

HARMONY GENERATOR



- ★ Fixed accurate harmonies, unison, 3rd and 5th
- ★ Pitch shift up or down 3 octaves
- ★ Ideal accessory for the synthesist
- ★ Powered by a single PP3 battery

by Paul Williams

**KIT
COST ONLY
£15.45**

Harmonisers are beginning to attract much attention from musicians, particularly for use in live performances where they can 'thicken up' the sound tremendously. Most musicians, however, cannot savour the delights of the harmoniser due to its very high cost. The only pitch change device within the price range of the average musician is the octave divider type of accessory used by guitarists. Between these two devices there appears to be a void.

The E&MM Harmony Generator is intended to fill this void, being a compromise between the simplicity of the octave divider and the versatility of the harmoniser. The Harmony Generator can give up to three octaves of pitch shift, up or down, including individually selectable intervals of '3rd' and '5th' harmonics. The pitch shifts are digitally derived and are thus very stable, obviating the need for precise setting-up and pitch shift adjustments during a performance. The Harmony Generator can, however, only accept monophonic signals from a source such as a mono synthesiser. Indeed this is an ideal device for use with a single VCO synthesiser, greatly extending its versatility.

The Harmony Generator will not only follow the pitch of the instrument, but also the amplitude, applying the same amplitude envelope to the harmony signal as that of the instrument. A mixer is provided so that the contrast between the instrument and harmony signals can be optimised.

Design Principles

The block diagram, Figure 1 shows the basic functional circuit

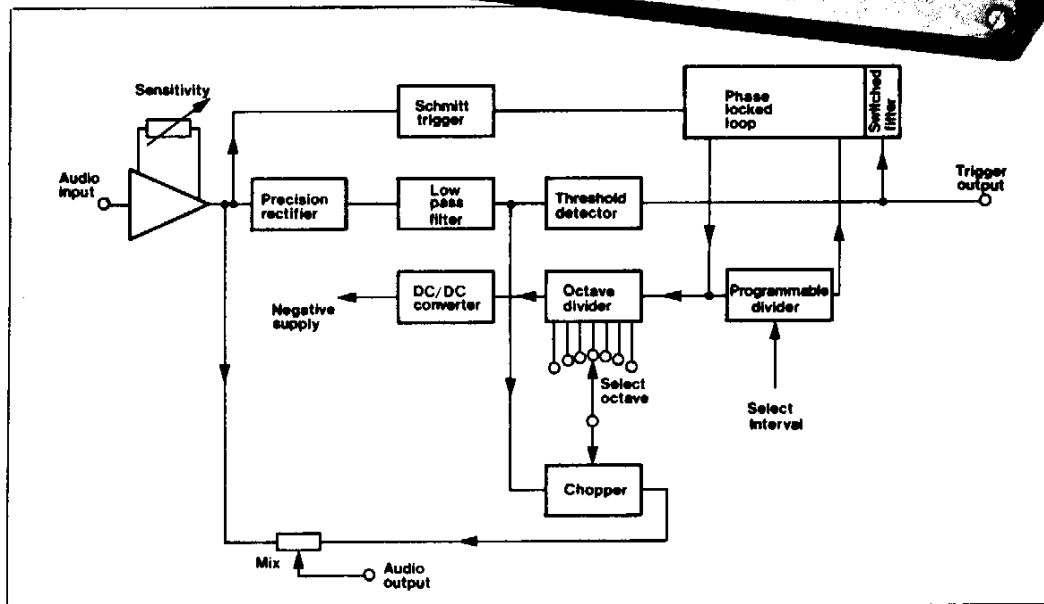


Figure 1. Harmony Generator block diagram.

elements. The heart of the unit is the phase-locked loop (PLL), which allows frequency multiplication to be performed. The PLL effectively compares the input frequency with that fed back from the output of its internal voltage controlled oscillator (VCO). It will adjust the voltage applied to the control input of the VCO, and hence alter its frequency until the two frequencies are the same. Since the programmable divider is in the feedback path of the PLL, the VCO output frequency will be a multiple of the input frequency. The ratio between them being the same as the division ratio of the programmable divider, which is selectable. The octave divider successively divides the fre-

quency from the VCO output providing several outputs at one octave intervals below the VCO output frequency.

The nominal division ratio of both the programmable divider and octave divider is 64, thus for unison harmony, the VCO will operate at 64 times the input frequency. To achieve the interval '3rd', the pitch must be shifted up by 4 semitones, which is an increase in frequency of $(\sqrt[12]{2})^4 = 1.26$, close to $81/64$. Thus for the interval '3rd', the programmable divider must be set to $\div 81$. Similarly for the interval '5th', a 7 semitone shift is needed, or $(\sqrt[12]{2})^7 = 1.5$, or $96/64$. Thus the programmable divider must be set to $\div 96$.

The precision rectifier provides a DC voltage which follows the amplitude envelope of the input signal. The threshold detector senses when the signal is of sufficient amplitude to reliably operate the Schmitt trigger in the PLL input line. Also at this signal level the trigger output is activated for the operation of external envelope generators, synthesisers etc. Below this threshold level, the PLL filter is switched in such a way as to 'freeze' the operating frequency, enabling the note to decay normally, even when the input signal level falls below the Schmitt trigger threshold.

Another DC output is taken from the precision rectifier which

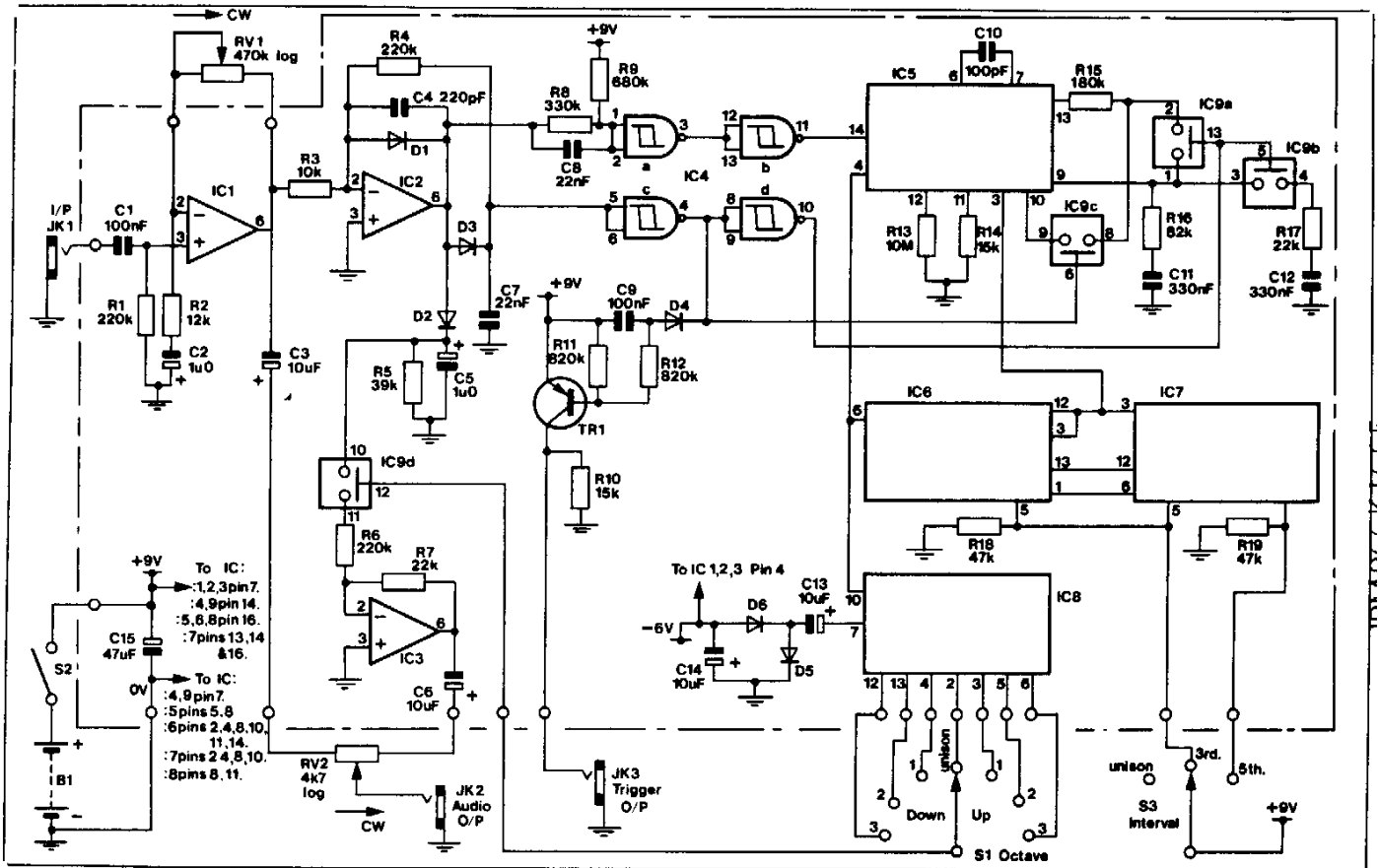


Figure 2. Harmony Generator circuit diagram.

is chopped at the frequency selected from the octave divider. This AC signal which has the amplitude of the input signal and the frequency of the octave divider output selected, is the harmony signal. It takes the form of a square wave and is mixed with the input signal to become the combined output.

Circuit

IC1 forms a conventional non-inverting AC amplifier, its gain being adjusted by RV1, allowing an input signal range of 5mV to 200mV RMS to be accepted. IC4a, b form the Schmitt trigger which 'cleans up' the signal from the precision rectifier, IC2, to the

output. PLL, IC5. C4 provides some attenuation of the higher frequency harmonics of the input signal.

The threshold detector IC4c, d controls the switches IC9a, c, which cause the PLL to freeze by disconnecting the voltage control source, pin 13, from the VCO input, pin 9. IC9b helps to keep the VCO frequency constant during a decaying note by disconnecting the short time constant filter R17, C12, leaving the longer time constant R16, C11 in circuit when the input signal amplitude becomes low. At higher signal levels, IC4 pin 4 will go low, causing TR1 to switch on to provide a positive-going trigger

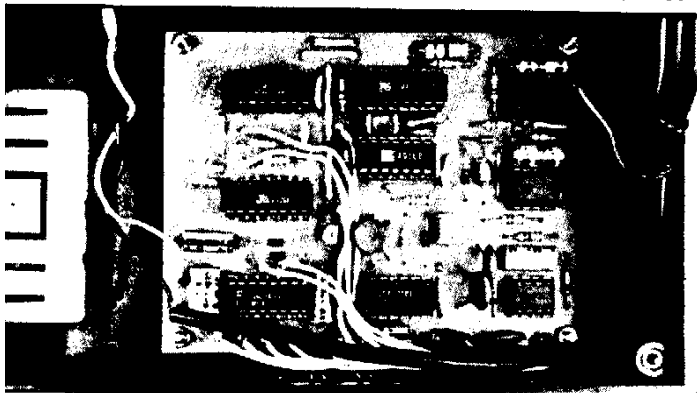
output.

IC6 & 7 comprise the programmable divider. Its division ratio is determined by the conditions on the programming inputs, selected by S3. A binary divider IC8 forms the octave divider, which again provides a division ratio of 64, with other outputs of divide by 8, 16, 32, 128, 256 or 512 selectable via S1. The selected signal controls the chopper IC9d, IC3. RV2 then mixes the chopped DC voltage from the precision rectifier with the untreated instrument signal from the output of IC1. The combined output signal at the wiper of RV2 has a typical RMS amplitude of 200mV.

An output from IC8 is used in conjunction with C13, 14, D5 and 6 to form a DC/DC converter, providing a negative supply voltage for the operational amplifiers. R13 ensures that the PLL VCO free-running frequency, and hence the frequency at pin 7 of IC8, is sufficiently high to allow the DC/DC converter to operate correctly. Since the circuit is CMOS based, the complete unit takes very little power; approximately 4mA from a PP3 battery.

and component layout of which is shown in Figure 3. Assembly should commence with the resistors, diodes and capacitors, taking care with the polarisation of diodes and electrolytic capacitors, according to the component layout shown. Next solder in the IC sockets for all the CMOS ICs (IC4-9), but do not insert the ICs at this stage. The operational amplifiers IC1, 2 and 3 can be soldered directly into the PCB, along with the transistor TR1, again taking care with orientation. When assembly of the PCB is complete, the CMOS ICs may be inserted into their appropriate sockets, exercising the usual anti-static precautions.

Before mounting the jack-sockets, pots and switches on the front panel, adjust the rotary switch end-stops by inserting the tab of the washer into the appropriate end-stop hole; 7 for S1 and 3 for S3. Wire the sockets, pots, switches and the battery holder to the PCB according to the wiring diagram Figure 3. Use screened cable for the connections to the input socket, JK1, and sensitivity control, RV1. The screen of the cable to RV1 does not go to 0V but is used as the through connection from IC1 pin 6 to RV1.



Internal view of Harmony Generator.

Construction

All the components are contained on a single PCB, the track

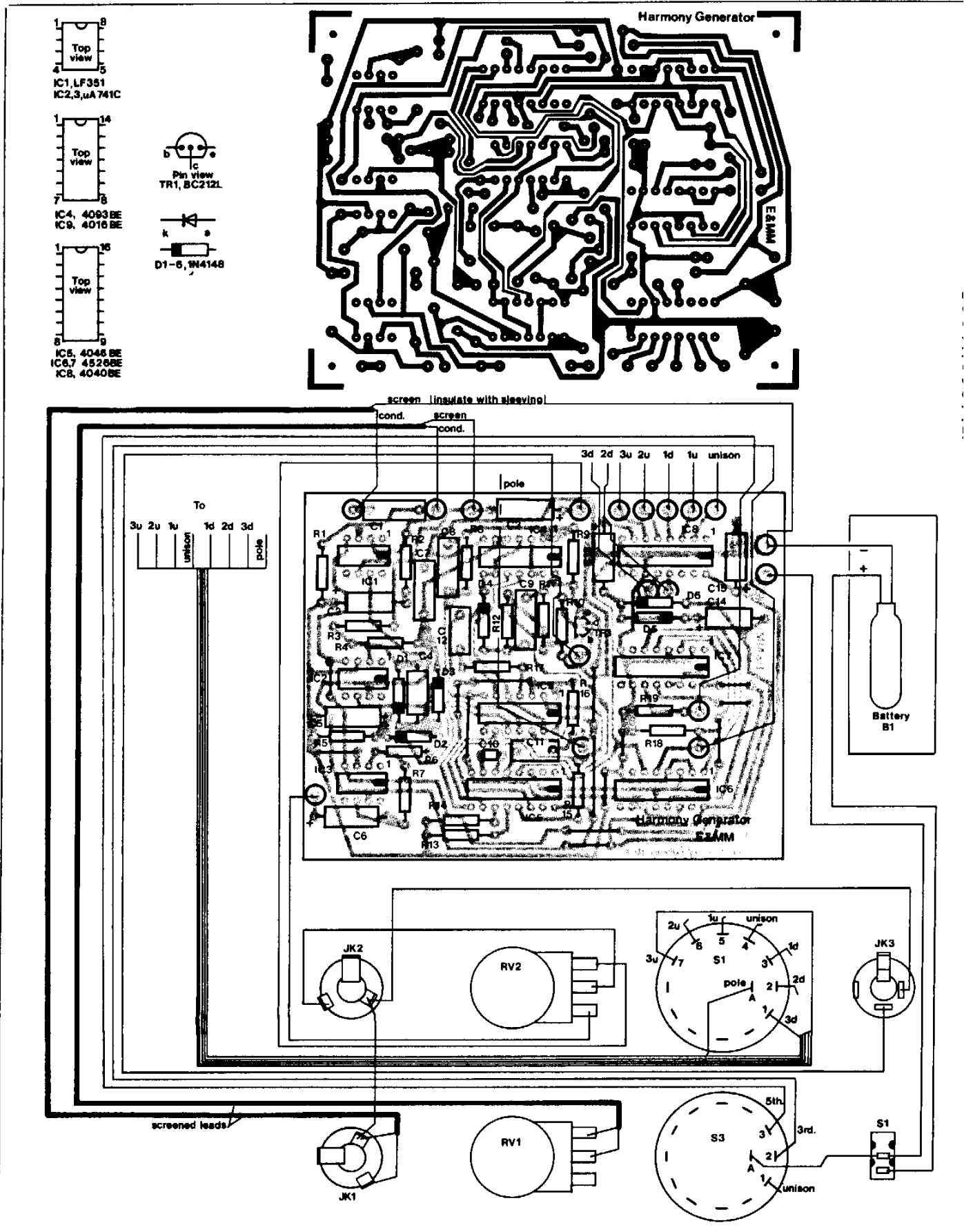


Figure 3. PCB track, component layout and wiring diagram.

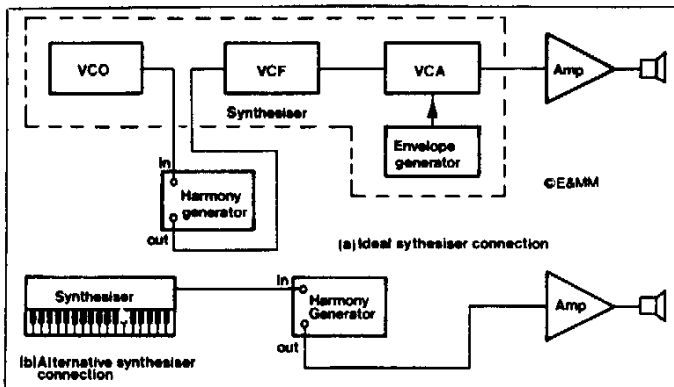


Figure 4. Harmony Generator/synthesizer connections.

Operation

There are no presets to adjust in this project; just connect the Harmony Generator's input to your synthesiser and the output to your monitor amplifier. Switch the unit on and set the controls initially as follows: sensitivity anticlockwise; mix clockwise; interval and octave as required. Play some notes on the synthesiser and advance the sensitivity control until the Harmony Generator just starts to lock on to and follow the frequency of the synthesiser. The mix control can then be adjusted to give the desired contrast between instrument and harmony signals. The Harmony Generator is now ready for use.

It is as well to understand the few limitations of this device so that the best use can be made of it. Only a single note at a time can be handled; it is not capable of dealing with polyphonic signals. Since high amplitude harmonics can also cause instability, high VCF Q values should be avoided. This applies also to the use of audio frequency FM, although the unit can cope with vibrato type FM. AM does not present quite such a serious problem, as long as the modulation depth is not too great. If a slow attack is used, then a pitch jump might be noticed as the amplitude passes through the threshold level. This effect can be

reduced by advancing the sensitivity control.

The fact that the harmony signal is a square wave does not seem to be too much of a disadvantage since the mixed instrument signal gives the overall sound sufficient character. This can be further improved by putting all treatments such as phaser, flanger, reverb, echo etc, after the Harmony Generator.

Most of the above problems can be avoided altogether by using the ideal synthesiser connection scheme shown in Figure 4a. Here, the Harmony Generator is fed directly from the synthesiser VCO. The VCF Q setting will then make no difference to the stability. Also, the VCF will filter the Harmony Generator square wave, giving it extra character. The slow attack pitch jump problem also disappears since the amplitude envelope is applied after the Harmony Generator. If, however, you do not have access to these connections on your synthesiser, then you will have to settle for the connection scheme shown in Figure 5b.

Although this project was designed primarily for use with a synthesiser, there is no reason why the circuit should not be used, or adapted for use with other instruments such as guitars (Figure 5), brass and reed instruments or even vocals. The main criterion to be satisfied is to

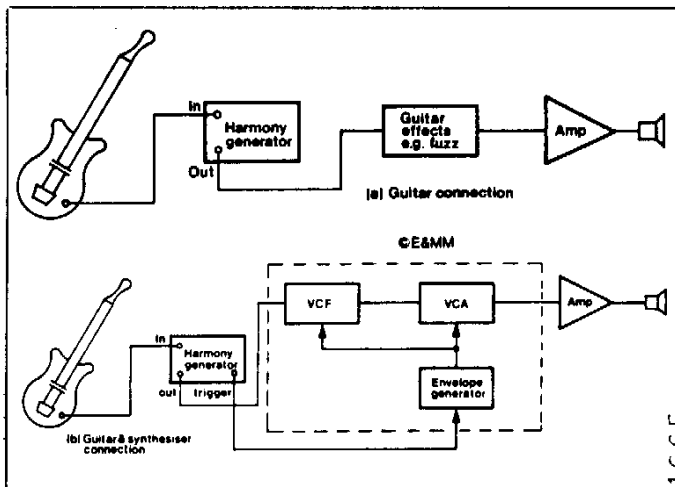


Figure 5. Harmony Generator/guitar connections.

attenuate any high amplitude harmonics. This might be achieved by altering the value of C4, or more ideally by preceding the Harmony Generator by a sharp cut-off low-pass filter. With the circuit in its present form, bass instruments cannot be used since the response to pitch

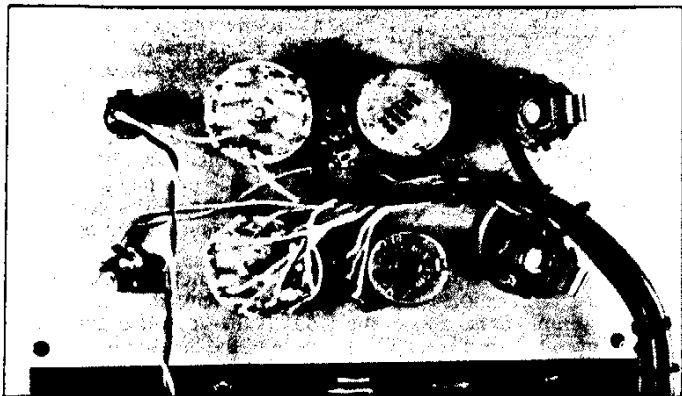
change becomes very slow at low frequencies. This could be improved somewhat by increasing the value of C7.

Once the synthesist has become familiar with this unit, he will find it an invaluable addition to his accessory collection.

PARTS LIST FOR HARMONY GENERATOR

Resistors — all 1% 0.4W metal film unless specified			
R1,4,6	220k	3 off	(M220K)
R2	12k		(M12K)
R3	10k		(M10K)
R5	99k		(M99K)
R7,17	22k	2 off	(M22K)
R8	330k		(M330K)
R9	680k		(M680K)
R10,14	15k	2 off	(M15K)
R11,12	820k	2 off	(M820K)
R13	10M		(M10M)
R15	180k		(M180K)
R16	82k		(M82K)
R18,19	47k	2 off	(M47K)
RV1	470k log pot		(PW27E)
RV2	4k7 lin pot		(PW01B)
Capacitors			
C1,9	100n ceramic	2 off	(BX03D)
C2,5	1u 63V axial electrolytic	2 off	(FB12H)
C3,6,13,14	10u 25V axial electrolytic	4 off	(FB22Y)
C4	220p polystyrene		(BX30H)
C7,8	22n ceramic	2 off	(BX01B)
C10	100p metalised ceramic		(W356L)
C11,12	330n polycarbonate	2 off	(W478)
C15	47u 10V axial electrolytic		(FB28H)
Semiconductors			
D1-6	1N4148	6 off	(QL80B)
TR1	BC212L		(QB60Q)
IC1	LF351		(WQ30H)
IC2,3	uA741C	2 off	(QL22Y)
IC4	4093BE		(QW53H)
IC5	4040BE		(QW32H)
IC6,7	4526BE	2 off	(QO44H)
IC8	4040BE		(QW27E)
IC9	4016BE		(QX06D)
Miscellaneous			
JK1,2	Jack socket	2 off	(WF91Y)
JK3	3.5mm socket		(WF82D)
S1,3	12-way rotary switch	2 off	(FF73Q)
S2	Ultra min toggle switch		(FH97F)
	14-pin DIL socket	2 off	(BL18U)
	16-pin DIL socket	4 off	(BL19V)
	Box M4005		(WY02C)
	PCB		(GA48C)
	Knob KB4	4 off	(RW87U)
	PP3 battery holder		(QO33L)
	PP3 battery		

Note: A complete kit (LW91Y) of all the parts listed is available from Maplin Electronic Supplies Ltd for a price of just £15.45 inc. VAT and P&P.



Rear view of front panel.

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