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

V8.3 Installation Manual

September 19, 2013

The latest version of this document is always available from http://www.emotorwerks.com/JuiceBox_Public/8.3/

Message from the Founder

Dear Fellow EV Enthusiast!

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

Remember that even with a fully assembled unit, you can 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 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.

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

By installing this product, 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.

What am I installing?

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

This product was initially successfully funded from a KickStarter campaign. The project received over 230% of the target funding amount from around 300 backers.

The device is a full-featured J1772 charging station and supplies up to 60A 15kW to your J1772 vehicle (all production cars 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.

It's built around an Arduino microcontroller and EMW is making both the hardware and software open source. It 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.

It is also completely 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 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 ~10x7x3" weather-resistant enclosure. The cables are exiting from the bottom of the enclosure (from one of the small 7x3" sizes) so you will need some space below the JuiceBox to allow for cable routing.

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 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) Full GFCI protection comes standard - recommended for outdoor & permanent installations
(4) Larger, very cool-looking, unique enclosure custom-designed for EMW JuiceBox - with provisions for LCD screen, USB programming connection, etc.
(5) 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 5-5.5" diameter cylinder, 16-17" in height (as of September 16th, the final dimensions are being finalized). 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
  - Size: 11x7x3” (Base), 17x5.5x5.5 (Premium)
  - Environmental protection level: waterproof up to IP66 (when properly assembled and mounted)
  - Operating conditions
    - Outside temperature: -20C – 65C
    - Humidity: up to 100%
- Features:
  - Multiple protection levels
    - GFCI (Ground Fault Circuit Interrupter) – ~20mA trip point – protect from electric shock
    - 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)
  - LCD interface for display of major parameters (user adjustable through firmware)
  - Remote control (premium edition) 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)
  - 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
    - Automatic WPS-based WIFI configuration with a single button press
    - Note: a purchase of an EMW WiFI shield is required to enable WiFI functionality

Part 0. Before you start

Note that if you bought your JuiceBox with cables, we will generally connect those before shipping

1. **Required tools:**
    1. Screwdrivers
        a. Small flat
            i. Set current
            ii. Connect output cable
        b. Large flat / Philips for input wiring
    2. Wire stripper & crimper capable of AWG 8
    3. Drill & 3/16”-1/4” drillbit (for mounting the unit)

2. **Required components (commodity hardware etc) - not included**
    1. Screws to mount the unit
    2. Silicone sealant to protect the mounting points from moisture
    3. Ring terminals for input wire

3. **Education**
    1. Wouldn’t it be nice to actually understand what you are installing?
    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. Connect the cables

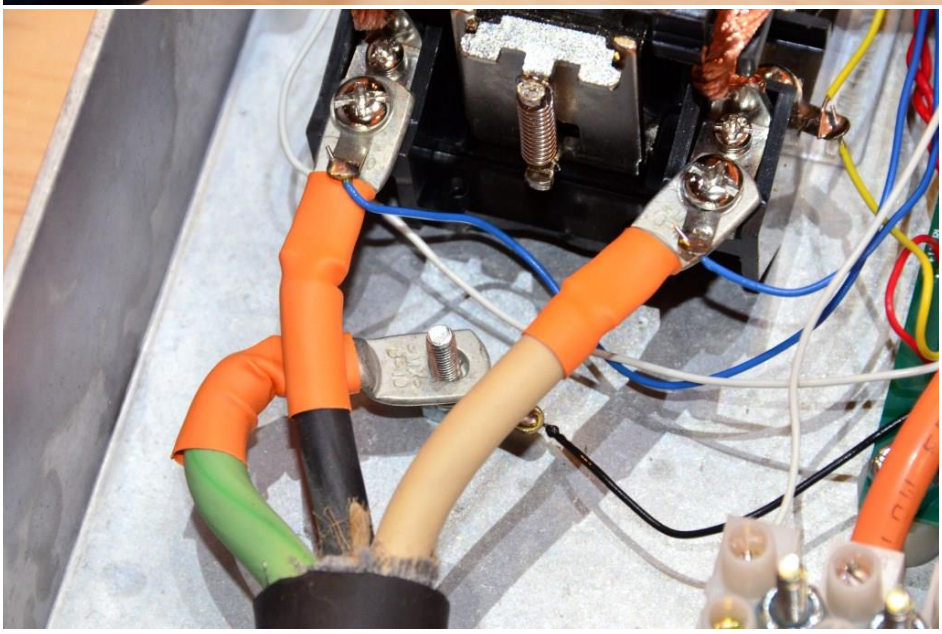
You will not need to do this if you have purchased JuiceBox with cables from us

All references below are made using the picture on the right. Mounting positions are as follows (from left to right):

1. Relay (middle-left of the box) – bottom-left: one of the input AC lines
2. Ground post – machine screw mounted to the box, with ~1/2” of the thread remaining: input ground, output J1772 ground, board ground
3. Relay – bottom-right: the second input AC line
4. White or black input terminal on the bottom right of the box)
    a. Position 1 (left-most): J1772 pilot signal
    b. Position 2: one of the output J1772 lines
    c. Position 3: the other output J1772 line


CS2
AC1050, AC1060,
AC1075 – GFCI

1. Connect the input cable
    a. Remove ~4” of the outer cable jacket
    b. Fit 3 lugs / ring terminals with #8 / #10 holes to the hot and ground lines of the input cable
    c. Thread the input cable through the input cable gland (left gland)
    d. Bolt one of the hot lines 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)
    e. Bolt the other hot line and AC signal wire onto the other relay’s common position
    f. Place the ground wire from input cable onto the ground post - along with a ground signal wire from the PCB



2. 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 2 and 3
    ii. Pilot to position 1
e. Connect J1772 Ground onto the ground post and fasten using a locknut

3. Tighten the input and output glands to that the cables cannot be moved by pulling / pushing from outside
    a. You may need to use a pipe wrench or a large adjustable wrench to do this

Part 2. WiFi installation (if applicable)

At this point, WiFi option on a Base unit is not possible due to a full-metal enclosure. We are working with our enclosure manufacturer to provide additional options and will post an update to our website shortly

Part 3. Full Power Test

1. **Ensure you follow proper High Voltage safety procedures**
2. Using a small flat screwdriver, set the output current of your JuiceBox
    a. Normally a yellow 3-terminal part on the right side of the PCB, in the middle
    b. Left-most trimpot position = 0A, right-most = 60A – set yours at the level desired AND supported by your input and output cables (i.e. do not set 60A if you are using a 30A outlet and your car can draw 60A if allowed)
3. Close the lid – make sure you apply enough torque to the screws to see a visible squeeze of the gasket
4. Plug in your JuiceBox into the 240V outlet
5. Wait 15-30 seconds for the system to initialize
6. Plug your J1772 output into the car
7. Confirm charging by your car's charging indicators
8. Observe your cable connections for the first 30 minutes of charge - check all potential heat producers in a circular pattern following the power flow
    a. Input wires as they enter the relay
    b. Relay wiring and contacts
    c. Power wiring (all AWG 6 wiring)
    d. Output wires as they enter and exit the output terminal strip
9. Unplug from the car
10. Unplug from the AC line

You are now ready to use your JuiceBox as a mobile charging device!

Part 4: Mounting your JuiceBox

In some of the early units, we were pre-drilling 2 holes located on the vertical centerline of the enclosure.

For most recent shipments, 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.

Congrats!

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

More powerful.

More extensible.

More mobile.

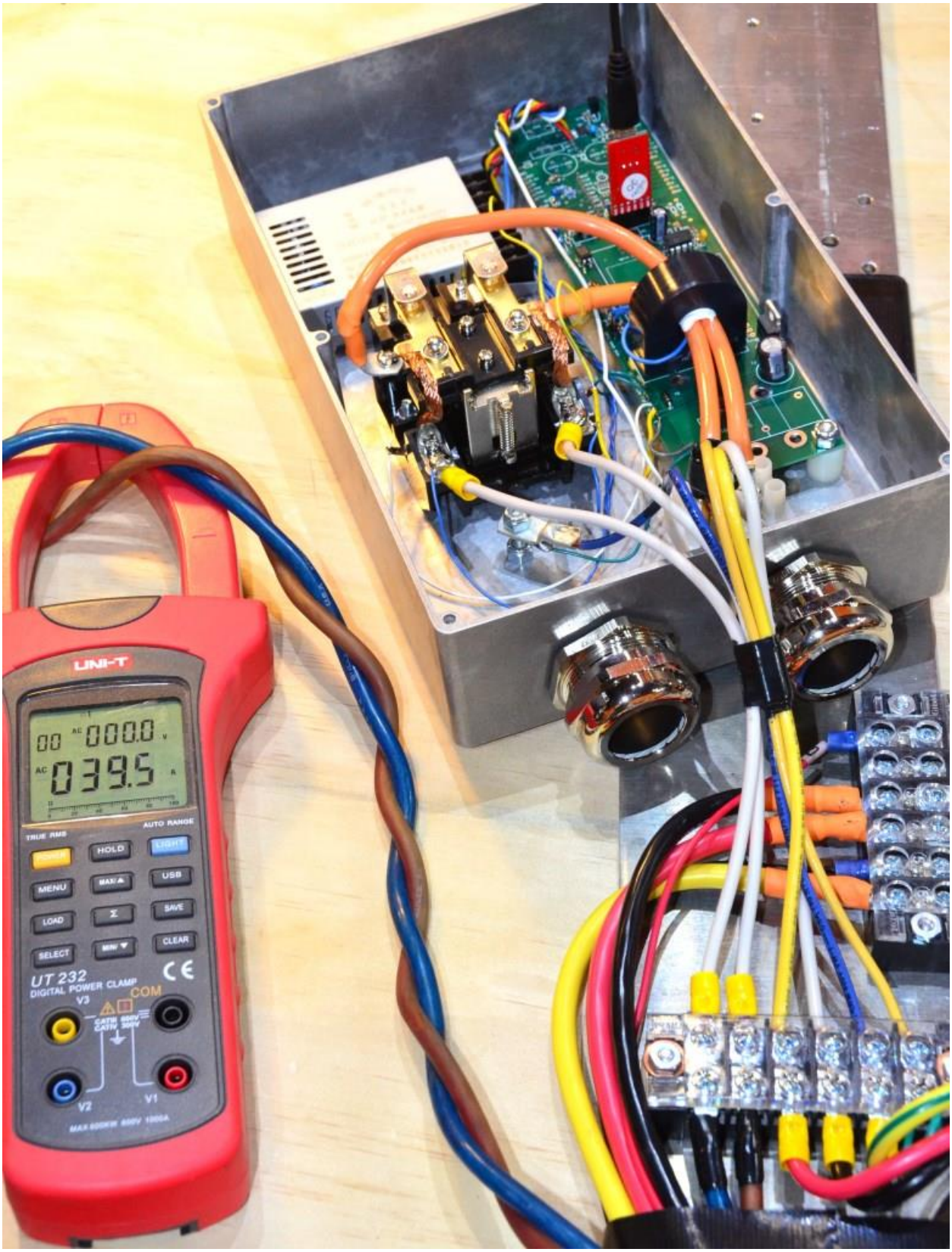
Sturdier.

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