INTELLEC® 800
MICROCOMPUTER DEVELOPMENT SYSTEM
OPERATOR'S MANUAL

98-129A

PREFACE

This manual contains information on the use of the Intellec® Microcomputer Development System. The Intellec MDS is a design and debugging tool for designers who are using the Intel® 8080 CPU or Series 3000 computing elements in OEM designs. Through the use of MDS system peripherals, optional plug-in modules, and the software provided, the system can be made to operate as a stand-alone computing system to check out software techniques; or as a partial system simulator which checks out a user's hardware and software, while the software is executing from RAM in the Intellec MDS; with OEM hardware; or as a chip simulator, to verify the operation of the user's system after the software is committed to ROM.

The following features of MDS software are discussed:

- MDS MONITOR Program. The MDS Monitor provides the basic utility functions for the Intellec MDS. These functions include program loading, memory display, memory modification, PROM programming, program checkout and debugging facilities, and a generalized extensible I/O system which is accessible by user programs.

- TEXT EDITOR Program. The Text Editor provides facilities for creating new source programs or correcting existing ones.

- 8080 ASSEMBLER Program. The Assembler program accepts 8080 source language statements and generates a list file and object code file.

It is assumed that the reader of this manual has prior knowledge of computing systems and is familiar with 8080 programming.

Related Publications

8080 Assembly Language Programming Manual
Intel Publication # 98-004

Intellec MDS Hardware Reference Manual
Intel Publication # 98-132

Universal PROM Programmer Hardware Reference Manual
Intel Publication # 98-133

Intel High-Speed Paper Tape Reader
Instruction and Operation Guide
Intel Publication # 98-016

Reference manuals and specifications may be obtained by contacting:

Intel Corporation
Customer Services
3065 Bowers Avenue
Santa Clara, California 95051

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GENERAL INFORMATION

INTRODUCTION

The Intellec® Microcomputer Development System (MDS) is a complete design and debugging tool which allows the integration of both microcomputer hardware and software development. The system operates under control of an 8080 microcomputer which supervises all system resources such as main memory, I/O peripheral devices, Intellec bus facilities, and optional system facilities such as DMA (Direct Memory Access) and ICE (In-Circuit Emulator). The Intellec MDS is a self-contained modular microcomputer development system.

SYSTEM DESCRIPTION

The standard Intellec® MDS consists of four microcomputer modules, an interconnecting printed circuit motherboard, power supplies, fans, a chassis, and a front panel. The four microcomputer modules mentioned above, consist of the 8080 CPU Module, 16K of RAM memory, Front Panel Control Module, and the Monitor Module. Modular expansion capability is provided by the additional 14 sockets on the motherboard.

8080 CPU Module

The CPU Module contains an Intel® 8080 CPU, an n-MOS 8-bit microprocessor. The CPU provides 2 us cycle time, 78 instructions, unlimited subroutine nesting, vectored interrupt, DMA capabilities, and a 16-line address bus which is associated with a bidirectional eight-line data bus.

Besides the 8080 itself, the CPU Module contains a real-time clock, CPU initialization logic, and logic to control the Intellec bus. It also implements a sophisticated priority interrupt mechanism. The CPU Module contains a priority encoder, which allows eight different levels of interrupts to be serviced. An interrupt mask register on the CPU Module allows the 8080 software to block interrupts at some levels, while allowing interrupts at other levels to be serviced. All signals

required by the 8080's own interrupt system are generated by the CPU Module. A complete discussion of interrupt processing and programming requirements on the Intellec MDS is included in Appendix F.

Monitor Module

The monitor module contains the Intellec® MDS Monitor and all MDS peripheral interface hardware. This module contains all necessary clocks, control, and data transfer circuitry to interface the following peripherals:

- Teletype
- CRT (RS232 Interface Specification)
- High Speed Paper Tape Reader
- High Speed Paper Tape Punch
- Line Printer
- Universal PROM Programmer

Use of the Monitor is discussed in Section 3.

Front Panel Control Module

The Front Panel Control module contains circuits for controlling the front panel operations. It also provides much of the system overhead for bus control, clock generation, and the bootstrap program. A bus time-out system is included to prevent the CPU from halting operation if a nonexistent memory location or an incorrect I/O port is addressed.

The Intellec MDS front panel is intended to augment the console which is the primary user interactive device. Controls and indicators are kept to a minumum. These include eight interrupt initiation switches with corresponding indicators, RUN and HALT indicators, a BOOTSTRAP initialization switch, and a RESET switch. The use of these controls is discussed in detail below.

Optional Modules

The basic Intellec MDS capabilities may be significantly enhanced by the addition of the following optional modules.

- ICE (In-Circuit Emulator)
- Customized User I/O Facilities with the installation of additional I/O modules
- Additional PROM or RAM memory modules to expand memory

in increments of 6K (PROM) or 16K (RAM) 8-bit bytes, up to a maximum of 12K of PROM and 64K of RAM.

- DMA (Direct Memory Access)

Software Support

The following software is provided for use in the Intellec MDS. These software packages are described in detail in Sections 3, 4, and 5.

- System Monitor
- Text Editor
- Macro Assembler

MEMORY REQUIREMENTS

The Intellec® MDS memory is arranged into 65,536 addressable 8-bit bytes. Figure 1-1 describes the memory in the form of a memory map. The upper 2048 locations are reserved for a 2048 by 8-bit ROM containing the Intellec MDS Monitor program. The lower 256 bytes may be read from RAM or a "Shadow PROM", depending on the setting of the front panel BOOTSTRAP switch. When the BOOTSTRAP switch is on, reading locations 00 through 255 retrieves the bytes from the "Shadow PROM"; writing into these same locations causes the data to be stored in RAM. When the BOOTSTRAP switch is off, reading and writing from locations 00 through 255 moves data to and from RAM only. This 256 byte "Shadow PROM" contains the BOOTSTRAP portion of the Monitor program. Having the BOOTSTRAP portion of the Monitor in "Shadow PROM" allows the initialization code, invoked by the front panel RESET switch to be executed starting at location 00. If a user program is run while the system is in BOOTSTRAP mode, the results will be unpredictable.

User accessible RAM may be installed in locations 00 through F7FFH, in increments of 16,384 bytes. Depending on the amount of memory available, it may be installed contiguously or in segments. The only restriction imposed with respect to memory installation is that at least one block of memory be installed in the low order memory locations (starting at location 00). It should be noted that the user must be aware of any addressing discontinuities and produce code accordingly.

The Intellec MDS Monitor reserves 331 bytes of RAM for its own use. These are:

- Locations 0 through 7;
- Locations 11 through 15 (0BH through 0FH);
- The 318 locations at the top of the first contiguous block of RAM.

The location of the upper 318 bytes is determined when the system is initialized during the BOOTSTRAP procedure. The Monitor checks location 256 (100H) for a successful write/read operation, verifying the presence of a block of RAM in locations 256 through 511 (100H through 1FFH). If the test is successful, it is repeated at address 512 (200H). This process is continued at memory address intervals of 256 (100H) until a nonexistent memory block is found. The reserved area is placed immediately below the last contiguous memory location. For example, in a 16K system, the Monitor will use addresses 3EC0H through 3FFFH.

If memory is installed in noncontiguous segments, the 318 reserved locations are placed immediately below the last contiguous location. However, RAM may be installed in the locations above the missing segment, providing usable memory above the reserved locations. Normally, memory is installed from location 00, upward to the highest available location without discontinuities.

When a full complement of memory is installed, the high order RAM which would normally be accessible by addressing locations F800H through FFFFH is shadowed by the Monitor ROM and cannot be accessed. This restriction also applies to any configuration of RAM which has portions in locations F800H through FFFFH.

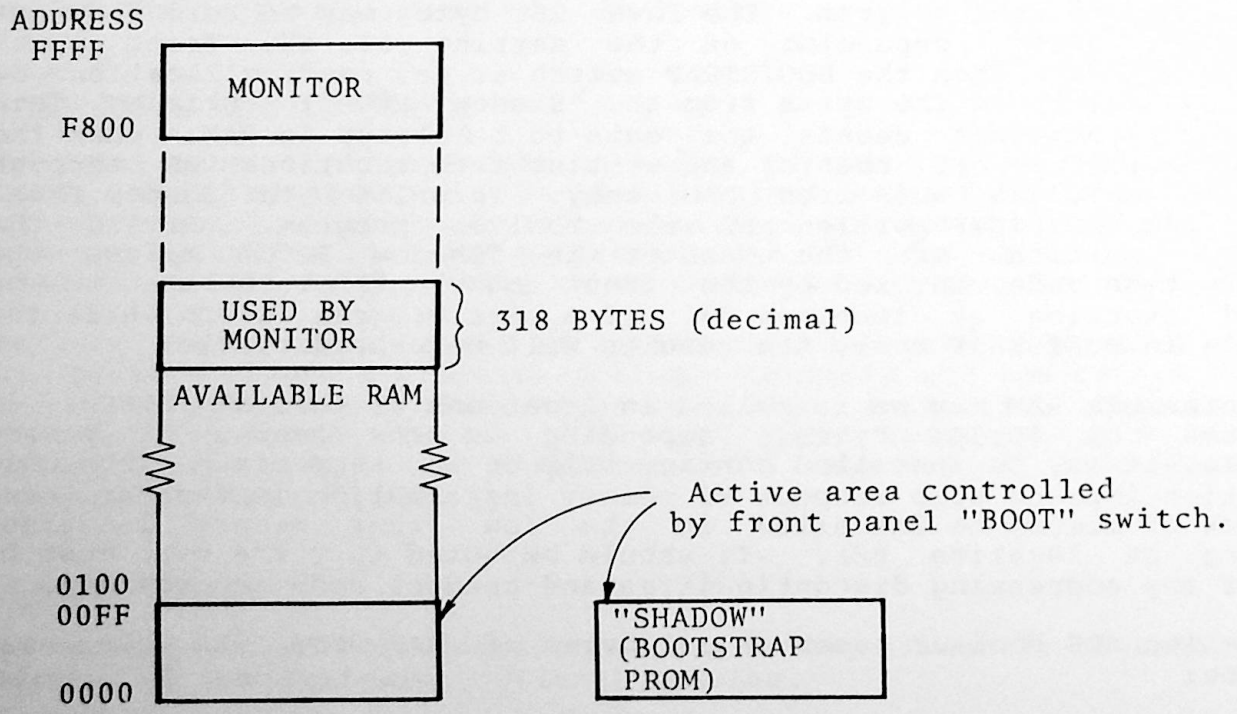


Figure 1-1: Intellec® MDS Memory Map

I/O SYSTEM CONFIGURATION

An Intellec® MDS microcomputer system may be configured with a variety of peripheral devices ranging from a basic 10-character-per-second Teletype to higher speed devices such as a paper tape reader, punch, or CRT. The following logical devices are necessary as the minimum peripheral device complement to run the Intellec MDS Monitor. These devices may be assigned to various physical peripheral devices using the Monitor "Assign" Command, which is discussed in Section 3.

CONSOLE An interactive, character-oriented input/output device.

READER A character-oriented input stream device which transfers data upon command and signals the calling program when no more data is available (End Of File).

PUNCH A character-oriented output stream device which accepts a character from the calling program and records it on some extermal medium.

LIST A character-oriented output device which accepts a character from the calling program and records it on some external medium in human readable form.

Facilities are provided so that up to four distinct physical devices may be assigned to each logical device; the operator may select only one device at a time. Each logical device has a default physical device which is assigned at startup time (during the BOOTSTRAP procedure). However, the user has the option to specify any of the remaining three physical devices for that logical device.

SECTION 2

OPERATING THE INTELLEC® MDS

INTRODUCTION

The Intellec MDS is designed with a simplified front panel which reguires a minimum of button pushing. No data transfer facilities are incorporated into front panel operations. Except for cold-starting the MDS system, computer/operator dialogue is under control of the system Monitor, which provides facilities to operate an interactive console and other peripheral devices, and to accept operator commands. The system is at all times under control of the operator, through the Monitor.

The operator may select one of four console devices, one of four listing devices, one of four punching devices, and one of four paper tape reading devices. Once the system is configured, the operator may load a source 8080 program, edit it, and then assemble it into machine language object code. When the operation is completed, the operator may test the program by executing it in the MDS, then may output the code onto punched paper tape or may program a PROM.

The following section describes the operation of various peripherals, describes cold start and restart procedures, describes the procedures for loading and using the Assembler and Text Editor programs, and contains comprehensive instructions for the operation of the Monitor program which controls and supervises system operation.

EQUIPMENT DESCRIPTION

The following paragraphs describe the operation of the Intellec MDS front panel and the various peripherals which are used during normal operation. This information is not intended to replace the operating procedures which accompany the equipment, but to serve as a convenient reference showing major operating controls and indicators. The discussion will include descriptions of the following:

Intellec MDS Front Panel

Teletype Console

High Speed Paper Tape Reader

Universal PROM Programmer

Intellec® MDS Front Panel Description

The Intellec MDS is pictured in Figure 2-1. The description of each control and indicator is as follows:

POWER Switch	A two-position, key-operated switch to turn main power on and off.
POWER Indicator	Lights to indicate power on status.
INTERRUPT Switches	Eight momentary switches, numbered Ø through 7. When a switch is pressed, an interrupt of the corresponding level is generated on the Intellec MDS bus.
INTERRUPT Indicators	Eight indicator lights, each associated with the corresponding interrupt level. Lights when an interrupt at the associated level is pending. Goes out when the interrupt is serviced.
HALT Indicator	Lights when the Intellec MDS is in the HALT state.
RUN Indicator	Lights when the Intellec MDS is in the RUN state. If both the HALT and RUN indicators are off, and power is on, the MDS is in a WAIT state. If both are on, the MDS is oscillating rapidly between the RUN and HALT states.
BOOT Switch	When operated, switches the Intellec MDS into the BOOTSTRAP mode.
RESET Switch	Momentary action switch which, when operated, resets the program counter in the 8080 to address Ø, clears all pending interrupts, and resets all other MDS logic to its initialized state. The contents of RAM, however, are not affected.

Attaching Peripherals to the Intellec® MDS

The Intellec MDS back panel contains two rows of six slots each, used for mounting cable connectors for various peripheral devices. In a standard Intellec MDS, the rightmost six slots are occupied by connectors for six standard peripherals: a Teletype, a CRT, a paper tape reader, a paper tape punch, a line printer, and the Universal PROM Programmer. The function of each connector is shown in a legend, which is stenciled in the upper right-hand corner of the MDS back panel. Additional spaces are provided on the legend for the user to indicate the functions of additional connectors he may install.

Figure 2-1: Intellec® MDS Front Panel Controls And Indicators

Teletype Description

An ASR-33 Teletype is used in various applications. This peripheral contains a printer, keyboard, paper tape reader, and a paper tape punch. The ASR-33 Teletype is pictured in Figure 2-2. The controls are labeled in the figure; the function of each control is listed as follows:

CONTROL KNOB	Three-position switch: OFF Turns Teletype off. LINE Teletype is on and connected to Intellec MDS. LOCAL Teletype is on, but is not connected to Intellec MDS.
KEYBOARD	The keyboard contains the operating keys to produce printing, non-printing, and control characters.
PRINTER	The printer produces a typed copy of input and output at a maximum rate of ten characters per second. When the control knob is in the LINE position, the printer types the output characters transmitted from the computer. When the control knob is in the LOCAL position, the printer prints the characters typed in on the keyboard.
TAPE PUNCH	The tape punch is used to record information on punched paper tape at a rate of 10 characters per second.
REL	Disengages the paper tape to allow loading or unloading of tape.
B.SP	Backspaces the paper tape one character for each depression.
ON	Engages the tape punch and enables punching of tape.
OFF	Disengages the tape punch.
TAPE READER	The tape reader reads characters which are punched on paper tape. This information is read at a rate of 10 characters per second.
START	Begins reading tape.
STOP	Stops reading tape.
FREE	Disengages paper tape in the reader by releasing the sprocket wheel. Allows tape to be pulled through reader.

Before an ASR-33 Teletype can be used with the Intellec MDS, several simple modifications must be made to the Teletype. These are described in the Intellec MDS Hardware Reference Manual.

Operation of the ASR-33 Teletype is described in the Teletype operator's

manual. This information includes loading paper into the printer, loading paper tape into the punch, inserting punched paper tape into the tape reader, and general operations of the ASR-33 Teletype.

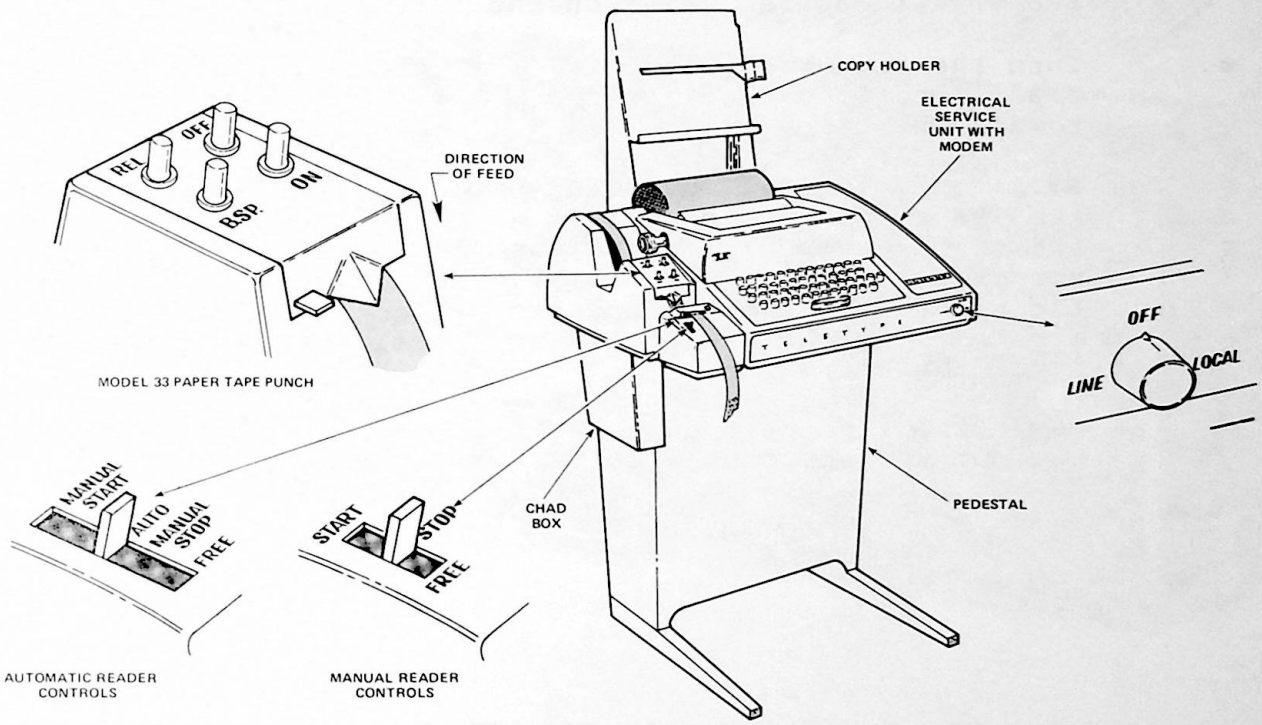


Figure 2-2: ASR-33 Teletype Controls

High Speed Paper Tape Reader

The MDS-PTR High-Speed Paper Tape Reader, shown in Figure 2-3, permits paper tape to be loaded into the Intellec MDS approximately twenty times as fast as is possible using the Teletype. Operation of the reader is very simple:

- Connect the cable leading from the Paper Tape Reader to the socket labeled "PTR" on the Intellec MDS back panel.
- Turn the tape reader on, and load the paper tape to be read into the left hopper, with the sprocket holes toward the rear.
- Raise the tape gate over the sprocket wheel, and thread the tape under the metal tape guide on the left, over the sprocket wheel (making sure the wheel engages the sprocket holes in the tape), and under the tape guide on the right. If enough leader is available on the tape, arrange one or two folds of tape in the bottom of the right hopper.
- Lower the tape gate onto the tape, thereby holding it against the sprocket wheel.

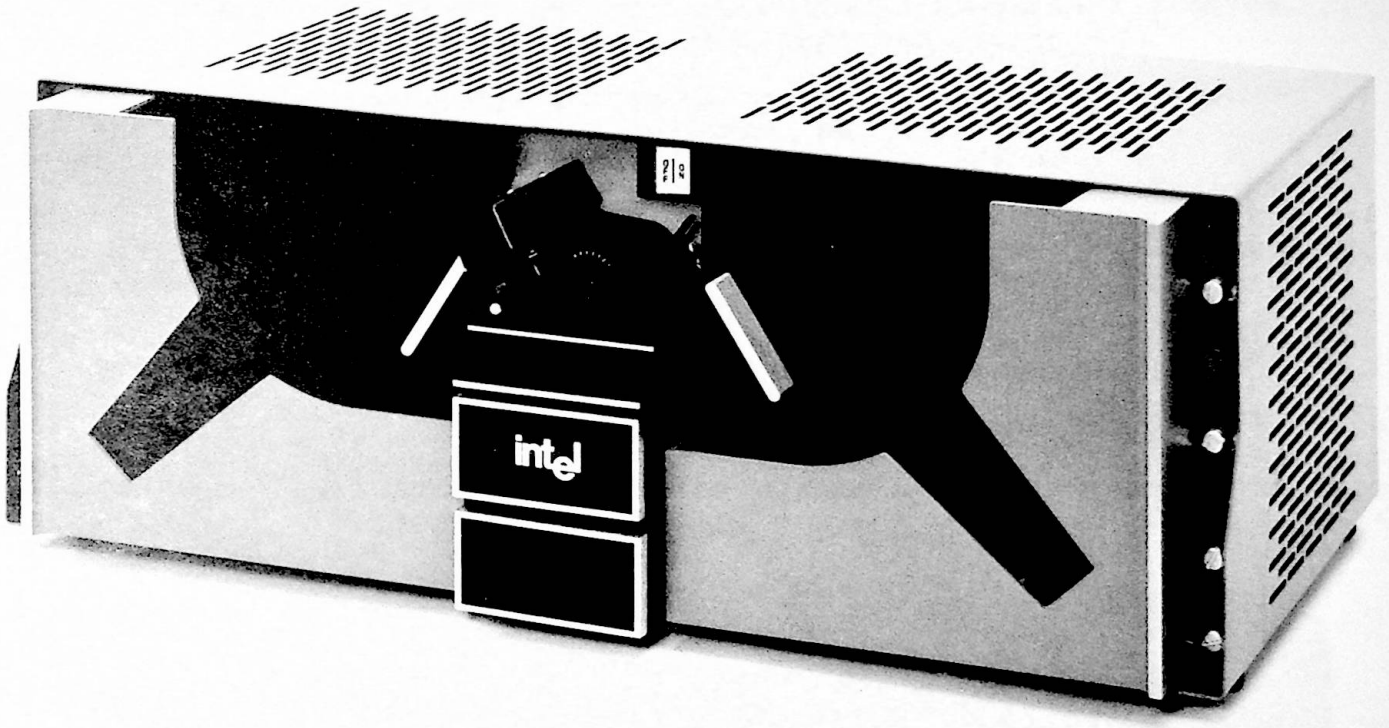


Figure 2-3: MDS-PTR High-Speed Paper Tape Reader

Universal PROM Programmer

The MDS-UPP Universal PROM Programmer allows the Intellec MDS user to program any Intel PROM. The UPP contains two zero-insertion-force sockets, labeled "Socket 1" and "Socket 2". Socket 2 is used for programming 24-pin PROMs; Socket 1 can be ordered in both a 16-pin and a 24-pin configuration. Programming different kinds of PROMs involves merely inserting the proper "personality card" for that PROM (available from Intel) into a slot in the UPP.

As shown in Figure 2-4, the front panel of the UPP is very simple and straightforward. Besides the PROM sockets, there are two switches (POWER and RESET) and two lights (POWER and PROGRAMMING). The POWER light indicates that AC power is applied to the UPP; the PROGRAMMING light indicates that the UPP is performing a programming operation. The RESET switch is not normally needed, but can be used to reinitialize the UPP if it is necessary to abort a programming operation in progress.

The UPP is operated as follows:

- Connect the cable from the UPP to the socket labeled "PROM" on the MDS back panel.
- Flip the POWER switch on the UPP to its UP position, and check that the POWER light comes on.
- Move the locking arm on the appropriate PROM socket to its released position (sticking out). Insert the PROM in the socket, and move the locking arm to its locked position (up).
- Enter the appropriate Monitor command on the MDS CONSOLE, as described in Section 3 of this manual.
- When the PROM operation is complete, lower the locking arm on the UPP socket and remove the PROM.

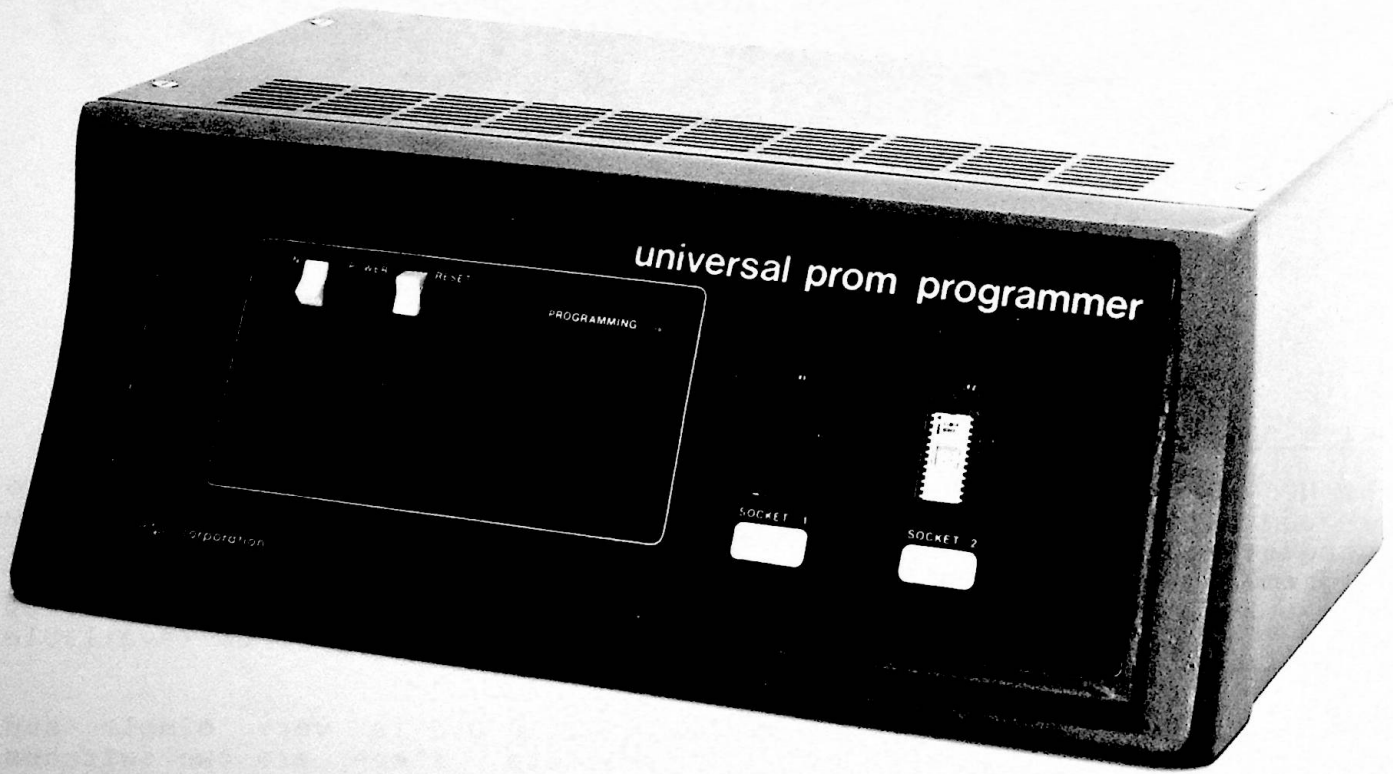


Figure 2-4: Universal PROM Programmer

STARTUP PROCEDURES

The startup procedures consist of turning the system power on and initiating operation of the Monitor. Procedures are included for a cold start from a power off condition, executing a user program, interrupting a user program temporarily, and manually terminating a user program.

Cold Start Procedures

To start the Monitor, perform the following:

- Turn power on by inserting key in power switch and turning clockwise. The POWER indicator should light.
- Set the BOOT switch to ON.
- Press the RESET switch.
- Type the "space" character on the device that is selected to be the system CONSOLE. The Monitor polls all devices capable of assuming the console function (Teletype or CRT), and assigns the first device that is used as the CONSOLE.

  The Monitor then types the following message:

  MDS MONITOR, Vx.x

- After the above message is typed, set the BOOT switch to the OFF position. The Monitor them prompts with a period (.) to indicate that it is ready to accept a command.

Return to Monitor from User Program

If a user program is running, the Monitor can be reentered and the user program terminated by pressing the INTERRUPT Ø switch. The Monitor responds by printing an asterisk (*) and the value of the user's Program Counter at the point where the interrupt occurred. The Monitor message may appear as follows:

*FC98

If the user's program has disabled the 8080 interrupt system (using a DI instruction, for example), or the program or the operator has altered the Intellec MDS Interrupt Mask Register (with an X command from the CONSOLE, for example), the Intellec MDS may not be sensitive to an INTERRUPT Ø. In this case, it will be necessary to repeat the BOOTSTRAP procedure described above to re-enter the Monitor.

SECTION 3

THE MDS MONITOR

INTRODUCTION

The Intellec® MDS Monitor is an Intel 8080 program available as eight 1702A PROMs or one 8316 Mask-Programmed ROM. The Monitor accepts and acts upon user commands to operate the Intellec MDS system. It also provides input and output facilities in the form of I/O drivers for user peripheral devices. The Monitor provides the following facilities:

- Punching selected areas of memory onto paper tape in BNPF or hexadecimal format.
- Checking the contents of a PROM by comparing with selected areas of memory.
- Displaying selected areas of memory.
- Initiating execution of user programs.
- Modifying contents of memory and processor registers.
- Inputting hexadecimal file from external device to memory
- Transferring the contents of an external PROM into memory.
- Inserting breakpoints into user programs before execution.
- Loading and executing the Text Editor and Assembler.
- Programming PROMs in conjunction with the Universal PROM Programmer (UPP).

The Monitor communicates with the user through an interactive console device, normally a Teletype. The dialogue between the operator and Monitor consists of user-originated commands in the Monitor's command language, and Monitor responses, either in the form of a printed message or an action being performed. After the cold start procedure (described under the heading, "STARTUP PROCEDURES" in Section 2), the Monitor begins the dialogue by typing the sign-on message on the console and requesting a command by presenting a prompt character, '.' (period).

MONITOR OPERATIONS

The Intellec® MDS Monitor is a command controlled operations supervisor for the Intellec MDS system. Control commands are discussed in the paragraphs titled, "Intellec MDS Command Structure". The following discussion considers the control commands in functional order.

Monitor I/O Configuration

The Monitor is designed to have versatile I/O facilities so that a user may select the peripheral device that is to be used for each of the I/O functions. The Monitor itself must have at least four system devices assigned to perform the functions defined as CONSOLE, READER, PUNCH, and LIST. The user is then given the option to select the actual peripheral device which is to perform the required system operation. Where applicable, a peripheral device may be used for more than one system I/O function. Selection of I/O devices for system use is the function of the ASSIGN or A command and is discussed under the paragraph titled, "I/O ASSIGNMENT".

The user is also given the facility to use non-standard I/O peripheral devices. No system coding (drivers) are provided to use these devices. However, system linkages are provided so that a user may prepare a device driver and link it to the Monitor I/O system. Procedures to code and link user generated device drivers is discussed in Section 6.

The Q command is included to notify the user of the assignment status of peripheral devices. When the Intellec MDS is initialized, default I/O assignments are made by the system. Following the initialization procedures, the device assignments may be changed as desired. The Q command provides the required quick check of system configuration.

Memory Control

The DISPLAY, MOVE, FILL, and SUBSTITUTE commands provide the user with control of Intellec MDS memory. These commands allow the user to read and write data in the MDS memory.

The DISPLAY command, as the name implies, allows the user to display the contents of blocks of memory on the LIST device. The MOVE command allows the user to move blocks of memory from ROM or RAM into RAM. The FILL command allows the user to replace the contents of all locations in

a specified memory area with a constant value. The SUBSTITUTE command allows the user to examine the contents of individual memory locations, modifying each as it is displayed or leaving it unchanged.

Register Control

The 8080 CPU registers and the Intellec MDS Interrupt Mask Register may be examined and modified with the X command. The Monitor maintains its own environment and the user operating environment separate. It saves and restores each environment each time control is passed between the user's program and the Monitor. The X command provides the user with the capability to examine amd modify the data in the user's registers. The registers associated with the Monitor cannot be accessed or modified with this command.

Paper Tape Input Control

Two commands, READ HEXADECIMAL FILE and LOAD BNPF TAPE, are included. These commands read data from the PUNCH device and interpret the data according to the specified format. Hexadecimal and BNPF formats are described in Appendix D.

The R command (READ HEXADECIMAL FILE) is used to read a file of hexadecimal records, terminated with an End-of-File record. An entry point address may be optionally included in the EOF record. The L command (LOAD BNPF TAPE) is used to read BNPF words from tape into memory. Because a low memory address and a high memory address are specified in the B command, only the number of words needed to fill the specified memory area are read. The command is terminated when the specified memory is filled. The R command is open ended, waiting for an EOF record to be read in to terminate the command.

Paper Tape Output Control

Four commands are included to control data output to the PUNCH device. The B command formats memory data into BNPF words and outputs it onto punched paper tape. The format of the BNPF tape is four words, separated by single spaces, and ending with a carriage return/line feed character pair. Thus, when printing the contents of BNPF tape, it is four words to a line.

The WRITE MEMORY or W command formats memory into hexadecimal formatted records. Each record contains its own load address, data, and checksum.

The END OF FILE or E command is used to terminate a file generated with the W command. Facilities are provided to include an entry point address which is used with the G command.

The NULL or N command is used to produce leader and trailer on the paper tape files. Use of this command causes sixty blank characters to be punched on the tape (sprocket holes only). The command may be used more

than once to generate greater lengths of leader.

Universal PROM Programmer Control

Three commands are included to control the operations of the UPP. These consist of the COMPARE or C command, the PROGRAM PROM or P command, and the TRANSFER PROM or T command.

The COMPARE command is used to compare the contents of a PROM that is installed in a socket on the UPP with the contents of a specified range of memory locations. If differences are encountered, an output is generated for the CONSOLE device showing the contents of both memory and PROM at the location that did not compare correctly.

The PROGRAM PROM command transfers the contents of a specified area of Intellec MDS memory into a PROM which is installed into a socket on the UPP.

The TRANSFER PROM or T command transfers the contents of a PROM which is installed in the UPP, into a specified area of Intellec MDS memory.

User Program Execution

The PROGRAM EXECUTE command, G, is used to execute a user program. This command transfers control to the user's program at a specified location. Prior to transferring control, the Monitor sets up the user environment. As control is passed back and forth between the Monitor and the user's program, the operating environment is saved and and reestablished. The state of user registers, as displayed with the X command (described above), are the values of the register contents just before control is transferred to the Monitor.

The G command also allows the operator to set breakpoints in his program. When the program arrives at a breakpoint, control will be returned to the Monitor, allowing the user to examine the status of MDS memory, the 8080 CPU registers, etc.

Utility Routine

As an added convenience, the Monitor will perform addition and subtraction of any two four-digit hexadecimal numbers, displaying the results on the CONSOLE.

COMMAND DESCRIPTIONS

Intellec® MDS Monitor commands consist of a single alphabetic character specifying a command, followed by a list of numeric or alphabetic characters. Numeric parameters are entered as hexadecimal numbers. Leading zeros may be omitted. Single commas (,) or space characters may be used as delimiters between arguments in the parameter list. The

valid range of numerical values is from 0000 through FFFFH (0 through 65,535 decimal). Longer numbers may be entered, but only the last four hexadecimal digits are significant. Alphabetic parameters may be a single character or a string of characters; the specific requirement is described in the appropriate command description. The normal command terminator character is the carriage return. Command syntax is discussed in the individual command descriptions.

In the examples contained within the command descriptions, all characters typed by the user are underlined to distinguish them from characters generated by the Monitor. Commands may be terminated before execution by entering a Control/C before the command terminator is typed in.

Several Monitor commands require a pair of parameters which are referred to below as "<low address>,<high address>". These parameters define a section of MDS memory, which is to be used in the command. In all commands in which this address pair is used, the following applies:

> The command begins execution at <low address>, and continues until <high address> is exceeded. The data at <high address>, therefore, is included in the command's scope.
>
> Normally, <low address> will be less than or equal to <high address>. If, however, the value specified for <low address> exceeds that specified for <high address>, the command acts on the data at <low address>, then terminates.

The following paragraphs contain descriptions of the individual commands. A summary of this information is also included in Appendix A.

I/O System Configuration Commands - A, Q

I/O ASSIGNMENT - A

A<logical device>=<physical device>

The Monitor requires that at least four system peripheral devices be assigned as a minimum complement of peripheral equipment. These devices may be selected at run time from the group of peripherals (physical devices) which are available to the system. If no selection is made with the A command, default values are assigned by the system.

The system devices are defined as follows:

C or CONSOLE	An interactive, character-oriented input/output device.
R or READER	A character-oriented input device, such as a paper tape reader, which transfers data upon

command and signals the calling program when no more data is available (End-Or-File).

P or PUNCH — A character-oriented output device, such as a paper tape punch, which accepts a character from the calling program an records it on an external medium.

L or LIST — A character-oriented output device which accepts a character from the calling program and records it on some external medium in human readable form.

One of four peripheral devices may be selected for each system device. The physical device specified must be able to perform the functions which are defined for the system device. Thus, a line printer (LPT) cannot be specified as the CONSOLE; or a paper tape punch (PTP) cannot be specified as the READER. The standard device designations which are discussed below refer to system devices normally supplied with the Intellec MDS system. Drivers for these peripheral devices are included in the Monitor. It should be noted that the designation 'CRT' does not apply to all CRT devices, but only to those that are compatible with the MDS system. Similarly all of the device designations used herein apply to system compatible devices. Facilities are included for the user to write his own device-specific driver coding and link it to the Monitor. This allows a user to use his own console, paper tape punch/reader, and listing device which may appear as non-standard equipment to the Intellec MDS system. The standard devices are designated with the following symbols. Either the single letter abbreviation or three letter (or more) designation may be used:

T or TTY — Teletype console with keyboard, printer, paper tape reader, and paper tape punch.

C or CRT — Compatible CRT.

B or BATCH — BATCH mode is a non-interactive mode in which CONSOLE input is read from the assigned READER device and written to the assigned LIST device. In preparing a command file for BATCH input, the user should enter commands in exactly the same way as if the system were in interactive mode. Each command should end with a carriage return/line feed pair. The period (prompt) character which is generated by the Monitor in interactive mode should not appear as part of the command. Since the Monitor will continue to read from the READER until the CONSOLE is reassigned, the last command in the BATCH command file should reassign the CONSOLE to prevent the Monitor from reading off the end of the tape.

P or PTR	When used with the READER, this designation refers to the high speed paper tape reader.
P or PTP	When used with the PUNCH, this designation refers to the high speed paper tape punch
L or LPT	System line printer.

The following are valid device assignments. Only the first character need be entered; the additional characters in each device name are allowed for clarity.

CONSOLE Assignment

.AC=x or .ACONSOLE=x

Select one of the following for 'x':

T or TTY C or CRT B or BATCH	(Default as assigned during Cold Start sequence described in Section 2)
1	Specifies a user-defined device for which a user-written device driver is present.

READER Assignment

.AR=x or .AREADER=x

Select one of the following for 'x':

T or TTY P or PTR	(Default)
1	Specifies a user-defined device for which a user-written device driver is present.
2	Specifies a user-defined device for which a user-written device driver is present.

PUNCH Assignment

.AP=x or .APUNCH=x

Select one of the following for 'x':

T or TTY P or PTP	(Default)

1	Specifies a user-defined device for which a user-written device driver is present.
2	Specifies a user-defined device for which a user-written device driver is present.

LIST Assignment

.AL=x or .ALIST=x

Select one of the following for 'x':

T or TTY	(Default)
C or CRT	
L or LPT	
1	Specifies a user-defined device for which a user-written device driver is present.

SYSTEM STATUS QUERY - Q

Q

The Q command allows the operator to determine the current status of the assignable I/O system. The Q command produces a list of the logical devices and the physical devices currently assigned to them.

The Q command causes the following to be printed on the CONSOLE device.

```
.Q

C=T
R=P
P=T
L=T
```

Memory and Register Control Commands - D, F, M, S, X

DISPLAY MEMORY - D

D<low address>,<high address>

The contents of the memory area defined by the input parameters <low address> through <high address> are output as a formatted listing on the LIST device. Each line of the listing begins with the address of the

first memory location displayed on that line. Following the four hexadecimal digit memory address are up to 16 two-digit hexadecimal numbers, which represent the contents of contiguous memory locations.

For example, if we wish to display the contents of memory locations 09H through 2AH, the D command will appear as follows:

```
.D9,2A
```

The requested data will be output on the LIST device, formatted as follows: (data are typical)

```
0009 00 11 22 33 44 55 66
0010 77 88 99 AA BB CC DD EE FF 10 20 30 40 50 60 70
0020 80 90 A0 B0 C0 D0 E0 F0 01 02 03
```

FILL - F

F<low address>,<high address>,<constant>

The F command may be used to initialize an area of RAM to a constant value. The <low address> parameter specifies the low memory address of the range; the <high address> parameter specifies the high memory address of the range. The <constant> parameter specifies the 8-bit pattern to be stored in the designated memory. If an area in ROM or PROM is inadvertently specified within the range, the operation will continue until its normal completion even though no writing will take place in ROM/PROM.

For example, if the user wishes to write 'FF' in all memory from addresses 0020H through 0FFFH, the command will appear as follows:

```
.F20,FFF,FF
```

MOVE MEMORY - M

M<low address>,<high address>,<destination address>

The M command may be used to reposition blocks of data in memory. Memory data is fetched from one location, specified by parameter <low address>, and stored in location <destination address>. Parameters <low address> and <destination address> are then incremented and the process continues until the value of <low address> is greater than or equal to the value of <high address>.

For example, the following M command will move the contents of memory locations 100 through 2FF to locations 600 through 7FF:

```
.M100,2FF,600
```

SUBSTITUTE MEMORY - S

S<address>

The S command displays memory locations on an individual basis and allows the user the option of modifying each location as it is displayed. The procedure for using the S command is as follows:

1. Type in an S, followed by the hexadecimal address of the first memory location that is to be examined. Type in a space. The contents of the location will be displayed, followed by a dash.

2. You now have the facility to type in new data, followed with a space or carriage return; a space character only; or a carriage return character only.

   Typing in a space character signifies that you wish to retain the displayed data, in the specified address. The contents of the next memory location will then be displayed followed with a dash

   To modify the contents of the displayed location, type in a two-digit hexadecimal number. The contents of the specified location will be changed. If more than two characters are typed, only the last two will be used.

   To terminate the command, type in a carriage return. If the previous operation was entry of modification data, the Monitor will replace the contents of the specified location with the new data and terminate the command. If the previous operation was simply to display the specified location (space was typed in) the Monitor will terminate the command.

For example, a user wishes to examine the contents of locations 20 through 27 and each time the value 7C is found replace it with FF. The S command will appear as follows:

```
.S20 03- 1E- 41- 7C-FF D3- 46- E4- 39-
.D20,27
0020 03 1E 41 FF D3 46 E4 39
```

EXAMINE AND MODIFY CPU REGISTERS - X

X<register identifier>

The X command displays and permits modification of the CPU registers. The <register identifier> parameter selects the particular register to be displayed, or if omitted, select all CPU registers for display. The

<register identifier> parameter is a single alphabetic character defined as follows:

A	8080 CPU A Register
B	8080 CPU B Register
C	8080 CPU C Register
D	8080 CPU D Register
E	8080 CPU E Register
F	8080 CPU Flag byte. The values of the 8080's condition flags are packed into this byte, as follows:

```
7  6  5  4  3  2  1  0
|  |  |  |  |  |  |  |-------Carry
|  |  |  |  |  |  |----------Always 1
|  |  |  |  |  |-------------Parity
|  |  |  |  |----------------Always 0
|  |  |  |-------------------Auxiliary Carry
|  |  |----------------------Always 0
|  |-------------------------Zero
|----------------------------Sign
```

H	8080 CPU H Register
I	Intellec MDS Interrupt Mask
L	8080 CPU L Register
M	8080 CPU H and L Registers combined
P	8080 CPU Program Counter
S	8080 CPU Stack Pointer

The procedure for using the X command is as follows:

1. Type in an X, followed by either a <register identifier> or a carriage return.

2. If a carriage return is typed in, an alphabetical list of all registers and their contents is displayed on the CONSOLE. A typical list would appear as follows:

```
A=AA B=23 C=CC D=01 E=EE F=FF H=12 I=FB L=34 M=1234 P=0100 S=2F00
```

3. If a register identifier is typed in following the X, the contents of the register are displayed (two or four hexadecimal digits are displayed, depending on the selected register). A dash (-) character follows the last hexadecimal digit.

```
.XE EE-
```

4. The register may be modified at this time by typing in the new value, followed by either a space or a carriage return. If no register modification is required, just type in the space character or carriage return

character, without the register modification data.

5. If a space character is typed in, the next register, in alphabetic sequence, is displayed. The procedure in step 4 (above) may be repeated.

6. If a carriage return is typed in, the register in question is modified (if modification was performed in step 4), then the command is terminated.

For example, if the user wishes to see all of the registers, the following command should be used:

.X

This command will display all of the registers and terminate the command.

If the user wishes to modify Register A, he may type in:

.XA

The Monitor responds by printing the contents of Register A immediately following the command, as follows:

.XA 7F-

If the user wishes to modify the contents from 7F to 00, he may type in the hexadecimal value 00, as follows:

.XA 7F-00

Pressing the space key immediately following the modified data input causes the Monitor to display the next register, which in this case is the B Register. The B Register may similarly be modified. However, if instead of the space key, the carriage return key were pressed following the modified data entry, the command would be terminated.

Paper Tape I/O Commands - B, L, R, W, E, N

BNPF PUNCH - B

B<low address>,<high address>

The BNPF PUNCH command punches the contents of the memory range

specified by <low address> through <high address> in BNPF format on the PUNCH device. Output data is formatted into groups of four words, each group ending with a carriage return/line feed character combination, and the words within each group separated with spaces. A detailed description of BNPF format is included in Appendix D.

The following example will punch the contents of memory locations 100H through 1FFH:

```
.B100,1FF
```

LOAD BNPF TAPE - L

```
L<low address>,<high address>
```

The L command loads a BNPF tape in the Intellec MDS system from the READER device. Starting and ending locations of the loading process are specified by the parameters <low address> and <high address>. Additional BNPF words on the tape, in excess of the RAM memory range specified by <low address> and <high address> are disregarded. if an insufficient number of BNPF words are available to fill in the specified memory range, what is available will be loaded; the excess memory locations will remain unchanged. An error prompt (*) will be output.

An example of the L command is as follows:

```
.L100,1FF
```

READ HEXADECIMAL FILE - R

```
R<bias>
```

In the Intellec MDS system, object programs are normally saved on punched paper tape in hexadecimal format. This format is described in detail in Appendix D. The R command reads a hexadecimal tape from the READER device and loads the data into the locations specified by the address fields in the hexadecimal records.

The bias address is added to the load addresses in each of the hexadecimal records and the data is loaded into a memory area which is offset by the value of the bias address. For most applications the address is zero. The data which is loaded remains unchanged; the addition of the bias address does not imply that the program code is relocatable. In most cases, the code cannot be executed at the biased location.

A typical R command will appear as follows:

```
.R0
```

WRITE HEXADECIMAL FILE - W

W<low address>,<high address>

The W command outputs portions of Intellec MDS memory to punched paper tape, on the PUNCH device. Data is in hexadecimal format.

Multiple W commands may be used to save non-contiguous memory areas as one file. The final record in the file must be an End-of-File record, which is generated with the E command. Refer to the description of the E command for details.

An example of the Write Hexadecimal file operation is as follows:

.W200,3AF

This command punches out the contents of memory locations 200 through 3AF.

END FILE - E

E<entry point address>

The E command is used in conjunction with the W command during production of a hexadecimal output file, to generate the End-of-File record. The <entry point address> input parameter defines the entry point of the file for subsequent execution. If this is non-zero, the subsequent R command (which reads the hexadecimal tape) transfers the <entry point address> to the user's Program Counter. This allows the user to start execution of the program immediately after reading the tape with the R command, by entering the G command without giving further consideraton to a starting address. If the value of the <entry point address> is zero, the subsequent R command does not alter the user's program counter.

For example, assume a hexadecimal formatted tape is puched with the W command. An End-of-File record must also be punched to properly terminate the file. Also, the user wishes to start execution of the program represented by the punched paper tape at address 1000H. The E command would appear as follows:

.E1000

NULL LEADER/TRAILER - N

N

The N command produces a tape leader or trailer by outputting sixty NULL characters on the PUNCH device.

Universal PROM Programmer Commands - P, C, T

The Universal PROM Programmer allows the Intellec MDS user to program a wide variety of Intel PROMs. The UPP is available in two configurations: one configuration contains one 24-pin socket and one 16-pin socket, while the other contains two 24-pin sockets. The 16-pin socket, if present, must be in the "Socket 1" position on the UPP front panel. The 16-pin socket is used for programming PROMs having a word size of 4 bits; the 24-pin socket is used with PROMs having a word size of 8 bits.

The three commands which are used with the UPP each require two alphabetic parameters, in addition to numeric parameters. One of these is referred to below as <socket option>, which specifies whether the PROM being acted upon is in Socket 1 or Socket 2 and, if the PROM word size is 4 bits, with which half of an 8-bit MDS memory byte the PROM word corresponds. This parameter may take on the values X, Y, or Z, which have the following meanings:

X — Select Socket 2 on the UPP for this operation. Treat all data as 8-bit quantities.

Y — Select Socket 1 on the UPP. Correlate the 4 bits of data in each PROM word with the 4 most significant bits (bits 7-4) in each byte in MDS memory.

Z — Select Socket 1 on the UPP. Correlate the 4 bits of data in each PROM word with the 4 least significant bits (bits 3-Ø) in each byte in MDS memory.

The above discussion assumes that Socket 1 contains a 16-pin PROM. If Socket 1 contains a 24-pin PROM, the specification of <socket option> must be considered separately for the C, P, and T commands. This is dealt with below.

The other alphabetic parameter required by all three commands is the <true/false>, or <t/f>, parameter. This parameter establishes the "sense" of the PROM with respect to MDS RAM, as follows:

If <t/f> = T, the Monitor assumes that the data in PROM appears in the same sense as it does in MDS RAM; i.e, a "1" bit in PROM corresponds to a "1" bit in RAM, and a "Ø" bit in PROM corresponds to a "Ø" bit in RAM.

If <t/f> = F, the Monitor assumes that the data in PROM is the complement of the corresponding data in MDS RAM; i.e., a "1" bit in PROM corresponds to a "Ø" bit in RAM, and vice versa.

Each command below requires the UPP to be connected to the Intellec MDS, with power on, at the time the command is entered. If the UPP is not in a READY state, the Monitor will immediately issue an error indicator (*) as the command is entered.

PROM PROGRAMMING - P

P<t/f><socket option><low address>,<high address>,<PROM address>

The P command programs the PROM in the socket specified by <socket option> with data taken from MDS memory locations <low address> through <high address>. Data from <low address> is transferred to the PROM at <PROM address>, where each PROM is assumed to have a starting address of Ø. If <t/f> = F, the data from MDS memory is complemented as it is transferred to the UPP. The data in MDS memory always remains unchanged.

The Monitor always transfers 8 bits of data to the UPP for each location being programmed. If the <socket option> parameter is Y or Z, and Socket 1 contains a 16-pin PROM, the UPP uses the information provided by the Y or Z to determine which four bits to use in the programming operation. If Socket 1 contains a 24-pin PROM, the UPP will use all eight bits of data in the programming operation. Thus, to program a 24-pin PROM installed in Socket 1 of the UPP, the operator may specify a <socket option> of either Y or Z. If the 24-pin PROM is installed in Socket 2, he should use a <socket option> of X.

The UPP reads back and compares each location it programs in PROM with the original data it received from the MDS. If the two values differ, it transmits an error indicator to the Monitor, which displays the current <PROM address> value followed by an error indicator (*), then terminates the programming operation.

NOTE: The P command in the MDS Monitor cannot be used to program the 2704, 2708, 8704, or 8708 PROMs. Intel distributes a special MDS program for this purpose.

COMPARE - C

C<t/f><socket option><low address>,<high address>

The C command compares the contents of a PROM located on the UPP, in the socket specified by the <socket option> input parameter, with the contents of memory in the area specified by the input parameters <low address> through <high address>. If the contents of a PROM location are not equal to the contents of the corresponding memory location, the memory address, the contents of the memory location, and the contents of the PROM are printed on the CONSOLE for inspection.

The Monitor always reads 8 bits of data from the UPP. If the Y or Z socket option is specified, the monitor masks off the appropriate 4 bits from the contents of the selected memory location so that either the low or high four bits remain to be compared with the 4 bits of the PROM location. Assume that the Z socket option is specified. A typical byte from the UPP may appear as follows:

Ø7

The Monitor retrieves the corresponding byte from memory (let us say, F7) and masks off the most significant 4 bits to produce a byte with a value of 07. The comparison is then made. Similarly, if the Y socket option is selected, the byte from the UPP would be 'F0' and the corresponding byte from memory would be masked to produce 'F0', then the comparison made. Therefore, to compare a 24-pin PROM installed in Socket 1 of the UPP with the contents of MDS memory, the operator should do two C commands: once using a <socket option> of Y, and once using a <socket option> of Z.

For example, the contents of an 8-bit by 256 word PROM is specified as true logic, and is to be compared with the contents of memory from locations 0A00H through 0AFFH. The C command is as follows:

```
.CTXA00,AFF
```

Assume that the contents of memory locations 0A06 and 0A91 are not equal to the contents of the corresponding PROM locations. The Monitor will print the following message:

```
0A06 AA FF              (Typical data)
0A91 00 01
```

TRANSFER PROM - T

```
T<t/f><socket option><low address>,<high address>
```

The T command transfers the contents of the PROM in the socket specified by <socket option> to the area of MDS RAM specified by the <low address>,<high address> pair. If the range of memory locations is smaller than the contents of the PROM, the excess data in the PROM is disregarded. If the range is greater than the size of the PROM, the PROM data will be transferred; the excess memory locations will remain unchanged; an error prompt (*) will be printed by the Monitor. If <t/f> = F, the data coming from the UPP is complemented before being stored in MDS RAM.

The Monitor always receives 8 bits of data from the UPP, and stores the entire 8 bits in the next consecutive RAM location. Therefore, a <socket option> of either Y or Z may be used to transfer data from a 24-pin PROM located in Socket 1 of the UPP.

For example, a user wishes to transfer an 8-bit by 256 byte PROM to memory locations 100 through 1FF. The status of the data is false logic. A typical T command appears as follows:

```
.TFX100,1FF
```

PROGRAM EXECUTE - G

G<start address>,<breakpoint 1>,<breakpoint 2>

The G command transfers control of the Intellec MDS from the Monitor program to the user program starting at the location specified by the <start address> parameter.

The <start address> parameter is a four-digit value which specifies the address to be placed into the user's Program Counter. If this parameter is omitted, the stored value of the user Program Counter is used as the starting address. It is possible to have a previously stored value in the user Program Counter due to four operations:

1 When the user program is interrupted with the Interrupt Ø switch on the MDS front panel, the status of the user registers, including the user Program Counter, are saved. This value of the user program counter allows a user program to be resumed at the instruction immediately following the interrupt.

2 When a non-zero <entry point address> is included in the End-of-File record in a hexadecimal object file.

3 If the user has manually modified the user program counter with a Monitor X command.

4 When the user program reaches a breakpoint set by a previous G command.

The <breakpoint 1> and <breakpoint 2> parameters are two 16-bit values that specify breakpoint addresses in the user program. If either is omitted, no corresponding breakpoint is set. If either breakpoint address is encountered while executing the user program, both breakpoints are reset and control is passed back to the Monitor.

A breakpoint enables the user to temporarily suspend execution of the user program, examine the state of the program's memory and registers, make modifications if desired, and then continue the program from the point of suspension. When the address where the breakpoint is inserted in the user program is reached, the user program is terminated, all pertinent user data is saved, and control is returned to the Monitor program. Immediately following a breakpoint, the value of the user Program Counter points to the memory location in which the previous breakpoint instruction was held. The user program may thus be reentered at a point just beyond the halt.

The Monitor implements breakpoints by saving the contents of the RAM locations specified as the breakpoint addresses, then substituting RST Ø instructions at these addresses. When the RST Ø instruction is encountered during execution, the Intellec MDS hardware branches to address Ø, which contains a branch to the Monitor. When the Monitor is

entered through this entry point, all status of the 8080 CPU is saved and the original contents of the breakpoint addresses are restored.

The MDS interrupt system is enabled when the Monitor is entered. Since the Monitor cannot determine the previous state of the interrupt system, just prior to the exit from the user program, the assumption is made that the interrupt system was enabled. When control is returned to the user program, the interrupt system remains enabled. It is the user's responsibility to either enable or disable the interrupt system (EI and DI instructions).

An interrupt from a user program may be performed by pressing the front panel INTERRUPT 0 switch. The suspension of the user program is similar to that performed by a breakpoint interrupt. All user program status, including the Program Counter, is saved. When the user program is resumed, the saved value of the program counter may be used to restart the program at the instruction immediately following the interrupted instruction.

To use the G command, proceed as follows:

1. Type a G. If a starting address other than the current (stored) value of the Program Counter is desired, enter it immediately following the G.

2. If no breakpoints are desired, terminate the command with a carriage return.

3. To set breakpoints, enter a comma or space. The Monitor will type a dash (-) to indicate that it is ready to receive a breakpoint. Enter the desired breakpoint address.

4. To set only one breakpoint, enter a carriage return. To set another breakpoint, return to step 3. At most two breakpoints may be entered. If the character following the second breakpoint is not a carriage return, the Monitor will issue an error indicator (*) and abort the command.

For example, a user program starts at location 20 and a breakpoint is to be inserted at location 2FEH. To start executing the program, a user will enter the following command:

```
.G20,-2FE
```

However, if the program was loaded from a hexadecimal tape, with the R command, and an entry point address was specified in the End-of-File record on the tape, the starting address need not be included in the G command. In this case, the user may enter the command as follows:

```
.G,-2FE
```

The delimiter (,) immediately following the letter G indicates that the

entry point is assumed to be at the location specified by the present contents of the user program counter. If desired, breakpoints may be inserted following the delimiter, in the normal manner.

If the user wishes to start executing a program at location 1FA but does not wish to use breakpoints, the command will be as follows:

```
.G1FA
```

If a user wishes to re-enter a program after a breakpoint suspension or a front panel INTERRUPT 0, and new breakpoints are to be specified at locations FF and 1AB, the command will be as follows:

```
.G,-FF,-1AB
```

If no breakpoints are to be specified, and the user wishes to reenter a program after a breakpoint or interrupt, the command will simply be:

```
.G
```

If the G command is aborted while it is being entered (e.g., by a Control/C) or if it contains a syntax error, no breakpoints will be set.

HEXADECIMAL ARITHMETIC - H

```
H<number 1>,<number 2>
```

For the convenience of the user, the Monitor has the capability of performing simple hexadecimal calculations. The sum (number 1 + number 2) and difference (number 1 - number 2) of the two numeric parameters entered are calculated and displayed on the CONSOLE. Arithmetic is performed modulo 65,536 (2**16). The input parameters may be up to four digits in length. Negative numbers must be entered in their two's complement representation: for example, -2 would be entered as FFFE. Negative results will be displayed in two's complement form.

For example, a typical hexadecimal arithmetic operation may be performed as follows:

```
.H200,1FE
03FE 0002
```

MONITOR ERROR CONDITIONS

The Monitor checks for several error conditions. Depending on the particular error, either an error indication is output on the CONSOLE, or the command is rejected. The Monitor's response to error conditions is as follows:

INVALID CHARACTERS. The Monitor checks the validity of each character as it is entered from the CONSOLE. As soon as the Monitor determines that the last character entered is illegal in its context, it aborts the command and displays a '*' to indicate the error.

For example, suppose a character 'G' is entered in a parameter list where only hexadecimal digits (0-9, A-F) and delimiters (comma, space, carriage return) are valid, the output on the console will be as follows:

```
.H100,10G*
```

Suppose the character 'Y' is used as a command. The Monitor will reject this character and indicate the error as follows:

```
.Y*
```

ADDRESS VALUE ERRORS. Many commands require an address pair of the form, <low address>,<high address>. If, in these commands, the value of <low address> is greater than the value of <high address>, the action indicated by the command will be performed on the data at <low address> only.

Addresses are evaluated modulo 65,536. Thus, if a hexadecimal address of more than FFFFH (four digits) is entered, only the last four digits are significant. For example suppose the following address range were entered:

```
.M04532AC,945216FCF,0
```

The above command would be equivalent to M32AC,6FCF,0.

Another type of address error may occur when the user specifies an address in memory which does not exist in the Intellec MDS system. For example, a user with a 16K system may enter an address above the highest memory address, as follows:

```
.M0,FFF,4000
```

or

```
.D6000,60FF
```

No error indication is generated by the Monitor for these error addresses. In general, if the source address (address from which data is taken) is nonexistent, the data fetched is unpredictable. If the destination address (address to which the data is to be transmitted) is nonexistent, the command has no effect.

CHECKSUM ERRORS. If the Monitor determines that a data record read in an 'R' command contains a checksum error, all of the data from that record is destroyed and an error indication of an '*' is output on the CONSOLE.

If no checksum error exists, the Monitor reads the next record on the tape.

PROM PROGRAMMING ERRORS. If an error is signalled from the UPP, during a 'P' command, the command is terminated and a '*' message is output on the CONSOLE. If the UPP is not connected to the MDS when a P, T, or C command is input, an error condition is immediately indicated with the '*' message on the CONSOLE.

PERIPHERAL DEVICE ERRORS. Non-existent peripheral devices or devices which are not ready cause a condition where the Monitor outputs the data then waits indefinitely for the device to become ready. No other indication is provided.

SECTION 4

MDS TEXT EDITOR

INTRODUCTION

The Intellec® MDS Text Editor enables the user to create and edit ASCII text files. The Text Editor may be used to edit any ASCII text; in this system it is used primarily to create and edit source programs for the 8080 MDS Macro Assembler.

The Text Editor is character oriented. That is, one or more characters in a line of text can be replaced or deleted, or new characters inserted without disturbing any of the other characters in the same line. Line numbers or other extraneous information need not be appended to the text in order for the Text Editor to operate correctly. All editing can be accomplished by using the commands which are described in the following paragraphs.

GENERAL INFORMATION

The Intellec® MDS Text Editor occupies approximately 4K bytes of RAM memory. All of the remaining RAM memory is available for use as the Text Editor's working area, which is referred to as the Text Buffer.

The normal editing procedure to create a new file is to start the editor, type in the text, edit the text (to incorporate additions and corrections), and output the text file. Similarly, to edit an already existing file, one would start the editor, input the text file, edit the text, and output the edited version. If the file is already prepared and is being stored on punched paper tape, it may be entered through the system READER device. If a new file is to be created, it may be entered by typing the text on the system CONSOLE device.

Text Buffer and Buffer Pointer

The text buffer is maintained by the Text Editor as the storage area into which text strings are placed. The size of the Text Buffer is

variable, enlarging as text is entered, and shrinking as text is deleted. When the buffer is empty, the start of buffer and the end of buffer coincide and the buffer size is zero.

Since the MDS Text Editor is character oriented, the Buffer Pointer is needed to locate the character which is to be acted upon. The Buffer Pointer is simply a movable position indicator which is positioned either between two adjacent characters, before the first character in the buffer (start of buffer), or immediately following the last character in the buffer (end of buffer). The Buffer Pointer is never positioned directly over a particular character, but may point before it or after it. Text is placed into the buffer at a point immediately following the buffer pointer. As each character is entered, the buffer pointer is moved ahead one character position.

The user has the facility, through certain of the Text Editor commands, to move the buffer pointer to any position inside the buffer. The buffer pointer cannot be moved beyond the boundaries of the text buffer; it cannot be moved further back than the start of buffer position, nor further forward than the end of buffer position. Any command attempting to move the buffer pointer beyond the boundaries of the Text Buffer is terminated when the Buffer Pointer reaches the boundary, even though the number of operations specified has not been completed.

Buffer Pointer movement may be either in terms of characters or lines. The consideration of text in terms of lines is convenient because most text is divided into lines. A line of text, in the Text Buffer, is a string of characters having a line feed (ØAH) character as its last character. The next character in the Text Buffer, immediately following the line feed, is in the next line. If no line feed characters are used in the text, the entire text is considered to be one line.

Commands and Command Strings

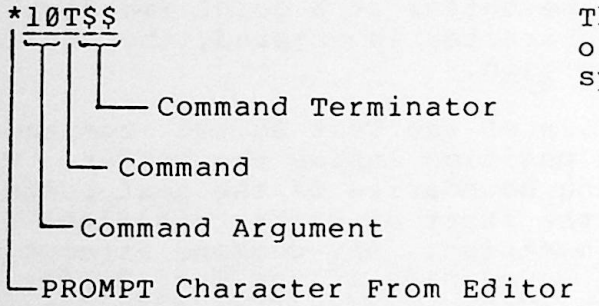
Each editor command consists of a single letter command designator. Certain of the commands take arguments. Commands may be entered one at a time or may be combined into command strings. The Text Editor signals its readiness to accept commands by printing a prompting asterisk (*) in the left-most column of the system CONSOLE device. Command strings must be terminated with a pair of ALT MODE or ESC characters (depending on the type of the console device). Except where otherwise noted below, individual commands in a command string need not be terminated. If a text string is included in a command string, the text string must be terminated with a single ALT MODE or ESC character.

Command strings are stored in the same memory area that is reserved for the text buffer. In order not to interfere with the text, command strings are stored at the high end of the memory, above the 'end of buffer'. Command strings are stored in reverse order, with the first character of the command in the highest available location, and the remainder of the characters in the command in descending locations. When the reserved area is full, the command part may attempt to overwrite text. This condition is trapped. The procedures to escape

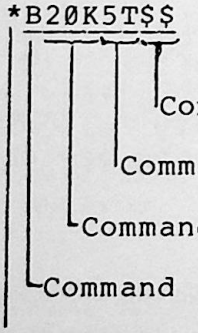
this condition are discussed in the following paragraphs.

Examples of Commands

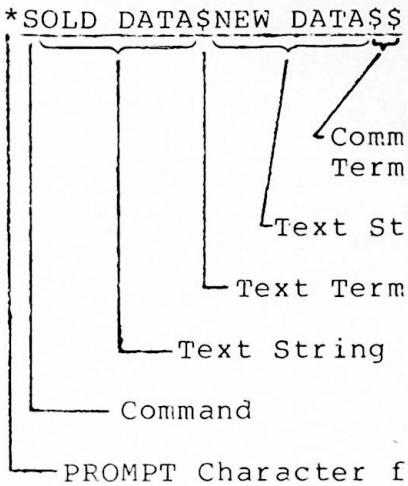
The following examples show a typical command, command string, and command string combined with a text string. In all examples in this section, characters typed by the operator are underlined; those typed by the Monitor or Text Editor are not.



This command causes ten lines of text to be printed on the system CONSOLE device.



This command string causes the Buffer Pointer to be moved to the start of the buffer, 20 lines of text to be deleted, and the following five lines to be output on the system console device. The command terminator is placed at the end of the command string; the individual commands do not need separate terminators.



This command string causes a search for the text string 'OLD DATA' in the text buffer. When found, it is deleted and the text string 'NEW DATA' is used as a replacement. The single $ character represents the text terminator for 'OLD DATA'; the pair $$ represents the text terminator for 'NEW DATA' in addition to being the command terminator.

OPERATING FEATURES

User input to the Editor may be either a command, a command string, or a text string. The Editor signals the user that it is ready to accept a new command by printing an asterisk (*) in the left-hand column of the system CONSOLE device. The user may specify text input by issuing the INSERT command. User input immediately following this command is accepted by the Editor as text. As long as the editor is accepting input characters as text, the PROMPT character (*) is not issued. A command or command string is executed immediately following a command terminator, which consists of two ALT MODE or ESC characters typed in consecutively. The Editor echoes these terminator characters as dollar signs ($$).

Aborting Commands

A command string may be aborted while it is being entered, before the command terminator is issued. If it is necessary to delete an entire command string, without any consideration to its contents, entering a Control/C will remove the entire command string and cause the Text Editor to reprompt for a new command.

Also, after the command terminator is entered, and the commands are being executed, the operation may be aborted by entering a Control/C. The Text Editor will terminate its operation and reprompt for a new command.

Deleting Typographic Errors

Any typographic errors in a command string or text string may be removed by pressing the RUBOUT key once for each character to be removed. As each character, starting from the last one entered, is deleted, the Editor echoes the deleted character. Corrections of this nature can

only be performed prior to entering the command string terminator.

Use of TAB Characters

The Editor accepts the horizontal TAB character (Ø9H), which is generated by a Control/I on the keyboard. This character is stored in the text buffer as a single character. The Intellec MDS system accepts this character to generate a sufficient number of spaces to position the curser to the next tab position. Tab stops are located every eight character positions across a line of text.

Carriage Return and Line Feed Characters

Carriage return and line feed characters are saved in the text buffer the same as any other ASCII character. However, because these two characters are commonly used to format text listings, they are given special significance, in the following respects:

During an INSERT command (to be described later) entering a carriage return on the system console causes a line feed character to be generated by the Editor and appended to the carriage return character. Thus, the entry of a single carriage return character causes a pair of characters to be stored in the text buffer.

During an APPEND command (to be described later), entering a carriage return character via punched paper tape, causes only the carriage return to be placed in the text buffer. Text may be prepared off-line, using both the carriage return and line feed characters to format the off line listing. The punched paper tape, containing both the carriage return and line feed characters, may then be input to the Editor, without causing additional line feed characters to be generated. The carriage return and line feed characters are accepted and stored as single characters.

LOADING THE TEXT EDITOR

The Text Editor program is supplied on punched paper tape and is loaded into the system using the loading facilities of the MDS Monitor. Because the Editor uses the I/O facilities of the Monitor, all peripheral devices must be defined before starting execution of the Editor.

The following start-up procedures can be used to load and start the Intellec MDS Text Editor:

- If it is not already operating, start the system Monitor and assign the CONSOLE and READER devices to the

peripherals to be used during the loading of the Editor program.

- Place the tape containing the Text Editor into the peripheral assigned as the system READER.

- Type in the READ HEXADECIMAL FILE command (R) on the system CONSOLE.

  .R0

  The paper tape will be read by the reader until an end-of-file record is read. The MONITOR will prompt for a new command by printing a period (.) in the left-most column of the CONSOLE device. If required, new device assignments may be made at this time to assign the system PUNCH and LIST devices, or to change the system CONSOLE or READER devices.

- To start executing the Editor, type in the following command:

  .G20

  The Text Editor will assume control and print the following message:

  ```
  INTELLEC MDS TEXT EDITOR, - VERSION x.x
  *
  ```

  The Text Editor is now ready to accept commands on the system CONSOLE device.

EDITOR COMMANDS

Editor commands are provided to perform four groups of operations, including: Text Input/Output, Buffer Pointer manipulation, Text modification, and String Searches. In the following discussion, the order in which the commands are discussed allows the user to initially operate the Editor with a minimum of commands. Then, as more commands are learned, the user can perform more complex editing operations.

Commands B, Z, I, T

B - BEGINNING OF TEXT BUFFER

The B command is a pointer manipulation command used to move the buffer pointer to the beginning of the text buffer to the position defined as 'Start of Buffer'. This command is useful in several respects, for example:

- Setting a reference point for counting lines of text;
- Defining a starting point when the whole text buffer contents are to be typed out;
- Moving the Buffer Pointer to the start of buffer prior to starting a search for a selected text string;
- Inserting text at the beginning of the text buffer, before text already in the buffer.

Z - END OF WORKSPACE

The Z command is a pointer manipulation command used to move the buffer pointer to the end of buffer position, immediately following the last character in the buffer. This command is used mainly to position the pointer so that new text will be inserted at the end of old text and be appended to it.

I - INSERT TEXT

The I command is a text input command used to enter text into the text buffer from the system CONSOLE device. Placement of the new text in the text buffer is dependent on the position of the Buffer Pointer.

If the buffer is empty, the buffer pointer will be positioned at the start of buffer. Thus, any text input with the I command would be placed into the buffer starting at the beginning. If the buffer already contains text and the buffer pointer is at some intermediate position in the text, the new text will be inserted immediately following the buffer pointer position, splitting the old text. If the text buffer already contains text and the buffer pointer is at the end of buffer, the new text will be inserted at the position immediately following the old text. After insertion, the pointer will be positioned after the last character in the new text.

Entering a carriage return character causes a line feed character to be generated by the Editor and appended to the carriage return character. Thus, the entry of a carriage return character causes a pair of characters to be stored in the text buffer. Note that this only occurs during the I command.

After recognizing the letter 'I' as a command, the Editor accepts all subsequent input as text (including the carriage return and appended line feed characters) until an ALT MODE, ESC, or Control/C is input. The ALT MODE or ESC character specifies the termination of the text string; the Control/C character aborts the command.

T - TYPE OUT TEXT

The T command is an output command, used to type out lines of text.

This command uses an argument which is placed in front of the command as follows:

*nnnT$$	nnn represents any decimal number from -65,535 to +65,534.

If the argument is positive, typing starts at the current location of the buffer pointer; the argument value specifies the number of lines to be typed. If the argument is negative, typing begins at the location defined by the current location of the buffer pointer minus the number of lines specified by the argument value. Typing continues until the location of the buffer pointer is reached. If the argument value is zero, typing starts at the beginning of the current line. All characters up to the buffer pointer are typed. If no value is specified, the Editor assumes a default value of 1.

If the argument value is greater than the number of lines of text between the buffer pointer and the appropriate buffer boundary, all the specified text in the buffer will be typed. However, the command will be terminated automatically when the buffer boundary is reached.

Examples Of Editing Using B, Z, I, and T Commands

Suppose a user has entered data into the text buffer using the I command, and now wishes to type out the entire buffer. The following command string may be used:

*B500T$$	The B command moves the buffer pointer to the beginning of the text buffer. The 500T command types out 500 lines of text. The argument 500 is assumed to be larger than the number of lines of text present in the buffer. This being the case, the T command is terminated when the end of buffer is reached, even though the full count is not reached.

Suppose the user is entering a source program, using the I command, and has already entered a large number of text lines. For some reason the I command is terminated and the buffer pointer is moved to some other location in the buffer. When the user wishes to resume entering the source file, the buffer pointer is simply moved to the end of buffer and the I command is initiated. A typical command string will be as follows:

*ZITEXT STRING----------$$	The new text will be inserted following the old text.

If the user is entering text and wishes to see the previous five lines entered, without moving the buffer pointer, the following command may be used:

*-5T$$	The five lines before the current line (the one in which the buffer pointer is located) are printed on the system CONSOLE device. The current line is not printed.

The following command may be used to print the current line of text:

*ØTT$$	The 'ØT' part of the command prints from the beginning of the line up to the buffer pointer. The following 'T' command prints from the buffer pointer to the end of the line.

Commands L, K

L - LINE

The L command is a line-oriented pointer manipulation command. This command uses an argument which is placed in front of the command as follows:

*nnnL$$	nnn represents any decimal number from -65,535 to +65,534.

The pointer cannot be moved outside the boundaries of the text buffer. If the user issues an L command to move the buffer pointer forward beyond the end of buffer, or backward beyond the start of buffer, the buffer pointer will be moved to the respective buffer boundary; the L command will then be terminated.

The line feed character (ØAH) serves as the delimiter between lines. A line of text is defined as having a line feed character as its last character.

When the argument value is 1 or no argument used (default value of 1 assumed), the buffer pointer is advanced to the start of the next line. A positive argument value advances the buffer pointer to the beginning of the nth line following the current line (n = positive argument value). A negative argument value moves the buffer pointer back to the beginning of the nth line preceding the current line (n = negative argument value). When the argument value is -1 or just -, the buffer pointer is moved back to the beginning of the line preceding the current line. Finally, if the argument is Ø, the buffer pointer is moved back to the beginning of the current line.

K - KILL

The K command is a line-oriented deletion command used to delete lines of text. This command uses an argument which is placed in front of the command as follows:

*nnnK$$	nnn represents any decimal number from -65,535 to +65,534.

The numeric argument used with this command specifies a number and sign. The number represents the number of lines to be deleted; the sign indicates the direction. A negative argument deletes lines prior to the line containing the buffer pointer. A positive argument deletes lines following the line containing the buffer pointer. If the argument is zero, the characters from the start of the current line up to the buffer pointer are deleted. If the argument is 1, the characters from the buffer pointer, up to and including the line feed character which is used to terminate the line, are deleted. When no argument is included, a default value of 1 is implied.

If the argument value is greater than the number of lines of text between the buffer pointer and the text buffer boundary, the lines between the buffer pointer and boundary are deleted. The command is terminated when the buffer pointer reaches the boundary.

Examples of Editing Using the B, Z, I, T, L, and K Commands

A user wishes to move the pointer back 5 lines of text and have the line where the pointer is positioned typed out. The following command string may be used:

*-5LT$$	The buffer pointer is moved back to the start of the fifth line before the current line. This new line becomes the current line. The T command causes the line to be typed out.

If the pointer is at some intermediate position in a line and the user wishes to return the pointer to the start of the line, the following command may be used:

*ØL$$	ØL causes the buffer pointer to move to the start of the current line.

The following text is present in the text buffer:

```
THIS IS LINE 1
THIS IS LINE 2
THIS IS LINE 3
THIS IS LINE 4
THIS IS LINE 5
THIS IS LINE 6
THIS IS LINE 7
THIS IS LINE 8
THIS IS LINE 9
THIS IS LINE 10
```

Assume that the buffer pointer is in line 6, positioned between the I

and the S in the word IS. Each of the commands in the following examples will produce the specified type out:

```
*ØT$$

THIS I*
```

Types out from the start of the current line (line 6) up to the buffer pointer.

```
*T$$

S LINE 6
*
```

Types from the buffer pointer to the end of line.

```
*ØTT$$

THIS IS LINE 6
*
```

Types the whole line without moving the buffer pointer.

```
*-5T$$

THIS IS LINE 1
THIS IS LINE 2
THIS IS LINE 3
THIS IS LINE 4
THIS IS LINE 5
THIS I*
```

Types 5 lines preceeding the current pointer line. Types the current line from its start to the pointer position.

```
*5T$$

S LINE 6
THIS IS LINE 7
THIS IS LINE 8
THIS IS LINE 9
THIS IS LINE 1Ø
*
```

Types five lines including part of current line from position of buffer pointer. In this case, the five lines were typed. However, if the command were ´6T´, the sixth line would not be typed because the sixth line after line 6 does not exist inside the text buffer boundaries. The five lines would be printed as in the example to the left; then the command would be terminated.

```
*-5T5T$$

THIS IS LINE 1
THIS IS LINE 2
THIS IS LINE 3
THIS IS LINE 4
THIS IS LINE 5
THIS IS LINE 6
THIS IS LINE 7
THIS IS LINE 8
```

Types all ten lines of the buffer. Includes the five lines preceeding the buffer pointer, the line containing the buffer pointer (from the beginning of the line up to the pointer), the remainder of the current line (from the pointer to the end), and the four remaining lines.

```
THIS IS LINE 9
THIS IS LINE 10
*
```

The buffer pointer is located in line 6, between the characters I and S in the word IS. The user wishes to delete lines 3,4,5,and 6.

```
THIS IS LINE 1
THIS IS LINE 2
THIS IS LINE 3
THIS IS LINE 4
THIS IS LINE 5
THIS IS LINE 6
THIS IS LINE 7
THIS IS LINE 8
THIS IS LINE 9
THIS IS LINE 10
```

Before this operation can be started, the buffer pointer should be positioned either before or after the lines which are to be deleted. First, let us move the pointer in front of the lines and use a positive argument K command. Because the pointer is in line 6, it must be moved in front of line 3, then the four lines 3,4,5,and 6 can be deleted. The command is as follows:

*-3L4K$$	The -3L moves the pointer to the start of line 3. The 4K deletes the next four lines.

The pointer may be moved to the line following the lines to be removed and a negative argument K command used, as follows:

*L-4K$$	The L moves the pointer to the start of line 7. The -4K deletes lines 6,5,4,and 3.

Commands E, W, N

The E (End), W (Write), and N (Null) commands generate output on the system PUNCH device, as described below. The operation of each of these commands differs slightly, depending on which device is assigned as the system PUNCH device. If the Teletype is assigned as the system PUNCH device when an E, W, or N command is executed, the Editor recognizes this and starts the punch operation with the message:

```
START PUNCH, TYPE CHAR
```

The Editor is requesting the user to turn on the Teletype punch, then type in any character on the keyboard, to resume Editor operation.

Punching starts and continues until the specified number of lines are

punched out. The operation then stops, allowing the operator to turn the punch off. To return the Editor to a prompt mode, type in any character; the Editor will reply by prompting with an asterisk.

If the high speed punch is assigned as the PUNCH device and the Teletype or CRT is assigned as the CONSOLE device, paper tape punching is initiated immediately, without any requests for operator intervention.

E - EXIT

The E command is used to punch out the entire contents of the text buffer at the completion of a work session. Output is on the system PUNCH device. The text buffer is cleared after punching; the Editor program is effectively restarted and will accept new text immediately following the E command execution.

No leader is generated by the E command. However, 60 NULL characters are generated at the end of the tape to act as trailer. If leader is needed, the N command (described below) can be used.

After the buffer contents are punched on tape, the text buffer is cleared, and the remaining input (on the READER device) is read in and copied directly to the PUNCH device. The Editor then punches an End-of-File mark (Control/Z) into the tape. If this tape is subsequently input by an A command (to be described later), this character will be recognized by the Editor as the end of the tape. The editor is reinitialized, and the following message is printed:

INTELLEC MDS TEXT EDITOR, - VERSION x.x

If the text buffer is empty, the E command may be used to copy punched paper tape. The procedure to perform tape copying operations is as follows:

- While operating the Monitor, assign the READER and PUNCH devices required to perform the tape copying operation.
- Start the Text Editor as described in this section.
- Place the tape to be copied into the READER.
- Make sure that both the READER and PUNCH are turned on, then type in the following command:

  *E$$

W - WRITE

The W command is an output command used to punch out a specified number of lines from the text buffer onto the system PUNCH device. The text is always taken from the beginning of the text buffer, regardless of the current position of the buffer pointer. As text is punched, the line

punched is deleted from the text buffer, and the remaining text is compacted up to the start of text. This command uses an argument which is placed in front of the command as follows:

*nnnW$$	nnn represents any decimal number from -65,535 to +65,534. Both positive and negative arguments are treated as positive values. An argument value of zero causes no punching to occur.

N - PUNCH 60 NULL CHARACTERS

The N command is an output command used to punch leader and trailer into punched paper tape. Each ´N´ entered into the command punches 60 NULL characters.

Examples Of Editing Using The E, W, And N Commands

Assume a text buffer with 100 lines of text. The first 25 lines are satisfactory and require no further editing. The user selects to output these lines of text to punched paper tape before continuing with the editing. The command will appear as follows:

*25W$$

The first 25 lines in the text buffer are punched on the system PUNCH device. The pointer is moved to the start of buffer; line 26 becomes line 1 and all of the subsequent lines of text are moved up a corresponding amount.

If the user requires leader or trailer on the punched paper tape, it should be produced with the ´N´ command or the manual facilities of the PUNCH device. No leader or trailer is generated with the ´W´ command.

If a text file is being inserted and, for some reason, the user finds it necessary to terminate the editing session before the file is complete, the integrity of the text file can be maintained by punching out the contents of the text buffer and reloading it when editing is resumed. The ´E´ command and ´N´ command can be used, as follows:

*NNE$$	Punches out 120 NULL characters, then punches the contents of the whole text buffer.

This procedure is handy when the user has to stop an editing job temporarily and wishes to save the current contents of the text buffer for subsequent continuation of the job.

A condition may occur where the text buffer part of reserved memory is

almost full and the command string is attempting to overwrite the last character in the text string. This condition is trapped and the last character of the command string is rejected. When this condition occurs, the only character that will be accepted is the RUBOUT.

The user must type in a sufficient number of RUBOUT characters so that enough buffer is made available to input a command terminator. At this point, the user must clear out part of the text buffer so that the remainder of the input text, or part of it, may be input to the text buffer. The most expedient manner to empty the text buffer while maintaining the integrity of the text is to punch out the text that is already edited. The 'W' command is best suited to this task. Suppose that the first 500 lines of text are edited and can be output. The following command string will output 500 lines of text:

*NN500WNN$$	This command string will punch 120 NULL characters, punch out 500 lines of text, relocate the remaining text to the front of the text buffer, and then punch 120 NULL characters as trailer.

Command A

A - APPEND

The A command is used to enter text into the text buffer from the system READER device. The input text is appended to the text already in the buffer, with the new text being stored at the end of the buffer. Once initiated, the A command continues reading text until one of the following conditions is satisfied:

- The end of tape is reached.
- An End-of-File character is read (Control/Z). The Control/Z is not placed into the text buffer.
- The workspace is full.
- A Form Feed character is read (Control/L). The Form Feed is placed into the text buffer.
- 50 lines of text are read.

If needed to enter a large text file, the A command may be repeated as many times as needed to enter the entire file. Each A command is terminated when one of the above conditions is satisfied. If the READER is turned off during an A command, the system recognizes this as an End Of Tape and terminates the command.

Examples Of Editing Using The A Command

Suppose that, in the last example, the tape was to be reentered and the editing job continued. Also, suppose that 150 lines of text are saved (punched). The following procedure will reenter the saved text into the text buffer:

- Start the Editor
- Place the tape into the tape READER.
- Type in the following command,

  *AAA$$

The tape READER will start and 150 lines of text will be read. The text may now be edited, or new text appended.

Commands C, D

C - CHARACTER

The C command is a pointer manipulation command used to move the pointer a specified number of character positions. An argument is used with this command and is placed in front of the command as follows:

*nnnC$$	nnn represents any decimal number from -65,535 to +65,534.

The pointer cannot be moved beyond the boundaries of the text buffer. Thus, if the buffer contains 5,000 characters, the command "7000C" will move the buffer pointer 5,000 characters, until the buffer pointer reaches the boundary, then the command will be terminated. Similarly, a command to move the buffer pointer in a negative direction, past the start of buffer, will be terminated once the start of buffer boundary is reached.

Normally, the C command is not the best way to move the pointer over large distances. This command is best utilized when pointer movement, on a character basis, is restricted to one line of text. Larger pointer movements are more easily performed by using the 'L' or 'F' (to be described later) commands.

D - DELETE CHARACTER

The D command is used to delete a specified number of characters from the text. The numeric argument used with this command specifies a number and sign. The number represents the number of characters to be deleted; the sign indicates in which direction, moving from the buffer pointer position, the deletion is to occur. A negative argument deletes characters in front of the buffer pointer; a positive argument deletes characters following the buffer pointer. The format of the D command is

as follows:

*nnnD$$	nnn represents any decimal number from -65,535 to +65,534.

An argument with a value larger than the number of characters between the buffer pointer and either boundary of the buffer cannot be used to move the delete operation out of the text buffer. The delete operation will continue until the end of buffer or beginning of buffer (when the argument is negative), at which time the command will be terminated.

Examples Of Editing Using The C and D Commands

A user wishes to delete a character from a line of text. The buffer pointer is at the beginning of the line. Consider the following line of text where the word MULTUIPLY can be corrected by simply deleting the extraneous letter U.

```
;  THIS ROUTINE WILL MULTUIPLY TWO 16-BIT NUMBERS
```

Because the buffer pointer is at the beginning of the text line, it must be moved 23 character positions to the point immediately before the letter U; whereupon the letter U may be simply deleted with the D command. The command to perform these operations is as follows:

```
*23CD$$
```

This is a clumsy way to position the buffer pointer and delete a character. It is included here as an example to show use of the C command. A better way to perform the same operation would be initiated with the SUBSTITUTE 'S' command (to be described later).

If no argument is used with the C or D commands, the default value of 1 is assumed. If a value of Ø is used, the pointer does not move and the command has no effect.

Commands F, S

F - FIND TEXT STRING

The F command is a search command used to find a text string of up to sixteen characters. The characters ALT MODE, ESC, and Control/C are not considered to be text because of their control functions, and cannot be included in the set of text characters.

The F command causes the Editor to search for the first occurrence of a character string matching the character string specified in the command All characters must match, including printing and non-printing characters. The search is started at the current location of the buffer pointer and continues until either the end of buffer is reached or a successful match is made. If a successful match is made, the Editor terminates the command leaving the buffer pointer at a location

immediately following the last character in the search string. A prompt character is output, requesting the next command. If no match is found when the end of the buffer is reached, the Editor prints the message:

```
CANNOT FIND "xxxxxxxxxx"    where xxxxxxxxxx represents
    *BREAK*                 the specified string.
```

The buffer pointer, in this case, is left at the end of the buffer. If the specified string is larger than sixteen characters, only the first sixteen will be used.

The format of the ´F´ command is as follows:

```
*FTHIS IS THE STRING$$
```

If the command is to be part of a command string, a single $ (ESC) terminator character will terminate the text string, allowing additional commands to be appended. If no other commands are to be included, the text string and command string can both be terminated with the double $$. It is important to remember to terminate the text string before additional commands are appended. Otherwise, the additional commands will be treated as part of the text string. For example, the string:

```
*FDIVIDEØLT$$
```

initiates a search for the string ´DIVIDEØLT´, instead of the intended string ´DIVIDE´. The appended command ØLT is part of the text string. The correct format for this command is as follows:

```
*FDIVIDE$ØLT$$
```

Note that the text string DIVIDE is itself terminated with a single $.

It is wise to verify the match of the requested text string with the text string found. In some cases a string may appear in several unexpected places prior to the line being searched for. For example, if the label DIV: is being searched for and several occurrences of the string DIV are present (i.e. DIVIDE, DIV1, DIV2, DIV3, etc) specifying DIV as the search string will produce spurious results. A unique combination of characters are required; in this case, it would be better to search for DIV: (include the colon), and then verify search results by typing out the line.

S - SUBSTITUTE TEXT STRING

The S command is a search command used to find a text string and replace it with another text string. The search part of the S command is similar to the F command. The substitute part of this command occurs if the search is successful. Any number of characters may be substituted for the characters in the search string. At the completion of the S command, the buffer pointer will be placed after the last character in the replacement string. The format of the S command is as follows:

*SSTRING 1$STRING 2$$

Each of the strings must be terminated with a $. The first string STRING 1 is the search string, which must be limited to sixteen characters. STRING 2 is the substitution string and may contain any number of characters (excluding the characters ALT MODE, ESC, and Control/C). The substitute string must be terminated with an ESC or ALT MODE.

If no substitution string is included, the search string will be found and deleted. The S command is used in this manner to selectively delete strings up to 16 characters long.

Examples Of Editing Using The F And S Commands

There are three extraneous characters which are to be deleted with the D command. The line of text appears as follows:

PARAM: CALL BACKOFF ; BACK IS THE RETN

The user would like to delete the three characters OFF from the word BACKOFF. First the pointer must be positioned adjacent to the string OFF, and then the deletion performed. The command will appear as follows:

*BFBACK$3D$ØTT$$ — This command string moves the pointer to the start of buffer, then commences a search for the string BACK. At the first occurrence of this string, the pointer is positioned following the K in BACK. The next three characters are deleted (OFF), and finally the line is typed out. The $$ terminates the command string.

When completed, the line of text will appear as follows:

PARAM: CALL BACK ; BACK IS THE RETN

If for some reason the pointer is positioned immeditaely after the string of charcters which are to be deleted, the D command may be used with a negative argument. Consider the following example. A user wishes to delete the label PARAM:

PARAM: CALL SUB1

The command would appear as follows:

*FPARAM:$-6D$$ — The string PARAM: would be searched for, and when found, the pointer will be positioned following the colon (:). By deleting the preceding six characters

the six character string PARAM: is deleted.

An error to be corrected consists of a misspelled word. The following command is used to search for the incorrect word and replace it with the correct one. Once corrected, a typeout is specified to verify the operation.

```
*SINITAIL$INITIAL$ØTT$$
```

The Editor responds by performing the substitution and typing out the corrected line. At the termination of the operation, the buffer pointer is positioned at the location between the L in INITIAL and the following blank character. The corrected line is typed out as follows:

```
        LXI     H,Ø     ;  INITIAL VALUE FOR REMAINDER
```

If a carriage return occurs in the search string of an F or S command, or in the replacement string of an S command, the Text Editor will automatically generate a line feed following it. Thus, the command

```
*FEND.
NEXT$$
```

will search for the characters "END.<cr><lf>NEXT".

Command Iterations

A command or command string may be repeated any number of times by enclosing the string in angle brackets "<" and ">", preceded by a number which specifies the number of times the iteration is to be performed. The format of the command is as follows:

```
n<command or command string>$$
```

where n specifies the number of times the command enclosed between the symbols '<' and '>' is executed.

For example, if a user program is written using a label 'DIVID' which is included fewer than ten times in the source file and wishes to shorten the label to DIV, an iterative substitute (S command) would be used as follows:

```
*Bl0<SDIVID$DIV$>$$
```

The B command moves the pointer to the beginning of the text buffer. The iterative command is repeated ten times; it searches for the text string DIVID, and each time it finds the string, replaces it with the new string DIV.

Command iterations may be nested up to eight deep. Any attempt to nest

command iterations more than eight deep is trapped and an error message is printed on the console device:

ITERATION STACK FAULT

For example, suppose the text buffer contains the SINEs of angles from 0 degrees to 90 degrees in increments of one degree. Assume these are arranged one per line and each is listed to 15 digits of accuracy as follows:

```
0.000000000000000
0.017452406437284
0.034899496702501
0.052335956242944
    "
    "
0.999390827019096
0.999847695156391
1.000000000000000
```

To improve the readability, it would be helpful to break each number up into groups of five digits by inserting spaces, so that each one would appear as follows:

```
0.00000 00000 00000
0.01745 24064 37284
0.03489 94967 02501
    "
    "
0.99939 08270 19096
0.99984 76951 56391
1.00000 00000 00000
```

This can be done by nesting two iterated commands: One level will insert a space at every fifth character on each line, and the other level will advance through the 91 lines in the file.
The command is:

```
*B91<2C2<5CI $>L>$$
```

TEXT EDITOR MESSAGES

The Intellec® MDS Text Editor prints messages on the system CONSOLE device to notify the user of various status conditions.

There are three error messages as follows:

"n" ILLEGAL IN THIS CONTEXT

The "n" represents the illegal alphanumeric character that was incorrectly typed in.

CANNOT FIND "xxxxxxx"

The xxxxx represents the text string which the editor could not find during an F or S command. This message further prints *BREAK* to signal that the command is aborted.

ITERATION STACK FAULT

This message is a notification to the user that iterated commands were nested more than eight levels deep. The command is aborted.

A start-up message:

INTELLEC MDS TEXT EDITOR, - VERSION x.x

A device status message:

START PUNCH, TYPE CHARACTER

This message is device sensitive, appearing only when a punched paper tape is output with an 'E', 'W', or 'N' command, while the Teletype is being used as the system PUNCH device. The system waits for the requested operation.

USE OF EDITOR TO CORRECT SAMPLE PROGRAM

The following consists of a sample program that needs correction, the Editor commands and responses while making corrections, and a final output showing the corrected listing.

```
;
; REENTRANT DIVIDE ROUTINE
;
DIV:
        MOV     A,D             ; NEGATE THE DIVISOR
        CMA
        MOV     D,A
        MOV     A,E
        CMA
        MOV     E,A
        INX     D
        LXI     H,0             ; INITAIL VALUE FOR REMAINDER
        MVI     A,17            ; INITIALIZE LOOP COUNTER
DIV0:
        PUSH    H               ; SAVE REMAINDER
        DAD     D               ; SUBTRACT DIVISOR (ADD NEGATIVE)
        JNC     DIV1            ; UNDER FLOW, RESTORE HL
        XTHL
DIV1:
        POP     H
        PUSH    PCW             ; SAVE LOOP COUNTER
        MOV     A,C             ; 4 REGISTER LEFT SHIFT
        RAL                     ; WITH CARRY
        MOV     C,A             ; CY -> C -> B -> L -> H
        MOV     A,B
        RAL
        MOV     B,A
        MOV     A,L
        RAL
        MOV     L,A
        MOV     A,H
        RAL
        MOV     H,A
        POP     PCW             ; RESTORE LOOP COUNTER
        DCR     A               ; DECREMENT IT
        JNZ     DIV0            ; KEEP LOOPING
DIV2:                           ; POST-DIVIDE CLEAN UP
        ORA     A               ; SHIFT REMAINDER RIGHT AND RETURN IN DE
        MOV     A,H
        RAR
        MOV     D,A
        MOV     A,L
        RAR
        MOV     E,A
        RET
        END
```

Figure 4-1: Sample Program Before Editing

The three comments may be entered into the text with the following command string:

```
*3LI; BC = DIVIDEND/QUOTIENT
; HL = TEMPORARY
; DE = DIVISOR/REMAINDER
;
$$
```

The next error to be corrected consists of a misspelled word. The following command is used to search for the incorrect word and replace it with the correct one. Once corrected, a typeout is specified to verify the operation

```
*SINITAIL$INITIAL$ØTT$$
```

The Editor responds by performing the substitution and typing out the corrected line. At the termination of the operation, the buffer pointer is positioned at the location between the L in INITIAL and the following blank character. The corrected line is typed out as follows:

```
        LXI     H,Ø     ; INITIAL VALUE FOR REMAINDER
```

The next task is to find all occurrences of the label DIVØ and replace it with the string DVØ. The number 1Ø is selected because it is known that there are fewer than 1Ø occurrences of the label DIVØ. As each occurrence is matched during search, it is replaced and the corrected line is typed out. The command appears as follows:

```
*1Ø<SDIVØ$DVØ$ØTT>$$
```

The editor will reply with the following:

```
DVØ:
        JNZ     DVØ     ; KEEP LOOPING

CANNOT FIND "DIVØ"

*BREAK*
```

Similarly, we can replace 'DIV1' with 'DV1' throughout.

Next, the register named PSW is incorrectly called PCW in the source coding. A search will be made for the text string PCW, and each time it is found it will be replaced with the text string PSW. The command is as follows:

```
*B1Ø<SPCW$PSW$ØTT>$$
```

The operation is similar to that described above. The Editor output is as follows:

```
        PUSH    PSW     ; SAVE LOOP COUNTER
        POP     PSW     ; RESTORE LOOP COUNTER
```

```
CANNOT FIND "PCW"

*BREAK*
```

We have found all occurrences of DIV0, DIV1, and PCW and corrected them. The buffer pointer is at the end of the buffer. The next task is to delete the label DIV2 (which is not referenced in any of the statements) and move the comments over to the left-hand margin. Also, comment lines will be generated to precede and follow the "; POST DIVIDE CLEAN UP" message. In addition, the word "POST DIVIDE" will be hyphenated. The command string will appear as follows:

```
*BFKEEP LOOPING$LI;
$9DFPOST$DI-$LI; SHIFT REMAINDER RIGHT AND RETURN IN DE
;
$-4T$$
```

The first command, B, returns the pointer to the start of the buffer. Although text string "KEEP LOOPING" is on the previous line, it is convenient to use F to locate the required line.

The next command, L, moves the buffer pointer to the next line where the semicolon and carriage return/line feed are inserted. Nine characters are deleted, removing the label and four TAB characters, moving the comment to the left-hand margin. The string POST is searched for and quickly found because it is immediately following the pointer. This positions the pointer after the letter T in POST. One character is deleted and replaced with the dash (-) character. The L command moves the pointer to the next line, where another comment line, a carriage return/line feed, a semicolon, and another carriage return/line feed combination are inserted. The -4T command is used to verify the operation. The Editor prints the following:

```
;
; POST-DIVIDE CLEAN UP
; SHIFT REMAINDER RIGHT AND RETURN IN DE
;
```

The next task is to insert two "RAR" commands. The command to locate the line and insert the first RAR is as follows:

```
*2<FMOV$>0LI    RAR
$-2T$$
```

From the current pointer position, following the last operation, a search is made for two occurrences of the text string MOV. Note that this command would produce unpredictable results if started when the position of the pointer is unknown. However, remembering the last command string and determining that the pointer is left at a position between the line feed from the line containing the ";" and the <tab> character preceeding the O in ORA, the position of the next two MOV

strings is known.

After the second MOV is located, the pointer is positioned following the V in the second MOV. The pointer is then moved to the start of the current line and a line is inserted, containing <tab>, RAR, <cr,lf>. The -2T command is used to look at the previous line and the current line to verify the insertion. The Editor prints out the following:

```
MOV     A,H
RAR
```

In the last command string, the pointer is moved forward three lines, then the string <tab>, RAR, <cr,lf> is inserted. The current line and the previous line are output. The command appears as follows:

```
*3LI    RAR
$-2T$$
```

The Editor replies by printing out:

```
MOV     A,L
RAR
```

The program is now complete. A corrected version of the text appears in Figure 4-2.

```
;
; REENTRANT DIVIDE ROUTINE
;
; BC = DIVIDEND/QUOTIENT
; HL = TEMPORARY
; DE = DIVISOR/REMAINDER
;
DIV:
        MOV     A,D             ; NEGATE THE DIVISOR
        CMA
        MOV     D,A
        MOV     A,E
        CMA
        MOV     E,A
        INX     D
        LXI     H,0             ; INITIAL VALUE FOR REMAINDER
        MVI     A,17            ; INITIALIZE LOOP COUNTER
DV0:
        PUSH    H               ; SAVE REMAINDER
        DAD     D               ; SUBTRACT DIVISOR (ADD NEGATIVE)
        JNC     DV1             ; UNDER FLOW, RESTORE HL
        XTHL
DV1:
        POP     H
        PUSH    PSW             ; SAVE LOOP COUNTER
        MOV     A,C             ; 4 REGISTER LEFT SHIFT
        RAL                     ; WITH CARRY
        MOV     C,A             ; CY -> C -> B -> L -> H
        MOV     A,B
        RAL
        MOV     B,A
        MOV     A,L
        RAL
        MOV     L,A
        MOV     A,H
        RAL
        MOV     H,A
        POP     PSW             ; RESTORE LOOP COUNTER
        DCR     A               ; DECREMENT IT
        JNZ     DV0             ; KEEP LOOPING
;
; POST-DIVIDE CLEAN UP
; SHIFT REMAINDER RIGHT AND RETURN IN DE
;
        ORA     A
        MOV     A,H
        RAR
        MOV     D,A
        MOV     A,L
        RAR
        MOV     E,A
        RET
        END
```

Figure 4-2: Sample Program After Editing

SECTION 5

MDS ASSEMBLER

INTRODUCTION

The Intellec® MDS Assembler accepts 8080 source language statements and, in two or three passes, depending on the peripheral devices available, generates a listing (including symbol table) and a hexadecimal object file on punched paper tape. A full description of assembly language syntax and semantics is included in the 8080 Assembly Language Programming Manual, Intel publication # 98-004.

In use, the assembler is loaded into the Intellec MDS system using the hexadecimal loading facilities of the system Monitor. When initially loaded and started, the Assembler prints an introductory header message. The operator now specifies which pass of the Assembler is to be executed. The source tape of the program being assembled is read during each pass. After each pass the tape must be rewound and prepared for the next pass. The assembler outputs a list file and a hexadecimal object file.

The user's reply to the prompt question depends on the system I/O format, specifically on the peripheral devices available for system I/O. This is discussed below.

LOADING THE ASSEMBLER

The assembler is supplied on punched paper tape and is loaded into the system using the tape loading facilities of the system Monitor. Because the assembler uses the I/O facilities of the monitor, all peripheral devices must be defined before starting execution of the assembler. The following procedures load and start execution of the Intellec® MDS Assembler:

1. If the Monitor is not already operating, start the system as described in the "START UP" procedures.

2. With the Monitor running, assign (using the Monitor "A"

command) the peripherals required for loading the Assembler, as the CONSOLE and READER devices.

3 Place the tape containing the MDS Assembler into the peripheral assigned as the system READER device.

4 Type in the R command as follows:

```
.RØ
```

The paper tape will be read by the READER until an End-Of-File record is read. The Monitor will prompt for a new command by printing a period (.) in the left-most column of the system CONSOLE device. If required, new device assignments may be made at this time, to assign the system PUNCH and LIST devices, or to change the system CONSOLE or READER devices.

5 To start executing the Assembler, type in the following command:

```
.G2Ø
```

The Assembler will assume control and print the following introductory message:

```
8Ø8Ø MDS MACRO ASSEMBLER VERSION x.x
P=
```

The Assembler is now ready to read a source program from punched paper tape. If the user has a single LIST/PUNCH device, such as a Teletype, the assembler requires three passes to produce a listing and hexadecimal object code output. A user with separate punch and list devices may generate the list and object file outputs in two passes. The user has control of assembler operations by replying to the "P=" prompt with an appropriate reply (by typing in the numerals 1, 2, 3, or 4).

It should be noted that a user with separate list and punch devices is not limited to assembling a source program in two passes. However, the user with a single list/punch device will produce an unusable object output file if an assembly operation is performed in two passes.

The significance of the user's replies to "P=" are as follows:

P=1 Reads punched paper tape source file and sets up symbol table for the subsequent passes. This reply is normally used for the first pass of an assembly. It must be run before any of the other passes can be run.

P=2 Reads source file again (user must first rewind the source tape after pass 1) and generates a listing on the LIST device.

P=3 Reads source file again (user must first rewind the source tape after pass 1 or pass 2) and generates a hexadecimal object file on the PUNCH device.

P=4 Reads the source file again (user must first rewind the source tape after pass 1) and generates a listing on the LIST device concurrently with a hexadecimal object file on the PUNCH device. If the LIST and PUNCH devices are combined into a common unit, an unusable object file will be generated.

Once the operator has run pass 1, he may run passes 2, 3, or 4 in any order, executing each pass any number of times. This is useful when multiple listings and/or object tapes are needed.

Twelve inches of tape leader and trailer are generated automatically each time a hexadecimal object file is punched on paper tape. Additional leader and trailer may be produced by using the manual facilities of the PUNCH device. When using a Teletype, the procedure is as follows:

1 Switch Teletype to LOCAL mode.

2 Turn on the PUNCH.

3 Press HERE IS. Approximately 15 feed characters are generated each time the HERE IS key is pressed.

4 Turn off the PUNCH.

5 Switch Teletype to LINE mode and continue.

If using a tape PUNCH device, press the FEED (or equivalent) switch to generate tape with sprocket holes only.

Facilities are provided with both the MDS Monitor and MDS Editor to punch NULL characters as leader or trailer. Refer to the appropriate paragraphs discussing the "N" command. Leader prepared in this way must be done prior to entering the assembly program execution. Trailer may be prepared after returning control to the Monitor.

ASSEMBLING A PROGRAM

The following procedure is suggested:

1 Prepare a source file using the Intellec® MDS Text Editor. This file should be on punched paper tape. The file format required is described below.

2 Place the paper tape into the system READER device.

3 In reply to the prompt, "P=", type in the numbe. 1. The

tape will be read in and a symbol table generated internally.

4 Rewind the tape.

5 Depending on the peripherals available and on the job requirements, type in 2, 3, or 4, in reply to the P= prompt. The tape will be read in a second time. As the tape is read, the listing is generated (P=2) or an object file is generated (P=3), or both a listing and object file are generated concurrently (P=4), with separate LIST and PUNCH devices.

6 Rewind the source tape and return to step 5 until all of the required operations are performed.

7 To terminate the assembly, press the INTERRUPT 0 switch on the front panel.

Input File Format

The input file consists of lines of assembly language statements. A line must be terminated with a carriage return/line feed character combination, or a carriage return/form feed character combination; each line can be at most 72 characters long. A complete description of the 8080 Assembly Language may be found in the 8080 Assembly Language Programming Manual.

List Output

The list file is a formatted file created by the assembler. The data is designed to be output to a printer. The significance of each column in the listing is discussed in Table 5-1 below, with a sample listing shown in Figure 5-2.

COLUMNS	DESCRIPTION
1	ASSEMBLER ERROR CODE. If the assembler encountered a syntax error in this source line, the appropriate error code (see Appendix C) will appear in this column. Otherwise, this column will be blank.
2	Blank.
3-6	CURRENT VALUE OF THE PROGRAM LOCATION COUNTER. The address assigned to the first byte of the object code shown in columns 8-9 of this line is printed in hexadecimal. In addition, the result of the value-generating pseudo-ops ORG, EQU, and SET will appear in this field.
7	Blank.
8-9	FIRST BYTE OF OBJECT CODE. The first byte of object code produced by the assembler for this source line is printed here in hexadecimal. If this source statement produces no object code (e.g., is a comment, or a pseudo-op), this field will be blank.
10-11	SECOND BYTE OF OBJECT CODE. This field will be blank if the source statement generates no object code (comments and pseudo-ops), or generates only one byte of object code. Again, this field is printed in hexadecimal.
12-13	THIRD BYTE OF OBJECT CODE, if this statement produced three bytes of code; otherwise blank.
14-15	FOURTH BYTE OF OBJECT CODE, if generated; otherwise blank.
16	MACRO EXPANSION FLAG. A "+" in this column indicates that this source line was produced as a result of a macro expansion. Otherwise, this column will be blank.
17-...	LISTING OF THE ASSEMBLER SOURCE TEXT. This field terminates at column 72 for all output devices other than the line printer, and at column 120 for the line printer.

Table 5-1: Assembler List File Format

```
8080 MDS MACRO ASSEMBLER VERSION 1.0                    PAGE 1

                        ;
                        ; REENTRANT DIVIDE ROUTINE
                        ;
                        ; BC = DIVIDEND/QUOTIENT
                        ; HL = TEMPORARY
                        ; DE = DIVISOR/REMAINDER
                        ;
 0000                   DIV:
 0000 7A                        MOV     A,D             ; NEGATE THE DIVISOR
 0001 2F                        CMA
 0002 57                        MOV     D,A
 0003 7B                        MOV     A,E
 0004 2F                        CMA
 0005 5F                        MOV     E,A
 0006 13                        INX     D
 0007 210000                    LXI     H,0             ; INITIAL VALUE FOR REMA
 000A 3E11                      MVI     A,17            ; INITIALIZE LOOP COUNTE
 000C                   DV0:
 000C E5                        PUSH    H               ; SAVE REMAINDER
 000D 19                        DAD     D               ; SUBTRACT DIVISOR (ADD
 000E D21200                    JNC     DV1             ; UNDER FLOW, RESTORE HL
 0011 E3                        XTHL
 0012                   DV1:
 0012 E1                        POP     H
 0013 F5                        PUSH    PSW             ; SAVE LOOP COUNTER
 0014 79                        MOV     A,C             ; 4 REGISTER LEFT SHIFT
 0015 17                        RAL                     ; WITH CARRY
 0016 4F                        MOV     C,A             ; CY -> C -> B -> L -> H
 0017 78                        MOV     A,B
 0018 17                        RAL
 0019 47                        MOV     B,A
 001A 7D                        MOV     A,L
 001B 17                        RAL
 001C 6F                        MOV     L,A
 001D 7C                        MOV     A,H
 001E 17                        RAL
 001F 67                        MOV     H,A
 0020 F1                        POP     PSW             ; RESTORE LOOP COUNTER
 0021 3D                        DCR     A               ; DECREMENT IT
 0022 C20C00                    JNZ     DV0             ; KEEP LOOPING
                        ;
                        ; POST-DIVIDE CLEAN UP
                        ; SHIFT REMAINDER RIGHT AND RETURN IN DE
                        ;
 0025 B7                        ORA     A
 0026 7C                        MOV     A,H
 0027 1F                        RAR
 0028 57                        MOV     D,A
 0029 7D                        MOV     A,L
 002A 1F                        RAR
 002B 5F                        MOV     E,A
 002C C9                        RET
                                END
```

```
8080 MDS MACRO ASSEMBLER VERSION 1.0                    PAGE 2

 DIV     0000       DV0     000C       DV1     0012
```

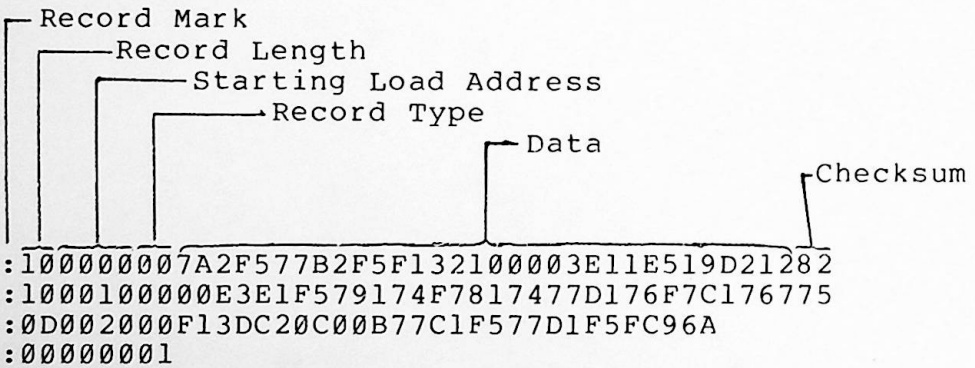
Figure 5-2: Sample Assembler List Output

Object Code Output Format

The object code output tape contains the contents of program memory which result from loading the assembled source program. The code is formatted in hexadecimal records. The punched paper tape contains the ASCII representation of the hexadecimal bytes of data.

The format of the object code is a series of records, each containing its record length, type, memory load address, checksum, and data. Figure 5-3 shows a typical output file in hexadecimal format. A complete description of hexadecimal object file format is given in Appendix D.

Twelve inches of paper tape leader, consisting of feed holes only (NULL characters) is generated in front of the hexadecimal object file. Similarly, twelve inches of trailer are generated immediately following the last hexadecimal record in the output file.



Because Record Length = 0 and Record Type = 01, this record specifies End-of-File.

Figure 5-3: Sample Object File

Object Code Output For PROM Programming

No special output code is generated with the Intellec MDS Assembler to program PROMs or ROMs. Control of the operations of the Universal PROM Programmer is performed with the Intellec MDS Monitor, which accepts hexadecimal object files as input.

The Monitor is also able to load a hexadecimal file and dump the memory contents in BNPF format. This facility is useful when a BNPF punched paper tape is needed to produce ROMs on another system which uses BNPF tapes.

ASSEMBLER ERROR MESSAGES

Errors detected by the Assembler are indicated by single letter codes in column 1 on the output listing. When multiple errors are detected in a single source statement, the first error determines the error code listed. The following is a list of the Assembler error codes. A full discussion is included in Appendix C.

CODE	NAME
B	Balance Error
E	Expression Error
F	Format Error
I	Illegal Character
M	Multiple Definition
N	Nesting Error
P	Phase Error
Q	Questionable Syntax
R	Register Error
S	Stack Overflow
T	Table Overflow
U	Undefined Identifier
V	Illegal Value

Table 5-4: Assembler Error Codes

SECTION 6

USE OF MONITOR'S I/O SYSTEM

INTRODUCTION

This section describes the use of the Intellec® MDS Monitor I/O facilities. This information will enable a programmer to use the I/O drivers already included in the Monitor coding to perform I/O operations in the user routines. Also, information is included to allow a programmer to write special device-specific drivers and link these to the system I/O facilities so that the monitor may have access to these drivers.

In some cases it may be better to write a user driver for a special peripheral and access the driver directly from the user program. However, by providing linkages from the monitor to the user driver and accessing the driver through the monitor, additional versatility is achieved because of several factors which include:

- Common access point to driver for all user and monitor calls.
- Availability of driver to other programs such as MDS Editor and Assembler.
- Device selection can be controlled with the Monitor 'A' (ASSIGN) command.

USING THE I/O SYSTEM

The Intellec® MDS I/O system contains drivers for several peripheral devices, including a Teletype console/reader/punch, a high speed paper tape reader, a high speed paper tape punch, a CRT console, and a line printer. Access to any of these devices can be made through the Monitor I/O system. A user can program his routine to access any of the four logical devices, to perform the I/O function, and, before executing the routine, assign (using the Monitor 'A' command) the required physical device. The user may also assign a device dynamically using the Monitor

'IOSET' call (described in the following paragraphs).

Accessible I/O Routines

The user may access the Monitor I/O system from his programs (as do other Intellec MDS system programs) by calling the routine provided by the Monitor to perform the desired function.

The calling sequence for each system I/O routine consists of a subroutine jump to a reserved address. Each system I/O routine has a unique starting address. These fixed addresses are listed in Appendix E. Samples of driver access are included in the examples below.

Parameter passing from the user routine to the system I/O routine consists of placing the parameter in the C-Register (if it is a byte value), or in the C- and D-Registers (if it is an address value) then calling the I/O routine. When address values are used, the least significant byte must be placed in the C-Register; the most significant byte must be placed in the D-Register.

Parameter passing from the system I/O routine to the user routine consists of calling the I/O routine first, then retrieving the data from the A-Register (if it is a byte value), or from the A- and B-Registers (if the data is an address value). The least significant byte is retrieved from the A-Register and the most significant byte is retrieved from the B-Register.

This mechanism of parameter passing is the same as that performed by PL/M[T.M.]. It is equivalent to the operation produced by declaring and calling a byte procedure with parameters of type address. A user program written in PL/M has the mechanism to pass data to and from the Monitor's drivers.

Accessible I/O can be considered from two general points of view: A user can pass data to and from the Monitor's drivers, and can call a driver; a user can request system status information, including device status, memory size, and I/O system status.

I/O DRIVER ROUTINES

The following paragraphs contain descriptions of the use of the I/O driver routines. The following functions are included:

- CI Console Input
- CO Console Output
- RI Reader Input
- PO Punch Output
- LO List Output

CI - Console Input

The CI routine is an Intellec/MDS Monitor driver that returns a character received from the selected system console device and places it in the A-Register. Once started, the CI routine loops until a character is input. No timeout facilities are included. The character read is not echoed. The A-Register and the CPU condition code are affected by this operation.

Examples:

The basic assembly language calling sequence is as follows:

```
CI      EQU     0F803H
        .
        .
        .
        CALL    CI
        LXI     H,DATA
        MOV     M,A
```

The following routine is a sample of assembly language coding in which the Console Input facilities are used. This routine will input a string of characters from the console device and terminate its operation when either a carriage return is detected as an input character or the number of characters specified in BUFSIZ have already been read. The two exits DONE and OVFL correspond to the CR detected and buffer full conditions respectively.

```
; CONSOLE INPUT ROUTINE
; INPUT UP TO 72 CHARACTERS FROM CONSOLE DEVICE
; A CARRIAGE RETURN IN INPUT CAUSES EXIT TO 'FULL'
; INPUT OF 72 CHARACTERS CAUSES EXIT TO 'OVFL'
;
        ORG     20H
CI      EQU     0F803H  ; RESERVED ADDRESS OF CI ROUTN
CR      EQU     0DH     ; CARRIAGE RETN
BUFSIZ  EQU     72      ; BUFFER SIZE 72 CHAR
;
START:
        LXI     H,BUFFR ; SET UP BUFFER POINTER
        MVI     D,BUFSIZ; SET UP BUFFER SIZE
BPC:
        CALL    CI      ; GET CHARACTER
        ANI     7FH     ; STRIP OFF PARITY BIT
        MOV     M,A     ; SAVE CHARACTER
        CPI     CR      ; IS IT CARRIAGE RETN
        JZ      DONE    ; YES, TAKE DONE EXIT
        INX     H       ; NO, MOVE BUFFER POINTER
        DCR     D       ; DECR CHARACTER COUNT
        JZ      OVFL    ; IF BUFFER FULL, TAKE 'OVFL'
```

```
                                    ; EXIT
            JMP     BPC
;
DONE:       xxxx    xxxx
            '
            '
OVFL:       xxxx    xxxx
            '
            '
BUFFR:      DS      BUFSIZ  ; RESERVE 72 LOCATIONS FOR
                            ; BYTES RETURNED BY CI
```

CO - Console Output

The CO routine is an Intellec MDS Monitor driver that takes a character from the C-Register and transmits it to the system CONSOLE for output. The A-Register, C-Register, and CPU Condition Codes are affected by this operation.

Examples:

The basic assembly language calling sequence is as follows:

```
CO          EQU     0F809H
            '
            '
            MOV     C,M
            CALL    CO
            '
            '
            '
```

The following routine is a sample of assembly language programming in which the Console Output facilities are used. This routine allows a user to output a string of characters on the CONSOLE. The operation terminates when a carriage return is detected in the text string. The carriage return character is output, then the operation is terminated.

```
CR          EQU     ODH
CO          EQU     0F809H  ; RESERVED ADDRESS
OTPT:
            LXI     H,MSGBUF; GET BASE ADDRESS OF MESSAGE
                            ; BUFFER
            MOV     C,M     ; GET CHAR FROM BUFFER
            CALL    CO      ; OUTPUT CHARACTER
            MVI     A,CR    ; IS CHAR CR?
            CMP     M
            JZ      RTN     ; YES, EXIT THROUGH 'RTN'
            INX     H       ; INCREMENT BUFFER POINTER
```

```
        JMP     OTPT
RTN:
        XXXX    XXXX
MSGBUF: ; MSGBUF IS THE BASE ADDRESS OF
        ; THE STRING OF CHARACTERS WHICH
        ; ARE OUTPUT TO THE CONSOLE DEVICE
          '
          '
          '
```

RI - Reader Input

The RI routine is an Intellec MDS Monitor driver that returns a character from the system READER and places it in the A-Register. If no character is read within a waiting period of 250 milliseconds, due to an end of file condition, the A-Register is zeroed and the Carry condition bit in the 8080 is set to one. Thus, immediately following a call to this driver, a check can be made to determine if the carry bit is set or reset. If the carry bit is one, the character in the A-Register is invalid or is zero. If the carry bit is zero, the character in the A-Register is a valid character. Once the end of file condition is sensed, control is returned to the calling program.

The A-Register and the CPU condition codes are affected by this operation.

Examples:

The basic assembly language calling sequence is as follows:

```
RI      EQU     0F806H
          '
          '
          '
        CALL    RI
        JC      LAST
        LXI     H,DATA
        MOV     M,A
          '
          '
          '
```

The following routine is a sample of assembly language programming in which the reader input facilities are used. This routine reads a string of characters from paper tape and stores them in an expanded buffer area. When the reader either runs out of punched tape, or a Control/Z (1A Hexadecimal) character is read (it is used in this context as an EOF character), the operation is terminated and control is returned to the calling program.

```
        ORG     20H
RI      EQU     0F806H
EOF     EQU     1AH     ; USED AS EOF CHAR
;
START:
        LXI     H,BUFF  ; BASE OF ADDR BUFFR
LOOP:
        CALL    RI      ; GET CHARACTER
        JC      EFEX    ; IF CY NOT ZERO TAKE
                        ; 'EFEX' EXIT
                        ; NO CHAR FOR 250 MS
        ANI     7FH     ; STRIP OFF PARITY BIT
        MOV     M,A     ; STORE CHAR IN BUFFR
        CPI     EOF     ; IS CHAR EOF ?
        JZ      EFEX    ; YES, TAKE EFEX EXIT
        INX     H       ; NO, ENLARGE BUFFER
        JMP     LOOP
EFEX:   xxxx    xxxx    ;; EOF EXIT
        '
        '
BUFF:
        DS      1
        '
        '
```

PO - Punch Output

The PO routine is an Intellec MDS Monitor driver that takes a character from tne C-Register and transmits it to the device selected as the system punch device.

The A-Register, C-Register, and CPU condition codes are affected by this operation.

Examples:

The basic assembly language calling sequence is as follows:

```
PO      EQU     0F80CH
        '
        '
        '
        MOV     C,M
        CALL    PO
        '
        '
```

LO - List Output

The LO routine is an Intellec MDS Monitor driver that takes a character from the C-Register and transmits it to the system LIST device.

The A-Register, C-Register, and CPU condition codes are affected by this operation

Examples:

The basic assembly language calling sequence is as follows:

```
LO      EQU     0F80FH
        .
        .
        .
        MOV     C,M
        CALL    PO
        .
        .
        .
```

The following routine is a sample of assembly language programming in which the LIST output device is used. This routine reads characters from a buffer area in memory and continues outputting contiguous characters until an ETX (03H) character is encountered in the text string.

```
        ORG     20H
LO      EQU     0F80FH  ; LO ROUTINE FIXED
                        ; ADDRESS
ETX     EQU     03H     ; TERMINAL CHAR
START:
        LXI     H,BUFFR ; SET UP POINTER
PRNT:
        MOV     A,M     ; CHAR INTO ACCUM
        CPI     ETX     ; IS IT 'ETX'?
        JZ      XIT     ; YES, EXIT
        MOV     C,M     ; NO, SET UP CHAR
        CALL    LO      ; PRINT CHAR
        JMP     PRNT    ; RETURN FOR NEXT CHAR
BUFFR:  DB      'THIS IS THE MESSAGE'
        DB      ETX     ; TERMINAL CHARACTER AT
                        ; END OF BUFFER
XIT:    xxxx    xxxx
                        ; EXIT
        END
```

SYSTEM STATUS ROUTINES

The system status information routines include the following:

- CSTS Console Input Status
- IOCHK Check I/O System Configuration

- IOSET Set I/O System Configuration
- MEMCHK Determine Size Of RAM Memory

CSTS - Console Input Status

In many applications there is a need to poll the console device to see if the operator wishes to terminate the current operation. The CSTS routine allows the caller to test the console to see if a character is ready for input. In other words, it checks to see if a console keyboard key was pressed since the last CI operation. If no key was pressed, the value of 00 is returned in the A-Register. If a key was pressed, a value of 0FFH is returned in the A-Register. A CI operation may then be initiated to retrieve the character.

Examples:

The basic assembly language calling sequence is as follows:

```
CSTS    EQU     0F812H
        .
        .
        .
CALL    CSTS
        RRC
        JNC     NOCHAR  ; NO KEY WAS PRESSED
KYPRS:  xxxx            ; KEY WAS PRESSED
        .
        .
        .
NOCHAR:
        xxxx
```

The following routine is an example of use of the CSTS routine. During a print (console output) operation, it is necessary to monitor the keyboard so that the operator has facilities to signal that the operation is to be terminated.

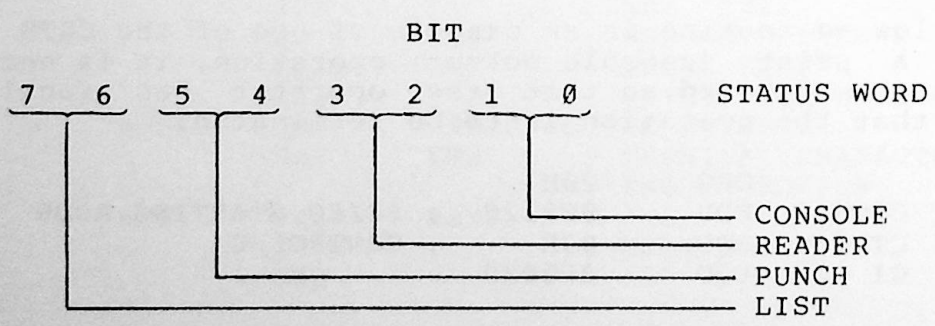
```
        ORG     20H
CSTS    EQU     0F812H  ; FIXED STARTING ADDR
CTLC    EQU     03H     ; CONTROL/C
CI      EQU     0F803H
        .
        .
        .
        CALL    CSTS    ; GET STATUS
        RRC             ; ROTATE ACC INTO CY
        JNC     CONT    ; NO CHAR, CONTINUE
        CALL    CI      ; GET CHAR
        CPI     CTLC    ; IS IT CONTROL/C?
        JZ      STP     ; YES, JMP TO INTERRUPT
        .
```

```
                ,
                ,
CONT:
                xxxx    xxxx
                ,
                ,
                ,
STP:
                xxxx    xxxx    ; BREAK ROUTINE
                ,
                ,
```

IOCHK - Check I/O System Configuration

The IOCHK routine returns an 8-bit value in the A-Register which describes the current assignment of physical devices to logical devices. This routine allows the user to programmatically select I/O devices and configure the I/O system. For example, if the system punch device can be assigned to either a free standing punch device or a combination print and punch device, the manner in which data is output may be different for each device. The free standing punch device may be left in an active mode at all times and be used by the user calling program at any time. However, a combination punch/printer device usually requires that the punch be turned off while printing. Otherwise, massive amounts of tape will be wasted. Before using this type of punch device, the user must be notified to turn it on, and similarly to turn it off. Using the IOCHK routine, a user may determine which device is being used, and tailor the user coding to the device.

The status byte that is returned contains the current mapping of logical I/O devices to physical I/O devices. The 8-bit byte is divided into four 2-bit fields as shown below:



Each field may contain a value of Ø through 3 which represents the physical device currently assigned to it. Each of the fields is described as follows:

CONSOLE	Ø	Assigned to TTY

	1	Assigned to CRT
	2	BATCH: Special assignment where CONSOLE input function is reassigned to system READER device, and CONSOLE output function is reassigned to system LIST device.
	3	Assigned to user-defined I/O device (to be discussed later).
READER	Ø	Assigned to TTY
	1	Assigned to high speed paper tape reader
	2	Assigned to user-defined I/O device 1 (to be discussed later).
	3	Assigned to user-defined I/O device 2 (to be discussed later).
PUNCH	Ø	Assigned to TTY
	1	Assigned to high speed paper tape punch
	2	Assigned to user-defined I/O device 1 (to be discussed later)
	3	Assigned to user-defined I/O device 2 (to be discussed later)
LIST	Ø	Assigned to TTY
	1	Assigned to CRT
	2	Assigned to line printer
	3	Assigned to user-defined I/O device 1 (to be discussed later)

The Monitor is initially configured at cold start time to assign the CONSOLE to the device that is first operated during initialization, and the TTY to all other devices.

Example:

The basic assembly language calling sequence is as follows:

```
IOCHK   EQU     0F815H
```

```
        .
        .
        CALL    IOCHK
        ANI     DEVMSK
        CPI     DEVICE
        JZ
        .
        .
        .
```

Values for DEVMSK are as follows:

CONSOLE	03H	00000011B
READER	0CH	00001100B
PUNCH	30H	00110000B
LIST	C0H	11000000B

Values for the peripheral devices for DEVICE are as follows:

CONSOLE	TTY	00	00000000B
	CRT	01	00000001B
	BATCH	02	00000010B
	User	03	00000011B
READER	TTY	00	00000000B
	PTR	04	00000100B
	User 1	08	00001000B
	User 2	0CH	00001100B
PUNCH	TTY	00	00000000B
	PTP	10H	00010000B
	User 1	20H	00100000B
	User 2	30H	00110000B
LIST	TTY	00	00000000B
	CRT	40H	01000000B
	LPTR	80H	10000000B
	User	C0H	11000000B

In the following example, a check is made to determine if the CONSOLE device is a CRT. If it is not, the routine exit is 'CONTINUE'. If it is a CRT, the routine exit is 'OUTCRT'.

```
IOCHK   EQU     0F815H
DEVMSK  EQU     03H
DEVICE  EQU     1
        .
        .
        CALL    IOCHK
        ANI     DEVMSK  ; MASK ALL BUT CONSOLE
```

```
        CPI     DEVICE  ; IS IT A CRT?
        JZ      OUTCRT  ; YES,
CONTINUE:               ; NO
        xxxx    xxxx
        xxxx    xxxx
        xxxx    xxxx
OUTCRT:
        xxxx    xxxx
```

IOSET - Set I/O System Configuration

The IOSET routine allows the user to modify the system status word. The new value of the status byte is placed in the C-Register before calling the IOSET routine.

The A-Register, C-Register, and the CPU flags are modified by this routine.

Examples:

The basic assembly language calling sequence is as follows:

```
IOSET   EQU     0F818H
IOCHK   EQU     0F815H
        .
        .
        .
        CALL    IOCHK   ; GET STATUS WORD
        ANI     NOT DEVMSK
                        ; CLEAR CURRENT DEV
        ORI     NEWDEV  ; ENTER NEW DEV
        MOV     C,A
        CALL    IOSET   ; REPLACE STATUS BYTE
        .               .
```

Suppose a user wishes to change the I/O Status byte to change the CONSOLE device from CRT to TTY. The following is an example of the coding:

```
IOSET   EQU     0F818H
IOCHK   EQU     0F815H
DEVMSK  EQU     03H
NEWDEV  EQU     0
        .
        .
        .
        CALL    IOCHK   ; GET STATUS BYTE
        ANI     NOT DEVMSK
                        ; CLEAR CURRENT CONSOLE
                        ; DEVICE ASSIGNMENT
```

```
        ORI     NEWDEV  ; ASSIGN TTY TO
                        ; CONSOLE
        MOV     C,A
        CALL    IOSET   ; STORE MODIFIED BYTE
```

MEMCHK - Determine Size of RAM Memory

The MEMCHK routine provides the user the ability to determine the highest RAM address which is currently available in the system. MEMCHK returns the highest address available to the user after the Monitor has allocated its own storage at the top of contiguous RAM memory.

If RAM memory is installed in segments, instead of contiguously from address 0000 upward, the Monitor will assign its own storage area at the top of the first segment of RAM memory. In this case, additional memory will exist above the memory address determined by the MEMCHK routine. However, the location and extent of this memory must be determined by the user.

Examples:

The basic assembly language calling sequence is as follows:

```
MEMCHK  EQU     0F81BH
        .
        .
        .
        CALL    MEMCHK
        LXI     H,MEXMEM        ; LOCATION ASSIGNED
                                ; TO HOLD ADDRESS
        MOV     M,A             ; LSB IN A
        INX     H
        MOV     M,B             ; MSB IN B
        .
        .
        .
```

A practical example of the use of MEMCHK is the setting up of the Stack Pointer. A full description of the Stack Pointer is included in the 8080 Assembly Language Programming Manual. Generally, it is advisable to move the Stack Pointer into high memory, away from the user coding. A suitable location to start the Stack Pointer is at the high memory location determined from MEMCHK. The coding to set up the Stack Pointer is as follows:

```
MEMCHK  EQU     0F81BH
        .
        .
        .
        CALL    MEMCHK          ; FIND HIGH MEM ADDR
        MOV     H,B             ; MSB IN B
        MOV     L,A             ; LSB IN A
```

```
                SPHL                    ; LOAD ADDRESS INTO
                                        ; STACK POINTER
                .
                .
                .
```

EXTENDING THE I/O SYSTEM

The user may write special drivers for non-standard system devices and install them into the Intellec MDS system. By having them installed into the I/O system, all system programs and user programs may access them.

IODEF - Define User-Written I/O Routines

The Monitor program defines a set of absolute addresses that it will branch to in the event that the I/O status byte contains a selection of user-defined I/O devices. The system routine IODEF allows a user to define the logical device category of the device in question and the starting address of the routine. IODEF requires two parameters as follows:

(1) A byte value from the following table, defining the logical device category. This value must be placed in the C-Register prior to calling IODEF.

Ø	User Defined Console Input
1	User Defined Console Output
2	User Defined Reader 1
3	User Defined Reader 2
4	User Defined Punch 1
5	User Defined Punch 2
6	User Defined List Device
7	User Defined Console Status

(2) The starting address of the driver routine, written by the user. This address value must be placed in the D- and E-Registers prior to calling IODEF, with the most significant byte in the D-Register and the least significant byte in the E-Register.

The driver routines written by the user should save and restore any CPU registers that are not specifically used to pass parameters.

Examples:

```
IODEF   EQU     ØF81EH
```

```
          .
          .
          MVI     C,LOGDEV        ; SET UP LOGIC
                                  ; DEVICE SELECTION
          LXI     D,DRVADD        ; GET DRIVER
                                  ; STARTING ADDRESS
          CALL    IODEF
          .
          .
          .
```

For example, if a user wishes to write a driver for a magnetic tape cassette and define it as a system PUNCH device, the following coding can be used to install the driver into the Monitor I/O system. Assume that the driver starting address is labeled, 'MAGDRVR'.

```
IODEF     EQU     ØF81EH
PlLOC     EQU     4
          .
          .
          .
          MVI     C,PlLOC         ; SET UP PUNCH1
          LXI     D,MAGDRVR       ; ADDR OF DRVR
          CALL    IODEF
          .
          .
          .
```

APPENDIX A

INTELLEC® MDS MONITOR COMMANDS

The following brief descriptions are intended as a quick reference to the function and syntax of the Intellec MDS Monitor commands. More complete descriptions of the commands are given in Section 3 of the manual.

A ASSIGN I/O DEVICE

A<logical dev>=<physical dev>

Valid values for <logical dev> and <physical dev> are:

<logical dev>	<physical dev>
C or CONSOLE	B or BATCH C or CRT (Default)* T or TTY (Default)* 1 (user-defined device)
L or LIST	C or CRT L or LPT T or TTY (Default) 1 (user-defined device)
P or PUNCH	P or PTP T or TTY (Default) 1 (user-defined device) 2 (user-defined device)
R or READER	P or PTR T or TTY (Default) 1 (user-defined device) 2 (user-defined device)

*One assigned during Cold Start procedure. See Section 2.

B PUNCH BNPF FILE

B<low address>,<high address>

C COMPARE PROM TO RAM

C<t/f><socket option><low address>,<high address>

where <t/f> = T for positive TRUE, F for negative TRUE; and <socket option> = X for Socket 2 (24 pin), Y for Socket 1 (high 4 bits), and Z for Socket 1 (low 4 bits).

D DISPLAY CONTENTS OF MEMORY

D<low address>,<high address>

E PUNCH HEXADECIMAL END-OF-FILE

E<start address>

F FILL RAM WITH CONSTANT

F<low address>,<high address>,<constant>

G EXECUTE PROGRAM (GO)

G<start address>,<breakpoint 1>,<breakpoint 2>

where <breakpoint 1> and <breakpoint 2> are always optional. If <start address> is absent, execution resumes at stored value of user's Program Counter.

H HEXADECIMAL ARITHMETIC

H<number 1>,<number 2>

The two results printed are ((<number 1>+<number 2>) MOD 2**16) and ((<number 1>-<number 2>) MOD 2**16), respectively.

L LOAD BNPF FILE

L<low address>,<high address>

M MOVE MEMORY

M<low address>,<high address>,<destination address>

N PUNCH NULL CHARACTERS

N

Each N will punch 60 NULL characters.

P PROGRAM A PROM

P<t/f><socket option><low address>,<high address>,<PROM address>

For values for <t/f> and <socket option>, see the C command.

Q I/O STATUS QUERY

Q

For meaning of values displayed, see the A command.

R READ HEXADECIMAL FILE

R<bias>

<bias> will be added (MOD 2**16) to indicated load addresses.

S SUBSTITUTE MEMORY

S<address>

Continue command with ' ' or ',' ; terminate with carriage return.

T TRANSFER PROM TO RAM

T<t/f><socket option><low address>,<high address>

For values for <t/f> and <socket option>, see the C command.

W WRITE HEXADECIMAL FILE

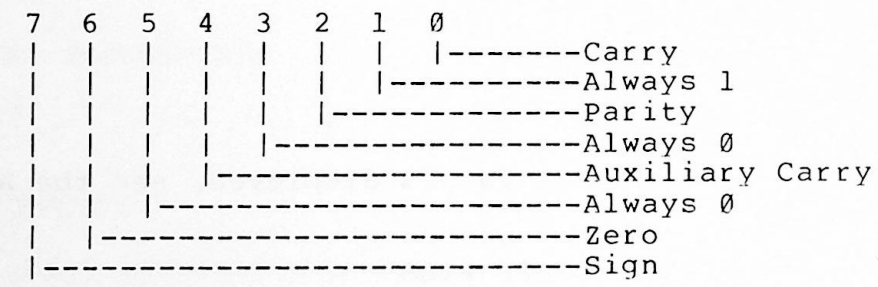
W<low address>,<high address>

X EXAMINE AND MODIFY CPU REGISTERS

X<register identifier>

where <register identifier> has the following meanings:

A,B,C,D,E,H,L	Corresponding 8080 CPU register.
M	H and L together.
P	Program Counter.
S	Stack Pointer
I	Intellec MDS Interrupt Mask Register.
F	8080 CPU flags, packed as follows:



If <register identifier> is absent, the Monitor will display each register in alphabetical order. Type a ' ' or ',' to continue command, or a carriage return to terminate.

APPENDIX B

TEXT EDITOR COMMANDS

A — Append text from READER to Text Buffer.

B — Move buffer pointer to beginning of Text Buffer.

nC — Move buffer pointer "n" character positions to the right (if n is positive) or to the left (if n is negative).

nD — Delete the "n" characters to the right (if n is positive) or to the left (if n is negative) of the buffer pointer.

E — Empty Text Buffer to PUNCH; copy remaining input in READER to PUNCH; reinitialize Text Editor.

Fstring$ — Find the first occurrence of "string" following the buffer pointer.

Istring$ — Insert "string" into Text Buffer at current buffer pointer position.

nK — Delete ("Kill") the "n" lines following (if n is positive) or preceding (if n is negative) the buffer pointer.

nL — Move the buffer pointer "n" lines forward (if n is positive) or backward (if n is negative).

N Punch 60 NULL characters.

Sstring 1$string 2$
Substitute "string 2" for the first occurrence of "string 1" following the buffer pointer.

nT Type the "n" lines following (if n is positive) or preceding (if n is negative) the buffer pointer.

nW Write the first "n" lines of the Text Buffer to the PUNCH; delete these lines from the Text Buffer. Note: "n" is interpreted as a positive number, regardless of the sign used in the command.

Z Move buffer pointer to end of Text Buffer.

n< ... >
Repeat the commands enclosed in "< ... >" "n" times.

APPENDIX C

ASSEMBLER ERROR MESSAGES

Errors detected by the assembler are indicated by single-letter codes on the output listing. When multiple errors are detected in a single line of code, only the first error is flagged.

The error flags and their meanings are:

B Balance Error

This error indicates that the parentheses in an expression are unbalanced, or that the quotes in a string are unbalanced.

Example:

```
ORG $/256+1)*256-$
DB 'A''
```

E Expression Error

This error indicates a badly constructed expression. It usually occurs due to a missing operator, omitted comma, or a misspelled opcode.

Example:

```
ORG ($/256+1)256-$
```

F Format Error

This message indicates an error in the format of a statement. It is usually caused by a missing operand or an extraneous operand.

Example:

```
MOV A,
MOV A,B,C
```

I Illegal Character

This message indicates that an invalid ASCII character is present in the statement. It is also caused by a numeric character which is too big for the base of the number in which it occurs.

Example:

```
MVI A,Ø2B
ADI A,79Q
```

M Multiple Definition

The M error message indicates that a symbol or a macro is defined more than once. The M error will occur on all definitions of, and all references to, the multiply-defined symbol. Recall that symbols must be unique in the first five characters; therefore, long symbol names which differ only at the end may cause an M error.

Example:

```
LOCATION1:  NOP
LOCATION2:  NOP
```

will cause an M error.

N Nesting Error

This message indicates that an ENDIF, ENDM, or END statement is improperly nested.

Example:

```
ENDIF
```

will cause an N error if no "IF" statement precedes it in the program.

P Phase Error

This message indicates that the value of an element being defined changed between pass one and pass two of of the assembly.

Example:

The following segment of code will cause every label in the assembly to produce a P error:

```
        ORG BEGIN
        .
        .
        .
BEGIN   EQU 5
        .
        .
```

During pass one, the symbol "BEGIN" is undefined when the "ORG" is encountered. The assembler will assume it to be at location zero and begin assembling the program at that location. During pass two, the symbol "BEGIN" is equal to 5. Therefore the location assigned to every label in the program will have increased by 5, producing a P error.

Q Questionable Syntax

This message is usually caused by omitting or misspelling an opcode.

Example:

```
... 34H,B3H
```

R Register Error

This message indicates that a register specified for an operation is invalid for the operation.

Example:

```
INR 9
```

S Stack Overflow

This error indicates that the assembler's internal expression evaluation stack became too large and overflowed the memory available to the assembler. It may be caused by using extremely long character strings, too many nested macros, too many nested "IF" statements, or expressions which are too complex.

Example:

A nested "IF" statement is one which occurs between another "IF/ENDIF" pair. Thus, long sequences of the form:

```
IF <EXPRESSION>
IF <EXPRESSION>
IF <EXPRESSION>
.
.
.
ENDIF
ENDIF
ENDIF
```

may cause an S error.

T Table Overflow

This message indicates that the assembler's symbol table space has been exhausted. This is caused by using too many symbols in one assembly, or by accumulating more macro text than the assembler can store in the memory available.

U Undefined Identifier

This message indicates that a symbol used in an operand field has never been defined by appearing in the label field of another instruction.

Example:

If the statement

```
JMP LAB1
```

is in the program, but LAB1 does not appear in the label field of any other statement, it will cause a "U" error.

V Illegal Value

This message indicates that the value of an operand or expression exceeds the range required for a particular operation.

Example:

The statement

```
MVI A,257
```

will cause a "V" error because the second operand of an "MVI" instruction must be in the number range 0 to 255.

APPENDIX D

OBJECT CODE FORMATS

Hexadecimal Object File Format

Hexadecimal object code format is an ASCII representation of program memory, expressed as a series of hexadecimal digits. These are blocked into records, each of which contains the record length, type, memory load address, and checksum, in addition to data. The description below applies to paper tape on a frame-by-frame basis.

Frame 0: RECORD MARK

A colon (3A in base 16) is used to signal the start of a record.

Frames 1, 2: RECORD LENGTH

This is the count of the actual data bytes in the record. Frame 1 contains the high-order digit of the count, and frame 2 contains the low-order digit. A record length of zero indicates end of file.

Frames 3-6: LOAD ADDRESS

The four-character starting address at which the following data will be loaded. The high-order digit of the load address is in frame 3, and the low-order digit is in frame 6. The first data byte is stored in the location indicated by the load address. Successive data bytes are stored in successive memory locations.

Frames 7, 8: RECORD TYPE

A two-digit code in this field specifies the type of this record. The high-order digit of this code is located in frame 7. Currently, all data records are type 0. End-of-file records may be type 0 or type 1; in either case, they are distinguished by a zero RECORD LENGTH field (see above). Other possible values for this field are reserved for future expansion.

Frames 9 to 9+2*(record length)-1: DATA

Each 8-bit memory word is represented by two frames containing ASCII characters Ø-9,A-F, which represent a hexadecimal value between Ø and FF (Ø and 255 decimal). The high-order digit of each byte is located in the first frame of each pair.

Frames 9+2*(record length) to 9+2*(record length)+1: CHECKSUM

The checksum is the negative of the sum of all 8-bit bytes in the record, beginning with the RECORD LENGTH and ending with the last DATA byte, evaluated modulo 256. The sum of all bytes in the record (including the checksum) should be zero.

BNPF Object File Format

BNPF format is an ASCII representation of a byte in pure binary form. A B is punched to indicate the beginning of a byte. Following the B, a string of P's and N's will be punched, with a 'P' representing a '1' bit, and an 'N' representing a '0' bit. An 'F' is used to indicate the end of a byte. All characters following the F are ignored until another B is encountered. This allows comments (not containing the letter B) to appear between bytes of data in BNPF format.

Bits of data in a BNPF byte appear in left-to-right order from most significant to least significant.

Example: The two bytes '3AF0' would be represented in BNPF format as

BNNPPPNPNF BPPPPNNNNF

APPENDIX E

MDS MONITOR I/O SYSTEM

Entry Point Addresses for MDS Monitor I/O Routines

Routine	Address	Function
CI	0F803H	Console Input
RI	0F806H	Reader Input
CO	0F809H	Console Output
PO	0F80CH	Punch Output
LO	0F80FH	List Output
CSTS	0F812H	Console Status
IOCHK	0F815H	Check I/O System Configuration
IOSET	0F818H	Set I/O System Configuration
MEMCHK	0F81BH	Determine Size of Available RAM
IODEF	0F81EH	Incorporate User-Written I/O Drivers

Device Selection Codes for Use with IODEF

Driver Function	Code
Console Input	0
Console Output	1
Reader (1)	2
Reader (2)	3
Punch (1)	4
Punch (2)	5
List	6
Console Status	7

Description of the I/O status byte

The I/O system status byte contains the current mapping of logical I/O devices to physical I/O devices. The 8-bit byte is subdivided into four 2-bit fields, each field corresponding to a logical device as follows:

bits 0,1	-	CONSOLE
bits 2,3	-	READER
bits 4,5	-	PUNCH
bits 6,7	-	LIST

Each field can contain a value 0-3 which represents the physical device currently assigned to it. The following paragraphs discuss each field in detail.

CONSOLE field, bits 0,1

00 - CONSOLE is assigned to the TTY
01 - CONSOLE is assigned to the CRT
10 - BATCH mode: use the READER as CONSOLE input, the LIST device as CONSOLE output.
11 - User-defined CONSOLE

READER field, bits 2,3

00 - READER = TTY
01 - READER = high speed reader, PTR
10 - User-defined READER (1)
11 - User-defined READER (2)

PUNCH field, bits 4,5

00 - PUNCH = TTY
01 - PUNCH = high speed punch, PTP
10 - User-defined PUNCH (1)
11 - User-defined PUNCH (2)

LIST field, bits 6,7

00 - LIST = TTY
01 - LIST = CRT
10 - LIST = LPT
11 - User-defined LIST device (1)

APPENDIX F

INTERRUPT PROCESSING ON THE INTELLEC® MDS

Introduction

Interrupt processing on the Intellec MDS is controlled by logic on the 8080 CPU Module. This module provides an eight-level priority interrupt structure, using an Interrupt Mask Register and a "current operating level" indicator, which keeps track of the level of interrupt (if any) currently being serviced. The Interrupt Mask Register, which can be set by a program or from the CONSOLE, permits the user to select which interrupts will be acknowledged at any time.

Priority of Interrupts

The Intellec MDS bus provides eight interrupt lines, numbered 0 through 7, corresponding to the eight Interrupt switches and lights on the MDS Front Panel. Interrupt 0 is the highest priority, and Interrupt 7 is the lowest. Thus, for example, an interrupt of level 4 which is currently being serviced can itself be interrupted to service an interrupt of level 3, 2, 1, or 0, but cannot be interrupted to service one of level 5, 6, or 7, nor by another interrupt of level 4.

The Interrupt Mask Register

The Interrupt Mask Register on the 8080 CPU Module determines which interrupts will be accepted by the MDS. The Interrupt Mask Register contains 8 bits, numbered 0 (least significant) through 7 (most significant). Each bit controls the recognition of interrupts at the corresponding level. A "1" bit in the Interrupt Mask Register prevents the corresponding interrupt from being serviced; a "0" bit allows the interrupt to be serviced. For example, the MDS Monitor sets the Interrupt Mask Register to 0FEH = 11111110, thereby blocking all interrupts but Interrupt 0.

The Interrupt Mask Register can be set programmatically by writing the desired value to Port 0FCH; thus

```
MVI     A,0F0H
OUT     0FCH
```

sets the Interrupt Mask Register to 11110000, blocking interrupts 4 - 7 and permitting interrupts 0 - 3.

A program can also read the current value of the Interrupt Mask Register from Port 0FCH:

```
IN      0FCH
```

places the current value of the Interrupt Mask Register into the A-register.

There are three phases to interrupt processing on the MDS:

- Initialization
- Acceptance
- Removal

These are discussed in detail below.

Initialization

The interrupt logic on the 8080 CPU Module must be initialized whenever the RESET switch on the front panel is used. The following steps must be done in the order indicated:

- A value of 12H must be written to Port 0FDH.
- A value of 00H must be written to Port 0FCH.
- The Interrupt Mask Register must be set to the desired value.

This can be accomplished as follows:

```
        .
        .
        .
MVI     A,12H
OUT     0FDH
MVI     A,00H
OUT     0FCH
MVI     A,MASK
OUT     0FCH
        .
        .
        .
```

where MASK has been set by an EQU or SET statement.

Interrupt Acceptance

When an interrupt occurs, the 8080 CPU Module checks the Interrupt Mask Register to see if an interrupt at that level is permitted. If it is not, no further action is taken; in particular, the interrupt is not cleared, and remains pending on the Intellec bus. If the interrupt is permitted, the CPU Module checks the "current operating level" to see if another interrupt of equal or higher priority is being serviced. If so, the new interrupt remains pending until the value of the "current operating level" is less than the priority of the new interrupt.

If this interrupt can be serviced now, the following actions take place:

- The CPU Module transmits a signal to the Interrupt Request line of the 8080, then locks out all interrupts coming from the Intellec bus.
- When the 8080 responds with an Interrupt Acknowledge, the CPU Module generates an RST instruction to one of eight addresses (see table below), stacks the current operating level to reflect the new interrupt, and resets the 8080 Interrupt Request Line.
- The lockout placed on interrupts from the Intellec bus is removed.

The addresses called when an interrupt is accepted are:

Interrupt Level	Address
0	0000H
1	0008H
2	0010H
3	0018H
4	0020H
5	0028H
6	0030H
7	0038H

Interrupt Removal

The program servicing the interrupt must do two things: it must transmit a signal to the interrupting device, telling it to remove the interrupt signal it generated initially; and it must restore the current operating level maintained by the CPU Module. The former action is device-dependent; the latter is accomplished by writing a value of 20H to Port 0FDH. This must be done with interrupts disabled. If the code permits another interrupt to be serviced while this is being done, a stack overflow could result. A sample sequence for doing this is:

```
        .
        .
        .
        <remove interrupt signal from external device>
        DI
        MVI     A,20H
        OUT     0FDH
        POP     PSW     ; RESTORE A REGISTER AND FLAGS
        EI
          .
          .
          .
```

The example below shows the code necessary to service an interrupt at level 1.

```
        ORG     8       ; RST ADDRESS FOR INTERRUPT 1
        JMP     INT1
        ORG     40H     ; ABOVE AREA USED BY MONITOR AND RST'S
INT1:
        EI              ; INTERRUPT ROUTINES CAN BE INTERRUPTED
        PUSH    PSW     ; SAVE REGISTERS
        PUSH    B
        PUSH    D
        PUSH    H
          '
          '
          '
        <code to service interrupt and remove signal>
          '
          '
          '
        POP     H       ; RESTORE REGISTERS
        POP     D
        POP     B
        DI              ; CRITICAL SECTION: DISABLE INTERRUPTS
        MVI     A,20H   ; RESTORE CURRENT OPERATING LEVEL
        OUT     0FDH
        POP     PSW     ; RESTORE A REGISTER AND FLAGS
        EI              ; PERMIT INTERRUPTS AFTER NEXT INSTRUCTION
        RET             ; MUST IMMEDIATELY FOLLOW 'EI' TO
                        ; MAKE SURE IT'S EXECUTED BEFORE ANOTHER
                        ; INTERRUPT OCCURS
```