STMicroelectronics

ST7 Assembler Linker

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User manual

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UM0144
User Manual

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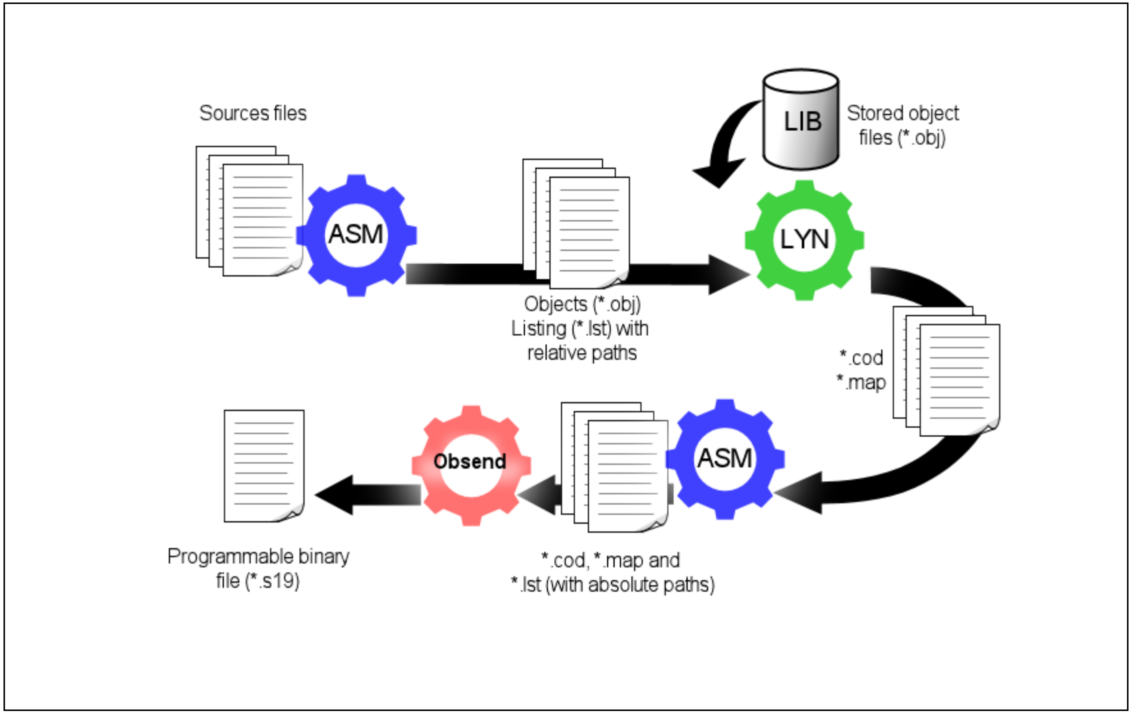
Introduction

Thanks for choosing ST7! This manual describes how to use the ST7 Assembler-Linker to develop applications for **ST7** microcontrollers. The assembly tools described in this book form a development system that assembles, links and formats your source code.

Figure 1. Schematic overview of the ST7 assembler toolset



The ST7 Assembler-Linker includes the following tools:

- **Assembler (ASM)**: translates your source code (**.ASM**) written in assembly language, into object code (**.OBJ**) specific to the target machine and an optional listing file (**.LST**).
- **Linker (LYN)**: processes the object files (**.OBJ**) produced by the assembler, resolves all cross-references between object files and locates all the modules in memory. The resulting code is output in an object code file (**.COD**). In a second pass, the Assembler uses these files to produce an object code file, map and listing with absolute paths.
- **Obsend (OBS)**: translates the object code file to produce the final executable in a default format (**.FIN**) or other format that you specify (e.g. ST S-record, Motorola S-record, Intel Hex...).
- **LIB (Librarian)**: The librarian enables you to store frequently used subroutines in one location for use with any number of ST7 applications.

Note: The utility file **`asli.bat`** *automatically runs ASM, LYN, and OBSEND one after the other for you. Use this batch file only if you have only one assembly source file ".ASM".*

About the user manuals...

This manual provides information about producing an application executable for ST7 from your application source code in Assembly language. Here, you will find:

- An overview of Assembly language for ST7
- Instructions for running the ST7 Assembler-Linker
- Descriptions of the Assembler output

For information on related subjects refer to the following documentation:

ST7xxxx Datasheet – full description of your ST7.

ST7 Programming Manual – a complete reference to ST7 Assembly language

Host PC system requirements

This tool has been designed to operate on a PC that meets the following:

- One of the following operating systems: Microsoft® Windows® 98, 2000, Millennium, NT® or XP®.
- Intel® Pentium (or compatible) processor with minimum speed of 133 MHz.
- Minimum RAM of 32 MB (64 MB recommended).
- 60 MB of free hard disk space to install all of the ST7 tools.

Getting assistance

For more information, application notes, FAQs and software updates for all the ST microcontroller development tools, check out the CD-ROM or our website:

www.st.com/mcu

For assistance on all ST microcontroller subjects, or for help developing applications that use your microcontroller's MSCI peripheral, refer to the contact list provided in *Product Support* on page 108. We'll be glad to help you.

Contents

1 Getting Started

Installing the ST7 Assembler-Linker

The ST7 Assembler-Linker is delivered as part of the ST7 toolset. A free installation package is available at **www.st.com/mcu**. To install it:

1. Select ***ST7>ST7 toolchain*** from the main menu of the "Microcontroller Development Tools" CD-ROM, or...
2. Run the installation executable that you have downloaded from the internet.

Note: Windows® 2000, NT® and XP®users must have administrator privileges to install certain software components.

After installation, the installation directory should contain the following (*Table 1*):.

Table 1. Description of installed files

`ASM.EXE`	ST7 Assembler
`LYN.EXE`	ST7 Linker
`OBSEND.EXE`	output file formatter
`LIB.EXE`	librarian
`ST7.TAB`	ST7 description files
`ASLI.BAT`	batch file ASM+LYN+OBSEND
`RELEASE_NOTES.PDF`	release notes

Up-to-date release notes are provided in PDF format. An additional file contains demonstration examples.

2 ST7 Addressing Modes

2.1 Overview of ST7 addressing modes

The ST7 assembler instruction set incorporates the following different addressing modes:

Table 2. ST7 Addressing modes

Instruction Set	Addressing Mode	Example
ST7	Inherent	`nop`
	Immediate	`ld A,#$F5`
	Direct (short address)	`ld A,$F5`
	Direct (long address)	`ld A,$F5C2`
	X or Y Indexed (no offset)	`ld A,(X)`
	X or Y Indexed (short offset)	`ld A,($F5,X)`
	X or Y Indexed (long offset)	`ld A,($F5C2,X)`
	Short Pointer Indirect (short pointed data)	`ld A,[$F5]`
	Short Pointer Indirect (long pointed data)	`ld A,[$F5.w]`
	Short Pointer Indirect (short pointed data) X or Y Indexed	`ld A,([$F5],X)`
	Short Pointer Indirect (long pointed data) X or Y Indexed	`ld A,([$F5.w],X)`
	Direct Relative (short offset)	`jrt $F5`
	Short Pointer Indirect Relative (short pointed data)	`jrt [$F5]`
	Bit operation	`bset byte, #5`

All ST7 addressing modes are described in full detail, with specific examples, in the *ST7 Family 8-bit MCUs Programming Manual*. This chapter seeks only to give a brief explanation of the main addressing mode types.

2.2 General instruction syntax

The ST7 instruction set provide a single source-coding model regardless of which components are operands—the accumulator (A), an index register (X or Y), an 8-bit stack pointer (S) for ST7, the condition code register (CC), or a memory location. For example, a single instruction, **`ld`**, originates register to register transfers as well as memory to accumulator data movements.

Two-operand instructions are coded with destination operand appearing at first position. For example:

```
lab01    ld A,memory       ; load accumulator A with memory contents
lab02    ld memory,A       ; load memory location with A contents
         ld X,A            ; load X with accumulator contents
```

2.3 Short and long addressing modes

For ST7 there are two addressing modes that differ in memory address size (i.e. one byte for short mode and two bytes for long mode).

Because of these different addressing modes, the target address range of the operands will depend upon the addressing mode chosen:

```
0-$FF                         for short addressing mode
$100-$FFFF                    for long addressing mode
```

Some instructions accept both long and short addressing modes, while others only accept one or the other.

For example:

```
lab10    add  A,memory     ; accepts both types of addressing modes
lab11    inc  memory       ;  accepts only short addressing mode
```

For ST7 instructions supporting both short and long formats, when external symbols are referenced, long mode is chosen by the Assembler. For example:

```
         EXTERN symb3      ;
symb1    equ   $10         ;
...
         ld    A,symb1     ; short mode
         ld    A,symb3     ; long mode chosen
```

2.4 Inherent addressing mode

This concept is hardware-oriented, meaning that instruction operands are coded inside the operation code. At the source coding level, operands are written explicitly.

Examples:

```
lab06    push  A           ; put accumulator A onto the stack
lab07    mul   X,A         ; multiply X by A
```

2.5 Immediate operands

Immediate operands permit you to input a specific value for use with an instruction. They are signaled by the use of a sharp sign (#) before the value.

Examples:

```
lab08    ld    A,#1                ; load A with immediate value 1
lab09    bset  memory,#3           ; set bit #3 in memory location
         btjt  memory,#3,label     ; test bit #3 of memory and
                                     jump if true (set)
```

The range for an 8-bit immediate operand is from 0 to 255.

2.6 Direct and indirect modes

A **direct addressing mode** means that the data byte required to do the operation is found by its memory address, which follows the op-code.

An **indirect addressing mode** means that the data byte required to do the operation is found by its memory address which is located in memory (pointer). The pointer address follows the op-code.

This last group consists of memory indirect variants:

- short indirect (short pointed data),
- long indirect (long pointed data),
- short indirect indexed (short pointed data),
- long indirect indexed (long pointed data),

For ST7 devices, the address specified must always be in page 0 (i.e. its address must be less than $100). Examples:

```
          ld    A,[80]              ; short indirect
          ld    A,[80.b]            ; short indirect
          ld    A,[80.w]            ; long  indirect

lab12     equ   80
          ld    A,([lab12],X)       ; short indirect X-indexed
          ld    A,([lab12.b],X)     ; short indirect X-indexed
          ld    A,([lab12.w],Y)     ; long indirect Y-indexed
```

To make the distinction between short and long indirect addressing mode, the suffix **`.w`** is specified to indicate that you want to work in long indirect mode (this is also true for indexed addressing mode). Implicitly, if nothing is specified, the short indirect addressing mode is assumed.

For ST7 devices, you can also use **`.b`** to specify short indirect addressing mode (as with the indexed addressing mode).

2.7 Indexed modes

The ST7 hardware supports four types of indexed mode:

- indexed without offset,
- indexed with a 8-bit unsigned offset (range [0 ,255]),
- indexed with a 16-bit offset,

The source coding syntax is:

`(X)` or `(Y)` for no-offset indexing.

`(offset,X)` or `(offset,Y)` for indexed with offset.

Some instructions (such as **`ld A`** or **`add`**) support the first three types of indexed mode. Some ST7 instructions (such as **`inc`**) only support the first two types (i.e. indexed without offset and indexed with 8-bit unsigned offset). Examples:

```
ld    A,(X)                ; no-offset mode
ld    A,(0,X)              ; 8-bit offset mode
ld    A,(127,X)            ; 8-bit offset mode
ld    A,(259,X)            ; 16-bit offset mode
```

2.8 Relative mode

This addressing mode is used to modify the Program Counter (PC) register value by adding an 8-bit signed offset to it (i.e. in the range -128 to +127). The relative addressing mode is made up of two sub-modes:

- **relative (direct)**—where the offset is following the op-code.
- **relative (indirect)**—where the offset is defined in memory, whose address follows the op-code.

Relative mode is used by the instructions **`JRxx, CALLR,`** and **`BTJx`**.

At source coding level, the target label is specified (and the assembler computes the displacement).

2.9 High, low addressing modes

In some instances, it may be necessary to access the highest part of an address (8 highest bits) or the lowest part of an address (8 lowest bits) as well. For this feature, the syntax is the following one:

`<`**`expression`**`>`

where **`expression`** is:

`symbol.H (highest part) ,` or

`symbol.L (lowest part).`

Examples:

```
lab12       equ    $0012
            nop
            ld     A,#lab12.h       ; load A with $00
            ld     A,#lab12.l       ; load A with $12
```

For more information about each instruction and the various addressing modes, refer to the *ST7 Programming Manual*, which can be downloaded from the Internet at **www.st.com/mcu**.

3 ST7 Assembler

3.1 Overview

The ST7 Assembler program is a cross-assembler, meaning that it produces code for a target machine—an ST7 microprocessor—which is different from the host machine.

The assembler turns your source code files into relocatable object modules ready for linking.

During the process, it checks for many different types of errors. These errors are recorded in an ASCII file called **cbe.err**. (Note that the linker also writes to this file.) Error messages are explained in on page 78.

To produce code ready for execution, you must run the assembler (**ASM**), the linker (**LYN**), and the object code formatter (**OBSEND**).

3.2 Source files

Source program code is written in the ST7 Assembler language and is saved in an ASCII text file named **source file**. A source file has the extension **`.asm`**. It is made up of lines, each of which is terminated by a new line character.

For a complete reference to the ST7 Assembler language, refer to the *ST7 Programming Manual*.

3.3 Assembly source code format

The first line of an assembly source code file is reserved for specifying the *.tab file for the **target processor**. You cannot put other instructions or comments in this line.

Use this line to specify the directory location of the *.tab file. If the directory is not specified, by default the Assembler searches first in the current directory, then in the directory where the Assembler's executable is located.

The '.tab' suffix may be left out—as the assembler only looks for this file type.

For example, the first line of your source code might look like:

```
c:\st7tools\asm\st7\
```

If the file `st7.tab` can't be found in the specified or default directories, then an error is produced and assembly is aborted.

The rest of the source code lines have the following general format:

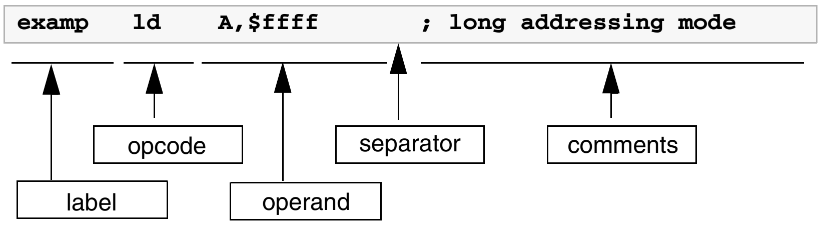
```
[label[:]]<space>[opcode]<space>[operand]<space>[;comment]
```

where `<space>` refers to either a SPACE (**`$20`**) or a TAB (**`$09`**) character.

All four fields may be left blank, but the **`<space>`** fields are mandatory unless:

- the whole line is blank, or
- the line begins as a comment, or
- the line ends before the remaining fields.

For example:



The next sections describe the main components of a source code file.

3.3.1 About labels

Label structure

Labels must start in column one. A label may contain up to 30 of any of the following characters:

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

The first letter of a label must be a letter or an underscore. Note that upper and lower case are treated differently because the assembler is case sensitive.

Upon assembly, any label that exceeds 30 characters is truncated and a warning alerts the user that this has occurred. When truncated, if two of more labels have the same name, a phase inconsistency error is generated.

When labels are defined, several attributes are defined along with the value.

These are:

- **Size** (Byte, Word or Long)
- **Relativity** (Linker Relative or Absolute)
- **Scope** (Internally or Externally defined)

The function of each attribute is explained in the following sections.

Label size

Defining a label’s size allows the assembler to determine what kind of addressing mode to choose even if the value associated with the label is undefined.

The default size of the memory location for a label is word (2 bytes). Whenever the label has no suffix, then the default size is assumed. The directives BYTES， WORDS and LONGS (4 bytes) allow you to change the default.

Regardless of the default size, you can define the size for a specific label by adding a suffix to it: **.b** for byte, **.w** for word and **.l** for long. The suffix is not used when the label is referred to. Using of any suffixes other than .b, .w and .l will result in an error upon assembly.

For example:

```
lab             equ 0              ; word-size label (default)
label1.b        equ 5              ; byte-size label
label2.l        equ 123            ; long label
         segment byte at: 80 'ram'
                bytes              ; force the size of the label to
                                   ; bytes
count           ds.b               ; byte-size label
pointer         ds.w               ; byte-size label with a word-size
                                   ; space reserved at this address
```

Label relativity

There are two sorts of labels: *absolute* labels and *relative* labels.

- *Absolute* labels are usually assigned to constants, such as IO port addresses, or common values used within the program.
- *Relative* labels are defined as (or derived from) an *external* label or a label derived from the position of some program code. They are exclusively used for labels defined within pieces of program or data.

For example:

```
lab             equ 0                 ; absolute label 'count'
ioport          equ $8000             ; absolute word label 'ioport'


         segment 'eprom'
start           ld X,#count
                ld A,#'*'
loop            ld ioport,A
                dec X
                jrne loop
stop            jp stop               ; then loop for ever
```

Only the linker can sort out the actual address of the code, as the assembler has no idea how many segments precede this one in the class. At assembly time, labels such as '**start**' or '**loop**' are actually allocated 'blank' values ($0000). These values will be filled later by the linker. Labels such as '**count**' or '**ioport**', which were defined absolutely will be filled by the assembler.

Source code lines that have arguments containing relative labels are marked with an 'R' on the listing, showing that they are 'linker relative'. Segments are discussed in *Section 3.4* on page 22.

Label scope

Often, in multi-module programs, a piece of code will need to refer to a label that is actually defined in another module. To do this, the module that exports the label must declare it PUBLIC, and the module which imports the label must declare it EXTERN. The two directives EXTERN and PUBLIC go together as a pair.

Most labels in a program will be of no interest for other pieces of the program—these are known as 'internal' labels since they are only used in the module where they are defined. Labels are 'internal' by default.

Here are two incomplete example modules that pass labels between them:

```
module 1
        EXTERN _sig1.w            ; import _sig1
        EXTERN _sig2.w            ; import _sig2
        PUBLIC _handlers          ; export _handlers
        segment byte 'P'
_handlers:                        ; define _handlers
        jp _sig1                  ; refer to _sig1
        jp _sig2                  ; refer to _sig2
        end
module 2
        EXTERN _handlers.w        ; import _handlers (addr. is a word)
        PUBLIC _sig2              ; export _sig2
        segment byte 'P'
_sig2:                            ; define _sig2
        ...
        call _handlers            ; refer to _handlers
        ...
        ret
        end
```

As you can see, module 1 refers to the '**_sig2**' subroutine which is defined in module 2. Note that when module 1 refers to the '**_sig2**' label in an EXTERN directive it specifies a WORD size with the '**.w**' suffix. Because the assembler cannot look up the definition of '**_sig2**' it has to be told its address size explicitly. It doesn't need to be told relativity: **all external labels are assumed to be relative**.

Absolute labels declared between modules should be defined in an INCLUDE file that is called by all modules in the program; this idea of using INCLUDE files is very important since it can reduce the number of PUBLIC symbols—and therefore the link time—significantly.

Lines in the source code listing which refer to external labels are marked with an X and given 'empty' values for the linker to fill.

As a short cut, labels may be declared as **PUBLIC** by preceding them with a '**.**' at their definition. If this is done the label name need not be given in a **PUBLIC** directive. For example, the following code fragment declares the label '**lab4**' as PUBLIC automatically:

```
lab3            ld A,#0

                ret

.lab4           nop

                ret
```

3.3.2 About opcodes

The Opcode field may serve three different purposes. It may contain:

- The opcode mnemonic for an assembly instruction,
- The name of a directive,
- The name of a macro to be invoked.

Opcodes must be separated from the preceding field (i.e. label, if there is one) by a space or a tab.

A comprehensive Opcode description can be found in the *ST7 Programming Manual*.

Macros are discussed in *Section 3.5* on page 26.

Directives are discussed in on page 48.

3.3.3 About operands

Operands may be any of the following:

- Numbers and addresses,
- String and character constants,
- Program Counter references,
- Expressions.

The following paragraphs explain how to use these types of operands.

Number and address representation

By default, the representation of numbers and addresses follows the MOTOROLA syntax. When you want to use hexadecimal number with instructions or labels, they must be preceded by $. When nothing is specified, the default base is decimal.

For example:

```
lab03         equ 10                 ; decimal 10

lab04         equ $10                ; hexadecimal 10

              ld A,$ffff             ; long addressing mode

              ld A,#$cb              ; immediate addressing mode

              ld A,#100              ; decimal representation
```

You can change the Motorola format representation by using directives (.INTEL, .TEXAS) to indicate the new setting format. For more information, refer to   on page 48.

Caution: Addresses for SEGMENT definition are always given in hexadecimal:

```
segment byte at: 100-1FF 'test'
```

The segment '`test`' is defined within the 256-511 address range.

Numeric constants and radix

Constants may need special characters to define the radix of the given number.

The assembler supports the MOTOROLA format by default. INTEL, TEXAS, ZILOG formats are also available if the format is forced by .INTEL .TEXAS or .ZILOG directives. *Table 3* on page 18 shows a summary of these formats.

Note: Decimal constants are always the default, and require no special characters.

Table 3. Numeric constants and radix formats

Format	Hex	Binary	Octal	Current PC
Motorola	$ABCD or &ABCD	%100	~665	* (use `MULT` for MULTIPLY)
Intel	0ABCDh	100b	665o or 665q	$
Texas	>ABCD	?100	~665	$
Zilog	%ABCD	%(2)100	%(8)665	$

String constants

String constants are strings of ASCII characters surrounded by **double quotes**.

For example:

```
"This is an ASCII string"
```

ASCII character constants

The assembler's arithmetic parser also handles ASCII characters in **single quotes**, returning the ASCII of the given character(s).

For example:

```
'A'        $41
'6'        $06
'AB'       $4142
```

Up to 4 characters may be used within a single pair of quotes to give a long constant. The following special sequences are used to denote special characters:

`'\b'`	`$7F`	`backspace`
`'\f'`	`$0C`	`formfeed`
`'\n'`	`$0A`	`linefeed`
`'\r'`	`$0D`	`carriage return`
`'\t'`	`$09`	`tabulation`
`'\\'`	`$5C`	`slash`
`'\'`	`$27`	`single-quote`
`'\0'`	`$00`	`null`
`'\"'`	`$22`	`double-quote`

Program counter reference

The current value of the program counter (PC) can be specified by an asterisk "*****".

For example:

```
lab05   jra *
```

Expressions and operators

Expressions are numeric values that may be made up from labels, constants, brackets and operators.

Labels and constants have been discussed in previous paragraphs.

Arithmetic brackets are allowed up to 8 nested levels—the curly braces {} are used instead of the common “()” because instructions may use a parenthesis to denote indexed addressing modes.

Operators have 4 levels of precedence. Operators in level #1 (listed in *Table 4*) take precedence over operators in level #2 (listed in *Table 5*), and so on. In each level, operators have same precedence—they are evaluated from left to right.

Table 4. Level 1 operators

Operation	Result, level #1
-a	negated a
a and b	logical AND of A and B
a or b	logical OR of A and B
a xor b	logical XOR of A and B
a shr b	a shifted right b times
a shl b	a shifted left b times
a lt b	1 if a<b, else 0
a gt b	1 if a>b, else 0
a eq b	1 if a=b, else 0
a ge b	1 if a>=b, else 0
a ne b	1 if a unequal b, else 0
high a	a/256, force arg to BYTE type
low a	a MOD 256, force arg to BYTE type
offset a	a MOD 65536, force arg to WORD*16 type
seg a	a/65536, force arg to WORD*16 type
bnot a	invert low 8 bits of a
wnot a	invert low 16 bits of a
lnot a	invert all 32 bits of a
sexbw a	sign extend byte to 16 bits
sexbl a	sign extend byte a to 32 bits
sexwl a	sign extend word to 32 bits

Table 5. Level 2 operators

Operation	Result, level #2
a/b	a divided by b
a div b	a divided by b

Table 6. Level 3 operators

Operation	Result, level #3
a * b	a multiplied by b
a mult b	as above for motorola (character * is reserved)

Table 7. Level 4 operators

Operation	Result, level #4
a-b	a minus b
a+b	a plus b

Operator names longer than one character must be followed by a space character. For example, '**1 AND 2**' is correct, '**1AND2**' is not.

Place the curly braces { } around arithmetic expressions.

Also, always use curly braces at the top-level, when defining a numeric expression. Not doing so may produce unexpected results.

Wrong syntax:

```
#define SIZE 128
DS.W SIZE+1             ; Wrong, syntax error
#IF SIZE eq 1           ; Wrong, same as #IF SIZE
#ENDIF
```

Correct syntax:

```
#define SIZE 128
DS.W {SIZE+1}           ; OK
#IF {SIZE eq 1}         ; OK
#ENDIF
```

3.3.4 Comments

Comments are preceded by a semicolon. Characters following a semicolon are ignored by the assembler.

3.3.5 A source code example

Below is an example of a short source code.

```
st7/
; small example module showing source formats
ioport              equ $8000           ; 8 bit IO port A
handshake           equ $9000           ; write xx here to strobe

                    segment 'program'
start               ld a,#0             ; zero counter
loop                ld ioport,x         ; store into ioport
```

```
segment word at: FFFC 'code'

WORD start

end
```

Don't worry if some directives don't make sense yet; they will be covered soon. Also, take special notice of the SEGMENT directive.

3.4 Segmentation

Segments are very important. You have to understand segments before you can use the assembler. Take the time to understand them now and you'll save yourself a lot of puzzling later.

Segmentation is a way of 'naming' areas of your code and making sure that the linker collates areas of the same name together in the same memory area, whatever the order of the segments in the object files. Up to 128 different segments may be defined in each module.

The segment directive itself has four arguments, separated by spaces:

```
[<name>]  SEGMENT [<align>] [<combine>] '<class>' [cod]
```

For example:

FILE1:

```
st7/
                      BYTES
                      segment byte at: 80-FF 'RAM0'
counter.b             ds.b                          ; loop counter
address.b             ds.w                          ; address storage
                      ds.b 15                       ; stack allocation
stack                 ds.b                          ; stack grows downward

                      segment byte at: E000-FFFF 'eprom'
                      ld A,#stack
                      ld S,A                        ; init stack pointer
                      end
```

FILE2:

```
st7/

                       segment 'RAM0'

serialtemp             ds.b

serialcou              ds.b


                       WORDS

                       segment 'eprom'

serial_in              ld A,#0

                       end
```

In the preceding example, FILE1 and FILE2 are two separate modules belonging to the same program. FILE1 introduces two classes: **`'RAM0'`** and **`'eprom'`**. The class-names may be any names you choose up to 30 characters.

The first time a class is used—introduced—you have to declare the default alignment, the start and the end addresses of the class, and of course, the name of the class.

Users generally specify a new class for each 'area' of their target system.

In the examples above, the user has one class for the 128 bytes of on-chip RAM from **`0080`** to **`00FF`** (**`'RAM0'`**) and another for the **`'eprom'`**.

The code is stored from **`E000`** to **`FFFF`** (**`'eprom'`**). You have to supply all this information the very first time you use a new class, otherwise only the class-name is necessary, as in FILE2.

3.4.1 Parameters

The following paragraphs describe each argument in detail.

Name

The **`<name>`** argument is optional; it can contain a name of up to 12 characters. If it does, then all segments with the same name are grouped together within their class, in the order that new names are defined.

Align

The **`<align>`** argument defines the threshold on which each segment must start. The default is the alignment specified at the introduction of the class (if none is specified in the class introduction then `para` alignment is assumed), although the alignment types described in *Table 8* are allowed to be specified overriding the default.

Table 8. Alignment types

Type	Description	Examples
byte	Any address	
word	Next address on boundary	1001->1002
para	Next address on 16-byte boundary	1001->1010
64	Next address on 64-byte boundary	1001->1040
128	Next address on 128-byte boundary	1001->1080
page	Next address on 256-byte boundary	1001->1100
long	Next address on 4-byte boundary	1001->1004
1k	Next address on 1k-byte boundary	1001->1400
4k	Next address on 4K-byte boundary	1001->2000

Looking back to our example on *page 22*, you should now be able to see that the **'RAM0'** class will allocate **80** to **counter**, **81** to **address**, **92** to **stack** in FILE1, and when the linker meets the segment in FILE2 of the same class, **serialtemp** will be allocated **93**, and **serialcou 94**. The same processing happens to the two **'eprom'** class segments—the second, in FILE2, will be tacked on to the end of the first in FILE1. If the FILE2 **'eprom'** class segment had specified, say, the **long** align type instead of the default **byte**, then that segment would have been put on the next long-word boundary after the end of the FILE1 **'eprom'** class segment.

Combine

The **<combine>** argument tells the assembler and linker how to treat the segment. There are three types to handle it:

Table 9. Combine types

Type	Description
at:X[-Y]	Starts a new class from address X [to address Y]
common	All common segments that have the same class name will start at the same address. This address is determined by the linker.
<none>	Follows on from end of last segment of this class.

The at-type <combine> must be used at the introduction of a class, only once.

The **at**-type **<combine>** must have one argument: the start address of the class, and may optionally be given the end address (or limit) of the class too. If given, the linker checks that no items in the class have gone over the limit address; if this does occur, a warning is issued at link time. The hexadecimal numbers X and Y should not have radix specifiers.

All **common**-type **<combine>** segments that have the same class name will start at the same address. The linker keeps track of the longest segment. **common** segments can be used for sharing data across different applications.

For example:

```
st7/
dat1           segment byte at: 10 'DATA'
               ds.w
com1           segment common 'DATA'
.lab1          ds.w 4
com1           segment common 'DATA'
.lab2          ds.w 2
com2           segment common 'DATA'
.lab3          ds.w
com2           segment common 'DATA'
.lab4          ds.w 2
dat2           segment 'DATA'
.lab5          ds.w 2
               end
```

The values for labels **`lab1`**, **`lab2`**, **`lab3`**, **`lab4,`** and **`lab5`** are **`12`**, **`12`**, **`1A`**, **`1A`** and **`1E,`** respectively.

*Note: Since you can't specify both **`at`** and **`common`** combines simultaneously, the only way to specify the exact location of commons is to insert an empty **`at`** combine segment before the first **`common`** declaration.*

For example:

```
com1           segment byte at: 10 'DATA'
com1           segment common 'DATA'
               ...
com1           segment common 'DATA'
               ...
```

`cod` parameter, output file control

The last field of a **`SEGMENT`** directive controls where the linker places the code for a given class. When introducing a class, if this field is not specified, the code for this class will be sent to the normal, default **`.COD`** file by the linker. If the **`[cod]`** file is given a number between **`0`** and **`9`** then all code generated under the class being introduced will be sent to a different **`'.COD`**' file by the linker.

If the linker produces a file called '**`prog.cod`**', for example, then all code produced under classes with no **`[cod]`** field will go into that file, as normal.

If one class is introduced with a **`[cod]`** field of **`1`**, though, then all code produced under that class is sent instead to a file **`prog_1.cod`**. The code produced under the other classes is sent on as usual to **`prog.cod`**.

Using this scheme, you can do bank switching schemes quickly and directly, even when multiple EPROMs share the same addressing space. Simply allocate each EPROM class of its own, and introduce each class with a different **`[cod]`** field. This will result in the linker collating EPROM's contents into a different .COD file for you to OBSEND independently.

For example:

```
                segment byte at:8000-BFFF 'eprom1' 1

                segment byte at:8000-BFFF 'eprom2' 2
```

3.4.2 Copying code

It sometimes happens that you need to copy a block of code from EPROM to RAM. This presents some difficulties because all labels in that piece of code must have the RAM addresses, otherwise any absolute address references in the code will point back to the EPROM copy.

In this case, it helps to specify a class for **execution**, and use a different class for **storage**, as in the following example:

```
                segment byte at: 0 'code'

                segment byte at: 8000 'ram'

                segment 'ram>code'

label1:         nop
```

The code starting from '**`label1`**' will be stored in the '**`code`**' class as usual, but all the labels in that special segment will be given addresses in the '**`ram`**' class, and memory will also be reserved in the **`ram`** class for the contents of the special segment.

3.5 Macros

Macros are **assembly-time subroutines**.

When you call an execution-time subroutine you have to go through several time-consuming steps: loading registers with the arguments for the subroutine, having saved and emptied out the old contents of the registers if necessary, pushing registers used by the subroutine (with its attendant stack activity) and returning from the subroutine (more stack activity) then popping off preserved registers and continuing.

Although macros don't get rid of all these problems, they can go a long way toward making your program execute faster than using subroutines—at a cost. The cost is program size.

Each time you invoke a macro to do a particular job, the whole macro assembly code is inserted into your source code.

This means there is no stacking for return addresses—your program just runs straight into the code; but it's obviously not feasible to do this for subroutines above certain size.

The true use of macros is in small snippets of code that you use repeatedly— perhaps with different arguments—which can be formalized into a 'template' for the macros' definition.

3.5.1 Defining macros

Macros are defined using three directives: **MACRO, MEND** and **LOCAL**.

The format is:

```
<macro-name>MACRO  [parameter-1][, parameter-2 ...]
   [LOCAL] <label-name>[, label-name ...]]
   <body-of-macro>
   MEND
```

For example:

```
add16                        MACRO first,second,result
                             ld A,first
                             adc A,second
                             ld result,A
                             MEND
```

The piece of code of the example might be called by:

```
   add16 index,offset,index
```

which would add the following statements to the source code at that point:

```
   ld A,index

   adc A,offset

   ld index.X,A
```

Note that the formal parameters given in the definition have been replaced by the actual parameters given on the calling line. These new parameters may be expressions or strings as well as label names or constants. Because they may be complex expressions, they are bracketed when there is any extra numeric activity; this is to make sure they come out with the precedence correctly parsed.

Macros do not need to have any parameters. You may leave the MACRO argument field blank (and, in this case, give no parameters on the calling line).

There is one further problem: because a macro may be called several times in the same module, any labels defined in the macro will be duplicated. The **`LOCAL`** directive gets around this problem:

For example:

```
getio                        MACRO
                             LOCAL loop
loop                         ld A,$C000
                             jra loop
                             MEND
```

This macro creates the code for a loop to await IO port at **`$C000`** to go low. Without the **`LOCAL`** directive, the label '**`loop`**' would be defined as many times as the macro is called, producing syntax errors at assembly time.

Because it's been declared **`LOCAL`** at the start of the **`MACRO`** definition, the assembler takes care of it. Wherever it sees the label '**`loop`**' inside the macro, it changes the name '**`loop`**' to '**`LOCXXXX`**' where **`XXXX`** is a hex number from **`0000`** to **`FFFF`**.

Each time a local label is used, **`XXXX`** is incremented. So, the first time the **`getio`** macro is called, '**`loop`**' is actually defined as '**`LOC0`**', the second time as '**`LOC1`**' and so on, each of these being a unique reference name. The reference to '**`loop`**' in the 'if' statement is also detected and changed to the appropriate new local variable.

The directives in *Table 10* are very useful, in conjunction with macros:

Table 10. Some useful directives

Directive	Usage
`#IFB`	To implement macro optional parameters.
`#IFDEF`	To test if a parameter is defined.
`#IFLAB`	To test if a parameter is a label.
`#IFIDN`	To compare a parameter to a given string.

3.5.2 Parameter substitution

The assembler looks for macro parameters after every space character. If you want to embed a parameter, for example, in the middle of a label, you must precede the parameter name with an ampersand '**`&`**' character, to make the parameter visible to the preprocessor. For example, if we have a parameter called '**`param`**'.,

```
   dc.w param
```

it works as expected, but the ampersand is necessary on:

```
label&param:nop

label&param&_&param:nop
```

Otherwise '**`labelparam`**' would be left as a valid label name; If the macro parameter '**`param`**' had the value '**`5`**', then '**`label5`**' and '**`label5_5`**' would be created.

3.6 Conditional assembly

Conditional assembly is used to choose to ignore or select whole areas of assembler code. This is useful for generating different versions of a program by setting a particular variable in an **`INCLUDE`** file that forces the use of certain pieces of code instead of others.

3.6.1 #IF, #ELSE and #ENDIF directives

There are three main directives used to perform conditional assembly, as shown in *Table 11*.

Table 11. Summary of assembly directives

Directive	Usage
`#IF`	marks the start of the conditional and decides whether the following zone will be assembled or not.
`#ELSE`	optionally reserves the condition of the previous #IF for the following zone.
`#ENDIF`	marks the end of the previous #IF's.

The condition given with the '**`#IF`**' may take the form of any numeric expression. The rule for deciding whether it resolves to 'true' or 'false' is simple: if it has a zero value then it's false, else it's true. These directives should NOT start at column 1 of line, reserved for labels. For example:

```
#IF {count eq 1}

%OUT 'true'

#ELSE

%OUT 'false'

#ENDIF
```

This sequence would print '**`true`**' if the label '**`count`**' did equal 1, and '**`false`**' if it didn't. For example:

```
#IF  {count gt 1}

%OUT count more than one

#IF  {count gt 2}

%OUT ...and more of TWO !

#ELSE

%OUT ...but not more than two!

#ENDIF

#ELSE

%OUT count not more than one

#ENDIF
```

As you can see, conditionals may be nested—the **`#ELSE`** and **`#ENDIF`** directive are assumed to apply to the most recent unterminated **`#IF`**.

Other special **`#IF`** directives are available as shown in *Table 12*.

Table 12. Special `#If` directives

Directive	Usage
`#IF1 and #IF2`	require no conditional argument. If the appropriate pass is. being assembled, the condition is considered '**true**'; for instance **#IF1** will be considered true while the assembler is in first pass, **#IF2** while in the second pass.
`#IFDEF`	checks for label definition.
`#IFB`	checks for empty argument (i.e., empty, or containing spaces / tabs), useful for testing macro parameter existence.
`#IFF`	(IF False) is similar to #IF, but checks the negation of the condition argument.
`#IFIDN`	tests for string equality between two arguments separated by a space. This is useful for testing macro parameters against fixed strings.
`#IFLAB`	checks if the argument is a predefined label.

3.7 Running the assembler

3.7.1 Command line

The assembler needs the following arguments:

```
ASM <file to assemble>, <listing file>, <switches> [;]
```

If any or all the arguments are left out of the command line, you'll be prompted for the remaining arguments.

For example:

```
ASM
STMicroelectronics - Assembler - rel. 4.44
File to Assemble: game
```

In the example above, no parameters were given on the command line, so all the parameters were prompted for.

The **`<file to assemble>`** parameter assumes a default suffix **`".ASM"`**. For example, if you type '**`game`**' then '**`game.asm`**' is the actual filename used.

The listing file is the file to which the assembly report is sent if selected. The default filename (which is displayed in square brackets), is made from the path and base-name of the file to assemble. The default filename suffix for the assembly report file is "**`.LST`**". For instance, if you type '**`game`**', then '**`game.lst`**' is the actual filename used.

Note that unless the assembler is told to create either a pass-1 or pass-2 complete listing by the options argument, the listing file will not be created.

3.7.2 About options

Options are always preceded with a minus sign '-'. Upper and lower cases are accepted to define options. Supported options are listed in *Table 13*.

Table 13. Command line options

Option	Function
`-SYM`	enable symbol table listing

`-LI`
`-LI=<listfile>`
	enable pass-2 listing
	enable listing and specify name of .LST file

`-OBJ=<path>`	specify .OBJ file
`-FI=<mapfile>`	specify 'final' listing mode
`-D <1> <2>`	#define <1> <2>
`-I`	specify paths for included or loaded files
`-M`	output make rule
`-PA`	enable pass-1 listing
`-NP`	disable phase errors

SYM option

Description: This option allows the generation of a symbol table.

Format: `ASM <file> -sym`

Example: `ASM prog -sym`
The output is the file `prog.sym`

LI option

Description: Request to generate a complete listing file.
Use the option `-li=<pathname>` to specify the pathname for the generated .LST file.

Format: `ASM <file> -li`
or
`ASM <file> -li=<pathname>`

Example: `ASM prog -li`
The output is the file `prog.lst` in the current directory
`ASM prog -li=obj\prog`
The output is the file `obj\prog.lst`

OBJ option

Description:	You can specify the pathname for the generated .OBJ file, using the following option:
Format:	`ASM <file> -obj=<pathname>`
Example:	`ASM prog -obj=obj\prog` Forces the assembler to generate the object file `obj\prog.obj`.

FI option

Description:

One side effect of using a linker is that all modules are assembled separately, leaving inter modules' cross-references to be fixed up by the linker. As a result the assembler listing file set all unresolved references to 0, and displays a warning character.

The '`-fi`' option enables you to perform an absolute patch on the desired listing. Therefore, you must have produced a listing file (`.LST`) and linked your application to compute relocations and produce a `.COD` file and a map file.

When you want a full listing to be generated, you must not have made any edits since the last link (otherwise the named map-file would be 'out of date' for the module being assembled). This is not usually a problem since full listings are only needed after all the code has been completed. `-fi` automatically selects a complete listing.

Format:

```
ASM <file> -fi=<file>.map
```

The output `<file>.lst` contains the absolute patches.

*Note: When assembling in '**`-fi`**' mode, the assembler uses the map file produced by the linker, and no object files are generated.*

Example:	`ASM -li ex1`	(produces `ex1.lst`)
	`ASM -li ex2`	(produces `ex2.lst`)
	`LYN ex1+ex2,ex`	(produces `ex.map`, `ex.cod`) (see *Chapter : Linker* on page 35)
	`ASM ex1 -fi=ex.map`	(produces new `ex1.lst`)
	`ASM ex2 -fi=ex.map`	(produces new `ex2.lst`)

*Note: When using the option **`-fi=<file>.map`**, the assembler step may fail under certain circumstances:*

***If there are empty segments (Error 73).** To avoid this, comment out any empty segments.*

If you try to assemble a file that has not been used to produce the .map file (Error 73).

***Some EXTERN labels are never used (Warning 80).** To avoid this, comment the unused EXTERN labels out.*

D option

Description: The `-D` option allows you to specify a string that is to be replaced by another during the assembly.

A **blank space** or **=** is required between the string to be replaced and the replacement string. For example `-D <string> 2` is the same as `-D <string>=2`.

It is possible to specify only one argument (`-D <string>`). In which case, `<string>` is replaced with 1.

This is extremely useful for changing the assembly of a module using `#IF` directives, because you can change the value of the `#IF` tests from the assembler's command line. It means that you can run the assembler with different `-D` switches on the same source file, to produce different codes.

Format:

```
ASM <file> -D <string> <string>
```

or

```
ASM <file> -D <string>=<string>
```

or

```
ASM <file> -D <string>
```

Example:

```
ASM ex1 -D EPROM 2 -D RAM 3
ASM ex1 -D EPROM=2 -D RAM=3
```

In both cases the string `EPROM` is replaced with `2`. The string `RAM` is replaced with `3`.

```
ASM ex1 -D EPROM
```

In this case `EPROM` is replaced with `1`.

Note: If you specify multiple ***-D*** *switches, they should always be separated by a space.*

I option

Description: The `-I` option is used to specify the list of search paths for files that are included (with #include) or loaded (with #load).

The different paths can be separated by the ; character and the path list must be enclosed within double quotes. You can also enter multiple include paths by using the`-I` option more than once and separating each with a blank space.

The current working directory is always searched first. After that, the ST7 assembler searches directories in the same order as they were specified (from left to right) in the command line.

Format:

```
ASM -I="<path1>;<path2>;...;<pathN>" call
```

or

```
ASM -I="<path1>" -I="<path2>"... -I="<pathN>" call
```

Example:

```
ASM -I="include;include2" call
```

or

```
ASM -I="include" -I="include2" call
```

M option

Description: The `-M` option tells the ST7 assembler to output a rule suitable for make, describing the dependencies to make an object file.

For a given source file, the ST7 assembler outputs one make rule whose target is the object file name for that source file and whose dependencies are all the included (#include) source files and loaded (#load) binary files it uses. The rule is printed on the standard output.

Format: `-M <source file name>`

Example: ASM -I="include;include2" -M call

The output appears on the screen as the rule:

call.obj: call.asm include\map.inc include2\map2.inc include\map3.inc include\code.bin

PA option

Description: Request to generate a pass-1 listing. In this listing internal forward references are not yet known. They are marked as undefined with a 'U' in the listing file.

Format: `ASM <file> -pa`

Example: `ASM file1 -pa`

The output file is `file1.lst`

NP option

Description: This option disables the error generation.

Format: `ASM <file> -np`

Example: `ASM file1 -np`

4 Linker

4.1 What the linker does

After having separately assembled all the component modules in your program, the next step is to link them together into a **.COD** file which can then be sent on to its final destination using **OBSEND.**

This linking process is not just as a simple concatenation of the object modules. It resolves all the external references. If a referenced label is not defined as **PUBLIC**, an error is detected. It also checks the type of relocation to do, places the segment according to your mapping, and checks if any of them is overrun.

4.2 Invoking the linker

4.3 Command line

The linker needs the following arguments:

```
LYN <.OBJ file>[+<.OBJ file>...],
[<.COD file>],[<lib>][+<lib>...]
```

If all or any arguments are left out of the command line, you'll be prompted.

For example:

```
LYN
STMicroelectronics - Linker - rel  3.00
.OBJ files: begin
.COD file [begin.cod]: begin
Libraries:
```

The **.OBJ** files are simply a list of all the object files that form your program. The **.OBJ** suffix may be left out, and if more than one is specified they should be separated by '**+**' characters, for example **game+scores+keys** would tell the linker to link '**game.obj**', '**scores.obj**' and '**key.obj**'. Object file path names should not include '**-**' or '**;**' characters. Character '**.**' should be avoided, except for suffixes.

The **.COD** file has a default name formed of the first object file's name with forced suffix of '**.COD**'. This will be the name of the file produced at the end of the link session. It contains all the information from the link session in a special format: however, **OBSEND** must be used on the **.COD** file before it is ready to use. If the default filename is not what you want, the filename given at the prompt is used instead. The suffix will be forced to **.COD** if left blank. The default is selected by leaving this argument blank at the command line, or pressing **<ENTER>** at the prompt.

The '**Libraries**' prompt asks for a list of library files generated by the lib utility that should be searched in case of finding unresolved external references. The format for giving multiple libraries is the same as for the **.OBJ** list, except the suffix **.LIB** is assumed.

Some examples:

Linking together the modules **game.obj**, **scores.obj**, **key.obj**, **game1.obj, game2.obj** and **game3.obj** without using any libraries and generating a .COD file named **game.cod**, requires the following command line:

```
LYN game+scores+keys+game1+game2+game3;
```

Linking the same modules in the same environment, but generating a **.cod** file named **prog.cod** requires:

```
LYN game+scores+keys+game1+game2+game3,prog;
```

4.3.1 Response files

Response files are text files that replace the command line to generate the arguments required. Although they can be used on the assembler and linker, it only really makes sense to use them on the linker.

The command line given with the name of the program to execute (here **`LYN`**) can only take up to 128 characters as its argument. For most programs this is fine, but the linker allows up to128 modules to be linked in one run; all their names have to be declared to the linker in its first argument.

This is where response files come in—**they allow you to redirect the command line parser to a file** instead of expecting arguments to come from the command line or the keyboard. A response file is invoked by giving an '**`@`**' sign and a filename in response to the first argument you want to come from the response file.

The filename is assumed to have a suffix '**`.RSP`**' if none is supplied. Repeating our example used as earlier, but this time with a response file called **`game.rsp`**:

```
LYN @game.rsp
```

is all that needs to be typed, and the file **`game.rsp`** must contain:

```
game+scores+keys+

game1+

game2+game3

prog
```

Which echoes what would have been typed at the keyboard. If the response file ends prematurely, the remaining arguments are prompted for at the keyboard. In very large session, the **`.OBJ`** files argument won't fit on one line: it can be continued to the next by ending the last **`.OBJ`** file on the first line with a '**`+`**'.

Note that when using response files, there must be at least two carriage returns at the end of the file.

4.4 Linking in detail

4.4.1 PUBLICs and EXTERNs

All labels declared external in the modules being linked together must have a corresponding **`PUBLIC`** definition in another module. If it doesn't, it may be an error. Similarly, there must only be one **`PUBLIC`** definition of a given label.

The bulk of the linker's job is filling those relative or external blanks left by the assembler in the **`.OBJ`** files; to a lesser extent, it also handles special functions such as **`DATE`** or **`SKIP`** directives. Equally important, it has to collate together and allocate addresses to segments.

4.4.2 Segments in the linker

A typical system may look like the diagram alongside: a good candidate for four different segments, perhaps named 'RAM0', 'RAM1', 'EPROM' and 'ROM'.

If the reset and interrupt vectors live at the end of the map, perhaps from FFEE-FFFF then we might mark a fifth segment called 'vectors' at those addresses and truncate 'ROM' to end at FFED; that way the linker will warn us if 'ROM' has so much code in it that it overflows into where the vectors live.

These classes would be introduced as follows:

```
segment byte at: 0-FF'RAM0'

segment byte at: 100-027F'RAM1'

segment byte at: 8000-BFFF'EPROM'

segment byte at: C000-FFDF'ROM'

segment byte at: FFE0-FFFF'VECTORS'
```

After their full introduction that needs only be done once in the whole program, the rest of the program can refer to the classes just by giving the class names in quotes, for example:

```
        segment 'RAM0'

xtemp   ds.w            ; temp storage for X register

time    ds.b            ; timer count index

        segment 'ROM'

hex     ld A,#1

        add A,#10

        nop
```

If this example followed immediately after the class instruction the '**xtemp**' label would be given the value **0**, **time** would be given **2** and **hex C000**. If, however, the code was several modules away from the introduction with segments of the classes '**RAM0**' or '**ROM**', then the value allocated to all the labels will depend on how much space was used up by those modules.

The linker takes care of all this allocation. This is the way the linker handles the problems of relocatability; keep in mind that this link system is going to have to handle compiled code from high level languages and you'll perhaps begin to understand why things have to be generalized so much.

So far the segments we've looked at have had no **<name>** field, or, more accurately, they all had a null name field. You can ensure that related segments of the same class, perhaps scattered all over your modules with segments of the same class are collated together in a contiguous area of the class memory by giving them the same name.

For example:

```
grafix      segment byte at: 100-027F 'RAM1'
cursor_buf  ds.b 64          ; buffer for map under cursor
            segment byte at: 8000-BFFF 'ROM'
show_page   nop
            segment 'RAM1'
field-buf   ds.b {{256 mult 256}/8}
            segment 'ROM'
dump_buf    ld A,field_buffer
grafix      segment 'RAM1'
cursor_temp ds.b 64
```

This complex sequence of segments shows now instances of the class '**RAM1**' being used with a segment name of '**grafix**'. Because the first instance of the class '**RAM1**' had the name '**grafix**' the two '**grafix**' RAM1 segments are placed in memory first followed by the null-name RAM1 segment (which defines '**field_buf**'). Note this is not the order of the segments in the code—segments with the same name are collated together (even from separate **.OBJ** files), and the lumps of segments of the same name are put into memory in the order that the names are found in the **.OBJ** files.

As explained in *Section* on page 25, if **x** is your cod file suffix when introducing a class, all code for that code is sent into a new cod-file named **file_x.cod**, where **file** is the name of the first cod file, and **x** is the cod-file suffix (**1-9**).

4.4.3 Symbol files

At the end of a successful link, one or more **.OBJ** files will have been combined into a single **.COD** file. A **.MAP** file will have been produced, containing textual information about the segments, classes and external labels used by the **.OBJ** module(s). Finally a compact **.SYM** file is generated, containing all **PUBLIC** symbols found in the link with their final values.

The linker supports a special feature—you can link in **.SYM** files from other link sessions. This means that with big programs, you cannot only partition your code at assembler level, but divide the code up into 'lumps' which are linked and loaded separately, but have access to each other's label as **EXTERNs**.

You can 'link in' a symbol table simply by giving its name with the suffix **.SYM**. Always give symbol tables at the start of the object file list.

OBJ File Example:

```
  LYN prog1.sym+prog2,vectors,irq;
```

Once this is done, all the **PUBLIC** symbols from **prog1.sym** are now available as **PUBLICs** to **prog2.obj**, **vectors.obj** and **irq.obj**.

Because changes in one link will not automatically update references to the changed link code in other links, it's necessary when using this technique to 'fix' each link in an area of memory, and have a 'jump table' at the top of each area. This means that all 'function' addresses are permanently fixed as jump table offset, and changes to each link will result in automatic redirection of the jump targets to the new start of each routine. Put another way, each link must have entry fixed points to all its routine, otherwise re-linking one 'lump' of a program could make references to its addresses in other modules out of date.

4.5 The linker in more detail

4.5.1 The composition of the .OBJ files

The .OBJ files produced by the assembler contain an enormous amount of overhead, mostly as coded expressions describing exactly what needs to go into the 'blank spaces' the assembler has been so liberal with. The linker contains a full arithmetic parser for 'working out' complex expressions that include external labels: This means (unlike most other assemblers) there are few restrictions on where external labels may appear.

The assembler also includes line-number information with the **`.OBJ`** file, connecting each piece of generated object code with a line number from a given source file.

`OBJ` files also contain 'special' markers for handling **`SKIP`** and **`DATE`** type directive.

4.5.2 The composition of the .COD files

`.COD` files, on the other hand, contain very little overhead; there are six bytes per segment that describe the start address and length of that segment. Besides that, the rest of the code is in its final form. A segment of zero length marks the end of the file. It only remains for **`OBSEND`** to take the code segment by segment and send it on to its destination.

4.5.3 Reading a mapfile listing

The linker also generates files with the suffix **`.SYM`** and **`.MAP`** in addition to the **`.COD`** file we have already discussed. The **`.SYM`** file contains a compact symbol table list suitable with the debuggers and simulators.

The **`.MAP`** file listing shows three important things: a table of segments with their absolute address, a table of all classes in the program, and a list of all external labels with their true values, modules they were defined in and size.

Here is an example **MAPFILE**, where one of the class, **`ROM`**, has gone past its limit, overwriting (or more correctly, having part of itself overwritten by) **`VECTORS`**.

The **`[void]`** on some segments in the segment list says that these segments were not used to create object code, but were used for non-coding-creating tasks such as allocating label values with **`ds.b`** etc. The number in straight brackets on the segment as true address list shows how many segments 'into' the module this segment is, i.e., the 1st, 2nd etc. of the given module. The first x-y shows the range of addresses. The **`def (line)`** field on the external labels list shows the source code file and line number that his label was defined in. The number at the start of each class list line is the cod-file that the class contents were sent to (default is **`0`**).

Segment Address List:

```
prog [1]      10-     86      0-      6       ‘RAM0' [void]
prog [2]      88-     278     100-    138     'RAM1' [void]
main [1]      8-      563     8000-   875B    'eprom'
prog [4]      282-    889     C000-   C508    'rom'
main [2]      568-    1456    C509-   F578    'rom'
monitor [1]   8-      446     F579-   FFF9    'rom'
monitor [2]   448-    467     FFEE-   FFFF    'vectors’
```

Class List:

```
0    ‘RAM0'    byte from 0 to 78 (lim   FF) 45% D
0    ‘RAM1'    byte from 100 to 138 (lim 27F) 50% D
0    ‘eprom'   byte from 8000 to 875B (lim BFFF) 21% C
0    ‘rom'     byte from C000 to FFF9 (lim FFDF) C*Overrun*
0    ‘vectors' byte from FFEE to FFFF (lim FFFF) 100% D
```

External Label List:

```
Symbol Name      Value        Size      Def(line)


char             64           BYTE      game.obj(10)
char1            66           BYTE      game.obj(11)
label            ABCD         WORD      game.obj(25)


3 labels
```

The **external label list** only includes labels that were declared **`PUBLIC`**: labels used internally to the module are not included. This table is most useful for debugging purposes, since the values of labels are likely to be relocated between assemblies. The labels are given in first-character-alphabetic order.

5 OBSEND

5.1 What OBSEND does for you

After your program has been assembled and linked to form a '**.COD**' file it needs to be sent on to the place where it will be executed. Right now, your code is just stored as a file on a disk where the target system can't get at it.

OBSEND is a general purpose utility for **.COD** files in various ways using various formats.

5.2 Invoking OBSEND

OBSEND follows the same standard formats as the rest of the assembler / linker; arguments can be given from the command line, keyboard or response file. The general syntax is:

```
   OBSEND <file>,<destination>[,<args>],<format>
```

where **<file>** is the name of the **.COD** file to be formatted (default extension **.COD**). If the filename is not given on the command line, you're prompted at the keyboard with:

```
OBSEND
STMicroelectronics - Obsend - rel. .2.00
File to Send: test
Destination Type (<f>ile,<v>ideo): f
Final Object code Filename [test.fin]: test.s19
Object Format <ENTER>=Straight Binary, ...,

        ST REC <2>, ST REC <4>: s
```

5.2.1 Destination type

<destination> can be "**f**" (file) or "**v**" (video). Only a single character is required.

5.2.2 Destination arguments

When the destination type is "**f**" (file) the argument **<filename>** tells OBSEND where to send the code. The default suffix '**.FIN**' is assumed if none is given.

For example:

```
OBSEND test,f,image.s19,s
```

The command generates the file '**image.s19**' containing the code from '**test.cod**', in S-record **s** format.

When the destination code is "**v**" (video), this field is void.

5.2.3 Format definitions

`<format>` specifies the output format. Output format options are listed in *Table 14*.

Table 14. Output formats

<format>	Output Format
`<none>`	straight binary, i.e., a bit for bit image
`i`	Intel Hex
`i32`	Intel Hex with 32-byte data per line
`ix`	Intel Hex extended
`s`	Motorola S-record (1 byte per address, e.g. ST7)
`x`	Motorola S-record extended with symbol file
`2`	ST S-record 2 (2 bytes per address, e.g. D950)
`4`	ST S-record 4 (4 bytes per address, e.g. ST18932 program space)
`f`	'Filled' straight binary format
`g`	GP Industrial binary format

5.2.4 Straight binary format

```
<format>= <none>
```

This is the simplest of the formats. It's nothing but a bit-for-bit copy of the original file. This the usual mode for sending to the EPROM Emulators, etc., and is the default if no format argument is given.

*Note: When the destination is the screen (the destination code is "**v**"), don't use this format; otherwise you will only get weird control codes.*

```
<format>= <f>
```

This is the ‘filled’ straight binary format where gaps between adjacent segments are filled with **`$FF`**.

5.2.5 Intel Hex format

```
<format>= i
```

This format is very much more complex. Intel Hex bears similarities to S-record that we'll be looking at later. Let's look at a line of the Intel Hex format in detail:

```
:10190000FFFFFFFFFFC00064FFC0006462856285E0

10   number of data bytes (16 in decimal)

1900 address

00   record type

...  data bytes

E0   checksum
```

The first thing to note is that every thing is in printable ASCII. Eight bit numbers are converted into two-characters hexadecimal representation.

Each line begins with an ASCII '**:**' (**$3A**) character.

The next two characters form a byte that declares how many data bytes follow in the data byte section little further along. The next four characters form a 16-bit high-byte first number that specifies the address for the first byte of this data; the rest follows on sequentially.

The next two characters are the record type for this line: **00** is a data line, and **01** signals EOF. The following characters until the last two are up the 16 data bytes for this line and, the last two are a checksum for the line, calculated by starting with **$00** subtracting the real value of all characters sent after the '**:**' until the checksum itself. 'Real value' means that for example, the two characters **3** and **0** should subtract **$30** from the checksum, not **51** and **48**. Every line ends with a CR-LF combination, **$0A** and **$0D**.

The last line sent must be an END-OF-FILE line, which is denoted by a line with no data bytes and a record type of 01 instead of 00.

Giving I32 or i32 instead of intel as the argument uses the same format, but sends 32 bytes of data per line.

5.2.6 Motorola S-record format

```
<format>= s
```

This is another complex method for sending data. Again it cuts the data into 16-byte 'records' with overhead either sides. S-record come in four types: **S0**, known as a header record, **S1** and **S2** data records with 16 and 24-bit address fields, and **S9**and **S8** EOF records with 16 and 24-bit address fields.

*Note: The convention is to close a **S1** 16-bit data record with the **S9** 16-bit EOF record, and to close a **S2** 24-bit data record with the **S8** 24-bit EOF record.*

```
S10D0010E0006285E000628562856D

S1    record type

0D    number of bytes left, address, data and
      checksum (13 in decimal)

0010  address

....  data bytes

6D    checksum
```

The first two characters define the record type: **S0**, **S1**, **S2**, **S8** or **S9**.

The next two characters form a hexadecimal representation of the numbers of bytes left in the record (i.e., numbers of characters /2) This count must include the checksum and addresses bytes that follow. The address field is four characters wide in **S0**, **S1**, **S9** and six characters wide in **S2** and **S8**. The most significant character always comes first.

OBSEND will always use **S1** type records wherever possible (i.e., when the address is less than **$10000**) and use **S2** type data records where it has to (i.e., address > **$FFFF**).

Up to 16 data bytes then follow, with the checksum appended on the end. The checksum is calculated by starting with **$FF** and subtracting the 'real value' of all bytes sent from and including the byte count field until the checksum itself. In this context, 'real value' means the value of the byte before it is expanded into two ASCII characters.

The record is concluded by a CR-LF combination **`$0A`**, **`$0D`**. The **`S0`**, **`S8`** and **`S9`** (i.e., header and EOF) records are always the same:

```
S00600004844521B
```

and:

```
S804000000FB

S9030000FC
```

a complete example of S-record transmission may look like:

```
S00600004844521B

S113001AFF120094FF130094D08AFF390094FF1250

S20801C004FFC0000073
```

```
<format>= x
```

The **extended S-record format**, selected by format x, sends code as described above, except that after the **`S9`**, it sends a list of **`SX`** records, one after the other, in the format:

```
SX  0000 LABEL
```

where **`0000`** are four ASCII zeroes, and LABEL is five ASCII characters. There are two spaces after the **`SX`** and one space after the **`0000`**. **`0000`** represents the hexadecimal value of the label. LABEL may extend to 31 characters, and end with a carriage return.

5.2.7 ST 2 and ST 4 S-record formats

```
<format>= 2

<format>= 4
```

These are industrial formats defined for specific needs.

`2:` This format allows to specify 2-byte words for one address.

`4:` This format allows to specify 4-byte words for one address.

5.2.8 GP binary

```
<format>= g
```

This format is simple. It has a 16-byte count at the beginning low-byte first, calculated by starting at **`0`**, and adding the value of each byte until the end of the data is reached. If there are any 'gaps' in your code, obsend will fill them in with **`$FF`**, and adjust the checksum accordingly. After that four bytes of header information, the data follows in one big block.

6 Librarian

6.1 Overview

If you do a lot of work on similar boards especially those with the same processor, it makes a great deal of sense to reuse lumps of code you've already written to do the same task in a different program. At the simplest level, you could just copy the source code as a block of text into the new program. This works fine, but has a subtle disadvantage: if you update the subroutine, you have to hunt around all the usages of it, performing the update on each.

To get around this problem, many people have the source for common routines in one place, and link the **.OBJ** module with each program needing routine. Then you only need to update the source code once, reassemble it to get a new **.OBJ** file, then link again all the users of the routine, who will now have the new **.OBJ** file.

While this scheme works well, it generates some problems of its own. For example, each routine needs its own **.OBJ** file. By nature, these common routines tend to be small, so you end up giving dozens of extra **.OBJ** modules to the linker, and having the **.OBJ** modules scattered around your hard disk.

The base concept of a librarian is to combine all these small, useful **.OBJ** modules into one large **.LIB** library file. You could then tell the linker about the library, and it would take care of sorting out which **.OBJ** modules to pull into link. It would know which ones to pull by the fact that the main code being linked would have undefined externals, for example, to call the missing library routines. The librarian simply takes each undefined external in turn, and checks it against all the modules in the library. If any of the modules declares a **PUBLIC** of the same name, it knows you need that **.OBJ** module and it includes it automatically.

6.2 Invoking the librarian

The librarian is called **LIB**, and takes one command line argument that is the name of the library to operate on. If not given, you'll be prompted for it.

```
LIB [library name]
```

.LIB is added if the suffix is left off.

If the library you indicate doesn't exist, LIB asks you if it's a new library.

For example:

```
LIB LIB1
STMicroelectronics - Librarian - rel 1.00
Couldn't open Library file 'LIB1.LIB'
is it a new file? (y/n): y
```

If the answer is '**n**', LIB aborts. If the library exists, LIB prints up a report on the library.

```
Library LIB1.LIB is 2K long.

16/1024 Public labels used in 2/128 modules.
```

Next you're faced with the main prompt:

```
LIB1.LIB: Operation (<ENTER> for help):
```

Pressing **ENTER** gives you access to the options shown in *Table 15*.

Table 15. Library file options

Operation	Description
+filename	add/update object module to/in library
-filename	delete object module from library
!filename	update object module in library
***filename**	copy object module to separate file from library
?	list contents of library
x	Exit to DOS

6.3 Adding modules to a library

Typing for example:

```
+user1\board
```

would look for a file, called **user1\board.obj**, and add it to the library.

If LIB can't find the named file, LIB reports the fact and returns to the operations prompt. Else LIB issues the following message:

```
Adding new board.obj ...
15 labels added
Done.
```

If the library already contained a file **board.obj**, it would prompt you with:

```
board.obj already in library LIB1.LIB,
replace with board.obj (Y/N):
```

Responding with '**N**' returns you to the operations prompt, while '**Y**' first removes the old **board.obj** then continues as above.

6.4 Deleting modules from a library

This is done by, for example:

```
-board
```

If LIB cannot find **board.obj** in the current library, it reports an error and aborts back to the operation prompt. If it can find it, it makes sure you know what you are doing with:

```
board.obj to be deleted from library LIB1.LIB: Are you sure (Y/N):
```

N' aborts to operation prompt. 'Y' continues, reporting:

```
Removing old board.obj ...

Done.
```

6.5 Copying modules from a library

To make a copy of a .OBJ module located in a library back to your hard disk, use, for example:

```
*board
```

This will check the existence of **board.obj** in the current library, if not it'll report the failure and abort the operation prompt. If it does find it, it invites you to give it the name of the hard disk file to create to contain the copy of the **.OBJ** module.

```
Copy into .obj file [board.obj]:
```

if you type <**ENTER**>, it'll select the original name of the object module as the copy's name. Otherwise, give it a path spec. If the file you give already exists, LIB says:

```
File board.obj already exists; overwrite? (Y/N):
```

Again, responding '**N**' aborts to the operations prompt, while '**Y**' does the copy with the message:

```
Copying board.obj to disk...

Done.
```

6.6 Getting details in your library

The last operation:

```
?
```

causes LIB to print out details on the current library.

```
Library LIB1.LIB is 2K long

16/1024 Publics labels used on 2/128 modules

0: z1.obj (z1.asm) length 2DE

1: board.obj (board.asm) length 7FFF
```

The name in brackets is the source module from which the named object module was assembled.

Appendix A Assembler Directives

A.1 Introduction

Each directive has been given a new section to itself, and an entry in the index. The name of the directive, which will always appear in the second field is given in the heading at the top of the section.

Next there is a line showing arguments allowed (if any) for this directive. The penultimate section describes the action of the directive and the format and nature of the argument specified in the previous section, and the last section gives one or more example of the directive in use.

There is a 'see also' cross reference at the bottom of the page.

All the directives must be placed in the second, OPCODE, field, with any arguments one tab away in the argument field.

A.2 .BELL

Purpose:	Ring bell on console.
Format:	`.BELL`
Description:	This directive simply rings the bell at the console; it can be used to signal the end of pass-1 or pass-2 with #IF1 or #IF2. This directive does not generate assembly code or data.
Example:	`        .BELL`
See Also:	

A.3 BYTE

Purpose:	Define byte in object code.
Format:	`BYTE <exp or "string">,[,<exp or "string">...]`
Description:	This directive forces the byte(s) in its argument list into the object code at the current address. The argument may be composed of complex expressions, which may even include external labels. If the argument was an expression and had a value greater than 255 then the lower 8 bits of the expression are used and no errors are generated. String argument(s) must be surrounded by double quotes: theses are translated into ASCII and processed byte by byte. It's generally used for defining data tables. Synonymous with STRING and DC.B.

Example:	`BYTE 1,2,3 ; generates 01,02,03`
	`BYTE "HELLO" ; generates 48,45,4C,4C,4F`
	`BYTE "HELLO",0 ; generates 48,45,4C,4C,4F,0`
	`0`

See Also:	DC.B, STRING, WORD, LONG, DC.W, DC.L

A.4 BYTES

Purpose:	Label type definition where type = byte.
Format:	`BYTES`
Description:	When a label is defined, 4 separate attributes are defined with it: scope (internally or externally defined), value (actual numerical value of the label), relativity (absolute or relative), and length, (BYTE, WORD and LONG). All of these attributes, except length, are defined explicitly before or at the definition. You can force the label to be a certain length by giving a dot suffix—eg. 'label.b' forces it to be byte length. You may also define a default state for label length: labels are created to this length unless otherwise forced with a suffix. The default is set to WORD at the start of the assembly, but may be changed by BYTES, WORDS or LONGS to the appropriate length.

Example:	`BYTES`
	`lab1 EQU 5 ; byte length for lab1`

See Also:	LONGS, WORDS

A.5 CEQU

Purpose:	Equate pre-existing label to expression.
Format:	`label  CEQU <exp>`
Description:	This directive is similar to EQU, but allows to change the label's value. Used in macros and as counter for REPEAT / UNTIL.
Example:	`lab1    CEQU {lab1+1} ; inc lab1`
See Also:	EQU, REPEAT, UNTIL

A.6 .CTRL

Purpose:	Send control codes to the printer.
Format:	`.CTRL <ctrl>[,<ctrl>]...`
Description:	This directive is used to send printing and non printing control codes to the selected listing device. It's intended for sending control codes to embolden or underline, etc. areas of listing on a printer. The arguments are sent to the listing device if the listing is currently selected. This directive does not generate assembly code or data.
Example:	`.CTRL 27,18`
See Also:	.LIST, .NOLIST, .BELL

A.7 DATE

Purpose:	Define 12-byte ASCII date into object code.
Format:	`DATE`
Description:	This directive leaves a message for the linker to place the date of the link in a 12-byte block the assembler leaves spare at the position of the DATE directive. This means that every link will leave its date in the object code, allowing automatic version control. The date takes the form (in ASCII) DD_MMM_YYYY where character '_' represents a space; for example 18 JUL. 1988. The date is left for the linker to fill instead of the assembler since the source code module containing the DATE directive may not be reassembled after every editing session and it would be possible to lose track.
Example:	`DATE`
See Also:	

A.8 DC.B

Purpose: Define byte(s) in object code.

Format: `DC.B <exp or "string">,[,<exp or "string">]`

Description: This directive forces the byte(s) in its argument list into the object code at the current address. The argument may be composed of complex expressions, which may even include external labels. If the argument was an expression and had a value greater than 255 then the lower 8 bits of the expression are used and no errors are generated. String argument(s) must be surrounded by double-quotes: these are translated into ASCII and processed byte by byte.

It's generally used for defining data tables. Synonymous with **BYTE** and **STRING**.

Example:

```
        DC.B 1,2,3      ; generates 01,02,03
        DC.B "HELLO"    ; generates 48,45,4C,4C,4F
        DC.B "HELLO",0 ; generates 48,45,4C,4C,4F,00
```

A.9 DC.W

Purpose: Define word(s) in object code.

Format: `DC.W<exp>[, <exp>...]`

Description: This directive forces the word(s) in its argument list into the object code at the current address. The arguments may be composed of complex expressions, which may even include external labels. If the argument was an expression and had a value greater than FFFF then the lower 16 bits of the expression are used and no errors are generated. DC.W sends the words with the most significant byte first.

It's generally used for defining data tables. Synonymous with **WORD**, except that DC.W places the words in High / Low order.

Example:

```
        DC.W 1,2,3,4,$1234  ;0001,0002,0003,0004,1234
```

See Also: DC.B, BYTE, STRING, WORD, LONG, DC.L

A.10 DC.L

Purpose:	Define long word(s) in object code.
Format:	`DC.L <exp>[,<exp>...]`
Description:	This directive forces the long word(s) argument list into the object code at the current address. The arguments may be composed of complex expressions, which may even include external labels. If the argument was an expression and had a value greater than FFFFFFFF then the 32 bits of the expression are used and no errors are generated. **DC.L** sends the words with the most significant byte first. It's generally used for defining data tables. Synonymous with **LONG**, except that DC.L stores the long-words in High / Low order.

Example:	`DC.L 1,$12345678     ; 0000,0001,1234,5678`
	`LONG 1,$12345678     ; 0100,0000,7856,3421`

See Also:	DC.B, DC.W, BYTE, STRING, WORD, LONG

```
DC.L 1,$12345678     ; 0000,0001,1234,5678
LONG 1,$12345678     ; 0100,0000,7856,3421
```

A.11 #DEFINE

Purpose:	Define manifest constant.
Format:	`#DEFINE <CONSTANT ID> <real characters>`
Description:	The benefits of using labels in assembler level programming are obvious and well known. Sometimes, though, values other than the straight numerics allowed in labels are used repeatedly in programs and are ideal candidates for special labelling. The #DEFINE directive allows you to define special labels called 'manifest constants'. These are basically labels that contain strings instead of numeric constants. During the assembly, wherever a manifest ID is found in the source code, it is replaced by its real argument before the assembly proceeds. The #DEFINE is not the definition of a label, so a space must precede the declaration. The number of defines that the Assembler can manage is limited to 4096. However, this depends on the number of characters in the statements. Depending on their length, you may reach this limit sooner.

Example:	`#define value 5`
	`ld a,#value          ; ld a,#5`

See Also:	

A.12 DS.B

Purpose:	Define byte space in object code.
Format:	**`DS.B [optional number of bytes]`**

Description:	This directive is used to 'space out' label definitions. For example let's say we need a set of byte-sized temporary storage locations to be defined in RAM, starting at address $4000. We could write:
	`        segment byte at 4000 'RAM'`
	`temp1   equ $4000`
	`temp2   equ $4001`
	which would work fine, however, we recommend you to write:
	`        segment byte at 4000 'RAM'`
	`temp1   DS.B`
	`temp2   DS.B`
	which does the same job. The advantage is that the **PC** increments automatically. There are two other types of DS instructions available for doing WORD and LONG length storage areas: DS.W and DS.L. Note that the areas in question are not initialized to any value; it's merely a way of allocating values to labels.
	The optional argument specifies how many bytes to allocate; the default is 1.
	Because no code is generated to fill the space, you are not allowed to use DS.B in segments containing code, only for segments with data definitions.

Example:	**`labl     DS.B`**
See Also:	DS.W, DS.L

A.13 DS.W

Purpose: Define word space in object code.

Format: `DS.W [optional number of words]`

Description: This directive is used to 'space out' label definitions. For example let's say we need a set of word-sized temporary storage locations to be defined in RAM, starting at address $4000. We could write:

```
        segment byte at 4000 'RAM'
temp1   equ $4000
temp2   equ $4002
```

which would work fine, however, we recommend you to write:

```
        segment byte at 4000 'RAM'
temp1   DS.W
temp2   DS.W
```

which does the same job. The advantage is that the **PC** increments automatically. There are two other types of DS instructions available for doing BYTE and LONG length storage areas: DS.B and DS.L. Note that the areas in question are not initialized to any value; it's merely a way of allocating values to labels.

The optional argument specifies how many bytes to allocate; the default is 1.

Because no code is generated to fill the space, you are not allowed to use DS.W in segments containing code, only for segments with data definitions.

Example:

```
labl     DS.W
```

See Also: DS.B, DS.L

A.14 DS.L

Purpose: Define long space in object code.

Format: `DS.L [optional number of long words]`

Description: This directive is used to 'space out' label definitions. For example let's say we need a set of long-word-sized temporary storage locations to be defined in RAM, starting at address $4000. We could write:

```
        segment byte at 4000 'RAM'
temp1   equ $4000
temp2   equ $4004
```

which would work fine, however, we recommend you to write:

```
        segment byte at 4000 'RAM'
temp1   DS.L
temp2   DS.L
```

which does the same job. The advantage is that the **PC** increments automatically. There are two other types of DS instructions available for doing BYTE and WORD length storage areas: DS.B and DS.W. Note that the areas in question are not initialized to any value; it's merely a way of allocating values to labels.

The optional argument specifies how many bytes to allocate; the default is 1.

Because no code is generated to fill the space, you are not allowed to use DS.L in segments containing code, only for segments with data definitions.

Example:

```
labl      DS.L
```

See Also: DS.B, DS.W

A.15 END

Purpose: End of source code.

Format: `END`

Description: This directive marks the end of the assembly on the main source code file. If no **END** directive is supplied in a source-code file then an illegal EOF error will be generated by the assembler. Include files do not require an END directive.

Example:

```
          END
```

See Also:

A.16 EQU

Purpose:	Equate the label to expression.
Format:	`label EQU <EXPRESSIONS>`
Description:	Most labels created in a program are attached to a source code line that generates object code, and are used as a target for jumps or memory references. The rest are labels used as 'constants', used for example, to hold the IO port number for the system keyboard: a number that will remain constant throughout the program. The **EQU** directive allocates the value, segment type and length to the label field. The value is derived from the result of the expression, the relativity (absolute or segment-relative derived from the most recent segment), the length is BYTE, WORD or LONG, derived from the size default (starts off as WORD and may be changed by directives **BYTES**, **WORDS** or **LONGS**).
Example:	`labl    END 5`
See Also:	

A.17 EXTERN

Purpose:	Declare external labels.
Format:	`EXTERN`
Description:	When your program consists of several modules, some modules need to refer to labels that are defined in other modules. Since the modules are assembled separately, it is not until the link stage that all the necessary label values are going to be known. Whenever a label appears in an **EXTERN** directive, a note is made for the linker to resolve the reference. Declaring a label external is a way of telling the assembler not to expect the label to be defined in this module, although it will be used. Obviously, external labels must be defined in other modules at link stage, so that all the gaps left by the assembler can be filled with the right values. Because the labels declared external are not actually defined, the assembler has no way of knowing the length, i.e., (byte, word or long) of the label. Therefore, a suffix must be used on each label in an **EXTERN** directive declaring its type; if the type is undefined, the current default label scope (set by BYTES, WORDS, LONGS directives) is assumed.
Example:	`EXTERN label.w, label1.b, label2.l`
See Also:	PUBLIC

A.18 #ELSE

Purpose:	Conditional ELSE.
Format:	`#ELSE`
Description:	Forces execution of the statements until the next **#ENDIF** if the last **#IF** statement was found false or disables execution of the statements until the next **#ENDIF** if the last **#IF** statement was found true. The **#ELSE** is optional in **#IF / #ENDIF** structures. In case of nested **#ELSE** statements, a **#ELSE** refers to the last #**IF**.
Example:	see below
See Also:	#IF, #ENDIF

Example:

```
        #IF {1 eq 0}   ;
                         ; block A ... not assembled
        #ELSE
                         ; block B ... assembled
        #ENDIF
```

A.19 #ENDIF

Purpose:	Conditional terminator.
Format:	`#ENDIF`
Description:	This is the non optional terminator of a **#IF** structure. If there is only one level of **#IF** nesting in force, then the statements after this directive will never be ignored, no matter what the result of the previous #IF was. In other words, the **#ENDIF** ends the capability of the previous #IF to suppress assembly. When used in a nested situation it does the same job, but if the last **#IF / #ENDIF** structure was in a block of source suppressed by a previous #IF still in force, the whole of the last **#IF / #ENDIF** structure will be ignored no matter what the result of the previous #IF was.
Example:	see below
See Also:	#IF, #ELSE

Example:

```
        #IF {count gt 0}
        ...
        #ENDIF
```

A.20 FCS

Purpose:	Form constant string.
Format:	`FCS <"string"> |<bytes> [<"string"> |<bytes>]...`
Description:	This directive works in the same way as the common STRING directive, except that the last character in any string argument has bit 7 (e.g. MSB) forced high. Numeric arguments in the same list are left untouched.

Example:	`FCS "ALLO"       ; 41,4C,4C,CF`
	`STRING "ALLO"    ; 41,4C,4C,4F`

See Also:	STRING

A.21 .FORM

Purpose:	Set form length of the listing device.
Format:	`.FORM <exp>`
Description:	The assembler paginates the listing (when selected) with a default of 66 lines per page. This directive changes the page length from the default. This directive does not generate assembly code or data.
Example:	`.FORM 72`
See Also:	TITLE, SUBTTL, %OUT, .LALL, .XALL, .SALL, .LIST,.NOLIST

A.22 GROUP

Purpose:	Name area of source code.
Format:	`GROUP <exp>`
Description:	All source code following a GROUP directive until the next GROUP directive or the end of the file - 'belongs' to the named group. Source code not included inside a group is allocated to a special group called 'Default'.
Example:	`GROUP mainloop`
See Also:	

A.23 #IF

Purpose:	Start conditional assembly.
Format:	`#IF <exp>`
Description:	Sometimes it is necessary to have different versions of a program or macro. This can be achieved by completely SEPARATE programs / macros, but this solution has the associated problem that changes to any part of the program common to all the versions requires all of them being changed, which can be tedious. Conditional assembly offers the solution of controlled 'switching off' assembly of the source code, depending on the value of the numeric expressions. The structure is known as '**IF/ELSE/ENDIF**': see the example for the format. The **#ELSE** statement is optional. If the expression resolves to 0 the expression is assumed to have a 'false' result: the source code between the false **#IF** and the next **#ENDIF** (or **#ELSE** if supplied) will not be assembled. If the **#ELSE** is supplied, the code following the **#ELSE** will be assembled only if the condition is false. **Conditionals may be nested up to 15 levels**: when nesting them, keep in mind that each **#IF** must have a **#ENDIF** at its level, and that **#ENDIFs** and **#ELSEs** refer to the last unterminated **#IF**.

Example:	`#IF {1 eq 1}`
	`%out true`
	`#FALSE`
	`%out false`
	`#ENDIF`

See Also:	#ENDIF, #ELSE, #IF1, #IF2

A.24 #IF1 Conditional

Purpose:	Conditional on being in pass #1.
Format:	`#IF1`
Description:	This directive works just like #IF except it has no argument and only evaluates itself as true if the assembler is on its first pass through the source code. Can use #ELSE and requires #ENDIF.

Example:	`#IF1`
	`%OUT "Starting Assembly"`
	`#ENDIF`

See Also:	#IF2, #ELSE, #IF, #ENDIF

A.25 #IF2

Purpose:	Conditional on being in pass #2.
Format:	`#IF2`
Description:	This directive works just like #IF except it has no argument and evaluates itself as true only if the assembler is on its second pass through the source code.

Example:	`#IF2`
	`%OUT "GONE through PASS-1 OK"`
	`#ENDIF`

See Also:	#IF1, #IF, #ENDIF, #ELSE

A.26 #IFB

Purpose:	Conditional on argument being blank.
Format:	`#IFB <arg>`
Description:	This directive works just like #IF except it doesn't evaluate its argument: it simply checks to see if it is empty or blank. Spaces count as blank.

Example:	`check   MACRO param1`
	`        #IFB param1`
	`        %OUT "No param1"`
	`        #ELSE`
	`        %OUT param1`
	`        #ENDIF`
	`        MEND`
	`        ...`
	`        check ,`
	`        check 5`

See Also:	#IF2, #ELSE, #IF, #END

A.27 #IFIDN

Purpose:	Conditional on arguments being identical.
Format:	`#IFIDN <arg-1> <arg-2>`
Description:	This directive works just like #IF except it compares two strings separated by a space. If identical, the result is true.
Example:	(see below)
See Also:	#IF2, #ELSE, #IF, #END

```
check   MACRO param1
        #IFIDN param1 HELLO
        %OUT "Hello"
        #ELSE
        %OUT "No Hello"
        #ENDIF
        MEND
```

A.28 #IFDEF

Purpose:	Conditional on argument being defined.
Format:	`#IFDEF <exp>`
Description:	This directive works just like #IF except it tests for its argument being defined.
Example:	(see below)
See Also:	#IF2, #ELSE, #IF, #END

```
check   MACRO param1
        #IFDEF param1
        %OUT "Arg is OK"
        #ELSE
        %OUT "Arg is undefined"
        #ENDIF
        MEND
```

A.29 #IFLAB

Purpose:	Conditional on argument being a label.
Format:	`#IFLAB <arg>`
Description:	This directive works just like #IF except it tests that its argument is a valid, pre-defined label.
Example:	see below
See Also:	#IF2, #ELSE, #IF, #END

```
check   MACRO param1
        #IFLAB param1
        %OUT "LABEL"
        #ENDIF
        MEND
```

A.30 #INCLUDE

Purpose: Insert external source code file.

Format: `#INCLUDE "<filename>"`

Description: **INCLUDE** files are source code files in the same format as normal modules but with two important differences: the first line usually reserved for the processor name is like any other source line, and they have no **END** directive. They are used to contain **#DEFINE** and macro definitions that may be used by many different modules in your program.

Instead of having each module declare its own set of #DEFINE and macro definitions, each module just includes the contents of the same #INCLUDE file. The assembler goes off to the named INCLUDE file and assembles this file before returning to the line after the #INCLUDE directive in the former source code file.

The benefit is that any alterations made to a macro must be done once, in the include file; but you'll still have to reassemble all modules referring to the changed entry.

NOTE that the filename must be inside double-quotes.

Example:

```
st7/
        #include "defst7.h"
        ...
        END
```

See Also:

A.31 INTEL

Purpose:	Force Intel-style radix specifier.
Format:	`INTEL`
Description:	The Intel style: `0ABh` Hexadecimal `17o or 17q` Octal `100b` Binary `17` Decimal (default) `$` Current program counter This directive forces the Intel format to be required during the assembly.

Example:	`INTEL`
	`ld X,0FFFFh`

See Also:	MOTOROLA, TEXAS, ZILOG

A.32 INTERRUPT

Purpose:	Specifies to the debugger that a routine is an interrupt rather than a function.
Format:	`INTERRUPT <string>`
Description:	This directive is used with interrupt handlers and so aids the debugger in correctly searching the stack for return address of the interrupted function.

Example:	`PUBLIC trap_handler`
	`INTERRUPT trap_handler`
	`trap_handler IRET`

See Also:	NEAR

A.33 .LALL

Purpose:	List whole body of macro calls.
Format:	`.LALL`
Description:	This directive forces the complete listing of a macro expansion each time a macro is invoked. This is the default. This directive does not generate assembly code or data.
Example:	`.LALL`
See Also:	.XALL, .SALL

A.34 .LIST

Purpose:	Enable listing (default).
Format:	`.LIST`
Description:	This directive switches on the listing if a previous .**NOLIST** has disabled it. The **-'pa**' or **-'li**' options must also have been set from the command line to generate a listing. This directive, in conjunction with the directive **.NOLIST**, can be used to control the listing of macro definitions. This directive does not generate assembly code or data.
Example:	`.LIST`
See Also:	.NOLIST

A.35 #LOAD

Purpose:	Load named object file at link time.
Format:	`#LOAD "pathname\filename[.ext]"`
Description:	This directive leaves a message for the linker to load the contents of the named file at the current position in the current segment. The file should be in '**straight binary**' format, i.e., a direct image of the bytes you want in the object code. It should not be in Motorola (.s19) or Intel (.hex) format.

Example:	`segment byte at 8000-C000 'EPROM1'`
	`#LOAD "table.bin"`

See Also:	

A.36 LOCAL

Purpose:	Define labels as local to macro.
Format:	`LOCAL <arg>`

Description:	A macro that generates loop code gives rise to an assembly problem since the loop label would be defined as many times as the macro is called. The LOCAL directive enables you to overcome this difficulty.
	Consider the following piece of code:
	`waiter MACRO ads`
	`loop   ld A,ads`
	`       jrne loop`
	`        MEND`
	If this macro is called twice, you will be creating two labels called '**loop**'. The answer is to declare very early in the **MACRO** all labels created by the macro as **LOCAL**. This has the effect of replacing the actual name of a local label (here '**loop**') with **LOCXXXX** where **XXXX** starts from 0 and increments each time a local label is used. This provides each occurrence of the labels created inside the macro with a unique identity.

Example:	
	```
	waiter MACRO ads
	       LOCAL loop
	loop   led Aids
	       drone loop
	       MEND
	```

See Also:	MACRO, MEND

A.37 LONG

Purpose:	Define long word in object code.
Format:	`LONG <exp>[,<exp>...]`
Description:	This directive forces the long word(s) in its argument list into the object code at the current address. The arguments may be composed of complex expressions, which may even include external labels. If the argument was an expression and had a value greater than FFFFFFFF then the 32 bits of the expression are used and no errors are generated. **LONG** sends long words with the least significant byte first. It's generally used for defining data tables. Synonymous with **DC.L**, except that **LONG** sends the low-byte first.

Example:	
	```
	DC.L 1,$12345678     ; 0000,0001,1234,5678
	LONG 1,$12345678     ; 0100,0000,7856,3421
	```

See Also:	DC.B, DC.L, DC.W, BYTE, STRING, WORD

A.38 LONGS

Purpose: Default new label length long.

Format: `LONGS`

Description: When a label is defined, four SEPARATE attributes are defined with it: scope (internally or externally defined), value (actual numerical value of the label), relativity (**absolute** or **relative**), and lastly, length (BYTE, WORD or LONG).

All these attributes except length are defined explicitly before or at the end of the definition: you can force a label to be a certain length by giving a dot suffix, e.g. 'label.b' forces it to be byte length.

You may also define a default state for label length: labels are created to this length unless otherwise forced with a suffix. The default is set to WORD at the start of the assembly, but may be changed by BYTES, WORDS or LONGS to the appropriate length.

Example:

```
        LONGS
lab1    EQU 5            ; long length for lab1
```

See Also: BYTES, WORDS

A.39 MACRO

Purpose: Define macro template.

Format: `<macro> MACRO [param-1][,param-2]...`

Description: This directive defines a macro template that can be invoked later in the program. The label field holds the name of the macro: this name is used to invoke the rest of the macro whenever it is found in the opcode field. The arguments are dummy names for parameters that will be passed to the macro when it is used: these dummy names will be replaced by the actual calling line's arguments.

Note: If you don't want the definition of the macro to be listed, insert directive .NOLIST before the macro definition, and append directive .LIST after the macro definition.

Example:

```
cmp16    MACRO first,second,result
         LOCAL trylow
         ld A,first
         add A,second
         cp A,#0
         jreq trylow
         cpl A
trylow   ld result,A
         MEND
```

See Also: MEND, .LALL, .SALL, .XAL

A.40 MEND

Purpose:	End of macro definition.
Format:	`MEND`
Description:	End of macro definition.
Example:	see below
See Also:	MACRO

```
cmp16    MACRO first,second,result
         LOCAL trylow
         ld A,first
         add A,second
         cp A,#0
         jreq trylow
         cpl A
trylow   ld result,A
         MEND
```

A.41 MOTOROLA

Purpose: Force Motorola-style radix specifier.

Format: `MOTOROLA`

Description: The Motorola style:

`$AB`	Hexadecimal
`~17`	Octal
`%100`	Binary
`17`	Decimal (default)
`*`	Current program counter

This directive forces the Motorola format to be required during the assembly. The default format is **MOTOROLA**.

Example:

```
         MOTOROLA
         ld X,$FFFF
```

See Also: INTEL, TEXAS, ZILOG

A.42 NEAR

Purpose:	Specifies to debuggers that the return address in the stack for functions using this directive is written over two bytes.
Format:	`NEAR <"string">`
Description:	This directive is used with functions called by CALL or CALLR, whose return stack address spans two bytes. Every function called by CALL or CALLR must be classified as NEAR.

Example:	`PUBLIC func`
	`NEAR func`
	`func ret`

See Also:	INTERRUPT

A.43 .NOCHANGE

Purpose:	List original #define strings.
Format:	`.NOCHANGE`
Description:	Strings named in the first argument of a #DEFINE directive will be changed to the second argument of the #DEFINE: the default is that the changed strings will be listed. If you want the original source code to be listed instead, place a .NOCHANGE directive near the start of your source code. This directive does not generate assembly code or data.
Example:	`.NOCHANGE`
See Also:	#DEFINE

A.44 .NOLIST

Purpose:	Turn off listing.
Format:	`.NOLIST`
Description:	Certain parts of your modules may not be required on a listing; this directive disables the listing until the next **.LIST** directive. The default is for the listing to be enabled. This directive, in conjunction with the directive **.LIST**, can be used to control the listing of macro definitions. This directive does not generate assembly code or data.
Example:	`.NOLIST`
See Also:	LIST

A.45 %OUT

Purpose:	Output string to the console.
Format:	`%OUT string`
Description:	This directive prints its argument (which does not need to be enclosed in quotes) to the console. This directive does not generate assembly code or data.
Example:	`%OUT hello!`
See Also:	

A.46 .PAGE

Purpose:	Perform a form feed.
Format:	`.PAGE`
Description:	Forces a new page listing. This directive does not generate assembly code or data.
Example:	`.PAGE`
See Also:	

A.47 PUBLIC

Purpose: Make labels public.

Format: `PUBLIC <arg>`

Description: This directive marks out given labels defined during an assembly as '**PUBLIC**', i.e., accessible by other modules. This directive is related to **EXTERN**; if one module wants to use a label defined in another, then the other module must have that label declared **PUBLIC**.

A label may also be declared PUBLIC as its definition by preceding the label name with a dot; it won't need to be declared in a PUBLIC directive then.

Example:

```
module1.asm
       EXTERN print.w, print1.w
       ...
       call print
       ...
       jp print1
module2.asm
       PUBLIC print
       print nop
       .print1 nop
```

See Also: EXTERN

A.48 REPEAT

Purpose:	Assembly-time loop initiator.
Format:	`REPEAT`
Description:	Used together with UNTIL to make assembly-time loops; it is useful for making tables etc. This directive should not be used within macros.
Example:	`REPEAT`
See Also:	CEQU, UNTIL

A.49 .SALL

Purpose:	Suppress all body of called macro.
Format:	`.SALL`
Description:	This directive forces the complete suppression of the listing of a macro expansion each time a macro is invoked. This instruction is never listed. **Note:**This directive may produce confusing listings.
Example:	`.SALL`
See Also:	.LALL, .XALL

A.50 SEGMENT

Purpose:	Start of new segment.
Format:	`[<name>] SEGMENT <align> <combine> '<class>' [cod]`
Description:	The SEGMENT directive is very important: every module in your program will need at least one. The **`<name>`** field may be up to 11 characters in length, and may include underscores. The <align> field is one of the following:
Align Type:	**`byte`** no alignment; can start on any byte boundaries **`word`** aligned to next word boundaries if necessary, i.e., 8001=8002 **`para`** aligned to the next paragraph (=16 bytes) boundary, i.e., 8001=8010 **`64`** aligned to the next 64-byte boundary, i.e., 8001=8040 **`128`** aligned to the next 128-byte boundary, i.e., 8001=8080 **`page`** aligned to the next page (=256 bytes) boundary, i.e., 8001=8100 **`long`** aligned to the next long-word(=4 bytes) boundary, i.e., 8001=8004 **`1K`** aligned to next 1K boundaries, i.e., 8001=8400 **`4K`** aligned to next 4K boundaries, i.e., 8001=9000
Combine: at	**`X[-Y]`** Introduces new class that starts from X and goes through to address Y. Address Y is optional. **`<none>`** Tack this code on the end of the last segment of this class. **`common`** Put the segment at the same address than other common segments that have the same name, and note the longest length segment. The optional **`[cod]`** suffix is a number from 0 to 9 - it decides into which. COD file the linker sends the contents of this class. 0 is the default and is chosen if the suffix is left off. A suffix of 1-9 will cause the linker to open the [cod] suffix, and send the contents of this class into the cod file instead of the default. This allows bank switching to be supported directly at link level- different code areas at the same address can be separated out into different .cod files.
See Also:	For more information, see *Section 3.4* on page 22.

A.51 .SETDP

Purpose:	Set base address for direct page.
Format:	`.SETDP <base address>`
Description:	If you have used an ST7 processor, you'll be aware of its 'zero-page' or 'direct' addressing modes. These use addresses in the range 00..FF in shorter, faster instructions than the more general 0000..FFFF versions. Other processors use the same scheme, but with a twist: you can choose the 'base page' where the direct mode does not have to be in range 0000 00FF but can be from nn00..nnFF where nn00 is the 'base page', loaded into a register at run-time. Because the assembler cannot track what's in the base page register at run-time, you need to fill it in about the current 'base page' with the .SETDP directive. At the start of the assembly, SETDP defaults to 0000.

Example:	`.SETDP $400`
	`ld A,$401        ; direct mode chosen`

See Also:	

A.52 SKIP

Purpose:	Inserts given number of bytes with an initialization value.
Format:	`SKIP <number of bytes>,<value to fill>`
Description:	This directive leaves a message for the linker that you want X number of Y bytes to be inserted into the object code at this point. Both the arguments must be absolute values rather than external or relative values.
Example:	`SKIP 100,$FF     ; insert 100 bytes all $FF`
See Also:	

A.53 STRING

Purpose:	Define a byte-level string.
Format:	`STRING <exp or "string">,[,<exp or "string">...]`
Description:	This directive forces the byte(s) in its argument list into the object code at the current address. The arguments may be composed of complex expressions, which may even include external labels. If the argument was an expression and had a value greater than 255 the lower 8 bits of the expression are used and no errors are generated. String argument(s) must be surrounded by double-quotes: these are translated into ASCII and processed byte by byte. It's generally used for defining data tables. Synonymous **BYTE** and **DC.B.**

Example:	`STRING 1,2,3      ; generates 01,02,03`
	`STRING "HELLO"    ; generates 48,45,4C,4C,4F`
	`STRING "HELLO",0 ; generates 48,45,4C,4C,4F,00`

See Also:	DC.B, BYTE, WORD, LONG, DC.W, DC.L, FCS

A.54 SUBTTL

Purpose:	Define a subtitle for listing heading.
Format:	`SUBTTL "<Subtitle string>"`
Description:	This directive is related to the **TITLE** directive: its argument is used as a subtitle at the beginning of each page on a listing. We recommend that individual subtitles are generated for each module in a program, while the **TITLE** is defined once in the include file called by all the modules. This directive does not generate assembly code or data.
Example:	`SUBTTL "A/D control routines"`
See Also:	TITLE

A.55 .TAB

Purpose:	Set listing field lengths.
Format:	`.TAB <label>,<Opcode>,<operand>,<comment>`
Description:	Sets the size of the four source code fields for listings. The defaults of 0, 8, 16, 24 are for 80-column printer; if yours can go wider, you need to tell the assembler using this directive. The four fields are the width of the label field, the opcode field, operand and comment. This directive does not generate assembly code or data.
Example:	`.tab 10,6,16,40`
See Also:	.LIST, .NOLIST

A.56 TEXAS

Purpose:	Texas Instruments-style radix specifier.
Format:	`TEXAS`
Description:	The Motorola style: `>AB` Hexadecimal `~17` Octal `?100` Binary `17` Decimal (default) `$` Current program counter This directive forces the Texas Instruments format to be required during the assembly.

Example:	`TEXAS`
	`ld X,>FFFF`

See Also:	INTEL, MOTOROLA, ZILOG

A.57 TITLE

Purpose:	Define main title for listing.
Format:	`TITLE "<Title string>"`
Description:	The first fifty-nine characters of the argument (which must be enclosed in double-quotes) will be included on the first line of each page in a listing as the main title for the listing. We suggest you set the title in the include file called by each module in your program, and give each module a separate subtitle (see SUBTTL section). This directive does not generate assembly code or data.
Example:	`TITLE "ST7 controller program"`
See Also:	SUBTTL

A.58 UNTIL

Purpose:	Assembly time loop terminator.
Format:	`UNTIL <exp>`
Description:	Related to REPEAT directive: if the expression in the argument resolves to a non zero value then the assembler returns to the line following the last REPEAT directive. This directive cannot be used inside macros.
Example:	see below
See Also:	CEQU, REPEAT

```
    val     CEQU 0
            REPEAT
            DC.L {10 mult val}
    val     CEQU {val+1}
            UNTIL {val eq 50}
```

A.59 WORD

Purpose:	Define word in object code.
Format:	`WORD <exp>[, <exp>...]`
Description:	This directive forces the word(s) in its argument list into the object code at the current address. The arguments may be composed of complex expressions that may even include external labels. If the argument was an expression and had a value greater than FFFF then the lower 16 bits of the expression are used and no errors are generated. WORD sends the words with the least significant byte first. It's generally used for defining data tables. Synonymous with DC.W.
Example:	`WORD 1,2,3,4,$1234 ;0001,0002,0003,0004,1234`
See Also:	DC.B, BYTE, STRING, DC.W, LONG, DC.L

A.60 WORDS

Purpose:	Default new label length word.
Format:	`WORDS`
Description:	When a label is defined, four SEPARATE attributes are defined with its scope (internal or external defined) value (actual numerical value of the label) relativity (the label is ABSOLUTE or RELATIVE), and lastly length (BYTE, WORD, or LONG). All these attributes except length are defined explicitly before or at the definition: you can force the label to be of a certain length by giving a dot suffix, e.g. '**label.b**' forces it to byte length. You may also define a default state for label length: the label is created to this length unless otherwise forced with a suffix. The default is set to WORD at the start of the assembly, but may be CHANGED by **BYTES, WORDS** or **LONGS** to the appropriate length.

Example:	
	```
	        WORDS
	lab1    EQU 5          ; word length for lab1
	```

See Also:	BYTES, WORDS

A.61 .XALL

Purpose:	List only code producing macro lines.
Format:	`.XALL`
Description:	This directive forces a reduced listing of a macro expansion each time a macro is invoked. Only those lines of the macro that generated object code are listed. This instruction itself is not listed. This directive does not generate assembly code or data.
Example:	`.XALL`
See Also:	.LALL,.SALL

A.62 ZILOG

Purpose: Force Zilog-style radix specifiers.

Format: `ZILOG`

Description: The Motorola style:

`%AB`	Hexadecimal
`%(8)17`	Octal
`%(2)100`	Binary
`17`	Decimal (default)
`$`	Current program counter

This directive forces the Zilog format to be required during the assembly.

Example:

```
          ZILOG
          ld X,%FFFF
```

See Also: INTEL, MOTOROLA, TEXAS

Appendix B Error Messages

B.1 Format of error messages

There are two classes of errors trapped by the assembler: **fatal** and **recoverable**.

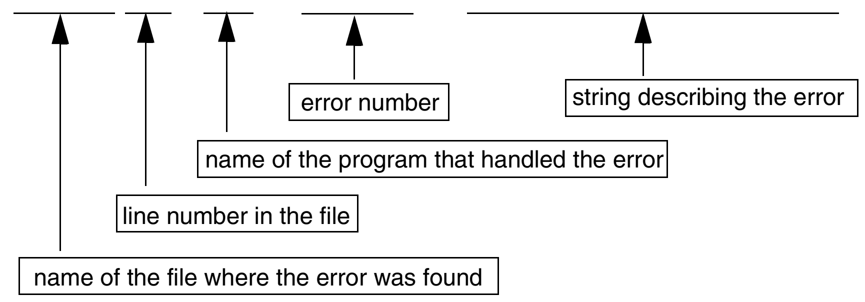
A fatal error stops the assembly there and then, returning you to the caller (which may or may not be DOS; CBE can also invoke the assembler) with a message and error number describing the problem.

The actual format of the error messages is as follows:

```
file.asm(line): as<pass> : Error <errno> : <message> '<text>'
```

For Example:

```
prog.asm(10): as2 : Error 50 : Doubly defined label 'fred'
```


error number
string describing the error
name of the program that handled the error
line number in the file
name of the file where the error was found

*Note: The name of the program that handled the error (third field), can be **as1** or **as2** depending on the pass in progress when the error was found.*

The error number (fourth field) can be used as an index to find a more complete description of the error in the next section (fatal errors read 'FATAL nn', instead of 'ERROR nn').

B.2 File CBE.ERR

Fatal and recoverable errors both are copied into the file CBE.ERR as they occur. CBE can use this error file to give automatic error-finding. Most linker errors are also copied into CBE.ERR.

LINKER errors are described *page 84*.

B.3 Assembler errors

1 Empty file

The assembler couldn't read even the first line of the given source code file.

2 EOF while in Macro Definition

The file ended while a macro was being defined; you should end the last macro definition properly with a MEND statement.

3 Couldn't return to old place in source file 'X.asm'

This error should never occur; it implies you have a disk fault of some kind. After a #include, the assembler returns to the line after the #include itself. If it cannot return to that line this error is produced.

4 Illegal Source EOF

Main source code files must end with an END directive and a carriage-return.

5 EOF before line terminator

The END directive must have at least one CR after it: for example <TAB> END <EOF> will generate this error while <TAB> END <EOF> will work fine.

6 Code produced outside Segment

Any code produced by the assembler is going to have to be placed on a given address in the target system at the end of the day. Since segments are the assemblers way of allocating addresses to lumps of code, any code generated before the first SEGMENT directive is nonsense.

```
^T 55 Move to top line of current window

^V 56 Move to last line of current window

^U 57 Undo changes to last edited line

^[ 58 Drop start of black marker

^] 59 Drop end of black marker

^F 60 Find Source Code for Hex address

^J 61 Report value of given label

^N 62 Report address of current Editor line
```

These functions mostly explain themselves; **the Alternate functions do the same job as the original functions of the same name:** having two indexes for the same job allows the cursor keys and control codes to move the cursor, whichever the user prefers. Some indexes are not used by the default key sequence matrix; these allow some WordStar-like commands to be implemented with more meaning.

Multiple-key sequences, such as those found in WordStar format control codes need to be implemented as follows: take the sequence <^Y><L>, i.e., CTRL-Y followed by the letter L should be coded as ^Y+L where the + denotes that the following character needs no CTRL or SHIFT.

18 File capture Error

#Include had problems finding the named file.

19 Can't find position in Source File

Again to do with #include, another 'impossible' error reporting that it couldn't find the current position of the source file to remember it for after the #include.

20 Can't have more than 4096 #defines

Each #define has to be checked for in each possible position in each source line: having too many of them slows the assembly noticeably. Although you can have up to 4096 #defines, there are also limits on the storage space for both the arguments (error 23); an average of eight characters for both arguments is recommended.

21 Run out of #define storage space (1)

See Error 20.

22 #define has no second argument

#define requires a **space** between the two parts of its argument to delimit it.

23 Run out of #define storage space (2)

See Errors 20 and 21 above; you've reached the limit of the storage space set aside for the second argument of #defines.

24 No strings in DC.W

Strings are only allowed as parts of BYTE, DC.B or STRING directives.

25 No strings in DC.L

Strings are only allowed as parts of BYTE, DC.B or STRING directives.

26 Illegal External Suffix

Only the suffixes .b, .B, .w, .W, .l, .L are legal after an external label in an external directive. If the suffix is left out then the default label size is used (as set by BYTES, WORDS or LONGS; default is WORDS).

27 Bad Character in public line

28 More than four characters in single quotes

This assembler uses double-quotes to surround string items and single-quotes to surround character constants. See *Section 3.3* on page 13.

29 Uneven Single Quotes

Single-quoted items must have a closing quote to delimit.

30 Sequential operator error

It does not allow arithmetic operators to be hard up against each other.

31 No lvalue in Expression.

An lvalue is the left-hand argument of an operator: a + b has 'a' as its lvalue. +b would cause this error.

32 Divide by zero

Attempt to divide a number by zero, in a numeric expression.

33 Ifs nested past 15 levels

Exceeded maximum number of nested #IF statements.

34 Spurious ELSE

An ELSE was discovered when no active IF was in force.

35 Spurious ENDIF

An ENDIF was discovered when no active IF was in force.

36 Only allowed inside Macros

A LOCAL directive was attempted outside a Macro definition.

37 No strings in Word

See Error 24.

38 No string in Long

See Error 25.

39 No REPEAT for this UNTIL

An UNTIL directive is found with no matching REPEAT directive.

40 Couldn't return to old place in Source

Similar to Error 3 but generated by UNTIL instead of #include.

43 Syntax Error in SKIP arguments

SKIP expects two numeric arguments, separated by a comma.

44 First SKIP argument is extern/relative; SKIP aborted

SKIP arguments must be known to the assembler absolutely. Extern or relative arguments are not allowed, although arithmetic is. If you need to move up to a new page, for example, use a new SEGMENT of the same class with a **page** align type.

45 Second SKIP argument is extern/Relative; SKIP aborted

See Error 44.

46 Undefined label

This error happens when a reference is made to an undefined label.

47 Out of label space

A maximum of 1024 labels are allowed per module, and 10k is set aside to contain their names. If either of these limits is exceeded, this error results. Cut the module into two smaller ones; the assemblies will happen twice as fast and you'll only have to reassemble the half you've made changes to, speeding things up.

48 Label more than 30 characters

Labels longer than 30 characters are not allowed.

49 Label defined as PUBLIC twice

This warning occurs if the same label appears more than once in a PUBLIC statement. It's trapped because the second appearance may be a typographical error of a slightly different label you wanted declared as public.

50 Doubly Defined label

This happens when a label is defined twice or more.

51 Phase Inconsistency (P1=X,P2=Y) 'label'

Reports that the named label was allocated different values from pass-1 and pass-2, implies awful things. It's generally caused when for some reason the assembler has generated different lengths for the same instruction between pass-1 and pass-2. Sometimes if the assembler has problems identifying which addressing mode you wanted for a particular instruction because of typographical errors, or labels that are discovered to be undefined during the second pass it may give an error (see Error 54) and create no object code for that line. All labels after that line will then be allocated different values seeing as the object code is now that many bytes shorter, causing tons of Phase Inconsistency errors. Because this mass of Error 51s can sometimes hide the real cause of the error, a special assembler switch **/np** for 'no phase [errors]' can be used to switch them off. We strongly suggest that you don't always use **/np** on all your assemblies; only use it when you need it or you might miss critical phase errors.

52 Public Symbol Undefined

You defined a symbol in a PUBLIC directive that was not defined in the module.

53 Missing Hex Number

The assembler was led to expect a hex number but found one of zero length.

54 Can't match Addressing Mode

This error is a catchall for the assembler if it cannot see anything wrong with your line but cannot match it to a known addressing mode either.

There are two main causes of errors: significant ordering and numeric range errors. The significant ordering error is a simple typographical error: what should have been (val),y was coded as (valy, or whatever. All the components of the addressing mode are properly formed; it's just that the ordering is wrong. The numeric range errors can be harder to detect. For example, an 8-bit relative branch branching out of range would be trapped as an addressing mode error.

To aid diagnostics of what went wrong the assembler dumps out its model of the line to the screen just before the error. Numerics are printed as a hex value followed by an attribute string: INTernal, EXTernal, ABSolute, RELative and .b, .w, .l. Significands are printed as the characters they represent, and strings are printed with their string.

Numeric range errors are also trapped at the link stage (See *Section 4.1* on page 35).

55 Bad PSIG Index

An 'impossible' error that could only occur through corruption of the .TAB file.

56 Un-recognized Opcode

The Opcode (second field) could not be matched against any opcode names for this instruction set, nor could it be matched against any macro names or directives.

57 No closing quote

String must have closing double-quote before the end of the line.

58 No more than 12 Numerics allowed on one line

These's a limit of 12 Numeric units allowed on one line: this usually only matters on long DC.B-type directives where data tables are being defined. If it's a problem, simply cut the offending long line into two shorter lines.

59 Out of space for Macro Definition

The Macro Storage area (ca 64K) has been overflowed. You must have some really big macros!

60 Too many Macros Attempted

There is a limit of 128 Macros allowed per source code module.

61 Mend only allowed in Macro

MEND directive found with no matching MACRO directive.

62 No closing single Quote

See error 29.

63 Bad Ending

Another 'impossible' error, saying that the CR on the end of a source code line was missing.

64 Bad Character in line

As each source code line is read into the assembler it's checked for non-ASCII characters (i.e., >128).

65 Parameter Mismatch

The macro definition implies that there is a different number of parameters than there actually were in this calling line.

66 Currently Unknown Numeric type

An error in your Tabgen File, or a corrupted .TAB file: the numeric handler was asked to check a number against an undefined numeric type. Are you using the latest version of ASM.EXE and your .TAB file?

67 Improper Characters

Unusual characters have been spotted in the source file, of value >127.

68 Label used before its EXTERN definition

Labels must be declared EXTERNAL before their use, preferably in a group at the top of the file.

69 Ambiguous Label Name

The label name in the single-quotes at the end of the error-line can be confused with a register name in this instruction set. Change the name.

70 Cannot have DS.X in segments containing code/data! (only for [void] segs!)

DS.X does not produce any code; it simply advances the assembler's notional Program Counter. It cannot be used in the same segment as real 'code' or data.

71 Cannot have code in segments previously containing DS.X (only for non-void segs!)

DS.X does not produce any code; it simply advances the assembler's notional Program Counter. It cannot be used in the same segment as real 'code' or data.

72 Constant too large for directive 'value'

A DC.B cannot be given an argument >255, for example. Use LOW or OFFSET operators to truncate any wild arguments.

73 Couldn't find entry for segment in mapfile

This is for listings produced with '-fi' option. Complex include file structures and empty segments can sometimes throw the assembler off the track.

74 COD index only allowed on Introduction

When you're using the multiple linker output file scheme, you can only specify the linker output file number for a particular class at the time of that class's introduction.

75 #LOAD before Segment!

The #load has to be but at a given address! Before the first segment the assembler won't know what address to put it at! Shift the #load after a SEGMENT directive.

76 #LOAD before Segment!

The assembler had problems finding the file you've named in a #LOAD directive.

77 All EQUs Involving External args must be before first segment!

78 Cannot nest #includes > 5 levels

79 Couldn't find label list in mapfile

Happens with option '-fi' - Implies problem with the mapfile itself, or unsuccessful previous link, etc.

80 Couldn't find label in mapfile

As above. Is the Mapfile up to date with your Edits? A label may be declared EXTERN, but never used.

81 Couldn't find label in mapfile

The date info has to be stored at a given address - before a SEGMENT there is no address information for the assembler to work on.

82 No string given on FCS line?

FCS is used for defining strings. Why is there no string on this line? Did you intend that? If so, use DC.B or BYTE.

83 Address not on WORD boundary

For 68000 and certain other genuine 16-bit, Opcodes must be on word boundary. This error occurs if you have assembled an instruction at an odd address. Your processor would crash!

84 Byte size label has value >255 (need WORDS?)

85 Word size label has value > 65535 (need LONGS?)

86 Over 250 Macline Pull

Internal Error.

87 Run out of Source File

Internal Error.

88 TAB arguments incorrect

Must be in order num, num, num, num for example, TAB 8, 8, 12, 32.

89 Illegal suffix

An unknown suffix has been used with a label. Recognized suffixes are `.b, .w` and `.l`.

101 Label defined as NEAR and INTERRUPT

103 Label defined as NEAR twice

105 Label defined as INTERRUPT twice

B.4 Linker errors

The following is a list of linker error numbers and their definitions:

1 **File List must be supplied**

2, 3, 11, 13 Incomplete Object File

Fatal error - the linker has identified that the given object file has been truncated. How are you for disk space?

4, 23 Size mismatch on EXTERN from F1 says .X, PUBLIC from F2 says .Y.

When declared PUBLIC in file F2 the label L was given size attribute Y. However, when you came to use it in file F1, the EXTERN statement named L as being of size .X - they didn't tally. They must. Find out which is incorrect and alter it.

5 No info on start address of class 'class'

The first time the linker sees a class (remember it goes through the object files in the order given on the link command line), it must be given the full 'introduction' to the class, with start and stop addresses. See *Section 3.4* on page 22.

6 Too many secondary externals (32)

Secondary Externals ought to occur only rarely in your code - If you're using >32 then your structure has something seriously wrong with it. Hint - all your labels that are used all over the place, like constants, addresses of IO, and the like: make a module just for them, just containing EQUs and/or DS.Xs, all declared public. Any arithmetic needs doing more than once throughout your code, do it there, and declare the result with its own public label. Then refer to these PUBLICs using simple EXTERNs in each module.

7, 19 Corrupted Object File

Disk Nastiness. Reassemble. There may be an object code inconsistency: re-assemble all the files, and link again.

8 Public of same name as secondary EXTERN already exists!

This error cannot be seen until link time. Rename one or the other.

9 To many XREFs to link (12048)

10 Undefined EXTERN L (from F1)

12 Couldn't seek back in file 'F1'

Internal Error. Should never occur.

14 Unexpected 7f

Disk nastiness. Reassemble.

15 Byte size exp >Offh 'value'

Needs looking at. If it is what you intended, either use the LOW operator to saw off upper bits, or change the size attribute.

Appendix C Revision History

Date	Revision	Description of changes
1-Jul-2001	1	• Initial release
30-Jun-2005	2	• Updated *Introduction* • Updated *Getting Started* installation procedure • Added *Revision History*

Appendix D Product Support

If you experience any problems with this product, or contact the distributor or the STMicroelectronics sales office where you purchased the product. Phone numbers for major sales regions are provided in the *Contact List*, below.

In addition, at our Internet site **www.st.com/mcu**, you will find a complete listing of ST sales offices and distributors, as well as documentation, software downloads and user discussion groups to help you answer questions and stay up to date with our latest product developments.

D.1 Software updates

3. All our latest software and related documentation are available for download from the ST Internet site, **www.st.com/mcu**.

Contact List

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San Jose, CA 95131
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Note: For American and Canadian customers seeking technical support the US/Canada is split in 3 territories. According to your area, contact the appropriate sales office from the list above and ask to be transferred to an 8-bit microcontroller Field Applications Engineer.

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