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INTRODUCTION:

This sound effects board utilizing two of the General Instruments AY-3-8910 programmable sound generators allows your computer to generate an infinite number of real time complex sounds. Each stereo chip's sounds may vary in complexity from simple tones all the way upto triple tones with frequency sweeps mixed with noise and modulated by an envelope control. The types and number of sounds possible is limited only by your imagination and your computer's memory size.

FEATURES:

S-100 Compatible

Two GI AY-3-8910 Sound ICs on board.

Two on board audio amps for stereo effects.

Two low level outputs available for external amps.

Prototyping area on board.

Four I/O ports available.

PC board is solder masked and silkscreened.

Gold plated contact fingers for long life.

This complete kit includes all parts, sockets, ICs, etc.

Board is buffered and liberally bypassed for trouble free operation.

Designed for quick and easy assembly.

Addressable as any 4 of the 256 available ports.

Compatible with Sound Command Language (SCL tm) programs.

Works with either 8080 or Z-80 CPU.

CPU is free to do other tasks once a sound is started.

Programmed I/O; does not conflict with system memory.

PARTS LIST

2	40 pin IC sockets
8	16 pin IC sockets
10	14 pin IC sockets
11	2.2K resistors
2	1K resistors
2	2.7 ohm resistors
13	.01 mfd Bypass Disc Caps (value not critical)
2	.1 mfd. Caps
3	6.8 mfd >15 V Tantalum (value not critical)
1	.33 mfd >25V Tantalum (value not critical)
4	100 mfd 16V Electrolytic
2	10K to 50K Trim pots
2	TO-220 Heatsinks (with hardware) for voltage regulators
1	7805 +5VDC Voltage Regulator
1	7812 +12VDC Voltage Regulator
3	7400 (or LS) TTL Gate
2	7404 (or LS) TTL Gate
1	7410 (or LS) TTL Gate
2	7474 (or LS) TTL Flip flop
2	8242 (or 74LS266) TTL Gate
3	74367 (or LS or 8T97) Tri-State Buffers
2	LM380 (612162-1) Audio Amps
2	GI AY-3-8910 Sound Chips
1	PC Board

General Construction Hints

For soldering we recommend a 32 watt soldering pencil. DO NOT use a soldering gun!!! Use small diameter (such as 22 Ga.) rosin core 60/40 alloy solder.

Keep the soldering pencil CLEAN with a wet sponge or cloth.

After components such as resistors or caps have been soldered, use a small pair of diagonal cutters to remove the excess lead length.

Observe polarities of all tantalum and electrolytic caps.

For a professional appearance insure that all sockets are mounted flush against the PC board.

LIMITED WARRANTY

Digital Research Computers warrants all components in this kit to be free of defects in material and workmanship for a period of 90 days. Any defective parts must be returned to us and will be replaced at no charge. Any board purchased as a kit which malfunctions during the warranty period and has not been subjected to abuse and has been assembled with reasonable care will be repaired or replaced (our option) at no charge.

Any unassembled kit purchased from us may be returned within 14 days of receipt for a FULL "no questions asked" refund. NO reason is necessary. The above limited warranties also apply to kits assembled by DR:Computers.

Any board which is not covered by the above warranties will be repaired at a cost commensurate with the work required. This charge will not exceed $20 without prior approval.

This warranty is made in lieu of any other warranty expressed or implied and is limited in all cases to the repair or replacement of the kit involved. Absolutely no claims are made for the suitability or reliability of this product in any application or system, and we are in no way responsible for any case of consequential damage. If the terms of this warranty are not acceptable, the product must be returned for a refund. Retention of the product by the customer shall constitute a agreement that he has read and accepts the terms of this limited warranty.

ASSEMBLY INSTRUCTIONS

( ) Give the PC board a good visual inspection for any obvious defects. A few minutes spent here could save hours of work later.

( ) Using an ohm meter, insure that there are no shorts between Buss pins 1,2,and 50.

( ) Install and solder 14 pin sockets in IC locations 1,2,3,10,11,12,13,14,17,and 18. Note that there is a notch or indentation on each of the IC sockets. These should be oriented in the same direction as the small dot on the PC board. Each dot signifies pin #1 of each IC.NOTE: Do Not install sockets in locations 15 and 22. To do so would eliminate the heatsinking for the LM380 audio amps.

( ) Install and solder 16 pin sockets in locations 4,5,8,9,19,20,21, and S1.

( ) Install and solder 40 pin sockets in locations 6 and 7.

( ) Install and solder the 2 LM380 audio amps in locations 15 and 22. Insure that pin one of the devices is adjacent to the dots on the board.

( ) Install and solder the 13 bypass caps in locations C1-C4,C6-C9,C12-C16. Note: capacitor C5 is not used.

( ) Install and solder .1 mfd caps in locations C10 and C17.

( ) Install and solder the four 100 mfd caps in locations C11,C18,C22 and C23. Observe polarity.

( ) Install and solder the 6.8 mfd >15V tantalums in locations C19,C20,and C24. Observe polarity

( ) Install and solder the .33 mfd >25V tantalum cap at location C21. Observe the polarity.

( ) Install and solder the 11 2.2K resistors in locations R1,4-6,9-15.

( ) Install and solder the 2 1K resistors in locations 2 and 3.

( ) Install and solder the 2 2.7 ohm resistors in locations R8 and 17.

( ) Install and solder the 2 trim pots at locations R7 and R16.

( ) Mount and solder the 7805 voltage regulator with its heatsink in location Z16 using the hardware supplied.

( ) Mount and solder the 7812 voltage regulator with its heatsink in location Z23 using the hardware supplied.

( ) Plug the board in your system (preferably using an extender board). Using either regulator mounting tab as ground, measure the output of each regulator. The 7805 should measure +5VDC + or - 5%. The 7812 should measure +12VDC + or - 5%. If either regulator is defective, replacement is necessary before completing the board.

( ) Insert the 7400s in locations 10,12,and 13. Be extremely careful to match pin #1 of each IC (denoted by a small notch or indentation) with the small dot on the board.

( ) Insert the 7404s in locations 11 and 14.

( ) Insert the 7410 in location 2.

( ) Insert the 7474s in locations 1 and 3.

( ) Insert the 8242s (or 74LS266) in locations 17 and 18.

( ) Insert the 74367s in locations 19,20, and 21.

( ) Insert the GI AY-3-8910s in locations 6 and 7. Note these are MOS devices and should be handled using static electricity precaution.

( ) It is a good idea to repeat the above procedures again, double checking your work for mistakes. Also, recheck the voltage regulators for proper operation.

( ) Before connecting the speakers, set the trim pots to approximately the center of their rotation.

INITIAL SET UP AND USE

The first thing that you should do before trying to use the Sound Board is to read and study the GI AY-3-8910 Data Manual included with the kit. This book will give you an understanding of how the sound chip works. Try to memorize pages 8 and 9 of the manual, this will make programming easier. To understand the sound chip is to understand the sound board.

Hidden Gotchas in the Data Manual:
The internal registers are referred to by their octal number in the manual. Remember Basic talks in decimal, and most system monitors talk in hex. It is recommended that you obtain a good 8080 or Z-80 programming card which contains hex, octal, decimal, and ASCII equivalents.
The table shown on page 47 on the data manual is for 1.79 mhz clock compared to the 2.00 mhz clock used from the S-100 buss.
Resister 7 (Enable Register) is all important, and is active low. Nothing will work unless this resister is treated with utmost care. Also R7 controls the direction of the I/O ports A and B.

All of our software presumes that the board is addressed at ports 80H thru 83H (128 thru 131 decimal). To select this port address, location S1 (address select), position A2 thru A6 should be jumpered or closed. Leave position A7 open. If you are using a Z-80 CPU at 4 Mhz you must jumper or close position labeled "4 Mhz". This inserts two Wait states when the sound board is accessed.

If port 80H conflicts with any of your software you may use S1 to select any other group of 4 I/O ports. S1 works like this: the binary representation of the desired block of ports is represented by A2-A7. A logical zero is a closed switch and a logical one is an open switch, i.e. ports 0 thru 3 would be selected when switch positions A2 thru A7 are closed; ports B0 thru B3 are selected when positions A2,A3,and A6 are closed.

Two types of audio outputs are provided, low and high level. The low level outputs are designed to drive an external amplifier such as a home stereo. These low level outputs are marked "A and B Input" since they are inputs into your stereo. The high level outputs are designed to drive speakers directly. Full output is approx. 2 to 5 watts per side. Speakers are connected at E3-E4 and E7-E8 for chips A and B respectively. A speaker impedance of 8 ohms or more is recommended. Sheilded audio cable is necessary to connect the low level inputs (E1-E2 and E5-E6) to your external amp. It is very important to observe proper grounding practices. All even E numbers are ground, and all odd are signals.

The most important thing to remember is that the GI chips are subsystems of their own. These subsystems are totally controlled by the contents of each sound chip's 16 resisters. The main function of your computer is to initialize or modify the contents of these resisters. As the resisters change the sounds produced change. The main function of the S-100 Sound Effects Board is to provide the hardware interface between your computer and the sound chips.

The internal resisters are not directly addressable. Resister addressing is accomplished by Outputing the Resister number as data to the EVEN port numbers. The resister number is latched internally by the sound chip and anticipates that the data to be loaded to that resister will be Output to the ODD port on the next board access. So remember, it takes two Outputs to load data into the sound chips resisters. Exception: since the Resister number is latched, it is possible to continually modify the SAME resister's contents once the Resister number is specified. This is nice for frequency sweeps, etc.

For most systems the quickest way to talk to the S-100 Sound Effects Board is via BASIC. If your BASIC has INPUT and OUTPUT commands, then you are in business! If you cannot use BASIC then it will take the machine code instructions INP (DBH) and OUT (D3H) to talk to the board. Why do you need any input instructions? Inputing from the ODD ports reads the contents of the last latched Resister. This is a programming aid, allowing you to read the resisters' data. This is useful when you come

up with a good sound and want to know exactly how you did it. It is also nice when a sound does not work.

The following is actually two BASIC programs. Run at 10 is a program to write into Sound Chip A. It asks first for which register you want to modify, then it requests the data. Run at 100 is a program to dump all 16 register.

```
10 PRINT "ALL VALUES ARE DECIMAL"
15 PRINT "IT TAKES TWO OUTPUTS TO WRITE TO A REGISTER"
20 PRINT "ONE TO SPECIFY THE REGISTER"
22 PRINT "THE OTHER TO SPECIFY THE DATA"
24 PRINT "THE REGISTER # IS SENT TO THE EVEN PORT"
25 PRINT "THE DATA IS SENT TO THE ODD PORT"
26 INPUT "REGISTER #";R
30 OUT 128,R
40 INPUT "DATA";D
50 OUT 129,D
60 GOTO 26
100 J=0
110 FOR I=1 TO 16
120 OUT 128,J
130 PRINT J,INP(129)
135 J=J+1
140 NEXT I
150 END
```

By loading the following registers with the accompaning data a nice chime sound is produced.

Register #		Data
2 (decimal)	4B	75
4	6B	107
7	F8	248
8	10	16
9	10	16
10	10	16
11	FF	255
12	2B	43
13	08	8

Set all other registers to 0. Register 14 and 15 are I/O ports and not used in sound generation.
Refering to page 8 of the Data Manual, we are loading two differant tones into channels B and C (registers 2 and 4). Register 7 (Enable reg.) is loaded with 248 which is F8H leaving bits 0, 1, and 2 LOW. This enables all three tone channels, disables Noise on all three channels, and sets I/O ports A and B for input only. The values loaded in registers 8, 9, and 10 set the amplitude. The values loaded in registers 11 and 12 set the modulation Envelope period. The value loaded in register 13 determines the Envelope shape as shown on page 26 (third waveform).

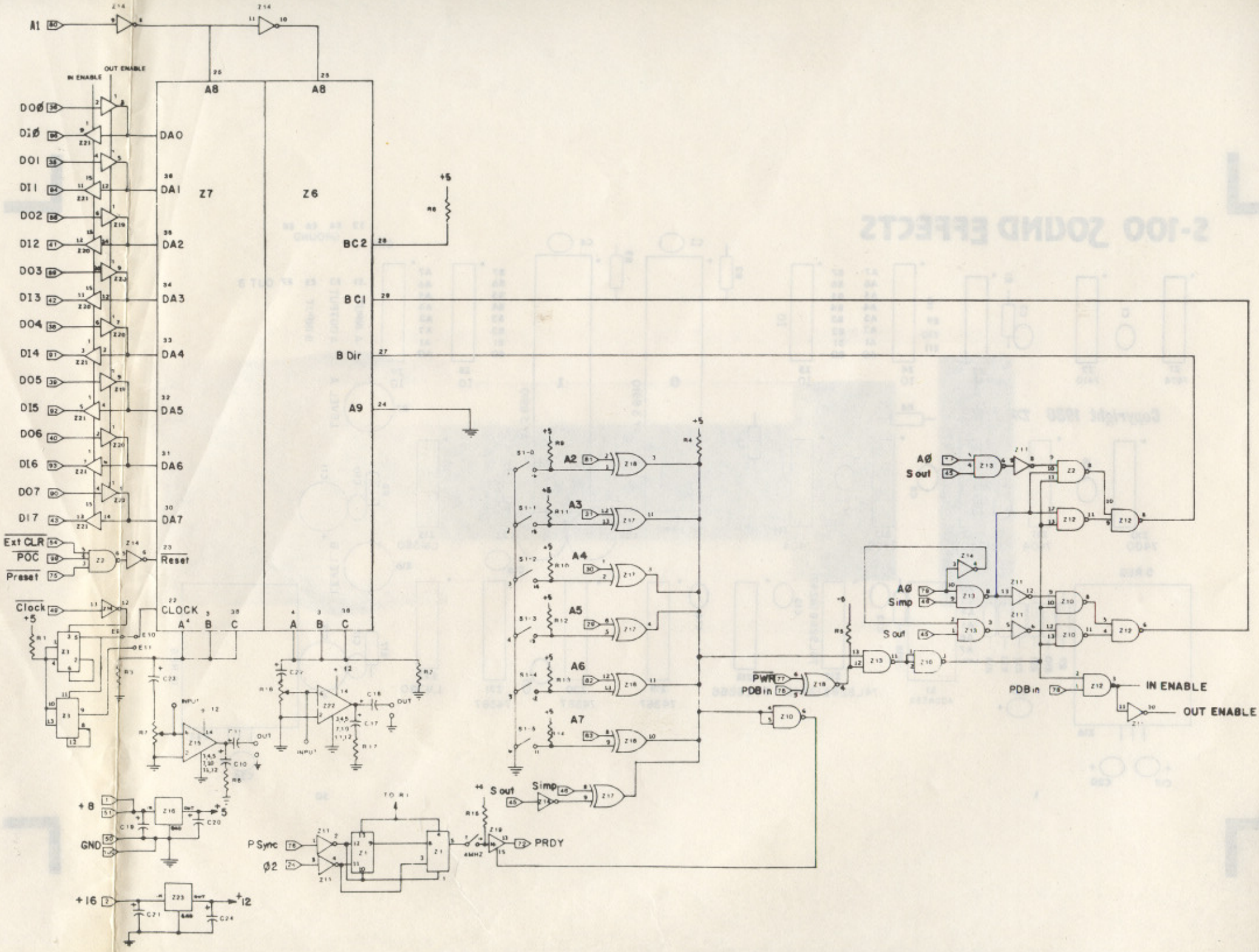
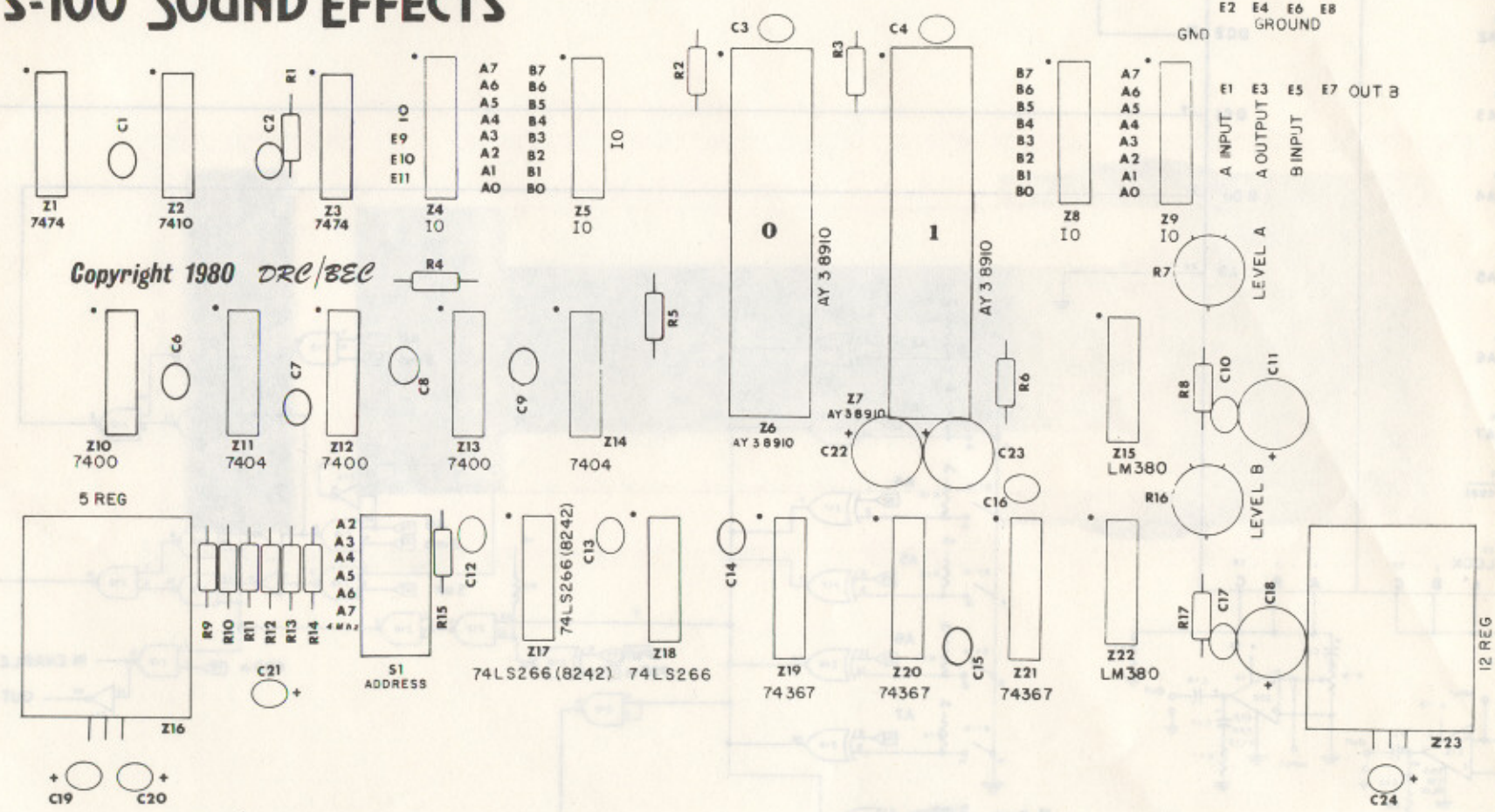
To create the same sound via assembly language you would use the following program.

```
0000    3E 02    MVI A,02H       ;LOAD A WITH REG.#
0002    D3 80    OUT 80H         ;LATCH REG.#
0004    3E 4B    MVI A,4BH       ;LOAD A WITH DATA
0006    D3 81    OUT 81H         ;PUT DATA IN REG.
0008    3E 04    MVI A,04H       ;MORE OF THE SAME
000A    D3 80
000C    3E 6B
000E    D3 81
0010    3E 07
0012    D3 80
0014    3E F8
0016    D3 81
0018    3E 08
001A    D3 80
001C    3E 10
001E    D3 81
0020    3E 09
0022    D3 80
0024    3E 10
0026    D3 81
0028    3E 0A
002A    D3 80
002C    3E 10
002E    D3 81
0030    3E 0B
0032    D3 80
0034    3E FF
0036    D3 81
0038    3E 0C
003A    D3 80
003C    3E 2B
003E    D3 81
0040    3E 0D
0042    D3 80
0044    3E 08
0046    D3 81                    ;PFM
0048    C9          RET          ;GO BACK, ALL DONE
```

THEORY OF OPERATION

The S-100 Sound Effects Board is basically a Parallel I/O board. The basic functions are Port Decode, Data Bufferins and Enablins, Buss Control, Power Supplies, Wait States, and Clock conditionins. This board varies from the above by includins audio amps. Port decode is accomplished by Z17 and 18 and switch S1. Data bufferins is handled by Z19, 20, and 21. Buss control is developed by several gates of Z2 and Z10 thru 14. These gates convert control signals from the buss into signals the sound chip interprets into read and write commands. Z16 supplies regulated +5VDC to all digital devices on the board. Z23 supplies regulated +12VDC for the audio amps. Z1 provides Wait states necessary for processors faster than 500 ns clock periods. Z3 divides Buss Pin 49 (Clock) by two and optionally by four. This requires a cut of the trace from E9 to E10, and a jumper installed from E10 to E11. This will lower all

frequencies and noises, it is not recommended unless your application requires this effect. Z15 and Z22 provide high level outputs capable of driving speakers with "room filling sound". Low level outputs are also brought out. The sound chips are Reset by Buss pin 75 (Preset), Buss pin 99 (POC), or Buss pin 54 (Ext Clr). If your computer does not provide Ext Clr, we highly recommend you provide this funtion.


A1
OUT ENABLE
IN ENABLE
A8
A8
DO0
DI0
DO1
DI1
DO2
DI2
DO3
DI3
DO4
DI4
DO5
DI5
DO6
DI6
DO7
DI7
DA0
DA1
DA2
DA3
DA4
DA5
DA6
DA7
Z7
Z6
+5
BC2
BC1
B Dir
A9
Ext CLR
POC
Preset
Reset
Clock
+5
CLOCK
A
B
C
A
B
C
A2
A3
A4
A5
A6
A7
S1-0
S1-1
S1-2
S1-3
S1-4
S1-5
AØ
S out
AØ
Simp
S out
PWR
PDBin
PDBin
IN ENABLE
OUT ENABLE
+8
GND
+5
+16
+12
PSync
Ø2
PRDY
4MHZ
S out
Simp
TO R1

S-100 SOUND EFFECTS