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Growing with KIM

expansion PC board

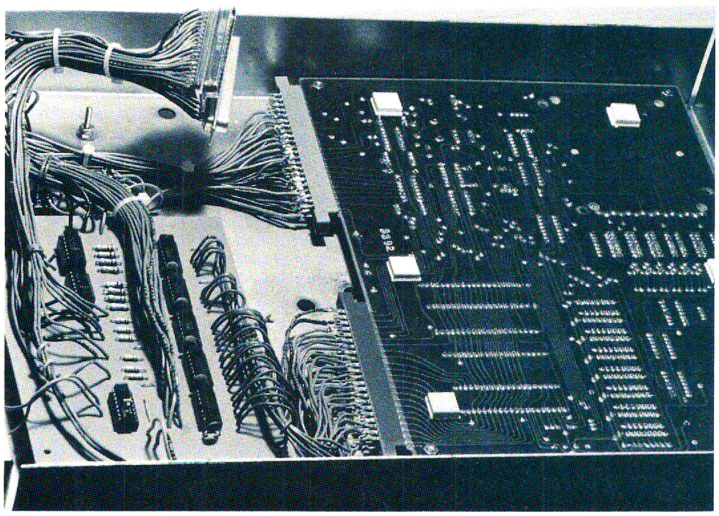
The KIM-1 Microcomputer by MOS Technology is a versatile computer-on-a-card that is used by many hobbyists. However, a disadvantage of the KIM-1 is its incompatibility with the Altair bus. This article describes the construction and operation of an interface board that allows the KIM-1 owner to use a variety of peripherals available for the Altair bus.

How Does It Work?

The schematic for the KIM Expander board is shown in Fig. 1. Connector pins to the rest of the system are labeled as follows: KE, KIM-1 Expansion connector; KA, KIM-1 Applications connector; and S, for the Altair bus pin number. The 16 address lines from the KIM-1 are buffered by ICs 3, 4, and 5 to drive the Altair bus address lines. The three highest address lines (A13, A14, and A15) also drive a 3/8 decoder (IC6). The 0 and 7 outputs of IC6 are connected together and control the KIM-1 decode enable line (KA-K). If the KIM-1 addresses the normal KIM range of 0000_h-$1FFF_h$, then the KIM-1 on-board decoder will be enabled by the 0 output of IC6. If the KIM addresses in the range of $E000_h$-$FFFF_h$, then the 7 output of IC6 will enable the KIM-1. This means that the RESET, NMI, and IRQ vectors that are stored in ROM on the KIM-1 will be properly fetched by the CPU.

The KIM-1 has an 8-bit bidirectional data bus for data transfers, while the Altair bus uses an 8-bit Data Out bus and a separate 8-bit Data In bus. ICs 1 and 2 perform the function of buffering and splitting the KIM-1 data bus.

Care must be taken to ensure that the Data In buffers are enabled only when the CPU is reading data from the Altair bus. If the Data In buffers are enabled while the CPU is addressing the KIM-1 on-board memory, the data would be lost or altered. In



Close-up of KIM and Expander board.

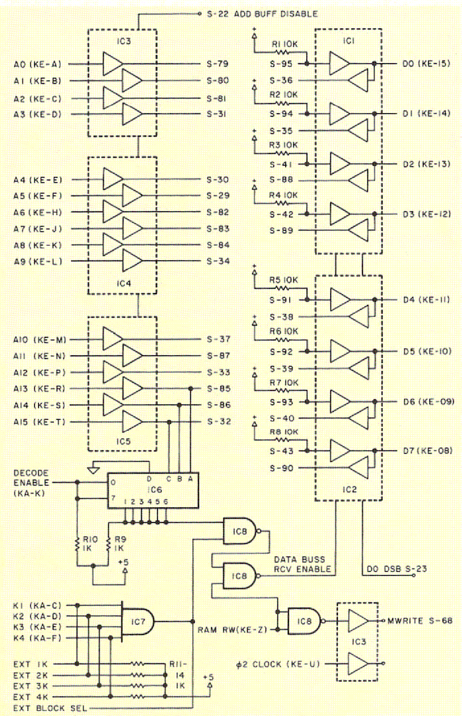


Fig. 1a. Schematic diagram of KIM Expander board.

order to ensure that only one data source is enabled at any one time a special control signal is generated. IC6, which supplied the KIM-1 decode enable signal, is used to determine when the Altair bus is being addressed. Outputs 1 through 6 are wired together and are normally high but will drop to 0 when the CPU addresses in the range of 2000_h-$DFFF_h$. Most of the memory and peripherals plugged into the Altair bus should reside in this range.

The only exception to this is a 4K memory block that is left vacant by the KIM-1. The KIM-1 resides in an 8K block of memory but only uses 4K for memory and I/O. The unused 4K is divided into four 1K blocks by the decoder on the KIM-1 board and is available on the KIM-1 applications connector.

In order to allow the user to fill this void with a memory board, the KIM Expander ANDs these four 1K outputs (K1, K2, K3 and K4) together with IC7. The result is a normally high signal that drops to 0 when the CPU addresses from 0400_h to $13FF_h$.

This signal is NANDed by IC8 with the Altair bus selected signal from IC6. The result is a signal that is normally low but rises to logic 1 whenever the CPU is addressing memory that is on the Altair bus. This signal is then gated with the RAM R/W signal from the KIM-1 to disable the Data In buffers when the CPU is either outputting data or reading from on-board memory.

The RAM R/W signal is also inverted and sent to the Altair bus via IC3. This signal acts as a MWRITE signal for the bus and goes from 0 to 1 during Ø2 of a write cycle. This is the only time that a MOS 6502 is outputting valid data. The Ø2 clock is buffered and available if any of the user's peripherals require a systems clock signal.

In order to properly use the KIM Expander some jumpers must be placed on the Altair bus. ADDRS DIS (S-22) and Data Out DIS (S-23) must be jumpered to ground. These should only be disconnected to implement a second processor or a DMA board. Raising these lines above ground will effectively disable the buffers and remove the address, Data out, MWRITE and Ø2 clock signals from the Altair bus. Control of the bus can then be assumed by another board. The user may want the KIM-1 to operate using its on-board memory while the bus is being controlled by another device. If so, the KIM-1 Decode Enable should be grounded during the time that the Address buffers are disabled.

The Altair bus was designed for an 8080 microprocessor, which uses a different type of input/output than a MOS 6502. Three lines on the bus, (S_{memr}, S_{in}, and S_{out}) are used to tell the system whether the processor wants memory, an input channel or an output channel. Since the MOS 6502 does not have input/output instructions, it handles everything as a transfer to or from a memory location. Therefore, S_{in} (S-46) and S_{out} (S-45) must be jumpered to ground and S_{memr} (S-47) must be jumpered to +5 V dc in order to operate most memory boards. PDBIN (S-78) should also be jumpered to +5 V dc.

Compatibility

Although the KIM Expander will allow the KIM-1 to control many Altair compatible boards, it will not control all of them. There are some basic differences between a MOS 6502 and an Intel 8080 that cannot be compensated for by the KIM Expander.

An example of this is the Cromemco Bytesaver board. This ROM reader/programmer is designed to program ROMs by having the CPU write data into the desired ROM location. This kicks off an internal timing chain on the board that will stop the processor via the READY line. It also pulses the write enable pins on the

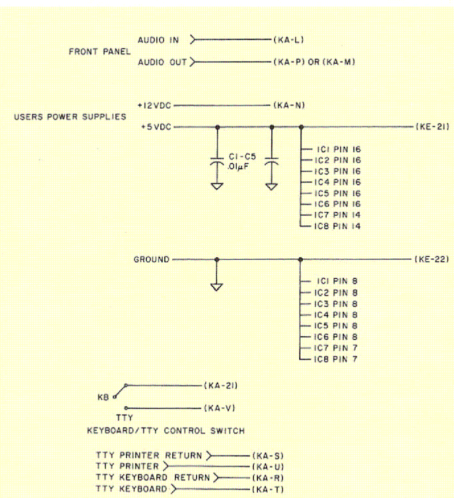


Fig. 1b. Schematic diagram of power distribution and I/O connections.

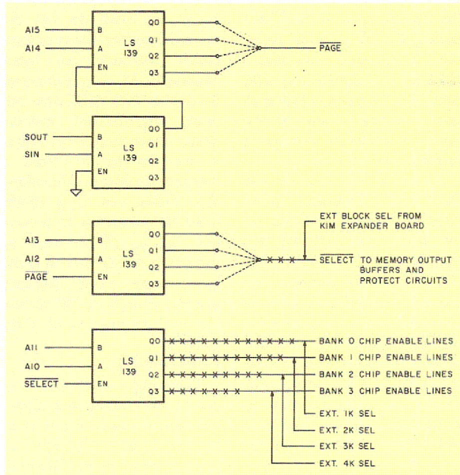


Fig. 2. Modifications on Econoram 4K memory board to allow it to reside in KIM-1 memory space.

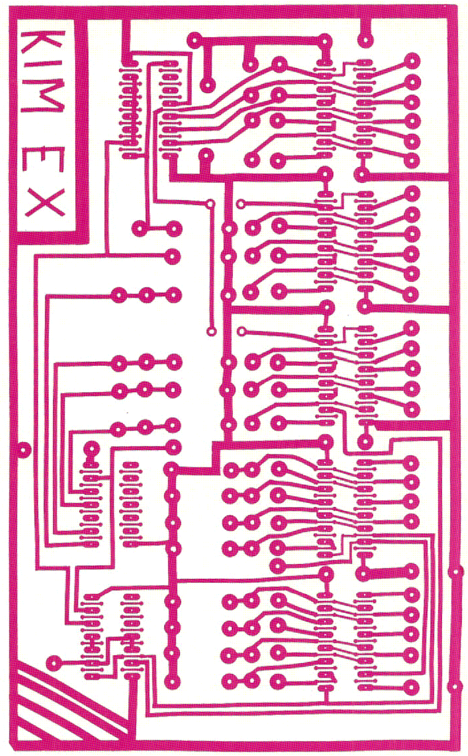


Fig. 3. Printed circuit diagram for the KIM Expander (full size).

ROM to allow it to accept the data that the CPU is holding on the Data Out bus. This works fine on an 8080-based system but will not work on a 6502-based system like the KIM-1. The reason is that a 6502 will not stop on a write cycle, and so the ROM address and data will not remain on the bus long enough to be accepted by the ROM. The KIM-1 will be able to read preprogrammed ROMs from the Bytesaver but will not be able to program them as an 8080 system can.

When considering buying any peripheral for use with this system, make sure that it will work with a MOS 6502. Some boards may require special signals that are not available from the KIM-1. Be especially careful about requirements for the ready line and clock signals. Memory boards that require the computer to wait are generally not compatible with the KIM-1; it will not hold data on the Data Out bus long enough for the memory to pick it up.

Memory Assignments

Filling the 4K memory void between 0400_h and $13FF_h$ requires special handling. Most memory boards can occupy only one of 16 preset slots in memory. This means that a 4K memory board can occupy from address 0000_h to $0FFF_h$ or from 1000_h to $1FFF_h$, but it could not fit in the area left empty by the KIM-1. One method of filling this void using a 4K memory board is shown in Fig. 2. This shows how a Godbout 4K Econoram can be placed in the KIM-1 system starting at address 0400. The four-chip enable lines to all the 2102s are disconnected from their on-board decoders and are reconnected to the K1 through K4 signals from the KIM-1. The EXT Block SEL signal from IC7 enables the Data Out buffers on the memory board whenever the KIM-1 addresses any memory in this 4K block.

If you use any memory board that has memory protect features then you may want to wire up a front panel switch to set or reset the protect status flip-flop on the board. A panel-mounted LED used as a status indicator also would be helpful. If this is not desired, then simply jumper the protect input (S-70) to ground. This assures that all memory will be unprotected.

Construction

The printed circuit diagram shown in Fig. 3 will easily fit on a 6 x 4 in. printed circuit board with enough space left at the corners to allow for mounting holes. A Vector CU 65/45-1R single-sided PC board was used in the prototype. Although connection to the Altair bus can be directly wired, it is recommended that a multipin connector be used to allow the KIM-1 and KIM Expander to be disconnected from the bus.

In my prototype system the power supply and a 22-slot motherboard are mounted in a 17x18x7 in. cabinet. The KIM-1 and the KIM Expander card are mounted in a 17x12x2 in. enclosure that mounts on top of the motherboard chassis. All connections between the two sections are made through two 37-pin D-type connectors. This provides for 74 pins — enough for all connections to the Altair bus plus all of the KIM-1 I/O pins. The KIM-1 is mounted to the top of the chassis using standoffs, and an access hole allows the keyboard and display to be used.

The Altair bus requires power supplies of +16, -16 and +8 V dc in order to operate the peripheral boards. The KIM-1 and KIM Expander require +5 and +12 V dc. When the system is assembled the KIM-1 should be operational. If pushing the

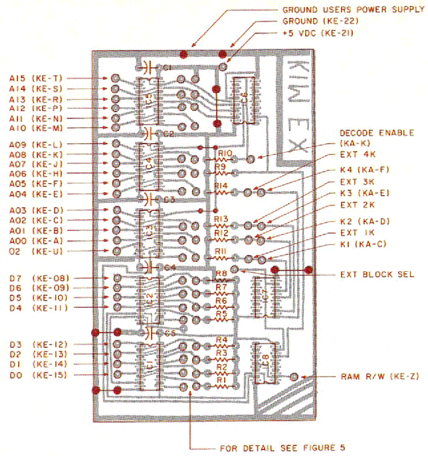


Fig. 4. Parts-placement and wiring diagram for connections on the KIM Expander Board.

reset button does not cause the display to light try shorting the KIM-1 Decode Enable (KA-K) to ground. If it then works properly check IC6 for proper operation. If the display still remains dark, then remove ICs 1 and 2. If they are defective or not being enabled properly, the KIM-1 monitor program will not run.

Checkout and Troubleshooting

When you get the KIM-1 display lit you can use the keyboard to address any byte of memory on the Altair bus as well as the KIM-1 on-board memory. If there is no peripheral located at the selected address on the bus, the KIM-1 will display data as FF_h. This is different from the basic KIM-1, where an unimplemented address will cause its high order address byte to be displayed as data. You can verify this by addressing 0400_h with a basic KIM-1, and the data will read 04_h. With the KIM Expander and no external memory on the Altair bus it will read FF_h. When memory is placed on the bus the KIM-1 will be able to read and write into it in the same manner as its on-board memory.

You can troubleshoot the offboard peripherals using the KIM-1 keyboard and display if you understand how the KIM-1 monitor program operates. If you don't, even the simplest problem will seem monumental. For example, let's assume that you have a memory board with a bad chip in the Data 0 slot that causes the lowest bit in memory to always read 1. Testing this type of fault using an Altair-style front panel would be easy since you could write all 0s into memory and see the bad bit.

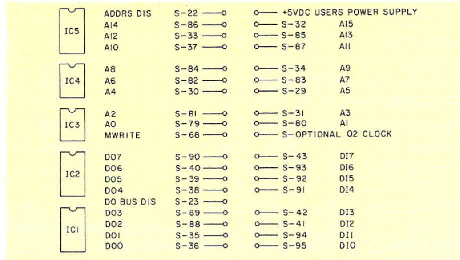
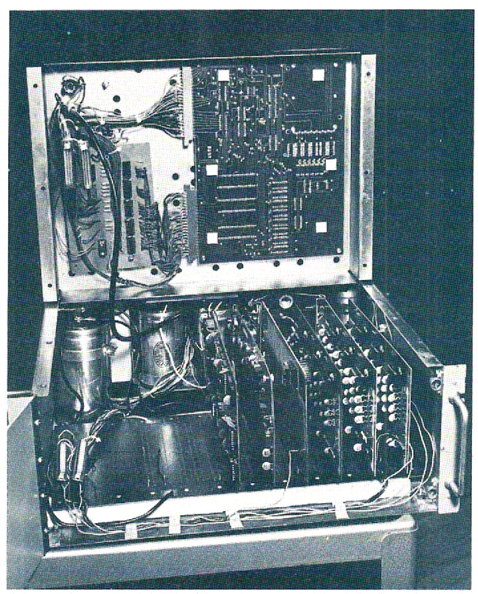


Fig. 5. Enlarged diagram of Altair bus connectors to the KIM Expander Board.

The KIM-1 uses software to perform all front panel operations. When data is to be deposited into memory, the old data is read out and the new data is serially shifted into a register one bit at a time, which is then written into memory. If any bits of memory are stuck at 1 or 0 the KIM-1 will just shift that value into the higher bits. In our example of data line 0 being stuck at 1, the result of trying to enter any data would be to set bits 1 through 7 to 1, and you would see FF_h on the display.

If the keyboard and display do not help in isolating the trouble, then try writing a short program to write a test value (00_h or FF_h) into memory and read it back.

By building the KIM Expander you can increase the power and versatility of the KIM-1. And you can use Altair compatible kits, which are normally less expensive than assembled units. ■



The system. KIM-1 is mounted in top of cabinet along with Expander board. Motherboard with Altair bus boards is located in bottom.

C 1-5	.01 uF bypass capacitor
IC 1&2	833 quad bus transceiver
IC 3,4&5	8097 hex bus driver
IC6	7415 BDC decimal decoder
IC7	7421 dual quad input AND
IC8	7400 Quad NAND gate
R 1-8	10k ¼ Watt resistor
R 9-14	1k ¼ Watt resistor

Table 1. Parts list.