H8 8080A/Z80 64K RAM ORG0 V1.3

Assembly, Configuration and Installation Guide

Board Revision 1.3

Gerber File Revision 3

David Troendle

Document Revision 8

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1 Disclaimer of Liability

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2 Introduction

The H8 8080A/Z80 64K RAM ORG0 V1.3 is a 64K replacement memory board for the Heathkit H8 computer that provides on-board ORG 0 functionality. This documentation is for board revision 1.0 (Gerber file revision 1).

3 Technical Assistance

The best way to obtain technical assistance and ask questions is via the SEBHC Google group located here: https://groups.google.com/forum/#!forum/sebhc.

There are many experts that hang out in this group who are willing to help.

The SEBHC main website is loaded with helpful documentation on vintage Heathkit computers. That site is here: http://sebhc.lesbird.com/.

Norberto Collado's website has many replacement cards for those who are restoring vintage Heathkit computers. This includes the H8 8080A/Z80 64K RAM ORG0 V1.3 board. Norberto's website is here: http://koyado.com/. Please report all errata to this guide at the SEBHC Google group.

4 Ordering the Card

The H8 8080A/Z80 64K RAM ORG0 V1.3 card can be ordered from OurPCB. To order a board, email Cathy Ma_OurPCB <sales06@ourpcb.com> requesting a re-run of order 17081876-2. Specify the color of the solder mask (green, blue or red). You will be charged the re-order rate rather than full price.

To be worthwhile you will probably have to order a minimum of 5 boards. It is customary for members of the SEBHC group to post their intent to order and/or offer extra boards to the group at cost.

5 Board Views

Figure 4.1 on page 3 shows an X-Ray view of the board. It is a high resolution photo that can be zoomed for more detail. This view can serve as a handy reference for locating parts.

Figure 4.2 on page 4 shows a fully assembled boards with all options. This can help clarify any ambiguities related to the mechanical aspects of the assembly.

5.1 Bottom Side Rework

Refer to Figure 4.3 on page 5. In order to solder the LEDs, a simple bottom side solder mask rework is required. Using an X-Acto knife or similar instrument, scratch away the solder mask on the six indicate pads. The X-Acto knife is a sharp instrument. Follow the safety precaution brochure for the instrument you are using.

6 Getting Ready

6.1 Bill of Material (BOM)

§7 (Assembly and Bill of Material (BOM)) details the board assembly process. It contains a description and quantity for each part. This can be used as the BOM. This helps searching sites for the desired components.

6.2 Identifying Resistor Values

Resistors are color coded. See Appendix A on page 21 (Resistor Identification) for the codes and an example.

The resistors on this board are metal film 5% axial mount resistors.

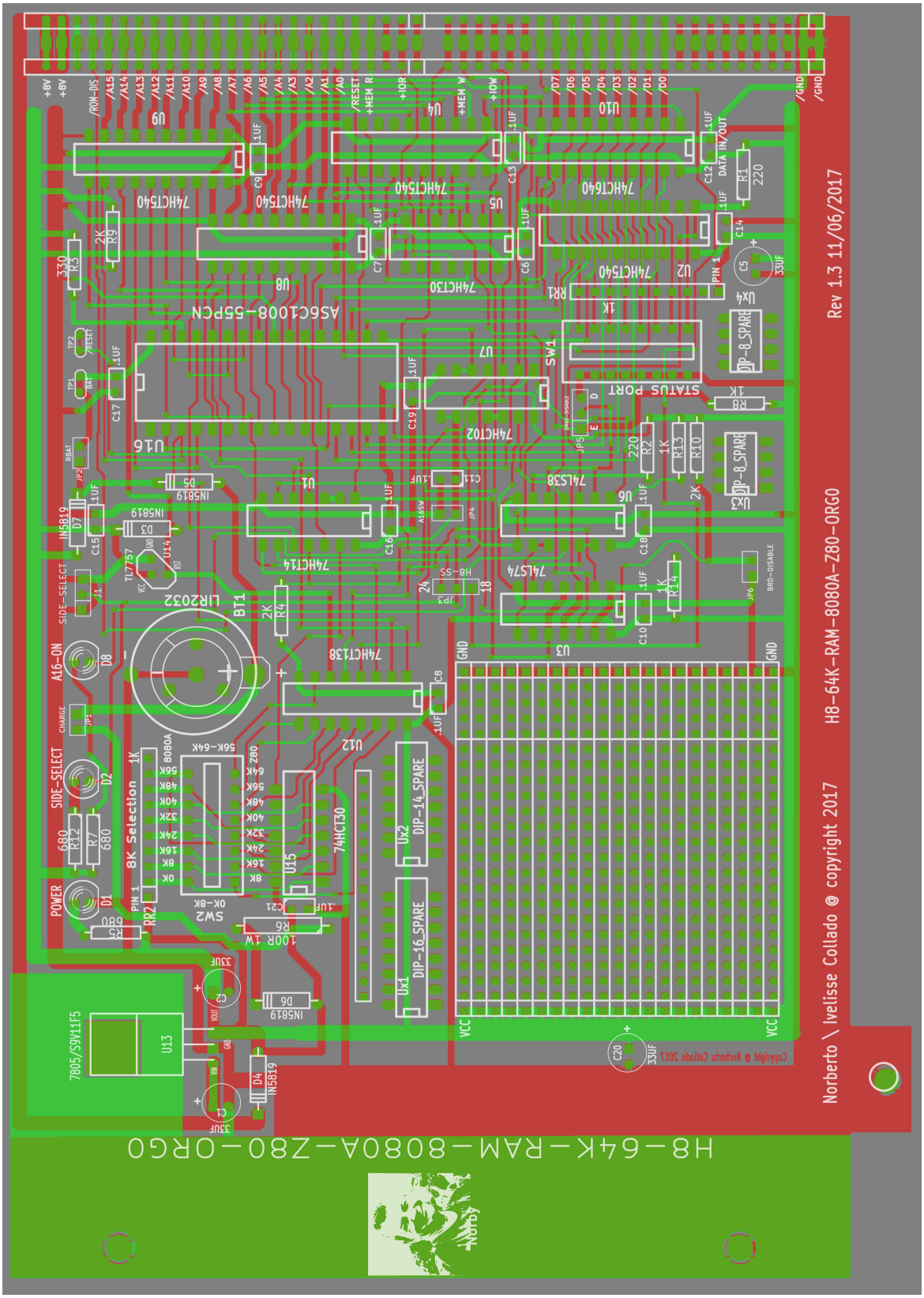


Figure 4.1: X-Ray View (Red=Bottom, Green=Top and White=Silk Screen)

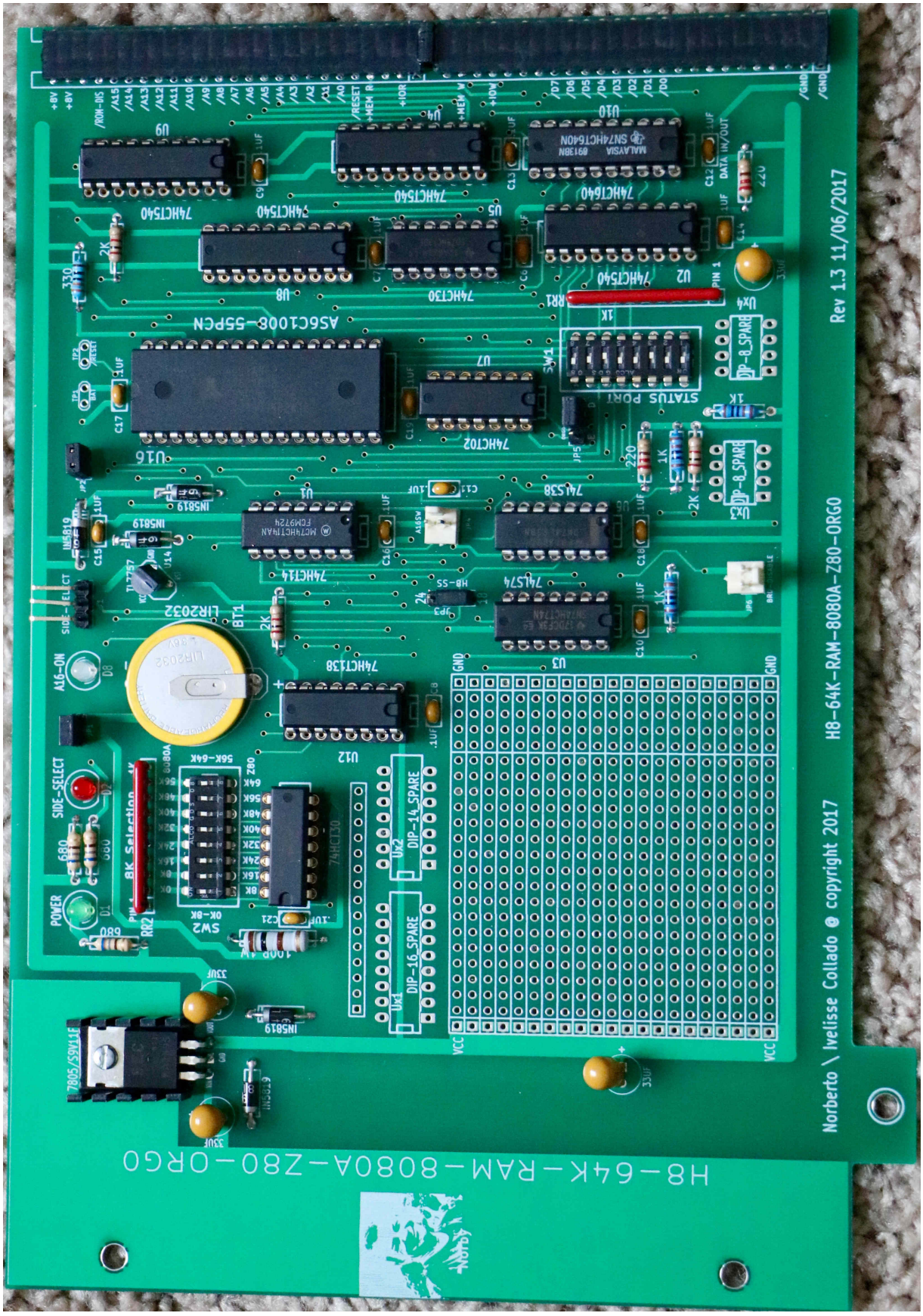


Figure 4.2: Fully Assembled Board

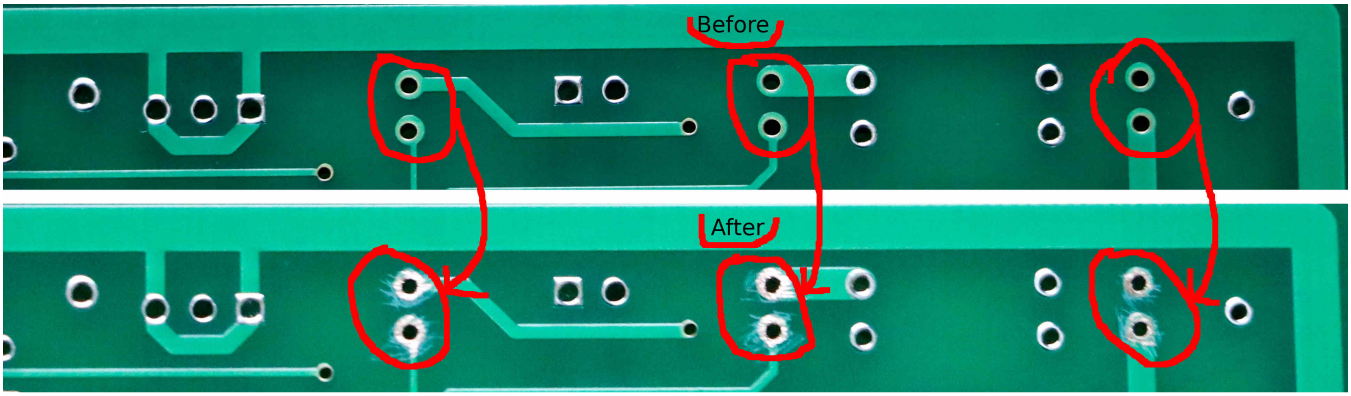


Figure 4.3: Bottom Side Solder Mask Rework

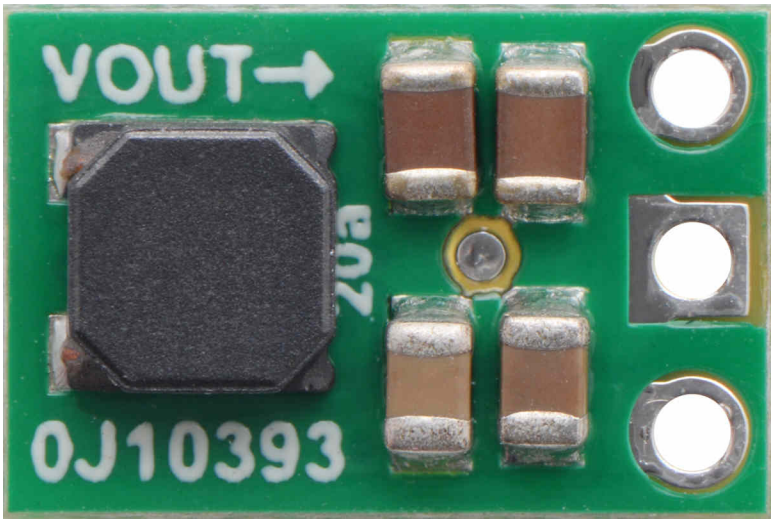


Figure 6.1: S9V11F5 Switching Step Up/Down Regulator

6.3 Polarized Components

Tantilum capacitors, LEDs and diodes are polarized devices. I.E., the "+" and "-" leads must be install correctly. Diodes have a black band that must align white line on the board. For the other devices the "+" lead is longer than the "-" lead. Often they are also marked with a "+". Ensure these devices are installed with the correct polarity.

Appendix B (Polarized Devices) details identifying the polarity of these devices.

6.4 Optional Switching Regulator

Two H8 backplanes are in use – the original H8 backplane which uses 8V, and Les Bird's H8 backplane which uses 5V. The S9V11F5 is a switching step up/down voltage regulator that is compatible which either backplane and without any alterations. Figure 6.1 on page 5 shows a

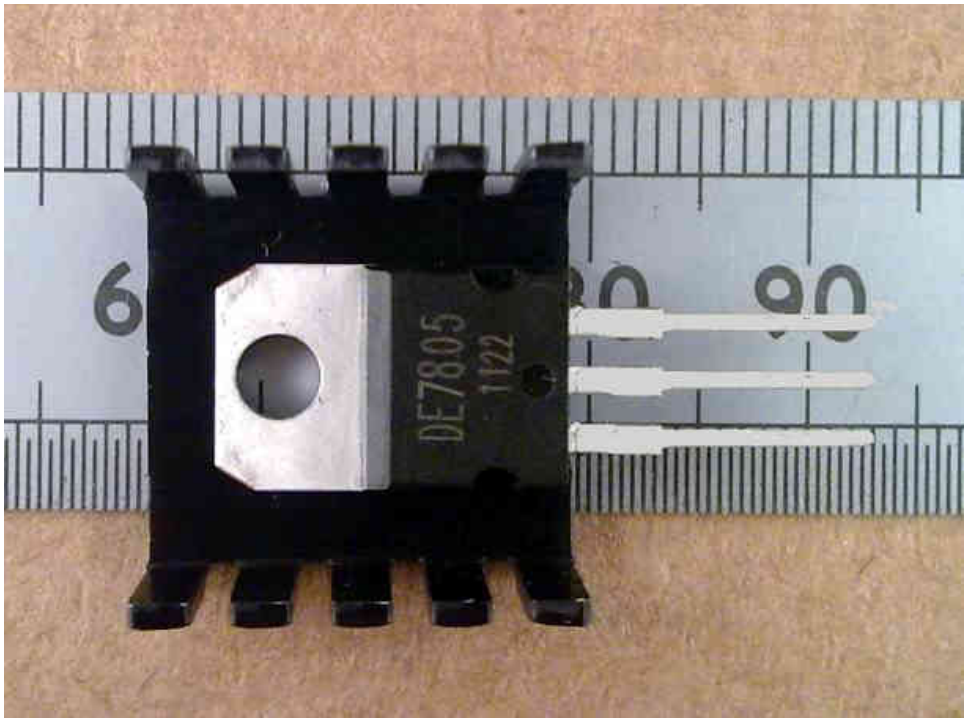


Figure 6.2: Placing a Regulator on its Heatsink

S9V11F5 regulator. It can be found at: https://www.pololu.com/product/2836. The S9V11F5 regulator along with a straight-through 3-pin header can be used in lieu of the 7805/heatsink. Caution: The S9V11F5 can run hot enough to burn during normal operation.

6.5 Mounting the Voltage Regulators

Voltage regulators are installed with a regulator, heat sink, screw, nut and thermal paste. The best screw is a 3/8" panhead M3 screw and corresponding nut. These are not included in the assembly section, but need to be ordered.

Figure 6.2 on page 6 shows how to position a regulator on its heatsink. Thermal compound is placed between the regulator and heatsink. Before placing the regulator and heatsink on the board, the three leads exiting the regulator must be bent down 90° where the leads narrow. The M3 screw is placed through the holes on the regulator, heatsink and board and affixed to the bottom of the board using a nut. The three leads go through the hole on the board. (See Figure 4.2 on page 4) for a view of the final assembly.

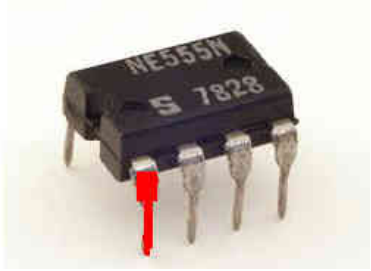


Figure 6.3: Pin 1 Shown in Red

6.6 About ICs

When placing ICs in their socket, orienting pin 1 correctly is important. There are three ways to do this. In order, they are:

1. Most ICs have a dot or circular indentation over pin 1.
2. If a dot is not present, there is usually a notch. The notch is the top of the IC. Pin 1 is to the left of the notch. Beware, some ICs have two notches. Use the larger notch.
3. If all else fails, you can use the text on the IC. Pin 1 will be the leftmost pin below the text.

Refer to Figure 6.3 on page 7. Here, any of the three methods will work.

6.7 Handling Electrostatic Sensitive Devices

CMOS devices such as SRAM are electrostatic sensitive devices. A static charge buildup can damage these devices.

Here are some tips for handling electrostatic sensitive devices:

- Limit your movement while handling these devices. Movement can cause static electricity to build up around you.
- Just before removing the device from it protective package, touch the package against the board. This will help dissipate any static charge.
- After touching the board, immediately remove the device and install it in its socket. This helps prevent building up a static charge.

6.8 Clocking And Speed Considerations

If you plan on pushing the clock speed as fast as possible, consider ordering a fast AS6C1008-55CN SRAM.

There is no fixed formula to use, but the faster the component the faster the clock speed the board will likely support.

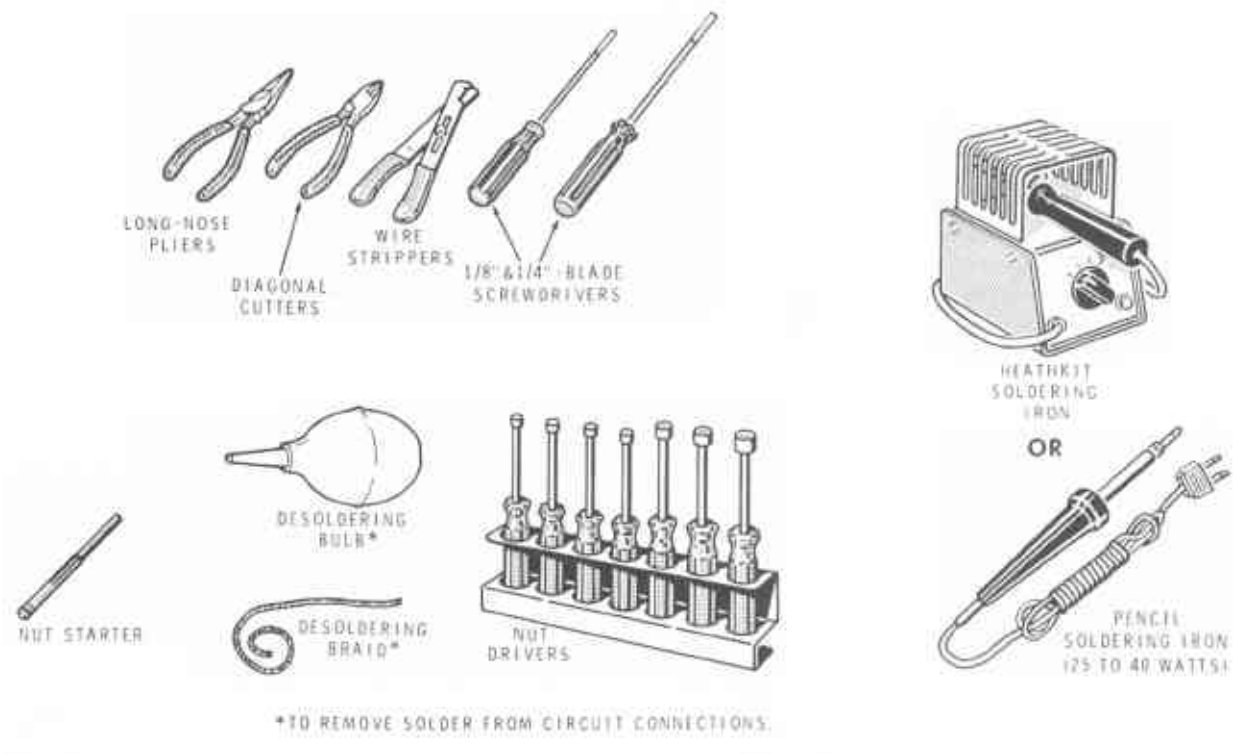


Figure 6.4: Tools

6.9 Tools and Mechanical Considerations

Part mounted in holes on the board must be soldered into place. To avoid cold joints and solder bridges, a temperature controlled soldering station is highly recommended.

Figure 6.4 on page 8 shows tools frequently used in assembling boards:

6.10 Soldering

Figure 6.5 on page 9 shows how to make a good solder connection. For best results, the soldering iron should touch both the component lead and board at a 45° angle so that both are properly heated and will accept the solder. If you notice a buildup of old solder and rosin, you should clean the soldering iron tip.

This is best done by brushing the tip on a wet sponge using a swiping motion.

Two common soldering problems are cold joints and bridges. A cold joint occurs when the lead and board are not heated evenly. Figure 6.5 shows the two ways this can happen – either the soldering iron is placed on the lead or board (but not both).

The other problem is a solder bridge. Figure 6.6 on page 10 shows this. (The H8 8080A/Z80 64K RAM ORG0 V1.3 has a solder mask that helps reduce the chance for a solder bridge.)

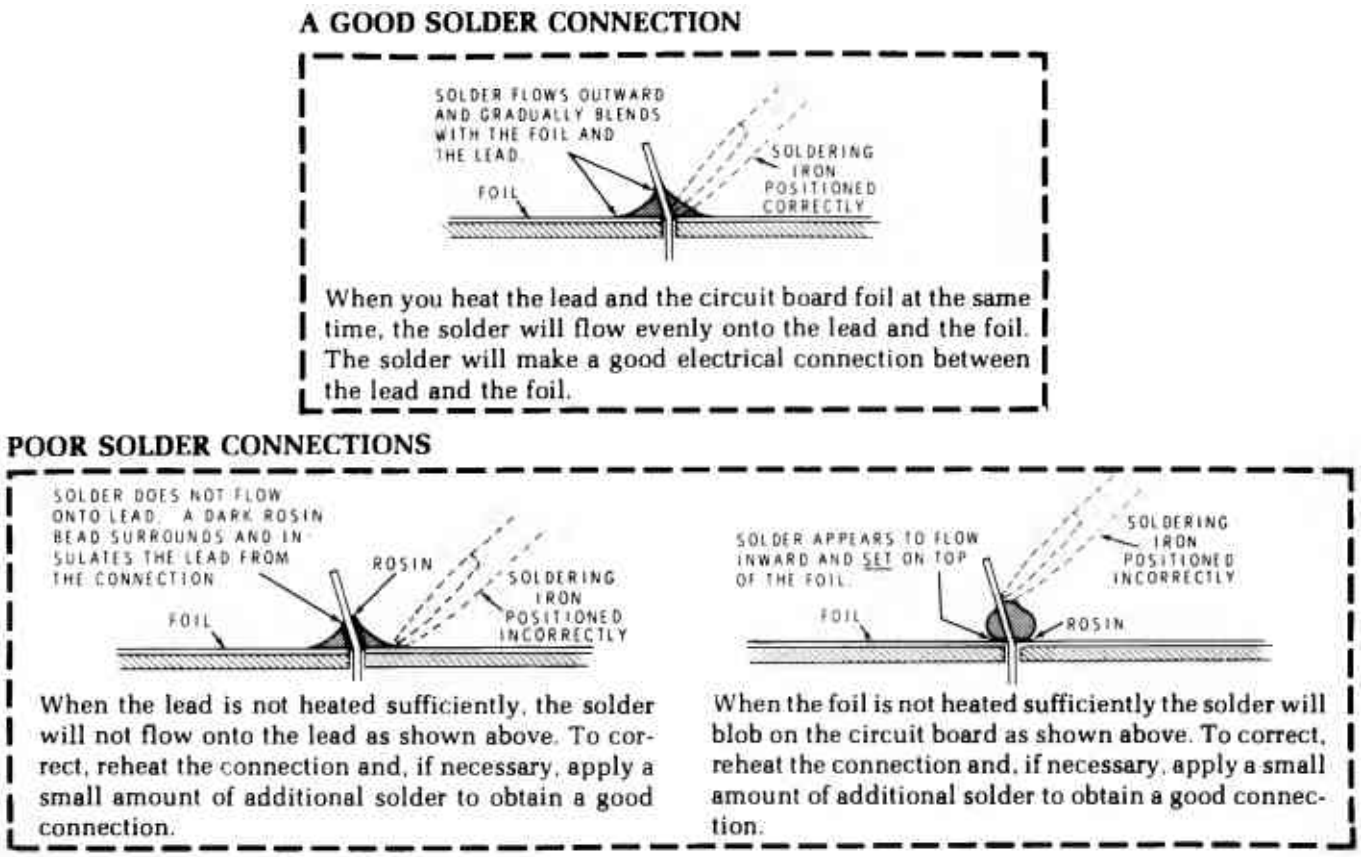


Figure 6.5: Soldering Hints

A solder bridge between two adjacent foils is shown in Figure 6.6(A). Figure 6.6(B) shows how the connection should appear. A solder bridge may occur if you accidentally touch an adjacent previously soldered connection, if you use too much solder, or if you "drag" the soldering iron across other foils as you remove it from the connection. A good rule to follow is: always take a good look at the foil area around each lead before you solder it. Then, when you solder the connection, make sure the solder remains in this area and does not bridge to another foil. This is especially important when the foils are small and close together. NOTE: It is alright for solder to bridge two connections on the same foil. Use only enough solder to make a good connection, and lift the soldering iron straight up from the circuit board. If a solder bridge should develop, reheat the bridge and use the desoldering braid or suction device to remove the solder.

6.11 Headers

The assembly instructions in §7 (Assembly and Bill of Material (BOM)) details each individual header. However, for ordering, it is more practical to cut the headers from 1xn and 2xn header strips. The headers can be consolidated and ordered as 1xn and 2xn header strips.

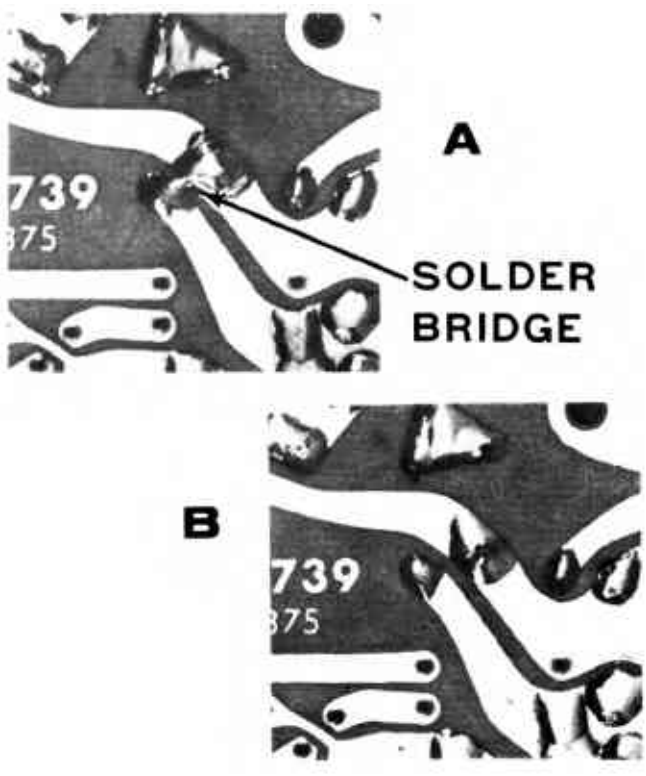


Figure 6.6: Solder Bridges

The holes on the board are a tight fit for the headers. The headers can be inserted by gently rocking the header into the holes while applying downward pressure. Because of the tight fit and to avoid mechanical interference from other parts, the headers are installed first.

7 Assembly and Bill of Material (BOM)

If you have not read §6 (Getting Ready), at least follow the steps below in order.

This section documents the parts ordering and assembly process. Following the instructions in sequence helps minimize mechanical interference and assembly errors. Parts are grouped into part types (e.g., resistors, capacitors, etc.). These form the assembly sections below.

Within each assembly section, parts of that type are listed as bullet items. For each part, the number of parts required along with a full description of the part are included. Beneath each item, the locations where that part is used are listed. There is a space on the left to check off each item as you install it. Note that some parts are optional.

Installing all instances of a part at a time helps reduces assembly errors and eases pulling parts. The order of assembly helps reduce mechanical problems. As each component is installed, check it off.

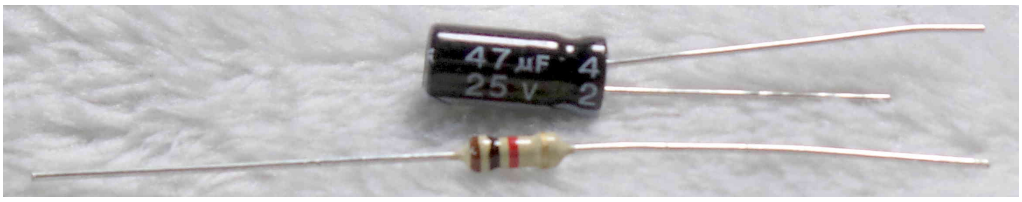


Figure 7.1: Axial vs Radial Components

7.1 Axial vs Radial

Some components are available in either axial or radial packages. This terminology refers to how the leads exit the component. When the leads exit the component on either side through the center axis, the package is said to be *axial*. When the leads exit the component on one side, the package is said to

Figure 7.1 on page 11 shows a 47μf 25V radial capacitor on top, and a 1KΩ axial resistor on the bottom. (Both are used during the assembly process.)

7.2 Resistors

- Install 1, 100Ω (metal film , 5%, 1W , axial, 0.25") as follows:

  (__) $\Rightarrow$ at R6.

- Install 2, 220Ω (carbon/metal film, 5%, 1/4W, axial, 0.25") as follows:

  (__) $\Rightarrow$ at R1.
  (__) $\Rightarrow$ at R2.

- Install 1, 330Ω (carbon/metal film, 5%, 1/4W, axial, 0.25") as follows:

  (__) $\Rightarrow$ at R3.

- Install 3, 680Ω (carbon/metal film, 5%, 1/4W, axial, 0.25") as follows:

  (__) $\Rightarrow$ at R5.
  (__) $\Rightarrow$ at R7.
  (__) $\Rightarrow$ at R12.

- Install 3, 1KΩ (carbon/metal film, 5%, 1/4W, axial, 0.25") as follows:

  (__) $\Rightarrow$ at R8.
  (__) $\Rightarrow$ at R13.
  (__) $\Rightarrow$ at R14.

- Install 3, 2KΩ (carbon/metal film, 5%, 1/4W, axial, 0.25") as follows:

  (__) ⇒ at R4.
  (__) ⇒ at R9.
  (__) ⇒ at R10.

7.3 Diodes

- Install 5, 1N5819 (DO-41) as follows:

  (__) ⇒ at D3.
  (__) ⇒ at D4.
  (__) ⇒ at D5.
  (__) ⇒ at D6.
  (__) ⇒ at D7.

7.4 LEDs

- Install 1, LED (radial, green, 0.1") (See §5.1 on page 2 for required solder mask rework.) as follows:

  (__) ⇒ D1/POWER-LED.

- Install 1, LED (radial, red, 0.1") (See §5.1 on page 2 for required solder mask rework.) as follows:

  (__) ⇒ D2/Side-Select.

- Install 1, LED (radial, blue, 0.1") (See §5.1 on page 2 for required solder mask rework.) as follows:

  (__) ⇒ D8/A16 ENABLED.

7.5 Capacitors

- Install 15, .1μf (ceramic, radial, 0.1") as follows:

  (__) ⇒ at C6.
  (__) ⇒ at C7.
  (__) ⇒ at C8.
  (__) ⇒ at C9.
  (__) ⇒ at C10.

(__) ⇒ at C11.
(__) ⇒ at C12.
(__) ⇒ at C13.
(__) ⇒ at C14.
(__) ⇒ at C15.
(__) ⇒ at C16.
(__) ⇒ at C17.
(__) ⇒ at C18.
(__) ⇒ at C19.
(__) ⇒ at C21.

7.6 Tantalum Capacitors

- Install 4, 33μf (tantalum, 25V, radial, 0.1") as follows:

  (__) ⇒ at C1.
  (__) ⇒ at C2.
  (__) ⇒ at C20.
  (__) ⇒ at C5.

7.7 Resistor Packs

- Install 2, 1KΩ bussed (SIP-9) as follows:

  (__) ⇒ at RR1.
  (__) ⇒ at RR2.

7.8 Edge Connectors

- Install 2, 25 Position Receptacle Connector 0.100" right angle gold (Samtec BCS-125-L-S-HE, Digi-Key SAM1009-25-ND) as follows:

  (__) ⇒ at P1.
  (__) ⇒ at P2.

7.9 Jumpers

- Install 4, 1x2 Straight Male Pin Header (0.1", 0.025" square posts) as follows:

  (__) ⇒ at JP1.

(__) ⇒ at JP2.
(__) ⇒ at JP4.
(__) ⇒ at JP6.

- Install 3, 1x3 Straight Male Pin Header (0.1”, 0.025” square posts) as follows:

  (__) ⇒ at JP3.
  (__) ⇒ at JP5.
  (__) ⇒ at J1.

7.10 Switches

- Install 2, 8 position DIP switch (DIP-16, 0.3”) as follows:

  (__) ⇒ at SW1.
  (__) ⇒ at SW2.

7.11 Sockets

- Install 6, 14-Pin socket (DIP, 0.3”) as follows:

  (__) ⇒ at U1.
  (__) ⇒ at U15.
  (__) ⇒ at U3.
  (__) ⇒ at U5.
  (__) ⇒ at U6.
  (__) ⇒ at U7.

- Install 1, 16-Pin socket (DIP, 0.3”) as follows:

  (__) ⇒ at U12.

- Install 5, 20-Pin socket (DIP, 0.3”) as follows:

  (__) ⇒ at U10.
  (__) ⇒ at U2.
  (__) ⇒ at U4.
  (__) ⇒ at U8.
  (__) ⇒ at U9.

- Install 1, 32-Pin socket (DIP, 0.6”) as follows:

  (__) ⇒ at U16.

- Install 1, LIR2032 battery socket as follows:

  (__) ⇒ at BT1.

7.12 Integrated Circuits

- Install 1, 74HCT/LS02 (Quad 2-input NOR gates, DIP-14, 0.3") as follows:

  (__) ⇒ at U7.

- Install 1, 74HCT/LS14 (Hex inverters w/Schmitt Trigger, DIP-14, 0.3") as follows:

  (__) ⇒ at U1.

- Install 2, 74HCT/LS30 (8-input NAND gate, DIP-14, 0.3") as follows:

  (__) ⇒ at U5.
  (__) ⇒ at U15.

- Install 1, 74HCT/LS38 (Quad 2-input Open Collector NAND gates, DIP-14, 0.3") as follows:

  (__) ⇒ at U6.

- Install 1, 74HCT/LS74 (Dual positive-edge-triggered D flipflops, DIP-14, 0.3") as follows:

  (__) ⇒ at U3.

- Install 1, 74HCT/LS138 (3 To 8 Decoder/Demultiplexer, DIP-16, 0.3") as follows:

  (__) ⇒ at U12.

- Install 4, 74HCT/LS540 (Octal buffer/line driver with 3-state outputs, DIP-20, 0.3") as follows:

  (__) ⇒ at U2.
  (__) ⇒ at U4.
  (__) ⇒ at U8.
  (__) ⇒ at U9.

- Install 1, 74HCT/LS640 (Octal bus transceivers, DIP-20, 0.3") as follows:

  (__) ⇒ at U10.

- Install 1, AS6C1008-55PCN (128Kx8 SRAM, DIP-32, 0.6") (See §6.7 on page 7 for handling considerations and §6.8 on page 7 for speed considerations.) as follows:

(__) ⇒ at U16.

- Install 1, DS1210 (Nonvolatile Controller Chip, DIP-8, 0.3") (See §**??** on page **??** for ordering details.) as follows:

  (__) ⇒ at U17.

- Install 1, TL7757 (Supply-Voltage Supervisor, TO-92) as follows:

  (__) ⇒ at U14.

7.13 Voltage Regulators

- Install 1, 7805 5V Voltage regulator (TO-220) (See §6.5, page 6 for special mounting instructions.) (Not used when S7V7F5 is used. See §6.4, page 5.) as follows:

  (__) ⇒ at U13.

7.14 Heatsinks

- Install 1, Heatsink (TO-220, compact, 0.5" width) (See §6.5, page 6 for special mounting instructions.) (Not used when S7V7F5 is used. See §6.4, page 5.) as follows:

  (__) ⇒ at U13.

7.15 Battery Cells

- Install 1, LIR2032 Li-ion Rechargeable Button Coin Cell Battery w/Tab (3.6V, 40mAh) as follows:

  (__) ⇒ at BT1.

XCON-8/PAM37 Monitors		
Memory Bank	Address Range (Octal)	Switch Position
8K	000-000Q to 037-377Q	1 = ON
16K	040-000Q to 077-377Q	2 = ON
24K	100-000Q to 137-377Q	3 = ON
32K	140-000Q to 177-377Q	4 = ON
40K	200-000Q to 237-377Q	5 = ON
48K	240-000Q to 277-377Q	6 = ON
56K	300-000Q to 337-377Q	7 = ON
64K	340-000Q to 377-377Q	8 = ON

(a) XCON-8/PAM37 Monitors

PAM-8 Monitor		
Memory Bank	Address Range (Octal)	Switch Position
0K	000-000Q to 037-377Q (Reserved for Monitor)	1 = OFF
8K	040-000Q to 077-377Q	2 = ON
16K	100-000Q to 137-377Q	3 = ON
24K	140-000Q to 177-377Q	4 = ON
32K	200-000Q to 237-377Q	5 = ON
40K	240-000Q to 277-377Q	6 = ON
48K	300-000Q to 337-377Q	7 = ON
56K	340-000Q to 377-377Q	8 = ON

(b) PAM-8 Monitor

Table 7.1: SW2 Settings

8 Configuration

1. Refer to Figure 7.2 on page 18 to set the Extended Configuration 8-position DIP switch at SW1 (Status Port). Note the numbering on the switch may not match the numbering on the silkscreen. Always use the number on the silkscreen. Also, the mechanism for closing the switch varies with the switch. Always use the documentation on the switch to determine the on/off position.

2. Table 7.1 on page 17 details the address selection switch settings for the PAM/8 and XCON-8/PAM37 monitors. Set SW2 to the settings appropriate for your monitor. As before, use the switch numbering on the silkscreen and the on/off position marked on the switch.

3. Jumpers:

   - **JP1 - "CHARGE"**: By default is installed as it is used to charge the battery. Remove it if the battery is non-rechargeable.
   - **JP2 - "RBAT (Remove Battery)"**: On for normal operation. Removed when replacing the RAM IC.

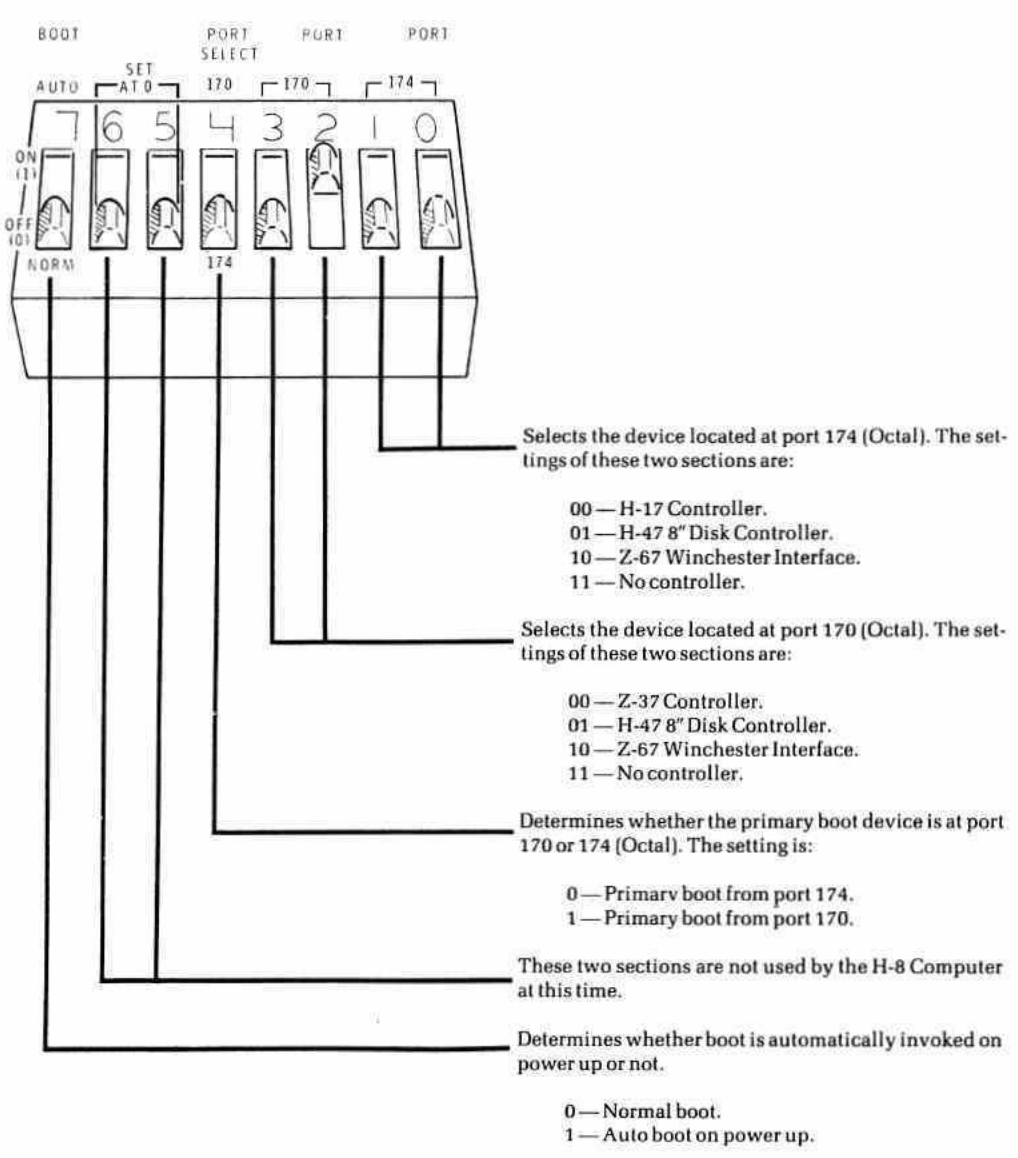


Figure 7.2: ORG 0 Extended Configuration Settings

- **JP3 - "H8-SS (Side Select)"**: Select which backplane pin receives the side select signal for the H17 controller. Choices are pin #18 or pin #24.
- **JP4 - "A16SW (RAM Address A16 Connects to an External Switch)"**: External switch "OFF" for normal operation. When external switch is "ON", it enables the second bank of the 64K RAM, so that the user can key-in manually any programs that they want to preserved. LED D8 turns on when switch is in the "ON" position.
- **JP5 - "ORG-DISABLE"**: Insert jumper between pins 1-2 for normal operation. Insert jumper between pins 2-3 to disable the circuit if using the Heath ORG0 card. Please disable when using Heath/Zenith Z80 or Les Bird's Z80 CPU board. Please enable for the 8080 CPU board.
- **JP6 - "BRD-DISABLE"**: This is useful for bank switching and adding more than 1 board.
- **"TP1 BAT"**: This the test point. Should be 4.75V when power is on and 4.50V when power is off.
- **"TP2-RESET"**: This the test point.

9 Final Assembly

There is a gap between the edge connectors on the right side of the board. On Heathkit boards a solid nylon spacer is installed in the gap. The spacer ensures the board is aligned properly when plugged into the backplane. Similar provisions should be made for this board. One easy solution is to glue a jumper header into gap using Gorilla glue.

The last step is a visual inspection of the board looking for:

- Unsoldered connections
- Cold solder joints
- Solder bridges
- The correct ICs are inserted into their sockets
- The ICs are oriented in their socket correctly and there are no bent pins
- Jumpers are installed correctly

10 Installation

- If the system contains an HA8-8 Extended Configuration Card (commonly known as an ORG 0 board), remove it.

- Install the H8 8080A/Z80 64K RAM ORG0 V1.3 in a backplane the slot behind the CPU card. Ensure the edge connectors properly align with the backplane pins.

11 Acknowledgements

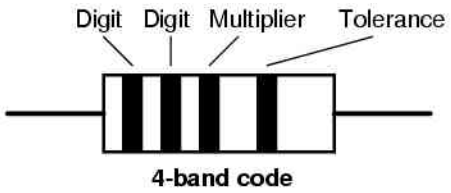
The author is grateful for the input and assistance of Norberto Collado.

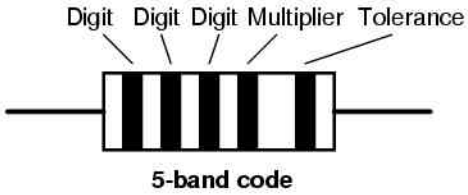
Appendices

A Resistor Identification

Color		Digit	Multiplier	Tolerance %
Black		0	10^0	
Brown		1	10^1	1%
Red		2	10^2	2%
Orange		3	10^3	
Yellow		4	10^4	
Green		5	10^5	0.5%
Blue		6	10^6	0.25%
Violet		7	10^7	0.1%
Grey		8	10^8	
White		9	10^9	
Gold			10^{-1}	5%
Silver			10^{-2}	10%
(none)				20%

Table A.1: Resistor Color Codes





Example: The resistor below colored Orange-Orange-Black-Brown-Violet would be 3.3 kΩ with a tolerance of +/- 0.1%.

B Polarized Devices

A polarized device has positive (anode) and negative (cathode) leads. Polarized devices must be inserted into the holes that match the lead's polarity.

On the H8 8080A/Z80 64K RAM ORG0 V1.3 four polarized devices are used: diodes, LEDS, tantalum capacitors, and electrolytic capacitors.

B.1 Diodes

Figure B.1: Diode in a DO-35 Package

Figure B.1 on page 22 shows a diode in a DO-35 package. Notice the black band on the left side of the glass bead. This is the cathode ("-" lead). This should be aligned with the bar on the silkscreen.

B.2 LEDs

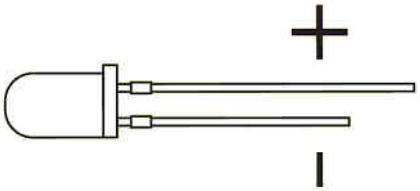


Figure B.2: LED

Figure B.2 on page 22 shows a LED. Notice one lead is longer than the other. The longer lead is the anode ("+").

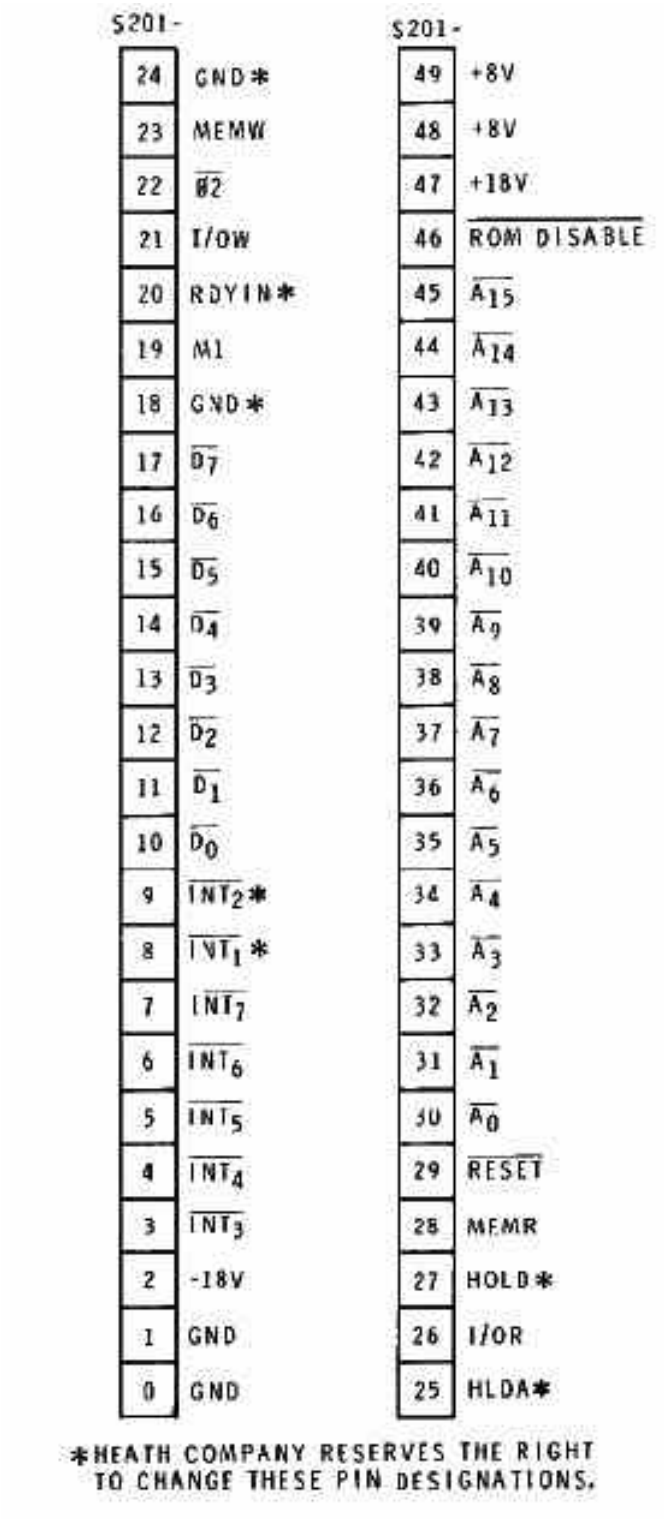
B.3 Tantalum Capacitors

Figure B.3: Tantalum Capacitor

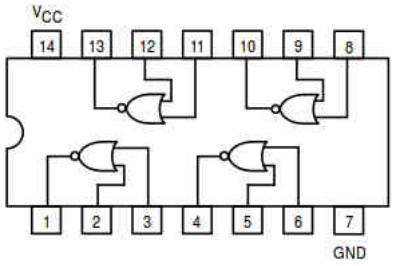
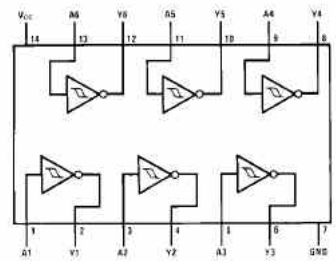
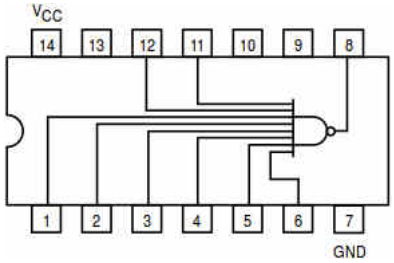
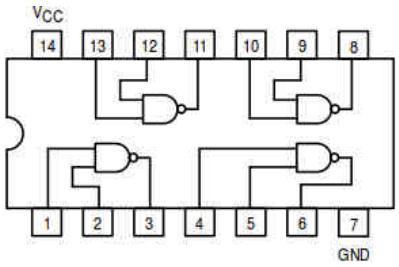
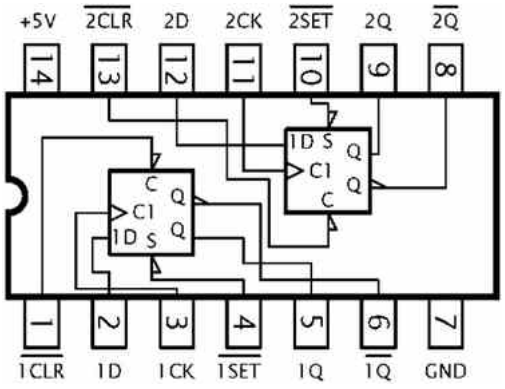
Figure B.3 on page 23 shows a tantalum capacitor. Notice one lead is longer than the other. The longer lead is the anode (“+”).

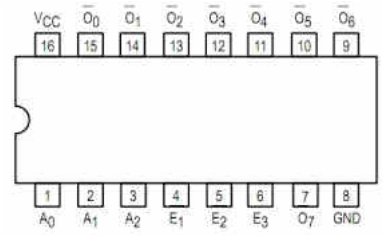
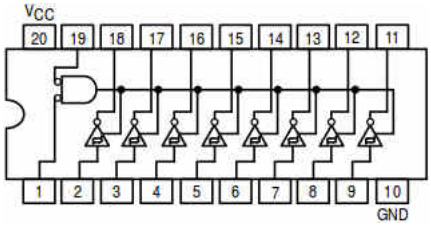
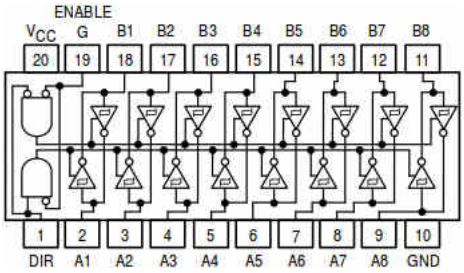
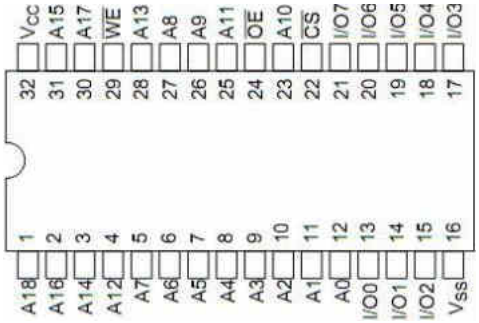
C Connector Pinouts

C.1 H8 Backplane Connector

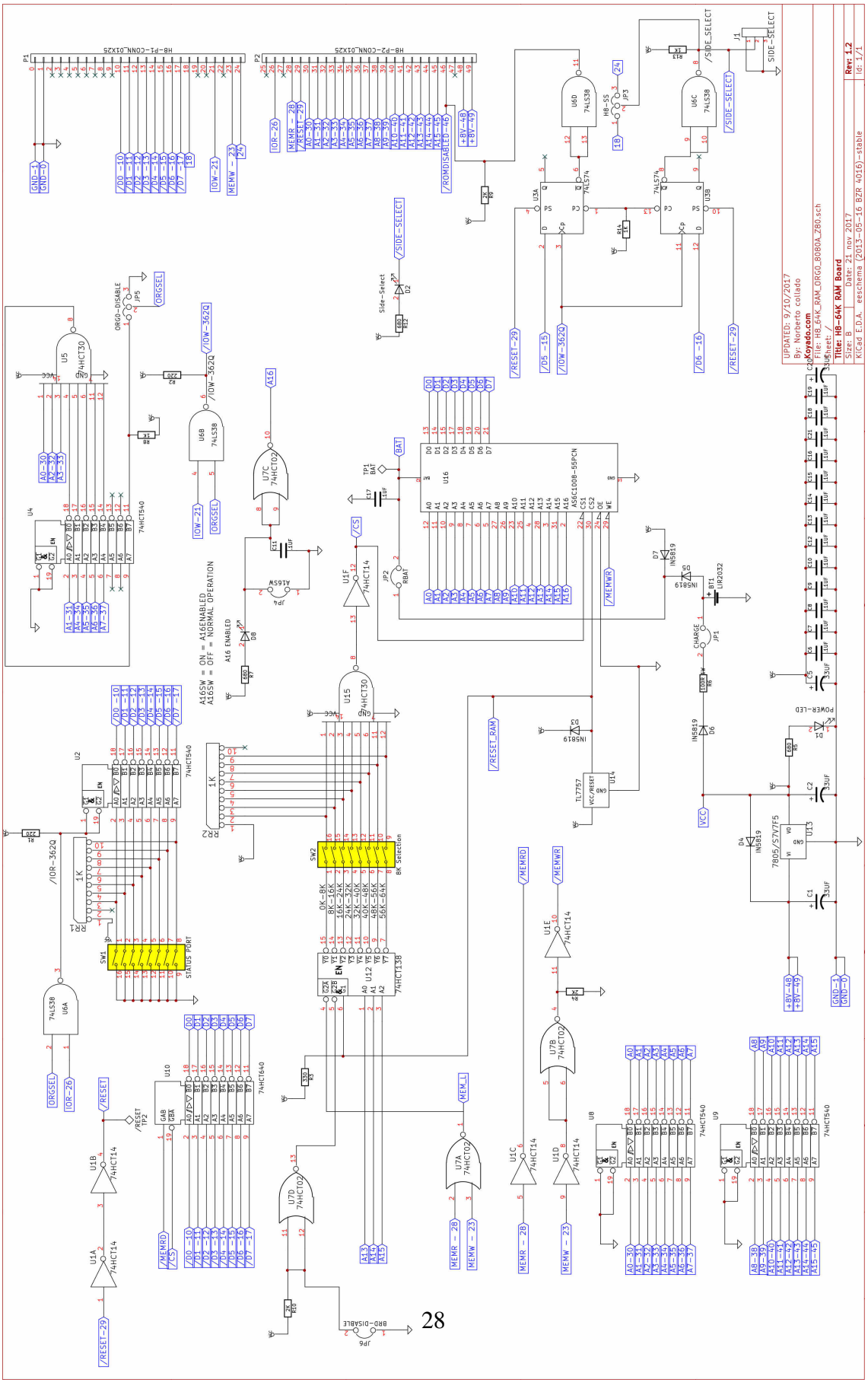


D IC Pinouts

74HCT02	Quad 2-input NOR gate	
74HCT14	Hex inverter w/Schmitt Trigger	
74HCT30	8-input NAND	
74LS38	Quad 2-input Open Collector NAND gate	
74LS74	Dual D-flop	

74HCT138	Dual D-flop	
74HCT540	Octal buffer/line driver with 3-state outputs	
74HCT640	Octal bus transceivers	
AS6C1008	128KBx8 SRAM	

E Schematic


UPDATED: 9/10/2017
By: Norberto collado
Koyado.com
File: H8_64K_RAM_ORG0_8080A_Z80.sch
Sheet: /
Title: H8-64K RAM Board
Size: B
Date: 21 nov 2017
Rev: 1.2
KiCad E.D.A. eeschema (2013-05-16 BZR 4016)-stable
Id: 1/1
ORG0-DISABLE
A16 ENABLED
A16SW = ON = A16ENABLED
A16SW = OFF = NORMAL OPERATION
8K Selection
STATUS PORT
SIDE-SELECT
Side-Select
POWER-LED
CHARGE
BRG-DISABLE