NorthStar Computers Inc.
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North Star
16K Ram Board

RAM-16-DOC
Revision 2

Table of Contents

REVISION 2

INTRODUCTION

The North Star 16K byte RAM board (RAM-16-A) is compatible with S-100 computers. The board will operate at full speed with both 8080 and Z80 microcomputers, even with 4 MHz operation. The industry standard 16-pin 4027 RAM chip (200 nanoseconds access) is used. A parity option is available for use with the RAM-16-A. The RAM-16-A may be addressed to any 16K region beginning at any 8K boundary. The RAM-16-A has a bank switching feature which allows more than 64K bytes of RAM to be used in the computer, and also facilitates special software applications such as time-sharing.

If you have purchased the RAM-16-A as a kit, then first skim the entire manual. Be sure to carefully read the Assembly Information section before beginning assembly. If you have purchased the RAM-16-A in assembled form, you may skip the Assembly section. Regardless of whether you purchased the RAM-16-A as a kit or assembled, be sure to read the Configuration section which discusses how to configure the RAM-16-A for each individual application.

CAUTIONS

1. Correct this document from the errata sheets, if any before doing anything else.

2. Assembly of this product from a kit is a complex, demanding project. It should not be attempted without previous kit building experience.

3. Do NOT insert or remove any boards from the computer when the power is on. Note that power is not completely off until the capacitors have discharged, several seconds after turning off the computer power switch.

4. Do NOT insert or remove IC's from any board while the power is turned on.

5. Be sure that all IC's are inserted in their correct positions and with correct orientation before turning on the power. Be sure that all IC pins are correctly inserted in the socket and are not bent under the IC and are not outside the socket.

6. Carefully observe the prescribed rules for handling the MOS type integrated cirucits. The handling procedures are described in the Assembly Information section of this manual.

LIMITED WARRANTY

North Star Computers, Inc. warrants the electrical and mechanical parts and workmanship of this product to be free of defects for a period of 90 days from date of purchase. If such defects occur, North Star Computers, Inc. will repair the defect at no cost to the purchaser. This warranty does not extend to defects resulting from improper use or assembly by purchaser, nor does it cover transportation to the factory. Also, the warranty is invalid if all instructions included in the accompanying documentation are not carefully followed. Should a unit returned for warranty repair be deemed by North Star Computers, Inc. to be defective due to purchaser's action, then a repair charge not to exceed $30 without purchaser's consent will be assessed. ANY UNIT OR PART RETURNED FOR WARRANTY REPAIR MUST BE ACCOMPANIED BY A COPY OF THE ORIGINAL SALES RECEIPT. This limited warranty is made in lieu of all other warranties, expressed or implied, and is limited to the repair or replacement of the product. No warranty, expressed or implied, is extended concerning the completeness, correctness, or suitability of the North Star equipment for any particular application. There are no warranties which extend beyond those expressly stated herein.

OUT OF WARRANTY REPAIR

If your unit is out of warranty and you are unsuccessful at diagnosing or repairing the problem, out-of-warranty service may be arranged with a local dealer or other experienced local computer technician. Alternatively, any North Star products may be shipped PREPAID to the North Star address with a clear written description of the problem. Include as many details as possible about the problem and about your system configuration. Your unit will be returned, C.O.D., within 30 days after receipt by North Star. Out-of-warranty repair service is billed at the rate of $25.00 per hour. If you wish to place an upper limit on the amount of time spent on your unit, mention this in the written description.

RAM-16-A PARTS LIST

1	RAM-16-A Manual
1	RAM-16-A printed circuit board, 5" x 10"
2	20-pin IC sockets
39	16-pin IC sockets
21	14-pin IC sockets
1	14-pin DIP header
1	8-position DIP switch
1	delay line, DDU-4-7781 or STTLDM-400
1	+5 volt regulator, 7805 or 340T-5
1	+12 volt regulator, 7812 or 340T-12
1	-5 volt regulator, 79L05
1	heat sink, 6106B-14
1	heat sink, 6107B-14
2	6-32x3/8" machine screws
2	#6 lock washers
2	6-32 nuts

Integrated Circuits

2	74LS00
1	74LS02
1	74LS08
1	74LS13
2	74LS14
1	74LS30
1	74LS74
1	74LS75
1	74LS123 (or 74123)
2	74LS132
1	74LS241
3	74LS352
1	74LS373
1	74LS393 (or 74393)
1	7402
1	74S00
2	74S10
1	74S30
1	74S74
1	74S113
1	74S138
1	74S175
32	4027-3 (MOS)

Resistors

8	2.2K ohm	1/4W	red-red-red
1	220 ohm	1/4W	red-red-brown
3	330 ohm	1/4W	orange-orange-brown
1	470 ohm	1/4W	yellow-violet-brown
1	10K ohm	1/4W	brown-black-orange
1	18K ohm	1/4W	brown-gray-orange
8	22 ohm	1/4W	red-red-black
	4.7K ohm resistor network, 10-pin		

Capacitors

2	.0047uF	dipped mylar
1	33pF	dipped mica (may be marked "330J03"
3	47pF	ceramic disc
1	100pF	dipped mica
5	6.8uF	dipped tantalum
2	2.2uF	dipped tantalum
60	.047uF	ceramic disc

PARITY OPTION PARTS LIST

1	74LS109 IC
2	74LS280 IC
1	75452 IC (8-pin)
4	4027-3 IC (MOS)
5	16-pin IC sockets
2	14-pin IC sockets
1	8-pin IC socket
1	220 ohm 1/4W resistor (red-red-brown)
1	LED

ASSEMBLY INFORMATION

Read completely through each section before beginning the first instruction step of that section. Perform all operations in the sequence indicated. Read each step entirely, including any notes that accompany the step, before beginning to follow the step.

WORK AREA AND TOOLS

Start with a clean, well-lit and well-ventilated area to work. The area should be large enough to accommodate the kit, tools, parts and assembly instructions. Suggested tools are: screwdrivers, needle-nose pliers, diagonal cutters, soldering iron, solder, and masking tape. A number of tests will require using a VOM (ohmmeter-voltmeter) or VTVM. Also highly desirable, but not necessary, are an IC inserter, a screw-holding screwdriver, an oscilloscope or logic probe, and an extender card. [Note that if you do not have an oscilloscope or logic probe, waveforms can be detected by one of the procedures described in Appendix 1.]

SOLDERING TIPS

For best results use a 15 to 25 watt soldering iron or an iron with a temperature controlled tip (approximately 700 degrees). The tip should be no wider than the solder pads on the printed circuit board. Use only a fine gauge rosin core solder (60/40 or 63/37). Do NOT use acid core solder as this can severely damage a printed circuit board. When soldering, keep the soldering iron tip on the pad just long enough for the solder to completely flow. If the solder does not draw up the wire then more solder is required. Do not use so much solder that it overflows the pad. If a solidified joint is not shiny, it may be a cold solder joint and should be remelted. The soldering iron tip should be cleaned frequently by wiping on a damp sponge

When you have completed assembly of a board, inspect it for unintended solder connections or "bridges", as well as unsoldered leads. After soldering, it is recommended that the rosin flux be removed from the board using flux remover, FREON or paint-thinner type solvent. This will make looking for soldering problems easier and give the board a clean, professional appearance.

IC SOCKET INSTALLATION

Integrated circuit (IC) sockets can be installed by first inserting them into the printed circuit board, then placing another flat board over the IC sockets and finally turning over this sandwich. Be sure that each IC socket is inserted into the proper location and is oriented such that pin 1 of the socket corresponds to the pin 1 indication on the PC board layout legend. (Refer to figure 1A to identify pin 1 on an IC socket.) To solder IC sockets, first solder just two opposite corner pins

for all sockets being installed. Then remelt the corner connections while applying pressure down on the board. This will remove any gaps that may be present between the IC sockets and the PC board. Finally, solder the remaining pins of the IC sockets.

DIP HEADER SOLDERING

When making jumper connections on a DIP header, solder resistor or capacitor lead snippings between the leads to be connected. When more than two pins are to be connected together, bend a single wire so that it routes to each pin, and solder each pin once. Insert the header in an IC socket on a PC board to hold it during soldering. Overheating the pins with the soldering iron will melt the plastic of the header. If there are multiple jumpers on a header, make sure that no unintended connections are made by carefully routing the jumpers, or by insulating each jumper with some wire insulation.

RESISTOR AND CAPACITOR INSTALLATION

To install resistors or capacitors, first make right angle bends in the leads to fit the PC board hole spacing. (Some capacitor leads are already appropriately spaced and do not need bending.) Then insert the leads as far as possible through the correct holes in the PC board and spread the leads slightly on the solder side of the board to keep the part in place. After a group of resistors or capacitors has been inserted, then solder the leads on the solder side of the board and snip off the excess leads as close to the board as possible. Use caution to avoid eye injury from flying bits of wire. Save the lead clippings for later use in making jumper connections.

PRINTED CIRCUIT BOARD LAYOUT

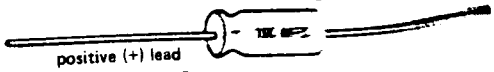
The white component layout legend is printed on the component side of a printed circuit (PC) board. All components are inserted from this side (component side) and soldered on the other side (solder side). Locations on the PC board are identified by two-character codes as marked on the board: a digit followed by a letter indicating the horizontal and vertical coordinates of the location. Note that in North Star kits, IC's can be found on styrene pads in positions corresponding to their intended locations on the PC board.

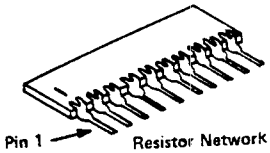
Pin numbering conventions for the S-100 edge pins are as follows: When viewing the component side of the board (with the pin edge facing down), pins 1,2, ... 50 range from left to right. When viewing the solder side of the board, pins 100, 99, ..., 51 range from left to right.

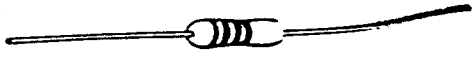
MOS INTEGRATED CIRCUIT HANDLING

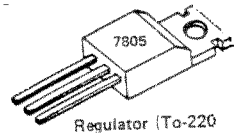
Some North Star PC boards use some MOS-type IC's. These parts are identified as such in the instructions. MOS devices can be damaged by static electricity discharge, so special handling is necessary to protect them. Handle MOS devices as little as possible and avoid touching the pins. Place the conductive foam or tube which contains the MOS device onto the PC board before removing the device from the foam or tube. Also, be sure both hands are touching the foam or tube when the device is removed from the foam or tube.

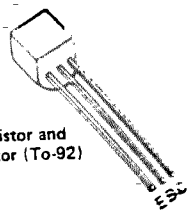
Once an MOS device has been installed in a PC board, handle the board as little as possible. Of course, never insert or remove any IC while power is applied to the board, and never remove or insert a PC board while power is applied to the motherboard.

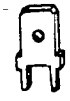


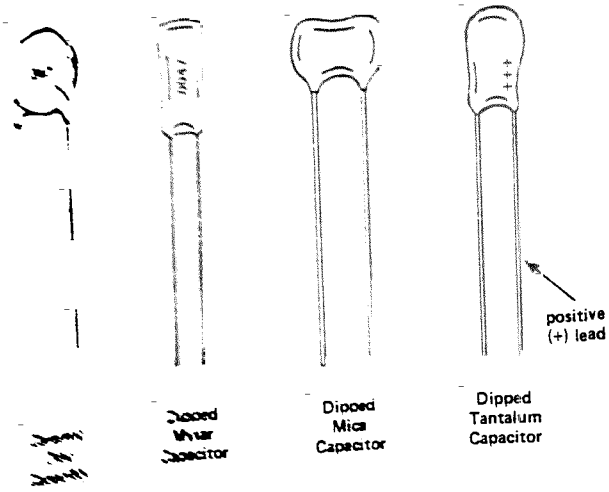


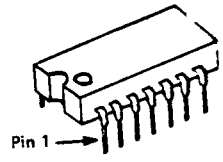




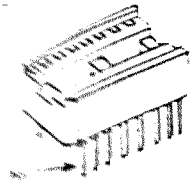




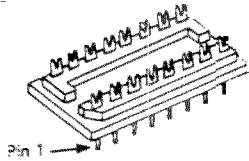




Integrated Circuit (IC:



Socket



DIP Header

orientation of components.

16K RAM BOARD

RAM BOARD ASSEMBLY

Before beginning assembly of the RAM board, first check that you have all the parts listed in the parts list. This manual applies to the RAM-16-A3 board revision - check the PC board marking to be sure you do not have a RAM-16-A2 board. Note that in the following instructions, "left" and "right" refer to those directions when viewing the component side of the PC board with the 100-pin connector facing down.

Using an ohmmeter, check for open circuits between the pair of solder pads for each of the following six capacitor locations: C1, C2, C3, C4, C5, and C6. If any shorts are found, locate and correct the problem or return the PC board for replacement.

Insert and solder the two 20-pin IC sockets at locations 8D and 17E on the PC board. Follow the procedure described in the Assembly Information section. Be sure the sockets are installed with the correct orientation (all the IC's have pin 1 toward the top of the board.

Insert and solder the thirty-nine 16-pin sockets with correct orientation. Do not install a socket at the switch position (7A). Do not install any sockets in the positions reserved for the parity option unless you will be assembling the parity option at this time. The parity option sockets are located at positions 3A, 9A, 9B, 9C, and 9D.

R4 Insert and solder the twenty-one 14-pin sockets with correct orientation. Do not install sockets at locations 10E or 15E, unless you are assembling the parity option at this time.

Now check all the solder joints for possible solder bridges between adjacent solder pads, unsoldered connections, or cold solder joints.

R6. Insert and solder the following resistors:

Resistor	Value	Size	Location	Color-code
( ) R1	2.2K	1/4W	0A	red-red-red
( ) R3	330	1/4W	2D	org-org-brn
( ) R4	2.2K	1/4W	7A	red-red-red
( ) R5	18K	1/4W	1A	brn-gry-org
( ) R6	470	1/4W	1B	yel-vio-brn
( ) R7	10K	1/4W	2A	brn-blk-org
( ) R8	2.2K	1/4W	7A	red-red-red
( ) R9	2.2K	1/4W	3D	red-red-red
( ) R10	330	1/4W	10E	org-org-brn
( ) R11	2.2K	1/4W	6A	red-red-red
( ) R13	2.2K	1/4W	5C	red-red-red

( )	R14	2.2K	1/4W	6C	red-red-red
( )	R15	2.2K	1/4W	1B	red-red-red
( )	R16	22	1/4W	8B	red-red-blk
( )	R17	22	1/4W	8B	red-red-blk
( )	R18	22	1/4W	8B	red-red-blk
( )	R19	22	1/4W	8B	red-red-blk
( )	R20	22	1/4W	8B	red-red-blk
( )	R21	22	1/4W	8B	red-red-blk
( )	R22	22	1/4W	8B	red-red-blk
( )	R23	22	1/4W	8B	red-red-blk
)	R24	330	1/4W	12E	org-org-brn

R7. Insert and solder the single-in-line (SIP) resistor network labeled RN1 on the layout legend at location 16E. Orient the SIP so the end marked with a "1" (sometimes this end has a beveled corner) corresponds to the end marked with a dot on the layout legend.

Save the resistor R12 (220 ohm, red-red-brn) for future special DMA applications. See the Special DMA Applications section for details. Note that the other omitted resistor, R2, is only installed with the parity option.

R8. Insert and solder the 8-position DIP switch at location 7A. Orient the switch so that "ON" is to the right. The DIP switch solders directly to the board without a socket.

R9. Install and solder the 5 volt 7805 regulator and 6106-14 heat sink (the larger of the two heat sinks) at location Q4. Neatly bend the regulator leads so they will route over the edge of the heat sink and down through the holes in the PC board without touching the heat sink or each other. Insert the regulator leads into the PC board holes and then attach the regulator and heat sink to the board with a 6-32x3/8" machine screw so that the following order results from bottom to top: machine screw head, PC board, heat sink, regulator, lock washer and nut. Before tightening the machine screw, position the heat sink regulator assembly as far as possible from the edge of the PC board. Finally, solder the regulator leads.

R10. Install and solder the 12 volt 7812 regulator and 6107-14 heat sink at location Q3. Follow the procedure of the previous step.

R11. Ins
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R12. Insert and solder the following tantalum capacitors, being careful to insert the + lead of each capacitor into the hole marked "+" on the layout legend. The + lead is sometimes indicated by a red dot on the capacitor. Refer to the

Assembly Information section for capacitor installation procedures.

Capacitor	Value	Location
( ) C1	2.2uF	ØA
( ) C2	2.2uF	ØA
( ) C3	6.8uF	ØB
( ) C4	6.8uF	ØB
( ) C5	6.8uF	ØD
( ) C6	6.8uF	ØD
( ) C11	6.8uF	8A

Insert and solder the following capacitors:

Capacitor	Value	Location	Type
( ) C7	.ØØ47uF	1A	dipped mylar
( ) C8	1ØØpF	1C	dipped mica
( ) C9	.ØØ47uF	2A	dipped mylar
( ) C12	47pF	2E	ceramic disk
( ) C13	47pF	12E	ceramic disk
( ) C14	47pF	12E	ceramic disk

R14. Insert and solder the sixty .Ø47uF ceramic disk capacitors at the 6Ø locations marked on the layout legend with asterisks.

Save the remaining 33pF capacitor (C1Ø) for special DMA applications. See the Special DMA Applications section for details.

Be sure the computer power is off and then insert the RAM-16-A board into the computer motherboard. Now turn on the power and check for the following voltages across each indicated pair of capacitor leads:

Capacitor	Voltage
( ) C5	+5V ±5%
( ) C3	+12V ±5%
( ) C1	-5V ±5%

Turn off the computer power. If any of the voltages are not correct, then locate and correct the problem before proceeding.

R17. Install the delay line module in the socket at location 5A. Orient the delay line so that pin 1 (indicated by a dot or "IN") is inserted in pin 1 of the socket.

R18. Install the 28 TTL integrated circuits (all but the memory IC's). Be careful to orient each IC so that pin 1 is

inserted into pin 1 of the socket.

	Location	IC
( )	1A	74LS123 (or 74123)
( )	1B	74LS13
( )	1C	74LS132
( )	1D	74LS14
( )	2A	74S175
( )	2B	74LS00
( )	2C	74LS14
( )	2D	74S74
( )	3B	74LS08
( )	3C	74LS132
( )	3D	74LS352
( )	4A	7402
( )	4B	74S30
( )	4C	74LS02
( )	4D	74LS352
( )	5B	74S113
( )	5C	74LS393
( )	5D	74LS352
( )	6A	74S138
( )	6B	74LS75
( )	6C	74LS74
( )	6D	74LS30
( )	7B	74S00
( )	7C	74LS00
( )	8A	74S10
( )	8C	74S10
)	8D	74LS241
)	17E	74LS373

Carefully following the MOS device handling procedures described in the Assembly Information section, install the thirty-two 4027 memory IC's. Be careful to orient each memory IC so that pin 1 is inserted into pin 1 of the socket. Since the capacitors cause a tight fit, it is easier to insert rows B and C before rows A and D.

Inspect the PC board to see that all the IC pins are properly inserted into the socket holes. Check that no pins are bent under the IC, and that no pins are outside the socket.

R21. If you are assembling the RAM-16-A board for use with the HORIZON computer, install the three "G" jumpers at locations 2E. 5E, and 6E by soldering with a piece of resistor snipping. If you have a different computer, it is strongly recommended that bus pins 20, 61, and 70 (if not used for other purposes) be connected to ground on the motherboard so that the "G" jumpers may be used on the RAM-16-A board. If all three jumpers cannot be used, use as many as possible.

Connecting these pins to ground will help reduce excessive ground noise on some S-100 computers.

Configure the 14-pin DIP header for location 7D as follows:

A. Connect pin 1 to pins 2 and 3.

B. Connect pin 6 to pin 7.

This configuration of the header is for use of the RAM-16-A board with a Z80 or Z80A microprocessor in an application where bank switching is not needed. For 8080 and/or bank switching use, configure the header as described in the Configuration and Using Bank Switching sections.

If this board is to be used with a processor board which sources POC/ (bus pin 99) as an indication that the processor is being reset (e.g., North Star, Imsai, Vector Graphics, Processor Technology) then skip this step. For use with other processors (e.g., Altair 8800), cut the trace connecting 3C pin 5 with 3C pin 4 on the solder side of the board, and add a jumper between PRESET/ (bus pin 75) and 3C pin 4 on the component side of the board.

The assembly of the RAM-16-A board (less parity option) is now complete. Proceed to the checkout section.

RAM BOARD CHECKOUT

The following checkout procedure should be followed for a newly assembled board. It can also be used to diagnose problems in previously operational boards.

The following terms are used in specifying expected test results:

GND	ground, 0 volts DC
LOW	logic zero, 0-.7 volts, normally about .3 volts
HIGH	logic one, 2.4-5.0 volts, normally about 3 volts
+5V	+5 volts from power supply
AC	Signal with pulses (as opposed to DC signal)

When referring to the name of a signal from the schematic drawings, if the signal is identified with a bar over its name, then the name is followed by a slash (e.g., STORE/) in the checkout instructions. When describing an AC pulse, the notation ($\pm$W,P) refers to a positive or negative pulse with a width of W appearing with a period of P. For example, a positive pulse with width 120 nanoseconds appearing every 25 microseconds would be described as (+120ns,25us). See Appendix 1 for details on how to detect pulse signals.

If an oscilloscope will be used to test the board, a "scope gound" may be installed by soldering a "bridge" of jumper wire between two of the three PC board holes that connect edge connector pins 50 and 100 near location 13E. Note that either of the two regulator machine screws can also be used for ground test points.

C1. If your S-100 bus computer has a control panel, then check out control panel operation of the RAM-16-A as described in this step. Otherwise, skip to step C2.

   A. Set the address select switches for the region where the RAM-16-A will be used (refer to the Configuration section for details).

   B. With the computer power off, install the RAM-16-A board into the motherboard.

   C. Using the control panel, attempt to deposit the zero value in the first byte of each 4K address region on the board. Then examine these addresses. If the values examined are not all zero, then skip to step C3. Otherwise, continue at step C2.

C2. If you do not already have a working computer, then skip to step C3. Otherwise, set the address select switches for an available 16K address region (see the Configuration section). Then, with the computer power off, install the RAM-16-A board into the computer motherboard. Now use a

memory test program to verify correct operation of the board. If you do not have a memory test program (such as the TM command in the North Star Monitor), then use the program listed in Appendix 2.

If the RAM-16-A does not fail the memory test after several hours of operation, then the board is operational and you may skip the remaining checkout steps. If systematic data or addressing errors are detected, then refer to the schematic drawings to diagnose and correct the problem. (The correspondence between addresses and RAM chips is given in Appendix 3.) If the RAM-16-A does not operate at all, then continue with step C3.

Set the address switches labeled "2" and "3" on the DIP switch (2nd and 3rd from the top) to the "ON" position. The other six switches should be OFF. With the computer power off, install ONLY the processor board and the RAM-16-A into the computer motherboard. Turn on the power and depress and hold down the computer reset switch so that no memory requests are being made.

A. Check the following memory cycle request signals while the computer reset switch is depressed:

Signal	Location	Description
STORE/	4B pin 5	HIGH
INSTRUCTION-FETCH/	4B pin 11	HIGH
FETCH/	4B pin 6	HIGH
RUNNING-REFRESH/	6C pin 6	HIGH
DEPOSIT-CY/	4B pin 4	HIGH

If the signals are not as listed then refer to the schematic drawings and trace backwards to locate and correct the problem.

B. WAITING-REFRESH cycles should occur approximately every 25 microseconds. In the following table, let T refer to the period of PHI 2 in your computer (e.g., 250ns with a 4MHz processor and 500ns with a 2MHz processor). Check the following signals while the computer reset switch is depressed:

Signal	Location	Description
WRF	2A pin 3	AC, (+T,25us)
WAITING-REFRESH/	1C pin 12	AC, (-T,25us)
CYCLE-START	4B pin 8	AC, (+T,25us)
delay tap T1	5A pin 12	AC, (+T,25us)
delay tap T2	5A pin 4	AC, (+T,25us)
delay tap T3	5A pin 10	AC, (+T,25us)
delay tap T4	5A pin 6	AC, (+T,25us)

delay tap T5	5A pin 8	AC, (+T,25us)
CYC-END/	8C pin 6	AC, (-T-135ns,25us)
RAS-A/	9A pin 4	AC, (-T-40ns,25us)
RAS-B/	9B pin 4	AC, (-T-40ns,25us)
RAS-C/	9C pin 4	AC, (-T-40ns,25us)
RAS-D/	9D pin 4	AC, (-T-40ns,25us)
chip address bit 0	9A pin 5	AC, see note
chip address bit 1	9A pin 7	AC, see note
chip address bit 2	9A pin 6	AC, see note
chip address bit 3	9A pin 12	AC, see note
chip address bit 4	9A pin 11	AC, see note
chip address bit 5	9A pin 10	AC, see note

Note: Sometimes (+T,25us) and sometimes (+T-90ns,25us)

If the signals are not as listed, then refer to the schematic drawings and trace backwards to locate and correct the problem.

C4. Use the same setup as step C3. If the computer includes an auto-jump capability, then it should be set to jump to some address outside of the range 2000 hex through 5FFF hex (for example, E800 hex or 0). If the processor board has a PROM option at address 0, it should be disabled for this step. With the computer power on, depress and release the reset switch. The processor should repeatedly execute RST 7 instructions (FF hex) from address 38 hex. This should cause memory store requests to all addresses (resulting from the RST instruction stack pushes). Check the following signals:

Signal	Location	Description
INSTRUCTION-FETCH/	4B pin 11	AC, (-220ns,11T)
FETCH/	4B pin 6	AC, see note 1
STORE/	4B pin 5	AC, (-220ns twice,11T)
RUNNING-REFESH/	6C pin 6	AC, (-260ns,11T)
RAS-A/	9A pin 4	AC, see note 2
RAS-B/	9B pin 4	AC, see note 2
RAS-C/	9C pin 4	AC, see note 2
RAS-D/	9D pin 4	AC, see note 2
chip write enable	9A pin 3	AC, (-220ns twice,11T)
CAS-A/	9A pin 15	AC, (-210ns thrice,11T)
CAS-B/	9B pin 15	AC, (-210ns thrice,11T)
CAS-C/	9C pin 15	AC, (-210ns thrice,11T)
CAS-D/	9D pin 15	AC, (-210ns thrice,11T)

Note 1: -100ns,11T) with Z80A, -210ns,11T) with 8080.

Note 2: Sometimes (-225ns,11T) and sometimes (-225ns twice,11T).

If the signals are not as listed, refer to the schematic

This step will test the memory fetch and store operations by forcing the computer to execute alternating RST 7 and MOV A,A instructions repeatedly.

A. Set the address select switches labeled "1" and "2" on the DIP switch (1st and 2nd from top) to the ON position. The other six switches should be OFF.

B. With the power off, remove the 74LS373 IC from location 17E of the RAM board. (This disconnects the RAM-16-A from the DI bus.)

C. With a piece of jumper wire, make a temporary solder connection between 17E pin 15 (DI7) and 5D pin 6 (AØ) on the solder side of the RAM-16-A.

D. If the processor board has a PROM option, it should be disabled for this step.

E. With the power off, install ONLY the processor board and the RAM-16-A board in the computer motherboard.

F. Turn on the computer power. The repeated executions of the RST 7 instruction should fill the entire RAM-16-A board with alternating bytes containing 3A hex and ØØ (resulting from the stack pushes of the RST instruction).

G. Check the following signals at the memory chip at location 1ØD:

Signal	Location	Description
Vbb	1ØD pin 1	-5V
DI	1ØD pin 2	mostly HIGH, LOW during first PWR
WE/	1ØD pin 3	AC, two pulses, one during each PWR
RAS/	1ØD pin 4	AC, see note 1
AØ/	1ØD pin 5	AC, see note 2
A2/	1ØD pin 6	AC, see note 2
A1/	1ØD pin 7	AC, see note 2
Vdd	1ØD pin 8	+12V
Vcc	1ØD pin 9	+5V
A5/	1ØD pin 10	AC, see note 2
A4/	1ØD pin 11	AC, see note 2
A3/	1ØD pin 12	AC, see note 2
CS/	1ØD pin 13	GND
DO	1ØD pin 14	AC, see note 3
CAS/	1ØD pin 15	AC, see note 4
Vss	1ØD pin 16	ØV

Note 1: Usually four pulses per loop (15T or 16T), two at M1 leading edges for fetches; two at M1 trailing edges

for refresh. Occasionally two more during stores.

Note 2: Signal is complicated, with many transitions per loop.

Note 3: Rises during one SM1 pulse, falls during the next, alternately. Additionally, for those stores that actually reference the chip (1/16 of the stores), the signal goes LOW during the first store and HIGH during the second.

Note 4: Four pulses per loop, two fetches and two stores.

H. Check the following data output signals on the RAM-16-A. If you are using an oscilloscope, then trigger on 1D pin 11 or the upper end of R1Ø at 12E ($\overline{SM1}$) on the RAM-16-A.

Signal	Location	Description
MD5	1ØA pin 14	AC, see note 3 above
MD4	11A pin 14	AC, see note 3 above
MD6	12A pin 14	see note 5 below
MD1	13A pin 14	AC, see note 3 above
MDØ	14A pin 14	see not 5 below
MD2	15A pin 14	see note 5 below
MD3	16A pin 14	AC, see note 3 above
MD7	17A pin 14	see note 5 below

Note 5: Mostly low, high during store cycles outside of the address range of the board.

I. Replace the 74LS373 at location 17E, replace the 74LS28Ø at location 1ØE if it was removed, remove the jumper wire, and re-enable the processor board PROM option if it was disabled.

PARITY OPTION ASSEMBLY AND CHECKOUT

Skip this section if you did not purchase a parity option (RAM-16-PAR) for your RAM-16-A board. If you are installing the parity option, first be sure the board is completely checked out without the parity option.

P1. Insert and solder the five 16-pin IC sockets at locations 3A, 9A, 9B, 9C, and 9D, referring to the Assembly Information section for correct installation procedure. Orient the sockets so that pin 1 of each socket is inserted into the hole marked for pin 1 on the layout legend.

P2. Insert and solder the two 14-pin sockets at locations 10E and 15E. Also, insert and solder the 8-pin socket at location 0A. Be sure that the orientation is correct.

P3. Insert and solder the following resistor, referring to the Assembly Information section for correct resistor installation procedures.

	Resistor	Value	Size	Location	Color-code
( )	R2	220	1/4W	0B	red-red-brn

P4. Insert and solder the LED indicator near location 1A. The edge of the red plastic bulb of the LED near one of the two leads is either flat or notched. The LED should be oriented so that this lead is towards the left (nearest C2). For best visiblity when the board is mounted in the computer, bend the leads so that the LED lies parallel to the board, pointing towards the top of the board.

P5. Add a jumper to the DIP header at location 7D from pin 4 to pin 8. This selects bit 6 as the parity control bit for the memory board. See the Configuration section for details.

P6. Insert the four TTL integrated circuits. Be sure that pin 1 of each IC is inserted into pin 1 of its socket.

	Location	IC
( )	0A	75452
( )	3A	74LS109
( )	10E	74LS280
( )	15E	74LS280

P7. Using the MOS device handling procedures described in the Assembly Information section, install the four memory IC's in locations 9A, 9B, 9C, and 9D. Be sure that pin 1 of each memory IC is inserted into pin 1 of its socket.

P8. Visually inspect the PC board to see that all the IC pins