



POWER UP

Open Source & Nissan Leaf Batteries



Richard O'Donoghue

This evening's talk

- The disposable car problem & my anger towards automotive manufacturers
- Dalathegreat – Star of the show
- How hard is it to replace / upgrade a Leaf battery – entire process walkthrough
- Reuse / Recycle – What do I do with the old battery after an upgrade?

The disposable car

- Perfectly good cars end up being “mechanically totalled” due to one or two components going bad.
- Manufacturers use tactics to block you and me from being able to repair our own vehicles.
- EV's are especially vulnerable to this with replacement batteries being out of the question.

Mechanically totalled reasons:

- a control module goes bad, sensor dies which requires an engine out situation, a battery back degrades or is damaged.

Manufacturer tactics

- Proprietary software with restricted use (dealer or factory only) blocks from repairing vehicles. Industry grade aftermarket software and tooling is available but is out of the price range of most people.
- Simple repairs can require the use of said tools. No more changing your brake pads, you need the computer to release calipers electronically or risk bricking the car.
- Extortionate parts pricing – parts are far more complicated than they need to be.
- Cars are not designed to be repairable in the first place. Common service items or failure points often require hours of labour or specialty tools.

Examples of anti-repair practices

- BMW I3 – Range extender cam shaft sensor failure requires an engine out job to replace.
- Toyota Land Cruiser starter motor replacement requires partial engine disassembly.
- Mazda 3 – Entire fuse junction box has to be removed to replace the cabin filter.
- Many modern cars becoming bricked when servicing brakes without dealer software due to electronic parking brakes.

BMW I3 – Some DIY and shops realised a hole could be drilled in the carbon composite panel behind the rear passenger seat for easy access – saving thousands in labour costs.

Land cruiser – normally starter motors are very easy to access from under a vehicle and replacing one takes 10 minutes

Mazda 3 – On most cars a 5 minute job.

E-brake systems require adaption after changing pads and rotors otherwise they will either clamp down too hard, throw an error code and lock the car in park. This usually cannot be done without dealership or industry grade software.

Great people come from Finland



Like Linus, the champion of this story is from Finland.

dalathegreat

- Daniel Öster (dalathegreat), an automation engineer dedicated much of his spare time to reverse engineering the Nissan Leaf ZE platform.
- He made all of his findings available under GPL 3.0 on Github including guides, CAN dumps, message decoding, firmware for CAN bridges and repurposing old batteries in solar arrays.
- He now runs his own business “Dala’s EV Repair” which is dedicated to extending the life of EV’s.

Daniel runs a discord server where many ev enthusiasts work together to reverse engineer other cars of other makes and models.

So your Nissan Leaf battery is dying, what do you do?

- Pay between \$10k-\$20k through an independent shop to have your battery pack replaced or repaired (terrible option).
- Find replacement good cells, somehow manage to balance them without the equipment to do so and install them without exposing yourself to 400V of electricity.
- Find a second hand battery with a same or higher capacity from a donor car and DIY the swap.

Independent shops have popped up over the past decade to “solve this problem” although the cost is outrageous.

Replacing bad cells with new cells is a high risk, time consuming and dangerous way of fixing the problem. Overtime you'll just need to replace more as other cells degrade. Often cells wear more evenly than you may think.

The last option is far more palatable. The recommended swap is to find a deregistered, or damaged AZE1 with a 40kWh battery. These can be fetched at Turners damaged auctions or on marketplace for \$3500-6000 depending on condition. On the second hand market, a running driving AZE1 is climbing in value due to fuel costs. Often costing close to or above the \$20k mark.

When you should do this

- You own a 2013-2017 Nissan Leaf and your battery pack has either low range, low resistance or poor state of health (SOH) or all of the above.
- You can do this on a 2011-2012 car but the swap is has more steps, and IMO not worth it due to several short comings on the earlier models.

2011-2012 cars have a different main connector for the battery vs 2013 onwards meaning an adapter harness or repinning of the loom is needed (22 pin to 36 pin connector).

2011-2012 cars aren't as well built, known for bad water leaks (trust me I know).

They also have a very unreliable and inefficient heater unit (consumes 5-6kw continuously) vs the heatpump unit which uses 1-2kw.

Regenerative braking is far better and more aggressive on 2013+ cars.

2013 cars also feature other creature comforts such as heated seats and steering wheels as options which are common on jap imports as typically only higher spec models are imported.

What's needed for a swap

- Basic electrical knowledge and tools (soldering iron or soldered heat-shrink, wire strippers etc)
- Hand tools (ratchet, 10mm, 13mm, 16mm, 18mm sockets).
- Access to a two post hoist, or jack-stands and hydraulic jack.
- CAN-Bus Bridge – MB CAN 18 in 1 board and STM32 flasher
- LeafSpy Pro Android app (closed source and paid BOOO) & OBD2 dongle (LELink) (Needed to clear any DTC's).
- Donor car & healthy battery.

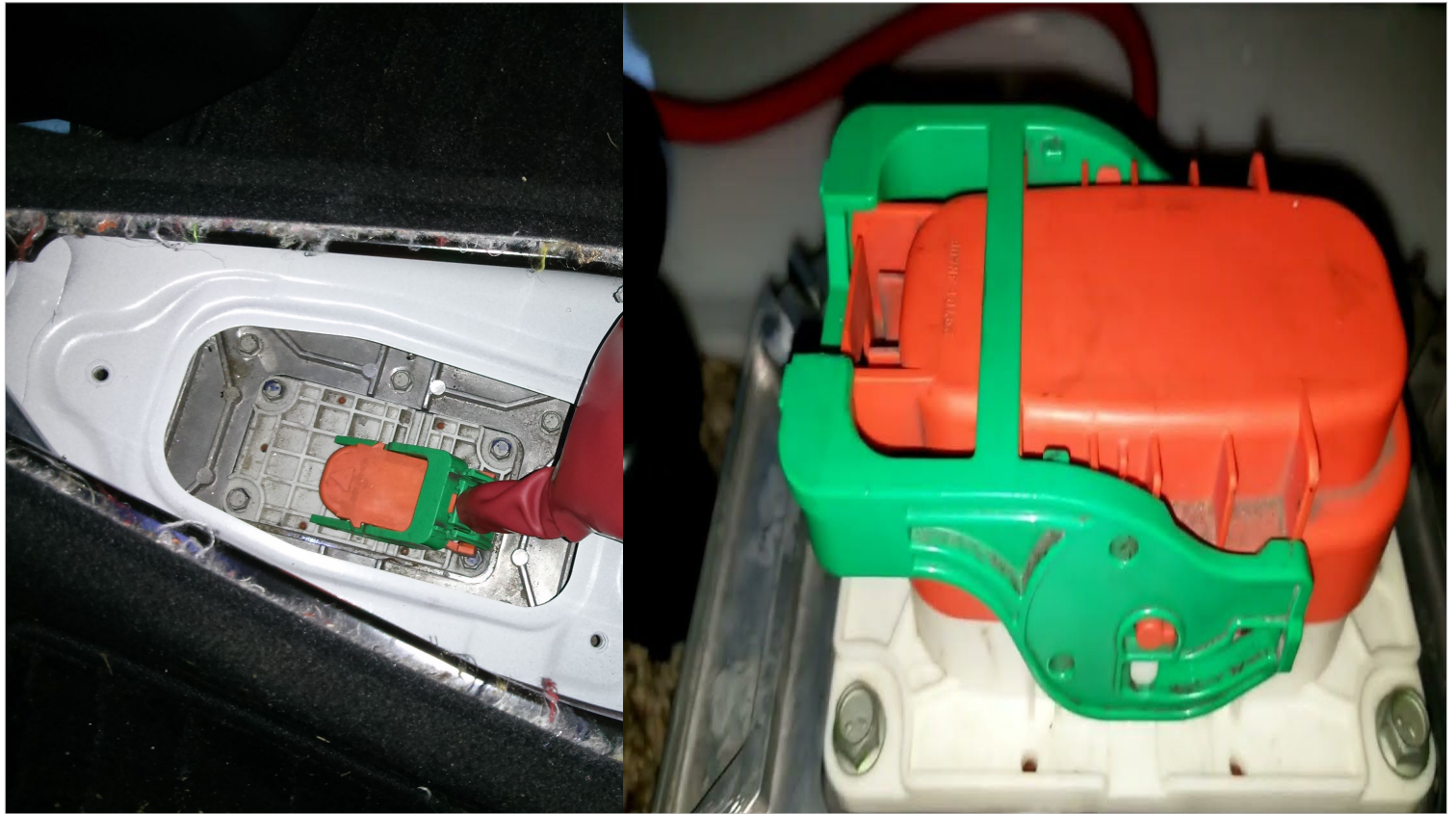
Diagnostic Trouble Code

LeafSpy an unfortunate but cheap closed source app that allows you to analyse battery health and interact with the car.

STM32 Link cable \$10-20, MB CAN 18 in 1 board can be picked up for \$20 on Ali Express + shipping

Where do we begin?

- Jack up the car or preferably use a two post hoist if you have access to one.
- 10mm wrench to disconnect the 12V Battery under the bonnet.
- Lift up the flap on the floor behind the centre console, undo the three bolts, lift up the cover and then release and pull the high voltage disconnect.



Left photo:

On the left you'll see the inverter under the hood of the car where there would normally be a ICE. Right next to it is the tiny 12v battery which can be disconnected with a 10mm deep socket or spanner. Just be careful of the voltage sensors on the harnesses.

Right photo:

On the right you'll see the high voltage disconnect. The green handle acts like a lever, unlocking the connector and pushing it upwards as you push the lever towards the front of the car. The HV disconnect just has a large fuse rated for 450v @ 220amps. Otherwise its nothing special. Some people like to replace the bolts with thumb screws so that in the unlikely event of an emergency, you can get to the disconnect without needing any tools.

Battery Removal

- Disconnect the Main battery loom and PTC heater power cable from the rear of the battery.
- Undo 16 bolts around the outside of the battery housing.
- Get ready to catch it....

If using a hoist, set a trolley or table underneath the car and lower it down to receive the battery.

Otherwise on the ground use an assortment of hydraulic jacks and dollies.



Underside of the car.



Left PTC heater cable. (positive temperature coefficient) basically a large heating element. As it gets hotter, its electrical resistance increases automatically which limits the amount of current draw.

Middle is the main power cable which goes to the charging circuit and up to the inverter

The right plug is a diagnostic / canbus network port for the battery. This loom is what we will be tracing further into the car to install the canbridge.

Installing the new battery.

- Rinse and repeat on donor car.
- Do the reverse of removal with new battery
- Note if your car does not have a PTC power cable to the battery you will need a PTC Plug cover to put over the connector.

Programming and Installing the Can bridge

- Download the software from the repo. Both 2 and 3 port boards are supported.
- Flash the correct build across for your board
- Optionally you can 3D print a case for the board. STL files are included for this.

<https://github.com/dalathegreat/Nissan-LEAF-Battery-Upgrade.git>

Installing the Can Bridge

- Remove the center console from the car by undoing a couple of screws in the arm rest pocket being mindful of the looms for the gear selector.
- Wire it up. Note: wire colour may vary

Red wire #1 -> +12V constant (fuse with 3A)

Red wire #2 -> +12V constant (fuse with 3A, join together with other red wire)

CAN-1L (Purple?) -> EV-CAN Low, Green wire (battery side)

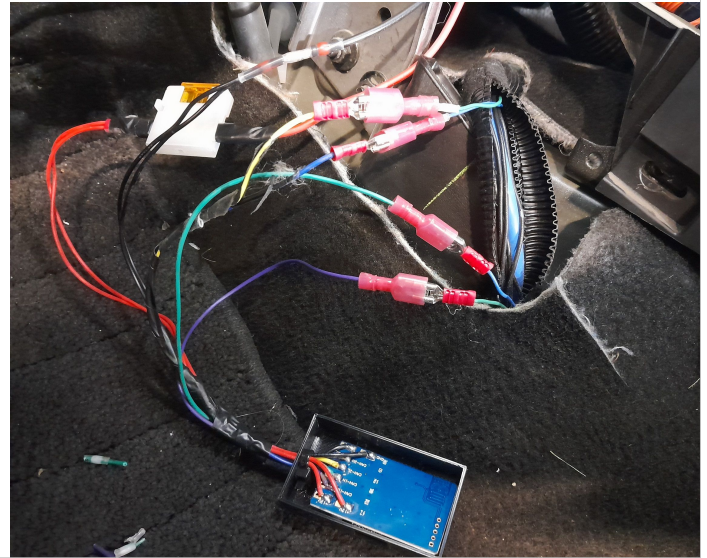
CAN-1H (Green?) -> EV-CAN High, Blue wire (battery side)

CAN-2L (Yellow?) -> EV-CAN Low, Green wire (vehicle side)

CAN-2H (Blue?) -> EV-CAN High, Blue wire (vehicle side)

Black -> Ground

Black -> Ground



Pairing the battery to the car

- Plug in your OBD2 dongle
- Power up the car
- Open LeafSpyPro and begin a DTC scan
- Expect a P3102 error code
- A hidden pair battery utility option will become available in the dropdown menu
- Execute the pairing procedure and then power cycle the car.

The result

- A car which should hopefully serve you for another decade (as long as you take care of the battery).
- Better range if you went from 24kwh or 30kwh to 40kwh (~120km new to ~260km).
- Big savings
- Only draw back is charging times – these will increase substantially.

What do I do with the rest of the donor car?

- The seats, steering wheel, wheels and tyres can be kept or transferred to your car.
- If your donor car is a 2018+ onwards you could swap the inverter over for more power. Dala has a guide for this too.
- The rest can be recycled or sent to the wreckers.

What do I do with my dead old battery?

- DIY Solar storage.
- Dala's Battery Emulator software project allows you to wire up the battery BCM to an inverter to allow it to be used for storage in a solar array.
- Once again GPL 3.0 licenced.
- Dala's youtube channel is filled with videos on how he set up his DIY Solar storage.
- You'll save thousands on battery storage.



Questions

- Sources:

<https://github.com/dalathegreat>

<https://www.youtube.com/@DalasEVRepair>