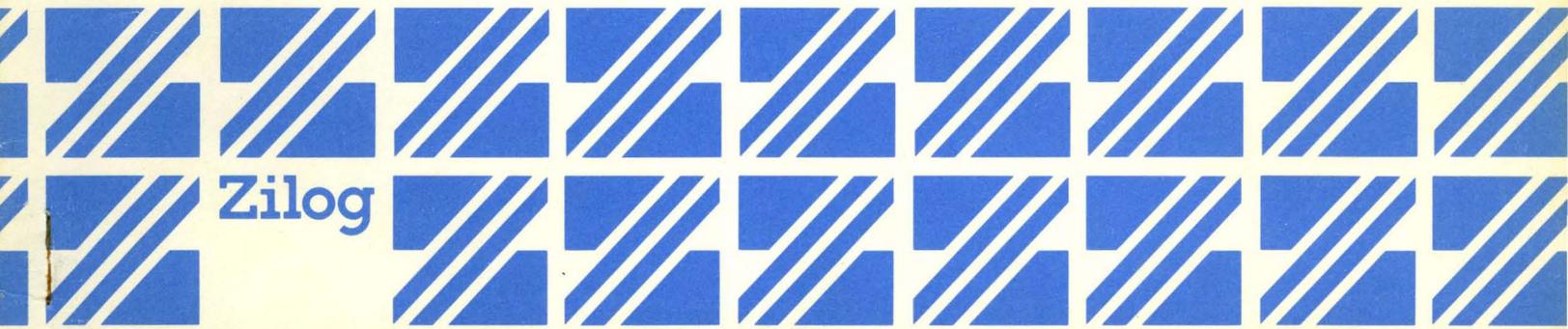




ZDS 1/25,1/40

PROM User's Manual



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1.0 INTRODUCTION

The Development System 3K Monitor is intended to provide the basic debugging commands, basic Input/Output, and bootstrap portions of a floppy disk-based operating and development system. The system consists of a bootstrap loader, a floppy disk driver, a terminal handler, and a command interpreter. The system resides in 3K bytes of PROM memory, starting at address 0, and uses 1K bytes of RAM, including 256 bytes allocated for the system stack.

At the time of system RESET, the 3K Monitor reads from the terminal to determine the baud rate required at the serial interface. The user should input a carriage return at this time. Then all variable parameters are set in RAM to their initial values. Next the USART is programmed for asynchronous operation with two transmit stop bits, no parity, 8 data bits, and divide by sixty-four operation. After this the USART is further programmed to generate active (low) signals on REQUEST TO SEND and DATA TERMINAL READY and both the receiver and transmitter are enabled. Finally, the disk interface is set to the bit control mode on both of its ports and appropriate directions are assigned to the bits.

There is a slight delay while the baud rate is being determined, after which the Monitor outputs a prompt '>' signifying that it is ready for its first command string from the terminal. If that command is a simple carriage return, the bootstrap logic is entered. If not, the Debug command scanner is entered.

The bootstrap procedure involves reading in 128 bytes of data then transferring control to it. This data will be read from a fixed sector on the system drive (Drive 0).

2.0 FLOPPY DISK DRIVER

The floppy driver (FLOPPY) is used to read and write from the disk. The FLOPPY routine is only capable of accessing preformatted Zilog diskettes. The driver accepts a standard parameter vector as follows:

IY+0	IGNORED
IY+1	REQUEST - TYPE OF ACTION NEEDED
IY+2, IY+3	DATA TRANSFER ADDRESS
IY+4, IY+5	DATA LENGTH IN BYTES
IY+6, IY+7	COMPLETION RETURN ADDRESS
IY+8, IY+9	ERROR RETURN ADDRESS
IY+10	COMPLETION CODE
IY+11, IY+12	DISK ADDRESS

There are two valid requests for the floppy driver. They are RDBIN(0AH), which will read data from the disk to the area pointed to by the data transfer address, and WRTBIN(0EH), which will write data from the area pointed to by the data transfer address to the disk.

If the request code is increased by one, then the driver will return as soon as the request has been initiated, permitting it to continue under interrupt control and jumping to the completion return address after the operation is complete. The routine at the completion return address should act as an interrupt routine, except that it should not execute an RETI. (A simple RET should be used.) If the request code is used as given, FLOPPY will return after the operation is completed. In this case the completion return address is ignored.

If the data transfer length is not divisible by the sector size, i.e., 128 bytes, it will be increased to the next integral multiple of the sector size. Data will be written/read from contiguous sectors. The length should be such that the entire transfer will take place between the sector where transfer starts and the end of the track. If this limitation is not observed, a sector error will result on a read operation and a permanent sector error will be written on a write operation, resulting in certain sectors being permanently inaccessible without reformatting the disk.

If an error occurs and the error return address is non-zero, the routine at that address will be called. It may take whatever action is appropriate and return. If the address is zero, the return would be as though there were no error, except for the setting of the condition code.

Bit 7 of the condition code byte is set when the operation is completed. Bit 6 is set to indicate that an error occurred. The bottom six bits indicate which error it was. Possible return codes are:

- *Normal Return (80H)
- *Invalid Operation Request (C1H)
- *Not Ready - Disk is signalling a "Not Ready" condition. (C2H)
- *Disk is write protected. (C3H)
- *Sector Error - The Sector address in the sector header did not agree with the sector position. (C4H)
- *Track Error - The Track address in the sector header did not agree with the head position. (C5H)
- *CRC Error - The Cyclic Redundancy Checker (CRC) indicates one or more data bits in error. (C6H)

The disk address at which the transfer is to begin is represented as a track address from 0 to 77 decimal and a sector address from 0 to 31 decimal. Additionally, three bits indicating which of the two possible drives is to be used for the transfer are carried as the top three bits of the sector address. (The drives are numbered 0 and 1.) The track address is considered to be the most significant part of the disk address (and therefore goes in IY+12), while the sector address is considered to be the least significant (and therefore goes in IY+11).

The entry point for the floppy driver is at location 0BFDH.

3.0 TTY DRIVER

The TTY driver is used to read and write from the terminal. On entry, IY should be pointing to a standard parameter vector identical in format to that used by FLOPPY with the exception, of course, of the last field (disk address) which is ignored. Because of the differences of the hardware devices in use, the operation of these routines is necessarily different. The significance of parameters to TTY is as follows.

There are four requests handled by the terminal driver. These are RDBIN(0AH), WRTBIN(0EH), RDLIN(0CH), and WRTLIN(10H). The binary operations read or write the specified length of data between the serial interface and the block of memory beginning at the data transfer address. No special characters are honored in binary operations. No echoing is performed on RDBIN.

The RDLIN operation begins with the issuing of a prompt character to the terminal and proceeds to input characters to the data transfer area from the serial interface. All input characters are echoed. Special line delete (initialized by the 3K Monitor to "!", or ASCII 21H) and character delete (initialized by the 3K Monitor to "@", or ASCII 40H) are honored by this routine. A RDLIN operation will terminate either on receipt of the number of characters specified as the transfer length or on receipt of a carriage return. The carriage return will be echoed and the number of line feeds and null characters specified in system RAM (see Section 5.0) will be generated.

The WRITE operation also proceeds either for the number of characters specified as the transfer length or until a carriage return is encountered. After a carriage return is encountered, the end of line sequence described above (insertion of LF and NULs) is performed.

Both ASCII line operations return a count of the number of characters actually transferred in the transfer length field.

If one is added to the request code, control will be transferred to the completion return address after the operation. The routine at this address should act as an interrupt routine, except that it should not execute an RETI (a simple RET should be used). If one is not added to the request, TTY will return normally after the operation is completed. In this case, the completion return address is ignored.

If an error occurs and the return address is non-zero, the routine at that address will be called. It may take whatever action is appropriate and return. If the address is zero, the return is normal, except for the setting of the completion code.

Bit 7 of the completion code is set when the operation is completed. Bit 6 is set to indicate that an error occurred. The only error condition returned is Invalid Operation. This will occur for request codes greater (arithmetically) than those honored by TTY - lower request codes return complete with no error but with no effect either.

The two line-edit commands interpreted by the TTY driver, delete last character and delete current line, can be changed from the Debug environment as follows:

To change the Delete last character command:

Set memory location 0FC3H to the ASCII code for the character desired. For example, to make the "@" the character delete, one would set the location to 40H.

To change the Delete current line command:

Set memory location 0FC2H to the ASCII code for the character desired. For example, to make "!" the line delete, one would set the location to 21H.

Note that both of the above addresses are in System RAM, thus they are equivalent to addresses FFC3H and FFC2H when looking at the user address space.

These characters are also changed when OS is bootstrapped to its defaults, or by the Set command in RIO OS. This means that if Debug is entered from OS, the characters may not function in the same way.

The Development System interfaces to any terminal using a standard 8-bit ASCII asynchronous transmission mode, with or without parity, on RS-232 or 20 ma. current loop. The interface will operate at the following speeds: 9600 baud, 4800 baud, 2400 baud, 1200 baud, 600 baud, 300 baud, 200 baud, 150 baud, 134.5 baud, 110 baud, 75 baud, 50 baud.

The entry point for the TTY driver is at location 0BEEH.

4.0 DEBUG ENVIRONMENT

4.1 DEBUG COMMANDS

In the following command descriptions, angle brackets (" $\langle \rangle$ ") are used to enclose descriptive names for the quantities to be entered, and are not actually to be entered. Square brackets ("[]") enclose optional quantities. Vertical bar ("|") indicates a choice may be made, e.g., A|B means either A or B may be specified. Capital letters specify the minimum acceptable abbreviation of a command. Parentheses are used for grouping repetitive items. For example, a valid Display command (see below) would be

```
D 1000 10
```

The PROM Debug environment offers the following commands:

```
Break [[MR|MW|Ml [Address  $\langle n1 \rangle$ ]] | [PR|PW [Port  $\langle n2 \rangle$ ]]]
      [Data  $\langle n3 \rangle$  [Mask  $\langle n4 \rangle$ ]]
```

The Break command is used to program the Hardware Breakpoint Module with the specified combination of bus transactions that will terminate real-time execution of the user's program and return control to the Debug environment. Once in the Debug environment, the user can employ Debug commands to determine if his program is executing correctly, to modify the program or CPU status, and then return to the real-time execution of the user program via a Go command. Upon occurrence of a hardware break the entire status of the user's CPU is saved, allowing execution to be resumed at a later date with the entire status restored to its former condition.

The first parameter of the command specifies the type of transaction that will generate the break. Either Memory Read (MR), Memory Write (MW), Instruction Fetch Cycle (Ml), Port Read (PR), or Port Write (PW) can be specified. If no other parameters are entered, the system will break on the first occurrence of a transaction of the specified type. For example, if the command B PW is entered and the user program executed, the system would break on the first Port Write to any port.

The second parameter specifies a memory or port address. This parameter is entered only if it is desired to specify a specified memory or port address at which the Break will occur. For example, the command B MR A 2001 will cause the system to break when the first Memory Read from address 2001 occurs.

The third parameter allows the user to specify an 8-bit data field that must match the processor's data bus for a break to occur. For example, B MW D 32 would break if a 32H is written to any memory location. The mask parameter can be used with the data parameter, and causes specified bit positions to be ignored if the mask bit is zero for these positions.

If the Break command is issued with no parameters, it clears any existing Breakpoint set-up.

Note that Breakpoints are disabled when executing in Monitor mode.

COMPARE <n1> <n2> <n3>

The Compare command is used to compare the contents of two blocks of memory. n1 and n2 specify the starting addresses of the two blocks, while n3 specifies the number of bytes to be compared. If any locations of the two blocks differ, the addresses and contents of those locations are printed on the user's terminal.

Display <address> [<number of bytes>]

The display command displays on the terminal the contents of memory locations starting at the given address, for the given number of bytes. If no number of bytes is given, memory locations will be displayed one at a time, with an opportunity to change each byte. For each byte, the address will be typed, followed by the contents of the location, followed by a space. If it is desired to change the contents of that location, the new contents can be typed. A carriage return, either alone or after the new contents, will cause the next sequential location to be displayed. A "Q" (for Quit) followed by a carriage return will terminate the command.

FILL <addr1> <addr2> <data>

Stores the data byte given into all memory locations from addr1 to addr2. This range must not include any areas of ROM or non-existent memory.

GO [<address>]

The Go command will branch to the given address, thus executing the user's program. If no address is given, Go will cause a branch to the last stored PC, thus continuing program execution where it was last interrupted. In either case all registers are restored before branching. The Go command causes a switch to User mode.

History [<n>]

During execution of a user program "events" are stored in the Real-Time Storage Module. Each event consists of the storing of the address bus, the data bus and the control bus. The History command causes the last n events that were stored in the Real-Time Storage Module during user program execution to be printed at the terminal. If no parameter is entered the system will print all events that have occurred since the last break. n may be between 0 and 0FFH.

The format for the output from the storage module is:

A D C

where: A = 16-bit Address Bus
D = 8-bit Data Bus
C = 8-bit Control Bus Information

The control Bus information is interpreted as follows:

Bit 0 - First even stored marker
Bit 1 - Halt acknowledge (Inverted)
Bit 2 - M1
Bit 3 - Bus acknowledge
Bit 4 - MW
Bit 5 - MR
Bit 6 - PW
Bit 7 - PR

Interrupt Status

The Interrupt Status command displays the state of the interrupt enable flip-flop when the user program was executing.

0 for interrupts disabled
1 for interrupts enabled

The user can then change the status by entering a 0 (DI) or a 1 (EI) or he may terminate the command with a "Q" or carriage return.

Jump [<address>]

The Jump command will branch unconditionally to the given address. Registers are restored before branching; however, unlike the Go command, the transition to User mode is not made. If no address is given, Jump will cause a branch to the last stored PC.

Move <dest> <source> <n>

The Move command is used to move the contents of a block of memory from the source address specified by <source>, to the destination address specified by <dest>. n is the length of the block to be moved. There are no restrictions on <source>, <dest>, or n, except that they be positive integers, and that the blocks be bound within the 64K bytes addressed by the Z80 CPU.

Next [<n>]

The Next command will cause the execution of the next n machine instructions, starting at the current PC, and display all registers after each instruction execution. If n is not given, 1 is assumed. After a NEXT command, hitting successive carriage returns will cause execution and tracing of the following instructions.

Port <n>

An input is done from port n and the value is displayed on the terminal. The user can then output to this port by entering a hex value followed by a carriage return.

Pulse [[MR|MW|MI [Address <n1>]] | [PR|PW [Port <n2>]]]
[Data <n3> [Mask <n4>]]

The Pulse command is exactly like the Break command; however, program execution is not halted when the specified condition occurs. Instead, a sync pulse is generated at the BNC co-axial connector at the rear of the Development System cabinet.

Quit

This command will cause the user to leave the Debug environment and return to OS or to another specified routine (see Section 4.2). If OS has not been loaded, the Quit command will not be interpreted and the system will respond with a "?".

Register [<register name>|IM|AD]

The Register command permits the contents of the indicated register, interrupt mode flag or address flag to be examined and modified. If no register name is given, all registers will be displayed on one line. If a register name is given, individual registers will be displayed starting with the one given. The register name will be typed followed by its contents, followed by a space. If it is desired to change the contents of that register the new contents can be typed. A

carriage return, either alone or after new contents, will cause the next register to be displayed. If no more registers are desired, a "Q" (for Quit) should be entered, followed by a carriage return. This will terminate the command. The contents of the address offset flag (AD) and the User Interrupt Mode (IM) can also be displayed and modified in this same manner.

The registers being examined and modified are memory locations in which the indicated registers are saved at the start of the program and at each breakpoint, and from which they are restored at each Go command.

The sequence in which the registers are displayed when they are stepped from one to the next is:
IM, A, B, C, D, E, F, H, L, I, A', B', C', D', E', F', H', L', IX, IY, PC, SP, ADR.

Set <address> <data> <data> <data> ...

The Set command stores the given data words into sequential memory locations starting at the given address.

Trace [MR] [MW] [PR] [PW]

The Trace command is used to specify which types of bus transactions will be stored in the Real-Time Storage Module. The Trace command will accept from one to four of these parameters, in any order. If no parameters are specified, the command resets the Trace and no transactions will be stored. At power-on the system automatically specifies a Trace of all four parameters.

All of the above commands may be abbreviated to their first letter, or may have the command spelled out to any desired length. The first character typed on a new line will be taken as the key to which command is being invoked. If a command is not understood, a "?" will be typed and a new command requested. All numbers may be entered in free-form hex, with leading zeros omitted. If more than four hex digits are entered, the last four will form the number used. All fields are blank delimited.

4.2 DEBUG INTERFACE

There are two ways in which an external routine can interface with the PROM Debug package. With either, a flag is set and a return address is stored in an associated location.

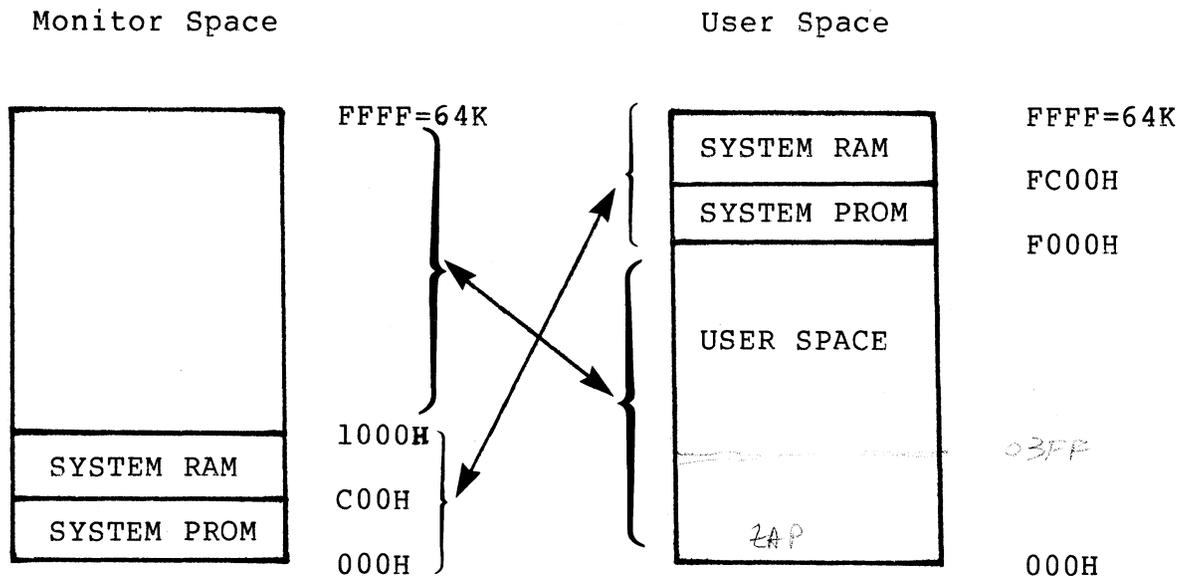
The first way is to make a call into the Debug environment, thus passing control to the Debug command interpreter until a Quit command is issued. This is done by setting bit 5 of location 0FC4H (BRKFLG) in system RAM (FFC4H in user space), storing the return address at locations 0FB5H, 0FB6H (FFB5H, FFB6H in user space) (EXTRET), and jumping to the Debug command interpreter at 0BFAH.

The second method is used when an external routine is used to handle breakpoints. If bit 7 of 0FC4H (FFC4H in user space) is set, the occurrence of a breakpoint will cause a jump to the location stored at 0FC5H, 0FC6H (FFC5H, FFC6H in user space) (BRKRTN).

4.3 MEMORY MAPPING

The Development System hardware provides two operating modes -- Monitor mode and User mode (for a detailed description of these modes, see the Z80 Development System Hardware User's Manual).

When in Monitor mode the Monitor and system RAM is mapped into the bottom of memory address 0 -> 0FFFH, where they are designed to execute. In User mode they are mapped into addresses F000H -> FFFFH. Thus to execute PROM routines in User mode they must be moved down to the range 0 -> FFFH (see Section 4.1). Although the Debug commands execute in Monitor mode, they are designed to operate on the user address space, thus 1000H is added to the specified addresses when using the Display, Get, Load, Save, and Move commands. If the user wishes to deal with the monitor address space this addition can be inhibited. This is done by setting location 0FD8H and 0FD9H (ADRFLG) to zero (FFD8H, FFD9H in user space).



4.4 EXECUTING A PROGRAM IN USER MODE

To execute a program in User mode, it should be loaded from the debugger via the LOAD or GET commands. Execution is started via the GO command which switches to user mode. Breakpoints and traces can be set via the BREAK and TRACE commands before executing the GO command. Note that ADRFLG should be set to 1000H.

4.5 EXECUTING PROGRAMS IN MONITOR MODE

The following section describes how to prepare and debug a program to be executed in Monitor mode.

After assembling the program, a procedure file must be created. With the RIO system this is done by linking the assembled object file.

When using the GET command from the Debugger, ADRFLG (described in 4.2) should be set to zero so that no offset is added to the load address. If this flag is not reset, then the program must be moved down 1000H bytes after loading.

Once a procedure file has been created it is executed from the executive by simply typing its name:

Examples:

RIO System

```
%ASM MONITOR.PROGRAM
PASS 1 COMPLETE
0 ASSEMBLY ERRORS
ASSEMBLY COMPLETE
%LINK $=4000 MONITOR.PROGRAM
LINK COMPLETE
%MONITOR.PROGRAM
```

execution begins

Non-Maskable Interrupt (NMI) and RST 38 may be trapped by a user program. The variables NMIDSP (system RAM address EEEH) and RSTDSP (system RAM address EECH) specify the addresses to branch to on these conditions. All registers are preserved and the address at which the condition occurred is on the stack. Both of these variables are initialized to 0 on reset.

4.6 DEBUGGING A PROGRAM WHICH IS INTENDED TO RUN IN MONITOR MODE

The DEBUG services of the Development System are all designed for use with programs running in the User mode. Thus, it is necessary to run in User mode while debugging. This can be accomplished by using the following procedure after the program has been prepared for execution in the Monitor mode as described above:

1. Move Monitor program into dynamic memory (User mode address 0)

```
>M 0 F000 C00
```

2. Set desired breakpoints and trace mode

```
>B M1 A 1C80  
>T MR MW
```

NOTE: The RIO system sizes memory via execution of a memory write followed by a memory read. Thus, to prevent the sizing routine from causing a break, M1 should be specified instead of MR.

3. Transfer control to the copy of the Monitor program in User memory

```
>G 0
```

NOTE: This places the system in User mode and is equivalent to a system Reset. It is, therefore, necessary to supply a speed recognition character (CR) and a bootstrap command (CR or OS), after which the system will be at the executive level, but executing in User mode.

```
>
```

4. The file name would then be typed thus beginning execution of the program.

At this point, the breakpoint set in step 2 above would be encountered and the system would return to the Monitor mode.

```
BREAK AT xxxx
```

5.0 SYSTEM PARAMETERS

There are several system parameters which are accessible to the user. They are:

NULLCT -- Null Count (FBFH)

In this location, the number of null characters which will be inserted after a carriage return (and whatever number of line feeds which are also inserted) is stored. Modifying the null count is the means of adapting the MCS to the carriage return delays of various terminals. NULLCT is initialized to 0.

LFCNT -- Line Feed Count (FC0H)

In this location, the number of line feeds which will be inserted after a carriage return is stored. Modifying the line feed count permits automatic multiple spacing. LFCNT is initialized to 1.

PROMPT -- Prompt Character (FC1H)

In this location, the character output by the TTY routine before reading a line from the terminal is stored. Modifying the prompt character permits various levels of interactive software to identify themselves in each command query. Prompting can be effectively eliminated by setting this location to a null character (ASCII 0). PROMPT is initialized to '>'.

LINDEL -- Line Delete (FC2H)

In this location, the character interpreted by the TTY routine as a line delete is stored. When it is encountered in the ASCII input stream from the terminal, this routine purges the buffer and continues reading the input stream. LINDEL is initialized to 21H.

CHRDEL -- Character Delete (FC3H)

In this location, the character interpreted by the TTY routine as a character delete is stored. When it is encountered in the ASCII input stream, the last character entered is purged from the input buffer. Multiple character deletes may be used to delete the last "n" characters entered. CHRDEL is initialized to 40H.

BRKFLG -- Breakpoint Flag (FC4H)

Bit 5 of this location is used to determine the return address for the QUIT command. Bit 7 is used to signal the existence of an external breakpoint handler (see Section 4.2). BRKFLG is initialized to 0.

BRKRTN -- Breakpoint Return (FC5H, FC6H)
This location is used with BRKFLG to make use of
an external breakpoint handler (see Section 4.2).
BRKRTN is initialized to 0.

EXTRET -- External Return (FB5H, FB6H)
This location is used with BRKFLG when calling
the Debug command interpreter (see Section 4.2).

NMIDSP -- Non maskable interrupt Dispatch (EEEH, EEFH). The
contents of this location specifies the address to branch
to on Non-Maskable Interrupt (NMI). NMIDSP is initialize
to 0.

RSTPSP -- RST 38 dispatch (EECH, EEDH). The contents of this
location specify the addresses to branch to when a RST 38
is executed. RSTDSP is initialized to 0.

There are several equates used by the system. They are:

ZDS SYSTEM HARDWARE I/O PORT ADDRESS

PORT	ADDRESS
USART DATA	F4
USART CONTROL/STATUS	F5
BAUD RATE DETECTION	FF
CTC CHAN 0	F0
CTC CHAN 1	F1
CTC CHAN 2	F2
CTC CHAN 3	F3
REAL TIME STORAGE MODULE	FC
BREAKPOINT	FB
SYSTEM RESET	FD
SYSTEM STATUS	FE
DISK DATA	F8
DISK CONTROL	F9
DISK STATUS	FA

3K MONITOR I/O ROUTINE CODES

FLOPPY REQUEST CODE	VALUE
---------------------	-------

RDBIN	0A
WRTBIN	0E

TTY REQUEST CODE	VALUE
------------------	-------

RDBIN	0A
RDLIN	0C
WRTBIN	0E
WRTLIN	10

ERROR CODES	VALUE
-------------	-------

NORMAL RETURN	80
INVALID OPERATION REQUEST	C1
DISK NOT READY	C2
DISK WRITE PROTECTED	C3
SECTOR ERROR	C4
TRACK ERROR	C5
CRC ERROR	C6

CPU INITIAL STATE	VALUE
-------------------	-------

INTERRUPT MODE	2
INTERRUPT VECTOR	0F
INTERRUPT FLIP/FLOP	ENABLED
STACK POINTER	0D00

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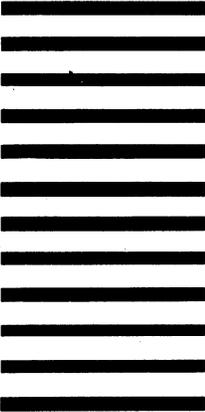
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