M68LLD(D4)

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MDOS LINKING LOADER

REFERENCE MANUAL

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CHAPTER 1

GENERAL INFORMATION

1.1 INTRODUCTION

The MDOS Linking Loader combines relocatable object modules produced by the Resident M6800 and Macro Assemblers, M6800 Resident FORTRAN Compiler, or Resident MPL Compiler into an absolute load module. This resultant load module is in a format suitable for loading by either the EXORciser loader or disk operating system loader.

The Linking Loader is a two-pass loader requiring each input module to be read twice. During Pass 1, a global symbol table is constructed describing the attributes of the various global symbols. During Pass 2, the input modules are read again and assigned absolute memory addresses. Module relocation and linking is performed during the second pass, and an absolute load module is produced.

1.2 OPERATING ENVIRONMENT

The minimum equipment required to use the Linking Loader is:

a. An EXORciser system

b. An EXORdisk II or EXORdisk III floppy disk drive system

c. An EXORciser-compatible terminal

d. 24K of Random Access Memory

e. Motorola Disk Operating System software (MDOS).

1.3 ADVANTAGES OF THE LINKING LOADER

In conjunction with the Resident M6800 Assembler, Macro Assembler, MPL Compiler, and FORTRAN Compiler, the Linking Loader permits the user to:

- Segment source programs and data
- Relocate object modules
- Link modules via global symbols
- Search user created libraries to satisfy unresolved global symbols
- Dynamically assign memory
- Create a memory map describing the location of each object module and data block loaded
- Create a larger system than possible without linking by making smaller assembly modules.

ASCT - Absolute Section (non-relocatable)

There may be an unlimited number of absolute sections in a user's program. These sections are used to allocate/load/initialize memory locations assigned by the programmer rather than the loader; for example, addresses assigned to ACIA's and PIA's.

BSCT - Base Section (direct addressing)

There is only one base section. The Linking Loader allocates portions of this section to each module that needs space in BSCT. BSCT is generally used for variables that will be referenced via direct addressing. BSCT is limited to locations within the addressing range of Ø through 255 ($Ø through $ØØFF).

CSCT - Blank Common (uninitialized)

There is only one CSCT. This section is used for blank common (similar to FORTRAN blank common). This section cannot be initialized.

DSCT - Data Section

There is only one data section. The Linking Loader allocates portions of this section to each module that needs a part of DSCT. DSCT is generally used for variables (RAM) which are to be accessed via extended mode addressing ($100-$FFFF).

PSCT - Program Section

PSCT is similar to DSCT except that it is intended to be used for instructions. The PSCT/DSCT division was made to facilitate a RAM/ROM dichotomy.

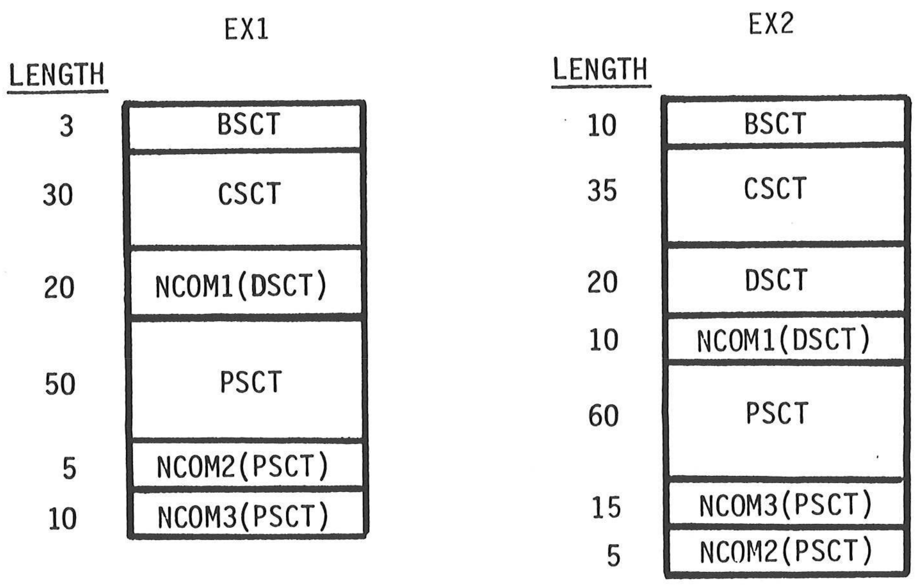
This section concept is preserved by the Loader during the load process. As a module is being loaded, each of its sections is combined with the corresponding sections of previously-loaded modules. As a result, the absolute load module produced by the Loader will contain one continuous memory area for each section type encountered during the load operation.

In addition to the program segmentation provided by the section concept, the relocation and linking scheme supports named common. The named common concept provides the function of initialization common areas within BSCT, DSCT, and PSCT. In processing named common definitions, the Loader will:

. Assign to each named common area a size equal to the largest size defined for the named common during the load process.

. Allocate memory at the end of each section for the named common blocks defined within that section.

The load maps shown in Figure 1-1 describe the load process with regard to sections and named common. The module EX1 requires memory to be reserved in BSCT, CSCT, DSCT, and PSCT, although the only space necessary in DSCT is for the named common NCOM1. The module EX2 requires that memory be allocated in BSCT, CSCT, DSCT, and PSCT. Neither module defines any ASCT blocks.



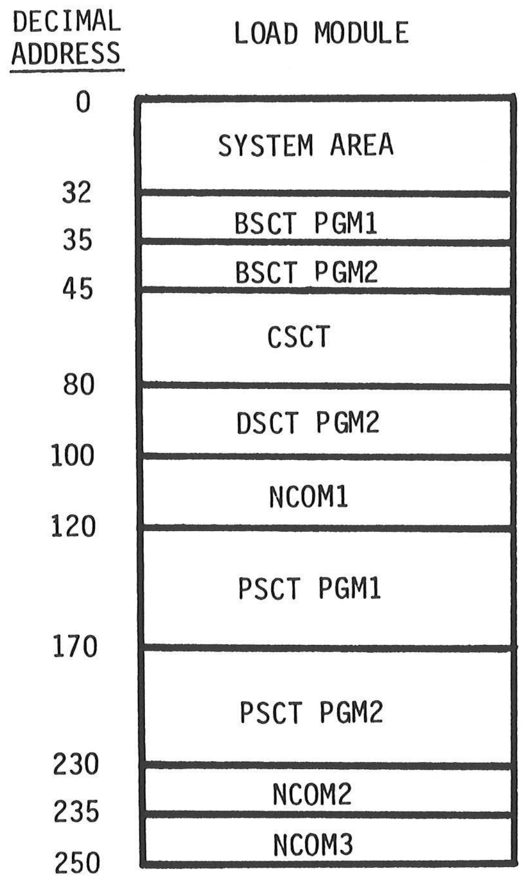


FIGURE 1-1. Load Maps - Example 1

The load module map illustrates a typical memory map that might be produced by loading EX1 and EX2. The BSCT for both EX1 and EX2 are allocated memory within the first 256 bytes of memory. As shown, the first 32 ($20 hex) bytes of BSCT are reserved by the Loader for use by the disk operating system, unless otherwise directed. After BSCT, space for blank common is allocated, followed by space for the EX2 DSCT. Since EX1 requires no DSCT for its exclusive use, none will be allocated. The named common block NCOM1 within DSCT is assigned memory at the end of DSCT. Finally, the PSCT's for EX1 and EX2 are allocated along with the PSCT common blocks NCOM2 and NCOM3.

The Loader assigns memory within sections in the order in which the modules are specified. Named common blocks are allocated memory at the end of their corresponding section, in the order in which they are defined. Figure 1-2 illustrates a load module map produced by loading EX2, followed by EX1. This load module map is slightly different from the map in Figure 1-1 where EX1 was loaded first.

1.4 RELOCATION

Relocation allows the user to assemble/compile a source program without assigning absolute addresses at the time of assembly or compilation. Instead, absolute memory assignment is performed at load time. In order to relocate a program (within memory), the source program must be assembled with the Assembler, using the OPT REL directive, or compiled with the M6800 Resident FORTRAN Compiler. The assembler or compiler will produce a relocatable object module. These relocatable object modules contain information describing the size of each section (ASCT, BSCT, CSCT, and DSCT) and named common area, as well as the relocation data.

In order to load any relocatable object module, the MDOS Linking Loader must be used. The Loader assigns addresses and produces an absolute object module compatible with the system loader.

The advantages of using relocation are:

- Re-assembly is not required for each new absolute load address
- Relocation via the Linking Loader is faster than re-assembly
- Dynamic memory assignment of modules is possible
- Larger programs can be written than was possible before.

1.5 LINKING

Linking allows instructions in one program to refer to instructions or data which reside within other programs. If all programs are assigned absolute addresses during assembly time, it is possible to directly reference another program via absolute addresses. However, when using relocatable programs, absolute load addresses are not generally known until load time. In order to access other relocatable programs or data blocks, external reference symbols must be used. These external symbols are commonly called global symbols since they may be referenced by any module at load time. Although global symbols are used to link modules at load time, they must be explicitly defined and referencd at assembly time. This is accomplished by the Assembler directives, XDEF and XREF. The XDEF directive indicates which labels defined within a module can be referenced by other modules. The XREF directive indicates that the label being referenced is defined outside the module. For FORTRAN programs, the compiler will generate an XDEF and XREF for each SUBROUTINE and CALL statement, respectively.

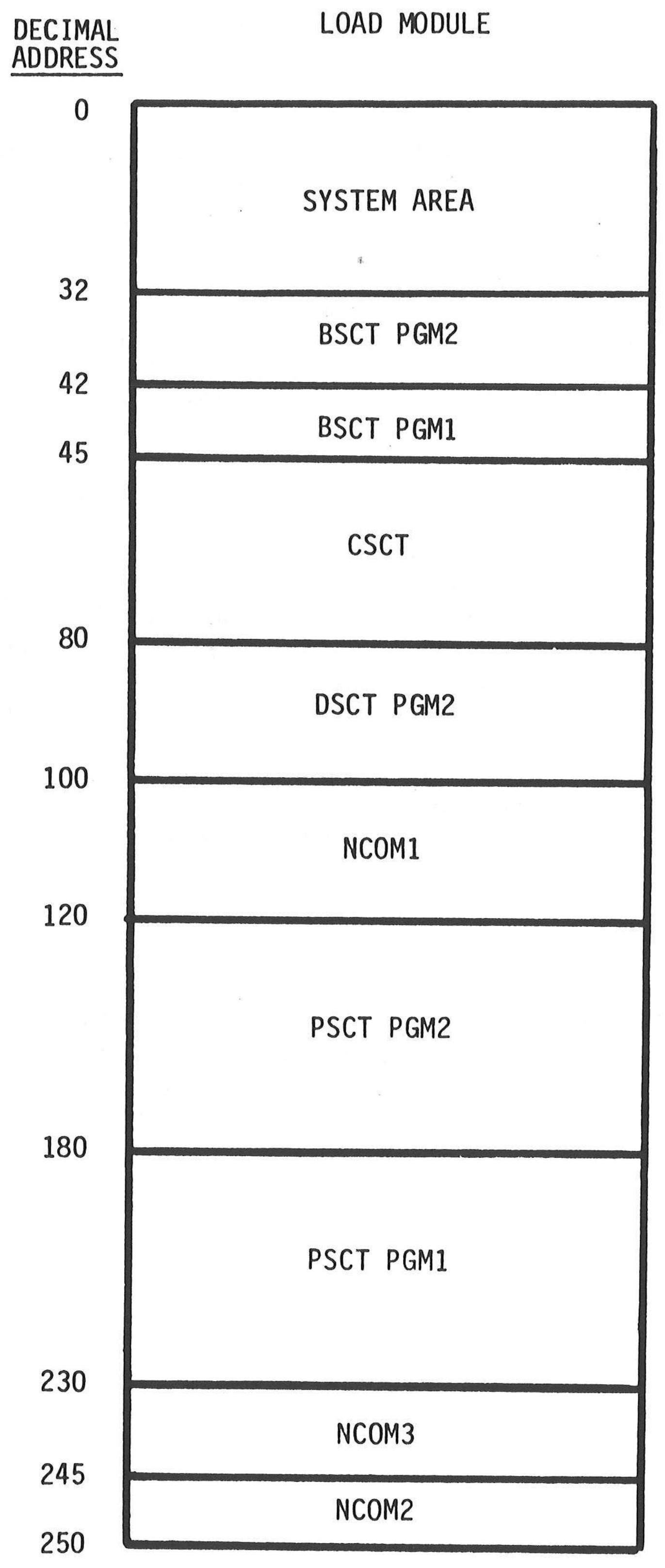


FIGURE 1-2. Load Map - Example 2

At load time, global references are matched with their corresponding global definitions. Any reference within a module to a global symbol is updated with the load address of the global symbol. If the loader detects a global reference without an associated global definition, an undefined global error will be printed and a load address of zero will be assigned to the reference.

1.6 MODULE LIBRARIES

The Linking Loader can automatically search a file for modules which contain definitions satisfying any unresolved global symbols. Such a file is called a library file and is composed of one or more object modules merged together. The Loader sequentially searches the library file. If a module is found that contains a symbol definition satisfying an unresolved global symbol, that module will be loaded. Only those modules which can satisfy an unresolved reference will be loaded. Since a library file is searched only once, modules which reference other modules within the library file should occur within the library file before the referenced module. Otherwise, the user must direct the Loader to search the library again.

1.7 MEMORY ASSIGNMENT

During the load process, absolute addresses are assigned to the program sections within the specified modules. Normally, the loader will automatically perform this assignment by allocating memory by sections in the order: ASCT, BSCT, CSCT, DSCT, and PSCT. However, the user may define the starting and/or ending address of any non-ASCT section. In this case, the Loader will first reserve memory for those sections with defined load addresses before allocating space for any other section. The Loader also permits a user to specify the relative section offset of a module within a section. However, a section of a module is always loaded in the associated load section in the order in which the module was specified. Named common blocks are always assigned memory at the end of the associated load section.

1.8 LOAD MAPS

The Loader will optionally produce a load map describing the memory layout resulting from the loading of the specified modules. Figure 1-3 is an example of some of the features included in a typical load map. In addition to this full load map, the Loader may be directed to product partial load maps listing only the undefined global symbols or section load addresses.

```
  NO UNDEFINED SYMBOLS

MEMORY MAP

  S SIZE  STR  END COMN
  A 0006 4510 4515
  A 0006 4406 440B
  B 001A 0000 0019 0000
  C 0030 0020 004F 0030
  D 0042 0400 0441 0020
  P 0088 1000 1087 0000

MODULE NAME BSCT DSCT PSCT
  PG1       0000 0400 1000
  PG3       0005 040E 1060
  PG2       0005 040E 1070

COMMON SECTIONS

   NAME   S SIZE  STR
  DCOMM   D 0008 0422
  DCOMM2  D 0018 042A

DEFINED SYMBOLS


MODULE NAME: PG1
  CR      A 000D      EOT    A 0004     EXBPRT A F024     LF     A 000A
  MSG1    P 1000      MSG2   D 0400     MSGSIZ B 0000     PG1NE  P 1016
  START   P 100A

MODULE NAME: PG3
  ATEST   A 4406      POWERS P 1060

MODULE NAME: PG2
  EXBENT  A F564      MSG3   D 040E     MSG4   D 0418     PGM2   P 1070
  STACK   B 0019
```

FIGURE 1-3. Loader-Produced Memory Map

CHAPTER 2

LINKING LOADER COMMANDS

2.1 INVOKING THE LINKING LOADER

The Linking Loader must be called while under the control of the MDOS disk operating system. When the user types the command:

```
        =RLOAD <c/r>
```

the disk executive will load the Linking Loader. Upon entry, the loader prints:

```
        M6800 LINKING LOADER REV n.m
        ?
                                    (where n.m is the revision number)
```

The character ? is the Loader prompt, and is printed whenever the Loader has completed the last command and is ready for another.

2.2 LOADER INPUT

The input to the Loader is in one of two forms -- commands or object modules. The Loader commands control the relocation and linking of desired object modules. Object modules are produced by the MPL Compiler, or Assembler, or Resident FORTRAN Compiler. Each source program assembled or compiled creates a single relocatable object module on a disk file. These disk files, or those files created by merging one or more of these files, are used as the input to the Loader. The Loader command structure provides for the loading of an entire file or selected modules within a file. In addition, a disk file may be used as a library file. The Loader may also be run under the MDOS CHAIN command.

2.3 COMMAND FORMAT

Each Loader command line consists of a sequence of commands and comments, followed by a carriage return. The first space in a command line terminates the command portion of the line, and the remainder is assumed to be comments. Multiple commands may appear on a line by using a semicolon (;) as a command separator. The format of a command line may thus be defined as:

$$\left[\langle\text{command}\rangle[;\langle\text{command}\rangle]_{0}^{99}\right]\left[\langle\text{space}\rangle[\langle\text{comments}\rangle]\right]\langle\text{c/r}\rangle$$

```
EXAMPLE:   STRB=Ø;STRD=$1000;STRP=$4000
           IDON
           LOAD=PG1
```

The commands in a command line are executed only after the Loader detects a carriage return.

If a command line is entered incorrectly, the line may be corrected in either of two manners. First, the command line may be deleted completely by typing CTRL X (the CTRL and X keys typed simultaneously). This causes the Loader to ignore the current command line, and issue a CR, LF, and await a new command input line. However, instead of deleting the entire command line, it may be corrected by deleting the character(s) in error. This is accomplished by typing a RUBOUT to delete the last character typed. The typing of a RUBOUT also causes the last character entered to be printed. After deleting the character(s) in error, the corrected version of the command line may be entered. The (MDOS) CTRL D key allows the operator to redisplay the line to show a "clean" copy of the line for operator inspection. Thus, full compatibility is maintained with the normal MDOS .KEYIN special character functions.

The Loader will execute all the commands in a command line before another prompt is issued. If an error is detected while attempting to process a command, that command will be terminated. The remaining commands in the command line will be ignored.

When using multiple commands per line, it should be noted that selected commands require that they are the last command on a line, and include:

- INIT
- all intermediate file commands (IF, IFOF, IFON)
- OBJ

2.4 LOADER COMMANDS

The Loader commands are divided into three classes:

1. control commands
2. load directives
3. state directives.

The control commands are used to initiate Passes 1 and 2 of the Loader, as well as to return to EXbug or the disk operating system. The load directives are used to identify the modules to be loaded. Finally, the state directives direct the assignment of memory to the various program sections and the production of a load map.

2.4.1 Command Nomenclature

<f-name>	-	Used to indicate the name of a disk file to be used by the Loader. Unless specified, the file is assumed to have a suffix of "RO" and drive number of Ø. For the format of the file name, consult the MDOS Manual. (Example: PG1.RO:1)
<number>	-	Used to indicate a decimal or hexadecimal number. Unless preceded by a $ character (which is used to denote hexadecimal), the number will be interpreted as decimal. Unless explicitly stated otherwise, the allowable number range will be: Ø - 65,535 (decimal) $Ø - $FFFF (hexadecimal)
[ ]	-	Used to indicate that the enclosed directive(s) is optional.
$[\quad]_{0}^{99}$	-	Used to indicate that the enclosed directive may be repeated from Ø to 99 times, up to a total of 79 characters maximum.
$\{\quad\}$	-	Indicates that one of the enclosed options <u>must</u> be used.

2.5 CONTROL COMMANDS

2.5.1 EXIT

FORMAT: $\text{EXIT}\left[=\begin{Bmatrix}\langle\text{number}\rangle\\ \langle\text{namel}\rangle\end{Bmatrix}\right]$

DESCRIPTION: The EXIT command causes control to be returned to the disk operating system after all Loader files have been closed.

The MDOS version of the Loader allows the user to define the starting execution address of the object program. If the <number> option is specified, the given absolute number will be used as the starting execution address. This address must be a valid address within the program. The <namel> option is similar to the <number> option except that <name> must be a valid global symbol. If neither option is used, the starting address defaults to the address associated with the label appearing in the operand field of the END statement in the assembled program. If two or more modules have END statements with operands, the operand associated with the first module loaded will be used as the starting address.

2.5.2 IDOF - Suppress Printing of Module ID

FORMAT: IDOF

DESCRIPTION: This command suppresses the printing of the name and printable information associated with each object module loaded or encountered in a library file. For assembly language programs, this information is specified via the NAM and IDNT directives.

2.5.3 IDON - Print Module ID

FORMAT: IDON

DESCRIPTION: This command causes the name and printable information associated with each object module loaded or encountered in a library file to be printed at the console device. For assembly language programs, this information is specified via the NAM and IDNT directives.

2.5.4 IF - Intermediate File

FORMAT: IF=<f-name>

DESCRIPTION: The IF command defines a file to be used as an intermediate file. An intermediate file is a copy of all Pass 1 Loader commands and object modules. It is used to direct the load operation during Pass 2, instead of requiring the user to retype the Pass 1 command sequence during Pass 2. The IF command also automatically places the Loader in intermediate file mode similar to the IFON command. Like the IFON command, the IF command <u>must</u> be the last command in a command line.

The IF file name must be a valid disk file name and may not be the name of an existing file on the specified diskette. Upon proper exiting from the Loader, the IF file is deleted.

EXAMPLE: IF=IFILE Defines IFILE on drive Ø as the intermediate file. Default suffix is "IF".

2.5.5 IFOF - Intermediate File Mode Off

FORMAT: IFOF

DESCRIPTION: IFOF temporarily suppresses the creation of the intermediate file until an IFON directive is encountered. This command must be the last command in a command line.

2.5.6 IFON - Intermediate File Mode On

FORMAT: IFON

DESCRIPTION: This command directs the Loader to write all further commands and object modules onto the intermediate file. This directive remains in effect until an IFOF or Pass 2 command is detected. The IFON command must be the last command on a command line. IFON is implied when the intermediate file is defined by the IF command. If an intermediate file is to be used during Pass 2, the IFON directive must be in effect.

2.5.7 INIT - Initialize Loader

FORMAT: INIT

DESCRIPTION: INIT initializes the Loader for Pass 1. This command is performed automatically when the Loader is first initiated. The use of this command permits the user to restart the Loader when entry errors are made, without having to exit back to MDOS. Any previously created object and/or intermediate files will be deleted. The INIT comand <u>must</u> be the last command in a command line.

2.5.8 MO - Map Output

FORMAT: MO= $\begin{bmatrix}\text{<f-name>}\\ \text{<device>}\end{bmatrix}$

DESCRIPTION: The MO command is used to specify the media on which the map output is to be produced. The MAP output will default to the console printer.

If a file name is specified, it must not be the name of an existing disk file. The map cannot be directed to a file during Pass 2 or whenever an intermediate file is being used.

A map can be produced on the console printer or line printer by specifying the mnemonic #CN or #LP, respectively.

EXAMPLE:

MO=MAPFL	All output generated by the MAP command will be written on file MAPFL on drive Ø.
MO=#LP	The line printer will be used for all future map output.

2.5.9 OBJ - Produces Load Module

FORMAT: OBJA=<file-name>

OBJX=<file-name>[,printed information]

DESCRIPTION: This loader command is used with the MDOS Loader to initiate the second pass of the Loader. During this pass, an object file is created on disk with the name <file-name>. This file may not be the name of an existing file on the specified disk. The file will be created on disk Ø unless disk 1 is specified in <file-name>. The type of object file produced by the Loader is determined by the command form as follows:

OBJA - This format creates an absolute memory image file suitable for loading via the MDOS LOAD command. A default file suffix of 'LO' and drive Ø will be used if none are specified.

OBJX - An object file in EXORciser loadable format (SØ, S1, and S9 records) is created via this command form. This file may <u>not</u> be loaded via the MDOS LOAD command without first using the MDOS EXBIN command. However, files created in EXORciser loadable format may be copied to cassette or paper tape and loaded via EXbug. A default suffix of 'LX' and drive Ø will be used if none are specified with the file name.

If an intermediate file (IF) was generated during the first pass of the Loader, the second pass automatically processes the commands entered during the first pass. In the event that an intermediate file was not created, the <u>same</u> sequence of commands used during the first pass must be repeated. Regardless of the use of an intermediate file, the OBJA or OBJX command must be the last command on the command line.

EXAMPLES: OBJX=SORT,BINARY SORT PROGRAM

This command initiates the second pass of the Loader, which will create an EXORciser loadable file on disk file 'SORT.LX:0'. The S0 record will contain the file named SORT and the ASCII character string 'BINARY SORT PROGRAM'.

OBJA=REPORT:1

The Loader will create the absolute object file on file 'REPORT.LO' on drive 1.

2.6 LOAD DIRECTIVES

2.6.1 LIB - Library Search

FORMAT: LIB=<f-name> $\left[,[\text{<f-name>}] \right]_{0}^{99}$

DESCRIPTION: The LIB command instructs the Loader to search the specified file name(s) for those modules which satisfy any undefined global references. Any module that satisfies an unresolved global reference will be loaded. A suffix of .RO and logical drive of :Ø are assumed for <f-name>.

A library file is a collection of individual relocatable object modules which were merged into a single file.

Modules loaded via the LIB command may also reference global symbols that are not defined. Since a library file is searched only once for each LIB command, it should be made with care so that no module has any reference to a prior (higher level) module, or multiple passes of the same library must be done.

It should be noted that the Macro Assembler and certain compilers (FORTRAN) produce a single relocatable object module in a file. Since these single object module files can be merged together into other (library) files, the terms "object file" and "object module" are not necessarily equivalent.

EXAMPLE: LIB=MLIB:1 The modules on file MLIB.RO on drive 1 will be searched to resolve any unsatisfied global references.

2.6.2 LOAD - Load a File

FORMAT: LOAD=<f-name>$\left[,[\text{<f-name>}]\right]_{0}^{99}$

DESCRIPTION: The LOAD command directs the Loader to load the specified object files.

The LOAD command directs the Loader to load all object modules found in the specified file name(s). The file name could be a library file, but the LOAD command, unlike the LIB command, will load each object module found, irregardless of whether or not it is needed.

A suffix of .RO and logical drive :Ø are assumed.

EXAMPLE:

LOAD=PGM1:1	Loads all modules within file PGM1.RO on disk drive 1
LOAD=PGM1,RAM:1,PGM2,PGM3	Loads all modules within files PGM1.RO on drive Ø, RAM.RO on drive 1, PGM2.RO on drive Ø, and PGM3.RO on drive Ø.

2.7 STATE COMMANDS

2.7.1 BASE - Initialize Minimum Load Address

FORMAT: BASE [=<number>]

DESCRIPTION: The BASE command allows the user to specify an address above which his program will load. The BASE command affects only the memory assignment of CSCT, DSCT, and PSCT. Memory assignments related to BSCT, ASCT, and those sections with defined starting/ending addresses (via commands STR or END) are not affected by this command.

The use of the <number> option is used to define the lowest address which may be assigned to CSCT, DSCT, or PSCT. If the <number> option is not specified, the lowest assignable address will default to the next modulo 8 address following MDOS. This format of BASE allows the user to load his program above MDOS without having to know where MDOS ends. If the BASE command is not specified, a default address of $20 (32 decimal) will be used as the lowest load address during memory assignment.

EXAMPLE:

BASE	Unassigned CSCT, DSCT, and PSCT will be assigned load addresses above MDOS.

2.7.2 CUR - Set Current Location Counter

FORMAT: $\mathrm{CUR}\begin{Bmatrix}\mathrm{B}\\\mathrm{D}\\\mathrm{P}\end{Bmatrix}=\begin{bmatrix}\backslash\end{bmatrix}\langle\mathrm{number}\rangle$

DESCRIPTION: The CUR command is used to modify the Loader's current relative loading address of the specified section (BSCT, DSCT, or PSCT). The CUR command must be used prior to the LOAD or LIB command so as to update the loading address first. If the '\' option is not specified, the relative load address for the appropriate section will be set equal to the given <number> starting section plus its value (see STR command). This <number> must be equal to or greater than the section's current relative load address. This form of the CUR command allows the user to start a module section at a defined address. For PSCT, the <number> entered is added to the absolute value for STRP to obtain the new PSCT load address value. The following example loads four 1K EPROM's at $4400, $4800, $5000, and $8C00 from multiple files. Each LOAD command utilizes less than $400 bytes in PSCT (starting PSCT=$4400).

EXAMPLE:

```
?STRP=$4400
?LOAD=FILE11, FILE12,FILE13         EPROM at $4400
?CURP=$400
?LOAD=FILE21,FILE22,FILE23          EPROM at $4800 ($4400 + $400)
?CURP=$C00
?LOAD=FILE31,FILE32                 EPROM at $5000 ($4400 + $C00)
?CURP=$4800
?LOAD=FILE41,FILE42,FILE43,FILE44   EPROM at $8C00 ($4400 + $4800)
```

The '\' option affects the section's relative load address in a different manner. This option causes all future modules to be loaded at an address which is a power of two relative to the start of the section (2,4,8, etc.). The specified <number> defines the given power of two. This option remains in effect until the option is specified again or until the current pass of the Loader is complete. If the '\' option is in effect when memory is assigned to the starting section addresses, the starting address of the section will also be assigned a load address which is a power of two. This option does not apply to named common blocks within the specified section.

If the CUR directive is not used, each module will normally be loaded at the next load address in the appropriate section (contiguously loaded modules). However, modules created via the FORTRAN Compiler will be loaded at the next even address.

EXAMPLE:

CURP=$100	Sets the relative PSCT location counter to $100 plus STRP value.
CURP=\16	Causes the Loader to load all future PSCT sections at a relative address within PSCT which is modulo 16 plus the STRP value.

NOTE

When using the CUR command within an MDOS chain file, the '\' option must use '\\' instead of '\'. (See CHAIN command description in the MDOS Manual.)

EXAMPLE:

```
STRP=$4001
CURP= $400
LOAD=PG1,PG2,PG3
```

If each file is a single module with less than 1K of PSCT in each one, then each module's starting PSCT address would be assigned as follows:

```
PG1=$4001
PG2=$4401
PG3=$4801
```

2.7.3 DEF - Loader Symbol Definition

FORMAT: $$\text{DEF: <name1>=}\left\{\begin{matrix}\text{<number>}\\ \text{<name2>}\end{matrix}\right\}\left[\begin{matrix}\text{ASCT}\\ \text{BSCT}\\ \text{,DSCT}\\ \text{PSCT}\end{matrix}\right]$$

DESCRIPTION: The DEF command is used to define a global symbol and enter it in the global symbol table. The symbol to be defined is given by name1 and must be a valid Macro Assembler variable name. The symbol may not currently be defined. If the <number> option is used, the symbol will be defined with the given number as the relatived address within the specified section. The DEF command may be used to provide another name for a previously defined symbol by using the <name2> option. <name2> must be a currently defined global symbol. The section options -- ASCT, BSCT, DSCT, PSCT -- are used to define the section associated with the defined section. ASCT is the default section.

EXAMPLE: DEF:ACIA1=$EC10,ASCT — Defines symbol ACIA1 as an ASCT symbol with absolute address $EC10 (hexadecimal).

2.7.4 END - Ending Address

FORMAT: $$\text{END}\left\{\begin{matrix}\text{B}\\ \text{C}\\ \text{D}\\ \text{P}\end{matrix}\right\}\text{=<number>}$$

DESCRIPTION: The END commands are used to set the absolute ending address of the associated section (BSCT, CSCT, DSCT, PSCT). If both an ending and starting address are defined, the size described by these boundaries must be equal to or greater than the size of the associated section.

NOTE

An ending address of $0000 will reset any previous END directive for the corresponding section.

EXAMPLE: ENDB=255 — BSCT will be allocated such that the last address reserved is 255 (decimal).

2.7.5 MAP - Prints Load Maps

FORMAT: $\text{MAP}\begin{Bmatrix}\text{C}\\ \text{F}\\ \text{S}\\ \text{U}\end{Bmatrix}$

DESCRIPTION: The MAP commands are used to display the current state of the modules loaded or the Loader's state directives.

MAPC - Prints the current size, user defined starting address, and user defined ending address for each of the sections, as well as the size, starting address, and ending address for each ASCT defined.

MAPF - A full map of the state of the loaded modules is produced after the Loader assigns memory. This map includes a list of any undefined symbols, a section load map, a load map for each defined module and named common, and a defined global symbol map. If a user assignment error (UAE) exists, this command cannot be completed. Use the MAPC command to determine the cause of the error.

MAPS - The Loader assigns memory to those sections not defined by a user supplied starting and/or ending address. A memory load map, which defines the size, starting address and ending address for each section, is printed. If a user assignment error (UAE) exists, this command cannot be completed. Use the MAPC command to determine the cause of the error.

MAPU - Prints a list of all global references which currently remain undefined.

2.7.6 STR - Starting Address

FORMAT: $\text{STR}\begin{Bmatrix}\text{B}\\ \text{C}\\ \text{D}\\ \text{P}\end{Bmatrix}=\begin{Bmatrix}\text{<number>}\\ \text{<global ASCT symbol>}\end{Bmatrix}$

DESCRIPTION: The STR commands set the absolute starting address of the associated section (BSCT, CSCT, DSCT, PSCT). Those sections whose starting address is not defined by the user will be assigned a starting address by the loader.

NOTE

A starting address of $FFFF will reset any previous STR directive for the corresponding section. This will allow the Loader to define the starting address.

EXAMPLE: STRP=$1000 PSCT will be allocated memory starting at $1000.

CHAPTER 3

SAMPLE OPERATIONS WITH THE LINKING LOADER

3.1 INTRODUCTION

This chapter provides a description of the operation of the Loader in typical applications. To demonstrate the use of the Loader, a simple message printing program will be used. This program consists of three modules which reference instruction sequences or data within each other. As assembly listing of each module is shown in Figures 3-1, 3-2, and 3-3.

3.2 SIMPLIFIED LOADER OPERATION

The simplest form of the Loader's operation is shown in Figure 3-4. In this example, all three files -- PG1, PG2, and PG3 -- are loaded, and the object file PG123 is created. The sequence of steps shown in Figure 3-4 is as follows:

1. The LOAD command loads the first file, PG1.RO:Ø. During all load operations, a global symbol table of all external definitions and references is built.

2. The LOAD command loads the next two files, PG2 and PG3. Notice the default suffix 'RO' and drive number 'Ø' are assumed.

3. The OBJA command starts pass 2 of the load function, which will create an absolute memory image object file named PG123 on drive Ø with the suffix 'LO'. This command also assigns memory addresses to the various program sections. The use of the OBJX command, instead of OBJA, would have a similar effect, except an EXORciser load image would be produced.

4. Since an intermediate file was not created in pass 1, all commands entered in pass 1, with the exception of MAP commands, must be repeated. In pass 2, the LOAD command generates the absolute code for the object file. Notice that all three files are loaded with one load command this time.

5. The MAPU command is not really necessary here, but was entered to verify that no undefined symbols exist.

6. A complete memory map is produced by the MAPF command. In the first part of the map (6a), any undefined external references are listed. In the next part (6b), the section type, the size, starting address, ending address, and size of the section's common block are listed for each program section. For example, PG123's DSCT area will have a size of 42 (hex) bytes, of which 20 (hex) bytes are in common. The DSCT area will start at address $6A and end at $AB. The starting address of the various sections for each program module is given in the next map part (6c). As seen from the map, PG2 PSCT starts at address $FD, which corresponds to the PG2 instruction:

```
PGM2   CLRA
```

```
PAGE  001  PG1      .SA:1  PG1    PROGRAM TO PRINT OUT MESSAGES (MAIN)

                               NAM    PG1
                               OPT    REL,CREF,NOG
                               TTL    PROGRAM TO PRINT OUT MESSAGES (MAIN)
                               IDNT   08/10/79 MAIN MESG PROGRAM  - MODULE #1

                        * ASSEMBLY PROCEDURE:  RASM 3.00  MDOS 3.00
                        *     =RASM PG1;LN=76
                        *
                        *   PROGRAM PARTS:  PG1, PG2, PG3
                        *        COMPUTER:  M6800



               F024   A EXBPRT EQU    $F024     EXBUG PRINT ROUTINE


                        * ASCII CHARACTER EQUATES
                        *
               0004   A EOT    EQU    4         END OF TEXT
               000A   A LF     EQU    $A        LINE FEED
               000D   A CR     EQU    $D        CARRIAGE RETURN


                        * EXTERNAL REFERENCES
                        *
                               XREF   ATEST
                               XREF   DSCT:MSG3,MSG4,ANY:STACK
                               XREF   EXBENT,PGM2


                        * EXTERNAL DEFINITIONS
                        *
                               XDEF   MSG2,MSG1,EXBPRT,START,PG1NE
                               XDEF   MSGSIZ,EOT,LF,CR
```

FIGURE 3-1. Message Program 1 (PG1)

```
PAGE  002  PG1      .SA:1  PG1    PROGRAM TO PRINT OUT MESSAGES (MAIN)

00031                      * COMMON MESSAGE AREA
00032                      *  (NAMED COMMON "DCOMM" IN DSCT)
00033                      *
00034N 0000                DCOMM  COMM   DSCT
00035N 0000      0000   P  MSG1P  FDB    MSG1      PTR TO MESG 1 (IN PSCT)
00036N 0002      0000   D  MSG2P  FDB    MSG2      PTR TO MESG 2 (IN DSCT)
00037N 0004      0000   A  MSG3P  FDB    MSG3      PTR TO MESG 3 (XREF IN DSCT)
00038N 0006      0000   A  MSG4P  FDB    MSG4      PTR TO MESG 4 (XREF IN DSCT)


00040                      * MESSAGES 1 AND 2
00041                      *  (NEW NAMED COMMON "DCOMM2" IN DSCT)
00042                      *
00043N 0000                DCOMM2 COMM   DSCT
00044N 0000      0001   A  CMSGCT RMB    1         COMMON MESSAGE COUNT
00045N 0001      0014   A  CMSG   RMB    20        COMMON MESSAGE


00047C 0000                       CSCT             BLANK COMMON SECTION
00048C 0000      0010   A  MSGCST RMB    16        RESERVE 16 BYTES


00050D 0000                       DSCT             DATA SECTION
00051D 0000      4D     A  MSG2   FCC    \MESSAGE 2\
00052D 0009      04     A         FCB    EOT       DELINEATE END OF MESSAGE


00054P 0000                       PSCT             PROGRAM SECTION
00055P 0000      4D     A  MSG1   FCC    \MESSAGE 1\
00056P 0009      04     A         FCB    EOT


00058B 0000                       BSCT             BASE SECTION
00059B 0000      0001   A  MSGSIZ RMB    1         MESG SIZE STORAGE
```

FIGURE 3-1. Message Program 1 (PG1) (cont'd)

```
PAGE  003  PG1      .SA:1  PG1    PROGRAM TO PRINT OUT MESSAGES (MAIN)

00061                      * PROGRAM SECTION
00062                      * EXECUTION STARTS AT "START"
00063                      *
00064P 000A                       PSCT              PROGRAM SECTION

00066P 000A 8E 0000   A START     LDS     #STACK    SET UP STACK REGISTER (XREF)
00067P 000D FE 0000   N           LDX     MSG1P     GET MESSAGE 1 POINTER
00068P 0010 BD F024   A           JSR     EXBPRT    PRINT MESSAGE 1
00069P 0013 7E 0000   A           JMP     PGM2      GO TO PROGRAM 2 (XREF)
00070                      *
00071                      * PROGRAM 2 RETURNS TO THIS POINT (XDEF)
00072                      *
00073P 0016 CE 0000   A PG1NE     LDX     #MSG3     GET MESSAGE 3 ADDRESS
00074P 0019 BD F024   A           JSR     EXBPRT    PRINT MESSAGE 3
00075P 001C FE 0004   N           LDX     MSG3P     GET MESSAGE 3 POINTER
00076P 001F BD F024   A           JSR     EXBPRT    PRINT MESSAGE 3 AGAIN
00077P 0022 CE 0000   A           LDX     #MSG4     PRINT MESSAGE 4
00078P 0025 BD F024   A           JSR     EXBPRT
00079                      *
00080                      * MOVE MESSAGE FROM CMSG IN DCOMM2 TO BLANK COMMON
00081                      *
00082P 0028 CE 0000   C           LDX     #MSGCST   MESSAGE DESTINATION ADDRESS
00083P 002B FF 0003   B           STX     TOPNTR
00084P 002E CE 0001   N           LDX     #CMSG     MESSAGE ADDRESS (FROM)
00085P 0031 FF 0001   B           STX     FROMPT
00086P 0034 F6 0000   N           LDAB    CMSGCT    MESSAGE LENGTH
00087P 0037 D7 00     B           STAB    MSGSIZ    SAVE MESG LENGTH
00088P 0039 FE 0001   B LOOP1     LDX     FROMPT    GET SOURCE POINTER
00089P 003C A6 00     A           LDAA    0,X       GET BYTE
00090P 003E 08                    INX               UPDATE SOURCE POINTER
00091P 003F FF 0001   B           STX     FROMPT
00092P 0042 FE 0003   B           LDX     TOPNTR    GET DESTINATION POINTER
00093P 0045 A7 00     A           STAA    0,X       SAVE BYTE
00094P 0047 08                    INX               UPDATE DESTINATION POINTER
00095P 0048 FF 0003   B           STX     TOPNTR
00096P 004B 5A                    DECB              UPDATE CHARACTER COUNTER
00097P 004C 26 EB 0039            BNE     LOOP1     LOOP
00098P 004E 7E 0000   A           JMP     ATEST     GOTO PROGRAM W/ASCT REGIONS


00100B 0001                       BSCT              DIRECT ADDRESSING SECTION
00101                      * NOTE: IF FORWARD REFERENCED, EXTENDED ADDR IS USED.
00102                      *       THEREFORE ALL BSCT VARIABLES SHOULD BE
00103                      *       DEFINED BEFORE REFERENCED.
00104                      *
00105B 0001      0002   A FROMPT  RMB     2         FROM POINTER
00106B 0003      0002   A TOPNTR  RMB     2         TO POINTER


00108D 000A                       DSCT              DATA SECTION
00109D 000A 96 01     B           LDAA    FROMPT    ***DIRECT ADDRESSING USED***
00110D 000C DE 03     B           LDX     TOPNTR    (EXAMPLES ONLY - NOT EXECUTED)

00112                             TTL     CROSS REFERENCE TABLE
00113            000A   P         END     START
TOTAL ERRORS 00000--00000
```

FIGURE 3-1. Message Program 1 (PG1) (cont'd)

```
PAGE  004  PG1      .SA:1  PG1    CROSS REFERENCE TABLE

R          ATEST   00022*00098
ND 0001    CMSG    00045*00084
ND 0000    CMSGCT  00044*00086
D  000D    CR      00018*00029
ND         DCOMM   00034*
ND         DCOMM2  00043*
D  0004    EOT     00016*00029 00052 00056
R          EXBENT  00024*
D  F024    EXBPRT  00012*00028 00068 00074 00076 00078
 B 0001    FRCMPT  00085 00088 00091 00105*00109
D  000A    LF      00017*00029
 P 0039    LOOP1   00088*00097
DP 0000    MSG1    00028 00035 00055*
ND 0000    MSG1P   00035*00067
DD 0000    MSG2    00028 00036 00051*
ND 0002    MSG2P   00036*
RD         MSG3    00023*00037 00073
ND 0004    MSG3P   00037*00075
RD         MSG4    00023*00038 00077
ND 0006    MSG4P   00038*
 C 0000    MSGCST  00048*00082
DB 0000    MSGSIZ  00029 00059*00087
DP 0016    PG1NE   00028 00073*
R          PGM2    00024*00069
R          STACK   00023*00066
DP 000A    START   00028 00066*00113
 B 0003    TOPNTR  00083 00092 00095 00106*00110
```

FIGURE 3-1. Message Program 1 (PG1) (cont'd)

```
PAGE  001  PG2     .SA:1  PG2    MESSAGE PRINTER SUBPROGRAM

00001                          NAM    PG2
00002                          OPT    CREF,REL,NOG
00003                          TTL    MESSAGE PRINTER SUBPROGRAM
00004                          IDNT   08/10/79 MESG PRNTR SUBPROG - MODULE #2

00006                   * ASSEMBLY PROCEDURE:  RASM 3.00  MDOS 3.00
00007                   *    =RASM PG2;LN=76
00008                   *
00009                   *   PROGRAM PARTS:  PG1, PG2, PG3
00010                   *        COMPUTER:  M6800

00012           F564  A EXBENT EQU    $F564    EXBUG ENTRY POINT


00014                   *
00015                   * XDEFS AND XREFS
00016                   *
00017                          XDEF   MSG3,MSG4,STACK,EXBENT,PGM2
00018                          XREF   BSCT:MSGSIZ
00019                          XREF   EXBPRT,PG1NE,MSG1,MSG2
00020                          XREF   EOT,CR,LF




00022                   * MESSAGE POINTER AREA (DCOMM)
00023                   *
00024N 0000             DCOMM  COMM   DSCT
00025N 0000     0002  A MSG1PT RMB    2
00026N 0002     0002  A MSG2PT RMB    2
00027N 0004     0002  A MSG3PT RMB    2
00028N 0006     0002  A MSG4PT RMB    2


00030N 0000             DCOMM2 COMM   DSCT
00031N 0000     17    A CMSGCT FCB    CMSGE-CMSG . COMMON MESSAGE CHAR COUNT!
00032N 0001     43    A CMSG   FCC    \COMMON TEST PROGRAM\
00033N 0014     0C    A        FCB    CR,LF,LF,EOT
00034           0018  N CMSGE  EQU    *        END OF MESSAGE


00036                   * MESSAGES 3 AND 4
00037                   *
00038D 0000                    DSCT
00039D 0000     4D    A MSG3   FCC    \MESSAGE 3\
00040D 0009     00    A        FCB    EOT
00041D 000A     4D    A MSG4   FCC    \MESSAGE 4\
00042D 0013     00    A        FCB    EOT
```

FIGURE 3-2. Message Program 2 (PG2)

```
00044                         * START OF PROGRAM 2
00045                         *
00046P 0000                            PSCT
00047P 0000 4F                PGM2     CLRA
00048P 0001 97 00       A              STAA     MSGSIZ     INIT. MESG LENGTH
00049P 0003 FE 0000     N              LDX      MSG1PT     PRINT MESSAGE 1
00050P 0006 BD 0000     A              JSR      EXBPRT
00051P 0009 CE 0000     A              LDX      #MSG2      PRINT MESSAGE 2
00052P 000C BD 0000     A              JSR      EXBPRT
00053P 000F FE 0002     N              LDX      MSG2PT     PRINT MESSAGE 2 AGAIN
00054P 0012 BD 0000     A              JSR      EXBPRT
00055P 0015 7E 0000     A              JMP      PG1NE      RETURN TO PROGRAM ONE



00057B 0000                            BSCT                DIRECT ADDRESSING SECTION
00058B 0000         0014  A            RMB      20
00059B 0014         0001  A STACK      RMB      1          STACK STORAGE AREA


00061                                  END
TOTAL ERRORS 00000--00000



ND  0001  CMSG     00031 00032*
ND  0000  CMSGCT   00031*
ND  0018  CMSGE    00031 00034*
R         CR       00020*00033
ND        DCOMM    00024*
ND        DCOMM2   00030*
R         EOT      00020*00033 00040 00042
D   F564  EXBENT   00012*00017
R         EXBPRT   00019*00050 00052 00054
R         LF       00020*00033 00033
R         MSG1     00019*
ND  0000  MSG1PT   00025*00049
R         MSG2     00019*00051
ND  0002  MSG2PT   00026*00053
DD  0000  MSG3     00017 00039*
ND  0004  MSG3PT   00027*
DD  000A  MSG4     00017 00041*
ND  0006  MSG4PT   00028*
RB        MSGSIZ   00018*00048
R         PG1NE    00019*00055
DP  0000  PGM2     00017 00047*
DB  0014  STACK    00017 00059*
```

FIGURE 3-2. Message Program 2 (PG2) (cont'd)

```
PAGE  001  PG3      .SA:1  PG3    ***PROGRAM TO ILLUSTRATE USE OF ASCT

00001                              NAM    PG3
00002                              TTL    ***PROGRAM TO ILLUSTRATE USE OF ASCT
00003                              OPT    REL,CREF
00004                              IDNT   08/10/79 ASCT ILLUSTRATION  - MODULE #3

00006                       * ASSEMBLY PROCEDURE:  RASM 3.00  MDOS 3.00
00007                       *    =RASM PG3:1;LN=76
00008                       *
00009                       *    PROGRAM PARTS:  PG1, PG2, PG3
00010                       *        COMPUTER:  M6800


00012                              XDEF   ATEST,POWERS
00013                              XREF   EXBPRT,EXBENT


00015                       *  BLANK COMMON
00016                       *
00017C 0000                        CSCT
00018C 0000     0030  A CMSG       RMB    $30



00020A 0000                        ASCT               UNNECESSARY!
00021A 4406                        ORG    $4406       .  ORG CAUSES ASCT!
00022A 4406 CE 0000  C ATEST       LDX    #CMSG       START OF COMMON MESSAGE
00023A 4409 7E 4510  A             JMP    ATEST2



00025A 4510                        ORG    $4510
00026A 4510 BD 0000  A ATEST2      JSR    EXBPRT      PRINT MESSAGE
00027A 4513 7E 0000  A             JMP    EXBENT      GOTO EXBUG/DON'T STOP



00029P 0000                        PSCT               PROGRAM SECTION
00030P 0000     0001  A POWERS     FDB    1           POWERS OF TEN TABLE
00031P 0002     000A  A            FDB    10
00032P 0004     0064  A            FDB    100
00033P 0006     03E8  A            FDB    1000
00034P 0008     2710  A            FDB    10000


00036                              END
TOTAL ERRORS 00000--00000



D   4406 ATEST   00012 00022*
    4510 ATEST2  00023 00026*
 C  0000 CMSG    00018*00022
R        EXBENT  00013*00027
R        EXBPRT  00013*00026
DP  0000 POWERS  00012 00030*
```

FIGURE 3-3. Message Program 3 (PG3)

```
   =RLOAD
   MDOS LINKING LOADER REV 03.00
   COPYRIGHT BY MOTOROLA 1977
(1)?LOAD=PG1.RO:0 -------------------------- LOAD FIRST FILE
(2)?LOAD=PG2,PG3 --------------------------- LOAD OTHER TWO FILES
(3)?OBJA=PG123 ----------------------------- START PASS 2
(4)?LOAD=PG1,PG2,PG3 ----------------------- REPEAT PASS 1 COMMANDS
(5)?MAPU ----------------------------------- PRINT UNDEFINED SYMBOLS MAP
     NO UNDEFINED SYMBOLS
(6)?MAPF ----------------------------------- PRINT FULL MEMORY/SYMBOL MAP
     NO UNDEFINED SYMBOLS      6a

   MEMORY MAP

     S SIZE  STR  END  COMN
     A 0006 4510 4515
     A 0006 4406 440B
     B 001A 0020 0039 0000      6b
     C 0030 003A 0069 0030
     D 0042 006A 00AB 0020
     P 0073 00AC 011E 0000

   MODULE NAME BSCT DSCT PSCT
     PG1        0020 006A 00AC    6c
     PG2        0025 0078 00FD
     PG3        003A 008C 0115

   COMMON SECTIONS

      NAME   S SIZE  STR
     DCOMM   D 0008 008C     6d
     DCOMM2  D 0018 0094

   DEFINED SYMBOLS


   MODULE NAME: PG1
     CR     A 000D     EOT     A 0004     EXBPRT A F024     LF      A 000A    6e
     MSG1   P 00AC     MSG2    D 006A     MSGSIZ B 0020     PG1NE   P 00C2
     START  P 00B6

   MODULE NAME: PG2
     EXBENT A F564     MSG3    D 0078     MSG4    D 0082    PGM2    P 00FD    6f
     STACK  B 0039

   MODULE NAME: PG3
     ATEST  A 4406     POWERS P 0115    6g
(7)?EXIT ----------------------------------- RETURN TO MDOS
   =LOAD PG123;V --------------------------- LOAD OBJECT PROGRAM FILE

   ◆E ;P ----------------------------------- START PROGRAM EXECUTION
   MESSAGE 1
   MESSAGE 1
   MESSAGE 2
   MESSAGE 2
   MESSAGE 3
   MESSAGE 3
   MESSAGE 4
   COMMON TEST PROGRAM


   EXBUG 2.1
   ◆E
```

FIGURE 3-4. Basic Loader Operation

The fourth area of the map (6d) defines the size and starting address of any named common blocks. Thus, the PG1 variable CMSGST, which is the first variable in the DCOMM2 common block, will be located at address $8C. The final map feature provides an alphatized list of all global symbols by modules (6e, 6f, 6g). The modules are listed in the order that they were loaded. Thus, the PG1 variable START has an absolute address of $B6.

7. To return to MDOS, the EXIT command is used. This command may, in addition, be used to assign a starting execution address. In this example, PG123's starting address will be at address $B6, since the variable START appears as the operand on PG1's END statement. Two alternate methods of defining the execution address are:

```
              EXIT=START
        or    EXIT=$B6
```

3.3 LOADER OPERATIONS USING INTERMEDIATE FILES

As shown in the previous example, most commands must be re-entered during pass 2 of the Loader. The use of an intermediate file eliminates the need to retype Loader commands. Figure 3-5 is an example of the use of intermediate files. Commands used in the sequence are explained below, with the exception of those commands previously discussed.

1. The intermediate file feature is invoked by defining a new file for use as the intermediate file.

2. The IDON command turns the identifier option on to allow printing of the IDNT assembly directive as entered in the files.

3. This command line shows how more than one command may be specified on the same line by using the ';' feature. The STR command is used to define the starting section addresses of $400 and $1000 for DSCT and PCST, respectively. These starting addresses are reflected in the map generated in pass 2.

4. The CUR command with the '\' option causes the PSCT section of each module to start at an address which is modulo $10 from the start of PSCT. This feature permits the user to easily debug relocatable programs, since modules start at convenient addresses. Thus, in the example of Figure 3-5, the first PSCT code for module PG2 will start at $1070.

5. Notice that the loading order is different from the example in Figure 3-4. As each file/module is loaded, its identifier is printed (5a).

6. As in the previous example, the OBJA command initiates pass 2 of the Loader. However, since the intermediate file feature is being used, the second pass 2 is automatically performed without the user re-entering the commands. Notice the identifiers are also printed here as each file/module is loaded (6a).

7. The Loader has completed processing all commands entered in pass 1; the user may now enter any non-load command such as a MAP command or EXIT. In this case, all map output is directed to the line printer with the MO=#LP command.

```
     =RLOAD
     MDOS LINKING LOADER REV 03.00
     COPYRIGHT BY MOTOROLA 1977
(1)  ?IF=TEMP ---------------------------------  CREATE INTERMEDIATE FILE = TEMP
(2)  ?IDON ------------------------------------  TURN ON IDENTIFIERS
(3)  ?STRD=$400;STRP=$1000;STRB=0 -------------  DEFINE STARTING SECTION ADDRESSES
(4)  ?CURP=\$10 -------------------------------  START PSCT ON MODULO 10 (HEX) BOUNDARIES
(5)  ?LOAD=PG1,PG3,PG2 ------------------------  LOAD FILES
       PG1      08/10/79 MAIN MESG PROGRAM   - MODULE #1
(5a)   PG3      08/10/79 ASCT ILLUSTRATION   - MODULE #3
       PG2      08/10/79 MESG PRNTR SUBPROG  - MODULE #2
(6)  ?OBJA=PG132 ------------------------------  START PASS 2 - CONTROLLED BY INTERMEDIATE FILE
       PG1      08/10/79 MAIN MESG PROGRAM   - MODULE #1
(6a)   PG3      08/10/79 ASCT ILLUSTRATION   - MODULE #3
       PG2      08/10/79 MESG PRNTR SUBPROG  - MODULE #2
(7)  ?MO=#LP ----------------------------------  ASSIGN MAP OUTPUT TO LINE PRINTER
(8)  ?MAPF ------------------------------------  FULL MEMORY/SYMBOL MAP TO LINE PRINTER
(9)  ?EXIT ------------------------------------  RETURN TO MDOS
     =LOAD PG132;V ----------------------------  LOAD OBJECT PROGRAM FILE

     ◆E ;P ------------------------------------  START PROGRAM EXECUTION
     MESSAGE 1
     MESSAGE 1
     MESSAGE 2
     MESSAGE 2
     MESSAGE 3
     MESSAGE 3
     MESSAGE 4
     COMMON TEST PROGRAM

     EXBUG 2.1
     ◆E
```

FIGURE 3-5. Using an Intermediate File

8. A full map is sent to the line printer to produce a hard copy with the MAPF command. The line printer map output is shown in Figure 1-3.

9. The object file is closed and control is returned to MDOS via the EXIT command.

3.4 LOADER OPERATIONS USING A LIBRARY FILE/CREATING AN MDOS COMMAND

The previous examples have described the loading procedure performed via the LOAD command. In these examples, the user was aware of each module that had to be loaded. However, in other cases, the user may be aware of only the entry point name required to perform a desired function. In such instances, the user can create a file which contains a collection of utility modules. The Loader may be used to extract only the required modules from this library file. The use of a library file is shown in Figure 3-6, and a description of the various steps is explained below:

1. The MDOS MERGE command is used to build a library file PGLIB. This file contains the modules in files PG1, PG2, and PG3.

2. The use of the BASE command directs the Loader to assign memory for CSCT, DSCT, and PSCT above the MDOS system area. As a result, the user program may be invoked directly as an MDOS command without using the LOAD command. However, if the program has initialized BSCT, the MDOS LOAD command must be used to execute the program. The effect of the BASE command is shown in the program's memory map where CSCT, DSCT, and PSCT are assigned memory above $2000.

3. All currently undefined symbols are listed via the MAPU command. In this example, the six undefined symbols correspond to the six external references in PG1.

4. The LIB command searches the file PGLIB for any modules which satisfy the current undefined symbols. Since PG2 and PG3 are modules in PGLIB that satisfy these undefined symbols (i.e., PG2 and PG3 have XDEF's for ATTEST, EXBENT MSG3, MSG4, PGM2, and STACK), they will be loaded via the LIB command. PG1, which is also in PGLIB, will not be loaded again.

5. The second MAPU command shows that all external references have now been satisfied.

6. The second pass of the Loader is initiated with the OBJA command, and creates an object file with the name MESSAGE. The use of the suffix 'CM', along with the Loader's BASE command, permits the created file to be treated as an MDOS command (see item 9).

7. Since an intermediate file was not created during pass 1, all commands entered in pass 1 must be repeated in pass 2. The MAP, END, and STR commands are the only exceptions to this rule.

8. The EXIT command completes pass 2 of the Loader and returns to MDOS.

9. The file created by the Loader is treated as an MDOS command and, therefore, is loaded and executed automatically.

```
(1)=MERGE PG1.RO,PG2.RO,PG3.RO,PGLIB.RO --------BUILD LIBRARY FILE
   =RLOAD
   MDOS LINKING LOADER REV 03.00
   COPYRIGHT BY MOTOROLA 1977
(2)?BASE -----------------------------------------LOCATE PROGRAM ABOVE MDOS
   ?LOAD=PG1 -------------------------------------LOAD FIRST FILE
(3)?MAPU -----------------------------------------PRINT UNDEFINED SYMBOLS
     ATEST   EXBENT MSG3    MSG4    PGM2    STACK
   0006 UNDEFINED SYMBOLS
(4)?LIB=PGLIB ------------------------------------SEARCH LIBRARY FILE
(5)?MAPU -----------------------------------------PRINT UNDEFINED SYMBOLS
    NO UNDEFINED SYMBOLS
(6)?OBJA=MESSAGE.CM ------------------------------START PASS 2 - BUILD COMMAND FILE
(7)?BASE -----------------------------------------REPEAT PASS 1 COMMANDS
   ?LOAD=PG1;LIB=PGLIB
   ?MAPF -----------------------------------------PRINT FULL MEMORY/SYMBOL MAP
    NO UNDEFINED SYMBOLS

   MEMORY MAP

    S SIZE  STR  END  COMN
    A 0006 4510 4515
    A 0006 4406 440B
    B 001A 0020 0039 0000
    C 0030 2000 202F 0030
    D 0042 2030 2071 0020
    P 0073 2072 20E4 0000

   MODULE NAME BSCT DSCT PSCT
    PG1        0020 2030 2072
    PG2        0025 203E 20C3
    PG3        003A 2052 20DB

   COMMON SECTIONS

     NAME   S SIZE  STR
    DCOMM   D 0008 2052
    DCOMM2  D 0018 205A

   DEFINED SYMBOLS


   MODULE NAME: PG1
    CR      A 000D     EOT    A 0004     EXBPRT A F024     LF     A 000A
    MSG1    P 2072     MSG2   D 2030     MSGSIZ B 0020     PG1NE  P 2088
    START   P 207C

   MODULE NAME: PG2
    EXBENT  A F564     MSG3   D 203E     MSG4   D 2048     PGM2   P 20C3
    STACK   B 0039

   MODULE NAME: PG3
    ATEST   A 4406     POWERS P 20DB
(8)?EXIT ---------------------------------------- RETURN TO MDOS
(9)=MESSAGE ------------------------------------- LOAD AND EXECUTE NEW MDOS COMMAND

   MESSAGE 1
   MESSAGE 1
   MESSAGE 2
   MESSAGE 2
   MESSAGE 3
   MESSAGE 3
   MESSAGE 4
   COMMON TEST PROGRAM


   EXBUG 2.1
   *E
```

FIGURE 3-6. Using a Library File

3.5 LOADER OPERATIONS USING A CHAIN FILE

For programs requiring more than a few modules, the use of the MDOS CHAIN command to link them becomes a virtual necessity. It also provides a self-documenting listing of how to link the program. A sample chain file is shown in Figure 3-7. The use of this chain file is shown in Figure 3-8, and a description of the various steps is explained below.

1. The chain file (LINK.CF) is invoked using the MDOS CHAIN command. There are five option parameters which will be passed on to the chain file. This is the only line entered by the operator until (7).

2. The chain file pauses here to give the operator a chance to abort, if so desired, without destroying anything.

3. The previous map and object file are deleted.

4. The Linking Loader is invoked via the RLOAD command. The parameters from the command line (1) are substituted to define the section values.

5. Map output is directed to an output file called PG321.MO. This provides a permanent listing of the map output which can be listed at any time.

6. The MDOS LIST command is invoked to produce a hard copy of the map file on the line printer. Note the header option is used and the DATE command line parameter is substituted. The line printer listing of the map output files is shown in Figure 3-9.

7. The chain file processing ends and the input stream returns to the keyboard for operator input.

```
PAGE 001  LINK    .CF:0

/*
/*     *******************************************
/*     ** LINK MESSAGE PROGRAMS CHAIN PROCESSOR **
/*     **              08/10/79                **
/*     *******************************************
/*
@*
@*    WARNING!  GOING TO DELETE THE FOLLOWING FILES:
@*    -------        PG321.LO:0   (OLD OBJECT)
@*                   PG321.MO:0   (OLD RLOAD MAP)
@*
@*              ABORT WITH 'BREAK' KEY OR
@.              STRIKE 'RETURN' TO CONTINUE...
@*
@SET,M 8
DEL PG321.LO,PG321.MO
@SET,M 0
RLOAD
IDON
STRD=$%D%;STRP=$%P%;STRB=$%B%
/IFS CP
CURP=\\$%CP%
/XIF
LOAD=PG3,PG2,PG1
MAPU
OBJA=PG321
STRD=$%D%;STRP=$%P%;STRB=$%B%
/IFS CP
CURP=\\$%CP%
/XIF
LOAD=PG3,PG2,PG1
MAPU
MO=PG321.MO
MAPF
EXIT
@*
LIST PG321.MO;LH
MESSAGE PROGRAM TEST RLOAD MAP - %DATE%
@*
/IFC B,D,P,DATE
/*
/* COCKPIT ERROR DETECTED!
/*
/*   MUST SPECIFY THE FOLLOWING OPTIONS:
/*   ----------------------------------
/*        B = START BASE SEGMENT ADDRESS (HEX, NO $)
/*        D =   "   DATA    "       "    (HEX, NO $)
/*        P =   "  PROGRAM  "       "    (HEX, NO $)
/*     DATE = TODAY'S DATE FOR MAP LISTING
/*
/*                 OPTIONAL
/*       CP = HEX VALUE (NO $) FOR "CURP=\\" COMMAND
/*
/* *** CHAIN ABORTED ***
/*
/ABORT
/XIF
```

FIGURE 3-7. Listing of Chain File Invoking RLOAD

```
(1)=CHAIN LINK;DATE%10 AUG. 1979%,B%0%,D%400%,P%1000%,CP%100%

      *****************************************
      ** LINK MESSAGE PROGRAMS CHAIN PROCESSOR **
      **               08/10/79                **
      *****************************************

   ?*
   ?*   WARNING!   GOING TO DELETE THE FOLLOWING FILES:
   ?*   --------        PG321.LO:0    (OLD OBJECT)
   ?*                   PG321.MO:0    (OLD RLOAD MAP)
   ?*
   ?*              ABORT WITH 'BREAK' KEY OR
(2)?.              STRIKE 'RETURN' TO CONTINUE...

   ?*
   ?SET FOFF 0800
(3)DEL PG321.LO,PG321.MO
   PG321    .LO:0 DELETED
   PG321    .MO:0 DELETED
   ?SET FOFF 0000
(4)RLOAD
   MDOS LINKING LOADER REV 03.00
   COPYRIGHT BY MOTOROLA 1977
   ?IDON
   ?STRD=$400;STRP=$1000;STRB=$0
   ?CURP=\$100
   ?LOAD=PG3,PG2,PG1
     PG3      08/10/79 ASCT ILLUSTRATION    - MODULE #3
     PG2      08/10/79 MESG PRNTR SUBPROG - MODULE #2
     PG1      08/10/79 MAIN MESG PROGRAM   - MODULE #1
   ?MAPU
     NO UNDEFINED SYMBOLS
   ?OBJA=PG321
   ?STRD=$400;STRP=$1000;STRB=$0
   ?CURP=\$100
   ?LOAD=PG3,PG2,PG1
     PG3      08/10/79 ASCT ILLUSTRATION    - MODULE #3
     PG2      08/10/79 MESG PRNTR SUBPROG - MODULE #2
     PG1      08/10/79 MAIN MESG PROGRAM   - MODULE #1
   ?MAPU
     NO UNDEFINED SYMBOLS
(5)?MO=PG321.MO
   ?MAPF
   ?EXIT
   ?*
(6)LIST PG321.MO;LH
   ENTER HEADING: MESSAGE PROGRAM TEST RLOAD MAP - 10 AUG. 1979
   ?*
   END CHAIN
(7)=LOAD PG321;V  -------------------------- LOAD OBJECT PROGRAM

(8)*E ;P ------------------------------------ START PROGRAM EXECUTION
   MESSAGE 1
   MESSAGE 1
   MESSAGE 2
   MESSAGE 2
   MESSAGE 3
   MESSAGE 3
   MESSAGE 4
   COMMON TEST PROGRAM


   EXBUG 2.1
   *E
```

FIGURE 3-8. Using a Chain file and RLOAD

```
PAGE 001  PG321   .MO:0  MESSAGE PROGRAM TEST RLOAD MAP - 10 AUG. 1979

  NO UNDEFINED SYMBOLS

MEMORY MAP

  S SIZE  STR  END COMN
  A 0006 4510 4515
  A 0006 4406 440B
  B 001A 0000 0019 0000
  C 0030 0020 004F 0030
  D 0042 0400 0441 0020
  P 0251 1000 1250 0000

MODULE NAME BSCT DSCT PSCT
  PG3       0000 0400 1000
  PG2       0000 0400 1100
  PG1       0015 0414 1200

COMMON SECTIONS

   NAME  S SIZE  STR
  DCOMM  D 0008 0422
  DCOMM2 D 0018 042A

DEFINED SYMBOLS


MODULE NAME: PG3
  ATEST  A 4406    POWERS P 1000

MODULE NAME: PG2
  EXBENT A F564    MSG3   D 0400    MSG4   D 040A    PGM2   P 1100
  STACK  B 0014

MODULE NAME: PG1
  CR     A 000D    EOT    A 0004    EXBPRT A F024    LF     A 000A
  MSG1   P 1200    MSG2   D 0414    MSGSIZ B 0015    PG1NE  P 1216
  START  P 120A
```

FIGURE 3-9. Map Output File Listing

APPENDIX A

A SUMMARY OF LINKING LOADER COMMANDS

<u>COMMAND</u>	<u>FUNCTION</u>
<u>CONTROL COMANDS</u>	
BASE[=<number>]	LOAD CSCT, DSCT, and PSCT above defined address (default=MDOS compatible)
EXIT $\left\{=\begin{matrix}\text{<name1>}\\ \text{<number>}\end{matrix}\right\}$	Give control to the disk operating system
IDOF	Suppress identification printing
IDON	Print module identification information
IF=<f-name>	Specify the intermediate file
IFOF	Intermediate file mode off
IFON	Intermediate file mode on
INIT	Initialize the Loader
OBJ $\begin{bmatrix}\text{A}\\ \text{X}\end{bmatrix}$=<f-name>	Initiates Pass 2
MO= $\begin{Bmatrix}\text{<device>}\\ \text{<f-name>}\end{Bmatrix}$	MAP output
<u>LOAD DIRECTIVES</u>	
LIB=<f-name> $\left[\text{,[<f-name>]}\right]_{0}^{99}$	Enter file mode
LOAD=<f-name> $\left[\text{,[<f-name>]}\right]_{0}^{99}$	Load the indicated file(s)/module(s)

COMMAND	FUNCTION
STATE COMMANDS	
$\text{CUR}\begin{Bmatrix}\text{B}\\ \text{D}\\ \text{P}\end{Bmatrix}\text{=[\textbackslash]<number>}$	Set current location counter
$\text{DEF: <name1>=}\begin{Bmatrix}\text{<number>}\\ \text{<name2>}\end{Bmatrix}\left[\begin{matrix}\text{ASCT}\\ \text{BSCT}\\ \text{,DSCT}\\ \text{PSCT}\end{matrix}\right]$	Define a symbol
$\text{END}\begin{Bmatrix}\text{B}\\ \text{C}\\ \text{D}\\ \text{P}\end{Bmatrix}\text{=<number>}$	Set section ending address
MAPC	List user assigned section sizes and addresses
MAPF	List full load map
MAPS	List loader assigned section sizes and addresses
MAPU	List undefined symbols
$\text{STR}\begin{Bmatrix}\text{B}\\ \text{C}\\ \text{D}\\ \text{P}\end{Bmatrix}\text{=<number>}$	Set section starting address

APPENDIX B

LINKING LOADER ERROR MESSAGES

Errors detected by the Linking Loader, while processing a command or loading a module, will result in an error message being printed at the user terminal. These errors are divided into two classifications: fatal errors and non-fatal (warning) errors. When the Loader detects a non-recoverable error, a fatal error message will be printed. Any commands not processed on the last command line will be ignored and a new prompt printed. If the Loader can recover from an error, only a warning message will be printed.

FATAL ERROR MESSAGES

MESSAGE	
BAE	BSCT Assignment Error - the combined size of BSCT is greater than the amount that can be allocated in the defined BSCT area.
COV	Common Overflow - the size of a section's common is greater than 65,535.
GAE	General Assignment Error - the Loader cannot assign absolute memory addresses. This may result from: . address conflicts associated with ASCT's . user assignment of section addresses . the combined length of all sections exceeding 65,535 . the order in which the Loader assigns memory.
ICM	Illegal Command
IOR	Illegal Object Record - the input module is not a valid relocatable object module.
ISA	Illegal Stream Assignment - this error occurs when an invalid I/O device is assigned to a Loader I/O stream.
ISY	Illegal Syntax - error in the option or specification field of a command. This error may also occur when a command is not terminated by a semicolon, space, or carriage return.
LOV	Local Symbol Table Overflow - not enough memory for all the local (external) symbols defined by the current object module. Check for contiguous memory from location Ø.
GOV	Global Symbol Table Overflow - not enough memory for all the global (external) symbols defined by the object modules. Check for contiguous memory from location Ø.
PHS	Phase Error - the absolute address assigned to a global symbol at the end of Pass 1 does not agree with the address computed during Pass 2.
SOV	Section Overflow - the size of a section is greater than 65,535.

FATAL
ERROR MESSAGES

MESSAGE

UAE	User Assignment Error - the user has incorrectly defined load addresses. Use the MAPC command to produce a map for determining the cause of this error. The UAE error occurs when: . the user defined end address is less than the user defined start address . the space allocated by the user defined start and end addresses is less than that required for the section. . the user has defined load section addresses which overlap . the user defined execution address is out of range . the user has defined ASCT below $20 . the user has initialized locations in BSCT which are assigned below $20
UIF	Undefined IF File
UOI	Undefined Object Input File

WARNING MESSAGES

IAM - <address> - Illegal Address Mode - a global symbol is referenced as a one-byte operand, and the most significant byte of the global symbol address is non-zero. One byte relocation is performed, using only the least significant byte of the global symbol address. The warning message indicates the absolute address of such a reference.

MDS - <symbol> - Multiply Defined Symbol - the Loader has encountered another definition for the previously defined global symbol. Only the first definition will be valid. This can also be caused by section conflicts for the symbol -- i.e., defined via an EQU directive (ASCT) and referenced in another module as BSCT.

UDS - <symbol> - Undefined Symbol - the symbol was not defined during Pass 1. A load address of zero will be assumed.