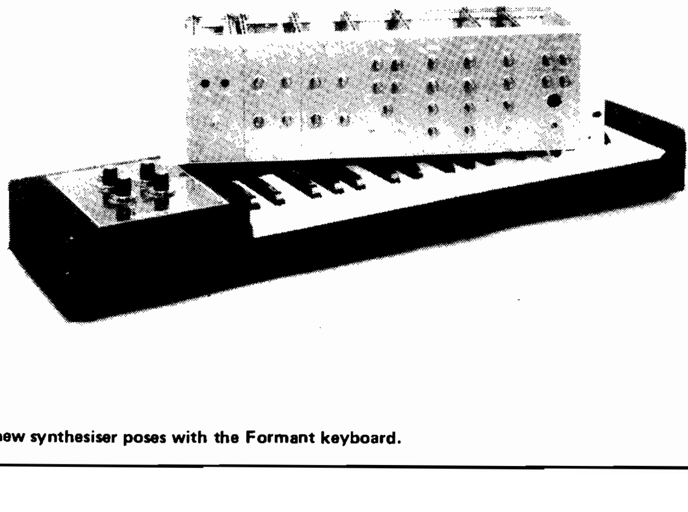
combined VCF/VCA module...

. . . for the new Elektor synthesiser

The VCO module described in the December issue of Elektor by no means provides a complete synthesiser. Connection to at least one voltage controlled amplifier (VCA) and a voltage controlled filter (VCF) is required to obtain a simple, playable instrument. A very compact 24 dB/octave low pass filter can be constructed around the Curtis integrated circuit type CEM 3320. With the aid of this device *two* VCAs (using the already established Formant circuitry) can be accommodated on the same printed circuit board.



The new synthesiser poses with the Formant keyboard.

The voltage controlled filter

As with the VCO, the VCF module contains a number of CMOS switches as well as the various 'active' integrated components. The former enable the circuit to be controlled externally. This is accomplished by applying digital information to the relevant inputs during the 'preset' mode of operation.

The circuit diagram of the filter section is shown in the upper portion of figure 1. The major part of the VCF is taken up by the CEM 3320, which was described in the October 1981 issue of Elektor. The rest of the filter circuitry is made up from a small assortment of resistors and capacitors.

Provision has been made for two VCO input signals and one noise input. The amplitude of the VCO signals can be controlled by potentiometers P1 and P2. These signals are then mixed with the noise input by means of opamp A1. The resultant signal is then fed to the input of the filter IC. (The potentiometer used to adjust the amplitude of the noise signal is situated on the front panel of the NOISE/LFO module. This module will be described in a future issue of Elektor.)

The resonance (Q factor) of the low pass filter is determined by a control voltage derived from potentiometer P4 and is fed to pin 9 of IC1 via the CMOS switch S1 (pins 8 and 9 of IC3). This parameter can also be affected by an external control voltage applied via S2 (pins 10 and 11 of IC3). As with the VCO module, S1 has to be temporarily replaced by a wire link until such time as the complementary control circuits are published.

The cut-off frequency of the filter is determined by a number of factors: coarse and fine adjustment by means of potentiometer P3 and preset P7, respectively; the keyboard output voltage, KOV (tracking filter); and the LFO and ADSR envelope signals. The sources of these voltages are connected to the inverting input of A3 via R23, R42, P8, P9 and P10. These components, together with A3 itself, form a simple mixing stage. The combined output signal is then fed to the frequency control input (pin 12) of the filter IC.

CMOS switches S4 and S6 also have to be replaced by wire links temporarily, otherwise the envelope control signal (via P5) and the control voltage provided by P3 cannot be used. External frequency control can be provided via CMOS switch S3. If this facility is required then the wire link must be moved from the S4 position to S3. The amplitude of the envelope waveform can be varied between zero and maximum by a control voltage applied to the 'envelope amplitude program' input (connection point 10 in the circuit diagram), provided S5 is closed and S6 is open.

The waveform at the 'envelope' input (point 8) is not only connected to potentiometer P5, but also to the signal

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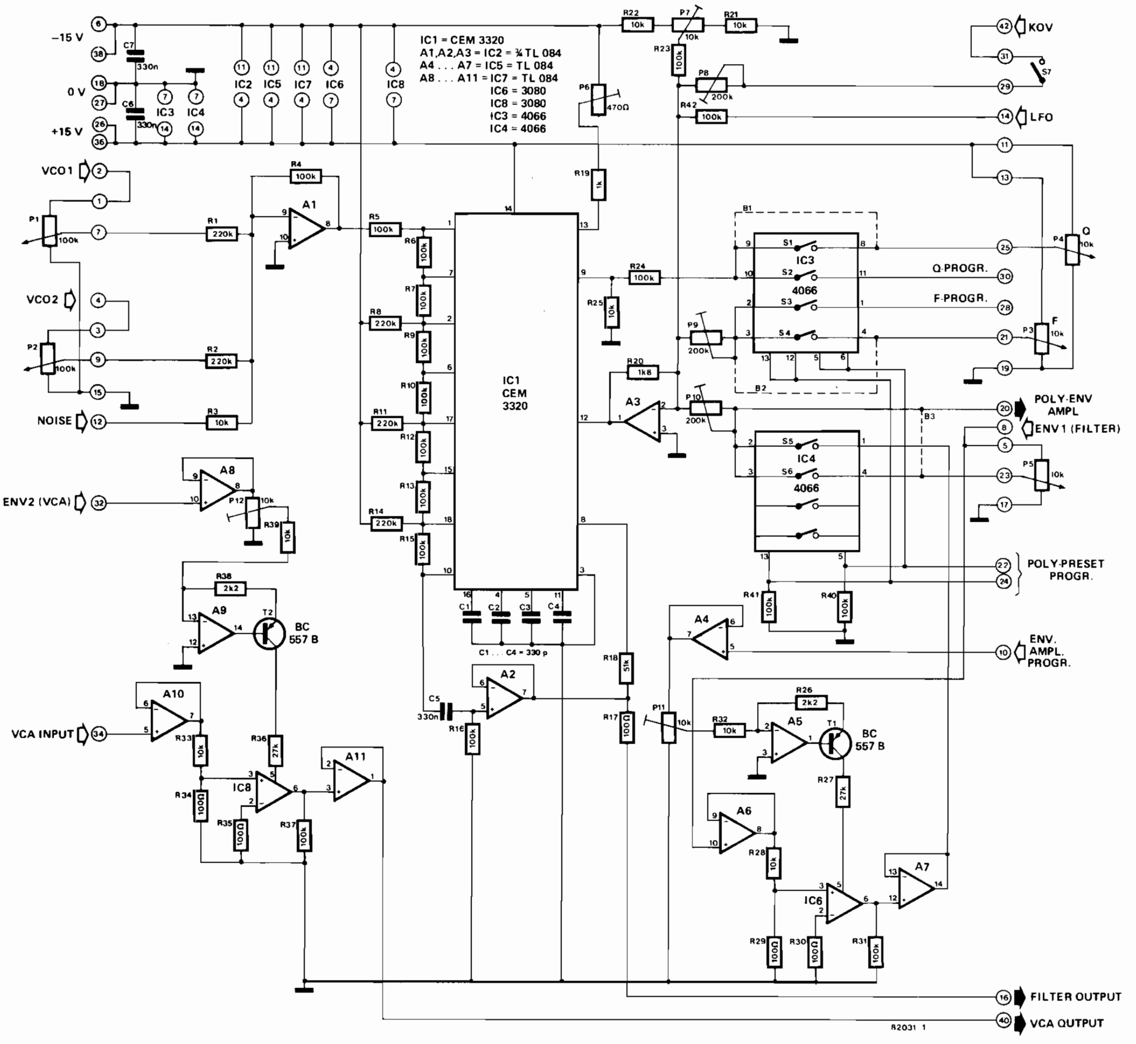

Figure 1. The complete circuit diagram of the combined VCF/VCA module. The Curtis IC (CEM 3320) contains just about all that is required to construct a voltage controlled 24 dB/octave low pass filter.

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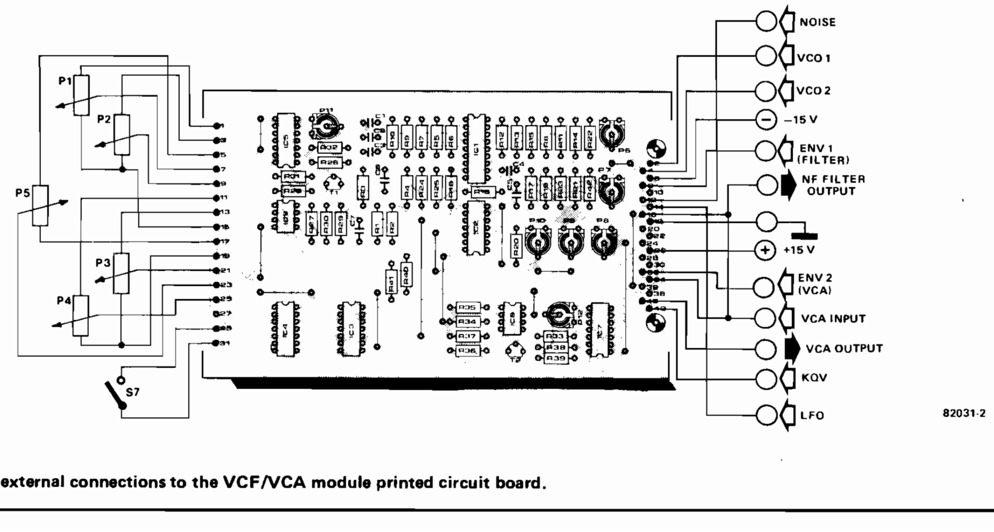
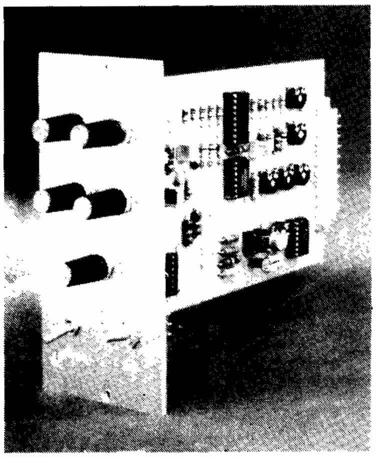


Figure 2. The external connections to the VCF/VCA module printed circuit board.



The completed VCF/VCA module.

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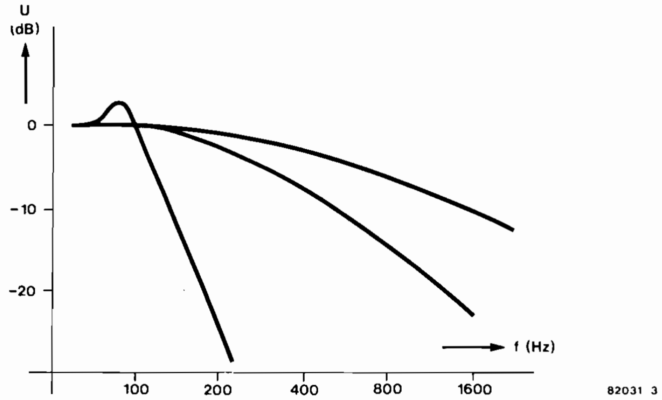

Figure 3. The frequency characteristics of the filter for different settings of P4.

input of a VCA. This means that either the output of the VCA or the voltage present on the wiper of P5 can be fed to the input of the mixer (A3) via CMOS switches S5 and S6. The construction of this VCA is identical to that which controls the amplitude of the VCO signals (shown in the lower left-hand corner of figure 1), the details of the VCAs are about to be described.

The voltage controlled amplifier

As mentioned previously, the design of the VCA is based on the well-proven Formant circuitry. The central component of the amplifier is a so-called OTA (operational transconductance amplifier) type CA3080. Effectively, this device is a current controlled amplifier. As both VCAs are virtually identical, only one needs to be described. Opamp A5 and transistor T1 convert the control voltage into a control current, which is fed to pin 5 of the OTA via resistor R27. Opamps A8, A10 and A11 serve as buffers. The input signal is attenuated by the voltage divider network R28/R29 down to a level that the OTA can handle. The output of the OTA is buffered by the voltage follower A7 before being fed to the mixer A3. The OTA VCA is constructed separately from and its operation does not depend on the VCF. The circuit is very easy to construct, is very inexpensive and, above all, it performs very well. It has a major advantage over the Curtis VCA (CEM 3330) in that the latter was found to be unable to follow very short attack times. This means that percussive sounds (piano, cymbals, xylophone, etc.) cannot be realised with the Curtis device.

Calibration and operation

The component overlay of the printed circuit board for the VCF/VCA module is shown in figure 2. The various sections of the module are tested separately. After installing the wire links B1 . . . B3 instead of IC3 and IC4, check that the correct supply voltages are present at the corresponding pins of the IC sockets. The audio output of the voltage controlled oscillator (low frequency range, sawtooth waveform) is connected to the input of the filter (P1 or P2).

The module can be checked 'by ear' by connecting an audio amplifier to the output of the filter. Potentiometers P3 and P4 are turned fully anti-clockwise. Following this, preset potentiometer P7 is adjusted until the level of the sawtooth signal at the filter output is just audible. The centre frequency of the filter will now be in the sub-sonic range. Potentiometer P3 is used to vary the control voltage in stages; as the voltage is increased the harmonics of the fundamental filter frequency plus the overtones of the sawtooth signal are produced. When P3 is turned fully clockwise, the upper threshold for the cut-off frequency of the filter can be set by means of preset potentiometer P9.

Again, the easiest way to adjust this parameter is 'by ear'. Potentiometer P4 is then turned fully clockwise. The frequency characteristic of the filter becomes visibly steeper until a resonance peak is reached (see figure 3). If the control voltage is increased still further, the filter will tend to oscillate: at a certain point the frequency of oscillation will coincide with the centre frequency of the filter. Preset potentiometer P9 is then adjusted so that the frequency of these oscillations is so high when P3 is fully turned up, that they are just beyond the human hearing range. Then the entire tone frequency range can be covered by means of potentiometer P3.

Calibration of P8

By closing switch S7 the frequency of the filter will be determined by the notes played on the keyboard, provided P8 is correctly calibrated. Adjust P3 until the filter starts to oscillate, in other words, it acts like a VCO. Now calibrate P8 in exactly the same manner as P5 of the VCO was calibrated (see the article published in the December 1981 issue of Elektor). To calibrate P10 the envelope generator, which will be described in a future article, needs to be connected. Obviously, the Curtis filter can also be combined with a Formant envelope generator. In this instance a sustain value of 100% must be set before adjusting P10. By depressing a key, turning P3 fully anti-clockwise and P4 until the filter starts oscillate, P10 is adjusted until the frequency of the filter is just inaudible to the human ear.

Calibrating the VCA

All that is needed to calibrate the VCA is a single potentiometer to prevent the input to the OTA from being overmodulated. Again an envelope generator needs to be connected to pin 3 of A8. Connect an oscilloscope to pin 8 of A11. Link the audio output of the VCF to the audio input of the VCA. Connect a sawtooth signal to the filter input and turn P1 and P3 fully clockwise. Adjust preset potentiometer P12 slowly from its minimum to its maximum setting.

The amplitude of the sawtooth waveform will increase as P12 is turned. Eventually a certain point is reached where the amplitude will no longer increase. When this occurs P12 will be correctly calibrated. The setting of P6 is not quite so critical: the wiper should be set in the centre position!

This completes the calibration of the complete module. For further details with regard to calibrating and using the VCF and VCA, readers are referred to the articles previously published in Elektor (E-30, October 1977; E-31, November 1977 and E-32, December 1977) and Formant Book 1.

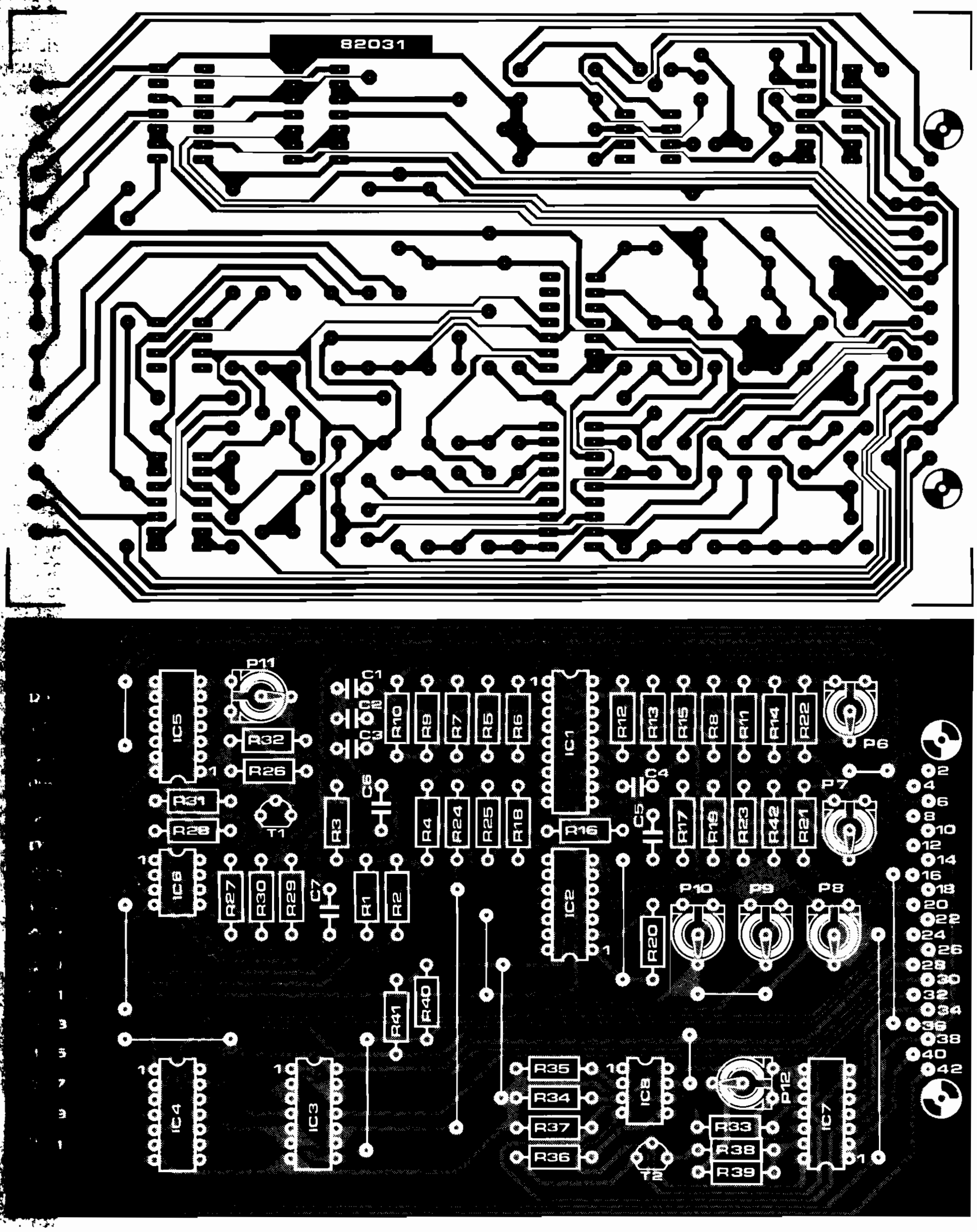

Figure 4. The track pattern and component overlay for the VCF/VCA module printed circuit board.

Parts list

Resistors:
R1,R2,R8,R11,R14 = 220 k
R3,[illegible]25,R28,R32,R33,R39 = 10 k
R4 . . . [illegible]R10,R12,R13,R15,R16,R23,
[illegible]7,R40 . . . R42 = 100 k
[illegible],R34,R35 = 100 Ω
R18 = 51 k
R19 = 1 k
R20 = 1k8
R26,R38 = 2k2
R27,R36 = 27 k
(R5 . . . R15 = 1% metal film)
P1,P2 = 100 k log
P3 . . . P5 = 10 k lin
P6 = 470 Ω preset
P7,P11,P12 = 10 k preset
P8 . . . P10 = 200 (220, 250) k preset

Capacitors:
C1 . . . C4 = 330 p
C5 . . . C7 = 330 n

Semiconductors:
T1,T2 = BC 557B
IC1 = CEM 3320
IC2,IC5,IC7 = TL 084
IC3,IC4 = 4066 (not yet required)
IC6,IC8 = 3080