Soft start/Fuses

Preliminary note:
Because of the large inrush currents the primary and secondary fuses are much larger than actually needed for normal operation. To further increase the reliability of operation the goal is to reduce the fuse values significantly. To do this I realized the following considerations:

1. **Smoothing electrolytic capacitors**

Large smoothing electrolytic capacitors are charged from the ring core (main) transformer (here anode voltage, 600 V range and G2 voltage). Large capacitors are good regarding the ripple. But at the same time two problems arise:
Charge current peaks (requires large fuse values)
High charge. With a sudden short at the output the MOSFets must endure discharge of the capacitors (it takes a little time until the current limiting circuit responds. To prevent the MOSFets from damage smaller capacitors should be used.

I experimented and reduced the capacitors a little bit:

up to now

	Anode voltage and 600-V-range	G2-Voltage
Elkos built into my RoeTest	660 µF	270 µF
Measured ripple	2V at 200 mA	1,5V at 50 mA
current fuse value	0,8 AT	0,5 AT

new:

	Anode voltage and 600-V-range	G2-voltage
Elkos newly inserted into the RoeTest	220 µF	100 µF
Measured ripple	7V at 200 mA	4V at 50 mA
new fuse value	0,63 AT	0,2 AT

Conclusion:
Smaller Elkos are possible the slightly higher ripple can be tolerated as the output voltages are accurately controlled by the MOSFets.
The primary fuses could be significantly reduced in value.
Side effect: Using smaller elkos saves some euros. The PCB space freed can be used for other purposes

2. **Softstart for the ring core transformer**

Ring core transformers have many advantages (small, light low idle current...). The single disadvantage is the large inrush current. This requires a large, slow blow primary fuse that has a value far above the nominal current. This is of course unsatisfying.

Solution: Soft start using a NTC (thanks to Kurt for this proposal).

A NTC (NTC 22R, available at Conrad) is put series with the primary winding of the ring core transformer. This reduces the inrush current seriously

After that I could further reduce the fuse values:

Primary new: 1,5 AT (up to now 2,5 AT)
Secondary new: Anode voltage and 600-V-range: 0,4 AT, G2-voltage: 0,1 AT (in conjunction with the smaller Elkos)

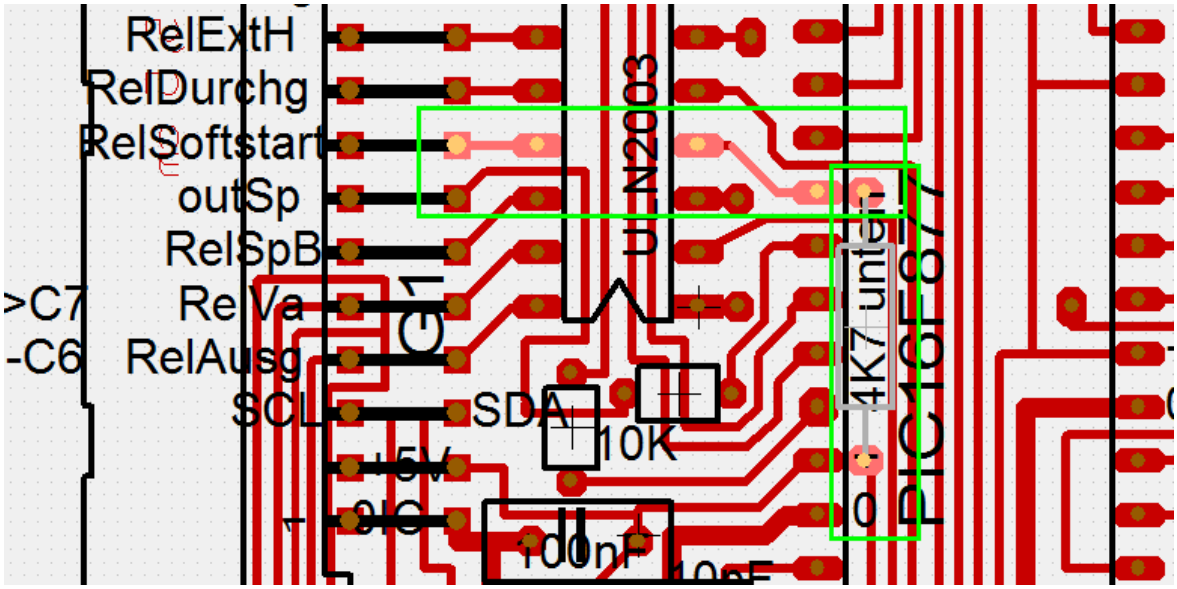
Result: The fuse values are now reduced such that they will blow promptly in case of a fault condition.

The series connection of the NTC and the ring core transformer has two disadvantages:
Voltage drop (I did not test if this has any influence)
If the device is switched off and immediately switched on again the NTC is eventually too warm what causes a current peak that will blow the fuses

Solution:
After switching on the device the NTC should be bypassed with a delay so it can cool down again.

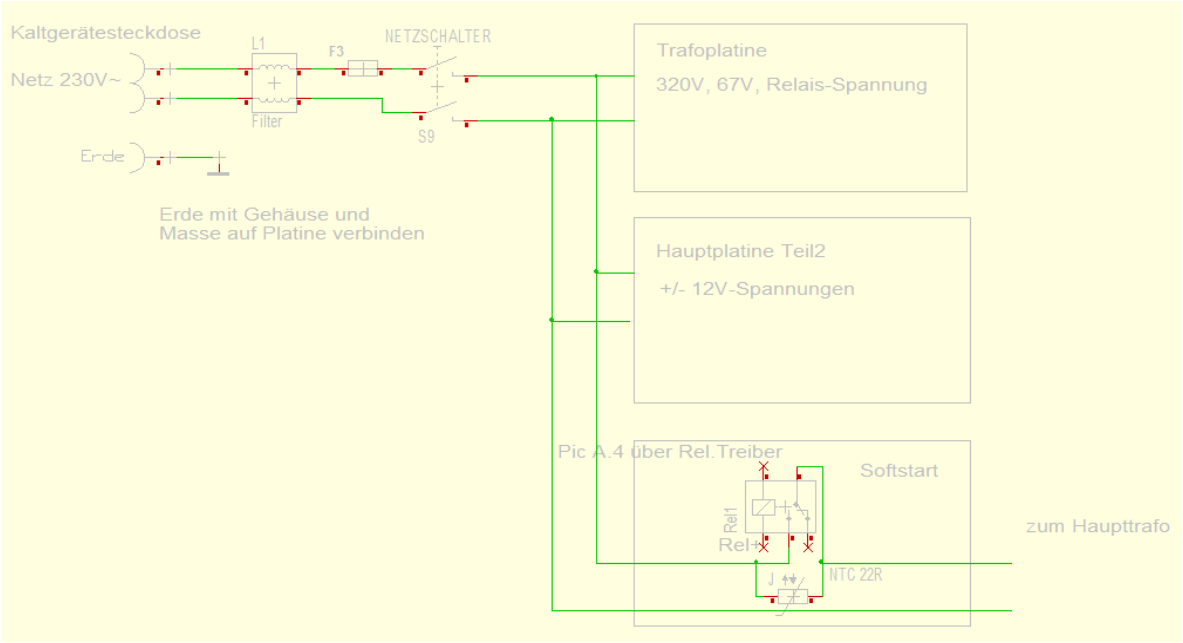
There are several possibilities:
Generate the delay with a timer Owners of the RoeTest2 already have a switch on delay for the relay voltage and can connect a relay to the delayed relay voltage.
Owners since RoeTest4: Here the firmware of the Pic is prepared for that purpose (Porta.4 is switched on with a time delay). You just have to build the following circuit extension:

Microprocessor board: Porta.4 is connected via a relay driver to the VG connector
Further a 4k7 resistor must be soldered to the bottom side of the PCB (Porta.4 is an open drain output that is the reason for the pull up resistor)



A 12 V relay is mounted near the mains connection and the coil is connected to the positive relay supply and the VG connector. The relay will bypass the NTC some seconds after switching on.

The new primary circuit of the RoeTest looks like that:



Remark:
In the future the layout will be adapted, i.e. connect the traces on the microprocessor board to the relay driver and the VG connector (resistor on bottom side will remain there) and I will provide the relay and the NTC for soft start on the main board part 2.

I recommend to all RoeTest owners to upgrade both changes.
These changes are fast and easily to realize.