TM-179
1st printing

CAT BOX

COMPUTER ASSISTED TROUBLESHOOTER

USER'S GUIDE

ATARI®

CAT Box Cheat Sheet

CAT Box Pin Out

1	GROUND
2	GROUND
3	GROUND
4	GROUND
5	GROUND
6	CBCLK DIS*
7	ABUS 10
8	ABUS 11
9	ABUS 8
10	ABUS 9
11	ABUS 6
12	ABUS 7
13	ABUS 4
14	ABUS 5
15	ABUS 2
16	ABUS 3
17	ABUS 0
18	ABUS 1
19	ABUS 14
20	ABUS 15
21	ABUS 12
22	ABUS 13
23	DBUS 6
24	DBUS 7
25	DBUS 4
26	DBUS 4
27	DBUS 2
28	DBUS 3
29	DBUS 0
30	DBUS 1
31	GAME Φ2
32	GAME R/$\overline{W}$
33	GAME VMAΔ
34	NOT USED
35	GAME
36	GAME BAΔ
37	NOT USED
38	NOT USED
39	NOT USED
40	NOT USED
41	NOT USED
42	NOT USED
43	NOT USED
44	NOT USED
45	NOT USED
46	NOT USED
47	NOT USED
48	NOT USED
49	NOT USED
50	NOT USED

* When connected to an Atari game PCB edge connector, disables the CAT Box internal clock. Thus, the game clock is the CAT Box clock.

Δ 6800 microprocessor-based circuits only.

Self-Test Procedure

For more information see the CAT Box Manual, Section 7.

INSTRUCTION	IF TEST PASSES
POWER and TESTER SELF-TEST to ON. Press TESTER RESET.	UNSTABLE SIGNATURE, LOOPING and COMPARE ERROR LEDs and all display segments light.
Press DATA SET.	COMPARE ERROR, LOOPING and UNSTABLE LEDs and all display segments are not lighted.
Press DATA SET.	Each display digit, COMPARE ERROR, LOOPING and UNSTABLE SIGNATURE LEDs light one at a time.
Press DATA SET.	Each display segment lights one at a time. UNSTABLE SIGNATURE lights with segment g. COMPARE ERROR lights with decimal point segment. LOOPING lights with segment f.
Press DATA SET. Set each switch to a different position.	A 7. is displayed. The 7. changes to E, or vice versa, with each new position of switch.

Hexadecimal Conversion Chart

DECIMAL	BINARY	HEXADECIMAL
0	0000	0
1	0001	1
2	0010	2
3	0011	3
4	0100	
5	0101	5
6	0110	6
7	0111	7
8	1000	8
9	1001	9
10	1010	A
11	1011	B
12	1100	C
13	1101	D
14	1110	E
15	1111	F

Control Panel Description

For more detailed information, see the CAT Box Manual, Section 8.

READ/WRITE CONTROL Section

R/$\overline{W}$ MODE: permits read or write operations
    (OFF): key in address
    PULSE: continuous read or write operation
R/$\overline{W}$: reads to or writes from circuit under test
ERROR DATA DISPLAY: data read differs from data comparing to
    GAME: DATA display data is from data bus
    TESTER: DATA display data was written to circuit under test
BYTES: selects number of bytes you write to or read from circuit under test
DBUS SOURCE: lets you select data when writing to circuit under test, or data compared to when reading from circuit under test
    DATA: data written to circuit under test
    ADDR, ADDR: data from ADDRESS/SIGNATURE display is written to RAM of circuit under test
COMPARE ERROR LED: lights when data read differs from data compared to

SIG ANALYSIS CONTROL Section

START, STOP, CLOCK: up—chooses rising edge of signal
    down—chooses falling edge of signal
UNSTABLE SIGNATURE LED: lights when there is a failure
GATE LED: lights when signatures are being taken from circuit under test

TESTER CONTROL Section

ADDRESS/SIGNATURE Display: indicates address CAT Box writes to or reads, or indicates signatures
DATA Display: displays data
ADDRESS INCR: increments display address by one address
DATA SET: clears DATA display, enter new byte of data with keypad
KEYPAD: press to enter address or data
LOOPING LED: lights when CAT Box is performing a continuous operation
TESTER MODE: activates either Read/Write or Signature Analysis section of the CAT Box
NO CLOCK LED: lights when no clock coming from circuit under test
TESTER RESET: microcomputer of CAT Box goes to start of its program
TESTER SELF-TEST: causes CAT Box to enter self-test program
LOOPING LED: lights when CAT Box is performing a continuous operation

DATA PROBE Section

DATA: with logic probe, determines logic state of signal or probes circuits for signatures
PULSE MODE: UNLATCHED detects repetitive signal, LATCHED detects one-shot signal, RESET clears pulse LED

CAT Box
Computer-Assisted Troubleshooter

USER'S GUIDE

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Table of Contents

CAT BOX SERIAL NUMBER LOCATION

The CAT Box serial number is stamped on a plate on the outside of the box. Please mention this number whenever calling your distributor for service.

1 Introduction

The Atari CAT Box can become your most valuable tool for troubleshooting and repairing Atari game boards. By utilizing its powerful testing capabilities, your ability to track down and correct a problem will be increased.

The purpose of this manual is to teach you how to use the CAT Box to its best potential.

The CAT Box can be used to troubleshoot any Atari game produced since Sprint 2®, built in 1976. Signatures, however, have been in use since Battlezone™, built in 1980. Presently, Atari is striving to improve this troubleshooting information with every new game.

The CAT Box is four electronic test instruments in one:

- Signature Analysis
- Logic Probe
- Bus Controller
- RAM Tester

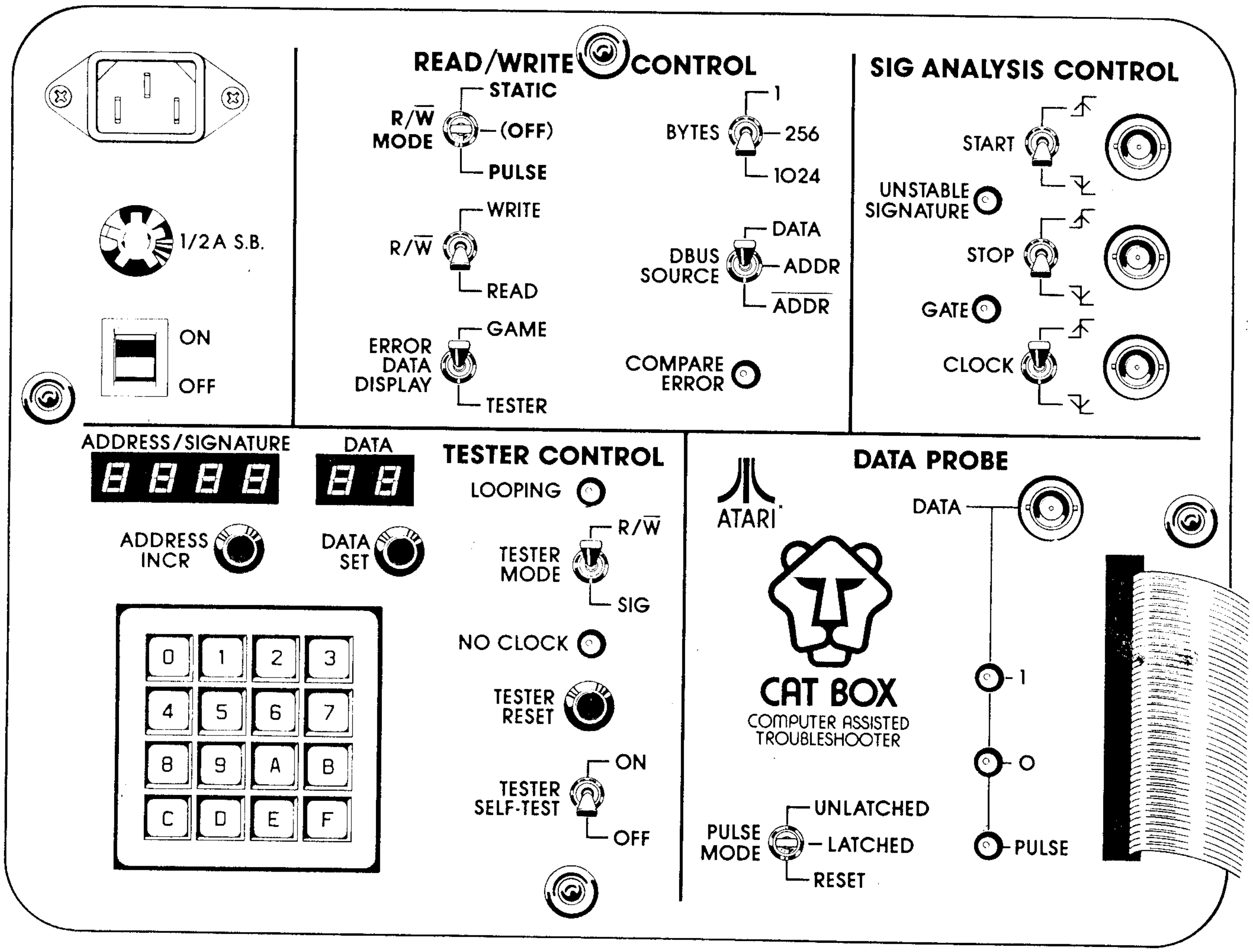


Figure 1.1 CAT Box Front Panel

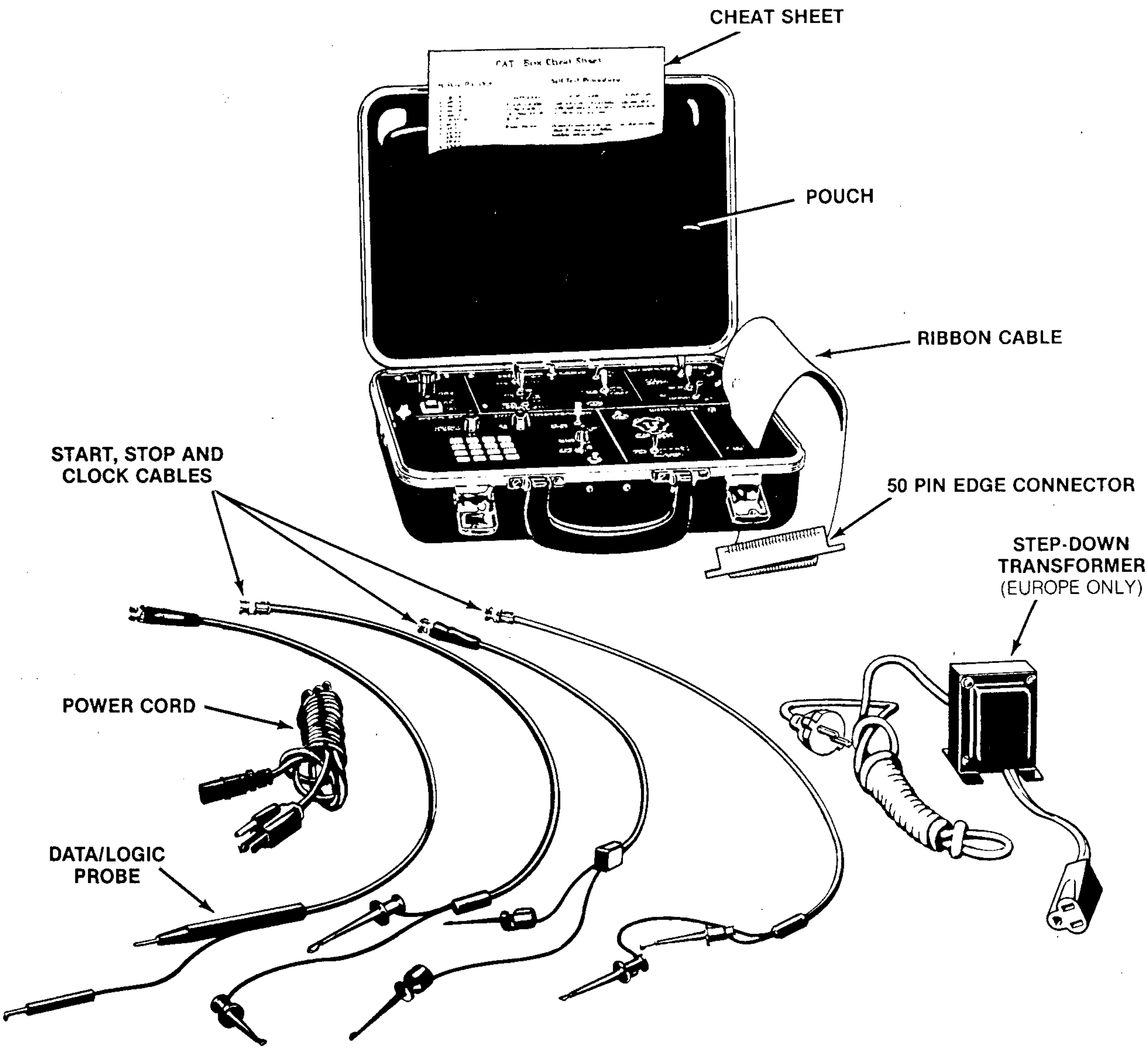


Figure 1.2 CAT Box

2 Hex to Binary Conversion

Address and data lines contain 16 and 8 bits respectively. Addresses are most often described by 4 hexadecimal (hex) digits. Data is most often described by 2 hex digits. Each hex digit represents 4 binary digits. Thus, with 4 hex numbers we can describe the binary state of each of the 16 bits in an address. With 2 hex numbers we can describe the binary state of the 8 bits that make up the data bus.

The Memory Map and the CAT Box use a 4-digit hex number for addresses. Being able to convert a 4-digit hex number into a 16-digit binary number will be of great value to you. For example, the hex number 853F converted to binary is 1000 0101 0011 1111. Each binary digit corresponds to an address line being in a 1 (active high) or a 0 (active low) condition.

Another example converts the hex number 3C07 into a binary number.

Hex	Binary							
3C07	A15	A14	A13	A12	A11	A10	A9	A8
	0	0	1	1	1	1	0	0
	A7	A6	A5	A4	A3	A2	A1	A0
	0	0	0	0	1	1	1	1

You can see which address lines are 1 or 0. (Remember that 1 means greater than 2.4 volts and 0 means less than 0.8 volt.)

To convert from hex to binary, consider each hex digit separately. Consult Table 2.1 and convert each hex digit into the corresponding 4-digit binary number. For example, to convert *E39B*:

E = 1110
3 = 0011
9 = 1001
B = 1011

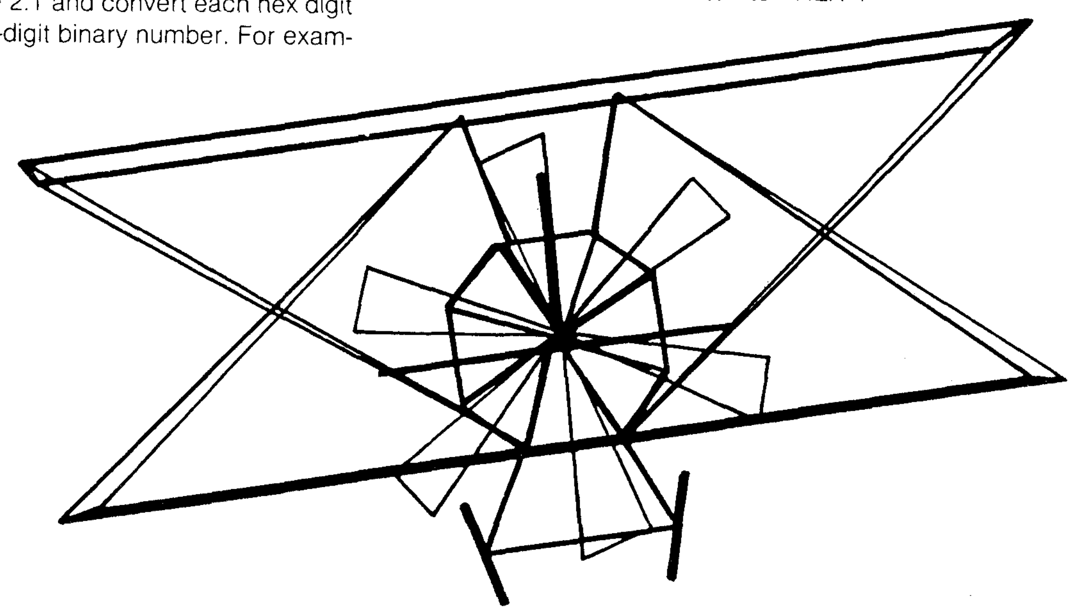
E39B = 1110 0011 1001 1011

Table 2.1 Hex to Binary Conversion

Hex	Binary	Hex	Binary	Hex	Binary	Hex	Binary
0	0000	4	0100	8	1000	C	1100
1	0001	5	0101	9	1001	D	1101
2	0010	6	0110	A	1010	E	1110
3	0011	7	0111	B	1011	F	1111

Table 2.2 Hex to Binary Glossary

BINARY	Numbering systems where all values are expressed using two digits (0 and 1).
BIT	Binary digit; either a 1 or a 0.
BYTE	Smallest addressable unit of storage; a group of 8 bits.
DATA	Information used by a computer for processing.
HEXADECIMAL	Numbering system using 16 digits, namely 0-9 and A-F. Frequently abbreviated to "HEX".



3 Reading Memory Maps

The memory map contains the address and data information you need to use for the CAT Box troubleshooting tests. The following paragraphs describe the Missile Command™ memory map.

Address	Remarks
0000–3FFF	This is 16K of play field and system RAM. RAM is read-write memory. The CAT Box reads and writes to RAM in 1K blocks, so a RAM test should be done on each 1K block of RAM. To test the RAM in Missile Command™, divide the RAM into 1K blocks and test each separately. 1K means 1,024 bytes. In hexadecimal 1,024 is expressed as 400. Therefore, the addresses of each 1K of RAM are multiples of the hexadecimal 400: 0000, 0400, 0800, 0C00, 1000, 1400, 1800, 1C00, 2000, 2400, 2800, 2C00, 3000, 3400, 3800 and 3B00. These are the addresses you enter during the RAM test. *Section 6.12* describes the RAM test in greater detail.
4000–400F	4000 to 400F are the addresses of the Custom Audio I/O chip in Missile Command™. When testing this chip, you write to addresses 4000-400F. Testing this chip is described further in *Section 6.5.*
4800	Missile Command™ address 4800 is an I/O location. As an output it controls FLIP, coin counters, LEDs and CTRLD. FLIP is the signal that allows the video to "flip" upside-down for the cocktail version. See *Section 6.8* for further details about testing these outputs. As an input, address 4800 multiplexes between player operated switches and Trak Ball™ displacement inputs. As described in the memory map, the CTRLD bit determines which group of inputs is read at this address. To test Trak Ball™ inputs, first *write* to address 4800, making sure data bit 0 is high. To test player switch inputs, first *write* to address 4800, making sure data bit 1 is low. Testing switch inputs is described further in *Section 6.4.* Testing Trak Ball™ inputs is described further in *Section 6.7.*
4900	Missile Command™ address 4900 is an input. Inputs read at this address include Trak Ball™ direction, player switches and VBLANK.
4A00	Missile Command™ address 4A00 is an input. Operator option switches are read at this address. See *Section 6.4* for details on testing switch inputs.
4B00–4B07	This is the Missile Command™ color RAM containing 8 addresses, 4 bits wide. This RAM cannot be directly read by the CAT Box.
4C00	Missile Command™ address 4C00 is an output signal (WATCHDOG) activated periodically by the address decoder.
4D00	The Interrupt Acknowledge address is 4D00. The processor writes to this address when responding to an interrupt (IRQ).
5000–7FFF	5000–7FFF are Missile Command™ ROM addresses. ROMs are Read Only Memory chips. These chips hold the instructions for the microprocessor. These chips can be checked for proper operation using the signature Analysis procedure described in *Section 6.14.*

Table 3.1 Missile Command™ Memory Map

HEXA-DECIMAL ADDRESS	R/$\overline{W}$	D7	D6	D5	D4	D3	D2	D1	D0	FUNCTION
					DATA					
0000-01FF		D	D	D	D	D	D	D	D	512 Bytes of Working RAM
0200-05FF		D	D	D	D	D	D	D	D	3rd-color-bit region of Screen RAM
0600-063F		D	D	D	D	D	D	D	D	More Working RAM
06F0-3FFF		D	D	D	D	D	D	D	D	2-color-bit region of Screen RAM
4000-400F	R/$\overline{W}$	D	D	D	D	D	D	D	D	Custom Audio I/O Chip
4800	R	D								Right Coin Switch Input
	R		D							Center Coin Switch Input
	R			D						Left Coin Switch Input
	R				D					1-player Start Switch Input
	R					D				2-player Start Switch Input
	R						D			2nd-player left Fire Switch Input (Cocktail Only)
	R							D		2nd-player center Fire Switch Input (Cocktail Only)
	R								D	2nd-player right Fire Switch Input (Cocktail Only)
	R					D	D	D	D	Horizontal Trak Ball displacement if $\overline{CTRLD}$ latched high
	R	D	D	D	D					Vertical Trak Ball displacement if $\overline{CTRLD}$ latched high
	W		D							Screen Flip
	W			D						Left Coin Counter Output
	W				D					Center Coin Counter Output
	W					D				Right Coin Counter Output
	W						D			2-player Start LED Output
	W							D		$\overline{1\text{-player}}$ Start LED Output
	W								D	CTRLD-If low, read switches. If high, read Trak Ball™
4900	R	D								VBLANK read
	R		D							Self-Test Switch Input
	R			D						SLAM Switch Input
	R				D					Horizontal Trak Ball™ Direction Input
	R					D				Vertical Trak Ball™ Direction Input
	R						D			1st-player left Fire Switch Input
	R							D		1st-player center Fire Switch Input
	R								D	1st-player right Fire Switch Input
4A00	R	D	D	D	D	D	D	D	D	Option Switch Inputs
4B00-4B07	W					D	D	D	D	Color RAM
4C00	W									Watchdog
4D00	W									Interrupt Acknowledge
5000-7FFF	R	D	D	D	D	D	D	D	D	Program ROM

4 General Information

4.1 Game Self-Test

A self-test is described in the manual you receive with each Atari game. Use the self-test to troubleshoot down to the circuit level, and then use the CAT Box to isolate the defective component.

4.2 CAT Box Tests

The CAT Box tests described in this manual are "tailored" to particular games. For example, the test describing discrete audio circuits gives specific directions for testing the discrete audio circuits of Asteroids Deluxe™. This was done to give specific directions, rather than vague general directions.

Of course, Asteroids Deluxe™ will not be the only game you will need to test. By showing you the use of the CAT Box on a specific game, we hope you will be able to test other games. The memory map provided with each Atari game is the key to "tailoring" the test procedures to the game board you are repairing.

4.3 Complex Circuits

Because of the complexity of some of the circuits tested with the CAT Box, circuit theory is not described. If you have isolated a problem in a circuit that you just don't understand, please feel free to contact the Atari Customer Service Office nearest you. The locations and telephone numbers are listed near the front of this manual.

5 CAT Box Preliminary Set-Up

Remove

1. Power from the game.
2. The main printed circuit board from the game.
3. The microprocessor from the socket (6502 or 6800).

Connect

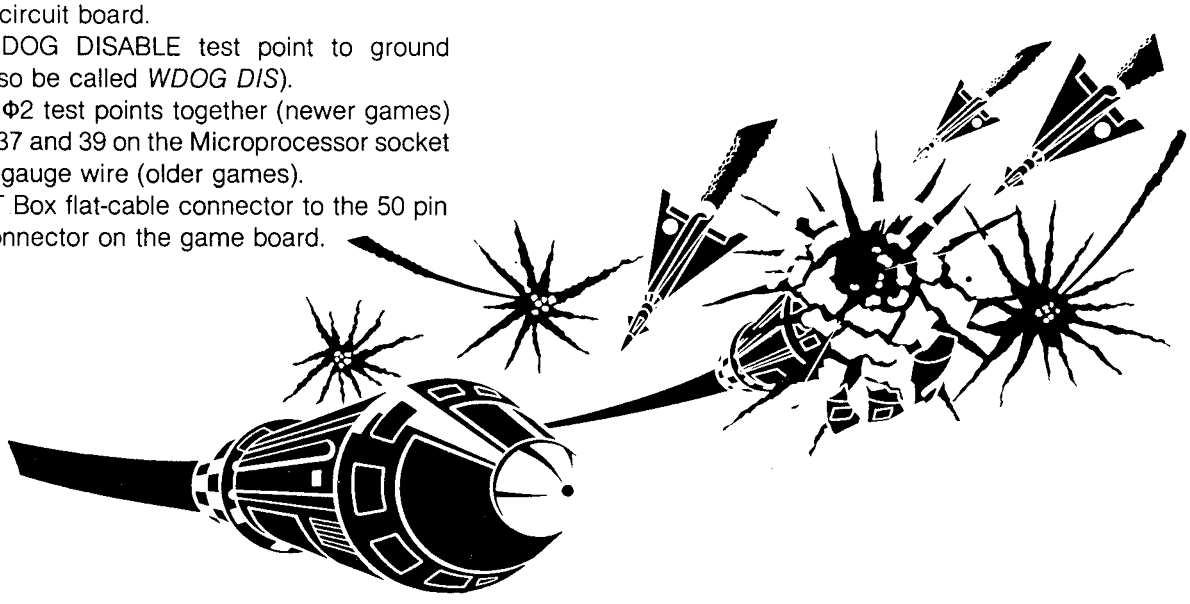
1. The harness(es) from the game to the main printed circuit board.
2. WATCHDOG DISABLE test point to ground (may also be called *WDOG DIS*).
3. Φ0 and Φ2 test points together (newer games) or Pins 37 and 39 on the Microprocessor socket with 28 gauge wire (older games).
4. The CAT Box flat-cable connector to the 50 pin edge connector on the game board.

Power Up

1. The game.
2. The CAT Box.

Set CAT Box Switches

1. TESTER SELF-TEST: OFF
2. TESTER MODE: $R/\overline{W}$
3. Press Tester Reset.



6 CAT Box Tests

6.1 DATA PROBE

Brief Theory

The DATA PROBE LEDs (light-emitting diodes) quickly determine if a digital signal is high or low.

Specific Theory

LED 0 lights if a signal is less than 1 volt. LED 1 lights if a signal is more than 2 volts.

CAT Box preliminary set-up is not necessary. The DATA PROBE is larger than the other probes. Connect the BNC connector of the DATA PROBE to the BNC connector marked *DATA*. Attach the ground clip of the DATA PROBE to one of the ground test points of the game board.

Set the PULSE MODE switch to UNLATCHED.

Test Procedure

Touch the DATA PROBE to one of the ground test points. The "0" LED should light up.

Touch the DATA PROBE to one of the +5V test points. The "1" LED should light up.

Test Results

The DATA PROBE is not just for checking the power supply. In the bus control and signature tests, the DATA PROBE can probe specific ICs for high and low conditions.

In the LATCHED position of the PULSE MODE, the DATA PROBE will continuously light the PULSE LED after the first pulse is detected.

6.2 Address and Data Buses

This example uses the Asteroids Deluxe™ game.

Theory

Check address and data buses for shorts by writing a non-changing pattern. Check buses after they have been buffered. A short on either the address or data bus will cause a game to become completely non-functional.

Test Procedure

1. Perform the CAT Box Preliminary set-up.
2. Connect the DATA PROBE to the CAT Box and the game ground test point.
3. TESTER MODE: R/$\overline{W}$
4. BYTES: 1
5. PULSE MODE: UNLATCHED
6. R/$\overline{W}$ MODE: (OFF)
7. Key in pattern on the keyboard (use AAAA to start).
8. Push DATA SET.
9. Key in data pattern (use AA to start).
10. R/$\overline{W}$ MODE: STATIC
11. Probe the IC-pin with the data probe and check for 1 or 0 as indicated by Table 6.2. Repeat this step for every address and data line.
12. To write in another pattern, go to Step 6 and continue (suggested pattern: ADD = 5555, DATA = 55).

Test Results

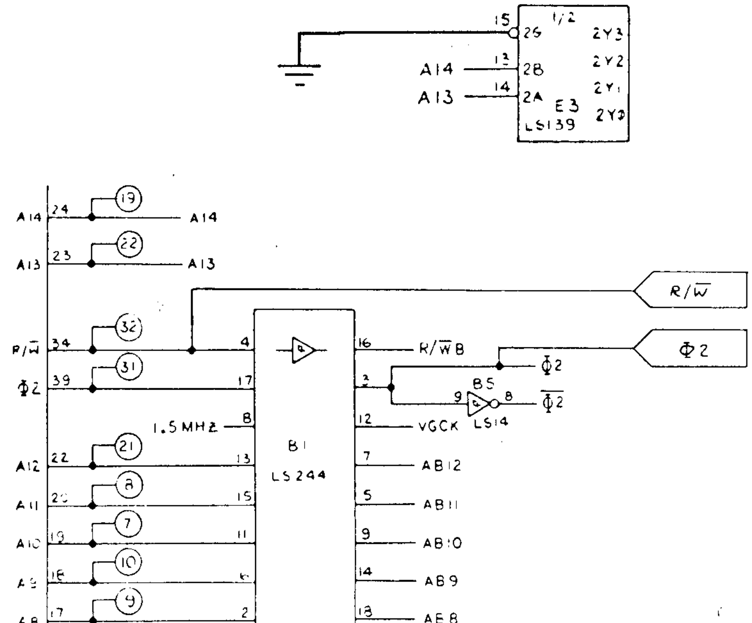
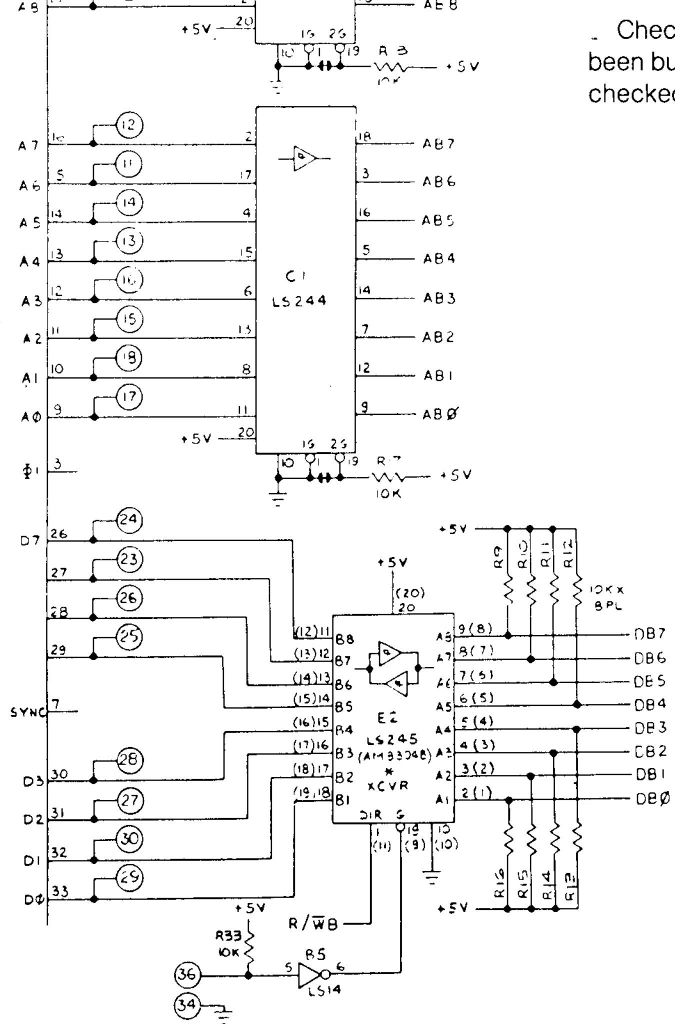
Writing patterns like AAAA or 5555 verifies that a particular bus signal is not shorted to ground, to +5V or to an adjacent bus signal.

Now check R/$\overline{W}$, Φ2, Φ2 and VGCK. R/$\overline{W}$ should pulse when the R/$\overline{W}$ CAT Box switch is moved. Φ2, Φ2 and VGCK should be pulsing at all times.

Table 6.2 Address and Data Logic States

Note: This table assumes that IC E2 is a 74LS245.

When Writing AAAA Pattern	*Address and Data Lines*	*When Writing 5555 Pattern*
Logic State	**Pin**	**Logic State**
0	E3-13	1
1	E3-14	0
0	B1-7	1
1	B1-5	0
0	B1-9	1
1	B1-14	0
0	B1-18	1
1	C1-18	0
0	C1-3	1
1	C1-16	0
0	C1-5	1
1	C1-14	0
0	C1-7	1
1	C1-12	0
0	C1-9	1
1	E2-9	0
0	E2-8	1
1	E2-7	0
0	E2-6	1
1	E2-5	0
0	E2-4	1
1	E2-3	0
0	E2-2	1

Check the address and data buses after they have been buffered. A14 and A13 are not buffered and can be checked at E3-14 and E3-13.

Figure 6.2 Schematic from Asteroids Deluxe™

6.3 Address Decoding Circuits

This example uses schematics and memory addresses from the Asteroids Deluxe™ game.

Brief Theory

The address decoder enables the right circuits at the right time. This exact time defines when data should be transferred back and forth between the game circuitry and the MPU.

Specific Theory

Static addresses can be put on the bus, and address decoding signals can be checked using the data probe.

Test Procedure

1. Perform the CAT Box preliminary set-up.
2. Connect Data Probe to the CAT box and test point ground on game.
3. TESTER MODE: R/W̄ (Puts CAT Box into R/W mode).
4. BYTES: 1 (one address at a time).
5. PULSE MODE: UNLATCHED (see pulses as they occur).
6. R/W̄ MODE: (OFF) (allows address to be keyed in).
7. Key in address from Table 6.3.
8. R/W̄: READ or WRITE from Table 6.3.
9. R/W̄ MODE: STATIC
10. Probe IC-pin and check for condition indicated in Table 6.3.
11. To check the next signal repeat steps 6–10.

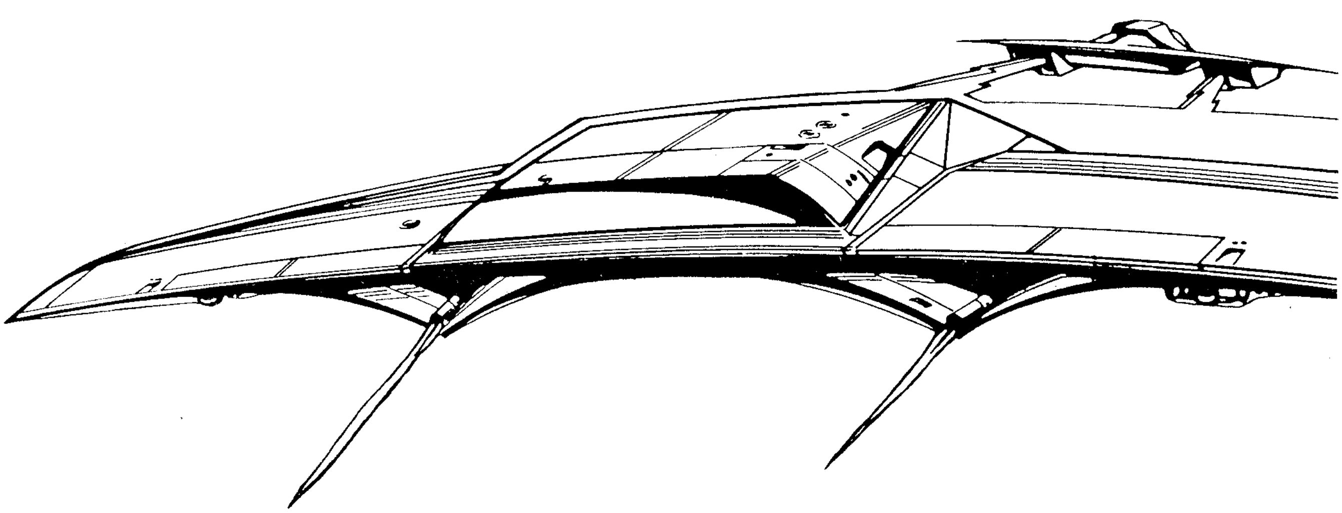
Test Results

This test has verified that the address decoder enabled both the memory chips and the I/O latches.

For games other than Asteroids Deluxe™, read the address from the Memory Map, or compute the address from the truth tables.

Table 6.3 Address Decoding

Address	R/W	IC-Pin	Signal Name	Data Probe LED
0000	R	E3-12	ZPAGE	0
4000	R	E3-10	VMEN	0
6000	R	E3-9	PMEM	0
2800	R	E3-6	OPTS	0
2400	R	E3-5	SINP1	0
2000	R	E3-4	SINP0	0
7800	R	L2-7	PROM3	0
7000	R	L2-6	PROM2	0
6800	R	L2-5	PROM1	0
6000	R	L2-4	PROM0	0
3E00	W	L5-9	NOISERESET	PULSE
3C00	W	L5-7	AUDIO	PULSE
3A00	W	L5-6	EACONTROL	PULSE
3600	W	L5-4	EXPLODE	PULSE
3400	W	L5-3	WDCLR	PULSE
3200	W	L5-2	EAADDRL	PULSE
3000	W	L5-1	DMAGO	PULSE



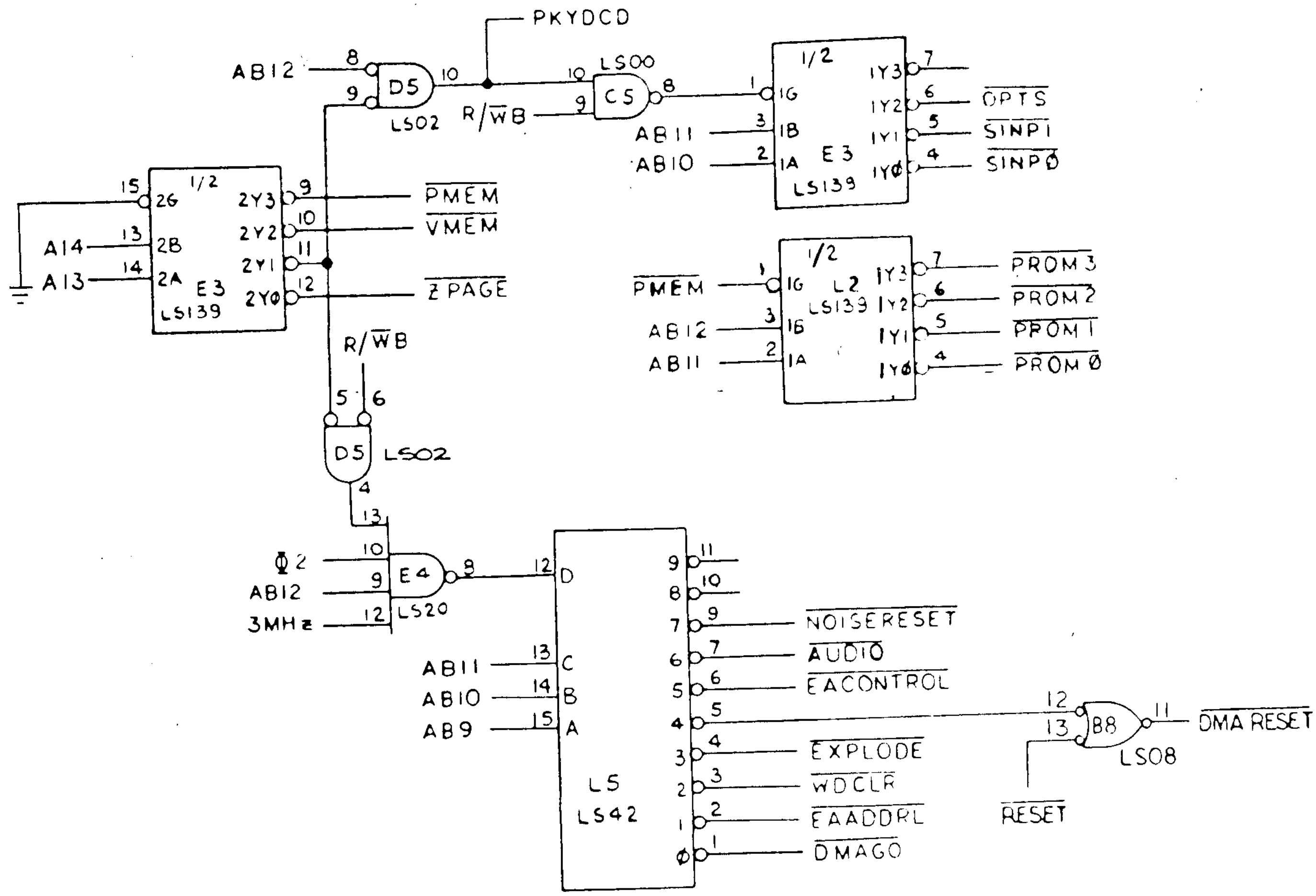


Figure 6.3 Address Decoding (Asteroids Deluxe™)

6.4 Switch Inputs

The following example is for Asteroids Deluxe™. Consult the memory map when troubleshooting other games.

Theory

When a switch input fails, the CAT Box can locate the failure. Let's assume the 2-player start switch is not functioning.

Test Procedure

1. Perform the CAT Box preliminary set-up.
2. BYTES: 1
3. R/W̄: READ
4. R/W̄ MODE: (OFF)
5. Key in 2404.
6. R/W̄ MODE: STATIC
7. The DATA display should read 7F, but when the 2-player game switch is depressed the DATA display should read FF.
8. If you didn't get the proper results in step 7, check the following signals with the DATA PROBE:

   ⓐ SINP1 originates at the address decoder and should be low.

   ⓑ J10-15 should be low when the 2-player switch is pressed and high when it is not pressed.

   ⓒ J10-6 should be high when the 2-player switch is pressed and low when it is not pressed.

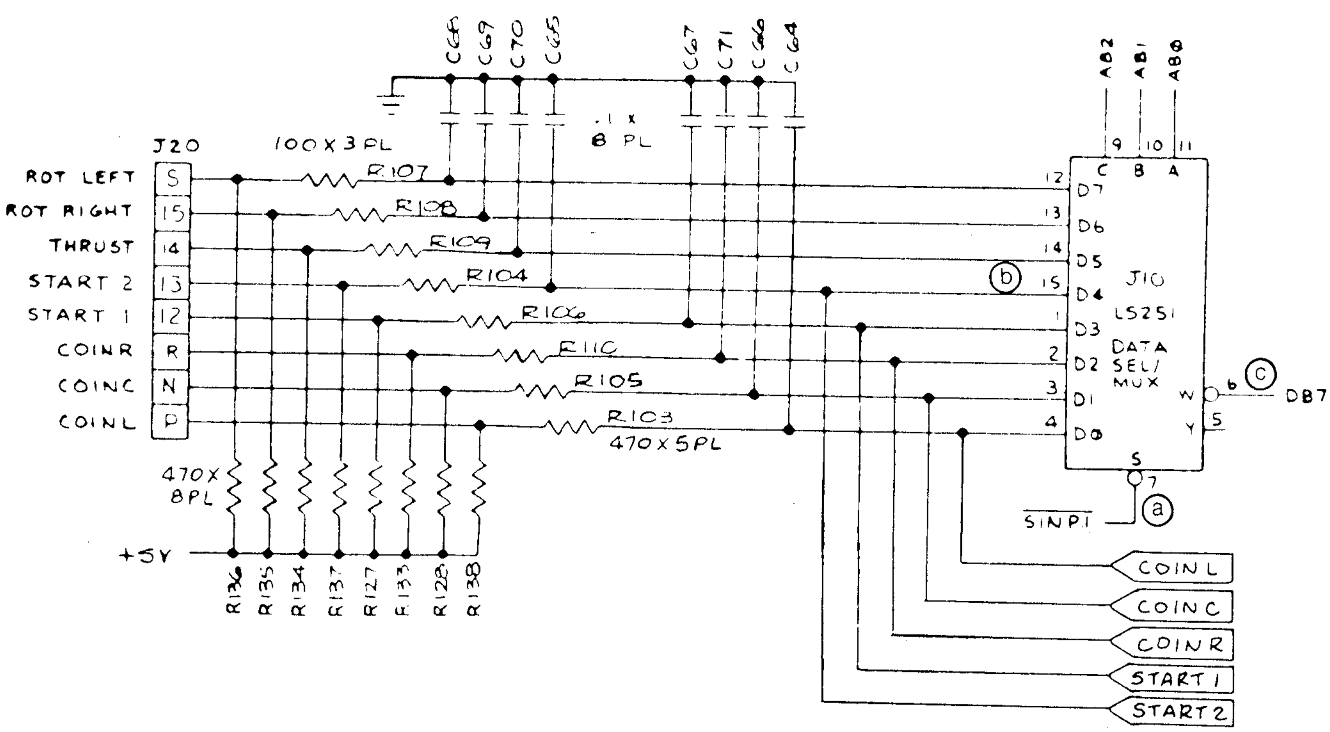


Figure 6.4 Switch Inputs (Asteroids Deluxe™)

6.5 The Custom Audio I/O Chip (POKEY)

This example applies to all games since Missile Command™ which was built in 1980. Some games have two POKEY chips, and each POKEY should be tested separately.

Theory

This test verifies operation of the custom audio chip. Audio amplifiers, speakers, and speaker connectors must be operational to hear the output of the custom audio chip.

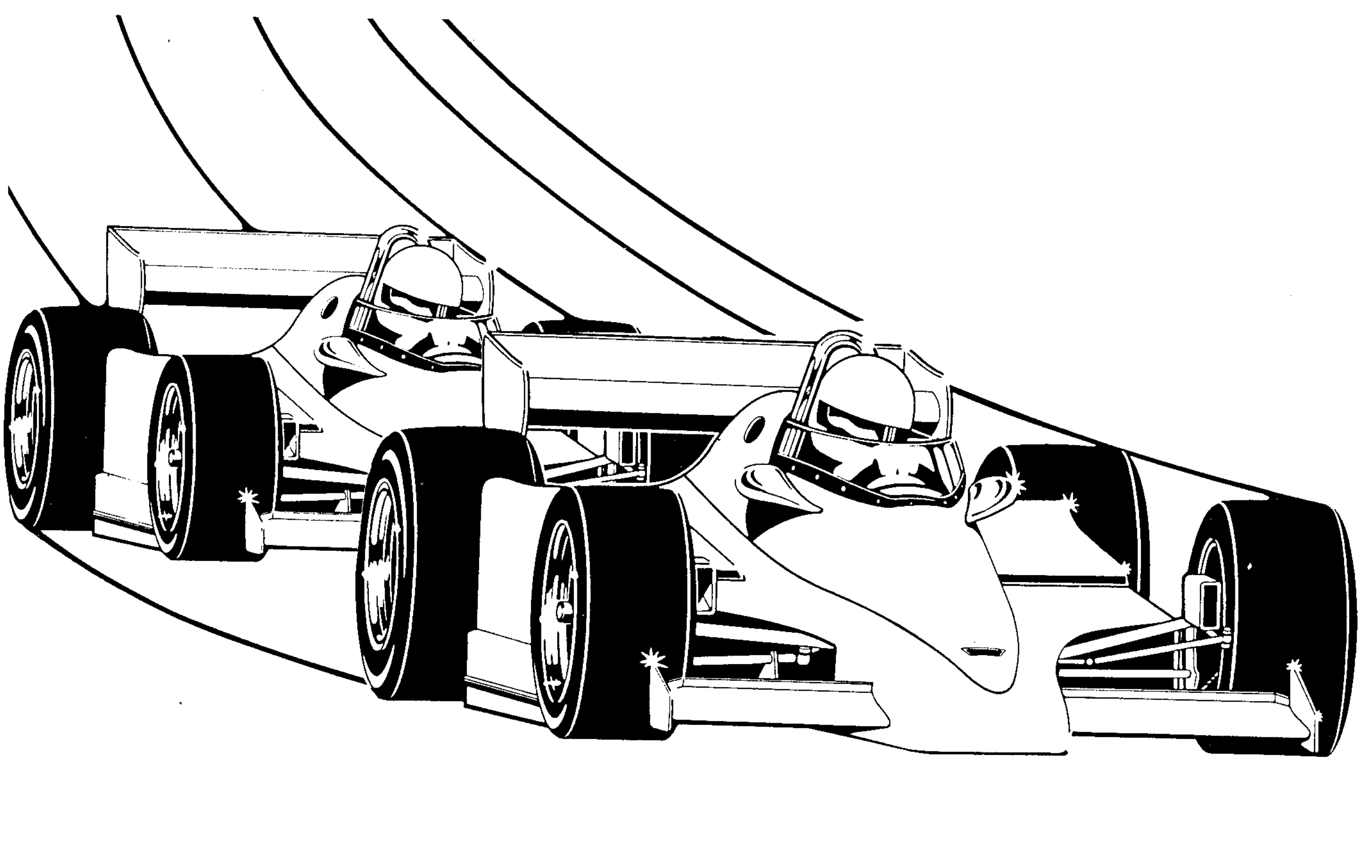
Test Procedure

1. Perform the CAT Box preliminary set-up.
2. BYTES: 1
3. R/W̄: WRITE
4. R/W̄MODE: (OFF)
5. Enter the address from the table that follows.
6. Press DATA SET.
7. Enter the data from Table 6.5.
8. R/W̄ MODE to PULSE and back to (OFF)
9. Repeat from Step 5.

XXX implies the first three hexadecimal numbers of the POKEY chip address. This address can be found on the memory map of the game to be tested. For Asteroids Deluxe™, this address is 2C00, so the first address of this table would be 2C0F.

Table 6.5 Testing the Custom Audio Chip

ADDRESS	DATA	TEST RESULTS
XXXF	00	
XXXF	03	
XXX0	55	
XXX1	AF	POKEY channel 1 produces pure tone
XXX1	00	POKEY channel 1 off.
XXX2	55	
XXX3	AF	POKEY channel 2 produces pure tone.
XXX3	00	POKEY channel 2 off.
XXX4	55	
XXX5	AF	POKEY channel 3 produces pure tone.
XXX5	00	POKEY channel 3 off.
XXX6	55	
XXX7	AF	POKEY channel 4 produces pure tone.
XXX7	00	POKEY channel 4 off.



6.6 Discrete Audio Outputs

The following example is for Asteroids Deluxe™. Consult the memory map when troubleshooting other games.

Theory

Beginning with Missile Command™ in 1980, Atari has been using the Custom I/O chip for most of the audio generation on a PCB. Sounds such as ship thrust, explosion, and motor sound are often from discrete circuits and summed with the Custom I/O audio output.

This example tests the discrete explosion sound. The audio amplifier and speaker must be working to hear the sound.

Test Procedure

1. Perform the CAT Box Preliminary set-up.
2. BYTES: 1
3. R/$\overline{W}$: WRITE
4. R/$\overline{W}$ MODE: (OFF)
5. Key in 3600.
6. Press DATA SET.
7. Key in FF.
8. Toggle R/$\overline{W}$ MODE to PULSE then back to (OFF)

At this point, if the circuitry is working, the explosion sound should be heard from the game speaker. If there is no sound, continue with step 9.

9. Toggle R/$\overline{W}$ MODE to STATIC. Probe the following signals with the data probe:
   - The outputs of AND gate R6 should be pulsing. If they are pulsing, your should suspect problems in the audio output, audio amplifier board or the speaker circuits.
   - Check the NOISE and 12 KHz signals for pulsing. If they are not pulsing, suspect problems in the circuits where these signals originate.
   - EXPLODE should be low.
   - The output of the counter P7-15 should be pulsing.

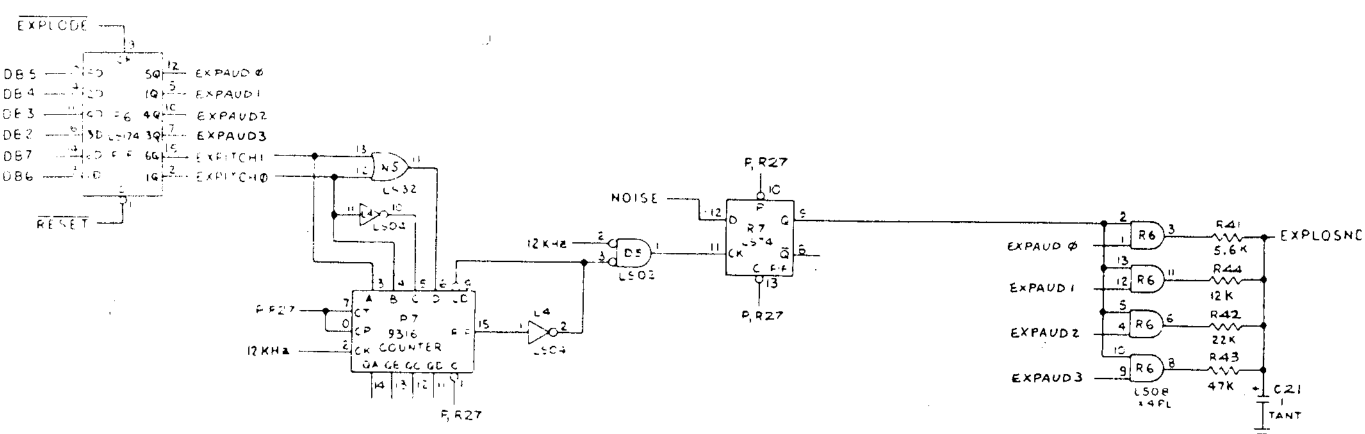


Figure 6.6 Discrete Audio Outputs (Asteroids Deluxe™)

6.7 Trak Ball™

This example is from the Centipede™ game.

Theory

This tests Trak Ball™ and Mini-Trak Ball™ inputs.

Test Procedure

1. Perform the CAT Box preliminary set-up.
2. DBUS SOURCE: DATA
3. BYTES: 1
4. R/W̄: READ
5. Key in address *0C00* (vertical) or *0C02* (horizontal).
6. R/W̄ MODE: STATIC
7. Spin the Mini-Trak Ball™ while monitoring the DATA DISPLAY. The DATA DISPLAY will change if the Mini-Trak Ball™ input is functioning.
8. If a problem still exists, probe the points indicated on the schematic that follows.
   a. Check these points for pulses as you move the Trak Ball™.
   b. Moving the Trak Ball™ in one direction should produce an unchanging "1" or "0" here.
   c. These counters should count up or down when moving the Trak Ball™. Check these counter outputs for pulse.

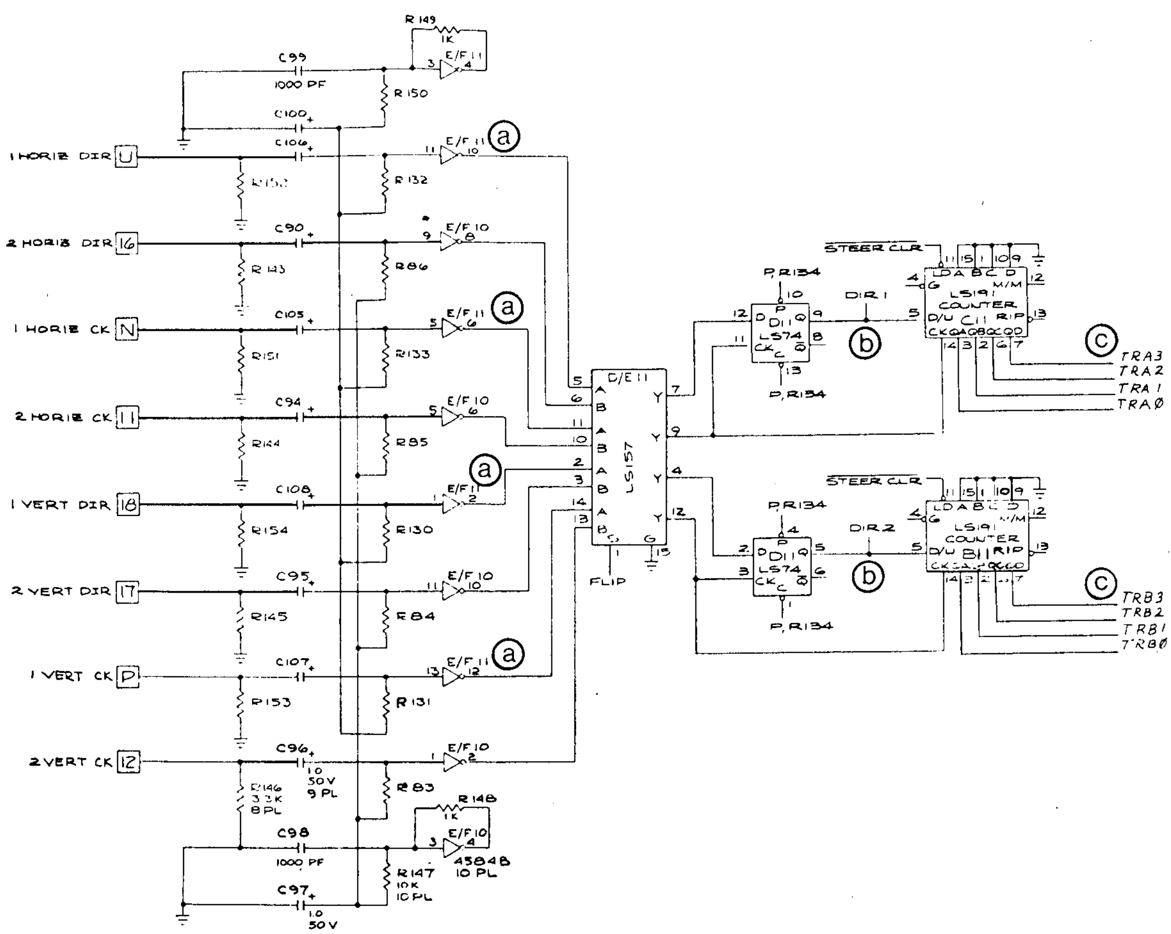


Figure 6.7 Mini-Trak Ball™ Inputs

6.8 LED And Coin Counter Outputs

This example uses the Asteroids Deluxe™ game.

Theory

Most LED and coin counter outputs involve writing data to a specific address. This address enables an output latch, from which the LEDs and coin counter solenoids are wired.

If you write data that activates a solenoid, deactivate it by pressing the reset button on the game board or by writing "off" data. If you leave a solenoid activated for more than about 10 seconds it will overheat and may have to be replaced.

Test Procedure

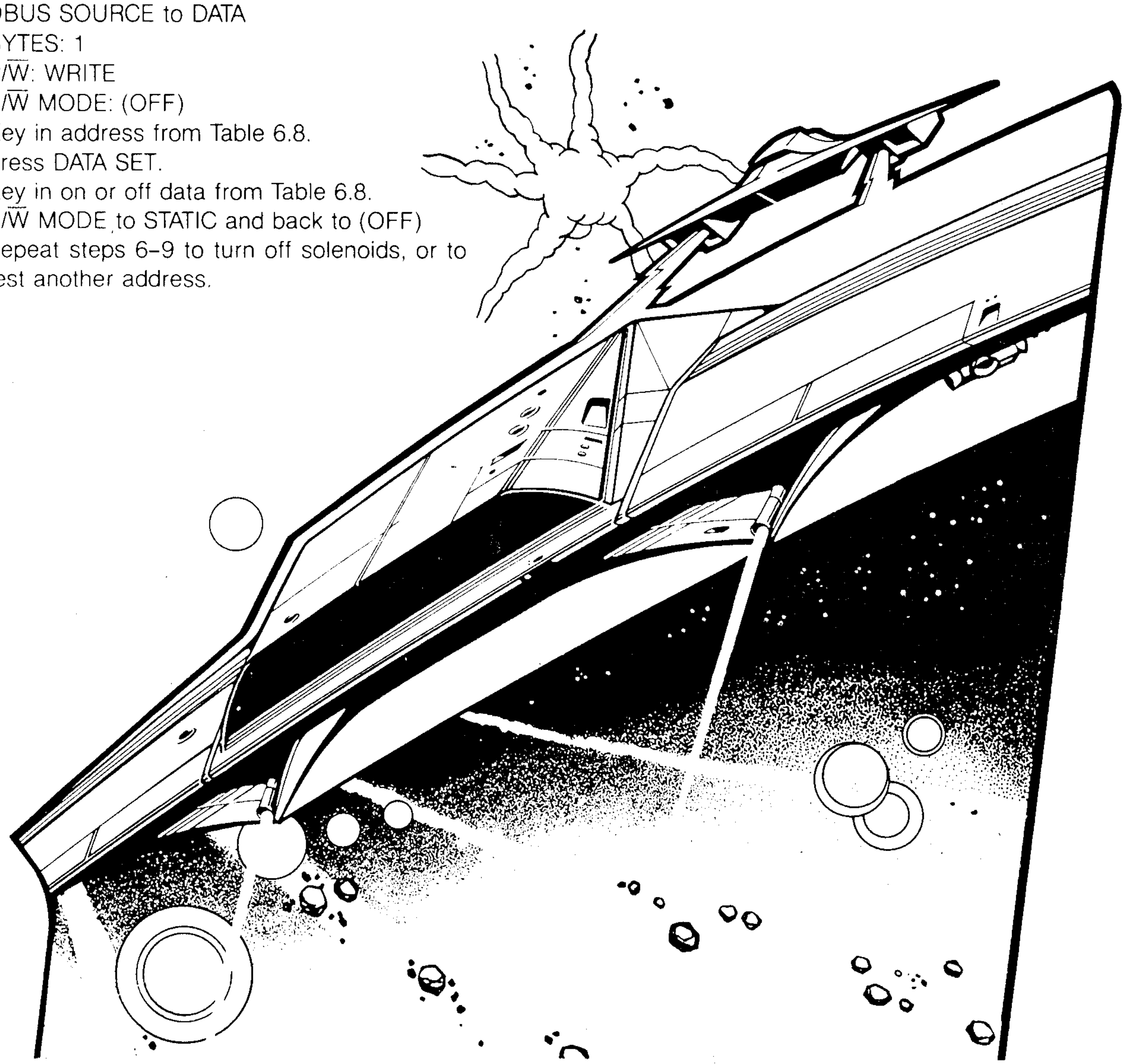
1. Perform the CAT Box preliminary set-up.
2. DBUS SOURCE to DATA
3. BYTES: 1
4. R/W̄: WRITE
5. R/W̄ MODE: (OFF)
6. Key in address from Table 6.8.
7. Press DATA SET.
8. Key in on or off data from Table 6.8.
9. R/W̄ MODE to STATIC and back to (OFF)
10. Repeat steps 6–9 to turn off solenoids, or to test another address.

Table 6.8 LED and Coin Counter Addresses

ADDRESS	ON-DATA	OFF-DATA	OUTPUT NAME
3C00	00	80	1-player start LED
3C01	00	80	2-player start LED
3C05	80	00	Left coin counter
3C06	80	00	Center coin counter
3C07	80	00	Right coin counter

Test Results

This test verifies proper operation of LEDs and coin counter outputs. When the R/W̄ MODE is set to STATIC (Step 9), the output latches and transistors can be checked for proper operation.



6.9 Analog Vector-Generator

The analog vector-generator is used in the Red Baron, Battlezone™ and Tempest™ games. This example applies only to these games.

Theory

To test the video circuit of an analog vector-generator, first find the address locations of the vector RAM and VG GO from the memory map of the schematic diagram. The addresses for the following tests are represented by XX00 through XX23.

Substitute the most significant byte of the address from the memory map for the xx of the addresses in Table 6.9. For Red Baron, Battlezone™ and Tempest, the RAM address is 2000.

Test

1. Perform CAT Box preliminary set-up.
2. DATA SOURCE: DATA
3. R/$\overline{W}$: WRITE
4. R/$\overline{W}$ MODE: (OFF)
5. Key in address from Table 6.9 or press ADDRESS INC.
6. Press DATA SET.
7. Key in data from Table 6.9.
8. Set R/$\overline{W}$ MODE to PULSE and then to (OFF).
9. Repeat steps 5-8 for each address in Table 6.9.

CAUTION

You may damage the circuitry of the X-Y monitor if you key in the VG GO signal without first checking all the addresses and data. Check the data by reading each address location, following steps 10-14.

10. R/$\overline{W}$: READ
11. R/$\overline{W}$ MODE: (OFF)
12. Key in address or press ADDRESS INC.
13. R/$\overline{W}$ MODE: PULSE
14. Check the data in the DATA DISPLAY against the data in Table 6.9.

If you are sure the data is correct, proceed to steps 15-19.

15. R/$\overline{W}$ MODE: WRITE
16. R/$\overline{W}$: (OFF)
17. Key in VG GO address (1200 for Red Baron and Battlezone™, 4800 for Tempest™).
18. R/$\overline{W}$ to PULSE and then back to (OFF).
19. Check the monitor against the diagram in Test Results section of this test.

Table 6.9 Analog Vector-Generator Data*

Address	Data	Address	Data	Address	Data
XX00	40	XX0C	FF	XX18	00
XX01	80	XX0D	03	XX19	40
XX02	00	XX0E	00	XX1A	80
XX03	70	XX0F	62	XX1B	00
XX04	00	XX10	40	XX1C	80
XX05	1E	XX11	80	XX1D	1F
XX06	00	XX12	80	XX1E	00
XX07	1E	XX13	00	XX1F	00
XX08	00	XX14	00	XX20	FF
XX09	60	XX15	00	XX21	40
XX0A	FF	XX16	01	XX22	00
XX0B	03	XX17	1F	XX23	E0

*For Red Baron, Battlezone™, and Tempest™, XX = 20.

Test Results

After writing to the VG GO address, the monitor should show a large plus sign.

Failure of the horizontal or vertical circuits shows up as a single line drawn on the monitor.

If your monitor does not display a large plus sign, contact Atari Customer Service.

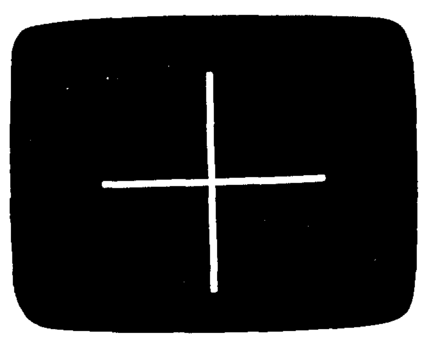


Figure 6.9 Analog Vector-Generator Display

6.10 The Digital Vector-Generator

The digital X-Y vector-generator is used in Lunar Lander™, Asteroids™ and Asteroids Deluxe™.

Theory

The video generation for an X-Y image is developed digitally, then fed to an analog circuit for filtering and amplification.

To conduct this test, data must be written to the starting locations of Vector RAM.

Test Procedure-Part 1

1. Perform the CAT Box preliminary set-up.
2. BYTES: 1
3. R/$\overline{W}$: WRITE
4. Key in starting Address from Table 6.10 or press ADDRESS INCR.
5. Press DATA SET.
6. Key in DATA from Table 6.10.
7. Toggle R/$\overline{W}$ MODE to PULSE then back to (OFF).
8. Repeat from Step 4 using Table 6.10 for the addresses and data.

Table 6.10 Digital Vector-Generator

ADDRESS	DATA	ADDRESS	DATA
4000	FF	4009	A2
4001	A3	400A	00
4002	00	400B	00
4003	02	400C	00
4004	FF	400D	90
4005	97	400E	FF
4006	00	400F	33
4007	90	4010	00
4008	00	4011	E0

CAUTION

You may damage the circuitry of the X-Y monitor if you key in the DMA GO or START VG signals before inputting all the other addresses and data, or if you key in incorrect data.

Check the data by reading each address location before writing the DMA GO or start VG address.

Test Procedure-Part 2

To check the data, follow Steps 1-5:

1. R/$\overline{W}$ MODE: READ
2. Key in address or press ADDRESS INCR.
3. R/$\overline{W}$ MODE to PULSE and then back (OFF).
4. Check that the proper data appears in the DATA display for each address.
5. Repeat from Step 2.

Test Procedure-Part 3

Once you have verified that the proper data has been written, start the vector-generator by following steps 1-4. This is the DMA GO address.

1. R/$\overline{W}$ MODE: (OFF)
2. R/$\overline{W}$: WRITE
3. Key in 3000.
4. R/$\overline{W}$ MODE to PULSE then to (OFF).

At this point, the monitor should display a large plus sign. If you do not get this display, there is a failure within the vector-generator circuitry or the monitor circuitry. Contact Atari Customer Service for further information.

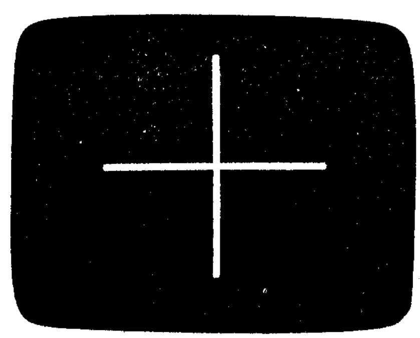


Figure 6.10 Digital Vector-Generator Display

6.11 Raster Scan Video

This test uses the Atari Centipede™ game.

Theory

By writing to certain parts of video RAM, a motion object can be written to a specific place on the monitor. The following test writes a spider to the center of the monitor.

Test Procedure

1. Perform the CAT Box preliminary set-up.
2. R/W̄ MODE: (OFF)
3. R/W̄: WRITE
4. DBUS SOURCE: DATA
5. BYTES switch to position indicated by Table 6.11.
6. Key in address from Table 6.11.
7. Press DATA SET.
8. Key in data from Table 6.11.
9. Toggle R/W̄ MODE to PULSE and back to (OFF)
10. Repeat steps 5–9 for each address.

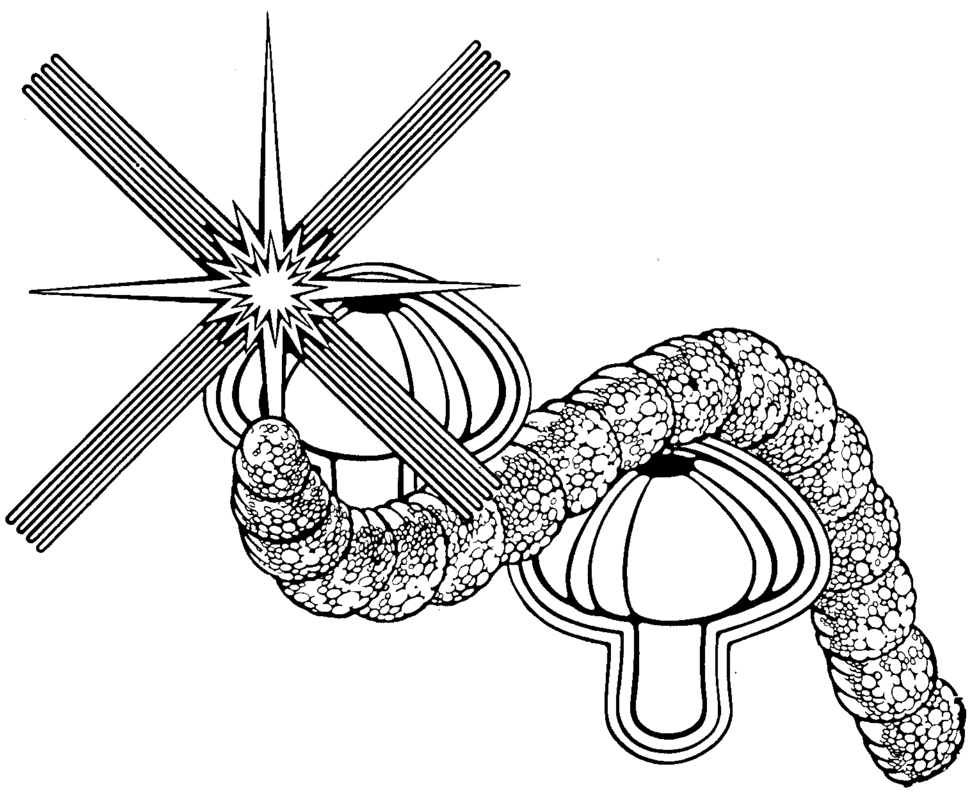
Test Results

A spider should be centered on the monitor on a black background. The spider should be colored as follows:

- eyes-red
- body-green
- legs-pale yellow

Table 6.11 Centipede Raster Data

Address	Data	BYTES Switch
0400	00	1024
07C0	14	1
07D0	80	1
07E0	80	1
07F0	39	1
1400	FF	1024
140D	00	1
140E	0E	1
140F	0D	1



6.12 RAM

This example uses the Asteroids Deluxe™ game.

Theory

Atari games use two groups of RAM, the system RAM and the video RAM. The system RAM contains the microprocessor memory. The video RAM contains the information needed to draw a particular video image. Both types are easy to test using the CAT Box.

Test Procedure

1. Perform the CAT Box preliminary procedure.
2. BYTES: 1024
3. R/$\overline{W}$: WRITE
4. R/$\overline{W}$ MODE: (OFF)
5. DBUS SOURCE: ADDR
6. Enter 4000 on the keyboard
7. Toggle R/$\overline{W}$ MODE switch to PULSE and then back to (OFF).
8. R/$\overline{W}$: READ
9. Toggle R/$\overline{W}$ MODE switch to PULSE and then back to (OFF).

At this point, you have written to every address from 4000 to 43FF. In addition, you have read those same locations. If no failure is seen, the CAT Box will show 4400 in the address display. If an error is detected, the CAT Box stops at that address and lights the COMPARE ERROR LED.

10. If a failure has been detected, switch ERROR DATA DISPLAY to TESTER.
    Record the number in the data display, because this is the data that was written to that address.

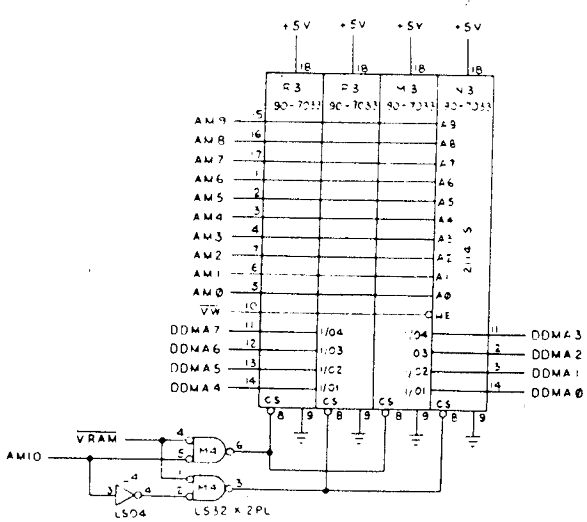


Figure 6.12 Vector RAM

11. Switch ERROR DATA DISPLAY to GAME.
    Record the data that is now at that address. From this information, determine if the failure is in the high order bits, the low order bits, or both. Replace the IC causing the failure, and repeat the test.

Additional Information

Asteroids Deluxe™ has 3K of RAM so the test must be repeated at least three times. The three different addresses to be entered at step 6 are *4000, 4400* and *0000.*

Sometimes a RAM can pass this test, yet still have an undetected fault condition. Therefore, if you suspect a fault, we recommend that you run the test a total of four times for each 1K of RAM. To run the other three tests, repeat the RAM test with the following differences:

$\overline{\text{ADDR}}$ TEST–At step 5, DBUS SOURCE: $\overline{\text{ADDR}}$.

AA DATA TEST–At step 5, DBUS SOURCE: DATA. Between steps 6 and 7, push DATA SET button and enter AA on the keyboard.

55 DATA TEST–At step 5, DBUS SOURCE: DATA. Between steps 6 and 7, push DATA SET button and enter 55 on the keyboard.

RAM R3 contains the high order bits for addresses 4000–43FF
RAM P3 contains the high order bits for addresses 4400–47FF
RAM M3 contains the low order bits for addresses 4000–43FF
RAM N3 contains the low order bits for addresses 4400–47FF

6.13 Signature Analysis

Signature analysis reduces a large binary-bit stream into a four-digit word. The word produced by the signature analysis process is called a "signature". Signatures taken from a board under test can be compared with signatures provided by Atari. By comparing these signatures, problems on the board can be isolated.

Beginning with Battlezone™, Atari included the specific information necessary to use signature analysis. Signatures are provided by Atari for each new game introduced.

The four signals you use when taking signatures are:

START: This signal defines the beginning of a signature.

STOP: This signal defines the end of a signature.

CLOCK: This signal defines the time at which data is read as a 1 or 0.

DATA: The data probe is used to read data into the CAT Box. The data is processed by the CAT Box, and a four digit signature is produced.

Refer to *ROM Test, Section 6.14,* for an example of signature analysis.

6.14 Testing ROM Using Signature Analysis

This example uses the Atari Centipede™ game.

Signature analysis is an excellent way to test ROM. Single bit errors are easily detected. During signature analysis the CAT Box automatically increments the address bus.

When the ROMs are enabled by the address decoder, the data probe gathers data from the data pins of the ROM. From this data, the signature is calculated.

1. Perform the CAT Box preliminary set-up.
2. Connect the three BNC cables (supplied with CAT Box) to the three SIGNATURE ANALYSIS CONTROL jacks. These jacks are marked START, STOP and CLOCK.
3. Connect the data probe to the DATA jack on the CAT Box.
4. Connect the three black E-Z clips to a ground test point.
5. Connect the data probe alligator clip to a ground test point.
6. Set TESTER MODE to SIG.

At this point follow the instructions provided with each Atari game. The following instructions apply to the Centipede™ game only.

7. Connect the colored E-Z clips to the test points indicated by the ROM 3 Test set-up.
   - START - ROM3 testpoint
   - STOP - ROM3 testpoint
   - CLOCK - Φ2 testpoint
8. Set the SIGNATURE ANALYSIS CONTROL switches to the positions indicated by the ROM3 Test set-up.
   - START: ‾|_
   - STOP: _|‾
   - CLOCK: ‾|_
9. Probe the ROM3 (IC J1) data pins and check for the results indicated by the following table.

Table 6.14 Signatures for Centipede™ ROM3, (136001-210)

IC/Pin	Signal	Signature
J1/9	DB0	476H
J1/10	DB1	2A2C
J1/11	DB2	2337
J1/13	DB3	FP07
J1/14	DB4	A9AF
J1/15	DB5	12HA
J1/16	DB6	2367
J1/17	DB7	8P82

If the above signatures are obtained during the test, you have verified that the ROM contains the proper data. If proper signatures are not obtained, do the following:

1. Check your set-up to make sure the signature test is being properly done.
2. Check the START, STOP and CLOCK signals to see that they are pulsing.
3. If the ROM3 signatures still fail, replace ROM3 (IC J1).

7 Performing the CAT Box Self-Test

Brief Theory

The CAT Box is programmed to conduct a self-test. To help isolate failures inside the CAT Box, follow the step-by-step self-test procedure.

Self-Test Procedure

1. The CAT Box is programmed to provide data that shows the passing or failing of its circuitry, displays or switches. In the Self-Test sequence, the microcomputer functions are tested first when the TESTER SELF-TEST switch is set to ON. If the CAT Box displays a 0000 in the ADDRESS/SIGNATURE display, the TESTER SELF-TEST switch or data selector B2 is failing. If the display is dead, look at the NO CLOCK LED. If lighted, there is a problem with the tester clock circuit. If unlighted, suspect the entire CAT Box microcomputer circuit.
2. The first portion of this test checks the address lines, address decoder F5, data lines, and RAM E4. If one of these fails, the number 1 appears in the DATA display.
3. Next, address decoder F5 and ROM C5 are checked. If one fails, the number 2 appears in the DATA display.
4. Then IRQ generated by RAM E4 is checked. If it fails, the number 3 appears in the DATA display.
5. The self-test will not advance beyond a failing microcomputer function test indicated by the number in the DATA display. If all tests pass, the Self-Test automatically advances to the displays test.
6. In the displays test, the microcomputer exercises its output ports. This test is done in four steps; the second through fourth are activated by pressing either the ADDRESS INCR or DATA SET pushbutton. If the display tests of steps 7 or 8 fail, then use steps 9 and 10 to isolate the problem.
7. In the first portion of this test, the microcomter lights all its output LEDs. Therefore, "8." (eight plus decimal point) is displayed in the ADDRESS/SIGNATURE and DATA displays and the UNSTABLE ADDRESS, COMPARE ERROR and LOOPING LEDs light. If the UNSTABLE ADDRESS, COMPARE ERROR or LOOPING LEDs fail to light, check to see if the center horizontal and decimal point segments of the ADDRESS/SIGNATURE or DATA displays are lighted. If not, then there is a failure in address decoder F5; data latch D1, decoder A7, or driver Q15 of the anode driver circuit; or latch C1 or anode drivers Q2 and Q3. If the center horizontal and decimal point segments are lighted, then the UNSTABLE ADDRESS, COMPARE LED or LOOPING LED itself is failing. If any of the other segments of the two displays are unlighted, then data latch D1, decoder A7 or anode drivers Q9 thru Q14; data latch C1 or cathode drivers Q1, Q4 thru Q8; or the display segment itself is failing. The Self-Test failure of this test or any of the following tests indicates the failure of either the ADDRESS INCR, DATA SET pushbuttons, or buffers A1 or D1.
8. In the next portion of the displays test, the microcomputer turns all output LEDs off. This test in initiated by pressing either the ADDRESS INCR or DATA SET pushbuttons. If either the UNSTABLE SIGNATURE, COMPARE ERROR or LOOPING LEDs stay on, check to see if the horizontal and decimal-point segments of the ADDRESS/SIGNATURE and DATA displays are lighted. If they are not on, then data latch D1, decoder A7 or cathode driver Q15 is failing. If any of the other segments of the two displays are lighted, then data latch D1, decoder A7, anode drivers Q9 thru Q15, data latch C1, or drivers Q1, Q3 thru Q8 are failing.
9. In the next portion of the displays test, the microcomputer lights all the segments of each of the six digits in the displays and the UNSTABLE SIGNATURE LED, COMPARE LED and LOOPING LED one at a time. This test first lights the least significant digit of the DATA display and advances one digit at a time until the most significant digit of the ADDRESS/SIGNATURE display lights. Then it lights the UNSTABLE SIGNATURE LED, LOOPING LED, and the COMPARE ERROR LED. Any failure to light indicates a failure of data latch D1, decoder A7, Q9 thru Q15 in the anode driving circuit or the unlighted LED.
10. In the last portion of the displays test, the microcomputer lights each segment of the two displays and the UNSTABLE SIGNATURE, COMPARE ERROR and LOOPING LEDs. This

test first lights segments a, b, c, d, e, f, g, then the decimal point. When segment g lights, the UNSTABLE SIGNATURE LED lights. When the decimal point segments light, the COMPARE ERROR LED lights. When segment f lights, the LOOPING LED lights. Any failure to light indicates a failure of data latch C1 or drivers Q1 thru Q8 of the unlighted LED.

11. The switches test is the last programmed test. It immediately follows the displays test and is activated by pressing either the ADDRESS INCR or DATA SET pushbutton. When this test is entered, a "7." (seven plus decimal point) or "E" is displayed in all digits of the ADDRESS/SIGNATURE and DATA displays. If the position of any of the switches connected to the microcomputer inputs is changed, the displayed number changes from "7." to "E" or vice versa. When "7." is displayed, the COMPARE ERROR LED is lighted. When "E" is displayed, both UNSTABLE SIGNATURE and LOOPING LEDs are lighted. Any switch failing to change the displayed digit indicates the failure of either the switch or multiplexer B2. The following switches are tested:

All keypad switches
R/$\overline{W}$ MODE
R/$\overline{W}$
ERROR DATA DISPLAY
BYTES
DBUS SOURCE
TESTER MODE

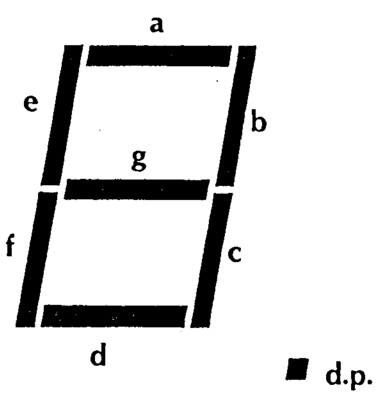


Figure 7.1 LED Segments

8 CAT Box Switch Setting Summary

8.1 Data Probe Switches and Displays

Displays-DATA LEDs

1. 0-indicates a digital low
2. 1-indicates a digital high
3. PULSE-indicates a pulse or pulses have been detected.

Switches-PULSE MODE

1. UNLATCHED-The PULSE LED lights only when pulses are being read.
2. LATCHED-The PULSE LED lights up and remains on after the first pulse is detected. The pulse can be a negative or positive going pulse.
3. RESET-This position is used with the LATCHED position. When the switch is momentarily toggled to RESET, the PULSE LED is turned off. The next PULSE can then be detected in the LATCHED mode.

8.2 Signature Analysis Control Switches

The TESTER MODE switch must be set to *SIG* to perform signature analysis.

Signatures are read from the ADDRESS/SIGNATURE display.

The START switch chooses between the rising edge or the falling edge of the starting signal.

The STOP switch chooses between the rising or falling edge of the stopping signal.

The CLOCK switch chooses between the rising or falling edge of the clocking signal.

The START, STOP and CLOCK switches should be set according to the signature analysis test set-up included with recent games.

The UNSTABLE SIGNATURE LED indicates the CAT Box cannot get a single repeatable signature. This can be caused by failing game board circuitry or by an improper test set-up. If this LED lights, check your test set-up before replacing any game components.

The GATE LED lights when a signature is taken. For every signature cycle, as defined by START and STOP, the GATE LED will light momentarily.

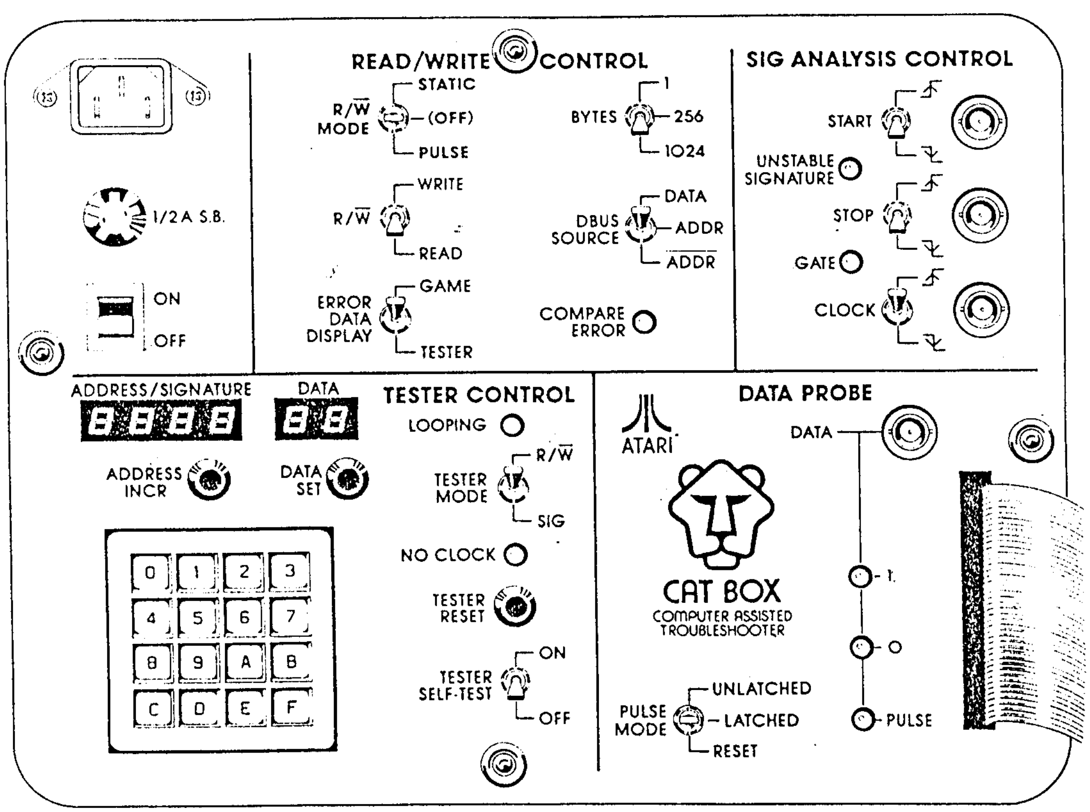


Figure 8.1 The CAT Box Control Panel

8.3 TESTER CONTROL Switches and Displays

The Tester Control section of the CAT Box is used in conjunction with the Signature Analysis Control and Read/Write Control sections. The switches and displays of the Tester Control are defined in the following paragraphs.

The TESTER SELF-TEST switch, when set to ON, causes the CAT Box to enter the self-test program. For information about the self-test, refer to the Self-Test Section of this manual. When set to OFF, the CAT Box operates in the Read/Write Control or Signature Analysis Control mode as selected by the TESTER MODE switch. The Data Probe is always active, no matter where the TESTER SELF-TEST switch is set.

The TESTER RESET switch causes the microcomputer of the CAT Box to go to the starting position of its program. Often, the CAT Box can "lock up". This usually happens during the CAT Box preliminary set-up. Pressing TESTER RESET restores the CAT Box to proper operation.

The NO CLOCK LED lights when the 50-pin connector is connected, but there is no clock coming from the game board. If this happens, you should check the preliminary set-up or the game board clock circuit.

The TESTER MODE switch, when set to R/$\overline{W}$, activates the Read/Write Control section of the CAT Box. When set to SIG, the Signature Analysis Control section of the CAT Box is activated. The Data Probe is always active, no matter where the TESTER MODE switch is set.

The keypad has two functions: keying in an address, or keying in data. To use the keypad for entering either an address or data, the R/$\overline{W}$ MODE switch must be set to (OFF). The use of the keypad is defined as follows:

ADDRESS — To enter an address, press the keys for the four-digit address. The ADDRESS/SIGNATURE display immediately displays each digit of the address. The left digit represents A15 through A12. The second digit from the left represents A11 through A8. The third digit from the left represents A7 through A4. The right digit represents A3 thru A0.

DATA — To enter data, first press the DATA SET pushbutton, then press the keys for the two-digit data. The DATA display immediately displays the data. The left digit represents D7 through D4; the right digit represents D3 through D0.

Pressing the ADDRESS INCR switch increments the ADDRESS/SIGNATURE display address one address each time it is pressed. To increment the address, the R/$\overline{W}$ MODE switch must be set to (OFF).

Pressing the DATA SET switch enables you to enter a new byte of data with the keypad. To enter new data, the R/$\overline{W}$ MODE switch must be set to (OFF).

The ADDRESS/SIGNATURE display has two functions, depending on the position of the TESTER MODE switch. When the switch is set to R/$\overline{W}$, and the R/$\overline{W}$ MODE switch is set to (OFF), the addresses keyed into the keypad are displayed. When the TESTER MODE switch is set to the SIG position, the signatures read by the Signature Analysis Control are displayed. The digits of the ADDRESS/SIGNATURE display for the two functions are defined as follows:

ADDRESS: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A., b., C., d., E., and F.
SIGNATURE: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, C, F, H, P, and U.

The DATA display shows the data entered into the keypad when the R/$\overline{W}$ MODE switch is set to (OFF) and after the DATA SET pushbutton is pressed. The digits of the DATA display are as follows: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A., b., C., d., E., and F.

The LOOPING LED indicates that the CAT Box is performing a continuous test operation, such as continuously reading or writing to an address or addresses.

8.4 READ/WRITE CONTROL Switches and Display

The TESTER MODE switch must be set to $R/\overline{W}$ to perform read/write functions.

The DBUS SOURCE switch determines what data will be written to an address or addresses. The three positions are defined as follows:

- DATA — In this position, the DATA display data is written to the circuit under test. (You can change the data in the DATA display by pressing *DATA SET* and entering the data on the keyboard.) This positon is used when writing either to RAM or to a specific output of the circuit under test.
- ADDR — This position is used only when testing RAM. When writing or reading, the CAT Box sets the data equal to the rightmost 2 digits of the current address.
  Example: At address 0357, data is 57.
- ADDR — This position is used only when testing RAM. When writing or reading, the CAT Box sets data equal to the 1's complement of the least significant byte of the current address.
  Example: At address 0357, data is A8.

The BYTES switch determines the number of consecutive addresses to be written to or read from. The three positions are described as follows:

- 1 — In this position, the DATA display data is written to the ADDRESS/SIGNATURE address of the circuit under test. It is used for writing or reading the RAM, or writing to a specific output of the circuit under test.
- 256 — In this position, 256 bytes of data are written to or read from 256 consecutive addresses, beginning with the ADDRESS/SIGNATURE display address. It is used for writing to or reading from the RAM.
- 1024 — In this position, 1024 bytes of data are written to or read from 1024 consecutive addresses, beginning with the ADDRESS/SIGNATURE display address. It is used for writing to or reading from the RAM.

The ERROR DATA DISPLAY switch is active only if the COMPARE ERROR LED lights. The lighting of the COMPARE ERROR LED is an indication that the data the CAT Box is reading differs from the data that it is comparing to. If the DBUS SOURCE switch is set to DATA, the CAT Box compares the data being read to the data of the DATA display. If the DBUS SOURCE switch is set to ADDR, the CAT Box compares the data to the least-significant byte of the address beginning with the ADDRESS/SIGNATURE display address. If the DBUS SOURCE switch is set to $\overline{ADDR}$, the CAT Box compares the data being read to the inverse of the least-significant byte of the address beginning with the ADDRESS/SIGNATURE display address. When this error occurs, the positions of the ERROR DATA DISPLAY switch are as follows:

- GAME — In this position, the data shown in the DATA display is the data being read from the data bus from the circuit under test at the address shown in the ADDRESS/SIGNATURE display.
- TESTER — In this position, the data shown in the DATA display is the data that was written to the circuit under test at the address shown in the ADDRESS/SIGNATURE display.

The $R/\overline{W}$ switch enables you to write to or read from the circuit under test. This switch is used in conjunction with DBUS SOURCE, BYTES, and $R/\overline{W}$ MODE switches. The positions of this switch are defined as follows:

- WRITE — When set to WRITE, the CAT Box is set to write the data as defined by the BYTES and DBUS SOURCE switches at, or starting at, the ADDRESS/SIGNATURE display address. However, the write operation does not occur until the $R/\overline{W}$ MODE switch is set to STATIC or PULSE.
- READ — When set to READ, the CAT Box is set to read the data as defined by the BYTES and DBUS SOURCE switches at, or starting at, the ADDRESS/SIGNATURE display address. However, read operation does not occur until the $R/\overline{W}$ MODE switch is set to STATIC or PULSE.

The $R/\overline{W}$ MODE switch is the "go" switch for read or write operations. It is used in conjunction with $R/\overline{W}$ BYTES, and DBUS SOURCE switches. The positions of the $R/\overline{W}$ MODE switch are defined as follows:

- (OFF) — In this position, the desired address or data may be keyed into the CAT Box via the hexadecimal keypad.
- STATIC — In this position one operation of read or write is performed and the bus is held in this position continuously. The address and data buses are held in non-pulsing logic states. This position is useful for writing to single addresses only.
- PULSE — In this position, an operation of read or write is performed repeatedly. When writing to or reading from RAM with the BYTES switch set to *256* or *1024*, the CAT Box reads or writes all locations repetitively.

9 CAT Box Specifications

Table 9.1 Data Probe Specifications

Maximum Load:		V_{in} = .4 V I_{source} = .8 mA
		V_{in} = 2.7 V I_{sink} = 44 uA
		Capacitance = 90 pF
Logic 0 Indicated:		Less than 1 VDC nominal
Logic 1 Indicated:		Greater than 2 VDC nominal
Input Protection:		± 25 VDC
Pulse Mode:	Latched:	Shortest pulse detected = 25 ns = 40 MHz
	Unlatched:	Shortest pulse detected = 40 ns = 25 MHz
		Pulse Stretch = 55 ms nominal
	Trigger Level:	High going: Greater than or = 1.9 V
		Low going: Less than-or = .5 V

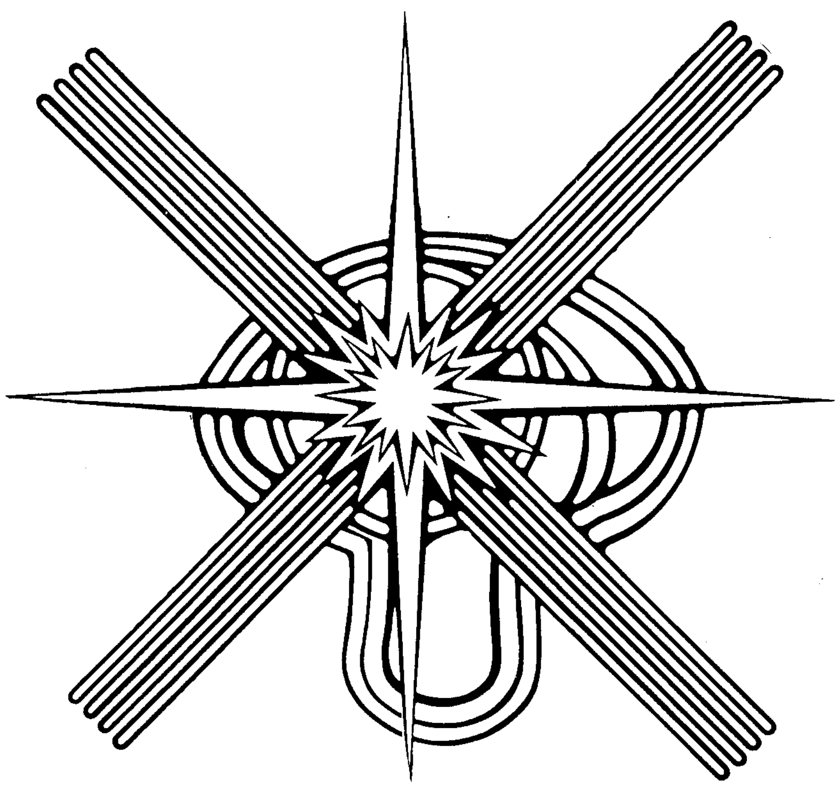
Table 9.2 Signature Analysis Specifications

Maximum Loading of START, STOP, and CLOCK:	V_{in} = .4 V	I_{source} = .8 mA
	V_{in} = 2.7 V	I_{sink} = 44 uA
	Capacitance = 90 pF	
START, STOP, and CLOCK Input Protection:	± 25 VDC	
Maximum CLOCK Input Frequency:	10 MHz	
Data Setup Time Before Selected CLOCK Edge:	25 ns	
Data Hold Time After Selected CLOCK Edge:	13 ns	
Minimum Time Between Selected START Edge and First Selected CLOCK Edge:	24 ns	
Minimum Time Between Selected START Edge and Previous CLOCK Edge:	0 ns	
Minimum Time Between Selected STOP Edge and Following CLOCK Edge:	24 ns	
Minimum Time Between Selected STOP Edge and Previous Selected CLOCK Edge:	0 ns	
Minimum Pulse Duration for START and STOP:	50 ns	
Minimum Pulse Duration for CLOCK:	50 ns	
Minimum Time Between Selected STOP Edge and Next Selected START Edge*:	0 ns	

*CAT Box does not sample every signature unless STOP to START is greater than 2 ms.

Table 9.3 READ/WRITE Specifications

Maximum Speed of Input Clock (Phase 2):		1.79 MHz
Maximum Drive Capability of Address Bus:	High:	I_{source} = approx. 2.6 mA
	Low:	I_{sink} = approx. 24 mA
Maximum Drive Capability of Data Bus:	High:	I_{source} = 2.6 mA
	Low:	I_{sink} = 24 mA
Maximum Loading of Data Bus:	High	I_{source} = 20 uA
	Low:	I_{sink} = 200 uA
Maximum Input Clock Loading:	High:	I_{source} = 30 uA
	Low:	I_{sink} = 30 uA
Maximum Drive of R/$\overline{W}$:	High:	I_{source} = 380 uA
	Low:	I_{sink} = 7.6 mA
Loading on BA and VMA (6800 only):	10 K to +5 V	



10 CAT Box PCB Assemblies

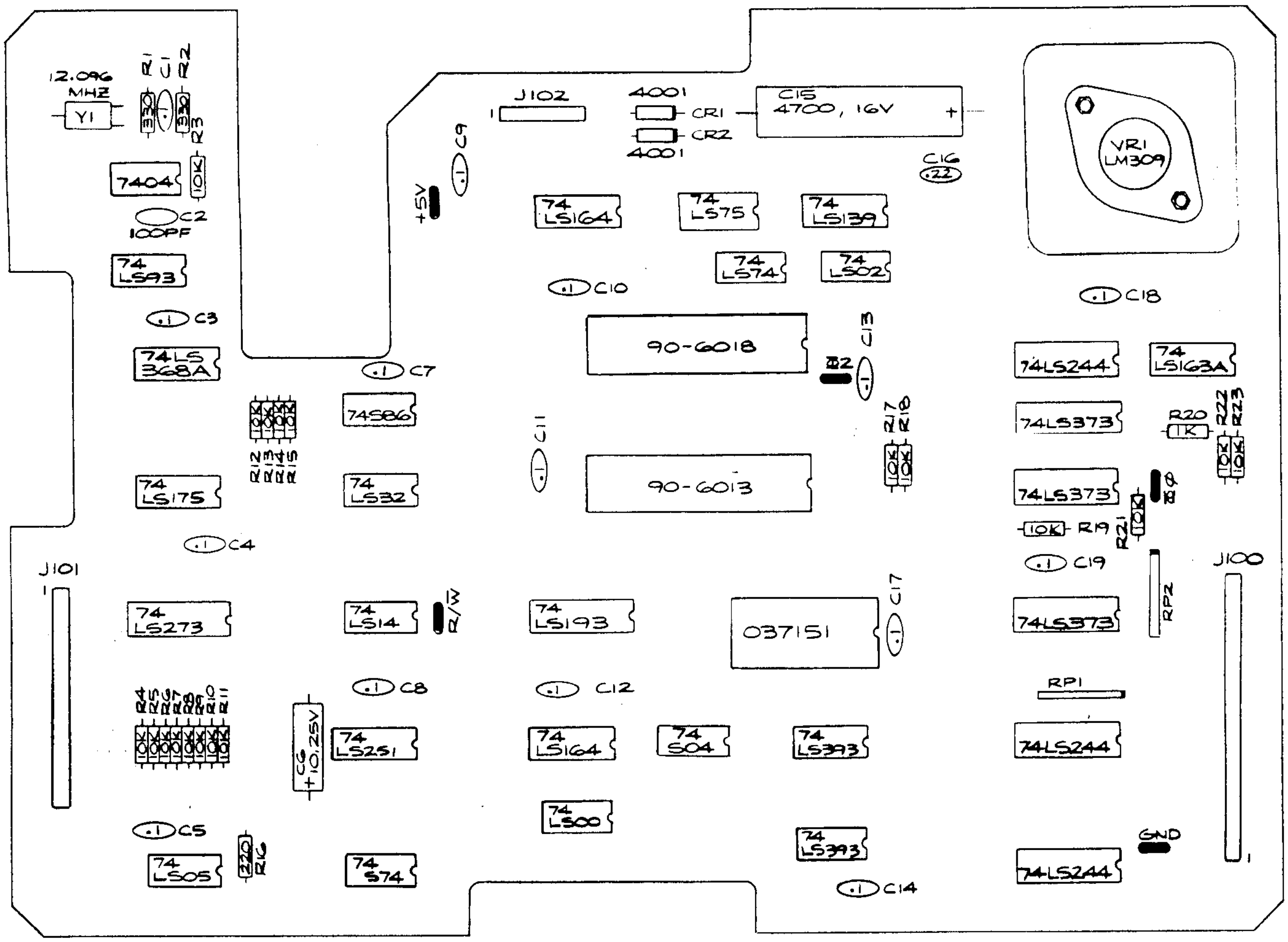


Figure 10.1 Logic Board Layout

Figure 10.1 CAT Box Logic Board Assembly Parts List

Part No.	*Description (Reference Designations and Locations in Bold)*
19-007	10K Resistor Network **(RP1, 2)**
24-160478	4700 μf Electrolytic Fixed Axial-Lead 16V Capacitor **(C15)**
24-250106	10 μf Aluminum Electrolytic Fixed Axial-Lead 25V Capacitor **(C6)**
27-250104	.1 μf Ceramic-Disc Radial-Lead 25V Capacitor **(C1)**
29-088	.1 μf Ceramic-Disc Radial-Lead 25V Capacitor **(C3-5, 7-14, 17-19)**
31-1N4001	Type-1N4001 50V Switching Diode **(CR1, 2)**
37-LM309K	Type-LM309K Voltage Regulator **(VR1)**
37-7404	Type-7404 Hex Inverter, Integrated Circuit **(H1)**
37-74LS00	Type-74LS00 Quad 2-Input Nand Gate, Integrated Circuit **(A3)**
37-74LS02	Type-74LS02 Quad 2-Input Positive Nor Gate, Integrated Circuit **(E/F5)**
37-74LS14	Type-74LS14 Hex Inverter, Integrated Circuit **(C2)**
37-74LS32	Type-74LS32 Quad 2-Input Or Gate, Integrated Circuit **(D2)**
37-74LS74	Type-74LS74 Dual 'D' J-K Flip-Flop, Integrated Circuit **(E/F4)**
37-74LS75	Type-74LS75 Dual 2-Bit Latch, Integrated Circuit **(F4)**
37-74LS93	Type-74LS93 4-Bit Binary Ripple Counter, Integrated Circuit **(F1)**
37-74LS139	Type-74LS139 Dual 1-of-4 Decoder/Demultiplexer, Integrated Circuit **(F5)**
37-74LS163A	Type-74LS163A 4-Bit Binary Counter, Integrated Circuit **(E7)**
37-74LS164	Type-74LS164 8-Bit Shift Register, Integrated Circuit **(B3, F3)**
37-74LS175	Type-74LS175 Quad 'D' Flip-Flop, Integrated Circuit **(D1)**
37-74LS193	Type-74LS193 4-Bit Up/Down Counter, Integrated Circuit **(C3)**
37-74LS244	Type-74LS244 3-State Octal Buffer, Integrated Circuit **(A6, B6, E6)**
37-74LS251	Type-74LS251 8-Input Multiplexer, Integrated Circuit **(B2)**
37-74LS273	Type-74LS273 Octal 'D' Flip-Flop, Integrated Circuit **(C1)**
37-74LS373	Type-74LS373 3-State Octal Latch, Integrated Circuit **(C6, D6, D/E6)**
37-74LS393	Type-74LS393 Dual 4-Bit Binary Ripple Counter, Integrated Circuit **(A5, B5)**
37-74S04	Type-74S04 Hex Inverter, Integrated Circuit **(B4)**
37-74S74	Type-74S74 Dual 'D' Flip-Flop, Integrated Circuit **(A2)**
78-06005	Heat Sink
78-16005	Thermally Conductive Compound
79-42C24	24-Pin Medium-Insertion-Force Integrated Circuit Socket **(C5)**
79-42C40	40-Pin Medium-Insertion-Force Integrated Circuit Socket **(D4, E4)**
79-58096	5-Pin Connector **(J102)**
90-102	12.096, ±.005%, Crystal **(Y1)**
90-6013	Type-6502A Microprocessor, Integrated Circuit **(D4)**
90-6018	Type-6532A RAM I/O Timer, Integrated Circuit **(E4)**
020670-01	Test Point
037151-01	Read-Only Memory, 2Kx8 **(C5)**
110000-102	1K Ohm, ±5%, ¼W Resistor **(R20)**
110000-103	10K Ohm, ±5%, ¼W Resistor **(R3-15, 17-19, 21-23)**
110000-221	220 Ohm, ±5%, ¼W Resistor **(R16)**
110000-331	330 Ohm, ±5%, ¼W Resistor **(R1, 2)**
122004-224	.22 μf Ceramic-Disc Radial-Lead 25V Capacitor **(C16)**
128002-101	100 pf Radial-Lead Epoxy-Dipped 100V Mica Capacitor **(C2)**
137002-001	Type-74S86 Quad 2-Input Exclusive OR Gate, Integrated Circuit **(E2)**
137167-001	Type-74LS05 Open Collector Hex Inverter, Integrated Circuit **(A1)**
137168-001	Type-74LS368A Hex Inverter Buffer, Integrated Circuit **(E1)**
179021-040	40-Pin Connector **(J101)**
179022-050	50-Pin Connector **(J100)**

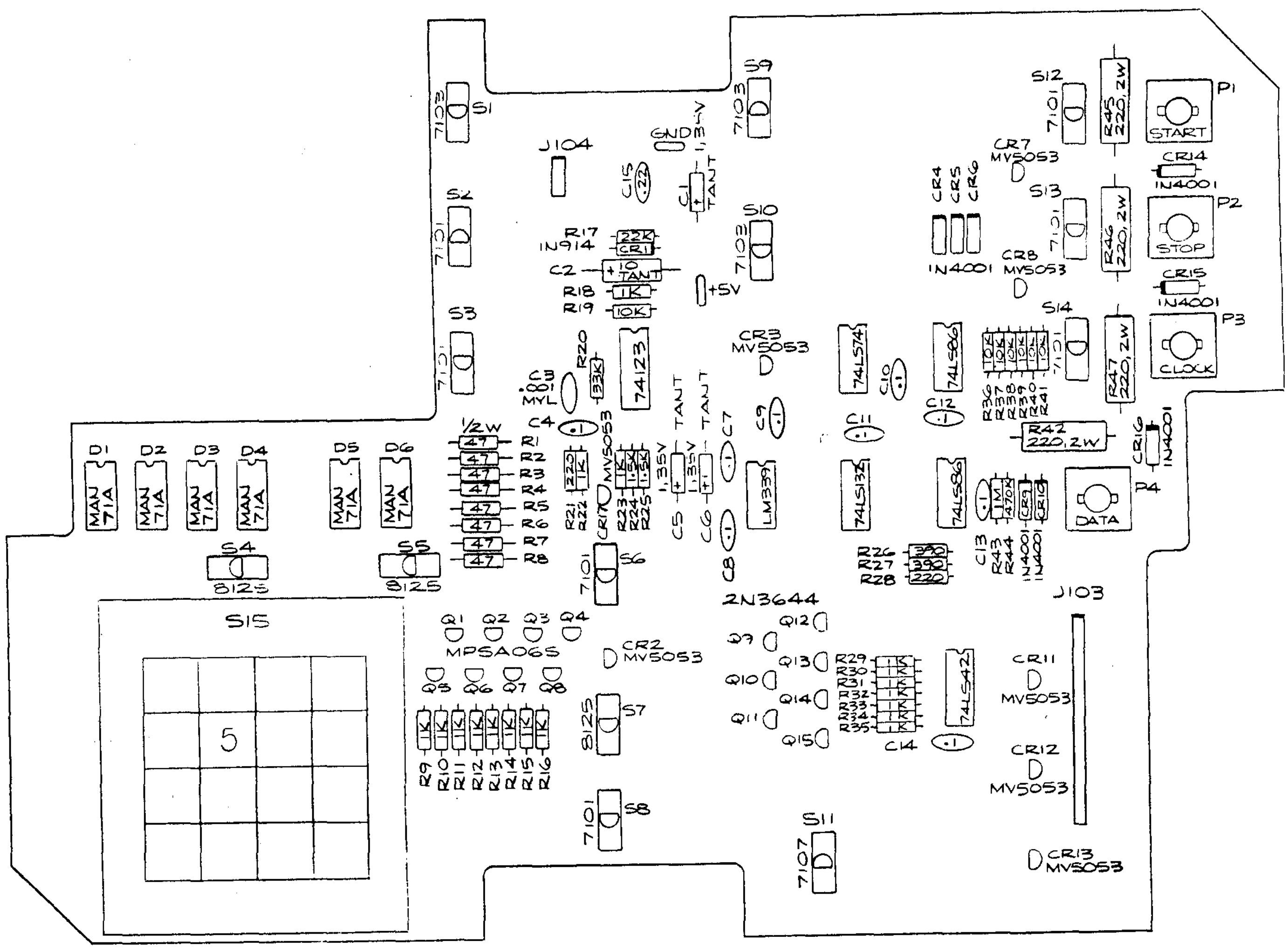


Figure 10.2 Switch Board Layout

Figure 10.2 CAT Box Switch Board Assembly Parts List

Part No.	*Description (Reference Designations and Locations in Bold)*
13-5221	220 Ohm, ±5%, 2W Resistor **(R42, 45-47)**
21-101102	.001 μf Mylar Fixed Radial-Lead 100V Capacitor **(C3)**
29-006	1 μf Tantalum Radial-Lead 35V Capacitor **(C1, 5, 6)**
29-046	10 μf Tantalum Axial-Lead 20V Capacitor **(C2)**
29-088	.1 μf Ceramic-Disc, Radial-Lead 25V Capacitor **(C4, 7-14)**
31-1N914	Type-1N914 75V Switching Diode **(CR1)**
31-1N4001	Type-1N4001 75V Switching Diode **(CR4-6, 9, 10, 14-16)**
33-2N3644	Type-2N3644 PNP Silicon Transistor **(Q9-15)**
34-MPSA06S	Type-MPSA06S NPN Silicon Transistor **(Q1-8)**
37-LM339	Type-LM339 Quad Comparator, Integrated Circuit **(A4)**
37-74LS42	Type-74LS42 BCD-To-Decimal Decoder, Integrated Circuit **(A7)**
37-74LS74	Type-74LS74 Dual "D" Flip-Flop, Integrated Circuit **(A2)**
37-74LS86	Type-74LS86 Quad 2-Input Exclusive-Or Gate, Integrated Circuit **(A3, 6)**
37-74LS132	Type-74LS132 Quad 2-Input Nand Schmitt Trigger, Integrated Circuit **(A5)**
38-MAN71A	Type-MAN71A LED **(D1-6)**
38-MV5053	Type-MV5053 LED **(CR2, 3, 7, 8, 11-13, 17)**
61-011C	SPDT Toggle Switch **(S2, 3, 6, 8, 12-14)**
79-42114	14-Pin Integrated Circuit Socket **(D1-6)**
020670-01	Test Point
110000-102	1K Ohm, ±5%, ¼W Resistor **(R9-16, 18, 22, 23, 29-35)**
110000-103	10K Ohm ±5%, ¼W Resistor **(R19, 36-41)**
110000-105	1 MegOhm, ±5%, ¼W Resistor **(R43)**
110000-152	1.5K Ohm, ±5%, ¼W Resistor **(R24, 25)**
110000-221	220 Ohm, ±5%, ¼W Resistor **(R21, 28)**
110000-223	22K Ohm, ±5%, ¼W Resistor **(R17)**
110000-333	33 Ohm, ±5%, ¼W Resistor **(R20)**
110000-391	390 Ohm, ±5%, ¼W Resistor **(R26, 27)**
110000-474	470K Ohm, ±5%, ¼W Resistor **(R44)**
110001-470	47 Ohm, ±5%, ½W Resistor **(R1-8)**
122004-224	.22 μf Ceramic-Disc 25V Radial-Lead Capacitor **(C15)**
137166-001	Type-74123 Dual Retriggerable Monostable Multivibrator, Integrated Circuit **(A1)**
160006-001	4×4 Keyboard **(S15)**
160007-001	SPDT Toggle Switch **(S1, 9, 10)**
160008-001	SPDT Toggle Switch **(S11)**
160009-001	SPST Push-Button Switch **(S4, 5, 7)**
178020-312	LED Support **(CR2, 3, 7, 8, 11-13, 17)**
179013-001	BNC Receptacle **(P1-4)**
179020-040	40-Pin Connector **(J103)**
179024-003	3-Pin Connector **(J104)**

Figure 10.3 CAT Box Final Assembly Parts List
A037162-01 A

Part No.	Description
A037102-01	Power Harness Assembly
A037103-01	40-Pin PCB Interconnect Assembly
A037104-01	50-Pin PCB Interconnect Assembly
CO-179	CAT Box Instruction Card *(Contains abbreviated instructions)*
TM-179	CAT Box Instruction and Service Manual
46-2010502	½ Amp. 250V, 3 AG Slow-Blow Glass Cartridge-Type Fuse
78-802001N	1 ¼-Inch Circuit-Board Support
79-4411001	Non-Indicating 3AG Cartridge-Type Fuse Post
021270-04	Red Display Overlay
036987-01	CAT Box Accessory Bag
037138-01	Control Panel with Graphics
150000-001	Power Cord
160010-001	SPDT On/Off Switch
178021-001	CAT Box Carrying Case
179025-001	Power Cord Receptacle
179040-224	Red Test Probe
179040-424	Yellow Test Probe
179040-524	Green Test Probe
179045-030	Pin Test Probe

11 CAT Box Schematics

MEMORY MAP

HEXA-DECIMAL ADDRESS	R/W	D7	D6	D5	D4	D3	D2	D1	D0	FUNCTION
0000-0007F	R/W	D	D	D	D	D	D	D	D	6532 (Timer, Signature)
0800-00FF	R/W	D	D	D	D	D	D	D	D	6532 (RAM)
2000	W								D	Game/Box Counter
2B00	W	D	D	D	D	D	D	D	D	Segment Select
3000	W	D	D	D						Digit Select
3000	W				D					1 = Sig. An. Enabled
3800	W									Sig. An. Reset
4000	R	D								1 = Address
4001	R	D								1 = Data
4002	R	D								1 = 1 Byte
4003	R	D								1 = 1K Byte
4004	R	D								Spare Input
4005	R	D								0 = Write 1 = Read
4006	R	D								1 = Self Test
4007	R	D								0 = Sig. An. Done
4008	R				D					1 = Game 0 = Tester
4008	R					D				1 = Address Incr.
4008	R						D			1 = Data Set
4008	R							D		1 = Sig. An. 0 = R/W
4010	R				D	D	D	D		3, 7, B, F
4020	R				D	D	D	D		2, 6, A, E
4040	R				D	D	D	D		1, 5, 9, D
4080	R				D	D	D	D		0, 4, 8, C
4100	R						D			1 = Static
4100	R							D		1 = Pulse
6000-67FF	R	D	D	D	D	D	D	D	D	Program ROM (2K)

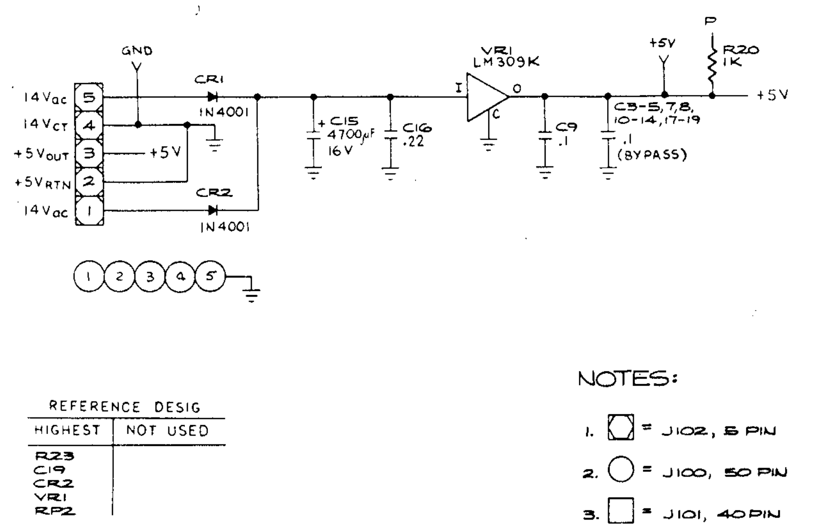


Figure 11.1 Logic Board

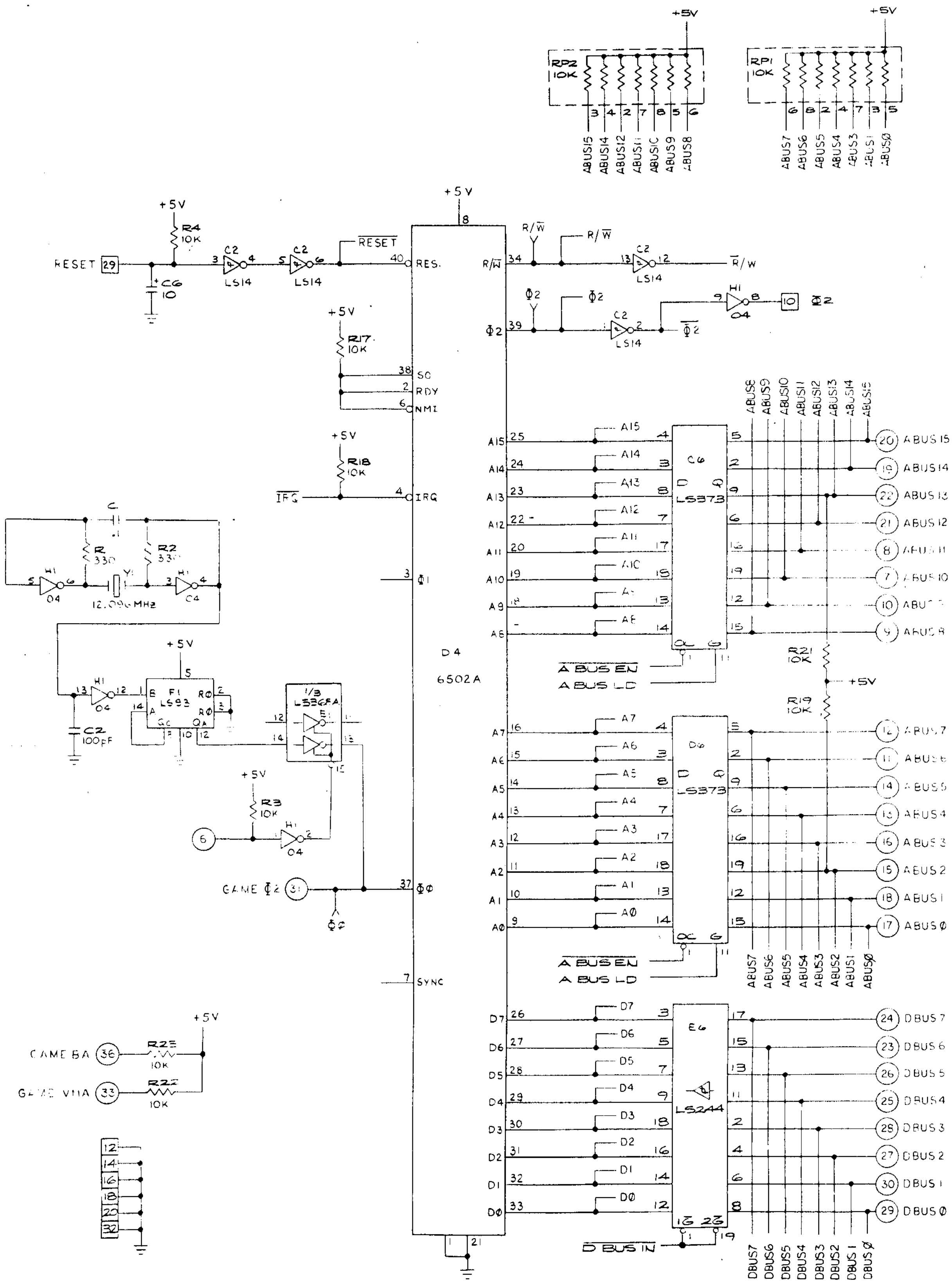


Figure 11.1 Logic Board, continued

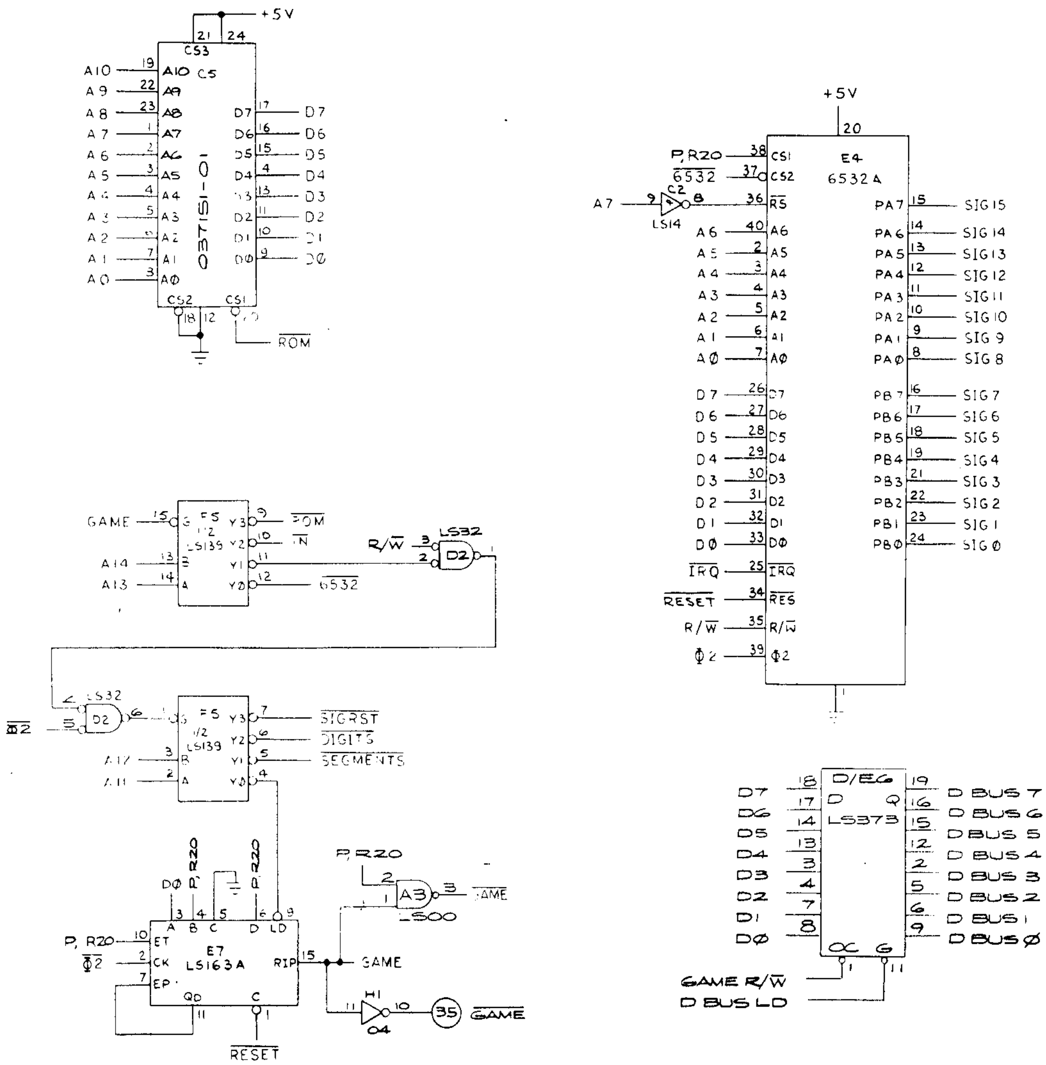


Figure 11.1 Logic Board, continued

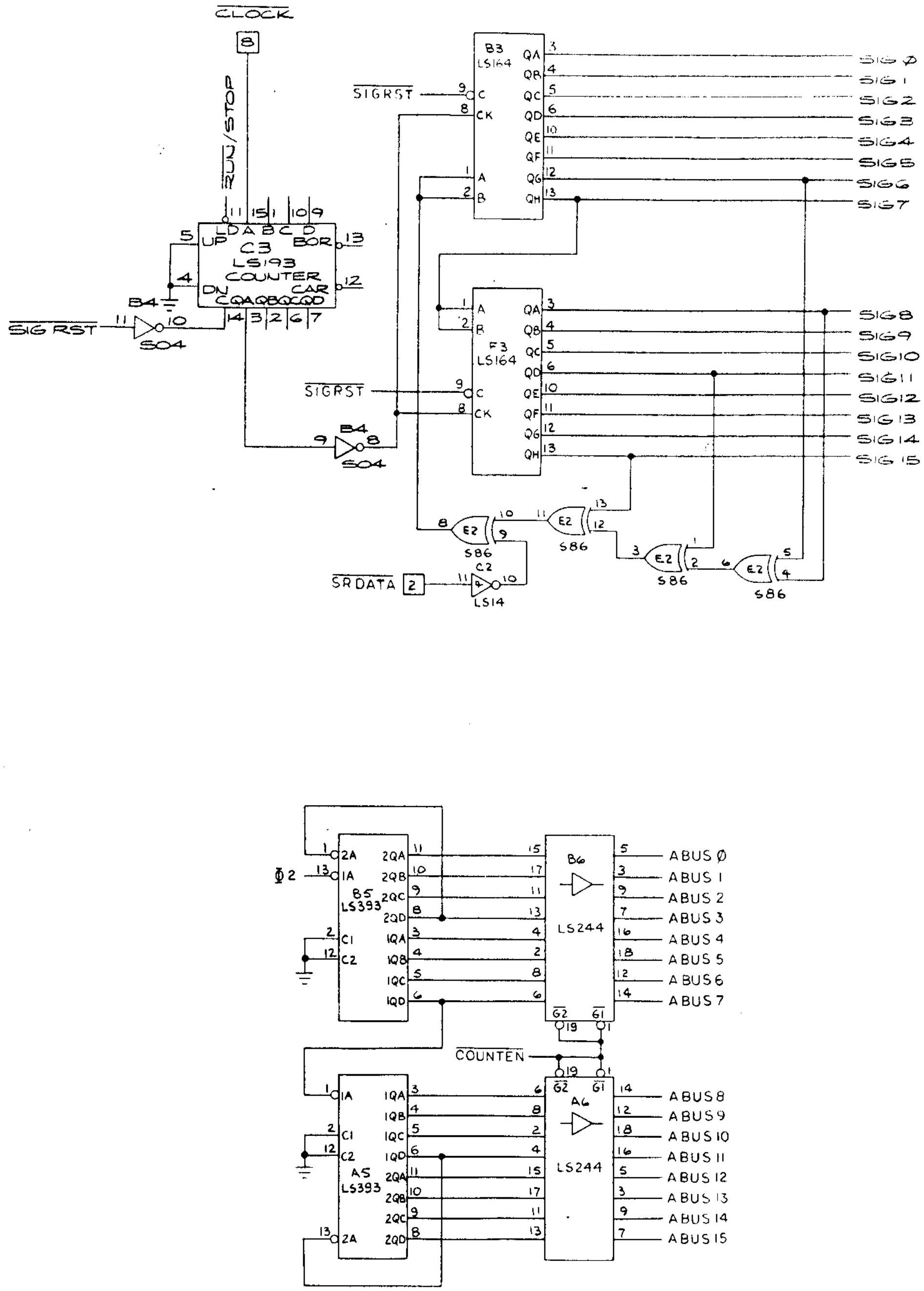


Figure 11.1 Logic Board, continued

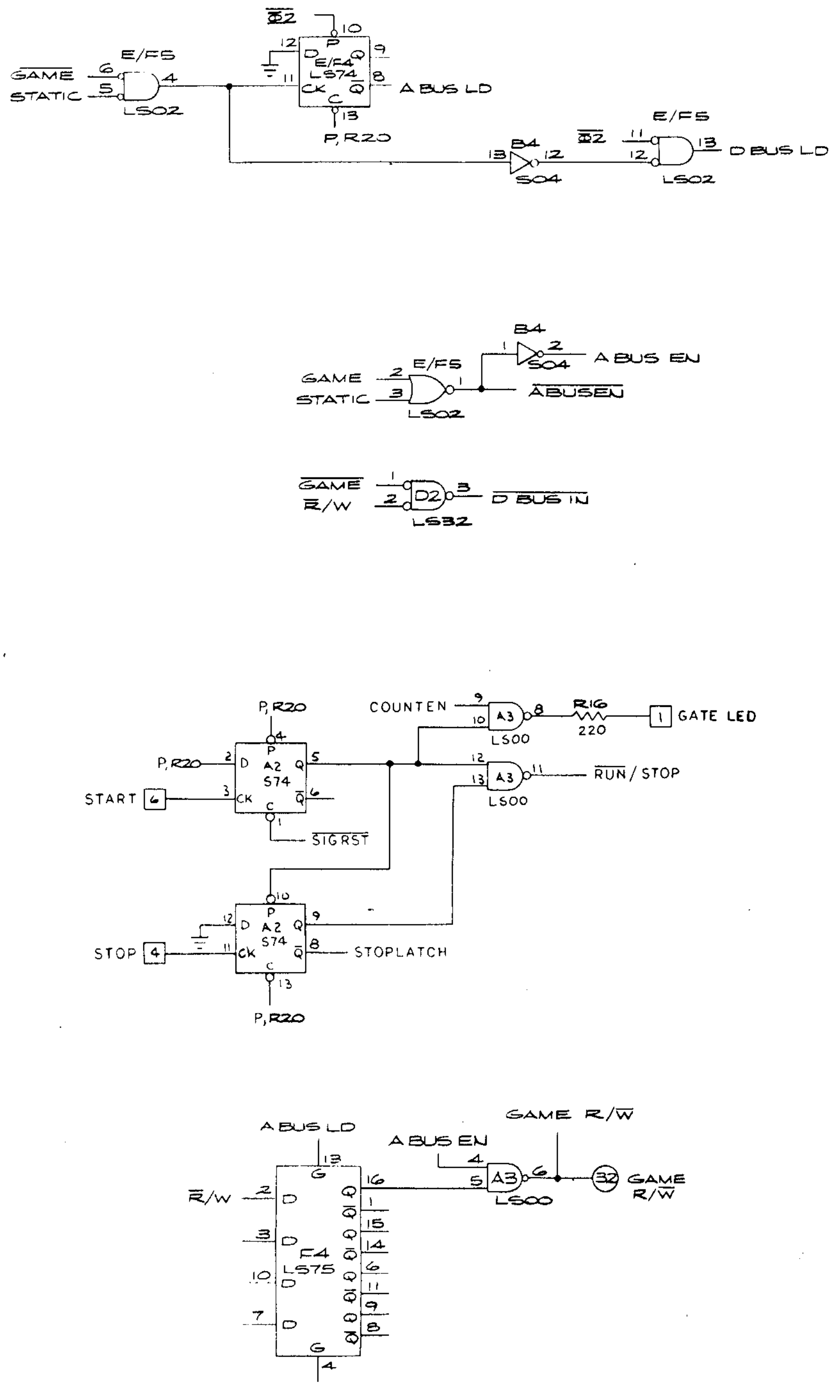


Figure 11.1 Logic Board, continued

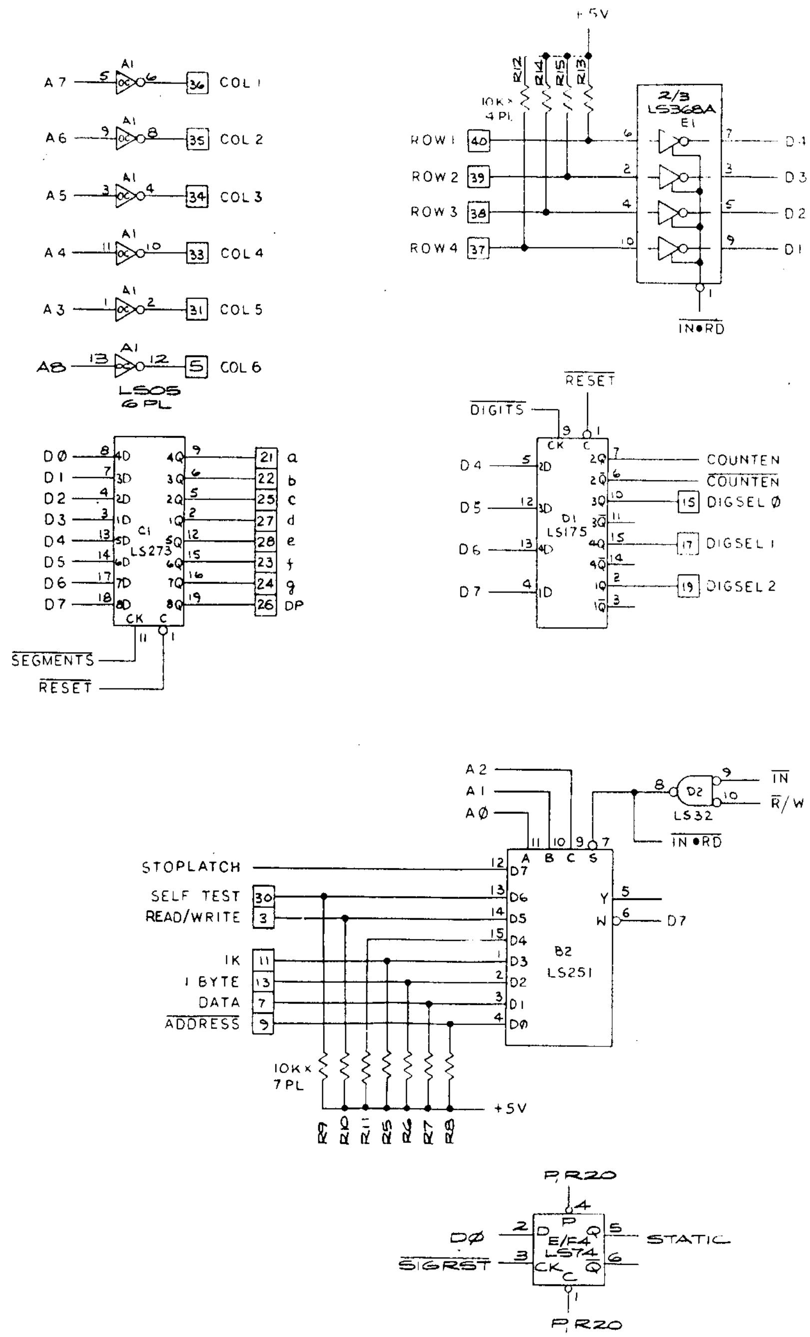


Figure 11.1 Logic Board, continued

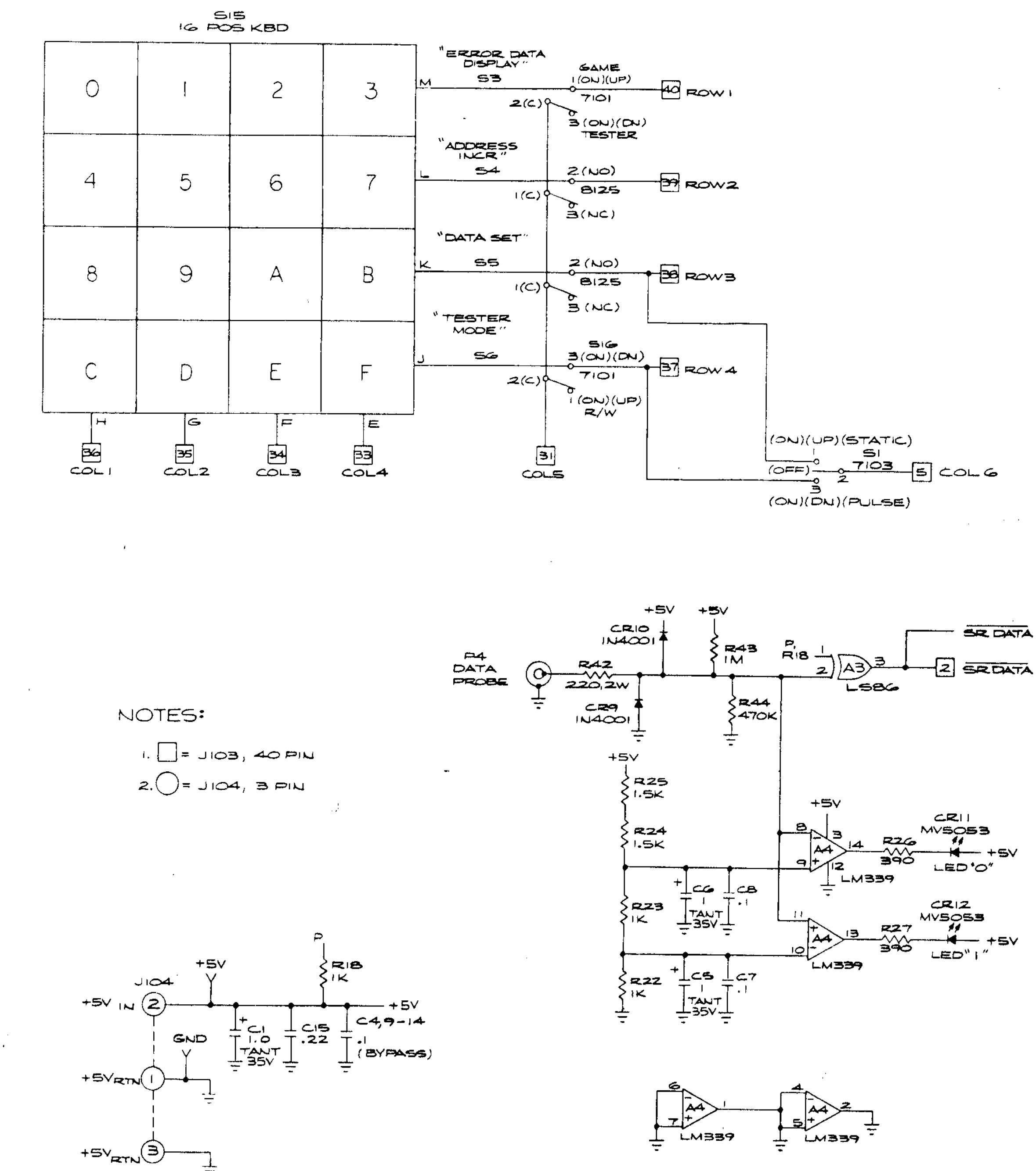


Figure 11.2 Switch Board

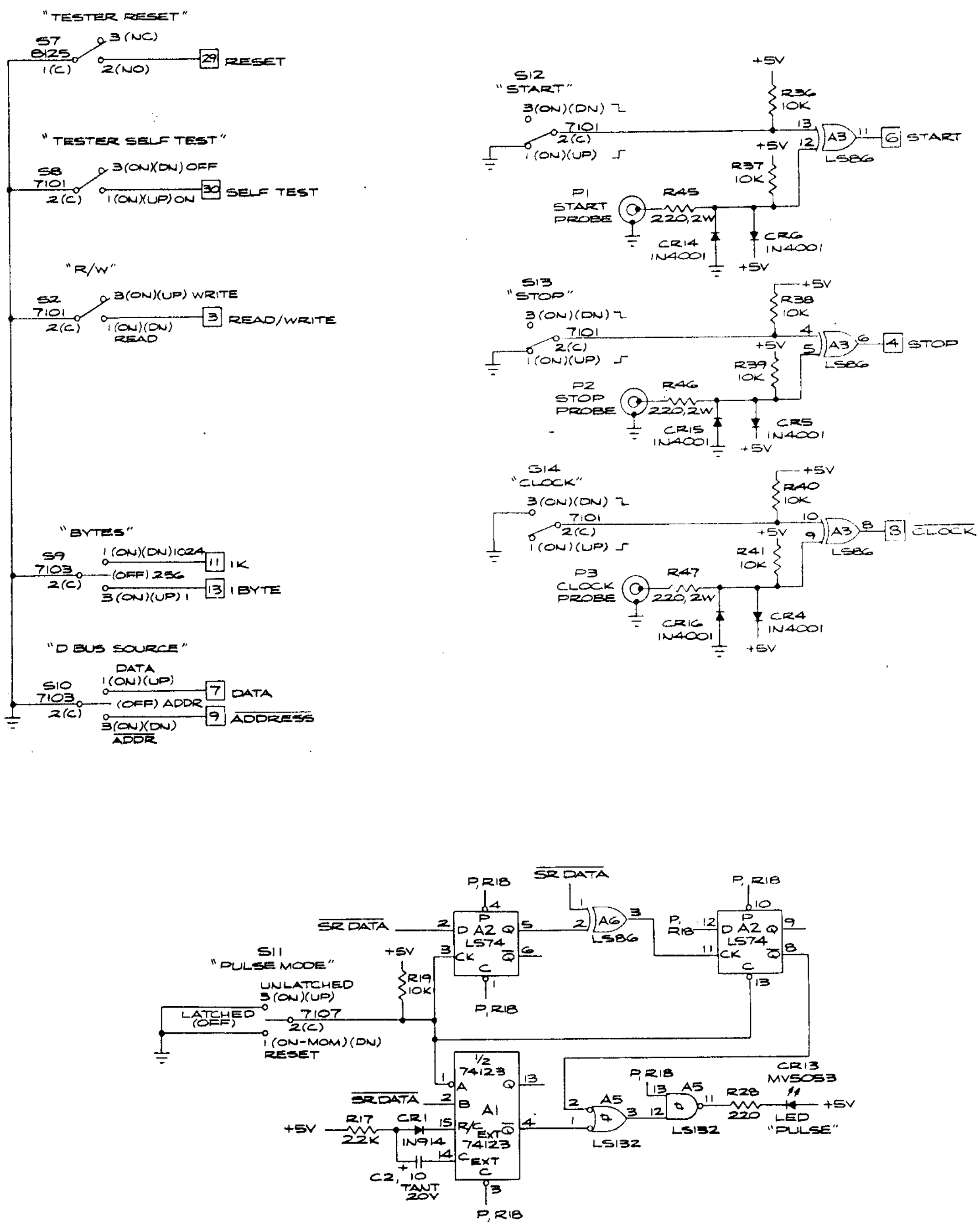


Figure 11.2 Switch Board, continued

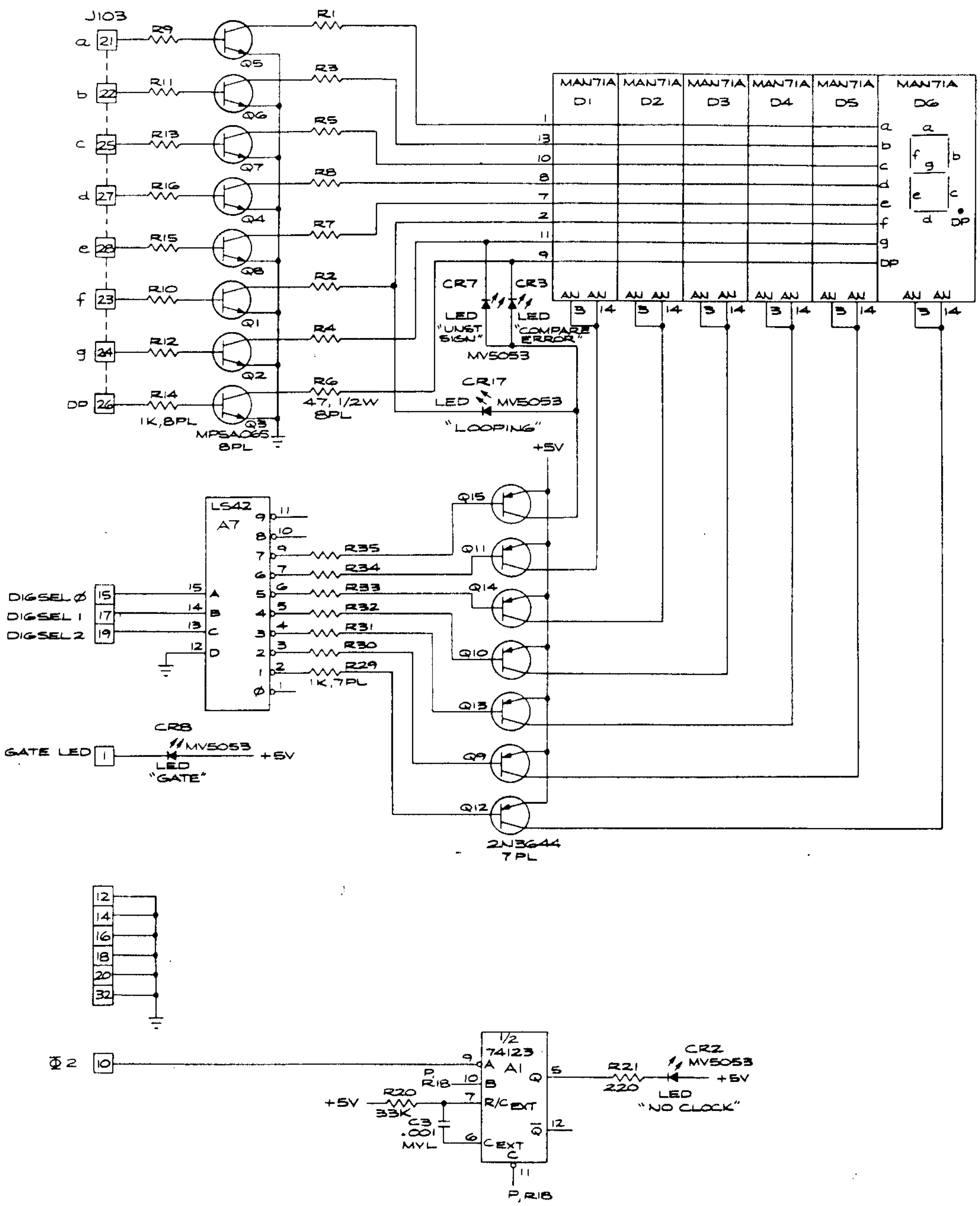


Figure 11.2 Switch Board, continued

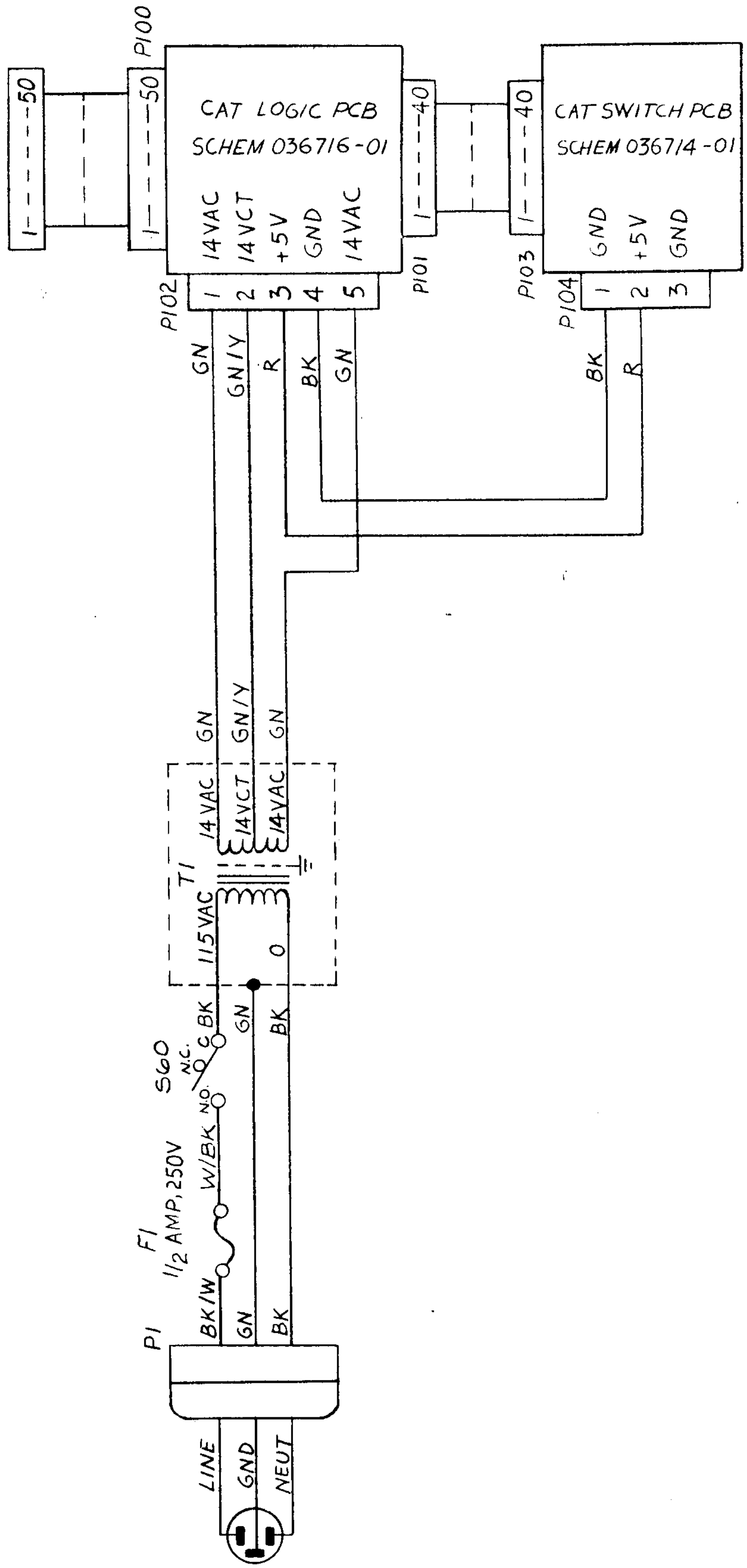


Figure 11.3 Wiring Diagram