EMW JuiceBox – an Open Source 15kW 60A Level 2 EVSE

V8.0 Build Instructions (matching V8.0 July 22 PCB edition)

August 25, 2013

<VIDEO OF THE ASSEMBLY – COMING SOON>

Message from the Founder

Dear Fellow EV Enthusiast!

Congratulations on purchasing the 15kW 60A Open Source JuiceBox Kit!

By assembling this device yourself, you will better understand how the modern EV charging systems work and will enjoy your EV much more – knowing that you have built part of your charging 'infrastructure' yourself.

You will also learn a good bit about open-source microcontroller hardware - the exciting revolution that is happening in the hardware world today. By moving power to make things from big corporations to people like you, we all will innovate faster and make things better faster for all to enjoy!

Finally, you will be able to easily adapt the JuiceBox to your liking – all the designs are completely open source and the latest versions are always available from Electric Motor Werks. Contact us anytime at charger@emotorwerks.com if you have any questions.

Thank you again for joining us on this journey to more sustainable and fun transportation!

A special thank you goes to all our KickStarter backers! Without you, this product would not exist. If you are not our KickStarter backer, check out our original KS campaign at http://www.kickstarter.com/projects/emw/emw-juicebox-an-open-source-level-2-ev-charging-st - it's got a lot of good info on the product, our philosophy and what we are trying to do.

This is NOT just another EVSE!

Go Electric!
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Valery Miftakhov, Founder, Electric Motor Werks, Inc. – on behalf of our great Team!

CAUTION!

This is a High-Voltage, High-Power design.

It is NOT your average weekend electronics project so do NOT treat it like one.

If not approached with caution and extreme attention to detail, this project can kill you, burn your house, etc.

By starting this project, you expressly agree that neither EMW nor any of its directors, employees, or partners are liable for any damage that may result from this project and associated activities.

Furthermore, there is no explicit or implicit warranty or guarantee of applicability for any particular purpose. For JuiceBox Kits, EMW will only warranty the parts to be free from manufacturing defects for 1 (one) year from the date of purchase. For the assembled units, EMW will warranty the parts and complete assembly to be free from manufacturing defects for 1 (one) year from the date of purchase.

Release notes for V8.0

You MAY receive a partially assembled board. In this case, please go through the instructions below and identify parts that are not installed. Follow instructions to place them

You MAY receive an incomplete KIT. As mentioned in our KickStarter update #16 (linked from our main KickStarter project page at http://www.kickstarter.com/projects/emw/emw-juicebox-an-open-source-level-2-ev-charging-st), we have decided to start shipping electronic part of the kit before the cables and enclosures – this will allow you to get started on assembly / software testing while we are waiting for shipments of the remaining large parts to come from China. A container ship takes up to a month to cross the ocean so we understandably have some delays.

Build support

Just like with our other products (see http://emotorwerks.com/tech/electronics for example), we are committed to getting our customers to the finish line on their builds! We have never abandoned a single customer and some of our build assistance threads run into hundreds of emails on our most complex products!

That said, we CANNOT offer phone support for any consumer purchases. This is how we are able to maintain our low prices – phone support is EXTREMELY expensive and INEFFICIENT. It is a well-known fact that email resolution of a problem costs less than 20% of the cost of resolving the same problem over the phone. A lot of times, it is also faster to resolve things over email. Finally, in email, there is always a record of what's happening – which is always very useful for debugging issues.

As a summary, only email support will be available. Email all JuiceBox questions to JB-support@emotorwerks.com

Finally, please understand that we assume that if you bought a KIT and not a fully assembled product, you know what you are doing. If you have never soldered anything before, it's a BAD IDEA to buy a kit like this – see our CAUTION page for details.

Part 0. Before you start

1. **Required tools:**
    1. Soldering setup
        a. A low-power soldering station with a relatively fine element
            i. 20W MINIMUM, 40W MAXIMUM or adjustable
            ii. Something like this (what we use at EMW, $20 from Amazon)
        b. Electrical solder
            i. Make sure you never use a plumbing solder as it may have conductive flux!
            ii. Ideally 0.3-0.5mm thick
        c. If you haven't done much soldering before, check http://www.dummies.com/how-to/content/what-is-soldering-and-how-do-you-use-solder-tools.html
        d. Some quick tips
            i. Heat the lead, not solder – feed solder into the joint and let it melt & cover the entire joint before you remove the iron
            ii. Especially follow this for ground plane connections – where the pin connects to wide copper areas – they tend to dissipate heat very quickly and you will have to hold your iron on them up to 2x longer
    2. Screwdrivers
    3. Wire stripper & crimper
    4. Small snips for wire / lead cutting
    5. Small pliers
    6. Drill & drillbits (base kit with non-machined enclosure only)
        a. 7/32" drillbit for majority of the work
        b. A 1 7/16" hole saw that's rated for aluminum (available at any Home Depot store or similar). You can use a 1 3/8" size if you can't find 1 7/16" (in that case, you might need to file away a small bit of material)
    7. Multi-meter with Capacitance / Resistance measurements
        a. Also download / print the resistor color coding reference: http://en.wikipedia.org/wiki/Electronic_color_code
    8. Clear Protective Goggles
    9. FTDI cable (something like https://www.sparkfun.com/products/9716
        a. **For limited time, we will be including these in kit shipments as a token of recognition to our supporters!**)
    10. Strongly recommended tools
        a. Clamp meter with 100A+ AC current measurement capacity (something like this – $40 on Amazon)
        b. Infrared thermometer such as this ($40 on Amazon)
        c. Scope with at least 1MHz bandwidth. You can get one of these small units – they are open source and generally don't have huge bandwidths / feature sets but will do the job just fine. In fact, we love these due to their portability – you can take this battery-powered unit anywhere!

2. **Required components (commodity hardware etc) - not included in the kit**

1. 8-32 machine screws: 8x 1.5” long
2. 8-32 locknuts or regular nuts + lockwashers: 8x
3. ~6 feet of the signal wire (AWG22-24 is ideal) to make various connections (heavy-duty power wire and lugs are included with kit)
4. In some early kits, we did not include nylon spacers (our mistake) – in that case you’d need 4x 3/8”-1/2” long #8 nylon spacers for PCB mounting

3. Helpful aids

1. Flat piece of thin plastic / carton to hold the parts while you turn over the board to solder so that components don’t fall out
2. Small soldering vise to hold PCB while you solder
3. Magnifying glass to read small parts’ markings

4. Assembly Tips

1. Sequence of assembly is often quite important: some parts may not be able to fit after others have been soldered – be especially careful in the areas where parts are placed from both sides of the board
2. Read instructions for the ENTIRE step before proceeding with the first instruction under that step. Ideally, you should scan this entire doc before starting assembly
3. Place many parts at a time, bending pins on the other side of the board so that the parts stay in place when you turn over the board to solder
4. To prevent circuit shorts, make sure all unnecessary solder is cleaned from board.
5. Do not overheat the SMD parts – short leads make them prone to overheating. Set your soldering gun to 330-340C
6. It is a good idea to use the standard resistor color code for wire colors on connectors. So brown=1, red=2, ..., white=9, black-10, then start again with brown=11. Or you can use white/brown stripe for 11, etc.

5. Education

1. Wouldn’t it be nice to actually understand what you are building?
2. You can pick up quite a bit by looking at a few good references
    a. http://en.wikipedia.org/wiki/SAE_J1772
    b. http://code.google.com/p/open-evse/wiki/J1772Basics

Part 1. Project description

Assuming you have all the tools available, and have good experience in electronic assembly, you should allow 1 hour for PCB assembly, 1 hour for component mounting and wiring, and ~1 hour for testing of the Base version and 2x that for the Premium version.

This does not include the time required to make any adjustments you might need to make to your house's electrical system to provide adequate / desired AC power to JuiceBox.

To provide AC power to the JuiceBox, we recommend you to have a standard 14-50R RV outlet installed near the location where you are planning to mount your JuiceBox. You could also plug the JuiceBox into the 30A dryer outlets but the power will be limited to the outlet rating (note that you still have to set the power limitation on the JuiceBox – it will NOT automatically sense the power capability of your circuit – all 240V sources will look the same to the internal circuitry).

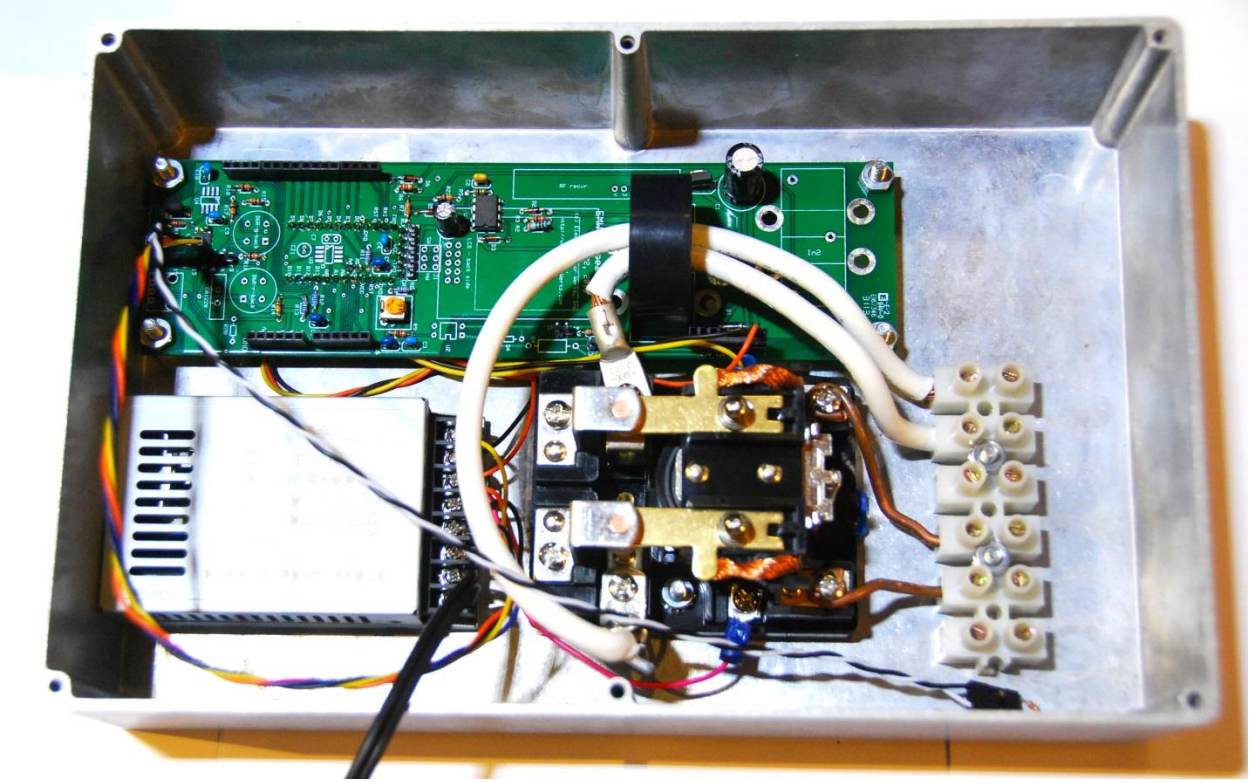
Some stats:

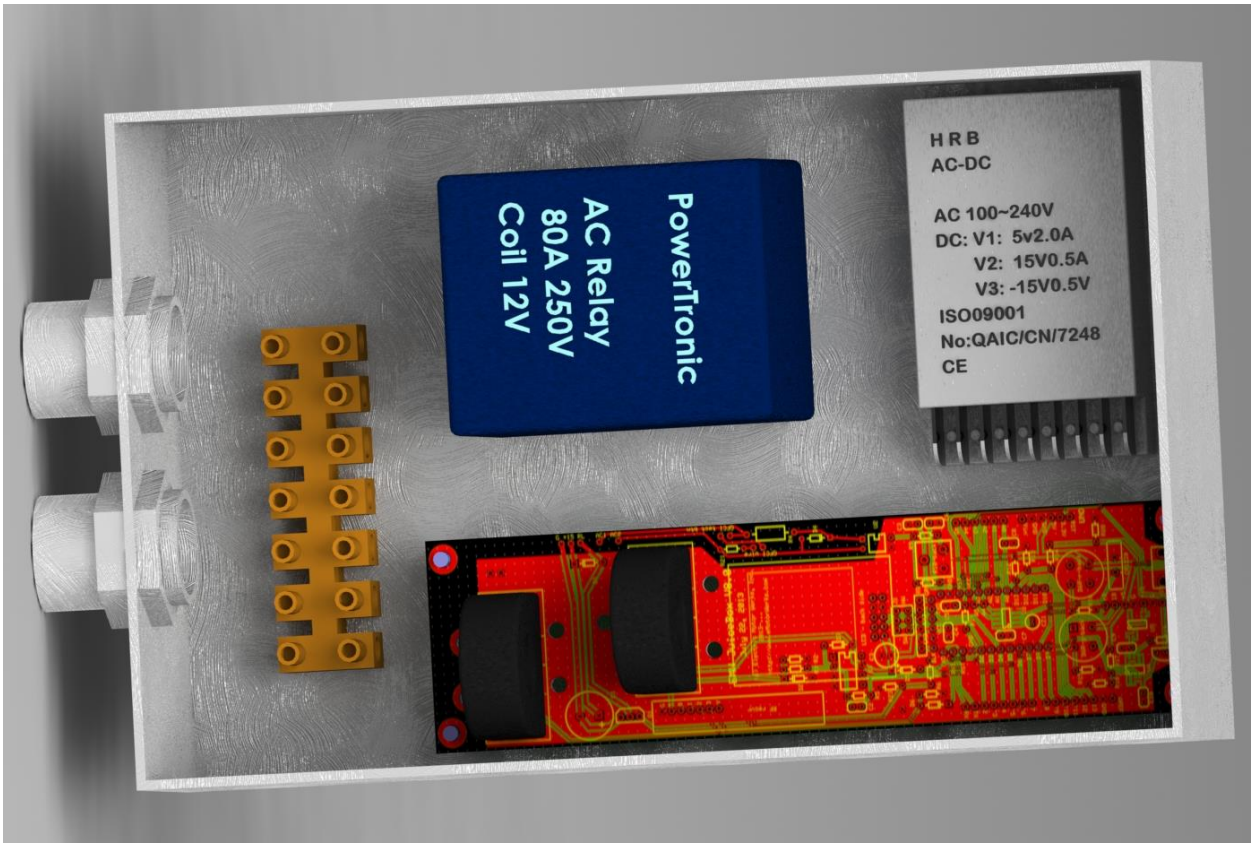
1. Total electronic parts count: ~50 for Base version, 55 for Premium version
2. Total unique electronic part count: ~30 for Base, ~50 for Premium
3. Total other electric parts: ~20 (e.g., relay, power supply, wiring, etc)

Overall build reference:

Use the image below to get a general idea of relative placement of components (Base Edition shown). Specific details are described in the corresponding sections of this document.

Note: shown with 6-position terminal input strip (7-position in the CAD rendering). The final layout uses 4-terminal strip, with direct input AC connection to the relay. See the wiring instructions below for full info.





Part 2. Kit Contents

Please refer to the Bill Of Materials file <COMING SOON> on our site for more details on component lists, part numbers, etc: http://www.emotorwerks.com/JuiceBox_Public/.

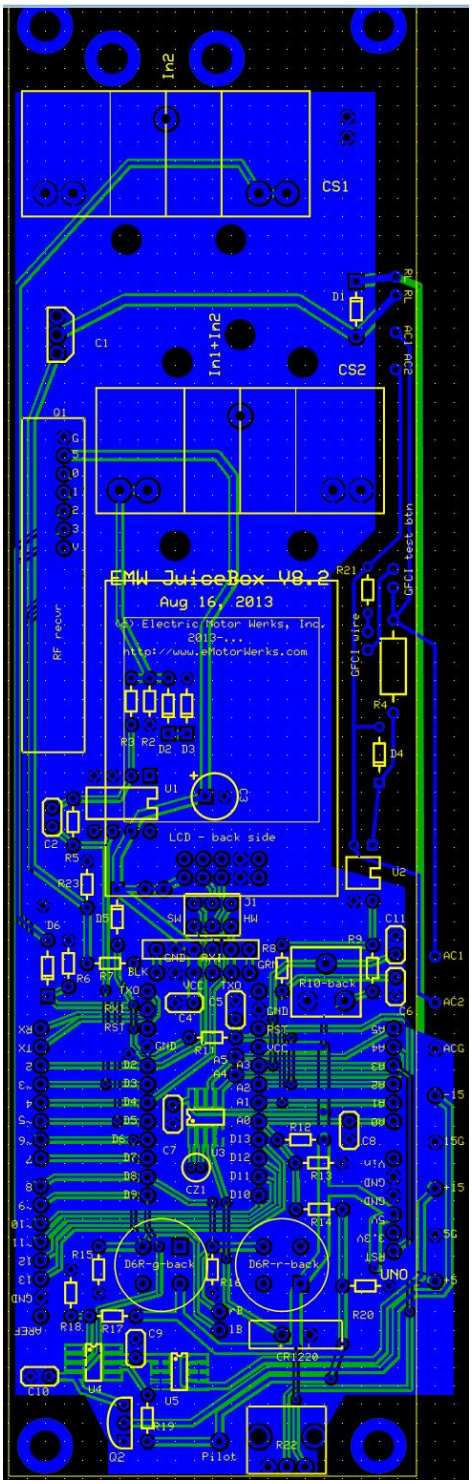
Tip: enter part number into the DigiKey (http://www.DigiKey.com) search box to get a detailed part info page with full datasheets, photos, etc.

Most of the smaller parts will be placed in a plastic organizer, with types of parts separated (all resistors in one compartment, capacitors in another, etc.). Majority of the parts will have clear manufacturer labeling on them, except resistors. You will have to use a color-code aid to decipher the resistor values (see required tools section above for links to all such aids)

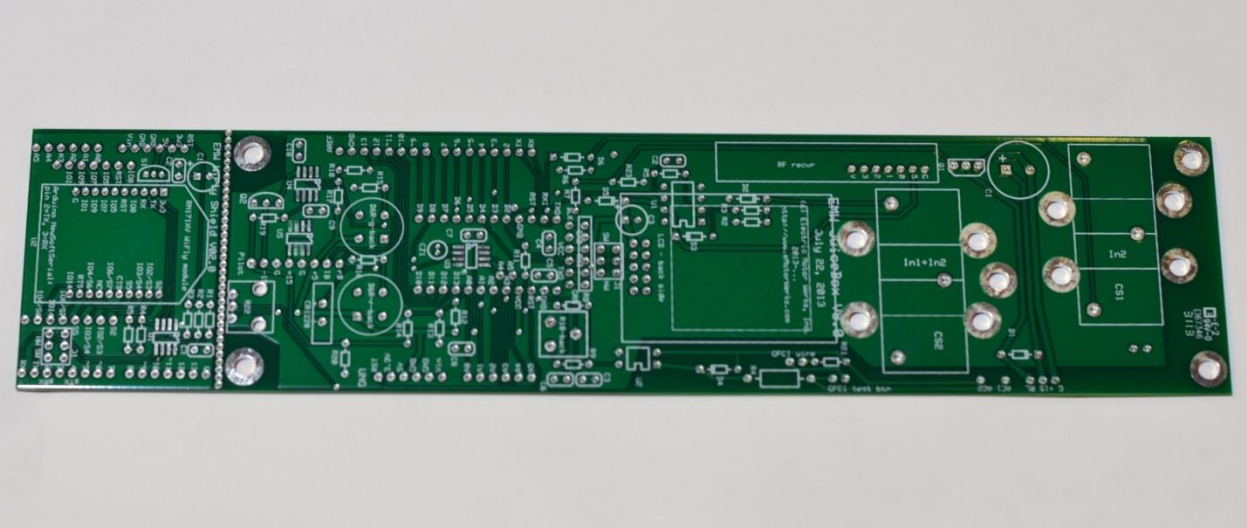
<PIC OF KIT HERE – COMING SOON>

Part 3. Assemble the main PCB

PCB file (V8.2 shown below, for V8.0 refer to http://www.eMotorWerks.com/JuiceBox_Public/)



This is how the PCB will look when you receive it (shown together with an optional WiFi shield on the left – if you did not order a WiFi shield, you will just get the main board on the right side):

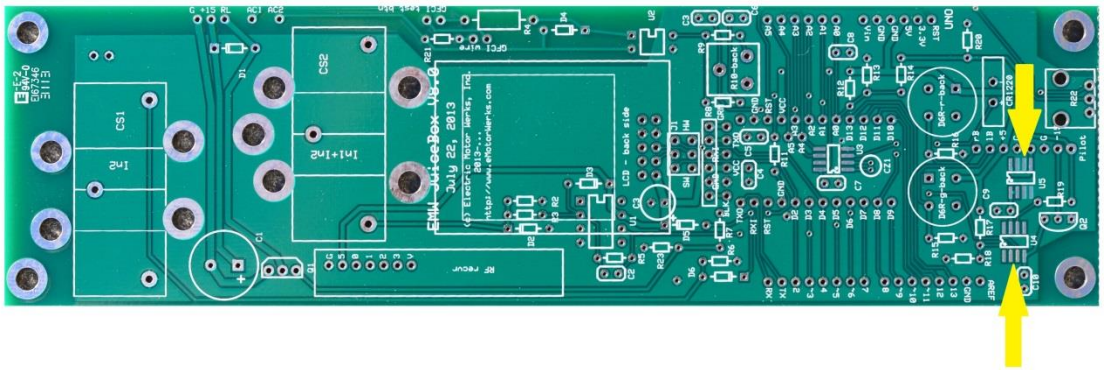


Note: there WILL ALWAYS be some part outlines on the board that are NOT filled in – we are using universal boards that fit many variations of the product. This allows us to lower your prices quite dramatically. Please do not panic if you 'don't have all the parts' – follow the instructions, identify the parts you really need, find them in your kit and if you still believe you're missing parts, then contact us.

Note: as mentioned in a KickStarter update, we will be shipping some first kits with nearly fully assembled boards. See KickStarter update #16 for more details (http://www.kickstarter.com/projects/emw/emw-juicebox-an-open-source-level-2-ev-charging-st/posts). If you are one of the lucky recipients of such a board, you just need to go through the build sequence below and check if any parts are missing. Such missing parts will normally be included in your shipment for you to place.

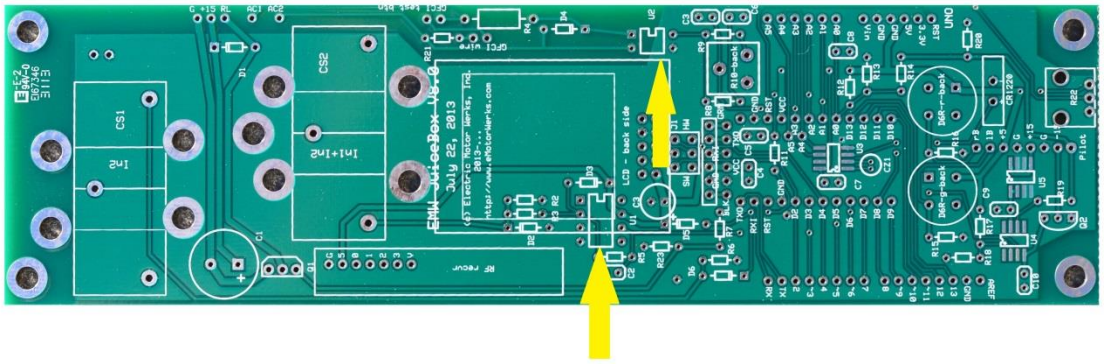
1. **Base Edition Sequence** (GFCI components marked with a * - optional for the non-GFCI version)**:**

a. Group 1: SMD components



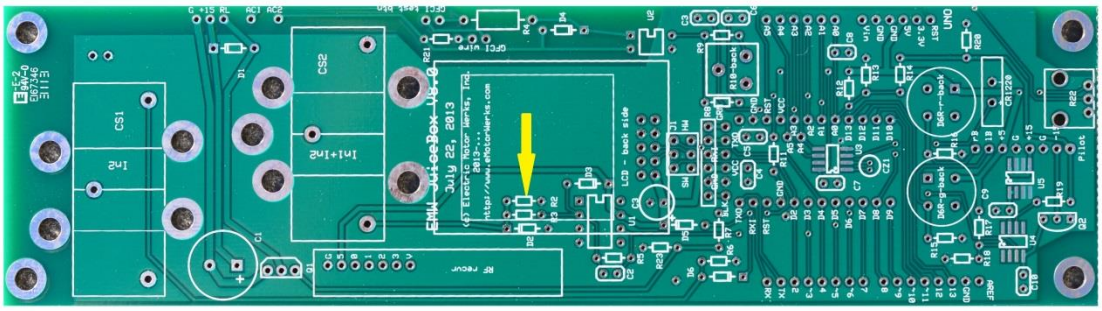
   a. Place Output Op Amp (SOIC-8 package, part ID OPA171 or LM7321MA): U4 – ENSURE CORRECT ORIENTATION!. Solder
   b. Place +12 Precision LDO (SOIC-8 package, part ID J25A3 or similar – black on black – we know it's not a convenient color scheme but that's not our fault…): U5 – ENSURE CORRECT ORIENTATION! Solder

b. Group 2: ICs

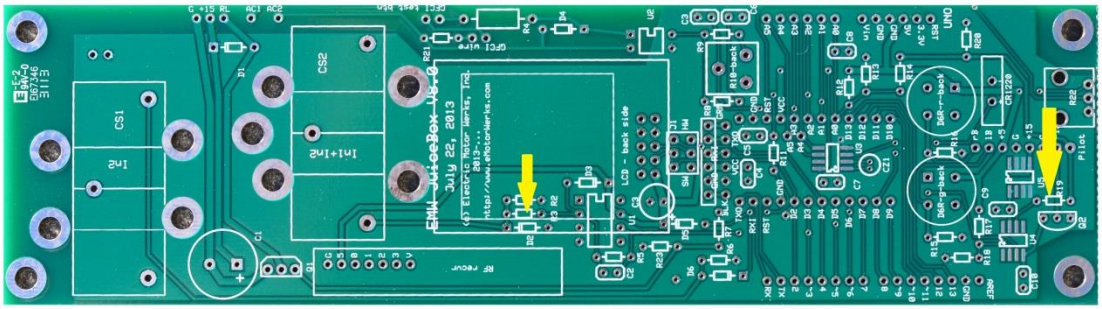


   a. Place PC 817 opto-coupler: U2
      i. Optional if you plan to always use JuiceBox in 240V mode
   b. Place MCP 6231: U1*
   c. Turn PCB over, Solder components

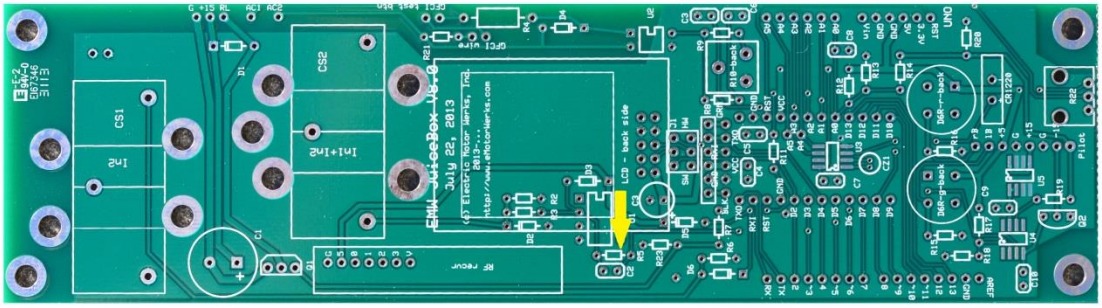
c. Group 3: Resistors, Small capacitors, etc.
    i. Resistors
        a. Place 390 ohm: R2*



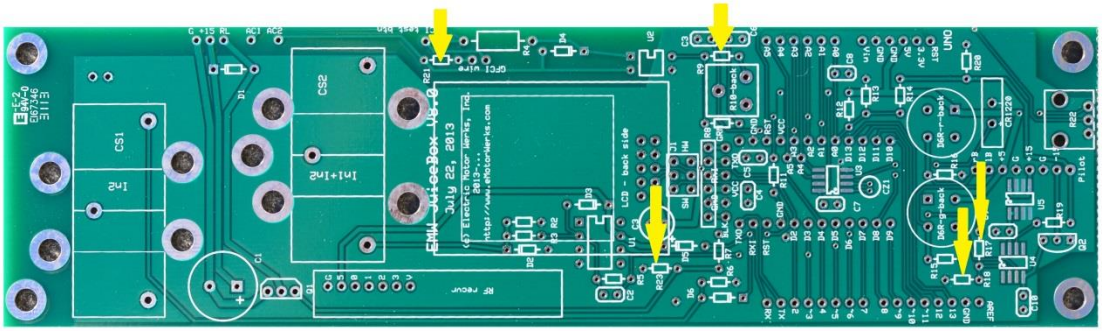
        b. Place 1k: R3*, R19



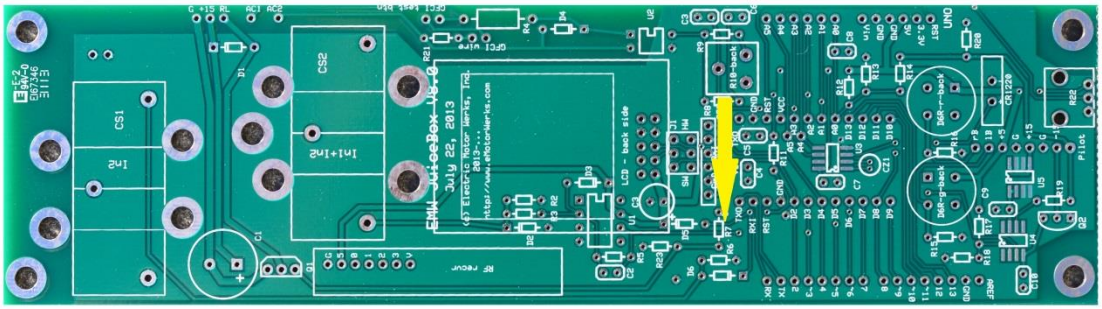
        c. Place 470k: R5* (may be supplied with 2x 1M resistors – in that case, connect in parallel)



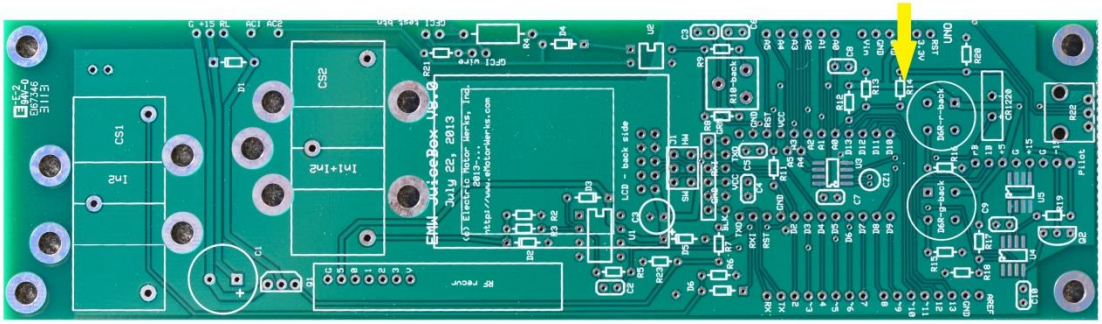
d. Place 10k: R9, R17, R18, R21*, R23



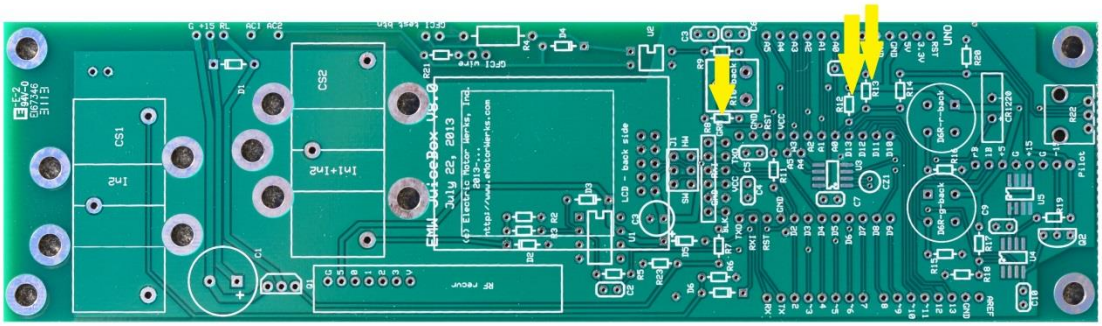
e. Place 100-120R: R7



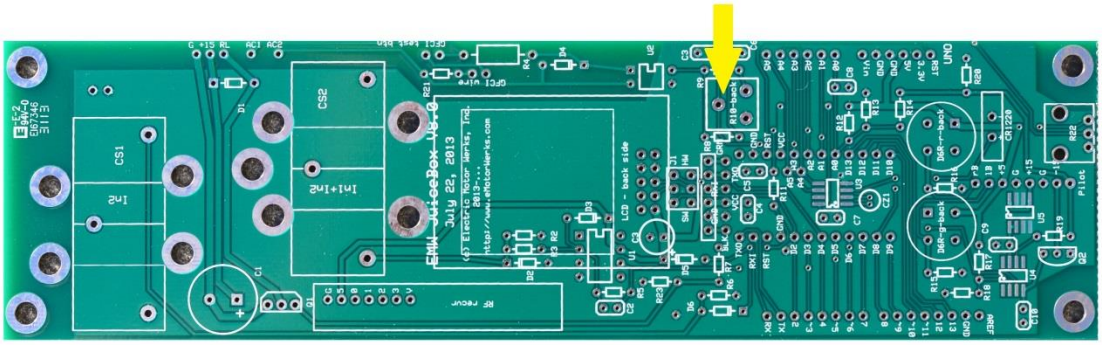
f. Place 100k: R14



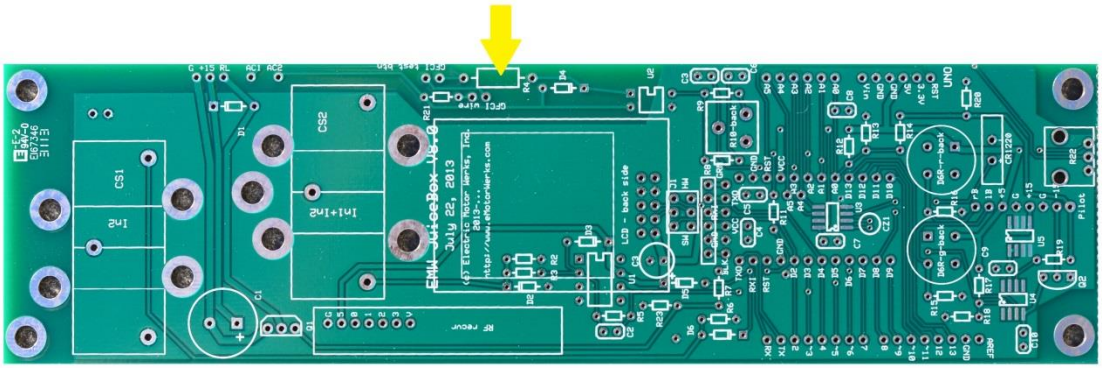
g. Place 27k: R8, R12, R13
    1. R8 Optional if you plan to always use JuiceBox in 240V mode



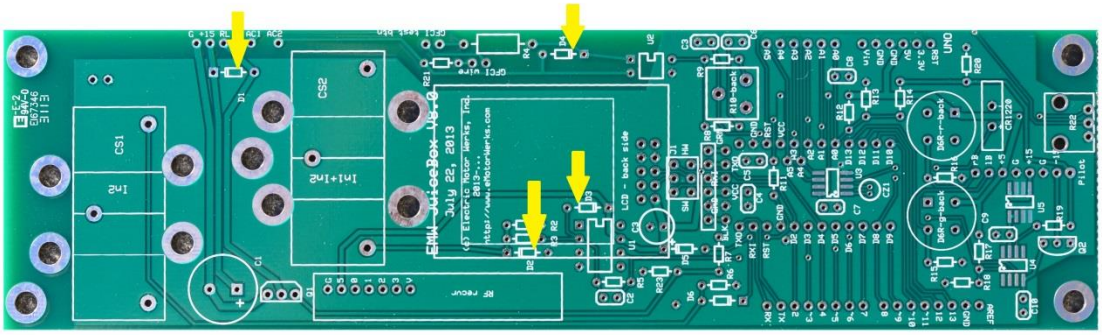
h. Place output current setting trimpot: R10
    i. If the external control of the output current limit is required / desired, you can also install R22 instead of R10 (right-angle trimpot, designed to be sticking out of the enclosure when installed – not included in the default kits)
    ii. Note that if R22 is installed and is protruding through the enclosure, the JuiceBox will no longer be waterproof or weather-resistant



i. Place 200k 1W or higher: R4
    i. Optional if you plan to always use JuiceBox in 240V mode
    ii. Try not to place flush with the board – this resistor will heat up considerably at 240V input – best to leave 3-5mm space between the resistor and the PCB



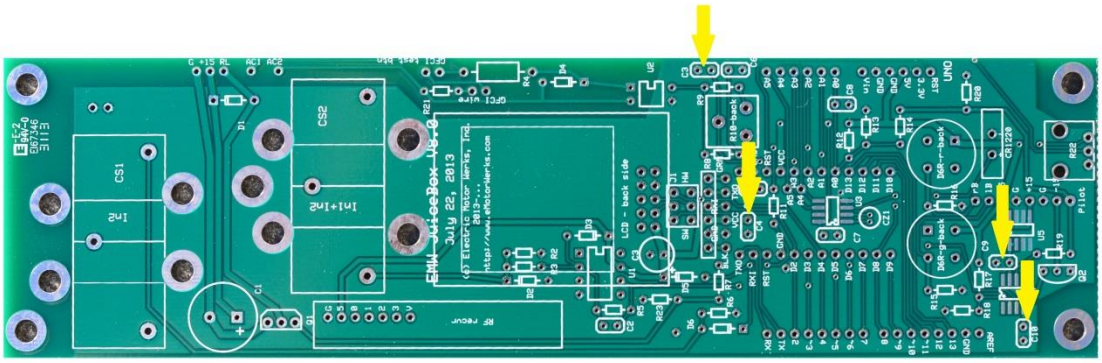
ii. Diodes
    a. Place Fast Diode: D1
    b. Place signal diodes: D2*, D3*, D4
        i. D4 Optional if you plan to always use JuiceBox in 240V mode



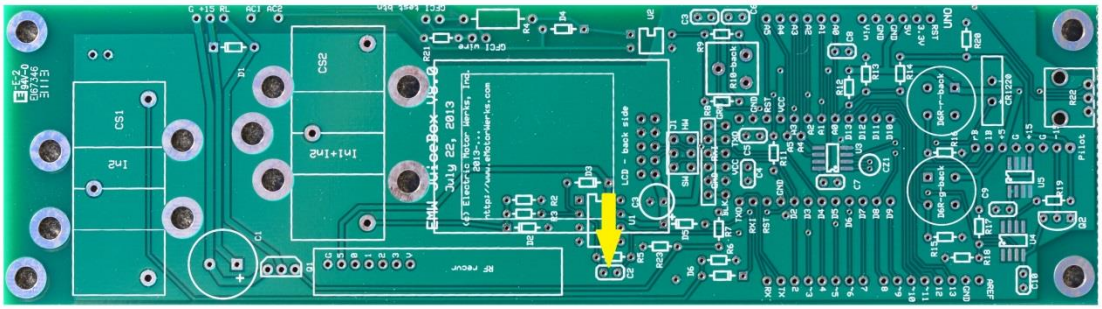
iii. Capacitors

a. Place 0.1uF (104) cap: C4, C9, C10, C11

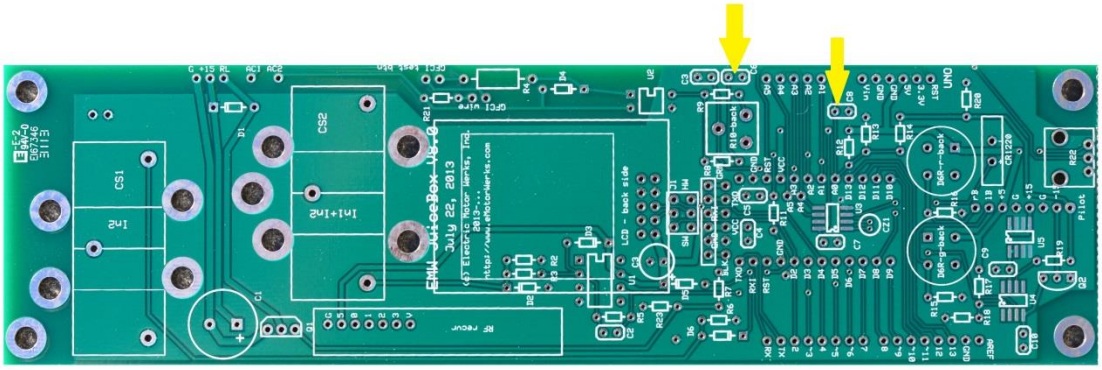
i. C11 may also be marked as C3 on some early boards (next to C6)



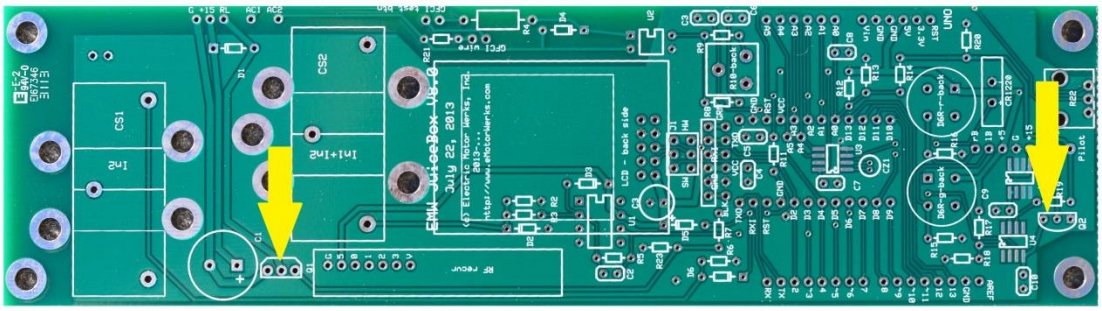
b. Place 330 cap: C2*



c. Place 3.3uF (335) cap: C6, C8

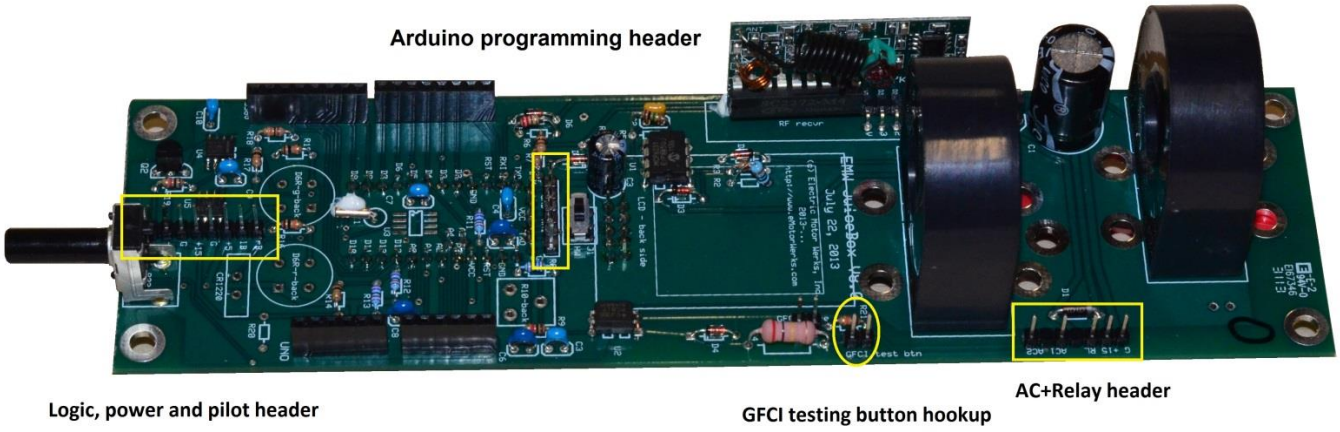


iv. Other semiconductors
    a. Place -12V LDO regulator (TO-92 3-pin package): Q2
    b. Place 30V 6.9A N-channel FET (NTD4815N-35G): Q1



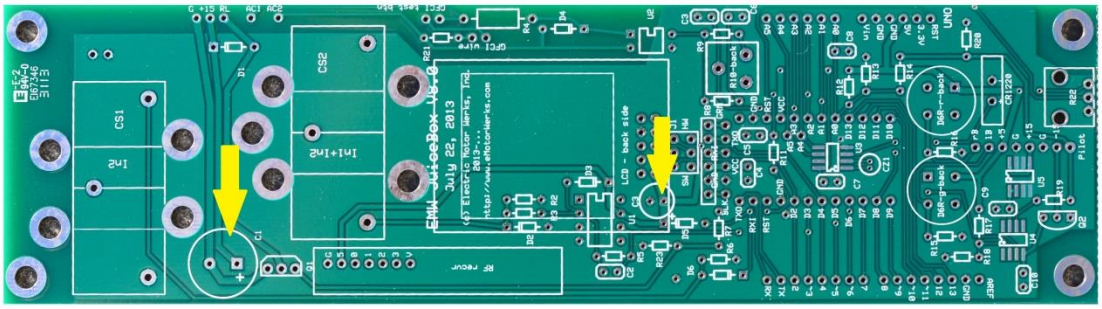
v. Turn PCB over, Solder components, cut the leads.

d. Group 4: Pins and Sockets
    i. Place 0.1” Male Pins: Refer to picture- will need
        a. 1x 6-pin: Arduino programming header
        b. 1x 2-pin*: GFCI testing button hookup
        c. 1x 7-pin: AC + Relay header. This header could be replaced by wires simply soldered to the board
            i. If you use a header, you will need to pull 2 of the 7 pins to allow for spacing between high-voltage pins
        d. 1x 6-pin: Logic power & pilot header.
            i. This header could be replaced by wires simply soldered to the board
            ii. You would use only bottom 6 positions on the board

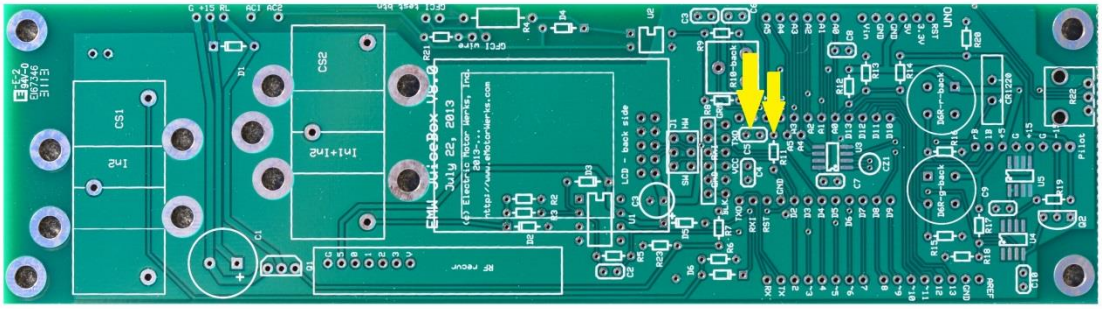


ii. Place flat object over top of the board to hold everything in place and turn PCB over, solder pins

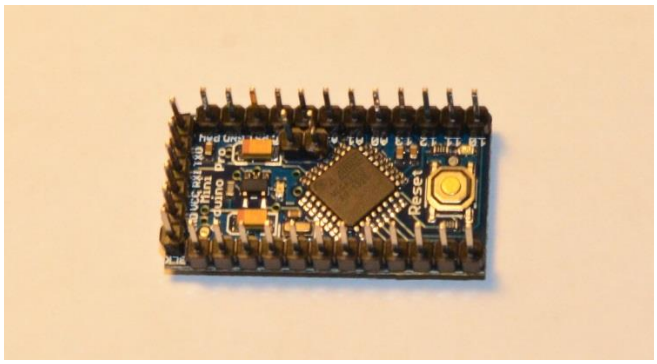
e. Group 5: Larger Top Board components
    i. Place 47uF 16V (or higher) capacitor: C3
    ii. Place 330-1000uF 25V (or higher) capacitor: C1
    iii. Turn PCB over, solder, cut leads.



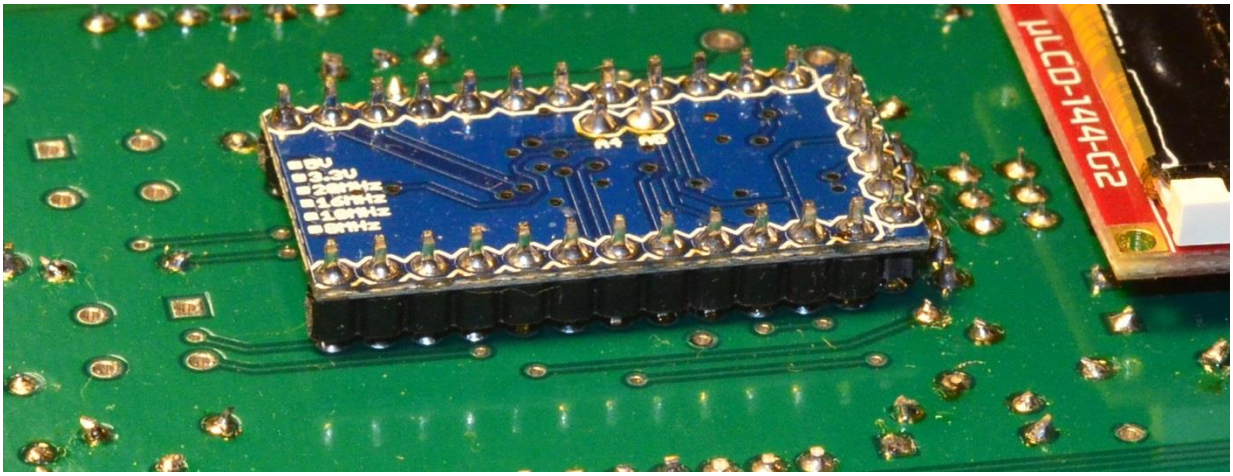
f. Group 6: Back Side Components
    i. At this point, check all your solder connections – once you place parts on the opposite side, it will be very difficult to correct any placements under then
    ii. **Note:** if you think that you MIGHT later upgrade your JuiceBox to Premium edition, you will need to place R11 and C5 components now!



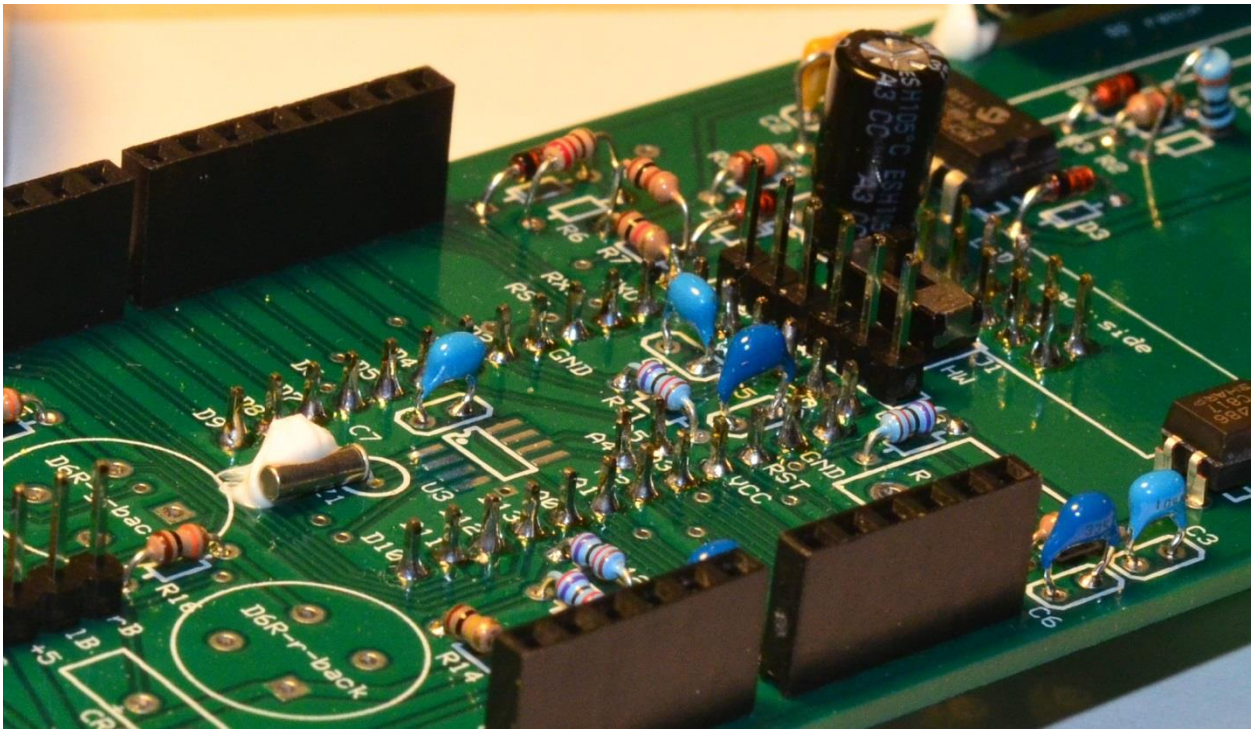
    iii. Place Arduino Pro Mini 5V
        a. Make sure all Arduino pads have pins soldered to them & those pins stick out from the COMPONENT side of the Arduino board



b. Arduino is inserted from the Back Side of the main PCB- refer to the picture below

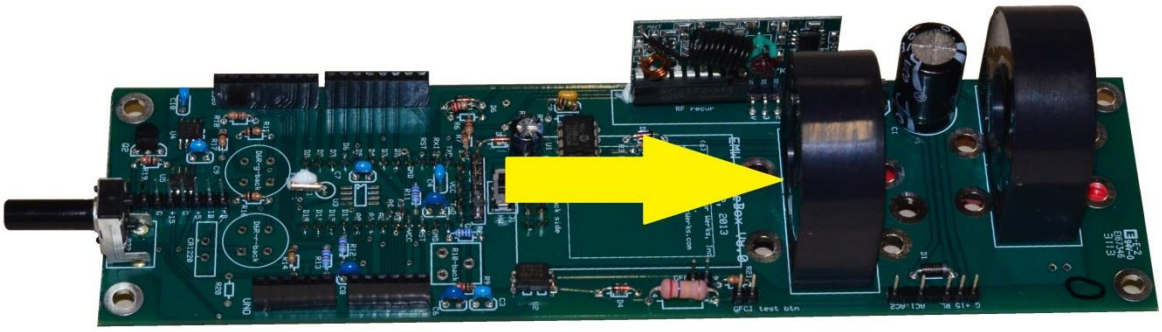


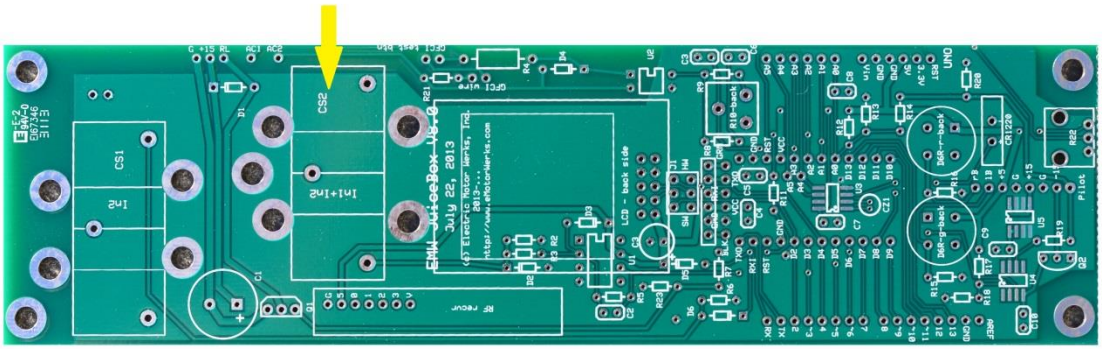
c. Do not insert Arduino board all the way to avoid shorting of the to the board / leads of components inserted from the other side – keep 5-6mm clearance between the Arduino board and the main PCB & visually check clearance to any component leads that might be sticking out from the other side



iv. Turn over to the top side of board and solder pins.

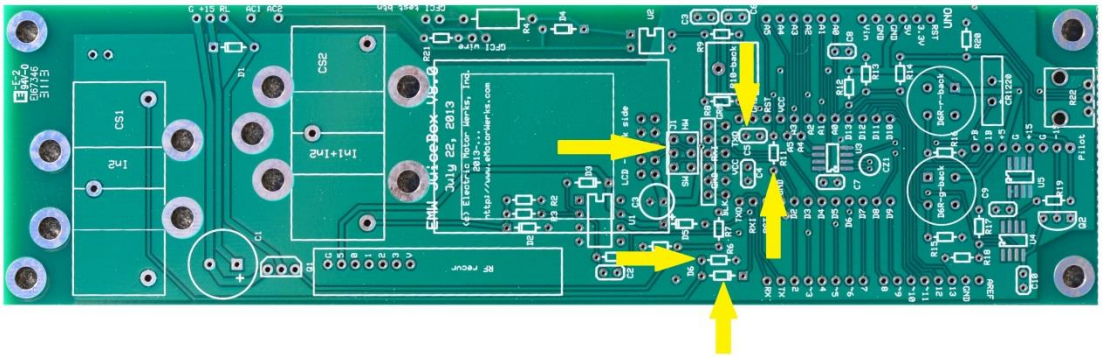
g. Group 7: Largest Top Board components
   iv. Back on the main component side of the board
   v. Place & solder GFCI Current Transformer: CS2*
   vi. Cut 4.5-5” of the signal wire, thread through the transformer you just placed, and solder the ends to the ‘GFCI wire’ pads



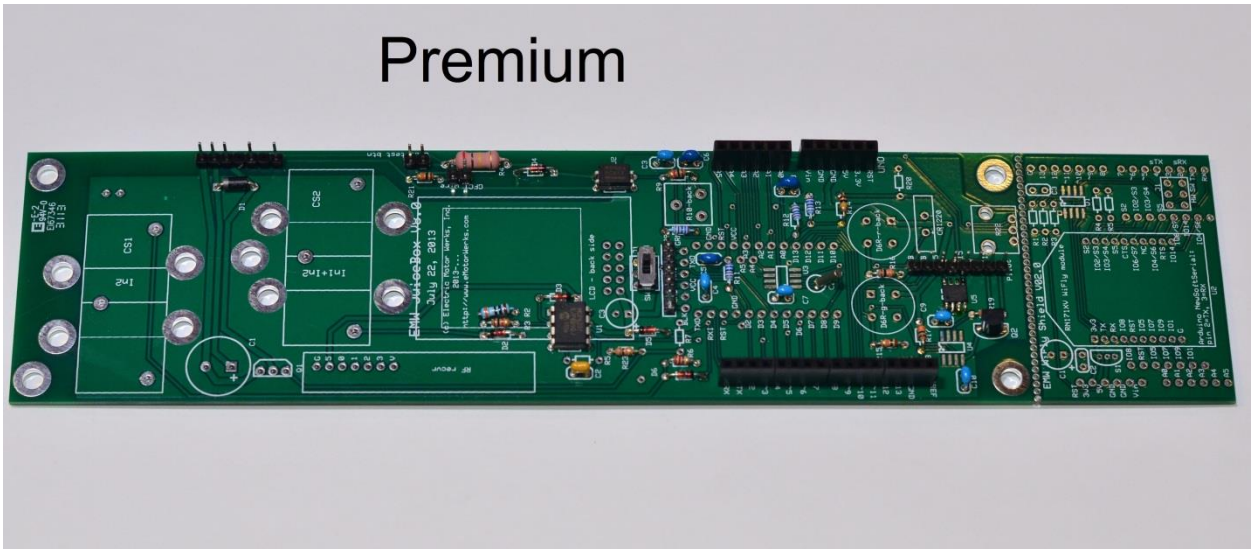


2. **Premium Edition sequence:** Above Sequence with Additional Parts. PLEASE use the Base Edition sequence and refer to this section for additional parts GROUP BY GROUP. Failure to do so will result in difficult assembly due to broken sequence of part placement!

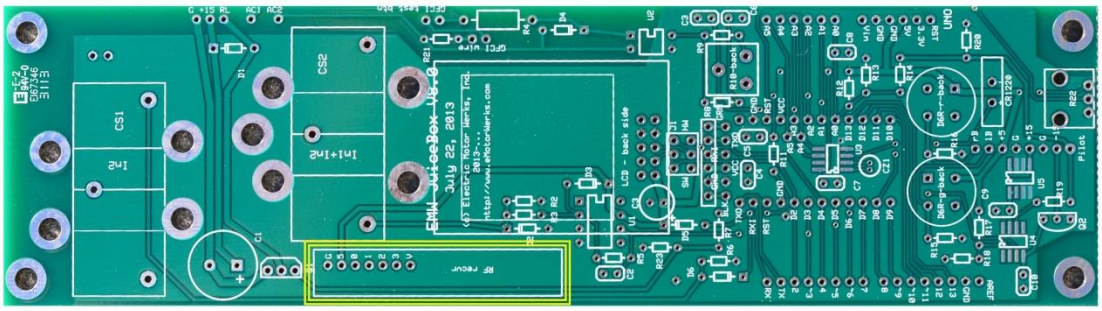
a. Group 3: Extra Parts
    i. Place 120R: R6
    ii. Place 27k: R11
    iii. Place 3.3uF: C5
    iv. Place signal diode: D6
    v. Place Slide Switch: J1



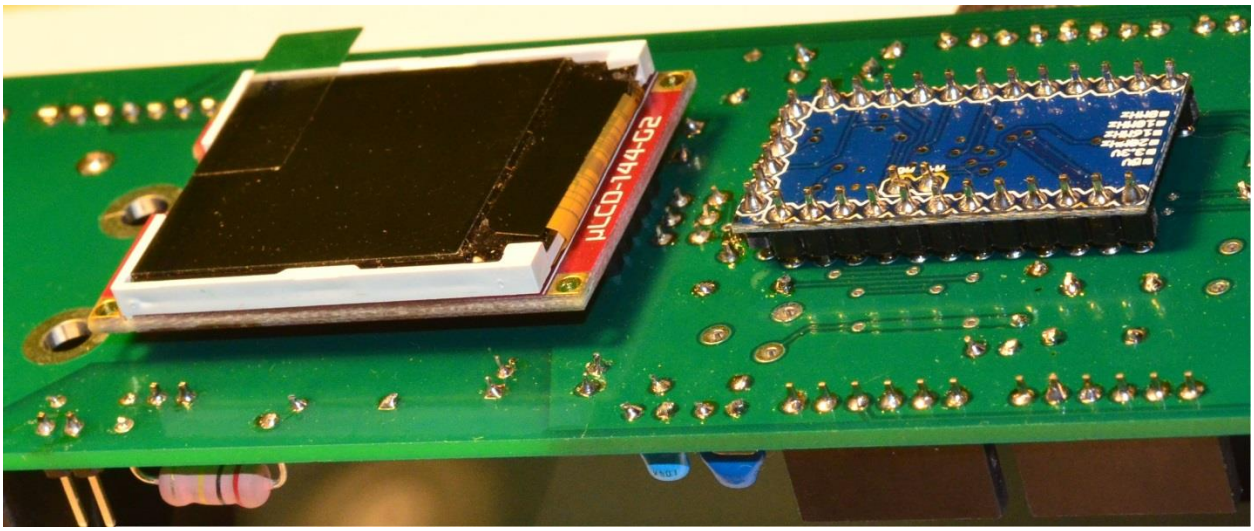
b. Group 4: Extra parts
    a. Place 0.1” Female Sockets for Shields:
        i. Optional – needed only if you plan to install shields
        ii. Refer to picture- will need 2x 8-pin and 2x 6-pin
    b. Place flat object over top of the board to hold everything in place and turn PCB over, solder pins
    c. This is what the board should look like at this stage (shown with an optional WiFi shield):



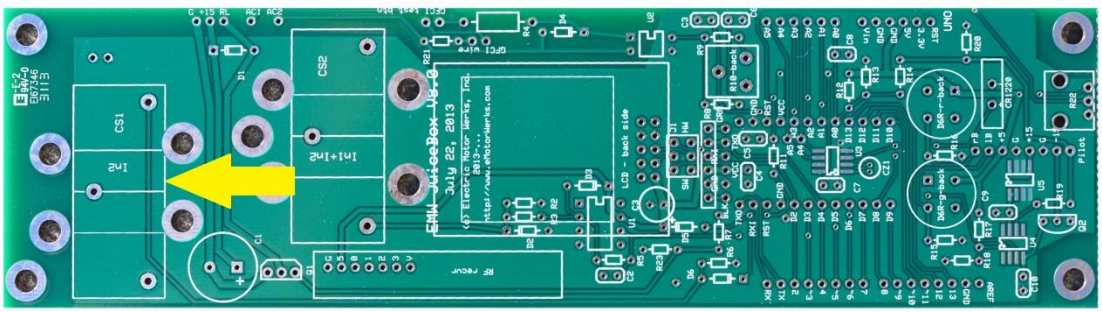
c. Group 5: Larger Top Board components
    i. Place RF Receiver: labeled on board as RF recvr, pins orient pins to match labeling



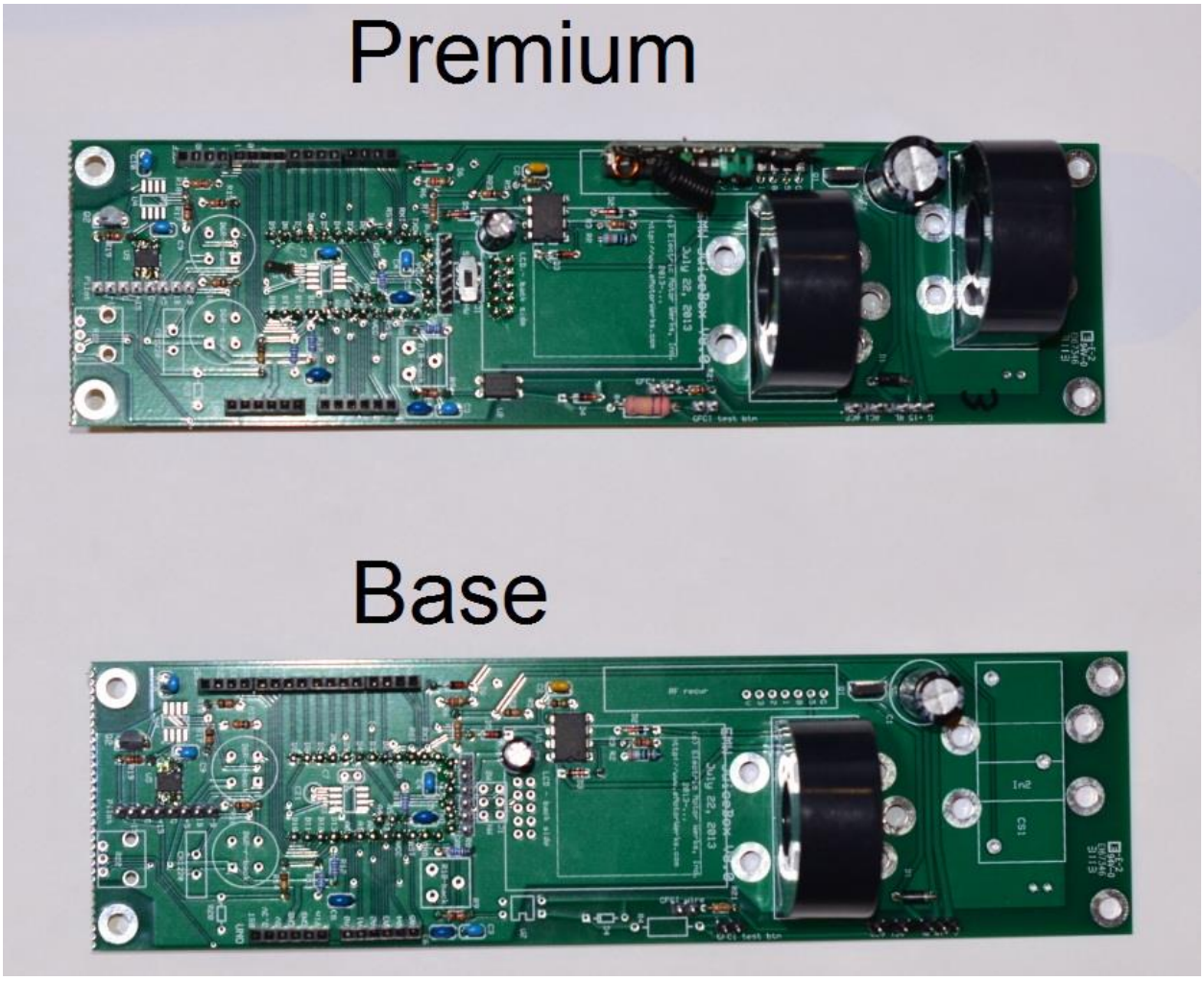
d. Group 6: Back Side Components
    i. Place LCD: labeled as LCD-Backside on top of board.



e. Group 7: Largest Top Board components
    a. Place Current transformer: CS1



These are the completed boards (GFCI versions shown):



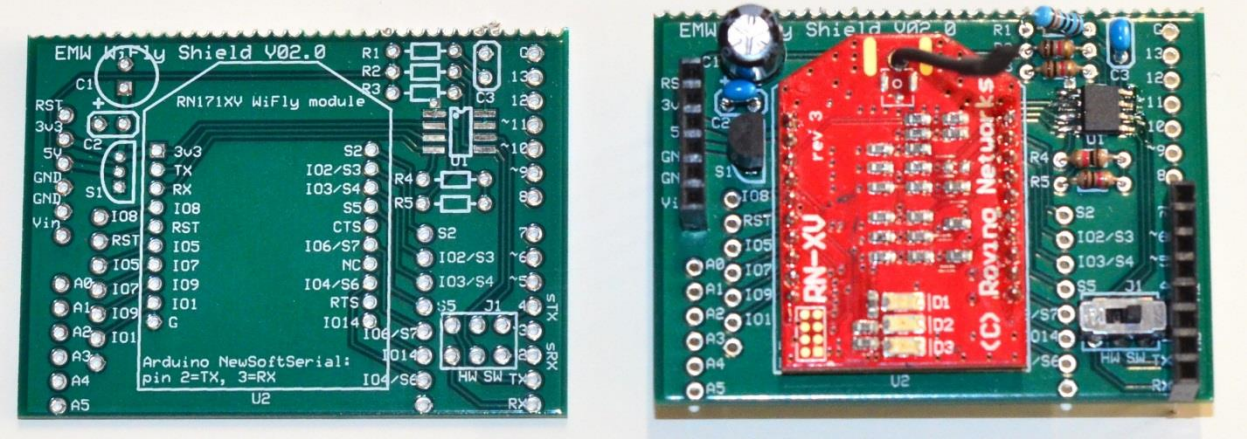
WiFi Shield board assembly

Note: do not overheat SMD parts

1. If the main board is not yet separated from the WiFi shield board, break them apart. Use a file to file away any remaining metallization in the perforation holes
2. Group 1 – SMD components
    a. Place & solder the level translator IC (PCA9306): U1
3. Group 2 – ICs
    a. Place the WiFly module
    b. Turn over, solder
4. Group 3 - small parts that can't be fixed to the board
    a. Place & solder switch J1. This switch controls how the WiFi board is connected to the Arduino. Normally, you would connect WiFI to pins 2,4 of the Arduino for SoftSerial communication. The ONLY reason to connect WiFI to hardware serial pins 0,1 of the Arduino is if you use high-speed add-on shields that need to push data at rates over 50kbps (you will NEVER need this kind of speed for EVSE data push)

i. Alternatively, can install 2 3-pin male headers and use jumpers to set the connection path for WiFI module
ii. Alternatively, if no change in connection path is expected in the future, use short pieces of wire (or component leads you cut off earlier) to short the middle pad on each row of 3-position connectors to the rightmost pad

5. Group 4 – other small parts
    a. Place 100-200k: R1
    b. Place 1k: R2, R3, R4, R5
    c. Place 10-50uF cap: C1
    d. Place 0.1uF (104) cap: C2
    e. Place 3.3v voltage regulator: S1
    f. Place long-lead female headers (2x 6-pin, 2x 8-pin)
        i. If you don't feel like soldering unnecessary pins, you can solder just 1x 6-pin and 1x 8-pin connectors (see the board to determine which connectors do have connections to the board's components)
    g. Place flat object over top of the board to hold everything in place and turn PCB over, solder pins
6. Your WiFI shield is ready to be inserted into the main board!
    a. When inserting, make sure that nothing is shorting to anything under the shield
    b. Here's a quick photo of a bare and a completed board



Part 4. Prepare the enclosure

Base

Note: unless explicitly mentioned otherwise, here and in the rest of this document, enclosure is assumed to be oriented one of its shorter sides facing you, with you looking into the enclosure cavity.

7. Cut the holes for input & output cable glands
    a. Use a 1 7/16” hole saw that’s rated for aluminum (available at any home depot)
    b. You can use a 1 3/8” size if you can’t find 1 7/16”. You might need to file away a small bit of material in this case to widen the hole
    c. Position the holes slightly to the left side of the enclosure
        i. Input cable gland – center hole at 1 ¾” from the left side of the enclosure, 1” from the bottom
        ii. Output cable gland - 4” from the left, 1” from the bottom
8. Drill 7/32” mounting holes for all components
    a. Please use the ExpressPCB file below for layout of the mounting holes in the base enclosure
        i. Link to file: <COMING SOON>
        ii. File shows configuration as seen from the inside of the enclosure
        iii. You can flip the picture in ExpressPCB if you want to drill from the back (easier)

<EXPRESS PCB PIC COMING SOON>

Part 5. Mounting the components to enclosure

Base

1. Mount the PCB
    a. Use 4x 1-inch long 8-32 machine screws, 3/8-1/2-inch nylon spacers, lock washers, and nuts
    b. Orient PCB with the current sensors facing DOWN, close to the JuiceBox entrance
2. Mount the power supply
    a. Use 2x ½-inch long 4-40 machine screws and washers
    b. Orient power supply with the terminals facing DOWN
3. Wire power supply to the PCB
    a. Prepare a 6-pin power & pilot female header
        i. This header will plug into the bottom of the 8-pin male header on the end of the PCB opposite to the current sensors
        ii. Use 10” of signal wire (AWG 22-28) for pilot pin
            1. Leave the other end of this wire open for now
        iii. Use 6” of signal wire for +5 / G / +15 / -15 pins (you will skip one of the ground pins on the male connector)
        iv. Connect the other ends of these 6” wires to the power supply
            1. +5V to V1
            2. G to G1
            3. +15 to V2
            4. -15 to V3
    b. Connect all power supply grounds together
        i. Cut a 10” long signal wire, bare ~3 inches on one end
        ii. Use the bare portion to connect all 3 ground pins of the power supply together
        iii. Leave the other end open for now
4. Prepare power supply wiring for the relay
    a. Use a 7 or 8-pin female header
    b. Use 6” of signal wires for RL, +15, G, and AC1/AC2 positions
    c. Leave the other ends of the RL / AC1 / AC2 wires open for now
    d. Connect G to power supply ground (since all ground terminals on the power supply are now tied together, it does not matter which one you use)
    e. Prepare one loose 6” signal wire, tie it together with the +15 signal wire you prepared before, and connect both to the V2 terminal of the power supply
5. Mount the Relay
    a. Use 2x 1-inch long 8-32 machine screws, lock washers, and nuts
    b. Orient relay with the common terminals facing DOWN
6. Wire the pilot line
    a. Connect the pilot wire to position 2 of the output terminal strip
7. Pre-wire the output
    a. Line 1
        i. Use 6” of AWG 6 wire

    ii. Fit a proper lug (with #8 / #10 hole) on one end of the wire, keep the other end bare (1/2" or so)
    iii. Insert the bare end into the position 3 of the output terminal strip (4-terminal strip, counting from the left), fasten
    iv. Pass the wire through the GFCI current sensor (CS2) and bend to the left in order to mount to the relay
  b. Line 2
    i. Use 10" of AWG 6 wire
    ii. Fit a proper lug (with #8 / #10 hole) on one end of the wire, keep the other end bare (1/2" or so)
    iii. Bend the lug so that the wire exits the relay in the upward direction (see picture below)
    iv. Bend the wire around to the right and pass through the same CS2 sensor
    v. Insert the bare end into the position 4 of the output terminal strip
    vi. Ensure that the wires pass through the current sensors as parallel as possible, and are at the same height from the base of the sensor. Failure to do this will likely cause false trips of the GFCI circuit above ~20-30A output
  c. Ground
    i. Insert the ground into position 1 of the output terminal strip
8. Connect the input cable
  a. Prepare AC1/AC2 wires for the connection to the input terminals of the relay
  b. Prepare the input cable
    i. Remove ~4" of the outer cable jacket
    ii. Fit proper lugs to the hot lines of the input cable – use lugs with #8 / #10 holes
    iii. Strip ½" end of the ground wire
    iv. Thread the input cable through the input cable gland (left)
  c. Connect the input AC
    i. Bolt one of the hot lines and AC1 wire onto one of the relay's common positions
      1. Make sure that the high-current wire contacts the relay pad directly (i.e. AC1 wire is NOT in between the relay pad and the hot line input)
    ii. Bolt the other hot line and AC2 wire onto the other relay's common position
    iii. Insert the ground wire from input cable into the position 1 of the output terminal strip
      1. From the top entry point (not from the bottom of the connector)
      2. Together with the other end of the ground wire from the power supply (a 10" signal wire you used to connect all the power supply's grounds together)
9. Connect the output J1772 cable
  a. Strip ~2" of outer cable jacket
  b. Strip ~1/2" of the isolation from all 4 wires
  c. Thread the cable end through the output cable gland (right)
  d. Connect wires to the output terminal
    i. Hot lines to positions 3 and 4

ii. Pilot to position 2
iii. Ground to position 1

10. Tighten the input and output glands to that the cables cannot be moved by pulling / pushing from outside

Part 7. Programming the Arduino

Note: for a limited time, all kits are shipped with Arduino already programmed to the latest (at the time of shipment) version of the firmware.

1. Install Arduino environment on your PC
    a. Firmware currently tested on Arduino V1.5.2
    b. Should work in any 1.0 or later versions, as well
2. Connect the supplied FTDI cable to your PC
3. Make sure your PC recognizes the cable and assigns it a separate COM port
4. Download firmware from the EMW site (in Firmware folder)
    a. Required libraries: TimerOne, uLCD144 (zip files)
    b. Latest firmware (.ino file)
    c. Open Arduino IDE, navigate to Sketch->Add Library and point to the library zip files you've downloaded (you have to do this for every zip file)
    d. Open the main firmware in Arduino IDE
5. Make sure your downloaded code is configured correctly for your version of the charger kit
    a. File->Tools->Board, select 'Arduino Pro or Pro' as the board type
    b. File->Tools->Processor, select 'Mini (5V, 16MHz) w / ATmega328P'
    c. Check the "#define …" statements in the first 2 pages of the code (marked as '---------- MAIN SWITCHES ----------')
        i. Comment out '#define DEBUG'
        ii. Uncomment '#define AC1075'
        iii. If you have a WiFi shield you got from us, uncomment '#define WiFi'
            1. You might want to initially leave this commented out and first make sure that the JuiceBox works as expected without WiFi support
            2. Then, once you confirm operation without WiFi, you can enable WiFi code by uncommenting the switch
        iv. If your kit came with a programmed Arduino, it will be programmed with non-DEBUG, AC1075, non-WiFi configuration
6. Upload the code to the EVSE
    a. Connect the FTDI board to the programming header on the main PCB
        i. Align the FTDI so than 'GND' on FTDI connector plugs into the 'BLK' position on the programming header
    b. If you have a premium version / WiFI shield, ensure that BOTH slide switches (by the LCD and on the WiFi shield) are flipped into 'SW' position. If not done, they will interfere with the upload
    c. In Arduino IDE, click Compile icon, confirm error-less compilation
    d. Click Upload icon, confirm error-less upload

Part 8. Logic test

1. Make sure your FTDI is connected to the main PCB programming header. Do not connect input AC power to the JuiceBox yet
2. If you have a Premium version, flip the LCD slide switch back to 'HW' position
3. From Arduino IDE, launch a Serial Monitor (Tools menu)
4. The board should reset and start outputting info into the Serial Monitor
    a. Depending on the Edition of JuiceBox, the output will be slightly different
    b. Regardless of the format, after ~5-10 seconds past reset you should see the ~1/second printout of the main parameters (voltage, current settings, etc)
    c. Turn the current setting trimpot. The current setting should change accordingly. Set a desired value for your configuration.
        i. If the trimpot is at the far left position, the current will be set to a default 30A output
        ii. Otherwise, the setting is linear to the angle of the trimpot
            1. The range is from 0A (trimpot position just to the right of the left stop) to 60A max current (right stop).
            2. Example: you want to setup your JuiceBox to draw 40A: 40A is 2/3rd of 60A full range -> Turn the trimpot 2/3rd to the right -> confirm in the Serial monitor
5. Test J1772 operation. There are 2 options:
    a. Build a small test rig (optional but preferred as it will allow to test operation to a larger extent)
    b. Just use your EV
6. Option 1 – build a small test rig
    a. You will use a few combinations of resistors and diodes to simulate various states of J1772 on the car side
        i. You will be connecting all these combinations between the pilot output and ground
        ii. If a combo has a diode, you would be connecting the diode's anode towards the pilot output line (not the ground)
    b. "Something is connected but not a proper J1772 load (e.g., fingers)"
        i. Use a 1k resistor
    c. "Car connected"
        i. Use a small signal diode and 2.7k resistor in series
    d. "Car requests power"
        i. Use a small signal diode and 1k resistor in series
    e. Using the above combinations, imitate the car sequence below in Option 2
        i. The additional important feature you will be testing with this rig is the ability of your JuiceBox to recognize the dangerious situation of non-J1772 load being connected to the J plug (could be child's fingers, or some water creating low-impedance path, etc)
7. Option 2 – just use your EV
    a. **Ensure you follow proper High Voltage safety procedures**
        i. Wear rubber-soled shoes
        ii. Treat every exposed terminal / pin / PCB trace as live high-voltage terminal – EVEN IF YOU 'KNOW' IT IS NOT CONNECTED

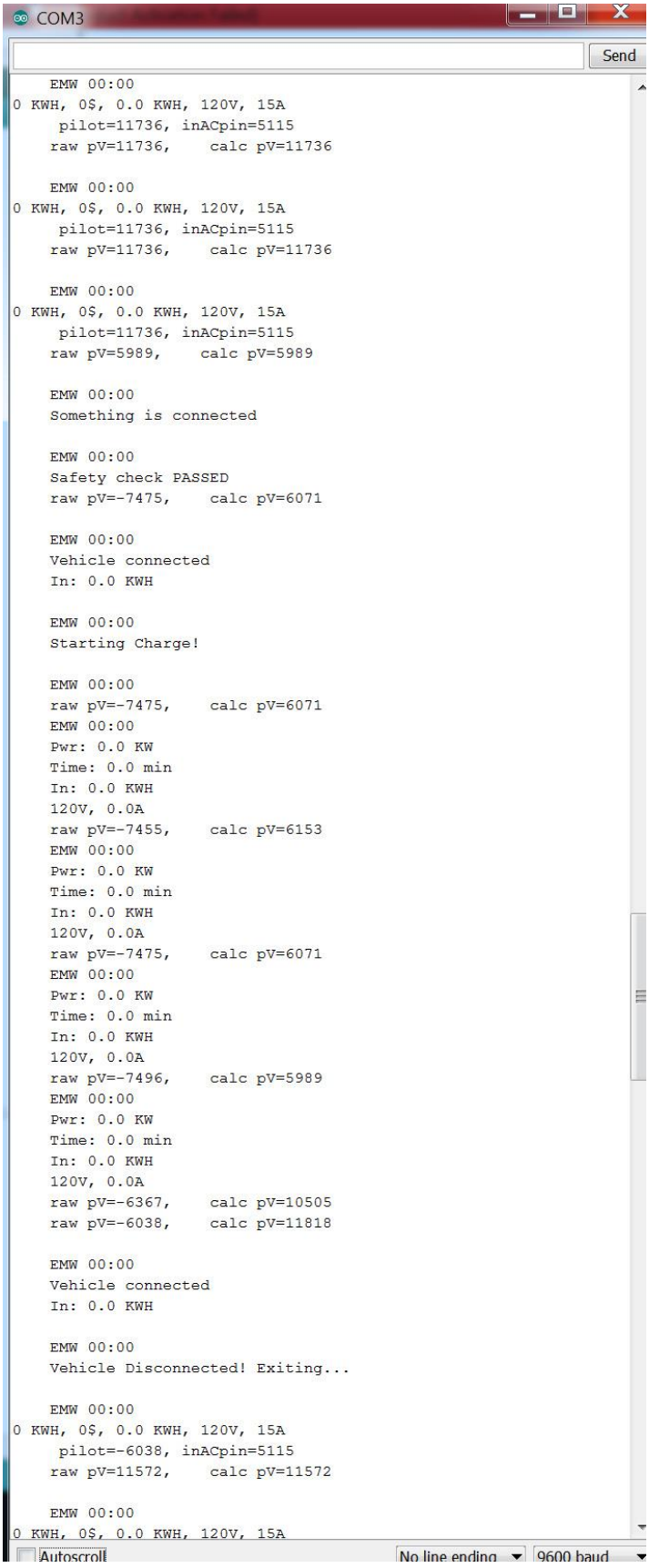
iii. Never touch any two terminals at the same time.
    1. Best practice is to do ANY work on the circuit with one hand once the circuit is energized.
    2. This prevents you from creating an electrical path between your hands – the most dangerous of all as it passes through your chest
iv. If you need to use two hands or handle the circuit, unplug everything (input AND output) and measure voltage on the input and output lines before touching anything (there are no high-voltage capacitors in the JuiceBox so at least that type of danger does not exist)
v. Be very careful connecting any AC-powered equipment to the circuit when circuit is energized
    1. Main danger is connecting the equipment ground to live AC line
    2. Most often happens with scopes (e.g., attempt to measure voltage between the two hot AC lines), solder guns
    3. If absolutely needed to make such connections while circuit is live, use battery-operated equipment
vi. Wear protective shop glasses

b. Remove FTDI header from the board
    i. If you'd like to monitor the JuiceBox over Serial monitor while the AC is applied, you need to remove a small jumper from the FTDI board. Otherwise the USB power supply will be fighting the JuiceBox power supply on the 5V line and supply voltages get unreliable
c. Connect 120V AC to your JuiceBox (always start testing at lower voltages and through a protective power strip)
d. Wait for 15-30 seconds to make sure all initialization processes complete
e. Measure (or monitor with a scope) the voltage on the pilot pin of the main PCB
    i. Should show ~12V
f. Connect the J1772 plug into your car
g. You car should recognize the JuiceBox and request power
    i. You should see a momentary dip of the pilot voltage to ~9V
    ii. JuiceBox should turn on the 50% duty +/-12V square wave on the pilot to test for diode on the car side (you will see this on the scope as -12V to +9V square wave)
    iii. You should see a further dip of the top of the square wave to ~6V as the car requests power
    iv. Juicebox will change the duty cycle to match your current setting
    v. Juicebox will close the main relay
    vi. Car will indicate charging
h. Test charge interruption
    i. Press a button on the J plug (but do not remove yet)
    ii. The top of the wave on pilot signal should go back to 9V ('car connected)
    iii. Remove the plug
    iv. The top of the wave should go back to 12V
    v. The pilot line will turn solid 12V (no wave) shortly
    vi. The power relay should open, disconnecting output power
    vii. Re-connect the plug
    viii. Charge initiation sequence from the previous step should repeat and car should restart charging

i. Test GFCI interruption
    i. Using small isolated screwdriver, briefly short the GFCI test button pins on the main PCB
    ii. The relay should open immediately
    iii. LCD should show (Premium version only) that GFCI has tripped
    iv. GFCI will re-attempt in 15 min (unless DEBUG flag is set in the firmware in which case the connection will be re-attempted immediately)

Here’s an example of the Serial Monitor Output

Transition from standby (J1772 state A) to vehicle connected & requesting power (state C) and back is shown (Base unit)


COM3
Send
EMW 00:00
0 KWH, 0$, 0.0 KWH, 120V, 15A
pilot=11736, inACpin=5115
raw pV=11736, calc pV=11736
EMW 00:00
0 KWH, 0$, 0.0 KWH, 120V, 15A
pilot=11736, inACpin=5115
raw pV=11736, calc pV=11736
EMW 00:00
0 KWH, 0$, 0.0 KWH, 120V, 15A
pilot=11736, inACpin=5115
raw pV=5989, calc pV=5989
EMW 00:00
Something is connected
EMW 00:00
Safety check PASSED
raw pV=-7475, calc pV=6071
EMW 00:00
Vehicle connected
In: 0.0 KWH
EMW 00:00
Starting Charge!
EMW 00:00
raw pV=-7475, calc pV=6071
EMW 00:00
Pwr: 0.0 KW
Time: 0.0 min
In: 0.0 KWH
120V, 0.0A
raw pV=-7455, calc pV=6153
EMW 00:00
Pwr: 0.0 KW
Time: 0.0 min
In: 0.0 KWH
120V, 0.0A
raw pV=-7475, calc pV=6071
EMW 00:00
Pwr: 0.0 KW
Time: 0.0 min
In: 0.0 KWH
120V, 0.0A
raw pV=-7496, calc pV=5989
EMW 00:00
Pwr: 0.0 KW
Time: 0.0 min
In: 0.0 KWH
120V, 0.0A
raw pV=-6367, calc pV=10505
raw pV=-6038, calc pV=11818
EMW 00:00
Vehicle connected
In: 0.0 KWH
EMW 00:00
Vehicle Disconnected! Exiting...
EMW 00:00
0 KWH, 0$, 0.0 KWH, 120V, 15A
pilot=-6038, inACpin=5115
raw pV=11572, calc pV=11572
EMW 00:00
0 KWH, 0$, 0.0 KWH, 120V, 15A
Autoscroll
No line ending
9600 baud

Part 9. Full Power Test

1. **Ensure you follow proper High Voltage safety procedures**
2. Place a current clamp-meter on one of the input lines
3. Plug in your JuiceBox into the 240V outlet
4. Wait 15-30 seconds
5. Plug your J1772 output into the car
6. Confirm charging by your car's charging indicators
7. Monitor charging current on clamp meter
    a. If Premium edition, confirm agreement with the onboard current sensor (shown on LCD display)
    b. Confirm expected charging current (e.g., ~30A for a 6.6kW Nissan Leaf charger)
8. Monitor temperature every 1-2 minutes in the first 30 minutes of charge
    a. Use infrared thermometer
    b. Check all potential heat producers in a circular pattern
        i. Input wires as they enter the relay
        ii. Output wires as they enter and exit the output terminal strip
        iii. Relay wiring and contacts
        iv. Power wiring (all AWG 6 wiring)
    c. All contacts / wiring should show no more than 20C above ambient at any output current setting within 30 min
9. Monitor temperature every 15-30 min after the first 30 min until the end of charge
    a. All contacts / wiring should show no more than 30C above ambient at any output current setting

Part 10: Mounting your JuiceBox

BASE Edition:

To mount your JuiceBox, you would use the 2 holes located on the vertical centerline of the bottom of your enclosure. These should be the only 2 holes that are not yet occupied with the components. Note that for some kits, we may not have drilled these holes to allow you the flexibility of mounting the boxes. In that case, adapt the mounting to your specific situations.

You can use a number of different techniques to mount the enclosure

1. Directly to a wall / post (just make sure you use a spacer between the box and the mounting surface to avoid any gaps for moisture to enter (especially in the outdoor installations)
2. Via a mounting bracket – you could get a 15" piece of ½"-wide ¼" thick aluminum rectangular bar (such as http://www.onlinemetals.com/merchant.cfm?pid=19552&step=4&showunits=inches&id=997&top_cat=60 or similar) and mount it to the back of the unit and then use the ends of the bar to mount to any surface.

For full weather protection, use a silicone sealant around your bolts to seal off the water.

Congrats!

You now have one of the best EVSEs money can buy.

And you built it yourself!

Go Electric!

Yours truly,
EMW Power Electronics Crew