# Electric Motor Werks JuiceBox – an Open Source 15kW 60A Level 2 EVSE

V8.6 Build Instructions

Updated: December 23, 2013

The latest full version of this assembly manual is always available from http://www.emotorwerks.com/JuiceBox_Public/8.6/ (Assembly Manuals folder). We now also have a full assembly video in HD at http://www.youtube.com/watch?v=sSllx7zaC6A!


## 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 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 JB-support@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 has a lot of good info on the product, our philosophy and what we are trying to do.

E-MotorWerks JuiceBox is not just another EVSE – it's a completely flexible EV charging platform.

Go Electric!
--
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.

**WARNING:** This document describes circuitry that is directly connected to the AC mains, and contact with any part of the circuit may result in death or serious injury. By reading past this point, you explicitly accept all responsibility for any such death or injury, and hold Electric Motor Werks, Inc. harmless against litigation or prosecution even if errors or omissions in this warning or the document itself contribute in any way to death or injury. All mains wiring should be performed by suitably qualified persons, and it may be an offence in your country to perform such wiring unless so qualified

# What am I building?

EMW JuiceBox  is an Open Source 60A / 15kW Level 2 EV charging station costing 10x lower than currently existing EVSEs of similar power.

This product was initially funded from a <u>KickStarter campaign</u>, receiving over 230% of the target funding amount from 300 backers in 30 days.

The device is a full-featured J1772 charging station and supplies up to 60A 15kW to your J1772 vehicle (any production car sold today) and operates on any voltage between 100V and 240V. This means up to 10x faster charging than from a regular household outlet (when wired to 240V supply, subject to charging speed limitations of the charger onboard of your EV). Generally, most of the newer EVs will experience at least 4-5x improvement by going to 240v with JuiceBox.

JuiceBox is built around an Arduino microcontroller (open source hardware platform) and is small enough to be used as a mobile charger (plug in at the RV park, friend's house's dryer outlet, etc). It is faster. It is Wi-Fi ready. It is more affordable and flexible than other EVSEs available on the market today.

EMW is making both the hardware and software open source. We expect many extensions to be made available in the future - developed by EMW or our JuiceBox developer community. You will be able to get the benefit of the great open source community around this product and get much more mileage out of your investment.

Finally, the JuiceBox is designed to be inherently portable. The Base version's dimensions (~11x7x3" box + cables) allow you to take it everywhere and enjoy up to 15kW of charging power. There is an automatic power derating for 120V outlets so you don't have to worry about overloading your house wiring in that unfortunate event when you have to resort to 120V charging.

There are FOUR main configurations of the JuiceBox - Base Kit, Base Assembled, Premium Kit, and Premium Assembled.


## Base Edition - DIY Kit

Includes all electronic components and matching enclosure needed to enable J1772 charging of your vehicle up to 240V 60A (output current limit is user-adjustable). No LCD screen or advanced controls.

Size: portable with ~11x7x3" waterproof enclosure. The cables are exiting from the bottom of the enclosure (from one of the small 7x3" sides) so you will need some space below the JuiceBox to allow for cable routing. The cables pass through a set of water-tight strain-relief glands.

You will need to add input and output cables - e.g., a dryer plug with cord for input and J1772 cord for output - a variety of options are available through EMW store - check related products. Or you can reuse the J1772 charging cord that you got with your EV.

Basic electronics assembly and safety skills required. Estimated assembly & testing time is 1-2 hours

## Base Edition - Assembled

Same functionality as our Base Kits but fully assembled & ready to go. Just add input and output cables (check related products in our store for more information for cable details. Or you can reuse the 120V charging cord that you got with your EV. If you buy cables from us before your JuiceBox ships, we will connect them to your JuiceBox for free).

## Premium Edition - DIY Kit

Same functionality as our Base Kits PLUS:

(1) Color LCD Screen with charging info, total $ saved by driving electric, total energy consumed, etc.
(2) Time of Day charging control - save money by charging at night without having to remember to plug in at midnight
(3) Larger, very cool-looking, unique enclosure custom-designed for EMW JuiceBox - with provisions for LCD screen, USB programming connection, etc.
(4) Remote control via a secure keyfob

The kits will require just basic electronics safety and assembly / soldering skills and can be assembled in 3-4 hours.

Size: the enclosure is a ~6" diameter 5/8$^{th}$ of a cylinder with flat backing, 16-17" in height. The cables are exiting from the bottom of the cylinder so you will need some space below the JuiceBox to allow for cable routing.

## Premium Edition - Assembled

Same functionality as our Premium Kits but fully assembled & ready to go. Just add input and output cables (see related products in our store for cable details; if you buy cables from us before your JuiceBox ships, we will connect them to your JuiceBox for free)

# Specifications and Features

- Specifications:
    - Input voltage: 100-265V
    - Output power: 15kW / 60A
        - Whichever is smaller (i.e. at 208V supply, the JuiceBox allows 208*60 ~ 12.5kW)
        - Automatic power derating for 120V use – no need to reset the power limit when changing between 120V and 240V
    - Output type: J1772 AC
    - Size: 11x7x3" (Base), 16x6"D (Premium)
    - Environmental protection level: waterproof up to IP66 (when properly assembled and mounted)
    - Operating conditions
        - Outside temperature: -20C – 65C
        - Humidity: up to 100% non-condensing
- Features:
    - Multiple protection levels
        - GFCI (Ground Fault Circuit Interrupter) – ~20mA trip point – protect from electric shock (satisfied UL 2231-2 standard)
        - Standard J1772 power interlock – the output is not energized unless connected to a properly configured J1772 vehicle
        - Stuck relay protection – charging is disabled if internal relay is stuck closed
    - Variable output current limit – set via an internal variable resistor (Base) and / or via an LCD interface (Premium)
    - (Premium) LCD interface for display of major parameters (user adjustable through firmware)
    - (Premium) Remote control via a secure KeyFob with 4 buttons
    - Full hardware and software expansion potential
        - Open source hardware and software design
        - Hardware expansion through Arduino shields (UNO footprint provided on PCB)
    - Wi-FI ready
        - Firmware and hardware fully ready for an addition of the Wi-FI expansion shield (based on a Roving Networks RN171-XV WiFi module)
        - Server-side application is being developed to allow JuiceBox owners to monitor their JuiceBoxes via internet (most of the work is not completed, with a few beta users already on the service!)
        - Automatic WPS-based WIFI configuration with a single button press
        - Note: a purchase of an EMW WiFi shield is required to enable WiFI functionality – please visit our online store at http://emotorwerks.com/products/online-store/product/show/44-emw-

juicebox-an-open-source-level-2-15kw-ev-charging-station and scroll down to 'Related Products'

## 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 generally 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 as it is more factual and structured means of communication. Finally, in email, there is always a record of what's happening – which is always very useful for debugging issues.

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. 25W MINIMUM
            ii. Something like this (what we use at EMW, $20 from Amazon)
        b. Electrical solder
            i. Make sure you never use plumbing solder as it may have conductive flux!
            ii. Ideally 0.3-0.5mm thick
        c. If you need a refresher on your soldering skills, 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 – small flat, medium Fillips
    3. Wire stripper & crimper
        a. For AWG6 wire crimp, we recommend something like this (budget version) or this (the real deal)
    4. Small snips for wire / lead cutting
    5. Small pliers
    6. Clear Protective Goggles

2. **Recommended but not required tools**
    1. Multi-meter with Capacitance / Resistance measurements – something like this ($25 on Amazon):
        a. Also download / print the resistor color coding reference: http://en.wikipedia.org/wiki/Electronic_color_code

3. **Helpful but not required tools**
    1. Clamp meter with 100A+ AC current measurement capacity (something like this – $40 on Amazon)
    2. Infrared thermometer such as this ($40 on Amazon)
    3. Scope with 1MHz bandwidth (or better)
        a. 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!
        b. Or, if you think this is not your last project where scope would be helpful, take a look at Owon scopes on ebay or Amazon – those are

great and relatively inexpensive devices that can be battery powered and small enough to be taken almost anywhere.

4. **Assembly Tips**
    1. Sequence of assembly is often important
    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. To prevent circuit shorts, make sure all unnecessary solder is cleaned from board.

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 30-60 minutes for component mounting and wiring, 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
    a. All of these parts will be pre-installed on the PCB – you will get a complete PCB with all parts installed
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.

As of October 10, 2013, we have made some changes to the assembly procedure. Specifically, the internal AWG6 wiring is no longer required. We now advise to connect the J1772 cable wires directly to the output of the relay.

FTDI programming cable is also not supplied anymore since the Arduino is now shipped fully programmed. You can always order your FTDI unit from us if you need to modify any part of the software or would like to monitor JuiceBox output – see our store at http://emotorwerks.com/products/online-store

The latest version of the assembled unit (with and without input / output cables) is shown below:

# EWM BASE EDITION

Printed Circuit Board power connections

Power supply

Relay Output

Relay Input

Ground connection

J4

J3

J2

GFI Sensor

Pilot

Input 120/240

Output to J1772
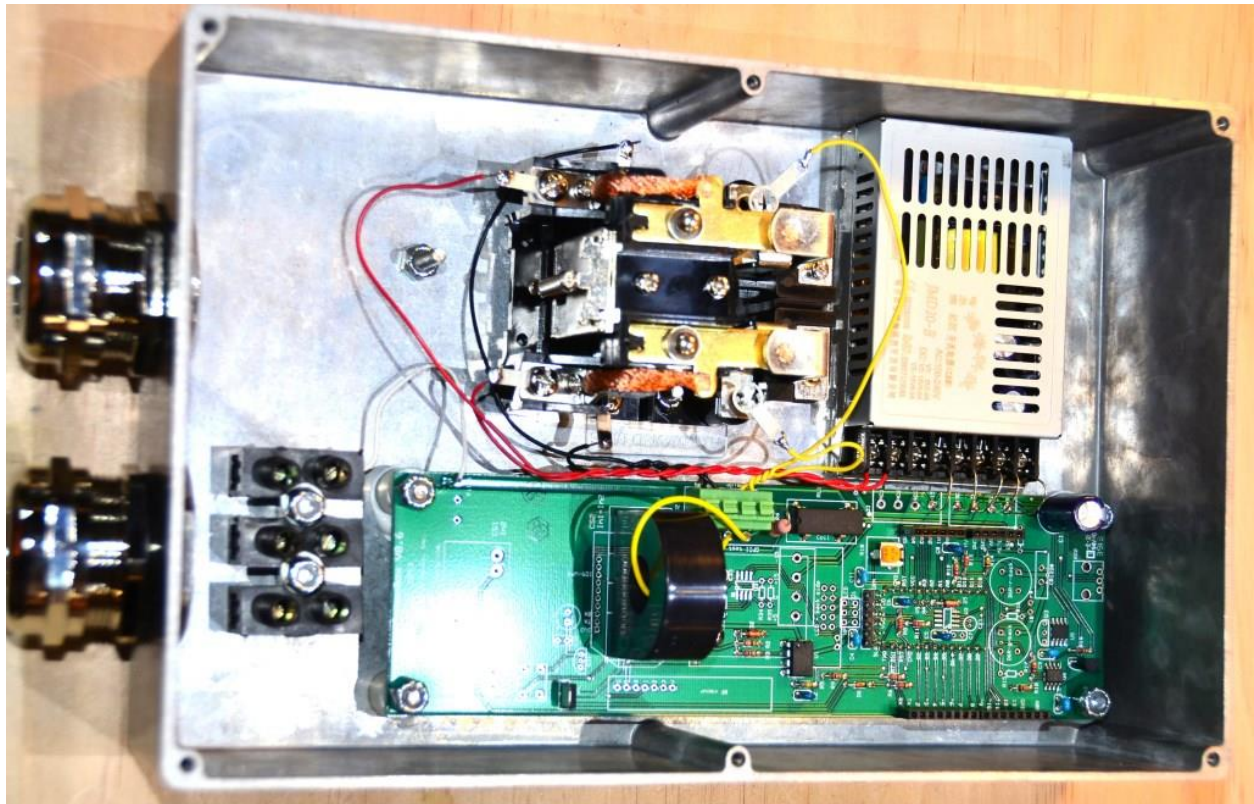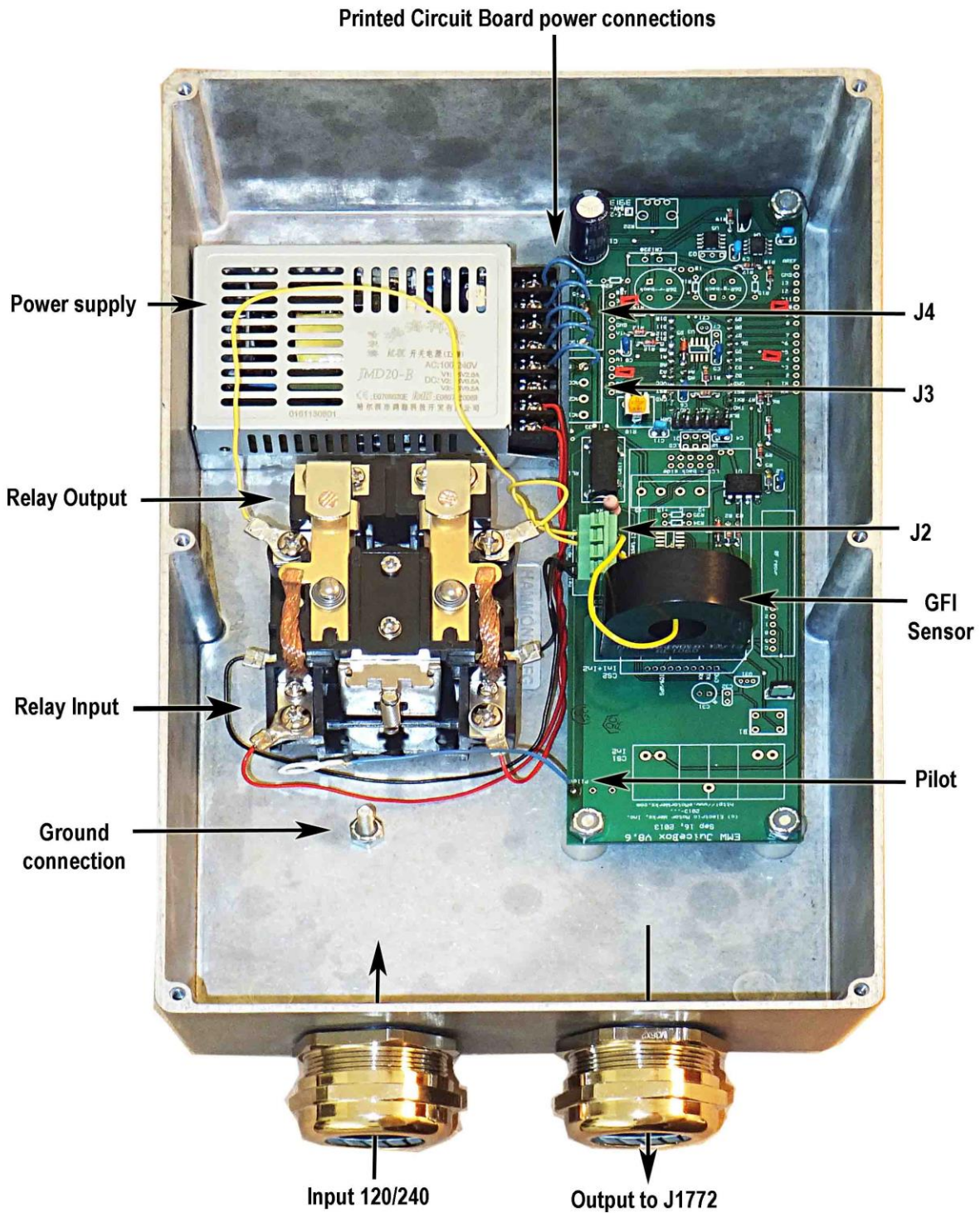
# Part 2. Kit Contents

Please refer to the Bill Of Materials file on our site for more details on component lists, part numbers, etc: http://www.emotorwerks.com/JuiceBox_Public/8.6/.

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.

We are still working out what the best way is to organize the kits. Some of you will receive parts taped to a piece of paper with part names, some of you will get parts separated in a few anti-static bags, etc.

Majority of the parts will have clear manufacturer labeling on them, except resistors. You MAY have to use a color-code aid to decipher the resistor values (see required tools section above for links to all such aids)

Update (October 10, 2013): Internal AWG6 cabling is no longer required. Also, PCBs are shipped fully assembled so there are no component bags. See instructions in the rest of this document for details.

# Part 3. Assemble the main PCB

## Starting October 10, 2013, all kits ship with the PCB FULLY assembled!

For assembly instructions (if you got an earlier version of the kit or just curious) are still available in the Appendix section of this document

# Part 4. Prepare the enclosure

## Starting October 1, 2013, all kits ship with the Enclosure FULLY prepared!

For enclosure prep instructions (if you got an earlier version of the kit or just curious) are still see the Appendix section of this document

# Part 5. Mounting the components to enclosure – BASE EDITION

**Overall mounting tips:** Use the supplied sealer washers on all screws entering the enclosure. When used correctly, these will preserve the waterproof status of the enclosure. The main requirement is to tighten the screws to just the right torque so that the conical aluminum washer becomes flat – see photo below.



In this photo, the washer on the left is not tightened, the washer on the far right is tightened just to the right amount of torque

1. Mount the Relay
    a. Remove and discard the plastic cover on top of the relay. There is sufficient clearance between the relay terminals and the enclosure to prevent any electrical contact.
    b. Remove terminal screws from the common terminals (bottom terminals on the picture), coil terminals (next ones towards the top), and bottom contact terminals (next ones towards the top)
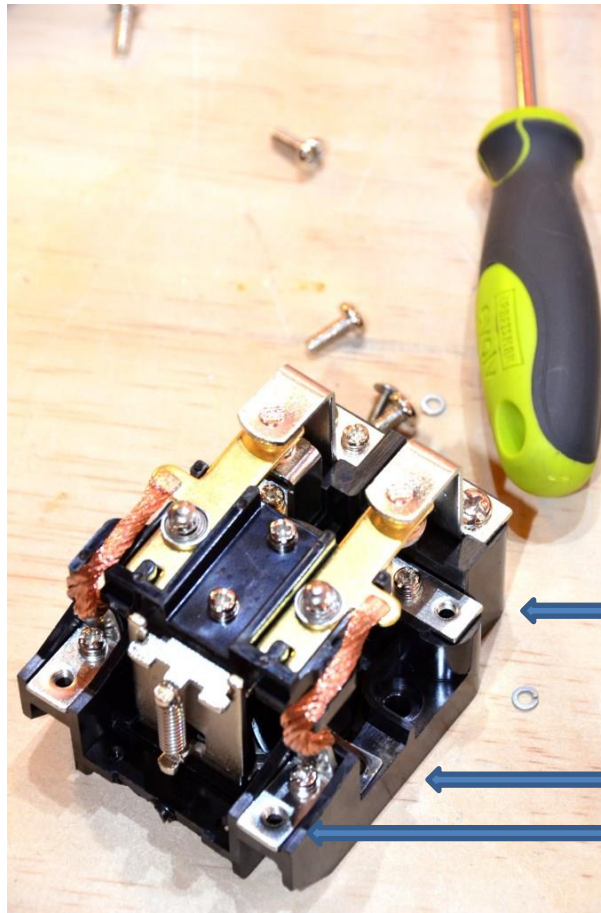
AC-Jside terminals (or 'output termianls') – one on each side

Coil terminals (one on each side of the relay)

Input terminals (one on each side of the relay) – also referred to as 'common' positions

    c. Orient relay with the input (common) terminals facing DOWN
    d. Using 2x 1-inch long 8-32 machine screws and lock nuts, mount the relay inside the enclosure

2. Wire power supply to the PCB
    a. Prepare 5x 1.5" signal wires (solid AWG 20-24 are easiest to deal with in this application)
    b. Solder one end of the wires to the board connectors J3 and J4 (use all positions in J4 and only '-15' position in J3)
    c. Insert the other ends into the power supply – orient supply facing the PCB. The order of J3/J4's positions is the same as the order of the terminals on the supply. Double-check against markings on board and the supply
    d. Prepare 6" and 8" signal wire, connect one end to the AC terminals of the power supply – one wire to each terminal. Twist the first 4" of the wires. These wires will go to the input terminals of the relay
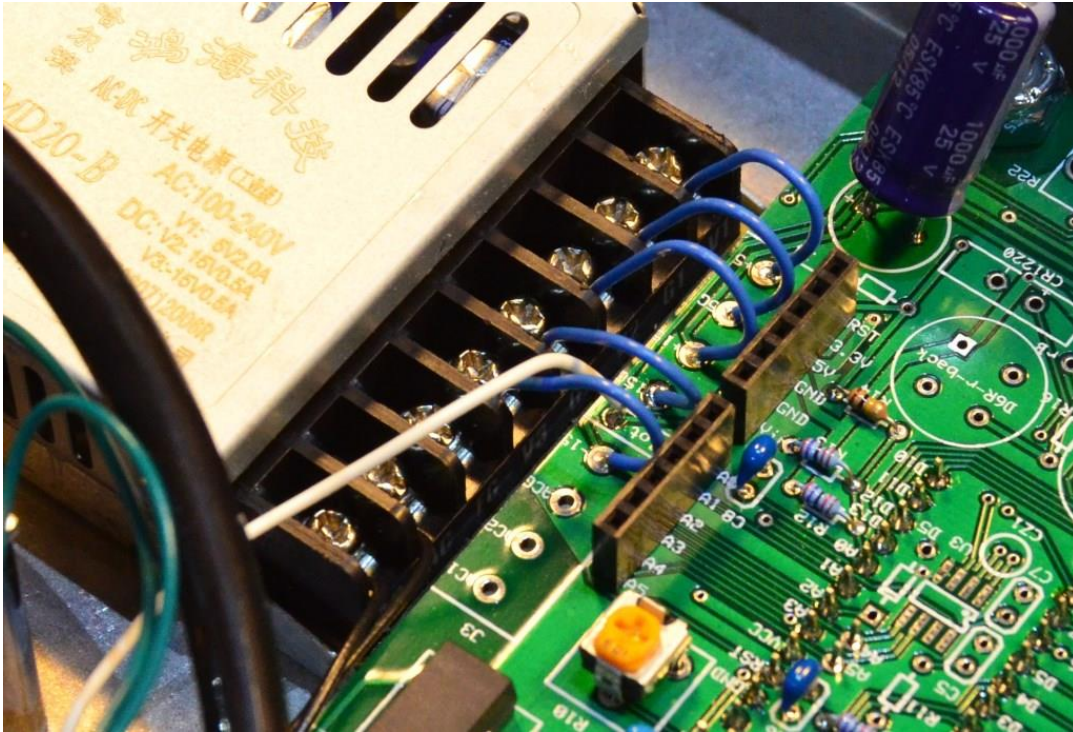
(5x 1.5" wires connecting power supply to the PCB)

3. Prepare wiring for the relay
   a. Use 3" and 8" signal wires for the 2 'Relay' positions of J2 connector – these will later be connected to the relay coil
   b. Use another set of same length wires for the 2 AC-Jside positions of J2 connector – these will later be connected to the AC_Jside (Normally Opened) relay terminals
   c. Solder one end of all wires to the PCB (or insert into the J2 connector if it's already placed on your board – you need to push on the locking tab from the top and insert the wire then release the tab). Twist the first 1.5-2" of the wires

4. Mount the PCB / power supply assembly
   a. For PCB, use 4x 1-inch long 8-32 machine screws, 3/8-1/2-inch nylon spacers, and locknuts
   b. Orient PCB with the current sensors facing DOWN, close to the JuiceBox cable entrance
   c. For power supply
      i. If your enclosure was shipped with the 2 holes pre-drilled for mounting the power supply, use 2x ½-inch long 4-40 machine screws and washers
      ii. Otherwise, use double-sided mounting tape (available from any Home Depot or similar store) to mount the supply to the box. Make sure you remove the protective polyethylene film from the power supply before mounting

5. Connect coil wires to the relay

a. These are the wires coming from the 'Relay' positions of J2 connector on the PCB

b. Coil terminals are the lowest (closest to the relay's base). See the relay photo above for reference. You can also ID them by measuring resistance between each pair of terminals (between left and right terminal in a pair) – the one with non-infinite resistance is the coil terminal pair

6. Mount the output terminal (large black 3-position terminal) using 2x 1-2" 8-32 machine screws and locknuts

   a. As of October 30$^{th}$, this terminal is optional and is no longer provided in kits or built units – the pilot line from the J1772 cable is now soldered directly to the small wire you will connect in the next step (pilot line)

7. Wire the pilot line

   a. The pilot solder pad is located in the top right corner of the PCB

   b. Solder a 3"-long signal wire to this pad

   c. Connect this wire to position 1 of the output terminal strip

8. Install a ground post – a simple 8-32 1" machine screw through the hole closest to the left cable gland – secure with a locknut

9. Cut a 3" signal wire and solder one end to one of the ground pads next to the pilot pad on the PCB. Use the other end to make a ring loop & thread it onto the ground post you just built.

**Your main Base Edition Main Unit is now fully assembled and is ready to be wired with input and output cables!**

# Part 5.B Mounting the components to enclosure – PREMIUM EDITION

1. Ensure you have everything (a number of these components may be mounted to the backplate already)
   a. Relay
   b. PCB (with current sensor, wireless remote, slide switch, and LCD already mounted per instructions above)
   c. Backplate
   d. Power supply
   e. 5-6 position terminal strip
   f. Hardware kit
      i. 4 2.5" standoffs & 4 matching ½"-long machine screws
      ii. 5 lock washers and 5 nuts (or 5 locknuts)
2. Mount the first set of components to backplate
   a. Terminal with 2 lockwashers & nuts (or 2 locknuts if supplied)
   b. Relay with 2 spacers and 2 nuts
   c. We recommend to apply a small amount of silicone caulk to the bottom of these components before mounting to firmly affix them to the backplate
3. Prepare the PCB
   a. Cut 2 pieces of AWG6 (or AWG8-10 if wiring for 30A installation) wire, 19" long
   b. Thread both wires through the sensors
      i. One wire should go through both sensors
      ii. Another wire should go through just CS2 sensor
      iii. Leave ~6" of wire sticking from CS2 going into the direction of the 'EMW JuiceBox V8.x' label on the board
      iv. Refer to the photo below

      **c.** Crimp supplied lugs onto the shorter ends of the wires

      **d.** Adjust the current-setting trimpot[s] to the desired value

      **e.** Make sure the slide switch is set to 'LCD' setting

**4.** Mount the PCB onto the backplate

      **a.** LCD facing up…

      **b.** Use 4 2.5" standoffs and matching ½" screws to secure the board to backplate

      **c.** Mount the ends of the power wires with lugs to the output terminals of the relay

**d.** Secure the other ends of the power wires in the rightmost positions of the terminal strip

**e.** Refer to the photo below



**5.** Connect the input terminals of the relay

**a.** Use 2 pieces of ~3" of the solid copper wire or supplied AWG6 wires to make a connection between the terminal and input terminals of the relay

**b.** Refer to photo below

6. Connect all the signal wiring using the supplied AWG 20-22 wire. To secure the wire to the screw terminals, strip ~3/4" of the wire, make a small loop and fix with solder to make a simple ring terminal from the wire. Tip: route all the wires between the 2 center PCB standoffs – the installation will look much neater this way
   a. AC from power supply to input terminals of the relay (order does not matter)
   b. V1, G1, V2, G2, V3 terminals of the power supply to the corresponding pads on the PCB – the pads are laid out in the same sequence as the power supply's terminals for easy connection
   c. Connect J2 terminal's pads
        i. 'AC-Jside' pads - to the output terminals of the relay
        ii. 'Relay' pads – to the coil terminals of the relay
   d. Pilot pad on the end of the PCB to the output strip position between the 2 AC input positions
   e. Refer to the photo below
        i. Note that the photo shows WiFi module mounted on the main PCB – this is a cleaner way to install WiFi but also more complex since you have to find your way around the already installed PCB components
        ii. Another way to install WiFi is to build on a separate shield.
        iii. Both options are described in the rest of this document

**Your main Premium Edition Main Unit is now fully assembled and is ready to be wired with input and output cables!**

# Part 6.A. Connecting the cables – BASE EDITION

1. Connect the input cable. Note that the instructions correspond to the standard input primary cable – 240V cable with a 14-50P plug. If you are wiring your JuiceBox for any alternate input cable, make sure that the power is delivered to the input terminals of the relay (e.g. for a standard 120V cable this would mean that you should use phase (normally black) and neutral (normally white) wires – this is DIFFERENT from the instructions below so please pay attention)
   a. Remove ~4" of the outer cable jacket
   b. Strip ~1.5" of isolation from three wires (hot #1, hot #2, ground). If your cable has a white neutral wire, it is not used in the JuiceBox installation and can be cut
   c. Fit 3 lugs with #8 / #10 mounting holes to the hot (phase & neutral) and ground lines of the input cable
   d. Thread the input cable through the input cable gland (left gland)
   e. Bolt hot #1 and one of the AC signal wires (the one going to the power supply) onto one of the relay's common positions
      i. 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)
   f. Bolt hot #2 and AC signal wire onto the other relay's common position
   g. Place the ground lug onto the ground post



For your reference, types of plugs outlets and wiring diagrams for various types of sockets / plugs in the US:

| VOLTAGE | NEMA | 15 AMPERE Receptacle | 15 AMPERE Plug | 20 AMPERE Receptacle | 20 AMPERE Plug | 30 AMPERE Receptacle | 30 AMPERE Plug | 50 AMPERE Receptacle | 50 AMPERE Plug | 60 AMPERE Receptacle | 60 AMPERE Plug |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 125 V | 1 | 1-15R | 1-15P | | | | | | | | |
| 250V | 2 | | 2-15P | 2-20R | 2-20P | 2-30R | 2-30P | | | | |
| 125V | 5 | 5-15R | 5-15P | 5-20R | 5-20P | 5-30R | 5-30P | 5-50R | 5-50P | | |
| 250V | 6 | 6-15R | 6-15P | 6-20R | 6-20P | 6-30R | 6-30P | 6-50R | 6-50P | | |
| 277V, A.C. | 7 | 7-15R | 7-15P | 7-20R | 7-20P | 7-30R | 7-30P | 7-50R | 7-50P | | |
| 125/ 250V | 10 | | | 10-20R | 10-20P | 10-30R | 10-30P | 10-50R | 10-50P | | |
| 3∅ 250V | 11 | 11-15R | 11-15P | 11-20R | 11-20P | 11-30R | 11-30P | 11-50R | 11-50P | | |
| 125/ 250V | 14 | 14-15R | 14-15P | 14-20R | 14-20P | 14-30R | 14-30P | 14-50R | 14-50P | 14-60R | 14-60P |
| 3∅ 250V | 15 | 15-15R | 15-15P | 15-20R | 15-20P | 15-30R | 15-30P | 15-50R | 15-50P | 15-60R | 15-60P |
| 3∅ Y 120/208V | 18 | 18-15R | 18-15P | 18-20R | 18-20P | 18-30R | 18-30P | 18-50R | 18-50P | 18-60R | 18-60P |

ANSI/NEMA WD-6    14-15R    14-20R    14-30R    14-50R    14-60R    L14-20R    L14-30R
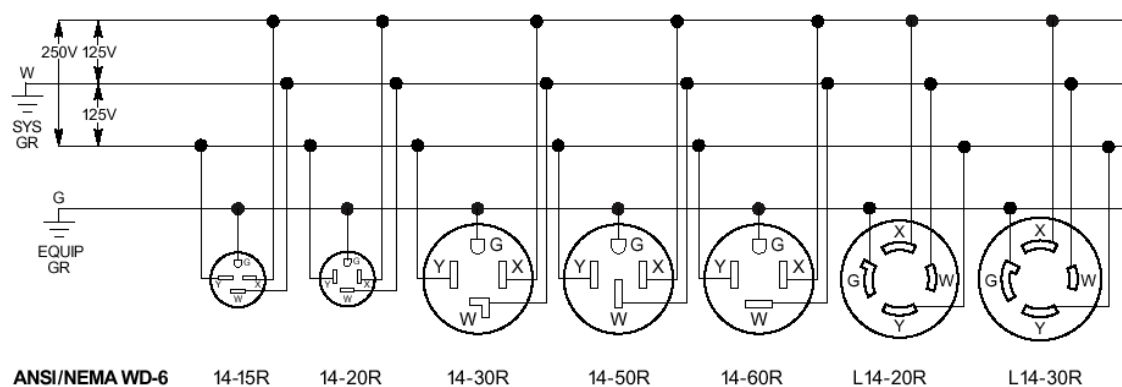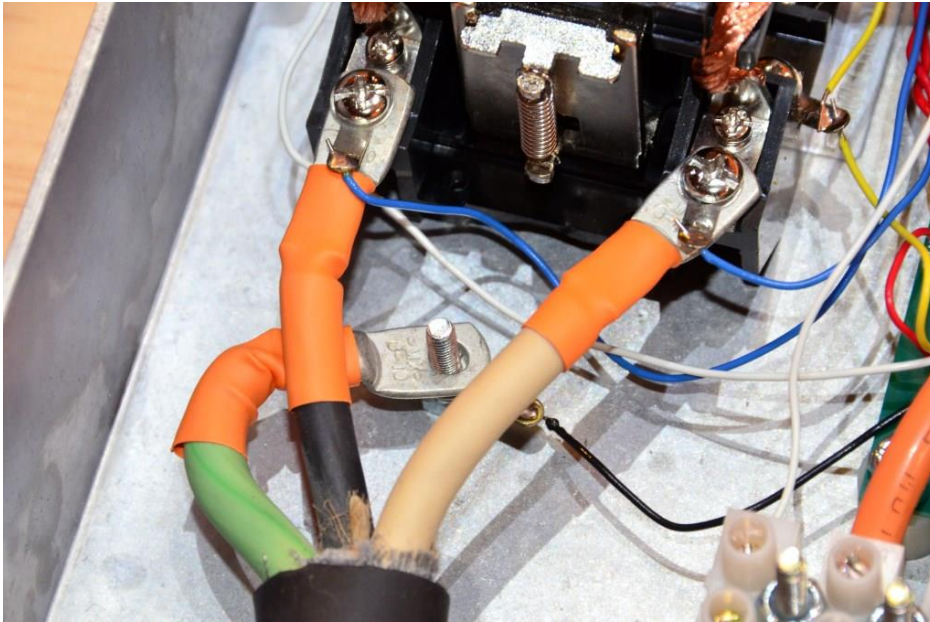
2. Connect the output J1772 cable
    a. Normally ~6" of the cable jacket would already be stripped – this is now sufficient prep for the cable. If your J1772 cable has less than 6" of jacket stripped, strip some more of the jacket
    b. Strip ~1/2" of the insulation from all 5 wires
    c. Crimp a supplied AWG6 lug to Ground, Hot1 and Hot2 wires
        i. You can use a dedicated crimper or a simple hammer – just ensure very tight compression fit
    d. Measure the resistance between Ground Wire (Green) and smaller gauge wires.
        i. One of the wires will have 150 Ohm resistance to Ground. Cut this wire flush with the J1772 cable jacket
        ii. Smaller gauge wire that has no connection to Ground (infinite resistance) is the "Pilot" wire
    e. Thread the prepared J1772 cable through the output cable gland (the one on the right side)
    f. Place the ground lug onto the ground post
    g. Thread the two hot wires through the CS2 current sensor
    h. Connect hot line 1
        i. Sharply bend the wire to the left after it exits the current sensor
        ii. Connect to the right AC-Jside relay terminal (see relay photo above), together with one of the AC wires from the J2 connector
        iii. You may need to bend a lug slightly to avoid interfering with the J2 connector
    i. Connect hot line 2
        i. Bend the lug so that the wire exits the relay in the upward direction (see picture below)
        ii. Bend the wire to the left to arc over to the left relay terminal for the bottom contact set
        iii. Connect to the left AC-Jside relay terminal (see relay photo above), together with the second AC wire from the J2 connector

j.  Ensure that the wires pass through the current sensor as parallel as possible, and are at the same height from the base of the sensor.
    i.  Failure to do this will likely cause false trips of the GFCI circuit above ~20-30A output
    ii.  You may need to adjust the wires if you are getting nuisance GFI trips (rare)
k.  Secure the wires' position in the sensor with some silicone sealant
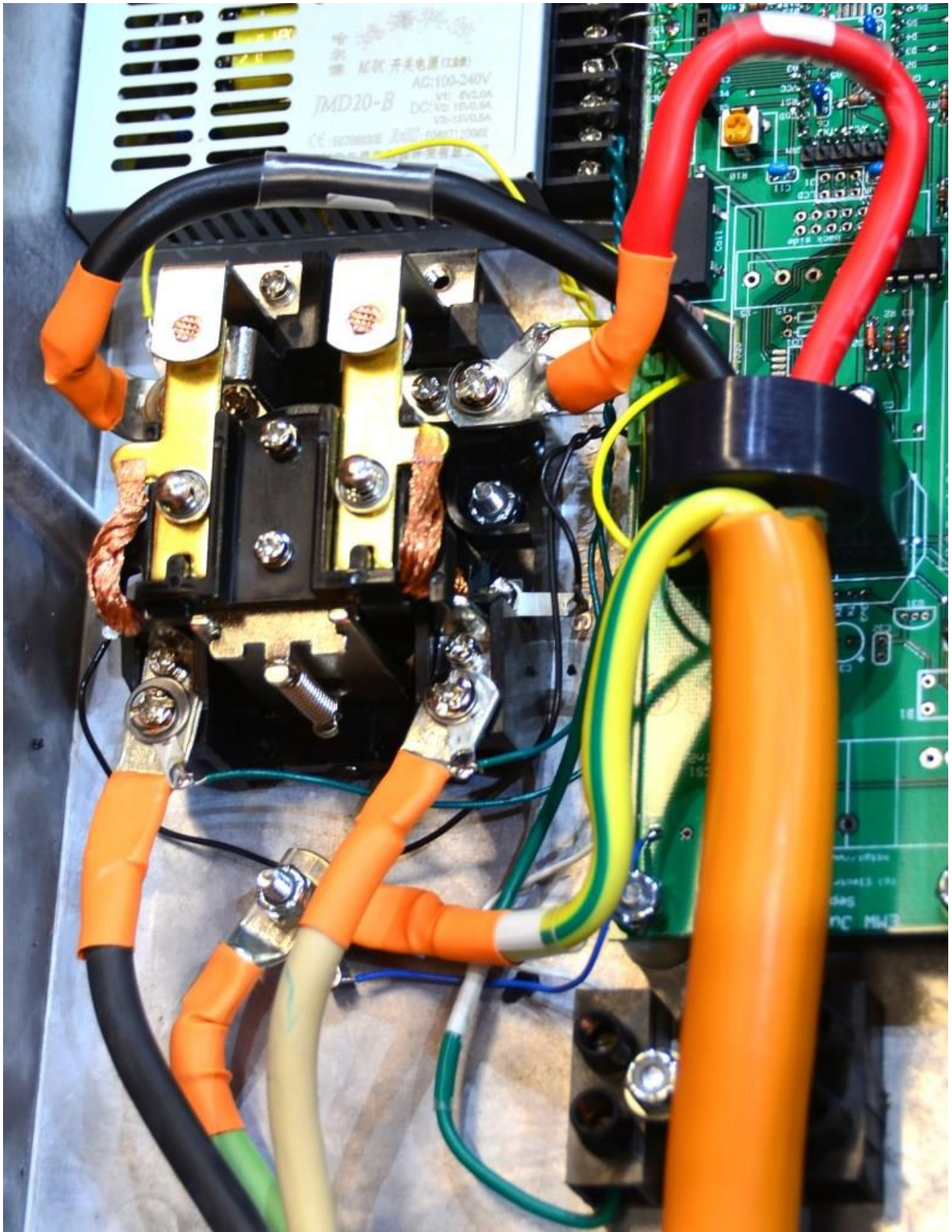
l. Solder the pilot wire to the pilot line you made in one of the steps above
    i. Protect the joint with a heat shrink tube or a piece of electrical tape

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

**Your Base Edition JuiceBox is now fully assembled!**

# Part 6.A. Connecting the cables – PREMIUM EDITION

1. Pass both input and output J cable through the glands in the top half of the enclosure. Ideally, pull ~3-4 feet through the glands and set the top aside.
2. Connect the input cable. Note that the instructions correspond to the standard input primary cable – 240V cable with a 14-50P plug. If you are wiring your JuiceBox for any alternate input cable, make sure that the power is delivered to the input terminals of the relay
   a. In a standard EMW cable, you would connect the red and black wires (2 hot lines) to the input positions on the main terminal (the ones that you connected to the input terminals of the relay)
   b. Neutral is not used and can be cut
   c. Ground wire gets a lug and goes to the ground post on the backplate
3. Connect the J cable
   a. Dual-color wire is ground – goes to the same ground post
   b. The other 2 thick wires are hot lines and go to the output positions of the main terminal (the 2 rightmost positions if you followed the assembly instructions above)
   c. Pilot wire (normally marked 'CP') goes to the same position you used to connect pilot wire from the PCB
      i. If you are not sure which wire is a pilot wire, follow instructions from Base edition assembly section to determine the right wire

**Your Premium Edition JuiceBox is now fully assembled!**

# Part 7. Programming the Arduino

## As of October 10, 2013, all kits come with Arduino board fully programmed with the latest firmware!

If you need to change the firmware (it's open source, after all) or if your newly assembled JuiceBox doesn't work right away, or you are just curious, the instructions are still available in the appendix.

# Part 8. Full Power Test / First Connection

1. **Ensure you follow proper High Voltage safety procedures**
   a. **Wear rubber-soled shoes**
   b. **Wear protective goggles**
   c. **Do not touch any terminals – even if you 'know' they are not live**
      i. **Be especially careful of inadvertently touching the live parts of the relay while holding the box – the box is metallic and grounded so there will be AC potential between the box and the relay terminals and contacts**
2. MAKE SURE ALL THE CONNECTIONS ARE TIGHT – double-check all the high-voltage connections – loose connections in a high-current circuit will likely mean overheating wires and melted isolation within a couple of minutes!
3. [OPTIONAL] Place a current clamp-meter on one of the input lines
4. Set current limit to the desired value (usually defined by the input circuit breaker / wiring)
   a. The adjustment is done via R10 trimpot on the main PCB (look for a small yellow head ~4-5mm in diameter)
   b. Left stop (counterclockwise) is defaulted to 30A in the firmware
   c. Just to the right of that, the 0-60A range starts, ending at 60A at the right stop
   d. Example: to set 15A output current, you would turn the trimpot just a couple of degrees past ¼ turn from the leftmost position
   e. Note that this setting has effect ONLY on 240V operation – 120V capacity is always defaulted to 15A in firmware. You can change that limit of 15A by editing the corresponding part of the firmware and re-uploading the new code to your JuiceBox.
5. [OPTIONAL] Plug in your JuiceBox into a 120V outlet protected by GFI and / or a protected power strip
6. If no immediate issues (e.g., sparks, smoke, etc), plug your JuiceBox into a 240V outlet
7. Wait 15-30 seconds. JuiceBox should cycle the main relay. If that does not happen, something is wrong. Time to debug.
8. Plug your J1772 cable into the car
9. Relay should close within a few seconds and stay closed
10. Confirm charging by your car's charging indicators
11. Monitor charging current on clamp meter
    a. If Premium edition, confirm [approximate] 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)
12. [OPTIONAL] 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 following the power flow
       i. Input wires as they enter the relay
       ii. Relay wiring and contacts
       iii. Power wiring
    c. All contacts / wiring should show no more than 20-40C above ambient at any output current setting within 30 min

13. [OPTIONAL] 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 30-50C above ambient at any output current setting
14. Disconnect JuiceBox, close the lid.

**Your Base Edition JuiceBox is now fully functional!**

# Part 10: Mounting your JuiceBox

**BASE Edition:**

In some of the early kits, we have pre-drilled 2 holes located on the vertical centerline of the enclosure. These should be the only 2 holes that are not yet occupied with the components.

For most recent kits, we are no longer drilling 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.

# Part 11: Using your JuiceBox

Basic use is really simple – just plug in and use

1. As of V8.6.3 firmware, you no longer need to observe certain sequence in plugging the JuiceBox into the AC line and the car
2. Prior top V8.6.3 firmware, you need to plug in AC first, wait for relay clicking, and only then plugging into the car

**WiFi:**

1. **[THE FOLLOWING IS NOT YET FULLY IMPLEMENTED / TESTED]**:
   a. Power up your JuiceBox
   b. Press button 'D' on your wireless remote for at least 2 seconds
   c. The JuiceBox should respond by printing its unique ID string on the screen. For ease of copying, the ID will be printed on multiple lines – you will have to later enter this ID without any line breaks
   d. Write down that ID and bring it to your internet-connected PC
   e. On your PC, open a web browser and go to http://www.emotorwerks.com/cgi-bin/JB_data.pl?ID=<ID> (instead of <ID>, enter your unique ID - without '<' or '>' symbols and line breaks)
      i. If you want to just see how the output looks at this point, visit this page – it shows the status of one of our units that is used to charge our company cars
   f. If your JuiceBox has previously successfully connected to our server, you will see some output in your browser window along with some timestamps. If not, you will see a 'no data' error message
   g. If you do see a 'no data' error message or if you don't see any recent timestamps, please repeat the steps in this appendix and if still cannot see the data, contact us at JB-support email address mentioned in the beginning of this document

**Premium Edition features**

1. **Wireless remote**
   a. Button C is the main Control button
   b. Button D is 'print JuiceBox ID' button
   c. Buttons A and B are not used at this point but are wired to specific Arduino Pins and can be user-programmed to do anything via changes in firmware. Refer to the firmware listing and PCB layout / schematics files for more info
2. **LCD**
   a. Should be pretty straightforward…
   b. You can modify what's displayed very easily by editing the firmware.
   c. For advanced functions, you will probably need to refer to the LCD datasheet – posted to the 'Supporting Docs' folder on our site

# Congratulations!

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

**More powerful.**

    **More extensible.**

        **More mobile.**

            **Sturdier.**

                **More protected.**

**And you built it yourself!**

**Go Electric!**

Yours truly,
EMW Power Electronics Crew
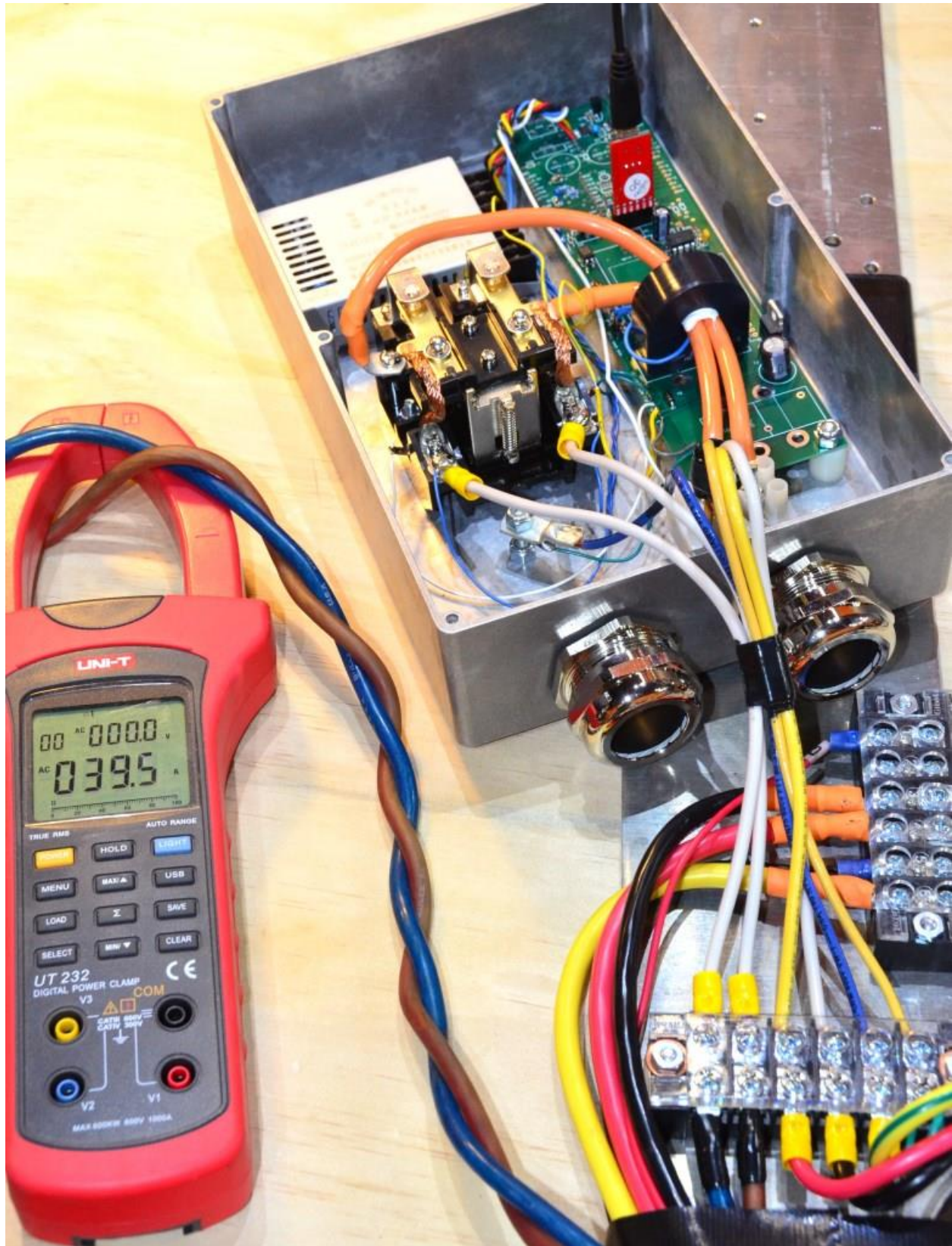
## JuiceBox charging a 2013 RAV4 EV at 40A

All assembled units are tested on this car before they ship – both at 120V and 240V

# APPENDIX A

**Premium Edition assembly sequence – starting from a fully assembled Base Edition board you will be getting as a part of your kit**

  a.  Place Slide Switch: J1
  b.  Place RF Receiver: labeled on board as RF recvr, orient pins to match labeling on the board
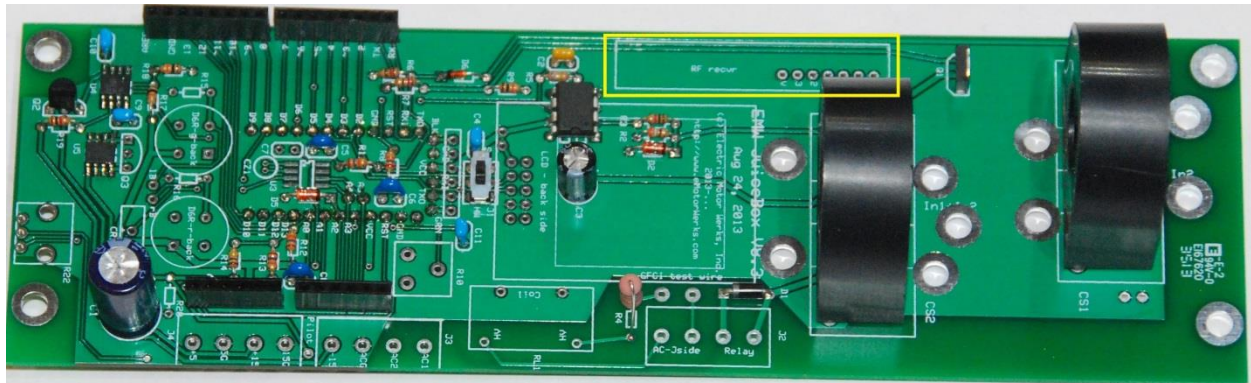


  c.  Place Current transformer: CS1
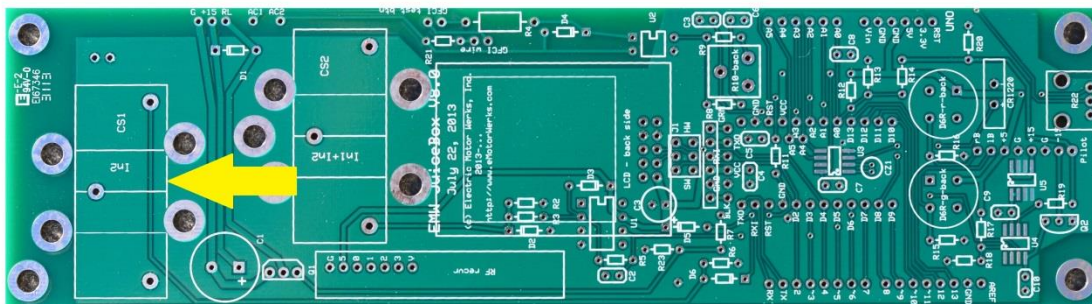


  d.  Additional Back Side Components
      i.  **If you are planning to install a WiFi module on the main PCB (possible from V8.6 of the main PCB), you will need to follow corresponding instructions found elsewhere in this manual BEFORE you place the LCD!!**
      ii.  Place LCD: labeled as LCD-Backside on top of board
          a.  Apply a 2" piece of electrical tape to the PCB under the LCD to prevent microUSB
          b.  Do not insert the LCD fully into the board – set LCD at ~4-5mm off the PCB surface
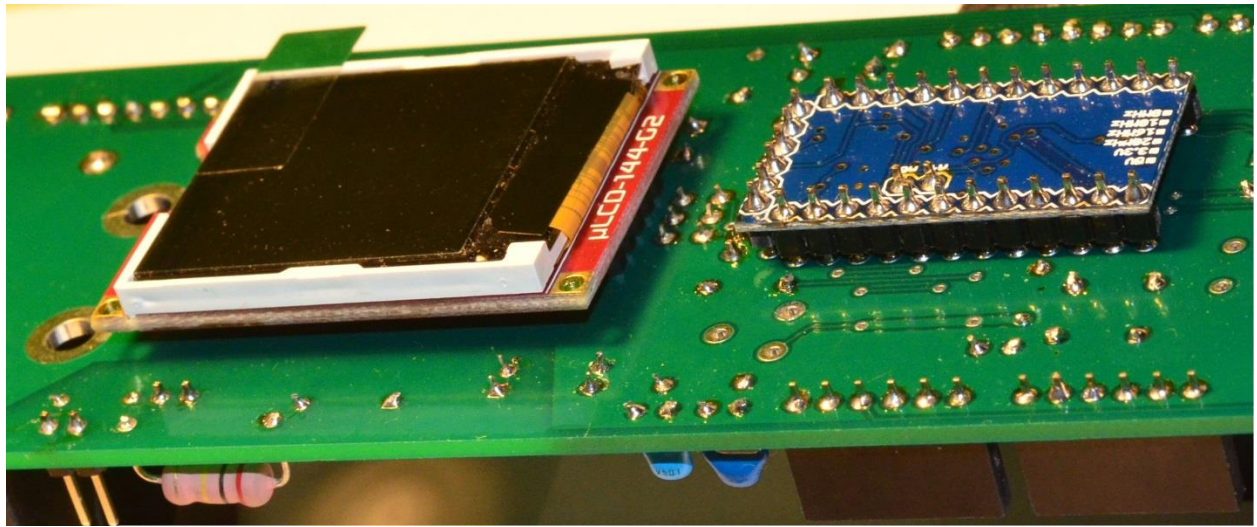
# APPENDIX B.1:

## WiFi assembly – on a separate Shield board

**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 remove 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 is to program the WiFi module directly from your PC
        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

Here's a quick photo of a bare and a completed board (V2.0)
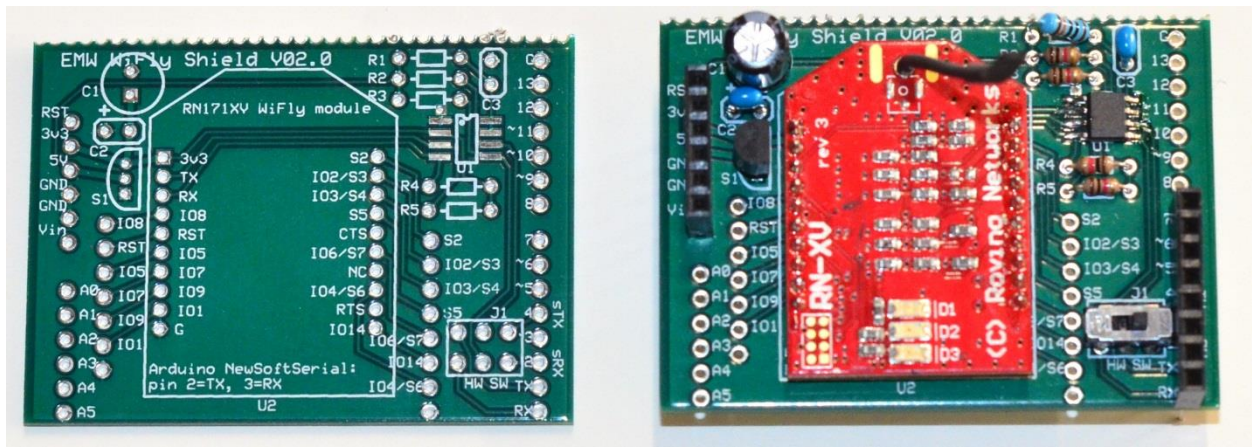
And here is the photo of the V3 board populated (all boards shipped after Dec 2013):
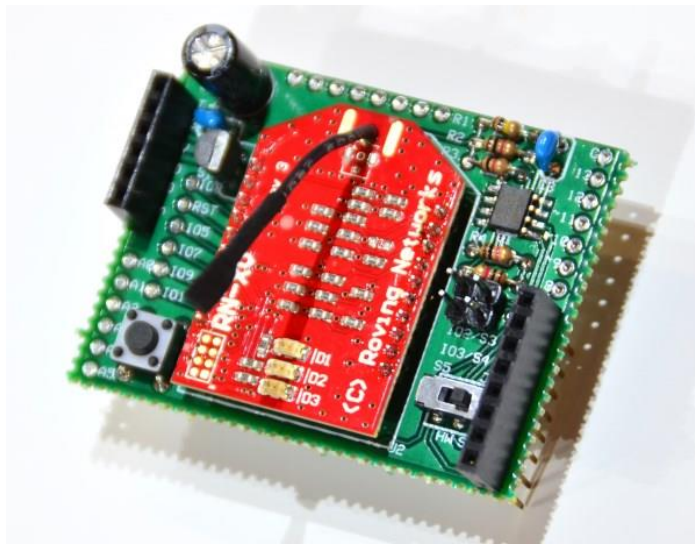


Finally, here is a photo of the board with external antenna (now available as an option from eMotorWerks store)
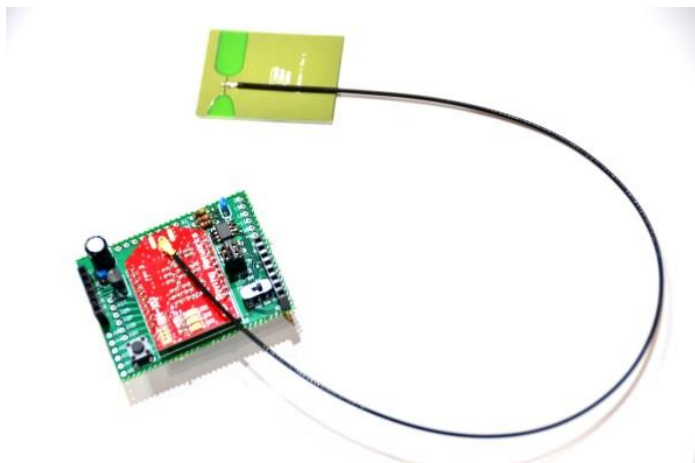
# APPENDIX B.2:

## WiFi assembly – on the main PCB

**These instructions are applicable for assembling WiFi unit right on the main PCB.** This is a default mode for Premium units and all JuiceBox PCBs starting with V8.6 will have a provision for this type of assembly. If you have ordered a Base edition JuiceBox and would like to add WiFI functionality, you would need to order our JuiceBox WiFi shield as a kit and then use these instructions to put it together on the main board

**If you are assembling a Premium Edition, you will need to perform these steps BEFORE you mount LCD!**

**Note:** do not overheat SMD parts

1. Group 1 – SMD components
    a. Place & solder the level translator IC (PCA9306): U31
2. Group 2 – ICs
    a. Place the WiFly module – from the BACK side
        i. Make sure the current sensor's leads are trimmed as flat to the board as possible
        ii. Apply a piece of electrical tape to the bottom of the WiFly module to prevent current sensor's leads contacting the grounded case of the WiFi module
        iii. Insert the WiFly module from the back side
            1. Observe orientation to match the module's outline on the board!
            2. Insert just enough to have the module's leads flush with the PCB on the other side – do NOT insert all the way – you want to preserve some spacing between the bottom of the module and the current sensor's leads
    b. Turn over, solder
        i. You might need to solder one corner lead first, adjust the position of the module if needed
        ii. Then solder an opposite corner lead, adjust position again as needed
        iii. Then solder the remaining leads
3. Group 3 - other small parts
    a. Place 100-200k: R31
    b. Place 1k: R32, R33, R34, R35
    c. Place 10-50uF cap: C31
    d. Place 0.1uF (104) cap: C32, C33
    e. Place 3.3v voltage regulator: Q31
    f. Place WPS button B1
    g. Solder pins
    h. Place small slide switch J1, hold it in place, turn board over, solder

## APPENDIX C:

## Enclosure preparation: Base Edition

**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.

1. 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
2. Drill 7x 7/32" mounting holes for all components
    a. Please use the CAD 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 CAD program if you want to drill from the back (easier)



<CAD file with hole map coming soon>
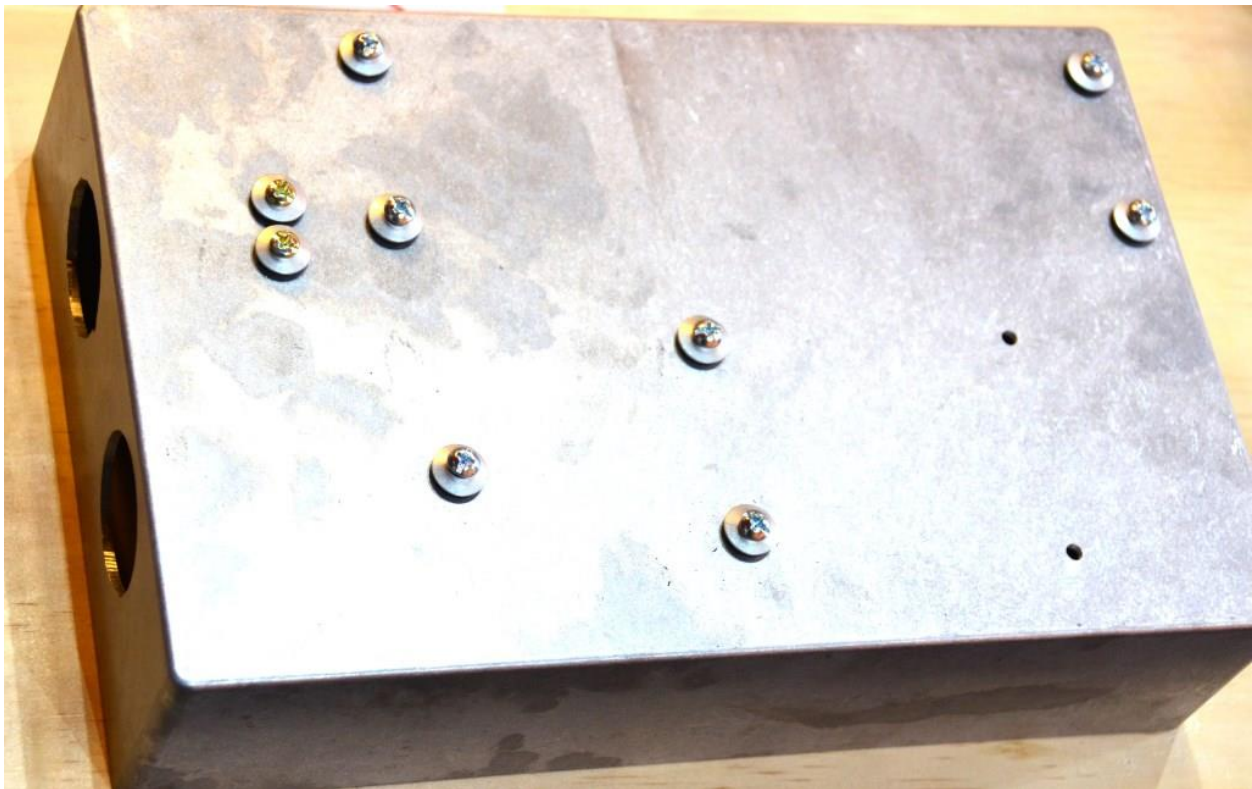
# APPENDIX D: Arduino Programming – main firmware

1. Install Arduino environment on your PC
   a. Firmware currently tested on Arduino V1.5.2
      i. Should work in any 1.0 or later versions, as well
   b. Main link at http://arduino.cc/en/main/software - you can download a stable 1.0.5 version or latest
2. Connect the FTDI cable to your PC
   a. As mentioned above, the FTDI cables are not supplied anymore as the Arduino chip is shipped fully programmed
   b. You can always order the FTDI cable from our online store (http://emotorwerks.com/products/online-store)
3. Make sure your PC recognizes the cable and assigns it a separate COM port
4. Download required Arduino libraries and firmware from the EMW site
   a. All files are in Firmware folder at http://www.emotorwerks.com/JuiceBox_Public/
   b. Make sure you select the right version folder based on the PCB version number printed on your PCB
   c. If a zip file available in the folder, download that file and unzip into some temporary folder on your hard drive
   d. Copy the libraries (TimerOne, uLCD144_SPE - files provided in the 'libs' subfolder) into your Arduino libraries folder (default location is C:\Arduino\libraries\
   e. Launch Arduino IDE you just installed
   f. From Arduino IDE, File->Open the main firmware (.ino file in 'EMW_EVSE_firmware' subfolder)
   g. You are now ready to edit the code
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 Mini' as the board type
   b. File->Tools->Processor, select 'ATmega 328 (5V, 16MHz)'
   c. [OPTIONAL] Check the "#define …" statements in the first 2 pages of the code (marked as '--------- MAIN SWITCHES -----------')
      i. Comment out '#define DEBUG' (so the line reads '// #define DEBUG')
      ii. Uncomment '#define AC1075' (so the line reads '#define AC1075')
      iii. If you have a WiFi shield you got from us, uncomment '#define JB_WiFi_simple'
         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 already configured as needed for the non-WiFi configuration
6. Upload the code to the JuiceBox
   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
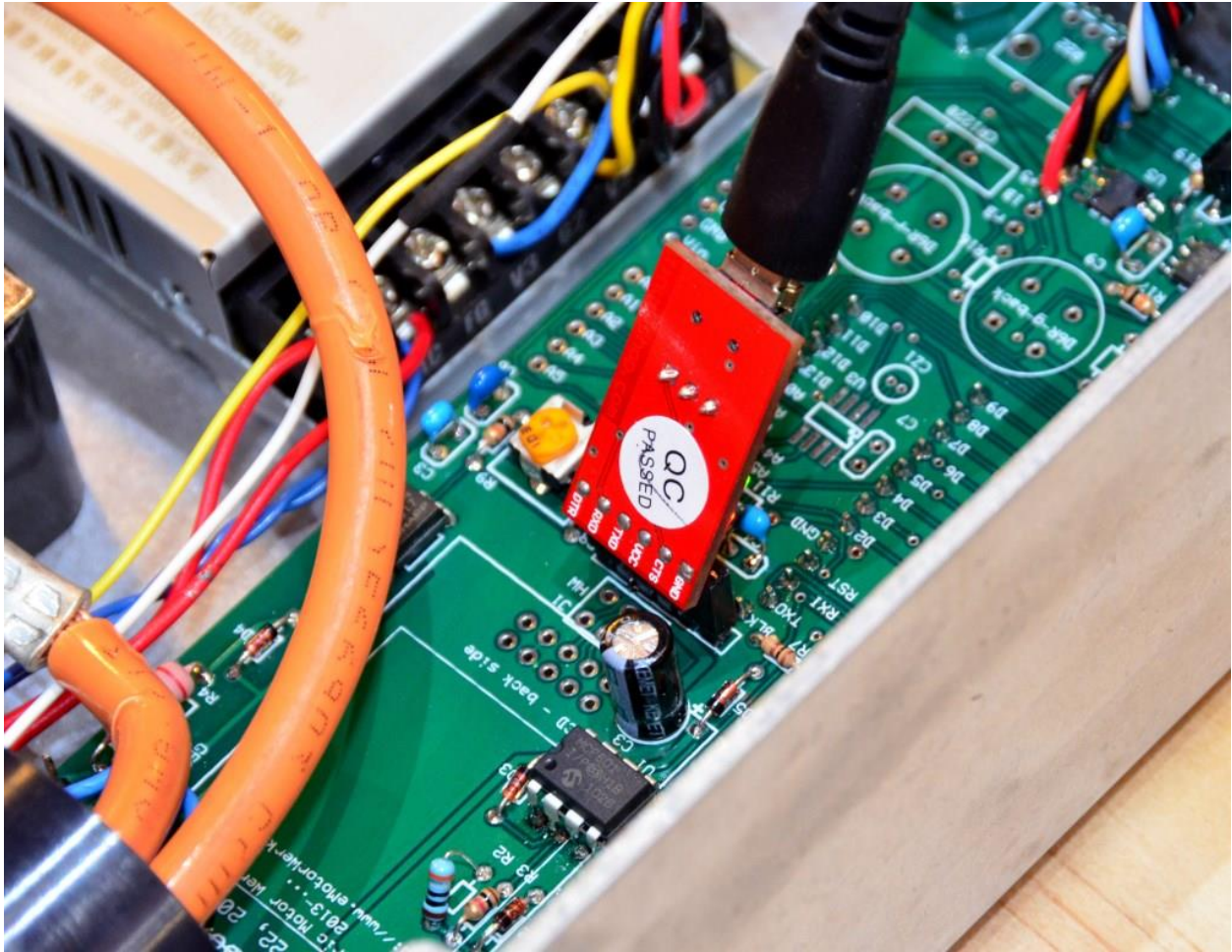


b. If you have a premium version / WiFI shield, ensure that BOTH slide switches (by the LCD and on the WiFi shield) are flipped into 'SW' position. If not done, they will interfere with the upload
c. In Arduino IDE, click Verify / Compile icon, confirm error-less compilation
d. Click Upload icon, confirm error-less upload

| | | |
|---|---|---|
| tton emulation | China | |
| he main Display | 4D systems | |
| rrent transformer | DigiKey | AC1075 |
| TC chip for non-volatile timekeeping | Tinyos DigiKey | DS1307 |
| sonator for RTC | DigiKey | |
| ttery for RTC | DigiKey | |
| ain contactor | China | |
| ain power supply, universal input | China | |
| wer entry / exit | China | JDM20-B |
| ut cable outer diameter is 0.9" | China | |
| ?A=0.7", 70A=0.84" | China | |
| 5", 11" | China | |
| 5 feet | China | |
| ttery - shape | USA - cus | |

dware design - VM    WiFi setup - VM    🔒 BOM V8.0 - VM

```
// #define JB_WiFi_simple // is WiFi installed and we are just pc
// #define LCD_SGC
#define PCB_81 // 8.1 version of the PCB
// #define PCB_83 // 8.3 version of the PCB
//-------------------------- END MAIN SWITCHES --------------

#include <Arduino.h>
#include <avr/interrupt.h>

// EEPROM handler
#include <EEPROM.h>
#include "EEPROM_VMcharger.h"

// WiFi library mega slon
#include <SoftwareSerial.h>
#include <WiFlyHQ.h>

//-------------------------- WiFi UDP settings -------------
```

Done uploading.

Binary sketch size: 18,722 bytes (of a 30,720 byte maximum) - 60% u

# APPENDIX D.1: Logic test

1. Disconnect FTDI header
2. If you have a Premium version, flip the LCD slide switch back to 'HW' position
3. Connect FTDI to the main PCB programming header. Do not connect input AC power to the JuiceBox yet
4. From Arduino IDE, launch a Serial Monitor (Tools menu). 9600 baud rate (should be already pre-loaded as default)
5. The board should reset and start outputting info into the Serial Monitor
   a. Depending on the Edition of JuiceBox, the output may be slightly different from what is shown below
   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 $2/3^{rd}$ of 60A full range -> Turn the trimpot $2/3^{rd}$ to the right -> confirm in the Serial monitor
6. 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
7. 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)
8. 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. Your 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)

```
    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
```

# APPENDIX E: Configuring your WiFi module

**Note: these instructions are applicable to WiFi modules installed on the main PCB or on a separate WiFi shield.**

**If you have ordered your WiFi shield together with your ASSEMBLED JuiceBox, or you have ordered ASSEMBLED JuiceBox with WiFi built-in, you can skip to WPS step below**

3. Connect FTDI cable to the programming header
   a. If you plug in the FTDI cable when the main AC power is connected, you will need to remove a small jumper from the FTDI board to avoid conflict of 5V power from USB with the 5V power from the JuiceBox's power supply
   b. Confirm connection by opening your Arduino IDE (see Arduino programming section for details) and navigating to 'Tools->Serial Port' in the menu. You should see some COM port – make sure it's checked
4. Configure the WiFI module
   a. All configuration is now done by Arduino - you need to upload a separate configuration program to Arduino and that program will configure the WiFI board – this sketch is now available from our Firmware folder on our site – make sure you use the code from the right folder for your PCB version
   b. Find 'EMW_EVSE_WiFi_programmer.ino' sketch file or similar in the firmware folder on our site
   c. Set the J1 switch into 'LCD' position
   d. Open the WiFi configuration sketch in the Arduino IDE
   e. You can edit the code to update SSID and Passphrase to the right ones for your network.
      i. That way, your WiFi module will be fully operational and ready to connect to your network right after upload.
      ii. You may need to refer to the RN-171 module's user guide – available from our site – in the 'Supporting docs' folder
      iii. Alternatively, you can use the WPS step described below for one-button configuration of the module
   f. Compile sketch and upload
   g. Right after the upload, open a Serial Monitor in Arduino IDE (Ctrl-Shift-M)
      i. Some of the settings reported by the unit may not be correct for your network – please ignore as you will set the unit up for your network through WPS process later
      ii. You will generally see something like this in your Serial Monitor:
         Starting
         Free memory: 826
         Success starting wifly
         DHCP NOW ON
         WLAN AUTH NOW 4 (WPA2)
         WLAN JOIN NOW 1
         SSID NOW FoxFi94
         PASSPHRASE NOW kolobok27
         IP PROTOCOL NOW 1

<div style="text-align: center">

IP REMOTE PORT NOW set
IP HOST NOW 50.21.181.240
COMM TIME NOW 0
COMM MATCH NOW 0xD
WPS IS NOW ON
RTC IS NOW ON from 64.90.182.55:123
LEDs are now available for JuiceBox's use
WiFly initialization COMPLETE!

</div>

   iii. If you don't see the last message (WiFly initialization COMPLETE!), something went wrong in the configuration sequence and you need to rerun it

     1. Close Serial Monitor and re-open it – this will trigger re-running the configuration program

     2. If you don't get the success message after 5 tries, contact us for help. Sometimes it will require a few tries due to some timing expectations within the module hence we are asking for 5 attempts before contacting us

**5.** Re-upload the main JuiceBox firmware

  **a.** Set the J1 switch into 'LCD' position

  **b.** Open the main firmware sketch file in your Arduino IDE

  **c.** The only thing you need to do is uncomment '#define JB_WiFi_simple' line

  **d.** Compile & upload to JuiceBox

**6.** **[WPS Step** – optional if you have programmed your network settings directly into the configuration sketch**]** Configure JuiceBox WiFi module for your network

  **a.** This is now done through WPS process – all your network parameters will be set with two button presses

  **b.** This is a one-time procedure – you need to do it only once. You can repeat these steps if your network config changes and you need to reprogram JuiceBox to match the new settings

  **c.** It is easier if your JuiceBox is in close proximity of your network router

  d. Make sure your JuiceBox is powered – USB connection via FTDI cable is sufficient (remember to re-install a small jumper on FTDI board if FTDI is the sole power supplier to the JuiceBox board)

  e. Make sure your wireless router is powered and connected to the internet

  **f.** Press WPS button on your router

  **g.** Within 15-30 seconds, press B1 button on the JuiceBox's main PCB (a small PCB button next to the wireless receiver)

  **h.** This should initiate the matching sequence – upon completion in a few seconds, your JuiceBox will be connected to the internet

**7.** Test JuiceBox's connection to the internet

  **a.** Upon successful connection, JuiceBox will start pushing data to our server

    **i.** Each JuiceBox generates a unique ID stamp the first time it is powered up. This positive ID allows to associate your JuiceBox with your online account on EMW server

    **ii.** Message structure: <JuiceBox_ID>:<data>:<END_OF_PACKET_CHAR>

    **iii.** <data> structure depends on the context (idle state vs charging state, etc) but generally follows the format:

<div style="text-align: center">57</div>

<var1_ID><var1_value>,<var2_ID><var2_value>,… var_ID is a one-letter variable identifier, var_value is an integer value for that variable. See firmware for specific identifiers

    **iv.** Normally, the following transmissions are made:

        **1.** Upon each power-on: "Power ON" message

        **2.** Every 10 minutes while in idle mode (no car charging): overall stats for JuiceBox operation to date

        **3.** Every 1 minute while charging: stats for this charging session and instantaneous power readings

        **4.** Every time there is an error: specific error message

**See 'Using your JuiceBox' section for details on how to access your data.**

# APPENDIX F: JuiceBox MODS! For Base Edition

**Note: these instructions are applicable to Base Edition JuiceBox only. They might or might not work for the Premium edition**

**MOD 1: Adding LCD to your JuiceBox**

1. X
2. Y
3. Z

**MOD 2: Adding WiFI to your JuiceBox**

1. X
2. Y
3. Z

**MOD 3: Adding a WebCam to your [WiFi-connected] JuiceBox**

1. X
2. Y
3. Z