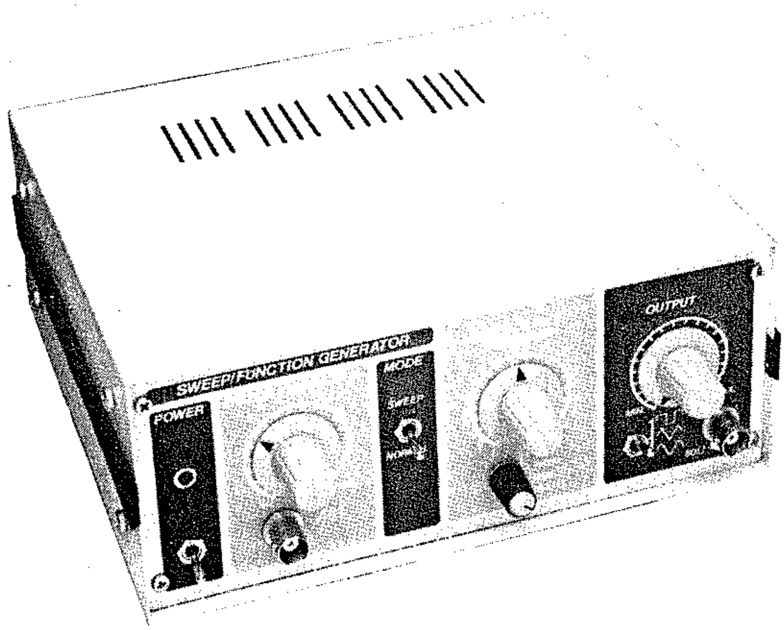
BUDGET SWEEP/FUNCTION GENERATOR



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This month we add yet another item to our series of budget test instruments. The signal generator described has a built-in sweep function which is ideal for audio measurements. Based on the well-known XR2206 function generator IC with very few external components, the instrument offers a hard-to-beat price/performance ratio.

It is not wise to disregard the XR2206 from Exar when designing an all-round function generator The device is versatile like no other, and guarantees a fairly simple circuit for the given application. Furthermore, its cost makes any attempt at designing an equivalent circuit based on discrete components a waste of time, while its output signal distortion figures are not spectacular, but none the less low compared to those of a competitive chip like the 8038

For use as a basic function generator, the XR2206 requires only a handful of passive parts The frequency adjustment and the sweep function are simple to implement by the addition of one dual opamp and three transistors. The output amplifier of the instrument also follows the general line of comprising of as few components as possible: only one power opamp is required

The generator

The XR2206 forms the heart of the circuit (see Fig. 1). With the external components configuration used here, the IC supplies a sine-wave and a triangular wave at output pin 2 The d.c. operating point is set to half the supply voltage (6 V at pin 3) by potential divider R_{15}-R_{16}. The resistance at the potential divider junction, 16.5 kΩ, and the voltage at the AM input, pin 1 (0 V) determine the amplitude of the output signal.

The waveform selection is effected by one contact of S_4 In the position shown, resistor R_{17} is connected to pin 14 of the XR2206 The current flow through R_{17} enables the IC to convert the triangular signal into a sine-wave The value of R_{17} determines to what extent the inflection points of the triangle are rounded to give a sine-wave For the sake of simplicity, a fixed resistor instead of the expected (multiturn) preset is used to set this current.

When the contact of S_4 is opened, pin 2 supplies a triangular signal whose peak amplitude is twice that of the sine-wave The rectangular wave is supplied via pin 11. This open-collector output of the XR2206 is pulled to ground at the generator pulse rate by an n-p-n transistor Voltage divider R_{18}-R_{19}-R_{20} at pin 11 sets the amplitude of the rectangular wave. The maximum and minimum voltage le-

MAIN FEATURES

- Frequency ranges: 3 (10 Hz – 20 kHz) or 4 (10 Hz – 200 kHz)
- Sweep frequency: 0.1 Hz – 100 Hz
- Sweep range: 0 – 1:20
- Sweep output: 5 V_{pp}; sawtooth; Z_o = 1 kΩ
- Waveforms: sine-wave, triangle, rectangle
- Distortion (sine-wave): 0.5% typ. (in AF range)
- AC output: all waveforms; Z_0 = 50 Ω, short-circuit resistant
- Output amplitude (R_L = 50 Ω):
  0.1 mV_{pp} – 1 V_{pp} (sine-wave)
  0.1 mV_{pp} – 2.5 V_{pp} (triangle)
  0.1 mV_{pp} – 1.5 V_{pp} (rectangle)
- Output amplitude (R_L = 600 Ω):
  0.1 mV_{pp} to 1.8 V_{pp} (sine-wave)
  0.1 mV_{pp} – 4.5 V_{pp} (triangle)
  0.1 mV_{pp} – 3 V_{pp} (rectangle)
- Current consumption: approx. 100 mA at 12 V

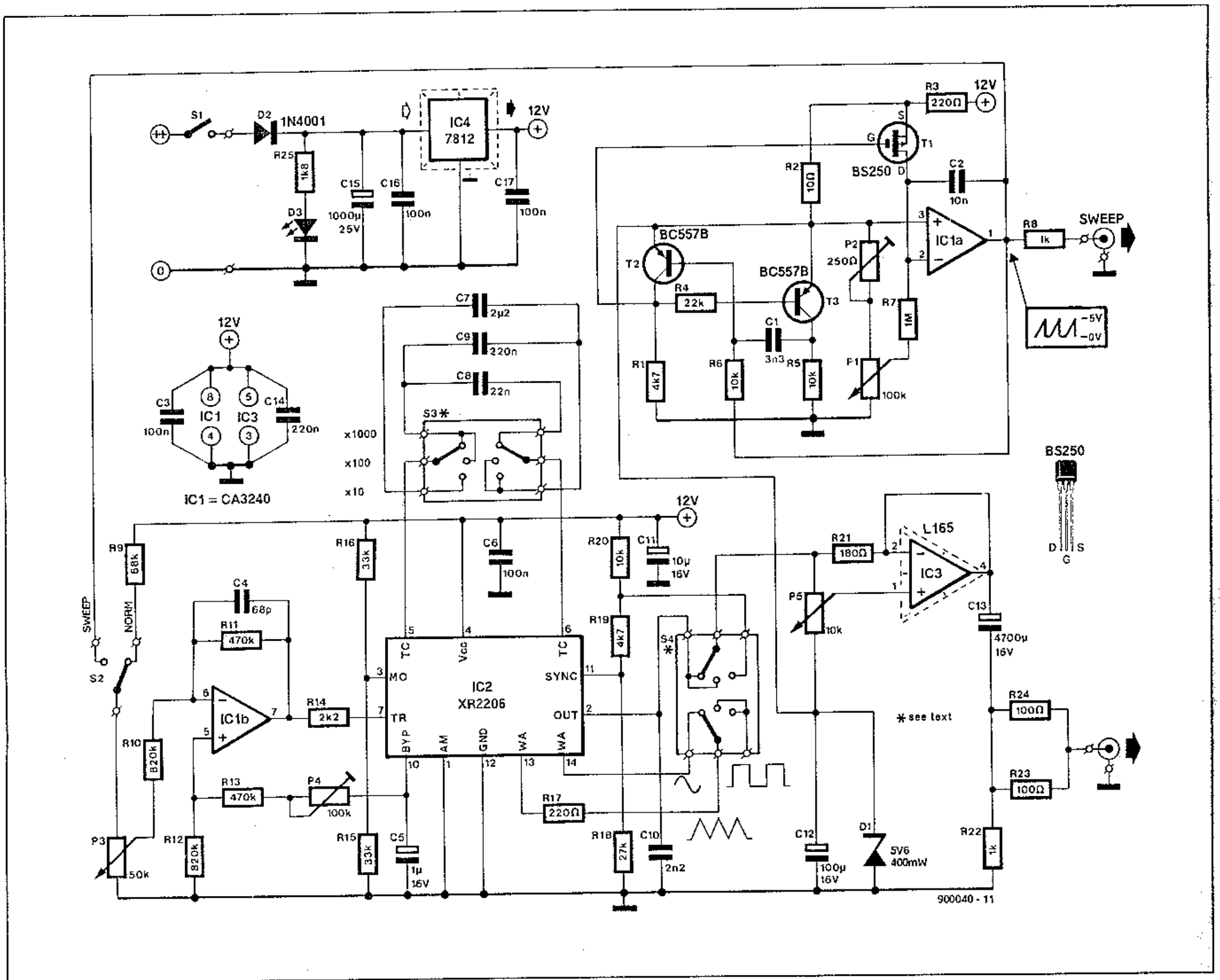


Fig. 1. Circuit diagram of the sweep/function generator. The heart of the circuit is formed by IC_2 an XR2206 from Exar.

vels are 9 1 V and 3 8 V respectively This swing is close to the optimum drive margin of the power opamp that follows the XR2208

The second contact of S_4 selects either of the two IC outputs and passes the relevant waveform to the output amplifier

Frequency control

The frequency of the signal supplied by the XR2206 is determined by two factors: the capacitance between pin 5 and pin 6 and the current drawn from pin 7

The capacitance is determined by the three capacitors selected by the frequency range switch, S_3 A fourth range (up to 200 kHz) may be added by providing an extra switch position and a capacitor of 2 2 nF (see the section on construction further on).

Pin 7 of the XR2206 supplies a temperature-compensated reference voltage of 3 V, which is also available at pin 10, where it is decoupled by C_5. The voltage at pin 3 is loaded by a resistor, R_{14}, and the output of opamp IC_{1b}. Hence the output voltage of the opamp determines the current through R_{14} and with it the signal frequency, f:

$$f = I_{R14}/3C$$

where I_{R14} is in ampères Factor C is the capacitance (in farads) between pins 5 and 6

Frequency and frequency sweep adjustment are effected manually by potentiometer P_3 at the –input of IC_{1b}. When S_2 is set to the 'normal' position, P_3 and R_9 form a potential divider that limits the voltage at the wiper to a value between 0 V to 5 V Resistors R_{10}-R_{11} set the amplification of the inverting opamp to a value that results in output voltages of virtually 0 V and 3 V with P_3 set to maximum and minimum (wiper to ground) respectively. The d c operating point —and with it the start of the frequency range — is determined by P_4-R_{13} and R_{12}, which ensure that a part of the 3-V reference voltage is applied to the non-inverting input of IC_{1b}

Sweep function

When the generator frequency is set manually, a fixed resistor, R_9, provides the direct voltage to potentiometer P_3 When S_2 is switched to the other position, however, P_3 is supplied with the output voltage of a ramp generator In this mode, the potentiometer sets the swept frequency range rather than the frequency itself. In other words, it determines to what extent (in Hz/V) the ramp generator can change the set generator frequency

The ramp generator is formed by opamp IC_{1a} and integrator C_2. The integration time is set by the voltage at the wiper of P_1: the higher the voltage, the faster the capacitor is charged, and the faster the sawtooth voltage rises. Potentiometer P_1 allows the sweep time to be set to a value between 10 ms and 10 s The maximum time is calibrated by preset P_2, which also serves as an off-set compensation for IC_{1a}

The rise of the sawtooth voltage at the integrator output is ended via T_2 and T_1 The emitter of T_2 is held at a reference potential provided by zener diode D_1 The transistor conducts and T_1 and T_3 are kept off as long as its base voltage is below the reference As soon as the sawtooth reaches a level of about 0.5 V below the reference voltage, T_2 is briefly turned off, so that its collector voltage is pulled to about 0 V via R_1 As a result, T_3 conducts and resets the integrator by making the inverting input of IC_{1b} positive with respect to the non-in-

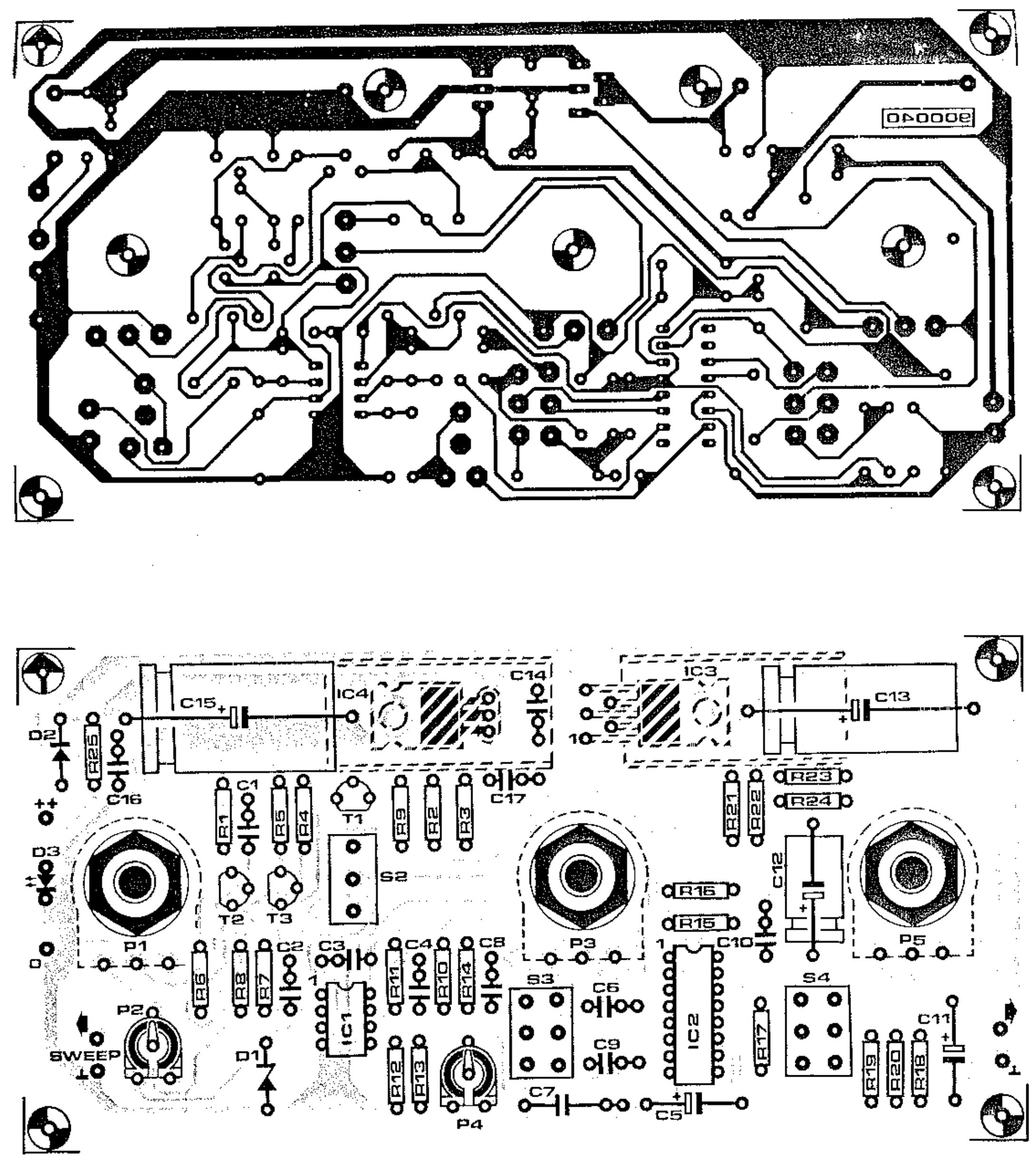


Fig. 2. Track layout (mirror image) and component mounting plan of the single-sided printed circuit board for the generator.

verting input. This is achieved with the aid of T_1. In the monostable formed by T_2-T_3, C_1 ensures that the integration capacitor is discharged rapidly to provide the trailing edge of the sawtooth. The reference voltage provided by D_1 thus determines the amplitude of the sawtooth voltage that sweeps the frequency of the function generator.

The sawtooth voltage is also available at a separate sweep output on the instrument. Resistor R_8 sets the output impedance to about 1 kΩ. The sweep output is short-circuit resistant and may be used for driving the X amplifier of an oscilloscope for swept-frequency measurements.

Output amplifier

The Type L165 opamp used in the output amplifier is capable of providing ample output current at a reasonable price. The IC is used in a conservatively rated configuration and is therefore not likely to actuate its internal overheating protection. The power opamp is wired as an non-inverting buffer (voltage follower), so that the amplitude and phase of the output signal correspond to those of the input signal at the wiper of amplitude control P_5. An electrolytic capacitor, C_{13}, is required to decouple the d.c. component at the output since a non-symmetrical supply is used. The parallel resistor combination at the output is not strictly required for overload protection (which the L165 provides by itself). It does, however, limit the output current to a safe value. At the same time, it sets the generator output impedance to 50 Ω, which is a commonly used value on test equipment.

COMPONENTS LIST

Resistors:

2	4k7	R_1;R_{19}
1	10Ω	R_2
2	220Ω	R_3;R_{17}
1	22k	R_4
3	10k	R_5;R_6;R_{20}
1	1M0	R_7
2	1k0	R_8;R_{22}
1	68k	R_9
2	470k	R_{11};R_{13}
2	820k	R_{10};R_{12}
1	2k2	R_{14}
2	33k	R_{15};R_{16}
1	27k	R_{18}
1	180Ω	R_{21}
2	100Ω	R_{23};R_{24}
1	1k8	R_{25}
1	100k lin potentiometer	P_1
1	250Ω preset H	P_2
1	50k lin potentiometer	P_3
1	100k preset H	P_4
1	10k lin potentiometer	P_5

Capacitors:

1	3n3	C_1
1	10n	C_2
4	100n	C_3;C_6;C_{18};C_{17}
1	68p	C_4
1	1µ0 16V axial	C_5
1	2µ2 MKT	C_7
1	22n	C_8
2	220n	C_9;C_{14}
1	2n2	C_{10}
1	2n2 (optional)	C_{16}
1	10µF 16V axial	C_{11}
1	100µF 16V axial	C_{12}
1	4700µF 16V axial	C_{13}
1	1000µF 25V axial	C_{15}

Semiconductors:

1	5V6 400mW zener diode	D_1
1	1N4001	D_2
1	LED	D_3
1	BS250	T_1
2	BC557B	T_2;T_3
1	CA3240E	IC_1
1	XR2206	IC_2
1	L165	IC_3
1	7812	IC_4

Miscellaneous:

1	miniature SPST switch	S_1
1	miniature SPDT switch	S_2
2	2-pole 3-way switch (Knitter MTA206PA or C&K 7211) (S_3 may be replaced by a miniature 1-pole 4-way rotary switch)	S_3;S_4
2	BNC socket	K_1;K_2
2	TO-220 style heat-sink	
1	printed-circuit board	900040
1	front panel foil	900040-F

Construction

The single-sided printed-circuit board on which the generator is constructed is shown in Fig 2. Population of the PCB is straightforward with the possible exception of the following points:

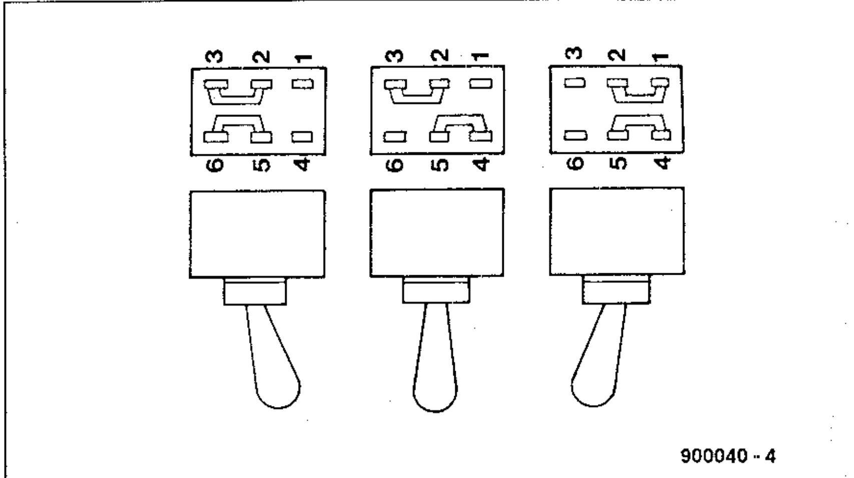


Fig. 3. Connections made in the 3-position switches from C&K.

- The spindles of potentiometers P_1, P_2 and P_3 are inserted from the track side of the PCB to enable the nuts on the shafts to be locked at the component side. Use short wires to connect the potentiometer terminals to the relevant copper tracks.
- As shown in Fig. 5, IC_3 and IC_4 are fitted at the track side of the board. Do observe their correct orientation and the electrical insulation of the heat-sinks.
- Switches S_1, S_3 and S_4, and the BNC sockets are mounted on the front panel. Their positions correspond to those provided on the overlay printed on the ready-made circuit board. The connections are made in short lengths of light-duty insulated wire.

It is not strictly necessary to use IC sockets although the small additional investment may prove worth while if a faulty IC is suspected. Since the instrument has its own single-phase rectifier, smoothing capacitor and 12-V voltage regulator, it may be powered from an unregulated AC or DC supply with an output of 15 V to 18 V. If a transformer is used, observe the necessary safety precautions as regards insulation of the mains voltage and the fuse rating.

Setting up

It is recommended to adjust the completed printed-circuit board before it is fitted into the enclosure. This means that the switches and the output sockets have to be connected provisionally.

Apply power and allow a few minutes for the circuit to warm up. Set S_2 to NORMAL, and P_3 to a frequency roughly at the centre of a range, e.g., 100 Hz. Connect a frequency meter to the signal output and adjust P_4 until the measured frequency equals that set on the scale.

If you do not have access to a frequency meter to perform this adjustment, use the beat frequency method instead. Feed the 100 Hz signal obtained with the aid of a small mains transformer, a bridge rectifier and a series network of a 100-Ω resistor and a 100-µF capacitor, to a loudspeaker. Drive another loudspeaker with the generator output signal. Listen to the two signals and adjust P_4 for zero frequency difference. This method gives quite accurate results (for use with a 60-Hz mains, set the generator to 120 Hz).

The adjustment of the sweep function is carried out at the greatest sweep time, 10 s. Turn P_1 fully counter-clockwise and connect an analogue voltmeter or a LED to the sweep output of the instrument. Adjust P_2 until a time period of 10 s is obtained.

Tips and options

In the basic arrangement, the waveform and frequency range selection are effected with 3-position miniature switches from C&K. The switching configurations are shown in Fig 3. In the case of S_3, the use

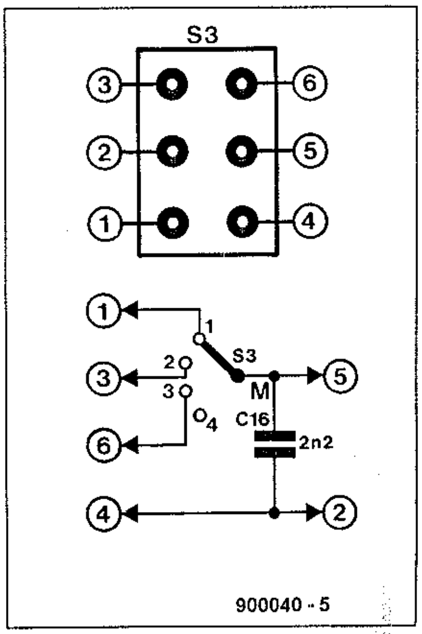
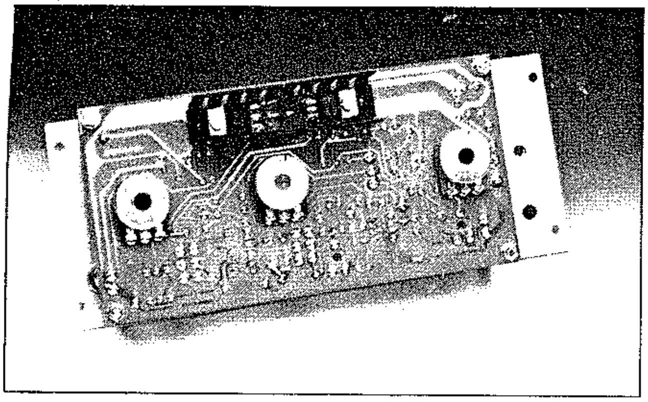


Fig. 4. Alternative switch connection which enables the frequency range of the generator to be extended to about 200 kHz.



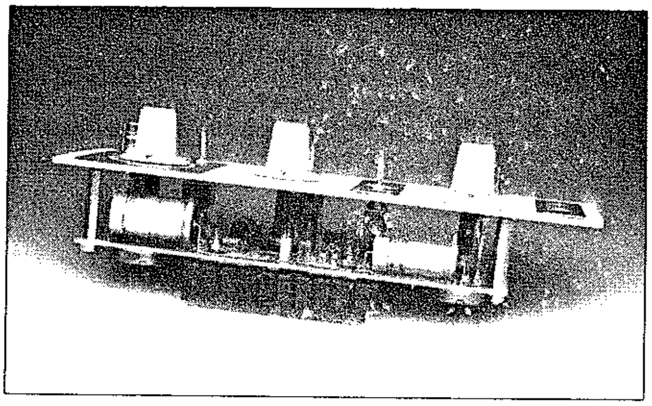


Fig 5. Completed PCB-front panel assembly seen from the PCB track side (left) and from the side (right).

of a switch that has only three positions limits the frequency range of the instrument to about 20 kHz. A fourth range, which may be desirable in a number of cases, may be added by replacing the toggle switch with a small, four-position, rotary switch, which is wired as shown in Fig 4. The numbers 1 to 6 on the overlay mark the connections of the terminals of S_3. To create a 200 kHz range, solder an additional 2.2 nF capacitor, C_{16}, to the centre terminals, numbers 2 and 5, and solder a wire between terminals 2 and 4. Next, connect the contacts (1, 2 and 3) and the pole of the rotary switch to the PCB terminals 1, 3, 6 and 5.

As already noted, the value of R_{17} determines the shape of the sine-wave. At relatively high generator frequencies it may be useful to replace the resistor by a 500-Ω preset to enable the distortion to be minimized. From a number of practical tests, the XR2206 supplies a fairly clean sinusoidal signal up to about 100 kHz. Towards 200 kHz, the sine-wave gradually changes into a triangular waveform.

The L165 is capable of providing considerably more output power than it is allowed to by the 50-Ω output. If it is desired to use the generator for swept-frequency measurements on loudspeakers or drive units, a low-impedance output may be provided on the instrument by fitting two binding posts on the rear panel. The signal outlet is connected direct to the negative terminal of C_{13} to negate the effect of the two 100-Ω series resistors. Note, however, that this extension requires a rather larger power supply. In that context, it is recommended to use a mains transformer capable of supplying at least 1 A of secondary current, a bridge rectifier (4×1N4001) and an additional 1000 µF smoothing capacitor. The single phase rectifier on the board, D_2, is replaced by a wire link. The 1-A power supply enables the function generator to provide ample driving power for 4-Ω and 8-Ω loudspeakers. The use of a bridge rectifier instead of the single-phase rectifier allows a mains transformer with a secondary voltage of 12 V to be used instead of a 15-V type. ■

LOW-BUDGET TEST EQUIPMENT

This is the fifth instalment in a series of articles describing test equipment no serious electronics enthusiast or design engineer can do without. All instruments are housed in an attractive metal cabinet type LC-850 from Telet, which comes with with protective strips at the sides. The switch areas on the front panels are grey, light blue or dark blue with white lettering, and their size is geared to the front panel of the LC-850 enclosure. Shown in the picture are the instruments described so far in this series. The **power supply** shown in front will be next month's subject.

The pile of four instruments behind the **sweep/function generator** consists of (top to bottom):

- **LF/HF signal tracer (January 1990)**
- **Q meter (May 1990)**
- **RF inductance meter (November 1989)**
- **AC millivoltmeter (February 1990)**

The pointer knobs used on the instruments are made by applying a small arrow or triangle (available as transfer symbols) on to the collet and protecting it with plastic spray.