COSMIC Software

Version 4.2

C Cross Compiler User's Guide for ST Microelectronics STM8

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Preface

The *Cross Compiler User's Guide for STM8* is a reference guide for programmers writing C programs for STM8 microcontroller environments. It provides an overview of how the cross compiler works, and explains how to compile, assemble, link and debug programs. It also describes the programming support utilities included with the cross compiler and provides tutorial and reference information to help you configure executable images to meet specific requirements. This manual assumes that you are familiar with your host operating system and with your specific target environment.

Organization of this Manual

This manual is divided into eight chapters and four appendixes.

Chapter 1, "*Introduction*", describes the basic organization of the C compiler and programming support utilities.

Chapter 2, "*Tutorial Introduction*", is a series of examples that demonstrates how to compile, assemble and link a simple C program.

Chapter 3, "*Programming Environments*", explains how to use the features of C for STM8 to meet the requirements of your particular application. It explains how to create a runtime startup for your application, and how to write C routines that perform special tasks such as: serial I/O, direct references to hardware addresses, interrupt handling, and assembly language calls.

Chapter 4, "*Using The Compiler*", describes the compiler options. This chapter also describes the functions in the C runtime library.

Chapter 5, "*Using The Assembler*", describes the STM8 assembler and its options. It explains the rules that your assembly language source must follow, and it documents all the directives supported by the assembler.

Chapter 6, "*Using The Linker*", describes the linker and its options. This chapter describes in detail all the features of the linker and their use.

Chapter 7, "*Debugging Support*", describes the support available for COSMIC's C source level cross debugger and for other debuggers or in-circuit emulators.

Chapter 8, "*Programming Support*", describes the programming support utilities. Examples of how to use these utilities are also included.

Appendix A, "*Compiler Error Messages*", is a list of compile time error messages that the C compiler may generate.

Appendix B, "*Modifying Compiler Operation*", describes the "configuration file" that serves as default behaviour to the C compiler.

Appendix C, "*STM8 Machine Library*", describes the assembly language routines that provide support for the C runtime library.

Appendix D, "*Compiler Passes*", describes the specifics of the parser, code generator and assembly language optimizer and the command line options that each accepts.

This manual also contains an Index.

CHAPTER 1

Introduction

This chapter explains how the compiler operates. It also provides a basic understanding of the compiler architecture. This chapter includes the following sections:

Introduction

The C cross compiler targeting the STM8 microcontroller reads C source files, assembly language source files, and object code files, and produces an executable file. You can request listings that show your C source interspersed with the assembly language code and object code that the compiler generates. You can also request that the compiler generate an object module that contains debugging information that can be used by COSMIC's C source level cross debugger or by other debuggers or in-circuit emulators.

You begin compilation by invoking the **cxstm8** compiler driver with the specific options you need and the files to be compiled.

Document Conventions

In this documentation set, we use a number of styles and typefaces to demonstrate the syntax of various commands and to show sample text you might type at a terminal or observe in a file. The following is a list of these conventions.

Typewriter font

Used for user input/screen output. `Typewriter` (or `courier`) font is used in the text and in examples to represent what you might type at a terminal: command names, directives, switches, literal filenames, or any other text which must be typed exactly as shown. It is also used in other examples to represent what you might see on a screen or in a printed listing and to denote executables.

To distinguish it from other examples or listings, input from the user will appear in a shaded box throughout the text. Output to the terminal or to a file will appear in a line box.

For example, if you were instructed to type the compiler command that generates debugging information, it would appears as:

```
cxstm8 +debug acia.c
```

Typewriter font enclosed in a shaded box indicates that this line is entered by the user at the terminal.

If, however, the text included a partial listing of the file *acia.c* 'an example of text from a file or from output to the terminal' then typewriter font would still be used, but would be enclosed in a line box:

```
/* defines the ACIA as a structure */
struct acia {
        char status;
        char data;
        } acia @0x6000;
```

NOTE

Due to the page width limitations of this manual, a single invocation line may be represented as two or more lines. You should, however, type the invocation as one line unless otherwise directed.

Italics

Used for value substitution. *Italic* type indicates categories of items for which you must substitute appropriate values, such as arguments or hypothetical filenames. For example, if the text was demonstrating a hypothetical command line to compile and generate debugging information for any file, it might appear as:

```
cxstm8 +debug file.c
```

In this example, `cxstm8 +debug file.c` is shown in typewriter font because it must be typed exactly as shown. Because the filename must be specified by the user, however, *file* is shown in italics.

[Brackets]

Items enclosed in brackets are optional. For example, the line:

[*options*]

means that zero or more options may be specified because options appears in brackets. Conversely, the line:

options

means that one or more options must be specified because options is not enclosed by brackets.

As another example, the line:

```
file1.[o|sm8]
```

means that one file with the extension `.o` or `.sm8` may be specified, and the line:

```
file1 [ file2 . . . ]
```

means that additional files may be specified.

Conventions

All the compiler utilities share the same optional arguments syntax. They are invoked by typing a command line.

Command Line

A command line is generally composed of three major parts:

```
program_name [<flags>] <files>
```

where *<program_name>* is the name of the program to run, *<flags>* an optional series of flags, and *<files>* a series of files. Each element of a command line is usually a string separated by whitespace from all the others.

Flags

Flags are used to select options or specify parameters. Options are recognized by their first character, which is always a '-' or a '+', followed by the name of the flag (usually a single letter). Some flags are simply ***yes*** or ***no*** indicators, but some must be followed by a value or some additional information. The value, if required, may be a character string, a single character, or an integer. The flags may be given in any order, and two or more may be combined in the same argument, so long as the second flag can't be mistaken for a value that goes with the previous one.

It is possible for each utility to display a list of accepted options by specifying the **-help** option. Each option will be displayed alphabetically on a separate line with its name and a brief description. If an option requires additional information, then the type of information is indicated by one of the following code, displayed immediately after the option name:

Code	Type of information
*	character string
#	short integer
##	long integer
?	single character

If the code is immediately followed by the character '>', the option may be specified more than once with different values. In that case, the option name must be repeated for every specification.

For example, the options of the **chex** utility are:

```
chex [options] file
     -a##    absolute file start address
     -b##    address bias
     -e##    entry point address
     -f?     output format
     -h      suppress header
     +h*     specify header string
     -m#     maximum data bytes per line
     -n*>    output only named segments
     -o*     output file name
     -p      use paged address format
     -pp     use paged address with mapping
     -pn     use paged address in bank only
     -s      output increasing addresses
     -x*     exclude named segment
```

chex accepts the following distinct flags:

Flag	Function
-a	accept a long integer value
-b	accept a long integer value

Flag	Function
-e	accept a long integer value
-f	accept a single character
-h	simply a flag indicator
+h	accept a character string
-m	accept a short integer value
-n	accept a character string and may be repeated
-o	accept a character string
-p	simply a flag indicator
-pn	simply a flag indicator
-pp	simply a flag indicator
-s	simply a flag indicator
-x	accept a character string and may be repeated

Compiler Architecture

The C compiler consists of several programs that work together to translate your C source files to executable files and listings. **cxstm8** controls the operation of these programs automatically, using the options you specify, and runs the programs described below in the order listed:

cpstm8 - the C preprocessor and language parser. *cpstm8* expands directives in your C source and parses the resulting text.

cgstm8 - the code generator. *cgstm8* accepts the output of *cpstm8* and generates assembly language statements.

costm8 - the assembly language optimizer. *costm8* optimizes the assembly language code that *cgstm8* generates.

castm8 - the assembler. *castm8* converts the assembly language output of *costm8* to a relocatable object module.

Predefined Symbol

The COSMIC compiler defines the **__CSMC__** preprocessor symbol. It expands to a numerical value whose each bit indicates if a specific option has been activated:

bit 2	set if unsigned char option specified (**-pu**)
bit 4	set if reverse bitfield option specified (**+rev**)
bit 5	set if no enum optimization specified (**-pne**)

Linking

clnk combines all the object modules that make up your program with the appropriate modules from the C library. You can also build your own libraries and have the linker select files from them as well. The linker generates an executable file which, after further processing with the *chex* utility, can be downloaded and run on your target system. If you specify debugging options when you invoke **cxstm8**, the compiler will generate a file that contains debugging information. You can then use the COSMIC's debugger to debug your code.

Programming Support Utilities

Once object files are produced, you run **clnk** (the linker) to produce an executable image for your target system; you can use the programming support utilities to inspect the executable.

chex - absolute hex file generator. *chex* translates executable images produced by the linker into hexadecimal interchange formats, for use with in-circuit emulators and PROM programmers. *chex* produces the following formats:

- Motorola S-record format
- standard Intel hex format

clabs - absolute listing utility. *clabs* translates relocatable listings produced by the assembler by replacing all relocatable information by absolute information. This utility must to be used only after the linker.

clib - build and maintain object module libraries. *clib* allows you to collect related files into a single named library file for convenient storage. You use it to build and maintain object module libraries in standard library format.

cobj - object module inspector. *cobj* allows you to examine standard format executable and relocatable object files for symbol table information and to determine their size and configuration.

cv695 - IEEE695 format converter. *cv695* allows you to generate IEEE695 format file. This utility must to be used only after the linker.

cvdwarf - ELF/DWARF format converter. *cvdwarf* allows you to convert a file produced by the linker into an ELF/DWARF format file.

Listings

Several options for listings are available. If you request no listings, then error messages from the compiler are directed to your terminal, but no additional information is provided. Each error is labelled with the C source file name and line number where the error was detected.

If you request an assembly language and object code listing with interspersed C source, the compiler merges the C source as comments among the assembly language statements and lines of object code that it generates. Unless you specify otherwise, the error messages are still written to your terminal. Your listing is the listing output from the assembler.

Optimizations

The C cross compiler performs a number of compile time and optimizations that help make your application smaller and faster:

- The compiler will perform arithmetic operations in 8-bit precision if the operands are 8-bit.
- The compiler eliminates unreachable code.
- The compiler performs multiplication by powers of two as faster shift instructions.

- Branch shortening logic chooses the smallest possible jump/ branch instructions. Jumps to jumps and jumps over jumps are eliminated as well.

- Integer and float constant expressions are folded at compile time.

- Redundant load and store operations are removed.

- **enum** is large enough to represent all of its declared values, each of which is given a name. The names of **enum** values occupy the same space as type definitions, functions and object names. The compiler provides the ability to declare an **enum** using the smallest type char, int or long:

- An optimized switch statement produces combinations of tests and branches, jump tables for closely spaced case labels, a scan table for a small group of loosely spaced case labels, or a sorted table for an efficient search.

- The functions in the C library are packaged in three separate libraries; one of them is built without floating point support. If your application does not perform floating point calculations, you can decrease its size and increase its runtime efficiency by linking with the non-floating-point version of the modules needed.

Support for ROMable Code

The compiler provides the following features to support ROMable code production. See Chapter 3 for more information.

- Referencing of absolute hardware addresses;

- Control of the STM8 interrupt system;

- Automatic data initialization;

- User configurable runtime startup file;

- Support for mixing C and assembly language code; and

- User configurable executable images suitable for direct input to a PROM programmer or for direct downloading to a target system.

Support for eeprom

The compiler provides the following features to support **eeprom** handling:

- **@eeprom** type qualifier to describe a variable as an *eeprom* location. The compiler generates special sequences when the variable is modified.

- Library functions for erasure, initialization and copy of *eeprom* locations.

NOTE

The basic routine to program an eeprom byte is located in the library file ***eeprom.s*** *and has been written using the default input/output address . This file must be modified if using a different base address.*

These basic routines are not updating any watchdog, so applications enabling a watchdog must modify these routines to add watchdog updates in the wait loops.

Memory Models

The STM8 compiler supports several memory models allowing you to choose the best configuration for your processor and your application. You can choose to use the physical stack for functions arguments and local variables, or to simulate such a stack in memory thus leaving more space on the stack for return addresses and interrupt stacks. You can also specify where those areas are located in the memory space, inside or outside the zero page (short addressing). For more information, please refer to Chapter 3.

For information on using the compiler, see *Chapter 4*.
For information on using the assembler, see *Chapter 5*.
For information on using the linker, see *Chapter 6*.
For information on debugging support, see *Chapter 7*.
For information on using the programming utilities, see *Chapter 8*.
For information on the compiler passes, see *Appendix D*.

CHAPTER

2

Tutorial Introduction

This chapter will demonstrate, step by step, how to compile, assemble and link the example program **acia.c**, which is included on your distribution media. Although this tutorial cannot show all the topics relevant to the COSMIC tools, it will demonstrate the basics of using the compiler for the most common applications.

In this tutorial you will find information on the following topics:

Acia.c, Example file

The following is a listing of *acia.c*. This C source file is copied during the installation of the compiler:

```
/*     STM8 EXAMPLE PROGRAM WITH INTERRUPT HANDLING
 *     Copyright (c) 2007 by COSMIC Software
 */
#include <iostm8.h>

#define SIZE64                    /* buffer size */
#define TRDE0x80                  /* transmit ready bit */

/*     Authorize interrupts.
 */
#define rim() _asm("rim")

/*     Some variables
 */
char buffer[SIZE];                /* reception buffer */
char *ptlec;                      /* read pointer */
char *ptecr;                      /* write pointer */

/*     Character reception.
 *     Loops until a character is received.
 */
char getch(void)
      {
      char c;                     /* character to be returned */

      while (ptlec == ptecr)  /* equal pointers => loop */
            ;
      c = *ptlec++;               /* get the received char */
      if (ptlec >= &buffer[SIZE])/* put in in buffer */
            ptlec = buffer;
      return (c);
      }

/*     Send a char to the SCI.
 */
void outch(char c)
      {
      while (!(USART_SR & TRDE))/* wait for READY */
            ;
      USART_DR = c;               /* send it */
      }
```



```
/*    Character reception routine.
 *    This routine is called on interrupt.
 *    It puts the received char in the buffer.
 */
@interrupt void recept(void)
      {
      USART_SR;                     /* clear interrupt */
      *ptecr++ = USART_DR;          /* get the char */
      if (ptecr >= &buffer[SIZE])   /* put it in buffer */
            ptecr = buffer;
      }

/*    Main program.
 *    Sets up the SCI and starts an infinite loop
 *    of receive transmit.
 */
void main(void)
      {
      ptecr = ptlec = buffer; /* initialize pointers */
      USART_BRR1 = 0xc9;      /* parameter for baud rate */
      USART_CR1 = 0x00;       /* param. for word length */
      USART_CR2 = 0x2c;       /* parameters for interrupt */
      rim();                  /* authorize interrupts */
      for (;;)                /* loop */
            outch(getch());   /* get and put a char */
      }
```

Default Compiler Operation

By default, the compiler compiles and assembles your program. You may then link object files using **clnk** to create an executable program.

The compiler supports several memory models, for applications smaller or larger than 64K, defining how the stack is used and where variables are allocated. A model option should always be specified on the command line; if nothing is specified, the compiler assumes the **+modsl** option (physical stack and globals in long range). See "*Memory Models for code smaller than 64K*" in **Chapter 3** and "*Memory Models for code larger than 64K*" in **Chapter 3** for more information.

As it processes the command line, **cxstm8** echoes the name of each input file to the standard output file (your terminal screen by default). You can change the amount of information the compiler sends to your terminal screen using command line options, as described later.

According to the options you will use, the following files, recognized by the COSMIC naming conventions, will be generated:

file.s	Assembler source module
file.o	Relocatable object module
file.sm8	input (*e.g*. libraries) or output (*e.g.* absolute executable) file for the linker

Compiling and Linking

To compile and assemble *acia.c* using the short stack model, type:

```
cxstm8 +mods acia.c
```

The compiler writes the name of the input file it processes:

```
acia.c:
```

The result of the compilation process is an object module named *acia.o* produced by the assembler. We will, now, show you how to use the different components.

Step 1: Compiling

The first step consists in compiling the C source file and producing an assembly language file named **acia.s**.

```
cxstm8 +mods -s acia.c
```

The **-s** option directs **cxstm8** to stop after having produced the assembly file *acia.s*. You can then edit this file with your favourite editor. You can also visualize it with the appropriate system command (*type*, *cat*, *more*,...). For example under MS/DOS you would type:

```
type acia.s
```

If you wish to get an interspersed C and assembly language file, you should type:

```
cxstm8 +mods -l acia.c
```

The **-l** option directs the compiler to produce an assembly language file with C source line interspersed in it. Please note that the C source lines are commented in the assembly language file: they start with '**;**'.

As you use the C compiler, you may find it useful to see the various actions taken by the compiler and to verify the options you selected. The **-v** option, known as verbose mode, instructs the C compiler to display all of its actions. For example if you type:

```
cxstm8 +mods -v -s acia.c
```

the display will look like something similar to the following:

```
acia.c:
        cpstm8 -o \2.cx1 -i\cxstm8\hstm8 -u -hmods.h acia.c
        cgstm8 -o \2.cx2 \2.cx1
        costm8 -o acia.s \2.cx2
```

The compiler runs each pass:

cpstm8	the C parser
cgstm8	the assembly code generator
costm8	the optimizer

Step 2: Assembler

The second step of the compilation is to assemble the code previously produced. The relocatable object file produced is *acia.o*.

```
cxstm8 acia.s
```

or

```
castm8 -i\cxstm8\hstm8 acia.s
```

if you want to use directly the macro cross assembler.

The cross assembler can provide, when necessary, listings, symbol table, cross reference and more. The following command will generate a listing file named *acia.ls* that will also contain a cross reference:

```
castm8 -c -l acia.s
```

For more information, see **Chapter 5**, “*Using The Assembler*”.

Step 3: Linking

This step consists in linking relocatable files, also referred to as object modules, produced by the compiler or by the assembler (**<files>.o**) into an absolute executable file: **acia.sm8** in our example. Code and data sections will be located at absolute memory addresses. The linker is used with a command file (*acia.lkf* in this example).

An application that uses one or more object module(s) may require several sections (code, data, interrupt vectors, etc.,...) located at different addresses. Each object module contains several sections. The compiler creates the following sections:

Type	Description
.text	code (or program) section (*e.g.* **ROM**)
.fconst	large constant and literal data (*e.g.* **ROM**, see **@far**)
.const	constant and literal data (*e.g.* **ROM**)
.data	initialized data in **long addressing range** memory (see **@near** in chapter 3) (*e.g.* **RAM**)
.bss	all non initialized data in **long range** memory (*e.g.* **RAM**)
.bsct	initialized data in the first 256 bytes (see **@tiny** in chapter 3), also called **zero page** or **short addressing range**.
.ubsct	non initialized data in the *zero page*
.fdata	large variables (**@far**)
.eeprom	any variable in eeprom (**@eeprom**)
.bit	bit variables in the *zero page*

In our example, and in the test file provided with the compiler, the *acia.lkf* file contains the following information:

```
line 1 # LINK COMMAND FILE FOR TEST PROGRAM
line 2 # Copyright (c) 2002 by COSMIC Software
line 3 #
line 4 +seg .text -b0xf000 -n.text# program start address
line 5 +seg .const -a .text   # constants follow code
line 6 +seg .bsct -b0x0 -m0x100# zero page start address
line 7 +seg .ubsct            # uninitialized zero page
line 8 crts.o                 # startup routine
line 9 acia.o                 # application program
line 10 \cx32\lib\libis.sm8   # C library (if needed)
line 11 \cx32\lib\libm.sm8    # machine library
line 12 +seg .vector -b0x8000 # vectors start address
line 13 vector.o              # interrupt vectors
```

You can create your own link command file by modifying the one provided with the compiler.

Here is the explanation of the lines in *acia.lkf*:

lines 1 to 3: These are comment lines. Each line can include comments. They must be prefixed by the “#” character.

line 4: **`+seg .text -b0xf000`** creates a text (code) segment located at **`f000`** (hex address) named *.text*.

line 5: **`+seg .const -n.text`** creates a constant segment following the text segment.

line 6: **`+seg .bsct -b0x0 -m0x100`** creates a zero page segment located at **`0`** (hex address) with a maximum size of 256 bytes.

line 7: **`+seg .ubsct`** creates an uninitialized zero page segment located by default after the *.bsct* segment.

line 8: **`crts.o`** runtime startup code. It will be located at **`0xf000`** (code segment)

line 9: **`acia.o`**, the file that constitutes your application. It follows the startup routine for code and data

line 10: `libis.sm8` the integer library to resolve references

line 11: `libm.sm8` the machine library to resolve references

line 12: `+seg .vector -b0x8000` creates a segment vector (const) segment located at `8000` (hex address)

line 13: `vectors.o` interrupt vectors file

By default and in our example, the *.bss* segment follows the *.data* segment.

The *crts.o* file contains the runtime startup that performs the following operations:

- initialize the *bss*, if any
- initialize the stack pointer
- call *main()* or any other chosen entry point.

For more information, see "*Modifying the Runtime Startup*" in **Chapter 3**.

After you have modified the linker command file, you can link by typing:

```
clnk -o acia.sm8 acia.lkf
```

Step 4: Generating S-Records file

Although *acia.sm8* is an executable image, it may not be in the correct format to be loaded on your target. Use the **chex** utility to translate the format produced by the linker into standard formats. To translate *acia.sm8* to *Motorola standard S-record* format:

```
chex acia.sm8 > acia.hex
```

or

```
chex -o acia.hex acia.sm8
```

acia.hex is now an executable image in *Motorola S-record* format and is ready to be loaded in your target system.

For more information, see "*The chex Utility*" in **Chapter 8**.

Linking Your Application

You can create as many *text*, *data* and *bss* segments as your application requires. For example, assume we have one *bss*, two *data* and two *text* segments. Our link command file will look like:

```
+seg .text -b 0xf000 -n .text # program start address
+seg .const -a .text          # constant follow
+seg .data -b 0x100           # data start address
+seg .bss -b 0x200            # bss start address
+seg .bsct -b0x0 -m0x100      # zpage start address
+seg .ubsct -n iram           # uninitialized zero page
crts.o                        # startup routine
acia.o                        # main program
module1.o                     # application program
+seg .text -b 0x2000          # start new text section
module2.o                     # application program
module3.o                     # application program
\cx\lib\libis.sm8             # C library (if needed)
\cx\lib\libm.sm8              # machine library
+seg .vector -b0x8000         # vectors start address
vector.o                      # interrupt vectors
#
# define these symbols if crtsi is used
#
#+def __endzp=@.ubsct         # end of uninitialized zpage
#+def __memory=@.bss          # symbol used by startup
```

In this example the linker will locate and merge *crts.o*, *acia.o* and *module1.o* in a *text* segment at `0xf000`, a *data* segment at `0x100` and a *bss* segment, if needed at `0x200`. *zero page* variables will be located at `0x0`. The rest of the application, *module2.o* and *module3.o* and the libraries will be located and merged in a new *text* segment at `0x2000` then the interrupt vectors file, *vector.o* in a *vector* segment at `0x8000`. All constants will be located after the first *text* segment.

For more information about the linker, see **Chapter 6**, “*Using The Linker*”.

Generating Automatic Data Initialization

Usually, in embedded applications, your program must reside in ROM.

This is not an issue when your application contains code and read-only data (such as string or const variables). All you have to do is burn a PROM with the correct values and plug it into your application board.

The problem comes up when your application uses initial data values that you have defined with initialized static data. These static data values must reside in RAM.

There are two types of static data initializations:

1) data that is explicitly initialized to a non-zero value:

```
char var1 = 25;
```

which is generated into the **.bsct** section and

2) data that is explicitly initialized to zero or left uninitialized:

```
char var2;
```

which is generated into the **.ubsct** section.

There is one exception to the above rules when you declare data that will be located in the **external memory**, using the **@near** type qualifier. In this case, the data is generated into the **.data** section if it is initialized or in the **.bss** section otherwise.

The first method to ensure that these values are correct consists in adding code in your application that reinitializes them from a copy that you have created and located in ROM, at each restart of the application.

The second method is to use the **crtsi.sm8** start-up file:

1) that defines a symbol that will force the linker to create a copy of the initialized RAM in ROM

2) and that will do the copy from ROM to RAM

The following link file demonstrates how to achieve automatic data initialization.

```
# demo.lkf: link command with automatic init
+seg .text -b 0xf000 -n .text # program start address
+seg .const -a .text          # constant follow
+seg .bsct -b 0x0 -m 0x100    # zpage start address
+seg .data -b0x100            # data start address
\cx32\lib\crtsi.sm8           # startup with auto-init
acia.o                        # main program
module1.o                     # module program
\cx32\lib\libis.sm8           # C library (if needed)
\cx32\lib\libm.sm8            # machine library
+seg .vector -b 0x8000        # vectors start address
vector.o                      # interrupt vectors
# define these symbols if crtsi is used
+def __endzp=@.ubsct           # end of uninitialized zpage
+def __memory=@.bss            # end of bss segment
```

In the above example, the *text* segment is located at address `0xf000`, the *data* segment is located at address `0x100`, immediately followed by the *bss* segment that contains uninitialized data. The initialized data in ROM will follow the descriptor created by the linker after the code segment.

In case of multiple code and data segments, a link command file could be:

```
# demoinit.lkf: link command with automatic init
+seg .text -b 0xf000 -n .text # program start address
+seg .const -a .text          # constant follow
+seg .bsct -b 0x0 -m 0x100    # zpage start address
+seg .data -b0x100            # data start address
\cx32\lib\crtsi.sm8           # startup with auto-init
acia.o                        # main program
module1.o                     # module program
+seg .text -b0xf800           # new code segment
module2.o                     # module program
module3.o                     # module program
\cx32\lib\libis.sm8           # C library (if needed)
\cx32\lib\libm.sm8            # machine library
+seg .vector -b 0x8000        # vectors start address
vector.o                      # interrupt vectors
# define these symbols if crtsi is used
+def __endzp=@.ubsct           # end of uninitialized zpage
+def __memory=@.bss            # end of bss segment
```

or

```
# demoinit.lkf: link command with automatic init
+seg .text -b 0xf000 -n .text # program start address
+seg .const -a .text          # constant follow
+seg .bsct -b 0x0 -m 0x100    # zpage start address
+seg .data -b0x100            # data start address
\cx32\lib\crtsi.sm8           # startup with auto-init
acia.o                        # main program
module1.o                     # module program
+seg .text -b0xf800 -it       # sets the section attribute
module2.o                     # module program
module3.o                     # module program
\cx32\lib\libis.sm8           # C library (if needed)
\cx32\lib\libm.sm8            # machine library
+seg .vector -b 0x8000        # vectors start address
vector.o                      # interrupt vectors
# define these symbols if crtsi is used
+def __endzp=@.ubsct           # end of uninitialized zpage
+def __memory=@.bss            # end of bss segment
```

In the first case, the initialized data will be located after the first code segment. In the second case, the **-it** option instructs the linker to locate the initialized data after the segment marked with this flag. The initialized data will be located after the second code segment located at address `0xf800`.

For more information, see "*Initializing data in RAM*" in **Chapter 3** and "*Automatic Data Initialization*" in **Chapter 6**.

Specifying Command Line Options

You specify command line options to **cxstm8** to control the compilation process.

To compile and get a relocatable file, type:

```
cxstm8 +mods acia.c
```

The file produced is *acia.o*.

The **-v** option instructs the compiler driver to echo the name and options of each program it calls. The **-l** option instructs the compiler driver to create a mixed listing of C code and assembly language code in the file *acia.ls*.

To perform the operations described above, enter the command:

```
cxstm8 +mods -v -l acia.c
```

When the compiler exits, the following files are left in your current directory:

- the C source file **acia.c**
- the C and assembly language listing **acia.ls**
- the object module **acia.o**

It is possible to locate listings and object files in specified directories if they are different from the current one, by using respectively the **-cl** and **-co** options:

```
cxstm8 +mods -cl\mylist -co\myobj -l acia.c
```

This command will compile the *acia.c* file, create a listing named *acia.ls* in the *\mylist* directory and an object file named *acia.o* in the *\myobj* directory.

cxstm8 allows you to compile more than one file. The input files can be C source files or assembly source files. You can also mix all of these files.

If your application is composed with the following files: two C source files and one assembly source file, you would type:

```
cxstm8 +mods -v start.s acia.c getchar.c
```

This command will assemble the *start.s* file, and compile the two C source files.

See "*Compiler Command Line Options*" in **Chapter 4** for information on these and other command line options.

CHAPTER

3

Programming Environments

This chapter explains how to use the COSMIC program development system to perform special tasks required by various STM8 applications.

Introduction

This chapter provides details about:

- Modifying the Runtime Startup
- Initializing data in RAM
- Memory Models for code smaller than 64K
- Memory Models for code larger than 64K
- Handling Large Code and Constants
- Bit Variables
- The const and volatile Type Qualifiers
- Performing Input/Output in C
- Referencing Absolute Addresses
- Accessing Internal Registers
- Placing Data Objects in The Bss Section
- Placing Data Objects in Short Range Memory
- Placing Data Objects in Long Range Memory
- Placing Data Objects in the EEPROM Space
- Redefining Sections
- Inserting Inline Assembly Instructions
- Writing Interrupt Handlers
- Placing Addresses in Interrupt Vectors
- Inline Function
- Interfacing C to Assembly Language

- Register Usage
- Data Representation

Modifying the Runtime Startup

The runtime startup module performs many important functions to establish a runtime environment for C. The runtime startup file included with the standard distribution provides the following:

- Initialization of the **bss** section if any,
- ROM into RAM copy if required,
- Initialization of the stack pointer,
- *f_main* or other program entry point call, and
- An exit sequence to return from the C environment. Most users must modify the exit sequence provided to meet the needs of their specific execution environment.

The following is a listing of the standard runtime startup file **crts.sm8** included on your distribution media. It does not perform automatic data initialization. The runtime startup file can be placed anywhere in memory. Usually, the startup will be “linked” with the **RESET** interrupt, and the startup file may be at any convenient location.

```
;   C STARTUP FOR STM8
;   WITHOUT ANY DATA INITIALIZATION
;   Copyright (c) 2006 by COSMIC Software
;
    xref  f_main, __stack
    xdef  f_exit, __stext, f__stext
;
;   startup routine from reset vector
;
    switch .text
__stext:
f__stext:
;
;   initialize stack pointer
;
    ldw   x,#__stack  ; stack pointer
    ldw   sp,x        ; in place
;
;   execute main() function
;   may be called by a 'jpf' instruction if no return
```



```
expected
21 ;
22    callf f_main      ; execute main
23 f_exit:
24    jra   f_exit      ; and stay here
25 ;
26    end
```

Description of Runtime Startup Code

f_main is the entry point into the user C program.

Line 15 resets the stack pointer.

Line 22 calls *main()* in the user's C program.

Lines 23 to 24 trap a return from *main()*. If your application must return to a monitor, for example, you must modify this line.

Initializing data in RAM

If you have initialized static variables, which are located in **RAM**, you need to perform their initialization before you start your C program. The **clnk** linker will take care of that: it moves the initialized data segments after the **first** text segment, or the one you have selected with the **-it** option, and creates a descriptor giving the starting address, destination and size of each segment.

The table thus created and the copy of the **RAM** are located in **ROM** by the linker, and used to do the initialization. An example of how to do this is provided in the **crtsi.s** file, located in the headers sub-directory.

```
;      C STARTUP FOR STM8
;      WITH AUTOMATIC DATA INITIALISATION
;      Copyright (c) 2006 by COSMIC Software
;
       xref   f_main, __memory, __idesc__, __stack
       xref.b c_x, c_y, __endzp
       xdef   f_exit, __stext, f__stext
;
;      start address of zpage
;
       switch .ubsct
__suzp:
;
;      start address of bss
;
       switch .bss
__sbss:
;
;      startup routine from reset vector
;
       switch.text
__stext:
f__stext:
;
;      initialize stack pointer
;
       ldw    x,#__stack  ; stack pointer
       ldw    sp,x        ; in place
;
;      setup initialized data
;
       ldw    y,__idesc__ ; data start address
```

```
        ldw   x,#__idesc__+2    ; descriptor address
ibcl:
        ld    a,(x)         ; test flag byte
        jreq  zero          ; no more segment
        bcp   a,#$60        ; test for moveable code segment
        jreq  qbcl          ; yes, skip it
        ldw   c_x,x         ; save pointer
        ldw   x,(3,x)       ; move end address
        ldw   c_y,x         ; in memory
        ldw   x,c_x         ; reload pointer
        ldw   x,(1,x)       ; start address
dbcl:
        ld    a,(y)         ; transfer
        ld    (x),a         ; byte
        incw  x             ; increment
        incw  y             ; pointers
        cpw   y,c_y         ; last byte ?
        jrne  dbcl          ; no, loop again
        ldw   x,c_x         ; reload pointer
qbcl:
        addw  x,#5          ; next descriptor
        jra   ibcl          ; and loop
;
;       reset uninitialized data in zero page
;
zero:
        ldw   x,#__suzp     ; start of uninitialized zpage
        jra   loop          ; test segment end first
zbcl:
        ld    (x),a         ; clear byte
        incw  x             ; next byte
loop:
        cpw   x,#__endzp    ; end of zpage
        jrne  zbcl          ; no, continue
;
;       reset uninitialized data in bss
;
        ldw   x,#__sbss     ; start address
        jra   ok            ; test segment end first
bbcl:
        ld    (x),a         ; clear byte
        incw  x             ; next byte
ok:
        cpw   x,#__memory   ; compare end
        jrne  bbcl          ; not equal, continue
;
```

```
;      execute main() function
;      may be called by a 'jpf' instruction if no return
expected
;
       callf f_main       ; execute main
f_exit:
       jra    f_exit      ; and stay here
;
       end
```

crtsi.s performs the same function as described with the *crts.s*, but with one additional step. Lines (marked in bold) in *crtsi.s* include code to copy the contents of initialized static data, which has been placed in the text section by the linker, to the desired location in RAM.

The compiler is provided with several startup files implementing the automatic data initialization depending on the range of variables to be initialized and the range of the initialization table:

Startup	Initialize	From Table in
crtsi.s	@near	@near
crtsx.s	@near and @far	@near
crtsif.s	@near	@far
crtsxf.s	@near and @far	@far

For more information, see "*Generating Automatic Data Initialization*" in **Chapter 2** and "*Automatic Data Initialization*" in **Chapter 6**.

Memory Models for code smaller than 64K

The STM8 compiler supports two memory models for application smaller than 64K, allowing you to choose the most efficient behavior depending on your processor configuration and your application. All these models handle code smaller than 64K and then function pointers are defaulted to **@near** pointers (2 bytes). Data pointers are defaulted to **@near** pointers (2 bytes). The supported models are:

- **Stack Short** (**mods0**) stack is physically in *long range* and global variables are defaulted to *short range*. Any global object in long range will have to be accessed explicitly with the **@near** modifier unless accessed through a pointer.

- **Stack Long** (**modsl0**) stack is physically in *long range* and global variables are also defaulted to *long range*. Any object in long range will have to be accessed explicitly with the **@tiny** modifier.

The following table shows for each model how and where the stack is implemented, how globals are defaulted and how pointers are defaulted.

Models	Stack	Globals
Stack Short	Physical in Long Range	Zero Page
Stack Long	Physical in Long Range	Long Range

The physical stack is implemented in the long range and its value is set by the symbol **__stack** in the linker file, if you use the run time setup files provided with the compiler. The user must insure that the stack and the variables do not overlap at run time.

The choice of the appropriate model for a given application should be driven by the amount of globals and locals compared with the available space in memory. Zero Page variables are more efficient than Long Range variables but the Zero Page size is limited to **256** bytes.

NOTE

When using a model for application smaller than 64K, you must link with the specific set of libraries (names ending with '0').

Memory Models for code larger than 64K

The STM8 compiler supports two memory models for application larger than 64K, allowing you to choose the most efficient behavior depending on your processor configuration and your application. All these models allow the code to be larger than 64K and then function pointers are defaulted to **@far** pointers (3 bytes). Data pointers are defaulted to **@near** pointers (2 bytes) unless explicitly declared with the **@far** modifier. The supported models are:

- **Stack Short** (**mods**) stack is physically in *long range* and global variables are defaulted to *short range*. Any global object in long range will have to be accessed explicitly with the **@near** modifier unless accessed through a pointer.

- **Stack Long** (**modsl**) stack is physically in *long range* and global variables are also defaulted to *long range*. Any object in long range will have to be accessed explicitly with the **@tiny** modifier.

The following table shows for each model how and where the stack is implemented, how globals are defaulted and how pointers are defaulted.

Models	Stack	Globals
Stack Short	Physical in Long Range	Zero Page
Stack Long	Physical in Long Range	Long Range

The physical stack is implemented in the long range and its value is set by the symbol **__stack** in the linker file, if you use the run time setup files provided with the compiler. The user must insure that the stack and the variables do not overlap at run time.

The choice of the appropriate model for a given application should be driven by the amount of globals and locals compared with the available space in memory. Zero Page variables are more efficient than Long Range variables but the Zero Page size is limited to **256** bytes.

Handling Large Code and Constants

The STM8 addresses more than 64K of code, dividing the total space in 64K large sections. The compiler allows by default functions to be as large as needed and to be allocated anywhere in the total space, regardless of any sections boundary crossing. Interrupt functions need to be located in the first section. The assembly name of functions allocated anywhere, implicitly declared as **@far** functions, is prefixed with the sequence "**f_**", the function beeing called by a *callf* instruction and ended with a *retf* instruction, while the name of functions declared explicitly as **@near** functions is prefixed with a single "**_**", the function beeing called by a *call* instruction and ended with a *ret* instruction. Such **@near** functions must be completely located inside the same section and called only by functions located in the same section. Unless trying to optimize the code space, the **@near** modifier should be restricted to interrupt functions. Such a difference in the function names allows the linker to check that **@far** and **@near** functions are called properly, any mixing beeing forbidden as the stack display would not be the same.

In order to allow large functions to cross section boundaries, the compiler has to use the far jump instruction **jpf** for any unconditional jump inside the function when the range is too large for a **jra** instruction. This makes the code larger even if such a function is not actually crossing a section boundary. It is possible to force the compiler using the **jp** instruction on any function by using the **-gnc** option. Such functions may still be **@far** or **@near** but cannot be larger than 64K and cannot be allocated across section. Such functions and **@near** functions are checked by the linker in order to verify this constraint.

Constants and literals are normally produced in the **.const** section which must be located in the first section. Large constants may be declared with an **@far** modifier. In such a case, they are produced in a **.fconst** section which may be located anywhere. Although the *far* space is used for code and constants, the compiler allows variables to be declared with the **@far** modifier. Such variables are allocated in a **.fdata** section which may be located anywhere.

Bit Variables

The C compiler implements bit variables using the **_Bool** type name as defined by the new ANSI/ISO standard *C99* (also referenced as *C9X*). A **_Bool** variable is a boolean object which only contains the values *true* and *false*. They are implemented on single bits with value **1** for *true* and **0** for *false*. When assigning an expression to a **_Bool** variable, the compiler compares the expression against zero and assigns the boolean result to the boolean variable. So, any integer, real or pointer expression can be assigned to a boolean variable. It is not possible to declare arrays of booleans nor pointers to booleans, but booleans can be used as structure or union fields. Consecutive **_Bool** fields will be packed in bytes.

The compiler packs global **_Bool** variables in bytes using a bit section named **.bit** which needs to be allocated in the zero page in order to allow and efficient handling using the bit instructions. Local **_Bool** variables are also packed in bytes regardless of the memory model. **_Bool** arguments are passed widened to a single byte.

```
_Bool in_range;
_Bool p_valid;
char *ptr;

in_range = (value >= 10) && (value <= 20);
p_valid = ptr;    /* p_valid is true if ptr not 0 */
if (p_valid && in_range)
    *ptr = value;
```


The const and volatile Type Qualifiers

You can add the type qualifiers **const** and **volatile** to any base type or pointer type attribute.

Volatile types are useful for declaring data objects that appear to be in conventional storage but are actually represented in machine registers with special properties. You use the type qualifier *volatile* to declare memory mapped input/output control registers, shared data objects, and data objects accessed by signal handlers. The compiler will not optimize references to *volatile* data.

An expression that stores a value in a data object of *volatile* type stores the value immediately. An expression that accesses a value in a data object of *volatile* type obtains the stored value for each access. Your program will not reuse the value accessed earlier from a data object of *volatile* type.

NOTE

The volatile keyword must be used for any data object (variables) that can be modified outside of the normal flow of the function. Without the volatile keyword, all data objects are subject to normal redundant code removal optimizations. Volatile ***MUST*** *be used for the following conditions:*

1) All data objects or variables associated with a memory mapped hardware register e.g. `volatile char DDRB @0x05;`

2) All global variable that can be modified (written to) by an interrupt service routine either directly or indirectly. e.g. a global variable used as a counter in an interrupt service routine.

You use *const* to declare data objects whose stored values you do not intend to alter during execution of your program. You can therefore place data objects of *const* type in ROM or in write protected program segments. The cross compiler generates an error message if it encounters an expression that alters the value stored in a *const* data object.

If you declare a static data object of *const* type at either file level or at block level, you may specify its stored value by writing a data initializer. The compiler determines its stored value from its data initializer before program startup, and the stored value continues to exist unchanged until program termination. If you specify no data initializer, the stored value is zero. If you declare a data object of *const* type at argument level, you tell the compiler that your program will not alter the value stored in that argument in the related function. If you declare a data object of *const* type and dynamic lifetime at block level, you must specify its stored value by writing a data initializer. If you specify no data initializer, the stored value is undefined.

The *const* keyword implies the **@near** memory space to allow such a variable to be located in the code space. If a memory space modifier is explicitly given on a declaration using the *const* keyword, the compiler uses the given space instead of the default one, meaning that the object may not be located in the code space depending on the memory space given. In such a case, the *const* keyword still enforces the assignment checking.

You may specify *const* and *volatile* together, in either order. A *const volatile* data object could be a Read-only status register, or a status variable whose value may be set by another program.

Examples of data objects declared with type qualifiers are:

```
char * const x;      /* const pointer to char */
int * volatile y;    /* volatile pointer to int */
const float pi = 355.0 / 113.0; /* pi is never changed */
```


Performing Input/Output in C

You perform input and output in C by using the C library functions *getchar, gets, printf, putchar, puts* and *sprintf*. They are described in chapter 4.

The C source code for these and all other C library functions is included with the distribution, so that you can modify them to meet your specific needs. Note that all input/output performed by C library functions is supported by underlying calls to *getchar* and *putchar*. These two functions provide access to all input/output library functions. The library is built in such a way so that you need only modify *getchar* and *putchar*, the rest of the library is independent of the runtime environment.

Function definitions for *getchar* and *putchar* are:

```
char getchar(void);
char putchar(char c);
```

Referencing Absolute Addresses

This C compiler allows you to read from and write to absolute addresses, and to assign an absolute address to a function entry point or to a data object. You can give a memory location a symbolic name and associated type, and use it as you would do with any C identifier. This feature is usefull for accessing memory mapped I/O ports or for calling functions at known addresses in ROM.

References to absolute addresses have the general form **@<address>**, where <*address*> is a valid memory location in your environment. For example, to associate an I/O port at address **0x20** with the identifier name *ttystat*, write a definition of the form:

```
char MISCR1 @0x20;
```

where **@0x20** indicates an absolute address specification and not a data initializer. Since input/output on the STM8 architecture is memory mapped, performing I/O in this way is equivalent to writing in any given location in memory.

Such a declaration does not reserve any space in memory. The compiler still creates a label, using an *equate* definition, in order to reference the C object symbolically. This symbol is made *public* to allow external usage from any other file.

Individual bits can also be declared as **_Bool** objects by adding a bit number to the address using the syntax **@<address>:<bitnum>**, where **<address>** is a byte memory location and **<bitnum>** a bit number expressed by a constant value (or expression) between 0 and 7. For example, to define bit 3 of memory byte at **0x01** as *PB3*:

```
_Bool PB3 @0x01:3;
```

To use the I/O port in your application, write:

```
char c;
c = MISCR1; /* to read from input port */
MISCR1 = c; /* to write to output port */
```


Another solutions is to use a **#define** directive with a cast to the type of the object being accessed, such as:

```
#define MISCR1 *(char *)0x20
```

which is both inelegant and confusing. The COSMIC implementation is more efficient and easier to use, at the cost of a slight loss in portability.

Note that COSMIC C does support the pointer and #define methods of implementing I/O access.

Another example of how to reference a direct memory address, defines a structure at absolute address **0x6000**:

```
struct acia
    {
    char status;
    char data;
    } acia @0x6000
```

Using this declaration, references to **acia.status** will refer to memory location **0x6000** and **acia.data** will refer to memory location **0x6001**. This is very useful if you are building your own custom I/O hardware that must reside at some location in the STM8 memory map.

Accessing Internal Registers

All registers are declared in **io*.h** files provided with the compiler, each one dedicated to a specific processor. One of these files should be included in each file using the input-output registers, for example by a:

```
#include <io75f51x.h>
```

All the register names are defined by assembly *equates* which are made *public*. This allows any assembler source to use directly the input-output register names by defining them with an *xref* directive. All those definitions are already provided in a **io*.s** file which may be included in an assembly source by a:

```
        include "io75f51x.s"
```

Note that the compiler will access to these registers as standard variables. In some case of reading or writing some "*int*" registers, you should declare an **union** (with two char and one int) instead of using directly the I/O register.

Placing Data Objects in The Bss Section

The compiler automatically reserves space for uninitialized data object. All such data are placed in the **.bss** section. All initialized static data are placed in the **.data** section. The bss section is located, by default, after the data section by the linker.

The run-time startup files, *crtsi.s* and *crtsi.s*, contain code which initializes the bss section space to zero.

The compiler provides a special option, **+nobss**, which forces uninitialized data to be explicitly located in the **.data** section. In such a case, these variables are considered as being explicitly initialized to zero.

Placing Data Objects in Short Range Memory

The **Stack Short** model allocates global variables by default in *short range* memory. Such variables are located into the section **.bsct** if they are initialized, or in the section **.ubsct** otherwise. An external object name is published via a **xref.b** declaration at the assembly language level. A variable can be explicitly allocated in *zero page* by using the **@tiny** modifier:

```
@tiny char c;
```

To place data objects into short range memory on a file basis, if not yet selected the memory model, you can use the **#pragma** directive of the compiler:

```
#pragma space extern [] @tiny
```

instructs the compiler to place all data objects of storage class **extern** or **static** into short range memory for the current unit of compilation (usually a file). The section must end with a **#pragma space extern [] @near** to revert to the default compiler behaviour.

NOTE

The code generator does not check for zero page overflow.

Setting Zero Page Size

You can set the size of the *zero page* section of your object image at link time by specifying the following options on the linker command line:

```
+seg .bsct -m##
```

where ## represents the size of the *zero page* section in bytes. Note that the size of the zero page section can never exceed **256 bytes**.

Placing Data Objects in Long Range Memory

The **Stack Long** model allocates global variables by default in *long range* memory. Such variables will be located into the **.data** section if they are initialized, or in the **.bss** section otherwise. An external object name is published via a **xref** declaration at the assembly language level. A variable can be explicitly allocated in *Long Range* memory by using the **@near** modifier. The following declaration:

```
@near char ext;
```

instructs the compiler to locate the variable *ext* in the long range memory.

To place data objects into long range memory on a file basis, if not yet selected by the memory model, you can use the **#pragma** directive of the compiler:

```
#pragma space extern [] @near
```

instructs the compiler to place all data objects of storage class **extern** or **static** into *Long Range memory* for the current unit of compilation (usually a file).

The section must end with a **#pragma space extern [] @tiny** to revert to the default compiler behaviour.

Placing Data Objects in the EEPROM Space

The compiler allows the use to define a variable as an **eeprom** location, using the type qualifier **@eeprom**. This causes the compiler to produce special code when such a variable is modified. When the compiler detects a write to an *eeprom* location, it calls a machine library function which performs the actual write. An example of such a definition is:

```
@eeprom char var;
```

To place all data objects from a file into *eeprom*, you can use the **#pragma** directive of the compiler:

```
#pragma space extern [] @eeprom @near
```

instructs the compiler to treat all *extern* and *static* data in the current file as *eeprom* locations. The **@near** modifier is necessary because the eeprom is located outside the zero page.

The section must end with a **#pragma space extern [] @near** or **@tiny**, depending on the memory model selected.

The compiler allocates *@eeprom* variables in a separate section named **.eeprom**, which will be located at link time.

The linker directive:

```
seg .eeprom -b0xb600 -m512
var_eeprom.o
```

will create a segment located at address **0xb600**, with a maximum size of 512 bytes.

NOTE

The code generator cannot check if data address will be eeprom addresses after linkage.

Redefining Sections

The compiler uses by default predefined sections to output the various component of a C program. The default sections are:

Section	Description
.text	executable code
.const	text string and constants
.fconst	large constant variables (**@far**)
.data	initialized variables (**@near**)
.bss	uninitialized variables (**@near**)
.bsct	initialized variables in zero page (**@tiny** by default)
.ubsct	uninitialized variables in zero page (**@tiny** by default)
.fdata	large variables (**@far**)
.eeprom	any variable in eeprom (**@eeprom**)
.bit	bit variables in the *zero page*

It is possible to redirect any of these components to any user defined section by using the following pragma definition:

#pragma section <*attribute*> <*qualified_name*>

where <*attribute*> is either **empty** or one of the following sequences:

const
_Bool
@tiny
@near
@far
@eeprom

and <*qualified_name*> is a section *name* enclosed as follows:

(name) - parenthesis indicating a code section
[name] - square brackets indicating uninitialized data
{name} - curly braces indicating initialized data

A section name is a plain C identifier which *does not* begin with a dot character, and which is no longer than **13** characters. The compiler will prefix automatically the section name with a dot character when passing this information to the assembler. It is possible to switch back to the default sections by omitting the section name in the <*qualified_name*> sequence.

Each pragma directive starts redirecting the selected component from the next declarations. Redefining the *bss* section forces the compiler to produce the memory definitions for all the previous *bss* declarations before to switch to the new section.

The following directives:

```
#pragma section (code)
#pragma section const {string}
#pragma section @near [udata]
#pragma section @near {idata}
#pragma section @tiny [uzpage]
#pragma section @tiny {izpage}
#pragma section @eeprom @near {e2prom}
#pragma section _Bool {bdata}
```

redefine the default sections (or the previous one) as following:

- executable code is redirected to section **.code**
- strings and constants are redirected to section **.string**
- uninitialized variables are redirected to section **.udata**
- initialized data are redirected to section **.idata**
- uninitialized zpage variables are redirected to section **.uzpage**
- initialized zpage variables are redirected to section **.izpage**
- eeprom variables are redirected to section **.e2prom**
- bit variables are redirected to section **.bdata**

Note that **{name}** and **[name]** are equivalent for constant and eeprom sections as they are all considered as initialized.

The following directive:

```
#pragma section ()
```

switches back the code section to the default section **.text**.

Inserting Inline Assembly Instructions

The compiler features two ways to insert assembly instructions in a C file. The first method uses **#pragma** directives to enclose assembly instructions. The second method uses a special function call to insert assembly instructions. The first one is more convenient for large sequences but does not provide any connection with C object. The second one is more convenient to interface with C objects but is more limited regarding the code length.

Inlining with pragmas

The compiler accepts the following pragma sequences to start and finish assembly instruction blocks:

Directive	Description
#pragma asm	start assembler block
#pragma endasm	end assembler block

The compiler also accepts shorter sequences with the same meaning:

Directive	Description
#asm	start assembler block
#endasm	end assembler block

Such an assembler block may be located anywhere, inside or outside a function. Outside a function, it behaves syntactically as a declaration. This means that such an assembler block cannot split a C declaration somewhere in the middle. Inside a function, it behaves syntactically as one C instruction. This means that there is no trailing semicolon at the end, and no need for enclosing braces. It also means that such an assembler block cannot split a C instruction or expression somewhere in the middle.

The following example shows a correct syntax:

```
#pragma asm
     xref asmvar
#pragma endasm

extern char test;

void func(void)
     {
     if (test)
#asm       /* no need for { */
     scf   ; set carry bit
     rlc asmvar; access assembler variable
#endasm
     else
      test = 1;
     }
```

Inlining with _asm

The **_asm()** function inserts inline assembly code in your C program. The syntax is:

```
_asm("string constant", arguments...);
```

The "*string constant*" argument is the assembly code you want embedded in your C program. "*arguments*" follow the standard C rules for passing arguments. The string you specify follows standard C rules. For example, carriage returns can be denoted by the '**\n**' character.

For example, to produce the following assembly sequence:

```
ldw x,sp
callf f_main
```

you would write

```
_asm("ldw x,sp\n callf f_main\n");
```

The '\n' character is used to separate the instructions when writing multiple instructions in the same line.

NOTE

*The argument string **must** be shorter than **255** characters. If you wish to insert longer assembly code strings you will have to split your input among consecutive calls to _asm().*

_asm() does not perform any checks on its argument string. Only the assembler can detect errors in code passed as argument to an *_asm()* call.

_asm() can be used in expressions, if the code produced by *_asm* complies with the rules for function returns. For example:

```
var = _asm("sra a\n rlc a\n rlc a\n", var);
```

allows to rotate the variable *var* passed as argument in the **a** register, and store the result in the same variable. The variable *var* is supposed to be declared as a *char*, and is loaded in the **a** register because it is considered as a first argument. The result is expected in the **a** register in order to comply with the return register convention, as described below.

NOTE

*With both methods, the assembler source is added as is to the code during the compilation. The optimizer **does not** modify the specified instructions, unless the **-a** option is specified on the code generator. The assembler input can use lowercase or uppercase mnemonics, and may include assembler comments.*

By default, *_asm()* is returning an **int** as any undeclared function. To avoid the need of several definitions (usually conflictuous) when *_asm()* is used with different return types, the compiler implements a special behaviour when a cast is applied to *_asm()*. In such a case, the cast is considered to define the return type of *_asm()* instead of asking for a type conversion. There is no need for any prototype for the *_asm()* function as the parser verifies that the first argument is a string constant.

Inlining Labels

When labels are necessary in the inlined assembly code, the compiler provides a special syntax allowing local labels to be created and handled without interaction with other labels and the optimizer. The sequence **$N** in the assembly source is replaced by a new label name while the sequence **$L** is replaced by the label name created by the last **$N**. Using this syntax, a simple wait loop may be entered as follow:

```
#asm
     ld   a,#7
$N:
     dec  a
     jrne $L   ; loop on the previous label
#endasm
```


Writing Interrupt Handlers

A function declared with the type qualifier **@interrupt** is suitable for direct connection to an interrupt (hardware or software). *@interrupt* functions may not return a value. *@interrupt* functions are allowed to have arguments, although hardware generated interrupts are not likely to supply anything meaningful.

When you define an *@interrupt* function, the compiler uses the "**iret**" instruction for the return sequence, and saves, *if necessary*, the **y** register and the memory bytes used by the compiler for its internal usage. Those areas are **c_x** (3 bytes), **c_y** (3 bytes) and **c_lreg** (4 bytes). Those bytes will be saved and restored if the interrupt function uses them directly. If the interrupt function does not uses these areas directly, but calls another C function, the *c_x* and *c_y* areas will be automatically saved and restored, unless using the type qualifier **@nosvf** on the interrupt function definition. This qualifier can be used when the called functions are known not using those areas, but the compiler does not perform any verification. The *c_lreg* area is not saved implicitly in such a case, in order to keep the interrupt function as efficient as possible. If any function called by the interrupt function uses **longs** or **floats**, the *c_lreg* area can be saved by using the type qualifier **@svlreg** on the interrupt function definition. Whatever the model used is, these copies are made directly on the stack.

Because the STM8 allows several levels of interrupts, the compiler by default enforces a **stack model** for the interrupt function.

The STM8 architecture forces any interrupt function to be located in the first 64K. The interrupt vector table containing 2-byte addresses, interrupt functions declared in C **must** be declared with the **@near** modifier if the vector table is also written in C.

You define an *@interrupt* function by using the type qualifier *@interrupt* to qualify the type returned by the function you declare. An example of such a definition is:

```
@interrupt @near void it_handler(void)
      {
      ...
      }
```

NOTE

The @interrupt modifier is an extension to the ANSI standard.

Placing Addresses in Interrupt Vectors

You may use either an assembly language program or a C program to place the addresses of interrupt handlers in interrupt vectors. The assembly language program would be similar to the following example:

```
        switch .text
        xref handler1, handler2, handler3
vector1:dc.w handler1
vector2:dc.w handler2
vector3:dc.w handler3
        end
```

where *handler1* and so forth are interrupt handlers.

A small C routine that performs the same operation is:

```
extern @near void handler1(), handler2(), handler3();
@near void (* const vector[])() =
        {
        handler1,
        handler2,
        handler3,
        };
```

where *handler1* and so forth are interrupt handlers. Then, at link time, include the following options on the link line:

```
+seg .const -b0x8000 vector.o
```

where *vector.o* is the file which contains the vector table. This file is provided in the compiler package.

Inline Function

The compiler is able to inline a function body instead of producing a function call. This feature allows the program to run faster but produces a larger code. A function to be inlined has to be defined with the **@inline** modifier. Such a function is kept by the compiler and does not produced any code yet. Each time this function is called in the same source file, the call is replaced by the full body of the inlined function. Because inlined functions are in fact local to a source file, they should be defined in a header file if they have to be used by several source files. To allow the arguments to be passed properly, inlined functions must be defined with prototypes.

NOTE

Inline functions cannot declare static local variables and cannot call themselves either directly or indirectly.

The compiler allows access to specific instructions or features of the STM8 processor, using **@inline** functions. Such functions shall be declared as external functions with the *@inline* modifier. The compiler recognizes three predefined functions when explicitly declared as follows:

```
@inline char carry(void);
@inline char irq(void);
@inline char imask(void);
```

carry	the *carry* function is used to test or get the carry bit from the condition register. If the *carry* function is used in a test, the compiler produces a **jnrc** or **jrc** instruction. If the *carry* function is used in any other expression, the compiler produces a code sequence setting the **a** register to 0 or 1 depending on the carry bit value.
irq	the *irq* function is used to test the interrupt line level using the **jrih** or **jril** instruction. The *irq* function can be used only in a test
imask	the *imask* function is used to test the interrupt mask bit in the condition register using the **jrm** or **jrnm** instruction. The *imask* function can be used only in a test.

These functions are predeclared in the *processor.h* header file. A full description with examples is provided in Chapter 4.

Any other function declared as an *@inline* will be translated into a call to a user provided macro. The macro name is obtained by prefixing the *@inline* function name with the '_' character. Arguments are allowed but should be restricted to variable references. Each reference is translated into the proper assembler expression (same translation as applied by the compiler) and then passed to the macro as a quoted text string.

@inline functions may use the registers **a** and/or **x**, but the compiler can not check their use and will not save them. To save the registers before they are used by *@inline* functions, you must add the **@usea** and/or the **@usex** modifiers.

For example:

```
@inline @usea lsub();
```

tells the compiler that *lsub()* uses the register **a**, so that the compiler will save it. If both registers are used, you must specify both modifiers.

Interfacing C to Assembly Language

The C cross compiler translates C programs into assembly language according to the specifications described in this section.

You may write external identifiers in both uppercase and lowercase. The compiler prepends an underscore '_' character to each identifier. If the identifier is the name of an **@far** function, the compiler prepends a '**f**' character to the extra underscore.

The compiler places function code in the **.text** section. Function code is not to be altered or read as data. External function names are published via **xdef** declarations.

Literal data such as strings, float or long constants, and switch tables, are normally generated into the **.const** section. An option on the code generator allows such constants to be produced in the **.text** section. Const variables declared with the **@far** modifier are published in the **.fconst** section.

The compiler generates initialized data declared with the **@near** modifier into the **.data** section. Such external data names are published via **xref** declarations. Data you declare to be of "const" type by adding the type qualifier *const* to its base type is normally generated into the **.const** section. Initialized data declared with the **@tiny** space modifier will be generated into the **.bsct** section. Such external data names are published via **xref.b** declarations. Uninitialized data are normally generated into the **.bss** section for **@near** variables or the **.ubsct** section for **@tiny** variables, unless forced to the **.data** or **.bsct** section by the compiler option **+nobss**. Variables declared with the **@far** modifier are published in the **.fdata** section. **_Bool** data is generated in the **.bit** section and external names are published via **xbit.b** declarations.

Section	Declaration	Reference
.bsct	@tiny char i =2;	xdef
.ubsct	@tiny char i;	xdef
.data	int init = 1	xdef
.bss	int uninit	xdef

Section	Declaration	Reference
.text	char putchar(c);	xdef
.const	const char c = 1;	xdef
.fconst	@far const char c = 1;	xdef
.fdata	@far char i;	xdef
.bit	_Bool Pb3;	xdef
Any of above	extern int out;	xref, xbit

Function calls are performed according to the following:

1) Arguments are evaluated from right to left. The first argument is stored in the **a** register if it is a char or a **@tiny** pointer, or in the **x** register if its type is *short*, *int* or **@near** pointer, and if the function does not return a structure larger than 2 bytes. Other arguments are pushed to the stack if a *Stack* model is selected, or stored in memory otherwise.

2) The function is called via a *callf f_func* instruction.

3) Stacked arguments are cleaned out if a *Stack* model is selected.

Register Usage

Except for the return value, the registers **a**, **x**, **y** and the condition codes are undefined on return from a function call. The return value is in **a** if it is of type char, **@tiny** pointer or a one byte structure, **x** if it is of type short, integer, **@near** pointer or a two byte structure. The return value is in the memory located at symbol **c_lreg** if it is of type long or float. The return value is in the memory location **c_x** (two upper bytes) and the **x** register (lower byte) if it is of type **@far** pointer.

The first argument may be hold in register, and will be stored at the function entry. Such a function declaration:

```
int func(int arg1, int arg2, int arg3)
```

will create the following memory area:

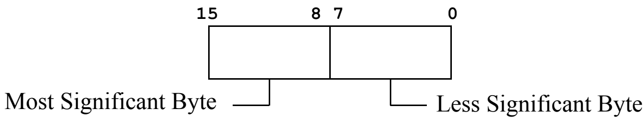
locals	arg1	return address	arg2	arg3

↑ **Stack pointer**

Data Representation

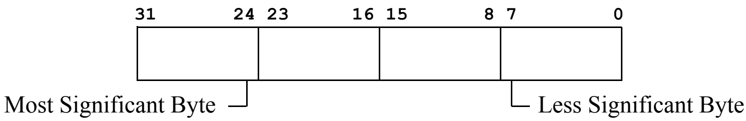
Data objects of type *char* are stored as one byte. A plain *char* is defaulted to type *unsigned char*.

Data objects of type *short int* and *int* are stored as two bytes, more significant byte first.



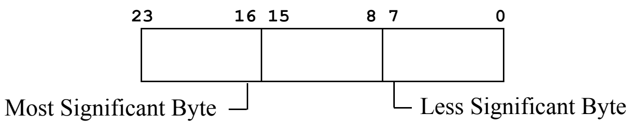
Short Int, Int

Data objects of type *long int* are stored as four bytes, in descending order of significance.



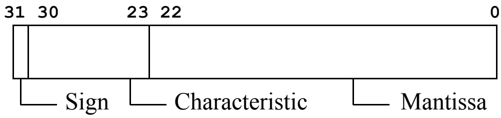
Long

@tiny pointers (short range) are stored as one byte. *@near* pointers (long range) are stored as two bytes. *@far* pointers are stored as three bytes, in descending order of significance.



@far Pointer

Data objects of type *float* are represented as for the proposed IEEE Floating Point Standard; four bytes stored in descending order of significance. The IEEE representation is: most significant bit is one for negative numbers, and zero otherwise; the next eight bits are the characteristic, biased such that the binary exponent of the number is the characteristic minus 126; the remaining bits are the fraction, starting with the weighted bit. If the characteristic is zero, the entire number is taken as zero, and should be all zeros to avoid confusing some routines that do not process the entire number. Otherwise there is an assumed 0.5 (assertion of the weighted bit) added to all fractions to put them in the interval [0.5, 1.0). The value of the number is the fraction, multiplied by -1 if the sign bit is set, multiplied by 2 raised to the exponent.



Float representation

CHAPTER

4

Using The Compiler

This chapter explains how to use the C cross compiler to compile programs on your host system. It explains how to invoke the compiler, and describes its options. It also describes the functions which constitute the C library. This chapter includes the following sections:

- Invoking the Compiler
- File Naming Conventions
- Generating Listings
- Generating an Error File
- C Library Support
- Descriptions of C Library Functions

Invoking the Compiler

To invoke the cross compiler, type the command **cxstm8**, followed by the compiler options and the name(s) of the file(s) you want to compile. All the valid compiler options are described in this chapter. Commands to compile source files have the form:

```
cxstm8 [options] <files>.[c|s]
```

cxstm8 is the name of the *compiler*. The option list is optional. You must include the name of at least one input file <*file*>. <*file*> can be a C source file with the suffix '**.c**', or an assembly language source file with the suffix '**.s**'. You may specify multiple input files with any combination of these suffixes in any order.

If you do not specify any command line options, **cxstm8** will compile your <*files*> with the default options. It will also write the name of each file as it is processed. It writes any error messages to STDERR.

The following command line:

```
cxstm8 +mods acia.c
```

compiles and assembles the *acia.c* C program, using the *Stack Short* model, creating the relocatable program **acia.o**.

If the compiler finds an error in your program, it halts compilation. When an error occurs, the compiler sends an error message to your terminal screen unless the option **-e** has been specified on the command line. In this case, all error messages are written to a file whose name is obtained by replacing the suffix *.c* of the source file by the suffix *.err*. An error message is still output on the terminal screen to indicate that errors have been found. **Appendix A**, "*Compiler Error Messages*" lists the error messages the compiler generates. If one or more command line arguments are invalid, **cxstm8** processes the next file name on the command line and begins the compilation process again.

The example command above does not specify any compiler options. In this case, the compiler will use only default options to compile and assemble your program. You can change the operation of the compiler by specifying the options you want when you run the compiler.

To specify options to the compiler, type the appropriate option or options on the command line as shown in the first example above. Options should be separated with spaces. You must include the '-' or '+' that is part of the option name.

Compiler Command Line Options

The **cxstm8** compiler accepts the following command line options, each of which is described in detail below:

```
cxstm8 [options] <files>
    -a*>  assembler options
    -ce*  path for errors
    -cl*  path for listings
    -co*  path for objects
    -d*>  define symbol
    -e    create error file
    -ec   all C files
    -es   all assembler files
    -ex*  prefix executables
    -f*   configuration file
    -g*>  code generator options
    -i*>  path for include
    -l    create listing
    -no   do not use optimizer
    -o*>  optimizer options
    -p*>  parser options
    -sm   create only dependencies
    -s    create only assembler file
    -sp   create only preprocessor file
    -t*   path for temporary files
    -v    verbose
    -x    do not execute
    +*>   select compiler options
```

Cxstm8 Option Usage

Option	Description
-a*>	specify assembler options. Up to 60 options can be specified on the same command line. See **Chapter 5**, "*Using The Assembler*", for the list of all accepted options.
-ce*	specify a path for the error files. By default, errors are created in the same directory than the source files.
-cl*	specify a path for the listing files. By default, listings are created in the same directory than the source files.
-co*	specify a path for the object files. By default, objects are created in the same directory than the source files.
-d*^	specify * as the name of a user-defined preprocessor symbol (**#define**). The form of the definition is **-dsymbol[=value]**; the symbol is set to **1** if value is omitted. You can specify up to 60 such definitions.
-e	log errors from parser in a file instead of displaying them on the terminal screen. The error file name is defaulted to *<file>.err*, and is created only if there are errors.
-ec	treat all files as C source files.
-es	treat all files as assembler source files.
-ex	use the compiler driver's path as prefix to quickly locate the executable passes. Default is to use the path variable environment. This method is faster than the default behavior but reduces the command line length.
-f*	specify * as the name of a configuration file. This file contains a list of options which will be automatically used by the compiler. If no file name is specified, then the compiler looks for a default configuration file named *cxstm8.cxf* in the compiler directory as specified in the installation process. For more information, see **Appendix B**, "*The Configuration File*".
-g*>	specify code generation options. Up to 60 options can be specified. See "*The cgstm8 Code Generator*" in **Appendix D**, for the list of all accepted options.

Cxstm8 Option Usage (cont.)

Option	Description
-i*>	define include path. You can define up to 128 different paths. Each path is a directory name, **not** terminated by any directory separator character, or a file containing a list of directory names.
-l	merge C source listing with assembly language code; listing output defaults to *<file>.ls*.
-no	do not use the optimizer.
-o*>	specify optimizer options. Up to 60 options can be specified. See "*The costm8 Assembly Language Optimizer*" in **Appendix D**, for the list of all accepted options.
-p*>	specify parser options. Up to 60 options can be specified. See "*The cpstm8 Parser*" in **Appendix D**, for the list of all accepted options.
-s	create only assembler files and stop. Do not assemble the files produced.
-sm	create only a list of 'make' compatible dependencies consisting for each source file in the object name followed by a list of header files needed to compile that file.
-sp	create only preprocessed files and stop. Do not compile files produced. Preprocessed output defaults to <file>.p. The produced files can be compiled as C source files.
-t*	specify path for temporary files. The path is a directory name, **not** terminated by any directory separator character.
-v	be "verbose". Before executing a command, print the command, along with its arguments, to STDOUT. The default is to output only the names of each file processed. Each name is followed by a colon and newline.
-x	do not execute the passes, instead write to STDOUT the commands which otherwise would have been performed.

Cxstm8 Option Usage (cont.)

Option	Description
+*>	select a predefined compiler option. These options are predefined in the configuration file. You can specify up to 60 compiler options on the command line. The following documents the available options as provided by the default configuration file
+compact	produce a smaller code but slower than the default behaviour. Smaller code is produced by enabling the optimizer factorization feature with a default depth of seven instructions.
+debug	produce debug information to be used by the debug utilities provided with the compiler and by any external debugger.
+mods	select the **Stack Short** model. Stack is physically in *long range*, variables are in *short range* memory but pointers are pointing to *long range* memory. See "*Memory Models for code larger than 64K*" in **Chapter 3**.
+modsl	select the **Stack Long** mode. Stack is physically in *long range*, variables and pointers are in and pointing to *long range* memory. See "*Memory Models for code larger than 64K*" in **Chapter 3**.
+mods0	select the **Stack Short** model for application smaller than 64K. Stack is physically in *long range*, variables are in *short range* memory but pointers are pointing to *long range* memory. See "*Memory Models for code smaller than 64K*" in **Chapter 3**.
+modsl0	select the **Stack Long** model for application smaller than 64K. Stack is physically in *long range*, variables and pointers are in and pointing to *long range* memory. See "*Memory Models for code smaller than 64K*" in **Chapter 3**.
+nobss	do not use the **.bss** section for variables allocated in external memory. By default, such uninitialized variables are defined into the *.bss* section. This option is useful to force all variables to be grouped into a single section.
+nocst	output literals and constants in the code section **.text** instead of the specific section **.const**.

Cxstm8 Option Usage (cont.)

Option	Description
+proto	enforce prototype declaration for functions. An error message is issued if a function is used and no prototype declaration is found for it. By default, the compiler accepts both syntaxes without any error.
+rev	reverse the bitfield filling order. By default, bitfields are filled from the Less Significant Bit (LSB) towards the Most Significant Bit (MSB) of a memory cell. If the **+rev** option is specified, bitfields are filled from the *msb* to the *lsb*.
+split	create a separate sub-section per function, up to a maximum number of 256 sections, thus allowing the linker to suppress unused functions if the **-k** option has been specified on at least one segment in the linker command file. For objects with more than 256 functions, the functions will be grouped together to a minimum number of functions per sub-section to not exceed the maximum number of 256 sub-sections. See "*Segment Control Options*" in **Chapter 6**.
+strict	direct the compiler to enforce stronger type checking.
+warn	enable warnings.

File Naming Conventions

The programs making up the C cross compiler generate the following output file names, by default. See the documentation on a specific program for information about how to change the default file names accepted as input or generated as output.

Program	Input File Name	Output File Name
cpstm8	<file>.c	<file>.1
cgstm8	<file>.1	<file>.2
costm8	<file>.2	<file>.s
error listing	<file>.c	<file>.err
assembler listing	<file>.[c|s]	<file>.ls
C header files	<file>.h	
castm8	<file>.s	<file>.o
source listing	<file>.s	<file>.ls
clnk	<file>.o	name required
chex	<file>	STDOUT
clabs	<file.sm8>	<files>.la
clib	<file>	name required
cobj	<file>	STDOUT
cv695	<file.sm8>	<file>.695
cvdwarf	<file.sm8>	<file>.elf

Generating Listings

You can generate listings of the output of any (or all) the compiler passes by specifying the **-l** option to **cxstm8**. You can locate the listing file in a different directory by using the **-cl** option.

The example program provided in the package shows the listing produced by compiling the C source file *acia.c* with the **-l** option:

```
cxstm8 +mods -l acia.c
```

Generating an Error File

You can generate a file containing all the error messages output by the parser by specifying the **-e** option to **cxstm8**. You can locate the error file in a different directory by using the **-ce** option. For example, you would type:

```
cxstm8 +mods -e prog.c
```

The error file name is obtained from the source filename by replacing the *.c* suffix by the *.err* suffix.

Return Status

cxstm8 returns success if it can process all files successfully. It prints a message to STDERR and returns failure if there are errors in at least one processed file.

Examples

To echo the names of each program that the compiler runs:

```
cxstm8 +mods -v file.c
```

To save the intermediate files created by the code generator and halt before the assembler:

```
cxstm8 +mods -s file.c
```

C Library Support

This section describes the facilities provided by the C library. The C cross compiler for STM8 includes all useful functions for programmers writing applications for ROM-based systems.

How C Library Functions are Packaged

The functions in the C library are packaged in three separate sub-libraries; one for machine-dependent routines (the *machine* library), one that does not support floating point (the *integer* library) and one that provides full floating point support (the *floating point* library). If your application does not perform floating point calculations, you can decrease its size and increase its runtime efficiency by including only the integer library.

Inserting Assembler Code Directly

Assembler instructions can be quoted directly into C source files, and entered unchanged into the output assembly stream, by use of the *_asm()* function. This function is not part of any library as it is recognized by the compiler itself. See "*Inserting Inline Assembly Instructions*" in **Chapter 3**.

Linking Libraries with Your Program

If your application requires floating point support, you must specify the floating point library **before** the integer library in the linker command file. Modules common to both libraries will therefore be loaded from the floating point library, followed by the appropriate modules from the floating point and integer libraries, in that order.

NOTE

When using a model for application smaller than 64K, you must link with the specific set of libraries (names ending with '0').

Integer Library Functions

The following table lists the C library functions in the integer library.

```
_asm          isalpha     memcmp      strcmp
checksum      iscntrl     memcpy      strcpy
checksum16    isdigit     memmove     strcspn
checksum16x   isgraph     memset      strlen
```


checksumx	islower	printf	strncat
abs	isprint	putchar	strncmp
atoi	ispunct	puts	strncpy
atol	isqrt	rand	strpbrk
calloc	isspace	realloc	strrchr
div	isupper	sbreak	strspn
free	isxdigit	scanf	strstr
getchar	labs	sprintf	strtol
gets	ldiv	srand	tolower
imask	lsqrt	sscanf	toupper
irq	malloc	strcat	
isalnum	memchr	strchr	

Floating Point Library Functions

The following table lists the C library functions in the float library.

acos	cosh	log	sprintf
asin	exp	log10	sqrt
atan	fabs	modf	strtod
atan2	floor	pow	tan
atof	fmod	printf	tanh
ceil	frexp	sin	
cos	ldexp	sinh	

Common Input/Output Functions

Two of the functions that perform stream output are included in both the integer and floating point libraries. The functionalities of the versions in the integer library are a subset of the functionalities of their floating point counterparts. The versions in the integer library cannot print or manipulate floating point numbers. These functions are: *printf*, *sprintf*.

Functions Implemented as Macros

Two of the functions in the C library are actually implemented as "macros". Unlike other functions, which (if they do not return *int*) are declared in header files and defined in a separate object module that is linked in with your program later, functions implemented as macros are defined using **#define** preprocessor directives in the header file that declares them. Macros can therefore be used independently of any library by including the header file that defines and declares them with your program, as explained below. The functions in the C library that are implemented as macros are: *max* and *min*.

Including Header Files

If your application calls a C library function, you must include the header file that declares the function at compile time, in order to use the proper return type and the proper function prototyping, so that all the expected arguments are properly evaluated. You do this by writing a preprocessor directive of the form:

```
#include <header_name>
```

in your program, where *<header_name>* is the name of the appropriate header file enclosed in angle brackets. The required header file should be included before you refer to any function that it declares.

The names of the header files packaged with the C library and the functions declared in each header are listed below.

<assert.h> - Header file for the assertion macro: *assert*.

<ctype.h> - Header file for the character functions: *isalnum, isalpha, iscntrl, isgraph, isprint, ispunct, isspace, isxdigit, isdigit, isupper, islower, tolower* and *toupper*.

<float.h> - Header file for limit constants for floating point values.

<io*.h> - Header files for input-output registers. Each register has an upper-case name which matches the data sheet definition. The compiler provides a large set of header files for most derivative processors.

<limits.h> - Header file for limit constants of the compiler.

<math.h> - Header file for mathematical functions: *acos, asin, atan, atan2, ceil, cos, cosh, exp, fabs, floor, fmod, frexp, ldexp, log, log10, modf, pow, sin, sinh, sqrt, tan* and *tanh*.

<processor.h> - Header file for **inline** functions: *carry, irq, imask*.

<stdbool.h> - Header file for type *bool* and values *true, false*.

<stddef.h> - Header file for types: *size_t, wchar_t* and *ptrdiff_t*.

<stdio.h> - Header file for stream input/output: *getchar, gets, printf, putchar, puts* and *sprintf*.

<stdlib.h> - Header file for general utilities: *abs, abort, atof, atoi, atol, div, exit, labs, ldiv, rand, srand, strtod, strtol* and *strtoul*.

<string.h> - Header file for string functions: *memchr, memcmp, memcpy, memmove, memset, strcat, strchr, strcmp, strcpy, strcspn, strlen, strncat, strncmp, strncpy, strpbrk, strrchr, strspn* and *strstr*.

Functions returning int - C library functions that return *int* and can therefore be called without any header file are: *isalnum, isalpha, iscntrl, isgraph, isprint, ispunct, isspace, isxdigit, isdigit, isupper, islower, sbreak, tolower* and *toupper.*

Descriptions of C Library Functions

The following pages describe each of the functions in the C library in quick reference format. The descriptions are in alphabetical order by function name.

The *syntax* field describes the function prototype with the return type and the expected arguments, and if any, the header file name where this function has been declared.

_asm

Description

Generate inline assembly code

Syntax

```
_asm("string constant", arguments...)
```

Function

_asm() generates inline assembly code by copying <*string constant*> and quoting it into the output assembly code stream. <*arguments*> are first evaluated following the usual rules for passing arguments. The first argument is kept in the **a** register or the **x:a** register pair whenever possible, and all other arguments are pushed onto the stack. After the <*string constant*> code is output, arguments pushed to the stack are removed before to continue.

Return Value

Nothing, unless *_asm()* is used in an expression. In that case, standard return conventions must be followed. See "*Register Usage*" in **Chapter 3**.

Example

The sequence *inc x; call _main*, may be generated by the following call:

```
_asm("inc x\n call _main");
```

Note that the string-quoting syntax matches the familiar *printf()* function.

Notes

_asm() is not packaged in any library. It is recognized by the compiler itself.

For more information, see "*Inserting Inline Assembly Instructions*" in **Chapter 3**.

abort

Description

Abort program execution

Syntax

```
#include <stdlib.h>
void abort(void)
```

Function

abort stops the program execution by calling the *exit* function which is placed by the startup module just after the call to the main function.

Return Value

abort never returns.

Example

To abort in case of error:

```
if (fatal_error)
        abort();
```

See Also

exit

Notes

abort is a macro equivalent to the function name *exit*.

abs

Description

Find absolute value

Syntax

```
#include <stdlib.h>
int abs(int i)
```

Function

abs obtains the absolute value of **i**. No check is made to see that the result can be properly represented.

Return Value

abs returns the absolute value of **i**, expressed as an int.

Example

To print out a debit or credit balance:

```
printf("balance %d%s\n", abs(bal), (bal < 0)? "CR" : "");
```

See Also

labs, fabs

Notes

abs is packaged in the integer library, and may be implemented as a **macro**.

acos

Description

Arccosine

Syntax

```
#include <math.h>
double acos(double x)
```

Function

acos computes the angle in radians the cosine of which is **x**, to full double precision.

Return Value

acos returns the closest internal representation to *acos(x)*, expressed as a double floating value in the range [0, pi]. If **x** is outside the range [-1, 1], *acos* returns zero.

Example

To find the arccosine of **x**:

```
theta = acos(x);
```

See Also

asin, atan, atan2

Notes

acos is packaged in the floating point library.

asin

Description

Arcsine

Syntax

```
#include <math.h>
double asin(double x)
```

Function

asin computes the angle in radians the sine of which is **x**, to full double precision.

Return Value

asin returns the nearest internal representation to *asin(x)*, expressed as a double floating value in the range [-pi/2, pi/2]. If **x** is outside the range [-1, 1], *asin* returns zero.

Example

To compute the arcsine of **y**:

```
theta = asin(y);
```

See Also

acos, atan, atan2

Notes

asin is packaged in the floating point library.

atan

Description

Arctangent

Syntax

```
#include <math.h>
double atan(double x)
```

Function

atan computes the angle in radians; the tangent of which is **x**, *atan* computes the angle in radians; the tangent of which is **x**, to full double precision.

Return Value

atan returns the nearest internal representation to *atan(x)*, expressed as a double floating value in the range [-pi/2, pi/2].

Example

To find the phase angle of a vector in degrees:

```
theta = atan(y/x) * 180.0 / pi;
```

See Also

acos, asin, atan2

Notes

atan is packaged in the floating point library.

atan2

Description

Arctangent of y/x

Syntax

```
#include <math.h>
double atan2(double y, double x)
```

Function

atan2 computes the angle in radians the tangent of which is **y/x** to full double precision. If **y** is negative, the result is negative. If **x** is negative, the magnitude of the result is greater than pi/2.

Return Value

atan2 returns the closest internal representation to *atan(y/x)*, expressed as a double floating value in the range [-pi, pi]. If both input arguments are zero, *atan2* returns zero.

Example

To find the phase angle of a vector in degrees:

```
theta = atan2(y/x) * 180.0/pi;
```

See Also

acos, asin, atan

Notes

atan2 is packaged in the floating point library.

atof

Description

Convert buffer to double

Syntax

```
#include <stdlib.h>
double atof(char *nptr)
```

Function

atof converts the string at *nptr* into a double. The string is taken as the text representation of a decimal number, with an optional fraction and exponent. Leading whitespace is skipped and an optional sign is permitted; conversion stops on the first unrecognizable character. Acceptable inputs match the pattern:

[+|-]d*[.d*][e[+|-]dd*]

where **d** is any decimal digit and **e** is the character '**e**' or '**E**'. No checks are made against overflow, underflow, or invalid character strings.

Return Value

atof returns the converted double value. If the string has no recognizable characters, it returns zero.

Example

To read a string from STDIN and convert it to a double at **d**:

```
gets(buf);
d = atof(buf);
```

See Also

atoi, atol, strtol, strtod

Notes

atof is packaged in the floating point library.

atoi

Description

Convert buffer to integer

Syntax

```
#include <stdlib.h>
int atoi(char *nptr)
```

Function

atoi converts the string at *nptr* into an integer. The string is taken as the text representation of a decimal number. Leading whitespace is skipped and an optional sign is permitted; conversion stops on the first unrecognizable character. Acceptable characters are the decimal digits. If the stop character is **l** or **L**, it is skipped over.

No checks are made against overflow or invalid character strings.

Return Value

atoi returns the converted integer value. If the string has no recognizable characters, zero is returned.

Example

To read a string from STDIN and convert it to an *int* at **i**:

```
gets(buf);
i = atoi(buf);
```

See Also

atof, atol, strtol, strtod

Notes

atoi is packaged in the integer library.

atol

Description

Convert buffer to long

Syntax

```
#include <stdlib.h>
long atol(char *nptr)
```

Function

atol converts the string at *nptr* into a long integer. The string is taken as the text representation of a decimal number. Leading whitespace is skipped and an optional sign is permitted; conversion stops on the first unrecognizable character. Acceptable characters are the decimal digits. If the stop character is **l** or **L** it is skipped over.

No checks are made against overflow or invalid character strings.

Return Value

atol returns the converted long integer. If the string has no recognizable characters, zero is returned.

Example

To read a string from STDIN and convert it to a long **l**:

```
gets(buf);
l = atol(buf);
```

See Also

atof, atoi, strtol, strtod

Notes

atol is packaged in the integer library.

carry

Description

Test or get the carry bit

Syntax

```
#include <processor.h>
@inline char carry(void)
```

Function

carry is an *inline* function allowing to test or get the value of the *carry* bit. When used in an *if* construct, this function expands directly to a **bcc** or **bcs** instruction. When used in an expression, it expands in order to build in the **a** register the value **0** or **1** depending on the *carry* bit value.

Return Value

carry returns **0** or **1** in the **a** register if such a value is needed.

Example

```
low <<= 1;          produces            sll   _low
if (carry())                            jruge L1
      ++high;                           inc   _high
                                  L1:

low <<= 1;          produces            sll   _low
high = carry()                          clr   a
                                        rlc   a
                                        ld    _high,a
```

Notes

carry is an *inline* function and then is not defined in any library. It is therefore not possible to take its address. For more information, see "*Inline Function*" in **Chapter 3**.

ceil

Description

Round to next higher integer

Syntax

```
#include <math.h>
double ceil(double x)
```

Function

ceil computes the smallest integer greater than or equal to **x**.

Return Value

ceil returns the smallest integer greater than or equal to **x**, expressed as a double floating value.

Example

```
     x       ceil(x)

    5.1       6.0
    5.0       5.0
    0.0       0.0
   -5.0      -5.0
   -5.1      -5.0
```

See Also

floor

Notes

ceil is packaged in the floating point library.

_checksum

Description

Verify the recorded checksum

Syntax

```
int _checksum()
```

Function

_checksum scans the descriptor built by the linker and controls that the computed checksum is equal to the one expected. For more infomation, see "*Checksum Computation*" in **Chapter 6**.

Return Value

_checksum returns 0 if the checksum is correct, or a value different of 0 otherwise.

Example

```
if (_checksum())
        abort();
```

Notes

The descriptor is built by the linker only if the *_checksum* function is called by the application, even if there are segments marked with the **-ck** option.

_checksum is packaged in the integer library.

See Also

_checksumx, _checksum16, _checksum16x

_checksumx

Description

Verify the recorded checksum

Syntax

```
int _checksumx()
```

Function

_checksumx scans the descriptor built by the linker and controls at the end that the computed 8 bit checksum is equal to the one expected. For more infomation, see "*Checksum Computation*" in **Chapter 6**.

Return Value

_checksumx returns 0 if the checksum is correct, or a value different of 0 otherwise.

Example

```
if (_checksumx())
        abort();
```

Notes

The descriptor is built by the linker only if the *_checksumx* function is called by the application, even if there are segments marked with the **-ck** option.

_checksumx is packaged in the integer library.

See Also

_checksum, _checksum16, _checksum16x

_checksum16

Description

Verify the recorded checksum

Syntax

```
int _checksum16()
```

Function

_checksum16 scans the descriptor built by the linker and controls at the end that the computed 16 bit checksum is equal to the one expected. For more infomation, see "*Checksum Computation*" in **Chapter 6**.

Return Value

_checksum16 returns 0 if the checksum is correct, or a value different of 0 otherwise.

Example

```
if (_checksum16())
        abort();
```

Notes

The descriptor is built by the linker only if the *_checksum16* function is called by the application, even if there are segments marked with the **-ck** option.

_checksum16 is packaged in the integer library.

See Also

_checksum, _checksumx, _checksum16x

_checksum16x

Description

Verify the recorded checksum

Syntax

```
int _checksum16x()
```

Function

_checksum16x scans the descriptor built by the linker and controls at the end that the computed 16 bit checksum is equal to the one expected. For more infomation, see "*Checksum Computation*" in **Chapter 6**.

Return Value

_checksum16x returns 0 if the checksum is correct, or a value different of 0 otherwise.

Example

```
if (_checksum16x())
        abort();
```

Notes

The descriptor is built by the linker only if the *_checksum16x* function is called by the application, even if there are segments marked with the **-ck** option.

_checksum16x is packaged in the integer library.

See Also

_checksum, _checksumx, _checksum16

cos

Description

Cosine

Syntax

```
#include <math.h>
double cos(double x)
```

Function

cos computes the cosine of **x**, expressed in radians, to full double precision. If the magnitude of **x** is too large to contain a fractional quadrant part, the value of *cos* is 1.

Return Value

cos returns the nearest internal representation to *cos(x)* in the range [0, pi], expressed as a double floating value. A large argument may return a meaningless value.

Example

To rotate a vector through the angle **theta**:

```
xnew = xold * cos(theta) - yold * sin(theta);
ynew = xold * sin(theta) + yold * cos(theta);
```

See Also

sin, tan

Notes

cos is packaged in the floating point library.

cosh

Description

Hyperbolic cosine

Syntax

```
#include <math.h>
double cosh(double x)
```

Function

cosh computes the hyperbolic cosine of **x** to full double precision.

Return Value

cosh returns the nearest internal representation to *cosh(x)* expressed as a double floating value. If the result is too large to be properly represented, *cosh* returns zero.

Example

To use the Moivre's theorem to compute *(cosh x + sinh x)* to the nth power:

```
demoivre = cosh(n * x) + sinh(n * x);
```

See Also

exp, sinh, tanh

Notes

cosh is packaged in the floating point library.

div

Description

Divide with quotient and remainder

Syntax

```
#include <stdlib.h>
div_t div(int numer, int denom)
```

Function

div divides the integer *numer* by the integer *denom* and returns the quotient and the remainder in a structure of type *div_t*. The field *quot* contains the quotient and the field *rem* contains the remainder.

Return Value

div returns a structure of type *div_t* containing both quotient and remainder.

Example

To get minutes and seconds from a delay in seconds:

```
div_t result;
        result = div(time, 60);
        min = result.quo;
        sec = result.rem;
```

See Also

ldiv

Notes

div is packaged in the integer library.

eepera

Description

Erase the full *eeprom* space

Syntax

```
void eepera(void)
```

Function

eepera erases the full *eeprom* space with the global erase sequence. It does not erase the **config** register.

Return Value

Nothing.

Example

To erase the full *eeprom* space:

```
eepera();
```

See Also

Notes

eepera is packaged in the machine library.

exit

Description

Exit program execution

Syntax

```
#include <stdlib.h>
void exit(int status)
```

Function

exit stops the execution of a program by switching to the startup module just after the call to the *main* function. The status argument is not used by the current implementation.

Return Value

exit never returns.

Example

To *exit* in case of error:

```
if (fatal_error)
        exit();
```

See Also

abort

Notes

exit is in the startup module.

exp

Description

Exponential

Syntax

```
#include <math.h>
double exp(double x)
```

Function

exp computes the exponential of **x** to full double precision.

Return Value

exp returns the nearest internal representation to *exp* **x**, expressed as a double floating value. If the result is too large to be properly represented, *exp* returns zero.

Example

To compute the hyperbolic sine of **x**:

```
sinh = (exp(x) - exp(-x)) / 2.0;
```

See Also

log

Notes

exp is packaged in the floating point library.

fabs

Description

Find double absolute value

Syntax

```
#include <math.h>
double fabs(double x)
```

Function

fabs obtains the absolute value of **x**.

Return Value

fabs returns the absolute value of **x**, expressed as a double floating value.

Example

```
       x      fabs(x)

      5.0       5.0
      0.0       0.0
     -3.7       3.7
```

See Also

abs, labs

Notes

fabs is packaged in the floating point library.

_fctcpy

Description

Copy a moveable code segment in RAM

Syntax

```
int _fctcpy(char name);
```

Function

_fctcpy copies a moveable code segment in RAM from its storage location in ROM. *_fctcpy* scans the descriptor built by the linker and looks for a moveable segment whose flag byte matches the given argument. If such a segment is found, it is entirely copied in RAM. Any function defined in that segment may then be called directly. For more information, see "*Moveable Code*" in **Chapter 6**.

Return Value

_fctcpy returns a non zero value if a segment has been found and copied. It returns 0 otherwise.

Example

```
if (_fctcpy('b'))
        flash();
```

Notes

_fctcpy is packaged in the machine library.

floor

Description

Round to next lower integer

Syntax

```
#include <math.h>
double floor(double x)
```

Function

floor computes the largest integer less than or equal to **x**.

Return Value

floor returns the largest integer less than or equal to **x**, expressed as a double floating value.

Example

```
      x       floor(x)

    5.1       5.0
    5.0       5.0
    0.0       0.0
   -5.0      -5.0
   -5.1      -6.0
```

See Also

ceil

Notes

floor is packaged in the floating point library.

fmod

Description

Find double modulus

Syntax

```
#include <math.h>
double fmod(double x, double y)
```

Function

fmod computes the floating point remainder of **x** / **y**, to full double precision. The return value of **f** is determined using the formula:

f = x - i * y

where **i** is some integer, **f** is the same sign as **x**, and the absolute value of **f** is less than the absolute value of **y**.

Return Value

fmod returns the value of **f** expressed as a double floating value. If **y** is zero, *fmod* returns zero.

Example

```
    x       y       fmod(x, y)

   5.5     5.0        0.5
   5.0     5.0        0.0
   0.0     0.0        0.0
  -5.5     5.0       -0.5
```

Notes

fmod is packaged in the floating point library.

frexp

Description

Extract fraction from exponent part

Syntax

```
#include <math.h>
double frexp(double val, int *exp)
```

Function

frexp partitions the double at *val*, which should be non-zero, into a fraction in the interval [1/2, 1) times two raised to an integer power. It then delivers the integer power to **exp*, and returns the fractional portion as the value of the function. The exponent is generally meaningless if *val* is zero.

Return Value

frexp returns the power of two fraction of the double at *val* as the return value of the function, and writes the exponent at **exp*.

Example

To implement the *sqrt(x)* function:

```
double sqrt(double x)
        {
        extern double newton(double);
        int n;

        x = frexp(x, &n);
        x = newton(x);
        if (n & 1)
                x *= SQRT2;
        return (ldexp(x, n / 2));
        }
```

See Also

ldexp

Notes

frexp is packaged in the floating point library.

getchar

Description

Get character from input stream

Syntax

```
#include <stdio.h>
int getchar(void)
```

Function

getchar obtains the next input character, if any, from the user supplied input stream. This user must rewrite this function in C or in assembly language to provide an interface to the input mechanism of the C library.

Return Value

getchar returns the next character from the input stream. If end of file (break) is encountered, or a read error occurs, getchar returns EOF.

Example

To copy characters from the input stream to the output stream:

```
while ((c = getchar()) != EOF)
        putchar(c);
```

See Also

putchar

Notes

getchar is packaged in the integer library, and is by default using the first serial port **SCI 1**.

gets

Description

Get a text line from input stream

Syntax

```
#include <stdio.h>
char *gets(char *s)
```

Function

gets copies characters from the input stream to the buffer starting at **s**. Characters are copied until a newline is reached or end of file is reached. If a newline is reached, it is discarded and a NUL is written immediately following the last character read into **s**.

gets uses *getchar* to read each character.

Return Value

gets returns **s** if successful. If end of file is reached, *gets* returns NULL. If a read error occurs, the array contents are indeterminate and *gets* returns NULL.

Example

To copy input to output, line by line:

```
while (puts(gets(buf)))
        ;
```

See Also

puts

Notes

There is no assured limit on the size of the line read by *gets*.

gets is packaged in the integer library.

imask

Description

Test the interrupt mask bit

Syntax

```
#include <processor.h>
@inline char imask(void)
```

Function

imask is an *inline* function allowing to test the interrupt mask bit. The *imask* function can only be used in an *if* construct. This function expands directly to a **bms** or **bmc** instruction.

Return Value

None.

Example

```
if (imask())           produces              jrnm  L3
      ++high;                                inc   _high
                                       L3:

if (!imask())          produces              bms   L1
      ++high                                 inc   _high
                                       L1:
```

Notes

imask is an *inline* function and then is not defined in any library. It is therefore not possible to take its address. For more information, see "*Inline Function*" in **Chapter 3**.

irq

Description

Test the interrupt line level

Syntax

```
#include <processor.h>
@inline char irq(void)
```

Function

irq is an *inline* function allowing to test the interrupt line level. The *irq* function can only be used in an *if* construct. This function expands directly to a **bih** or **bil** instruction.

Return Value

None.

Example

```
if (irq())          produces            jril    L3
      ++high;                           inc     _high
                                  L3:

if (!irq())         produces            bih     L1
      ++high                            inc     _high
                                  L1:
```

Notes

irq is an *inline* function and then is not defined in any library. It is therefore not possible to take its address. For more information, see "*Inline Function*" in **Chapter 3**.

isalnum

Description

Test for alphabetic or numeric character

Syntax

```
#include <ctype.h>
int isalnum(char c)
```

Function

isalnum tests whether **c** is an alphabetic character (either upper or lower case), or a decimal digit.

Return Value

isalnum returns nonzero if the argument is an alphabetic or numeric character; otherwise the value returned is zero.

Example

To test for a valid C identifier:

```
if (isalpha(*s) || *s == '_')
        for (++s; isalnum(*s) || *s == '_'; ++s)
                ;
```

See Also

isalpha, isdigit, islower, isupper, isxdigit, tolower, toupper

Notes

If the argument is outside the range [-1, 255], the result is undefined.

isalnum is packaged in the integer library.

isalpha

Description

Test for alphabetic character

Syntax

```
#include <ctype.h>
int isalpha(char c)
```

Function

isalpha tests whether **c** is an alphabetic character, either upper or lower case.

Return Value

isalpha returns nonzero if the argument is an alphabetic character. Otherwise the value returned is zero.

Example

To find the end points of an alphabetic string:

```
while (*first && !isalpha(*first))
        ++first;
for (last = first; isalpha(*last); ++last)
        ;
```

See Also

isalnum, isdigit, islower, isupper, isxdigit, tolower, toupper

Notes

If the argument is outside the range [-1, 255], the result is undefined.

isalpha is packaged in the integer library.

iscntrl

Description

Test for control character

Syntax

```
#include <ctype.h>
int iscntrl(char c)
```

Function

iscntrl tests whether **c** is a delete character (0177 in ASCII), or an ordinary control character (less than 040 in ASCII).

Return Value

iscntrl returns nonzero if c is a control character; otherwise the value is zero.

Example

To map control characters to percent signs:

```
for (; *s; ++s)
        if (iscntrl(*s))
                *s = '%';
```

See Also

isgraph, isprint, ispunct, isspace

Notes

If the argument is outside the range [-1, 255], the result is undefined.

iscntrl is packaged in the integer library.

isdigit

Description

Test for digit

Syntax

```
#include <ctype.h>
int isdigit(char c)
```

Function

isdigit tests whether **c** is a decimal digit.

Return Value

isdigit returns nonzero if **c** is a decimal digit; otherwise the value returned is zero.

Example

To convert a decimal digit string to a number:

```
for (sum = 0; isdigit(*s); ++s)
        sum = sum * 10 + *s - '0';
```

See Also

isalnum, isalpha, islower, isupper, isxdigit, tolower, toupper

Notes

If the argument is outside the range [-1, 255], the result is undefined.

isdigit is packaged in the integer library.

isgraph

Description

Test for graphic character

Syntax

```
#include <ctype.h>
int isgraph(char c)
```

Function

isgraph tests whether **c** is a graphic character; i.e. any printing character except a space (040 in ASCII).

Return Value

isgraph returns nonzero if **c** is a graphic character. Otherwise the value returned is zero.

Example

To output only graphic characters:

```
for (; *s; ++s)
        if (isgraph(*s))
                putchar(*s);
```

See Also

iscntrl, isprint, ispunct, isspace

Notes

If the argument is outside the range [-1, 255], the result is undefined.

isgraph is packaged in the integer library.

islower

Description

Test for lowercase character

Syntax

```
#include <ctype.h>
int islower(char c)
```

Function

islower tests whether **c** is a lowercase alphabetic character.

Return Value

islower returns nonzero if **c** is a lowercase character; otherwise the value returned is zero.

Example

To convert to uppercase:

```
if (islower(c))
        c += 'A' - 'a';      /* also see toupper() */
```

See Also

isalnum, isalpha, isdigit, isupper, isxdigit, tolower, toupper

Notes

If the argument is outside the range [-1, 255], the result is undefined.

islower is packaged in the integer library.

isprint

Description

Test for printing character

Syntax

```
#include <ctype.h>
int isprint(char c)
```

Function

isprint tests whether **c** is any printing character. Printing characters are all characters between a space (040 in ASCII) and a tilde '~' character (0176 in ASCII).

Return Value

isprint returns nonzero if **c** is a printing character; otherwise the value returned is zero.

Example

To output only printable characters:

```
for (; *s; ++s)
        if (isprint(*s))
                putchar(*s);
```

See Also

iscntrl, isgraph, ispunct, isspace

Notes

If the argument is outside the range [-1, 255], the result is undefined.

isprint is packaged in the integer library.

ispunct

Description

Test for punctuation character

Syntax

```
#include <ctype.h>
int ispunct(char c)
```

Function

ispunct tests whether **c** is a punctuation character. Punctuation characters include any printing character except space, a digit, or a letter.

Return Value

ispunct returns nonzero if **c** is a punctuation character; otherwise the value returned is zero.

Example

To collect all punctuation characters in a string into a buffer:

```
for (i = 0; *s; ++s)
        if (ispunct(*s))
                buf[i++] = *s;
```

See Also

iscntrl, isgraph, isprint, isspace

Notes

If the argument is outside the range [-1, 255], the result is undefined.

ispunct is packaged in the integer library.

isspace

Description

Test for whitespace character

Syntax

```
#include <ctype.h>
int isspace(char c)
```

Function

isspace tests whether **c** is a whitespace character. Whitespace characters are horizontal tab ('**\t**'), newline ('**\n**'), vertical tab ('**\v**'), form feed ('**\f**'), carriage return ('**\r**'), and space (' ').

Return Value

isspace returns nonzero if **c** is a whitespace character; otherwise the value returned is zero.

Example

To skip leading whitespace:

```
while (isspace(*s))
        ++s;
```

See Also

iscntrl, isgraph, isprint, ispunct

Notes

If the argument is outside the range [-1, 255], the result is undefined.

isspace is packaged in the integer library.

isupper

Description

Test for uppercase character

Syntax

```
int isupper(char c)
```

Function

isupper tests whether **c** is an uppercase alphabetic character.

Return Value

isupper returns nonzero if **c** is an uppercase character; otherwise the value returned is zero.

Example

To convert to lowercase:

```
if (isupper(c))
        c += 'a' - 'A'; /* also see tolower() */
```

See Also

isalnum, isalpha, isdigit, islower, isxdigit, tolower, toupper

Notes

If the argument is outside the range [-1, 255], the result is undefined.

isupper is packaged in the integer library.

isxdigit

Description

Test for hexadecimal digit

Syntax

```
#include <ctype.h>
int isxdigit(char c)
```

Function

isxdigit tests whether **c** is a hexadecimal digit, *i.e.* in the set [0123456789abcdefABCDEF].

Return Value

isxdigit returns nonzero if **c** is a hexadecimal digit; otherwise the value returned is zero.

Example

To accumulate a hexadecimal digit:

```
for (sum = 0; isxdigit(*s); ++s)
        if (isdigit(*s)
                sum = sum * 10 + *s - '0';
        else
                sum = sum * 10 + tolower(*s) + (10 - 'a');
```

See Also

isalnum, isalpha, isdigit, islower, isupper, tolower, toupper

Notes

If the argument is outside the range [-1, 255], the result is undefined.

isxdigit is packaged in the integer library.

labs

Description

Find long absolute value

Syntax

```
#include <stdlib.h>
long labs(long l)
```

Function

labs obtains the absolute value of **l**. No check is made to see that the result can be properly represented.

Return Value

labs returns the absolute value of **l**, expressed as an long int.

Example

To print out a debit or credit balance:

```
printf("balance %ld%s\n",labs(bal),(bal < 0) ? "CR" : "");
```

See Also

abs, fabs

Notes

labs is packaged in the integer library.

ldexp

Description

Scale double exponent

Syntax

```
#include <math.h>
double ldexp(double x, int exp)
```

Function

ldexp multiplies the double **x** by two raised to the integer power **exp**.

Return Value

ldexp returns the double result *x * (1 << exp)* expressed as a double floating value. If a range error occurs, *ldexp* returns **HUGE_VAL**.

Example

```
 x      exp    ldexp(x, exp)

1.0      1       2.0
1.0      0       1.0
1.0     -1       0.5
0.0      0       0.0
```

See Also

frexp, modf

Notes

ldexp is packaged in the floating point library.

ldiv

Description

Long divide with quotient and remainder

Syntax

```
#include <stdlib.h>
ldiv_t ldiv(long numer, long denom)
```

Function

ldiv divides the long integer *numer* by the long integer *denom* and returns the quotient and the remainder in a structure of type *ldiv_t*. The field *quot* contains the quotient and the field *rem* contains the remainder.

Return Value

ldiv returns a structure of type *ldiv_t* containing both quotient and remainder.

Example

To get minutes and seconds from a delay in seconds:

```
ldiv_t result;
      result = ldiv(time, 60L);
      min = result.quo;
      sec = result.rem;
```

See Also

div

Notes

ldiv is packaged in the integer library.

log

Description

Natural logarithm

Syntax

```
#include <math.h>
double log(double x)
```

Function

log computes the natural logarithm of **x** to full double precision.

Return Value

log returns the closest internal representation to *log(x)*, expressed as a double floating value. If the input argument is less than zero, or is too large to be represented, log returns zero.

Example

To compute the hyperbolic arccosine of **x**:

```
arccosh = log(x + sqrt(x * x - 1));
```

See Also

exp

Notes

log is packaged in the floating point library.

log10

Description

Common logarithm

Syntax

```
#include <math.h>
double log10(double x)
```

Function

log10 computes the common log of **x** to full double precision by computing the natural log of **x** divided by the natural log of 10. If the input argument is less than zero, a domain error will occur. If the input argument is zero, a range error will occur.

Return Value

log10 returns the nearest internal representation to *log10* **x**, expressed as a double floating value. If the input argument is less than or equal to zero, *log10* returns zero.

Example

To determine the number of digits in **x**, where **x** is a positive integer expressed as a double:

```
ndig = log10(x) + 1;
```

See Also

log

Notes

log10 is packaged in the floating point library.

max

Description

Test for maximum

Syntax

```
#include <stdlib.h>
max(a,b)
```

Function

max obtains the maximum of its two arguments, **a** and **b**. Since *max* is implemented as a C preprocessor macro, its arguments can be any numerical type, and type coercion occurs automatically.

Return Value

max is a numerical rvalue of the form **((a < b) ? b : a)**, suitably parenthesized.

Example

To set a new maximum level:

```
hiwater = max(hiwater, level);
```

See Also

min

Notes

max is an extension to the proposed ANSI C standard.

max is a macro declared in the *<stdlib.h>* header file. You can use it by including *<stdlib.h>* with your program. Because it is a macro, *max* cannot be called from non-C programs, nor can its address be taken. Arguments with side effects may be evaluated other than once.

memchr

Description

Scan buffer for character

Syntax

```
#include <string.h>
void *memchr(void *s, char c, unsigned char n)
```

Function

memchr looks for the first occurrence of a specific character **c** in an **n** character buffer starting at **s**.

Return Value

memchr returns a pointer to the first character that matches **c**, or NULL if no character matches.

Example

To map *keybuf[]* characters into *subst[]* characters:

```
if ((t = memchr(keybuf, *s, KEYSIZ)) != NULL)
      *s = subst[t - keybuf];
```

See Also

strchr, strcspn, strpbrk, strrchr, strspn

Notes

memchr is packaged in the integer library.

memcmp

Description

Compare two buffers for lexical order

Syntax

```
#include <string.h>
int memcmp(void *s1, void *s2, unsigned char n)
```

Function

memcmp compares two text buffers, character by character, for lexical order in the character collating sequence. The first buffer starts at **s1**, the second at **s2**; both buffers are **n** characters long.

Return Value

memcmp returns a short integer greater than, equal to, or less than zero, according to whether **s1** is lexicographically greater than, equal to, or less than **s2**.

Example

To look for the string “*include*” in name:

```
if (memcmp(name, "include", 7) == 0)
        doinclude();
```

See Also

strcmp, strncmp

Notes

memcmp is packaged in the integer library.

memcpy

Description

Copy one buffer to another

Syntax

```
#include <string.h>
void *memcpy(void *s1, void *s2, unsigned char n)
```

Function

memcpy copies the first **n** characters starting at location **s2** into the buffer beginning at **s1**.

Return Value

memcpy returns **s1**.

Example

To place "*first string, second string*" in *buf[]*:

```
memcpy(buf, "first string", 12);
memcpy(buf + 13, ", second string", 15);
```

See Also

strcpy, strncpy

Notes

memcpy is packaged in the integer library and may be implemented as an *inline* function.

memmove

Description

Copy one buffer to another

Syntax

```
#include <string.h>
void *memmove(void *s1, void *s2, unsigned char n)
```

Function

memmove copies the first **n** characters starting at location **s2** into the buffer beginning at **s1**. If the two buffers overlap, the function performs the copy in the appropriate sequence, so the copy is not corrupted.

Return Value

memmove returns **s1**.

Example

To shift an array of characters:

```
memmove(buf, &buf[5], 10);
```

See Also

memcpy

Notes

memmove is packaged in the integer library.

memset

Description

Propagate fill character throughout buffer

Syntax

```
#include <string.h>
void *memset(void *s, char c, unsigned char n)
```

Function

memset floods the **n** character buffer starting at **s** with fill character **c**.

Return Value

memset returns **s**.

Example

To flood a 512-byte buffer with NULs:

```
memset(buf,'\0', BUFSIZ);
```

Notes

memset is packaged in the integer library and may be implemented as an *inline* function.

min

Description

Test for minimum

Syntax

```
#include <stdlib.h>
min(a, b)
```

Function

min obtains the minimum of its two arguments, **a** and **b**. Since *min* is implemented as a C preprocessor macro, its arguments can be any numerical type, and type coercion occurs automatically.

Return Value

min is a numerical rvalue of the form **((a < b) ? a : b)**, suitably parenthesized.

Example

To set a new minimum level:

```
nmove = min(space, size);
```

See Also

max

Notes

min is an extension to the ANSI C standard.

min is a macro declared in the *<stdlib.h>* header file. You can use it by including *<stdlib.h>* with your program. Because it is a macro, *min* cannot be called from non-C programs, nor can its address be taken. Arguments with side effects may be evaluated more than once.

modf

Description

Extract fraction and integer from double

Syntax

```
#include <math.h>
double modf(double val, double *pd)
```

Function

modf partitions the double *val* into an integer portion, which is delivered to **pd*, and a fractional portion, which is returned as the value of the function. If the integer portion cannot be represented properly in an int, the result is truncated on the left without complaint.

Return Value

modf returns the signed fractional portion of *val* as a double floating value, and writes the integer portion at **pd*.

Example

```
  val    *pd    modf(val, *pd)

  5.1     5       0.1
  5.0     5       0.0
  4.9     4       0.9
  0.0     0       0.0
 -1.4    -1      -0.4
```

See Also

frexp, ldexp

Notes

modf is packaged in the floating point library.

pow

Description

Raise x to the y power

Syntax

```
#include <math.h>
double pow(double x, double y)
```

Function

pow computes the value of **x** raised to the power of **y**.

Return Value

pow returns the value of **x** raised to the power of **y**, expressed as a double floating value. If **x** is zero and **y** is less than or equal to zero, or if **x** is negative and **y** is not an integer, *pow* returns zero.

Example

```
     x       y       pow(x, y)

   2.0     2.0        4.0
   2.0     1.0        2.0
   2.0     0.0        1.0
   1.0     any        1.0
   0.0    -2.0        0
  -1.0     2.0        1.0
  -1.0     2.1        0
```

See Also

exp

Notes

pow is packaged in the floating point library.

printf

Description

Output formatted arguments to stdout

Syntax

```
#include <stdio.h>
int printf(@near char *fmt, ...)
```

Function

printf writes formatted output to the output stream using the format string at *fmt* and the arguments specified by ..., as described below.

printf uses *putchar* to output each character.

Format Specifiers

The format string at *fmt* consists of literal text to be output, interspersed with conversion specifications that determine how the arguments are to be interpreted and how they are to be converted for output. If there are insufficient arguments for the format, the results are undefined. If the format is exhausted while arguments remain, the excess arguments are evaluated but otherwise ignored. *printf* returns when the end of the format string is encountered.

Each <*conversion specification*> is started by the character '**%**'. After the '**%**', the following appear in sequence:

<flags> - zero or more which modify the meaning of the conversion specification.

<field width> - a decimal number which optionally specifies a minimum field width. If the converted value has fewer characters than the field width, it is padded on the left (or right, if the left adjustment flag has been given) to the field width. The padding is with spaces unless the field width digit string starts with zero, in which case the padding is with zeros.

<precision> - a decimal number which specifies the minimum number of digits to appear for **d**, **i**, **o**, **u**, **x**, and **X** conversions, the number of digits to appear after the decimal point for **e**, **E**, and **f** conversions, the maximum number of significant digits for the **g** and **G** conversions, or the maximum number of characters to be printed from a string in an **s** conversion. The precision takes the form of a period followed by a decimal digit string. A null digit string is treated as zero.

h - optionally specifies that the following **d**, **i**, **o**, **u**, **x**, or **X** conversion character applies to a short int or unsigned short int argument (the argument will have been widened according to the integral widening conversions, and its value must be cast to short or unsigned short before printing). It specifies a short pointer argument if associated with the **p** conversion character. If an **h** appears with any other conversion character, it is ignored.

l - optionally specifies that the **d**, **i**, **o**, **u**, **x**, and **X** conversion character applies to a long int or unsigned long int argument. It specifies a long or far pointer argument if used with the **p** conversion character. If the **l** appears with any other conversion character, it is ignored.

L - optionally specifies that the following **e**, **E**, **f**, **g**, and **G** conversion character applies to a long double argument. If the **L** appears with any other conversion character, it is ignored.

<conversion character> - character that indicates the type of conversion to be applied.

A field width or precision, or both, may be indicated by an asterisk '*' instead of a digit string. In this case, an int argument supplies the field width or precision. The arguments supplying field width must appear before the optional argument to be converted. A negative field width argument is taken as a **-** flag followed by a positive field width. A negative precision argument is taken as if it were missing.

The *<flags>* field is zero or more of the following:

space - a space will be prepended if the first character of a signed conversion is not a sign. This flag will be ignored if space and + flags are both specified.

**-** result is to be converted to an “alternate form”. For **c**, **d**, **i**, **s**, and **u** conversions, the flag has no effect. For **o** conversion, it increases the precision to force the first digit of the result to be zero. For **p**, **x** and **X** conversion, a non-zero result will have **Ox** or **OX** prepended to it. For **e**, **E**, **f**, **g**, and **G** conversions, the result will contain a decimal point, even if no digits follow the point. For **g** and **G** conversions, trailing zeros will not be removed from the result, as they normally are. For **p** conversion, it designates hexadecimal output.

+ - result of signed conversion will begin with a plus or minus sign.

- **-** result of conversion will be left justified within the field.

The <*conversion character*> is one of the following:

% **-** a ‘**%**’ is printed. No argument is converted.

c **-** the char argument is converted to a character and printed.

d, i, o, u, x, X **-** the int argument is converted to signed decimal (**d** or **i**), unsigned octal (**o**), unsigned decimal (**u**), or unsigned hexadecimal notation (**x** or **X**); the letters **abcdef** are used for **x** conversion and the letters **ABCDEF** are used for **X** conversion. The precision specifies the minimum number of digits to appear; if the value being converted can be represented in fewer digits, it will be expanded with leading zeros. The default precision is **1**. The result of converting a zero value with precision of zero is no characters.

e, E **-** the double argument is converted in the style **[-]d.ddde+dd**, where there is one digit before the decimal point and the number of digits after it is equal to the precision. If the precision is missing, six digits are produced; if the precision is zero, no decimal point appears. The **E** format code will produce a number with **E** instead of **e** introducing the exponent. The exponent always contains at least two digits. However, if the magnitude to be printed is greater than or equal to **1E+100**, additional exponent digits will be printed as necessary.

f **-** the double argument is converted to decimal notation in the style **[-]ddd.ddd**, where the number of digits following the decimal point is equal to the precision specification. If the precision is missing, it is taken as 6. If the precision is explicitly zero, no decimal point appears. If a decimal point appears, at least one digit appears before it.

g, G - the double argument is printed in style **f** or **e** (or in style **E** in the case of a **G** format code), with the precision specifying the number of significant digits. The style used depends on the value converted; style e will be used only if the exponent resulting from the conversion is less than -4 or greater than the precision. Trailing zeros are removed from the result; a decimal point appears only if it is followed by a digit.

n - the argument is taken to be an int * pointer to an integer into which is written the number of characters written to the output stream so far by this call to *printf*. No argument is converted.

p - the argument is taken to be a *void* * pointer to an object. The value of the pointer is converted to a sequence of printable characters, and printed as a hexadecimal number with the number of digits printed being determined by the field width.

s, S - the argument is taken to be a *char* * pointer to a string. When the **Compact** model is used, the **s** format will use a **@tiny** pointer and the **S** format will use a **@near** pointer. Characters from the string are written up to, but not including, the terminating NUL, or until the number of characters indicated by the precision are written. If the precision is missing, it is taken to be arbitrarily large, so all characters before the first NUL are printed.

If the character after '**%**' is not a valid conversion character, the behavior is undefined.

If any argument is or points to an aggregate (except for an array of characters using **%s** conversion or any pointer using **%p** conversion), unpredictable results will occur.

A nonexistent or small field width does not cause truncation of a field; if the result is wider than the field width, the field is expanded to contain the conversion result.

Return Value

printf returns the number of characters transmitted, or a negative number if a write error occurs.

Notes

A call with more conversion specifiers than argument variables will cause unpredictable results.

Example

To print **`arg`**, which is a double with the value **`5100.53`**:

```
printf("%8.2f\n", arg);
printf("%*.*f\n", 8, 2, arg);
```

both forms will output: **`05100.53`**

See Also

sprintf

Notes

printf is packaged in both the integer library and the floating point library. The functionality of the integer only version of *printf* is a subset of the functionality of the floating point version. The integer only version cannot print or manipulate floating point numbers. If your programs call the integer only version of *printf*, the following conversion specifiers are invalid: **e**, **E**, **f**, **g** and **G**. The **L** modifier is also invalid.

If *printf* encounters an invalid conversion specifier, the invalid specifier is ignored and no special message is generated.

putchar

Description

Put a character to output stream

Syntax

```
#include <stdio.h>
int putchar(char c)
```

Function

putchar copies **c** to the user specified output stream.

You must rewrite *putchar* in either C or assembly language to provide an interface to the output mechanism to the C library.

Return Value

putchar returns **c**. If a write error occurs, putchar returns EOF.

Example

To copy input to output:

```
while ((c = getchar()) != EOF)
        putchar(c);
```

See Also

getchar

Notes

putchar is packaged in the integer library, and is by default using the first serial port **SCI 1**.

puts

Description

Put a text line to output stream

Syntax

```
#include <stdio.h>
int puts(char *s)
```

Function

puts copies characters from the buffer starting at **s** to the output stream and appends a newline character to the output stream.

puts uses *putchar* to output each character. The terminating NUL is not copied.

Return Value

puts returns zero if successful, or else nonzero if a write error occurs.

Example

To copy input to output, line by line:

```
while (puts(gets(buf)))
          ;
```

See Also

gets

Notes

puts is packaged in the integer library.

rand

Description

Generate pseudo-random number

Syntax

```
#include <stdlib.h>
int rand(void)
```

Function

rand computes successive pseudo-random integers in the range [0, 32767], using a linear multiplicative algorithm which has a period of 2 raised to the power of 32.

Example

```
int dice()
        {
        return (rand() % 6 + 1);
        }
```

Return Value

rand returns a pseudo-random integer.

See Also

srand

Notes

rand is packaged in the integer library.

sin

Description

Sin

Syntax

```
#include <math.h>
double sin(double x)
```

Function

sin computes the sine of **x**, expressed in radians, to full double precision. If the magnitude of **x** is too large to contain a fractional quadrant part, the value of sin is 0.

Return Value

sin returns the closest internal representation to *sin(x)* in the range [-pi/2, pi/2], expressed as a double floating value. A large argument may return a meaningless result.

Example

To rotate a vector through the angle *theta*:

```
xnew = xold * cos(theta) - yold * sin(theta);
ynew = xold * sin(theta) + yold * cos(theta);
```

See Also

cos, tan

Notes

sin is packaged in the floating point library.

sinh

Description

Hyperbolic sine

Syntax

```
#include <math.h>
double sinh(double x)
```

Function

sinh computes the hyperbolic sine of **x** to full double precision.

Return Value

sinh returns the closest internal representation to *sinh(x)*, expressed as a double floating value. If the result is too large to be properly represented, *sinh* returns zero.

Example

To obtain the hyperbolic sine of complex **z**:

```
typedef struct
      {
      double x, iy;
      }complex;

complex z;

      z.x = sinh(z.x) * cos(z.iy);
      z.iy = cosh(z.x) * sin(z.iy);
```

See Also

cosh, exp, tanh

Notes

sinh is packaged in the floating point library.

sprintf

Description

Output arguments formatted to buffer

Syntax

```
#include <stdio.h>
int sprintf(char *s, @near char fmt, ...)
```

Function

sprintf writes formatted to the buffer pointed at by **s** using the format string at *fmt* and the arguments specified by ..., in exactly the same way as *printf*. See the description of the *printf* function for information on the format conversion specifiers. A NUL character is written after the last character in the buffer.

Return Value

sprintf returns the numbers of characters written, not including the terminating NUL character.

Example

To format a double at **d** into *buf*:

```
sprintf(buf, "%10f\n", d);
```

See Also

printf

Notes

sprintf is packaged in both the integer library and the floating point library. The functionality of the integer only version of *sprintf* is a subset of the functionality of the floating point version. The integer only version cannot print or manipulate floating point numbers. If your programs call the integer only version of *sprintf*, the following conversion specifiers are invalid: **e**, **E**, **f**, **g** and **G**. The **L** flag is also invalid.

sqrt

Description

Real square root

Syntax

```
#include <math.h>
double sqrt(double x)
```

Function

sqrt computes the square root of **x** to full double precision.

Return Value

sqrt returns the nearest internal representation to *sqrt(x)*, expressed as a double floating value. If **x** is negative, *sqrt* returns zero.

Example

To use *sqrt* to check whether **`n > 2`** is a prime number:

```
if (!(n & 01))
        return (NOTPRIME);
sq = sqrt((double)n);
for (div = 3; div <= sq; div += 2)
        if (!(n % div))
                return (NOTPRIME);
return (PRIME);
```

Notes

sqrt is packaged in the floating point library.

srand

Description

Seed pseudo-random number generator

Syntax

```
#include <stdlib.h>
void srand(unsigned char nseed)
```

Function

srand uses *nseed* as a seed for a new sequence of pseudo-random numbers to be returned by subsequent calls to *rand*. If *srand* is called with the same seed value, the sequence of pseudo-random numbers will be repeated. The initial seed value used by *rand* and *srand* is 1.

Return Value

Nothing.

Example

To set up a new sequence of random numbers:

```
srand(103);
```

See Also

rand

Notes

srand is packaged in the integer library.

strcat

Description

Concatenate strings

Syntax

```
#include <string.h>
char *strcat(char *s1, char *s2)
```

Function

strcat appends a copy of the NUL terminated string at **s2** to the end of the NUL terminated string at **s1**. The first character of **s2** overlaps the NUL at the end of **s1**. A terminating NUL is always appended to **s1**.

Return Value

strcat returns **s1**.

Example

To place the strings "*first string, second string*" in *buf[]*:

```
buf[0] = '\0';
strcpy(buf, "first string");
strcat(buf, ", second string");
```

See Also

strncat

Notes

There is no way to specify the size of the destination area to prevent storage overwrites.

strcat is packaged in the integer library.

strchr

Description

Scan string for first occurrence of character

Syntax

```
#include <string.h>
char *strchr(char *s1, char c)
```

Function

strchr looks for the first occurrence of a specific character **c** in a NUL terminated target string **s**.

Return Value

strchr returns a pointer to the first character that matches **c**, or NULL if none does.

Example

To map *keystr[]* characters into *subst[]* characters:

```
if (t = strchr(keystr, *s))
        *s = subst[t - keystr];
```

See Also

memchr, strcspn, strpbrk, strrchr, strspn

Notes

strchr is packaged in the integer library.

strcmp

Description

Compare two strings for lexical order

Syntax

```
#include <string.h>
int strcmp(char *s1, char *s2)
```

Function

strcmp compares two text strings, character by character, for lexical order in the character collating sequence. The first string starts at **s1**, the second at **s2**. The strings must match, including their terminating NUL characters, in order for them to be equal.

Return Value

strcmp returns an integer greater than, equal to, or less than zero, according to whether **s1** is lexicographically greater than, equal to, or less than **s2**.

Example

To look for the string “*include*”:

```
if (strcmp(buf, “include”) == 0)
        doinclude();
```

See Also

memcmp, strncmp

Notes

strcmp is packaged in the integer library.

strcpy

Description

Copy one string to another

Syntax

```
#include <string.h>
char *strcpy(char *s1, char *s2)
```

Function

strcpy copies the NUL terminated string at **s2** to the buffer pointed at by **s1**. The terminating NUL is also copied.

Return Value

strcpy returns **s1**.

Example

To make a copy of the string **s2** in **`dest`**:

```
strcpy(dest, s2);
```

See Also

memcpy, strncpy

Notes

There is no way to specify the size of the destination area, to prevent storage overwrites.

strcpy is packaged in the integer library, and may be implemented as an *inline* function.

strcspn

Description

Find the end of a span of characters in a set

Syntax

```
#include <string.h>
unsigned int strcspn(char *s1, char *s2)
```

Function

strcspn scans the string starting at **s1** for the first occurrence of a character in the string starting at **s2**. It computes a subscript **i** such that:

- **s1[i]** is a character in the string starting at **s1**
- **s1[i]** compares equal to some character in the string starting at **s2**, which may be its terminating null character.

Return Value

strcspn returns the lowest possible value of **i**. **s1[i]** designates the terminating null character if none of the characters in **s1** are in **s2**.

Example

To find the start of a decimal constant in a text string:

```
if (!str[i = strcspn(str, "0123456789+-")])
    printf("can't find number\n");
```

See Also

memchr, strchr, strpbrk, strrchr, strspn

Notes

strcspn is packaged in the integer library.

strlen

Description

Find length of a string

Syntax

```
#include <string.h>
unsigned int strlen(char *s)
```

Function

strlen scans the text string starting at **s** to determine the number of characters before the terminating NUL.

Return Value

The value returned is the number of characters in the string before the NUL.

Notes

strlen is packaged in the integer library and may be implemented as an *inline* function.

strncat

Description

Concatenate strings of length n

Syntax

```
#include <string.h>
char *strncat(char *s1, char *s2, unsigned char n)
```

Function

strncat appends a copy of the NUL terminated string at **s2** to the end of the NUL terminated string at **s1**. The first character of **s2** overlaps the NUL at the end of **s1**. **n** specifies the maximum number of characters to be copied, unless the terminating NUL in **s2** is encountered first. A terminating NUL is always appended to **s1**.

Return Value

strncat returns **s1**.

Example

To concatenate the strings "*day*" and "*light*":

```
strcpy(s, "day");
strncat(s + 3, "light", 5);
```

See Also

strcat

Notes

strncat is packaged in the integer library.

strncmp

Description

Compare two n length strings for lexical order

Syntax

```
#include <string.h>
int strncmp(char *s1, char *s2, unsigned char n)
```

Function

strncmp compares two text strings, character by character, for lexical order in the character collating sequence. The first string starts at **s1**, the second at **s2**. **n** specifies the maximum number of characters to be compared, unless the terminating NUL in **s1** or **s2** is encountered first. The strings must match, including their terminating NUL character, in order for them to be equal.

Return Value

strncmp returns an integer greater than, equal to, or less than zero, according to whether **s1** is lexicographically greater than, equal to, or less than **s2**.

Example

To check for a particular error message:

```
if (strncmp(errmsg,
        "can't write output file", 23) == 0)
        cleanup(errmsg);
```

See Also

memcmp, strcmp

Notes

strncmp is packaged in the integer library.

strncpy

Description

Copy n length string

Syntax

```
#include <string.h>
char *strncpy(char *s1, char *s2, unsigned char n)
```

Function

strncpy copies the first **n** characters starting at location **s2** into the buffer beginning at **s1**. **n** specifies the maximum number of characters to be copied, unless the terminating NUL in **s2** is encountered first. In that case, additional NUL padding is appended to **s2** to copy a total of **n** characters.

Return Value

strncpy returns **s1**.

Example

To make a copy of the string **s2** in *dest*:

```
strncpy(dest, s2, n);
```

See Also

memcpy, strcpy

Notes

If the string **s2** points at is longer than **n** characters, the result may not be NUL-terminated.

strncpy is packaged in the integer library.

strpbrk

Description

Find occurrence in string of character in set

Syntax

```
#include <string.h>
char *strpbrk(char *s1, char *s2)
```

Function

strpbrk scans the NUL terminated string starting at **s1** for the first occurrence of a character in the NUL terminated set **s2**.

Return Value

strpbrk returns a pointer to the first character in **s1** that is also contained in the set **s2**, or a NULL if none does.

Example

To replace unprintable characters (as for a 64 character terminal):

```
while (string = strpbrk(string, “`{|}~”))
        *string = '@';
```

See Also

memchr, strchr, strcspn, strrchr, strspn

Notes

strpbrk is packaged in the integer library.

strrchr

Description

Scan string for last occurrence of character

Syntax

```
#include <string.h>
char *strrchr(char *s, char c)
```

Function

strrchr looks for the last occurrence of a specific character **c** in a NUL terminated string starting at **s**.

Return Value

strrchr returns a pointer to the last character that matches **c**, or NULL if none does.

Example

To find a filename within a directory pathname:

```
if (s = strrchr(“/usr/lib/libc.user”, '/')
        ++s;
```

See Also

memchr, strchr, strpbrk, strcspn, strspn

Notes

strrchr is packaged in the integer library.

strspn

Description

Find the end of a span of characters not in set

Syntax

```
#include <string.h>
unsigned int strspn(char *s1, char *s2)
```

Function

strspn scans the string starting at **s1** for the first occurrence of a character not in the string starting at **s2**. It computes a subscript **i** such that

- **s1[i]** is a character in the string starting at **s1**
- **s1[i]** compares equal to no character in the string starting at **s2**, except possibly its terminating null character.

Return Value

strspn returns the lowest possible value of **i**. **s1[i]** designates the terminating null character if all of the characters in **s1** are in **s2**.

Example

To check a string for characters other than decimal digits:

```
if (str[strspn(str, "0123456789")])
        printf("invalid number\n");
```

See Also

memchr, strcspn, strchr, strpbrk, strrchr

Notes

strspn is packaged in the integer library.

strstr

Description

Scan string for first occurrence of string

Syntax

```
#include <string.h>
char *strstr(char *s1, char *s2)
```

Function

strstr looks for the first occurrence of a specific string **s2** not including its terminating NUL, in a NUL terminated target string **s1**.

Return Value

strstr returns a pointer to the first character that matches **c**, or NULL if none does.

Example

To look for a keyword in a string:

```
if (t = strstr(buf, "LIST"))
        do_list(t);
```

See Also

memchr, strcspn, strpbrk, strrchr, strspn

Notes

strstr is packaged in the integer library.

strtod

Description

Convert buffer to double

Syntax

```
#include <stdlib.h>
double strtod(char *nptr, char **endptr)
```

Function

strtod converts the string at *nptr* into a double. The string is taken as the text representation of a decimal number, with an optional fraction and exponent. Leading whitespace is skipped and an optional sign is permitted; conversion stops on the first unrecognizable character. Acceptable inputs match the pattern:

[+|-]d*[.d*][e[+|-]dd*]

where **d** is any decimal digit and **e** is the character '**e**' or '**E**'. If *endptr* is not a null pointer, **endptr* is set to the address of the first unconverted character remaining in the string nptr. No checks are made against overflow, underflow, or invalid character strings.

Return Value

strtod returns the converted double value. If the string has no recognizable characters, it returns zero.

Example

To read a string from STDIN and convert it to a double at **d**:

```
gets(buf);
d = strtod(buf, NULL);
```

See Also

atoi, atol, strtol, strtoul

Notes

strtod is packaged in the floating point library.

strtol

Description

Convert buffer to long

Syntax

```
#include <stdlib.h>
long strtol(char *nptr, char **endptr, char base)
```

Function

strtol converts the string at *nptr* into a long integer. Leading whitespace is skipped and an optional sign is permitted; conversion stops on the first unrecognizable character. If base is not zero, characters `a-z` or `A-Z` represents digits in range 10-36. If base is zero, a leading "`0x`" or "`0X`" in the string indicates hexadecimal, a leading "`0`" indicates octal, otherwise the string is take as a decimal representation. If base is 16 and a leading "`0x`" or "`0X`" is present, it is skipped before to convert. If *endptr* is not a null pointer, **endptr* is set to the address of the first unconverted character in the string *nptr*.

No checks are made against overflow or invalid character strings.

Return Value

strtol returns the converted long integer. If the string has no recognizable characters, zero is returned.

Example

To read a string from STDIN and convert it to a long **l**:

```
gets(buf);
l = strtol(buf, NULL, 0);
```

See Also

atof, atoi, strtoul, strtod

Notes

strtol is packaged in the integer library.

strtoul

Description

Convert buffer to unsigned long

Syntax

```
#include <stdlib.h>
unsigned long strtoul(char *nptr, char **endptr,
                      char base)
```

Function

strtoul converts the string at *nptr* into a long integer. Leading whitespace is skipped and an optional sign is permitted; conversion stops on the first unrecognizable character. If base is not zero, characters **a-z** or **A-Z** represents digits in range 10-36. If base is zero, a leading "**0x**" or "**0X**" in the string indicates hexadecimal, a leading "**0**" indicates octal, otherwise the string is take as a decimal representation. If base is 16 and a leading "**0x**" or "**0X**" is present, it is skipped before to convert. If *endptr* is not a null pointer, **endptr* is set to the address of the first unconverted character in the string *nptr*.

No checks are made against overflow or invalid character strings.

Return Value

strtoul returns the converted long integer. If the string has no recognizable characters, zero is returned.

Example

To read a string from STDIN and convert it to a long **l**:

```
gets(buf);
l = strtoul(buf, NULL, 0);
```

See Also

atof, atoi, strtol, strtod

Notes

strtoul is a macro redefined to *strtol*.

tan

Description

Tangent

Syntax

```
#include <math.h>
double tan(double x)
```

Function

tan computes the tangent of **x**, expressed in radians, to full double precision.

Return Value

tan returns the nearest internal representation to *tan(x)*, in the range [-pi/2, pi/2], expressed as a double floating value. If the number in x is too large to be represented, tan returns zero. An argument with a large size may return a meaningless value, *i.e.* when **x/(2 * pi)** has no fraction bits.

Example

To compute the tangent of *theta*:

```
y = tan(theta);
```

See Also

cos, sin

Notes

tan is packaged in the floating point library.

tanh

Description

Hyperbolic tangent

Syntax

```
#include <math.h>
double tanh(double x)
```

Function

tanh computes the value of the hyperbolic tangent of x to double precision.

Return Value

tanh returns the nearest internal representation to *tanh(x)*, expressed as a double floating value. If the result is too large to be properly represented, tanh returns zero.

Example

To compute the hyperbolic tangent of **x**:

```
y = tanh(x);
```

See Also

cosh, exp, sinh

Notes

tanh is packaged in the floating point library.

tolower

Description

Convert character to lowercase if necessary

Syntax

```
#include <ctype.h>
int tolower(char c)
```

Function

tolower converts an uppercase letter to its lowercase equivalent, leaving all other characters unmodified.

Return Value

tolower returns the corresponding lowercase letter, or the unchanged character.

Example

To accumulate a hexadecimal digit:

```
for (sum = 0; isxdigit(*s); ++s)
        if (isdigit(*s)
                sum = sum * 16 + *s - '0';
        else
                sum = sum * 16 + tolower(*s) + (10 - 'a');
```

See Also

toupper

Notes

tolower is packaged in the integer library.

toupper

Description

Convert character to uppercase if necessary

Syntax

```
#include <ctype.h>
int toupper(char c)
```

Function

toupper converts a lowercase letter to its uppercase equivalent, leaving all other characters unmodified.

Return Value

toupper returns the corresponding uppercase letter, or the unchanged character.

Example

To convert a character string to uppercase letters:

```
for (i = 0; i < size; ++i)
        buf[i] = toupper(buf[i]);
```

See Also

tolower

Notes

toupper is packaged in the integer library.

CHAPTER

5

Using The Assembler

The **castm8** cross assembler translates your assembly language source files into relocatable object files. The C cross compiler calls *castm8* to assemble your code automatically, unless specified otherwise. *castm8* generates also listings if requested. This chapter includes the following sections:

Invoking castm8

castm8 accepts the following command line options, each of which is described in detail below:

```
castm8 [options] <files>
        -a    absolute assembler
        -b    do not optimizes branches
        -c    output cross reference
        -d*>  define symbol=value
        +e*   error file name
        -ff   use formfeed in listing
        -ft   force title in listing
        -f#   fill byte value
        -h*   include header
        -i*>  include path
        -l    output listing
        +l*   listing file name
        -m    accept old syntax
        -mi   accept label syntax
        -o*   output file name
        -pe   all equates public
        -p    all symbols public
        -pl   keep local symbol
        -u    undefined in listing
        -v    be verbose
        -x    include line debug info
        -xp   no path in debug info
        -xx   include full debug info
```

Castm8 Option Usage

Option	Description
-a	map all sections to absolute, including the predefined ones.
-b	do not optimize branch instructions. By default, the assembler replaces long branches by short branches wherever a shorter instruction can be used, and short branches by long branches wherever the displacement is too large. This optimization also applies to jump and jump to subroutines instructions.

Castm8 Option Usage (cont.)

Option	Description
-c	produce cross-reference information. The cross-reference information will be added at the end of the listing file. This option enforces the **-l** option.
-d*>	where * has the form **name=value**, defines **name** to have the value specified by **value**. This option is equivalent to using an **equ** directive in each of the source files.
+e*	log errors from assembler in the text file * instead of displaying the messages on the terminal screen.
-ff	use *formfeed* character to skip pages in listing instead of using blank lines.
-ft	output a title in listing (date, file name, page). By default, no title is output.
-f#	define the value of the filling byte used to fill any gap created by the assembler directives. Default is **0**.
-h*	include the file specified by * before starting assembly. It is equivalent to an **include** directive in each source file.
-i*>	define a path to be used by the **include** directive. Up to 20 paths can be defined. A path is a directory name and is **not** ended by any directory separator character.
-l	create a listing file. The name of the listing file is derived from the input file name by replacing the suffix by the '*.ls*' extension, unless the **+l** option has been specified.
+l*	create a listing file in the text file *. If both **-l** and **+l** are specified, the listing file name is given by the **+l** option.
-m	accept the old syntax.
-mi	accept label that is not ended with a '**:**' character.
-o*	write object code to the file *. If no file name is specified, the output file name is derived from the input file name, by replacing the rightmost extension in the input file name with the character '*o*'. For example, if the input file name is *prog.s*, the default output file name is *prog.o*.

Castm8 Option Usage (cont.)

Option	Description
-pe	mark all symbols defined by an **equ** directive as **public**. This option has the same effect than adding a **xdef** directive for each of those symbols.
-pl	put locals in the symbol table. They are not published as externals and will be only displayed in the linker map file.
-p	mark all defined symbols as **public**. This option has the same effect than adding a **xdef** directive for each label.
-u	produce an error message in the listing file for all occurrence of an undefined symbol. This option enforces the **-l** option.
-v	display the name of each file which is processed.
-x	add line debug information to the object file.
-xp	do not prefix filenames in the debug information with any absolute path name. Debuggers will have to be informed about the actual files location.
-xx	add debug information in the object file for any label defining code or data. This option disables the **-p** option as only public or used labels are selected.

Each source file specified by <*files*> will be assembled separately, and will produce separate object and listing files. For each source file, if no errors are detected, *castm8* generates an object file. If requested by the **-l** or **-c** options, *castm8* generates a listing file even if errors are detected. Such lines are followed by an error message in the listing.

Object File

The object file produced by the assembler is a relocatable object in a format suitable for the linker *clnk*. This will normally consist of machine code, initialized data and relocation information. The object file also contains information about the sections used, a symbol table, and a debug symbol table.

Listings

The listing stream contains the source code used as input to the assembler, together with the hexadecimal representation of the corresponding object code and the address for which it was generated. The contents of the listing stream depends on the occurrence of the **list**, **nolist**, **clist**, **dlist** and **mlist** directives in the source. The format of the output is as follows:

<*address*> <*generated_code*> <*source_line*>

where <*address*> is the hexadecimal relocatable address where the <*source_line*> has been assembled, <*generated_code*> is the hexadecimal representation of the object code generated by the assembler and <*source_line*> is the original source line input to the assembler. If expansion of data, macros and included files is not enabled, the <*generated_code*> print will not contain a complete listing of all generated code.

Addresses in the listing output are the offsets from the start of the current section. After the linker has been executed, the listing files may be updated to contain absolute information by the **clabs** utility. Addresses and code will be updated to reflect the actual values as built by the linker.

Several directives are available to modify the listing display, such as **title** for the page header, **plen** for the page length, **page** for starting a new page, **tabs** for the tabulation characters expansion. By default, the listing file is not paginated. Pagination is enabled by using at least one **title** directive in the source file, or by specifying the **-ft** option on the command line. Otherwise, the **plen** and **page** directives are simply ignored. Some other directives such as **clist**, **mlist** or **dlist** control the amount of information produced in the listing.

A **cross-reference** table will be appended to the listing if the **-c** option has been specified. This table gives for each symbol its value, its attributes, the line number of the line where it has been defined, and the list of line numbers where it is referenced.

Assembly Language Syntax

The assembler *castm8* conforms to the STM8 syntax as described in the document *Assembly Language Input Standard*. The assembly language consists of lines of text in the form:

[label:] [command [operands]] [; comment]

or

; comment

where '**:**' indicates the end of a label and '**;**' defines the start of a comment. The end of a line terminates a comment. The *command* field may be an **instruction**, a **directive** or a **macro call**.

Instruction mnemonics and assembler directives may be written in upper or lower case. The C compiler generates lowercase assembly language.

A source file must end with the **end** directive. All the following lines will be ignored by the assembler. If an **end** directive is found in an included file, it stops only the process for the included file.

Instructions

castm8 recognizes the following instructions:

adc	ccf	incw	jrnh	ldf	rim	sra
add	clr	iret	jrnm	ldw	rlc	sraw
addw	clrw	jp	jrnv	mov	rlcw	srl
and	cp	jpf	jrpl	mul	rlwa	srlw
bccm	cpl	jra	jrsge	neg	rrc	sub
bcp	cplw	jrc	jrsgt	negw	rrcw	subw
bcpl	cpw	jreq	jrsle	nop	rrwa	swap
bkpt	dec	jrf	jrslt	or	rvf	swapw
bres	decw	jrh	jrt	pop	sbc	tnz
bset	div	jrih	jruge	popw	scf	tnzw
btjf	divw	jril	jrugt	push	sim	trap
btjt	exg	jrm	jrule	pushw	sla	wfe
call	exgw	jrmi	jrult	rcf	slaw	wfi
callf	halt	jrnc	jrv	ret	sll	xor
callr	inc	jrne	ld	retf	sllw	

The **operand** field of an instruction uses an addressing mode to describe the instruction argument. The following examples demonstrate the accepted syntax:

```
        rcf                     ; implicit
        push    y               ; register
        ld      a,#1            ; immediate
        and     a,var           ; short, long
        ld      a,(2,x)         ; indexed
        ld      a,[var]         ; indirect
        ld      a,([var.w],y)   ; indirect indexed long
        jrne    loop            ; relative
        bset    2,#1            ; bit number
        btjt    2,#1,loop       ; bit test and branch
```

The assembler chooses the smallest addressing mode where several solutions are possible. *Short* addressing mode is selected when using a label defined in the *.bsct* section.

For an exact description of the above instructions, refer to the ST Microelectronics's *STM8 Family Programming Manual*.

Labels

A source line may begin with a label. Some directives require a label on the same line, otherwise this field is optional. A label must begin with an alphabetic character, the underscore character '**_**' or the period character '**.**'. It is continued by alphabetic (A-Z or a-z) or numeric (0-9) characters, underscores, dollar signs (**$**) or periods. Labels are case sensitive. The processor register names '*a*' and '*x*' are reserved and cannot be used as labels.

```
data1: dc.b     $56
c_reg: ds.b     1
```

When a label is used within a macro, it may be expanded more than once and in that case, the assembler will fail with a *multiply defined symbol* error. In order to avoid that problem, the special sequence '**\@**' may be used as a label prefix. This sequence will be replaced by a unique sequence for each macro expansion. This prefix is only allowed inside a macro definition.

```
wait:  macro
\@loop:btjf     PORTA,#1,\@loop
       endm
```

Temporary Labels

The assembler allows temporary labels to be defined when there is no need to give them an explicit name. Such a label is composed by a decimal number immediately followed by a '**$**' character. Such a label is valid until the next standard label or the *local* directive. Then the same temporary label may be redefined without getting a multiply defined error message.

```
1$:    dec
       jrne 1$
2$:    dec
       jrne 2$
```

Temporary labels do not appear in the symbol table or the cross reference list.

For example, to define 3 different local blocks and create and use 3 different local labels named 10$:

```
function1:
10$:   ld       a,var
       jreq     10$
       ld       a,var2
       local
10$:   ld       a,var2
       jreq     10$
       ld       a,var
       ret
function2:
10$:   ld       a,var2
       sub      a,var
       jrne     10$
       ret
```

Constants

The assembler accepts **numeric** constants and **string** constants. *Numeric* constants are expressed in different bases depending on a *prefix* character as follows:

Number	Base
10	decimal (no prefix)
%1010	binary
@12	octal
$A	hexadecimal

The assembler also accepts numerics constants in different bases depending on a *suffix* character as follow:

Suffix	Base
D, d or none	decimal (no prefix)
B or b	binary
Q or q	octal
0AH or 0Ah	hexadecimal

The suffix letter can be entered uppercase or lowercase. Hexadecimal numbers still need to start with a digit.

String constants are a series of printable characters between single or double quote characters:

```
'This is a string'
"This is also a string"
```

Depending on the context, a string constant will be seen either as a series of bytes, for a data initialization, or as a numeric; in which case, the string constant should be reduced to only one character.

```
hexa:   dc.b     '0123456789ABCDEF'
start:  cp       x,#'A'   ; ASCII value of 'A'
```

Expressions

An expression consists of a number of labels and constants connected together by operators. Expressions are evaluated to 32-bit precision. Note that operators have the same precedence than in the C language.

A special label written '*' is used to represent the current location address. Note that when '*' is used as the operand of an instruction, it has the value of the program counter **before** code generation for that instruction. The set of accepted operators is:

```
+       addition
-       subtraction (negation)
*       multiplication
/       division
%       remainder (modulus)
&       bitwise and
|       bitwise or
^       bitwise exclusive or
~       bitwise complement
<<      left shift
>>      right shift
==      equality
!=      difference
<       less than
<=      less than or equal
>       greater than
>=      greater than or equal
&&      logical and
||      logical or
!       logical complement
```

These operators may be applied to constants without restrictions, but are restricted when applied to *relocatable* labels. For those labels, the **addition** and **substraction** operators only are accepted and only in the following cases:

```
label + constant
label - constant
label1 - label2
```

NOTE

The difference of two relocatable labels is valid only if both symbols are not external symbols, and are defined in the same section.

An expression may also be constructed with a special operator. These expressions cannot be used with the previous operators and have to be specified alone.

high(expression)	upper byte
low(expression)	lower byte
page(expression)	page byte

These special operators evaluate an **expression** and extract the appropriate information from the result. The expression may be relocatable, and may use the set of operators if allowed.

high - extract the upper byte of the 16-bit expression

low - extract the lower byte of the 16-bit expression

page - extract the *page* value of the expression. It is computed by the linker according to the **-bs** option used. This is used to get the address extension when bank switching is used.

Macro Instructions

A **macro** instruction is a list of assembler commands collected under a unique name. This name becomes a new command for the following of the program. A **macro** begins with a **macro** directive and ends with a **endm** directive. All the lines between these two directives are recorded and associated with the macro name specified with the **macro** directive.

```
signex:macro            ; sign extension
       clr     x        ; prepare MSB
       tnz     a        ; test sign
       jrpl    \@pos    ; if not positive
       cpl     x        ; invert MSB
\@pos:
       endm             ; end of macro
```

This macro is named *signex* and contains the code needed to perform a sign extension of **a** into **x**. Whenever needed, this macro can be expanded just by using its name in place of a standard instruction:

```
       ld      a,char+1; load LSB
       signex           ; expand macro
       ld      char,x   ; store result
```

The resulting code will be the same as if the following code had been written:

```
        ld      a,char+1; load LSB
        clr     x       ; prepare MSB
        tnz     a       ; test sign
        jrpl    pos     ; if not positive
        cpl     x       ; invert MSB
pos:
        ld      char,x  ; store result
```

A **macro** may have up to 35 *parameters*. A *parameter* is written **\1, \2,... \9, \A,...,\Z** inside the macro body and refers explicitly to the first, second,... ninth *argument* and **\A** to **\Z** to denote the tenth to 35th operand on the invocation line, which are placed after the macro name, and separated by commas. Each *argument* replaces each occurrence of its corresponding *parameter*. An *argument* may be expressed as a **string** constant if it contains a comma character.

A macro can also handle named arguments instead of numbered argument. In such a case, the macro directive is followed by a list of argument named, each prefixed by a \ character, and separated by commas. Inside the macro body, arguments will be specified using the same syntax or a sequence starting by a \ character followed by the argument named placed between parenthesis. This alternate syntax is useful to catenate the argument with a text string immediately starting with alphanumeric characters.

The special *parameter* \# is replaced by a numeric value corresponding to the number of *arguments* actually found on the invocation line.

In order to operate directly in memory, the previous macro may have been written using the **numbered** syntax:

```
signex:macro            ; sign extension
        clr     x       ; prepare MSB
        ld      a,\1    ; load LSB
        jrpl    \@pos   ; if not positive
        cpl     x       ; invert MSB
\@pos:
        ld      \1,x    ; store MSB
        endm            ; end of macro
```


And called:

```
        signex char      ; sign extend char
```

This macro may also be written using the **named** syntax:

```
signex:macro    \value              ; sign extension
        clr     x                   ; prepare MSB
        ld      a,\value            ; load LSB
        jrpl    \@pos               ; if not positive
        cpl     x                   ; invert MSB
\@pos:
        ld      \(value),x          ; store MSB
        endm                        ; end of macro
```

The form of a macro call is:

```
name>[.<ext>]  [<arguments>]
```

The special parameter **\0** corresponds to an extension <*ext*> which may follow the macro name, separated by the period character '**.**'. An extension is a single letter which may represent the size of the operands and the result. For example:

```
table: macro
        dc.\0   1,2,3,4
        endm
```

When invoking the macro:

```
        table.b
```

will generate a table of byte:

```
        dc.b    1,2,3,4
```

When invoking the macro:

```
        table.w
```

will generate a table of word:

```
        dc.w    1,2,3,4
```

The special parameter ***** is replaced by a sequence containing the list of all the passed arguments separated by commas. This syntax is useful to pass all the macro arguments to another macro or a **repeatl** directive.

The directive **mexit** may be used at any time to stop the macro expansion. It is generally used in conjunction with a conditional directive.

A macro call may be used within another macro definition, all macros must then be defined before their first call. A macro definition cannot contain another macro definition.

If a listing is produced, the macro expansion lines are printed if enabled by the **mlist** directive. If enabled, the invocation line is not printed, and all the expanded lines are printed with all the *parameters* replaced by their corresponding *arguments*. Otherwise, the invocation line only is printed.

Conditional Directives

A **conditional directive** allows parts of the program to be assembled or not depending on a specific condition expressed in an **if** directive. The condition is an expression following the **if** command. The expression cannot be relocatable, and shall evaluate to a numeric result. If the condition is *false* (expression evaluated to zero), the lines following the **if** directive are skipped until an **endif** or **else** directive. Otherwise, the lines are normally assembled. If an **else** directive is encountered, the condition status is reversed, and the conditional process continues until the next **endif** directive.

```
if      debug == 1
ld      x,#message
call    print
endif
```

If the symbol `debug` is equal to 1, the next two lines are assembled. Otherwise they are skipped.

```
if      offset != 1         ; if offset too large
addptr  offset              ; call a macro
else                        ; otherwise
inc     x                   ; increment X register
endif
```


If the symbol *offset* is not one, the macro `addptr` is expanded with *offset* as argument, otherwise the *aix* instruction is directly assembled.

Conditional directives may be nested. An **else** directive refers to the closest previous **if** directive, and an **endif** directive refers to the closest previous **if** or **else** directive.

If a listing is produced, the skipped lines are printed only if enabled by the **clist** directive. Otherwise, only the assembled lines are printed.

Sections

The assembler allows code and data to be splitted in **sections**. A *section* is a set of code or data referenced by a section name, and providing a contiguous block of relocatable information. A *section* is defined with a *section* directive, which creates a new section and redirects the following code and data thereto. The directive **switch** can be used to redirect the following code and data to another *section*.

```
data:   section          ; defines data section
text:   section          ; defines text section
start:
        ld      x,#value; fills text section
        jp      print
        switch  data     ; use now data section
value:
        dc.b    1,2,3    ; fills data section
```

The assembler allows up to **255** different sections. A section name is limited to **15** characters. If a section name is too long, it is simply truncated without any error message.

The assembler predefines the following sections, meaning that a *section* directive is *not* needed before to use them:

Section	Description
.text	executable code
.data	initialized data
.bss	uninitialized data
.bsct	initialized data in zero page
.ubsct	non initialized data in zero page

The sections **.bsct** and **.ubsct** are used for locating data in the zero page of the processor. The zero page is defined as the memory addresses between **0x00** and **0xFF** inclusive, i.e. the memory directly addressable by a single byte. Several processors include special instructions and/or addressing modes that take advantage of this special address range. The Cosmic assembler will automatically use the most efficient addressing mode if the data objects are allocated in the **.bsct**, **.ubsct** or a section with the same attributes. If zero page data objects are defined in another file then the directive **xref.b** must be used to externally reference the data object. This directive specifies that the address for these data object is only one byte and therefore the assembler may use 8 bit addressing modes.

```
        switch  .bsct
zvar2:  ds.b    1
        switch  .bss
var2:   ds.b    1
        switch  .text
        ld      a,var
        ld      a,zvar
        ld      a,var2
        ld      a,var2
        end
```

Bit Handling

The assembler allows symbols specifying bit addresses instead of byte addresses. A bit address is obtained from a byte address and a bit number by or'ing the bit number with the byte address 3-bit shifted to the left. Such symbol can be defined either by an equate definition or as member of a bit section. Such a section can be defined by using the **sec-**

tion directive with the **bit** attribute. In a bit section, any directive creating or reserving bytes can be used, but will create or reserve bits. Bit symbols can be directly used by the bit instructions with a shortened syntax, as a bit symbol is defining both a byte and a bit in this byte. Bit symbols can be declared as external by using the **xbit** directive. External definitions for bit symbols located in the zero page will used the **xbit.b** directive.

```
        xbit.b   b1        ; external bit declaration
PA3:    equ      PORTA:3 ; bit 3 of byte PORTA
.bit:   section   zpage,bit; create bit section named ".bit"
b0:     ds.b     1         ; allocates one bit
        switch   .text
        btjf     PA3,skip; use directly bit symbol
        bset     b0        ; with bit instructions
skip:
        bres     b1
```

Bit sections are located at link time either at specified bit addresses or attached to any zero page section. The linker is computing the proper addresses when hooking bit sections to byte sections, or byte sections to bit sections.

Includes

The **include** directive specifies a file to be included and assembled in place of the **include** directive. The file name is written between double quotes, and may be any character string describing a file on the host system. If the file cannot be found using the given name, it is searched from all the include paths defined by the **-i** options on the command line, and from the paths defined by the environment symbol **CXLIB,** if such a symbol has been defined before the assembler invocation. This symbol may contain several paths separated by the usual path separator of the host operating system ('**;**' for MSDOS and '**:**' for UNIX).

The **-h** option can specify a file to be "included". The file specified will be included as if the program had an **include** directive at its very top. The specified file will be included before **any** source file specified on the command line.

Branch Optimization

Branch instructions are by default automatically optimized to produce the shortest code possible. This behaviour may be disabled by the **-b** option. This optimization operates on conditional branches, on jumps and jumps to subroutine.

A *conditional* branch offset is limited to the range **[-128,127]**. If such an instruction cannot be encoded properly, the assembler will replace it by a sequence containing an inverted branch to the next location followed immediately by a jump to the original target address. The assembler keep track of the last replacement for each label, so if a long branch has already been expanded for the same label at a location close enough from the current instruction, the target address of the short branch will be changed only to branch on the already existing jump instruction to the specified label.

```
jreq    farlabel   becomes     jrne    *+5
                               jp      farlabel
```

Note that a *jra* instruction will be replaced by a single *jp* instruction if it cannot be encoded as a relative branch.

A *jp* or *call* instruction will be replaced by a *jra* or *callr* instruction if the destination address is in the same section than the current one, and if the displacement is in the range allowed by a relative branch.

Old Syntax

The **-m** option allows the assembler to accept old constructs which are now obsolete. The following features are added to the standard behaviour:

- a comment line may begin with a ‘*****’ character;
- a label starting in the first column does not need to be ended with a ‘**:**’ character;
- no error message is issued if an operand of the **dc.b** directive is too large;
- the **section** directive handles *numbered* sections;

The comment separator at the end of an instruction is still the ‘**;**’ character because the ‘*****’ character is interpreted as the multiply operator.

C Style Directives

The assembler also supports C style directives matching the preprocessor directives of a C compiler. The following directives list shows the equivalence with the standard directives:

C Style	Assembler Style
#include “file”	include “file”
#define label expression	label: equ expression
#define label	label: equ 1
#if expression	if expression
#ifdef label	ifdef label
#ifndef label	ifndef label
#else	else
#endif	endif
#error “message”	fail “message”

NOTE

The #define directive does not implement all the text replacement features provided by a C compiler. It can be used only to define a symbol equal to a numerical value.

Assembler Directives

This section consists of quick reference descriptions for each of the *castm8* assembler directives.

align

Description

Align the next instruction on a given boundary

Syntax

```
align <expression>,[<fill_value>]
```

Function

The **align** directive forces the next instruction to start on a specific boundary. The **align** directive is followed by a constant expression which must be positive. The next instruction will start at the next address which is a multiple of the specified value. If bytes are added in the section, they are set to the value of the filling byte defined by the **-f** option. If **<fill_value>** is specified, it will be used locally as the filling byte, instead of the one specified by the **-f** option.

Example

```
align   3        ; next address is multiple of 3
ds.b    1
```

See Also

even

base

Description

Define the default base for numerical constants

Syntax

```
base <expression>
```

Function

The **base** directive sets the default base for numerical constants beginning with a digit. The **base** directive is followed by a constant expression which value must be one of **2**, **8**, **10** or **16**. The decimal base is used by default. When another base is selected, it is no more possible to enter decimal constants.

Example

```
base    8               ; select octal base
ld      a,#377          ; load $FF
```

bsct

Description

Switch to the predefined **.bsct** section.

Syntax

```
bsct
```

Function

The **bsct** directive switches input to a section named **.bsct**, also known as the **zero page** section. The assembler will automatically select the *short* addressing mode when referencing an object defined in the *.bsct* section.

Example

```
        bsct
c_reg:
        ds.b    1
```

Notes

The *.bsct* section is limited to 256 bytes, but the assembler does not check the *.bsct* section size. This will be done by the linker.

See Also

section, switch

clist

Description

Turn listing of conditionally excluded code on or off.

Syntax

```
clist [on|off]
```

Function

The **clist** directive controls the output in the listing file of conditionally excluded code. It is effective if and only if listings are requested; it is ignored otherwise.

The parts of the program to be listed are the program lines which are not assembled as a consequence of **if**, **else** and **endif** directives.

See Also

if, else, endif

dc

Description

Allocate constant(s)

Syntax

```
dc[.size] <expression>[,<expression>...]
```

Function

The **dc** directive allocates and initializes storage for constants. If <*expression*> is a string constant, one byte is allocated for each character of the string. Initialization can be specified for each item by giving a series of values separated by commas or by using a repeat count.

The **dc** and **dc.b** directives will allocate one byte per <*expression*>.

The **dc.w** directive will allocate one word per <*expression*>.

The **dc.l** directive will allocate one long word per <*expression*>.

Example

```
digit: dc.b    10,'0123456789'
       dc.w    digit
```

Note

For compatibility with previous assemblers, the directive **fcb** is alias to **dc.b**, and the directive **fdb** is alias to **dc.w**.

dcb

Description

Allocate constant block

Syntax

```
dcb.<size> <count>,<value>
```

Function

The **dcb** directive allocates a memory block and initializes storage for constants. The size area is the number of the specified value <*count*> of <*size*>. The memory area can be initialized with the <*value*> specified.

The **dcb** and **dcb.b** directives will allocate one **byte** per <*count*>.

The **dcb.w** directive will allocate one **word** per <*count*>.

The **dcb.l** directive will allocate one **long word** per <*count*>.

Example

```
digit: dcb.b   10,5     ; allocate 10 bytes,
                        ; all initialized to 5
```

dlist

Description

Turn listing of debug directives on or off.

Syntax

```
dlist [on|off]
```

Function

The **dlist** directive controls the visibility of any debug directives in the listing. It is effective if and only if listings are requested; it is ignored otherwise.

ds

Description

Allocate variable(s)

Syntax

```
ds[.size] <space>
```

Function

The **ds** directive allocates storage space for variables. <*space*> must be an absolute expression. Bytes created are set to the value of the filling byte defined by the **-f** option.

The **ds** and **ds.b** directives will allocate <*space*> bytes.

The **ds.w** directive will allocate <*space*> words.

The **ds.l** directive will allocate <*space*> long words.

Example

```
ptlec:  ds.b   2
ptecr:  ds.b   2
chrbuf: ds.w   128
```

Note

For compatibility with previous assemblers, the directive **rmb** is alias to **ds.b**.

else

Description

Conditional assembly

Syntax

```
if <expression>
instructions
else
instructions
endc
```

Function

The **else** directive follows an **if** directive to define an alternative conditional sequence. It reverts the condition status for the following instructions up to the next matching **endif** directive. An **else** directive applies to the closest previous **if** directive.

Example

```
if      offset != 1     ; if offset too large
addptr  offset          ; call a macro
else                    ; otherwise
inc     x               ; increment X register
endif
```

Note

The **else** and **elsec** directives are equivalent and may used without distinction. They are provided for compatibility with previous assemblers.

See Also

if, endif, clist

elsec

Description

Conditional assembly

Syntax

```
if <expression>
instructions
elsec
instructions
endc
```

Function

The **elsec** directive follows an **if** directive to define an alternative conditional sequence. It reverts the condition status for the following instructions up to the next matching **endc** directive. An **elsec** directive applies to the closest previous **if** directive.

Example

```
ifge      offset-127      ; if offset too large
addptr    offset          ; call a macro
elsec                     ; otherwise
inc       x               ; increment X register
endc
```

Note

The **elsec** and **else** directives are equivalent and may used without distinction. They are provided for compatibility with previous assemblers.

See Also

if, endc, clist, else

end

Description

Stop the assembly

Syntax

```
end
```

Function

The **end** directive stops the assembly process. Any statements following it are ignored. If the **end** directive is encountered in an included file, it will stop the assembly process for the included file only.

endc

Description

End conditional assembly

Syntax

```
if<cc> <expression>
instructions
endc
```

Function

The **endc** directive closes an **if<cc>** or **elsec** conditional directive. The conditional status reverts to the one existing before entering the **if<cc>** directives. The **endc** directive applies to the closest previous **if<cc>** or **elsec** directive.

Example

```
ifge     offset-127      ; if offset too large
addptr   offset          ; call a macro
elsec                    ; otherwise
inc      x               ; increment X register
endc
```

Note

The **endc** and **endif** directives are equivalent and may used without distinction. They are provided for compatibility with previous assemblers.

See Also

if<cc>, elsec, clist, end

endif

Description

End conditional assembly

Syntax

```
if <expression>
instructions
endif
```

Function

The **endif** directive closes an **if**, or **else** conditional directive. The conditional status reverts to the one existing before entering the **if** directive. The **endif** directive applies to the closest previous **if** or **else** directive.

Example

```
        if        offset != 1      ; if offset too large
        addptr    offset           ; call a macro
        else                       ; otherwise
        inc       x                ; increment X register
        endif
```

Note

The **endif** and **endc** directives are equivalent and may used without distinction. They are provided for compatibility with previous assemblers.

See Also

if, else, clist

endm

Description

End macro definition

Syntax

```
label: macro
       <macro_body>
       endm
```

Function

The **endm** directive is used to terminate macro definitions.

Example

```
; define a macro that places the length of
; a string in a byte prior to the string

ltext:          macro
        ds.b    \@2 - \@1
\@1:
        ds.b    \1
\@2:
        endm
```

See Also

mexit, macro

endr

Description

End repeat section

Syntax

```
        repeat
        <repeat_body>
        endr
```

Function

The endr directive is used to terminate repeat sections.

Example

```
; shift a value n times
asln:   macro
        repeat \1
        sla
        endr
        endm

; use of above macro
        asln 10         ;shift 10 times
```

See Also

repeat, repeatl, rexit

equ

Description

Give a permanent value to a symbol

Syntax

```
label: equ <expression>
```

Function

The **equ** directive is used to associate a permanent value to a symbol (label). Symbols declared with the **equ** directive may not subsequently have their value altered otherwise the **set** directive should be used. *<expression>* must be either a constant expression, or a relocatable expression involving a symbol declared in the same section as the current one.

The **equ** directive can also be used to define a **bit** symbol by suffixing the defining expression with an absolute bit number. The expression and the bit number are separated by a colon character '**:**'. The expression can be absolute or relocatable.

Example

```
false:  equ 0  ; initialize these values
true:   equ 1
tablen: equ tabfin - tabsta;compute table length
nul:    equ $0 ; define strings for ascii characters
soh:    equ $1
stx:    equ $2
etx:    equ $3
eot:    equ $4
enq:    equ $5

PORTB:  equ $1
PB2:    equ PORTB:2
```

See Also

lit, set

even

Description

Assemble next byte at the next even address relative to the start of a section.

Syntax

```
even [fill_<value>]
```

Function

The **even** directive forces the next assembled byte to the next even address. If a byte is added to the section, it is set to the value of the filling byte defined by the **-f** option. If **<fill_value>** is specified, it will be used locally as the filling byte, instead of the one specified by the **-f** option.

Example

```
vowtab: dc.b    'aeiou'
        even            ; ensure aligned at even address
tentab: dc.w    1, 10, 100, 1000
```


fail

Description

Generate error message.

Syntax

```
fail "string"
```

Function

The **fail** directive outputs "*string*" as an error message. No output file is produced as this directive creates an assembly error. *fail* is generally used with conditional directives.

Example

```
Max:    equ     512
        ifge    value - Max
        fail    "Value too large"
```

if

Description

Conditional assembly

Syntax

```
if <expression>        or      if <expression>
instructions                   instructions
endif                          else
                               instructions
                               endif
```

Function

The **if**, **else** and **endif** directives allow conditional assembly. The **if** directive is followed by a constant expression. If the result of the expression is **not** zero, the following instructions are assembled up to the next matching **endif** or **else** directive; otherwise, the following instructions up to the next matching **endif** or **else** directive are skipped.

If the **if** statement ends with an **else** directive, the expression result is inverted and the same process applies to the following instructions up to the next matching **endif.** So, if the **if** expression was **not** zero, the instructions between **else** and **endif** are skipped; otherwise, the instructions between **else** and **endif** are assembled. An **else** directive applies to the closest previous **if** directive.

The **if** directives may be nested. The skipped lines may or may not be in the listing depending on the **clist** directive status.

Example

```
if       offset != 1     ; if offset too large
addptr   offset          ; call a macro
else                     ; otherwise
inc      x               ; increment X register
endif
```

See Also

else, endif, clist

ifc

Description

Conditional assembly

Syntax

```
ifc <string1>,<string2> or ifc <string1>,<string2>
instructions               instructions
endc                       elsec
                           instructions
                           endc
```

Function

The **ifc**, **else** and **endc** directives allow conditional assembly. The **ifc** directive is followed by a constant expression. If *<string1>* and *<string2>* are equals, the following instructions are assembled up to the next matching **endc** or **elsec** directive; otherwise, the following instructions up to the next matching **endc** or **elsec** directive are skipped.

If the **ifc** statement ends with an **elsec** directive, the expression result is inverted and the same process applies to the following instructions up to the next matching **endc.** So, if the **ifc** expression was **not** zero, the instructions between **elsec** and **endc** are skipped; otherwise, the instructions between **elsec** and **endc** are assembled. An **elsec** directive applies to the closest previous **if** directive.

The **if** directives may be nested. The skipped lines may or may not be in the listing depending on the **clist** directive status.

Example

```
ifc     "hello", \2        ; if "hello" equals argument
ld      a,#45              ; load 45
elsec                      ; otherwise...
ld      a,#0
endc
```

See Also

elsec, endc, clist

ifdef

Description

Conditional assembly

Syntax

```
ifdef <label>       or        ifdef <label>
instructions                  instructions
endc                          elsec
                              instructions
                              endc
```

Function

The **ifdef**, **elsec** and **endc** directives allow conditional assembly. The **ifdef** directive is followed by a label *<label>*. If *<label>* is defined, the following instructions are assembled up to the next matching **endc** or **elsec** directive; otherwise, the following instructions up to the next matching **endc** or **elsec** directive are skipped. *<label>* must be first defined. It cannot be a forward reference.

If the **ifdef** statement ends with an **elsec** directive, the expression result is inverted and the same process applies to the following instructions up to the next matching **endif**. So, if the **ifdef** expression was **not** zero, the instructions between **elsec** and **endc** are skipped; otherwise, the instructions between **elsec** and **endc** are assembled. An **elsec** directive applies to the closest previous **if** directive.

The **if** directives may be nested. The skipped lines may or may not be in the listing depending on the **clist** directive status.

Example

```
ifdef     offset1          ; if offset1 is defined
addptr    offset1          ; call a macro
elsec                      ; otherwise
addptr    offset2          ; call a macro
endif
```

See Also

ifndef, elsec, endc, clist

ifeq

Description

Conditional assembly

Syntax

```
ifeq <expression>     or    ifeq <expression>
instructions                instructions
endc                        elsec
                            instructions
                            endc
```

Function

The **ifeq**, **elsec** and **endc** directives allow conditional assembly. The **ifeq** directive is followed by a constant expression. If the result of the expression is **equal** to zero, the following instructions are assembled up to the next matching **endc** or **elsec** directive; otherwise, the following instructions up to the next matching **endc** or **elsec** directive are skipped.

If the **ifeq** statement ends with an **elsec** directive, the expression result is inverted and the same process applies to the following instructions up to the next matching **endc.** So, if the **ifeq** expression is **equal** to zero, the instructions between **elsec** and **endc** are skipped; otherwise, the instructions between **elsec** and **endc** are assembled. An **elsec** directive applies to the closest previous **if** directive.

The **if** directives may be nested. The skipped lines may or may not be in the listing depending on the **clist** directive status.

Example

```
ifeq    offset          ; if offset nul
tnz     a               ; just test it
elsec                   ; otherwise
add     a,#offset       ; add to accu
endc
```

See Also

elsec, endc, clist

ifge

Description

Conditional assembly

Syntax

```
ifge <expression>     or     ifge <expression>
instructions                 instructions
endc                         elsec
                             instructions
                             endc
```

Function

The **ifge**, **elsec** and **endc** directives allow conditional assembly. The **ifge** directive is followed by a constant expression. If the result of the expression is **greater or equal** to zero, the following instructions are assembled up to the next matching **endc** or **elsec** directive; otherwise, the following instructions up to the next matching **endc** or **elsec** directive are skipped.

If the **ifge** statement ends with an **elsec** directive, the expression result is inverted and the same process applies to the following instructions up to the next matching **endc.** So, if the **ifge** expression is **greater or equal** to zero, the instructions between **elsec** and **endc** are skipped; otherwise, the instructions between **elsec** and **endc** are assembled. An **elsec** directive applies to the closest previous **if** directive.

The **if** directives may be nested. The skipped lines may or may not be in the listing depending on the **clist** directive status.

Example

```
        ifge     offset-127      ; if offset too large
        addptr   offset          ; call a macro
        elsec                    ; otherwise
        inc      x               ; increment X register
        endc
```

See Also

elsec, endc, clist

ifgt

Description

Conditional assembly

Syntax

```
ifgt <expression>     or    ifgt <expression>
instructions                instructions
endc                        elsec
                            instructions
                            endc
```

Function

The **ifgt**, **elsec** and **endc** directives allow conditional assembly. The **ifgt** directive is followed by a constant expression. If the result of the expression is **greater than** zero, the following instructions are assembled up to the next matching **endc** or **elsec** directive; otherwise, the following instructions up to the next matching **endc** or **elsec** directive are skipped.

If the **ifgt** statement ends with an **elsec** directive, the expression result is inverted and the same process applies to the following instructions up to the next matching **endc.** So, if the **ifgt** expression was **greater** than zero, the instructions between **elsec** and **endc** are skipped; otherwise, the instructions between **elsec** and **endc** are assembled. An **elsec** directive applies to the closest previous **if** directive.

The **if** directives may be nested. The skipped lines may or may not be in the listing depending on the **clist** directive status.

Example

```
ifgt    offset-127      ; if offset too large
addptr  offset          ; call a macro
elsec                   ; otherwise
inc     x               ; increment X register
endc
```

See Also

elsec, endc, clist

ifle

Description

Conditional assembly

Syntax

```
ifle <expression>     or    ifle <expression>
instructions                instructions
endc                        elsec
                            instructions
                            endc
```

Function

The **ifle**, **elsec** and **endc** directives allow conditional assembly. The **ifle** directive is followed by a constant expression. If the result of the expression is **less or equal** to zero, the following instructions are assembled up to the next matching **endc** or **elsec** directive; otherwise, the following instructions up to the next matching **endc** or **elsec** directive are skipped.

If the **ifle** statement ends with an **elsec** directive, the expression result is inverted and the same process applies to the following instructions up to the next matching **endc.** So, if the **ifle** expression was **less or equal** to zero, the instructions between **elsec** and **endc** are skipped; otherwise, the instructions between **elsec** and **endc** are assembled. An **elsec** directive applies to the closest previous **if** directive.

The **if** directives may be nested. The skipped lines may or may not be in the listing depending on the **clist** directive status.

Example

```
ifle      offset-127       ; if offset small enough
inc       x                ; increment X register
elsec                      ; otherwise
addptr    offset           ; call a macro
endc
```

See Also

elsec, endc, clist

iflt

Description

Conditional assembly

Syntax

```
iflt <expression>     or     iflt <expression>
instructions                 instructions
endc                         elsec
                             instructions
                             endc
```

Function

The **iflt**, **else** and **endc** directives allow conditional assembly. The **iflt** directive is followed by a constant expression. If the result of the expression is **less than** zero, the following instructions are assembled up to the next matching **endc** or **elsec** directive; otherwise, the following instructions up to the next matching **endc** or **elsec** directive are skipped.

If the **iflt** statement ends with an **elsec** directive, the expression result is inverted and the same process applies to the following instructions up to the next matching **endc.** So, if the **iflt** expression was **less than** zero, the instructions between **elsec** and **endc** are skipped; otherwise, the instructions between **elsec** and **endc** are assembled. An **elsec** directive applies to the closest previous **if** directive.

The **if** directives may be nested. The skipped lines may or may not be in the listing depending on the **clist** directive status.

Example

```
iflt    offset-127      ; if offset small enough
inc     x               ; increment X register
elsec                   ; otherwise
addptr  offset          ; call a macro
endc
```

See Also

elsec, endc, clist

ifndef

Description

Conditional assembly

Syntax

```
ifndef <label>      or      ifndef <label>
instructions                instructions
endc                        elsec
                            instructions
                            endc
```

Function

The **ifndef**, **else** and **endc** directives allow conditional assembly. The **ifndef** directive is followed by a label *<label>*. If *<label>* is not defined, the following instructions are assembled up to the next matching **endc** or **elsec** directive; otherwise, the following instructions up to the next matching **endc** or **elsec** directive are skipped. *<label>* must be first defined. It cannot be a forward reference.

If the **ifndef** statement ends with an **elsec** directive, the expression result is inverted and the same process applies to the following instructions up to the next matching **endif**. So, if the **ifndef** expression was **not** zero, the instructions between **elsec** and **endc** are skipped; otherwise, the instructions between **elsec** and **endc** are assembled. An **elsec** directive applies to the closest previous **if** directive.

The **if** directives may be nested. The skipped lines may or may not be in the listing depending on the **clist** directive status.

Example

```
ifndef   offset1        ; if offset1 is not defined
addptr   offset2        ; call a macro
elsec                   ; otherwise
addptr   offset1        ; call a macro
endif
```

See Also

ifdef, elsec, endc, clist

ifne

Description

Conditional assembly

Syntax

```
ifne <expression>     or     ifne <expression>
instructions                 instructions
endc                         elsec
                             instructions
                             endc
```

Function

The **ifne**, **elsec** and **endc** directives allow conditional assembly. The **ifne** directive is followed by a constant expression. If the result of the expression is **not equal** to zero, the following instructions are assembled up to the next matching **endc** or **elsec** directive; otherwise, the following instructions up to the next matching **endc** or **elsec** directive are skipped.

If the **ifne** statement ends with an **elsec** directive, the expression result is inverted and the same process applies to the following instructions up to the next matching **endc.** So, if the **ifne** expression was **not equal** to zero, the instructions between **elsec** and **endc** are skipped; otherwise, the instructions between **elsec** and **endc** are assembled. An **elsec** directive applies to the closest previous **if** directive.

The **if** directives may be nested. The skipped lines may or may not be in the listing depending on the **clist** directive status.

Example

```
        ifne    offset          ; if offset not nul
        add     a,#offset       ; add to accu
        elsec                   ; otherwise
        tnz     a               ; just test it
        endc
```

See Also

elsec, endc, clist

ifnc

Description

Conditional assembly

Syntax

```
ifnc <string1>,string2> or ifnc <string1><string2>
instructions                 instructions
endc                         elsec
                             instructions
                             endc
```

Function

The **ifnc**, **elsec** and **endc** directives allow conditional assembly. The **ifnc** directive is followed by a constant expression. If <*string1*> and <*string2*> are different, the following instructions are assembled up to the next matching **endc** or **elsec** directive; otherwise, the following instructions up to the next matching **endc** or **elsec** directive are skipped.

If the **ifnc** statement ends with an **elsec** directive, the expression result is inverted and the same process applies to the following instructions up to the next matching **endc.** So, if the **ifnc** expression was **not** zero, the instructions between **elsec** and **endc** are skipped; otherwise, the instructions between **elsec** and **endc** are assembled. An **elsec** directive applies to the closest previous **if** directive.

The **if** directives may be nested. The skipped lines may or may not be in the listing depending on the **clist** directive status.

Example

```
ifnc      “hello”, \2
addptr    offset          ; call a macro
else                      ; otherwise
inc       x               ; increment X register
endif
```

See Also

elsec, endc, clist

include

Description

Include text from another text file

Syntax

```
include "filename"
```

Function

The **include** directive causes the assembler to switch its input to the specified *filename* until end of file is reached, at which point the assembler resumes input from the line following the **include** directive in the current file. The directive is followed by a string which gives the name of the file to be included. This string must match exactly the name and extension of the file to be included; the host system convention for uppercase/lowercase characters should be respected.

Example

```
include “datstr”  ; use data structure library
include “bldstd”  ; use current build standard
include “matmac”  ; use maths macros
include “ports82” ; use ports definition
```

list

Description

Turn on listing during assembly.

Syntax

```
list
```

Function

The **list** directive controls the parts of the program which will be written to the listing file. It is effective if and only if listings are requested; it is ignored otherwise.

Example

```
list    ; expand source code until end or nolist
dc.b 1,2,4,8,16
end
```

See Also

nolist

lit

Description

Give a text equivalent to a symbol

Syntax

```
label: lit “string”
```

Function

The **lit** directive is used to associate a text string to a symbol (label). This symbol is replaced by the string content when parsed in any assembler instruction or directive.

Example

```
nbr:    lit     “#5”
        ld      a,nbr           ; expand as ‘ld a,#5’
```

See Also

equ, set

local

Description

Create a new local block

Syntax

```
local
```

Function

The **local** directive is used to create a new local block. When the *local* directive is used, all temporary labels defined before the local directive will be undefined after the local label. New local labels can then be defined in the new local block. Local labels can only be referenced within their own local block. A local label block is the area between two standard labels or local directives or a combination of the two.

Example

```
var:    ds.b 1
var2:   ds.b 1
function1:
10$:    ld      a,var
        jreq    10$
        ld      var2,a
local
10$:    ld      a,var2
        jreq    10$
        ld      var,a
        ret
```


macro

Description

Define a macro

Syntax

```
label: macro
       <macro_body>
       endm
```

Function

The **macro** directive is used to define a macro. The name may be any previously unused name, a name already used as a macro, or an instruction mnemonic for the microprocessor.

Macros are expanded when the name of a previously defined macro is encountered. Operands, where given, follow the name and are separated from each other by commas.

The <*argument_list*> is optional and, if specified, is declaring each argument by name. Each argument name is prefixed by a \ character, and separated from any other name by a comma. An argument name is an identifier which may contain **.** and **_** characters.

The <*macro_body*> consists of a sequence of instructions not including the directives **macro** or **endm**. It may contain macro variables which will be replaced, when the macro is expanded, by the corresponding operands following the macro invocation. These macro variables take the form **\1** to **\9** to denote the first to ninth operand respectively and **\A** to **\Z** to denote the tenth to 35th operand respectively, if the macro has been defined without any <*argument_list*>. Otherwise, macro variables are denoted by their name prefixed by a \ character. The macro variable name can also be enclosed by parenthesis to avoid unwanted concatenation with the remaining text. In addition, the macro variable \# contains the number of actual operands for a macro invocation.

The special parameter ***** is expanded to the full list of passed arguments separated by commas.

The special parameter **\0** corresponds to an extension <*ext*> which may follow the macro name, separated by the period character '**.**'. For more information, see "*Macro Instructions*" on page 179.

A macro expansion may be terminated early by using the **mexit** directive which, when encountered, acts as if the end of the macro has been reached.

The sequence '\@' may be inserted in a label in order to allow a unique name expansion. The sequence '\@' will be replaced by a unique number.

A macro can not be defined within another macro.

Example

```
; define a macro that places the length of a string
; in a byte in front of the string using numbered syntax
;
ltext: macro
       dc.b    \@2-\@1
\@1:
       dc.b    \1 ; text given as first operand
\@2:
       endm

; define a macro that places the length of a string
; in a byte in front of the string using named syntax
;
ltext: macro   \string
       dc.b    \@2-\@1
\@1:
       dc.b    \string ; text given as first operand
\@2:
       endm
```

See Also

endm, mexit

messg

Description

Send a message out to STDOUT

Syntax

```
messg  "<text>"
messg  '<text>'
```

Function

The **messg** directive is used to send a message out to the host system's standard output (STDOUT).

Example

```
messg "Test code for debug"
       ld      a,_#2
       ld      _SCR,a
```

See Also

title

mexit

Description

Terminate a macro definition

Syntax

```
mexit
```

Function

The **mexit** directive is used to exit from a macro definition before the **endm** directive is reached. *mexit* is usually placed after a conditional assembly directive.

Example

```
ctrace:macro
       if tflag == 0
               mexit
       endif
       jp      \1
       endm
```

See Also

endm, macro

mlist

Description

Turn on or off listing of macro expansion.

Syntax

```
mlist [on|off]
```

Function

The **mlist** directive controls the parts of the program which will be written to the listing file produced by a macro expansion. It is effective if and only if listings are requested; it is ignored otherwise.

The parts of the program to be listed are the lines which are assembled in a macro expansion.

See Also

macro

nolist

Description

Turn off listing.

Syntax

```
nolist
```

Function

The **nolist** directive controls the parts of the program which will be **not** written to the listing file until an **end** or a **list** directive is encountered. It is effective if and only if listings are requested; it is ignored otherwise.

See Also

list

Note

For compatibility with previous assemblers, the directive **nol** is alias to **nolist**.

nopage

Description

Disable pagination in the listing file

Syntax

```
nopage
```

Function

The **nopage** directive stops the pagination mechanism in the listing output. It is ignored if no listing has been required.

Example

```
        xref      mult, div
        nopage
        ds.b      charin, charout
        ds.w      a, b, sum
```

See Also

plen, title

offset

Description

Creates absolute symbols

Syntax

```
offset <expresion>
```

Function

The *offset* directive starts an absolute section which will only be used to define symbols, and not to produce any code or data. This section starts at the address specified by *<expression>*, and remains active while no directive or instructions producing code or data is entered. This absolute section is then destroyed and the current section is restored to the one which was active when the *offset* directive has been entered. All the labels defined is this section become absolute symbols.

<expression> must be a valid absolute expression. It must not contain any forward or external references.

Example

```
        offset  0
next:
        ds.b    2
buffer:
        ds.b    80

        switch  .text
size:
        ld      x,next   ; ends the offset section
```


org

Description

Sets the location counter to an offset from the beginning of a section.

Syntax

```
org <expresion>
```

Function

<expression> must be a valid absolute expression. It must not contain any forward or external references.

For an absolute section, the first *org* before any code or data defines the starting address.

An *org* directive cannot define an address smaller than the location counter of the current section.

Any gap created by an *org* directive is filled with the byte defined by the **-f** option.

page

Description

Start a new page in the listing file

Syntax

```
page
```

Function

The **page** directive causes a formfeed to be inserted in the listing output if pagination is enabled by either a **title** directive or the **-ft** option.

Example

```
        xref    mult, div
        page
        ds.b    charin, charout
        ds.w    a, b, sum
```

See Also

plen, title

plen

Description

Specify the number of lines per pages in the listing file

Syntax

```
plen <page_length>
```

Function

The **plen** directive causes *<page_length>* lines to be output per page in the listing output if pagination is enabled by either a **title** directive or the **-ft** option. If the number of lines already output on the current page is less than *<page_length>*, then the new page length becomes effective with *<page_length>*. If the number of lines already output on the current page is greater than or equal to *<page_length>*, a new page will be started and the new page length is set to *<page_length>*.

Example

```
        plen    58
```

See Also

page, title

repeat

Description

Repeat a list of lines a number of times

Syntax

```
repeat <expression>
    repeat_body
endr
```

Function

The repeat directive is used to cause the assembler to repeat the following list of source line up to the next endr directive. The number of times the source lines will be repeated is specified by the expression operand. The repeat directive is equivalent to a macro definition followed by the same number of calls on that macro.

Example

```
; shift a value n times
asln:   macro
        repeat \1
        sla     (x)
        endr
        endm

; use of above macro
        asln 5
```

See Also

endr, repeatl, rexit

repeatl

Description

Repeat a list of lines a number of times

Syntax

```
repeatl <arguments>
    repeat_body
endr
```

Function

The **repeatl** directive is used to cause the assembler to repeat the following list of source line up to the next **endr** directive. The number of times the source lines will be repeated is specified by the number of arguments, separated with commas (with a maximum of 36 arguments) and executed each time with the value of an argument. The **repeatl** directive is equivalent to a macro definition followed by the same number of calls on that macro with each time a different argument. The repeat argument is denoted **\1** unless the argument list is starting by a name prefixed by a **** character. In such a case, the repeat argument is specified by its name prefixed by a **** character.

A **repeatl** directive may be terminated early by using the **rexit** directive which, when encountered, acts as if the end of the **repeatl** has been reached.

Example

```
; test a value using the numbered syntax
repeatl          1,2,3
        add      a,#\1           ; add to accu
endr
end
```

or

```
; test a value using the named syntax
repeatl          \count,1,2,3
        add      a,#\count       ; add to accu
endr
end
```

```
will both produce:

 2              ; test a value
 9  0000 ab01    add     a,#1        ; add to accu
 9  0002 ab02    add     a,#2        ; add to accu
 9  0004 ab03    add     a,#3        ; add to accu
10               end
```

See Also

endr, repeat, rexit

restore

Description

Restore saved section

Syntax

```
restore
```

Function

The **restore** directive is used to restore the last saved section. This is equivalent to a switch to the saved section.

Example

```
       switch   .bss
var:   ds.b     1
var2:  ds.b     1
       save
       switch   .text

function1:
10$:   ld       a,var
       jreq     10$
       ld       var2,a
function2:
10$:   ld       a,var2
       sub      a,var
       jrne     10$
       ret
       restore
var3:  ds.b     1
var4:  ds.b     1

       switch   .text

       ld       a,var3
       ld       var4,a
end
```

See Also

save, section

rexit

Description

Terminate a repeat definition

Syntax

```
rexit
```

Function

The **rexit** directive is used to exit from a **repeat** definition before the **endr** directive is reached. *rexit* is usually placed after a conditional assembly directive.

Example

```
; shift a value n times
asln:   macro
        repeat \1
        if \1 == 0
                rexit
        endif
        sla
        endr
        endm

; use of above macro
        asln 5
```

See Also

endr, repeat, repeatl

save

Description

Save section

Syntax

```
save
```

Function

The **save** directive is used to save the current section so it may be restored later in the source file.

Example

```
        switch   .bss
var:    ds.b     1
var2:   ds.b     1
        save
        switch   .text

function1:
10$:    ld       a,var
        jreq     10$
        ld       var2,a
function2:
10$:    ld       a,var2
        sub      a,var
        jrne     10$
        ret
        restore
var3:   ds.b     1
var4:   ds.b     1

        switch   .text

        ld       a,var3
        ld       var4,a
end
```

See Also

restore, section

scross

Description

Turn on or off section crossing

Syntax

```
scross [on|off]
```

Function

The **scross** directive controls the branch instructions optimization and forces the usage of **jpf** instruction if scross is set (**on**) or **jp** instruction otherwise. The assembler starts with scross on by default.

section

Description

Define a new section

Syntax

```
<section_name>: section [<attributes>]
```

Function

The **section** directive defines a new section, and indicates that the following program is to be assembled into a section named *<section_name>*. The *section* directive cannot be used to redefine an already existing section. If no name and no attributes are specified to the section, the default is to defined the section as a *text* section with its same attributes. It is possible to associate *<attributes>* to the new section. An attribute is either the name of an existing section or an attribute keyword. Attributes may be added if prefixed by a '+' character or not prefixed, or deleted if prefixed by a '-' character. Several attributes may be specified separated by commas. Attribute keywords are:

abs	absolute section
bss	bss style section (no data)
hilo	values are stored in descending order of significance
even	enforce even starting address and size
zpage	enforce 8 bit relocation
long	enforce 32 bit relocation
bit	bit section

Example

```
CODE:  section   .text   ; section of text
lab1:  ds.b     5
DATA:  section   .data   ; section of data
lab2:  ds.b     6
       switch    CODE
lab3:  ds.b     7
       switch    DATA
lab4:  ds.b     8
```

This will place **lab1** and then **lab3** into consecutive locations in section CODE and **lab2** and **lab4** in consecutive locations in section DATA.

```
.frame:         section         .bsct,even
```

The *.frame* section is declared with same attributes than the *.bsct* section and with the *even* attribute.

```
.bit:   section         +zpage,+even,-hilo
```

The *.bit* section is declared using 8 bit relocation, with an even alignment and storing data with an ascending order of significance.

When the **-m** option is used, the *section* directive also accepts a number as operand. In that case, a labelled directive is considered as a section definition, and an unlabelled directive is considered as a section opening (*switch*).

```
.rom:   section 1       ; define section 1
        nop
.ram:   section 2       ; define section 2
        dc.b    1
        section 1       ; switch back to section 1
        nop
```

It is still possible to add attributes after the section number of a section definition line, separated by a comma.

See Also

switch, bsct

set

Description

Give a resetable value to a symbol

Syntax

```
label: set <expression>
```

Function

The **set** directive allows a value to be associated with a symbol. Symbols declared with **set** may be altered by a subsequent **set**. The **equ** directive should be used for symbols that will have a constant value. *<expression>* must be fully defined at the time the **equ** directive is assembled.

Example

```
OFST:   set     10
```

See Also

equ, lit

spc

Description

Insert a number of blank lines before the next statement in the listing file.

Syntax

```
spc <num_lines>
```

Function

The **spc** directive causes <*num_lines*> blank lines to be inserted in the listing output before the next statement.

Example

```
        spc     5
        title   "new file"
```

If listing is requested, 5 blank lines will be inserted, then the title will be output.

See Also

title

switch

Description

Place code into a section.

Syntax

```
switch <section_name>
```

Function

The **switch** directive switches output to the section defined with the **section** directive. *<section_name>* is the name of the target section, and has to be already defined. All code and data following the *switch* directive up to the next *section*, *switch*, *bsct* or *end* directive are placed in the section *<section_name>*.

Example

```
         switch    .bss
buffer:ds.b      512
         xdef     buffer
```

This will place **buffer** into the *.bss* section.

See Also

section, bsct

tabs

Description

Specify the number of spaces for a tab character in the listing file

Syntax

```
tabs <tab_size>
```

Function

The **tabs** directive sets the number of spaces to be substituted to the tab character in the listing output. The minimum value of *<tab_size>* is 0 and the maximum value is 128.

Example

```
        tabs    6
```

title

Description

Define default header

Syntax

```
title "name"
```

Function

The **title** directive is used to enable the listing pagination and set the default page header used when a new page is written to the listing output.

Example

```
        title   “My Application”
```

See Also

page, plen

Note

For compatibility with previous assemblers, the directive **ttl** is alias to **title**.

xbit

Description

Declare bit symbol as being defined elsewhere

Syntax

```
xbit[.b] identifier[,identifier...]
```

Function

Visibility of bit symbols between modules is controlled by the **xref** and **xbit** directives. Symbols which are defined in other modules must be declared as *xbit*. A symbol may be declared both *xdef* and *xbit* in the same module, to allow for usage of common headers.

The directive *xbit.b* declares external symbols located in the *.bsct* section.

Example

```
xbit      otherprog
xbit.b    zpage           ; is in .bsct section
```

See Also

xdef, xref

xdef

Description

Declare a variable to be visible

Syntax

```
xdef identifier[,identifier...]
```

Function

Visibility of symbols between modules is controlled by the **xdef** and **xref** directives. A symbol may only be declared as *xdef* in one module. A symbol may be declared both *xdef* and *xref* in the same module, to allow for usage of common headers.

Example

```
        xdef    sqrt    ; allow sqrt to be called
                        ; from another module
sqrt:                   ; routine to return a square root
                        ; of a number >= zero
```

See Also

xbit, xref

xref

Description

Declare symbol as being defined elsewhere

Syntax

```
xref[.b] identifier[,identifier...]
```

Function

Visibility of symbols between modules is controlled by the **xref** and **xdef** directives. Symbols which are defined in other modules must be declared as *xref*. A symbol may be declared both *xdef* and *xref* in the same module, to allow for usage of common headers.

The directive *xref.b* declares external symbols located in the *.bsct* section.

Example

```
xref      otherprog
xref.b    zpage            ; is in .bsct section
```

See Also

xbit, xdef

CHAPTER

6

Using The Linker

This chapter discusses the **clnk** linker and details how it operates. It describes each linker option, and explains how to use the linker's many special features. It also provides example linker command lines that show you how to perform some useful operations. This chapter includes the following sections:

Introduction

The linker combines relocatable object files, selectively loading from libraries of such files made with *clib*, to create an executable image for standalone execution or for input to other binary reformatters.

clnk will also allow the object image that it creates to have local symbol regions, so the same library can be loaded multiple times for different segments, and so that more control is provided over which symbols are exposed. On microcontroller architectures this feature is useful if your executable image must be loaded into several noncontiguous areas in memory.

NOTE

The terms "segment" and "section" refer to different entities and are carefully kept distinct throughout this chapter. A "section" is a contiguous subcomponent of an object module that the linker treats as indivisible.

The assembler creates several sections in each object module. The linker combines input sections in various ways, but will not break one up. The linker then maps these combined input sections into output segments in the executable image using the options you specify.

A "*segment*" is a logically unified block of memory in the executable image. An example is the code segment which contains the executable instructions.

For most applications, the "*sections*" in an object module that the linker accepts as input are equivalent to the "segments" of the executable image that the linker generates as output.

Overview

You use the linker to build your executable program from a variety of modules. These modules can be the output of the C cross compiler, or can be generated from handwritten assembly language code. Some modules can be linked unconditionally, while others can be selected only as needed from function libraries. All input to the linker, regardless of its source, must be reduced to object modules, which are then combined to produce the program file.

The linker can be used to build freestanding programs such as system bootstraps and embedded applications. It can also be used to make object modules that are loaded one place in memory but are designed to execute somewhere else. For example, a data segment in ROM to be copied into RAM at program startup can be linked to run at its actual target memory location. Pointers will be initialized and address references will be in place.

As a side effect of producing files that can be reprocessed, *clnk* retains information in the final program file that can be quite useful. The symbol table, or list of external identifiers, is handy when debugging programs, and the utility *cobj* can be made to produce a readable list of symbols from an object file. Finally, each object module has in its header useful information such as segment sizes.

In most cases, the final program file created by *clnk* is structurally identical to the object module input to *clnk*. The only difference is that the executable file is complete and contains everything that it needs to run. There are a variety of utilities which will take the executable file and convert it to a form required for execution in specific microcontroller environments. The linker itself can perform some conversions, if all that is required is for certain portions of the executable file to be stripped off and for segments to be relocated in a particular way. You can therefore create executable programs using the linker that can be passed directly to a PROM programmer.

The linker works as follows:

- Options applying to the linker configuration. These options are referred to in this chapter as "*Global Command Line Options*" on page 257.
- Command file options apply only to specific sections of the object being built. These options are referred to in this chapter as "*Segment Control Options*" on page 258.
- Sections can be relocated to execute at arbitrary places in physical memory, or "stacked" on suitable storage boundaries one after the other.
- The final output of the linker is a header, followed by all the segments and the symbol table. There may also be an additional debug symbol table, which contains information used for debugging purposes.

Linker Command File Processing

The command file of the linker is a small control language designed to give the user a great deal of power in directing the actions of the linker. The basic structure of the command file is a series of command items. A command item is either an explicit linker option or the name of an input file (which serves as an implicit directive to link in that file or, if it is a library, scan it and link in any required modules of the library).

An explicit linker option consists of an option keyword followed by any parameters that the option may require. The options fall into five groups:

Group 1
(**+seg** *<section>*) controls the creation of new segments and has parameters which are selected from the set of local flags. (**+grp** *<section>*) controls the section grouping.
Group 2
(**+inc***) is used to include files
Group 3
(**+new**, **+pub** and **+pri**) controls name regions and takes no parameters.
Group 4
(**+def** *<symbol>*) is used to define symbols and aliases and takes one required parameter, a string of the form **ident1=ident2**, a string of the form **ident1=constant**, or a string of the form **ident1=@segment**.
Group 5
(**+spc** *<segment>*) is used to reserve space in a particular *<segment>* and has a required parameter

A description of each of these command line options appears below.

The manner in which the linker relocates the various sections is controlled by the **+seg** option and its parameters. If the size of a current segment is zero when a command to start a new segment of the same name is encountered, it is discarded. Several different sections can be redirected directly to the same segment by using the **+grp** option.

clnk links the <*files*> you specify in order. If a file is a library, it is scanned as long as there are modules to load. Only those library modules that define public symbols for which there are currently outstanding unsatisfied references are included.

Inserting comments in Linker commands

Each input line may be ended by a comment, which must be prefixed by a # character. If you have to use the # as a significant character, you can escape it, using the syntax \#.

Here is an example for an indirect link file:

```
# Link for EPROM
+seg .text -b0x8100 -n .text  # start eprom address
+seg .const -a .text          # constants follow program
+seg .bsct -b 0x0 -m 0x100    # zero page start address
+seg .data -b 0x100 -n .data  # uninitialized data
+seg .bss -a .data -n .bss    # initialized data to 0
\cxstm8\lib\crts.sm8          # startup object file
mod1.o mod2.o                 # input object files
\cxstm8\lib\libisl.sm8        # C library
\cxstm8\lib\libm.sm8          # machine library
+seg .vector -b0x8000 -0x7f   # vectors eprom address
vector.o                      # reset and interrupt vectors
```

Linker Options

The linker accepts the following options, each of which is described in detail below.

```
clnk [options] <file.lkf> [<files>]
      -bs# bank size
      -e*  error file name
      -l*> library path
      -m*  map file name
      -o*  output file name
      -p   phys addr in map
      -s   symbol table only
      -sa  sort symbol by address
      -sl  output local symbols
      -v   verbose
```

The **output file name** and the **link command file** **must** be present on the command line. The options are described in terms of the two groups listed above; the global options that apply to the linker, and the segment control options that apply only to specific segments.

Global Command Line Options

The global command line options that the linker accepts are:

Global linker Options

Option	Description
-bs#	set the window shift to #, which implies that the number of bytes in a window is **2**#**. The default value is 0 (bank switching disabled). For more information, see the section "*Address Specification*" on page 268.
-e*	log errors in the text file * instead of displaying the messages on the terminal screen.
-l*>	specify library path. You can specify up to 20 different paths. Each path is a directory name, **not** terminated by any directory separator character.
-m*	produce map information for the program being built to file *.
-o*	write output to the file *. This option is required and has no default value.
-p	display symbols with physical address instead of logical address in the map file.
-s	create an output file containing only an absolute symbol table, but still with an object file format. The resulting file can then be used in another link to provide the symbol table of an existing application.
-sa	display symbols sort by address instead of alphabetic order in the map file.
-sl	output local symbols in the executable file.
-v	be "verbose".

Segment Control Options

This section describes the segment control options that control the structure of individual segments of the output module.

A group of options to control a specific segment must begin with a **+seg** option. Such an option must precede any group of options so that the linker can determine which segment the options that follow apply to. The linker allows up to **255** different segments.

+seg <section> <options> start a new segment loading assembler section type <*section*> and build it as directed by the <*options*> that follow:

Segment Control Option Usage

Option	Description
-a*	make the current segment follow the segment *, where * refers to a segment name given explicitly by a **-n** option. Options **-b**, **-e** and **-o** cannot be specified if **-a** has been specified.
-b*	set the physical start address of the segment to *. Option **-e** or **-a** cannot be specified if **-b** has been specified.
-c	do not output any code/data for the segment.
-ck	mark the segment you want to check. For more information, see "*Checksum Computation*" on page 275.
-ds#	set the bank size for paged addresses calculation. This option overwrites the global **-bs** option for that segment.
-e*	set the physical end address of the segment to *. Option **-b** or **-a** cannot be specified if **-e** has been specified.
-f#	fill the segment up to the value specified by the **-m** option with bytes whose value is **#**. This option has no effect if no **-m** option is specified for that segment.

Segment Control Option Usage (cont.)

Option	Description
-i?	define the initialization option. Valid options are: **-it**: use this segment to host the descriptor and images copies of initialized data used for automatic data initialization **-id**: initialize this segment **-ib**: do not initialize this segment **-is**: mark this segment as shared data **-ik**: mark this segment as checksum segment **-ic**: mark this segment as moveable segment
-k	mark the segment as a root segment for the unused section suppression. This flags is usually applied on the reset and interrupt vectors section, and as soon as it is specified at least once in the linker command file, enables the section suppression mechanism. This option can be used on any other segment to force the linker to keep it even if it is not used.
-m*	set the maximum size of the segment to * bytes. If not specify, there is no checking on any segment size. If a segment is declared with the **-a** option as following a segment which is marked with the **-m** option, then set the maximum available space for all the possible consecutive segments.

Segment Control Option Usage (cont.)

Option	Description

-n*	set the output name of the segment to *. Segment output names have at most **15** characters; longer names are truncated. If no name is given with a **-n** option, the segment inheritates a default name equal to its assembler section name.
	For example, use this option when you want to generate the hex records for a particular PROM, such as:
	`+seg .text -b0x2000 -n prom1`
	`<object_files>`
	`+seg .text -b0x4000 -n prom2`
	`<object_files>`
	`...`
	You can generate the hex records for **`prom1`** by typing:
	`chex -n prom1 file.sm8`
	For more information, see "*The chex Utility*" in **Chapter 8**.

-o*	set the logical start address of the segment to * if **-b** option is specified or the logical end address if **-e** option is specified. The default is to set the logical address equal to the physical address. Options **-b** and **-e** cannot be specified both if **-o** has been specified.
-r*	round up the starting address of the segment and all the loaded sections. The expression defines the power of two of the alignment value. The option **-r3** will align the start address to an 8 bytes boundary. This option has no effect if the start address is explicitly defined by a **-b** option.
-s*	define a space name for the segment. This segment will be verified for overlapping only against segments defined with the same space name. See "*Overlapping Control*" on page 268.
-v	do not verify overlapping for the segment.
-w*	set the window size for banked applications, and activate the automatic bank segment creation.

Segment Control Option Usage (cont.)

Option	Description
-x	expandable segment. Allow a segment to spill in the next segment of the same section type if its size exceeds the value given by the **-m** option. The next segment must be declared **before** the object causing the overflow. This option has no effect if no **-m** option is specified for the expandable segment. Options **-e** and **-w** cannot be specified.

Options defining a numerical value (addresses and sizes) can be entered as constant, symbols, or simple expression combined them with '**+**' and '**-**' operators. Any symbol used has to be defined before to be used, either by a **+def** directive or loaded as an absolute symbol from a previously loaded object file. The operators are applied from left to right without any priority and parenthesis **()** are not allowed. Such expressions CANNOT contain any whitespace. For example:

```
+def START=0x1000
+def MAXSIZE=0x2000
+seg .text -bSTART+0x100 -mMAXSIZE-0x100
```

The first line defines the symbol `START` equals to the absolute value `1000` (hex value), the second line defines the symbol `MAXSIZE` equals to the absolute value `2000` (hex value). The last line opens a **.text** segment located at 1100 (hex value) with a maximum size of 1f00 (hex value). For more information, see the section "*Symbol Definition Option*" on page 265.

Unless **-b*** is given to set the *bss* segment start address, the *bss* segment will be made to follow the last *data* segment in the output file. Unless **-b*** is given to set the *data* segment start address, the *data* segment will be made to follow the last *bsct* segment in the output file. The *bsct* and *text* segments are set to start at zero unless you specify otherwise by using **-b** option. It is permissible for all segments to overlap, as far as *clnk* is concerned; the target machine may or may not make sense of this situation (as with separate instruction and data spaces).

NOTE

A new segment of the specified type will not actually be created if the last segment of the same name has a size of zero. However, the new options will be processed and will override the previous values.

Segment Grouping

Different sections can be redirected directly to the same segment with the **+grp** directive:

+grp <section>=<section list> where <*section*> is the name of the target section, and <*section list*> a list of section names separated by commas. When loading an object file, each section listed in the right part of the declaration will be loaded as if it was named as defined in the left part of the declaration. The target section may be a new section name or the name of an existing section (including the predefined ones). When using a new name, this directive has to be preceded by a matching **+seg** definition.

NOTE

*Whitespaces are **not** allowed aside the equal sign '=' and the commas.*

Linking Files on the Command line

The linker supports linking objects from the command line. The link command file has to be modified to indicate where the objects are to be loaded using the following **@#** syntax.

@1, @2,...	include each individual object file at its positional location on the command line and insert them at the respective locations in the link file (**@1** is the first object file, and so on).
@*	include all of the objects on the command line and insert them at this location in the link file.

Example

Linking objects from the command line:

```
clnk -o test.sm8 test.lkf file1.o file2.o

## Test.lkf:
+seg  .text -b0x5000
+seg .data -b0x100
@1
+seg .text -b0x7000
@2

Is equivalent to

clnk -o test.sm8 test.lkf
## test.lkf
+seg  .text -b0x5000
+seg .data -b0x100
file1.o
+seg .text -b0x7000
file2.o
```

Include Option

Subparts of the link command file can be included from other files by using the following option:

+inc*	include the file specified by *. This is equivalent to expanding the text file into the link file directly at the location of the **+inc** line.

Example

Include the file "`seg2.txt`" in the link file "`test.lkf`":

```
## Test.lkf:
+seg  .text -b0x5000
+seg .data -b0x100
file1.o file2.o
+seg .text -b0x7000
+inc seg2.txt

## seg2.txt:
mod1.o mod2.o mod3.o

## Resultant link file
+seg  .text -b0x5000
+seg .data -b0x100
file1.o  file2.o
+seg .text -b0x7000
mod1.o mod2.o mod3.o
```

Private Region Options

Options that control code regions are:

+new	start a new region. A “region” is a user definable group of input object modules which may have both public and private portions. The private portions of a region are local to that region and may not access or be accessed by anything outside the region. By default, a new region is given public access.
+pub	make the following portion of a given region public.
+pri	make the following portion of a given region private.

Symbol Definition Option

The option controlling symbol definition and aliases is:

+def* define new symbols to the linker. The string * must be of the form:

ident=constant	where *ident* is a valid identifier and *constant* is a valid constant expressed with the standard C language syntax. This form is used to add *ident* to the symbol table as a defined absolute symbol with a value equal to *constant*.
ident=constant:bitnum	where *ident* is a valid identifier, *constant* is a valid constant expressed with the standard C language syntax and *bitnum* a constant expression between 0 and 7. This form is used to add *ident* to the symbol table as a defined absolute bit symbol with a value equal to *constant* 3-bit left shifted and or'ed with *bitnum*.
ident1=ident2	where *ident1* and *ident2* are both valid identifiers. This form is used to define aliases. The symbol *ident1* is defined as the alias for the symbol *ident2* and goes in the symbol table as an external DEF (a DEF is an entity defined by a given module.) If *ident2* is not already in the symbol table, it is placed there as a REF (a REF is an entity referred to by a given module).
ident1=ident2:bitnum	where *ident1* and *ident2* are both valid identifiers, and *bitnum* a constant between 0 and 7. This form is used to define bit aliases. The symbol *ident1* is defined as the alias for the corresponding bit of symbol *ident2* which cannot be already a bit symbol itself, and goes in the symbol table as an external DEF (a DEF is an entity defined by a given module.) If *ident2* is not already in the symbol table, it is placed there as a REF (a REF is an entity referred to by a given module).
ident=@section	where *ident* is a valid identifier, and *section* is the name of a section specified as the first argument of a **+seg** directive. This form is used to add *ident* to the symbol table as a defined symbol whose value is the address of the next byte to be loaded in the specified section.

ident=start(segment)	where segment is the name given to a segment by the -n option. This form is used to add ident to the symbol table as a defined symbol whose value is the logical start address of the designated segment. This directive can be placed anywhere in the link command file, even before the segment is defined.
ident=end(segment)	where segment is the name given to a segment by the -n option. This form is used to add ident to the symbol table as a defined symbol whose value is the logical end address of the designated segment. This directive can be placed anywhere in the link command file, even before the segment is defined.
ident=pstart(segment)	where segment is the name given to a segment by the -n option. This form is used to add ident to the symbol table as a defined symbol whose value is the physical start address of the designated segment. This directive can be placed anywhere in the link command file, even before the segment is defined.
ident=pend(segment)	where segment is the name given to a segment by the -n option. This form is used to add ident to the symbol table as a defined symbol whose value is the physical end address of the designated segment. This directive can be placed anywhere in the link command file, even before the segment is defined.
ident=size(segment)	where segment is the name given to a segment by the -n option. This form is used to add ident to the symbol table as a defined symbol whose value is the size of the designated segment. This directive can be placed anywhere in the link command file, even before the segment is defined.

NOTE

Whitespaces are ***not*** *allowed aside the equal sign '='.*

For more information about DEFs and REFs, refer to the section "*DEFs and REFs*" on page 277.

Reserve Space Option

The following option is used to reserve space in a given segment:

+spc <segment>=<value>	reserve *<value>* bytes of space at the current location in the segment named *<segment>*.
+spc <segment>=@section	reserve a space at the current location in the segment named *<segment>* equal to the current size of the opened segment where the given *section* is loaded. The size is evaluated at once, so if the reference segment grows after that directive, there is no further modification of the space reservation. If such a directive is used to duplicate an existing section, it has to be placed in the link command file after all the object files.

NOTE

*Whitespaces are **not** allowed aside the equal sign '='.*

Handle Dependencies

This directive allows creating or suppressing a dependency between two functions using their assembly level symbol:

+dep <func1>+<func2>	add a dependence marking *<func1>* as calling *<func2>*.
+dep <func1>-<func2>	suppress a dependence marking *<func1>* as not calling *<func2>*.

This directive is mostly used to help building complex applications using a static model.

NOTE

*Whitespaces are **not** allowed aside the + and - signs.*

Section Relocation

The linker relocates the sections of the input files into the segments of the output file.

An absolute section, by definition, cannot and should not be relocated. The linker will detect any conflicts between the placement of this file and its absolute address given at compile/assemble time.

In the case of a bank switched system, it is still possible for an absolute section to specify a physical address different from the one and at compile/assembly time, the logical address MUST match the one specified at compile/assemble time.

Address Specification

The two most important parameters describing a segment are its **bias** and its **offset**, respectively its physical and logical start addresses. In nonsegmented architectures there is no distinction between *bias* and *offset*. The *bias* is the address of the location in memory where the segment is relocated to run. The *offset* of a segment will be equal to the *bias*. In this case you must set only the *bias*. The linker sets the *offset* automatically.

Overlapping Control

The linker is verifying that a segment does not overlap any other one, by checking the physical addresses (*bias*). This control can be locally disabled for one segment by using the **-v** option. For targets implementing separated address spaces (such as bank switching), the linker allows several segments to be isolated from the other ones, by giving them a *space* name with the **-s** option. In such a case, a segment in a named space is checked only against the other segments of the same space. The unnamed segments are checked together.

Setting Bias and Offset

The bias and offset of a segment are controlled by the **-b*** option and **-o*** option. The rules for dealing with these options are described below.

Setting the Bias

If the **-b*** option is specified, the bias is set to the value specified by *. Otherwise, the bias is set to the end of the last segment of the same name. If the **-e*** option is specified, the bias is set to value obtain by subtracting the segment size to the value specified by *.

Setting the Offset

If the **-o*** option is specified, the offset is set to the value specified by *. Otherwise, the offset is set equal to the bias.

Using Default Placement

If none of **-b**, **-e** or **-o** options is specified, the segment may be placed *after* another one, by using the **-a*** option, where * is the name of another segment. Otherwise, the linker will try to use a default placement based on the segment name. The compiler produces specific sections for code (*.text*) and data (*.data*, *.bss*, *.bsct* and *.ubsct*). By default, *.text* and *.bsct* segments start at zero, *.ubsct* segment follows the latest *.bsct* segment, *.data* segment follows the latest *.ubsct* segment, and *.bss* segment follows the latest *.data* segment. Note that there is no default placement for the constants segment *.const* and the bit segment *.bit*.

Bit Segment Handling

Bit segments are allocated using bit addresses. A bit address is a value based on the byte address and the bit number in this byte. The bit address is equal to the byte address 3-bit left shifted or'ed with the bit number. The bias (or offset) value can be entered directly as a bit address or with a special syntax combining the byte address and the bit number. The following lines are identical:

```
+seg .bit -b 0x103
+seg .bit -b 0x20:3
```

When using the **-a** option, the linker automatically converts byte address to bit address when entering a bit segment from a byte segment, starting at bit 0, and converts a bit address to a byte address when leaving a bit segment to a byte segment, starting from next available byte.

Bit addresses are displayed in the map file using the combined syntax.

Linking Objects

A new segment is built by concatenating the corresponding sections of the input object modules in the order the linker encounters them. As each input section is added to the output segment, it is adjusted to be relocated relative to the end portion of the output segment so far constructed. The first input object module encountered is relocated relative to a value that can be specified to the linker. The size of the output *bss* segment is the sum of the sizes of the input *bss* sections.

Unless the **-v** option has been specified on a segment definition, the linker checks that the segment physical address range does not overlap any other segment of the application. Logical addresses are not checked as bank switching creates several segments starting at the same logical address.

Linking Library Objects

The linker will selectively include modules from a library when outstanding references to member functions are encountered. The library file must be place ***after*** all objects that may call it's modules to avoid unresolved references. The standard ANSI libraries are provided in two versions to provide the level of support that your application needs. This can save a significant amount of code space and execution time when full ANSI single precision floating point support is not needed. The first letter after "*lib*" in each library file denotes the library type (**f** for single precision, and **i** for integer). See below.

libf.sm8	Single Precision Library. This library is used for applications where only single precision floating point support is needed. Link this library ***before*** the other libraries when ***only*** single precision floats are used.
libi.sm8	Integer only Library. This library is designed for applications where **no** floating point is used. Floats can still be used for arithmetic but not with the standard library. Link this library ***before*** the other libraries when only integer libraries are needed.

Memory Model	Machine Library	Integer Only Library	Float Library
Stack Short	libm(0).sm8	libis(0).sm8	libfs(0).sm8
Stack Long		libisl(0).sm8	libfsl(0).sm8

NOTE

*When using a model for application smaller than 64K, you must link with the specific set of libraries (names ending with '**0**').*

Library Order

You should link your application with the libraries in the following orders:

Integer Only Application	Single Precision Float Application
libi.sm8	libf.sm8
libm.sm8	libi.sm8
	libm.sm8

For more information, see "*Linker Command Line Examples*" on page 285.

Libraries Setup Search Paths

The linker uses the environment variable **CXLIB** to search for objects and library files. If you don't specify the full path to the objects and/or libraries in the link command file AND they are not found in the local directory, the linker will then search all paths specified by the **CXLIB** environment variable. This allows you to specify just the names of the objects and libraries in your link command file. For example, setting the **CXLIB** environment variable to the **C:\COSMIC\LIB** directory is done as follow:

```
C>set CXLIB=C:\COSMIC\LIB
```

Automatic Data Initialization

The linker is able to configure the executable for an automatic data initialization. This mechanism is initiated automatically when the linker finds the symbol **__idesc__** in the symbol table, as an *undefined* symbol. *clnk* first locates a segment behind which it will add an image of the data, so called the *host* segment. The default behaviour is to select the **first** *.text* segment in the executable file, but you can override this by marking one segment with the **-it** option.

Then, *clnk* looks in the executable file for initialized segments. All the segments *.data* and *.bsct* are selected by default, unless disabled explicitly by the **-ib** option. Otherwise, renamed segments may also be selected by using the **-id** option. The **-id** option cannot be specified on a bss segment, default or renamed. Once all the selected segments are located, *clnk* builds a descriptor containing the starting address and length of each such segment, and moves the descriptor and the selected segments to the end of the *host* segment, without relocating the content of the selected segments.

For more information, see "*Generating Automatic Data Initialization*" in **Chapter 2** and "*Initializing data in RAM*" in **Chapter 3**.

Descriptor Format

The created descriptor has the following format:

```
 dc.w start_prom_address;starting address of the
      ; first image in prom
; for each segment:
 dc.b flag              ; segment type
 dc.w start_ram_address ; start address of segment in ram
 dc.w end_prom_address  ; address of last data byte
                        ; plus one in prom
; after the last segment:
 dc.b 0
```

The flag byte is used to detect the end of the descriptor, and also to specify a type for the data segment. The actual value is equal to the code of the first significant letter in the segment name.

If the RAM segment has been created using banked addresses (**-b** and **-o** values), the RAM start address is described using two words, the first giving the page value for that segment and the second giving the matching value for the start address in that space. A segment description is displayed as:

```
dc.b flag                   ; segment type
dc.w paged_ram_address      ; paged value of ram start address
dc.w start_ram_address      ; start address of segment in ram
dc.w end_prom_address       ; address of last data byte
```

The end address in PROM of one segment gives also the starting address in prom of the following segment, if any.

The address of the descriptor will be assigned to the symbol *__idesc__*, which is used by the *crtsi.s* startup routine. So all this mechanism will be activated just by linking the *crtsi.sm8* file with the application, or by referencing the symbol *__idesc__* in your own startup file.

If the *host* segment has been opened with a **-m** option giving a maximum size, *clnk* will check that there is enough space to move all the selected segments.

Moveable Code

The linker allows a code segment to be stored in the ROM part, but linked at another address which is supposed to be located in RAM. This feature is specially designed to allow an application to run FLASH programming routines or bootloader from the RAM space. This feature is sharing the same global mechanism than initialized data, and the common descriptor built by the linker contains both record types. The flag byte is used to qualify each entry. In order to implement such a feature, the link command file should contain a dedicated code segment marked with the **-ic** option:

```
#       LINKER EXAMPLE FOR MOVEABLE CODE
#
# mark this segment with -ic and link it at RAM address
#
+seg .text -b 0x100 -n boot -ic
flash.o
+seg .text -b 0x8000 -n code# application code
file.o
...
```

The function contained in the object flash.o is now linked at the RAM address 0x100 but stored somewhere in the code space along with any other initialized data. It is not necessary to link the application with the startup routine *crtsi.s* if the application does not contain initialized data but the descriptor will be built as soon as a moveable function is used by the application, but if the *crts.s* startup is used, moveable code segments are **not** copied in RAM at the application start up.

In order to use such a function, it is necessary to first copy it from ROM to RAM. This is done by calling the library function **_fctcpy()** with one character argument equal to the first significant letter of the moveable segment name. This argument allows an application to implement several different moveable segments for different kind of situations. In such a case, all the moveable segment names should have names with different first character. This function returns a boolean status equal to 0 if no moveable segment has been copied, or a value different of zero otherwise. Once the segment has been successfully copied, the RAM function can be called directly:

```
if (_fctcpy('b'))
      flash();
```

There is no possible name conflict between data segment names and moveable code segment names because the linker internally marks the flag byte differently.

Checksum Computation

This feature is activated by the detection of the symbol **__ckdesc__** as an undefined symbol. This is practically done by calling one of the provided checksum functions which uses that symbol and returns `0` if the checksum is correct. These functions are provided in the integer library and are the following:

_checksum()	check a 8 bit checksum stored once for all the selected segments.
_checksumx()	check a 8 bit checksum stored for every selected segments. This method allows a segment to be dynamically reloaded by updating the corresponding CRC byte.
_checksum16()	check a 16 bit checksum stored once for all the selected segments.
_checksum16x()	check a 16 bit checksum stored for every selected segments. This method allows a segment to be dynamically reloaded by updating the corresponding CRC word.

You then have to update the link command file in two ways:

1) Mark the segments (usually code segments) you want to check, by using the **-ck** option on the **+seg** line. Note that you need only to mark the first segment of a hooked list, meaning that if a segment is declared with **-a** option as following a segment which is marked with the **-ck** option, it will automatically inherit the **-ck** marker and will be also checked. Note also that if you are using the automatic initialization mechanism, and if the code segment hosting the init descriptor (**-it**) is also marked with **-ck**, the init segment and ALL the initialization copy segments will also be checked.

2) Create an empty segment which will contain the checksum descriptor. This has to be an empty segment, located wherever you want with a **-b** or **-a** option. This segment will NOT be checked, even if marked or hooked to a marked segment. The linker will fill this segment with a data descriptor allowing the checking function to scan all the requested segments and compute the final **crc**. This segment

has to be specially marked with the option **-ik** to allow the linker to recognize it as the checksum segment.

Here is an example of link command file showing how to use **-ck** and **-ik**:

```
#       LINKER EXAMPLE FOR CHECKSUM IMPLEMENTATION
#
# mark the first segment of an attached list with -ck
#
+seg .text -b 0x8000 -n code -ck# this segment is marked
+seg .const -a code -n const# this one is implicitly marked
#
# create an empty segment for checksum table marked with -ik
#
+seg .cksum -a const -n cksum -ik   # checksum segment
#
# remaining part should contain the verification code
#
+seg .data -b 0x100
crtsi.sm8
test.o
libis.sm8
libm.sm8
+def __memory=@.bss
```

The descriptor built by the linker is a list of entries followed by the expected CRC value, only once if functions *_checksum()* or *_checksum16()* are called, or after each entry if functions *_checksumx()* or *_checksum16x()* are called. An entry contains a flag byte, a start address and an end address. The flag byte is non-zero, and is *or'ed* with `0x80` if the start address contains a bank value (two words, page first then start address), otherwise it is just one word with the start address. The end address is always one word. The last entry is always followed by a nul byte (seen as an ending flag), and immediately followed by the expected CRC if functions *_checksum()* or *_checksum16()* are called. The linker compresses the list of entries by creating only one entry for contiguous segments (as long as they are in the same space (**-s*** option) and in the same bank/page).

The current linker implements only on algorithm. Starting with zero, the CRC byte/word is first rotated one bit left (a true bit rotation), then xor'ed with the code byte. The CRC values stored in the checksum descriptor are the one's complement value of the expected CRC.

DEFs and REFs

The linker builds a new symbol table based on the symbol tables in the input object modules, but it is not a simple concatenation with adjustments. There are two basic type of symbols that the linker puts into its internal symbol table: **REF**s and **DEF**s. DEFs are symbols that are defined in the object module in which they occur. REFs are symbols that are referenced by the object module in which they occur, but are not defined there.

The linker also builds a debug symbol table based on the debug symbol tables in any of the input object modules. It builds the debug symbol table by concatenating the debug symbol tables of each input object module in the order it encounters them. If debugging is not enabled for any of input object module, the debug symbol table will be of zero length.

An incoming REF is added to the symbol table as a REF if that symbol is not already entered in the symbol table; otherwise, it is ignored (that reference has already been satisfied by a DEF or the reference has already been noted). An incoming DEF is added to the symbol table as a DEF if that symbol is not already entered in the symbol table; its value is adjusted to reflect how the linker is relocating the input object module in which it occurred. If it is present as a REF, the entry is changed to a DEF and the symbol's adjusted value is entered in the symbol table entry. If it is present as a DEF, an error occurs (multiply defined symbol).

When the linker is processing a library, an object module in the library becomes an input object module to the linker only if it has at least one DEF which satisfies some outstanding REF in the linker's internal symbol table. Thus, the simplest use of *clnk* is to combine two files and check that no unused references remain.

The executable file created by the linker must have no REFs in its symbol table. Otherwise, the linker emits the error message "*undefined symbol*" and returns failure.

Special Topics

This section explains some special linker capabilities that may have limited applicability for building most kinds of microcontroller applications.

Private Name Regions

Private name regions are used when you wish to link together a group of files and expose only some to the symbol names that they define. This lets you link a larger program in groups without worrying about names intended only for local usage in one group colliding with identical names intended to be local to another group. Private name regions let you keep names truly local, so the problem of name space pollution is much more manageable.

An explicit use for private name regions in a STM8 environment is in building a paged program with duplication of the most used library functions in each page, in order to avoid extra page commutation. To avoid complaints when multiple copies of the same file redefine symbols, each such contribution is placed in a private name region accessible only to other files in the same page.

The basic sequence of commands for each island looks like:

```
+new <public files> +pri <private libraries>
```

Any symbols defined in *<public files>* are known outside this private name region. Any symbols defined in *<private libraries>* are known only within this region; hence they may safely be redefined as private to other regions as well.

NOTE

All symbols defined in a private region are local symbols and will not appear in the symbol table of the output file.

Renaming Symbols

At times it may be desirable to provide a symbol with an alias and to hide the original name (*i.e.*, to prevent its definition from being used by the linker as a DEF which satisfies REFs to that symbol name). As an example, suppose that the function *func* in the C library provided with the compiler does not do everything that is desired of it for some special application. There are three methods of handling this situation (we will ignore the alternative of trying to live with the existing function's deficiencies).

The first method is to write a new version of the function that performs as required and link it into the program being built before linking in the libraries. This will cause the new definition of *func* to satisfy any references to that function, so the linker does not include the version from the library because it is not needed. This method has two major drawbacks: first, a new function must be written and debugged to provide something which basically already exists; second, the details of exactly what the function must do and how it must do it may not be available, thus preventing a proper implementation of the function.

The second approach is to write a new function, say *my_func*, which does the extra processing required and then calls the standard function *func*. This approach will generally work, unless the original function *func* is called by other functions in the libraries. In that case, the extra function behavior cannot occur when *func* is called from library functions, since it is actually *my_func* that performs it.

The third approach is to use the aliasing capabilities of the linker. Like the second method, a new function will be written which performs the new behavior and then calls the old function. The twist is to give the old function a new name and hide its old name. Then the new function is given the old function's name and, when it calls the old function, it uses the new name, or alias, for that function. The following linker script provides a specific example of this technique for the function *func*:

```
line 1 +seg .text -b 0x1000
line 2 +seg .data -b0
line 3 +new
line 4 Crts.xx
line 5 +def _oldfunc=_func
line 6 +pri func.o
line 7 +new
line 8 prog.o newfunc.o
line 9 <libraries>
```

NOTE

The function name func as referenced here is the name as seen by the C programmer. The name which is used in the linker for purposes of aliasing is the name as seen at the object module level. For more information on this transformation, see the section "Interfacing C to Assembly Language" in ***Chapter 3****.*

The main thing to note here is that *func.o* and *new_func.o* both define a (different) function named *func*. The second function *func* defined in *newfunc.o* calls the old *func* function by its alias *oldfunc*.

Name regions provide limited scope control for symbol names. The **+new** command starts a new name region, which will be in effect until the next **+new** command. Within a region there are public and private name spaces. These are entered by the **+pub** and **+pri** commands; by default, **+new** starts in the public name space.

Lines 1,2 are the basic linker commands for setting up a separate I/D program. Note that there may be other options required here, either by the system itself or by the user.

Line 3 starts a new region, initially in the public name space.

Line 4 specifies the startup code for the system being used.

Line 5 establishes the symbol *_oldfunc* as an alias for the symbol *_func*. The symbol *_oldfunc* is entered in the symbol table as a public definition. The symbol *_func* is entered as a private reference in the current region.

Line 6 switches to the private name space in the current region. Then *func.o* is linked and provides a definition (private, of course) which satisfies the reference to *_func*.

Line 7 starts a new name region, which is in the public name space by default. Now no reference to the symbol *_func* can reach the definition created on **Line 6**. That definition can only be reached now by using the symbol *_oldfunc*, which is publicly defined as an alias for it.

Line 8 links the user program and the module *newfunc.o*, which provides a new (and public) definition of *_func*. In this module the old version is accessed by its alias. This new version will satisfy all references to *_func* made in *prog.o* and the libraries.

Line 9 links in the required libraries.

The rules governing which name space a symbol belongs to are as follows:

- Any symbol definition in the public space is public and satisfies all outstanding and future references to that symbol.
- Any symbol definition in the private space of the current region is private and will satisfy any private reference in the current region.
- All private definitions of a symbol must occur before a public definition of that symbol. After a public definition of a symbol, any other definition of that symbol will cause a "*multiply defined symbol*" error.
- Any number of private definitions are allowed, but each must be in a separate region to prevent a multiply defined symbol error.
- Any new reference is associated with the region in which the reference is made. It can be satisfied by a private definition in that region, or by a public definition. A previous definition of that symbol will satisfy the reference if that definition is public, or if the definition is private and the reference is made in the same region as the definition.
- If a new reference to a symbol occurs, and that symbol still has an outstanding unsatisfied reference made in another region, then that symbol is marked as requiring a public definition to satisfy it.
- Any definition of a symbol must satisfy all outstanding references to that symbol; therefore, a private definition of a symbol which requires a public definition causes a blocked symbol reference error.

- No symbol reference can "reach" any definition made earlier than the most recent definition.

Absolute Symbol Tables

Absolute Symbol tables are used to export symbols from one application to another, to share common functions for instance, or to use functions already built in a ROM, from an application downloaded into RAM. The linker option **-s** will modify the output file in order to contain only a symbol table, without any code, but still with an object file format, by using the same command file used to build the application itself. All symbols are flagged as *absolute* symbols. This file can be used in another link, and will then transmit its symbol table, allowing another application to use those symbols as *externals*. Note that the linker does not produce any map even if requested, when used with the **-s** option.

The basic sequence of commands looks like:

```
clnk -o appli.sm8 -m appli.map appli.lkf
clnk -o appli.sym -s appli.lkf
```

The first link builds the application itself using the *appli.lkf* command file. The second link uses the same command file and creates an object file containing only an absolute symbol table. This file can then be used as an input object file in any other link command file.

Description of The Map File

The linker can output a map file by using the **-m** option. The map file contains 4 sections: the *Segment* section, the *Modules* section, the *Stack Usage* section and the *Symbols* section.

Segment Describe the different segments which compose the application, specifying for each of them: the start address (in hexa), the end address (in hexa), the length (in decimal), and the name of the segment. Note that the end value is the address of the byte following the last one of the segment, meaning that an empty segment will have the same start and end addresses. If a segment is initialized, it is displayed twice, the first time with its final address, the second time with the address of the image copy.

Modules List all the modules which compose the application, giving for each the description of all the defined sections with the same format as in the *Segment* section. If an object has been assembled with the **-pl** option, local symbols are displayed just after the module description.

Stack Usage Describe the amount of memory needed for the stack. When using a **stack model**, each function of the application is listed by its name, followed by a '>' character indicating that this function is not called by any other one (the *main* function, *interrupt* functions, *task* entries...). The first number is the total size of the stack used by the function including all the internal calls. The second number between braces shows the stack need for that function alone. The entry may be flagged by the keyword "**Recursive**" meaning that this function is itself recursive or is calling directly or indirectly a recursive function, and that the total stack space displayed is not accurate. The linker may detect potential but not actual recursive functions when such functions are called by pointer. The linker displays at the end of the list a total stack size assuming interrupt functions cannot be themselves interrupted. Interrupt frames and machine library calls are properly counted.

Call Tree List all the functions sorted alphabetically followed by all the functions called inside. The display goes on recursively unless a function has already been listed. In such a case, the name is followed by the line number where the function is expanded. If a line becomes too long, the process is suspended and the line ends with a ... sequence indicating that this function is listed later. Functions called by pointer are listed between parenthesis, or between square brackets if called from an array of pointers.

Symbols List all the symbols defined in the application specifying for each its name, its value, the section where it is defined, and the modules where it is used. If the target processor supports bank switching, addresses are displayed as logical addresses by default. Physical addresses can be displayed by specifying the **-p** option on the linker command line. Addresses of bit symbols are displayed with the byte address followed by a colon character and the bit number.

Return Value

clnk returns success if no error messages are printed to STDOUT; that is, if no undefined symbols remain and if all reads and writes succeed. Otherwise it returns failure.

Linker Command Line Examples

This section shows you how to use the linker to perform some basic operations.

A linker command file consists of linker options, input and output file, and libraries. The options and files are read from a command file by the linker. For example, to create an STM8 file from *file.o* you can type at the system prompt:

```
clnk -o myapp.sm8 myapp.lkf
```

where *myapp.lkf* contains:

```
+seg .text -b0xf000 -n .text  # start eprom address
+seg .const -a .text          # constants follow program
+seg .bsct -b0x0 -niram -m 0x100# initialized zero page
+seg .data -b0x100            # start data address
\cxstm8\lib\crts.sm8          # startup object file
file1.o file2.o               # input object files
\cxstm8\lib\libis.sm8         # C library
\cxstm8\lib\libm.sm8          # machine library
+def __memory=@.bss           # symbol used by startup
```

The following link command file is an example for an application that does **not** use floating point data types and does **not** require automatic initialization.

```
# demo.lkf: link command WITHOUT automatic init
+seg .text -b 0xf000 -n.text  # program start address
+seg .const -a .text          # constants follow program
+seg .bsct -b0x0 -niram -m 0x100# initialized zero page
+seg .data -b0x100            # start data address
\cxstm8\lib\crts.sm8          # startup with NO-INIT
acia.o                        # main program
module1.o                     # module program
\cxstm8\lib\libis.sm8         # C library
\cxstm8\lib\libm.sm8          # machine library
+seg .const -b0x8000          # vectors eprom address
vector.o                      # reset & interrupt vectors
# define these symbols if crtsi is used
# +def __endzp=@.ubsct        # end of uninitialized zpage
# +def __memory=@.bss         # symbol used by library
```

The following link command file is an example for an application that uses single precision floating point data types and utilizes automatic data initialization.

```
# demo.lkf: link command WITH automatic init
+seg .text -bf000 0x -n.text  # program start address
+seg .const -a .text          # constants follow program
+seg .bsct -b0x80 -niram -m 0x80# initialized zero page
+seg .ubsct -n iram           # uninitialized zero page
+seg .data -b0x100            # start data address
\cxstm8\lib\crtsi.sm8         # startup with auto-init
acia.o                        # main program
module1.o                     # module program
\cxstm8\lib\libfs.sm8         # single precision library
\cxstm8\lib\libis.sm8         # integer library
\cxstm8\lib\libm.sm8          # machine library
+seg .const -b0x8000          # vectors eprom address
vector.o                      # reset & interrupt vectors
# define these symbols if crtsi is used
+def __endzp=@.ubsct          # end of uninitialized zpage
+def __memory=@.bss           # end of bss segment
```

CHAPTER

7

Debugging Support

This chapter describes the debugging support available with the cross compiler targeting the STM8. There are two levels of debugging support available, so you can use either the COSMIC's **Zap** C source level cross debugger or your own debugger or in-circuit emulator to debug your application. This chapter includes the following sections:

Generating Debugging Information

The compiler generates debugging information in response to command line options you pass to the compiler as described below. The compiler can generate the following debugging information:

1 line number information that allows COSMIC's C source level debugger or another debugger or emulator to locate the address of the code that a particular C source line (or set of lines) generates. You may put line number information into the object module in either of the two formats, or you can generate both line number information and information about program data and function arguments, as described below.

2 information about the name, type, storage class and address (absolute or relative to a stack offset) of program static data objects, function arguments, and automatic data objects that functions declare. Information about what source files produced which relocatable or executable files. This information may be localized by address (where the output file resides in memory). It may be written to a file, sorted by address or alphabetical order, or it may be output to a printer in paginated or unpaginated format.

Generating Line Number Information

The compiler puts line number information into a special debug symbol table. The debug symbol table is part of the relocatable object file produced by a compilation. It is also part of the output of the *clnk* linker. You can therefore obtain line number information about a single file, or about all the files making up an executable program. However, the compiler can produce line number information only for files that are **fewer** than 65,535 lines in length.

Generating Data Object Information

The **+debug** option directs the compiler to generate information about data objects and function arguments and return types. The debugging information the compiler generates is the information used by the COSMIC's C source level cross debugger or another debugger or emulator. The information produced about data objects includes their name, scope, type and address. The address can be either absolute or relative to a stack offset.

As with line number information alone, you can generate debugging information about a single file or about all the files making up an executable program.

cprd may be used to extract the debugging information from files compiled with the **+debug** option, as described below.

The cprd Utility

cprd extracts information about functions and data objects from an object module or executable image that has been compiled with the **+debug** option. *cprd* extracts and prints information on the name, type, storage class and address (absolute or offset) of program static data objects, function arguments, and automatic data objects that functions declare. For automatic data, the address provided is an offset from the frame pointer. For function arguments, the address provided is an offset from the stack pointer.

Command Line Options

cprd accepts the following command line options, each of which is described in detail below:

```
cprd [options] file
     -fc*  select function name
     -fl*  select file name
     -o*   output file name
     -r    recurse structure fields
     -s    display object size
```

where *<file>* is an object file compiled from C source with the compiler command line option **+debug** set.

Cprd Option Usage

Option	Description
-fc*	print debugging information only about the function *. By default, *cprd* prints debugging information on all functions in *<file>*. Note that information about global data objects is always displayed when available.
-fl*	print debugging information only about the file *. By default, *cprd* prints debugging information on all C source files.
-o*	print debugging information to file *. Debugging information is written to your terminal screen by default.
-r	Display structure fields with their offset.
-s	Display object size in bytes.

By default, *cprd* prints debugging information about all functions and global data objects in <*file*>.

Examples

The following example show sample output generated by running the *cprd* utility on an object file created by compiling the program acia.c with the compiler option **+debug** set.

```
cprd acia.sm8
```

```
Information extracted from acia.sm8

source file acia.c:

unsigned char buffer[64] at 0x0104
unsigned char *ptlec at 0x0102
unsigned char *ptecr at 0x0100

unsigned char getch() lines 26 to 36 at 0x810a-0x8135
    auto unsigned char c at -1 from frame pointer

void outch() lines 40 to 45 at 0x8136-0x8144
    argument unsigned char c at 0 from frame pointer

void recept() lines 51 to 57 at 0x8145-0x8167
    (no locals)

void main() lines 63 to 72 at 0x8168-0x818a
    (no locals)

source file vector.c:

void (*_vectab[16])() at 0x8000
```

The clst utility

The **clst** utility takes relocatable or executable files as arguments, and creates listings showing the C source files that were compiled or linked to obtain those relocatable or executable files. It is a convenient utility for finding where the source statements are implemented.

To use *clst* efficiently, its argument files must have been compiled with the **+debug** option.

clst can be instructed to limit its display to files occupying memory in a particular range of addresses, facilitating debugging by excluding extraneous data. *clst* will display the entire content of any files located between the endpoints of its specified address range.

Command Line Options

clst accepts the following command line options, each of which is described in detail below:

```
clst [options> file
     -a   list file alphabetically
     -f*> process selected file
     -i*> source file
     -l#  page length
     -o*  output file name
     -p   suppress pagination
     -r*  specify a line range #:#
```

Clst Option Usage

Option	Description
-a	when set, cause *clst* to list files in alphabetical order. The default is that they are listed by increasing addresses.
-f*>	specify ***** as the file to be processed. Default is to process all the files of the application. Up to 10 files can be specified.
-i*>	read string ***** to locate the source file in a specific directory. Source files will first be searched for in the current directory, then in the specified directories in the order they were given to *clst*. You can specify up to 20 different paths Each path is a directory name, **not** terminated by any directory separator character.

Clst Option Usage (cont.)

Option	Description
-l#	when paginating output, make the listings **#** lines long. By default, listings are paginated at 66 lines per page.

-o*	redirect output from *clst* to file *. You can achieve a similar effect by redirecting output in the command line.
	`clst -o acia.lst acia.sm8`
	is equivalent to:
	`clst acia.sm8 >acia.lst`

-p	suppress pagination. No page breaks will be output.
-r#:#	where **#:#** is a range specification. It must be of the form *<number>:<number>*. When this flag is specified, only those source files occupying memory in the specified range will be listed. If part of a file occupies memory in the specified range, that file will be listed in its entirety. The following is a valid use of **-r**: `-r 0xe000:0xe200`

CHAPTER

8

Programming Support

This chapter describes each of the programming support utilities packaged with the C cross compiler targeting the STM8. The following utilities are available:

Utility	Description
chex	translate object module format
clabs	generate absolute listings
clib	build and maintains libraries
cobj	examine objects modules
cv695	generate IEEE695 format
cvdwarf	generate ELF/DWARF format

The assembler is described in **Chapter 5**, "*Using The Assembler*". The linker is described in **Chapter 6**, "*Using The Linker*". Support for debugging is described in **Chapter 7**, "*Debugging Support*".

The description of each utility tells you what tasks it can perform, the command line options it accepts, and how you use it to perform some commonly required operations. At the end of the chapter are a series of examples that show you how to combine the programming support utilities to perform more complex operations.

The chex Utility

You use the **chex** utility to translate executable images produced by *clnk* to one of several hexadecimal interchange formats. These formats are: *Motorola S-record* format, and *Intel standard hex* format. You can also use *chex* to override text and data biases in an executable image or to output only a portion of the executable.

The executable image is read from the input file <*file*>.

Command Line Options

chex accepts the following command line options, each of which is described in detail below:

```
chex [options] file
     -a##    absolute file start address
     -b##    address bias
     -e##    entry point address
     -f?     output format
     -h      suppress header
     +h*     specify header string
     -m#     maximum data bytes per line
     -n*>    output only named segments
     -o*     output file name
     -p      use paged address format
     -pa     use paged address for data
     -pl##   page number for linear mapping
     -pn     use paged address in bank only
     -pp     use paged address with mapping
     -s      output increasing addresses
     -w      output word addresses
     -x*>    exclude named segments
```

Chex Option Usage

Option	Description
-a##	the argument file is a considered as a pure binary file and **##** is the output address of the first byte.
-b##	substract **##** to any address before output.

Chex Option Usage (cont.)

Option	Description
-e##	define **##** as the entry point address encoded in the dedicated record of the output format, if available.
-f?	define output file format. Valid options are: **i** — Intel Hex Format **m** — Motorola S19 format **2** — Motorola S2 format **3** — Motorola S3 format Default is to produced Motorola S-Records (**-fm**). Any other letter will select the default format
-h	do not output the header sequence if such a sequence exists for the selected format.
+h*	insert * in the header sequence if such a sequence exists for the selected format.
-m#	output **#** maximum data bytes per line. Default is to output 32 bytes per line.
-n*>	output only segments whose name is equal to the string *. Up to twenty different names may be specified on the command line. If there are several segments with the same name, they will all be produced. This option is used in combination with the **-n** option of the linker.
-o*	write output module to file *. The default is STDOUT.
-p	output addresses of banked segments using a paged format **<page_number><logical_address>**, instead of the default format **<physical>**.
-pa	output addresses of banked data segments using a paged format <page_number><logical_address>, instead of the default format <physical>.

Chex Option Usage (cont.)

Option	Description
-pl##	specify the page value of the segment localized between **0x8000** and **0xc000** when using a linear non-banked application. This option enforces a paged format for this segment.
-pn	behaves as **-p** but only when logical address is inside the banked area. This option has to be selected when producing an hex file for the Noral debugger.
-pp	behaves as **-p** but uses paged addresses for all banked segments, mapped or unmapped. This option has to be selected when producing an hex file for Promic tools.
-s	sort the output addresses in increasing order.
-w	output word addresses. Addresses must be aligned on even addresses. This option is useful for word processor type.
-x*>	do not output segments whose name is equal to the string *. Up to twenty different names may be specified on the command line. If there are several segments with the same name, they will not all be output.

Return Status

chex returns success if no error messages are printed; that is, if all records are valid and all reads and writes succeed. Otherwise it returns failure.

Examples

The file *hello.c*, consisting of:

```
char *p = {"hello world"};
```

when compiled produces the following the following *Motorola S-record* format:

```
chex hello.o
```

```
S00A000068656C6C6F2E6F44
S1110000020068656C6C6F20776F726C640090
S9030000FC
```

and the following *Intel standard hex* format:

```
chex -fi hello.o
```

```
:0E000000020068656C6C6F20776F726C640094
:00000001FF
```

The clabs Utility

clabs processes assembler listing files with the associated executable file to produce listing with updated code and address values.

clabs decodes an executable file to retrieve the list of all the files which have been used to create the executable. For each of these files, *clabs* looks for a matching listing file produced by the compiler ("**.ls**" file). If such a file exists, *clabs* creates a new listing file ("**.la**" file) with absolute addresses and code, extracted from the executable file.

To be able to produce any results, the compiler **must** have been used with the '**-l**' option.

Command Line Options

clabs accepts the following command line options, each of which is described in detail below.

```
clabs [options] file
      -a     process also library files
      -cl*   listings files
      -l     restrict to local directory
      -p     use paged address format
      -pn    use paged address in bank only
      -pp    use paged address with mapping
      -r*    relocatable listing suffix
      -s*    absolute listing suffix
      -v     echo processed file names
```

Clabs Option Usage

Option	Description
-a	process also files located in libraries. Default is to process only all the files of the application.
-cl*	specify a path for the listing files. By default, listings are created in the same directory than the source files.
-l	process files in the current directory only. Default is to process all the files of the application.

Clabs Option Usage (cont.)

Option	Description
-p	output addresses of banked segments using a paged format <page_number><logical_address>, instead of the default format <physical>.
-pn	behaves as **-p** but only when logical address is inside the banked area.
-pp	behaves as **-p** but uses paged addresses for all banked segments, mapped or unmapped.
-r*	specify the input suffix, including or not the dot '.' character. Default is "**.ls**"
-s*	specify the output suffix, including or not the dot '.' character. Default is "**.la**"
-v	be verbose. The name of each module of the application is output to STDOUT.

<*file*> specifies one file, which must be in executable format.

Return Status

clabs returns success if no error messages are printed; that is, if all reads and writes succeed. An error message is output if no relocatable listing files are found. Otherwise it returns failure.

Examples

The following command line:

```
clabs -v acia.sm8
```

will output:

```
crts.ls
acia.ls
vector.ls
```

and creates the following files:

```
crts.la
acia.la
vector.la
```

The following command line:

```
clabs -r.lst acia.sm8
```

will look for files with the suffix “**.lst**”:

The following command line:

```
clabs -s.lx acia.sm8
```

will generate:

```
crts.lx
acia.lx
vector.lx
```


The clib Utility

clib builds and maintains object module libraries. *clib* can also be used to collect arbitrary files in one place. *<library>* is the name of an existing library file or, in the case of replace or create operations, the name of the library to be constructed.

Command Line Options

clib accepts the following command line options, each of which is described in detail below:

```
clib [options] <library> <files>
     -a      accept absolute symbols
     -c      create a new library
     -d      delete modules from library
     -e      accept empty module
     -i*     object list filename
     -l      load all library at link
     -r      replace modules in library
     -s      list symbols in library
     -t      list files in library
     -v      be verbose
     -x      extract modules from library
```

Clib Option Usage

Option	Description
-a	include absolute symbols in the library symbol table.
-c	create a library containing *<files>*. Any existing *<library>* of the same name is removed before the new one is created.
-d	delete from the library the zero or more files in *<files>*.
-e	accept module with no symbol.
-i*	take object files from a list *. You can put several files per line or put one file per line. Each lines can include comments. They must be prefixed by the '**#**' character. If the command line contains *<files>*, then *<files>* will be also added to the library.

Clib Option Usage (cont.)

Option	Description
-l	when a library is built with this flag set, all the modules of the library will be loaded at link time. By default, the linker only loads modules necessary for the application.
-r	in an existing library, replace the zero or more files in <*files*>. If no library <*library*> exists, create a library containing <*files*>. The files in <*files*> not present in the library are added to it.
-s	list the symbols defined in the library with the module name to which they belong.
-t	list the files in the library.
-v	be verbose
-x	extract the files in <*files*> that are present in the library into discrete files with the same names. If no <*files*> are specified, all files in the library are extracted.

At most one of the options **-[c r t x]** may be specified at the same time. If none of these is specified, the **-t** option is assumed.

Return Status

clib returns success if no problems are encountered. Otherwise it returns failure. After most failures, an error message is printed to STDERR and the library file is not modified. Output from the **-t**, **-s** options, and verbose remarks, are written to STDOUT.

Examples

To build a library and check its contents:

```
clib -c libc one.o two.o three.o
clib -t libc
```

will output:

```
one.o
two.o
three.o
```


To build a library from a list file:

```
clib -ci list libc six.o seven.o
```

where *list* contains:

```
# files for the libc library
one.o
two.o
three.o
four.o
five.o
```

The cobj Utility

You use **cobj** to inspect relocatable object files or executable. Such files may have been output by the assembler or by the linker. *cobj* can be used to check the size and configuration of relocatable object files or to output information from their symbol tables.

Command Line Options

cobj accepts the following options, each of which is described in detail below.

```
cobj [options] file
     -d     output data flows
     -h     output header
     -n     output sections
     -o*    output file name
     -r     output relocation flows
     -s     output symbol table
     -v     display file addresses
     -x     output debug symbols
```

<*file*> specifies a file, which must be in relocatable format or executable format.

Cobj Option Usage

Option	Description
-d	output in hexadecimal the data part of each section.
-h	display all the fields of the object file header.
-n	display the name, size and attribute of each section.
-o*	write output module to file *. The default is STDOUT.
-r	output in symbolic form the relocation part of each section.
-s	display the symbol table.
-v	display seek addresses inside the object file.
-x	display the debug symbol table.

If none of these options is specified, the default is **-hns**.

Return Status

cobj returns success if no diagnostics are produced (*i.e.* if all reads are successful and all file formats are valid).

Examples

For example, to get the symbol table:

```
cobj -s acia.o
```

```
symbols:

_main:      0000003e section .text defined public
_outch:     0000001b section .text defined public
_buffer:    00000000 section .bss defined public
_ptecr:     00000000 section .bsct defined public zpage
_getch:     00000000 section .text defined public
_ptlec:     00000002 section .bsct defined public zpage
_recept:    00000028 section .text defined public
```

The information for each symbol is: name, address, section to which it belongs and attribute.

The cv695 Utility

cv695 is the utility used to convert a file produced by the linker into an IEEE695 format file.

Command Line Options

cv695 accepts the following options, each of which is described in detail below.

```
cv695 [options] file
     +V4    do not offset locals
     +bit   patch bit variables into chars
     -d     display usage info
     +dpage file uses data paging (HC12 only)
     -mod?  select compiler model
     +old   produce old format
     -o*    output file name
     +page# define pagination (HC12 only)
     -rb    reverse bitfield (L to R)
     -v     be verbose
```

<file> specifies a file, which must be in executable format.

Cv695 Option Usage

Option	Description
-V4	output information as per as *cv695* converter V4.x version. This flag is provided for compatibility with older version of *cv695* version. **DO NOT USE UNLESS SPECIFICALLY INSTRUCTION TO DO SO**.
+bit	patch bit variables into chars because IEEE695 format does not handle bit variables.
+dpage	output banked data addresses. **DO NOT USE THIS OPTION ON NON BANKED DATA APPLICATION. THIS FLAG IS CURRENTLY ONLY MEANINGFULL FOR THE HC12/HCS12.**

Cv695 Option Usage (cont.)

Option	Description
-d	dump to the screen the interface information such as: frame coding, register coding, *e.g.* all the processor specific coding for IEEE (note: some of these codings have been chosen by COSMIC because no specifications exist for them in the current published standard). **THIS INFORMATION IS ONLY RELEVANT FOR WRITING A READER OF THE PRODUCED IEEE FORMAT**.
-mod?	where **?** is a character used to specify the compilation model selected for the file to be converted. **THIS FLAG IS CURRENTLY ONLY MEANINGFULL FOR THE HC16.** This flag mimics the flag used with C. Acceptable values are: **c** — for compact model **s** — for short model **t** — for tiny model **l** — for large model
+old	output old format for MRI.
-o*	where * is a filename. * is used to specify the output file for *cv695*. By default, if **-o** is not specified, *cv695* send its output to the file whose name is obtained from the input file by replacing the filename extension with ".695".

Cv695 Option Usage (cont.)

Option	Description
+page#	output addresses in paged mode where # specifies the page type: **0** — for no paging **1** — for pages with PHYSICAL ADDRESSES **2** — for pages with banked addresses <page><offset_in_page> By default linear physical addresses are output. **THIS FLAG IS CURRENTLY ONLY MEANINGFULL FOR THE HC12/HCS12.**
-rb	reverse bitfield from left to right.
-v	select verbose mode. *cv695* will display information about its activity.

Return Status

cv695 returns success if no problems are encountered. Otherwise it returns failure.

```
cv695 C:\test\acia.sm8
```

and will produce: **C:\test\acia.695**

and the following command:

```
cv695 -o file C:\test\acia.sm8
```

will produce: **file**

Under UNIX, the command could be:

```
cv695 /test/acia.sm8
```

and will produce: **test/acia.695**

The cvdwarf Utility

cvdwarf is the utility used to convert a file produced by the linker into an ELF/DWARF format file.

Command Line Options

cvdwarf accepts the following options, each of which is described in detail below.

```
cvdwarf [options] file
      -bp##  bank start address
      -bs#   bank shift
      +dup   accept duplicate headers
      -loc   complex location description
      -o*    output file name
      +page# define pagination (HC12 only)
      -rb    reverse bitfield (L to R)
      -so    add stack offset
      -v     be verbose
```

<*file*> specifies a file, which must be in executable format.

Cvdwarf Option usage

Option	Description
-bp#	start address of the banking page.
-bs#	set the window shift to #, which implies that the number of bytes in a window is **2**#**. **THESE FLAGS ARE CURRENTLY ONLY MEANINGFULL FOR THE HC11K4.**
+dup	handle duplicate header files individually. By default, the converter assumes that all header files sharing the same name do have the same content or with conditional behaviours.
-loc	location lists are used in place of location expressions whenever the object whose location is being described can change location during its lifetime. **THIS POSSIBILITY IS NOT SUPPORTED BY ALL DEBUGGERS.**

Cvdwarf Option usage (cont.)

Option	Description
-o*	where * is a filename. * is used to specify the output file for *cvdwarf*. By default, if **-o** is not specified, *cvdwarf* send its output to the file whose name is obtained from the input file by replacing the filename extension with "**.elf**".
+page#	output addresses in paged mode where # specifies the page type: **#** | | **Valid usage for** | **Paging Window** **1** | for banked code | All HC12 and HCS12 paged derivatives when Code Paging used | FLASH 0x8000 to 0xbfff **2** | for banked data | Only for HC12A4 when Data Paging used | RAM 0x7000 to 0x7fff **3** | both (code and data) | Only for HC12A4 when Data and Code Paging used | FLASH 0x8000 to 0xbfff RAM 0x7000 to 0x7fff By default, the banked mode is disable. **THIS FLAG IS CURRENTLY ONLY MEANINGFULL FOR THE HC12/HCS12.** **THIS FLAG IS NOT TO BE USED ON ANY S12X PAGING, BASED ON THE EXISTING GLOBAL ADDRESS MODE.**
-rb	reverse bitfield from left to right.
-so	add stack offset. This option has to be selected when using debuggers using the SP value directly. **THIS FLAG IS CURRENTLY ONLY MEANINGFULL FOR THE HC08/HCS08.**

Cvdwarf Option usage (cont.)

Option	Description
-v	select verbose mode. *cvdwarf* will display information about its activity.

Return Status

cvdwarf returns success if no problems are encountered. Otherwise it returns failure.

Examples

Under MS/DOS, the command could be:

```
cvdwarfC:\test\acia.sm8
```

and will produce: **C:\test\acia.elf**

and the following command:

```
cvdwarf -o file C:\test\acia.sm8
```

will produce: **file**

Under UNIX, the command could be:

```
cvdwarf /test/acia.sm8
```

and will produce: **test/acia.elf**

APPENDIX

A

Compiler Error Messages

This appendix lists the error messages that the compiler may generate in response to errors in your program, or in response to problems in your host system environment, such as inadequate space for temporary intermediate files that the compiler creates.

The first pass of the compiler generally produces all user diagnostics. This pass deals with # control lines and lexical analysis, and then with everything else having to do with semantics. Only machine-dependent extensions are diagnosed in the code generator pass. If a pass produces diagnostics, later passes will not be run.

Any compiler message containing an exclamation mark **!** or the word '**PANIC**' indicates that the compiler has detected an inconsistent internal state. Such occurrences are uncommon and should be reported to the maintainers.

Parser (cpstm8) Error Messages

<name> not a member - field name not recognized for this struct/ union

<name> not an argument - a declaration has been specified for an argument not specified as a function parameter

<name> undefined - a function or a variable is never defined

FlexLM <message>- an error is detected by the license manager

_asm string too long - the string constant passed to *_asm* is larger than 255 characters

ambiguous space modifier - a space modifier attempts to redefine an already specified modifier

array size unknown - the *sizeof* operator has been applied to an array of unknown size

bad # argument in macro <name> - the argument of a # operator in a *#define* macro is not a parameter

bad # directive: <name> - an unknown *#directive* has been specified

bad # syntax - # is not followed by an identifier

bad ## argument in macro <name> - an argument of a ## operator in a *#define* macro is missing

bad #asm directive - a *#asm* directive is not entered at a valid declaration or instruction boundary

bad #define syntax - a *#define* is not followed by an identifier

bad #elif expression - a *#elif* is not followed by a constant expression

bad #else - a *#else* occurs without a previous *#if*, *#ifdef*, *#ifndef* or *#elif*

bad #endasm directive - a *#endasm* directive is not closing a previous *#asm* directive

bad #endif - a *#endif* occurs without a previous *#if*, *#ifdef*, *#ifndef*, *#elif* or *#else*

bad #if expression - the expression part of a *#if* is not a constant expression

bad #ifdef syntax - extra characters are found after the symbol name

bad #ifndef syntax - extra characters are found after the symbol name

bad #include syntax - extra characters are found after the file name

bad #pragma section directive - syntax for the *#pragma section* directive is incorrect

bad #pragma space directive - syntax for the *#pragma space* directive is incorrect

bad #undef syntax - *#undef* is not followed by an identifier

bad _asm() argument type - the first argument passed to *_asm* is missing or is not a character string

bad alias expression - alias definition is not a valid expression

bad alias value - alias definition is not a constant expression

bad bit number - a bit number is not a constant between 0 and 7

bad character <character> - *<character>* is not part of a legal token

bad defined syntax - the *defined* operator must be followed by an identifier, or by an identifier enclosed in parenthesis

bad function declaration - function declaration has not been terminated by a right parenthesis

bad integer constant - an invalid integer constant has been specified

bad invocation of macro <name> - a *#define* macro defined without arguments has been invoked with arguments

bad macro argument - a parameter in a *#define* macro is not an identifier

bad macro argument syntax - parameters in a *#define* macro are not separated by commas

bad proto argument type - function prototype argument is declared without an explicit type

bad real constant - an invalid real constant has been specified

bad space modifier - a modifier beginning with a @ character is not followed by an identifier

bad structure for return - the structure for return is not compatible with that of the function

bad struct/union operand - a structure or an union has been used as operand for an arithmetic operator

bad symbol definition - the syntax of a symbol defined by the **-d** option on the command line is not valid

bad void argument - the type *void* has not been used alone in a prototyped function declaration

can't create <name> - file *<name>* cannot be created for writing

can't open <name> - file *<name>* cannot be opened for reading

can't redefine macro <name> - macro *<name>* has been already defined

can't undef macro <name> - a *#undef* has been attempted on a predefined macro

compare out of range - a comparison is detected as beeing always true or always false (**+strict**)

const assignment - a *const* object is specified as left operand of an assignment operator

constant assignment in a test - an assignment operator has been used in the test expression of an *if, while, do, for* statements or a conditional expression (**+strict**)

duplicate case - two *case* labels have been defined with the same value in the same *switch* statement

duplicate default - a *default* label has been specified more than once in a *switch* statement

embedded usage of tag name <name> - a structure/union definition contains a reference to itself.

enum size unknown - the range of an enumeration is not available to choose the smallest integer type

exponent overflow in real - the exponent specified in a real constant is too large for the target encoding

float value too large for integer cast - a float constant is too large to be casted in an integer

hexadecimal constant too large - an hexadecimal constant is too large to be represented on an integer

illegal storage class - storage class is not legal in this context

illegal type specification - type specification is not recognizable

illegal void operation - an object of type *void* is used as operand of an arithmetic operator

illegal void usage - an object of type *void* is used as operand of an assignment operator

implicit int type in argument declaration - an argument has been declared without any type (**+strict**)

implicit int type in global declaration - a global variable has been declared without any type (**+strict**)

implicit int type in local declaration - a local variable has been declared without any type (**+strict**)

implicit int type in struct/union declaration - a structure or union field has been declared without any type (**+strict**)

incompatible argument type - the actual argument type does not match the corresponding type in the prototype

incompatible compare type - operands of comparison operators must be of scalar type

incompatible operand types - the operands of an arithmetic operator are not compatible

incompatible pointer assignment - assigned pointers must have the same type, or one of them must be a pointer to *void*

incompatible pointer operand - a scalar type is expected when operators += and -= are used on pointers

incompatible pointer operation - pointers are not allowed for that kind of operation

incompatible pointer types - the pointers of the assignment operator must be of equal or coercible type

incompatible return type - the return expression is not compatible with the declared function return type

incompatible struct/union operation - a structure or an union has been used as operand of an arithmetic operator

incompatible types in struct/union assignment - structures must be compatible for assignment

incomplete #elif expression - a *#elif* is followed by an incomplete expression

incomplete #if expression - a *#if* is followed by an incomplete expression

incomplete type - structure type is not followed by a tag or definition

incomplete type for debug information - a structure or union is not completely defined in a file compiled with the debug option set

integer constant too large - a decimal constant is too large to be represented on an integer

invalid case - a *case* label has been specified outside of a *switch* statement

invalid default - a *default* label has been specified outside of a *switch* statement

invalid ? test expression - the first expression of a ternary operator **(? :)** is not a testable expression

invalid address operand - the "address of" operator has been applied to a *register* variable or an rvalue expression

invalid address type - the "address of" operator has been applied to a bitfield

invalid alias - an alias has been applied to an *extern* object

invalid arithmetic operand - the operands of an arithmetic operator are not of the same or coercible types

invalid array dimension - an array has been declared with a dimension which is not a constant expression

invalid binary number - the syntax for a binary constant is not valid

invalid bit assignment - the expression assigned to a bit variable must be scalar

invalid bit initializer - the expression initializing a bit variable must be scalar

invalid bitfield size - a bitfield has been declared with a size larger than its type size

invalid bitfield type - a type other than *int*, *unsigned int*, *char*, *unsigned char* has been used in a bitfield.

invalid break - a break may be used only in *while, for, do*, or *switch* statements

invalid case operand - a case label has to be followed by a constant expression

invalid cast operand - the operand of a *cast* operator in not an expression

invalid cast type - a cast has been applied to an object that cannot be coerced to a specific type

invalid conditional operand - the operands of a conditional operator are not compatible

invalid constant expression - a constant expression is missing or is not reduced to a constant value

invalid continue - a continue statement may be used only in *while*, *for*, or *do* statements

invalid do test type - the expression of a *do ... while()* instruction is not a testable expression

invalid expression - an incomplete or ill-formed expression has been detected

invalid external initialization - an external object has been initialized

invalid floating point operation - an invalid operator has been applied to floating point operands

invalid for test type - the second expression of a *for(;;)* instruction is not a testable expression

invalid function member - a function has been declared within a structure or an union

invalid function type - the function call operator *()* has been applied to an object which is not a function or a pointer to a function

invalid if test type - the expression of an *if ()* instruction is not a testable expression

invalid indirection operand - the operand of unary * is not a pointer

invalid line number - the first parameter of a *#line* directive is not an integer

invalid local initialization - the initialization of a local object is incomplete or ill-formed

invalid lvalue - the left operand of an assignment operator is not a variable or a pointer reference

invalid narrow pointer cast - a cast operator is attempting to reduce the size of a pointer

invalid operand type - the operand of a unary operator has an incompatible type

invalid pointer cast operand - a cast to a function pointer has been applied to a pointer that is not a function pointer

invalid pointer initializer - initializer must be a pointer expression or the constant expression 0

invalid pointer operand - an expression which is not of integer type has been added to a pointer

invalid pointer operation - an illegal operator has been applied to a pointer operand

invalid pointer types - two incompatible pointers have been substracted

invalid shift count type - the right expression of a shift operator is not an integer

invalid sizeof operand type - the *sizeof* operator has been applied to a function

invalid storage class - storage class is not legal in this context

invalid struct/union operation - a structure or an union has been used as operand of an arithmetic operator

invalid switch test type - the expression of a *switch ()* instruction must be of integer type

invalid typedef usage - a typedef identifier is used in an expression

invalid void pointer - a *void* pointer has been used as operand of an addition or a substraction

invalid while test type - the expression of a *while ()* instruction is not a testable expression

missing ## argument in macro <name> - an argument of a ## operator in a *#define* macro is missing

missing '>' in #include - a file name of a *#include* directive begins with '<' and does not end with '>'

missing) in defined expansion - a '*(*' does not have a balancing '*)*' in a *defined* operator

missing ; in argument declaration - the declaration of a function argument does not end with '*;*'

missing ; in local declaration - the declaration of a local variable does not end with '*;*'

missing ; in member declaration - the declaration of a structure or union member does not end with '*;*'

missing ? test expression - the test expression is missing in a ternary operator **(? :)**

missing _asm() argument - the *_asm* function needs at least one argument

missing argument - the number of arguments in the actual function call is less than that of its prototype declaration

missing argument for macro <name> - a macro invocation has fewer arguments than its corresponding declaration

missing argument name - the name of an argument is missing in a prototyped function declaration

missing array subscript - an array element has been referenced with an empty subscript

missing do test expression - a *do ... while ()* instruction has been specified with an empty *while* expression

missing enumeration member - a member of an enumeration is not an identifier

missing explicit return - a return statement is not ending a non-void function (**+strict**)

missing exponent in real - a floating point constant has an empty exponent after the 'e' or 'E' character

missing expression - an expression is needed, but none is present

missing file name in #include - a *#include* directive is used, but no file name is present

missing goto label - an identifier is needed after a *goto* instruction

missing if test expression - an *if ()* instruction has been used with an empty test expression

missing initialization expression - a local variable has been declared with an ending '=' character not followed by an expression

missing initializer - a simple object has been declared with an ending '=' character not followed by an expression

missing local name - a local variable has been declared without a name

missing member declaration - a structure or union has been declared without any member

missing member name - a structure or union member has been declared without a name

missing name in declaration - a variable has been declared without a name

missing prototype - a function has been used without a fully prototyped declaration (**+strict**)

missing prototype for inline function - an inline function has been declared without a fully prototyped syntax

missing return expression - a simple return statement is used in a non-void function (**+strict**)

missing switch test expression - an expression in a *switch* instruction is needed, but is not present

missing while - a '*while*' is expected and not found

missing while test expression - an expression in a *while* instruction is needed, but none is present

missing : - a '*:*' is expected and not found

missing ; - a '*;*' is expected and not found. The parser reports such an error on the previous element as most of the time the ; is missing at the end of the declaration. When this error occurs on top of a file or just after a file include, the line number reported may not match the exact location where the problem is detected.

missing (- a '*(*' is expected and not found

missing) - a '*)*' is expected and not found

missing] - a '*]*' is expected and not found

missing { - a '*{*' is expected and not found

missing } - a '*}*' is expected and not found

missing } in enum definition - an enumeration list does not end with a '*}*' character

missing } in struct/union definition - a structure or union member list does not end with a '*}*' character

redeclared argument <name> - a function argument has conflicting declarations

redeclared enum member <name> - an *enum* element is already declared in the same scope

redeclared external <name> - an *external* object or function has conflicting declarations

redeclared local <name> - a *local* is already declared in the same scope

redeclared proto argument <name> - an identifier is used more than once in a prototype function declaration

redeclared typedef <name> - a *typedef* is already declared in the same scope

redefined alias <name> - an *alias* has been applied to an already declared object

redefined label <name> - a *label* is defined more than once in a function

redefined member <name> - an identifier is used more than once in structure member declaration

redefined tag <name> - a *tag* is specified more than once in a given scope

repeated type specification - the same type modifier occurs more than once in a type specification

scalar type required - type must be integer, floating, or pointer

size unknown - an attempt to compute the size of an unknown object has occurred

space attribute conflict - a space modifier attempts to redefine an already specified modifier

string too long - a string is used to initialize an array of characters shorter than the string length

struct/union size unknown - an attempt to compute a structure or union size has occurred on an undefined structure or union

syntax error - an unexpected identifier has been read

token overflow - an expression is too complex to be parsed

too many argument - the number of actual arguments in a function declaration does not match that of the previous prototype declaration

too many arguments for macro <name> - a macro invocation has more arguments than its corresponding macro declaration

too many initializers - initialization is completed for a given object before initializer list is exhausted

too many spaces modifiers - too many different names for '@' modifiers are used

truncating assignment - the right operand of an assignment is larger than the left operand (**+strict**)

unbalanced ' - a character constant does not end with a simple quote

unbalanced " - a string constant does not end with a double quote

<name> undefined - an undeclared identifier appears in an expression

undefined label <name> - a label is never defined

undefined struct/union - a structure or union is used and is never defined

unexpected end of file - last declaration is incomplete

unexpected return expression - a return with an expression has been used within a *void* function

unknown enum definition - an enumeration has been declared with no member

unknown structure - an attempt to initialize an undefined structure has been done

unknown union - an attempt to initialize an undefined union has been done

value out of range - a constant is assigned to a variable too small to represent its value (**+strict**)

zero divide - a divide by zero was detected

zero modulus - a modulus by zero was detected

Code Generator (cgstm8) Error Messages

bad builtin - the *@builtin* type modifier can be used only on functions

bad @interrupt usage - the *@interrupt* type modifier can only be used on functions.

invalid indirect call - a function has been called through a pointer with more than one *char* or *int* argument, or is returning a structure.

redefined space - the version of *cpstm8* you used to compile your program is incompatible with *cgstm8*.

unknown space - you have specified an invalid space modifier *@xxx*

unknown space modifier - you have specified an invalid space modifier *@xxx*

PANIC ! bad input file - cannot read input file

PANIC ! bad output file - cannot create output file

PANIC ! can't write - cannot write output file

All other **PANIC !** messages should never happen. If you get such a message, please report it with the corresponding source program to COSMIC.

Assembler (castm8) Error Messages

The following error messages may be generated by the assembler. Note that the assembler's input is machine-generated code from the compiler. Hence, it is usually impossible to fix things ‘on the fly’. The problem must be corrected in the source, and the offending program(s) recompiled.

bad .source directive - a *.source* directive is not followed by a string giving a file name and line numbers

bad addressing mode - an invalid addressing mode have been constructed

bad argument number- a parameter sequence *\n* uses a value negative or greater than 9

bad character constant - a character constant is too long for an expression

bad comment delimiter- an unexpected field is not a comment

bad constant - a constant uses illegal characters

bad else - an *else* directive has been found without a previous *if* directive

bad endif - an *endif* directive has been found without a previous *if* or *else* directive

bad file name - the *include* directive operand is not a character string

bad index register - an invalid register has been used in an indexed addressing mode

bad register - an invalid register has been specified as operand of an instruction

bad relocatable expression - an external label has been used in either a constant expression, or with illegal operators

bad string constant - a character constant does not end with a single or double quote

bad symbol name: <name> - an expected symbol is not an identifier

can't create <name> - the file <*name*> cannot be opened for writing

can't open <name> - the file <*name*> cannot be opened for reading

can't open source <name> - the file <*name*> cannot be included

cannot include from a macro - the directive *include* cannot be specified within a macro definition

cannot move back current pc - an *org* directive has a negative offset

illegal size - the size of a *ds* directive is negative or zero

missing label - a label must be specified for this directive

missing operand - operand is expected for this instruction

missing register - a register is expected for this instruction

missing string - a character string is expected for this directive

relocatable expression not allowed - a constant is needed

section name <name> too long - a section name has more than 15 characters

string constant too long - a string constant is longer than 255 characters

symbol <name> already defined - attempt to redefine an existing symbol

symbol <name> not defined - a symbol has been used but not declared

syntax error - an unexpected identifier or operator has been found

too many arguments - a macro has been invoked with more than 9 arguments

too many back tokens - an expression is too complex to be evaluated

unclosed if - an *if* directive is not ended by an *else* or *endif* directive

unknown instruction <name> - an instruction not recognized by the processor has been specified

value too large - an operand is too large for the instruction type

zero divide - a divide by zero has been detected

Linker (clnk) Error Messages

-a not allowed with -b or -o - the *after* option cannot be specified if any start address is specified.

+def symbol <symbol> multiply defined - the symbol defined by a *+def* directive is already defined.

bad address (<value>) for zero page symbol <name> - a symbol declared in the zero page is allocated to an address larger than 8 bits.

bad file format - an input file has not an object file format.

bad number in +def - the number provided in a **+def** directive does not follow the standard C syntax.

bad number in +spc <segment> - the number provided in a *+spc* directive does not follow the standard C syntax.

bad processor type - an object file has not the same configuration information than the others.

bad reloc code - an object file contains unexpected relocation information.

bad section name in +def - the name specified after the '@' in a **+def** directive is not the name of a segment.

can't create map file <file> - map file cannot be created.

can't create <file> - output file cannot be created.

can't locate .text segment for initialization - initialized data segments have been found but no host segment has been specified.

can't locate shared segment - shared datas have been found but no host segment has been specified.

can't open file <file> - input file cannot be found.

file already linked - an input file has already been processed by the linker.

function <function> is recursive - a *nostack* function has been detected as recursive and cannot be allocated.

function <function> is reentrant - a function has been detected as reentrant. The function is both called in an interrupt function and in the main code.

incomplete +def directive - the **+def** directive syntax is not correct.

incomplete +seg directive - the **+seg** directive syntax is not correct.

incomplete +spc directive - the **+spc** directive syntax is not correct.

init segment cannot be initialized - the host segment for initialization cannot be itself initialized.

invalid @ argument - the syntax of an optional input file is not correct.

invalid -i option - the **-i** directive is followed by an unexpected character.

missing command file - a link command file must be specified on the command line.

missing output file - the **-o** option must be specified.

missing '=' in +def - the **+def** directive syntax is not correct.

missing '=' in +spc <segment> - the **+spc** directive syntax is not correct.

named segment <segment> not defined - a segment name does not match already existing segments.

no default placement for segment <segment> - a segment is missing **-a** or **-b** option.

prefixed symbol <name> in conflict - a symbol beginning by '*f*_' (for a banked function) also exists without the '*f*' prefix.

read error - an input object file is corrupted

segment <segment> and <segment> overlap - a segment is overlapping an other segment.

segment <segment> size overflow - the size of a segment is larger than the maximum value allowed by the **-m** option.

shared segment not empty - the host segment for shared data is not empty and cannot be used for allocation.

symbol <symbol> multiply defined - an object file attempts to redefine a symbol.

symbol <symbol> not defined - a symbol has been referenced but never defined.

unknown directive - a directive name has not been recognized as a linker directive.

APPENDIX

B

Modifying Compiler Operation

This chapter tells you how to modify compiler operation by making changes to the standard configuration file. It also explains how to create your own programmable options" which you can use to modify compiler operation from the **cxstm8.cxf**.

The Configuration File

The configuration file is designed to define the default options and behaviour of the compiler passes. It will also allow the definition of programmable options thus simplifying the compiler configuration. A configuration file contains a list of options similar to the ones accepted for the compiler driver utility **cxstm8**.

These options are described in **Chapter 4**, "*Using The Compiler*". There are two differences: the option **-f** cannot be specified in a configuration file, and the extra **-m** option has been added to allow the definition of a programmable compiler option, as described in the next paragraph.

The contents of the configuration file **cxstm8.cxf** as provided by the default installation appears below:

```
# CONFIGURATION FILE FOR STM8 COMPILER
# Copyright (c) 2007 by COSMIC Software
#
-pu                       # unsigned char
-ppb                      # pack local bit variables
-i c:\cx32\hstm8          # include path
#
-m debug:x                # debug: produce debug info
-m compact:,,f7           # compact: do not factorize code
-m nobss:,bss             # nobss: do not use bss
-m nocst:,ct              # nocst: constant in text section
-m nocross:,nc            # functions do not cross boundaries
-m proto:p                # proto: enable prototype checking
-m rev:rb                 # rev: reverse bit field order
-m strict:ck              # strict: enforce type checking
-m split:,sf              # functions in different sections
-m mods:hmods.h           # stack model
-m modsl:hmodsl.h         # stack long model
-m mods0:hmods0.h         # stack model 64K
-m modsl0:hmodsl0.h       # stack long model 64K
-m warn:w1                # warn: enable warnings
```

The following command line:

```
cxstm8 hello.c
```


in combination with the above configuration file directs the **cxstm8** compiler to execute the following commands:

```
cpstm8 -o \2.cx1  -u -i\cosmic\hstm8 hello.c
cgstm8 -o \2.cx2 \2.cx1
costm8 -o \2.cx1 \2.cx2
castm8 -o hello.o -i\cosmic\hstm8 \2.cx1
```

Changing the Default Options

To change the combination of options that the compiler will use, edit the configuration file and add your specific options using the **-p** (for the **p**arser), **-g** (for the code **g**enerator), **-o** (for the **o**ptimizer) and **-a** (for the **a**ssembler) options. If you specify an invalid option or combination of options, compilation will not proceed beyond the step where the error occurred. You may define up to 60 such options.

Creating Your Own Options

To create a programmable option, edit the configuration file and define the parametrable option with the **-m*** option. The string * has the following format:

```
name:popt,gopt,oopt,aopt,exclude...
```

The first field defines the option *name* and must be ended by a colon character '**:**'. The four next fields describe the effect of this option on the four passes of the compiler, respectively the *parser*, the *generator*, the *optimizer* and the *assembler*. These fields are separated by a comma character '**,**'. If no specific option is needed on a pass, the field has to be specified empty. The remaining fields, if specified, describe a exclusive relationship with other defined options. If two *exclusive* options are specified on the command line, the compiler will stop with an error message. You may define up to 20 programmable options. At least one field has to be specified. Empty fields need to be specified only if a useful field has to be entered after.

In the following example:

```
-m dl1:l,dl1,,,dl2# dl1: line option 1
-m dl2:l,dl2,,,dl1# dl1: line option 2
```

the two options *dl1* and *dl2* are defined. If the option **+dl1** is specified on the compiler command line, the specific option **-l** will be used for the *parser* and the specific option **-dl1** will be used for the code *generator*. No specific option will be used for the *optimizer* and for the *assembler*. The option *dl1* is also declared to be exclusive with the option *dl2*, meaning that *dl1* and *dl2* will not be allowed together on the compiler command line. The option *dl2* is defined in the same way.

Example

The following command line

```
cxstm8 +nobss hello.c
```

in combination with the previous configuration file directs the **cxstm8** compiler to execute the following commands:

```
cpstm8-o \2.cx1  -u  -i\cosmic\hstm8 hello.c
cgstm8 -o \2.cx2 -bss \2.cx1
costm8 -o \2.cx1 \2.cx2
castm8-o hello.o -i\cosmic\hstm8 \2.cx1
```

APPENDIX

C

STM8 Machine Library

This appendix describes each of the functions in the Machine Library (**libm** and **libm0** (for application smaller then 64K)). These functions provide the interface between the STM8 microcontroller hardware and the functions required by the code generator. They are described in reference form, and listed alphabetically.

Note that machine library functions handle values as follows:

- **integer** in a register pair, **ax**, **x** and the memory location **c_x**, or in the **y** register and the memory location **c_y**. The **a** register holds the less significant byte. The **x** register holds the most significant byte when used by the register pair **ax**, and holds the less significant byte when used by the register **x** and the memory location **c_x**. The **y** register holds the less significant byte.

- **longs** and **floats** in the four byte memory location **c_lreg**, ("float register" or "long register" depending on context).

- **pointer** to **long** or **float** in internal memory in **x** or **y**, and in **x** and the memory location **c_x** or **y** and the memory location **c_y** otherwise.

The library functions using a pointer to external memory (or code) have a name beginning with the '**x**' letter, and the pointer is located in the pair composed by the **x** register for the lower byte, and the memory location **c_x** for the upper byte. The following describes only the function handling data in internal memory. Their equivalent functions have the same description except for the pointer location and size.

c_bitfw

Description

Update an int bitfield in external memory

Syntax

```
; bitfield address in y and c_y
; mask in c_x and c_x+1
; value in a and x
     call c_bitfw
```

Function

c_bitfw is used to update a 16 bits bitfield located in extended memory by a new value located in the **ax** register pair. The value loaded from extended memory is first and'ed with the mask located in the **c_x** memory location. It is then or'ed with the value in the **ax** register pair and stored back in extended memory.

Return Value

None.

c_cdivx

Description

Quotient of unsigned char division

Syntax

```
; dividend in x
; divisor in a
    call c_cdivx
; quotient in a
```

Function

c_cdivx divides the unsigned byte in **x** by the unsigned char in the **a** register. Values are assumed to be unsigned. If division by zero is attempted, the result is the unchanged dividend.

Return Value

The quotient is in **a**. Flags are not meaningful upon return.

See Also

c_cdivy, c_sdivx, c_sdivy

c_cdivy

Description

Quotient of unsigned char division

Syntax

```
; dividend in y
; divisor in a
    call c_cdivy
; quotient in a
```

Function

c_cdivy divides the unsigned byte in **y** by the unsigned char in the **a** register. Values are assumed to be unsigned. If division by zero is attempted, the result is the unchanged dividend.

Return Value

The quotient is in **a**. Flags are not meaningful upon return.

See Also

c_cdivx, c_sdivx, c_sdivy

c_eewbf

Description

Eeprom char bit field update

Syntax

```
; value in x
; address in c_x and extension
; mask in a
        call c_eewbfb
```

Function

c_eewbf updates a char bit field (8 bits sized) located in *eeprom* with a new value. The new value is in register **x** and is right justified. The byte address in *eeprom* is in **c_x** and **c_x+1**, and the mask, giving the bit field size and location, is in register **a**. The function waits for the time necessary to program the new value.

See Also

c_eewstr

c_eewrc

Description

Write a char in *eeprom*

Syntax

```
; value in a
; address in c_x and x
    call c_eewrc
```

Function

c_eewrc writes a byte in *eeprom*. The new byte value is in the **a** register and its address in *eeprom* is in **c_x** and **x**. The function tests if the erasure is necessary, and do it only in that case. Then if the new value is different from one in *eeprom*, the new byte is programmed. The function waits for the time necessary to program correctly the byte. The function does not test if the byte address is in the address range corresponding to the existing *eeprom*.

See Also

c_eewrl, c_eewrw

c_eewrl

Description

Write a long int in *eeprom*

Syntax

```
; value in c_lreg
; address in c_x and x
    call c_eewrl
```

Function

c_eewrl writes a long int in *eeprom*. The new value is in the long register, and its address in *eeprom* is in **c_x** and **x**. Each byte is programmed independently by the *c_eewrc* function.

See Also

c_eewrc, c_eewrw

c_eewrw

Description

Write a short int in *eeprom*

Syntax

```
  ; value in a and x
  ; address in c_x and c_x+1
      call c_eewrw
```

Function

c_eewrw writes a short int in *eeprom*. The new value is in the **ax** register pair, and its address in *eeprom* is in **c_x** and **c_x+1**. Each byte is programmed independently by the *c_eewrc* function.

See Also

c_eewrc, c_eewrl

c_eewstr

Description

Move a structure in *eeprom*

Syntax

```
; source address in y and c_y
; destination address in x and c_x
; size in a
        call c_eewstr
```

Function

c_eewstr moves a structure into an *eeprom* memory location. Pointer to source is in **y** and **c_y**, and pointer to destination is in **x** and **c_x**. The structure size is in register **a**. Each byte is programmed independently by the *c_eewrc* function.

See Also

c_eewbfb, c_eewrc

c_fadd

Description

Add float to float

Syntax

```
; left in float register
; pointer to right in x register
     call c_fadd
; result in float register
```

Function

c_fadd adds the float in *float register* to the float indicated by the **x** register. No check is made for overflow.

Return Value

The resulting value is in *float register*. Flags have no meaningful value upon return.

See Also

c_fsub

c_fcmp

Description

Compare floats

Syntax

```
; left in float register
; pointer to right in x register
     call c_fcmp
; result in flags
```

Function

c_fcmp compares the float in *float register* with the float pointered at by the **x** register.

Return Value

The **N** and **Z** flags are set to reflect the value (left-right).

c_fdiv

Description

Divide float by float

Syntax

```
; left in float register
; pointer to right in x register
     call c_fdiv
; result in float register
```

Function

c_fdiv divides the float in *float register* by the float pointered at by the **x** register.

Return Value

The resulting value is in *float register*. Flags have no meaningful value upon return.

c_fgadd

Description

Add float to float in memory

Syntax

```
; pointer to left in x register
; right in float register
     call c_fgadd
; result in memory
```

Function

c_fgadd adds the float in the float pointered at by the **x** register to the *float register*.

Return Value

The resulting value is stored at the location pointered at by the **x** register, meaning that the left operand is updated. Flags have no meaningful value upon return.

See Also

c_fgsub

c_fgmul

Description

Multiply float by float in memory

Syntax

```
; pointer to left in x register
; right in float register
    call c_fgmul
; result in memory
```

Function

c_fgmul multiplies the float in *float register* by the float pointered at by the **x** register.

Return Value

The resulting value is stored at the location pointered at by **x**. Flags have no meaningful value upon return.

c_fgsub

Description

Subtract float from float in memory

Syntax

```
; pointer to left in x register
; right in float register
     call c_fgsub
; result in memory
```

Function

c_fgsub subtracts the float pointered at by the **x** register from the float in *float register*. No check is made for overflow.

Return Value

The resulting value is stored at the location pointered at by **x**. Flags have no meaningful value upon return.

See Also

c_fgadd

c_fmul

Description

Multiply float by float

Syntax

```
; left in float register
; pointer to right in x register
    call c_fmul
; result in float register
```

Function

c_fmul multiplies the float in *float register* by the float pointered at by the **x** register.

Return Value

The resulting value is in *float register*. Flags have no meaningful value upon return

c_fneg

Description

Negate a float

Syntax

```
; operand in float register
     call c_fneg
; result in operand
```

Function

c_fneg negates the float pointered at by the *float register*.

Return Value

The resulting value is in *float register*. Flags have no meaningful value upon return.

c_fsub

Description

Subtract float from float

Syntax

```
; left in float register
; pointer to right in x register
    call c_fsub
; result in float register
```

Function

c_fsub subtracts the float pointed to by the **x** register from the float in *float register*. No check is made for overflow.

Return Value

The resulting value is in *float register*. Flags have no meaningful value upon return.

See Also

c_fadd

c_ftoi

Description

Convert float to integer

Syntax

```
; float in float register
    call c_ftoi
; result in ax register pair
```

Function

c_ftoi converts the float in *float register* to a two byte integer whose less significant byte is in the **a** register, and the most significant byte in the memory location **x**. No check is made for overflow.

Return Value

The resulting value is in **a** and **x**. Flags have no meaningful value upon return.

See Also

c_ftol, c_itof, c_itol, c_ltof

c_ftol

Description

Convert float into long integer

Syntax

```
  ; float in float register
       call c_ftol
  ;result in long register
```

Function

c_ftol converts the float in *float register* to a four byte integer in *long register*. No check is made for overflow.

Return Value

The resulting value is in *long register*. Flags have no meaningful value upon return.

See Also

c_ftoi, c_itof, c_itol, c_ltof

c_fzmp

Description

Compare a float in memory to zero

Syntax

```
; pointer to operand in x register
      call c_fzmp
; result in flags
```

Function

c_fzmp compares the float pointered by the **x** register against zero.

Return Value

The **N** and **Z** flags are set to reflect the operand value.

c_getlx

Description

Get a long word from external memory

Syntax

```
; long address in x and c_x
     call c_getlx
; result in long register
```

Function

c_getlx gets a long integer from external memory using a pointer loaded in **x** and **c_x**. The result is left in the *long register*.

Return Value

The byte is loaded in the *long register*. Flags have no meaningful value upon return.

See Also

c_getly, c_getwx, c_getwy

c_getly

Description

Get a long word from external memory

Syntax

```
; long address in y and c_y
    call c_gety
; result in long register
```

Function

c_getly gets a long integer from external memory using a pointer loaded in **y** and **c_y**. The result is left in the *long register*.

Return Value

The byte is loaded in the *long register*. Flags have no meaningful value upon return.

See Also

c_getlx, c_getwx, c_getwy

c_getwx

Description

Get a word from external memory

Syntax

```
; word address in x and c_x
    call c_getwx
; result in a and x
```

Function

c_getwx gets a word from extended memory using a pointer loaded in **x** and **c_x**. The result is left in the **a** and **x** registers.

Return Value

The word is loaded in the **a** and **x** registers. Flags have no meaningful value upon return.

See Also

c_getlx, c_getly, c_getwy

c_getwy

Description

Get a word from external memory

Syntax

```
; word address in y and c_y
     call c_getwy
; result in a and x
```

Function

c_getwy gets a word from extended memory using a pointer loaded in **y** and **c_y**. The result is left in the **a** and **x** registers.

Return Value

The word is loaded in the **a** and **x** registers. Flags have no meaningful value upon return.

See Also

c_getlx, c_getly, c_getwx

c_idiv

Description

Quotient of integer division

Syntax

```
; dividend in x and a
; divisor in y and c_y
     call c_idiv
; quotient in a and c_reg
```

Function

c_idiv divides the two byte integer in the **ax** register pair, by the two byte integer in the **y** register and the memory location **c_y**. Values are assumed to be signed. If division by zero is attempted, the result is the unchanged dividend.

Return Value

The quotient is placed in **a** and **x**. Flags have no meaningful value upon return.

See Also

c_udiv

c_imul

Description

Integer multiplication

Syntax

```
; left in a and x
; right in y and c_y
    call c_imul
; result in a and c_reg
```

Function

c_imul multiplies the two byte integer in the **ax** register pair, by the two byte integer in the **y** register and the memory location **c_y**. No check is made for overflow.

Return Value

The resulting value is in **a** and **x**. Flags have no meaningful value upon return

c_itof

Description

Convert integer into float

Syntax

```
; operand in a and x
     call c_itof
; result in float register
```

Function

c_itof converts the two byte integer in the **ax** register pair, to a float stored in *float register*.

Return Value

The resulting value is in *float register*. Flags have no meaningful value upon return.

See Also

c_ltof, c_ultof, c_xtof, c_uitof, c_uxtof

c_itol

Description

Convert integer into long

Syntax

```
    ; operand in a and x
          call c_itol
    ; result in long register
```

Function

c_itol converts the two byte integer in the **ax** register pair, to a long integer stored in *long register*.

Return Value

The resulting value is in *long register*. Flags have no meaningful value upon return.

See Also

c_xtol, c_uitol, c_uxtol

c_jltab

Description

Perform C switch statement on long

Syntax

```
  ; value in long register
  ; table address in x and c_x
      jp c_jltab
```

Function

c_jltab is called to switch to the proper code segment, depending on a value and an address table. The top of the table is found in the **x** register and the memory location **c_x**, and consists of a count followed by a list of pairs. A pair consists of a value followed by an address. The pair list is ended by the default address. All values are four byte integers. All addresses and the count are two byte integers.

Return Value

c_jltab jumps to the proper code. It never returns.

c_ladd

Description

Long integer addition

Syntax

```
; left in long register
; pointer to right in x register
    call c_ladd
; result in long register
```

Function

c_ladd adds the four byte integer in *long register* and the four byte integer pointered at by the **x** register.

Return Value

The result is in *long register*. Flags are not meaningful upon return.

See Also

c_lcmp, c_lsub

c_land

Description

Bitwise AND for long integers

Syntax

```
; left in long register
; pointer to right in x register
    call c_land
; result in long register
```

Function

c_land operates a bitwise AND between the operands. Each operand is taken to be a four byte integer.

Return Value

The result is in *long register*. Flags are not meaningful upon return.

See Also

c_lor, c_lxor

c_lcmp

Description

Long integer compare

Syntax

```
; left in long register
; pointer to right in x register
    call c_lcmp
; result in long flags
```

Function

c_lcmp compares the four byte integer in *long register* to the four byte integer pointered by the **x** register.

Return Value

Flags are set accordingly.

See Also

c_ladd, c_lsub

c_ldiv

Description

Quotient of long integer division

Syntax

```
; dividend in long register
; pointer to divisor in x register
     call c_ldiv
;quotient in long register
```

Function

c_ldiv divides the four byte integer in *long register* by the four byte integer pointered by the **x** register. Values are assumed to be signed. If division by zero is attempted, the result is the unchanged dividend.

Return Value

The quotient is in *long register* and the flags are not meaningful upon return.

See Also

c_ludv, c_lmod, c_lumd

c_lgadd

Description

Long addition

Syntax

```
; pointer to left in x register
; right in long register
    call c_lgadd
; result in left
```

Function

c_lgadd performs the long addition of the value pointered by the **x** register and the value in *long register*.

Return Value

The result is stored at the location pointered by the **x** register. Flags are not meaningful upon return.

c_lgand

Description

Long bitwise AND

Syntax

```
; left in long register
; pointer to right in x register
     call c_lgand
; result in left
```

Function

c_lgand performs the long bitwise AND of the value in *long register* and the value pointered by the **x** register.

Return Value

The result is stored in *long register*. Flags are not meaningful upon return.

c_lglsh

Description

Long shift left

Syntax

```
; pointer to long in x register
; shift count in a register
    call c_lglsh
; result in memory
```

Function

c_lglsh performs the long left shift of the value pointered by the **x** register by the bit count in the **a** register. No check is done against silly counts.

Return Value

The result is stored in the location pointered by **x**. Flags are not meaningful upon return.

c_lgmul

Description

Long multiplication in memory

Syntax

```
; pointer to left in x register
; right in long register
     call c_lgmul
; result in left
```

Function

c_lgmul performs the long multiplication of the value pointered by the **x** register, by the value in *long register*.

Return Value

The result is stored in the location pointered by **x**. Flags are not meaningful upon return.

See Also

c_lmul

c_lgneg

Description

Negate a long integer in memory

Syntax

```
; pointer to operand in x register
     call c_lneg
; result in memory
```

Function

c_lgneg negates the four byte integer pointered by the **x** register.

Return Value

The result is in the location pointered by **x**. The flags are not meaningful upon return.

See Also

c_lneg

c_lgor

Description

Long bitwise OR

Syntax

```
; pointer to left in x register
; right in long register
    call c_lgor
; result in left
```

Function

c_lgor performs the long bitwise OR of the value in *long register* and the value pointered by the **x** register.

Return Value

The result is stored in *long register*. Flags are not meaningful upon return.

c_lgrsh

Description

Signed long shift right

Syntax

```
; pointer to long in x register
; shift count in a register
    call c_lgrsh
; result in memory
```

Function

c_lgrsh performs the signed long right shift of the value pointered by the **x** register and the value in *long register*. No check is done against silly counts. Because the value is signed, arithmetic shift instructions are used.

Return Value

The result is stored in the location pointered by **x**. Flags are not meaningful upon return.

c_lgsub

Description

Long subtraction

Syntax

```
; pointer to left in x register
; right in long register
    call c_lgsub
; result in left
```

Function

c_lgsub evaluates the (long) difference between the value pointered by the **x** register and the value in *long register*.

Return Value

The result is stored in the location pointered by **x**. Flags are not meaningful upon return.

c_lgursh

Description

Unsigned long shift right

Syntax

```
; pointer to long in x register
; shift count in a register
    call c_lgursh
; result in memory
```

Function

c_lgursh performs the unsigned long right shift of the value pointered by the **x** register and the value in *long register*. No check is done against silly counts. Because the value is unsigned, logical shift instructions are used.

Return Value

The result is stored in the location pointered by **x**. Flags are not meaningful upon return.

c_lgxor

Description

Long bitwise exclusive OR

Syntax

```
; pointer to right in x register
; left in long register
     call c_lgxor
; result in left
```

Function

c_lgxor performs the long bitwise Exclusive OR of the value in *long register* and the value pointered by the **x** register.

Return Value

The result is stored in *long register*. Flags are not meaningful upon return.

c_llsh

Description

Long integer shift left

Syntax

```
; operand in long register
; shift count in a register
    call c_llsh
; result in long register
```

Function

c_llsh shifts left four byte integer in *long register* by the number of places specified by the **a** register. A zero count leaves the *long register* unchanged. No check is made for invalid counts.

Return Value

The resulting value is in *long register*. Flags are not meaningful upon return.

See Also

c_lrsh, c_lursh

c_lmod

Description

Remainder of long integer division

Syntax

```
; left in long register
; pointer to right in x register
     call c_lmod
; remainder in long register
```

Function

c_lmod divides the four byte integer in *long register* by the four byte integer pointered by the **x** register. Values are assumed to be signed. The dividend is returned if a division by zero is attempted.

Return Value

The remainder is stored in *long register*. Flags are not meaningful upon return.

See Also

c_lumd, c_ldiv, c_udiv

c_lmul

Description

Multiply long integer by long integer

Syntax

```
; left in long register
; pointer to right in x register
    call c_lmul
; result in long register
```

Function

c_lmul multiplies the four byte integer in *long register* by the four byte integer pointered by the **x** register. No check is made for overflow.

Return Value

The resulting value is in *long register*. Flags are not meaningful upon return.

See Also

c_lgmul

c_lneg

Description

Negate a long integer

Syntax

```
; operand in long register
     call c_lneg
; result in long register
```

Function

c_lneg negates the four byte integer in *long register*.

Return Value

The result is in *long register*. The flags are not meaningful upon return.

See Also

c_lgneg

c_lor

Description

Bitwise OR with long integers

Syntax

```
; left in long register
; pointer to right in x register
    call c_lor
; result in long register
```

Function

c_lor operates a bitwise OR between the contents of *long register* and the long pointered by the **x** register. Each operand is taken to be a four byte integer.

Return Value

The result is in *long register*. The flags are not meaningful upon return.

See Also

c_land, c_lxor

c_lrsh

Description

Long integer right shift

Syntax

```
; operand in long register
; shift count in a register
    call c_lrsh
; result in long register
```

Function

c_lrsh right shifts the four byte integer in *long register* by the number of bits specified by the **a** register. A zero count leaves the *long register* unchanged. No check is made for invalid counts. The value is assumed to be signed, so a negative value will stay negative as by an arithmetic shift.

Return Value

The resulting value stays in *long register.* Flags are not meaningful upon return.

See Also

c_llsh, c_lursh

c_lrzmp

Description

Long test against zero

Syntax

```
; operand in long register
     call c_lrzmp
; result in the flags
```

Function

c_lrzmp tests the value in the *long register* and updates the sign and zero flags.

Return Value

Nothing, but the flags.

See Also

c_lzmp

c_lsub

Description

Long integer subtraction

Syntax

```
; left in long register
; pointer to right in x register
    call c_lsub
; result in long register
```

Function

c_lsub subtracts the four byte integer pointered by the **x** register from the four byte integer in *long register*.

Return Value

The result is in *long register*. Flags are not meaningful upon return.

See Also

c_ladd, c_lcmp

c_ltof

Description

Convert long integer into float

Syntax

```
; operand in float integer
    call c_ltof
; result in float register
```

Function

c_ltof converts the four byte integer in *float registe*r to a float.

Return Value

The resulting value is in *float register*. Flags have no meaningful value upon return.

See Also

c_ftoi, c_ftol, c_itof, c_itol

c_ltor

Description

Load memory into long register

Syntax

```
; pointer to operand in x register
     call c_ltor
; result in float register
```

Function

c_ltor loads the four byte integer pointered by the **x** register into the *long register*.

Return Value

The resulting value is in *long register*. Flags have no meaningful value upon return.

See Also

c_rtol

c_ludv

Description

Quotient of unsigned long integer division

Syntax

```
; left in long register
; pointer to right in x register
    call c_ludv
; quotient in long register
```

Function

c_ludv divides the four byte integer in *long register* by the four byte integer pointered by the **x** register. Values are assumed to be unsigned. The dividend is returned if a division by zero is attempted.

Return Value

The quotient is in *long register*. Flags are not meaningful upon return.

See Also

c_ldiv, c_lmod, c_lumd

c_lumd

Description

Remainder of unsigned long integer division

Syntax

```
; left in long register
; pointer to right in x register
    call c_lumd
; remainder in long register
```

Function

c_lumd divides the four byte integer in *long register* by the four byte integer pointered by the **x** register. Values are assumed to be unsigned. The dividend is returned if a division by zero is attempted.

Return Value

The remainder is in *long register*. Flags are not meaningful upon return.

See Also

c_lmod, c_ldiv, c_ludv

c_lursh

Description

Unsigned long integer shift right

Syntax

```
; operand in long register
; shift count in a register
    call c_lursh
; result in long register
```

Function

c_lursh right shifts the four byte integer in *long register* by the number of bits specified by the **a** register. A zero count leaves the *long register* unchanged. No check is made for invalid counts. The value is assumed to be unsigned. The shift instruction used is therefore a logical shift.

Return Value

The resulting value is in *long register*. Flags are not meaningful upon return.

See Also

c_llsh, c_lrsh

c_lxor

Description

Bitwise exclusive OR with long integers

Syntax

```
; left in long integer
; pointer to right in x register
    call c_lxor
; result in long register
```

Function

c_lxor operates a bitwise Exclusive OR between the contents of *long register* and the long pointered by the **x** register. Each operand is taken to be a four byte integer.

Return Value

The result is in *long register*. The flags are not meaningful upon return.

See Also

c_land, c_lor

c_lzmp

Description

Compare a long integer to zero

Syntax

```
; pointer to operand in x register
     call c_lzmp
; result in the flags
```

Function

c_lzmp compares the four byte integer pointered by the **x** register to zero.

Return Value

Nothing, but the flags.

See Also

c_lrzmp

c_putlx

Description

Put a long integer in external memory

Syntax

```
; long address in x and c_x
; value in long register
    call c_putlx
```

Function

c_putlx puts the value in *long register* into extended memory using a pointer loaded in **x** and **c_x**.

Return Value

None.

See Also

c_getlx, c_getwx, c_putly, c_putw

c_putly

Description

Put a long integer in external memory

Syntax

```
  ; long address in y and c_y
  ; value in long register
        call c_putly
```

Function

c_putly puts the value in *long register* into extended memory using a pointer loaded in **y** and **c_y**.

Return Value

None.

See Also

c_getly, c_getwy, c_putlx, c_putw

c_putw

Description

Put a word in extended memory

Syntax

```
; word address in y and c_y
; value in a and x
    call c_putw
```

Function

c_putw puts the value in **a** and **x** registers into extended memory using a pointer loaded in **y** and **c_y**.

Return Value

None.

See Also

c_getlx, c_getly, c_getw, c_putlx, c_putly

c_rtol

Description

Store long register in memory

Syntax

```
; pointer to destination in x register
; operand in long integer
    call c_rtol
```

Function

c_rtol store the four byte integer in *long register* into the memory location pointered by the **x** register.

Return Value

The resulting value is in the memory location pointered by **x**. Flags have no meaningful value upon return.

See Also

c_ltor

c_rtoxl

Description

Store long register in external memory

Syntax

```
; pointer to destination in x register and c_x
; operand in long integer
    call c_rtoxl
```

Function

c_rtoxl store the four byte integer in *long register* into the memory location pointered by the **x** register and **c_x**.

Return Value

The resulting value is in the memory location pointered by **x**. Flags have no meaningful value upon return.

See Also

c_ltor

c_sdivx

Description

Quotient of signed char division

Syntax

```
; dividend in a register
; divisor in x register
     call c_sdivx
; quotient in a
```

Function

c_sdivx divides the signed byte in **a** by the signed byte in the **x** register. Values are assumed to be signed. If division by zero is attempted, the result is the unchanged dividend.

Return Value

The quotient is in **a**. Flags are not meaningful upon return.

See Also

c_cdivx, c_cdivy, c_sdivy

c_sdivy

Description

Quotient of signed char division

Syntax

```
; dividend in a register
; divisor in y register
      call c_sdivy
; quotient in a
```

Function

c_sdivy divides the signed byte in **a** by the signed byte in the **y** register. Values are assumed to be signed. If division by zero is attempted, the result is the unchanged dividend.

Return Value

The quotient is in **a**. Flags are not meaningful upon return.

See Also

c_cdivx, c_cdivy, c_sdivy

c_smul

Description

Multiply long integer by unsigned byte

Syntax

```
; left in long register
; right byte in a register
    call c_smul
; result in long register
```

Function

c_smul multiplies the four byte integer in *long register* by the unsigned byte in the **a** register. No check is made for overflow.

Return Value

The resulting value is in *long register*. Flags are not meaningful upon return.

See Also

c_lgmul

c_udiv

Description

Quotient of unsigned integer division

Syntax

```
; dividend in a and x
; divisor in y and c_y
     call c_udiv
; quotient in a and x
```

Function

c_udiv divides the two byte unsigned integer in **ax** register pair by the two byte unsigned integer in the **y** register and the memory location **c_y**. Values are assumed to be unsigned. If division by zero is attempted, the result is the unchanged dividend.

Return Value

The quotient is in **a** and **x**. Flags are not meaningful upon return.

See Also

c_idiv

c_uitof

Description

Convert unsigned integer into float

Syntax

```
 ; operand in a and x
        call c_uitof
 ; result in float register
```

Function

c_uitof converts the two byte unsigned integer in the **ax** register pair to a float stored in *float register*.

Return Value

The resulting value is in *float register*. Flags have no meaningful value upon return.

See Also

c_itof, c_ltof, c_ultof, c_xtof, c_uxtof

c_uitol

Description

Convert unsigned integer into long

Syntax

```
; operand in a and x
     call c_uitol
; result in long register
```

Function

c_uitol converts the two byte unsigned integer in the **ax** register pair, to a long integer stored in *long register.*

Return Value

The resulting value is in *long register*. Flags have no meaningful value upon return.

See Also

c_itol, c_xtol, c_uxtol

c_ultof

Description

Convert unsigned long integer into float

Syntax

```
    ; long in long register
        call c_ultof
    ; result in float register
```

Function

c_ultof converts the four unsigned byte integer in *long register* to a float.

Return Value

The resulting value is in *float register*. Flags have no meaningful value upon return.

See Also

c_itof, c_ltof, c_xtof, c_uitof, c_uxtof

c_xymov

Description

Copy a structure into another

Syntax

```
  ; pointer to source in y
  ; pointer to destination in x register
  ; size in a register
       call c_xymov
```

Function

c_xymov copy the source structure pointed by the memory location **y** into the structure pointed by the **x** register. The structures are in the zero page section (*.bsct*), so one byte addresses are enough. The structure size is located in the **a** register.

Return Value

None.

See Also

c_xymov, c_yxmov, c_xymvx, c_yxmvx

c_xymvx

Description

Copy a structure in external memory

Syntax

```
; pointer to source in y and c_y
; pointer to destination in x and c_x
; size in a
     call c_xymvx
```

Function

c_xymvx copy the source structure pointed by the **y** register and the memory location pointed by **c_y** into the structure pointed by the **x** register and the memory location pointed by **c_x**. The structure size is in the **a** memory location.

Return Value

None.

See Also

c_xymov, c_yxmov, c_xymvy

c_yxmov

Description

Copy a structure into another

Syntax

```
  ; pointer to source in x
  ; pointer to destination in y
  ; size in a
        call c_yxmov
```

Function

c_yxmov copy the source structure pointed by the **x** register into the structure pointed by the **y** register. The structures are in the zero page section (*.bsct*), so one byte addresses are enough. The structure size is in the **a** memory location.

Return Value

None.

See Also

c_xymov, c_xymvx, c_yxmvx

c_yxmvx

Description

Copy a structure in external memory

Syntax

```
; pointer to source in x and c_x
; pointer to destination in y and c_y
; size in a
     call c_yxmvx
```

Function

c_yxmvx copy the source structure pointed by the **x** register and the memory location pointed by **c_x** into the structure pointed by the **y** register and the memory location pointed by **c_y**. The structure size is in the **a** memory location.

Return Value

None.

See Also

c_xymov, c_yxmov, c_xymvy

APPENDIX

D

Compiler Passes

The information contained in this appendix is of interest to those users who want to modify the default operation of the cross compiler by changing the configuration file that the **cxstm8** compiler uses to control the compilation process.

This appendix describes each of the passes of the compiler:

cpstm8	the parser
cgstm8	the code generator
costm8	the assembly language optimizer

The cpstm8 Parser

cpstm8 is the parser used by the C compiler to expand *#defines*, *#includes*, and other directives signalled by a **#**, parse the resulting text, and outputs a sequential file of flow graphs and parse trees suitable for input to the code generator **cgstm8**.

Command Line Options

cpstm8 accepts the following options, each of which is described in detail below:

```
cpstm8 [options] file
      -ad     expand defines in assembly
      -c99    c99 type behaviour
      -ck     extra type checkings
      -cp     no constant propagation
      -csb    check signed bitfields
      -d*>    define symbol=value
      -e      run preprocessor only
      +e*     error file name
      -h*>    include header
      -i*>    include path
      -l      output line information
      -md     make dependencies
      -m#     model configuration
      -nb     no bitfield packing
      -nc     no const replacement
      -ne     no enum optimization
      -np     allow pointer narrowing
      -ns     do not share locals
      -o*     output file name
      -p      need prototypes
      -pb     pack bit variables
      -rb     reverse bitfield order
      -s      do not reorder locals
      -sa     strict ANSI conformance
      -u      plain char is unsigned
      -w#     enable warnings
      -xd     debug info for data
      -xp     no path in debug info
      -xu     no debug info if unused
      -xx     extended debug info
      -x      output debug info
```


Parser Option Usage

Options	Description
-ad	enable #define expansion inside inline assembly code between #asm and #endasm directives. By default, #define symbols are expanded only in the C code.
-c99	authorize the repetition of the const and volatile modifiers in the declaration either directly or indirectly in the typedef.
-ck	direct the compiler to enforce stronger type checking.
-cp	disable the constant propagation optimization. By default, when a variable is assigned with a constant, any subsequent access to that variable is replaced by the constant itself until the variable is modified or a flow break is encountered (function call, loop, label ...).
-csb	produce an error message if a bitfield is declared explicitly with the **signed** keyword. By default, the compiler silently ignores the signed feature and handles all bitfields as unsigned values.
-d*^	specify * as the name of a user-defined preprocessor symbol (**#define**). The form of the definition is **-dsymbol[=value]**; the symbol is set to **1** if value is omitted. You can specify up to 60 such definitions.
-e	run preprocessor only. *cpstm8* only outputs lines of text.
+e*	log errors in the text file * instead of displaying the messages on the terminal screen.
-h*>	include files before to start the compiler process. You can specify up to 60 files.
-i*>	specify include path. You can specify up to 128 different paths. Each path is a directory name, **not** terminated by any directory separator character, or a file containing a list of directory names.
-l	output line number information for listing or debug.
-md	create only a list of ‘make’ compatible dependencies consisting for each source file in the object name followed by a list of header files needed to compile that file.

Parser Option Usage (cont.)

Options	Description
-m#	the value **#** is used to configure the parser behaviour. It is a two bytes value, the upper byte specifies the default space for variables, and the lower byte specifies the default space for functions. A space byte is the or'ed value between a size specifier and several optional other specifiers. The allowed size specifiers are: **0x10** @tiny **0x20** @near **0x30** @far Allowed optional specifiers are: **0x02** @pack **0x04** @nostack Note that all the combinations are not significant for all the target processors.
-nb	do not pack bitfields. By default, trailing unused bits in the last bitfield of a structure are removed if this saves at least one byte.
-nc	do not replace an access to an initialized const object by its value. By default, the usage of a const object whose value is known is replaced by its constant value.
-ne	do not optimize size of *enum* variables. By default, the compiler selects the smallest integer type by checking the range of the declared *enum* members. This mechanism does not allow incomplete *enum* declaration. When the **-ne** option is selected, all *enum* variables are allocated as *int* variables, thus allowing incomplete declarations, as the knowledge of all the members is no more necessary to choose the proper integer type.

Parser Option Usage (cont.)

Options	Description
-np	allow pointer narrowing. By default, the compiler refuses to cast the pointer into any smaller object. This option should be used carefully as such conversions are truncating addresses.
-ns	do not share independent local variables. By default, the compiler tries to overlay variables in the same memory location or register if they are not used concurrently.
-o*	write the output to the file *. Default is STDOUT for output if **-e** is specified. Otherwise, an output file name is required.
-p	enforce prototype declaration for functions. An error message is issued if a function is used and no prototype declaration is found for it. By default, the compiler accepts both syntaxes without any error.
-pb	pack **_Bool** local variables. By default, **_Bool** local variables are allocated on one byte each.
-rb	reverse the bitfield fill order. By default, bitfields are filled from **less** significant bit (LSB) to **most** significant bit (MSB). If this option is specified, filling works from most significant bit to less significant bit.
-s	do not reorder local variables. By default, the compiler sorts the local variables of a function in order to allocate the most used variables as close as possible to the frame pointer. This allows to use the shortest addressing modes for the most used variables.
-sa	enforce a strict ANSI checking by rejecting any syntax or semantic extension. This option also disables the enum size optimization (**-ne**).
-u	take a plain char to be of type **unsigned char**, not signed char. This also affects in the same way strings constants.
-w#	enable warnings if # is greater or equal to 0. By default, warnings are disabled.

Parser Option Usage (cont.)

Options	Description
-x	generate debugging information for use by the cross debugger or some other debugger or in-circuit emulator. The default is to generate no debugging information.
-xd	add debug information in the object file only for data objects, hiding any function.
-xp	do not prefix filenames in the debug information with any absolute path name. Debuggers will have to be informed about the actual files location.
-xu	do not produce debug information for localized variables if they are not used. By default, the compiler produces a complete debug information regardless the variable is accessed or not.
-xx	add debug information in the object file for any label defining code or data.

Return Status

cpstm8 returns success if it produces no error diagnostics.

Example

cpstm8 is usually invoked before *cgstm8* the code generator, as in:

```
cpstm8 -o \2.cx1 -u -i \cosmic\hstm8 file.c
cgstm8 -o \2.cx2 \2.cx1
```


The cgstm8 Code Generator

cgstm8 is the code generating pass of the C compiler. It accepts a sequential file of flow graphs and parse trees from *cpstm8* and outputs a sequential file of assembly language statements.

As much as possible, the compiler generates freestanding code, but, for those operations which cannot be done compactly, it generates inline calls to a set of machine-dependent runtime library routines.

Command Line Options

cgstm8 accepts the following options, each of which is described in detail below:

```
cgstm8 [options] file
     -a       optimize _asm code
     -bss     do not use bss
     -ck      check stack frame
     -ct      constants in code
     -dl#     output line information
     +e*      error file name
     -f       full source display
     -fl      far library calls
     -l       output listing
     -na      do not xdef alias name
     -nc      functions do not cross section
     -no      do not use optimizer
     -o*      output file name
     -sf      split function sections
     -v       verbose
```

Code generator Option Usage

Option	Description
-a	optimize *_asm* code. By default, the assembly code inserted by a *_asm* call is left unchanged by the optimizer.
-bss	inhibit generating code into the *bss* section.
-ck	enable stack overflow checking.

Code generator Option Usage (cont.)

Option	Description
-ct	output constant in the **.text** section. By default, the compiler outputs literals and constants in the **.const** section.
-dl#	produce line number information. **#** must be either '**1**' or '**2**'. Line number information can be produced in two ways: *1)* function name and line number is obtained by specifying **-dl1**; *2)* file name and line number is obtained by specifying **-dl2**. All information is coded in symbols that are in the debug symbol table.
+e*	log errors in the text file ***** instead of displaying the messages on the terminal screen.
-f	merge all C source lines of functions producing code into the C and Assembly listing. By default, only C lines actually producing assembly code are shown in the listing.
-fl	use *callf* instruction for machine library calls, used for models allowing large applications. By default, machine library functions are called with a *call* instruction allowing only 64K application. This option is configured by the memory model selection.
-l	merge C source listing with assembly language code; listing output defaults to *<file>.ls*.
-na	do not produce an *xdef* directive for the *equate* names created for each C object declared with an absolute address.
-nc	do not allow functions to cross a section boundary.
-no	do not produce special directives for the post-optimizer.
-o*	write the output to the file * and write error messages to STDOUT. The default is STDOUT for output and STDERR for error messages.
-sf	produce each function in a different section, thus allowing the linker to suppress a function if it is not used by the application. By default, all the functions are packed in a single section.
-v	When this option is set, each function name is send to STDERR when *cgstm8* starts processing it.

Return Status

cgstm8 returns success if it produces no diagnostics.

Example

cgstm8 usually follows *cpstm8* as follows:

```
cpstm8 -o \2.cx1 -u -i\cosmic\hstm8 file.c
cgstm8 -o \2.cx2 \2.cx1
```

The costm8 Assembly Language Optimizer

costm8 is the code optimizing pass of the C compiler. It reads source files of STM8 assembly language source code, as generated by the *cgstm8* code generator, and writes assembly language statements. *costm8* is a peephole optimizer; it works by checking lines function by function for specific patterns. If the patterns are present, *costm8* replaces the lines where the patterns occur with an optimized line or set of lines. It repeatedly checks replaced patterns for further optimizations until no more are possible. It deals with redundant load/store operations, constants, stack handling, and other operations.

Command Line Options

costm8 accepts the following options, each of which is described in detail below:

```
costm8 [options] <file>
      -c       keep original lines as comments
      -d*      disable specific optimizations
      -f#      minimum code factorization
      -o*      output file name
      -v       print efficiency statistics
```

Optimizer Option Usage

Option	Description
-c	leave removed instructions as comments in the output file.
-d*	specify a list of codes allowing specific optimizations functions to be selectively disabled.
-f#	define the minimum of bytes for activating the code factorization. Any value smaller than 4 disables the feature. The default value is 7.
-o*	write the output to the file * and write error messages to STDOUT. The default is STDOUT for output and STDERR for error messages.
-v	write a log of modifications to STDERR. This displays the number of removed instructions followed by the number of modified instructions.

If <*file*> is present, it is used as the input file instead of the default STDIN.

Disabling Optimization

When using the optimizer with the **-c** option, lines which are changed or removed are kept in the assembly source as comment, followed by a code composed with a letter and a digit, identifying the internal function which performs the optimization. If an optimization appears to do something wrong, it is possible to disable selectively that function by specifying its code with the **-d** option. Several functions can be disabled by specifying a list of codes without any whitespaces. The code letter can be enter both lower or uppercase.

Return Status

costm8 returns success if it produces no diagnostics.

Example

costm8 is usually invoked after *cgstm8* as follows:

```
cpstm8 -o \2.cx1 -u -i\cosmic\hstm8 file.c
cgstm8 -o \2.cx2 \2.cx1
costm8 -o file.s \2.cx2
```

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