Control Strategy of Bidirectional Chargers for V2X Operations: Mitigating Battery Degradation

Degree programme: Master of Science in Engineering
Thesis advisor: Prof. Dr. Priscilla Caliandro
Expert: Prof. Dr. Fabrizio Sossan (Haute Ecole Spécialisée de la Suisse Occidentale)

Bidirectional chargers in Vehicle-to-Everything systems enable electric vehicles to both draw power and supply excess energy back to the grid. Intelligent energy management algorithms balance these energy flows, routing excess energy to the grid during peak demand or storing it for later use. Integrating bidirectional charging with renewable energy and battery optimization offers a comprehensive approach to clean mobility and energy management, enhancing grid reliability.

Objectives

The aim of this thesis is to develop a control strategy algorithm for bidirectional chargers to manage energy efficiently while minimizing battery degradation. The algorithm will create an optimal power profile based on dynamic energy pricing, the car's remaining connection time to the charger, and predicted degradation costs. A deep neural network (DNN) will be used to accurately estimate the battery's state of health (SoH).

Control strategy algorithm

The control strategy algorithm optimizes battery management with two main objectives: maximizing return on investment (RoI) and minimizing battery degradation. Using Vehicle-to-Everything (V2X) technology, it manages charging and discharging power, leveraging the Open-Sesame battery tool to plan an optimal power profile.

The algorithm operates following two main processes:

1. – Ensuring reliable charge by the end of the vehicle's connection time, considering the current state of charge (SoC) while minimizing degradation.
2. – Optimizing RoI by determining required charging time and planning the energy discharge profile.

At each energy price update, the algorithm revises the V2X strategy until the reserved charging time is reached, maximizing RoI. This is based on the power profile's impact on energy and degradation costs, assessed through stress factors. This approach balances energy efficiency with battery health maintenance, providing a reliable and cost-effective solution.

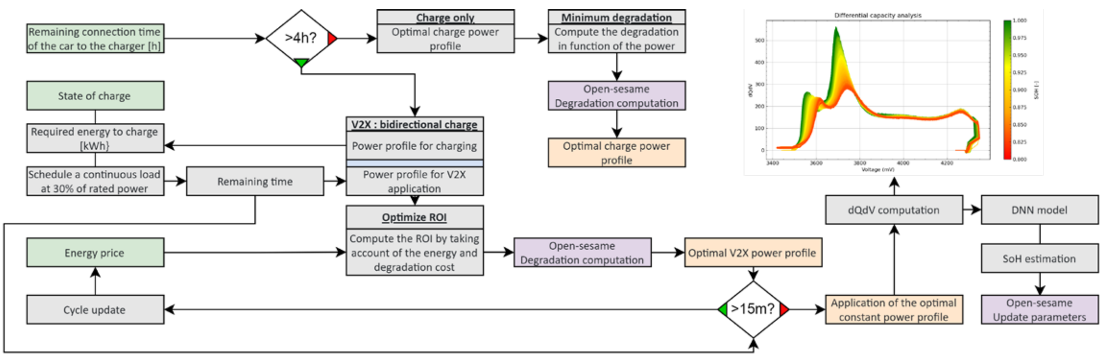
Predicting degradation

Both calendar and cyclic battery degradation are considered. Calendar aging is influenced by storage conditions such as temperature and SoC. Cyclic aging occurs during operation, influenced by current, temperature, DoD, DoC, and average SoC. Both processes can be accurately modeled with stress factors.

Deep Neural Network (DNN)

Accurate SoH estimation is crucial. By monitoring total charge and periodically extracting the differential capacity against voltage (dQ/dV), the DNN can analyze the dQ/dV curve within a SoC range of 40% to 95%. Peaks and valleys in the dQ/dV curve provide insights into electrochemical processes and reveal degradation variations, achieving an average error of 0.4%.

Bastien Binz
Mechatronics and Automation
binz.bastien@gmail.com



Control strategy algorithm