Waveform GENERATOR

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THIS versatile instrument provides sine, square, and triangular wave outputs of up to 10V peak-peak over a frequency range of 1Hz to 100kHz and is capable of driving resistive loads as low as 10Ω at full output. A separate 5V peak-peak square wave TTL-compatible output is available for testing logic circuits and for timing and synchronisation of the variable output where required. The instrument also incorporates a sweep facility which allows the output to be frequency modulated by an external signal. Thus permitting swept frequency response analysis and the generation of some interesting modulated tone effects.

The instrument uses four integrated circuits, three transistors and a handful of other components. Calibration is greatly simplified by the use of linear law frequency and output level controls. The specification more than adequately meets the electronic enthusiasts' requirements for a general purpose audio frequency signal generator. Furthermore, the added facilities make this an ideal project for constructors who wish to up-date their existing test equipment.

CIRCUIT DESCRIPTION

The complete circuit diagram of the Waveform Generator is shown in Figs. 1 and 2. The circuit is based on the versatile 8038 waveform generator integrated circuit which provides sine, square and triangular outputs derived from an internal voltage controlled oscillator. The frequency range is selected by S1 and decade capacitors C9 to C12. The duty cycle is set to 50 per cent by making R1 and R2 equal and fine frequency control is achieved by varying the d.c. potential at pin 8 of the 8038. Two pre-set resistors, VR2 and VR3, are used to set the maximum and minimum frequencies respectively at each end of VR1. Adjustment of the purity of the sine wave output is provided by VR4 and VR5. The desired output waveform is selected by S2 and fixed resistors, R4, R5 and R6, are included to provide equal peak-peak outputs with all three waveforms.

Control of the output amplitude is provided by VR6 with C13 included to remove the d.c. level from IC3 hence eliminating any d.c. off-set at the output of the direct coupled amplifier which follows. The TTL output is buffered by means of the emitter follower, TR3. Diode D2 provides protection from the reverse base-emitter voltage which occurs on negative half-cycles of the square wave output from IC3. The square wave output from TR3 emitter alternates between levels of 0V and +5V and is thus TTL compatible.

Operational amplifier, IC4, is used in non-inverting mode with pre-set gain adjusted by VR7 and frequency compensation provided by C16. Complementary symmetrical emitter followers, TR1 and TR2, provide current gain and reduce loading effects of the output on IC4. Fixed base bias for TR1

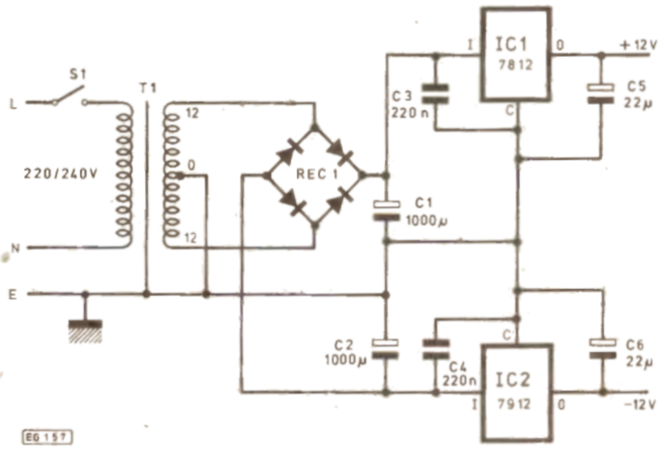


Fig. 1. Circuit diagram of the power supply

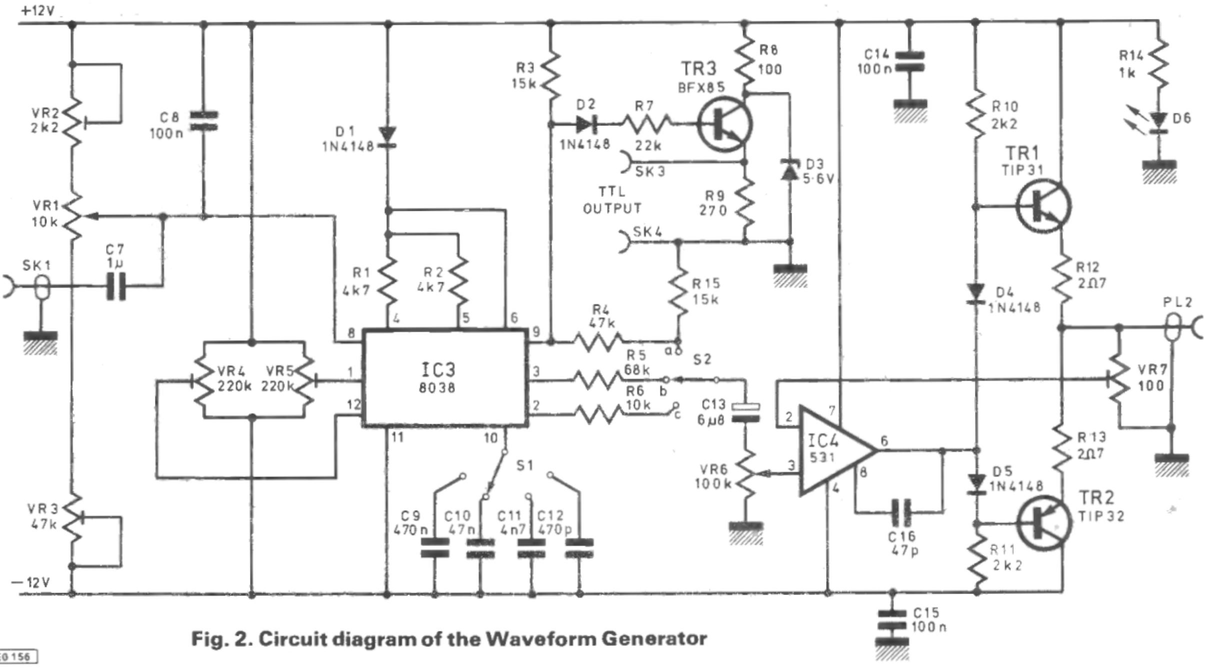


Fig. 2. Circuit diagram of the Waveform Generator

and TR2 is provided by forward biased silicon diodes, D4 and D5.

Two integrated circuit regulators, IC1 and IC2, are used to provide positive and negative 12V regulated supply rails. A conventional centre-tapped bridge rectifier arrangement provides a source of d.c. for the regulators.

CONSTRUCTION

With the exception of the front panel controls, sockets, mains transformer and capacitors, C1, C2, C7 and C9 to C13, all components are mounted on a single printed circuit board. The p.c.b. is shown in Fig. 3 and the component overlay in Fig. 4. When mounting components on the p.c.b.,

SPECIFICATION

Frequency Range
Continuously variable from 1Hz to 100kHz in four linear decade ranges:
1Hz to 100Hz
10Hz to 1kHz
100Hz to 10kHz
1kHz to 100kHz

Waveforms
Sine, square and triangle.
Separate TTL compatible square wave output.

Output voltage level
Variable up to 10V peak-peak in one linear range for pure resistive loads of greater than 100Ω. Maximum r.m.s. voltage developed into a 10Ω resistive load (sine wave at 1kHz) = 2·5V.
TTL output fixed at 5V peak-peak.

Output impedance (variable output)
Less than 0·25Ω measured at 1kHz sine wave.

Output impedance (TTL output).
100Ω measured at 1kHz.

Minimum recommended load impedance (variable output).
4Ω.

Optimum load impedance (variable output).
8Ω to 15Ω.

DC off-set at output (variable output).
Less than 10mV.

THD (sinewave).
Typically better than 3 per cent at 1kHz with full output developed into a 100Ω resistive load.

Ramp linearity (triangle wave).
Better than 3 per cent at 1kHz with full output developed into a 100Ω resistive load.

Rise time (variable output square wave)
typically better than 0·5μs at 1kHz measured using full output into a 100Ω resistive load.

Rise time (TTL output).
Typically better than 0·3μs at 1kHz measured using full output into a 100Ω resistive load.

FM sweep.
FM sweep input facility (a.c. coupled) provides frequency modulation of the output signal. The input impedance depends on the setting of the frequency control but is typically around 10kΩ. An input of 420mV peak-peak is sufficient to sweep the oscillator through approximately 10 per cent of the range selected. The FM sweep sensitivity on each range is as follows: 26·7Hz/V, 267Hz/V, 2·67kHz/V, 26·7kHz/V.

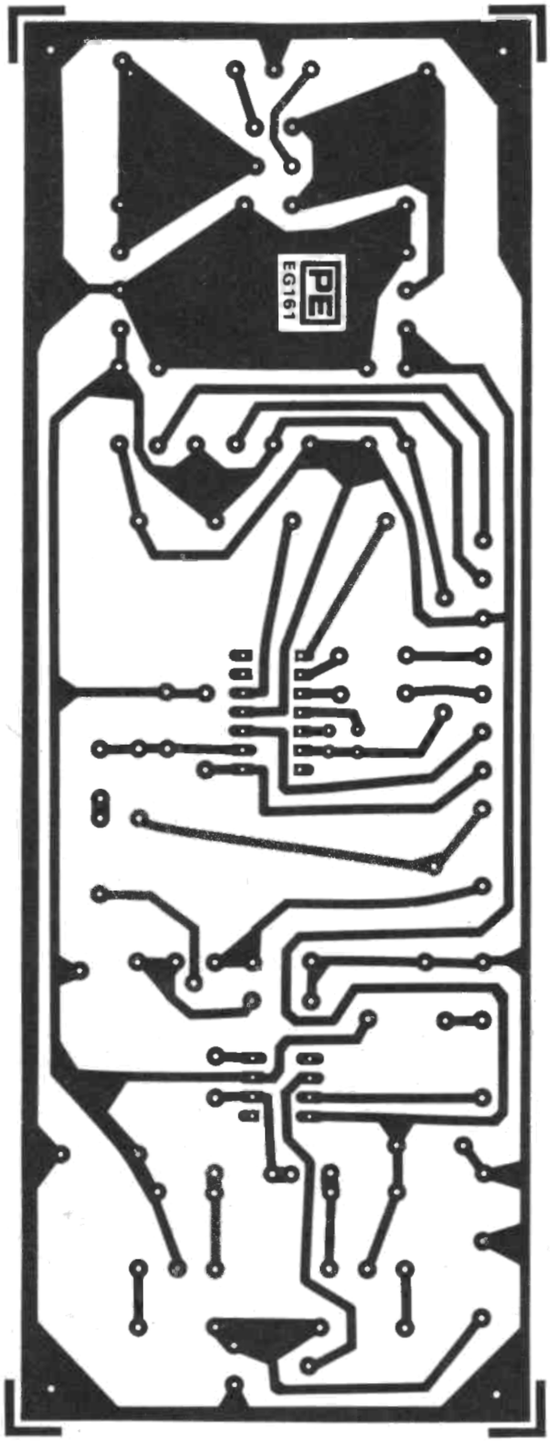


Fig. 3. Printed circuit board design

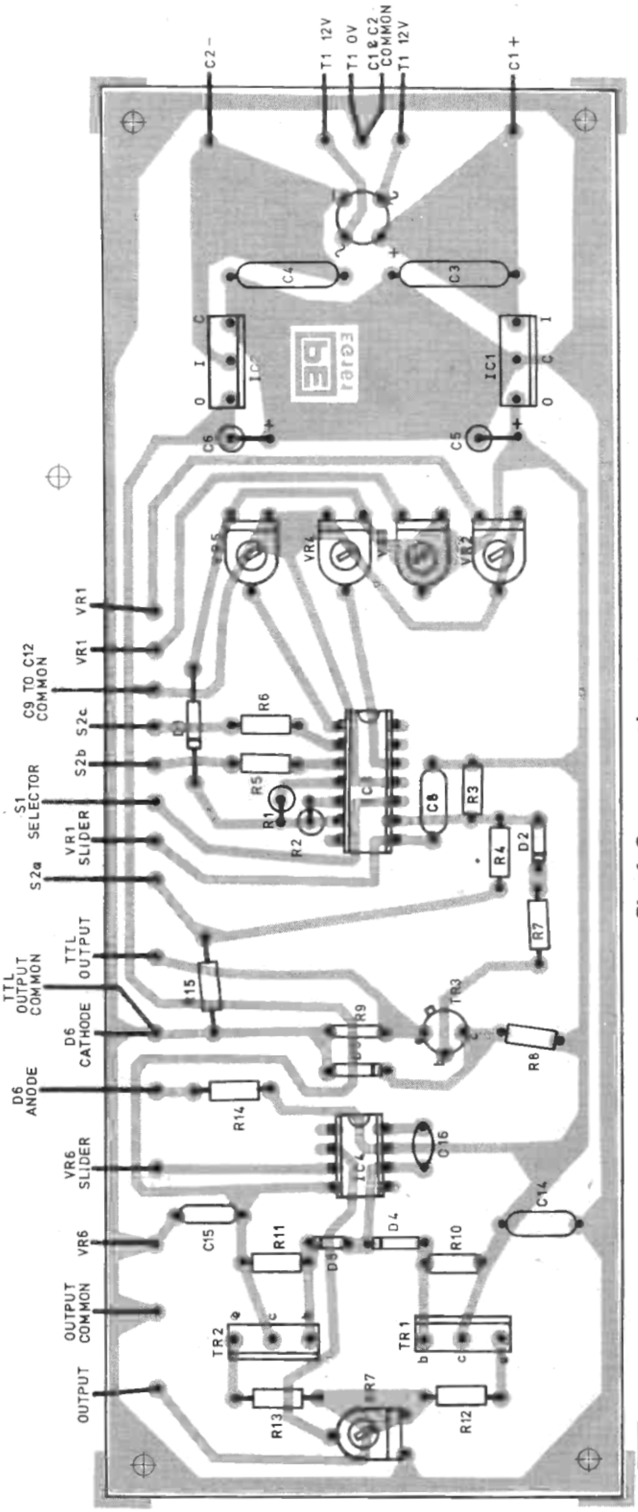


Fig. 4. Component layout

COMPONENTS . . .

Resistors

R1, R2	4k7 (2 off)
R3, R15	15k (2 off)
R4	47k
R5	68k
R6	10k
R7	22k
R8	100
R9	270
R10, R11	2k2 (2 off)
R12, R13	2Ω7 (2 off)
R14	1k

All resistors ¼W 5% carbon

Capacitors

C1, C2	1,000µ 25V elect
C3, C4	220n polyester
C5, C6	22µ 25V elect
C7	1µ polyester
C8, C14, C15	100n polyester
C9	470n polystyrene
C10	47n polystyrene
C11	4n7 polystyrene
C12	470p polyester
C13	6µ8 63V elect
C16	4µ7 ceramic

Potentiometers

VR1	10k lin
VR2	2k2 sub-min hor
VR3	47k sub-min hor
VR4, VR5	220k sub-min hor
VR6	100k lin
VR7	100 sub-min hor

Semiconductors

D1, D2, D4, D5	1N4148 (4 off)
D3	BZY88 5V6 Zener
D6	0·2 l.e.d.
REC 1	1A 100V bridge rectifier (WO1)
TR1	TIP 31
TR2	TIP 32
TR3	BFX85
IC1	7812 12V pos. reg.
IC2	7912 12V neg. reg.
IC3	8038
IC4	531

Miscellaneous

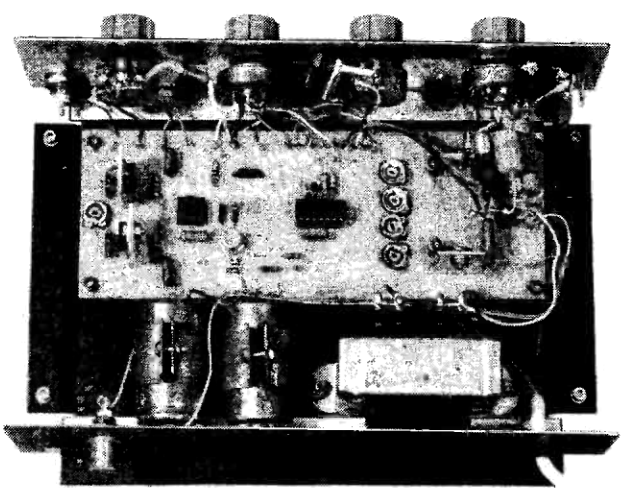
S1 1 pole 4 way rotary switch (3P 4W switch with two poles ignored)

S2 1 pole 3 way rotary switch (4P 3W switch with three poles ignored)

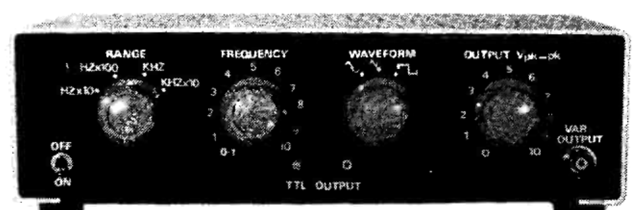
S3 miniature toggle switch s.p.s.t. Heat sinks (4 off) (see text).

T1 12V-0-12V 0·5A mains transformer

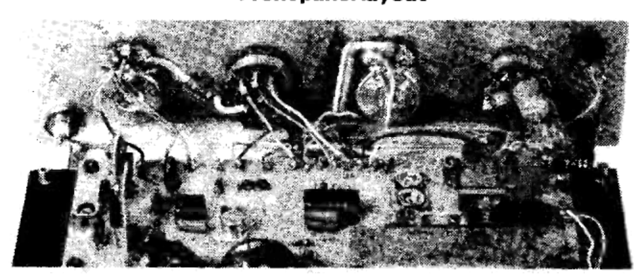
2mm sockets for TTL output (1 red, 1 black). BNC (or similar co-axial sockets) for variable output and FM input (2 off), knobs (4 off), case (Vero G-range G), printed circuit board, capacitor fixing clips (2 off), spacers (4 off).



Internal view of the Waveform Generator



Front panel layout

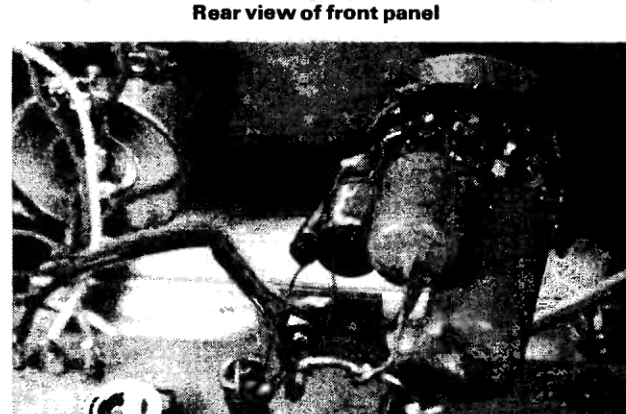


Rear view of front panel

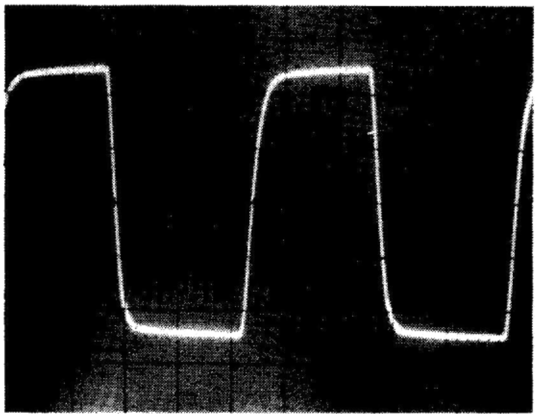
it is important to check the orientation of the transistors and integrated circuits. Four small heat sinks, consisting of around 900mm² 18 s.w.g. aluminium bent into a "U" shape (or proprietary types of between 15°C/W and 20°C/W), should be fitted to IC1, IC2, TR1 and TR2. The use of 14-pin and 8-pin dual in-line sockets in conjunction with IC3 and IC4 respectively is recommended. The p.c.b. is mounted using four short stand-off pillars located in the base of the instrument case. The reservoir capacitors, C1 and C2, are retained by two horizontal mounting clips.

Switch one has four capacitors (C9 to C12) soldered onto it with their ends soldered to a bus bar which can be formed out of 16 s.w.g. tinned copper wire as shown in the photograph.

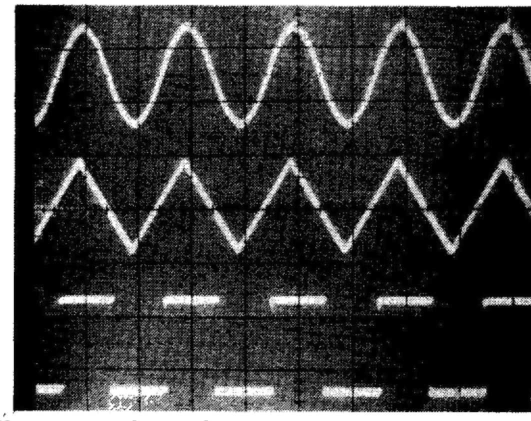
All the wiring leads should then be soldered including the links shown in Table 1.



Capacitor mounting on switch one



Square wave output at 100kHz. Vertical scale: 2V/cm; Horizontal scale: 2µs/cm



Sine, triangular and square wave outputs at 1kHz. Vertical scale: 2V/cm; Horizontal scale: 500µs/cm

WIRING LINKS (TABLE 1)

FROM	TO
VR1 slider	C7
S2 com.	C13 pos.
C13 neg	VR6
D6 cathode	Earth

INITIAL CHECKS AND CALIBRATION

After a careful visual examination of the p.c.b. and associated wiring, connect the mains supply and check that D6 is illuminated. The positive and negative supply rails should be checked using a d.c. meter. These should be within 0·5V of the nominal ±12V. Presets VR4, VR5 and VR7 should be set to mid-position. S1 should be set to position 2 (10Hz to 1kHz), S2 to "square", and VR6 set fully clockwise. VR3 and VR1 should be set fully anti-clockwise and VR2 adjusted to produce a square wave output at 8Hz as observed using either an oscilloscope or preferably a digital frequency meter. VR1 should then be set fully clockwise and VR3 adjusted for an output at 1·2kHz. The frequencies at the extreme ends of VR1 should then be checked on ranges 1, 3 and 4. If desired, calibration of the front panel control can be carried out at this stage. The 10Hz and 1kHz positions should be marked (these occurring almost at the extreme settings of VR1) as should intervals of 100Hz from 100Hz to 900Hz. The scale should be linear between these values.

Return S1 to position 2 and set VR1 to 1kHz. Check the sine and triangular wave outputs. VR4 and VR5 should, if necessary, be adjusted for a distortion free sine wave output. VR7 should be adjusted for a peak-peak output, at the maximum setting of VR6, of 10V. This is best accomplished by selecting square wave output and using an oscilloscope. VR6 can then be calibrated in 1V steps from 0V to 10V peak-peak output. Again, the scale should be linear. Finally, the 5V TTL output should be checked. A list of voltages is provided in Table 2 to assist in trouble-shooting the instrument. This completes the initial checks and calibration and the instrument is now ready for use. ★

TEST VOLTAGES (TABLE 2)

IC1	I	16·1		
	O	11·6		
	C	0		
IC2	I	−16·6		
	O	0		
	C	−12·3		
IC3	1	1·8	8	7·0
	2	−0·7	9	−2·3
	3	−0·7	10	−0·7
	4	7·0	11	−12·3
	5	7·0	12	−3·2
	6	10·8	13	0
	7	5·8	14	0
IC4	1	−11·9	5	−11·9
	2	0	6	0
	3	0	7	11·6
	4	−12·3	8	−10·8

		V
TR1	c	11·6
	b	0·6
	e	0
TR2	c	−12·3
	b	−0·6
	e	0
TR3	c	5·5
	b	2·6
	e	2·1

All of the voltages are measured relative to the common rail with the instrument adjusted to provide a sine wave at 1kHz and the variable output set to zero.