KEYBOARD CONTROLLER

Bring your Project 80 Modular Synthesiser to life with the final components — the keyboard assembly and keyboard controller. Design and development by Charles Blakey.

The design is based on the principle of digitally scanning each key in sequence so that the controller may be readily interfaced with a microprocessor to accomplish sequencing, composing, multi-voices and polyphonic control. The synthesiser can, therefore, be expanded to suit the needs of the user. The digitally scanned keyboard is equally well suited to a monophonic synthesiser and the design presented will suit keyboards having up to 64 keys. It is stable, accurate and readily adjusted to suit various volts per octave relationships. One of its best features is that it dispenses with the analogue 'Sample & Hold' (known to many as 'Sample & Droop'). With the digital version the key voltage can be held constant for days, although this is not very interesting musically!

Both the 80-8 and 80-10 envelope shapers have been designed to operate in the ADSR mode without an independent trigger voltage and so a trigger output voltage coincident with the gate voltage is not included. Instead a touch activated trigger is provided which may be connected to the independent trigger output of the 80-10 module to produce complex envelopes.

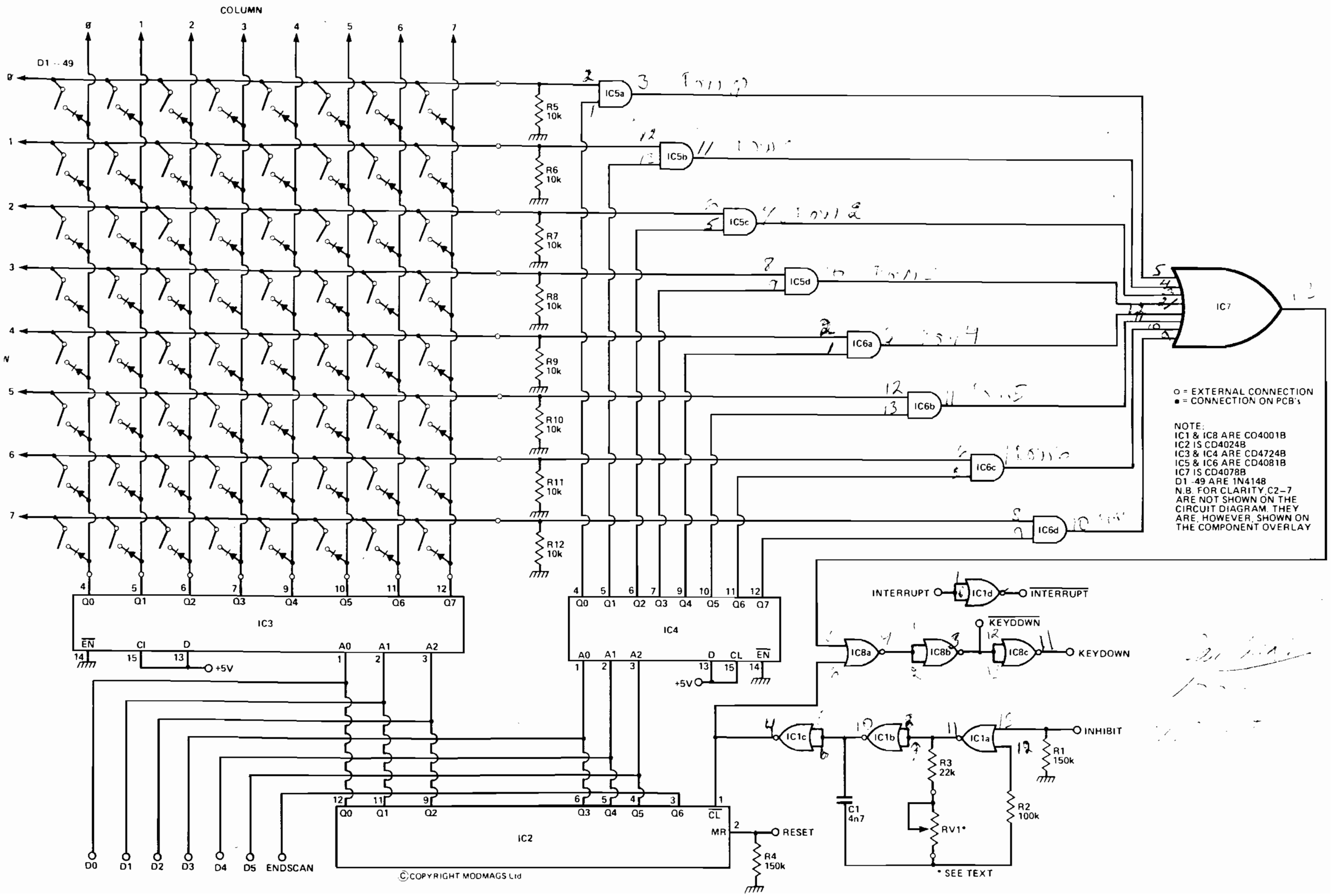
Keyboard and Scanner

Assume that the diode and key contact, which will connect Column 0 to Row 0, is the first key of the keyboard, Column 1 Row 0 is then the second key, Column 2 Row 0 the third key and so on until one gets to Column 7 Row 7 which would be the 64th key. IC3 is sequentially scanning the columns by outputting a positive voltage and so, when Q0 of IC3 is high this voltage will be present on all diodes of Column 0, that is on one side of the contacts for keys 1, 9, 17, 25, 33, 41, 49 and 57. IC4 is an identical sequential scanner to activate the rows and the step from row to row take-place when IC3 has completed a scan of the eight columns. The controller is, therefore, scanning the keyboard sequentially from first key to last key with an effective first key down priority. By way of an example let us follow what happens when key 25 is pressed. A logic '1' signal will be present on Row 3 and when Q3 of IC4 goes high the combined '1 + 1' logic signals at the IC5d AND gate will generate a '1' output. This may sound rather slow but in practice a 49 note keyboard will be completely scanned at a rate of about 100 times a second. A '1' from IC5d (or any AND gates) will cause the eight input NOR gate (IC7) to go low and further logic around IC8 generates two outputs when a key is pressed, namely $\overline{\text{KEYDOWN}}$, which is a logic '0' signal, and KEYDOWN which is a '1' output. In the monophonic arrangement KEYDOWN is connected to the INHIBIT line of the clock built around IC1 so that the clock stops and will stay off for the duration the key is held down. The KEYDOWN signal is, therefore, also used to form the gate voltage for the envelope shapers. Clearly with the clock stopped keyboard scanning ceases. Nevertheless the data on the output lines of the counter (IC2) used to drive IC3 and IC4 and which stopped simultaneously with the clock is still present at its outputs Q0 to Q5 (ignore Q6). These six data bits identify the key being held down and for the 25th key the binary code output will be 011000. A few additional codes for a 49 note C-C keyboard are listed below and for those not familiar with the binary code it will be worth the effort to make a complete listing. The listing assumes starting at Column 0 Row 0.

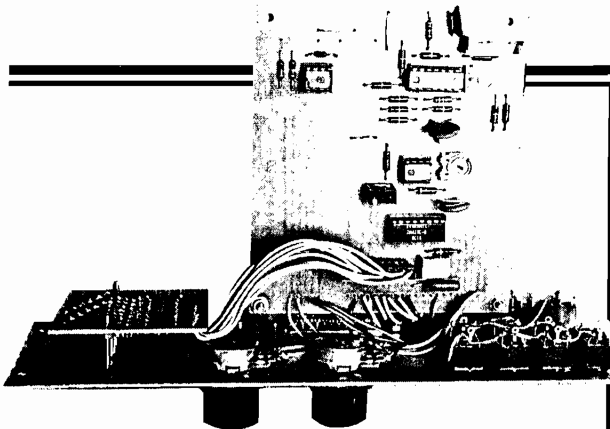
Key No.	Note	Binary Code
1	CC	000000
2	CC #	000001
25	C	011000
26	C #	011001
27	D	011010
28	D #	011011
29	E	011100
49	C	110000

When the key is released scanning recommences until another key is found down.

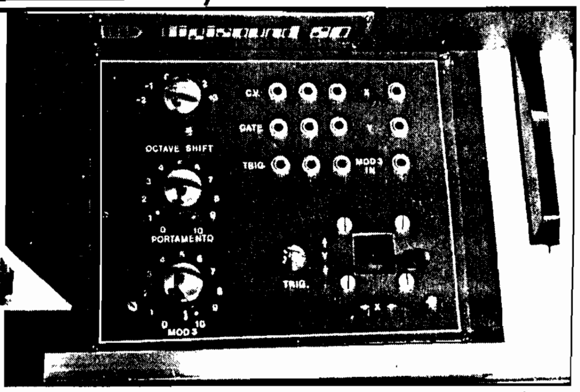
Fig.1 Circuit diagram of the keyboard matrix and scanner.



Keyboard Controller



If the Digital to Analogue Converter is mounted on its panel, the Logic Status Indicator board can be mounted as shown. Correct keyboard logic operation can then be checked by watching the LED patterns on the front panel (see text).



The option A layout, with Octave Shift, Portamento control X-Y control, Touch Trigger, etc, all in the keyboard case. (See Fig.14).

HOW IT WORKS

KEYBOARD CONTROLLER: The circuit diagrams comprise four parts: an 8 x 8 diode matrix mounted on the keyboard — or at least part of it equivalent to the number of keys on the keyboard; scanning and logic circuit for the keyboard; a digital to analogue converter; a + 5 V power supply sufficient to cope with the logic circuits. In the scanner circuit an astable is made from the NOR gates IC1a, b and c which will have a clock period of about 2.2R3C1 and so with the components used the clock rate is about 4.4 kHz. the clock may be stopped by a logic '1' at the input marked INHIBIT, which is normally pulled low by R1 connected to ground. Provision for adjusting the clock rate using RV1 has been included but not installed in the monophonic version. The astable is used to clock a seven stage counter, IC2, and the lower three bits (Q0 and Q2) are in turn used to drive an eight-bit addressable latch, IC3, which is arranged as an active high eight channel demultiplexer. Thus the output of IC3 is a series of logic '1' pulses which is sequentially scanning the eight columns of the diode matrix. The next three bits from the IC2 counter go to IC4 which is another eight channel demultiplexer. When all eight columns of the diode matrix have been scanned by IC3 then IC4 increments one step and puts a logic '1' on one input of the AND gates (IC5,6) which are associated with specific rows of the diode matrix. When a key contact is closed the '1' output from IC3 will be transmitted to the appropriate row bus and will take the other input of the AND gate high — which is normally held low by a resistor (R5-12) connected to ground. With two highs at the AND gates they will output a '1' and this is detected by the eight-input NOR gate, IC7, which goes low. Now the digital code for each of the available 64 key contacts will be defined by the first six bits of the IC2 counter. When IC7 goes low a KEYDOWN output (logic '0') is produced, which is used for latching the D to A Converter and also a complimentary KEYDOWN output which is wired to the INHIBIT line of the clock. Thus, whenever a key contact is closed both the clock and counter are stopped and the data present on the Q0 to Q5 outputs of the latter is the binary code for the particular key pressed. These data bits, D0 to D5, are connected to the Digital to Analogue Converter IC10. IC10 is an eight bit D to A Converter but only the first six bits are used. The converter may also be latched via pin 4 and so this pin is connected to the KEYDOWN signal from the scanner. When a key contact is closed KEYDOWN is low and this makes the D to A transparent to the data at its inputs, namely the binary code for the particular key pressed, and converts the data to a voltage. When the key is released then KEYDOWN goes high and the data present at the D to A is latched so that the output voltage remains until the next key is pressed and the sequence is repeated. IC10 includes an internal voltage reference which is utilised in this design with R16 deriving a reference current to the internal zener diode while C12 is for stabilising and decoupling. The output of IC10 needs to be buffered by a high impedance op amp having a low input bias current and this is provided by IC11. Also, when the internal reference voltage is used the output from IC10 will be about 10 mV per data bit whereas to obtain the required 1 V/octave an output of 83.3 mV/bit (83.3 mV/semitone) is necessary and so the gain of IC11 is made adjustable around a nominal gain of about eight. IC10 will not drive a high RC load directly and so the portamento components RV2 and C13 are taken from the output of IC11 and buffered by IC12a arranged as a voltage follower. The control voltage, with or without slewing (portamento), now goes to IC12b which is a summing amplifier with unity gain where it may be mixed (voltages added or subtracted) with other control voltage sources via R20/RV3, R21 or R23. The output of IC12b will be inverted and this is corrected by IC12c which is a unity gain inverter. PR3, R27, R28 and R29 are used to remove the offset voltages arising from IC12.

The KEYDOWN signal from the controller remains high for the duration the key is held down and is, therefore, the conventional gate signal which defines the duration of the sustain in ADSR envelope generators. For practical purposes this CMOS output needs to be buffered and this is done with IC13 arranged as a comparator. IC13 needs to be a high slew rate op amp capable of going back to near ground potential so as to be compatible with the internal logic of customised envelope generators. Another advantage of the CA3140E is that its output voltage may be clamped by placing a zener diode between pins 4 and 8 and the output voltage will be approximately equal to the zener voltage less two diode drops. This is the arrangement shown for use with the ETI 80 envelope generators. Other gate voltages may, however, be derived by using the resistive dividers R33/34 and R35/36 to operate IC11 from a variety of voltages.

A means of generating the + 5 V supply required for the CMOS devices and the D to A Converter is included on the scanner PCB. The input voltage for this section is taken from the rectified and smoothed positive supply of Module 80-1 and the voltage dropped across R13/14. This is then regulated by IC9 and will provide the 30 mA or so required for this part of the project.

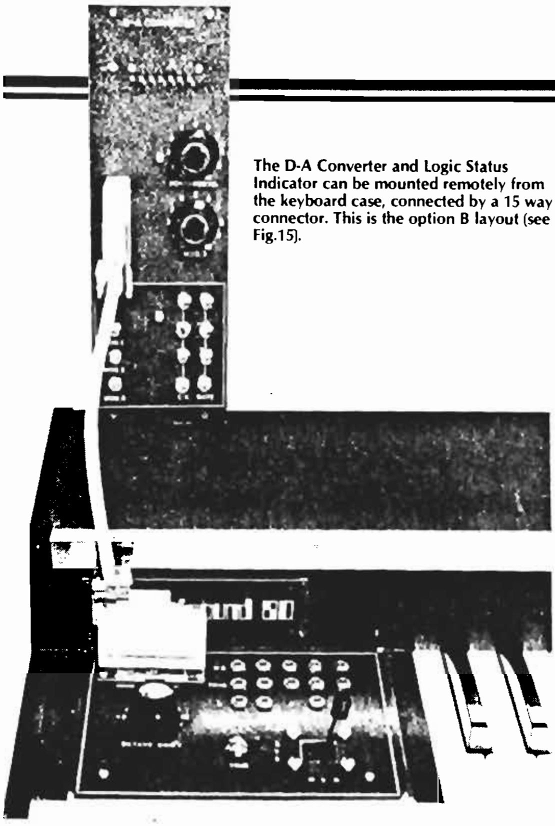
OCTAVE SHIFT, X-Y CONTROLLER, TOUCH TRIGGER: For the octave shifter IC14 is a programmable current source which, by adding D50 and making the sum of R38,39 and 40 equal to about 10 times that of R37, will be insensitive to temperature changes. The voltage increments developed at the junctions of R38,39 and 40 are taken via a rotary switch, SW1a, to a non-inverting amplifier whose gain may be adjusted with PR4 to give +3 V from the junction of IC14/R38 junction; +1 V at the R39/40 junction; and zero from the junction of R40 with ground. PR5 cancels the offset voltage in IC15. The positive outputs are made available at the pole of SW1b. The +2 V and +1 V outputs are inverted by IC16 and PR6 allows accurate adjustment to compensate for the small errors introduced by R44,45. PR7 is for offset adjustment of IC16. These negative outputs are also selectable by SW1b.

For the X-Y controller it was also convenient to use the reference voltage derived at the junction of IC14 and R38 and this voltage is buffered from IC17a and IC17c arranged as voltage followers. For the 'X' potentiometer of the joystick, RV4, the voltage is amplified by IC17c which is an inverting amplifier. The gain of the later is equal to

$$\frac{R49}{RV4 + R47}$$

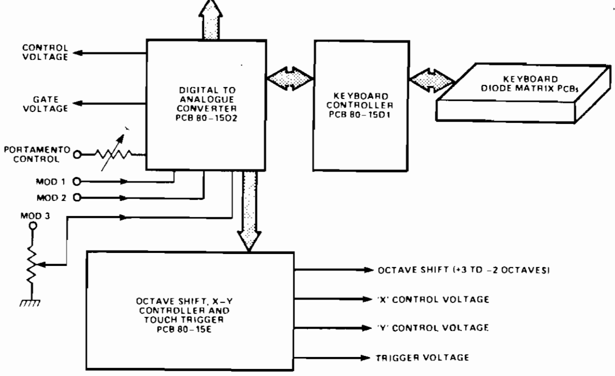
and thus the output voltage will vary from −2.7 X Vin to −0.84 X Vin and since Vin is about 0V5 this gives a range of approximately −0V4 to −1V4. PR8 and R48 are used both to convert these outputs into positive voltages and also to adjust the output to 0 V when the 'X' potentiometer is in the extreme left hand position. The net effect is a control voltage which is variable from zero to about 0V95. This range may be easily adjusted by altering the value of R49 and the general arrangement used allows a wide variety of values for the resistive range of the joystick potentiometer. The circuit for the 'Y' controller is identical to the 'X' controller.

A trigger pulse is derived from touching an insulated metal contact and is based on IC18 arranged as a comparator. R56 and R57 set up the switching level, which is about 150 mV. The impedance of the output is determined by R55 and on touching the metal conductor mains hum will be picked up and cause IC18 to switch between zero and about +13 V at around 50 Hz. The output is, therefore, smoothed sufficiently by C17 to be used as a trigger pulse for the 80-10 envelope generator, which has a fully independent trigger input. The sensitivity of the touch trigger may be changed by altering the value of R55 and/or adjustment of the comparator voltage set by R57 and R57.



The D-A Converter and Logic Status Indicator can be mounted remotely from the keyboard case, connected by a 15 way connector. This is the option B layout (see Fig.15).

Fig.2 (below) Block diagram of the keyboard circuits.



These are the basic features of the keyboard controller and the salient points to remember are: (a) only a single key contact is required to generate both the key code, which is subsequently converted to a control voltage, and the gate signal: (b) Pressing two keys in error will not cause problems because of the decoding arrangement used; (c) Key bounce is not a problem; (d) The only inputs and outputs of interest at this time are KEYDOWN, $\overline{\text{KEYDOWN}}$, (clock) INHIBIT, and the six data bits D0 to D5. Other connections are for future expansion and it is evident that their inclusion has only added a few pence to the cost.

Digital To Analogue Converter

The six data bits, D0 to D5, from the scanner have to be converted to an analogue control voltage and also scaled correctly, which for the ETI 80 and most commercial synthesisers is 1 V/octave. The essential component is IC10 which is a self-contained eight-bit digital to analogue converter. An advantage of using the ZN 428E-8 is that the device is designed to be microprocessor compatible and has a latch at pin 4. When the logic signal at this pin goes from '0' to '1' the data present when it was at '0' is latched into the IC and the output voltage remains constant. From the earlier discussion on the controller it will be recalled that when a key is pressed a $\overline{\text{KEYDOWN}}$ signal is generated. This signal is connected to pin 4 of IC10. Thus when a key is pressed the clock stops, $\overline{\text{KEYDOWN}}$ goes to logic '0', and the data bits D0 to D5 are available to IC10 which converts them into a voltage directly related to the binary code.

When the key is released $\overline{\text{KEYDOWN}}$ goes high and so the data from the last key pressed is held in IC10 and the voltage output remains constant.

Since the control voltage may be used to control a number of VCOs, perhaps set at different intervals, it is more convenient in some cases to modify the control voltage to all modules simultaneously. This may be done through any of the three inputs marked MOD. 1 to MOD. 3. The latter incorporates an attenuating potentiometer, RV3, and could be used for, say, frequency modulation.

The keyboard scanner is implemented in CMOS and so could be powered by +15 V, but the D to A converter, IC10, is designed to operate from a nominal +5 V supply (INPUTS IN EXCESS OF +7 V MAY DESTROY THE DEVICE) and in any event this 5 V logic level is used by most microprocessors. IC1-10 only require about 30 mA at +5 V and so there is no need for a separate power supply. The required power is taken from the 80-1 power supply and, to prevent wasting the fully regulated +15 V supply, the supply voltage is taken across C1 on the 80-1 PCB. THE +5 V POWER SUPPLY OF THE KEYBOARD SCANNER PCB MUST NOT BE USED FOR POWERING ADDITIONAL ICs OR EQUIPMENT.

A useful diagnostic and learning tool is provided by a logic status indicator. There are six red LEDs, one for each of the six data bits D0 to D5 and a green LED for the gate output (KEYDOWN). With the keyboard scanning and no keys pressed all the red LEDs will be on and the gate LED off. When a key is pressed, the binary code for the key will be displayed and the gate LED will turn on.

In electronic synthesis stability and accuracy of control voltages is essential. The octave shift generator uses a current generating IC, which can be operated with minimum temperature drift and is substantially insensitive to supply voltage. The voltages derived can be added to the control voltage via MOD. 1 or MOD. 2 inputs on the D to A Converter PCB and a shift of +3 V, +2 V, +1 V, 0, −1 V, or −2 V is available from a selector switch. These are equivalent to a shift from +3 to −2 octaves with the Project 80 modules.

X-Y Controller

As configured, the range available is about 0V9 (0.9 octaves) and with the joystick parked in the bottom left hand corner the output is zero. This latter arrangement is preferred to X-Y controllers with a centre off position, since rarely does the pot go *exactly* to the centre position and the chance of an offset voltage is increased because the pot is in mid range. The X-Y controller may be wired directly to one of the MOD. inputs on the D to A Converter, although this is not advised, since the unit does not have the same voltage stability as other inputs. The best approach is to patch the 'X' and 'Y' outputs directly to the control inputs as required.

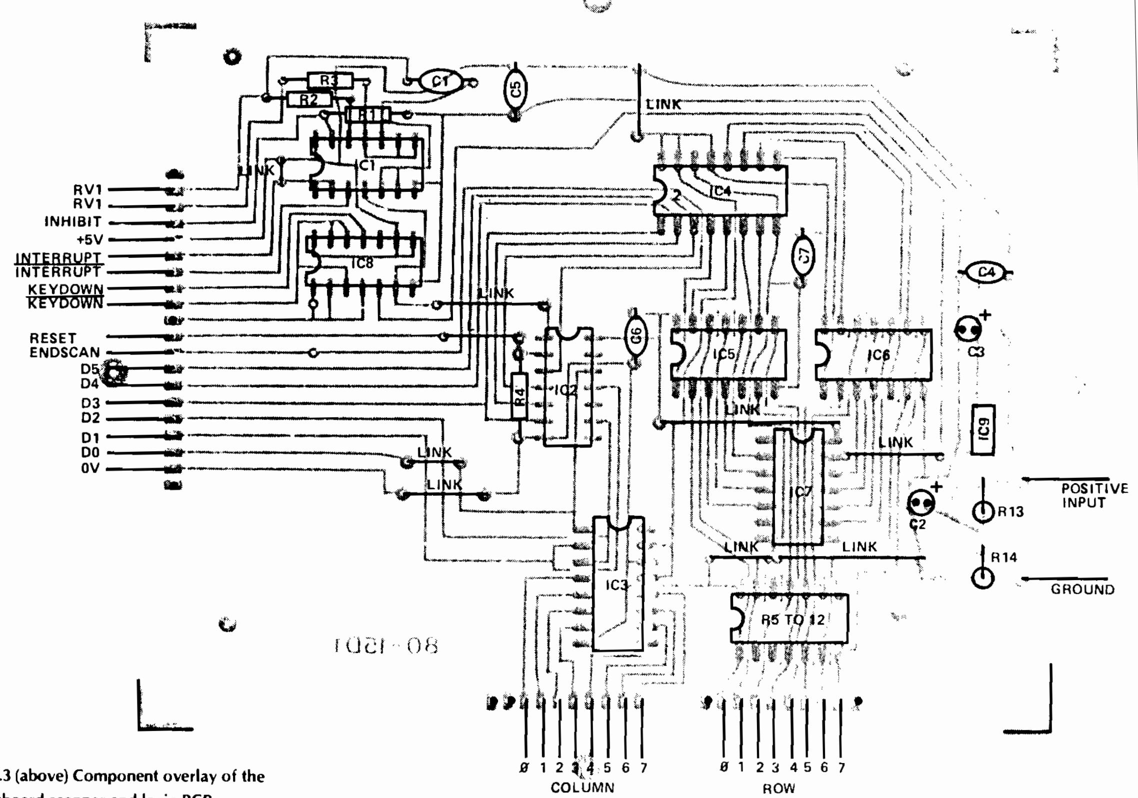


Fig.3 (above) Component overlay of the keyboard scanner and logic PCB.

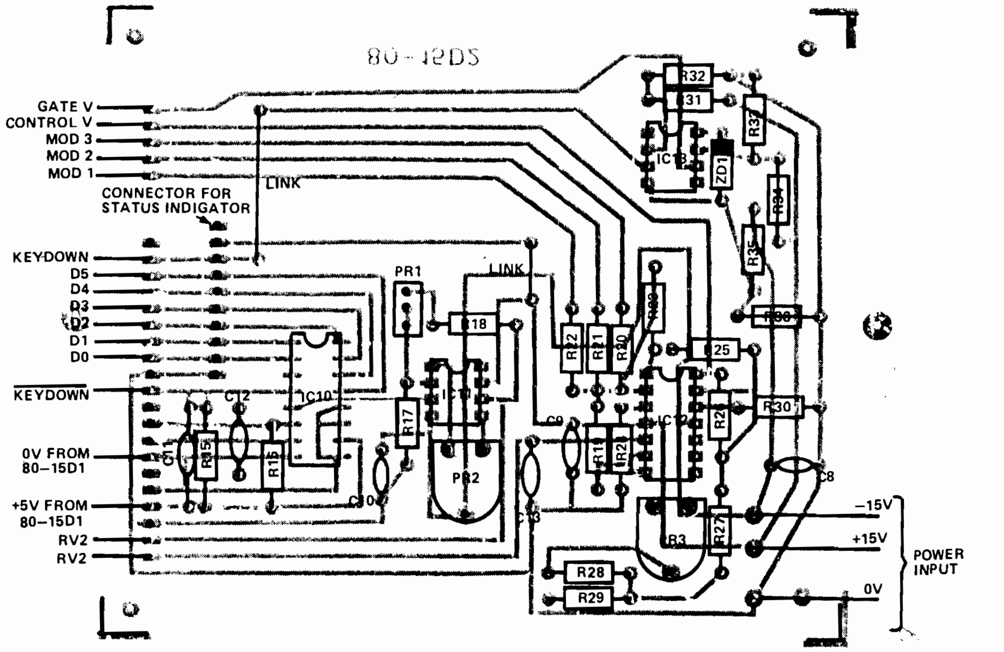
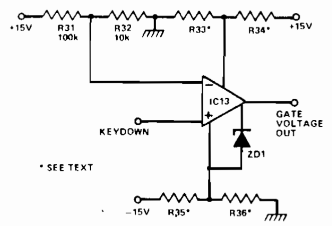
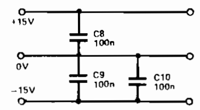


Fig.4 Component overlay of the digital to analogue converter.





Custom ICs for envelope generators generally require both a gate and a trigger voltage to produce a full ADSR envelope. To make the 80-8 and 80-10 envelope generators versatile and also allow manual generation of envelope signals the necessary trigger pulses are derived within these modules. The 80-10, however, also has an independent trigger output and so a method of providing trigger pulses at will is a useful addition to the keyboard controls.

For a 49 note keyboard there are four PCBs. The main reason for this is to make the PCBs acceptable for different makes of keyboard. They have been used with both the Kimber Allen SKA and the keyboard marketed by Clef Products. The first step is to identify the arrangement of PCBs (Fig. 10).

Turn the keyboard so that the keys face downwards and firmly support it in such a way that none of the keys are pressed down. Now arrange the four PCBs as outlined. Using some of the key contacts, position each PCB in turn so that the contacts line up with the solder connections on the PCB and also with the

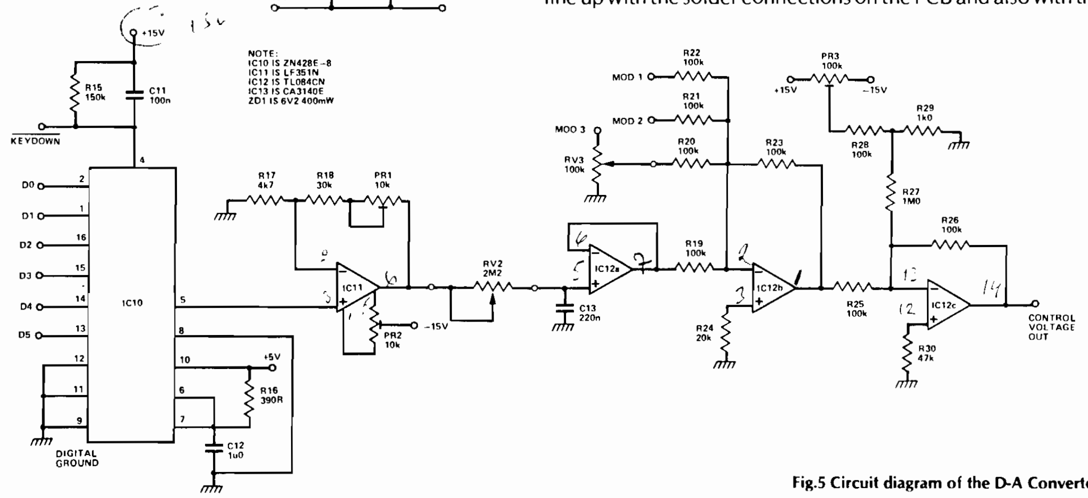


Fig.5 Circuit diagram of the D-A Converter.

PARTS LIST

49 NOTE KEYBOARD WITH CONTROLLER AND D TO A CONVERTER

Resistors	
Carbon Film ¼W 5%	
R1,4,15	150k
R2,31	100k
R3	22k
R24	20k
R30	47k
R32	10k
Metal Film ¼W 1% 100ppm TC	
R16	390R
R17	4k7
R18	30k
R19,20,21,22,23,25,26,28	100k
R27	1M0
R29	1k0
Others	
R5-12	10k DIL resistor network
R13	150R, 4 W wirewound
R14	330R, 4 W wirewound
Potentiometers	
RV1	for future expansion
RV2	2M2 logarithmic
RV3	100k linear

PR1	10k cermet multiturn
PR2	10k cermet
PR3	100k cermet
Capacitors	
C1	4n7 polycarbonate
C2	47u 25V PCB electrolytic
C3	10u 40V PCB electrolytic
C4-10	100n ceramic disc
C11	100n polyester
C12	1u0 MKH polyester
C13	220n MKH polyester
Semiconductors	
IC1,8	CD4001B
IC2	CD4024B
IC3,4	CD4724B
IC5,6	CD4081B
IC7	CD4078B
IC9	LM78L05ACZ
IC10	ZN428E-8
IC11	LF351N
IC12	TL084CN
IC13	CA3140E
D1-49	1N4148
ZD1	6V2 400 mW zener

Miscellaneous
49 note keyboard; 49 GJ SPCO key contacts; sundry PCB connectors.

key plunger. Keeping the PCB held down scribe its location onto the keyboard frame. The PCBs may now be glued to the frame with Araldite Rapid adhesive. The next step is to make connections between the tracks. In most cases there will be sufficient gap between the PCBs to allow the use of proprietary PCB connectors, suitably shortened, to make the connections between the tracks.

If possible, PCB connectors should be used when positioning the PCBs on the frame. They greatly simplify joining up. Cut the pins so that there is sufficient metal to bridge the gap between the PCBs, but will not interfere with the placement of the key contacts. Also, when soldering them in place, ensure that excess solder does not flow sideways as this may subsequently prevent the key contacts from seating properly.

Ensure that the keys are aligned properly. With the recommended type the top edge of the contact will line up with the top edge of the PCBs. After all keys have been glued allow the adhesive to set overnight. Then the connections can be soldered to the PCBs as shown in Fig. 11. The diodes are now soldered in place. D1 is connected betweeen the track for Column 0 and the pad for key 1; D2 from the track for Column 2 to key 2 and so on until D8 which connects Column 7 track with key 8.

The final step is to connect the keyboard to the scanner PCB. The use of Molex connectors on the latter PCB is recommended while the other end of the wire is soldered directly to the tracks. For the monophonic keyboard Column 0 and Row 0 go to the first key, since this will result in a zero voltage from this key when pressed and the output is used for calibration purposes. Furthermore the 80-2 VCO is set such that 0 V at the Control Input will produce a frequency of 65.41 Hz, which relates to the first key.

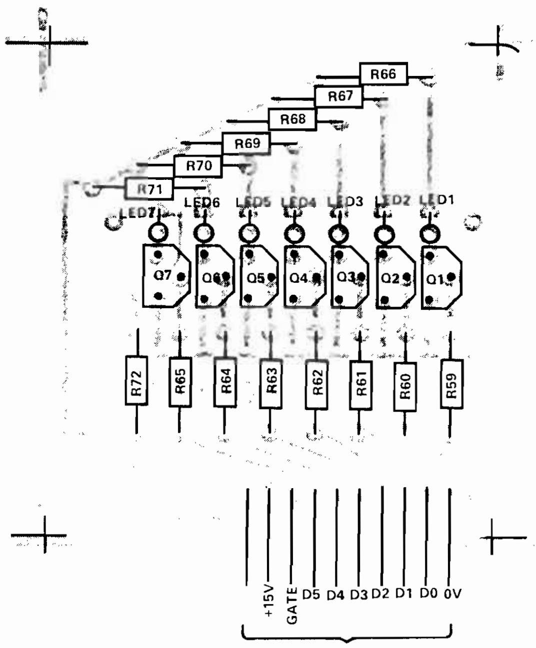


Fig.6 Component overlay of the keyboard controller status indicator. CONNECTS TO PCB 80–15D2

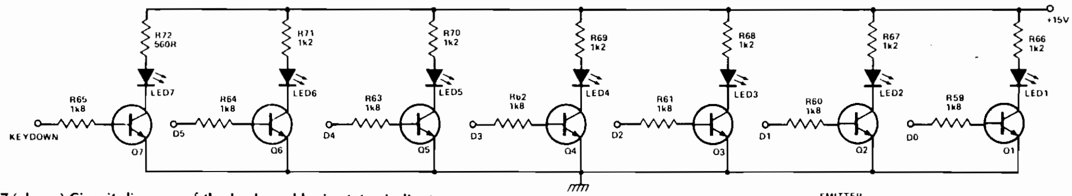
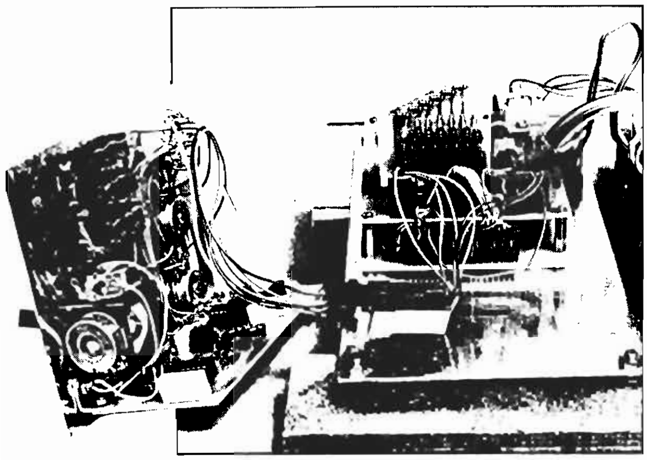


Fig.7 (above) Circuit diagram of the keyboard logic status indicator.

In the option A layout (below), the D-A Converter, Keyboard Scanner and Logic Board and Logic Status Indicator are incorporated in the keyboard case. (See also Fig.14).



PARTS LIST

LOGIC STATUS INDICATOR

Resistors

Carbon Film ¼W 5%

R59,60,61,62,63, 64,65	**1k8**
R66,67,68,69,70,71	**1k2**
R72	**560R**

Semiconductors

Q1-7	**BC548**
LED1-6	**3mm red LED**
LED7	**3mm green LED**

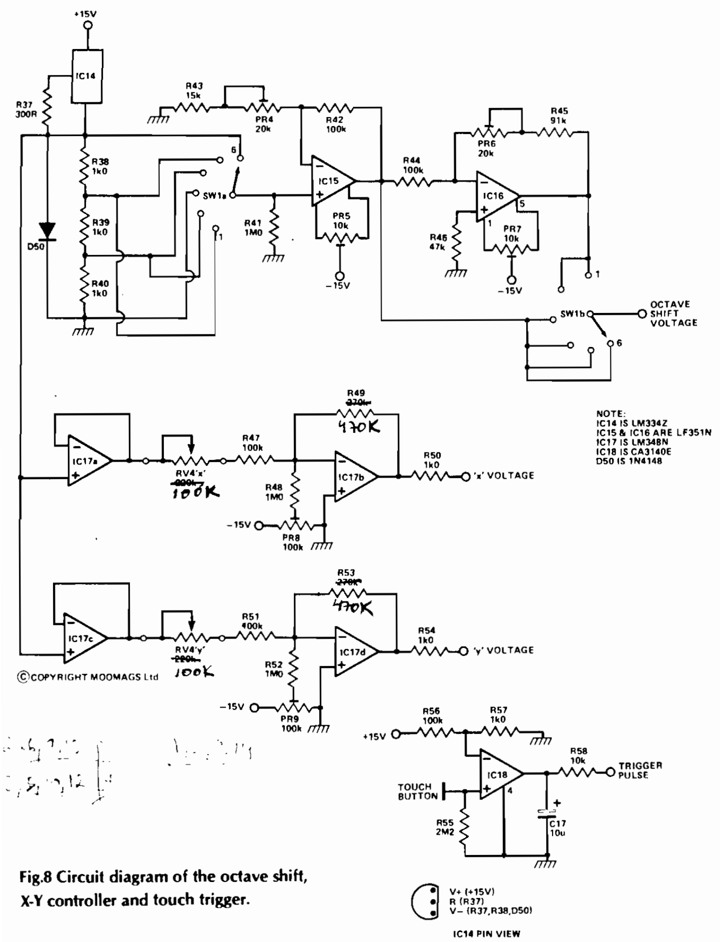
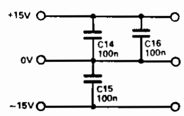


Fig.8 Circuit diagram of the octave shift, X-Y controller and touch trigger.



PARTS LIST

OCTAVE SHIFT: X-Y CONTROLLER: TOUCH TRIGGER

Resistors	
Carbon Film ¼W 5%	
R41,48,52	1M0
R46	47k
R47,51,56	100k
R50,54,57	1k0
R55	2M2
R58	10k
R49,53	~~270k~~ 470K
Metal Film ¼ 1% 100ppm TC	
R37	300R
R38,39,40	1k0
R42,44	100k
R43	15k
R45	91k
Potentiometers	
RV4	X-Y Joystick, ~~220k~~ 100K pots
PR4,6	20k cermet multiturn
PR5,7	10k cermet
PR8,9	100k carbon
Capacitors	
C14,15,16	100n polyester
C17	10u 40V PCB electrolytic
Semiconductors	
IC14	LM334Z
IC15,16	LF351N
IC17	LM348N
IC18	CA3140E
D50	1N4148
Miscellaneous	
SW1	2 pole 6 way rotary switch

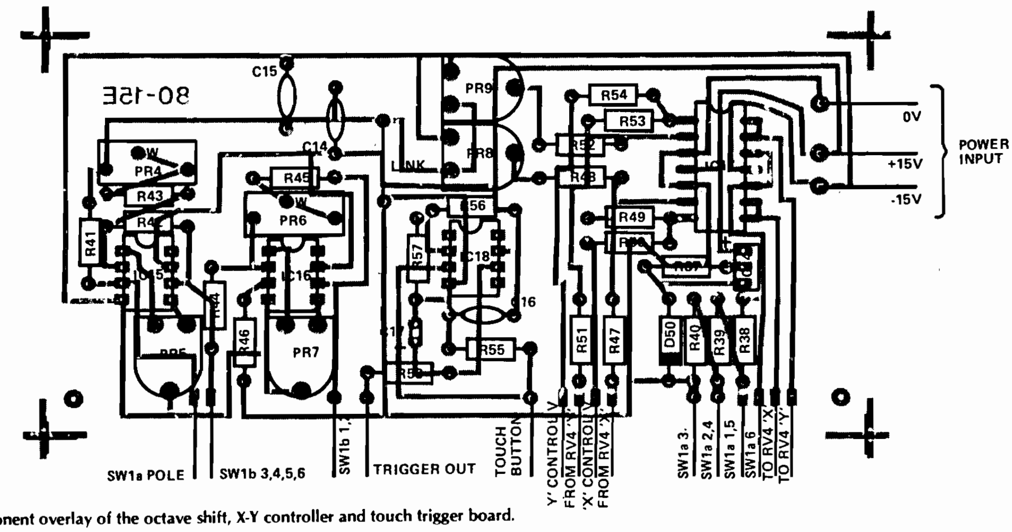


Fig.9 Component overlay of the octave shift, X-Y controller and touch trigger board.

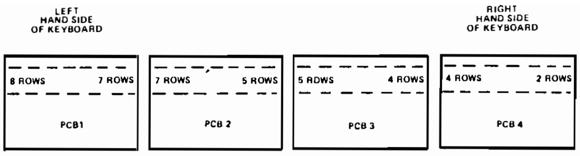


Fig.10 Arrangement of the keyboard PCBs.

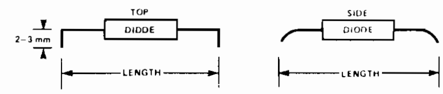


Fig.13 Shaping the diodes to avoid leads bridging across Column tracks.

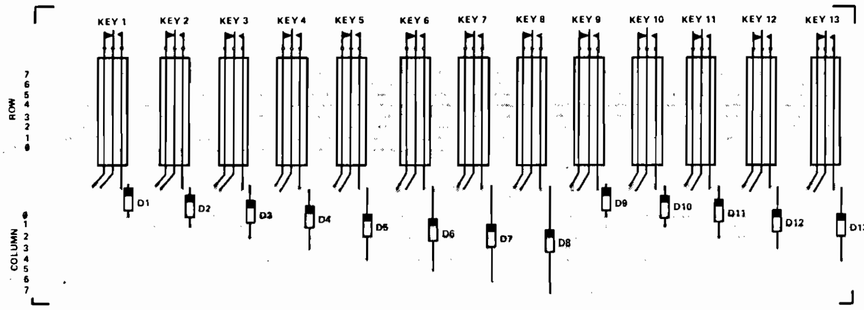


Fig.11 Keyboard component overlay.

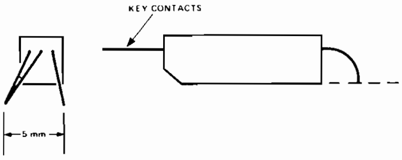


Fig.12 Shaping the key contacts. Each key should be firmly gripped at its sides when splaying the contacts, to avoid breaking the rivets. The leads should be level with the contact base. Before soldering, place the key contact on a flat surface to check that the leads are level. The key contacts can now be glued to the PCB with the same epoxy resin adhesive as before.

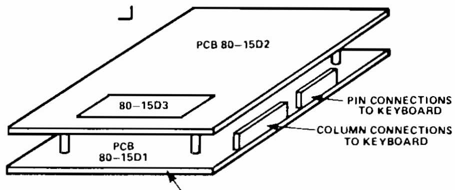


Fig.14 Option A layout.

Controller And D To A

There are two options for the connections between these two PCBs and for the general arrangement of the synthesiser controls. In Fig. 14 both the scanner PCB and the D to A Converter are housed within the keyboard case and the appropriate control voltages made available from the control panel sited to the left of the keyboard. The preferred arrangement is that in which the control data from the scanner is taken to a 15-way connector on the control panel and to house the D to A converter in a separate module.

When the 80-15D1 PCB is complete with the power supply components there will be three unused holes in the PCB, one adjacent to C17 and two adjacent to pin 1 of IC8. These should be ignored. On the 80-15D2 PCB to make the gate voltage compatible with the ETI-80 envelope generators put wire links in the places shown for R34 and R36 and ignore R33 and R35. Note that for option A (all PCBs within the case) both the 80-15D1 and 80-15D2 boards should be fitted with Molex PCB pins and 80-13D3, if used, will require a Molex edge connector. With option B the D to A converter only requires Molex pins for the 80-15D3 and the latter does not require an edge connector.

The last step is to make the connection to the 80-1 power supply. Constructors with a regulated +5 V supply which can be conveniently used will not have to install components R13, R14, C2, C3 and IC9 on the 80-15D1 PCB and the external supply goes to the positive and ground inputs shown in Fig. 3, but with a wire link made further down the 'positive' track and to the hole which would have been occupied by the positive lead of C3.

CONNECTIONS:

1. **BETWEEN OUTPUTS OF 80-15D1**
   a) Connect the two RV1 leads together
   b) Connect KEYDOWN TO INHIBIT
2. **BETWEEN 80-15D1 AND 80-15D2**
   a) D0 to D5 connections
   b) 0V connections
   c) +5V connections
   d) KEYDOWN connections
3. **BETWEEN 80-15D2 AND 80-15E**
   a) MOD. 1 to octave shift output
4. **BETWEEN 80-152 AND CONTROL PANEL**
   a) Control voltage output
   b) Gate voltage output
   c) Portamento control RV2 (two leads)
   d) Mod. 3 to RV3

Setting Up And Calibration

Keyboard Controller and D to A Converter: Using the logic status indicator press each key in turn and note that a stable keycode is displayed and the gate LED comes on. The best approach is to list any keys that do not function correctly when the key is lightly pressed. If only a few fail to function then most likely the key contacts require a slight adjustment. If more fail, look for patterns of eight which then may correspond to connections on a particular Column or Row, for example, if there is no response to keys 9 to 17 this indicates a fault on Row 1. The status indicator will also show that there are no crossed wires in the Column and Row wiring since, pressing the keys in the sequence lowest to highest will generate the six bit binary code in logical order.

If the status indicator is not used then connect a voltmeter to the gate output from the D to A Converter and note that about +5 V is obtained for each key pressed. Next connect the voltmeter to the control voltage output and note that the voltage increments as each key is pressed, from left to right.

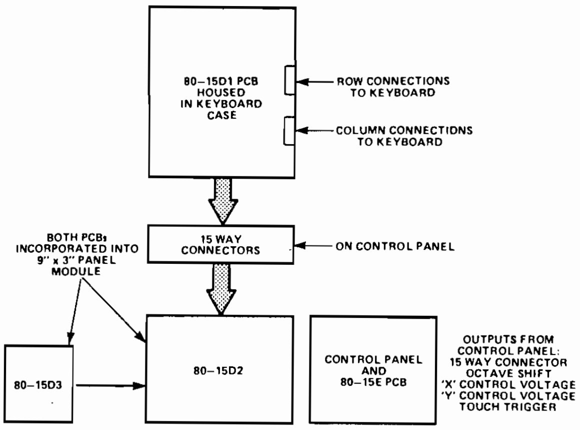
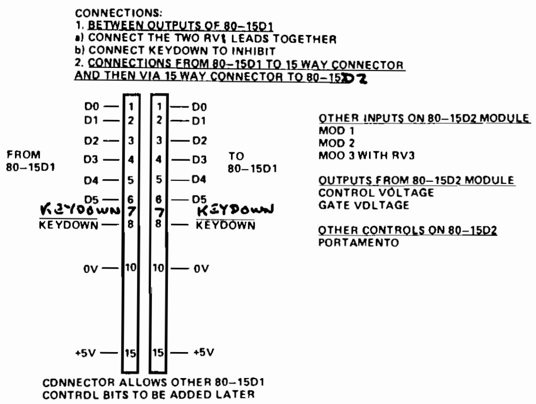


Fig.15 (above) Option B layout.



With the keyboard logic functioning and key contacts adjusted where necessary the last step is to calibrate the D to A Converter. Press the first note and keep it held down and ensure that the octave shift switch is on zero and the portamento control is fully anti-clockwise. Connect a voltmeter to R18 at the end which connects pin 6 to IC11 and adjust PR2 for 0V000. Next connect the voltmeter to the control voltage output and adjust PR3 to obtain 0V000. With the voltmeter still connected to the control voltage output release the first key, hold down key 49 and adjust PR1 to give 4V000. Lastly press all the C keys to determine that they produce 0, 1, 2, 3 and 4 V output. Some minor adjustments may have to be made to PR1 to obtain these values within a few millivolts of their correct values. Next check that the portamento control is functioning. ie, as the control is turned clockwise the time for the voltage to reach its true value will increase.

Place the octave shift switch on way 3 (0 V) and measure the voltage at the output. Adjust PR5 to give 0 V. Leave the switch in the same position and measure the voltage at R45 where it connects to pin 6 of IC16 and adjust PR7 for zero output. Turn switch to + 2 octaves and adjust PR4 to give 2V000 at the output. Lastly turn the switch to − 2 octaves and adjust PR6 to give − 2V000 at the output.

To adjust the X-Y controller keep the joystick in the bottom left hand position and first adjust PR8 for 0 V from the 'X' output and the PR9 for 0 V from the 'Y' output. Place the joystick in the top right hand corner and check that a voltage in excess of 0V9 is available from both 'X' and 'Y' outputs.

Keyboard Housing

Detailed construction for a housing is not provided since dimensions will vary according to the keyboard used.

1. Make the keyboard housing about 35inches (94cms) long so that a module housing containing a row (or rows) of 12 modules will seat neatly on top. This length also provides adequate space at the left hand side for the keyboard scanner PCB and the control panel.
2. The control panel is 162 x 115 mm and the hole in the keyboard casing should only be slightly smaller so as to allow this panel to be passed through the hole when assembling or dismantling.
3. The overall depth of the case is about 29 cm which provides a firm base for the module as well as leaving sufficient space behind the keyboard for the power supplies. Connections from these power supplies to the module housing can be made with miniature three-pole connectors and these should be clearly identified, or preferably of different design, to prevent wrong connections which will damage the modules.
4. The case should have a 7-8 cm step above the level of the key. This serves two purposes: (a) it allows the power supply PCB to be mounted vertically for easy access to the trimmers; and (b) it provides a valuable gap between the keyboard and the modules and avoids having patchcords drooping onto the keys.
5. The rear panel should be preferably ventilated.

KEYBOARD CONTROLLER. ADDITIONAL CONSTRUCTION NOTES

A. LOGIC CONTROLLER. 80-15D1

1. Wire links on PCB are denoted by solid lines between PCB holes, note the small link between IC 1 and the edge. Ignore links marked 'A' and 'B'.
2. If a +5V supply is available then this is connected between the inputs on rear of PCB marked 0V and +5V. Alternatively this external +5V supply may be connected at the appropriate inputs on the front edge of the PCB. When the supply is taken from the 80-1 PCB the positive input must be connected to input at rear marked '+V' and components R13, R14, C2 and IC9 installed. Install these before inserting the other IC's and check that about +5V is obtained. The 0V line can be picked up at the wire link going from the track to the right of C2 and the +5V is available at the link to the left and below IC4. This +5V supply is only for the keyboard controller kits and no external equipment must be attached to it.
3. RV 1, to alter clock rate, is not installed at this time and is not included in the kit.
4. Refer to construction notes regarding other edge connections.

B. D-A CONVERTER. 80-15D2

1. Resistors R33,34,35 and 36 are not included. Insert wire links ONLY in place of R34 and R36 which will produce a +5V gate pulse.
2. Other wire links shown by solid line between PCB holes.
3. Mount potentiometers on panels with pins facing downwards.
4. Both 0V and +5V must come from the logic controller supply via the 15 way connector.
5. The PCB can be hard wired between the 15 way socket and the PCB.
6. The PCB shows a capacitor, C_x, in parallel with R26. This is to avoid oscillation when a microprocessor is installed and is 22pF. It is included in the kit and should be installed now.

C. LOGIC STATUS INDICATOR. 80-15D3

1. This may be connected to 80-15D2 PCB using a Molex connector on the latter PCB or it may be hard wired.
2. The resistors and transistors should be soldered in place first. The top of the transistors should be about 9 to 10mms above the PCB surface.
3. Short lead of LED's towards the BC 548 transistors. The LED's must all be the same height which can be achieved by placing a strip of thin cardboard between the LED pins. The strip to be about 11 or 12mms wide, i.e., the base of the lens will be about 11/12mms above the PCB surface when finished. Nuts and bolts are provided for attaching PCB to proprietary panel.
4. Note the position of green LED before soldering LED's.

D. OCTAVE SHIFT, ETC. 80-15E

1. The X-Y potentiometer (RV4) is 100k and R49,53 become 470k which produces about a 1V swing on both X and Y axes.
2. The X-Y potentiometer should be mounted as illustrated in Figure 2 which is viewed from the top and can be adjusted to give zero X and Y outputs when paddle is in bottom left hand corner.
3. A black knob is included in the kit which can be glued to the paddle. The long bolts are for mounting the X-Y pot to the panel.
4. The touch trigger is constructed as shown in Figure 3. Put the sleeved grommet into the panel hole. Screw the pillar to the chrome head and push it through the grommet. Note that the thread on the chrome head is not very accurate and sometimes the pillar will slip over the thread. In all cases, however, we have found that the pillar will lock tight. Finally bolt the solder tag to the pillar.
5. The PCB is joined to the panel with L brackets provided and the foil side should face the front edge of the panel.

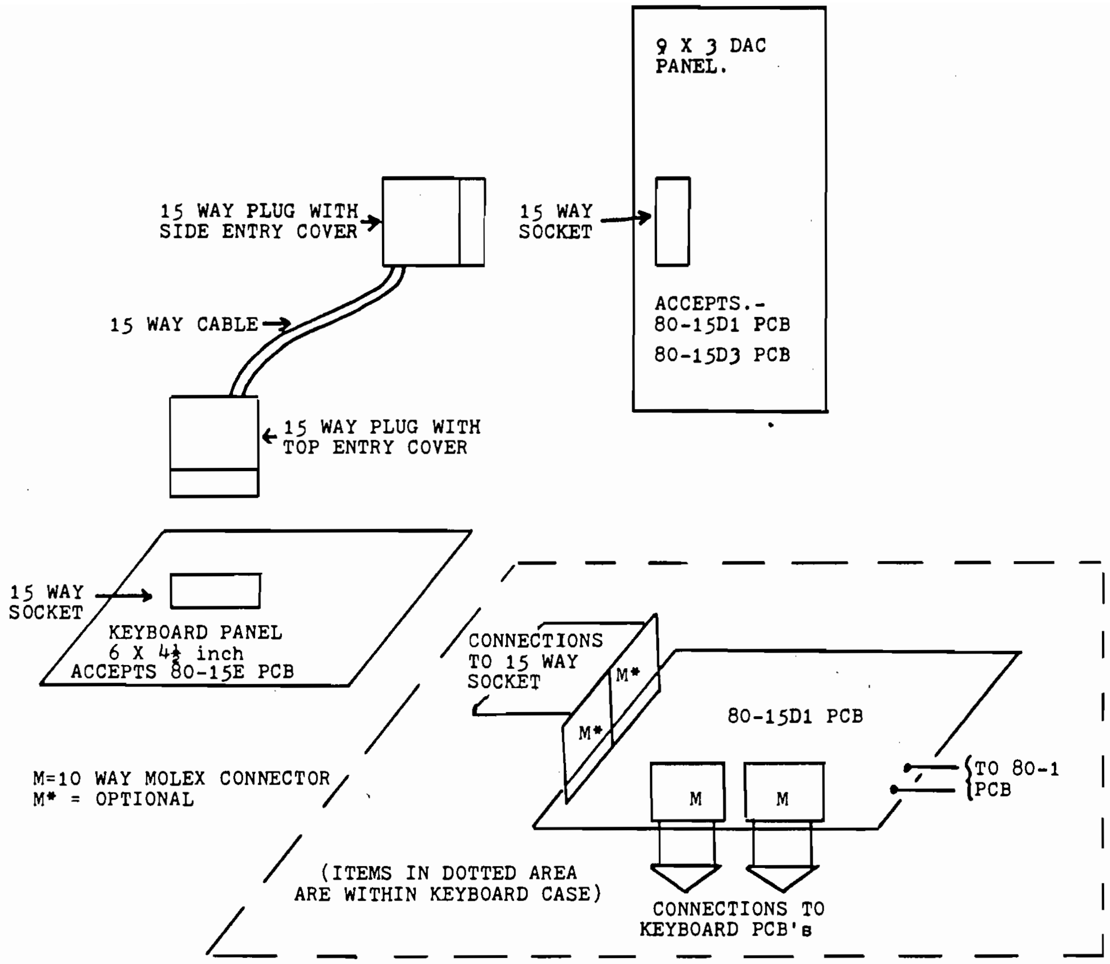


FIGURE 1. ARRANGEMENT OF KEYBOARD CONTROLLER. NOT TO SCALE. PANEL DETAILS NOT SHOWN.

The above arrangement simplifies future expansion when the 80-15D1 PCB must be accessed for changes to links and additional wires to the 15 way socket. It allows for a microprocessor to be interposed between 80-15D1 PCB and a digital to analogue converter(s). See price list for details of keyboard controller requirements.

NOTE: 1. On both panels the 15 way connector socket socket should be mounted with the flange behind the panel; 2. Keep logic control wires, i.e., to and from 15 way sockets and the plug link as short as possible.

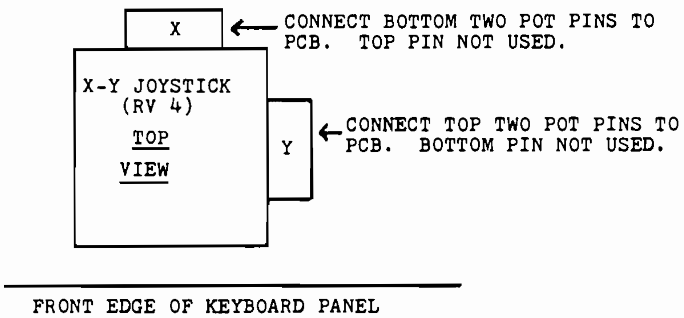


FIGURE 2. WIRING OF X-Y JOYSTICK. (RV 4)

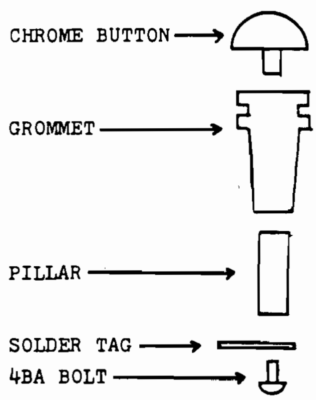


FIGURE 3. ASSEMBLY OF TOUCH TRIGGER