LOW COST AUDIO WAVEFORM GENERATOR

FEATURES

- Four Frequency Ranges
- Three Output Waveforms
- Push-Button Switching
- High and Low Level Outputs
- Minimal Wiring
- Battery Powered

APPLICATIONS

- Acoustic Engineering
- Testing Projects
- Gain and Phase Measurements
- Setting Filters
- Bandwidth Testing

by C S Barlow



The assembled unit.
(Box not included in kit).

Specification of prototype

DC power supply input:	±6V to ±9V
Current at ±9V:	±25mA
Standby current:	<±1µA
Waveforms:	Sine, Triangle, Square
Frequency ranges	
10 to 100Hz:	9Hz to 105Hz
0·1 to 1kHz:	100Hz to 1·1kHz
1 to 10kHz:	895Hz to 10kHz
10 to 100kHz:	9·2kHz to 106kHz
Output amplitude	
Full:	9V (Pk-to-Pk)
Attenuated:	400mV (Pk-to-Pk)
Output impedance:	600Ω
Sinewave distortion	
10Hz to 10kHz:	<1%
10kHz to 100kHz:	<4%
Triangle linearity	
10Hz to 40kHz:	<0·1%
40kHz to 100kHz:	<1%
Square rise/fall time:	<2µs

Introduction

To achieve optimum audio performance from home constructed kits, or manufactured equipment, usually requires a degree of testing and alignment. The majority of these tests are of a simple nature which normally require only a small adjustment of a preset component within the circuit. However, commercially available test gear often provide a level of technical sophistication which greatly exceeds that of the unit under test, and this fact is reflected in their high cost. For the hobbyist working on a restricted budget the need for a simple LOW COST audio waveform generator is apparent, and it was for this reason that Maplin have developed this project.

Every attempt has been made in making this kit as straightforward as possible, both in construction and operation. Three of the major stumbling blocks in any project design are as follows:

1. The number of off-board components.

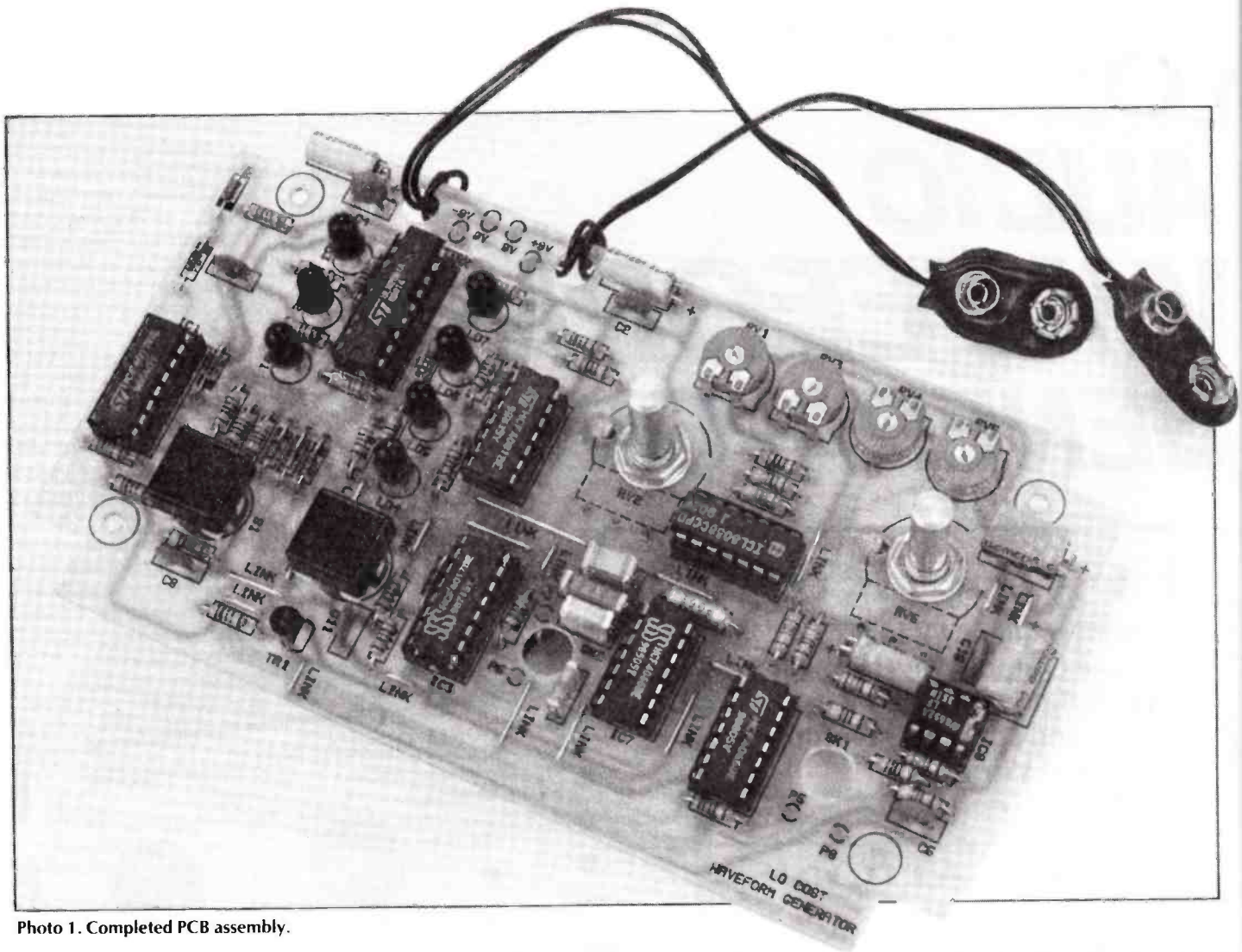


Photo 1. Completed PCB assembly.

2. The amount of wiring to and from the PCB.
3. Long term reliability.

In previous designs using standard rotary and toggle switches large amounts of messy wiring was necessary to hook everything up. Long term reliability was relatively poor owing to the number of moving parts within the switch mechanisms. However, by incorporating electronic switching all three design problems have been reduced to a minimum. This new project uses only two non-locking push-to-make PCB mounted switches to select one of four frequency ranges, one of three waveforms and power on/off.

Circuit Description

The 8038 waveform generator (IC6) is fabricated using advanced monolithic technology and only a few external components are actually required to produce a working system. However, to make it more versatile and controllable does require the following supporting ICs:

Function Control IC1 Power ON/OFF and waveform select.
Function Display IC2 LD1,2,3 Drive and −V power switch.
Function Output IC5 Sine, Triangle and Square output switch.
Range Control IC3 Selects one of four frequency ranges.
Range Display IC4 LD4, 5, 6, 7 Inhibitor.
Range Display IC2 LD4, 5, 6, 7 Drive.
Range Output IC7 Selects timing capacitor value on pin 10.
Output Buffer IC8 Provides a low impedance output.

Taking a closer look at IC6 reveals that the positive power supply is applied to pin 6, with the negative supply connecting to pin 11. The frequency of oscillation is set by two independent factors, the value of the timing capacitor on pin 10 and the sweep voltage applied to pin 7 and 8. Each timing capacitor is selected in turn by the switch action of IC7. For the lowest frequency range the largest value of capacitor is selected, which in this case is the combined values of C13 and C14. The second range switches in C15, next C16 and finally for the top range C17. To set the frequency sweep range a potential divider circuit comprising of RV1, RV2, RV3 and R31 is placed across the supply rails. Between the two preset resistors RV1, RV3 the upper and lower limits are set. Then the wiper of the main frequency control RV2 taps off the final voltage to pins 7 and 8 on IC6.

The symmetry of the three waveforms produced by IC6 is controlled by two fixed and two preset resistors. To achieve a duty cycle of 50%, R32 and R33 on pins 4 and 5 must be of identical value, the two preset resistors RV4 and RV5 on pins 1 and 12 are used to minimise sine-wave distortion. These corrected waveforms leave the IC on pin 2 sine, 3 triangle and 9 square, the signals then pass through IC5 which is used to select the desired waveform. Setting the amplitude of the waveform is achieved by adjusting RV6, but the impedance at this point is too high for some test applications. To correct this an amplifier, IC8, provides an output that will drive into loads as low as 600Ω. To provide a clean start/stop to the signal when the power is turned on and off the output passes through IC5 before connecting to the output sockets. The maximum output level produced by the generator on SK1 is approximately 9V peak to peak and this can result in overloading the input of some highly sensitive circuits. For this reason a second attenuated output with a maximum level of approximately 400mV peak-to-peak is made available on SK2.

The function and frequency range of the generator is governed by the electronic switching circuits IC1 to 5 and IC7. When the batteries are connected up for the first time, a reset pulse is generated and applied to pin 15 of IC1 and IC3. This ensures that the unit is in its power off mode, and the lowest frequency range is selected. Every time the function push switch S1, or the frequency range switch S2 is pressed a clock signal is generated on

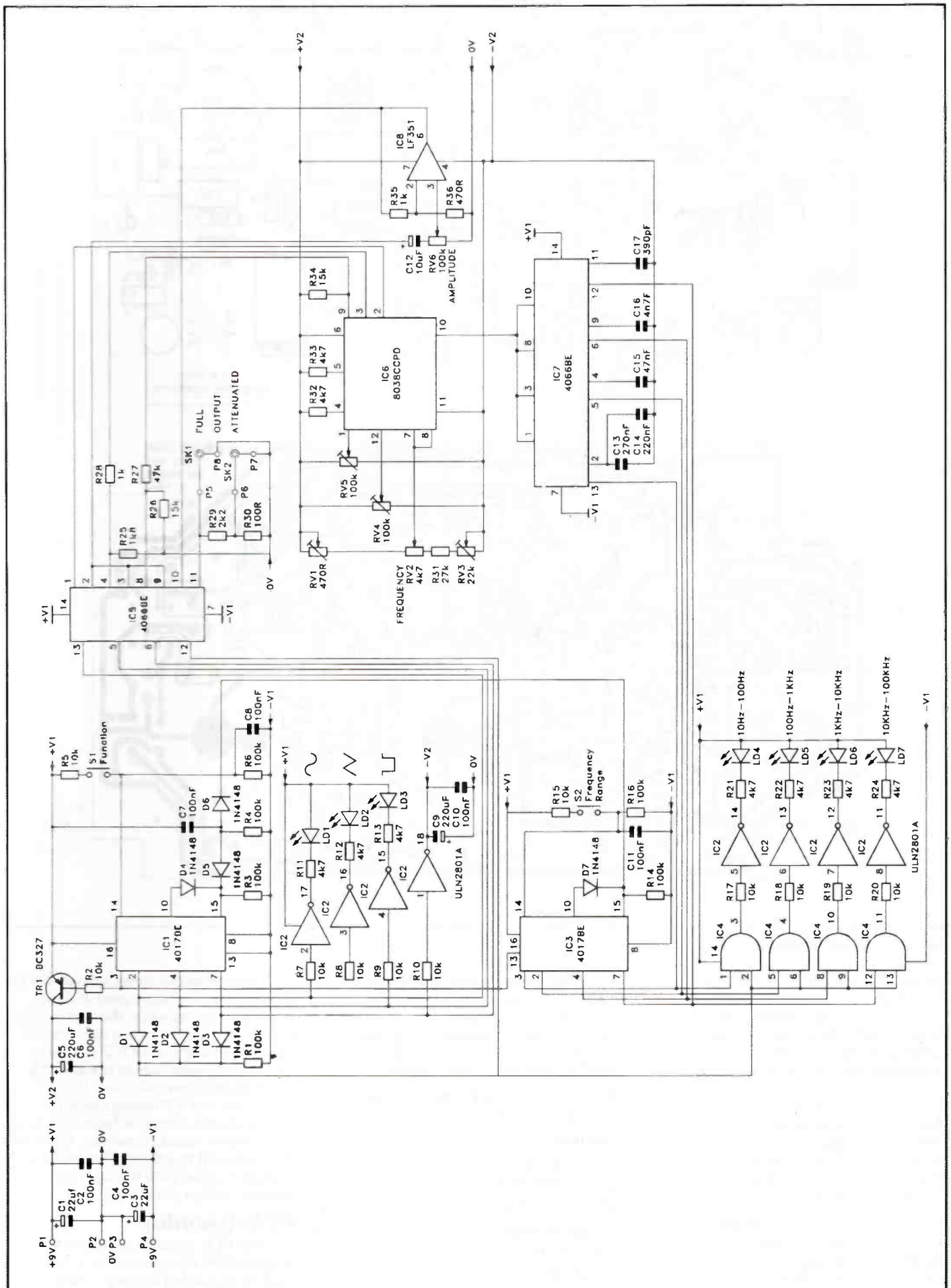


Figure 1. Circuit diagram.

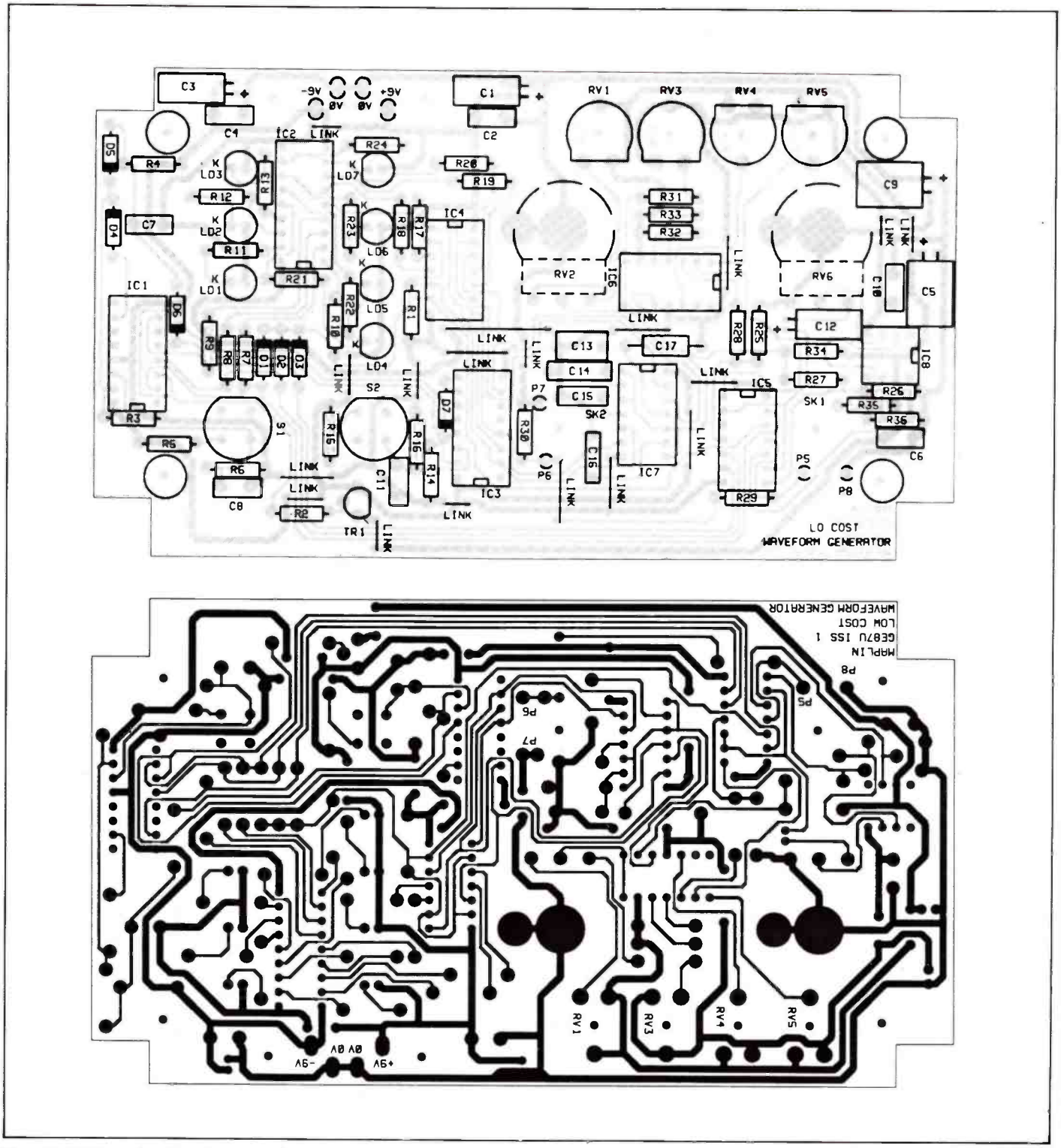


Figure 2. PCB legend and track.

pin 14 of their respective ICs (IC1 and IC3). Each IC has five outputs, the clock signal is used to step through them until the fifth one is reached which sends a reset pulse back to pin 15. The function of each IC pin is as follows:

IC1	Function
Pin 3	Power off
Pin 2	Sine-wave
Pin 4	Triangle-wave
Pin 7	Square-wave
Pin 10	Reset
IC3	Frequency Range
Pin 3	10 to 100Hz
Pin 2	0·1 to 1kHz
Pin 4	1 to 10kHz
Pin 7	10 to 100kHz
Pin 10	Reset

These outputs then control two more circuits which have similar characteristics to each other. To show which mode or frequency range you have selected each contains part of IC2 used to drive the following LEDs:

Function Control IC1 Power ON/OFF and waveform select.

Function

LD1 Sine-Wave

LD2 Triangle-Wave

LD3 Square-Wave

Frequency Range

LD4 10 to 100Hz

LD5 0·1 to 1kHz

LD6 1 to 10kHz

LD7 10 to 100kHz

The frequency range display circuit has an additional logic gate, IC4, to blank the display when the unit is in its power off mode, while in the function circuit, TR1 and part of IC2 is used to switch the power rails to IC6 and IC8.

The analogue switches, IC5 waveform and IC7 timing capacitor select, receive the same logic signals as the display circuits. However, this time they are used to activate the desired analogue signal path through the relative section of each IC.

PCB Assembly

The PCB supplied in the kit is a single-sided, fibreglass type, and a copy of its printed legend is shown in Figure 2. This should assist you in correctly positioning each component,

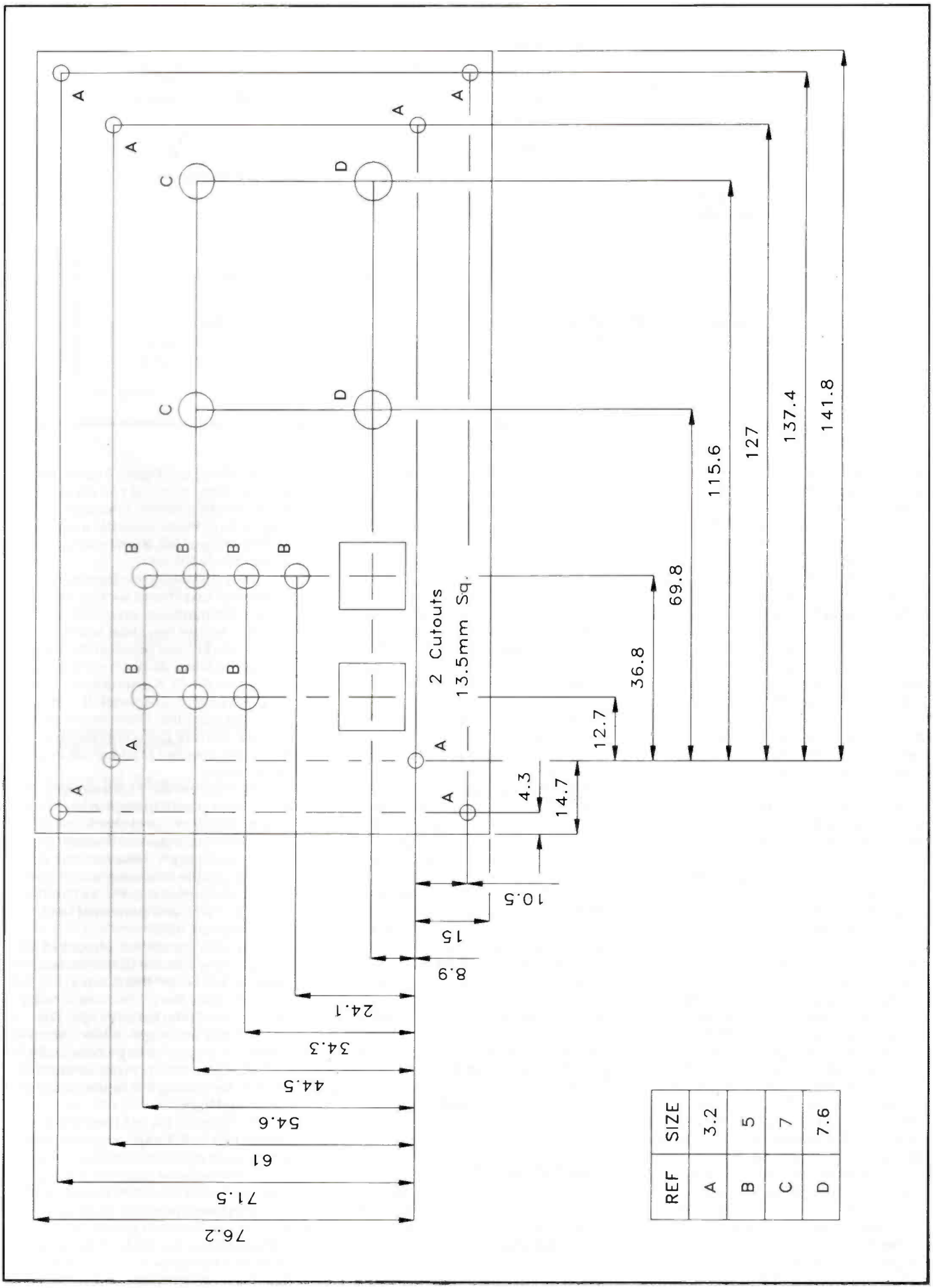


Figure 3. Front panel drilling details.

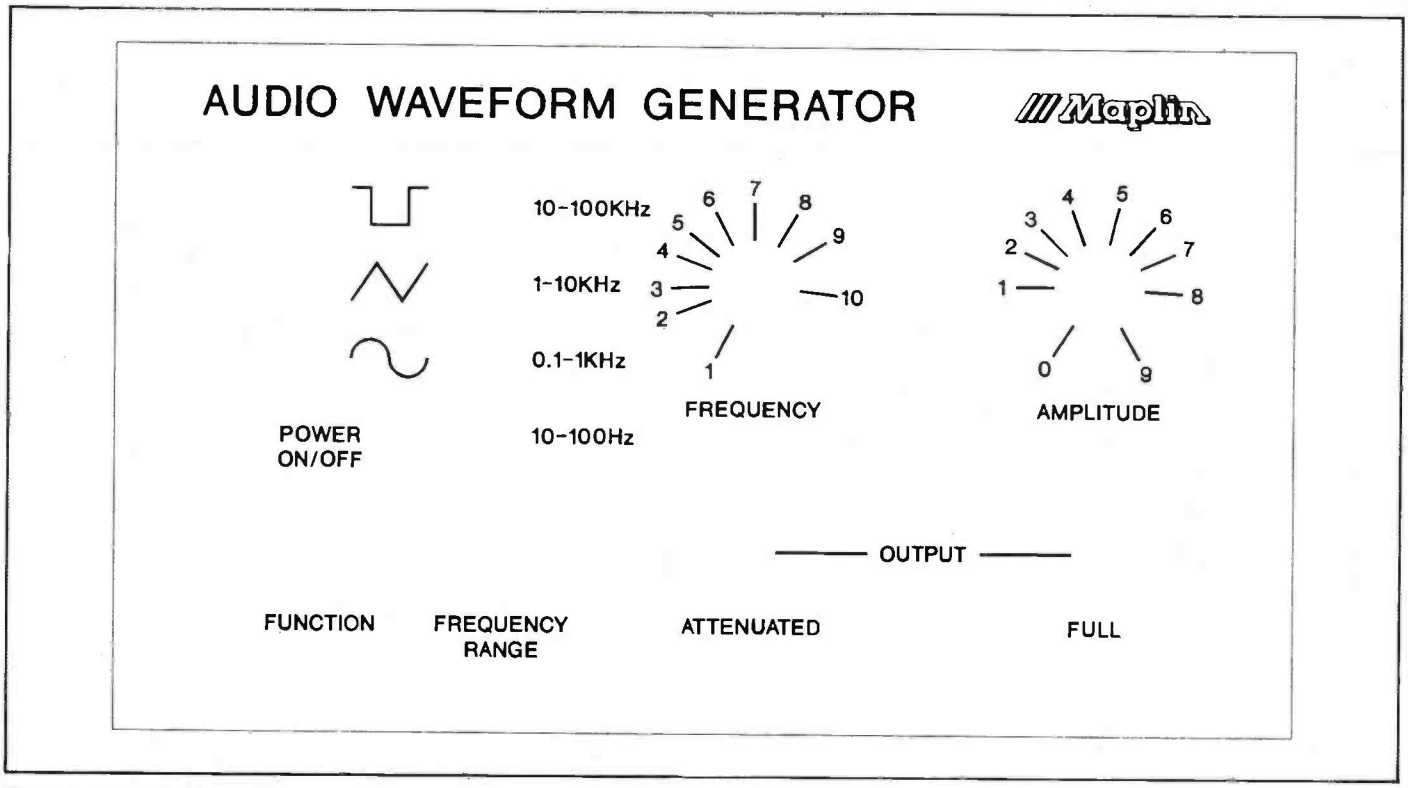


Figure 4. Front panel legend.

as removal of a misplaced item is quite difficult. Please double-check each component type, value and its polarity where appropriate, before soldering!

The sequence in which the components are fitted is not critical. However, the following instructions will be of use in making these tasks as straightforward as possible. For general information on soldering and assembly techniques please refer to the Constructors' Guide included in the Maplin kit. REMEMBER there is only a 10mm gap between the component surface of the PCB and the back of the front panel. Ensure that all the components, excluding the LEDs LD1 to LD7, are as close to the surface of the PCB as possible. Because of this restricted space the taller components must be pushed over so that they lie flat on the surface of the board. The following components have had their outlines printed on the legend to reflect this: C1 and C3, 22µF 25V PC Elect; C5 and C9, 220µF 16V PC Elect; C12, 10µF 50V PC Elect.

It is usually easier to start the assembly with the smaller components. Begin with the resistors R1 to R36 saving the component lead offcuts, using eighteen of these, bend them to fit the link positions on the PCB.

Next install the diodes, D1 to D7, making certain that the band on the component matches the markings on the board. When fitting the transistor TR1 ensure that its case matches the outline on the legend. The majority of the capacitors are installed and soldered in the conventional manner. However, when fitting the polarised electrolytic capacitors – C1, 3, 5, 9 & 12 – the lead nearest the negative symbol (–) on the component goes away from the positive sign on the legend, also remember to mount them as previously described.

When installing the two miniature rotary potentiometers RV2 and RV6 follow the mechanical assembly information provided in Figure 5, ensuring that you fit the correct value pot at each position. When secured, bend down the tags so that they are touching the pads on the track side of the PCB and solder them as shown. The seven LEDs LD1 to LD7 are all mounted 5mm above the surface of the board, see Figure 5. The short lead of each LED is cathode (K); this is also denoted by a flat along one side of the package, which must match up with its outline on the PCB legend.

Next mount the two click-effect push switches S1 and S2 making certain that the body of each switch matches its outline on the PCB. When fitting the IC sockets, make certain that you install the appropriate holder in each position, matching its end notch with the block on the legend.

Finally install the ICs ensuring that all the pins go into their sockets and the pin one marker is at the notched end. This completes the assembly of the PCB and you should now check your work very carefully making sure that all the solder joints are sound. It is also very important that the solder side of the circuit board does not have any trimmed component leads standing proud by more than 1mm, as this may result in a short circuit. The completed prototype PCB assembly is shown in Photo 1.

Final Assembly

The case in which the unit is designed to fit is the 'Metal Panel Box M4005' (WY02C). The main body of the box is moulded in black ABS plastic and does not have to be drilled or cut. In fact, the only preparation is to the aluminium top panel, see Figure 3 front panel drilling and Figure 4 front panel legend. *Don't panic*, if you do not have the means to produce your own, Maplin have made available a pre-drilled and printed aluminium panel (Order Code KW56L).

After preparing the front panel secure the two Phono sockets SK1 and 2 using the hardware provided, see Figure 5. Solder two short wire links on to each socket and position the solder tags so the wires do not have to cross over when the PCB assembly is attached to the front panel. It is also very important that these tags should not touch any of the components on the board as either could result in a short circuit.

Next mount the PCB assembly on to the front panel, using the four 10mm insulated spacers, and check that all seven LEDs have passed through the panel, see Figure 5. Now connect up SK1 and 2 to the following solder pads: SK1 Centre terminal to P5; SK1 Solder tag to P8; SK2 Centre terminal to P6; SK2 Solder tag to P7.

The only significant amount of off board wiring is to the batteries, see Figure 6. However, this is not a problem since the wires come already prepared with the battery clips. The positive red and negative black wires both loop through a large hole in the PCB, this provides a certain amount of strain relief during the replacement of exhausted batteries.

Finally push on to S1 and 2 the square black click caps and fit the two knobs so that their pointers are at the fully-anticlockwise position. Check that they travel smoothly round to the fully-clockwise position, without scraping on the front panel. This completes the assembly of the unit. Now check your work very carefully, making sure that all the wires and solder joints are sound.

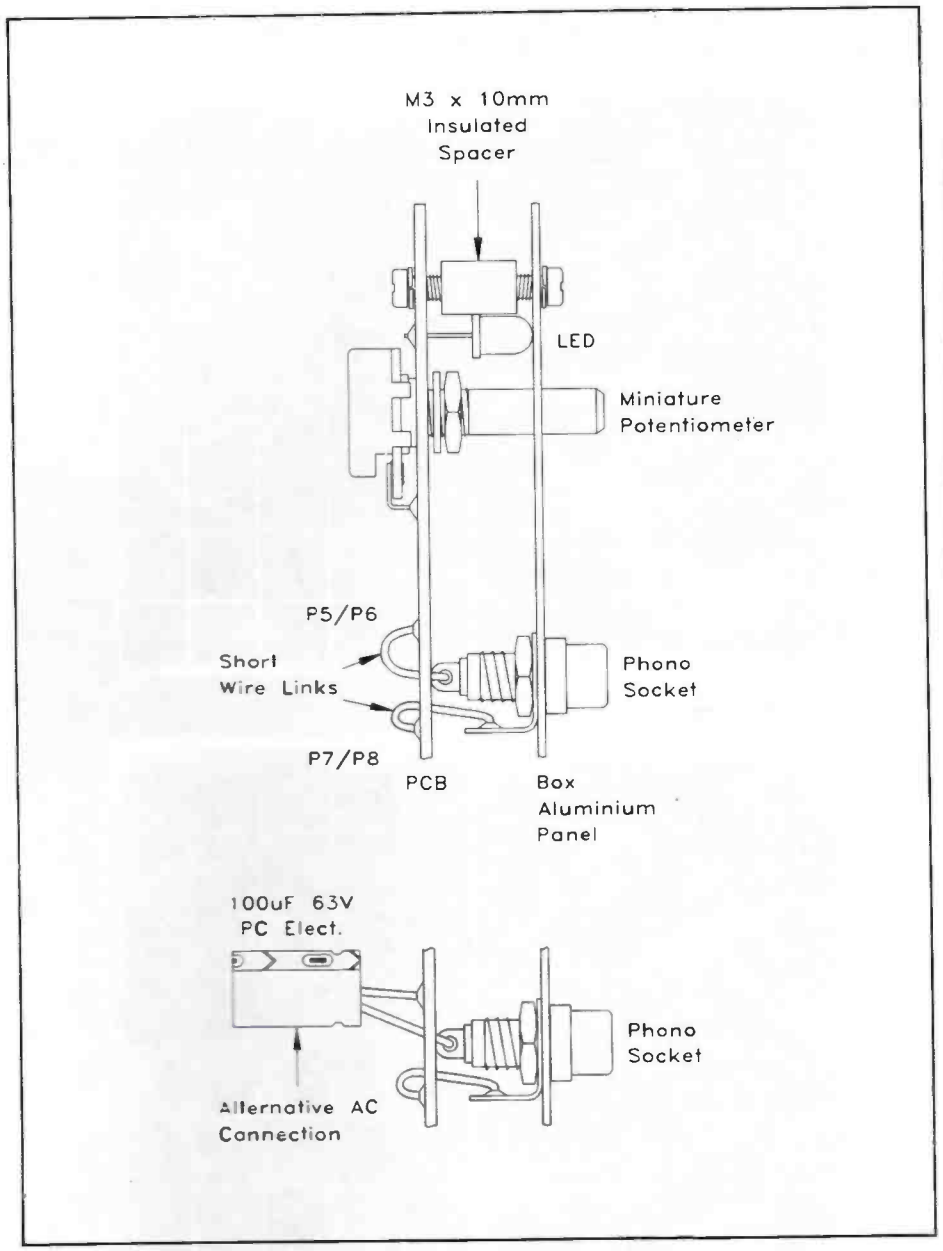


Figure 5. Mechanical assembly.

Testing and Alignment

All the DC tests are to be made using a multimeter and two PP6 nine volt batteries. The readings were taken from the prototype using a digital multimeter, some of the readings you obtain may vary slightly depending upon the type of meter employed. Before you commence testing the unit set the two rotary controls RV2 (frequency) and RV6 (amplitude) to their fully-anticlockwise positions.

The first test is to ensure that there are no short circuits on the power rails before you install the two PP6 batteries. Set your meter to read kΩ on its 20kΩ resistance range, and connect the test probes to one set of battery terminals. With the probes either way round a reading greater than 4kΩ should be obtained. Repeat this test on the other battery clip which should give a similar reading.

Next connect the two PP6 batteries. Although the power is now connected the generator should be in its power off mode (all LEDs off). To monitor the supply current, set your meter to read DC mA and place it in series with one of the batteries. Ensuring that none of the LEDs are lit, observe the current reading which should be less than 1μA, some multimeters may not possess sufficient resolution to read this extremely low standby current. Repeat this test on the other battery which should give a similar reading. When the function switch S1 is pressed once the generator should go to its initial power on mode, LD1 and LD4 lit. At the same the DC current should increase to approximately 25mA in both batteries.

Each time the function button is pressed the waveform indicators LD1 to LD3 should step to the next position, i.e., sine, triangle, square then power off. When the frequency range button is pressed a similar stepping action should be observed on the range indicators LD4 to LD7. When the generator is in its power off mode the selected frequency range is held and can not be advanced until the unit is powered up again. The current drain previously measured should not alter significantly as different waveforms and frequency ranges are selected. This completes the DC testing of the generator, now disconnect the multimeter from the unit.

The DC tests on their own do not prove conclusively that the generator is producing an output, to do this requires some additional test equipment. A simple output test can be performed by using nothing more than a crystal earpiece, or a small audio amplifier system. However, to accurately set up the sine wave purity and frequency limits does require the use of an oscilloscope and frequency counter.

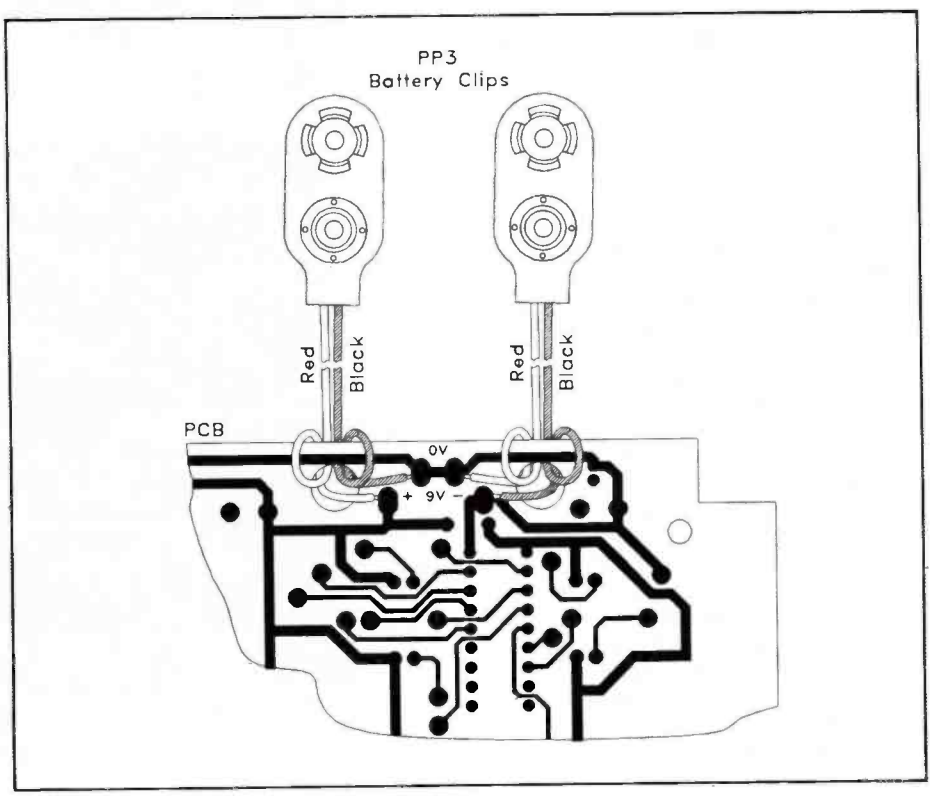


Figure 6. Battery wiring.

Before commencing the alignment set the PCB presets and the front panel controls to the following positions:

1. RV1, 3, 4 and 5 half way round.
2. Frequency control RV2 fully anticlockwise (number 1).
3. Amplitude control RV6 fully clockwise (number 9).
4. Function set to sine wave.
5. Range set to 1 – 10kHz.

Now connect the output of the generator to your oscilloscope's Y input channel. Select a suitable input sensitivity and sweep range, then observe the CRT display. If all is well, a waveform approximately corresponding to the sine wave shown in Photo 2 should appear. However, this is unlikely since the waveform purity presets RV4 and RV5 have to be critically adjusted in order to produce a sine wave with a minimum level of distortion. The effect of incorrectly adjusting these two controls can be seen in Photo 3. When the purity alignment has been successfully completed you should compare the other two waveforms against the triangle and square functions shown in Photo 2.

To set the minimum and maximum frequency control range limits a suitable frequency counter must be connected to the generators output. Some counters can give confusing results if the input signal contains too many harmonic products. For this reason it is advised that the generators sine wave function be used during the following alignment procedure. With its simple analogue dial it is not possible to obtain pinpoint accuracy over all the frequency ranges. In practice a compromise has to be made, and to achieve this the dial must have a certain amount of frequency overlap.

The two presets used to adjust the frequency limits are RV1 for the low end and RV3 for the high end. Altering either of these controls will have an affect on the other, so repeated realignment is necessary to obtain an optimised result. With the frequency control RV2 set to number one (fully anticlockwise) and the lowest range (10 – 100Hz) selected, adjust RV1 for a reading on the counter of 10Hz. Next set the frequency control to number ten and select the highest range (10 – 100kHz), adjust RV3 for a reading of 100kHz. Keep repeating this procedure while checking the other frequency ranges until your generator's calibration closely matches the specification given for the prototype unit shown in this article. Finally, using your oscilloscope check the peak to peak output levels. With the amplitude control set to maximum the full and attenuated outputs should be as follows: Full = 9V Pk-to-Pk; Attenuated = 400mV Pk-to-Pk.

Now carefully position the two PP6 batteries into the left-hand side of the

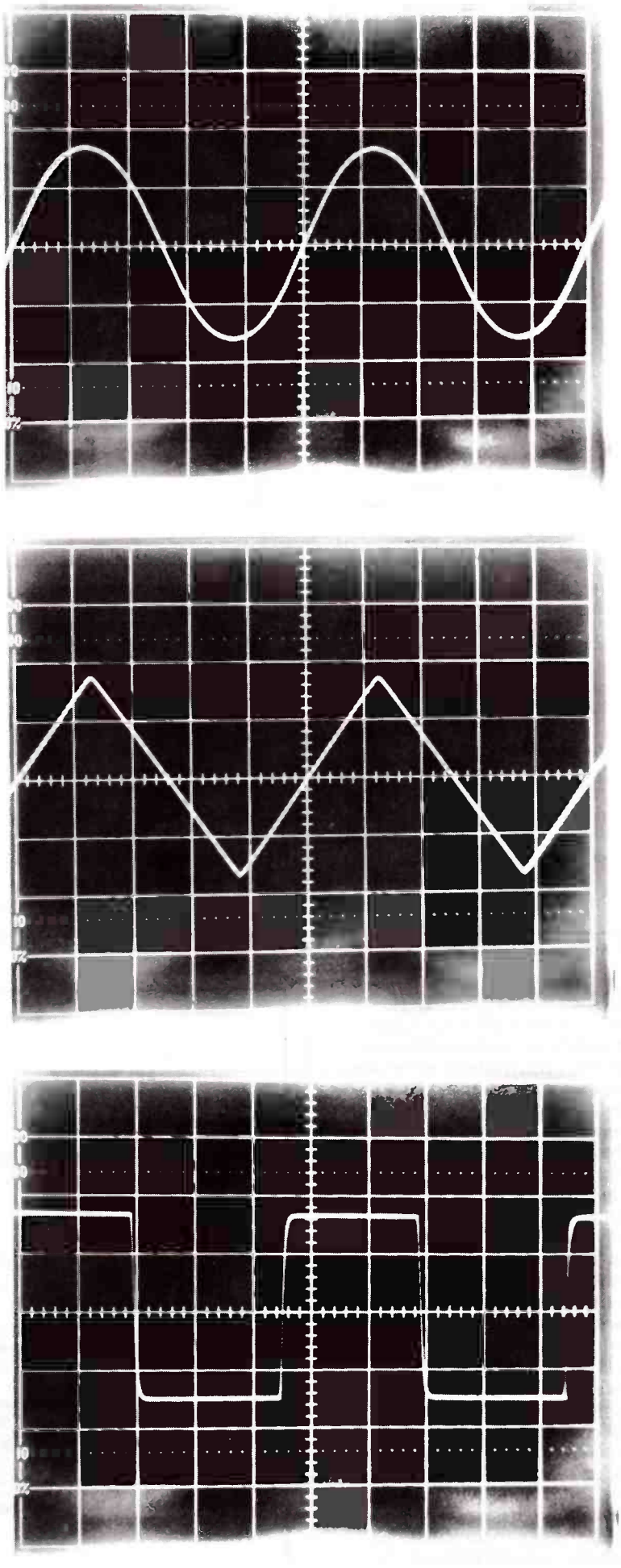


Photo 2. Correct sine, triangle and square waveforms.

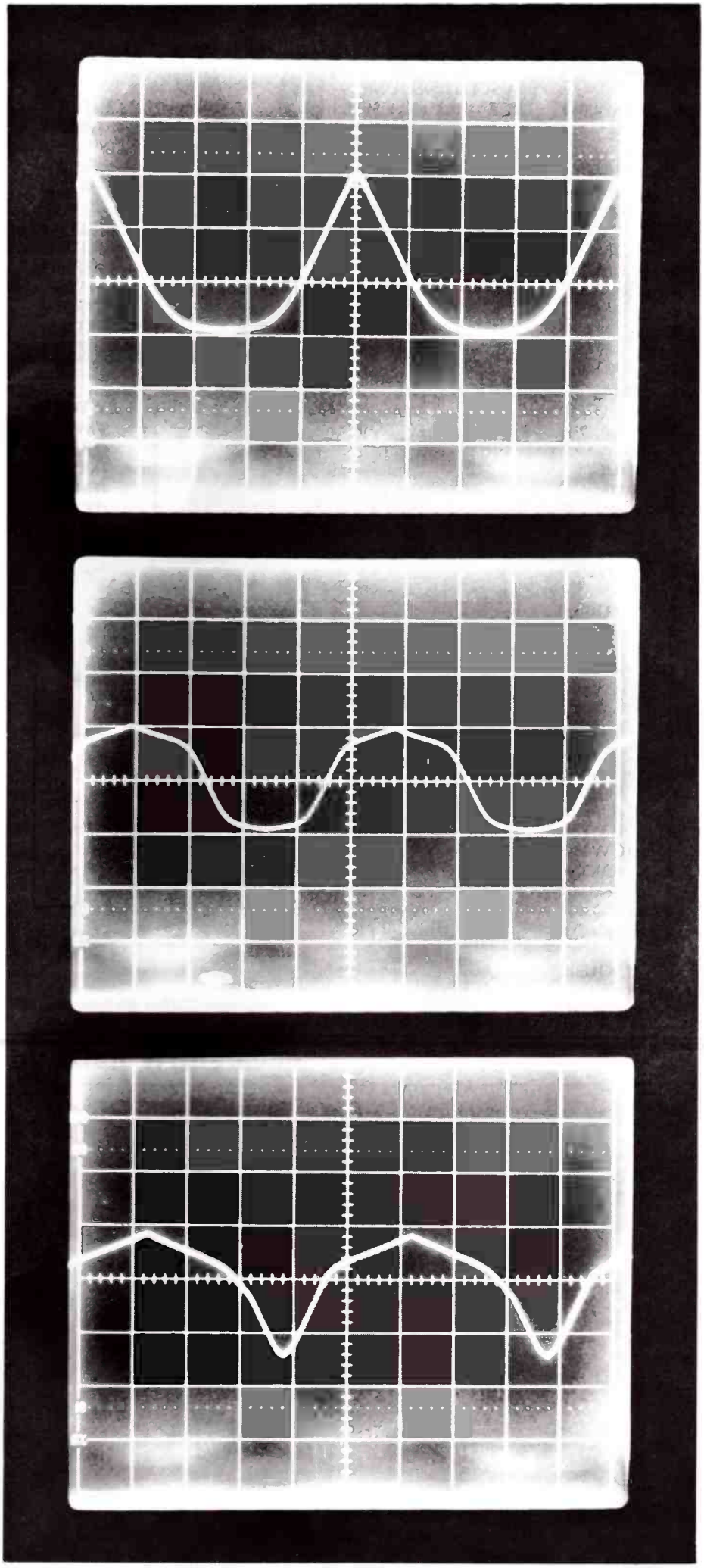


Photo 3. Incorrect sine wave.

box, so that when the front panel is in place they are behind the push buttons and LED indicators. To prevent the batteries from moving around almost any type of non-conductive packing material can be used to restrain them.

Using the Generator

There are many uses to which an audio waveform generator can be applied. In educational establishments they are often used to demonstrate the fundamentals of AC electronic theory. At a more practical level they become vital when applied to testing and fault finding on home constructed projects, or ready built pieces of electronic equipment.

IMPORTANT! THE OUTPUT OF THE GENERATOR IS DC COUPLED. When connected to an established signal input there is unlikely to be any DC voltage present as AC coupling is normally provided within the equipment under test. However, if you intend to probe around inside circuits you *must* use a suitable DC blocking capacitor placed in series with the output of the generator. To ensure good low frequency coupling when injecting the signal in to an unknown, possibly low impedance circuit, it is normal practice to use a high value capacitor, typically 100µF or higher. In order to keep its physical size as small as possible a polarised electrolytic type is often used. To operate correctly you must ensure that it is placed the right way round and its voltage rating is high enough to accommodate the piece of equipment under test. Because the polarity and DC voltage level can change from circuit to circuit this component is normally kept as a temporary feature at the end of the test lead. However, if the type of circuits under test have a known maximum voltage and fixed polarity a suitable capacitor may be placed inside the generator, see Figure 5.

A simple audio output lead can be quickly put together by using a phono plug, a length of screened cable and two insulated crocodile clips. To prevent any loss of signal, or stray electrical noise pick up, this lead should be kept as short as possible, i.e., up to one metre for normal practical use.

The overall performance of the generator is governed by the state of its two PP6 batteries. As these run down the peak output level will drop and the frequency control range will change slightly. Assuming that you start with a good set of full capacity batteries you can expect several hours of continuous use before any appreciable sign of waveform deterioration occurs. When the batteries are exhausted it is strongly recommended that you remove them from the unit as any chemical leakage can result in permanent circuit damage.

AUDIO GENERATOR PARTS LIST

RESISTORS: All 0·6W 1% Metal film (Unless specified)

R1,3,4,6,14,16	100k	6	(M100K)
R2,5,7,8,9,10,15,17,18,19,20	10k	11	(M10K)
R11,12,13,21,22,23,24,32,33	4k7	9	(M4K7)
R29	2k2	1	(M2K2)
R25	1k8	1	(M1K8)
R26,34	15k	2	(M15K)
R27	47k	1	(M47K)
R28,35	1k	2	(M1K)
R30	100Ω	1	(M100R)
R31	27k	1	(M27K)
R36	470Ω	1	(M470R)
RV1	470Ω Horizontal Encl Preset	1	(UF99H)
RV2	4k7 Min Pot Lin	1	(JM70M)
RV3	22k Horizontal Encl Preset	1	(UH04E)
RV4,5	100k Horizontal Encl Preset	2	(UH06G)
RV6	100k Min Pot Lin	1	(JM74R)

CAPACITORS

C1,3	22µF 25V PC Elect	2	(FF06G)
C2,4,6,7,8,10,11	100nF 16V Minidisc	7	(YR75S)
C5,9	220µF 16V PC Elect	2	(FF13P)
C12	10µF 50V PC Elect	1	(FF04E)
C13	270nF Poly Layer	1	(WW46A)
C14	220nF Poly Layer	1	(WW45Y)
C15	47nF Poly Layer	1	(WW37S)
C16	4n7F Poly Layer	1	(WW26D)
C17	390pF 1% Polystyrene	1	(BX52G)

SEMICONDUCTORS

IC1,3	4017BE	2	(QX09K)
IC2	ULN2801A	1	(QY78K)
IC4	4081BE	1	(QW48C)
IC5,7	4066BE	2	(QX23A)
IC6	ICL8038CCPD	1	(YH38R)
IC8	LF351N	1	(WQ30H)
TR1	BC327	1	(QB66W)
D1,2,3,4,5,6,7	1N4148	7	(QL80B)
LD1,2,3,4,5,6,7	Red LED 5mm 2mA	7	(UK48C)

MISCELLANEOUS

S1,2	Click Switch	2	(FF87U)
	Click Cap Black	2	(FF88V)
SK1,2	Chassis Phono Skt	2	(YW06G)
	Knob K14A	2	(FK38R)
	DIL Socket 8-pin	1	(BL17T)
	DIL Socket 14-pin	4	(BL18U)
	DIL Socket 16-pin	2	(BL19V)
	DIL Socket 18-pin	1	(HQ76H)
	PP3 Clip	2	(HF28F)
	M3 Insulated Spacer 10mm	4	(FS36P)*
	PCB	1	(GE87U)
	Instruction Leaflet	1	(XT16S)
	Constructors' Guide	1	(XH79L)

OPTIONAL (Not in kit)

	Metal Panel Box M4005	1	(WY02C)
	PP6 9V Battery	2	(FM03D)
	Screw-Cap Phono Black	1	(HQ54J)
	Cable Single Black	1m	(XR12N)
	Red Croc Clip	1	(FM37S)
	Black Croc Clip	1	(FK34M)
	100µF 63V PC Elect	2	(FF12N)
	Front Panel	1	(KW56L)

The Maplin 'Get-You-Working' Service is available for this project, see Constructors' Guide or current Maplin Catalogue for details.

The above items (excluding Optional) are available as a kit.

Order As LP01B (Low Cost Sig Gen Kit)

*Please Note: Order Code marked with a * is not available singly, see current Maplin Catalogue for full ordering information.*

The following new item (which is included in the kit) is also available separately.

Low Cost Sig Gen PCB ***Order As GE87U***