WAVEFORM MULTIPLIER

A single VCO on a synth is, to be honest, pretty boring. Generate rich multiple oscillator sounds by hooking it up to one of our multiplier boards. Design by David Ward-Hunt.

Many synthesisers, both mono and polyphonic, utilise two or more VCOs, slightly detuned, to generate a rich chorusing sound. Chorus or phasing treatment of a single VCO can go some way towards livening up the sound, but these tend to suffer from a rather repetitive sweep and on some units a considerable amount of background noise during periods of silence — not to mention aliasing when used with high frequency high harmonic content waveforms which any decent synthesiser is capable of producing.

The beauty of using two or more slightly detuned oscillators is that in addition to producing a full chorusing sound, the problems of background noise and bandwidth are eliminated. However, multiple VCOs don't come cheap! An alternative method of achieving a 'multiple oscillator sound' is to generate additional waveforms from the existing VCO output. If each of these 'new' waveforms is out of phase with the original and with each other, then a fuller sound will be heard. However, the richness of the sound from multiple oscillators comes not from the fact that they are out of phase with each other, but from the fact that the phase difference is continually changing — the ear perceives phase *change* rather than phase difference. Therefore it is necessary not only to have additional out-of-phase waveforms, but their phase differences should be continually moving with respect to each other and the original.

A Passing Phase

The circuit described here does just that. It will accept sawtooth, triangle or sine wave inputs, though with the latter two the output will bear little resemblance to the original waveform due to the circuit action: however, they are still useful sounds to experiment with. The circuit has been used successfully to treat the VCO sawtooth outputs from a number of synthesisers including the Transcendent, Digisound '80 and PE Minisonic; it has also been used with a Korg Sigma and Roland SH02 (see the interfacing notes below). The one disadvantage of the circuit (there has to be one, doesn't there?) is that for setting-up purposes, constructors will need access to a scope or a second VCO with which to adjust the circuit to produce the correct waveforms.

The picture shows how the prototype was mounted in a Teko Alba A23 case, but this is not essential and most people will build the boards into their synth.

Using The Multiplier

The multiplier board is fed with the output from your existing VCO. With a sawtooth waveform fed to the circuit, the output is a series of six sawtooth waveforms each individually phase modulated and mixed with the original sawtooth from the VCO. One multiplier PCB (generating six 'new' waveforms) is used with each VCO. If you do have two or more VCOs each feeding a separate multiplier board the effect is outstanding, especially when the VCOs are tuned to form a chord. The output from the multiplier(s) is then fed back to the synthesiser and treated by the VCF and VCA in the normal way.

Construction

The project consists of two PCBs. The first holds the modulation oscillators for phase modulating the multiplier; the second PCB holds the multipliers and associated circuitry. The reason for splitting the project into two PCBs is that one modulation PCB is sufficient to drive up to four multiplier PCBs. (In fact there is no reason why it wouldn't drive more; however, we believe that if you intend to use more than four multiplier boards, the small additional expense of another modulator is well worth it for adding an even richer sound.)

All the components are mounted on the two PCBs with the exception of two diodes which are mounted on a switch (thereby saving two wires from the PCB to the switch). The only external connections required are the VCO input and the output from the unit plus the power supply connections (see below) which ideally should

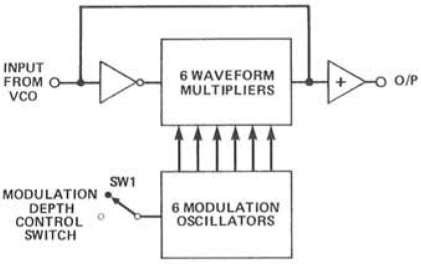

Fig. 1 Block diagram of the ETI Waveform Multiplier. Should you require an even richer sound, there's no reason why more than six multipliers shouldn't be used.

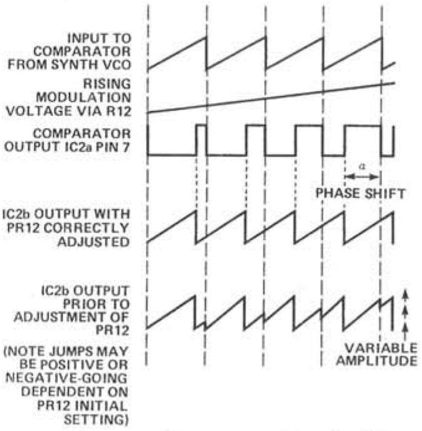

Fig. 2 The waveforms associated with various sections of the circuit. This indicates the operation of the unit and will also guide those people who are setting up the unit with an oscilloscope.

come from the same power supply as the VCO being input to the unit.

Interwiring between the PCBs should be clear from the diagram, as should the wiring up of the switch with its associated zener diodes. The switch is a DPDT with centre off and it is essential (for setting-up purposes if nothing else) to have this 'off' position (see Buylines).

A note is in order here about the component numbering. In order to make the numbering clearer and logically the same for each of the six multipliers on the PCB, each resistor or preset is designated by a two-figure number. The first figure indicates which of the six multipliers it is associated with, and the second is the 'relative number' of the component. For example, R11 is 'R1' on the first multiplier, R21 is 'R1' on the second multiplier, R35 is 'R5' on the third multiplier and so on.

With regard to the modulation PCB, though all the capacitors are of the same value, take care not to mix up the resistors associated with the two oscillators, as each oscillator should have all three of its resistors the same value. If not, the modulation output waveform will take on a pulse form at the output associated with the first op-amp in each oscillator.

PARTS LIST

MODULATION BOARD

Resistors (all ¼W, 5%)

R1–3	1M8
R4–6	2M2

Capacitors

C1–8	100n polyester

Semiconductors

IC1	LM324
IC2	LM1458
ZD1,2	6V2 400 mW zener

Miscellaneous

SW1	DPDT with centre off (see Buylines)
PCB	(see Buylines)

MULTIPLIER BOARD

Resistors (all ¼W, 5%)

R1–3, 11,12,13,14, 15,16,21,22, etc to 66	100k (39 in total)
R4	18k

Potentiometers

PR11–61	100k miniature horizontal preset (six in total)
PR12–62	220k miniature horizontal preset (six in total)

Capacitors

C1,2	47u 16 V PCB electrolytic
C3–6	100n polyester

Semiconductors

IC1	LM1458
IC2–4	LM324
D1–6	1N4148

Miscellaneous

PCB (see Buylines); case to suit (Teko Alba A23); sockets to suit.

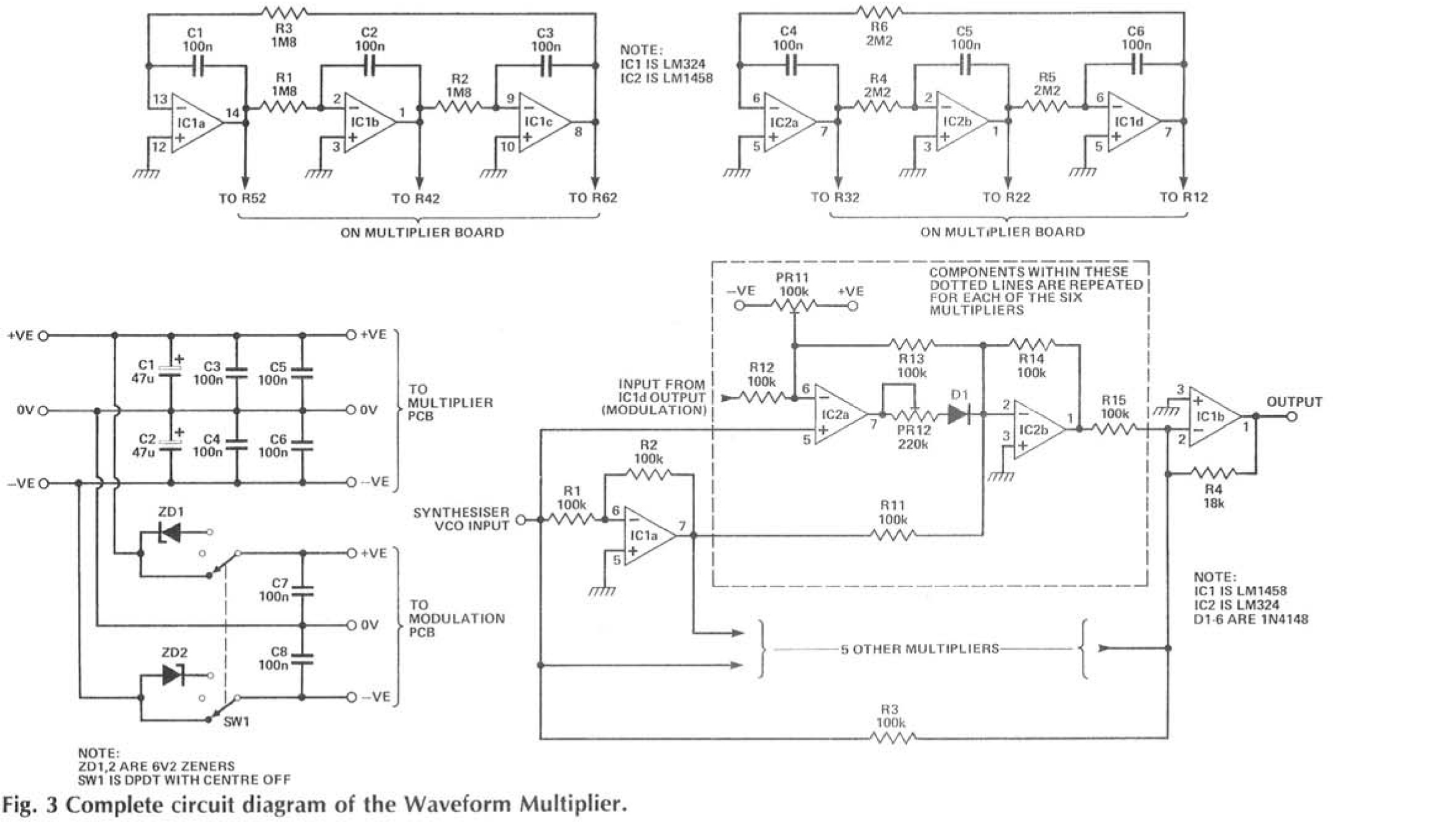

Fig. 3 Complete circuit diagram of the Waveform Multiplier.

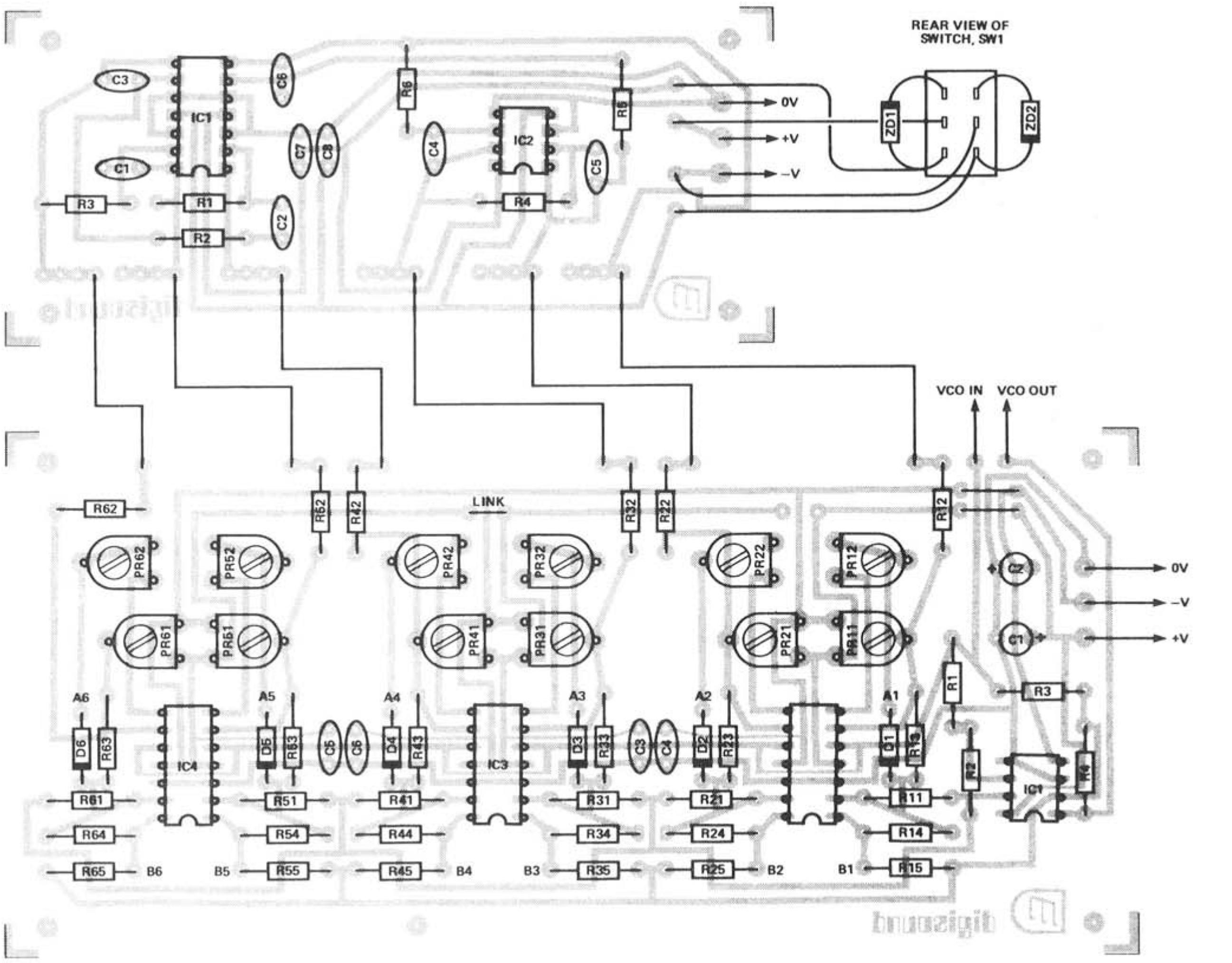

Fig. 4 Component overlays for the modulator board (top) and the multiplier board (bottom), and the interwiring required. Several multiplier boards may be driven from one modulator board.

HOW IT WORKS

The modulation oscillators are based on a standard three phase oscillator; two of these are used. Each of the three integrators in the loop outputs a waveform that is one-third of a cycle behind the others. The speed of the two oscillators is set at about 0.6 Hz and 0.4 Hz respectively. This modulation rate was found to give the best simulation of a number of oscillators running in free phase over a wide keyboard span.

It should be noted that the output of these oscillators is, in fact, a trapezoid shape waveform and it might be thought that some filtering would be required to produce a waveform more akin to a sine wave. This was tried in the development stage, but in practice the trapezoid waveform gave a better randomness to the overall output, whereas with a sine wave modulation a more definite sweep could be detected on long sustained notes.

Referring now to the multiplier circuit, the output from the synthesiser VCO is taken to IC1a configured as an inverter/buffer; the VCO waveform also goes to one input of the comparator IC2a. The other input of the comparator is fed with a voltage set up on PR11 together with the modulation voltage via R12. With a positive-going sawtooth, the point at which the comparator goes high is determined by the sum of the fixed voltage from PR11 and the modulating voltage via R12. As shown in the waveform diagram, with a rising modulation voltage the width of the pulse at the comparator's output increases. However, the comparator will, of course, always reset at the same moment as the VCO sawtooth. Thus the comparator's reset is synchronised with the original sawtooth, whereas its positive-going excursion can be voltage-controlled to any point within one cycle of the input waveform.

The output of the comparator is rectified by D1 and summed with the inverted sawtooth from IC1a via R11. These voltages (actually currents) result in a new sawtooth whose reset point is determined by the positive-going edge of the comparator. Thus, as shown in the waveform diagram, this new sawtooth is phase-shifted from the original and the amount of phase shift is dependent on the comparator pulse width. The output of the summing amplifier IC2b is taken via R15 and mixed with the other multiplier outputs plus the original sawtooth (via R3), where IC1b acts as the mixing amplifier.