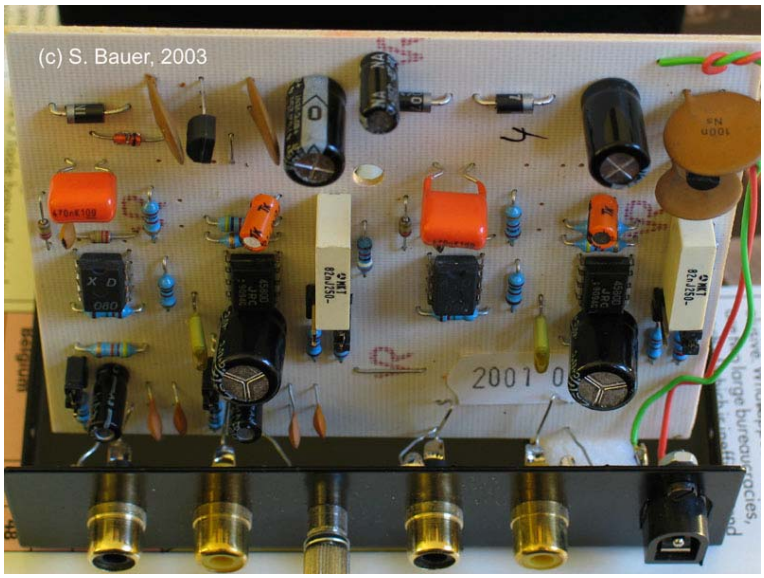
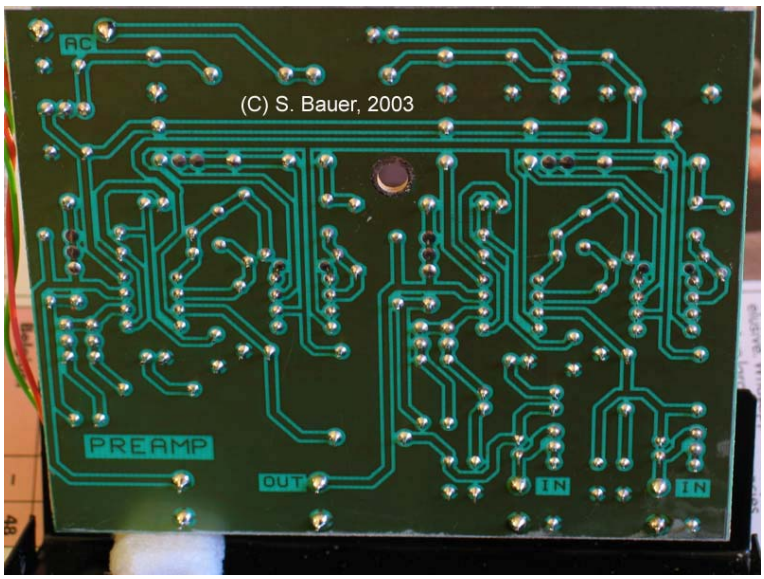
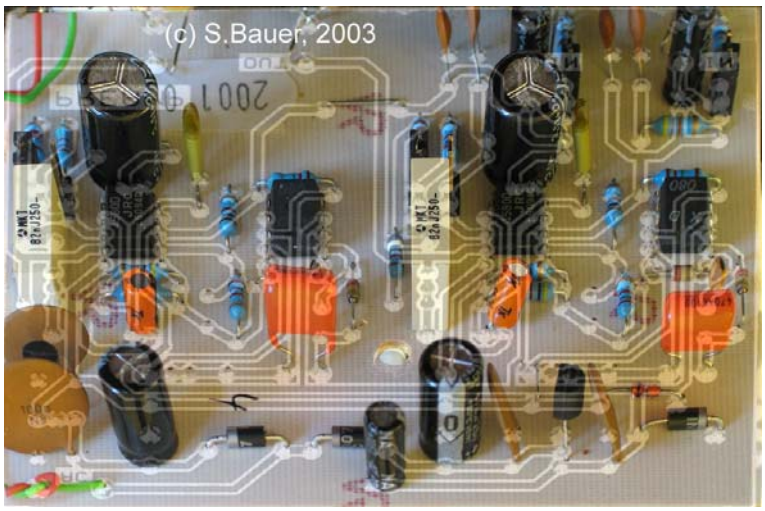
The phonobox story

In the April 2002 I had bought Pro-ject phono box for my friend, as a gift. When I bring it home, at first I opened it. Then I made some shots, but later I had found much better photos made by Stefan Bauer: http://home.arcor.de/bauer77/_private/project_phono_box.htm Here they are:

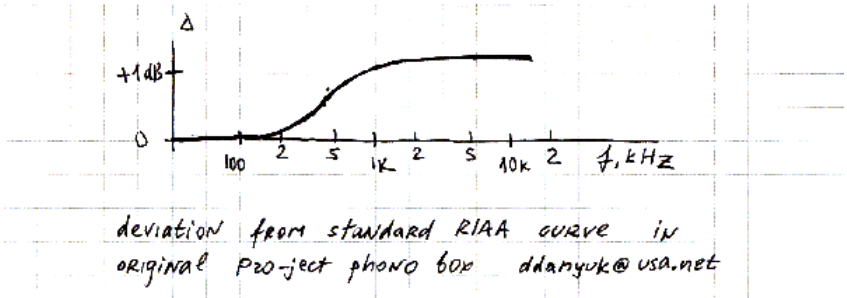
The



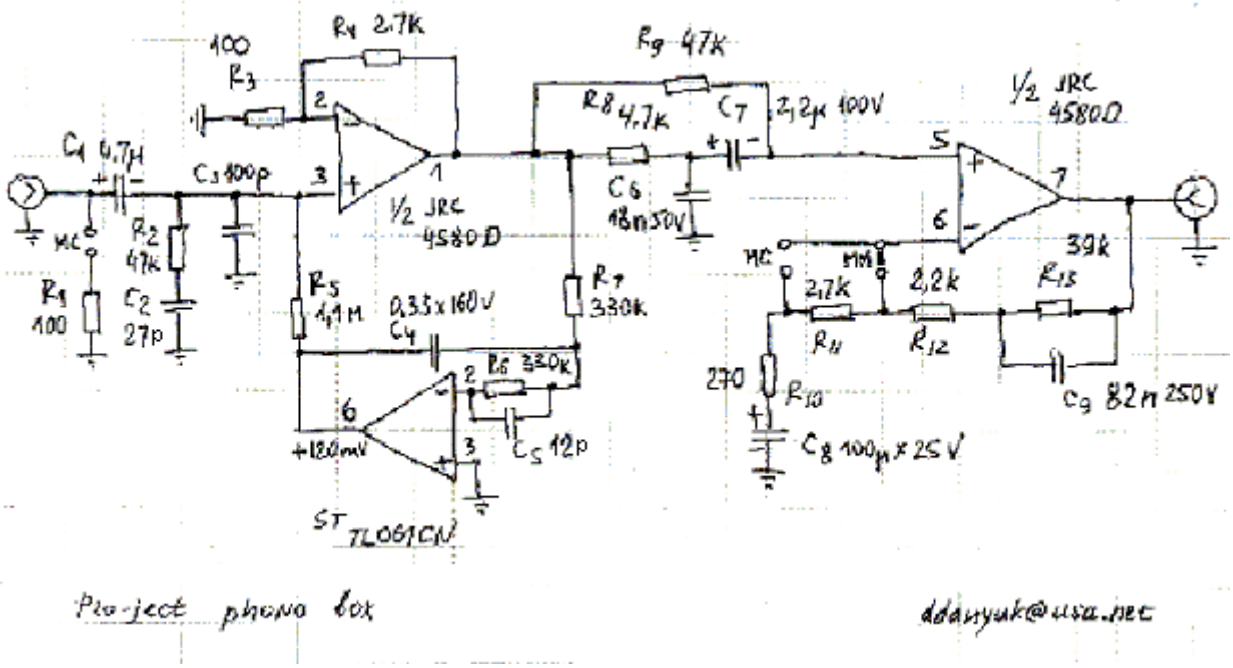


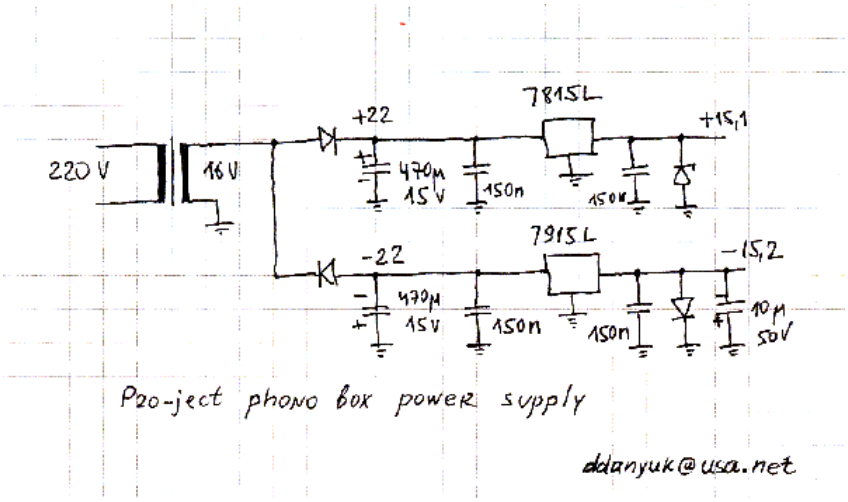


At first I measured the phonobox frequency response with the active inverse RIAA circuit [1] and found the deviation above 1kHz about 1.2 dB, while in manual [2,3] it is stated that deviation from standard RIAA curve should be less than 0.5dB.



My further step was reverse engineering. The op amps data is listed in [5,6]. The phono box and power supply circuit schematic is shown below.





The RIAA time constants are

$$\tau_1 = R_{13}C_9 = 39\cdot10^{3}\cdot82\cdot10^{-9} = 3198\ \mu s$$

$$\tau_2 = \frac{(R_{10}+R_{11}+R_{12})R_{13}}{R_{10}+R_{11}+R_{12}+R_{13}}C_9 = 4.56\cdot10^{3}\cdot82\cdot10^{-9} = 374\mu s$$

$$\tau_3 = \frac{R_8R_9}{R_8+R_9}C_6 = 4.27\cdot10^{3}\cdot18\cdot10^{-9} = 76.9\mu s$$

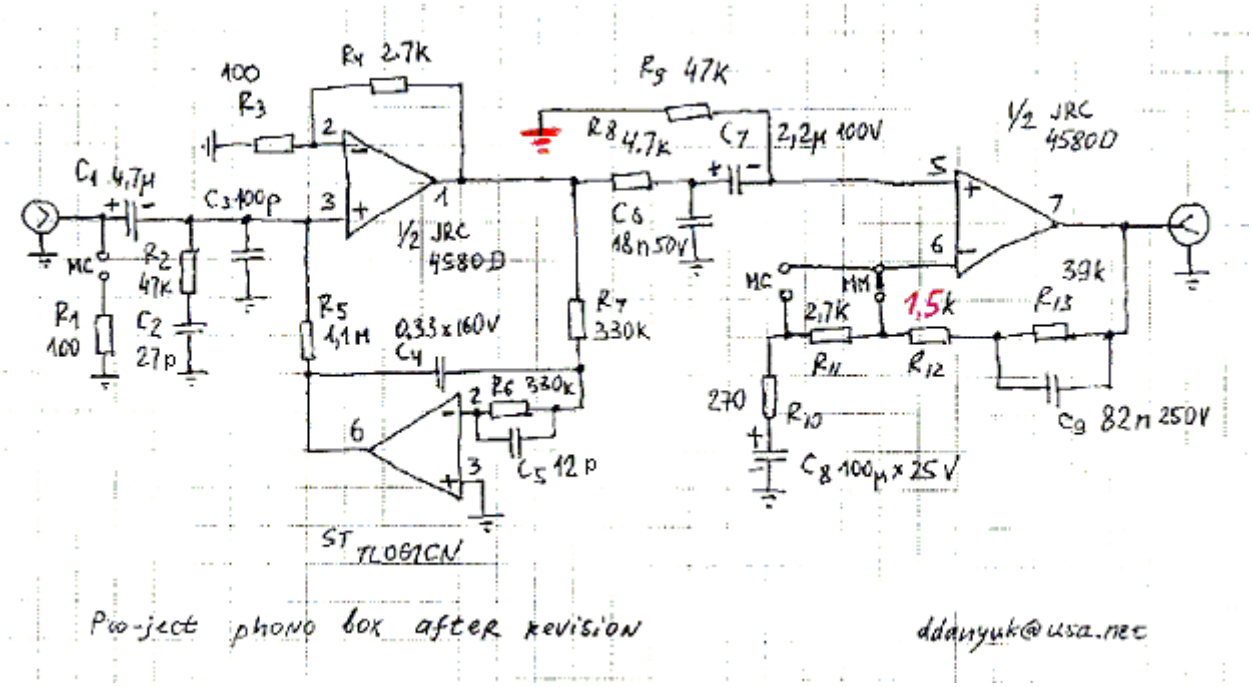
They should be

$\tau_1 = 3180\mu s$

$\tau_2 = 318\mu s$

$\tau_3 = 75\mu s$

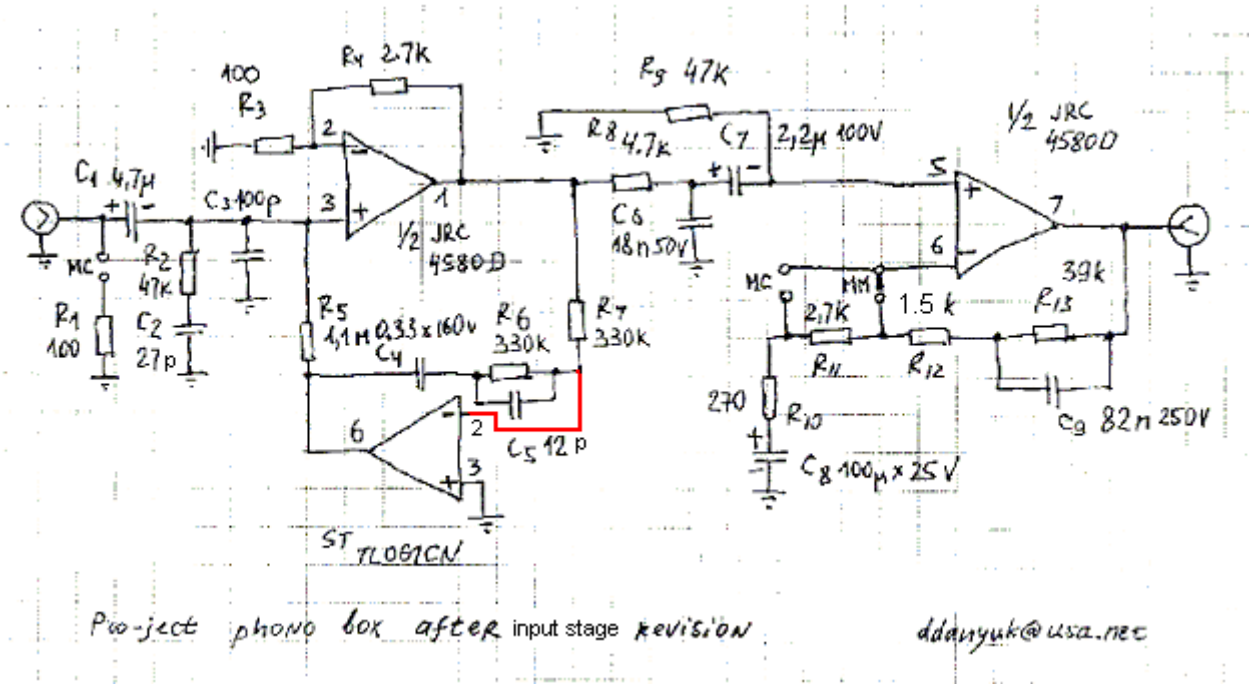
The second time constant has an error of 18%. For it correction the value of R_{12} should be $1.5k\Omega$. Another evident engineering error is that the right side of the resistor R_9 should be connected to ground, in that case R_9C_7 will be a rumble filter. Otherwise, the elements R_9, C_7 should be omitted, and the value of R_8 should be $4.3k\Omega$ for correct time constant. The circuit of the phonobox after revision is shown below.



My next step was the input stage with mysterious connection of R_6, C_5. Having in mind that the input resistance should be $47k\Omega$ R_6, C_5 should be connected in series with C_4. The input resistance of the phono stage is

$$R_{in} = \frac{R_5}{1+\frac{R_4}{R_3}} = 39k\Omega$$

The R_5 could be increased up to $1.3M\Omega$. This is so called 'electronic cooling'.
From Marcel van de Gevel EW paper [6]: "When the input stage and feedback network are properly designed, the thermal noise of the 47k resistor shunted across the input is usually the largest remaining noise contribution in the RIAA amplifier itself". Such connection will lower noise current spectral density from $47k\Omega$ resistor $1+\frac{R_4}{R_3}$, but overall s/n ratio will improved 1-3 dB



Smiffy aentity@**.com reported (Nov. 2003) another set of component values in his phono box
C2 is 33nf
C4 is 0.47
C5 is 10nf
C9 68nf

R5 1.2M
R6 220K
R7 220k
R13 47K

In this case the RIAA time constants are correct

$$\tau_1 = R_{13}C_9 = 47\cdot 10^3 \cdot 68\cdot 10^{-9} = 3196\mu s$$

$$\tau_2 = \frac{(R_{10}+R_{11}+R_{12})R_{13}}{R_{10}+R_{11}+R_{12}+R_{13}}C_9 = 4.66\cdot 10^3 \cdot 68\cdot 10^{-9} = 317\mu s$$

$$\tau_3 = \frac{R_8 R_9}{R_8 + R_9} C_6 = 4.27 \cdot 10^3 \cdot 18 \cdot 10^{-9} = 76.9 \mu s$$

I would like to thank Stephan from Hamburg, who reported (July 2004) the correct values of C_2, C_5, then checked his own Phonobox and found R_6, C_5 connected in series with C_4, as shown by red wire.

References

1. D. Danyuk, G. Pilko “An Active Inverse RIAA Circuit”, The Audio Amateur, 1991, Jan., pp.22-23, 64-65
2. Pro-ject phono box owner manual
3. Pro-ject phono box short info
4. NJM4580 – dual operational amplifier
5. TL061 - J-FET operational amplifier
6. Marcel van de Gevel “Noise and moving-magnet cartridges,” Electronics World, 2003, Oct.