MICRO TECHNOLOGY UNLIMITED
KIM - 1 16K BYTE MEMORY BOARD

Finally! A large capacity, low power, inexpensive memory expansion board designed especially for the KIM-1 is now available. This board may be connected directly to the KIM-1; no modifications of any kind are necessary and no external interface circuitry is needed. A motherboard is not required although the low cost K-1005 card file/motherboard simplifies the mechanical aspects of KIM-1 expansion. The user simply connects the K-1016 in parallel with the expansion connector of the KIM, applies power, and enjoys 16 times more memory capacity.

Special signals required by the KIM when memory is expanded beyond 4K (Decode Enable and K7) are generated by the K-1016 memory board. These are available at otherwise unused expansion connector pins and are simply wired to the corresponding pins on the KIM's application connector.

Although standard 22 pin dynamic memory IC's are used for low power consumption and minimum cost, refreshing is totally transparent so there are no wait states ever. Refreshing is done during Phase 1 when the 6502 microprocessor is setting up for the next cycle. Memory timing is precisely generated and synchronized to the 1.0mHz KIM bus by means of a phase-locked loop frequency multiplier and countdown state generator; no single-shots or R-C delays are used anywhere. As a matter of fact, the timing chain and refresh logic is the same as that used on our now famous Visible Memory high resolution graphic display generator for the KIM and other 6502/6800 based systems.

The K-1016 was designed with the power crunch in mind. The power consumption is less than 1/10 that of typical 8K memory boards for the KIM. In fact, it is so low that nearly any power supply that successfully powers the KIM can also power the K-1016. The inexpensive K-1000 power supply is guaranteed to power the KIM and 32K of K-1016 memory and can typically power 32K plus a K-1008 video graphics board! On-board regulators allow operation from unregulated +8 and +16 volt sources or with a simple jumper change regulated +5 and +12 volt sources. Negative 5 volts for the RAM's is generated on-board.

SHORT FORM SPECIFICATION

Memory Type - 22 pin dynamic, high level clock (National MM5280)
Access Time - Greater than 100NS data stable time prior to fall of system phase 2 clock
Cycle Time - Internally synchronized to 1 mHz system Phase 2 clock
Buffering - Maximum of 1 LS TTL load on address and data bus
Power requirement - +7.5 volts unregulated 0.2 amp, +16 volts unregulated 75MA standby, 200MA maximum with 100% access.
Addressing - The 16K must be contiguous but may start at any 4K boundary. IC socket provided for jumpers.
Inclusions - Assembled and tested board, instruction manual containing detailed principles of operation and complete schematic, and comprehensive memory diagnostic program listing.
Price - Assembled and tested $375.00
Bare board only $40.00 Quantity discounts available.
All prices are F.O.B Manchester, New Hampshire

Micro Technology Unlimited, Box 4596, Manchester, NH 03108

MICRO TECHNOLOGY UNLIMITED
Presents its full line of KIM-1 accessories

The KIM-1 microcomputer is undoubtedly the most popular of all of the single board starter systems. Micro Technology Unlimited specializes in the design and manufacture of a full line of KIM accessories and expansion products ranging from power supplies to 16K memories to graphic video displays. An important feature of our products is that they stand alone; any individual item will work with a totally unmodified KIM and itself, no extras such as motherboards are needed. Simultaneously, all MTU KIM products function well together, because they were designed as a system.

A listing of our current product line follows. Additional detailed information about any product is available on request. All products are fully assembled and tested and guaranteed to work perfectly with any unmodified KIM-1. All items except those starred are stocked for immediate delivery of small quantities. Starred items have been successfully prototyped and will be in production by summer. All prices are FOB Manchester, NH. Quantity discounts are available.

K-1000 Basic KIM-1 power supply, completely enclosed, terminal strip output +5V @ 1.2A, +12V @ .1A regulated; +7.5V @.75A, +16V @ .25A unregulated.
K-1000-2 Advanced KIM-1 power supply, suitable for most other one board systems. +5V @ 2A, +12V @ 1A regulated; +7.5V @ 2.5A, +16V @ .25A unregulated
K-1000 $40.00 K-1000-2 $74.00

K-1002 Eight bit digital-to-analog converter based music system. Forget all of the microcomputer music you have heard, this system plays 4-part harmony with organ quality tones derived from Fourier synthesis, not square waves or pulses (see BYTE 9/77). 8 bit DAC, 6 pole low pass filter, audio amp.
K-1002-1 Advanced software package, Fourier series program, music compiler
K-1002 $35.00 K-1002-1 $13.00 (software on cassette and source listing)

K-1005 Card file and motherboard, holds the KIM and up to 4 other KIM bus compatible boards underneath the KIM. Requires no more table space than the KIM itself. Six edge connectors and terminal strip for power.
K-1005 $68.00

K-1008 Visible Memory 8K byte memory expansion and graphic display generator. Acts just like 8K of read/write memory to the KIM but displays memory contents as a 320 wide by 200 high dot matrix. No wait states and no KIM modification required. Text as dense as 22 lines of 53 characters and graphics limited only by the imagination.
K-1008-1 Graphic subroutine package, 2 character display routines, dot and line drawing routines, LIFE and spiral demonstration routines.
*K-1008-2 BASIC patch package, mates Microsoft BASIC for the KIM with K-1008-1
K-1008 $289.00 K-1008-1 $20.00 K-1008-2 $10.00 Source listings only

*K-1012 PROM and I/O board, sockets for 12K of 2708 PROM in addition to 32 bits of parallel input/output and a UART based serial port with RS-232 interfacing. Very low power, scarcely more than a single 2708 PROM.
K-1012 $235.00

*K-1016 16K memory expansion board, very low power highly reliable add-on memory. Such low power that the K-1000 power supply can power the KIM and two of these boards and still have reserve capacity. No wait states, directly KIM compatible, 4K boundary addressable.
K-1016 $375.00

Micro Technology Unlimited, Box 4596, 29 Mead Street, Manchester, NH 03108

MTU and KIM - - - they go together, by design!

MICRO - TECHNOLOGY UNLIMITED
K-1000 Power Supply

The MTU model k-1000 power supply is especially designed to power the popular KIM-1 microcomputer board manufactured by MOS Technology and its optional 4K expansion memory module. The power supply is totally enclosed in a black bakelite box which measures 5 5/16" wide by 6 13/16" long by 2 13/16" high overall. The line cord exit and output terminal strip are hidden under the box which is supported on rubber feet. The aluminum botton plate serves as a heat sink and is at ground potential. An internal 1 amp fuse protects against component failure and shorts to the unregulated outputs. The regulated outputs have both internal current limit and thermal shutdown.

SPECIFICATIONS

1. Line Voltage Range - 110 to 125 volts 60 Hz AC.
   Lower input voltages may be accomodated by suitable output current derating.

2. Output voltages

   A. +5 volts regulated +- 5% cumulative tolerance due to line and load variation, ripple, and static regulator tolerance. Maximum load current 1.2 amps.

   B. +12 volts regulated +- 5% cumulative tolerance due to line and load variation, ripple, and static regulator tolerance. Maximum load current 100 MA.

   C. +7.5 volts unregulated tolerance +7 to +12 as a result of line and load variations. Maximum load current 750 MA. This output is provided for Powering an external 4K memory board or future MTU products for the KIM.

   D +16 volts unregulated tolerance +14 to +20 as a result of line and load variations. An external capacitor to ground must be provided if any current is drawn from this terminal. Maximum load current with a 1000 uF 25 volt capacitor is 250 MA. This output is provided for powering future MTU products.

3. Ambient temperature 0 to +40 decrees C.

4. List price $40.00

Micro Technology Unlimited, P. O. Box 4596, Manchester, NH 03108

MICRO TECHNOLOGY UNLIMITED
LOW POWER 12K PROM AND I/O BOARD FOR THE KIM-1

This KIM-1 system oriented expansion board is the missing link needed to make the KIM a powerful yet easy to use turn-key system. The 12K of industry standard PROM capacity is plenty to hold 12 digit precision Microsoft BASIC for the KIM in addition to input/output subroutines, the user's own monitor, or even the full MTU graphics software package for our famous Visible Memory high resolution graphic display board. Four eight bit parallel input/output ports with full handshaking and interrupt capability as well as a UART controlled serial port with programmable baud rate generator open the KIM's I/O bottleneck in expanded systems. This board may be connected directly to the KIM-1; no modifications of any kind and no external interface circuitry is required. Special signals required by the KIM when memory is expanded beyond 4K (Decode Enable and K7) are generated by the K-1012.

Although standard, traditionally power hungry, low cost 2708 PROM's are utilized, the K-1012 continues the MTU tradition of amazingly low power consumption and operation from standard KIM-1 power supply voltages. A unique power down circuit for each PROM disconnects its power when not accessed for longer than one microsecond. Since only one PROM can be accessed at a time, the total power consumption is scarcely more than that of one 2708! When no PROM's are accessed (such as when the KIM monitor is executing) power consumption is even lower. Negative 5 volts for the PROM's is supplied by a high efficiency on-board inverter circuit.

Parallel input/output is supplied by two PIA (6520) type circuits. Each of the 32 lines is individually programmable as an input or output. In addition 4 pairs of handshaking control lines are available for positive verification of data transfer to and from external devices or additional I/O functions. Also 4 independently maskable interrupts, each associated with 8 I/O lines and one pair of handshaking lines, are included. This interrupt capability is fully compatible with the KIM-1 monitor.

Serial input/output is provided by an Asynchronous Control Element (ACE) manufactured by National Semiconductor. This versitile IC has a built-in programmable baud rate generator that may by programmed for all of the standard baud rates up to 4800 as well as a nearly infinite variety of non-standard ones up to 50K baud. True RS-232 with proper positive and negative output voltages is the interface method. All of the important modem control signals are also provided. Full maskable interrupt operation for transmitted data, received data, and model control is provided.

PRELIMINARY SPECIFICATIONS

Access Time - 550NS maximum as required by KIM-1
Power Requirement - +7.5 volts unregulated .35 amp, +16 volts unregulated .25 amp
Addressing - 8K of PROM must be contiguous on an 8K boundary, remaining 4K may be scattered in a second 8K block. I/O requires 16 contiguous addresses between FE00 and FEFF. IC sockets provided for address jumpers.
Buffering - Buffering for both address and data busses is provided. Maximum bus load is 1 LS TTL gate input and one LS TTL tri-state output.
Inclusions - Assembled and tested board, instruction manual containing detailed principles of operation and complete schematic, loopback diagnostic program listing. PROM's are NOT included.
Price - Assembled and tested $235.00
Bare board only $40.00 Quantity discounts are available.
All prices are F.O.B. Manchester, New Hampshire

Micro Technology Unlimited, Box 4596, Manchester, NH 03108

MICRO TECHNOLOGY UNLIMITED
KIM - 1 CARD FILE AND MOTHERBOARD INSTRUCTIONS

The K-1005 motherboard/card file is supplied assembled, tested, and configured for an expanded KIM-1 system using at least one MTU expansion board. The user merely inserts his KIM-1, bolts it to the stiffener bar, inserts an expansion board, connects power and goes. The expansion bus has been carefully designed for short electrical length and proper grounding and sheilding thus allowing the standard unbuffered KIM bus to serve a moderate number (4) of expansion boards. Using available and soon to be released expansion boards from MTU, the KIM may be expanded to a 33K system with high resolution graphic display and either 12K of PROM and extra I/O ports or a floppy disk controller. The entire system plus an MTU power supply capable of driving it fits into the space required by the power supply alone on many S-100 systems!

CONFIGURATION

The motherboard is supplied with three wires already connected to the KIM application connector. Since all power enters through the terminal strip mounted to the motherboard and +12 volts does not appear on the KIM expansion bus, one of these wires connects +12 volts to pin N on the application connector.

When KIM memory is expanded beyond 4K it is necessary to provide additional address decoding. The DECODE ENABLE signal (application connector pin K) must be generated by the added decoder whenever the 6502 processor sends out an address in the range of 0000 - 1FFF. All MTU expansion boards generate this signal and make it available at pin 20 of their expansion connectors. This signal is the wire running from the pad marked "DECODE EN" on the motherboard to pin K on the application connector. The KIM will not run alone unless this signal is grounded as stated in the KIM manual. Thus if no expansion boards are plugged in it is necessary to ground this signal by connecting a jumper from pin K to pin 1 on the application connector. When expansion boards are used, this grounding jumper must be removed for proper operation of the expansion boards.

A third signal, also generated by all MTU expansion boards, is called "VECTOR FETCH" because it is generated whenever the 6502 processor sends out an address in the range of FF00 - FFFF. This signal is necessary to activate the KIM monitor ROM's when the processor is fetching an interrupt or reset vector address. In expanded systems this signal must be connected to "K7" (application connector pin J). The wire running from the pad marked "K7" on the motherboard to application connector pin J is this signal. This wire may be left in place whether or not expansion boards are in use.

Summarizing, the motherboard wiring may be used as supplied as long as at least one MTU or equivalent expansion board is plugged into the system. If the KIM is to run alone in the card file, it is necessary to add a jumper from pin K to pin 1 on the KIM's application connector.

MOUNTING THE KIM

The card file is normally supplied with the KIM support rail already mounted and aligned to match the mounting holes on the KIM. In addition, insulating tape or fibre washers should have been applied to the rail to prevent shorts to PC lands on the bottom of the KIM. To mount the KIM to the card file, execute the following program:

1. Remove the rubber feet from the bottom side of the KIM.
2. Remove the old application connector from the KIM and discard.
3. Remove the three loose screws and nuts from the support rail.
4. As gently as possible, insert the KIM into the top position of the card file (the slot with two edge connectors). Pass the KIM over the support rail. It should drop into place after being fully inserted into the two edge connectors.
5. Three of the mounting holes around the outside of the KIM should mate with the three holes in the rail. If not, it may necessary of loosen the rail and adjust it. In severe cases the motherboard can be loosened and adjusted slightly also. In the event that hole positions change in subsequent releases of the KIM, we will make every effort to provide both old and new sets of holes.
6. Securely bolt the KIM to the rail using the fibre insulating washers (if supplied) between the KIM and the rail.

When properly mounted, the area around the keyboard should be at least as rigid as before when the rubber feet were in use.

DO NOT ATTEMPT TO PLUG THE KIM INTO ANY OTHER SLOT OR THE CASSETTE CIRCUITRY WILL BE DESTROYED WHEN POWER IS APPLIED!

CONNECTING POWER

All power input to the KIM and expansion cards is through the 5 terminal strip mounted to the motherboard. For use of the KIM alone, only +5 and +12 volts regulated are needed. All expansion boards are designed for unregulated power and have their own on-board regulators. Thus +8 and +16 volts unregulated, such as found on the K-1000 series of power supplies, should also be connected when these boards are used. The voltage to be applied to each terminal is marked on the motherboard etch. The order of the connections is the same as the output terminal strip of K-1000 series power supplies.

The power cable between power supply and card file should be short and use adequately heavy wire. With 24 guage hookup wire (the most common guage) the cable should be no longer than 2 feet. Use of 18 guage wire will allow cables as long as 8 feet. Although the +16 unregulated voltage has a small current drain and is regulated on board, high ripple currents will be flowing because the majority of the filter capacitance is on the expansion boards rather than in the power supply. Therefore the +16 wiring should be as heavy as the other voltages. Positive 12 power wiring may be 24 guage for lengths up to 8 feet however because of its very low, steady drain.

MICRO TECHNOLOGY UNLIMITED
CARD FILE AND MOTHERBOARD FOR THE KIM-1

At last, a motherboard and card file for KIM-1 expansion is available that is compact and inexpensive. The model K-1005 is compact because the KIM and up to four KIM compatible expansion boards require no more table space than the KIM-1 alone! It is inexpensive because no logic IC's are needed on the motherboard. The KIM is mounted horizontally above the other boards and the card file top is open for easy access to the keyboard and displays. The periphery of the KIM is bolted to rigid supports while the other cards are supported in standard, deep slot card guides. The compact design with expansion boards out of the way assures maximum safety under conditions of heavy use.

The motherboard is double-sided plated-through G-10 glass-epoxy printed circuit material and contains parallel bussing for five standard 44 pin edge connectors. The bus is positioned to mate with the KIM's expansion connector. The five edge connectors are supplied assembled to the board and are glass filled diallyl phthalate plastic with bifurcated gold-plated contacts. The short bus runs and proper attention to shielding and grounding of the bus allows the full four low power Schottky load capability of the KIM bus to be realized.

A five position terminal strip provides power connections to the KIM (+5 and +12 volts regulated) and expansion boards (+7.5 and +16 volts unregulated). An additional connector that mates with the KIM application connector is also included and is already wired for power distribution and memory expansion signals (Decode enable and K7). Space and mounting holes are provided for additional edge connectors in the application position for use with our PROM/IO board or for other purposes.

Construction of the card file is one-piece .062 inch cadmium plated aluminum. The KIM support is of the same material but angled for maximum rigidity. Mounting holes on both the bottom and top surfaces of the card file allow solid mounting to a base and installation of a cover for the KIM if desired. Expansion boards are easily removable although the KIM must be unbolted from its supports to be removed.

SPECIFICATIONS

Approximate Dimensions - 11.25 inches deep, 8.5 inches wide and 4.75 inches high when in normal KIM operating position
Maximum Capacity - KIM-1 plus four 11 inch wide expansion boards
Bus - Unbuffered KIM-1 expansion bus
Connectors - 6 supplied, 5 on motherboard and 1 to mate with KIM appication connector. Standard 44 pin double sided .156" contact spacing edge connectors with printed circuit tab contacts.
Power Connector - 5 position terminal strip for +5, +7.5, +12, and +16 volt power input plus ground. The motherboard itself draws no power.
Price - K-1005 card file and motherboard completely assembled, aligned, and tested $68.00 Quantity discounts available
All prices are F.O.B Manchester, New Hampshire

Micro Technology Unlimited, Box 4596, Manchester, NH 03108

MICRO TECHNOLOGY UNLIMITED
GRAPHICS SOFTWARE PACKAGE FOR THE K-1008 VISABLE MEMORY

The graphics software package for the K-1008 Visable Memory is designed to provide the user with a library of basic graphics oriented subroutines. By incorporating calls to these routines, the user can create and manipulate text and graphic images whose complexity is limited only by the 320 by 200 display matrix size. Most routines operate on X and Y coordinate arguments stored in page 0. In addition to the subroutine library, two demonstration programs are provided.

Summary of Major Subroutines

1. STPIX, CLPIX, FLPIX WRPIX, RDPIX Set, clear, flip, write, and read the pixel at X1CORD,Y1CORD.
2. DRAW, ERASE Draws (white line) or erases (black line) a line between X1CORD,Y1CORD and X2CORD,Y2CORD.
3. PIXADR Returns the byte address and bit number of the pixel at X1CORD,Y1CORD.
4. DCHAR Displays a character whose upper left corner is X1CORD, Y1CORD. Character code is full ASCII and matrix is 5x7 with lower case descenders making it effectively 5x9
5. DTEXT Accepts ASCII characters and formats them into text. Interprets ASCII control codes CR, LF, BS, DC1-DC4 (cursor movement), SI and SO (baseline shift for sub/superscript). Text starts at X1CORD,Y1CORD which are updated following each call. Underline cursor at current location is provided. 5x9 matrix in a 6x11 field provides 18 lines of 53 characters.
6. SDTEXT Simplified version of DTEXT. Interprets CR, LF, BS, FF Underline cursor provided. Uses its own method of addressing. 5x7 matrix in an 6x9 field provides 22 lines of 53 characters

Summary of Demonstration Programs

1. LIFE Implements the game of Life in the full 320 by 200 matrix The KIM keyboard may be used to set the initial colony pattern and control evolution of the generations.
2. SWIRL Produces an infinite variety of patterns under the control of two parameters. Uses a simple difference equation algorithm.

The subroutine package is available as commented, assembled source listings only since the user is expected to assemble the routines needed into his own program. For convenience in hand relocation, all temporary storage is done in the stack and base page and relative jumps are used where possible. Locations that must be modified when relocating are designated by underlining.

The demonstration programs reside in the standard KIM RAM and assume that the Visable Memory starts at 2000. A cassette containing the demonstration programs only is also available.

Pricing

Graphics Software Package and demo programs, listing only $20.00
Above plus demo program cassette $25.00
First deliveries: May, 1978
Watch for our KIM BASIC Graphic Patch Package this summer.

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MICRO TECHNOLOGY UNLIMITED
KIM - 1 8K MEMORY / RASTER GRAPHIC DISPLAY GENERATOR

The MTU Visible Memory is a unique concept in microcomputer memory systems. For about what you would expect to pay for either an 8K memory board or a dense dot raster graphic display board alone you can have both! The MTU Visible Memory is an 8K memory add-on to the Commadore KIM-1 system which includes the circuitry to simultaneously display the memory contents as 64,000 dots on a TV monitor. Unlike many other add-on memory boards, this one is designed for the KIM-1 and is merely connected in parallel with the expansion connector on the KIM-1 with two wires also connecting to the application connector. No modifications to the KIM-1 itself are necessary. The KIM-1 continues to run at full speed with no wait states and no software overhead or CPU time required to refresh the display. Also there is no snow or other visible interference on the screen when the display memory is being accessed by the KIM CPU.

Applications of the Visible Memory are endless. The basic display format is 200 lines of 320 dots per line. With the optional character display package, up to 18 lines of 53 upper and lower case characters with true descenders can be displayed. With additional font tables of various sizes, characters of varying size can be displayed simultaneously as well as real subscripts, superscripts, and proportional spacing. In short, the Visible Memory makes an exceptionally versatile text display. With the optional graphing routines, many kinds of graphs and charts can be displayed. Animated and interactive graphics capabilities make all kinds of games possible with a degree of realism never before available on a hobby computer.

Extensive use of low power Shottky IC's and 4K dynamic RAM's is responsible for the low power consumption, low cost, and small size of the board. Problems experienced with dynamic memory in some other systems are absent in this board due to the superior bus control achitecture of the KIM-1 and advanced circuit design. The circuitry that generates the display also refreshes the memory automatically as it scans.

Jumpers select the 8K block of addresses to be assigned to the board. An extra jumper selectively disables the top or bottom half of the display thus allowing 4K to be used for program storage without showing up as a random pattern on the screen. The "Decode Enable" and "K7" signals needed when The KIM is expanded beyond 4K are generated by the board and need simply be connected to the proper pins of the KIM application connector. Up to four Visible Memory boards may be connected to a KIM without overloading its bus.

SHORT FORM SPECIFICATIONS

Display Format: 200 lines, 320 dots per line, non-interlace
Scanning Frequencies: (derived from KIM-1 crystal clock)
Horizontal: 15,625 Hz, Vertical: 60.1 Hz.
Required video bandwidth: 4 mHz
Output: 1.25 V p-p composite video into 75 ohms, sync negative
Adjustments: One, dot sync (prealigned on assembled units)
Power requirements: +7.5 volts unregulated .25 amp, +16 volts unregulated .25 amp.
Price: $289.00 FOB Manchester Quantity discounts available.

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K-1016 $375.00

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MTU and KIM - - - they go together, by design!

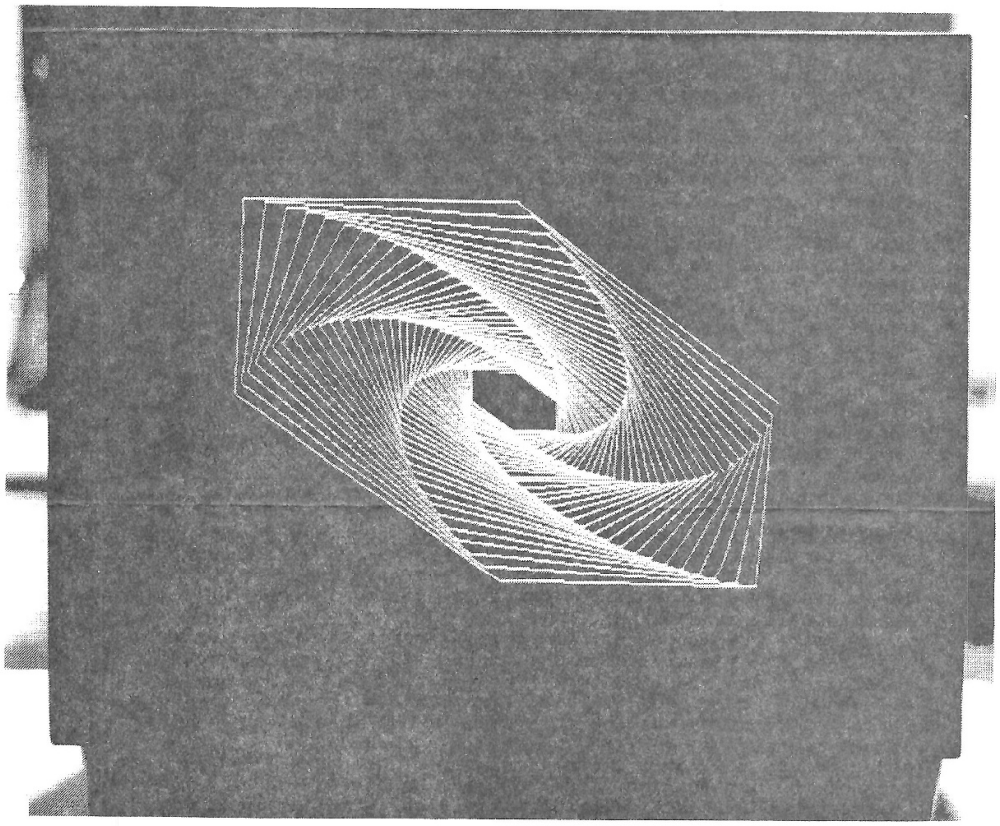
MICRO TECHNOLOGY UNLIMITED

Introduces its revolutionary

V i s a b l e M e m o r y

to the KIM-1 user

A low-cost high resolution graphic display device
designed specifically for the KIM-1 by
Hal Chamberlin



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Box 4596
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Manchester, New Hampshire 03108

MICRO TECHNOLOGY UNLIMITED

KIM - 1 8K MEMORY / RASTER GRAPHIC DISPLAY GENERATOR

The MTU Visable Memory is a unique concept in microcomputer memory systems. For about what you would expect to pay for either an 8K memory board or a dense dot raster graphic display board alone you can have both! The MTU Visable Memory is an 8K memory add-on to the Commadore KIM-1 system which includes the circuitry to simultaneously display the memory contents as 64,000 dots on a TV monitor. Unlike many other add-on memory boards, this one is designed for the KIM-1 and is merely connected in parallel with the expansion connector on the KIM-1 with two wires also connecting to the application connector. No modifications to the KIM-1 itself are necessary. The KIM-1 continues to run at full speed with no wait states and no software overhead or CPU time required to refresh the display. Also there is no snow or other visable interference on the screen when the display memory is being accessed or changed by the KIM CPU.

Applications of the Visable Memory are endless. The basic display format is 200 lines of 320 dots per line. With the optional character display package, up to 18 lines of 40 upper and lower case characters with true descenders can be displayed. As many as 53 characters per line is possible with some sacrifice in character generation speed. With alternate font tables (5X9 is included in the optional software package), characters of varying size and shape can be displayed simultaneously as well as real subscripts, superscripts, and proportional spacing. In short, the Visable Memory makes an exceptionally versatile text display. With the graphing routines in the software package, many kinds of graphs and charts can be displayed. With the "BASIC Patch Package", soon to be available, KIM BASIC can make full use of the display for both text and graphics applications.

Animated and interactive graphics capabilities make all kinds of games possible with a degree of realism never before available on a hobby computer. Since there is no snow or other interference on the screen ever, programming of moving images is completely unrestricted.

Extensive use of low power Shottky IC's and 4K dynamic RAM's is responsible for the low power consumption, low cost, and small size of the board. Problems experienced with dynamic memory in some other systems are absent in this board due to the superior bus control achitecture of the KIM-1 and advanced circuit design. The circuitry that generates the display also refreshes the memory automatically as it scans.

Jumpers or an optional DIP switch select the 8K block of addresses to be assigned to the board. An optional jumper selectively disables the top or bottom half of the display thus allowing 4K to be used for program storage without showing up as random patterns on the screen. The "Decode Enable" and "Vector Fetch" signals needed when The KIM is expanded beyond 4K are generated by the board and need simply be connected to the proper pins of the application connector. Up to three Visable Memory boards may be connected to the KIM without overloading the bus.

The board is designed to be mounted benieth the KIM-1. It is the same width as the KIM and the 44 pin edge connector is in the same position as the KIM's expansion connector.

SPECIFICATIONS

Display Format: 200 lines, 320 dots per line, non-interlace
Scanning Frequencies: (derived from KIM-1 crystal clock)
Horizontal: 15,625 Hz, Vertical: 60.1 Hz.
Required video bandwidth: 4 mHz minimum
Output: 1.25 V p-p composite video into 75 ohms, sync negative
Adjustments: One, dot sync (factory aligned on assembled units)
Power requirements: +7.5 volts unregulated .25 amp, +16 volts unregulated .25 amp.
Sockets: 16 memory IC's, address and blanking jumpers, and vector fetch gate (7430) are socketed.
Memory type: 22 pin 4K dynamic RAM, National Semi. MM5280 or equ.
Access time: greater than 100NS data stable time prior to fall of $\overline{\text{Phase 2}}$ clock
Cycle time: internally synchronized to 1.0mHz $\overline{\text{Phase 2}}$ clock from host system
Printed circuit board: 11" wide by 5" tall exclusive of gold-plated edge connector, plated-through holes
Inclusions: bare or assembled and tested board; instruction manual containing schematic, trouble-shooting tips, and memory diagnostic (fun to watch!)
Price: Assembled and tested - $289.00
Bare board - $40.00
Kits are not available.
Quantity discounts are available, please request on letterhead a current MTU price list.
Delivery: First retail delivery is January, 1978. Standard delivery schedule is stock to 2 weeks for retail orders. Delivery on larger quantities is individually negotiated.

PIN CONNECTIONS

Signal	KIM	K-1008	Signal	KIM	K-1008
SYNC	E-1	N.C.	ADDR BUS 0	E-A	A
RDY	E-2	N.C.	ADDR BUS 1	E-B	B
PHASE 1	E-3	N.C.	ADDR BUS 2	E-C	C
IRQ	E-4	N.C.	ADDR BUS 3	E-D	D
SET OVERFLOW	E-5	N.C.	ADDR BUS 4	E-E	E
NON-MASK INT.	E-6	N.C.	ADDR BUS 5	E-F	F
RESET	E-7	N.C.	ADDR BUS 6	E-H	H
DATA BUS 7	E-8	8	ADDR BUS 7	E-J	J
DATA BUS 6	E-9	9	ADDR BUS 8	E-K	K
DATA BUS 5	E-10	10	ADDR BUS 9	E-L	L
DATA BUS 4	E-11	11	ADDR BUS 10	E-M	M
DATA BUS 3	E-12	12	ADDR BUS 11	E-N	N
DATA BUS 2	E-13	13	ADDR BUS 12	E-P	P
DATA BUS 1	E-14	14	ADDR BUS 13	E-R	R
DATA BUS 0	E-15	15	ADDR BUS 14	E-S	S
K6	E-16	N.C.	ADDR BUS 15	E-T	T
SING. STP. OUT	E-17	N.C.	PHASE 2	E-U	N.C.
+7.5 UNREG	N.C.	18	$\overline{\text{READ/WRITE}}$	E-V	V
VECTOR FETCH	A-J	19	READ/WRITE	E-W	W
DECODE ENAB.	A-K	20	*+16 UNREG*	***	X
+5 REG.	E-21	N.C.	$\overline{\text{PHASE 2}}$	E-Y	Y
GROUND	E-22	22	RAM R/W	E-Z	N.C.

*** This signal must connect to the K-1008 only, not the KIM!

INTERFACING

The K-1008 Visable Memory is designed for the simplest possible interfacing to the KIM-1 microcomputer. Simply wire the K-1008 in parallel (except for pin X which is the PLL TEST pin) with the Expansion connector on the KIM-1 itself. Since the K-1008 edge connector is in the same relative position as the expansion connector, two 44 pin standard edge connectors wired together may be used. If additional expansion is not anticipated, it is possible to merely solder wires to the edge fingers on the boards. When wiring several edge connectors together for a large system, it is desirable that the pin 22 wiring (Ground) be done with braid (solder wick works well) or several strands of hookup wire. MTU will shortly have a simple, inexpensive 5 slot motherboard available that allows additional KIM compatible boards to be stacked undernieth and parallel to the KIM board.

The VECTOR FETCH and DECODE ENABLE signals provided by the K-1008 must also be connected to the appropriate inputs on the application connector to satisfy the KIM requirements when memory beyond 4K is added (see the pin connection table).

Up to 3 K-1008 boards can be connected to the KIM without buffering. However the 74LS30 that generates the VECTOR FETCH signal should be removed from all but one of the boards to minimize address bus loading.

The video output is designed with a precise 75 ohm source impedance to simplify connection to a standard monitor even over long lengths of coax cable. If only one monitor is at the end of the cable, termination at the monitor is not required since the K-1008 will absorb all line reflections. If several monitors are daisy-chained, the one at the far end must be terminated in 75 ohms to prevent the reflections from showing up on the middle monitors.

Connection to computers other than the KIM-1 is possible but the system must utilize either a Motorola 6800 or one of the MOS technology CPU's (such as a 6502, 6512, etc.) and must have a 1.0mHz clock. This includes OSI 6502 based products, SWTP 6800 products, APPLE, ECD, and Commodore but not the Altair 680 since it runs at .5mHz. Also, none of the 8080 or Z-80 based systems can be used since their bus control cannot support the flip-flop access method mentioned earlier. The extra KIM-related circuitry may be left intact when connecting to other systems. The K-1008 can be used with a "Kimsi" motherboard but connections between the K-1008 and the KIM should still be done at the KIM's expansion connector and not the Kimsi edge connectors.

Address jumpering on the board can be set at any 8K boundary. It is recommended that the first K-1008 be jumpered for 2000-3FFF, the second for 4000-5FFF, etc. Although physically possible, it is not recommended that the board be jumpered for either 0000 or E000 since it will then interfere with memory already on the KIM.

It is not possible to de-populate the board to 4K because all even addresses access one group of 8 RAM chips and all odd addresses access the other group. This was done to conserve power while allowing for self-refresh by the video generator.

The board may be run on +12 and +5 volt regulated power supplies by simply shorting the two outside pins of each on-board regulator IC together.

PROGRAMMING

Programming of the K-1008 to display text and graphics is very straightforward. The display is essentially a matrix of dots with 200 rows of 320 dots per row. For addressing purposes the dots can be numbered from 0 to 63,999 with dot 0 being the upper left-hand corner dot, dot 319 being at the upper right corner, dot 320 being the leftmost dot on the next row down, and 63,999 being the lower right-hand corner dot. Eight horizontally adjecant dots make up one byte of memory with the position of the dots on the display corresponding to the position of the bits in the byte. Thus dot 0 is the leftmost bit (bit 7) of the first byte in the visable memory (generally at memory address 2000_{16}). Conversely dot 319 would be the rightmost bit (bit 0) of the fourtieth byte (typically address 2037_{16}).

Usually graphics programming is performed using the X-Y method of identifying a particular dot position. Although the origin of the coordinate system can be assumed to be anywhere, it is convenient to place it at the lower left corner of the display. Thus all of the displayable points are in the first quadrant and X and Y are always positive numbers. To convert from X-Y point coordinates to a dot number is a simple matter involving evaluation of the equation: DOT # = (199-Y)*320+X . Conversion from the dot number to a byte address and bit number (assuming most significant bit is bit 0) is as follows: BYTE ADDR = VM BASE ADDR + INT(BIT #/8); BIT # = REM(BIT #/8) . Going directly from coordinates to byte address and bit number is as follows: BYTE ADDR = VM BASE ADDR + (199-Y)*40+INT(X/8); BIT # = REM(X/8) . Note that the multiplication by 40 can be accomplished in steps as follows: A*40=(A+A*4)*8 where multiplication by 4 and 8 is accomplished by shifting left 2 and 3 positions respectively. Divison by 8 is accomplished by shifting right 3 positions.

Once the byte and bit addresses are found, the dot may be turned on with the logical OR instruction, turned off with an AND instruction, or flipped with an EOR instruction. It is convenient to write subroutines that accept X and Y coordinates as input and set, reset, flip, write, or read a dot. These would in turn call a subroutine to compute the byte and bit addresses from X and Y coordinates. A more sophisticated subroutine would accept the coordinates of the endpoints of a line and fill in the points forming the closest approximation to the straight line between them. Characters may be drawn either as line segments or a dot matrix by using a font table and calls to the appropriate routine. In special cases drawing speed may be greatly increased by handling the 8 dots in a byte simultaneously.

Since the X coordinate may be as large as 319 which requires 9 bits to represent, the X coordinate must be a double-precision number. Although Y will fit into 8 bits, it too should be double precision for consistency and software compatibility with future display hardware upgrades. It is entirely possible that within two years from now we will see the introduction of a 640 wide by 400 high display using 16K dynamic RAM's!

Although it is a lot of fun to build up graphic subroutines yourself, it is possible that some users would prefer to have the work done for them. A set of utility routines including those discussed above plus some others and a full 320x200 LIFE game are under development and will be available shortly for $20.00 as printed, heavily commented source listings.

ABBREVIATED PRINCIPLES OF OPERATION

The K-1008 Visable Memory is basically an 8K dynamic memory board. However instead of letting the memory refresh cycles go to waste, the data read is formatted into a video signal and sent out. Thus, depending on your point of view, it is either a dynamic board with "visable" refresh or a static video display board.

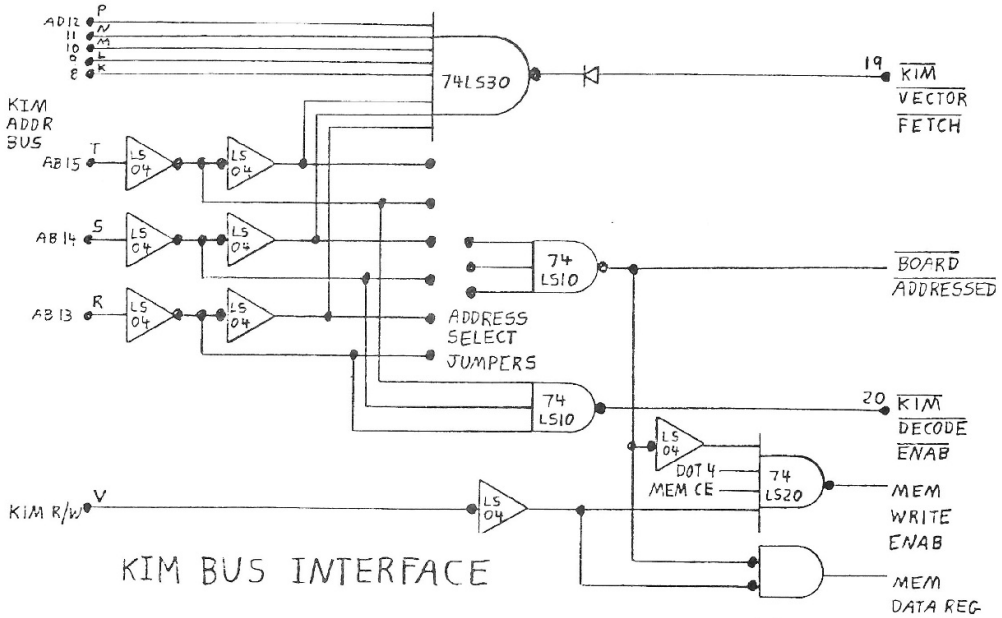
The key to the board's remarkable properties is the 6502 bus itself. A symmetrical 1.0 mHz two-phase clock is used by the KIM-1. The 6502 microprocessor really accesses memory only during Phase 2 with Phase 1 being used for setup. Thus the visable memory can use the 500NS period during Phase 1 to access the memory for display and then turn the memory over to the 6502 during phase 2. Access times approaching 300NS are required with this scheme but that figure is actually rather slow compared with modern 4K dynamic RAM standards. It is this "flip-flop" sharing between microprocessor and display that makes glitchless display quality possible under all operating conditions.

All of the board's timing is derived from an 8mHz oscillator which is phase-locked to the falling edge of the Phase 2 signal from the KIM. Each cycle of this oscillator represents 1 dot on the display. Every 4 cycles represents a single memory cycle which is alternately assigned to the video generator and the KIM as previously described. Timing within each memory cycle is generated by decoding the divide-by-4 counter. Every 8 cycles represents a byte of display data. Forty byte times make up the visable portion of a horizontal line and 24 more are allowed for retrace. Two-hundred horizontal scan cycles make up the visable portion of the vertical scan while 60 more are allowed for retrace. Thus the 1.0mHz KIM clock is multiplied to 8.0mHz and then divided down to 60Hz in several steps.

Dynamic RAM's have the desirable property that power is drawn only when they are clocked through a cycle. A power saver circuit determines precisely when each RAM chip is being accessed and only then does it get a clock pulse. Net power consumption from the +16 volt supply to refresh the display alone is less than 100MA. This rises to about 250MA with 100% access by the KIM. However, in the case of multiple boards, the KIM can only access one at a time so in effect the first board may require as much as 250MA but each additional one needs only 100MA! Exclusive use of low power Schottky for the peripheral logic keeps +5 volt current consumption under 250MA per board. As a result, the simple K-1000 power supply is rated to drive the KIM and 2 visable memory boards and typically can power 3 of them.

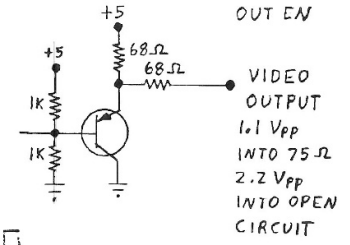
Negative 5 volts for the RAM's substrate bias is derived from a charge-pump cirucit powered from the +12 volt internal supply. On board regulators for both +5 and +12 allow the use of unregulated power supplies or the "raw" outputs of the K-1000 power supply.

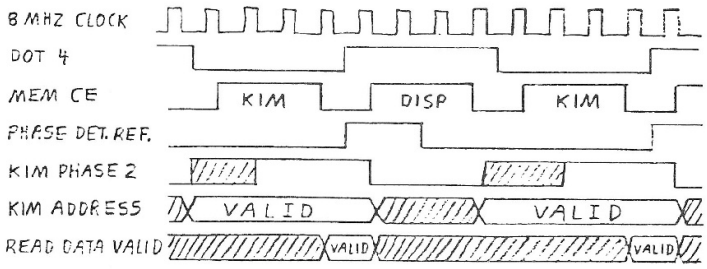
INTERFACE CIRCUITS ON K-1008 BOARD



KIM BUS INTERFACE

VIDEO OUTPUT CIRCUIT





INTERFACE TIMING

MTU K-1008 VISABLE MEMORY BLOCK DIAGRAM