Electric Vehicle Energy Measurement

Degree programme: BSc in Electrical Engineering and Information Technology
Specialisation: Electric Mobility
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The EV Energy Measurement device supports fair road-use taxation by integrating a secure energy monitoring system into charging cables. It calculates energy per session and transmits usage and location data via low-power LTE and GPS/cellular networks. Backup power ensures reliable operation and data integrity.

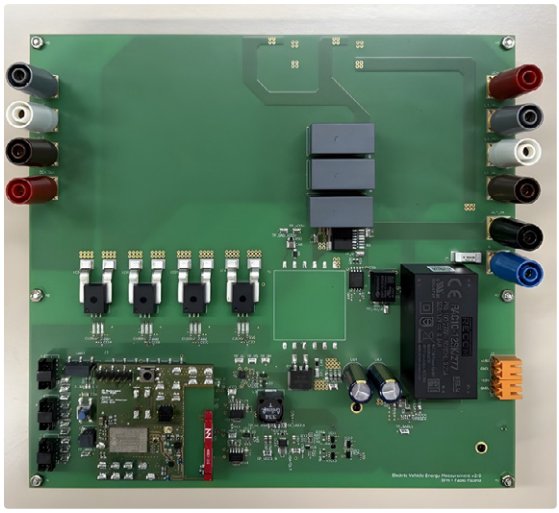
Introduction

By 2024, over 200'000 electric vehicles (EVs) were circulating in Switzerland, marking a rapid shift from fossil-fuel cars. This poses challenges for road infrastructure funding, as fuel taxes currently cover about half of maintenance costs. Today, electricity used for EV charging—whether at public stations or private setups—is billed but not subject to road-use taxes. Although energy consumption is measured for billing, it is not yet connected to taxation systems. Recent DETEC findings show that a fair, usage-based tax is possible with accurate measurement and secure data transmission. This project proposes a device integrated directly into charging cables to enable transparent, fair taxation based on actual energy use.

Goals

In this phase, focus was on:

- Prototype for EV charging energy measurement.
- Data transmission via LTE-M/NB-IoT.
- GPS/cellular localisation.
- Integrating grid power with backup battery and optimized standby.
- Maintaining a compact, tamper-resistant form.



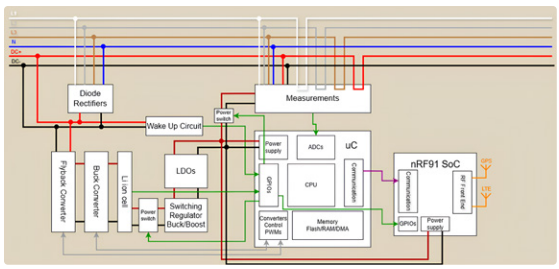
EV energy meter prototype; on top communication (LTE, GPS) and on the bottom energy measurement and MCU

Concept

The system consists of a low-power, tamper-resistant module embedded inside the charging cable, designed to support both AC (single and three-phase) and DC charging modes. Hall-effect sensors measure the charging current, while a dedicated voltage measurement circuit captures the voltage. A microcontroller processes these inputs in real time to calculate the total energy consumed during each charging session. At the end of the session, the collected data is transferred to an nRF9160 System in Package (SiP), which manages device localisation through GPS or cellular networks and sends the data via LTE-M or NB-IoT connectivity. The device is primarily powered by the electrical grid but includes a backup rechargeable lithium battery regulated with Buck/Boost converters and LDOs to ensure uninterrupted operation during power outages. GPIO pins monitor the power supply status to wake the device when grid power returns. After data transmission, the device enters a low-power sleep mode consuming less than 500 µA to maximize energy efficiency.

Expected/Outcome

The result is a prototype of a cable-integrated EV energy meter for fair road-use taxation. It includes AC/DC energy measurement, GPS/cellular localisation, and wireless data transmission via LTE-M/NB-IoT. The design ensures low power, tamper resistance, and reliable operation during outages.



General overview - scheme blocks

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