VOLTAGE CONTROLLED MIXER -A PROJECT 80 MODULE

This month we continue ETI's Project 80 with constructional details of the Voltage Controlled Mixer and Processor modules

Within a synthesiser there are a variety of sound sources, for example, the waveforms from the voltage controlled oscillators and the outputs from the noise generator. In addition there are treated sounds obtained by filtering, modulation and so on. Incorporating mixers greatly increases the scope for generating complex wave-shapes by additive or subtractive synthesis as well as providing the normal mixer function of proportioning the various inputs. Furthermore, mixing within the synthesiser maintains a compatible signal level and a high signal to noise ratio. The synthesiser this month is a four-channel mixer with pan control of the outputs. The unusual feature is that the input levels and pan have both manual and voltage control facility and some of their applications will be described.

Voltage Controlled Mixer

The design is based on a custom IC, namely, the CEM 3330 Dual Voltage Controlled Amplifier produced by Curtis Electromusic Specialties. At first sight this may seem an expensive approach, but the device has the essential features required for a good mixer — namely, low distortion, low noise and wide bandwidth. Furthermore, it is directly compatible with the signal and control voltages employed and has a summing node control input. These features eliminate the need for additional op amps for buffering and control purposes. Additionally, the performance of the CEM 3330 is satisfactory for the present application without employing trimmers and this is particularly useful to constructors having a limited amount of test equipment.

For synthesiser use, proportional (linear) mixing has been found simpler to use since the dial reading or control voltage is directly related to the proportion of each input being mixed. The input signal has been attenuated by a factor of four on each channel and maximum output is obtained with a 10V control signal derived from a rotary potentiometer, or from external sources. A manual master gain control has been provided for attenuating the output when required, or more commonly for maintaining signal level near to the standard 10V P-P. The output may be adjusted by a factor of $\pm$ 5. A visual peak level indicator has been included. After mixing, the output passes to another dual VCA operated at unity gain and with a pan facility such that a 10V control voltage results in a full swing from left to right outputs. This arrangement gives a constant total voltage output, but its distribution may be varied between two speakers with the aid of a stereo amplifier. If only one output is used then the pan control facility will function as a fade control. Panel space has dictated the number of controls incorporated in the mixer and the pan system is considered to be the most versatile especially if the outputs are being subjected to further treatment.

The design is fairly flexible insofar as component values may be changed to suit other control voltages and so on. Nevertheless it is designed to operate with signal levels commonly found within synthesisers. ▶

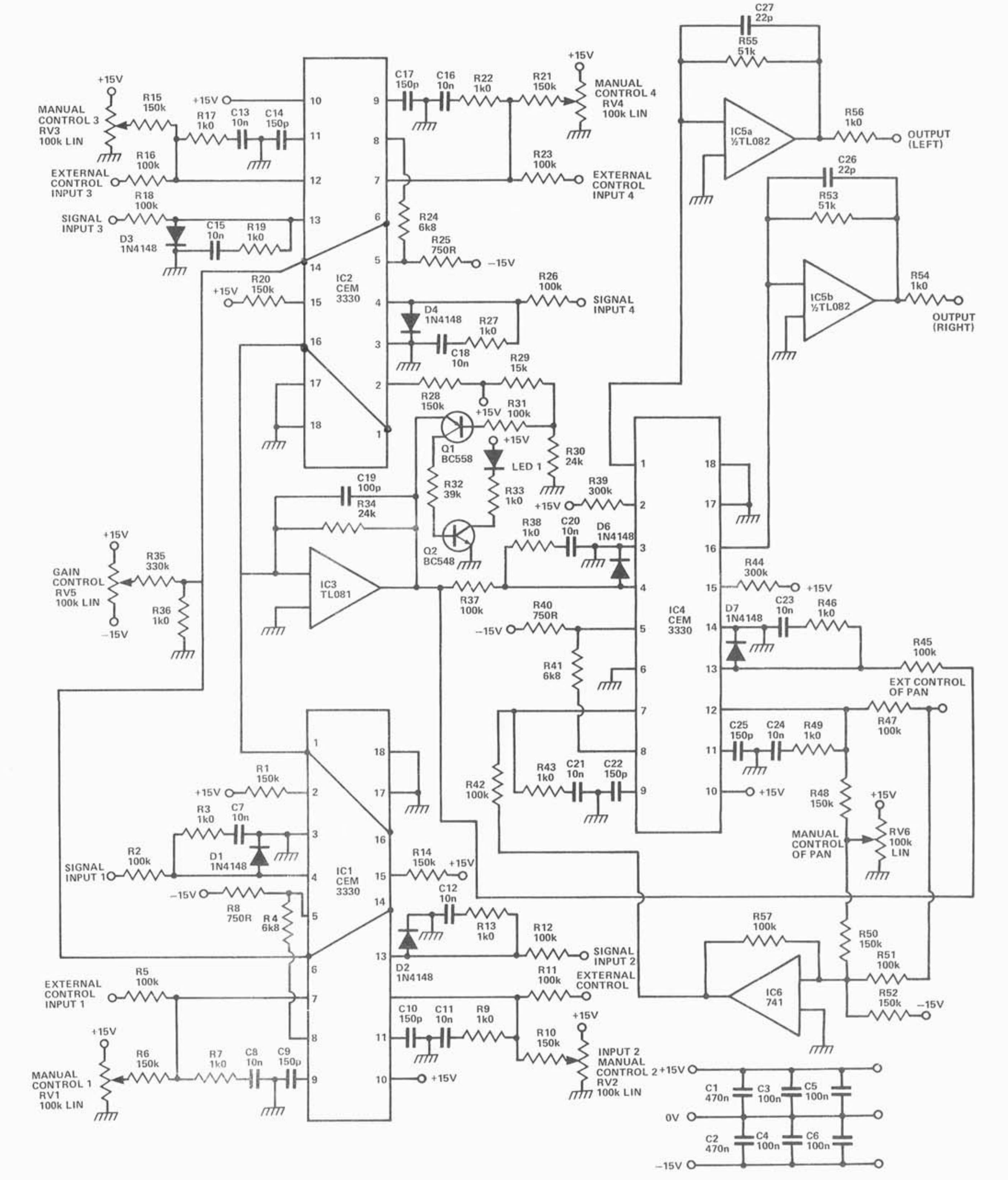


Fig.1. Circuit diagram of the voltage controlled mixer.

HOW IT WORKS

The CEM 3330, from Curtis Electromusic Specialties, contains two voltage controlled amplifiers each of which consists of a variable gain cell and a log converter. The gain cell is the curren-in, current-out type and has simultaneous linear and exponential controls. The log converter generates the logarithm of the linear control input current while transmitting the exponential control input unchanged to its output.

Reference to the circuit diagram and Pins 1 to 9 of IC1 illustrate the basic principle of the design and some of the features of the CEM 3330. The signal input (Pin 4) is a summing node and can, therefore, accept multiple inputs. In this application where we require independent control over each input only one input has been provided and with R2 = 100k the signal level should be kept to ±10V. R3 and C7 are compensation components and the diode, D1, is to prevent latch-up problems. R1 connected to +15V provides a reference current to the gain cell and this current should be limited to 100 uA for best linearity. The design is based on proportional mixing of up to four signals and thus the linear control input is used to independently control the gain of each signal input. Again this is a summing node input at Pin 7 which allows manual control of gain via RV1 and R6 or external control via R5 without additional op amps. By using a 150k resistor for R6 the control pot can make use of the standard +15V supply and provide the same gain as a 10V external control signal applied to the 100k resistor, R5. R7 and C8 compensation network stabilise the log converter. C9 is for compensation of the gain cell. A master gain control is obtained by injecting a small voltage into the exponential control input (Pin 6). This voltage is derived from RV5, R35 and R36 and is common to the four input stages.

The overall gain of the VCA is given by

$$A_V = -\frac{R_F}{R_i} \times \frac{I_{CL}}{I_{REF}} e^{-V_{CE}/V_T}$$

where R_F is the value of the output resistor (R34); R_i the signal input resistor (R2); I_{CL} the linear control current developed across R5 (or R6); I_{REF} the current input to Pin 2 via R1; and V_{CE} the exponential control voltage. This equation indicates how the mixer may be altered to suit other signal and control levels.

One of the unique features of the CEM 3330 is that the operating point of the amplifiers may be set anywhere from Class B to Class A according to which parameters are most important in a particular application. The quiescent standby current of the signal-carrying transistors is varied by placing a resistor between the I_{EE} pin (Pin 5) and the idle current adjust pin (Pin 8). In this application the amplifiers are run Class AB with the 6k8 resistor (R4) providing a standby current of about 7 uA.

The four signal input and control stages are identical and their output currents are summed at IC3 and converted to a voltage across R34. This voltage is applied to Q1 which is turned on when the peak output voltage is about 9V5 (normal signal level for the synthesiser), which is set by the voltage divider R29, R30. Q2 is also turned on when this peak voltage is reached and the LED (D5) will then light up. At constant amplitude high frequency the LED will tend to glow dimly but intermittent peak voltages are clearly indicated.

The output voltage from IC3 also goes to both VCAs in IC4 which is configured in a similar manner to ICs 1 and 2 except that the exponential output is grounded. The amplifiers and associated op amps (IC5a) and IC5b) are set to unity gain when a 10V control voltage is applied to R42 or R47. The panning effect is obtained through IC6 and associated components which provides a 10V output with zero volts at R47, or RV6, and 0V when there is 10V at R47, or when RV6 is fully clockwise. The left and right outputs are obtained by converting the current to a voltage across resistors R55 and R53 respectively. The use of op amp, IC5, provides low impedance outputs.

The CEM 3330 may be trimmed for precision control of gain and for use in high quality audio applications. The arrangement used in this design is entirely satisfactory for its intended use with high signal levels.

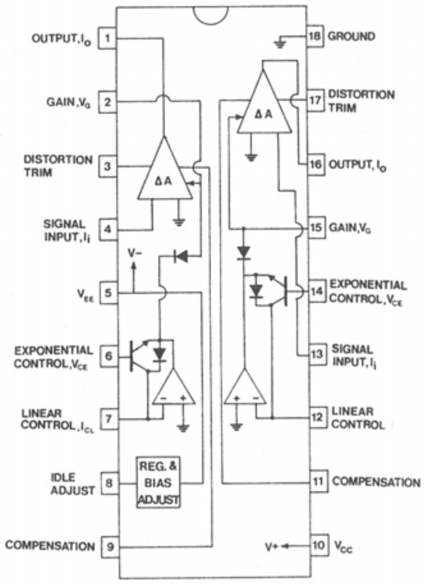


Fig.2. The internal structure of the CEM 3330 dual VCA.

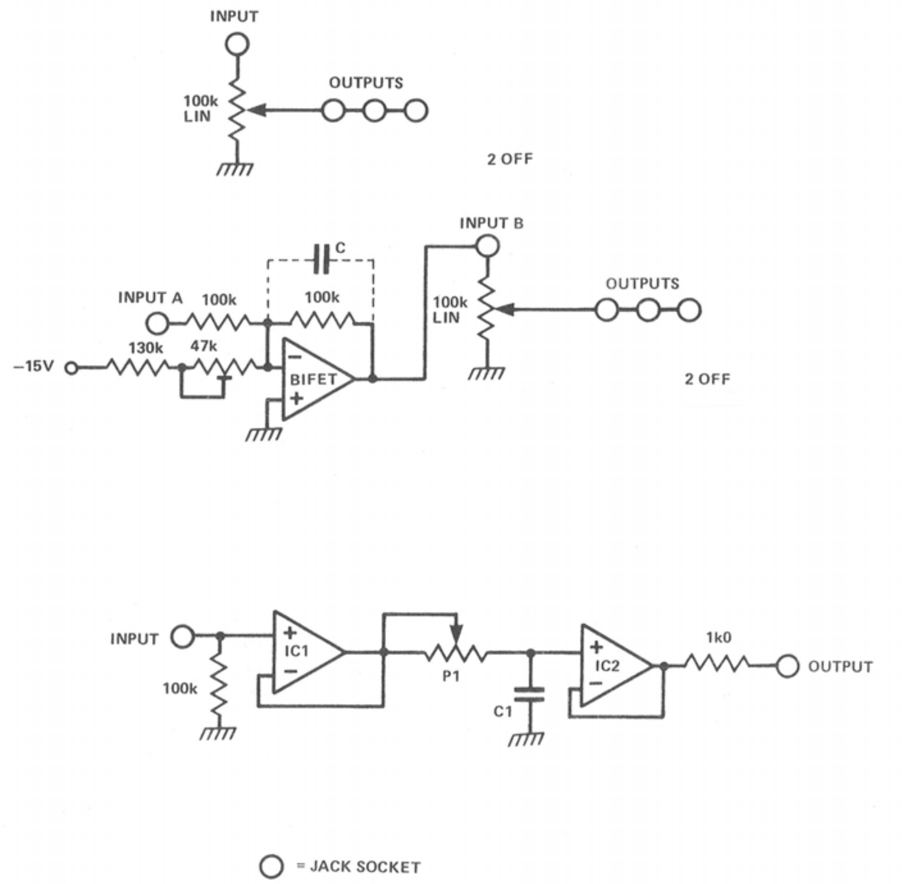


Fig.3. Circuit diagram of the simple processor.

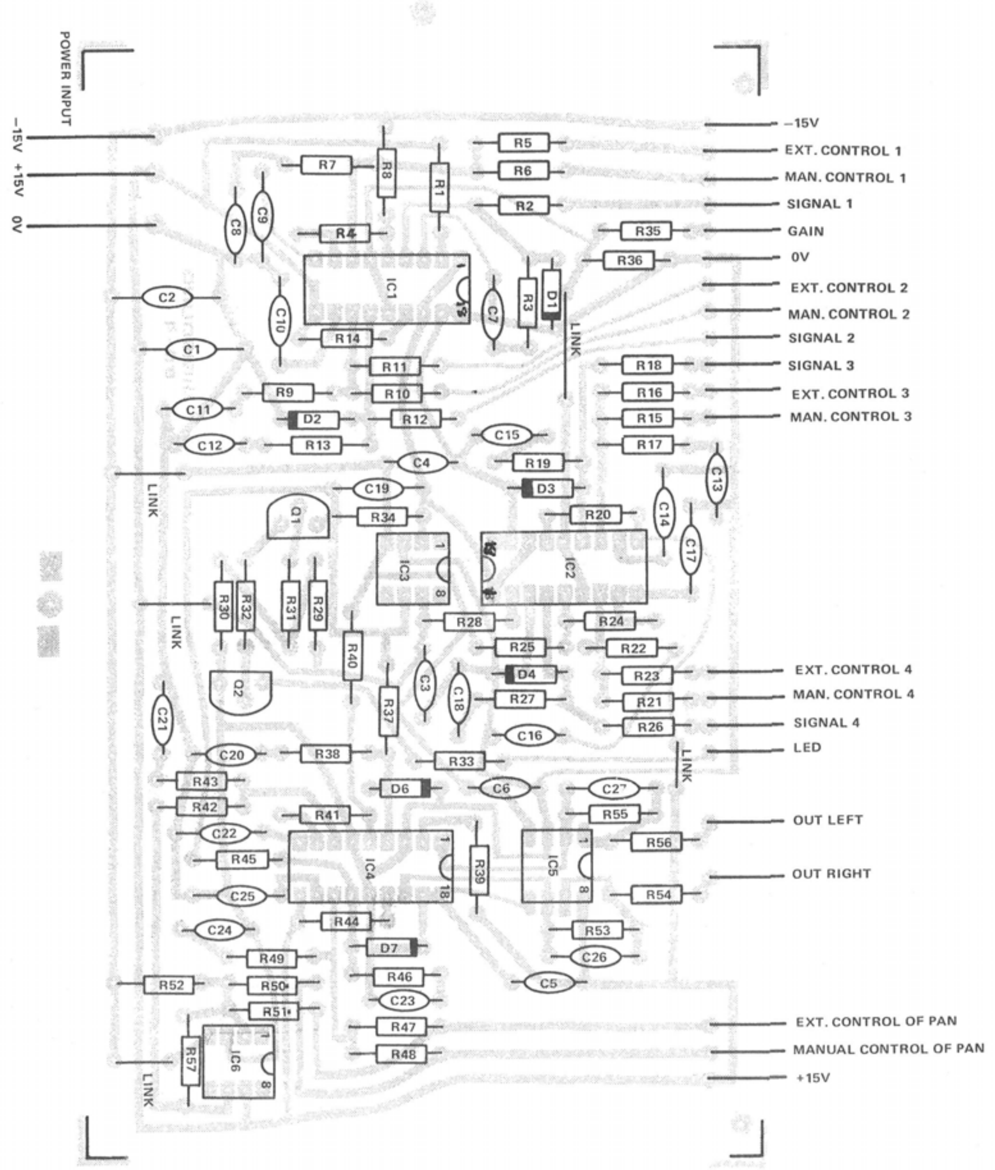


Fig.4. Component overlay of the VCM.

PARTS LIST

RESISTORS	
R1,14,20, 28,50,52	150k 1% metal film
R2,5,11, 12,16,18,23, 26,31,37,42, 45,47	100k
R3,7,9,13, 17,19,22,27, 33,36,38,43, 46,49,54,56	1k0
R4,24,41	6k8
R6,10,15, 21,48	150k
R8,25,40	750R
R29	15k
R30,34	24k
R32	39k
R35	330k
R39,44	300k 1% metal film
R51,57	100k 1% metal film
R53,55	51k
POTENTIOMETERS	
RV1–6	100k lin
CAPACITORS	
C1,2	470n polyester
C3,4,5,6	100n polyester
C7,8,11,12, 13,15,16,18, 20,21,23,24	10n polyester
C9,10,14, 17,22,25	150p polystyrene
C19	100p polystyrene
C26,27	22p polystyrene
SEMICONDUCTORS	
IC1,2,4	CEM3330
IC3	TL081CP or equivalent
IC5	TL082CP or equivalent
Q1	BC558
Q2	BC548
D1,2,3,4,6, 7	1N4148 (1N914)
D5	Red LED

BUYLINES

The voltage controlled mixer PCB and all the components shown on the circuit diagram are available for £24.62 including postage and VAT from Digisound Limited, 13 The Brooklands, Wrea Green, Preston, Lancashire PR4 2NQ.

Using The Mixer

A few guidelines on use are given to demonstrate the versatility achieved by incorporating voltage control.

1. A simplistic view would be to consider the mixer as four voltage controlled amplifiers with a common output. One technique often applied to a VCA is amplitude modulation (tremolo). Usually, however, the VCA is one of the last stages and, if a number of signals have been combined in a conventional mixer prior to the VCA, then the total signal has to be amplitude modulated. Using the voltage controlled mixer only parts of the signal need be modulated and the resultant effect can be more pleasing.

2. One of the early works with a synthesiser was Morton Subotnick's "The Wild Bull," recorded in 1968. In this work extensive use is made of a sawtooth waveform (high harmonic content) which is separated into four octave bands to provide the signals for a four-channel voltage controlled mixer. Each channel was controlled by an ASDR envelope shaper gated from a sequencer. This arrangement allows the separate timbral characteristics of any sound to be independently treated. Furthermore, by varying the speed of the sequencer the characteristics of the sound can be made to vary widely, for example, as the rate is increased the four bands begin to sound simultaneously. Only a simple digital sequencer is required for the above and the voltage controlled mixer becomes the heart of a useful music making instrument within the body of the synthesiser. This type of approach is particularly useful for those without access to multi-track recording equipment.

3. Adding and subtracting waveforms from two or more oscillators set to different pitches has not been widely used with synthesisers due to the tendency for the voltage controlled oscillators to track at different rates. The latter makes it impossible to maintain the same tone quality over several octaves. With the incorporation of synchronising facilities in modern VCOs this problem is overcome and additive and subtractive synthesis is a worthwhile field of exploration. Of course, subtractive synthesis is already widely employed by filtering techniques but more subtle tones can be obtained by mixing techniques.

4. A major application of the voltage controlled mixer is the ability to alter loudness and harmonic content with pitch. One of the criticisms of 'live' electronic music is the precise nature of its sounds and the initial excitement of a new sound turns to boredom as the brain adversely reacts to its repetitive nature. By applying the keyboard control voltage (or its inverse, or a proportion of either) to one or more of the mixer control inputs then the amplitude or harmonic content (often both) will vary with pitch and so provide a useful means of dynamically altering the timbral characteristics of the sound.
5. Applying a low frequency waveform to the pan control input can produce some interesting spatial and rotational effects, but for greatest impact this technique should be used sparingly.
6. Mention has been made of waveforms, envelope shapers and keyboard voltage for control of the mixer and in common with other voltage controlled modules any variable voltage source may be used. A foot pedal control adapted to provide a 10V output is particularly useful in conjunction with a mixer.

Processor Module

As discussed in Part 1, the low output impedance and high input impedance of the modules allows one output to drive several inputs without overloading or introducing appreciable errors. Thus attenuators should be on inputs rather than outputs so that their level can be independently adjusted. Likewise the modules should ideally have a number of commoned output sockets to facilitate distribution of the signal to other modules.

Additional attenuating potentiometers and jack sockets add to cost and also take up valuable panel space and so for situations where the controls are used infrequently a distribution panel was discussed last month.

A suggested configuration for the module (a 'processor') is two distribution blocks which allow one input to be distributed to three outputs with or without attenuation.

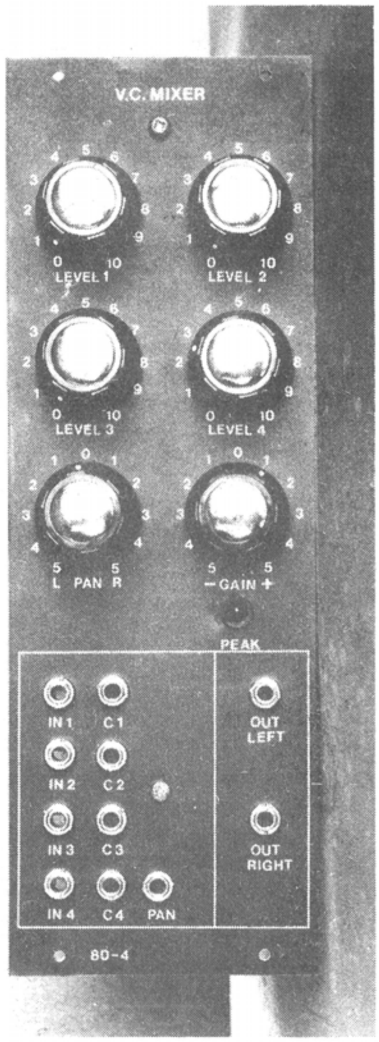
Secondly, there are a further two blocks which may be used as above, or the signal may be inverted via an op amp. In this instance inverting means subtracting the input voltage from 10 volts and not turning a positive input voltage into a negative one. This is achieved by adding components R3 and TP1 to a conventional unity gain inverter.

Another addition is the so-called 'lag processor' which is simply a low pass filter and akin to the usual portamento circuit. This is useful for slowing down fast control signals and also for delaying control signals.

Construction

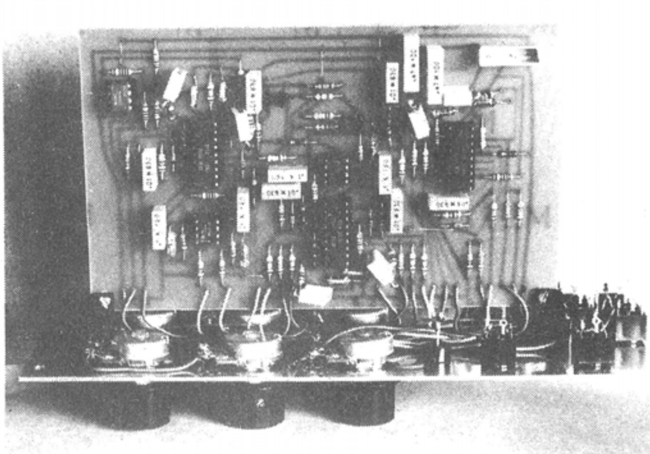
Because of the simple construction of the circuits no printed circuit board is shown but a few construction hints may be of value. For the inverter a BIFET type op amp (LF 351, TL 081, etc) should be used to prevent distortion of high frequency or fast signals. The main precaution is to keep the signal input resistor close to the inverting pin. A small capacitor (10 or 22p) across the op amp also reduces the likelihood of instability. Furthermore, if you decide to install more than two inverters on a board then 100n decoupling capacitors mounted close to the power supply pins of the IC will prevent the tendency of these devices to talk to one another. The circuit should be wired up so that the inverter stage is disabled when input jack socket 'B' is in use.

A LM1458 type op amp should be adequate for most applications of the lag processor. RV1 = 2M2 and C1 = 220n will provide sufficient delay and since short delays are the most useful a polyester capacitor may be employed. ETI



Panel layout of the mixer.

The mixer PCB attached to its front panel.



The mixer PCB installed in its case.