RIAA Preamp with FETs

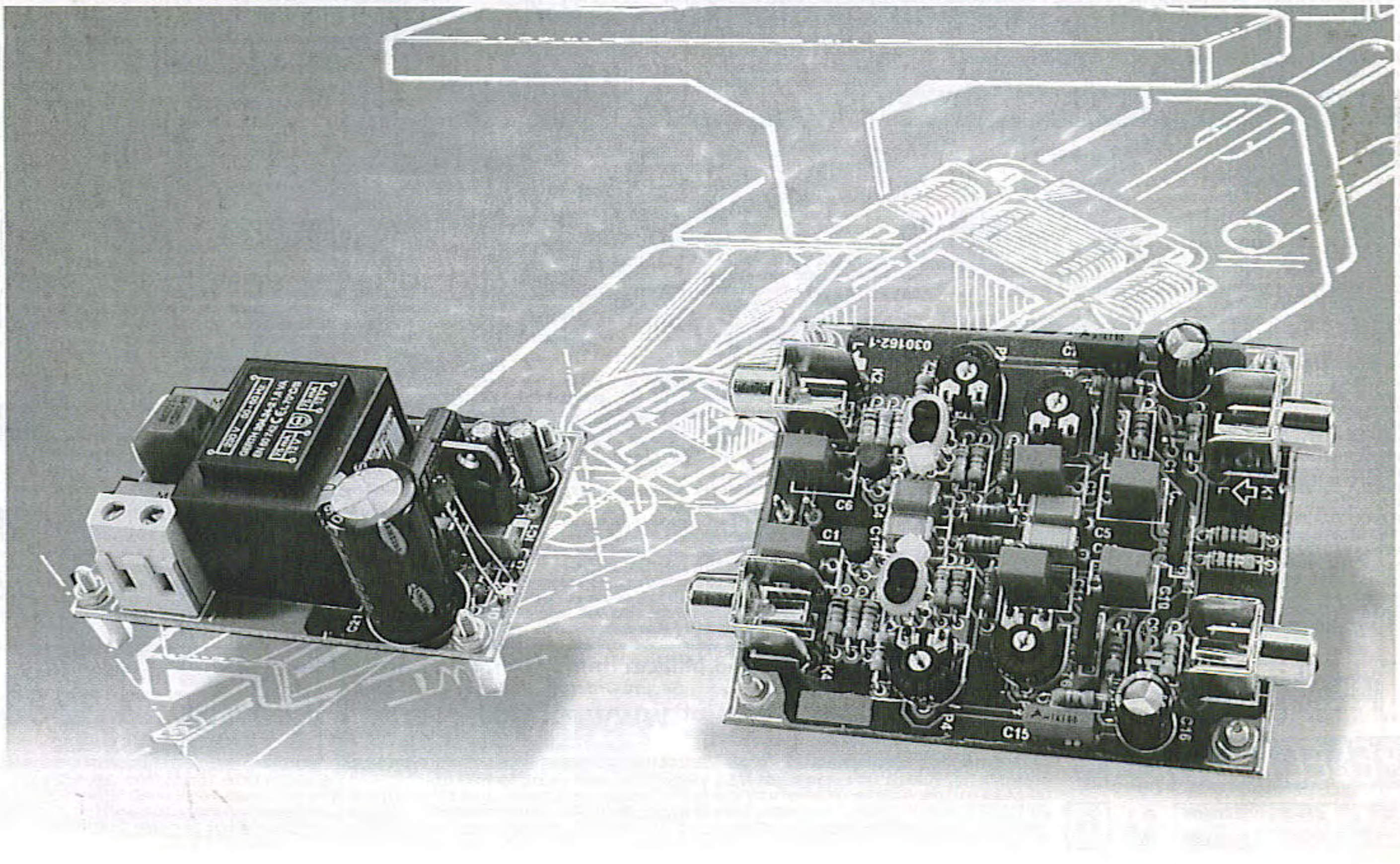
SRPP equaliser for moving magnet (MM) cartridges

Design by H. Breitzke

This preamplifier and equaliser is based around field effect transistors and is an updated version of the SRPP valve preamp we published in March and April 1987. Various changes are necessary due to the fact that the FET SRPP configuration offers a considerably higher gain and output impedance than its valve sibling.

The *Shunt Regulated Push-Pull* (SRPP) topology is frequently used in high-frequency applications, but is seldom seen in audio circuits. This is simply because SRPP works well with valve technology, but is not suitable for use with bipolar transistors or with operational amplifiers because the circuit does not employ negative feedback.

As a result distortion is considerably increased. Using FETs, however, we can employ the SRPP topology as effectively as with valves.



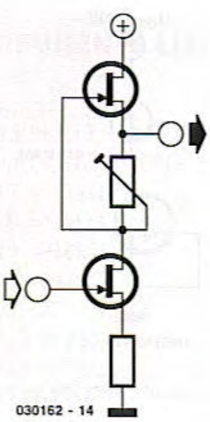
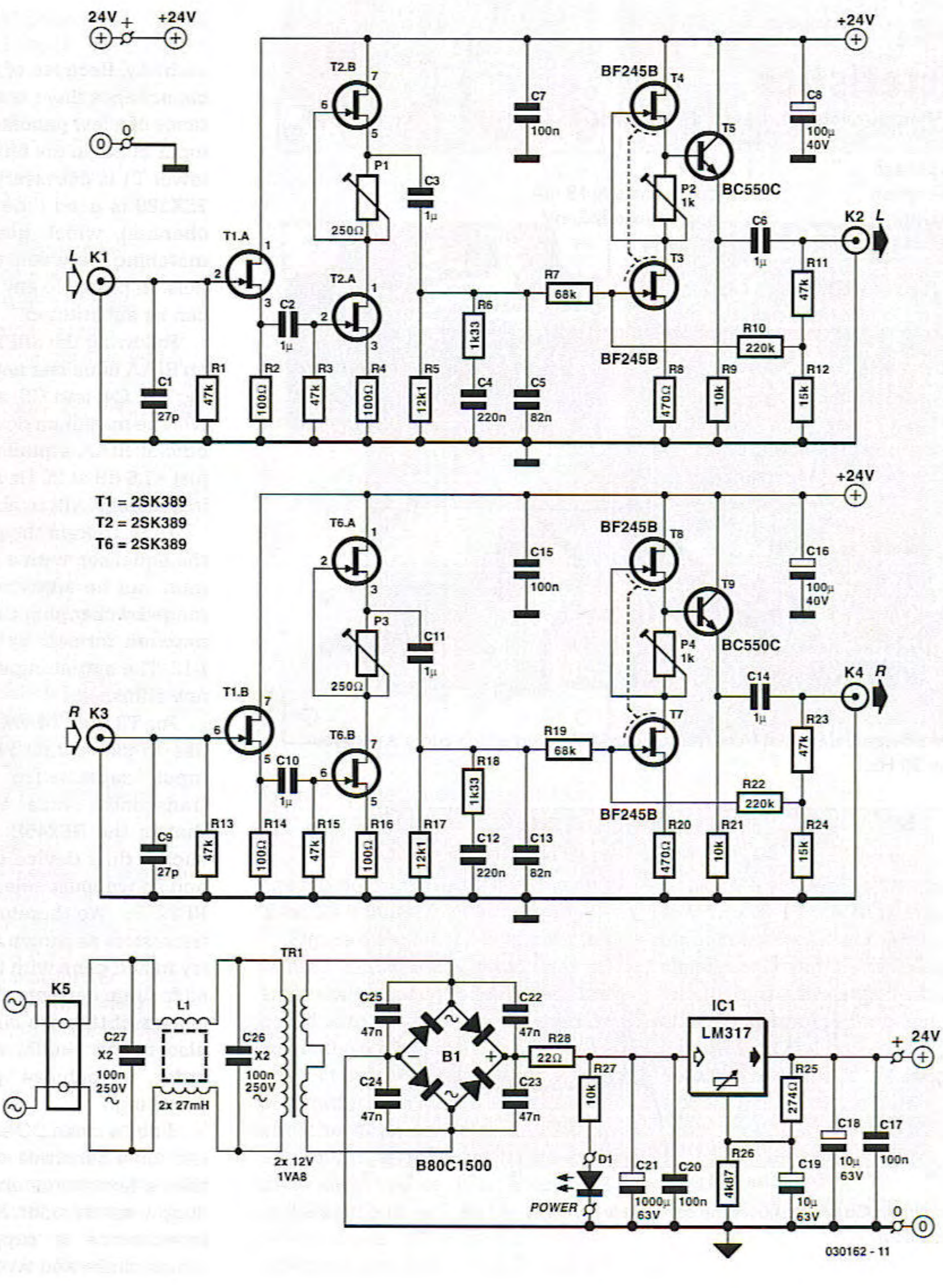


Figure 1. Push-pull circuit with SRPP topology.

SRPP

The SRPP technique is based on a push-pull arrangement (**Figure 1**), where the transistors or valves are, for the purposes of DC analysis, connected in series. The signal is taken to the gate of the lower FET. The AC voltage dropped across the impedance in the source connection of the upper FET serves as an out-of-phase drive voltage for the upper FET, since the drain of the lower FET is connected to the gate of the upper FET. Meanwhile, the DC voltage drop across the trimmer potentiometer provides the gate bias voltage for the upper FET. From the point of view of the

Figure 2. The circuit of the RIAA equaliser includes a high-quality power supply.



lower transistor the upper transistor appears as a current source, while the output is taken from the upper transistor in a source-follower arrangement. This special push-pull topology reduces the output impedance of the transistors by a factor of 3 or 4. The operation of the SRPP circuit is straightforward: it is surprising to discover, then, what advantages it offers both technically and in terms of how it sounds:

- very low distortion;
- extremely high linearity;
- high gain;
- generous headroom;
- low output impedance.

The Circuit

Aside from the power supply, the circuit in **Figure 2** consists of two identical amplifier stages: we will describe the left channel. Central to the amplifier is the SRPP arrangement around T2a and T2b, which has a gain of approximately 280. A type 2SK389 dual FET is used to reduce noise and to improve thermal stability. Because of the high input capacitance there is a Miller capacitance of a few nanofarads, and so an input buffer in the form of source-follower T1 is necessary. Here again a 2SK389 is used (one transistor per channel), which guarantees good matching between the two channels. In principle any low-noise FET can be substituted.

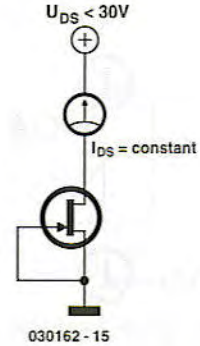


Figure 3. Circuit used for selecting FETs.

Following the SRPP stage there is an RIAA equaliser network comprising C3, C4, and C5, and R5, R6 and R7. The maximum deviation from the official RIAA equalisation curve is just –1.6 dB at 20 Hz and agreement is generally within about 0.3 dB.

T3 to T5 form the output stage of the equaliser, with a gain of 12. The gain can be adjusted over a wide range by changing the AC feedback network formed by R10, R11 and R12. The output impedance is just a few ohms.

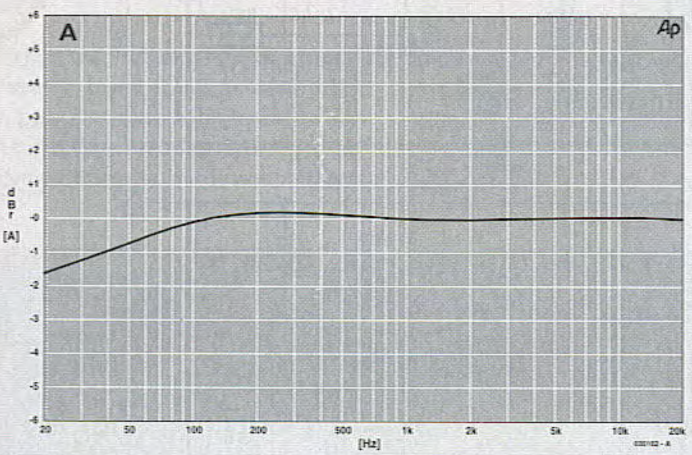
For T3 and T4 we would ideally like to use a dual FET with a low input capacitance but with a transconductance comparable to that of the BF245B. Unfortunately such a dual device does not exist, and so we must select two suitable BF245Bs. We therefore connect the transistors as shown in **Figure 3** and try to find pairs with the closest possible drain currents. The lower transistors of the two channels should also be as similar as possible in order to achieve good channel matching.

Since a clean DC supply is essential for a sensitive circuit such as this, a few words about the power supply are in order. High-frequency interference is suppressed by a mains choke and two capacitors on

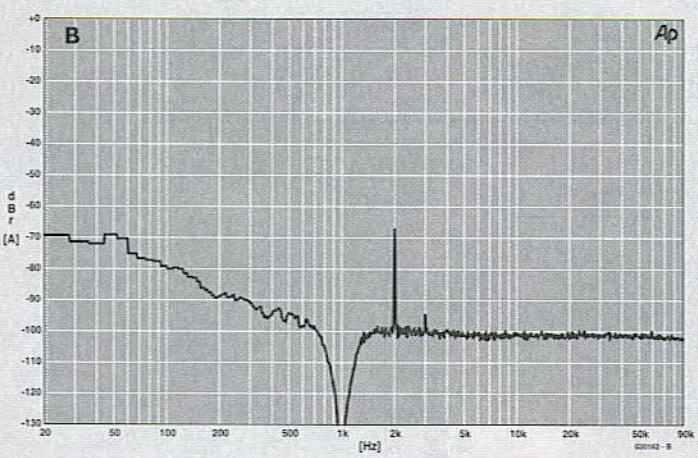
Characteristics

(with 200 mV output voltage, 1 kHz, 47 kΩ load)

Power supply voltage	24 V
Current consumption	approximately 18 mA
Nominal sensitivity	approximately 2 mV
THD+N (400 Hz to 22 kHz)	0.054 %
S/N	>71 dBA



Curve A shows that the deviation from the standard RIAA correction curve is very low: only –1.6 dB at 20 Hz.



The spectrum plot in **Curve B** shows the second harmonic at –67 dB. The third is barely above the noise floor.

COMPONENTS LIST

Resistors:
R1,R3,R11,R13,R15,R23 = 47kΩ
R2,R4,R14,R16 = 100Ω
R5,R17 = 12kΩ1
R6,R18 = 1kΩ33
R7,R19 = 68kΩ
R8,R20 = 470Ω
R9,R21,R27 = 10kΩ
R10,R22 = 220kΩ
R12,R24 = 15kΩ
R25 = 274Ω
R26 = 4kΩ87
R28 = 22Ω
P1,P3 = 250Ω preset
P2,P4 = 1kΩ preset

Capacitors:
C1,C9 = 27pF
C2,C3,C6,C10,C11,C14 = 1μF MKT, lead pitch 7.5mm
C4,C12 = 220nF
C5,C13 = 82nF
C7,C15,C17,C20 = 100nF
C8,C16 = 100μF 40V radial
C18,C19 = 10μF 63V radial
C21 = 1000μF 63V radial
C22-C25 = 47nF ceramic, lead pitch 5mm
C26,C27 = 100nF 250 VAC (Class X2), lead pitch 15mm

Inductors:
L1 = suppressor choke 2 x 27mH (Epcos # B82721-K2401-N21)

Semiconductors:
B1 = B80C1500 bridge rectifier, rectangular case (80V piv, 1.5 A)
D1 = LED, low current
T1,T2,T6 = 2SK389-BL (Toshiba), (www.reichelt.de)
T3,T4,T7,T8 = BF245B (see text)
T5,T9 = BC550C
IC1 = LM317 (TO220 case)

Miscellaneous:
K1-K4 = cinch socket, PCB mount (Monacor/Monarch # T-709G)
K5 = 2-way PCB terminal block, lead pitch 7.5m
TR1 = mains transformer, 2 x 12V / 1.8VA (e.g. Gerth # 304.24-2)
PCB, available from The PCBShop.

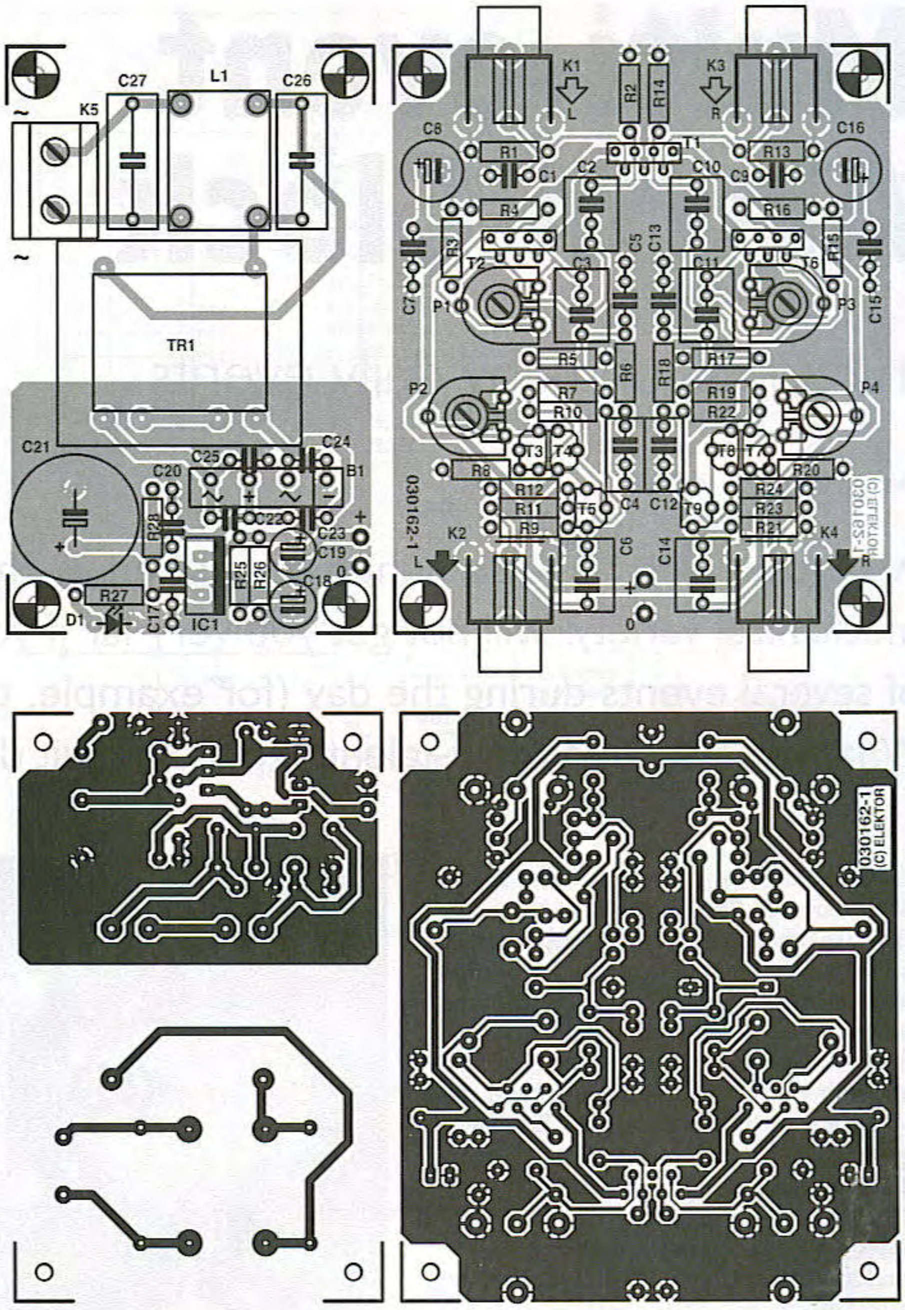


Figure 4. Printed circuit board layout.

the primary side of the small 24 V transformer. On the secondary side capacitors are connected across the diodes in the rectifier bridge, which suppress interference caused when the diodes switch. The LM317 voltage regulator produces a stable and clean 24 V supply.

Figure 4 shows the layout for the printed circuit board, which has an extensive ground plane. Unless the board is to be mounted as a whole inside the enclosure, the power supply section should be cut off before populating the board. The layout and the component arrangement are practically symmetrical, and there are two wire links, near to K2 and K4.

Alignment of the circuit involves adjusting potentiometers P1 and P2 so that the voltages at the source connections of T2b and T4 are each equal to $U_b/2$. The input capacitance of the circuit is formed by capacitor C1 and the input capacitance of T1, which, in the case of the 2SK389, is around 20 pF. The optimum input capacitance depends on the type of cartridge, and will normally be found in the specifications of the system.

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