Implementation of Grid-Friendly Charging Scheme to Electric Vehicle Off-board Charger for V2G

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1. New electrical demand
2. Controllable demand (ADR, Smart Charging)
3. Distributed energy storage (V2H, V2G)

--> Integration of EVs to Load Frequency Control

Autonomous distributed grid-friendly charging / V2G (df, SOC)
Centralized dispatching of TBC signal
Regional aggregated storage (SOC synchronization, V2V)

--> --> Implementation of Control Schemes to existing Electric Vehicle / Charging Infrastructure

Evaluation of response, efficiency, and impact to battery
Confirmation of control and communication interface
Schematic Diagram of EV / Infrastructure Test System

- **AC Power Source**: 1φ200V/15A/3kW
- **Grid Interconnection**: Quick Charging Port
- **Bi-directional Power Conditioner**: BMU, CAN, Serial
- **Battery Pack**: SOC Estimation, Grid-Friendly Charging / V2G
- **Electric Vehicle**: EV-ECU
- **Smart Interface Controller**: CHAdeMo Sequence
- **Smart Grid Digital Simulator**: Wind Park, Thermal, Hydro, Nuclear
- **Central Load Dispatching Center**: Selective LFC
- **Regional Load Dispatching Center**: SOC Ordering
- **Hardware In the Loop Simulation (HILS)**: Programmable /Frequency /Amplitude /Disturbance
- **Autonomous Distributed Control**: Frequency, V2G setpoint
- **Centralized LFC**: Coordination (and/or)
Laboratory Setup

- Bi-directional Power Conditioner
- Smart Grid Digital Simulator
- Smart Interface Controller
- Electric Vehicle Battery Test-bed
- Quick Charging Port (CHAdeMO protocol)
- Ground
- Charger start/stop1
- Charging enable/disable
- DC power (+)
- DC power (-)
- Connection check
- CAN (H)
- CAN (L)
- Charger start/stop2
Grid-Friendly Charging / V2G Scheme

AC Power [W]

Discharge

Droop Gain : 60000 [W/Hz]

V2G mode

Droop Gain : 20000 [W/Hz]

Smart Charging mode

Charge

Frequency deviation [Hz]

Dead Band

-0.05 [Hz]  0  0.05 [Hz]


Experimental Results of Grid-Friendly Charging

(a) Frequency [Hz]:

(b) AC Power [W]:

(c) G2V and V2G:

(d) SOC [%]:

Set point and actual output are indicated in the graphs.
Conclusions

Smart Charging / V2G available Off-board Charger
Seamless, flexible, efficient charging and discharging control
--> Coordinated control with HILS considering centralized LFC

Communication and Control Interface for V2G
AC or DC? PLC or CAN? Protocol with utility / aggregator?