Hardware Reference Manual

64K RAM Board

Central Data Corporation
64K RAM Board Manual

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1.0 Warrantee

The Central Data 64K RAM Board is fully warranted for a period of one year following the date of shipment. All units returned to Central Data Corporation postpaid during this period will be repaired and returned without charge.

This warrantee does not apply to boards which have been damaged, abused, or modified. Central Data reserves the right to change the design of the RAM Board without having to change any previously manufactured units.

2.0 Description

The Central Data 64K RAM Board is a random access read/write memory module designed to expand the memory capacity of S-100 computers. The Board is configured as four sections of 16K x 8 bits. The sections are separately addressable.

The memory integrated circuits used on the 64K RAM board are 4116-25 16K (or equivalent) dynamic RAMs for 2MHz boards, 4116-20 RAMs for 4MHz boards. These RAM's use considerably less power than static RAM as well as using less PC board space.

The circuitry has been designed to be independent of the processor type. This manual shows how to set up the board to be accessed by S-100 systems using the 8080, 280, or 2650 microprocessors. It will work with other types of bus masters as long as they simulate the memory access timing of the processor for which the board is strapped.

3.0 Processor Selection

First, there are two straps numbered 14 and 15 soldered on the board which determine which S-100 line is used for reset in your system. Strap 14 selects pin 75 as the reset source, and strap 15 selects pin 99 as the reset source. Normally, the board will work as strapped at the factory (for pin 75), but if you find that your board will not hold data during reset operations, you can change the strap to fix the problem. The strap locations can be found on the parts placement diagram at the end of this manual.

Two 16 pin DIP headers are used to program the RAM Board for use with various processors. Wires must be soldered in place connecting across these headers. The correct connections are shown in figure 1.
8080 PROCESSOR:

IC16

IC15

Z-80 PROCESSOR:

IC16

IC15

2650 PROCESSOR:

IC16

IC15

Figure 1

Two alternates for the Z-80 processor would be: on IC15, take out the wire between pins 8 and 9 and add a wire between pins 7 and 10. Then also add a wire between either pins 6 and 11 or pins 5 and 12, depending on which alternate you try. This changes the clock used in the refresh circuit.

4.0 Address Selection

When the RAM Board is used in an 8080 or Z80 system it will be addressable on 16K boundaries. When strapped for use in a 2650 system, it will be addressable on 8K boundaries. Two sets of address selection instructions are given below. Follow the instructions that correspond to the processor type being used.

4.1 Address Selection Instructions for 8080 or Z80 Systems

When strapped for 8080 or Z80 bus masters, the 64K RAM Board consists of up to four separate 16K sections. Each section can be addressed independently and can occupy any 16K block of memory address space.
For each 16K section there will be one blue "minijump" connector bridging the address selection area (16K boards will use one address strap minijump, 32K boards will use two, etc.). Refer to Figure 2 for the location of this area on the board. The exact placement of the minijumps will vary depending on whether you have a board with 16K or 32K of memory or one with 48K or 64K of memory. The detail on how to address the board is presented below in two sections, depending on the size of board that you have.

4.1.1 Addressing 16K/32K Boards with 8080 or Z80 Systems

For a 16K or 32K board, you will need to place one or two minijumps (depending on the board size) in the address selection strap area. The minijump for the top row of chips should be placed in the top row of the address selection strap area (see Figure 2). The minijump should be placed over the set of pins marked 0, 1, 2, or 3 to address the top row of RAMs to start at 0, H4000, H8000, or HC000. For a 32K board the second row of RAMs can be addressed in the same way, but with the minijump placed in the bottom row of the address selection strap area. Figure 2 shows the addressing for a 32K board whose top row of RAM's is addressed to start at H8000, and its second row of RAMs is addressed to start at HC000. The deselection straps shown in the figure have no effect on the basic addressing of the board and are explained in section 5.

![Figure 2](image)

4.1.2 Addressing for 48K/64K Boards on 8080 or Z80 Systems

For a 48K or 64K board, you will have to place three or four minijumps (depending on the board size) in the address selection strap area. One minijump will be used for each 16K block that you address. To address the first 32K of the board (the top two rows of RAMs), you will place two minijumps on the top row of the address selection strap area (see Figure 3). Each minijump should be placed to select
where a corresponding 16K block of memory should be addressed. A minijump is placed in column 0, 1, 2, or 3 to start addressing for the 16K section at address 0, H4000, H8000, or HC000. There is one restriction: the two minijumps must be adjacent. This means that the allowable combinations for addressing the first 32K of your board are:

0,1 (address 0 to H7FFF)
1,2 (address H4000 to HFFFF)
2,3 (address H8000 to HFFFF)
3,0 (address HC000 to HFFFF)

At this point, the remaining memory on the board can be addressed. To address the last 16K of a 48K board, a single minijump is placed in the correct column of the bottom row of the address selection strap area. For a 64K board, two minijumps are placed on the bottom row, addressing the bottom 32K of memory on the board. Note that these two minijumps must be adjacent as in selecting the top 32K of memory. Figure 3 shows a 48K board addressed from 0 to HFFFF.

![Figure 3](image)

With regard to 48K boards only, the last 16K of memory corresponds to the eight memory chips located either in the third or fourth row of the socketed memory area. If you are addressing this 16K segment to begin on an even 32K boundary (to start at address 0 or H8000) then the row of memory chips must be in the fourth (bottom) row of the memory area on the board. If you are addressing this 16K segment to begin at either H4000 or HC000 then the memory devices must be placed in the third row of sockets in the memory area (adjacent to the top 32K of memory). When the boards are shipped from Central Data they contain the memory on the bottom row of the board.

4.2 Addressing Instructions for 2650 Processors

To address a 16K board to be used in a 2650 system, put a minijump in positions 1 and 2 of the top row of the address selection strap area (see Figure 4). This addresses the board to have a continuous 16K of memory starting at address H2000.
To address a 32K board for a 2650 system, you will have to
deselect the portions of page zero which are used by the CPU
board. The straps should be set up as shown in Figure 5 for
this configuration.

5.0 Address Deselect Straps

In order to have the RAM Board fit around ROM monitors or
other dedicated areas of memory, from one to eight 2K
segments of any 16K address space can be deselected. The
instructions for setting these straps are given for all
non-2650 systems. Any 2650 users which need this feature
should consult the factory.

Use a minijump to select the 16K area in which the gap will
occur. Place the minijump in the column of the "Deselect
Block" area that corresponds to this block of memory. Now
place a minijump in each column of the "Deselect Strap" area
that you wish to have deselected.

Example:

You have a SOL-20 computer and wish to use the ALS-8 program
which requires 12K of memory from HD000 to HFFFF. A full
16K of RAM (HC000 to HFFFF) won't work because the monitor
(SOLOS) occupies 2K of memory space between HC000 and HC7FF.
Also, the SOL-20 has 2K of RAM between HC800 and HCF00.

A Central Data RAM Board can be used for this purpose by
deselecting the occupied areas. Put a minijump in the
address selection area to address the 16K of the board from
HC000 to HFFFF (see section 4.1). Since the area to be
deselected is in the top 16K put a minijump in column 3 of
the "Deselect Block." Now put a minjump in both column 0 and column 1 of the "Deselect Strap" section of the board to deselect the lowest 4K of this 16K. The board is now strapped to occupy the 12K from HD000 to HFFFF. Figure 2 shows a RAM Board addressed this way.

DESELECT 2K SEGMENTS #0 AND #1
SET Deselect BLOCK STRAP FOR TOP 16K
SET ADDRESS SELECT STRAP FOR TOP 16K

![Diagram of memory layout](image)

Figure 6

6.0 Installation

Before plugging the RAM Board into an S-100 card slot, make certain that the power has been off long enough to allow the power supply capacitors to discharge. Whenever any S-100 board is plugged in or removed, care should be taken to make sure that the edge connector lines up with the printed circuit board fingers.

Keeping these precautions in mind, put the board into the S-100 mainframe. Make sure the board faces the right direction. The power may now be applied. The RAM Board is ready for use.

7.0 Increasing your Memory Size

To increase the memory capacity of your board, you can purchase a set of memory ICs and capacitors from Central Data. The memory circuits should be carefully plugged into the next available row of sockets from the top of the board. The only exception to this is when you are upgrading to a 48K board where you may need to skip the third row in order to address the board correctly (see section 4.1.2 for
information concerning this).

The capacitors should be soldered in according to the parts placement diagram making sure of the polarity on the tantalum capacitors. The capacitors in the memory area of the parts placement diagram are numbered to indicate which ones are to be put in for the different sizes of boards. Capacitors with the number '1' should all be in for 16K boards, while 32K board should have capacitors for both numbers '1' and '2', etc.

Finally, if you upgraded a 16K or 32K board to a 48K or 64K board, you will have to change two jumper straps on the board. These are the straps numbered 1, 2, 3, and 4 on the parts placement diagram, and they should be wired as follows for the different sizes of boards:

```
  o o  o o
  o o  o o
16K, 32K  48K, 64K
```

8.0 Specifications

<table>
<thead>
<tr>
<th>Specification</th>
<th>16K, 32K, 48K, or 64K</th>
<th>16K boundaries</th>
<th>On all 1/8 lines</th>
</tr>
</thead>
<tbody>
<tr>
<td>Storage Capacity</td>
<td></td>
<td>16K boundaries</td>
<td>On all 1/8 lines</td>
</tr>
<tr>
<td>Addressing</td>
<td></td>
<td>16K boundaries</td>
<td>On all 1/8 lines</td>
</tr>
<tr>
<td>Buffering</td>
<td></td>
<td>16K boundaries</td>
<td>On all 1/8 lines</td>
</tr>
<tr>
<td>Access Time - 2MHz Rd.</td>
<td>450ns(max)</td>
<td>480ns(max)</td>
<td></td>
</tr>
<tr>
<td>Cycle Time</td>
<td>480ns(max)</td>
<td>480ns(max)</td>
<td></td>
</tr>
<tr>
<td>Refresh Period</td>
<td>15us(max)</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>Wait States Generated</td>
<td>None</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>DMA Rate</td>
<td>1MHz Max</td>
<td>1MHz Max</td>
<td></td>
</tr>
</tbody>
</table>

Power Consumption (16K, typ.):

<table>
<thead>
<tr>
<th>Voltage</th>
<th>Current</th>
</tr>
</thead>
<tbody>
<tr>
<td>+16</td>
<td>150ma</td>
</tr>
<tr>
<td>+8</td>
<td>300ma</td>
</tr>
<tr>
<td>-16</td>
<td>20ma</td>
</tr>
</tbody>
</table>

Power Consumption (each add’l 16K, typ.):

<table>
<thead>
<tr>
<th>Voltage</th>
<th>Current</th>
</tr>
</thead>
<tbody>
<tr>
<td>+16V</td>
<td>20ma</td>
</tr>
<tr>
<td>+8V</td>
<td>0ma</td>
</tr>
<tr>
<td>-16V</td>
<td>3ma</td>
</tr>
</tbody>
</table>
9.0 8080 Memory Test Program

The memory test program listed below can be used to test a 16K memory segment addressed for Block 1 (H4000-H7FFF). When an error is found the program stores information about the error and then halts. The error information is stored as follows:

<table>
<thead>
<tr>
<th>Address</th>
<th>Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>H0003</td>
<td>High byte of address</td>
</tr>
<tr>
<td>H0002</td>
<td>Low byte of address</td>
</tr>
<tr>
<td>H0001</td>
<td>Data written to byte</td>
</tr>
<tr>
<td>H0000</td>
<td>Data read from byte</td>
</tr>
</tbody>
</table>

A 32K memory segment can be tested by addressing the board for blocks 1 and 2 and changing the values at locations H16 and H2C to HCO.

This memory test program occupies memory starting at H0000 so a working RAM board must be at this part of memory.
ADDRESS

END ADDR

BEG  EQU  4000  HEX STARTING

END  EQU  80  TOP BYTE OF

*  ORG  4  CLEAR A,B
START  LXI  SP,4  STARTING ADDR
XRA  A

OVER  MOV  B,A
LXI  H,BEG
MOV  C,B

WRITE  MOV  M,C
LXI  N
MOV  H

INR  C
JNZ  SKIP

JNZ  WRITE

OFFSET PATTERN

0004  31 04 00  START
0007  AF
0008  47
0009  21 00 40  OVER
000C  48
000D  71  WRITE
000E  23
000F  0C
0010  C2 14 00
0013  0C

0014  7C
0015  FE 80
0017  C2 0D 00

*  MOV  A,H
SKIP

READ BACK LOOP

*C

READ  MOV  E,M
LXI  H,BEG
CMP  C

ERROR  JNZ  NDINC
INR  A

MLINC  MOV  C,A
INR  A

0018  21 00 40  READ
001E  5E
001F  DB
0020  C2 35 00
0023  23
0024  3C
0025  C2 29 00
0028  3C
0029  4F
002A  7C
002B  FE 80
002D  79
002E  C2 1E 00
0031  04
0032  C3 09 00

ERROR ROUTINE

*  MOV  A,H

0035  E5  ERROR
0036  57
0037  D5
0038  76

PUSH  H
MOV  D,A
PUSH  D
HLT
10.0 2650 Memory Test Program

A memory test program for the 2650 is listed here. The program loads into display memory at H1510 and occupies about 512 bytes. To set the address range to test, simply set the two bytes labeled STARTT and ENDT to the high bytes of the starting and ending addresses. For example, if you wanted to test memory between H2000 and H5FFF, you would change STARTT to H20 and ENDT to H60. Then just execute at 1510, and the test will begin. Since the program occupies display RAM, the screen will be broken up when it is being executed. The program terminates when a key is pressed. Errors are displayed on the screen in the following format:

+--------------------------+--------------------------+--------------------------+
| Address of the error     | Data that was written there | Data that was read back |
| !                        | !                        | !                        |
| XXXX XX XX               |                          |                          |
MEMORY TEST

POSSIBLE CONDITIONS

REGISTER DEFINITIONS
LOAD THE STARTING DATA VALUE
SAVE IT IN R3
SETUP INDEX REGISTER
GET NEXT DATA BYTE
COMPARE TO WHAT IT SHOULD BE
IF NOT THE SAME, GOTO ERROR
INCREMENT DATA
DONT ALLOW ZERO AGAIN
DO THIS LOOP 256 TIMES
READ KEYBOARD
RETURN IF KEY IS Pressed
INCREMENT RAM POINTER
SEE IF END OF TEST AREA
IF NOT, BRANCH
REDO THE WHOLE THING AGAIN

SAVE THE REGISTERS
LOAD THE HIGH BYTE
WRITE IT
WRITE THE LOW BYTE
WRITE A SPACE
WRITE THE DATA WRITTEN
WRITE A SPACE
WRITE THE DATA READ
RESTORE THE REGISTERS
RETURN