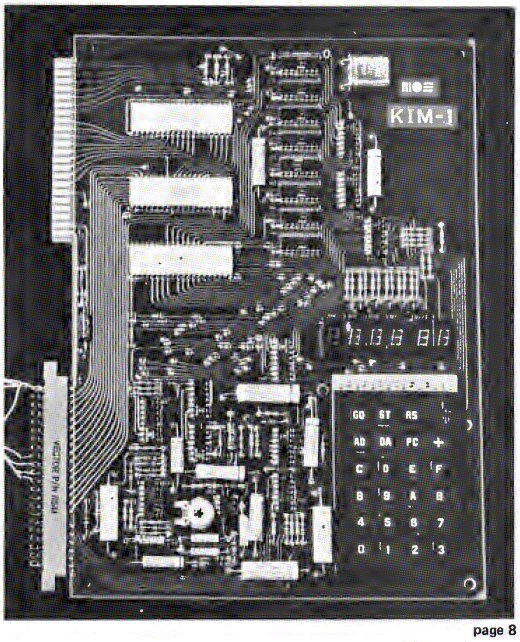

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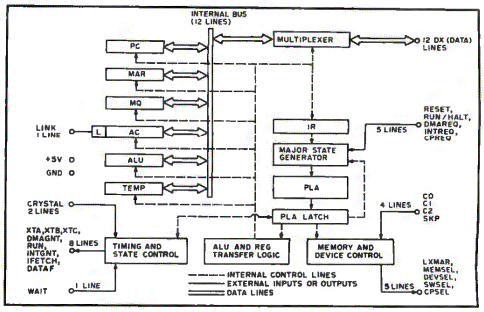

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In This BYTE

Richard Simpson describes his first **Date With KIM**, the new product from MOS Technology which comes assembled and ready to use. This product, which is the basis of his system, marks the first direct entry of a semiconductor manufacturer into the personal systems field.

Are different microcomputers equivalent? In **n Source**, RD Boudinot presents some excellent background information on multiple sources of components and systems, the mixing of products from different manufacturers and methods of evaluating products for use in a personal computing system.

Of what use is a nice friendly permanent memory? Dale Eichbauer contributes some ideas on the use of **Read Only Memories in Microcomputer Memory Address Space.**

Previous articles have covered programming and uses of some of the simpler fusible link read only memories. But how about erasable ROMs? Roger L Smith provides some **More Information on PROMs** including a method of programming the widely available 1702 parts.

One way to get a hard copy terminal is to use a receive only Teletype unit. Using an inexpensive ASCII keyboard and a UART circuit, Dr George Haller shows how to **Serialize the Bits From Your Mystery Keyboard** and achieve the same function as a keyboard send receive Teletype for about half the cost.

Dissatisfied with toggle switches? Use **An Octal Front Panel** similar to Herman DeMonstoy's design to replace toggle switches with an octal keyboard.

You'll be **SHOOTING STARS** in a fascinating logical game when you implement a version of Willard Nico's program on your computer. On the cover is artist Robert Tinney's impression of a SHOOTING STARS addict.

A simple signal generator might suffice for a radio man, but testing of computers and data communications hardware can require more sophisticated equipment. One such item is a **Serial ASCII Word Generator** such as the design Ronald Finger describes.

How do you take advantage of a decade of software experience? One way is to emulate another computer's architecture as Intersil has done with its IM6100. Robert Nelson describes a **"Chip" Off the Olde PDP-8E** in this first part of a two part article.

Can a computer measure voltages without hundreds of dollars worth of hardware? Of course it can. The secret is to use **Microprocessor Based Analog/ Digital Conversion Techniques** of the sort described in Roger Frank's article on a very basic interface.

One of the keys to creating an assembler is defining exactly what the input source language will look like. An appropriate choice which simplifies writing the assembler will greatly speed up the process of implementing the program. In his article on the subject, Gregory Jewell shows how to **Simplify Your Homemade Assembler** using techniques which are applicable to most microcomputers.

Photo 1: When you first open your KIM-1 box, you see a thick layer of documentation, including a large wall chart of the system's hardware details, an MCS650X Instruction Set Summary card, KIM-1 User Manual, Programming Manual *and* Hardware Manual. *Also shown in this picture is the KIM monitor listing copy which must be requested separately and is a must if you are to take advantage of KIM's subroutines in applications programs.*

A Date with KIM

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Here it is! In the November 1975 BYTE, Dan Fylstra reviewed the capabilities of the MOS Technology 6501 microprocessor chip in an article titled "Son of Motorola" (page 56). The article stated that "it will be three to six months before you see (a 6501) designed into a kit..." Well, MOS Technology has gone one better and introduced not a kit, but a completely assembled, tested and warranteed microcomputer with a price tag of only $250! Using the 6502 processor chip (a 6501 with an on-chip clock), the microcomputer features 1 K of RAM, 2 K of ROM containing the system executive, a complete audio cassette interface, a serial terminal interface, 15 bidirectional IO lines, a 23 key keypad and a six digit LED display. This completely assembled one board computer has all the programming features of the 6502 at a very competitive price.

If you have been hesitating over buying a microcomputer because of the difficulty of assembly and the fear that it won't work when you're finished, KIM-1 is for you. The only assembly required is to attach six self adhesive plastic feet to the back of the KIM-1 printed circuit board and attach a +5 volt, 1 ampere power supply to the 44 pin edge connector provided. You'll also need a supply of +12 V for the cassette interface; but a handful of flashlight batteries should work fine since only about 50 mA of +12 V is required, and that only when the interface is being used.

The name KIM is an acronym for Keyboard Input Monitor. The name really describes the ROM executive routines, not the whole unit, but it's a pleasant change from the manufacturer's name followed by a number. It's also significant that the system derives its name from its software.

The KIM-1 board can be operated in one of two modes: using the on board keypad and LED display, or using a serial terminal. The keypad and hexadecimal display is infinitely easier and less error prone than throwing toggle switches and reading results from binary lamps. In fact, for program entry and many simple applications, I prefer the 23 key keypad and bright LED display to my slow, noisy Teletype. The keys have a good, positive "feel" to them (MOS Tech-

Photo 2: The KIM-1 processor as it is removed from its box. The MOS Technology product comes in a neat package which has one foam padded and static protected KIM-1 board as its bottom layer.

nology should know about such things, since they are a major manufacturer of chips for calculators).

The switch in the upper right corner of the keypad puts the machine in single instruction (not single cycle) mode. When the switch is "on," each depression of the "GO" button causes a single instruction of your program to be executed. Control is then returned to the executive program in ROM and the contents of all six machine registers (PC, X, Y, S, P, and the accumulator) are stored in fixed memory locations where you can easily examine them through the keypad or terminal and then "GO" to the next instruction. This is an important capability, since if you just halt a microprocessor after each instruction there is no way of examining the registers (they're all inside the chip!).

I won't go into any detail on the instruction set (see Dan Fylstra's article for that) except to say that it is comprehensive. The variety of addressing modes makes complex programming (especially when processing lists) a lot easier. The 6502 architecture has no IO register or IO instructions, so any memory location can become an IO "port" if you build the hardware for it. KIM comes with a built-in 15 line bidirectional IO interface. TTL levels are acceptable, of course, and one of the lines can supply enough current (5 mA) to directly drive a power transistor. The manual shows how to use it to drive a small speaker for "microprocessor music" programmed in a manner similar to the Kluge Harp of October BYTE (page 14). Each line can be separately programmed for input or output by writing a status word into the correct memory location.

The cassette interface is carefully thought out and should be foolproof. Half of the executive ROM is devoted to the cassette interface software, which includes rudimentary file management and sophisticated programmed equivalents to UART operation. This software allows multiple dumps to a single cassette. A header written on each output segment allows you to say, in effect, "find me program number 34 on the tape and load it starting at location. . ." A checksum is stored at the end of each segment and the user is immediately informed if the computed checksum doesn't match when the tape is read back in. You can even record voice data between segments of digital data – the interface will ignore the voice. This feature could be used to verbally record the instructions for a game and then automatically load and run it. Both high and low level outputs are provided to interface with any type of cassette recorder. It's not a vital feature, but it indicates the care with which the entire system has been thought out.

The TTY interface is for a standard 20 mA current loop (figure 1 shows how I modified it for an RS-232 interface). A unique feature of the software is automatic data rate detection. As soon as the system is powered up, the user types a RUBOUT character on his terminal. The software

If you have been hesitating over buying a microcomputer because of the difficulty of assembly and the fear that it won't work when you're finished, then KIM-1 is for you.

KIM-1 derives its name from the software, a significant indication of the importance of good user support programs.

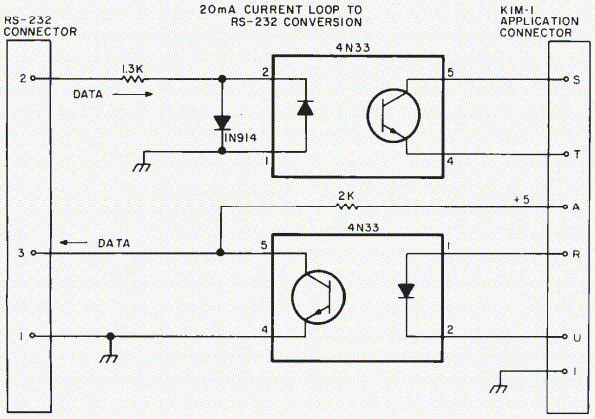


Figure 1: One way to interface KIM-1 with an RS-232 compatible terminal is illustrated in this diagram. Opto isolators are used to accomplish the coupling. The RS-232 pins 1, 2 and 3 will be sufficient for terminals which do not involve handshaking; on some terminals, pins 5, 6, 8 and 20 of the standard RS-232 plug may have to be tied together to bypass handshaking signals.

calculates the data rate (anything from 110 to 1200 baud is acceptable) and automatically adjusts all further conversation to that rate. No additional timing standards or switches are required for the interface.

The real beauty of the terminal interface is in the software, not the hardware. On request, MOS Technology supplies a complete listing of KIM. All the executive ROM software subroutines are documented and available to the user referencing this well-commented listing. Thus, to print the contents of the accumulator in hex on the terminal requires a simple one-instruction subroutine call. Those readers who have had to invent their own terminal interface software will have a deep appreciation for this capability. Similar subroutines are provided for reading characters from the terminal or keypad, printing one or a string of ASCII characters, or writing digits in the LED display.

To round out the terminal interface, software is provided in ROM to read and punch paper tape if your terminal is so equipped. Again, care has been taken to provide checksums on the punched tape which is automatically verified when the data is reloaded. This kind of attention to detail reflects the high caliber of the MOS Technology offering. One reason for this is the fact that MOS Technology sells a sizeable portion of the KIM units to industrial users. This policy of building to industrial rather than consumer standards is also evident in the quality of the PC board, the PC artwork, and the fact that the board is coated with a solder mask, a plastic coating which protects the printed wiring. To further emphasize their faith in KIM, MOS Technology gives you a 90 day warranty on the entire KIM system, not just the components. Mail-in repair service is available even after the warranty expires.

Interval Timer

Another feature of KIM which is finding its way into more and more microprocessors is the inclusion of a program controlled interval timer. The KIM board actually contains two programmable timers, but one is dedicated to control the keypad and cassette interface. Any count from 1 to 256 can be loaded into the timer by writing to the timer's memory location. The user can control the scale of the timer by programming it to count every clock pulse or to count every 8th, 64th, or 256th clock pulse. This prescaling of the counter is done by decoding the last two address bits for the timer. Thus, the time scale is controlled by which memory location is loaded with the count. You might consider using a similar scheme whenever you have to write more than eight bits to control an external device: Just use the least significant address bits as data.

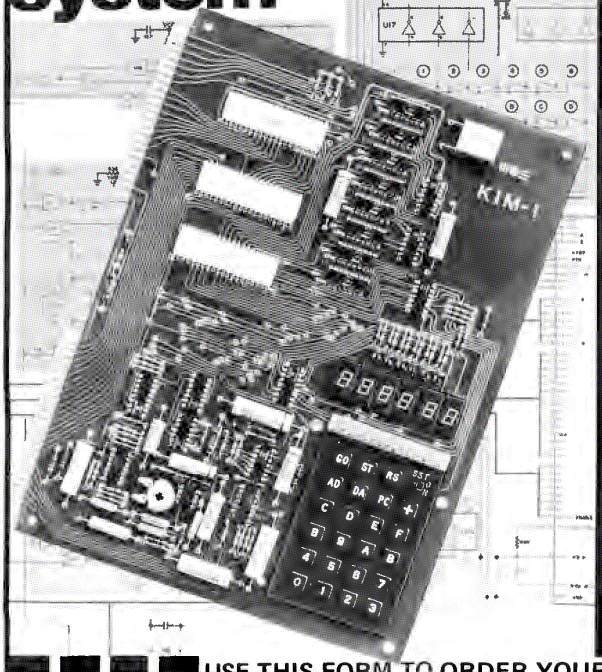
When the timer has counted down to zero, a software interrupt is generated, notifying the program that "time has run out." As soon as the interrupt is issued, the timer continues to count past zero (into negative numbers) at the clock rate. If the program is servicing other interrupts, it can read the counter register to determine how long ago (in machine cycles) the timer interrupt occurred.

Memory Expansion

If you are interested in expanding the KIM memory beyond the 1 K provided, you'll be glad to know that all the decoding for the first 4 K is provided right on the KIM board. All you need to provide is 4 K more of RAM chips and some buffers.

There are two connectors on the KIM board; one called the expansion connector is for adding memory and bus oriented devices. The second connector, called the application connector, interfaces directly to the outside world. The expansion connector has all the address, data, and memory control signals. The application connector terminates the lines for the audio cassette, the terminal send and receive signals, and the 15 IO lines. Connections are also provided so that the keypad can be removed from the KIM board and mounted elsewhere, a useful feature if

MOS KIM-1 microcomputer system



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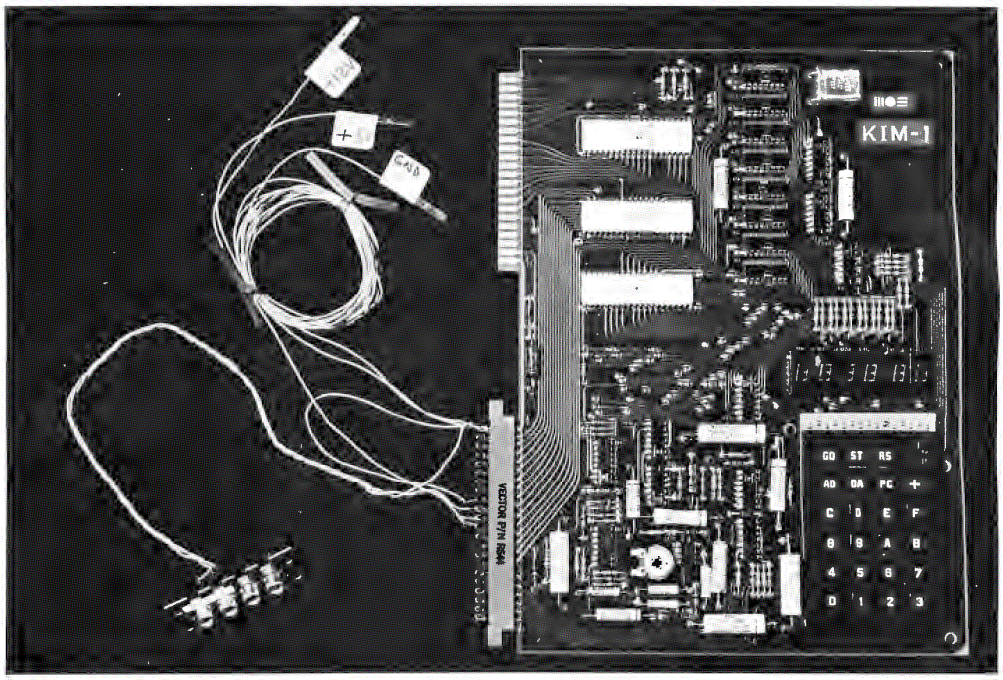

Photo 3: Wiring for Stand Alone Use. With due respect to the instructions in the KIM-1 user's manual, and addition of some miscellaneous parts, the results will be a wiring harness similar to that shown here. Wires have been attached and labelled for GND, +5 volts and +12 V. The audio cassette interface has been brought out to an RCA-style phono jack assembly purchased at a retail electronics store, along with interconnection cables for the recorder input and output. This setup enables the user to enter and test out programs through the KIM-1 control panel and LED display.

you want to wrap up the KIM printed circuit board in sheet metal along with a power supply.

Documentation

The documentation which comes with KIM is thorough and comprehensive. Any regular reader of BYTE should have no trouble following the details of the 200 page programming manual. There are plenty of examples; and the explanation of the operations which occur in each machine cycle of multicycle instructions, while not essential, is very instructive. Special sections of the manual are devoted to interrupt handling and use of the stack pointer. This is vital information often glossed over in other manuals.

I have to admit that I have not yet digested all the information in the 150 page hardware manual which came with my KIM, since my main interest is in programming my system as soon as possible. However, the manual seems to have a solid emphasis on IO interfacing and usage of the control lines.

The third manual provided is the actual KIM user's manual. This 100 page document explains how the keypad, cassette interface and terminal interface are to be used. It gives a few basic programming examples, including an example which goes through the entire design of a simple application using the IO lines. My only complaint is that no sample program was provided for the use of the programmable timer or the ROM executive subroutines. Also, the listing of KIM should have been supplied as a standard item.

Also included in the package is a pocket reference card for the instruction set and a wall size schematic of the entire KIM board. Two other useful documents are available from MOS Technology on request. One is the manual for the 6500 cross-assembler, which is available on several commercial time-sharing systems. The other is the well-commented listing of the executive programs stored in ROM as mentioned earlier.

In summary, the KIM is an excellent microcomputer requiring no assembly and which is very attractively priced. The only auxiliary equipment required is a power supply and a cassette recorder. The manuals are among the best available and the built-in keypad and display make KIM easy to get started with. The terminal interface and ease of memory expansion make it easy to upgrade as your requirements increase. Make a date with KIM — you'll enjoy it! ■