evs 27

The 27th INTERNATIONAL ELECTRIC VEHICLE SYMPOSIUM & EXHIBITION.

Barcelona, Spain
17th-20th November 2013

G2V and V2G operation 20 kW Battery Charger

Paper number: 6130341

Jordi Escoda[1], Joan Fontanilles[1],

Domingo Biel[2], Víctor Repecho[2], Rafel Cardoner[2], Robert Griñó[2]

[1]Lear Corporation. European Technological Center. Electrical Power Management Systems.
[2]Institute of Industrial and Control Engineering, Universitat Politècnica de Catalunya

Organized by Fira Barcelona avele

Hosted by AVERE mea Ajuntament de Barcelona

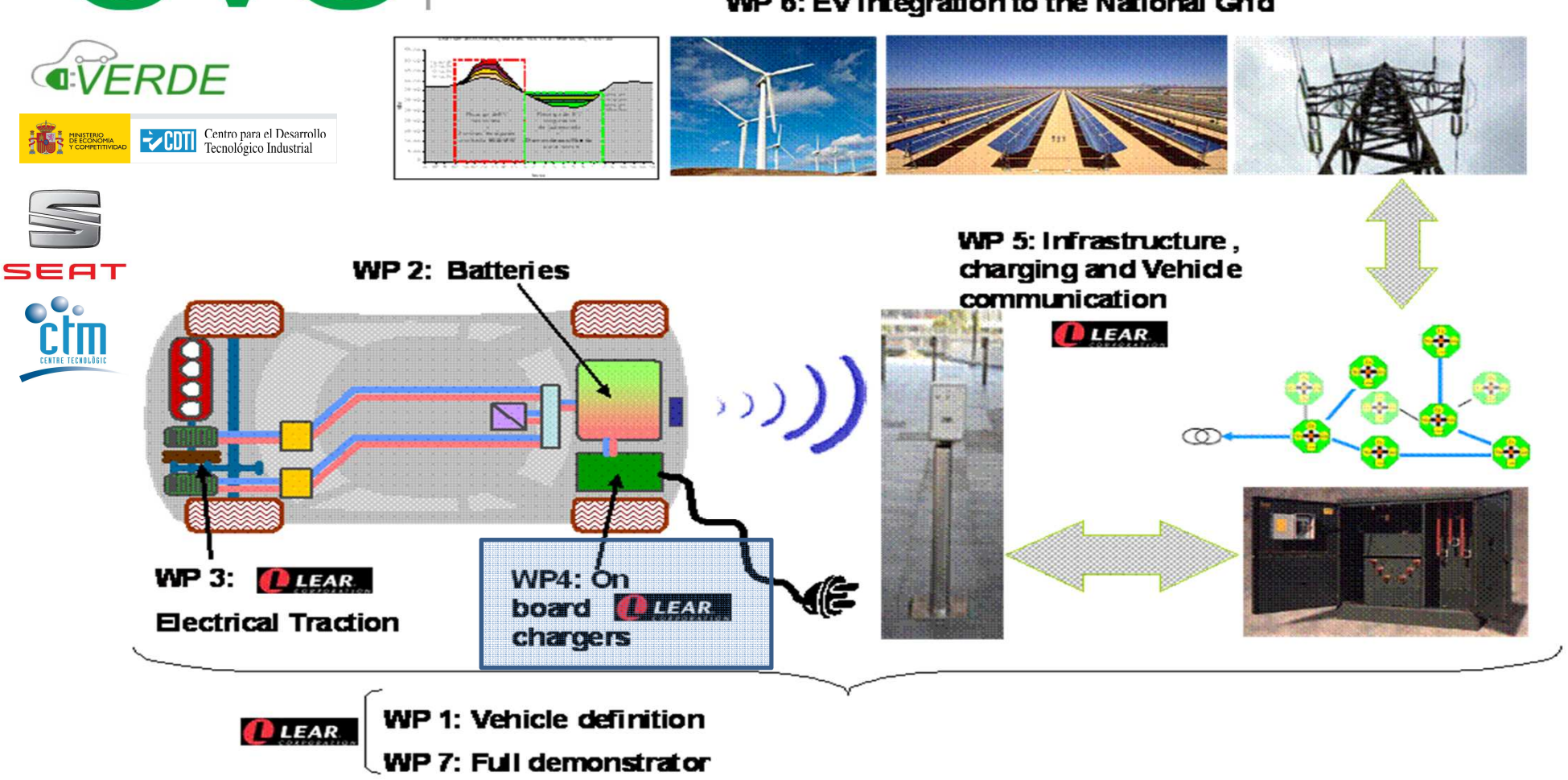
In collaboration with EVAAP EDTA

Supported by European Commission

Document Outline

1. CENIT VERDE Overview
2. Design Challenges
3. Technical Specification
4. Block Diagram
5. Base Topology
6. DCDC Stage Bi-directionality
7. Experimental Results
8. CENIT VERDE Prototype
9. Conclusions

CENIT VERDE Overview



Organized by Hosted by In collaboration with Supported by

Reason for a V2G G2V 20KW OBC

- Slow chargers state-of-art (3.3KW and 7KW) are the best approach for those commuters which can leave their EV charging for certain hours at home or at daily work. Problems appears when long distances needs to be covered and fast charging is needed to continue the trip.

- In three phase-plugs you can have easily 32A/phase and the recharging time of the EV battery can be reduced to 30 minutes

- 20KW is a trade-off solution between slow and DC fast charger stations (too bulky), allowing a reasonable short charging time

- V2G allows the integration of the vehicle into Smart Grids scenarios. When a car plugged to the grid, it allows to face power peaks demands shifting or even acting as a local backup supply in outages, contributing to global pollution reduction

Design Challenges

1. Automotive component
2. Efficiency, size and weight
3. Automatic detection of the grid (single phase and three phase)
4. V2G capability. Not disturb the grid
5. Galvanic isolation
6. Advanced digital controllers
7. Communications with the vehicle modules (CAN)
8. Communications with the Grid (PLC)

Technical Specification

Input characteristics:

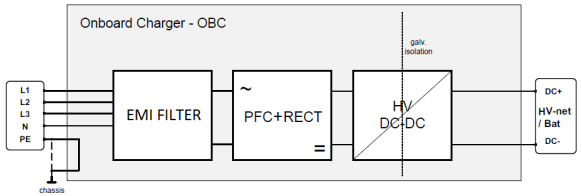
Phases	Voltage (RMS)	Frequency	Current (RMS)	Net tolerance	Power
1	230V	50Hz	16A	+/- 10%	3,3 kW
3	400V	50Hz	32A	+/- 10%	20 kW

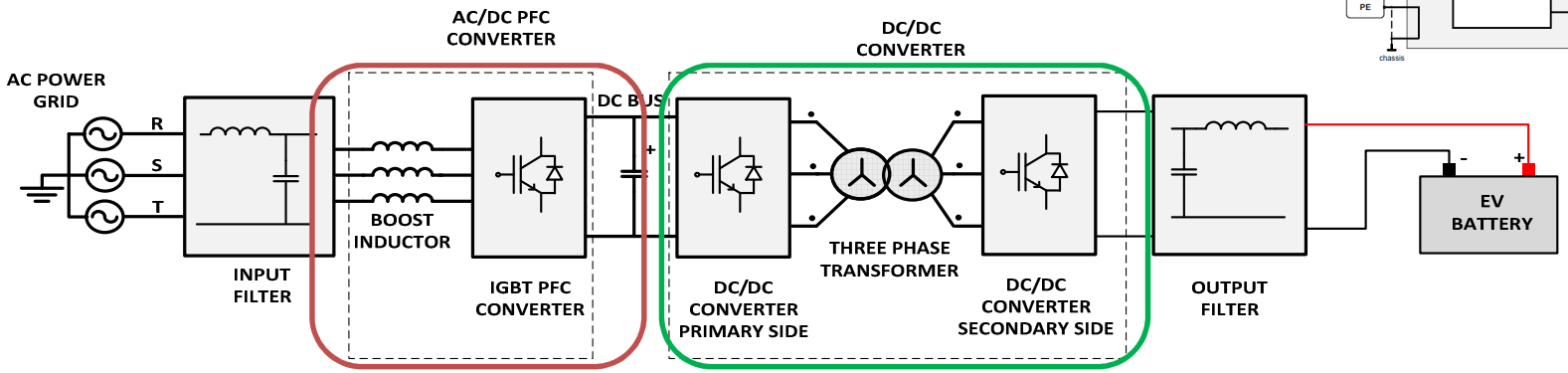
Output characteristics:

Mode	Voltage (DC)	Current (DC)	Voltage Ripple	Current Ripple
Normal	285V .. 360V	68A	5Vpp	5%

- Total efficiency close to 91%.
- Power factor correction > 99%.
- Bidirectional topology.
- Galvanic isolation (2,5 kV)
- Operating temp. -40 ºC÷50ºC (linear derating up to 50ºC until 60ºC).
- Liquid refrigerated system (200 l/h, 1,5 bar)
- Power density: 905W/l (1,1liter/KW)
- Engine compartment placement (EV or HEV).
- Safety protections (Overcurrents, overvoltages & overtemperatures)
- Communications CAN and PLC

Block Diagram





Goals:

- Input filter to reduce electromagnetic interferences.

- Capacitor bus has been minimized (high bus voltage ripple when single-phase connection) and the bus voltage has been properly regulated.

- DC/DC power circuit is a Zero Voltage Switching (ZVS) full-bridge DC/DC converter with phase-shift control.

- Galvanic isolation by using a high-frequency three-phase wye-wye connected transformer.

Base Topology

G2V or V2G operation depending on the phase between primary and secondary H-Bridges.

Three-phase transformer. Less output current ripple

Avoid peaks on DC Link at mains connection

Precharge Net

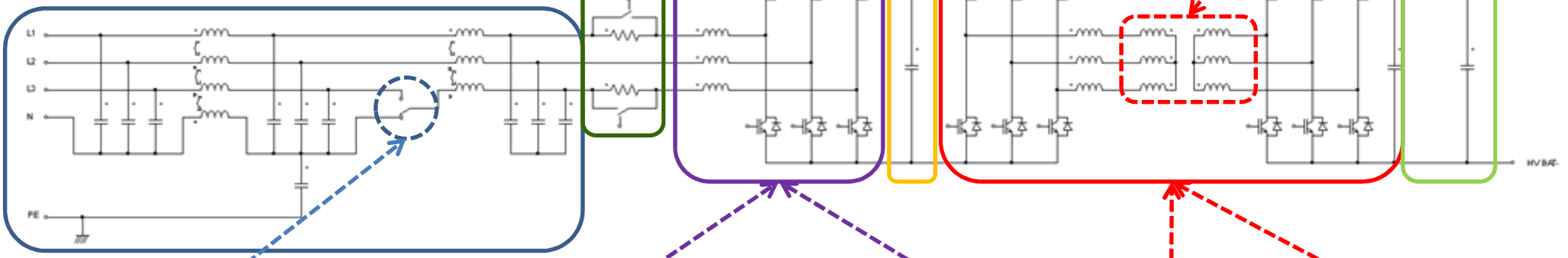
PFC Stage

DC Link

DCDC Stage

Output Filter

EMI Filter & Selection Mode Relay



Monphasic/Triphasic selection relay

G2V:
Works as boost PFC.
Up to three input current controls (following the mains voltage in order to achieve unity power factor) driven by an DC link voltage control

V2G:
Works as inverter.
Up to three output current controls (in against phase mains voltage).

V2G: DC link voltage control

G2V: Output current and output voltage control

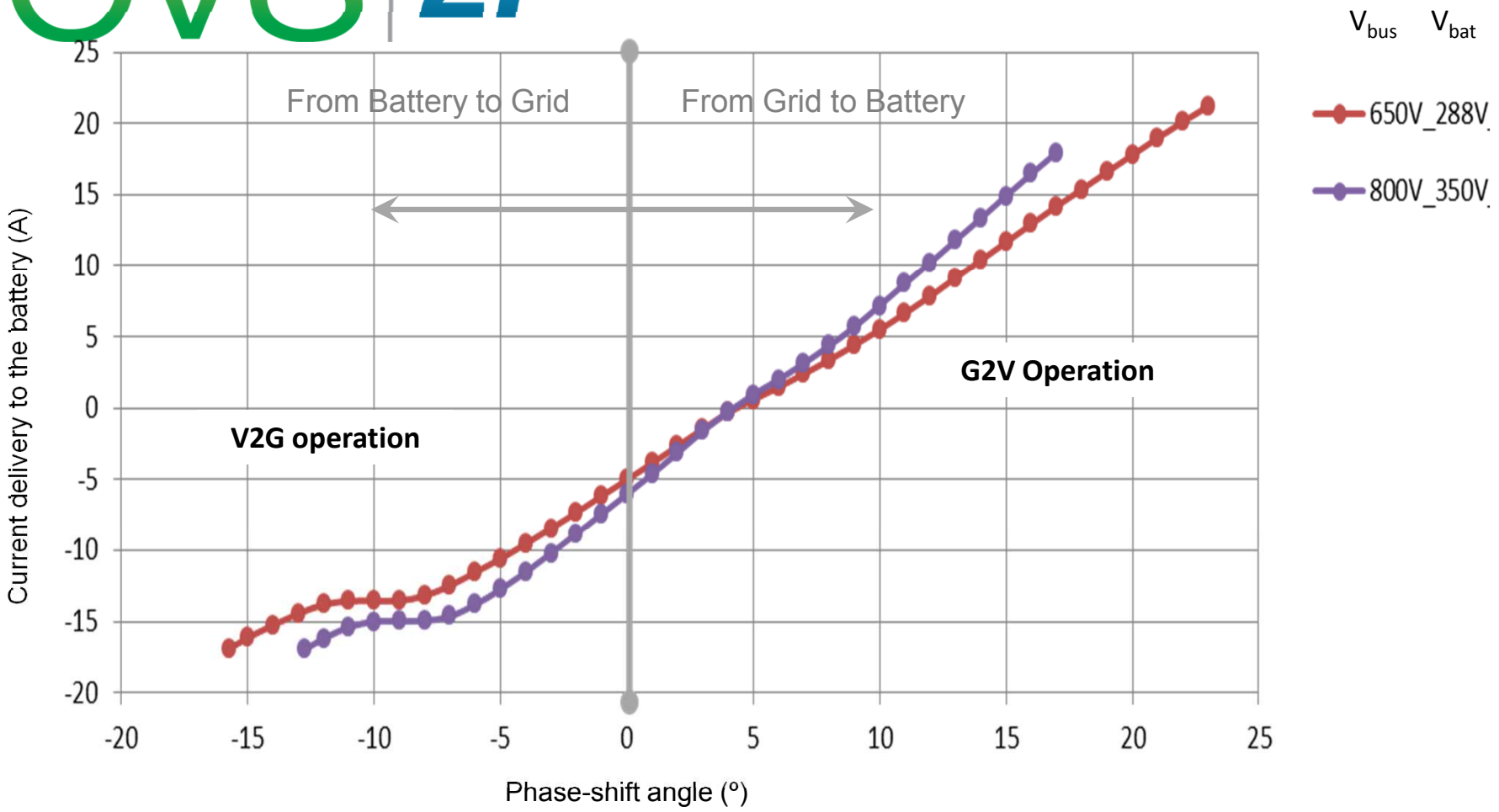
Organized by Fira Barcelona avele

Hosted by AVERE mea Ajuntament de Barcelona

In collaboration with EVAAP EDTA

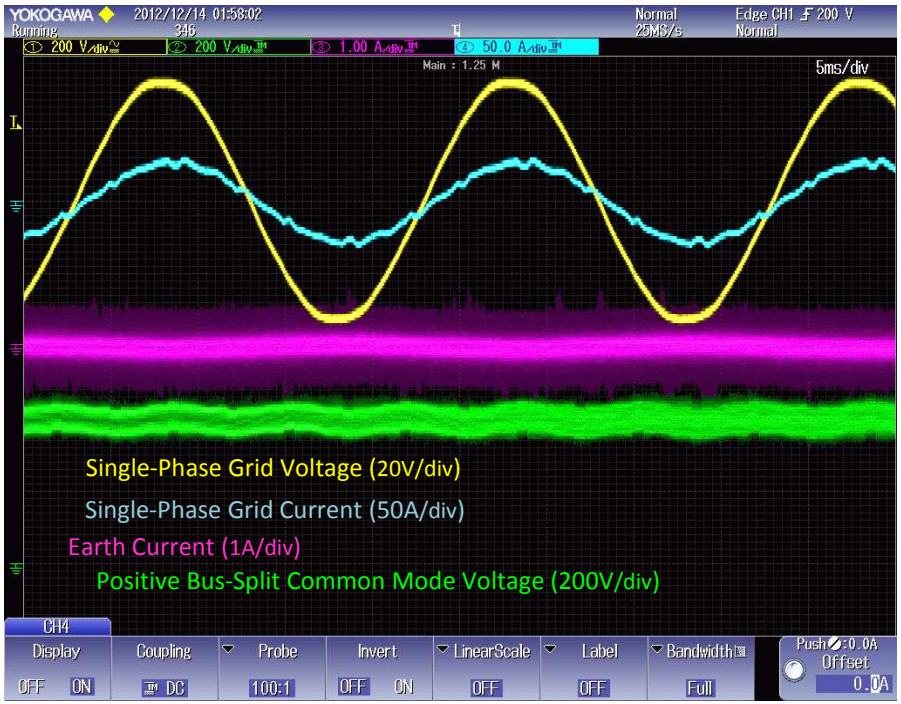
Supported by European Commission

DC-DC Stage bidirectionality

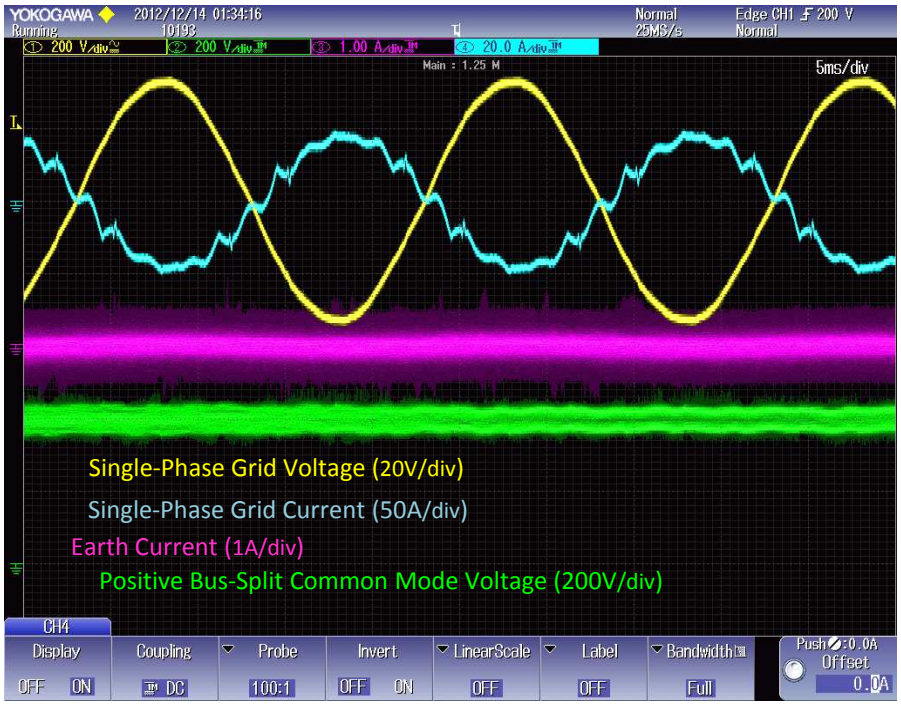


The phase shift between primary and secondary sides is used as a control action in both operation modes.

Experimental results (1)

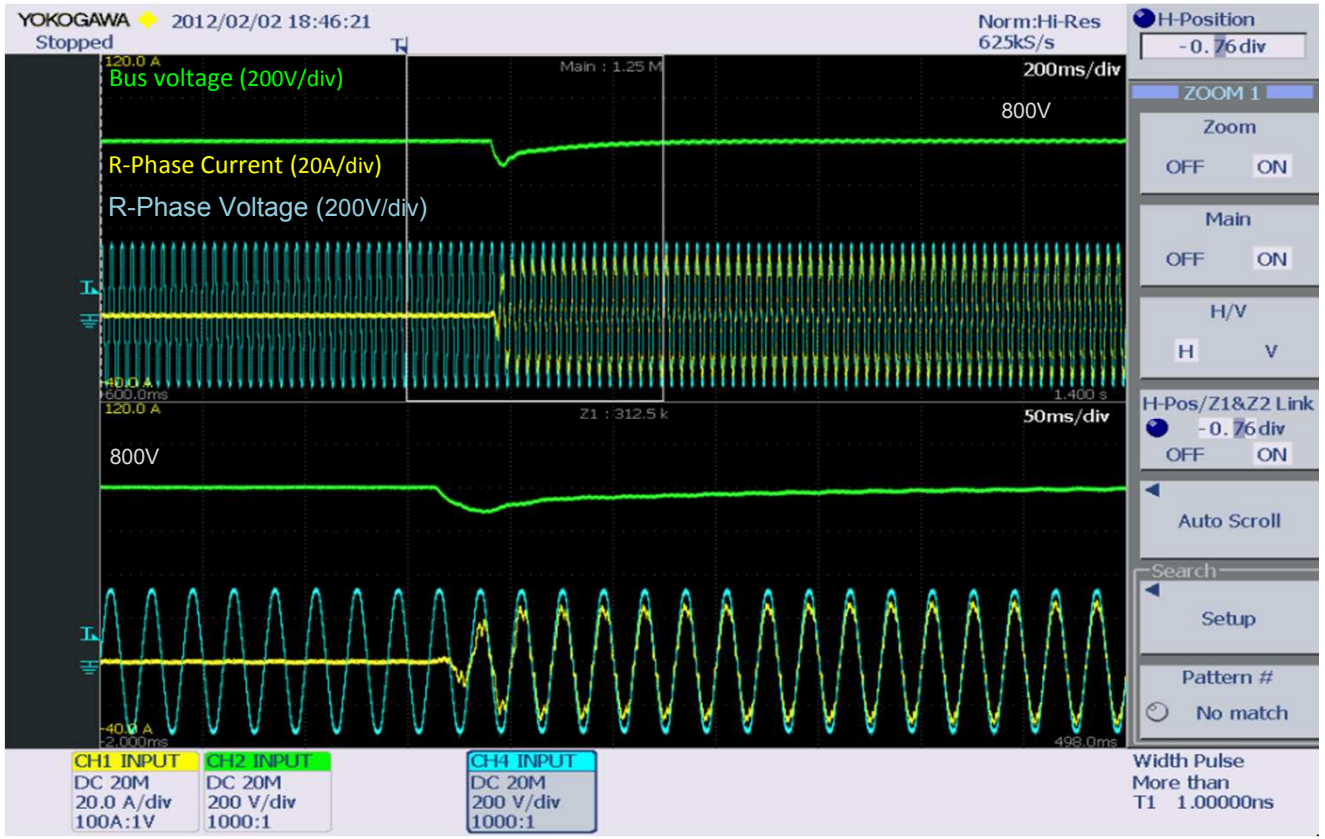


PFC stage G2V triphasic operation (10kW).



PFC stage V2G triphasic operation (10kW).
(working as inverter)

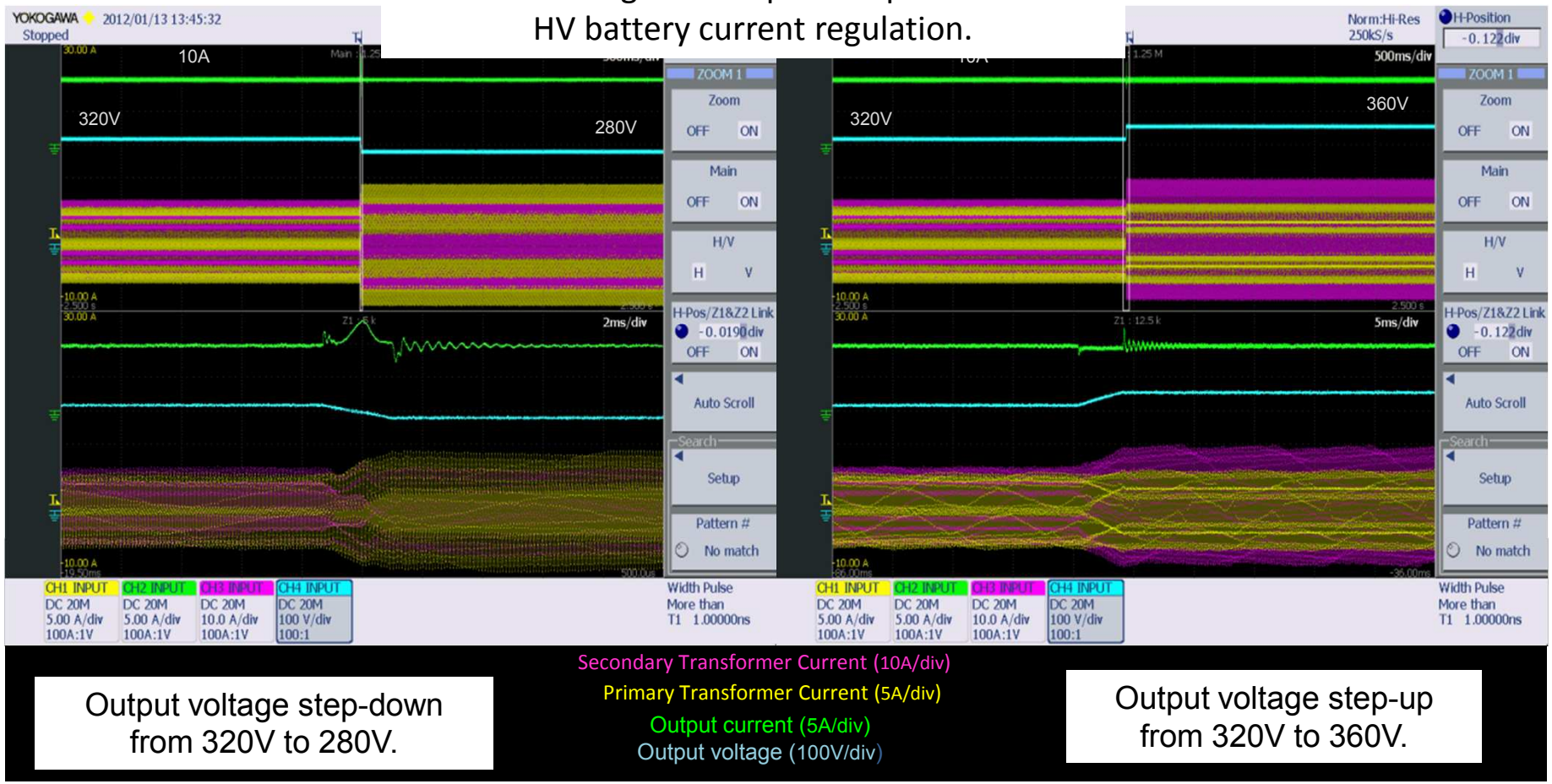
Experimental results (2)



PFC stage G2V triphasic operation.
DC Link voltage regulation.
Changes from no load to 13 kW.

Experimental results (3)

DCDC stage G2V triphasic operation.
HV battery current regulation.

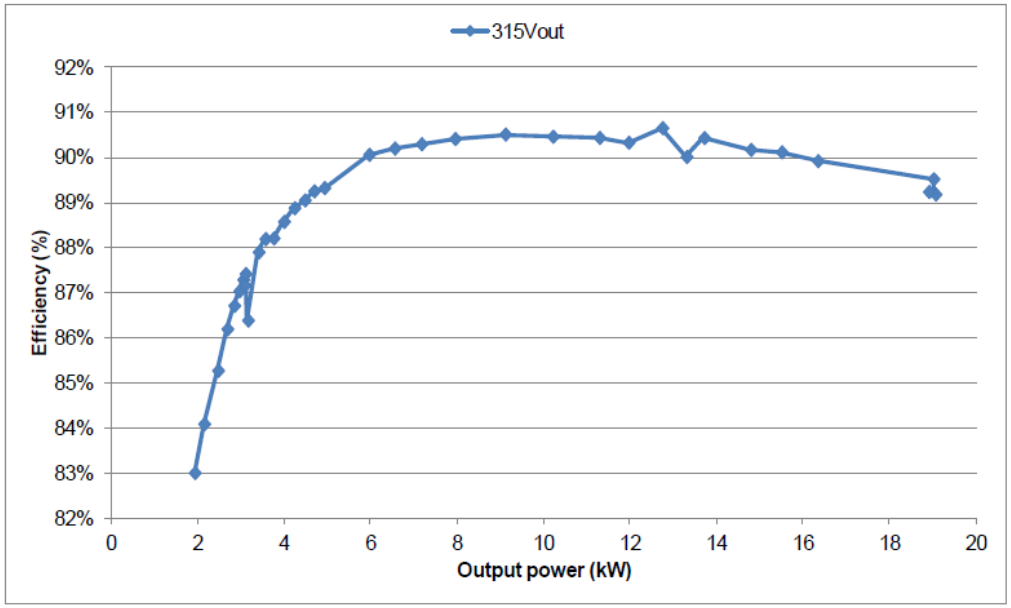


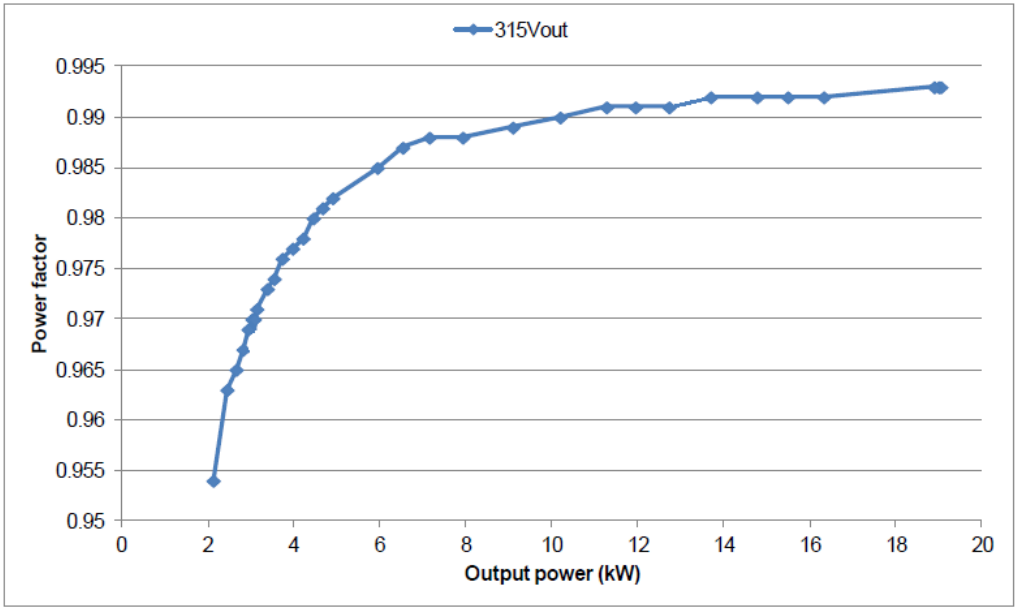
Output voltage step-down from 320V to 280V.

Secondary Transformer Current (10A/div)
Primary Transformer Current (5A/div)
Output current (5A/div)
Output voltage (100V/div)

Output voltage step-up from 320V to 360V.

Experimental Results (4)



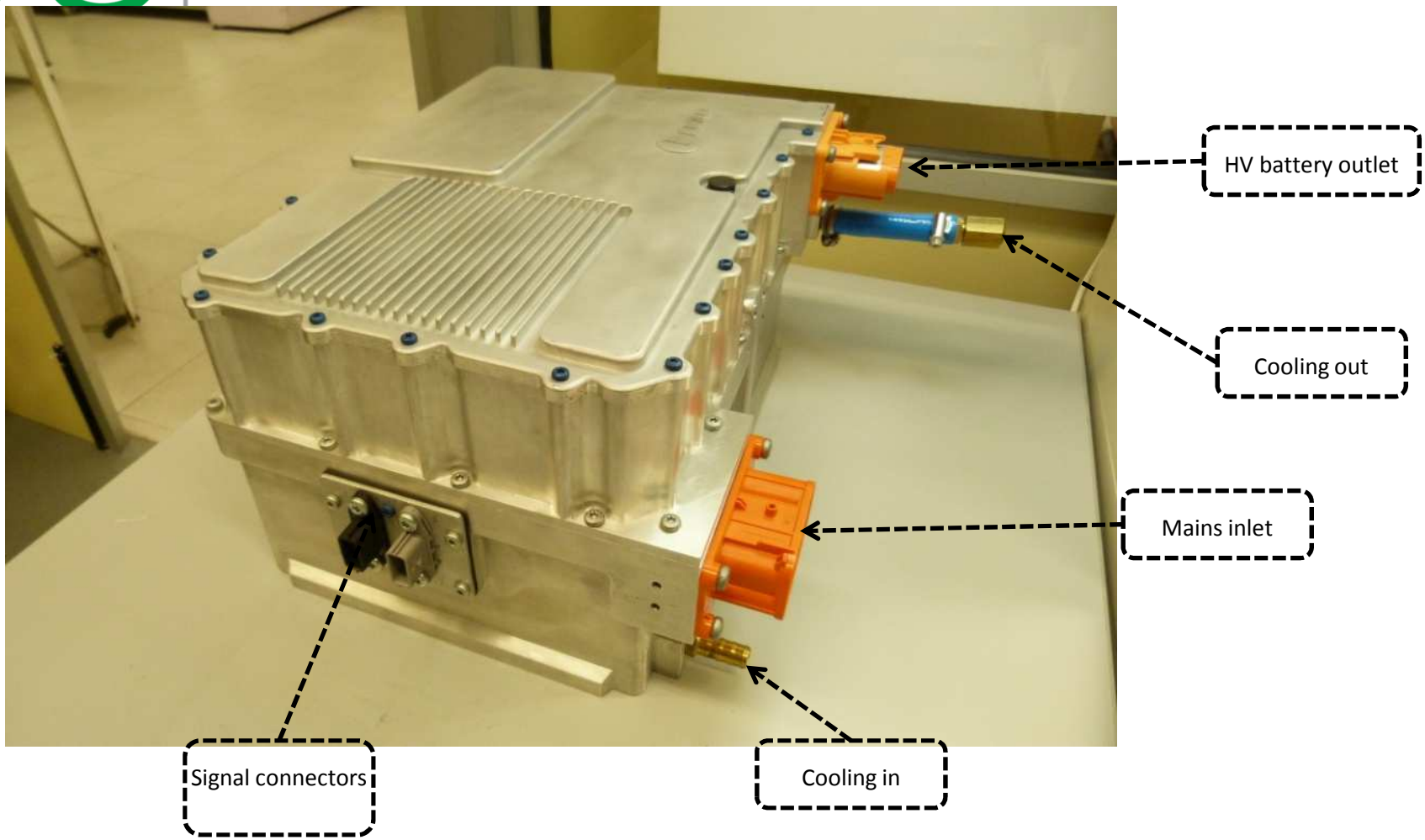


Complete system G2V operation efficiency and PF vs. output power

Measurements conditions:

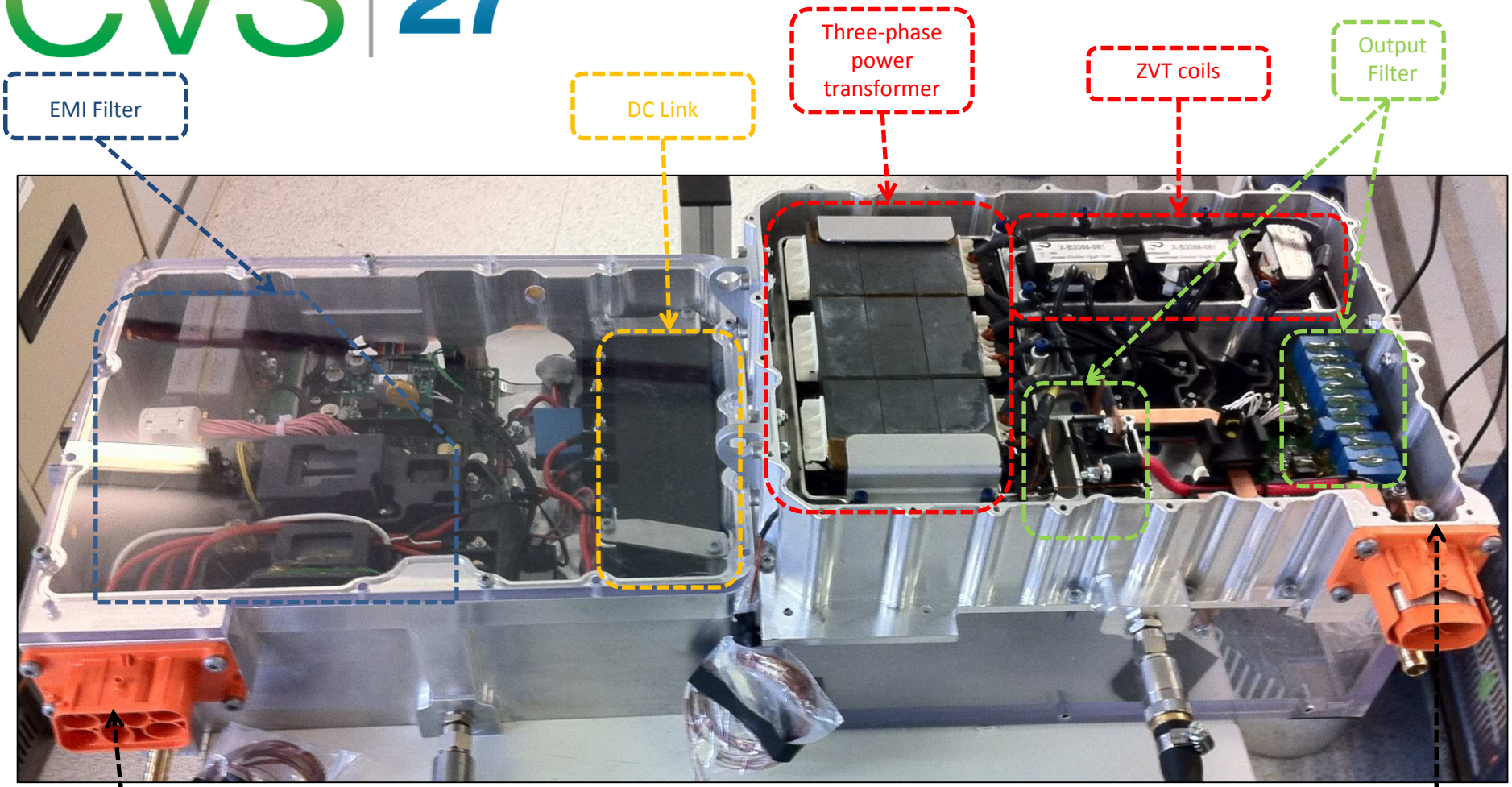
- Vin: 340 V Triphasic.
- Vout: 315 V.
- Temp: 25 ºC.

CENIT VERDE Prototype



evs 27

CENIT VERDE Prototype



- PFC STAGE
- DCDC STAGE (goes on top of PFC)

Organized by Fira Barcelona avele
Hosted by AVERE mea Ajuntament de Barcelona
In collaboration with EVAAP EDTA
Supported by European Commission

Conclusions

1. The designed 20kW on-board battery charger has a size of ~1KW/L
2. The OBC efficiency is above of 90% in medium and high transfer power in both operation modes: V2G y G2V.
3. Unity power factor and low harmonic distortion have been achieved.
4. The OBC provides good performance in both single-phase and three-phase connection.
5. Robust power control has been guarantied although a battery voltage variability between 280V and 360V.