PRIMER TRAINER EXTENDED MONITOR OPERATING SYSTEM USER'S MANUAL

Revision 2.1

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DISCLAIMER

MOS AND EMOS
REVISION HISTORY

EMOS VERSION 1.6 AND MOS VERSION 2.3

EMOS version 1.6 and MOS version 2.3 both have a feature that allows you to execute a service call in the MOS data entry mode without writing a program or changing the PC register or user memory. This is done by pressing "func." then "2". The C register should first be loaded with the desired service number and the other registers should be loaded with appropriate values, as needed by the service.

Also seven new MOS services were added as follows:

SERVICE 1A **LEDSTR** LED String output; This service routine allows you to individually turn off, or on, any of the segments on one or more of the numeric displays. The HL register pair will point to section of data for display bit patterns. The bit patterns stored here control the displays the same as the service LEDOUT (service 11). For example, the following program will send a pattern displays 4, 3 and 2 , leaving the others unchanged.

```
LEDSTR  EQU     1AH
MOS             EQU     1000H   ; address of MOS services
                ORG     0ff01h
                Mvi     c,LEDSTR        ; select LEDSTR service
                mvi     e,3             ; change 3 digits
                mvi     d,4             ; starting at display 4, going right
                lxi     h,bitpat  ; point to table of bit patterns
                call    MOS
loop:           jmp     loop            ; loop here so we can see displays
bitpat:         db      00010000b,00000100b,10000000b
```

```
MACHINE LANGUAGE
ADDRESS              DATA      INSTRUCTION
FF01                 0E        MVI C,1A
FF02                 1A
FF03                 1E        MVI E,3
FF04                 03
FF05                 16        MVI D,4
FF06                 04
FF07                 21        LXI H,FF10
FF08                 10
FF09                 FF
FF0A                 CD        CALL 1000
FF0B                 00
FF0C                 10
FF0D                 C3        JMP FF03
FF0E                 03
FF0F                 FF
FF10                 10        BIT PATTERN DATA
FF11                 04
FF12                 80
```

	INPUT	REGISTER C: 1A
		REGISTER E: Number of displays to change (1 to 6)
		REGISTER D: Starting display (numbered 5-0 from left to right).
		REGISTER PAIR HL: Address of string of bit pattern data to be shown on the displays
	OUTPUT	NONE

SERVICE 1B	**DDATA**	Display the hex byte in E on the DATA/OP displays
	INPUT	REGISTER C: 1B
	OUTPUT	NONE

The remaining five new services are used to support the EPROM programmer board.

EMAC's EPROM programmer (E020-8) allows you to program EPROMs of a variety of types and voltages. The smallest EPROM supported is a 2764 (8K x 8) and largest EPROM supported is 27512 (64K x 8). Each EPROM type is given an identification number. The 6 EPROM type numbers supported are as follows:

```
TYPE #1   27512 ( 64K x 8 ) EPROM WHICH PROGRAMS AT 12.5 VOLTS.
TYPE #2   27256 ( 32K x 8 ) EPROM WHICH PROGRAMS AT 12.5 VOLTS.
TYPE #3   27128 ( 16K x 8 ) EPROM WHICH PROGRAMS AT 12.5 VOLTS.
TYPE #4   27128 ( 16K x 8 ) EPROM WHICH PROGRAMS AT 21.0 VOLTS.
TYPE #5   2764  (  8K x 8 ) EPROM WHICH PROGRAMS AT 12.5 VOLTS.
TYPE #6   2764  (  8K x 8 ) EPROM WHICH PROGRAMS AT 21.0 VOLTS.
```

If an illegal type number is passed to one of the following services, the A register will return the value 4, with other registers unaffected.

There are four MOS services which support EMAC's EPROM programmer.

READ (service 1C)

Copies a number of bytes starting at an EPROM memory address and stores them in system memory.

VERIFY (service 1D)

VERIFY determines whether the data in the EPROM in the programmer matches a range of data in system memory.

BURN (service 1E)

This writes a number of bytes from system memory to EPROM.

The above commands require that you load the 8085 registers as follows:

H	High order byte of system memory address
L	High order byte of EPROM address
	(NOTE: The low order bytes of the system memory and EPROM addresses default to 0)

DE	Number of bytes
B	EPROM type (as in the table above)
C	Service number

When VERIFY or BURN, have finished executing with no errors, the A register will be 0 and the other registers(except the flag register) will be unaffected. If A is not 0, an error has occurred. and the registers will be returned with the following information.

BC	Address that error occurred in system memory
H	Value of data at address BC in system memory
DE	Address that error occurred in the EPROM in the programmer
L	Value of data at address DE in the EPROM in the programmer

ERASECHK (service 1F)

ERASECHK tells whether an EPROM is erased. This command requires you to load the registers as follows:

DE	Starting address from which to examine EPROM. It examines from this address down to 0.
B	EPROM type (as in the table above)
C	Service number 1Fh

The A register will be returned with 0 if the EPROM is erased.

ZAP (service 20)

ZAP allows you to put your own application program into a 32k EPROM. BURN also allows this, but ZAP will automatically examine the EPROM to see if it is erased, put in the initialization and MOS services code and verify that the data was written correctly. This command requires you to load the registers as follows:

H	High byte of starting address of user program (low byte defaults to 01)
DE	Number of bytes in program (this should be no bigger than 50FEH)
C	Service number 20h

If ZAP has finished executing with no errors, the A register will be 0 and the other registers (except the flag register) will be unaffected. If an error has occured, the A register will indicate the following:

A=1 Error during EPROM write (registers returned with same values as BURN error)
A=2 Error during verification (registers returned with same values as VERIFY error)
A=3 EPROM not erased (registers returned with same values as ERASECHK error)

To make an EPROM-based application:

1) Load and test your program. To make it easier to relocate your program to 2F01h, you should start at address XF01h, where X denotes a hex digit which would result in a valid RAM address. Address FF01h could be used, for example.

2) Rewrite the program to execute at address 2F01h. If you have an assembler, this will be easy. Otherwise you must look for all JMP's and CALL's that need to be changed. Remember that if your program refers to data tables, these should be relocated to EPROM, and all RAM variables should remain at the same address. Also, remember that all registers, except the stack pointer and program counter must be initialized by the user.

3) Put a blank 32k EPROM (type 2 EPROM) in the programmer, aligning pin 1 of the chip to pin 1 of the socket, then latch the socket

4) Load DE with the length of the program, H with the upper byte of the starting address of the program and C with 20h (for service 20). Press "func." then "2" to make MOS service call.

5) Remove power from the trainer and carefully replace its EPROM with the EPROM that was just programmed, making sure pin 1 of the EPROM goes to pin 1 of the socket. 0J2 must be in position B for a 32k EPROM. Place the unused EPROM in a static safe area.

6) Power up your unit and the program should begin to run. If it doesn't work, make sure you have followed these procedures carefully, especially step 2.

To insure desired results:

When inserting or removing EPROMS, make sure the EPROM burner power LED is off.

When performing an ERASECHK, VERIFY or BURN command make sure the EPROM type was correctly entered.

EMOS has a new menu option which is defined as follows:

Z --> Zap application EPROM

"Z" The Zap application command allows you to execute the ZAP service from the EMOS prompt

When the command is issued, the Monitor responds with:

STARTING HIGH ADDRESS ...

This is the upper byte of the start address of your program in memory (the lower byte of the address defaults to 01). Two hex digits should be typed here.

The monitor then responds with:

NO. OF BYTES..

This is the number of bytes in your program, and can be up to 4 hex digits.

After this, the program will begin to be written to the EPROM and the monitor will respond with appropriate error messages, if necessary.

EMOS VERSION 1.7

This version fixed a bug in the EPROM programmer drivers.

EMOS VERSION 1.8 AND MOS VERSION 2.4

Service 9 (ADCIN) was speeded up by using a successive approximation algorithm. This new routine is also more accurate at lower voltages since it now allows for settling time of the A/D circuitry.

The self test mode was modified to do a checksum on the ROM, and also adds a local loopback test of the optional serial port. At the beginning of the self-test (invoked when the "func." And "1" keys are pressed) a checksum is performed on the ROM and if an error is detected you will hear a beep and "b.E." will be shown on the right 2 displays indicating "Bad EPROM". Pressing a key at this point will resume the RAM diagnostics (indicated by "r.d." on the DATA/OP displays). If a bad RAM location is found, you will hear a beep, the address will be shown on the ADDRESS/REGISTER PAIR displays and "b.r." will be shown on the right 2 displays. Note that if you don't have a 32K RAM and you get a bad RAM error at 8000, this is not a valid error. Pressing a key after an error will resume the self-test.

After the RAM diagnostics, the self-test will try to determine whether there is a serial port. If there isn't or if it is not working, "n.u." will be displayed (indicating No UART).   If a serial port is detected, it is examined to see if it is configured for a local loopback test. It is configured for local loopback when the transmit and receive lines of the serial port are connected to each other (pins 2 and 3 respectively of the DB9 connector CN2). If it is not configured this way the self-test will work as the previous versions. This connection allows data transmitted, by the UART to be looped back to the UART, testing both the transmitter and the receiver.

In this configuration, if the serial port is working, the bytes 00 to FF hex will be transmitted and displayed on the left 2 displays (this will happen quite rapidly at higher baud rates, so if you want to watch it, set JP1 to around 2400 baud). If there is a problem with the serial communications, you will hear a beep and "b.S." will be shown on the right 2 displays indicating a Bad Serial port. Pressing a key after this will resume the self test and the UART will be disabled. If the local loopback test runs without errors "L.L." will be shown on the left 2 displays, the UART will be disabled and the self-test will continue and work the same as the previous versions. If "L.L." is not displayed and it has been verified that the transmit and receive lines were connected together, there is a problem with the serial port circuitry.

MOS VERSION 2.5

This includes the improvements to the EPROM programmer drivers from EMOS 1.7 and a new function key which allows the PRIMER to receive an Intel hex file via the serial port (part number E600-10 or E600-11). To invoke this function press "Func." then "3". After this, the displays will show "rEC.." indicating that the PRIMER is ready to receive the data. After an ending record is received, (a record in which the fourth pair of digits following the colon is 01), the PRIMER will return to entry mode. If any errors occur while receiving the hex file "Err.." will be displayed followed by a hex number. The bits in this number, after it is\ converted to binary indicate the following errors:

BIT#	ERROR
0	(not used)
1	checksum error
2	non-hex character encountered
3	escape character encountered
4-7	(not used)

Pressing a key after the error message will put the PRIMER back into entry mode. Receiving a hex file may be aborted any time by resetting the PRIMER or by sending an escape character (1Bh) to the PRIMER's serial port. Sending an escape character will result in an "Err..08".

EMOS VERSION 1.9 AND MOS VERSION 2.6

These change the protocol so that 1 instead of 2 stop bits are transmitted.

EMOS VERSION 2.0 AND MOS VERSION 2.7

This includes four new services and a full menu driven EPROM Programmer which allows you to burn, read, copy and modify EPROMS from your PC. To invoke the EPROM Programmer menu press ‘Func' then 4'. To use the EPROM Programmer Software, the PRIMER must be equipped with the EPROM Programmer Board (E020-8) and one of the upgrades (E600-10 or E600-11).

SERVICE 21	**DECPNT**	LED Decimal Point output. This service allows you to individually turn on or off the 6 decimal points on the LED display. The D register bits 0-5 correspond to digits 0-5. A 0 will turn off the decimal point and a 1 will turn it on.
	INPUT	REGISTER C: 21H REGISTER D: bit pattern to light or unlight appropriate decimal points.
	OUTPUT	NONE
SERVICE 22	**BIN2BCD**	Binary to Binary Coded Decimal. This service converts the 16 bit number in register pair DE to binary coded decimal with the low nibble in register E being the least significant digit
	INPUT	REGISTER C: 23H REGISTER PAIR DE: The number to be converted to BCD
	OUTPUT	REGISTER PAIR DE: The BCD number.
SERVICE 23	**BCD2BIN**	Binary Coded Decimal to Binary. This service converts a 4 digit BCD number in register pair DE to binary.
	INPUT	REGISTER C: 24H REGISTER PAIR DE: 4 digit BCD number
	OUTPUT	REGISTER PAIR DE: converted number in binary
SERVICE 24	**KPINPUT**	Keypad Input. This service allows the user to input up to a 4 digit number from the keypad. The number will be returned in the DE register pair. The numbers can be displayed on the LED display by loading D with 1 before the service is called. The LED display will be turned off if D = 0. The service will not return until the "ENT" key is pressed. Once ENTER is pressed, the last 4 digits entered will be loaded in DE with the last digit being the Least significant. If 4 digits are not entered, a 0 will be assumed for the leading digits.
	INPUT	REGISTER C: 24H REGISTER D: 1 for LED display on, 0 for LED display off.
	OUTPUT	REGISTER PAIR DE: 4 digit number from keypad

TABLE OF CONTENTS

APPENDICES

FEATURES

* Easy data entry via PC or dumb terminal.
* Ability to scan all 64K of memory space.
* Ability to change any RAM location.
* Ability to execute from any memory location.
* Ability to single step or run full speed with break.
* Ability to Examine and change the contents of any register.
* Separate user stack area.
* Provides services for console input/output etc.
* Timer, UART, and I/O ports.
* 6 bit A/D and D/A convertor.
* A sound port, which consists of a piezoelectric beeper driven by a programmable counter, can produce variable frequencies.
* 6 digit numeric LED display.
* 8 digital outputs with LEDs for status indication.
* Easy access to analog and digital I/O through headers.
* Assembly Language Drivers provided for I/O devices.

INTRODUCTION

The PRIMER Trainer is a compact, low cost, 8085 based microprocessor system, designed primarily for educational purposes. In spite of its low cost and small size, it contains many important and educational features. The PRIMER has digital I/O, analog I/O, and a display plus keypad for human interface. The unit is preprogrammed via a 32K EPROM to allow the user to single step and easily access the microprocessor registers. User programs can be stored virtually anywhere within 32K RAM space, providing ample room for even complex programs. Assembly language subroutine drivers and EMOS services are provided for each I/O device to ease programming.

GETTING STARTED

Before using EMOS, the PRIMER must have the Upgrade Option installed. Once this option is installed, the jumpers must be placed at the following positions:

OJ1 must have jumpers between pins 1 and 2, and pins 3 and 4
OJ2 must be moved to option B
OJ3 must be moved to option B

NOTE: Appendix A gives more detailed descriptions of the jumpers.

The PRIMER needs an appropriate power source. It requires a power supply in the range of 7 to 10 volts DC that can supply more than 480 milliamps of current. This power may be taken from a bench power supply, a wall mounted power supply or any other suitable power source. The power supply's output plug tip must be positive and the sleeve must be negative. A wall mounted power supply that meets all of the previous stated requirements may be obtained from EMAC Inc.

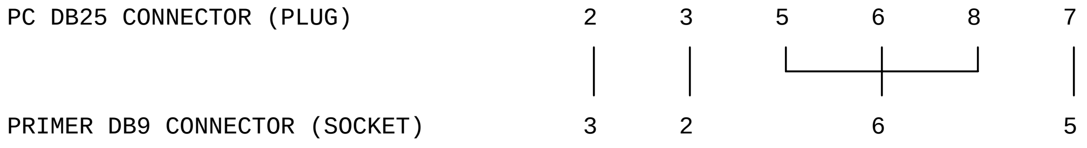
Once power has been correctly applied to the PRIMER's power jack, the PRIMER should give a tone and then show hex numbers on the digital displays. If this doesn't happen after about a second, remove the power immediately and make sure that the power supply meets the above stated requirements.

EMOS requires that a terminal be connected to the PRIMER. The PRIMER's baud rate must be the same as the PC or terminal it is communicating with. The baud rate can be set by placing a jumper in JP1 in the position corresponding to the desired baud rate. The baud rates are labeled 300, 600, 1200, 2400, 4800, 9600 and 19,200 next to this jumper. The PC or terminal must use serial protocol with 1 stop bit, 8 data bits and no parity.

The following information regarding the cable assembly should be followed carefully to assure correct operation.

“Handshaking" lines are not required by the PRIMER but may be necessary for the IBM PC and compatibles used as terminal emulators. To assure proper handshaking when using the PRIMER, tie RS-232 handshake lines CTS, DSR, and DCD (pins 5, 6, and 8 on the DB25 connector) to DTR (pin 6) of the DB9 PRIMER connector (socket). An alternate method involves wiring a null modem cable. This is easily accomplished by tying CTS, DSR, and DCD to DTR, pin 20 of the DB25 connector that plugs into the PC. One of the above methods should achieve success.

<u>The Receive (RxD pin 3) and Transmit (TxD pin 2) lines also require modification prior to being connected. See diagram below.</u>



Some terminals require pins 2 and 3 of the DB25 go to pins 2 and 3 of the DB9 respectively:

```
PC DB25 CONNECTOR (PLUG)              2    3    5    6    8    7
                                      │    │    └────┼────┘    │
PRIMER DB9 CONNECTOR (SOCKET)         2    3         6         5
```

When power is first applied to the PRIMER, EMOS starts executing a program called MOS which is included in the EPROM. This MOS is a simple version of EMOS that doesn't require terminal and uses the keypad and displays for interaction. MOS has a diagnosis function built in which allows you to check the dip switches, digital output LEDs, A/D convertor, 8155 timer, speaker, numeric displays, keypad and the serial RS232 port. To execute this function, press the "Func." key then "1". When the diagnosis begins, "....r.d." will be shown on the numeric displays indicating that "RAM Diagnostics" is occurring. If a faulty RAM location is detected, its memory address will be shown on the left 4 numeric displays and "b.r." (indicating Bad RAM) will be shown on the right 2 displays. Pressing a key following this error message will cause the diagnosis to continue. Note that no memory check is done on the RAM within the 8155 chip if a 32k RAM is in slot 1.

If the PRIMER is properly connected to a terminal, as soon as the memory check is finished the following will be shown on the terminal display:

```
UART test
>
```

If you type a key at the terminal, its hexadecimal ASCII value will be shown on the left two displays on the PRIMER, and the character will be echoed back to the terminal display. For example if the letters "A" and "B" are typed at the terminal, the following will be shown on the terminal display:

```
UART test
>A
>B
>
```

Note: If your terminal has the ability to "auto echo" you will see 2 characters displayed for each key pressed.

Also, after the memory test is done, the hexadecimal representation of the A/D input will be shown on the right 2 displays. If you want to test the A/D convertor you need to connect a variable voltage source, ranging from 0 to +5 volts, to the analog input of the external digital I/O connector CN3 (this is above and to the left of the ADDRESS/REGISTER PAIR displays). This can be simply done with a 10K potentiometer by connecting the wiper to the analog input and one of the other two connections to +5V and the other to ground. Connector CN3 provides +5 volts on pin 22, analog input on pin 20 and ground on pin 18. When the analog input voltage is ground the display should show "00". As you slowly increase the voltage to 5 volts, the display will show a value from 02 to 3F hex. Also when the display no longer shows "00" the speaker will begin to make a high pitched tone and which will gradually become lower pitched as the voltage approaches 5 volts. Turn the voltage back to 0 and the tone will stop.

Each dip switch is programmed to control an individual digital output LED. The best way to test the dip switches and the LEDs is to turn each of the switches on, allowing only one switch on at a time. Then turn all the switches on at once, and finally turn all of them off.

Pressing one of the keys on the keypad will cause the hexadecimal value of that key to be shown on the middle two displays. The hexadecimal values of the keys, starting at the top row and reading from left to right are 00 to 0F for the first 4 rows and 14 to 17 for the last row.

When you want to return to the Monitor Operating System, just press the reset button. If the PRIMER is properly connected to the terminal you can now start EMOS by pressing the "Func." key then the "0" key.

SOFTWARE REFERENCE

The Extended Monitor Operating System (EMOS) is a powerful software program that provides the user with the tools to enter and edit code as well as run, test, and debug the code. EMOS prompts the user for additional input and checks the input to be sure it is of the proper form. A help menu is available which lists each command with a brief description. The "escape" key or bad input will abort the issued command and cause a "?" to be displayed.

REMEMBER:

- When an "ADDRESS" is requested, enter a number of up to 4 HEX digits.
- When a "BLOCK" is requested, enter a number of up to 2 DEC (decimal) digits.

MONITOR COMMANDS

"?" The Help command displays the help menu which contains the Monitor commands and a short description of each command. The help menu screen is as follows:

EMOS Vx.xx HELP MENU

```
B --> Bring Block from RAMDISK to Memory
C --> Change register contents
D --> Dump memory contents
E --> Edit memory contents
F --> Fill memory with byte
G --> Go execute program { full speed }
H --> Hex/Decimal math {1st + 2nd, 1st - 2nd}
I --> Input from I/O port
L --> List memory contents using mnemonics
M --> Move section of memory
O --> Output to I/O port
R --> display Register contents
S --> MOS Service call
T --> Trace program execution
W --> Write memory to RAMDISK
< --> hex download from trainer to host
> --> hex upload to trainer from host
? --> display this help menu
```

"B" The Bring Block command allows the user to copy a block (256 bytes) or blocks of data from RAMDISK to memory.

When the Bring Block command is issued, the Monitor responds with:

DEST. ADDRESS ...

Enter the starting memory address, up to 4 HEX digits, where the RAMDISK data will be copied to.

The Monitor then responds with:

STARTING BLOCK ...

Enter the starting block number, up to 2 DEC digits, of the desired first block.

NOTE: Memory slot 2 contains blocks 1 - 75.

The Monitor then responds with:

NUMBER OF BLOCKS ...

Enter the number of blocks, up to 2 DEC digits, that are to be copied to memory.

NOTE: If (STARTING BLOCK + NUMBER OF BLOCKS) is greater than 75, the monitor will display:

ERROR BLOCK OUT OF RANGE !

and, after a short delay, return to the system prompt.
NOTE: See the section - USE OF RAMDISKS.

"C" The Change command allows the user to change any of the microprocessor's registers, the top element of the stack and the current memory location pointed to by the program counter.

When the Change command is issued, the Monitor program first displays the current contents of all the registers, and prompts the user with:

SELECT REG. [F,A,B,C,D,E,H,L,T,S,P,O]..

The Monitor then expects one of the capital letters contained within the brackets to be entered. The letter "F" stands for the Processor Status Word Flags, "A" is the Accumulator and "B,C,D,E,H,L" are the 8085 General Purpose Registers of the same name. Each of these registers can contain at most 2 HEX digits (8 bits). The letter "T" stands for the "top of stack" which are the next two bytes to be removed from the stack. Though this is not an actual register, it is treated like one so you can view and/or change the value on the top of the stack. The letter "S" stands for the Stack Pointer, which is initialized at power-up to address FFD4 HEX. The letter "P" stands for the Program Counter, which is initialized at power-up to address 8F01 HEX. Each of these registers can contain at most 4 HEX digits (16 bits). The last letter "O" stands for op code, and its selection allows the user to change the contents of the memory location pointed to by the Program Counter. This location is referred to as op code since it is assumed that any location the Program Counter points to is to be executed and thus must contain a valid op code. After entering a selected letter the Monitor then responds with:

CHANGE TO..

The maximum number of HEX digits that can be entered depends on which of the letters is chosen. The value entered will then replace the current contents and the registers are redisplayed.

"D" The Dump command allows the user to view the memory contents of any given section of memory. The contents are displayed in HEX with the associated ASCII characters displayed as well.

When the Dump command is issued the Monitor responds with:

STARTING ADDRESS..

The user then enters the starting address (up to 4 HEX digits are valid) of the section of memory to be Dumped.

After entering the starting address the Monitor then asks:

NUMBER OF BYTES..

The user then enters the number of bytes to display on the screen. Up to 3 HEX digits are valid and this number, as with most numbers returned by EMOS, is a HEX value. The Dump command automatically rounds this value so as to display a full line of 16 bytes.

"E" The Edit commands allows the user to easily enter and modify code or data in successive memory locations.

When the Edit command is issued the Monitor responds with:

STARTING ADDRESS..

The user then enters the starting address of where code is to be entered or modified. Up to 4 HEX digits are valid. The Edit command will then display this address and its contents. The user then enters the new contents (up to 2 HEX digits). The next successive address is then displayed with its contents. If the user does not want to change the contents of this address, he simply presses the <ENTER> key and the next successive address and memory contents are displayed. The ability to " backtrack " is also available; typing a minus sign " - " followed by one Hex digit (1 - F) will decrement the address pointer by the amount of the digit. To quit editing and return to the monitor prompt, press the <ESC> key.

"F" The Fill command allows the user to Fill the memory contents of any given section of memory with a given byte.

When the Fill command is issued the Monitor responds with:

STARTING ADDRESS..

The user then enters the starting address of the section of memory to be Filled. Up to 4 HEX digits are valid.

The Monitor then requests:

NUMBER OF BYTES..

The user then enters the number of memory bytes to Fill. Up to 3 HEX digits are valid.

The Monitor then requests:

FILL BYTE..

The user enters the byte (up to 2 HEX digits) to fill the selected memory with.

"G" The Go command allows the user to execute a program in memory at full speed with an optional breakpoint. The program will continue to execute until the breakpoint is encountered, a key is pressed, or until a RST 7 (FFH) instruction is executed.

When the Go command is issued the Monitor responds with:

STARTING ADDRESS..

The user then enters the starting address of the program to be executed. Up to 4 HEX digits are valid. If only the <ENTER> key is pressed the program will start to execute from the current contents of the Program Counter.

The Monitor then requests:

```
BREAKPOINT ADDRESS..
```

The user then enters the address (up to 4 HEX digits) of where the user wishes the execution to stop.
Note: If the program execution never reaches the breakpoint address or the breakpoint address is not that of an op code the program will not stop at the breakpoint address. If the <ENTER> key is pressed without entering the breakpoint address, no breakpoint is set.

"H" The Hex/Dec math command provides the user with the sum and difference of two numbers. This command allows the user to declare the base of the numbers that will be entered as either Hexadecimal or Decimal.

When the Hex/Dec command is issued, the monitor responds with:

```
DEC OR HEX (D/H)...
```

After a D (for Decimal) or an H (for Hexadecimal) is entered, the monitor responds with:

```
1ST NUMBER...
```

Enter the number, up to 4 digits for HEX or 5 digits for DEC, in the chosen base. The monitor then responds with:

```
2ND NUMBER...
```

Enter the second number, up to 4 digits for HEX or 5 digits for DEC, in the chosen base.
The monitor will respond with:

```
HEX SUM     = xxxx   DEC SUM     = xxxx   SIGNED DEC SUM     = xxxx
HEX DIFF    = xxxx   DEC DIFF    = xxxx   SIGNED DEC DIFF    = xxxx
```

where xxxx is the result of the math operation.
NOTE: To convert a number from one base to another, choose 0 as the response to the second number prompt.

"I" The Input command allows the user to Input the contents of an I/O port. The I/O address is an 8 bit HEX value and the content is also an 8 bit value displayed in HEX.

When the Input command is issued the Monitor responds with:

```
I/O PORT ADDRESS..
```

The user then enters the I/O address of the port to be read from. Up to 2 HEX digits are valid.

After entering the I/O port address the Monitor will respond with:

```
CONTENTS OF THE I/O PORT IS .. xx
```

where xx represents the contents of the specified I/O port displayed as an 8 bit hex value.

"L" The List command allows the user to view 16 machine language instructions beginning at any address in memory. The information that will be displayed, is the memory address of the instruction, its op code and then the mnemonic. All numbers displayed are in hex.

When the List command is issued the Monitor responds with:

STARTING ADDRESS..

The user then enters the starting address (up to 4 HEX digits are valid) of the section of memory to be Listed.

The 16 machine language instructions will be listed followed by the message...

ESC TO QUIT, ANY KEY TO CONTINUE.

If ESC is pressed the command will be aborted. If any other key is pressed, another 16 lines of instructions will be listed.

"M" The Move command allows the user to Move the memory contents of any given section of memory to another memory location. The source memory contents are left intact.

When the Move command is issued the Monitor responds with:

SOURCE ADDRESS..

The user then enters the source address of the section of memory to be moved. Up to 4 HEX digits are valid. After entering the starting address the Monitor then asks:

DESTINATION ADDRESS..

The user then enters the destination address of the section of memory to Move the source contents to. After entering the destination address (up to 4 HEX digits) the Monitor then prompts for the:

NO. OF BYTES..

The user then enters the number of memory bytes to Move. Up to 3 HEX digits are valid and this number is a HEX value.

"O" The Output command allows the user to output an 8 bit HEX value to a specified I/O port address. The I/O port address is entered as an 8 bit HEX value.

When the Output command is issued the Monitor responds with:

I/O PORT ADDRESS..

The user then enters the I/O address of the port to be written to. Up to 2 HEX digits are valid.

The Monitor will respond with:

I/O DATA BYTE..

The user then enters the 8 bit HEX value to be written to the specified I/O port address.

"R" The Register command displays the current contents of all accessible CPU registers, the flags, the value on the top of the stack and the op code pointed to by the Program Counter and the mnemonic of that op code.

"S" The MOS Service call allows the user to access EMOS Services without having to execute a CALL instruction.

When the Service command is issued, the monitor prompts the user for:

SERVICE NUMBER ..

For a listing of the available service calls, consult the section on EMOS services in this manual.
NOTE: The input parameters must be placed in the appropriate registers, before executing the S command. The C register is automatically loaded with the service number.

"T" The Trace command executes a single instruction and displays the register contents after each instruction.
Note: Since the Trace command is performed through software, operand fetches are not shown.

When the Trace command is issued the Monitor prompts the user for:

NUMBER OF INSTRUCTIONS..

The user enters up to a 2 HEX digit, value. This value determines the number of instructions executed. After each executed instruction the register contents are displayed. If the user does not enter the number of steps, but hits the <ENTER> key, then 1 instruction is executed.
NOTE: Instructions in EPROM cannot be traced so if a service call is traced, the service call is executed at full speed and, upon returning to the calling program, the Trace command resumes execution.

"W" The Write command allows the user to write the contents of memory to a RAMDISK block (or blocks).

When the Write command is issued the Monitor responds with:

SOURCE ADDRESS ...

Enter the starting memory address (up to 4 HEX digits) of the data to be copied.

The Monitor then responds with:

STARTING BLOCK ...

Enter the block in RAMDISK (up to 2 DEC digits) where the data is to be stored.

The Monitor then responds with:

NUMBER OF BLOCKS ...

Enter the number of blocks (up to 2 DEC digits) that will be needed to store the data.

If (STARTING BLOCK + NUMBER OF BLOCKS) is greater than 75 the error message

ERROR BLOCK OUT OF RANGE!

will be displayed, no Write action will be done, and the original prompt will return.
REMEMBER: The size of a block is 256 bytes.

">" The Hex upload command loads data from the host to the PRIMER in Intel HEX format.

When the upload command is issued, the Monitor responds with:

STARTING ADDRESS ...

this is the memory address in the PRIMER where the data is to be loaded (up to 4 HEX digits.)
The Monitor responds with:

READY TO RECEIVE, <ESC> TO ABORT

The transfer of data can be stopped by pressing <ESC>.
NOTE: This command is to be used in conjunction with a communication package running on a PC (see the section on COMMUNICATION USING ECOM).

"<" The Hex Download command saves data from the PRIMER to the host in Intel HEX format.

When the Download command is issued, the Monitor responds with:

STARTING ADDRESS ...

This is the starting memory address (in the PRIMER) of the data to be saved (up to 4 HEX digits).

The Monitor then responds with:

LAST ADDRESS ...

This is the ending address of the data to be saved (up to 4 HEX digits).

The Monitor then responds with:

OFFSET ADDRESS ...

The offset address is normally entered with the same address used for the starting address prompt. To begin downloading, press the <SPACE> key.
NOTE: This command is to be used in conjunction with a communication package running on a PC (see the section on COMMUNICATION USING ECOM).

EMOS SERVICES

EMOS allows the user to access services with a single function (subroutine) CALL to address 1000 Hex. In addition all registers that are not used as input or output to the service are preserved. The services are as follows:

SERVICE 0	**DEMO**	Demonstration; this service routine sends a pitch of increasing frequency to the speaker while flashing the output LEDs at an increasing rate.
	INPUT	REGISTER C: 0
	OUTPUT	NONE
SERVICE 1	**CONIN**	Console input; this service waits for a key from the terminal keyboard to be pressed. This service requires the optional serial port.
	INPUT	REGISTER C: 1
	OUTPUT	REGISTER L: ASCII character returned from keyboard.
SERVICE 2	**CONSTAT**	Console input status; this service returns a 0FFH if a key was pressed otherwise a 00H. This service is used in conjunction with a PC/Terminal device connected to the serial port. This service requires the optional serial port.
	INPUT	REGISTER C: 2
	OUTPUT	REGISTER L: Console status.
SERVICE 3	**CONOUT**	Console output; this service outputs a ASCII character to the terminal CRT. This service is used in conjunction with a PC/Terminal device connected to the serial port. This service requires the optional serial port.
	INPUT	REGISTER C: 3
		REGISTER E: ASCII character.
	OUTPUT	NONE
SERVICE 4	**PSTRING**	Print string; this service prints to the terminal display the string of ASCII characters starting at the address in the DE register pair until a "$" is encountered. The "$" delimiter is not printed. This service is used in conjunction with a PC/Terminal device connected to the serial port. This service requires the optional serial port.
	INPUT	REGISTER C: 4
		REGISTER PAIR DE: Starting character string address.
	OUTPUT	REGISTER PAIR DE: Address of character after the "$" character.
SERVICE 5	**UPRINT**	Unsigned print; this service prints to the terminal display a 16 bit number, in decimal without use of sign. This service is used in conjunction with a PC/Terminal device connected to the serial port. This service requires the optional serial port.
	INPUT	REGISTER C: 5
		REGISTER PAIR DE: 16 bit unsigned number to print.
	OUTPUT	NONE
SERVICE 6	**SPRINT**	Signed print; this service prints a 16 bit number to the terminal display, in decimal with use of sign (2's complement). This service is used in conjunction with a PC/Terminal device connected to the serial port. This service requires the optional serial port.
	INPUT	REGISTER C: 6
		REGISTER PAIR DE: 16 bit signed number to print.
	OUTPUT	NONE

SERVICE 7	**MULT**	Multiply; this service multiplies two 16 bit numbers. The HL register is returned as the most significant word and the DE register is returned as the least significant word.
	INPUT	REGISTER C: 7
		REGISTER PAIR DE: 16 bit multiplicand.
		REGISTER PAIR HL: 16 bit multiplier.
	OUTPUT	REGISTER PAIR HL: Most significant word of product.
	OUTPUT	REGISTER PAIR DE: Least significant word of product.
SERVICE 8	**DIV**	Unsigned division; this service divides HL by DE (HL/DE). The quotient is returned in HL and the remainder in DE.
	INPUT	REGISTER C: 8
		REGISTER PAIR HL: 16 bit dividend.
		REGISTER PAIR DE: 16 bit divisor.
	OUTPUT	REGISTER PAIR HL: 16 bit quotient.
		REGISTER PAIR DE: 16 bit remainder.
SERVICE 9	**ADCIN**	Analog to Digital input; this service returns a 6 bit value from the analog to digital converter.
	INPUT	REGISTER C: 9
	OUTPUT	REGISTER L: 6 bit analog conversion.
SERVICE A	**DIPSWIN**	Dip switch input; this service reads the current switch positions of the 8 position dipswitch.
	INPUT	REGISTER C: 0A
	OUTPUT	REGISTER L: Dipswitch value.
SERVICE B	**KEYIN**	Read the keypad; this service waits for a key to be pressed and returns the value in the L register.
	INPUT	REGISTER C: 0B
	OUTPUT	REGISTER L: Key value. Keys "0-F" return 00-0F respectively and the "Step", "Func.", "Dec.", and "Enter" keys return 14-17 respectively.
SERVICE C	**PTAOUT**	Port A output; this service writes to the digital output port A.
	INPUT	REGISTER C: C
		REGISTER E: 8 bit value to write to port A.
	OUTPUT	NONE
SERVICE D	**HEXPRINT**	Hex print; This service prints to the terminal display, the hex value of the DE register pair. Four hex digits are printed. This service is used in conjunction with a PC/Terminal device connected to the serial port. This service requires the optional serial port.
	INPUT	REGISTER C: 0D
		REGISTER PAIR DE: 16 bit number to print.
	OUTPUT	NONE
SERVICE E	**DACOUT**	Digital to Analog Converter output; This service routine outputs a 6 bit number in the E register to the Digital to Analog converter.
	INPUT	REGISTER C: 0E
		REGISTER E: 6 bit value to output to DAC.
	OUTPUT	REGISTERNONE

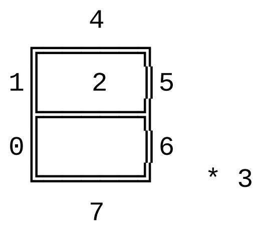
SERVICE 10 **PITCH** Pitch output; This service sends the 14 bit count (the upper two bits are ignored) in the DE register to the speaker timer. The larger the number the lower the pitch. If the DE register pair = 0, then the speaker tone is turned off.

INPUT REGISTER C: 10
REGISTER PAIR DE: 14 bit pitch value.
OUTPUT NONE

SERVICE 11 **LEDOUT** LED Display output; This service routine displays the pattern of LED segments according to the binary value of the E register to the LED digit specified by the D register. The digits are number 0-5 starting from the first digit on the right.

If a bit is 1 in any of the 8 bits in the E register it will cause the corresponding segment to shine. Below are the segments labeled with their corresponding bit numbers.

SEGMENTS LABELED WITH THEIR CORRESPONDING BIT NUMBERS



INPUT REGISTER C: 11
REGISTER E: Pattern of segments to display.
REGISTER D: 0 selects the digit farthest right and 5 selects the one farthest left.
OUTPUT NONE

SERVICE 12 **LEDHEX** LED Hexadecimal output; This service routine displays the number in the DE register pair in hex, in the four displays on the left.

INPUT REGISTER C: 12
REGISTER PAIR DE: 16 bit number to be displayed in HEX.
OUTPUT NONE

SERVICE 13 **LEDDEC** LED Decimal output; This service displays a number in the DE register pair in decimal, in the four displays on the left. The maximum decimal value displayed is 9999.

INPUT REGISTER C: 13
REGISTER PAIR DE: number to be displayed in Decimal.
OUTPUT NONE

SERVICE 14 **DELAY** Delay according to the value of the HL register pair. The larger the value, the longer the Delay.

INPUT REGISTER C: 14
REGISTER PAIR HL: Amount of delay.
OUTPUT NONE

SERVICE 15 **PTBIN** Return the complement of input port B. This is similar to the DIPSWIN service.

INPUT REGISTER C: 15
OUTPUT REGISTER L: Complement of data input to port B

SERVICE 16 **KEYSTAT** Return the status of the keypad in the HL register pair. If a key has been pressed H will

		be 1 and L will contain the value of the key, otherwise HL will be 0. Keys "0-F" return 00-0F hex respectively and the "Step", "Func.", "Dec.", and "Enter" keys return 14-17 hex respectively.
	INPUT	REGISTER C:16
	OUTPUT	REGISTER PAIR HL: Keypad status
SERVICE 17	**DIGOUT**	Show the hex digit in E on the display in D. The value for E must be less than 10 hex. The value in D should be a number from 0 to 5, with 0 denoting the rightmost display and 5 the leftmost.
	INPUT	REGISTER C:17 REGISTER E: Hex digit to show REGISTER D: Display to put digit
	OUTPUT	NONE
SERVICE 18	**WRSCL**	Write 8 bytes of memory, starting from the address in DE, to the optional real time clock. The clock provides timekeeping information in BCD including hundredths of seconds, seconds, minutes, hours, day, date, month and year information. The date at the end of the month is automatically adjusted for months with less than 31 days, including correction for leap years. The real time clock operates in either 24-hour or 12-hour format with an AM/PM indicator. The data pointed to by DE will be stored in the real time clock as follows:

RANGE	**BIT 7**							**BIT 0**	
DE	0.1 SEC				0.01 SEC				00-99
DE + 1	0	10 SEC			SECONDS				00-59
DE + 2	0	10 MIN			MINUTES				00-59
	(AM/PM mode)								
DE + 3	1	0	AM/PM	10 HR	HOURS				01-12
	(24 hour mode)								
	0	0	10 HOUR		HOURS				00-23
DE + 4	0	0	STOP	1	DAY				01-07
DE + 5	0	0	10 DAY		DATE				01-31
DE + 6	0	0	0	10MTH	MONTH				01-12
DE + 7	10 YEAR				YEAR				00-99

If bit 7 of address DE + 3 is 0 the clock will be in 24 hour mode after WRSCLK is executed. If it is 1 then AM/PM mode is selected and bit 5 of address DE + 3 will select AM or PM (PM is selected if bit 5 is 1). When changing from AM/PM mode to 24 hour mode and vice-versa you must change the hours to match the selected mode. Once the hours are correct, the real time clock will maintain the correct hour for the selected mode.

If bit 5 of address DE + 4 is set to 1 and WRSCL is executed, the real time clock will be stopped. The clock may be restarted by resetting the bit to 0 and executing WRSCL.

INPUT	REGISTER C: 18 REGISTER PAIR DE: Address of the first of 8 bytes to be written to the real time clock.
OUTPUT	NONE

SERVICE 19	**RDSCL**	Read 8 bytes of data from the optional real time clock and store them in the 8 consecutive bytes starting at the address in the DE register pair. The 8 bytes are formatted the same as the data passed to WRSCL.
	INPUT	REGISTER C: 19 REGISTER PAIR DE: Starting address to store the 8 bytes read from the real time clock.
	OUTPUT	NONE

Below is an example of using an EMOS service to display the character '0' to the display screen:

ASSEMBLY LANGUAGE

```
;OUTPUT THE CHARACTER 0 TO THE DISPLAY SCREEN
                ORG     8F01H
START:          MVI     C,3             ; CONOUT SERVICE ROUTINE
                MVI     E,30H           ; MOVE ASCII VALUE FOR 0 TO E
                CALL    1000H           ; CALL EMOS FOR CONOUT SERVICE
                RST     7               ; RETURN TO MONITOR SYSTEM
                END
```

MACHINE LANGUAGE

ADDRESS	**DATA**	**COMMENT**
8F01	0E	; MVI C,3
8F02	03	
8F03	1E	; MVI E,30H
8F04	30	
8F05	CD	; CALL 1000H
8F06	00	
8F07	10	
8F08	FF	; RST 7

USING INTERRUPTS

EMOS utilizes both the RST 5.5 and RST 6.5 hardware interrupts so these should not be used except by experienced programmers. The RST 7.5 interrupt (Highest Priority), however, is available to the user. Since EMOS occupies the lower 32K of memory where the interrupt vectors reside, a vector is provided in RAM at address FFE9. If a RST 7.5 interrupt takes place and the interrupt is enabled, the Monitor will place the contents of address FFE9 in the Program Counter. Care should be exercised when using interrupts as not to tamper with interrupts other than the RST 7.5. When utilizing interrupts, the Trace feature of the Monitor System may not function correctly. When using interrupts it is recommended to run your program at full speed for predictable results.

Below is an example program which uses the RST 7.5 interrupt. The program loads the vector at FFE9 with the address of the program's interrupt service routine (ISR) and the 8155 timer is set up to provide a 20hz square wave. The program then enables the RST 7.5 and 5.5 interrupts an enters an infinite loop which repeatedly reads a memory address and outputs the data to the digital output LEDs. Each time an interrupt occurs, this memory value will be incremented. The RST 5.5 interrupt was enabled, so the program could be stopped by pressing a key at the terminal. If the program is stopped this way, the interrupts are disabled and the program must be started from the beginning before it will work properly again.

```
vec7hlf        equ            FFE9h                 ; vector for 7.5 interrupt
leds           equ            11h                   ; discrete LED port
               ; 8155 timer ports
timerlo        equ            14h                   ; low byte of timer
timerhi        equ            15h                   ; hi byte and mode of
timer
cmdreg         equ            10h                   ; command register

               org            0ff01h
               di                                   ; disable interrupts
               lxi            h,ticsub              ; hl = address of ISR
               shld           vec7hlf               ; Store in vector
               mvi            a,0
               out            timerlo               ; lo 8 bits of counter=0
               mvi            a,7ch                 ; set 8155 square wave
               ; output mode

               out            timerhi               ; with timer at 20hz
               mvi            a,0cdh
               out            cmdreg                ; enable the timer
               mvi            a,11010b              ; a 0 bit enables the interrupt
               sim                                  ; enable 7.5 and 5.5
               ei                                   ; enable interrupts

               ; this is the main loop that will be interrupted
               ; by the ISR
loop:          lda            cntout                ;counter to output to LEDs
               out            leds                  ; display value of A register
               jmp            loop                  ; jump to loop

               ; This ISR increments CNTOUT
ticsub:        push           psw                   ; save A and flags
               lda            cntout                ; get counter value
               inr            a                     ; increment it
               sta            cntout                ; save it back
               pop            psw                   ; restore A and Flags
               ei                                   ; Re-enable interrupts
               ret                                  ; continue from point of interruption

cntout         ds             1                     ; reserve 1 byte for the counter
               end
```

Below are the actual hex codes of the program.

```
ADDRESS               DATA                  INSTRUCTION
FF01                  F3                    DI
FF02                  21                    LXI            H,FF20
FF03                  20
FF04                  FF
FF05                  22                    SHLD           FFE9
FF06                  E9
FF07                  FF
FF08                  3E                    MVI            A,0
FF09                  00
FF0A                  D3                    OUT            14
FF0B                  14
FF0C                  3E                    MVI            A,7C
FF0D                  7C
FF0E                  D3                    OUT            15
FF0F                  15
FF10                  3E                    MVI            A,CD
FF11                  CD
FF12                  D3                    OUT            10
FF13                  10
FF14                  3E                    MVI            A,0A
FF15                  0B
FF16                  30                    SIM
FF17                  FB                    EI
FF18                  3A                    LDA            FF2B
FF19                  2B
FF1A                  FF
FF1B                  D3                    OUT            11
FF1C                  11
FF1D                  C3                    JMP            FF18
FF1E                  18
FF1F                  FF
FF20                  F5                    PUSH           PSW
FF21                  3A                    LDA            FF2B
FF22                  2B
FF23                  FF
FF24                  3C                    INR            A
FF25                  32                    STA            FF2B
FF26                  2B
FF27                  FF
FF28                  F1                    POP            PSW
FF29                  FB                    EI
FF2A                  C9                    RET
FF2B                  00                    (The counter value)
```

TERMINATING PROGRAMS

Each user program should end with the RST 7 (FFH) software interrupt instruction. This instruction allows the Monitor to regain control of the CPU. The Monitor uses the RST 7 instruction also to implement a breakpoint when using the Go command. If additional breakpoints are required, RST 7 instructions can be hand inserted at the appropriate spots in the user's program. It is the user's responsibility to remove the hand inserted breakpoints when they are no longer needed.

USE OF RAMDISKS

The PRIMER can be purchased with an optional RAMDISK. The RAMDISK provides 32k of non-volatile battery backed RAM. Power to the PRIMER can be shut off without losing programs that have been stored on RAMDISK. RAMDISKS can even be removed from the PRIMER (when the power to the PRIMER is off) and inserted into another PRIMER, much like a floppy disk.

There are two memory slots on the PRIMER trainer. The first contains an EPROM which holds the EMOS and the second contains a 32K x 8 RAM which is used as standard user memory. The EMOS has partitioned 20k of this RAM to be used for RAMDISK. An optional real time clock (which also provides battery backup of a 32k RAM) may also be inserted in this slot.

The EMOS provides a standard method of access to RAMDISKs through the "B" (Bring Block) and "W" (Write Block) commands. The "B" command loads data from the RAMDISK into user memory and the "W" command copies a section of user memory to the RAMDISK. These commands allow the user to read and write programs or data to the RAMDISKs for storage. To write memory to RAMDISK the user selects the "W" command from the menu. The monitor then prompts the user for the source address. This address is usually the starting address of the program/data (normally at 8F01H). It is extremely important when saving programs to RAMDISK that the user remembers this starting address in order to retrieve the program to correct location. If programs are retrieved to the wrong memory address the program may not execute properly due to incorrect jump addresses etc. Therefore EMAC suggests using the address 8F01H as the starting address for all programs.

After specifying the source address the user must then specify the starting block number. The RAMDISK is divided into sections called blocks. Each block is 256 bytes in length, so there are 75 blocks in the 19k reserved for the RAMDISK. It is also important to remember the starting block number so that programs/data may be retrieved later. EMAC suggests, in the case of more than one user, that each user be given his own set of consecutive blocks for program storage.

After entering the starting block number the EMOS asks for the number of blocks. The user calculates how many blocks of storage are required to save his program and enters this value.

Once a program is saved using the "W" command it can be retrieved at any time and as many times as necessary using the "B" command. When using the "B" command the user is prompted for the destination address. This address should be the same as the source address used when saving, usually 8F01H (see above). After the user specifies the destination address, EMOS requests the starting block number. Once again, this is the same starting block number used when saving. After entering the starting block number, the user enters the number of blocks which is usually the same number used when saving. Retrieving a program is basically accomplished in the same manner as saving a program.

You can still use the RAMDISK commands even if the RAM in slot two is not battery backed. You can save and retrieve data but when you turn off the power the data in the RAM is lost.

Warning: A program gone astray could possibly wipe out information stored on the RAMDISK. If you have access to a terminal emulation program, using the "Hex Download" command would be a safer alternative for program storage.

HARDWARE REFERENCE

HARDWARE RESET

The PRIMER board can be reset through the reset button provided on the board. There is a reset output pin on the expansion connector which allows the resetting of the PRIMER to reset any devices that may be connected to the expansion connector.

SERIAL COMMUNICATION PORT

The PRIMER uses an RS232 standard serial communication port. The port interfaces to a PC or terminal through a DB-9 shell connector (communication cables are available as an accessory from EMAC).

The serial communication rate (or baud rate) must be set to the rate used by the terminal or PC. Placement of jumper JP1 can set the baud rate from 300 baud up to 19,200 baud. EMOS services are available which access the 8251 serial communication port.

DIP SWITCH

The dip switch has 8 switches which may be used for applications such as selection of program options. The dip switch is connected to the system data bus and is accessed through I/O, address 012H. See Appendix C "Assembly Language Drivers" for information on accessing the dip switch. EMOS services are available which access the dip switch.

DIGITAL OUTPUTS

The PRIMER has 8 outputs and each output can be independently programmed to an ON (+5v or binary 1) or OFF (0v or binary 0) state. The outputs are connected directly to the digital output LEDs and an LED can be turned on by the output of a binary 0, and turned off by the output of a binary 1. The outputs are also connected to the digital I/O connector CN3.
The output is driven by the 8155 I/O I.C. which, in the standard configuration, uses PORT A (11H) as the output port, PORT B (12H) as the input port and PORT C (13H) as an analog output port.

NOTE: The standard configuration of the 8155 which is set up by EMOS should not be changed. Also, since PORT A outputs have limited drive capabilities, buffering should be considered if these outputs are to be used by external devices.

DIGITAL INPUTS

The PRIMER allows 8 inputs through 8155 port B. These inputs are connected directly to the 8 station dip switch. The inputs are also connected to digital I/O connector CN3, so if the dip switches are all turned off, you may connect external TTL level input devices through this connector.

D/A

An analog output voltage in the range of approximately 0 to +5v can be output from the PRIMER. This digital to analog converter is implemented through an R-2R ladder which is connected to bits 0-5 of output PORT C. The output from the R-2R ladder is available on pin 19 of the Analog I/O connector CN3. EMOS provides a service which uses this D/A converter.

A/D

The PRIMER provides an analog input (Analog I/O Connector CN3 pin 20) which can convert a voltage in the range of 0 to +5 volts to a 6 bit value. This conversion is done by an EMOS service using the D/A convertor and a comparator. The service starts by outputting 0 volts from the D/A convertor and then increasing the output voltage until the comparator senses that the output voltage exceeds the input voltage. When the input voltage has been exceeded, the last number that was output to the D/A convertor is the digital representation of the analog input voltage. The driver that performs this conversion is in Appendix C "Assembly Language Divers", and the schematic of the circuitry for D/A and A/D is in the Self Instruction Manual on schematic page 6.

NOTE: Since the service that performs the A/D conversion uses the D/A convertor, the D/A convertor cannot be used at the same time an analog signal is being converted to digital.

TIMER/COUNTER

The PRIMER comes equipped with a 14 bit timer/event counter. This timer/counter is resident in the 8155 I/O I.C. By loading a user programmable termination count, time intervals from 3.25 microseconds to 53.3 milliseconds can be achieved. When the termination count is reached, a RST 7.5 interrupt can then be issued to the CPU. If interrupts are not desirable the timer can be read directly or the interrupt line can be polled. The timer can also be set up to reload itself or to stop counting upon reaching the termination count. In either case, an interrupt can be issued.
NOTE: See the section on interrupts under software reference.

The timer/counter is a 14 bit down counter that counts the 'timer input' pulses and provides a pulse or square wave to the 8085 RST 7.5 interrupt when the terminal pulse is reached. The user can reprogram the length of the count before the termination pulse is reached if so desired. The user can also determine the timer interval by programming the counter register from values 2H to 3FFFH. The timer/counter has four operating modes which are:

Mode 0 No operation mode (NOP) does not affect the timer.

Mode 1 Stop mode stops the timer/counter if it is running otherwise NOP.

Mode 2 Stops the timer if running immediately after the terminal count has been reached otherwise NOP.

Mode 3 The start mode loads the output mode and count length and starts the timer/counter immediately if timer is not running, otherwise it waits for the terminal count then starts the timer/counter.

The timer/counter has four output modes which are as follows:

Mode 0 Outputs a low during the second half of the count, which is equivalent to a single square wave.

Mode 1 Outputs a continuous square wave when the terminal count is reached.

Mode 2 Outputs a single pulse when the terminal count is reached.

Mode 3 Outputs a single pulse and reloads automatically.

The timer/counter operating modes are programmed through the 8155 control register (I/O address 10H). The lower 8 bits of the count length is written to I/O address 14H. The upper 6 bits of the count length along with the 2 bit output mode is written to I/O address 15H.

The timer/counter can be used as an external program interval timer. If you wish to perform a software operation at a specific time interval, then the timer/counter can be programmed to that interval. Upon the resulting timer interrupt your program can execute the desired software (refer to Appendix C "Assembly Language Drivers" for timer/counter set-up.)

The timer/counter is also used to drive the PRIMER's speaker. Different frequencies can be output from the speaker using the PITCH EMOS service (see EMOS SERVICES).

ADDITIONAL DETAILS ON THE 8155 TIMER/COUNTER MAY BE OBTAINED FROM INTEL CORPORATION'S LITERATURE DEPARTMENT.

EXPANSION CONNECTOR

The PRIMER has a 40 pin expansion connector (CN1) on board which provides additional expansion capabilities. Primarily, this port gives access to the Data and Low Address Busses and Control Lines. See Appendix A "EXPANSION CONNECTOR CN1" drawing for a detailed description.

NOTE: EMAC HAS MODULAR EXPANSION BOARDS AVAILABLE FOR THIS CONNECTOR.

OPTIONAL ON BOARD HARDWARE FEATURES

REAL TIME CLOCK CALENDAR:

The PRIMER can be equipped with a real time clock/calendar (RTC). The RTC contains a lithium energy cell which maintains clock information and RAM memory data. The clock keeps time in hundredths of seconds, seconds, minutes, hours, day of week, date of month, month and year. The month and year determine the number of days in each month. If you have the real time clock option refer to the specification sheet included in your RTC Supplement for technical and programming specifications. This option can be installed at any time by the user or at the factory before shipping.

32K x 8 NON-VOLATILE RAM (RAMDISK):

EMAC has an 32K RAMDISK available for source code or data storage. The RAMDISK has a built-in lithium energy cell which maintains data in RAM memory. The RAMDISK resides in the memory socket (U1). Source code or data can be written into and stored for later use in the RAMDISK. The RAMDISK may be removed from the PRIMER and replaced at a later time without loss of memory which allows the RAMDISKS(s) to be removed/inserted much like floppy disks.

OTHER OPTIONS FOR THE PRIMER

EPROM PROGRAMMER BOARD:

A simple solution to making permanent EPROM resident programs.

PROGRAMMABLE 32 LINE PARALLEL BOARD:

An alternative to the E-PAC EXPANSION Board when 32 lines of I/O are sufficient.

SUPPORT SOFTWARE:

When your PRIMER needs to communicate with PCs.

APPENDIX A

JUMPER DESCRIPTIONS

JUMPER	DESCRIPTION
JP1	This allows the selection of one of the following baud rates: 300, 600, 1200, 4800, 9600 and 19,200.
OJ1	This is used to select the sources for the 8085's RST 5.5 and RST 6.5 interrupt inputs. The RST 5.5 interrupt pin is connected to the 8279 interrupt request line when there is a connector between pins 4 and 5, or, if a connector is between pins 3 and 4, it is connected to the 8251 receiver ready line. The RST 6.5 interrupt pin is connected to the 8251 receiver ready line when there is a connector between pins 2 and 3. Putting a connector between pins 1 and 2 connects RST 6.5 to +5v. This jumper can also be used to connect RST 5.5 and RST 6.5 to external interrupt sources. Pin 2 of the jumper is connected to RST 6.5 and pin 4 is connected to RST 5.5.
0J2	This jumper selects the EPROM size. Position 'A' allows an 8 or 16K EPROM to be placed in slot 0 and position 'B' allows a 32K EPROM to be placed in the slot.
0J3	This selects one of the two memory maps which are as follows:

POSITION 'A' MEMORY MAP

SLOT 0	0000 TO 3FFF
SLOT 1	4000 TO BFFF
8155 RAM	C000 TO FFFF (only 256 bytes available)

POSITION 'B' MEMORY MAP

SLOT 0	0000 TO 7FFF
SLOT 1	8000 TO FFFF
8155 RAM	(not accessible)

APPENDIX B

I/O AND MEMORY ADDRESS DESCRIPTIONS

REFERENCE	I/O ADDRESS	DESCRIPTION
8251 DATA REGISTER	80 H	DATA INPUT/OUTPUT
8251 CONTROL REGISTER	81 H	CONFIGURATION
8155 CONTROL REGISTER	10 H	CONFIGURATION
PORT A	11 H	OUTPUT PORT
PORT B	12 H	INPUT PORT
PORT C	13 H	ANALOG OUTPUT PORT
TIMER LOW	14 H	LOW ORDER TIMING BYTE
TIMER HIGH	15 H	HIGH ORDER TIMING BYTE & CONTROL
EXPANSION I/O	C0 - FF H	EXPANSION CONNECTOR

MEMORY	ADDRESS	DESCRIPTION
For OJ3 position A		
	0000 H - 3FFF H	EPROM SLOT
	4000 H - BFFF H	32K RAM SLOT
	C000 H - FFFF H	256 BYTES IN 8155 (with multiple addresses)
For OJ3 position B		
	0000 H - 8000 H	EPROM SLOT
	8000 H - FFFF H	32K RAM SLOT

APPENDIX C

ASSEMBLY LANGUAGE DRIVERS

```
;               PRIMER SOURCE DRIVERS

INIT            MVI     A,0DH           ;  INITIALIZE THE ( 8155 ) PORTS
                OUT     10H             ;  PORT A OUTPUT, PORT B INPUT, PORT C OUTPUT
                RET

PTAOUT          CMA                     ;  CONTENTS OF ACCUMULATOR IS WRITTEN TO
                OUT     11H             ;  OUTPUT PORT A
                RET

PTAIN           IN      11H             ;  RETURNS CONTENTS OF OUTPUT PORT A IN
                CMA                     ;  ACCUMULATOR (AFTER COMPLEMENTING)
                RET

PTBIN           IN      12H             ; RETURNS CONTENTS OF INPUT PORT B (DIPSWITCH)
                CMA                     ; IN ACCUMULATOR (AFTER COMPLEMENTING)
                RET


DPSWIN          IN      012H            ; RETURNS DIP SWITCH SETTING IN ACCUMULATOR
                CMA
                RET


; **********************************************************************
;    ACCEPTS TIMER MODE AND COUNT LENGTH IN H,L REGISTER PAIR
;    ACCEPTS TIMER COMMAND IN BIT POSITION 0 AND 1 OF ACCUMULATOR
;    REFER TO INTEL MICROSYSTEM COMPONENTS HANDBOOK VOL. II FOR
;    ADDITIONAL INFORMATION ON ( 8155 ) IC.

TIMER           PUSH    B
                MOV     B,A
                MOV     A,L
                OUT     14H             ; OUTPUT TIMER LOW BYTE
                MOV     A,H
                OUT     15H             ; OUTPUT TIMER MODE AND HIGH BYTE
                XRA     A
                ORA     B
                JZ      TIM1            ; NO OPERATION
                ANI     03H
                RRC
                RRC                     ; MOVE BITS 0 AND 1 TO BIT POSITIONS 6 AND 7
                ORI     0DH
                OUT     10H             ; OUTPUT TIMER COMMAND
TIM1            POP     B
                RET


;
; Speaker controller.  If SOD is on, speaker is on and vice versa
buzzon:         mvi     b,0c0h          ; this turns on SOD pin
                jmp     sod
buzzoff:        mvi     b,40h           ; this turns off SOD pin

sod:            rim
                ani     1fh
                ora     b
                sim
                ret
```

```
; Send the frequency in HL to 8155.  HL is limited to <=3fffh
sdiv:          mov    a,l
               out    14h           ; timer frequency low byte
               mov    a,h
               mvi    a,3fh
               ana    h
               ori    40h
               out    15h           ; timer frequency mode and hi byte
               mvi    a,0cdh
               out    10h           ; output timer command
               ret


; B E E P :   This beeps the speaker.
beep:          push   h
               lxi    h,0200h
               call   sdiv          ; set the frequency
               call   buzzon
               lxi    h,03000h
               call   dlay
               call   buzzoff
               pop    h
               ret

dlay:          dcx    h
               mov    a,h
               ora    l
               jnz    dlay
               ret

; *********************************************************************
; COM1 8251 UART DRIVER ROUTINES
; INITIALIZE THE 8251 TO 8 DATA BITS, NO PARITY

SERDTA         EQU    80H
SERCOM         EQU    81H

COMINIT        MVI    A,0CEH
               OUT    SERCOM
               MVI    A,27H
               OUT    SERCOM
               RET


; INPUT A CHARACTER INTO THE ACCUMULATOR FROM THE 8251

COMIN          IN     SERCOM        ;  WAIT FOR CHARACTER TO BE SENT
               ANI    02
               JZ     COMIN
               IN     SERDTA
               RET


; OUTPUT A CHARACTER IN THE ACCUMULATOR

COMOUT         MOV    L,A
COMOUT0        IN     SERCOM        ;  WAIT FOR TRANSMITTER CLEAR
               ANI    01
               JZ     COMOUT0
               MOV    A,L
               OUT    SERDTA
               RET


;**************************************************************************
; DACOUT:  This converts the 6 bit value in A to a proportional voltage on
;  pin 19 of Analog I/O connector CN3.
dacout:        ani    00111111b     ; mask off extra bits
               out    13h           ; port C
               ret
```

```
;***********************************************************************
; ADCIN converts a voltage on pin 20 of digital I/O connector CN3 to a 6 bit
; number in L.  The PRIMER has a comparator which compares the analog input
; voltage to the  analog output voltage.  When the  output voltage exceeds
; the input voltage the comparator will cause the SID input line to go high.
; This program outputs the value of the L register to port C which generates a
; output voltage proportional to the value of L.  The value of L is
; incremented and output to port C until the SID input line goes high.  When
; SID goes high, L is the digital representation of the input voltage.
ADCIN:          push    psw
                Mvi     l,-1            ; l starts at the lowest voltage -1
adcin1:         inr     l
                mov     a,l
                out     13h             ; send a voltage out of the R-2R
ladder
                rim                     ; has it exceeded the input voltage?
                ora     a               ; SID will be high if so.
                Jm      adcin2          ; if A is negative, exit
                Mov     a,l
                Cpi     63
                Jc      adcin1          ; if l<63 increment and output the
next voltage
adcin2:         xra     a
                out     13h             ; set d/a to 0 volts
                pop     psw
                ret

;****************************************************************************
; Initialize the 8279 keypad and display controller
in8279:         mvi     a,0             ; select eight 8 bit character display, with
                out     41h             ; encoded scan keyboard - 2 key lockout
                mvi     a,3fh           ; program clock for input freq. Divided by 31 decimal
                out     41h
                mvi     a,0c1h          ; clear display RAM
                out     41h
                lxi     h,0ffffh
                call    dlay            ; delay for a moment while clearing RAM
                mvi     a,80h           ; select display 0
                out     41h
                ret

;****************************************************************************
; RDKEY Waits until key buffer is not empty.  When not empty, it will get
; the keypad value and return it in A
; keys 0-f will return 00-0fh
; 10h-13h are not used
; step,func,dec,ent/inc = 14h-17h respectively

rdkey:          push    b
                push    d
                push    h
rdkey1:         in      41h             ; see if key buffer is > 0
                ani     07h
                jz      rdkey1          ; loop until key pressed
                mvi     a,40h
                out     41h             ; clear interrupt
                in      40h             ; get the scanned key.
                                        ; bit pattern is  CNTRL,SHFT,3 bits SCAN,3 bits RETURN

                ani     3fh             ; bit 7 not used
                mov     b,a             ; preserve A
                ani     00111000b       ; masking off all but scan and..
                rrc                     ; dividing by 2 makes scan=scan*4
                mov     c,a             ; c=scan*4
                mov     a,b             ; A=original scanned key
                ani     00000111b       ; mask all but the value for RETURN
                add     c               ; add to scan*4
                pop     h
                pop     d
                pop     b
                ret
```

```
; This outputs the digit in A (0-f) to the display number in B (80-85 hex)
; Displays are numbered 85-80 from left to right
; only hl is preserved

digout:         push    h
                lxi     h,dmap          ; point to bit map table
                add     l               ; add A to HL
                mov     l,a
                mvi     a,0
                adc     h
                mov     h,a             ; hl=hl+a
                mov     a,b             ; b= 80h-85h
                out     41h             ; select display
                mov     a,m             ; get bit map from (hl)
                out     40h             ; output bit pattern to the display
                pop     h
                ret

dmap:           db      0f3h,60h,0b5h,0f4h,66h,0d6h,0d7h,70h,0f7h ; zero thru
                db      0f6h,77h,0c7h,93h,0e5h,97h,17h            ; F
```

APPENDIX D

COMMUNICATION USING ECOM

ECOM is a powerful communication software package that is ideally suited for use with the PRIMER trainer, and with other EMAC systems. ECOM runs on IBM PCs, and compatibles, using COM ports 1-2 at baud rates of up to 19,200 baud. ECOM also allows for menu options; like file/printer logging, and fully automated file transfers.

STARTING ECOM

If you have the ECOM disk, you can run the program by placing the disk into a 5.25 inch drive and typing ECOM at the DOS prompt. A message will appear on the screen describing which trainer system your ECOM is for use with, (in this case, EMOS). Press the space bar to clear this message and start ECOM.

The main screen of ECOM is an ADM-3A terminal emulation screen with a top menu bar. This main screen is what you use to communicate with the trainer. Most of what you type is sent directly to the trainer and echoed back onto this screen. Conversely, the trainer will send messages, such as a command menu or memory dump. This information will also be displayed on the main screen.

The top menu bar describes functions and pop up windows that are used for things like file transfer, and systems setup. To use these functions, press the <ALT> key plus the highlighted letter of the function you wish to use. (For monochrome monitors: Type the <ALT> key plus the capital letter, of a function you wish to use.) In addition, the menu bar lists the current serial port settings, (baud, parity, etc), and logging status, (FILE, PRN, or none).

SETTING UP ECOM FOR USE WITH THE PRIMER

Once in the main screen, press the <ENTER> key. ECOM should display the EMOS prompt, "-". If this prompt **does** appear, you are ready to issue commands through ECOM to your trainer. For example typing a "?" at your keyboard should result in a command menu list.

If you press the enter key and ECOM **does not** display a prompt, follow the these steps. First, make sure that your trainer is set up and operating correctly. For details on this refer to the section of this manual "Getting Started". Once your are sure the trainer is operating properly, and communications still does not occur, enter the setup menu listed in the top menu bar. This is done by pressing the <ALT> and "S" keys together.

THE SETUP MENU

The Setup menu is a pull down window that lists seven fields. They are as follows:

Baud
Parity
Length
Stop bit
Comm Port
Protocol
Write

The first six fields are for changing the serial port parameters of your computer to match the settings of your trainer. To move between these fields, press the UP and DOWN keys on the numeric keypad of your keyboard. (Make sure <Num Lock> is off.) This will move the highlighted bar over the field you wish to select. To select that field, press the <ENTER> key. To exit the menu, press the <ESC> key.

When starting your trainer, the first field to be concerned with is the **Comm Port** field. You will want to change this field to match the serial port on which the trainer is connected. Move the highlighted bar over the **Comm Port** field and press <ENTER>. A sub menu will appear to the right of the first seven fields. This sub menu will allow you to change the current serial port setting. Use the UP and DOWN keys on your numeric keypad to move between the options, and press <ENTER> to make a selection.

In addition to your serial port setting, you may also need to change the communications settings. For a typical trainer, these settings are (9600) baud, (N)o parity, (8) bits, and (1) stop bit. Check your trainer to be sure. To change a communications setting, such as baud rate, do the same as before. Move the highlighted bar in the setup menu over **Baud**, and press <ENTER>. Make a selection in the sub menu, and leave the setup menu by pressing <ESC>.

The top menu bar will display the new port and communications settings. Should you wish to save these settings, move to the field named **Write** in the setup menu, and press <ENTER>. ECOM will save the changes in the directory ECOM is running from. This file will have the extension *.cfg. After this, every time you run ECOM, it will default to the new changes.

FILE TRANSFER FOR EMOS

ECOM for EMOS uploads and dowloads Intel Hex files. Intel Hex files are a standard type of ASCII file produced by 8085 assemblers and some compilers and excepted by EPROM programmers and other hardware devices. If the user assembles a program, the resulting Intel Hex file can be uploaded, saving the user from entering in the prgram by hand. Programs that were entered in by hand can be saved to a disk file on the PC by downloading the program to the specified file. When the program is needed the user can upload the file to the trainer and run it.

ECOM allows for automated file transfers to and from your trainer. To transfer a file, press the <ALT> and "F" keys together to bring down the file transfer menu. This menu has two options:

Upload to EMAC board
Download from EMAC board

The first option will allow you to send Intel hex files to your trainer, and the second will allow you to receive Intel hex files from your trainer.

To **upload** a file to your trainer, enter into the **F**ile I/O menu by pressing the <ALT> and "F" keys on your keyboard. Move the highlighted bar over the **Upload to EMAC board** field, (it should be highlighted by default), using the UP and DOWN keys on the numeric keypad of your keyboard. Press <ENTER> and a sub menu will appear which has two fields that look like this:

Enter PC filename: [drv]:\[pth]\fn.ext
Enter Starting Address: 8F01h

The first field in the sub menu is a prompt for the filename to upload. This filename is the source of the transfer, and will originate from the PC. Type the name of the file and press <ENTER>. The second field in the sub menu is a prompt for the destination address on the trainer which defaults to 8F01h. Type the destination address and press <ENTER>. Once you are done entering the file transfer information, you will be prompted to begin the file transfer. Press the space bar to toggle between Y or N. Press <ENTER> to select a choice. If you choose Y, the file will be transferred to your trainer. At the end of a successful transfer, a "FILE TRANSFER COMPLETED" will flash in the main file transfer menu. If the file transfer is interrupted, an abort message will flash. This is caused by a bad checksum, or a user break (the <ESC> key was pressed twice).

A file **download** is done by entering the File I/O menu, (<ALT> and "F"), and selecting the **Download from EMAC board** field. In this case, the sub menu will appear as follows:

Enter PC filename: [drv]:\[pth]\fn.ext
Enter starting address: 8F01h
Enter last address: 8F01h
Enter offset address: 0000h

The first field is a prompt for the name of the destination file. This will be a file on your PC. If this file already exists, it will be overwritten, otherwise, ECOM will create it. Type the filename and press <ENTER>. For the meaning of starting address, last address and offset address, see the description of the EMOS command "<". ECOM will prompt you to start the file transfer. Toggle between Y or N with the space bar, and press <ENTER>. If you select Y, the file will be transferred from your trainer. At the end of a successful file transfer, a "FILE TRANSFER COMPLETED" message will flash on the main file transfer menu. An abort message will flash if there was a user break or checksum error during the transfer.

LOGGING

ECOM allows for screen logging either to a file, to a printer, or to both. To enter the Logging menu, press <ALT> and "L" at your keyboard. The following fields will be displayed:

Logging to printer: DISABLED
Logging to file: DISABLED
Filename: [drv]:\[pth]\fn.ext

To move between each field, press the UP and DOWN keys on the numeric keypad of your keyboard. Both the printer and file logging fields have three options: DISABLED, ENABLED, and SOFTWARE ENABLED. Press the space bar to toggle between these options. Press <ESC> if you need to leave the logging menu. The current logging status, either PRN, or FILE, or none, is displayed on the menu bar of the main communications screen.

NOTE: You must specify a filename in the **Filename** field if you choose either ENABLED or SOFTWARE ENABLED for the **Logging to file field**.

The SOFTWARE ENABLED option allows your trainer to turn on and off printer and file logging through special extended ASCII characters/codes. These characters/codes are as follows:

Printer ON:	AEH
Printer OFF:	AFH
File write ON:	F3H
File write OFF:	F2H

These codes can be sent from the trainer to ECOM, allowing automated printing and file logging without user intervention. In addition, the trainer can take advantage of the ADM cursor and screen control codes to format display output.

APPENDIX E

UPLOADING & DOWNLOADING INTEL HEX FILES

This example assumes the user is using an IBM PC or compatible computer with an ECOM disk in the A: drive and has some familiarity with EMOS.

To start the example, first invoke ECOM by typing A:ECOM. Establish communications and verify that correct communication has taken place (see COMMUNICATION USING ECOM).

UPLOADING

At this point the user has configured ECOM and is successfully communicating with the trainer. The user is now ready to upload the example assembled program, TRAINTST.HEX. This ASCII file is included on the ECOM disk and contains all the op codes and operands necessary to upload and subsequently run this program on the PRIMER. The steps to upload are as follows:

1. Press <ALT> "F" to select File I/O menu.

2. Select the "Upload to EMAC board" option.

3. At the sub menu PC filename prompt, type TRAINTST.HEX and press enter. Press enter at the starting address prompt and the default value will be entered

4. The top line of the screen will have a message asking if you want to transfer the file. Press enter to start file transfer.

5. After the upload is complete, press <ESC> to return to the terminal screen and choose the "D" command to do a memory dump of 70 bytes at address 8F01. The Dump command displays the contents of memory allowing verification of the upload. The screen should look similar to:

```
D  STARTING ADDRESS.. 8F01      NO. OF BYTES.. 70

        0  1  2  3  4  5  6  7  8  9  A  B  C  D  E  F  0123456789ABCDEF
8F01    6  1  E  3 1E  D CD  0 10 1E  A CD  0 10  6  1        .    .
8F11    E  4 11 52 8F CD  0 10  E  A CD  0 10  6  1  E     R..    .
8F21    3 1E 20 CD  0 10  6  1  E  D 16  0 5D CD  0 10     .        ].
8F31    CD 43 8F  6  1  E  3 1E  D CD  0 10 7D B7 C2 19  .C.     .  }..
8F41    8F FF F5 E5 21  0 80  0 2B 7D B4 C2 48 8F E1 F1  ....! . +}..H...
8F51    C9  D  A  A 20 54 48 45 20 44 49 50 53 57 49 54  .     THE DIPSWIT
8F61    43 48 20 4E 4F 57 20 52 45 41 44 53 20  D  A  A  CH NOW READS

-
```

7. Choose the "G" command at address 8F01 with no breakpoint. NOTE: To prevent the program from terminating, at least one dip switch should be in the ON position.

The program, once executed, will display a message to the screen and then display to the screen the contents of the dip switch in HEX. To exit the program, set the dip switch to 0 (all off). To suspend the program press any key. Once suspended the program can continue to run by choosing the "G" command with no options. For more information on the EMOSTST program see the EMOSTST.LST listing.

DOWNLOADING

In the next part of the example we will modify the program and store it back to disk as an Intel hex file. The modification to the program will involve changing the dip switch output from being displayed in HEX to being displayed in Decimal. This involves changing the service call from 0D (PRINTHEX) to 05 (UPRINT). This change is made at address 8F22. The steps are as follows:

1. If TRAINTST is still running, stop execution by setting the dip switch to 0 (all off).

2. Choose the "E" command to edit at address 8F22.

3. Change 0D to 05 and press <ENTER>.

4. Press <ESC> to leave the Edit mode.

5. Choose the "G" command at address 8F01 with no breakpoint. Remember to leave at least one of the dip switches in the on position to keep the program from terminating. After that, verify that the program is outputting the dip switch in decimal and stop execution as in step 1.

6. Press <ALT> "F" to select File I/O menu.

7. Select the "Download from EMAC board" option.

8. At the sub menu PC filename prompt, type TEST.HEX and press enter. Press enter at the starting address prompt and the default value will be entered.

9. At the last address prompt, type 8F67, and press enter at the offset address prompt and the default of 0000h will be used.

10. The top line of the screen will have a message asking if you want to transfer thefile. Press enter to start file transfer.

11. After the download is complete the message "FILE TRANSFER COMPLETE" will be flashing. Press <ESC> to return to the terminal screen.

The file TEST.HEX is now on residing on floppy in the A: drive. At any time this file can be uploaded to the trainer and executed following the procedures that were used to load TRAINTST.HEX.

APPENDIX F

TRAINTST.LST LISTING

```

                 ; THIS PROGRAM DEMONSTRATES SOME OF THE CONCEPTS OF ASSEMBLEY
                 ; LANGUAGE USING SERVICE CALLS ON THE TRAINER.
                 ; THIS PROGRAM CAN BE ASSEMBLED AND THE RESULTING HEX FILE
                 ; UPLOADED (USING ECOM, PROCOMM OR SOME OTHER COMMUNICATIONS PACKAGE)
                 ; TO THE TRAINER OR CAN BE HAND ASSEMBLED AND ENTERED
                 ; BY HAND IF A HOST COMPUTER IS NOT AVAILABLE.
                 ;
                 ; NOTE:  IF UPLOADING THE PROGRAM FROM A COMPUTER BE SURE TO SPECIFY
                 ;        THE STARTING ADDRESS AS 8F01H. THE REASON BEING THAT THIS
                 ;        PROGRAM IS NOT WRITTEN TO BE RELOCATABLE ( IT USES ABSOLUTE
                 ;        ADDRESSES ). IF A DIFFERENT STARTING ADDRESS IS DESIRABLE
                 ;        CHANGE THE CONSTANT "STARTADD" TO ORG THE PROGRAM AT A
                 ;        DIFFERENT LOCATION AND REASSEMBLE.
                 ;
                 ;
                 ; CONSTANT DECLARATIONS
                 ;
  8F01 =         STARTADD EQU      8F01H    ; STARTING ADDRESS FOR PROGRAM
  8000 =         DELAYTIM EQU      8000H    ; CONSTANT USED TO DETERMINE THE DELAY
  1000 =         MOS      EQU      1000H    ; ADDRESS OF MOS OPERATING SYSTEM
  000A =         DPSWIN   EQU      0AH      ; DIPSWITCH SERVICE NUMBER
  0004 =         PSTRING  EQU      04H      ; PRINT STRING SERVICE NUMBER
  000D =         HEXPRINT EQU      0DH      ; HEX PRINT SERVICE NUMBER
  0003 =         CONOUT   EQU      03H      ; CONSOLE OUTPUT SERVICE NUMBER
                 ;
  000D =         CR       EQU      0DH      ; ASCII CARRAGE RETURN
  000A =         LF       EQU      0AH      ; ASCII LINE FEED
  0020 =         SPACE    EQU      20H      ; ASCII SPACE
                 ;
                 ;
                 ; THIS PROGRAM DISPLAYS A GREETING MESSAGE AND THEN WILL
                 ; PROCEED TO DISPLAY THE CONTENTS OF THE DIP SWITCH TO THE
                 ; CONSOLE UNTIL THE DIP SWITCH EQUALS ZERO. AT THIS POINT THE
                 ; PROGRAM WILL RETURN CONTROL TO THE MONITOR.
                 ;
                 ;
  8F01                    ORG      STARTADD ; TELL THE ASSEMBLER WHERE TO START


8F01 0601             MAIN:    MVI      B,COMPORT
8F03 0E03                      MVI      C,CONOUT
8F05 1E0D                      MVI      E,CR
8F07 CD0010                    CALL     MOS      ; OUTPUT A CR TO THE CONSOLE
8F0A 1E0A                      MVI      E,LF
8F0C CD0010                    CALL     MOS      ; OUTPUT A LF TO THE CONSOLE
8F0F 0601                      MVI      B,COMPORT
8F11 0E04                      MVI      C,PSTRING
8F13 11528F                    LXI      D,MESSAGE
8F16 CD0010                    CALL     MOS      ; OUTPUT THE MESSAGE TO THE CONSOLE
8F19 0E0A             LOOP:    MVI      C,DPSWIN
8F1B CD0010                    CALL     MOS      ; INPUT THE CONTENTS OF THE DIPSWITCH
8F1E 0601                      MVI      B,COMPORT
8F20 0E03                      MVI      C,CONOUT
8F22 1E20                      MVI      E,SPACE
8F24 CD0010                    CALL     MOS      ; OUTPUT A SPACE TO THE CONSOLE
8F27 0601                      MVI      B,COMPORT
8F29 0E0D                      MVI      C,HEXPRINT
8F2B 1600                      MVI      D,0
8F2D 5D                        MOV      E,L
8F2E CD0010                    CALL     MOS      ; OUTPUT THE CONTENTS OF THE DIPSWITCH
8F31 CD438F                    CALL     DELAY    ; DELAY THE NEXT PRINTING
8F34 0601                      MVI      B,COMPORT
8F36 0E03                      MVI      C,CONOUT
8F38 1E0D                      MVI      E,CR
```

```
8F3A CD0010                    CALL     MOS      ; RETURN THE CURSOR TO THE BEGINNING
8F3D 7D                        MOV      A,L      ; MOVE DIPSWITCH VALUE TO A REG.
8F3E B7                        ORA      A        ; SET FLAGS
8F3F C2198F                    JNZ      LOOP     ; IF DIPSWITCH NOT EQUAL 0 CONTINUE
8F42 FF               STOP:    RST      7        ; ELSE RETURN CONTROL TO THE MONITOR
8F43                  ;
8F43                  ;
8F43                  ; THIS SUBROUTINE PERFORMS A 16 BIT DELAY. THE 16 BIT DELAY
8F43                  ; CONSTANT IS PLACED IN THE H/L REGISTER PAIR. ALL REGISTERS
8F43                  ; ARE PRESERVED.
8F43                  ; INPUT:  NONE
8F43                  ; OUTPUT: NONE
8F43                  ;
8F43 F5               DELAY:   PUSH     PSW
8F44 E5                        PUSH     H
8F45 210080                    LXI      H,DELAYTIM
8F48 00               DLOOP:   NOP
8F49 2B                        DCX      H        ; DCX DOES NOT SET FLAGS SO OR H & L
8F4A 7D                        MOV      A,L      ; TOGETHER AND IF THE RESULT IS 0
8F4B B4                        ORA      H        ; WE'RE DONE
8F4C C2488F                    JNZ      DLOOP
8F4F E1                        POP      H
8F50 F1                        POP      PSW
8F51 C9                        RET
8F52                  ;
8F52                  ;
8F52                  ; ASCII MESSAGE TO BE DISPLAYED. DON'T FORGET THE '$' DELIMETER.
8F52                  ;
8F52 0D0A0A2054484520 MESSAGE: DB       CR,LF,LF," THE DIPSWITCH NOW READS ",CR,LF,LF,'$'
8F5A 4449505357495443
8F62 48204E4F57205245
8F6A 414453200D0A0A24
8F72                  ;
8F72                  ;
8F72                           END     MAIN      ; STOP ASSEMBLING
```

After assembling, the following is similar to the contents of the TRAINTST.HEX file:

```
:108F010006010E031E0DCD00101E0ACD0010060134
:108F11000E0411528FCD00100E0ACD001006010E65
:108F2100031E20CD001006010E0D16005DCD0010B0
:108F3100CD438F06010E031E0DCD00107DB7C21962
:108F41008FFFF5E5210080002B7DB4C2488FE1F150
:108F5100C90D0A0A20544845204449505357495443E1
:108F61004348204E4F5720524541445320 0D0A0A91
:018F710024DB
:0000000000
```