DISCRETE PREAMPLIFIER

Quality-conscious audio buffs still prefer discrete designs. And quite rightly so, because although there are very good operational amplifiers available, discrete designs offer just that little bit extra.

The present preamplifier is a symmetrical Class A design. The input is a double differential amplifier consisting of dual transistors Type MAT02 or MAT03. A stable d.c. operating point is ensured by current sources T_3 and T_4, which use LEDs as reference—D_1 and D_2 respectively.

The current through the LEDs is held stable by current source T_5. It is essential for good thermal stability that the transistors and associated diodes (T_3 and D_1, and T_4 and D_2) are mounted in close contact.

The input signals are applied to push-pull drivers T_6 and T_7, which feed the output stages, consisting of emitter followers T_{10} and T_{11}. Transistors T_8 and T_9 ensure a constant quiescent current through the emitter followers. It is necessary for good thermal stability that T_8 and T_{10}, and T_9 and T_{11}, are mounted in close contact. To this end, their flat sides, with heat conducting paste in between, are juxtaposed. The pairs are held together with a loop of bare copper wire.

Before the mains is switched on, set P_1 to maximum resistance. Switch on the mains, wait for about a minute and then adjust P_1 for a quiescent current through T_{10} and T_{11} of 15 mA, corresponding to a voltage drop of 150 mV across R_{23} and R_{24}.

Since the amplifier is d.c. coupled throughout, the likelihood of a fairly high direct voltage at the output would be great, the more so because the input transistors are not truly complementary. This is, however, obviated by an active d.c. correction that holds the direct voltage at the output at zero in all circumstances. For this purpose, the output signal is passed via low-pass filter R_{26}-C_{13} to integrator IC_1. Tis arrangement does not affect fast variations of the signal. If, however, the output signal has a d.c. component, T_{12} will conduct to some degree, so that the bases of T_1 and T_2 are pulled into a negative direction. In a negative direction, because T_1 (n-p-n) has an inherently greater voltage amplification (×3) than T_2 (p-n-p).

Adjust P_2 immediately on switch-on for as low a direct voltage at the output as possible. From then on, any variations caused by temperature changes will be corrected by IC_1. The speed at which the correction takes place can be increased by giving R_{26} and R_{27} lower values.

It is important for optimum

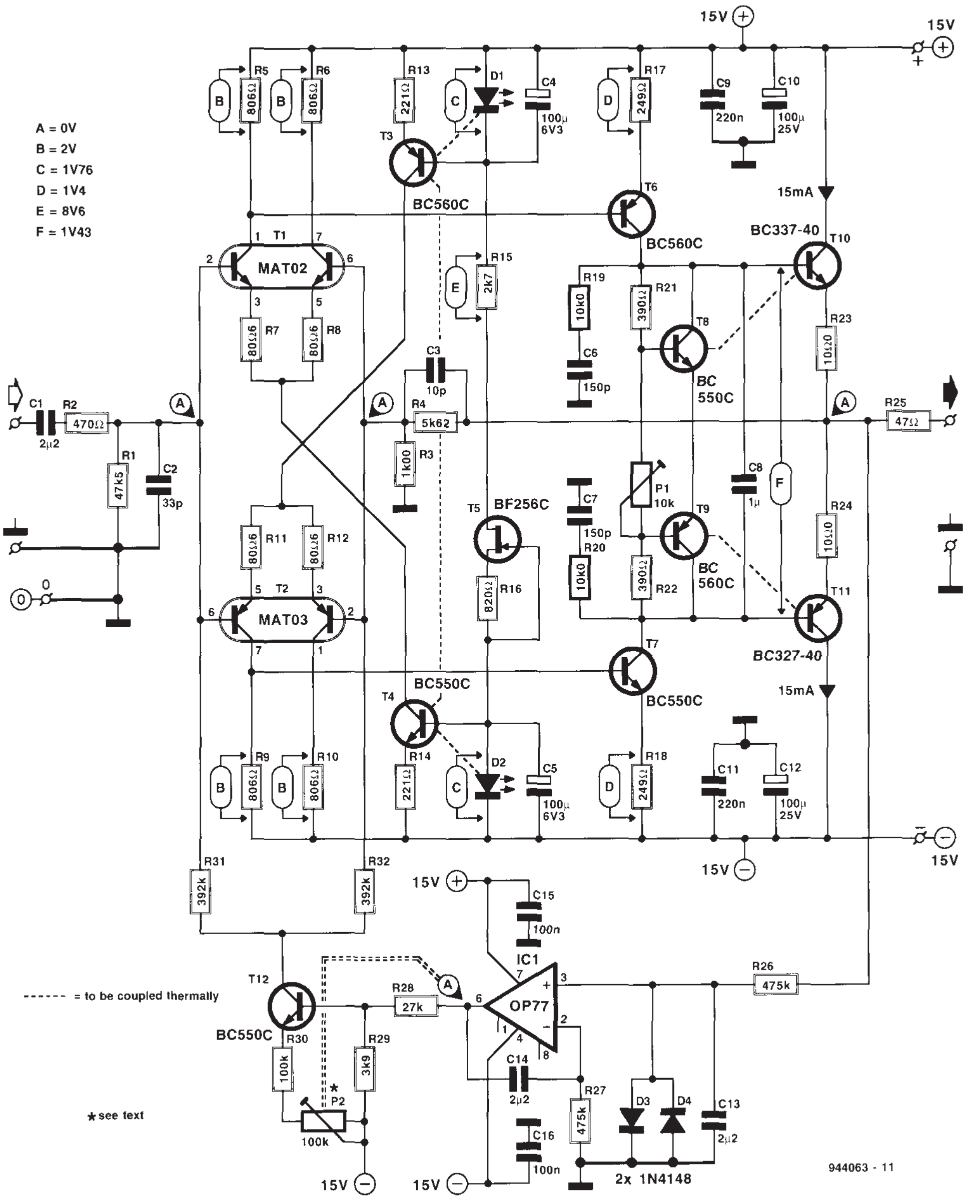

Fig. 1. Circuit diagram of the discrete preamplifier

Some parameters

(measured with an output of 1 V r.m.s. across 47 kΩ)

THD	≤0.00005% (at 1 kHz)
	≤0.0004% (at 20 kHz)
THD + N (B = 22 Hz–80 kHz)	<0.0012% (20 Hz–20 kHz)
Signal-to-noise ratio (B = 22 Hz–22 kHz)	>104 dB
Bandwidth	1.5 Hz–3.7 MHz
Slew rate	about 200 V μs^{-1}
Rise time	about 0.1 μs
Input impedance	47 kΩ
Sensitivity	150 mV
Peak output voltage	about 9 V r.m.s.

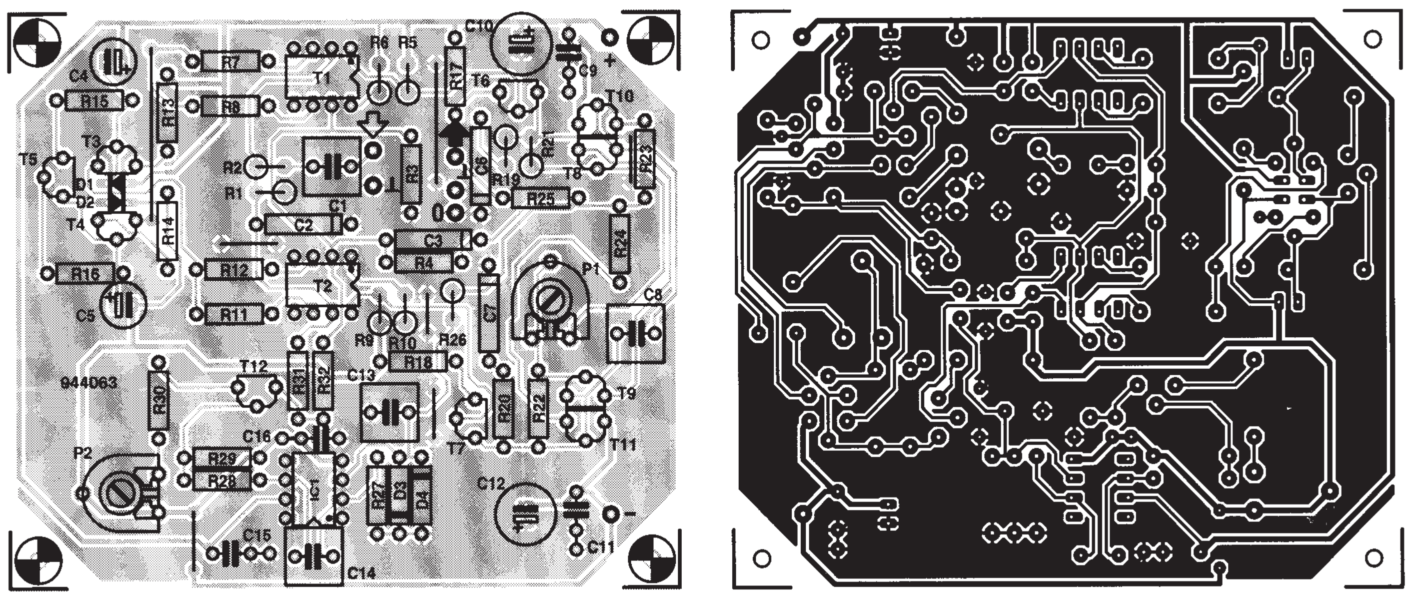

Fig. 2.Printed circuit board for the discrete preamplifier.

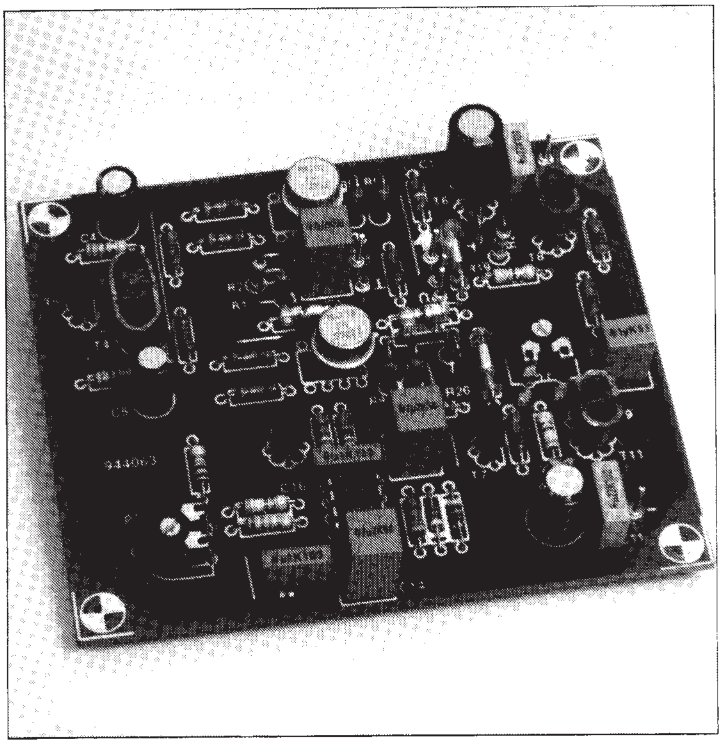

Fig. 3. Completed printed circuit board.

symmetry that the currents through T_1 and T_2 (and thus the voltage drops across R_9 and R_{10}) are equal. This can only be if the potentials across D_1 and D_2 are equal, and it is, therefore, advisable to match these diodes for equal voltage with a test current through them of 3 mA. When the diodes are matched, the drops across R_{13} and R_{14} should not differ by more than a few millivolts.

The same applies to T_6 and T_7: for good symmetry they should be matched for equal base/emitter voltage, with a current through them of 5 mA. This matching can not be done in the circuit, because the voltage drops across R_{17} and R_{18} will be equal whatever, otherwise the output would not be zero.

Low-pass filter R_2-C_2 is designed for maximum slew rate at a cut-off point of 9–10 MHz. If this large bandwidth results in high sensitivity to interference, it may be advisable to lower the cut-off point. If the value of C_2 is increased to 680 pF, the cut-off point drops to about 400 kHz. At the same time, the slew rate deteriorates to about 20 V μs^{-1}.

The preamplifier is best built on the PCB in **Fig. 2**, which is available ready-made.

The supply lines should be stabilized by a suitable voltage regulator.

Parts list

Resistors:
R_1 = 47.5 kΩ, 1%
R_2 = 470 Ω
R_3 = 1.00 kΩ, 1%
R_4 = 5.62 kΩ, 1%
R_5, R_6, R_9, R_{10} = 806 Ω, 1%
R_7, R_8, R_{11}, R_{12} = 80.6 Ω, 1%
R_{13}, R_{14} = 221 Ω, 1%
R_{15} = 2.7 kΩ
R_{16} = 820 Ω
R_{17}, R_{18} = 249 Ω, 1%
R_{19}, R_{20} = 10.0 kΩ, 1%
R_{21}, R_{22} = 390 Ω
R_{23}, R_{24} = 10.0 Ω, 1%
R_{25} = 47 Ω
R_{26}, R_{27} = 475 kΩ, 1%
R_{28} = 27 kΩ
R_{29} = 3.9 kΩ
R_{30} = 100 kΩ
R_{31}, R_{32} = 392 kΩ, 1%
P_1 = 10 kΩ preset potmeter
P_2 = 100 kΩ preset potmeter

Capacitors:
C_1, C_{13}, C_{14} = 2.2 μF, 50 V, pitch 5 mm
C_2 = 33 pF, 160 V, polystyrene
C_3 = 10 pF, 160 V, polystyrene
C_4, C_5 = 100 μF, 6.3 V, radial
C_6, C_7 = 150 pF, 160 V, polystyrene
C_8 = 1 μF, pitch 5 mm
C_9, C_{11} = 220 nF
C_{10}, C_{12} = 100 μF, 25 V, radial
C_{15}, C_{16} = 100 nF

Semiconductors:
D_1, D_2 = LED, red, flat
D_3, D_4 = 1N4148
T_1 = MAT02
T_2 = MAT03
T_3, T_6, T_9 = BC560C
T_4, T_7, T_8, T_{12} = BC550C
T_5 = BF256C
T_{10} = BC337-40
T_{11} = BC327-40

Integrated circuits:
IC_1 = OP77

Miscellaneous:
PCB Ref. 944063 (p. 110)

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[944063]