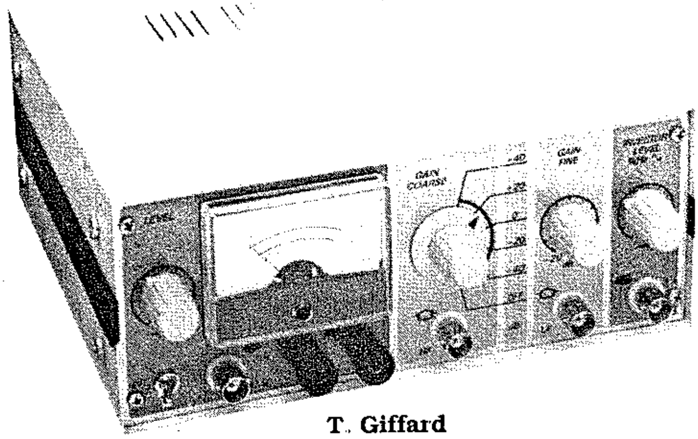
LF/HF SIGNAL TRACER



T. Giffard

Second in our series of budget test equipment, the signal tracer presented here is a versatile instrument that offers a signal generator, a tracing amplifier, a millivolt meter and an AF monitor amplifier with loudspeaker output in a single, compact enclosure. These functions make the instrument particularly suited to testing, servicing and aligning a wide range of electronic equipment.

One particularly useful feature of the present sinal tracer is that every one of its functions mentioned above is available separately For instance, the preamplifier with accurately defined, selectable, gain may be used as a 'drop-in' amplifier which is often required for measurements at low signal levels Similarly, the sine-wave oscillator, the millivolt meter and the monitor amplifier may be used on their own

Input circuit

The signal tracer has two inputs — see the circuit diagram in Fig 1. The LF (low frequency) input socket is connected direct to a high-impedance (1 MΩ) resistor lad-

LF/HF SIGNAL TRACER

Measurement ranges	
Alternating voltage:	–40 dB (10 mV) –20 dB (100 mV) 0 dB (1 V) +20 dB (10 V) +40 dB (100 V)
Bandwidth:	15 Hz to 350 kHz (–3 dB) 30 Hz to 200 kHz (–1 dB)
Input impedance:	>1 MΩ
Measurement amplifier	
Output impedance:	600 Ω
Bandwidth:	see 'Measurement ranges'
Amplification:	100 (40 dB) (10 mV range, attenuator at 0 dB)
Monitor amplifier	
Bandwidth:	35 Hz to 21 kHz (–3 dB)
Output voltage:	0 V to 6 V_{pp} (2.2 V_{rms})
Nominal load resistance:	8 Ω
Nominal output power:	560 mW
Sine-wave generator	
Frequency:	1 kHz
Output amplitude:	0 V to 4.25 V_{pp} (1.5 V_{rms})
Distortion:	less than 0.05% (2nd harmonic)
Output impedance:	max. 3 kΩ
Power supply	
Input voltage (mains powered):	min. 11 VDC
Stand-by current @ 11 V:	5 mA (S_1 off) 18 mA (S_1 on)
Stand-by current @ 9 V (battery powered):	<0.1 µA (S_1 off) approx. 13 mA (S_1 on)
Maximum current consumption at nominal AF output power:	125 mA @ 9 V (battery powered) 125 mA @ 8 V (mains-powered)

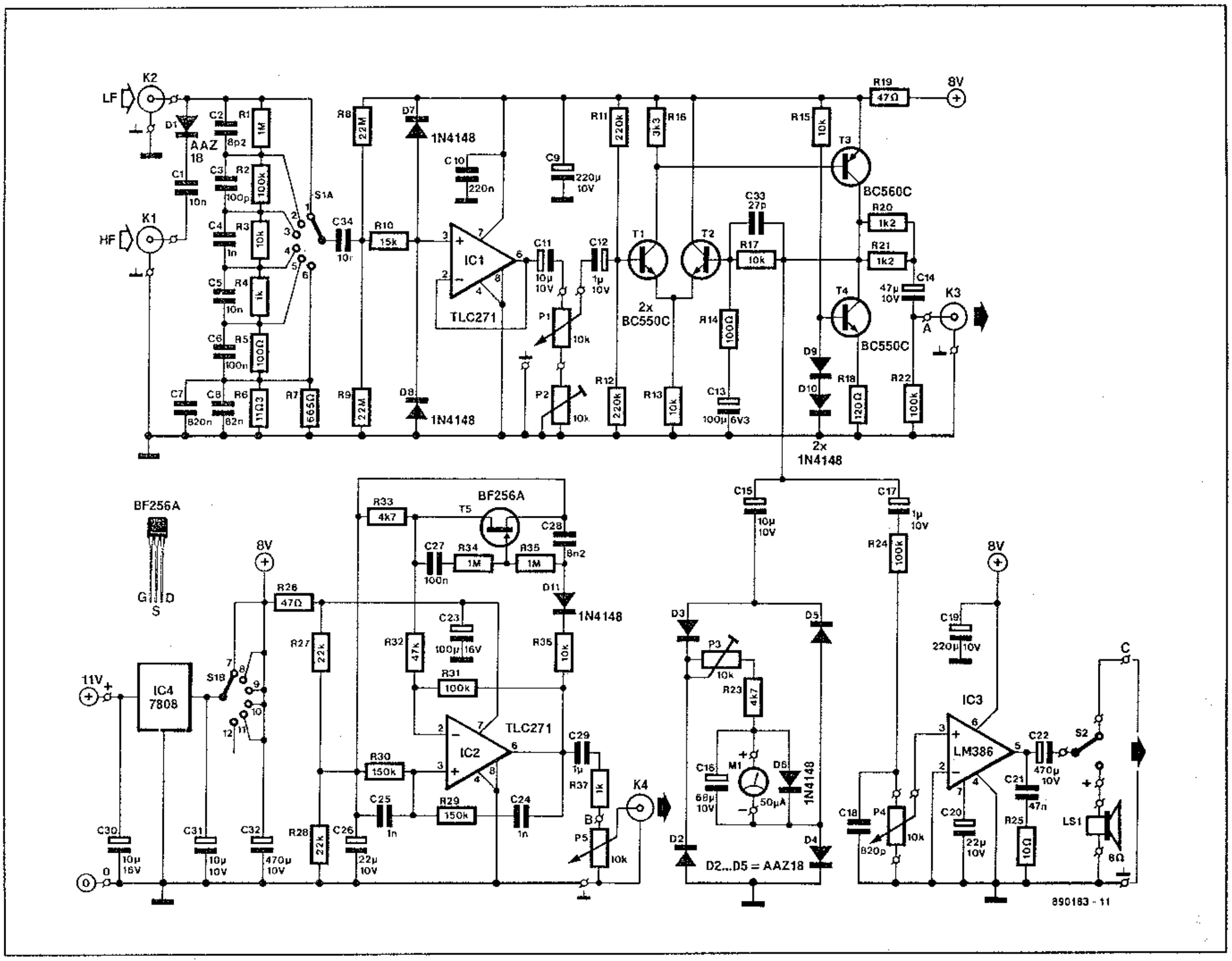


Fig. 1. Circuit diagram of the versatile signal tracer.

der network. The HF input also feeds this network via a germanium diode, D_1, and a coupling capacitor, C_1. The LF input socket is used for all alternating-voltage measurements. The HF input is intended for tracing amplitude-modulated (AM) high-frequency signals in receiver circuits. The diode and the coupling capacitor form an AM demodulator whose output signal is fed to the resistor ladder network. Next, level selection switch S_1 passes the signal to the input of IC_1. The AM demodulator is particularly suited to repair work on receivers and communications equipment, and enables amplitude-modulated audio and video signals at intermediate frequencies to be traced.

Double-pole rotary switch S_1 functions as a range selector (S_{1a}) and an on/off switch (S_{1b}).

The voltage range of both inputs is 0 V to 100 V, as determined by the relevant rating of the input capacitor. In theory, the lowest setting of the range switch (contact 6 of S_{1a}) creates a 1,000 V range. Apart from being far outside the voltage rating of the input capacitor, such a range has no practical use in combination with a millivolt meter having a dB (decibel) read-out. Switch positions 1 (10 mV) through 5 (100 V) form the normal ranges, divided into decades. The instrument is turned off by selecting position 6.

The 100 V range should be ample for most applications: after all, a peak voltage 100 V, supplied by an AF amplifier with 4 Ω output impedance, corresponds to a power output of no less than 1,250 W.

Diodes D_7 and D_8 protect the high-impedance input amplifier, IC_1, against voltage peaks greater than about 100 V. Resistor R_{10} and the two diodes can not, however, afford protection against continuous overvoltage. The input may be given a higher maximum input voltage by increasing R_{10}, but only at the cost of a significant bandwidth reduction.

The high input impedance (1 MΩ) of the signal tracer is inevitably coupled to a relatively large, negative, effect of stray capacitance associated with the resistors and the rotary switch. Capacitors C_2 through C_8 are provided to compensate this capacitance, and result in a 3 dB bandwidth of about 350 kHz.

A low-power CMOS opamp Type TLC271 is used as the input amplifier because it offers high input impedance and bandwidth when powered from a single supply rail. The required drive margin is ensured with potential divider R_8-R_9, which holds the + input of the opamp at about half the supply voltage. The high value of these resistors, 22 MΩ, ensures that the resistor ladder network is only lightly loaded.

Tracing amplifier

The output signal of the input amplifier, IC_1, is applied to a linear potentiometer, P_1, before it arrives at the input of the measurement amplifier, a discrete circuit around T_1 and T_2. Preset P_2 allows the range of P_1 to be set to about 20 dB, corresponding to the ranges of S_1. The potentiometer serves as a variable attenuator that enables a particular reference level to be set on the moving-coil meter. If, for instance, the reference level is set to 0 dB, the –3 dB and –6 dB levels are easily read from the meter scale.

The measurement amplifier has a bandwidth of about 800 kHz. The lower cut-off frequency is set to 16 Hz by C_{13}, the decoupling capacitor with feedback resistor R_{14}. A lower cut-off frequency would be achievable by a increasing C_{13}. This is not recommended, however, since it lengthens the stabilization period of the in-

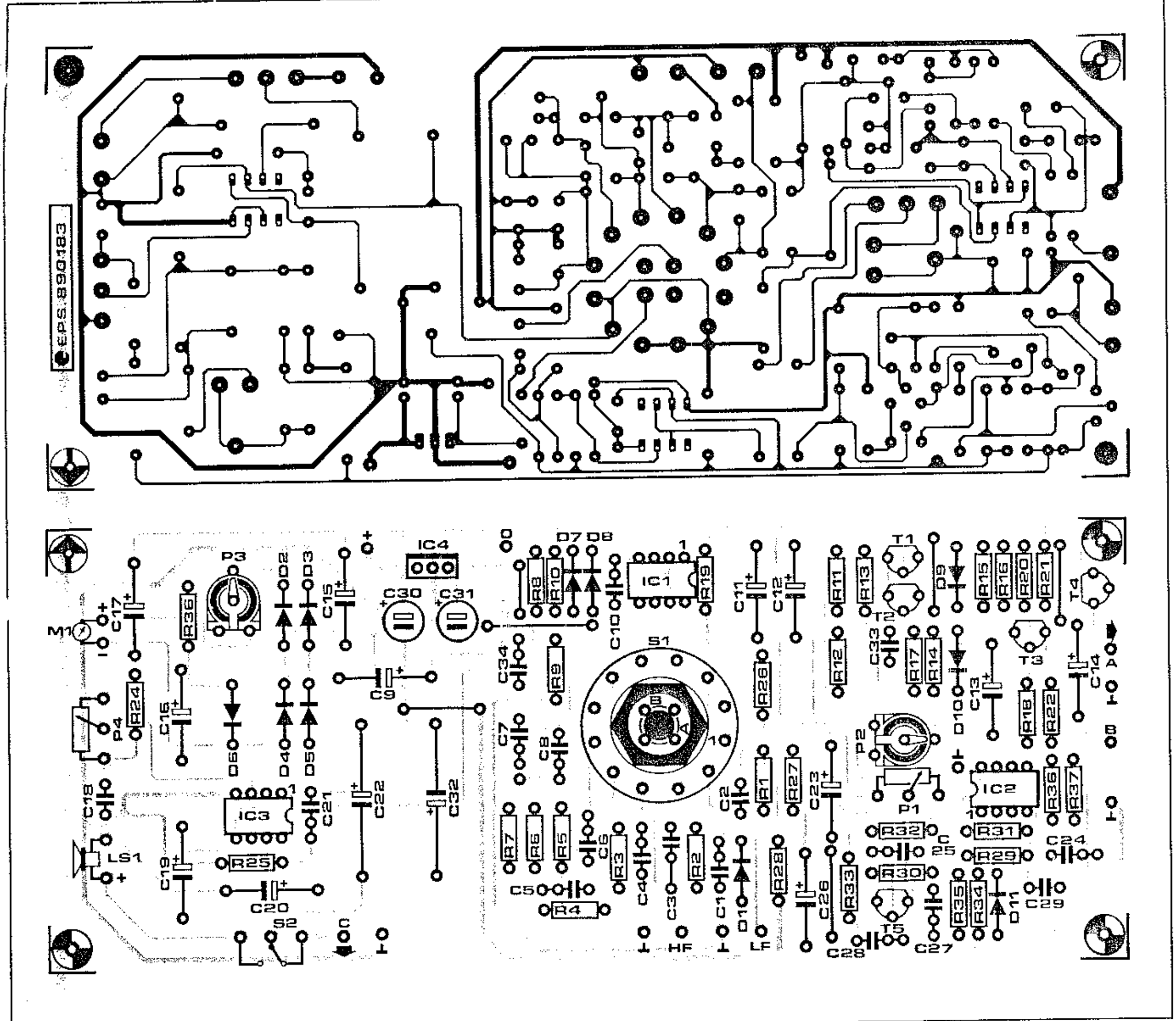


Fig. 2. The printed-circuit board is geared to the front-panel foil to give a compact and simple-to-build test instrument.

strument at power-on. With C_{13} at the given value, this stabilization period takes about 1 s. Feedback network R_{14}-R_{17} is dimensioned for a voltage amplification of 100 (40 dB).

The power stage of the measurement amplifier has an output impedance of about 600 Ω, as determined by R_{20}-R_{21}. The output signal is fed to socket K_3 via C_{14}, to the moving-coil meter circuit via C_{15}, and to a small monitor amplifier via C_{17}.

Summarizing the above, the circuit between the LF input socket and the 600 Ω output is a calibrated amplifier with high bandwidth, having a gain range of −40 dB to +40 dB in 20 dB steps, and an additional, continuously variable, 20 dB attenuator.

The meter circuit

The passive rectifier with germanium diodes D_2 – D_5 and moving-coil meter M_1 offers a relatively high bandwidth and a slightly logarithmic behaviour in the lower part of the meter range, which allows a dB scale to be made that is easily read (see the scale design in Fig. 3).

The Type AAZ18 diodes drop only 0.15 V at a forward current of 50 µA, and hardly affect the linearity in the lower part of the meter scale. Although other, similar, germanium diodes may be used, it should be noted that these may have slightly different characteristics, requiring the given meter scale to be modified.

The value of electrolytic capacitor C_{16} connected across the meter terminals has been chosen to stabilize the indication at relatively low frequencies without slowing down the average value conversion. Silicon diode D_6 protects the meter coil against voltages greater than about 0.6 V.

The meter circuit is simple to align: controls P_1 and S_1 are set to 0 dB, and preset P_3 is adjusted for full-scale deflection (f.s.d.) when an alternating voltage of 1 V_{rms} is applied to the LF input. The f.s.d. values in the other decade ranges of S_1 are 10 mV (−40 dB), 100 mV (−20 dB), 10 V (+20 dB) and 100 V (+40 dB). The meter may, of course, be provided with a voltage scale, provided this is corrected as required by the non-linear indication at small deflections.

The meter used for the prototype has a double scale, which was found particularly useful for AF measurements. The upper scale indicates dBs relative to 1 mW into 600 Ω, and has a 0 dB indication corresponding to 0.775 V. The f.s.d. value of 1 V is reached at an AF signal level slightly higher than +2 dB. On the lower dB scale, the 0 dB indication at f.s.d. is defined at a voltage level of 1 V.

Monitor amplifier

The monitor amplifier IC_3, receives the output signal of the measurement amplifier via coupling capacitor C_{17}. The famil-

Parts list

Resistors:
R1 = 1M0; 1%
R2 = 100k; 1%
R3 = 10k; 1%
R4 = 1k0; 1%
R5 = 100Ω; 1%
R6 = 11Ω3; 1% (E96)
R7 = 665Ω; 1% (E96)
R8;R9 = 22M
R10 = 15k
R11;R12 = 220k
R13;R15;R17;R36 = 10k
R14 = 100Ω
R16 = 3k3
R18 = 120Ω
R19;R26 = 47Ω
R20;R21 = 1k2
R22;R24;R31 = 100k
R23;R33 = 4k7
R25 = 10Ω
R27;R28 = 22k
R29;R30 = 150k
R32 = 47k
R34;R35 = 1M0
R37 = 1k0
P1 = 10k linear potentiometer
P2;P3 = 10k preset H
P4;P5 = 10k logarithmic potentiometer

Capacitors:
C1 = 10n ceramic
C2 = 8p2
C3 = 100p
C4;C24;C25 = 1n0
C5;C34 = 10n
C6;C27 = 100n
C7 = 820n
C8 = 82n
C29 = 1µ0; MKT
C9;C19 = 220µ; 10 V
C10 = 220n
C11;C15 = 10µ; 10 V
C12;C17 = 1µ0; 10 V
C13 = 100µ; 6V3
C14 = 47µ; 10 V
C16 = 68µ; 10 V
C18 = 820p
C20;C26 = 22µ; 10 V
C21 = 47n
C22;C32 = 470µ; 10 V
C23 = 100µ; 16 V
C28 = 8n2
C30 = 10µ; 16 V; radial
C31 = 10µ; 10 V; radial
C33 = 27p

Semiconductors:
D1 – D5 = AAZ18
D6 – D11 = 1N4148
T1;T2;T4 = BC550C
T3 = BC560C
T5 = BF256A
IC1;IC2 = TLC271
IC3 = LM386
IC4 = 7808 or 7809

Miscellaneous:
S1 = PCB-mount dual-pole 6-way rotary switch.
S2 = miniature SPDT switch.
M1 = 50 µA moving-coil meter, e.g., Monacor Type PM-2, order code 29.0660.
LS1 = 8 Ω; 0.5 W loudspeaker.
K1;K2;K3;K4 = insulated BNC-sockets, e.g., Monacor order code 34.1880
Enclosure: e.g., Telet LC-850 (C-I Electronics).
PCB Type 890183 (see Readers Services page)
Front panel foil Type 890183-F (see Readers Services page).

iar Type LM386 AF amplifier chip is used in a standard application circuit with a Boucherot network, C21-R25, at its output. The input signal for the amplifier is reduced by R24 to a level where full drive coincides with f.s.d. on the meter. This level results in an output voltage of about 6 V_{pp} (2.2 V_{rms}), or 0.56 W into a load resistance of 8 Ω. The output signal is made available on the front panel of the instrument to enable an external loudspeaker or a pair of headphones to be connected.

Sine-wave oscillator

A high-quality sine-wave oscillator is provided to locate faulty AF circuits by means of the audible distortion they introduce. The oscillator consists of a Type TLC271 opamp with a Wien-bridge feedback circuit, C24-R29 and C25-R30, to achieve amplitude stabilization. Feedback circuit R31-R32-T5 determines the closed-loop amplification of the oscillator. The drain-source junction of the FET forms a resistor whose value is a function of the output voltage rectified by D11 and fed back to the gate. Resistor R33 determines the minimum amplification when the FET is turned off completely, and at the same time linearizes the control characteristic.

The test oscillator has a distortion lower than 0.05% at a second harmonic level of −75 dB. The output frequency is about 1 kHz and the output signal level is adjustable between 0 V and 1.5 V_{rms}.

Power supply

The on-board 8 V regulator allows an inexpensive mains adapter to be used with an output voltage of about 12 V. The 8 V regulator, IC4, may be replaced by a 9 V Type 7809. It is also possible to power the instrument from a single 9 V battery, or a battery pack consisting of six 1.5 V monocells. When a battery is used, IC4 is omitted and a wire is fitted to connect the holes provided for its input and output terminals.

Current consumption of the signal tracer depends mainly on the drive applied to the monitor amplifier. At relatively low volumes, the instrument draws 15 mA to 18 mA from a 9 V battery.

Construction

The printed-circuit board (Fig. 2) and the front-panel foil (Fig. 3) are both available ready-made, and make the signal tracer a simple-to-build project by reducing the wiring to a minimum. All sockets and controls are mounted direct on to the printed-circuit board, which is fitted vertically behind the front panel. The distance between the front panel and the printed-circuit board is determined by the length of the spindle of the rotary switch.

The rear panel of the enclosure holds the supply socket, the loudspeaker and the battery holder, if used.

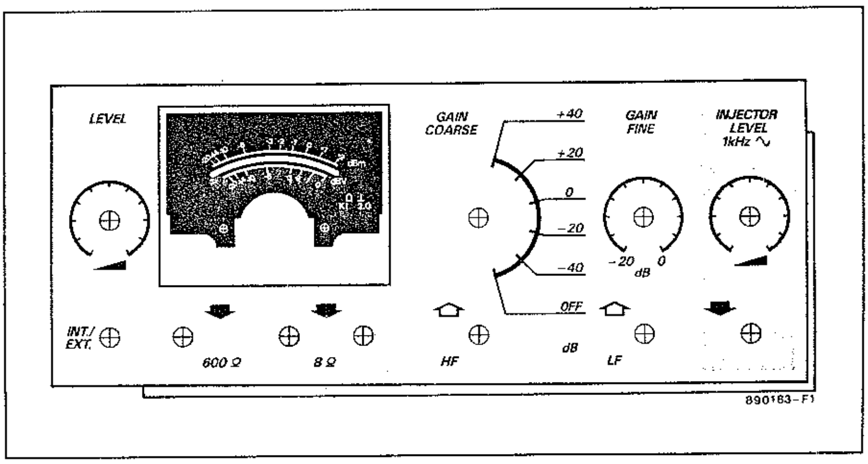


Fig. 3. Lay-out of the front-panel foil, which is available ready-made (shown at 60%).