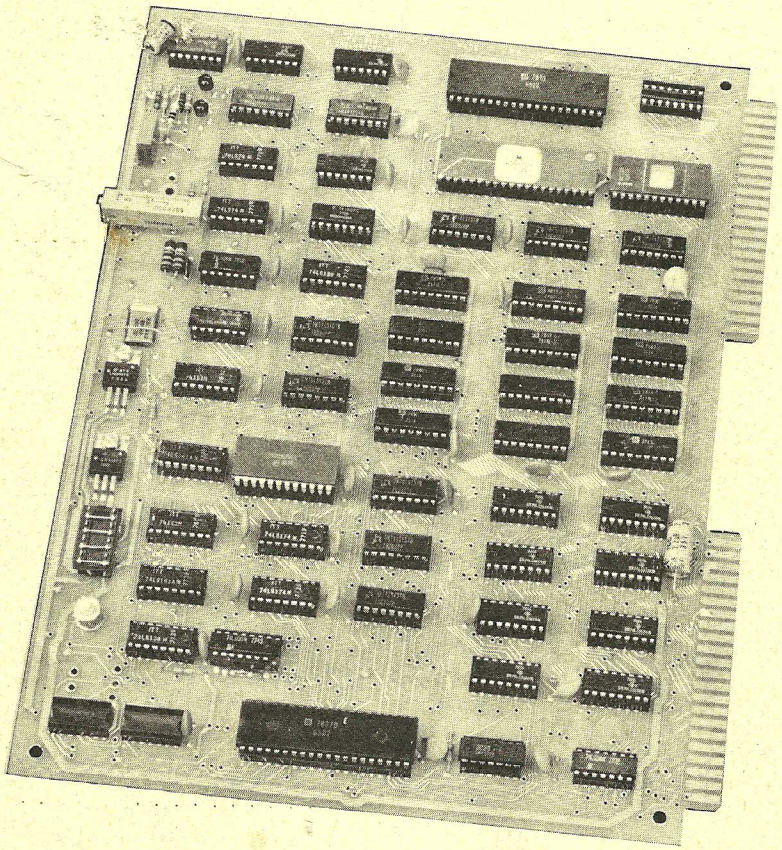
VIDEO PLUS™



AIM · SYM · KIM

LIMITED WARRANTY AND SERVICE

Should you experience difficulty with your VIDEO PLUS board and be unable to diagnose or correct the problem, you may return the board to The COMPUTERIST, Inc. for repair. VIDEO PLUS is warranted by The COMPUTERIST, Inc. against defects in workmanship and materials for a period of ninety (90) days from date of delivery. During the warranty period, The COMPUTERIST, Inc. will repair or, at its option, replace at no charge components that prove to be defective provided that the board is returned, shipping prepaid, to:

The COMPUTERIST, Inc.
Service Department
34 Chelmsford Street
Chelmsford, MA 01824

The warranty does not apply if the board has been damaged by accident or misuse, or as a result of repairs or modifications made by other than authorized personnel at the above service facility. No other warranty is expressed or implied. The COMPUTERIST, Inc. is not liable for consequential damages.

Beyond the ninety (90) day warranty period, VIDEO PLUS boards will be repaired for a reasonable service fee. All service work performed by The COMPUTERIST, Inc. beyond the warranty period is warranted for an additional ninety (90) day period after shipment of the repaired board.

It is the customer's responsibility to return the board with shipping charges prepaid to the above service facility. For in-warranty service, the board will be returned to the customer, shipping prepaid, by the fastest economical carrier. For out-of-warranty service, the customer will pay for shipping charges both ways. The repaired board will be returned to the customer COD unless the repairs and shipping charges have been prepaid by the customer.

If you have any minor problems, please call us at 617/256-3649 and ask for "Service".

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INTRODUCTION

VIDEO PLUS[tm] has been designed specifically to work with the KIM-1, SYM-1 and AIM 65 microcomputers. In addition, with the adding of a 6502 microprocessor chip and two other IC's, it is possible to use VIDEO PLUS as a stand-alone system or terminal. VIDEO PLUS greatly expands the power of the basic MICRO by providing the following facilities:

RAM Memory: Up to 4K bytes of Display RAM and up to 2K Programmable Character Generator RAM for a total of 6K RAM

ROM Memory: Provision for a 2K EPROM for storage of support software

Versatile Interface Adapter: Two 8-bit programmable I/O ports with additional handshaking lines. Two timers, a serial-to-parallel/parallel-to-serial shift register, may be used for handling a keyboard, light pen, communications, ...

CRT Controller: The "brains" of the VIDEO PLUS board are contained in this specialized chip which controls the display format, refreshing the display, servicing the light pen, providing the video timing signals, ...

Character Generator ROM: This provides 128 permanently defined ASCII characters. It uses a 7 x 9 dot matrix for the characters, and provides true descenders for the lower case characters.

ASCII Keyboard Interface: Provision for easily attaching a standard ASCII keyboard. Other types of keyboards may also be supported - usually only requiring a change in the software.

Stand-Alone Capability: The VIDEO PLUS is so complete that with the addition of a 6502, a 7400 and a 7404, it can be used as a stand-alone system or terminal. This means that it can be used with any computer system and is not limited to the KIM/SYM/AIM systems.

Other features of VIDEO PLUS include:

On-board +5 volt regulators: The user need only supply +8 volts unregulated (or +5V regulated) to run the entire board. No other voltages are required.

All IC's are Socketted: In the event of a chip failure, sockets make the problem easier to diagnose and to fix, often eliminating the need to send a unit "back-to-the-factory" for minor problems.

Compatible with the MICRO Bus: The connections between the AIM/SYM/KIM and the VIDEO PLUS follow the same conventions used by the original KIM-4 mother board. The VIDEO PLUS may be interfaced via a cable or the MOTHER PLUS board.

Switch Selectable Addressing: VIDEO PLUS may reside in any 8K segment of memory. This includes all of the RAM, ROM, VIA and CRT.

Will work with American or European TV sets and/or Monitors.

Fully Assembled, Burned-in, and Tested.

Set Up and Check Out

The quickest way to get your VIDEO PLUS board "up and running" with your MICRO is to take your time and follow all of the steps outlined below.

1. Carefully unpack your VIDEO PLUS board from its individual box, padding, and protective anti-static wrapping. While none of the components on this board are unusually susceptible to static, any chip can be damaged by a large static shock. So, take some care about avoiding static buildup.

2. Examine the board for any visible damage which may have occured in shipping. Push all IC's firmly into their sockets. Unbend any capacitors which may have been bent.

3. Read briefly the entire VIDEO PLUS Manual. Pay particular attention to the main sections on "Connections", "Power", "RAM Memory", and "Versatile Interface Adapter", but do not try to memorize everything.

4. Build the required connector cables following the wiring list, or if you have purchased the optional VP Cable set or are planning to use the MOTHER PLUS board for interconnections go on to the next step.

5. Since the KIM-1 Microcomputer requires a DECODE signal from an expansion board in many cases, this signal has been provided on the VIDEO PLUS. If you are using your VIDEO PLUS with a SYM-1, AIM 65, or with a KIM-1 via a MOTHER PLUS board, then this signal is not required and should be removed. Either remove the 74LS00 chip from U16 or the wire from U16 to E16 which runs on the front side of the board. If you simply remove the IC chip, then it can be replaced later if the board does get used with an "unbuffered" KIM-1.

6. If you have built your own cable, carefully check for errors.

7. Set up your power for VIDEO PLUS in one of the following ways:

   a. If you have a single +5V supply which is going to run both the MICRO and VIDEO PLUS (VIDEO PLUS will require about 2.5 amps), then the following connections should be made:

      VP E-21 to MICRO E-21
      VP E-Y to MICRO E-21

      If you are using a MOTHER PLUS, then these connections are already made on the MOTHER PLUS board.

      The HEADER between the rotary Address Switch and the Voltage Regulators must be positioned so that the notch is near the Switch. This will leave the lowest pair of connections open. The VIDEO PLUS is shipped with the HEADER in the correct position for use with regulated +5 voltage.

   b. If you have a separate +5V regulated supply for VIDEO PLUS, the above VP to MICRO connections must not be made. The HEADER should be positioned as above and the +5 side of the supply attached to VP E-21/E-Y and the Ground to any of the ground pins: E-A, E-1, E-Z, or E-22.

c. If you have a +8V unregulated supply, then the HEADER should be reversed so that the end nearest the rotary Address Switch has a wire between the end connections. Attach the +8V side of the supply to VP E-19/E-20 and the ground to any of the four ground locations: E-A, E-1, E-Z, or E-22. The voltage regulators on the VIDEO PLUS are adequate for a fully loaded VIDEO PLUS board, but do not have any reserve power. Power for other devices, such as the keyboard, should not be drawn from the on-board regulators.

8. Connect your MICRO and VIDEO PLUS together via the cable or MOTHER PLUS.

9. Set the Address Select Switch to the 4000 position. This will give the following addresses to the components on the board:

4000 - 4FFF	Display Memory if 4K implemented.
4000 - 47FF	Display Memory if 2K implemented. (Default)
5000 - 57FF	Programmable Character Generator - if implemented.
5800 & 5801	CRT Controller Registers
5810 - 581F	6522 VIA Registers
5820 - 5FFF	EPROM - if implemented.

10. Turn on the power supply. Using your MICRO's monitor, examine and modify a few RAM locations to verify that they basically work. With the Address Select Switch set to 4000, locations 4000 to 47FF will be valid RAM and location 4800 to 4FFF will also be RAM if the Display RAM has been fully populated. If you are unable to examine and modify these locations, then check steps 2 to 9 for any errors. If you can not find anything you did wrong, then go to the section on "VIDEO PLUS Testing and Field Repair" for guidence.

11. If the above preliminary examination of RAM memory is successful, then you are ready to run a more rigorous memory test. Follow the instructions in the section on "RAM Memory Test". If these tests work, then you can move on to step 12. If not, re-check all steps and review the "Memory" portion of "VIDEO PLUS Testing and Field Repair".

12. A quick test of the 6522 VIA can be made as follows: press the RESET button/key/switch on your MICRO and then examine the VIA locations which should have the following contents:

5810	FF	
5811	FF	
5812	00	
5813	00	
5814	88	Flickering Display (on KIM, changing value on each)
5815	88	Since You Are Examining Timer (SYM/AIM access)

If you observe the above results, then the VIA is probably functioning properly.

13. The EPROM/PROM space can be tested by inserting an EPROM or PROM with known contents into the EPROM socket. Since the first 20 hex locations have been used for addressing the CRT Controller chip and the 6522 VIA, these locations can not be used by the EPROM. They are effectively "lost". The EPROM memory starts at 5820 and extends up through location 5FFF.

14. If you wish to attach an ASCII Keyboard, follow the instructions on "Adding an ASCII Keyboard". Then examine location 5811 to see the effect of pressing a key. First press your RESET. Then press any key on the keyboard. Now examine 5811. It should contain the ASCII equivalent of the key you pressed. For example, if you press a "A", then 5811 should contain a 41. This value will remain until you have cleared it via a RESET.

15. Now you are ready to test the CRT Controller. Attach your monitor to the RCA connector on the board. (If you are using a TV, read the section on "TV Connections and Modifications" and make the required jumper changes.) Load the VIDEO Program from the cassette tape. This is recorded in standard KIM-1 Cassette Tape format which may be read by a KIM, SYM or AIM. The program has a Tape ID of 10 and loads into memory starting at 2000. A second version has Tape ID and loads into memory starting at 0400. It is identical to the 2000 version with the exception of the obvious addressing differences. After loading, start the program at location 2394 (0794). This will permit you to type from your keyboard onto the display. Read "A Sample Program" for details.

EXPANSION

VIDEO PLUS to MICRO Connections

Function	VIDEO PLUS Pin #	MICRO Pin #	VIDEO PLUS Pin #	Function	VIDEO PLUS Pin #	MICRO Pin #
Ground	E-1	E-22		Ground	E-A	E-22
	E-2			AB0	E-B	E-A
	E-3			AB1	E-C	E-B
IRQ	E-4	E-4		AB2	E-D	E-C
	E-5			AB3	E-E	E-D
	E-6			AB4	E-F	E-E
RST	E-7	E-7		AB5	E-H	E-F
DB7	E-8	E-8		AB6	E-J	E-H
DB6	E-9	E-9		AB7	E-K	E-J
DB5	E-10	E-10		AB8	E-L	E-K
DB4	E-11	E-11		AB9	E-M	E-L
DB3	E-12	E-12		AB10	E-N	E-M
DB2	E-13	E-13		AB11	E-P	E-N
DB1	E-14	E-14		AB12	E-R	E-P
DB0	E-15	E-15		AB13	E-S	E-R
(DECODE)	E-16	(A-K)		AB14	E-T	E-S
	E-17			AB15	E-U	E-T
	E-18			Phase 2	E-V	E-U
+8V Unreg.	E-19			Read/Write	E-W	E-V
+8V Unreg.	E-20			Phase $\overline{2}$	E-X	E-Y
+5V Regulated	E-21	E-21		+5 Regulated	E-Y	E-21
Ground	E-22	E-22		Ground	E-Z	E-22

APPLICATION

Function	VIDEO PLUS Pin #	MICRO Pin #	Function	VIDEO PLUS Pin #	MICRO Pin #
Ground	A-1	A-1		A-A	
VPA1	A-2		VPB6	A-B	
VPA2	A-3			A-C	
VPA3	A-4			A-D	
VPA4	A-5			A-E	
VPA5	A-6			A-F	
VPA6	A-7		VCB1	A-H	
VPA7	A-8		VCB2	A-J	
VPB0	A-9			A-K	
VPB1	A-10			A-L	
VPB2	A-11			A-M	
VPB3	A-12			A-N	
VPB4	A-13			A-P	
VPA0	A-14			A-R	
VPB7	A-15			A-S	
VPB5	A-16			A-T	
	A-17			A-U	
	A-18			A-V	
	A-19			A-W	
	A-20			A-X	
	A-21			A-Y	
	A-22		LPSTB	A-Z	

Cassette Loading Instructions

The VIDEO PLUS Subroutines are recorded in standard KIM format at the normal rate. The subroutines have been written so that they will run on a KIM-1, SYM-1 or AIM 65 without any modification. There may be a problem loading the cassette tape on the SYM-1 since the original monitor has a "bug" and can not load past a valid 2F byte of data. The new SYM-1 monitor, Version 1.2, has this bug fixed and should cause no trouble. If you have a SYM-1 which can not load the KIM format, a special version of the VIDEO PLUS Subroutine cassette tape may be purchased from The COMPUTERIST which has the programs in the SYM-1 format.

The first program on the cassette is a MEMORY TEST. It has program ID = 10 and loads into locations 0000 through 00D8. It is set up to test memory from 4000 to 47FF - the VIDEO PLUS "normal" memory space. See the section on "MEMORY TEST" for details on using this program. It will run on a KIM-1, SYM-1 or AIM 65.

The second program on the cassette is the VIDEO PLUS Subroutines and a short Example Program. It has program ID = 20 and loads into locations 2000 to about 23FF. These Subroutines provide the basic code needed to initialize the CRT Controller, handle control codes such as carriage return, line feed,..., service a standard ASCII Keyboard, and so forth. See the section on "VIDEO PLUS Subroutines" for a full description of the routines and a complete program listing.

The third program on the cassette is a version of the VIDEO PLUS Subroutines assembled to run in the memory usually reserved for the Programmable Character Generator - 5000 to 53FF. While running the code in this memory will cause some interference on the screen, it is provided so that the VIDEO PLUS can be used without requiring memory on another board for support. Since the code is identical to that provided in the standard version, no separate listings are provided. The user will have to make the appropriate changes to the listing - address 2345 becomes 5345, etc. Program ID = 30.

The fourth program on the cassette is a version of the VIDEO PLUS Subroutines assembled to run in the EPROM memory. This runs in locations 5820 to 5BFF, the normal VIDEO PLUS EPROM locations, and is provided so that the user may place the subroutines into EPROM. The only difference between this version and the regular version, aside from the obvious address differences caused by the relocation, is that the default initialization table which starts at 2010 in the regular version has been moved to 5820 in the EPROM version, and the variables area that appears as 2000 to 200F in the regular version has been moved to 57F0 to 57FF in the EPROM version. Program ID = 40. Start at 5B99.

SYSTEM ORGANIZATION

Since the VIDEO PLUS board contains a number of separate elements which require addressing space, it is important that the user be aware of the organization of the board.

Display RAM: There is provision for up to 4K of Display RAM. The board normally comes with 2K and the user can add an additional 2K by simply inserting four 2114 type RAM chips in the sockets already installed. The Display RAM occupies the lowest 4K addressing space of the board. If the VIDEO PLUS has been selected to start at 4000 (the default address for all discussions in this manual), then Display RAM will be
from 4000 to 47FF (the original 2K provided) and
from 4800 to 4FFF (the second 2K added by the user).

Programmable Character Generator RAM: There is provision for up to 2K of RAM. This may be used for the Programmable Character Generator or, with minimal display interference, as general system RAM. The addition of 1K would provide the user with 64 Programmable Characters, the 2nd K would provide an additional 64 characters for a total of 128 characters. The address of the PCG RAM is
from 5000 to 53FF (the first 1K added) and
from 5400 to 57FF (the second 1K added).

CRT Controller - 6845: The CRT Controller requires two addresses. The first address is a "register select" and the second address accesses the "register" selected by the first address. This may be a bit confusing at first, but information and details can be found in the 6845 Data Sheet provided as an appendix to this manual. The addresses assigned are:
location 5800 for the CRT Register, and,
location 5801 for the CRT Data.

Versatile Interface Adpater - 6522: This is a general purpose I/O and timer device which can be used for a nubmer of purposes on the VIDEO PLUS. Its main purpose is to provide an interface for an ASCII Keyboard. It also is used by the Light Pen interface. It can be used, in stand-alone mode, as the communication channel between VIDEO PLUS and any host processor. The timers may be used for a variety of functions. The VIA occupies the addressing space 5810 to 581F. See the 6522 Data Sheet provided as an appendix to this manual for details.

EPROM - 2716: VIDEO PLUS has provision for a 2K EPROM. Unfortunately, if VIDEO PLUS is to keep within a reasonalbe 8K addressing space, there is not quite enough room left for 2K of EPROM. Only location 5820 to 5FFF remain, 20 hex locations less than 2K. So be it. VIDEO PLUS has some special decoding on-board so that the 2K EPROM "gives up" the first 20 hex locations for use by the CRT Controller and VIA chips, and starts having valid addresses at 5820. The EPROM then covers the addressing space 5820 to 5FFF. The EPROM was given the highest addresses so that in the event that a user wished to implement the "stand-alone" option, adding a 6502 and running VIDEO PLUS as a complete system, he could have his interrupt vectors in the EPROM up in the highest memory where they belong.

SYSTEM Summary:

On-Board Address	"Normal Address"	Function
0000 to 07FF	4000 to 47FF	Display RAM - 1st 2K
0800 to 0FFF	4800 to 4FFF	Display RAM - 2nd 2K
1000 to 17FF	5000 to 57FF	P. C. G. RAM - 2K
1800 to 180F	5800 to 580F	CRT Controller
1810 to 181F	5810 to 581F	VIA - 6522
1820 to 1FFF	5820 to 5FFF	EPROM - 2716 - 2K

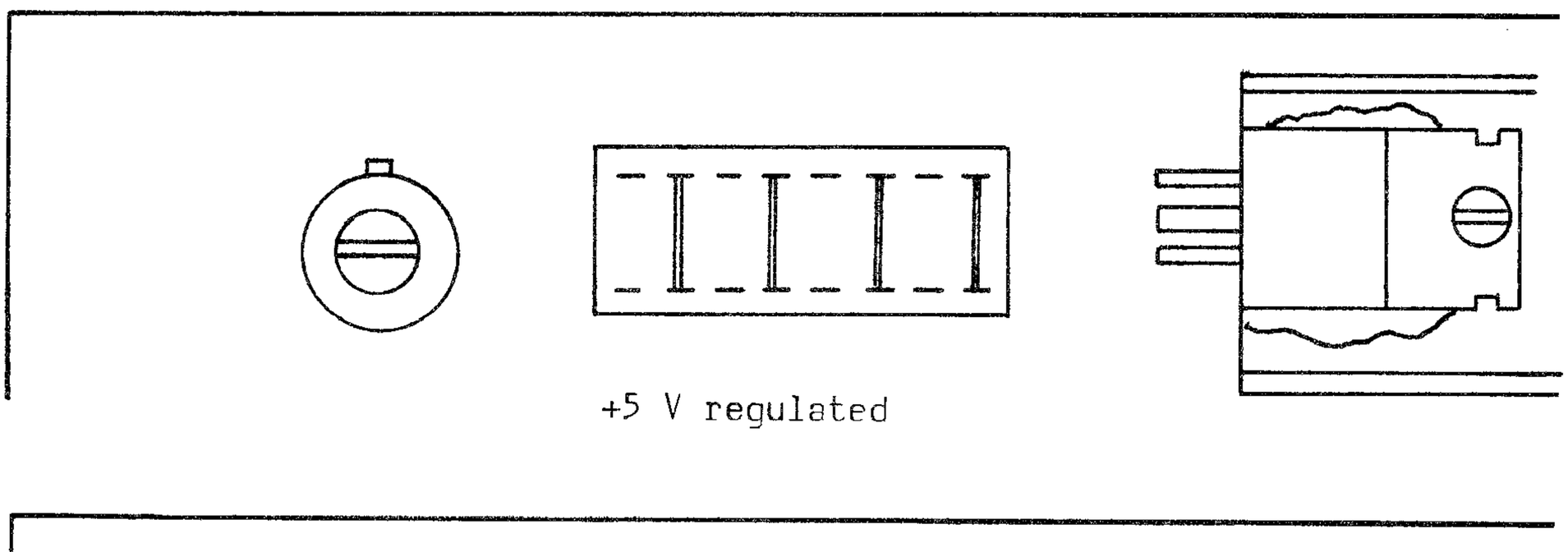
POWER

The power requirements for VIDEO PLUS are simple and on-board regulators are provided to make powering the board even easier. VIDEO PLUS requires only +5 volts at about 2.5 amps. There are two ways in which this power requirement may be met.

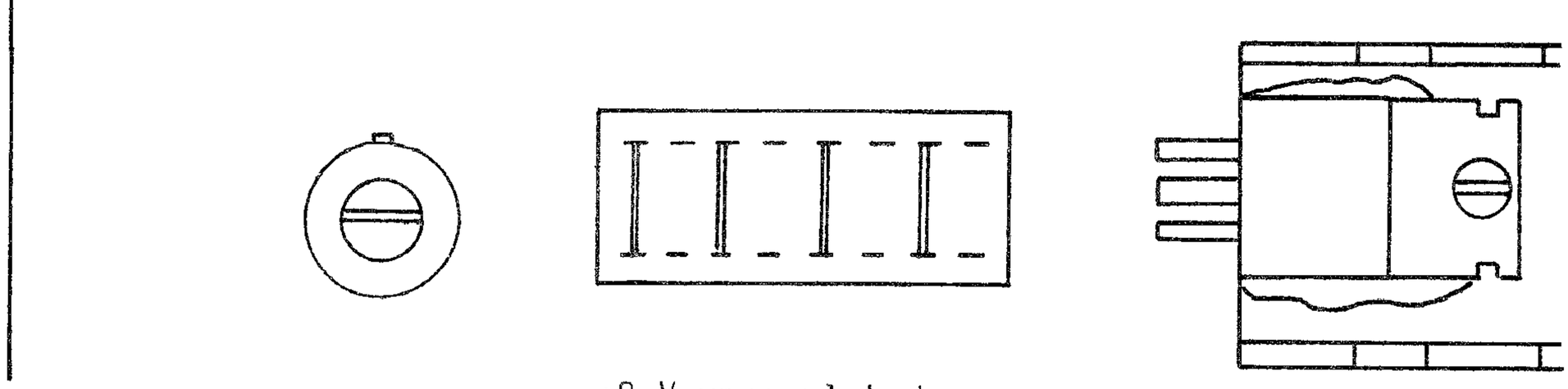
Regulated +5 volt supply. If the VIDEO PLUS is to be powered by regulated +5 volts, then the supply should be connected to pins E-21 and E-Y on the VIDEO PLUS Expansion connector. The supply should be capable of supplying at least 2.5 amps in addition to any other board it is driving, such as a KIM-1, SYM-1 or AIM 65. The HEADER at the top of the board should be positioned so that the end nearest the Address Select Switch does <u>not</u> have a wire connected.

Unregulated +8 volt supply. If the VIDEO PLUS is to be powered by an unregulated supply, then the supply should be connected to pins E-19 and E-20 on the VIDEO PLUS Expansion connector. The supply must be capable of supplying at least 2.5 amps. Two regulators on-board convert the unregulated +8 volts to regulated +5 volts. The HEADER at the top of the board should be positioned so that the end nearest the Address Select Switch does have a wire connected. IMPORTANT: The two regulators are adequate to provide the power required for a fully loaded VIDEO PLUS board - 6K RAM, 2K EPROM, and the optional 6502 - but does not have any appreciable "extra" power for use with other devices. In particular, the on-board regulators must not be used to power a keyboard. Many ASCII keyboards draw up to 1.0 amps (or more). Separate power must be provided for them.

Both sets of power connections may be applied to the board at the same time without any harm. The HEADER determines which of the two methods - +5 volt regulated or +8 volt unregulated - is being used at any time. There is no need to remove either set of connections from the VIDEO PLUS Expansion connector when using the other set.



+5 V regulated



+8 V unregulated

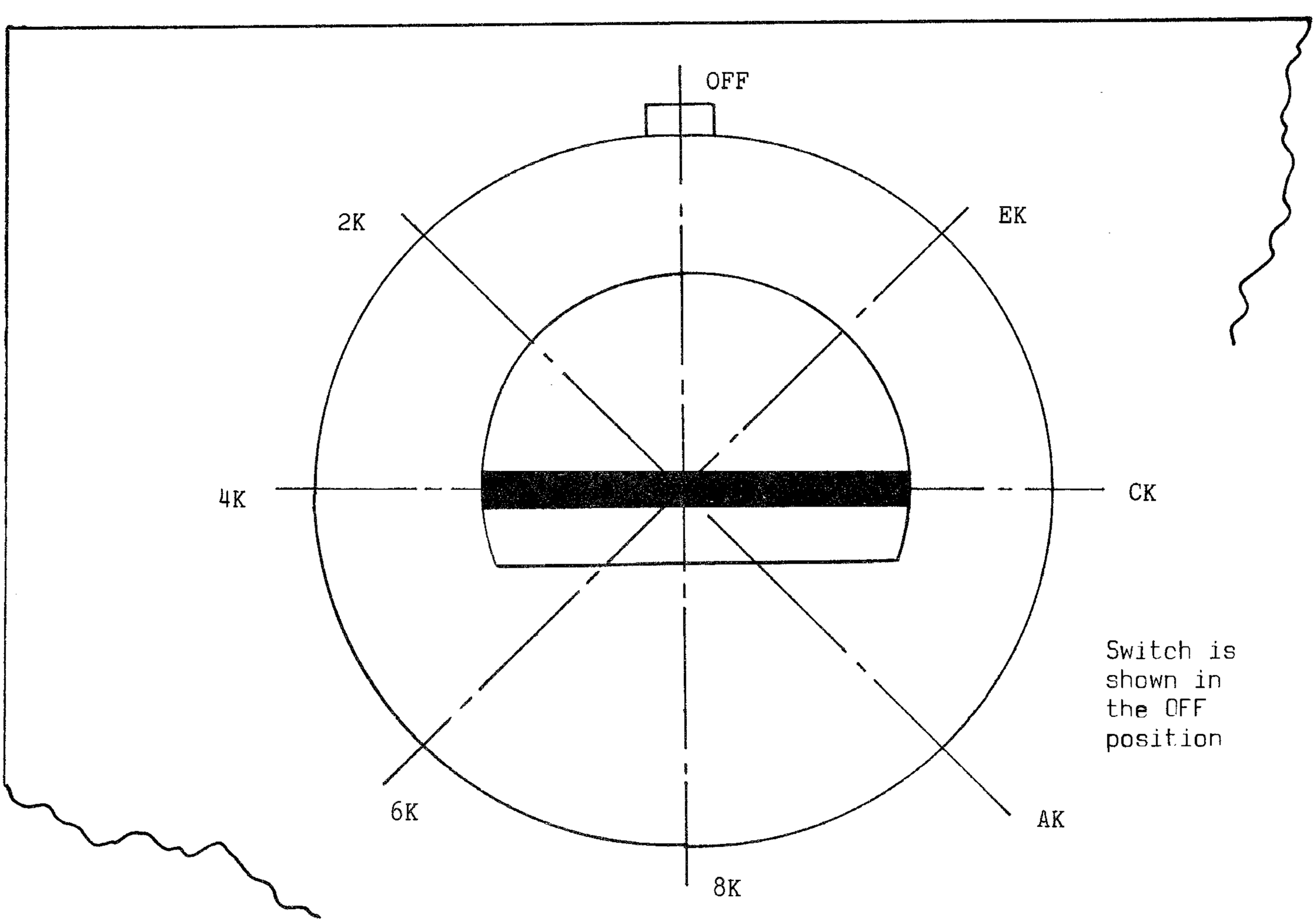
RAM Memory

There is provision on VIDEO PLUS for up to 6K bytes of RAM memory. This is 2114 type low power static RAM. Each 2114 chip contains 4096 bits of memory, and is organized as 1024 locations with 4 bits of information per location. A pair of 2114 chips in parallel are used to produce 1024 (1K) 8 bit bytes. 2114 chips must always be added in pairs to provide the required 8 bit bytes.

The VIDEO PLUS has provision for up to 4K bytes of Display RAM. This memory is located as the lower half of the 8K addressing space used by the VIDEO PLUS board. VIDEO PLUS is normally sold with only 2K of the Display RAM implemented. The user may add the additional Display RAM as his application requires. The additional RAM may be added 1K at a time.

The VIDEO PLUS also has provision for up to 2K bytes of Programmable Character Generator RAM (PCG). This is also of the 2114 type. All of the decoding and addressing circuitry is present on the standard VIDEO PLUS board to implement the PCG features. All that is required is the addition of the PCG RAM.

The address of all of the RAM is determined by the board Address Selection Switch. This rotary switch may be set to any one of seven 8K starting addresses - 2000, 4000, 6000, 8000, A000, C000, or E000 - although the E000 address has implications for the interrupt vectors and should, in general, be avoided. In this manual and on the cassette tape provided, it is assumed that the VIDEO PLUS board has been selected at 4000. To set the switch for this, or any other, address, use the following diagram as a guide:



Display RAM

The VIDEO PLUS board automatically refreshes the display based on the contents of the Display RAM. The Display RAM (DRAM) is simply additional memory to the microcomputer. Any location may be directly examined and/or modified by the user program. The CRT Controller chip determines what portion of the DRAM is to be displayed, based on parameters provided by the microcomputer. Within the portion of DRAM selected for presentation to the display, each 8 bit byte represents a character. Any value in the range 00 through 7F will be converted to a particular display format by the on-board ROM Character Generator. Any value in the range 80 through FF will be converted by the Programmable Character Generator RAM (PCG). The user may write his own program to place information into the DRAM, or may use the subroutines provided with the VIDEO PLUS. In any case, all that is required to produce a character on the screen is to place the code for that character into the proper location in the DRAM. No code conversion or dot pattern generation is required on the part of the user.

ROM Character Generator

When a character code in the range 00 through 7F is selected by the CRT controller for displaying, it is used to "look up" a set of dot patterns contained in a Character Generator ROM. The type of ROM is a Motorola 667xx. This is a class of ROMs which have a number of different display sets. The normal set used with VIDEO PLUS is the MCM66750. This contains UPPER and lower case ASCII characters with true descenders on the lower case "g, j, p, q, and y" characters. It also provides the standard ASCII characters for punctuation and digits. For the control codes, 00 through 1F, it provides a two-character code to represent the ASCII name for the control code:

N_U = NULL S_H = SOH, C_R = CARRIAGE RETURN, and so forth.

Other ROMS are available in the MCM667xx series. The main difference is in the characters generated for the control codes. There are sets with Europen character, Hebrew characters, Greek, and so forth. All of the ROMs in the MCM667xx series are compatible and may be readily interchanged. Since the ROM is socketted on the VIDEO PLUS board, the replacement procedure simply requires removing one ROM with a screw driver or other "prying" device and putting the new ROM in its place. Contact your Motorola representative for a data sheet detailing the available ROMs in this MCM667xx series.

Programmable Character Generator

The PCG is actually composed of two basic parts. The first part is the decoding and latching logic which determines where a character should be generated from. Any code from 00 to 7F is handled by the ROM Character Generator and does not involve the PCG. Any code from 80 to FF is handled by the PCG. Bit 80 is used to "switch" between the two display character generation modes. The displayable matrix supported by the CRT Controller is 8 dots wide by 16 rows deep. The display pattern for the PCG is contained in the PCG RAM memory - an optional 2K RAM area which may be implimented by the user by inserting 2114 type static RAM chips into the on-board sockets. The organization of the PCG RAM is set up so that the first sixteen (16) bytes of the PCG RAM contain the 16 rows for the display pattern for character number 80, the next 16 bytes for character 81, and so on.

CRT Controller - 6845

The CRT Controller is the "brains" behind the entire VIDEO PLUS board. It performs a large number of complex timing operations which include generating the addresses for selecting bytes from the Display RAM for refreshing; selecting the rows on successive scans of the same characters to make up the multi-row display format; positioning the cursor; generating the horizontal and vertical syncs for the monitor; and much more. The reader is refered to the 6845 Data Sheet which is included as an appendix to this manual. It has all the info you want - and then some. One area which may cause confusion to the user at first is the use of two memory locations to access 18 registers. In order to reduce the memory space required by the CRT Controller, the designers resorted to a trick. Instead of having each of the 18 registers have a unique memory address, they chose to have one location be used as a pointer to the register to be accessed - a sort of indexed addressing where the memory location is used to index the registers. To access register 7 in the CRT chip, you first place the number 7 into the first register (normally at address 5800 in VIDEO PLUS) and then read or write to the next address (normally address 5801). One word of caution: for reasons which I do not understand, using the KIM monitor to place the register value in 5800 and then writing to the selected register via 5801 did not seem to work. This "manual" mode of operation did not seem to affect the CRT Controller registers. The only way that worked was to have a program which set 5800 to the proper register value and then read or wrote to 5801.

Versatile Interface Adapter - 6522

This wonderful little chip is used to provide a simple yet powerful I/O capability. It is normally used to accept data and a strobe from an ASCII Keyboard and a strobe from a Light Pen. It may also be used for a number of other purposes. A 6522 Data Sheet is included in the appendix to this manual. Most of the VIA signals are brought out to the Application Connector as has been described in the "VIDEO PLUS to MICRO Connections" section. Port A, CA1 and CA2 are also brought out to a 16 pin socket to make it easy to connect and disconnect an ASCII keyboard. The pin assignements are given in the table below:

Signal From VIA	Socket Pin #	Application Pin #	Keyboard
PA0	8	A-14	Bit 0
PA1	3	A-2	Bit 1
PA2	2	A-3	Bit 2
PA3	1	A-4	Bit 3
PA4	4	A-5	Bit 4
PA5	5	A-6	Bit 5
PA6	6	A-7	Bit 6
PA7	7	A-8	
CA1	15	None	Strobe
CA2	16	None	Light Pen

The "other half" of the VIA - Port B - as well as the two sets of timers and the serial/parallel shift register are normally available to the user for any purpose without interfering with the VIDEO PLUS's main functions.

The first byte of the 16 represents the dot pattern for the top row of the character, the second byte represents the second row, and so on down to the last row. The highest bit (MSB) in each byte is the left-most dot, and so on down to the lowest bit (LSB) in each byte which is the right-most dot. For example, character 80 would have the following memory contents to display the dot pattern shown: (Assume that the PCG RAM starts at 5000)

Memory Address	Contents		Display Pattern
5000	C3	11000011	* * * *
5001	C3	11000011	* * * *
5002	66	01100110	* * * *
5003	3C	00111100	* * * *
5004	24	00100100	* *
5005	24	00100100	* *
5006	3C	00111100	* * * *
5007	66	01100110	* * * *
5008	C3	11000011	* * * *
5009	C3	11000011	* * * *
500A	7E	01111110	* * * * * *
500B	7E	01111110	* * * * * *
500C	42	01000010	* *
500D	42	01000010	* *
500E	7E	01111110	* * * * * *
500F	FF	11111111	* * * * * * * *

A few ideas to ponder. Since the CRT Controller puts out 8 bits per character, the PCG can have characters that are contiguous, as in the example above. This means that it is possible to define a fairly good graphics set, to use several individual characters together to form a "super" character, and so forth. While all 16 rows may be defined, only the number of rows defined by the CRT Controller will be displayed. Since the character definition is in RAM instead of ROM, it is easy to change characters under program control. For example, it is possible to have a program invert some or all of the PCG characters. Or underline them. Or turn them "upside-down" ! The possibilities are almost unlimited. More information, ideas, and programs will be available as application notes (free) and application packages (for sale).

EPROM - 2716

Since many applications will want VIDEO PLUS to work independently of other system software as much as possible, and will not want to use other system RAM for VIDEO PLUS supporting software, provision has been made for a 2K EPROM on-board. The EPROM is the INTEL 2716 type. The only slightly unusual thing about its use on the VIDEO PLUS board is that 20 hex locations have been "stolen" from the EPROM addressing space to make room for the VIA and the CRT Controller. Therefore, the EPROM only has 2016 useable locations instead of the normal 2048. The EPROM addresses start at 5820 normally and run up to 5FFF. If your system contains a MEMORY PLUS board, then you have everything you need to program your own EPROMs. If not, it would be quite easy to build an EPROM Programmer based on the VIDEO PLUS VIA chip. If there is enough interest, I can issue an application note covering this topic.

The cassette tape which you received with VIDEO PLUS includes a set of code for the subroutines assembled for the EPROM addresses

VIDEO PLUS Software

There are three categories of software required to successfully use the VIDEO PLUS. The cassette tape supplied with VIDEO PLUS contains a set of subroutines to handle the basic software requirements. As described in the section on "Cassette Loading Instructions" there are several versions of the software - each assembled for a different set of memory locations - so that most users will be able to find a set which fits their system configuration with minimal modifications required. The listing presented here is for the software assembled for memory 2000 to 23FF. The only differences between the listing for this version and the other versions is in the addresses which naturally get changed on assembly to another address.

The first category of software required is to Initialize and Maintain the CRT Controller parameters. The CRT Controller parameters control such items as the display format, start of display memory, cursor position, etc.

INIT Set up Video Plus System Parameters and Init CRT Controller

A table is used to provide the initialization values. The default table is located from 2010 to 2021. If the user starts at entry INIT, then this table of values will be used. If the user wishes to use other values, he may either modify the existing table and enter at INIT, or may create a totally new table, set up pointers to the new table by putting the low address of the table into location 0008 and the high address of the table into location 0009, and enter at location USRINT. Initialization must be performed to get the CRT Controller chip working. Refer to the listing for details on what get initialized and how.

SETOFF Set Start of Display Memory for CRT Display

The CRT Controller registers C and D control an offset which is used to determine where in the Display RAM to start displaying characters. If this offset is zero, then characters are displayed from the beginning of the Display RAM. The offset is set to zero at initialization time. By changing the offset, the user can cause the display to scroll - one character position, one line, one page, or any other amount. SETOFF uses the contents of the A and X registers as the new offset amount and updates the C and D registers of the CRT Controller. This subroutine is used by the scrolling routines.

GETCUR Get the Current CRT Controller Cursor Values

This routine reads the current cursor values from the CRT Controller and converts them into display memory addresses. It is used by some of the Control Code routines and may be used directly by the user programs.

SETCUR Set the CRT Controller Cursor to the Memory Values

This routine takes the current memory address pointers and converts them into the Cursor offsets required by the CRT Controller to properly display the Cursor. It is essentially the opposite of GETCUR.

RCMEM Converts Row and Column Addresses into Memory Addresses

Since it is usually easier for user programs to consider the display memory divided into rows and columns than as a single N byte long memory vector, this routine is provided to convert a row/column addressing scheme into actual memory addresses.

INCR/DECR Increment and Decrement the Column and Row Pointers

This routine is used to maintain the Row/Column addressing by modifying the Row and Column pointers and testing for "overflow" and "underflow" to keep the Row and Column pointers within the valid limits set by the initialization parameters.

CRTSET Put a Value into a CRT Controller Register

Since the CRT Controller has a slightly funny scheme for addressing its internal registers, this routine is provided to make it easy to change CRT register contents.

CURSET Set the CRT Cursor

This permits the calling routine to specify the cursor location in Row and Column coordinates, have it converted to display memory coordinates, and the correct values placed in the appropriate CRT Controller registers to set the cursor.

The second category of software is provided to service the I/O devices - Keyboard and Light Pen - as well as the display itself.

KBTEST/KBREAD/KBWAIT Keyboard Servicing Routines

KBTEST tests the CA1 flag of the VIA to determine if there has been any activity from the ASCII keyboard - returning with the Carry bit = 0 if there is no data or the Carry bit = 1 if there is data.

KBREAD first tests (via KBTEST) it there is data present, and if there is, then it reads the data from the VIA Port A, clearing the data present CA1 flag, and returns with the data in the A reg and the Carry bit = 1. If there is no data present, it returns with Carry bit = 0.

KBWAIT uses KBTEST to test for data present, and waits in a loop until data is present. It then uses KBREAD to read the data and return to the calling routine.

GETCHR/INCHAR Fancier Keyboard Service Routines

GETCHR uses KBWAIT to read a keyboard character, and then tests for the ESCAPE code. If the key is an ESCAPE, it then reads another character and turns on bit 80 to convert the second character into a Programmable Character Generator code. If the first key is not an ESCAPE, then that key code is passed back to the calling program unchanged. For example, the sequence "ESCAPE t" would be returned as "F4" which is 74 for "t" plus 80 for the ESCAPE. A "t" by itself would be returned as "74".

INCHAR first calls GETCHR to get, and if necessary convert, keyboard input, and then calls on the Control Routines to service any Control Codes.

LPTEST/LPREAD/LPWAIT Light Pen Servicing Routines

LPTEST tests the CA2 flag of the VIA to determine if there has been a light pen "hit". If there has been a hit, Carry bit is set to = 1, if no hit, it is set to = 0.

LPREAD first tests for a light pen hit using LPTEST. If there has been a hit, it then gets the address information from the CRT Controller light pen registers, combines with a "fudge factor" for any light pen delay and returns the memory address of the light pen hit in the A and Y registers.

LPWAIT keeps testing for a light pen hit using LPTEST until a hit occurs, and then uses LPREAD to get the data and return it to the calling routine.

READ/RINC/WRITE/WINC Display Character Servicing Routines

READ simply reads a character from the current memory pointer location and returns it to the calling routine in A.

RINC reads a character from the current memory pointer location, increment the memory pointer, and returns the character to the calling routine in A.

WRITE writes a character from the A register to the current memory pointer location.

WINC writes a character from the A register to the current memory pointer location and then increments the memory pointer.

The third category of software is provided to perform the "higher level" display control functions. These, for the most part, actually are just performing operations on the memory addresses and pointers to control such activities as Carriage Return, Line Feed, and the like.

CONTRL Service the Standard Control Functions

Each of the control functions may be invoked in two ways: first, by having a control code in the A register and testing the collection of implemented control codes, or, second, by going directly to the particular control code function. For example, if the A register has a Carriage Return code (0D), and a call is made to CONTRL, then one of the character tests will determine that the CRET function should be invoked. Or, the calling routine could go directly to the CRET function without doing any character tests. The Control functions supported, and their ASCII keys/codes are:

Carriage Return	CRET	CR	^M	0D	Move to start of next line
Line Feed	DOWN	LF	^J	0A	Move down to next line
Up one Line	UP	VT	^K	0B	Move up to previous line
Forward Space	RIGHT	FS	^\	1C	Move right one position
Back Space	LEFT	BS	^H	08	Move left one position
Start of Screen	HOME	FF	^L	0C	Move to start of display
End of Screen	SETEND	HT	^I	09	Move to end of display
Clear to End Line	CLREOL	DC1	^Q	11	Clear to End of Line
Clear to End Scr.	CLREOF	DC2	^R	12	Clear to End of Screen
Fill to End Line	FILEOL	DC3	^S	13	Fill to End of Line
Fill to End Scr.	FILEOF	DC4	^T	14	Fill to End of Screen
Scroll Up	UPSCRL	SO	^N	0E	Scroll Up
Scroll Down	DNSCRL	SI	^O	0F	Scroll Down
Toggle Display	TOGGLE	CAN	^X	18	Toggle CB2 to control display of Control Code (see App Note #1)

Video Interfacing

There are several ways in which VIDEO PLUS may be interfaced to a Video Monitor (VM) or a Television (TV), and both the American and European protocols are supported.

1. American Video Monitor. Simply connact a coaxial cable with an RCA type of jack to the connector provided on the board, or connect a cable directly to the two pads located immediately in front of the phono jack. The Video output will be a standard EIA type of signal: +1.0 volt for white, +0.25 volts for black, 0.0 volts for sync. The actual voltage may be varied using the trim pot located to the left of the connector jack. The jack to the right of the connector jack is not used for American protocols.

2. American Television. A commercially available RF convertor may be connected to the video output jack and the output of the RF connector fed into a standard TV set. Since the standard TV does not have the high band-width of a quality monitor, provision has been made to change the output band-width of VIDEO PLUS to match the requirements of the TV. To do this, move jumper W3 (refer to the VIDEO PLUS Schematic for details) from its original Ground connection to the Pull Up. This will change the basic clock from 16 MHz to 8 MHz, effectively halving the band-width. On a TV you will only be able to display about 40 characters. It is possible for the user program to test the position of the connectors and to adjust the initialization accordingly. The address 5804 (assumming 4000 as the base address) will contain an FC in the normal monitor mode and an FE in the TV mode after the above jumper change has been made. The program can test this address and set the appropriate parameters for the CRT initialization. This means that a ROM program could still be self-adapting to the monitor/TV modes.

3. European Video Monitor. A separate output is provided for the European protocol. This is a pad near the normal video output. This pad is adjacent to the right-hand trim pot. A coaxial cable can be soldered directly to this pad and the ground to any convenient ground pad. The right-hand pot controls the output level of the signal. This circuit was "lifted" from other documentation and is presumed to work. We do not have access to a European system at present, and can only hope that the output provided is close enough to what is needed to work.

4. European Video Monitor. Make the same changes as suggested above for American TV.

General Information. The CRT Controller chip - 6845 - performs most of the "VIDEO" functions on the VIDEO PLUS board. Its operation is not necessarily easy to understand, but the complete data sheet has been provided. You may have to do a fair amount of experimentation to determine the best set of parameters for your particular equipment and raquirements. By using the alternate initialization entry point in the Video Subroutines it is quite easy to do this testing.

VIDEO PLUS Parts List

ITEM	WHERE USED	QTY	PN	DESCRIPTION
1.	U3* U10 U47	3	74LS04	Hex Inverter
2.	U14	1	74LS08	Quadruple 2-Input Positive and Gates
3.	U9	1	74LS10	Triple 3-Input Positive NAND Gate
4.	U24 U26	2	74LS32	Quad 2-Input Positive Or Gates
5.	U11 U12	2	74LS74	Dual D Type Positive Edge Triggered Flip Flop
6.	U2	1	74LS86	Quadruple 2-Input Exclusive Or Gates
7.	U4	1	74LS138	3 To 8 Line Decoder
8.	U13 U22 U25	3	74LS139	Expandable Dual 2-4 Decoder
9.	U20 U21 U27 U28 U29 U34 U46 U56	8	74LS157	Quadruple 2 Line To 1 Line Data Selector/Multiplexers
10.	U5 U7	2	74LS161	Binary Counter
11.	U17 U18	2	74LS174	Hex Quadruple D Type Flip Flop
12.	U38 U40 U48 U50	4	74LS365 or 367	Hex Bus Driver With 3 State Outputs
13.	U39 U41 U49 U51	4	74LS367	Hex Bus Driver with 3 State Outputs
14.	U1* U16	2	7400	Quadruple 2 Input Positive NAND Gate
15.	U37	1	7430	8 Input NAND Gate
16.	U6 U8	2	74153	Dual 4 to 1 Multiplexer
17.	U23	1	74166	8 Bit Shift Register
18.	U30 U31 U32 U33 U42 U43 U44 U45 U52 U53 U54 U55	12	2114L	Static 450 NS Low Power
19.	U36	1	6522	Versatle Interface Adapter
20.	U35	1	6845L	CRT Controller
21.	U19	1	66750	Char Gen ROM
22.		1	32 MZ Crystal	
23.		1	200 OHM Pot Adjustable	
24.		1	500 OHM Pot Adjustable	
25.		2	7805-T220 5V Voltage Regulator	
26.		1	SPST Rotary Switch	
27.		1	2N2222 Transistor	
28.		1	22 PF @ 35V Capacitor	
29.		1	22 Mfd @ 25V Capacitor	
30.		28	.01 @ 50V Capacitor	
31.		7	3.3K 1/4 5% Resistor	
32.		1	330 OHM 1/4 5% Resistor	
33.		1	27 OHM 1/4 5% Resistor	
34.		1	510 OHM 1/4 5% Resistor	
35.		1	10 OHM 1/4 5% Resistor	
36.		1	390 OHM 1/4 5% Resistor	
37.		2	T220 Heat Sink	
38.		2	40 Pin Socket Low Profile	
39.		2	24 Pin Socket Low Profile	
40.		12	18 Pin Socket Low Profile	
41.		30	16 Pin Socket Low Profile	
42.		10	14 Pin Socket Low Profile	
43.		1	16 Pin Header	
44.		1	Phono Jack	

Note: Video Plus is socketed for 8 additional 2114L's and 1 2716. Also space provided for adding the chips required for a stand-alone terminal.

Non LS Parts may be substituted for LS, E.G. 7421 may be used in place of 74LS21.

THE COMPUTERIST MADE IN U.S.A. VIDEO PLUS

22,Z

3.3K
U2
LS86
.01
U14
LS08
U26
LS32
.01
U36
6522
I/O SOCKET
330
33K
10Ω
510
390
2N3694
U13
LS139
U25
LS139
.01
500Ω
U12
LS74
U24
LS32
.01
U35
XC6845L
U57
2716
RCA JACK
27
3.3K
U11
LS74
.01
U23
166
U34
LS157
.01
U46
LS157
U56
LS157
200Ω
.01
U33
2114L-3
.01
U45
2114L-3
U55
2114L-3
.01
330Ω
330Ω
U10
LS04
.01
U22
LS139
22PF
U32
2114L-3
U44
2114L-3
U54
2114L-3
U9
LS10
.01
U21
LS157
32.000mHz
U31
2114L-3
U43
2114L-3
U53
2114L-3
7805
U8
153N
.01
U20
LS157
U30
2114L-3
.01
U42
2114L-3
U52
2114L-3
3.3K
7805
3.3K
U7
LS161
U19
66750
.01
U29
LS157
.01
U41
LS367
.01
U51
LS367
.01
22uf
HEADER
U6
153N
.01
U18
LS174
.01
U28
LS157
U40
LS365
U50
LS365
U5
LS161
.01
U17
LS174
.01
U27
LS157
.01
U39
LS367
U49
LS367
ROTARY SWITCH
U4
LS138
.01
U16
LS00
U38
LS365
.01
U48
LS365
3.3K
U1*
LS00
U3*
LS04
.01
U15*
6502
.01
U37
7430
3.3K
.01
U47
LS04
3.3K
3.3K

A

1,A

22,Z

E

1,A

Application Note Number 1

Blanking Control Codes

The Character Generator ROM used in Video Plus produces a two character code for the Control Codes. The Control Codes are the hex values 00 through 1F. These do not have any standard ASCII display character assigned, and in the ROM are given a special display which consists of two characters of the ASCII name for the Control Code. For example, a hex 00 is a NULL. The ROM will display a combined character which will look like $^{N}_{U}$ occupying one character space. While this may be nice for certain applications, there may be times where this display of the control codes is not desired. There is a simple way to control whether or not these codes are displayed. Add the following circuit to your Video Plus board.

Connect U17 Pin 5 to U26 Pin 13. This is hex bit 20 of the character code.
Connect U17 Pin 7 to U26 Pin 12. This is hex bit 40 of the character code.
Connect U26 Pin 11 to U26 Pin 10. This is the logical OR of 20 and 40.
Connect U26 Pin 8 to U10 Pin 8. This will invert the signal.
Connect U10 Pin 9 to U20, U21 Pin 15. This now becomes the enable for the output.
Remove U20, U21 Pin 15 from ground.

There is one more wire to connect. This will determine how you use this Blanking feature. If you want the control codes to ALWAYS be displayed,

Connect U26 Pin 9 to +5 through a 3.3K resistor. This will result in your system working just as it normally does without any of the above changes. It might be used if you have implemented the above changes and then decided that you wanted the control codes always displayed after all.

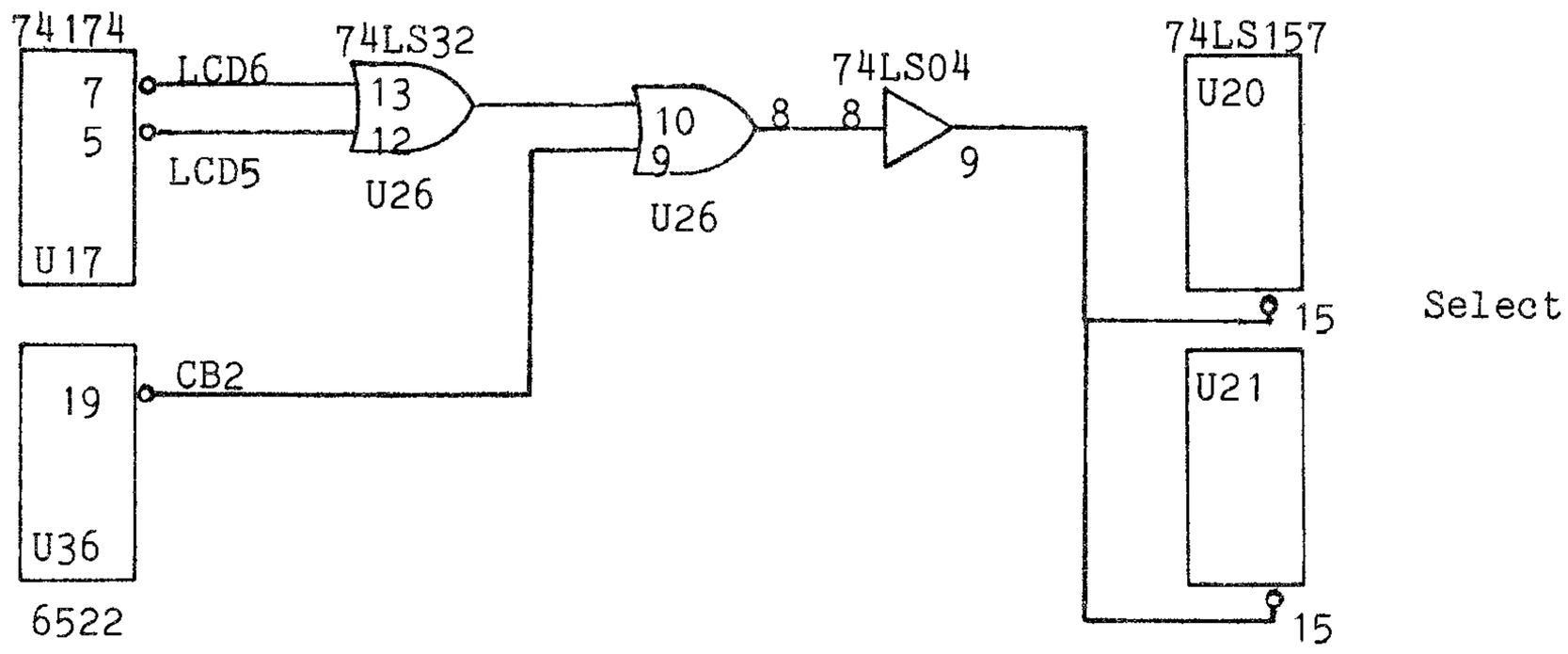
If you want the control codes to NEVER be displayed,

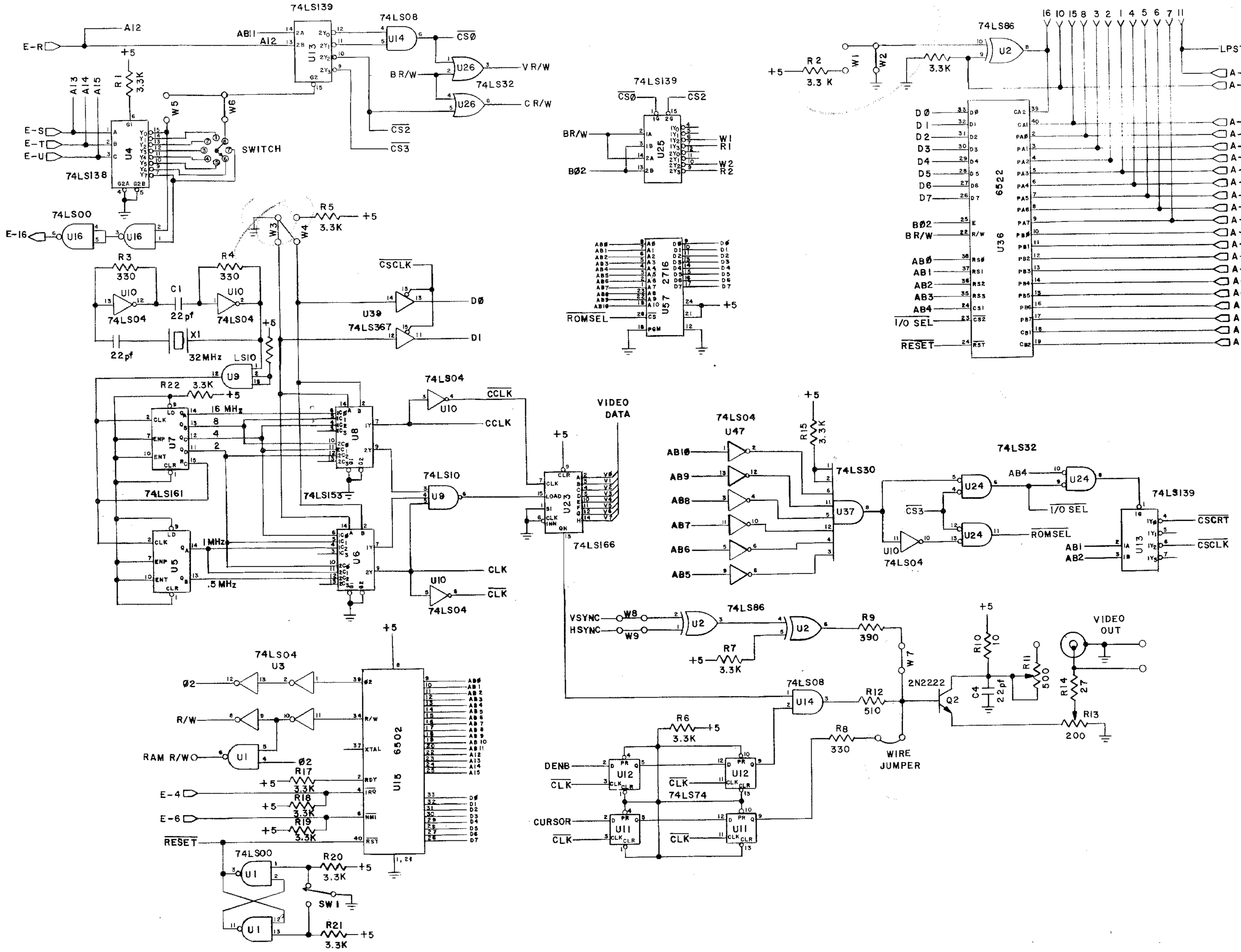
Connect U26 Pin 9 to Ground. This will permanently disable the control codes.

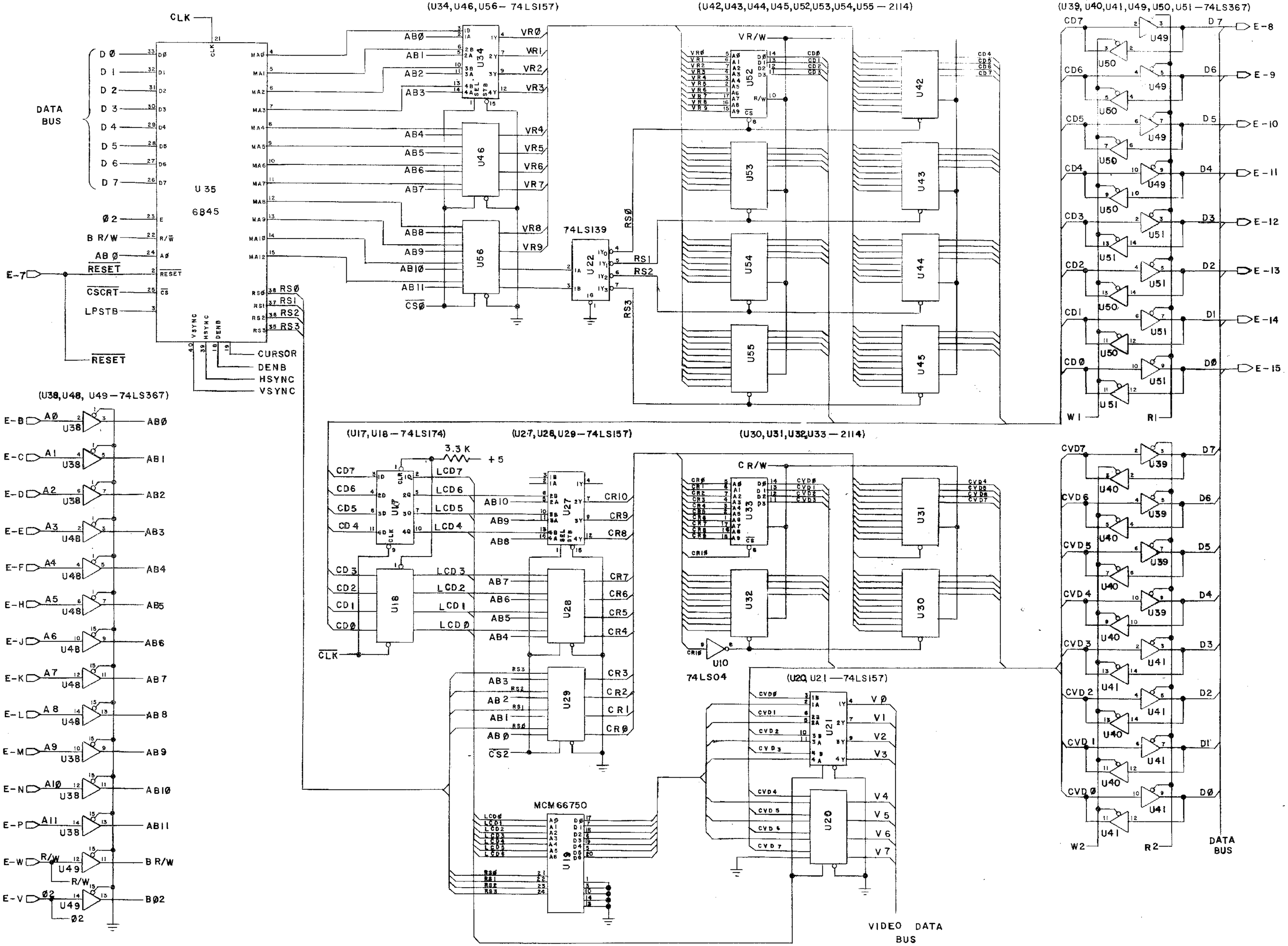
If you want to be able to control the display/non-display of the control codes from your program, then you can use the VIA 6522.

Connect U36 Pin 19 (CB2) to U26 Pin 9. Now, whenever CB2 is HIGH, the control codes will displayed. Whenever CB2 is LOW, the control codes will be surpressed and not displayed. This may be turned on and off under program control.

NOTE: In addition to turning on/off codes 00 to 1F, the Control Codes, this will also turn on/off characters 80 to 9F in the programmable character generator. By ORing in bit 80 (pin 2) with the other two signals, it is possible to have only the 00 to 1F control codes blanked.




74LS139
74LS08
74LS32
74LS86
74LS00
74LS04
74LS10
74LS138
74LS161
74LS153
74LS166
74LS30
74LS74
74LS367
74LS139
6502
6522
2716
2N2222
J1
U1
U2
U3
U4
U5
U6
U7
U8
U9
U10
U11
U12
U13
U14
U15
U16
U23
U24
U25
U26
U36
U37
U39
U47
U57
R1 3.3K
R2 3.3K
R3 330
R4 330
R5 3.3K
R6 3.3K
R7 3.3K
R8 330
R9 390
R10 10
R11 500
R12 510
R13 200
R14 27
R15 3.3K
R17 3.3K
R18 3.3K
R19 3.3K
R20 3.3K
R21 3.3K
R22 3.3K
C1 22pf
C4 22pf
X1 32MHz
16 MHz
1 MHz
.5 MHz
SWITCH
WIRE JUMPER
VIDEO DATA
VIDEO OUT
LPSTB
A-Z
A-X
A-Y
A-14
A-2
A-3
A-4
A-5
A-6
A-7
A-8
A-9
A-10
A-11
A-12
A-13
A-16
A-B
A-15
A-H
A-J
E-R
E-S
E-T
E-U
E-16
E-4
E-6
CSCLK
CCLK
CLK
CSCRT
CS0
CS2
CS3
VR/W
CR/W
BR/W
ROMSEL
I/O SEL
RESET
RAM R/W
DENB
CURSOR
VSYNC
HSYNC
+5


(U34, U46, U56 – 74LS157)
(U42, U43, U44, U45, U52, U53, U54, U55 – 2114)
(U39, U40, U41, U49, U50, U51 – 74LS367)
CLK
DATA BUS
U 35
6845
RESET
CSCRT
LPSTB
Ø2
B R/W
AB Ø
E-7
CURSOR
DENB
HSYNC
VSYNC
U34
U46
U56
74LS139
U22
RSØ
RS1
RS2
RS3
VR/W
U52
U53
U54
U55
U42
U43
U44
U45
CD7
CD6
CD5
CD4
CD3
CD2
CD1
CDØ
D7
D6
D5
D4
D3
D2
D1
DØ
E-8
E-9
E-10
E-11
E-12
E-13
E-14
E-15
W1
R1
(U38, U48, U49 – 74LS367)
E-B
E-C
E-D
E-E
E-F
E-H
E-J
E-K
E-L
E-M
E-N
E-P
E-W
E-V
ABØ
AB1
AB2
AB3
AB4
AB5
AB6
AB7
AB8
AB9
ABIØ
AB11
B R/W
BØ2
(U17, U18 – 74LS174)
(U27, U28, U29 – 74LS157)
(U30, U31, U32, U33 – 2114)
3.3 K
+5
U17
U18
U27
U28
U29
U33
U31
U32
U30
CR/W
U10
74LS04
CRIØ
CR1
CR2
CR3
CR4
CR5
CR6
CR7
CR8
CR9
CRIØ
CLK
CS2
(U20, U21 – 74LS157)
U21
U20
V Ø
V1
V2
V3
V4
V5
V6
V7
MCM66750
U19
VIDEO DATA BUS
CVD7
CVD6
CVD5
CVD4
CVD3
CVD2
CVD1
CVDØ
U39
U40
U41
W2
R2
DATA BUS

```
MEMORY TEST   9 FEBRUARY 1979

MEMORY ORG    $0000

ACCESS *      $8B86  SYM-1 ACCESS ENTRY
OUTBYT *      $82FA  SYM-1 OUTPUT BYTE
SCANDS *      $8906  SYM-1 SCAN DISPLAY

GOKIM  *      $1C4F  KIM-1 ENTRY POINT
LPOINT *      $00FA  KIM DISPLAY POINTERS
HPOINT *      $00FB

ASCOUT *      $EF7B  AIM 65 OUTPUT ASCII

0000 20       BEGIN  =      $20     STARTING TEST PAGE
0001 3F       END    =      $3F     ENDING TEST PAGE

0002 A9 00    START  LDAIM $00     ZERO POINTERS
0004 A8              TAY           FOR LOW ORDER ADDRESSES
0005 48              PHA           SET ALL STATUS BITS TO ZERO
0006 28              PLP
0007 85 D1           STAZ  POINTL

0009 85 D3    BIGLP  STAZ  FLAG    = 00 FIRST PASS, = FF SECOND PASS
000B A2 02           LDXIM $02
000D 86 D5           STXZ  PASS    SET 3 TESTS EACH PASS

000F A5 00    NPASS  LDAZ  BEGIN   SET POINTER TO
0011 85 D2           STAZ  POINTH  START OF TEST AREA
0013 A6 01           LDXZ  END
0015 A5 D3           LDAZ  FLAG
0017 49 FF           EORIM $FF     REVERSE FLAG
0019 85 D4           STAZ  FLIP    = FF FIRST PASS, = 00 SECOND PASS

001B 91 D1    CLEAR  STAIY POINTL  WRITE FLIP VALUE
001D C8              INY           INTO ALL LOCATIONS
001E D0 FB           BNE   CLEAR
0020 E6 D2           INCZ  POINTH
0022 E4 D2           CPXZ  POINTH
0024 BC F5           BCS   CLEAR

                FLIP VALUE IN ALL LOCATIONS.  NOW CHANGE 1 IN 3

0026 A6 D5           LDXZ  PASS
0028 A5 00           LDAZ  BEGIN   SET POINTER
002A 85 D2           STAZ  POINTH  BACK TO START

002C A5 D3    FILL   LDAZ  FLAG    CHANGE VALUE
002E CA       TOP    DEX
002F 10 04           BPL   SKIP    SKIP 2 OUT OF 3
0031 A2 02           LDXIM $02     RESTORE 3 COUNTER
0033 91 D1           STAIY POINTL  CHANGE 1 OUT OF 3
0035 C8       SKIP   INY
0036 D0 F6           BNE   TOP
0038 E6 D2           INCZ  POINTH  NEW PAGE
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003A A5 01              LDAZ  END     HAVE WE PASSED
003C C5 D2              CMPZ  POINTH  END OF TEST AREA?
003E B0 EC              BCS   FILL    NO. KEEP GOING

                  MEMORY SET UP.  NOW TEST IT

0040 A5 00              LDAZ  BEGIN   SET POINTER
0042 85 D2              STAZ  POINTH  BACK TO START
0044 A6 D5              LDXZ  PASS    SET UP 3 COUNTER

0046 A5 D4      POP     LDAZ  FLIP    TEST FOR FLIP VALUE
0048 CA                 DEX           2 OUT OF 3 TIMES
0049 10 04              BPL   SLIP    OR
004B A2 02              LDXIM $02     1 OUT OF 3 TIMES
004D A5 D3              LDAZ  FLAG    TEST FOR FLAG VALUE

004F D1 D1      SLIP    CMPIY POINTL  HER IS THE TEST
0051 D0 15              BNE   OUT     BRANCH IF FAILED
0053 C8                 INY           BUMP POINTER
0054 D0 F0              BNE   POP     IF NOT DONE, KEEP BOING
0056 E6 D2              INCZ  POINTH
0058 A5 01              LDAZ  END     TEST END
005A C5 D2              CMPZ  POINTH
005C B0 E8              BCS   POP

                  ABOVE TEST OKAY.  CHANGE AND REPEAT

005E C6 D5              DECZ  PASS    CHANGE 1 IN 3 POSITION
0060 10 AD              BPL   NPASS   AND DO NEXT PASS
0062 A5 D3              LDAZ  FLAG    INVERT FLAG
0064 49 FF              EORIM $FF     FOR PASS TWO
0066 30 A1              BMI   BIGLP   AND REPEAT BIG LOOP

0068 84 D1      OUT     STYZ  POINTL  PUT LOW ORDER ADDRESS FOR DISPLAY
006A AD FD FF           LDA   $FFFD   TEST HIGH BYTE OF INTERRUPT VECTOR
006D C9 8B              CMPIM $8B     = SYM-1
006F F0 46              BEQ   SYM
0071 C9 E0              CMPIM $E0     = AIM 65
0073 F0 0B              BEQ   AIM

0075 A5 D1      KIM     LDAZ  POINTL  MOVE POINTERS FOR KIM
0077 85 FA              STAZ  LPOINT
0079 A5 D2              LDAZ  POINTH
007B 85 FB              STAZ  HPOINT
007D 4C 4F 1C           JMP   GOKIM   RETURN TO KIM MONITOR

0080 A5 D2      AIM     LDAZ  POINTH  MOVE DATA FOR AIM DISPLAY
0082 85 D6              STAZ  AHIGH
0084 A5 D1              LDAZ  POINTL
0086 85 D7              STAZ  ALOW
0088 A2 00              LDXIM $00     GET DATA AT ADDRESS
008A A1 D1              LDAIX POINTL
008C 85 D8              STAZ  ADATA
008E A2 13              LDXIM $13     START AT POSITION 19.

0090 8A         ALOOP   TXA           SAVE X VALUE
```

```
0091 48                 PHA             ON STACK
0092 A0 04              LDYIM $04       SHIFT 4 POSITIONS PER CHARACTER
0094 A5 D8              LDAZ  ADATA     GET DATA
0096 29 0F              ANDIM $0F       MASK TO NIBBLE
0098 C9 0A              CMPIM $0A       TEST DECIMAL
009A 30 03              BMI   AOKAY     DECIMAL
009C 18                 CLC             A - F.  MUST CONVERT TO
009D 69 07              ADCIM $07       ASCII
009F 18          AOKAY  CLC             FINISH CONVERSION
00A0 69 B0              ADCIM $B0       ASCII + AIM FLAG
00A2 20 7B EF           JSR   ASCOUT    OUTPUT TO DISPLAY
00A5 46 D6       AMOVE  LSRZ  AHIGH     MOVE TO NEXT NIBBLE
00A7 66 D7              RORZ  ALOW
00A9 66 D8              RORZ  ADATA
00AB 88                 DEY
00AC D0 F7              BNE   AMOVE

00AE 68                 PLA             RESTORE X
00AF AA                 TAX
00B0 CA                 DEX
00B1 E0 0E              CPXIM $0E       DONE?
00B3 B0 DB              BCS   ALOOP     NO
00B5 90 C9  22 (to D9   BCC   AIM       YES. REPEAT

00B7 20 86 8B    SYM    JSR   ACCESS    ENABLE SYM MOEMORY
00BA A5 D2              LDAZ  POINTH
00BC 20 FA 82           JSR   OUTBYT    OUTPUT
00BF A5 D1              LDAZ  POINTL
00C1 20 FA 82           JSR   OUTBYT
00C4 A0 00              LDYIM $00
00C6 B1 D1              LDAIY POINTL    GET DATA
00C8 20 FA 82           JSR   OUTBYT

00CB 20 06 89    DISPLY JSR   SCANDS    SCAN DISPLAY
00CE 4C CB 00           JMP   DISPLY    CONTINUE

00D1 00          POINTL =     $00
00D2 00          POINTH =     $00
00D3 00          FLAG   =     $00
00D4 00          FLIP   =     $00
00D5 00          PASS   =     $00
00D6 00          AHIGH  =     $00
00D7 00          ALOW   =     $00
00D8 00          ADATA  =     $00
```

D9 JMP 0002