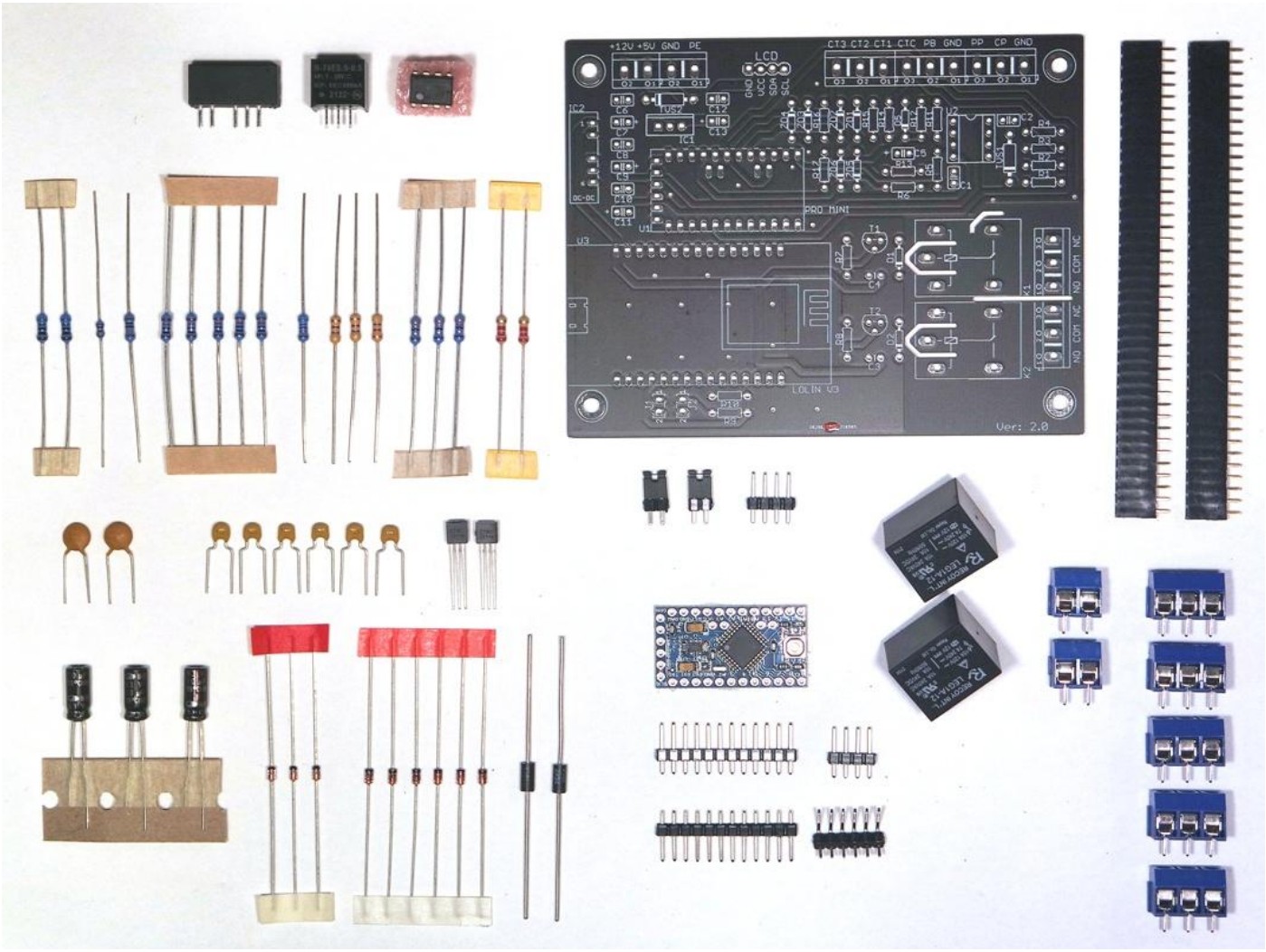
DIY EVSE v2.0
Assembly Instruction Manual



V2.0c

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 this project on, 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.

CONTENTS

1. Safety instructions:

1.1 Safety and compliance

Safety signs

Danger: these signs represent 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're 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 enclosure 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.

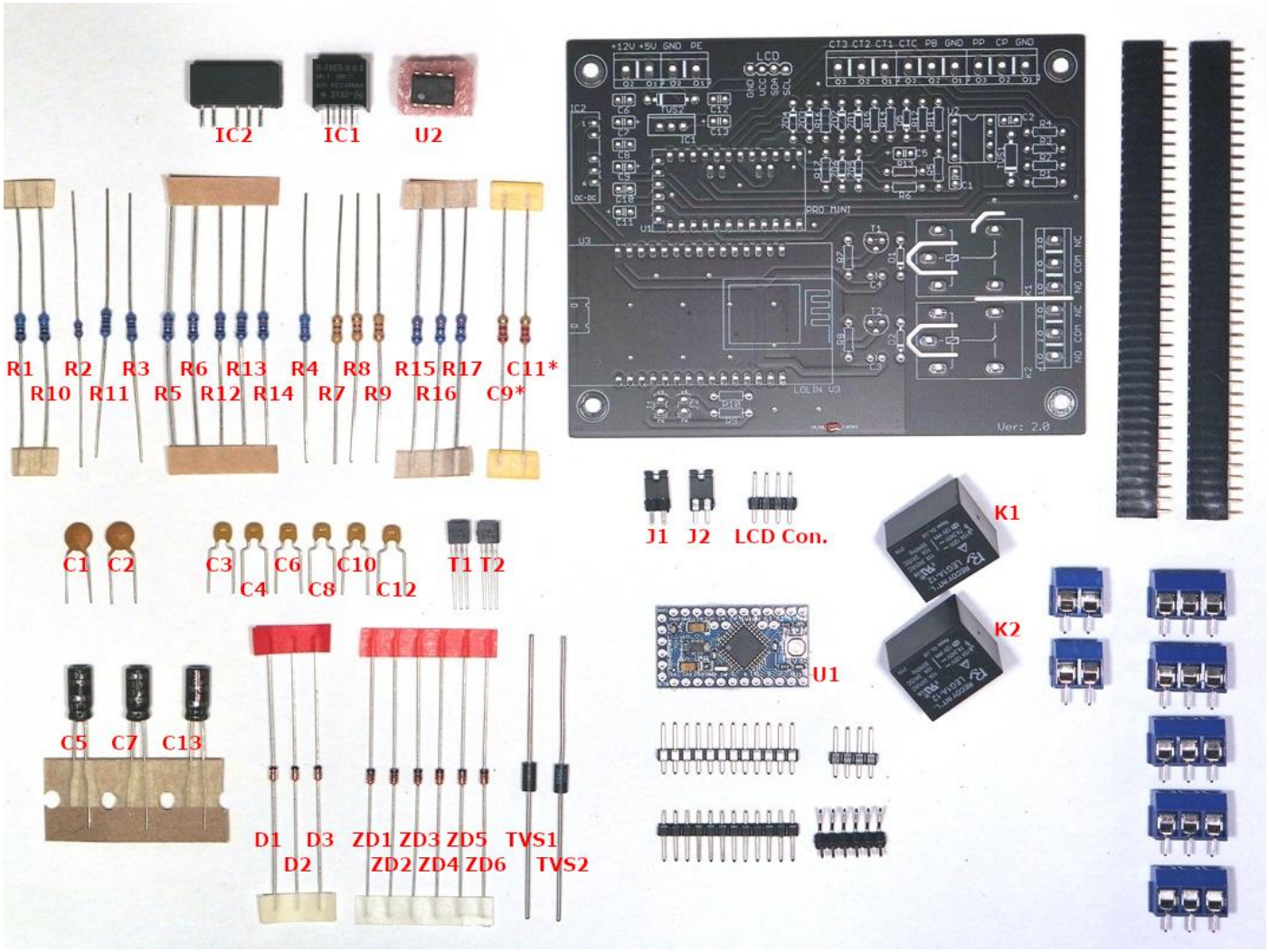
1.3 Residual current protection

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. Components received from us might vary slightly. You will receive actual component list sheet with your kit. Please refer to the component list received with your kit when assembling board.



2.2 Component list

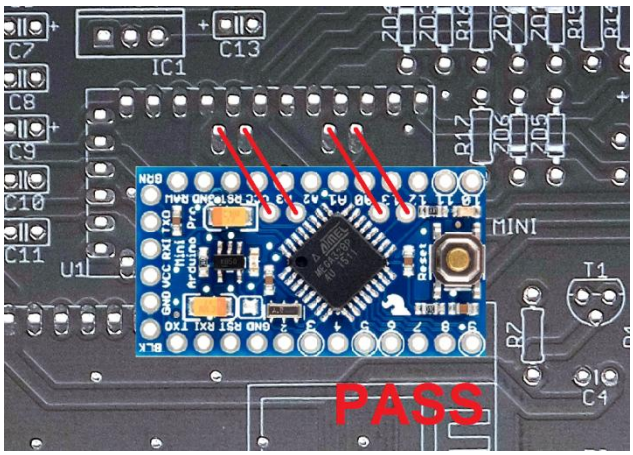
Component name	Qty.
U1 – Pro Mini ATmega328P 16MHz 5V microcontroller board	1
U2 – TL072IP operational amplifier	1
U3 – LoLin V3 WiFi board (optional, does not come with kit)	1
LCD Con – 4 pin 2.54mm terminal strip (LCD connector)	1
X1, X2 – DG301 2P THT terminal blocks	2
X3, X4, X5, X6, X7 – DG301 3P THT terminal block	5
X8, X9 – 40 pin 2.54mm female terminal strip	2
J1, J2 – 2 pin2.54mm terminal strip + jumper	2
K1, K2 – LEG1A-12 relay	2
D1, D2, D5 – 1N4148 diode	3
ZD1, ZD2, ZD3, ZD4, ZD5, ZD6 – BZX55C2V4 zener diode	6
T1, T2 – BC337-16 transistor	2
C1, C2 – 100nF 50V ceramic capacitor	2
C3, C4, C6, C8, C10, C12 – 1uF 50V multilayer ceramic capacitor	6
C5, C7, C13 – 10uF 63V electrolytic capacitor	3
R1, R10 – 680Ohm 1% resistor	2
R11 – 1kOhm 1% resistor	1
R2 – 200kOhm 1% resistor	1
R3 – 100kOhm 1% resistor	1
R4 – 56kOhm 1% resistor	1
R5, R6, R12, R13, R14 – 10kOhm 1% resistor	5
R7, R8, R9 – 470Ohm resistor	3
R15*, R16*, R17* – 33Ohm resistor	3
C9**, C11** – 2.2kOhm resistor (Update!!! Ignore C markings)	2
PCB – Custom made PCB by EV-OLUTION.NET	1
IC1 – R-78E5.0-0.5 DC/DC voltage converter	1
IC2 – AM1D-1212D-NZ DC/DC voltage converter	1
TVS1 – P6KE16CA bidirectional transient voltage suppressor	1
TVS2 – P6KE15CA bidirectional transient voltage suppressor	1

* R15, R16 and R17 resistors must NOT be used if STC-013 050 50A/1V split core transformer is used in this project, as it already has integrated burden resistor.
** C9 and C11 - Testing revealed that load resistors are necessary for correct AM1D-1212D-NZ DC/DC voltage converter operation. So C9 and C11 capacitors were replaced with 2.2kOhm load resistors.

3. Choosing correct components

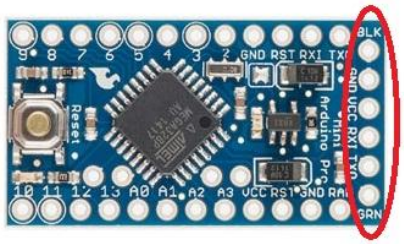
3.1 Pro Mini Board

Before starting this project, double check, that you have correct components.
Pro Mini Board must be 5V 16MHz. If you will use Arduino clone boards, please make sure pinout is exactly same as original design. Please see the image bellow:



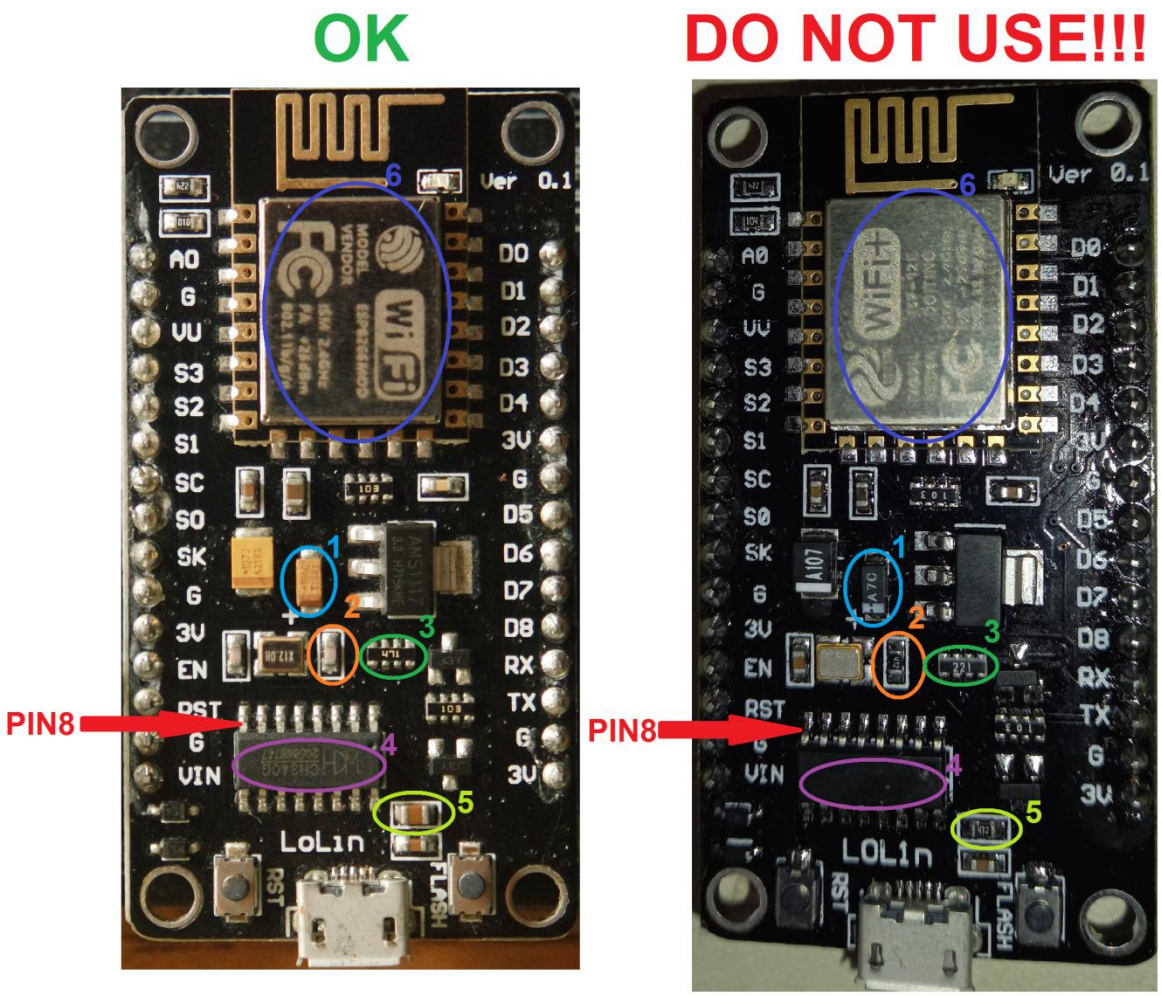
Also remember that quality of Pro Mini board and genuinity of ATMEL chip will affect the stability of finished project. Poor quality or cheap clone microprocessors can freeze/reset and affect the safety of the finished product.

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



3.2 IMPORTANT!!! Correct LoLin V3 Board

There were some reports of LoLin board instant damage after they were used with our project. This is because there are a lot of badly designed and low quality fake LoLin boards on sale now. Please study the following picture closely and identify if you've got good LoLin board or the one that is bad quality. If, after comparing it to this picture, you are still unsure if you got good board, please contact us and we will help you to identify if you can use your LoLin board without any further modifications.



CH340G PIN8 on the left (correct) board is connected to crystal oscillator. CH340G(?) PIN8 on the right (fake) board is connected to Vin after a diode!!! This will damage fake board instantly when connected to our EVSE board!

1. Left board has correctly rated 16V capacitor. Right board capacitor is only rated to 10V! It will be damaged instantly when connected to our EVSE board!

2. Note the diffecence between good and bad boards. Left (good) has capacitor next to crystal oscillator. Bad one has resistor.

3. Note the difference between resistor net values.

4. On bad board CH340G has no marking. My guess is that it's not even genuine CH340G.

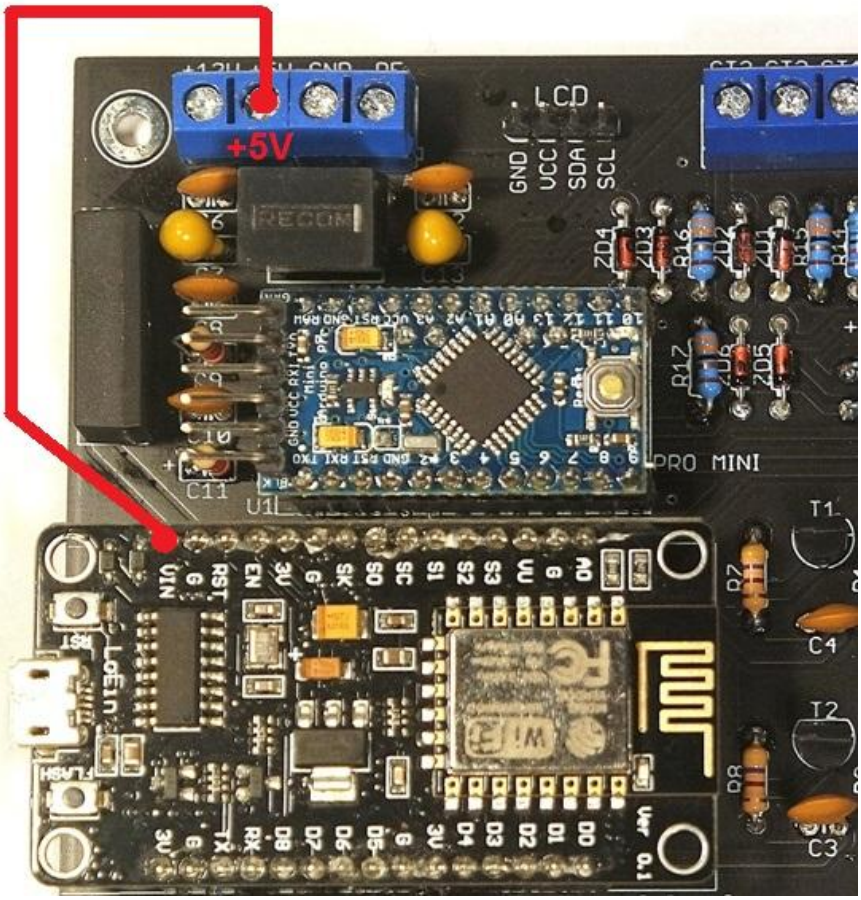
5. Note the difference between components. Left board (good one) has capacitor and right board (bad one) has resistor soldered in same place.

6.Good board has ESP8266MOD WiFi module. Bad one has ESP-12E module.

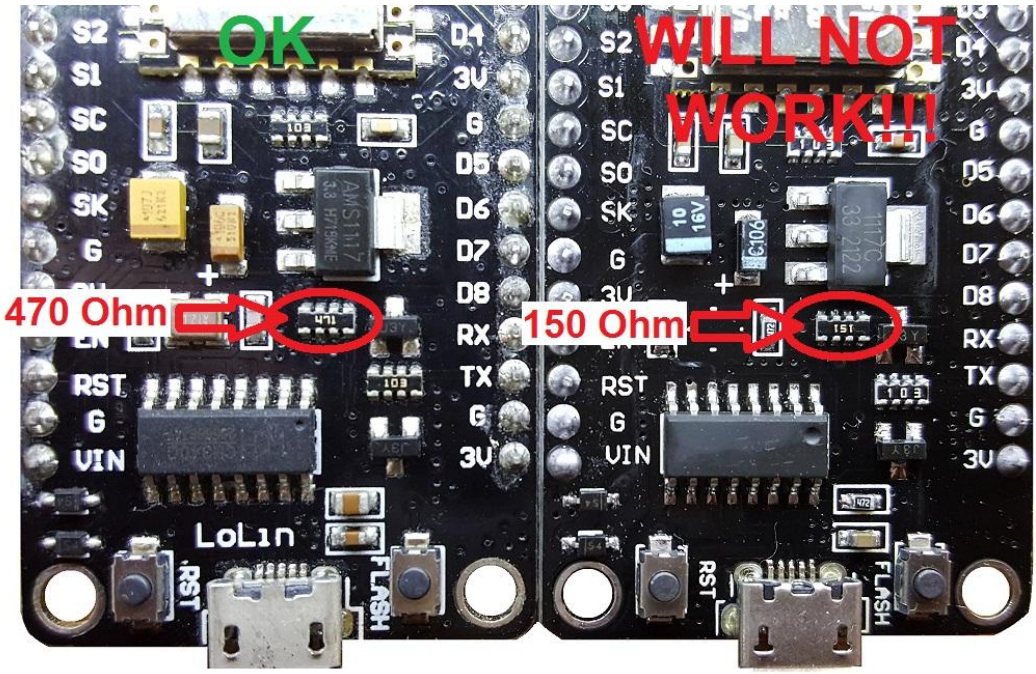
If your LoLin board does not match the left board shown in this picture. DO NOT USE IT WITHOUT CONSULTING WITH US FIRST!!!

If you did managed to buy bad quality LoLin board you've got two options. First option is to return this board back to seller and try to get it somewhere else. The second option is to do a slight modification. You

need to make sure pin VIN is not connected to main DIY EVSE board. Easiest way to do that is to shorten female connector on main DIY EVSE board so there is no connector for VIN pin. Then solder wire to VIN pin on LoLin board and connect this wire to power supply terminal marked +5V on DIY EVSE main board as shown in the picture bellow. This will prevent your LoLin board from getting damaged.



Also please take a look to the next picture, and compare your own board with this example:



Check if your LoLin board has exactly same resistor network as marked in "OK" example. It should be marked as 471, which means it's 470 Ohm resistor network. If your board has resistor network which is marked as 151 (150 Ohm), it will not communicate with Arduino board and needs additional modifications. Please do not use such board or contact us for further modification instructions.

3.3 Relays

DIY EVSE V2 board was designed to be used with G5LE-1 12VDC relays. But any similar relays with same pinout pattern as G5LE-1 will suit this project. Here is a list of other suitable relays: G5LE-14 12VDC, LEG-12 (12VDC), LEG-12F (12VDC), AZ943-1CH-12DE, FL-3FF-S-Z (12VDC).

Your kit most likely will come with LEG1A-12 relays. Which are SPST-NO 4 pin relays.

Please note, that these relays must only be used to power external contactors coil and not to be used as main relays for main power switching!

3.4 Power Supply

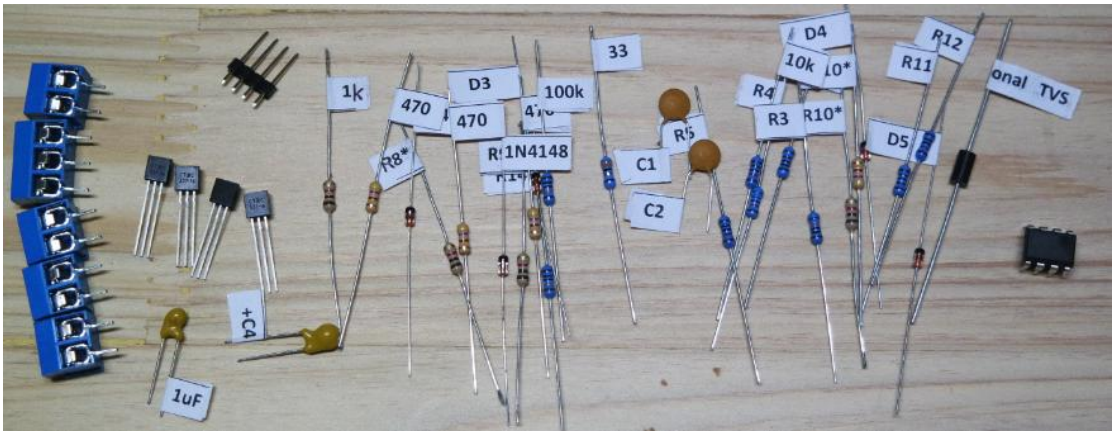
Finished EVSE board requires 12VDC power supply, so external power supply is needed. **Power supply output voltage must never exceed 12.8V!** Always use Switching Power Supply Units and never use Transformer type Power Supply Units! Make sure your Power Supply Unit is designed to be used with very small loads. Some Power Supply Units produce very unstable output voltage when powering small loads. Output current ratings of power supply unit must be: at least 500mA if you choose not to use LoLin WiFi board and 1A if you will be using LoLin WiFi board.

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

4. Assembly guide

4.1 Soldering components

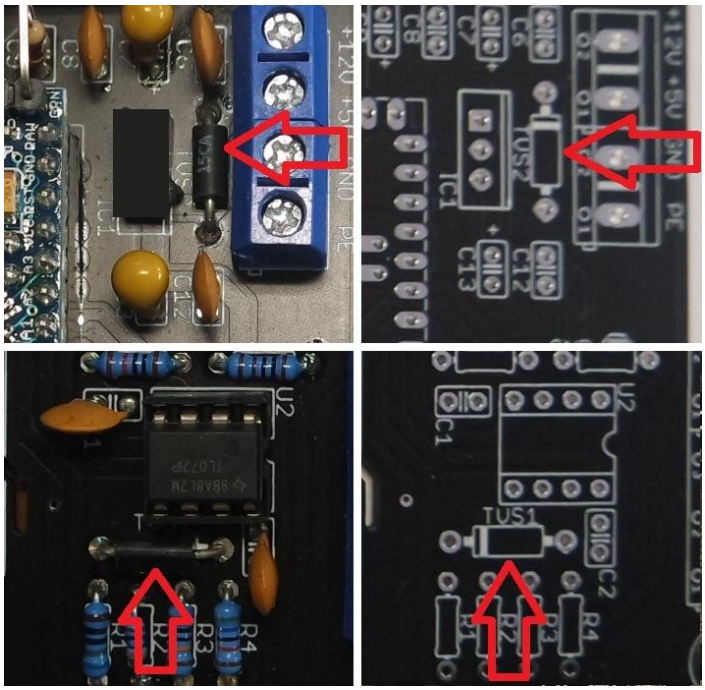
Most components, if bought, will come labeled, so it makes it easier to identify correct places on PCB.



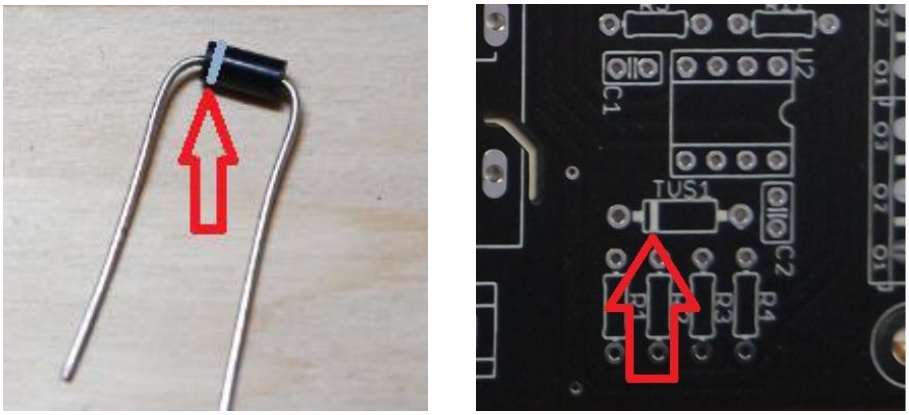
To properly solder electronic components to this board you will need good quality soldering iron with power output of at least 60W. Do not try to solder it with low power soldering iron, as this will damage components

due to excessive time needed to heat the soldering points.
Start soldering by choosing lowest profile components, such as TVS diodes, diodes, zener diodes and resistors. This will make your work much easier.

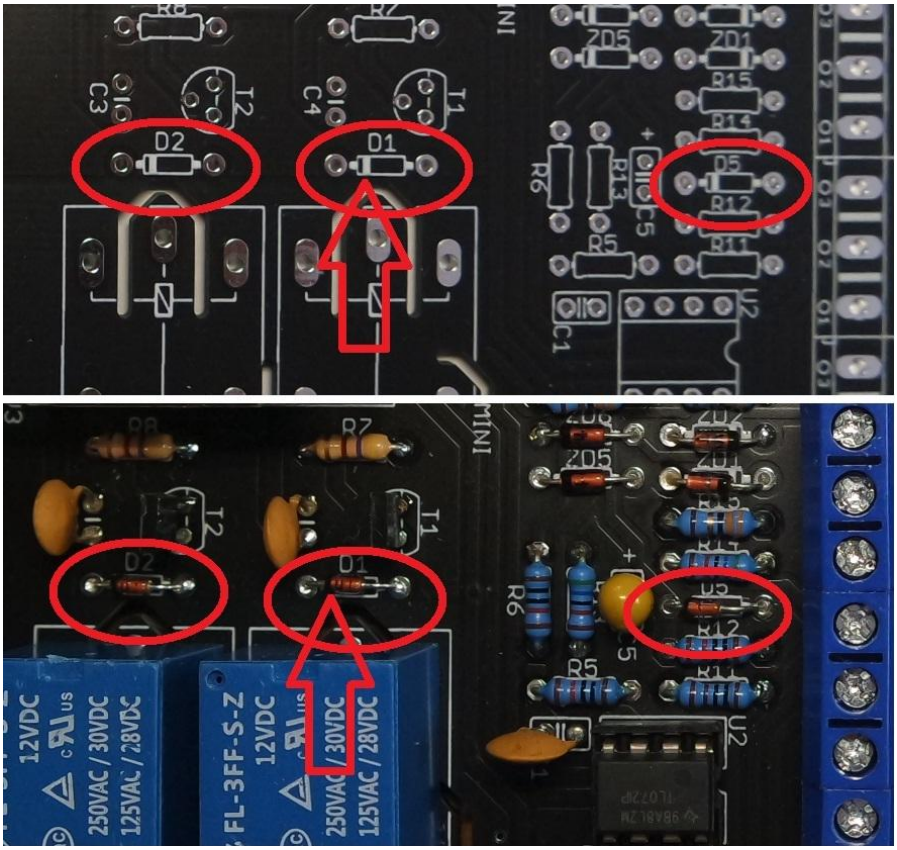
Solder TVS1 and TVS2. If you bought complete kit from us you will get bidirectional TVS diodes, which are perfectly fine for this project. It can be fitted either way ignoring the markings on PCB.



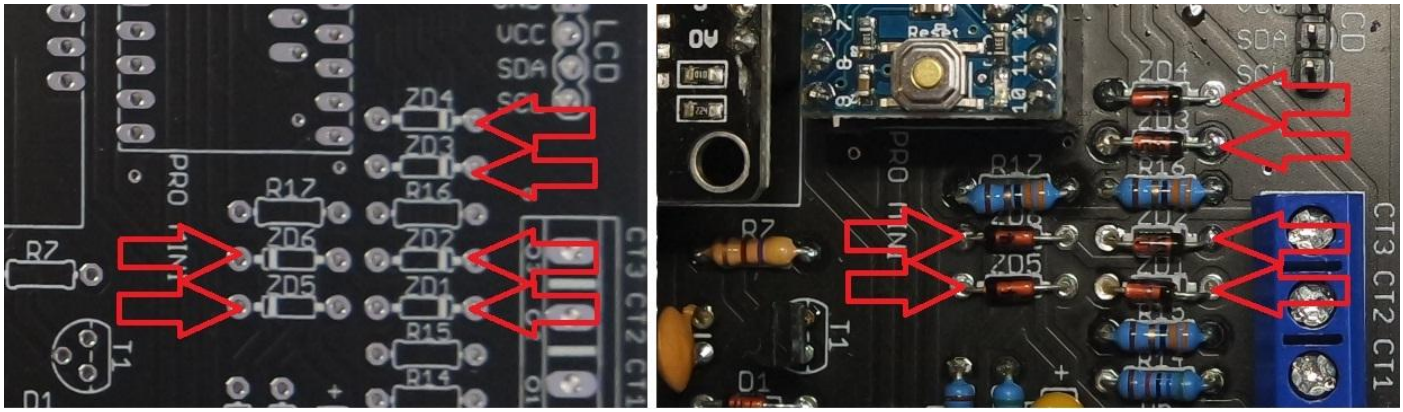
If you got unidirectional TVS diodes, then please follow the markings on a PCB.



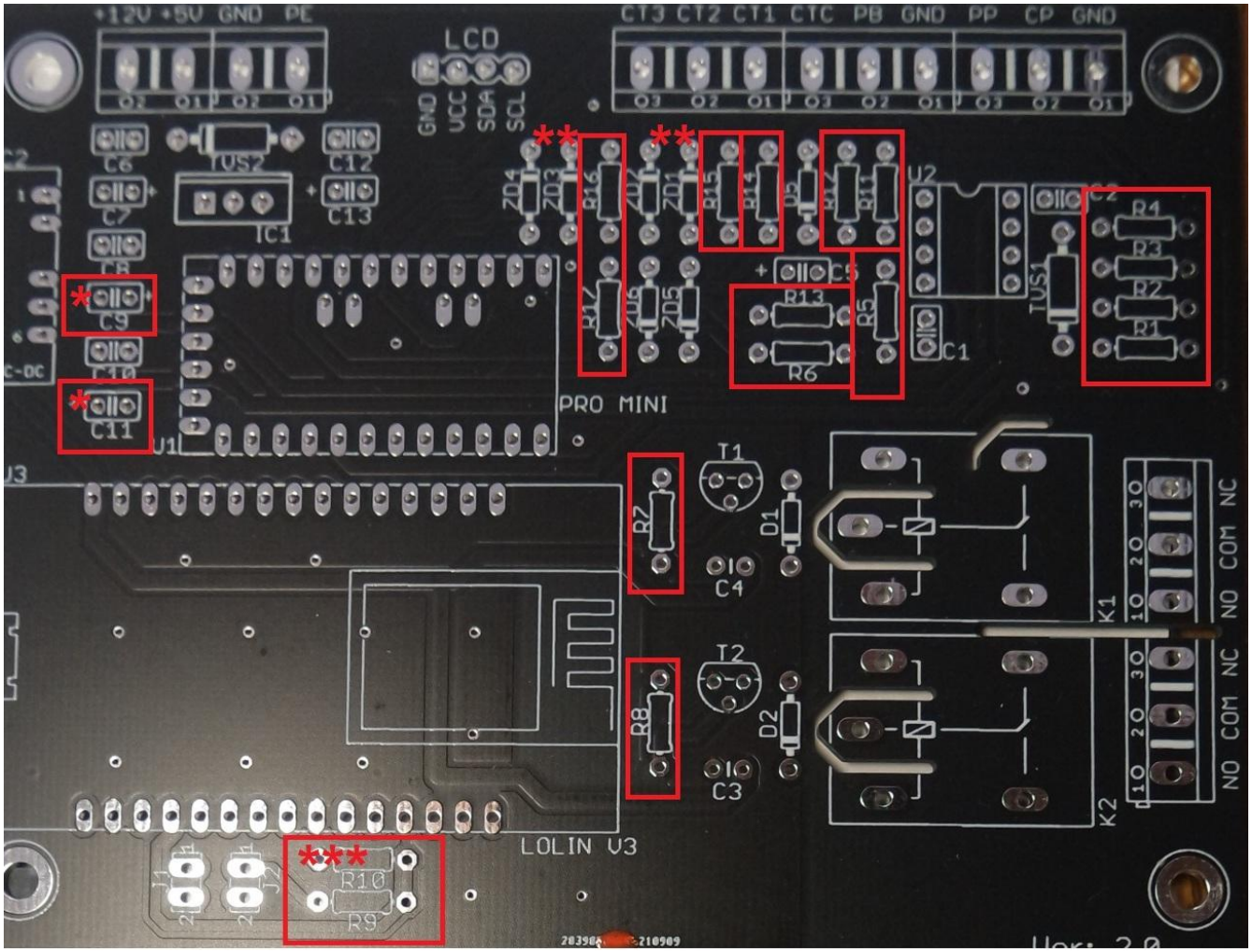
Solder diodes D1, D2 and D3. D3 diode is incorrectly marked as D5 diode on a PCB. Diode correct orientation must be observed, please follow markings on PCB. D3(marked as D5 on PCB) can be left unsoldered if you are building tethered charging point (with its own charging cable and plug).



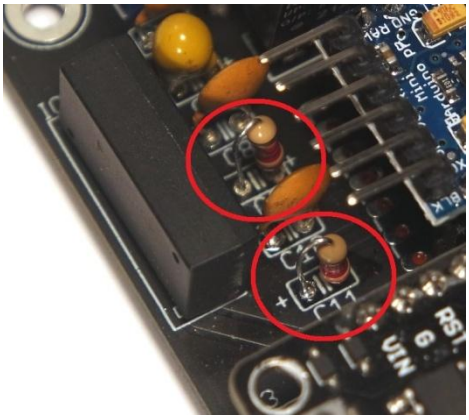
If you choose to use current transformers for current monitoring then please solder ZD1, ZD2, ZD3, ZD4, ZD5 and ZD6 zener diodes. Observe correct orientation.



Solder all needed resistors to PCB.

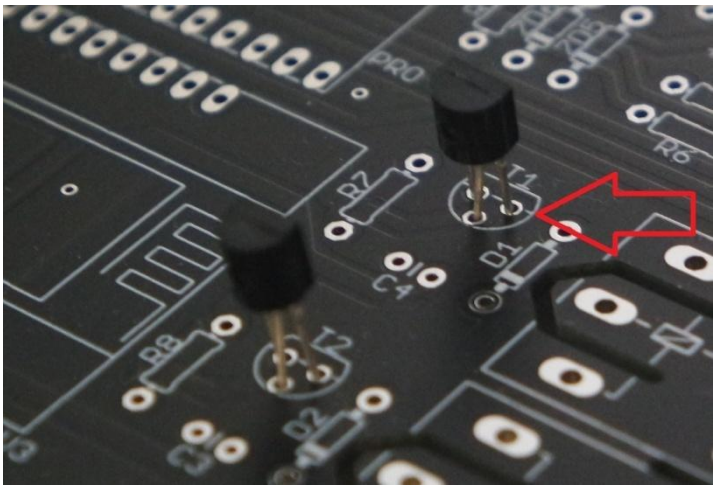


- * - C9 and C11 must be populated with 2.2kOhm resistors. Testing revealed that load resistor is necessary for correct AM1D-1212DZ and AM1D-1212D-NZ DC/DC converter (IC2) operation. So C9 and C11 capacitors were replaced with load resistors.

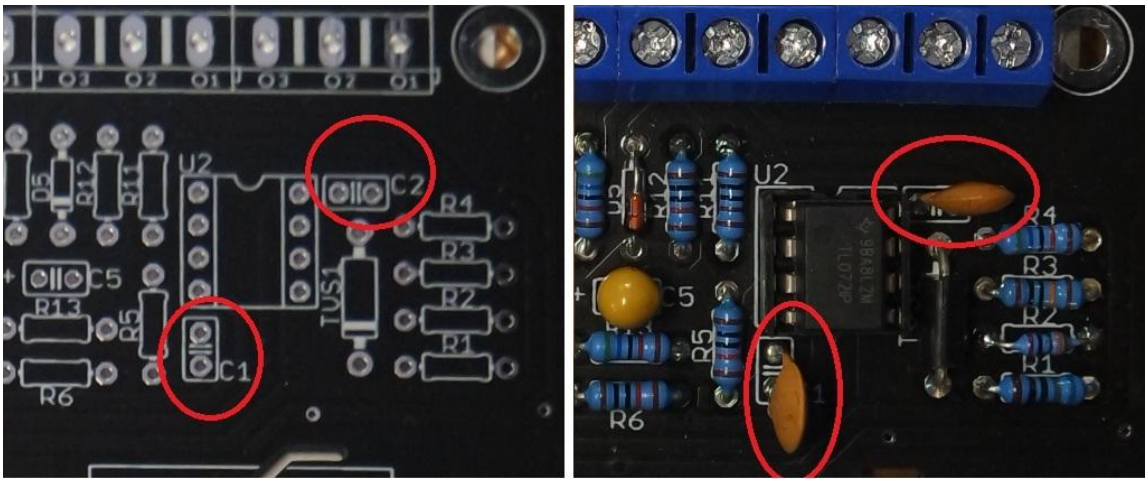


- ** - R15, R16 and R17 must be used if you are using current transformers for current monitoring. Otherwise you can leave them unsoldered. Do not use R15, R16 and R17 resistors if you are going to use current transformers with inbuilt resistors!
- R13 and R14 can be left unsoldered if you are not going to use current transformers for current monitoring.
- *** - R10 and R9 can be left unsoldered if you are not going to use LoLin V3 WiFi board.
- R11 and R12 can be left unsoldered if you are building tethered charging point (with its own charging cable and plug).

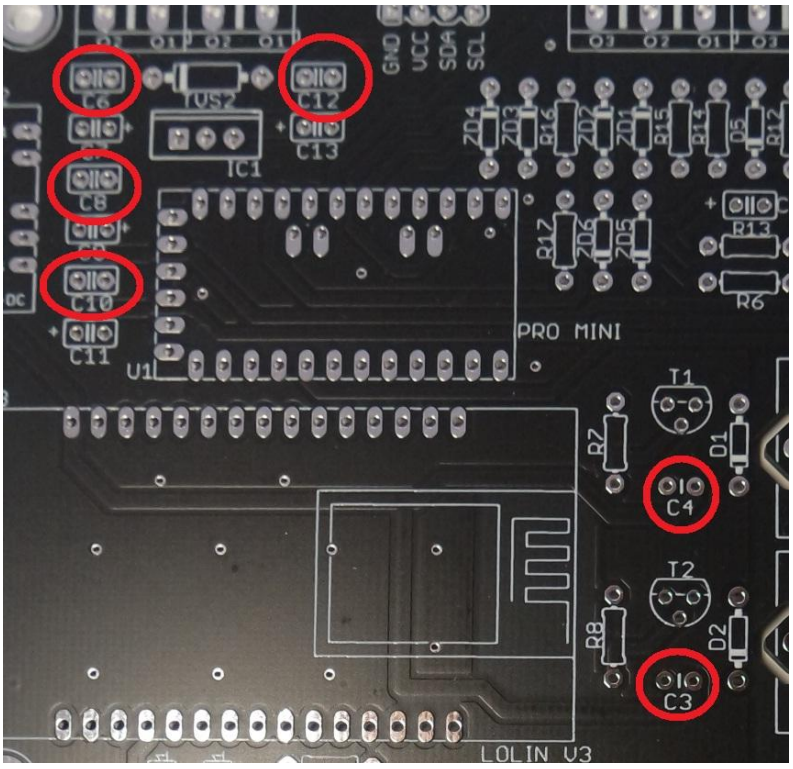
Solder transistors T1 and T2. When fitting transistors please follow orientation marks on PCB.



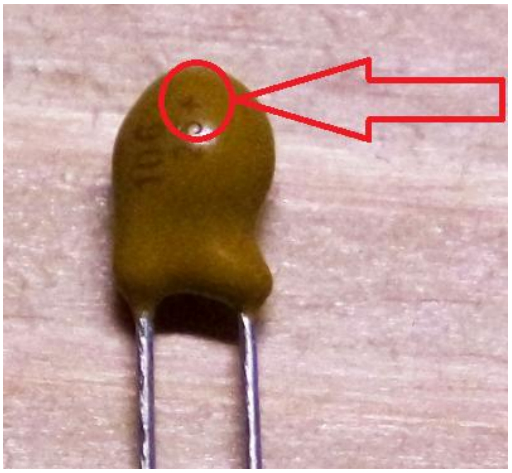
Solder ceramic capacitors C1 and C2. Orientation is not important

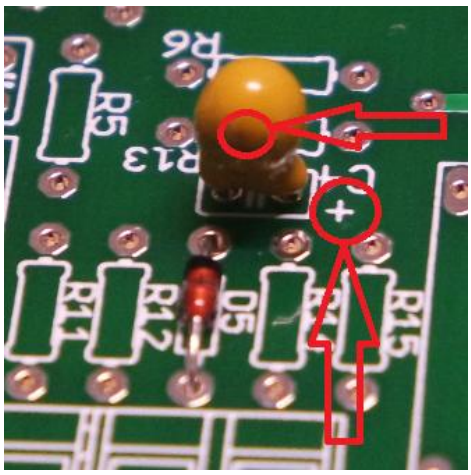


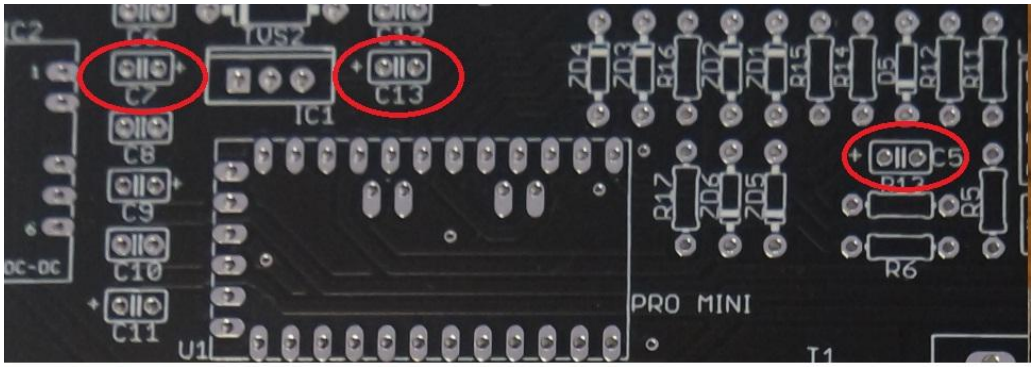
Solder multilayer ceramic capacitors C3, C4, C6, C8, C10 and C12. Orientation is not important.

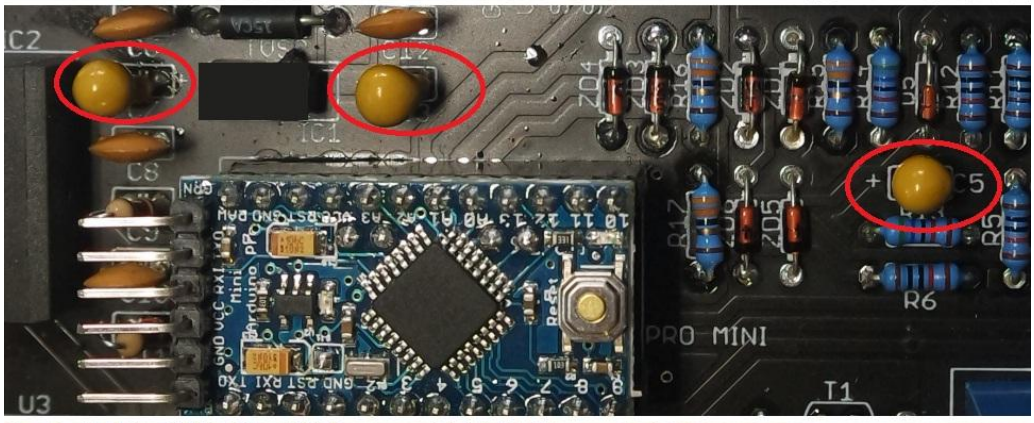


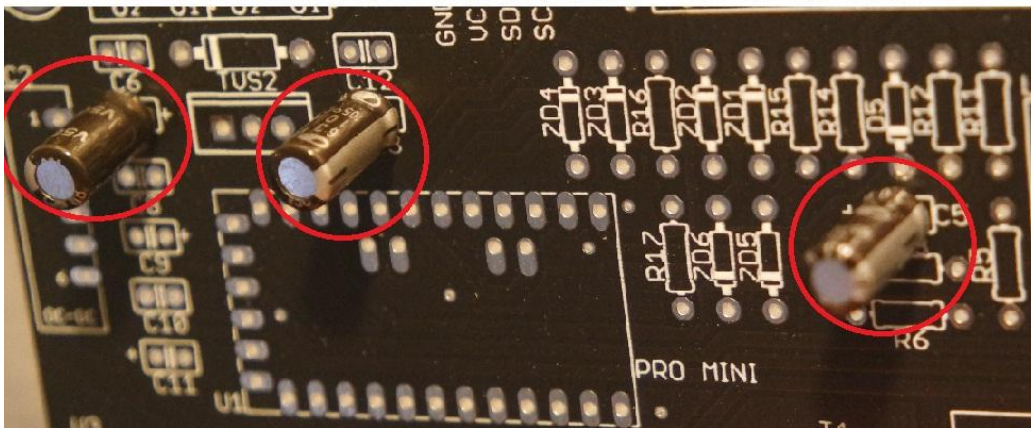
Solder electrolytic or tantalum capacitors C5, C7 and C13. C5 can be left unsoldered if you are not using current transformers for current monitoring. Please note that these capacitors orientation is critical and damage will occur if soldered incorrectly. Look for "+" sign on PCB. If tantalum capacitors are used please look for "+" sign on them which indicates positive terminal. If electrolytic capacitor is used look for "–" sign on it, which indicates negative terminal. So when using electrolytic capacitors always make sure capacitors "–" mark is on the opposite side of the "+" mark on the PCB.



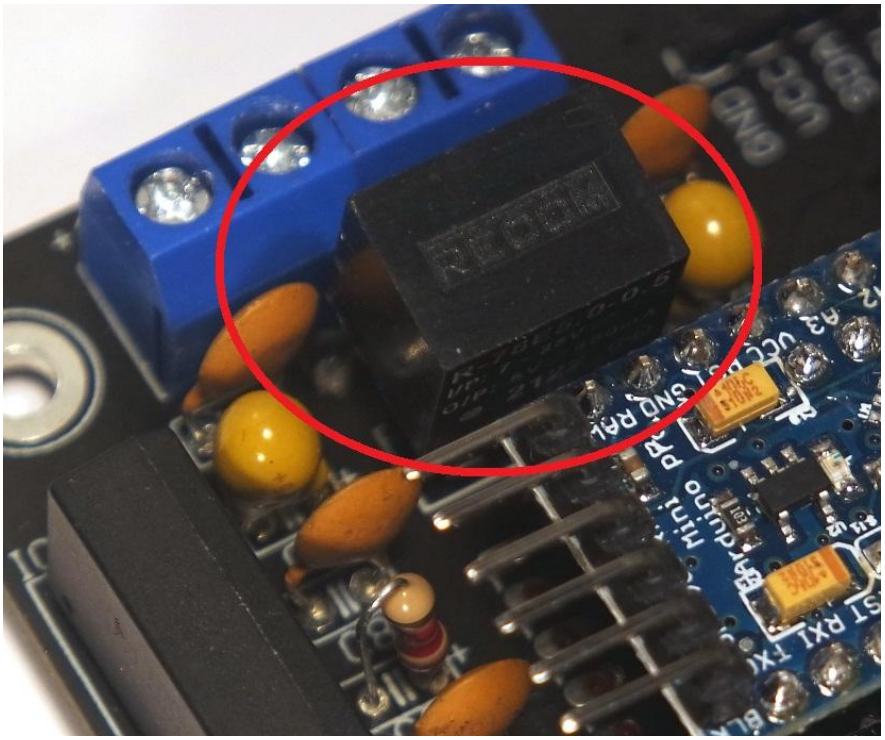




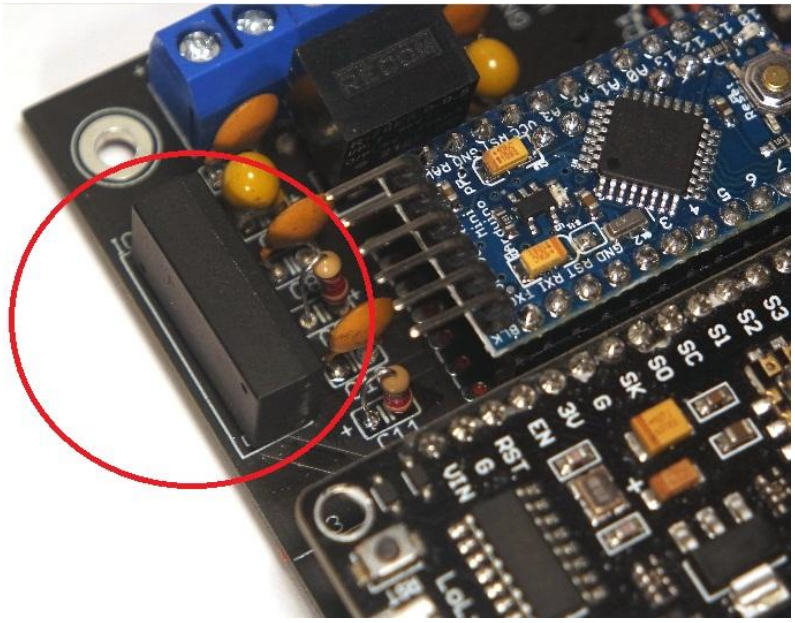




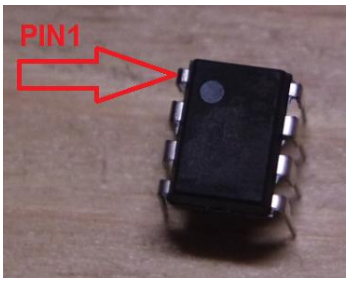
Solder IC1. Originally board was designed to be used with NTE960 voltage regulator as IC1. Which is also fine, but while testing we found out that 5V voltage is much more precise if we use RECOM R-78E5.0-0.5 DC/DC voltage converter. So we've decided to include R-78E5.0-0.5 DC/DC voltage converter in our kit instead of NTE960 regulator. But because R-78E5.0-0.5 dimensions are slightly bigger than NTE960, R-78E5.0-0.5 covers TVS2 diode. That's why TVS2 diode must be soldered first. Please mind the correct mounting direction. Writings on R-78E5.0-0.5 must face Arduino board as showed in the following picture.

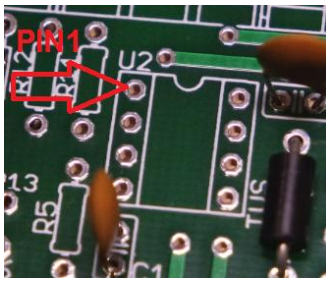


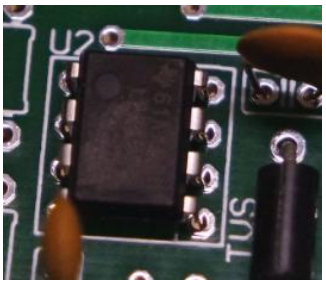
Solder AM1D-1212D-NZ to IC2.



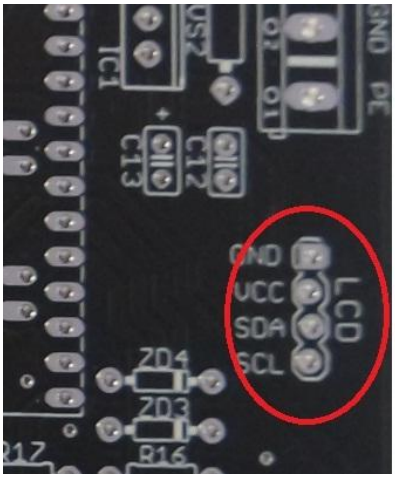
Solder TL072IP to U2. Keep attention to correct component orientation.

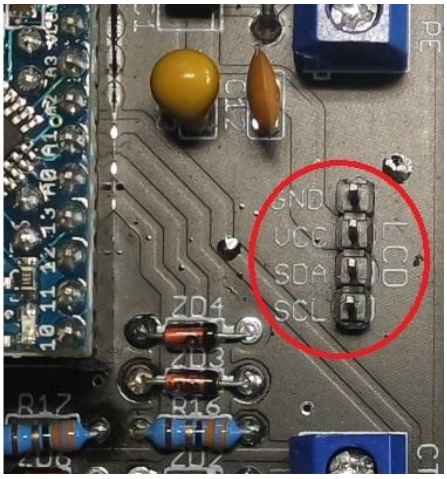




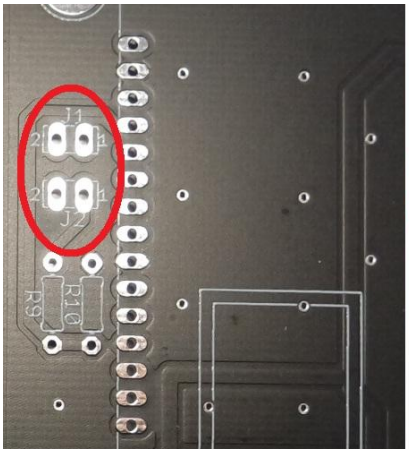


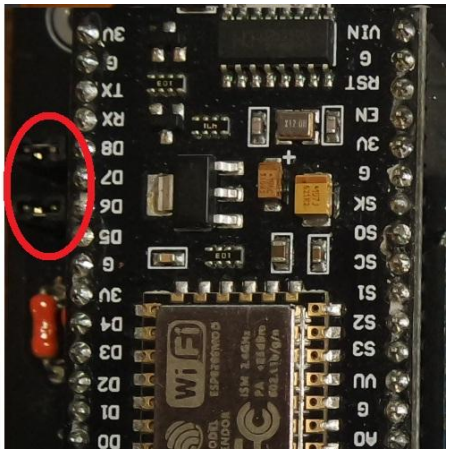
Solder terminal strip connector for LCD.



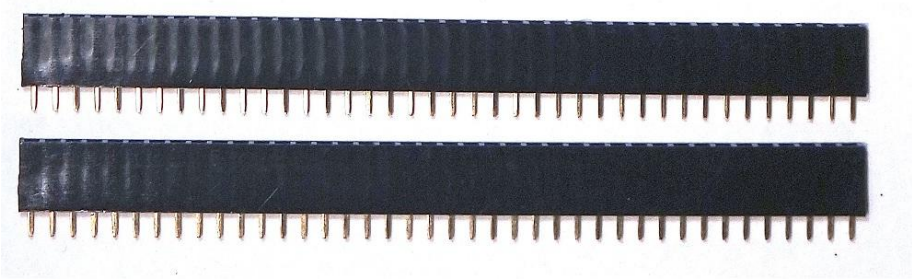


If you're going to use LoLin Wifi board, solder J1 and J2 terminal strip connectors to PCB.

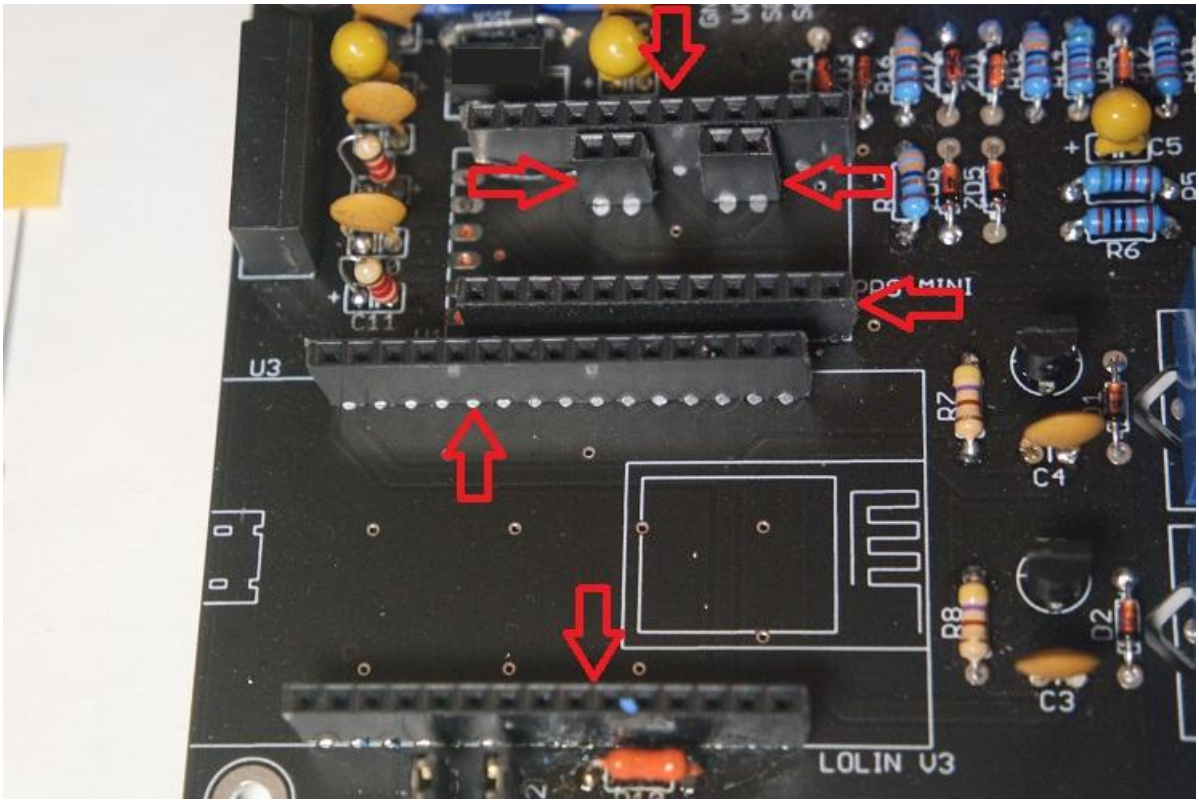




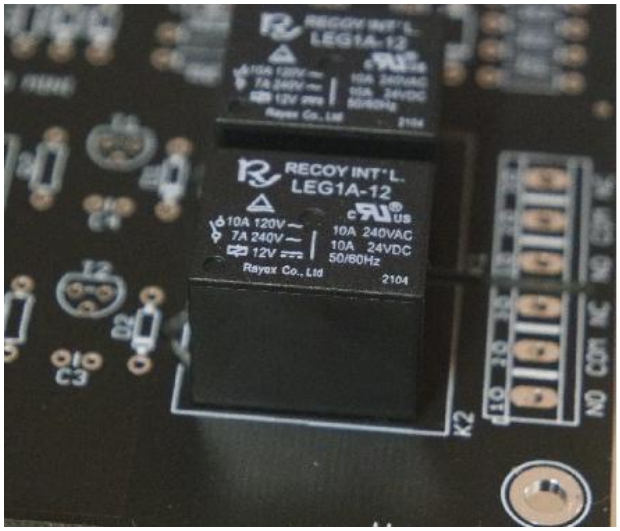
Cut 40 pin 2.54mm female terminal strips into correct lengths. You need 2x 12pin strips and 2x 2pin strips for Arduino board connector. If you're going to use LoLin WiFi board then also cut 2x 15pin strips.

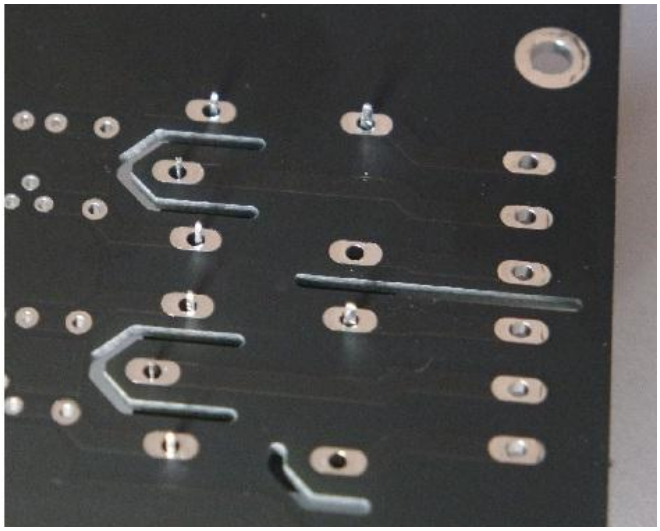


Solder them to your EVSE controller PCB.

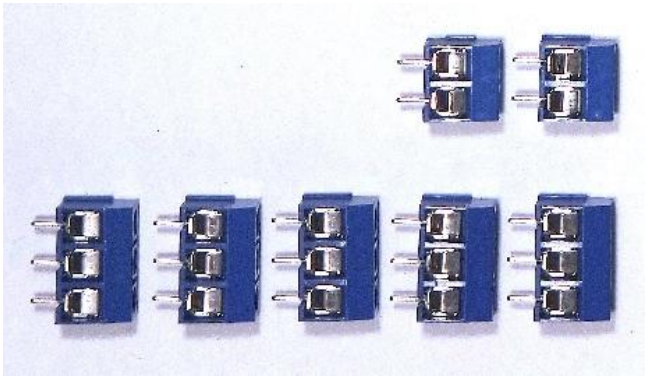


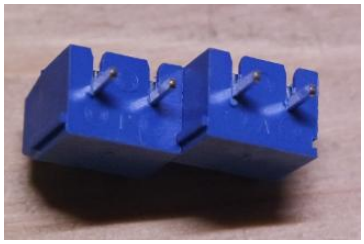
Solder relays to K1 and K2. Note that relays sent with our kit got only 4pins. That's perfectly fine and as they suit this project needs.

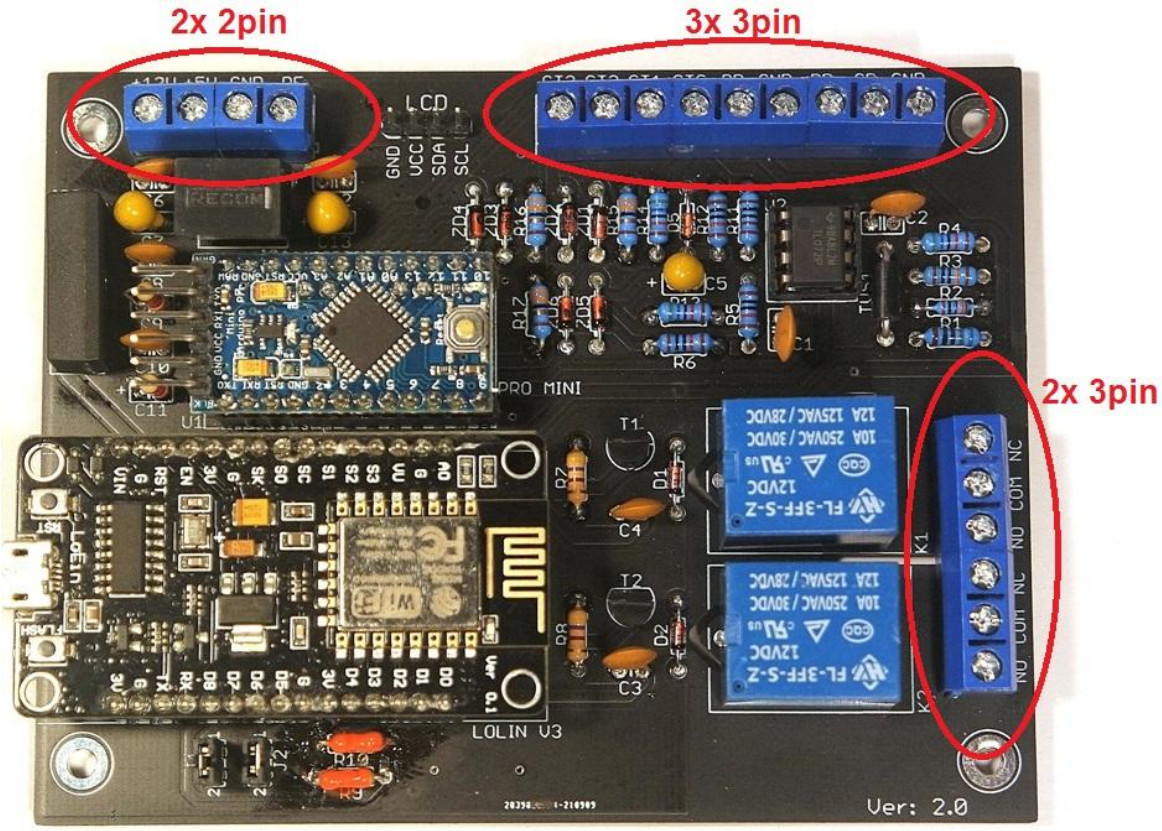




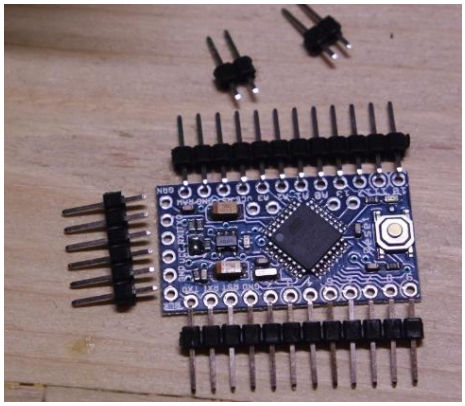
Prepare and solder THT screw terminal connectors.



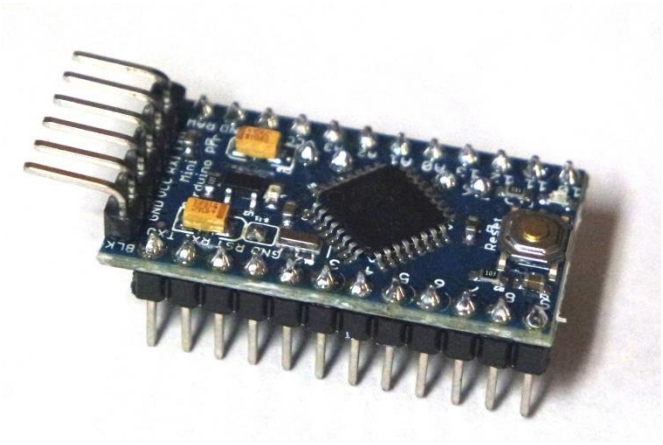


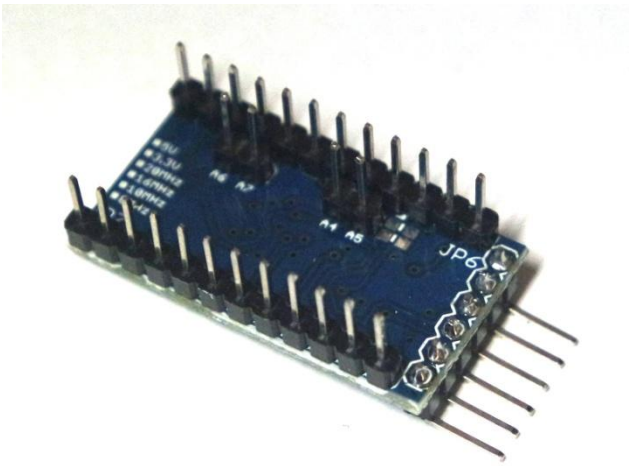


Prepare your Pro Mini board.



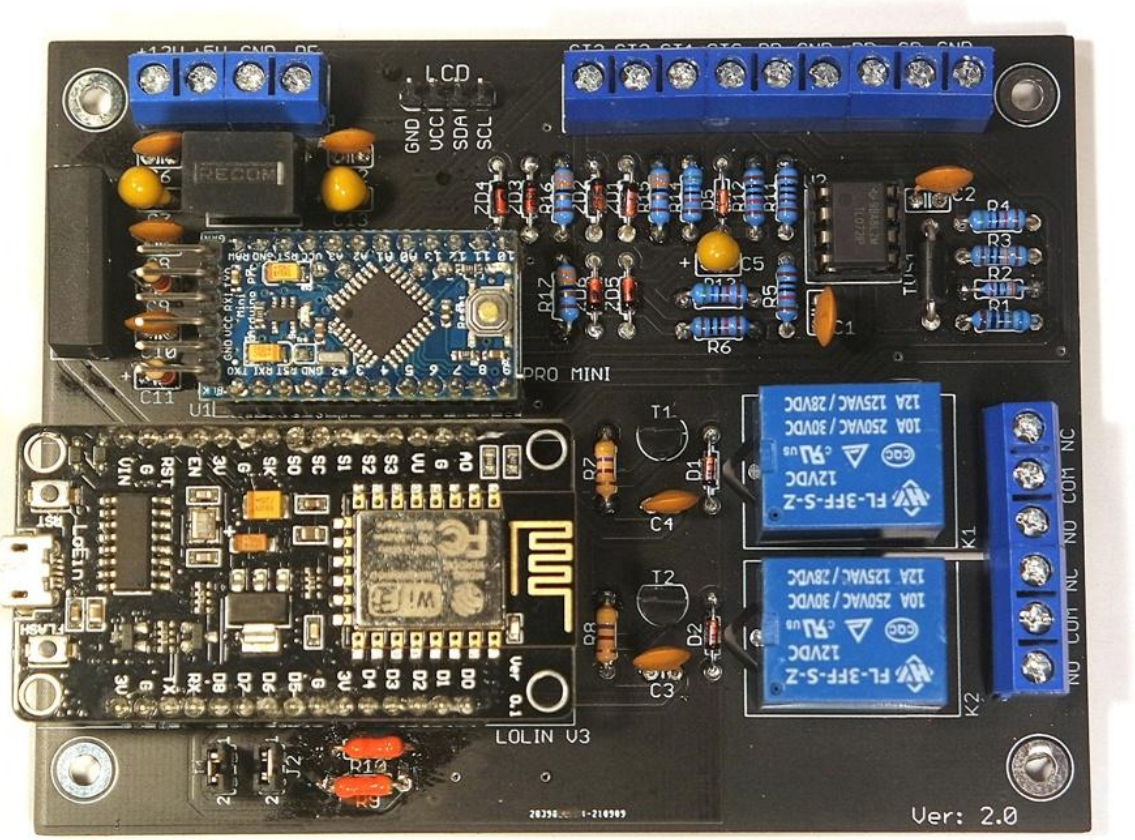
Solder pins as shown in the following pictures. In such way you will be able to access programming pins easily for later firmware updates.





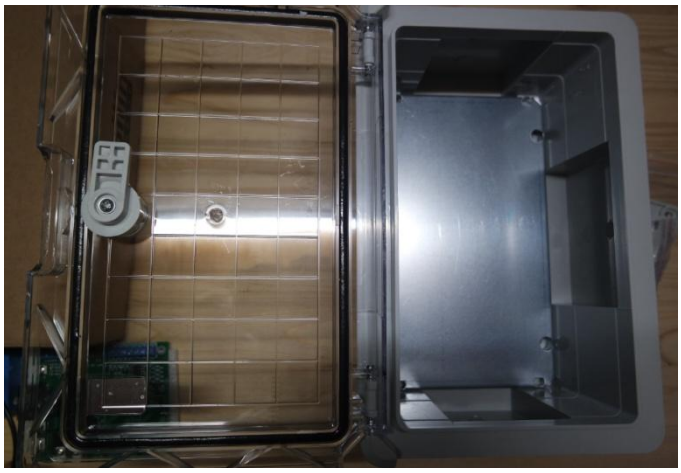
Install Arduino and LoLin boards onto main board.

After soldering all components to PCB, it should look similar as this picture below.



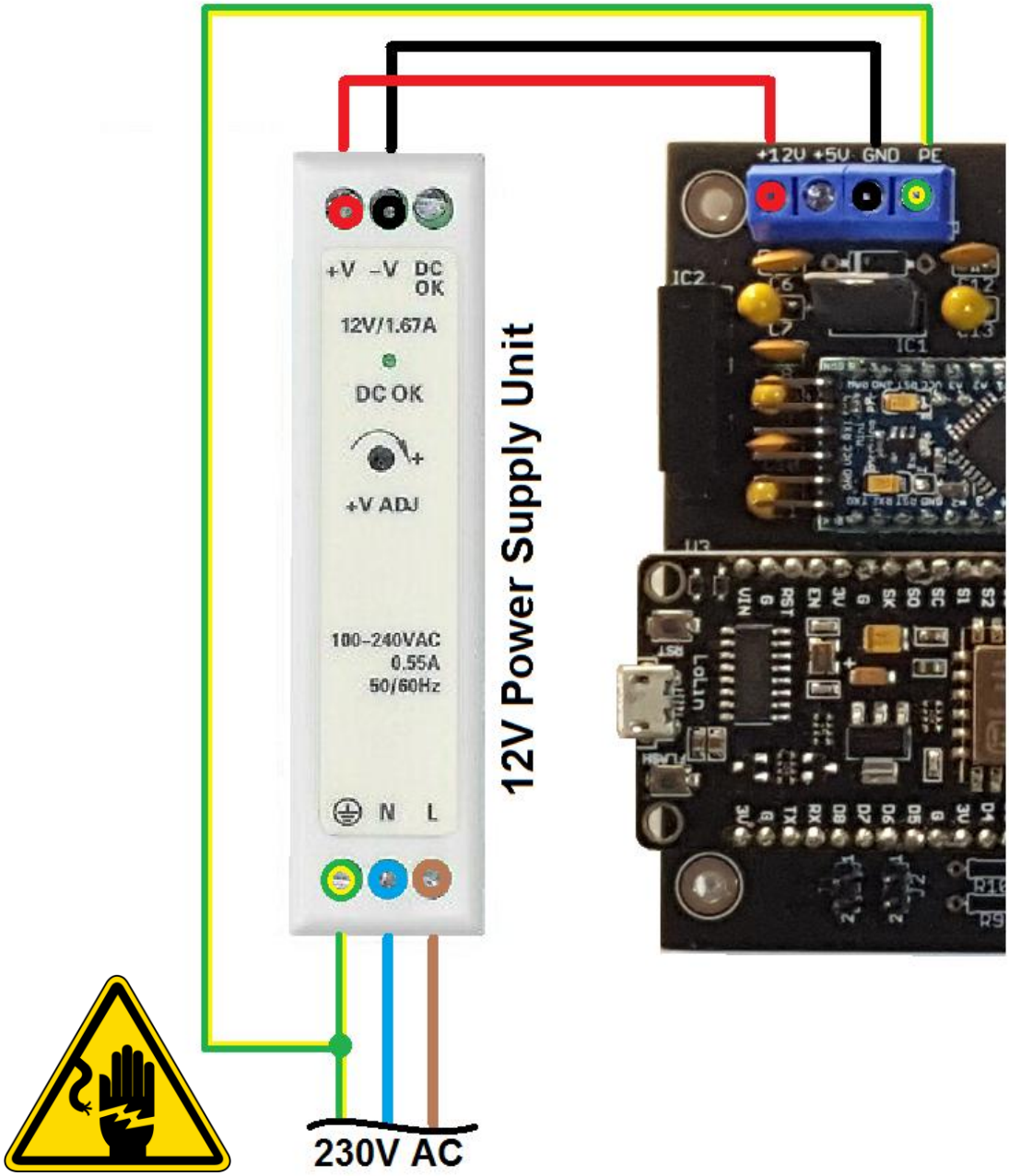
4.2 Enclosure

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.



4.3 Connecting wires

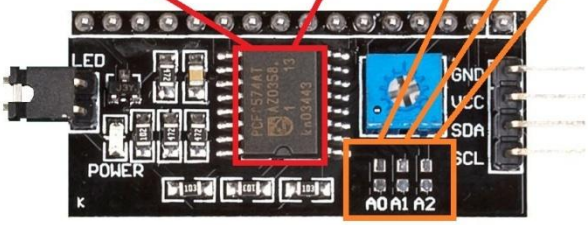
After you've done that, connect your power supply unit to your main board. Power supply unit is not provided with our kit, so you must source it yourself.



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.

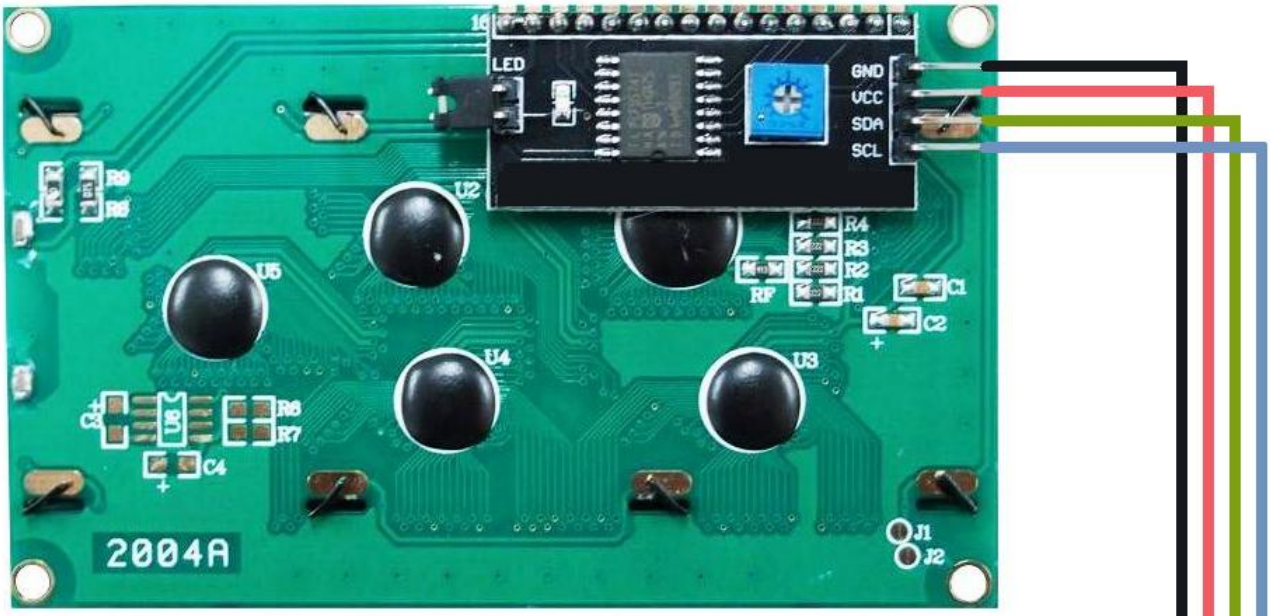
PCF8574 and PCF8574A I²C-Bus Slave Address Map

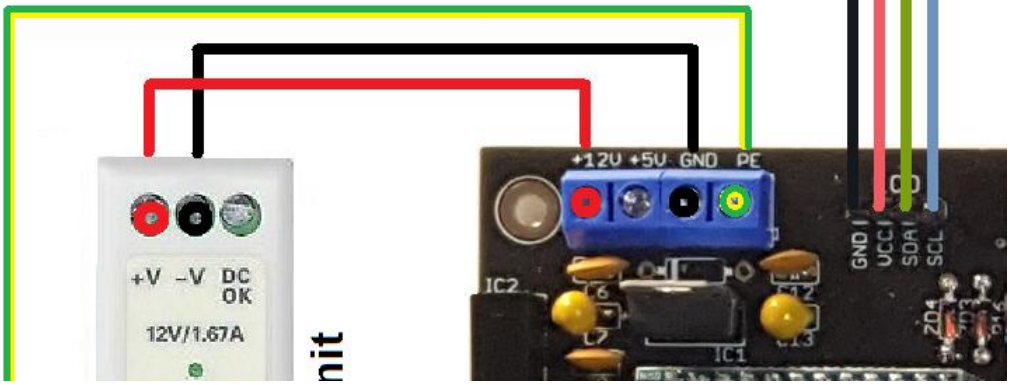
PCF8574 I²C-Bus Slave Address	PCF8574A I²C-Bus Slave Address	INPUTS A0	A1	A2
20 (hexadecimal)	38 (hexadecimal)	L	L	L
21 (hexadecimal)	39 (hexadecimal)	H	L	L
22 (hexadecimal)	3A (hexadecimal)	L	H	L
23 (hexadecimal)	3B (hexadecimal)	H	H	L
24 (hexadecimal)	3C (hexadecimal)	L	L	H
25 (hexadecimal)	3D (hexadecimal)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



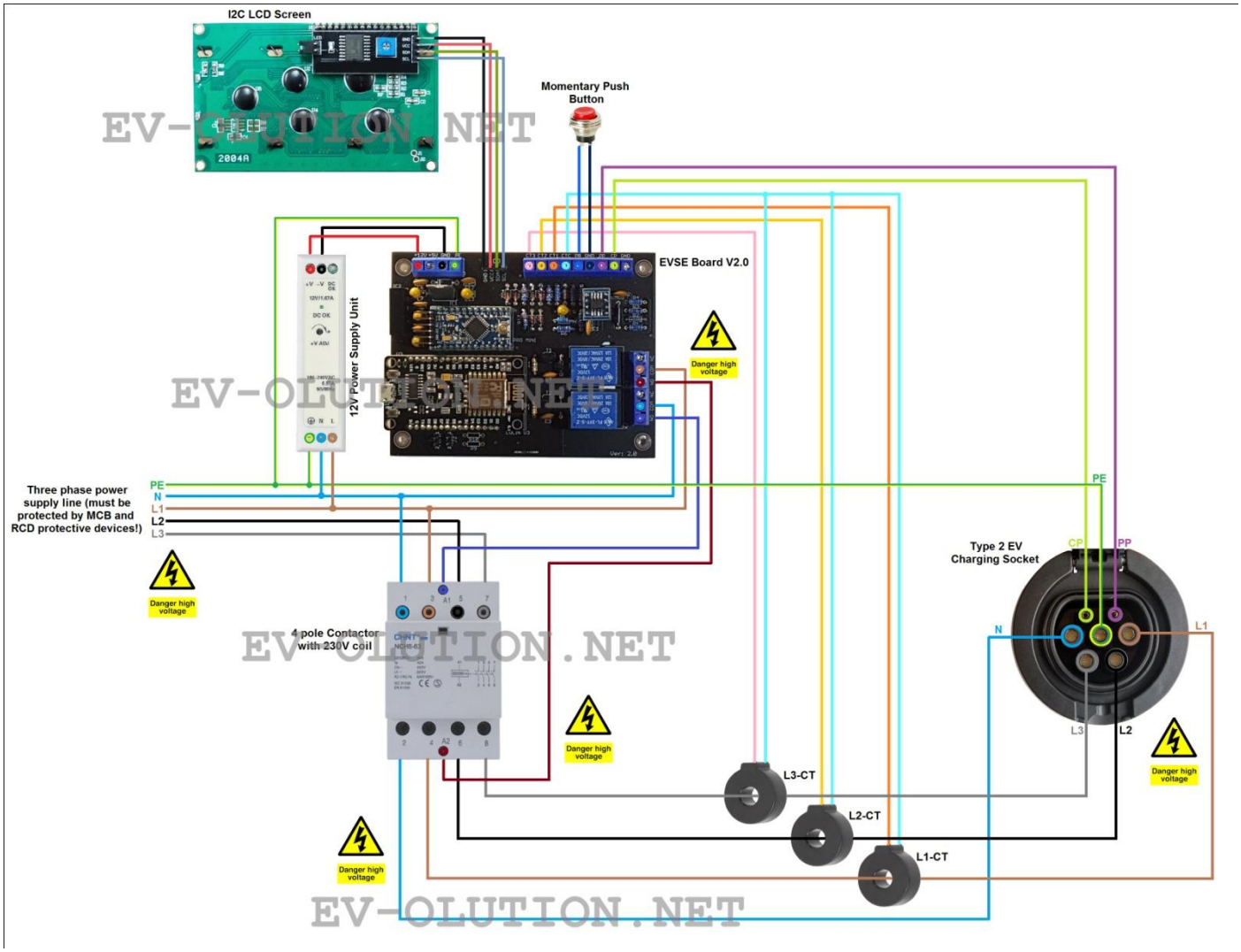
H = not bridged
L = bridged

I2C LCD Screen





Connect rest of the wires to mains connection, EV plug/socket, push button switch and current transformers (if used) to main board and power supply unit. Please download connection diagram separately from our website for better resolution!



Please note, that diagram above shows three-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.
Please leave CT1, CT2, CT3 and CTC terminals 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.

4.4 Using current transformers (current sensor)

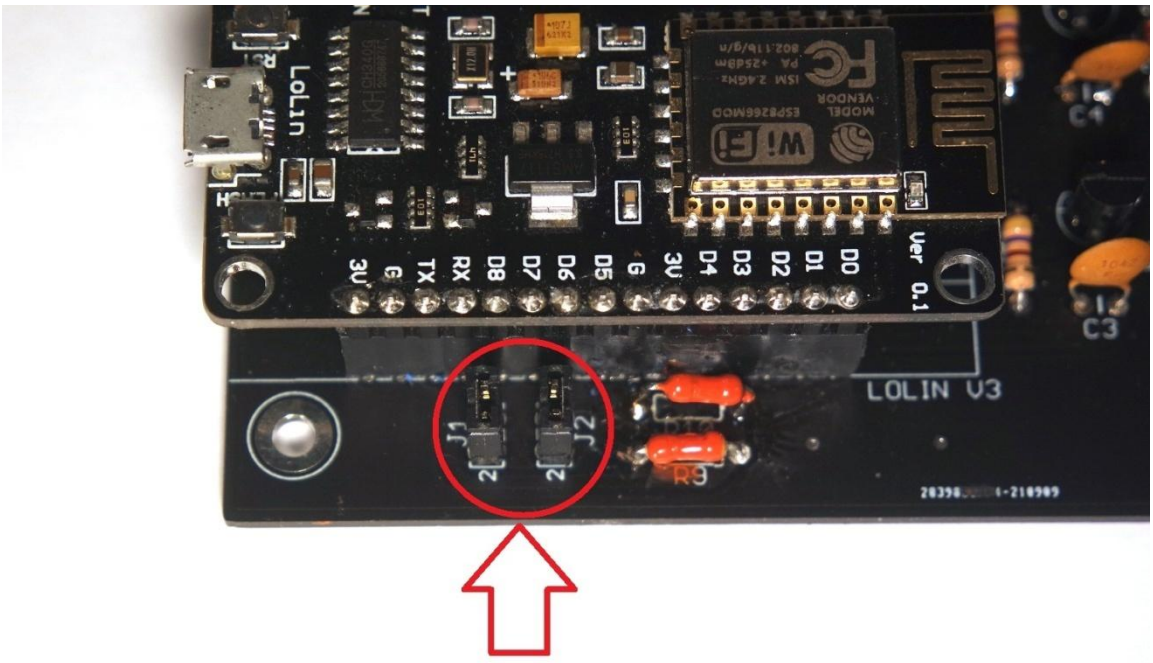
You can use any current transformer with ratio 2000:1 without inbuilt burden resistor. If you are using current transformer such as SCT013-050, which has inbuilt burden resistor, please leave R15, R16 and R17 unpopulated on the main EVSE board. Otherwise you will get incorrect current readings.

If you will use current transformers without inbuilt burden resistor you might need to change current sensor calibration settings in EVSE settings menu, as EVSE firmware was designed originally to be used with SCT013-050 current transformer, which has inbuilt burden resistor of 29Ohm and DIY EVSE V2 kit comes with 33Ohm resistors to be used as burden resistors for current transformers. 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 .

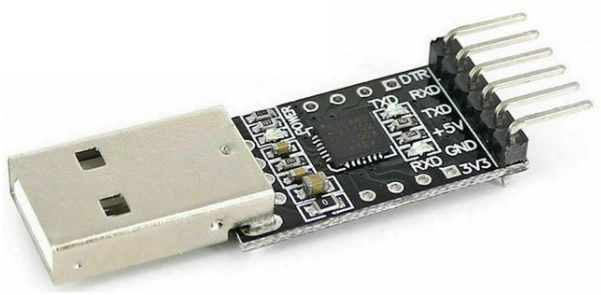
5. Uploading firmware to Pro Mini

Your Pro Mini will already contain firmware uploaded in it. Firmware uploaded is designed for Three phase non tethered charging point with current monitoring option and works with 2004 (20x4) I2C display. If you need different version of firmware please update Pro Mini firmware with required version. Please use firmware provided only by us, unless you are developing your own firmware. Always check our website for latest firmware updates: https://ev-olution.yolasite.com/evse-firmware.php

Before trying to upload firmware to your Arduino or LoLin board please remove jumpers from J1 and J2 terminals. Install them back after you finished with uploading your code.



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 got our Pro Mini board supplied with a kit, 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.

6. Powering EVSE for a first time

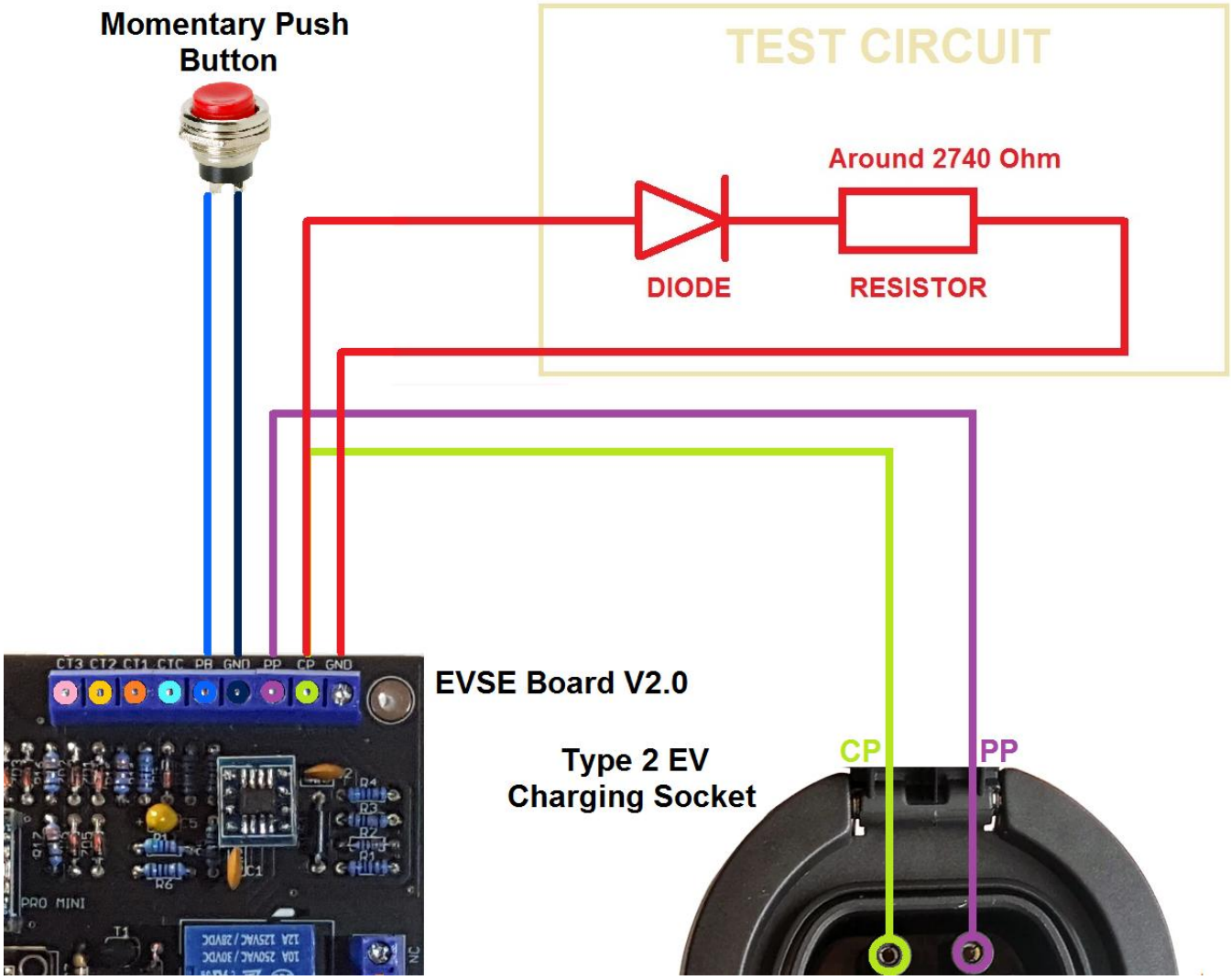
After powering DIY EVSE for the first time, you should see our website name on the LCD screen and set current value (6A).

7. 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 (not provided with a kit).

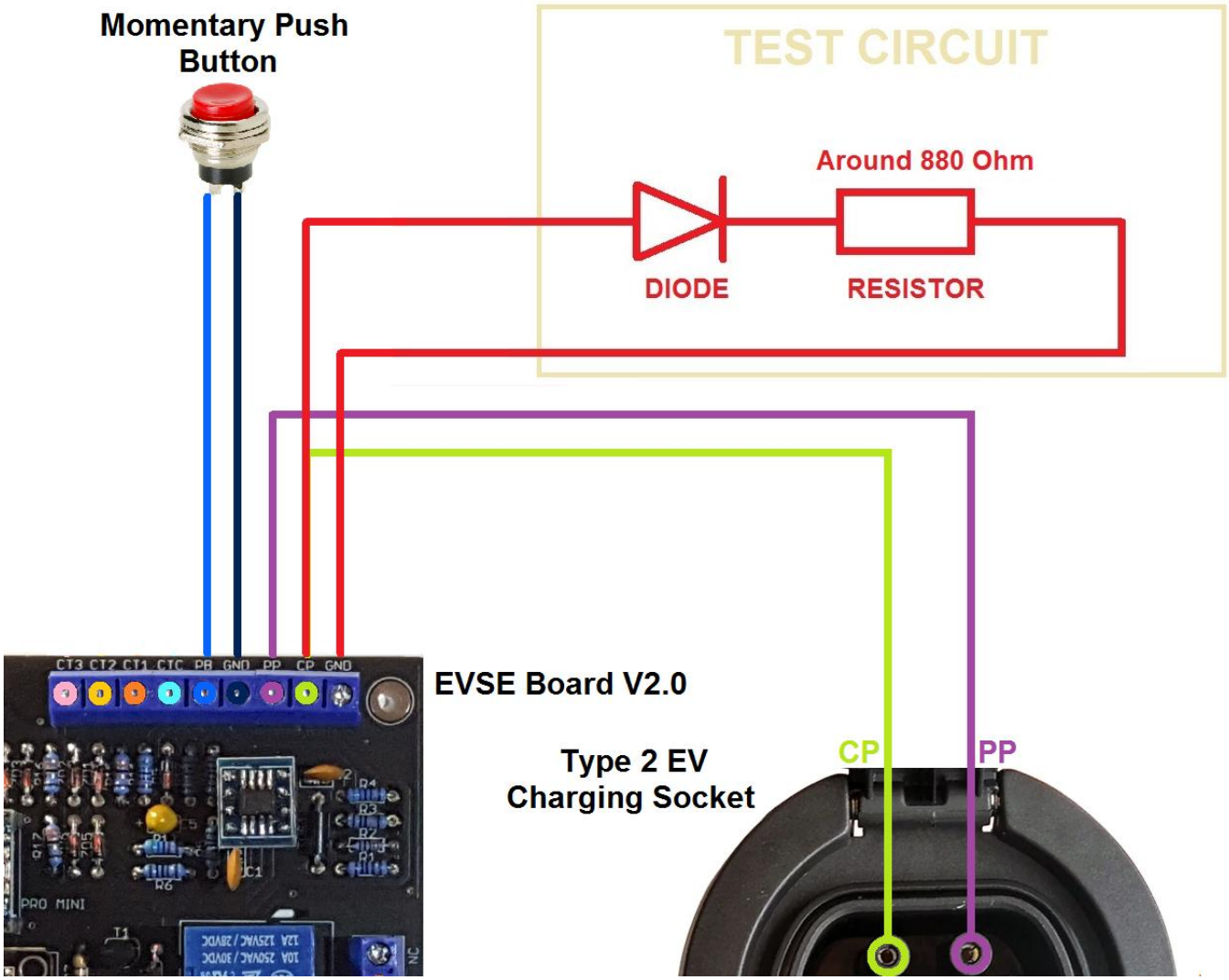
WHILE PERFORMING THIS TEST ALWAYS SWITCH THE GRID MAINS POWER OFF BEFORE GETTING NEAR EVSE INTERNAL COMPONNETS!

Install diode and resistor as shown in this picture.



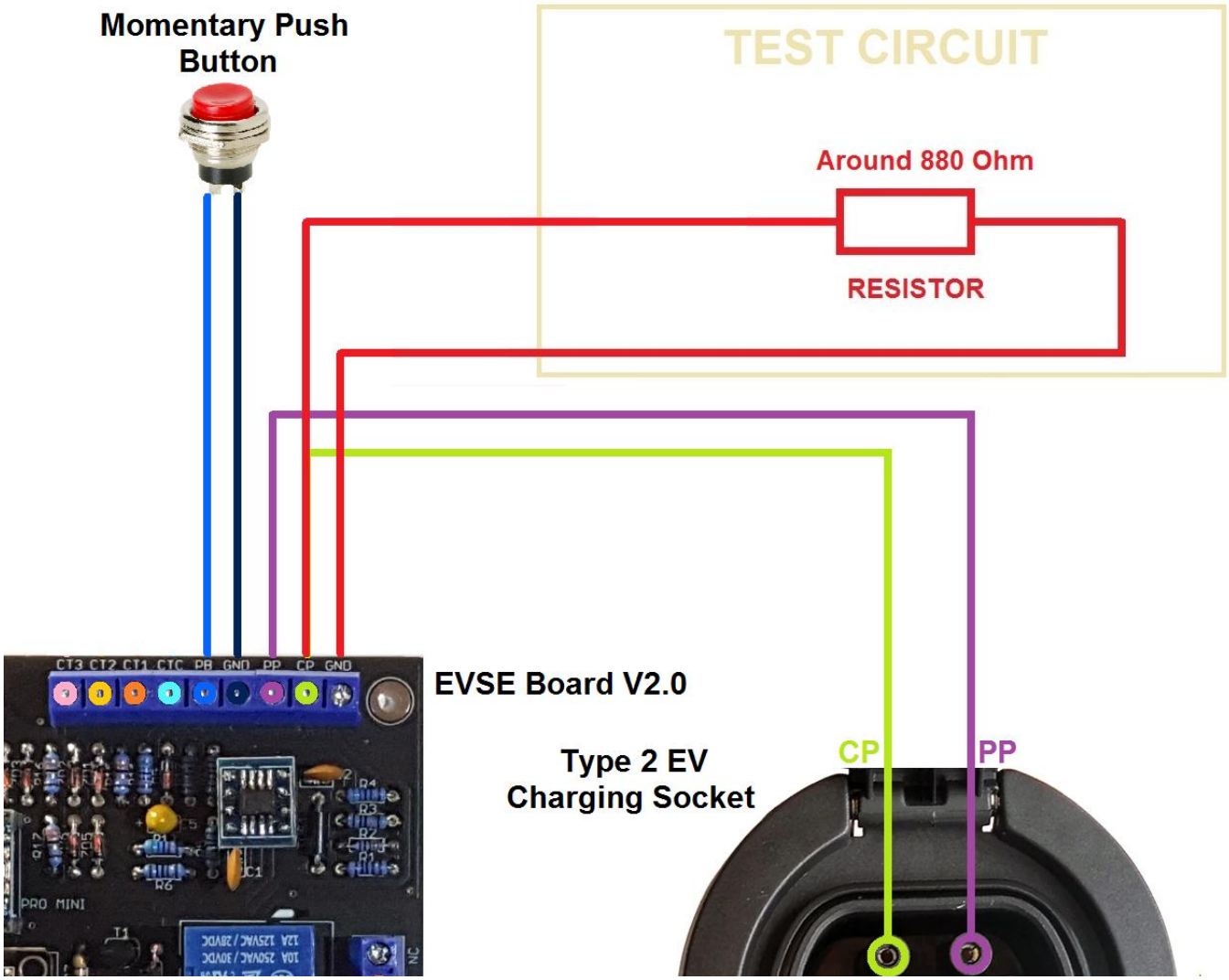
After you've done this, close enclosure and do not touch any components or wires of your EVSE. Switch mains power on. You should see "CONNECTED" on your EVSE LCD screen.

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



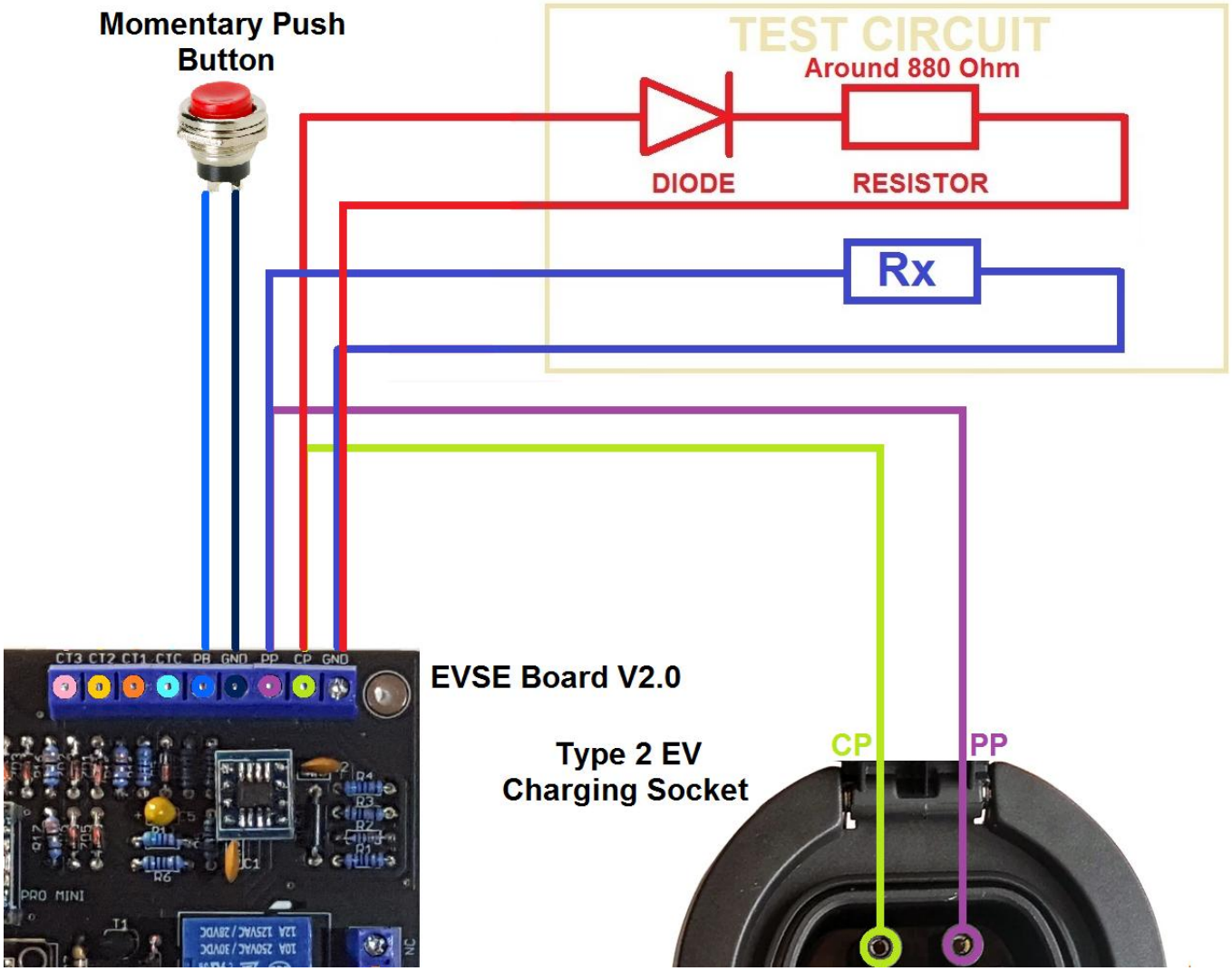
After you've connected test circuit, switch the mains power on again without touching any wires or components of your EVSE. This time you should hear relays clicking and LCD display showing "CHARGING" or battery symbol.

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.

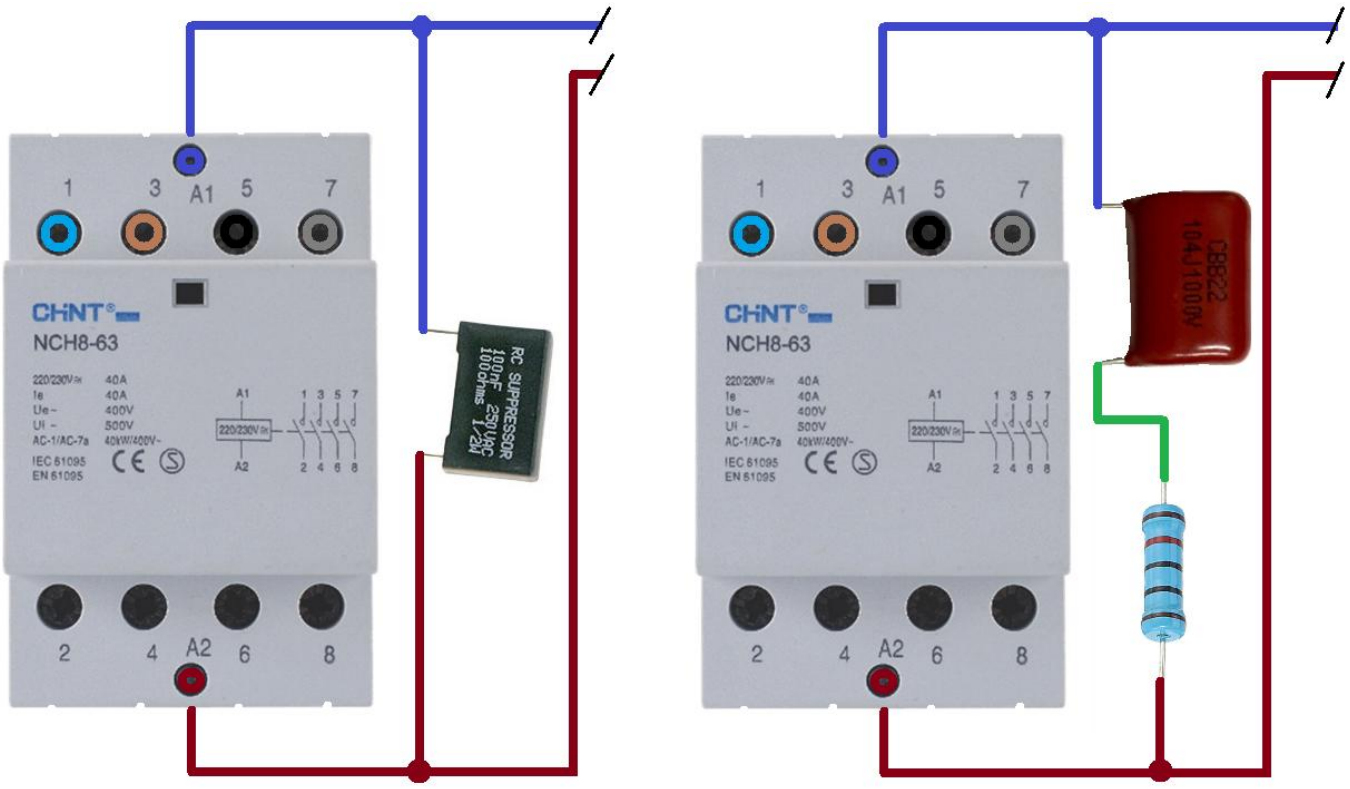
If all tests passed, congratulations, you've finished the project successfully. If any tests failed, please go over this manual again and check, if all components connected and soldered correctly, check if all wires connected correctly. If you can't trace the problem, please contact us for troubleshooting.

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.

8. Known issues and guidance to resolve them

1. Some LoLin boards get damaged instantly when connected to our DIY EVSE main board. Go back to page 6 to see why this happens and how to prevent it.

2. LCD starts displaying random symbols after contactor was engaged or switched off. This is caused by EMI (Electro-Magnetic Interference). EMI corrupts data sent on I2C bus. There are few ways to prevent this from happening. First and probably the main way is to use correctly rated RC snubber connected to contactor AC coil. Although some top brand manufacturers include RC snubber in their contactor design, many cheap contactors have no RC snubber integrated in them. So you must always check contactor datasheet and see if it's present in your contactor design. If not, or you can't find such information, please always use additional RC snubber. Component values will vary depending on contactor coil characteristics. But usually they are 0.1 to 0.5 uF capacitor (it must be rated not less than 600 VAC) and a 20 to 200 Ohms resistor (0.5...5 Watt). Also you can choose RC snubber which has all needed components integrated in one component. RC snubber must be installed as close as possible to contactor coil terminals. See the following example picture:



Other ways to minimize EMI:

- Keep LCD and other microcontroller signal wires as short as possible. The longer they are the higher possibility that they will be affected by EMI.
- Use ferrite bead on LCD wiring.
- Use shielded wires for LCD and button switch, connecting drain wire to GND terminal on EVSE board. Note that drain wire must be kept shorter than 5cm.
- Never run microcontroller signal wires close or parallel with AC wires.
- Microcontroller signal wires should be routed as far away as possible from relays, contactor, power supply unit and other noisy equipment.
- Keep checking for firmware updates, as we plan to update our firmware with code which would reset I2C bus more often, so LCD would not be much affected even if you couldn't eliminate EMI in your setup.