OMDAC

PARTS COST GUIDE £60

- ★ **Microcomputer Peripheral for Music Applications**
- ★ **Microcomposing!**
- ★ **Polyphonic Sequencing!**
- ★ **Patch Programming!**
- ★ **Dynamic Rhythm Control!**

by Jim Grant and Kenneth McAlpine

The use of computers in electronic music production can be divided into roughly three categories.

1) Digital recording: where the music is digitised, stored, perhaps edited and converted back to an audio signal using a DAC. This requires fast audio convertors and lots of storage (about 540 bits/sec of music).

2) Direct digital synthesis: where the sound is calculated from various formulea, perhaps Fourier components or Walsh functions. In this case the speed of the computer is paramount since we require about 40K sample/per sec for a 15kHz bandwidth.

3) Control: here the computer supplies sound generating equipment e.g. synthesisers or sound chips with parameters to alter the sound. The common denominator of most synthesisers is that they are voltage controlled and that the voltages vary fairly slowly in computer terms.

Since the average personal computer is either not fast enough or has insufficient storage, method (3) at the moment has the most to offer the home musician. Certainly using a computer as the controller/supervisor element in an electronic music system can be very rewarding since the computer can be regarded as a logic board whose wires are the program.

There exists a definate relationship between logic hardware and computer software to the point that they are almost functionally indistinguishable. This being the case all we require is a general hardware system upon which we superimpose the 'personalities' of different programs to perform different tasks.

The OMDAC (Octal Music Digital to Analogue Convertor) is a step in this direction, it offers a very general layout of digital to analogue conversion, sample and holds, a multiplexer and digital in/out channels. The function of the system is under software control and be configured to suit specific requirements. For example OMDAC could be used to provide an eight channel polyphonic sequencer, a drum machine controller with programmable dynamics or memory storage for 1,000's of voltage controlled parameters in banks of eight. Four external clocks or switches can be connected to synchronise software processes. The ADC provides a means to input quantised control voltages for storage or modification.

Circuit Description

The original test circuit was implemented on a 6502 based system, the ACORN ATOM, but provision has been made for SPECTRUM compatibility simply by changing three PCB links. Several ATOM programs have been included to demonstrate the capabilities of the OMDAC and the equivalent SPECTRUM programs are currently under development and will be published soon. In addtion the OMDAC is expected to form the basis for several SOFTMUSIC features and new software such as a polysequencer will appear in forthcoming issues.

Layout of the OMDAC can be seen in Figure 1, the block diagram. In order to make full use of the OMDAC it is necessary to understand the relationship between various functional blocks.

The ADC and PIA (Parallel Interface Adaptor) are connected directly to the computer's data buss and selected by decoding its address lines. The PIA has 3 ports which are configured as shown. Port A sends data to the DAC, Port B provides trigger outputs while Port C is split to control the multiplexer nd allow user connections into the system.

Eight sample and holds are used to

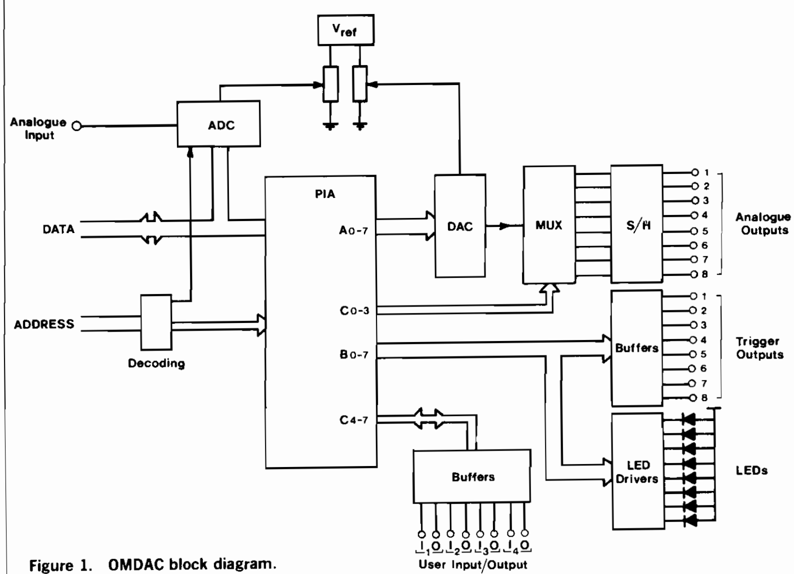


Figure 1. OMDAC block diagram.

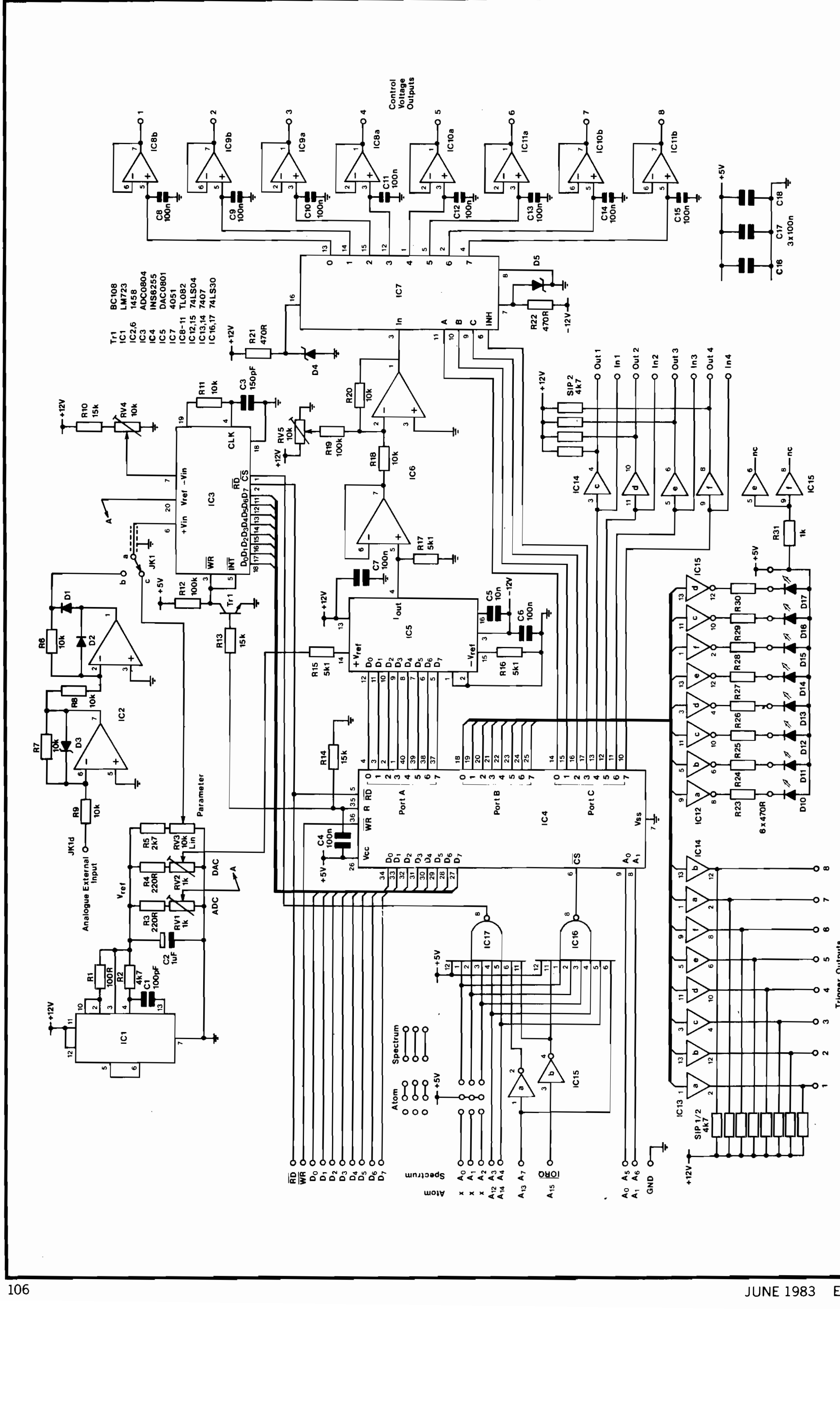


Figure 2. OMDAC circuit diagram.

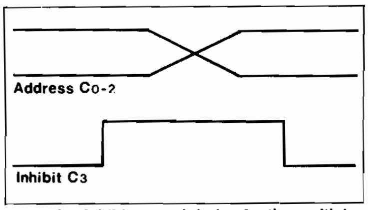


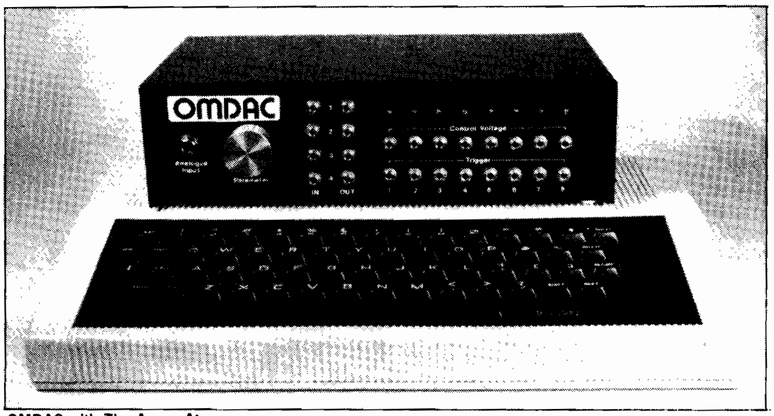
Figure 3. Inhibit control timing for the multiplexer.

store the multiplexed voltages and provide 8 control voltages. LEDs give a visual indication of the trigger status or can be configured to display program information.

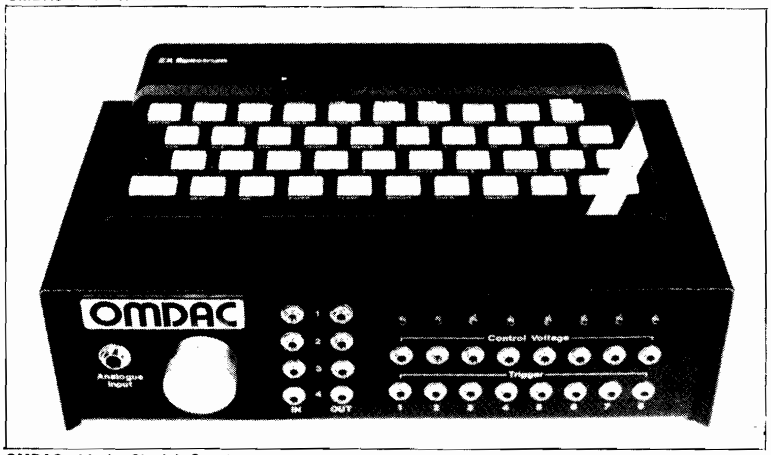
A temperature compensated reference voltage is provided which has presets allowing the ADC and DAC to be 'musically scaled' to 1V/Octave.

A complete circuit diagram showing the system in more detail is given in Figure 2. The ATOM and the SPECTRUM differ radically in the sense that the ATOM has memory mapped I/O whereas the SPECTRUM uses special I/O commands. Table 1 gives the relevant addresses at which the ADC and PIA appear relative to both machines. Although the address decoding is tailored for the ATOM and SPECTRUM it would be a simple matter to wire the inputs of IC's 15, 16 and 17 differently to the address lines of other machines to decode their address spaces.

The ADC is really separate from the rest of the circuit since it only shares the data bus and the $\overline{RD}$ signal. When the circuit is powered up TR1 delivers an initial 'Start Conversion' pulse to the



OMDAC with The Acorn Atom.



OMDAC with the Sinclair Spectrum.

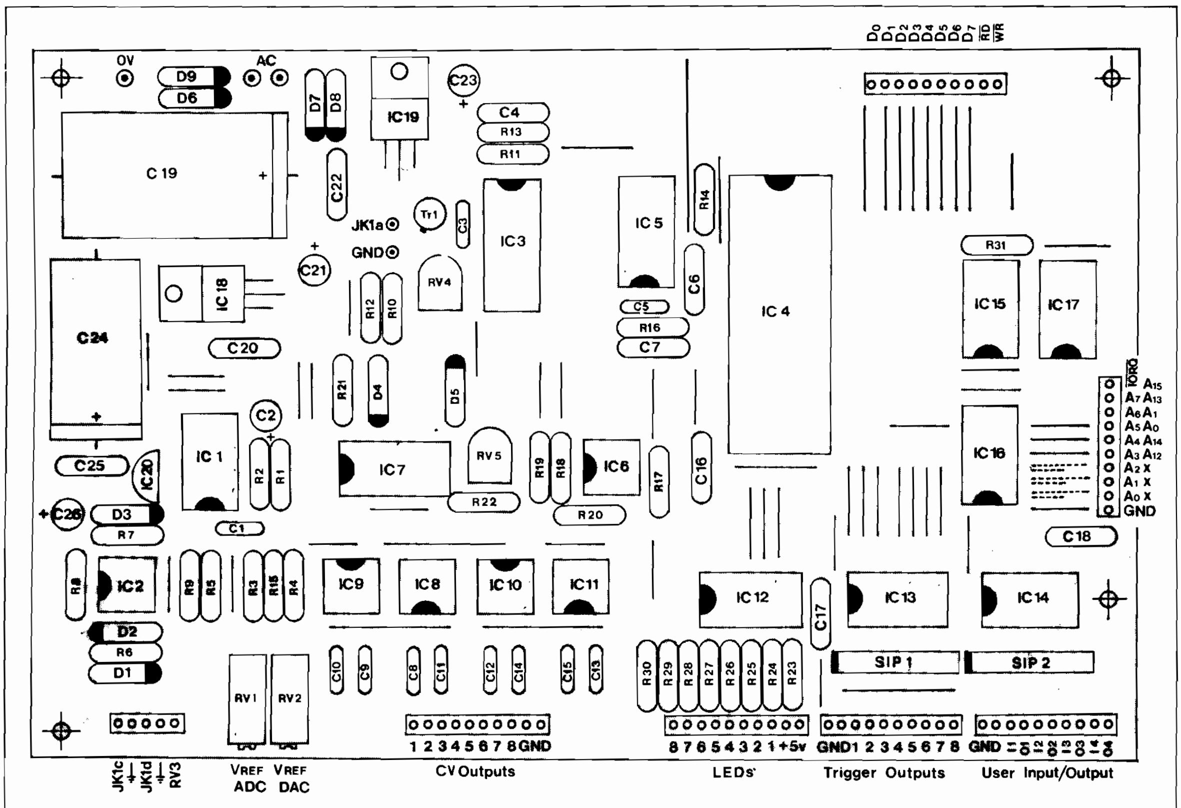


Figure 4. Component overlay for the OMDAC.

Atom	Spectrum	Selection
#5000	31	ADC
#7000	159	Port A
#7001	191	Port B
#7002	223	Port C
#7003	255	Control Word

Table 1. Port Addresses.

ADC and thereafter the ADC continually quantises the voltage appearing at the 'Analogue In' pin. Conversion data can be read by the computer by executing a PEEK (ATOM) or an IN (SPECTRUM) statement at the address decoded for the ADC.

Op Amp, IC2, buffers and limits the external input voltage to a safe range of (0-5.6) v which gives just over 5 octaves. Inserting a jack plug into the 'Analogue Input' disconnects the internally wired parameter control from the ADC.

The rest of the circuit is controlled by the 8255 PIA. This has three I/O registers which are configured by a Control Word register.

Table 2 gives the value of the control register for various Port configurations. It is important that this register is set before any attempt is made to use the Ports.

Port A is used as an output since it supplies the DAC with digital data. The output from the DAC is buffered and scaled by Op Amp IC6 and fed to a multiplexer. The multiplexer is an electronic switch which connects it's input, in this case the DAC, to one of eight outputs selected by a three bit address $(2^3=8)$. Port C is divided into two groups. Bits 0-2 control the address of the multiplexer and determine which sample and hold the DAC voltage is routed. To prevent glitches appearing on the output channels the multiplexer has an Inhibit control. When this is HI all channels are off and the DAC voltages are blocked from the sample and holds regardless of the address selected. Bit 3 of Port C controls the Inhibit and it's proper use is very important during rapid scanning of the sample and holds.

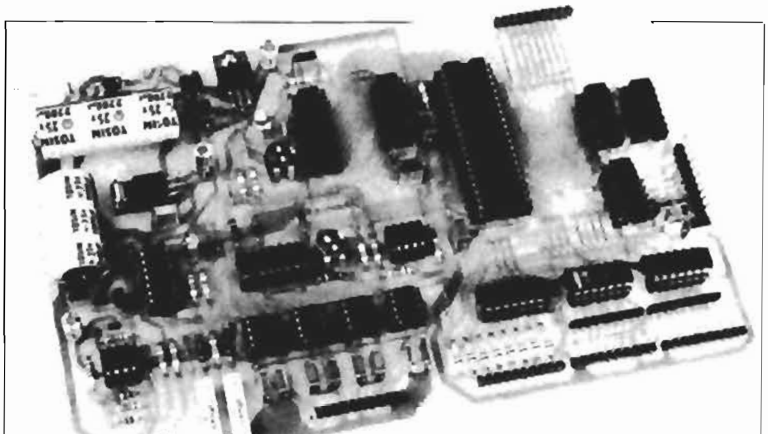
The rule is very simple: when changing the multiplexer address

a) bring the Inhibit HI, i.e. set bit 4 of PC.

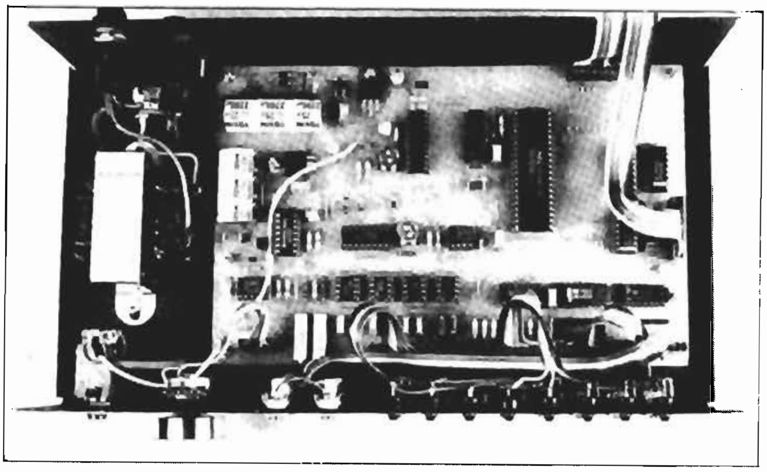
b) change the address without changing bit 4 of PC.

c) bring the Inhibit LO i.e. reset bit 4 of PC.

This is shown in Figure 3 and is quite easily achieved by simple programming.



The completed PCB.



Internal view of the OMDAC.

The remaining 4 bits of Port C PC4-PC7 can be used as general digital I/O channels. Port C is the only port that can be split with a dual I/O function by setting the appropriate control word. This means that we can use the lower four bits to control the multiplexer and still accept or output data with the remaining top bits.

Port B must be configured as an output and will usually be used to trigger analogue modules such as envelope shapers. It is connected to buffers with pull up resistors so that the outputs have a 12v ON state suitable for synthesiser triggers. Obviously this is no longer TTL compatible. The LED's mirror the output of this port and can be useful for displaying ADC data or trigger outputs.

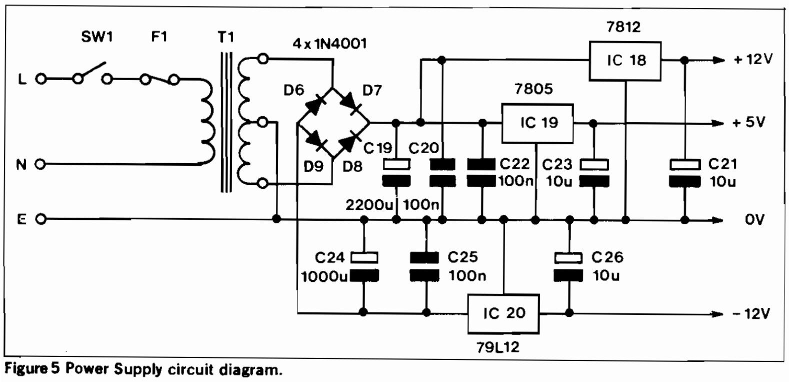


Figure 5 Power Supply circuit diagram.

Construction

Assembly should be fairly straight forward since all the parts, apart from the transformer, are mounted on a PCB. Using the component overlay shown in Figure 4, the links, IC sockets and the molex connectors should be soldered in first. Next mount the resistors, capacitors and the presets. The diodes, three regulators and TR1 can then be soldered in and the circuit powered up to check that the correct voltages are supplied to the IC sockets. If every thing is OK insert the IC's with the power off taking extra care with the 40 pin 8255 PIA. All that remains is to house the PCB in a suitable case and wire up the pot, sockets and LED's as shown in the photographs.

Testing and Calibration

Before calibration first check that the OMDAC is working properly. The ADC can be tested by running a simple single-line program.

ATOM 1Ø DO P.?5ØØØ;U.Ø

SPECTRUM 1Ø PRINT AT Ø,Ø ; IN 31 ; " " : GOTO 10

```
 10 REM 8 CHANNEL SAWTOOTH
 20 REM     BY JIM GRANT
 30 REM      MARCH 1983
 40 DIM LL8
 50 ?#7003=#80
 60 REM                     TWO PASS ASSEMBLY
 70 F.A=1 TO 2
 80 DIM P-1
 90 P.$21
100[
110:LL0 LDY @0              SCAN CHANNELS
120 LDX @8
130 STX #7002
140:LL7 STY #7002
150 STX #80;LDX @#80
160:LL2 DEX;BNE LL2
170 LDX #80
180 STX #7002
190 INY;CPY @8
200 BEQ LL6
210 INX;STX #7002
220 JMP LL7
230:LL6 RTS
240:LL5 INC #7000           GENERATE SAWTOOTH
250 INC #7001               MIRROR TO LED'S
260 JSR LL0
270 JMP LL5
280]
290 N.
300 P.$6
310 REM                     LOOP FOREVER
320 REM                     BREAK KEY TO EXIT
330 LINK LL5
340 END
```

```
 10 REM OMDAC INTERRUPT SCAN
 20 REM     BY JIM  GRANT
 30 REM      MARCH 1983
 40 REM                     SET INTERRUPT VECTOR
 50 DIM LL4
 60 T=#3B40
 70 ?#204=0
 80 ?#205=#3B
 90 ?#7003=#80
100 P.$12,$21
110 REM                     TWO PASS ASSEMBLY
120 F.A=1 TO 2
130 P=#3B00
140[
150 TXA;PHA;TYA;PHA         SAVE REGISTERS ON STACK
160 LDY @0                  CH NOS INHIBIT=0
170 LDX @8                  CH NOS INHIBIT=1
180 STX #7002
190:LL0 LDA T,Y             GET VALUE FROM TABLE
200 STA #7000               SEND TO DAC
210 STY #7002               SEND CH NOS INHIBIT=0
220 JSR LL2                 DELAY FOR S/H
230 STX #7002               SEND CH NOS INHIBIT=1
240 INY;CPY @8
250 BEQ LL1                 RTI IF TABLE SCAN DONE
260 INX;STX #7002
270 JSR LL2;JMP LL0         NEXT VALUE
280:LL1 STX #7002
290 PLA;TAY;PLA;TAX;PLA     RESTORE REGISTERS
300 RTI
310:LL2 STX #80;LDX @#80    DELAY ROUTINE
320:LL3 DEX;BNE LL3
330 LDX #80;RTS
340]
350 N.
360 P.$6
370 G.a
380 REM                      DIAGNOSTIC ROUTINES
390 REM                      FILL TABLE WITH ZEROS
400 F.A=0 TO 7;T?A=0;N.;E.
410 REM                      FILL TABLE WITH #FF
420 F.A=0 TO 7;T?A=#FF;N.;E.
430 REM                      FILL TABLE WITH RAMP
440 F.A=0 TO 7;T?A=31*A;N.;E.
450 REM                      SEND ADC TO CH-1
460 REM                      MIRROR ADC TO LED'S
470 DO T?0=?#5000
480 ?#7001=?#5000;U.0
490 REM                      SET IRQ MASK
500aQ=TOP;!Q=#6058;LINK Q;E.
```

Acorn Atom application programs.

```
 10 REM OMDAC "FRONT PANEL"
 20 REM     BY JIM GRANT
 30 REM      MARCH 1983
 40 L=#DE;W=#FE52
 50 ?#7003=#80
 60f P.$12
 70 P."SELECT RANGE"''
 80 P."1......0-255"''
 90 P."2......0-63"''
100 INPUT A
110 IF A=1 S=1;D=#FF;G.g
120 IF A=2 S=4;D=#FC;G.g
130 G.f
140gP.$21
150 DIM LL6,V(8)
160 REM                     TWO PASS ASSEMBLY
170 F.A=1 TO 2
180 DIM P(-1)
190[
200:LL0 JSR #FE71           SINGLE KEY SCAN
210 BCS LL1                 RTS IF NO KEY DOWN
220 CLC
230 TYA
240 ADC @#20                CONVERT TO VDU CODE
250 CMP @#31;BMI LL1        TEST IF
260 CMP @#39;BPL LL1        KEY 1-8
270 JSR W                   PRINT KEY NOS
280 SEC
290 SBC @#30                CONVERT TO DECIMAL
300 STA #324                STORE AT "C"
310:LL1 RTS                 KEY SCAN DONE
320:LL2 LDY @0              CH NOS INHIBIT=0
330 LDX @8                  CH NOS INHIBIT=1
340 STX #7002
350:LL3 LDA V+1,Y           GET VALUE FROM TABLE
360 STA #7000               SEND TO DAC
370 STY #7002               SEND CH NOS INHIBIT=0
380 JSR LL4                 DELAY FOR S/H
390 STX #7002               SEND CH NOS INHIBIT=1
400 INY;CPY @8;BEQ LL6      RTS IF TABLE SCAN DONE
410 INX;STX #7002
420 JSR LL4;JMP LL3         NEXT VALUE
430:LL6 RTS
440:LL4 STX #80             DELAY ROUTINE
450 LDX @#FF
460:LL5 DEX;BNE LL5
470 LDX #80;RTS
480]
490 N.
500 P.$6
510 G.s
520 REM                     BOX DRAW
530a MOVE X,Y
540 PLOT1,A,0;PLOT1,0,-B
550 PLOT1,-A,0;PLOT1,0,B
560 R.
570 REM                     SELECT CHANNEL
580c @=0;!L=#028020
590 L?2=8*C-6
600 IF C>4 L?0=#C0;L?2=8*C-38
610 P."ch";A=#9A;LINK W
620 A=C+#90;LINK W
630 R.
640 REM                     DE-SELECT CHANNEL
650b @=0;!L=#028020
660 L?2=8*C-6
670 IF C>4 L?0=#C0;L?2=8*C-38
680 P."CH:",C;R.
690 REM                     PRINT ADC VALUE
700e @=3;!L=#028060
710 L?2=8*C-6
720 IF C>4 THEN !L=#028100;L?2=8*C-38
730 P.(V?C)/S;R.
740sCLEAR0
750 REM                     DRAW "DISPLAY"
760 X=0;Y=47;A=63;B=47
770 GOS.a
780 B=16;GOS.a
790 B=32;GOS.a
800 A=16;GOS.a
810 A=32;GOS.a
820 A=48;GOS.a
830 REM                     DEFAULT TO CH-1
840 F.C=1 TO 8;GOS.b
850 V?C=0;GOS.e;N.
860 O=1;C=1;GOS.c
870 !L=#0281A0
880 P."SELECT CHANNEL:"
890 REM                     SCAN KEYS & ADC FOREVER
900d!L=#1281A0
910 LINK LL0
920 ?#7001=?#5000&D
930 GOS.e;V?C=?#5000&D
940 LINK LL2
950 IF C=O G.d
960 T=C;C=O;GOS.b
970 O=T;C=T;GOS.c
980 G.d
990 END
```

Control Word		Ports			
Dec	Hex	A	B	C(Upper)	C(lower)
128	8Ø	OUT	OUT	OUT	OUT
129	81	OUT	OUT	OUT	IN
130	82	OUT	IN	OUT	OUT
131	83	OUT	IN	OUT	IN
136	88	OUT	OUT	IN	OUT
137	89	OUT	OUT	IN	IN
138	8A	OUT	IN	IN	OUT
139	8B	OUT	IN	IN	IN
144	9Ø	IN	OUT	OUT	OUT
145	91	IN	OUT	OUT	IN
146	92	IN	IN	OUT	OUT
147	93	IN	IN	OUT	IN
152	98	IN	OUT	IN	OUT
153	99	IN	OUT	IN	IN
154	9A	IN	IN	IN	OUT
155	9B	IN	IN	IN	IN

Table 2. Definition of 8255 Port control, Mode Ø.

This will cause the current conversion to printed on the screen. If all is well then the parameter pot should sweep the value printed through the range of 0-255. The ADC can be calibrated by injecting a known reference voltage into the 'Analogue Input' and adjusting RV1 until the desired number is printed on the screen. The preset RV2 is provided to allow for an offset on the external voltage.

The ADC can be used to test the PIA. We must send a control word to the CR to configure the Port. Next PEEK (or equivalent) the value of the ADC and send to PB. This should result in the digital code of the current version being displayed on the LED's.

```
ATOM      1Ø ?#7ØØ3=#8Ø
          2Ø DO ?#7ØØ1=#5ØØØ;U.Ø
SPECTRUM  1Ø OUT 255,128
          2Ø OUT 191, IN 31 :
          GOTO 2Ø
```

The sample and hold channels can be tested by sending the ADC value to the DAC and supplying addresses to multiplexer via PC. A control voltage that varies directly with the ADC should appear on the selected channel.

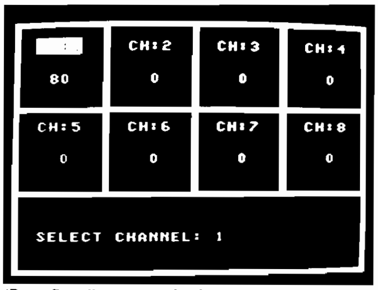
```
ATOM      1Ø ?#7ØØ3=#8Ø
          2Ø ?#7ØØ2=Ø
          3Ø DO ?#7ØØØ=?#5ØØØ;U.Ø
SPECTRUM  1Ø OUT 255, 128
          2Ø OUT 223, Ø
          3Ø OUT 159, IN 31 :
          GOTO 2Ø
```

The DAC can be calibrated by sending a suitable number via one of the output channels and adjusting RV2 until the desired voltage is obtained. Preset RV5 can be used to add a small negative offset voltage of about 1.2v to the DAC output. This is useful since the DAC generates only positive voltages.

Applications

Three complete ATOM programs are given to illustrate channel scanning and to demonstrate the possibilities of the OMDAC. The 8 channel sawtooth program outputs the same low frequency 256 step sawtooth waveform via all the sample and holds. A much more useful program is the Interrupt Scan. The program assembles a short routine which is pointed to by the Interrupt request (IRQ) vector set by lines 70 and 80. Included in the program is an 8 entry table starting at location #3b40. When the routine is triggered by an IRQ the values stored in the table are multiplexed to their corresponding output channels, 1-1 2-2 etc. A suitable circuit for generating IRQ pules was given in Softmuse article (Jan. '83). This should be connected to pin 28a of the ATOM connector.

The interrupt routine has many applications since we can develop programs to fill the table, perhaps from music keyboard data, and have the sample and holds continuously refreshed by an external and transparent interrupt.



'Front Panel' program display.

The 'Front Panel' program is much more self contained. It presents the user with a digital readout showing the value being scanned on each of the sample and holds, see photo. By selecting a number (1-8) on the ATOM keyboard we can open a direct link between the ADC and any of the output channels. The current conversion value of the ADC is also mirrored on the LED's. A good use for this program is to connect each of the eight output channels to a different voltage controlled parameter on a synthesiser and set them up using the ADC parameter control. The 0-63 range should be used since this will result in the ADC control stepping in semitones (provided the system has been calibrated for 1V/Octave). Every twelve steps should give rise to an octave.

OMDAC offers endless possibilities and can form the basis of many computer controlled music systems for little expense and a little programming effort. **E&MM**

OMDAC PARTS LIST

Resistors — all ¼W, 5% carbon film

R1	100R	
R2	4k7	
R3,4	220R	2 off
R5	2k7	
R6,7,8,9,11,18,20	10k	7 off
R10,13,14	15k	3 off
R12,19	100k	2 off
R15,16,17	5k1	3 off
R21,22,23-30	470R	10 off
R31	1k	
SIP1,2	4k7 Resistor package	2 off

Potentiometers

RV1,2	1k 15 turn pre-set	2 off
RV3	10k lin	
RV4,5	10k pre-set	2 off

Capacitors

C1	100pF ceramic	
C2	1uF 16V PCB mounting	
C3	150pF ceramic	
C4,6-18,20,22,25	100nF polycarbonate	17 off
C5	10nF polycarbonate	
C19	2200uF 25V axial	
C21,23,26	10uF 16V PCB mounting	3 off
C24	1000uF 25V axial	

Semiconductors

D1,2	1N4148	2 off
D3	5V6 400mW zener	
D4,5	5V1 400mW zener	2 off
D6-9	1N4001	4 off
D10-17	LED	8 off
TR1	BC108B	
IC1	LM723	
IC2,6	1458	2 off
IC3	ADC0804	
IC4	INS8255	
IC5	DAC0801	
IC7	4051	
IC8,9,10,11	TL082	4 off
IC12,15	74LS04	2 off
IC13,14	7407	2 off
IC16,17	74LS30	2 off
IC18	7812, 12V, 1A	
IC19	7805, 5V, 1A	
IC20	79L12 -12V, 100mA	

Miscellaneous

JK1	¼" jack socket with DPDT	
JK2-25	3.5mm open jack socket	24 off
	LED holders	8 off
T1	12-0-12 500mA transformer	
F1	1A 20mm fuse	
	20mm fuseholder	
SW1	SPST mains switch	
	European mains connector, plug and socket	
	3A mains cable	
	10 way Minicon latch plug	6 off
	10 way Minicon latch housing	6 off
	5 way Minicon latch plug	
	5 way Minicon latch housing	
	20 way ribbon cable, 1M	
	Knob	
	Case	
	6BA nuts and bolts	
	Connector to suit computer	
	IC sockets	

The PCB for the OMDAC is available from E&MM, 282 London Road, Westcliff-on-Sea, Essex SS0 7JG at £5.95 inc. VAT and P&P. Please order as: OMDAC PCB.