Valve Preamplifier

Part 2: construction

Design by Bob Stuurman

In the first part of this article, we described all of the circuit boards. Now it's time to look at how they fit together. We first describe the mechanical construction, after which we turn our attention to wiring the entire assembly. We conclude with a brief look at the specifications and performance.

An important factor with this type of equipment is the enclosure. For the prototype, we selected a standard model from the Conrad line. It consists of black top and bottom covers made from robust 1.5-mm sheet steel and two 1-mm aluminium face panels. The top and bottom covers have ventilation openings. The edges of the face panels are bent at right angles to form lips, to which the top and bottom covers are fastened using four self-tapping screws. The face panels have a brushed matte finish and protective cover foils. For the sake of simplicity, we call the face panel at the front the 'front panel' and the other face panel the 'rear panel'.

Mechanical construction

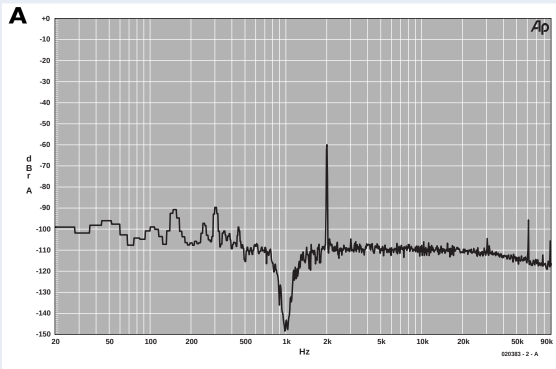
The construction chosen by the author is the peak of simplicity. It uses a U-shaped channel section formed from 1.5-mm sheet aluminium, with dimensions of 290 × 155 × 85 mm (**Figure 1**). All of the preamplifier subassemblies are fitted on or inside this channel section. Four 15-mm brass standoffs are fitted to the front, and another four 20-mm standoffs are fitted to the rear. The face panels of the enclosure are attached to the standoffs using M3×5 screws. The end result is that the aluminium channel section is 'suspended' between the front and rear panels.

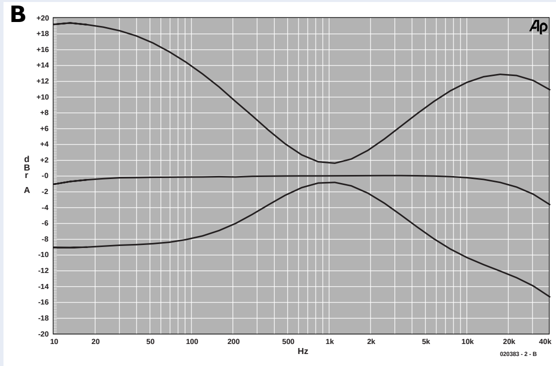
There is a 15-mm space between the front face of the channel section and the front panel. This provides room for the fixing nuts of the potentiometers and switch and the gearwheels of the balance potentiometers. The LED indicator lamp and the actuating button for the mains switch are fitted directly to the front panel. At the rear, the space is 20 mm deep. This region holds the I/O board (on 15-mm standoffs), the mains filter and IEC appliance receptacle and a small fan.

The power supply is fitted against the back of the channel section, with the transformer stack in the middle, the low-voltage circuit board to the left and the high-voltage circuit board to the right. The two amplifier boards are fitted at the front of the channel section. All of these circuit boards are screwed to 10-mm standoffs, with plastic standoffs being used for the high-voltage board. An aluminium plate with a thickness of 1 mm and a height of 55 mm, with a turned-up lip along one edge, is placed between the power supply

Specifications

Nominal signal level, 'Out'	450 mV (380 mV in)
Nominal signal level, 'Line Out'	220 mV (380 mV in)
Input impedance (CD/Tuner/...)	120 kΩ
THD+N, 'Out'	0.1 % (450 mV out)
Signal-to-noise ratio, 'Out'	80 dBA
Bandwidth (maximum volume)	< 10 Hz–35 kHz (–3 dB)
Crosstalk	< –65 dB (1 kHz) <–40 dB (20 kHz)
Channel separation	> 76 dB (1 kHz) > 60 dB (20 kHz)
Phono sensitivity (450 mV out)	5 mV (1 kHz)
Signal-to-noise ratio, Phono	> 53 dB
Bass adjustment (theoretical)	+18/–9 dB (50 Hz)
Treble adjustment (theoretical)	+9/–10 dB (10 kHz)





Measured response curves:

Chart A shows the frequency spectrum at maximum volume. The distortion primarily consists of the 2nd harmonic at –60 dB, which explains the value of 0.1 % for THD+N. The fundamental was suppressed for the measurement. The supply-voltage ripple and induced noise from the transformers lie below –90 dB and are negligible.

Chart B shows the frequency response with the tone controls in the neutral, minimum and maximum positions. The actual frequency response may vary due to component tolerances (potentiometers and capacitors).

and the amplifier boards. The lip of this plate is fitted underneath the standoffs for the amplifier boards in order to securely attach it to the channel section. In the prototype, a length of plastic cable duct (the type with a hinged snap cover) was fitted along the top edge of this aluminium plate on the side towards amplifier boards, in order to provide a cableway for several cables. This cable duct can be clearly seen on the photo in **Figure 2**, which also shows the placement of the circuit boards and other components.

Details

Cooling fan

The ventilation openings in the top and bottom covers are not sufficient for the amount of heat to be dissipated. We did not want to deface the enclosure by making large holes in it, so we fitted a small fan at the rear of the enclosure. A series resistor (82 Ω in the prototype) causes the fan to turn quite slowly, and since it is fitted using rubber bushings, it is practically inaudible. The air stream from the fan is directed toward the heat sink of the LM317. This forced airflow through the enclosure also removes the heat generated by the valves.

After the front and rear panels have been firmly screwed to the standoffs, the fastening holes for the top and bottom covers will quite likely not align exactly with the corresponding holes in the face panels. This is because it is nearly impossible to form the U-shaped channel section to a precise dimension. Consequently, the standoffs at the rear must be lengthened using shim washers until the holes are aligned. This also prevents the fan from being clamped between the two surfaces, so it can do its job without making any noise.

On/off switch

In order to keep the mains wiring (a potential source of interference) as short as possible,

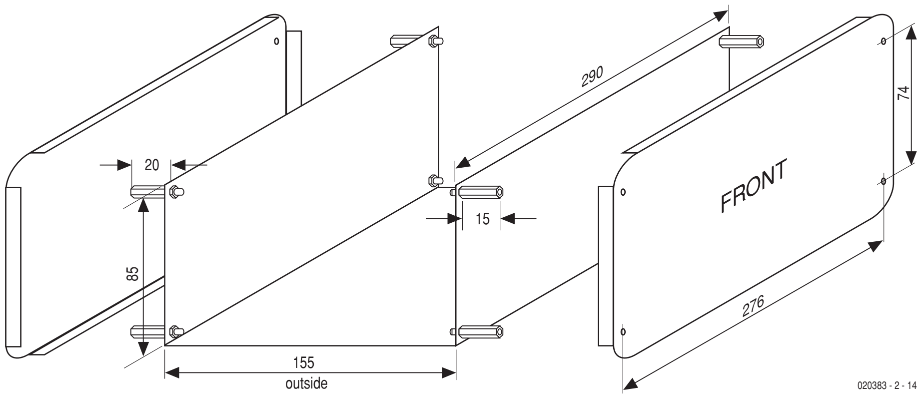


Figure 1. A U-shaped aluminium channel section is suspended between the front and rear panels of the enclosure, using 15-mm standoffs at the front and 20-mm standoffs at the rear.

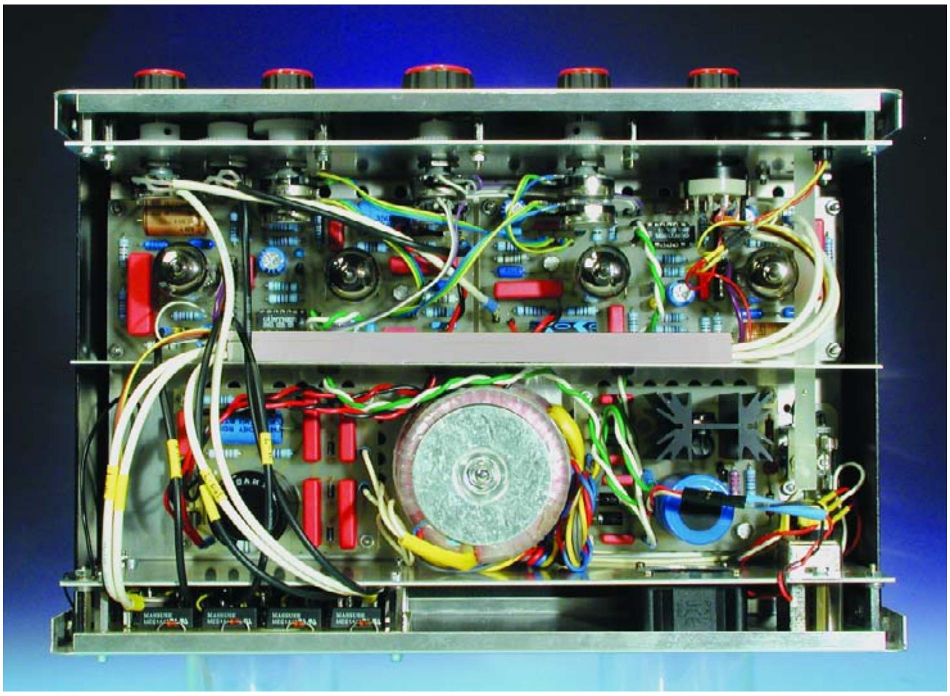


Figure 2. A 'bird's-eye view' of the inside of the preamplifier. All of the wiring is in place, the front and rear panels have been fastened to the channel section and the knobs are fitted.

the on/off switch should preferably be fitted as close as possible to the appliance receptacle. A pushbutton switch with a suitable mechanical extension reaching to the front panel is thus recommended. In the prototype, a special construction was used for this purpose, consisting of a rocker switch with a homemade extension arm, but we won't bore you with further details.

Balance control

As already mentioned in the first part of this article, the balance control is constructed using two log-taper potentiometers that are mechanically coupled using gearwheels (see **Figure 3**). Drill and tap the gearwheels for M3 setscrews. As the material is quite soft, it's a good idea to file flats on the shafts of the potentiometers. This will allow the gearwheels to be securely anchored with only moderate tightening of the setscrews.

Next comes a tip: it's quite easy to equip the balance potentiometers with a tangible midrange position and 'click stops'. This can be done by fitting the shafts of the volume and tone control potentiometers with the same type of gearwheels as used for the balance control. If you arrange a leaf spring such that it presses a steel ball (from bicycle bearing, for example) against the teeth of the gearwheel, you obtain click stops. A tangible midrange position can be produced by removing one tooth at the midrange position. All of this is clearly shown on the photo in **Figure 3**.

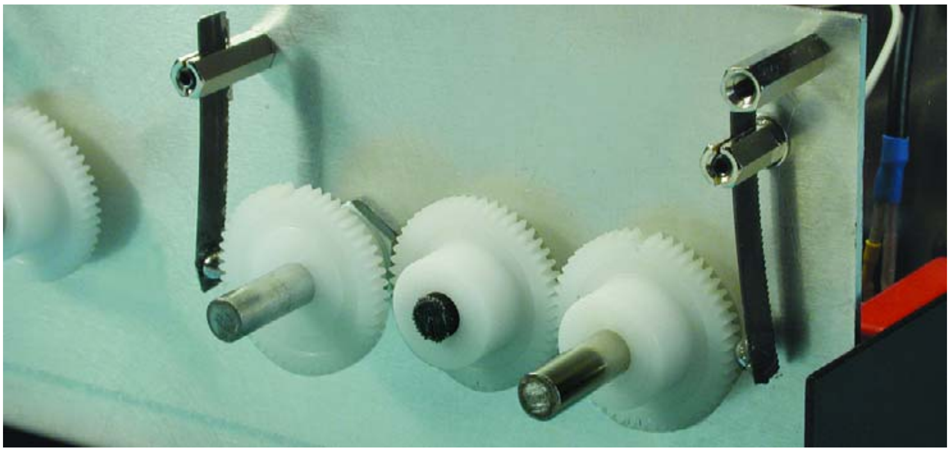


Figure 3. The balance potentiometers are coupled by a pair of gearwheels. The centre-to-centre spacing is 25 mm.

Front panel layout

You are naturally free to label the front panel with text and/or symbols according to your personal taste. For those who prefer a ready-made solution, a front panel layout is available on the *Elektor Electronics* website for download free of charge. It is also ideal for use as a drilling template for the front panel.

Wiring

The aluminium middle plate has four holes with feedthrough bushings, aligned with the circuit board connections for the filament voltage and high voltage, to allow the wiring to pass through the plate. These holes are located at half the height of the plate.

Figure 4 shows how the power wiring of the preamplifier should be fitted. Start by connecting the transformers to the power supply circuit boards, fitting the wiring for the cooling fan and making the mains voltage connections between the IEC appliance receptacle and the switch, fuse and mains filter. Connect the filter terminal to a solder lug screwed to the channel section. Next, make the connections to the filament and high-voltage terminals using twisted-pair wiring passing through the feedthrough bushings. Fit the 'filament' jumpers to the K2 connectors on the circuit boards and connect the filaments of the EF86s in series with a length of wire. This wire is routed through the cable duct. Finally, connect the LED indicator lamp and the input selector switch (S1). Terminal 1 of S1 connects directly to K2/1–2 on the left-hand amplifier board, and then to K2/1–2 on the right-hand amplifier board via a length of flat cable. This six-way flat cable (which is reduced to 5 leads before continuing to the I/O board) also runs through the cable duct.

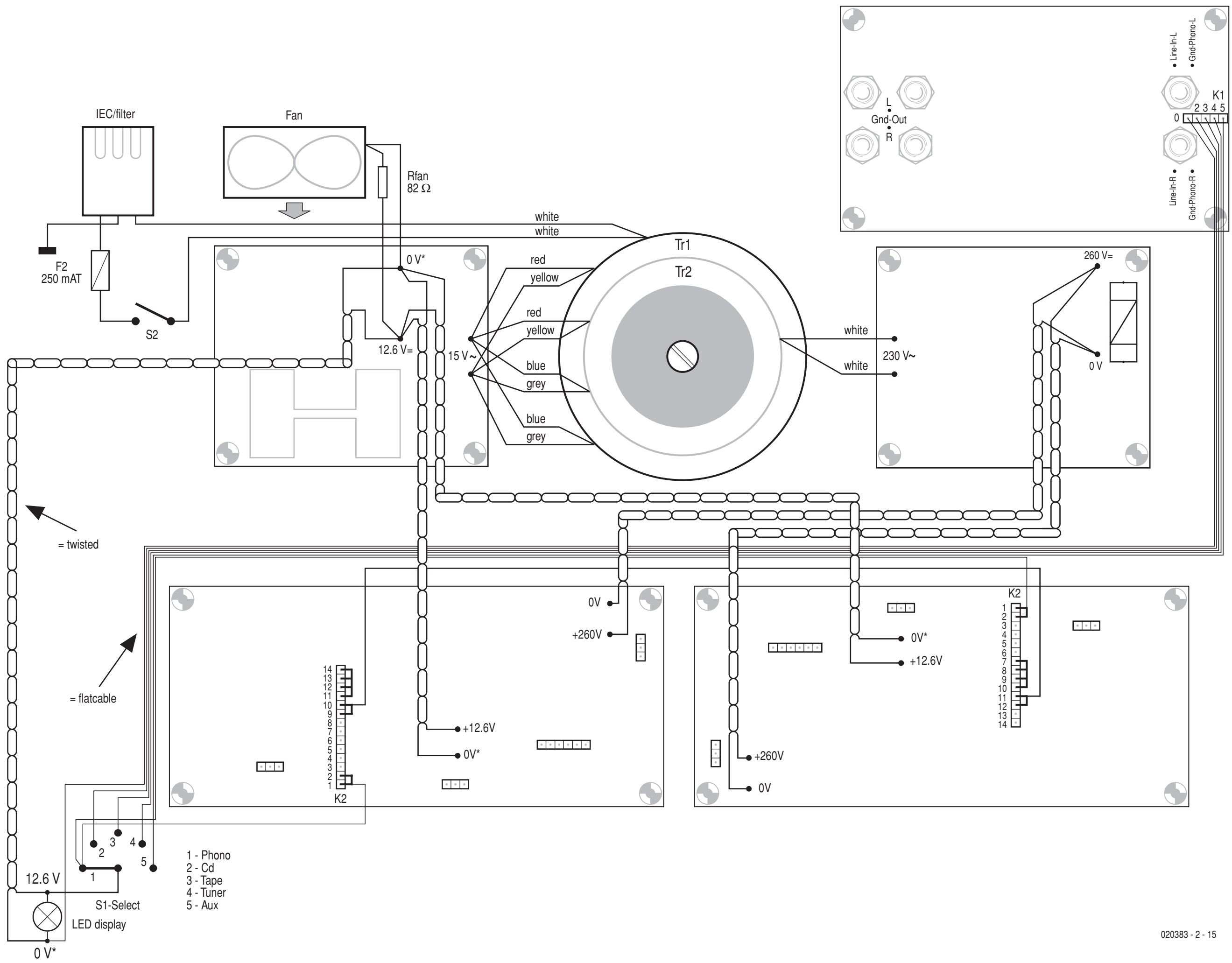


Figure 4. Connection diagram for the power wiring.

Figure 5 shows how the signal wiring must be fitted. The volume, treble and bass potentiometers are connected using short lengths of flat cable, while the rest of the connections are made using screened cable. It is convenient to first cut lengths of screened cable and connect them to the I/O board before it is screwed in place, since it is then still readily accessible.

Be particularly careful with the connections for the cable screens. At the Phono In connectors, the screen is connected to the ground point on the circuit board, and on the I/O board the same screen is connected to Gnd L or Gnd R, respectively, which is also the connection point for the screen of the Line In cable. For the output cables, the screens are jumpered to the circuit-board ground points at P5 on each amplifier board. At the balance potentiometers, the screens are connected to the terminals on the left, and on the I/O board they are connected to Gnd Out, which is also the connection point for the screens of the Line Out cables. The three screened cables leading to the left-hand amplifier board run through the cable duct. The ‘ground network’ is connected to the aluminium channel section at one point only, which is Gnd L on the I/O board.

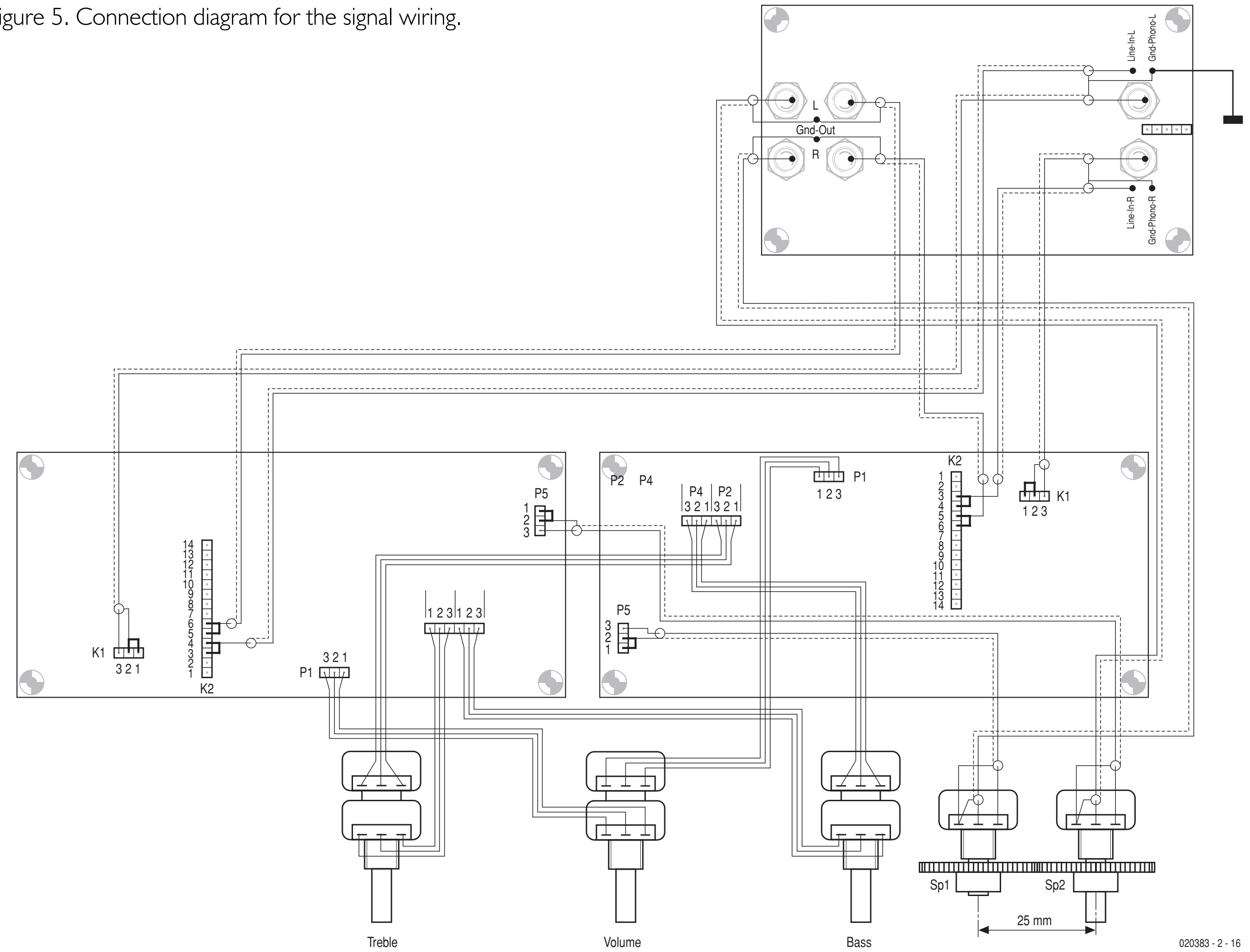
As can also be seen in Figure 5, the additional DC blocking capacitors Cx and Cy can best be soldered directly to the Line In sockets on the I/O board.

Alignment

Aligning the tone controls is best done by connecting an oscilloscope or AC millivoltmeter to the output. Turn P2 and P4 to the left and right limits of travel in turn, and at each position, adjust P3 to make the minimum and maximum values for the left and right channels as nearly as possible the same (at 50 Hz and 10 kHz, respectively). Since log-taper potentiometers are used for the tone controls, the midrange position will not precisely coincide with a flat frequency response. In order to find the setting where the response is flat, apply a 1-kHz square wave signal to the input (not the Phono input) and observe the output signal on an oscilloscope. Turn the bass and treble controls until the square wave is as good as possible. With the potentiometers adjusted to achieve this condition, secure the knobs for the tone controls with their arrows pointing to ‘0’.

To align the balance control, start by setting the right-channel balance potentiometer (to which the knob will be attached) to its midrange position. Then rotate the other potentiometer (but not the gearwheel!) until the output signals of the two amplifiers have equal amplitudes. With the potentiometers in

Figure 5. Connection diagram for the signal wiring.



this position, secure the gearwheel in place. If any small difference remains, it can be adjusted by slightly rotating the case of the potentiometer.

After the final (output) amplifier is connected, a slight amount of noise and some residual hum will be audible when the volume control is set to maximum and the Phono input is selected. When the volume control is rotated, you will probably hear a weak 'rasping' noise. This can be eliminated by using a small metal spring to electrically connect the shaft of the potentiometer to the enclosure. The hum will also disappear after the upper and lower metal covers of the enclosure have been fitted in place. The two halves of the enclosure can be connected to the central grounding point via lengths of flexible wire.

Connection to the final amplifier

Screened audio cable sometimes has rather high capacitance (as much as 200 pF per metre). If the distance between the preamplifier and the final amplifier is forced to be rather large, it is worthwhile to give some attention to the connecting cables. In this case, you should select cables with low capacitance, so the high frequencies will be affected as little as possible. The author even built cables using RG-59 75-Ω coaxial cable (diameter 6.2 mm) and 'high-end' Cinch connectors. This type of cable has a capacitance of only 69 pF/m, so it can easily cover distances of up to several metres.

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MECHANICAL COMPONENTS LIST

- Two-section steel enclosure, 300x200x110 mm (wxdxh), Conrad Electronics # 520489*
- IEC appliance socket with internal filter
- Ventilator 40 x 40 mm, 20mm thick, 12V_{DC}
- 2 ABS gearwheels 50.M0.5, Conrad Electronics # 237850*
- S1 = rotary switch, 6 positions, 2 poles, break before make, Conrad Electronics 709751*
- S2 = mains switch
- F2 = fuse 250 mAT (slow), with holder
- LED signal lamp, 12 V_{DC}
- 4 black buttons, 21mm
- 4 button caps, red, with line, 21mm
- 1 button, 28mm
- 1 button cap, red, 28mm

* www.int.conradcom.de