of the memory location specified by Am and displacement d to An.<br>8- and 16-bit displacements are sign-extended. |
| | MOV (d, SP), An | Transfers the contents of the memory location specified by SP and displacement d to An.<br>8- and 16-bit displacements are zero-extended. |
| | MOV (d8, Am), SP | Transfers the contents of the memory location specified by Am and displacement d to SP.<br>8- and 16-bit displacements are sign-extended. |
| | MOV Dm, (d, An) | Transfers the contents of Dm to the memory location specified by An and displacement d.<br>8- and 16-bit displacements are sign-extended. |
| | MOV Dm, (d, SP) | Transfers the contents of Dm to the memory location specified by SP and displacement d.<br>8- and 16-bit displacements are zero-extended. |
| | MOV Am, (d, An) | Transfers the contents of Am to the memory location specified by An and displacement d.<br>8- and 16-bit displacements are sign-extended. |
| | MOV Am, (d, SP) | Transfers the contents of Am to the memory location specified by SP and displacement d.<br>8- and 16-bit displacements are zero-extended. |
| | MOV SP, (d8, An) | Transfers the contents of SP to the memory location specified by An and 8-bit displacement d8.<br>8- bit displacements are sign-extended. |
| | MOVBU (d, Am), Dn | Transfers, with zero-extension, the 8-bit contents of the memory location specified by Am and displacement d to Dn.<br>8- and 16-bit displacements are sign-extended. |
| | MOVBU (d, SP), Dn | Transfers, with zero-extension, the 8-bit contents of the memory location specified by SP and displacement d to Dn.<br>8- and 16-bit displacements are zero-extended. |
| | MOVBU Dm, (d, An) | Transfers the lowest 8 bits of Dm to the memory location specified by An and displacement d.<br>8- and 16-bit displacements are sign-extended. |
| | MOVBU Dm, (d, SP) | Transfers the lowest 8 bits of Dm to the memory location specified by SP and displacement d.<br>8- and 16-bit displacements are zero-extended. |
| | MOVB (d, Am), Dn | Transfers, with sign-extension, the 8-bit contents of the memory location specified by Am and displacement d to Dn.<br>8- and 16-bit displacements are sign-extended. |
| | MOVB (d, SP), Dn | Transfers, with sign-extension, the 8-bit contents of the memory location specified by SP and displacement d to Dn.<br>8- and 16-bit displacements are zero-extended. |
| | MOVB Dm, (d, An) | Transfers the lowest 8 bits of Dm to the memory location specified by An and displacement d.<br>8- and 16-bit displacements are sign-extended. |
| | MOVB Dm, (d, SP) | Transfers the lowest 8 bits of Dm to the memory location specified by SP and displacement d.<br>8- and 16-bit displacements are zero-extended. |

| | Mnemonic | Description of operation |
|---|---|---|
| Register Relative Indirect | MOVHU (d, Am), Dn | Transfers, with zero-extension, the 16-bit contents of the memory location specified by Am and displacement d to Dn.<br>8- and 16-bit displacements are sign-extended. |
| | MOVHU (d, SP), Dn | Transfers, with zero-extension, the 16-bit contents of the memory location specified by SP and displacement d to Dn.<br>8- and 16-bit displacements are zero-extended. |
| | MOVHU Dm, (d, An) | Transfers the lowest 16 bits of Dm to the memory location specified by An and displacement d.<br>8- and 16-bit displacements are sign-extended. |
| | MOVHU Dm, (d, SP) | Transfers the lowest 16 bits of Dm to the memory location specified by SP and displacement d.<br>8- and 16-bit displacements are zero-extended. |
| | MOVH (d, Am), Dn | Transfers, with sign-extension, the 16-bit contents of the memory location specified by Am and displacement d to Dn.<br>8- and 16-bit displacements are sign-extended. |
| | MOVH (d, SP), Dn | Transfers, with sign-extension, the 16-bit contents of the memory location specified by SP and displacement d to Dn. 8- and 16-bit displacements are zero-extended. |
| | MOVH Dm, (d, An) | Transfers the lowest 16 bits of Dm to the memory location specified by An and displacement d.<br>8- and 16-bit displacements are sign-extended. |
| | MOVH Dm, (d, SP) | Transfers the lowest 16 bits of Dm to the memory location specified by SP and displacement d.<br>8- and 16-bit displacements are zero-extended. |
| Index | MOV (Di, Am), Dn | Transfers the 32-bit contents of the memory location specified by Di and Am to Dn. |
| | MOV (Di, Am), An | Transfers the 32-bit contents of the memory location specified by Di and Am to An. |
| | MOV Dm, (Di, An) | Transfers the contents of Dm to the memory location specified by Di and An. |
| | MOV Am, (Di, An) | Transfers the contents of Am to the memory location specified by Di and An. |
| | MOVBU (Di, Am), Dn | Transfers, with zero-extension, the 8-bit contents of the memory location specified by Di and Am to Dn. |
| | MOVBU Dm, (Di, An) | Transfers the lowest 8 bits of Dm to the memory location specified by Di and An. |
| | MOVB (Di, Am), Dn | Transfers, with sign-extension, the 8-bit contents of the memory location specified by Di and Am to Dn. |
| | MOVB Dm, (Di, An) | Transfers the lowest 8 bits of Dm to the memory location specified by Di and An. |
| | MOVHU (Di,Am), Dn | Transfers, with zero-extension, the 16-bit contents of the memory location specified by Di and Am to Dn. |
| | MOVHU Dm, (Di, An) | Transfers the lowest 16 bits of Dm to the memory location specified by Di and An. |
| | MOVH (Di, Am), Dn | Transfers, with sign-extension, the 16-bit contents of the memory location specified by Di and Am to Dn. |
| | MOVH Dm, (Di, An) | Transfers the lowest 16 bits of Dm to the memory location specified by Di and An. |
| | MOV (abs16), Dn | Transfer the 32-bit contents of the memory location specified by abs16 to Dn. abs16 is zero-extended. |

| | Mnemonic | Description of operation |
|---|---|---|
| Absolute | MOV (abs32), Dn | Transfer the 32-bit contents of the memory location specified by abs32 to Dn. |
| | MOV (abs16), An | Transfer the 32-bit contents of the memory location specified by abs16 to An. abs16 is zero-extended. |
| | MOV (abs32), An | Transfer the 32-bit contents of the memory location specified by abs32 to An. |
| | MOV Dm, (abs16) | Transfer the contents of Dm to the memory location specified by abs16. abs16 is zero-extended. |
| | MOV Dm, (abs32) | Transfer the contents of Dm to the memory location specified by abs32. |
| | MOV Am, (abs16) | Transfer the contents of Am to the memory location specified by abs16. abs16 is zero-extended. |
| | MOV Am, (abs32) | Transfer the contents of Am to the memory location specified by abs32. |
| | MOVBU (abs16), Dn | Transfer, with zero-extension, the 8-bit contents of the memory location specified by abs16 to Dn. abs16 is zero-extended. |
| | MOVBU (abs32), Dn | Transfer, with zero-extension, the 8-bit contents of the memory location specified by abs32 to Dn. |
| | MOVBU Dm, (abs16) | Transfer the lowest 8 bits of Dm to the memory location specified by abs16. abs16 is zero-extended. |
| | MOVBU Dm, (abs32) | Transfer the lowest 8 bits of Dm to the memory location specified by abs32. |
| | MOVB (abs16), Dn | Transfer, with sign-extension, the 8-bit contents of the memory location specified by abs16 to Dn. abs16 is zero-extended. |
| | MOVB (abs32), Dn | Transfer, with sign-extension, the 8-bit contents of the memory location specified by abs32 to Dn. |
| | MOVB Dm, (abs16) | Transfer the lowest 8 bits of Dm to the memory location specified by abs16. abs16 is zero-extended. |
| | MOVB Dm, (abs32) | Transfer the lowest 8 bits of Dm to the memory location specified by abs32. |
| | MOVHU (abs16), Dn | Transfer, with zero-extension, the 16-bit contents of the memory location specified by abs16 to Dn. abs16 is zero-extended. |
| | MOVHU (abs32), Dn | Transfer, with zero-extension, the 16-bit contents of the memory location specified by abs32 to Dn. |
| | MOVHU Dm, (abs16) | Transfer the lowest 16 bits of Dm to the memory location specified by abs16. abs16 is zero-extended. |
| | MOVHU Dm, (abs32) | Transfer the lowest 16 bits of Dm to the memory location specified by abs32. |
| | MOVH (abs16), Dn | Transfer, with sign-extension, the 16-bit contents of the memory location specified by abs16 to Dn. abs16 is zero-extended. |
| | MOVH (abs32), Dn | Transfer, with sign-extension, the 16-bit contents of the memory location specified by abs32 to Dn. |
| | MOVH Dm, (abs16) | Transfer the lowest 16 bits of Dm to the memory location specified by abs16. abs16 is zero-extended. |
| | MOVH Dm, (abs32) | Transfer the lowest 16 bits of Dm to the memory location specified by abs32. |

## EXTEND Sign

| Mnemonic | Description of operation |
|---|---|
| EXT Dn | Extend Dn to 64 bits and store the highest 32 bits in MDR. |
| EXTB Dn | Sign-extend the lowest 8 bits of Dn to fill Dn. |
| EXTBU Dn | Zero-extend the lowest 8 bits of Dn to fill Dn. |
| EXTH Dn | Sign-extend the lowest 16 bits of Dn to fill Dn. |
| EXTHU Dn | Zero-extend the lowest 16 bits of Dn to fill Dn. |

## MOVM

| Mnemonic | Description of operation |
|---|---|
| MOVM (SP), regs | Load the specified registers from a block in memory. |
| MOVM regs, (SP) | Save the specified registers to a block in memory. |

## CLR

| Mnemonic | Description of operation |
|---|---|
| CLR Dn | Clear Dn to zero. |

## 12.3.2 Arithmetic Instructions

### ADD

| Mnemonic | Description of operation |
|---|---|
| ADD Dm, Dn | Add the contents of Dm and Dn and store the result in Dn. |
| ADD Dm, An | Add the contents of Dm and An and store the result in An. |
| ADD Am, Dn | Add the contents of Am and Dn and store the result in Dn. |
| ADD Am, An | Add the contents of Am and An and store the result in An. |
| ADD imm, Dn | Add the sign-extended imm8, sign-extended imm16, or imm32 to the contents of Dn and store the result in Dn. |
| ADD imm, An | Add the sign-extended imm8, sign-extended imm16, or imm32 to the contents of An and store the result in An. |
| ADD imm, SP | Add the sign-extended imm8, sign-extended imm16, or imm32 to the contents of SP and store the result in SP. |

### ADD with CARRY

| Mnemonic | Description of operation |
|---|---|
| ADDC Dm, Dn | Add the contents of Dm and the carry flag to Dn and store the result in Dn. |

### SUBTRACT

| Mnemonic | Description of operation |
|---|---|
| SUB Dm, Dn | Subtract the contents of Dm from Dn and store the result in Dn. |
| SUB Dm, An | Subtract the contents of Dm from An and store the result in An. |
| SUB Am, Dn | Subtract the contents of Am from Dn and store the result in Dn. |
| SUB Am, An | Subtract the contents of Am from An and store the result in An. |
| SUB imm32, Dn | Subtract imm32 from Dn and store the result in Dn. |

### SUBTRACT with BORROW

| Mnemonic | Description of operation |
|---|---|
| SUBC Dm, Dn | Subtract the contents of Dm and the carry flag from Dn and store the result in Dn. |

## MULTIPLY

| Mnemonic | Description of operation |
|---|---|
| MUL Dm, Dn | Multiplies the 32-bit signed integer multiplicand in Dm by the 32-bit signed integer multiplier in Dn and store the upper 32 bits of the product in MDR and the lower 32 bits in Dn. |
| MULU Dm, Dn | Multiplies the 32-bit unsigned integer multiplicand in Dm by the 32-bit unsigned integer multiplier in Dn and store the upper 32 bits of the product in MDR and the lower 32 bits in Dn. |

## DIVIDE

| Mnemonic | Description of operation |
|---|---|
| DIV Dm, Dn | Divide the 64-bit signed integer dividend with its upper 32 bits in MDR and its lower 32 bits in Dn by the 32-bit signed divisor in Dm and store the 32-bit remainder in MDR and the 32-bit quotient in Dn. |
| DIVU Dm, Dn | Divide the 64-bit unsigned integer dividend with its upper 32 bits in MDR and its lower 32 bits in Dn by the 32-bit unsigned divisor in Dm and store the 32-bit remainder in MDR and the 32-bit quotient in Dn. |

## INC

| Mnemonic | Description of operation |
|---|---|
| INC Dn | Add 1 to the contents of Dn and store the result in Dn. |
| INC An | Add 1 to the contents of An and store the result in An. |
| INC4 An | Add 4 to the contents of An and store the result in An. |

## COMPARE source with destination

| Mnemonic | Description of operation |
|---|---|
| CMP Dm, Dn | Subtract the contents of Dm from Dn and set the flags according to the result. |
| CMP Dm, An | Subtract the contents of Dm from An and set the flags according to the result. |
| CMP Am, Dn | Subtract the contents of Am from Dn and set the flags according to the result. |
| CMP Am, An | Subtract the contents of Am from Dn and set the flags according to the result. |
| CMP imm, Dn | Subtract the sign-extended imm8, sign-extended imm16, or imm32 from Dn and set the flags according to the result. |
| CMP imm, An | Subtract the zero-extended imm8, zero-extended imm16, or imm32 from An and set the flags according to the result. |

## 12.3.3 Logical Instructions

### AND source with destination

| Mnemonic | Description of operation |
|---|---|
| AND Dm, Dn | AND Dm with Dn and store the result in Dn. |
| AND imm, Dn | AND the zero-extended imm8, zero-extended imm16, or imm32 with Dn and store the result in Dn. |
| AND imm16, PSW | AND imm16 with PSW and store the result in PSW. |

### OR source with destination

| Mnemonic | Description of operation |
|---|---|
| OR Dn, Dm | OR Dm with Dn and store the result in Dn. |
| OR imm, Dn | OR the zero-extended imm8, zero-extended imm16, or imm32 with Dn and store the result in Dn. |
| OR imm16, PSW | OR imm16 with PSW and store the result in PSW. |

### EXCLUSIVE-OR source with destination

| Mnemonic | Description of operation |
|---|---|
| XOR Dm, Dn | XOR Dm with Dn and store the result in Dn. |
| XOR imm, Dn | XOR the zero-extended imm16 or imm32 with Dn and store the result in Dn. |

### NOT destination

| Mnemonic | Description of operation |
|---|---|
| NOT Dn | Reverse all bits in Dn and store the result in Dn. |

## ARITHMETIC SHIFT RIGHT

| Mnemonic | Description of operation |
|---|---|
| ASR Dm, Dn | Arithmetically shift the contents of Dn right the number of bits specified in Dm and store the result in Dn. |
| ASR imm8, Dn | Arithmetically shift the contents of Dn right the number of bits specified by imm8 and store the result in Dn. |
| ASR Dn | Arithmetically shift the contents of Dn right one bit and store the result in Dn. |

## LOGICAL SHIFT RIGHT

| Mnemonic | Description of operation |
|---|---|
| LSR Dm, Dn | Logically shift the contents of Dn right the number of bits specified in Dm and store the result in Dn. |
| LSR imm8, Dn | Logically shift the contents of Dn right the number of bits specified by imm8 and store the result in Dn. |
| LSR Dn | Logically shift the contents of Dn right one bit and store the result in Dn. |

## ARITHMETIC SHIFT LEFT

| Mnemonic | Description of operation |
|---|---|
| ASL Dm, Dn | Arithmetically shift the contents of Dn left the number of bits specified in Dm and store the result in Dn.<br>Zeros enter from the least significant bit. |
| ASL imm8, Dn | Arithmetically shift the contents of Dn left the number of bits specified by imm8 and store the result in Dn.<br>Zeros enter from the least significant bit. |
| ASL2 Dn | Arithmetically shift the contents of Dn left two bits and store the result in Dn.<br>Zeros enter from the least significant bit.. |

## ROTATE RIGHT

| Mnemonic | Description of operation |
|---|---|
| ROR Dn | Rotate the contents of Dn plus the C flag right one bit and store the result in Dn. |

## ROTATE LEFT

| Mnemonic | Description of operation |
|---|---|
| ROL Dn | Rotate the contents of Dn plus the C flag left one bit and store the result in Dn. |

## 12.3.4 Bit Manipulation Instructions

### Bit operations

| Mnemonic | Description of operation |
|---|---|
| BTST imm, Dn | AND the zero-extended imm8, zero-extended imm16, or imm32 with the contents of Dn and set the flags according to the result. |
| BTST imm8, (d8,An) | AND the zero-extended imm8 with the zero-extended 8-bit contents of the memory location specified by d8 and An and set the flags according to the result. |
| BTST imm8, (abs32) | AND the zero-extended imm8 with the zero-extended 8-bit contents of the memory location specified by abs32 and set the flags according to the result. |
| BSET Dm, (An) | This instruction proceeds through the following three stages:<br>1.Transfer, with zero-extension, the 8-bit contents of the memory location specified with An to a 32-bit internal temporary register.<br>2.AND the temporary register with the contents of Dm and set the flags according to the result.<br>3.OR the temporary register with the contents of Dm and store the lowest 8 bits of the result in the memory location specified with An. |
| BSET imm8, (d8,An) | This instruction proceeds through the following three stages:<br>1.Transfer, with zero-extension, the 8-bit contents of the memory location specified with d8 and An to a 32-bit internal temporary register.<br>2.AND the temporary register with zero-extended imm8 and set the flags according to the result<br>3.OR the temporary register with zero-extended imm8 and store the lowest 8 bits of the result in the memory location specified with d8 and An. |
| BSET imm8, (abs32) | This instruction proceeds through the following three stages:<br>1.Transfer, with zero-extension, the 8-bit contents of the memory location specified with abs32 to a 32-bit internal temporary register<br>2.AND the temporary register with zero-extended imm8 and set the flags according to the result.<br>3.OR the temporary register with zero-extended imm8 and store the lowest 8 bits of the result in the memory location specified with abs32. |
| BCLR Dm,(An) | This instruction proceeds through the following three stages:<br>1.Transfer, with zero-extension, the 8-bit contents of the memory location specified with An to a 32-bit internal temporary register.<br>2.AND the temporary register with the contents of Dm and set the flags according to the result.<br>3.AND the temporary register with the ones complement of the contents of Dm and store the lowest 8 bits of the result in the memory location specified with An. |
| BCLR imm8,(d8,An) | This instruction proceeds through the following three stages:<br>1.Transfer, with zero-extension, the 8-bit contents of the memory location specified with d8 and An to a 32-bit internal temporary register.<br>2.AND the temporary register with zero-extended imm8 and set the flags according to the result.<br>3.AND the temporary register with the ones complement of zero-extended imm8 and store the lowest 8 bits of the result in the memory location specified with d8 and An. |

| Mnemonic | Description of operation |
|---|---|
| BCLR imm8,(abs32) | This instruction proceeds through the following three stages:<br>1.Transfer, with zero-extension, the 8-bit contents of the memory location specified with abs32 to a 32-bit internal temporary register.<br>2.AND the temporary register with zero-extended imm8 and set the flags according to the result.<br>3.AND the temporary register with the ones complement of zero-extended imm8 and store the lowest 8 bits of the result in the memory location specified with abs32. |

## 12.3.5 Branching Instructions

### CALL Subroutine

| Mnemonic | Description of operation |
|---|---|
| CALL label | label is either (d16,PC) or (d32,PC). Push the program counter containing the address of the next instruction and necessary registers onto the stack, secure the necessary stack area, and branch to the specified address.<br>This instruction is used paired with either a RET or RETF instruction. This pair provides high-speed saving and restoring of registers to and from the stack and the securing and release of the stack area. |
| CALLS (An) | Push the program counter containing the address of the next instruction onto the stack and branch to the specified address. This instruction is used paired with a RETS instruction for table jumps and other situations where the registers to be saved and the size of the stack area are not known and for situations requiring backward compatibility with JSR. |
| CALLS label | label is either (d16,PC) or (d32,PC). Push the program counter onto the stack and branch to the specified address. This instruction is used paired with a RETS instruction for table jumps and other situations where the registers to be saved and the size of the stack area are not known and for situations requiring backward compatibility with JSR. |
| RET | Restore saved registers from the stack, free the stack area, and branch to the return address saved on the stack. RET is used paired with CALL and the funcinfo directive. |
| RETF | Restore saved registers from the stack, free the stack area, and branch to the return address stored in MDR. RETF is used paired with CALL and the funcinfo directive. |
| RETS | Branch to the return address saved on the stack. RETS is used paired with CALLS. It is also used to maintain backward compatibility with RTS. |
| JSR (An) | Push the program counter containing the address of the next instruction onto the stack and branch to the specified address. |
| JSR label | label is either (d16,PC) or (d32,PC). Push the program counter containing the address of the next instruction onto the stack and branch to the specified address. |
| RTS | Branch to the return address saved on the stack.<br>RTS is used paired with JSR to maintain backward compatibility. |
| RTI | Return from an interrupt service routine.<br>Restore the PSW stored on the stack and branch to the return address saved on the stack. |
| TRAP | Push the program counter containing the address of the next instruction onto the stack and branch to the predefined address (0x40000010).<br>This instruction is used for system calls to the operating system and libraries. |

## Unconditional BRANCH

| Mnemonic | Description of operation |
|---|---|
| JMP (An) | Store the contents of An in the program counter. |
| JMP label | If label is (d16,PC), the 16-bit displacement is sign-extended and added to the program counter. The result is stored in the program counter. Any overflow during the addition is ignored. The result is stored in the program counter.<br>If label is (d32,PC), the 32-bit displacement is added to the program counter. The result is stored in the program counter. Any overflow during the addition is ignored. The result is stored in the program counter. |

## Conditional BRANCH

| Mnemonic | Meaning | Description of operation |
|---|---|---|
| BEQ label | =<br>ZF=1 | If ZF = 1, execute a relative branch to the address specified by label. (Range: -128 to 127)<br>If ZF = 0, execute next instruction. |
| BNE label | ≠<br>ZF=0 | If ZF = 0, execute a relative branch to the address specified by label. (Range: -128 to 127)<br>If ZF = 1, execute next instruction. |
| BGT label | < (signed) | If ZF = 0 and NF = VF, execute a relative branch to the address specified by label. (Range: -128 to 127)<br>If ZF =1 or NF != VF, execute next instruction. |
| BGE label | ≤ (signed) | If NF = VF, execute a relative branch to the address specified by label. (Range: -128 to 127)<br>If NF != VF, execute next instruction. |
| BLE label | ≥ (signed) | If CF = 1 or ZF = 1, execute a relative branch to the address specified by label. (Range: -128 to 127)<br>If CF = 0 and ZF = 0, execute next instruction. |
| BLT label | > (signed) | If NF = 1 and VF = 1 or NF = 0 and VF = 0, execute a relative branch to the address specified by label. (Range: -128 to 127)<br>If NF = 1 and VF = 0 or NF = 0 and VF = 1, execute next instruction. |
| BHI label | < (unsigned) | If CF = 0 and ZF = 0, execute a relative branch to the address specified by label. (Range: -128 to 127)<br>If CF = 1 or ZF = 1, execute next instruction. |
| BCC label | ≤ (unsigned)<br>CF=0 | If CF = 0, execute a relative branch to the address specified by label. (Range: -128 to 127)<br>If CF = 1, execute next instruction. |
| BLS label | ≥ (unsigned) | If CF = 1 or ZF = 1, execute a relative branch to the address specified by label. (Range: -128 to 127)<br>If CF = 0 and ZF = 0, execute next instruction. |
| BCS label | ≤ (unsigned)<br>CF=1 | If CF = 1, execute a relative branch to the address specified by label. (Range: -128 to 127)<br>If CF = 0, execute next instruction. |
| BVC label | VF=0 | If VF = 0, execute a relative branch to the address specified by label. (Range: -128 to 127)<br>If VF = 1, execute next instruction. |
| BVS label | VF=1 | If VF = 1, execute a relative branch to the address specified by label. (Range: -128 to 127)<br>If VF = 0, execute next instruction. |
| BNC label | NF=0 | If NF = 0, execute a relative branch to the address specified by label. (Range: -128 to 127)<br>If NF = 1, execute next instruction. |
| BNS label | NF=1 | If NF = 1, execute a relative branch to the address specified by label. (Range: -128 to 127)<br>If NF = 0, execute next instruction. |
| BRA label | 1 | Unconditionally execute a relative branch to the address specified by label. (Range: -128 to 127) |

## Conditional BRANCH for LOOP

| Mnemonic | Meaning | Description of operation |
|---|---|---|
| LEQ | =<br>ZF=1 | If ZF = 1, branch to the top of the loop as specified with SETLB.<br>If ZF = 0, execute next instruction. |
| LNE | ≠<br>ZF=0 | If ZF = 0, branch to the top of the loop as specified with SETLB.<br>If ZF = 1, execute next instruction. |
| LGT | < (signed) | If ZF = 0 and NF = VF, branch to the top of the loop as specified with SETLB.<br>If ZF = 1 or NF != VF, execute next instruction. |
| LGE | ≤ (signed) | If NF = VF, branch to the top of the loop as specified with SETLB.<br>If NF != VF, execute next instruction. |
| LLE | ≥ (signed) | If CF = 1 or ZF = 1, branch to the top of the loop as specified with SETLB.<br>IUf CF = 0 and ZF = 0, execute next instruction. |
| LLT | > (signed) | If NF = 1 and VF = 1 or NF = 0 and VF = 0, branch to the top of the loop as specified with SETLB.<br>If NF = 1 and VF = 0 or NF = 0 and VF = 1, execute next instruction. |
| LHI | < (unsigned) | If CF = 0 and ZF = 0, branch to the top of the loop as specified with SETLB.<br>If CF = 1 or ZF = 1, execute next instruction. |
| LCC | ≤ (unsigned)<br>CF=0 | If CF = 0, branch to the top of the loop as specified with SETLB.<br>If CF = 1, execute next instruction. |
| LLS | ≥ (unsigned) | If CF = 1 or ZF = 1, branch to the top of the loop as specified with SETLB.<br>If CF = 0 and ZF = 0, execute next instruction. |
| LCS | ≤ (unsigned)<br>CF=1 | If CF = 1, branch to the top of the loop as specified with SETLB.<br>If CF = 0, execute next instruction. |
| LRA | 1 | Unconditionally branch to the top of the loop as specified with SETLB. |

| Mnemonic | Description of operation |
|---|---|
| SETLB | Store the four bytes following the SETLB and the address of the fifth byte in the Loop Instruction Register (LIR) and the Instruction Fetch Address Register (LSR), respectively. |

## 12.3.6 User-Defined Instructions

### User Defined FUNCTION

| Mnemonic | Description of operation |
|---|---|
| UDFnn Dm, Dn | If nn is between 00 and 15, compute with the contents of Dm and Dn and store the result in Dn. The nature of the calculation and the effects on the flags are user defined.<br>If nn is between 20 and 35, compute with the contents of Dm and Dn. Do not store the result in Dn or modify the flags. |
| UDFnn imm, Dn | Compute with the contents of Dn and the sign-extended imm8, sign-extended imm16, or imm32 and store the result in Dn. The nature of the calculation and the effects on the flags are user defined. |
| UDFUnn imm, Dn | If nn is between 00 and 15, compute with the contents of Dn and the zero-extended imm8, zero-extended imm16, or imm32 and store the result in Dn. The nature of the calculation and the effects on the flags are user defined. |

## 12.3.7 Other Instructions

### NO OPERATION

| Mnemonic | Description of operation |
|---|---|
| NOP | Do nothing. |

# Chapter 13 Error Messages

# 13.1 Purpose of This Chapter

Error messages are divided into three categories depending on the severity of the error.

- Warnings
- Errors
- Fatal errors

These messages are displayed during assembler and linker operations.

A warning message warns the user of some state and consists of the marker "Warning," the warning number, and the text of the message. After displaying the warning message, the assembler or linker continues processing.

An error message notifies the user of an error and consists of the marker "Error," the error number, and the text of the message.

A fatal error message notifies the user of a system error and consists of the marker "Fatal error," the error number, and the text of the message. The assembler or linker aborts after displaying the message.

# 13.2 Assembler Errors

The assembler displays three types of messages: warning messages, error messages, and fatal error messages.

## 13.2.1 Warning Messages

| | |
|---|---|
| 2001 | `Operand error` |
| | An operand is of the wrong type. |
| | Check the number and types of operands, |
| 2002 | `Illegal operand value` |
| | An operand does not have an acceptable value. |
| | Change the value of the operand. |
| 2003 | `Define symbol multiple defined.` |
| | The same symbol is defined twice. |
| | Change the identifier after the #define or use the #undef control statement. |
| 2004 | `Define symbol not defined.` |
| | The identifier specified in an #undef statement has not been defined. |
| | Check the spelling of the identifier. |
| 2005 | `Ignore RADIX.` |
| | If an expression uses extended language syntax, the assembler ignores the radix directive. |
| | Delete the radix directive. |
| 2006 | `Change RADIX equal 10.` |
| | An expression using extended language syntax does not use a radix of 10. |
| | Use the radix directive to change the radix to 10. |
| 2007 | `Line too long.` |
| | A source statement exceeds the length limit. |
| | Edit the source statement so that its length is within the limit. |
| 2008 | `Macro name multiple defined.` |
| | Multiple macros share the same name. |
| | Change the names of the extra macros. |
| 2009 | `The usage of a series of instructions may be restricted in MN1030/103S series` |
| | The usage of a series of instructions may be restricted in MN1030 series. Careful operation is needed as some operations are not guaranteed. |
| | Refer to the notes, attentions or warnings written in MN1030/MN103S Series Instruction Manual for 32-bit and ensure that the expected operation is guaranteed. If it is not guaranteed, modify the program. See Chapter 3, "How to Use Instructions" in the Instruction Manual 3rd version (or later) or "Chapter 5 section 2, "Programming Notes" in the former versions. |
| 2010 | `The usage of this instruction may be restricted in MN1030/103S series.` |
| | The usage of a series of instructions may be restricted in MN1030 series hardware. Careful operation is needed as some operations are not guaranteed. |
| | Refer to the notes, attentions or warnings written in MN1030/MN103S Series Instruction Manual for 32-bit and ensure that the expected operation is guaranteed. If it is not guaranteed, modify the program. See Chapter 3, "How to Use Instructions" in the Instruction Manual 3rd version (or later) or "Chapter 5 section 2, "Programming Notes" in the former versions. |

| | |
|---|---|
| 2011 | `Not guaranteed operand by the instruction allocation.` |
| | The usage of a series of instructions may be restricted in the microcomputer. Careful operation is needed as some operations are not guaranteed. |
| | Refer to the notes, attentions or warnings written in the Instruction Manual for 32-bit and ensure that the expected operation is guaranteed. If it is not guaranteed, modify the program. |
| 2012 | `Symbol name too long.` |
| | The symbol name exceeds the length limit. |
| | Edit the symbol name so that its length is within the limit. |
| 2013 | `The line of the source file exceed 65535 lines.` |
| | Some pieces of debug information are not outputted for the instruction after the 65536th line. |
| | Divide the source file into files under 65535 lines per file. |

## 13.2.2 Error Messages

| | |
|---|---|
| 2301 | `Syntax error.` |
| | The current line contains a syntax error. |
| | Consult this Manual and the MN1030/MN103S Series Instruction Manual. |
| 2302 | `Illegal character.` |
| | A string contains an illegal character. |
| | Use only legal characters |
| 2303 | `Illegal string.` |
| | A string contains an error. |
| | Correct the string. |
| 2304 | `Instruction not found` |
| | The specified instruction does not exist. |
| | Consult this Manual and the MN1030/MN103S Series Instruction Manual. |
| 2305 | `Code size overflow.` |
| | A section contains too much code. |
| | Divide the section into smaller parts. |
| 2306 | `Multiple define symbol.` |
| | A symbol is defined more than once. |
| | Use different symbol names. |
| 2307 | `Illegal symbol name.` |
| | There is an error in a symbol name. |
| | Change the symbol name. |
| 2308 | `Label (symbol) is reserved word.` |
| | A reserved word is used as a label. |
| | Change the label name. |
| 2309 | `Label not permitted.` |
| | A label specification is not permitted here. |
| | Eliminate the label specification. |
| 2310 | `Label nothing.` |
| | The label specification is missing. |
| | Specify a label. |
| 2311 | `Illegal operand size.` |
| | An operand is of the wrong size. |
| | Check the size specification. |
| 2312 | `Out of section error.` |
| | A specification is not inside a section. |
| | Move the specification inside a section. |
| 2313 | `Section name count over (max 255)` |
| | There are more than 255 section names. |
| | Reduce the number of section names to within 255. |

| | |
|---|---|
| 2314 | `Illegal section name.` |
| | There is an error in a section name. |
| | Check the spelling of the section name. |
| 2315 | `Operand error.` |
| | An operand of the wrong type is used. |
| | Check the number and types of operands. |
| 2316 | `Illegal operand expression.` |
| | An operand expression does not evaluate to a value within the specified range. |
| | Check the operand expression. |
| 2317 | `Too many operands.` |
| | An operand of the wrong type is used. |
| | Check the number and types of operands, |
| 2318 | `Illegal operand value.` |
| | An operand has a value that is not within the specified range. |
| | Check the operand value to place it within the specified range. |
| 2319 | `Operand type should be absolute.` |
| | An operand does not have an absolute value. |
| | Specify an absolute value for the operand. |
| 2320 | `Debug operand error.` |
| | The assembler and the C compiler have different version numbers. |
| | Check that the assembler and C compiler are the most recent versions. |
| 2321 | `Illegal location counter.` |
| | The location counter value for an org direction has an illegal value. |
| | Change the location counter value for the org directive. |
| 2322 | `Operand not need.` |
| | There is a superfluous operand. |
| | Eliminate the superfluous operand. |
| 2323 | `Include file cannot read.` |
| | There is a mistake in the file name specification. |
| | Check the file name specification. |
| 2324 | `Too many “#else”.` |
| | There are too many #else. |
| | Check the #else specification. |
| 2325 | `Too many “#if” or “#endif”.` |
| | The #if and #endif are not balanced. |
| | Check the #if and #endif. |
| 2326 | `Missing endm.` |
| | A macro statement is missing its closing endm. |
| | Check all macro and endm statements. |
| 2327 | `Macro symbol is used recursively.` |
| | A macro is defined recursively. |
| | Check the macro definitions. |

| | |
|---|---|
| 2328 | `Too many arguments.` |
| | A macro invocation has too many arguments. |
| | Check the macro definition. |
| 2329 | `Can't find FUNCINFO directive.` |
| | There is a ret or retf machine instruction before the corresponding funcinfo directive. |
| | Declare funcinfo directive before the ret or retf machine instruction. |
| 2330 | `Line too long.` |
| | A source statement exceeds the length limit. |
| | Edit the source statement so that its length is within the limit. |
| 2331 | `No optimizing information.` |
| | The map file does not contain optimization information. |
| | Check the map file. |
| 2332 | `Error in configure file.` |
| | There is an error in the start-up file. |
| | Correct the start-up file. |
| 2333 | `Illegal map file value.` |
| | The map file and the assembly result disagree. |
| | Check the value in the map file. |

## 13.2.3 Fatal Error Messages

| | |
|---|---|
| 2501 | `Illegal option (string).` |
| | There is an unrecognized option on the command line. |
| | Check the command line options. |
| 2502 | `Too many input files (filename).` |
| | There is more than one input file name on the command line. |
| | Limit the command line to a single input file. |
| 2503 | `Input file name not found.` |
| | There is no input file specification. |
| | Specify an input file. |
| 2504 | `Output file name not found.` |
| | There is no output file specification. |
| | Specify an output file. |
| 2505 | `Can’t open (filename) file.` |
| | There is an error in the input/output file specifications. Alternatively, the disk is full or defective. |
| | In the former case, check the file name specification; in the latter, check the disk. |
| 2506 | `Memory allocation error.` |
| | The assembler was unable to allocate memory. |
| | Check the amount of memory available. |
| 2507 | `Data write error.` |
| | The assembler was unable to write data to the output file. |
| | Check the file system capacity. |
| 2508 | `File is used recursively. (filename)` |
| | The specified file is used recursively. |
| | Check the file specifications. |
| 2509 | `Illegal map file information.` |
| | The map file information is incorrect. |
| | Check the map file information. |

# 13.3 Linker Errors

The linker displays three types of messages: warning messages, error messages, and fatal error messages.

## 13.3.1 Warning Messages

| | |
|---|---|
| 3000 | `filename: Section not found. This file ignored.` |
| | The input file does not contain section information. |
| | Check the contents of the specified input file. |
| 3001 | `filename: Illegal section[name] attribute or align value.` |
| | Different files have sections with the same name, but different attributes or alignment values. |
| | Make sure that the attributes and alignment value for all sections with the same name agree across files. |
| 3002 | `Extra symbol[name] address aligned. (address)` |
| | The linker's alignment processing has changed the address assigned to the specified extra symbol. |
| | Generate a map file and check the value for the extra symbol. |
| 3003 | `Address overlay with IRAM manager.` |
| | A section address overlaps the area assigned to the instruction RAM status management table. |
| | Generate a map file, check the address, and change the command line options to eliminate the overlap. |

## 13.3.2 Error Messages

| | |
|---|---|
| 3300 | `Bad option switch.(string)` |
| | There is an error in the option specifications. |
| | Check the option specifications |
| 3301 | `No parameter for (option) option.` |
| | There is no parameter for the specified option. |
| | Check the command line options. |
| 3302 | `Illegal parameter with (option) option.` |
| | The parameter for the specified option is in the wrong format. |
| | Check the option specifications. |
| 3303 | `Illegal address with (option) option. (addr)` |
| | The specified address is invalid. |
| | Check the specified address value. |
| 3304 | `Illegal value with (option) option. (value)` |
| | The specified value is invalid. |
| | Check the specified value. |
| 3305 | `Conflicting option specified. (option,..)` |
| | Conflicting options have been specified. |
| | Check the option specifications. |
| 3306 | `filename: Parameter-file already specified.` |
| | The parameter file includes another parameter file. |
| | Edit the parameter file to eliminate the duplication. |
| 3307 | `Multiply defined symbol.` |
| | A symbol is defined more than once. |
| | Check the symbol declarations. |
| 3308 | `Undefined symbol.` |
| | A symbol is undefined. |
| | Check the symbol declarations. |
| 3309 | `filename: Relocation address out of range.(line lineno)` |
| | The results of a relocatable address calculation are out of range. |
| | Check the specified line in the source file. |
| 3310 | `filename: Symbol[name] not defined with FUNCINFO. (line lineno)` |
| | The specified input file contains a CALL instruction to a label without a FUNCINFO directive. |
| | Check the specified line in the source file. |
| 3311 | `Program ID multiplied.` |
| | Two or more -OVL options to use different numbers. |
| | Edit the -OVL options to use different numbers. |
| 3312 | `filename: Section not found specified by OVL (ID=id).` |
| | Either the target files do not contain the specified section or there are no target files. |
| | Check the section specification for the specified -OVL option as well as the file names following it. |

| | |
|---|---|
| 3313 | `Extra symbol[name] used as normal symbol.` |
| | The extra symbol, which is reserved for instruction RAM use, is used in a context other than a -PUT option. |
| | Modify the program to use a different symbol in that context. |

## 13.3.3 Fatal Error Messages

| | |
|---|---|
| 3500 | `No memory space.` |
| | There is insufficient memory. |
| | Make sure that there is sufficient memory capacity available |
| 3501 | `fileneme: Cannot open file.` |
| | The specified input file does not exist. |
| | Check the disk for the file. |
| 3502 | `filename: Cannot read file.` |
| | There is an error with the input file. |
| | Reassemble the corresponding source file and check the disk for hardware errors. |
| 3503 | `filename: Cannot read parameter-file.` |
| | There is an error in the parameter file. |
| | Make sure that the parameter file exists and has the proper access permissions. If it passes both tests, check the file for illegal characters. |
| 3504 | `Object file not specified.` |
| | There is no object file (with extension .rf) specified as an input file. |
| | Make sure that the object file is properly specified. |
| 3505 | `filename: This file is not a object file for MN1030` |
| | The input file is not a relocatable object file. |
| | Check the file name specification for errors. |
| 3506 | `filename: This file is not a library file for MN1030` |
| | The input file is not a library file. |
| | Check the file name specification for errors. |
| 3507 | `filename: Invalid file information type.[type]` |
| | There is a problem with the specified file. |
| | Reassemble the corresponding source file and check the disk for hardware errors. |
| 3508 | `filename: Bad file search.` |
| | There is a problem with the specified file. |
| | Reassemble the corresponding source file and check the disk for hardware errors. |
| 3509 | `filename: Illegal section attribute.` |
| | A section attribute in the specified input file is invalid. |
| | Reassemble the corresponding source file and check the disk for hardware errors. |
| 3510 | `filename: Invalid symbol detail information type.[type]` |
| | The symbol detailed information in the specified input file is invalid |
| | Reassemble the corresponding source file and check the disk for hardware errors. |
| 3511 | `filename: Cannot make output-file.` |
| | There is a problem creating the output file. |
| | Check the file system capacity and other factors affecting file creation. |

| | |
|---|---|
| 3512 | `filename: Illegal relocation information.(line lineno)` |
| | The relocation information in the specified input file is invalid. |
| | Check the specified line in the source file. If there are no problems there, reassemble the corresponding source file and check the disk for hardware errors. |
| 3513 | `filename: Illegal optimize information.(line lineno)` |
| | The optimization information in the specified input file is invalid. |
| | Check the specified line in the source file. If there are no problems there, reassemble the corresponding source file and check the disk for hardware errors. |
| 3514 | `filename: Illegal relocation/optimization data format.(line lineno)` |
| | The relocation/optimization data in the specified input file is in the wrong format. |
| | Check the specified line in the source file. |
| 3515 | `Section size overflow.` |
| | The section's layout overflows the upper bound of memory. |
| | If a map file is available, check that. Re-evaluate the options for specifying section layout or the program itself. |
| 3516 | `Section address overlay.` |
| | Sections have relocation address that overlap. |
| | If a map file is available, check that. Re-evaluate the options for specifying section layout or the program itself. |
| 3517 | `Not exist CODE section in external memory.` |
| | -OVL options have relocated all CODE sections to instruction RAM. |
| | Modify the program so that there is at least on CODE section in external memory. |
| 3518 | `filename: Referring to symbol[name] defined in a program(ID=id) which overlap at IRAM area.` |
| | The input file contains a program with a reference to a symbol in the program with the specified ID, and the two programs cannot coexist in the IRAM area because their addresses overlap. |
| | Either change the -OVL options so that the two programs can coexist in the IRAM area or revise the entire program. |
| 3519 | `Internal Error.[string]` |
| | The linker has detected an internal fault. |
| | Contact Matsushita Electronics. |

Chapter 14 Readinig List Files

# 14.1 Purpose of This Chapter

This chapter explains how to read the list files output during assembly.
There are two types of information output in a list file.

- Machine language code
- Symbol table

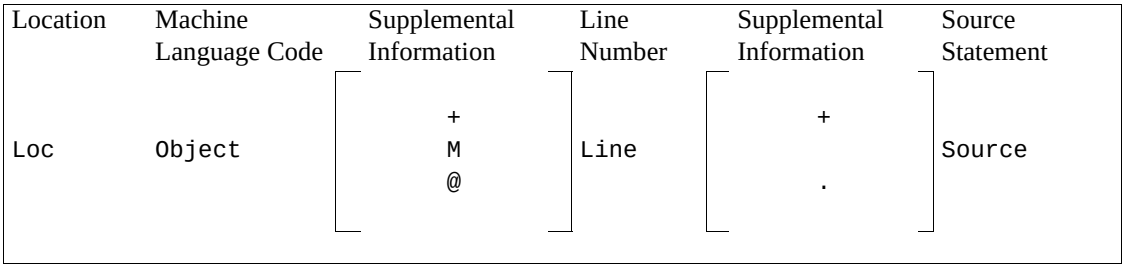
This chapter also explains how to read the information added by individual options and the meanings of special symbols.

## 14.2 Reading List Files

Adding the l (letter) option, when the assembler is invoked, will generate the list file in the current directory. List file contents are entirely in text format, so those can be viewed by using an editor.

## 14.2.1 Output Format of Machine Language Code

The output format of the machine language code section is shown below.




Each of these fields is described below.

### Location (Loc)

The location field shows the location counter values during assembly.

For section address format programs, the location field shows the relative value from the start of the section. However, if the assembly is to output the final list by incorporating the map file from linking, the location field will match the execution addresses.

### Machine language code (Object)

This field shows machine language code.

The eight bits of one byte are shown as two hexadecimal digits. These are 1-byte, 2-byte, 3-byte and 4-byte instructions.

### Machine language code supplemental information

The characters +, M, and @ may be added to the machine language code as supplemental information. The meaning of each character is as follows.

| | |
|---|---|
| + | This line includes an externally defined symbol whose value will be determined during linking. The machine language code does not indicate the final values. |
| M | This line is a result of macro expansion. |
| @ | This line includes an instruction whose value will be the object of optimization during linking. The machine language code does not indicate the final values. |

### Line number (Line)

The assembler adds a line number to each source statement.

## Supplemental information

A line number can provide additional information in the form of preceding periods and the suffixes X or +.

"." Line numbers preceding by a period indicate that the line was included by an include directive. The number of periods indicate the nesting levels of include directives. For example, "." means the line was included by an include directive that itself was within an include file.

```
.10    #include
..10   #include, #include
...10  #include, #include, #include
```

If the Li option is added when the assembler is invoked, output of lines included by include directives will be suppressed.

X The suffix on the line number indicates a line that the assembler ignores and does not process. During conditional assembly this is used for lines in the block of the unfulfilled condition.

If the Lc option is added when the assembler is invoked, output of blocks of unfulfilled conditions will be suppressed.

+ Line numbers followed by a plus sign indicate the line was a result of macro expansion. In addition to macro expansions defined by macro directives, a plus sign is added to expansions by irp and rept directives.

## Source statement (Source)

The source statements of the source file are output as is.

If the Lm option is added when the assembler is invoked, output of source statements resulting from macro expansion will be suppressed.

Below are example of source statement.

```
                            listspl.lst             Page 1
                  *** PanaX Series MN1030 Cross Assembler ***
Loc       Object       Line  Source
                       1     #include                “outlist.h”
                       .1    data        equ         0x12345678
                       2
                       3                 global      move
                       4
                       M5    load        macro
                       6                 mov         (A0), D0
                       7                 mov         D0, (A1)
                       8                 add         4, A0
                       9                 add         4, A1
                       10                endm
                       11
                       12    _TEXT       section     CODE, PUBLIC, 1
00000000               13    main
                       14    #ifdef      VERSION
                       15x               mov         data, D0
                       16x               mov         D0, (A0)
                       17    #else
                       M18               load
00000000  70           18+               mov         (A0), D0
00000001  61           18+               mov         D0, (A1)
00000002  2004         18+               add         4, A0
00000004  2104         18+               add         4, A1
00000006  70           19                mov         (A0), D0
00000007  61           20                mov         D0, (A1)
00000008  2004         21                add         4, A0
0000000a  2104         22                add         4, A1
                       23    #endif
0000000c  FCFF0000000  +24               calls       move
          0
                       25                end


                                      listspl.lst       Page 2
*** Symbol Table ***


          12345678     A     data
                       -U    move
          00000000     T     main
```

## 14.2.2 Symbol Table

If only the l (letter) option is specified, and not the c or s options, when the assembler is invoked, the assembler will output a symbol table to the list file after the machine language code section.

If the c option is specified, a cross-reference table will be output instead of the symbol table.

The symbol table outputs the name, value, and type of every symbol in the source file. It has the following format.

```
Symbol Value      Supplemental       Symbol Type      Symbol Name
                  Information
                  ┌       ┐        ┌       ┐
                  │   *   │        │   A   │
00000000          │       │        │   T   │ XXXXXX
                  │   +   │        │   U   │
                  │   -   │        │   D   │
                  └       ┘        └       ┘
```

### Symbol Value

The symbol's value is shown as eight hexadecimal digits.

### Supplemental Information

The symbol type may be preceded by a * or +.

| | |
|---|---|
| * | This indicates an externally defined symbol. |
| + | This indicates an undefined symbol. |
| - | This indicates an externally referenced symbol. |

### Symbol Type

This indicates the type of symbol. All symbols can be classified into four types: A, U, T, and D.

| | |
|---|---|
| A | This indicates that the symbol value is absolute. |
| T | This indicates a symbol with the CODE attribute and an address as its symbol value. |
| U | This indicates that the symbol is not defined in the source file. |
| D | This indicates a symbol with the DATA attribute and an address as its symbol value. |

## Symbol Name

Symbol names are shown up to 255 characters.

An output example of a symbol table is shown below.

```
                          listspl.lst                          Page 2
***  Symbol Table   ***
12345678          A       data
                  -U      move
00000000          T       main
```

# Chapter 15 Using Library Manager

15

# 15.1 Purpose of This Chapter

A library file is a collection of relocatable object files which you can pull out as needed. Library files are convenient for placing frequently used modules.

When a module is called from within a program, the linker searches the library file, extracts only the required relocatable object file, and loads it in the executable format file.

The library manager is a utility for managing library files. It can create library files and add, delete, replace, and search for relocatable object files.

This chapter explains how to use the library manager.

# 15.2 Starting Library Manager

The library manager is started by entering a command name and parameters, just as for other MS-DOS external commands.

## General format of commands

Below is the general format of the command to use when starting the library manager.

```
slib103 library_file_name[options](relocatable_object_file_name) ...
```

Contents of brackets [ ] may be omitted.

Table 15-1 Library Manager Options

| Option type | Option | Description |
|---|---|---|
| Error message options | j | Output error and warning messages in Japanese |
| | Je | Output error and warning messages in Japanese using EUC encoding |
| | Js | Output error and warning messages in Japanese using Shift JIS encoding. |
| | Jj | Output error and warning messages in Japanese using JIS encoding. |
| | e | Output error and warning messages in English. |
| | W number | Do not output warning messages of the specified number. |
| | Wall | Do not output any warning messages. |
| Program generation options | c | Create a new library manager displays an update confirmation prompt. |
| | f | Force creation of a library file. |
| Functional options | a | Add the specified relocatable object file to the library file. |
| | d | Delete the specified relocatable object file from the library file. |
| | p | Output information about externally defined symbols in the library file. |
| | r | Replace the specified relocatable object file in the library file. |
| | t | Output a list of the relocatable object file that makes up the library file. |
| | x | Extract the specified relocatable object file from the library file. |
| Other options | @filename | Specify a parameter file. |
| | h | Display a listing available library manager’s options on the console. |
| | v | Display the library manager’s version number on the console. |

NOTE: When slib103 is used to group relocatable object files into libraries, it will store them in the relocatable object files after deleting debug information if such debug information exists.
Therefore, when an ordinary relocatable object file is placed, in a library, it will be the same as that file when extracted form the library. However, there will be differences if the relocatable file was generated with the -g option.

# 15.3 Command Options

This section describes the options using the following categories.

## 15.3.1 Error Message Options

| | |
|---|---|
| j | Output error and warning messages in Japanese |

### Functional description

This option causes an error and warning messages and help screens sent to the console to appear in Japanese.

The character coding depends on the host machine and the operating system.

| Host machine | Character coding |
|---|---|
| Sun/Sparc | EUC |
| DOS/V | Shift JIS |
| PC/AT | not supported |

### Rules of use

To specify the option, enter the hyphen(-) followed by the lower case letter “j”.

```
slib103 test.lib -f -j test1.rf test2.rf test3.rf
```

NOTE: This option is not available on PC/AT machines.

### Default specification

The default language used depends on the host machine and the operating system.

| Host machine | Character coding |
|---|---|
| Sun/Sparc | English |
| DOS/V | Japanese in Shift JIS |
| PC/AT | English |

| | |
|---|---|
| Je | Output error and warning messages in Japanese using EUC encoding |

## Functional description

This option causes all error and warning messages and help screens sent to the console to appear in Japanese using EUC coding.

## Rules of use

To specify the option, enter the hyphen (-) followed by the upper case letter “J” and the lower case letter “e”. The two letters together function as a single option.

```
slib103  test.lib  -f  -Je  test1.rf test2.rf test3.rf
```

NOTE: This option is not available on DOS/V or PC/AT machines.

## Default specification

The default language used depends on the host machine and the operating system.

| Host machine | Message language |
|---|---|
| Sun/Sparc | English |
| DOS/V | Japanese in Shift JIS |
| PC/AT | English |

| | |
|---|---|
| Js | Output error and warning messages in Japanese using Shift JIS encoding |

## Functional description

This option causes all error and warning messages and help screens sent to the console to appear in Japanese using Shift JIS coding.

## Rules of use

To specify the option, enter the hyphen(-) followed by the upper case letter 'J' and the lower case letter 's'. The two letters together function as a single option.

```
slib103  test.lib -f -Js test1.rf  test2.rf  test3.rf
```

NOTE: This option is not available on PC/AT machines.

## Default specification

The default language used depends on the host machine and the operating system.

| Host machine | Message language |
|---|---|
| Sun/Sparc | English |
| DOS/V | Japanese in Shift JIS |
| PC/AT | English |

| | |
|---|---|
| Jj | Output error and warning messages in Japanese using JIS encoding |

## Functional description

This option causes all error and warning messages and help screens sent to the console to appear in Japanese using JIS coding.

## Rules os use

To specify the option, enter the hyphen (-) followed by the upper case letter “J” and the lower case letter “j”. The two letters together function as a single option.

```
slig103  test.lib  -f  -Jj test1.rf  test2.rf  test3.rf
```

NOTE: This option is not available on DOS/V or PC/AT machines.

## Default specification

The default language used depends on the host machine and the operating system.

| Host machine | Message language |
|---|---|
| Sun/Sparc | English |
| DOS/V | Japanese in Shift JIS |
| PC/AT | English |

| | |
|---|---|
| e | Output error and warning messages in English |

## Functional description

This option causes all error and warning messages and help screens sent to the console to appear in English.

## Rules of use

To specify the option, enter the hyphen (-) followed by the lower case letter”e”.

```
slib103  test.lib  -f  -e  test1.rf  test2.rf  test3.rf
```

## Default specification

The default language used depends on the host machine and the operating system.

| Host machine | Message language |
|---|---|
| Sun/Sparc | English |
| DOS/V | Japanese in Shift JIS |
| PC/AT | English |

| | |
|---|---|
| W number | Do not output warning messages of the specific number |

## Functional description

This option suppresses output of warning messages generated during library manager operation. For a list of warning messages and numbers, see Chapter 15 “Using the Library Manager” Section 15.4 “Error Messages” Section 15.4.1.”Warning Messages”.

The library manager ignores specifications for warning numbers that do not have messages assigned to them.

## Rules of use

To specify the option, enter the hyphen(-) followed by the upper case letter “W” and the number.

```
slib103  test.lib  -W4001  -o  test1.rf test2.rf  test3.rf
```

## Default specification

The default is to display all warning messages.

| | |
|---|---|
| Wall | Do not output any warning messages |

## Functional description

This option suppresses output of all warning messages generated during library manager operation.

## Rules of use

To specify the option, enter the hyphen (-) followed by the letters “Wall”.

```
slib103  test.lib  -Wall  -c test1.rf  test2.rf  test3.rf
```

## Default specification

The default is to display all warning messages.

## 15.3.2 Program Generation Options

| | |
|---|---|
| c | Create a new library file |

### Functional description

If a file with same name of the specified library file already exists, the library manager will inquire if the file should be modified. Based on the response, the library manager with determine whether or not to create the library file.

### Rules of use

To specify the option, enter the hyphen (-) followed by the lower case letter “c”.

```
slib103  test.lib  -c test1.rf
```

### Operation example

```
slib103  test.lib  -c test1.rf  test2.rf  test3.rf  test4.rf
```

This example will create a library file called test.lib from the four relocatable object files test1.rf, test2.rf, test3.rf and test4.rf

NOTE: slib103 cannot create a library file from an relocatable object file with the same name.

NOTE: If specifying file name with path name for a relocatable object file, its file name without path name will be registered in a library file.

| | |
|---|---|
| f | Force creation of a library file |

## Functional description

This option forces creation of the library file. If a file with the same name as the specified library file already exist, the library manager will overwrite it.

## Rules of use

To specify the option, enter the hyphen (-) followed by the lower case letter “r”.

```
slib103  test.lib  -f  test1.rf
```

## Operation example

```
slib103  test.lib  -f  test1.rf  test2.rf  test3.rf  test4.rf
```

This example will create a library file called test.lib from the four relocatable object files. test1.rf, test2.rf, test3.rf and test4.rf.

NOTE: With slib103, files that mutually reference symbols cannot be placed in library files with the same name.

NOTE: If specifying a file name with path name for relocatable object file, its file name without path name will be registered in a library file.

## 15.3.3 Functional Options

| | |
|---|---|
| a | Add the specified relocatable object file to the library file |

### Functional description

This option is used to add relocatable object files to the library file.

### Rules of use

To specify the option, enter the hyphen (-) followed by the lower case letter “a”.

```
slib103  test.lib  -a test.1.rf
```

### Operation example

```
slib103  test.lib  -a test.1.rf
```

The example adds the relocatable file test1.rf to the library file test.lib.

Multiple files can be added with one -a option. To add test.rf, test2.rf and test3.rf to test.lib, specify the following.

```
slib103  test.lib  -a test1.rf test2.rf test3.rf
```

NOTE: If any of the relocatable object files to add already exists in this library file, the library manage will output an error messages and terminates without performing any processing. If specifying a file name with path name, its file name without path name will be added in the library file.

| | |
|---|---|
| d | Delete the specified relocatable object file from the library file |

## Functional description

This option is used to delete relocatable object files from the library file.

If a specified file does not exist in the library file, the library manager will output a warning message and continue processing.

## Rules of use

To specify the option, enter the hyphen (-) followed by the lower case letter “d”.

```
slib103  test.lib  -d  test1.rf
```

## Operation example

```
slib103 test.lib -d test1.rf
```

This example deletes the relocatable file test1.rf from the library file test.lib.

Multiple files can be deleted with one -d option. To delete test1.rf, test2.rf, and test3.rf from test.lib, specify the following.

```
slib103 test.lib  -d test1.rf test2.rf test3.rf
```

| | |
|---|---|
| p | Output information about externally defined symbols in the library file |

## Functional description

This option is used when you want know the externally defined symbol names that exist in the library file.

When a relocatable object file name is specified following the -p option, and a file with the same name exists in the library file, the externally defined symbol names in that relocatable object file will be output. If the file does not exist, the library manager will output a warning message and continue processing.

When no relocatable object file name is specified, the externally defined symbols in all relocatable object files that exist in the library file will be output.

## Rules of use

To specify the option, enter the hyphen (-) followed by the lower case letter “p”.

```
slib103  test.lib  -p
```

## Operation example

```
slib103  test.lib -p test1.rf
slib103  test.lib -p
```

The first example checks whether or not the file test1.rf exists in test.lib, and if it does, outputs the externally defined symbols within it. The second example outputs the externally defined symbols in all relocatable object files in test.lib.

| | |
|---|---|
| r | Replace the specified relocatable object file in the library file |

## Functional description

This option is used to replace relocatable object files in the library file.

If a specified file does not exist in the library file, the library manager will output a message add the relocatable object file.

## Rules of use

To specify the option, enter the hyphen (-) followed by the lower case letter “r”.

```
slib103  test.lib  -r  test1.rf
```

## Operation example

Specify the following to replace the relocatable object file test1.rf in the library file test.lib.

```
slib103 test.lib -r test1.rf
```

Multiple files can be replaced with one -r option. To delete test1.rf, test2.rf, and test3.rf from test.lib, specify the following.

```
slib103   test.lib  -r test1.rf test2.rf test3.rf
```

This example replaces the relocatable object files test1.rf, test2.rf, and test3.rf in test.lib.

NOTE: If specifying a file names with path name for relocatable object file to be switched, the file name without path name exists or will be traced in the library file.

| | |
|---|---|
| t | Output a list of the relocatable object files that make up the library file. |

## Functional description

This option is used when you want to know the names of the relocatable object files that exist in the library file.

When a relocatable object file name is specified following the -t option, and a file with the same name exists in the library file, that file name will be output. If the file does not exist, the library manager will output a warning message and continue processing.

When no relocatable object file name is specified, the names of all relocatable object files that exist in the library file will be output.

## Rules of use

To specify the option, enter the hyphen (-) followed by the lower case letter “t”.

```
slib103  test.lib  -t test1.rf
```

## Operation example

```
slib103 test.lib -t test1.rf
slib103 test.lib -t
```

The first example checks whether or not the file test1.rf exists in test.lib. The second example outputs the names of all relocatable object files in test.lib.

| | |
|---|---|
| x | Extract the specified relocatable object file from the library file |

## Functional description

This option is used when you want to extract relocatable object files that exist in the library file.

When a relocatable object file name is specified following the -x option, and a file with the same name exists in the library file, that relocatable object file will be extracted into the specified file name. If the file does not exist, the library manager will output a warning message and continue processing.

When no relocatable object file name is specified, all relocatable object files that exist in the library file will be extracted.

## Rules of use

To specify the option, enter the hyphen (-) followed by the lower case letter “x”.

```
slib103  test.lib  -x test1.rf
```

## Operation example

```
slib103  test.lib -x test1.rf
slib103  test.lib -x
```

The first example checks whether or not the file test1.rf exists in test.lib, and if it does, extracts test1.rf.

The second example extracts all relocatable object files in test.lib.

NOTE: When an object file is extracted, it will overwrite any file of the same name existing in the current directory.

# 15.3.4 Other Options

| | |
|---|---|
| @filename | Specify a parameter file. |

## Functional description

The options you will use with slib103 can be written to a file, so instead of specifying all those options for execution, you can specify just that file name.

Every option other than the @ option can be written in a parameter file.

If a parameter file that doesn't exist is specified, the library manager will display an error message.

## Rules of use

This option uses neither a hyphen (-) nor an option letter. Enter alone @ followed by the name of the parameter file.

```
slib103 @pfile
```

## Default specification

There is no default specification.

## Operation example

Assume that the file pfile contains the following line.

```
test.lib   -f  test1.rf  test2.rf   test3.rf
```

```
slib103  @pfile
slib103  test.lib  -f test1.rf  test2.rf  test3.rf
```

The above command line then produces the same result as the following one.

| | |
|---|---|
| h | Display a listing at available library manager's options on the console |

## Functional description

This option displays the library manager's version number, command line options and a brief description on the console.

The -j, -Je, -Js, -Jj and -e options, if they appear, control the language and the coding scheme used to display this information.

## Rules of use

To specify the option, enter the hyphen (-) followed by the lower case letter "h".

```
slib103  -h
```

## Default specification

The default is not to display this help information on the console.

NOTE: If the -h option is not used, input of slib103 will also display help information.

| | |
|---|---|
| v | Display the library manager's version number on the console |

## Functional description

This option displays the library manager's version number on the console.

## Rules of use

To specify the option, enter the hyphen (-) followed by the lower case letter "v".

```
slib103  -v
```

## Default specification

The default is not to display the version number.

# 15.4 Error Messages

The library manager displays three types of messages: warning message, error messages, and fatal error messages.

These messages are display during library manager operation.

A warning message warns the user of some state and consists of the marker “warning”, the warning number, and the text of the message. After displaying the warning message, the library manager continue processing.

An error message notifies the user of an error and consists of the marker “error”, the error number, and the text of the message.

A fatal error message notifies the user of a system error and consists of the marker “Fatal error”, the error number, and the text of the message. The library manager aborts after displaying the message.

The following pages list the error messages that may appear during library manager operation. The list uses the following format.

## How to read

The meanings of each entry in the error message tables are as shown below.

| | |
|---|---|
| `error_number` | `displayed_message` |
| | cause |
| | solutions |

## 15.4.1 Warning Messages

| | |
|---|---|
| 4001 | `Filename not found` |
| | The specified file is not in the library. |
| | Check the list of files in the library file. |
| 4002 | `This file has no public symbol information.(filename)` |
| | There is no public symbol information for the file filename. |
| | Check whether the file is actually needed. |
| 4003 | `“filename” not found. In addition to library.` |
| | This message indicates that the file to be replaced does not exist in the library.<br>In this case, slib103 adds the file to the library. |
| | Check whether the object file to be replaced is in the library. |

## 15.4.2 Error Messages

| | |
|---|---|
| 4301 | `Multiply specified object file name.(filename)` |
| | Either the same object file is specified twice on the command line or an object file with the same name is in the library. |
| | Check the filename specifications. If necessary, change the file names. |
| 4302 | `Premature EOF. (filename)` |
| | There is something wrong with the contents of the specified file. |
| | Since the file is most likely corrupted, re-create it. |
| 4303 | `Can not create temporary file name.` |
| | The creation of the temporary file failed for some reason. |
| | Check the memory capacity. |
| 4304 | `Can not create library file. (filename)` |
| | The library manager could not create the library file. |
| | Check the file system’s capacity. |
| 4305 | `This file is not object file for MN1030. (filename)` |
| | The specified object file is not an object file. |
| | Check the object file specifications. If they are correct, the file is most likely corrupted, so re-create it. |
| 4306 | `This file is not library file for MN1030. (filename)` |
| | The specified library file is not a library file. |
| | Check the library file specification. If it is correct, the file is most likely corrupted, so re-create it. |
| 4307 | `Object file name not found.` |
| | An option calling for an object file name is missing an object file specification. |
| | Check the option syntax. |
| 4308 | `Invalid file information type exist. (filename)` |
| | The specified file contains incorrect file information. |
| | Since the object file is most likely corrupted, re-create it. |
| 4309 | `Conflicting option specified. (option)` |
| | The command line contains options that cannot occur together (0e and -f, for example). |
| | Check the command line options. |
| 4310 | `This file has redefined public symbol. (filename)` |
| | The specified file redefines a public symbol already in the library. |
| | Check the object files making up the library. |
| 4311 | `Object file number over. (max 65535)` |
| | The number of object files in the library exceeds the limit. |
| | Reduce the number of object files to within the limit. |
| 4312 | `Symbol name length over. (max 66). (symbol)` |
| | A symbol in an object file exceeds the length limit. |
| | Re-create the object file using a shorter name for the symbol. |

| | |
|---|---|
| 4313 | `Parameter-file already specified. (filename)` |
| | The same parameter file is specified more than once. |
| | Eliminate the duplicate specifications. |
| 4314 | `Cannot read parameter-file. (filename)` |
| | The library manager cannot read the parameter file--because it contains illegal characters, for example. |
| | Check the parameter file for control characters and kanji codes outside comments. If the parameter file passes this test, the problem could be insufficient memory, so check the memory capacity. |
| 4315 | `Not warning message number.` |
| | There is no warning message for the number specified with the -W option. |
| | Check the number specification. |

## 15.4.3 Fatal Error Messages

| | |
|---|---|
| 4501 | `Illegal option. (string)` |
| | The library manager does not support the specified option. |
| | Check the command line option specifications. |
| 4502 | `Library file name not found.` |
| | Either the command line contains no library file specification or the specification is in the wrong place. |
| | Check the library file specification. |
| 4503 | `Multiply specified library file name. (filename)` |
| | The command name contains multiple library file specification. |
| | Check the library file specification. |
| 4504 | `Memory allocation error.` |
| | The library manager was unable to allocate memory. |
| | Check the amount of memory available. |
| 4505 | `Cannot open file. (filename)` |
| | The library manager was unable to open the specified file. |
| | Make sure that the file name exists and has the proper access permissions. |
| 4506 | `Cannot read file. (filename)` |
| | The library manager was unable to read the specified file. |
| | Make sure that the filename exists and has the proper access permissions. |
| 4507 | `Cannot write file. (filename)` |
| | The library manager was unable to write to the specified output file. |
| | Check the file system capacity. |

# 16.1 Purpose of This Chapter

This chapter contains descriptions left out of other chapters.

# 16.2 Personal Computer Versions

This section contains notes on using the personal computer versions of the software in this package.

## 16.2.1 Operating Environment

This system runs on the following personal computers and compatibles.

| Host Machine | Operating System | Version of OS |
|---|---|---|
| PC/AT | Windows | 98/2000/Me/XP |
| DOS/V | Windows | 98/2000/Me/XP |

## 16.2.2 Files

The installation media for this system contains the following files.

AS103.EXE (Assembler)

AS103.EXE is the assembler. For a description, see the chapter 5 “Using the Assembler.”

LD103.EXE (linker)

LD103.EXE is the linker. For a description, see the chapter 6 “Using the Linker.”

SLIB103.EXE (library manager)

SLIB103.EXE is the library manager; a utility for creating library files. For a description, see the chapter 15 “Using the Library Manager.”

EXCV103.EXE (file conversion utility)

This utility converts an executable produced by the linker into a file in Motorola S format, Intel HEX format, or Matsushita format.

## 16.2.3 Installation

For the installation media, installation procedures, and notes on installation, see the MN1030 Series Installation Manual.

## 16.2.4 Environment Settings

Before using this series Cross-Assembler, verify or change the following two files.

### CONFIG.SIS

If FILES and BUFFER specifications do not already exist in CONFIG.SYS, you must add them. If they do already exist, check their settings and change them if necessary.

```
FILES=20
BUFFERS=20
```

NOTE: Be sure to make these settings. If the assembler is started without them, the error message "bad tmpboss(w)" will be output and processing will stop. This means that the number of files, that can be opened, simultaneously is insufficient.

Terminology: CONFIG.SYS
This is the file that sets the MS-DOS operating environment. FILES specifies the number of files that can be read and written simultaneously.
BUFFERS specifies the size of memory used for reading/writing disks.

### AUTOEXEC BAT

To be able to run the software simply by typing in its name, include its directory in the path search list given by the environment variable PATH.

Under MS-DOS, adding the directory in which the software is installed to the PATH variable and activating the new value for PATH allows you to run the programs in this system simply by entering their names.

```
SET PATH=A:\usr\local\bin
```

NOTE: Ending a directory specification in the PATH environment variable with a backslash results in errors. The following are examples of incorrect PATH settings.
Example) SET PATH=A:\
SET PATH=A:\usr\local\bin

NOTE: Once you have edited AUTOEXEC.BAT, reset the computer and restart. The new setting will then automatically take effect.

Terminology: AUTOEXEC.BAT
AUTOEXEC.BAT is a batch file that MS-DOS automatically runs when it loads. SET is the command for setting MS-DOS environment variables. Application programs have free access to these variables.

## Start-up files

The assembler and linker start by reading start-up files that provides a means of changing initial settings.

For a detailed description, see Chapter 1 “Getting Started” Section 1.5 “Setup” Paragraph “Start-Up Files” and substitute the file names AS103.RC and LD103.RC for .as103rc and .ld103rc, respectively.

## 16.2.5 Differences From Workstation Versions

The personal computer versions of the assembler, linker function and the library manager are exactly the same as their workstation counterparts.

### Command line differences

- When specifying the command name, omit the file extension .EXE.
- The personal computer versions use the forward slash(/) and backslash (\) as directory separators.

NOTE: Example:

```
AS103-1  -0  \USER\TMP\SAMPLE.RF SAMPLE.ASM
```

## 16.2.6 Error Correction Using Tag Jumps

This section describes a convenient way to fix errors. When code mistakes, syntax errors, or other errors and warnings occur in a source file, further development cannot proceed unless they are fixed.

In long source files, it can be a lot of work to find the source statements in which errors and warnings were detected.

The error correction method described in this section uses the tag jump function of editors such as MIFES™, etc.

This assumes the necessity of an error file that incorporates tag jumps.

Assembler error messages implement the tag jump function. When the assembler detects an error, it outputs an error message to the display. It will also output error messages to the list file if the 1 option was specified.

When the 1 option has not been specified and the assembler detects errors, you can assemble again such that errors are not displayed to the screen but are redirected to an error files that the assembler generates. The list file will include correct source statements in which errors were not detected, while the file created by redirection will consist only of source statements in which errors were detected. It is accordingly faster to access the file created by redirection when the source file is large.

### Generate error file

The example below shows the generation of an error of an error file (ERROR9 by redirection. This example assembles MAIN.ASM and outputs error messages to the file ERROR instead of the screen.

First assemble a file that actually includes errors and generate an error file. The following source file (MAIN.ASM) includes two errors.

```
_CODE       section      CODE, PUBLIC, 1
data        equ          -1
main
            mov          0x11, D0
            move         0x11, D0
            mov          D0, (data)
main
            end
```

The assembler will detect the errors, so it will generate an error file by redirection.

```
AS103       MAIN.ASM > ERROR
```

The contents of the generated error file (ERROR) are as follows.

```
                              5           move        0x11, D0
MAIN.ASM(5):Error 2304: Instruction not found.
                              7           main
MAIN.ASM(7):Error 2306: Multiple define symbol.
                 Errors: 2  Warnings: 0  (MAIN.ASM)
```

The following explanation is for the programmer's editor MIFES. Start up MIFES and open two files.

```
MI MAIN.ASM ERROR
```

The contents of the file ERROR will be displayed on the screen.

```
                              5           move        0x11, D0
MAIN.ASM(5):Error 2304: Instruction not found.
                              7           main
MAIN.ASM(7):Error 2306: Multiple define symbol.
                 Errors: 2  Warnings: 0  (MAIN.ASM)
```

## Tag jumps

The first error message matches this display on the screen.

```
MAIN.ASM(5): Error 2304: Instruction not found.
```

This line works with tag jumps regardless of the character position on screen.

Look at the display of function key F10 on the CRT screen. It should be [Tag JP]. This key specifies a tag jump, so try pressing F10. The screen will switch, and the cursor will be placed at the source file statement in which the error was detected

.

```
_CODE       section      CODE, PUBLIC, 1
data        equ          -1
main
            mov          0x11, D0
            move         0x11, D0
            mov          D0, (data)
main
            end
```

## Fix errors

The cursor will be located on the fifth line. Fix the error here.

Change move to mov. That alone fixes the line. Switch the screen again to the error file.

## Return to error file

To return to the error file, press the HOME CLR key (above and to the left of the period key).

When the screen switches to the error file, the cursor will move to the next error line.

```
MAIN.ASM(7): Error 2306: Multiple define symbol.
```

Press F10 for the source screen.

By repeating this procedure, you can fix all the errors.

---

Supplemental Explanation:
You can use other editors that support tag jumps
(VZ Editor‘, RED++‘).

---

Chapter 17 Appendix

# 17.1 Numeric Restrictions

This section shows the numeric restrictions on this series cross-assembler. Be sure not to exceed these values when writing programs.

## Assembler restrictions

| Item | Numeric Restriction |
|---|---|
| Characters per symbol | 255 characters |
| Characters per line | 1022 characters |
| Lines per file | Certain restrictions apply to source files with 65536 lines or more |

## Linker restrictions

| Item | Numeric Restriction |
|---|---|
| Number of OVL options | 255 |

## Directive restrictions

| Item | Numeric Restriction |
|---|---|
| Section directives | Number of distinct section names: 255 |

## Assembler control directive restrictions

| Item | Numeric Restriction |
|---|---|
| Include nesting levels | 3 levels |
| ifXX nesting levels | 255 levels |

## Macro directive restrictions

| Item | Numeric Restriction |
|---|---|
| Macro nesting levels | 20 levels |
| Macro local symbols | 30 symbols (within one macro definition) |

## Parameter file restrictions

| Item | Numeric Restriction |
|---|---|
| String length | 1024 characters |

# 17.2 List of Command Options

## How to read

The entries in the command option tables below and their meanings are as follows.

| | |
|---|---|
| option_name | functional_description<br>specification_example |

# 17.2.1 List of Assembler Command Options

## Assembler command general format

Below is the general format of the command to use when starting the assembler.

```
as103 [options]      source_filename
```

Contents of brackets [ ] may be omitted.

## Output file options

| | |
|---|---|
| o file_name | Specify the relocatable object file name to be output.<br>`as103 -o/usr/obj/test.rf sample.asm` |
| l | Output a list file<br>`as103 -1 sample.asm` |
| Li | Do not output files included by #include to the list file.<br>`as103 -Li -l sample.asm` |
| Lm | Do not output assembler source created by macro expansion using macro or irp to the list file.<br>`as103 -Lm -l sample.asm` |
| Ls | Do not output a symbol table to the list file.<br>`as103 -Ls -l sample.asm` |
| Lc | Do not output source statements that were not assembled due to unfulfilled conditions of conditional assembly to the list file.<br>`as103 -Lc -l sample.asm` |
| a map_file name | Read the map file to output a list file with resolved address.<br>`as103 -l -a m103 sample.asm` |

## Error message options

| | |
|---|---|
| j | Output error and warning messages in Japanese<br>`as103 -j sample.asm` |
| Je | Output error and warning messages in Japanese using EUC encoding.<br>`as103 -Je sample.asm` |
| Js | Output error and warning messages in Japanese using Shift JIS encoding.<br>`as103 -Js sample.asm` |
| Jj | Output error and warning messages in Japanese using JIS encoding.<br>`as103 -Jj sample.asm` |
| e | Output error and warning messages in English<br>`as103 -e sample.asm` |
| W number | Do not output warning messages of the specified number.<br>`as103 -W 2016 sample.asm` |
| Wall | Do not output any warning messages.<br>`as103 -Wall sample.asm` |

## Preprocessor options

| | |
|---|---|
| I path_name | Specify the path name of the directory that contains files specified by include.<br>`as103 -I /usr/defs sample.asm` |
| D identifier | Specify an identifier to be used by ifdef during conditional assembly.<br>`as103 -D VERSION sample.asm` |

## Program generation options

| | |
|---|---|
| g | Output debug information to the relocatable object file.<br>`as103 -g sample.asm` |
| Od | Turn off optimization.<br>`as103 -Od sample.asm` |
| O | Turn on optimization.<br>`as103 -O sample.asm` |

## Others

| | |
|---|---|
| h | Display a listing of available assembler options on the console.<br>`as103 -h` |
| v | Display the assembler's version number on the console.<br>`as103 -v` |

# 17.2.2 List of Linker Command Options

## Linker command general format

Below is the general format of the command to use when starting the linker.

```
ld103 [options]      (filename)...
```

Contents of brackets [ ] may be omitted.

Ellipses (...) indicates item may be repeated.

## Output file options

| | |
|---|---|
| o filename | Specify the path name and file name of the executable format file to be output.<br>`ld103 -o /usr/tmp/test.ex main.rf sub.rf` |
| m | Output a map file.<br>`ld103 -m main.rf sub.rf` |

## Error message options

| | |
|---|---|
| j | Output error and warning messages in Japanese<br>`ld103 -j main.rf sub.rf` |
| Je | Output error and warning messages in Japanese using EUC encoding.<br>`ld103 -Je main.rf sub.rf` |
| Js | Output error and warning messages in Japanese using Shift JIS encoding.<br>`ld103 -Js main.rf sub.rf` |
| Jj | Output error and warning messages in Japanese using JIS encoding.<br>`ld103 -Jj main.rf sub.rf` |
| e | Output error and warning messages in English<br>`ld103 -e main.rf sub.rf` |
| W number | Do not output warning messages of the specified number.<br>`ld103 -W 3001 main.rf sub.rf` |
| Wall | Do not output any warning messages.<br>`ld103 -Wall main.rf sub.rf` |

## Program generation options

| | |
|---|---|
| g | Output debug information to the executable format file.<br>`ld103 -g main.rf sub.rf` |
| T section-address | Specify a section start address.<br>`ld103 -T_TEXT@CODE=80000000 -T@DATA=0 main.rf sub.rf` |
| r | Output an executable format file even if errors are detected.<br>`ld103 -r main.rf` |
| En | Do not output symbol table within the executable format file.<br>`ld103 -En main.rf sub.rf` |
| Ed | Enable output of DATA sections to the executable file.<br>`ld103 -Ed main.rf sub.rf` |

## Library file options

| | |
|---|---|
| l library_filename | Specify a library file.<br>`ld103 -l /usr/local/lib/sample.lib  main.rf sub.rf` |
| L path_name | Specify a pathname for library files.<br>`ld103 -L/usr/lib -L/usr/local/lib -lsample.lib main.rf sub.rf` |

## Instruction RAM options

| | |
|---|---|
| OVL ID_number: section=address | Specify starting address for section in instruction RAM.<br>`ldld103 -T @CODE=80000000 main.rf sub.rf`<br>`-OVL 1:_TEXT=40000000 seg1.rf`<br>`-OVL 2:_TEXT,_CONST=40000000 seg2.rf` |
| PUT extra_symbol =address | Specify address for extra symbol.<br>`ld103 -T @CODE=80000000 main.rf sub.rf`<br>`-OVL 1:_TEXT=40000000 seg1.rf`<br>`-OVL 2:_TEXT=40000000 seg2.rf`<br>`-PUT __overlay_table=a0000000`<br>`-PUT __iram_manage=30000000` |

## Others

| | |
|---|---|
| @ | Specify a parameter file.<br>`ld103 @ pfile` |
| h | Display help information on the console.<br>`ld103 -h` |
| v | Display the linker’s version number on the console.<br>`ld103 -v` |

# 17.3 List of Assembler Directives

This section provides a list of assembler directives.

## Directives for program control

| Syntax | | | Function & Notes |
|---|---|---|---|
| symbol | instruction | operand | |
| | align | expression | Adjust the location counter to be a multiple of the value indicated by expression. The expression must be a power of 2 in the range 1 to $2^{15}$ |
| | end | | Indicates the end of the program. |
| | org | expression | Change the program address to the value special by expression.<br>expression=label_name+constant |
| name | section | [definition1<br>[,definition2[,expression]]] | Sets the start of a section.<br>definition 1: section attribute<br>(CODE \| DATA)<br>definition 2: link type<br>(PUBLIC \| PRIVATE \| COMMON)<br>expression: location counter boundary<br>value (power of 2). |
| | opt | on \| off | Enables/disables optimization |

## Directives for symbols

| Syntax | | | Function & Notes |
|---|---|---|---|
| symbol | instruction | operand | |
| name | equ | value | Defines a name as the value of the expression coded in the operand. |
| name | assign | value | Defines a name as the value of the expression coded in the operand. |
| | global | name(,name)... | Declares global declarations and global references. |

## Directives for data area allocation

| Syntax | | | Function & Notes |
|---|---|---|---|
| symbol | instruction | operand | |
| | dc | definition \| expression(,definition \| expression)... | Allocates 8-bit data areas. |
| | dw | expression(,expression)... | Allocates 16-bit data areas. |
| | dd | expression(,expression)... | Allocates 32-bit data areas. |
| | ds | expression1 [,expression2[. expression3]] | Allocates the number of bytes specified by expression1 to a data area.<br>If expression2(initial value) is specified, the data area will be filled with that initial value. If expression3(repeat count) is specified, this operation will be repeated for the specific number of times. |

## Directives for list control

| Syntax | | | Function & Notes |
|---|---|---|---|
| symbol | instruction | operand | |
| | tit | [“string”] | Specifies the header for the list file. |
| | listoff | | Suppresses list output from the next line after this directives. |
| | liston | | Resume list output from the line of this directives. |
| | xlistoff | | Suppresses list output from the line of this directives. |
| | xliston | | Resume list output from the next line after this directives. |
| | page | lines[, columns] | Specifies the number of lines and columns on a page of list file. |

## Other directives

| Syntax | | | Function & Notes |
|---|---|---|---|
| symbol | instruction | operand | |
| | notation | format | Selects the coding format of numbers, format (CLANG \| INTEL \| PANA)<br>CLANG: Extended C language format (default)<br>INTEL: Intel format<br>PANA: Matsushita format |
| | radix | expression | Specifies the radix to be used by default. The result of expression must be either 2, 8, 10 or 16. If the default is 10 and if extended C language format has been selected, the radix will always be 10 regardless of the specification. |
| name | funcinfo | label,expression,register list | Specifies additional information for a function name that appears as an operand for the CALL machine language instruction. |

# 17.4 List of Assembler Control Statements

This section provides a list of assembler control statements.

| Syntax | | Function & Notes |
|---|---|---|
| #include | “file_name | Reads in the source file specified by file_name. |
| #define | identifier[replacement_string] | Replaces the identifier with the replacement_string. |
| #undef | identifier | Purges the identifier previously defined by #define. |
| #ifdef<br>[#else<br>#endif | identifier<br>block1<br>block2] | Assembles block1 if the identifier was defined before the #ifdef statement.<br>Assembles block2 if it was not defined (nothing will be assembled if there is no #else). |
| #ifndef<br>[#else<br>#endif | identifier<br>block1<br>block2] | Assembles block1 if the identifier was defined before the #ifdef statement.<br>Assembles block2 if it was not defined (nothing will be assembled if there is no #else. |
| #if<br>[#else<br>#endif | expression<br>block1<br>block2] | Assembles block1 if the expression is not 0.<br>Assembles block2 if it is 0 (nothing will be assembled if there is no #else). |
| #ifn<br>[#else<br>#endif | expression<br>block1<br>block2] | Assembles block1 if the expression is 0.<br>Assembles block2 if it is not 0 (nothing will be assembled if there is no #else). |
| #ifeq<br>[#else<br>#endif | parameter1, parameter2<br>block1<br>block2] | Assembles block1 if parameter1 and parameter2 are equal. Assembles block2 if they are not equal (nothing will be assembled if there is no #else). At least one or the other of parameter1 and parameter2 must be a dummy parameter within a macro definition. #ifeq can only be used within macro definitions. |
| #ifneq<br>[#else<br>#endif | parameter1, parameter2<br>block1<br>block2] | Assembles block1 if parameter1 and parameter2 are equal. Assembles block2 if they are not equal (nothing will be assembled if there is no #else). At least one or the other of parameter1 and parameter2 must be a dummy parameter within a macro definition. #ifneq can only be used within macro definitions. |

| Syntax | Function & Notes |
|---|---|
| #iflt expression<br>block1<br>[#else<br>block2]<br>#endif | Assembles block1 if the expression is negative. Assembles block2 if it is not negative (nothing will be assembled if there is no #else). |
| #ifle expression<br>block1<br>[#else<br>block2]<br>#endif | Assembles block1 if the expression is zero or negative. Assembles block2 if it is positive. (nothing will be assembled if there is no #else). |
| #ifgt expression<br>block1<br>[#else<br>block2]<br>#endif | Assembles block1 if the expression is positive. Assembles block2 if it is not positive (nothing will be assembled if there is no #else). |
| #ifge expression<br>block1<br>[#else<br>block2]<br>#endif | Assembles block1 if the expression is zero or positive. Assembles block2 if it is negative. (nothing will be assembled if there is no #else). |
| #ifb dummy_ parameter<br>block1<br>[#else<br>block2]<br>#endif | Assembles block1 if dummy_parameter is a null character. Assembles block2 if it is not equal (nothing will be assembled if there is no #else). #ifb can only be used within macro definitions. |
| #ifnb dummy_ parameter<br>block1<br>[#else<br>block2]<br>#endif | Assembles block1 if dummy_parameter is not a null character. Assembles block2 if it is equal (nothing will be assembled if there is no #else). #ifnb can only be used within macro definitions. |

# Index

## Symbols



## A



## B



## C



## D



## E



## F



## G



## H



## I

## J



## L



## M



## N



## O



## P



## R



## S



## T

## U



## W



## X

# MN1030 Series
# Cross Assembler User's Manual

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