dual ADSR and LFO/NOISE modules

. . . for the NEW Elektor synthesiser

The NEW Elektor synthesiser can be completed by the inclusion of the two modules described here. The dual ADSR module is constructed around two Curtis integrated envelope generators (CEM 3310) and very little else. The LFO module generates a versatile triangular waveform whose amplitude and frequency can be varied over a wide range. A straightforward NOISE generator has also been included on the LFO module. Together with the previously published VCF and VCA, the two modules described here are capable of producing a whole range of different sound effects similar to those described in the FORMANT books and articles.

As with the devices used in the rest of the synthesiser, the Curtis envelope generators require very few additional components. Another advantage is that the circuits do not require a great deal of calibration. As can be seen from the circuit diagram in figure 1, the two attack-decay-sustain-release (ADSR) generators are identical, therefore it will be sufficient to describe just one in detail. Pins 9, 12, 13 and 15 of IC1 are the control inputs. The voltage levels applied to these inputs determine the duration of the attack, decay and release times and the sustain level. In this respect the module differs a great deal from the circuit used in the FORMANT synthesiser. The latter is not suitable for polyphonic operation using the stored preset data scanning method.

The control voltages applied to pins 12, 13 and 15 of IC1 must be negative! For this reason, opamps A1 . . . A3 invert the input signals. This is necessary as all the control voltages must have the same polarity in order to allow preset 'programs' to be stored in 'memory'. The voltage at pin 9 (sustain) must not exceed 5 V. The maximum output voltage from opamps A1 . . . A3 may be as high as 15 V. The potential divider networks consisting of resistors R9 . . . R14 reduce the incoming control voltages for the attack, decay and release times to provide the correct sensitivity for the IC inputs. The circuits are designed for a gate input level of between 5 V and 15 V (although it must be 0 V when no key is depressed). When using the FORMANT keyboard, which supplies a gate pulse level of about 15 V, the FORMANT interface receiver board can be connected between the gate output of the keyboard and the ADSR (LFO) gate input. This will then provide a gate pulse level of between 0 and 5 V. Control direct from the keyboard (without using the interface receiver) requires no modification to the ADSR circuit, since diode D2 (D2'), prevents any negative voltage from reaching pin 4 of IC1. In this case, however, the FM delay circuit on the LFO board requires a minor modification. A diode (shown dotted in figure 5) must be placed across capacitor C1 in order to protect it against negative voltage levels. It should be noted that a gate input level of 15 V will cause C1 to charge more quickly than a 5 V level and this should be taken into consideration during the calibration of P1.
Sockets should be used for IC3 and IC4 and until these ICs are required, wire links should be installed between pins 1 and 2 and between pins 8 and 9. Consequently, all the wipers of the potentiometers will be connected directly to the circuit. These ICs are not required until the synthesiser is fully extended (details will be published in a future article).

Adjusting the envelope

The two gate inputs are connected together and linked to the gate output pulse of the FORMANT keyboard. When testing the circuit it is advisable to monitor the ADSR (1 and 2) outputs with the aid of an oscilloscope. The timebase frequency of the oscilloscope should be set to approximately 1 Hz. Set the sustain potentiometer (P4) to maximum (wiper towards 15 V) and depress any key on the keyboard.
If the wiper of P1 (attack) is turned towards ground (minimum), the output of the envelope generator IC will immediately rise to its maximum level. As this potentiometer is turned up, the time taken for the output of IC1 to reach its maximum level will increase. By releasing the key, the reverse procedure can be carried out with the aid of potentiometer P2 (release). In the event that potentiometer P4 (sustain) is not in the maximum position, adjusting P3 (decay) will determine the speed at which the output voltage of the envelope generator decreases to the level set by P4 while the key is still depressed. Once the key is released, the output voltage will drop to zero at a rate determined by the setting of P2 (release).
Thus, the ADSR module produces a 'typical' envelope signal. If a key is released before the preset sustain level is reached, the output voltage will automatically drop to zero. The time taken for this is determined by the setting of P2.

Alternative test method

Instead of the keyboard and associated gate pulse, a low frequency oscillator (see figure 2) can be used to control the ADSR circuitry. By applying a square-

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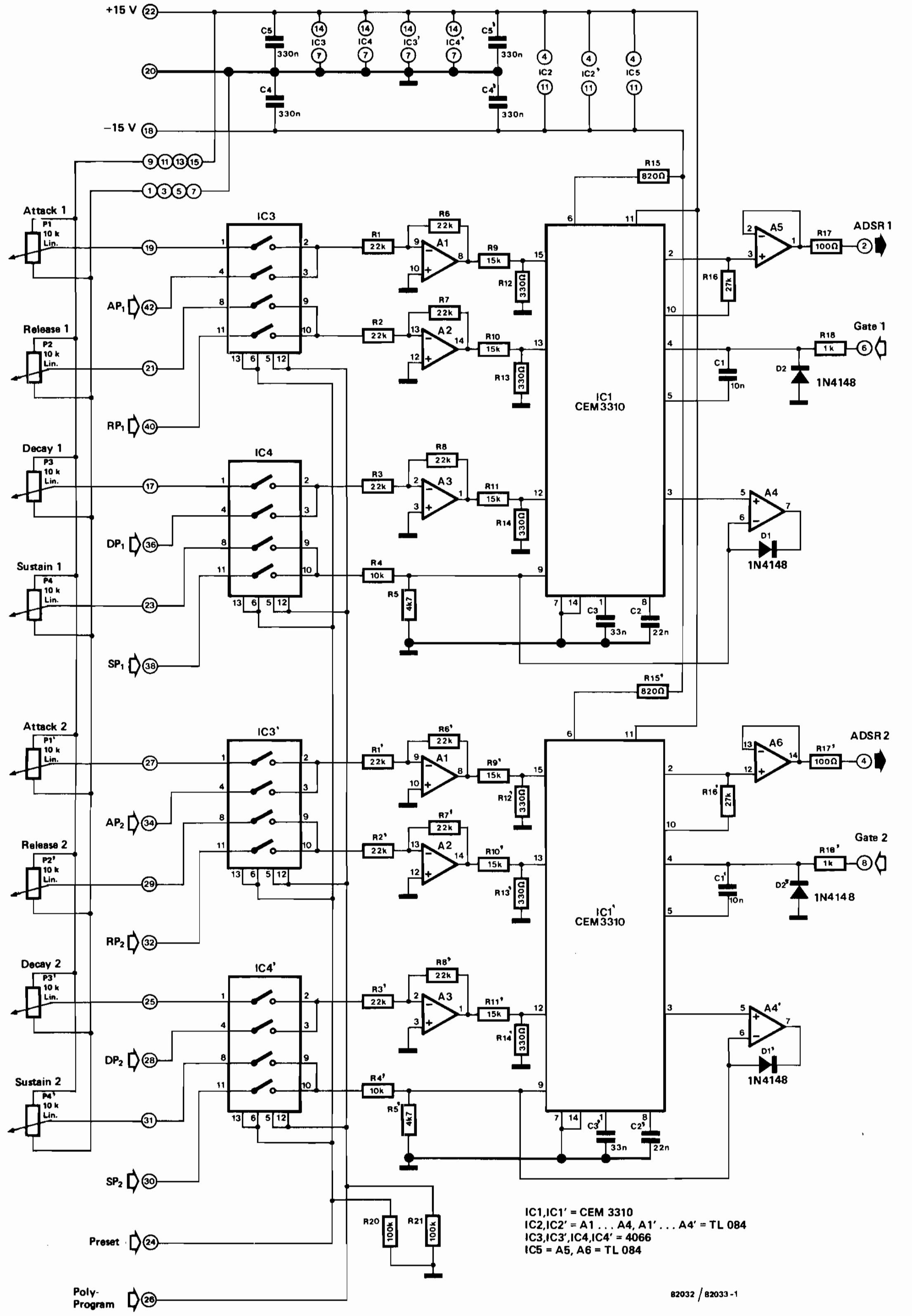

Figure 1. The circuit diagram of the dual ADSR envelope shapers. The attack, decay and release times and the sustain level can all be varied by means of potentiometers.

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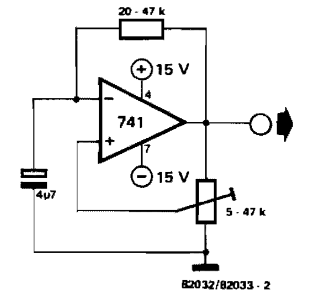

Figure 2. This squarewave oscillator can be used to test the envelope generators.

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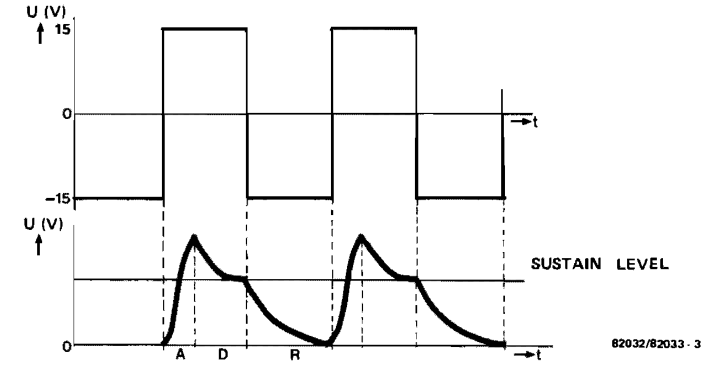

Figure 3. This is what the typical ADSR waveform looks like when the squarewave generator of figure 2 is connected to it.

wave signal (± 15 V) to the gate input of the module, the envelope generator will produce an envelope similar to that shown in figure 3. It is essential that the attack, decay and release times are shorter than the duration of the applied squarewave input signal. (For example, with an input frequency of 20 Hz, the A, D and R times should not be greater than 1/80th of a second.)
The various pin connections for the dual ADSR module are given in figure 4.

The LFO

Anyone familiar with the FORMANT circuitry will notice that the circuit of the low frequency oscillator in figure 5 does not possess a sawtooth or squarewave output. Although such waveforms are very handy for producing all sorts of

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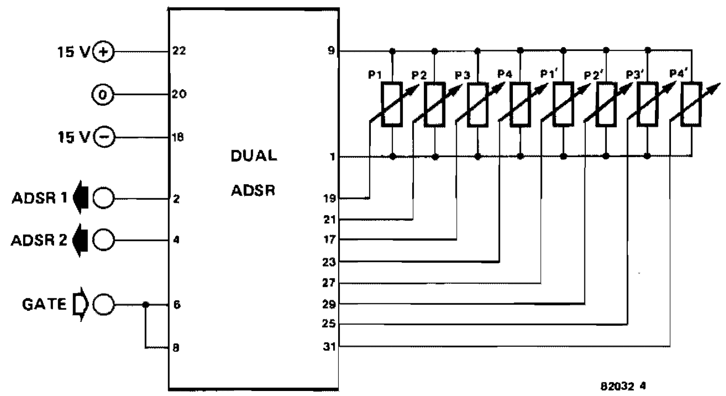

Figure 4. The wiring for the dual ADSR module. The board connection numbers correspond to those given in the component overlay of figure 8.

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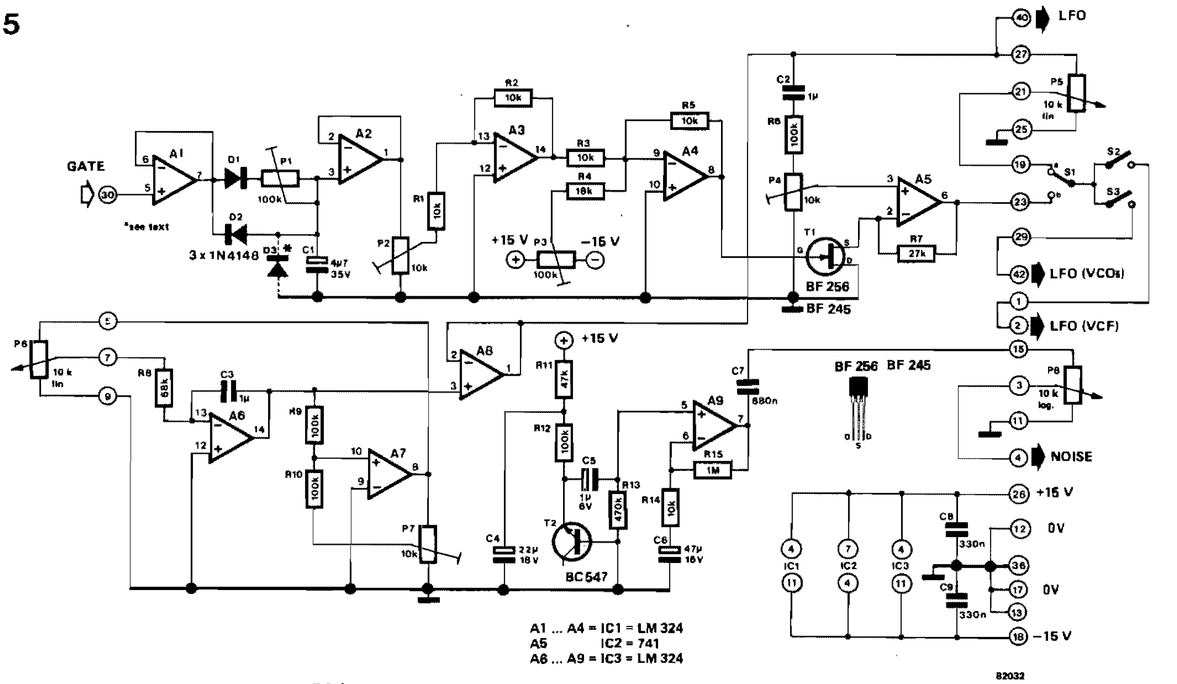

Figure 5. The circuit diagram of the LFO/NOISE module.

...effects, the main requirement at this moment is to produce good quality music and for this all that is needed is a triangular signal. The frequency and amplitude of the LFO should not be too high, as then excessive VCO frequency shift will cause the original pitch to be distorted beyond recognition. In fact the synthesiser will probably end up sounding somewhat like an American Police siren!
If the frequency of the LFO signal exceeds 16 kHz, mixture products, similar to ring modulator effects, will become audible. The LFO module is also capable of producing the popular delayed and continuous vibrato effects. What happens is that the LFO signal is fed to a VCA which is triggered by the keyboard gate pulse following a long attack time and a very short release time (100% sustain). The output waveform of the LFO module is shown in figure 6. A key has to be depressed for a relatively long time before any change occurs in the static sound spectrum. The effect is quite impressive and pleasant, but very difficult to describe. It will have to be heard to be fully appreciated!
The LFO and vibrato circuitry does not have to be elucidated at great length. An integrator (A6) with negative feedback applied produces a triangular output signal. The frequency of this signal can be varied over a wide range. The triangle signal is fed to the output of the LFO module via a voltage follower (A8).
The vibrato circuit is basically a non-

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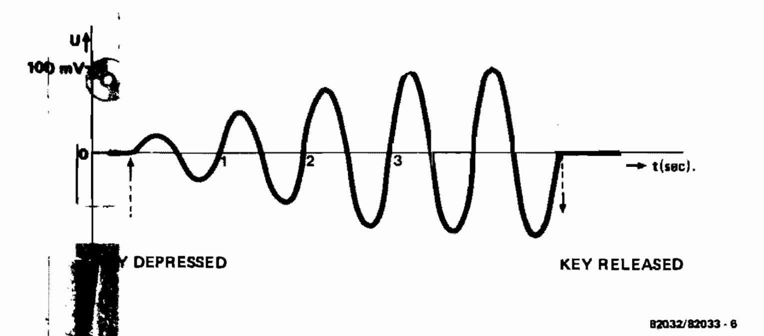

Figure 6. ...waveshape of the output voltage of A5 in figure 5. After a key is depressed, the amplitude ... the LFO signal increases gradually. This results in a delayed and gradual vibrato effect.

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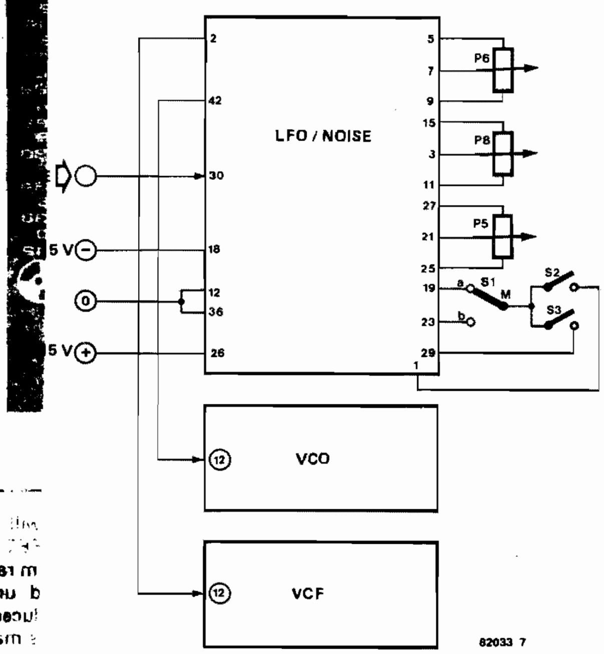

Figure 7. The wiring details of the LFO/NOISE module.

Parts list LFO-NOISE

Resistors:
R1,R2,R3,R5,R14 = 10 k
R4 = 18 k
R6,R9,R10,R12 = 100 k
R7 = 27 k
R8 = 68 k
R11 = 47 k
R13 = 470 k
R15 = 1 M
P1,P3 = 100 k preset
P2,P4,P7 = 10 k preset
P5,P6 = 10 k linear
P8 = 10 k logarithmic

Capacitors:
C1 = 4µ7/35 V
C2,C3 = 1 µ metal foil
C4 = 22 µ/16 V
C5 = 1 µ/6 V
C6 = 47 µ/16 V
C7 = 680 n
C8,C9 = 330 n

Semiconductors:
D1 . . . D3 = 1N4148
T1 = BF 256 (BF 245)
T2 = TUN (BC 547)
IC1 (A1,A2,A3,A4) = LM 324
IC2 (A5) = 741
IC3 (A6,A7,A8,A9) = LM 324

Miscellaneous:
S1,S2,S3 = spst switch
21 pin connector

Parts list ADSR

Resistors:
R1,R1',R2,R2',R3,R3',
R6,R6',R7,R7',R8,R8' = 22 k
R4,R4' = 10 k
R5,R5' = 4k7
R9,R9',R10,R10',R11,R11' = 15 k
R12,R12',R13,R13',R14,R14' = 330 Ω
R15,R15' = 820 Ω
R16,R16' = 27 k
R17,R17' = 100 Ω
R18,R18' = 1 k
R20,R21 = 100 k
P1 . . . P4,P1' . . . P4' = 10 k linear

Capacitors:
C1,C1' = 10 n
C2,C2' = 22 n
C3,C3' = 33 n
C4,C4',C5,C5' = 330 n

Semiconductors:
D1,D1',D2,D2' = 1N4148
IC1,IC1' = CEM 3310
IC2,IC2',IC5 = TL 084
IC3,IC3',IC4,IC4' = 4066
(not required for simple version)

Miscellaneous:
21 pin connector

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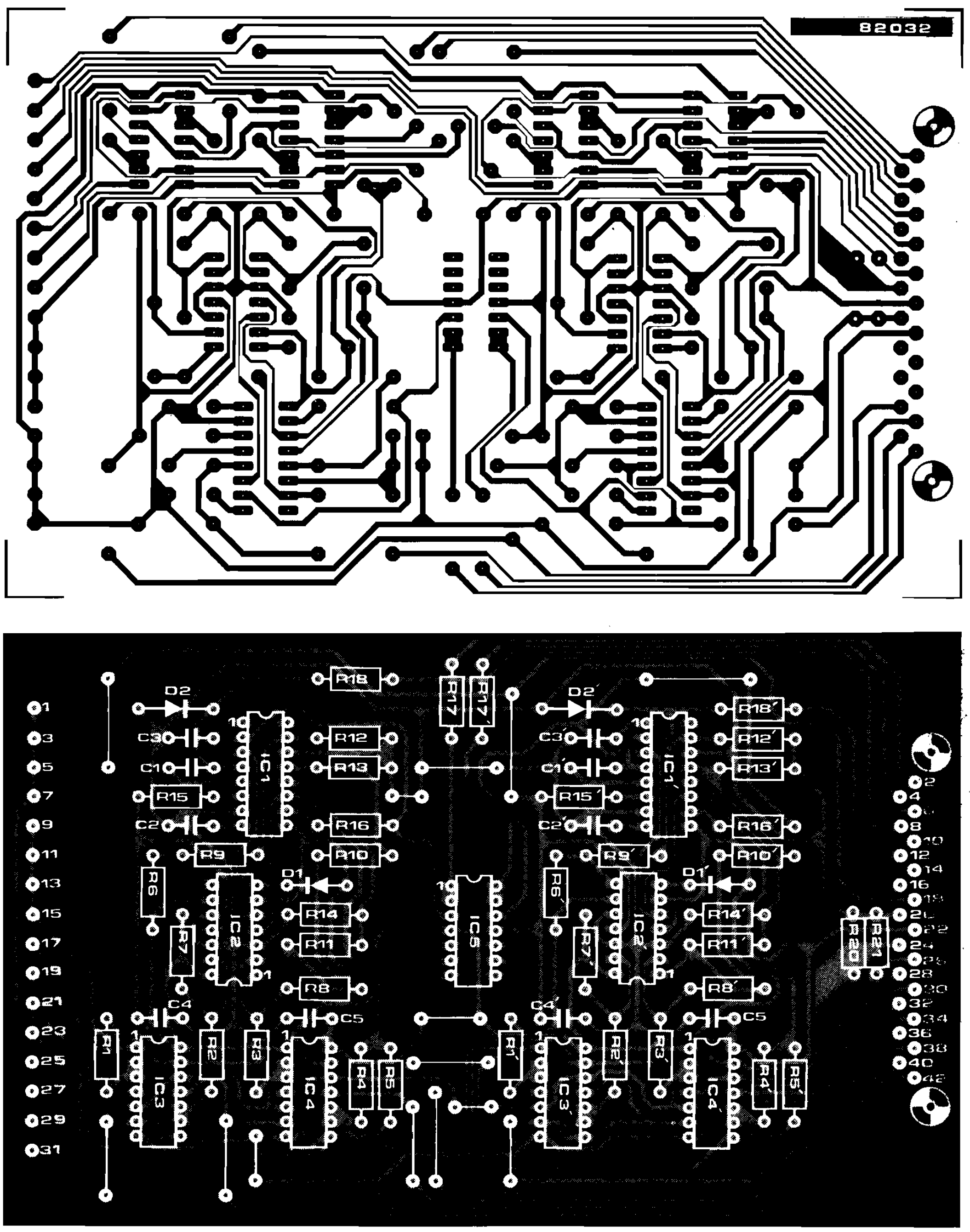

Figure 8. The printed circuit board and component overlay for the dual ADSR module.

inverting opamp (A4). One of the input bias resistors has been replaced by the drain/source junction of a field-effect transistor (FET). The bias voltage at the gate of the FET is adjusted by means of P4 until the device just stops conducting. Then preset potentiometer P3 is adjusted until the vibrato effect is no longer audible. The AR waveform produced from the gate pulse via D1, D2, P1, C1 and A2 causes the bias voltage to increase gradually. The drain/source impedance of the FET is therefore reduced and the vibrato effect becomes more pronounced. Preset potentiometer P2 should then be adjusted to ensure that the gate of T1 is not overmodulated. With a bias voltage of 0 V the maximum envelope level will be obtained. This allows the FET to be modulated within its optimum range. Preset P4 is then adjusted until the delayed vibrato effect produced when a key is depressed attains its maximum level. This particular adjustment can be carried out 'by ear', as the frequency shift should not span more than a

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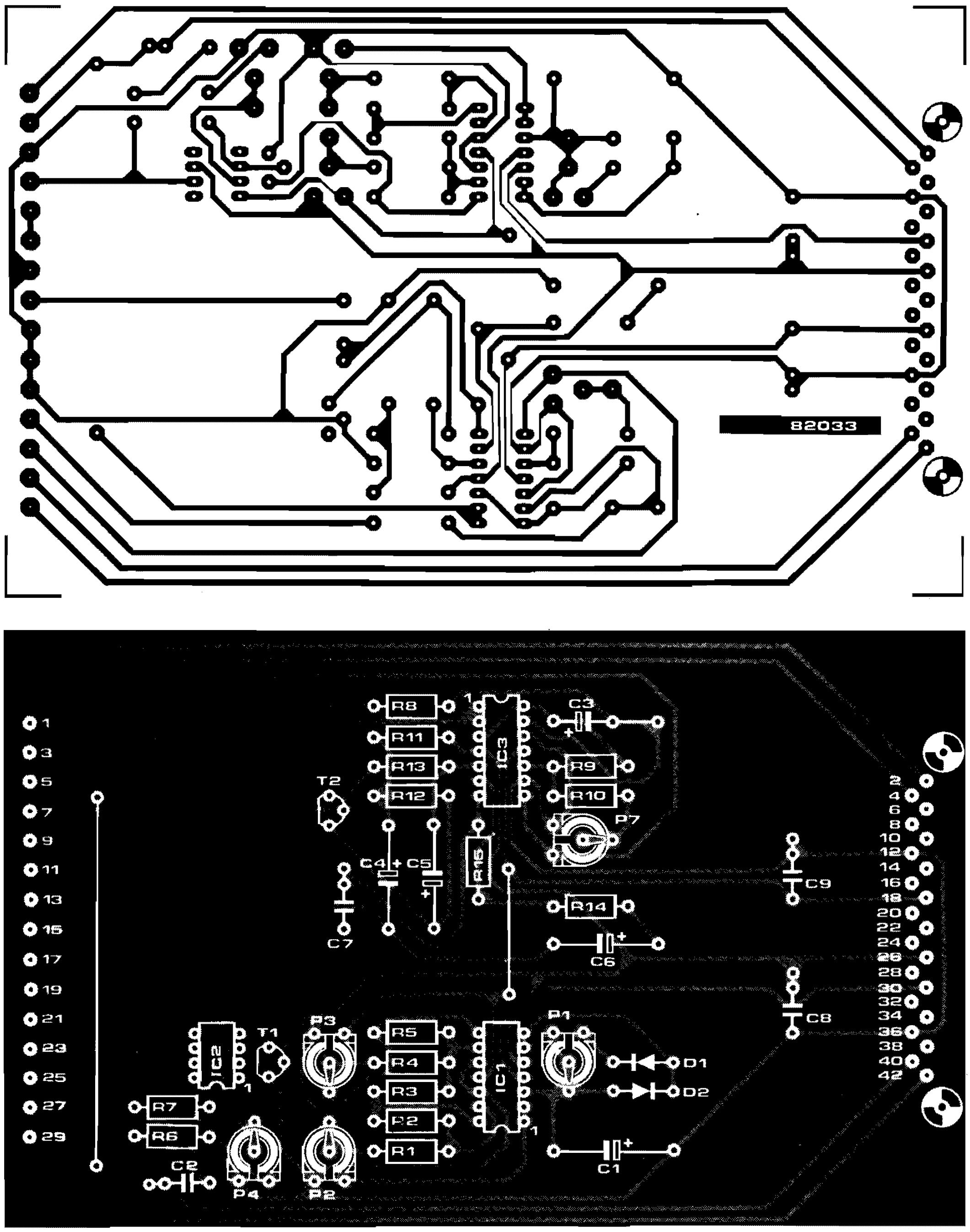

Figure 9. The printed circuit board and component overlay for the LFO/NOISE module.

quarter tone. The output voltage of the VCA should remain as low as possible.

Noise generator

The white noise produced by the base/emitter junction of an NPN transistor (with suitable gain) meets the requirements set for electronic music purposes (see lower section of figure 5). The noise signal can be fed directly to the audio input of the VCF (near R3 on the VCF/VCA module) by way of potentiometer P8.

If the filter is in the 'tracking' mode, melodies featuring pink noise can be played. The sound of the wind can be imitated by changing the cut-off characteristics of the filter. Figure 7 shows how to connect the LFO/NOISE module to the rest of the synthesiser. Steam engines, percussion effects and pistol shots can all be imitated by using various ADSR curves. ◼