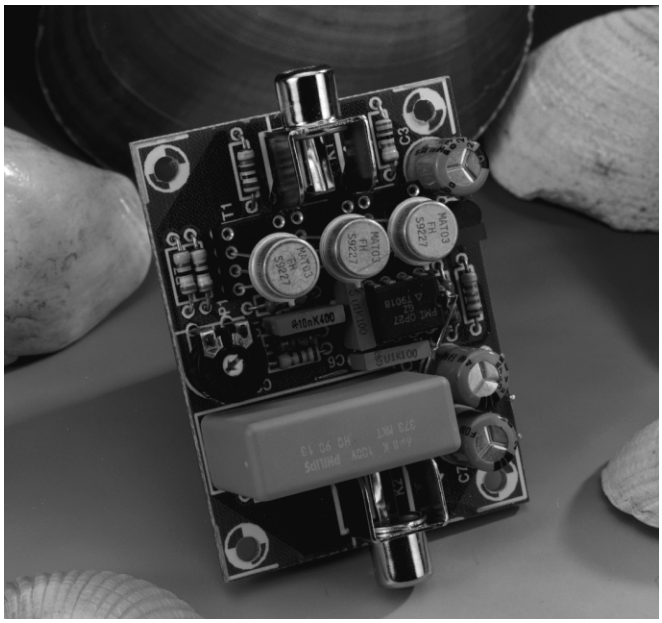
009 ultra low-noise MC preamplifier



This preamplifier was designed for low-impedance signal sources like MC (moving-coil) pick-up cartridges used in high-end record players (yes, they still exist). The actual input impedance of the preamplifier is 100 Ω. To keep the input noise as low as possible, three dual transistors type SSM2220 or MAT03 transistors are connected in parallel to form a discrete difference amplifier. By connecting this amplifier ahead of an opamp (OP27), the input noise of the opamp becomes immaterial. The base connections of the discrete amplifier then function as the inputs of a super-opamp with a very low input noise level. An advantage of the p-n-p transistors used here over their n-p-n counterparts is their much lower low-frequency noise level. On the down side, a fairly large bias current of about 5.5 μA is created at the input. This is the result of the 2-mA setting for each transistor in combination with the relatively low gain of the p-n-p devices.

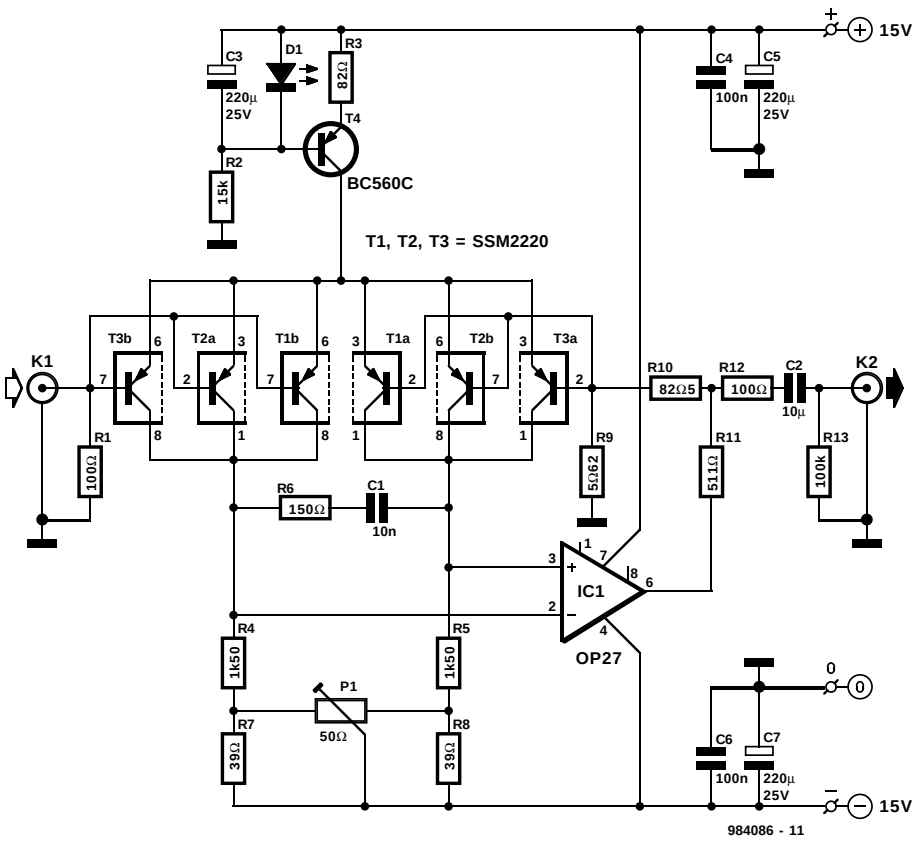
COMPONENTS LIST

Resistors:
R1,R12 = 100Ω
R2 = 15kΩ
R3 = 82Ω
R4,R5 = 1kΩ50
R6 = 150Ω
R7,R8 = 39Ω
R9 = 5Ω62
R10 = 82Ω5
R11 = 511Ω
R13 = 100kΩ
P1 = 50Ω preset H

Capacitors:
C1 = 10nF
C2 = 10μF MKT (Siemens) raster 22.5mm or 27.5mm
C3,C5,C7 = 220μF 25V radial
C4,C6 = 100nF

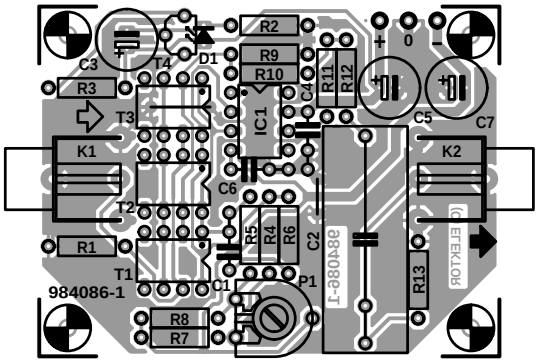
Semiconductors:
D1 = red LED, flat
T1,T2,T3 = SSM2220 or MAT03 (Analog Devices)
T4 = BC560C
IC1 = OP27GP (Analog Devices)

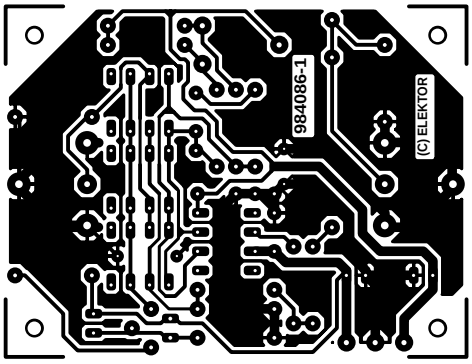
Miscellaneous:
K1,K2 = phono (line) socket, PCB mount, gold-plated, e.g. T-709G from Monacor/Monarch (available from C-I Electronics or Stippler Electronics)



Preset P1 and resistors R7/R8 enable you to iron out any tolerances on R4 and R5 in the difference amplifier output. Transistor T4 and LED D1 ensure a stable current setting for the difference amplifier. D1 should be a flat, red, LED which is fitted face-to-face against T4 for thermal coupling. Because the input noise level amounts to 0.4 nV/√Hz (theoretical value for a 10-Ω resistor), it is essential that the feedback adds as little as possible to the overall noise figure. Consequently, the impedance of the feedback circuit must be much lower than 10 Ω. Furthermore, the OP27 demands a certain minimum load impedance, so that the feedback impedance may not be less than 600 Ω. To ensure that a low value can be used for R9, a compromise had to be found between maximum gain (here, approx. 24 dB or 15.7 times) on the one hand, and the value of R9. By fitting an additional resistor, R11, ahead of the actual feedback, the opamp is not excessively loaded, while R9 adds 'only' 0.3 nV/√Hz to the input noise level, which, based on measurement data, amounts to 0.52 nV/√Hz. If more gain is needed, a noise figure of about 0.4 nV/√Hz may be achieved at a lower value of R9. The obvious disadvantage of adding R11 is a higher internal gain, causing a smaller bandwidth and a lower drive margin. Fortunately, these factors are of little consequence in the case of moving-coil elements.

There are two ways to adjust P1. The first is to adjust the output





voltage to nil (measure at IC1 pin 6). The second option is to measure the input offset, for example, 0.55 mV across 100 Ω. Assuming that the offset caused by T1, T2 and T3 is negligible, then the output voltage should be 15.68 x 0.55 mV for perfect symmetry, in other words, junction R10-R11-R12 should be at 8.62 mV with respect to ground.

Those of you who like to experiment may want to try the effects of reducing the number of input transistors from three to just one. You may want to do this, for example, to reduce the input bias current. Resistor R3 then has to be changed into 249 Ω. Do remember, however, that the input noise level then rises by 2.5 dB!

The output has a large, solid 10 μF MKT (metal theraphtelate, ask your local Siemens distributor) capacitor to prevent a large offset voltage being applied to the input of an MD amplifier.

The preamplifier is powered by a symmetrical, regulated 15-V supply, and draws about 16 mA on each rail. Finally, here are a few key figures measured on our prototypes:

Configuration: 3 x SSM2220/MAT03		
	signal: 0.5 mV/25 Ω	input short-circuited
S/N (BW = 22 kHz)	71.2 dB	74 dB
	74 dBA	76.2 dBA
Configuration: 1 x MAT03 (R3 = 249 Ω)		
S/N (BW = 22 kHz)	69.5 dB	71 dB
	72.3 dBA	73.7 dBA

The preamplifier is best built on the printed circuit board whose artwork is shown here. Construction is uncritical, but do not forget the wire links under transistor T3 and next to capacitor C2. The PCB is unfortunately not available ready-made from the Publishers.

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