858

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JANUARY 1991

INCORPORATING ELECTRONICS MONTHLY

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PCW SOUND GENERATOR

SPATIAL AUDIO POWER DISPLAY

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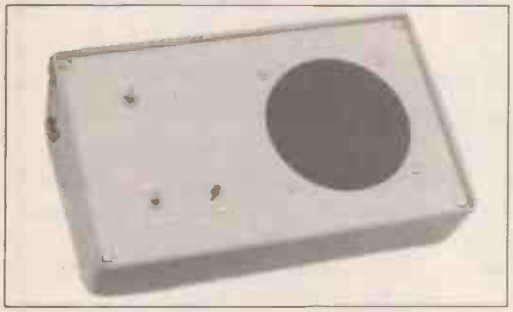
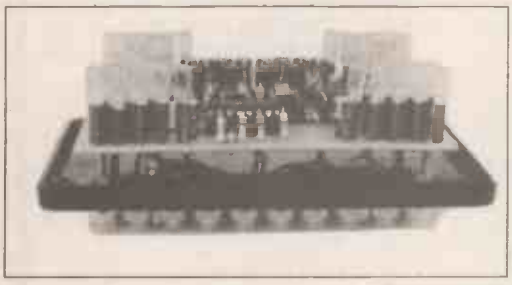
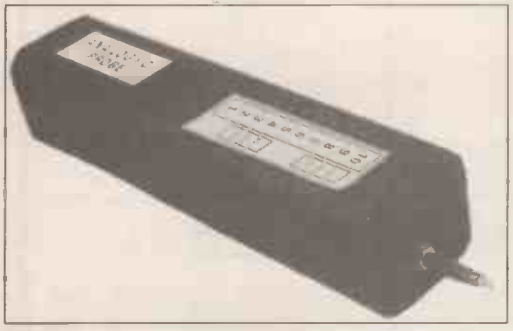
PROJECTS . . . THEORY . . . NEWS . . .
COMMENT . . . POPULAR FEATURES . . .







Merry Christmas
to all our readers

Projects

Series

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FREE WITH THIS ISSUE

Bull Electrical Catalogue **between pages 36 and 37**

Our February '91 Issue will be published on Friday, 4 January 1991. See page 3 for details.

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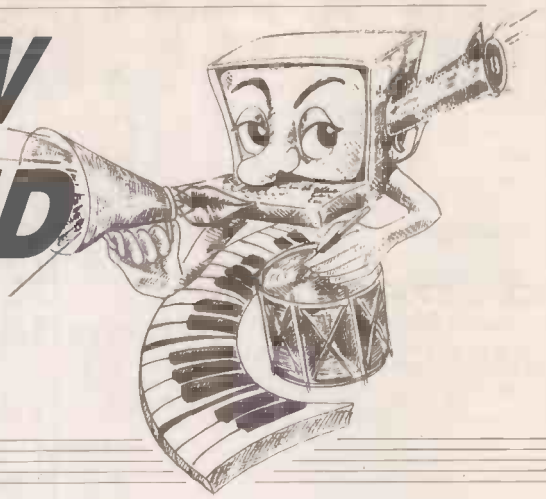
Constructional Project

AMSTRAD PCW STEREO SOUND GENERATOR



JASON SHARPE

Uninspired by your PCW's 'bleeping'? Well now you can have three channel stereo sound effects.

THIS project gives the PCW three channel (left, left and right (centre), right) stereo sound, the frequency and volume of each channel is software programmable, "noise" can also be mixed into any or all channels, there is also an envelope generator.

The circuit was originally designed and built around the AY-3-8913, however this chip is no longer available and the slightly more expensive AY-3-8912 has had to be substituted. The later type is an identical device but has an additional I/O port which is not required in this design.

HOW IT WORKS

The AY-3-8912 programmable sound generator (more about this chip later), is connected to the PCW using a Z80 PIO (IC1 in Fig.1). The PIO has two ports (port A and port B), port B is used to transfer data and addresses to IC4, three of the eight lines on port A are used for control signals and resetting IC4, the other five lines are unused.

Integrated circuit IC2 is a three to eight line decoder, which is used as an address decoder to select the PIO. The PIO is enabled between ports 160 and 163 (inclusive). IC3 divides the Z80's 4MHz clock by two, to supply IC4 with a 2MHz clock.

The three audio outputs (A,B,C) of the AY-3-8912 are available on pins 5, 4 and 1 respectively, these are fed into a simple mixer circuit comprising of resistors R1, R2, R3 and R4. The result is two sound channels, one consisting of channel A and half (volume) of channel B, the other channel C and half of channel B, this gives the

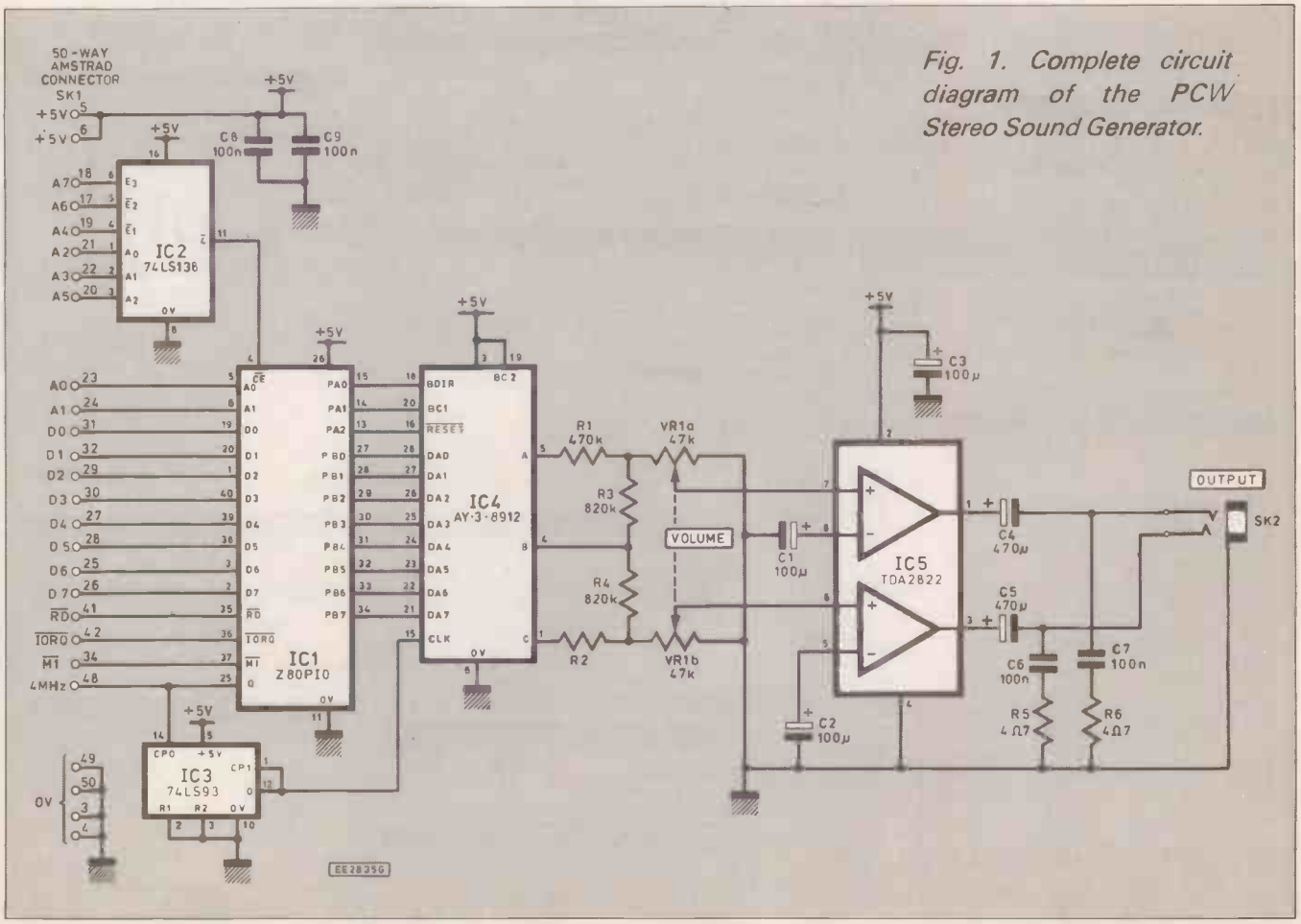


Fig. 1. Complete circuit diagram of the PCW Stereo Sound Generator.

effect of channel B being "between" the two speakers.

The output of the mixer is fed into a stereo amplifier (IC5) through volume control (VR1). IC5 is a TDA2822 low power stereo amplifier, this amplifier i.c. is used because of its low voltage requirement and also because it needs very few external components. The output of this i.c. is sufficient to drive a pair of personal stereo headphones or small speakers, alternatively the output can be amplified again by using an external amplifier.

CONSTRUCTION

The sound generator can be quite easily constructed on the p.c.b. shown in Fig. 2, when soldering in the components be very careful not to short out any tracks with solder as some of them are very close together.

When assembling fit the resistors and link first, then the i.c. sockets, followed by capacitors. The 50 way cable can now be connected to the board, the prototype used a ready made cable terminated with a 50 way edge connector at one end and a 50 way transition header at the other. Next insert the i.c.s and then the stereo output socket and volume control, use screened cable for these to prevent to much digital noise getting into the signal, also if the case of the volume control is metal connect it to 0V.

TESTING

Before plugging the unit into the computer check the board for short circuits caused by solder etc.

Make sure you have the edge connector the right way up, with pin 1 as shown in Fig. 2. (It is best to fit a polarising key between pins 22 and 24 (see Fig. 3.), and plug the unit into the expansion slot on the back of the PCW. Plug the headphones or speakers in, switch on and boot up as nor-

COMPONENTS

Resistors

R1, R2	470k (2 off)
R3, R4	820k (2 off)
R5, R6	4Ω7 (2 off)

All ¼W 5% carbon.

Potentiometers

VR1	47k stereo log.

Capacitors

C1 to C3	100µ elect. 12V (3 off)
C4, C5	470µ elect. 12V (2 off)
C6 to C9	100n (4 off)

Semiconductors

IC1	Z80PIO
IC2	74LS138
IC3	74LS93
IC4	AY-3-8912
IC5	TDA2822

Miscellaneous

SK1	50 way transition header with ribbon cable and Amstrad connector.
SK2	3.5m stereo jack socket

P.C.B., available from the *EE PCB Service*, order code EE715, screened lead for audio connections; suitable case, minimum size, 120 x 95 x 45mm; control knob.

Approx cost guidance only **£25**

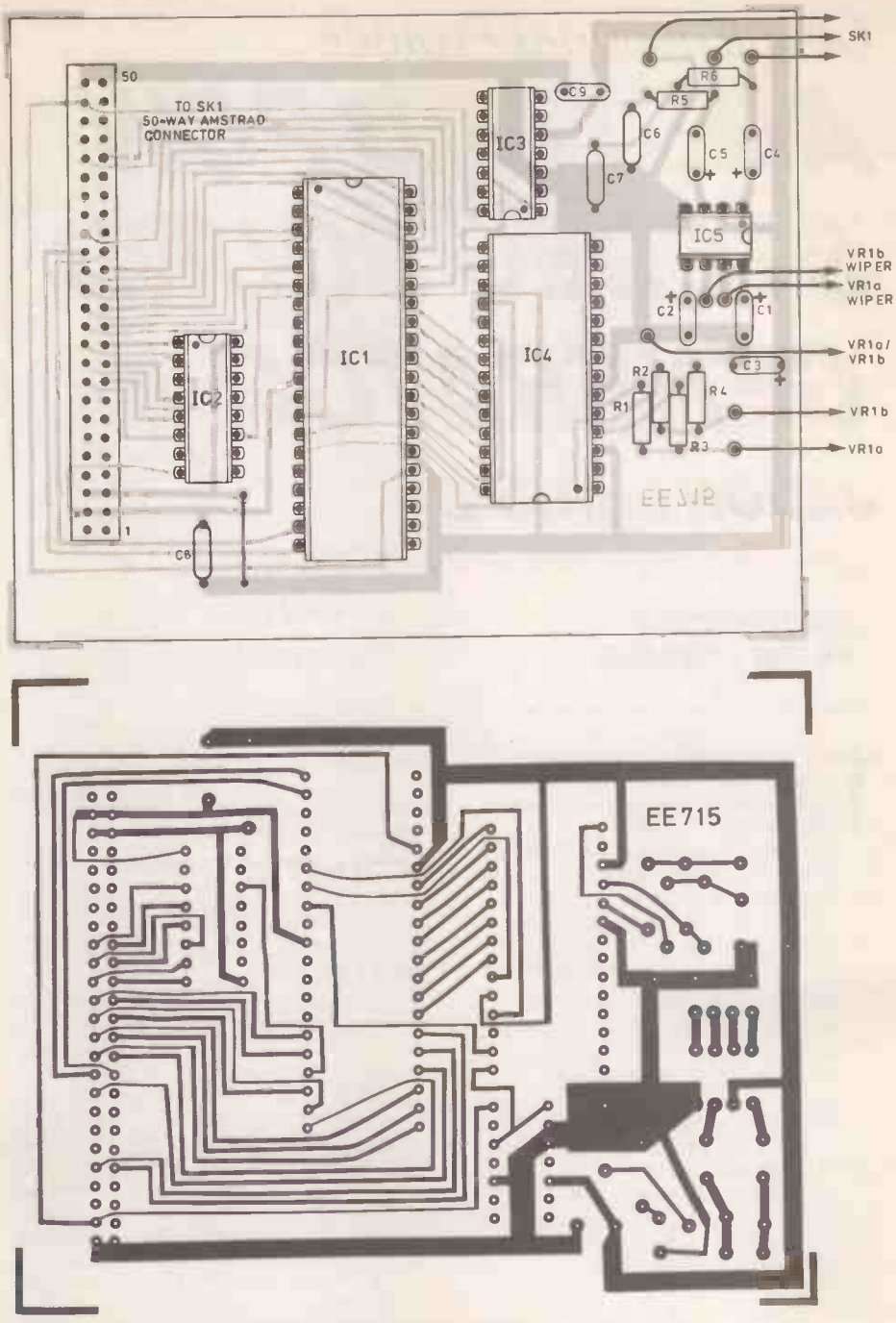
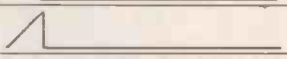
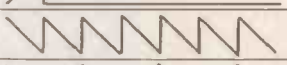


Fig. 2. P.C.B. for the sound generator.

Table 1. Register Functions

Register	Function	Range
0	Channel A frequency, fine tune	0→255
1	Channel A frequency, course tune	0→15
2	Channel B frequency, fine tune	0→255
3	Channel B frequency, course tune	0→15
4	Channel C frequency, fine tune	0→255
5	Channel C frequency, course tune	0→15
6	Noise frequency control	0→31
7	Not mixer enable	0→255
8	Channel A amplitude (15 loud, 16 envelope)	0→16
9	Channel B amplitude (15 loud, 16 envelope)	0→16
10	Channel C amplitude (15 loud, 16 envelope)	0→16
11	Envelope period, fine tune	0→255
12	Envelope period, course tune	0→255
13	Envelope shape cycle	0→15

Table 2

REG. VALUE	ENVELOPE CYCLE SHAPE
0	
4	
8	
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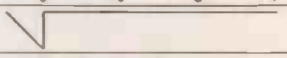
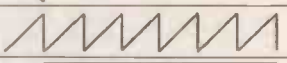
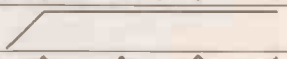
11	
12	
13	
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mal. If the computer will not boot up, or does anything abnormal, turn the computer off, unplug the unit and check all wiring, joints etc. For test program see PROGRAMMING.

REGISTER FUNCTIONS

The AY-3-8912 is register based, this means that you need to set the values of the registers (like memory locations) in the 8912 to certain values, depending on what you want it to do, the register functions are shown in Table 1, and explained below.

FREQUENCY CONTROL:

The frequency of each channel is determined by setting registers 0 to 5, the frequency of the output is equal to: $125000 \div (FTV + 256 \times CTV)$ where FTV is the FINE TUNE VALUE and CTV is the COURSE TUNE VALUE

NOISE CONTROL:

Noise can be mixed into any or all of the channels for special effects (drums, guns, waves, etc.)., the base frequency of the noise is given by: 125000 ÷ (VALUE OF NOISE REGISTER)

NOT MIXER ENABLE:

The value of this register controls which frequencies are "switched on" and whether the channels have noise mixed into them.

	NOT NOISE ENABLE			NOT FREQUENCY ENABLE		
CHANNEL	C	B	A	C	B	A
VALUE	32	16	8	4	2	1

The value you need to set this port to enable the required things can be worked out by $255 - (V_1 + V_2 + \ldots + V_n)$ Where V_1 to V_n are the values of the things you wish to enable, e.g. $255 - (16+4+2+1)$. This will enable all of the frequencies and enable noise to be mixed with channel B.

AMPLITUDE CONTROL:

The value of these registers control the amplitude of the channels. 0 is QUIET, 15 is LOUD, setting the register to 16 lets the amplitude of that signal be controlled by the envelope generator.

ENVELOPES:

As mentioned earlier the AY-3-8912 has envelope capability, but what is an envelope? An envelope is a waveform that varies the amplitued of a signal (in this case the channels that have the amplitued control set to 16), another way of explaining this is that it is similar to turning the volume control on a radio up to full and then down again then up to full etc. The speed at which you turn the volume down (or up) is the envelope period, this can be varied from approx. 7812Hz to about 0.12Hz (≅8.4 second period).

ENVELOPE PERIOD:

These registers determine the frequency of the envelope cycle which is given by: $7812 \div (256 \times ECT + EFT)$ Where ECT is the ENVELOPE COURSE TUNE value and EFT is the ENVELOPE FINE TUNE value.

ENVELOPE SHAPE:

This controls the shape of the envelope cycle (see Table 2).

PROGRAMMING

Program 1 selects random registers and then sends random data to the selected register, the effect is a jumble of frequencies, noise, etc. from the headphones, so this is a good program to test the sound generator.

If you wish to write your own programs you must include lines 100 to 140 as these set up the PIO and also reset the sound i.c. Line 220 is a subroutine to select a register, the value of which is in A. Line 240 is similar to 220 but sends data (in A) to the previously selected register.

Program 2 is almost the same as Program 1, but instead of choosing random registers and data they are input by the user.

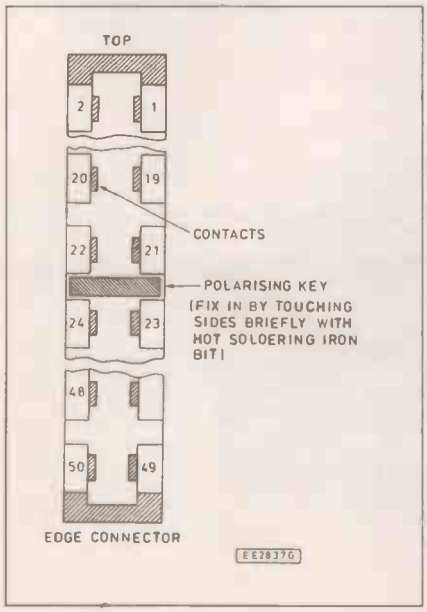
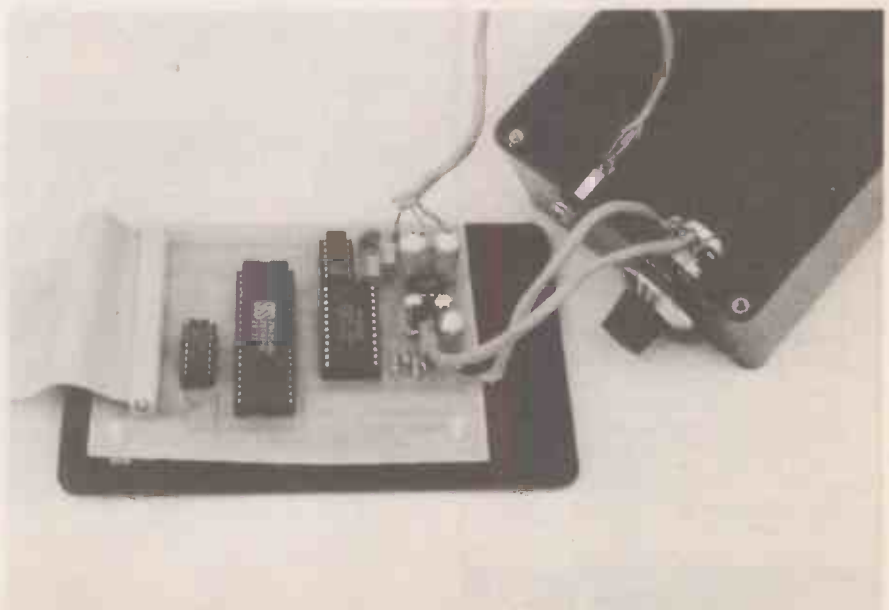


Fig. 3. Polarising key positioning in the Amstrad connector.



Prototype of the sound generator p.c.b.. In this verison the AY-3-8913 was used.

TEST PROGRAMS

PROGRAM ONE

```
100 PAD=160:PAC=161:PBD=162:PBC=162 :REM PAD=PORT A DATA
120 OUT PAC,15:OUT PBC,15:REM SET PIO TO OUTPUT MODE
140 OUT PAD,0 :REM ***RESET SOUND CHIP***
160 A=INT(RND*15) :PRINT "Register:";A;:GOSUB 220
180 A=INT(RND*255):PRINT " Value:";A   :GOSUB 240
200 GOTO 160
210 REM ******SELECT REGISTER (A) ON AY-3-8913******
220 OUT PAD,4:OUT PBD,A:OUT PAD,7:RETURN
230 REM **WRITE DATA (A) TO LAST REGISTER SELECTED**
240 OUT PAD,4:OUT PBD,A:OUT PAD,5:RETURN
```

PROGRAM TWO

```
100 PAD=160:PAC=161:PBD=162:PBC=162 :REM PAD=PORT A DATA
120 OUT PAC,15:OUT PBC,15:REM SET PIO TO OUTPUT MODE
140 OUT PAD,0 :REM ***RESET SOUND CHIP***
160 INPUT "Register:",A:GOSUB 220
180 INPUT " Value:",A  :GOSUB 240
200 GOTO 160
210 REM ******SELECT REGISTER (A) ON AY-3-8913******
220 OUT PAD,4:OUT PBD,A:OUT PAD,7:RETURN
230 REM **WRITE DATA (A) TO LAST REGISTER SELECTED**
240 OUT PAD,4:OUT PBD,A:OUT PAD,5:RETURN
```

Program 3 shows how noise can be used to create a drum effect, channel B is set-up so that the tone is disabled and the noise is enabled, the amplitude register is set to 16 (amplitude controlled by envelope generator). The effect of this is that this channel has plain "noise" on it, this is modulated by envelope cycle shape 8 (amplitude starts at 15 and fades to 0, this repeats until another envelope is defined or the i.c. is reset). This creates a (snare) drum beat.

If the tone on channel B is also enabled, and set to a high frequency, the drum will sound more metallic.

The next part of the program reads the data for notes from lines 280 onwards, until it finds a data statement with 999 in it, at which point the data is read from line 280, and repeats.

The data is in the form:- NOTE A, VOLUME A, NOTE C, VOLUME C, PAUSE

Where NOTE A,C is the frequency of the note (see Table 3).

VOLUME A,C is the volume of the channel (from 0 to 15).

PAUSE is the duration of this note.

The sound i.c. cannot use the frequency information directly, so it is converted at line 200 (and 210).

Frequencies can be converted into time periods for the sound i.c. by:

FTV = (125000/frequency) AND 255

CTV = INT (125000/(256 × frequency))

where FTV is the fine tune value.

CTV is the course tune value.

Frequency is in Hertz.

The minimum frequency possible is 31Hz and the maximum is 125kHz.

Program 4 is a simple piano program, use keys 1 to 7 to play notes. To make the piano sound slightly more realistic the note is modulated by an envelope similar to the drum in Program 3, although this only happens once (not repeatedly like the drum). This sound takes about a second to die away, unless another key is pressed first, in which case the new note will start immediately. Envelope cycle shape 0 is used for this, and must be initalised directly before the note is programmed into the i.c. (line 200).

Program 5 is a sound effect (that sounds quite like a plane diving and then exploding!). This shows the effect of mixing noise with a tone, if the noise is turned off you would just hear a "scale", but with the noise the sound is a lot more realistic.

The explosion at the end is created by turning off the tone, and then fading out the noise by using envelope cycle shape 0.

PROGRAM THREE

```
100 REM ****************SET UP PIO AND SOUND CHIP****************
110 PAD=160:PAC=161:PBD=162:PBC=163:OUT PBC,15:OUT PAC,15
120 OUT PAD,0:REM ***RESET SOUND CHIP***
130 REM ***SET CHANNEL B AS DRUM BEAT(NOISE & ENVELOPE ONLY)***
140 RESTORE:FOR N=1 TO 5:READ R,A:GOSUB 1010:NEXT
150 R=7:A=234:GOSUB 1010
160 RESTORE 280
170 REM ******READ NOTE A,VOLUME A,NOTE C, VOLUME C,PAUSE******
180 READ NA,VA,NB,VB,P:IF NA=999 THEN 160
190 REM **CHANGE FREQUENCY INTO PERIOD,AND SEND TO SOUND CHIP**
200 R=0:A=(125000!/NA) AND 255:GOSUB 1010:R=1:A=INT(125000!/(256*NA)):GOSUB 1010
210 R=4:A=(125000!/NB) AND 255:GOSUB 1010:R=5:A=INT(125000!/(256*NB)):GOSUB 1010
220 REM ************SET VOLUMES OF CHANNEL A&C****************
230 R=8:A=VA:GOSUB 1010:R=10:A=VB:GOSUB 1010
240 FOR N=1 TO P:NEXT:GOTO 180
250 REM ********************DRUM DATA**************************
260 DATA 9,16, 6,5, 11,30, 12,13, 13,8:REM VOL=16,NOISE=5,ENV=13*256+30,ENVSHAPE
270 REM ************MUSIC DATA (NA,VA,NB,VB,PAUSE)************
280 DATA 156,15,156,15,40, 175,15,175,15,30, 165,15,165,15,40 ,156,15,156,15,50
290 DATA 175,15,195,15,60, 185,15,175,15,60, 175,15,185,15,60 ,185,15,175,15,60
300 DATA 175,15,195,15,40, 195,15,175,15,40, 195,15,233,15,40 ,220,15,220,15,40
310 DATA 999,0,0,0,0
320 :
1000 REM ****************SELECT REGISTER (IN R)*****************
1010 OUT PAD,4:OUT PBD,R:OUT PAD,7
1020 REM ******WRITE DATA (IN A) TO LAST REGISTER SELECTED******
1030 OUT PAD,4:OUT PBD,A:OUT PAD,5:RETURN
```

PROGRAM FOUR

```
10 REM ********PIANO PROGRAM, USE KEYS 1(=A) TO 7(=G)**********
20 REM **BASIC NOTE FREQUENCY IS FADED OUT SLOWLY BY ENVELOPE**
30 :
100 REM ************SET UP PIO AND SOUND CHIP*****************
110 PAD=160:PAC=161:PBD=162:PBC=163:OUT PBC,15:OUT PAC,15
120 OUT PAD,0:REM            RESET SOUND CHIP
130 R=9 :A=16:GOSUB 280:REM SET VOLUME OF B TO BE CONTROLED BY ENVELOPE
140 R=11:A=0 :GOSUB 280:REM SET ENVELOPE FINE TUNE PERIOD
150 R=12:A=28:GOSUB 280:REM SET ENVELOPE COURSE TUNE PERIOD
160 R=7:A=253:GOSUB 280:REM ENABLE CHANNEL B ONLY
170 DIM F(7):FOR N=1 TO 7:READ F(N):NEXT:REM *READ NOTE FREQUENCIES*
180 A$=INKEY$:IF A$="" THEN 180 ELSE NA=VAL(A$)
190 IF NA<1 OR NA>7 THEN 180 ELSE NA=F(NA)
200 R=13:A=0:GOSUB 280:REM ****SET ENVELOPE CYCLE TO SHAPE 0***
210 REM **CHANGE FREQUENCY INTO PERIOD,AND SEND TO SOUND CHIP**
220 R=2:A=(125000!/NA) AND 255:GOSUB 280:R=3:A=INT(125000!/(256*NA)):GOSUB 280
230 GOTO 180
240 REM ******************NOTE/FREQUENCY DATA*****************
250 DATA 220,247,262,294,330,349,392
260 :
270 REM ****************SELECT REGISTER (IN R)*****************
280 OUT PAD,4:OUT PBD,R:OUT PAD,7
290 REM ******WRITE DATA (IN A) TO LAST REGISTER SELECTED******
300 OUT PAD,4:OUT PBD,A:OUT PAD,5:RETURN
```

Table 3 Notes and Frequencies

NOTE	FREQUENCY			
A	110	,220	,440	,880
B	123	,247	,494	,988
C	131 (LOW)	,262 (MIDDLE)	,523 (HIGH)	,1047
D	147	,294	,587	,1175
E	165	,330	,659	,1319
F	175	,349	,698	,1397
G	196	,392	,784	,1568

This table gives the approximate frequencies of the notes, though this is not the entire range of frequencies available.

PROGRAM FIVE

```
10 REM ********PLANE FALLING OUT OF SKY AND EXPLODING**********
20 REM ****************ON CONTACT WITH GROUND******************
30 :
100 REM *************SET UP PIO AND SOUND CHIP*****************
110 PAD=160:PAC=161:PBD=162:PBC=163:OUT PBC,15:OUT PAC,15
120 OUT PAD,0:REM              RESET SOUND CHIP
130 R=9 :A=9   :GOSUB 260:REM SET VOLUME OF B TO 9
140 R=11:A=0   :GOSUB 260:REM SET ENVELOPE FINE TUNE PERIOD
150 R=12:A=180:GOSUB 260:REM SET ENVELOPE COURSE TUNE PERIOD
160 R=7 :A=237:GOSUB 260:REM ENABLE CHANNEL B TONE AND NOISE
170 FOR NA=100 TO 450:REM     FREQUENCY OF NOTE INCREASES FROM 100Hz TO 450Hz
180 REM **CHANGE FREQUENCY INTO PERIOD,AND SEND TO SOUND CHIP**
190 R=2:A=(125000!/NA) AND 255:GOSUB 260:R=3:A=INT(125000!/(256*NA)):GOSUB 260
200 FOR N=1 TO 40:NEXT N,NA
210 REM ************************EXPLOSION************************
220 R=9:A=16:GOSUB 260:R=13:A=0:GOSUB 260:R=7:A=239:GOSUB 260
230 END
240 :
250 REM ****************SELECT REGISTER (IN R)*******************
260 OUT PAD,4:OUT PBD,R:OUT PAD,7
270 REM ******WRITE DATA (IN A) TO LAST REGISTER SELECTED******
280 OUT PAD,4:OUT PBD,A:OUT PAD,5:RETURN
```

SOUNDS

The sounds made by musical instruments have quite complex waveforms, which this unit is not capable of generating, but with the use of envelopes the sounds can be made slightly less digital (as with the piano program), and simple tunes can be played. Sound effects for cars, explosions, drums, etc. are a lot more realistic if they have noise mixed in with them rather than just the basic frequency.

When writing your own program follow this list..

1) Make sure the first thing you do is to set-up the PIO and reset the sound chip (lines 110 and 120).
2) Include lines 1010 to 1030 on your program, when you want to change the contents of a register set R = REGISTER N. A = NEW VALUE OF REGISTER. GOSUB 1010. On return register R will be set to value A.
3) Set the volumes of the channels of the channels you wish to use (and any envelope delays, noise, or frequencies that you need).
4) Enable the required channel (register 7).
5) Remember that if you want to use frequencies (the sound i.c. uses tone periods), to use the conversion program (at line 200). The first R is FINE TUNE VALUE Reg. (0 = A, 2 = B, 4 = C). The second R is COURSE TUNE Reg. (1 = A, 3 = B, 5 = C), and NA = frequency of required note (in Hz).

NOTE: All line numbers above refer to PROGRAM 3. □

SHOP TALK

with David Barrington

Kit News

The improvement in the quality, range and professional approach adopted by kit/module advertisers over the years is highlighted by a new audio company this month.

After an extensive search of the overseas manufacturers, **Platinum Audio** ***(0273 685904)*** has been set up to import a range of audio products in kit form. Ranging from simple preamplifiers to a 300W slave amplifier, all kits come complete with any necessary heatsinks/hardware.

Talking of amplifiers, we see that the latest 1990/91 Velleman catalogue from **High-Q Electronics** ***(0707 263 562)*** contains details of a "valve" amplifier that is claimed to give up to 200W *music power* output. The catalogue contains approximately 30 additions to their extensive range of kits.

CONSTRUCTIONAL PROJECTS

Simple Intercom

On checking out the prototype model for the *Simple Intercom,* this month's back-up project for the *Teach-In '91* series on *"Design Your Own Circuits,"* we have found that the loudspeaker used is a 3½in. diameter type. This speaker has a 35 ohm speech coil and was purchased from RS Components through **Electromail** ***(☎ 0536 204555)***, their mail order operation.

Although the speaker is stamped with the reference 9L957, looking through the catalogue it can only be from their general purpose range and be the one coded 248-274 (£4.78). Provided the speaker has a coil rated at 35 ohm, and it will fit inside the chosen case, practically any reasonable size speaker will be suitable for this simple circuit.

The printed circuit board for the intercom is available from the *EE PCB Service,* code 719. For those wishing to build up the two demonstration amplifiers contained in this month's Design Your Own Circuits teach-in, the General Purpose Transistor Amplifier (EE717) and the Operational Amplifier (EE718) boards are also available from the EE PCB Service, see page 68.

Analogic Test Probe

The interlocking plastic case for the *Analogic Test Probe* is only available from **Magenta Electronics.** The rest of the components seem to be standard lines and should not cause any local sourcing problems.

A full kit of parts including the printed circuit board, drilled case, but excluding battery, is available from **Magenta Electronics, Dept EE, 135 Hunter Street, Burton on Trent, Staffs, DE14 2ST** ***(☎ 0283 65435)*** for the sum of £12.95. Add a further £2 for posting and packing.

The small printed circuit board for the probe is available through the *EE PCB Service,* code EE720 (see page 68).

Amstrad PCW Sound Generator

There should be no purchasing problems when shopping for the components required to build the *Amstrad PCW Sound Generator.* However, the programmable sound generator chip AY-3-8912 may prove to be in short supply in some local areas. If you do have difficulty locating this device, it is currently listed by **Maplin** code RA90X (AY-3-8912). They also stock the 1W stereo amp i.c.

Most components suppliers stock a fairly good supply of computer parts and should be able to offer the 50-way header, with ribbon cable and Amstrad connector.

The single-sided printed circuit board is available from the *EE PCB Service,* code EE715, See page 68 for details.

Sound Operated Switch

We do not expect any component buying problems to be encountered when building the *Sound Operated Switch* project. Some component stockists may not carry the 4.7 megohm preset potentiometer and the designer suggests that a 2.2 megohm preset is more readily available and can be used in this circuit.

The crystal microphone inserts are generally available and come in two types of casing, metal or plastic. Because of the high sensitivity of the circuit, and to avoid "stray" pick up, it is best to use a metal case type and "earth" the casing as outlined in the article.

Spatial Power Display

Once again this month, there should be no nightmares about obtaining components for the *Spatial Power Display,* they are all standard "of-the-shelf" stock items.

When pricing up this project we found the bulk of the cost was taken up by the l.e.d.s. As we priced them on the high side at 26p each, quite a considerable saving could be made if you purchased one of the "l.e.d. component packs" on offer from **Greenweld** ***(☎ 0703 236363)***. In fact, it might be a good idea to approach your supplier about a "quantity" discount price.

The printed circuit board for the l.e.d. display project is available from the *EE PCB Service,* code EE714 (see page 68).

Help

We are trying to locate a source for the ML927 decoder i.c.