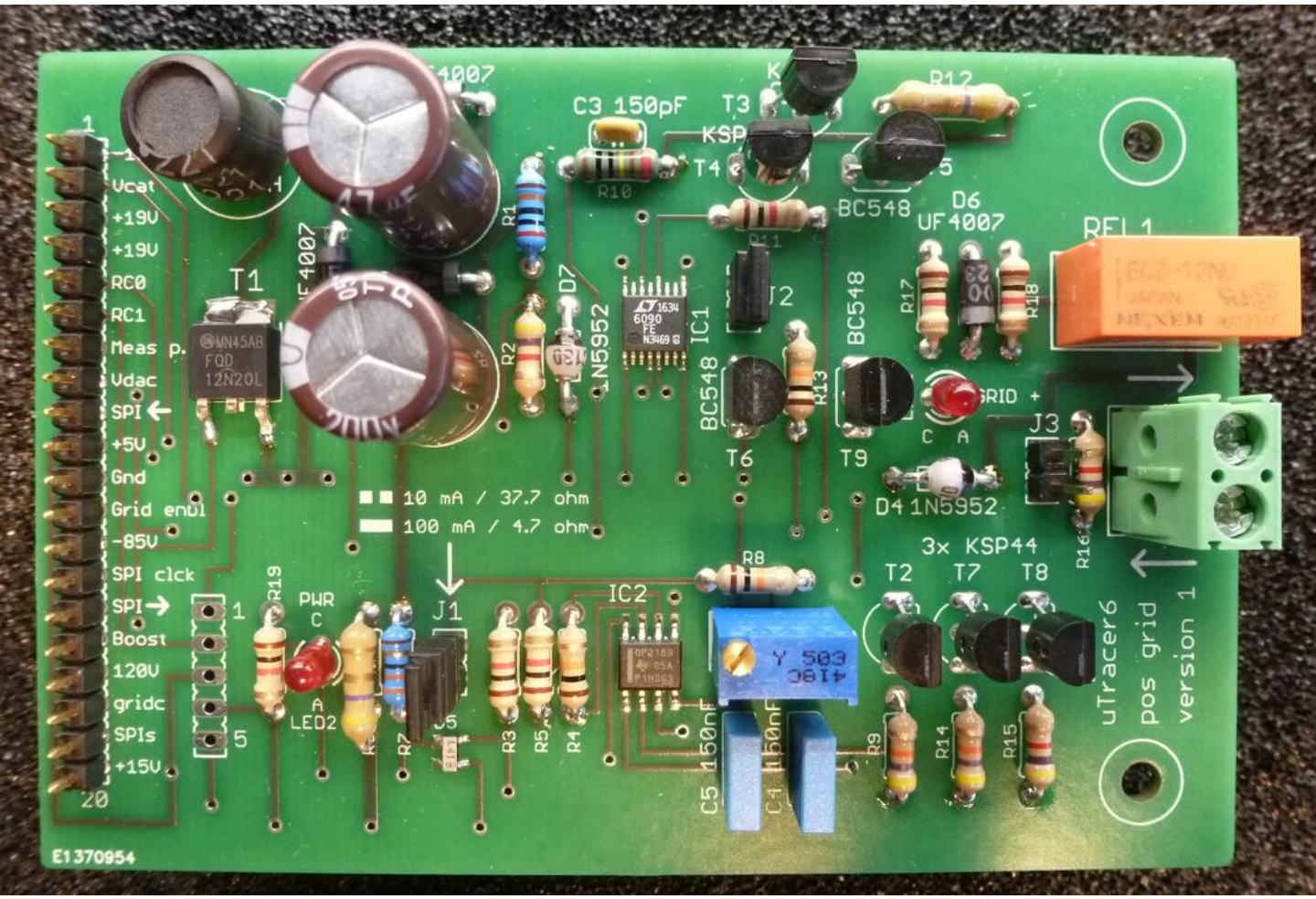
µTracer 6 Extension board

Construction Manual V2



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Important!

Please read this page carefully!

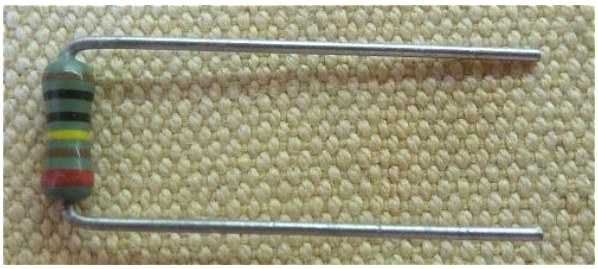
Although your uTracer is not directly connected to the mains, it generates dangerous and potentially lethal voltages. Please observe the following guidelines:

- Never touch the PCB when the high voltage LED is on!
- If you need to work on the circuit:
  1. First wait until the high voltage LED is off;
  2. Then switch off the power;
  3. Check with a DMM that the electrolythic caps are fully discharged
- When you test the circuit on the bench use the standoffs to distance the PCB from the table.
- Make sure that there are no loose wires or metal clipping lingering around or underneath the PCB.

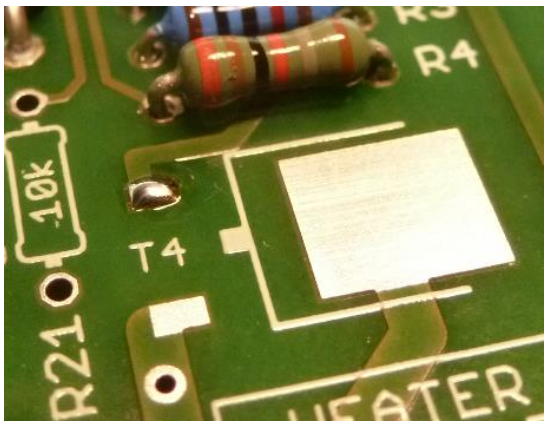
Please note that even when the high voltage LED is off, the -85V and +130V grid supplies are still working !

Tips and Tricks:

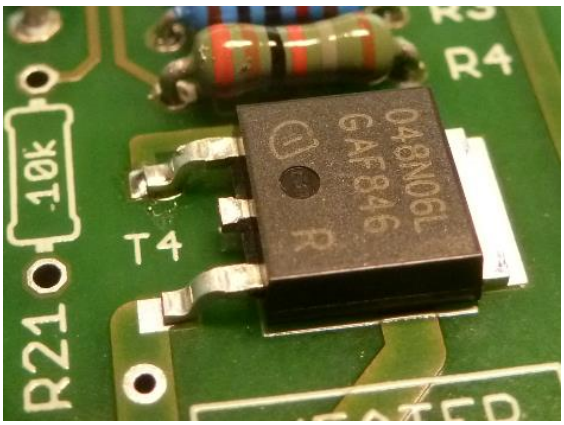
1. Bend the leads of the resistors in a sharp angle close to the body of the resistor.



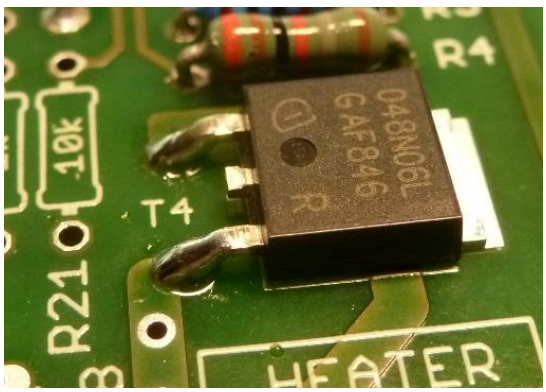
2. Soldering the SMD transistor



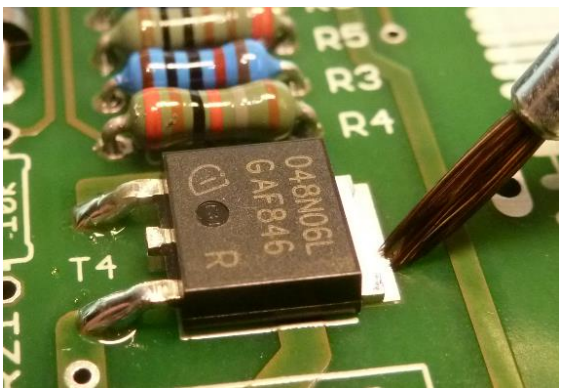
Apply solder to one pad



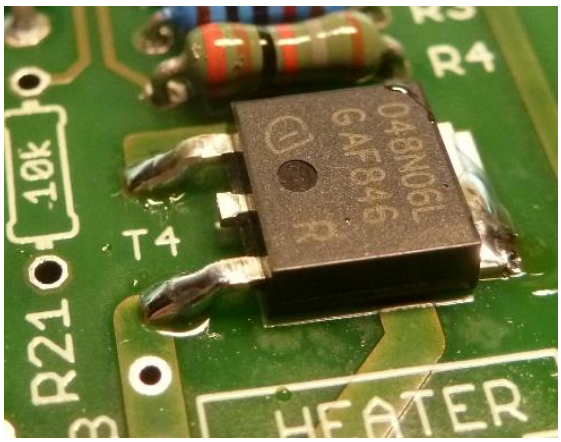
Fix one leg of the transistor and adjust position



Solder the other small terminal



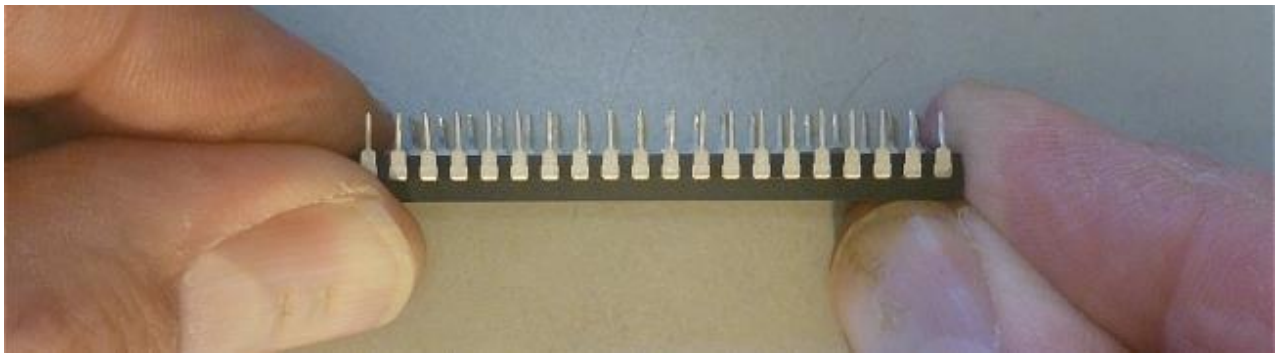
Apply some solder flux to the tab



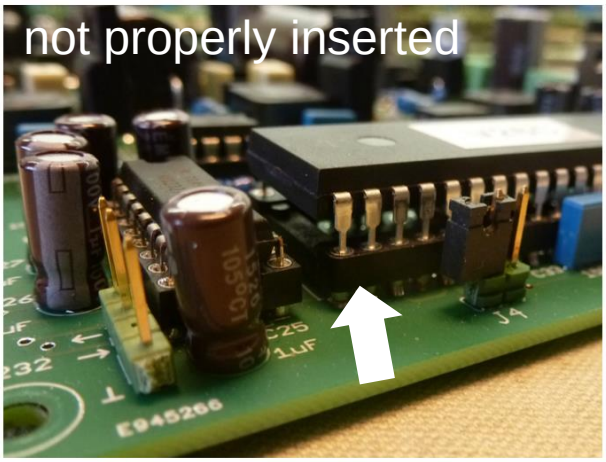
Heat the tab with your soldering iron and add a bit of solder. When hot enough the solder will ready flow between the tab and PCB.

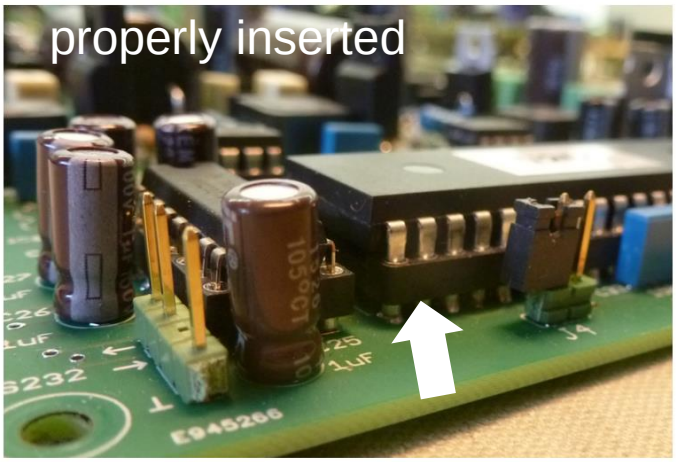
Note!
None of the transistors in the uTracer will get hot during operation, or conduct huge amounts of current. It is therefore sufficient to solder the tab only on one corner.

3 As usual, the pins of the PIC processor are at an angle so that the PIC doesn't fit directly in the 40 pin socket. The best way to adjust the angle of the pins is to hold the processor at the sides and correct the angle of 20 pins at once by bending them against a flat surface e.g. the table.

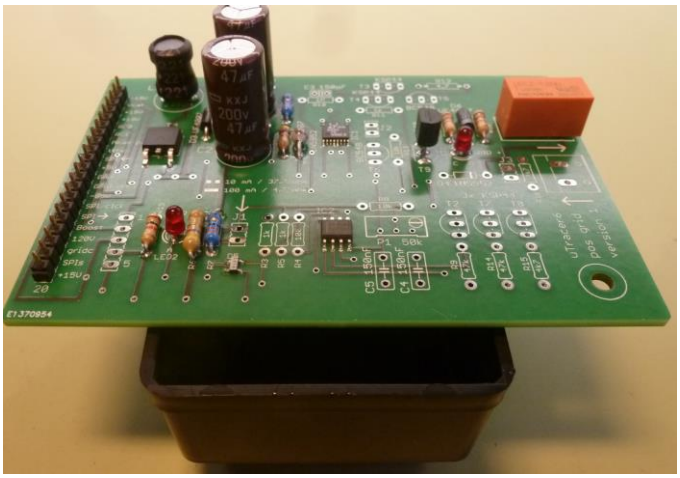


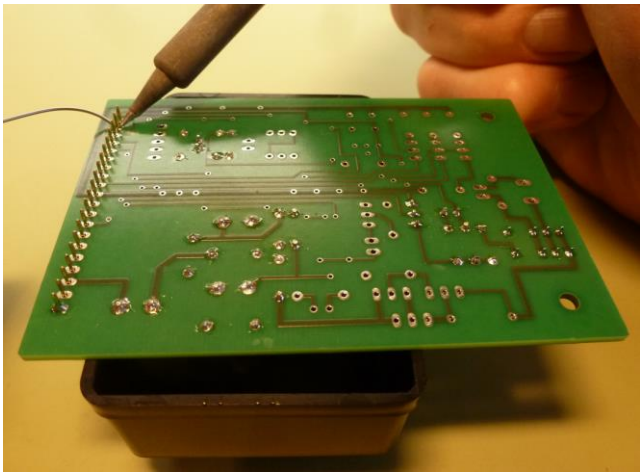
4. Make sure that you fully insert the PIC into the socket !! A not correctly (half) inserted PIC has given problems in a lot of instances causing faulty or erratic behavior. It requires the force of two thumbs to deeply and properly insert the PIC into the socket! (Picture taken from uTracer3+)





5. If you do not have a PCB holder, use a small box or something like that to make it easier to work on both sides of the PCBs





Always check the resistance value of each resistor with a multimeter before you assemble it onto the board.

When starting the construction of a new part, first read through the whole section and familiarize yourself with the photos. It can be that they clarify things that are otherwise perhaps difficult to understand from the text.

Some components may have been replaced by alternative types depending on availability from my supplier. Below you find a list of replacements used.

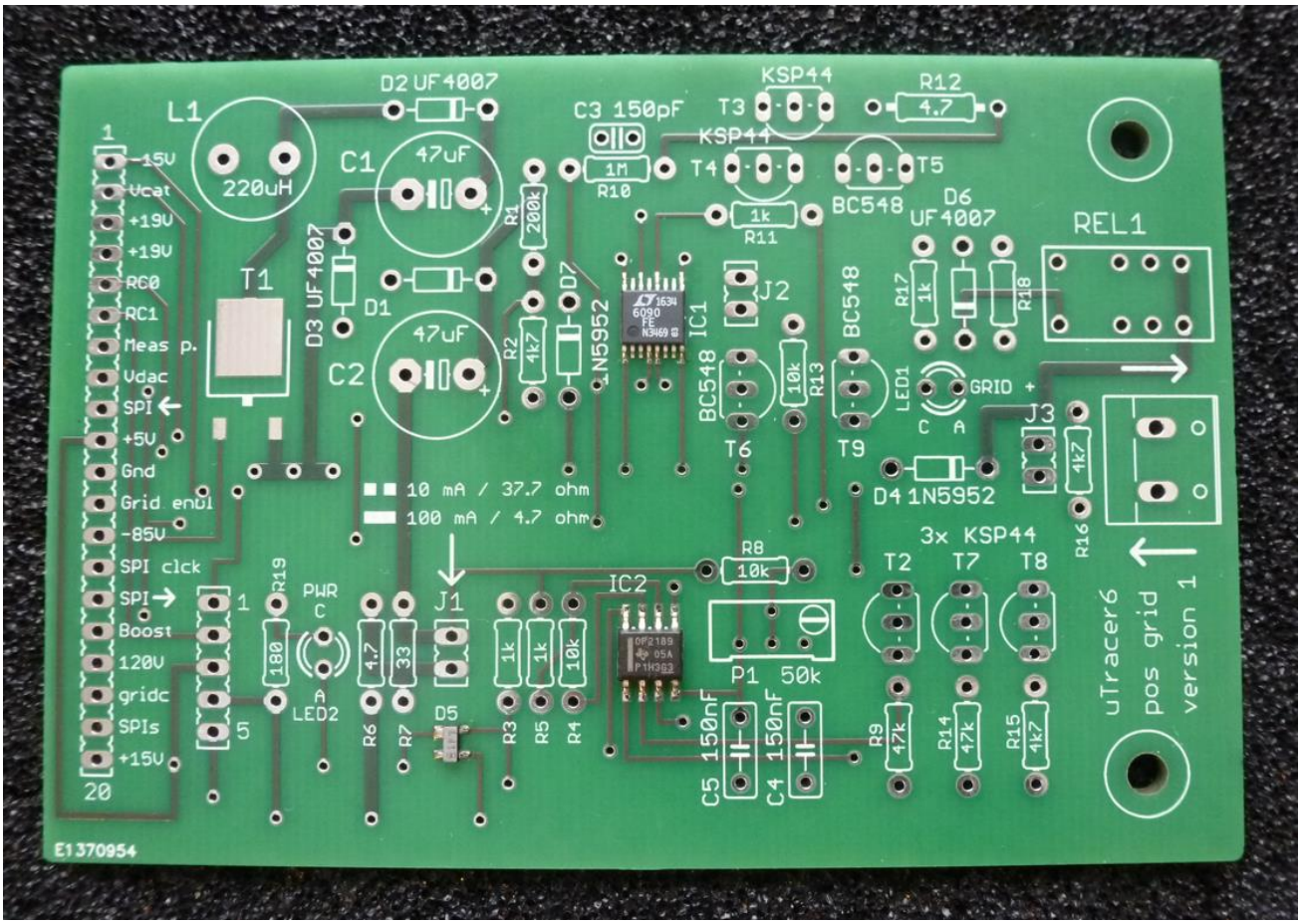
Component in circuit diagram	Replacement type(s)

Part 1. Install the new PIC (if needed)

Users that have a uTracer6 with PIC firmware V6.19 need to install the PIC with firmware version V6.29 that is supplied with the kit.

The firmware detects if the extension board is present. If it is not present, the firmware works as before with the GUI V1. When the board is installed on start up the new functionality is enabled and the firmware only works with GUI V2 or higher.

- ☐ 1. Carefully remove the original PIC supplied with the uTracer6 kit make sure not to bend the pins and save the PIC to be able to return to the original firm ware.
- ☐ 2. Insert the new PIC with the updated firmware (see tips and tricks).
- ☐ 3. Test your uTracer6. Without the extension board mounted it should function exactly as before.



The PCB as supplied with the kit with IC1, IC2 and D5 already installed

Part 2. The graphical user interface (GUI) update

The positive grid extension board requires GUI V6.2 or higher,
is can be downloaded from:
https://www.dos4ever.com/uTracer3/uTracer_6p2.zip
(note that there is an underscore between uTracer and 6p2)

It is assumed that GUI V6.1 is already installed and working

- ☐ 1. Start the old GUI (the one you are using now) and note down the calibration values.
- ☐ 2. Download the zip file containing V6.2 (or higher) and unzip it.
- ☐ 3. Move the executable to a folder from where you want to run the GUI.
- ☐ 4. Double click the executable to start the GUI.
- ☐ 5. On startup automatically a new calibration file will be created.
- ☐ 6. Open the calibration form and enter the calibration values recorded in step 1.
- ☐ 7. Save the calibration file.

Without the extension board you can still use the GUI V6.1

Part 3. Positive grid boost converter grid switch

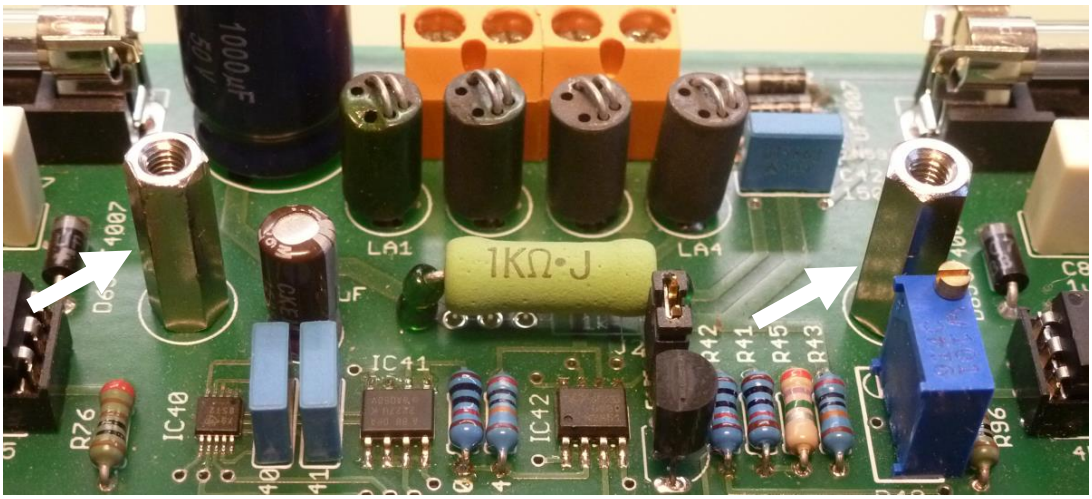
- [x] 1. IC1, LTC6090
- [x] 2. IC2, OPA2189
- [x] 3. D5, BAT74
- [ ] 4. T1, FQD12N20LTM
- [ ] 5. R1, 200k
- [ ] 6. R2, 4k7
- [ ] 7. R7, 33 ohm
- [ ] 8. R6, 4.7 ohm
- [ ] 9. D1, diode UF4007 note polarity !
- [ ] 10. D2, diode UF4007 note polarity !
- [ ] 11. D3, diode UF4007 note polarity !
- [ ] 12. D7, zener diode BZT03C130 note polarity !
- [ ] 13. L1, 220 uH
- [ ] 14. C1, 47uF / 160V note polarity !
- [ ] 15. C2, 47uF / 160V note polarity !
- [ ] 16. R17, 1k
- [ ] 17. R18, 1k (note that on the PCB the value is missing)
- [ ] 18. R19, 1k (note that on the PCB a value of 180 ohm is indicated)
- [ ] 19. D6, diode UF4007 note polarity !
- [ ] 20. L1, red LED note polarity ! → A = anode = long pin
- [ ] 21. L2, red LED note polarity ! → A = anode = long pin
- [ ] 22. T9, BC548 note orientation !
- [ ] 23. REL1, 12V miniature pcb relais.

Overview of the PCB after step 4. Note that the shape and color of components can vary depending on availability.

Part 4. The board-to-board connector

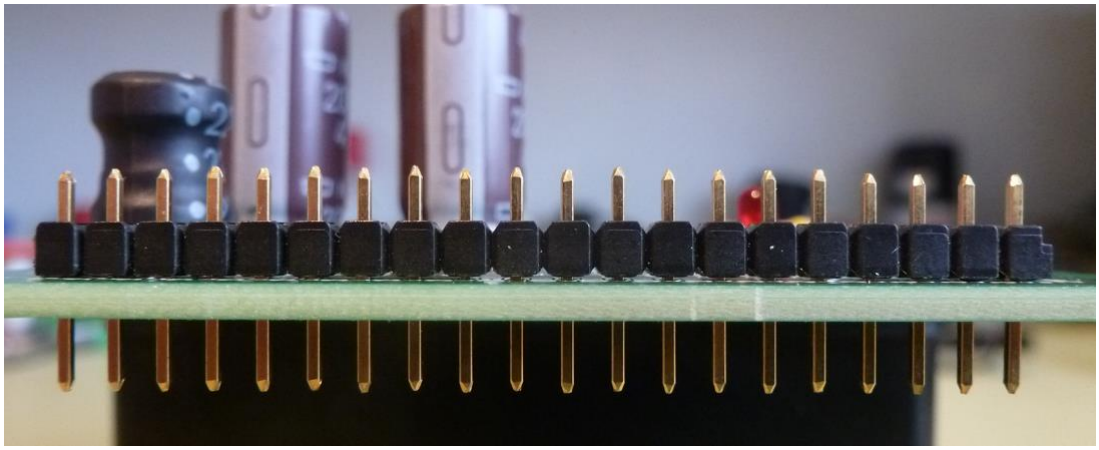
Installation of the board-to-board connector requires a bit of fiddling, but this is the solution I used. Feel free to use a solution that suits you better.

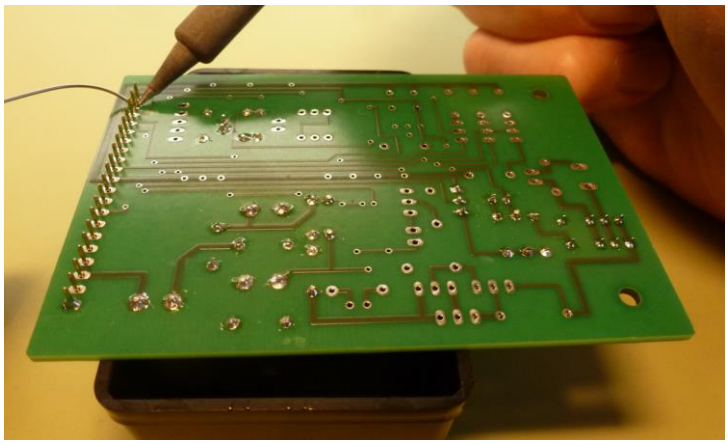
☐ 1. Install on the main board the two threaded standoffs.



☐ 2. Install one of the two 20 pin male pin headers on the extension board as shown below.

Note that the long pins are inserted into the PCB!

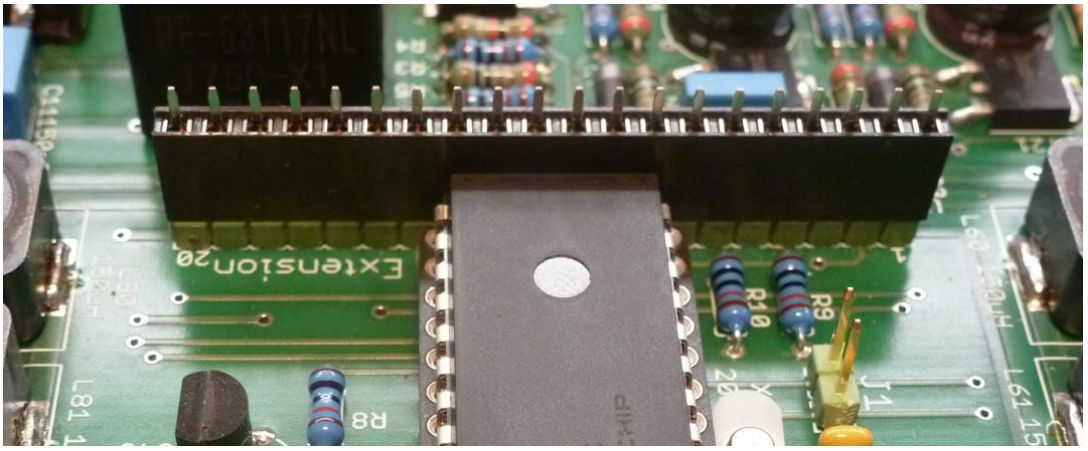




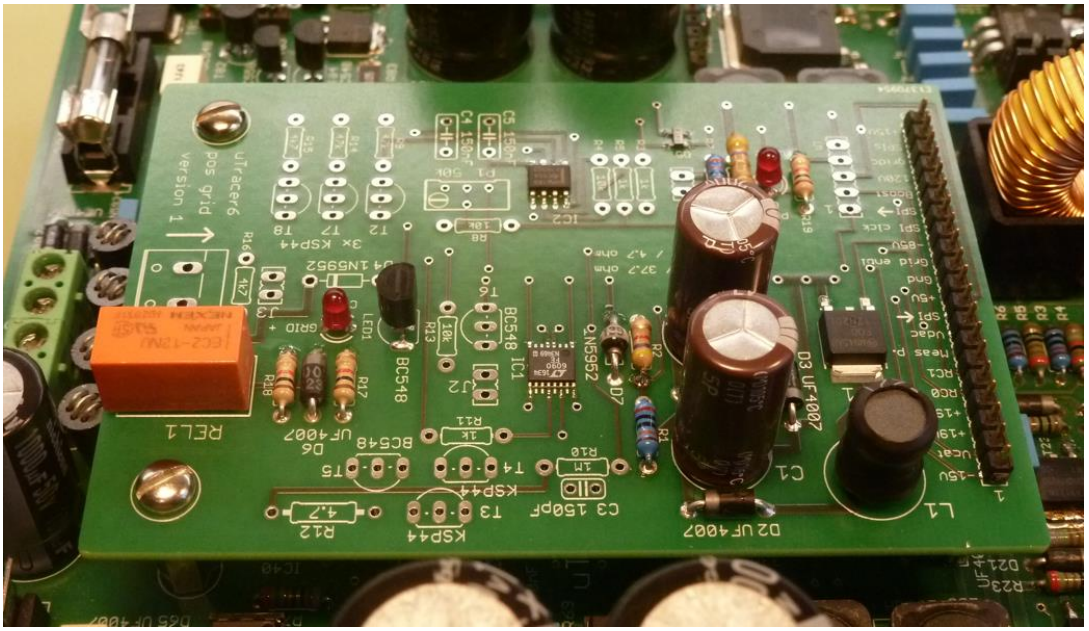
Solder the pins from the backside of the PCB and make sure the solder fills the pads.

☐ 3. Install on second 20 pin male pin header on the main board.

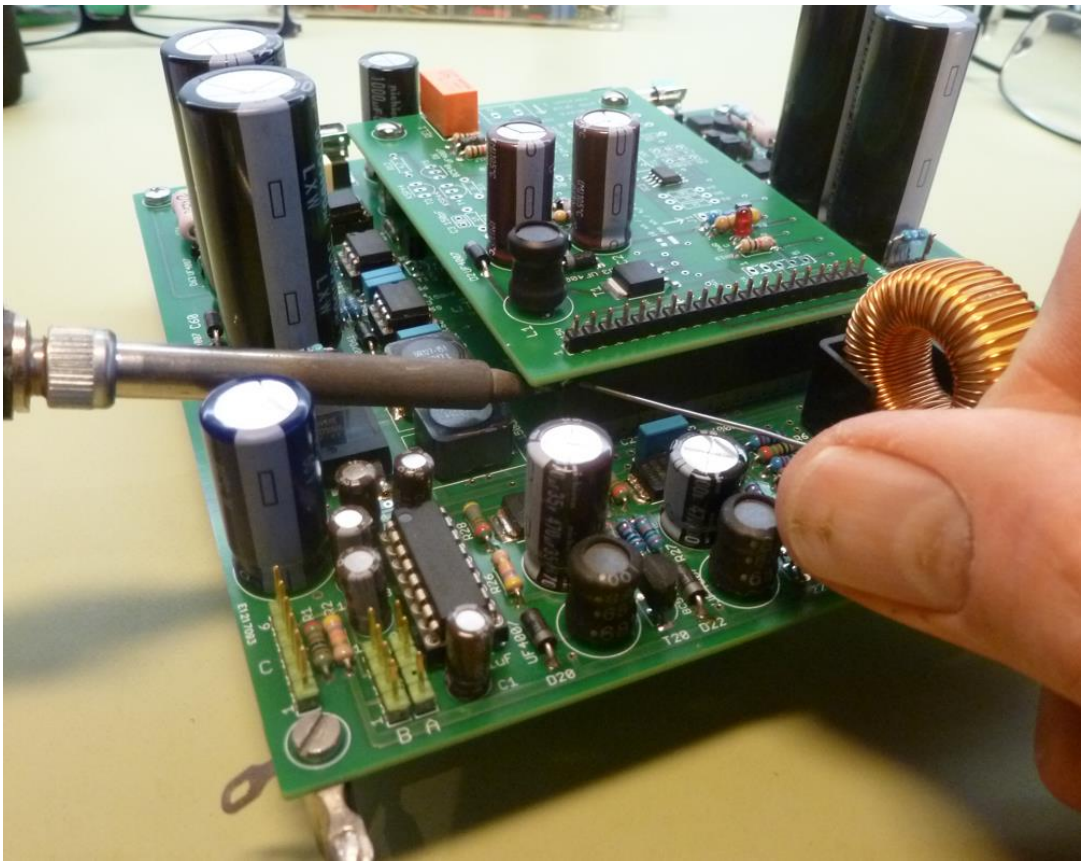
☐ 4. Press the 20 pin SIL socket on the pin header of the main board.



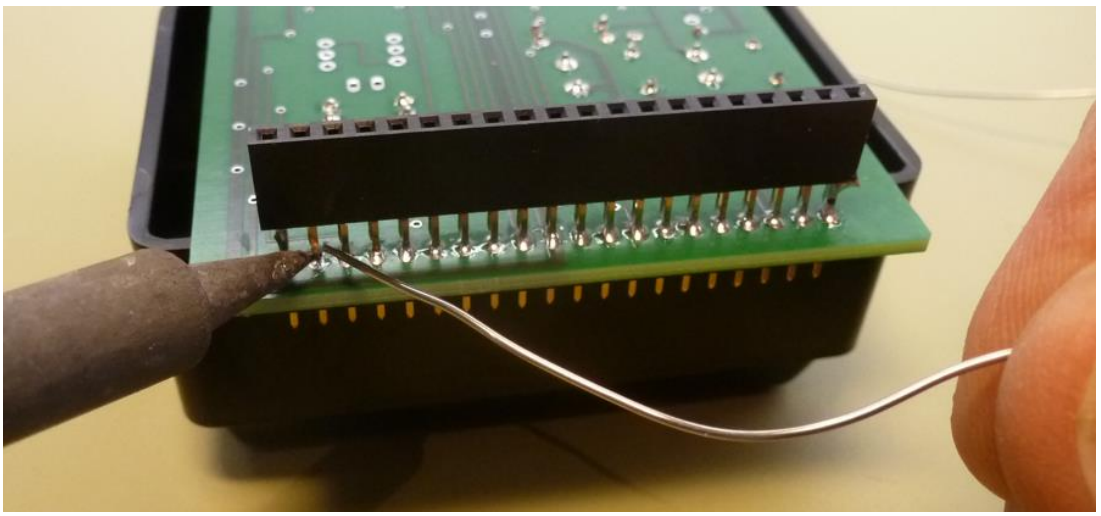
☐ 5. Place the extension board on the standoffs and loosely tighten the two M3 bolds.



☐ 6. Make sure the pins between the two boards are neatly aligned and then solder the pin 1 and 20 of the pin header to the single in line socket underneath.



☐ 7. Carefully remove the extension board from the main board and solder the remaining 18 pins.

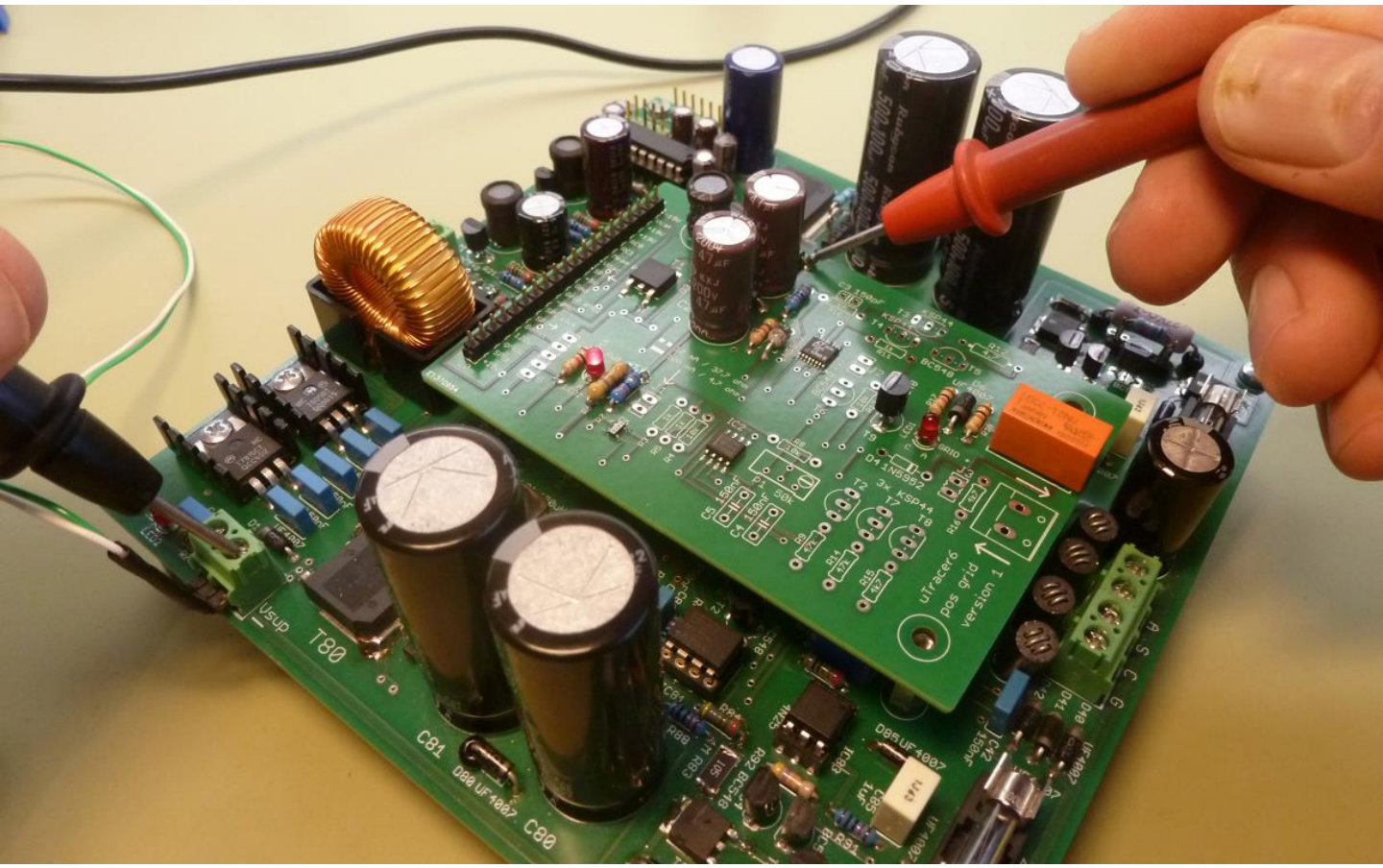


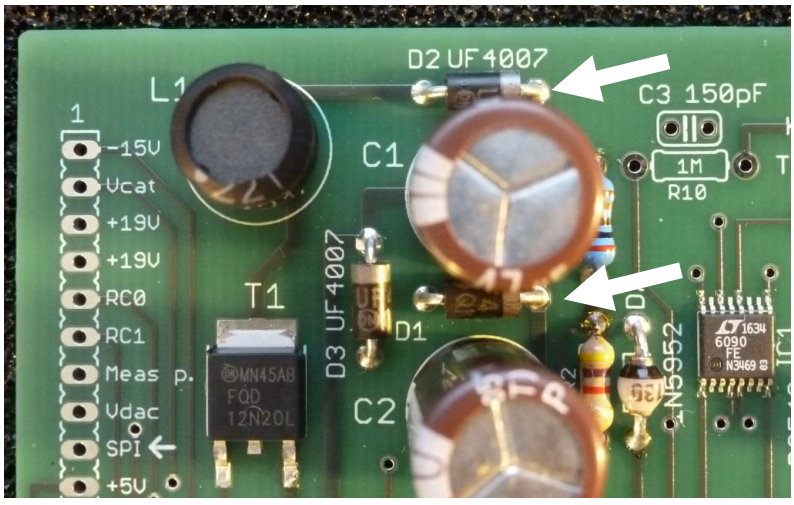
Part 5. testing the boost converter

Place the extension board on the main board.

Apply power to the main power.

Immediately LED 2 should turn on and then within a few seconds LED 1 (as well as the relay) will blink twice and then remain off. When this happens it is a sign that all three boost converters, the -15V and -85V on the main board, as well as the 120 V on the extension board, are all function correctly and have reached their setpoint values.





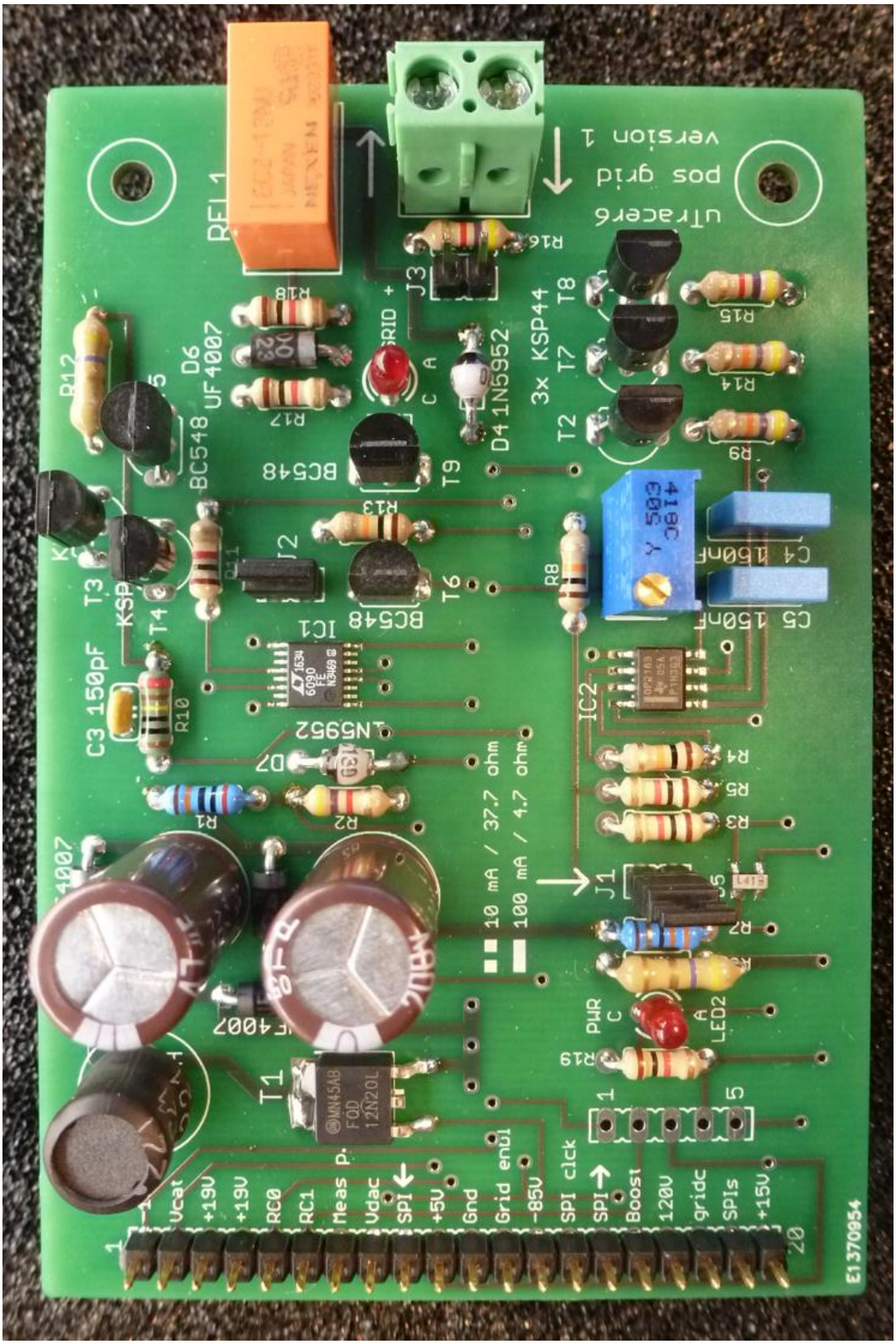
Check the voltages on the cathodes of D1 and D2 with respect to ground, they both should be between 120 – 130 V.

Do not slip with measurement probe!

Part 6. Completion of the circuit

- ☐ 1. R3, 1k
- ☐ 2. R5, 1k
- ☐ 3. R11, 1k
- ☐ 4. R4, 10k
- ☐ 5. R8, 10k
- ☐ 6. R13, 10k
- ☐ 7. R15, 4k7
- ☐ 8. R16, 4k7
- ☐ 9. R9, 47k
- ☐ 10. R14, 47k
- ☐ 11. R10, 1M
- ☐ 12. R12, 4.7 ohm
- ☐ 13. D4, zener diode BZT03C130 note polarity !
- ☐ 14. C4, 150 nF
- ☐ 15. C5, 150 nF
- ☐ 16. C3, 150 pF
- ☐ 17. P1, 50k potentiometer
- ☐ 18. T5, BC548 Note orientation !
- ☐ 19. T6, BC548 Note orientation !
- ☐ 20. T3, KSP44 Note orientation !
- ☐ 21. T4, KSP44 Note orientation !
- ☐ 22. T2, KSP44 Note orientation !
- ☐ 23. T7, KSP44 Note orientation !
- ☐ 24. T8, KSP44 Note orientation !
- ☐ 25. place 2 pin pin-header J1
- ☐ 26. place 2 pin pin-header J2
- ☐ 27. place 2 pin pin-header J3

- ☐ 28. place a jumper on pin-header J1
- ☐ 29. place a jumper on pin-header J2
- ☐ 30. place the PCB terminal block

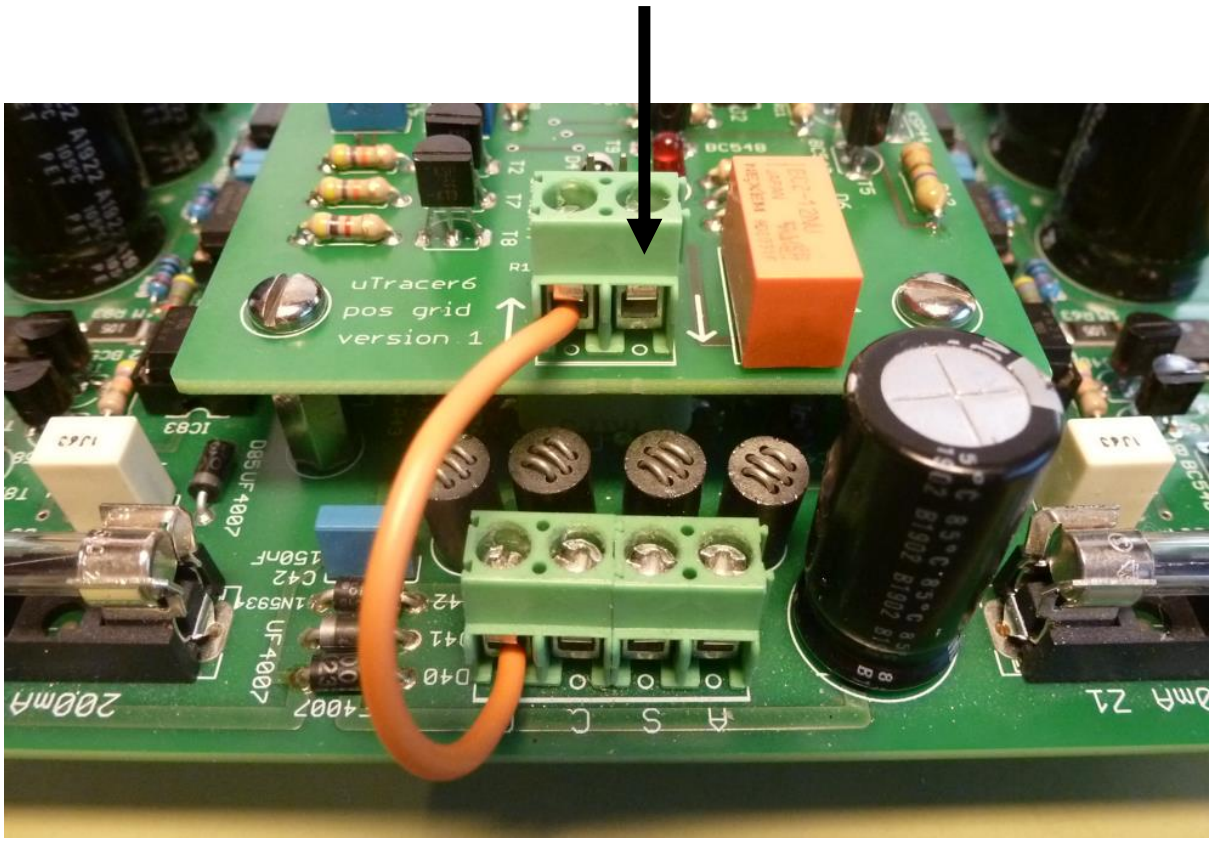


The extension board after completion

☐ 31. Install the extension board on the main board.

☐ 32. Connect the grid output of the main board with the grid input of the extension board (see below).

The grid output of the extension board is now the new grid connection of your uTracer. It will switch automatically between the negative grid supply on the main board and the positive grid supply on the extension board.



On the next pages the calibration procedure is described. It consists of 5 steps. Please note that during the calibration high voltages are present on the board. Always switch off power when you need to change something to the wiring or need to place or remove jumpers !

Part 7. Calibration 1 – offset adjustment

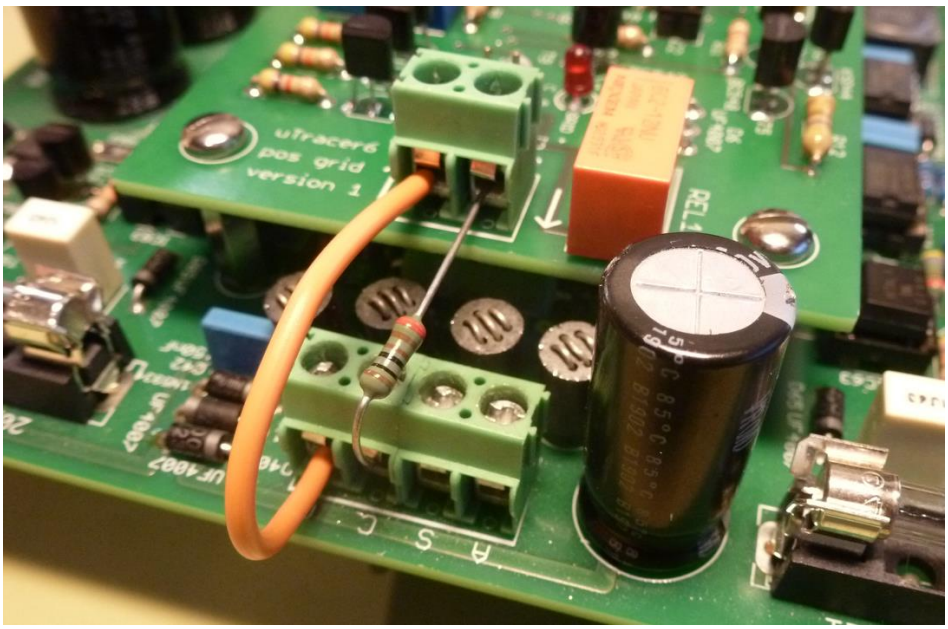
☐ 1. Make sure the jumpers are installed as follows:

Jumper 1 = installed

Jumper 2 = installed

Jumper 3 = removed

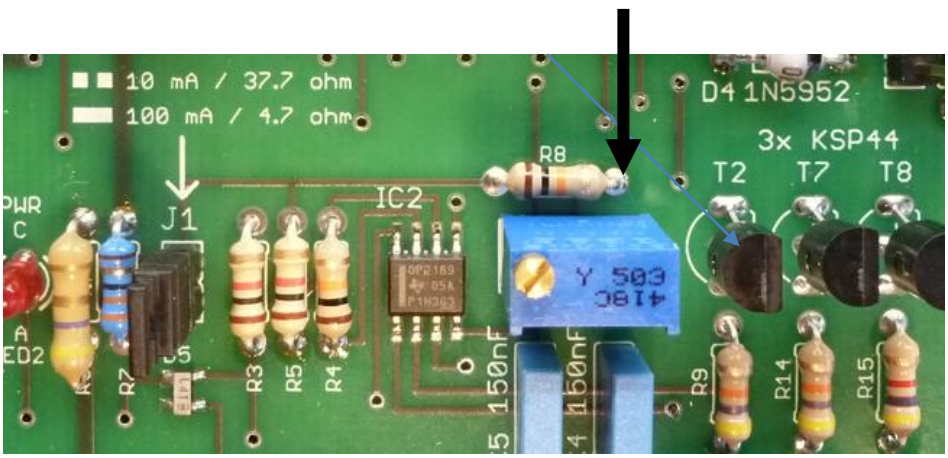
☐ 2. Connect a 10k resistor between the grid terminal on the extension board and the cathode terminal on the main board (see below).



☐ 3. Switch your uTracer on.

☐ 4. Measure the voltage between the slider of P1 and ground.

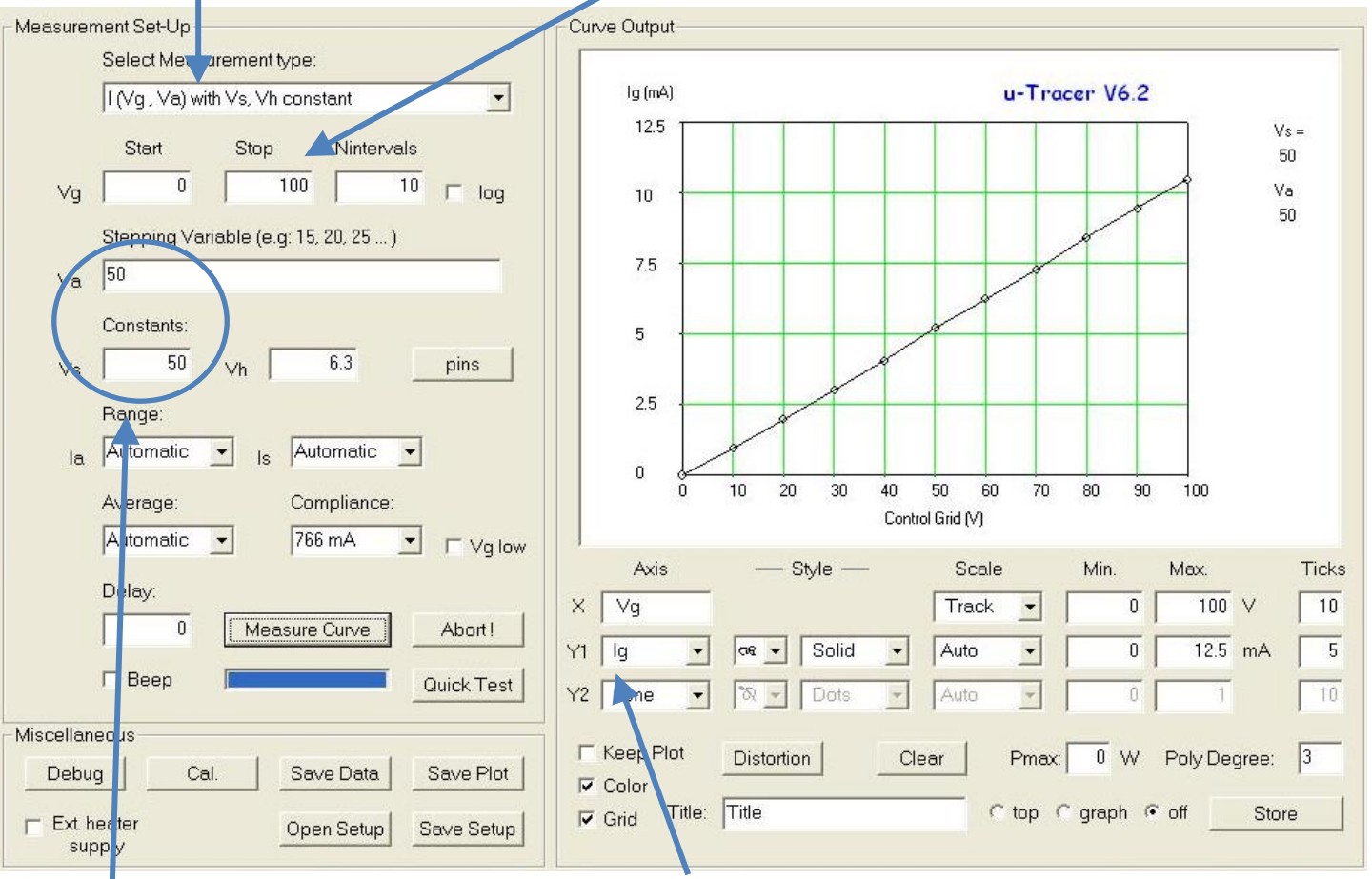
There is no need to remove the board of for this. The slider voltage can be probed on R8 (do not slip with your test pen).



- ☐ 5. Adjust P1 so that the voltage is approximately 0V.
- ☐ 6. Select the measurement and settings as shown below:

I(Vg,Va) with Vs, Vh constant

100 V

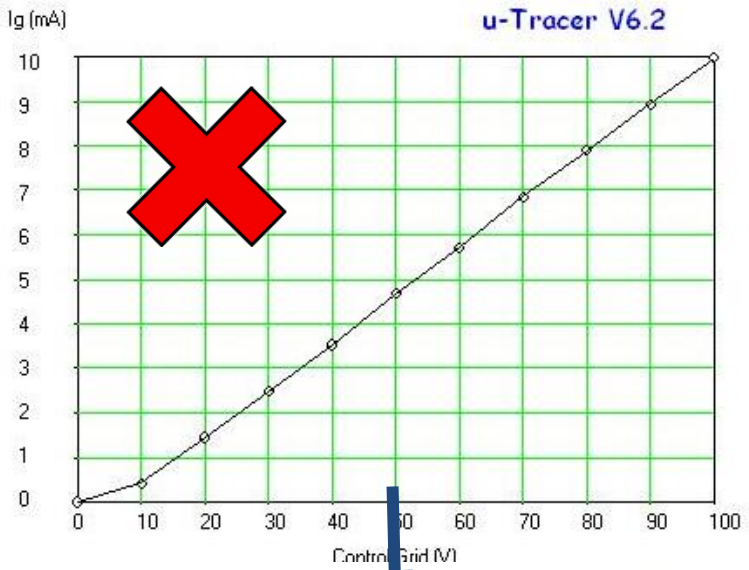


Select relatively safe voltages of 50 V

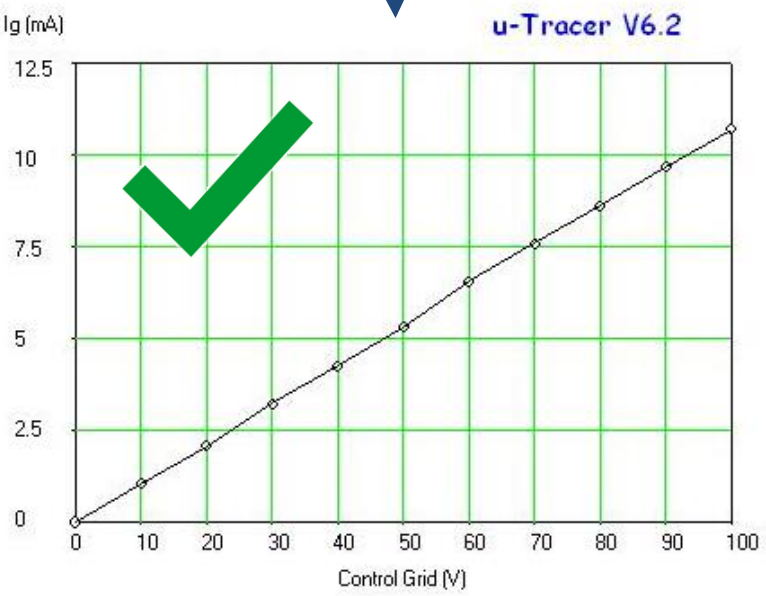
Make sure to select as plotting variable Ig

Please note that during the measurement
High voltages are present on both boards!

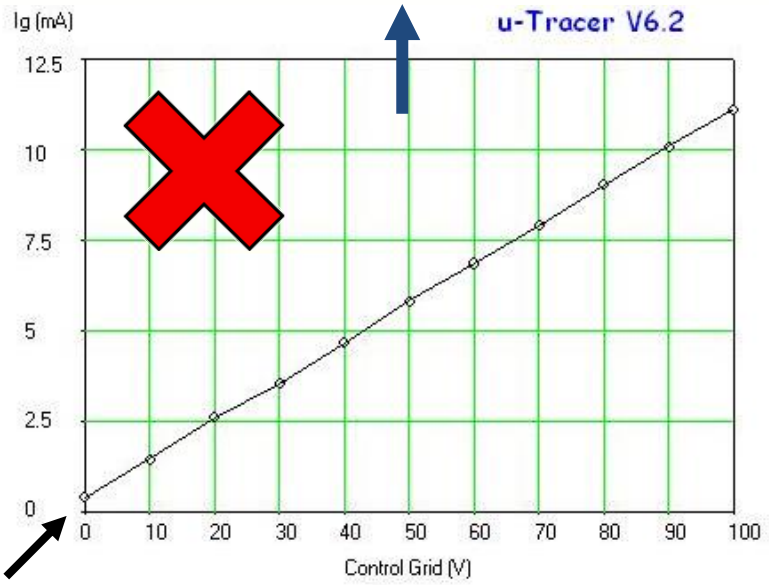
- ☐ 7. Start a measurement.
- ☐ 8. Now adjust P1.
- ☐ 9. Repeat steps 7 and 8 until the measurement is a nice straight line going through (0,0) . See figures on the next page.



Adjust P1 such that the voltage on its slider becomes more **negative.**



Perfect!



Adjust P1 such that the voltage on its slider becomes more **positive.**

offest

Part 8. Calibration 2 – voltage adjustment

- ☐ 1. Make sure the jumpers are installed as follows:

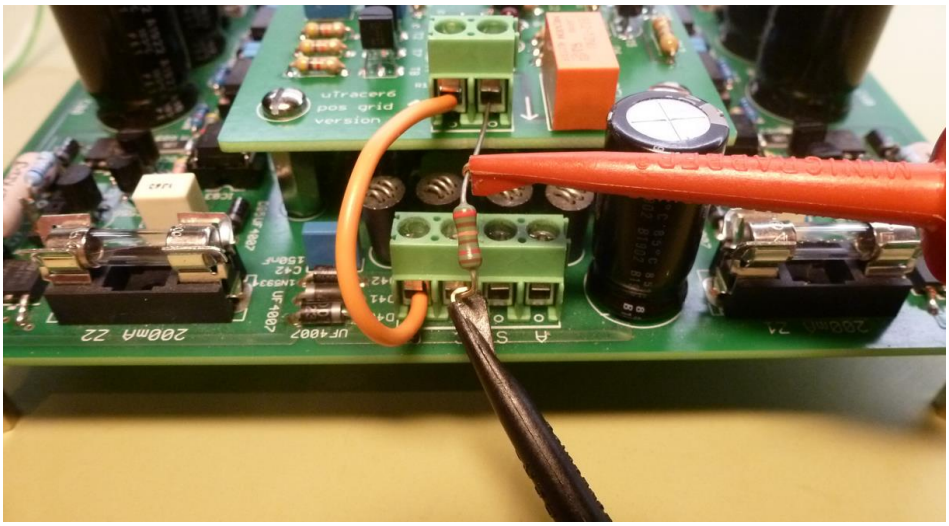
  Jumper 1 = installed

  Jumper 2 = removed !!!!! ⟵

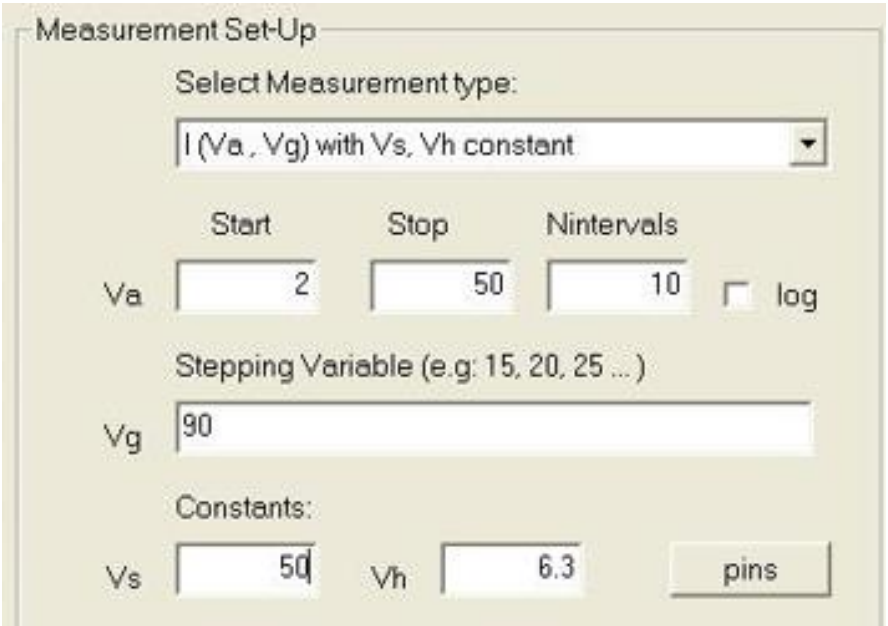
  Jumper 3 = removed

- ☐ 2. Connect a 100K resistor (value not critical) between grid and cathode terminals.

- ☐ 3. Connect you DVM (digital voltmeter) between grid and cathode terminals, see below:



- ☐ 4. Select the measurement shown below (all other settings standard):



- ☐ 5. Open the calibration form.
- ☐ 6. Start the measurement.
- ☐ 7. Read out the grid voltage from your DVM.
- ☐ 8. If the grid voltage is not 90 V, adjust the “Vgrid +” slider (below) and repeat step 6 till 8 until the voltage reads 90 V.

- ☐ 9. Save the calibration file.
- ☐ 10. **Place Jumper J2 back !!**

Part 9. Calibration 3 – current (high scale) adjustment

- ☐ 1. Make sure the jumpers are installed as follows:

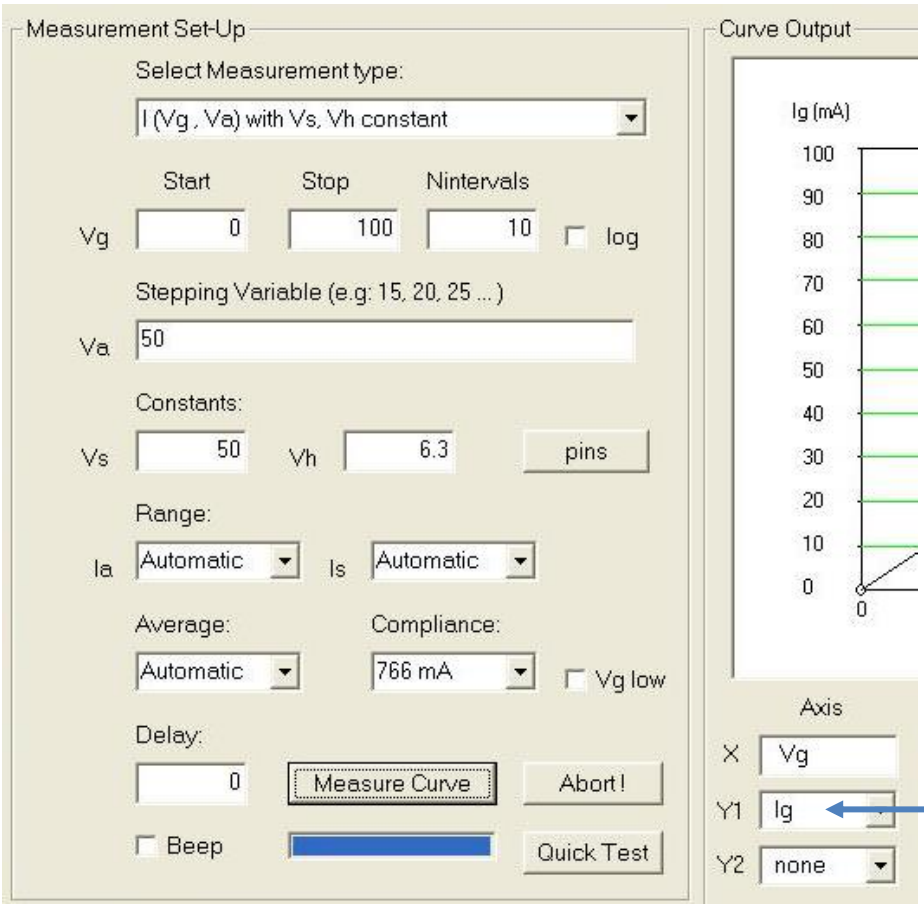
  Jumper 1 = installed

  Jumper 2 = installed

  Jumper 3 = removed

- ☐ 2. Connect a 1K resistor (preferably a 1% type) between grid and cathode terminals.

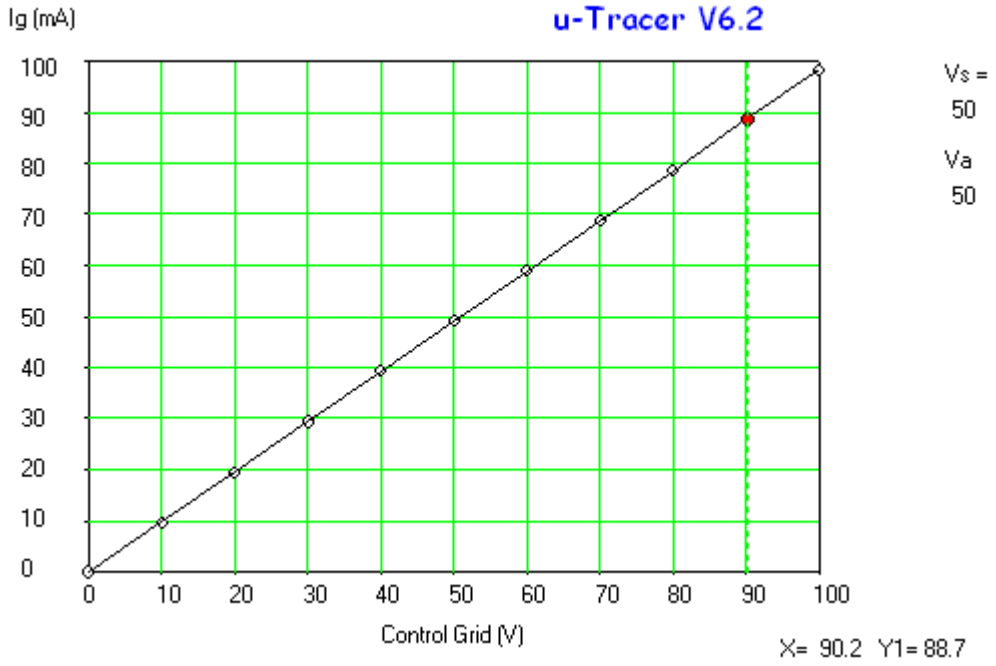
- ☐ 4. Select the measurement show below (all other settings standard):



Be sure to select the grid current as the plot variable

- ☐ 5. Switch your uTracer on.
- ☐ 6. Run a measurement.

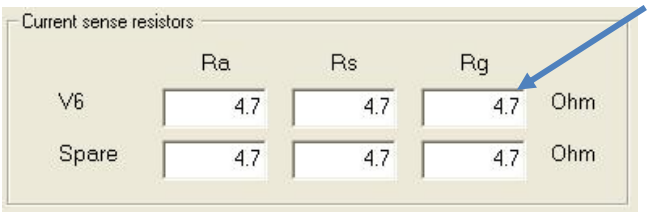
☐ 7. Place the cursor on the measured line somewhere in the area of 90V. Read out the current (I) in mA and the voltage (V) in V.



☐ 8. Calculate R = 4.7 * (I / V) with I in mA

So, in this example R = 4.7*(88.7/90.2) = 4.62 (ohm)

☐ 9. Open the calibration form and enter the corrected value for Rg.



here:

☐ 10. Save the calibration form

☐ 11. Close the GUI and start the GUI again to activate the new value for Rg

☐ 12. Run the measurement again to verify that at 90V the current measured is indeed 90mA

Note down the value for Rg (100mA) range:

Part 10. Calibration 4 – current (low scale) adjustment

- ☐ 1. Make sure the jumpers are installed as follows:

  Jumper 1 = removed !!!!! ⟵

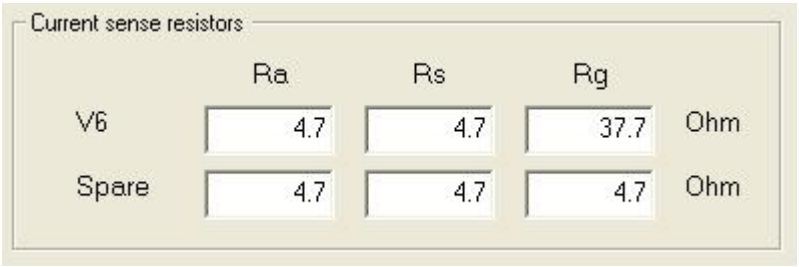
  Jumper 2 = installed

  Jumper 3 = removed

- ☐ 2. Connect a 10K resistor (preferably a 1% type) between grid and cathode terminals.

- ☐ 4. Start the GUI and open the calibration form.

- ☐ 5. Change Rg to 37.7 ohm.



- ☐ 6. Close the GUI and start it GUI again to activate the new value for Rg.

- ☐ 7. Run the same measurement as in Section 9.

- ☐ 8. Place the cursor on the measured line somewhere in the area of 90V. Read out the current (I) in mA and the voltage (V) in V. The current measured should be approximately 9 mA.

- ☐ 9. Calculate R = 37.7 * 10 * (I / V) with I in mA .

- ☐ 10. Open the calibration form and fill in this corrected value for Rg.

- ☐ 11. Save the calibration form.

- ☐ 12. Close the GUI and start the GUI again to activate the new value for Rg.

- ☐ 13. Run the measurement again to verify that at 90V the current measured is indeed 9 mA.

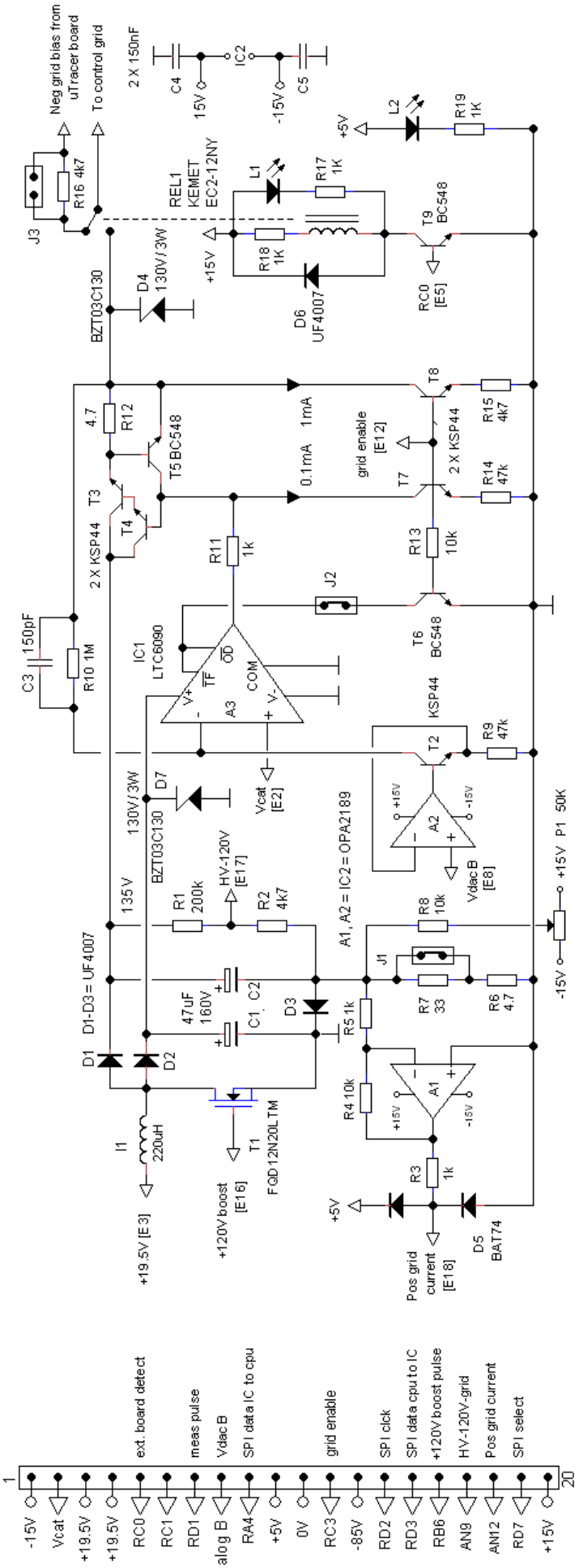
Note down the value for Rg (10 mA) range: ☐

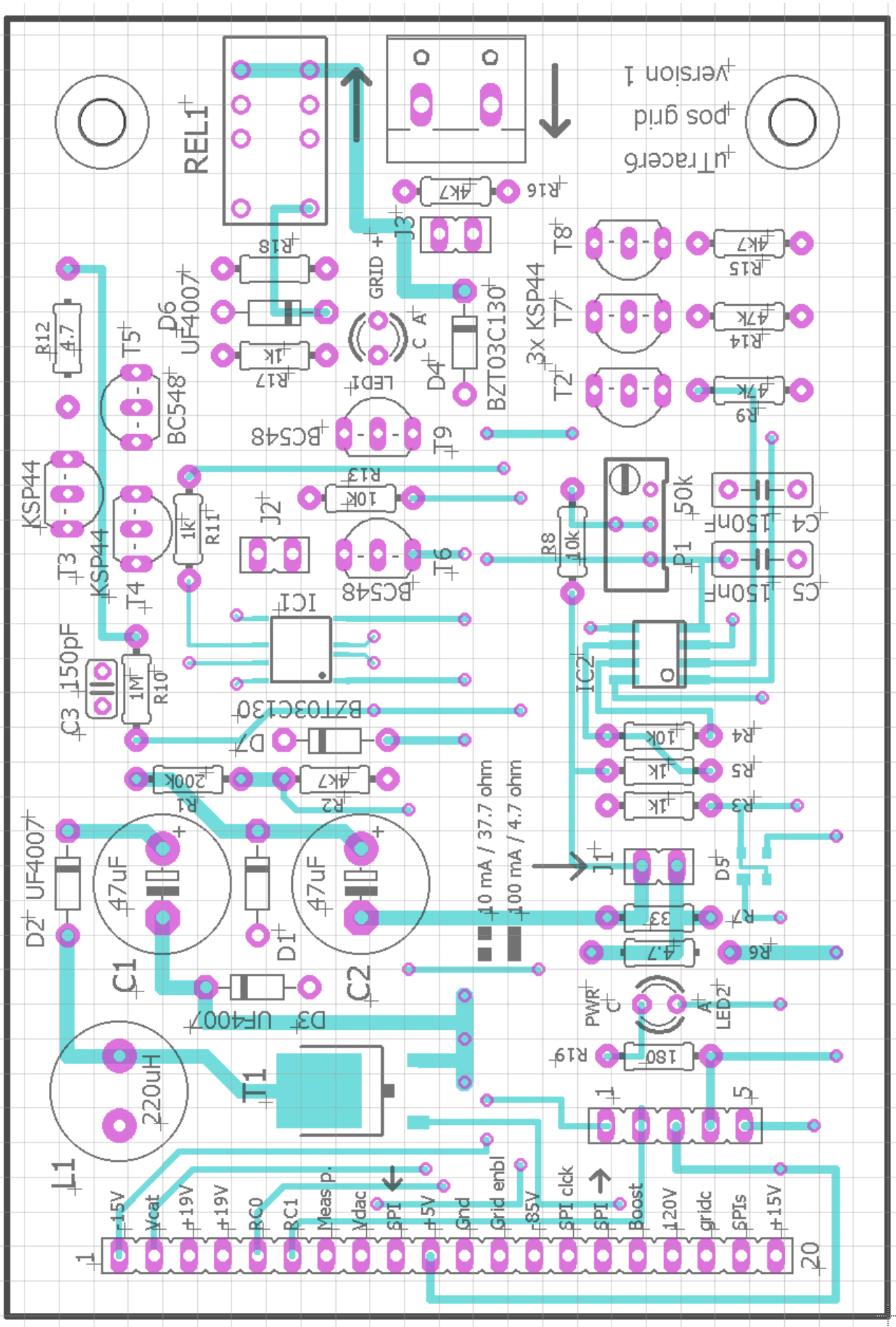
Depending on the current range you want to use place jumper J1 or remove it and change the value for Rg in the calibration form accordingly. Make sure to save the calibration file and shut down and start the GUI to make the changed value for Rg active.

Part 11. Calibration 5 – negative grid bias range

Since the negative grid bias calibration range has been increased in the new GUI, it is unfortunately necessary to recalibrate this negative grid section.

- ☐ 1. Temporarily remove the extension board.
- ☐ 2. Temporarily remove jumper J2 **on the main board.**
- ☐ 3. Connect a DVM between the grid and cathode terminals of the uTracer.
- ☐ 4. Run the same measurement as in part 8 but now with Vg = -90V.
- ☐ 5. Change Vgrid- in the calibration form if needed
- ☐ 6. Re-run the measurement until the measured until the measured grid voltage equals -90V.
- ☐ 7. Switch off the power.
- ☐ 8. Again install jumper J4 **on the main board.**
- ☐ 9. Re-install the extension board.


Neg grid bias from uTracer board
To control grid
2 X 150nF
C4
15V
IC2
-15V
C5
J3
R16 4k7
REL1 KEMET EC2-12NY
L1
R17 1K
+5V
L2
R19 1K
T9 BC548
+15V
R18 1K
D6 UF4007
RC0 [E5]
BZT03C130
D4 130V/3W
T8
R15 4k7
4.7
R12
T5 BC548
1mA
0.1mA
grid enable [E12]
T7
2 X KSP44
R14 47k
T3
T4
2 X KSP44
R11 1k
R13 10k
J2
T6 BC548
C3 150pF
R10 1M
IC1 LTC6090
TF
OD
COM
V+
V-
A3
KSP44
T2
R9 47k
D7
130V/3W
BZT03C130
Vcat [E2]
A2
+15V
-15V
Vdac B [E8]
P1 50K
+15V
-15V
135V
R1 200k
HV-120V [E17]
R2 4k7
A1, A2 = IC2 = OPA2189
R8 10k
J1
D1-D3 = UF4007
47uF 160V
C1, C2
D3
R5 1k
R7 33
R6 4.7
D1
D2
A1
R4 10k
I1 220uH
T1 FQD12N20LTM
R3 1k
+19.5V [E3]
+120V boost [E16]
+5V
D5 BAT74
Pos grid current [E18]
ext. board detect
meas pulse
Vdac B
SPI data IC to cpu
grid enable
SPI clck
SPI data cpu to IC
+120V boost pulse
HV-120V-grid
Pos grid current
SPI select
1
20
-15V
Vcat
+19.5V
+19.5V
RC0
RC1
RD1
analog B
RA4
+5V
0V
RC3
-85V
RD2
RD3
RB6
AN9
AN12
RD7
+15V



REL1
uTracer6
pos grid
version 1
R16
4k7
J3
GRID +
R18
D6
UF4007
R17
1k
C A
LED1
D4
BZT03C130
3x KSP44
T8
T7
T2
R15
4k7
R14
47k
R9
47k
R12
4.7
T5
BC548
BC548
T9
KSP44
T3
KSP44
T4
R11
1k
J2
R13
10k
BC548
T6
R8
10k
P1
50k
C4
150nF
C5
150nF
IC1
IC2
C3
150pF
R10
1M
BZT03C130
D7
R1
200k
R2
4k7
R4
10k
R5
1k
R3
1k
D2
UF4007
47uF
D1
47uF
C1
C2
10 mA / 37.7 ohm
100 mA / 4.7 ohm
J1
D5
R7
33
R6
4.7
PWR
C
A
LED2
D3
UF4007
R19
180
T1
220uH
L1
1
5
1
-15V
Vcat
+19V
+19V
RC0
RC1
Meas p.
Vdac
SPI
+5V
Gnd
Grid enbl
-85V
SPI clck
SPI
Boost
120V
gridc
SPIs
+15V
20