RCA

VIP EXPANSION KEYPAD VP580

VIP EXPANSION KEYPAD INTERFACE BOARD VP585

VIP COLOR BOARD VP590

VIP SIMPLE SOUND BOARD VP595

INSTRUCTION MANUAL INCLUDING CHIP-8X

RCA COSMAC VIP MARKETING
New Holland Avenue
Lancaster, PA 17604

71L233

CONTENTS

Chapter I

Introduction

Welcome to an expanded world of VIP fun!

This manual will show you how to install and use three expansion modules for your VIP: the VP-590 Color board, the VP-595 Simple Sound board, and the VP-580 Expansion Keypad. This manual also covers the use of the VP-585 Expansion Keypad Interface card, which you will need if you are using one or two Expansion Keypads and do not have the Color board.

All three boards are covered in one manual because they are designed to complement one another. A single game or other application can be programmed to use color, extended sound and a second keypad, so we have provided information on all three in the same manual. In Appendix A to this manual we have provided some games which use several of these features together.

To use these units together this manual contains a revised version of the CHIP-8 interpreter originally furnished with your VIP. Rather than relying on the use of specialized machine language subroutines, the new version of CHIP-8, which we have named CHIP-8X, allows you to program these new VIP capabilities just as you have programmed applications using the VIP alone.

Chapter II of this manual will show you how to modify your present version of CHIP-8 to create CHIP-8X, and will give you a brief description of the new commands. Chapter III explains how to install and use the Color board, Chapter IV covers the Simple Sound board, and Chapter V explains the use of the Expansion Keypad. Chapter VI gives schematics, parts lists, and a brief theory of operation for each module. Appendix A provides two games which use the features of these expansion modules.

Please take time to read this manual and try some of the sample programs we have provided. As always, the best way to learn is to <u>do</u>, so when you have read the material on a particular module, try writing a simple program which uses the new features.

All of the programming information in this manual assumes that you already know how to use the CHIP-8 language and are familiar with the hexidecimal notation used in VIP programming. If this is not the case, we suggest that you first read the VIP User Guide and try some programming in CHIP-8 before attempting to use the extended features provided in CHIP-8X.

A Note on Power Supplies

All three modules described in this manual can safely be used simultaneously when powered from the regulated power supply provided with your VIP. If you have expanded the memory used on your VIP, you should check that your VIP, with all modules installed, draws less than .6A from the power supply. The CMOS circuits used in the VIP and its expansion modules are very tolerant of power supply variations but the memory circuits require a voltage of 5.0V $\pm$ 5% for proper operation. Excessive current drawn from the power supply will also cause it to overheat, thus shortening its operational life.

Help

We have tried to make sure that the information in this manual is as accurate as possible, but nobody is perfect. If you think you have found an error in the manual, or if the information we have provided is unclear, contact the Product Manager for VIP Products, New Holland Pike, Lancaster, PA 17604. RCA cannot provide programs for specific applications, nor can we provide "debugging" assistance on user programs.

Chapter II

CHIP-8X

CHIP-8X is an expanded version of the original CHIP-8 interpreter which allows easy control over RCA's new options for the VIP: color card, simple sound, and expansion hex keyboard. Programs written in CHIP-8X will run on a standard VIP with none of the options installed, but for full feature use the options will greatly enhance your enjoyment.

All of the instructions from the original CHIP-8, <u>except BMMM</u>, are valid for CHIP-8X, and CHIP-8X offers these new instructions:

Instruction	Function
FXF8	VX → output port (used to program simple sound)
FXFB	Input port → VX (waits for EF4=1)
EXF2	Skip next instruction if VX= hex keypad 2
EXF5	Skip next instruction if VX≠ hex keypad 2
BXY0	Set VY color @ VX(#H), VX+1(NV) (provides low resolution color 8x8)
BXYN	N≠Ø, set VY color @ VX, VX+1 byte N bytes vertically (provides high resolution color 8x32)
02A0	Steps background 1 color (→ blue → black → green → red →)
5XY1	Let VX= VX+VY (hex digits ØØ to 77) (useful for manipulating the NH, NV parameters for low resolution color)

We will cover the use of these instructions in more detail in the subsequent chapters. Your first task is to enter the modifications which transform CHIP-8 into CHIP-8X. You begin this process by loading a copy of CHIP-8 into memory from tape. Loading the first two pages of any CHIP-8 game will give you the proper memory contents to begin. The new version of CHIP-8X will require three pages of memory (ØØØØ-Ø2FF).

CHIP-8X can be created by modifying the original CHIP-8 interpreter as follows:

1) Load the original CHIP-8 into M(ØØØØ) - M(Ø1FF).
2) Replace original codes with new codes shown below:
   (Those memory addresses which must be modified if you relocate this code to another memory area are flagged with an asterisk.)

Memory Address	New Code	Original Code
0015	02	01
0018	FA	FC
0055	00	01
*005B	02	01
0065	FE	95
*006B	00	A4
00FE	05F6	0000
0100	33A4	0000
0102	3095	0000
01A4	E606	F8F0
01A6	FA77	A7E7
01A8	5607	45F4
01AA	FA77	A586
01AC	F4FA	FA0F
01AE	7756	3BB2
01B0	15D4	FC01
01B2	0000	B5D4
01F2	3788	0000
01F4	D43F	0000
01F6	88D4	0000
01F8	E663	0000
01FA	D4E6	0000
01FC	3FFC	00E0
01FE	6BD4	004B

The following color subroutine must be entered starting at M(Ø2ØØ).

Memory Address	Codes
Ø2ØØ	92BD
Ø2Ø2	F89FAD
Ø2Ø5	ØD
*Ø2Ø6	32ØA
Ø2Ø8	45D4
Ø2ØA	ØØ45
Ø2ØC	FAØFAF
*Ø2ØF	3231
Ø211	46FA3F
Ø214	F6F6F6
Ø217	2252E2
Ø21A	Ø6FA1F
Ø21D	FEFEFE
Ø22Ø	F1AC12
Ø223	F8DØBC
Ø226	Ø75C8C
Ø229	FCØ8AC
Ø22C	2F8F
*Ø22E	3A26
Ø23Ø	D4
Ø231	Ø7BD
Ø233	46AC
Ø235	Ø6BC
Ø237	8CFAØ7
Ø23A	2252E2
Ø23D	F8CØBE
Ø240	9C
Ø241	F6F6F6F6
Ø245	FAØ7AD9C
Ø249	FEFEFEFEFE
Ø24E	F4AE8C
Ø251	F6F6F6F6
Ø255	FAØ7AF
Ø258	9EB7
Ø25A	8EA7
Ø25C	8DBC
Ø25E	F8Ø4AC
Ø261	9D5787
Ø264	FCØ8A7
Ø267	2C8C
*Ø269	3A61
Ø26B	9C
*Ø26C	3273
Ø26E	FFØ1BC
*Ø271	3Ø5E
Ø273	1E8E
Ø275	FAE7AE
Ø278	8F
*Ø279	327E
Ø27B	2F
Ø27C	3Ø58
Ø27E	12D4

The following code begins at M(Ø28Ø) and is a routine that scans for the color map at M(CØØØ). If the color map is found, a "ØØ" is stored at M(ØY9F). If no color map exists then an "Ø1" is placed in storage and color instructions DO NOT EXECUTE. This allows color programs to be run on a standard B&W VIP. This subroutine is automatically called during CHIP-8X initialization; you need not call it from your program.

Memory Address	Code
Ø28Ø	92BD
Ø282	F89FAD
Ø285	F8CØBC
Ø288	94AC
Ø28A	F8AA5C
Ø28D	94BCAC
Ø290	ØCFB91
Ø293	329C
Ø295	F8915C
Ø298	F8Ø15D
Ø29B	D4
Ø29C	F8ØØ5D
Ø29F	D4

At M(Ø2AØ) there is a 4 byte subroutine called from CHIP-8X programs to switch background colors.

Ø24Ø	E265
Ø2A2	22D4

The space between M(Ø2A5) and M(Ø2FA) is available for other machine language subroutines and is planned to contain routines for future expansions (i.e. Joy Sticks etc.).

Finally, these CHIP-8 instructions must be placed as follows:

Ø2FA	Ø28Ø	....scans for color map
Ø2FC	ØØEØ	....erase display page
Ø2FE	ØØ4B	....TV on

The listing below is a hex dump of CHIP-8X including the unmodified portions of CHIP-8. You can use this table as a master listing of CHIP-8X. Memory locations Ø2A4 through Ø2F9 can have any value without affecting the operation of CHIP-8X.

<u>CHIP-8X Listing</u>

```
0000  91 BB FF 01 B2 B6 F8 CF
0008  A2 F8 81 B1 F8 46 A1 90
0010  B4 F8 1B A4 F8 02 B5 F8
0018  FA A5 D4 96 B7 E2 94 BC
0020  45 AF F6 F6 F6 F6 32 44
0028  F9 50 AC 8F FA 0F F9 F0
0030  A6 05 F6 F6 F6 F6 F9 F0
0038  A7 4C B3 8C FC 0F AC 0C
0040  A3 D3 30 1B 8F FA 0F B3
0048  45 30 40 22 69 12 D4 00
0050  00 01 01 01 01 00 01 01
0058  01 01 01 02 01 00 01 01
0060  00 7C 75 83 8B FE B4 B7
0068  BC 91 EB 00 D9 70 99 05
0070  06 FA 07 BE 06 FA 3F F6
0078  F6 F6 22 52 07 FA 1F FE
0080  FE FE F1 AC 9B BC 45 FA
0088  0F AD A7 F8 D0 A6 93 AF
0090  87 32 F3 27 4A BD 9E AE
0098  8E 32 A4 9D F6 BD 8F 76
00A0  AF 2E 30 98 9D 56 16 8F
00A8  56 16 30 8E 00 EC F8 D0
00B0  A6 93 A7 8D 32 D9 06 F2
00B8  2D 32 BE F8 01 A7 46 F3
00C0  5C 02 FB 07 32 D2 1C 06
00C8  F2 32 CE F8 01 A7 06 F3
00D0  5C 2C 16 8C FC 08 AC 3B
00D8  B3 F8 FF A6 87 56 12 D4
00E0  9B BF F8 FF AF 93 5F 8F
00E8  32 DF 2F 30 E5 00 42 B5
00F0  42 A5 D4 8D A7 87 32 AC
00F8  2A 27 30 F5 00 00 05 F6
0100  33 A4 30 95 00 45 A3 98
0108  56 D4 F8 81 BC F8 95 AC
0110  22 DC 12 56 D4 06 B8 D4
0118  06 A8 D4 64 0A 01 E6 8A
0120  F4 AA 3B 28 9A FC 01 BA
0128  D4 F8 81 BA 06 FA 0F AA
0130  0A AA D4 E6 06 BF 93 BE
0138  F8 1B AE 2A 1A F8 00 5A
0140  0E F5 3B 4B 56 0A FC 01
0148  5A 30 40 4E F6 3B 3C 9F
0150  56 2A 2A D4 00 22 86 52
0158  F8 F0 A7 07 5A 87 F3 17
0160  1A 3A 5B 12 D4 22 86 52
0168  F8 F0 A7 0A 57 87 F3 17
0170  1A 3A 6B 12 D4 15 85 22
0178  73 95 52 25 45 A5 86 FA
0180  0F B5 D4 45 E6 F3 3A 82
0188  15 15 D4 45 E6 F3 3A 88
0190  D4 45 07 30 8C 45 07 30
0198  84 E6 62 26 45 A3 36 88
01A0  D4 3E 88 D4 E6 06 FA 77
01A8  56 07 FA 77 F4 FA 77 56
01B0  15 D4 00 00 45 56 D4 45
01B8  E6 F4 56 D4 45 FA 0F 3A
01C0  C4 07 56 D4 AF 22 F8 D3
01C8  73 8F F9 F0 52 E6 07 D2
01D0  56 F8 FF A6 F8 00 7E 56
01D8  D4 19 89 AE 93 BE 99 EE
01E0  F4 56 76 E6 F4 B9 56 45
01E8  F2 56 D4 45 AA 86 FA 0F
01F0  BA D4 37 88 D4 3F 88 D4
01F8  E6 63 D4 E6 3F FC 6B D4
0200  92 BD F8 9F AD 0D 32 0A
0208  45 D4 00 45 FA 0F AF 32
0210  31 46 FA 3F F6 F6 F6 22
0218  52 E2 06 FA 1F FE FE FE
0220  F1 AC 12 F8 D0 BC 07 5C
0228  8C FC 08 AC 2F 8F 3A 26
0230  D4 07 BD 46 AC 06 BC 8C
0238  FA 07 22 52 E2 F8 C0 BE
0240  9C F6 F6 F6 F6 FA 07 AD
0248  9C FE FE FE FE FE F4 AE
0250  8C F6 F6 F6 F6 FA 07 AF
0258  9E B7 8E A7 8D BC F8 04
0260  AC 9D 57 87 FC 08 A7 2C
0268  8C 3A 61 9C 32 73 FF 01
0270  BC 30 5E 1E 8E FA E7 AE
0278  8F 32 7E 2F 30 58 12 D4
0280  92 BD F8 9F AD F8 C0 BC
0288  94 AC F8 AA 5C 94 BC AC
0290  0C FB 91 32 9C F8 91 5C
0298  F8 01 5D D4 F8 00 5D D4
02A0  E2 65 22 D4 00 00 00 00
02A8  00 00 00 00 00 00 00 00
02B0  00 00 00 00 00 00 00 00
02B8  00 00 00 00 00 00 00 00
02C0  00 00 00 00 00 00 00 00
02C8  00 00 00 00 00 00 00 00
02D0  00 00 00 00 00 00 00 00
02D8  00 00 00 00 00 00 00 00
02E0  00 00 00 00 00 00 00 00
02E8  00 00 00 00 00 00 00 00
02F0  00 00 00 00 00 00 00 00
02F8  00 00 02 80 00 E0 00 4B
```

After you have loaded CHIP-8X and verified your entries, save a copy of CHIP-8X on tape. Remember to save three pages, not two.

Table I - CHIP-8X Instructions

1MMM	Go to 0MMM
2MMM	Do subroutine at 0MMM (must end with 00EE)
00EE	Return from subroutine
3XKK	Skip next instruction if VX=KK
4XKK	Skip next instruction if VX≠KK
5XY0	Skip next instruction if VX=VY
5XY1	Let VX=VX+VY (hex digits 00 to 77)
9XY0	Skip next instruction if VX≠VY
EX9E	Skip next instruction if VX=Hex key #1 (LSD)
EXA1	Skip next instruction if VX≠Hex key #1 (LSD)
EXF2	Skip next instruction if VX=Hex key #2 (LSD)
EXF5	Skip next instruction if VX≠Hex key #2 (LSD)
6XKK	Let VX=KK
CXKK	Let VX=Random Byte (KK=Mask)
7XKK	Let VX=VX+KK
8XY0	Let VX=VY
8XY1	Let VX=VX/VY (VF changed)
8XY2	Let VX=VX & VY (VF changed)
8XY4	Let VX=VX+VY (VF=00 if VX+VY≤FF, VF=01 if VX+VY>FF)
8XY5	Let VX=VX-VY (VF=00 if VX<VY, VF=01 if VX≥XY)
FX07	Let VX=current timer value
FX0A	Let VX=hex key digit (waits for any key pressed #1)
FX15	Set timer=VX (01=1/60 second)
FX18	Set tone duration=VX (01=1/60 second)
FXF8	VX to output port
FXFB	Input port to VX (waits for EF4=1)
AMMM	Let I=0MMM
FX1E	Let I=I+VX
FX29	Let I=5-byte display pattern for LSD of VX
FX33	Let MI=3-decimal digit equivalent of VX (I unchanged)
FX55	Let MI=V0 : VX (I=I+X+1)
FX65	Let V0 : VX=MI (I=I+1)
00E0	Erase display (all 0's)
DXYN	Show n-byte MI pattern at VX-VY coordinates. I unchanged. MI pattern is combined with existing display via EXCLUSIVE-OR function. VF=01 if a 1 in MI pattern matches 1 in existing display.
0MMM	Do machine language subroutine at 0MMM (subroutine must end with D4 byte)
BXY0	Set VY color @ VX(NH), VX+1(NV)
BXYN	N≠0, set VY color @ VX, VX+1 byte, N bytes vertically
02A0	Step background 1 color

Chapter III

The VP-590 Color Board

Installation

To connect your Color board, three steps are necessary. First, several components must be removed from your VIP. Second, the Color board must be installed on the VIP. Third, the Color board must be attached to your color display unit (monitor or TV set with a RF modulator).

1. Modifying your VIP - Disconnect all power from the VIP. Remove the dust cover from your VIP by loosening and removing the retaining nut on the RESET/RUN toggle switch. Remove the cover by gently prying the lower edge of the cover from one side of the VIP circuit board. The cover will then lift off. Locate the two integrated circuit chips mounted in sockets marked U3 and U4 (see Figure 1-III). Remove the integrated circuits by gently prying them up. Also remove the integrated circuit marked on the board as U2 (type 1861). Install a short wire jumper between pins 3 and 5 of the socket of U4. Figure 1 shows the location of U2, U3, and U4. Figure 2 shows the placement of the jumper. Before replacing the dust cover, you may wish to modify the speaker wiring if you also intend to use the Simple Sound board. See Chapter IV. Replace the dust cover by snapping it back over the VIP circuit board. Screw the retaining nut back onto the RESET/RUN switch. The 1861 integrated circuit removed from the VIP should now be inserted in the socket on the Color board - refer to diagram figure 3-III and gently snap the circuit into the socket. Make sure the notch on the IC is correctly oriented.
2. Place the Color board in the left socket on the rear of the VIP circuit board (the expansion connector). The components on the

Color board should face toward the front of the VIP. The color board should be pushed down firmly until it is completely inserted in the socket.

3. If you are using a color monitor for your video display, connect the coaxial cable from the Color board to the monitor input jack. If you are using an external RF modulator unit with a color TV set, follow the modulator manufacturer's instruction. You can now test your installation by applying power to the VIP and turning on your color monitor. Hold down the "C" key and move the toggle switch from RESET to RUN. The usual pattern of white dots should appear, but they should now appear on a blue background. Adjust the controls on the monitor or TV set for a satisfactory display. Note that the Color board will work satisfactorily with a black and white monitor providing gray levels instead of colors. There will be no output from the video cable attached to the VIP circuit board unless the Color board is disconnected, the jumper is removed and U2, 3, and 4 are replaced. Black and white CHIP-8 programs will operate normally on a VIP with the Color board installed, except that the display will now be white on blue. Only programs written using CHIP-8X color commands will appear in color.

A Color Test Program - load your copy of CHIP-8X from tape and enter the following color test program:

0300	A32E	0316	C577	0326	F807
0302	6200	0318	CC07	0328	3800
0304	6100	031A	B4C0	032A	1326
0306	D124	031C	C707	032C	1314
0308	7108	031E	4701	032E	FFFF
030A	3140	0320	02A0	0330	FFFF
030C	1306	0322	6820		
030E	7204	0324	F815		
0310	3220				
0312	1304				
0314	C477				

Table 1-III

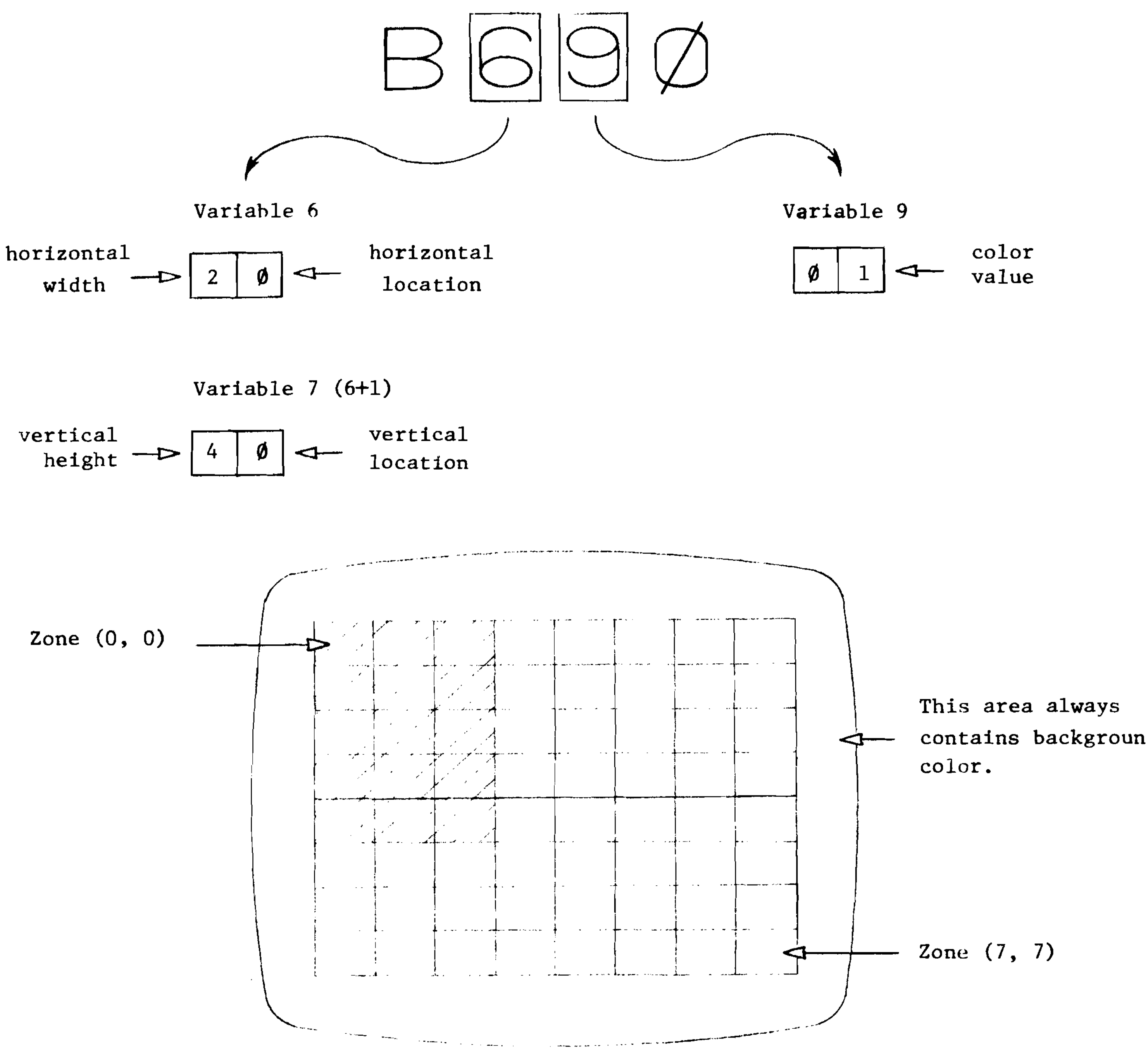
Color Value	Foreground Color
Ø	Black
1	Red
2	Blue
3	Violet
4	Green
5	Yellow
6	Aqua
7	White

The X in BXYØ represents the number of the variable which contains both the horizontal position and horizontal size of the area. The most significant digit of VX specifies the width (1 to 8 zones) of the area. The least significant digit of VX specifies the horizontal position (Ø-7) of the left-most zone in the area.

The vertical position and size of the area is specified by V(X+1), the next higher numbered variable. The size of the area defined is always one greater than the number specified (thus an area defined with a width of Ø will actually be 1 zone wide).

As an example, suppose we wanted to define a red area in the upper-left corner of the screen which was three zones wide and 5 zones high (24 dots x 20 dots). We will store this information in variables V9, V6 and V7. Store a value of Ø1 in V9 to define the color as red. V6 should be set to 2Ø (2+1=3 for the area width, zero for the horizontal coordinate). V7 should be set to 4Ø (4+1=5 for the area height, zero for the vertical coordinate).

The area would be defined by the instruction B69Ø.



= area defined as red foreground by B690, V6=2Ø, V7=4Ø, V9=Ø1

As another example, suppose you wanted to set yellow as foreground color for the entire display.

Address	Code	
0300	6205	V2=05 (yellow color value)
0302	6670	V6=70 (7=height-1, 0=horizontal coordinate)
0304	6770	V7=70 (7=width-1, 0=vertical coordinate)
0306	B620	Define 8 x 8 yellow area with upper left-hand corner at 0,0.

5XY1 - special addition routine for low-resolution color definition.

In the BXY0 instruction the variables VX and VX+1 are each treated as two single-digit hex numbers rather than a single two-digit number. In addition only the numbers 0-7 are valid for each digit. To assist in manipulating these variables, the 5XY1 instruction is provided in CHIP-8X. This instruction adds each digit in VX to each digit in VY, stores the result in VX, and translates the result to modulus 8. Thus if V7=36 and VA=22 then an instruction 57A1 would leave a value of 50 in V7. This occurs because 2+3=5 for the most significant digit and 6+2=8 for the least significant digit. Since the result of the addition of the two least significant digits is greater than seven only the value of the 3 least significant bits, which in this case is 0, is retained.

BXYN - set high resolution color foreground area.

For some applications it is useful to be able to divide the display screen into color zones smaller then the 8 x 4 dot area controlled by the BXY0 instruction. The BXYN does this by dividing the display area into zones which are each 8 x 1 dots. Thus each byte displayed on the screen can be defined separately. BXYN allows you to define a foreground color area which is one byte (eight dots) wide and one to fifteen dots high. Variable VY defines the color of the area, just as with the BXY0. The instruction works similarly to the DXYN instruction of CHIP-8X. It turns the color block containing the VX, VX+1 coordinates to the VY color, N bytes high. Thus the same coordinates used to show a pattern can be used to define color at the same location.* Variable VX defines the horizontal column (0-3F) and VX+1 defines the starting row (0-1F) for the area. N is a hex number (1-F) defining the height of the area. Thus to define a green foreground area for the third dot over from the left edge of the display area, starting at the ninth row of dots and extending downward for ten (decimal) rows you would:

1. Define a variable which contains 04 (green).
2. Define a variable which contains 02 (column number).
3. Define the next variable to contain 08 (the starting row of the area).
4. Use an N value of A (hexidecimal 10) for the height of the display.

For instance:

Instruction	Comments
6304	V3=04
6702	V7=02
6808	V8=08
B73A	set foreground to green for 10 vertical color blocks starting at (2,8)

*NOTE: Because of the CHIP-8X display format routines, if the pattern is more than 1 bit wide it is necessary to also change the next higher horizontal color blocks. This can be easily done by incrementing the VX variable by 8 (7X08), executing another set color instruction (BXYN) and decrementing VX to its original value (7XF8).

VIP Component Location Map

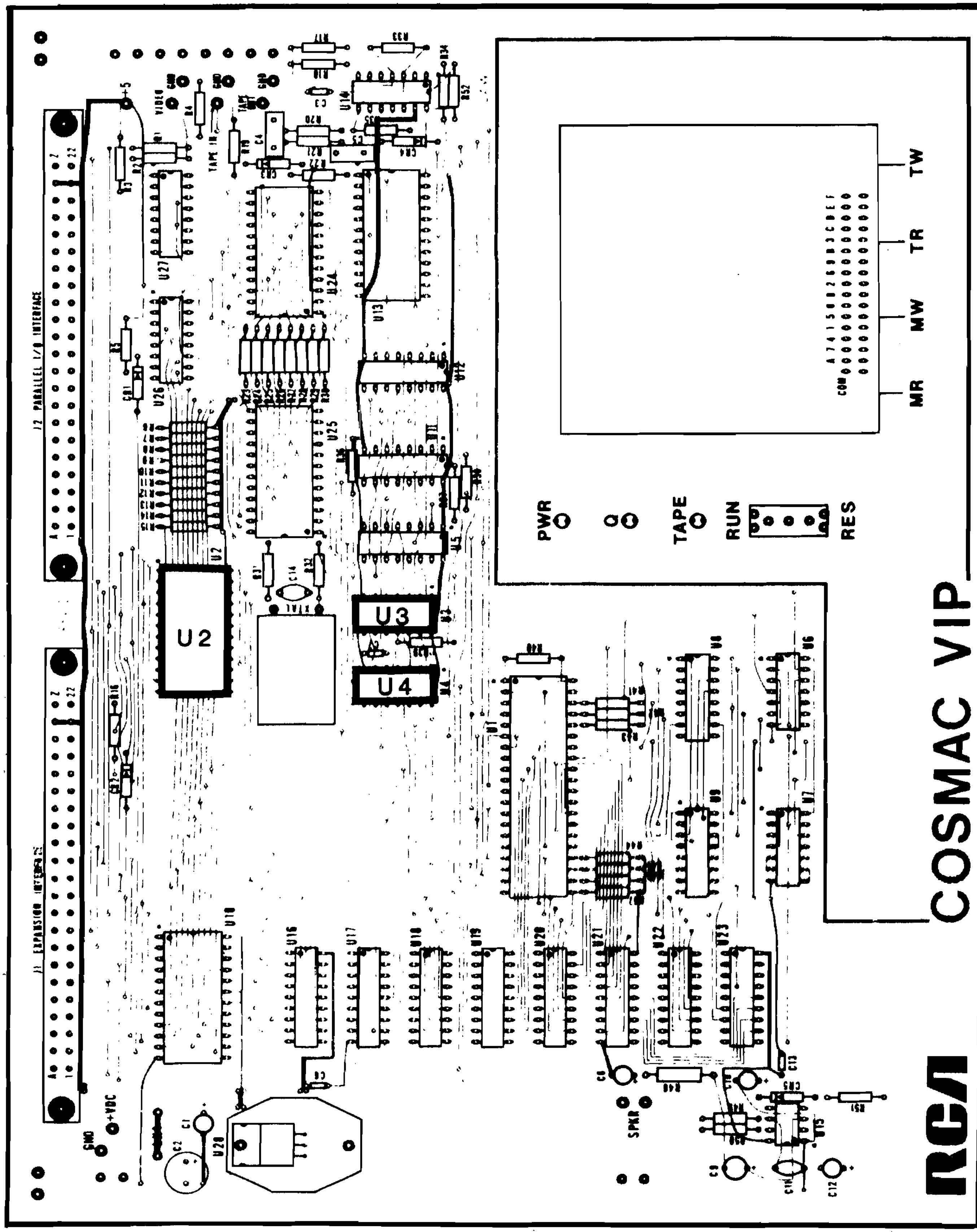


Figure 1-III

U4 Jumper Placement

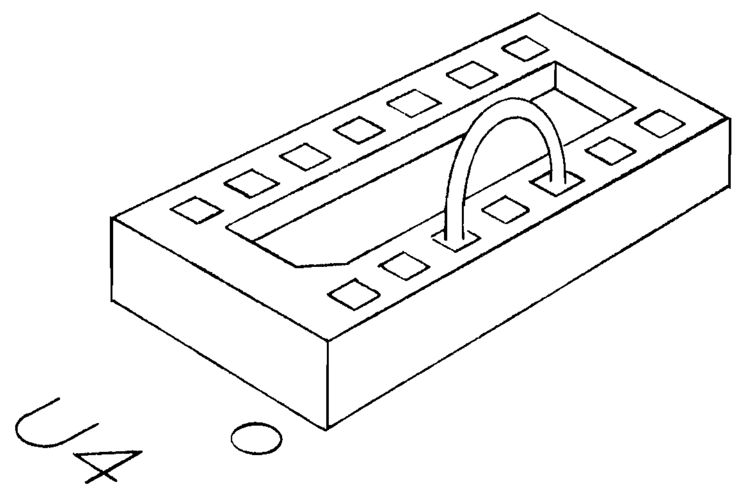


Figure 2-III

Color Board Component Location Map

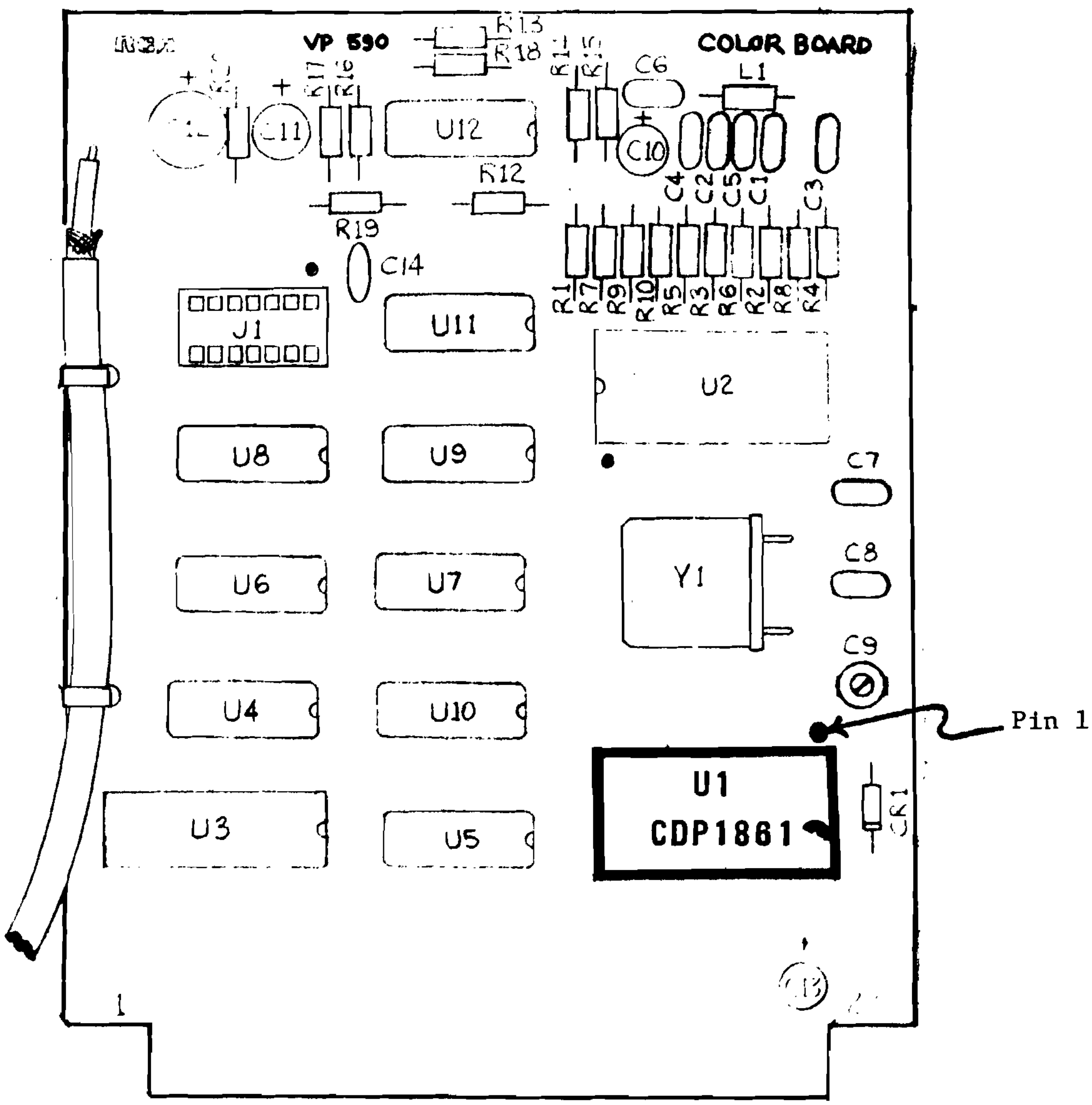


Figure 3-III

Chapter IV

The VP-595 Simple Sound Board

Installation

The Simple Sound board uses the processor Q line to turn the sound on and off. The Q line is also connected to the "beeper" circuitry of the VIP, so the VIP speaker must be disabled when the Simple Sound board is in use. The most flexible arrangement is to place a switch in series with one of the VIP speaker leads. This allows you to easily switch between the speaker and the Simple Sound output. If you intend to always leave the Simple Sound board connected to your VIP, just cutting a speaker lead is sufficient.

In any case, to get access to the VIP speaker leads you must remove the VIP dust cover, as described in Chapter II. You can then use a pair of wire cutters or even scissors to cut one of the speaker leads. Figure 1-IV shows the speaker location. If you wish to install a switch in the speaker lead, just unsolder one of the speaker leads from the printed circuit card, attach the free lead to a switch, and solder a wire from the other side of the switch to the point on the printed circuit card from which you removed the speaker wire. Replace the dust cover and your VIP modification is complete.

To install the Simple Sound board, insert it in the right-hand VIP connector (the I/O connector).

Testing

Once the board is installed, apply power to the VIP and move the toggle switch from RESET to RUN while holding down the "C" key. You should get a tone from the Simple Sound speaker as long as the "C" key is depressed. If you also get a tone from the VIP speaker, the switch you installed to cut off the speaker is in the wrong position.

To test CHIP-8X capabilities with Simple Sound, load CHIP-8X from tape and then enter the following program:

address	contents	remarks
0300	6008	V0=08
0302	6100	V1=00
0304	F1F8	V1→out
0306	F015	V0→Timer
0308	F018	V0→Tone
030A	F207	Timer→V2
030C	3200	Skip if V2=0
030E	130A	Go back 2 instructions
0310	7101	V1=V1 + 01
0312	1304	Go to third instruction

When you run this program you should hear a tone starting at a high pitch which descends in steps to a low pitch and then repeats.

Programming

There is only one instruction in CHIP-8X which is used with the Simple Sound board: FXF8. This instruction takes the byte stored in variable VX and puts it in the output port. This instruction can be used for general control of any device connected to the output port, but here we will only consider its use with the Simple Sound board.

The Simple Sound board (see Figure 2-IV for block diagram) is composed of a high frequency oscillator, whose frequency is about 440 Khz. This frequency may be varied slightly by the trimming resistor R2 on the Simple Sound board. This high frequency is fed into a programmable divider - a circuit whose output frequency is a function of the input frequency divided by the binary number present on the VIP output port. The general form of the equation defining frequency generated is:

$$\text{Frequency Generated} = \frac{\text{Input Frequency}}{(\text{Hex Code} + 1)_{10}\,(16)}\ \text{Hz}$$

The only exception to this rule occurs when a value of 00 is sent to the VIP output port. In this case special Circuity on the Simple Sound board forces a divide ratio of

129X16 which results in an output tone of about 213 cycles per second. This feature was added to the Simple Sound board because the VIP puts a value of 00 in the output port every time the VIP is initialized. Normally this would result in no tone being generated, which would interfere with the operation of the monitor program (no tone would be heard when you depressed a key on the keypad).

Regardless of the value stored in the output port, no tone will be generated unless the Q line is at logic one (high). Thus you are able to program an output frequency and then determine the length of the output tone by controlling how long the Q line is on. After passing through the switch controlled by the Q line, the tone is passed through an amplifier. The gain (volume) of the amplifier is controlled by potentiometer R4 on the right side of the Simple Sound board. The amplifier output is then connected to the speaker.

To put out a burst of sound from the Simple Sound speaker, you simply:

1. Put the desired divide ratio into a variable. (See Table 1-IV for frequency vs hex code data out.)

2. Transfer the contents of that variable to the output port through a FXF8 instruction.

3. Set a variable to the desired length of tone (in 1/60th of a second increments).

4. Set the tone output length with a FX18 instruction.

For example, to generate a one-second "beep" of a 2300 cps tone:

0300	603A	V0=3A (60_{10})
0302	6112	V1=12 (divide ratio)
0304	F1F8	V1 output port
0306	F018	V0 Tone + timer
0308	1308	loop forever here

Miscellaneous

The Q line is used to put out the pulse sequence used when saving memory contents on tape. This pulse train will be heard as a buzzing or rasping sound on the Simple

Sound output whenever data is saved.

If you wish to record the Simple Sound output or use an earphone for private listening, a jack is provided on the board. This jack can also be connected to a larger speaker or the auxiliary input of a larger amplifier. Whenever a plug is inserted in the jack, the on-board speaker is disconnected.

Table 1-VI provides a quick reference of hex code vs frequency along with the corresponding musical note and octave. You will find this convenient for composing tunes that compliment your CHIP-8X programs.

Speaker Switch Connection

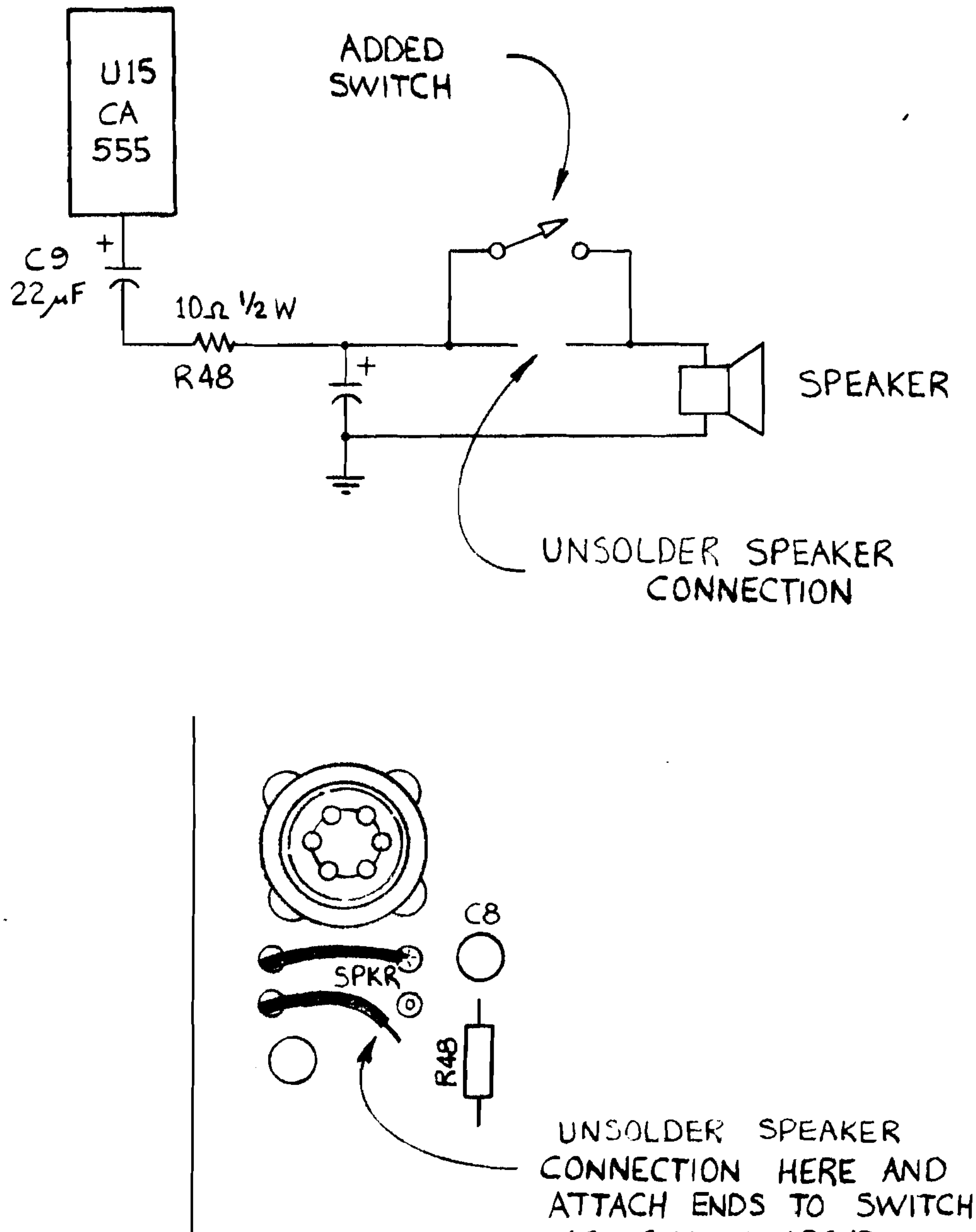


Figure 1-IV

Simple Sound Block Diagram

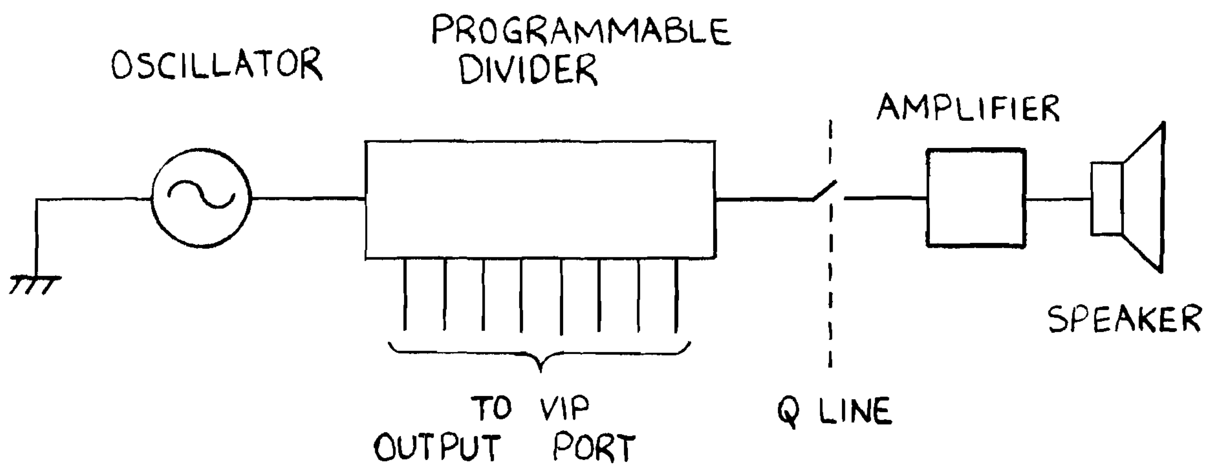


Figure 2-IV

Chapter V

VP-580 VIP Expansion Keypads

One or two Expansion Keypads may be added to your VIP. Sockets for connecting the Expansion Keypads are located on the VP-590 Color board. If you wish to use the keypads without a Color board, you will need a VP-585 Keypad Interface card.

Adding one keypad gives you a second input device for two-player games. CHIP-8X contains two new instructions for accessing this external keypad. If a second keypad is added, it duplicates the function of the VIP's on-board keypad. This keypad is accessed using the normal CHIP-8 keypad instructions. Through this text we will refer to the keypad which uses the new instructions as Keypad 2, and the keypad which duplicates the on-board as Keypad 1.

Installation

Prior to installing the external keypads, either a VP-590 Color board or a VP-585 Hex Keyboard Interface board must be installed in the expansion (left) socket.

To install either Keypad, insert the keypad cable through the appropriate slot in the Color board or keypad Interface card <u>from the rear</u> of the board. Loop the cable as shown in Figure 1-V and insert it in the appropriate socket. Keypad 1 should be inserted in the socket marked J1 on the Hex Keyboard Interface board or the socket marked #1 on the Color board. Keypad 2 is connected to socket J2 on the Hex Keyboard Interface board or socket #2 on the Color board.

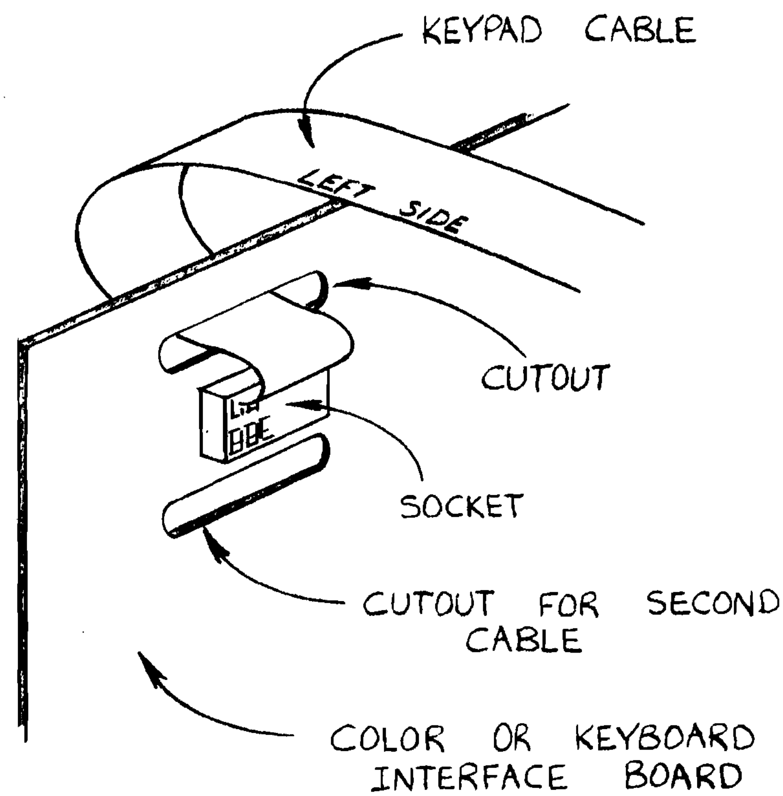

KEYPAD CABLE
LEFT SIDE
CUTOUT
SOCKET
CUTOUT FOR SECOND CABLE
COLOR OR KEYBOARD INTERFACE BOARD

Figure 1-V

Programming

CHIP-8X has two instructions for accessing Keypad 2:

```
EXF2     Skip next instruction if VX=Keypad 2
EXF5     Skip next instruction if VX≠Keypad 2
```

Their operation can be summarized as:

Instruction Executed	Condition		
	Key=VX	Key≠VX	No Key Depressed
EXF2 EXF5	Skip No Skip	No Skip Skip	No Skip Skip

Programming Examples:

1. Wait for key #3 to be depressed:

```
0300     6503     V5=3
0302     E5F2     Skip next if key=3
0304     1302     go back and check again
                  .
                  .
                  .
                  program continues
```

2. Wait for any key to be depressed and return its value in V6:

```
0300     7601     V6=V6+1
0302     E6F2     KEY=V6?
0304     1300     No, go back
0306     6A0F     yes, mask off MSD
0308     86A2     by AND ing with VA
                   continue
                  .
                  .
                  .
```

3. Go to subroutine at 0400 if key "F" is pressed, otherwise continue.

```
0300     640F     V4=0F
0302     E4F2     Skip if key=4V
0304     2400     go sub 400
0306              continue
```

4. Wait for any key to be pressed, then wait for key to be released. Return key value in V6. (This routine is useful when entering data from the keypad, since a key will continue to be read as long as it is depressed, causing possible multiple entry of the same key.)

0300	7601	V6=V6+1
0302	E6F2	Key=V6
0304	1300	No, go back
0306	6A0F	Yes, mask off MSD
0308	86A2	by ANDing with VA
030A	7303	V3=04
030C	F315	V3→Timer
030E	F307	Timer→V3
0310	3300	Test if V3=0
0312	130E	No, go back
0314	E6F5	Key≠V6
0316	1314	No, loop until key released
0318		continue

Instructions 030A through 0312 form a brief delay for key debouncing.

Chapter VI

Circuit Description and Schematic Diagrams

Color Board Circuit Description:

U1 and U2 combine to generate the necessary NTSC compatible color signals. U1, a CDP1861, generates the sync and spot signals while U2, a CDP1862, generates the color burst frequency and phases. The luminous, color, and sync signals are combined through resistors and capacitors and fed to a 75Ω video driver formed by the transistors of U12.

The color data is stored in U3, a CDP1822 (256 x 4 Bit RAM), and read at the appropriate time by U2. When reset the CDP1862 is locked into a mode in which all spots are white and the background color is blue. This mode continues during program execution until a memory write to any memory location in the range C000 to DFFF occurs. From this point U2 receives color information from the color memory, U3.

The most significant 4 bits of the memory address are latched by U4. These bits are then decoded by U6 and U8 to generate appropriate enable signals. U8 also acts as a one bit memory for selecting the high or low resolution mode for the color display.

The address of the color memory is assigned as follows:

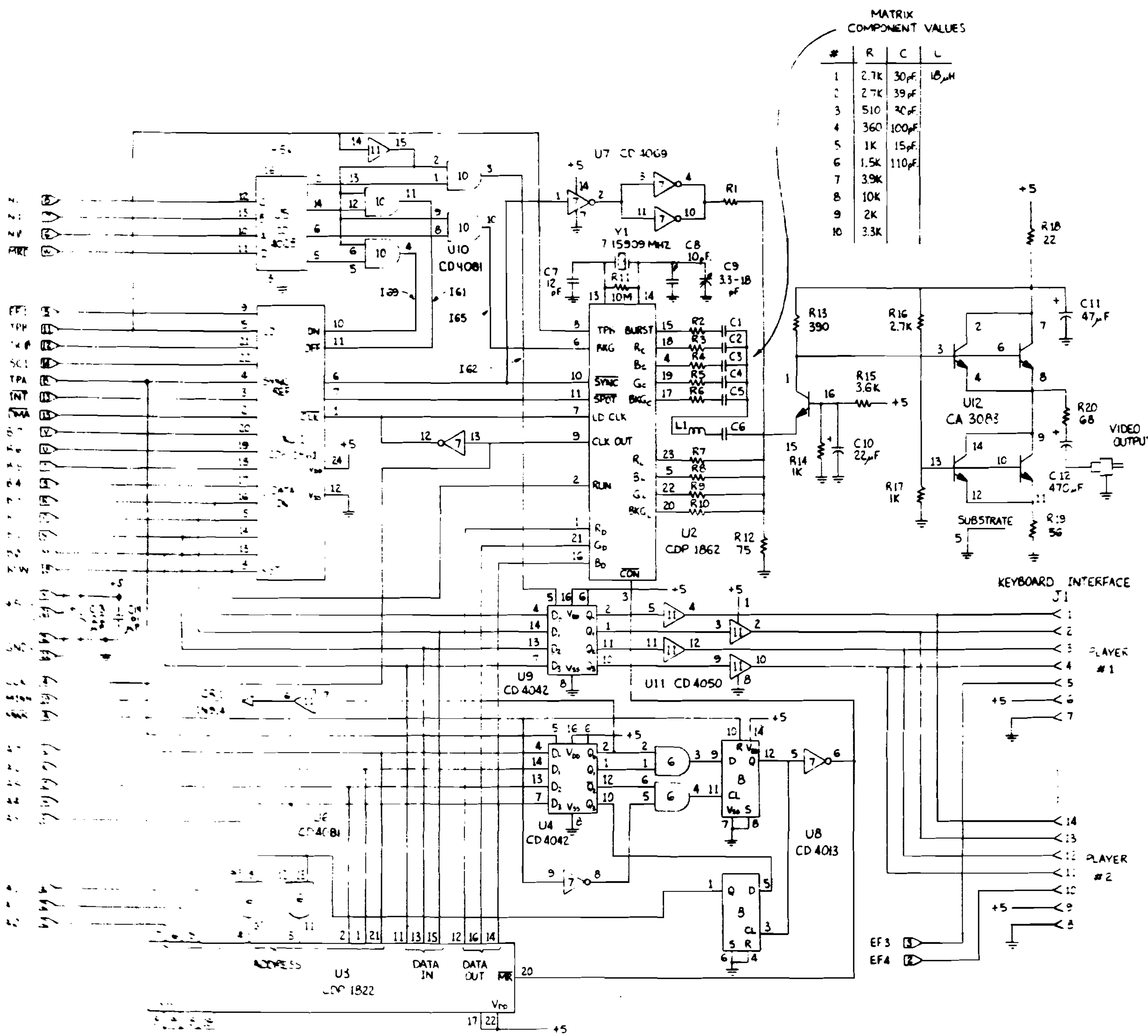
```
C000-C007 : Low Resolution (8x8) Color Overlay
C020-C027
C040-C047
C060-C067
C080-C087
C0A0-C0A7
C0C0-C0C7
C0E0-C0E7

D000-D007 : High Resolution (32x8) Color Overlay
D008-D00F
D010-D017
     .
     .
     .
     .
D0F8-D0FF
```

U5 and U10 form a decoder to generate input/output signals. I/O instructions are assigned as follows:

61 - Turn Display Off
62 - Output to Keyboard
65 - Switch Background Color
69 - Turn Display On

The external keyboard interface is implemented by U9, a 4-bit latch, and four drivers of U11.

VP590 Color Board Schematic



MATRIX COMPONENT VALUES

#	R	C	L
1	2.7K	30pF	18µH
2	2.7K	39pF	
3	510	30pF	
4	360	100pF	
5	1K	15pF	
6	1.5K	110pF	
7	3.9K		
8	10K		
9	2K		
10	3.3K		

Simple Sound Circuit Description:

U1, a CDP1863, is a programmable divide-by-n counter. It accepts a clock input, generated by two inverters at U2, on pin 2 and outputs the divided frequency on pin 14. The divided frequency is then buffered by 4 parallel inverters (U2) driving a transister amplifier. The n factor for the divide is determined by the data on Bus 0 through Bus 7 (output port on VIP). U3 and U4 decode 00 and inject 80 into U1. This is necessary since the output port latches 00 when the VIP is reset (00 produces an inaudible frequency).

The frequency adjust pot is factory adjusted such that:

$$\text{Frequency Generated} = \frac{27535}{(\text{Hex Code}+1)_{10}}\ \text{Hz}$$

The general form of the equation defining frequency generated is:

$$\text{Frequency Generated} = \frac{\text{Input Frequency}}{(\text{Hex Code}+1)_{10}\ (16)}\ \text{Hz}$$

Refer to Table 1 for hex code vs frequency generated information.

VP550 Simple Sound Schematic

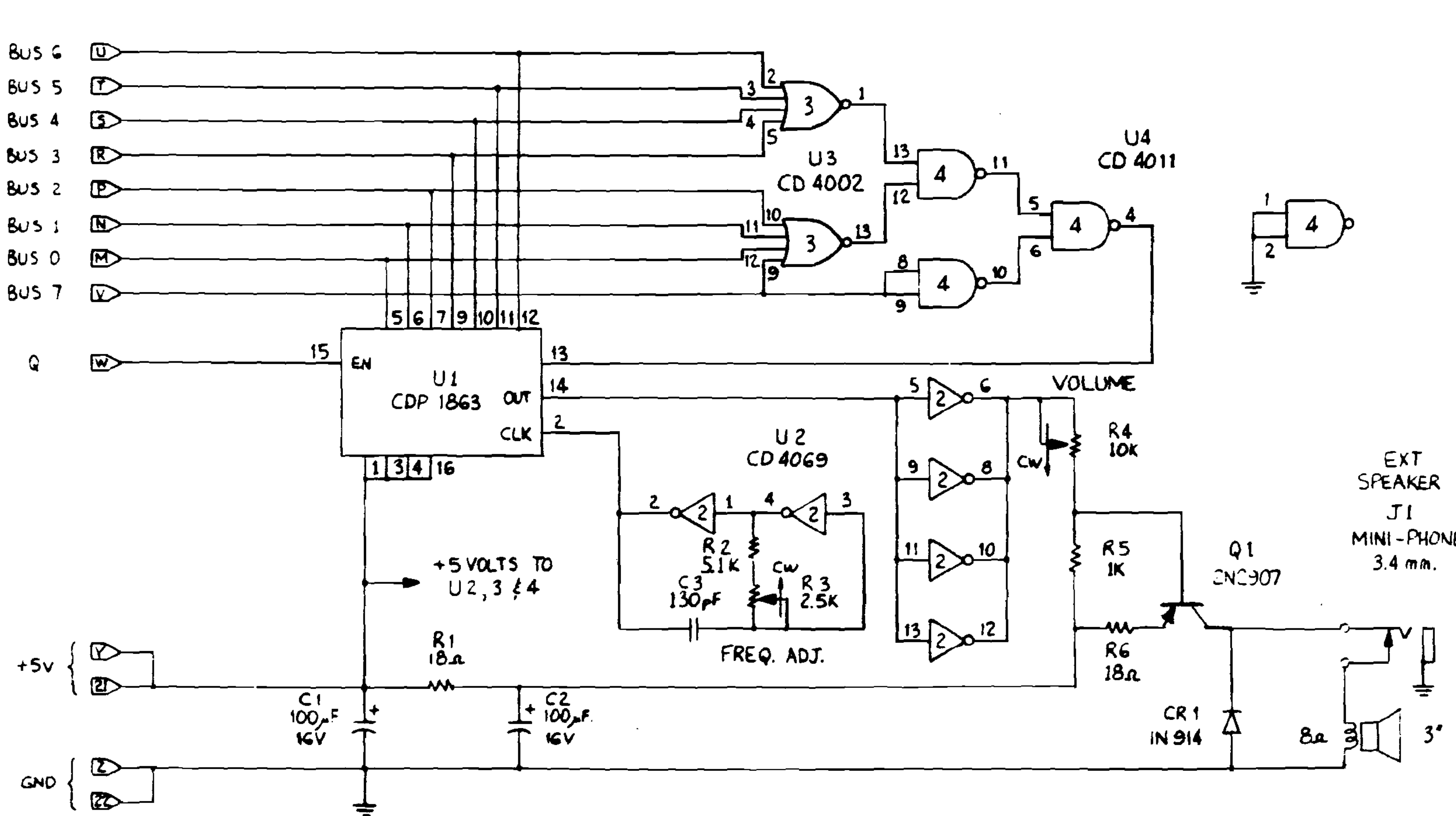


Table 1-VI Simple Sound Frequencies

Hex Code	Divide-By-N (Hex + 1)$_{10}$	Frequency Generated Hz	Note (and Octave)	Note Frequency Hz
FF	256	107.56		
FE	255	107.98		
FD	254	108.41		
FC	253	108.83		
FB	252	109.27		
FA	251	109.70		
F9	250	110.14	A2	110.00
F8	249	110.58		
F7	248	111.03		
F6	247	111.48		
F5	246	111.93		
F4	245	112.39		
F3	244	112.85		
F2	243	113.31		
F1	242	113.78		
F0	241	114.25		
EF	240	114.73		
EE	239	115.21		
ED	238	115.69		
EC	237	116.18		
EB	236	116.61	A#2	116.54
EA	235	117.17		
E9	234	117.67		
E8	233	118.18		
E7	232	118.69		
E6	231	119.20		
E5	230	119.72		
E4	229	120.24		
E3	228	120.77		
E2	227	121.30		
E1	226	121.84		
E0	225	122.38		
DF	224	122.92		
DE	223	123.48	B2	127.47
DD	222	124.03		
DC	221	124.59		
DB	220	125.16		
DA	219	125.73		
D9	218	126.31		
D8	217	126.89		
D7	216	127.48		
D6	215	128.07		
D5	214	128.67		
D4	213	129.27		
D3	212	129.88		
D2	211	130.50	C3	130.81
D1	210	131.12		
D0	209	131.75		
CF	208	132.38		
CE	207	133.02		
CD	206	133.67		
CC	205	134.32		
CB	204	134.98		

Hex Code	Divide-By-N $(\text{Hex} + 1)_{10}$	Frequency Generated Hz	Note (and Octave)	Note Frequency Hz
CA	203	135.64		
C9	202	136.31		
C8	201	136.99		
C7	200	137.68		
C6	199	138.37	C#3	138.59
C5	198	139.07		
C4	197	139.77		
C3	196	140.48		
C2	195	141.21		
C1	194	141.93		
C0	193	142.67		
BF	192	143.41		
BE	191	144.16		
BD	190	144.92		
BC	189	145.69		
BB	188	146.46	D3	146.83
BA	187	147.25		
B9	186	148.04		
B8	185	148.84		
B7	184	149.65		
B6	183	150.46		
B5	182	151.29		
B4	181	152.13		
B3	180	152.97		
B2	179	153.83		
B1	178	154.69		
B0	177	155.56	D#3	155.56
AF	176	156.45		
AE	175	157.34		
AD	174	158.25		
AC	173	159.16		
AB	172	160.09		
AA	171	161.02		
A9	170	161.97		
A8	169	162.93		
A7	168	163.90		
A6	167	164.88	E3	164.81
A5	166	165.87		
A4	165	166.88		
A3	164	167.90		
A2	163	168.93		
A1	162	169.97		
A0	161	171.02		
9F	160	172.09		
9E	159	173.18		
9D	158	174.27	F3	174.61
9C	157	175.38		
9B	156	176.51		
9A	155	177.65		
99	154	178.80		
98	153	179.97		
97	152	181.15		
96	151	182.35		
95	150	183.57		

Hex Code	Divide-By-N $(Hex + 1)_{10}$	Frequency Generated Hz	Note (and Octave)	Note Frequency Hz
94	149	184.80	F#3	185.00
93	148	186.05		
92	147	187.31		
91	146	188.60		
90	145	189.90		
8F	144	191.22		
8E	143	192.55		
8D	142	193.91		
8C	141	195.28		
8B	140	196.68	G3	196.00
8A	139	198.09		
89	138	199.53		
88	137	200.99		
87	136	202.46		
86	135	203.96		
85	134	205.49		
84	133	207.03	G#3	207.65
83	132	208.60		
82	131	210.19		
81	130	211.81		
80	129	213.45		
7F	128	215.12		
7E	127	216.81		
7D	126	218.53		
7C	125	220.28	A3	220.00
7B	124	222.06		
7A	123	223.86		
79	122	225.70		
78	121	227.56		
77	120	229.46		
76	119	231.39		
75	118	233.35	A#3	233.08
74	117	235.34		
73	116	237.37		
72	115	239.43		
71	114	241.54		
70	113	243.67		
6F	112	245.85	B3	246.94
6E	111	248.06		
6D	110	250.32		
6C	109	252.61		
6B	108	254.95		
6A	107	257.34		
69	106	259.76		
68	105	262.24	C4	261.63
67	104	264.76		
66	103	267.33		
65	102	269.95		
64	101	272.62		
63	100	275.35		
62	99	278.13	C#4	277.18
61	98	280.97		
60	97	283.87		

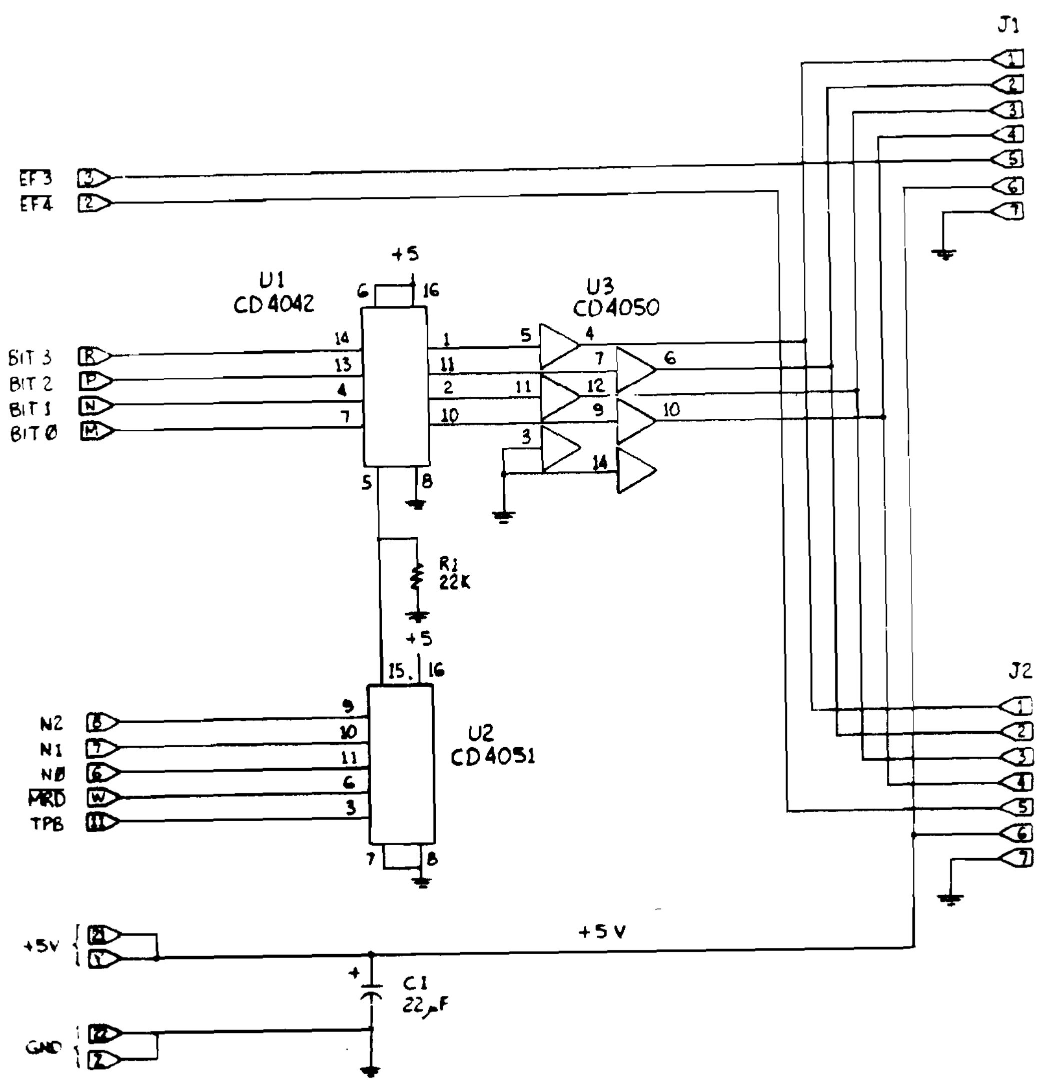
Hex Code	Divide-By-N $(Hex + 1)_{10}$	Frequency Generated Hz	Note (and Octave)	Note Frequency Hz
5F	96	286.82		
5E	95	289.84		
5D	94	292.93	D4	293.66
5C	93	296.08		
5B	92	299.29		
5A	91	302.58		
59	90	305.94		
58	89	309.38	D#4	311.13
57	88	312.90		
56	87	316.49		
55	88	320.17		
54	85	323.94		
53	84	327.80	E4	329.63
52	83	331.75		
51	82	335.79		
50	81	339.94		
4F	80	344.19		
4E	79	348.54	F4	349.23
4D	78	353.01		
4C	77	357.60		
4B	76	362.30		
4A	75	367.13		
49	74	372.09	F#3	369.99
48	73	377.19		
47	72	382.43		
46	71	387.82		
45	70	393.36	G4	392.00
44	69	399.06		
43	68	404.93		
42	67	410.97		
41	66	417.20	G#4	415.30
40	65	423.62		
3F	64	430.23		
3E	63	437.06	A4	440.00
3D	62	444.11		
3C	61	451.39		
3B	60	458.92		
3A	59	466.69	A#4	466.16
39	58	474.74		
38	57	483.07		
37	56	491.70	B4	493.88
36	55	500.64		
35	54	509.91		
34	53	519.53	C5	523.25
33	52	529.52		
32	51	539.91		
31	50	550.70	C#5	554.37
30	49	561.94		
2F	48	583.65		
2E	47	585.85	D5	587.33
2D	46	598.59		
2C	45	611.89		
2B	44	625.80	D#5	622.25

Hex Code	Divide-By-N (Hex + 1)$_{10}$	Frequency Generated Hz	Note (and Octave)	Note Frequency Hz
2A	43	640.35		
29	42	655.60	E5	659.26
28	41	671.59		
27	40	688.38		
26	39	706.03	F5	698.46
25	38	724.61		
24	37	744.19	F#5	739.99
23	36	764.86		
22	35	785.71	G5	783.99
21	34	809.85		
20	33	834.39	G#5	830.61
1F	32	860.47		
1E	31	888.23	A5	880.00
1D	30	917.83	A#5	932.33
1C	29	949.48		
1B	28	983.39	B5	987.77
1A	27	1019.81		
19	26	1059.04	C6	1046.5
18	25	1101.40	C#6	1108.7
17	24	1147.29		
16	23	1197.17	D6	1174.7
15	22	1251.59	D#6	1244.5
14	21	1311.19	E6	1318.5
13	20	1376.75	F6	1396.9
12	19	1449.21	F#6	1480.0
11	18	1529.72	G6	1661.2
10	17	1619.71	G#6	1661.2
0F	16	1720.94	A6	1760.0
0E	15	1835.67	A#6	1864.7
0D	14	1966.79	B6	1975.5
0C	13	2118.08	C7	2093.0
0B	12	2294.58	C#7	2217.5
0A	11	2503.18	D#7	2489.0
09	10	2753.50	F7	2793.8
08	9	3059.44	F#7	2960.0
07	8	3441.88	A7	3520.0
06	7	3933.57	B7	3951.1
05	6	4589.17	D8	4698.6
04	5	5507.00	F8	5587.7
03	4	6883.75	G#8	6644.9
02	3	9178.33		
01	2	13767.50		
00	1	27535.00		

Expansion Keypad Interface Card Circuit Description:

U1 is a 4-bit latch. A "62" output instruction, decoded by U2 causes the least significant 4 bits of the data bus to be strobed into U1. These latched bits are then buffered to the expansion hex keypad via U3.

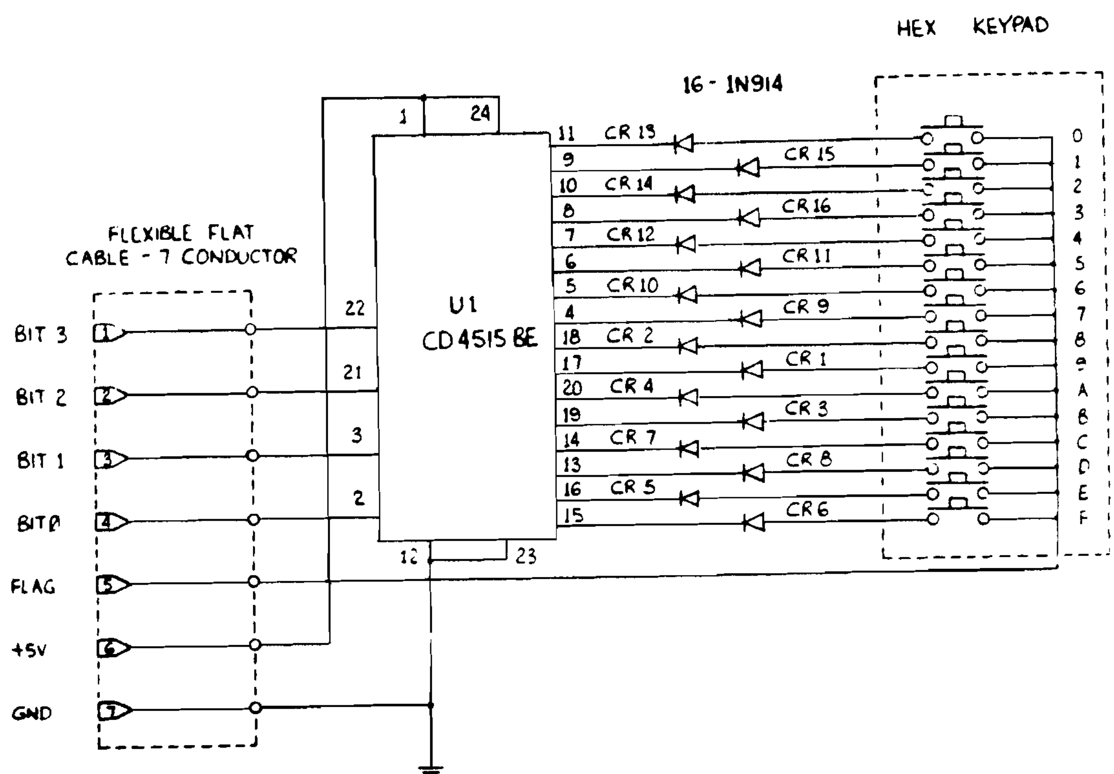
VP585 Expansion Keypad Interface Card Schematic



Expansion Keypad Circuit Description:

The Expansion Keypad consists of a 4 to 16 decoder (U1), 16 diodes, and 16 switches. The microprocessor outputs data to a 4-bit latch on the interface card. The latched 4 bits are decoded by U1 and a signal fed to one of the 16 switches. If that switch is closed the signal is transferred back to the microprocessor's data flag (EF3=Player #1 and EF4=Player #2). The flag may then be tested by the microprocessor's program. The 16 diodes prevent an undefined logic level should two or more switches be pressed simultaneously.

VP580 Expansion Keypad Schematic



APPENDIX A

CHIP-8X PROGRAMS

Color Kaleidoscope

This program uses the CHIP-8X Interpreter at ØØØØ-Ø2FF. Keys 2, 4, 6 and 8 are used to program patterns of up to 125 entries until the Kaleidoscope automatically starts. However, you may begin execution of the Kaleidoscope any time during the programming sequence by pressing key Ø. The colors are randomly selected by the program.

Requirements:

1 VP-590 Color Board

```
0300 237C DO 037C
0302 6383 V3=83
0304 611F V1=1F
0306 620F V2=0F
0308 2332 DO 0332
030A A300 I=0300
030C F31E I=I+V3
030E F00A V0=KEY
0310 F055 MI=V0:V0
0312 4000 SKIP;V0 NE 00
0314 131C GO 031C
0316 7301 V3+01
0318 3300 SKIP;V3 EQ 00
031A 1308 GO 0308
031C 6383 V3=83
031E A300 I=0300
0320 F31E I=I+V3
0322 F065 V0:V0=MI
0324 4000 SKIP;V0 NE 00
0326 131C GO 031C
0328 7301 V3+01
032A 4300 SKIP;V3 NE 00
032C 131C GO 031C
032E 2332 DO 0332
0330 131E GO 031E
0332 4002 SKIP;V0 NE 02
0334 72FF V2+FF
0336 4004 SKIP;V0 NE 04
0338 71FF V1+FF
033A 4006 SKIP;V0 NE 06
033C 7101 V1+01
033E 4008 SKIP;V0 NE 08
0340 7201 V2+01
0342 A382 I=0382
0344 6AE0 VA=E0
0346 8A12 VA=VA&V1
0348 6B1F VB=1F
034A 81B2 V1=V1&VB
034C 3A00 SKIP;VA EQ 00
034E 7201 V2+01
0350 6AF0 VA=F0
0352 8A22 VA=VA&V2
0354 6B0F VB=0F
0356 82B2 V2=V2&VB
0358 3A00 SKIP;VA EQ 00
035A 7101 V1+01
035C 6B1F VB=1F
035E 81B2 V1=V1&VB
0360 CC07 VC=RND
0362 B1C1 1 BLOCK VC COLOR @V1V2
0364 D121 SHOW 1MI@V1V2
0366 8A10 VA=V1
0368 6B1F VB=1F
036A 8B25 VB=VB-V2
036C 2376 DO 0376
036E 6A3F VA=3F
0370 8A15 VA=VA-V1
0372 2376 DO 0376
0374 8B20 VB=V2
0376 BAC1 1 BLOCK VC COLOR @VAVB
0378 DAB1 SHOW 1MI@VAVB
037A 00EE RET
037C 02A0 SWITCH BAKGRND
037E 6000 V0=00
0380 00EE RET
0382 8002
```

Appendix A-2

VIP BLOCKOUT

This is a fast action 2-player game of concentration, coordination, skill and luck!

Two players each using their own keypad control the movement of their respective lines. Key 2 moves the line up, 8-down, 4-left, and 6-right.

The objective is for each player to maneuver his/her line avoiding collision while, at the same time, trying to force the opponent to collide. As the play continues the speed of movement increases, demanding faster decisions and responses.

Running the program in the usual fashion (by flipping the toggle switch to run), surrounds the playing field by a border. However, if key Ø on either keypad is held while the run switch is flipped, no border is created and the lines can wrap around the screen. Watch out for yourself!

A match consists of 9 games the winner getting the most points (the least number of collisions).

Have fun!

Requirements:

A minimum of 1 VP-580 Hex Keypads. (2 VP-580 keypads are necessary for totally independent key action.)

Optional:

a) VP-590 - Color Board

b) VP-595 - Simple Sound Board

CHIP-8X INTERPRETER: ØØØØ-Ø2FF

```
0300 6609 V6=09
0302 6700 V7=00
0304 1486 GO 0486
0306 6701 V7=01
0308 A490 I=0490
030A 6000 V0=00
030C 6100 V1=00
030E F155 MI=V0:V1
0310 2424 DO 0424
0312 6EFF VE=FF
0314 2360 DO 0360
0316 2424 DO 0424
0318 6C05 VC=05
031A 6170 V1=70
031C 6270 V2=70
031E B1C0 VC COLOR @V1(NH),V2(NV)
0320 6880 V8=80
0322 6920 V9=20
0324 3701 SKIP;V7 EQ 01
0326 244C DO 044C
0328 6104 V1=04
032A 6204 V2=04
032C 6C08 VC=08
032E 633A V3=3A
0330 641A V4=1A
0332 6D02 VD=02
0334 CA01 VA=RND
0336 6500 V5=00
0338 4A00 SKIP;VA NE 00
033A 2376 DO 0376
033C 4A01 SKIP;VA NE 01
033E 23AE DO 03AE
0340 3F00 SKIP;VF EQ 00
0342 13E6 GO 03E6
0344 236A DO 036A
0346 7501 V5+01
0348 3502 SKIP;V5 EQ 02
034A 1338 GO 0338
034C 2350 DO 0350
034E 1336 GO 0336
0350 F8F8 OUTPUT=V8
0352 6E02 VE=02
0354 FE18 TONE=VE
0356 4902 SKIP;V9 NE 02
0358 135E GO 035E
035A 79FF V9+FF
035C 78FE V8+FE
035E 8E90 VE=V9
0360 FE15 TIME=VE
0362 FE07 VE=TIME
0364 3E00 SKIP;VE EQ 00
0366 1362 GO 0362
0368 00EE RET
036A 3A00 SKIP;VA EQ 00
036C 1372 GO 0372
036E 6A01 VA=01
0370 00EE RET
0372 6A00 VA=00
0374 00EE RET
0376 6B02 VB=02
0378 EBA1 SKIP;VB NE KEY #1
037A 1384 GO 0384
037C 7B02 VB+02
037E 3B0A SKIP;VB EQ 0A
0380 1378 GO 0378
0382 8BC0 VB=VC
0384 8CB0 VC=VB
0386 4B02 SKIP;VB NE 02
0388 1398 GO 0398
038A 4B04 SKIP;VB NE 04
038C 139E GO 039E
038E 4B06 SKIP;VB NE 06
0390 13A4 GO 03A4
0392 7100 V1+00
0394 7202 V2+02
0396 13A8 GO 03A8
0398 7100 V1+00
039A 72FE V2+FE
039C 13A8 GO 03A8
039E 71FE V1+FE
03A0 7200 V2+00
03A2 13A8 GO 03A8
03A4 7102 V1+02
03A6 7200 V2+00
03A8 A481 I=0481
03AA D122 SHOW 2MI@V1V2
03AC 00EE RET
03AE 6B02 VB=02
03B0 EBF5 SKIP;VB NE KEY #2
03B2 13BC GO 03BC
03B4 7B02 VB+02
03B6 3B0A SKIP;VB EQ 0A
03B8 13B0 GO 03B0
03BA 8BD0 VB=VD
03BC 8DB0 VD=VB
03BE 4B02 SKIP;VB NE 02
03C0 13D0 GO 03D0
03C2 4B04 SKIP;VB NE 04
03C4 13D6 GO 03D6
03C6 4B06 SKIP;VB NE 06
```

(continued on next page)

```
03C8 13DC GO 03DC
03CA 7300 V3+00
03CC 7402 V4+02
03CE 13E0 GO 03E0
03D0 7300 V3+00
03D2 74FE V4+FE
03D4 13E0 GO 03E0
03D6 73FE V3+FE
03D8 7400 V4+00
03DA 13E0 GO 03E0
03DC 7302 V3+02
03DE 7400 V4+00
03E0 A483 I=0483
03E2 D342 SHOW 2MI@V3V4
03E4 00EE RET
03E6 6EFF VE=FF
03E8 FE15 TIME=VE
03EA FE18 TONE=VE
03EC 4A00 SKIP;VA NE 00
03EE D122 SHOW 2MI@V1V2
03F0 4A01 SKIP;VA NE 01
03F2 D342 SHOW 2MI@V3V4
03F4 FE07 VE=TIME
03F6 3E00 SKIP;VE EQ 00
03F8 13EC GO 03EC
03FA A490 I=0490
03FC F165 V0:V1=MI
03FE A490 I=0490
0400 3A00 SKIP;VA EQ 00
0402 7001 V0+01
0404 3A01 SKIP;VA EQ 01
0406 7101 V1+01
0408 F155 MI=V0:V1
040A 00E0 ERASE
040C 2424 DO 0424
040E 76FF V6+FF
0410 3600 SKIP;V6 EQ 00
0412 1312 GO 0312
0414 6E02 VE=02
0416 FE18 TONE=VE
0418 6E04 VE=04
041A FE15 TIME=VE
041C FE07 VE=TIME
041E 3E00 SKIP;VE EQ 00
0420 141C GO 041C
0422 1414 GO 0414
0424 6C04 VC=04
0426 6130 V1=30
0428 6220 V2=20
042A B1C0 VC COLOR @V1(NH),V2(NV)
042C 6C06 VC=06
042E 6134 V1=34
0430 6220 V2=20
0432 B1C0 VC COLOR @V1(NH),V2(NV)
0434 A490 I=0490
0436 6110 V1=10
0438 6200 V2=00
043A 2444 DO 0444
043C A491 I=0491
043E 6128 V1=28
0440 2444 DO 0444
0442 00EE RET
0444 F065 V0:V0=MI
0446 F029 I=V0(LSDP)
0448 D125 SHOW 5MI@V1V2
044A 00EE RET
044C A483 I=0483
044E 6100 V1=00
0450 6200 V2=00
0452 D121 SHOW 1MI@V1V2
0454 3F00 SKIP;VF EQ 00
0456 D121 SHOW 1MI@V1V2
0458 62FF V2=FF
045A D121 SHOW 1MI@V1V2
045C 7101 V1+01
045E 3F01 SKIP;VF EQ 01
0460 1450 GO 0450
0462 71FF V1+FF
0464 D121 SHOW 1MI@V1V2
0466 6201 V2=01
0468 6100 V1=00
046A D121 SHOW 1MI@V1V2
046C 3F00 SKIP;VF EQ 00
046E D121 SHOW 1MI@V1V2
0470 61FF V1=FF
0472 D121 SHOW 1MI@V1V2
0474 7201 V2+01
0476 3F01 SKIP;VF EQ 01
0478 1468 GO 0468
047A 72FF V2+FF
047C D121 SHOW 1MI@V1V2
047E 00EE RET
0480 01C0
0482 C080
0484 40D4
0486 E7A1 SKIP;V7 NE KEY #1
0488 1306 GO 0306
048A E7F5 SKIP;V7 NE KEY #2
048C 1306 GO 0306
048E 1308 GO 0308
```