SORCERER 2 TECHNICAL MANUAL

390 Java Drive
Sunnyvale, California 94086

SECOND EDITION
DECEMBER 1979

PRINTED IN U.S.A.

COMPCOLOR II TECHNICAL MANUAL

[illegible] Java Drive
Sunnyvale, California 94086

SECOND EDITION
DECEMBER 1979

PRINTED IN U.S.A.

SORCERER 2 TECHNICAL MANUAL

CONTENTS

ILLUSTRATIONS

TABLES

FOREWORD

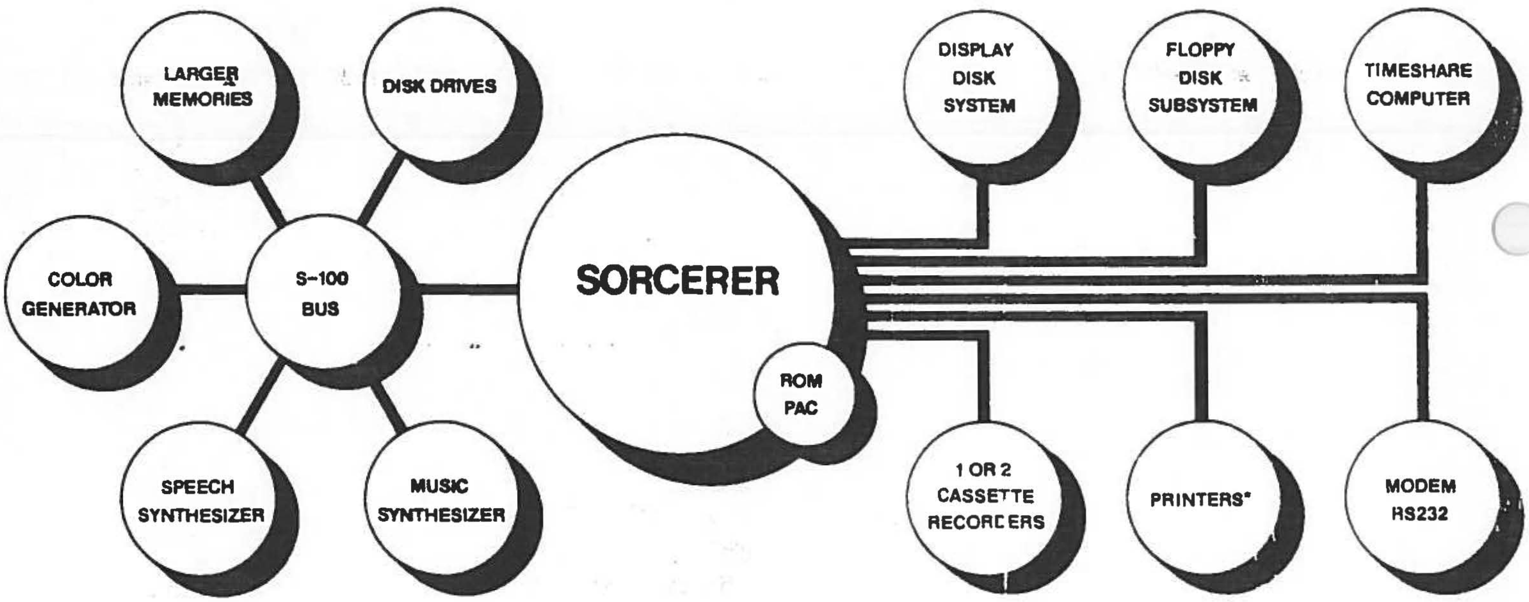
This is the manual for use with the Sorcerer 2. There is a silver label on the bottom of your Sorcerer that gives important information about your computer. The first five digits of the serial number give the date of manufacturer. The next several digits are specific to the individual unit, and then, if you have a Sorcerer 2, there are the letters II. Next comes the voltage designation. For example, serial number 10299 528 II 220V indicates a Sorcerer 2, manufactured on 10/29/79, unit number 528, of 220 volts. A serial number of 10299-529 110V indicates a Sorcerer 1, and you should have the manual whose Catalog Number is DP 5003.

Readers of this manual are referred to the Sorcerer's operating manual, A Guided Tour of Personal Computing, the Sorcerer Development PAC instruction manual, or any standard Z80 Assembly Language reference manual. Readers are also referred to the Sorcerer Software Manual (33-5018).

Hardware material in this manual is written for highly experienced technicians, although some of this information is useful to all Sorcerer owners. We assume the reader is as qualified as our own test and service personnel. We strongly recommend that owners not attempt to repair or modify their own units.

All service should be done by an authorized Sorcerer dealer; unauthorized service will void our warranty.

PART ONE
SOFTWARE



*SERIAL: RS 232
PARALLEL: CENTRONICS COMPATIBLE

MEMORY ADDRESSING AND ALLOCATION

> **NOTE**
>
> For more information about software, see the SORCERER SOFTWARE MANUAL (Exidy P/N DP5008).

ADDRESS, INPUT/OUTPUT PORT AND DATA NOTATION

The Sorcerer's Z80 CPU has sixteen address lines; every memory storage location has a sixteen digit binary number as its address. This means that the Sorcerer will recognize up to 65536 different memory addresses. (65535 is the largest number which can be written in no more than sixteen binary digits; but we start numbering the addresses at 0, instead of 1, so the total number is 65536).

It is more convenient to refer to these addresses in hexadecimal (base 16) notation than in binary (base 2) or decimal (base 10) notation. Any binary number with sixteen or fewer digits can be written as a hexadecimal number with four or fewer digits. Whenever we refer to a memory address we will always use a four digit hexadecimal number. To avoid confusion, we write the letter H at the end of the number to indicate hexadecimal notation. If the address is lower than 1000H, we add zeros on the left to make four digits total. (Example: the second address in memory is 0001H.)

The Z80 has eight data lines--one for each bit of storage in a memory location. Every memory location contains a number from 0 to 255. Eight bits constitute one byte. (255 is the largest number which can be written in eight or fewer binary digits.) Again we use hexadecimal notation for the memory contents; we write each such number as two hexadecimal digits, followed by an H. If the number is less than 10H, we add a zero on the left to make two digits total. (Example: we write 12 decimal as 0CH.)

> **NOTE**
>
> If the Z80 is instructed to read a memory address which is not connected to any RAM or ROM, it usually assumes the data is FFH.

Similarly, the first eight address lines can designate an input/output port (I/O port). Since these eight lines can be set to any number from 0 to 255, there are 256 I/O ports. We number them in hexadecimal, 00H to FFH.

SORCERER MEMORY MAP

Figure 1 shows the Sorcerer's memory allocations. Column A is the standard configuration (16K internal RAM and an 8K ROM PAC); the diagram is not drawn to scale. Column B is the same as Column A, but redrawn to approximate scale.

Columns C and D show alternate configurations. The lower portions show the addresses of internal RAM in the 32K and 48K Sorcerers, while the upper portions show the addresses of the 4K and 16K ROM PACs.

The unassigned addresses between the top of internal RAM and the bottom of the ROM PAC can be given to the S-100 Expansion Unit. If the ROM PAC is unplugged, its address space is also available to the S-100 Unit.

The Monitor stack, consisting of the Monitor RAM and the stack proper, is shown at the top of the internal RAM, the position it usually takes at power-on or reset (see Relocating the Monitor Stack, for details). But, note that if a block of expansion memory is assigned immediately above internal RAM, the stack will go to the top of that block.

Example:

In the 16K Sorcerer at power-on or reset, the Monitor stack occupies addresses 3F50H to 3FFFH. If 4K of memory (1000H addresses) is added to the Expansion Unit and assigned addresses 4000H through 4FFFH, the Monitor stack will occupy 4F50H through 4FFFH at power-on. However, if the new memory is assigned to 5000H through 5FFFH instead, the stack will remain at 3F50H to 3FFFH.

Screen RAM

Every charcter (alphanumeric, graphic or user-defined) is printed on the screen as an 8 x 8 array of dots. Each dot can be either ON (a white spot on the screen) or OFF (a dark spot). The exact shape of the character depends on which dots are turned on, and which are turned off.

Each row of the charcter is stored in the Sorcerer's character generator, in a separate memory address, with each dot of the row stored as one bit of that address. A 0 bit means OFF (black) and a 1 bit means ON (white).

To write a character onto the Sorcerer's screen, put its ASCII number into the screen RAM. The exact address you use determines where the character appears on the screen. The ASCII number directs the Sorcerer to eight successive addresses in the RAM or ROM character generator. These addresses store the eight lines of the character's dot matrix.

Each text line on screen is 64 characters long (40H) and there are 30 lines in all (1EH). The first address in screen RAM (F080H) is for the upper left corner of the screen. The next address (F081H) is for the second column in the first line, and so on to the end of the line (F0BFH). The pattern continues with the first column on the second line (F0C0H) and so forth. The last address (F7FFH) is for the lower right corner of the screen.

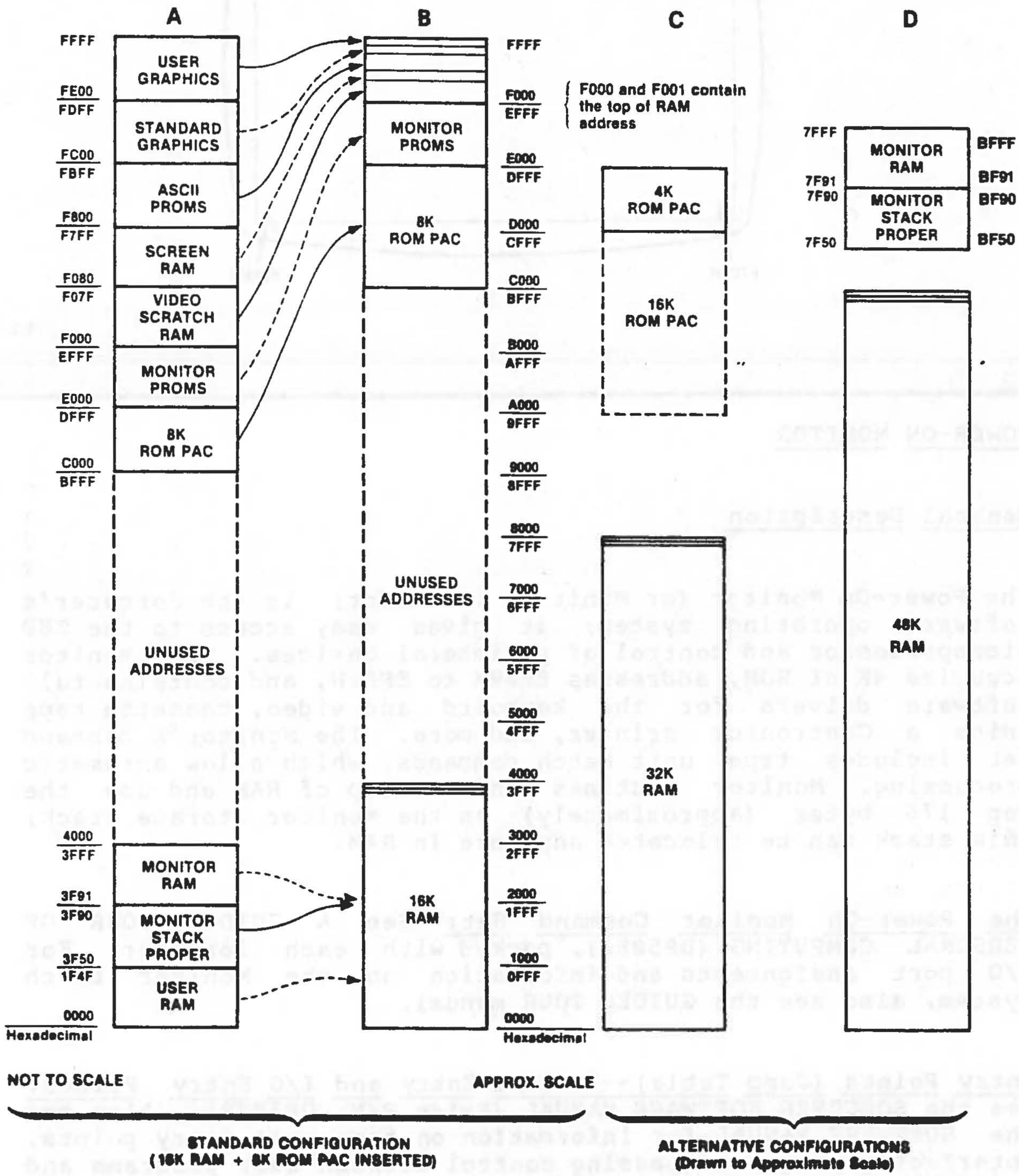
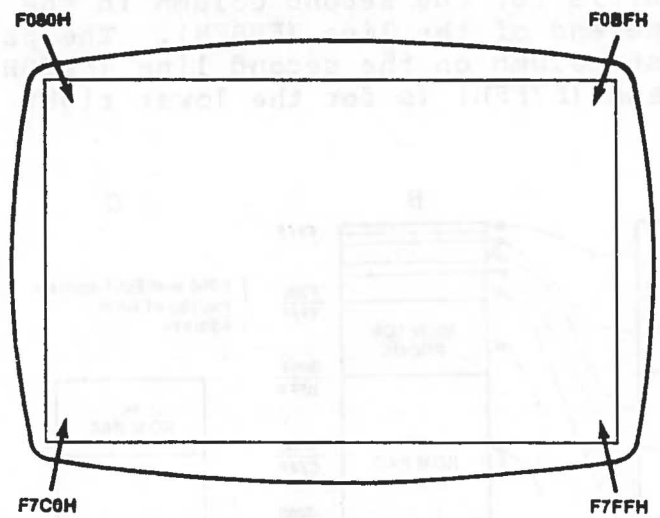


Figure 1 Sorcerer Memory Map

Figure 2 Screen RAM Addresses for the Corners of the Screen



POWER-ON MONITOR

General Description

The Power-On Monitor (or Monitor, for short) is the Sorcerer's software operating system; it gives easy access to the Z80 microprocessor and control of peripheral devices. The Monitor occupies 4K of ROM, addresses E000H to EFFFH, and contains full software drivers for the keyboard and video, cassette tape units a Centronics printer, and more. The Monitor's command set includes tape unit batch commands, which allow automatic processing. Monitor routines find the top of RAM and use the top 176 bytes (approximately) as the Monitor storage stack; this stack can be relocated anywhere in RAM.

The Power-On Monitor Command Set: See A GUIDED TOUR OF PERSONAL COMPUTING (DP5001), packed with each Sorcerer. For I/O port assignments and information on the Monitor batch system, also see the GUIDED TOUR manual.

Entry Points (Jump Table)--Initial Entry and I/O Entry Points: See the SORCERER SOFTWARE MANUAL (Exidy P/N DP5008). Also see the SOFTWARE MANUAL for information on tape unit entry points, interfacing programs (passing control between user programs and the Monitor, general input and output, cassette I/O routines).

RELOCATING THE MONITOR STACK

Introduction

The stack is a term which loosely denotes three separate areas of memory in the Sorcerer:

. The Monitor RAM
. The Monitor stack proper
. The stack pointer

To relocate the stack means to simultaneously move the Monitor RAM and stack proper, and reset the stack pointer.

The Monitor runs in ROM, but needs temporary scratchpad storage in RAM; this storage is the Monitor RAM, which is used to hold intermediate values during Monitor routines. The Monitor stack proper is used for temporary storage of Z80 registers (using PUSH and POP instructions), and to store return locations for Z80 CALL instructions. The stack pointer is a two byte register in the CPU which holds the lowest address currently used for stack storage.

At power-on, the Sorcerer searches RAM for the top RAM address. The 112 addresses (70H) from the top downward are used as the Monitor RAM; the next 64 addresses approximately (40H) are the Monitor stack proper.

Reasons to Relocate the Stack

If the stack is disturbed, the system may crash. This can happen in three ways:

1. A tape or disk file can overwrite the stack (the file header

2. A user program may overwrite the stack.

3. A user program may disturb the stack if it calls the Monitor I/O etrnry points.

You an recover from the crash by hitting the RESET keys, but you will still lose the contents of all RAM. To prevent a crash in any of these cases, you must relocate the stack to an area of RAM which won't be used by your program or tape file. This area must contain at least 176 bytes (B0H)--112 bytes for Monitor RAM storage and 64 bytes for the Monitor stack proper.

You must also relocate the stack before using the Monitor RAM test (command TE) on the area of RAM occupied by the stack.

How to Relocate the Stack

First, choose a suitable address XXYY for the top of the Monitor RAM; here, XX and YY are the high order and low order bytes of the address, respectively. Second, use the Monitor EN command to put these Z80 instructions into the addresses 0000 to 0005H:

```
21 YY XX C3 06 E0
```

This Z80 program loads the address XXYY into the HL register pair and then jumps to the Monitor USER entry point. Finally, give the command GO 0000. (And note that the address loaded is in the reverse order as appears in the program.)

Example:

To move the stack so that the top of RAM is at 0750H:

You type: EN 0000

Sorcerer replies: 0000:_

You type: 21 50 07 C3 06 E0/

Then type: GO 0000

The Sorcerer moves the stack and prints this message:

```
EXIDY STANDARD MONITOR

VERSION 1.X
COPYRIGHT (C) 19XX BY EXIDY INC.

THE TOP OF RAM IS 0750 HEX.
STACK BEGINS FROM 06E1 HEX.
```

PART TWO
HARDWARE

HARDWARE DESIGNATIONS

We refer to an IC device by its location on the board. Thus 1A is the devicef in column 1, row A of the board. Context will make clear which board is intended.

We refer to a pin of an IC device (and sometimes the signal at that pin) by a hyphenated number following the location. Thus 1A-5 is pin 5 of device 1A.

If an IC chip contains more than one device, we refer to each by one of its pins. Thus 1A-5 also designates one of the device on chip 1A--the one containing pin 5. Context will make clear whether a designation such as 1A-5 refers to a pin or to a device.

NOTE

All service should be done by an authorized Sorcerer dealer; unauthorized service will void our warranty.

HARDWARE MODIFICATIONS

110 V 60 Hz to 220 V 50 Hz Conversion

For use in the USA, the Sorcerer is wired for 110 V 60 Hz power. To convert to 220 V 50 Hz, both the power supply and the vertical sync generator must be modified.

1. For 100 V, the power supply transformer primary windings are connected in parallel; to convert to 220 V, disconnect them and rewire in series. Do this by cutting the black-yellow and black-red wires at the line filter, and soldering them together.

2. The vertical sync generator is configured by setting switch 1 at location 11A off for 60hz and on for 50hz.

EPROM - ROM Conversion

The Sorcerer logic board accepts either EPROMs or ROMs in sockets 1E, 2E and 21D (the Power-On Monitor and Character Generator). However, the board must be modified when switching from one type of device to the other. There are several jumper locations which select between EPROMs and ROMs (see Figure 3).

In early model Sorcerers the Power-On Monitor is EPROM-resident; and printed jumpers configure the board for EPROMs. In the later model Sorcerers, the Monitor is ROM-resident, and the board is configured for ROMs. If the owner of a later model Sorcerer wishes to put his own operating system on EPROMs, he must have the logic board rejumpered; cut the printed traces and rewire as shown in Figure 3.

Internal Memory Expansion

The Sorcerer computer normally has 16K of internal RAM; this is expandable to 32K or 48K. The RAM sockets are located in three rows in the upper left corner of the logic PC board (see Figure 4).

There are two options for internal memory expansion:

- Install RAMs in two or three rows of RAM sockets.

- Use either 4K RAMs or 16K RAMs.

This gives three possibilities:

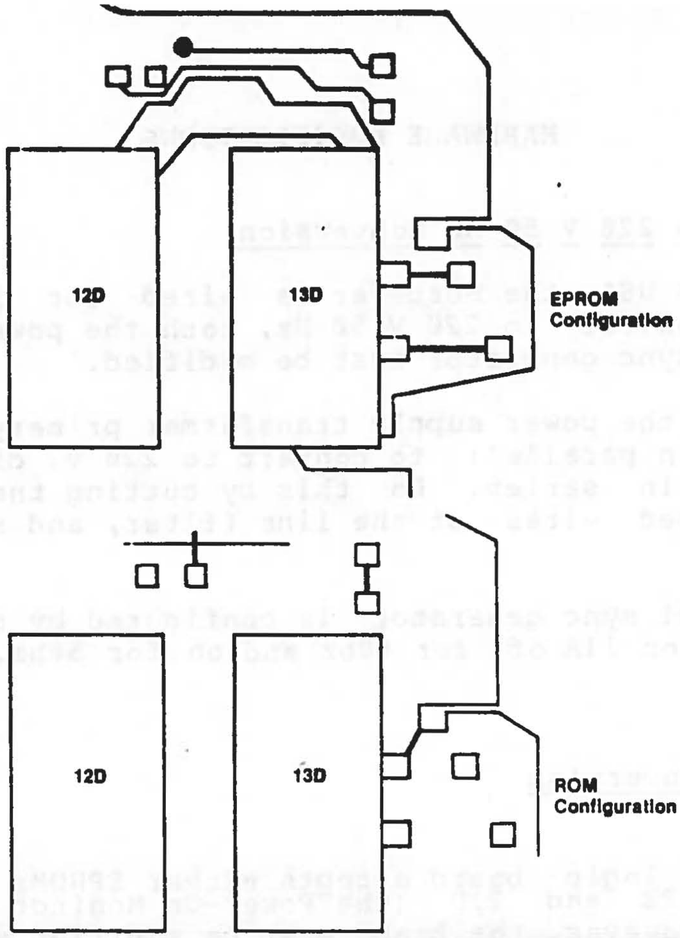


Figure 3 EPROM - ROM Jumpers

No. Rows	RAM Size	Total RAM (Bytes)	Remarks
1	16K	16K	The normal configuration.
2	16K	32K	1 Memory Expansion Kit (row 2).
3	16K	48K	2 Memory Expansion Kits (rows 1 and 2).

The Sorcerer Memory Expansion Kit contains eight 16K RAMs--enough to increase the Sorcerer's memory from 16K to 32K or from 32K to 48K. To increase memory from 16K to 48K use two Expansion Kits.

There are DIP switches at location 11A on the logic PC board (see Figures 4 and 5).

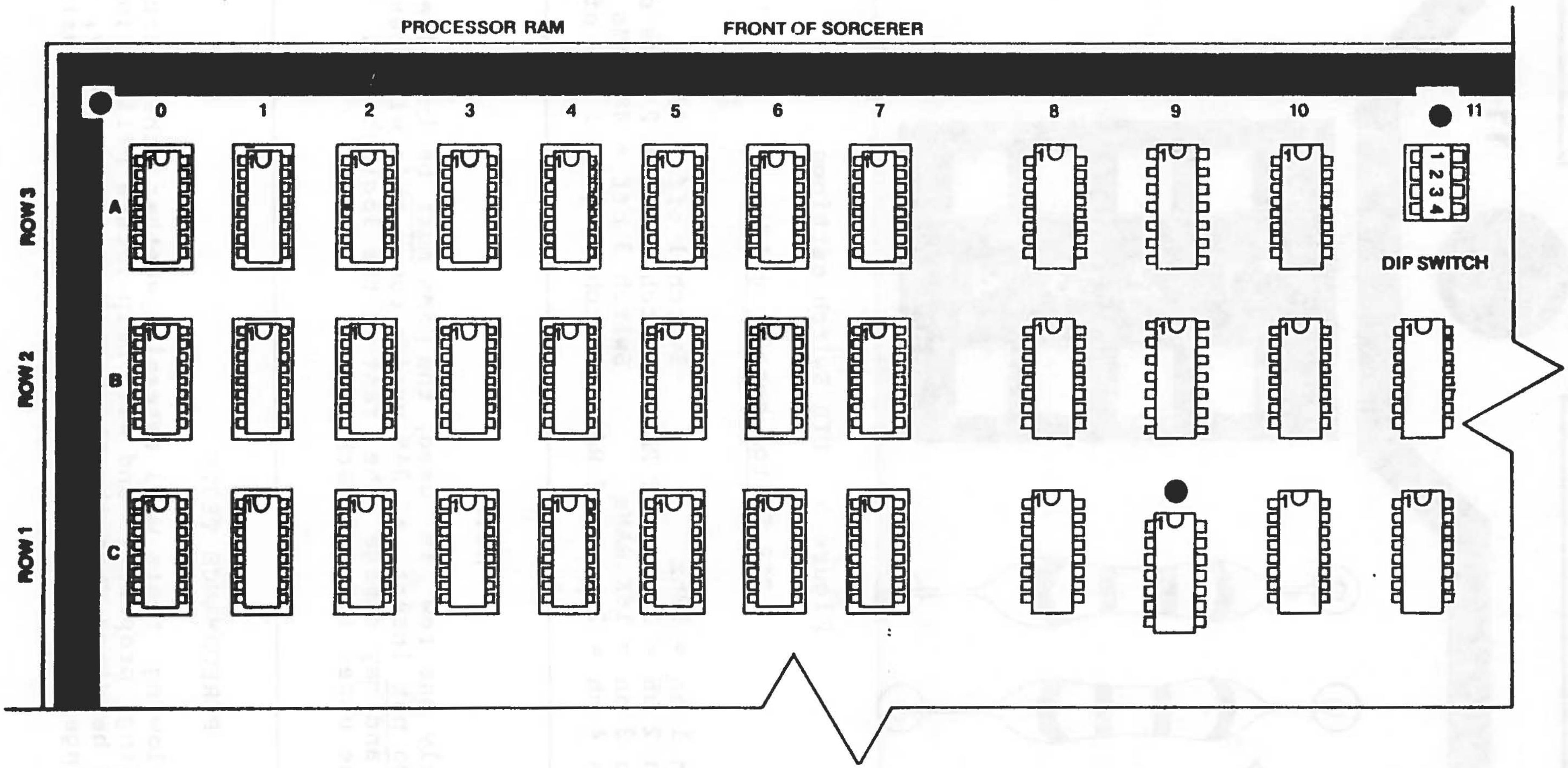


Figure 4   RAM Sockets and RAM DIP SWITCH, locations

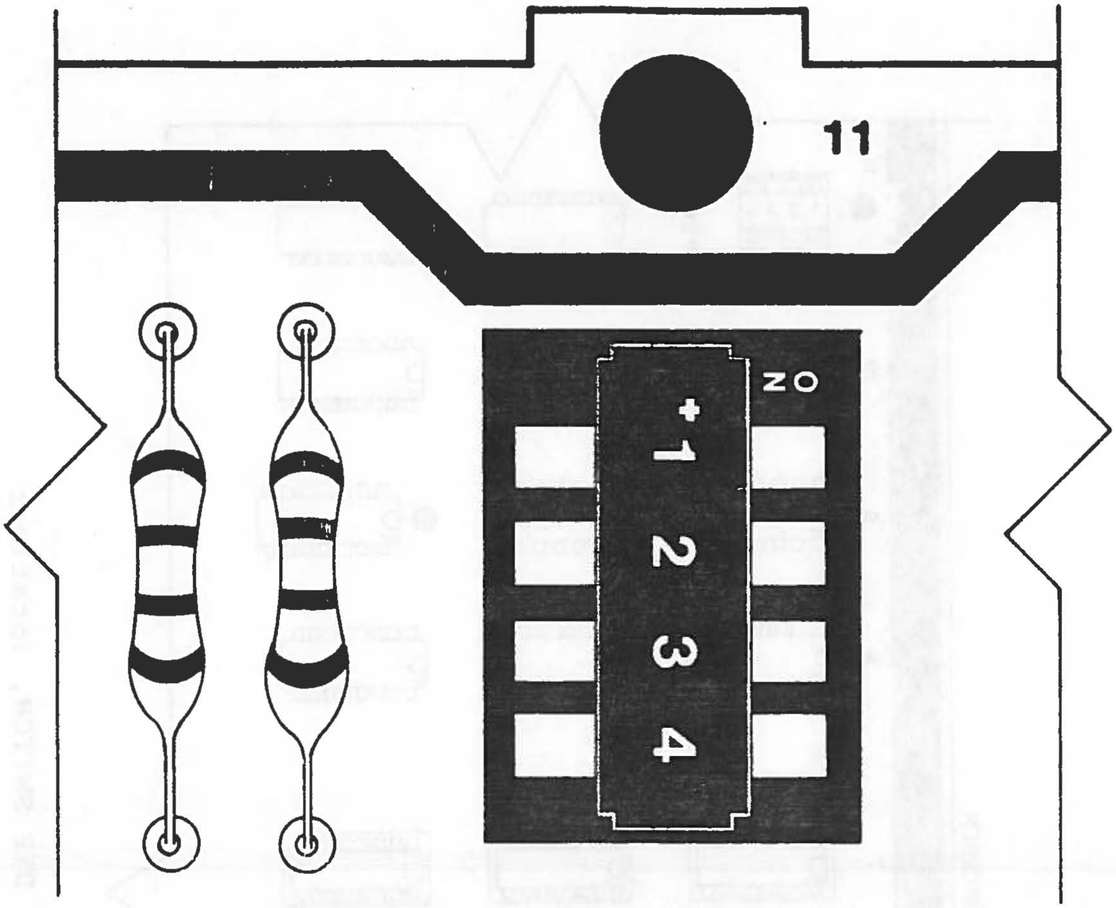


Figure 5   DIP Switch settings

DIP Switch setting guide

Switch 1 on = 5Øhz	Switch 1 off = 6Øhz
Switch 2 on = 3 rows of RAM	Switch 2 off = 2 rows of RAM
Switch 3 on = 16K RAMs	Switch 3 off = 4K RAMs
Switch 4 on = 2 rows of RAM	Switch 4 off = 1 row of RAM

NOTE

If only one row is used, the RAMs must be installed in Row 3. Do not insert a RAM upside down; this will destroy the RAM, and may damage the rest of the logic board. Pin 1 is at the upper left of each socket.

PERFORMANCE TESTS

The following tests will determine whether the Sorcerer is functioning properly, and will help locate malfunctions. The numbered headings describe the tests; where necessary, lettered subheadings give step-by-step instructions for the tests.

Logic Board

1. Parallel I/O--connect the output to the input and check whether the unit reads and writes properly. See Table 2 for the parallel interface connector pinouts.

2. RAM bit test--Use the Monitor TE command to test the screen RAM, character generator RAM and main RAM (see the memory map, Figure 1, for the addresses). You must test the screen RAM in two steps:

   . First, put the cursor into the top half of the screen, and run the bit test on addresses F400H to F7FFH.

   . Second, put the cursor into the bottom half of the screen, and run the test on addresses F002H to F3FFH.

   Do not use the bit test on addresses F000H and F001H.

   Before testing the main RAM, relocate the Monitor stack to another section of RAM. See Page 8 and Software Manual.

Cassette Interface Logic

These tests require a Serial Data Cable (Exidy Part No. DP4005) and an oscilloscope with a 50 mV per cm. setting.

1. Check both recorder remote-control outputs.

   a. Plug the REM 1 of the Serial Data Cable into the recorder remote-control jack. The recorder is now under computer control and should not be able to run. If the recorder is one you haven't run before and it runs continually, there may be a polarity problem. Reversing the leads on the REM plug will solve the polarity problem. Wrong polarity will not harm the computer or the recorder.

   b. Use the Monitor FI 1 command to turn the recorder on. Hit [RESET] to turn it off.

   c. Repeat step b, using the REM 2 plug and the FI 2 command.

   d. Hit [RESET]. This resets the baud rate to 1200; however the Sorcerer will not actually send the 1200 baud carrier until you give a Monitor tape command (such as LO, SA or FI). Until then, Sorcerer sends the 300 baud carrier signal.

   e. Give the Monitor command FI (this activates the 1200 baud carrier).

2. At 300 baud, check <u>all</u> of the MIC and and AUX outputs, for proper voltage levels and freedom from noise.

a. The correct voltages are 40 ±5 mV p-p for MIC and 210 ±20 mV p-p for AUX. These values are lower than the nominal 50 mV and 250 mV, since the tape interface attenuates the 300 baud carrier more than the 1200 baud carrier.

b. If there is excessive noise on either of the AUX outputs, write a 1200 baud file onto tape using the noisy output, and then read the file back to insure there were no errors. The length of the file should be 4K (E000H to EFFFH). Be sure that the AUX output is plugged into the AUX input on the recorder and not into the MIC input.

c. Reset the Sorcerer to insure the 300 baud carrier.

d. Use a ground clip on the scope probe.

e. Make sure no MIC or AUX cables are plugged into a recorder (otherwise the signal will be loaded down).

f. Check MIC 1 both from the phono jack and from the 25-pin serial interface connector.

g. Check MIC 2, AUX 1 and AUX 2 from the 25-pin connector.

4. Write and read a 300 baud, 128 byte file (E000H to E07FH) using MIC 2 and EAR 2 from the 25-pin serial interface connector.

   a. Plug the EAR 2 plug of the Serial Data Cable into the EAR jack on the recorder.

   b. Put the Sorcerer into the Power-On Monitor and type SE T=1.

   c. Put a scratch tape into the recorder and make sure it's rewound completely, otherwise you will get errors.

   d. Put the recorder in record.

   e. Type SAVE TEST E000 E080, but don't hit [RETURN].

   f. Wait until the tape leader is past the record head and then hit [RETURN]. (The command records pseudo-random data taken from addresses E000H through E080H.)

   g. When the recording is finished, rewind the tape and load it back in with the Monitor command LO.

   h. If you get a prompt character, and the message ERROR did not appear, the read was good.

5. When the UART is not sending data, the CASSWRIT signal goes high. The tape interface manchester encoder translates this as a steady stream of logic 1s--this is the normal cassette carrier signal. Connect EAR 2 and AUX 2 and check for this carrier at 1200 and at 300 baud. (Use AUX 2 rather than MIC 2 because the 50 mV MIC 2 signal is too weak.)

6. Test the tape interface's ability to write and read data generated by a diagnostic program.

a. Enter the following Z80 program into address 0000 to 0048H:

```
Addr  Obj Code   Label     Mnemonic        Comments

      003D       TAPES:    EQU   3DH
      0045       CMTRFG:   EQU   45H
      E003       WARM:     EQU   0E003H
      E1A2       GETIY:    EQU   0E1A2H
      E015       QUIKCK:   EQU   0E015H
      E00F       INTAPE:   EQU   0E00FH
      E012       OUTAPE:   EQU   0E012H
      E01B       VIDEO:    EQU   0E01BH
0000  18 27      WRITE:    JR    WR-$       ;START-POINT FOR WRITING
                 ;READING ROUTINE
0002  CD 33 01   READ:     CALL  BAUD       ;START-POINT FOR READING
0005  CD 0F E0             CALL  INTAPE
0008  FE E2                CP    0E2H
000A  20 0C                JR    NZ,ERROR-$
                 ;PRINT FLASHING ASTERISKS
000C  3E 2A                LD    A,'*'
000E  CD 1B E0             CALL  VIDEO
0011  3E 08                LD    A,08H      ;BACKSPACE
0013  CD 1B E0             CALL  VIDEO
0016  18 EA                JR    READ-$
                 ;PRINT "E"
0018  3E 45      ERROR:    LD    A,'E'
001A  CD 1B E0             CALL  VIDEO
001D  CD 33 01   LOOP:     CALL  BAUD
0020  CD 0F E0             CALL  INTAPE
0023  FE E2                CP    0E2H
0025  20 F6                JR    NZ,LOOP-$
0027  18 D9                JR    READ-$
                 ;WRITING ROUTINE
0029  CD 33 01   WR:       CALL  BAUD
002C  3E E2                LD    A,0E2H
002E  CD 12 E0             CALL  OUTAPE
0031  18 F6                JR    WR-$
                 ;BAUD RATE AND EXIT-CHECK SUBROUTINE
0033  FD E5      BAUD:     PUSH  IY
0035  CD A2 E1             CALL  GETIY      ;A MONITOR SUBROUTINE
0038  FD 7E 3D             LD    A,(IY+TAPES)
003B  FD 77 45             LD    (IY+CMTRFG),A
003E  D3 FE                OUT   (0FEH),A
0040  FD E1                POP   IY
0042  CD 15 E0             CALL  QUIKCK
0045  C2 03 E0             JP    NZ,WARM
0048  C9                   RET
```

b. Use the Monitor command SE to set the baud rate to 300 or 1200.

c. Turn on the recorder and give the command GO 0000.

d. Let the program write for at least 60 seconds. Then stop the recorder, and halt the program with [CTRL] [C], [ESC] or [RUN STOP].

e. Rewind the tape and start the recorder playing. Give the command GO 0002; this causes the program to read the recorded data.

f. The Sorcerer prints:

- A flashing asterisk (*) if it reads the data correctly.
- An E, for each error.
- Nothing, if it sees no data.

7. Use the diagnostic program in Step 6 above to write and read data, while you adjust the recorder's tone and volume controls. You should be able to read and write correctly over at least half of each control's tuning range (it doesn't matter which half).

CASSETTE INPUT/OUTPUT TROUBLE-SHOOTING HINTS

1. Make sure the tape is well past the leader before starting to record.

2. Make sure the two cassette cables are firmly plugged into the jacks on the recorder and the Sorcerer.

   a. First, plug the Sorcerer MIC output (at the RCA jack) to the recorder's MIC input.

   b. Then try connecting the Sorcerer's MIC and AUX outputs to the recorder's MIC and AUX inputs, in all possible combinations. MIC 2 and and the two AUX outputs are on the serial interface connector (see Table 1).

   c. In all cases, connect the recorder's EAR output to the Sorcerer's EAR input.

3. If the recorder is running on batteries, try using a line cord instead. If the recorder is running on a line cord, try using batteries (the power supply may filter poorly).

4. Try a different tape cassette, preferably low noise, high output, 15 to 20 minutes to a side. Longer tapes usually are satisfactory, but have more internal drag, and therefore don't run at uniform speed. Also, slight imperfections not normally a problem with audio recording can cause errors when recording data; it's best to use certified tape.

5. **Use this procedure to check the Sorcerer's ability to sync onto incoming tape data:**

   a. Give the Monitor command FI; this outputs a 1200 baud carrier signal. (The Monitor command SE T=0 will set the tape information rate to 1200 baud, but no carrier signal wil be sent until another tape command is given.)

   b. Record the 1200 baud carrier for 30 to 60 seconds.

   c. Locate the tape interface LED at the back of the Sorcerer. This LED is visible through the back grill behind the EAR jack, and should be on except when data is being played from the recorder.

   d. Play back the recorded 1200 baud carrier; the LED should go out (or flicker very faintly). If this does not happen, try different combinations of tone and volume setting. If the LED still stays on, try plugging the MIC cable into the recorder's AUX input.

   e. As a last resort, locate the potentiometer VR1 on the tape interface section (location 15H). There are two ways to adjust VR1:

      . Play the recorded 1200 baud carrier while moving VR1 back and forth over its entire range. The LED should stay out for at least half the range. Determine which subrange of settings turn the LED off and set VR1 to the middle of that subrange.

      . Disconnect the recorder, and jumper one of the Sorcerer's AUX outputs to one of its EAR inputs. Now adjust VR1 against the LED at both 300 and 1200 baud. Note that this method is independent of your recorder's idiosyncracies.

7. Some recorders have very sensitive MIC inputs which are overloaded by the Sorcerer's 50 mV MIC input. You can usually get good results by connecting the recorder's AUX input to one of the Sorcerer's AUX outputs; however, the recorder's AUX may not work with the Sorcerer's MIC. If you wish to use the Sorcerer MIC output, you must use an attenuator plug, which reduces the 50 mV output to a level the recorder's MIC will accept. Figure 6 shows how to make an attenuator plug.

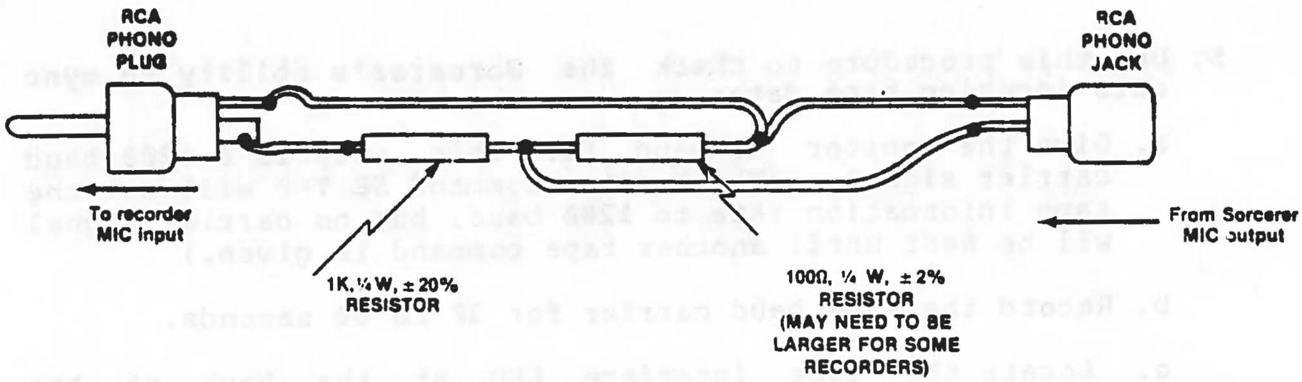


Figure 6 Attenuator Plug

SORCERER INTERFACE CONNECTORS--SPECIFICATIONS

The audio and video connectors are female RCA jacks, and mate with standard male RCA jacks. The serial and parallel interface connectors are standard female 25-pin D connectors and mate with standard male 25-pin plugs; the pinouts are given in Tables 1 and 2. The S-1ØØ interface connector is a 5Ø-pin male connector (dual 25 on .1 centers) printed onto the edge of the logic board; it mates with a female 5Ø-pin edge connector. The pinouts for the S-1ØØ interface are given in Table 3.

Pin #	Signal	Pin #	Signal
1	Shield 1	13	Motor # 2 +
2	RS232 OUT	14	Shield 2
3	RS232 IN	15	MIC 1
4	Ground	16	MIC 2
5	AUX 1	17	Ground
6	Ground	18	AUX 2
7	Ground	19	Ground
8	Ground	20	EAR 1
9	+ 12 Volts	21	EAR 2
10	Unused	22	Unused
11	RS232 IN	23	RS232 OUT
12	Motor # 1 +	24	Motor # 1—
		25	Motor # 2—

Table 1 Serial Interface, Pinouts

Pin #	Signal	Pin #	Signal
1	Ground	13	Input Bit 6
2	Output data accepted	14	Unused
3	Output data available	15	+5 volts
4	Output bit 7	16	Output bit 0
5	Output bit 6	17	Output bit 1
6	Output bit 5	18	Output bit 2
7	Output bit 4	19	Output bit 3
8	Ground	20	+5 volts
9	Input data available	21	Input data accepted
10	Input bit 0	22	Input bit 1
11	Input bit 2	23	Input bit 3
12	Input bit 4	24	Input bit 5
		25	Input bit 7

Table 2 Parallel Interface, Pinouts

Pin #	Signal	Pin #	Signal
1	$\overline{\text{PRESET}}$ (out of Sorcerer)	26	Address bit 11
2	$\overline{\text{INT}}$	27	Address bit 13
3	$\overline{\text{WAIT}}$	28	Address bit 14
4	Data Bus Enable (into Sorcerer)	29	Address bit 0
5	$\overline{\text{BUSRQ}}$	30	Address bit 12
6	$\overline{\text{NMI}}$	31	Address bit 2
7	BUSACK	32	Address bit 1
8	Data Bus Direction (into Sorcerer)	33	Address bit 4
9	RAM $\overline{\text{DR}}$ or $\overline{\text{ROM ENABLE}}$	34	Address bit 3
10	$\phi 1$	35	Address bit 6
11	ROM PRE	36	Address bit 5
12	Reset Acknowledge	37	Data bit 0
13	$\phi 2$ (Clock out)	38	Address bit 7
14	UP8K	39	Data bit 2
15	$\overline{\text{MREQ}}$	40	Data bit 1
16	$\overline{\text{M1}}$	41	Data bit 4
17	$\overline{\text{RD}}$	42	Data bit 3
18	$\overline{\text{IORQ}}$	43	Data bit 6
19	$\overline{\text{RFSH}}$	44	Data bit 5
20	$\overline{\text{WR}}$	45	RESET (into Sorcerer)
21	Address bit 8	46	Data bit 7
22	HALT	47	Unused
23	Address bit 10 }	48	I/O
24	Address bit 9 }	49	Ground
25	Address bit 15	50	

Table 3
Sorcerer 50-pin Edge Connector, Pinouts

Sorcerer End Pin #	Printer End Pin #	Signal
1	19 to 30	Ground
2	10	Acknowledge from Printer
3		Unused
4	1	Data strobe from Sorcerer
5	8	Data bit 6
6	7	Data bit 5
7	6	Data bit 4
8	19 to 30	Ground
9 to 15		Unused
16	2	Data bit 0
17	3	Data bit 1
18	4	Data bit 2
19	5	Data bit 3
20 to 24		Unused
25	11	Busy
	9	Unused
	11 to 18	Unused
	31 to 36	Unused

Table 4
Parallel Data Cable, Pinouts

DATA CABLES

Parallel Data Cable (Centronics Printer)

This cable (Exidy part number DP4003) connects the Sorcerer parallel interface to the input of a Centronics or Centronics-compatible printer. Table 4 gives the pinouts for the cable.

The data strobe signal from the Sorcerer is bit 7 of port FFH.

The busy signal from the printer is input to bit 7 of port FFH.

The acknowledge signal from the printer is used to reset the data available bit in the Sorcerer handshake latch (8F-8). The data strobe and acknowledge signals are both negative-going; the busy signal is positive-going.

NOTE

Do not plug the serial cable into the Sorcerer's parallel interface connector, as this will damage the Sorcerer.

Serial Data Cable (Tape Unit)

This cable (Exidy part number DP4005) connects the Sorcerer's serial interface to one or two cassette recorders or to an RS232 device; when connected to a recorder it allows the Sorcerer to control the recorder's motor. Single-pin Molex connectors in the motor control lines allow you to change the polarity of the motor control signal to suit your recorder.

Figure 7 shows the layout of the cable, and Figure 8 is the schematic.

NOTE

Do not plug the parallel cable into the Sorcerer's serial interface connector, as this will damage both the printer and the Sorcerer.

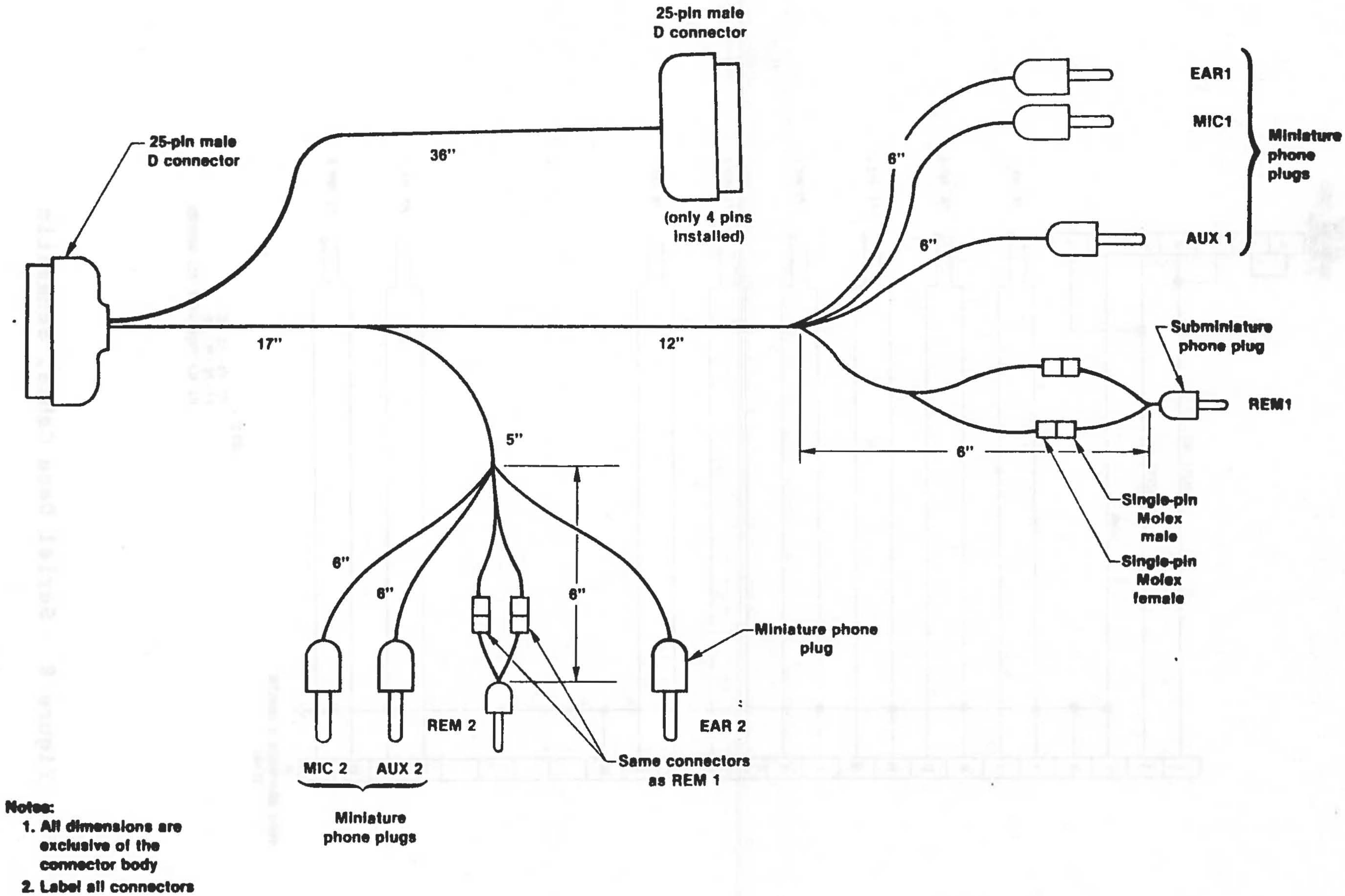


Figure 7 Serial Data Cable, Assembly Diagram

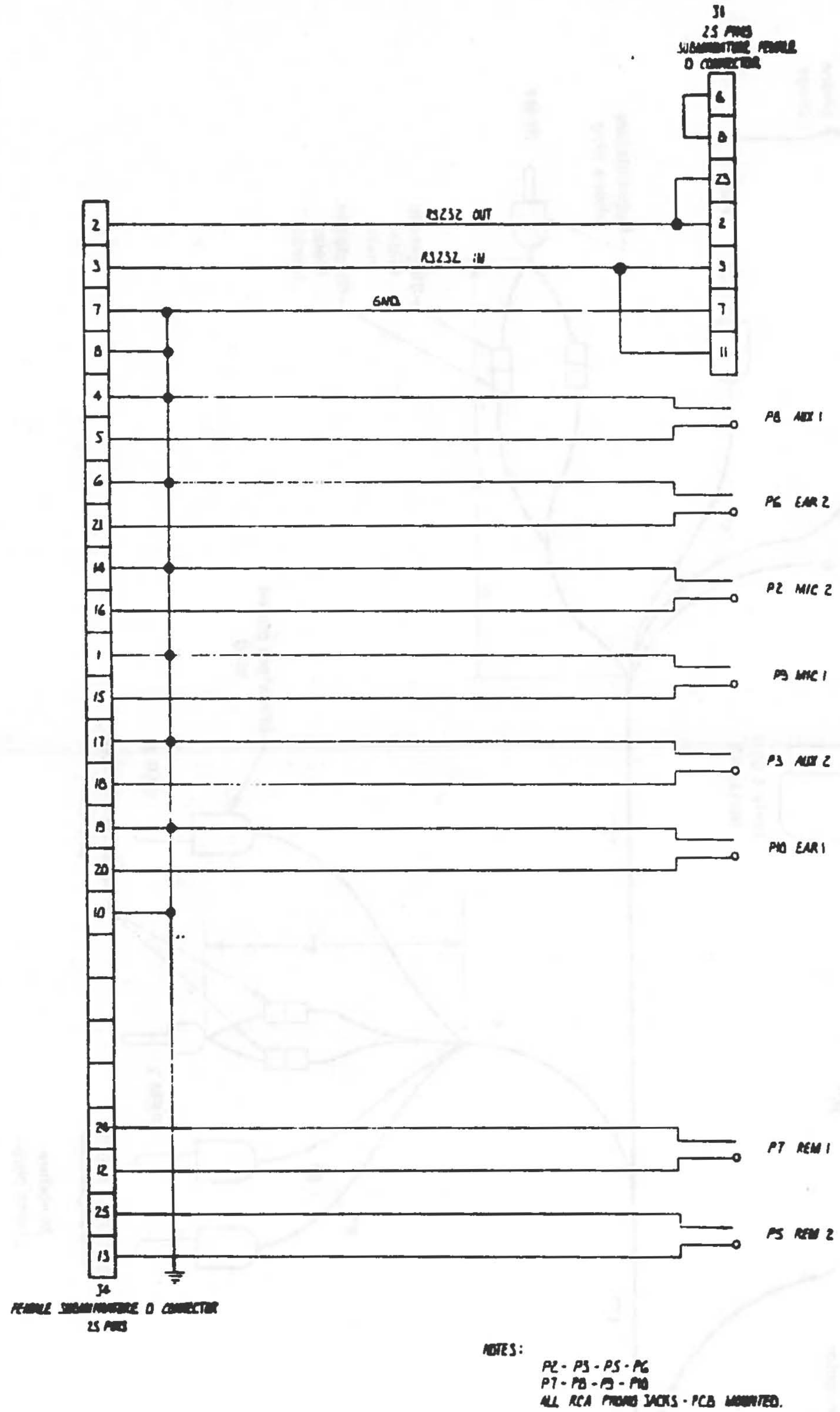


Figure 8 Serial Data Cable, Schematic

Theory of Operation Sections

THEORY OF OPERATION, LOGIC BOARD

Video Clock Generator

The 12.638 MHz crystal,22D-2 and 22D-4 form an oscillator with 22D-6 as a buffer. The flip-flop 22C divides the clock signal in half, providing CLK 6 (6 MHz approximately) and its inversion 5CLK6. The signal 5CLK12 which comes from 22D-6 is further divided by flip flops 22B-5 and 22B-9 to provide the signals CLOCK IN and Ø1 respectively.

Horizontal Sync Generator

22A, 21A and 18A provide the horizontal sync and blanking generation. 22A and 21A form a binary up-counter; the starting count is determined by the state of 18A-6. E1 through E256 are the horizontal scan element counts. 17A-9 shuts off the video during horizontal blanking; 17A-6 shuts off the video when the CPU accesses the screen. 2ØA is part of the video counter buffer.

Vertical Sync Generator

21B, 2ØB and 17A-9 work similarly to 22A, 21A and 18A; the start of count depends on the state of 18A-7. L1, L2 and L4 are the line counts of the 8 x 8 character matrices; L8 through L256 are the line counts for the text lines on screen. 16A and 18B-5 latch the vertical sync. 17B is part of the video count buffer. 5Ø Hz/6ØHz operation is selected by multiplexes 13A and 19B.

CPU Clock Generator

The signal CLOCK IN is fed into a divide by two flip-flop 9A and then inverted by 8D then fed into the proccessor.

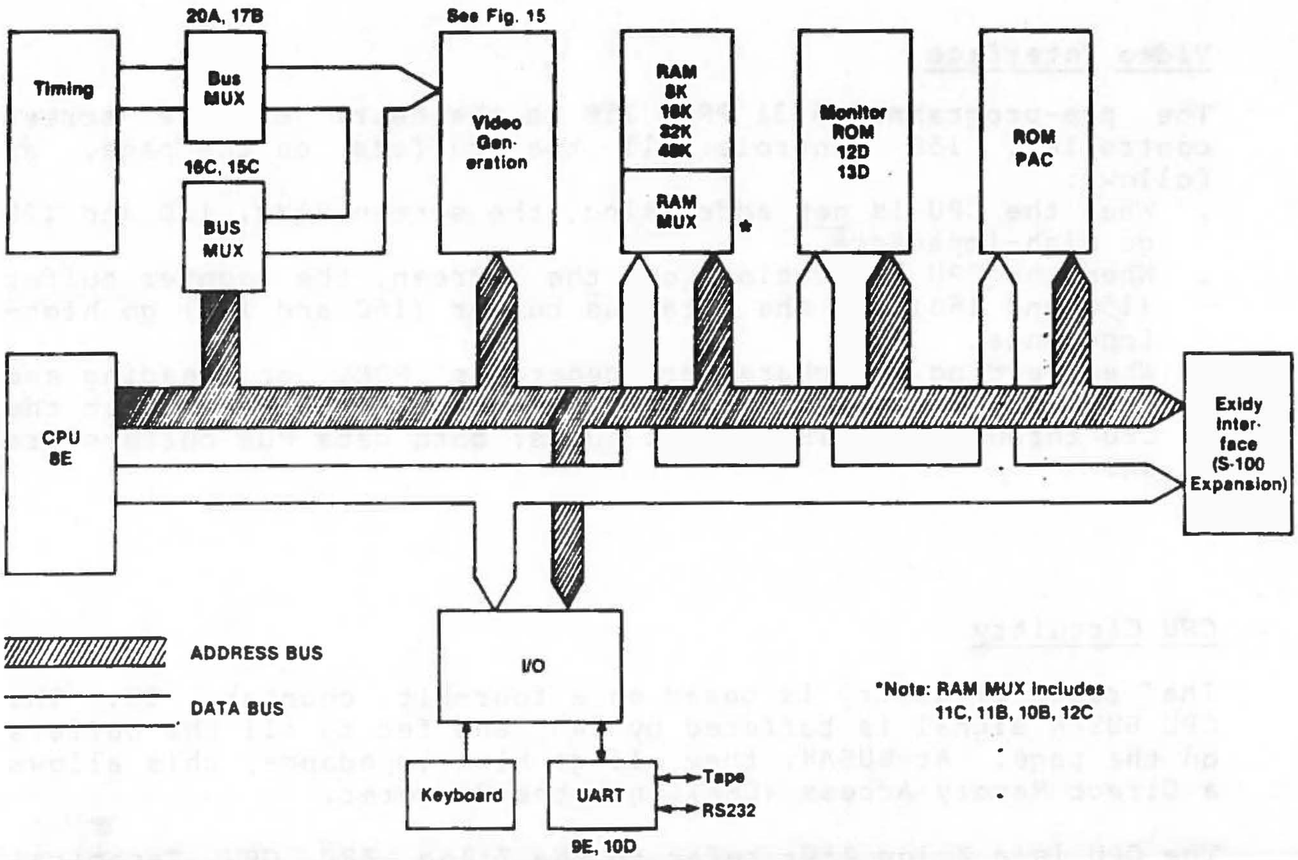


Figure 9 Logic Board Block Diagram

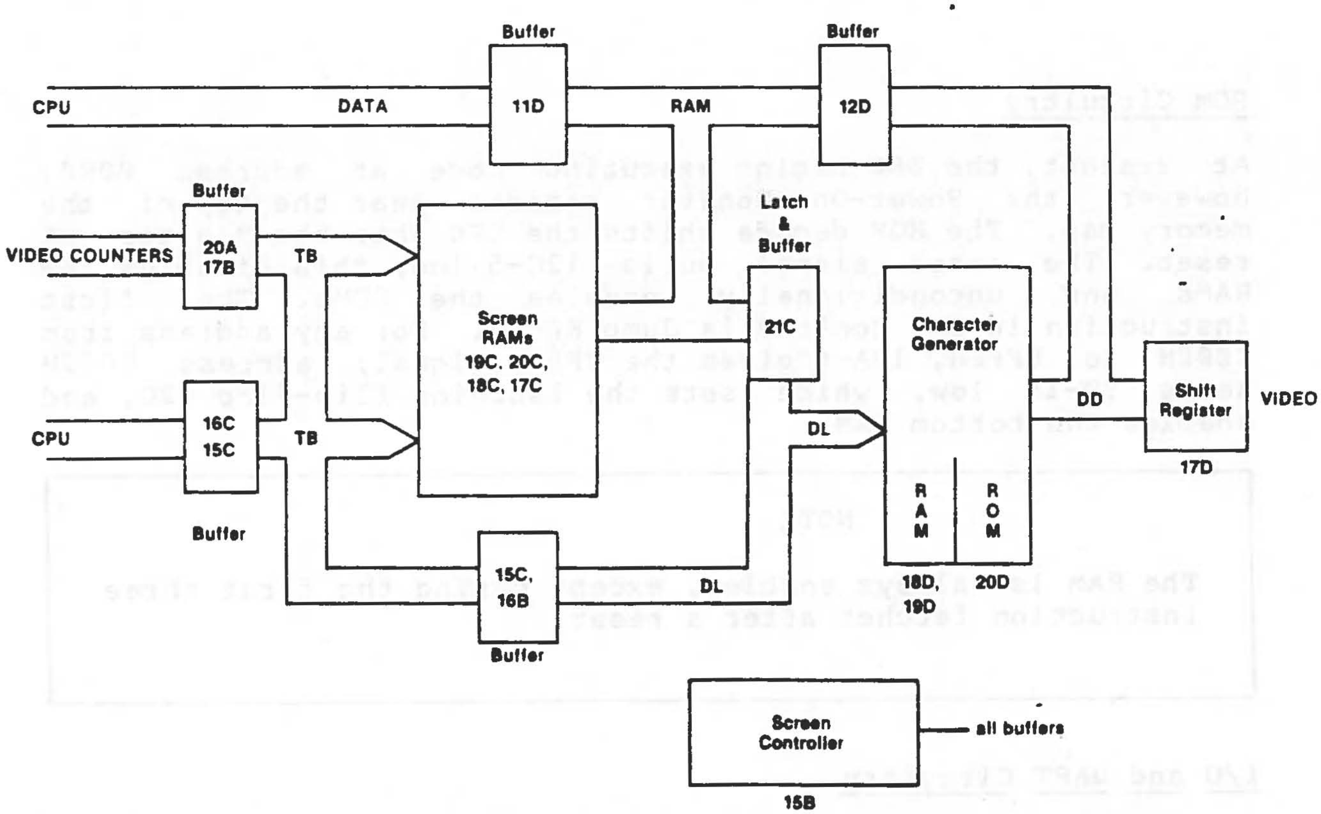


Figure 10 Video Generator Block Diagram

Video Interface

The pre-programmed 6331 PROM 15B is the heart of the screen controller. 15B controls all the buffers on the page, as follows:

- When the CPU is not addressing the screen RAMs, 11D and 12D go high-impedance.
- When the CPU is writing on the screen, the counter buffer (15C and 16B) and the data bus buffer (16C and 15C) go high-impedance.
- When reading the character generator ROM, or reading and writing character generator RAM, an address comes from the CPU through the TB and DL buses; both data bus buffers are on.

CPU Circuitry

The reset circuitry is based on a four-bit counter, 5D. The CPU BUSAK signal is buffered by 10H and fed to all the buffers on the page. At BUSAK, they all go high-impedance; this allows a Direct Memory Access (DMA) into the Sorcerer.

The CPU is a Zilog Z80; refer to the Zilog Z80 CPU Technical Manual, Zilog part number 03-0029-01.

ROM Circuitry

At restart, the Z80 begins executing code at address 0000; however, the Power-On Monitor resides near the top of the memory map. The ROM decode shifts the CPU into the Monitor at reset. The reset signal pulls 12C-5 low; this disables the RAMs and unconditionally enables the ROMs. The first instruction in the Monitor is Jump E062H. For any address from E000H to FFFFH, 10A-6 gives the UP8K signal; address E062H sends 9D-15 low, which sets the latching flip-flop 12C, and enables the bottom RAM.

> NOTE
>
> The RAM is always enabled, except during the first three instruction fetches after a reset.

I/O and UART Circuitry

6D and 7D handle I/O requests. 7D-8 gives the I/O request signal, and enables both halves of 6D. The RD and WR signals are the other enables for the first and second halves of 6D, respectively. The following I/O port designations come into 6D and A0 and A1:

Signal	Port	A1	A0
UART data (serial interface)	FCH	0	0
UART status	FDH	0	1
Sorcerer housekeeping input	FEH	1	0
Sorcerer user output (parallel interface)	FFH	1	1

The Sorcerer input port and the parallel input port are 3-state buffered by 1D and 8H, respectively. The enable signals for the buffers come from 6D. The Sorcerer output port and user output port are 8-bit latched, by 2D and 9H, respectively. Figure 16 shows the parallel output port timing signals.

The UART is a General Instruments AY-3-1015; refer to the manufacturer's technical publications. 10D buffers the UART output.

Interfaces

Cassette/UART Interface: This circuit communicates with the tape interface board.

Cassette Motor Drivers: 9F and Q2 form a Darlington pair; the reversed diode CR2 is turnoff protection for Q2. 9H, Q3 and CR3 are exactly similar.

Power Supply: The transformer has two primary windings in parallel; to convert the power supply to 220 V input, disconnect the windings and reconnect in series (see Hardware Modifications, 110 V 60 Hz to 220 V 50 Hz).

Exidy Bus Drivers: The CPU Control, Address, and Data signals are bi-directionally buffered by 1H to 5H. The bi-directional buffering allows DMA.

S-100 Control: When anything is happening on the logic-board or the tape interface board, 1F receives an input. This disconnects the S-100 Expansion Unit.

THEORY OF OPERATION, TAPE INTERFACE

General

The tape interface translates between the UART data format (non-return to zero) and the tape cassette format (frequency shift). The frequency-shift format uses a high frequency for logic 1, and a low frequency for logic Ø (see Figure ??). At 12ØØ baud, a logic 1 is 1 cycle of 12ØØ Hz and a logic Ø is 1/2 cycle of 6ØØ Hz; at 3ØØ baud, a logic 1 is 8 cycles of 24ØØ Hz and a logic Ø is 4 cycles of 12ØØ Hz. In both cases, the time required to transmit a logic 1 is the same as the time to transmit a logic Ø.

The interface also adjusts the output signal levels to approximately 25Ø mV p-p for the tape recorder AUX input and approximately 5Ø mV p-p for the tape MIC input. A jumper at board location 12H allows a 4 V p-p signal instead, for digital recorders (jumper points A, C).

Manchester Encoder

Flip-flop 16F synchronizes the input data with the 12ØØ Hz clock, triggering on the positive edge of the clock pulse. The signal is inverted in passing through 16F, but is otherwise unchanged. 13F6 and 13F7 frequency encode the data, giving a high frequency for logic 1 and a low frequency for logic Ø.

Level Adjustor/Pulse Shaper

C78 rounds the corners of the square waves (audio recorders don't like square waves); C79, C8Ø, C81 and C82 are DC isolators. The output voltage jumper (location 12H) is part of this circuit.

Clock Selector

This circuit selects a clock rate for the manchester encoder, dependent on the selected baud rate.

Frequency Divider (x 1/55)

13H and 14H form a six stage binary up-counter, which counts from 9 to 64 and then sends a lock pulse from 14H-13 and a carry from 14H-15 to 16E-9; the carry starts the count cycle.

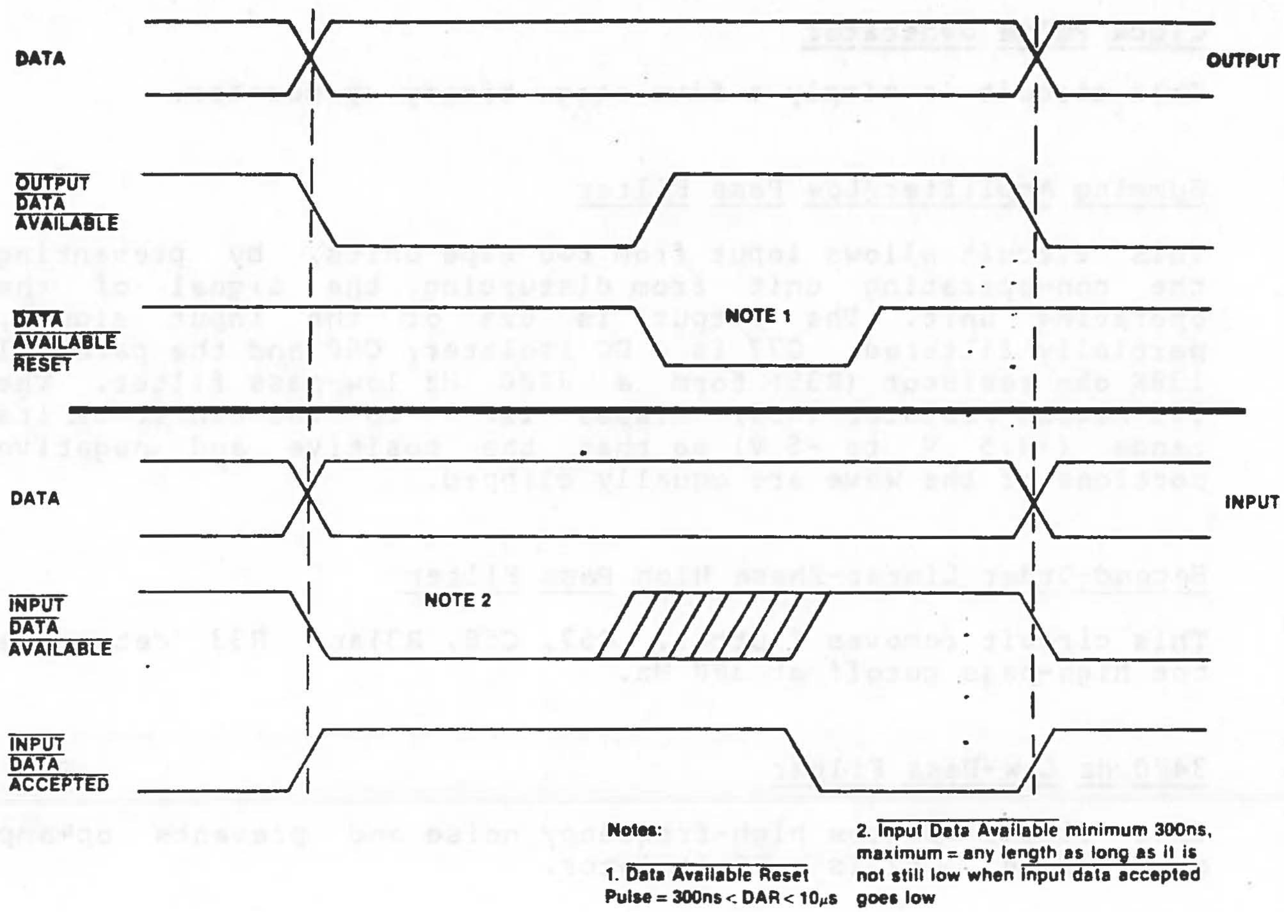


Figure 11 Parallel Port Timing System

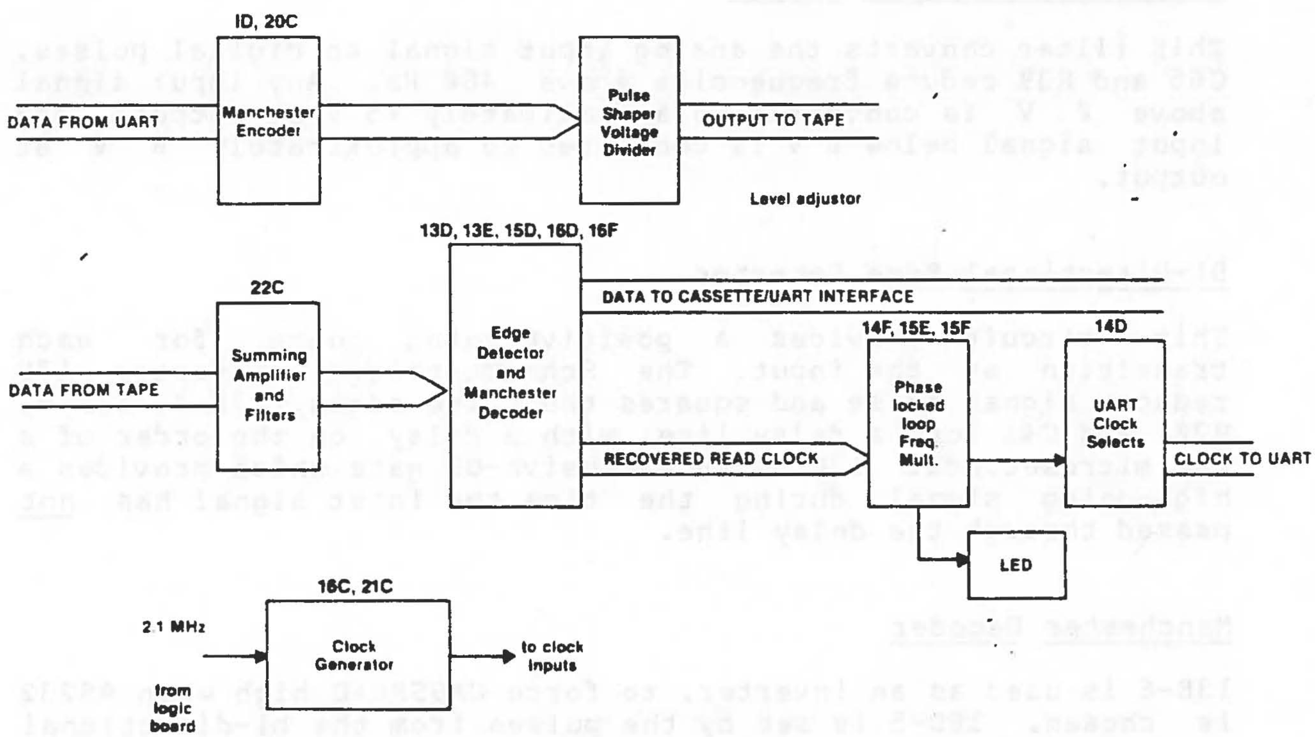


Figure 12 Tape Interface Block Diagram

Clock Pulse Generator

This circuit is simply a five stage binary up-counter.

Summing Amplifier/Low Pass Filter

This circuit allows input from two tape units, by preventing the non-operating unit from disturbing the signal of the operating unit. The output is 62% of the input signal, partially filtered. C77 is a DC isolater; C60 and the parallel 130K ohm resistor (R35) form a 3700 Hz low-pass filter. The 3.3 Megohm resistor (R34) biases 12F-7 to the center of its range (+4.5 V to -5 V) so that the positive and negative portions of the wave are equally clipped.

Second-Order Linear-Phase High Pass Filter

This circuit removes flutter. C57, C58, R31and R33 determine the high-pass cutoff at 300 Hz.

3400 Hz Low-Pass Filter

This filter reduces high-frequency noise and prevents op-amp oscillation. C62 is a DC isolator.

Comparator/Low-Pass Filter

This filter converts the analog input signal to digital pulses. C65 and R39 reduce frequencies above 480 Hz. Any input signal above 0 V is converted to approximately +5 V at output; any input signal below 0 V is converted to approximately 0 V at output.

Bi-Directional Edge Detector

This circuit provides a positive-going pulse for each transition at the input. The Schmidt-trigger inverter 13D reduces signal noise and squares the pulse edges. 13D-4, 13D-6, R20, and C41 form a delay line, with a delay on the order of a few microseconds. 13E is an exclusive-OR gate which provides a high-going signal during the time the input signal has not passed through the delay line.

Manchester Decoder

13E-6 is used as an inverter, to force CASSREAD high when RS232 is chosen. 16D-5 is set by the pulses from the bi-directional edge detector and produces a recovered clock signal. 15D is a binary up-counter which functions as one-shot to reset 16D-1.

15D counts from 4 to 15 before firing--this determines a critical period during which 16D-9 is either set or reset, and thus determines a maximum pulse width. Pulses narrower than this max width are considered 1s; wider pulses are 0s. 16D-5 synchronizes the 16D-9 signal with 16D-5's recovered clock signal.

Frequency Multiplier (x 8 or x 16)

14F is a phase-locked loop and 15E is a frequency- divider. 14F has voltage controlled oscillator, which is adjusted so that the signal out of 15E equals the recovered clock (that is, the signal out of 14F-4 is adjusted so that the signal into 14F-14 equals the signal in at 14F-3). 14F locks onto the recovered clock and provides a clock signal for the UART, at 16 times the data rate. 15F selects the working frequencies, depending on the chosen baud rate. C66 and its 150K resistor form a low-pass filtered feedback loop for the voltage controlled oscillator; C67, VR1 (location 15H) and the 68Kand 100K (pin 1) resistors set the center frequency and frequency range.

Sync Indicator

13E9 acts as a buffer. 14F-1 is high if the phase-locked loop is in sync. C84 filters out small pulses.

UART Clock Selector

This circuit selects working clock signals based on choice of RS232 or cassette, and baud rate.

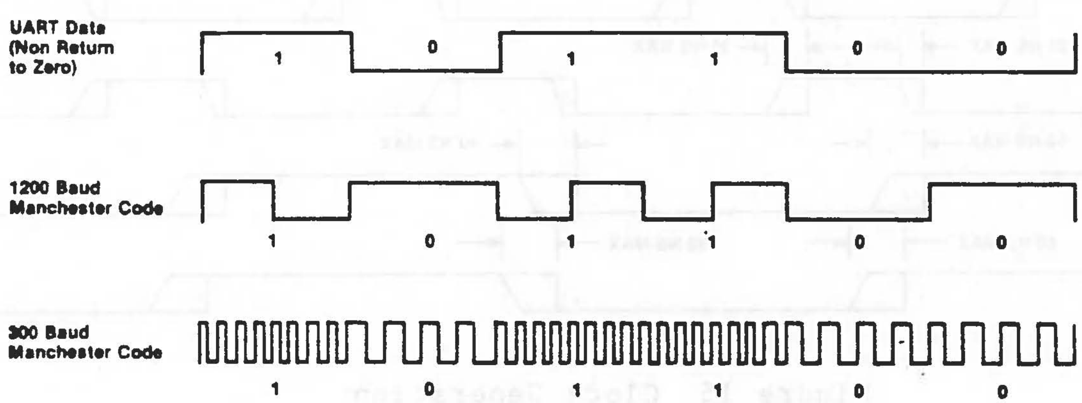


Figure 13 UART and Cassette Data Formats

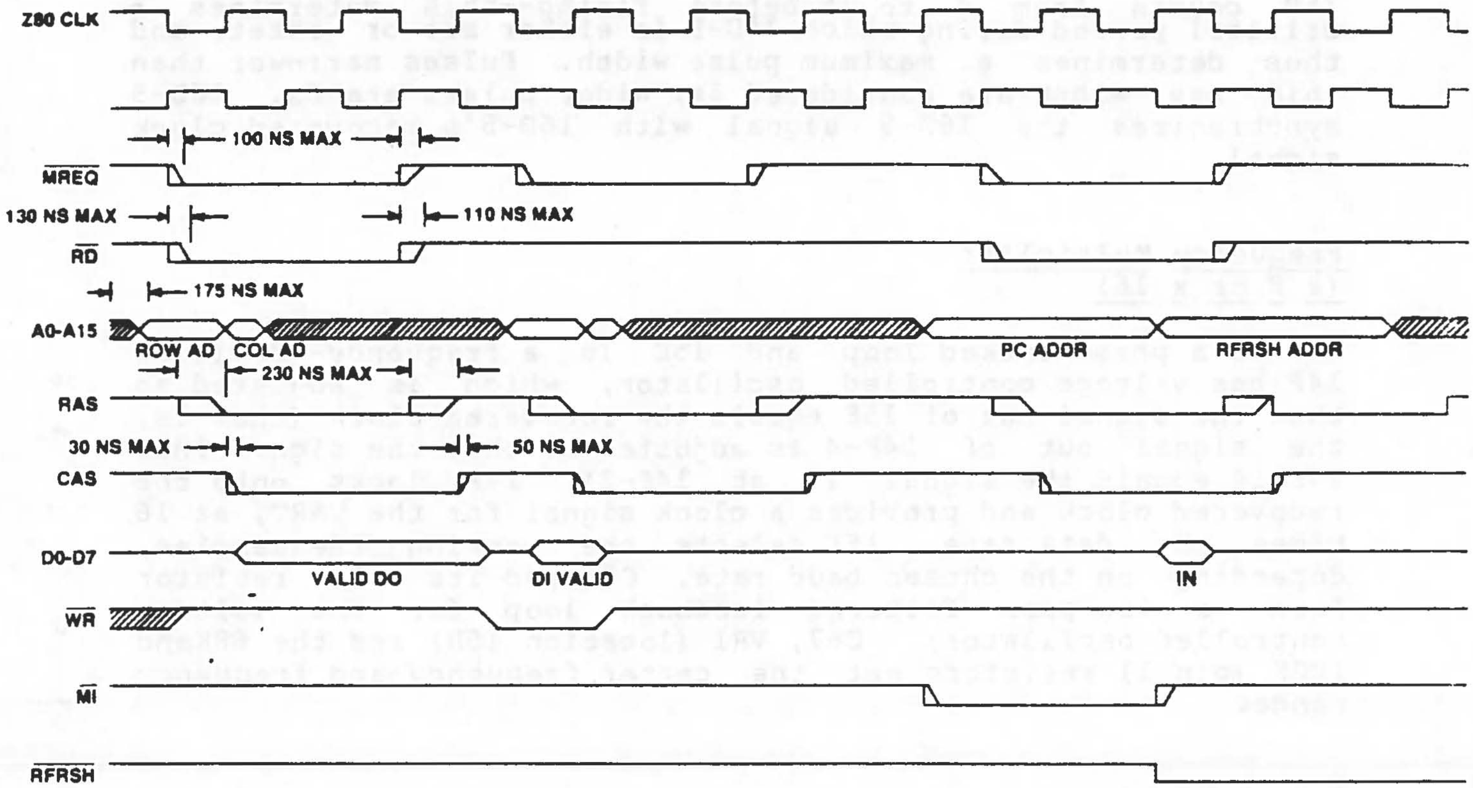


Figure 14 Memory Timing Diagram

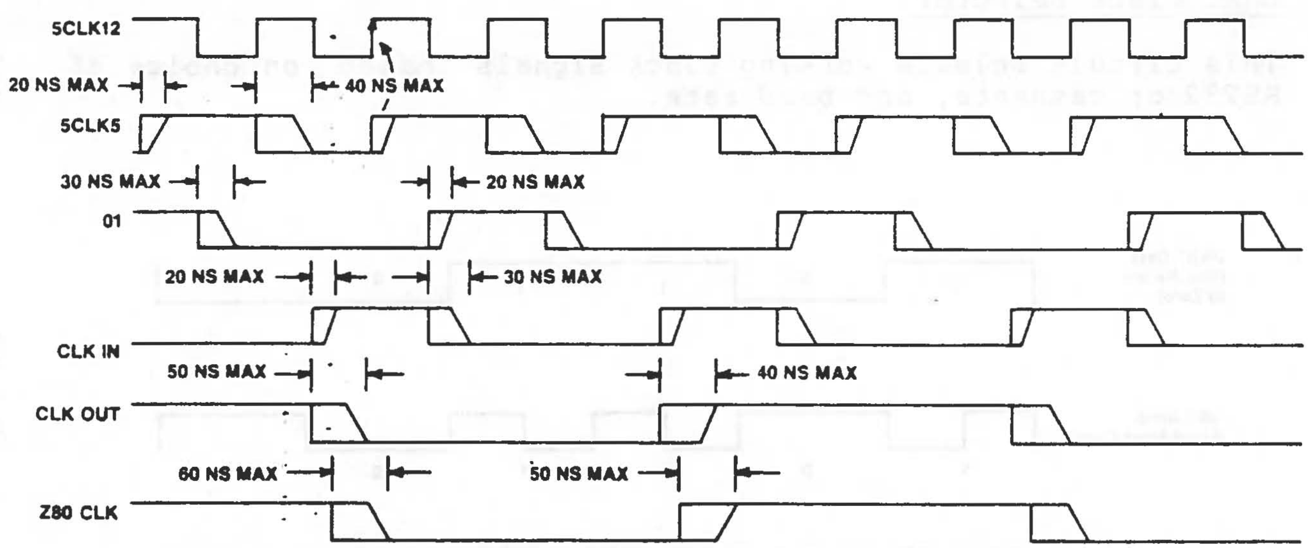


Figure 15 Clock Generation

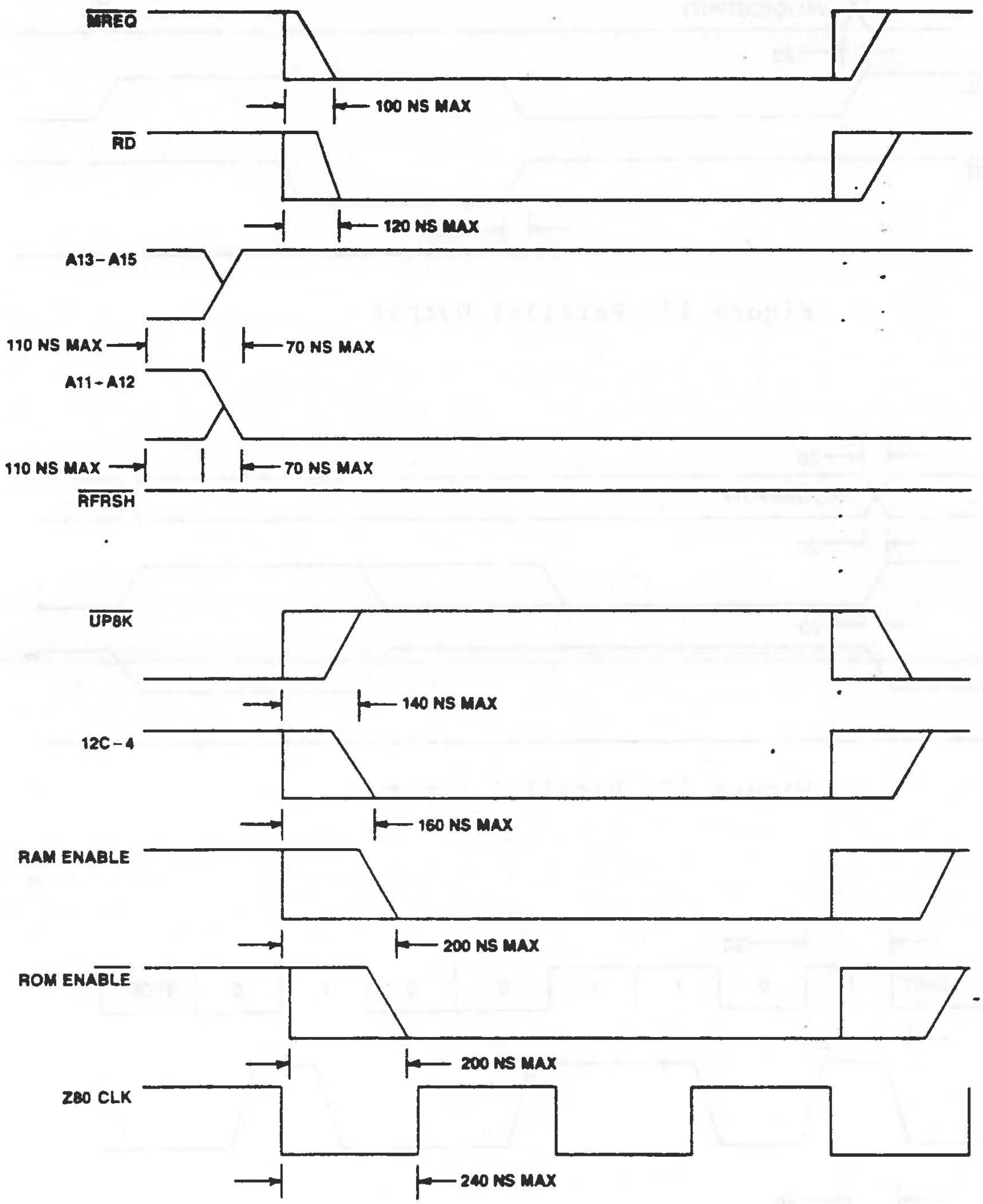


Figure 16 ROM Decode

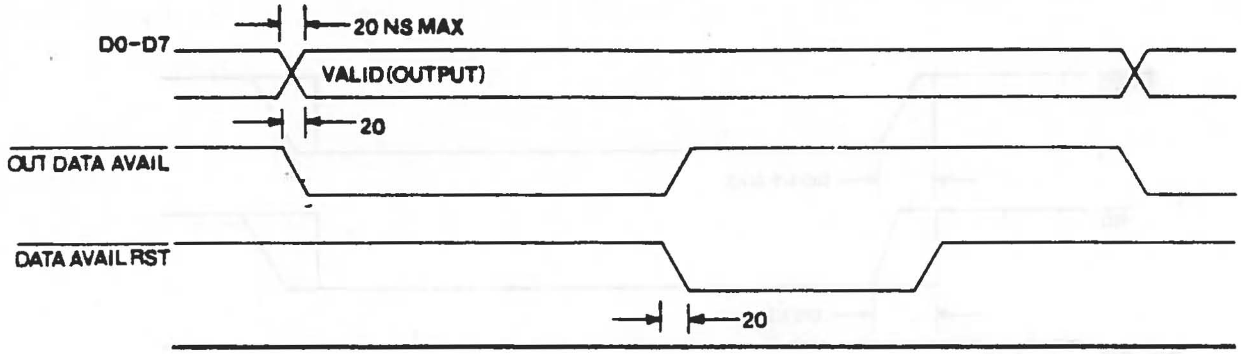


Figure 17 Parallel Output

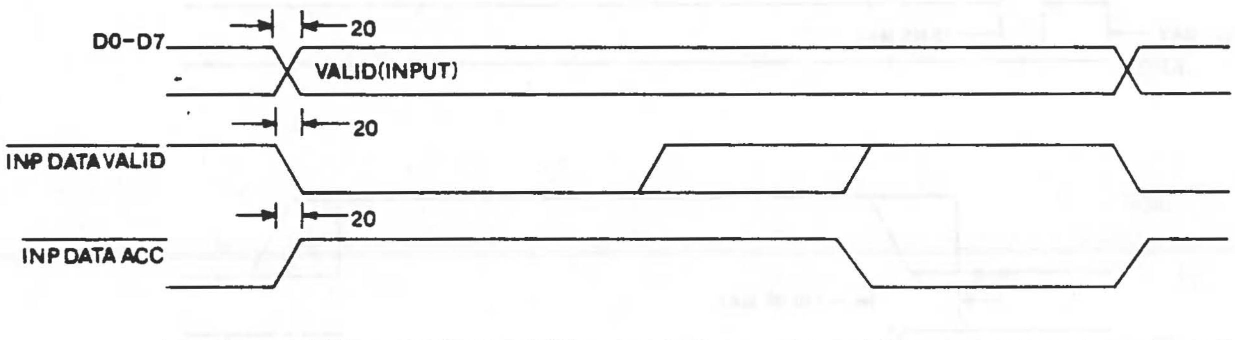


Figure 18 Parallel Input

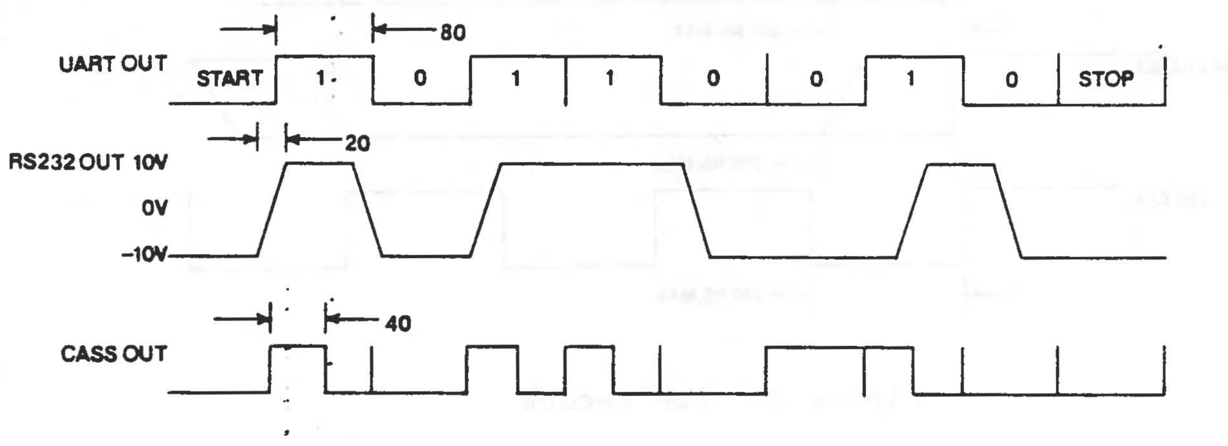


Figure 19 Serial and Cassette

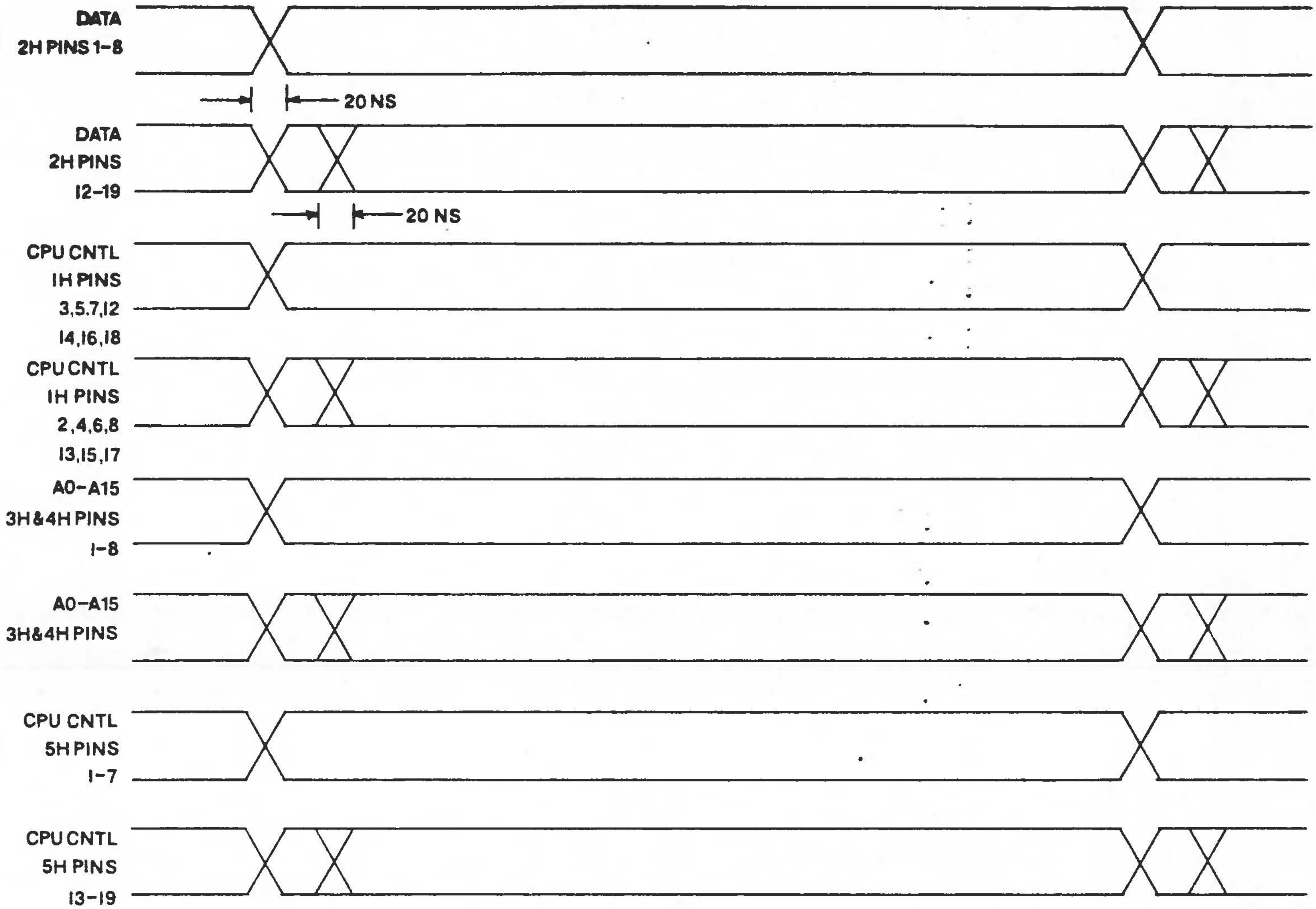


Figure 20: Expansion Unit

SORCERER 2 PARTS LIST

Complete Assemblies

Part	Qty/ Sorcerer	Exidy Part #
Logic Board Assembly	1	77-3240-25-A
Power Supply Assembly	1	77-3250-25-B
Keyboard Assembly	1	77-3140-15-A
Transformer Assembly	1	63-4030
ROM PAC PCB Assembly (does not include case or PROMs)	1	77-3115

Logic Board

Part	Qty/ Board	Location (or Reference)	Exidy Part #
Main logic PCB			77-3240-20-1
IC Socket 16 Pin PC TAB	25	A0-A7,B0-B7,C0-C7, 6D	61-8062
IC Socket 24 Pin PC TAB	3	20D,1E,2E	61-8045
IC Socket 40 Pin PC TAB	2	8E,9E	61-8035
Connector Molex 10 Pin	1	Power Supply Conn.	61-8041
Connector Amp 30 Pin	1	ROM PAC Conn.	61-8053
Connector 25 Pin D Sub.	2	Serial, Parallel	61-8063
Connector RCA Phone	3	Mic., Ear., Video	61-8066
Socket 14 Pin Keyboard	1	Keyboard Plug	71-2330
IC 74LS00	4	12B,10E,14E,14C	48-2300
IC 74LS04	6	19A,9C,8D,22D,16E, 10H	48-2302
IC 74LS08	3	9A,10C,2F	48-2312
IC 74LS10	1	14A	48-2306
IC 74LS11	1	10A	48-2332
IC 74LS14	1	13D	48-2340
IC 74LS21	1	13C	48-2316
IC 74LS27	1	16A	48-2304
IC 74LS30	1	7D	48-2324
IC 74LS32	2	9B,3F	48-2315
IC 74LS74	8	17A,14B,18B,12C, 22C,16D,10F,16F	48-2305
IC 74LS86	1	13E	48-2341
IC 74LS112	3	18A,2B,13F	48-2071
IC 74LS138	1	9D	48-2307
IC 74LS139	1	11B	48-2321

IC 74LS153	2	10B,14D	48-2322
IC 74LS155	1	6D	48-2325
IC 74LS157	5	8B,8C,15F,13A,19B	48-2323
IC 74LS161	11	21A,22A,20B,21B, 5D,15D,15E,13H, 14H,15H,16H	48-2308
IC 74LS166	1	17D	48-2309
IC 74LS174	1	11C	48-2333
IC 74LS241	14	20A,16B,17B,15C, 16C,1D,4D,10D,6E, 1F,6F,1H,6H,8H	48-2328
IC 74LS374	3	21C,2D,9H	48-2314
6331 PROM (BRUCE) (Screen Control)	1	15B	48-6331
IC 8304	7	11D,12D,2H,3H,4H, 5H,7H	48-2327
IC ROM EXMO1-1	1	1E	49-1004
IC ROM EXMO1-2	1	2E	49-1005
IC PROM EXCHR 1 (Character Generator)	1	20D	49-1006
IC Z80 CPU	1	8E	48-0Z80
IC AY51015	1	9E	48-2319
IC LM324	1	12F	48-2342
TIL 111 Opto Isolator	2	12Ea,12Eb	47-3040
IC 75150	1	11E	48-2335
IC CD4046BC	1	14F	48-2343
DIP Switch 4 Positions	1	11A	72-3024
IC RAM 2114	6	17C,18C,19C,20C, 18D,19D	48-2334
2N2222 Transistor Q1,Q2,Q3	3	11H	47-3039
TIL 220 LED CR5	1	17H	46-3040
Zener Diode IN749 CR1	1	11E	46-3051
Diode IN4002 CR2, CR3,CR4	3	11H,11H,5E	46-3025

RESISTORS:

47 Ohm 1/4 Watt 5%	4	R12,R10,R11,R15	59-5149
Resistor PAC Beckman 898-3-R47	2	3D,8A	59-5148
3.3K Ohm 1/4 Watt 5%	8	R13,R14,R17,R27, R28,R79,R25,R55	59-5100
2.2K Ohm 1/4 Watt 5%	14	R24,R26,R30,R37, R47,R48,R49,R50, R51,R52,R53,R54, R56,R59	59-5110
120 Ohm 1/4 Watt 5%	1	R60	59-5139
220 Ohm 1/4 Watt 5%	2	R16,R18	59-5138
330 Ohm 1/4 Watt 5%	2	R19,R20	59-5136
470 Ohm 1/4 Watt 5%	4	R21,R22,R64,R70	59-5135
68 Ohm 1/4 Watt 5%	1	R82	59-5146

1 Meg. 1/4 Watt 5%	1	R39	59-5025
10K Ohm 1/4 Watt 5%	3	R23,R38,R65	59-5080
2.7K Ohm 1/4 Watt 5%	1	R29	59-5105
200K Ohm 1/4 Watt 5%	2	R31,R33	59-5036
220K Ohm 1/4 Watt 5%	1	R40	59-5034
1K Ohm 1/4 Watt 5%	3	R32,R36,R43	59-5125
3.3 Meg. 1/4 Watt 5%	1	R34	59-5018
130K Ohm 1/4 Watt 5%	1	R35	59-5061
2K Ohm 1/4 Watt 5%	1	R41	59-5104
22K Ohm 1/4 Watt 5%	1	R42	59-5070
150K Ohm 1/4 Watt 5%	1	R44	59-5040
100K Ohm 1/4 Watt 5%	1	R45	59-5045
4.7K Ohm 1/4 Watt 5%	3	R46,R80,R81	59-5095
3K Ohm 1/4 Watt 5%	1	R61	59-5101
1.5K Ohm 1/4 Watt 5%	3	R58,R66,R67	59-5116
13K Ohm 1/4 Watt 5%	1	R62	59-5078
Variable Resistor 100K Pot (375 V 104B--Top Adj.)	1	VR1	54-5023
100 Ohm 1/4 Watt 5%	2	R63,R68	59-5140
68K Ohm 1/4 Watt 5%	1	R69	59-5050

CAPACITORS:

0.1 uF ceramic disc	56	C1,C2,C5,C6,C10, C14,C15,C16,C17, C20,C21,C24,C25, C27-C31,C33-C40, C42,C43,C46,C51, C52,C53,C55,C56, C59,C62,C63,C68, C70,C71,C72,C73, C75,C78,C79,C80-C84,C86-C90,C94	23-4035
33 uF 35 V Dip Tant	10	C47,C54,C64,C69, C74,C76,C85,C91, C92,C93	21-4010
1uF ceramic disc	12	C3,C4,C7,C8,C9, C11,C12,C13,C18, C19,C22,C23	23-4032
330 pF 5% ceramic disc	3	C26,C60,C65	23-4067
1000 pF 10% Dip silvered mica	2	C66,C67	25-1015
.001 uF ceramic disc DD102 50V	1	C50	23-4060
2200 pF NPO silver mica	1	C57	25-1003
3300 pF NPO silver mica	1	C58	25-1004
.047 uF X7R	1	C61	25-1006
.22 uF Mylar	1	C77	25-1016
.01 uF ceramic disc	3	C41,C44,C48	23-4050

Screw 4-40 x 1/2 phil pan head	2		74-5189
Kep nut 4-40	2		74-5191
Screw 6-32 x 3/8	2		74-5181
ROM PAC Guide	1		91-4003
#6 nylon washer	2		74-5173
12.638 MHz crystal	1	CR6	45-3038
RAM IC -- 48K	8	A0-A7	
RAM IC -- 32K	8	B0-B7	
RAM IC -- 16K	8	C0-C7	
18-pin IC socket	6	17C,18C,19C,20C, 18D,19D	61-8157

Power Supply

Part	Qty/ Board	Location (or Reference)	Exidy Part #
Power supply PCB			77-3250
Capacitor 470 uF 25V	1	C1	20-4004
Capacitor 1500 uF 25V	1	C2	25-1000
Capacitor 6000 uF 25V	1	C3	20-4013
Capacitor .1 uF ceramic disc	7	C4-C10	23-4035
Diode 6051	2	CR1,CR2	46-3016
Diode IN4002	6	CR3-CR8	46-3025
Resistor 5 ohm 10W	1	R1	55-5005
Voltage Regulator LM340-12 (or 7812)	1	VR1	48-2338
Voltage Regulator LM323	1	VR2	48-2336
Voltage Regulator LM320-5 (or 7905)	1	VR3	48-2337
Connector #641388-6MTS 6 pin header AMP	1	J1	61-8064
Connector 09-52-3102 10-pin 100 AMP	1	J2	61-8042
Heatsink #690-3 (no sub.)	1	VR2	68-7005
Hex nut #6 x 32 (small pattern)	4	VR2 x 2,VR1,VR3	75-3059
Screw 6-32 x .375 (stainless)	4	VR2 x 2,VR1,VR3	74-5181
Tie wrap (small)	1	C3	88-4002

Keyboard Assembly

Part	Qty/ Board	Exidy Part #
Keyboard PCB	1	77-3140-14-A
Key switch pad set-63, key top set-63, space		

bar	1	72-3050
IN270 germanium diode	2	46-3015
7414	1	48-2350
74L154	1	48-2320
3.3K ohm 1/4 watt resistor	5	59-5100
Set of 16 numeric keys with pad	1	72-3051
14 pin ribbon cable	1	71-2330

Transformer Assembly

Part	Qty/ Board	Exidy Part #
Transformer	1	63-4030
Mounting bracket (100-018)	1	68-7090-1
AC power cord	1	71-2328
Power cord retaining ring (strain relieve bushing #SR-4K-1)	1	74-5050
On-off switch	1	72-3052
Fuse holder (1 amp)	1	60-6038
1 amp fuse (lamp, slo blow)	1	60-6037
2K1 line filter	1	90-3000
6 pin Molex socket #09-50-3061	1	61-8043
Pin contact #08-50-0106	6	61-8044
Machine screw 6/32 x 3/8 phil. pan hd.	4	74-5181
Kep nut 6/32	4	74-5176
Shrink tubing 1/4"	a/r	88-4004
110V (or 220V) tape-on label	1	

General Mechanical Parts

Part	Qty/ Sorcerer	Exidy Part #
Upper Enclosure Assy.	1	37-0003
Lower Enclosure Assy.	1	37-0102
6/32 x 3/8 phil. pan hd. machine screw	5	74-5181
Video cable	1	71-2326
Cassette cable	2	71-2327
Operations manual	1	33-5001
Carrying case (point of purchase carton)	1	87-1073
Write-on label	1	89-1001
Serial # label	1	89-2006
Rubber bands	4	

Upper housing	1	91-4001
Heat vent screen (upper rear)	1	68-0001-10
Heat vent screen (upper side)	1	68-0001-20
Heat vent screen (lower front)	2	68-0001-20
Heat vent screen (lower side)	1	68-0001-30
6/32 x 1/4 phil. pan hd. machine screw	26	74-5182
#6 nylon washer	1	74-5173
Exidy logo overlay	1	89-2000
Keyboard panel overlay	1	89-2005
Strip front overlay	1	89-2001
Strip rear overlay	1	89-2002
Foam tape (3M 4" x 6" x 1/4")	1	88-4017
Microprocessor board assembly	1	37-0104
Power supply board assembly	1	37-0105
Transformer assembly	1	27-0103
Lower enclosure	1	91-4002
6/32 x 1/2 threaded standoff (aluminum)	6	74-5090
6/32 x 3/8 screw	4	74-5181
6/32 kep nut	4	74-5176
6/32 x 1/2 threaded standoff (nylon)	4	74-5075
Adhesive (IPS weld-on #1001)	A/R	

4		3		2		1	
Hex	Dec	Hex	Dec	Hex	Dec	Hex	Dec
0	0	0	0	0	0	0	0
1	4096	1	256	1	16	1	1
2	8192	2	512	2	32	2	2
3	12288	3	768	3	48	3	3
4	16384	4	1024	4	64	4	4
5	20480	5	1280	5	80	5	5
6	24576	6	1536	6	96	6	6
7	29672	7	1792	7	112	7	7
8	32768	8	2048	8	128	8	8
9	36864	9	2304	9	144	9	9
A	40960	A	2560	A	160	A	10
B	45056	B	2816	B	176	B	11
C	49152	C	3072	C	192	C	12
D	53248	D	3328	D	208	D	13
E	57344	E	3584	D	224	E	14
F	61440	F	3840	F	240	F	15
Bits 4-7		Bits 0-3		Bits 4-7		Bits 0-3	
HIGH ORDER BYTE				LOW ORDER BYTE			

Table 5 Hexadecimal - Decimal Conversion