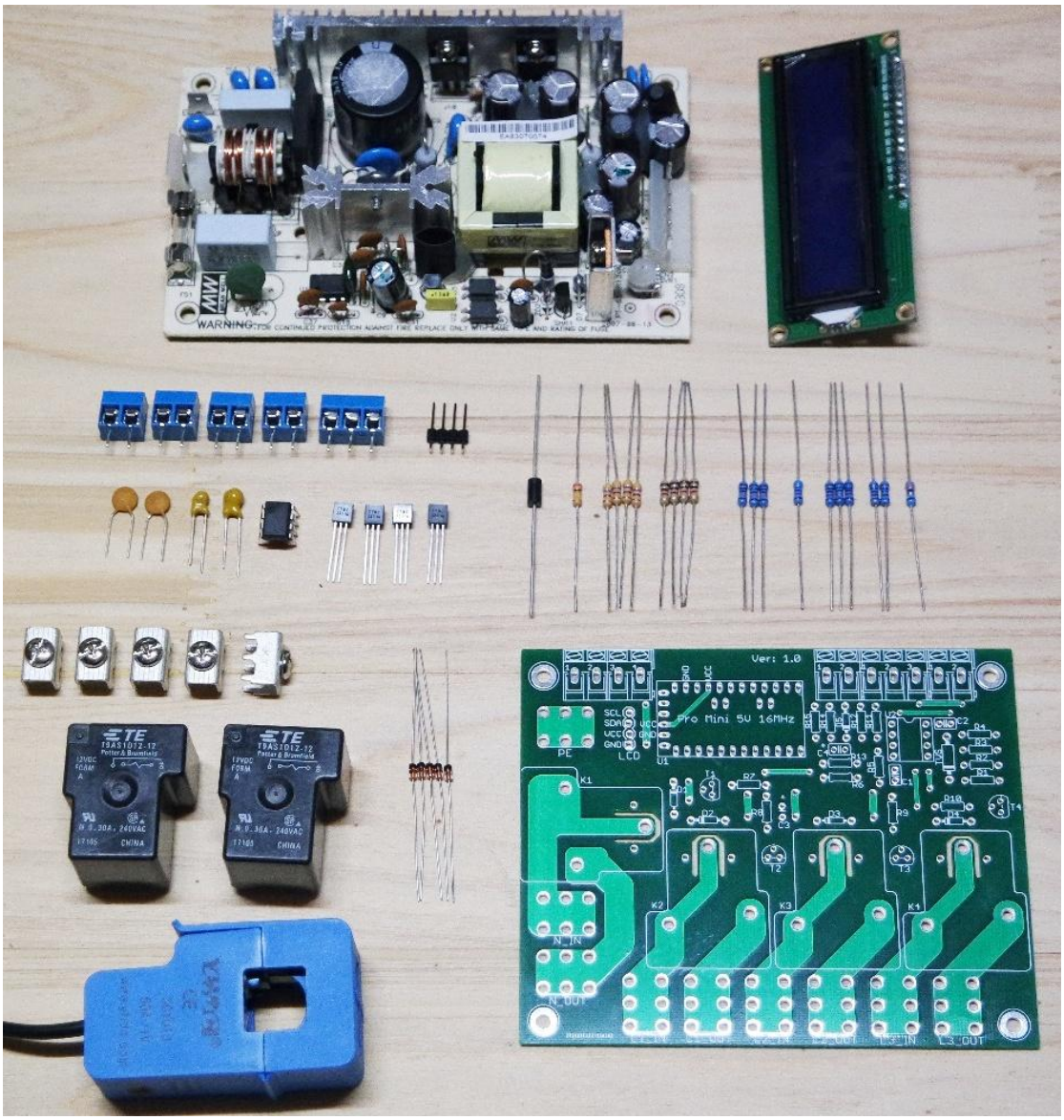
DIY EVSE
Assembly Instruction Manual



V1.0f

Dear Customer, Thank you for choosing our product. Please read this assembly manual carefully before you start your project. This DIY project is for people with electronics skills. If you are not familiar with electronics and electrical installations please don't take on this project, as it involves dealing with a deadly high voltage circuits and this is not the thing to play with! Mistakes can be fatal! This project is for educational purposes only and should not be used as a final product. If you decide to use it as a final product, you'll take all responsibility for correct assembly, final testing, certification and proper use. We won't take any responsibility for the property damage or personal injury or death caused by our products, because we are not involved in assembly and testing of these products.

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1. Safety instructions:

1.1 Safety and compliance

Safety signs

Caution: this sign represents it would create danger for user or damage the hardware seriously if operated improperly.

Danger: this sign represents presence of high voltage and risk to be electrocuted or risk of equipment damage if operated improperly.

WARNING:
Read all the instructions before assembling this DIY kit.
Do not use any components which show any indication of damage.
Do not let children anywhere close while you assembling, testing or using this product. Please supervise children who are nearby all the time. This kit contains very small components which can be fatal if swallowed by child.
The assembled product should be inspected by a qualified person before connecting it to mains. Connection to mains must be in compliance with local standards. User takes all responsibility to comply with all applicable codes and safety standards.
Do not install this product in a small, air tight enclosures as it might overheat.
This product must not be installed or used in the environment that contain volatile gas or flammable-explosive environment.
This product must be kept away from heat sources, fireworks, dusty and corrosive environment.

1.2 Earthing/Grounding instructions

Assembled product must be properly earthed/grounded when tested or in use. This should be done in compliance with all applicable electrical codes and standards. Failure to do so can cause property damage. Also incorrect earthing/grounding can cause personal injury or even death.

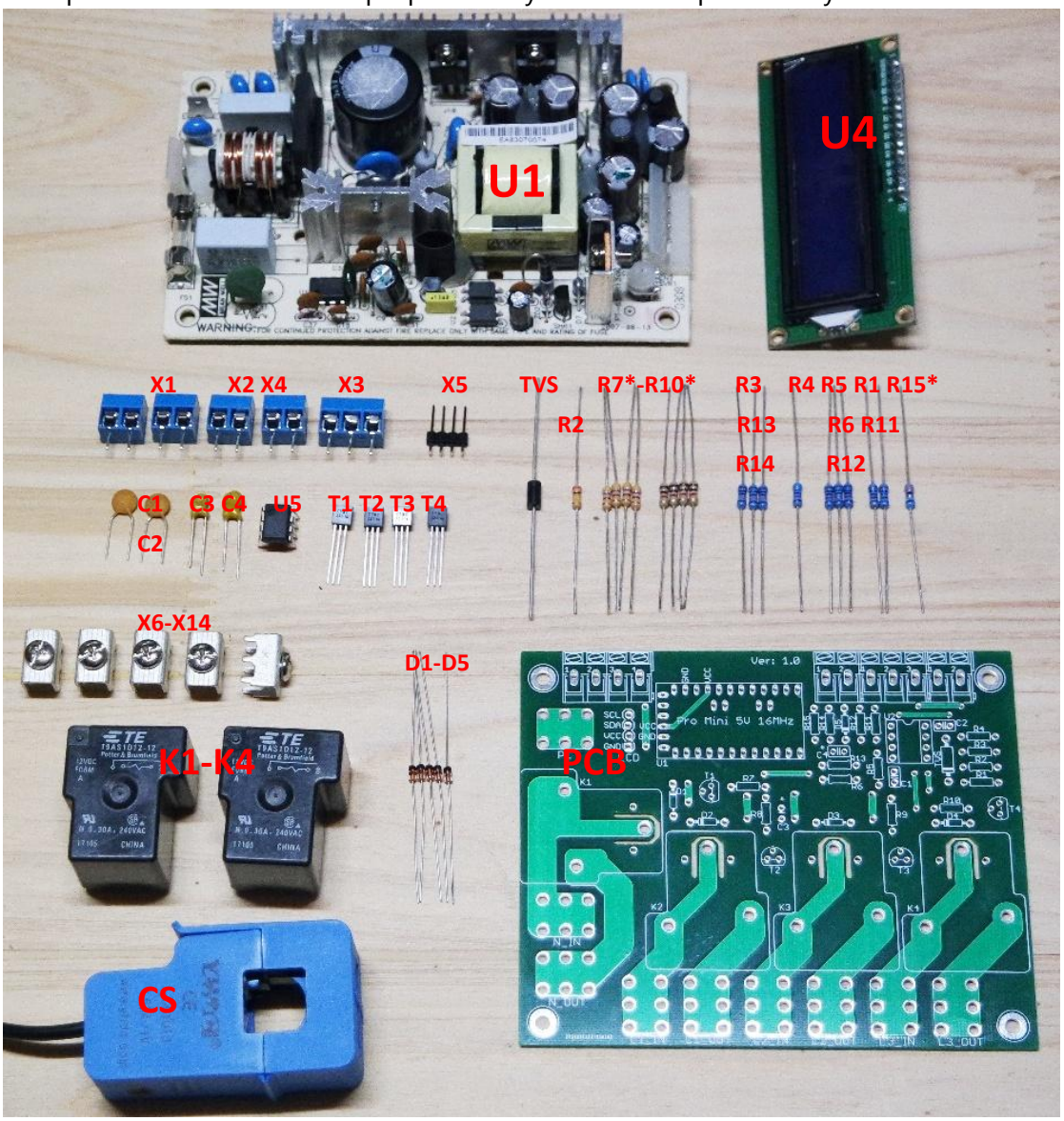
1.3 Residual current protection

Assembled product must only be used on RCD protected power supply. Please check your country regulations of what RCD protecting devices must be used.

2. Introduction:

2.1 DIY EVSE kit:

Please note this picture is for illustration purposes only and not the picture of your actual kit.



The components will vary depending of which kit you will buy. Also some component required quantity will vary, depending of which type of project you will choose to build. Some components can be replaced with different manufacturer and type. It's entirely up to user if he wants to follow original design and recommendations.

2.2 Component list

Three-phase non-tethered EVSE, with current monitoring:

Component name	Qty.
U1 – MEAN WELL PT-45B power supply board	1
U2 – Pro Mini ATmega328P 16MHz 5V microcontroller board	1
U4 – 20x4 LCD module with PCF8574 I2C module	1
U5 – LF353 operational amplifier	1
X1, X2, X4 – XY306 2P PCB terminal blocks	4
X3 – XY306 3P PCB terminal block	1
X5 – 1x4 RM2,54 PCB header pins strip	1
X6-X14 – PCB-20632F screw terminals	9
K1-K4 – HAT901CS30DC12 relays	4
D1-D5 – 1N4148 diodes	5
T1-T4 – BC337-16 transistors	4
C1, C2 – 100nF 50V ceramic capacitors	2
C3 – 1uF 30V tantalum capacitor	1
C4 – 10uF 25V tantalum capacitor	1
R1 – 680Ohm 1% resistors	1
R7*-R10*, R11 – 1kOhm 1% resistors	5
R2 – 200kOhm 1% resistor	1
R3, R13, R14 – 100kOhm 1% resistors	3
R4 – 56kOhm 1% resistor	1
R5, R6, R12 – 10kOhm 1% resistors	3
R15*-...* – 33Ohm resistors	3
PCB – Custom made PCB by EV-OLUTION.NET	1
CS – STC-013 050, 50A/1V split core transformer / current sensor	3
TVS – P6KE16CA bidirectional transient voltage suppressor	1

R7*-R10* resistors values depends of relays and transistors used. R15*-...* resistors must NOT be used if STC-013 050 50A/1V split core transformer is used in this project, as it already got integrated resistor.

Three-phase tethered EVSE, with current monitoring:

Component name	Qty.
U1 – MEAN WELL PT-45B power supply board	1
U2 – Pro Mini ATmega328P 16MHz 5V microcontroller board	1
U4 – 20x4 LCD module with PCF8574 I2C module	1
U5 – LF353 operational amplifier	1
X1, X2, X4 – XY306 2P PCB terminal blocks	4
X3 – XY306 3P PCB terminal block	1
X5 – 1x4 RM2,54 PCB header pins strip	1
X6-X14 – PCB-20632F screw terminals	9
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R2 – 200kOhm 1% resistor	1
R3, R13, R14 – 100kOhm 1% resistors	3
R4 – 56kOhm 1% resistor	1
R5, R6 – 10kOhm 1% resistors	2
R7*-R10* - 1kOhm resistors	4
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Three-phase non-tethered EVSE, without current monitoring:

Component name	Qty.
U1 – MEAN WELL PT-45B power supply board	1
U2 – Pro Mini ATmega328P 16MHz 5V microcontroller board	1
U4 – 16x2 LCD module with PCF8574 I2C module	1
U5 – LF353 operational amplifier	1
X1, X2 – XY306 2P PCB terminal blocks	3
X3 – XY306 3P PCB terminal block	1
X5 – 1x4 RM2,54 PCB header pins strip	1
X6-X14 – PCB-20632F screw terminals	9
K1-K4 – HAT901CS30DC12 relays	4
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T1-T4 – BC337-16 transistors	4
C1, C2 – 100nF 50V ceramic capacitors	2
C3 – 1uF 30V tantalum capacitor	1
R1 – 680Ohm 1% resistors	1
R7*-R10*, R11 – 1kOhm 1% resistors	5
R2 – 200kOhm 1% resistor	1
R3 – 100kOhm 1% resistor	1
R4 – 56kOhm 1% resistor	1
R5, R6, R12 – 10kOhm 1% resistors	3
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C1, C2 – 100nF 50V ceramic capacitors	2
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R1 – 680Ohm 1% resistors	1
R2 – 200kOhm 1% resistor	1
R3 – 100kOhm 1% resistor	1
R4 – 56kOhm 1% resistor	1
R5, R6 – 10kOhm 1% resistors	2
R7*-R10* - 1kOhm resistors	4
PCB – Custom made PCB by EV-OLUTION.NET	1
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Single-phase non-tethered EVSE, with current monitoring:

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U5 – LF353 operational amplifier	1
X1, X2, X4 – XY306 2P PCB terminal blocks	4
X3 – XY306 3P PCB terminal block	1
X5 – 1x4 RM2,54 PCB header pins strip	1
X6-X10 – PCB-20632F screw terminals	5
K1, K2 – HAT901CS30DC12 relays	2
D1, D2, D5 – 1N4148 diodes	3
T1, T2 – BC337-16 transistors	2
C1, C2 – 100nF 50V ceramic capacitors	2
C3 – 1uF 30V tantalum capacitor	1
C4 – 10uF 25V tantalum capacitor	1
R1 – 680Ohm 1% resistors	1
R7*, R8*, R11 – 1kOhm 1% resistors	3
R2 – 200kOhm 1% resistor	1
R3, R13, R14 – 100kOhm 1% resistors	3
R4 – 56kOhm 1% resistor	1
R5, R6, R12 – 10kOhm 1% resistors	3
R15* – 33Ohm resistor	1
PCB – Custom made PCB by EV-OLUTION.NET	1
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R7*-R8* resistors values depends of relays and transistors used. R15* resistor must NOT be used if STC-013 050 50A/1V split core transformer is used in this project, as it already got integrated resistor.

Single-phase tethered EVSE, with current monitoring:

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T1, T2 – BC337-16 transistors	2
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R2 – 200kOhm 1% resistor	1
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R4 – 56kOhm 1% resistor	1
R5, R6 – 10kOhm 1% resistors	2
R7*, R8* – 1kOhm resistors	2
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R3 – 100kOhm 1% resistor	1
R4 – 56kOhm 1% resistor	1
R5, R6 – 10kOhm 1% resistors	2
R7*, R8* – 1kOhm resistors	2
PCB – Custom made PCB by EV-OLUTION.NET	1
TVS – P6KE16CA bidirectional transient voltage suppressor	1

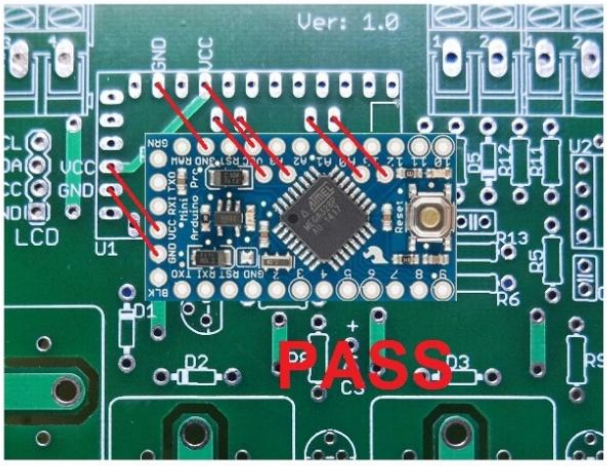
R7*-R8* resistors values depends of relays and transistors used.

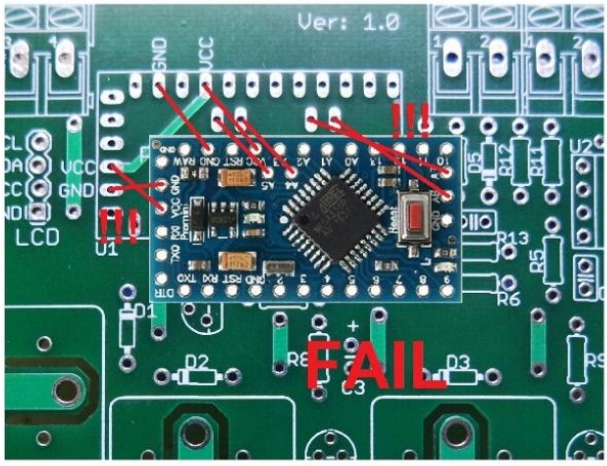
3. Assembly guide

3.1. Choosing right components

Before starting this project, double check, that you have correct components.

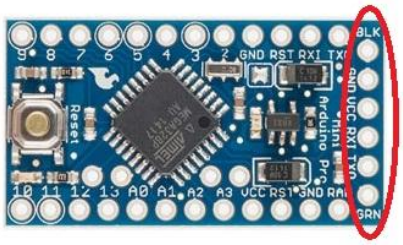
Pro Mini Board must be 5V 16MHz. If you use Arduino clone boards, please make sure pinout is exactly same as original design. Please see the image bellow to compare the different designs:





Also remember that quality of Pro Mini board and genuity of ATMEL chip will affect the stability of finished project. Poor quality or cheap clone microprocessors can freeze/reset and affect the safety of the finished product.

It is strongly advised to leave Pro Mini front pins not connected to a main board, so you can use them later for firmware update if needed.



X6 – X14 screw terminals

If PCB-20632F cannot be sourced, there are few other compatible options like: KEYS8197, KEYS7800, Uxcell PCB-26. If you building charging point with maximum current of 16A, then 4 pin terminals can be used, like: KEYS7769, KEYS7693, KEYS7797, Uxcell PCB-11.

Relays

Mistake was done while designing V1.0 PCB, so **ONLY these relays MUST be used**. These are 4 pin relays and they will not be affected by mistake in PCB design:

40A Relays:

R40N-3021-85-1012 made by **RELPOL**

HAT901ASDC12-1 made by **HASCO RELAYS**

NT90RNAS12CB (sealed)**, NT90RNAE12CB** (covered)

NT90RHAS12CB, NT90RHAE12CB (40A only approved by TUV and UL! CQC approved only 30A)

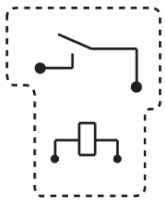
TR90-12VDC-SC-A4

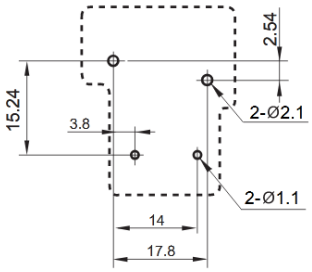
AZ2150-1A-12DE made by **ZETTLER** (6000 cycles at 40A resistive load)

AZ2150-1A-12DEF made by **ZETTLER** (6000 cycles at 40A resistive load)

2027395-5 / T9VV1K15-12S made by **TE Connectivity (TE)'s Potter & Brumfield** (this relay will require PCB drilling, as main pins are bigger than PCB trough holes)

DO NOT USE relays with 5 pins! Relays must have only 4 pins like shown in this picture below:





30A Relays:

R30N-3021-85-1012 made by **RELPOL**

HF105F-1/012DT-1HSTF made by **HONGFA RELAY**

L90AS-12W made by **RAYEX ELECTRONICS**

1-1393210-3 / **T9AS1D12-12** made by **TE Connectivity (TE)'s Potter & Brumfield**

T90S1D42-12 made by **TE Connectivity (TE)'s Potter & Brumfield**

T90N1D42-12 made by **TE Connectivity (TE)'s …** (open frame)

AZ2150-1A-12DE made by **ZETTLER**

AZ2150-1A-12DEF made by **ZETTLER**

AZ2150W-1AE-12DEF made by **ZETTLER**

AZ2150W-1AE-12DEFT made by **ZETTLER**

SLA-S-112DM made by **SANYOU**

SLA-S-112DM-F made by **SANYOU** (lead Free)

SHA-T90 SHA-12VDC-S-A made by **SHA** (be aware that 4 and 5 pin relays are sold with same code!)

CMP7-S-DC12V-AR made by **HKE**

Please note, that anything above 20A will need passive or active cooling (depending on your setup) for such small relays. But we strongly advise you not to use relays for anything above 20A. Instead please use correctly rated contactor.

Power Supply

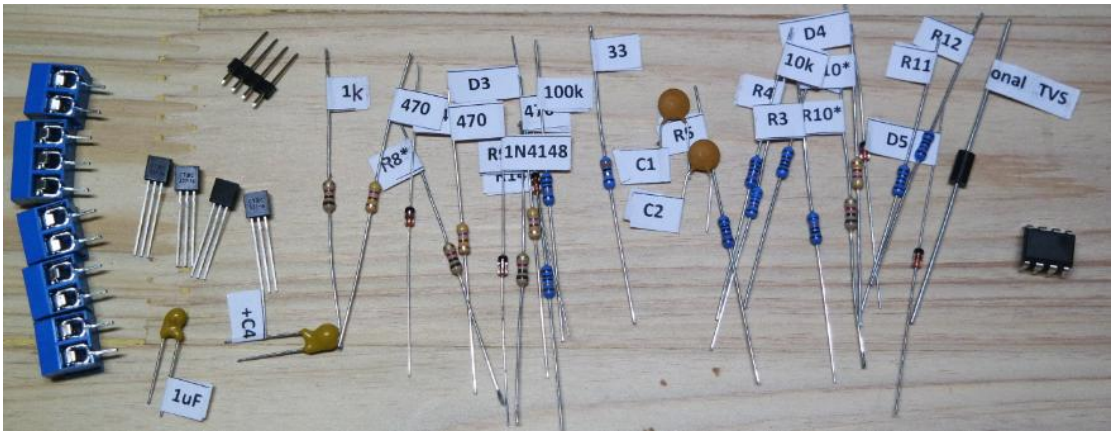
Finished EVSE board requires 12VDC, -12VDC and 5VDC power supply. So external power supply is needed. We've done it so, just to keep DIY EVSE PCB as simple as possible. Also it would be hard to implement all necessary protections to DIY power supply for a price lower than already existing products. We strongly recommend you to use MAEN WELL PT-45B power supply. As it comes with integrated short circuit, overload, over voltage protection, 2 year warranty and wide input voltage 90 – 264 VAC. We've been running PT-45B for a year now on our experimental setup, and we've never experienced any troubles.

If suggested power supply is hard to source, as alternative you can use any PC ATX power supply unit (PSU) or anything else that provide stable voltages mentioned earlier.

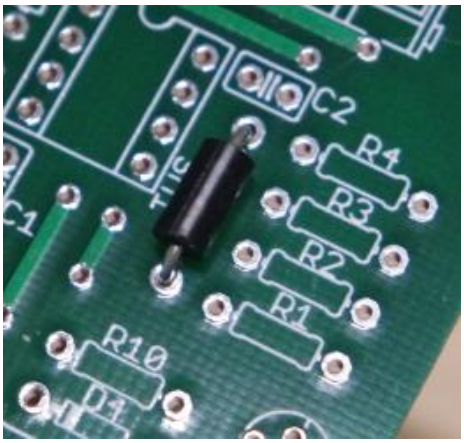
Please note, that power supply is also very critical for microprocessor work. Not stable, "noisy" or not protected power supply can make microprocessor unstable, which is very dangerous in such applications.

3.2 Soldering components

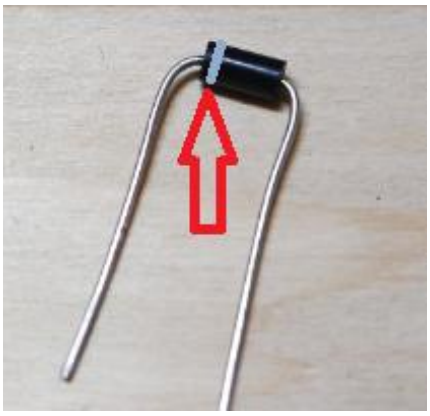
Most components, if bought, will come labeled, so it makes it easier to identify correct places on PCB.

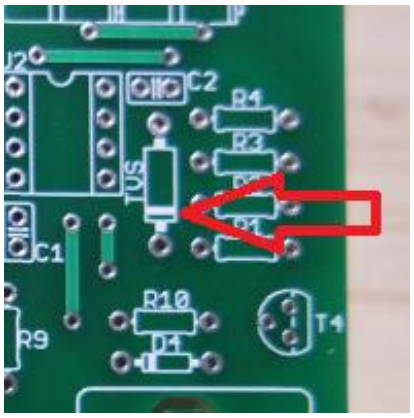


Solder TVS. Most likely you will get bidirectional TVS, which is perfectly fine for this project. It can be fitted either way ignoring a marking on PCB.

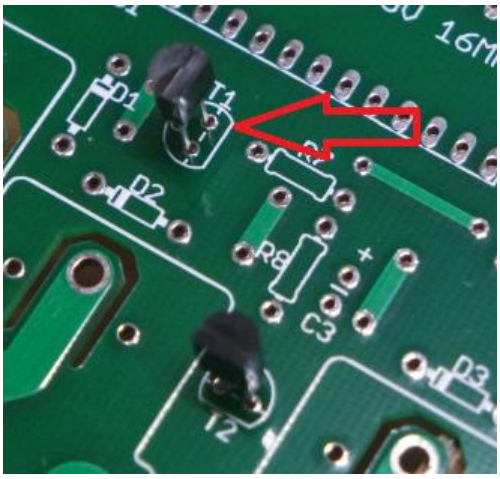


If you got unidirectional TVS, then please follow the markings on a PCB.

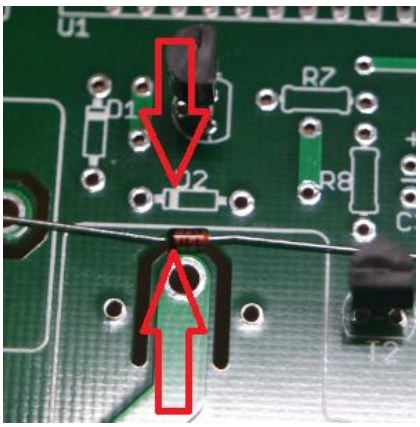


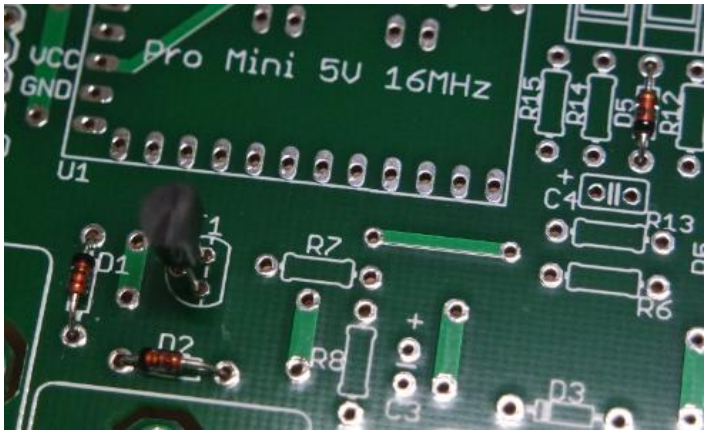


Solder transistors T1 and T2 (and T3, T4 for three-phase EVSE). Then fitting transistors please follow orientation marks on PCB.



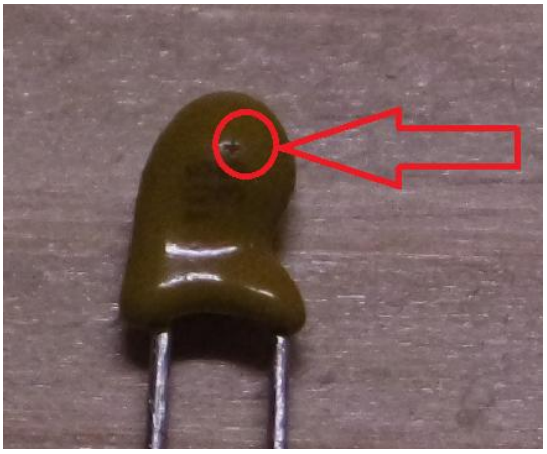
Solder diodes D1, D2, D5 (and D3, D4 for three-phase EVSE). Diode correct orientation also must be observed, please follow markings on PCB.

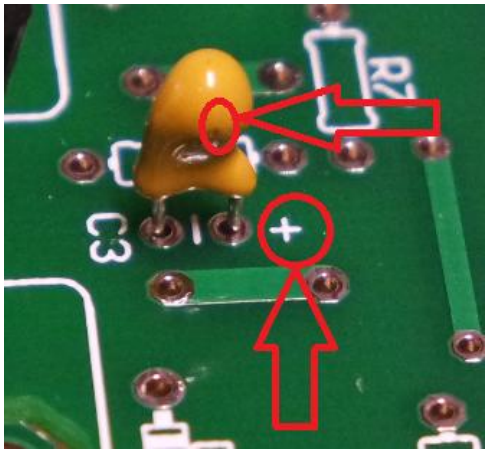




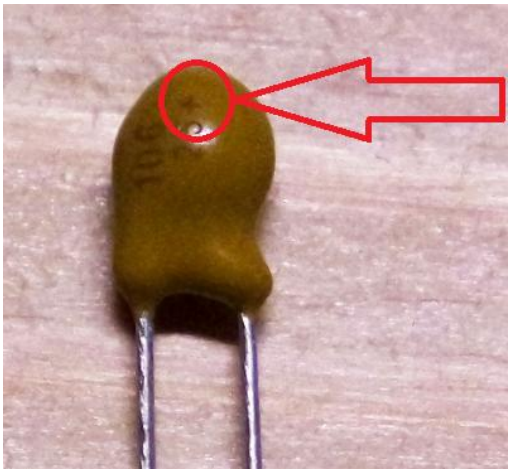
Solder ceramic capacitors C1 and C2. Orientation is not important on those.

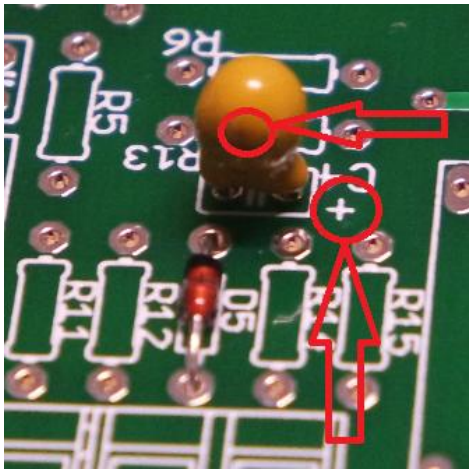
Solder tantalum capacitor C3. Please note that its orientation is critical and damage will occur if soldered incorrectly. Look for "+" sign on PCB and capacitor. If label attached, it will also show "+" on correct pin.



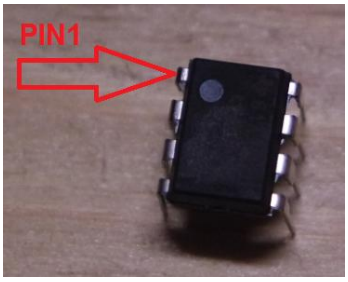


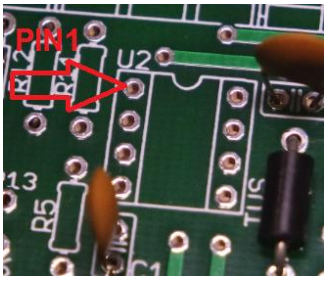
If you are using current sensor on your EVSE, then solder tantalum capacitor C4. Again keep attention on correct orientation.

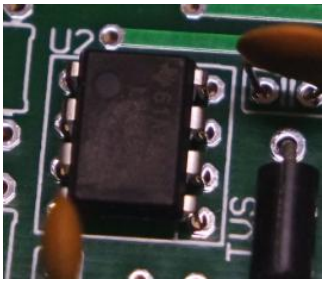




Solder LF353. Keep attention to correct component orientation.





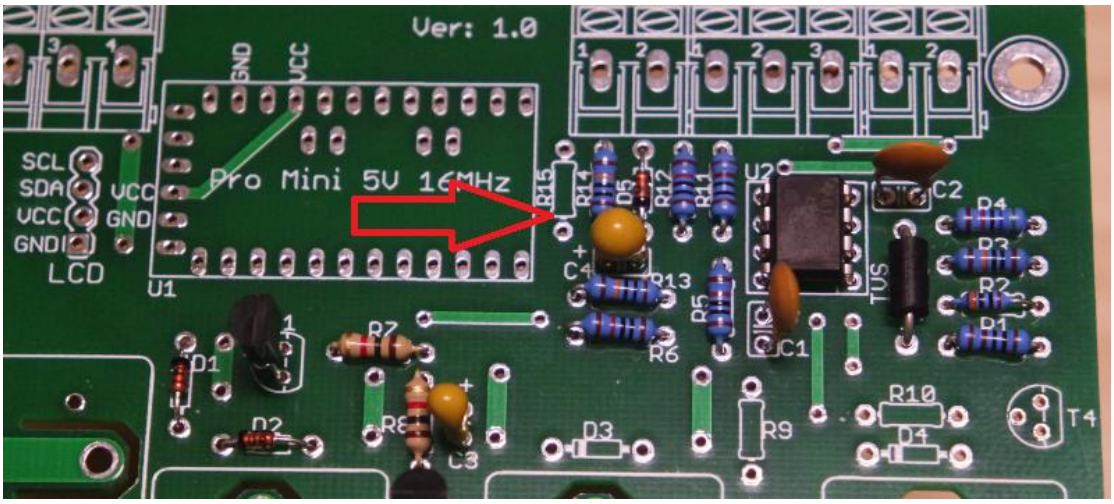


Solder all needed resistors to PCB. Please note that R15 must be left not soldered if used with STC-013 050, 50A/1V split core transformer.

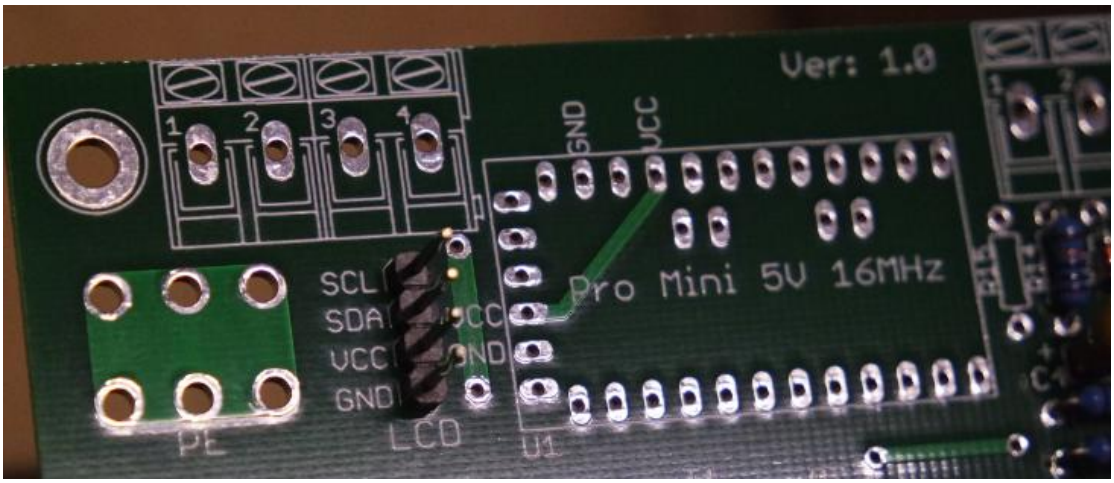
Also R7-R10 must be chosen accordingly to your used transistors and relays.

Copy this link to your browser to find out how to calculate which resistors should be used: https://www.petervis.com/GCSE_Design_and_Technology_Electronic_Products/transistor_base_resistor_calculator/transistor_base_resistor_calculator.html

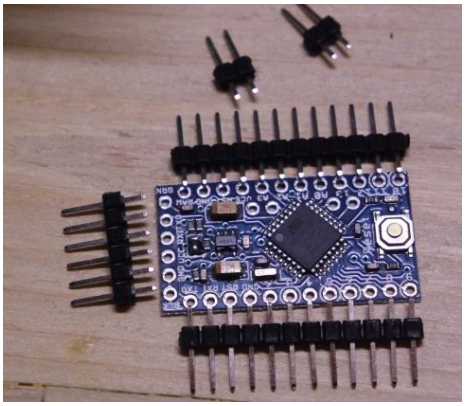
For example 6kOhm resistors are enough to activate relays, if used with BC337-16 transistors and T9AS1D12-12 relays (coil resistance 144Ohm). But in general practice 1kOhm resistors can be used without any problem. In theory 1kOhm resistor with BC337-16 transistor should be able to drive relays with coil resistance as low as 40 Ohm. But in practice this limit is bit higher. In general you should not need anything else than 1kOhm resistors as R7-R10 and BC337-16 transistors as K1-K4 to drive standard 12V relays.



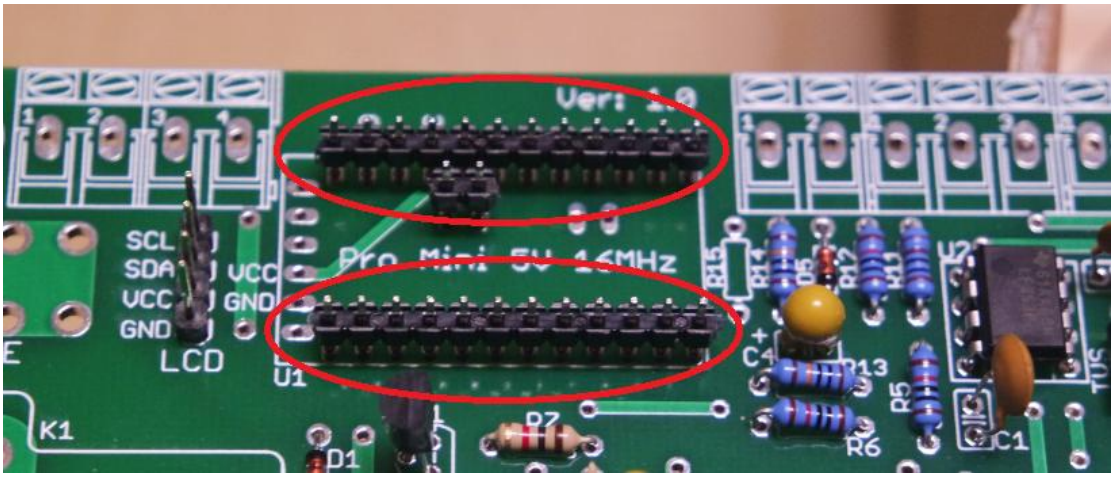
Solder pins for LCD connector X5.



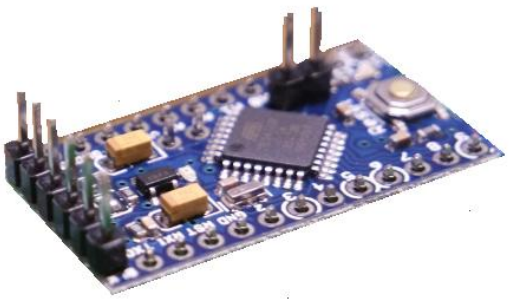
Prepare your Pro Mini board.



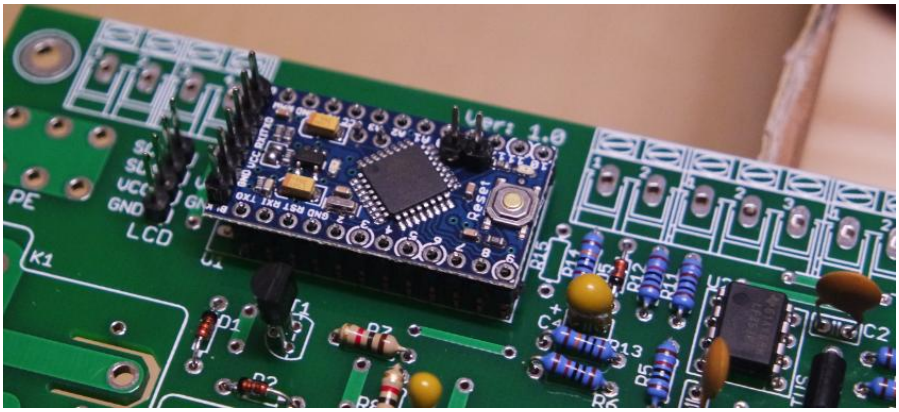
Please only solder these pins to PCB as shown in picture below.



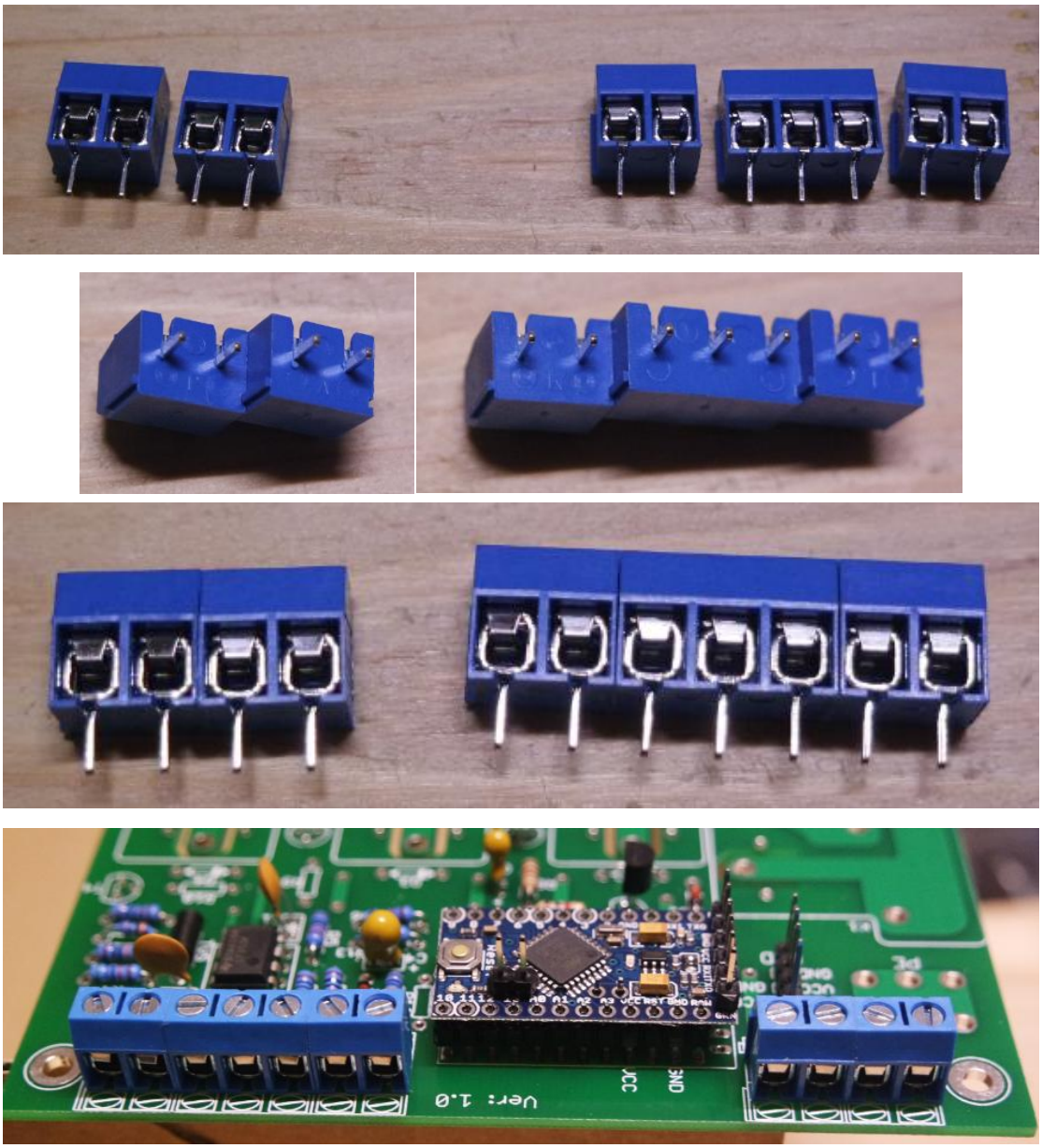
Solder the rest of pins to Pro Mini board facing upwards. These will be used for firmware updates and later developing. A6 and A7 will be connected directly to STC-013 current sensors on three-phase EVSE version.



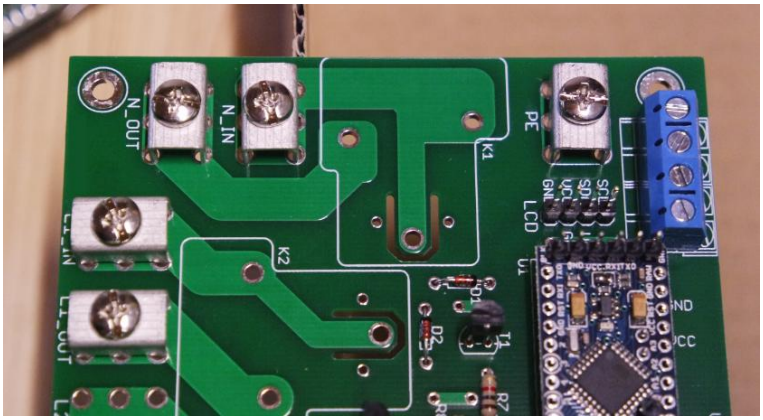
Solder Pro Mini board to PCB.



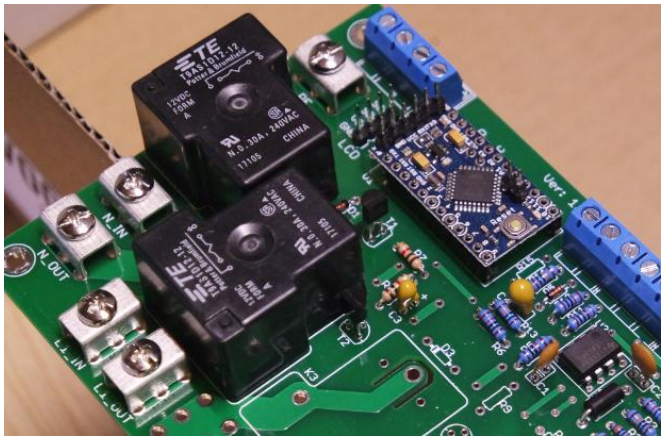
Prepare and solder X1-X4 connectors.



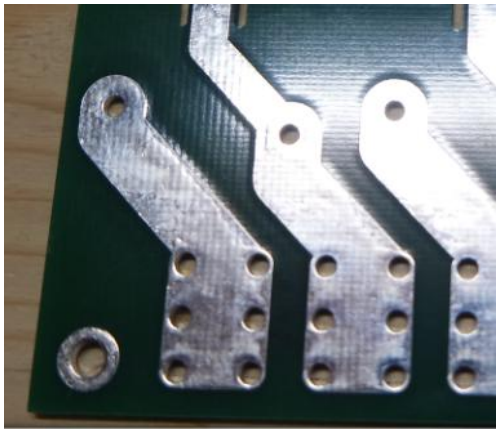
Solder screw terminals X6-X10 (X6-X14 for three-phase EVSE). Use high power soldering tool to make sure solder is done properly!



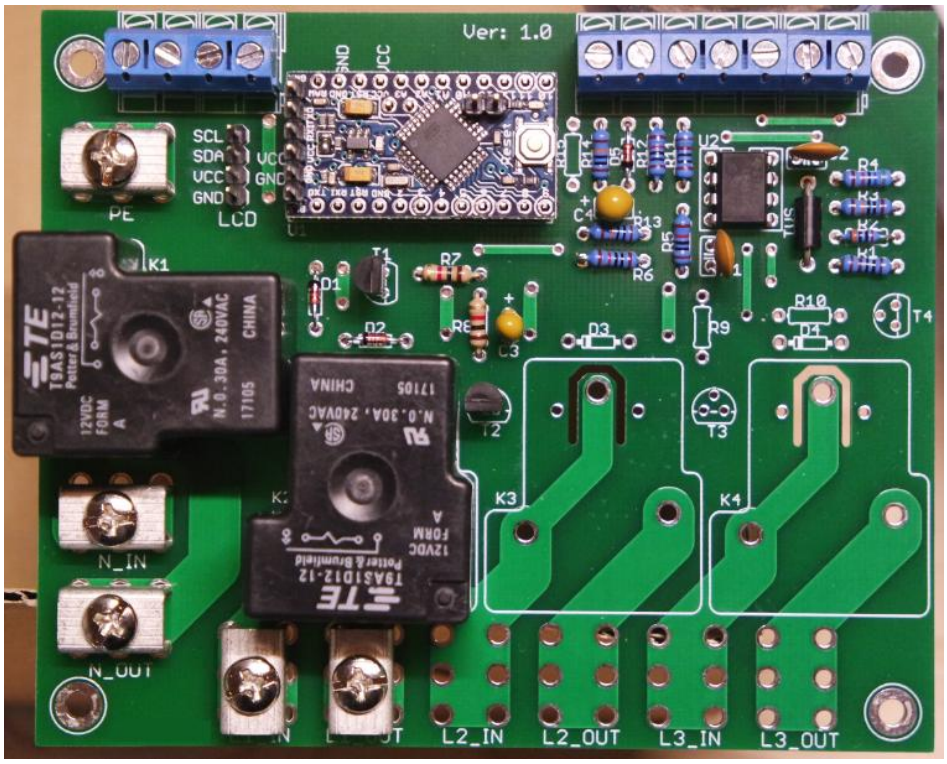
Solder relays to PCB. Please remember only 4 pin relays must be used with this PCB. Do not use 5 pin relays without modifying PCB!



Please apply some solder on the bottom side of PCB on mains traces. This must be done to increase conduit size to make sure board will be able to withstand high currents.

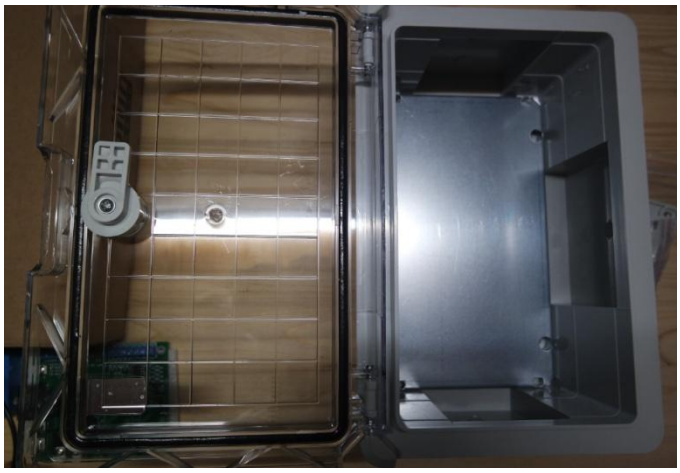


After soldering all components to PCB, it should look like in the picture below.
Please note this picture shows single-phase non-tethered with current monitoring version of EVSE.



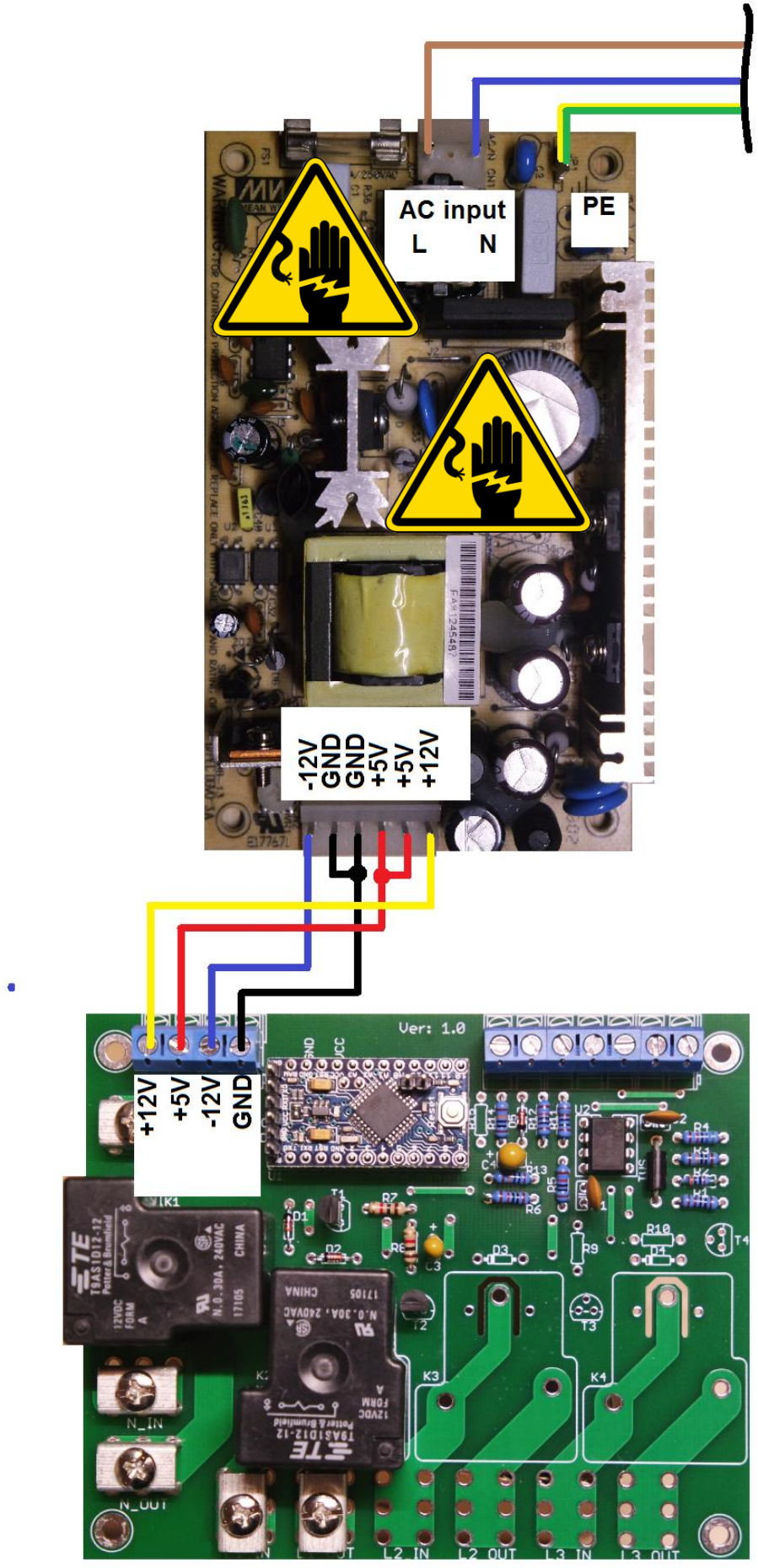
3.3 Enclosure

After you finished soldering, you must find proper enclosure and install all components to be protected from environment. We suggest you to use Arli make 200x300x130mm enclosure. It comes with a metal plate for easy component fitting inside.



3.4 Connecting wires

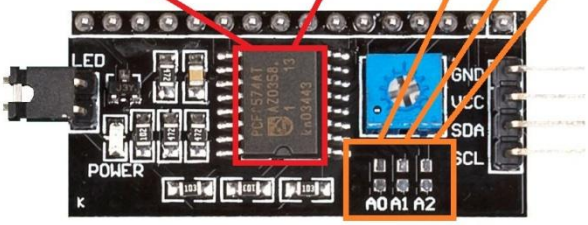
After you've done that, connect your power supply unit to your main board.



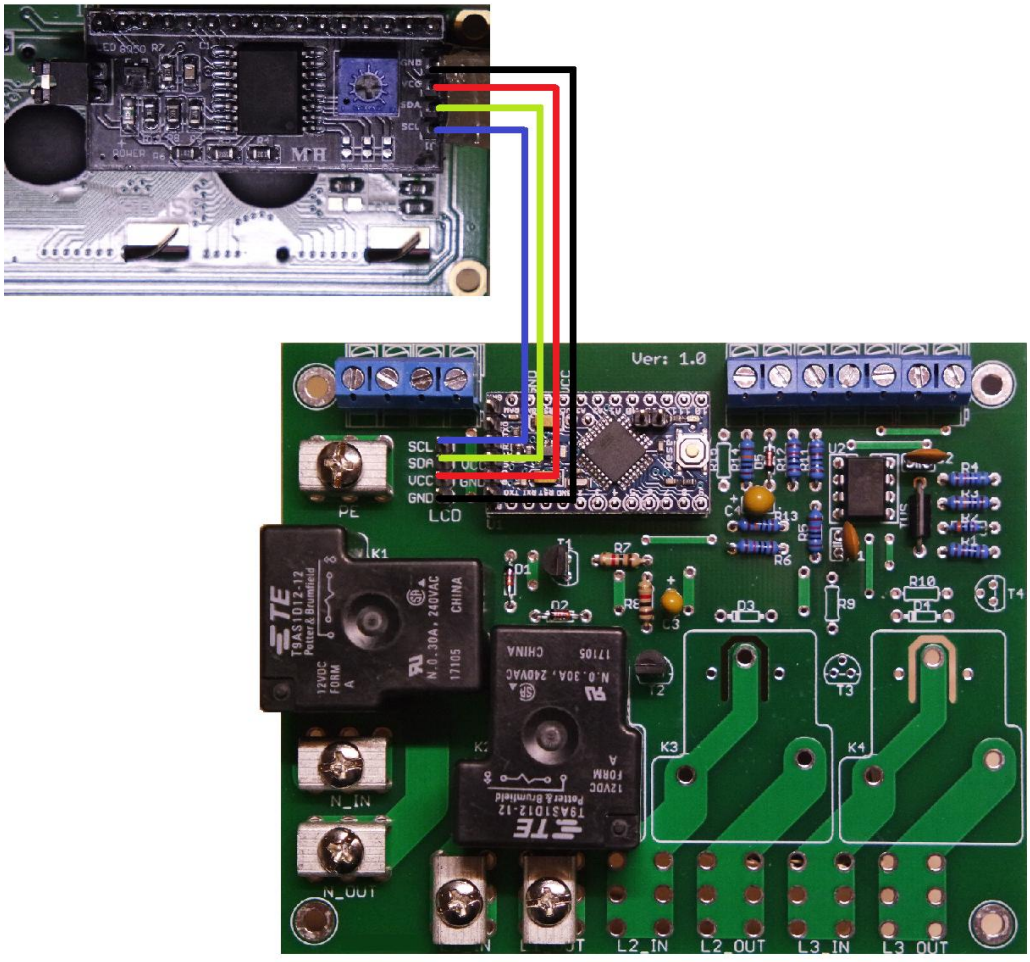
Connect I2C LCD screen to your main board. Please note that LCD address should be 0x27. If your I2C has PCF8574**A** IC, then please contact us for custom firmware as it has different address.

PCF8574 and PCF8574A I²C-Bus Slave Address Map

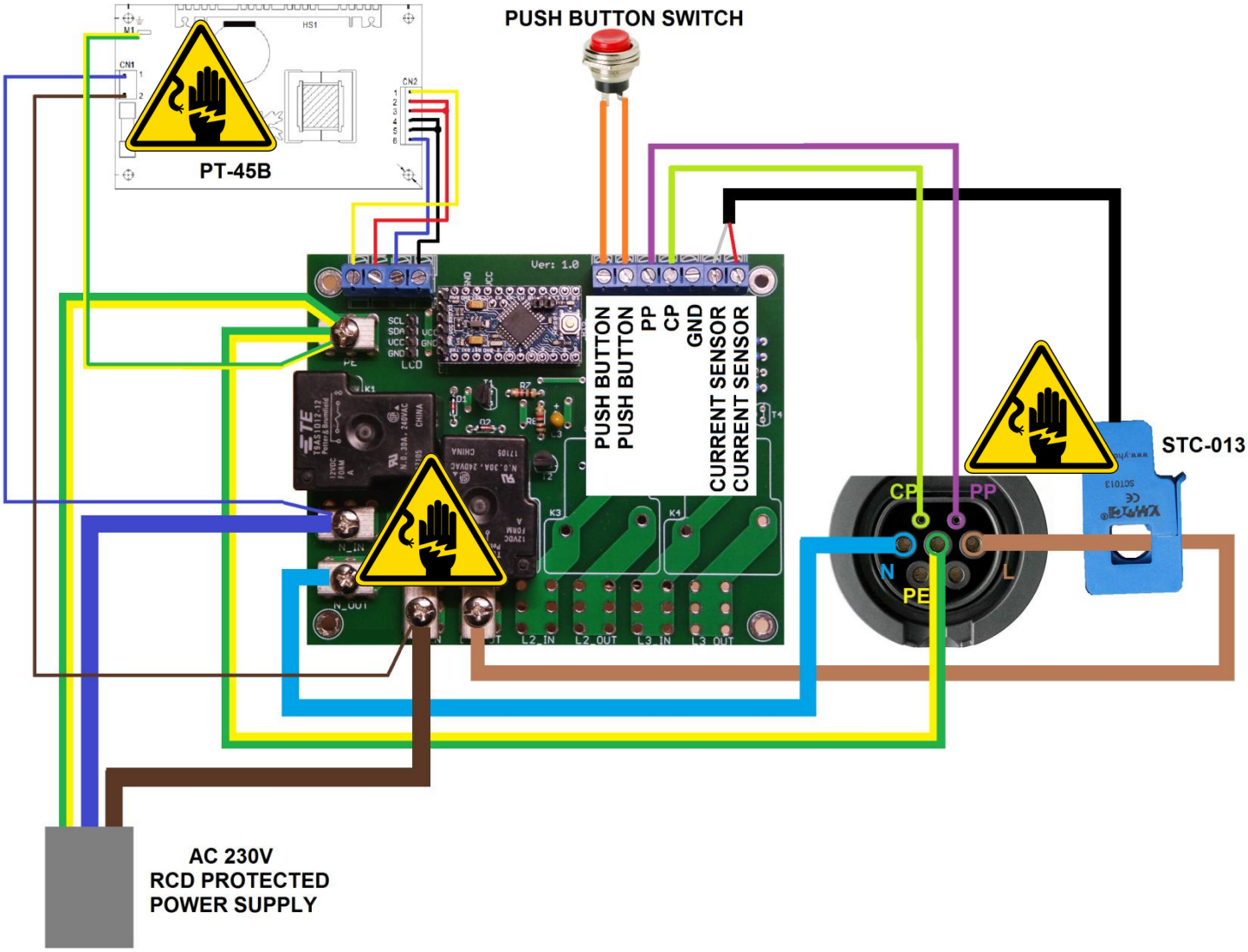
PCF8574 I²C-Bus Slave Address	PCF8574A I²C-Bus Slave Address	INPUTS A0	A1	A2
20 (hexadecimal)	38 (hexadecimal)	L	L	L
21 (hexadecimal)	39 (hexadecimal)	H	L	L
22 (hexadecimal)	3A (hexadecimal)	L	H	L
23 (hexadecimal)	3B (hexadecimal)	H	H	L
24 (hexadecimal)	3C (hexadecimal)	L	L	H
25 (hexadecimal)	3D (hexadecimal)	H	L	H
26 (hexadecimal)	3E (hexadecimal)	L	H	H
27 (hexadecimal)	3F (hexadecimal)	H	H	H



H = not bridged
L = bridged



Connect mains, EV plug/socket, push button switch and current sensor (if used) to main board and power supply unit.

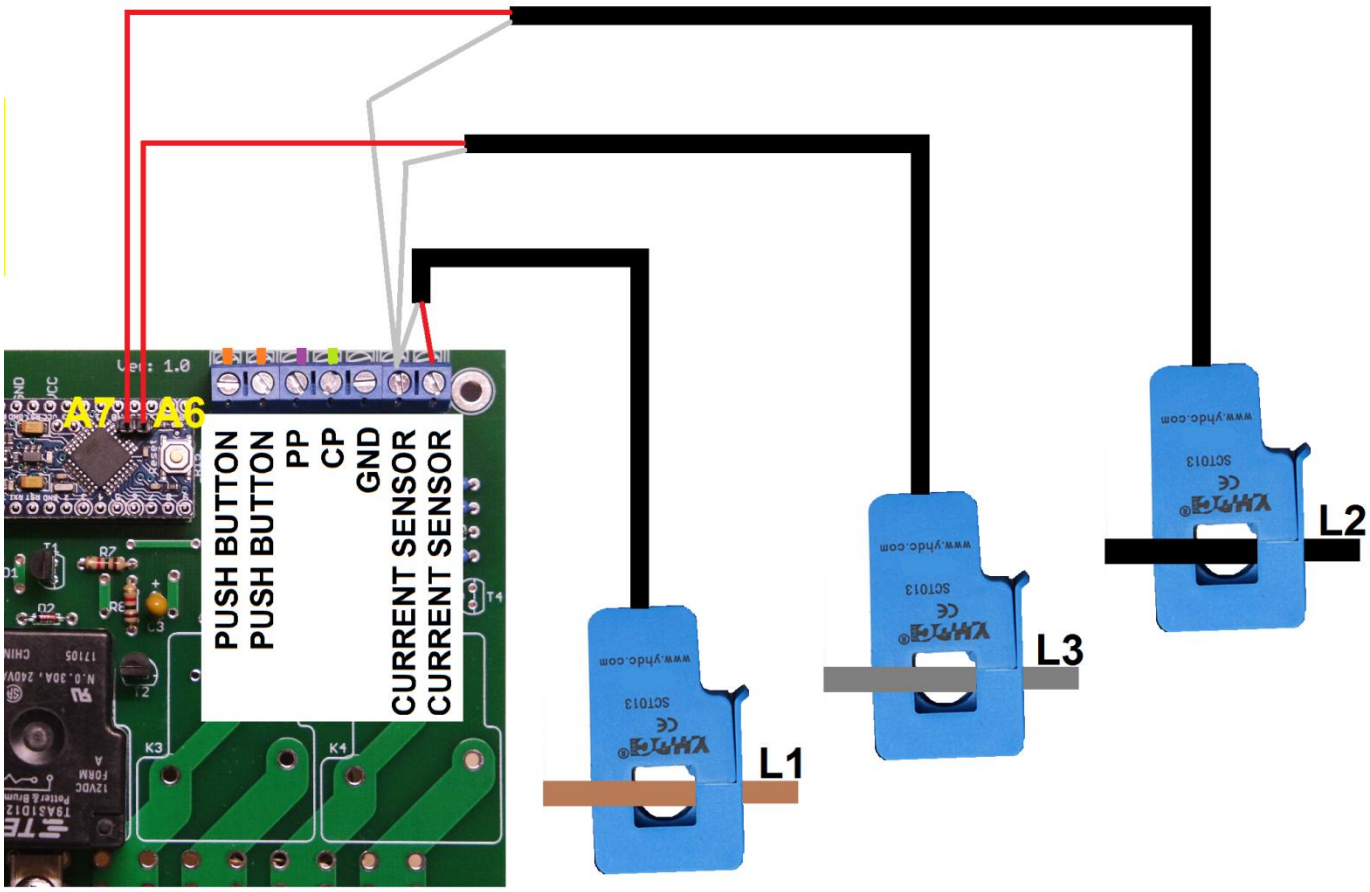


Please note, that diagram above shows single-phase configuration of non-tethered EVSE (**with Type 2 socket**) with current measurement option. Note that charging socket is shown from the front side. For tethered EVSE (**with its own cable and Type 2 plug**) please leave PP (proximity pilot) terminal disconnected from EVSE controller board. Make sure **Type 2 plug** (**NOT SOCKET!!!**) has in-built resistor between PP and PE terminals. It should be 200Ohm for 32A or 680Ohm for 20A rated plug and cable.
Also leave current sensor contacts disconnected, if you've built EVSE without current measurement option.

This is pinout, if you use Type 1 charging plug.

Please note that Type 1 EV plugs have internal resistors connected between PE, S pins and switch on locking pin. Please do research yourself about these resistors, if you're using Type 1 plug.

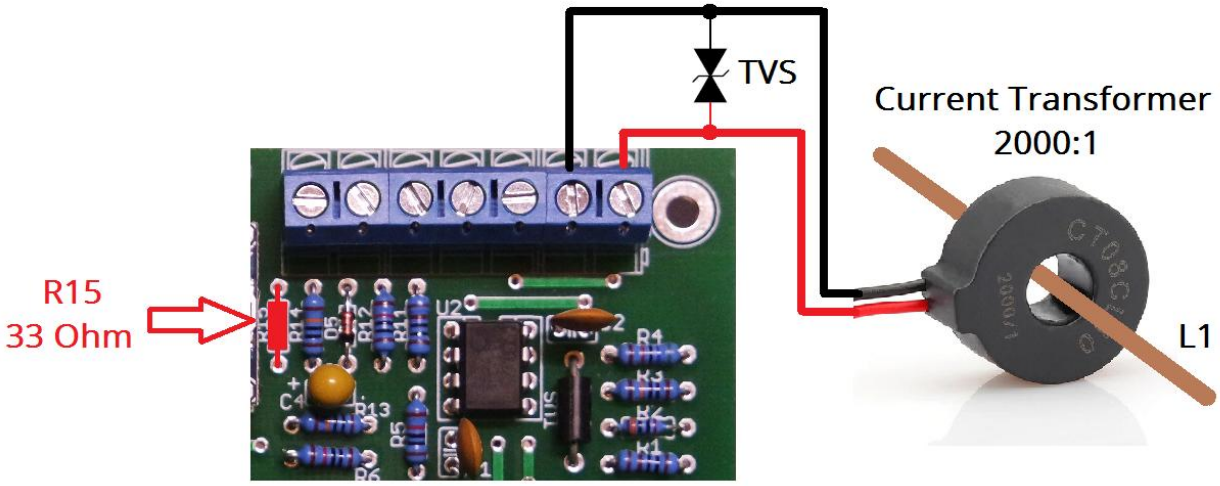
For three-phase version with current measuring option, please connect current sensors as shown in the picture below.



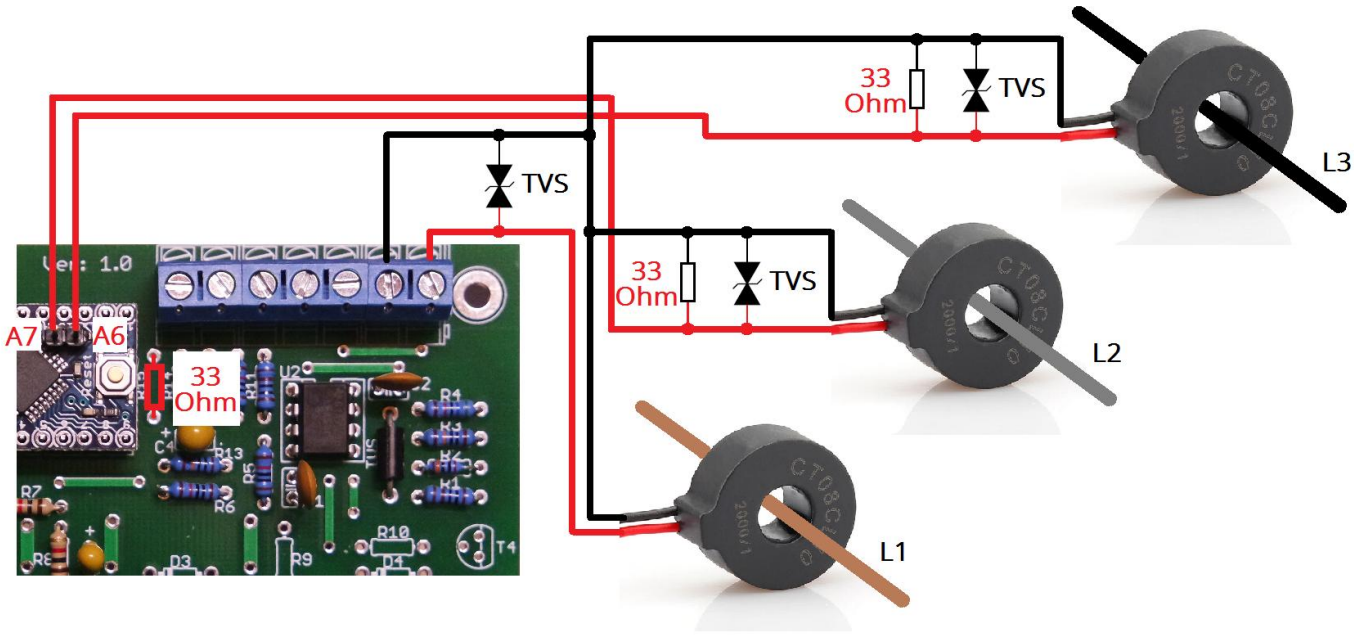
3.5 Using non SCT103 current transformer (current sensor)

You can use any current transformer with ratio 2000:1 instead of SCT103-050. In such case you must use burden resistor of 33Ohms connected in parallel to current transformer. If you're building single-phase EVSE controller, then you can solder burden resistor to PCB place marked R15. If you're building three-phase version, then phase two and phase three current transformer burden resistors must be connected directly to current transformer wires as there is no dedicated place on PCB for them. It is also recommended to use 2.5V TVS diode or Zener diodes connected parallel to current transformer outputs to protect microcontroller inputs from voltage spikes.

Single phase version



Three phase version

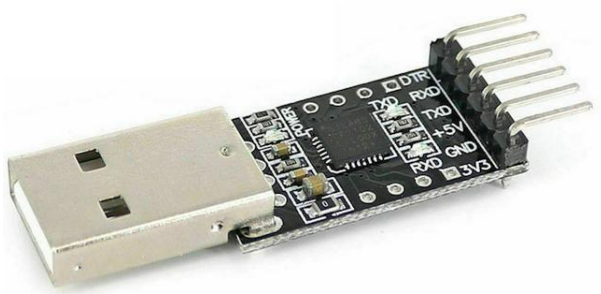


You might need to change current sensor calibration settings in EVSE settings menu, as SCT013-050 current transformer has inbuilt resistor of 29Ohm and EVSE code was written for SCT013-050 sensors. But this is not an issue as you can calibrate sensor readings by changing calibration settings. Please follow this link to see how to do this: https://youtu.be/XMWdDWNPO7o .

4. Uploading firmware to Pro Mini

After you've finished **assembling** EVSE, it's time to upload firmware to Pro Mini board. Please use firmware provided only by us. Always check our website for latest firmware updates: https://ev-olution.yolasite.com/evse-firmware.php

To upload a firmware you will need USB to TTL converter. We strongly recommend using CP2102 based adapters, as these gave least troubles for us.



Please connect it with your Pro Mini as shown bellow. Please note that pins might be different on different converters and different Pro Mini boards, so always check pin markings.

You must connect:

USB to TTL converter-	DTR > GRN RXT > TXD TXD > RXD +5V > VCC GND > GND	-Pro Mini 16MHz board

Download program called Xloader. You can find the link on our website. Open HEX file provided by us in Xloader. If you bought Pro Mini not from us and you haven't updated it with Uno bootloader, then choose Nano(ATmega 328) in Xloader board settings window. If you bought Pro Mini board from us, then you need to choose Uno in Xloader board settings window, as all our sold Pro Mini boards come with updated Uno bootloader. Then choose correct COM port for your adapter, connect your Pro Mini to adapter and press Upload. If you are using PL2303 (Not recommended!) based adapter please hold reset button on Pro Mini, and release it straight after you pressed Upload in Xloader.

5. Powering EVSE for a first time

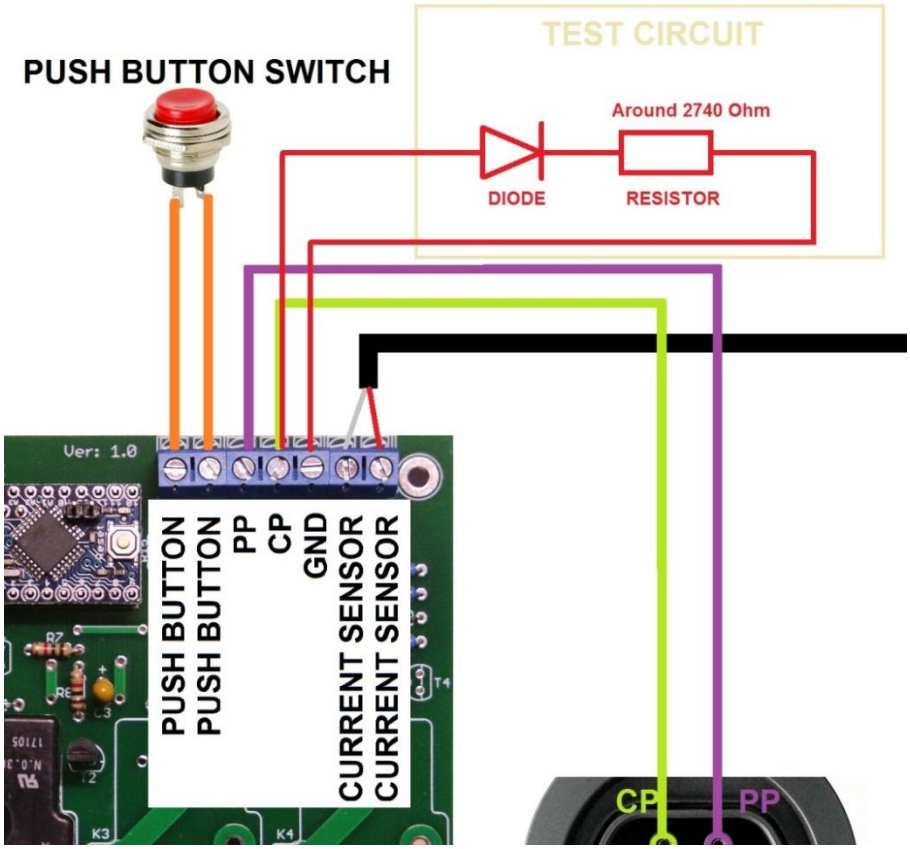
After powering Pro Mini for the first time, you should see our website name on the LCD screen and set current value (6A).

6. Testing your EVSE for a first time

DO NOT CONNECT YOUR EVSE TO VEHICLE before you've done initial test of EVSE using diode and couple resistors.

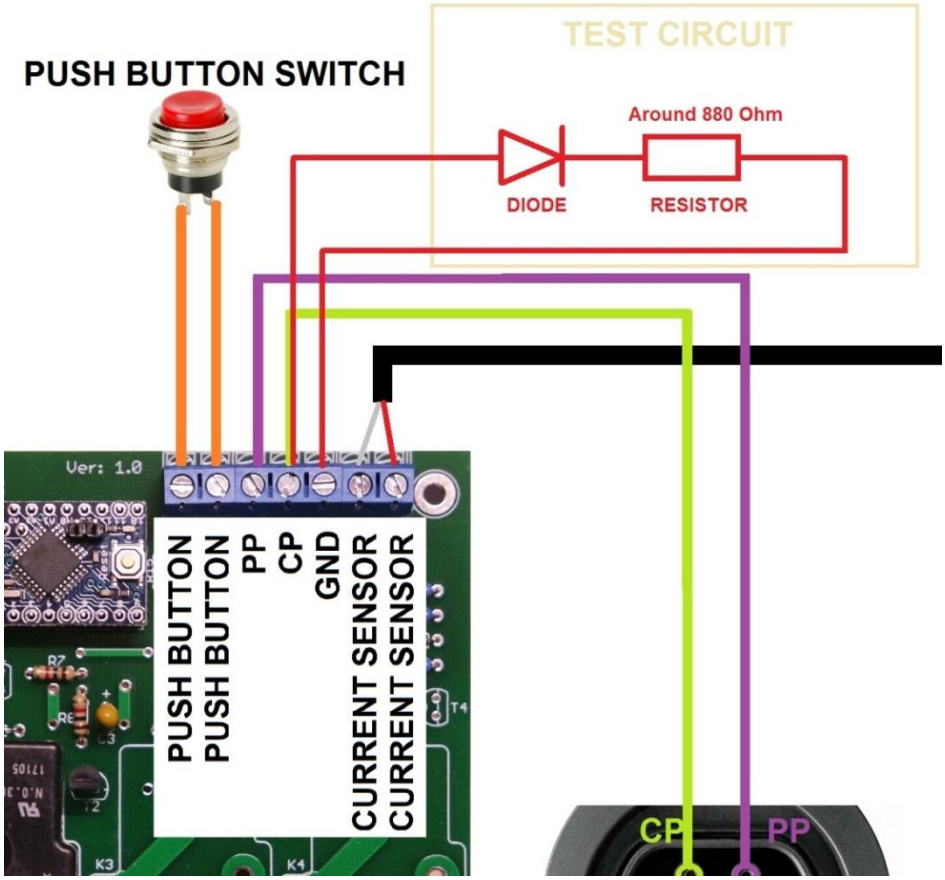
WHILE PERFORMING THIS TEST ALWAYS SWITCH THE GRID MAINS POWER OFF BEFORE GETTING NEAR EVSE INTERNAL COMPONNETS!

Install diode and resistor as shown in this picture.



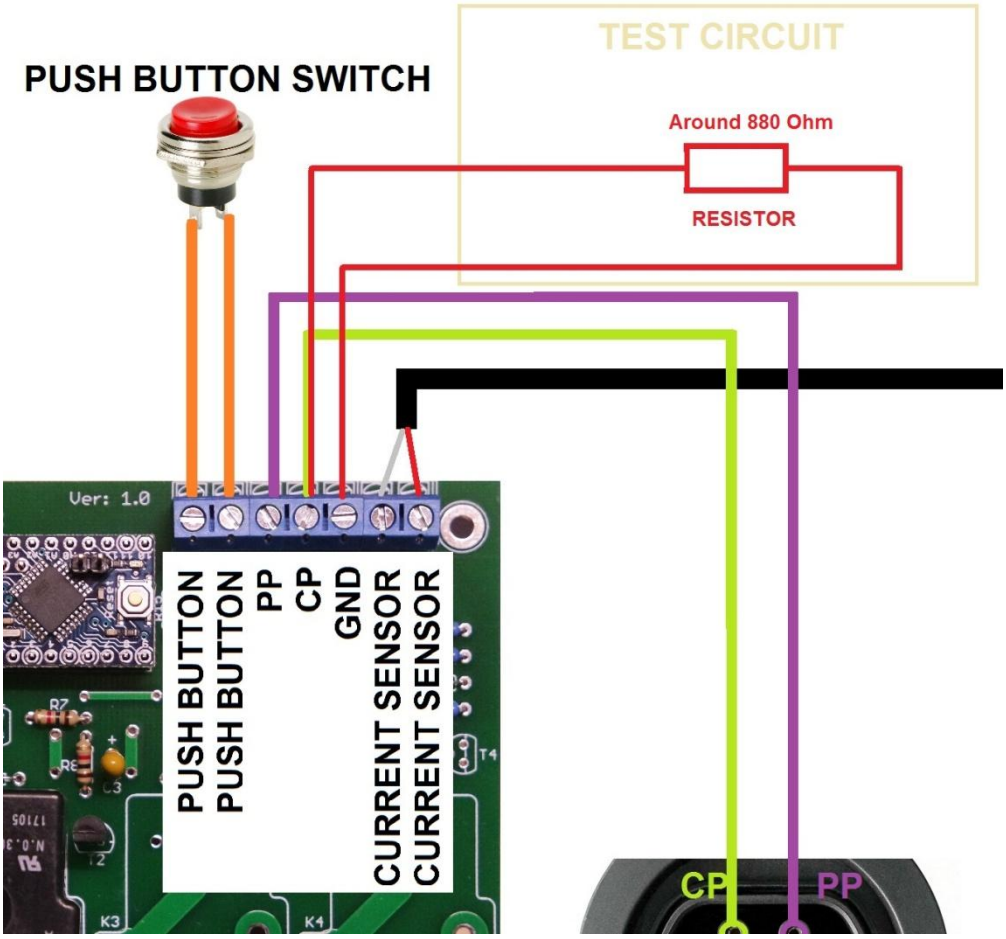
After you've done this, close enclosure and do not touch any components or wires of your EVSE. Switch mains power on. You should see "CONNECTED" on your EVSE LCD screen.

If test was successful, switch mains power off and do the next test.



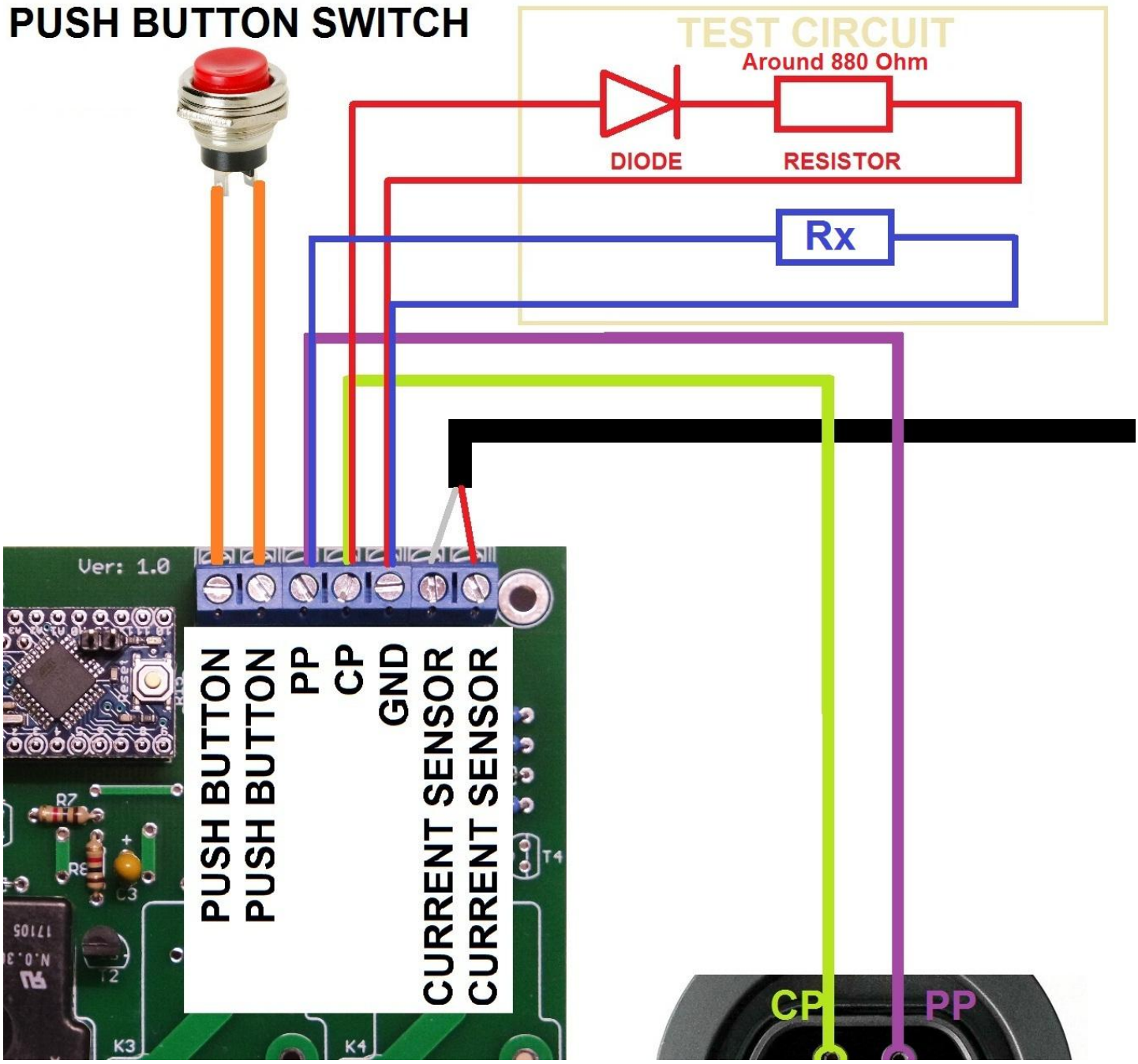
After you've connected test circuit, switch the mains power on again without touching any wires or components of your EVSE. This time you should hear relays clicking and LCD display showing "CHARGING" or battery symbol.

If test was successful, switch mains power off and do the next test.



After you've connected test circuit, switch the mains power on again without touching any wires or components of your EVSE. This time you should see "EVSE CHK FAILED" on your EVSE LCD screen.

If you've built non-tethered EVSE then you need to do the proximity pilot tests as well. Disconnect mains power for your EVSE. Connect two test circuits as shown in next picture.



This test must be repeated 4 times, one time without resistor Rx, and then three times while changing resistor Rx. You should get following results while doing this test:

1. Without resistor Rx, LCD should display charging state and you should be able to see plug symbol with number 6.
2. With resistor Rx of 1500 Ohm, LCD should display charging state and you should be able to see plug symbol with number 13.
3. With resistor Rx of 680 Ohm, LCD should display charging state and you should be able to see plug symbol with number 20.
4. With resistor Rx of 220 Ohm, LCD should display charging state and you should be able to see plug symbol with number 32.

After you've done proximity pilot test, please switch mains power off and remove all components used to do testing. Switch the mains power back on, if it is safe to do so.

Last test would be to check, if plug or socket is wired correctly. Double check if all wires are connected correctly. You must measure the voltage between L and N terminals on the plug/socket. There should be no voltage present while not connected to vehicle.

If all tests passed, congratulations, you've finished the project successfully. If any tests failed, please go over this manual again and check, if all components connected and soldered correctly, check if all wires connected correctly. If you can't trace the problem, please contact us for troubleshooting.

PLEASE NOTE THAT THESE TESTS ARE JUST THE BASIC TESTS TO SEE IF EVSE IF FUNCTIONING CORRECTLY. THESE ARE NOT THE SAFETY TESTS. EQUIPMENT SAFETY TESTS MUST BE DONE BY COMPETENT PERSON.
ALSO PERMANENT CONNECTION TO YOUR MAINS POWER SUPPLY MUST BE DONE/INSPECTED BY CERTIFIED ELECTRICIAN.