

2016

H89-SBC-SSD 4MB Hard Drive Controller



Norberto Collado
norby@koyado.com
10/2/2016

Revision History and Disclaimer

Revision History		
Revision	Date	Comments
1.0	09/03/2016	Initial draft by Norberto Collado
1.1	09/04/2016	Added Dan Emrick feedback
1.2	10/02/2016	Battery circuit rework to improve charge rate.

The purpose of this document is to “SUPPORT” those who still use these great Heathkit machines and to preserve the information of those who made a difference.

Also this document is to allow the surviving classic computers to continue to function. Without the proper software support, the hardware cannot be seen in action, and a piece of our digital history is lost. I have not included any material in this document which I believe has current commercial value. Most of the material in this document is the intellectual property of other companies or individuals. However many of the companies are no longer in existence, and I do not have current contact information to obtained permission to include them.

Please don't use any of this material for any purpose other than personal hobby/interest without checking with the owner of the material.

Thank you for your understanding and consideration.

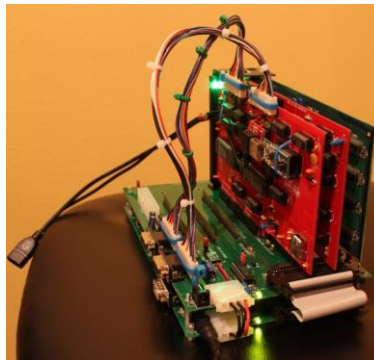


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Introduction

This document provides an overview on the H89-SSD 4MB Hard Drive controller board designed for the **H89-SBC** system. The H89-SBC SSD is a peripheral board created by Norberto Collado to be installed into his reimplement of the cherished H89 Z80 based computer. It is based on a concept that originally attempted in the late 1980s by Dan Emrick. The basic idea was to have a solid state “disk drive” on the H89 that would be fast and silent. There are some large HDOS programs that can take a considerable amount of time to load from the H17 floppy. In addition, programs like a C compiler are not only large but the source code files can also become quite large, thus the desire for fast peripheral storage.

Acknowledgments

The project team for development included Glenn Roberts, Ken Owen, Stanley Web, Norberto Collado and Dan Emrick. In addition, Terry Gulczynski's MTR90 ROM code provided a means for booting from the new SSD. Success of the project was possible only through the insight, experience and ideas of the team members. Thanks to all.

General Description

The H89-SBC SSD uses up to 8 AS6C-4008 static ram chips each with 512 kilobytes of 8-bit storage. These chips occupy a contiguous eight megabyte address space arranged in four banks of two for drive implementation. While not all memory chip sockets must be populated, chips must be used in pairs. A pair of chips provide the storage for one megabyte of random access data – one SSD drive. The drive implementation consists of four drives of one megabyte each. The base port address for this device is 270Q (0B8H). This is the I/O data port. Address ports are the next three ports. The address ports are write only and are latched to facilitate access to the SSD RAM chip contents. There is a battery backup (80mA) on the board that preserves the SSD contents between boots and/or power cycles and when combined with an external battery of 800mA it could provide about 1 year of data retention from a fully charged start position. The memory maintenance circuit can be powered from either the on-board battery or from an external source. The board with all logic and storage circuits plugs onto a “**USER I/O BOARDS**” position on the H89- SBC backplane and can be held in place by an **H89-SBC** peripheral board bracket.

Note: Refer to the following document written by Dan Emrick for details on the H89-SSD Operation: [H89-SBC SSD](#)

Host Computer Requirements

Firmware

1. Modified MTR-90 Boot ROM (AT27C256R-45PU) with SSD support.

Controller Card Ports Configuration

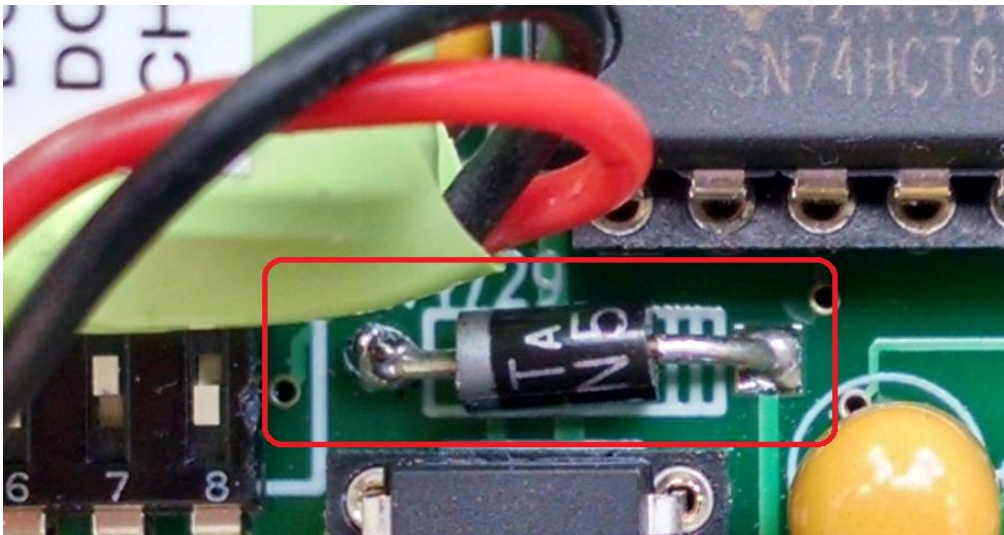
The following is a table summary of the controller ports configuration. Detailed documentation on the H17/Z37/H67 can be obtained at the following website:

<http://www.lesbird.com/sebhc/index.html>

CONTROLLER CARD	PORT
H17	7CH (174Q)
H89-Z37	78H (170Q)
H67	78H/7CH (170Q – 174Q)
H89-SSD	B8H (270Q)

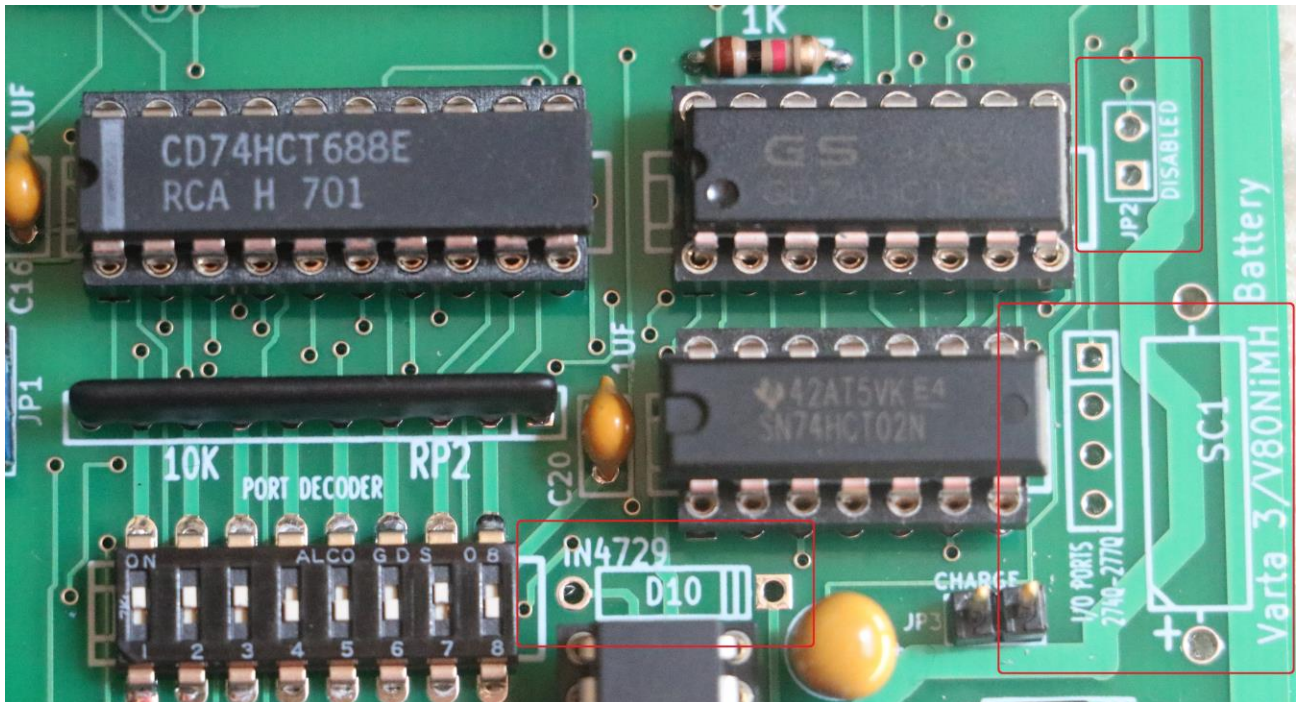
Assembly Notes

1. Do not solder the battery until indicated by the assembly instructions.
2. Do not install diode “D10” (1N4729) unless an external battery is installed. The external battery installation is optional. **Note: Use instead a 1N5819 diode when using an external battery in the “D10” position as shown below.**



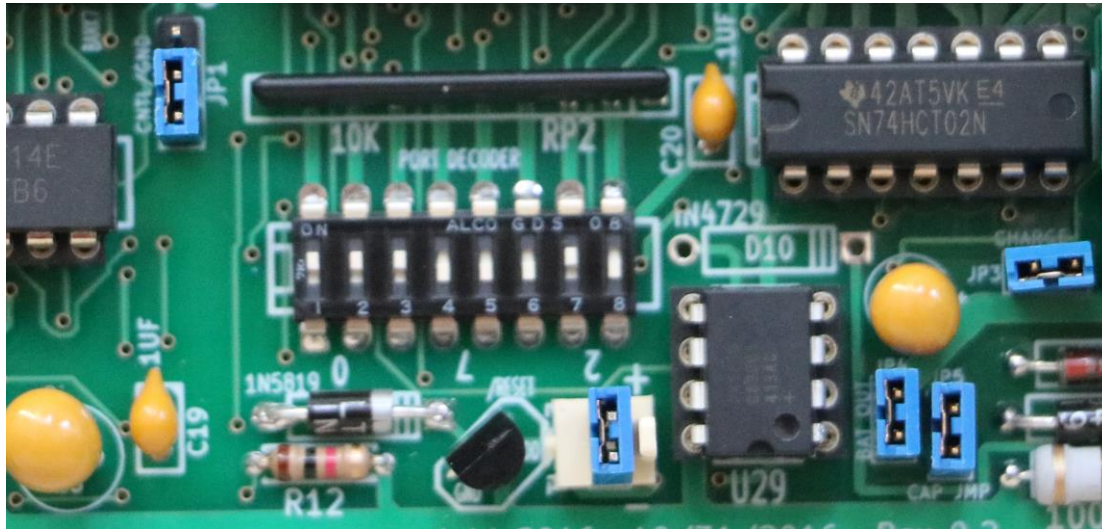
H89-SBC-SSD 4MB HARD DRIVE CONTROLLER

3. Do not install "JP2" Disabled two header jumper as shown below. This header is only used when two or more H89-SBC-SSD are installed into the same backplane. External switches will be used to select which board to enable during power-on or reset conditions.
4. Do not install 4 pin header jumper labeled "I/O Ports" as shown below.



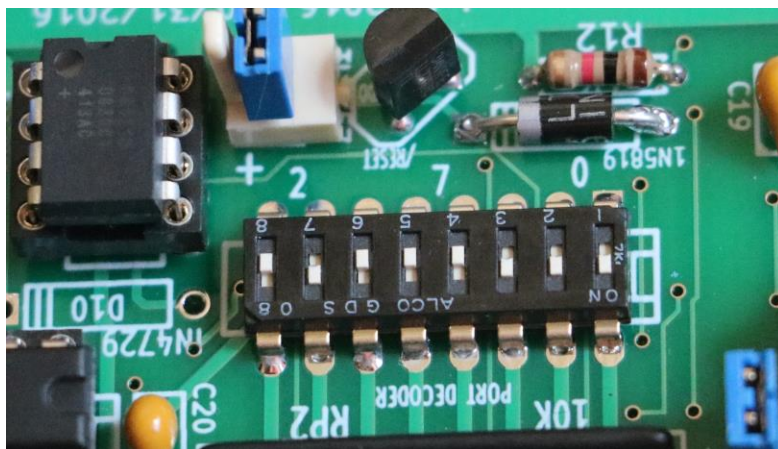
H89-SSD 4MB Jumper Configuration

() Once the board is assembled, configured the two/three pin header jumpers as shown below.



H89-SSD Port Decoder Switch Setting

() Once the board is assembled, configure the Port Decoder Switch to I/O address 270Q as shown below.

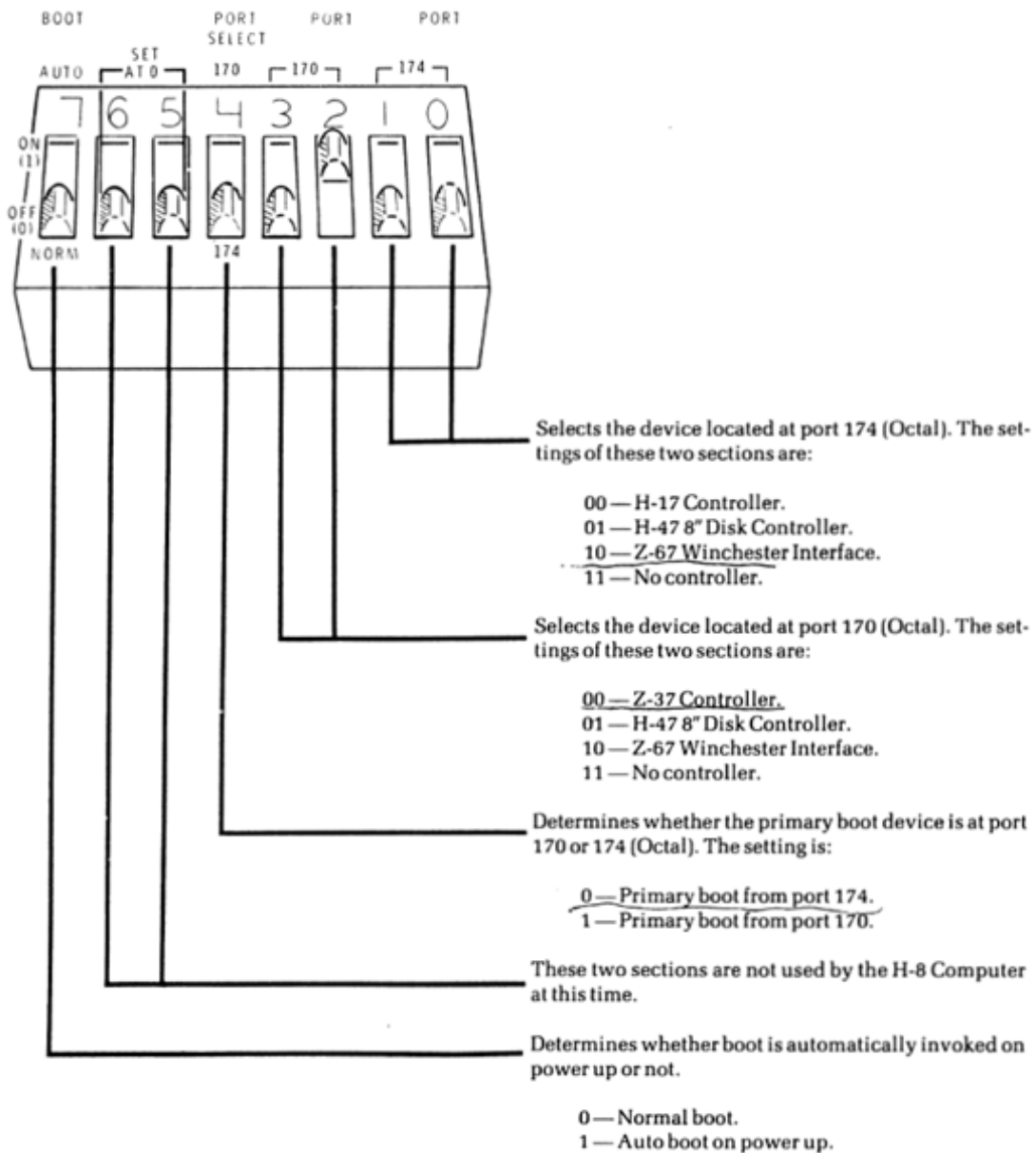


H89-SBC Switch Configuration

Switch Configuration (SW501)

If section 7 of switch SW1 on the H89 Z80 CPU board is set to **1**, the system will automatically boot from hardware unit **0** on the primary device when you turn the power on or perform a master clear reset.

Note: Auto boot feature is only for Hard Drives and for the H89-SBC-SSD controller. On floppy drives, the diskette could be accidentally erased during the power-on sequence inside the Computer.



Setting SW501 with MTR-90

The settings of SW501 for use with MTR-90 are the same as those for use with MTR-89 except that positions 0, 1, 2 and 3 are redefined as follows:

1,0	{	00	Port 174(7CH)/177Q(7FH) is H-88-1 controlled disk
		01	Port 174(7CH)/177Q(7FH) is H/Z-47 disk
		10	Port 174(7CH)/177Q(7FH) is Z-67 disk
		11	Port 270Q is H89-SSD-4MB
3,2	{	00	Port 170(78H)/173Q(7BH) is Z-89-37 controlled disk
		01	Port 170(78H)/173Q(7BH) is H/Z-47 disk
		10	Port 170(78H)/173Q(7BH) is Z-67 disk
		11	Port 270Q is H89-SSD-4MB

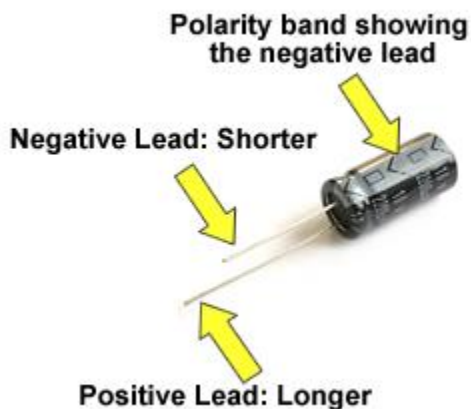
H89-SSD 4MB Board Assembly

() – A soldering iron drawing **30W** is plenty powerful for this job. Don't go any higher or else you'll risk damage to the board and/or components. Make sure you have a narrow tip.

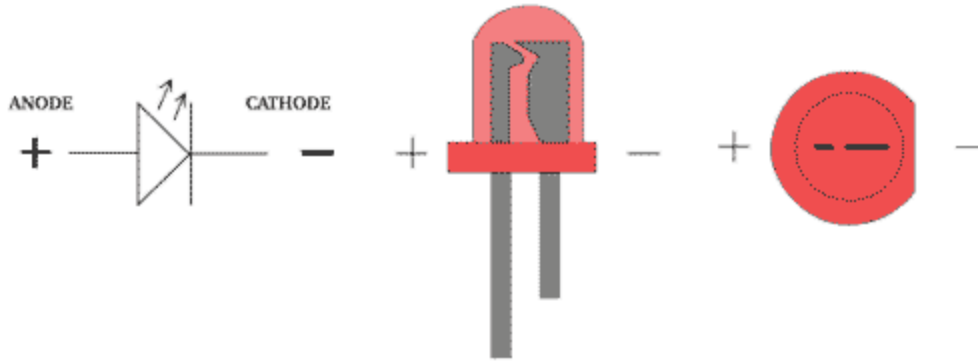
() – Latest BOM is at the following website; [BOM](#)

() – Solder 0.1uF, 50V capacitors (C23, C8, C9, C10, C11, C12, C13, C14, C15, C24, C25, C26, C27, C16, C20, C19, C6, C17, C22, C21, C7, C3)

() – Solder Ferrite Bead EMI Filter (L1, L2)



() – Solder 22uF cap (observed polarity) (C1, C2, C4, C5, C18, C28)



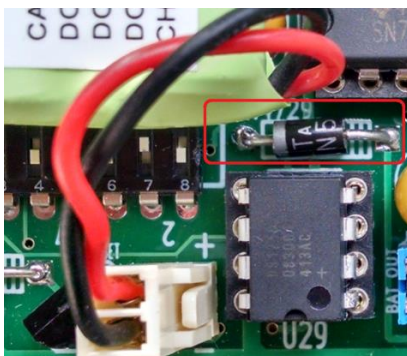
() – ~~Solder Diode Schottky 40 Volt 1A (D2, D9).~~ **Update:** Solder a 1N5819 Schottky Diode at position R10 (100R 1W) position as shown below and at the “D9” position.



() – ~~Solder 3.6 Volt diode (D8, D10).~~ **Update:** Solder a 1N5819 Schottky Diode instead at position D8 as shown below. Please note the new direction when inserting the **1N5819 Schottky Diode**.



() – If installing an external battery to the board proceed to solder a 1N5819 Schottky Diode at the D10 position as shown below. Do not install the 3.6 zener diode. Please note the new direction when inserting the **1N5819 Schottky Diode**.

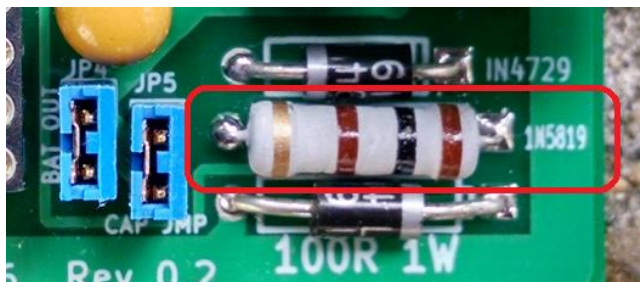


H89-SBC-SSD 4MB HARD DRIVE CONTROLLER

- () – Solder RED LED (D4 Power)
- () – Solder GREEN LED (D5, D6, D7 – BANK SELECT)
- () – Solder BLUE LED I/O (D1)

<u>Resistor Band Color Reference</u>				
<i>Color</i>	<i>Band 1</i>	<i>Band 2</i>	<i>Multiplier</i>	<i>Tolerance</i>
Black	0	0	x 1	not used
Brown	1	1	x 10	not used
Red	2	2	x 100	not used
Orange	3	3	x 1000 = 1K	not used
Yellow	4	4	x 10000 = 10K	not used
Green	5	5	x 100000 = 100K	not used
Blue	6	6	x 1000000 = 1M	not use
Violet	7	7	not used	not used
Gray	8	8	not used	not used
White	9	9	not used	not used
Gold	not used	not used	divide by 10	±5%
Silver	not used	not used	divide by 100	±10%
None	not used	not used	not used	±20%

- () – Solder 1k Ohm 1/4 Watt (R1, R2, R4, R12)
- () – Solder 680 Ohm 1/4 Watt (R5, R7, R8, R9, R11)
- () – Solder 150 Ohm 1/4 Watt (R14)
- () – Solder 2k Ohm 1/4 Watt (R6, R13)
- () – Solder 100 Ohms 1W (R10). **Update:** Solder a 100 Ohms 1W resistor at location “D2” (1N5819) instead as shown below.

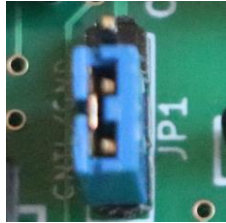


H89-SBC-SSD 4MB HARD DRIVE CONTROLLER

() – Solder 10 Pin 10k Ohm 2% Bussed Resistor (Observed pin1 for proper installation) (RP2)

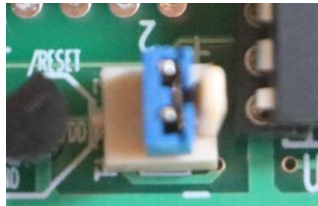


() – Solder 3 pin header (JP1)

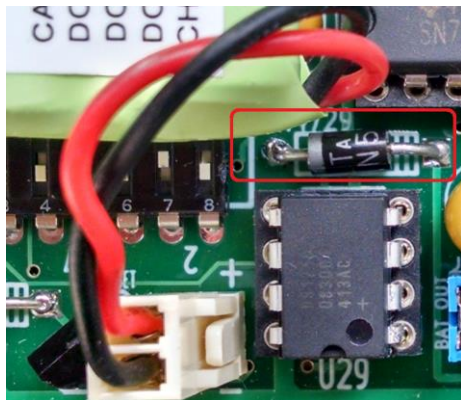


() – Solder 2 pin header (JP2, JP3, JP4, JP5)

() – Solder VBattery 2-pin header (External Bat) and insert jumper (*insert jumper only if not using an external battery and if diode D10 (1N4729-1N5819 Schottky Diode) is not installed.*)

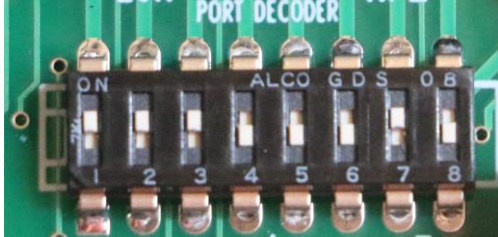


✓ Please note the new direction when inserting **1N5819 Schottky Diode**.



H89-SBC-SSD 4MB HARD DRIVE CONTROLLER

() – Solder 8 pin dip switch (SW2)



() – Solder TL7757CLP



() – Solder P1 (10 PIN MB Connectors) and P2 (25 PIN MB Connectors) female connectors.



() – Solder 8 PIN IC SOCKET, 8PIN

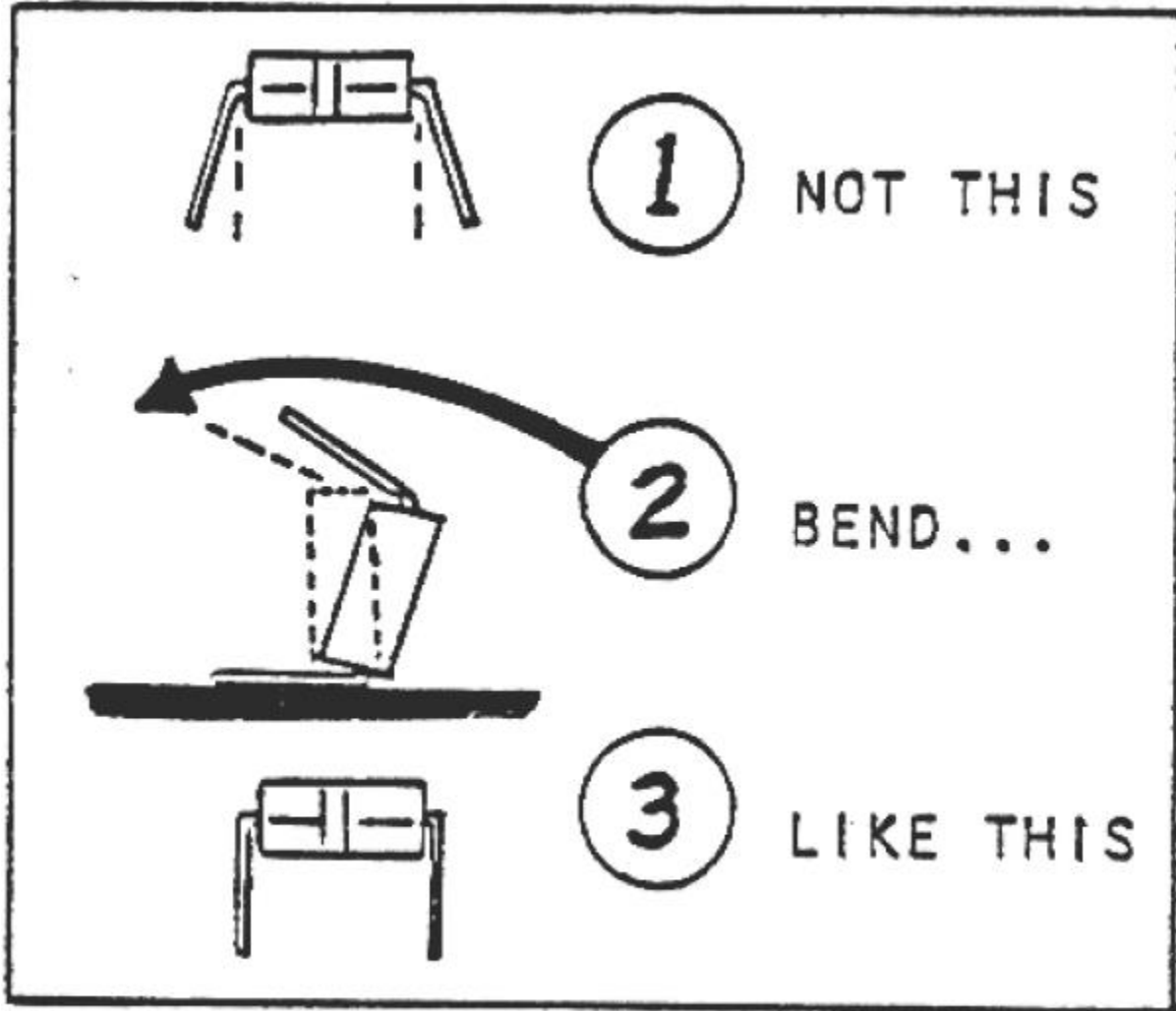
() – Solder all IC SOCKET, 14PIN

() – Solder all IC SOCKET, 16PIN

() – Solder all IC SOCKET, 20PIN

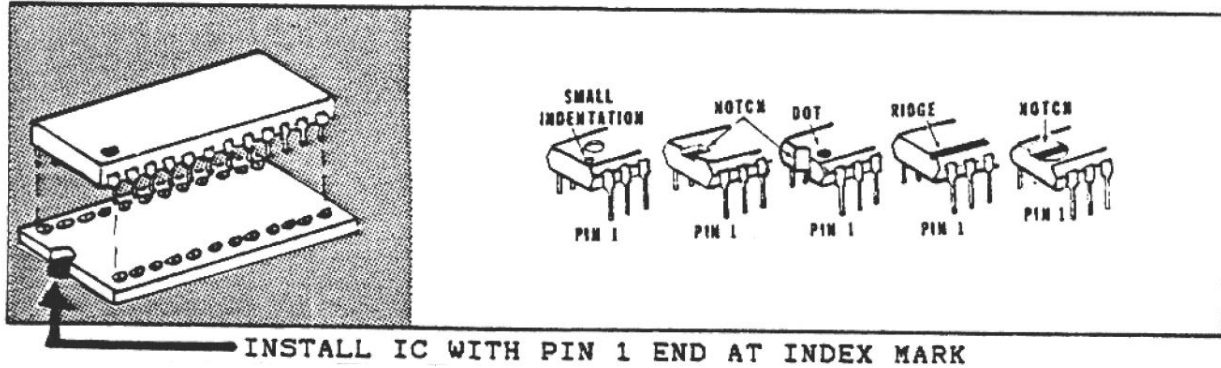
() – Solder all IC SOCKET, 32PIN

() – Straighten any bend pins on the IC's. The pins should be parallel to each other and at right angles to the case. Some IC's may have their pins spread out slight as shown below. If so, align the pins by gently pressing against a table top and bending as shown below.



STRAIGHTEN THE LEADS

() – When installing the IC's, align the notch and/or dot with the index mark on the board as shown below. Be sure all the pins enter the holes of the socket, and then press the IC into its socket.



- () – Install U17 – 74LS175
- () – Install U28 – 74HC138
- () – Install U24 – 74HCT138
- () – Install U1, U2, U3, U4, U5, U6, U7, U8 - AS6C4008-55PIN - SRAM 512K X 8
- () – Install U29 – DS1210
- () – Install U26 – 74HCT02
- () – Install U27 – 74HCT14
- () – Install U21 – 74HCT74
- () – Install U22 – 74HCT32
- () – Install U25 – 74HCT245
- () – Install U23 – 74HCT688
- () – Install U18, U19, U20 – 74HCT574

H89-SSD 4 MB Board Assembled



H89-SSD Power-on Tests

Insert the H89-SSD board only into the H89-SBC slots labeled **“USER I/O BOARDS”**. Failure to comply with this request might damage the board. ***Please do not install this board into the H89 computer right slots backplane.***

✓ Download the following files into a bootable H17/Z37 diskette or H67 Hard drive:

1. TESTSSD.ABS – [LINK HERE](#)
2. TESTBAT.ABS – [LINK HERE](#)
3. SD.DVD – [LINK HERE](#)
4. INITS.ABS – [LINK HERE](#)
5. LABELSSD.ABS – [LINK HERE](#)

Note: Refer to the following document written by Dan Emrick for details on the H89-SSD Operation: [H89-SBC SSD](#)

H89-SBC-SSD 4MB HARD DRIVE CONTROLLER

- ✓ Power-off the H89-SBC computer
- ✓ Insert H89-SSD board into the H89-SBC computer on slots labeled **"USER I/O BOARDS"**.
- ✓ Replace ROM with new MTR90 Monitor that supports the H89-SSD board
- ✓ Power-on the H89-SBC computer
- ✓ At the monitor type the following:

- H: Out 273,070
 - Note: All BANK LEDs ON



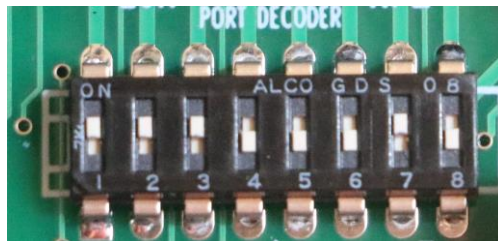
- H: Out 273,050
 - Note: D4 and D6 "ON".



- H: Out 273,000
 - Note: All BANK LEDs OFF



- If issues, check SW2 for proper settings (270Q)



- ✓ Boot the floppy drive or hard drive that contains the above files

SYSTEM HAS 56K OF RAM

HDOS Y2K Ver 2.0

Issue # 50.06.00

H89-SBC-SSD 4MB HARD DRIVE CONTROLLER

Date (10-Aug-16)?

Volume 001, Mounted on SY0:

Label: HDOS 2.0 (Y2K, SSM2, 2/4 MHZ) -- ASM SYSTEM

=>

- ✓ Type testssd at the HDOS prompt

TESTSSD - Test RAM on "Disk I/O 4MB SSD Board"

Version 1.5

By Stanley K. Webb - March, 2016

TESTSSD is using base PORT 270Q to test RAM on "Disk I/O 4MB SSD Board"

Press CTL+C to exit program, or any key to start test.

Testing...

BANK0 RAM Chip (U1) - TESTED OK!

BANK1 RAM Chip (U2) - TESTED OK!

BANK2 RAM Chip (U3) - TESTED OK!

BANK3 RAM Chip (U4) - TESTED OK!

BANK4 RAM Chip (U5) - TESTED OK!

BANK5 RAM Chip (U6) - TESTED OK!

BANK6 RAM Chip (U7) - TESTED OK!

BANK7 RAM Chip (U8) - TESTED OK!

NOTE: All RAM on board should begin in BANK0 (U1) and continue upwards with no gaps between RAM chips.

Note: If the above test fails, then check all the jumpers and switch settings. Check for cold solder joints or missed pins that were not soldered. Also verify that all IC's are in the correct sockets. Check for bend pins under the IC's, etc...

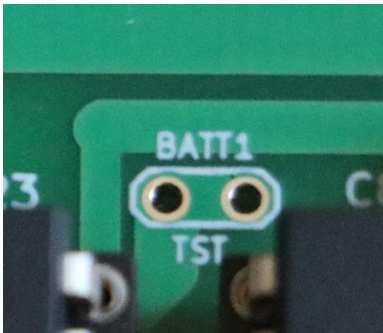
- ✓ Power-down the H89-SBC computer.
- ✓ Remove the H89-SSD board
- ✓ Before soldering the on-board battery, measure the voltage to be at least 3.6 volts. If not, this is an indication that the battery is old or that cannot hold its charge which is going to lead to future issues. ***Please make sure the battery is new and fully charged.***

H89-SBC-SSD 4MB HARD DRIVE CONTROLLER

- ✓ Solder the Varta 3/V80H 2 Pin 3.6V 80mAh NiMH Battery or equivalent battery.



- ✓ Insert H89-SSD board into the H89-SBC computer on slots labeled "**USER I/O BOARDS**".
- ✓ **A1:** Power-on the H89-SBC and wait two minutes for the DS1210 - Nonvolatile Controller to sync-up with the battery voltage.
- ✓ Power-down the H89-SBC computer and measure from "BATT1" test point to ground to about 3.6 volts. If voltage is 0.0V, then repeat above "**A1:**" step.



Note: When the batteries are first attached to one or both of the VBAT pins, VCCO will not provide battery back-up until VCCI exceeds VCCTP, as set by the TOL pin, and then falls below VBAT.

- ✓ Power-on the H89-SBC computer and boot HDOS from the floppy drive or hard drive
- ✓ Type testssd at the HDOS prompt

TESTSSD - Test RAM on "Disk I/O 4MB SSD Board"

Version 1.5

By Stanley K. Webb - March, 2016

TESTSSD is using base PORT 270Q to test RAM on "Disk I/O 4MB SSD Board"

Press CTL+C to exit program, or any key to start test.

Testing...

BANK0 RAM Chip (U1) - TESTED OK!
BANK1 RAM Chip (U2) - TESTED OK!
BANK2 RAM Chip (U3) - TESTED OK!
BANK3 RAM Chip (U4) - TESTED OK!
BANK4 RAM Chip (U5) - TESTED OK!
BANK5 RAM Chip (U6) - TESTED OK!
BANK6 RAM Chip (U7) - TESTED OK!
BANK7 RAM Chip (U8) - TESTED OK!

NOTE: All RAM on board should begin in BANK0 (U1) and continue upwards with no gaps between RAM chips.

- ✓ Power-down the H89-SBC computer and wait around 3 minutes.
- ✓ Power-on the H89-SBC computer and boot HDOS from the floppy drive or hard drive
- ✓ Type the following at the HDOS prompt: testbat

TESTBAT - Test Data Retention on "Disk I/O 4MB SSD Board"
Version 1.6
By Stanley K. Webb - April, 2016

To use this program, first run TESTSSD.ABS to get RAM into known state, then power down system for a period of time. Then boot up system and run this program to check data retention of battery backed RAM on SSD board.

TESTBAT is using base PORT 270Q to test RAM on "Disk I/O 4MB SSD Board"
Press CTL+C to exit program, or any key to start test.

Testing...

BANK0 RAM Chip (U1) - TESTED OK!
BANK1 RAM Chip (U2) - TESTED OK!
BANK2 RAM Chip (U3) - TESTED OK!
BANK3 RAM Chip (U4) - TESTED OK!
BANK4 RAM Chip (U5) - TESTED OK!
BANK5 RAM Chip (U6) - TESTED OK!

BANK6 RAM Chip (U7) - TESTED OK!

BANK7 RAM Chip (U8) - TESTED OK!

NOTE: All RAM on board should begin in BANK0 (U1) and continue upwards with no gaps between RAM chips.

- ✓ *If the battery circuit is working fine the above tests should pass. If not check all jumpers to be in the correct position. If the battery voltage is at 1.5V, the data on the RAM will be lost. Let the board circuit charge the battery if voltage is below 2V and repeat above tests after the battery is fully charged.*
- ✓ This completes the verification of the hardware.
- ✓ Done! 😊

Installing HDOS into the H89-SSD

- ✓ Boot HDOS from the floppy drive or hard drive that contains the H89-SSD driver and utilities.
- ✓ Type inits at the HDOS prompt to initialize all 4-SSD's on the board
 - =>**inits**
 - INITSSD3 - initialize 4 SSD drives each 1 MB.
 - Version 2.1, May 31, 2016
 - High mem. = 50411, Buffer = 10827, # bytes = 39424, # sectors = 154

 - This unit is operating at 4 MHz

 - INITIALIZE SSD?? <Y>

 - Initializing SSD
 - Now loading SD.DVD
 - SD.DVD - 4 drives, 1 MB each using port 270Q
 - Volume 001, Mounted on SD0:
 - Label: 1st 1MB SSD
- ✓ Type sysgen *.* at the HDOS command prompt to sysgen drive **SD3**:
 - =>**sysgen *.***

SYSGEN

Version: 2.0

Issue: #50.06.00

Destination Device<SY0:>? **SD3:**

Dismounting All Disks:

Volume 001, Dismounted from SD3:

Label: 1st 1MB SSD

Volume 001, Dismounted from SY0:

Label: HDOS 2.0 (Y2K, SSM2, 2/4 MHZ) -- ASM SYSTEM

Remove the Disk(s). Hit RETURN when ready:

Insert the Source Diskette in SY0:. Hit Return when Ready:

Insert the Destination Diskette in SD3:. Hit Return when Ready:

84 Files Copied

Install a bootable disk in SY0:. Hit RETURN to reboot:

- ✓ Reboot HDOS and repeat same process for SD0, SD1, & SD2.
- ✓ Power-down the H89-SBC system and wait about 1 minute.
- ✓ Now let's boot from **SD3:**

H: Boot3

Booting H89-SSD-4MB CTRL

SYSTEM HAS 56K OF RAM

HDOS Y2K Ver 2.0

Issue # 50.06.00

Date (05-Jun-13)?

SD.DVD - 4 drives, 1 MB each using port 270Q

Volume 004, Mounted on SY0:

Label: 4th 1MB SSD

=>

Note: At 10MHz it takes about 3 seconds to boot HDOS.

Changing the labels on the H89-SSD hard drives

Boot HDOS from the floppy drive or hard drive that contains the H89-SSD driver and utilities

- ✓ Type `labelssd` at the HDOS prompt if you have a need to change the label
=>**labelssd**

SSD re-label program

NOTICE: Cannot be used to change
a floppy label,
only an SSD label.

Change which device? (0, 1, 2, 3): 3

Current volume number is 004.

Current label is: "4th 1MB SSD"
"

Change (V)olume Number, (L)abel, or (E)xit? (V/L/E) :

Change label

Enter new label: Norby

New label is: NORBY

Is this correct? (Y/N) y

Label changed.

Change (V)olume Number, (L)abel, or (E)xit? (V/L/E) :

Change which device? (0, 1, 2, 3): 3

Current volume number is 004.

Current label is: "NORBY"

Change (V)olume Number, (L)abel, or (E)xit? (V/L/E) :v

H89-SBC-SSD 4MB HARD DRIVE CONTROLLER

Enter new volume number: 6

Change (V)olume Number, (L)abel, or (E)xit? (V/L/E) :

Change which device? (0, 1, 2, 3): 3

Current volume number is 006.

Current label is: "NORBY"

Change (V)olume Number, (L)abel, or (E)xit? (V/L/E) :v

Enter new volume number: 4

Change (V)olume Number, (L)abel, or (E)xit? (V/L/E) :

Change which device? (0, 1, 2, 3): 3

Current volume number is 004.

Current label is: "NORBY"

Change (V)olume Number, (L)abel, or (E)xit? (V/L/E) :l

Change label

Enter new label: 4th 1MB SSD

New label is: 4TH 1MB SSD

Is this correct? (Y/N) y

Label changed.

Change (V)olume Number, (L)abel, or (E)xit? (V/L/E) :

Change which device? (0, 1, 2, 3): 3

Current volume number is 004.

Current label is: "4TH 1MB SSD"

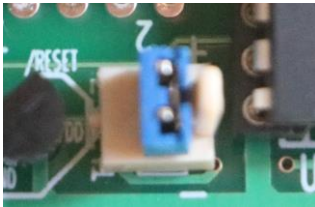
Change (V)olume Number, (L)abel, or (E)xit? (V/L/E) :e

=>

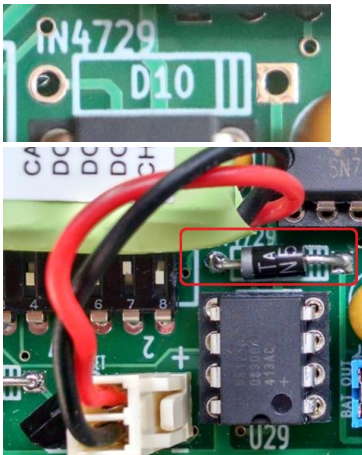
External Battery Support

The board will support an external battery as well. When the on-board battery is below certain voltage threshold the secondary or external battery will be enabled to keep the data on the RAM secure. **Note:** The DS1210 controller provides an internal isolation switch which allows the connection of two batteries. During battery backup operation the battery with the highest voltage is selected for use. If one battery should fail, the other will take over the load. The switch to a redundant battery is transparent to circuit operation and to the user. A battery status warning will occur when the battery in use falls below 2.0 volts.

- ✓ Remove jumper from Battery connector



- ✓ Solder diode 1N4729 (D10) or equivalent. **Update:** Solder a 1N5819 Schottky Diode at the D10 position as shown below. Please note the new direction when inserting the diode.



- ✓ Insert external battery. Observed polarity + (red cable) and – (black cable).

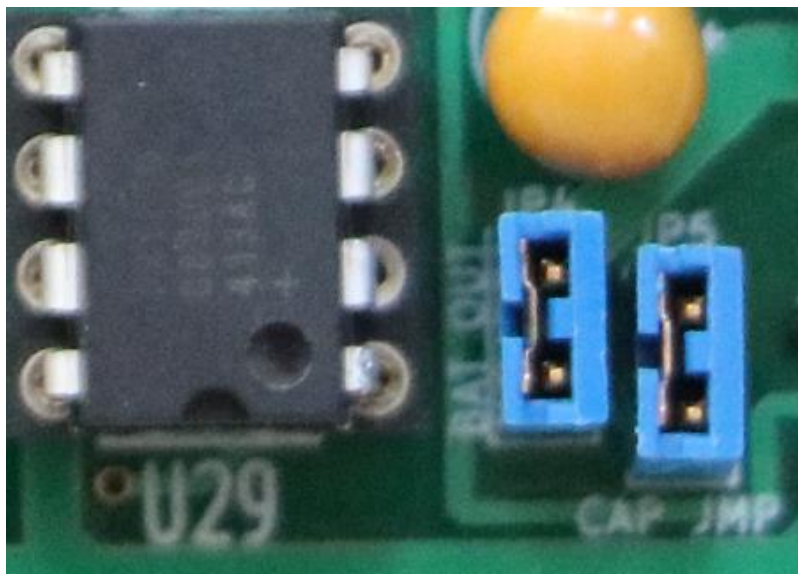


- ✓ Insert H89-SSD board into the H89-SBC computer on slots labeled "**USER I/O BOARDS**".
- ✓ Power-on the H89-SBC and wait two minutes for the DS1210 - Nonvolatile Controller to sync-up with the battery voltage.
- ✓ Power-down the H89-SBC computer and wait about a minute.
- ✓ Power-on the computer and enjoy booting HDOS at very high speeds.
- ✓ This completes the setup. 😊

Removing/Inserting RAM IC's when Battery Present.

Once the on-board battery is installed, the user must adhere to the following procedure to ensure that the RAM IC's are not damaged.

Before removing or inserting any RAM IC's be sure that JP4 and JP5 are removed. Also remove the external battery if present. Then proceed to insert JP4 and JP5 and the external battery once the procedure has been completed.



Battery Trickle Charge

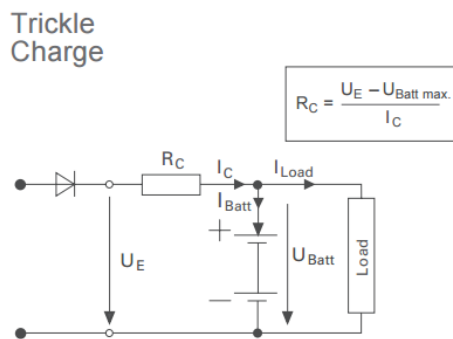
The battery charge circuit is based on the following trickle charge circuit. This board requires the use of batteries which are maintained in a fully charged condition as long the H89-SBC is on. In order to compensate the loss of capacity a trickle charge circuit is implemented.

$R_C = 100$ ohms

$U_E = 4.5$ volts

Max current = 4.5 volts/100 Ohms = 45ma

Nominal current = (4.5 volts – 3.6 volts)/100 Ohms = 9ma



Known Limitations

- ✓ Does not support CP/M at this time.
- ✓ If booting from the H89-SSD do not run the "INIT.ABS" utility to format for example a floppy drive. Always boot from the H17/Z37/H67 to run the "INIT.ABS" utility.
- ✓ Booting rom HDOS 3.0 is not supported at this time. However if you boot HDOS 3.0 from the H17/Z37/H67 you can mount all four SSD's drives without any issues and transfer files over if needed.

Always backup your data

As this is a RAM based solid state drive, it is important to always backup your "priceless" data in case the H89-SBC is not powered-on for an extended period of time.