

**TECHNICAL MANUAL  
NS11L  
MEMORY CARD ASSEMBLY**



**National Semiconductor**  
**Memory Systems**

**TECHNICAL MANUAL  
NS11L  
MEMORY CARD ASSEMBLY**

This document, and all subject matter disclosed herein, are proprietary items which National Semiconductor Corporation retains the exclusive rights of dissemination, reproduction, manufacture, and sale. This document is submitted in confidence for consideration by the designated recipient or intended using organization alone, unless permission for further disclosure is expressly granted in writing by National Semiconductor Corporation.



**National Semiconductor  
Minicomputer Systems**

Copyright © 1980 National Semiconductor Corporation

420103841 Rev C  
January 1981

## TABLE OF CONTENTS

SECTION	PAGE
I GENERAL DESCRIPTION	1-2
Introduction	1-2
Purpose	1-2
Physical Description	1-2
Functional Description	1-4
General Specifications	1-4
Environmental Specifications	1-6
Reliability	1-8
II INSTALLATION AND MAINTENANCE	2-1
General	2-1
Safety	2-7
Unpacking and Inspection	2-8
Switch Settings	2-9
CSR Address Assignment	2-10
Battery Back Up	2-11
I/O Configurations	2-11
Installation	2-11
Post Installation Checks	2-12
Maintenance	2-13
III THEORY OF OPERATION	3-1
General	3-1
Interface	3-1
Addressing	3-7
Timing and Control	3-11
Memory Array	3-14
Data Path	3-16
CSR/Parity Operation	3-16
DC to DC Convertor	3-21
IV DRAWINGS	Appendix A

## FIGURES

FIGURE		PAGE
1-1	NS11L Photo	1-1
1-2	Connector Locator	1-3
2-1	Defective Chip Locator	2-15
3-1	Bus Timing	3-4
3-2	Address Block Diagram	3-10
3-3	Timing and Control Block Diagram	3-13
3-4	Memory Array Block Diagram	3-15
3-5	CSR and Data Path Block Diagram	3-17
3-6	DC to DC Converter Block Diagram	3-23
3-7	System Block Diagram	3-24

## TABLES

TABLE		
1-1	NS11L Dimensions	1-3
1-2	Power Requirements	1-5
1-3	Access/Cycle Times	1-5
1-4	Operating Modes	1-6
2-1	Switch Designations & Settings	2-2
2-2	Starting Address	2-3
2-3	Starting Address	2-3
2-4	I/O Space Size Select	2-4
2-5	CSR Address Select	2-4
2-6	Memory Size Select	2-5
2-7	Jumper Placement Chart	2-6
3-1	Bus Signals	3-2

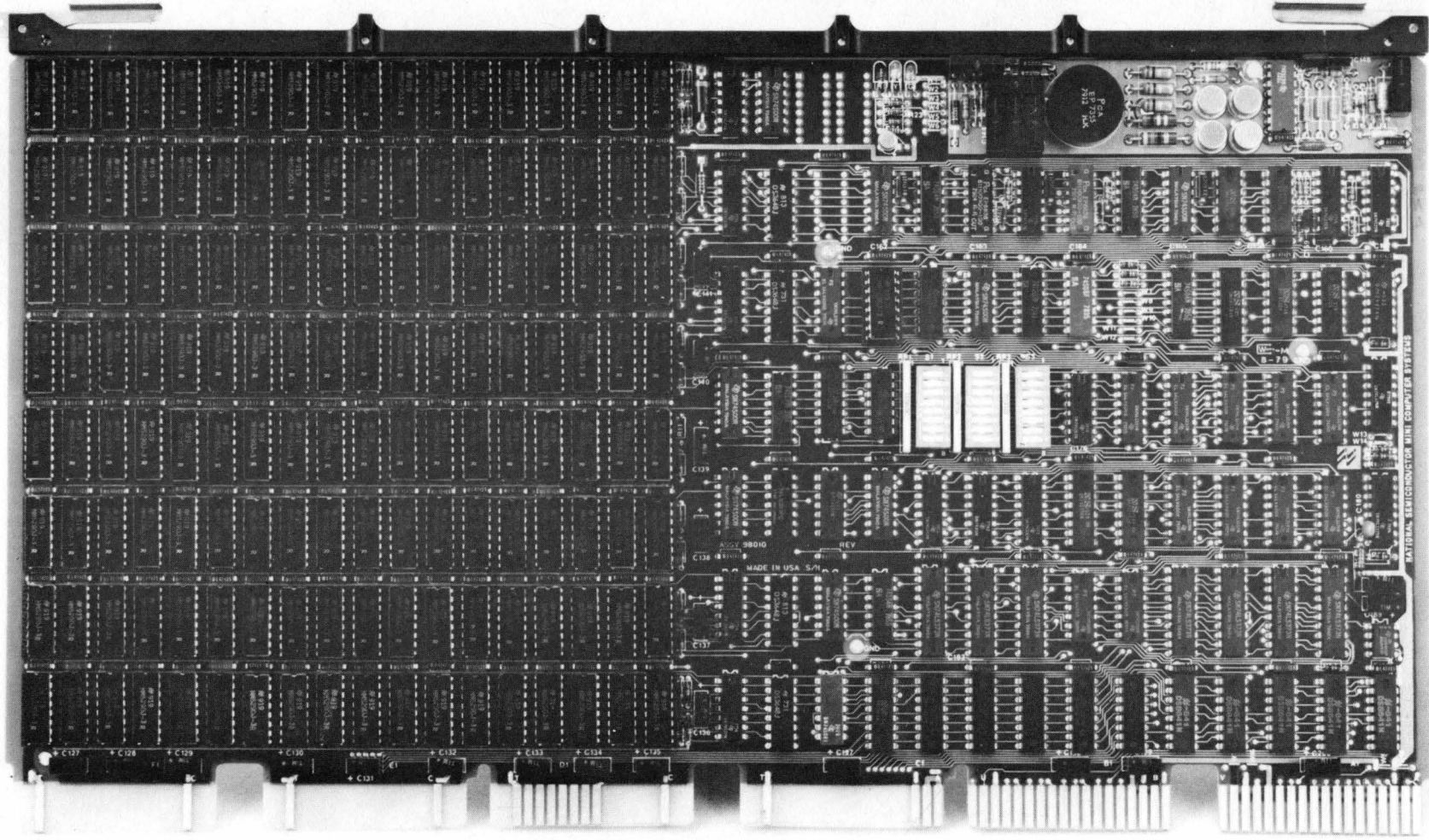


Fig. 1-1

SECTION I  
GENERAL DESCRIPTION

1.1 INTRODUCTION

This manual contains four sections which describe the NS11L Add-in Memory System. This information includes a general description, an installation and maintenance section, theory of operation, and a section containing assembly drawings, schematics, and bill of materials. Figure 1-1 is a photograph of the NS11L Add-In Memory System.

1.2 PURPOSE

The NS11L, P/N-980103841, is designed for use with DEC \* PDP-11 CPU's. The NS11L is directly compatible with any DEC UNIBUS/Modified UNIBUS/SPECIAL UNIBUS type backplane.

1.3 PHYSICAL DESCRIPTION

The NS11L memory is contained on one multilayer printed circuit card. See Table 1-1 for the physical dimensions of the NS11L.

\* DEC, UNIBUS, modified UNIBUS, and PDP11 are registered trade marks of Digital Equipment Corp., Maynard Mass.

Table 1-1 NS11L Dimensions

Thickness	.480	inches
Height	8.630	inches
Length	15.687	inches

The NS11L memory is designed to mount on a minimum center-to-center board spacing of 0.50". Two card ejectors permit easy removal of the card.

Figure 1-2 is a connector locator diagram.

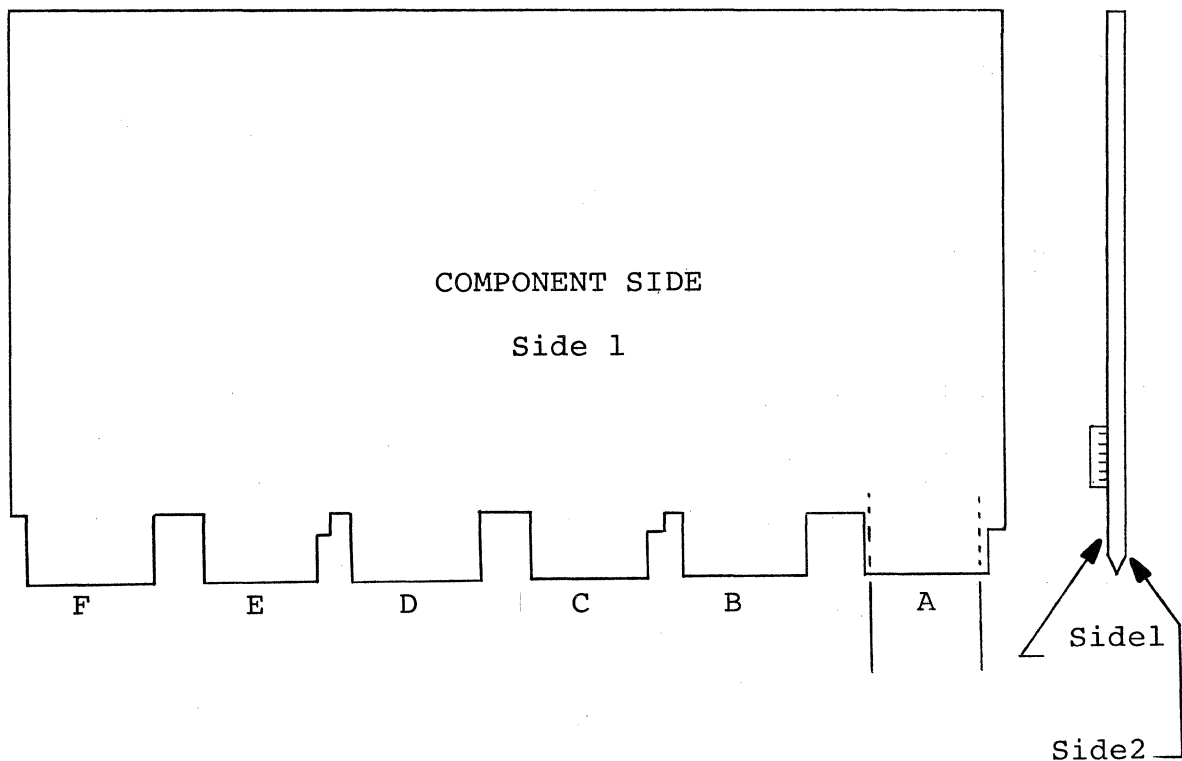


FIGURE 1-2

### 1.3.1 I/O Connectors

The NS11L Memory is designed to fit mechanically into the following PDP-11 backplanes:

1. DD11-DK slots 2-8
2. DD11-PK slots 3-8
3. DD11-CK slots 2-3

For installation in backplanes not listed above, the backplane connector pin assignments must be compatible with the NS11L pin assignments as listed in Table 3-1.

### 1.4 FUNCTIONAL DESCRIPTION

The NS11L is a 128Kx18 bit Add-In Memory for the DEC PDP-11 family of minicomputers. The NS11L board requires +5V only and generates +12V and -5V with an on board DC-to-DC converter. The board is designed for maximum reliability and speed. Additionally, the board contains an on-board CSR register, eliminating the need for a DEC M-7850 parity controller. The NS11L is completely hardware and software compatible with all DEC systems as described in paragraph 1.2.

### 1.5 GENERAL SPECIFICATIONS

The following tables list the general specifications of the NS11L Add-In Memory. Table 1-2 lists the power requirements and Table 1-3 lists access and cycle times.



Table 1-2 NS11L Power Requirements

Supply Voltage	Current-Amps					
	Operational		Standby		Battery Back-up	
	TYP.	MAX.	TYP.	MAX.	TYP.	MAX.
+5V	4.5	5.0	3.7	3.8	∅	∅
+5V <sub>BB</sub>	.9	1.0	.9	1.0	.9	1.0

Table 1-3 Access and Cycle Times

READ			
Cycle Time		405ns	MIN
Access Time		300ns	MAX
Parity Access Time		340ns	MAX
CSR ACCESS		100ns	MAX
WRITE			
Cycle Time		405ns	MIN
Access Time (Add/Data Latch)		100ns	MAX
REFRESH			
Cycle Time		405ns	MIN

(Cycle requests made during a refresh will extend the cycle and access time an additional 405ns Max).

NOTE:

- 1) Cycle time - The interval between memory reception of Bus MSYN L (at receiver input) and the availability of the memory to respond to the next Bus MSYN L.

- 2) Access Time - The interval between memory reception of Bus MSYN L and the assertion of Bus SSYN L.

### 1.5.1 Operating Modes

The operating mode of the memory is determined by the state of the C0 and C1 control lines and the A0 address line.

These modes are defined in Table 1-4 shown below.

Table 1-4 Operating Modes

A0	C1	C0	COMMAND	OPERATION
X	0	0	DATI	Read
X	0	1	DATIP	Read
X	1	0	DATO	Write Word
0	1	1	DATOB 0	Write Byte 0
1	1	1	DATOB 1	Write Byte 1

NOTE: Logic 1=0 volts (LOW)  
Logic 0=+ 3.4 volts (HIGH)

## 1.6 ENVIRONMENTAL SPECIFICATIONS

The NS11L is designed to operate over a variety of environmental conditions. Listed below are the environmental conditions and specifications.

### 1.6.1 Operating Specifications

- TEMPERATURE.....Ambient Air temperature range of 0°C to +50°C.
- THERMAL SHOCK.....The NS11L Memory can withstand a thermal shock with a maximum rate of change of 30°C per hour during operation.

- HUMIDITY.....The Memory has been designed to operate in a relative humidity of up to 95% (without condensation).
- ALTITUDE.....The system is capable of operation at altitudes from -1,000 feet msl to +10,000 feet msl.
- COOLING.....Suggested minimum air flow for the NS11L Memory is 25 cfm.

#### 1.6.2 Shipping and Storage Specifications

- TEMPERATURE.....The NS11L Memory can withstand a temperature range of  $-40^{\circ}\text{C}$  to  $+85^{\circ}\text{C}$  during shipment or storage.
- THERMAL SHOCK.....A thermal rate of change as high as  $10^{\circ}\text{C}$  per minute can be tolerated by the Memory.
- ALTITUDE.....A Shipping Altitude of 40,000 feet can be withstood.
- MECHANICAL SHOCK....The NS11L Memory, housed in its shipping container, can tolerate mechanical shock resulting from drop tests performed in accordance with MIL-STD-810B, Method 516, procedure V, without exhibiting damage or degradation.

## 1.7 RELIABILITY

This card was designed to the best commercial standards of workmanship. Vigorous testing is conducted (including testing over operating temperature range) to ensure a reliable service of ten years at 24-hours per day usage (exclusive of routine maintenance time). The design is such that catastrophic failure occurrence is minimized and minimal propagation of such failure will be experienced. Calculated MTBF using A+ logic and MIL Handbook 217B (where applicable) is 28,873 hours.



SECTION II  
INSTALLATION AND MAINTENANCE

2.1 GENERAL

The NS11L Memory is ready for installation upon receipt; however, the memory size and address switches and the option jumpers must be checked before the card is installed. Refer to paragraphs 2.4 thru 2.7., and Tables 2-1 through 2-7, for switch and jumper information.

The NS11L is completely compatible with DEC's PDP-11 computers and all standard DEC peripheral devices. It can be used in both parity and non-parity systems.

For installation in backplanes not listed below, the subject backplane connector pin assignments must be compatible with the NS11L pin assignments listed in Table 3-1.

The Memory is directly plug-compatible into the following DEC backplanes:

- DD11-DK (slots 2-8)
- DD11-PK (slots 3-8)
- DD11-CK (slots 2-3)

TABLE 2-1

SWITCH DESIGNATIONS AND SETTINGS

SWITCH 1	<table border="1" style="border-collapse: collapse; text-align: center;"> <thead> <tr> <th style="width: 20px;">0</th> <th style="width: 20px;">1</th> </tr> </thead> <tbody> <tr><td>1</td><td></td></tr> <tr><td>2</td><td></td></tr> <tr><td>3</td><td></td></tr> <tr><td>4</td><td></td></tr> <tr><td>5</td><td></td></tr> <tr><td>6</td><td></td></tr> <tr><td>7</td><td></td></tr> <tr><td>8</td><td></td></tr> </tbody> </table>	0	1	1		2		3		4		5		6		7		8		<p>1-5, UNIBUS Starting address select. Open=ADDR 0 See Table 2-2 on page 2-3.</p>
	0	1																		
1																				
2																				
3																				
4																				
5																				
6																				
7																				
8																				
<p>6-8, Special Bus starting address select. Open=ADDR 0 See Table 2-3 on page 2-3.</p>																				
SWITCH 2	<table border="1" style="border-collapse: collapse; text-align: center;"> <thead> <tr> <th style="width: 20px;">0</th> <th style="width: 20px;">1</th> </tr> </thead> <tbody> <tr><td>1</td><td></td></tr> <tr><td>2</td><td></td></tr> <tr><td>3</td><td></td></tr> <tr><td>4</td><td></td></tr> <tr><td>5</td><td></td></tr> <tr><td>6</td><td></td></tr> <tr><td>7</td><td></td></tr> <tr><td>8</td><td></td></tr> </tbody> </table>	0	1	1		2		3		4		5		6		7		8		<p>1-2, I/O space size select. See Table 2-4 on page 2-4. 4K I/O - 1=OPEN, 2=CLOSED.</p> <p>3, CSR/Parity disable. CLOSED=disable.</p> <p>4-6, Spare.</p> <p>7, Special Bus operation enable. CLOSED=enable.</p> <p>8, Special Bus starting address select. OPEN=ADDR 0 See Table 2-3 on page 2-3.</p>
	0	1																		
1																				
2																				
3																				
4																				
5																				
6																				
7																				
8																				
SWITCH 3	<table border="1" style="border-collapse: collapse; text-align: center;"> <thead> <tr> <th style="width: 20px;">0</th> <th style="width: 20px;">1</th> </tr> </thead> <tbody> <tr><td>1</td><td></td></tr> <tr><td>2</td><td></td></tr> <tr><td>3</td><td></td></tr> <tr><td>4</td><td></td></tr> <tr><td>5</td><td></td></tr> <tr><td>6</td><td></td></tr> <tr><td>7</td><td></td></tr> <tr><td>8</td><td></td></tr> </tbody> </table>	0	1	1		2		3		4		5		6		7		8		<p>1-4 CSR address select. CLOSED=772100. See Table 2-5 on page 2-4.</p> <p>5-8, Memory size select. CLOSED=128K. See Table 2-6 on page 2-5.</p>
	0	1																		
1																				
2																				
3																				
4																				
5																				
6																				
7																				
8																				

TABLE 2-2

UNIBUS STARTING ADDRESS (OCTAL)	MEMORY STARTING ADDRESS	SWITCH SETTING				
		S1-5	S1-4	S1-3	S1-2	S1-1
000000	0K	0	0	0	0	0
020000	4K	0	0	0	0	1
040000	8K	0	0	0	1	0
060000	12K	0	0	0	1	1
100000	16K	0	0	1	0	0
120000	20K	0	0	1	0	1
140000	24K	0	0	1	1	0
160000	28K	0	0	1	1	1
200000	32K	0	1	0	0	0
220000	36K	0	1	0	0	1
240000	40K	0	1	0	1	0
260000	44K	0	1	0	1	1
300000	48K	0	1	1	0	0
320000	52K	0	1	1	0	1
340000	56K	0	1	1	1	0
360000	60K	0	1	1	1	1
400000	64K	1	0	0	0	0
420000	68K	1	0	0	0	1
440000	72K	1	0	0	1	0
460000	76K	1	0	0	1	1
500000	80K	1	0	1	0	0
520000	84K	1	0	1	0	1
540000	88K	1	0	1	1	0
560000	92K	1	0	1	1	1
600000	96K	1	1	0	0	0
620000	100K	1	1	0	0	1
640000	104K	1	1	0	1	0
660000	108K	1	1	0	1	1
700000	112K	1	1	1	0	0
720000	116K	1	1	1	0	1
740000	120K	1	1	1	1	0
760000	124K	1	1	1	1	1

NOTES

A. 0=OPEN (OFF)  
1=CLOSED (ON)

B. For 18 bit addressing, S1-6, S1-7, S1-8 and S2-8 must be open. For 22 Bit addressing, see Table 2-5.

TABLE 2-3

SPECIAL BUS STARTING ADDR (OCTAL)	MEMORY STARTING ADDRESS	SWITCH SETTING			
		S2-8	S1-8	S1-7	S1-6
00000000	0K	0	0	0	0
01000000	128K	0	0	0	1
02000000	256K	0	0	1	0
03000000	384K	0	0	1	1
04000000	512K	0	1	0	0
05000000	640K	0	1	0	1
06000000	769K	0	1	1	0
07000000	896K	0	1	1	1
10000000	1024K	1	0	0	0
11000000	1152K	1	0	0	1
12000000	1280K	1	0	1	0
13000000	1408K	1	0	1	1
14000000	1536K	1	1	0	0
15000000	1664K	1	1	0	1
16000000	1792K	1	1	1	0
17000000	1920K	1	1	1	1

NOTES

A. 0=OPEN (OFF)  
1=CLOSED (ON)

B. For 22 bit address operation, S2-7 must be closed.



TABLE 2-4

## I/O SPACE SIZE SELECT

I/O SPACE SIZE	SWITCH SETTING	
	S2-2	S2-1
8K	0	0
4K	1	0
2K	1	1

TABLE 2-5

## CSR ADDRESS SELECT

CSR ADDRESS SELECTION		SWITCH SETTING			
UNIBUS ADDRESS	SPECIAL BUS ADDRESS	S3-4	S3-3	S3-2	S3-1
772100	17772100	1	1	1	1
772102	17772102	1	1	1	0
772104	17772104	1	1	0	1
772106	17772106	1	1	0	0
772110	17772110	1	0	1	1
772112	17772112	1	0	1	0
772114	17772114	1	0	0	1
772116	17772116	1	0	0	0
772120	17772120	0	1	1	1
772122	17772122	0	1	1	0
772124	17772124	0	1	0	1
772126	17772126	0	1	0	0
772130	17772130	0	0	1	1
772132	17772132	0	0	1	0
772134	17772134	0	0	0	1
772136	17772136	0	0	0	0

0=OPEN (off)  
1=CLOSED (on )

TABLE 2-6

## MEMORY SIZE SELECTION

ON BOARD MEMORY CAPACITY	SWITCH SETTING			
	S3-8	S3-7	S3-6	S3-5
8K	0	0	0	0
16K	0	0	0	1
24K	0	0	1	0
32K	0	0	1	1
40K	0	1	0	0
48K	0	1	0	1
56K	0	1	1	0
64K	0	1	1	1
72K	1	0	0	0
80K	1	0	0	1
88K	1	0	1	0
96K	1	0	1	1
104K	1	1	0	0
112K	1	1	0	1
120K	1	1	1	0
128K	1	1	1	1

0= OPEN (off)  
1= CLOSED (on )

TABLE 2-7

## JUMPER PLACEMENT CHART

JUMPER	FUNCTION	INSTALLED	REMOVED
W1	+12V From Converter to Array	Normal	During Test
W2	+V To Array	During Test	Normal
W3	Not Used	- -	Normal
W4	-5V From Converter to Array	Normal	During Test
W5	-V To Array	During Test	Normal
W6	Not Used	- -	Normal
W7	8K Partial RAM Configuration (Not Used)	Normal	-
W8		- -	Normal
W9		- -	Normal
W10		Normal	-
W11		- -	Normal
W12		- -	Normal
W13	Internal Refresh Disable	- -	Normal
W14	External Refresh In	- -	Normal
W15	+20V (AV2) In	- -	Normal
W16	+15V Batt. (AR1) In	During Test	Normal
W17	+5V Batt. (BD1) to +5VB Plane	For Batt. Back up	Normal
W18	+5V to +5VB Plane	Normal	For Batt. Back up
W19	I/O Space Disable	- -	Normal

Memory boards will be shipped with the jumpers in the "NORMAL" configuration.

### CAUTION

Do not attempt to install the NS11L Memory board into DEC backplanes listed below or damage to the equipment could result:

- MF11-U
- MF11-W

Maintenance of the NS11L is minimal, enhanced by the use of fixed timing sequences. Refer to paragraph 2.10 for maintenance information.

### 2.2 SAFETY

The following safety precautions should be observed during installation and maintenance:

#### WARNING

Proper concern for the safety of all personnel is vital when installing equipment. The following safety practices should always be observed, or injury could occur.

##### 2.2.1 Power

1. Remove all power from the system before installation using the related facility and/or system circuit breakers. Remove the AC power plug from the AC receptacle. (This is particularly important when cards or components are to be removed).

2. Tag all system circuit breakers with WARNING tags to ensure that circuit breakers will not be inadvertently turned on during installation.
3. When it is necessary to work on a system where power is present, never work alone. Two people must always be present when work is being done within a system, or on an interconnecting cable whenever system power is applied.

#### 2.2.2 Fire

1. Good housekeeping is a significant factor in fire and accident prevention. Keep benches and working areas clear of unnecessary articles.
2. Ensure fire extinguishers of the CO<sub>2</sub> type (for electrical fires) are readily available.

#### 2.3 UNPACKING AND INSPECTION

Follow the steps listed below to unpack and inspect the NS11L Memory board.

1. Remove all packing materials. (Failure to do so could result in damage to the equipment and present a fire hazard); store the reusable packing materials for future use.
2. Remove the Memory board from its container.
3. Inspect the board for visual damage, checking for bent stiffener, damaged IC's, broken wires or connectors, dislocated or broken switches or indicators, etc. Certain damage may not be detected until power has been applied and diagnostics performed.

NOTE: Visually damaged or inoperative boards should be  
returned to: NATIONAL SEMICONDUCTOR  
2900 Semiconductor Drive  
Santa Clara, California 95051

## 2.4 ADDRESS AND I/O SWITCH CONFIGURATIONS

### 2.4.1 Address

The NS11L Memory will accept a full 22 bit address with the least significant bit being used for Byte selection. The address lines to the memory are single rail; the addressing mode may be random. The address lines are identified as A0 through A21.

The NS11L may be used for expansion to 2M words using the 22 bits of address. When this expansion is used, address I/O pin assignments are as follows:

BUS A18-BE2  
BUS A19-BE1  
BUS A20-AP1  
BUS A21-AN1

A0 is used for Byte selection. A1 through A21 are decoded for one of 2,097,152 address locations.

A13 through A21 are 'strappable' on the memory module. These address lines may be strapped to set the initial address for a memory module. Nine switch positions located at S1 and S2 are provided to set the initial address. Five positions are used for initial address selection in the 0-128K address range.

The remaining four positions can be used for expansion to 2M words. See Table 2-2 for 0-128K Select. See Table 2-3 for expansion to 2M word. Address selection is in 128K blocks to 2M word. Addresses A18 thru A21 are switch settable via switches per Table 2-3. Address buffer for A18-A21 must be enabled by closing switch S2-7. For system expansion beyond 128K, Table 2-2 is used in conjunction with Table 2-3 to ascertain required switch settings.

Table 2-1 is a general guide to the address and I/O switch configurations, and lists the pages of this guide for switch selection. (See page 2-2).

## 2.5 CSR ADDRESS ASSIGNMENT

The NS11L contains an on-board CSR, which contains error information in the event of a parity error. There are 16 possible CSR addresses as listed in Table 2-5. When the NS11L is used in conjunction with DEC parity memory and a DEC M7850 parity controller, or multiple NS11L's, the CSR addresses of the M7850 and NS11L's must not be the same. The CSR can be disabled by closing switch S2-3. See Table 2-5 for CSR address selection.

NOTE: CSR address has no relevance to the memory starting address or storage capacity of the NS11L.

## 2.6 BATTERY BACK UP

The NS11L can be configured for battery back up by installing jumper W17 and removing jumper W18. See Table 2-7 for a list of jumper configurations.

## 2.7 I/O CONFIGURATIONS

### A. I/O Space Selection

The NS11L has a normal reserved I/O space of 4K but can be selectable to either 8K or 2K. The I/O space normally resides between 124K and 128K for Unibus operation. I/O space will reside at the top of the 2M words for 22-Bit address operation. See Table 2-4 for I/O space size selection switch settings.

### B. Memory Size Selection

The NS11L can be configured in 8K increments to 128K. Memory size must be set according to actual board capacity. See Table 2-6 for memory size select switch settings.

## 2.8 INSTALLATION

Perform the following steps in the order listed to install the NS11L Memory board:

1. Verify that the PDP11 system is performing properly by running the appropriate memory diagnostics before any changes to the CPU configuration are made.
2. Verify that jumper connections (Table 2-7) and switch settings (Tables 2-1 through 2-6) are correct according to the memory starting address, memory size, CSR address,



I/O space, and battery back-up, as per sections 2.4 thru 2.7.

3. Turn off CPU power.
4. Carefully slide the memory into the selected slot. Be sure that the component side faces the correct direction, and that the board is aligned in the card guides. Insert and remove slowly so contact is not made with adjacent boards. When the memory has engaged the connectors, press firmly on the card and seat it by exerting equal pressure on the two ejectors.
5. Replace any cables, covers, panels, etc., which were moved during installation. Turn on CPU power.
6. Perform post-installation checks listed in paragraph 2.9.

#### 2.9 POST INSTALLATION CHECKS

Post installation checks consist primarily of checking the operation of the memory unit as an integral part of the data processing system in which it is installed. Since the functional checks depend upon the data processing system configuration and user application, the test routines to be used are left to the discretion of the user. Owing to the all-electronic nature of the memory unit, there are no mechanical checks or inspections to be performed once the unit is installed.

NOTE: Any unused "modified bus" backplane slot must have a bus grant card in location D, or the CPU will show bus error.

Again verify that the system is performing properly by running the appropriate memory diagnostics.

## 2.10 MAINTENANCE

The maintainability of the NS11L Memory is enhanced by the use of fixed timing sequences. Since all timing is self-contained on the card, and one card type is used, complete interchangeability is realized. A spare card can be used in place of a failing unit without the need for any timing adjustments.

### 2.10.1 Pretested Memory Replacement

One pretested memory device is plugged into an on-board socket for spare requirements. This spare memory device can be used to replace any failing memory devices in the field. The spare memory is at location U167.

The memory devices are all mounted in sockets, so that repairs can be effected on-site.

Paragraph 2.10.2 contains a listing of steps to follow prior to troubleshooting at the component level.

### 2.10.2 Preliminary Checks

If the memory fails, the following preliminary procedure should be followed before component-level troubleshooting:

1. Check the memory installation; it must be installed facing the correct direction. (Memory components are facing the same direction as the CPU board components).

2. Insure that the YELLOW and RED LED's are not lit; the Yellow LED will light if the DC/DC convertor has failed and the Red LED will light if a parity error has occurred.
3. Remove memory and visually inspect; wipe edge-connector with clean cloth.
4. Re-check the jumper connections and switch settings.
5. Re-install the Memory, carefully seating module in the chassis connectors.
6. Using the peripheral equipment, interrogate various address areas of the memory. (This will assure the module is fully operational).
7. When possible, switch with another module known to be operating properly. (Use the results to determine whether the problem is in the module or in the processor interface).

Figure 2-1 may be used for locating defective memory devices.

FIGURE 2-1

MEMORY COMPONENT BIT AND ROW ADDRESS LOCATOR

U1																		U18
U19																		U36
U37																		U54
U55																		U72
U73																		U90
U91																		U108
U109																		U126
U127																		U144

BIT 0  
 BIT 1  
 BIT 2  
 BIT 3  
 BIT 4  
 BIT 5  
 BIT 6  
 BIT 7  
 BIT 8  
 BIT 9  
 BIT 10  
 BIT 11  
 BIT 12  
 BIT 13  
 BIT 14  
 BIT 15  
 BIT P0  
 BIT P1

RAM IC's                      MEMORY SYSTEM ADDRESS RANGE

U1-18                      0-16K(0-077776)  
 U19-36                    16-32K(100000-177776)  
 U37-54                    32-48K(200000-277776)  
 U55-72                    48-64K(300000-377776)  
 U73-90                    64-80K(400000-477776)  
 U91-108                   80-96K(500000-577776)  
 U109-126                 96-112K(600000-677776)  
 U127-144                 112-128K(700000-777776)



SECTION III  
THEORY OF OPERATION

3-1 GENERAL

This section comprises a functional description of the memory card assembly. Description is divided into general discussion and detailed circuit description, each referring to appropriate block diagrams and schematics. The schematic diagram is located in Appendix A.

3-2 INTERFACE

3.2.1 Unibus; Standard, Modified and Special Bus

The DEC PDP-11 Unibus has three configurations. The standard configuration differs slightly from the Modified and Special configuration in pin designation. The Unibus signals are delineated in Table 3-1.

TABLE 3-1 Bus Signals Viewed From The Connector End

<u>PIN NUMBER</u>	<u>STANDARD</u>	<u>MODIFIED</u>	<u>SPECIAL</u>
AA1	INIT L	INIT L	INIT L
AB1	INTR L*	INTR L*	INTR L*
AC1	DOO L	DOO L	DOO L
AD1	DO2 L	DO2 L	DO2 L
AE1	DO4 L	DO4 L	DO4 L
AF1	DO6 L	DO6 L	DO6 L
AH1	DO8 L	DO8 L	DO8 L
AJ1	D10 L	D10 L	D10 L
AK1	D12 L	D12 L	D12 L
AL1	D14 L	D14 L	D14 L
AM1	PA L*	PA L*	PA L*
AN1	GND*	PAR. P1*	A21 L
AP1	GND*	PAR P0	A20 L
AR1	GND*	+15 BATT*	+15 BATT*
AS1	GND*	-15 BATT*	-15 BATT*
AT1	GND*	GND	GND
AU1	NPG H*	+20V (CORE) *	+20V (CORE) *
AV1	BG7 S0*	+20V (CORE) *	+20V (CORE) *
AA2	+5V	+5V	+5V
AB2	GND*	TP*	TP*
AC2	GND	GND	GND
AD2	D01 L	D01 L	D01 L
AE2	D03 L	D03 L	D03 L
AF2	D05 L	D05 L	D05 L
AH2	D07 L	D07 L	D07 L
AJ2	D09 L	D09 L	D09 L
AK2	D11 L	D11 L	D11 L
AL2	D13 L	D13 L	D13 L
AM2	D15 L	D15 L	D15 L
AN2	PB L	PB L	PB L
AP2	BBSY L*	BBSY L*	BBSY L*
AR2	SACK L*	SACK L*	SACK L*
AS2	NPR L*	NPR L*	NPR L*
AT2	BR7 L*	BR7 L*	BR7 L*
AU2	BR6 L*	BR6 L*	BR6 L*
AV2	GND	+20V (CORE) *	+20V (CORE) *

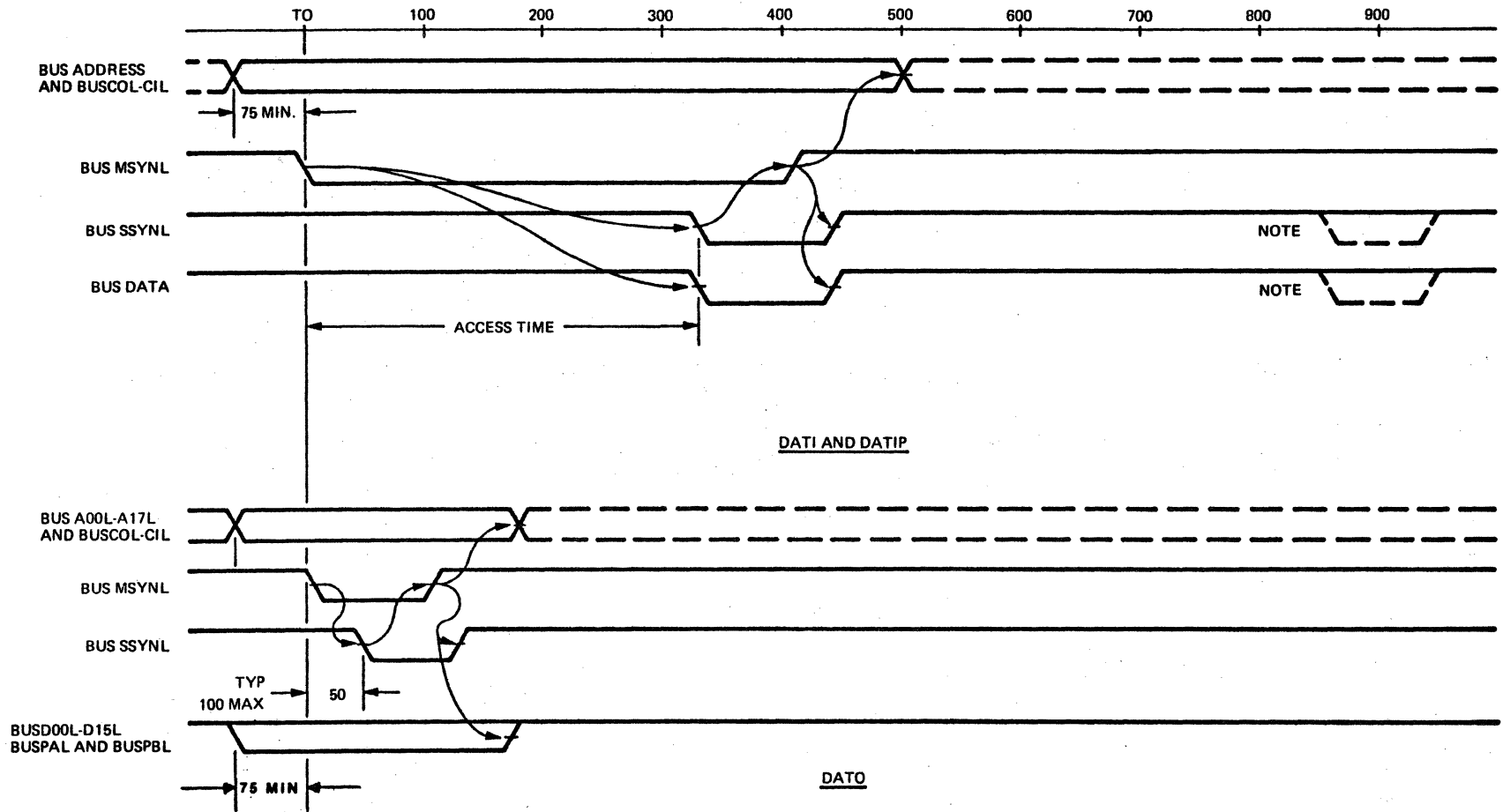
\*Pins assigned in Unibus connector but not used by memory.

TABLE 3-1 Bus Signals Viewed From The Connector End (Cont'd)

<u>PIN NUMBER</u>	<u>STANDARD</u>	<u>MODIFIED</u>	<u>SPECIAL</u>
BA1	BG6 H*	RESV*	RESV*
BB1	BG5 H*	RESV*	RESV*
BC1	BR5 L*	BR5 L*	BR5 L*
BD1	GND*	+5 BATT	+5 Batt
BE1	GND*	SSYN INT L*	A19 L
BF1	ACLO L*	ACLO L*	ACLO L*
BH1	A01 L	A01 L	A01 L
BJ1	A03 L	A03 L	A03 L
BK1	A05 L	A05 L	A05 L
BL1	A07 L	A07 L	A07 L
BM1	A09 L	A09 L	A09 L
BN1	A11 L	A11 L	A11 L
BP1	A13 L	A13 L	A13 L
BR1	A15 L	A15 L	A15 L
BS1	A17 L	A17 L	A17 L
BT1	GND	GND	GND
BU1	SSYN L	SSYN L	SSYN L
BV1	MSYN L	MSYN L	MSYN L
BA2	+5V *	+5V *	+5V *
BB2	GND *	TP *	TP *
BC2	GND *	GND *	GND *
BD2	BR4 L*	BR4 L*	BR4 L*
BE2	BG4 L*	PAR DET L*	A18 L
BF2	DC LO L	DC LO L	DC LO L
BH2	A00 L	A00 L	A00 L
BJ2	A02 L	A02 L	A02 L
BK2	A04 L	A04 L	A04 L
BL2	A06 L	A06 L	A06 L
BM2	A08 L	A08 L	A08 L
BN2	A10 L	A10 L	A10 L
BP2	A12 L	A12 L	A12 L
BR2	A14 L	A14 L	A14 L
BS2	A16 L	A16 L	A16 L
BT2	C1 L	C1 L	C1 L
BU2	C0 L	C0 L	C0 L
BV2	GND *	-5V (CORE) *	-5V (CORE) *

\*Pins assigned in Unibus connector but not used by memory.





NOTE DATA AND SSYNL MAY BE DLEAYED UP TO 405 ns DUE TO SIMULTANEOUS REFRESH AND MEMORY REQUEST.

FIGURE 3-1

### 3.2.2 SIGNALS

There are three types of signals; input, output and bidirectional. These signals are received, processed and passed back to the CPU in two logic levels: A high, or logic level one; and a low, or logic level zero. Specifications for these logic levels are as follows:

<u>TYPE OF SIGNAL</u>	<u>LEVEL ONE</u>	<u>LEVEL ZERO</u>
Bus Logic Levels	+0.8V or Less	+2.0V or More
Input Signal Logic Levels	1.3V Maximum 30 microamps typical at 0.8V	1.7V Minimum 80 microamps maximum at 2.5V
Output Signal Logic Levels	0.8V maximum at 70milliamps	2.4V minimum 25 microamps maximum at 3.5V

Memory System Interface Timing is given in figure 3-1. All timing is measured at the card edge connectors and is referenced to the +1.5V level of signal transition.

### 3.2.3 Types of Signals

There are three types of signals. Input signals, output signals and bi-directional signals.

#### Input Signals

These signals are address and command signals. A00 through A17 (BH1-BS1, BH2-BS2) are address lines which determine memory location. A0 determines which byte is written when Byte Write (DATOB) is executed.

When addresses A18 - A21 are used the following pin assignments are used (Special Bus Operation):

A18	-	BE2
A19	-	BE1
A20	-	AP1
A21	-	AN1

C0 and C1 are the signals which determine the cycle mode. C1 selects Read or Write Cycle. C0 selects Byte Write or Full Write.

Master Sync, MSYN, is the Bus control signal which initiates memory cycle when memory is available (BVI).

Initialize, INIT, is used as a clear signal before MSYN occurs. It clears the Control Status Registers (CSR's) for bits 0, 2, 14, and 15 (AAL).

DC LO, when asserted, causes the memory to perform Refresh only. It also allows data retention should the battery back-up voltage be activated (BF2).

#### Output Signals

SSYN is the Slave Sync signal. It tells the host system that memory is on line and data is ready for the Read Cycle. During the Write cycle, it indicates that address/data has been accepted by memory for processing (BU1).

PB is the signal which indicates that a parity error has been detected.

### Bi-directional Signals

D0 through D15 data lines are bi-directional. These 16 lines are used to communicate data information with the Unibus I/O (AC1 through AK1 and AD2 through AM2).

### 3.3 ADDRESS (FIGURE 3-2)

The NS11L Memory accepts a full 22-bit address with the least significant bit being used to control Byte Write. The address lines to the memory are single rail and the addressing mode is random. Address signals are identified as A0 through A21 (See Figure 3-2).

A0 is used in the Byte Write mode as the byte selection control bit. A1 through A21 can be decoded across a range of addresses from zero through 2,097,152 locations in memory. The extension of memory addressing through 2 Mega Words is achieved by the setting of Switch S2-7, which enables the buffer for bits A18 through A21 and allows them to be included in the address certification process.

Four Buffer chips receive the address from the bus. The address is stable on the Bus for 75 nsec, prior to receipt of MSYNC, the Master Sync pulse. During this time it is processed through the address selection circuitry (see Figure 3-2). The address buffers receive and pass all inputs from the bus to the

Address Latch, which is transparent until the Selection process is completed.

A0 through A17 are passed through the Address Latch chips. A1 through A14 go directly to the RAS/CAS Address Multiplexer where they select the Row and Column RAM address. This is discussed in greater detail later in this section.

A13 through A21 are presented at the Starting Address Select circuitry and compared with the initial address entered in the nine switch positions located on Switches S1 and S2. These nine switch positions represent the minimum bus address to which the card can respond. When the Starting Address Selection process is complete, one of two conditions has been recognized:

- The bus address is either less than the minimum address configuration set by S1-1 through S1-8, S2-8.
- Or it is equal to, or greater than, the minimum switch settings.

If the address is less than the switch settings, it is rejected and no further action is taken. If, however, the address is found to be equal to or greater than the minimum switch setting, the Starting Address Select function outputs a normalized address. This address is the difference between the bus address and the address set by the switches. If the normalized address (NA14-NA17) is in the range set by the Memory Size Select circuitry (value set by S3-5 thru S3-8), the +ADDR SEL signal

is generated. The +ADDR SEL signal, when enabled by MSYNC, latches the address in the Address Latch and begins a memory cycle.

When the two criteria cited above are met, address bits NA15 and NA16 are presented to the Row Decode circuitry which selects a row of RAM on the card.

A1-A7 are multiplexed with A3-A14 to become -Add 0-6, which transmit row address, then column address, during a normal cycle. During the Refresh Cycle the refresh addresses are provided by a refresh address counter.

The I/O Block is an area in Memory that is usually 4K words in size. It is normally located in the top 4K of Memory, i.e., from 124K words to 128K words, using a Unibus interface. It is located at the top of 2M words when interfacing with the Special Bus (from 1.996M to 2M). In the I/O address space, the Memory does not respond to Bus MSYN L unless the on-board CSR has been addressed. The I/O Block has a Size Select Switch which permits selection of 2K, 4K, or 8K words of I/O space. This switch (S2) is set as a part of the installation procedure. (Table 2-4)

CSR Address Selection is accomplished in the I/O region. The CSR, seen by the CPU as an I/O register, has assigned addresses which can be accessed (one of sixteen) by a Bus

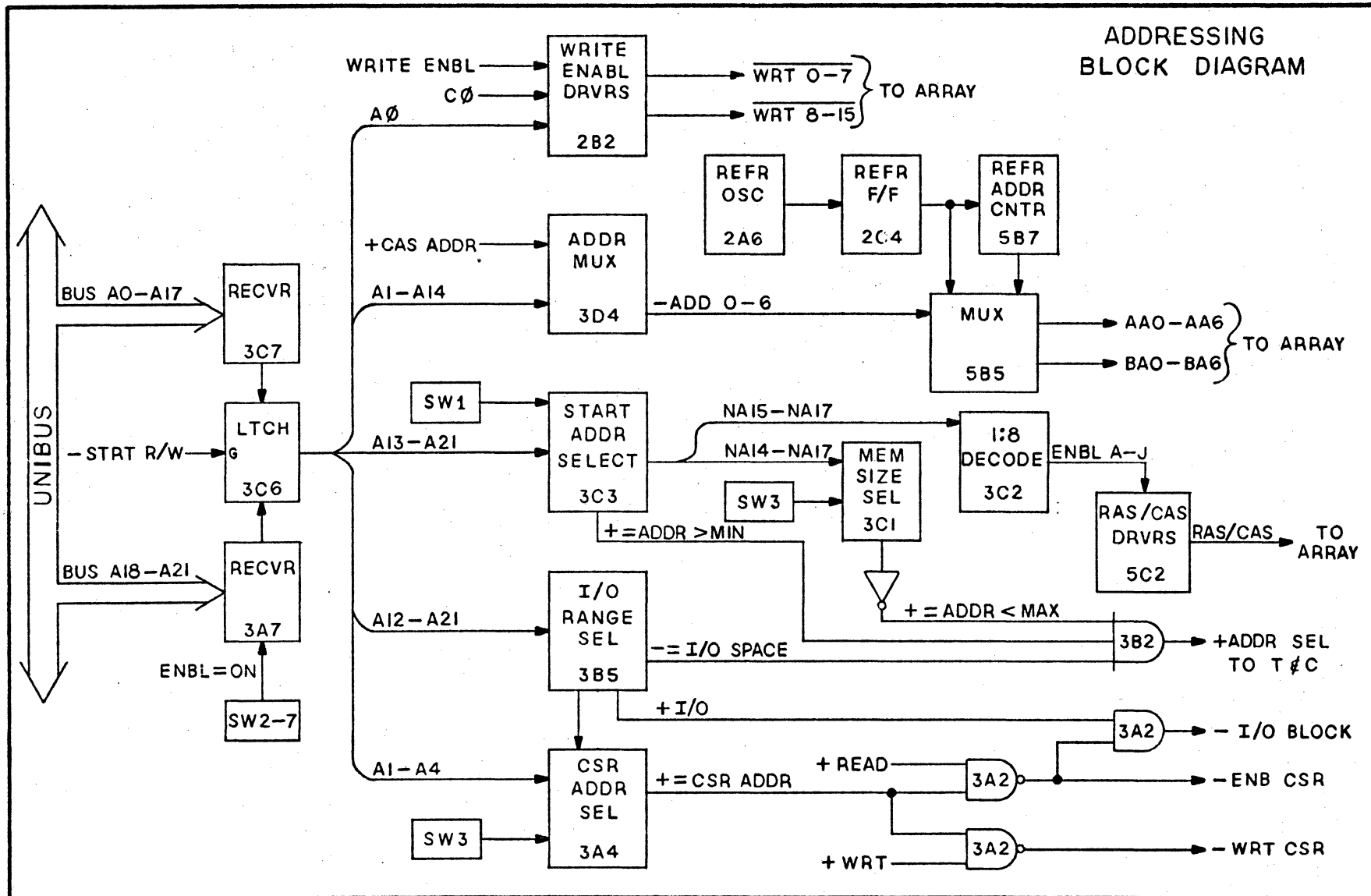


FIGURE 3-2

Master via the Unibus or Special Bus. This address will contain diagnostic and error information (error address to the nearest 1K) if an error has occurred. CSR operation can be disabled by closing S2-3.

The CSR starting address receives an enable from the I/O region (high) and A1-A4. The CSR address select circuitry compares A1-A4 with the CSR Addr switch setting (S3-1,2,3,4). If they are equal, then a +CSR ADDR signal is generated. These inputs combined with +MSYN, +READ or +WRITE produce -WRT CSR or -ENB CSR.

#### 3.4 TIMING AND CONTROL (FIGURE 3-3)

The timing and control circuitry provides the necessary timing and signal control to allow the memory card to run full or refresh cycles. The T and C contains the Refresh arbitration network and refresh oscillator. A bus cycle can be delayed as much as 405ns if the request arrives after a refresh cycle has begun.

The START ENABLE circuit tests the memory card status and is the cycle arbitrator. A memory request from a bus master is initiated only if the following conditions exist: there is no refresh request waiting, there is no cycle presently in progress, the address is in the range of the memory card, and the address is not in the I/O region. If a refresh request had been present, the memory would have done a refresh cycle and then honored the bus request.



If the memory status allows a bus request to be honored, the START ENABLE circuit output is delayed and then sets the START FLIP FLOP. The delay insures that a race condition between a cycle request and a refresh request does not exist. The START F/F sets the FULL CYCLE F/F and enables the read and write SSYN F/F's. The START F/F output also disables the refresh enable circuitry. The FULL CYCLE F/F output enters the delay lines (200ns) which provide the memory card timing.

If a refresh request had occurred during a memory cycle, the REFR REQ F/F would have been set. The refresh enable circuitry would have been disabled by the START F/F and the F CYCLE F/F. When both devices have been reset by memory timing at the end of the cycle, the refresh request is allowed to pass through the REFRESH ENABLE circuitry and a refresh cycle is initiated. The REFRESH ENABLE output also blocks any further bus requests until the refresh cycle is terminated.

Refresh of the dynamic RAM's takes place every 15 uSec. The RAM is refreshed to prevent loss of existing DATA. Refresh is accomplished by the selection of a particular Refresh RAS Address, and inhibiting Row Decode so that all rows of RAM are selected. A counter in the Refresh Address Counter and Multiplexer increments once each time a Refresh Cycle is completed. This counter sets up the RAS address selection process for the next Refresh Cycle, thereby stepping the refresh activity completely through the memory every 2 milliseconds.

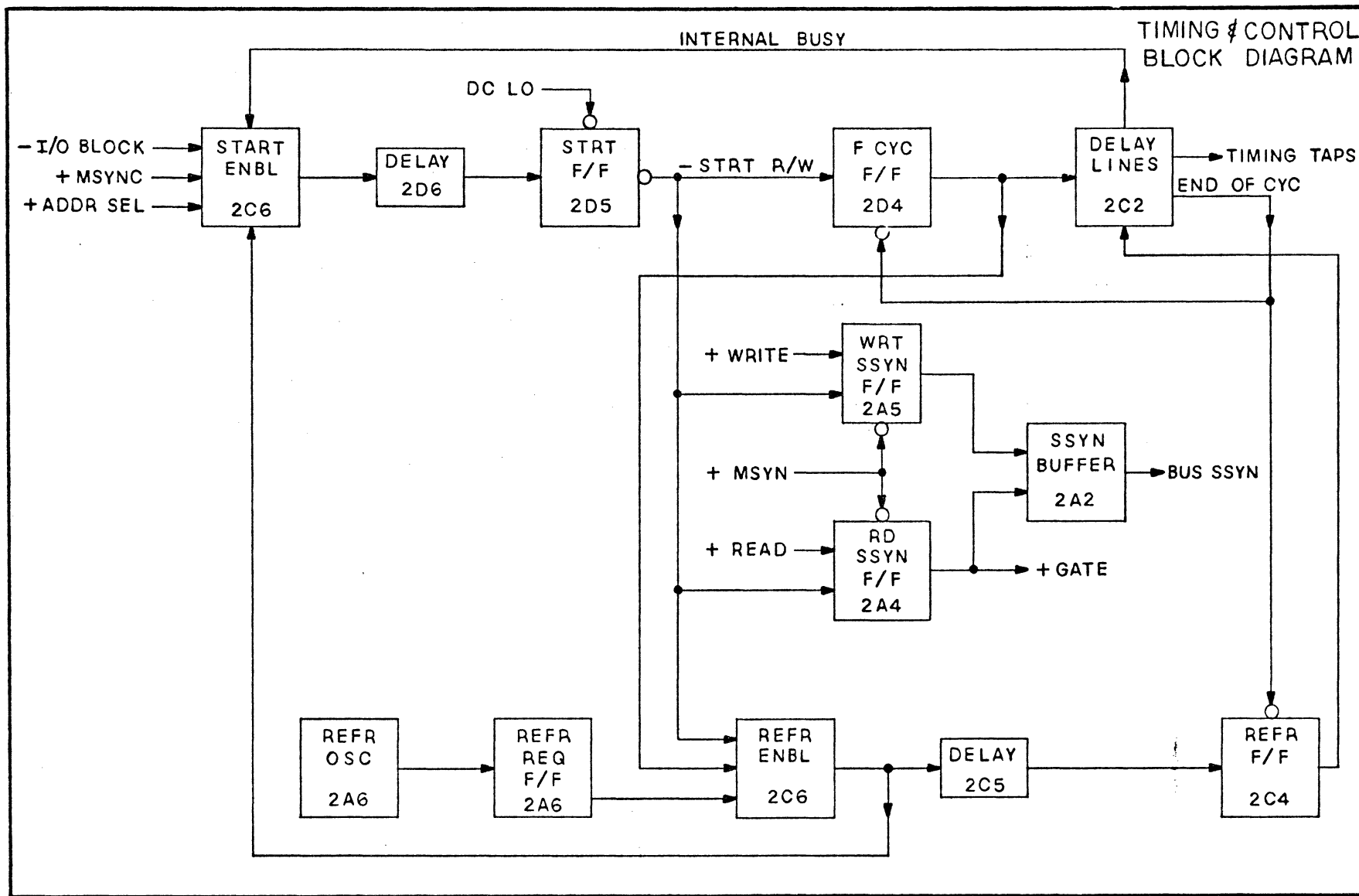


FIGURE 3-3

### 3.5 MEMORY ARRAY (FIGURE 3-4)

The Memory Array is comprised of 144 16K Dynamic Rams in a 8x18 matrix. Each Byte contains 128Kx9 bits of memory; eight data bits and a parity bit. Addresses A0 thru A6 are common to all Rams. RAS and CAS signals (1 of 3) are common to each row. Basic Array organization is shown in Figure 3-4.

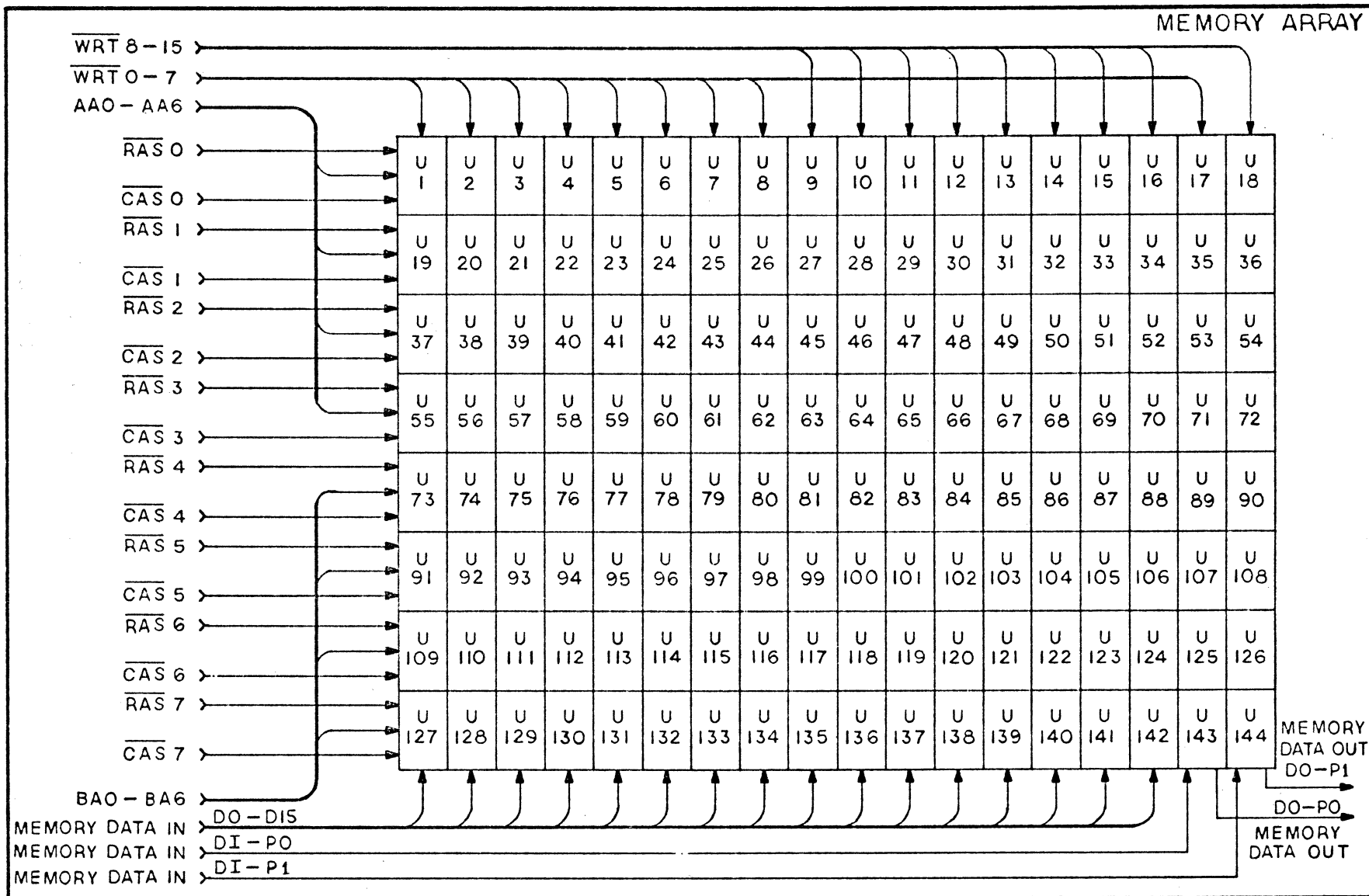


FIGURE 3-4

### 3.6 DATA PATH (FIGURE 3-5)

The read and write data paths are depicted in figure 3-5. During a write cycle, the bus data passes through the transceivers and is latched by the -LTCH and ENBL signal. The data latch outputs are tri-state and are enabled by the -CTRL signal. The data latch outputs are enabled during a WR cycle and for the last half of a RD cycle. The data lines to the array are bi-directional for bits 0-15. The data latch outputs drive the data lines to/from the array and also are tied to the parity generation and check circuit, where the parity bits (DIP $\emptyset$ , DIP1) are generated and sent to the array.

During a read cycle, the data from the array appears on the bi-directional data lines D0-D15. The data goes through the transceiver onto the bus, where it is fed back through the receiver portion of the transceiver and is latched by the data latches after the data stabilizes. The data latch outputs are then enabled, ensuring data on the bus until MSYN is no longer asserted. The data out of the array, along with the parity data outlines (DOP $\emptyset$ , DOP1) is checked by the Parity check circuit for odd parity. If an error is detected, the +error signal is generated and a parity error flag (BUS PB) can be asserted on the bus.

### 3.7 CSR/Parity Operation (Figure 3-5)

The NS11L memory is capable of performing parity and CSR functions equivalent to the M7850 parity controller. The

CSR & DATA PATH  
BLOCK DIAGRAM

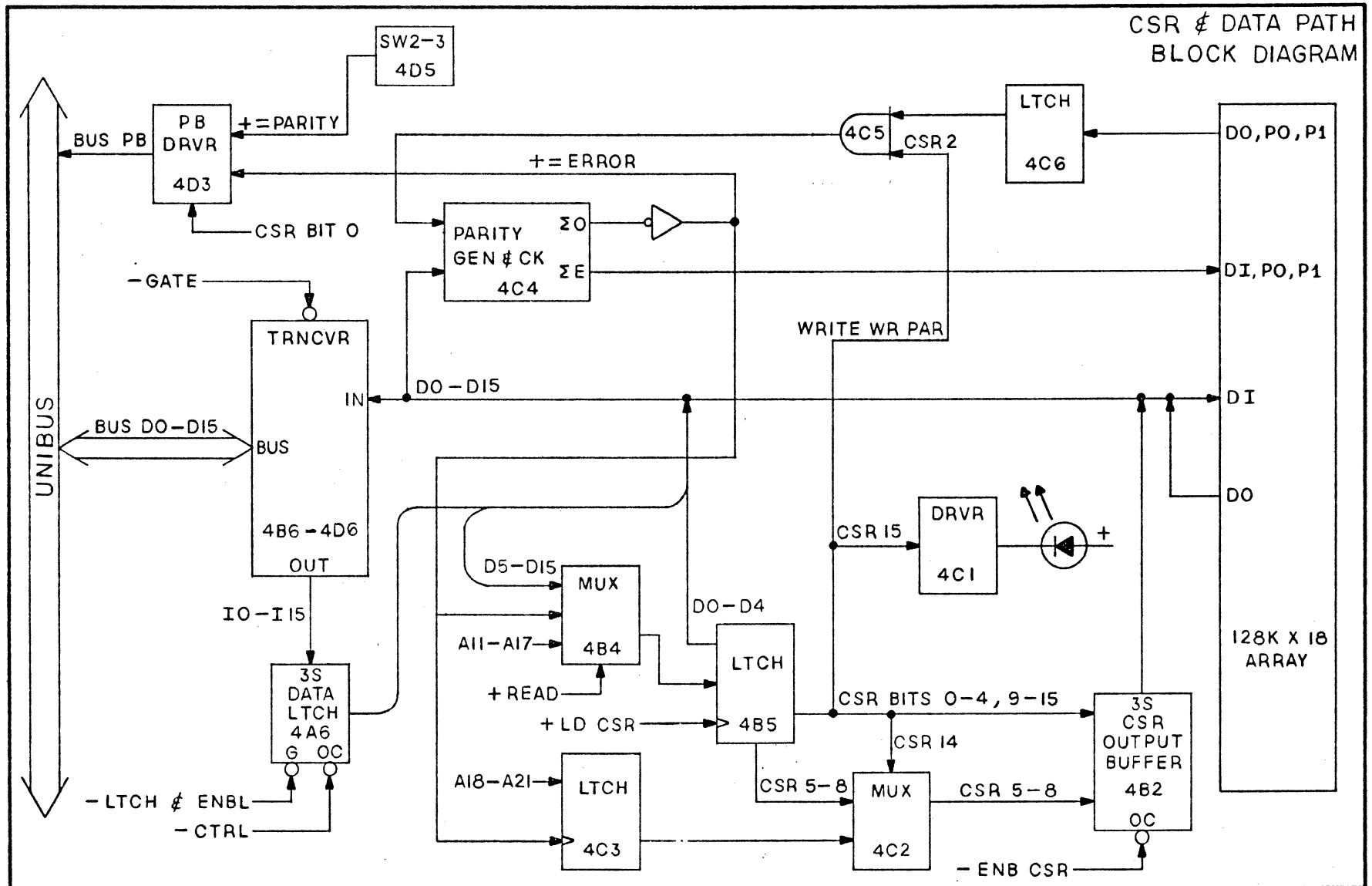
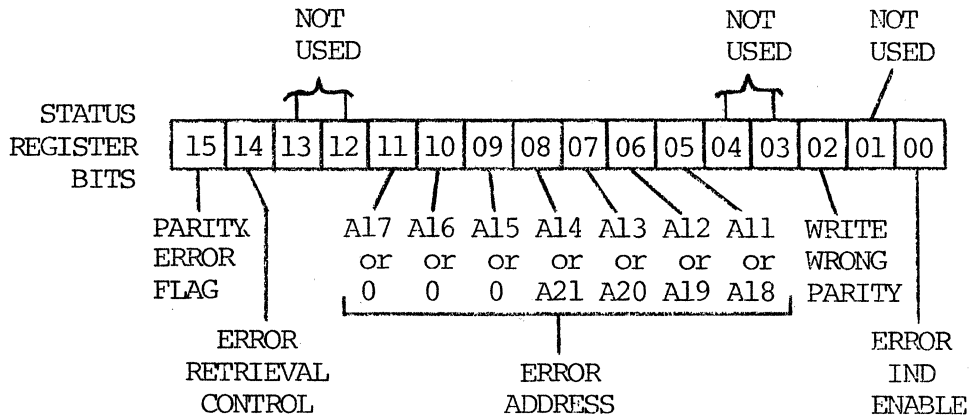


FIGURE 3-5

memory is compatible with all modified Unibus parity or non-parity memories. The memory does not require an M7850 parity controller; however, an M7850 may be required for other parity memories that may be on the same backplane. The presence of the M7850 does not affect the NS11L.

The control and status register (CSR) in the NS11L allows program control of certain parity functions and contains diagnostic information (error address to nearest 1K) if an error has occurred. The CSR is assigned an address and can be accessed by a bus master via the Unibus or the "special bus". Each NS11L or M7850, in a given backplane, must be assigned a different address. (For address assignment see Table 2-7). Some CSR bits are cleared by the assertion of BUS INIT I, as part of the processor power-up sequence. The CSR Bit assignments and operational description are as follows:



BITS 1,3,4,12,13

These Bits are not used and are always read as logical 0's. Writing into these Bits has no effect on the CSR.

#### BIT 0

Error Indication Enable - This Bit, when set (Logical 1), allows the memory to assert BUS PB L (AN2) when Data is retrieved from memory if a Parity error has been detected. This Bit is a Read/Write Bit and is cleared by BUS INIT L.

#### BIT 2

Write/Wrong Parity - This Bit, when set, causes the NS11L to Write Wrong Parity (even) when Data is written during a Write cycle (DATO or DATOB). A parity error will then be detected when this Data is read during a Read (DATI or DATIP) cycle. The detection of the parity error causes the parity error flag to be asserted. This Bit is set for diagnostic purposes and is cleared for normal operation. Bit 2 is a Read/Write Bit and is cleared by BUS INIT L.

#### BITS 5-11

Error Address - Once a parity error has been detected, these Bits contain a partial address of the faulty Data that caused the parity error. In Unibus operation, address Bits A11-A17 are in CSR Bits 5-11 respectively, specifying the faulty Data location to a 1K segment of memory. In special bus operation, the address placed in Bits 5-11 is determined by Bit 14. Bits 5-11 are Read/Write Bits and are not cleared by BUS INIT L.



#### BIT 14

Special Bus Error Retrieval - This Bit, when set, causes the memory to place A18-A21 of the faulty Data location into CSR Bits 5-8; logical 0's are placed in Bits 9-11. Address Bits A11-A17 are placed in Bits 5-11 when Bit 14 is cleared. In special bus operation, Bit 14 is a Read/Write Bit and is cleared by BUS INIT L. In Unibus operation, Bit 14 is a Read only Bit and is always a logic 0 (clear).

#### NOTE:

In normal special bus operation, Bit 14 is a logic 0. If a parity error has occurred during special Bus operation, the partial address (A11-A21) of the faulty Data is retrieved with the following sequence:

- a) Read CSR to obtain A11-A17. Bit 14 should be read as a logical 0.
- b) Write a logical 1 in Bit 14 of the CSR.
- c) Read CSR to obtain A18-A21. Bit 14 should be read as a logical 1.

#### BIT 15

Parity Error Bit - This Bit, when set, indicates that a parity error has occurred. Bit 15 is a Read/Write Bit and is cleared by BUS INIT L.

#### NOTE:

The on-board CSR can be disabled by closing (ON) Switch S2-3.

### 3.8 DC-TO-DC CONVERTOR (FIGURE 3-6)

The NS11L employs a DC-to-DC convertor switching regulator that operates as flyback convertor in a step-up mode. The basic circuit is shown in Figure 3.6.

When switch S1 closes, the applied voltage drops to almost zero ( $V_a = V_x$ ), and the voltage ( $V_{in} - V_s$ ) applied across the inductor, causing the inductor current to increase linearly. Because the applied voltage is less than the output voltage, the diode is reverse-biased and current cannot flow to the output. When the switch opens, the inductor current cannot change instantly and the applied voltage changes to the total of the output voltage plus the diode voltage. At this time current can flow through the diode to the load capacitance and the inductor current decreases at a linear rate, determined by  $V_{out} + V_D - V_{in}$ . Timing adjustments control the average diode current ( $I_{D1}$ ) so it is equal to the load current. The diode current can only flow during off-time, so the maximum output current is  $(I_{pk}/2) (T_{off}/T_{on} + T_{off})$ . If the load current is less than the maximum output current, off-time is increased by a dead time with no current to the output. Input current can flow during both on and off times, so the average input current is always greater than the maximum output current.

In figure 3-6, the designations correspond to schematic reference designations as follows:  $L=L1$ ,  $S_1=Q2$  thru  $Q5$ ,  $D1=CR5$ ,  $CR6$ ,  $C_o$ =all capacitance on +12V line.

Main control for the convertor is handled by a pulse width modulator that controls on time, off time, dead time, voltage regulation and soft-start sequence. If the DC-to-DC convertor circuitry should fail, or the convertor input voltage fuse should blow, the amber LED (DS2) will light.

DC TO DC CONVERTOR  
BLOCK DIAGRAM

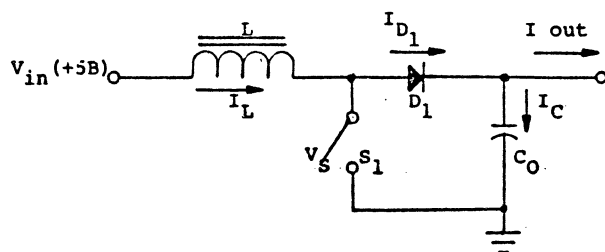
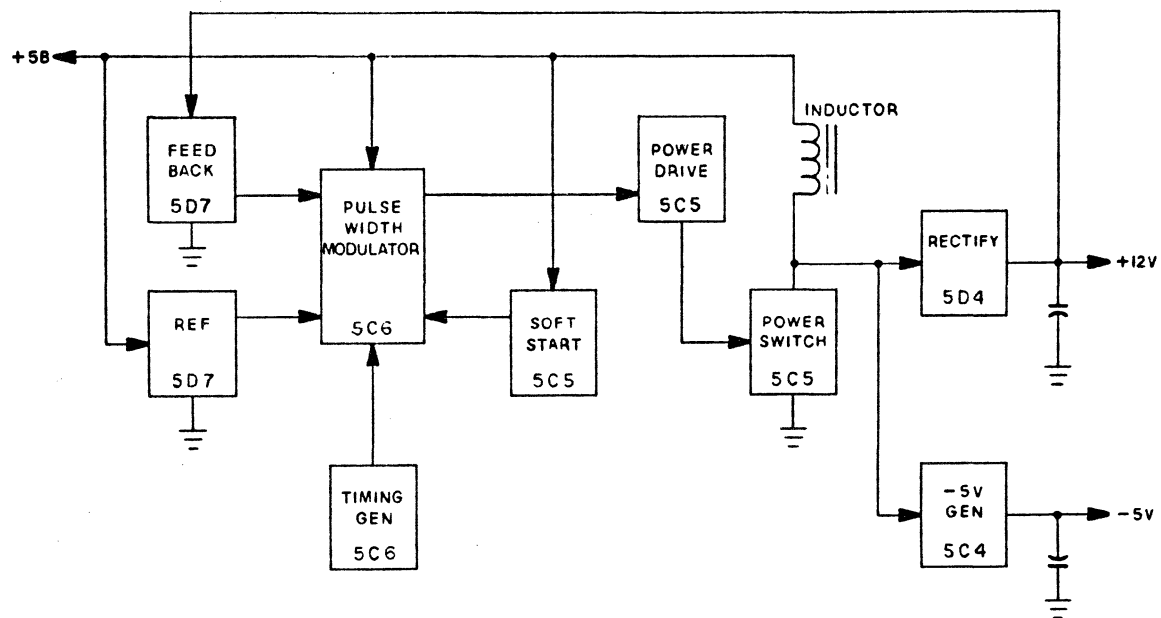


FIGURE 3.6

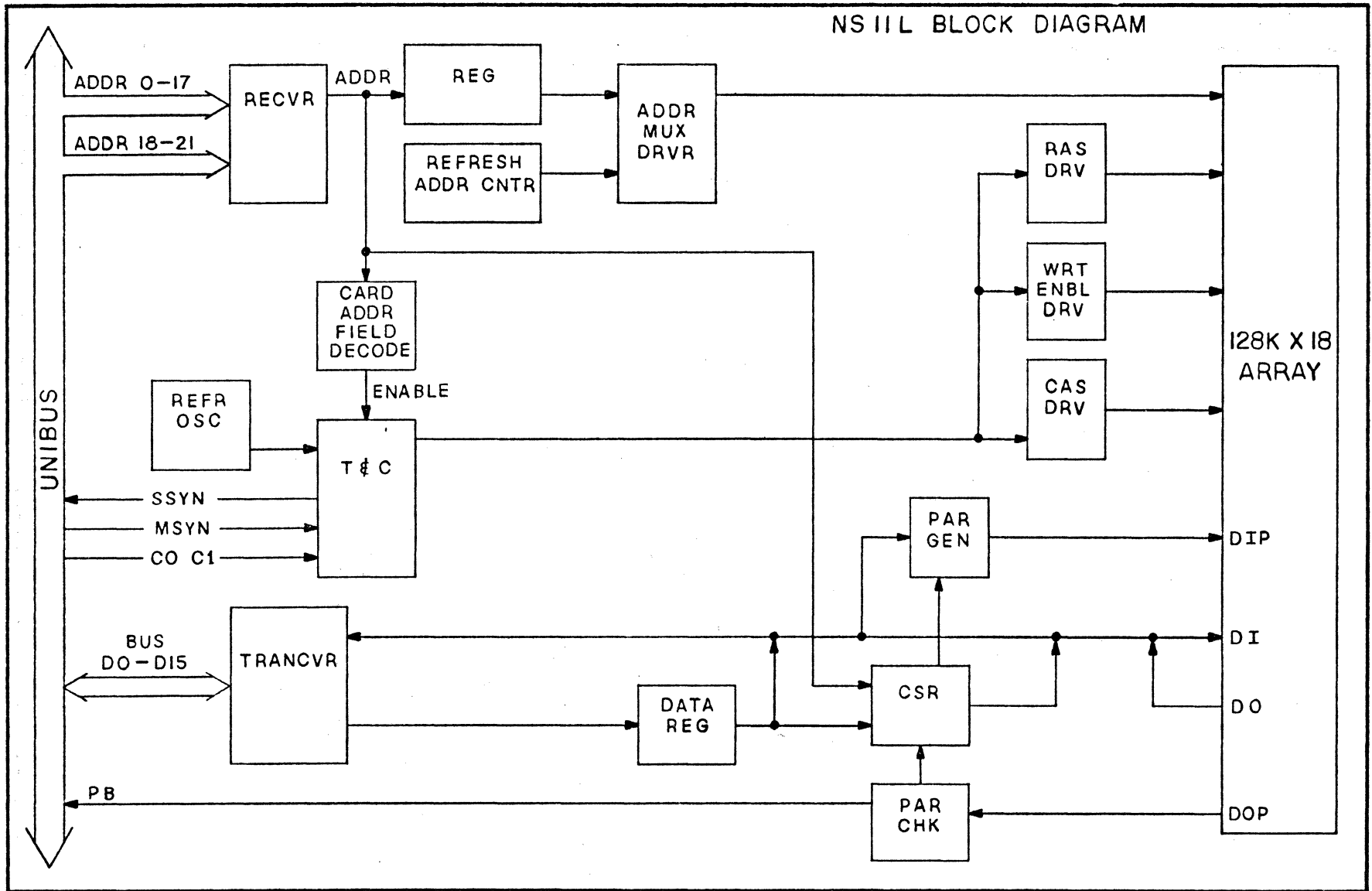


FIGURE 3-7

SECTION IV

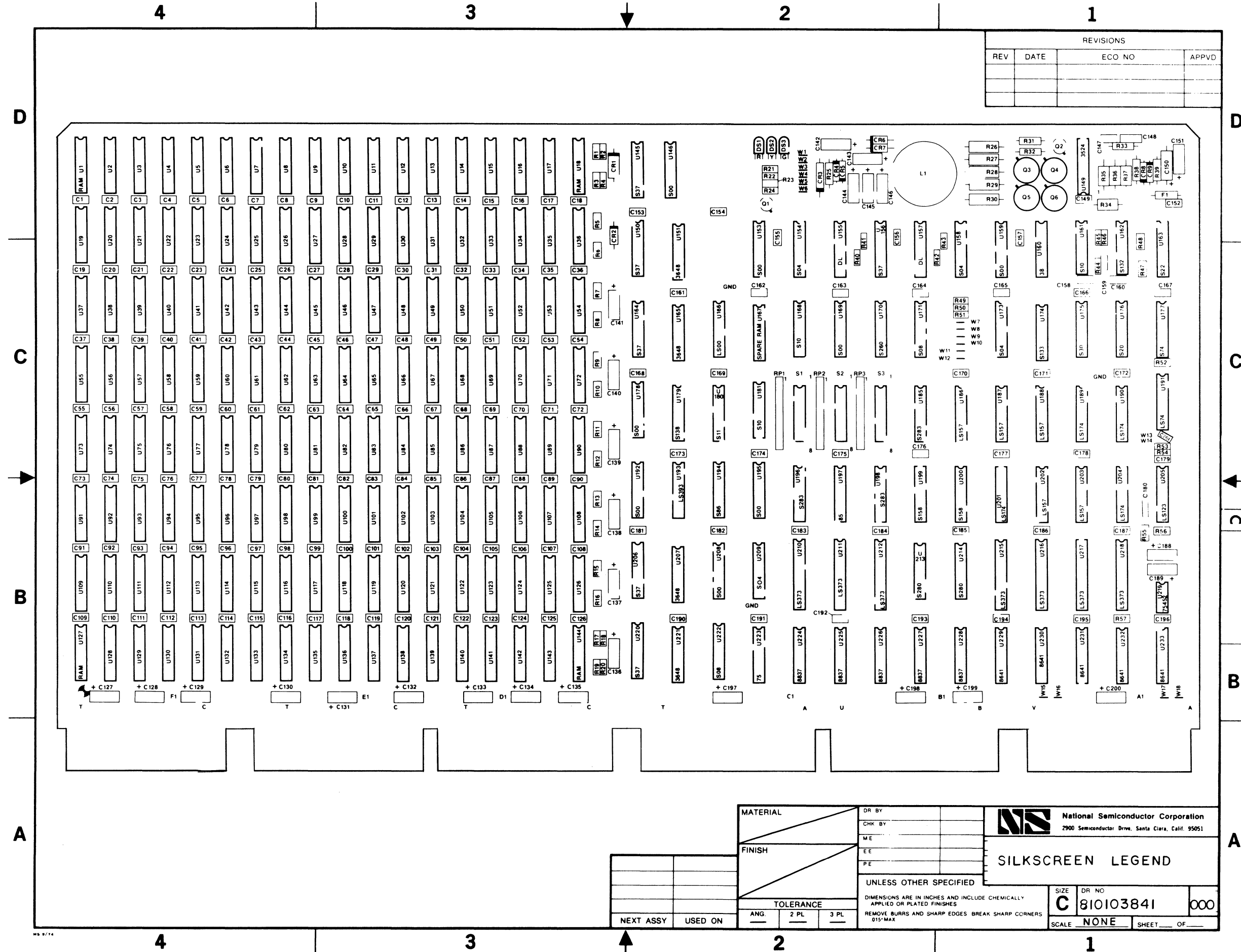
APPENDIX A

Reference Drawings

This appendix contains the schematic, assembly drawing and bill of material pertaining to the NS11L memory card.

870103841 Schematic

980103841 Assembly and Bill of Materials



REVISIONS			
REV	DATE	ECO NO	APPVD

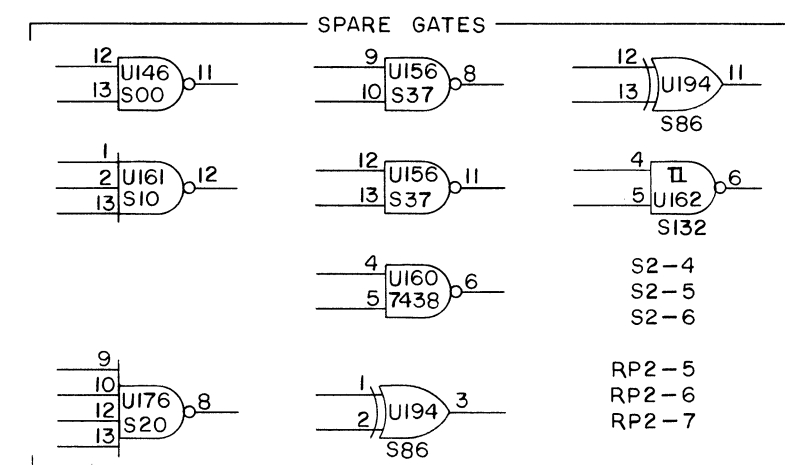
MATERIAL	DR BY	
	CHK BY	
FINISH	M E	
	E E	
TOLERANCE	P E	
	UNLESS OTHER SPECIFIED	
ANG.	DIMENSIONS ARE IN INCHES AND INCLUDE CHEMICALLY APPLIED OR PLATED FINISHES	
2 PL	SCALE	NONE
3 PL	DR NO	810103841
	REMOVE BURRS AND SHARP EDGES BREAK SHARP CORNERS 015" MAX	000
	SCALE	SHEET ___ OF ___

**National Semiconductor Corporation**  
 2900 Semiconductor Drive, Santa Clara, Calif. 95051

**SILKSCREEN LEGEND**

NEXT ASSY    USED ON

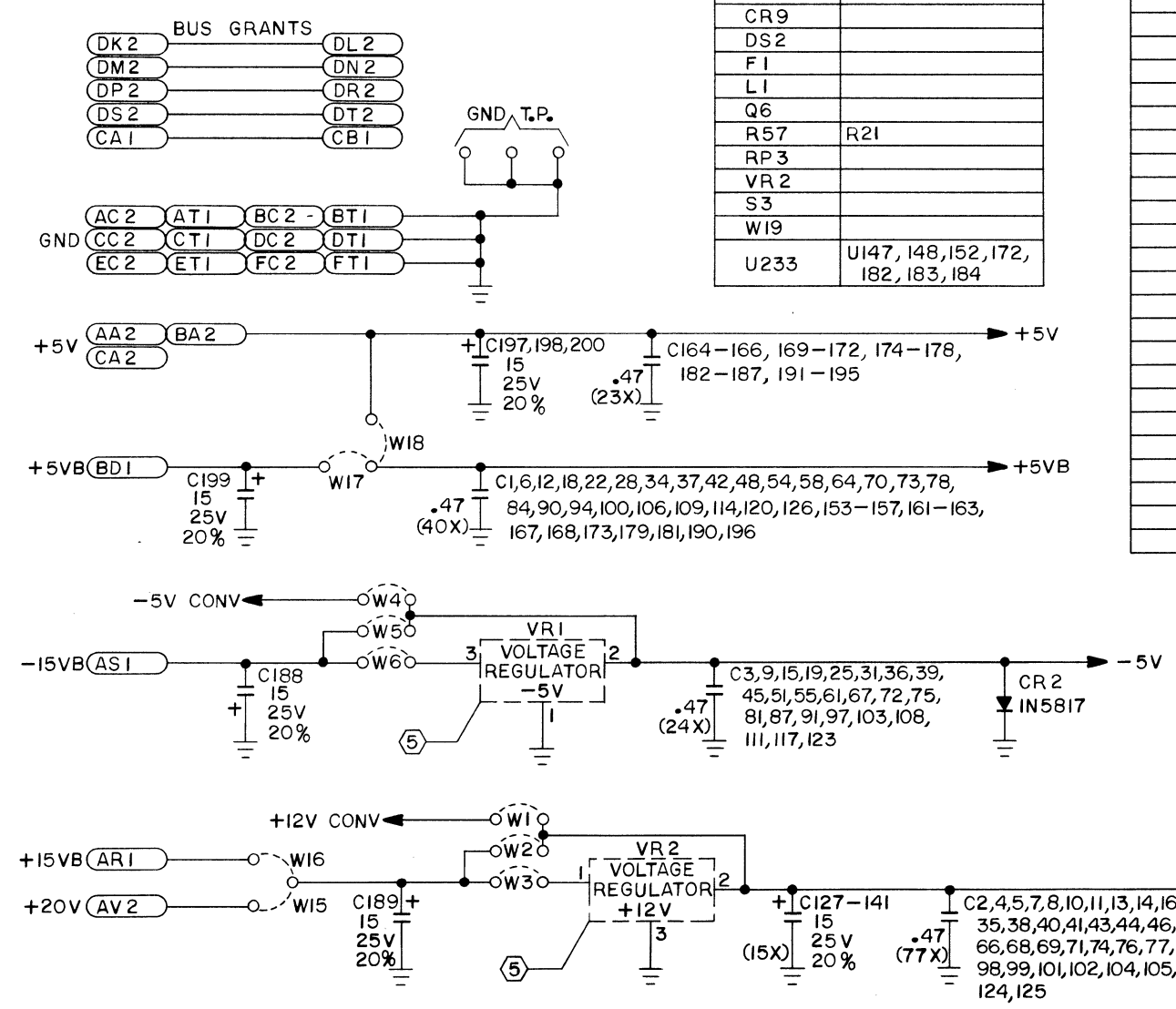
REVISIONS			
REV	DATE	ECO NO.	APPVD
A	11-77	PDD 3564	
B	6-25-79	PCO 23636	
C	7-1-80	ECO 44049	
D	1-6-81	ECO 44107	



REFERENCE DESIGNATIONS	
LAST USED	NOT USED
C201	
CR9	
DS2	
F1	
L1	
Q6	
R57	R21
RP3	
VR2	
S3	
W19	
U233	UI47, 148, 152, 172, 182, 183, 184

VOLTAGE TABLE				
DEVICE TYPE	+5V	+5VB	GND	REFERENCE DESIGNATIONS
DELAY LINE 100NS			8, 14	UI55, 157
74S00		14	7	UI46, 153, 159, 169, 178, 192
74S00	14		7	UI95, 208
74LS00	14		7	UI66
74S04		14	7	UI54, 158
74S04	14		7	UI73, 209
74S08	14		7	UI71, 222
74S10		14	7	UI61, 168
74S10	14		7	UI81
74S11	14		7	UI80
74S20	14		7	UI76
74S22		14	7	UI63
74S30	14		7	UI75
74S37		14	7	UI45, 150, 156, 164, 206, 220
7438		14	7	UI60
74S74		14	7	UI77
74LS74		14	7	UI91
7475	5		12	U223
7485	16		8	UI97
74S86	14		7	UI94
74LS123		16	8	U205
74S132		14	7	UI62
74S133	16		8	UI74
74S138	16		8	UI79
74LS157	16		8	UI86, 187, 188, 202, 203
74S158	16		8	UI99, 200
74LS174	16		8	UI89, 190, 201, 204
74S260	14		7	UI70
74S280	14		7	U213, 214
74S283	16		8	UI85, 196, 198
74LS373	20		10	U210, 211, 212, 215, 216, 217, 218
74LS393		14	7	UI93
75452		8	4	U219
3524		16	8	UI49
3648		16	8	UI51, 165, 207, 221
8641		16	8	U233
8641	16		8	U229, 230, 231, 232
8837	16		8	U224, 225, 226, 227, 228

- NOTES: UNLESS OTHERWISE SPECIFIED.
- CAPACITANCE VALUES IN MICROFARADS, 50V, 10%.
  - RESISTANCE VALUES IN OHMS, 1/8 W, 5%.
  - ALL DIODES ARE IN4531.
  - ALL TRANSISTORS ARE 2N3506.
  - FUTURE CIRCUIT CAPABILITY.

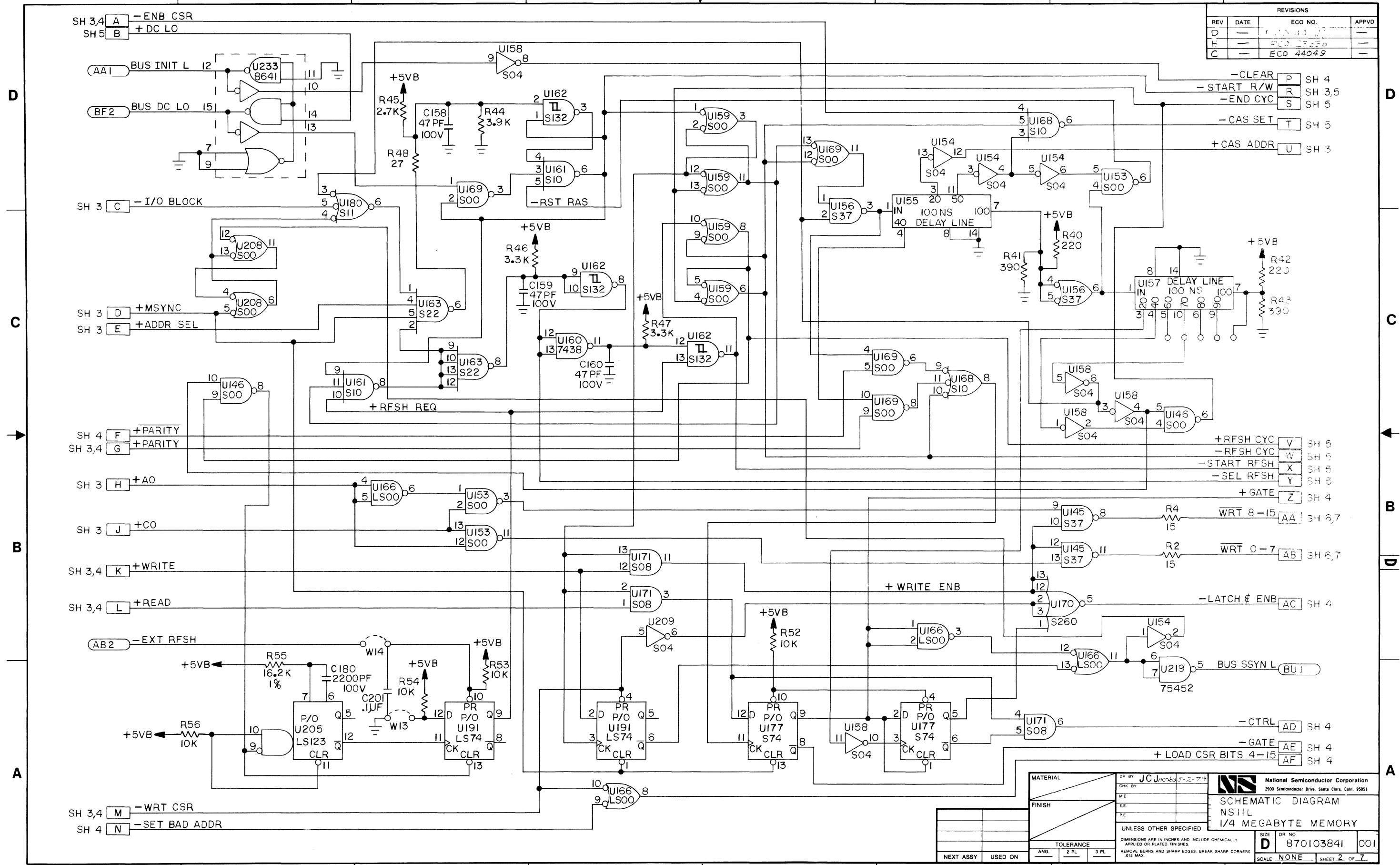


MATERIAL	DR BY J.C. Jacobs 5-2-79	National Semiconductor Corporation 2900 Semiconductor Drive, Santa Clara, Calif. 95051
FINISH	CHK BY	
TOLERANCE	M.E.	
SCALE NONE	P.E. G...	
NEXT ASSY	USED ON	SCHEMATIC DIAGRAM NS11L 1/4 MEGABYTE MEMORY SIZE D DR. NO. 870103841 001 SHEET 1 OF 7



8 7 6 5 4 3 2 1

REVISIONS			
REV	DATE	ECO NO.	APPVD
D		ECO 44049	
E		ECO 44049	
F		ECO 44049	



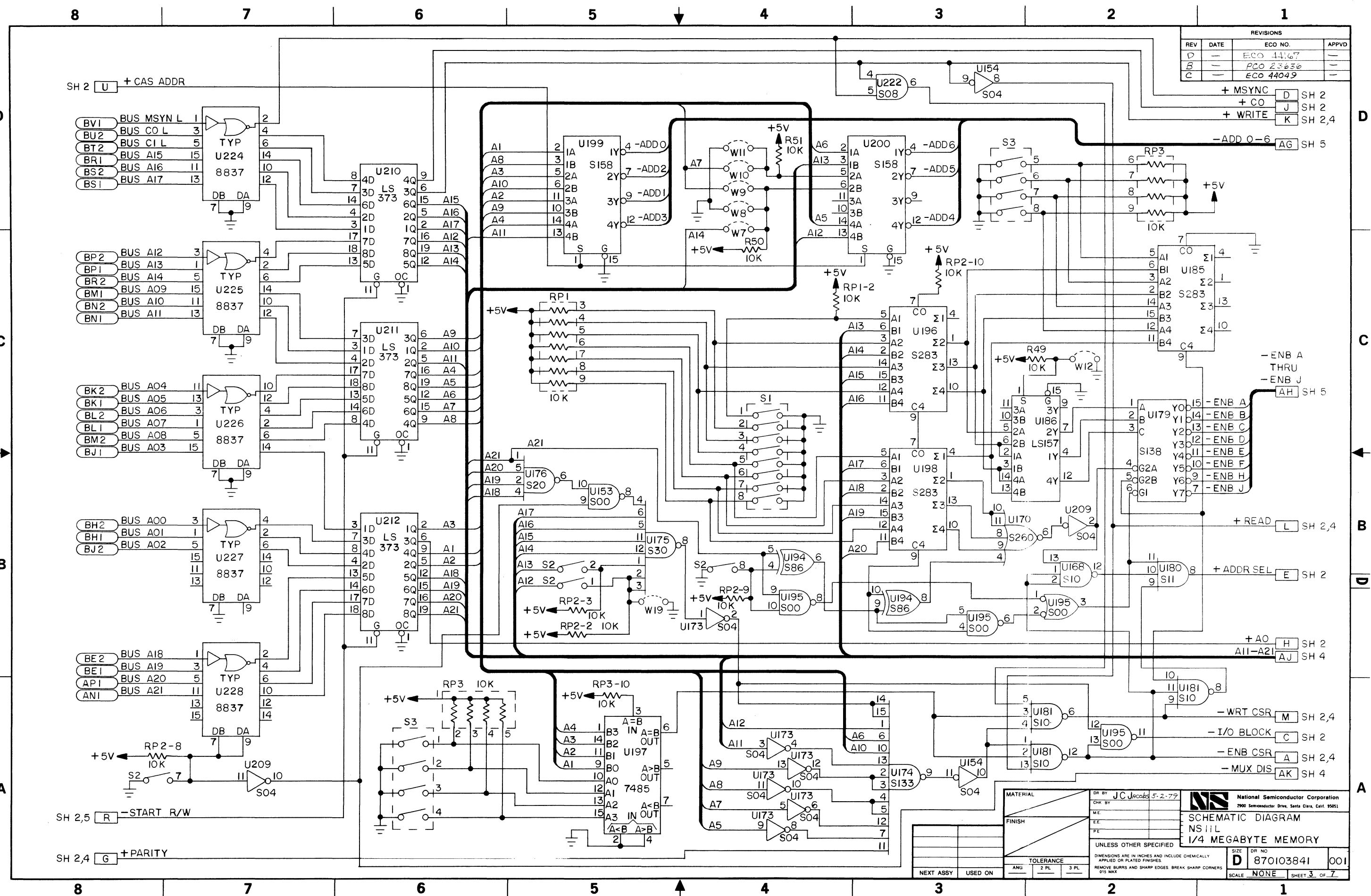
D  
C  
B  
A

D  
C  
B  
A

8 7 6 5 4 3 2 1

MATERIAL	DR BY JC Jacobs 5-2-79	 National Semiconductor Corporation 2900 Semiconductor Drive, Santa Clara, Calif. 95051
FINISH		
UNLESS OTHER SPECIFIED		
DIMENSIONS ARE IN INCHES AND INCLUDE CHEMICALLY APPLIED OR PLATED FINISHES. REMOVE BURRS AND SHARP EDGES. BREAK SHARP CORNERS .015 MAX.		
TOLERANCE		SIZE D 870103841 001
NEXT ASSY USED ON		SCALE NONE SHEET 2 OF 7

REVISIONS			
REV	DATE	ECO NO.	APPVD
D	-	ECO 4467	-
B	-	ECO 23636	-
C	-	ECO 44049	-



+MSYNC [D] SH 2  
 +CO [J] SH 2  
 +WRITE [K] SH 2,4  
 -ADD 0-6 [AG] SH 5

-ENB A  
 THRU  
 -ENB J [AH] SH 5

+READ [L] SH 2,4  
 +ADDR SEL [E] SH 2

+A0 [H] SH 2  
 A11-A21 [AJ] SH 4

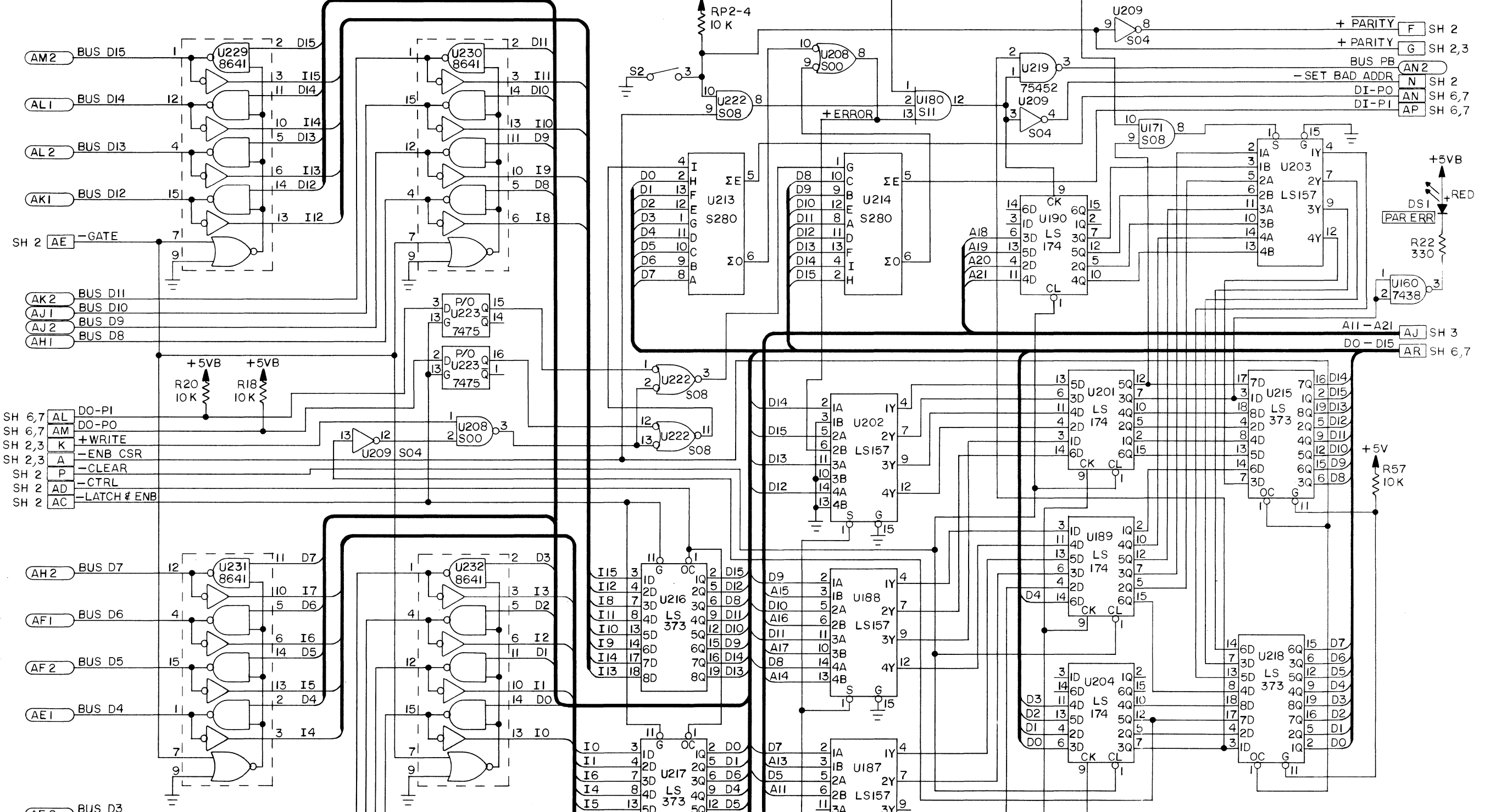
-WRT CSR [M] SH 2,4  
 -I/O BLOCK [C] SH 2  
 -ENB CSR [A] SH 2,4  
 -MUX DIS [AK] SH 4

MATERIAL		DR BY J.C. Jacobs 5-2-79		 National Semiconductor Corporation 2900 Semiconductor Drive, Santa Clara, Calif. 95051
FINISH		CHK BY		
TOLERANCE		SIZE DR NO		
UNLESS OTHERWISE SPECIFIED				DIMENSIONS ARE IN INCHES AND INCLUDE CHEMICALLY APPLIED OR PLATED FINISHES REMOVE BURRS AND SHARP EDGES. BREAK SHARP CORNERS 015 MAX
ANG	2 PL	3 PL	SIZE	DR NO
			D	870103841
NEXT ASSY USED ON				SCALE NONE SHEET 3 OF 7

8 7 6 5 4 3 2 1

REVISIONS			
REV	DATE	ECO NO.	APPRD
D		ECO 44167	
B		ECO 23636	
C		ECO 44049	

SH 3 AK -MUX DIS  
SH 2 Z +GATE



AK2 BUS D11  
AJ1 BUS D10  
AJ2 BUS D9  
AH1 BUS D8

SH 6,7 AL DO-PI  
SH 6,7 AM DO-PO  
SH 2,3 K +WRITE  
SH 2,3 A -ENB CSR  
SH 2 P -CLEAR  
SH 2 AD -CTRL  
SH 2 AC -LATCH # ENB

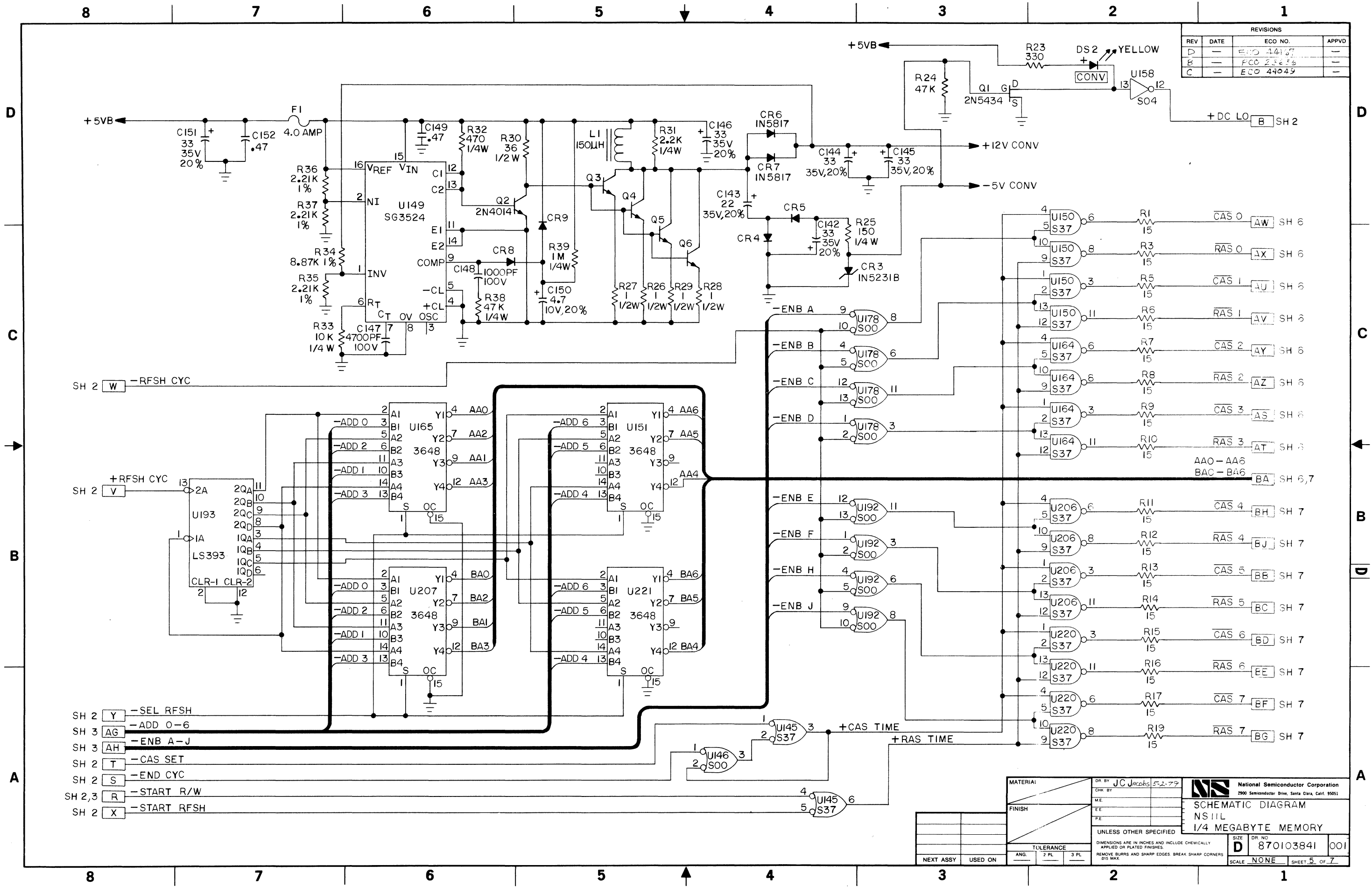
AE2 BUS D3  
AD1 BUS D2  
AD2 BUS D1  
AC1 BUS D0

SH 2,3 L +READ  
SH 2 AF +LOAD CSR BITS 4-15  
SH 2,3 M -WRT CSR

8 7 6 5 4 3 2 1

MATERIAL	DR BY JC Jacobs 5-2-79	 National Semiconductor Corporation 2900 Semiconductor Drive, Santa Clara, Calif. 95051
FINISH	CHK BY	
	ME	
	EE	
	PE	<b>SCHEMATIC DIAGRAM</b> NS11L <b>1/4 MEGABYTE MEMORY</b>
UNLESS OTHER SPECIFIED		DIMENSIONS ARE IN INCHES AND INCLUDE CHEMICALLY APPLIED OR PLATED FINISHES. REMOVE BURRS AND SHARP EDGES. BREAK SHARP CORNERS. SCALE NONE SHEET 4 OF 7
TOLERANCE		SIZE DR NO <b>D 870103841 001</b>
NEXT ASSY USED ON		

REVISIONS			
REV	DATE	ECO NO.	APPVD
D		ECO 44187	
B		ECO 25638	
C		ECO 44049	

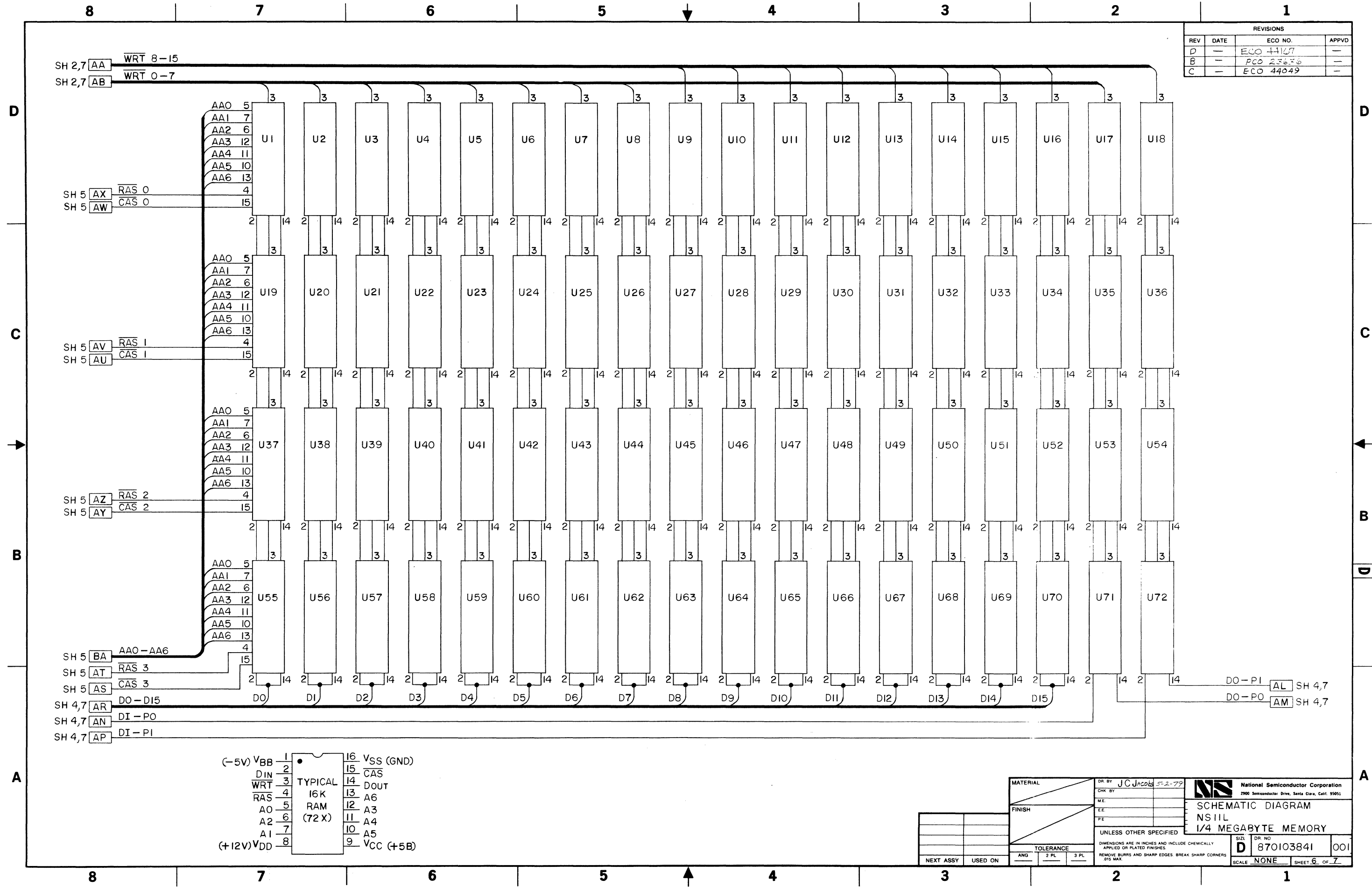


SH 2 [W] -RFSH CYC  
 SH 2 [V] +RFSH CYC  
 SH 2 [Y] -SEL RFSH  
 SH 3 [AG] -ADD 0-6  
 SH 3 [AH] -ENB A-J  
 SH 2 [T] -CAS SET  
 SH 2 [S] -END CYC  
 SH 2,3 [R] -START R/W  
 SH 2 [X] -START RFSH

+5VB  
 +12V CONV  
 -5V CONV  
 +DC LO [B] SH 2  
 CAS 0 [AW] SH 6  
 RAS 0 [AX] SH 6  
 CAS 1 [AU] SH 6  
 RAS 1 [AV] SH 6  
 CAS 2 [AY] SH 6  
 RAS 2 [AZ] SH 6  
 CAS 3 [AS] SH 6  
 RAS 3 [AT] SH 6  
 AAO-AA6  
 BAC-BA6 [BA] SH 6,7  
 CAS 4 [BH] SH 7  
 RAS 4 [BJ] SH 7  
 CAS 5 [BB] SH 7  
 RAS 5 [BC] SH 7  
 CAS 6 [BD] SH 7  
 RAS 6 [BE] SH 7  
 CAS 7 [BF] SH 7  
 RAS 7 [BG] SH 7

MATERIAL	DR BY J.C. Jacobs 5-2-79	 National Semiconductor Corporation 2900 Semiconductor Drive, Santa Clara, Calif. 95051
FINISH		
TOLERANCE		
UNLESS OTHERWISE SPECIFIED		DIMENSIONS ARE IN INCHES AND INCLUDE CHEMICALLY APPLIED OR PLATED FINISHES. REMOVE BURRS AND SHARP EDGES BREAK SHARP CORNERS .015 MAX.
NEXT ASSY USED ON		SCALE NONE SHEET 5 OF 7

REVISIONS			
REV	DATE	ECO NO.	APPVD
D		ECO 44167	
B		PCO 23636	
C		ECO 44049	



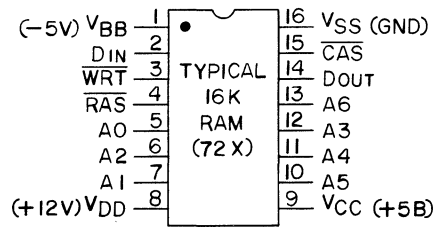
SH 2,7 AA WRT 8-15  
SH 2,7 AB WRT 0-7

SH 5 AX RAS 0  
SH 5 AW CAS 0

SH 5 AV RAS 1  
SH 5 AU CAS 1

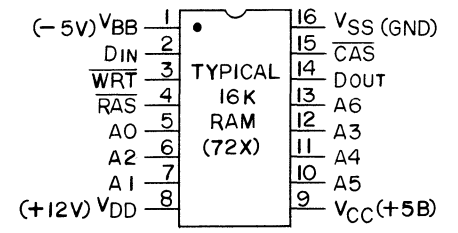
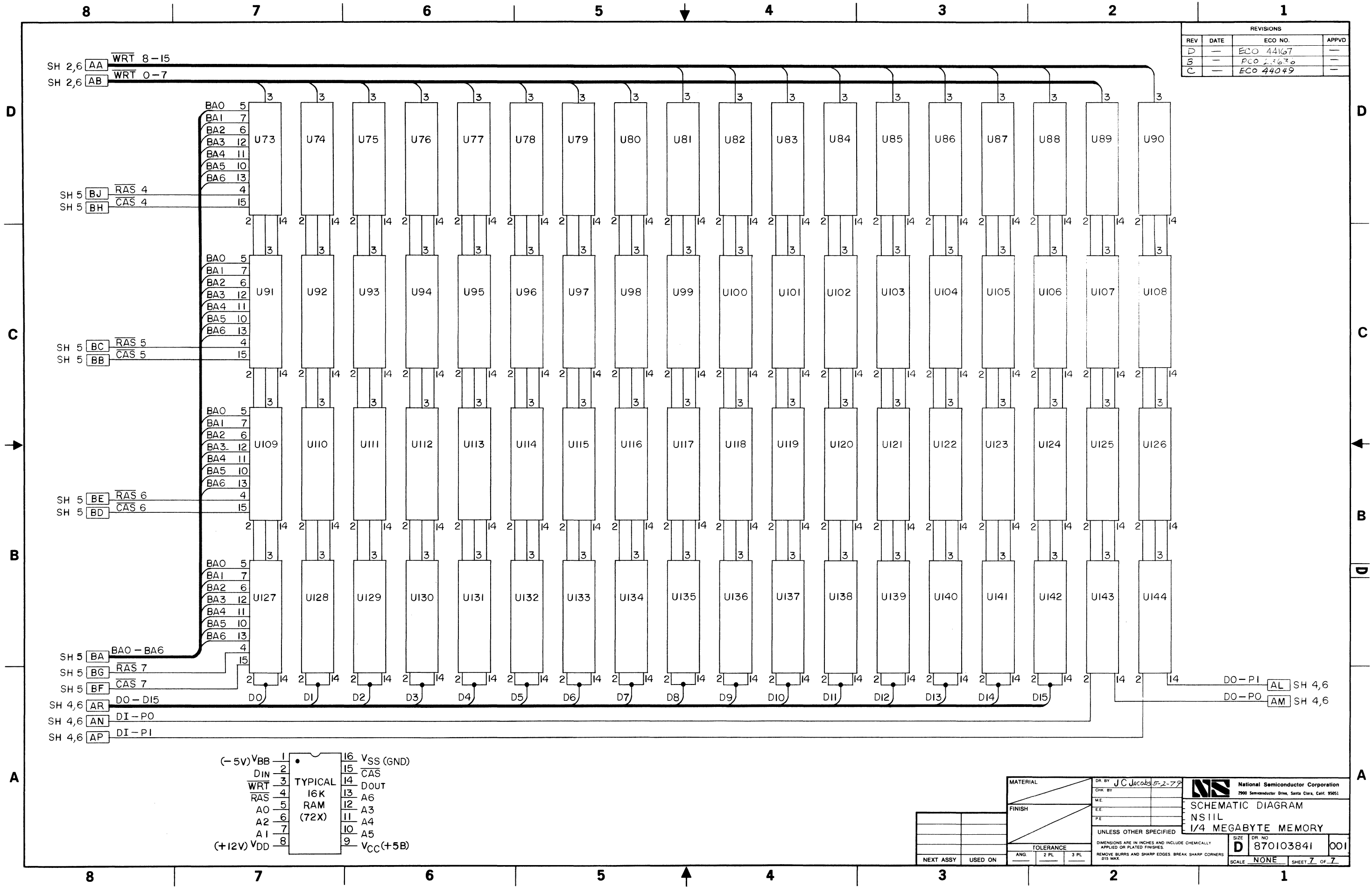
SH 5 AZ RAS 2  
SH 5 AY CAS 2

SH 5 BA AAO-AA6  
SH 5 AT RAS 3  
SH 5 AS CAS 3  
SH 4,7 AR DO-D15  
SH 4,7 AN DI-PO  
SH 4,7 AP DI-PI



MATERIAL	DR BY J C J+cob 5-2-79	 National Semiconductor Corporation 2900 Semiconductor Drive, Santa Clara, Calif. 95051
FINISH	CHK BY	
TOLERANCE		SCHEMATIC DIAGRAM NS11L 1/4 MEGABYTE MEMORY
NEXT ASSY USED ON		UNLESS OTHER SPECIFIED DIMENSIONS ARE IN INCHES AND INCLUDE CHEMICALLY APPLIED OR PLATED FINISHES. REMOVE BURRS AND SHARP EDGES. BREAK SHARP CORNERS. 015 MAX
SIZE D		DR. NO. 870103841 001 SCALE NONE SHEET 6 OF 7

REVISIONS			
REV	DATE	ECO NO.	APPVD
D	—	ECO 44167	—
B	—	ECO 44049	—
C	—	ECO 44049	—

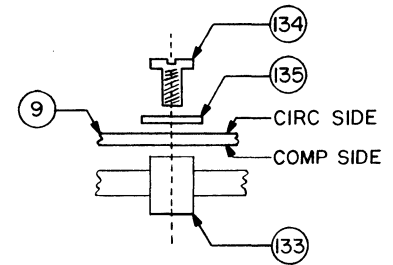
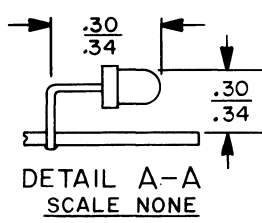
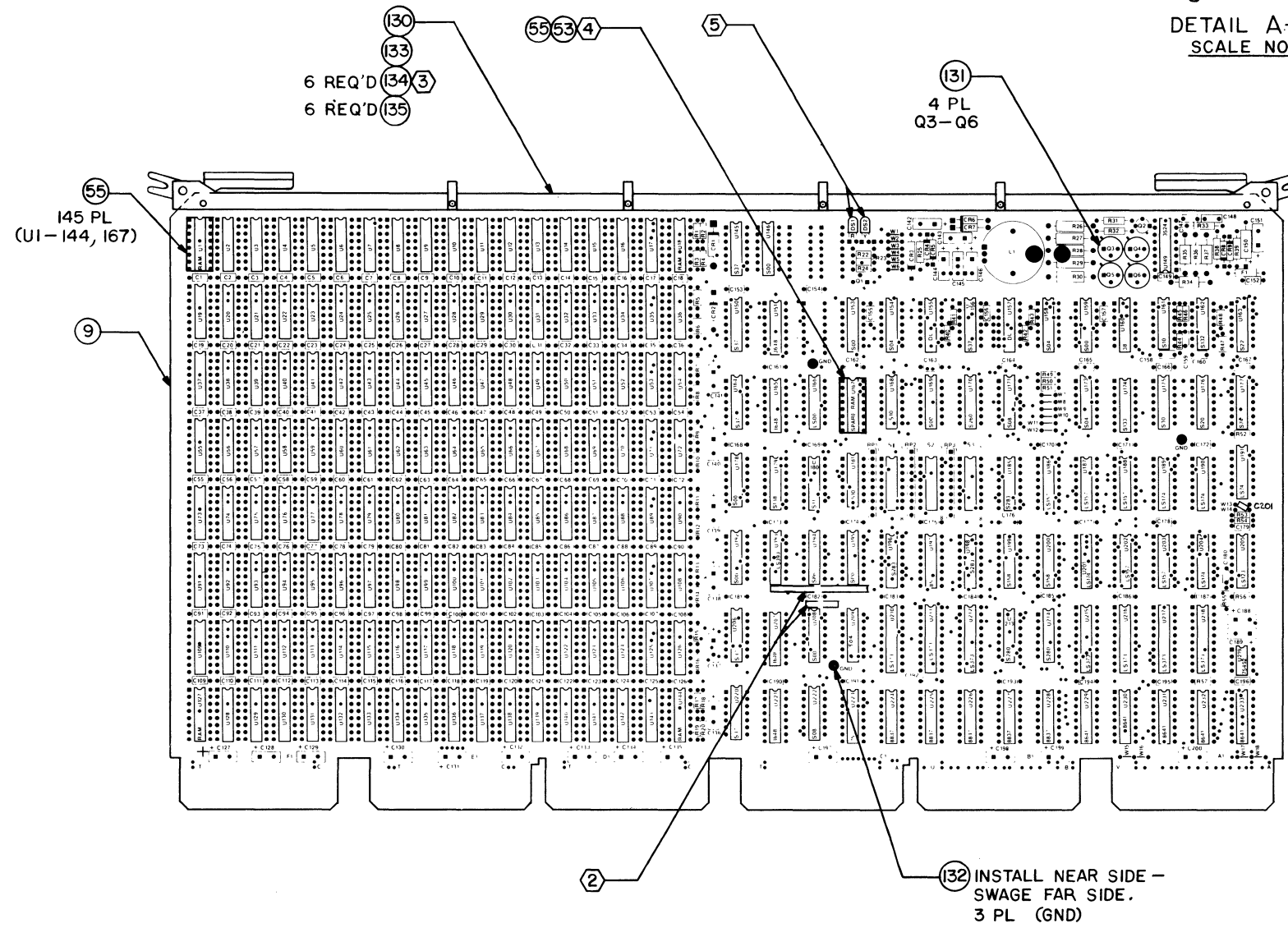


MATERIAL	DR. BY J.C. Jacobs 5-2-79	 National Semiconductor Corporation 2900 Semiconductor Drive, Santa Clara, Calif. 95051
FINISH	CHK BY	
UNLESS OTHER SPECIFIED DIMENSIONS ARE IN INCHES AND INCLUDE CHEMICALLY APPLIED OR PLATED FINISHES. REMOVE BURRS AND SHARP EDGES BREAK SHARP CORNERS .015 MAX.		SIZE D DR. NO. 870103841 001
TOLERANCE ANG. 2 PL. 3 PL.		SCALE NONE SHEET 7 OF 7

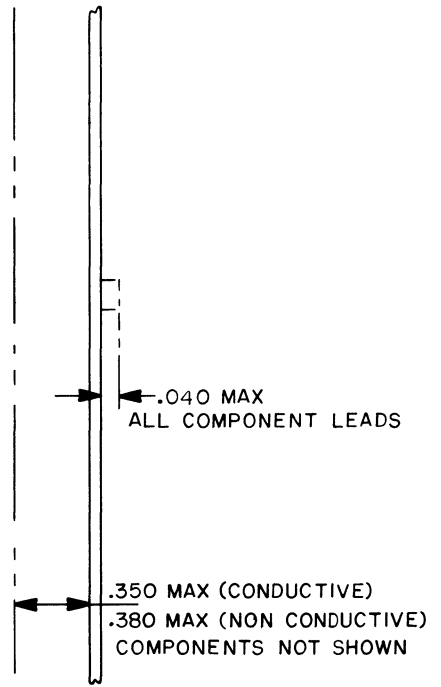
8 7 6 5 4 3 2 1

REVISIONS			
REV	DATE	ECO NO	APPV
A	7-18-76	PDD 3564	Green
B	10-25-76	PCO 23636	Green
C	2-6-79	PCO 24003	Green
D	12-7-79	PCO 24005	Green
E	2-6-80	PCO 24009	Green
F	7-2-80	PCO 24014	SLB
G	7-2-80	ECO 44049	SLB
B1	9-5-80	ECO 44076	SLS
H	1-2-81	ECO 44167	SLS

D  
C  
B  
A



- NOTES:
- ASSEMBLE AND SOLDER PER NSC SPEC. 429306098.
  - MARK ASSY. PART NO. 3841, DASH NO., REV. LEVEL AND S/N WITH .12-.18 HIGH CHARACTERS WHERE SHOWN.
  - APPLY ITEM 130 (LOCTITE) TO TAPPED HOLES IN ITEM 133 (STIFFENER) PRIOR TO INSERTING ITEM 134 (SCREWS).
  - INSTALL ITEM 53 AFTER PRE-TESTING PER TEST SPEC. 425103841.
  1. SHORT LEG IS CATHODE.  
2. CATHODE TO SQUARE PAD.  
3. BEND PER DETAIL A-A BEFORE INSTALLATION.
  - ALL JUMPER OPTIONS SHOULD BE INSTALLED USING ITEM 126.
  - INSTALL MEMORY I.C.'s ACCORDING TO THE TABULATED DATA CHART. THE MEMORY ELEMENT P/N IS ASSIGNED IN THE MEMORY ELEMENT P/N CHART.
  - INSTALL JUMPERS ACCORDING TO THE FACTORY INSTALL JUMPER TABLE.
  - AFTER FINAL TEST, INSTALL/REMOVE JUMPERS AS DEFINED BY THE MARKETING CONFIGURATION CODE TABLE.
  - VERSION NUMBERS ARE ESTABLISHED TO THE FOLLOWING CODE: -X,Y,Z.



D  
C  
B  
A

8 7 6 5 4 3 2 1

DR. BY: C. Jacobs	7-16-79	National Semiconductor Corporation 700 Semiconductor Drive Santa Clara, Calif. 95051	<b>P.C.B. ASSEMBLY DRAWING</b> <b>NS11L</b> <b>1/4 MEGABYTE MEMORY</b>
CHK. BY: B	7-17-79		
CON. BY: Conway	7-18-79		
CON. BY: Conway	7-18-79		
PART NO. 980103841 SHEET 1 OF 2		SIZE: D SCALE: 1:1	QTY: 000

8

7

6

5

4

3

2

1

REVISIONS			
REV	DATE	ECO NO.	APPVD
A	7-18-79	PDD 3564	
B		PCO 23636	
C	2-2-79	PCO 24003	
D	2-7-79	PCO 24005	
E	2-6-80	PCO 24009	
F		PCO 24014	
G		ECO 44049	
G1		ECO 44076	
H		ECO 44107	

7 TABULATED DATA CHART

VERSION ⑩	QTY	POPULATED MEMORY ELEMENT LOCATIONS		CAPACITY		
		REFERENCE	DESIGNATIONS	16K RAM	8K RAM	OPTION
-X01	144	UI - U144		128K	64K	PARITY
-X02	126	UI - U126		112K	56K	
-X03	108	UI - U108		96K	48K	
-X04	90	UI - U90		80K	40K	
-X05	72	UI - U72		64K	32K	
-X06	54	UI - U54		48K	24K	
-X07	36	UI - U36		32K	16K	
-X08	18	UI - U18		16K	8K	
-X11	128	UI - 16, U19 - 34, U37 - 52, U55 - 70, U73 - 88, U91 - 106, U109 - 124, U127 - 142		128K	64K	NON-PARITY
-X12	112	UI - 16, U19 - 34, U37 - 52, U55 - 70, U73 - 88, U91 - 106, U109 - 124		112K	56K	
-X13	96	UI - 16, U19 - 34, U37 - 52, U55 - 70, U73 - 88, U91 - 106		96K	48K	
-X14	80	UI - 16, U19 - 34, U37 - 52, U55 - 70, U73 - 88		80K	40K	
-X15	64	UI - 16, U19 - 34, U37 - 52, U55 - 70		64K	32K	
-X16	48	UI - 16, U19 - 34, U37 - 52		48K	24K	
-X17	32	UI - 16, U19 - 34		32K	16K	
-X18	16	UI - 16		16K	8K	

X = MEMORY CHIP TYPE  
(SEE MEMORY ELEMENT PART NUMBER CHART)

X = 0 16K  
X = 1 8K PARTIAL RH  
X = 2 8K PARTIAL LH

Y = OPTION  
Y = 0 PARITY  
Y = 1 NON-PARITY

Z = MEMORY ROW POPULATION  
Z = 1 ROWS 1-8  
Z = 2 ROWS 1-7  
Z = 3 ROWS 1-6  
Z = 4 ROWS 1-5  
Z = 5 ROWS 1-4  
Z = 6 ROWS 1-3  
Z = 7 ROWS 1-2  
Z = 8 ROW 1

8 FACTORY INSTALLED JUMPER TABLE


⑩ VERSION	JUMPERS INSTALLED	REMARKS
ALL	W1, W4, W18	
-001 THRU -016	W7, W10	16K RAMS
-101 THRU -116	W9, W11, W12	8K PARTIAL, RIGHT HALF
-201 THRU -216	W11, W12	8K PARTIAL, LEFT HALF

7 MEMORY ELEMENT PART NUMBER CHART

X ⑩	PART NUMBER	DESCRIPTION
0	482103730 - 001	16K x 1 DYNAMIC RAM, 200 NS
1	482102989 - 112	8K x 1 DYN. RAM, PARTIAL RH, 200 NS
2	482103060 - 112	8K x 1 DYN. RAM, PARTIAL LH, 200 NS

9 MARKETING CONFIGURATION CODE TABLE  
USER SELECTABLE OPTION JUMPERS

MKTG. CONFIG. CODE	JUMPERS		REMARKS
	INSTALLED	REMOVED	
00			NO OPTIONS ⑧
01	W17	W18	BATTERY BACKUP

MATERIAL	DR BY <i>C. Jacobs</i> 7-16-79	 <b>National Semiconductor Corporation</b> 2900 Semiconductor Drive, Santa Clara, Calif. 95051
FINISH	CHK BY	
	M.E.	
	PE	
UNLESS OTHER SPECIFIED		DIMENSIONS ARE IN INCHES AND INCLUDE CHEMICALLY APPLIED OR PLATED FINISHES. REMOVE BURRS AND SHARP EDGES. BREAK SHARP CORNERS .015 MAX.
NEXT ASSY	USED ON	TOLERANCE ANG. 2 PL 3 PL SIZE OR NO <b>D</b> 980103841 000 SCALE NONE SHEET 2 OF 2

8

7

6

5

4

3

2

1



UNIT OF MEAS.		QUANTITY PER ASSEMBLY	UNIT OF MEAS.	KEY	A WITH B/M	KEY	RELEASED FOR ASSEMBLY	BILL OF MATERIAL NO.
01 - EACH	02 - INCH	03 - FEET	04 - BULK	05 - AS RECD	06 - OTHER	111	121	980103841-000
1								
2								
3			0	04	R			
4			0	04	R	870103841-001	SCHEMATIC DIAGRAM	
5			0	04	S	427103841-001	TEST PROCEDURE	
6			0	04	S	425103841-001	TEST SPEC	
7			0	04	S	426103841-001	PRODUCT SPEC	
8								
9			1	04	D			
10						551103841-002	PC BOARD	
11			1	04		482000354-001	I.C. 74LS00	U166
12			8	04		482000079-001	74S00	U146,153
13								159,162,178
14								192,195,208
15			4	04		482000180-001	I.C. 74S04	U154,158
16								173,209

FORM NO. 0011A

UNIT OF MEAS.		QUANTITY PER ASSEMBLY	UNIT OF MEAS.	KEY	A WITH B/M	KEY	RELEASED FOR ASSEMBLY	BILL OF MATERIAL NO.
01 - EACH	02 - INCH	03 - FEET	04 - BULK	05 - AS RECD	06 - OTHER	111	121	980103841-000
17			2	04		482100672-001	I.C. 74S08	U171,222
18			3	04		482001344-001	74S10	U161,168,181
19			1	04		482000299-001	74S11	U180
20			1	04		482001345-001	74S20	U176
21			1	04		482000438-001	74S22	U163
22			1	04		482000335-001	74S30	U175
23			6	04		482100777-001	74S37	U145,150,156
24								164,206,220
25			1	04		482000164-001	7438	U160
26			1	04		482000179-001	74S74	U177
27			1	04		482100365-001	74LS74	U191
28			1	04		482000043-001	7475	U223
29			1	04		482103946-001	7485	U197
30			1	04		482000300-001	74S86	U194
31			1	04		482101175-001	74LS123	U205
32			1	04		482100840-001	I.C. 74S132	U162

FORM NO. 0011A

UNIT OF MEAS.		QUANTITY PER ASSEMBLY	UNIT OF MEAS.	KEY	A WITH B/M	KEY	RELEASED FOR ASSEMBLY	BILL OF MATERIAL NO.
01 - EACH	02 - INCH	03 - FEET	04 - BULK	05 - AS RECD	06 - OTHER	111	121	980103841-000
33			1	04		482000310-001	I.C. 74S133	U174
34			1	04		482000314-001	74S138	U179
35			5	04		482100784-001	74LS157	U186,187
36								188,202,203
37			2	04		482000312-001	74S158	U199,200
38			4	04		482100835-001	74LS174	U189,190
39								201,204
40			1	04		482101177-001	74S260	U170
41			2	04		482000342-001	74S280	U213,214
42			3	04		482102505-001	74S283	U185,196,198
43			7	04		482103947-001	74LS373	U210,211,212
44								215,216,217,218
45			1	04		482102639-001	74LS393	U193
46			1	04		482103971-001	75452	U219
47			1	04		482104567-001	I.C. 3524	U149
48								

FORM NO. 0011A

UNIT OF MEAS.		QUANTITY PER ASSEMBLY	UNIT OF MEAS.	KEY	A WITH B/M	KEY	RELEASED FOR ASSEMBLY	BILL OF MATERIAL NO.
01 - EACH	02 - INCH	03 - FEET	04 - BULK	05 - AS RECD	06 - OTHER	111	121	980103841-000
49			4	04		482102662-001	I.C. 3648	U151,165
50								207,221
51			5	04		482103697-001	8641	U229-233
52			5	04		482000248-001	8837	U224-228
53			1	04		482102598-012	RAM 16 K	U167
54								
55			145	04		214102685-003	I.C. SOCKET, 16 PIN	U1-144
56								167
57			2	04		611100900-100	DELAY LINE 100 NS	U155,157
58								
59								
60			3	04		513107003-008	SWITCH, DIP, SPST, 8 POS.	S1-3
61								
62			1	04		480105601-001	TRANSIENT SUPPRESSOR	CR1 GENERAL INDUSTRIES
63								
64								

FORM NO. 0011A

UNIT OF MEAS.		QUANTITY PER ASSEMBLY	UNIT OF MEAS.	KEY	A WITH B/M	KEY	RELEASED FOR ASSEMBLY	BILL OF MATERIAL NO.
01 - EACH	02 - INCH	03 - FEET	04 - BULK	05 - AS RECD	06 - OTHER	111	121	980103841-000
65			3	04		481100853-001	DIODE IN5817	CR2,6,7
66			1	04		481100775-001	DIODE IN5231B	CR3
67			4	04		481101049-001	DIODE IN4531	CR4,5,8,9
68								
69								
70			1	04		394105352-001	LED (RED)	DS1
71			1	04		394105352-002	LED (YELLOW)	DS2
72								
73								
74			1	04		518102113-011	FUSE 4.0 AMP	F1
75			1	04		180105031-001	INDUCTOR 150UH	L1
76								
77								
78			1	04		480103970-001	TRANSISTOR, FET, 2N5434	Q1
79			1	04		480104767-001	TRANSISTOR, 2N4014	Q2
80			4	04		480105342-001	TRANSISTOR, 2N3506	Q3-6

FORM NO. 0011A

UNIT OF MEAS	QTY PER ASSEMBLY	UNIT OF MEAS	KEY	KEY	PART NUMBER/REFERENCE DOCUMENT	TITLE/DESCRIPTION	REF DESIG.	REMARKS
	3	04			474101854-002	RES. MOD 10PIN SIP 10K	RPI-3	
	18	04			470101134-019	RES. CC 15K, 1/8W, 5%	R1-17,19	
	10	04			470101134-087	RES. CC 10K, 1/8W, 5%	R18,20	
							49-54, 56	
							57	
	3	04			470101134-051	RES. CC 330K, 1/8W, 5%	R21,22,23	
	1	04			470101134-103	RES. CC 47K, 1/8W, 5%	R24	
	1	04			470100611-043	RES. CC 150K, 1/4W, 5%	R25	
	4	04			470101135-001	RES. CC 1K, 1/2W, 5%	R26-29	
	1	04			470101135-038	RES. CC 36K, 1/2W, 5%	R30	
	1	04			470100611-071	RES. CC 2.2K, 1/4W, 5%	R31	
	1	04			470100611-055	RES. CC 470, 1/4W, 5%	R32	
	1	04			470100611-087	RES. CC 10K, 1/4W, 5%	R33	
	1	04			474102565-096	RES. FILM 8.87K, 1/8W, 1%	R34	
	3	04			474102565-038	RES. FILM 2.21K, 1/8W, 1%	R35-37	

REV F E G1 H E TITLE NS11L  
CHG NO. PCD ECG ECG ECG ECG PCD  
DATE 24914 44049 44076 44107 44009

WRITTEN BY DATE DESIGN DATE  
D. STAYLOR

NATIONAL SEMICONDUCTOR CORPORATION  
2900 SEMICONDUCTOR DRIVE, SANTA CLARA, CALIF. 95051

SIZE BILL OF MATERIAL NO. 980103841-000 SH 6 OF 9

UNIT OF MEAS	QTY PER ASSEMBLY	UNIT OF MEAS	KEY	KEY	PART NUMBER/REFERENCE DOCUMENT	TITLE/DESCRIPTION	REF DESIG.	REMARKS
	1	04			470100611-103	RES. CC 47K, 1/4W, 5%	R38	
	1	04			470100611-135	RES. CC 1M, 1/4W, 5%	R39	
	2	04			470101134-047	RES. CC 220K, 1/8W, 5%	R40,42	
	2	04			470101134-053	RES. CC 390K, 1/8W, 5%	R41,43	
	1	04			470101134-077	RES. CC 3.9K, 1/8W, 5%	R44	
	1	04			470101134-073	RES. CC 2.7K, 1/8W, 5%	R45	
	2	04			470101134-075	RES. CC 3.3K, 1/8W, 5%	R46,47	
	1	04			470101134-025	RES. CC 27K, 1/8W, 5%	R48	
	1	04			474102565-120	RES. FILM 16.2K, 1/8W, 1%	R55	
	166	04			151104975-012	CAP. CER. 47UF, 50V, 10%	C1-126,149	
							152-157	
							161-179	
							181-187	
							190-196	

REV F E G1 H E TITLE NS11L  
CHG NO. PCD ECG ECG ECG ECG PCD  
DATE 24914 44049 44076 44107 44009

WRITTEN BY DATE DESIGN DATE  
D. STAYLOR

NATIONAL SEMICONDUCTOR CORPORATION  
2900 SEMICONDUCTOR DRIVE, SANTA CLARA, CALIF. 95051

SIZE BILL OF MATERIAL NO. 980103841-000 SH 7 OF 9

UNIT OF MEAS	QTY PER ASSEMBLY	UNIT OF MEAS	KEY	KEY	PART NUMBER/REFERENCE DOCUMENT	TITLE/DESCRIPTION	REF DESIG.	REMARKS
	21	04			155105442-005	CAP. TANT. 15UF, 25V, 20%	C127-141	
								188, 189,
								197-200
	1	04			151000048-001	CAP. CER. 1UF, 50V	C201	
	1	04			155104570-003	CAP. TANT. 22UF, 35V, 20%	C143	
	1	04			155100628-017	CAP. TANT. 4.7UF, 10V, 20%	C150	
	3	04			151101308-009	CAP. CER. 47 PF, 100V, 10%	C158-160	
	1	04			151101308-025	CAP. CER. 1000 PF, 100V, 10%	C148	
	1	04			151101308-033	CAP. CER. 4700 PF, 100V, 10%	C147	
	1	04			151101308-029	CAP. CER. 2200 PF, 100V, 10%	C180	
	5	04			155104570-004	CAP. TANT. 33UF, 35V, 20%	C142	
								144-146,
								151
	0	04			600107004-005	WIRE, KYMAR INS, 24AWG, Solid Brn.		

REV F E G1 H E TITLE NS11L  
CHG NO. PCD ECG ECG ECG ECG PCD  
DATE 24914 44049 44076 44107 44009

WRITTEN BY DATE DESIGN DATE  
D. STAYLOR

NATIONAL SEMICONDUCTOR CORPORATION  
2900 SEMICONDUCTOR DRIVE, SANTA CLARA, CALIF. 95051

SIZE BILL OF MATERIAL NO. 980103841-000 SH 8 OF 9

UNIT OF MEAS	QTY PER ASSEMBLY	UNIT OF MEAS	KEY	KEY	PART NUMBER/REFERENCE DOCUMENT	TITLE/DESCRIPTION	REF DESIG.	REMARKS
	0	04			160101790-001	LOCTITE		
	4	04			790002971-001	TRANSISTOR PAD		Q3-6
	3	04			215100496-003	TERMINAL		
	1	04			980103847-001	STIFFENER-CHM LOCK		
	6	04			180100064-003	SCREW, 2-56 X 3/16LG, PH		
	6	04			282100453-008	WASHER, #2		
	0	04			482103730-001	I.C. 16K, RAM		(7)
	0	04			482102989-112	8K PARTIAL RAM, 4.5V, 200NS		(7)
	0	04			482103060-112	8K PARTIAL RAM, 4.5V, 200NS		(7)

REV F E G1 H E TITLE NS11L  
CHG NO. PCD ECG ECG ECG ECG PCD  
DATE 24914 44049 44076 44107 44009

WRITTEN BY DATE DESIGN DATE  
D. STAYLOR

NATIONAL SEMICONDUCTOR CORPORATION  
2900 SEMICONDUCTOR DRIVE, SANTA CLARA, CALIF. 95051

SIZE BILL OF MATERIAL NO. 980103841-000 SH 9 OF 9