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KIM Clone User Manual
Revision 5 and later Boards

Introduction

Thank you for buying our KIM Clone board, which provides an almost identical look-and-feel to the original MOS Technologies KIM-1 computer.

This board should be very compatible with the original KIM-1 but is not exactly the same, so there might be a few programs that won't work on it. However, we're kept the hardware very similar and preserved the entry points to all the major subroutines in the KIM monitor. Some functionality has been removed, such as the cassette interface, so any code that makes direct calls to cassette storage/retrieval functions will not work.

Overview

The KIM Clone has a lot of features packed into it while still employing a fairly standard design with commonly available parts.

- RAM from 0000 to 13FF. The original KIM-1 had only 0000 to 03FF.
- EEPROM from 1800 to 1FFF containing a modified KIM monitor.
- 6530-like I/O, timer and RAM like the original KIM.
- RAM from 2000 to DFFF.
- Either RAM or EEPROM from E000 to FFFF.
- Vectors can point to either the original KIM monitor or your own code.
- No cassette interface for program storage.
- The spare 6532 has a header for connection to a Corsham Tech SD Card System.

- The teletype interface is now a USB device that appears as a COM port on a personal computer.
- Bigger buttons on the keyboard.
- A standard power connector taking 7.5 to 9 volts DC input.
- A power switch.
- Expansion connectors.
➢ Power-on reset.

It's Out of the Box. Now What?

Let's make sure a few switches are set to the right positions. These should have all been set by us when we did final testing, but a quick check is always a good idea. Before plugging anything in, make sure these switches are set to the proper position:

- Set S1 (POWER) to OFF.
- Set SW2 to KBD.
- Set SW3 (VECTORS) to KIM.
- Set SW4 (SST) to OFF.

Plug in the power supply to the AC power and then J1 (8 VDC).

Are you ready? Turn on the Power switch and you should see LED1 (POWER) come on and the 7 segment displays all come on with a random pattern.

Congratulations! Your KIM Clone is up and running!

Where to Get More KIM Information

Or, where to go from here

There are two reference books you'll want to get, either via the many sites that host these documents or acquiring paper copies.

The KIM User Manual

This was one of three books that came with the original KIM-1 and was the most useful. It contains instructions on how to use the monitor program, how to expand, etc. There are many copies on-line but some of them are missing pages (as did some versions of the original paper version). This one is one of my favorites as it has all the pages and is nicely indexed:

The First Book of KIM (otherwise known as FBOK)

The User Manual was great, but lacked any useful programs, so a bunch of early KIM users gathered dozens of good programs and bundled them as the First Book of KIM. If you owned a KIM, you owned a FBOK.

Again, many copies are on-line, such as:

http://www.classiccmp.org/cini/pdf/Commodore/The%20First%20Book%20of%20KIM.pdf

Both of these appear on eBay and Amazon, usually at crazy prices, but sometimes you'll find them at reasonable prices.

FBOK in the KIM Clone

If you've looked through FBOK, you might have noticed a couple fun programs that we put into the KIM Clone EEPROMs. At address 1800 is Lunar Lander, and at 1803 is Farmer Brown. Read the instructions first, then run them with these sequences of key strokes:

Lunar Lander

[AD] [1] [8] [0] [0] [GO]

This was always a hit when family came over to visit and see what my computer could do. Remember that very, very few people had computers back then so being able to play a game was typically the first experience most people had back then with a computer they could see and touch.

As Lunar Lander is running, the leftmost four digits are the altitude while the two right digits are the current speed. The goal is to land with a speed of 5 or less, while not using all your fuel. You can see your fuel by pressing the F key, then switch back to altitude with the A key.

My late brother-in-law Glenn used to work on landing with the fewest number of keystrokes, the ultimate goal being able to land with one or two. I can't remember whether he ever achieved his goal, but here is a three-key sequence that works nicely for me:

When the lander hits a speed of 75, press 5. This applies enough thrust to maintain the current speed. Now just coast down towards the plant's surface. When the altitude reaches 1000 (feet? Meters?), press 8. You'll be dropping fast, but the rate of descent will slow down. Once your speed reaches 5, press the 5 bottom and just wait for a safe landing.

Short version:

- When speed reaches 75, press 5.
- When altitude reaches 1000, press 8.
- When speed reaches 5, press 5.

After Glenn passed away, I spent many hours trying to perfect various two-button solutions, but never got a one button solution that worked reliably. So here it is, but it requires careful attention when doing the first button press. If the speed reaches 83 then you'll almost certainly die:

- When speed reaches *exactly* 82, press 6.
- When speed reaches 5, press 5.

Farmer Brown

This was another favorite of family and friends. When this was loaded into RAM, the fun part was changing the table of the six animal patterns. Since this version is in EPROM you can't do that, but it's still a fun game. I like running this at vintage computer shows and demonstrate the "graphics" capabilities of a computer with six 7-segment LEDs (not much) to kids.

[AD] [1] [8] [0] [3] [GO]

Press RS (reset) to end either game.

Using the TTY Mode

Back when the KIM-1 was popular, teletypes were the most common terminal, as they were readily available used for a decent price. A lot has changed in 40 years. Now we use our PCs/Macs/whatever and run a terminal emulator.

The KIM Clone has a type B USB connector on the back edge. When this is plugged into your PC, it might take a minute for the proper device driver to be loaded, but you should get a new COM port corresponding to your KIM.

Suggested parameters are:

- 2400 baud
- 8 bits
- No parity
- Two stop bits

Set S2 to TTY, press RS (reset), then hit ENTER/RETURN on your keyboard and the KIM Clone should respond with a prompt like KIM Clone v1.0. Please reference the KIM User Manual for what to do at this point.

Known Issues

Despite our best efforts, there are some issues you should be aware of.

Rev 3 and older boards did not have expansion capability.

Some rev 1B boards do not support single step properly. All boards shipped since 12/3/2017 have a modification done to allow single step to work properly. For those with a rev 1B board who want to see if their board has been modified or not, look on the bottom of the board to see if there is a .001 uf capacitor between pins 7 and 8. If the capacitor is present, then the board supports single step.

For the 6502 in single step mode, it single steps everywhere except in the monitor EPROM, so any calls to functions in the extended monitor also single step.

While using single step, the NMI line is driven directly and is not using an open collector. Ie, single step and an external NMI won't work together.

Changes between Revision 2 and Revision 3 Boards

Revision 3 boards had a number of minor changes to fix know issues on Revision 2 boards. No new features or capabilities were added.

- IC19 was removed
- IC18 changed from 74AVC1T45 to 74LVC1T45
- IC16 changed to 74LS00
- IC7 and IC8 changed to 74LS145
- R37 and R38 changed to 470 ohms
- C18 was added
- IC17 had power routing fixed

Changes between Revision 3 and Revision 4 Boards

- Addition of expansion connectors
- Removal of reverse current protection diode
- Reset circuit was replaced by a single part which also does power-on reset
- Larger circuit board with many parts moved around

Connectors and Switches

There aren't a whole lot of switches and connectors, but the few deserve some explanation.

J1 – POWER

This is the power input jack. This feeds the 5 volt regulator so while supplies as high as 12 volts could be used, we really recommend 7.5 to 9 volts maximum so as not to overheat the regulator. The center pin is positive, outer sleeve is negative. There is a diode to protect the board from incorrect polarity.

S1 – Power

This is the main power on/off switch. No further explanation is necessary. Note that the USB interface chip derives power from the main PC, so the power switch does not turn off the USB interface.

SW2

This selects the input/output device. Normal KIM mode is to have it in the KBD position which means the LEDs and the keyboard are the "console" for the KIM. This is the normal mode for a KIM-1.

When the switch is set to TTY then the monitor will use the external terminal (USB) as the console.   Remember when you first choose TTY that you'll need to press RS (the red button) and then hit RETURN on your terminal so the monitor can measure the baud rate. Typically baud rates of 4800 or less work best.

SW3 – VECTORS

The 6502 has three interrupt vectors: RESET, NMI and IRQ. On the KIM they all default to pointing to code in the KIM monitor, but our board allows you to use vectors in the KIM EPROM or the expansion EEPROM.

This switch is normally set to the KIM position.

SW1 – SST

This enables the single-step option for the 6502 processor, but it requires a capacitor be added to the bottom side of the board on U16 between pins 7 and 8. Please reference the KIM User Manual for details.

JP1

This selects whether E000-FFFF are connected to RAM or EEPROM. If you wish to use the extended KIM monitor in the Expansion EEPROM socket, this must be set to the EEPROM position.

JP2 – AUX IRQ

Installing this jumper connects the interrupt line from IC9 to IRQ. This is normally not installed.

JP3 – MAIN IRQ

Installing this jumper connects the interrupt line from IC9 to IRQ. This is normally not installed.

JP4 – 6502

If you are using a 6502 processor then this must be installed. If you are using a 65C02, this must be removed. If installed, pin 1 of IC1 (the processor) is grounded.

SV1

This connector is used to access the I/O pins on the 6532 chip at IC9. It is meant to be used along with our SD Card System to provide mass storage for the KIM Clone, but can also be used for general purpose I/O. Be aware, though, that there is no buffering between these pins and the 6532 pins so care must be taken not to draw too much power or exceed 5 volts on these pins.

Pin 1 and 2 can be located from this photo of the board; the pin numbers are no longer visible once the connector is installed:
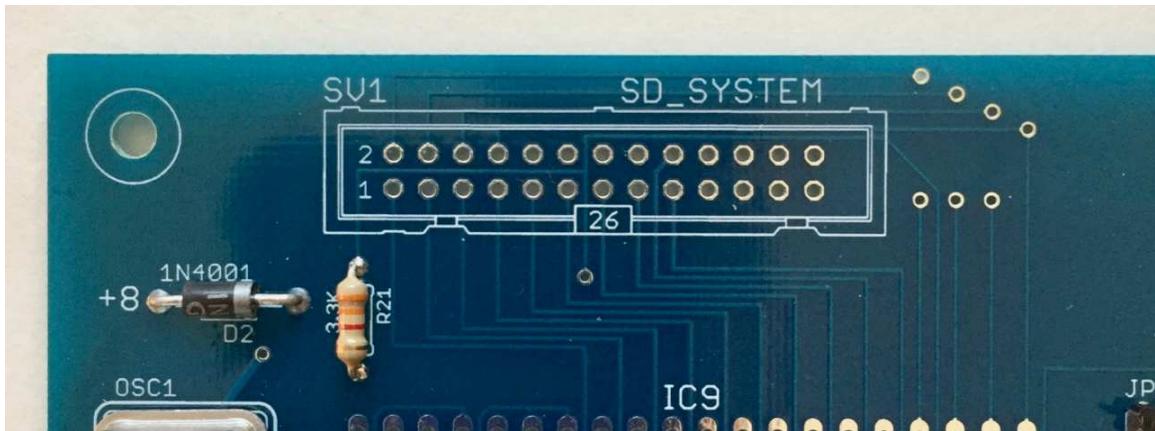
All of the even numbered pins are on row closest to the top edge of the circuit board while all the odd numbered pins are on the other row.

Pin	Use	Pin	Use
1	PA0	2	PB0
3	PA1	4	PB1
5	PA2	6	PB2
7	PA3	8	PB3
9	PA4	10	PB4
11	PA5	12	PB5
13	PA6		
15	PA7		
17	PB6	18	PB7
23	+8 volts	24	+8 volts
25	Ground	26	Ground

Any pins not in the chart above are not connected to any signals on the KIM Clone board. The +8 supply lines are most likely 8 volts, but whatever power level is applied to J1 and then run through the 1N4001 diode at D2. While we haven't rated exactly how much power can be drawn from these pins, it is meant to be enough to power a typical microcontroller such as an Arduino.

The pin usage might seem odd but they were arranged this way to agree with the SD Card System, which was based on pin mappings used on the Corsham Technologies SS-30 parallel card.

JP5 – 8K ENABLE

These jumpers control whether an address in that particular 8K address space will be mapped to the on-board RAM The four jumpers and their corresponding address rages are:

Label	Address Range
K1	0400-07FF
K2	0800-0BFF
K3	0C00-0FFF
K4	1000-13FF

JP6 – 1K ENABLE

These jumpers are normally installed. They control whether an address in that particular address space will be mapped to the on-board RAM The four jumpers and their corresponding address rages are:

Label/Address Range	Normally Installed
0000-1FFF	No
2000-3FFF	Yes
4000-5FFF	Yes
6000-7FFF	Yes
8000-9FFF	Yes
A000-BFFF	Yes
C000-DFFF	Yes
E000-FFFF	Yes

Addresses 000-1FFF are part of the KIM's lower 8K which are always mapped to on-board RAM, ROM, timers and I/O devices. Putting in the jumper for 0000-1FFF will cause a lot of confusion as multiple devices will respond to the same address.

Addresses E000-FFFF are also affected by JP1, so if the jumper is installed for that block, then JP1 determines if the space is mapped to RAM or EEPROM.

Expansion Connectors

The primary improvement in the Rev 4 design is the addition of many bus signals on two edge connectors to make it possible to add custom designed add-on boards.

Please note that none of the signals are buffered so it is highly recommended that any external board provide its own buffer so as not to load down the bus too much.

Any pin marked as reserved is not connected to any signals on the KIM Clone, but are meant for specific uses on motherboards. Please do not use them for custom boards.

Both connectors are female on the KIM Clone. EXPA has 30 connections while EXPB has 40. The connectors are standard 2x15 or 2x20 pins with .1" (2.54mm) spacing between pins.

EXPA is located above EXPB. The lower pins on EXPB (39 and 40) are centered 1.5" from the bottom edge of the board. The top pins (1 and 2) are located 3.4" from the bottom of the board. EXPA pins 29 and 30 are located 4.4" from the bottom of the board, and pins 1 and 2 are 5.8" from the bottom. These distances will remain the same in future versions unless there is major problem that requires changes.

EXPA Connector

Pin	KIM Clone	Use
1 & 2	Ground	
3 & 4	+8 VDC	
5 & 6	Reserved	Reserved for +5 on motherboards
7	/RESET	6502 RESET line, active low
8	PH2	6502 phase 2 clock
9	PH0	6502 phase 0 clock
10	SO	6502 SO signal
11	R/W	High = read, low = write
12	PH1	6502 phase 1 clock
13	/RDY	
14	/IRQ	
15	SYNC	
16	/NMI	
17	/RAM_SELECT	Pull low to select RAM on KIM Clone, or pulled low when KIM Clone RAM is selected.
18	Reserved	Reserved for motherboard use.
19 & 20	Reserved	
21 – 30	Not used	User-defined functionality

EXPB Connector

Pin	KIM Clone	Use
1 & 2	Ground	
3	A15	
4	A14	
5	A13	
6	A12	
7	A11	

8	A10	
9	A9	
10	A8	
11	A7	
12	A6	
13	A5	
14	A4	
15	A3	
16	A2	
17	A1	
18	A0	
19	Reserved	
20	Reserved	
21	Reserved	
22	Reserved	
23	Reserved	
24	Reserved	
25	D7	
26	/0000-1FFF	
27	D6	
28	/2000-3FFF	
29	D5	
30	/4000-5FFF	
31	D4	
32	/6000-7FFF	
33	D3	
34	/8000-9FFF	
35	D2	
36	/A000-BFFF	
37	D1	
38	/C000-DFFF	
39	D0	
40	/E000-FFFF	

6502 Vectors

If you've selected to use EEPROM in the top 8K, you have two options for the 6502's interrupt vectors. The interrupt vectors are at FFFA to FFFF, and normal operation would have the vectors fetched from the lower EEPROM, acting as the original KIM-1 did. However, our board allows you to use the vectors in the top of the high EEPROM so you can have your own interrupt code.

Using switch SW3, labeled as VECTORS, selects whether to retrieve vectors from the lower EEPROM by selecting KIM, or from the upper 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 lower EEPROM, 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."

Monitor Entry Points

We've kept all of the primary KIM-1 entry points but here is the official list of which ones are present in our modified KIM monitor:

Address	Name	Description
1C4F	START	
1C77	TTYKB	
1CD3	STEP	
1DC2	RTRN	
1DDB	SCAN	
1E1E	PRTPNT	
1E2F	CRLF	Print a CR/LF on the TTY.
1E3B	PRTBYT	Print value in A as two hex digits to TTY.
1E5A	GETCH	Get one character from TTY, return in A.
1E9E	OUTSP	Print one space to TTY.
1EA0	OUTCH	Print character in A to TTY.
1F19	SCAND	
1F40	Not named	Used by Farmer Brown, First Book of KIM
1F63	INCPT	Increment POINTL and POINTH
1F6A	GETKEY	
1F91	CHK	Add A to the checksum.
1F9D	GETBYT	Get two hex digits.
1FAC	PACK	

We are definitely open to user input, so if there is a subroutine in the original KIM-1 monitor that you feel is necessary to keep, just let us know. I've got a macro in the source code to make sure certain pieces of code are exactly where they should be, so adding a new "must not move" point is easy… just let me know where it is.

For Dave

Who's Dave? Dave McWherter, who was an amazing 6502 programmer who got started on personal computers with a KIM-1 computer. Dave went on to become VP of Engineering at Franklin Computer, designed several processors for Franklin Electronic Publishers, earned a number of patents, did the impossible on many occasions, and was a great inspiration for anyone who had the pleasure to work with him.

The story goes that Dave was a plumber's apprentice and his boss bought an HP programmable calculator that he became fascinated with. Dave bought a KIM-1 and started learning assembly language at night while caring for his family. He found his way to Delta Data Systems, clearly demonstrated an uncanny knack for assembly language programming and eventually was hired as the VP of Engineering at a young Franklin Computer Corporation, where he hired a 19 year old local 6502 programmer to join his staff (me). If you dig around the web you'll find lots of references to Dave in the lawsuit between Apple Computer and Franklin Computer.

Dave was completely outside the box all the time. There was no program that couldn't be improved and he'd tinker with working programs, sometimes coming back after a weekend saying he re-wrote the program to run several times faster, used half the memory, or now had a new feature nobody ever realized was needed but would soon become commonly used.

Dave astounded us almost constantly. Not liking the crude 6502 assemblers of the day, he wrote a better macro assembler that included a linker so that common routines could be written once and then linked in as needed. Over a weekend he wrote a complete editor that was faster, smaller and better suited to our job than anything else on the market. Even more amazing, he wrote all of these tools on an Atari 800 (also a 6502 based machine) and then ported them back to the Franklin system by use of a standard I/O library he developed.

Unfortunately, Dave passed away in 2015, leaving behind a lot of amazing code, outstanding development tools, and a lot of friends.

Bob Applegate
August 2017

Revision History

Version	Changes
1, 1A	Internal engineering versions.
1B	First release.
2	Renamed version 1B
3	Many minor improvements such as fixing noisy power issues.
4	Larger board better reset circuit, expansion connectors

Errata

None.

Parts List (definitely not done yet)

NOT UPDATED FOR REV 4 or 5 BOARDS YET!!!

Note that all capacitors are .1" (2.54mm) pin spacing.

All resistors are ¼ or 1/8 watt.

Part	Number	Description
PCB	1	Printed Circuit Board (Corsham Tech)
IC1	1	6502 or 65C02 processor
IC2	1	628128-7 128K static RAM
IC3, IC9	2	6532
IC4	1	FT232RL USB interface
IC5	1	28C64 EEPROM or 27C64 EPROM
IC6	1	28C16 EEPROM of 27C16 EPROM
IC7, IC8, IC10	3	74LS145
IC11	1	74133
IC12, IC13	2	74LS06
IC14	1	LM556
IC15	1	74LS138
IC16	1	74LS00
IC17	1	74LS08
IC18	1	SN74LVC1T45DBVT

	1	Power jack CUI Inc PJ-102A, Digikey CP-102A
Q1-Q6	6	2N4403
LED1	1	5mm blue LED
LED2-LED7	6	LTS-4802 seven segment LED, Digikey 160-1527-5
LED8, LED9	2	3mm blue LED
VR1	1	LM78S05 positive 5v regulator
Misc.		Heat sink and hardware for VR1
D1	1	EGP20A
D2	1	1N4001
OSC1	1	1 MHz oscillator
SV1	1	26 pin socket
JP1	1	3 pin header
JP2, JP3, JP4	3	2 pin header
SW1-3	3	1 position DIP switch
S1	1	Toggle switch, Digikey EG2362
S2-S24	23	OMRON B3F-4050, Digikey SW413
C1	1	22uf, 25v electrolytic cap
C2, C3, C7		1 uf disc capacitor
C4, C8-C17	11	.1 uf disc cap
C5, C6	2	.22 uf cap
C18	1	.001uf cap
R1, R8-R13, R30-R31	9	1K
R14-R19	6	220
R2-R7, R20-R22, R34-R35, R39	13	3.3K
R23-R29	7	130 ohms (can be higher value)
R32, R33	2	47K ohm
R37, R38	2	470
	1	Omron B32-1280 red keycap
	6	Omron B32-1240 blue keycap
	16	Omron B32-1210 black keycap
	7	Rubber stick-on feet

Notes:

IC6 can also be a 27C32/28C32 device. Put the monitor in the top 2K.