ALPHADAC 16

RECORDED ON CASSETTE NO. 3

SYNTHESISER CONTROLLER

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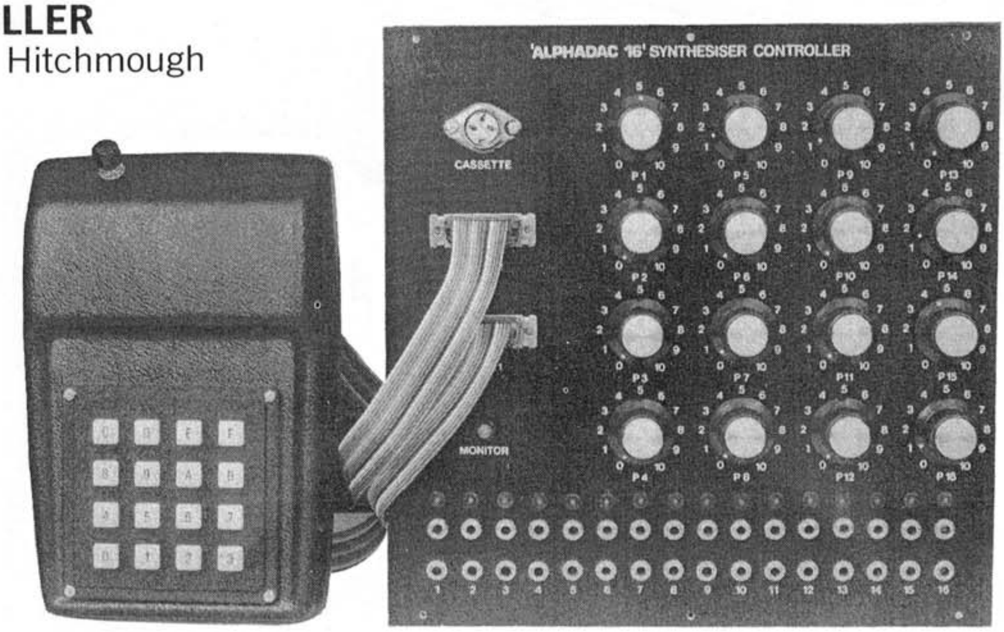
Digisound Limited

This low-cost micro-based system provides almost unlimited control possibilities for up to 16 monophonic synthesisers played in real time from one keyboard.



Since the introduction of the first voltage controlled synthesiser in the mid-Sixties two major aspects have concerned designers. The first being a polyphonic capability which was realised about ten years later and has since proliferated, although many have a restricted voicing capability. Secondly, and equally important, the ability to achieve real time control over such a versatile instrument without detracting from its capabilities. Recent reviews in E&MM reveal the cost range of such instruments. 'Alphadac 16' is a microprocessor based system which achieves both of these aims with extensive provision for extending the real time control features. Particular advantages are the ease of fitting to most existing synthesisers coupled with the ability of the current control program to greatly enhance the playing capabilities of equipment which only have one or two voices.

General Description

'Alphadac 16' is a multi-option system providing computer management of synthesisers having exponential voltage control response, that is most synthesisers, over a five octave range and up to sixteen voices. It is the versatility of the project which gives it an air of complexity but in reality getting the unit up and running only requires an ability for fine soldering and the use of a voltmeter to calibrate the control voltages. There is only one constraint, namely, that the unit works in conjunction with a digitally encoded keyboard but a suitable encoder is readily available which can be retro-fitted to the majority of popular keyboards. The digital encoder is low in cost and takes the place of the conventional keyboard interface with its resistive divider, sample and hold circuits and gate/trigger generators.

Let us look at two main options. Firstly we recognise that many keyboard players will not wish to get involved in computer programming and also a full computer option will be bulkier and more expensive. So 'Alphadac 16' will operate from a built and tested Controller Card produced by Tangerine Computer Systems and which simply goes into Slot 1 of Alphadac's motherboard. Programs for synthesiser control are provided in EPROMs (permanent memory which may be reprogrammed to incorporate future additions) and the selection of a particular effect is achieved using a sixteen key control pad which may be incorporated into the keyboard case or housed in a separate box adjacent to the keyboard. A single LED provides the necessary communication between the computer and the user. That is all there is to it — in this configuration one does not need to know anything about the operation or programming of computers but at the same time it allows those who so desire to become familiar with microprocessors and could act as a stepping stone to bigger things. 'Alphadac 16' will also operate from a minimum configuration Microtan 65 and Tanex, also produced by Tangerine Computer Systems. Again the keyboard control can be in EPROM and program selection uses the same control pad mentioned above. There are, however, two important differences. First the communication for the latter will be via a video display and, secondly, the Microtan and Tanex may be expanded to give the user the opportunity to write other synthesiser control programs. We can already hear some of you saying 'can Alphadac be used with my present computer'? Well, first the good news, none of the programs for Alphadac use TANBUG (Tangerine's monitor) and so it would be relatively easy to convert the programs to any 6502 based computer such as Apple, Pet, Superboard, Atari and so on. Difficulty may arise, however, in configuring the input/output port to accept the control pad and keyboard signals.

Each control voltage output from Alphadac uses a separate Digital to Analogue converter. At first sight this may seem rather extravagant but it greatly simplifies user programming. More important though is that it allows more compact programs so that several keyboard routines can operate simultaneously and this makes the additional cost well worth while. Six slots are provided on the motherboard and four of these are designated for the D to A converters. Each PCB for the latter contains four D to A converters, portamento selected by computer control on each channel, and four gate generators with LED drivers to indicate which gates are on. The actual number of D to A converters installed will be equal to the number of voices (VCOs, etc.) available, for example if you have three voices then only one PCB need be installed together with three Digital to Analogue converters on this PCB. Others may be added later, if required, up to a maximum of sixteen. We also realise that perhaps only a few users will want to fully expand the system to sixteen voices but the design of the motherboard and the front panel is such that we can install other types of controller into any spare slots. This approach keeps expansion costs low. The control voltage and gate signal for each voice is available from a miniature jack socket on the front panel and also from DIL sockets on the motherboard. We have aimed at giving the user as much flexibility as possible without significantly adding to the cost. For example, as already indicated, each control

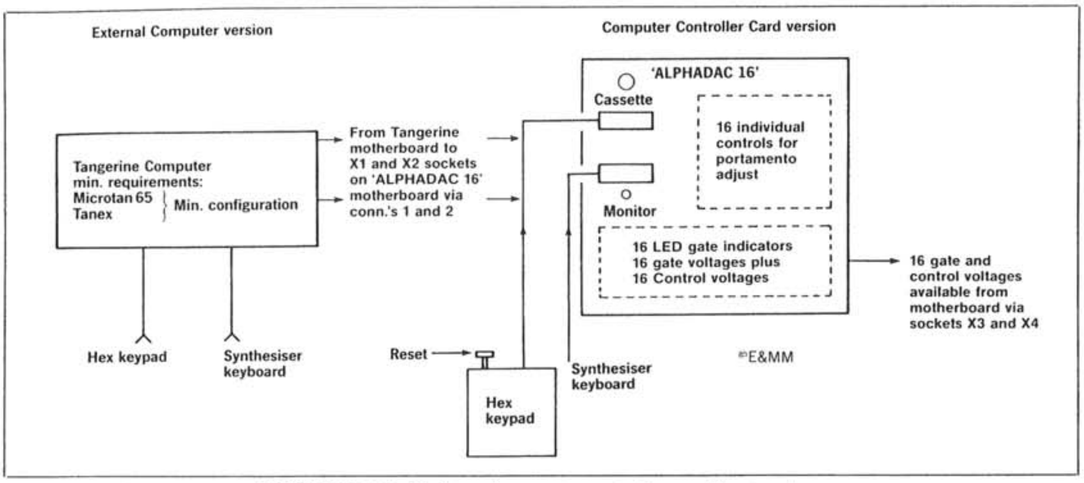


Figure 1. Basic arrangement of 'ALPHADAC 16' with internal computer controller or with external computer.

voltage has its own manual portamento adjustment. Typically, however, we would expect the controller to operate with up to four voices which can be user patched so as to take full advantage of the sound capabilities of the synthesiser and for additional voices to use pre-patched voices. The system will therefore be extended later with an intermediate controller having facility for master control over portamento and all of the other features normally found in polyphonic synthesisers.

Another option is packaging. The block diagram of Figure 1 represents 'Alphadac 16' mounted behind a 9 x 9 inch panel so as to fit in with a range of modular synthesisers. The motherboard and other PCBs could equally well be incorporated into a standard racking system or housed in some other type of portable case.

At the time of publication Alphadac comes complete with a set of keyboard routines in EPROM, called DIGI-1. First of all it is a polyphonic keyboard controller. DIGI-1 can assign control voltages and gates with intelligence, that is, it remembers the keys pressed down on the previous scan and will assign the key to the same voice and avoid note jumping. The memory of keys pressed remains up to the time when the output channel has to be used for another key because you have run out of voices. But polyphonic control is a trivial application for a microprocessor and one can get a better feel for the available power from the short summary below of other programs incorporated into DIGI-1.

a. Tune. Sends the same control voltage plus gate signal to all channels to allow tuning of oscillators and other setting up.

b. Keyboard Split. If selected will split the keyboard at any point determined by the first key you press on the keyboard after selection. Choice of whether top or bottom portion of synthesiser is to be the polyphonic section. The monophonic side may even be used to control a separate synthesiser or a voltage controlled module such as a VCO to obtain special effects.

c. Select Portamento. If the keyboard has been split then portamento may be independently selected for the monophonic and polyphonic sections. The degree of portamento on each voice is manually adjusted.

d. Transpose. Notes may be transposed up or down and at preselected intervals; tones, octaves or any semitone interval up to fifteen semitones. Again independent transpose on either side of a split keyboard is possible.

5. Arpeggiation. Arpeggiation in up or down or hold modes. Staccato and legato modes. Speed up and slow down. These routines are, of course, for the monophonic section but are very effective even with one or two voices and can act as a simple sequencer.

Remember that these facilities are brought into effect by use of the control pad which becomes a supplementary keyboard to bring the effects into play at any time. Furthermore all of the effects (not TUNE obviously) can be in use simultaneously.

Some of the above routines could be achieved by a skilled player using multi-track recording techniques but others are impossible to play manually. So what the micro-processor does is to give a new power to the synthesiser, even one with limited voices, and it begins to combine the voice capabilities of a synthesiser with the playability associated with modern electronic organs.

DIGI-1 occupies just an eighth (or a sixteenth by using larger EPROMs) of the EPROM storage area on the Tangerine Controller Card and so ample room for expansion exists. For a four voice controller the cost is about £50 per voice but thereafter each additional voice will be around £15 and a whole new set of programmes put into the existing EPROM somewhat less than the latter figure. The relatively high initial cost is therefore recovered later by savings in expensive add-ons such as sequencers and other hardware needed to simulate the software capabilities of the 'Alphadac 16'.

Circuit

No wiring is required between individual PCBs since they are connected together via a motherboard, illustrated in Figure 2, using 64-way DIN plug and sockets. Slot 1 is for the Tangerine Controller Card, Slot 2 for the interface card, and Slots 3, 4, 5 and 6 are identical, accepting a quad D to A converter PCB. DIL sockets X1 and X2 allow the Controller Card to be replaced by the Microtan 65/Tanex combination which connect to these sockets via the 15-way sockets mounted on the front panel. DIL sockets X3 and X4 are connected to the sixteen available control voltages and sixteen gate signals to facilitate connection of the Alphadac to future extensions. The only other components on the motherboard are inputs for the power supplies, which are ±15V and +5V; the decoupling capacitors C1, C2 and C3; and the common emitter driver for the monitor LED, D1, which is built around TR1, R1 and R2.

A simplified block diagram of the Controller Card is shown in Figure 3. This unit is supplied ready built and tested and fully socketed for easy expansion. The only component that may have to be soldered in later is a crystal for the serial input. The Controller Card has the following facilities: 6502 CPU (supplied); 8K RAM area using 2114's (1K supplied); 8 EPROM area using 2716's al-

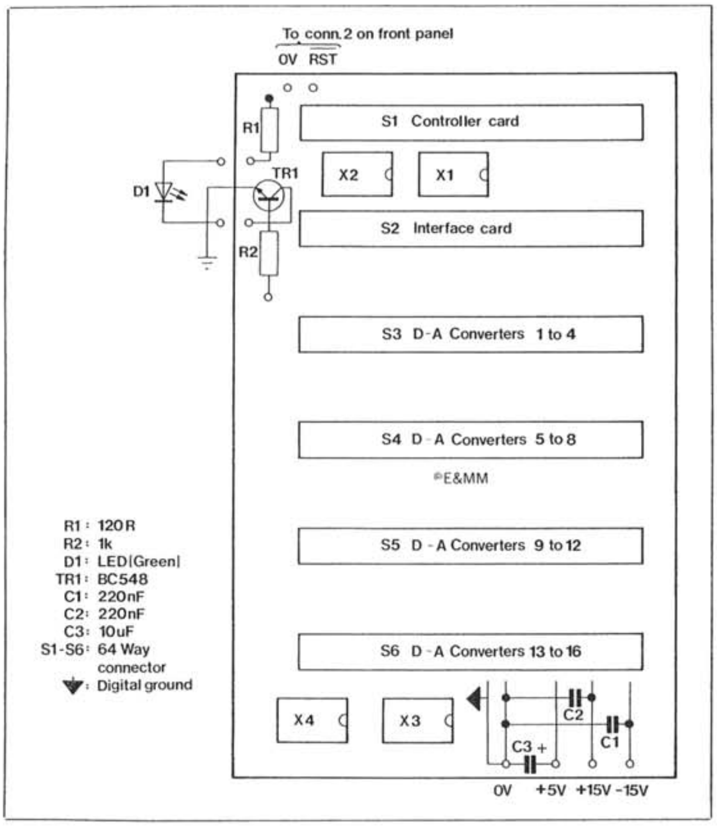


Figure 2. 'ALPHADAC 16' Motherboard.

though this may be expanded to 16K by using 2732's and changing a link on the PCB (2K EPROM supplied as DIGI-1); two 6522 VIA I/O ports (one required and supplied); a cassette interface; and a 6551 serial input.

Slot 2 accommodates the Interface Card whose circuit is illustrated in Figure 4. In reality this is only part of the inter-facing required, the remainder is on the quad D to A converter PCBs. The part on the latter will, however, be required with any computer and splitting the interface up in this way keeps the motherboard bus versatile so that it may be used to accommodate other types of control card in Slots 3 to 6. The nine inputs (don't worry since two have been ANDed together) to the 8-input NAND gate, IC2, are the most important since they are the six address bits (A4 to A9); the R/$\overline{W}$; the Input/Output (I/O) line; and ø2 from the microprocessor. The combination of these inputs provides a valid WRITE (actually inverted to suit subsequent hardware) signal to allow the keyboard information data bits, D0 to D6 to be converted to analogue outputs for controlling the synthesiser. D0 to D5 are the code bits representing the keys while D6 is a KEY-DOWN signal for the gate information. Bit D7 is a user generated signal to signify that portamento is required. Address bits A2 and A3 determine which of the four possible quad DAC cards are to be addressed while A0 and A1 determine which of the four DAC's, gates and portamentos are selected on the card determined by A2 and A3. These four address bits are simply buffered on the interface card. Likewise the data bits D0 to D7 are buffered. It should be observed that D7 is inverted and the reason for this will be apparent later.

Turning now to the circuit for the quad DAC board, as shown in Figure 5. From the interface card A2, A3 and $\overline{W}$ go to one half of a dual 1 of 4 decoder (IC1a, 74LS139). With the microprocessor program the first address is the highest, that is, A2 and A3 both at logic '1's' and so naturally the last address will be a '0' + '0'. When IC1a is enabled by the $\overline{W}$ signal going low it will respond to the A2 and A3 address bits and if both are high then pin 7 will go low. Notice that pin 7, and the other three outputs are connected to a DIL switch marked S1 to S4. With S1 closed the remaining logic on the quad DAC board is enabled whenever A2 and A3 are both high. The switch is not entirely necessary since we could have inserted a wire link in place of S1 for the quad DAC which goes into Slot 3 and provides the out-

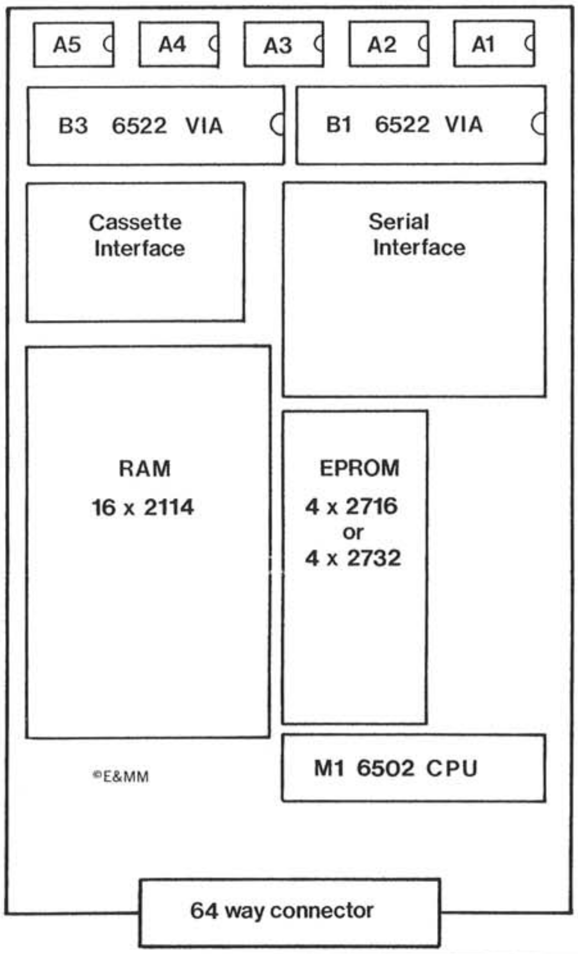


Figure 3. Simplified arrangement of controller card produced by Tangerine Computer Systems.

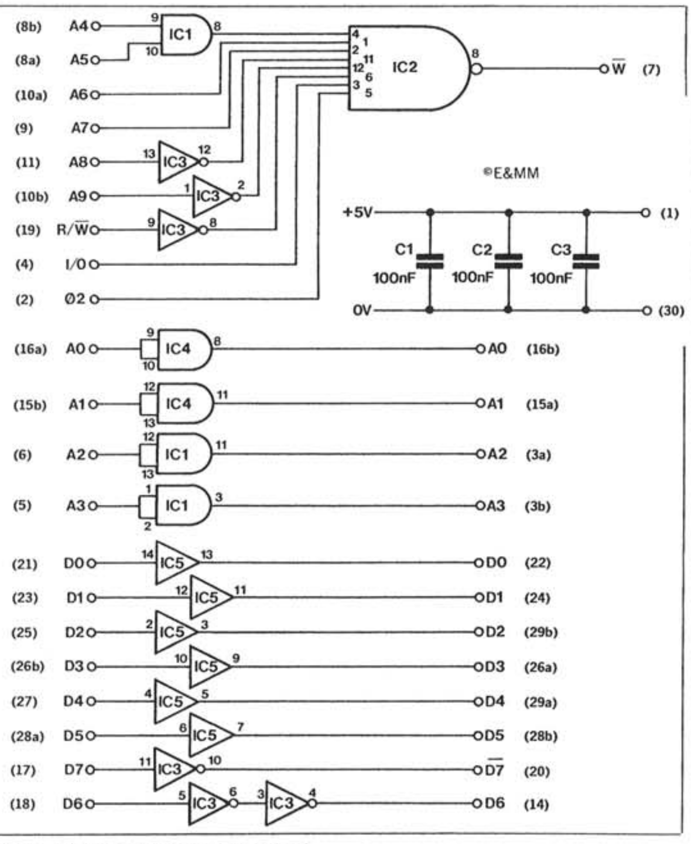


Figure 4. 'ALPHADAC 16' Interface Card.

puts for the first four voices. The switch is nevertheless useful for calibration and enables any quad DAC to go into Slots 3 to 6 by closing S1 to S4 respectively.

The $\overline{ENABLE}$ from IC1a (the exit side of S1 to S4) goes to both IC1b and IC2. IC1b operates in a similar manner to IC1a, namely with A0 and A1 high pin 9 goes low and this connects with IC3 which is the D to A converter for Channel 1. The four D to A converters are ZN428E-8's which are microprocessor compatible such that when their $\overline{ENABLE}$ line (pin 4) goes low the converter is transparent to the data bits (D0 to D5 in our case) at the appropriate inputs. Conversely when the $\overline{ENABLE}$ goes high the data bits are latched into the converter. Thus apart from converting the data bits into an analogue voltage the ZN428E-8 also acts as a perfect sample and hold — the output voltage will remain constant for an unlimited period until either the $\overline{ENABLE}$ goes low again and new data is presented or until the power is switched off! The ZN428E-8 also has an internal voltage reference from pin 7 and for IC3 this is connected to the voltage reference input at pin 6. R1 connected to the +5V supply produces the necessary reference current while C12 is a stabilising and decoupling capacitor. The same reference voltage used for IC3 is also connected to pin 6 of the other D to A converters, IC7, 9 and 11, which saves power as well as providing excellent gain tracking between the four converters. Apart from this voltage reference aspect all four D to A converters are the same and so we will just describe the first which is built around IC3, IC4, IC5a and IC6a. The ZN428E-8 is an 8-bit (256 increments) device although we are only using the lowest six bits (64 increments) and thus the nominal maximum output from pin 5 of IC3 will be 0V64, or 10mV for each bit increment. Now to achieve a 1V/octave relationship we require each step to increase by 1V/12 (semitones) = 83.33mV and so pin 5 of IC3 is connected to IC4 arranged as a non-inverting amplifier whose gain is precisely adjustable around the nominal gain of 8.3 by the use of the multiturn trimmer RV1. Trimmer RV2 is used to cancel out the small amount of offset in IC4 while C13 acts as a low pass filter sufficient to remove glitches arising from the D to A converter. It will be apparent that by altering the values of R2, R3 and perhaps RV1 the gain may be altered to suit relationships other than 1V/octave. RV3, C14 and voltage follower IC6a provide a portamento

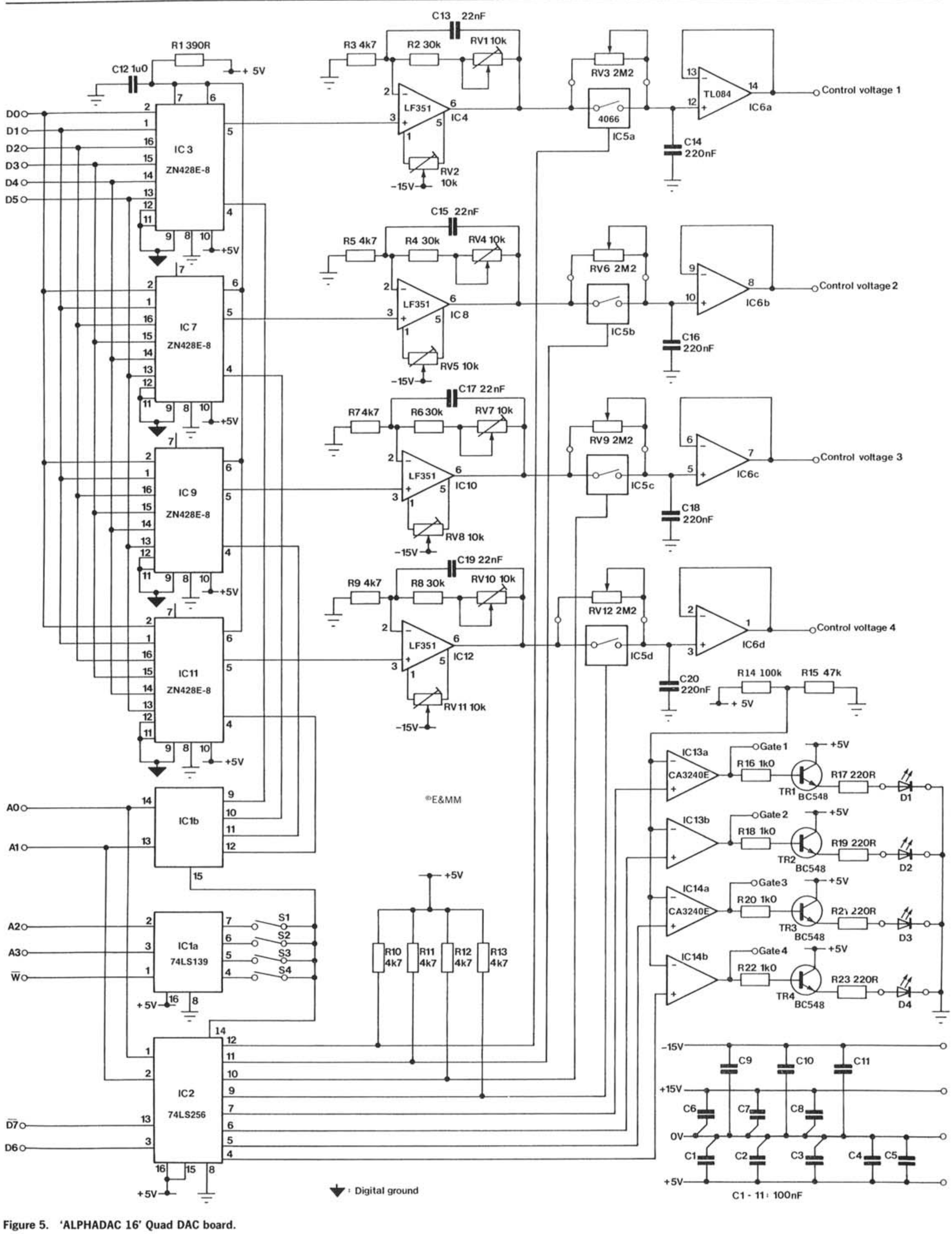


Figure 5. 'ALPHADAC 16' Quad DAC board.

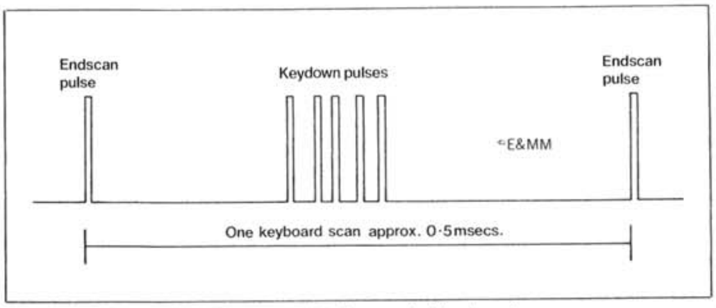


Figure 6. Example of outputs from digitally encoded keyboard.

circuit, i.e., by increasing the resistance of RV3 then C14 will take longer to reach the full voltage and so the rate of glide between notes will increase. A computer controlled facility is provided by IC5a, a voltage controlled switch. When the switch is closed then RV3 is by-passed and no glide will occur since C14 will charge up rapidly. When the switch is opened by the computer then the note will glide at a rate determined by the manual setting of RV3. The control voltage from channel 1 of the Alphadac which connects to the VCO, VCF, etc. is available from the output of IC6a.

Back to the logic circuitry. The $\overline{\text{ENABLE}}$ from IC1a also connects to IC2 (74LS256) which is a dual 4-bit addressable latch. When its $\overline{\text{ENABLE}}$ (pin 14) goes low the outputs will change to the logic status on the data inputs, D6 (gate control) at pin 3 and $\overline{\text{D7}}$ at pin 13. The outputs that change are, however, governed by the same address lines, A0 and A1, used for the D to A converters. When the $\overline{\text{ENABLE}}$ goes high the data is latched within the IC in much the same way as discussed for the ZN428E-8. You will recall that we inverted D7 on the interface card and the reason is simply that the computer outputs a logic '1' when portamento is selected. If this '1' were to pass through IC2 to IC5 then it would put the switch in the ON state and cancel the glide. Since this is the opposite to what we require then we simply invert D7. Resistors R10 to R13 on the portamento lines are pull-ups to ensure correct interfacing between the TTL IC2 and CMOS IC5. Gates are also set by a logic '1' on data bit D6. The gate outputs from IC2 go to a comparator (IC13 and IC14) which will go high on receipt of the logic '1' signal from IC2. The comparator reference voltage is set by R14 and R15. A gate output of about 4V5 comes direct from IC13 and IC14 and is fully short-circuit protected. Provision is made on the PCB board for operating ICs 13 and 14 from the +15V supply so as to give gate voltages of about +13V which suits many other synthesisers. Each gate output is connected to an LED, D1 to D4, via transistor drivers TR1 to TR4 so as to provide a visual indication of the channels which are in use.

Well, that is the hardware side of 'Alphadac 16' but its operation primarily depends on the keyboard electronics, a control pad made up of sixteen keys arranged as a 4 X 4 matrix, and above all on the software called DIGI-1 contained in an EPROM. The keyboard controller, whose electronics cost about £10, consists of two clock driven 8-bit scanners (CD4724's) which examine the keyboard, arranged as an 8x8 matrix, in a sequential manner. Each key up to a practical maximum of 63 therefore has a precisely defined 6-bit code, which is our data bits D0 to D5 discussed above. The scanners are driven by a clock which may be stopped (inhibited) under computer control. Each time a key is found down by the scanner other logic elements output a KEYDOWN pulse which tells the computer to store the value for the key and then carry on doing something else until it receives another instruction. When the scanner completes one scan of 64 steps an ENDSCAN pulse is produced. The computer recognises this pulse as ENDSCAN since the data lines

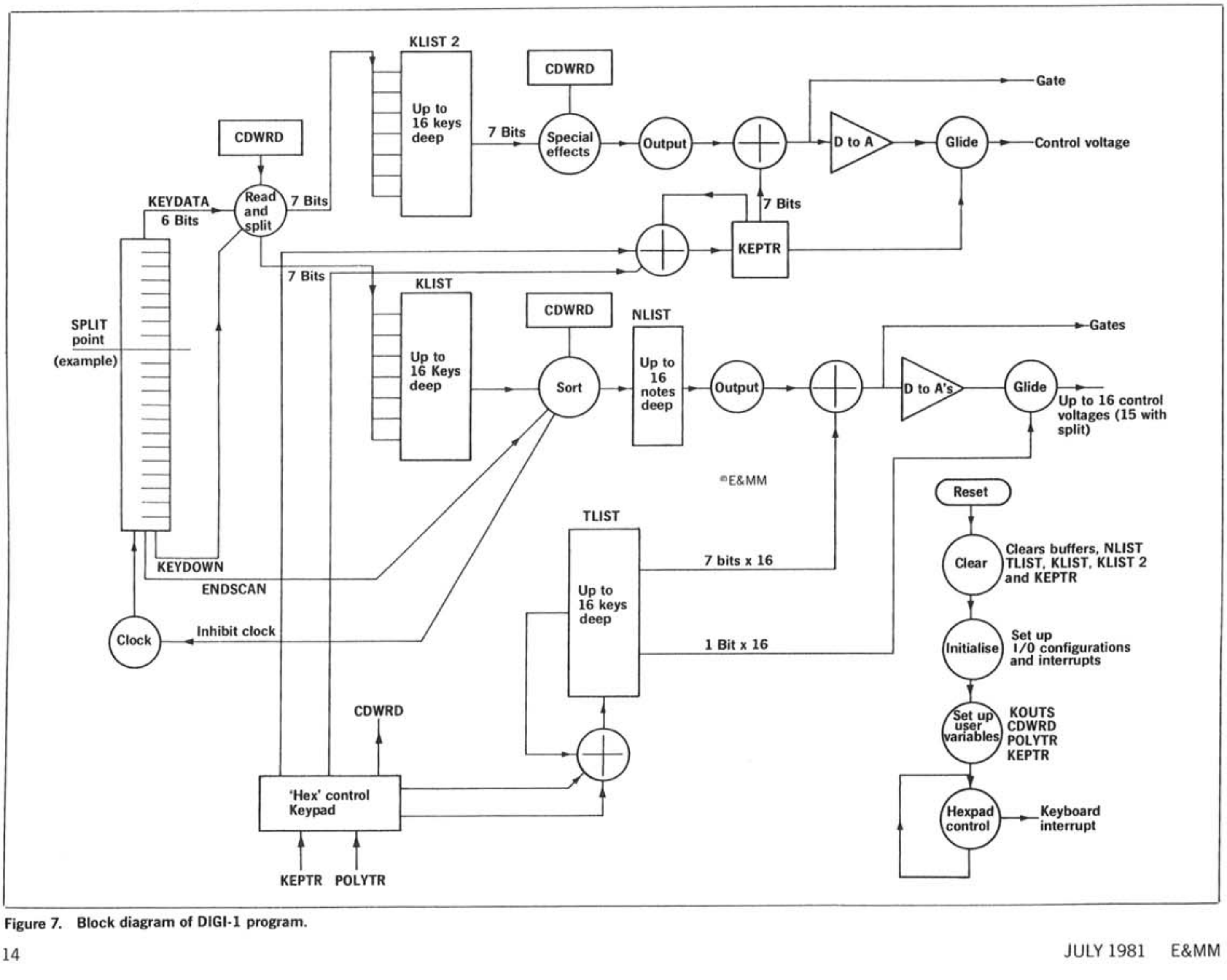


Figure 7. Block diagram of DIGI-1 program.

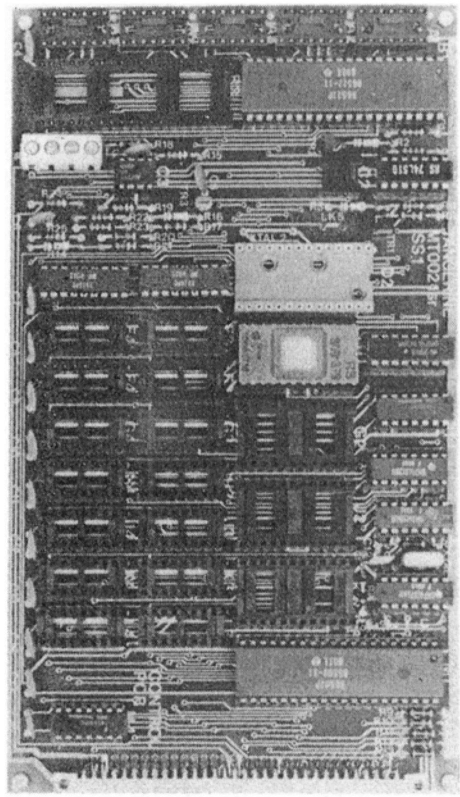
are at zero when it occurs (this is what limits us to 63 keys since zero is an invalid key response). It is a very short pulse but the computer now goes into a routine to decode all of the KEYDOWN pulses it received during the scan and during this time the keyboard scanning stops — but only for such a very short time that it has no aural effect. If we were to hold down, say, five keys then the various strobe pulses going to the computer would look like Figure 6.

Figure 7 is a block diagram to assist in understanding the operation of the computer program. Since the keyboard is counting upwards the data for keys found pressed are entered into a key list (KLIST) in ascending order. We do, however, have an option to split (SPLIT) the keyboard at any point into a monophonic portion and a polyphonic portion and in these circumstances the computer enters data from the mono section into KLIST2 while the poly side goes to KLIST. This housekeeping task is taken care of by CODEWORD (CDWRD). ENDSCAN initiates a SORT routine to put current valid data into NLIST. At the end of each scan data in NLIST is compared with that in KLIST to determine if a note (or notes) stored in NLIST, with or without gates set, has re-appeared in KLIST. If this is the case then it sets on the gate flag and rubs out the key code from KLIST. If a note present on a previous scan is no longer in KLIST the gate flag is removed. This routine assures that notes do not jump about from output to output as they do with simpler algorithms, or many hardware designs, and that they are all re-assigned to the same channel until such times as limited resources, namely, synthesiser voices, causes the channel to be used for another key. The routine also allows correct operation of ADSR's since once the gate flag is removed from NLIST the note will go into its release cycle. NLIST is filled up in sequence so that all notes played, assuming they are all different, find a slot in NLIST until it becomes full. It will be obvious, however, that the maximum number of notes in NLIST should not exceed the number of synthesiser voices otherwise missed notes will occur. Once keys are allocated to NLIST they are erased from KLIST so that the latter only contains information on keys that have just been pressed or were not able to find a home last time due to insufficient space. When a new note does appear in KLIST the routine looks at NLIST to find a space and it does so by choosing the first non-allocated space, for example, one where the gate flag is removed. All of this action: comparing KLIST with NLIST; updating NLIST; removing data from KLIST; and outputting data from NLIST to the hardware takes a matter of microseconds and so the scanner is soon running again looking for new keyboard information.

KLIST and NLIST relate to the 16 channel polyphonic keyboard and additional facilities in the program allow us to transpose notes up or down in real time by pressing keys on the control pad. The transpose interval is preselected at start up (it can be altered in under two seconds by resetting and entering a new transpose value) and may be any interval from one to fifteen semitones per press of the control key. The transpose value is held in TLIST and is added to the NLIST value prior to outputting the data to the digital to analogue converter. Remember though, the keyboard is restricted to six data bits or a little over five octaves and so if we add an octave transpose to the five octave data bit then some funny things will begin to happen and you will likely have a low note and the data bits will spill over and set the glide (portamento) on and perhaps take the gate off. Similar strange things are likely to happen when transposing down from a low note. It is relatively simple to alter the software to prevent this but in practice you should know what note you are on before doing a realtime transpose and so the strange effects should only happen when you want them to and we feel sure that some users will put it to good use. Lastly, for the polyphonic mode, another control key allows selection of portamento as described in the section dealing with the quad DAC card.

If SPLIT is selected then one less output is available from the polyphonic side — you only have fifteen left. Also in this event channel 1 output is always allocated for the monophonic side of the keyboard and so the output of NLIST starts at channel 2. The monophonic side of the split point obviously does not require any sophisticated allocation routines and so the monophonic data from the keyboard goes to KLIST2. The monophonic side does, however, still retain portamento select, and transpose, via the data stored in KEPTR, and these are independently controllable, that is, one may transpose up or down both or either of the polyphonic channels and each by different amounts.

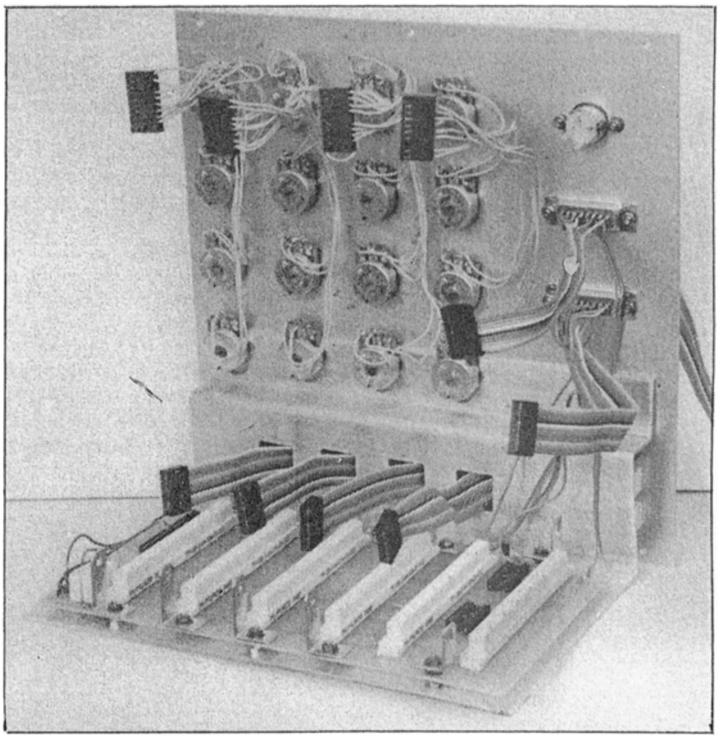
DIGI-1 also contains some SPECIAL EFFECTS for the monophonic channel which may be initialised on start-up of the system. These effects are described in the section dealing with the use of the Alphadac 16.



Tangergine Computer Systems Controller Card.

Construction

These construction notes assume that 'Alphadac 16' is panel mounted, as illustrated, although alterations to suit other methods should be obvious. Likewise to avoid confusion on connection listings only those relating to the installation of the Controller Card version are given. For those wishing to use the recommended external computer then additional construction information is available from Digisound Limited. All PCBs for this project have component overlays printed on



Motherboard and front panel wiring.

and so component placement is not shown here. Special care should be taken with orientation of ICs and the DIN connectors but again these are clearly marked on the PCBs.

Start by installing the components on the quad DAC card (PCB 80-C3) since the completed PCB is required for positioning purposes in the next stage. All links are marked and normally can be made with bare solid wire, such as 1/0.6mm, although insulated wire should be used where "INS. LINK" appears. IMPORTANT: THERE ARE TWO LINKS MARKED INSIDE BOXES, ONE IS MARKED "SP. LINK" AND IS THE LINK TO BE USED FOR A NOMINAL 5 VOLT GATE OUTPUT. THE OTHER IS MARKED "HIGH G LINK" AND IS TO BE MADE ONLY WHEN A NOMINAL +15 VOLT GATE IS REQUIRED IN WHICH CASE "SP. LINK" MUST NOT BE MADE. FAILURE TO OBSERVE THIS MAY RESULT IN COSTLY DAMAGE. Carefully check the foil side of the PCB after construction for excess solder or solder splashes which may make unwanted connections — this is normal practice with any project.

Next install the components on the motherboard PCB (PCB 80-C1) and if you are only going to be using four voices in the immediate future then install: the wire links; DIN sockets in Slots 1, 2, 3 and 4 (4 is for ease of calibrating); the components R1, R2, C1 to C3 and TR1; the power connector PCB plug. Next solder wires to: points marked $\overline{RST}$ and 0V near Slot 1 which are long enough to reach to CONN. 2 on panel; to points marked LED+ and LED 0V long enough to reach the monitor LED; and finally to point marked SKT A1, P11 which has to reach to socket A1 on the Controller Card. After cropping the leads from the underside of the PCB and making the usual check on soldering we are now ready to bolt the PCB to the mounting bracket at points adjacent to Slots 1, 4 and 6 and using nuts as spacers. Plastic nuts and bolts are used at Slots 4 and 6 on the PCB edge nearest the panel to remove the possibility of shorting out a PCB track. First, however, install 'L' brackets at either side of Slots 3 and 5 (plastic bolts at PCB panel edge) with their uprights towards the power supply input. Their precise location can be adjusted later but these brackets will be in front of the component side of the 80-C3 PCBs when the latter are installed in their slots. The PCB can now be put on to the six mounting bolts and spacers and the 'L' brackets installed for Slots 1 and 3. For the Controller Card in Slot 1 the mounting bracket is a

PIN 1 Channel 2 LED	PIN 6 Channel 4 C.V.	PIN 11 Channel 4 gate
PIN 2 Channel 1 LED	PIN 7 Channel 2 C.V.	PIN 12 Channel 2 gate
PIN 3 0V line	PIN 8 Not used	PIN 13 Channel 3 LED
PIN 4 Channel 1 gate	PIN 9 Channel 1 C.V.	PIN 14 Channel 4 LED
PIN 5 Channel 3 gate	PIN 10 Channel 3 C.V.	

Table 1

PIN 1	P1, input	PIN 5	P2, output	PIN 9	P4, output
PIN 2	P1, output	PIN 6	P3, input	PIN 10	Not used
PIN 3	Not used	PIN 7	P3, output		
PIN 4	P2, input	PIN 8	P4, input		

Input and output refer to the side of the voltage controlled switch, IC5

Table 2

PIN NO.	KEYPAD 15-WAY CABLE AND CONN. 2 15-WAY SOCKET	CONN. 2 15-WAY SOCKET TO 14 PIN HEADER TO A2 ON CONTROLLER CARD
1	N.C.	N.C.
2	C1	C1
3	C2	C2
4	C3	C3
5	C4	C4
6	R1	R1
7	N.C.	N.C.
8	N.C.	N.C.
9	R2	R2
10	R3	R3
11	R4	R4
12	N.C.	N.C.
13	N.C.	N.C.
14	0V	N.C.
15	$\overline{RST}$	

Table 3

PIN NO.	KEYBOARD CONTROLLER AND CONN. 1 15-WAY	14 PIN DIL HEADER FROM CONN. 1 TO A1 ON CONTROLLER CARD
1	D0	+5V
2	D1	D0
3	D2	D1
4	D3	D2
5	D4	D3
6	D5	D4
7	N.C.	0V
8	N.C.	0V
9	N.C.	D5
10	0V	N.C.
11	N.C.	TO R2 ON MOTHERBOARD
12	INHIBIT	INHIBIT
13	STROBE	STROBE
14	N.C.	+5V
15	+5V	

Table 4

shorter type and its upright should face the non-component side of the PCB. In this instance the PCB is secured with a plastic nut and bolt with another nut as an insulating spacer between the bracket and the PCB.

The DIL socket X5 on the quad DAC board for Slot 3, the first four voices, now connects with the first four sets of LEDs and pairs of jack sockets on the front panel. The 0V line from X5 is used for the ground connection to the LEDs (short lead) and the ground connection of the jack sockets. The jack socket just below the LED should be assigned to the gate output voltage. A length of ribbon cable is used to connect between the X5 DIL header and the panel components. This 13-way cable should be long enough so that the quad DAC card can operate from Slot 3 or Slot 4, but do not make it excessively long. The length can be gauged by offering up the motherboard bracket to the panel with the quad DAC in place. The X5 connections are shown in Table 1.

If more than one DAC card is fitted then the connections between X5 and the panel can be made the exact length for Slots 4 onwards. When all of the connections to the panel have been made then thread the DIL headers through the appropriate holes in the mounting bracket and join the latter to the panel using two or more of the bottom row of potentiometers. For the first quad DAC potentiometers P1 to P4 (equivalent to RV3, 6, 9 and 12 respectively on the circuit diagram) are now wired up to the Molex socket which connects to the DAC card as in Table 2.

Again by temporarily installing the DAC into its slot the wire lengths can be accurately gauged but for the DAC in Slot 3 the wires must be long enough for the DAC to be used in Slot 4. Viewing the potentiometers from the rear and their connections facing upwards the wiper and right hand connection are connected to one wire and the left hand connection to the other wire.

Now make up the control keypad. This may either be installed in the keyboard case or in a separate housing as illustrated. The housing shown allows space for expansion. The keypad should be located close to the bottom lip of this case and by turning the keypad over the hole positions can be marked and then drilled. A slot will have to be cut into the case to allow connections from the keypad to pass through and this is best done by drilling a row of holes of 5 to 6mms. diameter and cutting out the excess plastic between the holes — do this carefully since it is difficult to play keyboards with a bandaged hand! A hole is also required at the rear of the case to accept a 15-way cable. The photographs show the use of flat cable but most constructors will find it more convenient to use round cable. The RESET button is mounted on the top slope of the case at the rear about 20mm. in from the left edge so that it does not interfere with the internal clips. A 6.5mm (or ¼ inch) hole is required for this push-button switch. Finally the case should be fitted with four rubber feet at its extreme corners to prevent it slipping around when in use. The keypad connects to the 15-way socket, CONN. 2, on the panel and the connections are listed in Table 3.

The R and C numbers in Table 3 refer to the markings on the keypad used. Do not cut short any unused wires on the 15-way cable since they will be required at a later date.

If the keypad is installed into the keyboard case then the simplest technique is to also install a 15-way socket as well and to connect up with CONN. 2 using a length of 15-way cable terminated at each end with 15-way plugs.

Now install CONN. 1 which goes to the keyboard controller using 15-way miniature D connectors as above. The sockets are installed on the keyboard and the Alphadac panel and the connections are made using a short connecting lead with a plug at both ends. Behind the panel, CONN. 1 connects with socket A1 of the Controller Card using a 14-pin DIL header. The connections are shown in Table 4.

Next install the monitor LED and connect the remaining wires on the motherboard. The wire at the end of R2 on PCB goes to pin 11 of the DIL header for the A1 socket of the Controller Card, as listed above. The wire at the end of R1 (LED+) goes to the long lead of the monitor LED and that from TR1 collector (LED 0V) to the short lead. The 0V and $\overline{\text{RST}}$ wires near Slot 1 go to CONN. 1 connector as listed earlier in order to connect up with the RESET push button switch.

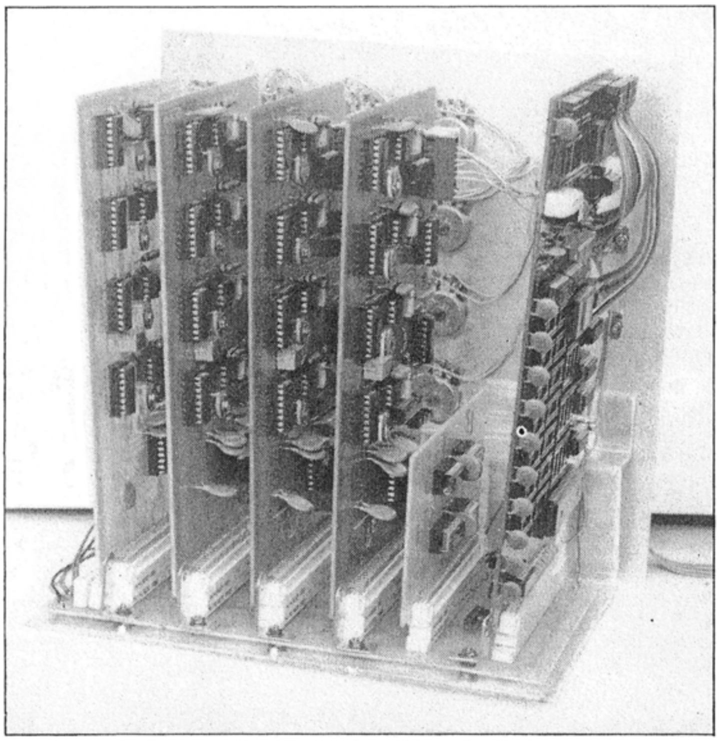
Finally, install the components on the Interface PCB (PCB 80-2). After inserting the DIGI-1 EPROM into socket F2 of the Controller Card we are now ready to go. Install the Controller Card in Slot 1; the Interface Card in Slot 2; and one quad DAC Card into Slot 4 for the calibration step with switch S2 on and the other switches off. Join up the Molex connector from P1 to P4 to the DAC Card and also the DIL header for channels 1 to 4 to socket X5 on the DAC. Power supplies required are ±15V and +5V and the 0V lines for both supplies should be commoned together. Life will be simpler if both power supplies are turned on from the same mains switch but if not then it is good practice to switch the +5V supply on first followed by the ±15V supplies. Likewise the latter should be switched off first followed by the +5V supply.

Operating and Calibrating the Alphadac 16

After switching on the power the first step is to press the RESET button associated with the control pad. With a computer operated system the video would ask four questions and expect the appropriate responses. These are:

A. **VOICES?** That is how many synthesiser voices are you going to use? Press key 1 to F which equals 1 to 15 while pressing key 0 at this time indicates that you have sixteen voices.

B. **CDWRD?** At this stage a CDWRD of 0 or 1 should be entered. Key 1 will indicate that you will require a top split, that is the top section of the keyboard will be used for the monophonic section with a high note priority and its output always going to channel 1 with the bottom portion of the keyboard being polyphonic with up to fifteen more available channels. Pressing key 0 gives a bottom split, the monophonic channel being at the lower portion of the keyboard. Note that the response to this question is preparing the computer for a subsequent control pad response.



Complete synthesiser controller with 4 DACs and Tangerine Card.

In other words you are only informing the computer that when you do select split (see later) it will be top or bottom and until such times as this additional command is given the keyboard will respond solely in the polyphonic mode. In fact CDWRD is more powerful than this and does allow you to enter into various keyboard routines immediately from this start up stage. For simplicity, however, will we stick with the 0 and 1 response to CDWRD and further details of the use of this function are provided with the programme listing.

C. **POLYTR?** Enter the transpose value for the polyphonic channels. Pressing keys 1 to F equal transpose values of 1 to 15 semitones, so for example key C will result in an octave transpose. As with split described above, the transpose will only take place in response to a subsequent control pad response so as to be able to effect the transpose in real time, but you are deciding beforehand the effect you will obtain.

D. **KEPTR?** Enter transpose value that may be required for the monophonic channel. The key values are the same as for POLYTR but note that the monophonic portion of the keyboard (if required) can have a different transpose value.

The computer then expects you to press any button on the keypad to start, so do it now.

Starting up with the Controller Card is just as easy. Press the RESET button at which time the monitor LED will be extinguished and remain off. Then press the control pad keys as though you were responding to the four questions listed above and then press any other key to start. On completion the monitor LED will now flash slowly and it will stay in this condition except when arpeggiation routines are in use at which time it will flash on and off at the arpeggiation rate.

Suppose then we wish to set up for four voices, top split and octave transposes on both polyphonic and monophonic channels. Just press RESET follow by control pad keys 4-1-C-C-C (the last C being the start command). The whole procedure takes less than two seconds. If a mistake is made during setting up, or the monitor LED stops flashing (perhaps a short power failure) or you wish to change the program then press RESET followed by the required keys on the control pad.

Calibration is also straightforward except that close packing of the PCBs restricts access to the quad DACs. In the construction we have recommended installing Slot 4 even though no more than four voices are installed initially. The first DAC is therefore put into Slot 4 as described earlier and using a small screwdriver or trimming tool there is now sufficient space to access the trimmers on the DAC Card. Remember switch S2 should be on and the others off when it is in this Slot. Turn power on, press RESET and press control keys 4-1-C-C-C in sequence. To be sure, now press key 0 on the control pad and adjust trimmers RV2, RV5, RV8 and RV11 so that the output from the respective ICs is exactly zero. The voltage can be measured at the Molex plug on the PCB by connecting up to the appropriate P 'input' as listed earlier, e.g., P2 input at pin 4 of the Molex connector will allow the offset of IC8 to be trimmed out using RV5. Now measure the control voltages from the jack sockets for channels 1 to 4 and use trimmers RV1, RV4, RV7 and RV10 respectively to obtain the required 1V/octave relationship. The initial voltage may be a millivolt or two from zero due to the small offset in IC6 but this should be ignored — trying to trim it out with the presets used above will make matters worse. Calibrate each channel in turn using the following procedure. Press control pad key 4 twice and adjust the appropriate multiturn trimmer to give exactly 2 volts. Press key 4 again and adjust trimmer, if necessary, to obtain exactly 3 volts. Next press key 5 which takes you back to 2 volts and keep pressing keys in the sequence 4-5-4-5-. . . until the values obtained are as close to 2 and 3 volts as you can make them. Pressing key 0 puts you back to zero and repeated pressing of key 4 (up to five times) takes you up in octave steps and so allows you to obtain the best linear response by using the trimmers.

Using the 'Alphadac 16'

There are a large number of effects available in the DIGI-1 program and they should be treated as an aid to playing and not taking full command of the synthesiser. In other words they increase the scope for experimentation to achieve some novel effects. This using section therefore lists the function of the sixteen keys on the control pad.

KEY 0. This is the CLEAR key. It clears all values entered from the keyboard or control pad and can be used at any time if you find yourself in an awkward situation. It does not affect the original program values — only pressing RESET and entering new values can do that.

KEY 1. TUNE. This key outputs the same key code to all channels and puts the gate on. It therefore allows all oscillators to be tuned exactly to each other. Pressing key 0 when tuning is complete puts the keyboard and control pad back into your control.

KEY 2. PORTAMENTO. Sets glide on all polyphonic channels. If glide is off then pressing the key puts it on while if it is already on then pressing key 2 will turn it off. This key will not affect channel 1 if split is in operation.

KEY 3. PORTAMENTO. Operates as key 2 but only on channel 1 when split keyboard is in use.

KEY 4. (POLY) TRANSPOSE UP. Pressing this key will transpose the polyphonic voices up by the interval selected at start-up. It does not affect channel 1 if split is in operation.

KEY 5. (POLY) TRANSPOSE DOWN. As key 4 but the polyphonic section is transposed down by the selected interval. Note that the control pad may be used like a second keyboard and the keys may be pressed in time with the music to give, for example, instantaneous transposition of any part of the music. Remember the strange effects that may occur if you transpose outside of the five octave range of the control bits. To put the keyboard into some other tune range still requires the normal octave shift facility found on most synthesisers.

KEY 6. (MONO) TRANSPOSE UP. As key 4 but operates on channel 1 if keyboard split is in use.

KEY 7. (MONO) TRANSPOSE DOWN. As key 5 but operates on channel 1 in split mode.

KEY 8. SELECT SPLIT POINT. After key 8 on the control pad has been pressed then the first key pressed on the keyboard becomes the split point, that is, the point where the keyboard changes from monophonic to polyphonic. Whether the monophonic section is at the top or bottom portion of the keyboard depends on the program value entered at start-up, as discussed earlier. If you find that the split point is not quite in the right position when you come to play the music then simply press key 0, press key 8 and then press the new note on the keyboard where you require the split to occur. You can, of course, always do a RESET and split the keyboard the other way round. Pressing key 8 again while in the split mode will make the keyboard revert back to polyphonic operation without having to clear other values you may be using.

With the split mode plus the ability to independently select portamento, transpose up and transpose down on each side in real time the playing possibilities become exciting. For example, with a bottom split (key 0 during setting up) channel 1 may be set to a bass guitar sound to accompany yourself on the polyphonic channels. The possibilities are, however, endless since you could also select top split and by transposing the top monophonic section down and the bottom polyphonic section up you would be able to play the bass line with your right hand! Much of the fun comes from experimenting with the effects yourself and learning their musical possibilities but, as other examples, the monophonic channel could be used to control another 1V/octave synthesiser or you may use it to control a separate low frequency VCO (or other voltage controlled module) to obtain dynamic control of modulation and so on.

KEY 9. This key puts you into the arpeggiation mode in the monophonic section of a split keyboard. Up to 16 keys may be held down in this mode and the computer will play each one in turn.

KEY A. Selects UP or DOWN arpeggiation. If the computer is reading up the scale then pressing the key will cause it to read down or vice versa.

KEY B. Pressing this key causes the arpeggiation to reverse direction automatically at the end of each scan of the keys being held down.

KEY C. Selects staccato or legato mode of arpeggiation. Again if you are in the staccato mode then pressing the key puts you into legato or vice versa.

KEY D. Increases the rate of arpeggiation each time the key is pressed.

KEY E. Decreases the rate of arpeggiation each time the key is pressed. When in the arpeggiation routine the monitor LED flashes at the arpeggiation rate.

KEY F. This key will turn the arpeggiation into a sequence which will continue to play even when all keys are released and so

PARTS LIST — MOTHERBOARD (4 VOICES)

Resistors — ¼W 5% carbon film		
R1	120R	
R2	1k0	
Capacitors		
C1,2	220nF polyester (Plessey Minibox)	(2 off)
C3	10uF 25V tantalum electrolytic	
Semiconductors		
TR1	BC548	
D1	SEL1710Y (5mm yellow LED)	
Miscellaneous		
64-way A/B DIN sockets		(4 off)
PCB 80-C1		
Sundry mounting hardware		

PARTS LIST — 'ALPHADAC' INTERFACE CARD

Capacitors		
C1,2,3	100nF ceramic disc	(3 off)
Semiconductors		
IC1,4	74LS08	(2 off)
IC2	74LS30	
IC3	74LS04	
IC5	74LS365	
Miscellaneous		
14 pin DIL sockets		(4 off)
16 pin DIL socket		
64-way A/B DIN plug		
PCB 80-C2		

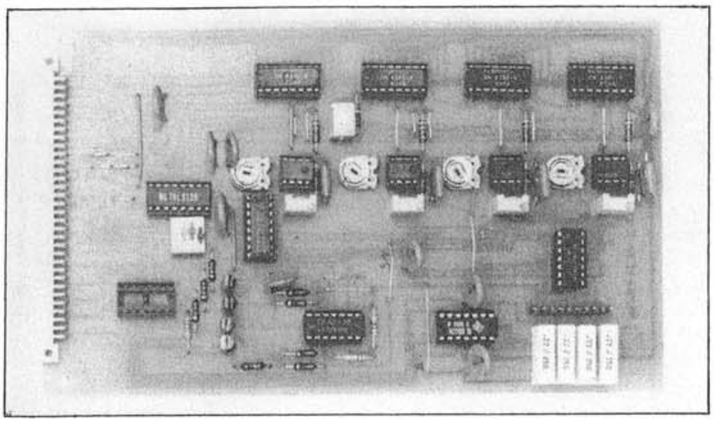
PARTS LIST — ADDITIONAL ITEMS FOR 'ALPHADAC 16'

TANGERINE 'CONTROLLER CARD' or 'MICROTAN 65'/'TANEX'	
Hex. Keypad. 4 x 4 matrix	
Optional case for above. West Hyde VDU PR4.	
Push to make switch	
15-way miniature-D plugs	(2 off)
15-way miniature-D sockets	(2 off)
3.5mm jack sockets	(8 off for four voices)
Panel, mounting bracket, miscellaneous hardware.	

PARTS LIST FOR QUAD DIGITAL TO ANALOGUE CONVERTER BOARD

Resistors — ¼W 1% metal film		
R1	390R	
R2,4,6,8	30k	(4 off)
R3,5,7,9	4k7	(4 off)
Resistors — ¼W 5% carbon film		
R10,11,12,13	4k7	
R14	100k	
R15	47k	
R16,18,20,22	1k0	(4 off)
R17,19,21,23	220R	(4 off)
Capacitors		
C1,2,3,4,5,6,7,8,9,10,11	100nF ceramic disc	(11 off)
C12	1uF MKH polyester	
C13,15,17,19	22nF polyester (Plessey Minibox)	(4 off)
C14,16,18,20	220nF polyester (Plessey Minibox)	(4 off)
Potentiometers		
RV1,4,7,10	10k, 25 turn cermet (Spectrol 64Y)	(4 off)
RV2,5,8,11	10k cermet (Egen 482H20)	(4 off)
RV3,6,9,12	2M2 log. potentiometers	(4 off)
Semiconductors		
IC1	74LS139	
IC2	74LS256	
IC3,7,9,11	ZN428E-8	(4 off)
IC4,8,10,12	LF351N	(4 off)
IC5	CD4066B	
IC6	TL084CN	
IC13,14	CA3240E	(2 off)
TR1,2,3,4	BC548	(4 off)
D1,2,3,4	SEL2110R and clips (3mm red LED)	(4 off)
Miscellaneous		
Switch, S1 to S4	4-pole SPST lateral DIL	(4 off)
8-pin DIL sockets		(4 off)
14-pin DIL sockets		(5 off)
16-pin DIL sockets		(6 off)
14-pin DIL header		
10-way 0.1 inch Molex connector (plug, cover and pins)		
64-way A/B DIN plug		
PCB 80-C3		

A complete set of parts for a 4-voice controller card version of 'Alphadac 16' as described above, is £193.50 plus VAT. Parts for control of an additional four voices is £50.44 plus VAT. These are available from Digisound Ltd, 13, The Brooklands, Wrea Green, Preston, Lancs. PR4 2NQ. Tel: 0772 683138. Both sets exclude single connecting wire, solder and the four control knobs — the latter being a user choice to match other equipment. It does include the programs in EPROM, keypad, panel, nuts and bolts, special wire (15-way cable and strip type), connectors and DIL sockets, PCBs and all electronic components.

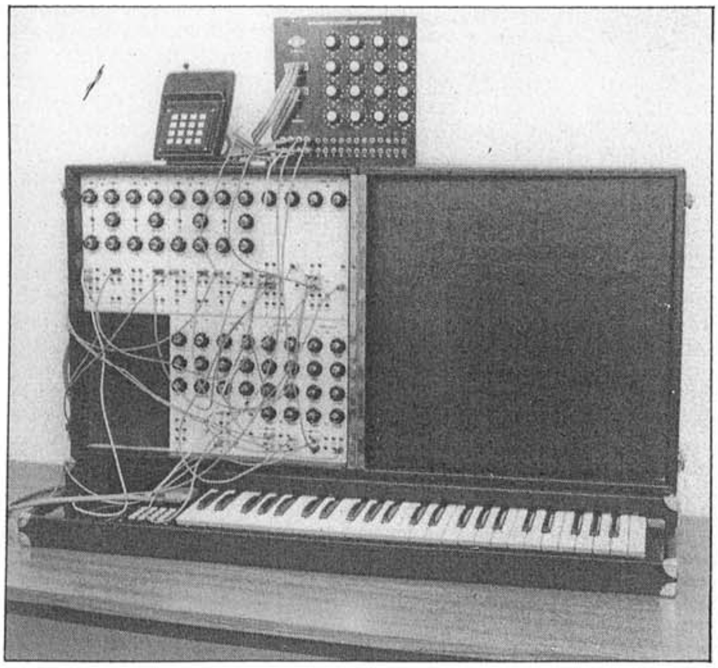


Alphadac 16 Quad DAC board.

provide an automatic accompaniment. One precaution has to be observed, namely, that the notes selected have to be released from the top of the keyboard downwards. This is quite easy to do. But the effect does not end there since pressing any other single key will now take the place of the lowest note that was originally pressed and all of the notes could be replaced by another sequence. Press key F again to stop this mode or key 0 to clear. Remember also that transpose and glide are still available while in the arpeggiation routines.

It is routines such as the arpeggiation techniques which add playability to the synthesiser even when only one or two voices are available. For example, pressing keys 9 and A and holding down a chord in the monophonic section will almost sound like a chord if the scanning rate is fast enough — press key D successively to increase the rate. Another effect could be obtained by connecting channel 2 output (on the polyphonic side) to a second control input on the arpeggiation oscillator (channel 1 monophonic portion) and with this patch pressing one key on the polyphonic side will effect a transpose at various intervals available on the latter portion. It is all good fun but it also has many musical possibilities as well and remember if you get in a muddle while learning then just press key 0 and start again.

Having run out of keys this seems a suitable stage at present to conclude the DIGI-1 program. In later versions, which will be exchanged for DIGI-1 at a small cost, we propose to keep to one control pad and have an external switch which will effectively double its capacity. Likewise other routines such as sequencing will be following on. There is, however, a great deal of music to be made with DIGI-1 and it is best to get to know this program thoroughly now so that you will be able to make the best use of later additions. **E&MM**



A complete 4-voice synthesiser controlled by Alphadac 16.

ADDITIONAL CONSTRUCTION NOTES FOR 'ALPHADAC 16'

E&MM ARTICLE, JULY 1981

No errors have been noted and their are adequate construction notes included. For mounting the 80-C1 Motherboard to the panel bracket 6BA nylon bolts are used on the edge nearest the panel with one nut as a spacer between bracket and PCB. On the other edge M2.5 nuts and bolts are provided and two nuts should be used as spacers. Ensure that no component leads are touching the bracket.

We have not found an alternative bracket for securing the Controller Card - the type used in the prototype has gone out of prod--uction. If we find a replacement they will be supplied but in the meantime avoid excessive leaverage on the Controller Card, e.g., when inserting an EPROM remove the card first.

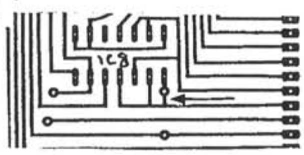
The pins on the hex keypad supplied are only marked 1 and 9 and the full pin connections which are relevant to Table 3 of the E&MM article are.-

	R3	C4	C3	R2	NC	R1	C2	C1	R4
	o	o	o	o	o	o	o	o	o
Pin No.	9	8	7	6	5	4	3	2	1

MODIFYING THE 80-15D1 KEYBOARD CONTROLLER

The following changes are necessary to the construction of the 80-15D1 in order to use it with the 'Alphadac 16'.

1. Cut the PCB track at pin 1 of IC8 between the connection for link marked 'A' and the unmarked line coming from the edge-which is the line between $\overline{KD}$ and RESET. This small piece of track is indicated by the arrow in the adjacent diagram which is part of the foil side of the PCB.



2. Make the link marked 'A' with a piece of wire.
3. Put a ~~1nF (1000pF)~~ 3n9 (3,900pF) polystyrene capacitor in link marked 'B'.
4. In place of the wire link going from the RESET line to pin 2 of IC2 put a 1k0 resistor.
5. In place of R4 (parallel to IC 2) put a ~~100nF Mullard C280~~ 1n (1,000pF) Polystyrene capacitor.
6. On the Molex edge connector the ONLY points to be joined together now are the RV 1 outputs (see 'ALPHADAC 16' OPERATING MANUAL for information on using RV 1) and a wire between ENDSCAN and RESET.
7. The Molex output marked KD (KEYDOWN) now becomes the STROBE used in the Alphadac construction text while INH is the INHIBIT referred to in the same text (Table 4 of E&MM article).

With a 3 or 4 octave keyboard it will now be best to have the first key going to Row 1 instead of Row 0 as recommended for the monophonic synthesiser. This is simply done by moving the appropriate Molex connector up one place. This step provides more latitude in using the transpose routine in DIGI-1. With a five octave keyboard it is still necessary to have the first key at Row 0. This means, however, that with the Alphadac the first key will not work since zero code is invalid.

POWER SUPPLY

A separate +5V power supply is required to drive any version of Alphadac and so if you have installed components on the 80-15D1 to produce sufficient current for the monophonic version these should now be removed and the separate +5V should be connected to the points marked +5 (not +V as before) and 0V on the rear of the PCB or to the +5V and 0V on the Molex front edge connector, whichever is most convenient. The +5V power supply unit should be connected to the point requiring most power and then other PCB's (such as 80-15D1) can be supplied from this main input. For example, with the Controller Card version the +5V will be connected at the Motherboard (80-C1) and for the Microtan/Tanex version it will go to the 80-C4 Motherboard (or one of Tangerine's motherboards). In the latter case CONN.1 15 way socket on the panel will have a +5V input which in turn connects up with socket X2 and so supply the Alphadac Motherboard. In other words do not connect the +5V supply directly to 80-15D1 and then distribute the power to the microprocessor via the 15 way cable. Also ensure that the ground lines of both the +5V supply and the ±15V supply are commoned. This connection can conveniently be made at the CHIRI connector on the 80-C1 Motherboard.

If you have greatly expanded the DIGISOUND 80 and are using the original power supply then you should check that it is not being overloaded. This can be done by removing each fuse in turn and measuring the AC current across the fuse holder. This should not be in excess of 500mA. To uprate the power supply to 1 amp per rail you will require -

50VA,0-15,0-15 transformer on price list.
2 X 2amp fuses to replace 1 amp fuses.
2 X 0R47 wirewound resistors to replace R2 and R7.
2 X TIP 3055 to replace the TIP 31A's.

GATING THE ADSR's

The nominal gate voltage from the 'Alphadac 16',when linked as recommended in the article, is +5V but in practice this voltage may only be about 3V5. Some difficulty may then be experienced in fast re-triggering of the 80-8 ADSR and so it would be better to make the link marked 'HIGH G LINK' to begin with. REMEMBER NOT TO MAKE THE LINK MARKED 'SP.LINK'. Although not essential less current will be drawn if resistors R9 and R10 on the 80-8 were made 10k and then to maintain good manual gating R11 should be reduced to 4k7. The only modification required to the 80-10ADSR is to replace R1 by a wire link and remove R2. IC 1 will now be operating at +15V and so accept the higher gate voltages. This change will not interfere with independent re-triggering of the 80-10 from lower voltages.

INSTALLING FOOTSWITCH FOR HEXPAD

The appropriate wires on the footswitch provided are blue and brown. Some users may find the wire on the footswitch too heavy and it may be replace by any twin wire cable or by screened cable. Connect the two wires to a 3.5mm jack plug and install a 3.5mm jack socket close to the hexpad (either on case or keyboard panel depending on arrangement). The ground connection of the jack socket is now connected to a 0V line, for example the 0V on the reset push button. The jack socket connection made on inserting the jack plug is then connected to the 15-way connector (pin 12) going to CONN.2 on the panel. From pin 12 of CONN.2 socket a wire must be taken to the 14 pin DIP header for A1 on the Controller Card. The connection is made to pin 10 of A1. With the Microtan/Tanex combination a similar situation arises, namely although other hexpad connections go to socket B1 on Tanex the non grounded footswitch wire goes to pin 10 of socket A1.

MICROTAN 65/TANEX CONNECTIONS

DIL sockets X1 and X2 on the 80-C1 Motherboard list the connections to be made with the Microtan 65/Tanex boards and must be taken from the motherboard connecting these two items together. This is easy to do if the connecting motherboard is our 80-C4 since the two DIL sockets on this board have the same connections readily available. Furthermore socket X1CM on 80-C4 has the same connections (not same pin orientation) as socket X1 on 80-C1. Likewise X2CM and X2 sockets marry up. If, however, you have the Tangerine system rack then the connections can be taken from the large Motherboard using a 64 way plug and hardwiring (refer to Tangerine manual for connections). The most difficult situation is a system using Tangerine's mini-motherboard since in this case the appropriate connections will have to be made by soldering wires onto the mini-motherboard. In all cases the system has been arranged so that connections from Microtan 65/Tanex can be made with Alphadac's 80-C1 Motherboard via the CONN.1 and CONN.2 sockets on the panel.

Other connections are -

HEXPAD to SOCKET B1 on Tanex - same pin out as Controller Card version described in E&MM article.

KEYBOARD (that is from 80-15D1) to SOCKET A1 on Tanex. Again same pin out as article.

DIGI-1 EPROM to SOCKET E2 on Tanex.

Please refer to Tangerine manual regarding connecting 20-way keypad or ASCII keyboard in order to reset the Alphadac prior to initialising.

DIGISOUND LIMITED

JUNE 1981

POSTSCRIPT:

Having constructed another couple of Alphadac's the following points are worthy of note.-

1. In the 80-C3 Quad DAC kit there is one 14-pin socket which is different to the rest. This Vero socket MUST be used for DIL socket X5 on the PCB - the normal DIL sockets will not fit the 14-pin DIP header supplied.
2. All IC's on the Controller Card face the same way, i.e., with the components facing you the notch of the IC faces to the right hand side of the board.
3. Be particularly careful when orientating the 64-way DIN sockets on the PCB's. The A and B positions and the 1 and 32 positions are printed on the PCB and so there is adequate information to orientate them correctly. The point is stressed, however, since if they are soldered in backwards then they will be virtually impossible to remove.
4. The 6522 on the Controller Card must be in SOCKET B1 - refer to photograph in E&MM article. There is a chance that the Card may be supplied with the 6522 in SOCKET B2 since this is the last test position. Also check that all IC's on the Controller Card and any other made up computer parts are firmly seated in their sockets.

JUNE 1981