8K RAM BOARD
Model RAM-68

Midwest Scientific Instruments, Inc.
Olathe, Kansas
THE MSI 8K RAM BOARD, MODEL RAM-68

GENERAL DESCRIPTION

The MSI Model RAM-68 is an 8K Memory Board which is designed to be compatible with the SS-50 bus architecture employed by the MSI 6800 or SWTP 6800 Computer Systems. The board contains 8,192 eight-bit bytes of fully buffered static memory, having an access time of 450 ns. The base address of the board is switch selectable and can be set to begin at any desired 8K increment of memory from 0 to 64K. A convenient DIP switch assembly on the board has eight toggle switches. Only one of the toggle switches may be in the "ON" position at a given time. The remaining seven must be turned "OFF". The Table below indicates the appropriate switch settings in order to address the desired memory segment.

<table>
<thead>
<tr>
<th>MEMORY SEGMENT</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
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<tr>
<td>0000 - 1FFF</td>
<td>OFF</td>
<td>OFF</td>
<td>OFF</td>
<td>OFF</td>
<td>OFF</td>
<td>OFF</td>
<td>OFF</td>
<td>ON</td>
</tr>
<tr>
<td>2000 - 3FFF</td>
<td>OFF</td>
<td>OFF</td>
<td>OFF</td>
<td>OFF</td>
<td>OFF</td>
<td>OFF</td>
<td>ON</td>
<td>OFF</td>
</tr>
<tr>
<td>4000 - 5FFF</td>
<td>OFF</td>
<td>OFF</td>
<td>OFF</td>
<td>OFF</td>
<td>ON</td>
<td>OFF</td>
<td>OFF</td>
<td>OFF</td>
</tr>
<tr>
<td>6000 - 7FFF</td>
<td>OFF</td>
<td>OFF</td>
<td>ON</td>
<td>OFF</td>
<td>OFF</td>
<td>ON</td>
<td>OFF</td>
<td>OFF</td>
</tr>
<tr>
<td>8000 - 9FFF</td>
<td>OFF</td>
<td>OFF</td>
<td>OFF</td>
<td>ON</td>
<td>OFF</td>
<td>OFF</td>
<td>OFF</td>
<td>OFF</td>
</tr>
<tr>
<td>A000 - BFFF</td>
<td>OFF</td>
<td>ON</td>
<td>OFF</td>
<td>OFF</td>
<td>OFF</td>
<td>OFF</td>
<td>OFF</td>
<td>OFF</td>
</tr>
<tr>
<td>C000 - DFFF</td>
<td>ON</td>
<td>OFF</td>
<td>OFF</td>
<td>OFF</td>
<td>OFF</td>
<td>OFF</td>
<td>OFF</td>
<td>OFF</td>
</tr>
<tr>
<td>E000 - FFFF</td>
<td>ON</td>
<td>OFF</td>
<td>OFF</td>
<td>OFF</td>
<td>OFF</td>
<td>OFF</td>
<td>OFF</td>
<td>OFF</td>
</tr>
</tbody>
</table>

NOTE: Switch must be mounted as shown in Figure 1 below:

![Figure 1](image-url)
A network of diodes and pull-up resistors is included so that back up Vcc may be supplied from a battery pack, if desired. This network insures that Vcc remains applied to all memory chips and that the chip select lines are also held in a high state so as to prevent loss of memory during a power failure. Refer to the Schematic Diagram and Assembly Drawing for the correct polarity of the battery connections. Four on-board 7805 regulator chips supply Vcc to the board. The bus must carry an unregulated supply of approximately +8V in order to power the board.

THEORY OF OPERATION

Address lines are brought to the RAM chips through buffer packages IC6 and IC7. These are non-inverting buffers (8T97) which remain permanently enabled at all times. The address lines are active high. Decoder package IC5 (74S138) is used to decode the three highest order address bits along with the valid memory address signal (VMA) and Phase 2 clock. The output of this decoder is fed to the DIP switch assembly in order to select the desired memory segment. The output of this decoder is, in turn, used to enable IC4 which decodes the lower order address lines in order to select a 1K memory segment on the board. The chip select outputs from decoder IC4 (74S138) are pulled up through a resistor and diode network to the standby Vcc power supply, if used. This network insures that the chip select lines remain high via the battery power supply during power failure.

P.C. BOARD ASSEMBLY INSTRUCTIONS

Before beginning assembly of the PC board, perform the following steps. Referring to the parts list, and the Assembly Drawing, carefully check the parts kit in order to properly identify each component and make sure that all the necessary parts are included.

Next, carefully examine the P.C. Board itself for any flaws or defects. A magnifying glass is helpful in identifying the presence of any hairline shorts between foils, incomplete etching of the board or breaks in the foil. Such defects are rare but a careful preliminary examination is very worthwhile. Any defects should be corrected before beginning assembly of the board. Normally, we recommend using a 30 watt soldering iron for all assembly. Use only solder having a resin core, never use any type of acid based solders. A 60/40 or 63/37 alloy is recommended.

I.C. sockets may be used if desired, however, use only the highest quality sockets available, such as the Texas Instruments Low Profile.

Note that the unmarked I.C. symbols on the PC Board
are the locations of the 2102 memory chips. Also note that
the assembly drawing shows more .01 bypass capacitors than
are shown on the PC Board silk screen. The extra capacitors
have been included.

The PC board has been silk screened to show the
proper placement of all components. Refer also to the
Assembly Drawing for correct placement and orientation of
all components. Refer also to the RAM-68 Schematic Diagram,
Drawing No. 100040, for the wiring configuration.

Data lines are buffered bi-directionally using
integrated circuits IC1, IC2, and IC3 (8T98) which are
tri-state bus driver packages. Appropriate segments of
these packages are enabled depending upon whether a read or
write operation is taking place.

The memory chips used in the RAM-68 Board are
low-power 2102 static RAMs having an access time of less
than 500 ns.

ASSEMBLY PROCEDURE

( ) Install the four 7805 voltage regulators in positions
Q1, Q2, Q3, and Q4. Place a heatsink under each of the
regulators. Use 4-40 x 3/8 BHMS, #4 lock washers, and
hexnuts which have been provided.

( ) Install the five 10 pin female Molex connectors on the
bottom edge of the PC Board. The body of the connector lies
on the component side of the circuit board. The connector
should be held firmly in position, with the body of the
connector lying flat against the circuit board and pushed
tightly against the edge of the circuit board, during
soldering. First solder only the end pins of each
connector. This procedure will insure correct alignment of
the connectors. After soldering the end pins, the remaining
pins of each connector may be soldered.

( ) Insert the small plastic keying pin into the index
position of the bottom edge connector. This will prevent
the PC Board from being accidentally plugged in backwards or
with the pins offset.

( ) Install resistors R1 thru R9 into their appropriate
positions on the PC Board. Solder.

( ) Install the capacitor C1 in its appropriate position
on the circuit board. Be careful to observe the polarity of
this electrolytic capacitor during installation to insure
that it is oriented correctly.

( ) Install the 8 position DIP switch on the PC Board.
Solder. The switch should be installed in an upright
position so that the numbers will correspond with the
address selection Table shown above.

RAM-1.3
Install diodes D1 thru D13 into their appropriate positions on the PC Board. Be careful to observe the banded end of the diode during installation to insure that each diode is oriented properly. Solder.

Install IC1 thru IC8 in their proper positions along the bottom of the PC Board. Be careful to orient the ICs correctly with respect to Pin 1. Solder.

Install the 2102 memory chips in positions IC9 thru IC72. Solder.

Install capacitors C2 thru C61 in their appropriate positions on the PC Board. These are bypass capacitors, which are located between the +5 Volt bus and ground throughout the PC Board.

Upon completion of the PC Board assembly, carefully examine the board for the presence of any solder splashes, solder bridges, or shorts between adjacent pads on the board. These must be carefully removed before proceeding with checkout of the board. A magnifying glass greatly aids in the detection of such defects. If available, excess flux may be removed from the board with trichlorethylene. This also makes defects much easier to locate.

MEMORY BOARD CHECKOUT PROCEDURE

Following careful examination of the PC Board, place the board into the computer system and apply power. The computer system should respond normally with the asterisk (*) prompt character. If the board prevents this response, then remove power from the system and examine the board for the presence of shorts or other defects on the address, data, or other lines which communicate with the computer bus.

Using a voltmeter, or an oscilloscope if available, determine that the output of each of the 7805 voltage regulators is +5 V.D.C. and is free of any ripple.

Perform the memory diagnostic program listed below.

MEMORY CHECKOUT PROCEDURES

INTRODUCTION

The execution of the following memory diagnostic program is essential following assembly of any memory board. Don't be misled by the various memory diagnostic programs, which are in circulation for 6800 systems, since most of these programs are very inadequate and fail to reveal memory problems in many cases. The program presented herein is the best that we have seen and will detect almost any memory problem which we have encountered thus far. The code can
be relocated easily and can be used on EPROM which is highly recommended for quick availability. This program is a part of the MSI Extended Monitor EPROM.

To execute the program, place the beginning address of the memory area to be tested in memory locations $F002-$F003 (Monitor RAM area). The ending memory location+1 is placed in memory locations $F004-$F005. Then execute the program at its beginning address. Be careful not to test the memory area which contains the MEMORY TEST program itself, or it will be wiped out.

If memory location $F020 contains a $00, then the program will print a "@" after each 256 passes through memory. If $F020 is not $00, then a "+" will be printed following each pass through memory. This is the most desirable for a quick check.

When memory defects are detected, the bad address, expected data, and actual data read back are printed on the terminal.

TYPES OF MEMORY PROBLEMS

If a single bit remains set, or fails to set, within a 1K segment of memory, then a single defective 2102 memory chip almost certainly is at fault. Refer to the schematics on the RAM-68 memory board in order to locate the bad chip.

If a single bit remains set, or fails to set, throughout all addresses on the memory board, then look for a more general problem with that particular data line or data bus driver package.

If the memory fails in a repetitive pattern through the board then look for a memory addressing problem, such as a shorted address line or a defective address buffer package.

Memory failures, not caused by bad memory chips, usually manifest themselves as one or more bits responding to multiple addresses. Locating such faults is relatively simple if the memory test first detects a failing location.

First zero memory as shown in example 1. Then examine the defective location and verify that the contents are actually zero. Write an $FF into the defective location(s) then check to see what other locations were simultaneously altered.

Consider the following possibilities:

1. Data going high changes the address by raising an address line high that should have remained low (data line shorted to address line).
2. Two address lines shorted. All bits in the address less that those shorted will have common data. Cause the processor to execute a $9D instruction and observe the address lines on the 2102 chips to see if they toggle in the correct relationship to each other.

3. Data bits alternately high and low usually indicate that the data line is actually displaying one bit of the address (data line and address line shorted together).

**MSI WARRANTY POLICY**

MSI warrants all equipment and materials to be free from defective workmanship and material for a period of 90 days beyond the date of purchase from either MSI directly or an authorized MSI dealer. Activation of product warranty must be by the return of the warranty registration card.

During the warranty period, any products purchased as wired and tested units will be repaired or replaced, at MSI's sole option, free of charge, when shipped to MSI prepaid, accompanied by a complete written description of the defect and a return authorization number, as long as the product has not been subjected to electrical or mechanical abuse, in the opinion of MSI. MSI accepts no responsibility for equipment returned freight collect, without a return authorization number, or without a written description of the defect.

During the warranty period, any products purchased in kit form will be repaired or replaced, at MSI's sole option, free of any charge for parts. However, labor charges for the repair will be assessed on a time required basis. MSI reserves the right to reject any product as not repairable if in our opinion it has been subjected to accident, abuse, or improper assembly procedures. Upon completion of repairs, the product will be returned to the customer collect.
### MSI 6800 COMPUTER, 8K-RAM BOARD

#### PARTS LIST

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<thead>
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<th>ITEM NO.</th>
<th>QUANTITY</th>
<th>DESCRIPTION</th>
<th>REFERENCE DESIGNATION</th>
<th>MSI PART NO.</th>
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<td>967</td>
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<td>3</td>
<td>9</td>
<td>RESISTOR, 6.8K,+10%, 1/4W</td>
<td>R1 thru R9</td>
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<td>26</td>
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RAM-1.7
MEMORY TEST PROGRAM

0030 * THIS ALGORITHM ORIGINALLY WRITTEN BY CHARLES MC COLLOUGH
0040 * RE-WRITTEN AND EXPANDED BY EDGAR R. ALLEN
0050 * THIS VERSION WRITTEN 1/26/78
0060
0070 * MOST MEMORY TESTS EITHER DEAL WITH A SINGLE
0080 * LOCATION ONLY, WHICH WILL NOT FIND BITS RESPONDING TO
0090 * MORE THAN ONE ADDRESS OR THEY FILL MEMORY WITH A BYTE
0100 * THEN CHANGE BITS IN THE TEST LOCATION THEN VERIFY THAT
0110 * NO OTHERS HAVE BEEN ALTERED. THE FIRST IS TOTALLY
0120 * INADEQUATE AND THE SECOND HAS AN EXPONENTIAL INCREASE
0130 * RATE. THIS MEANS THAT TESTING TWICE AS MUCH MEMORY
0140 * TAKES FOUR TIMES AS LONG. WE FEEL THIS IS UNACCEPTABLE
0150 * WITH TODAY'S LARGER MEMORY SIZES.
0160
0170 * THIS PROGRAM GENERATES A PATTERN DEPENDENT UPON A
0180 * SEED BYTE AND THE PLACEMENT OF THE CURRENT TEST LOC-
0190 * ATION. THEN THE SAME PATTERN IS GENERATED WITHIN
0200 * THE REGISTERS AND COMPARED TO THE DATA IN MEMORY.
0210 * IF THE EXPECTED AND ACTUAL DATA AGREE THEN THE NEXT
0220 * LOCATION IS EXAMINED. OTHERWISE THE FAILING ADDRESS,
0230 * THE FAILING BITS, THE EXPECTED DATA AND THE ACTUAL
0240 * DATA ARE PRINTED. THE EXPECTED AND ACTUAL DATA MAY AGREE,
0250 * THIS PROBABLY MEANS THAT THE MEMORY IS TOO SLOW. THIS
0260 * MAKES THE PRINT OF THE FAILED BITS QUITE HANDY.
0270 * THE WAY THE DATA IS GENERATED IS BY EXCLUSIVE-
0280 * ORING THE LOW AND HIGH BYTES OF THE COUNTER
0290 * WITH THE SEED. THIS COUNTER IS THEN INCREMENTED FOR
0300 * THE NEXT LOCATION. AFTER ALLLOCATIONS HAVE BEEN
0310 * FILLED THEY ARE COMPARED TO THE SAME DATA GENERATED
0320 * IN THE SAME WAY. THE SEED IS THEN INCREMENTED AND
0330 * ANOTHER PASS IS MADE. AFTER ALL COMBINATIONS OF THE
0340 * SEED HAVE BEEN TRIED THE COUNTER IN 'SAVEX' IS
0350 * INCREMENTED AND USED AS THE START OF ANOTHER 259 PASSES
0360 * OR ONE GROUP. THIS REMOVES ONE BYTE FROM THE FRONT OF THE
0370 * SERIES AND ADDS A NEW BYTE TO THE BACK. THIS HAS THE
0380 * EFFECT OF SHIFTING THE PATTERN OVER ONE ADDRESS
0390 * MEANING THE TRANSITIONS FROM ONE STATE TO THE OTHER
0400 * OF EACH BIT ALSO MOVES. THE TEST WILL DETECT ERRORS
0410 * WHEN THE FAILING BITS ATTEMPT TO MAKE A TRANSITION
0420 * BETWEEN THE TWO, OR MORE, ADDRESSES WHICH AFFECT
0430 * EACH OTHER.
0440 * THIS PROGRAM USES MSIBUG SCRATCHPAD RAM
0450 * LOCATIONS. THE PROGRAM ITSELF IS FULLY RELOCATABLE.
0460 * TO RUN THE MEMORY TEST, PUT THE BEGINNING ADDRESS
0470 * TO CHECK IN $F002 & $F003 AND THE END ADDRESS +1
0480 * IN $F004 & $F005. GO AT +0 INTO THE PROGRAM WHICH IS
0490 * $2000 IN THIS EXAMPLE. THE GROUP NUMBER IS PRINTED
0500 * AFTER 256 PASSES THROUGH MEMORY. IF $F020 IS NON-ZERO
0510 * A + IS PRINTED AFTER EACH PASS. WHEN AN ERROR OCCURS,
0520 * THE FAILING ADDRESS, THE FAILING BITS, THE EXPECTED
0530 * DATA AND THE ACTUAL DATA ARE PRINTED. TO START THE
0540 * MEMORY TEST ON A PARTICULAR GROUP, CLEAR THE SEED
0550 * ($F022), PUT THE DESIRED GROUP NUMBER IN $F026 & $F027,
0560 * AND GO AT +9 INTO THE PROGRAM WHICH IN THIS EXAMPLE
0570 * IS $2009.
* MIDWEST SCIENTIFIC INSTRUMENTS

* OPT 0

F002 FIRST EQU $F002
F004 LAST EQU $F004
F022 SEED EQU $F022
F024 COUNT EQU $F024
F026 GROUP EQU $F026
F028 SAVEX EQU $F028

ORG $2000
LDX #0000
FRX GROUP
LDX GROUP
LDX FIRST
LDX FIRST
LDX #$E17D
JSR $E07E
LDA A COUNT+1
EOR A COUNT
EOR A SEED
STA A 0,X
INC COUNT+1
BNE COMPl
INC COUNT
INX
CPX LAST
EOR A 0,X
BEQ CONTIN
LDA A COUNT+1
EOR A COUNT
EOR A SEED
TAB
EOR A 0,X
BEQ CONTIN
INC COUNT+1
SAVE THE EXPECTED DATA
LDA A COUNT+1
EOR A COUNT
EOR A SEED
TAB
EOR A 0,X
BEQ CONTIN
INC COUNT+1
PRINT ADDRESS
JSR $E0C8
POINTER TO FAILED BITS
JSR $EOCA
OUTPUT 2HEX AND SPACE
AND AGAIN
PUL A
PUL A
LDX SAVEX
JSR $E0CA
POINTER TO ACTUAL DATA
JSR $EOCA
PREPARE FOR CONTIN
INC COUNT+1
CONTIN
MEMTST

01150 206A 26 03  BNE  COMP2
01160 206C 7C F024  INC  COUNT
01170 206F 08  COMP2  INX
01180 2070 BC F004  CPX  LAST
01190 2073 26 C3  BNE  TEST  *GET NEW DATA
01200 2075 7C F022  NEXT  INC  SEED  *NEW SEED FOR NEXT PASS
01210 2078 26 0D  BNE  LOOP  *NEXT GROUP
01220 207A FE F026  LDX  GROUP
01230 207D 08  INX
01240 207E FF F026  STX  GROUP
01250 2081 CE F026  LDX  #GROUP
01260 2084 7E E0C8  JMP  $E0C8
01270 2087 7D F020  LOOP  TST  $F020
01280 208A 26 01  BNE  P1  *PRINT '?'
01290 208C 39  RTS  *NO
01300 208D 86 2B  P1  LDA A  #$2B  *YES
01310 208F 7E E1D1  PRINT  JMP  $E1D1
01320

TOTAL ERRORS 00000

ENTER PASS: 1P,2P,2L,2T
EXAMPLE 1 FILLS MEMORY WITH ZEROS
STARTING AT THE ADDRESS IN MEMSTR ($F002 & $F003), UP TO THE ADDRESS IN MEMEND ($F004 & $F005).

EXAMPLE 2 CHECKS MEMORY FOR ZEROS
FROM THE ADDRESS IN MEMSTR UP TO THE ADDRESS IN MEMEND. WHEN A NON-ZERO BYTE IS FOUND, THE SWI INSTRUCTION CAUSES THE REGISTERS TO BE PRINTED. THE INDEX REGISTER HAS THE ADDRESS OF THE NON-ZERO BYTE.

TOTAL ERRORS 00000

ENTER PASS : 1P,2P,2L,2T
NOTES: UNLESS OTHERWISE SPECIFIED

1. ALL RESISTORS ARE 6.8KOHMS ±10%, 1/4W.
2. ALL DIODES ARE IN4003.
3. 8797 IS INTERCHANGEABLE WITH 74367 OR 8097.
4. 8798 IS INTERCHANGEABLE WITH 74368 OR 8098.

8T98 IS INTERCHANGEABLE WITH 74368 OR 8098.
8T97 IS INTERCHANGEABLE WITH 74367 OR 8097.

MSI 6800 COMPUTER SCHEM. RAM-68, BK

REFERENCES:
"High Speed Integrated Logic," Motorola.
