KIM-1 Multifunction Board

Introduction

Thank you for buying our Multifunction board for the KIM-1 computer! We hope this ends your "not quite enough memory" problem ☺

This board combines several existing boards into one, and puts it into a form factor meant for those who have legacy motherboards such as the MTU K-1005, or any other motherboard that brings the raw Application and Expansion connectors to third party boards. It can also be used with the Corsham Technologies KIM Motherboard.

The board provides quite a few capabilities:

- 20 ma to RS-232 conversion (DB-9).
- Connectors for the cassette player.
- Convenient switch for selecting keyboard or TTY interface.
- 4K RAM from $0400 to $13FF.
- 56K RAM from $2000 to $FFF7.
- 8K EPROM can be selected for $E000 to $FFFF.
- Interrupt vectors can be fetched from the KIM or EEPROM.
- Spare KIM I/O lines brought to a header.
- Prototyping area provided for your own additions.
- Fully buffered bus signals; minimal load on the KIM bus.

Power

There are two options for where the board gets power, set by JP1 near the bottom center of the board. In the +5 position, it draws power directly from Expansion pin 21. When set to the 7.5 position, it draws power from the voltage regulator connected to Expansion pin 18 which is 7.5 volts. You will need to connect a 7.5 to 8 volt supply to pin 18 for this to work, but it is extremely important not to connect this higher voltage to the KIM-1!

Memory Options

The board can fill in the missing 4K in the lower RAM region as well as provide RAM for the top 56K of the 6502's address space. RAM can be enabled for any/all of the following areas:

    $0400 - $13FF
    $2000 - $FFFF

In addition, the block from $E000 to $FFFF can be configured as EPROM. The EPROM adds a lot of potential to a KIM system as it can contain an extended monitor, BASIC or other high level interpreter, a DOS, or the user's favorite demonstration programs.

There are actually a number of smaller blocks in those regions, so these are the individual blocks that can be enabled or disabled:

Start	End	Block Size
0400	07FF	1K
0800	0BFF	1K
0C00	0FFF	1K
1000	13FF	1K
2000	3FFF	8K
4000	5FFF	8K
6000	7FFF	8K
8000	9FFF	8K
A000	BFFF	8K
C000	DFFF	8K
E000	FFFF	8K

Block Enable Switches

SW3 is used to select which 8K blocks from $2000 to $FFFF are active, and for the block from $E000 to $FFFF it choses whether RAM or EPROM is selected. Six switches select the blocks in 8K chunks: $2000 to $3FFF, $4000 to $5FFF, $6000 to $7FFF, $8000 to $9FFF, $A000 to $BFFF, and $C000 to $DFFF.

The other two switches select whether $E000 to $FFFF are RAM or EPROM. Enable only one of those two switches!

SW1 selects which of the four 1K blocks in the bottom of KIM's memory are mapped to RAM on the board. Enabling all four of these blocks provides a 5K contiguous block of RAM from $0000 to $13FF.

6502 Vectors

If you've selected to use EPROM in the top 8K, you have two options for the 6502's interrupt vectors. The interrupt vectors are at FFFA to FFFF, and normally our memory boards do not decode those addresses, resulting in the default KIM vectors in the KIM ROMs being selected.

Using switch SW2, labeled as VECTORS, selects whether to retrieve vectors from the KIM ROM by selecting KIM, or from the EPROM by selecting ROM.

You might be asking yourself why does the last block stop at FFF7 instead of FFFF? Because this board maps the three 6502 IRQ, NMI and RESET vectors back to the KIM-1's ROM, preserving normal operation of the KIM-1. There is a complete discussion of this in the KIM-1 User Manual, section 6.2 "Interrupt Vector Management."

TTY Interface

The KIM-1 has a 20 ma current loop interface which was very common at the time for connecting to surplus teletype machines, but modern computers use RS-232. The Multifunction board does the electrical signal translation and brings them to a convenient DB-9 connector.

S1 provides a convenient way to select whether you want to use the KIM's default keypad or a terminal. When using a terminal, select 8 data bits, no parity and two stop bits, better known as 8N2. The KIM does all serial communication via "bit banging" so it can't support high speeds well. Typically 4800 or 2400 baud are best. When you switch to terminal mode, press the RS button on the KIM keypad, then press the RETURN/ENTER key on your terminal and the KIM should respond.

Hooking It Up

Using a Corsham Technologies I/O Board – Easy

Included with your board is a 10 pin cable that plugs right into the I/O Board. Just connect it as shown in this picture of our KIM with both boards installed:

Wiring It Up Yourself – Not as Easy

The 60K RAM/ROM board plugs into the KIM-1's Expansion bus, which is the bus on the upper left. It is not the one where you have power connected. This is the easiest part of the installation.

This board needs a bit more setup than some of our previous products because there are more control lines needed to control the external decoding. On the Application connector (the lower one) are a number of pins that are needed for the 60K board to operate:

Pin	Name	I/O	Use
C	K1	O	Low when 0400-07FF selected
D	K2	O	Low when 0800-0BFF selected
E	K3	O	Low when 0C00-0FFF selected
F	K4	O	Low when 1000-13FF selected
K	DECOD ENAB	I	When low, the lower 8K of address space of the 6502 is selected.

The default set-up of a KIM-1 is to wire pin K to ground, which always enables the on-board RAM, ROM and peripherals, but this pin will be fed from a pin on the 60K board. If an address in the lower 8K is selected, the 60K RAM/ROM board will pull this low, otherwise it will be held high and the RAM board decodes the address.

The K1 to K4 lines are outputs from the KIM-1 when the address selected is in each of those blocks. These signals are normally not used on an unexpanded KIM-1, but the 60K board can use their state to fill in the RAM in the lower 8K bank.

The easiest way to connect this to your KIM-1 is via a 10 pin cable from a Corsham Technologies I/O Expander board, since that brings over all the important signals.

The board has a 10 pin connector which brings a few needed signals to/from the board. This is designed to plug into the 10 pin connector on our KIM-1 I/O Expander board, but that board is not required. Here are the pin numbers on the 10

pin connector and which pins on the KIM-1's Application connector they should be connected to:

10 Pin Header	Application Connector	Description
1	C, D, E, F	From KIM-1 K1-K4 lines to select 1K memory blocks in lower 8K block. Output from the KIM-1.
2	K	DECODE ENABLE from 60K Memory board, input to the KIM-1. Goes low when lower 8K address is selected.
3-9		No connection
10		Ground

You can control which 8K blocks are assigned to RAM by use of the SW1 switches on the 60K Board. There are seven switches with hexadecimal page numbers next to them. To enable that block as RAM, slide the corresponding switch to the right (ON). If the switch is on the left, then that block will not be mapped to RAM. You can use other external PC boards to make use of those blocks not mapped to RAM.

Interrupt Vectors

As noted earlier, interrupt vectors can either be mapped back to the default vectors in the KIM-1 ROMs, or mapped to the top of the EPROM. The selection of where to get the vectors is controlled by SW2, labeled VECTORS and located between IC4 and IC6.

By setting SW2 to KIM, the system will use the vectors in the KIM ROMs. By selecting ROM, the vectors are taken from the EPROM in IC5.

If you are unsure how to set SW2, set it to KIM by default and your system will work as usual.

Secrets, or How to Get Another 60K

The RAM chip IC9 is 128K, but only the lower 64K are used on the board as-is. If that seems like a waste, you can modify the board to enable the upper 64K via bank selection. This isn't for the faint of heart, but here are some details.

First, you need to access the chip's A16 line, pin 2. Right now it's grounded to always select the lower 64K. By cutting the trace between ground and A16, and then bringing A16 to an unused I/O port you can select which bank by setting that I/O pin to 0 (lower 64K) or 1 (upper 64K). It would be a good idea to also pull this line high or low with a 1K or 2K resistor so it doesn't just float if the I/O pin isn't programmed.

If you implement this, keep in mind that the entire 60K is bank selected, so only the original RAM in the KIM-1 (0000 – 03FF) remains visible to both banks. You'll have to write some bank select logic and place it into low RAM so it's visible to code in both banks. A good place might be the small 64 byte RAM locations in the 6530 chips.

Why didn't we do that? Because it adds yet another layer of confusion that people might not want to deal with, but it might be added in a future version, probably with a pull-up resistor to select bank 1 by default and then bring A16 to the 10 pin connector which can go back to the Application connector. Again, this might be added in a later version.

Bus Differences

Expansion bus pin 18 is unused on the KIM-1, but can be used to supply positive 7.5 to 8 volts to the Multifunction board. This is compatible with the vintage MTU K-1005 motherboard.

If you use this pin for power, do not connect it to the KIM-1!

Greetings, Programs!

Hopefully you recognized this phrase from the movie TRON. Now that the KIM-1 can have a lot of RAM and EPROM, it seemed fitting to have the board greet all the new programs that can be added to it.

My KIM is calling me...

Bob Applegate
March 2017

Revision History

Version	Changes
1	Initial version. Never released
2	Changed IC4 and IC5 to 74LS244s, simplified the ON_BOARD logic.

Errata

Rev 2 boards need two additional filter capacitors added to increase reliability. Place a .1 uf capacitor between IC9 pins 16 and 32, and another .1 uf between IC10 pins 14 and 28.

Parts List

Part	Number	Description
PCB	1	Printed Circuit Board (Corsham Tech)
JP1, JP2	1	1x3 jumper block
JP3	1	2x8 jumper block
J1, J2	2	XXXXXXXXXXXXXXXXX
R1-R5	5	680 ohm
R6	1	1K resistor
R7	1	4.3K resistor
R8	1	6.8K resistor
C1,C3-C6	5	.1uf disc capacitor, .1" lead spacing
C2	1	10uf, 25v electrolytic capacitor
S1	1	SPDT toggle switch, Digikey EG2362
SW1	1	4 position DIP switch
SW2	1	1 position DIP switch
SW3	1	8 position DIP switch
Q1	1	2N2222
VR1	1	7805 voltage regulator
IC1	1	74LS145
IC2	1	74LS133
IC3, IC4	1	74LS244
IC6	1	74LS04
IC7	1	74LS08
IC8	1	74LS245
IC9	1	628128 8x128K static RAM
IC10	1	27C64 EPROM (optional)

IC11	1	74LS32
IC12	1	MAX233
	1	DB-9 female connector
	1	32 pin IC socket for IC9
	4	20 pin IC socket for IC3, IC4, IC8, IC12
	2	16 pin IC sockets for IC1 and IC2
	3	14 pin IC sockets for IC6, IC7, IC11
	1	28 pin IC socket for IC10