EVerest: AC and DC electric vehicle charging with open source software and hardware
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How to charge a car?

- **Basic AC charging**
  - at home: portable charger, wall mounted charging station up to 11/22kW
  - or in public with RFID/App authentication
- **“smart” AC charging** (not a lot of cars support that yet)
  - ISO 15118-(2/20), Plug&Charge
  - upcoming: bi-directional AC charging
- **DC charging**
  - DIN SPEC 70121, ISO 15118
  - highway fast chargers
  - smaller units at home, think DC-DC solar etc.
  - upcoming: bi-directional DC charging
What is EVerest?

- A complete software stack for EV chargers
- Runs on embedded Linux
- Apache 2.0 License
- Aims to support many different HW platforms
  - and you can build your own!
EVerest features

- Modular architecture
- Graphical setup web interface
- Energy management

Simple AC or DC Charger

AC+DC Hybrid Charger
EVerest features - Build a simple AC Charger
Step 1 of 6

EvseManager

- One charging connector
- Charging logic and session
- Orchestrates all other modules access to this one connector
EVerest features - Build a simple AC Charger
Step 2 of 6

Board support

Hardware driver:

- CP, Relais, RCD
EVerest features - Build a simple AC Charger
Step 3 of 6

Energy manager
- Minimal configuration, more advanced later
**EVerest features - Build a simple AC Charger**

**Step 4 of 6**

**Auth manager needs**

- Token providers (output tokens) and token validators (can check if token is valid)
- We add two token providers:
  - RFID (new module)
  - Autocharge (EvseManager also has a token provider interface for EVCCID)
EVerest features - Build a simple AC Charger
Step 5 of 6

Add Cloud backend

- OCPP 1.6J module
- Powermeter
- System module supports reboot/firmware update etc via OCPP
EVerest features - Build a simple AC Charger
Step 6 of 6
Add API for ext. applications
EVerest features - Configure energy management

Energy manager

Complex energy distribution trees can be represented to load balance multiple charging stations. Load sharing will work across the tree with different optimizer targets for each car.
EVerest features

- Software- and hardware in the loop simulation (IEC61851, ISO15118)
- Lots of protocols:
  - OCPP 1.6 (2.0.1 coming soon)
  - ISO 15118 (AC+DC)
  - DIN SPEC 70121
  - IEC 61851 / SAE J1772
  - ModBus
  - Sunspec
  - MQTT
- Multiple language bindings: C++17, Python, JavaScript
Basic PWM Charging

CP signal: +/-12V signal, 1 kOhm impedance

Car can lower positive part by adding load resistors and a diode to
- 9V (connected)
- 6V (wants to charge)
- 3V (charge with ventilation)

0V: Car fault or no power

-12V: EVSE fault

Duty cycle encodes available current (typically 6A to 32A)
Building a AC charger

- Not a battery charger just a smart relay
- Powerpath: Relays, RCD for safety, optional power meter plus a microcontroller
- Linux board to control more advanced things
Open Hardware: Yeti & Yak

You wouldn't download a car (charger) - or would you?

- [https://github.com/PionixPublic/reference-hardware](https://github.com/PionixPublic/reference-hardware)
- CERN Open Hardware Licence Version 2 - Permissive
- Developer friendly
- Designed with KiCAD 6 [https://www.kicad.org](https://www.kicad.org)
- Case design files for 3D printing available
Yeti

- 22kW AC 3 phase power board
Yeti features

- Control Pilot (CP) signal generation in compliance with IEC61851-1/SAE J1772
- CP signal sampling in sync with PWM
- Onboard 35A relay for three phase power switching
  - with mirror contacts for welding detection
- Onboard 3ph power metering
  - Supports up to 8 Khz sampling
  - Measures voltages, currents, power and frequency of all phases plus neutral
- RCD module
  - For 5/6mA DC ground faults and 20/30mA AC faults
  - Outputs measured leakage current for telemetry
Yeti features (continued)

- 10 pin connector for high level board with control UART
  - Connection to the Yak board
- External connector for a small SPI LCD
  - Useful if used as a standalone charger
- External RS485/ModBus
  - For external power meters etc.
- External GPIOs
- Power input:
  - Onboard 110V/230V -> 12V supply (or external)
    - Onboard ACDC can supply high level Yak board too!
- … and much more!

https://github.com/PionixPublic/reference-hardware#yeti-features
Yeti micro controller firmware

- STM32 firmware for Yeti power board
- [https://github.com/PionixPublic/yeti-firmware](https://github.com/PionixPublic/yeti-firmware)
- Apache 2.0 License
- Controls all devices on Yeti board
- All electrical safety relevant code encapsulated here
-Communicates via UART/Protobuf with EVerest
How to use Yeti

- As a standalone charger
- As a power path for a smart charger
- Automatic switching can be implemented to fall back to emergency free charging in case the higher level linux board fails
How to use Yeti - As a standalone charger

- Yeti is a complete AC charger for electric vehicles supporting IEC-61851-1 / SAE J1772 basic charging
- Contains the full charging logic, car charges immediately when connected
- UART to observe status with limited control over the charging session
- This mode is called "high level control" mode in the yeti firmware
How to use Yeti - As a power path for a smart charger

- Yeti firmware can be switched to "low level control" mode with a UART command
- Here the charging logic must be external, only the basic state machine for states A-F remains in the microcontroller
  - This basic state machine is essential for electrical safety
- An external board sets the PWM duty cycle and reads back the control pilot events
- This is the mode used by EVerest to also enable HLC (high level charging, ISO 15118-(2/20) / DIN SPEC 70121)
HLC High Level Charging

Uses Powerline communication on top of CP PWM signal (on the same wire, Homeplug GreenPHY standard)

1) Setup logical network between EVSE and car using SLAC
2) Assign IPv6 link local addresses on both sides
3) Car sends UDP broadcasts to find EVSE
   EVSE replies with its IP and port number
4) TCP/TLS connection from car to EVSE
5) ISO 15118 protocol through that TCP connection
   (XML data encoded with EXI)
Yak

- High level control board
- Runs EVerest on (embedded) Linux
Yak features

- Raspberry Pi Compute Module 4 (CM4)
- 10 pin connector for direct connection to Yeti board
- RTC with backup battery
- PLC GreenPhy modem for HLC communication with car
- UART/power connector for popular PN532 based RFID modules
- RS485/ModBus
- CAN bus
- Ethernet, Wireless LAN 2.4Ghz/5Ghz and Bluetooth 5
- USB ports
- USB client port to flash the EMMC of CM4
- External GPIOs
- [https://github.com/PionixPublic/reference-hardware#yak](https://github.com/PionixPublic/reference-hardware#yak)
Putting everything together

Yak high level control board

IEC 62196-2
Type 2 connector

Yeti power board

Mains 3 Phase Power In
Coming Soon: DIY Bidirectional DC

Yak board already prepared for everything that you need for DC communication

“just” needs some DC power electronics, isolation monitor

![Diagram of DC communication system]

stay tuned for more this summer!
How to get involved

Check out the code: https://github.com/EVerest
Hardware designs and microcontroller firmware: https://github.com/orgs/PionixPublic/repositories

EVerest Mailing list: https://lists.lfenergy.org/g/everest
EVerest project page on Linux Foundation Energy: https://www.lfenergy.org/projects/everest

Quick start guide: https://everest.github.io/general/quick_start_guide.html

Technical Steering Committee (TSC): Follow the evolution of EVerest, get involved, open to all!
   Every 4th thursday of the month, announced via mailing list
   Recordings available on YouTube: https://www.youtube.com/@lfe_everest

Weekly Tech Sync - Join the developers and start contributing
   Every Tuesday 10am -11am CET, meeting link via mailing list