

## APX-100 amplifier

The BEAG is a successful product with a 1970s design that was a strong title from the domestic industry. Vacuum tube design for public areas or large rooms. Nominal output power 100 Watt sinusoidal.

A output network is made for 100 Volt out to 100 Ohm load. (Year books 1979 issue of the amplifier supplies relevant information)

These amplifiers are available to fair prices on technical and old markets. 5000-30000 forints price.

The APX-100 instrument amplifier can be rebuild into a low cost high power music amplifier.

The most important task is to make a new output transformer, the original can not be rewound.

The new made transformer is equivelant to the network and is a resin varnish impregnated, tape wound core on hipersil material.

The APX-100 amplifiers circuit diagram is shown in figure 1.

V1, V2 and V3 is the ECC808 tubes. Today these tubes are almost impossible to find despite the large amount produced by Tungsram. The ECC808 is replaced by the ECC83 tube. The pinout of the two tubes are not similar, see figure 2, so changes must be made.

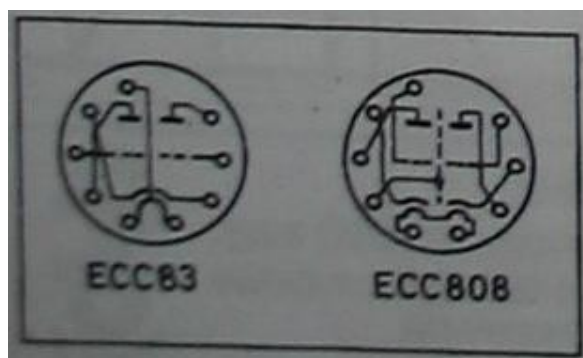


Figure 2.: The dual triode pinout seen from below.

The PL509 tubes are known from Casino amplifiers and colour television sets. The PL509 tubes are replaced by the higher current, more robust PL519. The connections are the same and so is the majority of specifications. Anode dissipation and cathode current is higher for the PL519. The APX-100 amplifiers that was made for export was made with PL519 tubes. The PL519 tube is known to last for more hours than its counterpart PL509.

The V1a and V1b intended to avoid service. Primarily from the strenghtening of the R4 feedback resistor stage. The amplifier drives the V2a and V2b in phase reverse. The anode-cathode phase reverse signals are used to drive the power amplifier tubes V4 and V5.

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V6 is a stabiliser tube type VR150 for the 150V grid voltage for the power amplifier tubes.

Cathode current for V4 flows through R21 and cathode current for V5 flows through R22.

Potentiometer P5 is used along with switch K2 to adjust until the meter M1 shows the same reading for both positions, in order to balance the cathode current between V4 and V5.

Winding data of the output transformer.

| Coil      | Sign | Number of turns | Wire size | Note                                                        |
|-----------|------|-----------------|-----------|-------------------------------------------------------------|
| Primary   | n4   | 360             | 0,4 mm    | 0,05 mm transformer insulation paper is used.               |
|           | n5   | 360             |           |                                                             |
|           | n6   | 360             |           |                                                             |
|           | n7   | 360             |           |                                                             |
| Secondary | n1   | 100             | 1 mm      | The primary coil, 2 rows of 0,15 mm insulation is required. |
|           | n2   | 100             |           |                                                             |
|           | n3   | 100             |           |                                                             |

The balance tube V6 removes spikes created by the one way rectification.

The bias voltage is adjusted on potentiometer P4 and differences between anode voltage is adjusted on potentiometer P3.

The making of a new output transformer can begin. A core of type SM102b is used.

The order of windings can be seen in figure 3.

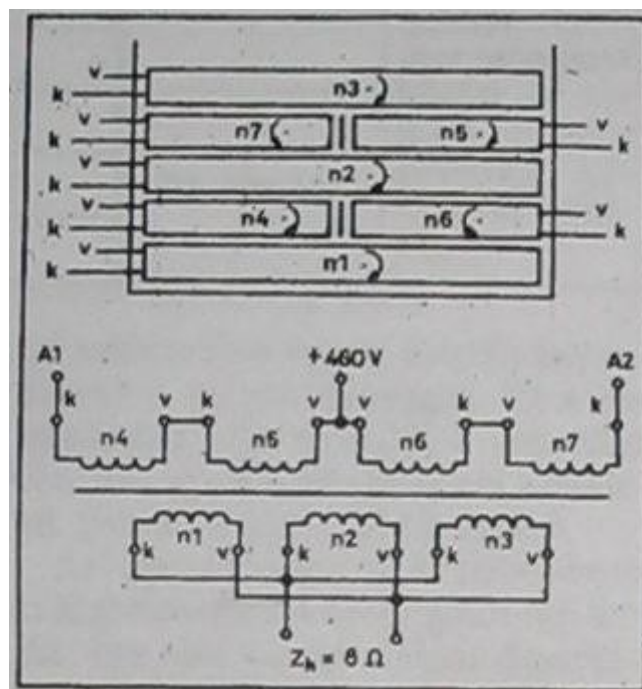


Figure 3.: Schematic of the output transformer structure.

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The primary coil is divided into four parts for the anode. The secondary winding is made of 3 parallel windings. The nominal load impedance is  $Z_n 8 \text{ Ohm}$ . It is important to obey the desired insulation. Make sure that the primary and secondary coil can not touch each other. We recommend using insulating discs between the coils that are 1,5 mm thick.

Make cuts in the insulating disc, tie the wire there to prevent slippage of the coils threads.

Mark each end of the coils with a different colour plastic tube, tape or insulation in order to know the phasing of each coil. This is to prevent that they are connected wrong later on.

To check the complete transformer the following test can be made. The secondary windings are connected to a 24VAC transformer it should be possible to measure 173VAC between Centertap and A1 and A2. Between terminals A1 and A2 you should be able to measure 346 VAC.

The anode voltage for the APX-100 power amplifier comes from a bridge rectifier of silicon diodes D1 to D4.

The resistance of the tubes filaments is very low and a problem arises when the amplifier is turned on. It takes a certain time before the filament/cathode to glow red hot.

The peak voltage of the semiconductor rectifiers when turned on will degrade the electrolytic capacitors. The cathode slowly heats up the tube to operating temperature and while heating the warmest parts of the filament will try to conduct the cathode current flowing and cold parts could risc to destroy the material contaminated filament. This will lead to early ageing of the electron tubes filament and its output power will decrease.

To prevent this problem we can delay the mains voltage. The schematic for such a delay is showed in figure 4.

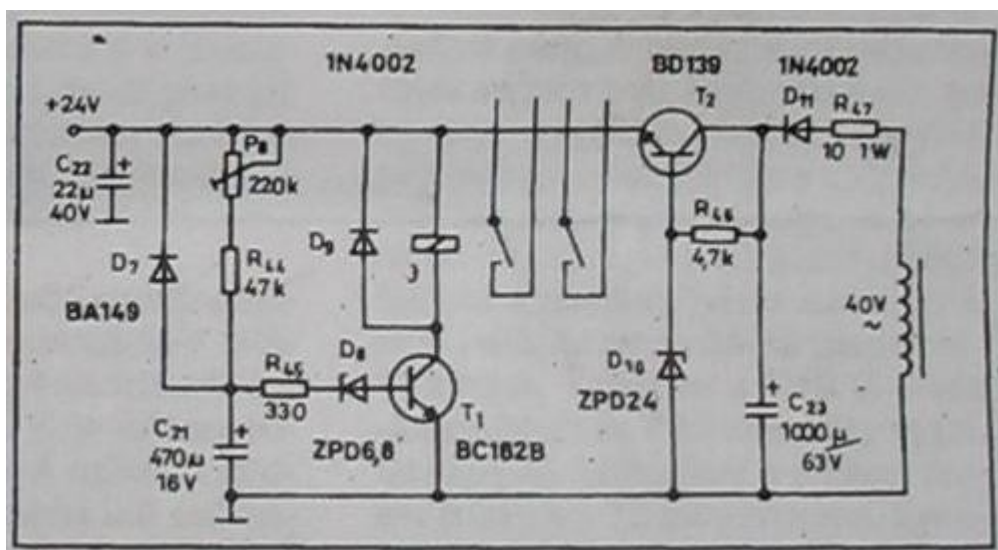


Figure 4.: Circuit diagram for delay of power amplifier tubes filament supply.

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The delay time is about 30 seconds and can be adjusted by the potentiometer P8. The relay is a Omron MY4 relay with a 24 Volt coil of 650 Ohm resistance. The same pinout can be found on the Hungarian made relay from CO-RE GPM4 with a coil resistance of 800 Ohm. The timer is powered from the 40 Volt winding of the power transformer.

The half wave rectification is smoothed by the electrolytic capacitor C23. The 24 VDC power supply is formed by the transistor T2 which base current is controlled by zener diode D10 and resistor R46. In this case approximately 0,8 Watt is dissipated in T2 and a heat sink is needed. A small heat sink of 1,5 mm aluminium should be sufficient.

This should only load the 40 VAC winding with about 40mA and this overload should be well tolerated by the power transformer.

Figure 5 shows the print and figure 6 shows the components layout. The relay is lying flat on its side on the board and will be soldered to the print with wires in order to save space in the height.

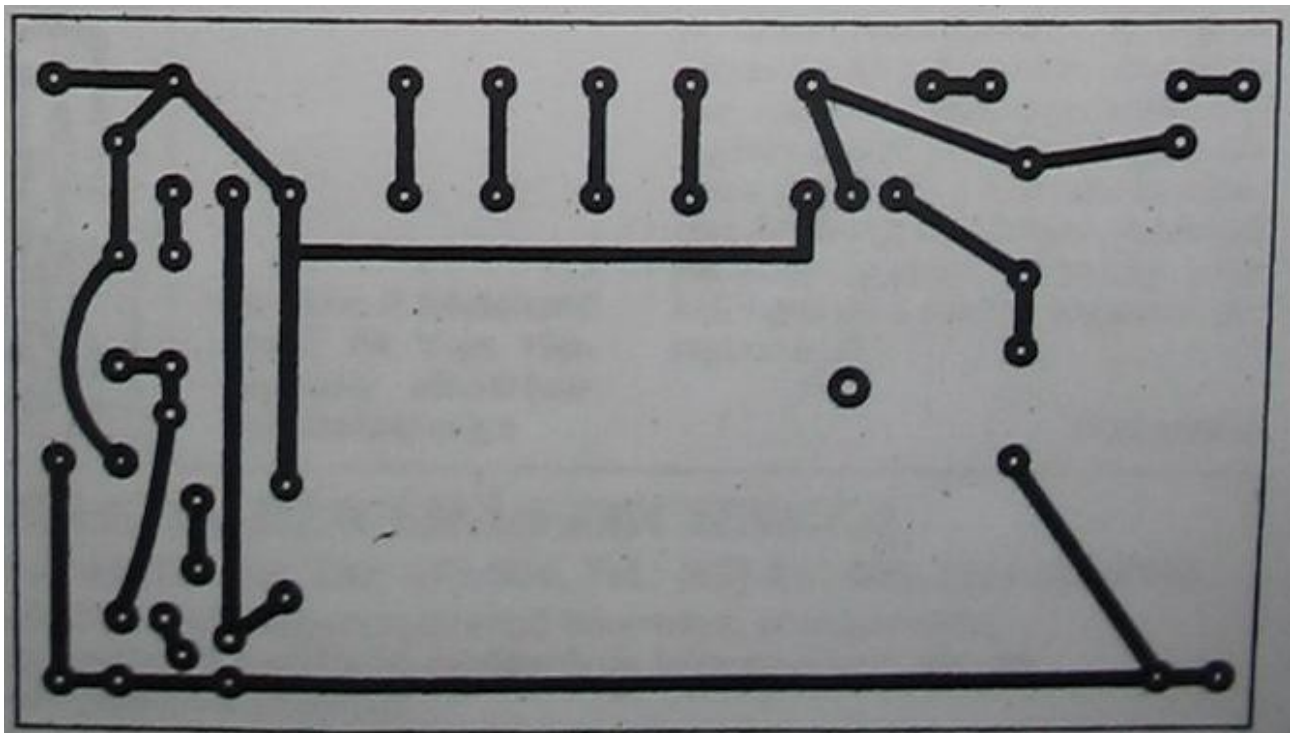


Figure 5.: 24VDC power supply and relay print

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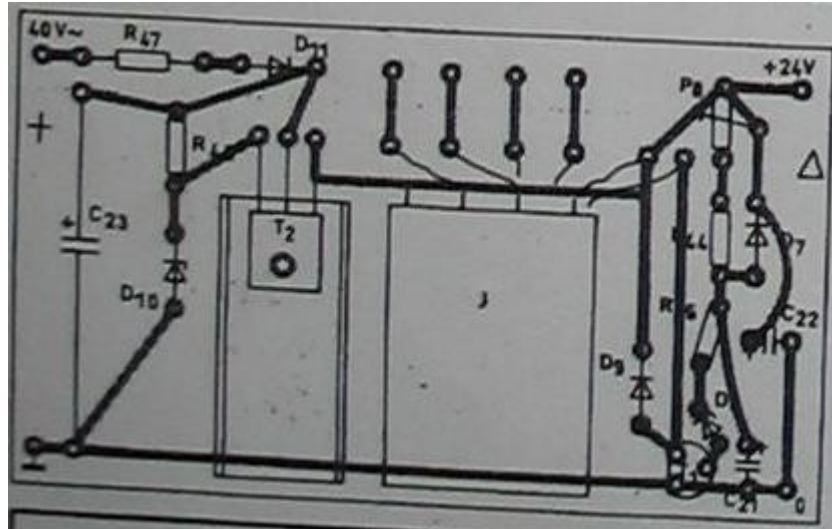


Figure 6.: 24VDC power supply and relay board layout

The following tasks need to be done in order to rebuilt the original APX-100 amplifier.

Dismount the old 100V output transformer. Reuse the metal spacers to mount the relays and the 24 Volt power supply. Mount the new 8 Ohm nominal impedance output transformer. Solder wires from the output transformer to the channel connections. The amplifiers frontpanel can be found at the H2 filament lamp mark. The 6,5V 0,1A bulbs should be replaced with 24V 50mA types joined with the connected 8 Ohm output. The lamp works as a level meter, threatening high amplifier current will be indicated. The 8 Ohm secondary of the output transformer will output less voltage than the original output transformer.

Thus the resistance of R25 should be reduced to 5K6, negative feedback will remain to work unchanged. The capacitor C10 and resistors in parallel are to be replaced with a value of 390pF.

The APX-100 amplifier got overload protection built in.

The V3 tube is activated when the output transformers secondary voltage raises significantly. Speaker over load or clipping will occur in some cases. The V3 tube stays on for a few seconds after shutting down the V1a grid and thus avoid destruction of the amplifier. The threshold for this over load shut down is set by potentiometer P6. The potentiometer is connected to the 8 Ohm output transformer secondary winding.

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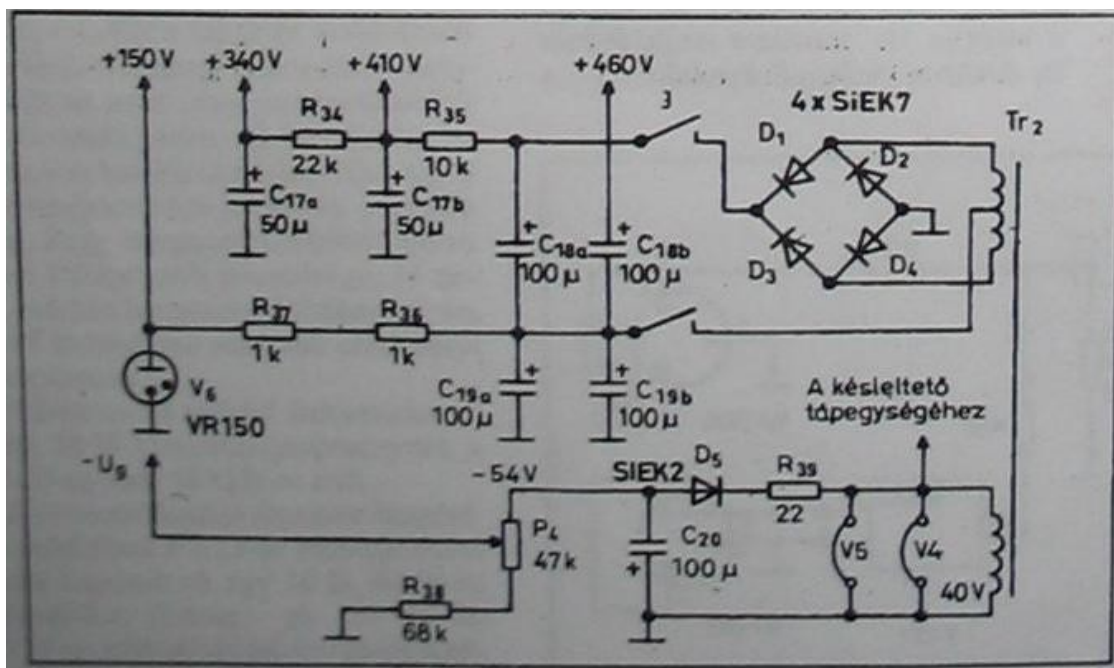


Figure 7.: The delay time board and 24 Volt power supply connections.

Verify the converted power amplifier by measuring the values in the following order. The output transformers secondary winding resistance should be close to 8 Ohm and be able to withstand atleast 120 Watt load. If this resistance value is higher, parasitic oscillations can occur.

Turn the volume potentiometer down and short circuit the input connection. The tubes begin to warm up. As the delay time goes the relay turns on the positive voltage supply.

If the output transformer starts to make noise, change polarity of the V4 and V5 tubes anode connection.

Please check the schematic and measure for the supplied DC voltages. Measure the voltage and resistance across R21 and R22. Adjust negative voltage potentiometer P4 to 75mV.

The cathode current of V4 and V5 is adjusted to the same with potentiometer P3, adjust potentiometer P4 again if necessary. (The 1 Ohm cathode resistor should have a voltage drop of 75mV and conduct 75mA).

Increase the cathode current to 240mA for full modulation and run in class AB. The relative low anode dissipation when the amplifier is resting will decrease tube losses and prolong the life of the tubes.

AC balance calibration should be done in the following order. The tools needed are a tone generator, AC voltmeter, oscilloscope and a harmonics distortion meter.

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The tone generator is connected to the amplifiers input. Set the tone generator to output a sine wave of 900mV at 1 kHz frequency.

Turn up the potentiometer P1 to the position where 6,3V is measured with the AC voltmeter and then we set the 8 Ohm load at the end (This corresponds to 5 Watt output power).

Inspect the sinusoidal shape of the waveform on the oscilloscope.

Turn the potentiometer P1 up to just below 28,3V, this corresponds to 100 Watt nominal output.

Here you can see the non distorted continuously sine wave nicely.

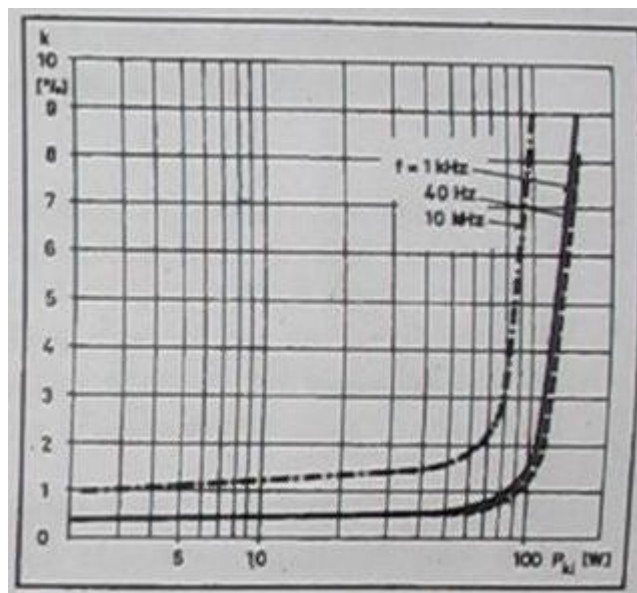


Figure 8.: Illustration of the waveform at different frequencies depending on output power.

It is clear that the distortion is greater on the 10 kHz signal compared to the 1 kHz signal.

This error is caused by the anode-cathode phase inverter. Other parts that play a role in the frequency response is the anode, cathode and other small signal interferences (the cathode has a significantly lower impedance so the frequency response is better).

Here I must note that this is no special significance for this instrument amplifier.

Respected brand name amplifiers can give much worse results than this.

The amplifiers frequency response to 70 Watt output power was measure to 18 kHz where it drops -3 dB.

To test the amplifier protection we need to create a situation where it would shut down. Couple a 16 Ohm 40 Watt resistor in parallel with the 8 Ohm output load (alternatively two 33 Ohm 20 Watt resistors can be used in parallel).

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With a higher resistance we will see a increase in output voltage. Adjust potentiometer P1 so that 34 Volt are measured with the 8+16 Ohm load. Turn potentiometer P6 down so that the threshold goes below the feedback signal for the protection. When the protection circuit is activated tube V3 will close the V1a triode grid. The output from the amplifier ceases.

If you switch back to 8 Ohm load operation, a few seconds later the protection circuit will stop keeping the V1a grid down.

The converted power amplifier have a input sensitivity of 850mV and a ouput power of 100 Watt at 1kHz.

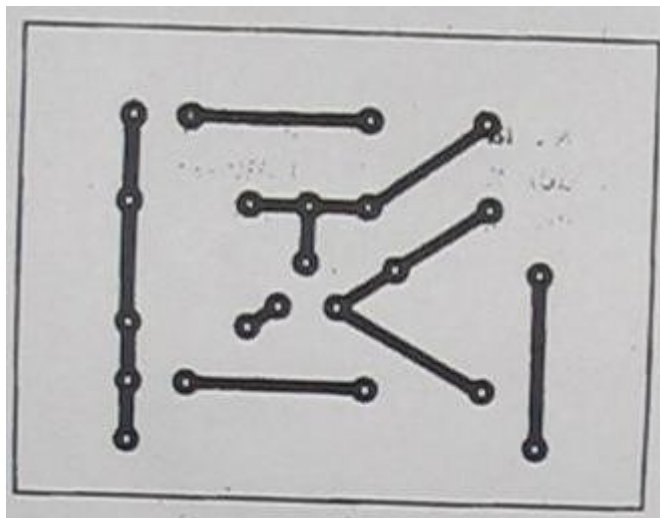


Figure 10.: Board layout of the preamplifier.

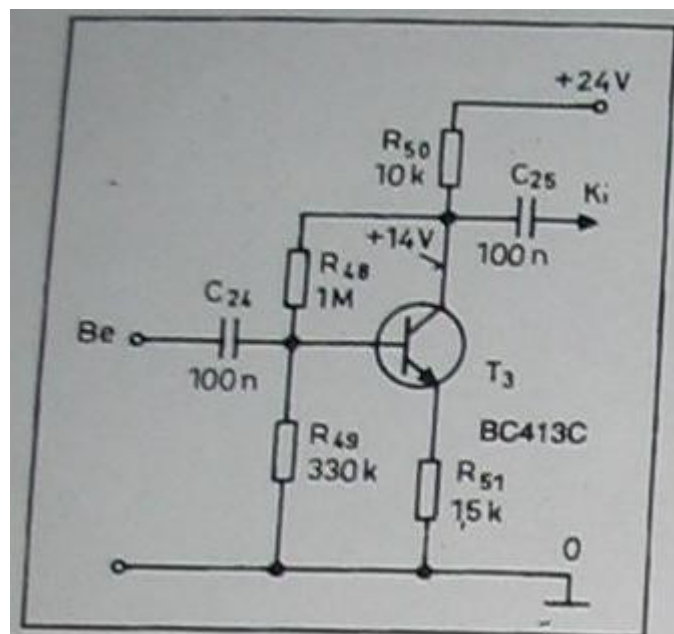


Figure 9.: Schematic of the installed pre-amplifier.

Not all drivers are alike so a mix of output levels from these to the input of the amplifier is expected.

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The preamplifier is built around the transistor T3 with a gain of 6. The two different levels of internal feedback gives a very stable operation.

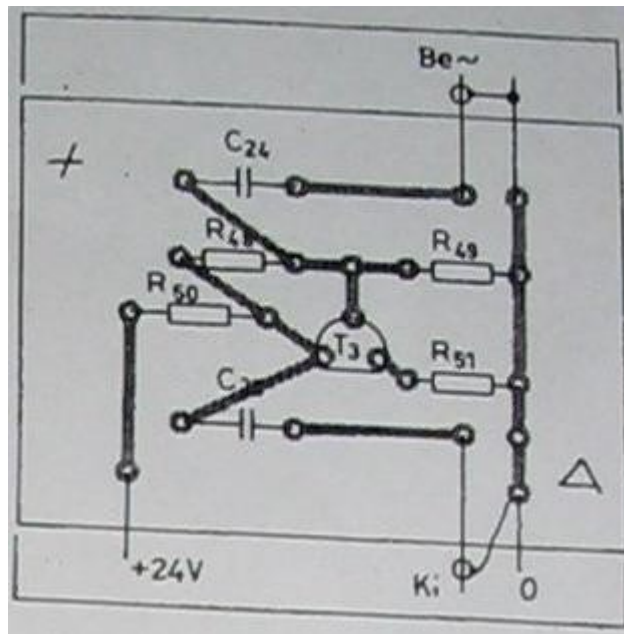


Figure 11.: Component layout of the pre-amplifier.

The pre-amplifier in figure 10 and 11 is integrated into the input with the input sockets. This amplifier has two input sockets. One for high level input and one with the pre-amplifier built in between input socket and volume potentiometer P1. Two 10K Ohm resistors are added so that two audio sources can be connected.

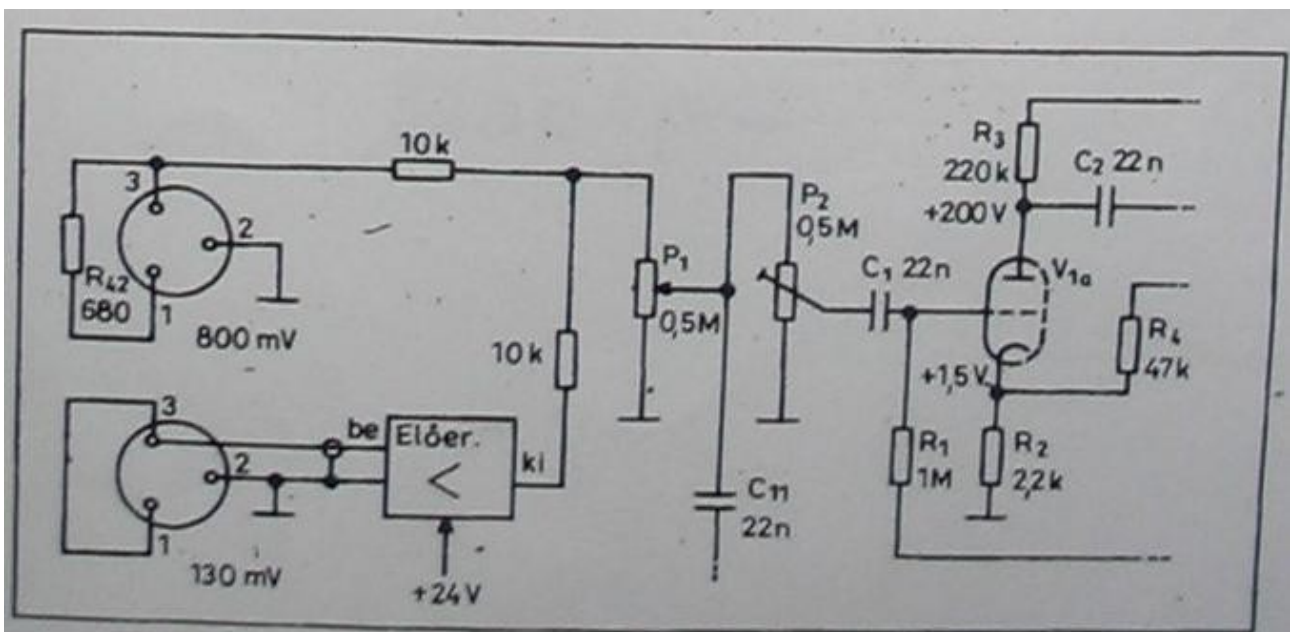


Figure 12.: Connection of the pre-amplifier.

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The amplifier is old and the electrolytic capacitors are properly dried out and will need to be replaced. The capacitors should be replaced by new capacitors of same capacity and voltage rating.

The stabilising tube VR150 can be replaced by incorporating Zener diodes instead. Several diodes in series can be put together for the 150 Volt level, for example six ZY24 diodes in series.

These diodes are comparable to the current rating of the stabiliser tube.

With the power amplifier tubes replaced it is possible to have the amplifier almost like a brand new copy of it.

Inspect the idle current of the anodes after 50-60 hours of operation. If necessary readjust the values as specified in the chapter about verifying the modified amplifier.

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<http://www.kaizerpowerelectronics.dk>