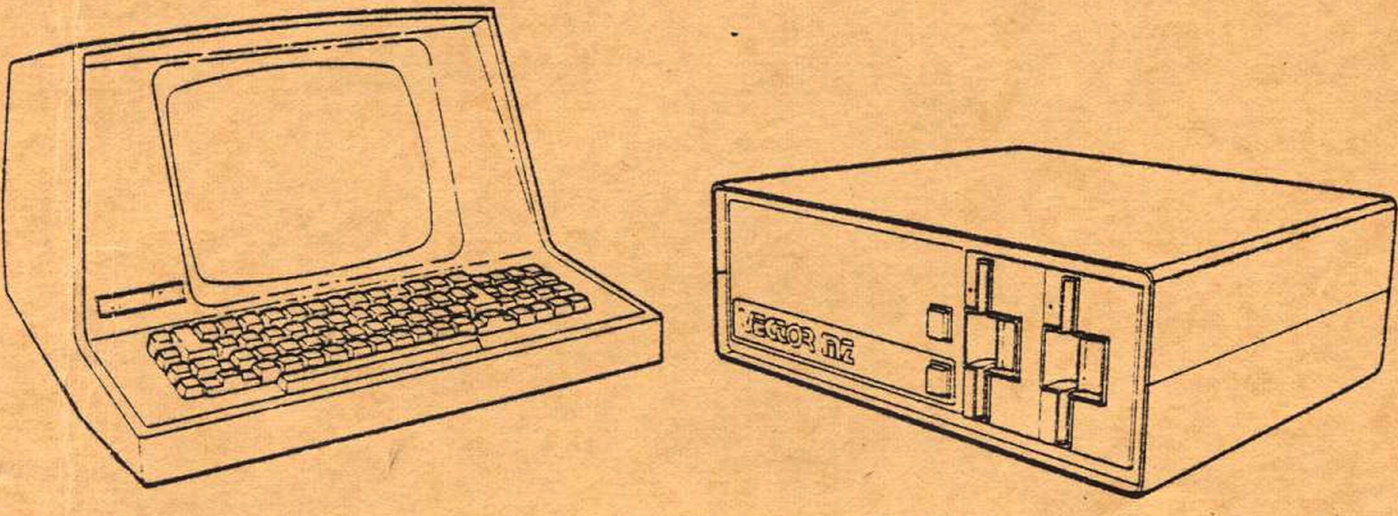
PROM RAM III

USERS MANUAL



VECTOR
VECTOR GRAPHIC, INC.

PROM/RAM III BOARD

Revision 1

and

PROM PROGRAMMING PROGRAM

Revision 1

USERS MANUAL

Revision A

July 16, 1979

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IV. Schematics

I. INTRODUCTION

1.1 SPECIFICATIONS

Bus Compatibility	S-100
Memory Capacity	RAM: 1K, included with the board PROM: Sockets for 12 PROMs.
PROM Programming	Can program 2708 or 2704 EPROMs
PROM Programming Program	Listing included in manual Executable version on MDOS System Diskettes 8.4 and later.
PROMs Included with Board	NONE
Memory Speed	RAM: 300 ns. PROM: User selected (450 ns. typ)
Memory Types	RAM: 2114 static PROM: 2708 (1K each) or 2704 (1/2K each)
Board Addressing	Two blocks (A and B) are separately addressed Block A has 8 PROM sockets Block B has 4 PROM sockets and 1K RAM
Addressing Options (jumper)	Base address of the two 8K blocks Block B PROM at top or bottom of block Address of 1K RAM within remaining 4K Disable unused 3K, for use by other boards
Standard Addressing	Block A: disabled Block B base address: C000H Block B PROMs: C000H - CFFFH Block B RAM: DC00H - DFFFH Block B disabled 3K: D000H - DBFFH
Standard Location of Systems Monitor PROM	C000H

(continued on back)

Power-on/Reset Jump	PRESET or POC causes jump to board
Power-on/Reset Jump Options (jumper)	Use PRESET or POC Jump to first instruction of Block A or B. Disable phantom generation Disable jump to on-board memory
Standard Power-on/Reset Jumpers	POC is used Jump to beginning of Block B Phantom and jump to on-board both enabled
MWRITE	Jumper option to generate MWRITE on board Standard: option not enabled
Wait state generation	Jumper option to generate one wait state each time board is addressed Standard: option not enabled
Bus load	1 TTL load on all inputs
Card extractors	Standard
Power	+8Vdc @ 450 mA (Typ) +18Vdc @ (depends on quantity of PROM) -18Vdc @ (depends on quantity of PROM)

1.2 DESCRIPTION OF THE PROM RAM III BOARD

Vector Graphic's PROM RAM III Board is a versatile, S-100 bus compatible, high density memory board combining the memory technologies of erasable programmable read only memories (EPROMs) and high speed random access memory (RAM). Of unique value, one of the PROM sockets on the board can be used to program a 2708 or 2704 EPROM, enabling any owner to create PROM-based software for use on this board or in any other microprocessor device. 1K of RAM is provided on the board, but no PROMs are included with purchase. The software which is used to program PROMs is provided as a listing in this manual, and is included on disk with all Vector Graphic systems shipped with this board.

By combining the use of MSI decoding logic and unique addressing features, a wide range of applications requirements may be met by this memory board. The addressing flexibility is as follows. The board offers two independently addressable 8K blocks of memory (A and B). You use jumpers to specify the two separate 8K addressing spaces assigned to these blocks. Block A can be used for up to 8K of PROM. Block B contains 1K of on-board RAM plus up to 4K of PROM.

For block B, you use jumpers to specify whether the PROM is at the top or the bottom of the 8K allocation, and then, within the remaining 4K, where the 1K of RAM is addressed. Once this is done, there are also jumper options for DISABLING some or all of the remaining 3K of addressing space allocated to block B, so that other boards in the system can use those addresses.

The addressing spaces are fully utilized if 2708 1K PROMs are used. If 2704 1/2K PROMs are used, then every other 1/2K of PROM allocation will be used, with 1/2K gaps between. Other features offered by the board are: jump on power-on or reset to on-board memory, with phantom generated to temporarily disable other memory boards, and a jumper option to use PRESET instead of POC to cause this jump; jumper option for on-board generation of the S-100 MWRITE signal; and a jumper option to generate a one-cycle wait-state each time the board is addressed.

Full buffering of all inputs and outputs is provided to minimize loading of the system S-100 bus to at most one TTL load. On-board power regulation and filtering is provided using IC regulators and heat sinks for power dissipation. Careful attention to good design practice and an awareness of the need for flexibility has resulted in a reliable board useful in a wide variety of systems and applications.

II. USERS GUIDE

This Users Guide begins with a description of the amount and kind of PROM which can be used on this board, followed by a description of the RAM included with the board, then a detailed description of the various options you have for addressing the PROMs and the RAM. Read it before attempting to re-jumper the board addressing. Following this section are a description of each of the jumper options possible on the board, including addressing options, power-on/reset jump, MWRITE input, and wait state generation. The diagrams of jumper pads show each of the pads as it is pre-jumpered at the factory. The guide ends with instructions for operating the PROM programming software provided with the board, as well as instructions for writing your own if desired. The listing of the program is provided.

2.1 PROM SELECTION AND USE

A maximum of 12K bytes (where K = 1024) of 2708 type PROMs may be installed in available sockets on the board. NO PROMS ARE INCLUDED WITH PURCHASE OF THE BOARD ALONE. Jumpers are used to determine where the PROMs are addressed.

The following discussion assumes that 2708 type PROMs (having 1K of 8-bit bytes each) are used. If 2704 PROMs (having 1/2K bytes each) are used, the issues are the same; the only difference is that wherever a 2704 PROM is used, there will be 1/2K bytes of PROM accessible by the system, followed immediately by a 1/2K gap which will not contain any memory at all.

The numbers 2708 and 2704 are Intel generic part numbers. Many other manufacturers make equivalents, with 2708 or 2704 as part of their proprietary part number. All 2708 or 2704 pin for pin equivalents can be used on this board.

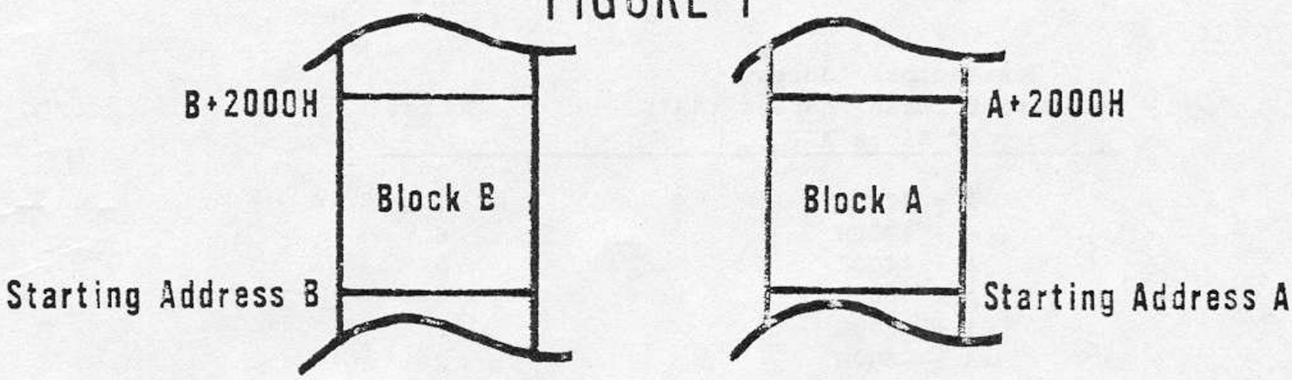
2.2 RAM

In addition to the PROM sockets, there is 1K of static RAM on the board, which IS included with purchase of the board alone. Jumpers are used to determine where this 1K of RAM is addressed.

2.3 BLOCK A AND BLOCK B - GENERAL

To begin specifying the addresses for the memory, there are two separately addressable blocks of memory space available on the board, called blocks A and B. Jumpers are used to specify what the base address is for each of these two blocks, within a 64K total memory space. Alternately, one (or both) blocks can be disabled completely. Jumper area F is normally used to specify the base address of (or disable) block A and jumper area E is normally used to specify the base address of (or disable) block B. If a block is not disabled, then that block will occupy exactly 8K bytes of memory, beginning at its base address. This is true for both blocks, as shown in Figure 1.

FIGURE 1



Note that both blocks together occupy 16K of memory. However, there are only 12 sockets for PROMs, and only 1K of RAM on the board, totalling 13K. What happens if the processor addresses memory in the remaining 3K portion? This memory space is NOT necessarily empty. A set of jumpers is provided which in effect specify that the unused 3K, within the 16K, is not on the PROM RAM III board at all, and therefore may be used on other boards.

It must be emphasized that except for the 3K specified as unused by jumper, the addresses assigned to the board for blocks A and B cannot be used by any other board, even if some of the PROM sockets are left empty. However, remember that you may choose not to use one (or both) of the blocks at all, by disabling it completely in jumper areas E and F. If you do this, then the corresponding memory space CAN be assigned to another board, and no space is wasted.

If the jumpers in area G are switched from the way the board is normally shipped, then the base address of block A will be controlled by jumper area E and the base address of block B will controlled by jumper area F, instead of the other way around. If this is done, then the address which is accessed for power-on jump will also be switched, becoming the first address in block A instead of the first address in block B. This is the purpose for using this option. (See Section 2.14) For simplicity of language, the Users Guide is written assuming that jumper area G is left as manufactured.

2.4 BLOCK A

Block A refers to the 8 PROM sockets at the top of the board (labeled 0 through 7). Insert PROMs which you want in block A into these sockets. Socket 0 corresponds to the 1K block beginning at the base address of block A. Socket 1 corresponds to the next 1K and so on, as shown in the following table:

Hexadecimal Address Relative to Base Address ("A") of Block A	Socket
A + 1C00H	7
A + 1800H	6
A + 1400H	5
A + 1000H	4
A + C00H	3
A + 800H	2
A + 400H	1
A	0

Jumper area F is normally used to determine the base address of block A, or to disable block A. When the board is sold, jumper area F is pre-wired to disable block A. No particular base address is thus specified until you install the jumpers.

2.5 BLOCK B

Block B includes the lower four PROM sockets on the board, labeled 8 through 11. The other 4K in block B is filled with the 1K of RAM on the board, plus the 3K of address space which can be, at you discretion, returned for use by other boards. The way you specify the address spaces within block B is as follows: First, you specify the base address of Block B using jumper area E (or you specify in area E that the block is disabled). If it is not disabled, then you use jumper area J to specify whether the 4K of PROM occupies the top or the bottom 4K of the block. These are the only two choices. The board is pre-jumpered so that the PROM occupies the lower 4K. Then, you specify using jumper area I which 1K within the other 4K is used for the on-board RAM. Lastly, you specify using jumper area H whether one of more of the last three 1K blocks is to be returned for use by other boards. (Normally you specify that all three of them are returned.)

Two typical configurations of Block B are shown in figures 2 and 3. Figure 2 is the standard - the one for which the board is pre-wired. Since in the pre-wired version, block B begins at C000H, Figure 2 shows that the standard address for scratch-pad RAM is DC00H, and the standard address for the System's Monitor PROM is C000H. Figure 3 shows the result of putting the PROM in the upper 4K and specifying that the RAM occupy the second 1K portion.

FIGURE 2

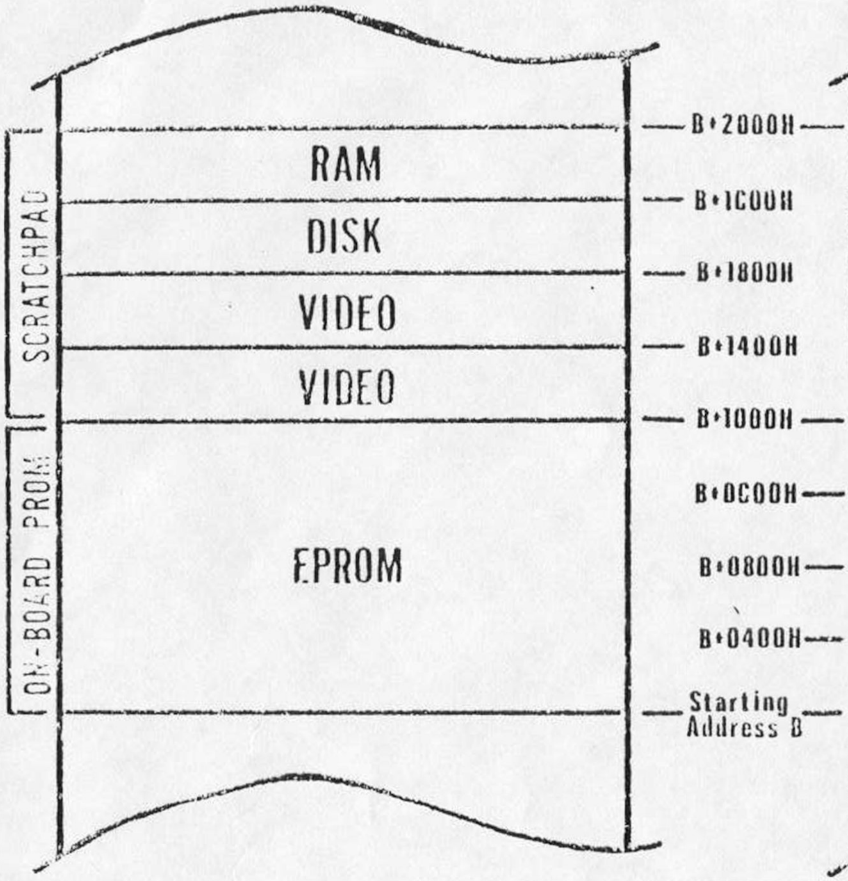
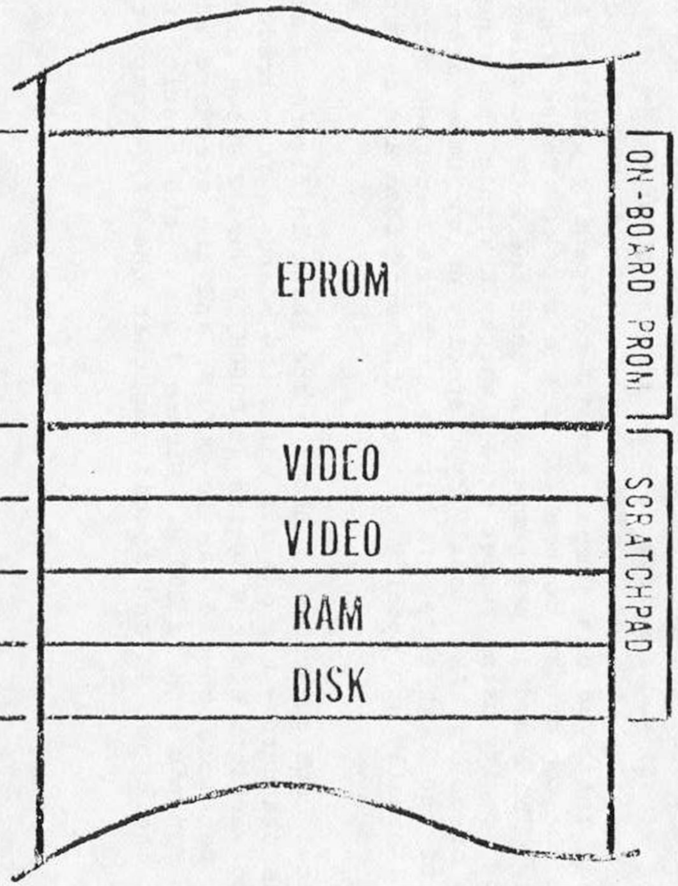
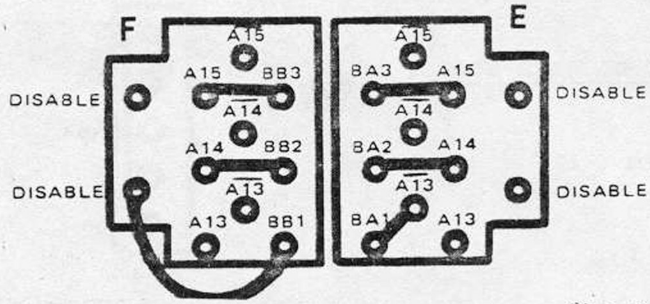


FIGURE 3



2.6 BLOCK SELECT ADDRESSING



Jumper areas: E & F

Jumper names: A13, A13, A14, A14, A15, A15 = address lines
BA1, BA2, BA3 = block B address pads
BB1, BB2, BB3 = block A address pads

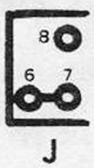
NOTE: The second letter in the block B address pads is "A", while the second letter in the block A address pads is "B". This occurs because historically, the pads were named before it was decided to manufacture the board with the "block swap" jumpers in area G reversed.

Function: Address lines A13, A14, A15 form the most significant bits of the address from the CPU. These three bits can select any of 8 possible 8K blocks of memory in a 64K memory space. See table 1.

Options: Table 2 tells you what jumpers to connect to specify any particular 8K block starting address.

2.7 PROM/SCRATCHPAD MEMORY INVERT

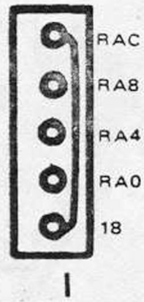
Jumper area: J



Function: The pre-wired connection specifies that the low order 4k bytes of block B consists of PROM. This jumper area is used to reverse this, putting the PROM at the high end of block B.

Options: If the PROM is to occupy the high order addresses of this block cut the jumper from 6 to 7 and tie 6 to 8.

2.8 RAM MEMORY ADDRESS SELECT IN BLOCK B

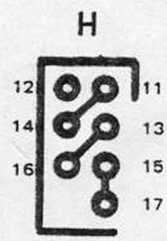


Jumper area: I

Function: These jumpers allow the user to selectively determine where the RAM addresses are to be located. With the board jumpered as manufactured, the 1K of RAM occupies the top-most 1K of addresses of the 4K scratchpad memory block.

Options: If you wish to alter the factory supplied connections, the following procedure is recommended: Cut the jumper from 18 to RAC. Then, determine the desired address for the 1K RAM from Table 3 and connect a jumper as specified. The third part of Table 3 is not relevent to this jumper area.

2.9 DISABLE 3K OF ADDRESS SPACE IN BLOCK B



Jumper area: H

Function: These jumpers allow the user to selectively determine which 3 of 4 1K blocks of memory are returned for use by other boards. These jumpers are selected in conjunction with the RAM memory address jumper in area I, so that together, all 4K of the non-PROM (scratchpad) address space in block B are accounted for. The factory supplied connections complement the factory supplied RAM address jumper, so that the bottom 3K of the scratchpad memory is allocated for use by other boards.

Options: If it is desired to alter the factory supplied connections, the following procedure is recommended: Verify the RAM memory address selected previously. Then, refer to Table 3 to find the RAM address selected, and connect jumpers as specified in the third part of the table.

2.10 POWER-ON/RESET JUMP - DESCRIPTION

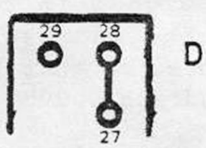
A power on/reset jump feature is also provided on this board. When the $\overline{\text{POC}}$ or $\overline{\text{PRESET}}$ (your choice of which, by jumper selection) line is low, the instruction stored in the first address of block A or B (determined by the jumper in area G, as explained below) will be executed by the CPU, and a "phantom" signal will be issued by the board on bus line 67 which disables other system memory boards.

After this initial instruction execution, the other memory boards will be re-enabled. However, if the instruction is a jump to the next instruction in the same block, then control will have been effectively transfered to that block on the PROM/RAM III board. Therefore, the second instruction should be the beginning of a system initialization routine followed by a systems executive. This is always the case in standard Vector Graphic computers.

Two additional jumper areas are provided, one to disconnect the phantom signal if it is not desired, and the other to disconnect the jump to the on-board PROM if this is not desired. These options give you maximum control over use of the board.

2.11 USE PRESET OR POC FOR POWER-ON/RESET JUMP

Jumper area: D



Function: In the factory version of the board, the $\overline{\text{POC}}$ signal is connected to the power-on/reset jump circuitry on the board. This is appropriate for standard Vector Graphic computers, because in these systems, both the RESET switch on the front panel and the initial power-on condition cause an active low pulse on the POC line, via circuitry on the Z80 board. If the CPU board used in your system does not have this feature, the $\overline{\text{PRESET}}$ signal can be connected to the power-on/reset circuitry by changing the jumper area D.

Options: To connect $\overline{\text{PRESET}}$ to the power-on/reset circuitry, cut the trace between 27 and 28 and tie 28 to 29.

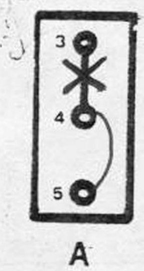
2.12 PHANTOM GENERATED IF POWER-ON/RESET

Jumper area: C

Function: When 1 and 2 are tied together, the phantom signal is generated whenever a POC or PRESET signal is received. Phantom disables other system memory boards. The Z80 (and 8080) processor chip immediately executes the instruction at 0000H when the $\overline{\text{POC}}$ or $\overline{\text{PRESET}}$ signal appears on the bus, assuming the CPU board is so designed. With the other memory boards in the system disabled, the PROM/RAM III Board is free to supply the instruction for address 0000H.

Options: To disable the generation of the phantom signal, cut the jumper from 1 to 2.

2.13 JUMP TO PROM/RAM III BOARD IF POWER-ON/RESET



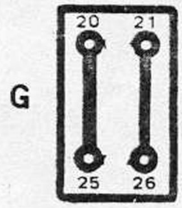
Jumper area: A

Function: When the $\overline{\text{POC}}$ or $\overline{\text{PRESET}}$ signal is received, a jumper in area A causes the board to respond to the address 0000H from the CPU. At your option, you may disable this feature, so that the PROM/RAM III board is NOT the board which responds to the address 0000H.

Options: To cause the board NOT to respond to address 0000H when $\overline{\text{POC}}$ or PRESET is received, cut the jumper from 3 to 4 and tie 4 to 5.

2.14 BLOCK SWAP

Jumper area: G



Function: With the board as manufactured, jumper area E is used to address block B, and jumper area F is used to address block A. Furthermore, if the power-on/reset jump feature is used, the jump will take place to the first address in block B.

Options: If you want to jump to block A instead, cut the jumpers from 20 to 21 and 25 to 26; tie 20 to 25 and 21 to 26. This change will also reverse the use of area E and F, so that area E is used to address block A, and area F is used to address block B.

2.15 DISABLE POWER-ON/RESET RESPONSE

To disable the power-on/reset response of the PROM/RAM III board entirely, disable both the generation of phantom and the jump to PROM/RAM III board. See Sections 2.12 and 2.13.

2.16 MWRITE INPUT

Jumper area: B

Function: If this board is installed in a system without a front panel, or other source of MWRITE, an MWRITE signal can be generated on board both for use on board and for feeding back to the bus as a fully buffered S-100 signal. This is not needed in Vector Graphic systems shipped after April 9, 1979, because the Z-80 boards in these systems now generate MWRITE.

Options: If the board is installed in a system without a source of MWRITE, add a jumper from 9 to 10.

2.17 WAIT STATE GENERATION

Jumper area: K

Function: The PRDY signal may be jumpered to the WAIT input in order to create one wait state each time the board is addressed. This is necessary when using memory slower than about 300 ns. in a 4 MHz (Z-80) system. PRDY is not connected to WAIT on the PROM/RAM III board as manufactured, because the Vector Graphic Z-80 board used in Vector Graphic systems generates the wait-state. You would want to generate the wait-state on the PROM/RAM III board if you are using memory faster than 300 ns. on other memory boards in the system, allowing you to disable the wait state that is built into the Vector Graphic Z-80 board (and some other manufacturers' Z-80 boards) yet continue to use a wait-state for the slower memory on the PROM RAM/III board.

For some Z-80 based CPU boards the WAIT output is not synchronized properly. If the WAIT is jumpered to the PRDY signal when such a Z-80 board is used, a possible oscillatory condition can arise on the PRDY and WAIT lines. Therefore, caution must be exercised in how this jumper is utilized. The Vector Graphic Z-80 board has a properly synchronized WAIT, so that with this Z-80 board, PRDY may be safely tied to WAIT, insuring reliable memory operation at high speeds.

Options: To tie PRDY to WAIT, jumper 22 to 23.

TABLE 1

H = Hexidecimal   D = Decimal

A15	A14	A13	8K BLOCK (A or B) STARTING ADDRESS
0	0	0	0000H = 0000D
0	0	1	2000H = 8192D
0	1	0	4000H = 16384D
0	1	1	6000H = 24576D
1	0	0	8000H = 32768D
1	0	1	A000H = 40960D
1	1	0	C000H = 49152D
1	1	1	E000H = 57344D

TABLE 2

x = Block A or B

If any 8x1, 8x2, 8x3 is tied to disable, that block of memory is disabled.

DESIRED 8K BLOCK STARTING ADDRESS	CONNECT 8x1 to:	8x2 to:	8x3 to:
0000H	$\overline{A13}$	$\overline{A14}$	$\overline{A15}$
2000H	A13	$\overline{A14}$	$\overline{A15}$
4000H	$\overline{A13}$	A14	$\overline{A15}$
6000H	A13	A14	$\overline{A15}$
8000H	$\overline{A13}$	$\overline{A14}$	A15
A000H	A13	$\overline{A14}$	A15
C000H	$\overline{A13}$	A14	A15
E000H	A13	A14	A15

TABLE 3

ADDRESS OF 1K RAM WITH RESPECT TO THE STARTING ADDRESS OF THE 4K BLOCK	JUMPERS FOR RAM ADDRESS WITHIN 4K BLOCK	JUMPERS FOR BUS DISABLE
0000H	18 to RA0	15 to 16, 13 to 14, 11 to 12
0400H	18 to RA4	15 to 17, 13 to 14, 11 to 12
0800H	18 to RA8	15 to 17, 13 to 16, 11 to 12
0C00H	18 to RAC	11 to 14, 13 to 16, 15 to 17

2.18 PROGRAMMING A PROM

This board is accompanied by a program which allows you to program any 2704 or 2708 type EPROM. The listing of this program is found in Section 2.21, below. This same program is found on MDOS System Diskettes, version 8.4 and later, which accompany all Vector Graphic computers that are equipped with PROM/RAM III boards. The program exists on the disk as an immediately executable utility. The program is written in machine language and is not dependent on any operating system (except that it uses the Extended Systems Monitor in Vector Graphic systems for console I/O.) The utility (called "PROM") runs beginning at address 2B00 Hex and takes up less than 1K. If you want to run it elsewhere, or want to revise it, reassemble it as described in Section 2.20.

If you use an operating system other than MDOS, but you have the MDOS diskette, simply load the program under MDOS and copy it to a disk using the other system. To load it, just type PROM (return) followed by control-C, under MDOS. If you do not have the MDOS diskette, enter the program from the listing. Once it is loaded in memory, you can execute it from any executive, including the Extended Systems Monitor executive. The following explains the use of this program. If you are not using MDOS, then substitute the MDOS commands given here by those that are relevent to you.

1. Make sure the computer power is OFF. Wait at least five seconds before pulling out any circuit boards.

2. Unscrew and remove the cover of the computer.

3. Find the PROM/RAM III board. If you cannot easily reach PROM socket 11 with your hand, pull the board out.

4. Insert the PROM you wish to program in socket 11. This is the right-hand socket in the second row. Make sure to insert the PROM with its notch pointed to the top of the board. The PROM used MUST have been erased using ultraviolet erasing techniques, unless it is new. The computer cannot simply write over any previously used PROM, because programming involves turning logical 1's into 0's, but cannot go the other way. Erasing fills the PROM with 1's, like a new PROM.

5. Return the board to a slot which allows you to reach socket 11 without pulling the board out in the future, if possible.

6. Turn computer power ON.

7. If the system is not in the Extended Systems Monitor executive (indicated by the Monitor prompt *) then depress RESET on the computer front panel.

8. Mount the MDOS system diskette in drive 0 (the right-hand drive.) Then,

depress B on the keyboard. MDOS will take control, as indicated by the MDOS prompt >.

9. Load the object code to be stored on PROM into a free area of memory. Alternately, you may generate the desired code by assembling or compiling a higher level program.

10. Following the MDOS prompt >, type PROM (return). The PROM programming program will take control.

11. In response to the question "Starting from: ", type the address in Hex of the first location you wish to program, within the block of memory assigned to PROM socket 11. Then press the RETURN key. Usually this starting address will be CC00. If programming less than the entire PROM, it can be any address between CC00 and CFF0. It must be an address ending in 0. If not, the machine will report "bad boundary address" and give you another chance. Letters must be in upper case. Do not tack on an H or any other symbol.

    CC00 is the starting address of PROM socket 11 if the board is left in factory-supplied format. If you enter an address outside the range CC00 to CFF0, the program will not accept it, and will report "out of range" and then give you another chance. If the addressing jumpers determining the location of socket 11 have been modified, you must modify the program to accept other addresses.

12. In reponse to the question "terminating at: ", type the address in Hex of the last location you wish to program, within the block of memory assigned to PROM socket 11. Then press the RETURN key. Usually this terminating addresss will be CFFF for 2708 PROMs and CDFF for 2704 PROMs. If programming less than the entire PROM, it can be any address between CC0F and CFFF. It must be an address ending in F, and must be greater than the starting address. If not ending in F, the machine will report "bad boundary address" and then give you another chance.

    As with the starting address, if you enter an address outside the range CC0F to CFFF, the program will not accept it, and will report "Out of range" and then give you another chance. Therefore, if the addressing jumpers determining the location of socket 11 have been modified, you must modify the PROM programming program to accept other addresses.

    After entering the terminating address, the computer will either continue with the next question, or it will report "specified portion of PROM is not erased." This message means either that the terminating address is less than the starting address, or that the PROM is not new and was not properly erased. This message is strictly a warning, because in certain rare cases you may want to write over an unerased PROM. After the message, the system will continue with the next question. If you want to start over to correct your mistake, instead of continuing, then depress the ESC key. This takes the system back to the Monitor. To get back to MDOS from the Monitor, depress J. Then begin the program again at step 10, above.

13. In response to the question "Source address: ", type the starting address in memory of the material you want to store on PROM. This can be any address in memory. Then press the RETURN key.

14. Slide the "programming" switch at the upper right-hand corner of the PROM/RAM III board to the LEFT.

15. Now, press the RETURN key again. This will begin programmming of the PROM. The computer must pass through the range of target addresses 256 times. A message will appear on the screen showing which pass the machine is currently on.

16. When programming is complete, one of two events will take place. If the computer detects no errors in comparing the programmed PROM without the original code, then the system will return to the MDOS executive or whichever other executive was used to call the programming program. If an error is discovered however, the screen will show the first address within the PROM at which a verification error was found. For example, if you forgot to slide the programming switch to the left, then, since the PROM will not have been programmed at all, the first address will be incorrect, so that the system will report an error at address CC00, or whatever was the starting address you had specified. After reporting the error, the system will return to the MDOS executive, so that you can start over.

17. When programming is complete, immediately slide the programming switch on the PROM/RAM III board to the RIGHT. Do not postpone this.

18. Remove the programmed PROM from socket 11. Alternately, you may use the PROM without removing it. For example, you may run a checksum of the PROM using the Extended System Monitor's Q command. To do this, depress <u>control-Q</u> or whichever other command your system uses to get to the Monitor executive. Then type <u>Q CC00 CFFF</u>. (The spaces will occur automatically.) The checksum, will appear immediately. (If PROM socket 11 has been readdressed, then use the appropriate addresses.) To return to MDOS from the Monitor, depress <u>J</u>.

depress B on the keyboard. MDOS will take control, as indicated by the MDOS prompt >.

9. Load the object code to be stored on PROM into a free area of memory. Alternately, you may generate the desired code by assembling or compiling a higher level program.

10. Following the MDOS prompt >, type PROM (return). The PROM programming program will take control.

11. In response to the question "Starting from: ", type the address in Hex of the first location you wish to program, within the block of memory assigned to PROM socket 11. Then press the RETURN key. Usually this starting address will be CC00. If programming less than the entire PROM, it can be any address between CC00 and CFF0. It must be an address ending in 0. If not, the machine will report "bad boundary address" and give you another chance. Letters must be in upper case. Do not tack on an H or any other symbol.

    CC00 is the starting address of PROM socket 11 if the board is left in factory-supplied format. If you enter an address outside the range CC00 to CFF0, the program will not accept it, and will report "out of range" and then give you another chance. If the addressing jumpers determining the location of socket 11 have been modified, you must modify the program to accept other addresses.

12. In reponse to the question "terminating at: ", type the address in Hex of the last location you wish to program, within the block of memory assigned to PROM socket 11. Then press the RETURN key. Usually this terminating addresss will be CFFF for 2708 PROMs and CDFF for 2704 PROMs. If programming less than the entire PROM, it can be any address between CCOF and CFFF. It must be an address ending in F, and must be greater than the starting address. If not ending in F, the machine will report "bad boundary address" and then give you another chance.

    As with the starting address, if you enter an address outside the range CC0F to CFFF, the program will not accept it, and will report "Out of range" and then give you another chance. Therefore, if the addressing jumpers determining the location of socket 11 have been modified, you must modify the PROM programming program to accept other addresses.

    After entering the terminating address, the computer will either continue with the next question, or it will report "specified portion of PROM is not erased." This message means either that the terminating address is less than the starting address, or that the PROM is not new and was not properly erased. This message is strictly a warning, because in certain rare cases you may want to write over an unerased PROM. After the message, the system will continue with the next question. If you want to start over to correct your mistake, instead of continuing, then depress the ESC key. This takes the system back to the Monitor. To get back to MDOS from the Monitor, depress J. Then begin the program again at step 10, above.

13. In response to the question "Source address: ", type the starting address in memory of the material you want to store on PROM. This can be any address in memory. Then press the RETURN key.

14. Slide the "programming" switch at the upper right-hand corner of the PROM/RAM III board to the LEFT.

15. Now, press the RETURN key again. This will begin programmming of the PROM. The computer must pass through the range of target addresses 256 times. A message will appear on the screen showing which pass the machine is currently on.

16. When programming is complete, one of two events will take place. If the computer detects no errors in comparing the programmed PROM without the original code, then the system will return to the MDOS executive or whichever other executive was used to call the programming program. If an error is discovered however, the screen will show the first address within the PROM at which a verification error was found. For example, if you forgot to slide the programming switch to the left, then, since the PROM will not have been programmed at all, the first address will be incorrect, so that the system will report an error at address CC00, or whatever was the starting address you had specified. After reporting the error, the system will return to the MDOS executive, so that you can start over.

17. When programming is complete, immediately slide the programming switch on the PROM/RAM III board to the RIGHT. Do not postpone this.

18. Remove the programmed PROM from socket 11. Alternately, you may use the PROM without removing it. For example, you may run a checksum of the PROM using the Extended System Monitor's Q command. To do this, depress <u>control-Q</u> or whichever other command your system uses to get to the Monitor executive. Then type <u>Q CC00 CFFF</u>. (The spaces will occur automatically.) The checksum, will appear immediately. (If PROM socket 11 has been readdressed, then use the appropriate addresses.) To return to MDOS from the Monitor, depress <u>J</u>.

2.19 WRITING A PROM PROGRAMMING PROGRAM

Although the PROM/RAM III board is supplied with a program for programming PROMs, this section explains the principles behind the program, for those wishing to write their own. The supplied program is listed in Section 2.21, for reference.

To program a 2708 or 2704 type EPROM, simply write the desired data to the locations assigned to PROM socket 11. The board hardware automatically interprets any writing of data to PROM socket 11 as an intent to program it. You do not have to program an entire PROM. You may program any part of it, down to blocks as short as 16 adjacent locations. Normally, you will program all 1K of a 2708 or all 512 bytes of a 2704. Write to all desired addresses in sequence. After finishing one such cycle, repeat it, using exactly the same data. You must repeat this cycle 256 times. In other words, you must write to each address 256 times, with a substantial delay between each time you write to each address. This delay is produced by the time taken to cycle through all the addresses, which is sufficiently long if 16 or more locations are programmed.

A good program has a comparison of the source and destination data, after programming the PROM is complete.

If your system has a dynamic memory board in it (such as all Vector Graphic systems shipped since about March 1, 1979), then there MUST be a delay loop after each byte is written to the PROM, so that the processor can refresh memory. The delay loop must execute at least 128 instructions each time it is accessed. You will find an example of this at the top of the fourth page in the listing in Section 2.21.

Before executing a programming procedure, you must slide the programming switch on the upper right-hand corner of the board TO THE LEFT. Then, put the PROM to be programmed into socket 11, which is the socket furthest to the right in the second row. After successfully programming it, slide the switch BACK. If you do not, you might accidently erase a PROM sitting in socket 11.

A PROM which you want to program must be either new or newly erased using the standard ultraviolet technique.

2.20 RE-ASSEMBLING THE PROM PROGRAMMING PROGRAM

The source code for the program is listed in Section 2.21 below. Enter the program using the MDOS editor LINEEDIT. You can assemble it wherever you like, although BC00 is not suggested because M.BASIC uses the very top of RAM for stack. The pre-assembled version on the diskette (under the name "PROM") is assembled to run at 2B00, at the beginning of the MDOS applications area. The program is less than 1K long.

You may modify PROM.S before you assemble it, by using the MDOS editor LINEEDIT. One modification which may be required are the addresses in the last two lines of PROM.S. You will have to change these if you change the jumpers on the PROM/RAM III board which assign the address of the on-board RAM. After entering and modifying the program, SAVE it on diskette under the name PROM.S. (Type NAME "PROM.S" (return) followed by SAVE (return) while in LINEEDIT.

To assemble PROM.S, use the ZSM assembler. With a diskette having both ZSM and PROM.S mounted in drive 0, and with MDOS in control, type ZSM "PROM.S" "PROM2" "E" (return). The assembler will ask where you want to run the program. Enter the address, for example 2B00H, that you want it to run at. Note that if the first character is a letter, it must be preceded by a 0 (zero), and the address must be followed by an H. The above ZSM statement will cause the program to be assembled with only errors printed. For other options possible with ZSM, see Section 4.5 of the User's Guide to Vector Graphic Systems Using MDOS.

After the assembly is complete, type TYPE "PROM2" 18 (return). This type will allow you to execute the program simply by typing PROM2 (return) while under MDOS.

If you want to put the PROM programming program on a PROM, in order to have a permanent PROM programming capability, first choose the memory location you want to give to this PROM, say E000, which is available on the PROM/RAM III board. Use this address when asked by the assembler where you want it to run at. Since there is no RAM at this address, you will have to load the assembled code into a different location before you can put it on a PROM. To do this change the type to 00 rather than 18, by typing TYPE "PROM2" 00 (return), after the assembly is complete. This will allow you to type LOAD "PROM2" 2B00 (return) after the MDOS prompt >, thus loading the code at RAM address 2B00, ready to be saved on a PROM.

2.21 PROM PROGRAMMING PROGRAM LISTING

```
Addr B1 B2 B3 B4 E Label          Opcd   Operand

0000                 ****************************
0000                 *                          *
0000                 * Prom Programming Program *
0000                 *         Version 1        *
0000                 *    for the Prom/Ram III  *
0000                 *                          *
0000                 *       by Lance Lewis,    *
0000                 *    Vector Graphic Inc.   *
0000                 *       20-July-79         *
0000                 *                          *
0000                 ****************************
0000                 *
0000                 *
0000                 * System equates
0000                 *
0000      C003   =   INPUT          EQU    0C003H         ;character input (C0DC on pre 3.0 monitors)
0000      C008   =   OUT            EQU    0C008H         ;video driver (C098 on pre 3.0 monitors)
0000                 *
0000                 * Definitions and Constants
0000                 *
0000      C000   =   PROM           EQU    0C000H         ;prom address
0000      00FF   =   BLANK          EQU    0FFH           ;erased byte of prom
0000      0D0A   =   CRLF           EQU    0D0AH          ;carriage return linefeed
0000      000A   =   LF             EQU    0AH            ;linefeed
0000      000D   =   CR             EQU    0DH            ;carriage return
0000      0080   =   MSB            EQU    80H            ;most significant bit
0000                 *
0000      2B00   =   ORIG           REQ    'Program to run at?'
0000                                ORG    ORIG           ;assemble here
2B00                 *
2B00                 * Here we go
2B00                 *
2B00 E5                             PUSH   H              ;save HL
2B01 D5                             PUSH   D              ;save DE
2B02 C5                             PUSH   B              ;saev BC
2B03 F5                             PUSH   PSW            ;save AF
2B04 21 00 00                       LXI    H,0
2B07 39                             DAD    SP             ;HL=SP
2B08 22 03 2E                       SHLD   STACK          ;store it
2B0B 31 00 D0                       LXI    SP,0D000H      ;reset stack pointer
2B0E                 *
2B0E CD 43 2D                       CALL   PRINT          ;send message
2B11 0D 0A                          DD     CRLF
2B13 20 20 20 20                    DT     '      Vector Graphic'
2B17 20 20 56 65
2B1B 63 74 6F 72
2B1F 20 47 72 61
2B23 70 68 69 63
2B27 0D 0A                          DD     CRLF           ;print CRLF
2B29 20 20 50 72                    DT     '  Prom Programming System'
2B2D 6F 6D 20 50
2B31 72 6F 67 72
2B35 61 6D 6D 69
2B39 6E 67 20 53
2B3D 79 73 74 65
2B41 6D
```

```
Addr B1 B2 B3 B4 E Label        Opcd  Operand

2B42 0D 0A                      DD    CRLF
2B44                *
2B44 0A                         DB    LF              ;down a line
2B45 20 20 50 72                DT    '  Program prom'
2B49 6F 67 72 61
2B4D 6D 20 70 72
2B51 6F 6D
2B53 0D 8A                      DD    CRLF+MSB        ;end of message
2B55                *
2B55 CD 43 2D       STARTADRS   CALL  PRINT           ;send message
2B58 20 20 53 74                DTH   '  Starting from :'
2B5C 61 72 74 69
2B60 6E 67 20 66
2B64 72 6F 6D 20
2B68 3A
2B69 CD 4F 2D                   CALL  ADRS            ;get start address
2B6C DA 55 2B                   JC    STARTADRS       ;if invalid try again
2B6F CD 43 2D                   CALL  PRINT
2B72 0D 8A                      DD    CRLF+MSB        ;print CRLF
2B74 CD 24 2D                   CALL  RANGERR         ;check for error
2B77 DA 55 2B                   JC    STARTADRS       ;try again if error
2B7A CD 96 2D                   CALL  MOD             ;check boundery
2B7D DA 55 2B                   JC    STARTADRS       ;no good
2B80 EB                         XCHG                  ;DE=start adrs
2B81                *
2B81 CD 43 2D       ENDADRS     CALL  PRINT           ;send message
2B84 20 20 54 65                DTH   '  Terminating at:'
2B88 72 6D 69 6E
2B8C 61 74 69 6E
2B90 67 20 61 74
2B94 3A
2B95 CD 4F 2D                   CALL  ADRS            ;get end address
2B98 DA 81 2B                   JC    ENDADRS         ;if invalid try again
2B9B CD 43 2D                   CALL  PRINT
2B9E 0D 8A                      DD    CRLF+MSB        ;carriage return linefeed
2BA0 CD 24 2D                   CALL  RANGERR         ;check for range error
2BA3 DA 81 2B                   JC    ENDADRS         ;try again if error
2BA6 23                         INX   H               ;compensate
2BA7 CD 96 2D                   CALL  MOD             ;check boundery
2BAA DA 81 2B                   JC    ENDADRS         ;no good
2BAD 44                         MOV   B,H             ;save end address
2BAE 4D                         MOV   C,L             ; in register pair BC
2BAF                *
2BAF 62                         MOV   H,D             ;save start address
2BB0 6B                         MOV   L,E             ; in register pair HL
2BB1 1A             TFFS        LDAX  D               ;get byte from prom
2BB2 FE FF                      CPI   BLANK           ;is it clear
2BB4 C2 B7 2D                   JNZ   BADPROM         ;print "bad prom"
2BB7 13                         INX   D               ;check next location
2BB8 CD F6 2C                   CALL  TEST            ;end of area
2BBB C2 B1 2B                   JNZ   TFFS            ;more to come
2BBE EB             RESTORE     XCHG                  ;restore registers
2BBF                *
2BBF CD 43 2D       SOURCEADRS  CALL  PRINT
2BC2 20 20 53 6F                DTH   '  Source address:'
2BC6 75 72 63 65
```

```
Addr B1 B2 B3 B4 E Label          Opcd   Operand

2BCA 20 61 64 64
2BCE 72 65 73 73
2BD2 3A
2BD3 CD 4F 2D                     CALL   ADRS           ;get source address
2BD6 DA BF 2B                     JC     SOURCEADRS     ;if not valid try again
2BD9                *
2BD9 CD 43 2D                     CALL   PRINT          ;send message
2BDC 0D 0A                        DD     CRLF
2BDE                *
2BDE 0D 0A                        DD     LF             ;format output
2BE0 20 20 54 75                  DT     '  Turn on the programming enable switch'
2BE4 72 6E 20 6F
2BE8 6E 20 74 68
2BEC 65 20 70 72
2BF0 6F 67 72 61
2BF4 6D 6D 69 6E
2BF8 67 20 65 6E
2BFC 61 62 6C 65
2C00 20 73 77 69
2C04 74 63 68
2C07 0D 0A                        DD     CRLF
2C09 20 20 48 69                  DTH    '  Hit return to continue?'
2C0D 74 20 72 65
2C11 74 75 72 6E
2C15 20 74 6F 20
2C19 63 6F 6E 74
2C1D 69 6E 75 65
2C21 BF
2C22                *
2C22 CD 03 C0       STAT          CALL   INPUT          ;check keyboard
2C25 CA 22 2C                     JZ     STAT           ;no character
2C28 FE 0D                        CPI    CR             ;is it a return
2C2A C2 22 2C                     JNZ    STAT           ;no try again
2C2D                *
2C2D CD 43 2D                     CALL   PRINT
2C30 0D 0A                        DD     CRLF
2C32 0A                           DB     LF
2C33 20 20 50 72                  DT     '  Programming in progress'
2C37 6F 67 72 61
2C3B 6D 6D 69 6E
2C3F 67 20 69 6E
2C43 20 70 72 6F
2C47 67 72 65 73
2C4B 73
2C4C 0D 0A                        DD     CRLF
2C4E 8A                           DB     LF+MSB         ;stop sending with linefeed
2C4F                *
2C4F AF                           XRA    A              ;zero
2C50 32 02 2E                     STA    PASS           ; pass counter
2C53                *
2C53 E5             SAVE          PUSH   H              ;save source address
2C54 D5                           PUSH   D              ;save it
2C55                *
2C55 7E             LOOP          MOV    A,M            ;get byte from source
2C56 12                           STAX   D              ;program it to destination
2C57                *
```

```
Addr B1 B2 B3 B4 E Label      Opcd  Operand

2C57 3E 64                    MVI   A,100         ;delay for dynamic memory
2C59 3D           DELAY       DCR   A             ;time up
2C5A C2 59 2C                 JNZ   DELAY         ;keep stalling
2C5D              *
2C5D 23                       INX   H
2C5E 13                       INX   D             ;advance pointers
2C5F CD F6 2C                 CALL  TEST          ;end of block
2C62 C2 55 2C                 JNZ   LOOP          ;no keep going
2C65              *
2C65 21 02 2E                 LXI   H,PASS        ;point to pass counter
2C68 34                       INR   M             ;256 passes
2C69 F5                       PUSH  PSW           ;save Z flag
2C6A C5                       PUSH  B             ;save end pointer
2C6B              *
2C6B CD 43 2D                 CALL  PRINT         ;send message
2C6E 0D                       DB    CR
2C6F 20 20 50 61              DTH   '  Pass '
2C73 73 73 A0
2C76 7E                       MOV   A,M           ;get pass number
2C77 0E 00                    MVI   C,0           ;clear number of digits
2C79 06 FF        LDIV        MVI   B,-1          ;compensate for increment
2C7B 04           DIV         INR   B             ;increment quotient
2C7C D6 0A                    SUI   10            ;subtract 10 from dividend
2C7E D2 7B 2C                 JNC   DIV           ;can more be subtracted
2C81 C6 3A                    ADI   10+'0'        ;adjust remainder 0 to 9 ASCII
2C83 F5                       PUSH  PSW           ;add to list of remainders
2C84 0C                       INR   C             ;one more digit
2C85 78                       MOV   A,B           ;prepare for next division
2C86 B7                       ORA   A             ;was quotient zero
2C87 C2 79 2C                 JNZ   LDIV          ;more to come
2C8A F1           LOUT        POP   PSW           ;get a remainder
2C8B CD 08 C0                 CALL  OUT           ;print it
2C8E 0D                       DCR   C             ;out of digits
2C8F C2 8A 2C                 JNZ   LOUT          ;no then keep printing
2C92              *
2C92 C1                       POP   B             ;restore end
2C93 F1                       POP   PSW           ;restore Z flag
2C94 D1                       POP   D             ;restore start address
2C95 E1                       POP   H             ;restore HL
2C96 C2 53 2C                 JNZ   SAVE          ;more passes to come
2C99              *
2C99 1A           VERIFY      LDAX  D             ;get byte from prom
2C9A BE                       CMP   M             ;is it the same
2C9B C2 FC 2C                 JNZ   VERIFYERR     ;print error
2C9E 23                       INX   H
2C9F 13                       INX   D             ;advance pointers
2CA0 CD F6 2C                 CALL  TEST          ;end of block
2CA3 C2 99 2C                 JNZ   VERIFY        ;still more to test
2CA6              *
2CA6 CD 43 2D                 CALL  PRINT
2CA9 0D                       DB    CR
2CAA 20 20 4E 6F              DT    '  No errors detected'
2CAE 20 65 72 72
2CB2 6F 72 73 20
2CB6 64 65 74 65
2CBA 63 74 65 64
```

```
Addr B1 B2 B3 B4 E Label        Opcd   Operand

2CBE 0D 8A                      DD     CRLF+MSB
2CC0                  *
2CC0 CD 43 2D         END       CALL   PRINT
2CC3 20 20 54 75                DT     '  Turn off the programming enable switch'
2CC7 72 6E 20 6F
2CCB 66 66 20 74
2CCF 68 65 20 70
2CD3 72 6F 67 72
2CD7 61 6D 6D 69
2CDB 6E 67 20 65
2CDF 6E 61 62 6C
2CE3 65 20 73 77
2CE7 69 74 63 68
2CEB 0D 8A                      DD     CRLF+MSB
2CED                  *
2CED 2A 03 2E                   LHLD   STACK          ;retrieve SP
2CF0 F9                         SPHL                  ;move it back
2CF1 F1                         POP    PSW            ;restore registers
2CF2 C1                         POP    B
2CF3 D1                         POP    D
2CF4 E1                         POP    H
2CF5 C9                         RET                   ;bye-bye
2CF6                  *
2CF6 78               TEST      MOV    A,B            ;get end byte
2CF7 BA                         CMP    D              ;same as start
2CF8 C0                         RNZ                   ;no then return
2CF9 79                         MOV    A,C
2CFA BB                         CMP    E              ;low half same
2CFB C9                         RET                   ;return with Z flag
2CFC                  *
2CFC CD 43 2D         VERIFYERR CALL   PRINT
2CFF 0D                         DB     CR
2D00 3F 20 76 65                DTH    '? verification error at '
2D04 72 69 66 69
2D08 63 61 74 69
2D0C 6F 6E 20 65
2D10 72 72 6F 72
2D14 20 61 74 A0
2D18 EB                         XCHG
2D19 CD E8 2D                   CALL   HEX            ;print hex address
2D1C CD 43 2D                   CALL   PRINT
2D1F 0D 8A                      DD     CRLF+MSB
2D21 C3 C0 2C                   JMP    END
2D24                  *
2D24 7C               RANGERR   MOV    A,H            ;get high address
2D25 FE CC                      CPI    PROM/256       ;valid address
2D27 DA 2E 2D                   JC     RANGEMES       ;no print message
2D2A FE D0                      CPI    PROM/256+4     ;valid address
2D2C 3F                         CMC                   ;compensate
2D2D D0                         RNC                   ;return with C in question
2D2E CD 43 2D         RANGEMES  CALL   PRINT
2D31 3F 20 6F 75                DT     '? out of range'
2D35 74 20 6F 66
2D39 20 72 61 6E
2D3D 67 65
2D3F 0D 8A                      DD     CRLF+MSB
```

```
Addr B1 B2 B3 B4 E Label      Opcc   Operand

2D41 37                        STC                       ;set error flag
2D42 C9                        RET
2D43                  *
2D43 E3               PRINT    XTHL                      ;save HL get SP
2D44 7E               LPRINT   MOV    A,M                ;get character
2D45 CD 08 C0                  CALL   OUT                ;print it
2D48 23                        INX    H                  ;advance pointer
2D49 B7                        ORA    A                  ;is MSB set
2D4A F2 44 2D                  JP     LPRINT             ;keep sending
2D4D E3                        XTHL                      ;restore HL and adjusted SP
2D4E C9                        RET
2D4F                  *
2D4F 21 00 00         ADRS     LXI    H,0                ;zero value
2D52 CD 03 C0         LADRS    CALL   INPUT              ;get character
2D55 CA 52 2D                  JZ     LADRS              ;is it there
2D58 CD 08 C0                  CALL   OUT                ;print it
2D5B FE 0D                     CPI    CR                 ;was it a return
2D5D C8                        RZ                        ;thats it
2D5E D6 30                     SUI    '0'                ;reduce to hex
2D60 DA 7B 2D                  JC     INVAL              ;invalid entry
2D63 FE 0A                     CPI    10                 ;alpha character
2D65 DA 72 2D                  JC     SAB
2D68 D6 07                     SUI    7                  ;alpha bias
2D6A DA 7B 2D                  JC     INVAL              ;bad character
2D6D FE 10                     CPI    16                 ;number out of range
2D6F D2 7B 2D                  JNC    INVAL
2D72 29               SAB      DAD    H                  ;multiply address by 16
2D73 29                        DAD    H
2D74 29                        DAD    H
2D75 29                        DAD    H
2D76 85                        ADD    L                  ;combine new value
2D77 6F                        MOV    L,A
2D78 C3 52 2D                  JMP    LADRS              ;keep going
2D7B                  *
2D7B CD 43 2D         INVAL    CALL   PRINT
2D7E 0D 0A                     DD     CRLF
2D80 3F 20 69 6E               DT     '? invalid response'
2D84 76 61 6C 69
2D88 64 20 72 65
2D8C 73 70 6F 6E
2D90 73 65
2D92 0D 8A                     DD     CRLF+MSB
2D94 37                        STC                       ;set error flag
2D95 C9                        RET
2D96                  *
2D96 7D               MOD      MOV    A,L                ;get low byte
2D97 E6 0F                     ANI    0FH                ;mask low nibble
2D99 C8                        RZ                        ;if zero fine
2D9A CD 43 2D                  CALL   PRINT
2D9D 3F 20 62 61               DT     '? bad boundery address'
2DA1 64 20 62 6F
2DA5 75 6E 64 65
2DA9 72 79 20 61
2DAD 64 64 72 65
2DB1 73 73
2DB3 0D 8A                     DD     CRLF+MSB
```

```
Addr B1 B2 B3 B4 E Label          Opcd   Operand

2DB5 37                           STC                    ;set error flag
2DB6 C9                           RET
2DB7                 *
2DB7 CD 43 2D        BADPROM      CALL   PRINT
2DBA 3F 20 73 70                  DT     '? specified portion of prom is not erased'
2DBE 65 63 69 66
2DC2 69 65 64 20
2DC6 70 6F 72 74
2DCA 69 6F 6E 20
2DCE 6F 66 20 70
2DD2 72 6F 6D 20
2DD6 69 73 20 6E
2DDA 6F 74 20 65
2DDE 72 61 73 65
2DE2 64
2DE3 0D 8A                        DD     CRLF+MSB
2DE5 C3 BE 2B                     JMP    RESTORE         ;continue and restore registers
2DE8                 *
2DE8 7C              HEX          MOV    A,H             ;first the high byte
2DE9 CD ED 2D                     CALL   BYTE            ;print hex byte
2DEC 7D                           MOV    A,L             ;now the low byte
2DED                 *
2DED CD F0 2D        BYTE         CALL   NIBBLE          ;print nibble
2DF0                 *
2DF0 0F              NIBBLE       RRC                    ;swap nibbles
2DF1 0F                           RRC
2DF2 0F                           RRC
2DF3 0F                           RRC
2DF4 F5                           PUSH   PSW             ;save A
2DF5 E6 0F                        ANI    0FH             ;mask high nibble
2DF7 C6 90                        ADI    90H             ;super short-cut
2DF9 27                           DAA                    ;technique for converting
2DFA CE 40                        ACI    40H             ;binary to ASCII
2DFC 27                           DAA                    ;ala NB
2DFD CD 08 C0                     CALL   OUT             ;print it
2E00 F1                           POP    PSW             ;restore A
2E01 C9                           RET
2E02                 *
2E02                 PASS         DS     1
2E03                 STACK        DS     1
```

III. THEORY OF OPERATION

3.1 ADDRESSING

Address input lines A0 to A9 are buffered in line receivers U13 and U14. The outputs of U13 and U14 are then connected to both the PROM and RAM memory address pins. Address input lines A10 to A15 are buffered in U12 before use on the board. Lines A10 to A12 are inverted by the buffers and used as inputs to decoders U8 and U9. These three lines enable one of eight outputs on U8 or U9, depending on which decoder is enabled. Note that since A10 to A12 are inverted, the decoding sequence is reversed. When A10 to A12 are all "0", the number 7 output of the enabled decoder is selected. Each of the eight outputs from each decoder is used to enable a specific 2708 PROM or the 1K block of on-board RAM, or one of the three 1K segments which are not used on this board.

Address input lines A13 to A15 are used to enable one or the other decoder. Jumper Areas E and F determine which specific 8K block of memory corresponds to each decoder. The decoders are enabled by the output of U18-13 and U10-6. (They are enabled when their D input is a logic low "0".) Which decoder is enabled by which line depends on the jumpering in Area G. Jumper Area G can be used to switch the memory blocks thus assigned to each decoder.

Inversion of the on-board PROM and scratchpad memory address within block B may be accomplished by changing the jumper in Area J. This jumper determines whether or not the A12 address line is inverted by U11-4 before being used by decoder U9.

Selection of which 1K segment of the memory space will be assigned to the on-board RAM and which three 1K segments will be returned for use by other boards is handled by U9 outputs pins 1, 2, 3, 4, gate U10-12 and jumpers in Areas I and H. Any time an input to gate U10-12 goes low, this board is inhibited from putting data on the DI bus by forcing the DI line drivers to the high impedence state. Therefore, the three outputs of U9 which are connected to the inputs to U10-12 cause output from this board to be inhibited when one of the corresponding addresses appear on the address bus. Likewise, whichever U9 output is tied to the CE input to the RAM will enable the on-board RAM when that address appears.

3.2 DATA INPUT/OUTPUT

The DO lines from the S-100 bus contain data from the CPU to the memory. RAM is contained in two 2114 chips (U1 and U2). U1 contains the low four data bits in each location and U2 the high four bits. Thus DO0 to DO3 are tied to the data pins of U1 and DO4 to DO7 to the data pins of U2. These data bus lines are also tied in parallel to the eight data lines of each 1K byte PROM chip.

Data outputs from the RAM and PROM are connected to the input of a tri-state line driver U16 or U17. This parallel bussing of outputs from the memory chips is possible since all data outputs on the chips are tri-state.

3.3 CONTROL SIGNALS

U15 buffers the data lines inputting to the board. This buffer is enabled so long as U5-10 is low, which is true if U4-11 is high, which is true if either the on-board RAM is being written to or if PROM socket 11 is being written to. This logic is accomplished as follows. U4-6 is the NAND of MWRITE and the inverted (active high at U5-4) chip select for PROM socket 11, so that U4-6 is low if both PROM socket 11 is selected and MWRITE is active. U20-6 is the NAND of MWRITE and the inverted RAM chip select (active high at U5-13) so that U20-6 is low if both RAM is selected and MWRITE is active. Since U4-11 is the NAND of U4-6 and U20-6, U4-11 will be high if either U4-6 or U20-6 is low.

Writing of data into the RAM is controlled by MWRITE. Depending on the jumper in Area B, MWRITE can be taken from the bus (if a front panel is used or if there is another source of MWRITE in the system), or it can be generated from SOUT and $\overline{\text{PWR}}$ on this board. To generate MWRITE on the board, when SOUT and $\overline{\text{PWR}}$ are both low, U18-10 is high. This signal is buffered at U14-9 and is available both to the bus and the board as MWRITE. MWRITE is NANDED with the RAM chip select (inverted to active high at U5-13), giving the RD/$\overline{\text{WR}}$ signal for RAM. Why is this necessary, since the signals are combined within the 2114? It is not necessary in order to generate RD/$\overline{\text{WR}}$, but to enable the data bus input driver U15, as exlained above, we needed external active low signals specifically for writing to RAM and to PROM. Rather than putting another inverter on the board, the same signal is used for RD/$\overline{\text{WR}}$ to RAM. A low on RD/$\overline{\text{WR}}$ puts the chip in the write mode. Data on lines DO0 to DO7 will be written into the RAMs, assuming the board has been addressed and the RAM selected by the chip enable from Area I.

When it is desired to read data from this board, the U19-6 must be low at the appropriate time, enabling the DI bus drivers U16 and U17. This is accomplished by generating the logic NAND function of numerous signals. When either block A or block B is selected, the output of U20-3 is high which is used as one input to U19-6. Another input to U19-6 is generated by SMEMR which indicates that a memory read is to be executed. SMEMR is inverted at U11-2, then gated through U18-1, before being connected to U19. To allow selective disabling of this board's data outputs for any of the three unused 1K memory blocks, the chosen chip select lines are connected to U10 pins 1, 2 and 13. So long as they are high (not active), then U10-12 is low. In combination with a low from U11-2 (inverted SMEMR), a high appears on U18-1, which goes to U19-1. Another input to U19-6 is from U18-4 which senses that both SOUT and SINP are low. The last input to U19-6 is PDBIN. When this signal is high it indicates that the DI lines are in the input mode. Therefore, when all four inputs are high, indicating on board memory can be read, U19-6 will go low, thus enabling the data output buffers U16 and U17.

The power on/reset jump feature is initiated by the $\overline{\text{POC}}$ or $\overline{\text{PRESET}}$ input (jumper option in Area D). Disabling of other system memory boards during the power on/reset jump is accomplished by the PHANTOM output from this board, assuming the other boards are so wired. The power on/reset feature is provided by an RS flip-flop in U20, with the $\overline{\text{POC}}$ or $\overline{\text{PRESET}}$ line from the bus connected to the set input (U20-9) of the flip-fop. The PHANTOM signal is generated by the U20-11 active low output, and the U20-8 active high output is used to set U18-13 low, thus enabling U8 or U9, depending on the jumper in Area G. Since the address on the bus will be 0000, this causes the processor to execute the first instruction in the enabled 8K block. If this instruction is a jump to the next instruction in the same block, then when that instruction is decoded causing a low at U10-8 and hence at U20-13, the flip-flip will reset and cancel the PHANTOM signal.

The PRDY signal can be tied to the WAIT input by jumpering Area K. If so, the PRDY driver is enabled whenever this board is addressed and the processor is not doing I/O (determined by U19 pins 9, 10, 12 and 13.) WAIT is low at this time, thus PRDY goes low, putting the processor in a wait state. This makes WAIT go high, so that when the next clock cycle occurs, PRDY goes high again. The result is a one-cycle WAIT state each time the board is addressed. Note there is an error in this logic: a wait state will be generated (if jumpered in Area K) so long as any part of blocks A or B are addressed, INCLUDING the 3K which are used by other boards. This other 3K may be a function such as video or disk controller, which should not have a wait state.

3.4 PROM PROGRAMMING

PROM socket 11 is used to program an EPROM. EPROMs are programmed as follows: With the desired data on the data inputs to the PROM and the desired low order address byte on the address lines to the PROM, chip select must be raised to 12V (rather than the usual 0 for reading and 5 for not-select.) Then after a delay of 10 micro-seconds, a 26V pulse on the chip's programming pin (pin 18) must occur for 400 micro-seconds. The CPU must be held in a wait state during this time, as well as an additional 1/2 micro-second. This will program one byte ONCE. Proper programming of 2708 EPROMs require that each byte be programmed 256 times, with a delay after each time. This is handled in software, which should program all the locations on the PROM once, and then repeat the cycle 256 times. Software does not have to send any special signal for programming a PROM, since hardware will interpret any memory write to the PROM as an intent to program it. Unintential writing to the PROM will thus cause programming if the 26V supply is accidently left on.

U3 contains two one-shots which are used to generate the timing for the programming pulse. Each of these one shots has different R and C values connected to it, creating different length pulses. A 10 micro-second active low pulse is generated at U3-4 and a 410 micro-second active high pulse is generated at U3-5. When these two are NANDED together at U4-3, the result is a 400 micro-second active low pulse following a 10 micro-second delay, as desired. This pulse begins when PSYNC (bus line 76) and clock-1 (bus line 25) are NANDED at U4-8 and put into U3-1 and U3-9, and at the same time the PROM socket 11 chip select arrives at U3-2 and U3-10. They will only fire if it is not a memory read cycle, because U11-2 keeps the one-shots reset (via reset pins U3-3 and U3-11) if SMEMR is active.

The low-high transition of the 410 micro-seond pulse at U3-5 generates an active low on XRDY (bus line 3) by inverting it at U6-2, in order to put the CPU in a wait state. This stays low for 1/2 micro-second after the pulse is over because of an RC delay tied to U6-2.

The 400 micro-second pulse is converted to active <u>open</u> at U6-10 and U6-12. The program pulse of 26V is then generated by a 2N3643 transister, using a supply voltage from U7 and related circuitry. U7 is turned on by the sliding programming switch. This switch must ONLY be on when programming a PROM, because erroneous writing to that PROM will otherwise alter it when not desired.

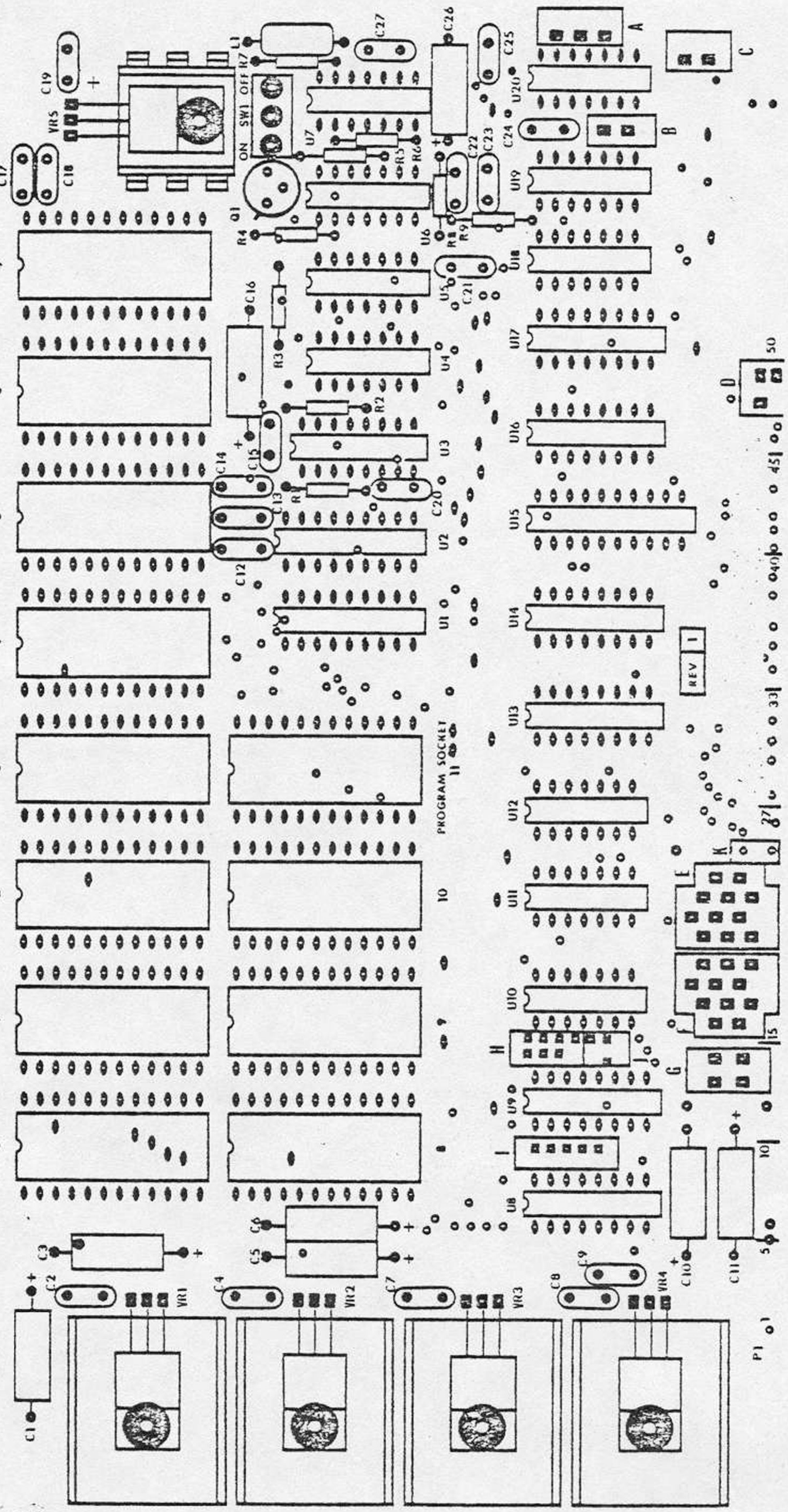
When the pulse is over and the wait line is released, the CPU is released to increment the address and program the next byte.

3.5 POWER SUPPLIES

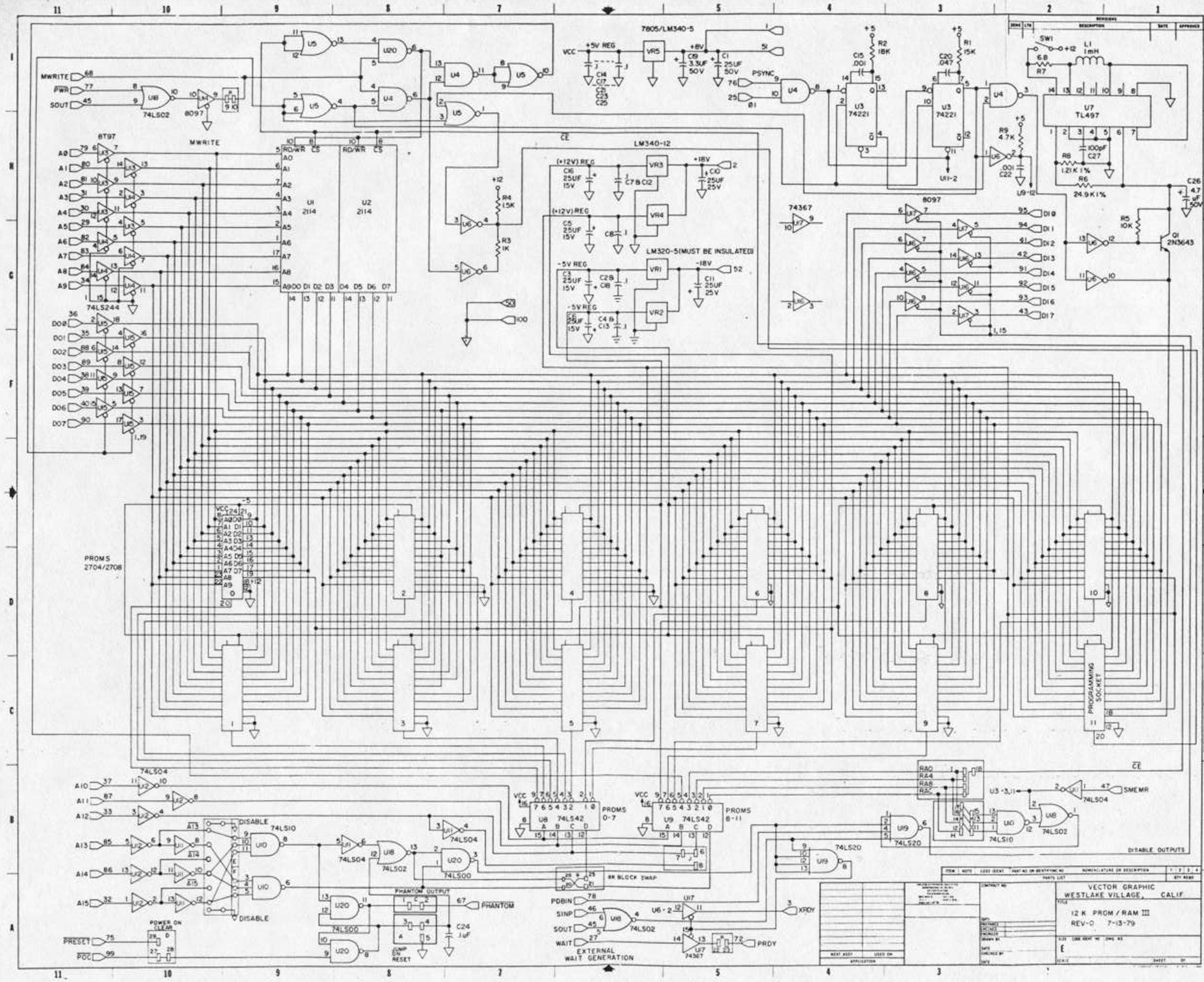
Power for this board is obtained from the unregulated +8V and plus or minus 18V supplies in the system.

Regulation of the input voltage to the required -5V and +12V is obtained by the use of four three-terminal regulators. Dual regulators are used to insure ample supply current. The +5V supply is regulated by one regulator. Bypass filtering on all power lines is accomplished by multiple electrolytic capacitors for each supply voltage. This filtering insures stable noise free operation of the board. Capacitors are also used on each regulator input for high frequency bypassing and regulator stability.

The +26V programming supply is produced from the +12V regulated supply by a TL497 switching voltage regulator in a low-power step-up configuration, using a 1 mH coil.



PROGRAM SOCKET
REV 1
U1
U2
U3
U4
U5
U6
U7
U8
U9
U10
U11
U12
U13
U14
U15
U16
U17
U18
U19
U20
VR1
VR2
VR3
VR4
VR5
SW1
ON
OFF
Q1
P1


VECTOR GRAPHIC
WESTLAKE VILLAGE, CALIF
12 K PROM / RAM III
REV-0 7-13-79
PROMS
2704/2708
PROGRAMMING SOCKET
7805/LM340-5
LM340-12
LM320-5(MUST BE INSULATED)
EXTERNAL
WAIT GENERATION
POWER ON CLEAR
PHANTOM OUTPUT
8K BLOCK SWAP
DISABLE OUTPUTS
PROMS 0-7
PROMS 8-11
MWRITE