ST6 Assembler-Linker (AST6-LST6) User Manual

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1 INTRODUCTION

AST6 is a macro-assembler that translates files that are written in assembler language into either executable files or object files. Executable files are files that are loaded into ST6 microcontrollers and can then be executed. Object files are intermediate files that you link together, forming a single executable file, using the LST6 linker. Whether you use AST6 to create an executable file, or create object files using AST6 then use LST6 to link them depends on your programming strategy, this is discussed later in this introduction.

AST6 and LST6 support the whole range of ST6 microcontrollers, including all variations and specifications.

1.1 Installing the ST6 Assember-Linker (AST6-LST6) software

1 Place the *MCU on CD* CD-ROM in your CD-ROM drive. The CD-ROM's autorun feature opens up a welcome screen on your PC.

If the autorun feature does not work, use Windows® Explorer to browse to the CD-ROM's root folder, and double-click on `welcome.exe`.

2 Select ***Install Your Development Tools*** from the list of options. A new screen appears listing the different families of STMicroelectronics MCUs.

3 Use your mouse to place the cursor over the ***ST6 TOOLS*** option. Choose ***ST TOOLS*** and ***ST6 TOOLCHAIN*** from the lists that appear.

4 The install wizard is launched. Follow the instructions that appear on the screen.

You can choose the package you wish to install. To install the complete ST6 Toolchain, select the **"Complete Toolchain"** option . This option will install the WGDB6 debugger version your , as well as a Windows Epromer and ST6 Assembler-Linker software.

Alternatively, you can choose to perform a custom installation where you choose which of the available software applications you wish to install.

*Note: If you do not choose any options, but click **Next>**, the ST6 Assembler-Linker will be installed by default.*

5 Follow the instructions that appear on your screen. You will be prompted to select the parallel port you wish to connect the emulator to, as well as the program folder that the software will be installed to.

1.2 Launching the ST6 Assembler-Linker

From Windows® 95, 98 or Windows® NT, click the **Start** button, point to **Programs** -> **ST6 Tool Chain -> Development Tools -> Assembler-Linker**. A MS-DOS window will open, with an `st6toolchain/asm/` prompt, ready for you to enter an AST6 line command.

1.3 How To Use This Guide

This guide provides background information and instructions on how to develop applications for AST6 and LST6.

Chapter 3 through to *Chapter 8* describe AST6 and LST6 features and the options available to you when developing programs for them. You should read these sections before attempting to develop AST6/LST6 applications.

Chapter 9 summarizes the directives and options you must use in relation to the structure of your application, and the tasks you must carry out during the application development process.

Chapter 10 and *Chapter 11* describe how to run AST6 and LST6, and the error messages they may return.

Chapter 12 describes all the AST6 and LST6 directives, and gives instructions on how to use them.

1.4 What Is Assembler Language?

Assembler language is a symbolic code in which you develop applications. Symbolic code is made up of mnemonics and operands. Mnemonics are commands that have meaningful names, for example the ADD mnemonic adds two values together. Operands express complementary information to commands, such as addresses and values. You can also use meaningful names in operands. For example, a calendar application could use the symbolic name DATE for the current date. Using symbolic mnemonics and operands simplifies the application development process, by letting you use meaningful names in your application. Files containing symbolic code are called source files.

Assembler programs are made up of the following elements:

- Machine instructions, or opcodes.
- Assembler Directives.

Machine instructions are codes that can be executed by the microcontroller without translation. Refer to the Databook for the ST6 microcontroller you are using for a full description of the machine instructions that it supports.

Assembler directives control the assembly process. They can be used, for example, to define macros, or specify where in the microcontroller's memory, executable code and data are stored. The AST6 and LST6 directives are listed in *Chapter 12* on page 69.

The source files in which you develop your application, and thus enter directives and machine instructions, have the extension **.ASM**. You can write them using any ASCII text editor.

1.5 Programming Strategies

Before you start developing an ST6 application, you must decide:

- Whether you want to develop your program in either modular source files or a single source file.
- Whether or not you will use the paged program space feature. This feature is described *Section 4.3* on page 30.

The choice you make determines the process you perform to generate the final, executable file.

1.5.1 Using Modular Source Files

Using modular source files means developing your program in a number of modules. Each module is held in a separate source file. The advantages of developing your program in modular source files are:

- Small programs are easier to debug, understand and maintain than large programs.
- You can test the output of a module in relation to the process it performs on the inputs.
- You can reuse modules in other programs.

1.5.2 Using Paged Program Space

The decision as to whether you use the paged program space is simple: if the final executable file will require more than 4 Kbytes of memory when loaded into the ST6, you must use the paged program space feature. Otherwise, you do not have to use it.

If you develop your program in modular source files, or if you use the paged program space feature, you must carry out the following steps in order to generate an executable file:

1 Assemble each of the source files that make up the program individually, using AST6. Assembled modular source files are called relocatable object files, and have the extension **.OBJ**. The word relocatable is used, because the exact location that the generated object code will have in the ST6 memory is unknown. To generate these you must run AST6 with the **-O** option (see *Chapter 10* on page 61).

2 Link the assembled object files into a single, executable file, using LST6. Executable files have the extension **.HEX**. The default file name generated by LST6 is ST6.HEX. You can change this using the **-O** option when you run LST6.

1.5.3 Using a Single Source File

If you are developing a small program, that does not exceed 4 Kbytes, the advantages of working with modular source files may not apply and you do not have to use the paged program space feature. In this case, it is simpler to develop your application in one module, since you can generate an executable file using AST6, without having to go through the linkage phase using LST6. The file generated by AST6 from a single-source file is called an absolute object, since you specify the exact location of the executable file in the ST6 memory using the .ORG directive (see *Section 12.3.27* on page 86).

1.6 Debugging Executable Files

Once you have generated your executable files, you can test and debug them using either the Windows-based ST6 program debugger, WGDB6, or the DOS-based ST6 program debugger, ST6NDB. Both debuggers simulate the behavior of your program when it is loaded into an ST6 microcontroller using either ST6 Simulator or the ST6 HDS Emulator.

The ST6 Simulator is a program that simulates the execution of ST6 programs. You can use it with either Wave Form Editor, that simulates ST6 pin output, or the Starter Kit board, that can emulate all transactions with the ST6 data space and peripherals.

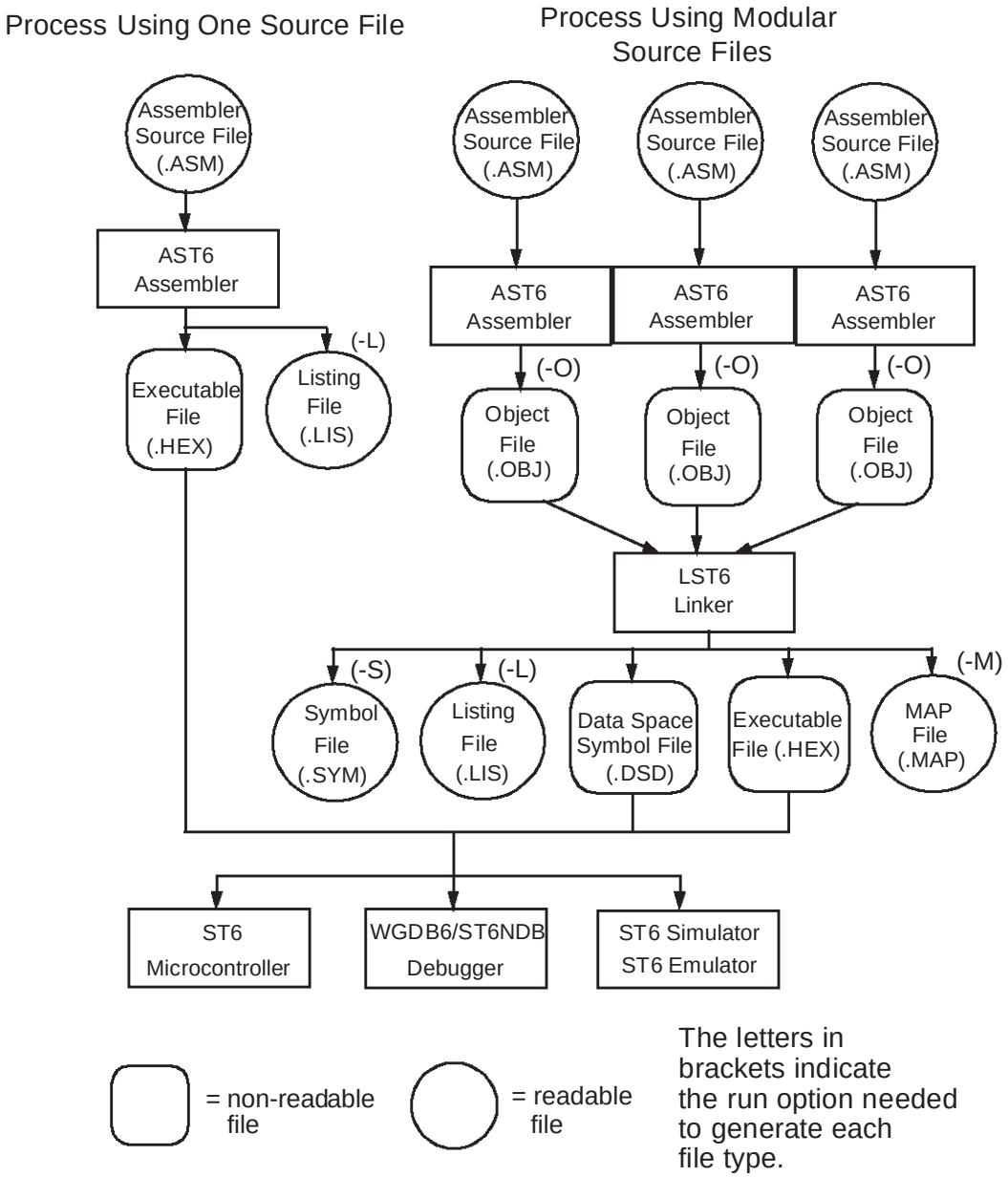
The ST6 HDS Emulator is a hardware system that enables real-time execution of ST6 applications.

Note that if you want to use either of the debuggers, you must generate **.DSD** and **.SYM** files during the assembly and link phases. Refer to *Chapter 9* on page 59 for instructions on how to generate these files.

1.7 Loading Executable Files into ST6 Microcontrollers

Once your program is ready, you can load it into ST6 microcontrollers using the EPROM programmer.

The following diagram summarizes the assembly and link processes.



1.8 ST6 Memory Structure

The ST6 memory is divided into two principal components, the program space and the data space.

The program space is an area of ROM in which the instructions to be executed, the data required for immediate addressing mode instructions, and the user-defined vectors are stored. It is addressed using the 12-bit Program Counter register. ST6 microcontrollers that have more than 4 Kbyte ROM optionally feature a paged program space. This means that the ROM consists of a static area and up to 30 dynamic pages. When referencing a page, the page is selected using the Program ROM Page Register (PRPR).

Using program space pagination imposes a number of program structure requirements. Refer to *Chapter 4* on page 29 for further details.

Source code that is stored in the program space can be divided into sections. Sections are identified by a number, from 0 to 32. Each section starts at address 0 for the current module. Sections enable you to write source code in any order, but specify the order in which they are linked into the final executable code. During the link edit phase, sections are allocated to pages. By default, LST6 allocates sections to pages by matching section numbers to page numbers, thus section 0 is allocated to page 0, section 1 is allocated to page 1, and so on. The default size of a section is 2 Kbytes, however you can modify this, as well as define which section is stored in each page, using the -P option when you run LST6. You can allocate any number of sections, from any source file, to a page in the program memory, as long as their total size does not exceed that of the page, which is 2 Kbytes.

The data space is an area of RAM memory that stores all the data required by the program. It also stores the standard ST6 registers. ST6 microcontrollers that have more than 64 byte RAM feature a paginated data space. In paginated ST6 data spaces, the area between addresses 0 and 3Fh is paginated into 64-byte RAM and EEPROM pages. When referencing data in a paged area, the page is selected using the Data RAM/EEPROM Bank Register (DRBR).

To provide you with additional data space, ST62 and ST63 family chips let you store read-only data, such as look up tables and constants in the program space. The area of program space used for storing data space information is called a Data ROM Window.

2 GLOSSARY OF TERMS

absolute object file. An object file whose location in memory is defined in the source code using the .ORG directive. Absolute objects are can only be generated from programs that are coded in one source file.

addressing mode. In order to decrease the size of instructions, and thus the space they take in the program memory and the time needed to execute them, instructions have different addressing modes, based on the minimum addressing information required for each instruction.

assembler language. A symbolic code in which you develop applications, and that is translated into object or executable files using an assembler.

AST6. The ST6 family macro-assembler that translates files that are written in assembler language into either executable files or object files.

conditional assembly. The use of conditions in source files, according to which the subsequent lines of code are or are not assembled. Conditional assembly can be used to generate different program versions or executable files for different ST6 microcontrollers from the same source file.

cross reference table file (.X). A file that lists the symbols used in a program, and specifies the numbers of the lines that define or reference each symbol.

Data RAM/EEPROM Bank register (DRBR). A register that selects the data page to be accessed by the subsequent instruction(s).

Data ROM Window. An area in the data space (RAM) through which you can access read-only data, such as look up tables and constants, that is stored in blocks of up to 64 Kbytes in the program space (ROM).

Data ROM Window Register (DRWR). A register that, together with an instruction address, specifies the block of data in the program space to be accessed via the Data ROM Window.

data space. An area of RAM memory that stores all the data required by the program and the standard ST6 registers.

data space symbol file (.dsd). A file that lists the data space symbols defined by a program. DSD files are required by the ST6 debuggers.

directives. Commands that control the assembly process. They can be used, for example, to define macros, or specify how executable code or data are stored in the microcontroller's memory.

dynamic pages. Virtual pages in the paged area of the program space. They are repetitions of the same area of ROM whose real address is 0 to 7FFh. Each dynamic page has a virtual address to distinguish it from the others.

emulator. A hardware device that simulates ST6 microcontrollers, enabling real-time execution of ST6 applications.

entry point. The starting address from which executable files are written to the program space.

error report file (.err). A file to which error and warning messages that are generated during assembly and linkage are optionally written.

executable file (.hex). A file that is ready to be loaded to a microcontroller and executed. ST6 executable file are in the Intel-HEX format.

expression. A constant or symbol, or any combination of the two, separated by an arithmetic operator.

external label. Labels that are external to a module are those that are defined in another module.

global symbol. Symbols that are defined in one source module, but that can be used by others.

label. A meaningful name that can be used to specify a memory location or symbol.

linker memory map file (.map). Linker memory map files list the start, end and size of all the sections in the program and the start locations and sizes of relocatable objects.

listing file (.lis). An ASCII text file that shows the lines of generated object code together with the source code they were generated from.

LST6. The ST6 family linker, that links relocatable objects (assembled source file modules) into a single, executable file that can be loaded into the ST6 memory.

machine instructions. Codes that can be executed by the microcontroller without translation. Machine instructions are also called opcodes.

macro. A sequence of assembler instructions and directives that can be inserted into the source program in place of the macro name. Macros enable you to simplify code and reduce code development time by reusing frequently-used functions.

macro-assembler. An assembler that includes macro-generation capabilities.

map section. A section that can be included at the end of a listing file of an absolute object, that lists the name, type and size of each section.

mnemonic. An instruction that is converted into machine code by the assembler. Mnemonics have meaningful names, for example the ADD mnemonic adds two values together.

object file (.obj). The file that is assembled from a source file that is one of many source files on which a program is coded. The assembled object files that make up a complete program must be linked using LST6 to create the final executable file.

opcode. See Machine Instructions.

operand. The part of an instruction line that specifies complementary information for the instruction. Operands may contain:

- Numbers
- String and character constants
- Program Counter References
- Expressions

paging. A way of increasing the size of the data space, the program space or both to beyond that of their addressable areas. This is done by duplicating an area of each space into ‘pages’. Pages are not physical areas of memory, they are repetitions of the same area, that are distinguished using virtual addresses.

program counter. A 12-bit register that points to the address of the instruction currently being executed in the program space.

Program ROM Page Register (PRPR). A register that indicates the program space page to be accessed.

program space. The area of ROM memory in an ST6 microcontroller in which programs are stored.

relocatable object. The separately-assembled source files that make up a program. The word relocatable is used because the exact location that the generated object code will have in the ST6 memory is unknown.

ROM Masking. A process that involves manually filling all reserved and unused areas of ROM with a predefined value. ROM masking is recommended, since it improves the reliability of your program when it is executed in the microcontroller.

sections. Divisions of code enabling you to write source code in any order, but specify the order in which they are linked into the final assembled code. During the link edit phase, sections are allocated to pages. By default, LST6 allocates sections to pages by matching section numbers to page numbers, thus section 0 is allocated to page 0, section 1 is allocated to page 1, and so on.

source file (.asm).An ASCII text file, in which you write source program code. Source files are made up of lines, each of which is terminated by a new line characters. Each line may contain labels, mnemonics, operands and comments.

static area. The real addressable area of ROM. It includes two static pages:

- Page 1, which is the second page within the overlaid area.
- Page 32, which located in the area between addresses 0FF0h and 0FFFh, and is thus not in the paginated area.

symbol table file (.sym). A file that lists the value and type of each symbol in an assembled program. Symbol table files are required by ST6 hardware emulators.

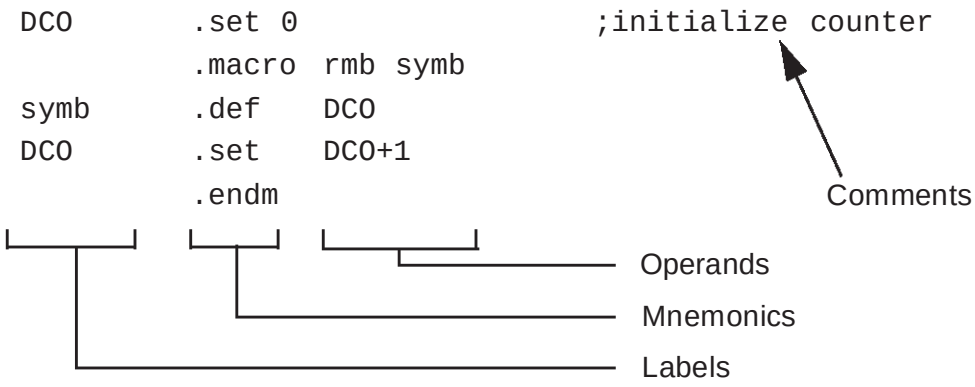
3 AST6 AND LST6 SOURCE AND GENERATED FILES

This section describes the format of AST6 source files, and the output files that AST6 and LST6 generate either automatically or when requested.

3.1 Source Files

AST6 source files have the extension **.asm**. They are made up of lines, each of which is terminated by a new line character.

Source files have the following format:



Each line may contain up to four types of information:

- Labels, which let you specify a memory location or symbol using a meaningful name.
- Mnemonics, which are instructions that are converted into machine code.
- Operands, which specify complementary information for an instruction, such as contents and symbols.
- Comments

These types of information must be entered in the above order. Each type of information must be separated by one or more spaces. The total width of a line can not exceed 400 characters. The following paragraphs describe labels, mnemonics and operands.

3.1.1 Labels

Labels let you specify a memory location or symbol using a meaningful name. When a label is defined, it takes the current value of the address counter.

Labels must start in column one. A label may contain up to eight of any of the following characters:

- Upper case letters (A - Z)
- Lower case letters (a - z)
- Digits (0 - 9)
- Dollar sign ($)
- Underscore (_)

The first character of a label must be a letter or an underscore. Labels are case sensitive.

3.1.2 Mnemonics

Mnemonics must be separated from the preceding label (if there is one) by a space or a tab. Mnemonics can be the name of a machine instruction, an assembler directive code or a macro call. If a mnemonic is omitted from a line, the program counter is assigned to the label (if present).

3.1.3 Operands

Operands must be separated from mnemonics by one or more spaces. If more than one operand is used, the operands must be separated by commas. Operands may include:

- Numbers
- String and character constants
- Program Counter References
- Expressions

The following paragraphs describe these.

3.1.3.1 Numbers

The default radix for numbers is decimal. You can use numbers in other formats by following the number with the appropriate letter:

This letter:	Indicates this radix:
b or B	Binary
o or O	Octal
h or H	Hexadecimal

In hexadecimal, the decimal digits 10 - 15 are represented by upper or lowercase letters from A to F. Hexadecimal numbers that start with a letter must be preceded by the number 0. All numbers are defined as 16-bit signed values.

For example, the decimal value 45 is represented by 01000101b in binary, 55o in octal, and 2dh in hexadecimal.

3.1.3.2 String and Character Constants

String constants are strings of ASCII characters enclosed by double quotes. For example: “This is an ASCII string”. Character constants are single ASCII character enclosed by single quotes. For example ‘T’.

3.1.3.3 Program Counter Reference

You can use the $ sign to identify the current value of the program counter (PC) in program space operands.

3.1.3.4 Expressions

Expressions in operands may contain numbers, labels or PC-relative references, separated by operators. Expressions are evaluated from left to right during assembly. Operators are evaluated according to their precedence, meaning that some operators are evaluated before others. Expressions within parentheses are evaluated first.

It is recommend that you use expressions containing program space symbols in jp/call instructions and variants of PC-relative instructions, such as jrr and jrs.

For example:

```
                ldi value, const1
        call subroutine1
subroutine1     ld A, value
                jrz out
                dec A
                jp subroutine1
out             ret
```

Such expressions are restricted to the following syntax:

```
expression = symbol
expression = symbol+constant_expression
expression = symbol-constant_expression
```

where ‘constant_expression’ contains absolute references only.

The following table lists the available operators and their precedence.

Operator on operand	Meaning	Priority[1]	Example
+	unary plus	1	+137
-	negation (2’s complement)	1	-137
~	Bit inversion (1’s complement)	1	~00111111 = 1100000
*	multiplication	2	38*3 = 114
/	division	2	114/3 = 38
%	modulo	2	38h%3 = 2
>> *n*	right shift[2]	2	
<< *n*	left shift[2]	2	
+	addition	3	038h+0FFh = 37h
-	subtraction	3	0FFh-038h = 0C7h
&	bitwise and	4	00001111&11111111 = 00001111
^	bitwise exclusive or	5	00001111^11111111 = 11110000
I	bitwise inclusive or	6	01001001I00010010 = 01011011

1) The lowest value has the highest priority.

2) Right shift and left shift the contents of the operand *n* places to the right or left respectively. For example:

```
sav_a   .def 08h
        ldi sav_a, 0FFh
        ldi A, sav_a >> 2    ; A=02h
        ldi A, sav_a << 2      ; A=20h
```

3.1.4 Comments

Comments are preceded by a semicolon. AST6 ignores all characters that follow a semicolon. Note that you can use semicolons in string and character constants.

3.2 Generated Files

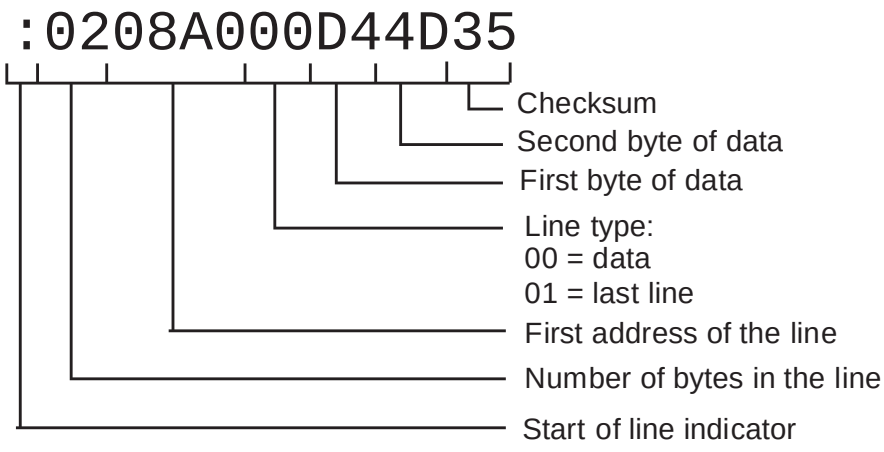
This section describes the files that are generated by AST6 and LST6.

3.2.1 Executable and Data Space Symbol Files

Executable (HEX) and data space symbol (DSD) files are automatically generated by AST6 if you run it without the -O option, or by LST6 if you use relocatable objects.

HEX files are in the INTEL-HEX format.

Below is an example line of a HEX file:



The checksum is calculated by starting at 0, then subtracting each byte from the previous result. Thus the total - the checksum = 0. For example, to calculate the checksum of the above example:

```
00-02-08-A0-00-D4-4D-35=00
```

DSD files list the symbols in the data space. They are required by the ST6 debuggers.

3.2.2 Listing Files

Listing files show the lines of generated object code together with the source code they were generated from. To output a listing file, run AST6 with the **-L** option.

If you generate relocatable objects, you can update the listing files during the linking process by running LST6 with the **-I** option. Listing files are named <prog>**.lis**, where <prog> is the name of the assembled file.

Examples:

To generate a listing file for an absolute object (single-source file program):

`AST6 -L myprog` Generates the files myprog.lis, myprog.hex and myprog.dsd.

To generate a listing file for relocatable objects (modular file programs or programs that use program space paging):

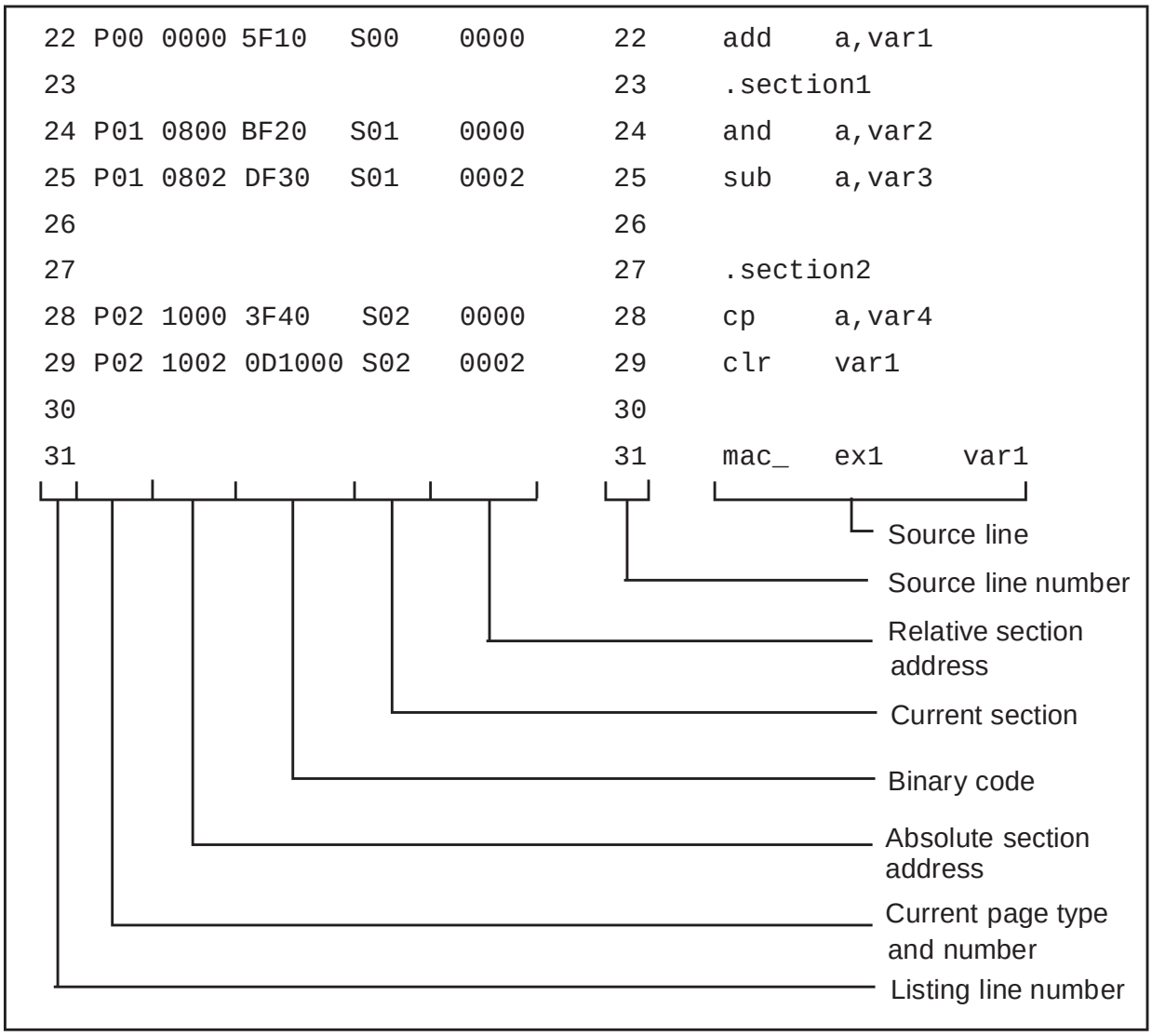
`AST6 -L -O myprog1` Generates the files myprog1.lis and myprog1.obj.

`AST6 -L -O myprog2` Generates the files myprog2.lis and myprog2.obj.

Then:

`LST6 -I -O myprog myprog1 myprog2` Updates the files myprog1.lis and myprog2.lis, and generates myprog.hex and myprog.dsd.

The following diagram shows an example AST6 listing file and describes what the various columns mean.



3.2.3 Including a Map Section

If you are using absolute objects (single-source file programs), you can include a map section at the end of listing files. If you are using relocatable objects, you can generate a separate map file using LST6 (see *Section 3.2.4* on page 25).

The following diagram shows an example map section:

```
 ** SPACE 'PAGE_0' SECTION MAP **

_____________________________________
|   name    | type |  size  |
|-----------------|--------|----------|
| PG0_0      | TEXT |   182 |
|_________________|________|__________|
Tue May 06 10:54:52 1997  file dummys.lis
page 19
** SPACE 'PAGE_1' SECTION MAP **

_____________________________________
|   name    | type |  size  |
|-----------------|--------|----------|
| PG1_0      | TEXT |   158 |
|_________________|________|__________|
Tue May 06 10:54:52 1997  file dummys.lis
page 20
** SPACE 'PAGE_32' SECTION MAP **

_____________________________________
|   name    | type |  size  |
|-----------------|--------|----------|
| PG32_0     | TEXT |    10 |
|_________________|________|__________|
```

The `type` column indicates the section type, this can be `text` for program space section or `data` for data space section.

To generate mapping information, run AST6 with the **-M** option as well as the **-L** option. For example:

`AST6 -L -M myprog` Generates the files myprog.lis which includes a map section, myprog.hex and myprog.dsd.

3.2.4 Linker Memory Maps

If you are using relocatable objects (modular file programs or programs that use program space paging), you can generate separate linker memory map files. Linker memory map files list the start, end and size of all the sections in the application and the start locations and sizes of relocatable objects. Link process errors and warnings are also reported in linker memory maps.

Below is an example line of a linker memory map:

```
 *** ST6 Linkage Editor: 'dummys' object file
Map ***
PROGRAM SECTIONS:
number  start   end     size
------  -----   ---     ----
0       0000    07FF    0182
1       0800    0F9F    014F
32      0FF0    0FFF    0010
WINDOW SECTIONS:
number  start   end     size
------  -----   ---     ----
0       0182    018A    0009
MODULE dummys.obj:
section    type    start    size
-------    ----    -----    ----
0          P       0000     0182
1          P       0800     014F
32         P       0FF0     0010
0          W       0182     0009
```

The `type` column in linker memory maps indicates the section type, this can be `P` for program space section or `W` for Data ROM Window section.

To generate a linker memory map, run LST6 with the **-M** option. The default linker memory map name is **ST6.MAP**. You can specify your own name by including the -**O** option when running LST6. In this case the file is named <prog>**.MAP**, where <prog> is the name of the assembled file. For example, the command:

LST6 -M -O myprog myprog1 myprog2

generates the files myprog.sym, myprog.hex and myprog.dsd.

3.2.5 Cross Reference Tables

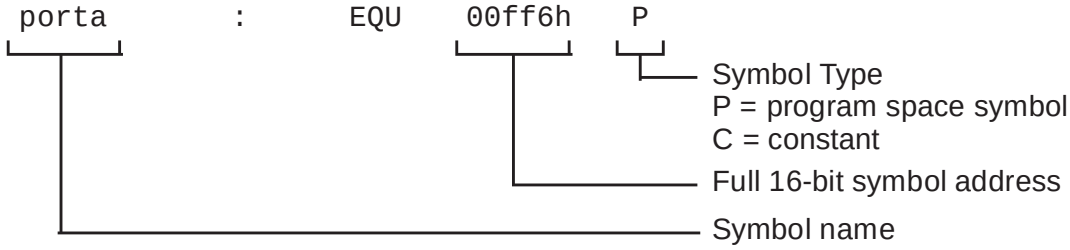
If you are using absolute objects (single-source file programs), you can generate cross-reference tables. These list, for each symbol, the numbers of the lines that define or reference that symbol. The line number that defines the symbol is followed by an asterisk (*). To generate a cross-reference table, run AST6 with the **-X** option. Cross reference tables are named <prog>**.X**, where <prog> is the name of the assembled file. For example, the command:

```
AST6 -X myprog
```

generates the file **myprog.X**

3.2.6 Symbol Table Files

Symbol table files list the value and type of each symbol in the assembled code. You must generate a symbol table file if you want to test your program using an emulator. Below is an example line of a symbol table file:



If you are using absolute objects (single-source file programs), to generate a symbol table file, run AST6 with the **-S** option. AST6 symbol table files are named <prog>**.sym**, where <prog> is the name of the assembled file. For example, the command:

```
AST6 myprog -S
```

generates the file **myprog.sym**

If you are using relocatable objects (modular file programs or programs that use program space paging), to generate a symbol table file, run LST6 with the **-S** option. The symbol table file is named **ST6.SYM** by default. You can specify your own name by including the -O option when running LST6. In this case the file is named <prog>**.SYM**, where <prog> is the name of the assembled file. For example, the command:

```
LST6 -S -O myprog myprog1 myprog2
```

generates the files myprog.map, myprog.hex and myprog.dsd.

*Note: If you run AST6 with the **-O** option (to generate a relocatable object), symbol table file generation is disabled, since in this case the program space symbols are defined in the link edit process.*

3.2.7 Error Reports

By default, AST6 error and warning messages are displayed on screen, and written to the listing file if you run AST6 with the **-L** option. You can choose to record error and warning messages in a separate error file, by running AST6 with the **-E** option. Error files are named <prog>**.err**, where <prog> is the name of the assembled file. For example, the command:

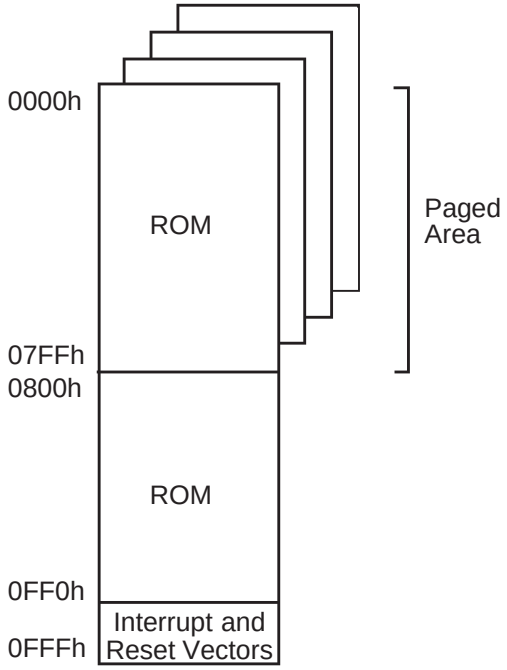
```
AST6 -E myprog
```

generates the file **myprog.err**

LST6 writes errors to the file **stdout**.

4 WORKING WITH THE PROGRAM SPACE

The program space is an area of ROM memory in which the instructions to be executed, the data required for immediate addressing mode instructions, and the user-defined vectors are stored. It is addressed using the 12-bit Program Counter register. The following diagram shows the ST6 program space structure.



4.1 Protecting Reserved Memory Areas

Certain areas of the program space are reserved, and must not be overwritten with program code. The addresses of the reserved areas are different for each ST6 type, refer to the Databook for the ST6 you are using for further details.

To prevent reserved areas from being overwritten with program code, use the .BLOCK directive. When the AST6 reaches the .BLOCK directive, it skips the number of bytes specified in the .BLOCK operand. Refer to *Section 12.3.2* on page 72.

For example, the .BLOCK directive in the following lines of code prevents the area from 0FF8h to 0FFBh from being overwritten:

```
;****Interrupt vectors****
    .section 32     ;Starts at 0FF0h
    jp dummy        ;AD converter Interrupt vector
    jp tim_int      ;TIMER Interrupt vector
    jp dummy        ;PORT B/C Interrupt vector
    jp dummy        ;PORT A Interrupt vector
    .block 4
    jp dummy        ;NMI Interrupt vector
    jp reset        ;RESET vector
```

4.2 Using Absolute Objects

You can generate absolute objects if your program is made up of one module only and you are not using a paged program memory. In this case, you can generate an executable file using AST6 only.

When developing absolute object applications, use the .ORG directive to specify the location of object code in the ST6 memory (see *Section 12.3.27* on page 86). .ORG specifies the starting address or the subsequent code.

Note that you can also use paging with single-source programs. See *Section 4.3.1* on page 31 for further details.

4.3 Paged Program Memory

ST6 microcontrollers that have more than 4 Kbytes of ROM feature a paginated program space.

This means that the ROM consists of a static area and up to 30 dynamic pages. Dynamic pages are virtual, they are repetitions of the same area of ROM whose real address is 0 to 7FFh. Each dynamic page has a virtual address to distinguish it from the others. Virtual address are allocated in relation to the page number, as shown in the table below.

The static area is the real addressable area of ROM. It includes two static pages:

- Page 1, which is the second page within the overlaid area.
- Page 32, which located in the area between addresses 0FF0h and 0FFFh, and is thus not in the overlaid area. Page 32 stores the interrupt and reset vectors.

It is better to think of pages 1 and 32 as areas of static ROM, although they are addressed as if they were pages.

To reference a page, the required page is selected using the Program ROM Page Register (PRPR).

You can perform jumps from the static area to any of the dynamic pages. You cannot, however jump directly from one dynamic page to another without first jumping to the static area. The following table shows the paged memory characteristics:

Page No.	Virtual Address	Real Address	Can jump to
0	0000 to 07FF	0000 to 07FF	Page 1
1	0800 to 0FEF	0800 to 0FEF	All pages
2	1000 to 17FF	0000 to 07FF	Page 1
3	1800 to 1FFF	0000 to 07FF	Page 1
n = 4 to 31	[n*800]-[(9n*80)+7FF]	0000 to 07FF	Page 1
32	0FF0 to 0FFF	0FF0 to 0FFF	All pages

The use of pages 2 to 31 is optional: use as many as are required to store your program.

4.3.1 Single-source Programs and Paging

You can also develop programs that have a single source file, and that are not linked using LST6, but do use the default sections: section 0, section 1 and section 32. To do this, all you have to do is include the .PP_ON directive at the beginning of the source file. In this case, you can use the .SECTION directive to specify the origin of your source file instead of .ORG.

4.4 Developing Programs for the Paged Area

Source code that uses paged memory must be divided into sections. Each section is a block of code that can be allocated to a page during the link phase. Each section starts at address 0 for the current module. Developing programs in sections has the advantage that sections enable you to write source code in any order, but specify the order in which they are linked into the final assembled code. You can allocate any number of sections, from any source file, to a page in the program memory, provided their total size does not exceed that of the page, which is 2 Kbytes.

By default, LST6 allocates sections to pages by matching section numbers to page numbers, thus section 0 is allocated to page 0, section 1 is allocated to page 1, and so on. If you define more than once section with the same number, the sections are

mapped to their appropriate pages contiguously, in the order in which their holding modules are listed when AST6 is executed.

The default size of a section is 2 Kbytes, however you can modify this, as well as define which section is stored in which page, using the **-P** option when you run LST6.

Allocating sections to pages using the **-P** option can be useful in two cases:

- For locating parts of the program, such as interrupt vectors, during the debugging phase.
- For limiting the memory space taken by final executable code and ensuring it is not written to any reserved areas of memory.

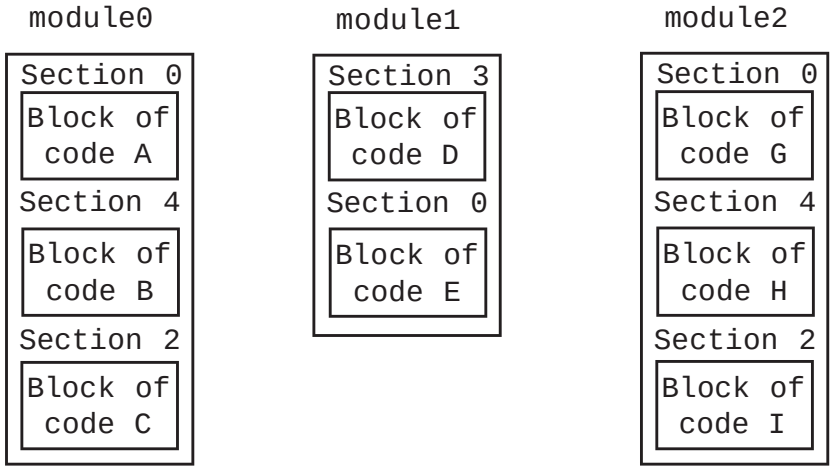
The **-P** option has the following format: **-P**<n>:<start>-<end>, where <n> is the section number, <start> is the start address and <end> is the end address. For example, the command:

```
LST6 -P0:000-3FF -P10:400-7FF
```

places section 10 in program page 0, at offset 400h.

The .SECTION directive enables you to divide modules into sections. The following diagram shows how LST6 allocates sections to pages when the -P option is not used:

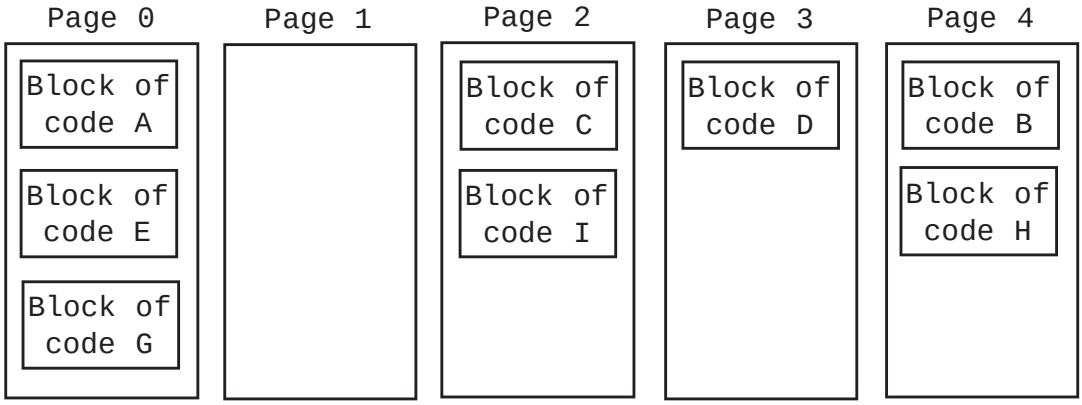
These modules:



Assembled as follows:

```
AST6 module0
AST6 module1
AST6 module2
```

Are mapped as follows:



You must assemble source files that use paged memory as relocatable objects, by executing AST6 with the -O option (see *Chapter 10* on page 61).

Note: To be able to use this feature, you must include the .PP_ON directive in your source code.

4.4.1 Accessing Paged Program Space

The Program ROM Page Register (PRPR) selects the page to be accessed. To simplify the use of the PRPR, you can use the <label>.P notation to load the location of the specified label to the PRPR. Thus, when jumping from one dynamic page to another, a jump is first made to page 1, where the <label>.P notation is used to load the target page. The jump is then made to the target. The following example shows how to program a jump from section 4 to section 5 (that are mapped to different pages during link editing):

```
          .pp_on
PRPR      .def 0cah        ; define PRPR
          .section 4
;         ...
          jp prs1          ;Jump to PRPR setter in page 1
caller    nop
          .section 1
          ...
prs1      ldi PRPR,target.p;set the page holding the label
                           ”target” in PRPR
          jp target        ;jump to the label ”target”
return    jp caller        ; return to calling section
;         ...
          .section 5
;         ...
target    nop              ;Start the process
;         ...
          jp return        ;return to page 1
```

4.5 ROM Masking

ROM masking means manually filling all reserved and unused areas of ROM with a predefined value. ROM masking is recommended, since it improves the reliability of your program when it is executed in the microcontroller. To implement ROM masking, you must execute LST6, or AST6 if LST6 is not being used, with the -D option. By default, reserved and unused areas are filled with the value FFh. You can change this by specifying the value you want to use after the -D option (see the examples below). To enable AST6 or LST6 to perform ROM masking, you must provide the following information:

- The target ST6 type, by including the .VERS directive in your source file. See *Section 12.3.36* on page 90.

- The size of the ROM in the target ST6, by including the .ROMSIZE directive in your source file. See *Section 12.3.31* on page 87.

Examples:

The following lines of source code define the target as being an ST6200, with 1 Kbyte ROM.

```
.VERS ”ST6200”
.ROMSIZE 1
```

The following command fills reserved and unused areas with the value 04h (the NOP instruction):

```
ast6 -d04 myprog
```

The following commands fill reserved and unused areas with the value FFh:

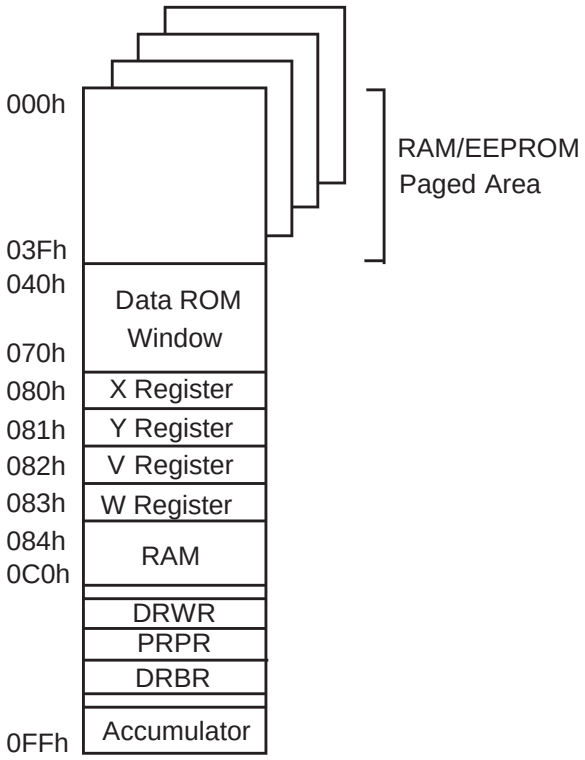
```
ast6 -O myprog
lst6 -d myprog
```

The following commands generate the file myprog.hex from myprog1.obj and myprog2.obj, and fill reserved and unused areas with the value 04h:

```
ast6 -O myprog1
ast6 -O myprog2
lst6 -d04 -O myprog myprog1 myprog2
```

5 WORKING WITH THE DATA SPACE

The data space is an area of RAM memory that stores the data required by the program. It also stores the accumulator, indirect registers, short direct registers I/O port registers, the peripheral data and control registers, the Data ROM Window register and the Data ROM Window (see the Databook for the ST6 microprocessor you are using for further details of its memory configuration). The following diagram shows the structure of the ST6 data space:



You must define the characteristics of each byte that you want to use in the data space using the .DEF directive (see *Section 12.3.5* on page 73). This includes the standard registers listed above. .DEF enables you to associate a label with an address and define the following characteristics:

- Read and write access.
- Its value.
- Whether or not it is referenced in the .DSD file, which is used by the ST6 hardware emulator.

For example, all data space definition sections will include the following lines, defining the accumulator (A) and the Index registers (X, Y, V and W):

```
a    .def       0ffh, 0ffh, 0ffh
x    .def       80h, 0ffh, 0ffh
y    .def       81h, 0ffh, 0ffh
```

```
w    .def       82h, 0ffh, 0ffh
v    .def       83h, 0ffh, 0ffh
```

You cannot export data space symbol definitions, and thus share them with all the source modules that make up a program, using the .GLOBAL directive. You should therefore place all .DEF definitions in a separate file, that is included at the beginning of each source module using the .INPUT directive (see *Section 12.3.18* on page 79). An example of such a file is given in *Section 5.1* on page 39.

Such multiple definition, however will cause a problem during the link edit phase: LST6 will find as many definitions of the same addresses as there are modules, and will thus generate appropriate error messages. This problem can be overcome by preventing the multiple transmission of the definitions to LST6 using the .NOTRANSMIT and .TRANSMIT directives (see *Section 12.3.35* on page 90). You must, however allow the transmission of the definitions file for one module, so that its details are stored in the .DSD file.

The following example shows how to include a file named defs.h in the beginning of the source modules that make up an application:

```
;module 1
          .INPUT ”defs.h”
;...
;module 2
          .NOTRANSMIT
          .INPUT ”defs.h”
          .TRANSMIT
;...
;defs.h
          .pp_on
a         .def ffh
;...
```

An alternative approach is to create a macro for defining data space definitions. For example:

```
DC0       .set 0     ;initialize data space location
                     ;counter
          .macro rmb symb
symb      .def DC0
DC0       .set DC0+1
          .endm
          rmb var1
          rmb var2
```

5.1 Example Data Space Definitions File

The following example data definitions file defines the data space for an ST626x microcontroller.

```
; ************************************
; *  REGISTER/VARIABLE DECLARATION *
; ************************************
x    .def 080h,0ffh,0ffh,m
y    .def 081h,0ffh,0ffh,m
v    .def 082h,0ffh,0ffh,m
w    .def 083h,0ffh,0ffh,m
a    .def 0ffh,0ffh,0ffh,m
IOR  .def 0c8h,0ffh,0ffh; Interrupt Option Register
DRWR.def 0c9h,0ffh,0ffh; DATA ROM Window Register
;    **************
;    *   PORT A   *
;    **************
DRA  .def 0c0h,0ffh,0ffh; Data Register A
DDRA.def 0c4h,0ffh,0ffh; Data Direction Register A
OPRA.def 0cch,0ffh,0ffh; Option register A
;    **************
;    *   PORT B   *
;    **************
DRB  .def 0c1h,0ffh,0ffh; Data Register B
DDRB.def 0c5h,0ffh,0ffh; Data Direction Register B
OPRB.def 0cdh,0ffh,0ffh; Option register B
;    **************
;    *   PORT C   *
;    **************
DRC  .def 0c2h,0ffh,0ffh; Data Register C
DDRC.def 0c6h,0ffh,0ffh; Data Direction Register C
OPRC.def 0ceh,0ffh,0ffh; Option register C
;    **************
;    * A/D CONVER *
;    **************
ADCR.def 0d1h,0ffh,0ffh; Control register
ADR  .def 0d0h,0ffh,0ffh; DATA register (result of conversion)
```

```
;    **************
;    *    TIMER     *
;    **************
;TSCR1.def 0d4h,0ffh,0ffh ; TIMER STATUS control register
;TCR1.def 0d3h,0ffh,0ffh  ; TIMER COUNTER register
;PSC1.def 0d2h,0ffh,0ffh  ; TIMER PRESCALER register
;    *********************
;    * AUTO RELOAD TIMER *
;    *********************
ARMC.def 0d5h,0ffh,0ffh   ; AR MODE control register
ARSC0.def 0d6h,0ffh,0ffh  ; AR STATUS control register 0
ARSC1.def 0d7h,0ffh,0ffh  ; AR STATUS control register 1
ARLR.def 0d8h,0ffh,0ffh   ; AR LOAD register
ARRC.def 0d9h,0ffh,0ffh   ; AR RELOAD/CAPTURE register
ARCP.def 0dah,0ffh,0ffh   ; AR COMPARE register

WDR .def    0d8h          ;watchdog register

psc .def    0d2h,m
tcr .def    0d3h,m
tscr.def    0d4h,m

tmz .equ    7
eti .equ    6
tout.equ    5
dout.equ    4
psi .equ    3
```

5.2 Paged Data Space

Certain ST6 microcontrollers, that have more than 64 bytes of RAM feature a paged data space. Refer to the Databook for the ST6 you are using for further details. In paged ST6 data spaces, the area between addresses 0 and 3Fh is paged into 64-byte RAM and EEPROM pages. When referencing a page, the required page is selected using the Data RAM/EEPROM Bank Register (DRBR).

To implement data space paging you must include the directive .DP_ON (see *Section 12.3.7* on page 74) in your source module.

5.2.1 Writing to Data Pages

The .PAGE_D directive defines the page to which subsequent data is written (see *Section 12.3.28* on page 86). The data following a .PAGE_D directive is written to the page number specified by the directive. For example:

```
          .DP_ON
          PAGE_D 0
v1        .def 0
v2        .def 1
;...
          .PAGE_D 1
count     .def 0
colour    .def 1
;...
```

5.2.2 Accessing Data Pages

The page of data to be accessed is defined using the Data RAM/EEPROM Bank Register (DRBR). To avoid having to set DRBR each time you want to reference a data page, you can use the <label>.P notation, that sets DRBR to the data page holding the specified label.

The DRBR register selects the data page to be accessed according to the bit number (0 to 7) that holds a 1. The DRBR is implemented in different ways, depending on the ST6 you are using (see the Databook for the ST6 microprocessor you are using for further details).

The following example shows the use of <label>.p in selecting the data space page to be accessed.

```
          .DP_ON
RAMSW     .def 0e8h
a         .def 0ffh

          .PAGE_D 2
xx        .def 0
yy        .def 1
; ...
          .PAGE_D 1
          ldi RAMSW,xx.p  ;select data page
                          containing xx
          ld a,xx
; ...
```

5.3 Using the Data ROM Window

To provide you with additional data space, ST62 and ST63 family microprocessors let you store read-only data, such as look up tables and constants, in blocks of up to 64 bytes in the program space. These blocks are accessed through the Data ROM Window. Although the blocks of data are physically located in the program space, the Data ROM Window, through which they are accessed is located at addresses 40h to 7Fh in the data space.

To implement the Data ROM Window, you must include the .W_ON directive in the beginning of your source files. You can allocate any number of blocks of data to a continuous area of up to 64 bytes in the ROM. You can create as many 64-byte blocks of data as you like within the ROM.

If you are generating relocatable object code, blocks of data to be stored in the Data ROM Window can be delimited using the .WINDOW and .WINDOWEND directives (see *Section 12.3.39* on page 91). In this case, LST6 automatically defines the defined blocks of data as accessible via the Data ROM Window, in the order in which the modules are listed when LST6 is executed. It allocates blocks of data to spaces left free in the ROM after the program sections have been allocated. It does not necessarily use all the 64 bytes available for the Data ROM Window. An example program that uses .WINDOW and .WINDOWEND is listed in *Section 5.5* on page 45.

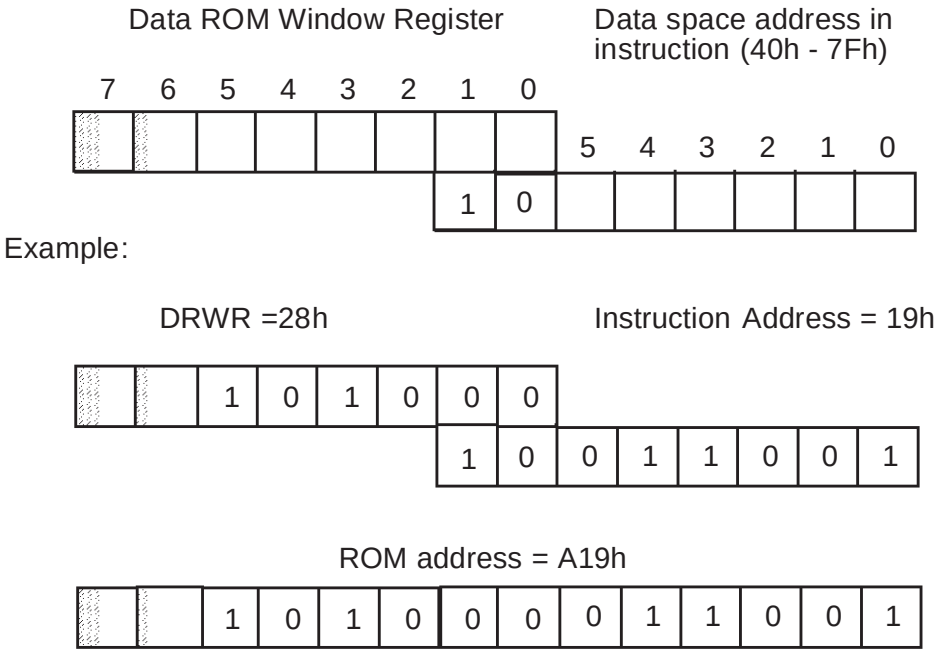
If you developing an absolute object, that will therefore not go through the link edit phase, you cannot delimit the window using .WINDOW and .WINDOWEND directives. In this case, you must define the boundary of the block of data to be accessed using the Data ROM Window using the .BLOCK directive (see the example on *page 44*).

5.4 Accessing Data Within the Data ROM Window

The location of the block of data in the ROM to be accessed by the Data ROM Window is specified by the Data ROM Window Register (DRWR) and the address operand of the instruction accessing its contents.

Bits 5 to 0 of the DRWR define the start address of the block to be accessed via the Data ROM Window. Bits 5 to 0 of the address operand define the offset of the address to be accessed from the beginning of the block pointed to by DRWR. If the block of data to be accessed is within a ROM page, the PRPR must be used to specify the page holding the block, in the same way that it is used to access any area of paginated ROM.

The following diagram shows how Data ROM Window addressing works.



5.4.1 Using <label>.D and <label>.W

To simplify the task of referencing data in the ROM via a Data ROM Window, AST6 includes two specific notations: <label>.D and <label>.W.

<label>.W enables you to set the DRWR to the block of data in ROM holding the specified label (see *Section 12.3.21* on page 82).

<label>.D enables you to set the offset to the specified label from the beginning of the block of data in ROM pointed to by the DRWR (see *Section 12.3.19* on page 80). This is then used in the instruction address.

The following example shows how to access a constant, labelled CST1, that is held in a Data ROM Window:

```
LDI DRWR, CST1.W      ;Set the DRWR to the block of
                      ;data holding CST1
LDI X, CST1.D         ;Set the X register to the
                      ;address of CST1
LDI A, 40h            ;Load the value 40h into the
                      ;accumulator
ADDI A, X             ;Add the value held in CST1 to
                      ;the accumulator contents (40h)
```

Some more complete examples of how to use the Data ROM Window are given below.

Examples:

Using WINDOW and WINDOWEND to define a block of Data ROM Window data, and label.W and label.D to reference that data:

```
            .PP_ON            ;Must be executed for LST6
            .W_ON             ;Enables the use of windows
a           .def 0ffh
x           .def 80h
DRWR        .def 0cah         ;Define Data ROM Window register
            .WINDOW
cst2        .byte 22h
string2     .ascii ”ABCDEF”
;           ...
            .WINDOWEND
.section 2
            ldi DRWR,cst2.W   ;Select block holding cst2 and
                              ;string 2
            ld a,cst2.D       ;put the address of cst2 into a
            ldi x,string2.D   ;put address of string2 into a
```

Using .BLOCK to delimit a block of Data ROM Window data, and label.W and label.D to reference that data:

```
            .PP_ON
            .W_ON             ;enables the use of windows
a           .def 0ffh
x           .def 80h
DRWR        .def 0cah         ;Define Data ROM Window register

            .section2
;           ...
            .block 64-$%64    ;Define 64-byte boundary
cst1        .byte 0ceh
string1     .ascii            ”abcdef”
;           ...
.section 0
ldi         DRW,cst1.W        ;select block holding cst1 and
                              ;string 1
```

```
            ld a,cst2.D     ;put the address of cst2 into a
            ldi x,string2.D ;put address of string2 into a
```

5.5 Example Data ROM Window Application

This example creates look-up tables in the ROM using the Data ROM Window. There are four 64-byte data tables, that are cascaded in order to provide a 256 byte non-linear correction table. For clarity, the table is applied to a linear 8-bit value, obtained from the ST6 on-chip analog-to-digital (A/D) converter. This example can easily be adapted to a wide range of applications, such as temperature sensing and control, frequency sensitivity correction, pattern generation and binary to bcd conversion.

To implement a 256-byte correction table, the two MSBs of the A/D result are used to reference one of the four 64-byte data tables. The remaining 6 LSBs of the result specify the offset from the beginning of the appropriate table.

```
;----- ST6 Table Look-up with Data ROM window
    .title  “tables.st6”
    .vers   “ST6215”
    .romsize 2
    .PP_ON                  ;enable linker
    .W_ON                   ;enable rom data window
;********************
;standard definitions
;********************
   .input “c:\st6\input\std_def.st6” ;st6 standard def file
;**********************
;local definitions here
;**********************
tablemask .equ  11000000b       ;mask for table number
offsetmask.equ 00111111b        ;mask for offset value
rdw_start .equ  040h            ;start of data-rom-window
watchtime .equ  0ffh            ;watchdog timeout period
storeacc  .def  084h,0ffh,0ffh  ;store accumulator during
INT
result    .def  085h,0ffh,0ffh,m;non-linear result storage
```

```
;**************
;initialisation
;**************
    .section 1
restart:
              reti                    ;ends reset condition
                                      ;enables nmi
    ldi   dwdr,#watchtime             ;reload watchdog
    clr   a                           ;clear the
accumulator
    set   ior4,ior                    ;enable interrupts
                                      ;configure port c
              ldi   drpc,#10h
              ldi   orpc,#10h
              ldi   ddrpc,#00h        ;pc4 is analog
;configure a/d
              set   pds,adcr          ;power up the a/d
    nop                               ;allow a/d to settle
    ldi   adcr,#0b0h                  ;enable a/d interrupt
                                      ;start conversion
;**************
;main code here
;**************
loop:         ldi   dwdr,#watchtime
              jp    loop              ;continue
;************
;subroutines
;************
;*************************
;interrupt service routines
;*************************
ad_int:       ldi   dwdr,#watchtime
              ld    storeacc,a        ;save accumulator
              ld      a,adr           ;get a/d result
    ld    y,a                         ;make another copy of a/d
                                      ;result
    andi  a,#tablemask                ;mask off lower six bits
                                      ;acc. now contains
```

```
                                        ;table number
testtab0:       cpi   a,#00000000b      ;table zero?
                jrnz  testtab1
                ldi   rdw,table0.w      ;point to table zero
                jp    offset
testtab1:       cpi   a,#01000000b      ;table one?
                jrnz  testtab2
                ldi   rdw,table1.w      ;point to table one
                jp offset
testtab2:       cpi   a,#10000000b      ;table two?
                jrnz  testtab3
                ldi   rdw,table2.w      ;point to table two
                jp offset
testtab3:       ldi   rdw,table3.w      ;point to table three
offset:                                 ;rdw now points to the
                                        ;correct table
    ld    a,y                           ;re-load a/d result
                andi  a,#offsetmask     ;mask off top bits
                addi  a,#rdw_start      ;add in rdw start
address
    ld    x,a
;x now points to the correct value (in the correct table!)
    ld    a,(x)
    ld    result,a
;”result” now contains the non-linear value corresponding
to the linear
;result obtained from the temperature measurement
    ldi   adcr,#0b0h                    ;start new conversion
    ld    a,storeacc                    ;recover accumulator
    reti
;*********************************
; timer interrupt service routine
;*********************************
tim_int:         reti
pbc_int:         reti
pa_int:          reti
nmi_int:         reti
```

```
;**************
; DATA TABLES *
;**************
     .window
table0:
     .byte   00h,00h,00h,00h,01h,01h,01h,01h
     .byte   02h,02h,02h,02h,03h,03h,03h,03h
     .byte   04h,04h,04h,04h,05h,05h,05h,05h
     .byte   06h,06h,06h,06h,07h,07h,07h,07h
     .byte   08h,08h,08h,08h,09h,09h,09h,09h
     .byte   0ah,0ah,0ah,0ah,0bh,0bh,0bh,0bh
     .byte   0ch,0ch,0ch,0ch,0dh,0dh,0dh,0dh
     .byte   0eh,0eh,0eh,0eh,0fh,0fh,0fh,0fh
     .windowend
     .window
table1:
     .byte   10h,10h,10h,11h,11h,11h,12h,12h
     .byte   12h,13h,13h,13h,14h,14h,14h,15h
     .byte   15h,15h,16h,16h,16h,17h,17h,17h
     .byte   18h,18h,18h,19h,19h,19h,1ah,1ah
     .byte   1ah,1bh,1bh,1bh,1ch,1ch,1ch,1dh
     .byte   1dh,1dh,1eh,1eh,1eh,1fh,1fh,1fh
     .byte   20h,20h,20h,21h,21h,21h,22h,22h
     .byte   22h,23h,23h,23h,24h,24h,24h,24h
     .windowend
     .window
table2:
     .byte   25h,25h,26h,26h,27h,27h,28h,28h
     .byte   29h,29h,2ah,2ah,2bh,2bh,2ch,2ch
     .byte   2dh,2dh,2eh,2eh,2fh,2fh,30h,30h
     .byte   31h,31h,32h,32h,33h,33h,34h,34h
     .byte   35h,35h,36h,36h,37h,37h,38h,38h
     .byte   39h,39h,3ah,3ah,3bh,3bh,3ch,3ch
     .byte   3dh,3dh,3eh,3eh,3fh,3fh,40h,41h
     .byte   42h,43h,44h,45h,46h,47h,48h,49h
     .windowend
     .window
```

```
table3:
    .byte   4ah,4bh,4ch,4dh,4eh,4fh,50h,52h
    .byte   54h,56h,58h,5ah,5ch,5eh,60h,62h
    .byte   64h,66h,68h,6ah,6ch,6eh,70h,72h
    .byte   75h,78h,7bh,7eh,81h,84h,87h,8ah
    .byte   8dh,90h,93h,96h,99h,9ch,9fh,0a2h
    .byte   0a6h,0aah,0aeh,0b2h,0b6h,0bah,0beh,0c2h
    .byte   0c6h,0cah,0ceh,0d2h,0d6h,0dah,0deh,0e2h
    .byte   0e6h,0eah,0eeh,0f2h,0f6h,0fah,0feh,0ffh
.windowend
;*******
;vectors
;*******
    .section 32          ;section 0FF0h...
    jp      ad_int       ;a/d interrupt vector
    jp      tim_int      ;timer interrupt vector
    jp      pbc_int      ;ports b&c interrupt vector
    jp      pa_int       ;port a interrupt vector
    nop                  ;4 reserved bytes
    nop
    nop
    nop
    jp      nmi_int      ;nmi interrupt vector
    jp      restart      ;reset vector
    .end
```

6 IMPORTING AND EXPORTING LABELS

Global symbols are those that are defined in one source module, but that can be used by others. LST6 allows you to use two types of global symbol: labels that are defined in program sections and labels that are defined in Data ROM Windows. You cannot import and export labels that are defined in the data space using the .DEF directive as global labels. Such labels should be defined in a separate file, that is included at the beginning of each source module using the .INPUT directive (see *Chapter 4* on page 29 for further details on how to do this).

To specify a symbol that is defined by the current module, but will be referenced by other modules, use the .GLOBAL directive (see *Section 12.3.16* on page 78). A symbol must be defined as global before it is defined.

To specify a symbol that is referenced by the current module, but is defined by another module, use the .EXTERN directive (see *Section 12.3.15* on page 77). The following example shows how to import and export program section labels:

```
;module 1
          PP_ON

          .global label, cste
          .section 1
          ...
label:
          ...
          .block 64-$%64
cste:
;module 2
          .PP_ON
          .W_ON
a         .def 0ffh
DRWR      .def 0cah
          .extern label, cste
          .section 0
          ...
nop       jp label
          ...
.byte     ldi DRWR, cste.w
          ld a,cste.d
```

Note: *Program Counter-relative jumps cannot be made to an external label.*
LST6 checks that `label` is located in program page 1 (the static page), or in the same page as that in which it is referenced. If not, it returns an error message.

The following example shows how to import and export Data ROM Window labels:

```
;module 1
          .PP_ON
          .W_ON
          .global wc1, wc2
          .window
wc1       .byte 11h
wc2       .ascii “ABCDEF”
          ...
          .windowend
;module 2
          .PP_ON
          .W_ON
a         .def 0ffh
x         .def 80h
DRWR      .def 0cah
          .extern wc1, wc2
          .section 3
          ldi DRWR,wc1.W
          ld a,wc1.D
          ld x,wc2.d
          ...
```

Note: *The <label>.D notation is used in module 2 because `wc1` and `wc2` are external and are thus assumed as being program section symbols.*

7 DEVELOPING MACROS

Macros are sequences of assembler instructions and directives that can be inserted into the assembled program in place of the macro name. Macros enable you to simplify code and reduce code development time by reusing frequently-used functions.

You define the beginning and end of a macro using the MACRO and ENDM directives. For example, the following macro moves the contents of the cell pointed to by X one the next address, so that X points to the same data but at another address:

```
.MACRO Move1;Start of Move1 macro definition
ld A, (X)
inc X
ld (X), A
.ENDM;End of macro definition
```

Once you have defined a macro, you call it by including the macro name as you would any other mnemonic. Macros are expanded in each place where their names are entered.

7.1 Nesting Macros

You can use two types of macro nesting: expansion nesting and definition nesting. Expansion nesting means calling, and thus expanding one macro from another macro. Definition nesting means defining and calling one macro from within the body of another macro.

An example of expansion nesting would be:

```
.MACRO Move2
Move1           ;Calls the macro Move1
ld A, (X)
inc X
ld (X), A
.ENDM           ;End of macro definition
```

In this case the body of macro Move1 is expanded within the body of macro Move2.

An example of definition nesting would be:

```
.MACRO Move2
.MACRO Move1    ;Start of Move1 macro definition
ld A, (X)
```

```
            inc X
            ld (X), A
            .ENDM           ;End of Move1 definition
            ld A, (X)
            inc X
            ld (X), A
            .ENDM           ;End of macro definition
```

7.2 Macro Parameters

Macro parameters let you fill in values when you call a macro. They let you develop generic macros whose use can vary within the context of where they are expanded.

The parameters to be included with a macro are listed after the macro name, in the .MACRO directive. Multiple parameters must be separated by commas. For example, the following line creates the macro Move1 with the parameters Par1 and Par2:

```
.MACRO Move1 Par1,Par2
```

AST6 lets you use three types of macro parameter: normal parameters, numeric parameters and label parameters.

Normal parameters are substituted by a string of characters when the macro is expanded. For example, a normal parameter could hold a label to which the macro makes a jump.

Numeric parameters enable you to use symbols to specify numeric values. The parameter name must be a defined symbol. Numeric parameters are preceded by a backslash (\).

Label parameters automatically define label names when macro is expanded. If you specify a label directly within a macro, for example, for a loop within the macro body, if the same macro is called successively, the second call will generate a double-defined label error. Using a label parameter overcomes this problem. Label parameters are preceded by a question mark (?).

The following example demonstrates the use of these three types of parameter:

```
            .macro zero start, \number, ?label
            ldi x, start
            ldi v, number
            clr a
  label     ld (x), a
            inc x
```

```
        dec v
        jrnz label
        .endm
```

This macro sets the number of bytes specified by `\number` to 0, from the start address specified by `start`. `?label` is replaced by the label specified when the macro is called. For example, the line:

```
zero flagx, 5, here
```

Sets the 5 bytes starting at address `flagx` to 0, and uses the label `here`.

You can omit the label name when you call a macro. In this case AST6 generates its own names each time it expands the macro. The names generated are L01$, L02$, L03$ and so on.

7.3 Concatenating Symbols During Macro Expansion

AST6 enables you to concatenate two symbols during macro expansion. To concatenate two symbols, place the ' operator between the two symbols you want to concatenate. You would concatenate two symbols, for example to assign different symbols to a label when calling the same macro twice:

The following example demonstrates the use of the concatenation operator:

```
        .macro zero start, \number, ?lab
        ldi x, start
        ldi v, number
        clr a
  sta'labld (x), a
        inc x
        dec v
        jrnz sta'lab
        .endm
```

The line:

```
        zero flagx, 5, here
```

results in the label `stahere` being generated.

8 USING CONDITIONAL ASSEMBLY

AST6 lets you specify conditions, according to which the subsequent lines of code are or are not assembled. Conditional assembly can be used to generate different program versions or executable files for different ST6 microcontrollers from the same source file. Three directives enable you to use conditional assembly: IFC, ELSE and ENDC. They have the following format:

```
.IFC <condition> <argument>
...       ;Code to assemble if condition is true
.ELSE
...       ;Code to assemble if condition is true
.ENDC
```

where:

<condition> is one of the following conditions:

Condition	Meaning
EQ	If the following symbol = 0
NE	If the following symbol != 0
GT	If the following symbol >0
LT	If the following symbol <0
LE	If the following symbol <=0
GE	If the following symbol >=0
DF	If the following symbol is defined.
NDF	If the following symbol is not defined

<argument> is a symbol or expression to be subjected to the condition.

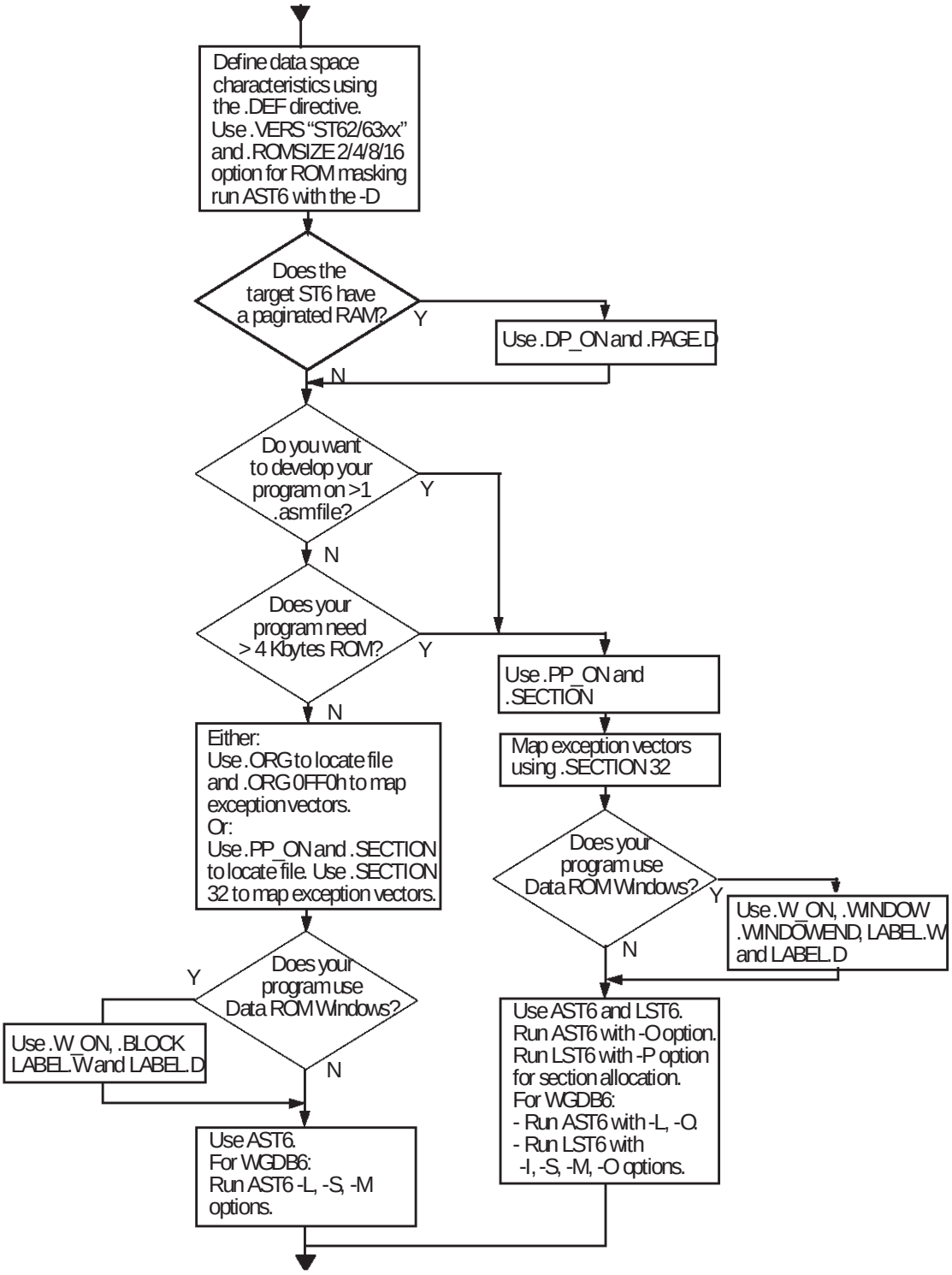
.ENDC identifies the end of the conditional assembler block.

Example:

```
HTYPE     .SET 0
          .IFC EQ HTYPE
          NOP             ;assemble if HTYPE == 0
          .ELSE
          JP $
          .ENDC
```

9 APPLICATION DEVELOPMENT SUMMARY

The chart below summarizes the directives you must use in relation to the size and structure of your application, and lists the tasks you must carry out during the application development process.



10 RUNNING AST6

To run AST6, enter the following command on the DOS command line.

```
AST6 [-<option1>...-<optionn>] <file1>[ <file2>...
<filen>]
```

Where:

`option` is any of the following options:

Option:	Meaning:

C	Only write generated code to the listing file if the conditional directives are true. For example, the code:
	`ldi sav_a, 0FFh`
	`.ifc eq sav_a`
	`ldi sav_a, 55h`
	`.else`
	`clr sav_a`
	`.endc`
	Generates the following lines in the listing if the -C option is used:
	`ldi sav_a, 0FFh`
	`clr sav_a`
	If you omit this option, both generated and ignored lines of code are written to the listing file.

L	Creates a listing file named: `<file>.lis` (see *Section 3.2.2* on page 22).
X	Creates a cross reference table in `<file>.x` (see *Section 3.2.5* on page 26).
M	Appends mapping information at the end of the listing files.
S	Creates a printable symbol table file in `<file>.sym` (see *Section 3.2.6* on page 26).
O	Use this option if your application includes more than one source file. Creates an object file in `<file>.obj`. Note that in this case the assembled files must be linked using LST6.
E	Creates an error file in `<file>.err` (see *Section 3.2.7* on page 27).

D[<pattern>]	Creates the ROM mask (see *Section 4.5* on page 34). If the D option is used without specifying the <pattern>, by default, the unused and reserved ROM areas are filled with FFh. If a <pattern> is specified, these ROM areas will be filled with the <pattern>. For example: `AST6 -D04 example.asm` will cause all unused and reserved ROM areas to be filled with 04h. This option can be used without the directive .PP_ON. If you use option O, this option is turned off.
F	Include the full path name to the source file in error messages displayed on screen or stored in the .ERR file. For example, the message: "`warning example.asm 53: (91) r/w access not...`" with -F option becomes: "`warning c:\st62\kit624x\example.asm 53: (91) r/w access` "
W<level>	Changes the warning level that is traced. Enter the level you want to trace in <level>, according to the table in *Section 10.2* on page 63.

`<file1>[ <file2>... <filen>]` is the name of the source (.asm) files to be assembled.

10.1 Example

The command:

```
AST6 -L -S prog
```

assembles **prog.asm**, generating **prog.hex** and creating a listing in **prog.lis**, a symbol table file in **prog.sym** and creating a file **prog.dsd** for the debugger.

To generate the files required by the WGDB6 debugger, use either of the following options:

```
ast6 -L -O
```

and

```
lst6 -I -M -S -O
```

or

```
ast6 -L -S -M
```

10.2 Warning Levels

The following table lists and describes the levels of warning that AST6 can return:

This level:	Means this:
0	No errors encountered.
1	Warning(s) were encountered. These are either printed on screen or written to a .ERR file if the -E option was chosen. These are listed below.
2	Error(s) were encountered. These are either printed on screen or written to a .ERR file if the -E option was chosen. These are listed below.
3	There was an error on the command line.
4	System error(s) were encountered. These are related to the computer you are using, and not the assembly process.

10.3 AST6 Errors and Warnings

The following table lists the errors and warnings that can be returned by AST6, and their associated levels:

Level	Description
0	Minimum length assumed.
1	Symbol already imported.
1	Symbol already exported.
1	Symbol declared external but unused.
1	Both symbols have the same definition.
2	R/W access control not performed on data space operand.

11 RUNNING LST6

Note: When you run LST6, it creates up to 8 temporary files. On DOS systems, you may have to increase the default number of open files (refer to the configuration command descriptions in your MS-DOS documentation for further information).

To run LST6, enter the following command from the operating system command line.

```
LST6 [-<option1>...-<optionn>] <file1>[ <file2>...
<filen>]
```

Where:

`option` is any of the following options:

Option	Meaning
F<Pattern>	Creates the ROM mask (see *Section 4.5* on page 34). By default, unused and reserved ROM areas are filled with FFh. To use another value, enter a value in <pattern>. Note that this option only works on programs that use the .WINDOW and .WINDOWEND directives. For other programs, use the -D option.
P<n>:<start>-<end>	Maps the contents of program section <n> to the virtual addresses in the range <start>--<end>. See *Section 4.4* on page 31 for further details.
E<name>	Assigns the entry point of the executable file to the global symbol specified in <name>. If this option is omitted, the entry point of the executable file is assigned to the start address of the program section. The entry point value is specified in the last record of the .HEX output file.
J	Includes each input module name before its local symbols in the symbol (.SYM) file. A pseudo-symbol is created: <module name> EQU <order> where module name is the input file name, and order is the order in which the module was linked.
S	Creates a printable symbol table file in <file>.sym (see *Section 3.2.6* on page 26).
O <name>	Generates output files with the name specified in <name>. If this option is omitted the default name “ST6” is given.
M	Generates a linker memory map. See *Section 3.2.4* on page 25 for further details.

T[<list>]	Traces references to, and definitions of, the symbols listed in <list>. If <list> is omitted, all the global symbols are traced.
V	Displays link progress information messages, such as which object modules are loaded, and their sizes.
D<pattern>	Creates the ROM mask (see *Section 4.5* on page 34). By default, unused and reserved ROM areas are filled with FFh. To fill masked areas with another value, enter a value in <pattern>. Note that if your program uses the .WINDOW and .WINDOWEND directives, you should use the -F option. If D is entered and the O option is omitted, the section numbers as defined by the .ROMSIZE and .VERS directives are used.
I	Updates the AST6 assembler listing files with the information that was modified during the link edit process.

`<file1>[ <file2>... <filen>]` is the name of the source (.obj) files to be linked.

11.1 Using Parameter Files

Instead of re-entering file names and options each time you run LST6, you can enter them in ASCII text files, that are referenced using the @ character. You can also use text files to prevent the LST6 command exceeding the command line limit of 128 characters in DOS.

For example, to execute the command:

```
LST6 -S -0 myprog m1 m2 m3
```

You could enter:

```
LST6 @ params.txt
```

Where params.txt contains:

```
-S -0 myprog m1 m2 m3
```

11.2 Examples

The command:

```
LST6 -S -0 myprog m1 m2 m3
```

Links the modules **m1.obj**, **m2.obj** and **m3.obj**, generating the files: **myprog.HEX**, **myprog.DSD** and **myprog.SYM**.

To generate the files required by the WGDB6 debugger, use the following options:

```
ast6 -L -O
```

followed by:

```
lst6 -I -M -S -O
```

11.3 Errors and Warnings

All LST6 messages are output to the file **stderr** under Windows or **stdout** under DOS.

The following table lists the status codes that are returned by LST6:

This status:	Means this:
0	No errors were encountered.
1	Warning(s) were encountered. These are listed below.
2	Error(s) were encountered. These are listed below.
3	There was an error on the command line. These are listed below.
4	System error(s) were encountered. These are related to the computer you are using, and not the assembly process.

11.4 Command Line Errors

The following table lists the error messages that can be returned by LST6:

Error message	Meaning
bad option <x>	<X> is not a valid command line option.
bad argument <xx>	Incorrect argument <xx> following a valid option.
no input file	No input file was specified on the command line.
can't open <file>	The file specified by <file> does not exist or read permission is denied.
conflicting start/end definitions <n> and <p>	The P option was used, and the sections <n> and <p> have overlapping start-end definitions. See *Section 4.4* on page 31 for further details.
start/end definitions for section <n> not bounded on 2 k	A program section exceeds a 2-Kbyte page.
entry point <symbol> not in program space	An entry point was assigned to a symbol that does not exist in the program space.

11.5 LST6 Error Messages

The following table lists the error messages that are written to the file **stdout**.

Error message:	Meaning:
undefined symbol <symbol>	The symbol <symbol> is referenced as being external by a module, but is not defined. See *Chapter 6* on page 51.
multidefined symbol <symbol>	An imported or exported symbol name was repeated. See *Chapter 6* on page 51.
section <n> overflow	Each program page is limited to 2048 bytes. While merging the contents of input files the maximum size was exceeded for section number <n>.
not enough space in any used page to map window <n>	There was not enough space left in the program page for the specified window number.
relocation overflow inside program section <n>, offset 0xHHH, <file>	The value of the external symbol, referenced at the specified offset, was too large to fit onto one byte or 3 hexadecimal digits.
type conflict relocating program section [window] <n>	An external reference was made to a symbol definition that is not in the same type of section (program or window) in the referencing and referenced modules.
illegal jump inside section <n>	A jump was made to a label that was neither in the current dynamic page nor in the static page.
invalid type of relocation in program section [window]	The versions of LST6 and AST6 that were used are incompatible. Check the version numbers.
reserved symbol <symbol> already defined	You tried to redefine the listed symbol, which is reserved.
bad magic number <file>	The listed file is not compatible with LST6.
memory allocation error <address>	Insufficient memory available for linking a large module. You must divide it into smaller modules.
<file> bad object file format	Unexpected construct found in the listed file.
<file> premature end of file	The listed file cannot be read by LST6.
internal error (<comment>)	Either an invalid input file was used or an LST6 bug was encountered.

12 DIRECTIVES

This section describes the AST6/LST6 directives.

12.1 Editorial Conventions

In the directive descriptions, the following conventions are used:

These characters:	Represent:
Square brackets ([ ])	Optional operands.
Angle brackets (<>)	Variable values to be replaced by real values.
Text in the `courier` font.	Text that is entered in source files.

12.2 Directive Summary

The following table summarizes the AST6 and LST6 directives.

Group	Action	Directive
Program Space Definition	Reserve a Block of Memory	[<label>] .BLOCK <expression>
	Generate Words of Object Code	[<label>] .WORD <expression>[,<expression>]
	Generate Bytes of Object Code	[<label>] .BYTE <expression>[,<expression>]
	Write Character String	[<label>] .ASCII “<string>” [<label>] .ASCIZ “<string>”
	Begin ROM Code Section.	.SECTION <number>
	Set Program Origin	.ORG <expression>
Data Space Data Definition	Define Data Space Location Characteristics	[<label>] .DEF <address> ,[<R-mask>],[<Wmask>],[<M|m>]
Data ROM Window directives	Enable Data ROM Windows	.W_ON
	Define Beginning of Data Block in Program Space	.WINDOW

Data ROM Window directives	Define End of Data Block in Program Space	.WINDOWEND
	Initialize Data ROM Window Register	<label>.W
	Address Data ROM Window Data	<label>.D
Symbol Definition	Assign a value to the label	<label> .EQU <expression>
	Assign a value to the label (that can be changed)	<label> .SET <expression>
Linker Directives	Define Symbols as Global	.GLOBAL <symbol1>[,<sym2>]...[,<sym>]
	Transmit Data Space Symbols to the Linker	.TRANSMIT
	Don't Transmit Data Space Symbols to the Linker	.NOTRANSMIT
	Define Symbols as External	.EXTERN <symbol1>[,<symbol2>]...[,<symboln>]
	Initialize PRPR or DRBR	<label>.P
Hardware-related directives	Enable Program Space paging	.PP_ON
	Enable Data Space paging	.DP_ON
	Specify Page Number for .DEF	.PAGE_D <number>
	Specify target ST6.	.VERS "<ST6>"
	Define ROM Size for ROM Masking.	.ROMSIZE <size>
Miscellaneous directives	Display a String	.DISPLAY "string"
	Define End of Source File	.END
	Read Source Statements from File	.INPUT "filename"
	Generate Error Message	.ERROR "string"
	Generate Warning Message	. WARNING "string"

Listing directives	Insert Listing Page Eject	.EJECT
	Start/Stop Listing	.LIST 0 or 1
	Change Listing Lines Per Page	.PL <expression>
	Change Listing Characters Per Line	.LINESIZE <expression>
	Set Listing Page Header Title	.TITLE “string”
	Insert Comment	.COMMENT <nn>
Conditional assembly directives	Begin Conditionally Assembled Code	.IFC <cond> <argument>
	Begin Alternative Assembled Code	.ELSE
	End Conditionally Assembled Code	.ENDC
Macro directives	Begin Macro Definition	[<label>] .MACRO macro_name [<par1>,...,<parN>]
	End a Macro Definition	[label] .ENDM
	End Macro Expansion	[label].MEXIT

12.3 Directive Descriptions

The following paragraphs describe the AST6 and LST6 directives in alphabetic order.

12.3.1 ASCII, ASCIZ - Write Character String

Syntax

```
[<label>] .ASCII ”<string>”
[<label>] .ASCIZ ”<string>”
```

Description

Writes a character string to the program space. .ASCIZ is the same as .ASCII, except that it adds a NULL character to the end of the string.

Example

```
KDMESS    .ASCIZ ”1-Key Display”
```

12.3.2 BLOCK - Reserve a Block of Memory

Syntax

```
[<label>] .BLOCK <expression>
```

Description

Reserves a block of memory in the program space. <expression> indicates the number of bytes to be reserved. If label is included, the first address of the first memory location is assigned to it. All symbols used in the expression must have been previously defined.

This directive is used to prevent reserved areas in the program space from being overwritten with program code. Refer to *Section 4.1* on page 29 for further details.

Example

To reserve a block of ROM memory to be accessed via the Data ROM Window, that starts at the beginning of a 64 Kbyte block and does not exceed 64 bytes:

```
.block          64-$%64
```

See Also

.W_ON, .WINDOW, .WINDOWEND

12.3.3 BYTE - Generate Bytes of Object Code

Syntax

```
[<label>] .BYTE <expression>[,<expression>]
```

Description

Generates successive bytes of object code in the program space, that contain the <expression> value in binary. The value of each expression is truncated to the first 8 bits.

Example

To generate a byte holding the value 0ceh (11001110).

```
.byte 0ceh
```

See Also

.WORD

12.3.4 COMMENT - Set Comment Tabs

Syntax

```
.COMMENT <nn>
```

Description

Sets tabs in the comments that are printed in the listing. The tabs are set at the column number specified by the argument NN.

NN must be a positive decimal integer that is less than either 256, or the value specified in .LINESIZE directive it this directive is used.

Example

To set a tab in column 50.

```
.comment 50
```

12.3.5 DEF - Define Data Space Location Characteristics

Syntax

```
[<label>] .DEF <address>,[<R-mask>],[<W-
mask>],[<value>][,<M|m>]
```

Description

Defines the characteristics of the specified location in the data space. This directive provides you with a useful tool for structuring the ST6 data space. If <label> is included, its value can be used in any place in the source file where a data symbol name can be used. You must define the characteristics of each byte that you want to use in the data space using this directive, even the standard registers. All the parameter values can be entered in any number base. Identifiers used in expressions and data addresses must be predefined.

<R-mask> specifies which bits can be read. If it is omitted, all the bits can be read. Each bit in <R-mask> that is set to 1 enables read access for the corresponding bit in the data space. For example, an <R-mask> value of 0FFh (11111111b) enables read access to all the bits at the specified address. 00Fh (00001111b) enables read access to bits 0-3.

<W-mask> specifies which bits can be written. If it is omitted, all the bits can be written. Each bit in <W-mask> that is set to 1 enables write access for the corresponding bit in the data space.

<M|m> places a marker in the .DSD file for this symbol, so that it can be viewed on screen during program simulation or emulation.

If a hardware register contains a mixed type of bits (Read/Write and Read-only/ Write-only), R-mask and W-mask are defined according to the following convention:

- If a non-zero bit exists in the mask, the corresponding location is assumed to be accessible for read or write by a Load (LD) instruction.
- Rights are checked at bit level on bit test/set instructions.
- An immediate load (LDI) to a location will be checked against a “1” to a bit declared as non-accessible for write.

Example

To define a byte called val1 at address 000h that is write-only:

```
val1 .DEF 000h,0ffh,0
```

See Also

.SET, .EQU

12.3.6 DISPLAY - Display a String

Syntax

```
.DISPLAY ”string”
```

Description

Displays the specified string on screen during the assembly process.

12.3.7 DP_ON - Enable Data Space paging

Syntax

```
.DP_ON
```

Description

Enables data space paging (in the data space address range 0-3Fh). See *Section 5.2* on page 40.

This directive enables you to use the .PAGE_D directive and the notation label.P (when referencing data space labels).

See Also

.PAGE_D, .LABEL.P

12.3.8 EJECT - Insert Listing Page Eject

Syntax

```
.EJECT
```

Description

Inserts a new page eject into the listing file. The form feed character (^L) is sent to the printer and a new header is printed.

12.3.9 ELSE - Begin Alternative Assembled Code

Syntax

```
.ELSE
```

Description

Provides an alternative block of code to assemble if the .IFC condition is not true.

See *Chapter 8* on page 57 for full details about conditional assembly.

Example

```
HTYPE    .SET 0
         .IFC EQ HTYPE
         NOP  ;assemble if HTYPE == 0
         .ELSE
         JP $
         .ENDC
```

See Also

.IFC, .ENDC

12.3.10 END - Define End of Source File

Syntax

```
.END
```

Description

Defines the end of the source file. All lines after this directive are ignored by the assembler. This directive is optional.

12.3.11 ENDC - End Conditionally Assembled Code

Syntax

```
.ENDC
```

Description

Defines the end of a block of conditionally assembled code.

See *Chapter 8* on page 57 for full details about conditional assembly.

Example

```
HTYPE     .SET 0
          .IFC EQ HTYPE
          NOP  ;assemble if HTYPE == 0
          .ELSE
          JP $
          .ENDC
```

See Also

- .IFC, .ELSE

12.3.12 ENDM - End a Macro Definition

```
[label].ENDM
```

Definition

Indicates the end of a macro definition. For full details about macros, see *Chapter 7* on page 53.

Example

```
.MACRO Move
ld A, (X)
inc X
ld (X), A
.ENDM; Defines end of macro definition
```

See Also

.MACRO, .MEXIT

12.3.13 EQU - Assign a Value to the Label

Syntax

```
[<label>] .EQU <expression>
```

Description

Assigns the value of the expression to the label. You cannot assign a value to the same label more than once using the .EQU directive, for this use .SET. The symbols in the expression must be predefined. Note that you cannot define global symbols using this directive.

Example

To define the symbol Charge to a constant value (800):

```
Charge .EQU 800
```

See Also

.SET, .DEF

12.3.14 ERROR - Generate Error Message

Syntax

```
.ERROR "string"
```

Description

Generates the message "string" in the error file or the standard error output. See *Chapter 3* on page 27 for further details.

12.3.15 EXTERN - Define Symbols as External

Syntax

```
.EXTERN <symbol1>[,<symbol2>]...[,<symboln>]
```

Description

Only use this directive for programs that include more than one source file.

Defines the listed symbols as external. External symbols are not defined in the current module, but they are defined in another. See *Chapter 6* on page 51 for further details.

You can only use this feature for symbols that are defined in the program space. Labels that are defined in the data space using the .SET, .DEF or .EQU directives should be defined in a separate file, that is included at the beginning of each source module using the .INPUT directive (see *Chapter 4* on page 29 for further details on how to do this).

Symbol names cannot exceed 8 characters. This directive must be executed before the symbol is referenced.

Example

To use the symbol Charge, that was defined in another module, in the current module:

```
.EXTERN Charge
```

See Also

.GLOBAL

12.3.16 GLOBAL - Define Symbols as Global

Syntax

```
.GLOBAL <symbol1>[,<symbol2>],...,[,<symboln>]
```

Description

To use this directive you must use the -O option on the command line when running AST6.

Defines a symbol as global, thus it can be used by other modules. Symbol names must not exceed 8 characters. This directive must be executed before the symbol is defined.

You can only use this feature for symbols that are defined in the program space. Labels that are defined in the data space using the .SET, .DEF or .EQU directives should be defined in a separate file, that is included at the beginning of each source module using the .INPUT directive (see *Chapter 4* on page 29 for further details on how to do this).

Example

To enable the symbol `Charge` to be used in another module:

```
.GLOBAL Charge
```

See Also

.EXTERN

12.3.17 IFC - Begin Conditionally Assembled Code

Syntax

```
.IFC <condition> <argument>
```

where:

<condition> is one of the following conditions:

Condition	Meaning
EQ	If the following symbol = 0
NE	If the following symbol != 0
GT	If the following symbol >0
LT	If the following symbol <0
LE	If the following symbol <=0
GE	If the following symbol >=0
DF	If the following symbol is defined.
NDF	If the following symbol is not defined

<argument> is a symbol or expression to be subjected to the condition.

See *Chapter 8* on page 57 for full details about conditional assembly.

Example

```
HTYPE     .SET 0
          .IFC EQ HTYPE
          NOP              ;assemble if HTYPE == 0
          .ELSE
          JP $
          .ENDC
```

See Also

.ELSE, .ENDC

12.3.18 INPUT - Read Source Statements from File

Syntax

```
.INPUT ”filename”
```

Description

Reads the source statement(s) from the specified file. When the assembler reaches the end of the file, it returns to the calling source file. .INPUT directives can be nested. See *Chapter 5* on page 37 for a full example of how to use this command.

Example

To include a file named defs.h in the beginning of a source module:

```
;module 1
          .INPUT "defs.h"
```

See Also

.TRANSMIT, .NOTRANSMIT

12.3.19 LABEL.D - Access Data in Data ROM Window

Syntax

```
<label>.D
```

Description

You can only use this notation after the `.W_ON` directive.

To simplify the task of referencing data in the ROM via a Data ROM Window, AST6 includes two specific notations: <label>.D and <label>.W.

<label>.W enables you to set the DRWR to the block of data in ROM holding the specified label.

<label>.D enables you to set the offset to the specified label from the beginning of the block of data in ROM pointed to by the DRWR. This is then used in the instruction address.

Example

```
          .PP_ON
          .W_ON           ;Enable the use of windows
a         .def 0ffh
x         .def 80h
DRWR      .def 0cah       ;Define Data ROM Window register

          .section2
;         ...
          .block 64-$%64  ;Define 64-byte boundary
```

```
cst1      .byte 0ceh
string1   .ascii ”abcdef”
;         ...
          .section 0
          ldi DRWR,cst1.W ;select window holding cst1 and
                          string 1
          ld a,cst1.D     ;read cst1
          ldi x,string.D  ;point to address of string
```

The arithmetic operations listed in *Section 3.1.3.4* on page 19 apply to <label>.D.

See Also

.W_ON, .BLOCK, .WINDOW, .WINDOWEND, .LABEL.W

12.3.20 LABEL.P - Initialize PRPR or DRBR

Syntax

```
<label>.P
```

Description

If used in a source file that includes .PP_ON, to reference a program space label, the <label>.P notation enables you to load the location of the specified label to the Program ROM Page Register (PRPR). The PRPR selects the program space page to be accessed. Thus, when jumping from one dynamic page to another, a jump is first made to page 1 (the static page), where the <label>.P notation is used to load the target page. The jump is then made to the target. For further details see *Section 4.4.1* on page 34.

If used in a source file that includes .DP_ON, to reference a data space label, the <label>.P notation that sets Data RAM/EEPROM Register (DRBR) to the data space page holding the specified label. The DRBR register selects the data page to be accessed.

Note: When referencing a program space label, if the specified label is in another module, the directive .EXTERN must be included before the use of label.P.

Example

To jump from section 4 to section 5 (that are mapped to different pages during link editing) via page 1:

```
          .pp_on
PRPR      .def 0cah;       define PRPR
          .section 4
```

```
;         ...
          jp prs1          ;Jump to PRPR setter in page 1
          .section 1
          ...
prs11     ldi PRPR,target.p;set the page holding
                           the label ”target” in PRPR
          jp target        ;jump to the label ”target”
;
          .section 5
;         ...
target    nop              ;Start the process
```

See Also

.DP_ON, .D_PAGE, .PP_ON, .SECTION

12.3.21 LABEL.W - Initialize Data ROM Window Register

Syntax

```
<label>.W
```

Description

You can only use this notation in files that include the `.W_ON` directive.

The <label>.W notation sets the Data ROM Window Register (DRWR) to the block of data in the program space holding the specified label. <label>.W works on labels that are in the program space and in .WINDOW/.WINDOWEND blocks.

You can then reference data in the Data ROM window using its label, or <label>.D. See *Section 5.3* on page 42 for further details on the Data ROM Window.

Example

```
          .WINDOW
cst2      .byte 22h
string2   .ascii           ”ABCDEF”
;         ...
          .WINDOWEND

          .section 2
          ldi DRWR,cst2.W ; select block holding cst2 and
                           string 2
          ld a,cst2        ; read cst2
```

```
            ldi x,string2.D ; point to the address of
                            string2
```

See Also

.W_ON, .BLOCK, .WINDOW, .WINDOWEND, LABEL.D

12.3.22 LINESIZE - Change Listing Characters Per Line

Syntax

```
.LINESIZE <expression>
```

Description

Changes the number of characters per line of the output listing to the value of `expression`. The default value is 131, the minimum value is 79.

Example

To set the output listing to 90 characters:

```
.LINESIZE 90
```

12.3.23 LIST - Start/Stop Listing

Syntax

```
.LIST 0 or 1
```

Description

Lines of code following .LIST 1 are written to the listing file.

Lines of code following .LIST 0 are not written to the listing file.

This directive can be useful for preventing the contents of files that are included using the .INPUT directive from being written to the listing file.

Example

```
.LIST 1
...; these lines are written to the output listing
.LIST0
...; these lines are not written to the output listing
.LIST1
...; these lines are written to the output listing
```

See Also

.TRANSMIT, .NOTRANSMIT, .INPUT

12.3.24 MACRO - Begin Macro Definition

Syntax

```
[<label>] .MACRO macro_name [<par1>,...,<parN>]
```

Definition

Macros are sequences of assembler instructions and directives that can be inserted into the source program in place of the macro name.

`macro_name` is the name of the macro. Once a macro is defined, it is expanded in each place where its name is entered.

`par1 ... parN` are macro parameters, which let you fill in values when you call the macro. They let you develop generic macros whose use can vary within the context of where it is expanded.

The MACRO directive defines the beginning of a macro definition. For full details about macros, see *Chapter 7* on page 53.

Example

The following macro moves the contents of the cell pointed to by X one space further, so that X points to the same data but at another address:

```
.MACRO Move1     ;Start of Move1 macro definition
ld A, (X)
inc X
ld (X), A
.ENDM            ;End of macro definition
```

See Also

.ENDM, .MEXIT

12.3.25 MEXIT - End Macro Expansion

Syntax

```
[label].MEXIT
```

Definition

Ends macro expansion before the end of its definition is reached. This directive is normally used in a conditional assembly block (see *Chapter 8* on page 57).

Example

```
type      .set 0          ;Set type to 0
```

```
.MACRO Move1 type; Defines start of macro Move1
...             ;(macro lines that are always
;expanded)
.IFC EQ type
.MEXIT          ;End expansion if type == 0
.ENDC
...             ;(macro lines that are expanded
                ;if type <>0)
.ENDM           ; End of macro definition
```

See Also

.MACRO, .MEXIT, .IFC, .ENDC, .ELSE

12.3.26 NOTRANSMIT - Don't Transmit Data Space Symbols to LST6

Syntax

```
.NOTRANSMIT
```

Description

This directive is only required for programs that have multiple source files.

TRANSMIT transmits data space symbols to LST6, so that they are common to all modules. NOTRANSMIT turns off data space symbol transmission to LST6. These directives aim to prevent the same symbol from being defined twice in the .DSD file that is produced by LST6. Define all the common data space symbols in one module without using the TRANSMIT and NOTRANSMIT directives, and use these directives when you define data space symbols in the other modules of the same program.

Example

Module 1.asm

```
.input "ST6STD.ASM";Common data space symbol
                   ;definition file
```

Module 2.asm

```
.notransmit
.input "ST6STD.ASM" ;
.transmit
```

See Also

.DEF, .INPUT, .TRANSMIT

12.3.27 ORG - Set Program Origin

Syntax

```
.ORG <expression>
```

Description

Sets the program origin for subsequent code to the address defined in <expression>. All symbols which appear in <expression> must have been previously defined. This directive can only be used when AST6 is executed to produce an absolute object (without the -O option).

.ORG only applies to program space sections.

Example

To locate the subsequent code in the memory area starting at address 200h.

```
.ORG 200h
```

12.3.28 PAGE_D - Specify Page Number for .DEF

Syntax

```
.PAGE_D <number>
```

Description

This directive can only be used after .DP_ON.

Specifies the data memory page number to which subsequent data space data definitions using the .DEF directive apply (in the data space address range 0-3F). The page number must be in the range 0 - 255.

Example

To place v1 and v2 in data page 0:

```
            .DP_ON
            PAGE_D 0
  v1        .def 0
  v2        .def 1
```

See Also

.DP_ON, .DEF, LABEL.P

12.3.29 PL - Change Listing Lines Per Page

Syntax

```
.PL <expression>
```

Description

Changes the number of lines per page on the output listing to the value of `expression`. The default value is 63 and the minimum value is 10. The first six and last six lines of a listing are empty.

Example

To set the number of lines in a listing page to 70:

```
.PL 70
```

12.3.30 PP_ON - Enable Program Space paging

Syntax

```
.PP_ON
```

Description

Enables program space paging, the .SECTION directive and the use of the notation <label>.P on program space symbols.

If you do not use this directive, you can only use the first 4 bytes in the program space.

See Also

.LABEL.P, .SECTION

12.3.31 ROMSIZE - Set ROM Size for ROM Masking

Syntax

```
.ROMSIZE n
```

Description

You must run AST6 with the -D option to be able to use this directive.

This directive sets the size of the ROM for ROM masking.

n defines the size of the microcontroller ROM, which must be one of the values 2, 4, 8 or 16.

This directive must be used in conjunction with the .VERS directive.

Example

```
.ROMSIZE 2
```

See Also

.VERS

12.3.32 SECTION - Begin Program Code Section

Syntax

```
.SECTION <number>
```

Description

Specifies the section number in which the subsequent code is placed. <number> specifies the section number, in the range 0-32.

You can only use this directive after the .PP_ON directive. Since the paged memory area (0 to 7FFh) is structured into overlaid pages, each page has a virtual address to distinguish it from the others. Virtual address are allocated in relation to the page number, as shown in the following table:

Page No.	Virtual Address	Real Address
0	0000 to 07FF	0000 to 07FF
1	0800 to 0FEF	0800 to 0FEF
2	1000 to 17FF	0000 to 07FF
3	1800 to 1FFF	0000 to 07FF
n = 4 to 31	[n*800]-[(9n*80)+7FF]	0000 to 07FF
32	0FF0 to 0FFF	0FF0 to 0FFF

The use of pages 2 to 31 is optional: use as many as are required to store your program.

Each section starts at address 0 in the current module.

During the link edit phase, sections are allocated to pages according to their numbers, thus section 0 is allocated to page 0, section 1 is allocated to page 1, and so on. You can allocate any number of sections, from any source module, to a page in the program memory, provided their total size does not exceed that of the page.

For further details about the use of sections and paged program space, see *Section 4.3* on page 30.

If you are not using LST6, you can still optionally use three default sections: sections 0, 1 and 32. In this case, you must include PP_ON, and you cannot use .ORG.

Example

Module 1

```
            .PP_ON
            .SECTION 1
   lab1     ldi  a,3
            .SECTION 2
            WAIT
            .SECTION 1
            NOP
```

Module 2

```
       .SECTION 1
       STOP
```

See Also

.LABEL.P, .PP_ON

12.3.33 SET - Assign a Value to the Label

Syntax

```
[<label>] .SET <expression>
```

Description

Assigns the value of the expression to the label. As opposed to the .EQU directive, you can reassign values to label values that are assigned using .SET. The symbols in the expression must be predefined.

Example

To define the symbol Charge to the value 800:

```
Charge    .SET 800
```

See Also

.DEF, .EQU

12.3.34 TITLE - Set Listing Page Header Title

Syntax

```
            .TITLE "string"
```

Description

Sets the title that is printed on output listing page headers.

12.3.35 TRANSMIT - Transmit Data Space Symbols to LST6

Syntax

```
.TRANSMIT
```

Description

This directive is only required for programs that have multiple source files.

TRANSMIT transmits data space symbols to LST6, so that they are common to all modules. NOTRANSMIT turns off data space symbol transmission to LST6. These directives aim to prevent the same symbol from being defined twice in the .DSD file that is produced by LST6. Define all the common data space symbols in one module without using the TRANSMIT and NOTRANSMIT directives, and use these directives when you define data space symbols in other modules of the same program.

Example

Module 1.asm

```
.input ”ST6STD.ASM”; common data space symbol
                     definition
```

Module 2.asm

```
.notransmit
.input ”ST6STD.ASM” ;
.transmit
```

See Also

.NOTRANSMIT, .INPUT

12.3.36 VERS - Define Target ST6

Syntax

```
.VERS ”<string>”
```

Description

Defines the ST6 type that the executable file will be loaded into. You must use this directive at the beginning of all source files. Specify the microcontroller name in <string>. If the microcontroller name includes a letter, omit the letter from the name, for example for an ST62E25 enter ST6225.

Example

```
.VERS ”ST6210”
```

See Also

.ROMSIZE

12.3.37 W_ON - Enable Data ROM Window

Syntax

```
.W_ON
```

Description

You must use this directive at the beginning of the source file if you want to use the Data ROM window (see *Section 5.3* on page 42 for further details on the Data ROM Window).

This directive enables the use of LABEL.D, LABEL.W, and WINDOW and WINDOWEND if LST6 is used.

See Also

.BLOCK, LABEL.D, LABEL.W, .WINDOW, .WINDOWEND

12.3.38 WARNING - Generate Warning Message

Syntax

```
. WARNING "string"
```

Description

Generates the message "`string`" in the error report file or the standard error output.

12.3.39 WINDOW, WINDOWEND - Define Data Block in Program Space

Syntax

```
.WINDOW
;...window data
.WINDOWEND
```

Description

.WINDOW defines the beginning of a block of data, stored in the program space, that can be accessed via the Data ROM window. .WINDOWEND defines the end of the block of data.

You can only use these directives in source modules for relocatable objects (thus, use the -O option on the command line when running AST6).

If you are developing a source file to create an absolute object, you cannot use .WINDOW and .WINDOWEND to delimit blocks of ROM data. Instead, you must define the boundary of the block of data using the .BLOCK directive.

These directives can only be used after the .W_ON directive (see *Section 12.3.37* on page 91). The directives you can use in with the Data ROM Window are: .BYTE, .WORD, .ASCII, .ASCIZ and .BLOCK.

For full details about Data ROM windows see *Section 5.3* on page 42. An example application that uses the .WINDOW and .WINDOWEND directives is provided in *Section 5.1* on page 39.

Example

```
            .PP_ON      ; Enables LST6
            .W_ON       ; Enables Data ROM Windows
   a        .def 0ffh
   x        .def 80h
   DRW      .def 0cah   ; Define DRWR

            .WINDOW     ; Start block of ROM data
   cst2     .byte 22h
   string2  .ascii      ”ABCDEF”
   ;        ...
            .WINDOWEND  ; End blobk of ROM data
```

See Also

.BLOCK, LABEL.D, LABEL.W, .W_ON

12.3.40 WORD - Generate Words of Object Code

Syntax

```
[<label>] .WORD <expression>[,<expression>]
```

Description

Generates successive 2-byte words of object code in the program space, that contain the <expression> value in binary. Words are stored in reverse order, thus the LSB has the lower address.

Example

```
val1    .WORD 0A0FFh
```

See Also

.BYTE

PRODUCT SUPPORT

Software Updates

You can get software updates from the ST Internet web site:

http://mcu.st.com

For information on firmware and hardware revisions, call your distributor or ST using the contact list given above.

If you experience any problems with a software tool, contact the distributor or ST sales office nearest you.

Contact List

*Note: For **American and Canadian customers** seeking technical support the US/Canada is split in 3 territories. According to your area, contact the following sales office and ask to be transferred to an 8-bit microcontroller Field Applications Engineer (FAE).*

Canada and East Coast

STMicroelectronics
Lexington Corporate Center
10 Maguire Road, Building 1, 3rd floor
Lexington, MA 02421
Phone: 781-402-2650

Mid West

STMicroelectronics
1300 East Woodfield Road, Suite 410
Schaumburg, IL 60173
Phone: 847-517-1890

West coast

STMicroelectronics, Inc.
30101 Agoura Court
Suite 118
Agoura Hills, CA 91301
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