Personal Computer

MZ-80B

Linker

SHARP

NOTICE

The MZ-80 series of sophisticated personal computers is manufactured by the SHARP CORPORATION. Hardware and software specifications are subject to change without prior notice; therefore, you are requested to pay special attention to version numbers of the monitor and the system software (supplied in the form of cassette tape or mini-floppy disk files).

This manual is for reference only and the SHARP CORPORATION will not be responsible for difficulties arising out of inconsistencies caused by version changes, typographical errors of omissions in the descriptions.

This manual is based on the SB-1500 series monitor and the SB-7000 series Floppy DOS.

— CONTENTS —

INTRODUCTION 1
LOADING ADDRESS 2
RELATIONSHIP BETWEEN THE EXECUTION ADDRESS AND LOADING ADDRESS 3
OFFSET 6
LOADING ADDRESS AND EXECUTION ADDRESS (ORG STATEMENT) 7
SYMBOL TABLE 8
LINK/T COMMAND 9
LINK MESSAGE EXAMPLES 11
ERROR MESSAGES 12

INTRODUCTION

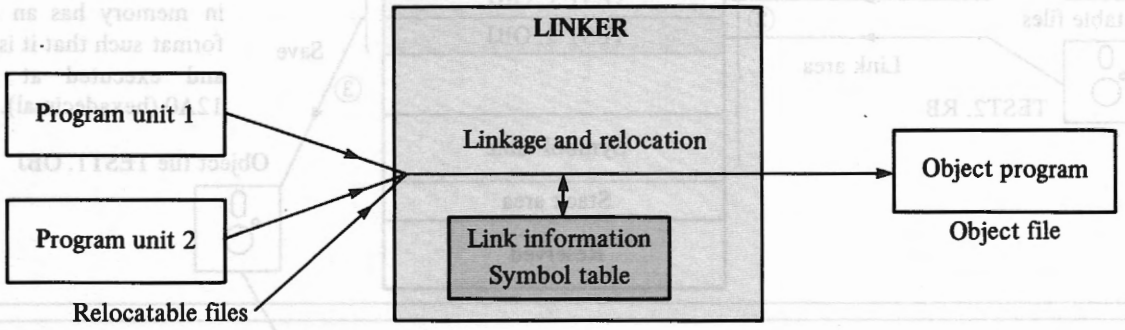
The linker for the SHARP MZ-80B inputs relocatable files output by the assembler or the BASIC compiler and outputs object files.

Relocatable files are not programs which are directly executable by the CPU, but are files which contain information used to keep programs relocatable. They also contain global symbols in ASCII code which are declared to link two or more program units.

The linker fetches relocation information and loads object programs into the link area in main memory while adding the programmer-specified loading address to the relocatable addresses. When two or more relocatable program units are loaded, units are appended to the first program unit (file), if the loading address is specified for the first unit.

The linkage operation itself is described in detail in Section 2.3, "Linker" of the System Command manual. However, the programmer does not need to be aware of details of the linkage operation details.

When outputting the object program (object file), it is necessary to specify the loading address and the execution address.

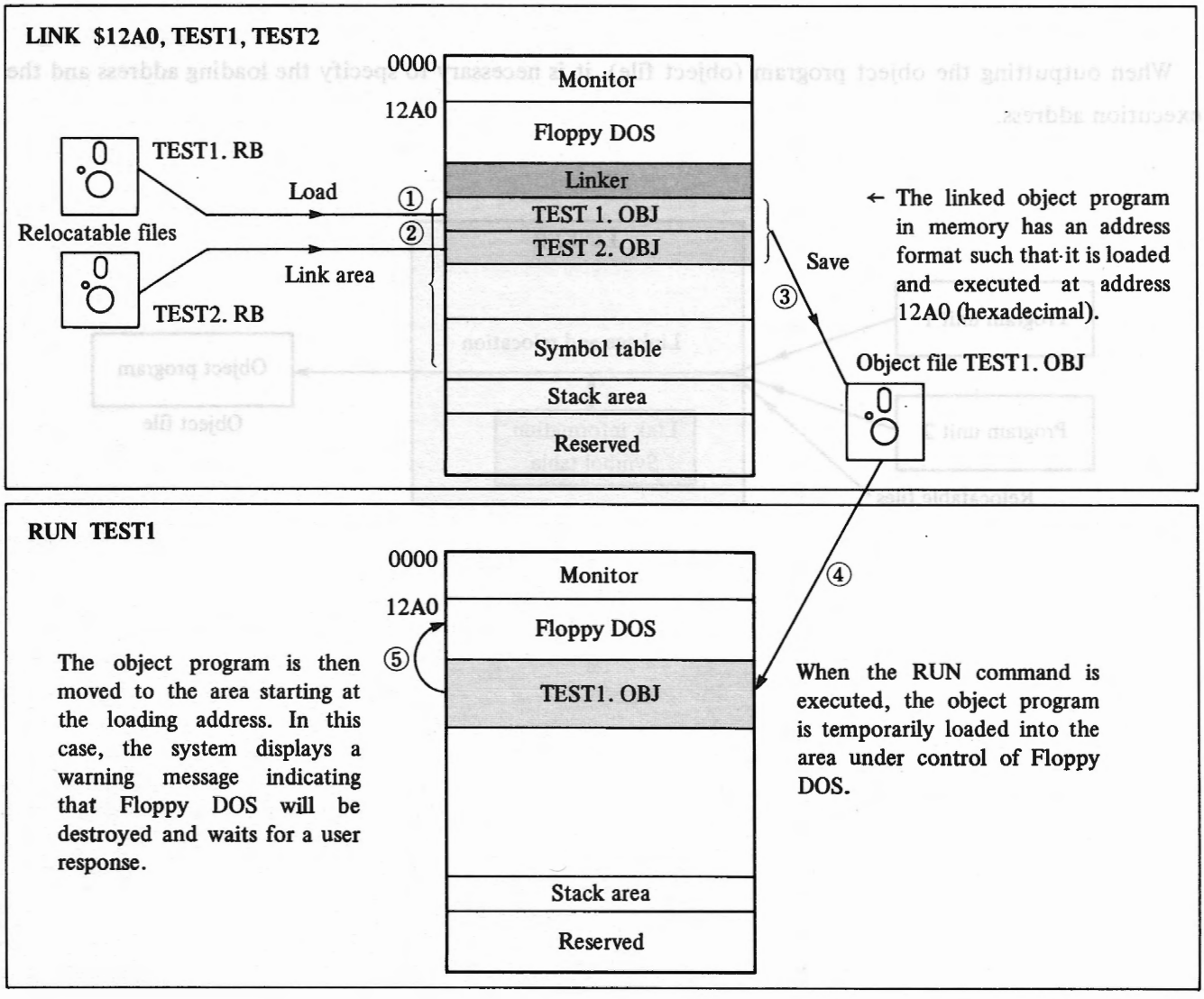


LOADING ADDRESS

The loading address specifies the address at which the object program is to be loaded. When this address is not specified, Floppy DOS assumes the starting address which can be managed by Floppy DOS as loading address.

LINK TEST1, TEST2	Links TEST1 and TEST2 and assigns the loading address to the beginning of the area managed by Floppy DOS.
LINK $12A0, TEST1, TEST2	Links TEST1 and TEST2 and assigns the loading address to 12A0H.

The figure below shows the flow of files from the time they are linked by the linker until they are executed with the RUN command. Numbers ① through ⑤ in the figure denote the processing sequence.



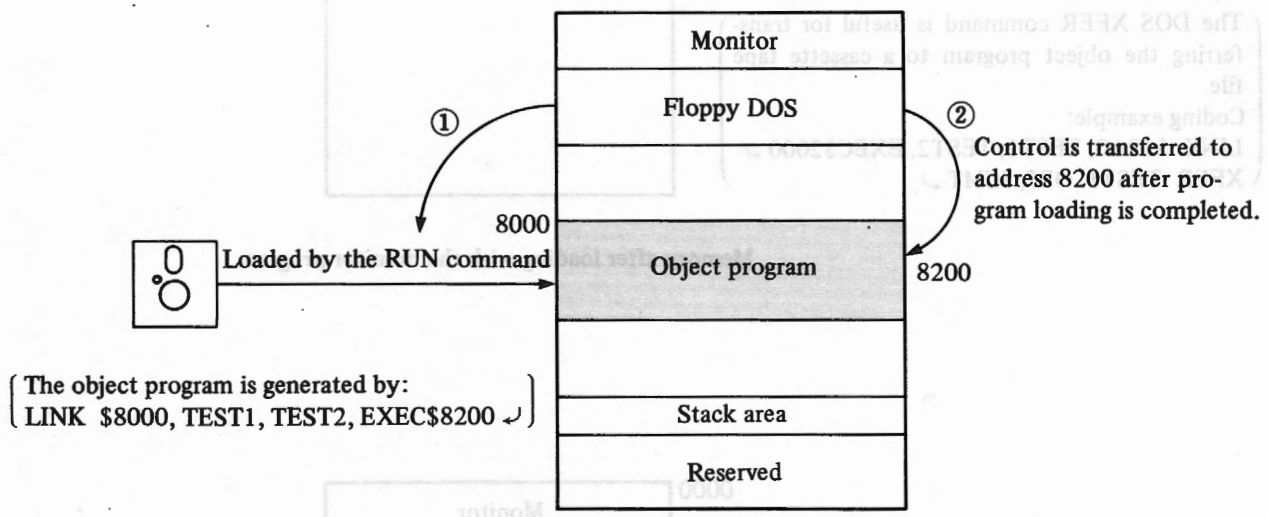
RELATIONSHIP BETWEEN THE EXECUTION ADDRESS AND LOADING ADDRESS

The programmer may specify the execution address as well as the loading address when outputting an object file through the linker.

```
LINK  $8000, TEST1, TEST2, EXEC$8200
```

The above command links and loads relocatable program unit files TEST1 and TEST2 into memory, specifying a loading address of 8000 (hex) and an execution address of 8200 (hex).

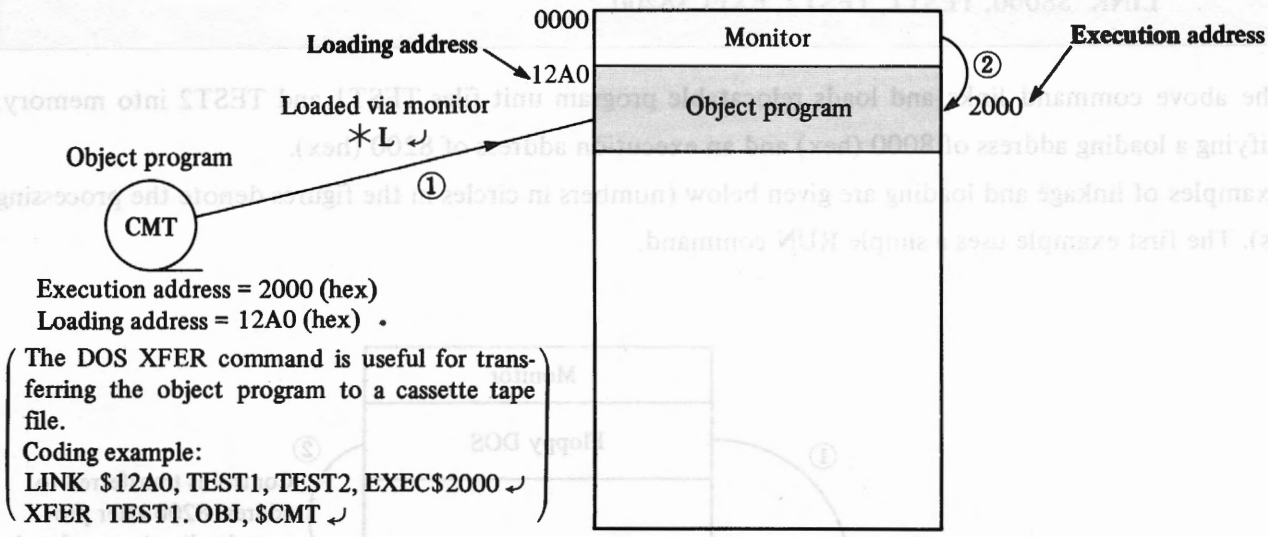
Examples of linkage and loading are given below (numbers in circles in the figures denote the processing steps). The first example uses a simple RUN command.



Memory after loading with Floppy DOS RUN command

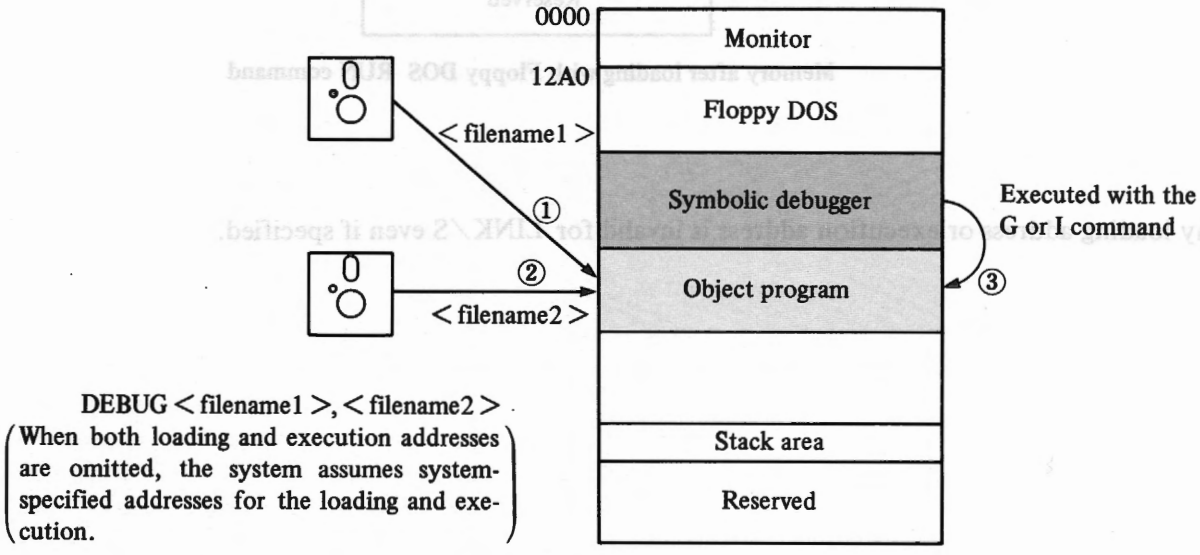
Note: Any loading address or execution address is invalid for LINK/S even if specified.

When the monitor is used to load the object program, its starting address in memory is designated by the loading address. The program counter is set to the address designated by the execution address after the object program is loaded. The figure below shows how an object program with a loading address of 12A0 and an execution address of 2000 is loaded and how control is transferred.



The DOS XFER command is useful for transferring the object program to a cassette tape file.
Coding example:
LINK $12A0, TEST1, TEST2, EXEC$2000 ↵
XFER TEST1.OBJ, $CMT ↵

Memory after loading with the monitor program



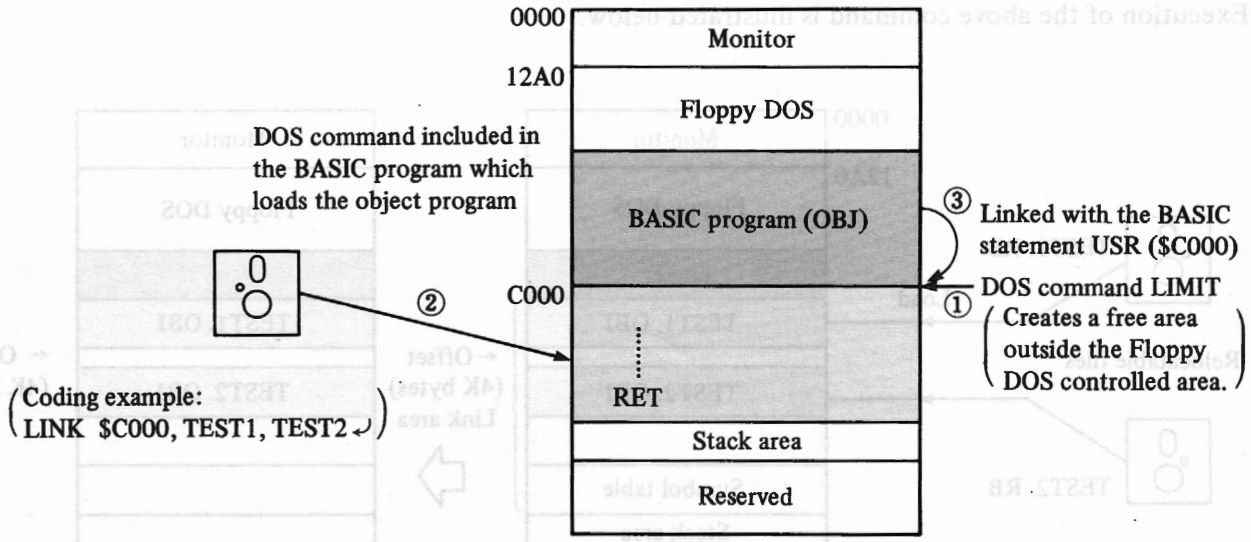
DEBUG < filename1 >, < filename2 >

When both loading and execution addresses are omitted, the system assumes system-specified addresses for the loading and execution.

Memory after loading with the symbolic debugger

Subroutine programs created with the assembler and BASIC programs created with the BASIC compiler may be linked using a library (see the "Programming Utility" manual) or the BASIC USR statement. Here, an example is given of linking an object program with a BASIC program using the USR statement.

The figure below shows how an object program is loaded and linked with a BASIC program. The area in memory which is managed by Floppy DOS is reduced with the DOS LIMIT command to create a free area. The object program is loaded into this free area with the Floppy DOS or BASIC LOAD statement. The BASIC program can then call the object program as a subroutine using the USR( ) statement.



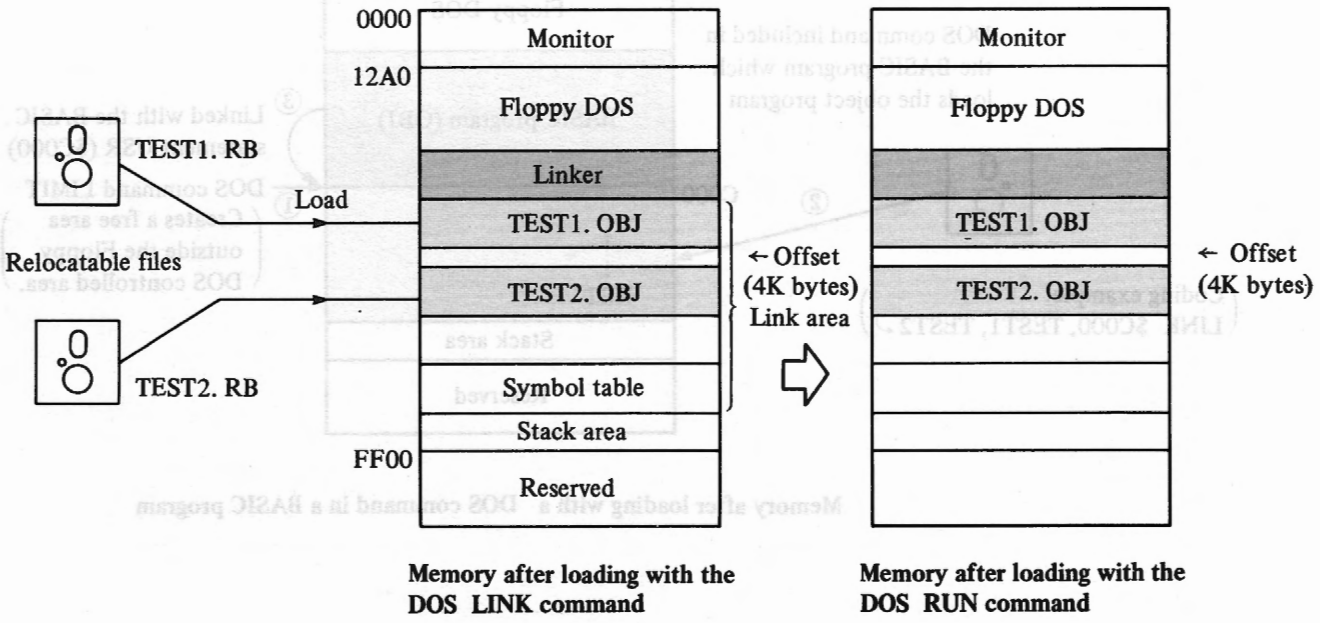
Memory after loading with a DOS command in a BASIC program

OFFSET

The programmer can specify an offset to reserve a free area between two object program units.

LINK TEST1, $1000, TEST2	Links TEST1 and TEST2 so that the object program is loaded at the area equivalent to 1000 (hex) addresses reserved between them.

Execution of the above command is illustrated below.



Note that the loading address and offset are carefully distinguished in the following command:

A 4-digit hexadecimal number preceded by a $ symbol in the first argument position is always interpreted as the loading address.

```
LINK $8000, TEST1, $1000, TEST2, TBL$20, EXEC$8200
```

Loading address — Offset (4K bytes) — Symbol table size (approx. 8K bytes) — Execution address

Note: Any loading address or execution address is invalid for LINK/S even if specified.

LOADING ADDRESS AND EXECUTION ADDRESS (ORG STATEMENT)

Although a loading address can be specified with the linker, it can also be specified with the ORG assembler directive during assembly. Assume that there are two relocatable files.

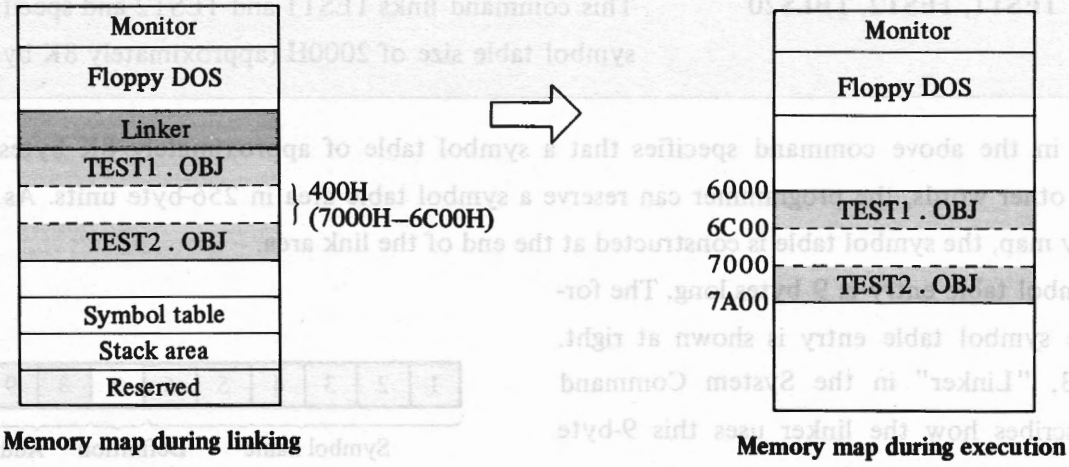
TEST1: Assembled with loading address 6000H specified. The object file will be loaded in the area from 6000H through 6C00H.

TEST2: Assembled with loading address 7000H specified. The object file will be loaded in the area from 7000H through 7A00H.

These are linked as follows.

LINK TEST1, TEST2

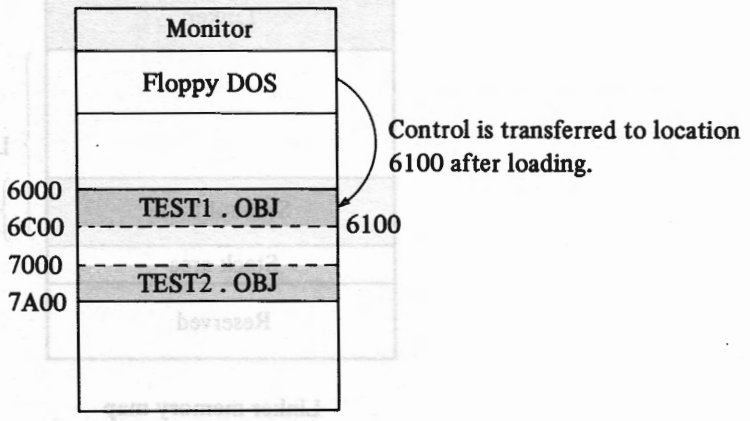
Then, the object files are loaded as shown in the memory map below and the execution address of TEST1 . OBJ is automatically set to 6000H.



Memory map during linking **Memory map during execution**

The loading addresses specified during assembly are valid even if the loading addresses and offsets are specified in the LINK command. However, when no loading address is specified for TEST2 during assembly, the offset specified in the LINK command is valid. The execution address specified in the LINK command is valid.

LINK $5000, TEST1, $3000, TEST2, EXEC$6100



Memory map during execution

Loading addresses specified during assembly are invalid when the LINK/S command is used to generate a system file.

SYMBOL TABLE

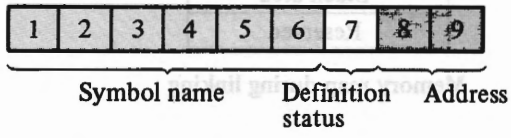
Information referred to as symbols in the linker and symbolic debugger indicates globally declared labels (that is, label symbols defined by the ENT or EQU assembler directive) in the source program. This information is stored in the relocatable file by the assembler for use in linking with other relocatable programs.

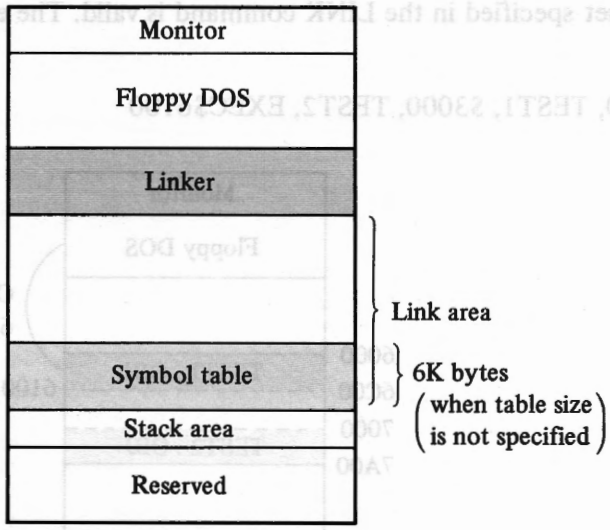
The linker loads label symbols into the symbol table while inputting program units in the relocatable files. The symbol table is placed at the end of the link area; its size is set to approximately 6K bytes by the linker unless otherwise specified by the programmer. The programmer can specify an area of more than 6K bytes for the symbol table area using the LINK command as follows:

LINK TEST1, TEST2, TBL$20	This command links TEST1 and TEST2 and specifies a symbol table size of 2000H (approximately 8K bytes).

TBL$20 in the above command specifies that a symbol table of approximately 8K bytes is to be created. In other words, the programmer can reserve a symbol table area in 256-byte units. As shown in the memory map, the symbol table is constructed at the end of the link area.

Each symbol table entry is 9 bytes long. The format of the symbol table entry is shown at right. Section 2.3, "Linker" in the System Command manual describes how the linker uses this 9-byte information to link relocatable program units.





Linker memory map

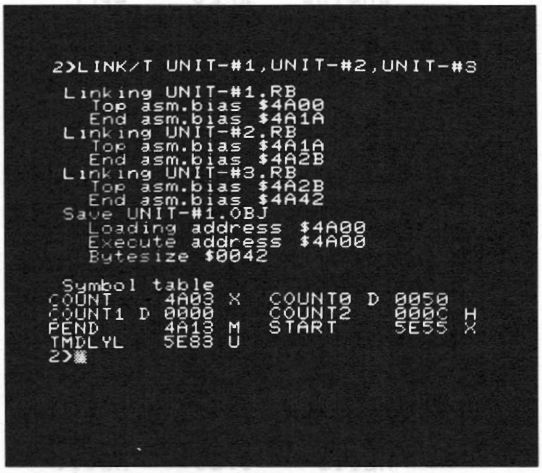
LINK/T COMMAND

The LINK/T command is used to display the contents of the symbol table after program linking is completed. It displays a symbol name, its absolute address (in hexadecimal representation) and the definition status for each symbol table entry. The user can detect symbol definition errors by checking the definition status.

The LINK/T command has two basic formats:

LINK/T TEST1, TEST2	Links TEST1 and TEST2 and displays the symbol table on the CRT screen.
LINK/T/P TEST1, TEST2	Links TEST1 and TEST2 and prints the symbol table on the printer.

— The photo at right shows link and symbol table information displayed on the CRT screen with the LINK/T command for the three program units shown on Page 11. Undefined symbols are labeled "U".



— Symbol definition messages are listed below.

Message	Definition
U	Undefined symbol (address or data)
M	Multi-defined symbol (address or data)
X	Cross-defined symbol (address or data)
H	Half-defined symbol (data)
D	EQU-defined symbol (data)

No message is attached to symbols for which an address has been defined. U, M, X and H indicate error conditions.

— If global switch/T is not specified, only error symbols (whose definition messages are U, M, X or H) are displayed or printed.

The listing below shows a printout of link and symbol table information. The symbol table entries have been sorted as may be seen from this listing.

```
Linking M-LANG#1.RB
  Top asm.bias $4A00
  End asm.bias $5678
Linking M-LANG#2.RB
  Top asm.bias $5678
  End asm.bias $5B14
Linking MONEQU.LIB
  Top asm.bias $5B14
  End asm.bias $5B14
Save M-LANG.OBJ
  Loading address $4A00
  Execute address $4A00
  Bytesize $1114

Symbol table
&MSG     57C2    &NL      57B4    &PRNT    57A1    &PRNTS   5796
1HEXO    574D    1SET     57F7    2HEXO    5760    2SET     5823
4HEXO    5776    4SET     5832    8080T    5888    ??KEY    0D77
?FEED    52D6    ?TABP    5374    @ERR1  D 0003    @ERR2  D 0004
@ERR3  D 0005    @ERR4  D 0006    ACCUM    4BF7    ARST7  D 0038
BDRIVE   4CF9    BELL     0A80    BKTBL    5A19    BPDUM    5A58
BPFLG    5A57    BPSIM    5A40    BREAD    4F9B    BREAK    4C7C
BRKEY    0527    BRST8  D 0039    BUFFR    5A74    BUSY     4F3A
BWRIT    50A4    CLBF0    4CED    CLBF1    4CEE    CLBF2    4CEF
CLBF3    4CF0    CLBP     5678    CLEAR    4A82    CMD      5A3F
COMMON   5511    COMPL    4BFC    COMPR    5688    CONT     5565
CONT9    5635    CR     D 00D8    CTBL     58E6    CURSOL   5375
DI       0E0E    DM     D 00DC    DR     D 00DB    EFREE  D FFF0
ERCODE   4CF2    ERJMP    4CF5    ERJPAD   4CF6    ERSECT   4CF4
ERTRK    4CF3    ESCPRT   52DA    FCMD     4CEB    FDERR    4AB5
GET1     56DF    GET1K    5741    GET2     5716    GET4     5731
GET44    572C    GETKY    0610    GETL     0BE5    GOTO     4CB0
HS     D 00DD    IBUFE    1180    JRTBL    58B2    LFLG     5A5A
LIST     4A9F    LISTA    529C    LISTM    5263    LISTN    5256
LISTS    529A    LOAD     4ABD    LOOK0    586B    LOOK1    5878
LPNT     5A3D    MAIN1    4A3A    MAIN2    4A48    MELDY    0AA3
MEMRY    4BA1    MES0     5914    MES1     5933    MES10    598A
MES11    5990    MES12    59A8    MES13    59C1    MES14    59D8
MES15    59E3    MES16    59E4    MES17    59E7    MES18    59ED
MES19    59F3    MES2     593D    MES20    59F7    MES21    59F9
MES22    59FE    MES23    5A05    MES24    5A0B    MES25    5A13
MES3     5944    MES4     594E    MES5     5959    MES6     5966
MES7     5972    MES8     597E    MES9     5985    MSG      06B5
MTFG     4CEC    MTOFF    4D71    MTON     4D44    NL       0757
NLMSG    57BF    PMSGX    5279    PNL      5251    POTFE  D 00FE
POTFF  D 00FF    PRNT     063C    PRNTS    063A    PROG     4C01
PROTC    57CF    PRTAB    52AE    PTAB0    58BD    PTAB1    58C3
PUSHR    0DF1    PWORK    58C6    RCLB     4F13    READY    4CFC
REGST    4C07    RETRY    4CF1    RSTRT    552B    SACC     569B
SAVE     4ABA    SCOMP    56B9    SCR    D 00DA    SEARCH   583D
SEEK     4D5A    SFREE  D 0000    SKPBL    57E7    SOUND    568E
SPROG    56C1    STAFG    5222    START    4A00    TR     D 00D9
TYPE0    577F    TYPE1    5782    TYPE2    578C    TYPE3    578F
VERIFY   5182    VRFCNT   4CF8    WARN     5A48    WRITE    4C13
WRK0     5A4E    WRK1     5A4F    WRK2     5A50    WRK3     5A51
WRK4     5A52    WRK5     5A53    WRK6     5A54    X1HEX    5752
X2HEX    5765    XFER     4B30    XGET1    56E2    XGET2    5719
XGET22   571D    XGET4    5734    XTEMP    09BE    Z80TB    589D
ZAF      5A5B    ZAFC     5A63    ZBC      5A5D    ZBCC     5A65
ZDE      5A5F    ZDEC     5A67    ZHL      5A61    ZHLC     5A69
ZIR      5A73    ZIX      5A6F    ZIY      5A71    ZPC      5A6B
ZSP      5A6D
```

(Note: This listing is not related to the programs on page 11.)

LINK MESSAGE EXAMPLES

First program unit loaded (UNIT–#1)

```
TMDLYH :    LD      HL, START
COUNT :     ENT
            DEC     HL
            LD      A, H
            CP      COUNT0
            JR      NZ, COUNT
            LD      A, L
            CP      COUNT1
            JR      NZ, COUNT
            CP      COUNT2
            JR      NZ, COUNT
            RET
PEND :      ENT
            DEFM    'TMDLYH'
            DEFB    0DH
COUNT1:     EQU     00H
COUNT0 :    EQU     50H
            END
```

Second program unit loaded (UNIT–#2)

```
TMDLYL :    LD      HL, START
LOOP1 :     DEC     H
            LD      A, H
            CP      COUNT
            JR      NZ, LOOP
            RET
PEND :      ENT
            DEFM    'TMDLYL'
            DEFB    0DH
START :     EQU     1000H
COUNT :     EQU     00H


            END
```

Third program unit loaded (UNIT–#3)

```
INPUT :     CALL    001BH
            CALL    TMDLYL
            CALL    001BH
            LD      HL, START
            CP      0DH
            JR      Z, END
            LD      (HL), A
            INC     HL
            JR      INPUT
END :       JP      0000H
COUNT2 :    EQU     12

            END
```

Refer to photo on page 9.

"START" X

START is not defined as an address in the first program, but is defined as data in the second or subsequent program with the START: EQU statement.

> **Note:**
> **The EQU statement should be placed at the beginning of the program unit.**

"COUNT2" H

COUNT2 is not defined as data in the first program, but is defined as data in the third program with the COUNT2: EQU statement.

"COUNT1" D

COUNT1 is defined as data (D indicates no error condition).

"COUNT" X

COUNT is defined as an address in the first program while it is simultaneously defined as data in the second program.

"PEND" M

PEND is defined as an address in the first program while it is simultaneously defined as an address in the second program (duplicated definition).

"TMDLYL" U

TMDLYL is neither defined as an address nor declared with the ENT directive in any other external program unit.

ERROR MESSAGES

The error messages issued by the linker are described in the System Command manual. Here, only error messages which require particular attention are described.

no memory space

Indicates that the symbol table is full; that is, that there are too many symbols to be cataloged. The symbol table size is set to approximately 6K bytes by the linker unless specified by the programmer. It is necessary to specify the TBL$ argument in the LINK command to increase or decrease the symbol table size.

memory protection

Indicates that the link area is inadequate, that is, that the linked data has reached the symbol table area located at the end of the link area. In this case, MLINK command is available.

il data

Indicates that the data read from the specified relocatable file has an illegal link format. This condition may be caused by a hardware read error in the floppy disk drive or by an assembly error in the source program.