digisound

MODULE 80-C9 VOICE

1. INTRODUCTION

The DIGISOUND 80-C9 voice card provides the complete sound processing circuitry for a monophonic synthesiser voice. On-board design includes two VCOs, a four pole low pass VCF, two ADSR envelope generators and five VCAs which together comprise a relatively elaborate synthesiser voice. Some of the interconnections between the above circuit blocks are hardwired, but a degree of flexibility has been maintained by the use of electronic analogue switches. The routing of these enables the most popular synthesiser patches/effects to be selected. The circuit functions are controlled either by means of manual potentiometers which are disabled on insertion of a jack plug into the appropriate CV input socket or by independent potentiometers and external CV input sockets.

A schematic diagram of the voice card circuitry is shown in Figure 2. The

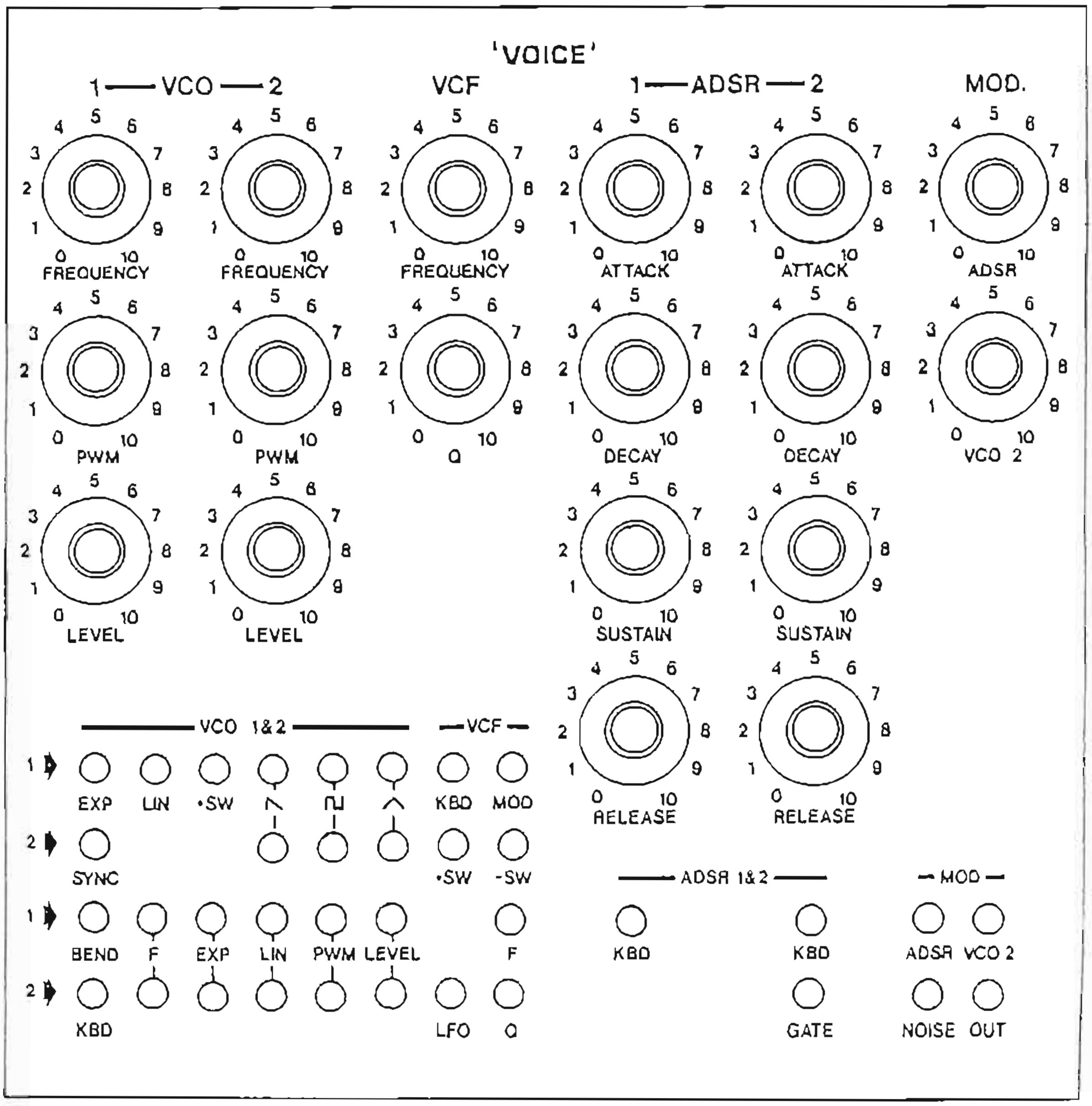

FIGURE 1. 80-C9 PANEL LAY-OUT

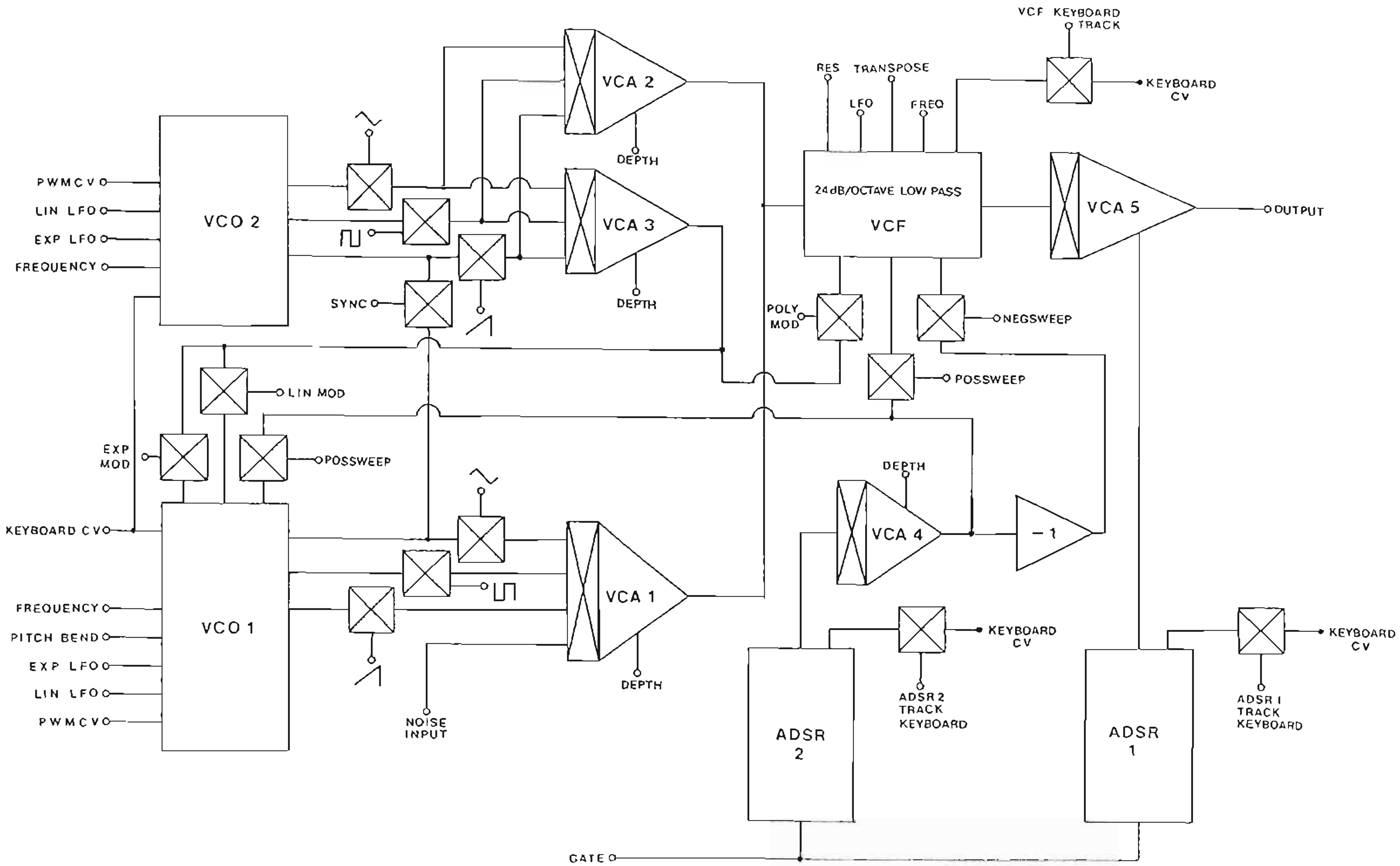

FIGURE 2. VOICE SCHEMATIC

design utilises two CEM 3310 VCTGs, two CEM 3340 VCOs, a CEM 3360 dual VCA and a CEM 3372 signal processor which together form a high quality voice requiring the minimum of calibration. An accurately scalable keyboard control input is provided and may be calibrated to the usual +1V/octave control voltage standard. Inputs are also provided to enable connection to external equipment such as LFOs, sample and hold networks and other control voltage generators. An audio input is also available, allowing an external noise source (or additional oscillators) to be mixed with the audio output of VCO 1.

2. DESIGN - GENERAL

The complete circuit diagram for the 80-C9 voice card is shown in Figure 3. The circuit design is centred around six custom music ICs from Curtis Electromusic Specialties. The use of these devices has enabled a highly compact dual VCO synthesiser voice to be built on a standard 100 x 200mm Eurocard.

The design utilises all electronic internal switching/patching (controlled by panel mounting SPDT sub min toggle switches S1 to S16) and is arranged for maximum flexibility. Connections to and from the PCB are grouped along one long edge of the board and may be effected either by hardwiring or by the use of Molex connectors and a small motherboard. The first of these options will be discussed here. There are 57 connections in all which may be subdivided into the following groups:- control voltage inputs (26), electronic analogue switch control lines (16), audio inputs (1), audio outputs (1), gate inputs (1), power supply connections (5) and reserved for future expansion (7). All the control inputs provided will accept voltages in the range -5V to +5V (see Table 1) making interfacing to microcomputers far simpler.

A. VCO 1 & 2

Both VCOs are based upon the CEM 3340 and are configured in a similar manner. For this reason detailed analysis of only one of these oscillator blocks is necessary, with any differences being mentioned at the relevant point. The main frequency control input is at pin 15, configured as a summing stage thus allowing multiple independent frequency control. In this application, resistors R1-8 effect the required voltage control with two on-board CV inputs and four independent CV inputs for connection to external equipment. The on-board CV inputs are:-

a) Possweep - ADSR output via VCA and to CEM 3340 via R4
b) Internal exponential modulation - from VCO 2 via a separate VCA.

The other inputs are:-

a) Frequency - via R1 to effect tuning of the oscillator
b) Keyboard CV - via R6 for connection to a musical keyboard (commoned to both VCOs)
c) Pitch bend - allows detuning of VCO 1 or connection to joystick controllers etc.
d) Exponential LFO - for connection to an external LFO whose output will vary frequency in an exponential manner

Pin 14 of the CEM 3340 is used as a scaling factor. Since the current gain of the internal multiplier is set near unity, 100K input resistors and a 1K8 scaling resistor (R16) produce the standard 1V/octave response and about 18mV at the base of Q1 (internal to IC). R8 and RV19 together with an incoming reference voltage (in this case +15V) set the initial frequency of the oscillator and have been chosen such that with no external voltage applied the frequency may be adjusted to 65.406 Hz (the lowest note of a four octave keyboard).

For greatest accuracy of the internal multiplier the current out of pin 2 should be close to that out of pin 1. This balance is achieved via RV20.

The exponential generator in the CEM 3340 is capable of delivering a current for charging and discharging the timing capacitor (C4) from greater than 500uA to less than the input bias current of the buffer which gives a typical frequency range of 500000:1. For synthesiser applications the most accurate portion of this range (50-100uA) is used. With a 1nF timing

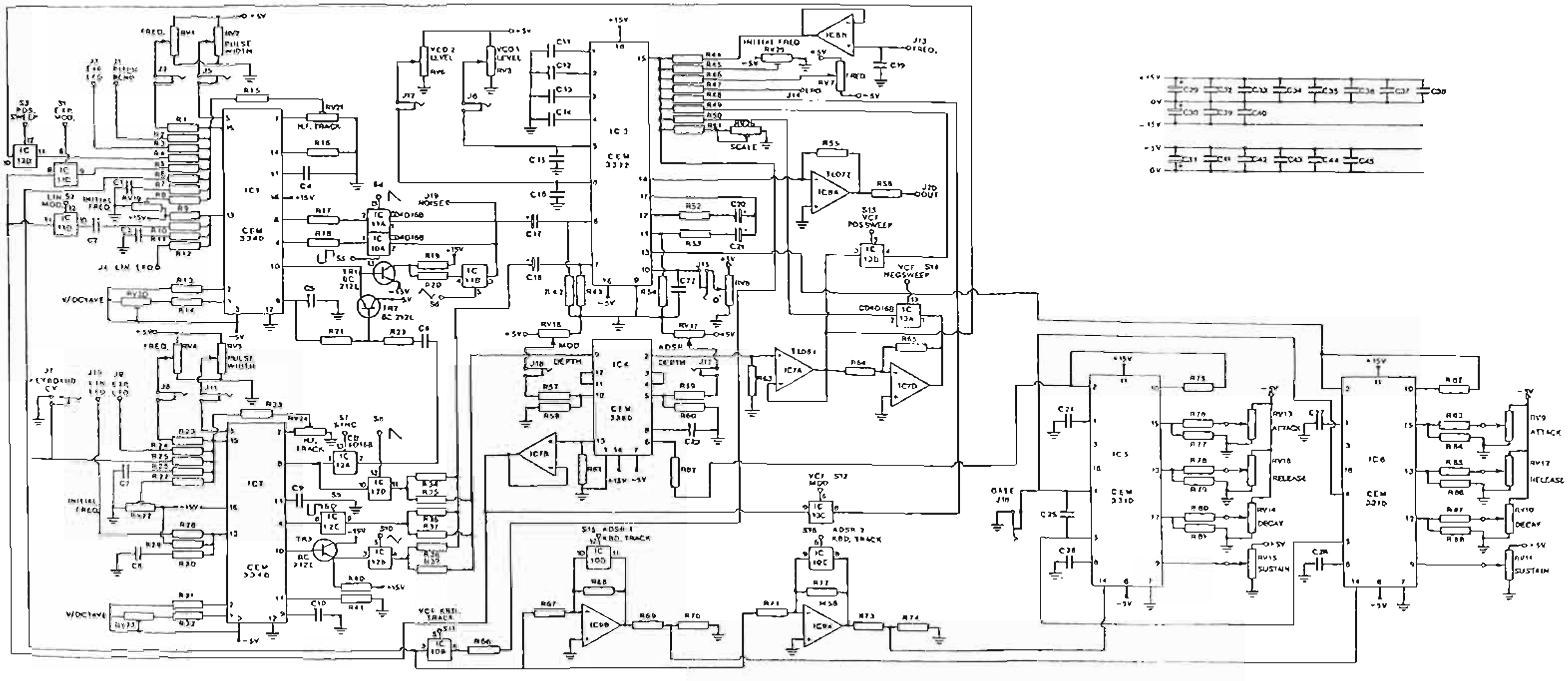

FIGURE 3. 80-C9 VOICE CIRCUIT DIAGRAM

capacitor and a 15V positive supply the most accurate range is therefore between 5Hz and 10KHz.

For accurate operation of the exponential generator in the CEM 3340 a reference voltage is required. In this application the +15V supply rail is suitable, providing the PSU is well regulated (as in Digisound modules 80-1/80-1A). This is connected to pins 15 (via RV19 & R8) and 13 (via R9). In the former case this provides a stable initial frequency while the latter establishes a reference current for the exponential generator which is derived via R9. Pin 13 is also available for use as a linear frequency control input with R12 present for connection to an external LFO. R12 produces a 10% change in frequency per volt at this input.

Similarly, the inclusion of R10 and the associated electronic switch (IC 11D) connects pin 13 to the output of VCO 2 in the same way (and to the same modulation bus) as the internal exponential modulation input.

It should be noted that if the output from a suitable LFO is not capacitively AC coupled, any DC offset present will cause detuning of the oscillators. Also, a negative current at pin 13 which is in excess of the reference current will gate the oscillator off.

One of the biggest drawbacks of exponential VCOs has been their temperature sensitivity which results in frequency drift as the device warms up. The CEM 3340 however incorporates temperature compensating circuitry. This is achieved by multiplying the current sourced into the control pin (pin 15) by a coefficient directly proportional to the absolute temperature. This coefficient is produced by the "Tempco Generator" and the cancellation is nearly perfect.

Included as part of the CEM 3340 is a method of overcoming high frequency tracking error, which is an effect resulting in a slight flattening of the frequency at the extreme high end of the audio range. This effect is caused by the bulk emitter resistance within the transistor based exponential generator circuitry becoming significant as current, and therefore frequency, is increased. To compensate for this undesirable effect, pin 7 outputs a current which is one quarter of the exponential generator current. This is converted into a voltage across RV21 (RV24 for VCO 2), a proportion of which is fed back to the frequency control input at pin 15 via R15 (R33 for VCO 2). Thus, as the frequency is increased this feedback voltage will sharpen the control voltage scale, but only at the high end of the frequency spectrum. This produces a reliable voltage to frequency conversion over the entire audio range.

Three simultaneously available waveform outputs are produced by the CEM 3340, namely sawtooth, pulse/square and triangle at pins 8, 4 and 10 respectively. The sawtooth and pulse/square outputs pass via R17 and R18 to CMOS analogue switches (IC 11A & IC 10A) for later mixing at the input of the VCF. However, the triangle output has a finite resistance and requires buffering to maintain VCO performance. In the worst case, neglect of this buffer may result in a lowering of the frequency due to loading effects. The buffer used is a single NPN transistor (TR1), which passes the triangle wave output via R20 to a third analogue switch (IC 11B).

Pulse width control is achieved by direct injection of a 0V to +5V analogue voltage to pin 5 allowing pulse width to be varied from 0 to 100% values of mark/space ratio, via RV2 or an external CV into J5.

The main difference between the two VCOs is the sync. arrangement. In this design VCO 1 becomes the "slave" oscillator and VCO 2 the "master". The method of sync. used (the CEM 3340 permits two types) is soft synchronisation which on selection causes the triangle upper peak to reverse direction prematurely with the result that the oscillation period is an integral multiple of the pulse period. This sync. technique is achieved by closing analogue switch IC 12A, thus supplying negative pulses to pin 9 of the "slave" oscillator (VCO 1). Capacitors C5 (VCO 1) and C10 (VCO 2) prevent unwanted sync. or waveform instability from any voltage spikes on the positive supply line.

The only other difference between the external circuitry of the two VCOs is that VCO 2 allows less resistive mixing of control voltage inputs namely possweep, int. exp. mod., int. lin. mod. (all three being internal to the PCB and derived from the output of VCO 2) and external pitch bend.

Power supply to both CEM 3340s is a stable +15V to pin 16 and -5V to pin 3. The use of well regulated supplies is essential to maintain oscillator performance.

B.VCF & VCA

The VCF in this design is based upon the recently available CEM 3372 signal processor. The heart of this IC is a four pole low pass voltage controllable filter employing open-loop design to give an enhanced "rich" quality to the processed input. The filter response is of the Butterworth type with a sharp 24dB/octave roll-off characteristic, ideal for electronic music applications. Internal to the CEM 3372 is a VCA to allow overall signal feedback, and hence resonance or "Q" value to be voltage controlled. The passband gain remains constant as the resonance is varied and this eliminates the drop in volume as resonance increases, commonly found in this type of filter. The CEM 3372 also features low noise, low control feedthrough and temperature compensated transconductors for cut-off frequency stability.

Audio input to the VCF has been made more versatile with the inclusion of a two channel voltage controlled mixer with independent control voltage inputs for each channel (pins 5 & 8 for channels 1 & 2 respectively). The two audio inputs (pins 6 & 7) are suitable for use as signal summing nodes and in this design mix the three outputs of both VCOs.

Also included on the chip is a VCA of the current in, current out type allowing ready mixing of multiple inputs. In this design the input to the VCA is direct from the output of the VCF so no mixing is required. The VCA also features extremely low noise and exceptionally low control feed-through without the need for additional trimmers. This makes it ideal for control by fast transient waveforms such as those produced by an ADSR envelope generator.

In this design the two channels of the voltage controllable input mixer are each fed by the three electronically switched outputs from the CEM 3340s. It is at this point that the attenuation of the output from both VCOs takes place in order to present their respective channel inputs with a total signal amplitude of approximately 80mV peak-to-peak. This is necessary to maintain low distortion, typically 5% THD. Attenuation on channel 1 is via resistors R17, R18 and R20 forming a potential divider network with R42. Channel 2 attenuation is via resistors R34, R36, R38 and R43. In addition, but on channel 1 only, there is a noise input to the VCF allowing a noise source to be mixed into the audio bus of the voice card. The two composite signal sources first pass through capacitors C17 and C18 (channels 1 and 2 respectively) in order to block any DC offset present on either of the VCO outputs. The signal levels of channels 1 and 2 are controlled by positive going control voltages (0V to +5V) to pins 5 and 8 respectively. Capacitors C15 and C16 shunt any AC voltage to ground.

Within the CEM 3372 the four independent filter stages are hard-wired to low pass configuration. Filter capacitors C11 - C14 are chosen such that the filter frequency range covers the entire audio range (less than 20Hz to greater than 20KHz) whilst control of the cut-off frequency is by means of voltage control at pin 15. In order that multiple voltage sources may simultaneously adjust the filter frequency, resistors R44 to R51 effect a summing stage. The voltage to frequency scale is adjustable to precisely +1V/octave by the combination of RV26 and R51. Provision has been made for connection to an external LFO via R47. Transposition of filter frequency by potentiometer RV7 is possible via R46. An initial cut-off frequency may be set up via RV25 and R45 such that with no frequency applied to pin 15 the VCF passes no audible frequencies (individual circumstances will dictate the most useful position of this trimmer). A suitable connection to an external CV jack socket (J13) may be made via R44 which is preceded by a standard sample-and-hold network (IC 8B and C19) included for future expansion. Resistor R48 is hardwired to the internal modulation bus which is sourced by VCO 2, thus implementing an internal VCLFO function. Resistors R49 and R50 carry the ADSR signal from the "sweep" bus, the former connection being positive going (hence possweep) and the latter being an inverted version of this. These two control voltages are selected by control of analogue switches IC 13B and IC 13A. If both are selected no change in filter frequency will occur.

The signal output of the VCF (pin 17) is routed via capacitors C20 and C21 (which provide a DC blocking action) to pins 11 and 12. Pin 11 is the input to the signal regeneration (resonance) VCA, control of which is by external voltage (0V to +5V via RV8 or external CV into J15) to pin 10 (capacitor C22 shunts AC to ground). This network allows resonance to be varied from a Q factor of 0.7 up to oscillation. Pin 12 is the signal input to the fixed VCA, the gain control of which is buffered, brought out to pin 13 and hardwired to the output of ADSR 1. The output of the fixed VCA is at pin 14 of the CEM 3372 and passes via a low noise BI-FET op amp to J20, the audio output.

C. ADSR 1&2

The production of suitable control envelopes is achieved by the use of two CEM 3310 envelope generators. In this design both ICs are gated simultaneously from a common gate input at pin 4. This gate voltage should be positive going and between 3V and 15V. The gate input jack socket (J16) is wired such that with no plug inserted the gate input is held at 0V. If this connection is omitted the gate input will float high. The CEM 3310 is equipped with separate gate and trigger inputs such that during the gate on/sustain period (ie after A,D) a positive voltage to the trigger input, pin 5, will restart the initial attack and decay cycles. This feature has not been used in this design and pins 4 and 5 are capacitively coupled together by C25 producing a differential gate pulse to the trigger input.

Pins 15,12,9 and 13 permit voltage control of attack, decay, sustain and release respectively. The attack, decay and release inputs are suitably attenuated by six potential divider networks formed around resistors R76 - R81 and R83 - R88, all of which are part of encapsulated SIL resistor network packages. These three inputs require negative going control voltages between 0V and -5V, whereas the sustain input requires a control voltage between 0V and +5V. In all cases the greater the deviation from 0V, the larger the A,D,S or R contour produced.

ADSR 1 is hardwired to control the final VCA (internal to the CEM 3372) whilst ADSR 2 controls the frequencies of VCO 1 and the VCF. The latter signal is first processed by a VCA, the depth (and therefore ADSR amplitude) of which is controlled by either potentiometer RV17 or an external CV via J17 (0 to +5V). This attenuatable ADSR signal is subsequently buffered by IC 7A and split so that two electronic switches allow the signal to alter both the pitch of VCO 1 and the cut-off frequency of the VCF. This same signal from IC 7A is also inverted by IC 7D providing an inverted sweep to change the VCF cut-off frequency. These three effects are selectable by closure of the relevant analogue switches whose controls are situated at S3(possweep VCO), S14(negsweep VCF) and S13(possweep VCF).

Simultaneous control of the three time constants (A, D and R) is possible by means of injecting a control voltage at pin 14 of the CEM 3310. In this design these control voltages are derived from the keyboard control voltage (J7) using the two op amps within IC 9. On closure of the two electronic switches IC 10C and IC 10D, feedback resistors R68 and R72 are effectively shorted out and thus the keyboard track ADSR functions are disabled. It can therefore be seen hat normally these control inputs will be at +15V and the effects may be selected by grounding these switch control inputs with toggle switches S15 and S16 (which are therefore wired in a reverse manner compared to the other 14 switches). Use of the keyboard CV to alter the A, D and R time constants produces larger envelopes at the lower end of the keyboard and short, staccato-like envelopes at the higher end. This is a common feature of many conventional instruments such as the piano.

Power to the CEM 3310s is +15V and -5V at pins 11 and 6 respectively.

).ADSR & MODULATION VCAs

As already mentioned, the output from ADSR 2 is passed through a VCA to allow attenuation of envelope amplitude. This VCA is one of a pair of independent VCAs available within the CEM 3360. The two VCAs are of the current in/current out type with both linear and exponential control of gain over greater than a 100dB range. The VCAs feature very low noise and wide bandwidth, making them ideal for precise signal processing.

The ADSR output is fed via current converting resistor R62 to pin 6 of IC 4 (signal input to VCA 1) and is vailable again at pin 2 (signal output). Control of signal amplitude is possible by positive going (0V to +5V) CV to pin 5 which allows access to the internal logarithmic converter. Thus an incoming linear control voltage (in this case potentially divided by resistors R59 and R60) will modify gain in an exponential manner. The output then passes to buffer IC 7A and inverter IC 7D as previously described.

The second VCA is utilised for modulation attenuation. Modulation waveforms are produced by VCO 2 and resistively mixed by resistors R35, R37 and R39 into pin 9 of IC 4, the modulation waveshape being selectable y IC 12B, IC 12C and IC 12D. Exponential control is at pin 10 (again potentially divided by resistors R57 and R58) by means of a control voltage ranging from 0V to +5V. The output is at pin 13 and is buffered by IC 7B before being bussed to the exponential and linear frequency control inputs of VCO 1 and the cut-off frequency control input of the VCF. These three routes are switchable by IC 11C, IC 11D and IC 13C respectively.

3.CONSTRUCTION

The 80-C9 voice card has been engineered to be built on a double sided 100 x 200mm PCB, the two sides being linked by track pins. It will be seen that component placement is extremely dense and for this reason extra care must be taken in assembly. Because of this high component density, groups of copper tracks run parallel to each other with minimal bare fibre-glass between them, thus providing increased opportunity for solder splashes to bridge two or more tracks. Therefore careful regulation of the amount of solder per joint is recommended, particularly for the track pins. If too little solder is used the track pin may not electrically connect to the component side, but if too much solder is used one risks bridging two track pins together or to a top track. The possibility of under soldering a joint may be alleviated by applying the solder between pin and track such that when heat is applied the solder seeps round under the pin rather than forming a useless "blob" on top of the track pin. Examination of each joint with a magnifying glass is strongly recommended.

Components are best assembled onto the board in the following order:-

a) Track pins
b) Resistors
c) IC Sockets
d) SIL Resistors
e) Trimmers
f) Capacitors
g) Transistors
h) ICs

Track pins should be located in <u>all</u> component side holes that terminate in a solder pad; any other holes are for normal components. Push the track pin firmly through the hole and snap off

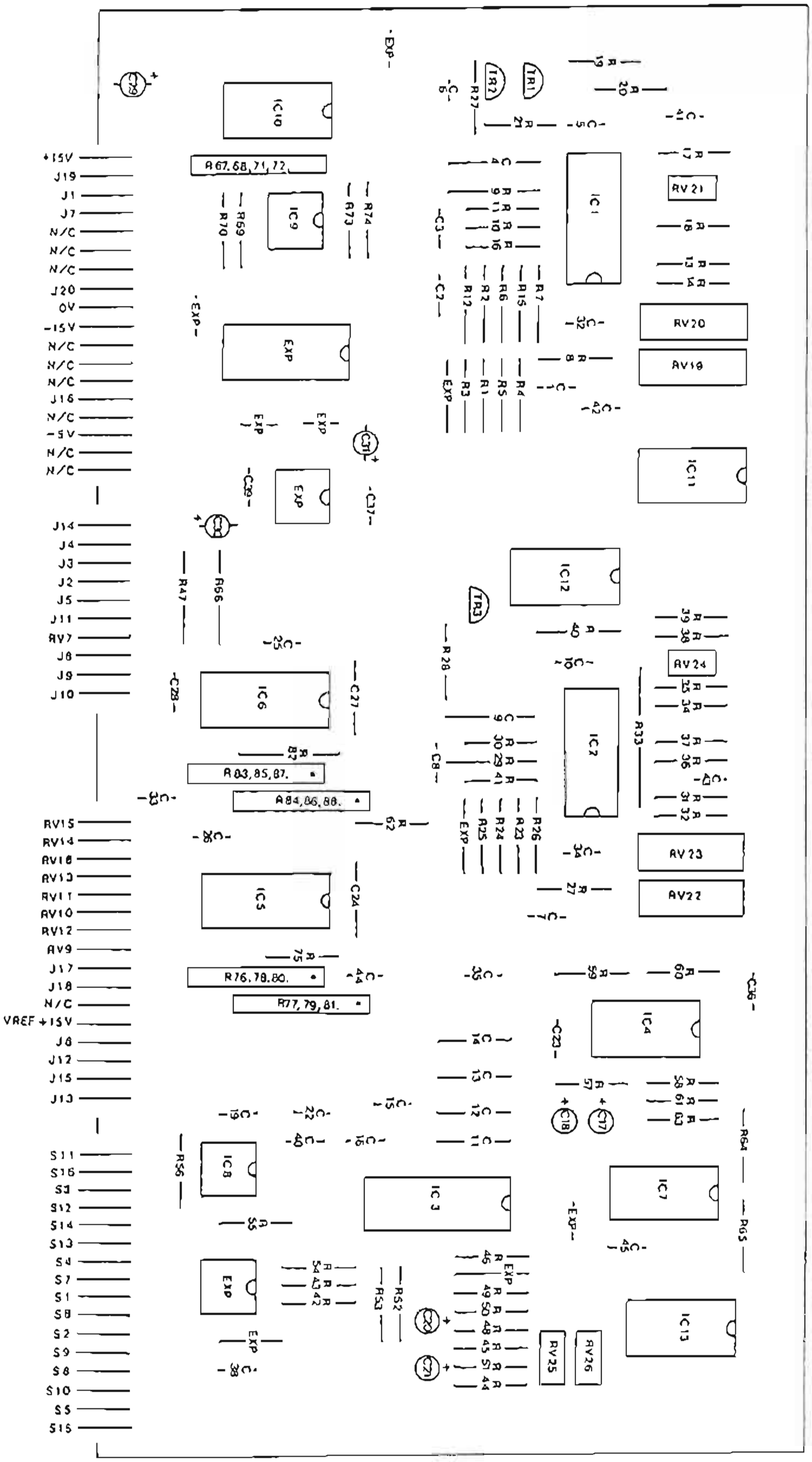

FIGURE 4. 80-C9 PCB COMPONENT LAY-OUT

from the strip of pins provided. Solder the top side of all pins first and then solder the underside, being careful to examine each joint (particularly on the component side).

Having pinned through the entire board, select and preform the resistors. Resistor leads should be bent such that no excess lead is evident, as on the component side this could give rise to a dry short with a nearby length of track. Component placement is detailed in Figure 4 and should be adhered to for all listed components. After installation of the components, the use of a PCB solvent cleaner is strongly recommended. This should be applied liberally with a fine real bristle paint brush, and removes all residual flux which may degrade circuit performance or even produce a short circuit.

The voice card PCB design is such that many options are available to suit individual users. As already mentioned, this board together with a keyboard and keyboard circuitry may be utilised as a complete monophonic synthesiser. It could also be one of several voices in a complex (possibly computer programmable) polyphonic system. The wiring for these two options is quite dissimilar, the main difference being the routing of CV inputs to either external jack sockets and potentiometers or to micro-processor based interface circuitry with a common bus. These notes concentrate on the former option.

The simplest option for using a voice card as a synthesiser in its own right requires most CV inputs to be hard-wired to potentiometers with the remainder being fed by dedicated LFOs or brought out of circuit to jack socket connectors. This type of adaptation should prove simple for most constructors and Figure 5 shows the wiring necessary to connect the PCB to the 9 x 9 inch panel supplied by Digisound Ltd. Constructors wishing to make use of this design in their own format should refer to Figures 4 and 5 and Table 1, from which it is possible to extrapolate all relevant wiring information.

To aid construction and connections to panel hardware, a PCB mounting bracket is used. This bracket is secured to the front panel by means of potentiometers RV3, RV6, RV11 & RV15 and the PCB is held in place by two PCB slides. The bracket is used in such a manner that the plastic-coated side is face up and parallel to the PCB, thus providing added insulation in the unlikely event that the PCB and bracket should touch. This method ensures that the wires between the PCB and externally mounted components remain as short as possible. Connections from the PCB may be made in one of two ways; either single sided terminal pins or standard Molex plug and socket arrangements. The former of these options effectively "hardwires" the PCB to the panel, while the latter facilitates its removal. Whichever method is chosen, a neat physical appearance may be achieved using either 1/0.6 single strand wire or multistrand 7/0.2 wire harnessed by a number of light-duty cable ties. Connections to the switches and 3.5mm jack sockets are best achieved by passing the appropriate wires through the two holes in the mounting bracket provided for this purpose. Before the toggle switches S1-S16 are wired up it is necessary to install a 4k7 pull down resistor (R89 - R104) on each one. Each resistor has one lead connected to 0V and the other to the switch pole i.e. the appropriate "S" point.

Panel wiring is arranged in such a manner that control potentiometers RV1, RV2, RV3, RV4, RV5, RV6, RV8, RV17 & RV18 are disabled after insertion of a jack plug into the appropriate socket, thus providing the facility for <u>either</u> potentiometer <u>or</u> external voltage control. Control of the functions of both envelope generators is by means of potentiometers only (RV9 - RV16), while VCF frequency may be controlled by both RV7 <u>and</u> externally via J13. Therefore the wipers of potentiometers RV7 and RV9-RV16 go directly to the appropriately marked points on the PCB, while all other connections from the PCB link to jack sockets (J1 - J20) and switches (S1 - S16).

As previously mentioned, the PCB is fixed onto the mounting bracket by two self-adhesive PCB slides. If terminal pins have been fitted it is

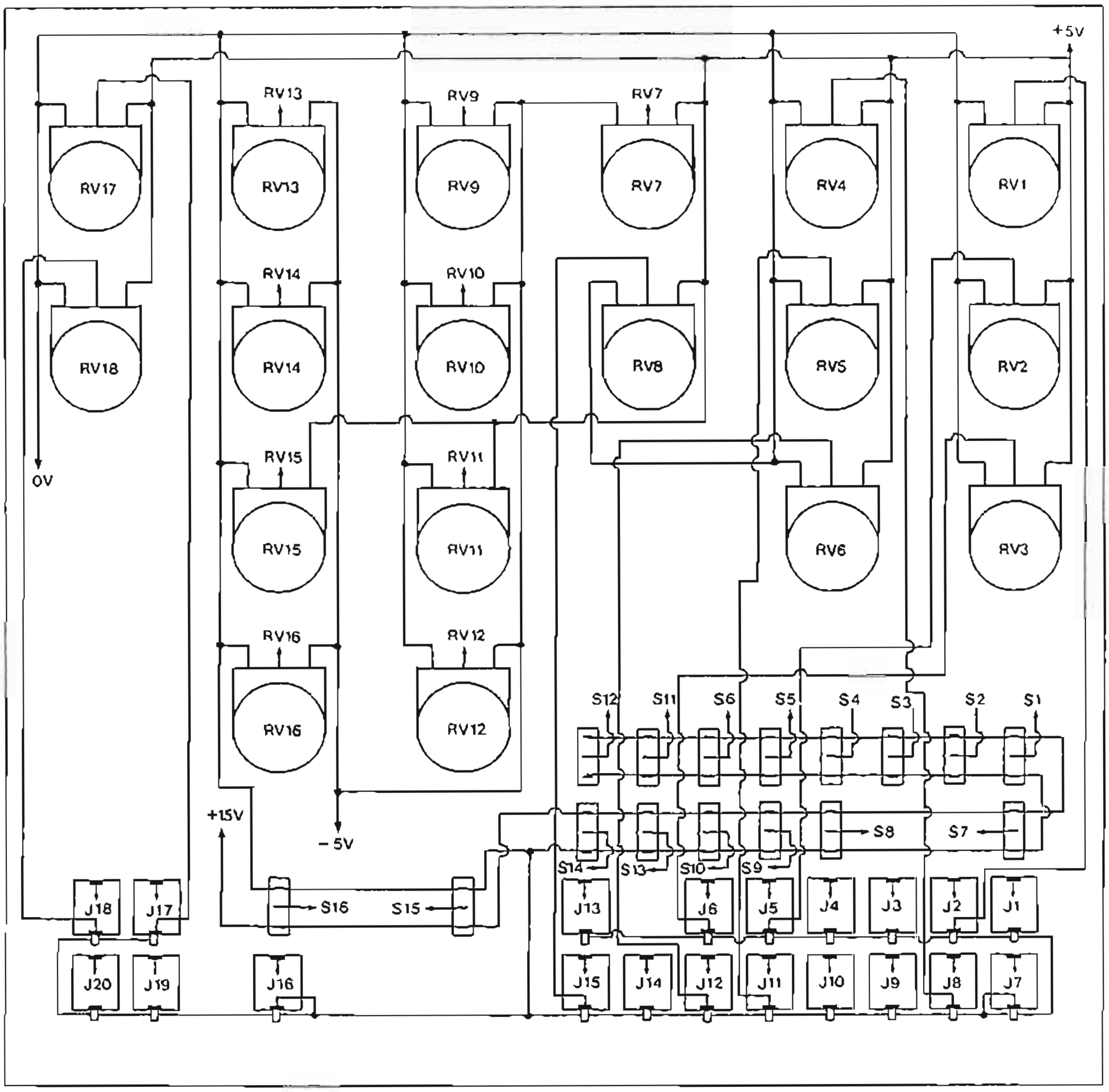

FIGURE 5. 80-C9 PANEL WIRING

recommended that the two slides be attached to the PCB but not stuck down onto the bracket until the board has been tested. This is because removal would require either the slides to be replaced or all the connections to be unsoldered. If however Molex plugs and sockets have been employed, the PCB may be unplugged and slid out for subsequent inspection.

Power supplies for a single voice card are a stable +/-15V at 300mA per rail and +/-5V at 100mA per rail. Note that the +5V rail is not connected to the PCB but is required to source a number of control potentiometers on the front panel. Other power supply connections are best taken direct to the PCB and from there to panel mounted components. Ultimate connections to the PSUs may be hardwired or use an appropriate "in-line" plug/socket connector (e.g. 5 pin DIN).

4. CALIBRATION

Calibration has been kept to a minimum by the use of specialised ICs and is a relatively sraightforward procedure for a design of this complexity. Trimming of the required functions is by way of eight multiturn presets, three for each of the oscillators and two for the single low pass filter, with all other circuit blocks requiring no calibration whatsoever. The procedure for calibration may be separated into two distinct types of adjustment. The first is the adjustment of a convenient starting frequency (pitch of the VCOs and cut-off frequency of the VCF). The second is calibration of the response of the VCOs and VCF to an incoming keyboard control voltage, i.e. the relationship between control voltage and frequency.

Taking VCO 1 first, RV19 has to be adjusted to provide a convenient starting pitch for the oscillator. This to some degree is a matter of personal taste, but it is suggested that this preset be adjusted such that with no input voltages the oscillator will be tuned to the lowest frequency of a four octave keyboard, i.e. 65.406Hz assuming a C-C keyboard. For VCO 2 it is recommended that the initial frequency is set the same as for VCO 1 so that the frequency potentiometers behave in a similar manner. However, such a starting frequency is too high for modulation purposes and it may be desirable to wire the switch on the exponential modulation control input socket (J9) to -5V. In this way VCO 2 will operate five octaves below VCO 1 until insertion of a jack plug into this socket. Alternatively RV22 may be set to a frequency to compromise performance as both an audio and modulation oscillator (i.e. 3 to 5 octaves below that of VCO 1).

In order to perform the calibration of initial frequency it is necessary to hear (or see) the oscillators. This is achieved by selection of any waveform and allowing the VCO signals to pass to the output sockets (i.e. provide a constant gate and turn VCO level, VCF frequency and ADSR sustain controls fully clockwise with all other controls fully anticlockwise).

The next step is to adjust both oscillators so that they accurately track an incoming keyboard control voltage, normally a +1V/octave relationship. For this, both oscillators are calibrated identically except that once VCO 1 is calibrated it may prove simplest to calibrate VCO 2 using VCO 1 as a reference oscillator. There are a number of ways to achieve this +1V/octave scaling. One is to use a previously calibrated oscillator (as above) and make the calibration using the beat frequency technique. Another approach is to employ two stable fixed frequency oscillators and use them in conjunction with an oscilloscope to generate Lissajous figures. Whichever method is chosen, a calibrated voltage source (e.g. from a keyboard) and an accurate voltmeter or oscilloscope will greatly simplify this process. Calibration may now proceed by firstly grounding RV21 (RV24 for VCO 2) such that pin 7 of the CEM 3340 is at 0V, and applying a positive control voltage to the keyboard CV input. This voltage is increased until a frequency of about 200Hz is produced by the oscillator. Then increase this voltage by one volt (as accurately as possible) and adjust RV20 (RV23 for VCO 2) until the frequency is exactly double that of the initial frequency. This step should be repeated several times in order to achieve an exact doubling of frequency per volt applied and it is recommended that the incoming control voltage be varied such that the calibration is carried out in the general range of 150 to 500Hz.

This procedure should now be repeated using an initial frequency of about 5kHz (i.e. increase the calibration voltage by between 4 and 5 volts) and adjusting RV21 (RV24 for VCO 2) until a doubling of frequency is obtained when the applied voltage is increased by exactly one volt. This is basically the same technique as used for calibrating RV20/RV23 but at a frequency 4 to 5 octaves higher. This adjustment is the previously mentioned high frequency track adjustment and is only possible after accurate calibration of RV20/RV23. Once the RV21/RV24 calibration has been carried out, recheck the low frequency calibration and observe that the VCOs now track correctly over the entire audio range. Both adjustments of the presets are best repeated after the voice card has been powered up for several hours.

Once RV20, RV21, RV23 & RV24 have been accurately adjusted, both oscillators have been accurately calibrated for an incoming keyboard control voltage. Other inputs will behave in a very similar manner but may be less accurate due to resistor tolerances. It is now necessary to repeat the adjustment of the initial frequency (as previously described via RV19 and RV22) since adjustment of the keyboard tracking presets will have altered the preset starting frequency.

The final stages of calibration involve similar techniques but relate to the voltage controlled filter. In this case RV25 will set an initial cut-off frequency and RV26 allows adjustment of the voltage to cut-off frequency scale. Calibration is best achieved by allowing the filter to oscillate. Then adjustment may be performed in a similar manner to that of a VCO. Sustained oscillation can be maintained by setting RV8 fully clockwise and adjusting RV7 such that the frequency of oscillation is within the audio range. (Note that to hear the filter oscillate both envelope generators must be constantly gated on with ADSR sustain controls fully clockwise). Once the sound of the oscillating filter has been identified, connect a variable voltage source or previously calibrated keyboard to J7 (as for calibration of the VCOs). It should now be possible to hear the frequency of oscillation vary with a change in voltage at J7. Calibration may now proceed by adjustment of RV26 in the same way as for the VCOs, but it is recommended that for adjustment of tracking the beat frequency method be employed using one or both of the previously calibrated VCOs. If this procedure is used then it is preferable to compare similar sounding waveforms. This is possible by using the triangle wave outputs. Once the VCF has been adjusted so that the cut-off frequency changes at +1V/octave, the initial frequency may be established by adjustment of RV25.

5. IN USE

The primary use of a synthesiser voice card is fairly obvious, as with the addition of a noise source and keyboard circuitry the user possesses a "complete" analogue synthesiser. However, it is anticipated that many users will wish to further process the audio signal using existing Digisound 80 modules, with for example the addition of external LFOs, ADSRs etc. This is easily achieved with reference to Table 1 which shows the relevant CV limits. A suitable output is produced by modules 80-2 (VCO) and 80-3 (VCLFO), but all other modules having outputs between 0V and +10V may be used if they are attenuated prior to connection to the voice inputs. For this we recommend use of module 80-5 (processor) which provides for attenuation of 4 independent channels. Alternatively, if it is envisaged that connections to +10V outputs will be made frequently, it may be preferable to construct a potential divider on the relevant input jack sockets. This is done using two 47k resistors joined together at one end. One free end is connected to the jack socket, the other free end to 0V and the join of the two resistors to the PCB input.

6. COMPONENTS

RESISTORS, 5%, 1/4w carbon film	
R7,11,26,30	470R
R17,34	470k
R18,36	620k
R19,22,40	10k
R20,38	270k
R21,39,55,61,62,63	47k
R35,64,65	100k
R37	130k
R42,43,54,56	1k
R52	24k
R53	27k
R57,59	30k
R58,60	20k
R69,73	5k6
R70,74	56R
R89-104 (16 off)	4k7

RESISTORS, 1%, 1/4w metal film, 100ppm	
R1,2,3,4,5,6,23,24,25	100k
R8,27	200k
R9,29	1M5
R10,12,15,28,33	1M
R13,31	5k6
R14,32	24k
R16,41	1k8
R44,45,46,47,48,49,50,66	56k
R51	910R
R75,82	27k

OTHER RESISTORS

R67,68,71,72	100k SIL, 4 individual (1 off)
R76,78,80,83,85,87	10k SIL, 7 commoned (2 off)
R77,79,81,84,86,88	470R SIL, 7 commoned (2 off)

CAPACITORS

C1,3,7,8,25	10n polyester
C2,5,10,32-45 (17 off)	100n polyester
C4,9	1n 1% polystyrene
C6	220p ceramic
C11	330p polycarbonate
C12,13,14,24,27	33n polycarbonate
C15,16,22	2n2 polypropylene
C17,18	1u PCB electrolytic
C19	1n polypropylene
C20,21	2u2 PCB electrolytic
C23	4n7 polyester
C26,28	22n polyester
C29,30,31	1u tantalum bead

PRESETS

RV19,22	100k horizontal multiturn
RV20,23	10k horizontal multiturn
RV21,24	10k min. multiturn, side adj.
RV25	50k min. multiturn, side adj.
RV26	500R min. multiturn, side adj.

SEMICONDUCTORS

IC1,2	CEM 3340
IC3	CEM 3372
IC4	CEM 3360
IC5,6	CEM 3310
IC7	TL 084
IC8	TL 072
IC9	LM 1458
IC10,11,12,13	4016B
TR1,2,3	BC 212L

POTS, SWITCHES (PANEL MOUNTING)

RV1-18	10k lin. rotary
S1-16	SPDT sub. min. toggle

TABLE 1.

Notation on PCB overlay	Parameter	Control voltage limits
+15V	Power supply input - to +15V rail of PSU	
J19	Noise/Audio input	
J1	VCO 1 Pitch bend/Frequency control	(-5V - +5V)
J7	Keyboard control voltage input	(-5V - +5V)
N/C		
N/C		
N/C	Reserved for future expansion	
J20	Audio output	
0V	Ground connections - to panel and to 0V rail of PSU	
-15V	Power supply input - to -15V rail of PSU	
N/C	Reserved for future expansion	
N/C	Reserved for future expansion	
N/C	Reserved for future expansion	
J16	Gate input for ADSR 1 & 2	
N/C	Reserved for future expansion	
-5V	Power supply input - to -5V rail of PSU	
N/C	Reserved for future expansion	
N/C	Reserved for future expansion	
J14	VCF Cut-off frequency CV input	(-5V - +5V)
J4	VCO 1 Linear frequency CV input	(-5V - +5V)
J3	VCO 1 Exponential frequency CV input	(-5V - +5V)
J2	VCO 1 Frequency CV input to RV1	(0V - +5V)
J5	VCO 1 Pulse width modulation CV input to RV2	(0V - +5V)
J11	VCO 2 Pulse width modulation CV input to RV5	(0V - +5V)
RV7	VCF Cut-off frequency control potentiometer	(-5V - +5V)
J8	VCO 2 Frequency CV input to RV4	(0V - +5V)
J9	VCO 2 Exponential frequency CV input	(-5V - +5V)
J10	VCO 2 Linear frequency CV input	(-5V - +5V)

RV15	ADSR 2 Sustain CV input	(0V - +5V)
RV14	ADSR 2 Decay CV input	(0V - -5V)
RV16	ADSR 2 Release CV input	(0V - -5V)
RV13	ADSR 2 Attack CV input	(0V - -5V)
RV11	ADSR 1 Sustain CV input	(0V - +5V)
RV10	ADSR 1 Decay CV input	(0V - -5V)
RV12	ADSR 1 Release CV input	(0V - -5V)
RV9	ADSR 1 Attack CV input	(0V - -5V)
J17	ADSR Modulation (VCA 4) depth CV input	(0V - +5V)
J18	VCO 2 Modulation (VCA 3) depth CV input	(0V - +5V)
N/C		
VREF	Voltage reference for VCOs 1 & 2 - to +15V rail of PSU	
J6	VCO 1 Output level (VCA 1) CV input	(0V - +5V)
J12	VCO 2 Output level (VCA 2) CV input	(0V - +5V)
J15	VCF Resonance/"Q" CV input	(0V - +5V)
J13	VCF Cut-off frequency CV input	(-5V - +5V)

S11	Keyboard CV track VCF cut-off frequency
S16	Keyboard CV track ADSR 2 time constants (inv. function)
S3	ADSR 2 Output to VCO 1 frequency control input
S12	VCO 2 Modulate VCF cut-off frequency
S14	ADSR 2 Inverted output to VCF cut-off frequency
S13	ADSR 2 Output to VCF cut-off frequency
S4	Select VCO 1 sawtooth output to VCA 1
S7	Synchronise VCO 1 to VCO 2
S1	VCO 2 Output to exp. frequency control input of VCO 1
S8	Select VCO 2 sawtooth output to VCA 2 & 3
S2	VCO 2 Output to lin. frequency control input of VCO 1
S9	Select VCO 2 pulse output to VCA 2 & 3
S6	Select VCO 1 triangle output to VCA 1
S10	Select VCO 2 triangle output to VCA 2 & 3
S5	Select VCO 1 pulse output to VCA 1
S15	Keyboard CV track ADSR 1 time constants (inv. function)

TABLE 1 CONT.

CORRECTIONS 13th NOVEMBER 1984

1) Page 7, Column 1, Line 2 - the second word should be potential not frequency.

2) Page 14 - resistors R76, 78, 80, 83, 85, 87 are contained in two 10k SIL, 4 individual (not 7 commoned) networks. This also means that they may be inserted either way round into the PCB.