PAL-1 Microcomputer

USER MANUAL

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Contents

PAL-1 HINTS

Thank you for supporting PAL-1!

The chips that have not been installed may be damaged by electrostatic discharge. Please pay attention to the electrostatic problem during installation! Although static electricity has little effect on the components that have been installed on the PCB (PAL motherboard), we still recommended to confirm the static electricity has been discharged before touch metal part.

PAL-1 is a single board computer based on the MOS 6502 microprocessor. The structure and design are basically copied from the MOS/Commodore KIM-1. The TTY RS232 interface and expansion interface part uses the design of Rich Dreher and Vince Briel.

PAL-1 is a replica of KIM-1, compatible with most of the programs written for KIM-1. However, since it is impossible to obtain some chips used by KIM-1, mainly the two 6530 RRIOT chips, PAL-1 uses 6532 RIOT chips to replace the 6530.
The functions of these two chips are very similar. The biggest difference is that the 6530 chip provides 1K bytes of ROM, while the 6532 does not. PAL-1 using an EPROM chip to store two 6530 ROM's data. The second difference is that the 6530 chip provides 64 bytes of RAM, while the 6532 provides 128 bytes of RAM, we can decode all the 128 bytes space originally provided by two 6530s to one 6532 chip.

PAL-1 reduced the two 6530s on the KIM-1 to one 6532. This is mainly to reduce the number of core chips, although 6532 can be found, it is also difficult.
After reducing half 6532, PAL-1 has a 50% less I/O port and timer compatible with KIM-1, nevertheless, PAL-1 can still be extended as needed.

I like this replica of KIM-1, it can bring me a super cool computing experience from the 1970s without worrying about damaging the rare and expensive original KIM-1.

Have fun & Happy Hacking with 6502!

KIM-1

KIM-1 is a single board computer based on the MOS 6502 microprocessor released by MOS Technology in 1976. It is considered one of the earliest single board computer, and achieved a great success in the 1970s.

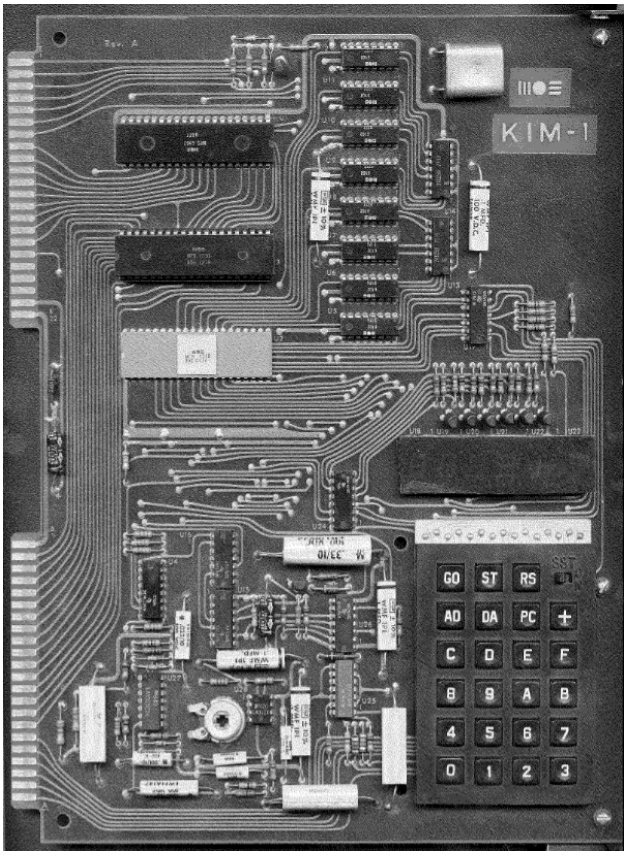

Figure1 KIM-1

Chunk Peddle designed the KIM-1, he is the director of the MOS 650x team. The MOS 650x team has played a very key role in the personal computer revolution. The name KIM is the abbreviation of Keyboard Input Monitor, this name illustrates the basic form of the computer: a keyboard is used to input programs and a monitor program for management of the system.

KIM-1 consists of two 6530 chips that provide 2K bytes of ROM (Monitor program, 1K bytes per chip), 128 bytes of RAM (64 bytes per chip), and four 8-bit bidirectional IOs. Ports (two per chip) and two programmable clocks/timers (one per chip). The RAM of KIM-1 is usually called 1K byte capacity, to be precise, the RAM space is 1152 bytes (8 * 1K bits RAM + 128 bytes RAM in two 6530s).
KIM-1 use 23-key hexadecimal keyboard for program and instruction input, 6 seven-segment LED displays show the address and data information of the address bus and data bus. KIM-1 also provides the capability of TTY terminal and can be connected to the tape recorder for store and load programs.

KIM-1 was the first computer based on the 6502 CPU. It attracted computer enthusiasts, magazines and software companies. Various computers based on the 6502 CPU followed, such as Commodore PET, Acorn BBC Micro and APPLE I, together with 8080 and Z80 opened the era of personal computers.

PAL-1

PAL-1 is also a single board computer, most of its structure uses the KIM-1 design, especially the original addressing mode is completely copied, it is almost fully compatible with KIM-1.

PAL-1 has 2KB ROM, 5KB RAM, a 6532 RIOT chip provides two 8-bit bidirectional I/O, these I/O are mainly used to support 23-key keyboard input and 6 seven-segment LED displays. In addition, PAL-1 also provides RS232 serial port terminal support and 40-pin expansion port to upgrades.

The assembled PAL-1 looks like this:

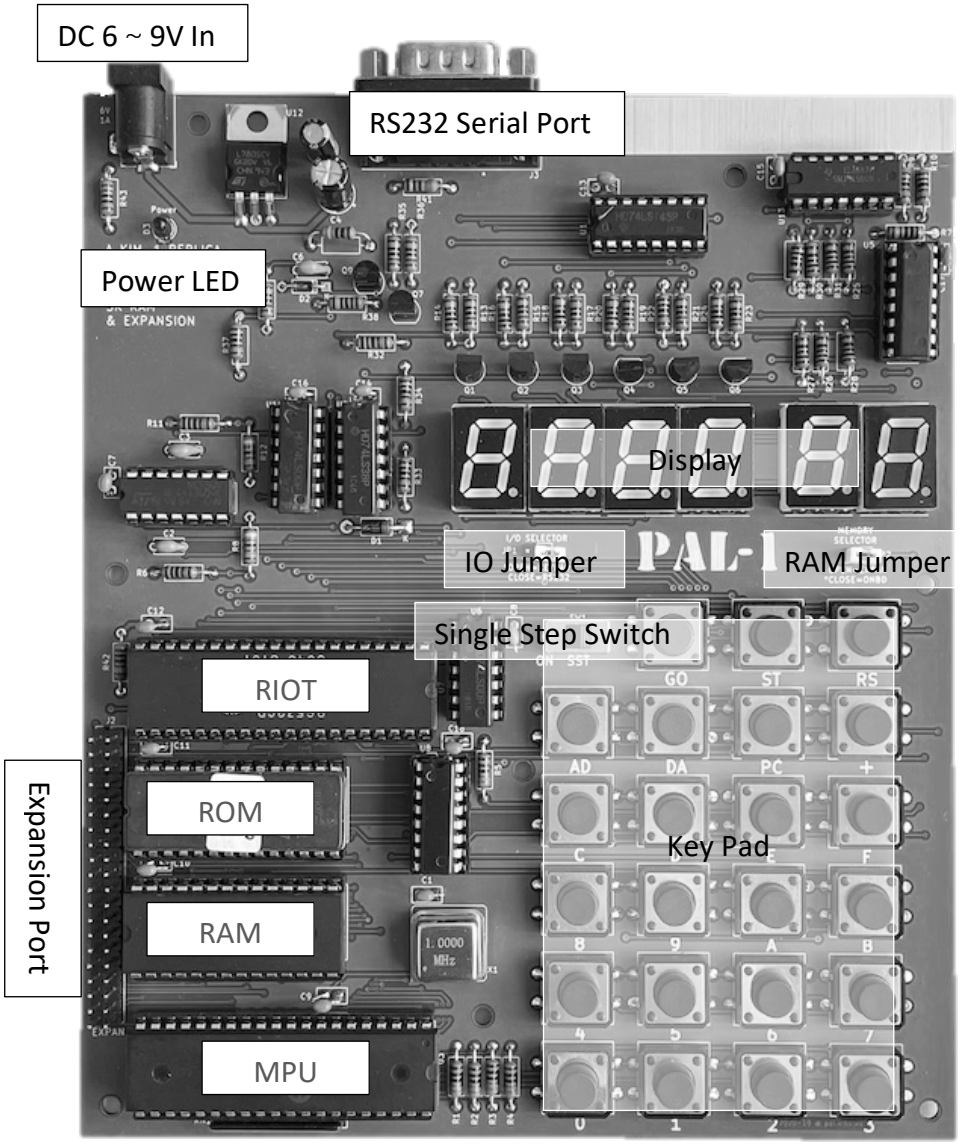

Figure2 PAL-1

Assembly

Before assembling, please check all components in your kit.
"Reference" column in BOM is the part number printed on the PCB, place the component in "Component" column, "Quantity" column indicate the number of components。

for example:
The meaning of the first row in the BOM table: there are *14* 0.1uF capacitors in the kit, they need to be installed in the mounting holes indicated C1, C7, C8, C9, C10, C11, C12, C13, C14, C15, C16, C17, C18 on the mainboard.

How To Identify Component

If you are not familiar with the components used in PAL-1, please read this section carefully!
Resistor: The resistance has been marked on the tape. If you get confused after cutting, please use a multimeter to identify each resistor.

Capacitor: 0.1uF marked 104, ceramic capacitor, No polarity
0.22uF marked 224, ceramic capacitor, No polarity
100uF marked 100uF, electrolytic capacitor, long-leg positive
10uF marked 10uF, electrolytic capacitor, long-leg positive

Diode: 1N4001, plastic package, white ring end aligned with PCB white line
1N4148, glass package, black ring end aligned with PCB white line

Power LED: Red 3mm LED, long-leg positive

7-segment LED: decimal point aligned with PCB print decimal point

Transistor: 2N4403, marked 2N4403, aligned with PCB print
2N4403, marked 2N4403, aligned with PCB print

Resistor Networks: marked A472J, white point end pin aligned with PCB square pin

IC: When installing, please pay attention to whether all the pins are vertical and the pin spacing is appropriate. If the chip pins are far away, you need to press the side of the pins on a flat surface before mounting to make the spacing suitable for PCB holes or IC sockets.
Correctly identify the Pin1, both IC chip and PCB print (half-moon shape).
There is a sticker on EPROM chip, please do not remove.

Crystal oscillator: marked 1MHz, aligned the right angle with PCB print.

Table1 BOM

Reference	Component	Quantity
> C1, C7-C18	0.1uF Capacitor	14
> C2, C3, C6	0.22uF Capacitor	3
C4	100uF Capacitor	1
C5	10uF Capacitor	1
D1	1N4001 Diode	1
D2	1N4148 Diode	1
D3	Red LED	1
J1	DC jack	1
J2	40 Pins	1
J3	RS232 male	1
JP1	2Pin jumper	1
JP2	2Pin jumper	1
> LED1-LED6	7 segment LED	6
> Q1-Q7	2N4403 PNP transistor	7
> Q8, Q9	2N4401 NPN transistor	2
> R1-R5, R39, R41	3.3K resistor	7
> R6, R7, R9-R11, R14, R16, R18, R20, R22, R24, R32-R34, R37, R42	1K resistor	16
> R8, R12	47K resistor	2
> R25-R31	100R resistor	7
> R13, R15, R17, R19, R21, R23, R35, R36, R38, R40, R43	220R resistor	11
RN1	4.7K resistor networks	1
SW1	SPDT switch	1
SW2 - SW24	Tactile switch	23
U2	74LS38	1
U3	6502 CPU	1
U4	NE556	1
> U1, U5	74LS145	2
> U6, U11	74LS00	2
U7	6532 RIOT	1
U8	74LS138	1
U9	6264 SRAM	1
U10	2764 EPROM	1
U12	L7805 线性稳压	1
U13	74LS06N	1
X1	1MHz oscillator	1
Mainboard	PAL-1 PCB	1
IC_Socket_40	IC socket 40P	2
IC_Socket_28	IC socket 28P	2
IC_Socket_16	IC socket 16P	3
IC_Socket_14	IC socket 14P	5

The kit does not include power supply. Recommended power supply rating: DC, output 7.5V/1A, interface 5.5*2.5/2.1mm, internal positive / external negative.

Basic Usage

Confirm the status of the two jumpers at the bottom of the displays, the I/O Selector on the left is disconnected (unplug the white jumper cap), the Memory Selector on the right is closed (plug in the jumper cap), the SST switch is at the right side, press RS key, the display should light up. Your PAL-1 has been assembled successfully!
The four displays on the left side are the current address bus content, the two displays on the right side are the current data bus content.

We can enter a simple program now. The PAL-1 keyboard has 23 keys, including 16 hexadecimal number input (0~F) keys and 7 control keys. The specific functions are as follows:

AD – ADDRESS, address input mode
DA – DATA, data input mode
PC – Program Counter, get PC content
+ – go to next address

GO – GO, run program
ST – STOP, stop program
RS – RESET, system reset

KEY	DISPLAY	STEP
AD	XXXX XX	1
0 0 0 0	0000 XX	2
DA	0000 XX	3
A 2	0000 A2	4
+ 0 2	0001 02	5
+ A 9	0002 A9	6
+ 9 0	0003 90	7
+ 8 D	0004 8d	8
+ 4 6	0005 46	9
+ 1 7	0006 17	10
+ 2 C	0007 2C	11
+ 4 7	0008 47	12
+ 1 7	0009 17	13
+ 1 0	000A 10	14
+ F B	000B Fb	15
+ C A	000C CA	16
+ D 0	000D d0	17
+ F 5	000E F5	18
+ 2 0	000F 20	19
+ 6 3	0010 63	20
+ 1 F	0011 1F	21
+ 2 0	0012 20	22
+ 1 F	0013 1F	23
+ 1 F	0014 1F	24
+ 4 C	0015 4C	25
+ 0 0	0016 00	26
+ 0 0	0017 00	27

The code just entered is stored in $0000-$0017 in the PAL-1's memory. The data of the corresponding address can be checked through the LED display.

Press the AD key to enter the *address input mode*, enter 0, 0, 0, 0 will go to the RAM address $0000, the left 4 LEDs (Address LED) should display 0000, the right side 2 LEDs (Data LED) will show the RAM data at address $0000.

Press the DA key to enter the *data input mode*. You can modify the data stored in the current address ($0000) through the keyboard.

Enter A, 2, and you can see the data on the data display. Press + to enter the next address space ($0001), continue to input data 0, 2; repeat this process until the program input completed.

To run the program, you need to set the current address to the beginning of the program ($0000). Press AD, enter 0000, and then press GO to start the program. Before starting, you can check the program by repeatedly pressing +.

This program will count on the screen, the screen will be displayed with a low brightness level. Now try to press the ST key to stop the program running, you will find that the ST key cannot stop counting, because the current interrupt processing entry address has not been specified.

Let's do the operations that should be performed every time the PAL-1 is turned on, set the NMI Interrupt processing. Press the RS button to reset the system, the counting program will stop running, press AD, then enter 17FA, press DA, enter 00, press +, enter 1C, complete the ST button and SST switch settings.

Now the ST button on the PAL-1 and The SST switch will work normally. Return to address 0000, run the program, and press the ST key to see if the program can stop normally.

For more details, please read "KIM-1 User Manual".

ASSEMBLY REFERENCE

```
COUNT       =2
DELAY       =90
0000                            *=$0000     ORG AT 0
0000  A2 02       START1        LDX   =COUNT
0002  A9 90                     LDA   =DELAY
0004  8D 46 17    AGAIN         STA   C64D
0007  2C 47 17    WAIT          BIT   SR
000A  10 FB                     BPL   WAIT
000C  CA                        DEX
000D  D0 F5                     BNE   AGAIN
000F  20 63 1F                  JSR   INCPT
0012  20 1F 1F                  JSR   SCANS
0015  4C 00 00                  JMP   START1
```

Serial Operation

PAL-1 supports simple TTY/RS232 serial communication operations and supports the read and store of paper tape format programs.

If you have a PC with serial port and Windows 95 installed, you can connect to PAL-1 with only one rs232 cable, or you can connect to PAL-1 by using USB to RS232 cable.

The PAL-1 onboard serial port is a DB-9 male connector, which is connected to the PC through a **direct/extended** serial port cable. Use HyperTerminal (Windows 95) or Tera Term for terminal simulation or any you preferred terminal software.
Set the terminal serial port to:

- Baud rate 1200
- Data bits 8
- No parity bit
- 1 stop bit
- No flow control

When serial cable connected, close the I/O Selector jumper (the onboard display will turn off), press the RS key after power-on, and press the *Enter* key on terminal, you will see the terminal display “KIM” with current address and data information (as follows Figure).
Now you can control PAL-1 on terminal, such as input programs, load paper tape programs or export PAL-1 memory data in paper tape format. Please refer to "KIM-1 User Manual" for more TTY commands.

- For terminal operation, please make sure that the keyboard caps lock is on. The KIM-1 monitor program can only accept uppercase letters.
- File sending delay settings: character 5ms, line 100ms

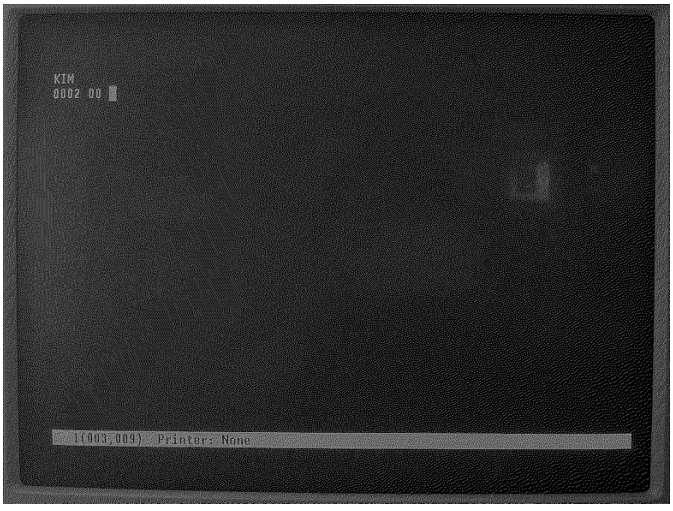

Figure3 Terminal demo

Troubleshooting

If the PAL-1 system appears unexpectedly, you can try to check and fix it as following table.

Issue	Solution to try
No Power LED	Check the DC output is normal. Confirm all components are soldered. Confirm the voltage regulator is warm.
Power LED on, but nothing on 7-seg LED	Confirm the Memory selector jumper is closed. Confirm the I/O selector jumper is open. Press RS to restart. (When using IC socket) Make sure that all chips are inserted firmly. Check the crystal oscillator output is normal (1MHz)
Keyboard not working	Confirm the I/O selector jumper is open. (When using IC socket) Make sure that all chips are inserted firmly.
Program cannot run completely	Check SST switch is OFF (stick at right side)
Only one digit is displayed and it is really bright	Press RS to restart. (When using IC socket) Make sure that all chips are inserted firmly.
Voltage regulator is hot	Replace the DC power supply with output at 7.5V.
Serial not working	Make sure that the serial cable is a normal cable, the Null-Modem cable cannot be used. Confirm the I/O selector is closed. Confirm that the terminal parameter settings are correct.

If the above operation does not solve the problem or the problem is not in the list, please contact us for support.

APPENDIX A: Memory Map

PAL-1		KIM-1	
$0000-$03FF	1K Byte RAM	$0000-$03FF	1K Byte RAM
$0400-$07FF	1K Byte RAM	$0400-$07FF	Optional
$0800-$0BFF	1K Byte RAM	$0800-$0BFF	Optional
$0C00-$0FFF	1K Byte RAM	$0C00-$0FFF	Optional
$1000-$13FF	1K Byte RAM	$1000-$13FF	Optional
$1400-$16FF	Optional	$1400-$16FF	Optional
$1700-$173F	Optional 6532 I/O, Timer	$1700-$173F	6530-002 I/O, Timer
$1740-$177F	6532 I/O, Timer	$1740-$177F	6530-003 I/O, Timer
$1780-$17BF	6532 64 Byte RAM	$1780-$17BF	6530-003 64 Byte RAM
$17C0-$17FF	6532 64 Byte RAM	$17C0-$17FF	6530-002 64 Byte RAM
$1800-$1BFF	EPROM 1K Byte ROM	$1800-$1BFF	6530-003 1K Byte ROM
$1C00-$1FFF	EPROM 1K Byte ROM	$1C00-$1FFF	6530-002 1K Byte ROM
$2000-$FFFF	Available for Expansion	$2000-$FFFF	Available for Expansion

APPENDIX B: Expansion Port Pinout

GND	1	40	GND
VCC	2	39	RESET
A0	3	38	A1
A2	4	37	A3
A4	5	36	A5
A6	6	35	A7
A8	7	34	A9
A10	8	33	A11
A12	9	32	A13
A14	10	31	A15
R/W	11	30	PHI2
D0	12	29	D1
D2	13	28	D3
D4	14	27	D5
D6	15	26	D7
SYNC	16	25	RDY
NMI	17	24	TAPE
DEN	18	23	SST
IO3	19	22	PB7
PHI1	20	21	IRQ

- PIN18 DEN onboard memory decode
- PIN19 IO3 For second 6532 expansion. Connect to the CS1(38) pin of second 6532.
- PIN24 TAPE expansion
- All pinout compatible with Micro-KIM