POWER ELECTRONICS TECHNOLOGIES FOR ELECTRIC MOBILITY

- Worldwide Energy NEtworK W-ENER 2021 -

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20 April 2021

Universidade do Minho
Escola de Engenharia

GEPE
Group of Energy and Power Electronics
www.gepe.dei.uminho.pt

CENTROALGORITMI

Vítor Monteiro

Invited Professor
University of Minho
Portugal

Speaker

João L. Afonso

Full Professor
University of Minho
Portugal

Panelist

Luís Monteiro

Associate Professor
Rio de Janeiro State University
Brazil

Panelist

- **Group of Power Electronics and Energy** - University of Minho - Portugal
- Power Electronics for **On-Board and Off-Board EV Chargers**
- Power Electronics for **EV Chargers with Innovative Operation Modes**
- Power Electronics for **Vehicle-to-Vehicle (V2V)** Interface
- Power Electronics for Interfacing **EVs and Renewables**
- Power Electronics for Interfacing **EVs, Renewables and Other Technologies**
- Power Electronics for **Wireless Power Transfer**
- Power Electronics for **Unified Traction and Charging Systems**
- Power Electronics for **Battery Management Systems**
- Power Electronics for **Railway Systems**
- Conclusions

section #1

Group of Power Electronics and Energy

University of Minho

Portugal


University of Minho
Ortigueira
Viveiro
Ferrol
A Coruña
Betanzos
Carballo
Lugo
Santiago de Compostela
Touro
Lalín
Rianxo
Cambados
Carballiño
Pontevedra
Vigo
Viana do Castelo
Braga
Guimarães
Póvoa de Varzim
Vila Real
Porto
Gondomar
S. João da Madeira
Aveiro
Viseu
Figueira da Foz
Coimbra
Pombal
Portugal
Gijón/Xixón
Oviedo
Langreo
Llanes
Santander
Torrelavega
Laredo
Getxo
Bilbao
Bayonne
Donostia-San Sebastián
Monte de Alduide
Vitoria-Gasteiz
Pamplona
León
Ponferrada
Burgos
Logroño
Palencia
Sierras de Demanda, Urbión, Cebollera y Cameros
Tudela
Tarazona
Aranda de Duero
Valladolid
Soria
Zamora
Ribeiras de Castronuño-Vega del Duero
Calatayud
Salamanca
Segovia
Sigüenza
Alcobendas
Madrid
Parque Natural del Alto Tajo
Ciudad Rodrigo
Guijuelo
Béjar
Fuenlabrada
Pinto
Cuenca
Plasencia
Aranjuez
Toledo
Coria
Navalmoral de la Mata
Talavera de la Reina
Cáceres
Trujillo
España (Spain)
E-70
E-5
E-804
E-80
E82
E1
E801
E80
E802
E-90
E-901
E806

Universidade do Minho

The **University of Minho**, Portugal, is comprised of two campi. These are the Gualtar Campus, in the city of Braga, and the Azurem, in the city of Guimarães.

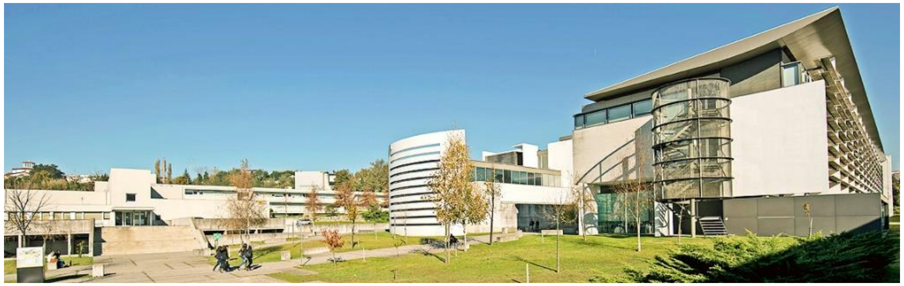
Gualtar Campus

City of Braga

Universidade do Minho

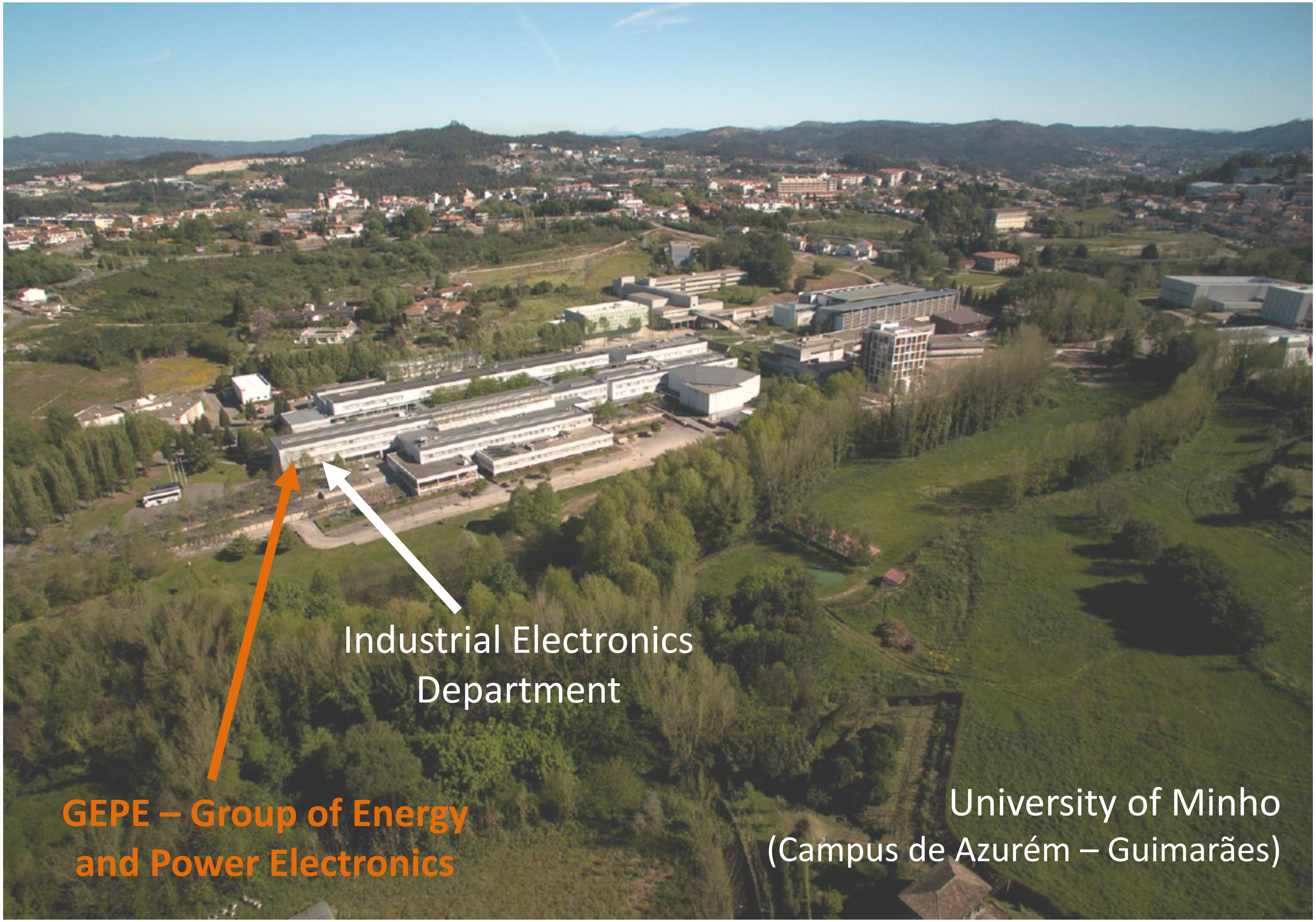
The **University of Minho**, Portugal, is comprised of two campi. These are the Gualtar Campus, in the city of Braga, and the Azurem, in the city of Guimarães.

Azurem Campus

City of Guimaraes




Industrial Electronics
Department
GEPE – Group of Energy
and Power Electronics
University of Minho
(Campus de Azurém – Guimarães)

Universidade do Minho
Escola de Engenharia

CENTROALGORITMI

Organização

- Advisory Board
- Board of Directors
- Scientific Steering Committee

SEOR – SYSTEMS ENGINEERING AND OPERATIONAL RESEARCH

IST – INFORMATION SYSTEMS AND TECHNOLOGY

IEM – INDUSTRIAL ENGINEERING AND MANAGEMENT

CCPM – COMPUTER COMMUNICATIONS AND PERVASIVE MEDIA

CST – COMPUTER SCIENCE AND TECHNOLOGY

IE – INDUSTRIAL ELECTRONICS

ISTOrg – INFORMATION SYSTEMS AND TECHNOLOGIES IN ORGANIZATIONS

SEMAG – SOFTWARE ENGINEERING AND MANAGEMENT GROUP

UBICOMP – MOBILE AND UBIQUITOUS SYSTEMS

GEPE – ENERGY AND POWER ELECTRONICS

ESRG – EMBEDDED SYSTEMS RESEARCH GROUP

IDS – INTELLIGENT DATA SYSTEMS

CCN – COMPUTER COMMUNICATIONS AND NETWORKS

engageLAB

CAR – CONTROL, AUTOMATION AND ROBOTICS

- 8 PhD Researchers
- 5 PhD Students
- 11 MSc Researchers
- 15 MSc Students


Power Quality
Electric Mobility
Renewable Energies
GEPE
Group of Power Electronics and Energy
Industrial Applications
Wireless Power Transfer
Conversor
Conversor
Railway Systems

GEPE SKILLS IN ELECTRIC MOBILITY TECHNOLOGIES

Development of Battery Chargers for Electric Vehicles

- Unidirectional and bidirectional charging systems for EV slow charging applications
- Unidirectional and bidirectional charging systems for EV fast charging applications
- Charging systems with new operation modes for smart grids
- Active and passive Battery Management Systems (BMS)
- Range extender systems (In collaboration with the department of mechanical engineer)
- Wireless charging systems for electric vehicles (Inductive Power Transfer)

Development of Traction Systems for Electric Vehicles

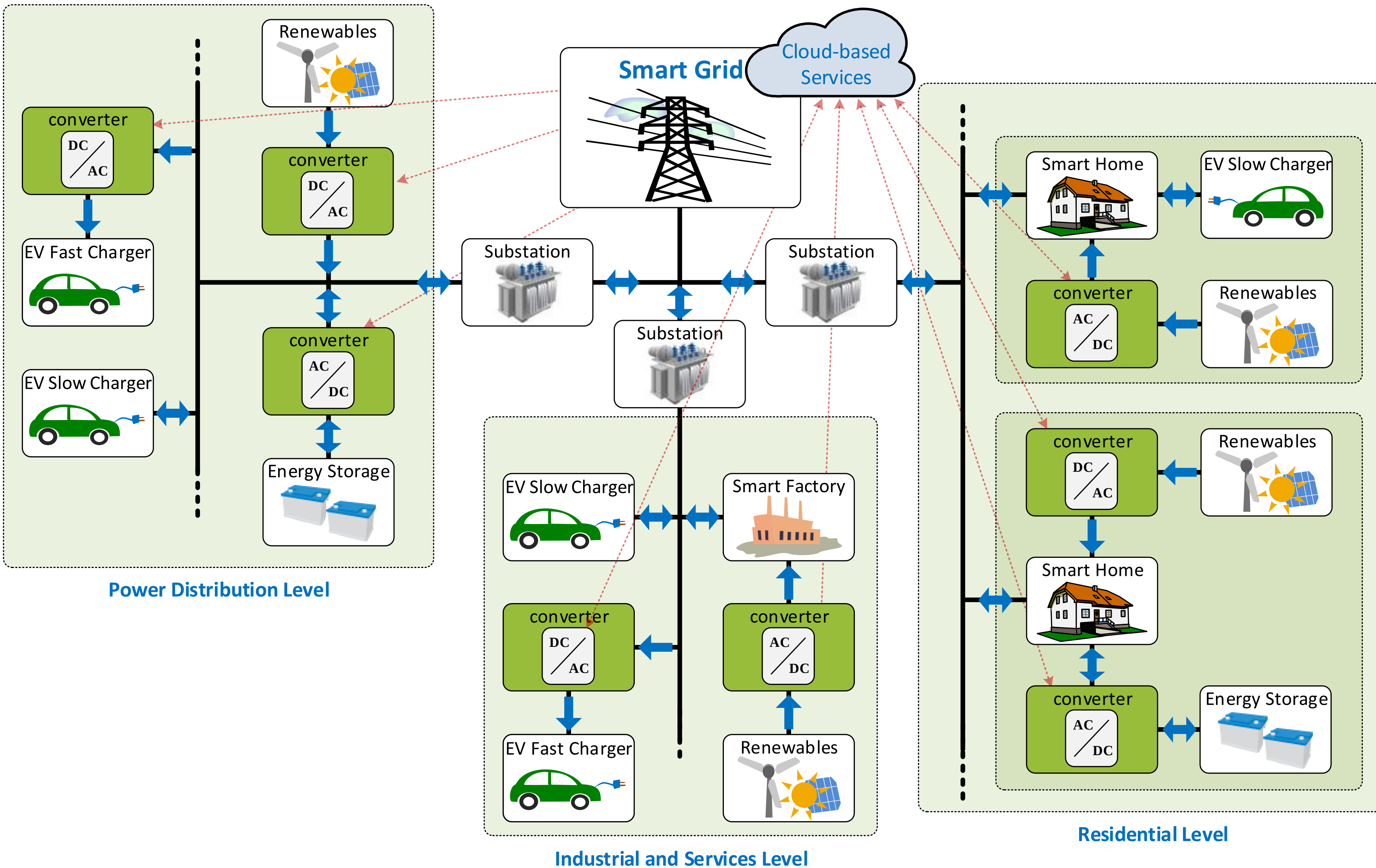
- Power electronics systems for motor drives
- Unified on-board converters for electric vehicle integrating the charging and tracking system
- Workbench for electric vehicle systems (with the department of mechanical engineer)
- Power electronics systems for electric bikes

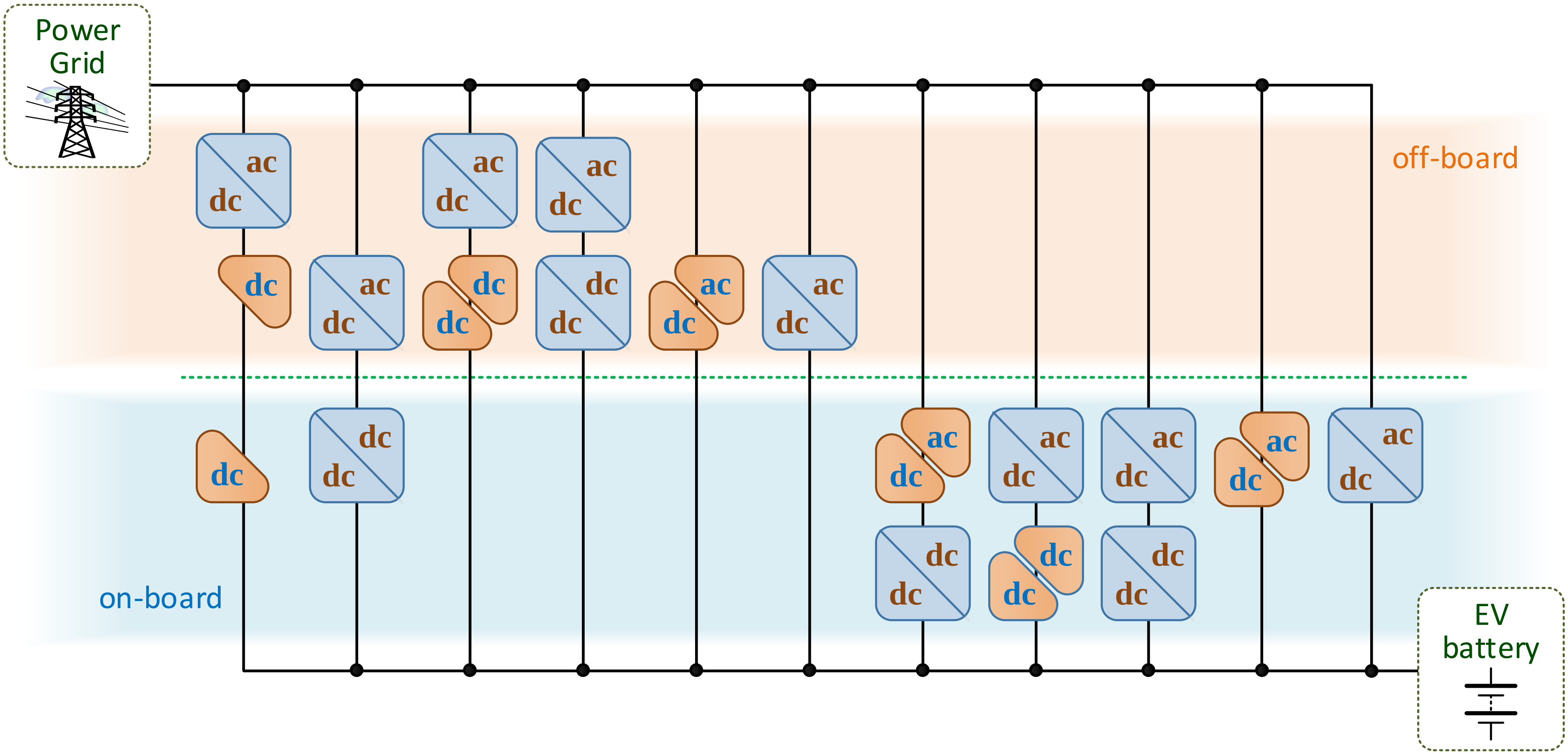
João. L. Afonso, Luiz Cardoso, Delfim Pedrosa, Tiago Sousa, Luís Machado, Mohamed Tanta, Vítor Monteiro, "A Review on Power Electronics Technologies for Electric Mobility", MDPI Energies, vol.13, no.23, pp.1-61, Dec. 2020.

Carro Elétrico Plug-In da Universidade do Minho (CEPIUM)

section #2

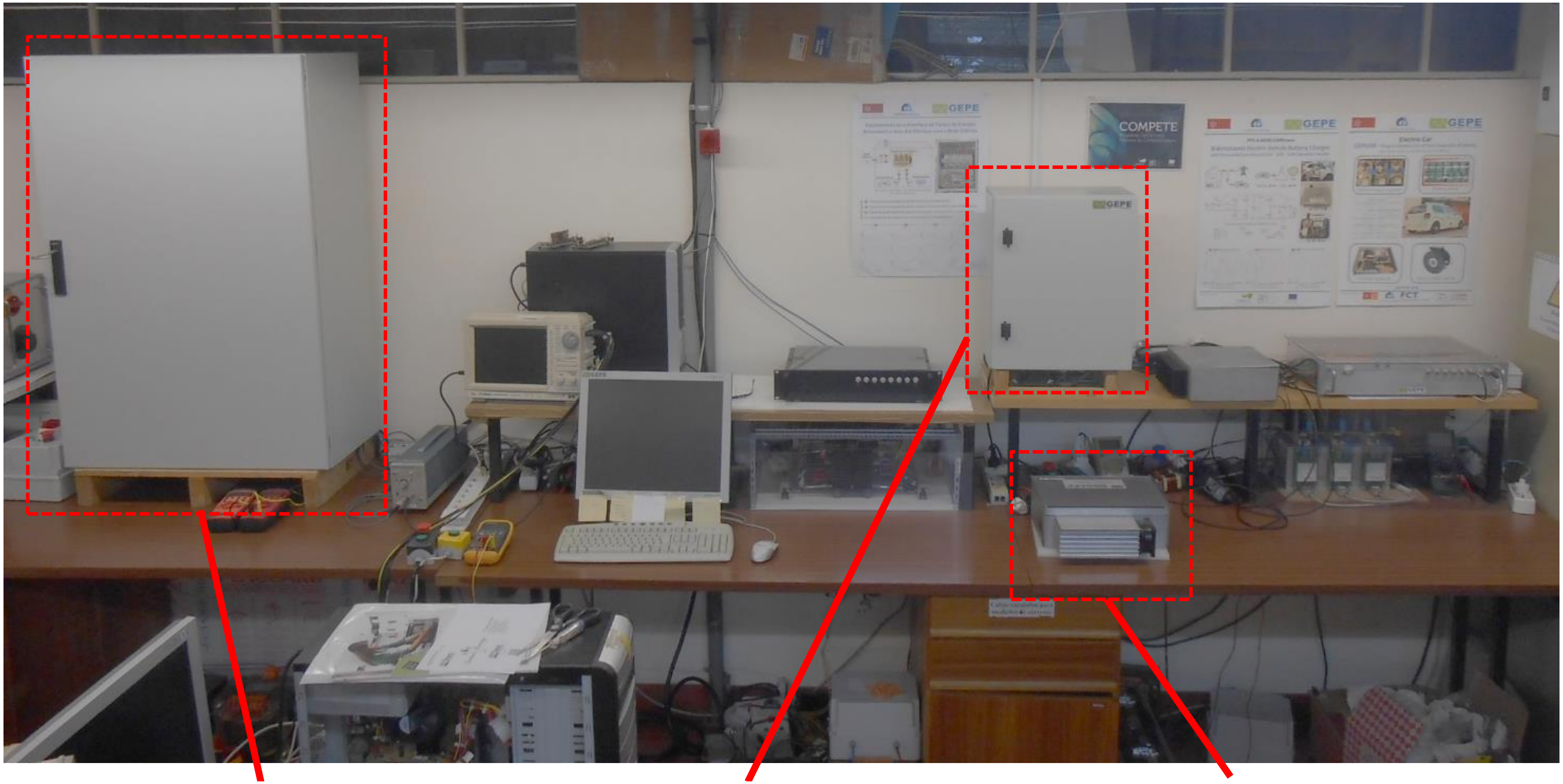
Power Electronics for On-Board and Off-Board EV Chargers


Smart Grid
Cloud-based Services
Renewables
converter
DC AC
EV Fast Charger
EV Slow Charger
AC DC
Energy Storage
Substation
Substation
Substation
Power Distribution Level
Smart Home
EV Slow Charger
converter
AC DC
Renewables
converter
DC AC
Renewables
Smart Home
converter
AC DC
Energy Storage
Residential Level
EV Slow Charger
Smart Factory
converter
DC AC
converter
AC DC
EV Fast Charger
Renewables
Industrial and Services Level



Classification of different structures for on-board and off-board electric vehicle (EV) battery chargers based on single or double power electronics stages.

Photography of the laboratory workbench with on-board and off-board EV chargers.

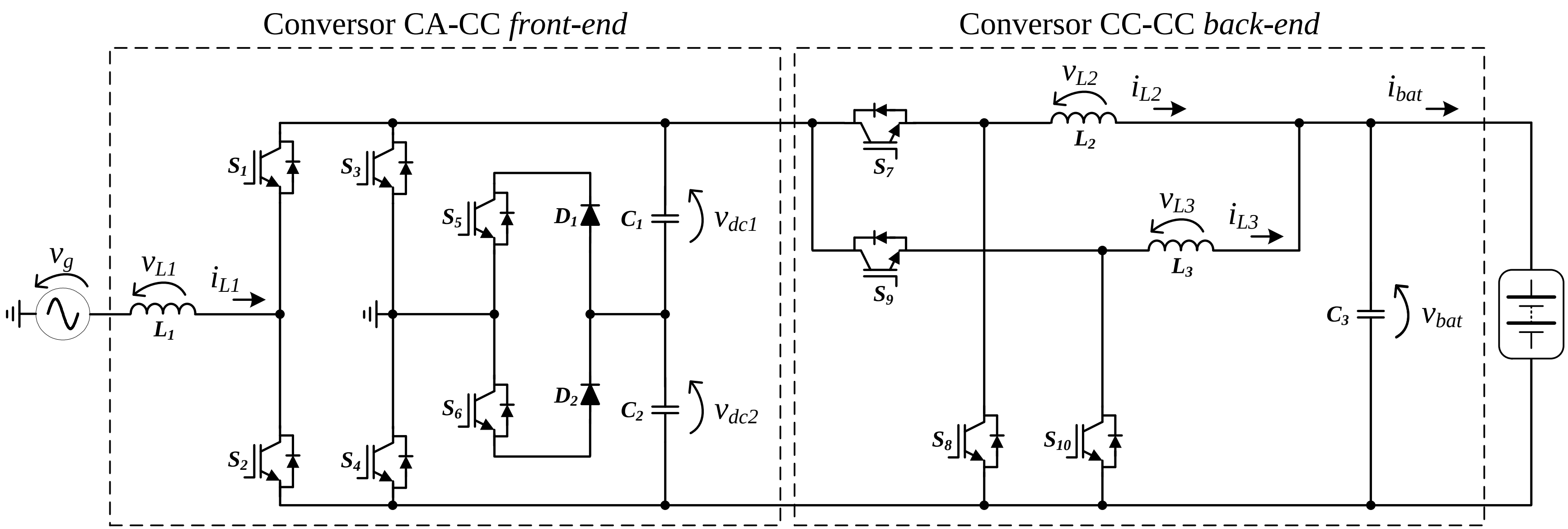


three-phase
off-board EVBC

single-phase
off-board EVBC

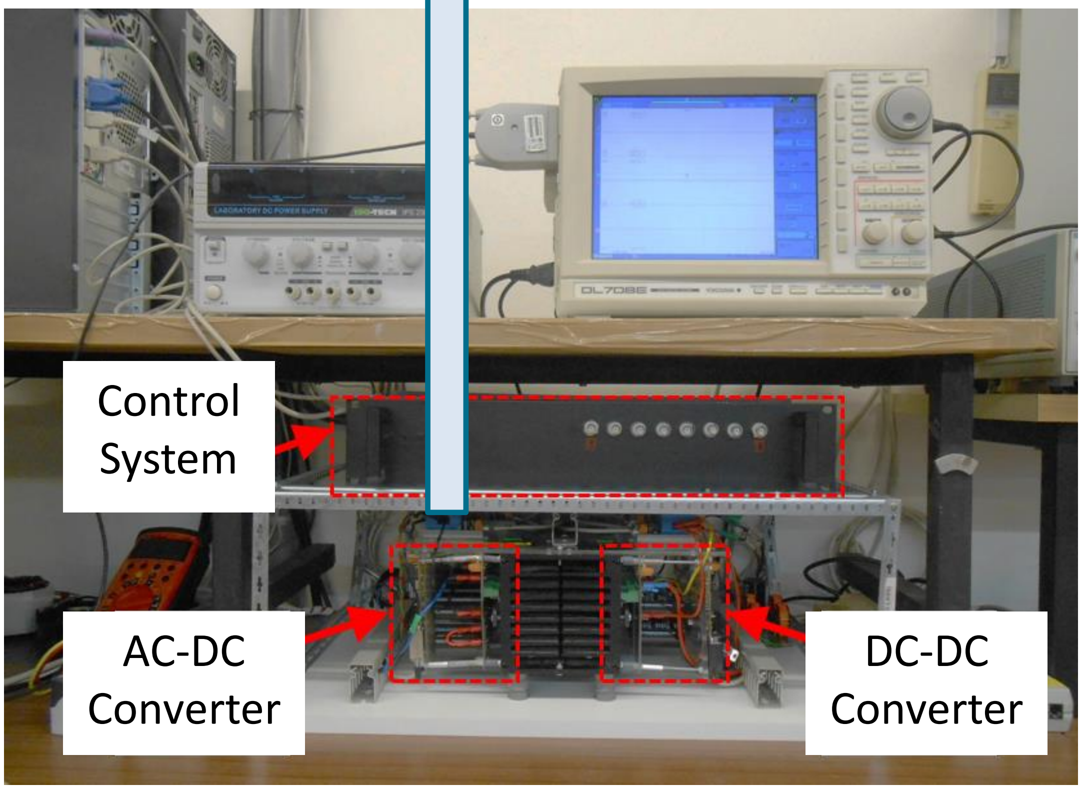
single-phase
on-board EVBC

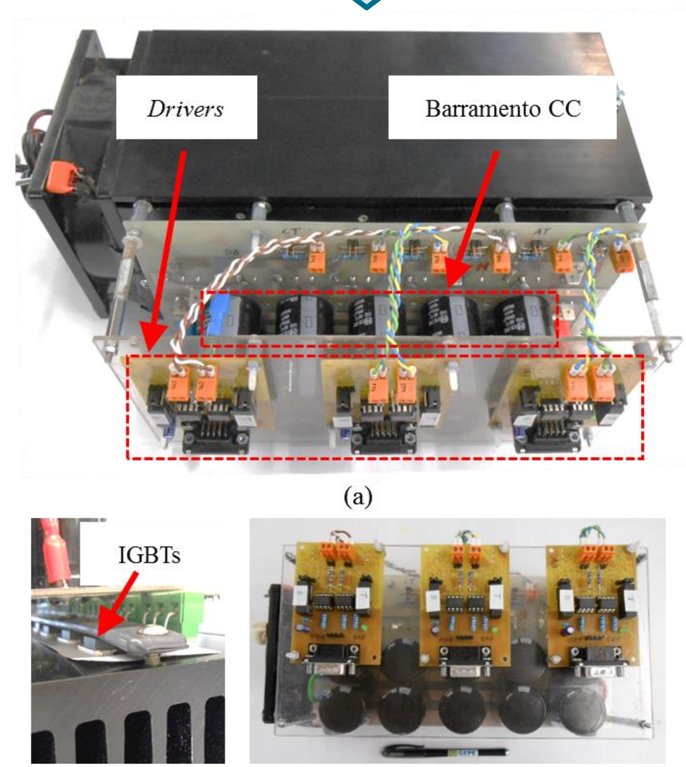
Structure of a developed on-board EV battery charger



Vítor Monteiro, João C. Ferreira, Andrés N. Melendez, João L. Afonso, "***Model Predictive Control Applied to an Improved Five-Level Bidirectional Converter***", IEEE Transactions on Industrial Electronics, vol.63, no.9, pp.5879-5890, Sept. 2016.

Developed prototype of the on-board EV battery charger.

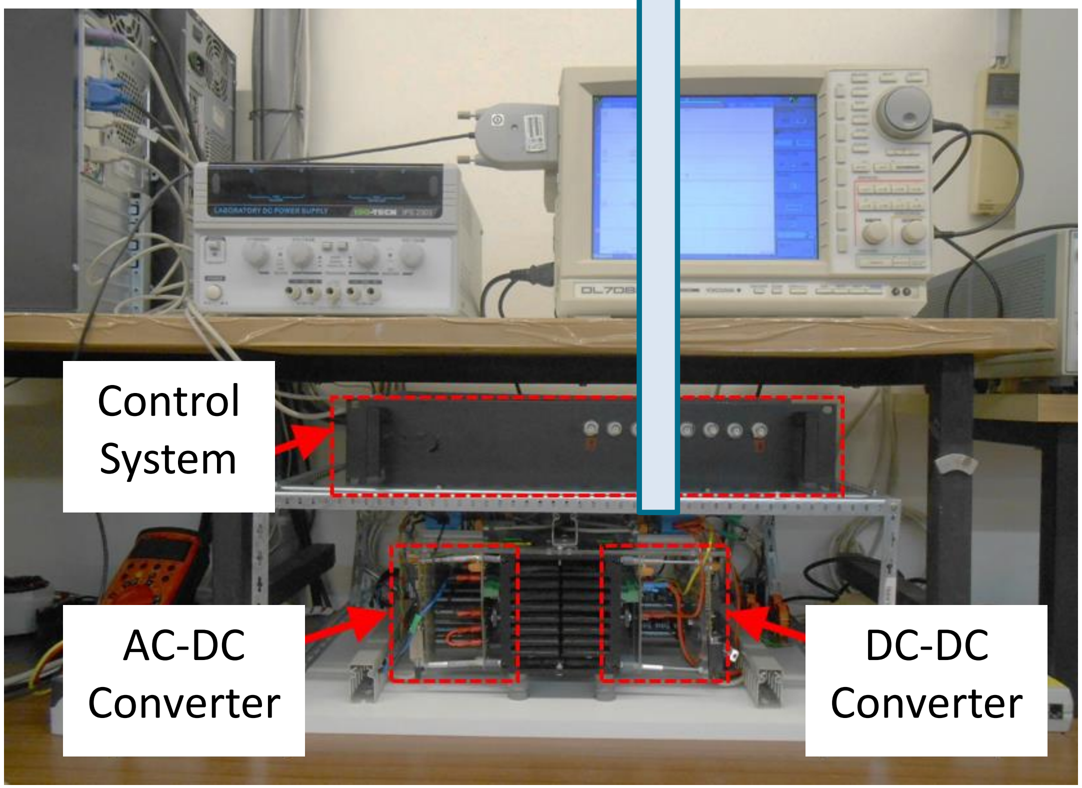


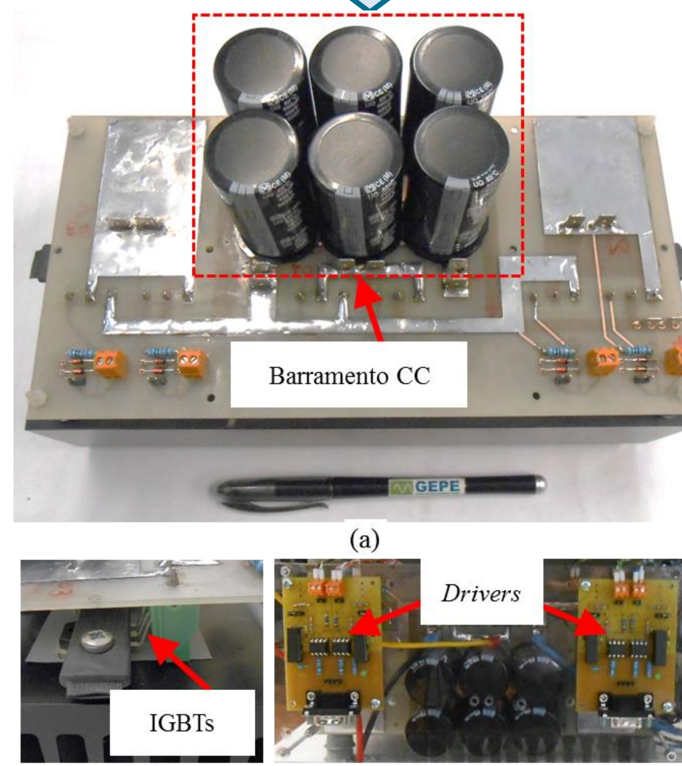


(a)

(b) (c)

Developed prototype of the on-board EV battery charger.

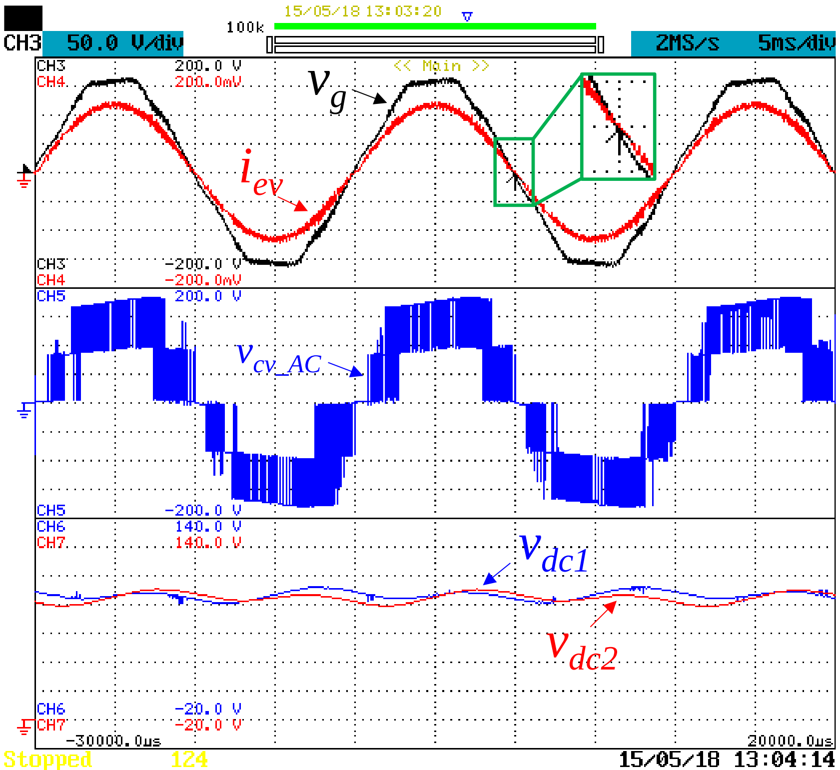




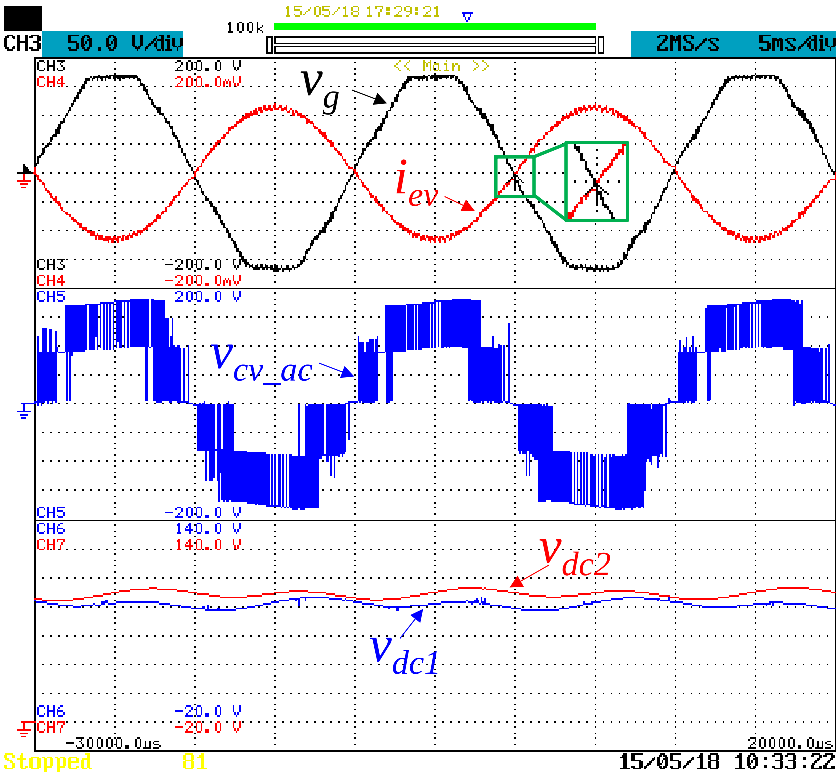
(a)

(b) (c)

Experimental results of the developed on-board EV battery charger.



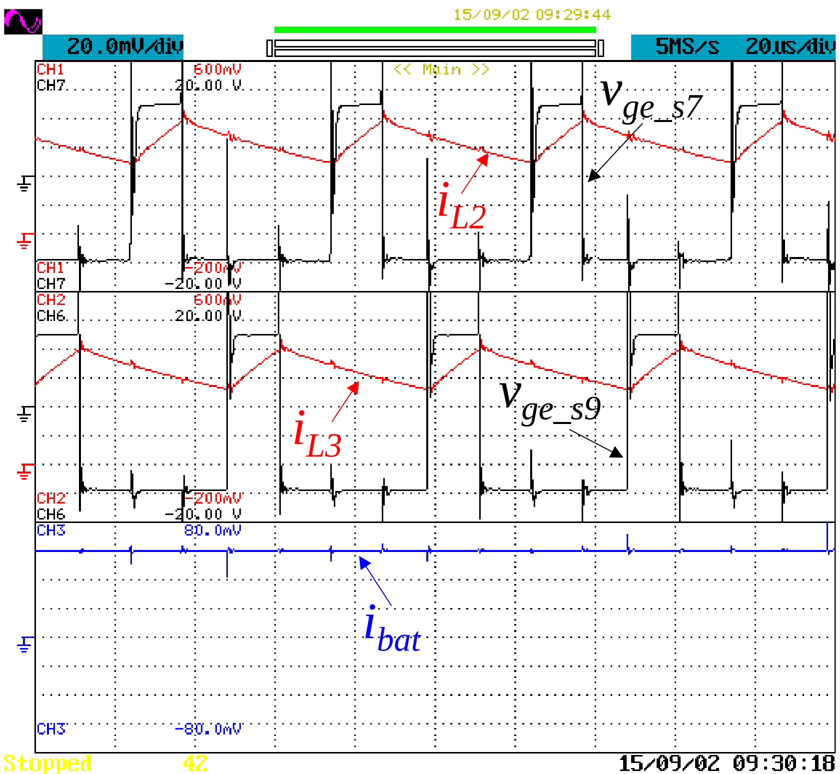
G2V mode



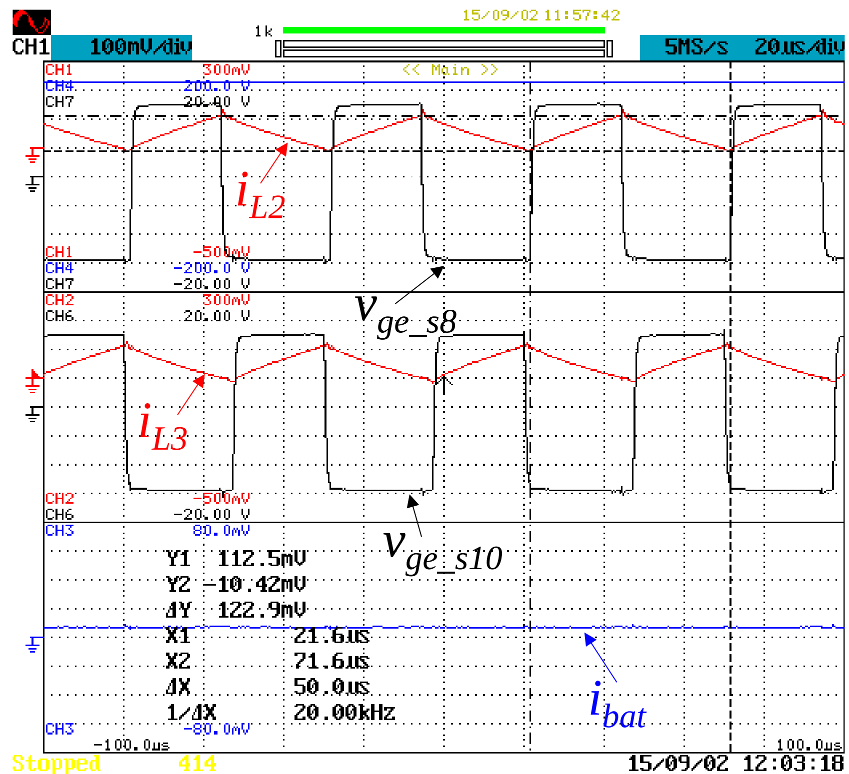
V2G mode

Power grid voltage (v_g: 50 V/div); EV current (i_{ev}: 5 A/div);
Voltage of the converter (v_{cv_AC}: 50 V/div); DC-link current (v_{dc}: 20 V/div).

Experimental results of the developed on-board EV battery charger.



G2V mode

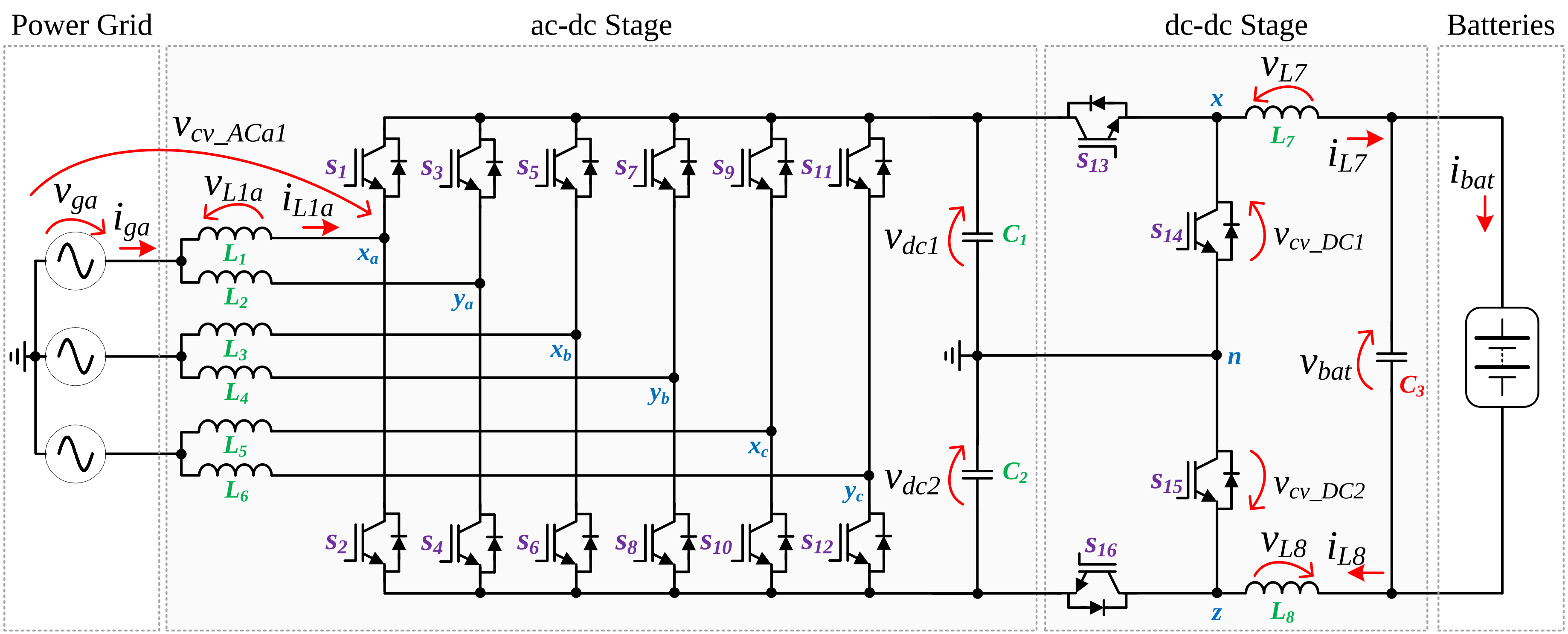


V2G mode

Current on L_2 (i_{L2}: 1 A/div) and L_3 (i_{L3}: 1 A/div);

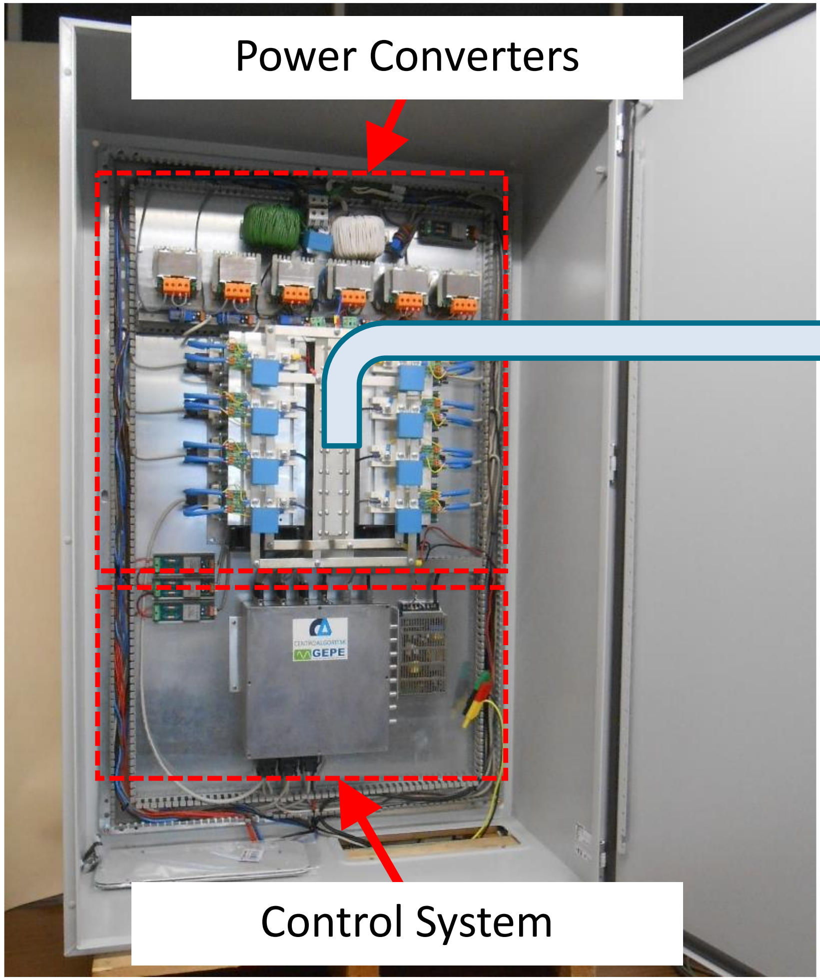
Voltage on the IGBTs (v_{ge}: 5 V/div); EV battery current (i_{bat}: 2 A/div).

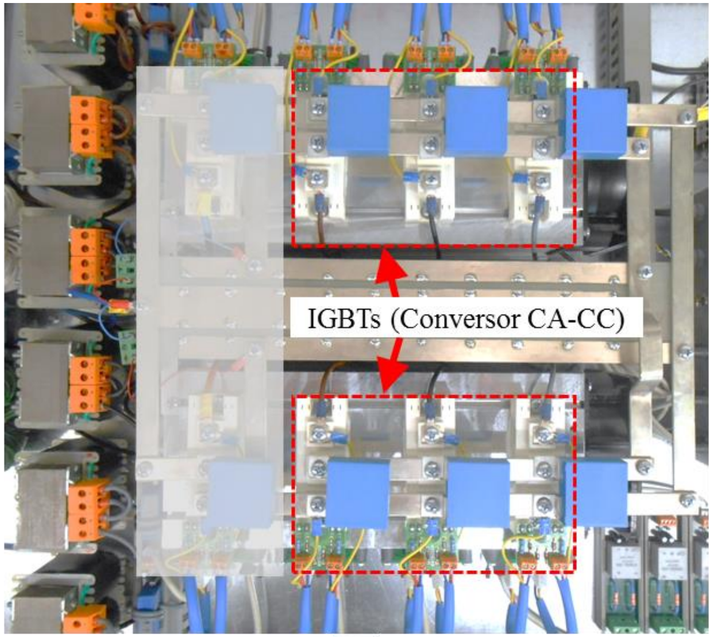
Structure of a developed off-board EV battery charger



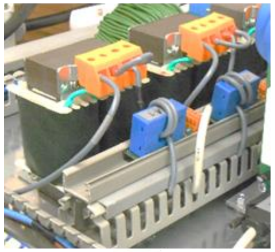
Vítor Monteiro, João C. Ferreira, Andrés A. Nogueiras Meléndez, Carlos Couto, João L. Afonso, "***Experimental Validation of a Novel Architecture Based on a Dual-Stage Converter for Off-Board Fast Battery Chargers of Electric Vehicles***", IEEE Transactions on Vehicular Technology, vol.67, no.2, pp.1000-1011, Feb. 2018.

Developed prototype of the off-board EV battery charger.

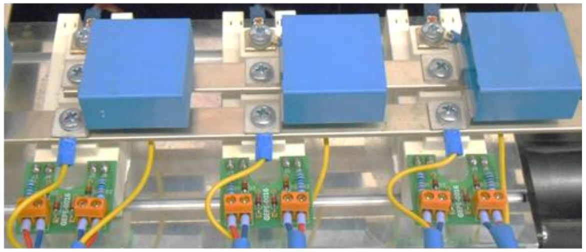




(a)

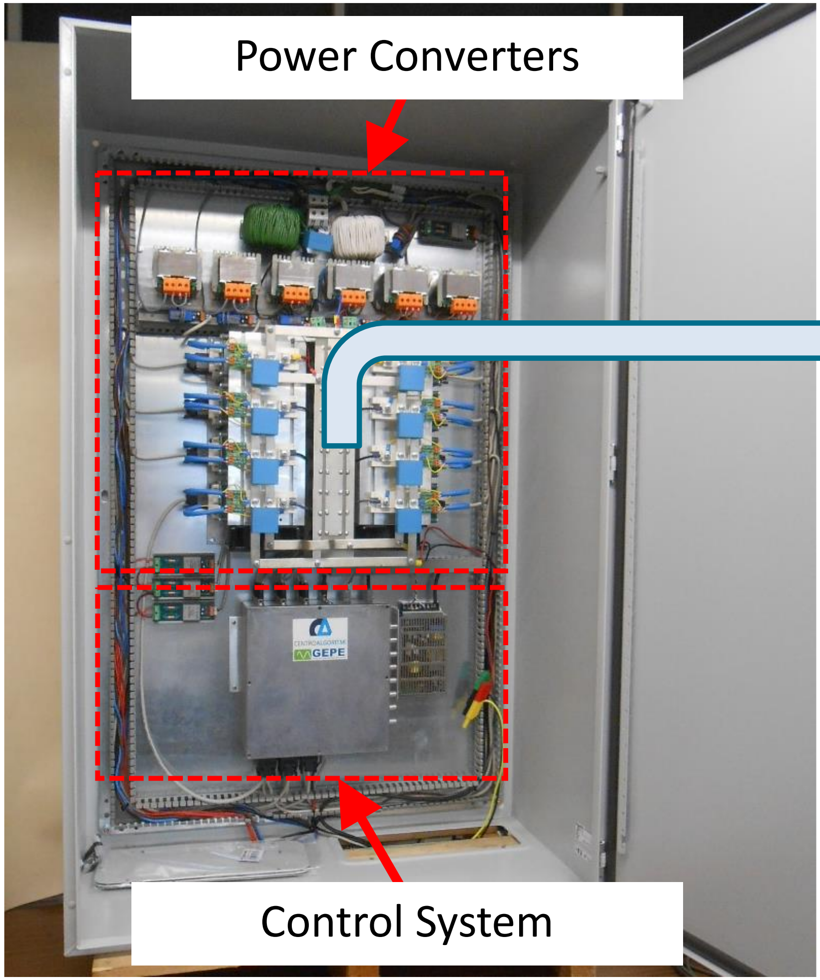


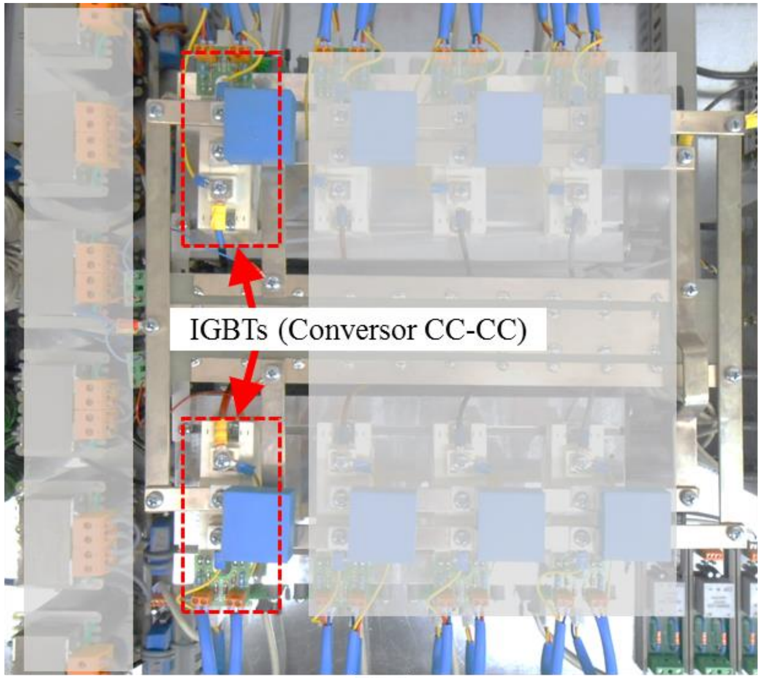
(b)



(c)

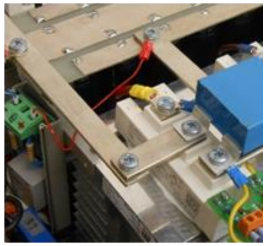
Developed prototype of the off-board EV battery charger.





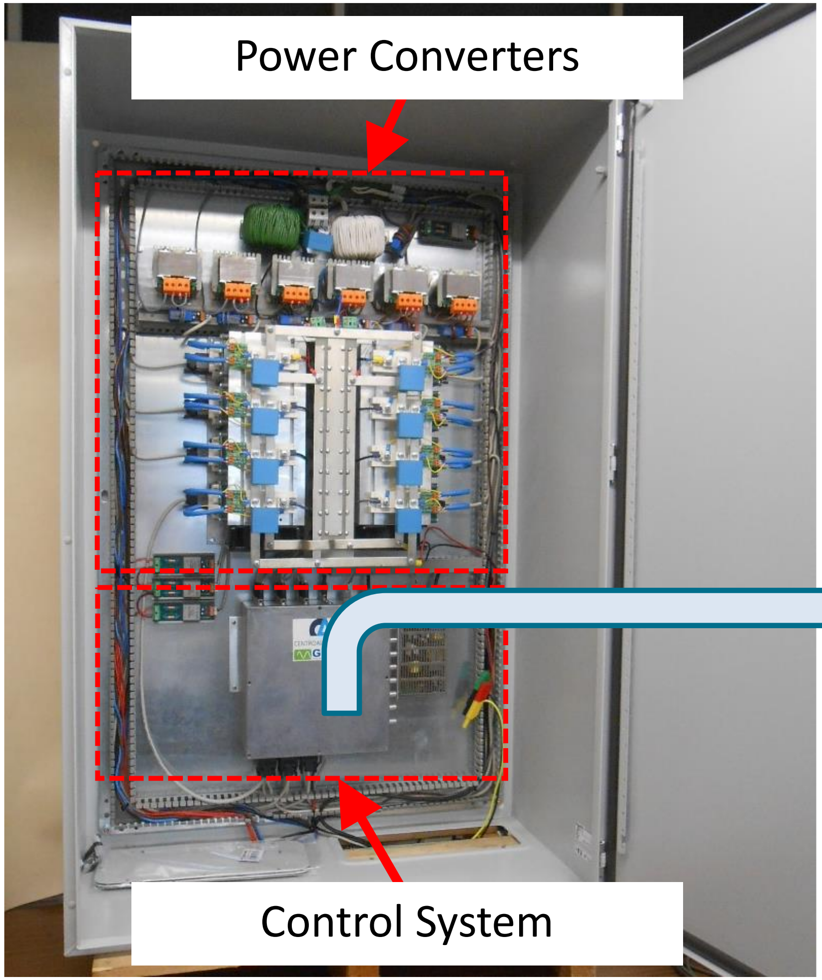
(a)

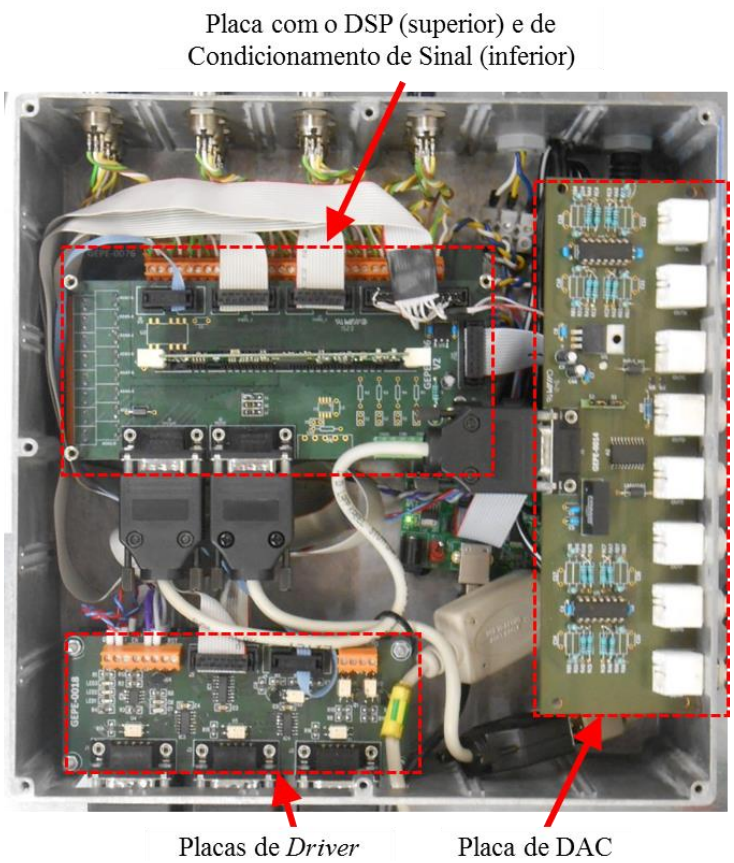
(b)



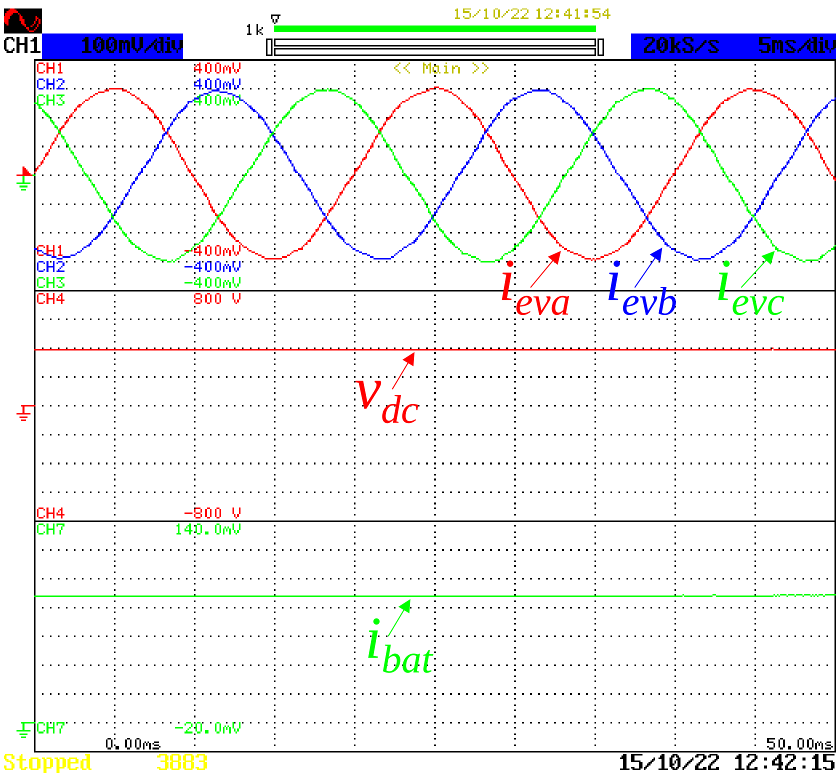
(c)

Developed prototype of the off-board EV battery charger.

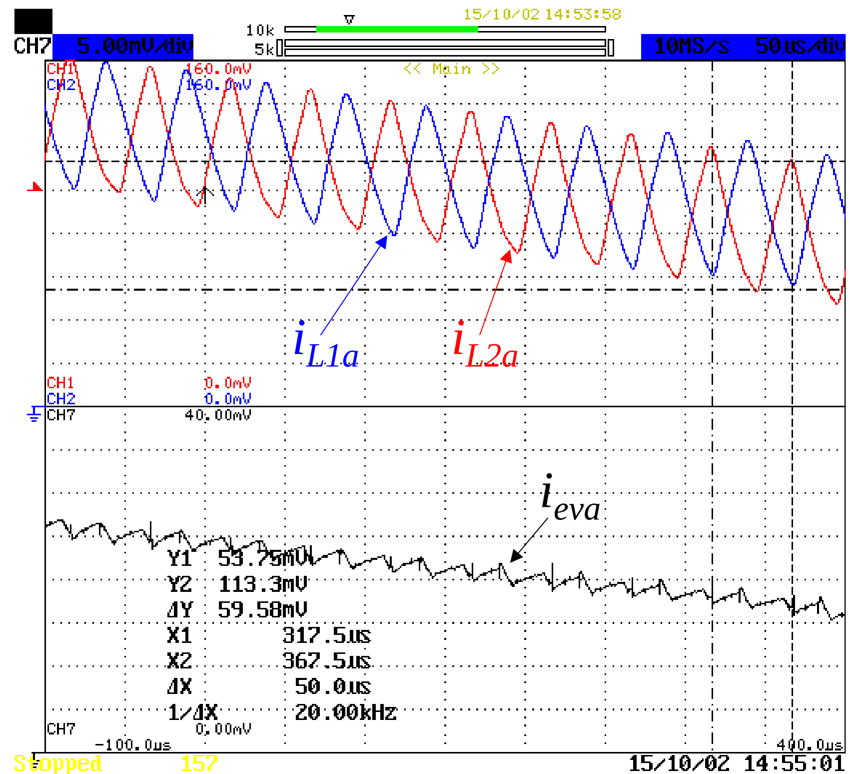




Experimental results of the developed off-board EV battery charger.

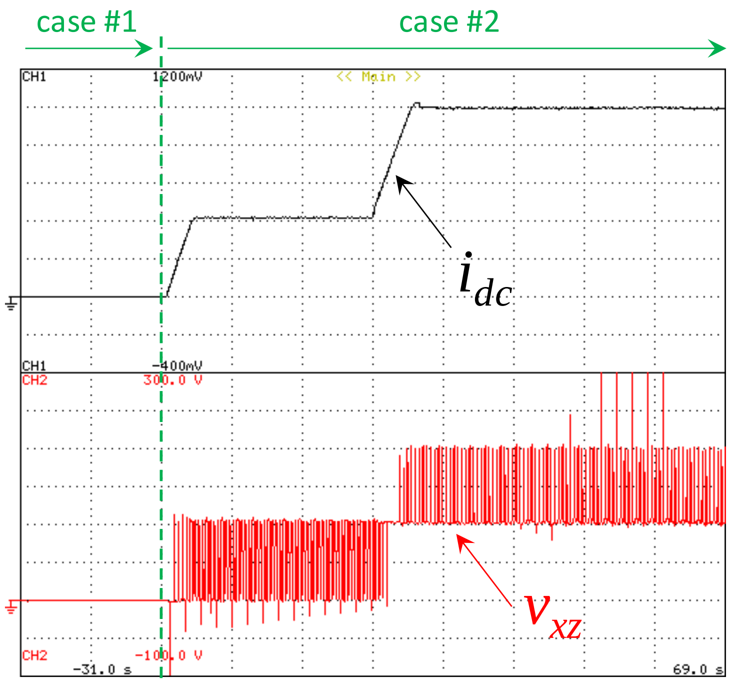


Currents in phases (i_{eva}, i_{evb}, i_{evc}: 10 A/div);
DC-link voltage (v_{dc}: 200 V/div);
EV battery current (i_{bat}: 4 A/div).

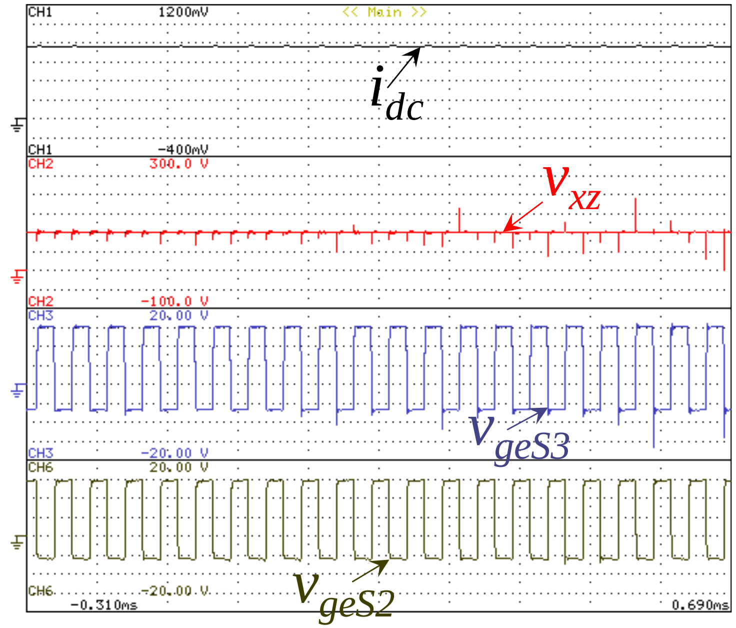


Current in L_1 (i_{L1a}: 0,2 A/div);
Current in L_2 (i_{L2a}: 0,2 A/div);
Current in phase *a* (i_{eva}: 0,5 A/div).

Experimental results of the developed off-board EV battery charger.

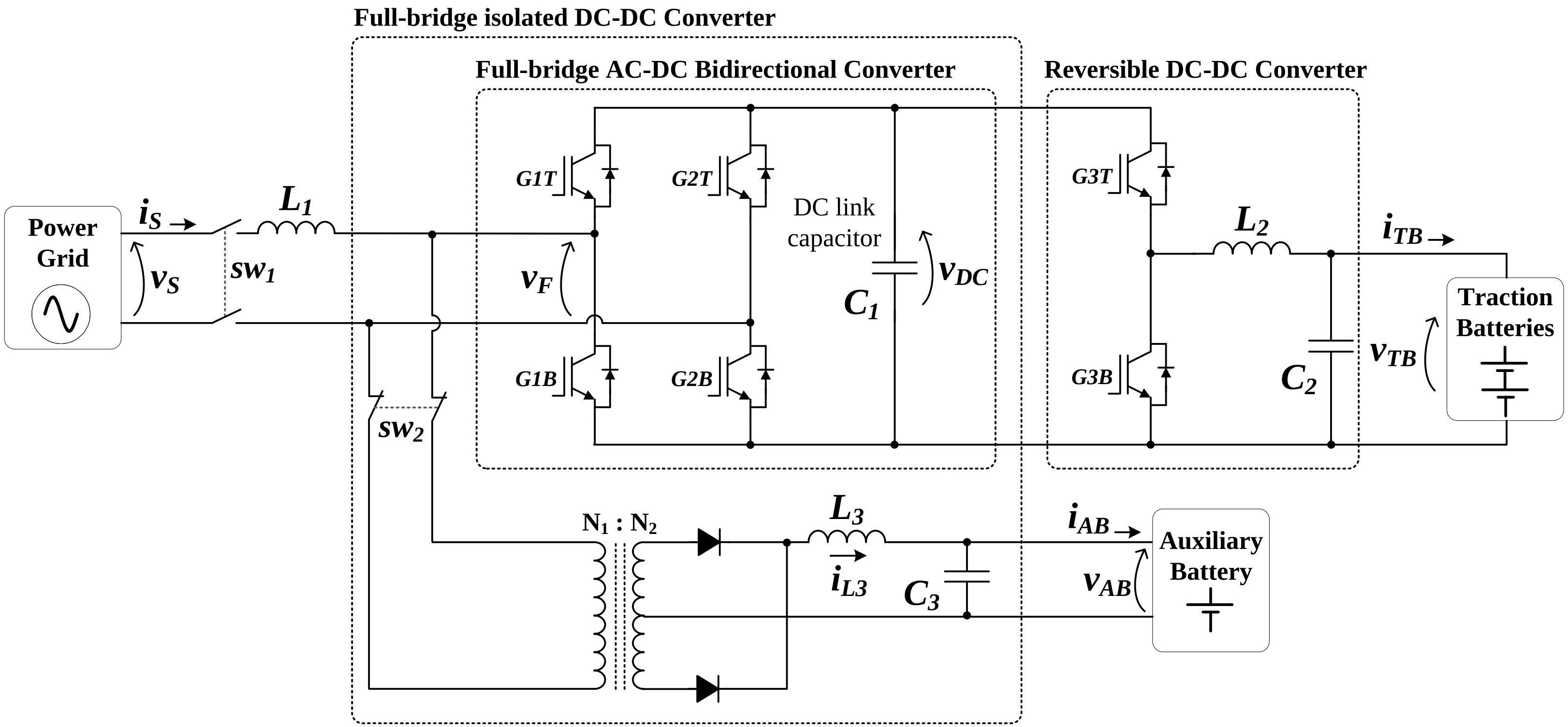


Experimental results of the off-board EV charger (buck-mode):
Current (idc: 2 A/div); Voltage produced by the converter (vxy: 50 V/div).



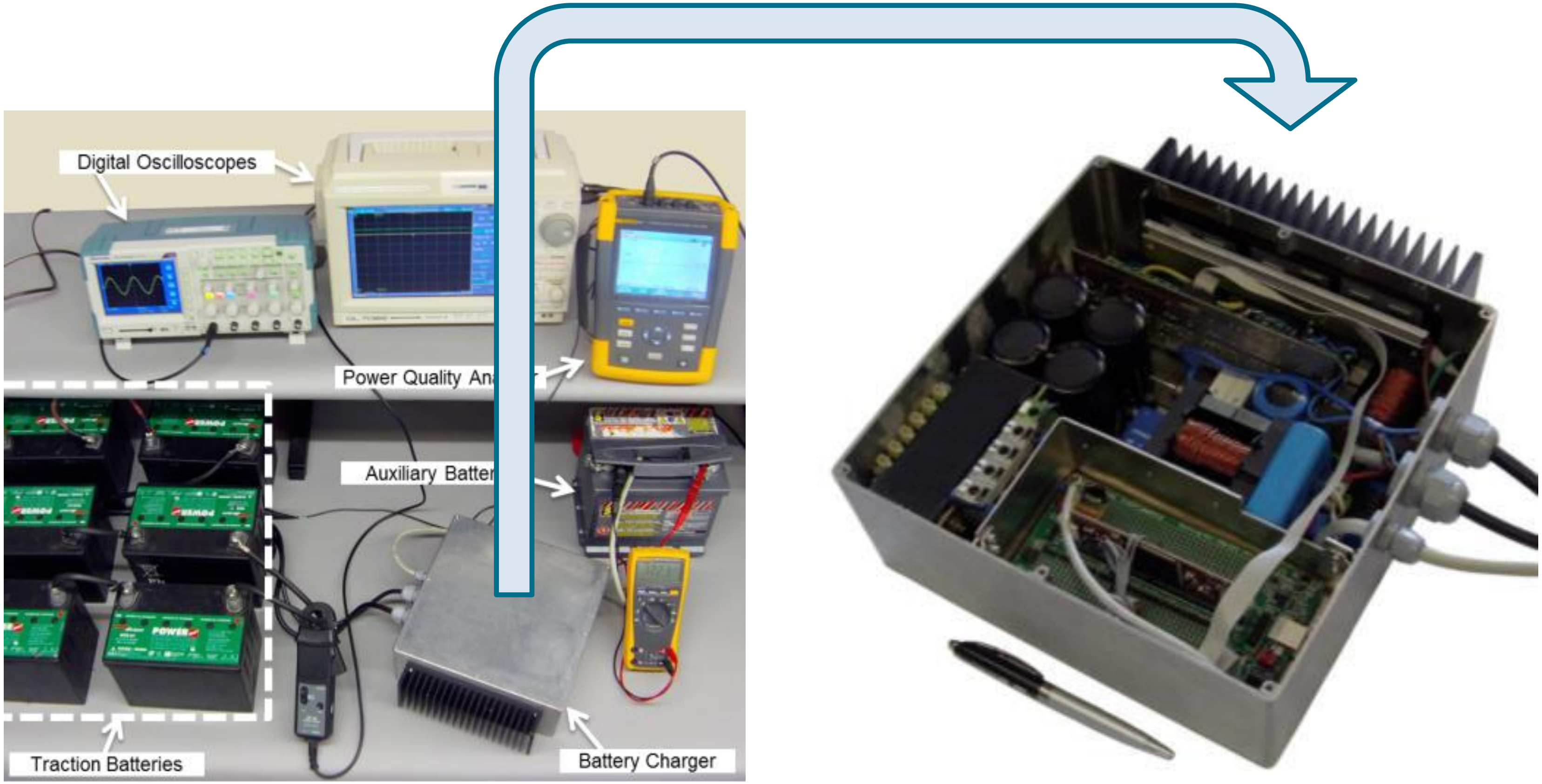
Experimental results in boost-mode: Current (idc: 2 A/div); Voltage of the converter (vxz: 50 V/div); Gate emitter voltage of the IGBTs s1 (vgeS1: 5 V/div) and s4 (vgeS4: 5 V/div).

On-Board Reconfigurable EV Charger with Traction-to-Auxiliary Mode

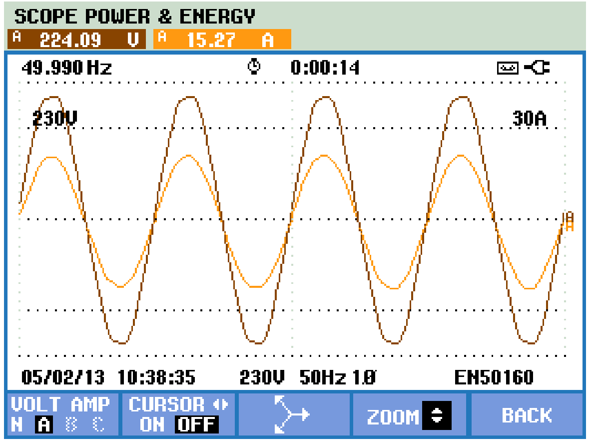


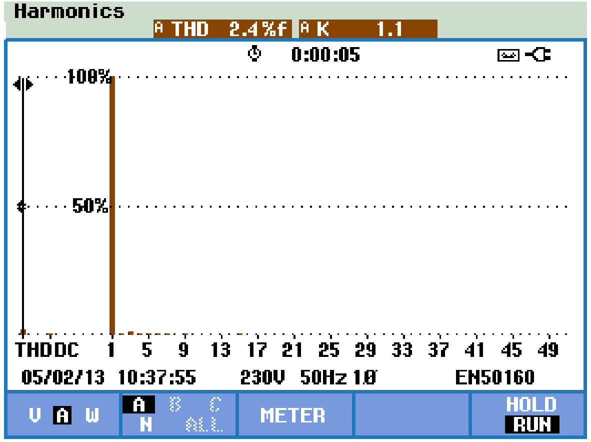
J. G. Pinto, Vítor Monteiro, Henrique Gonçalves, João L. Afonso, "***Onboard Reconfigurable Battery Charger for Electric Vehicles with Traction-to-Auxiliary Mode***", IEEE Transactions on Vehicular Technology, vol.63, no.3, pp.1104-1116, Mar. 2014.

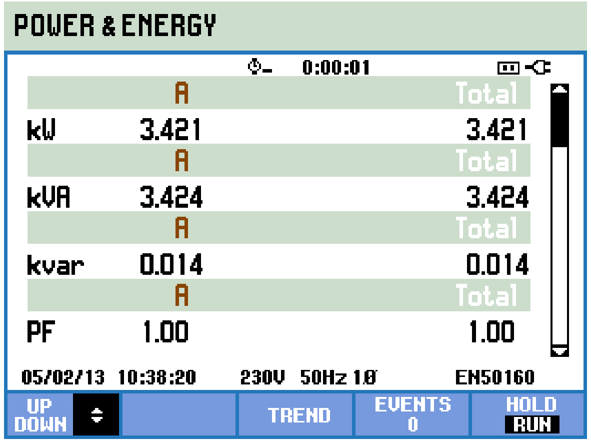
On-Board Reconfigurable EV Charger with Traction-to-Auxiliary Mode

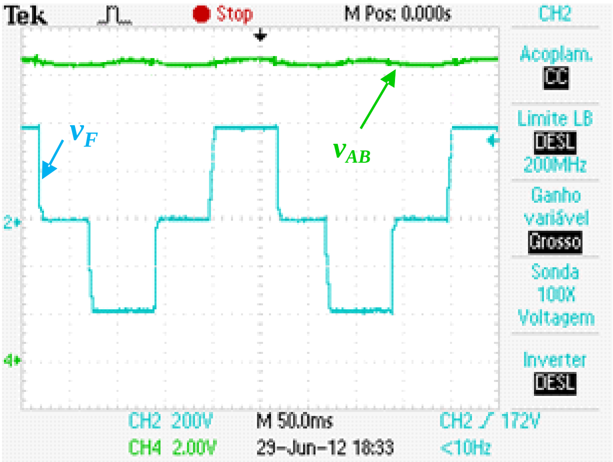


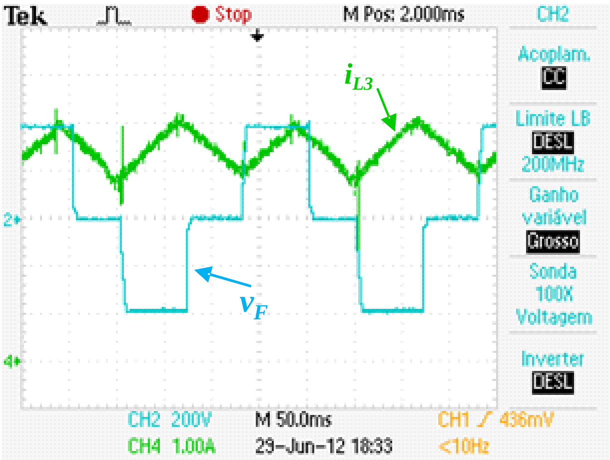
EV Charger with Traction-to-Auxiliary Mode – Experimental Validation



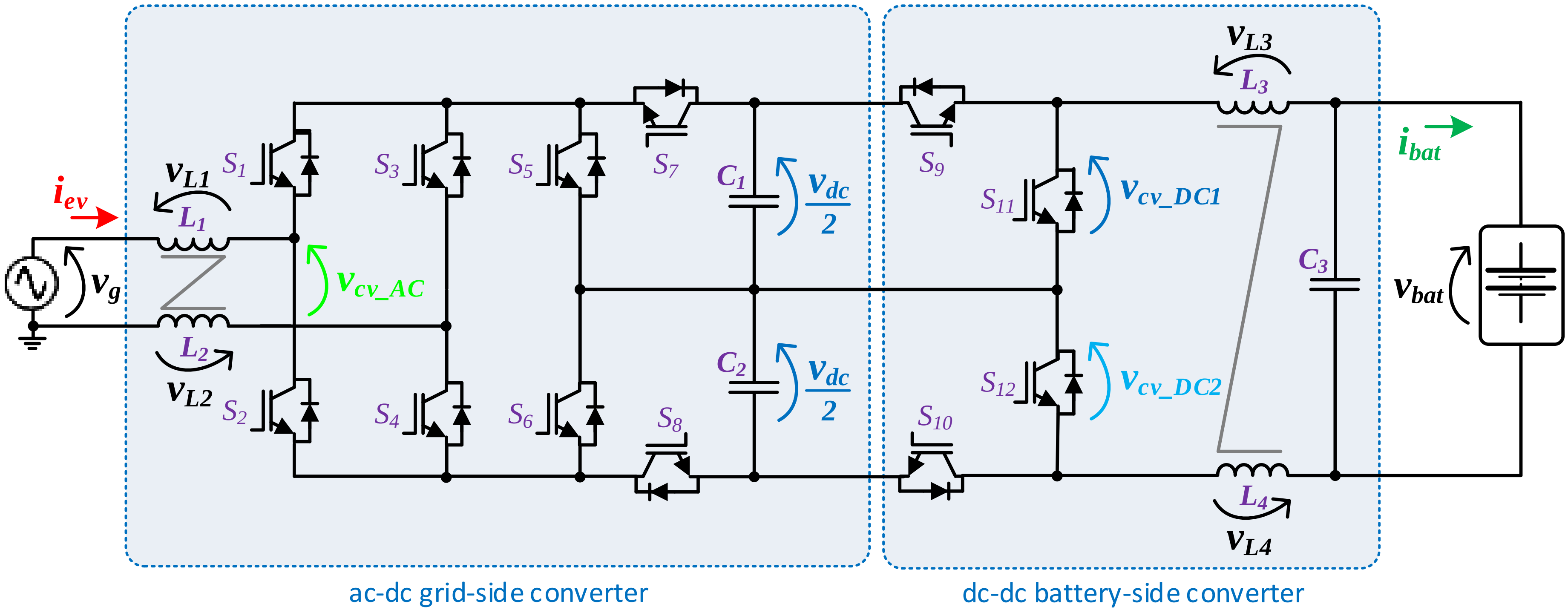






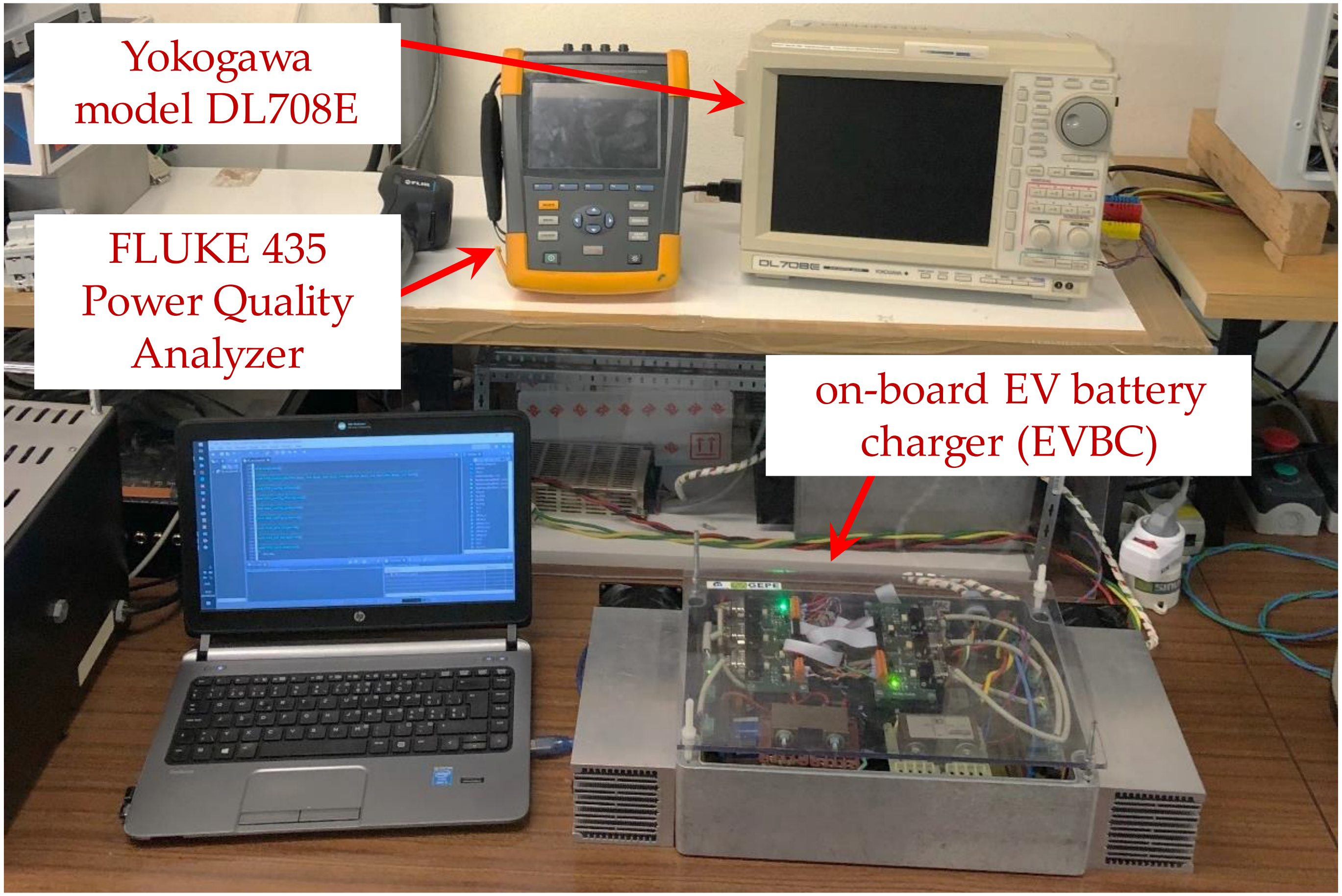


Multilevel Bidirectional Topology for On-Board EV Battery Chargers

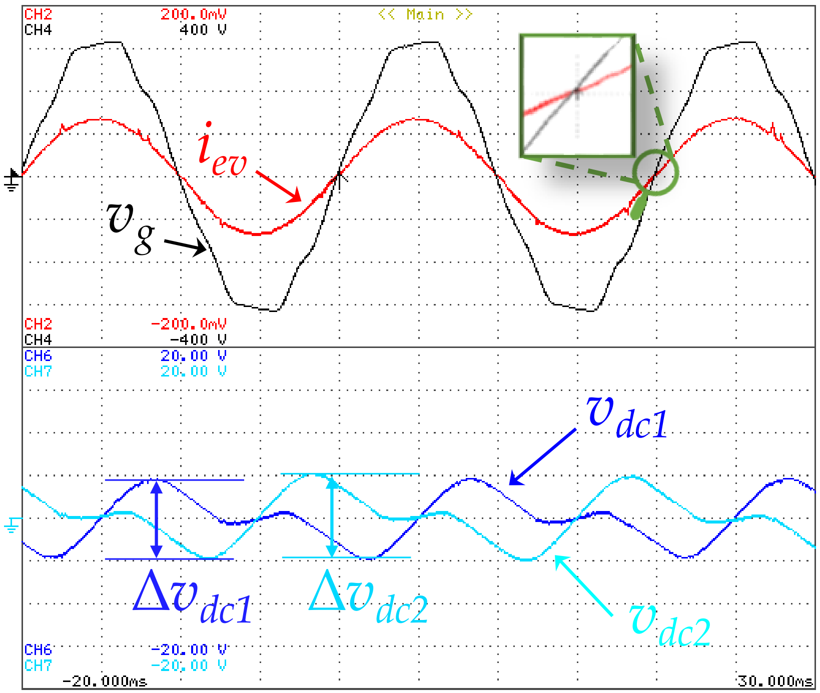


Rafael Leite, João L. Afonso, Vítor Monteiro, "***A Novel Multilevel Bidirectional Topology for On-Board EV Battery Chargers in Smart Grids***", MDPI Energies, vol.11, no.12, pp.1-21, Dec. 2018.

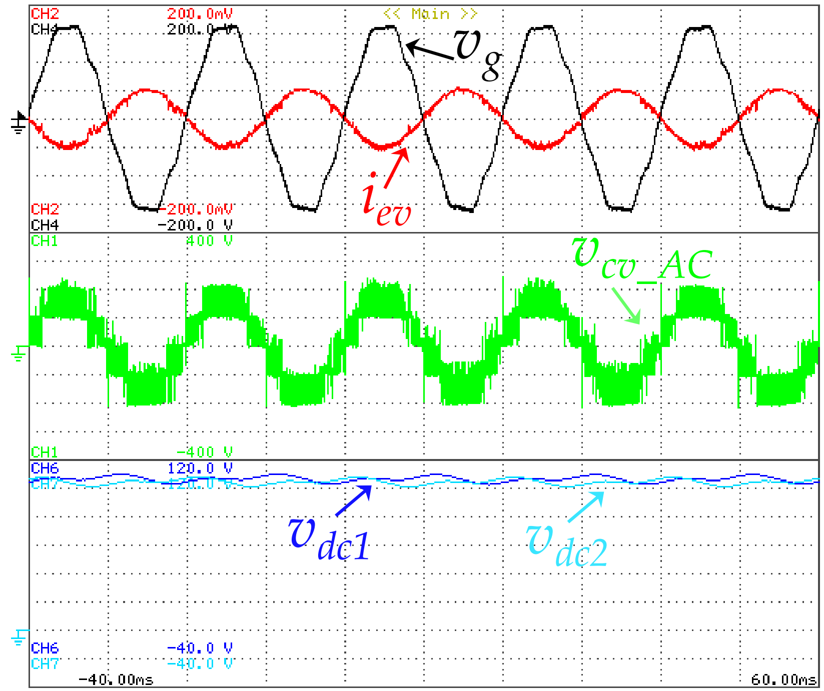
Multilevel Bidirectional Topology for On-Board EV Battery Chargers



Multilevel Bidirectional Topology for On-Board EV Battery Chargers



Experimental results in G2V mode showing the current (i_{ev}: 5 A/div), the voltage (v_g: 100 V/div), and the dc-link voltages (Δv_{dc1}: 5 V/div, Δv_{dc2}: 5 V/div).

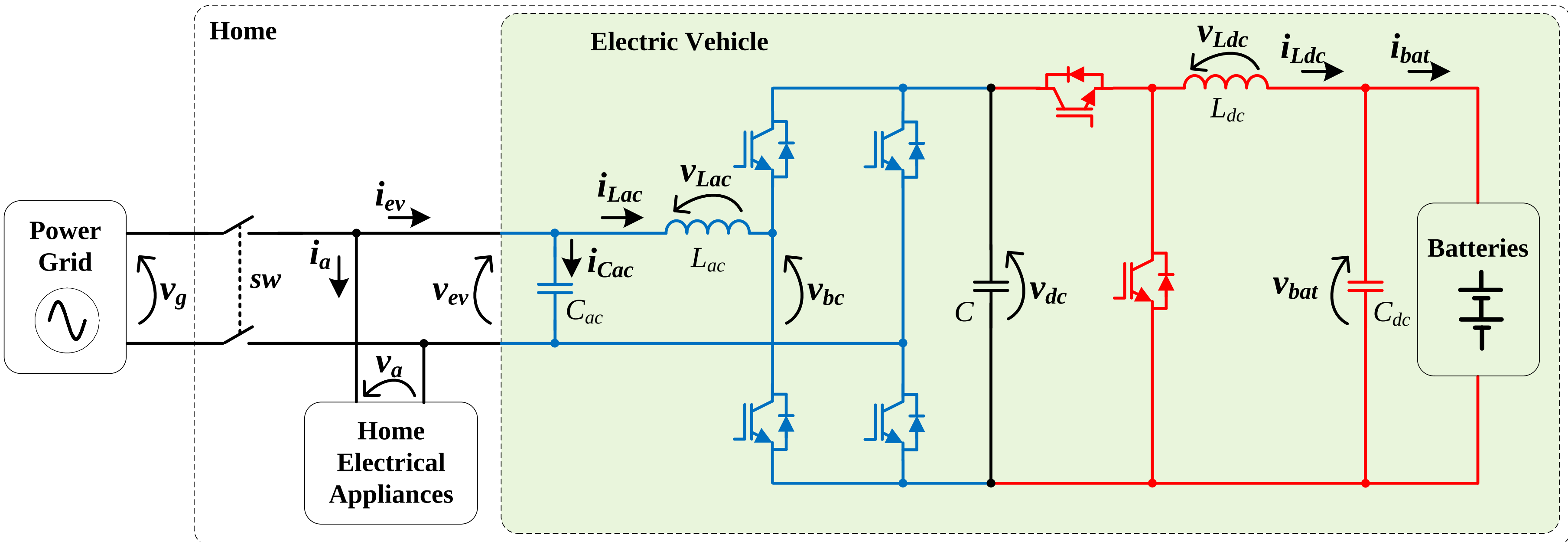


Experimental results in V2G operation mode showing the current (i_{ev}: 5 A/div), the voltage (v_g: 50 V/div), the voltage levels (v_{cv_AC}: 100 V/div) and the dc-link voltage (v_{dc1}: 20 V/div, v_{dc2}: 20 V/div).

section #3

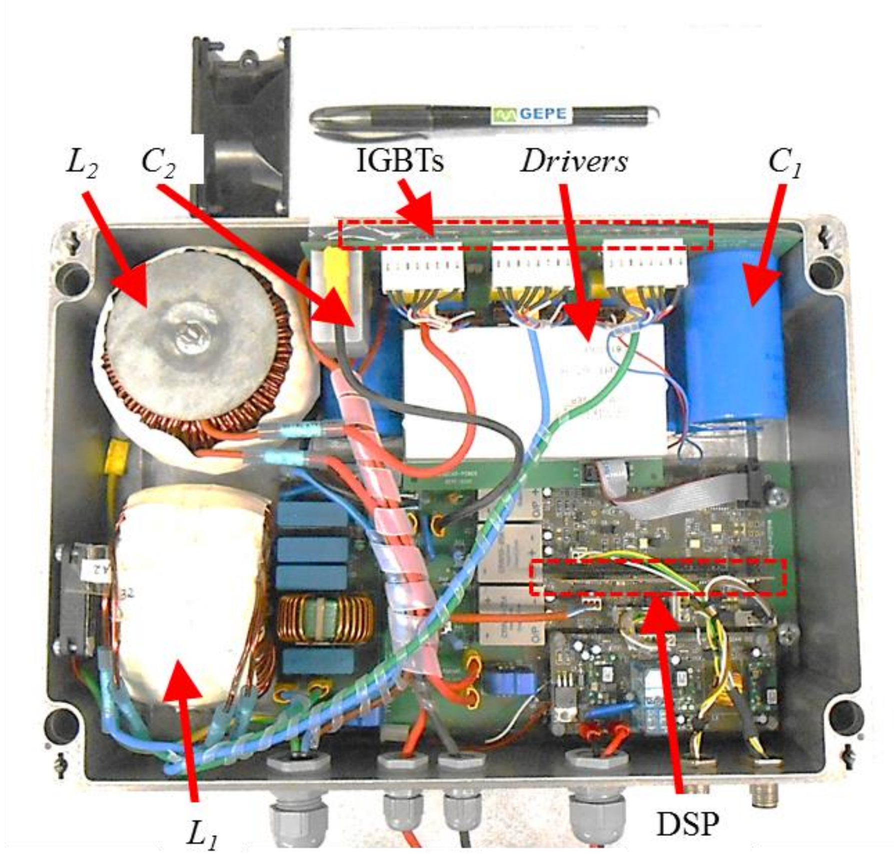
Power Electronics for EV Chargers with Innovative Operation Modes

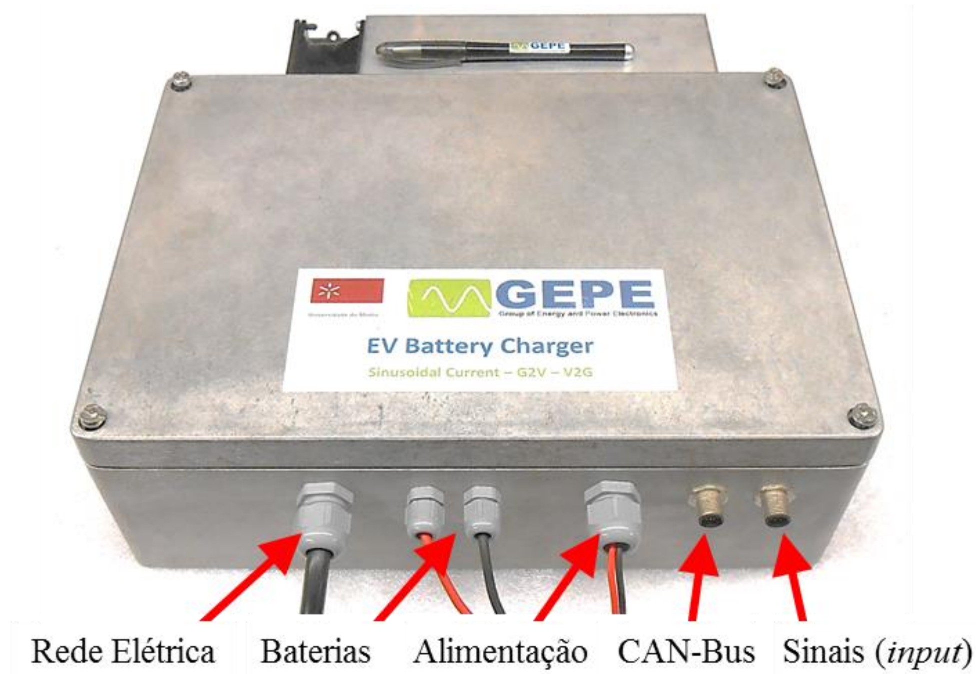
Developed prototype of obn-board EV battery charger.



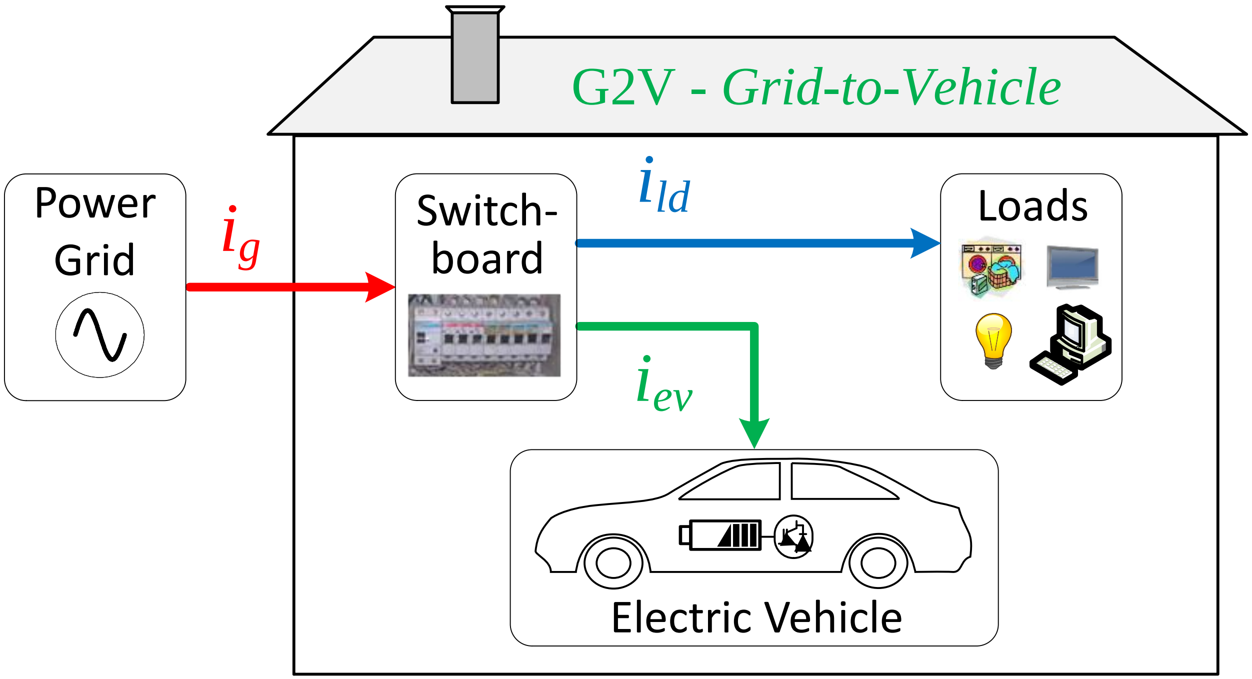
Vítor Monteiro, J. G. Pinto, João L. Afonso, "***Operation Modes for the Electric Vehicle in Smart Grids and Smart Homes: Present and Proposed Modes***", IEEE Transactions on Vehicular Technology, vol.65, no.3, pp.1007-1020, Mar. 2016.

Developed prototype of obn-board EV battery charger.





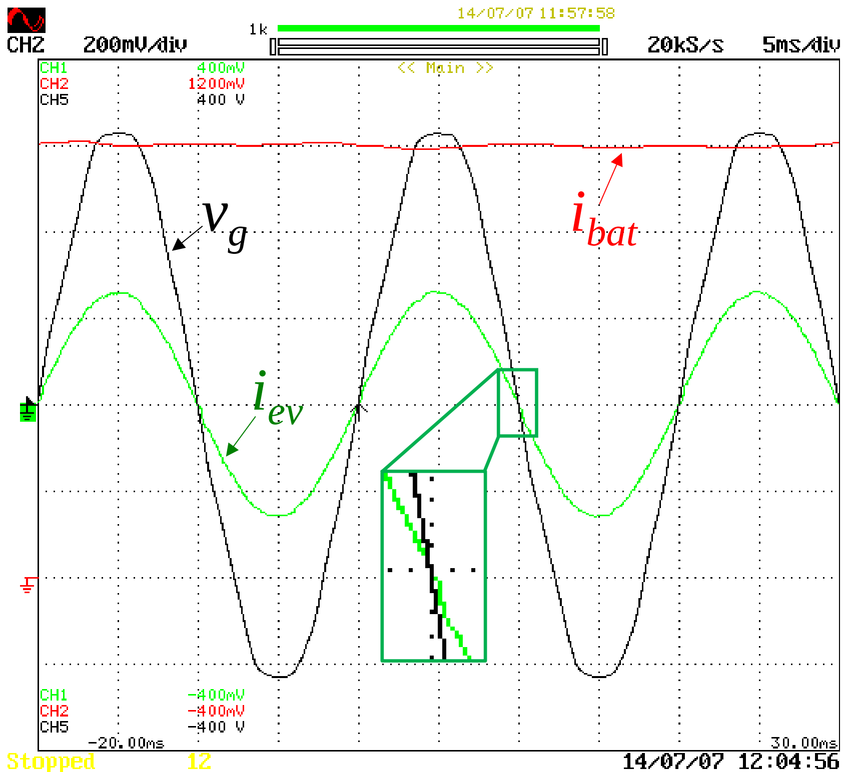
Operation Mode *Grid-to-Vehicle* (G2V).



Sinusoidal current in phase with the power grid voltage.

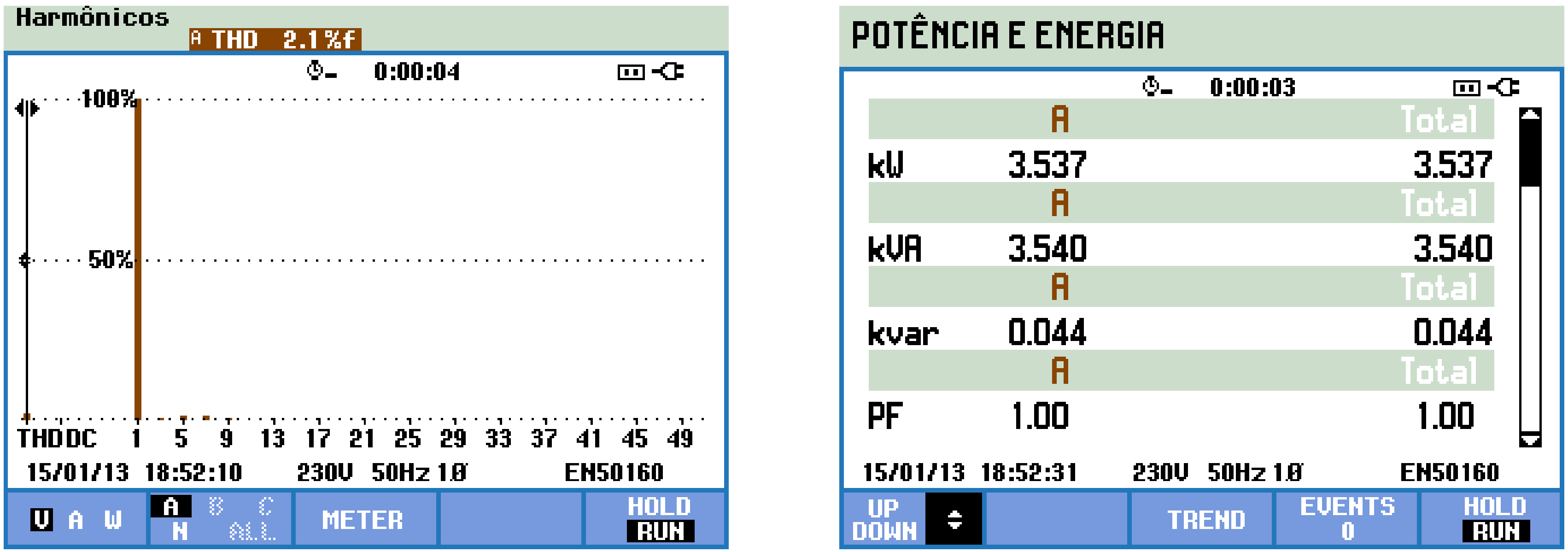
Battery charging with constant current or constant voltage.

Experimental results during the operation mode **G2V**.



Experimental results during the G2V mode:
power grid voltage (v_g: 100 V/div); EV current (i_{ev}: 5 A/div); EV battery current (i_{bat}: 2 A/div).

Experimental results during the operation mode G2V.

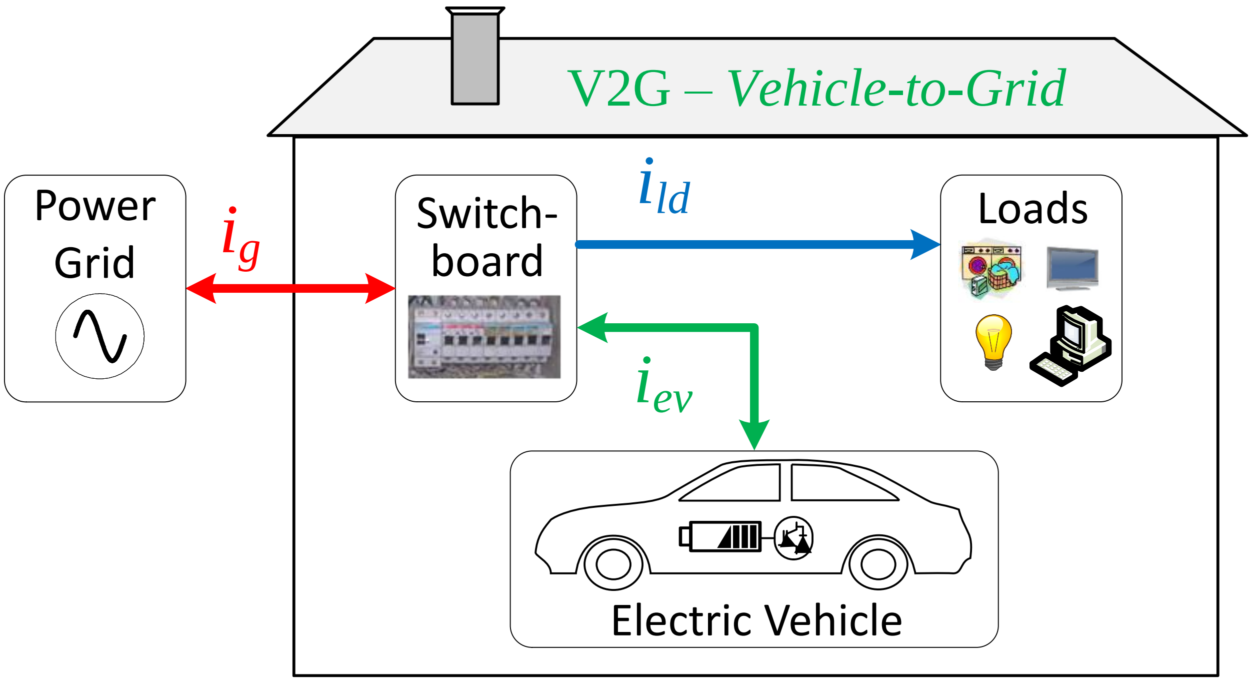


(a) (b)

Experimental results during the G2V mode:

(a) THD and harmonic spectrum; (b) operating power.

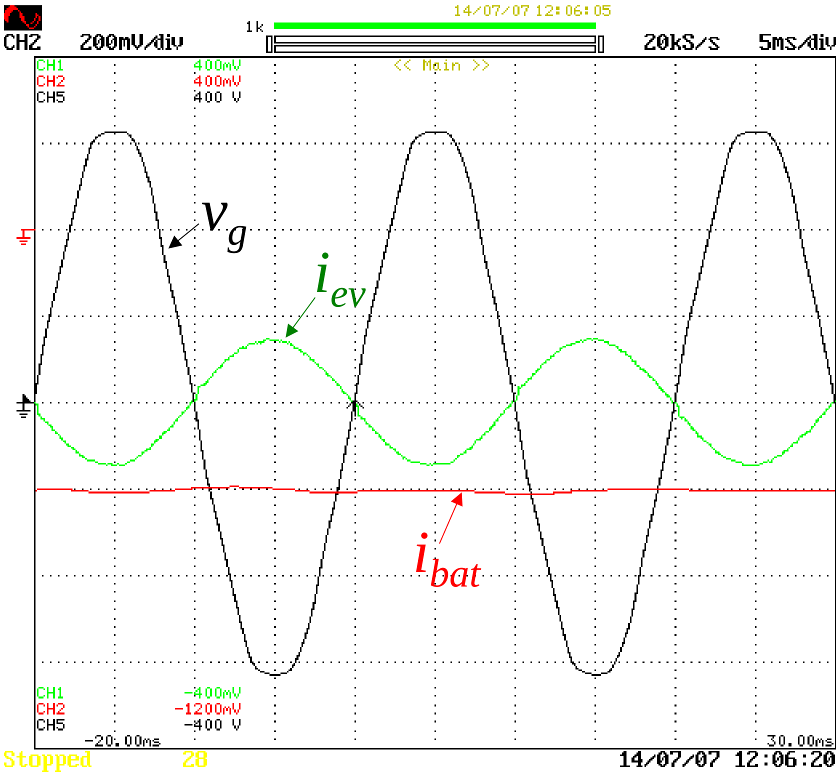
Operation Mode ***Vehicle-to-Grid* (V2G)**.



Sinusoidal current in phase opposition with the power grid voltage.

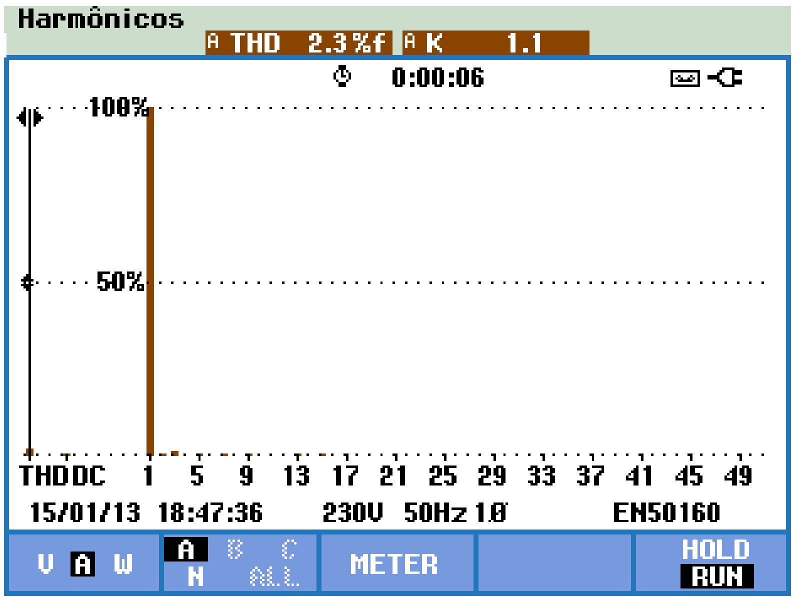
Discharge the battery with constant current.

Experimental results during the operation mode **V2G**.

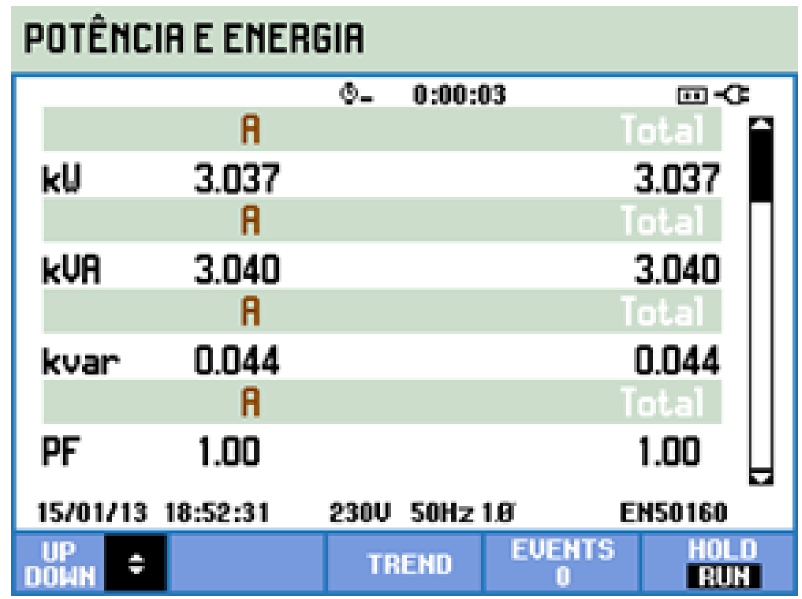


Experimental results during the V2G mode:
power grid voltage (v_g: 100 V/div); EV current (i_{ev}: 5 A/div); EV battery current (i_{bat}: 2 A/div).

Experimental results during the operation mode **V2G**.



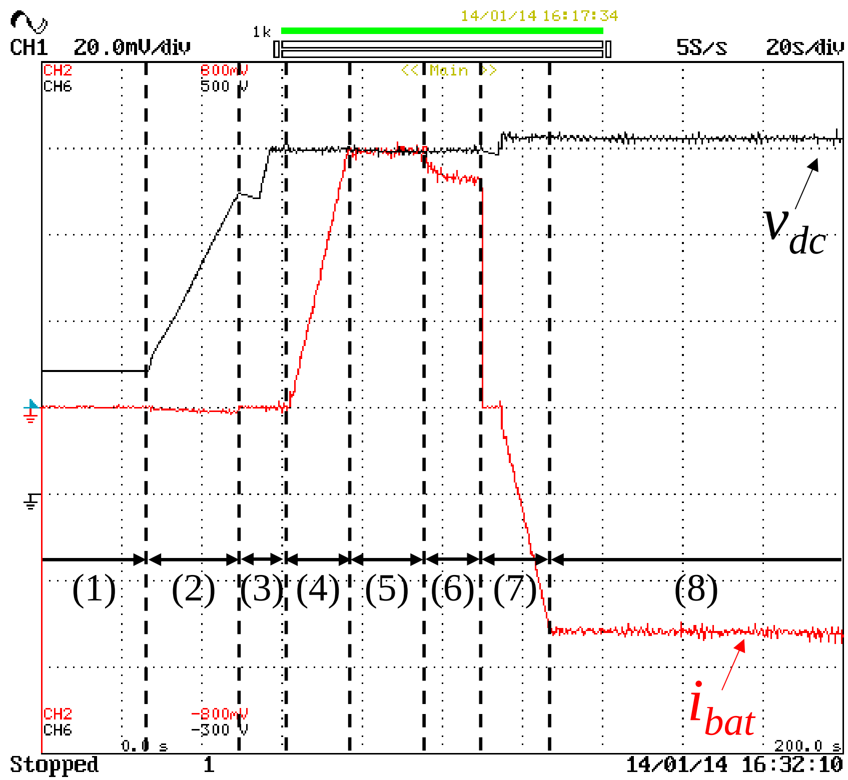
(a)



(b)

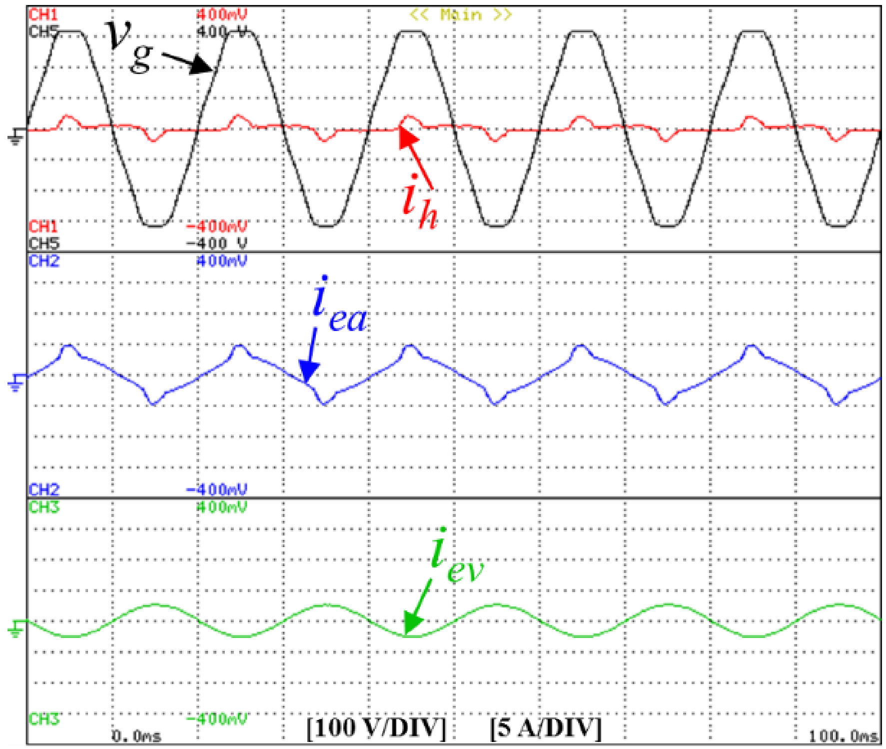
Experimental results during the V2G mode:
(a) THD and harmonic spectrum; (b) operating power.

Experimental results during the operation mode V2G.



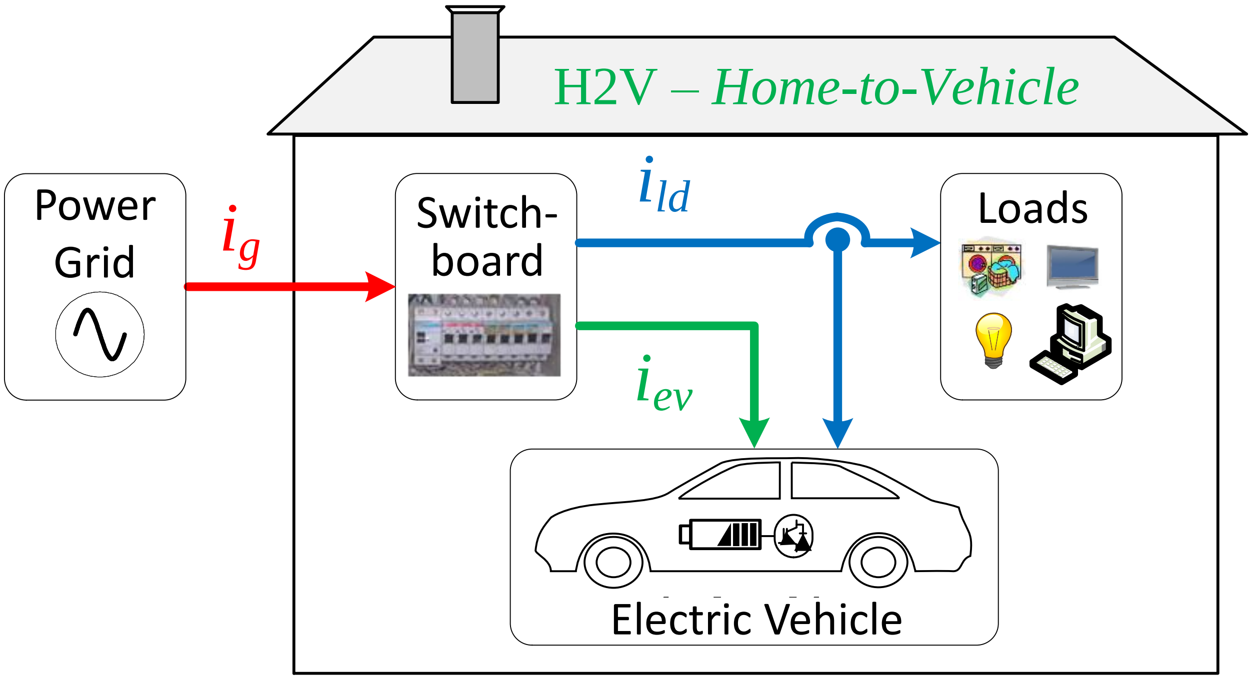
Experimental results during the G2V and V2G mode:
dc-link voltage (v_{dc}: 100 V/div); EV battery current (i_{bat}: 2 A/div).

Experimental results during the operation mode **V2G**.



Power grid voltage (v_g), total home current (i_h), electrical appliances current (i_{ea}) and EV current (i_{ev}) during the V2G mode, i.e., when is delivered energy to the power grid from the EV batteries.

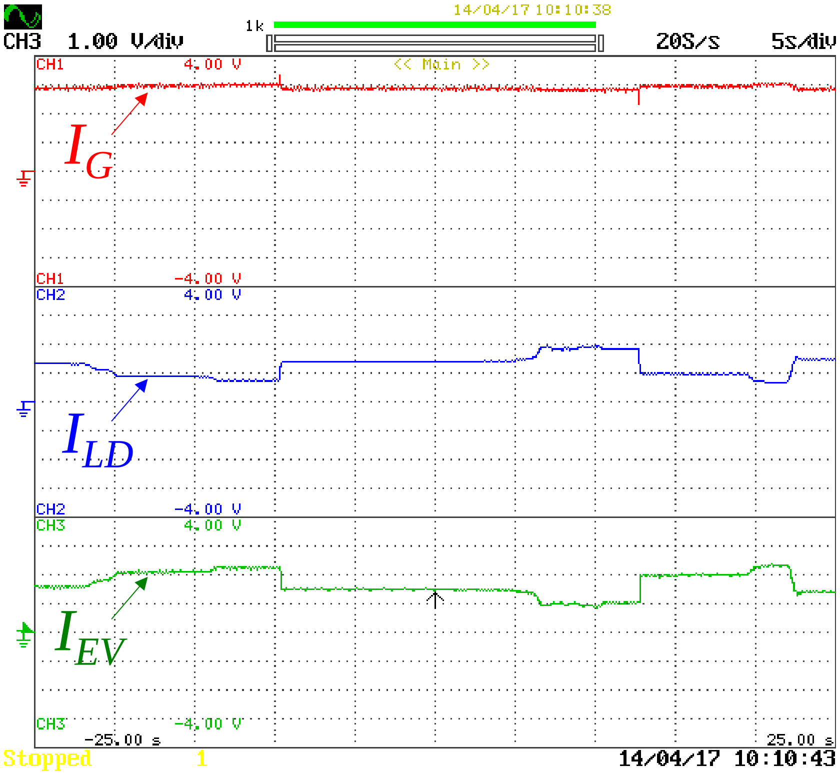
Operation Mode ***Home-to-Vehicle*** **(H2V)** (combined with G2V).



The RMS value of the EV current adjusted in function of the RMS of the loads.

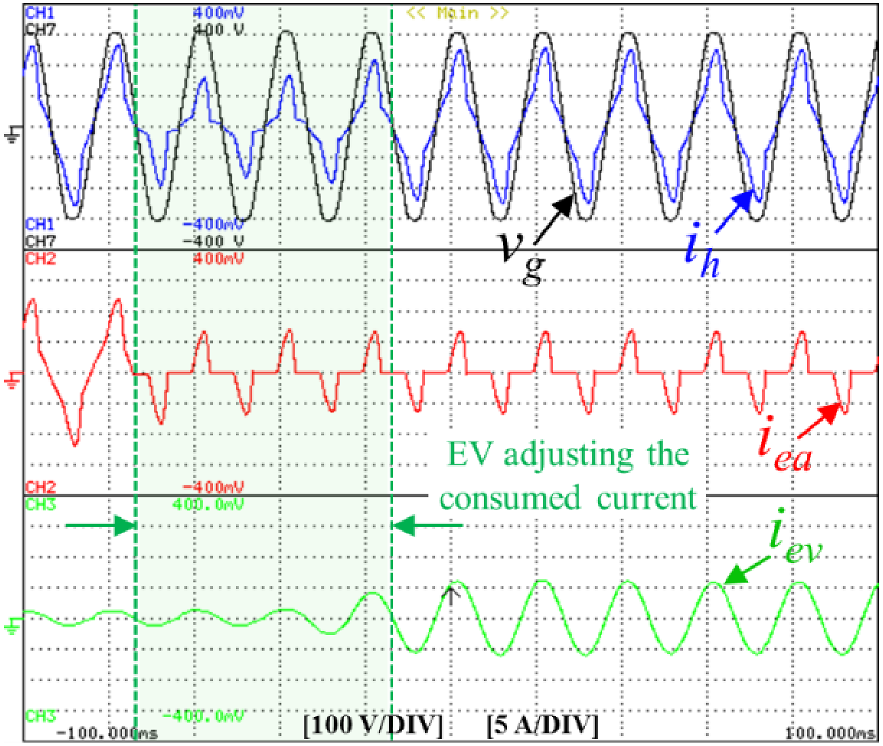
Battery charging with constant current or constant voltage.

Experimental results of the operation mode H2V (combined with G2V).



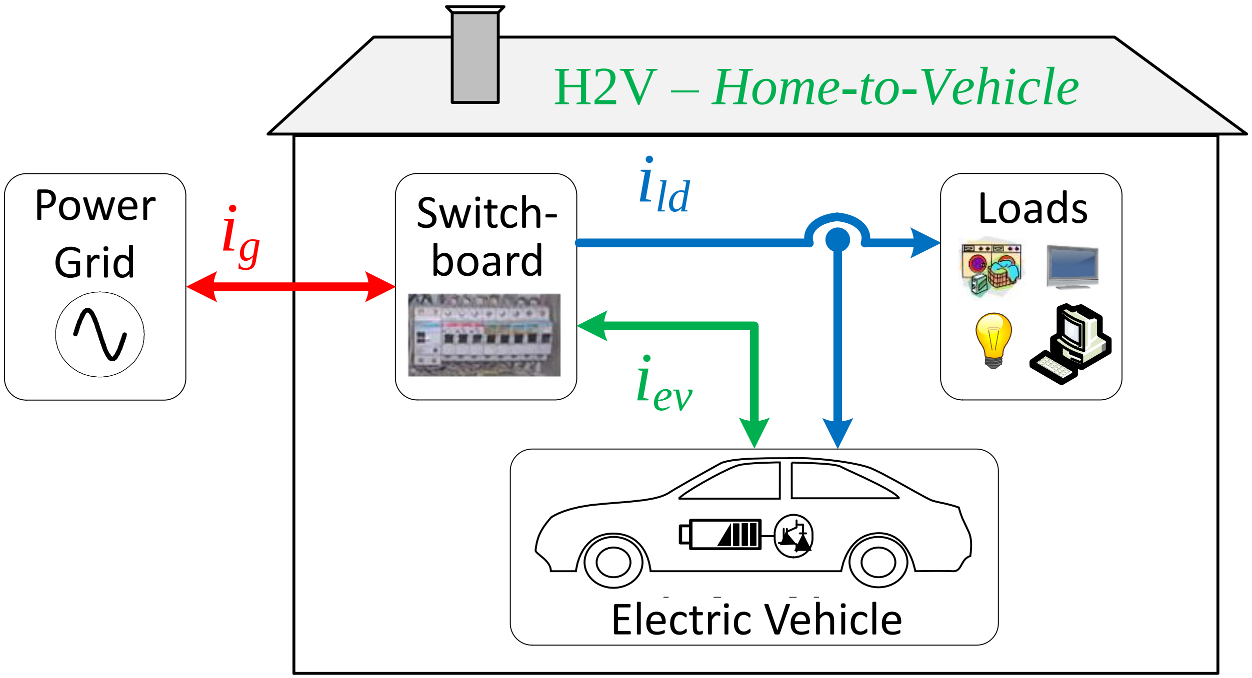
Experimental results during the H2V combined with G2V:
grid current (I_G: 5 A/div); loads current (I_{LD}: 5 A/div); EV current (I_{EV}: 5 A/div).

Experimental results of the operation mode **H2V** (combined with G2V).



This figure shows the instantaneous values of the same variables (as presented in the previous figure) in order to highlight the adjustment of the EV current.

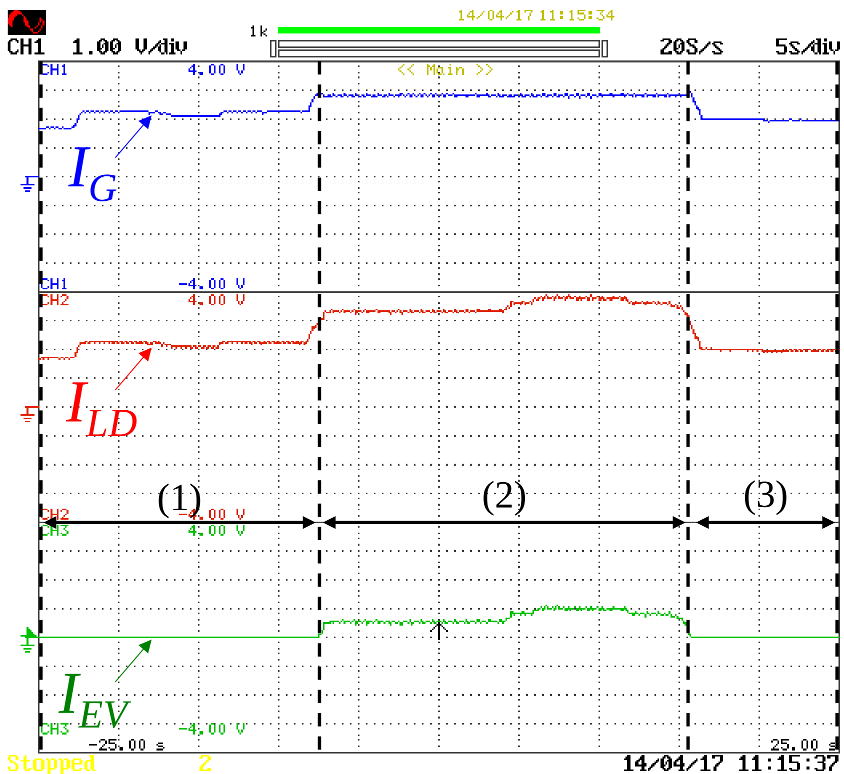
Operation Mode *Home-to-Vehicle* (H2G) (combined with V2G).



The RMS value of the EV current adjusted in function of the RMS of the loads.

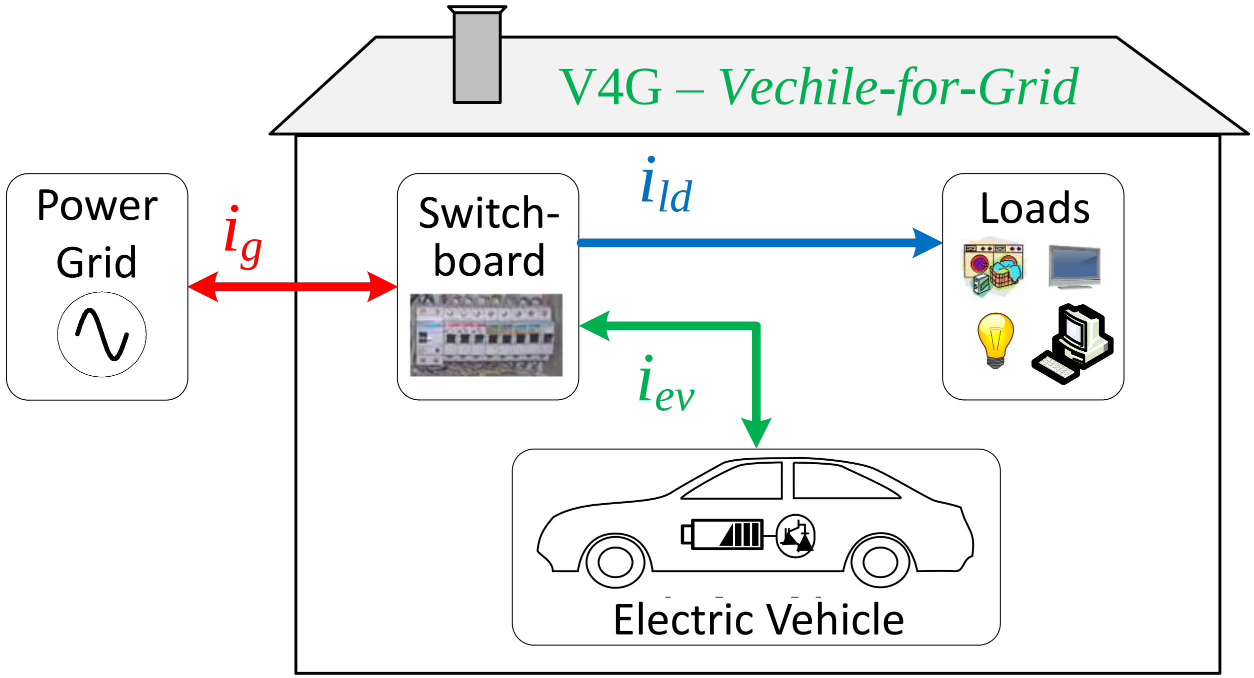
Battery discharging with constant current.

Experimental results of the operation mode **H2V** (combined with V2G).



Experimental results during the H2V combined with V2G:
grid current (I_G: 5 A/div); loads current (I_{LD}: 5 A/div); EV current (I_{EV}: 5 A/div).

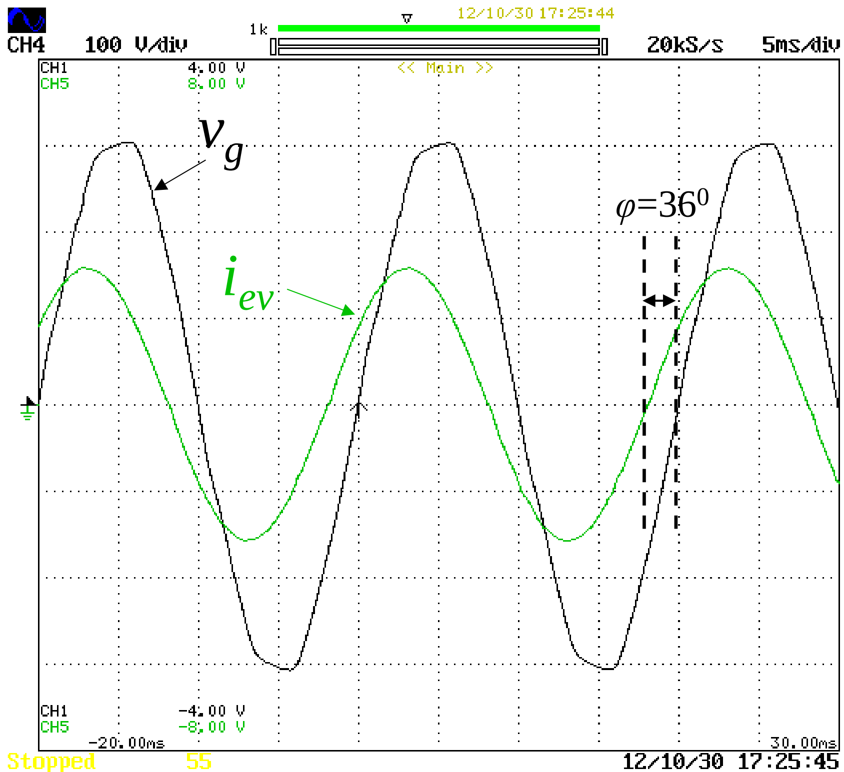
Operation Mode ***Vehicle-for-Grid*** **(V4G)** (reactive power).



EV operating with active and reactive power.

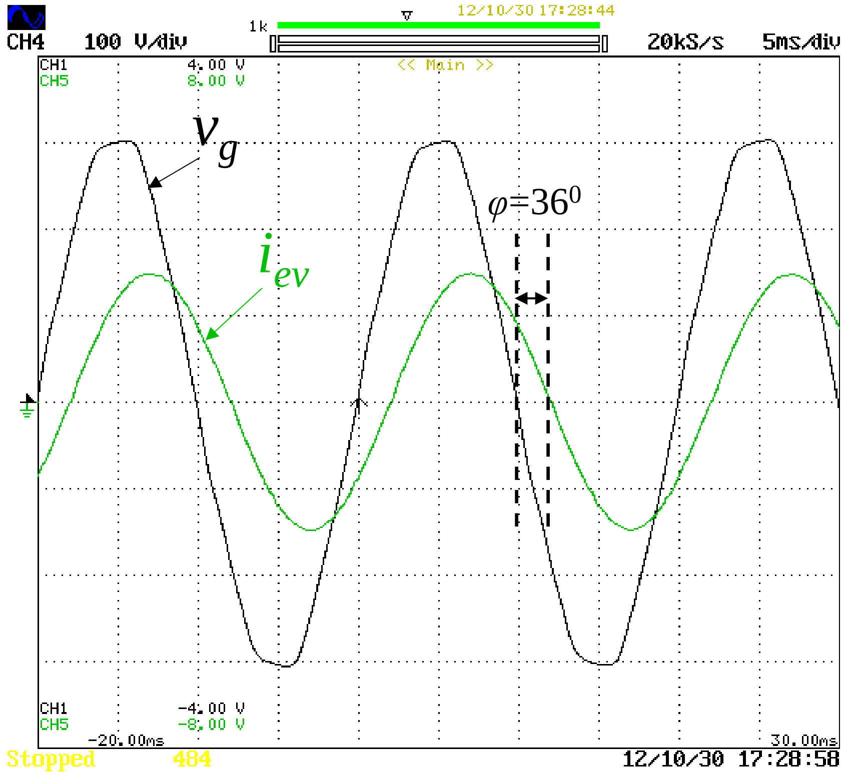
Battery charging or discharging with constant current or constant voltage.

Experimental results of the operation mode **V4G** producing reactive power.



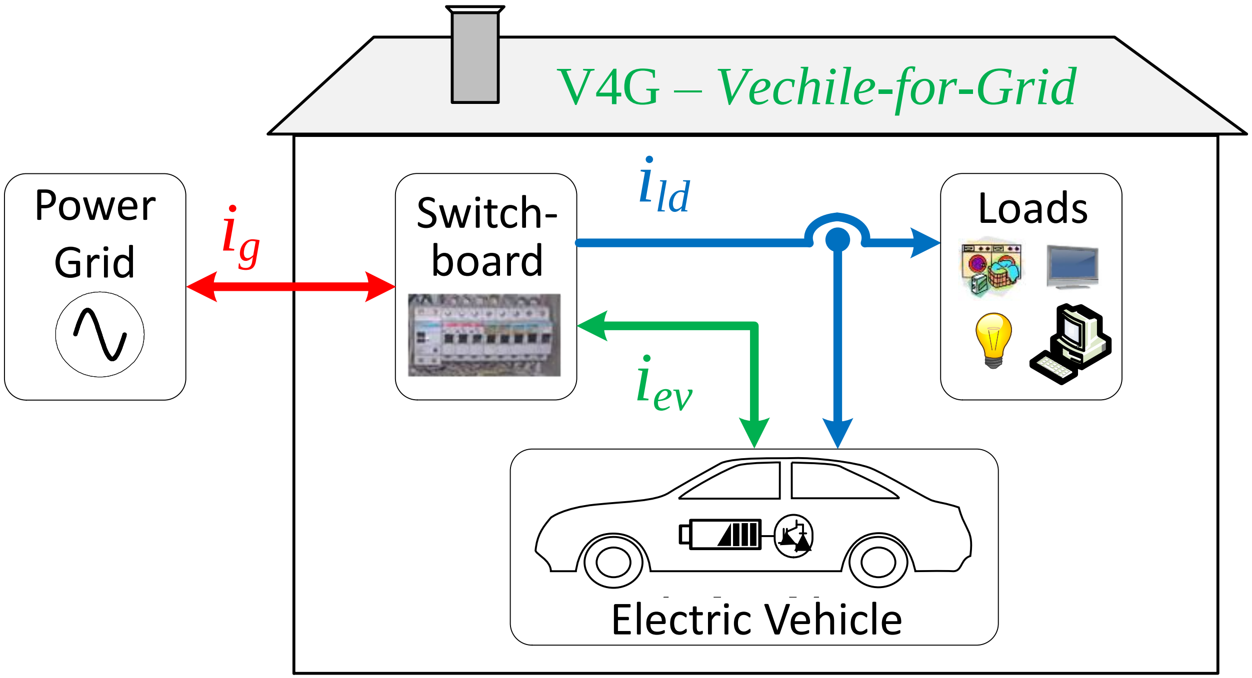
Experimental results during the V4G mode producing reactive power (capacitive): power grid voltage (v_g: 100 V/div); EV current (i_{ev}: 5 A/div).

Experimental results of the operation mode V4G producing reactive power.



Experimental results during the V4G mode producing reactive power (inductive): power grid voltage (v_g: 100 V/div); EV current (i_{ev}: 5 A/div).

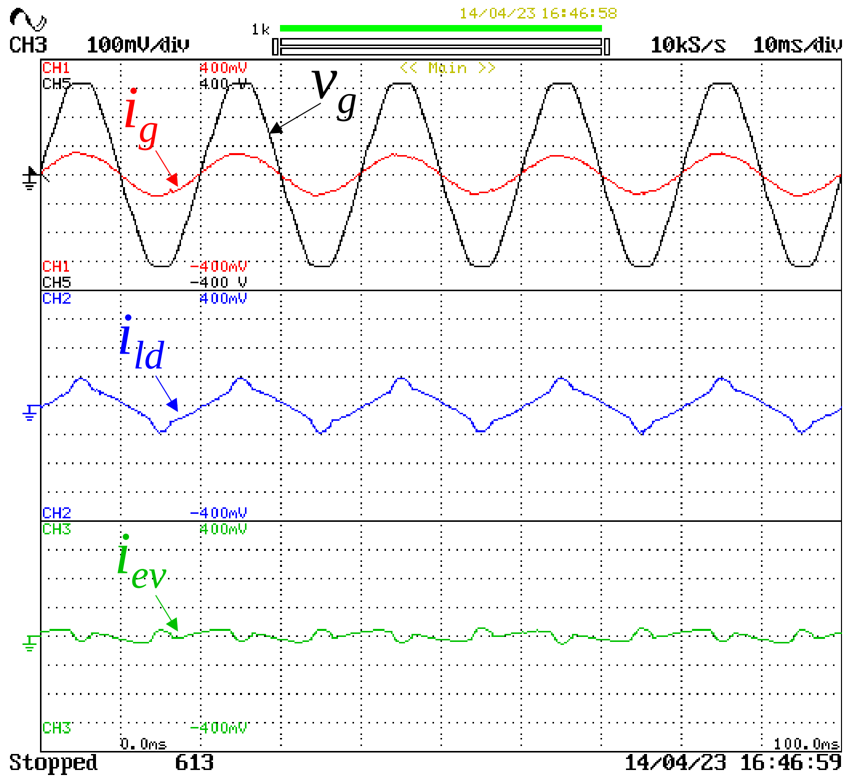
Operation Mode ***Vehicle-for-Grid* (V4G)** (reactive power and harmonics).



EV operating with active and reactive power and compensation of harmonics.

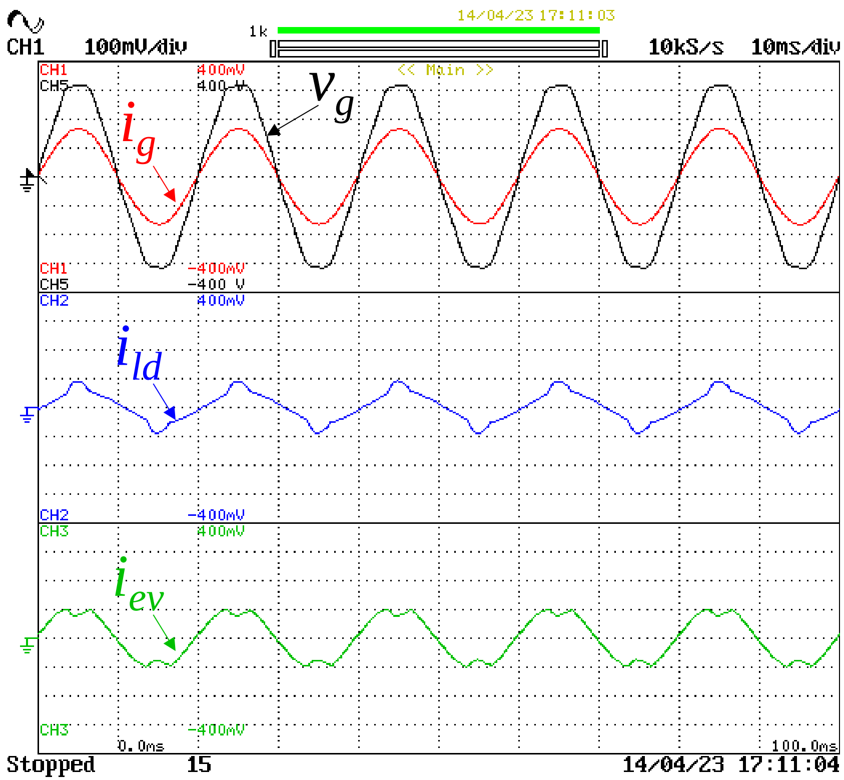
Battery charging or discharging with constant current or constant voltage.

Experimental results of the operation mode **V4G**.



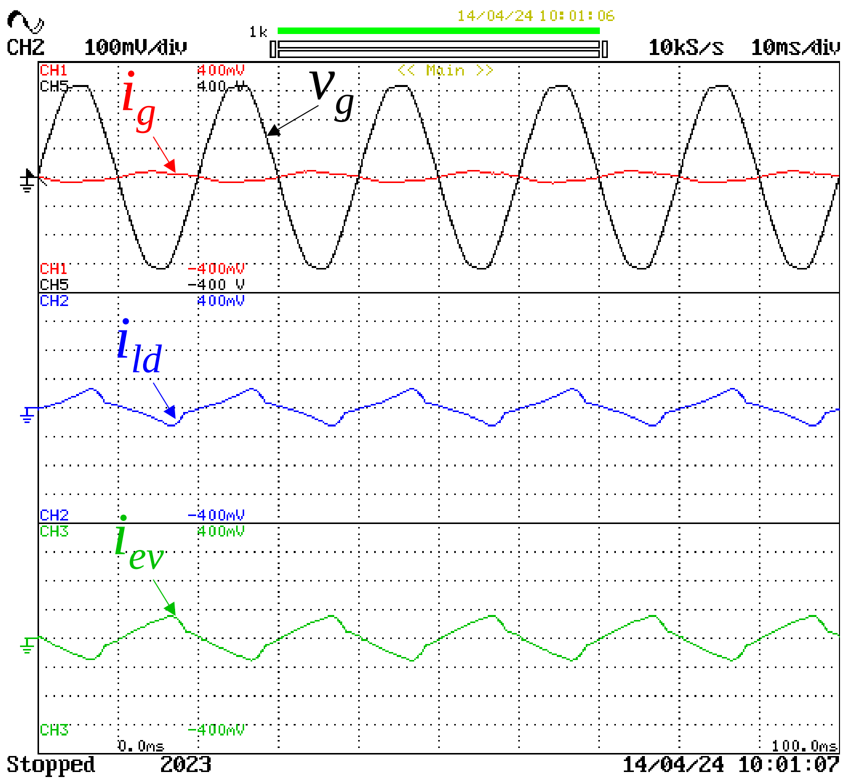
Experimental results in V4G mode only compensating power factor and harmonics: power grid voltage (v_g: 100 V/div); grid current (i_g: 5 A/div); loads current (i_{ld}: 5 A/div); EV current (i_{ev}: 5 A/div).

Experimental results of the operation mode V4G.



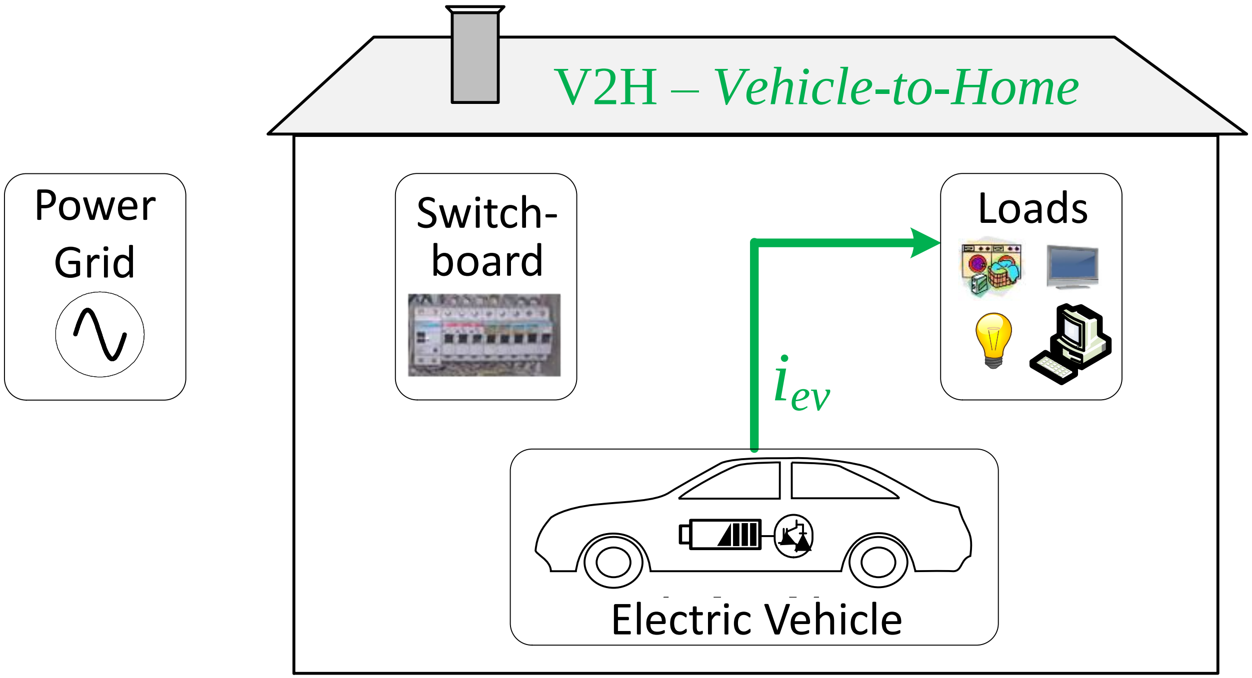
Experimental results in V4G mode compensating power factor and harmonics and with G2V (1 kW): power grid voltage (v_g: 100 V/div); grid current (i_g: 5 A/div); loads current (i_{ld}: 5 A/div); EV current (i_{ev}: 5 A/div).

Experimental results of the operation mode V4G.



Experimental results in V4G mode compensating power factor and harmonics and with V2G (1 kW): power grid voltage (v_g: 100 V/div); grid current (i_g: 5 A/div); loads current (i_{ld}: 5 A/div); EV current (i_{ev}: 5 A/div).

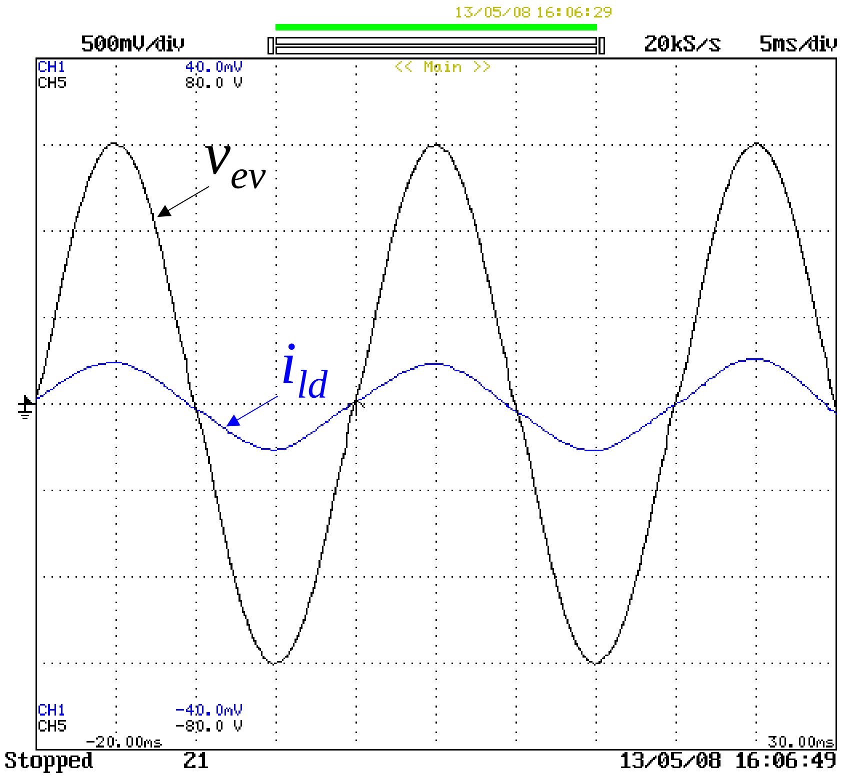
Operation Mode *Vehicle-to-Home* (V2H).



Voltage produced by the EV.

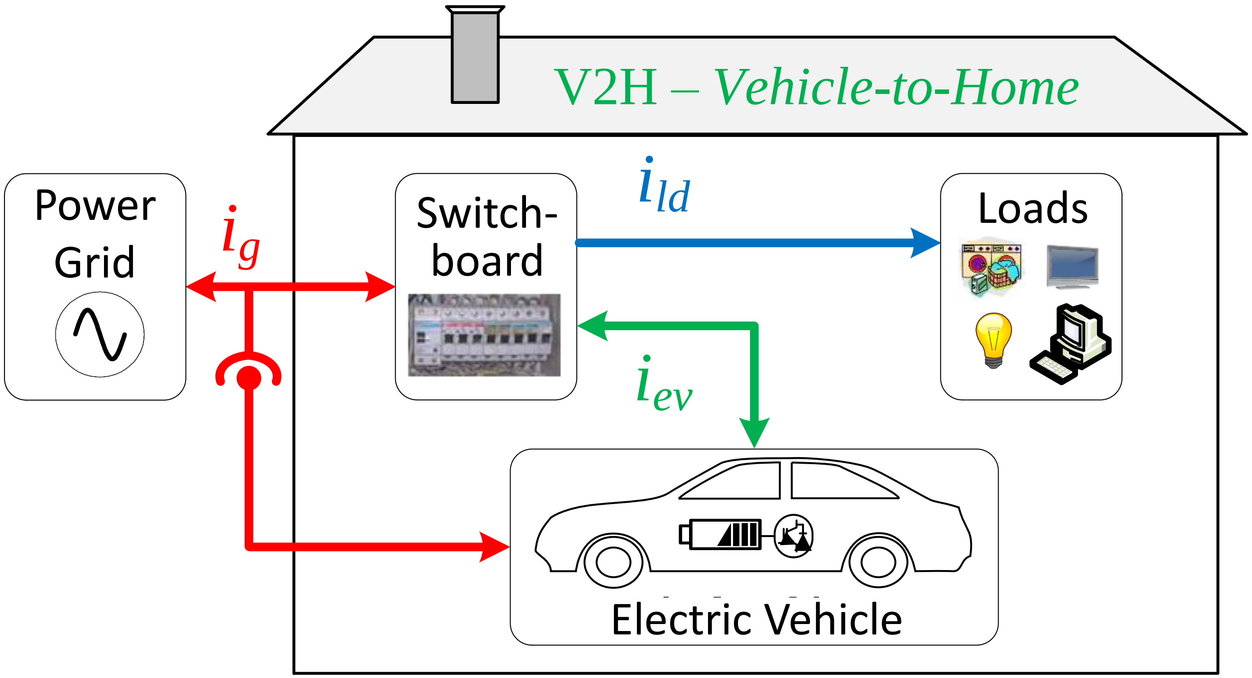
Battery discharging with variable current.

Experimental results of the operation mode H2V.



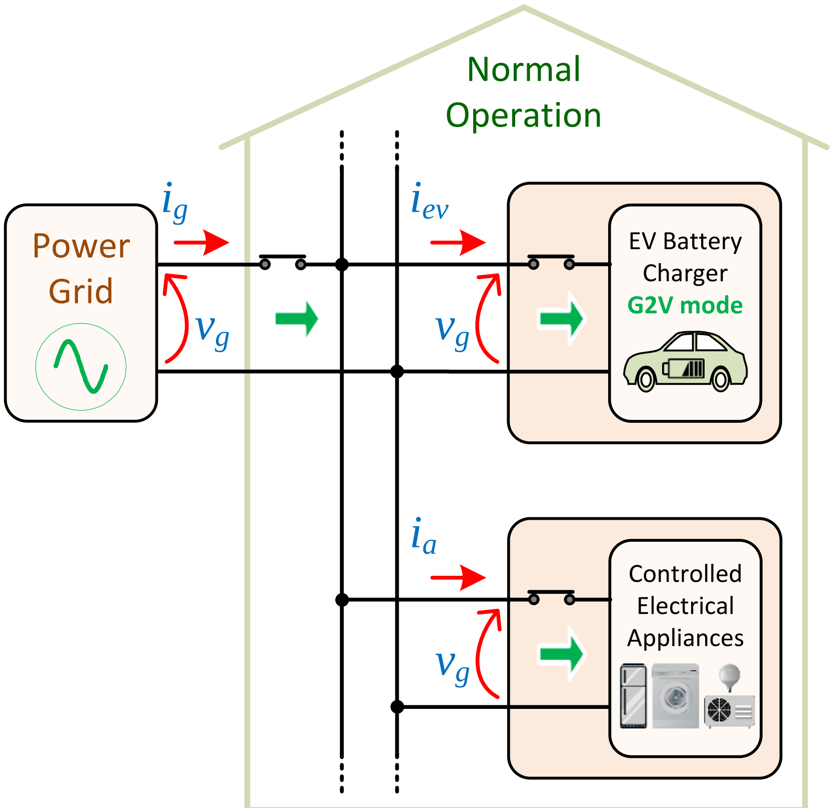
Experimental results during the V2H mode operating as na isolated grid: voltage produced by the EV (v_{ev}: 100 V/div); loads current (i_{ld}: 5 A/div).

Operation Mode *Vehicle-to-Home* (V2H).



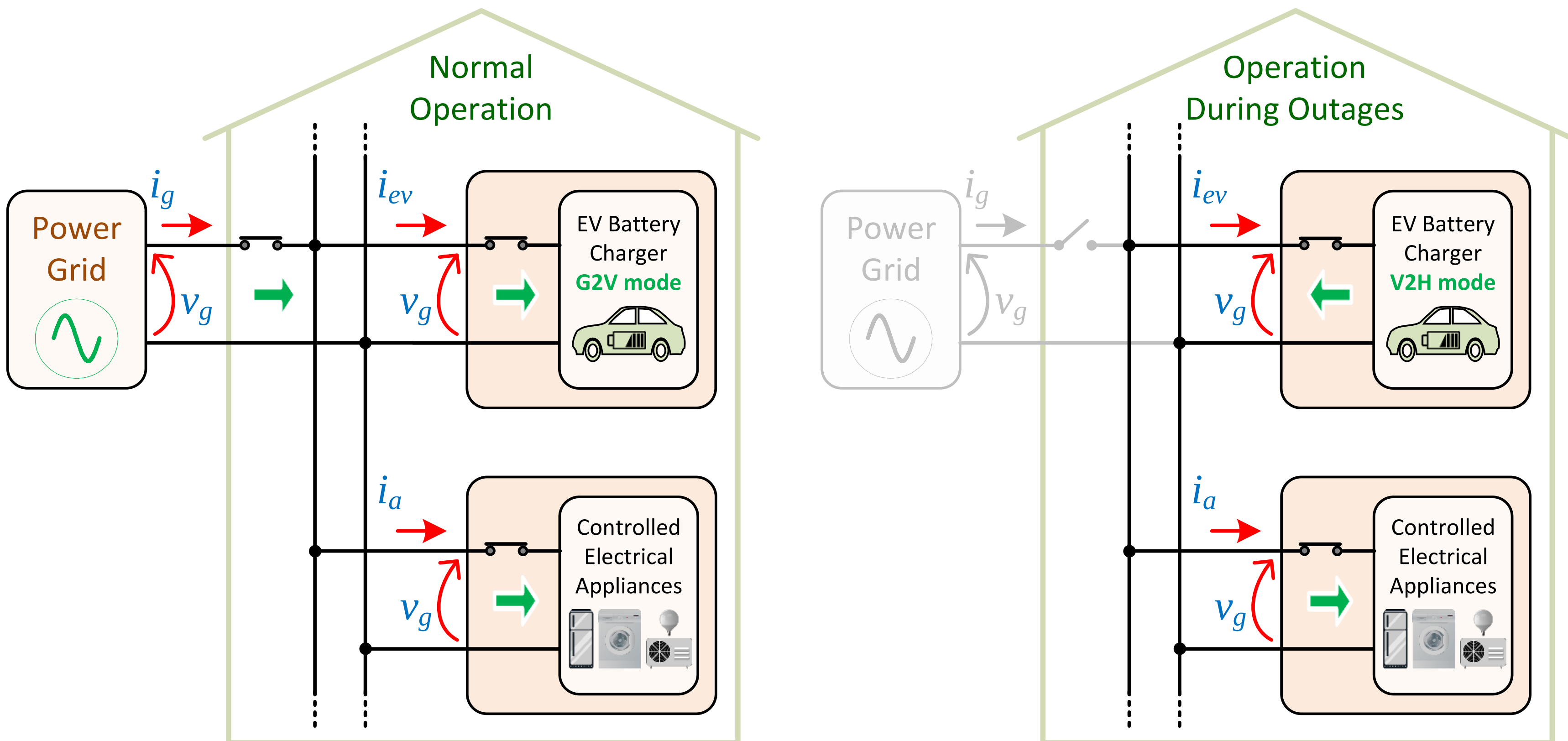
Voltage produced by the EV as an off-line UPS.

Battery discharging with variable current.



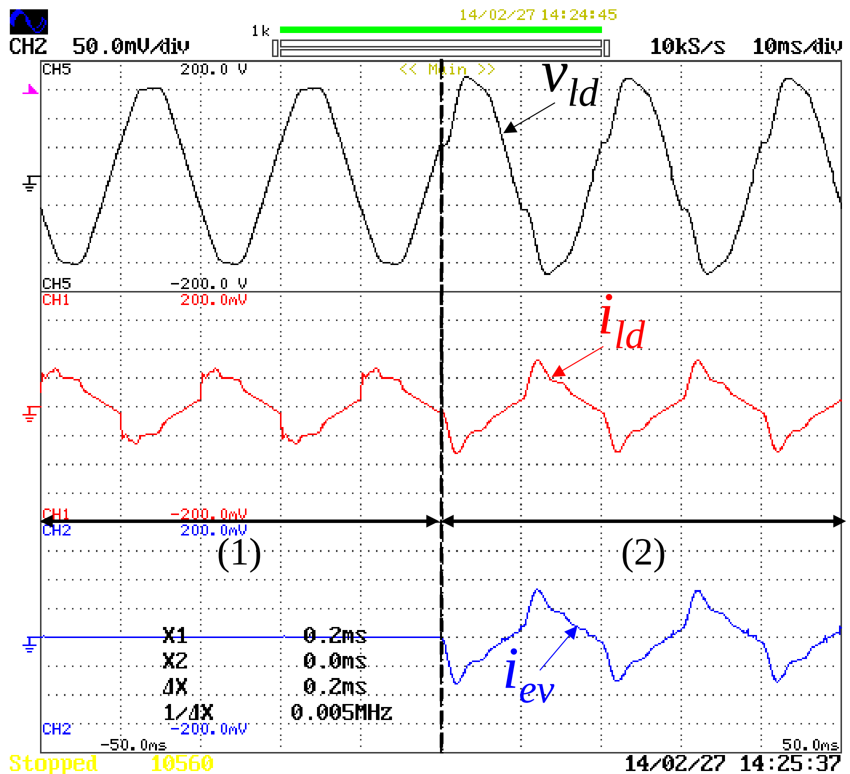
Introduction of the EV charger into a smart home during:

(a) Operation in G2V mode (charging the batteries);



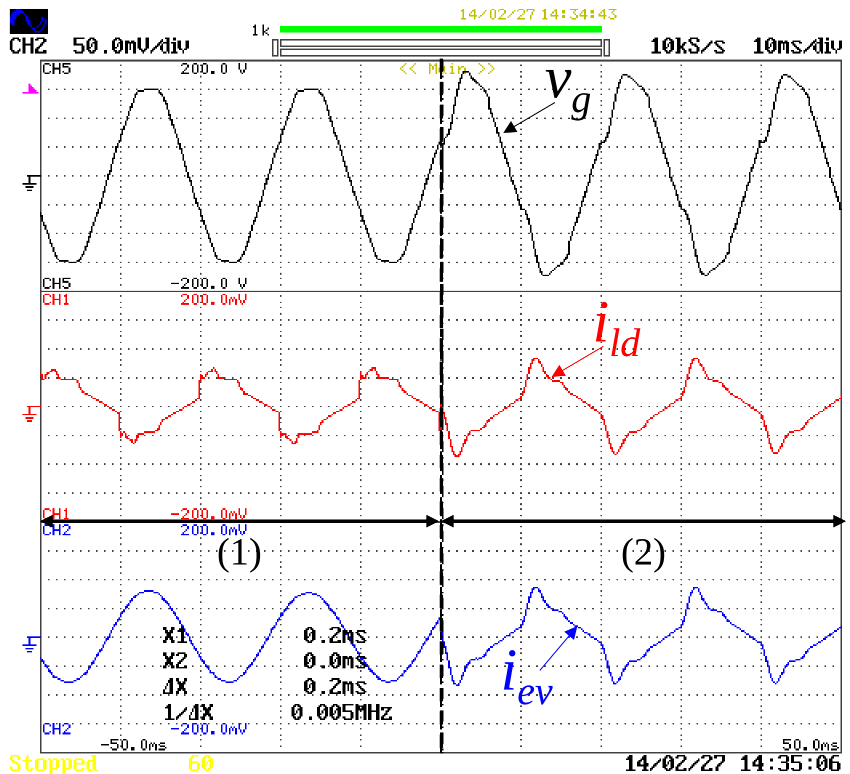
Introduction of the EV charger into a smart home during:
(a) Operation in G2V mode (charging the batteries);
(b) Operation in V2H mode (as an off-line UPS to supply electrical appliances).

Experimental results of the operation mode H2V.



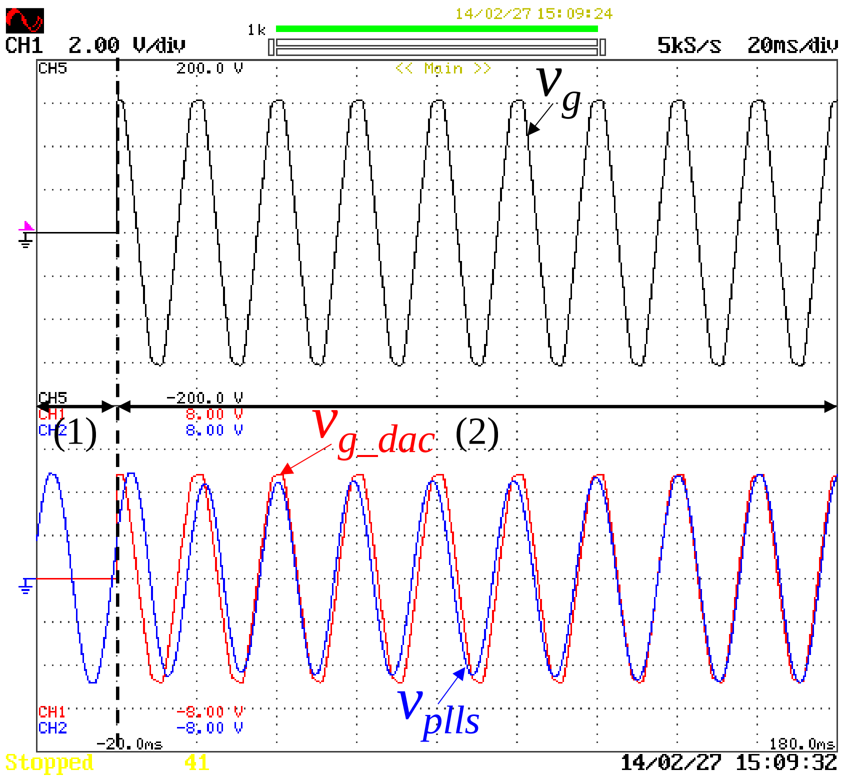
Experimental results during the V2H mode as UPS:
voltage in the loads (v_{ld}: 100 V/div); current in the loads (i_{ld}: 5 A/div); EV current (i_{ev}: 5 A/div).

Experimental results of the operation mode H2V.



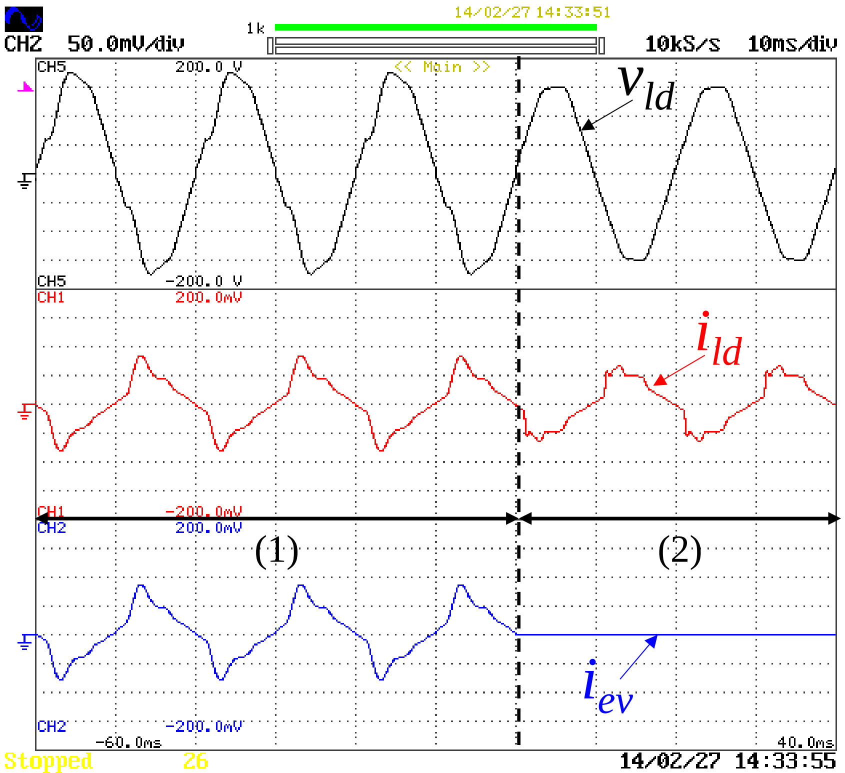
Experimental results during the V2H mode as UPS with G2V:
voltage in the loads (v_{ld}: 100 V/div); current in the loads (i_{ld}: 5 A/div); EV current (i_{ev}: 5 A/div).

Experimental results of the operation mode **H2V**.



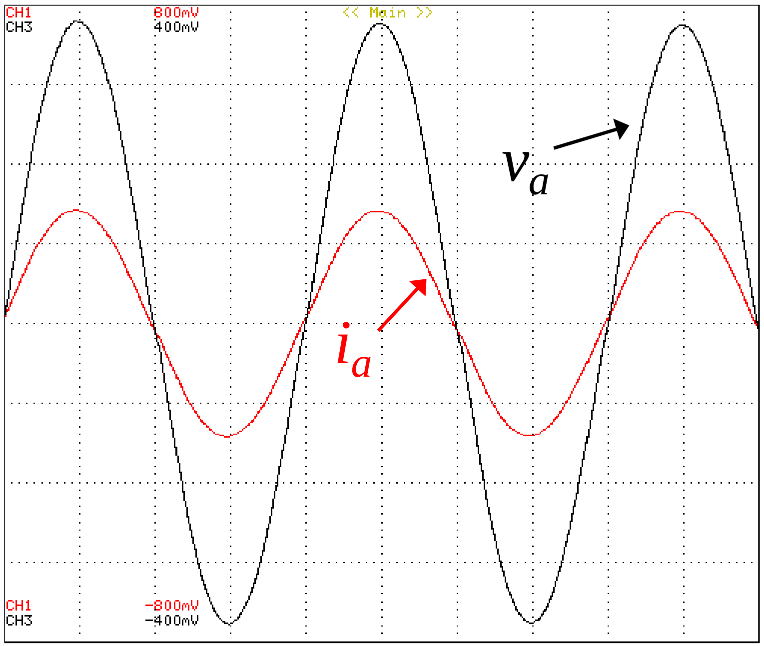
Experimental results during the V2H mode: power grid voltage (v_g: 100 V/div); power grid voltage from DAC (v_{g_dac}); output signal from PLL (v_{plls}).

Experimental results of the operation mode H2V.

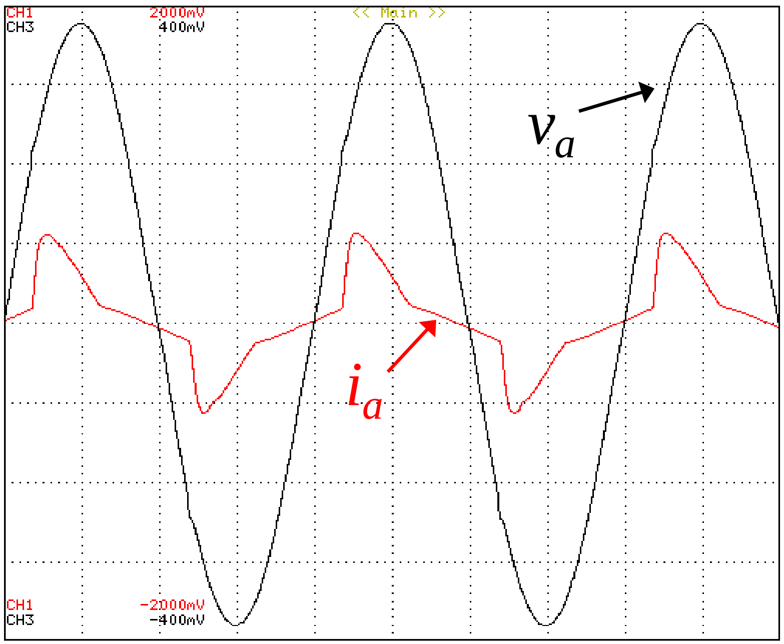


Experimental results during the V2H mode as UPS with G2V:
voltage in the loads (v_{ld}: 100 V/div); current in the loads (i_{ld}: 5 A/div); EV current (i_{ev}: 5 A/div).

Experimental results of the operation mode H2V.



(a)



(b)

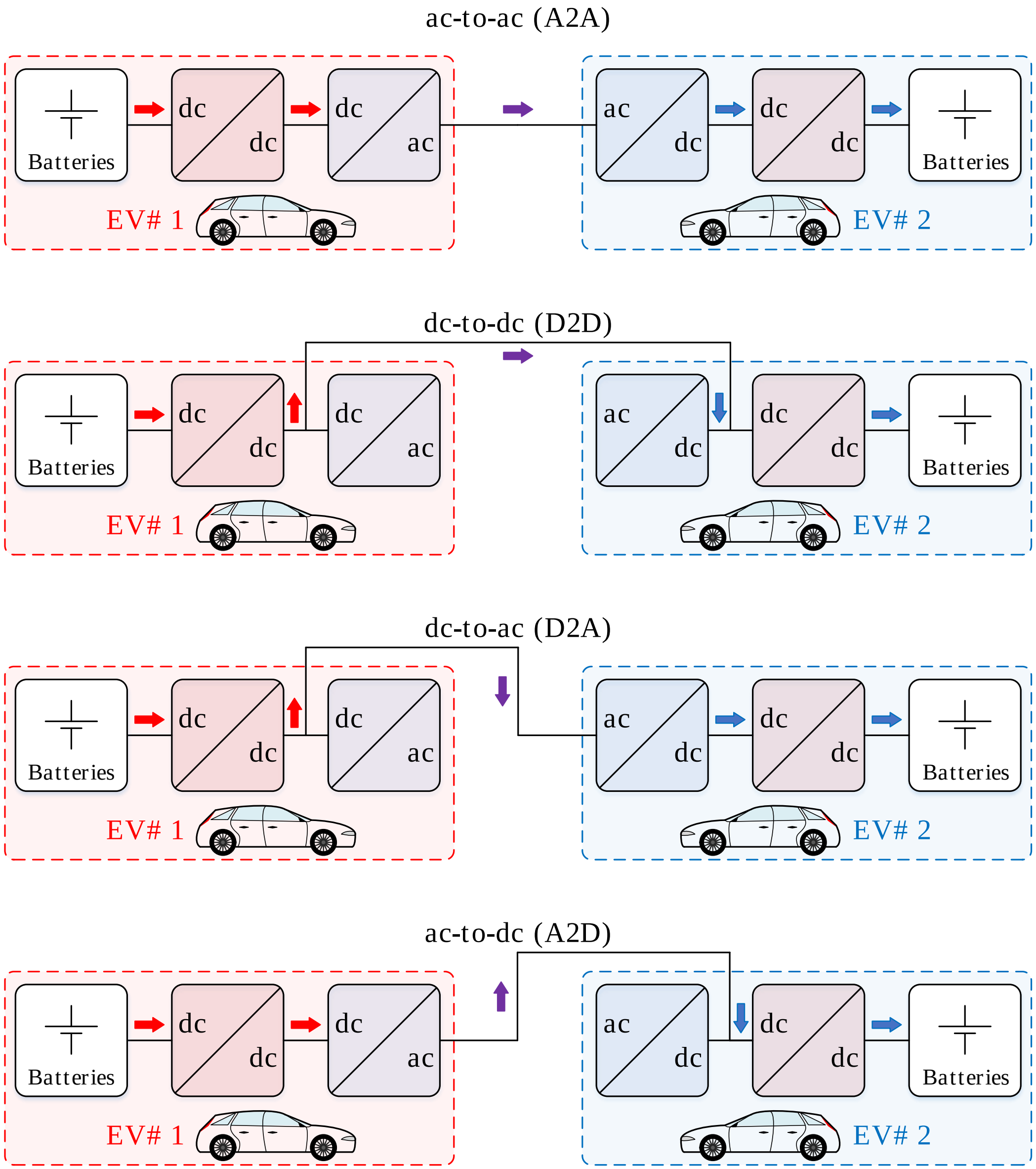
Experimental results of the produced voltage (v_a) and consumed current (i_a) during the V2H mode considering: (a) linear; and (b) nonlinear loads.

section #4

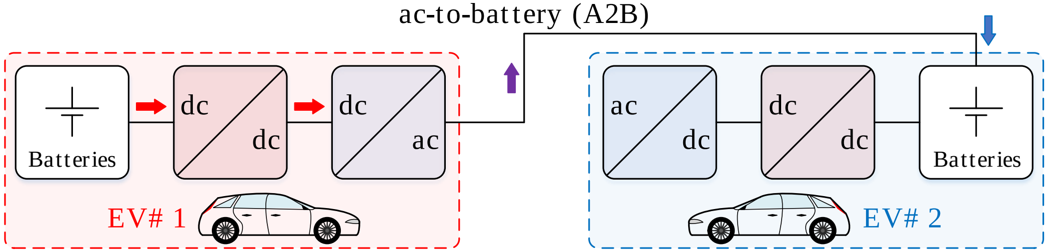
Power Electronics for Vehicle-to-Vehicle (V2V) Interface

- The **vehicle-to-vehicle (V2V)** designation is strongly associated to communication systems, but it can be also be considered for **power transfer between EV batteries**.
- A typical on-board EV battery charger contains a **front-end ac-dc converter** for the power grid interface and a **back-end dc-dc converter** for the battery interface.
- Hence, in the referred type of **V2V power transfer**, four power conversion stages are performed from one EV battery to the other.

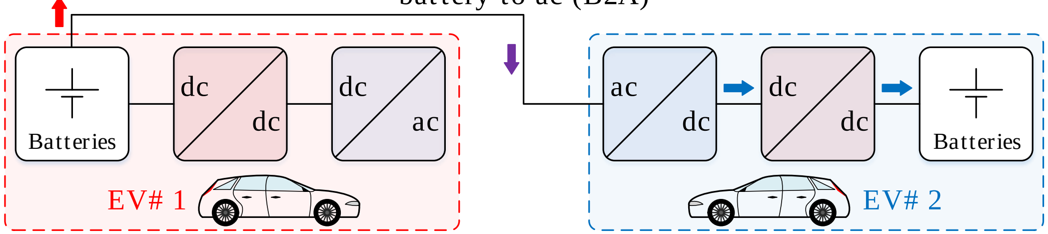
Tiago J. C. Sousa, Luís Machado, Delfim Pedrosa, C. Martins, Vítor Monteiro, João L. Afonso, "***Comparative Analysis of Vehicle-to-Vehicle (V2V) Power Transfer Configurations without Additional Power Converters***", IEEE CPE-POWERENG 2020, Setúbal, Portugal, July 2020, pp.88-93


ac-to-ac (A2A)
Batteries
dc
dc
dc
ac
ac
dc
dc
dc
Batteries
EV# 1
EV# 2
dc-to-dc (D2D)
Batteries
dc
dc
dc
ac
ac
dc
dc
dc
Batteries
EV# 1
EV# 2
dc-to-ac (D2A)
Batteries
dc
dc
dc
ac
ac
dc
dc
dc
Batteries
EV# 1
EV# 2
ac-to-dc (A2D)
Batteries
dc
dc
dc
ac
ac
dc
dc
dc
Batteries
EV# 1
EV# 2

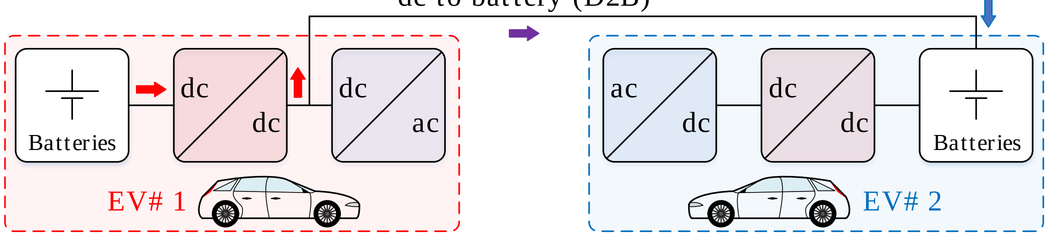
ac-to-battery (A2B)



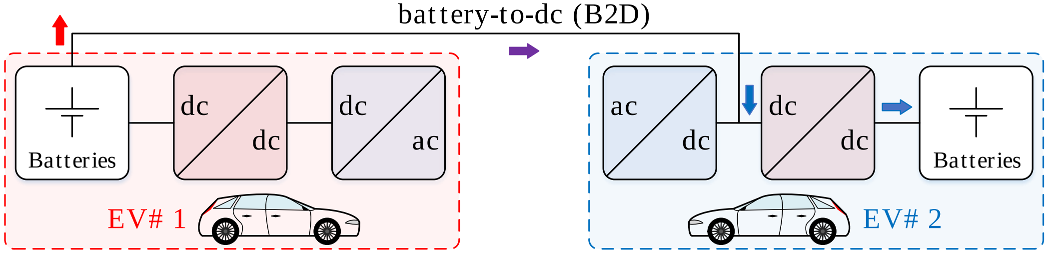
battery-to-ac (B2A)



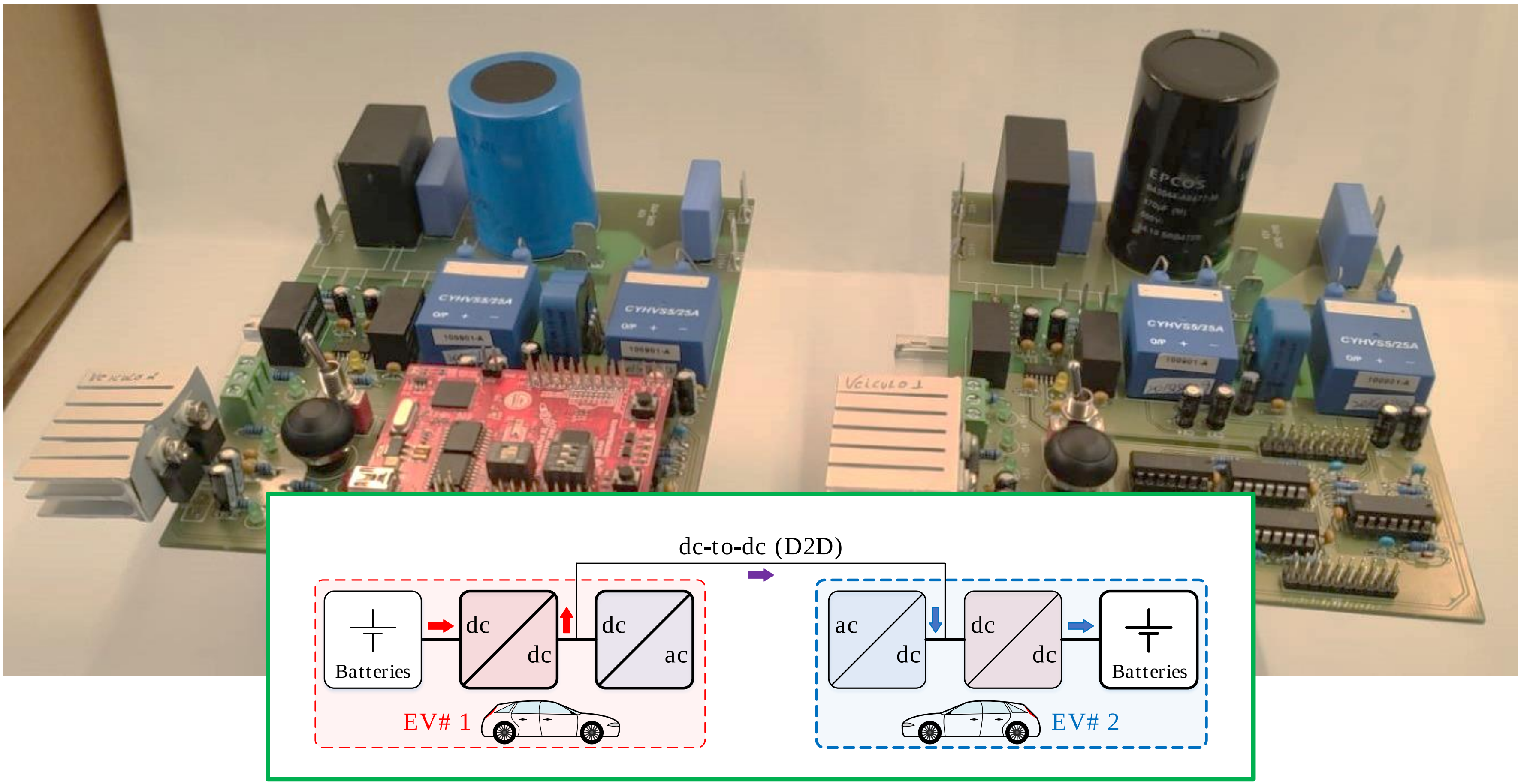
dc-to-battery (D2B)



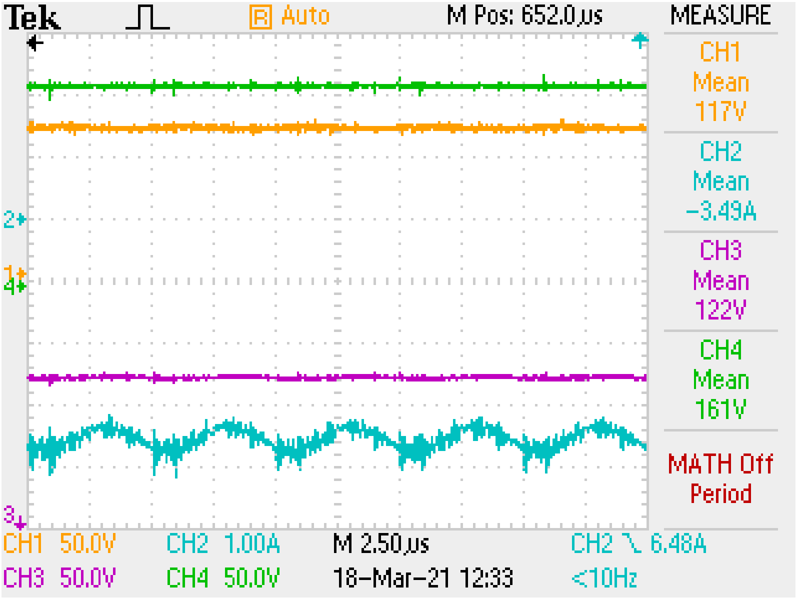
battery-to-dc (B2D)



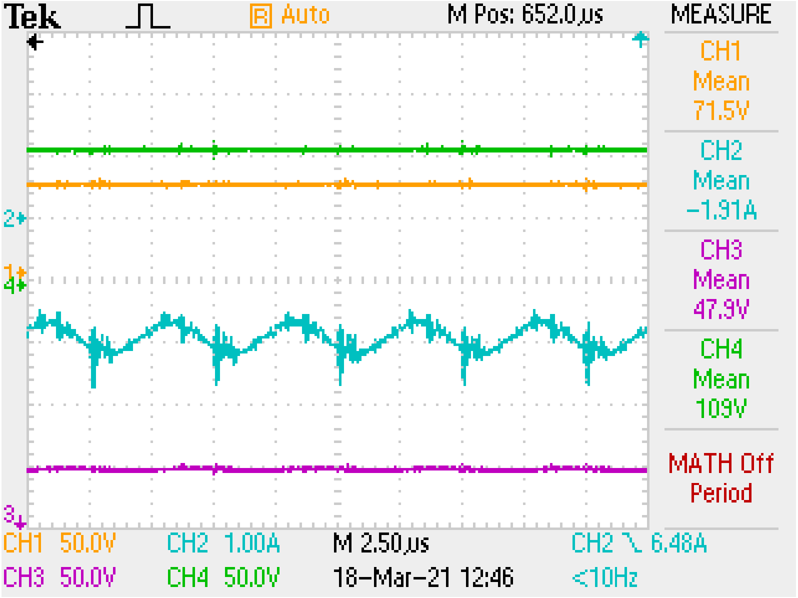
Developed prototypes based on DC-DC converters for validating the V2V mode



Experimental results of the DC-DC converters for validating the V2V mode



(a)



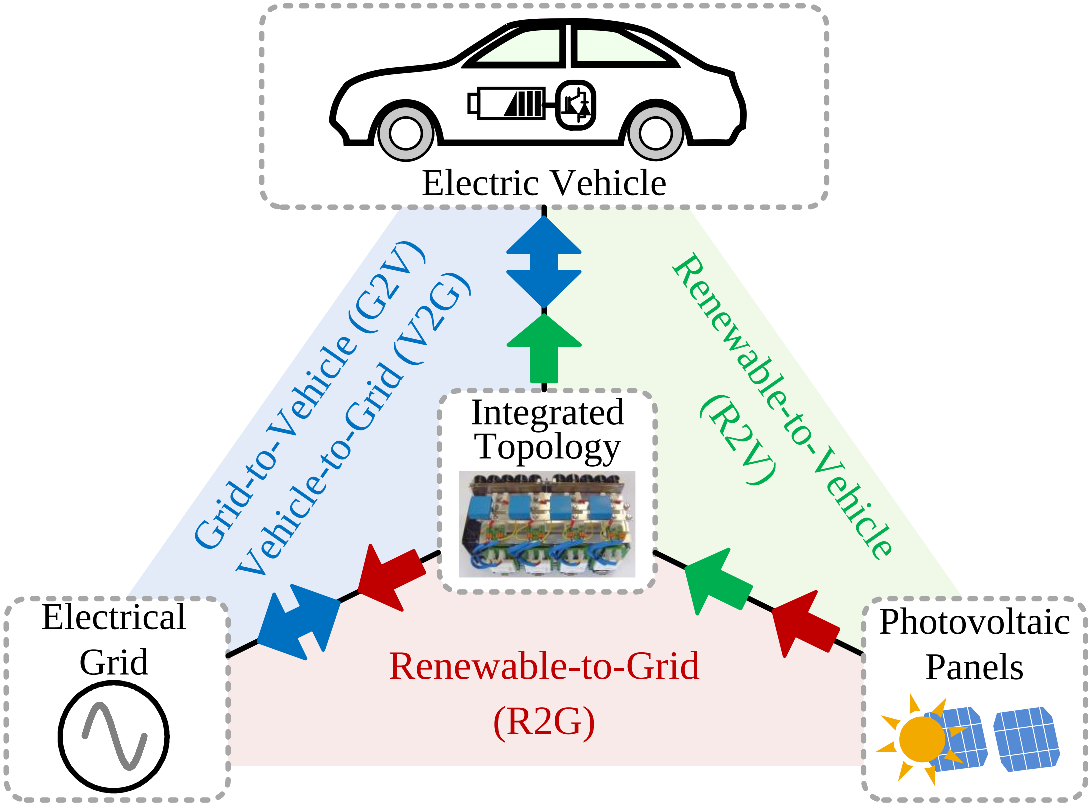
(b)

Output voltage in the converter (CH1: 50 V/div), DC-link current (CH2: 5 A/div), input voltage in the converter (CH3: 50 V/div) and DC-link voltage (CH4: 50 V/div): (a) with $V_{bat1} > V_{bat2}$; (b) $V_{bat2} > V_{bat1}$.

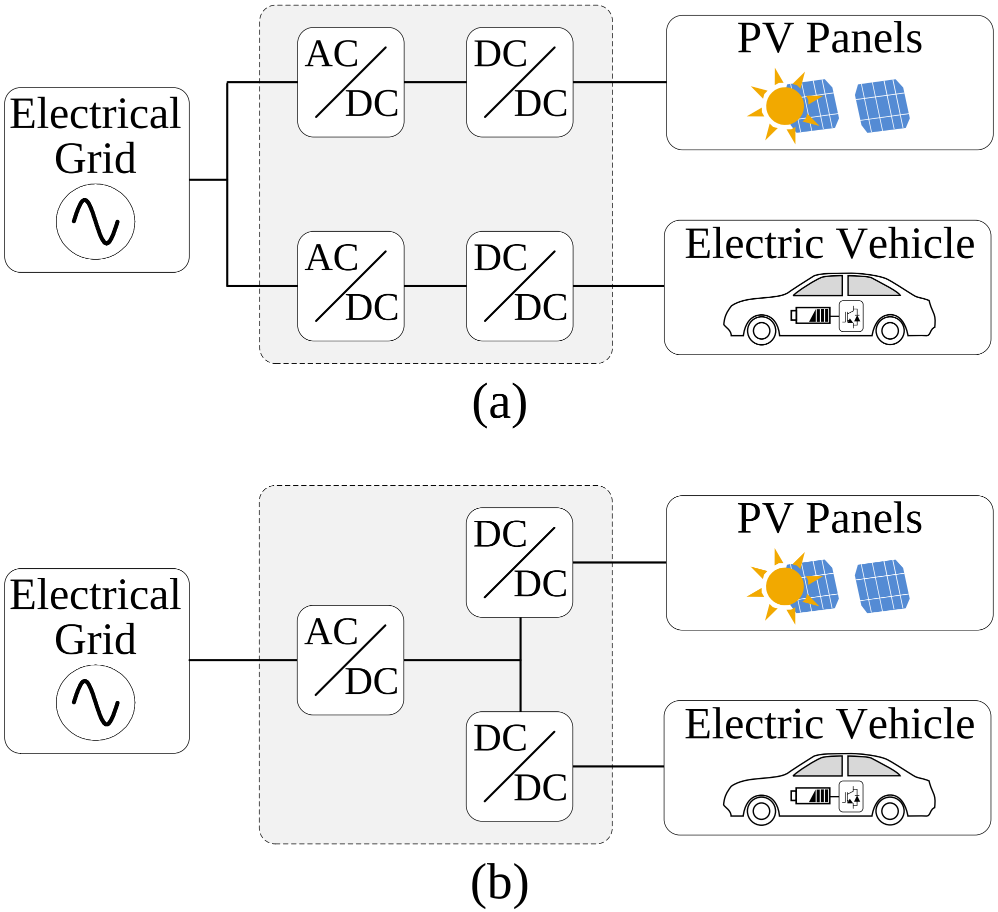
section #5

Power Electronics for Interfacing EVs and Renewables

Interface between an EV and PV panels with the electrical grid.

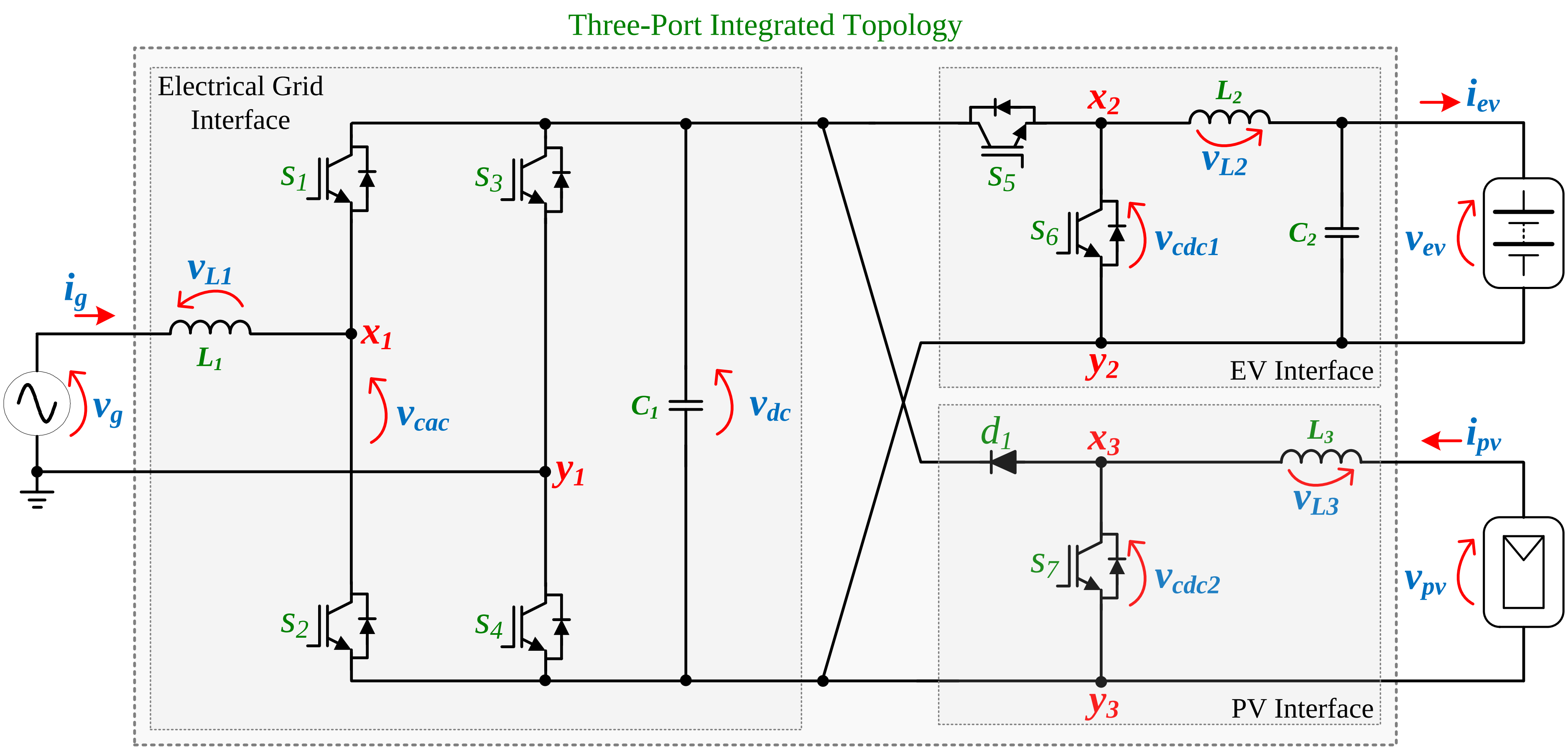


Vítor Monteiro, J. G. Pinto, João L. Afonso, "***Experimental Validation of a Three-Port Integrated Topology to Interface Electric Vehicles and Renewables with the Electrical Grid***", IEEE Transactions on Industrial Informatics, vol.14, no.6, pp.2364-2374, June 2018.

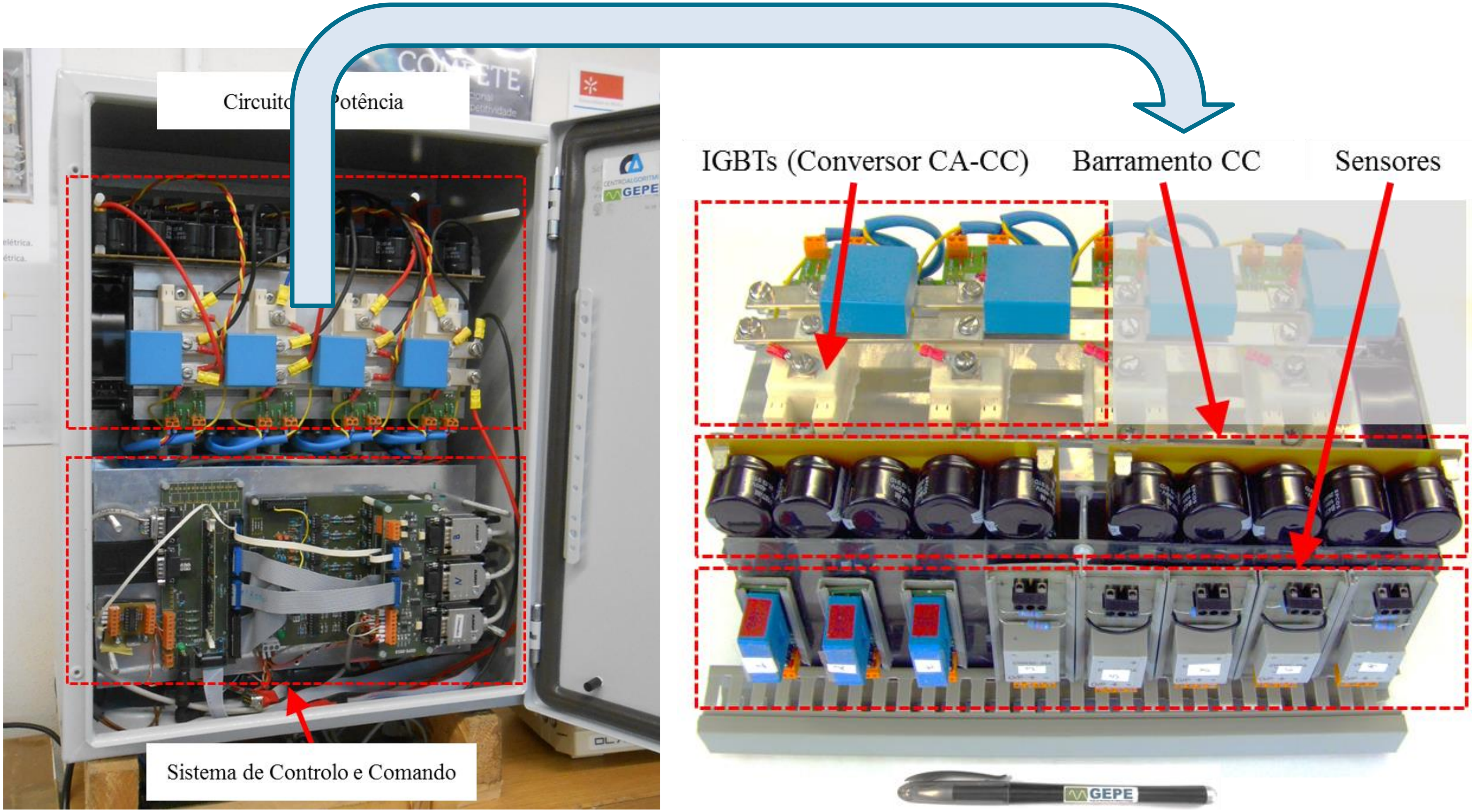


Interface between an EV and PV panels with the electrical grid:
(a) Classical topology; (b) Proposed topology.

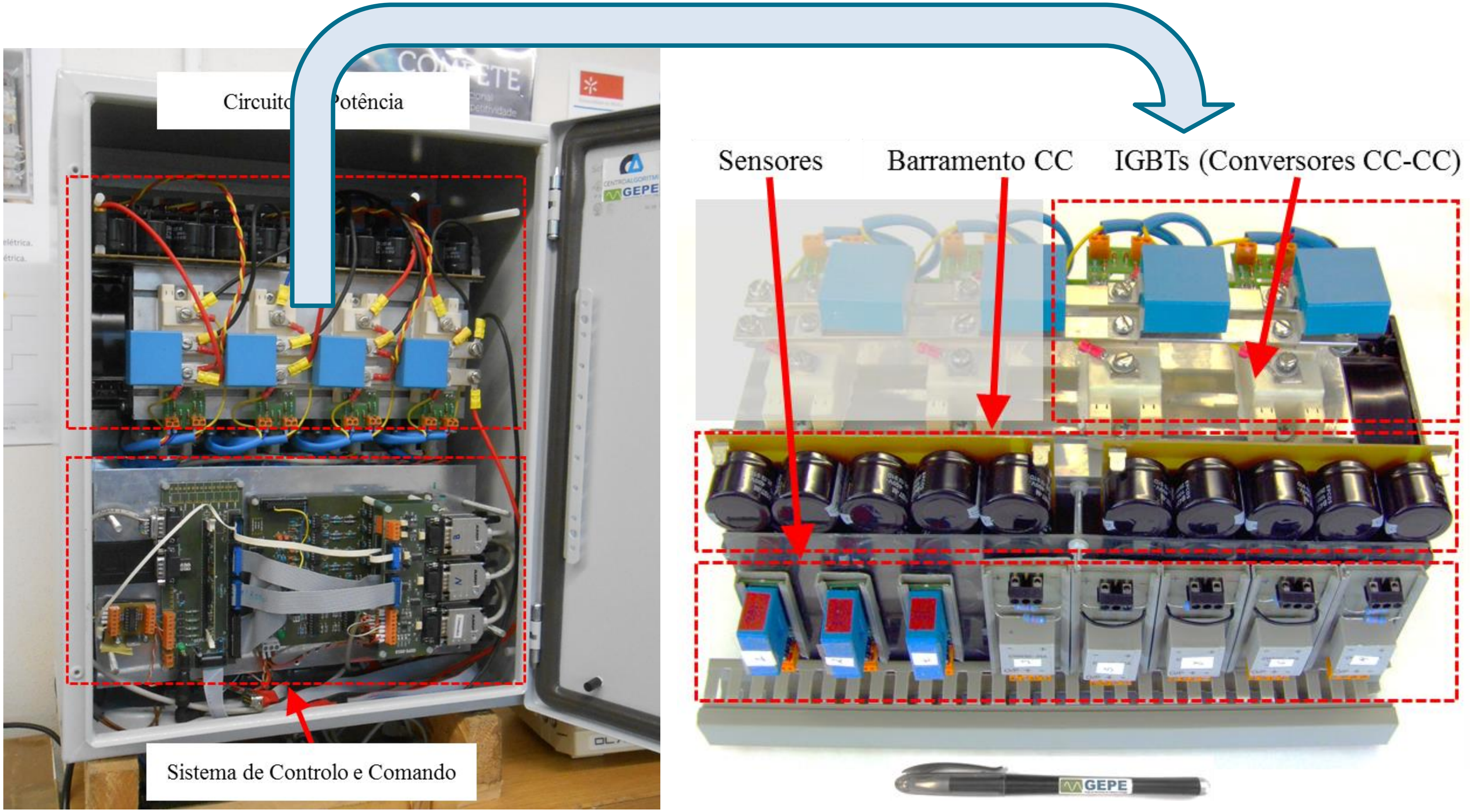
Three-port integrated topology used to interface EVs and renewables with the electrical grid.



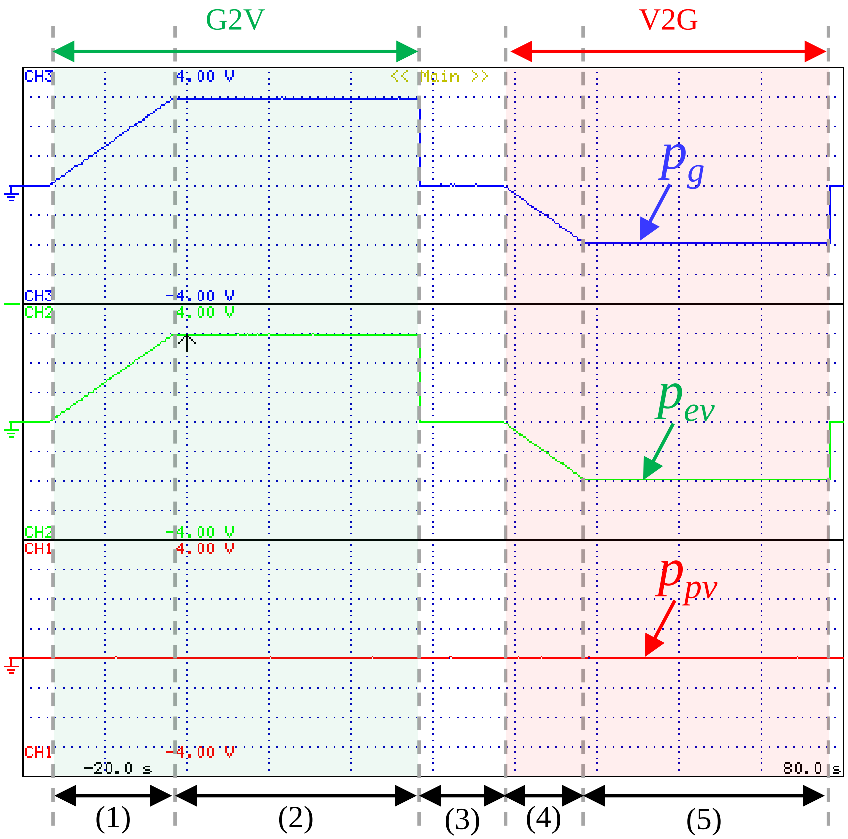
Developed prototype of the three-port integrated topology.



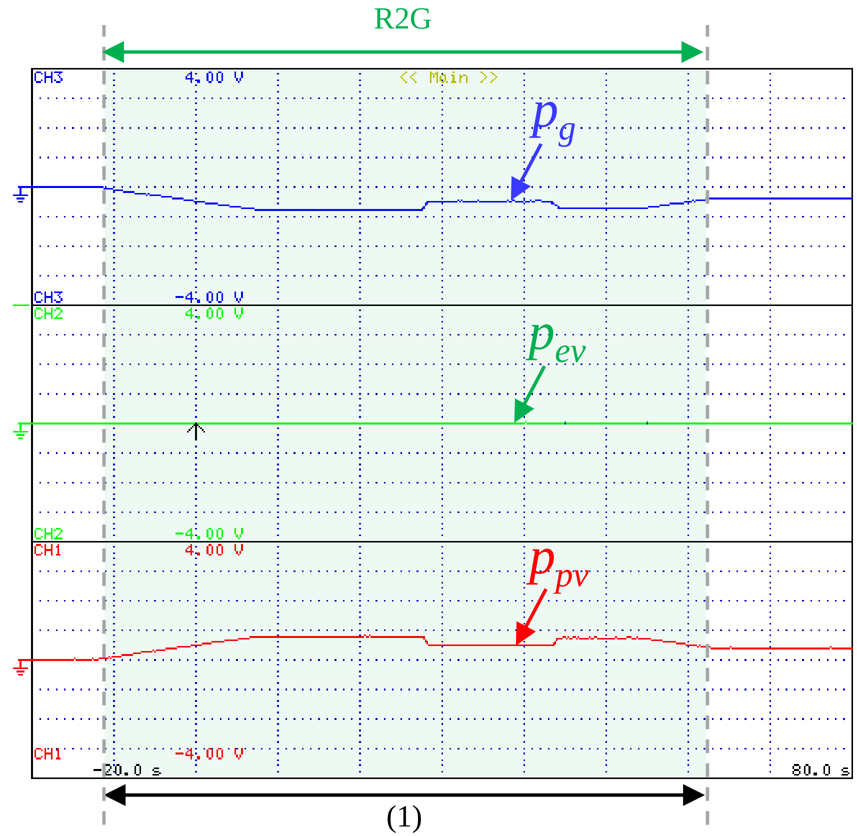
Developed prototype of the three-port integrated topology.



Experimental results of the three-port integrated topology used to interface EVs and renewables with the electrical grid.

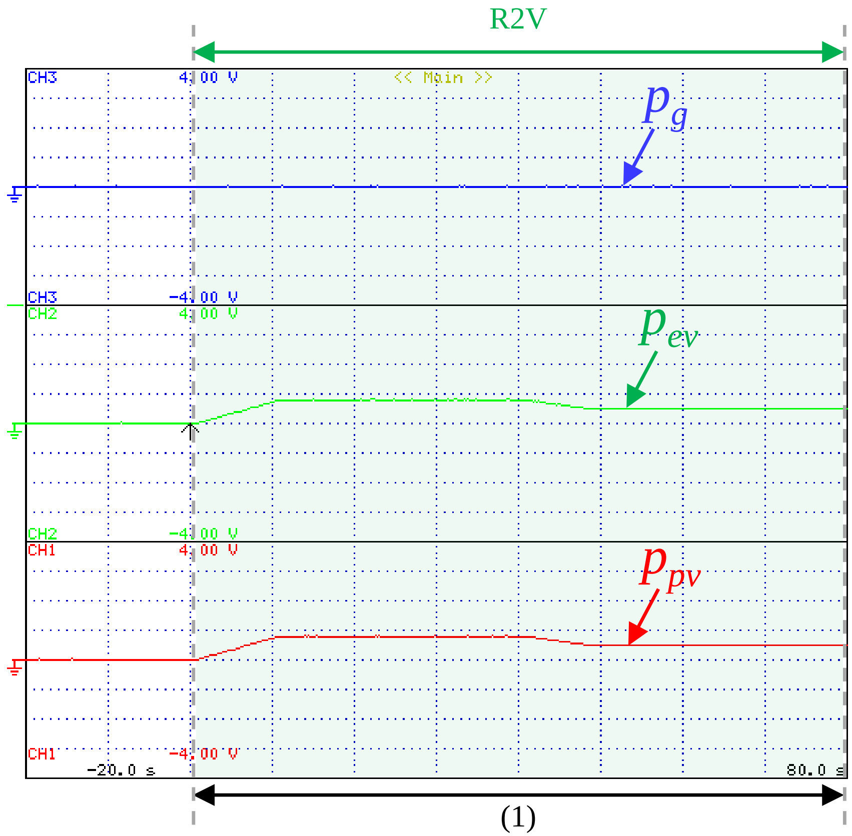


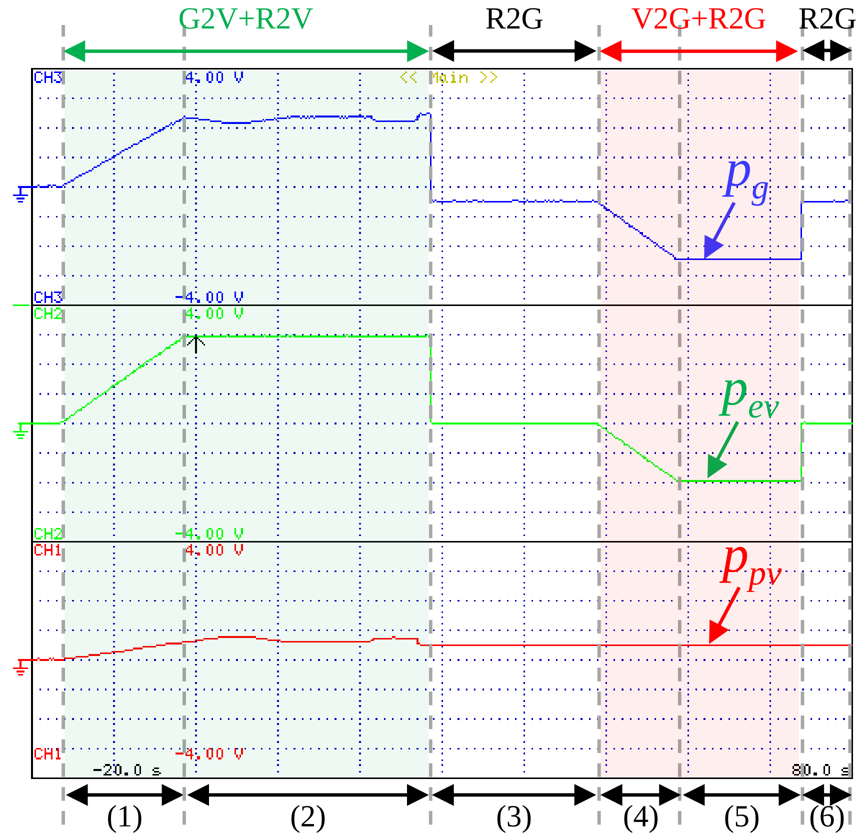
G2V and V2G operation modes:
Grid power (p_g: 1 kW/div); EV power (p_{ev}: 1 kW/div); PV power (p_{pv}: 1 kW/div).



R2G operation mode:
Grid power (p_g: 1 kW/div); EV power (p_{ev}: 1 kW/div); PV power (p_{pv}: 1 kW/div).

Experimental results of the three-port integrated topology used to interface EVs and renewables with the electrical grid.



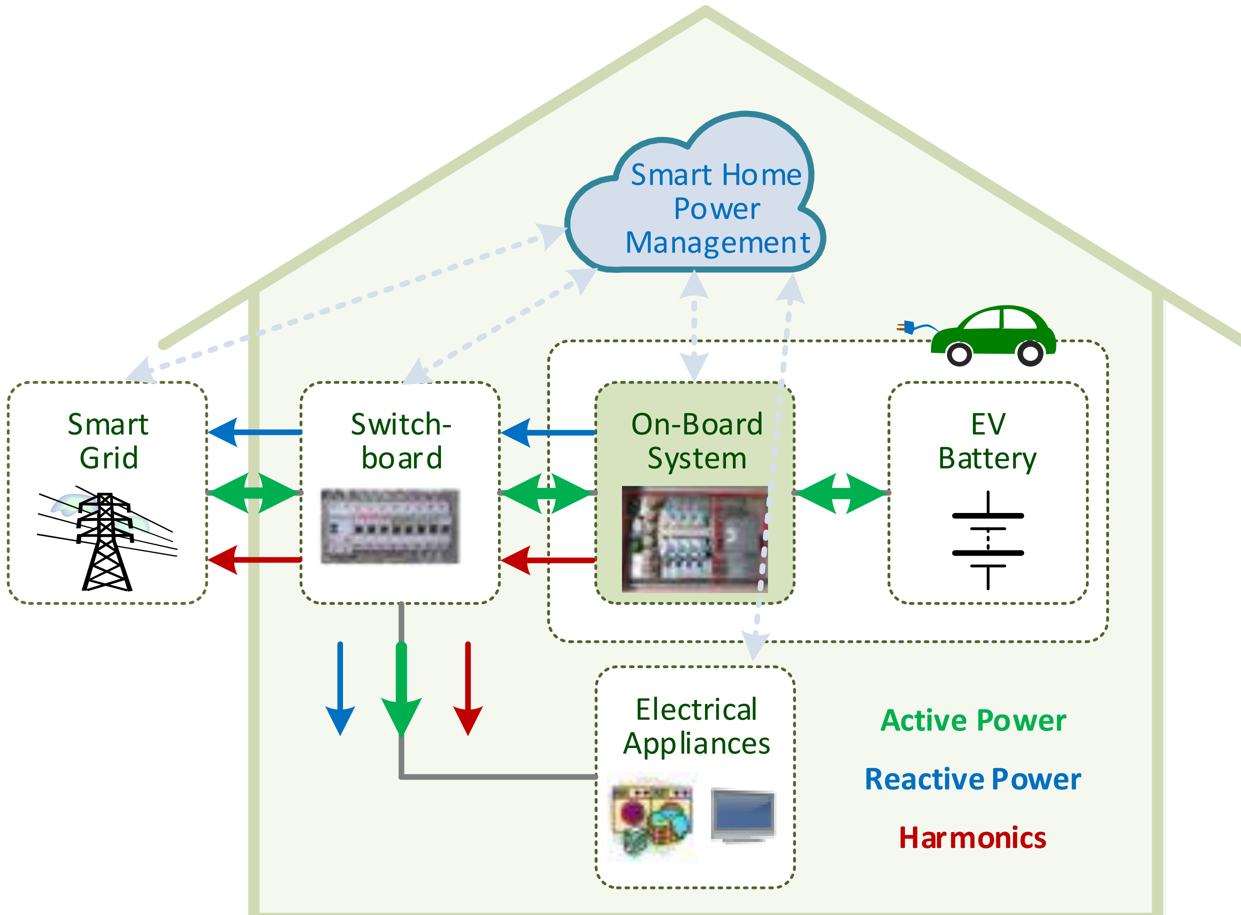


G2V and R2V operation modes: Grid power (p_g: 1 kW/div); EV power (p_{ev}: 1 kW/div); PV power (p_{pv}: 1 kW/div).

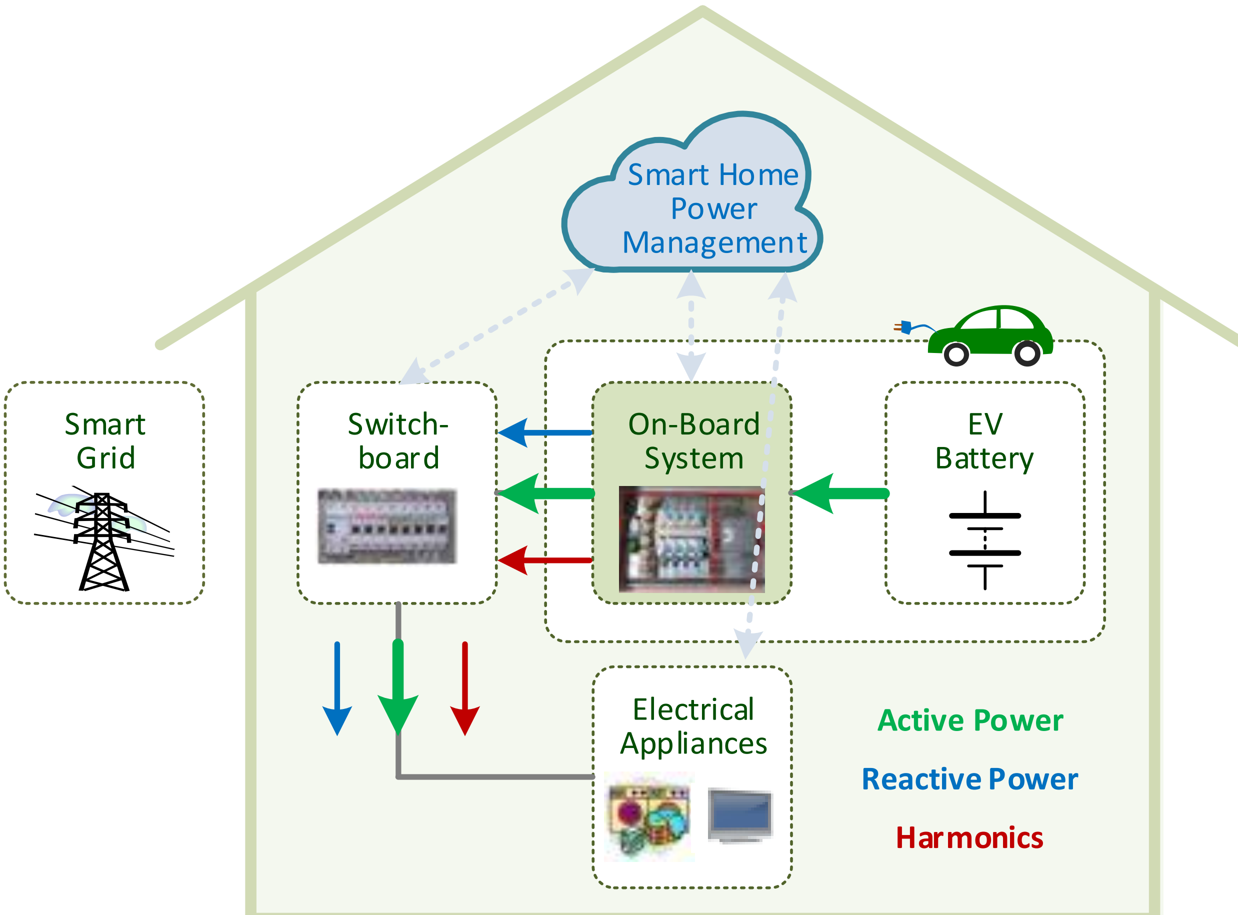
G2V, V2G, R2G and R2V operation modes: Grid power (p_g: 1 kW/div); EV power (p_{ev}: 1 kW/div); PV power (p_{pv}: 1 kW/div).

section #6

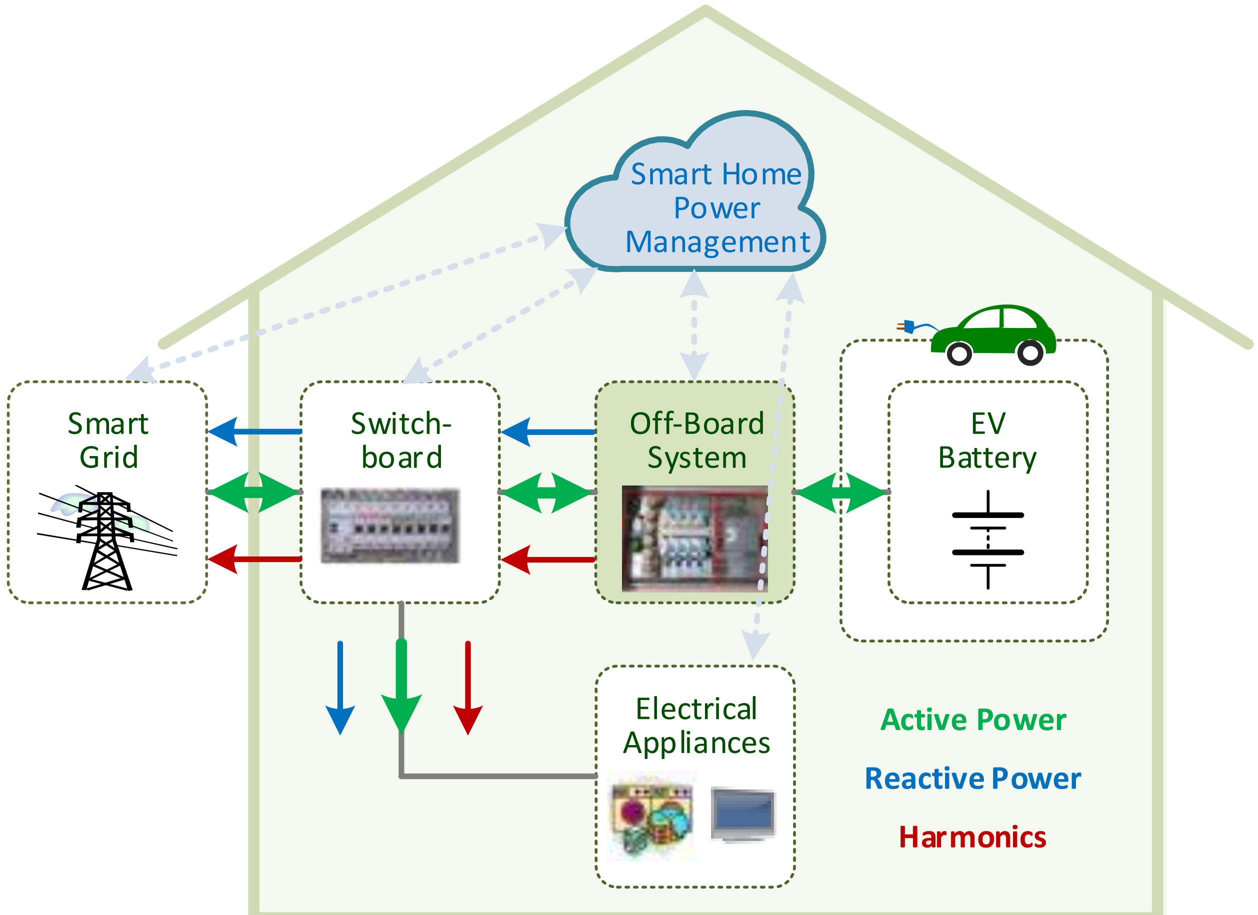
Power Electronics for Interfacing EVs, Renewables and Other Technologies



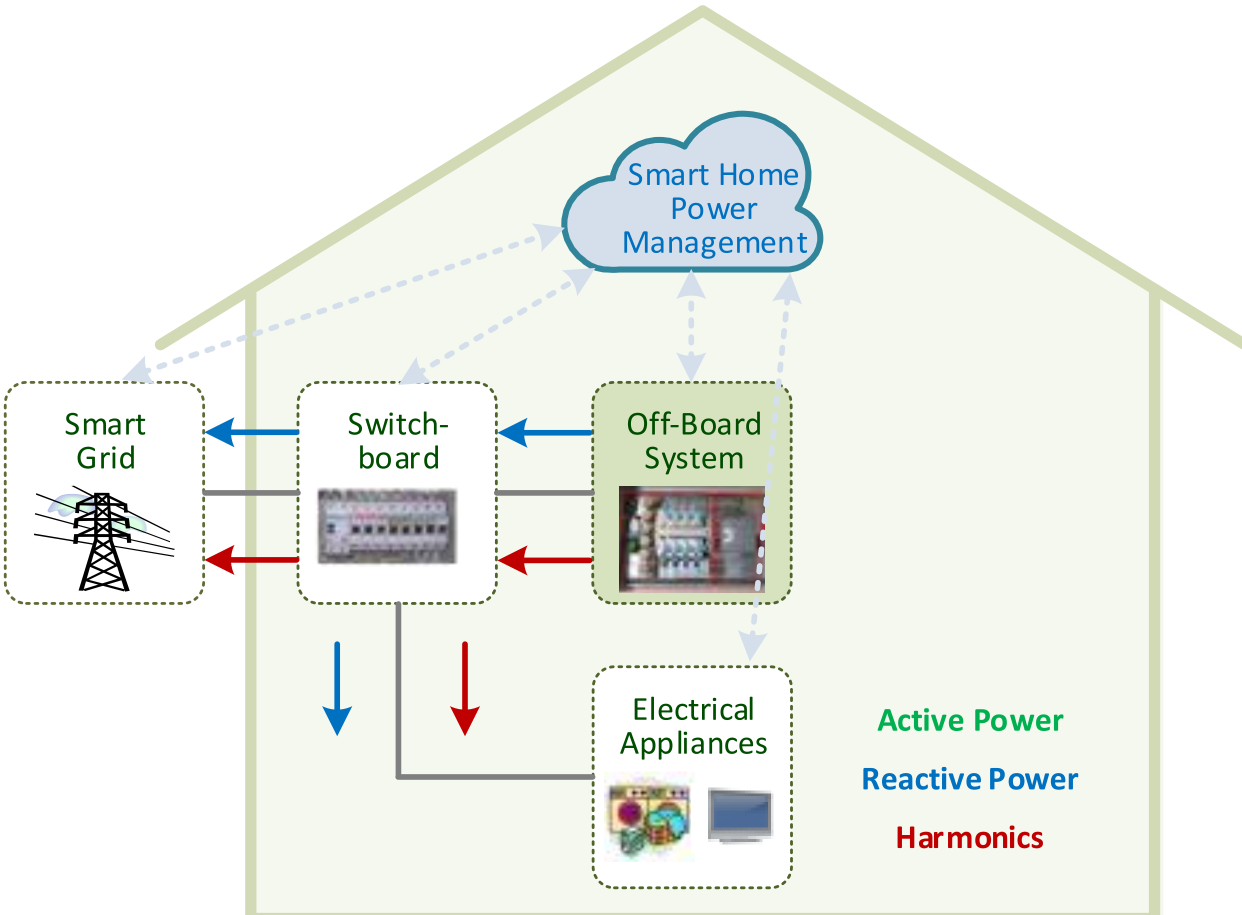
On-board with possibility of compensating power quality problems of harmonics and low power factor (reactive power for the smart home or grid).



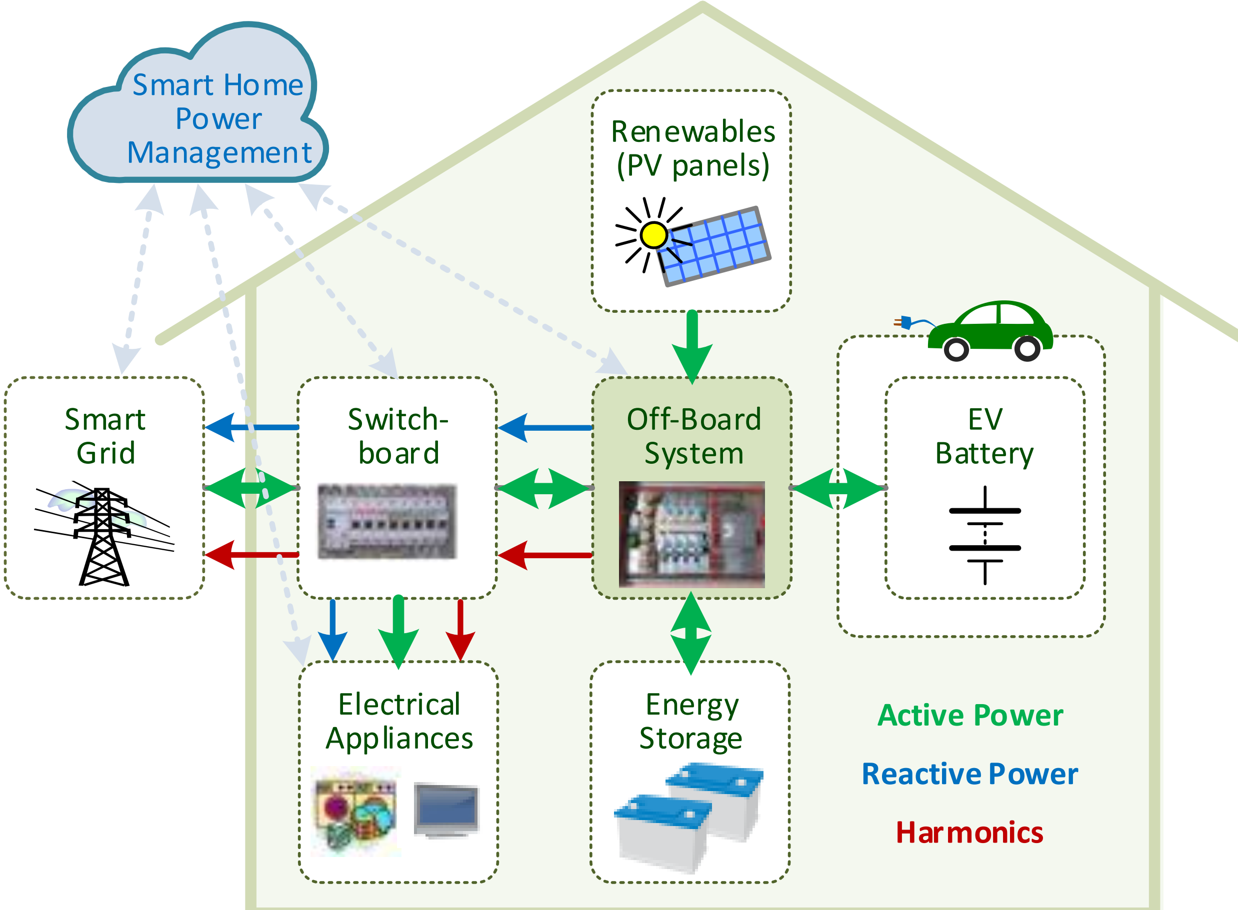
On-board EV BCS integrated into a smart home (with the previous modes) and with the possibility of compensating power outages.



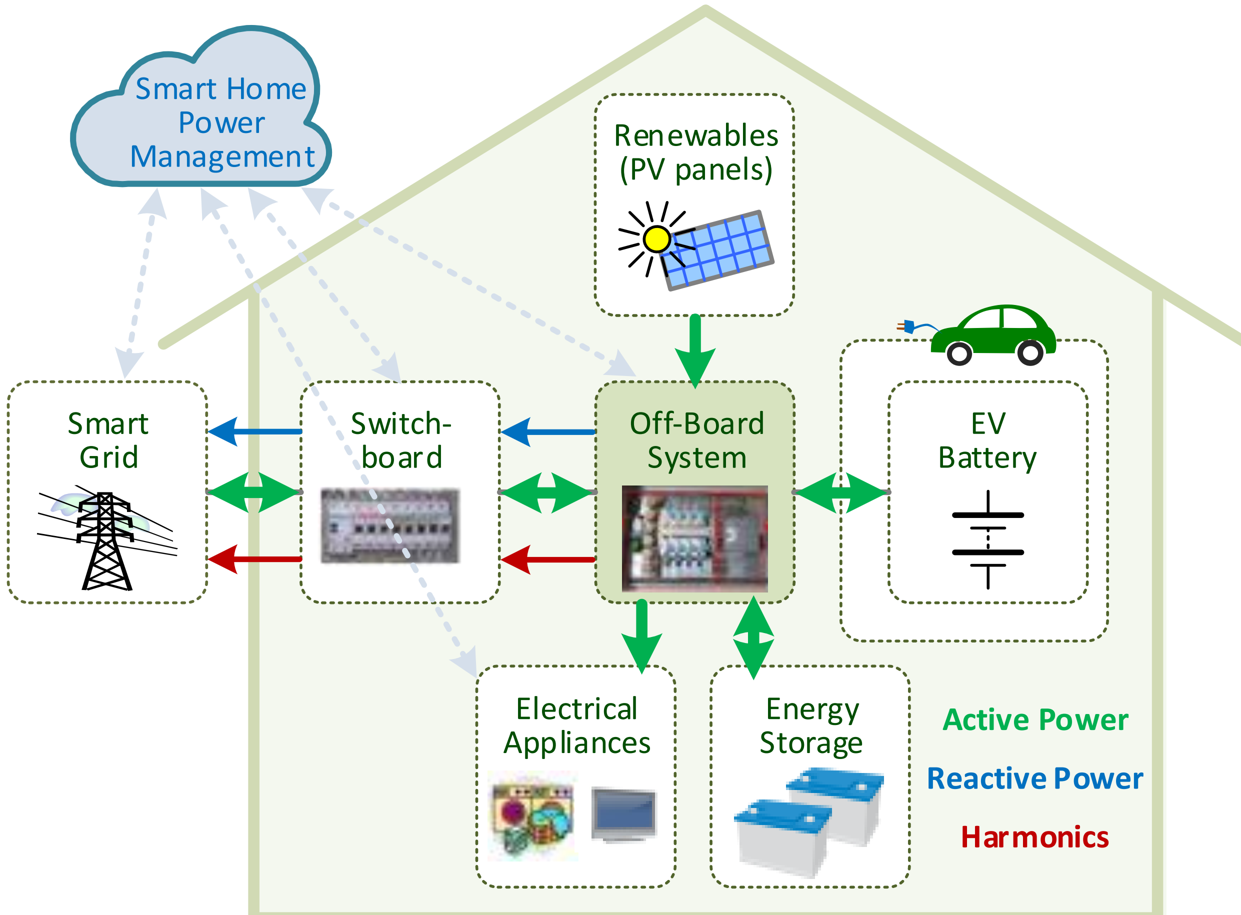
Off-board with possibility of compensating power quality problems of harmonics and low power factor (reactive power for the smart home or grid).



Off-board EV BCS integrated into a smart home, without a parked EV, but compensating power quality problems (harmonics and low power factor).



Off-board EV BCS integrated into a hybrid ac and dc smart home, with a parked EV and interfacing a RES and an ESS through dc-link.

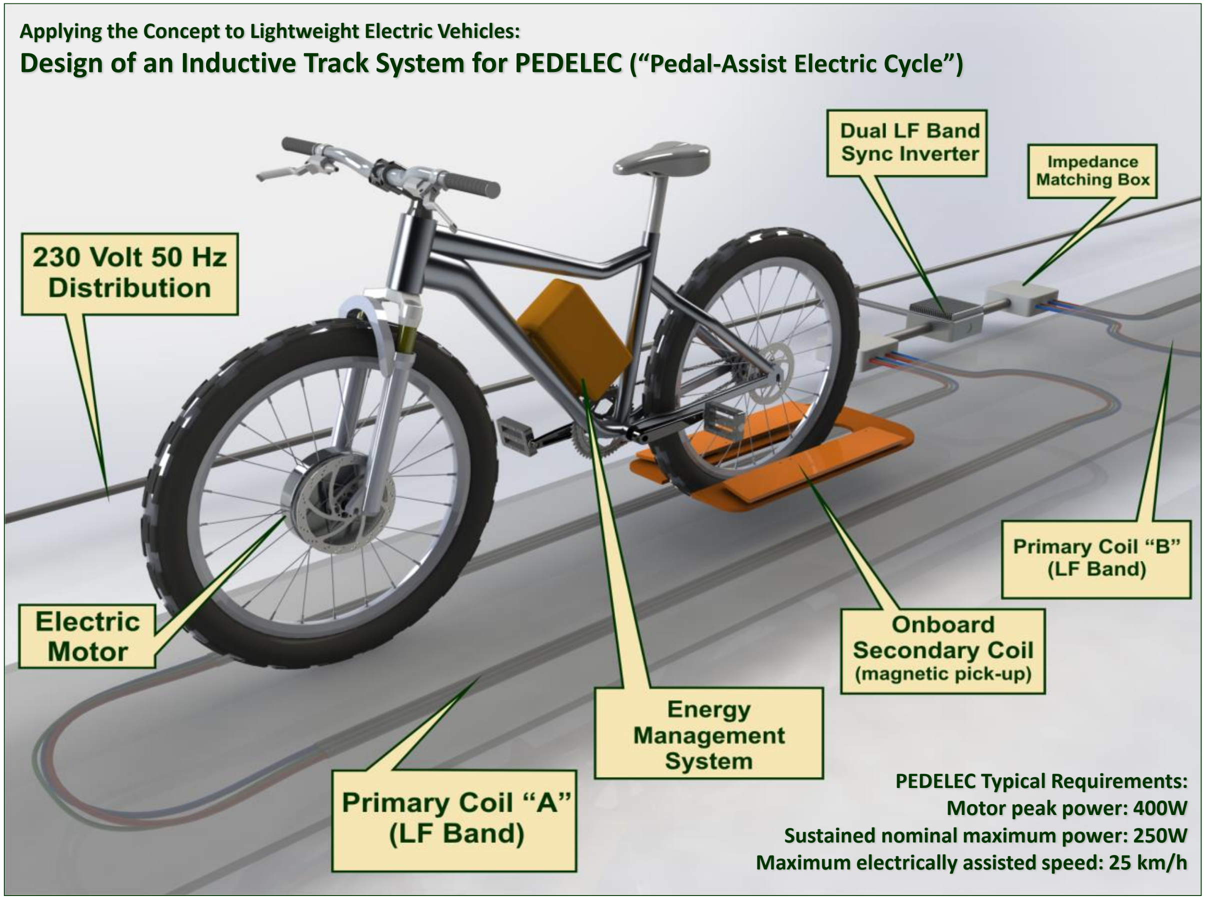


The electrical appliances are connected to the dc-link. The G2V/V2G modes are contemplated, as well as the compensation of power quality problems.

section #7

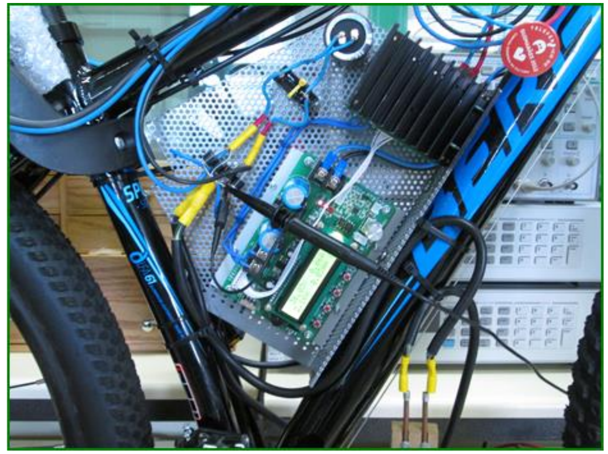
Power Electronics for Wireless Power Transfer

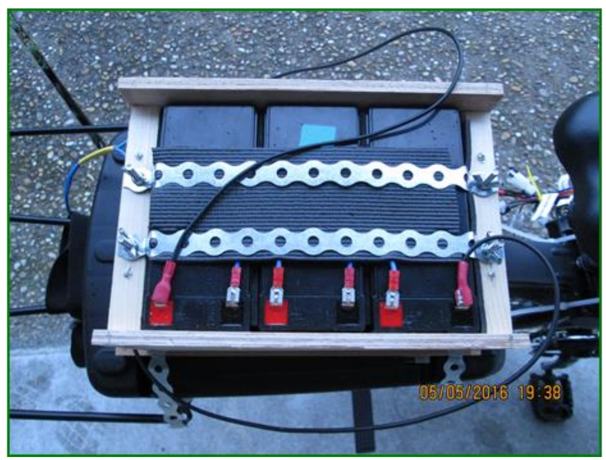
Dynamic Inductive Wireless Power Transfer for Lightweight Electric Vehicles



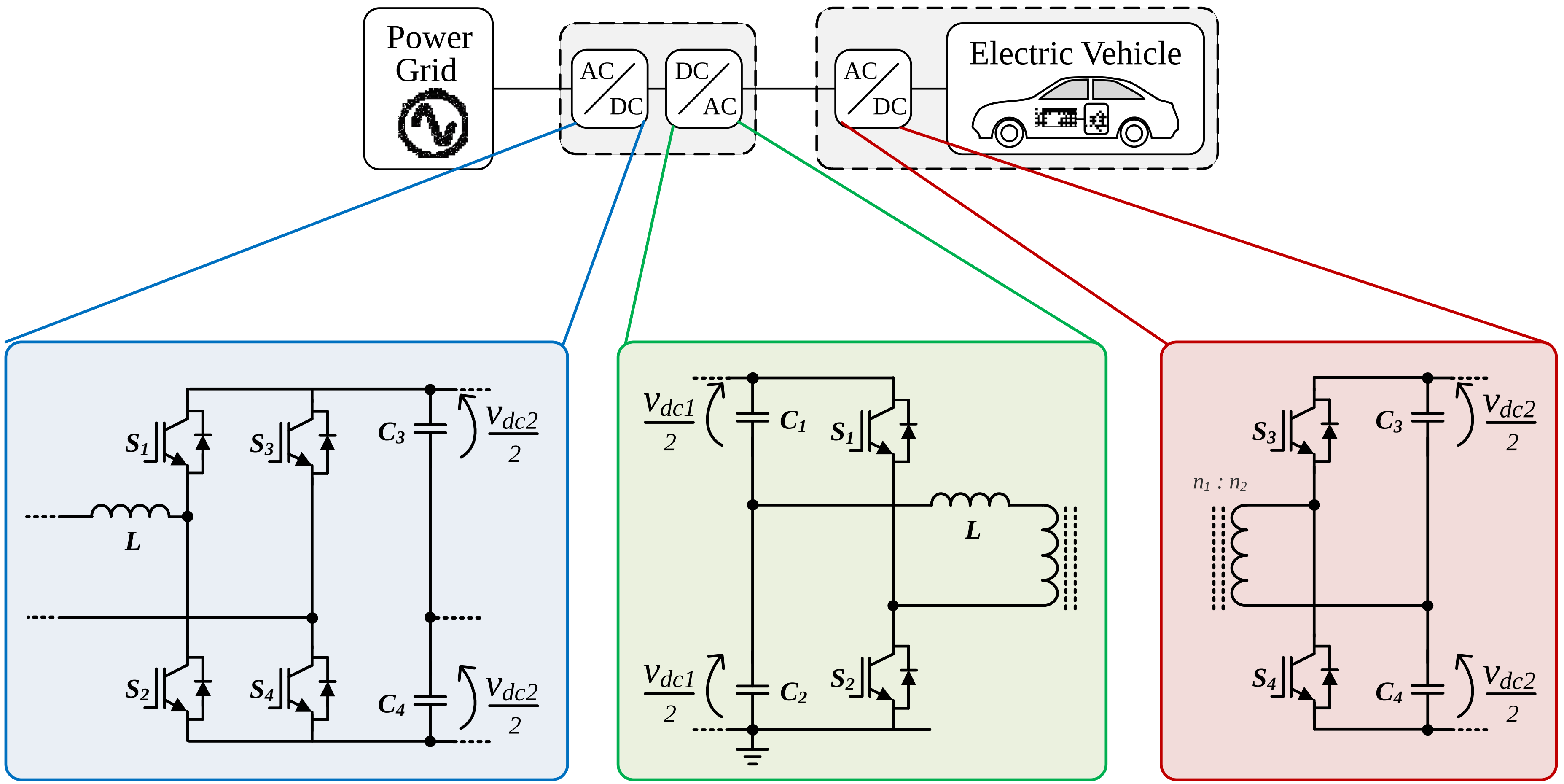
José A. Afonso, Hélder G. Duarte, Luiz A. Lisboa Cardoso, Vítor Monteiro, João L. Afonso, "***Wireless Communication and Management System for E-Bike Dynamic Inductive Power Transfer Lanes***", MDPI Electronics, vol.9, no.9, pp.1-30, Sept. 2020

Dynamic Inductive Wireless Power Transfer for Lightweight Electric Vehicles

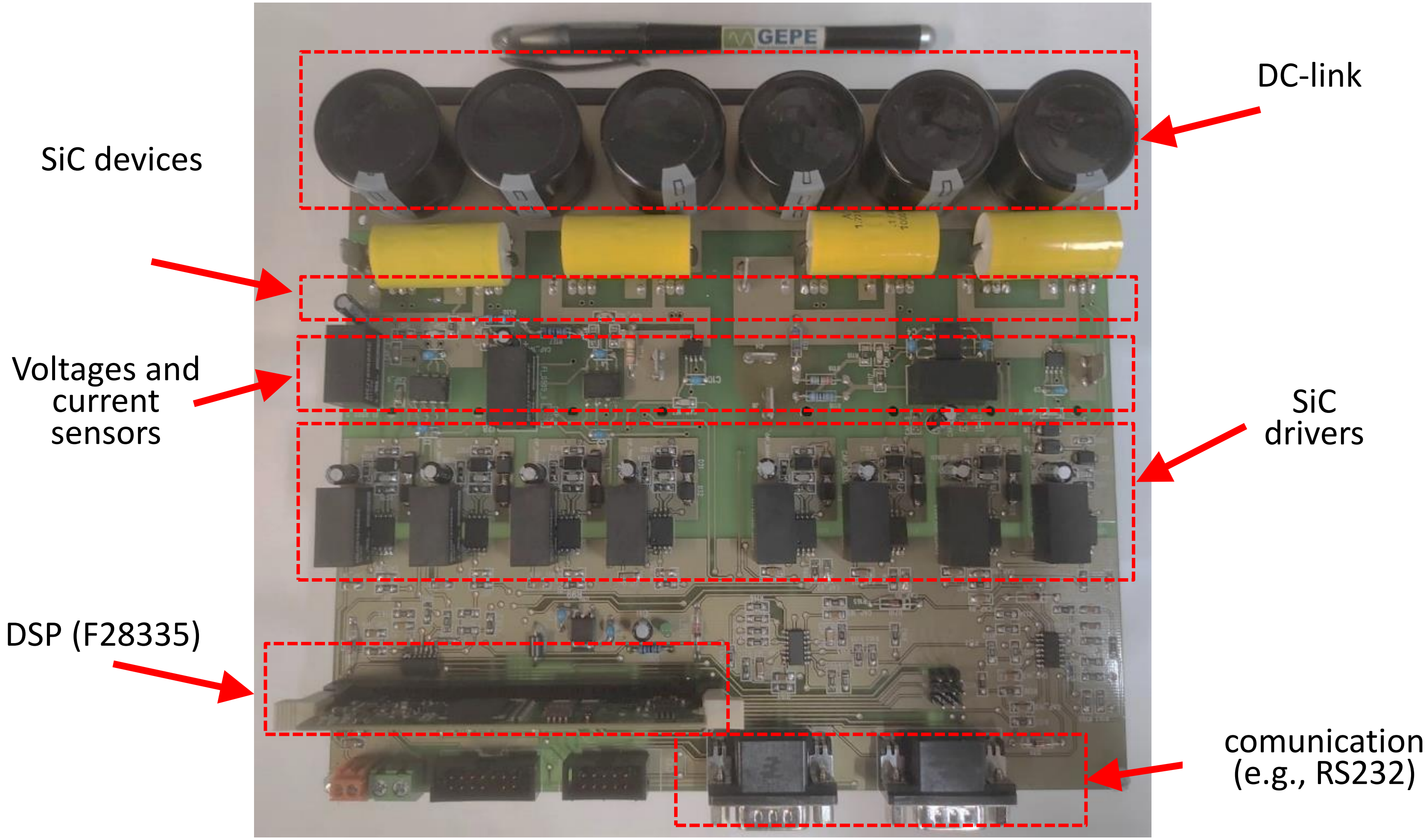




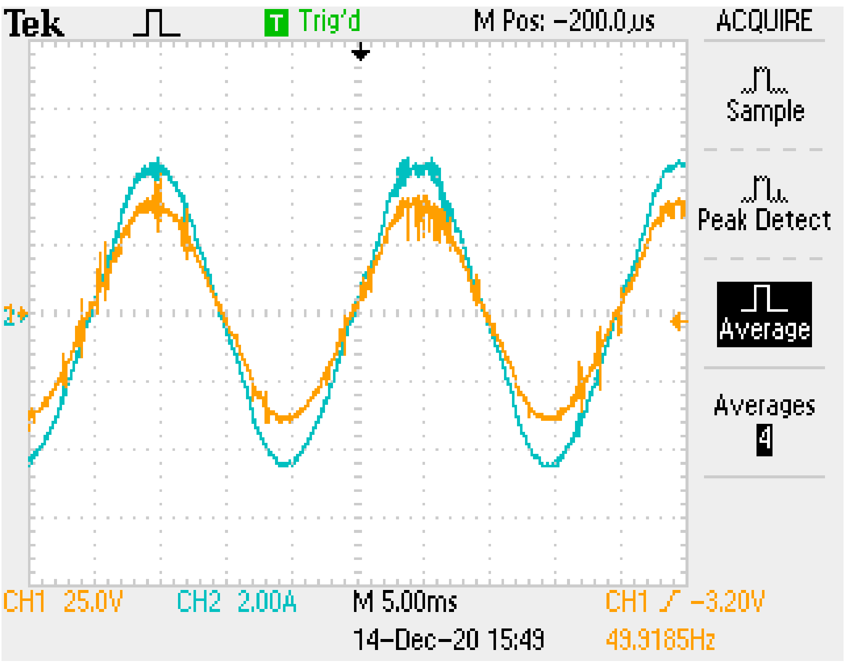
Power electronics converters for the WPT.



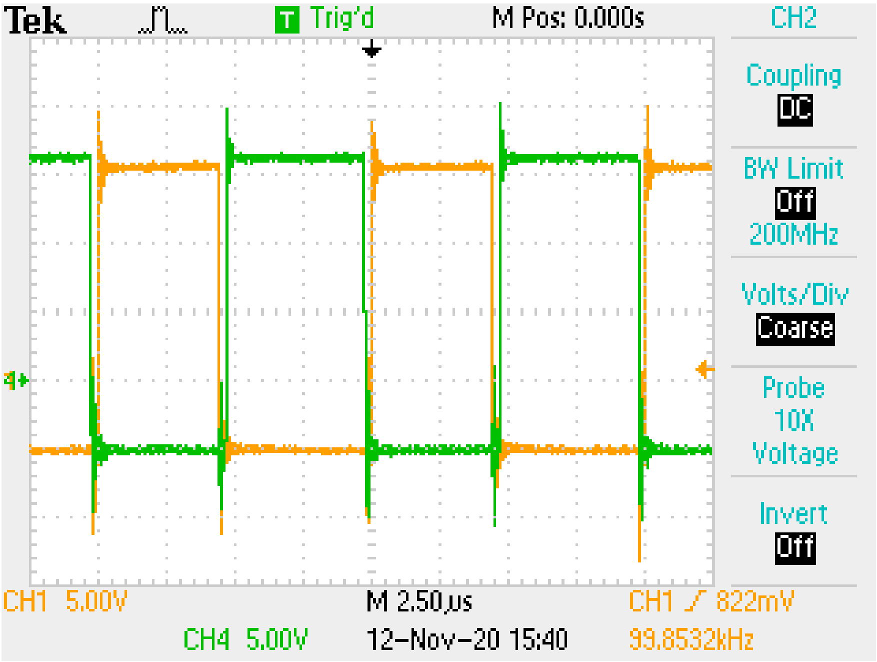
Developed AC-DC and DC-AC power converters for the WPT.



Exemplificative experimental results of the AC-DC and DC-AC power converters of the WPT.

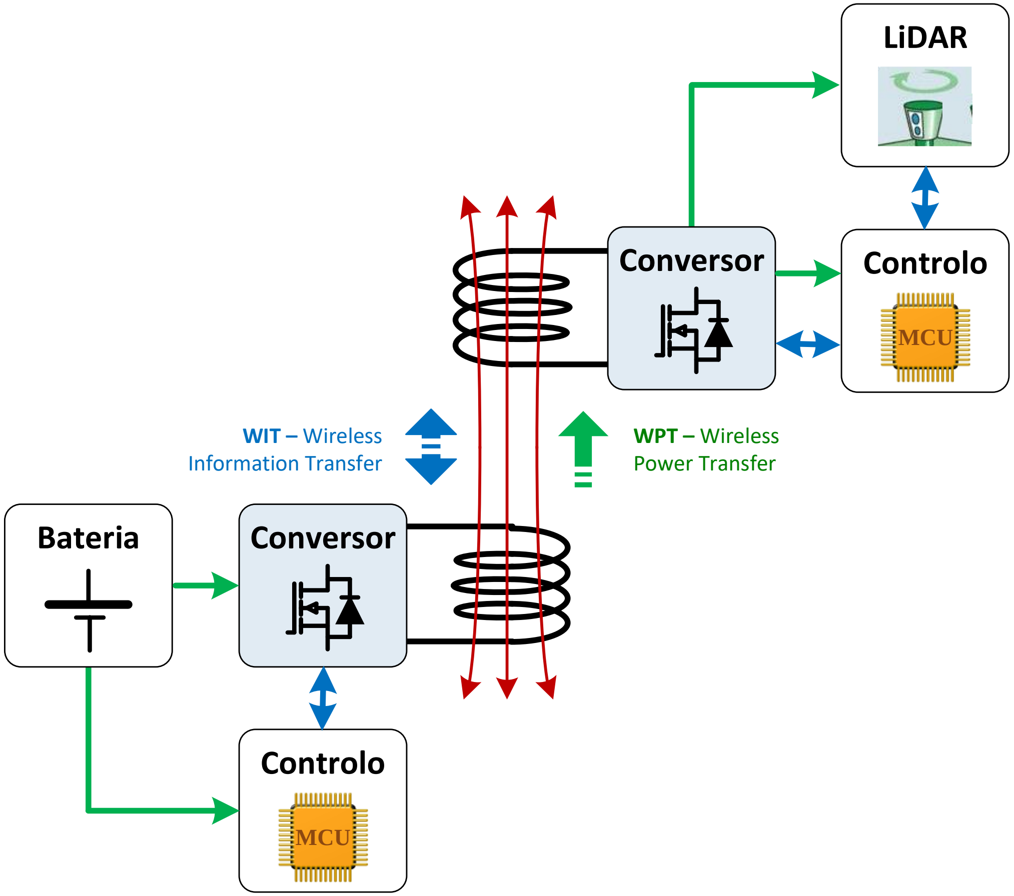


Experimental results of the AC-DC



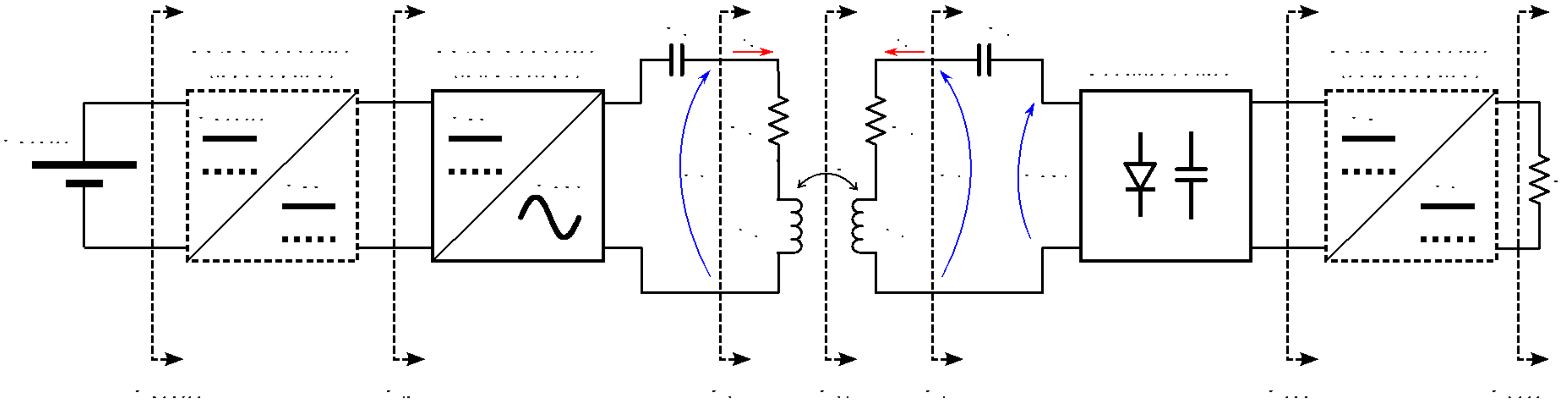
Experimental results of the DC-AC (100 kHz)

Power Electronics solutions for wireless power transfer systems (Inductive Wireless Power Transfer)

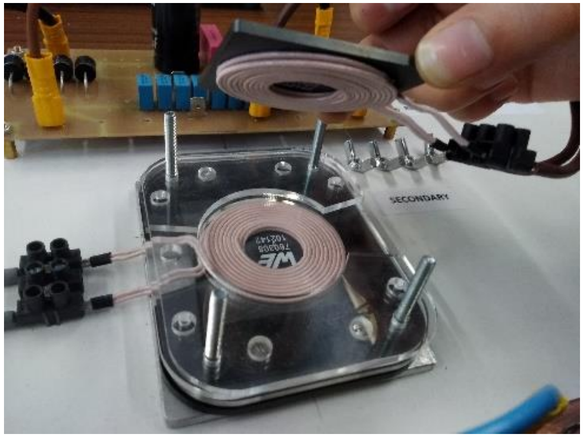


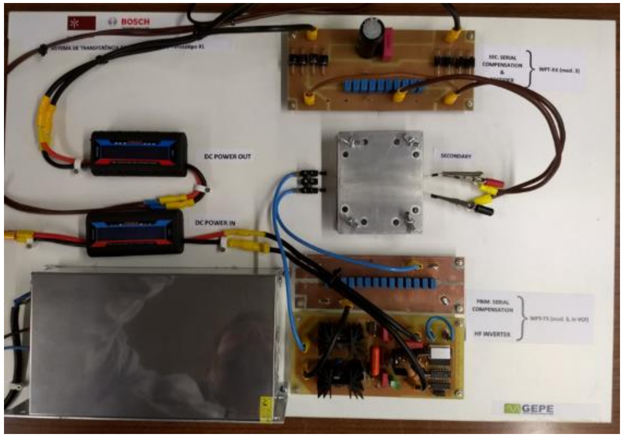
Luiz A. Lisboa Cardoso, Vítor Monteiro, J. G. Pinto, Miguel Nogueira, Adérito Abreu, José A. Afonso, João L. Afonso, "***Design of an intrinsically safe series-series compensation WPT system for automotive LiDAR***", MDPI Electronics, vol.9, no.1, pp.1-28, Jan. 2020.

Power Electronics for Wireless Power Transfer



Typical series-series (SS)-compensated WPT system architecture.

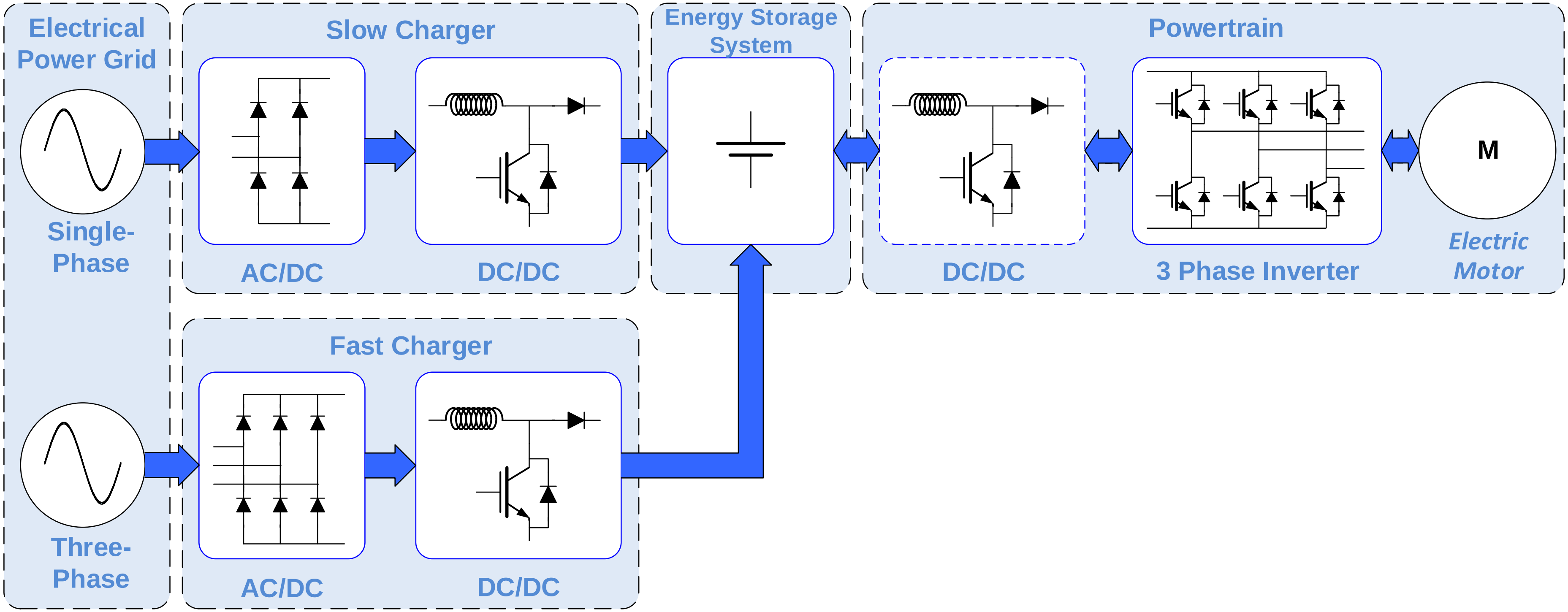




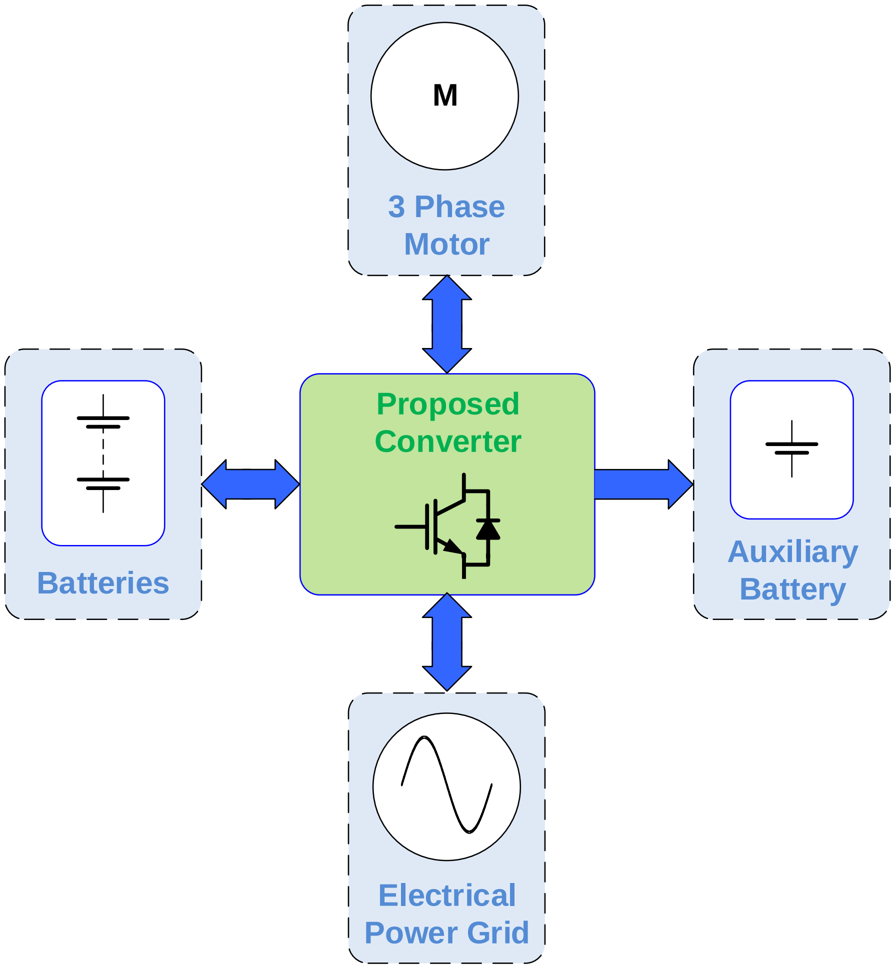
First conceptual prototype of the WPT subsystem of the LiDAR, achieving more than 175 W at 80.5% efficiency.

section #9

Power Electronics for Unified Traction and Charging Systems

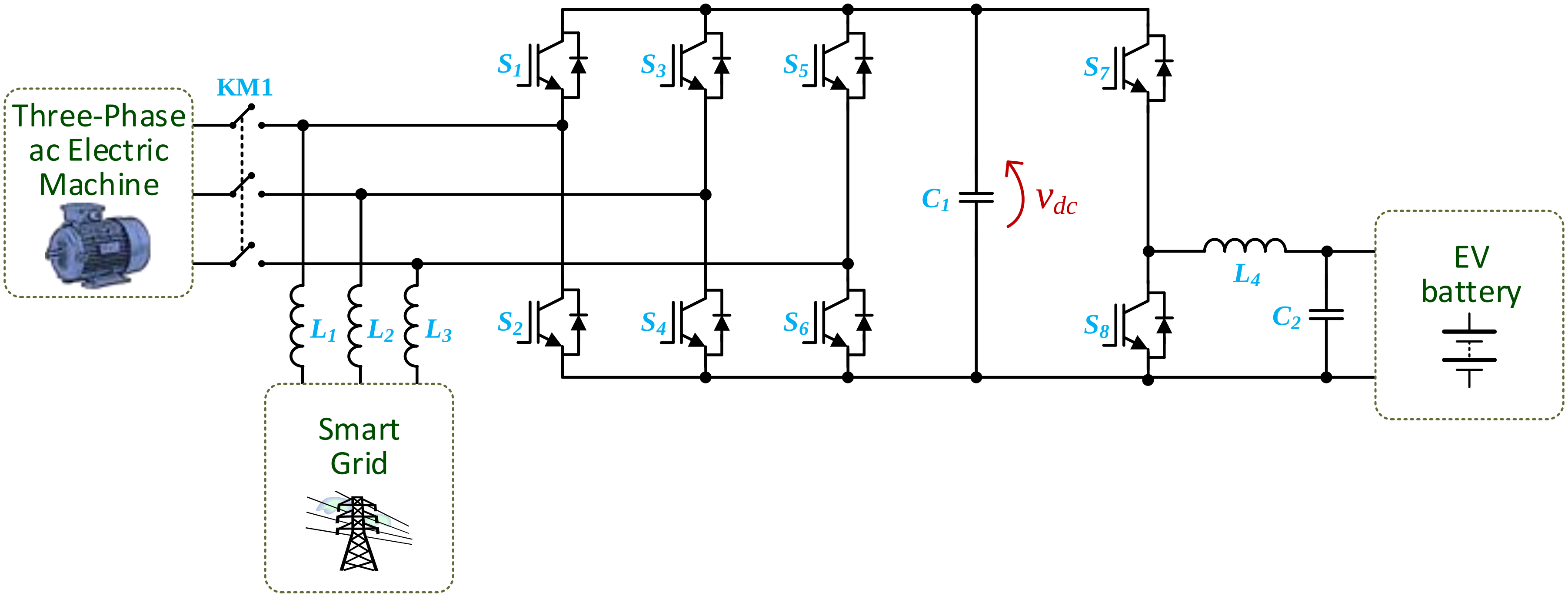


Traditional Solution



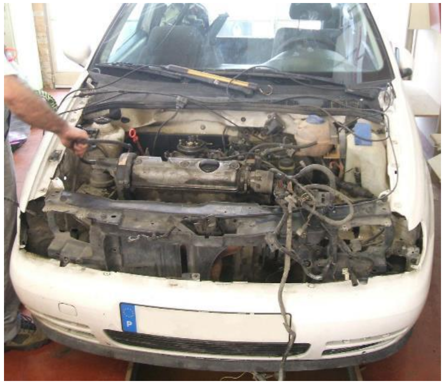
Proposed Solution

Unified power converter topology based on the disconnection of the three-phase ac electric machine.



Delfim Pedrosa, Vítor Monteiro, Henrique Gonçalves, Júlio S. Martins, João L. Afonso, "***A Case Study on the Conversion of an Internal Combustion Engine Vehicle into an Electric Vehicle***", IEEE VPPC 2014 - Vehicle Power and Propulsion Conference, Coimbra, Portugal, Oct. 2014, pp.1-5.

Carro Elétrico Plug-In da Universidade do Minho (CEPIUM)



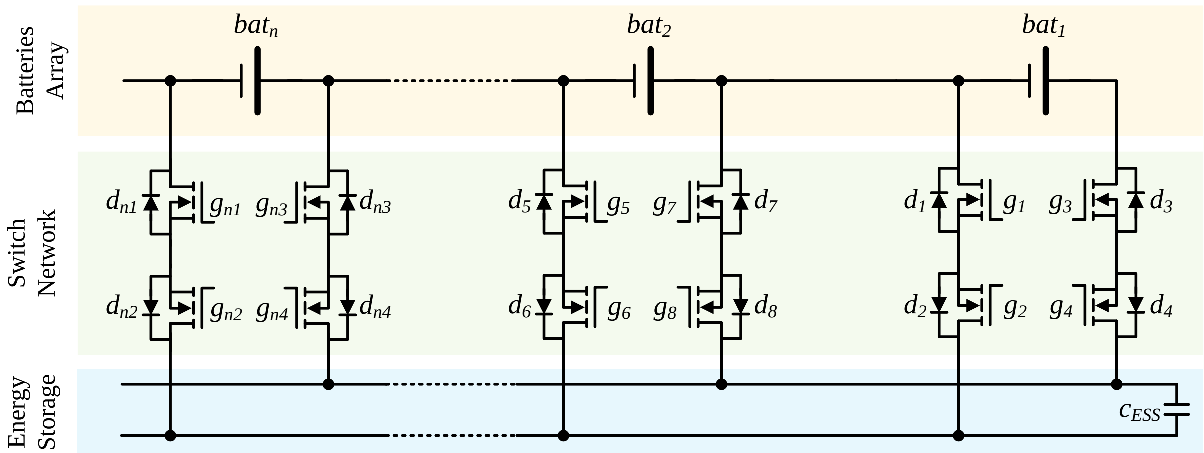
Workbench of the developed unified power converter topology

section #8

Power Electronics for Battery Management Systems

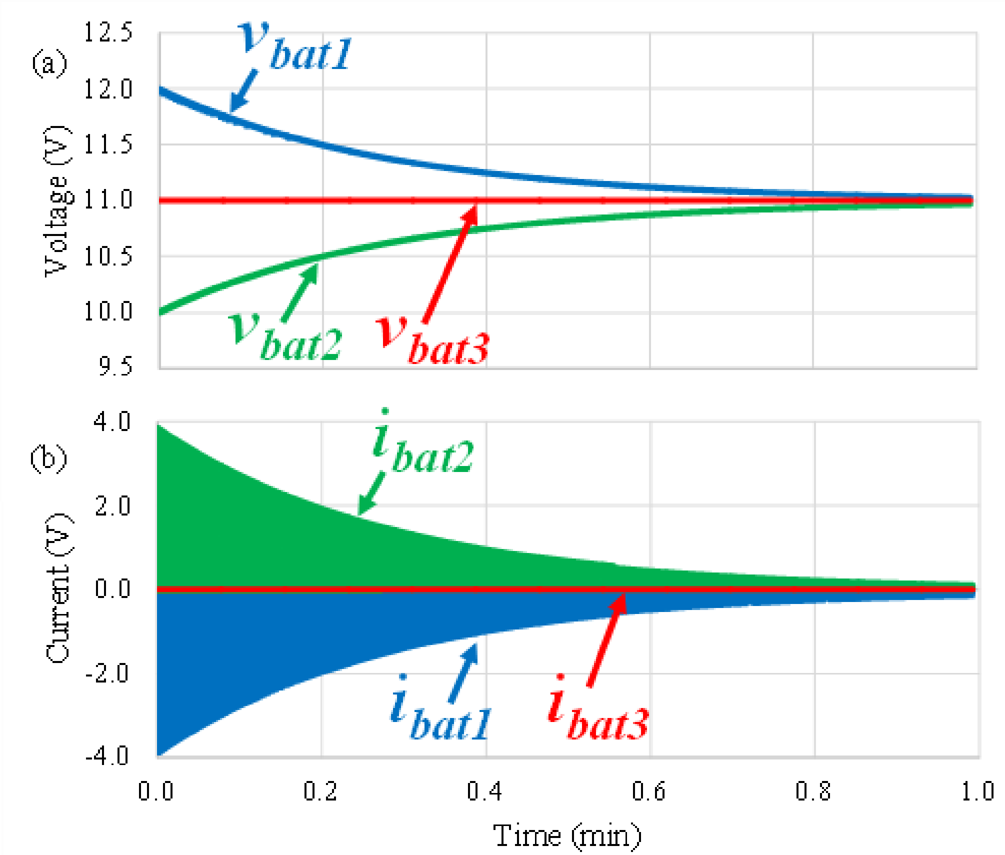
Modular topology for an active battery management system (BMS)

- Simple Control System
- Are required *2n* switches for *n* batteries
- Is required only one capacitor
- Modular topology to add or remove batteries
- Equalization of batteries independently of the position in the array



Vítor Monteiro, Pedro Alves, Andrés A. Nogueiras Meléndez, Carlos Couto, João L. Afonso, "***A Novel Modular Voltage Balancing Topology for Active Battery Management System***", IEEE ISIE 2016 - International Symposium on Industrial Electronics, Santa Clara CA USA, June 2016, pp.793-798.

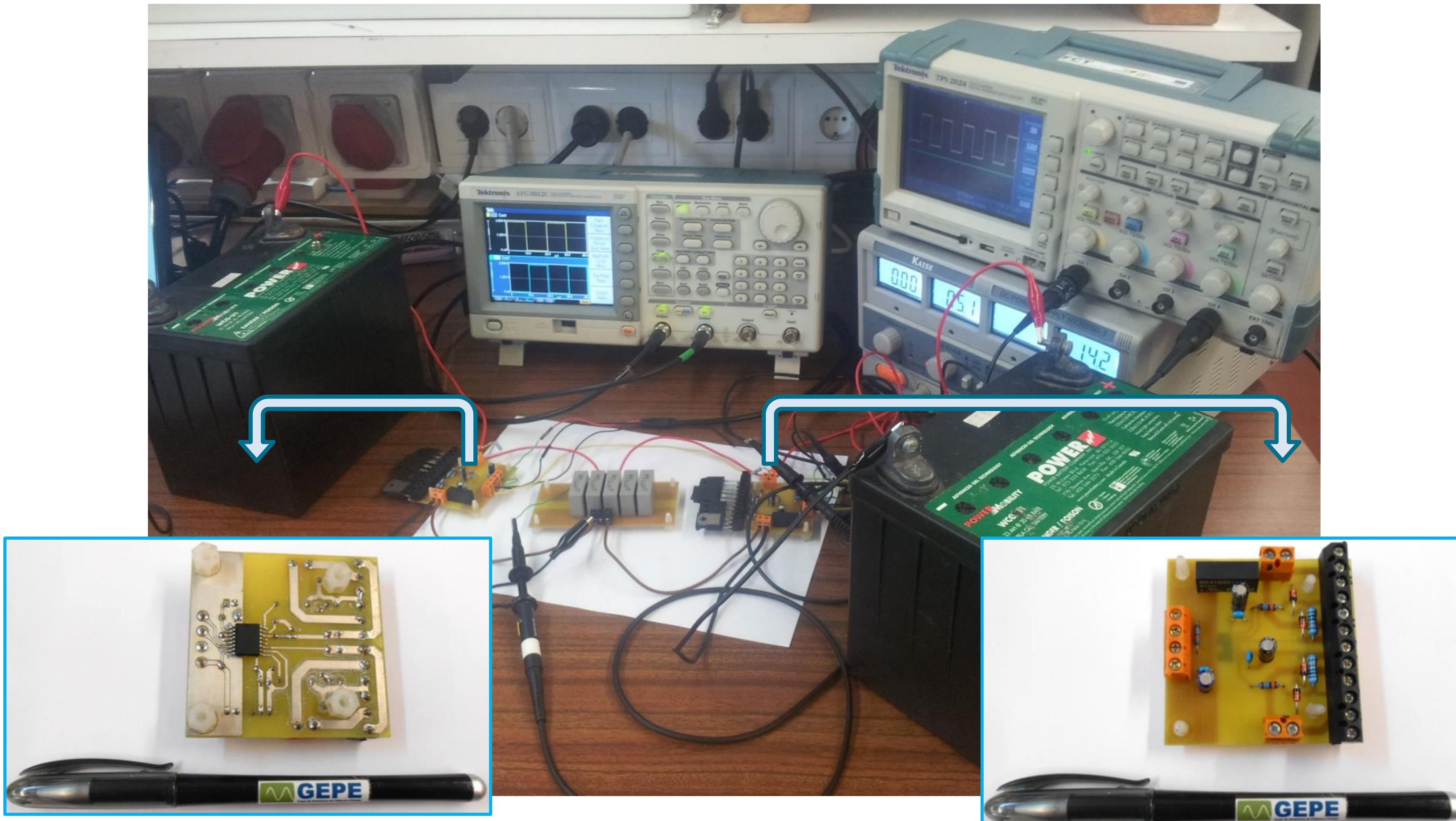
Principle of operation of the proposed modular topology for active BMS during the voltage balancing process

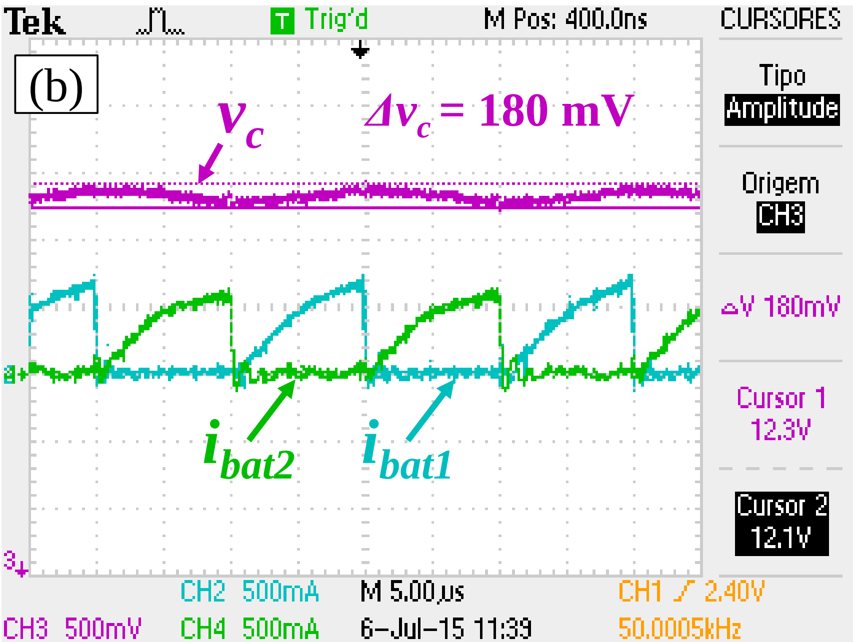


(a) Voltage in each battery (v_{bat1}, v_{bat2}, v_{bat3})

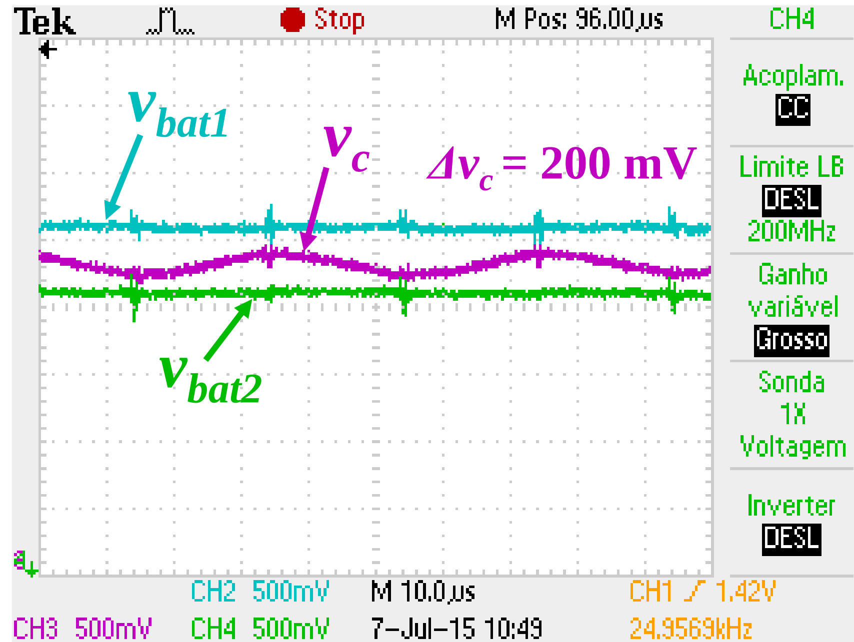
(b) Current in each battery (i_{bat1}, i_{bat2}, i_{bat3})

Laboratorial setup used to test the modular voltage balancing topology of active BMS





Experimental results of the voltage in the capacitor (v_c), current in the battery bat_1 (i_{bat1}), and current in the battery bat_2 (i_{bat2}).

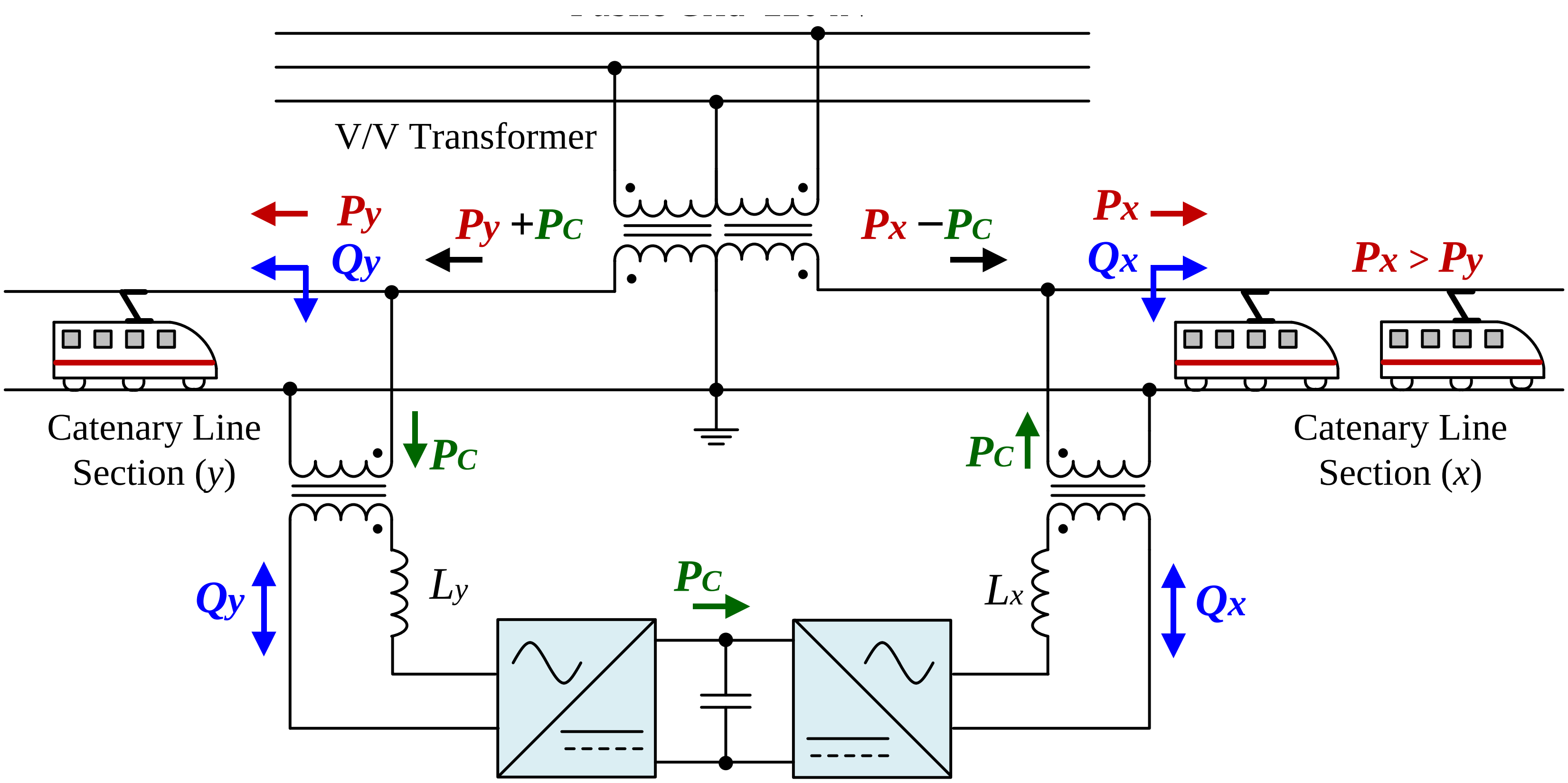


Experimental results of the voltage in the capacitor (v_c), and the voltage in the batteries bat_1 (v_{bat1}) and bat_2 (v_{bat2}).

section #10

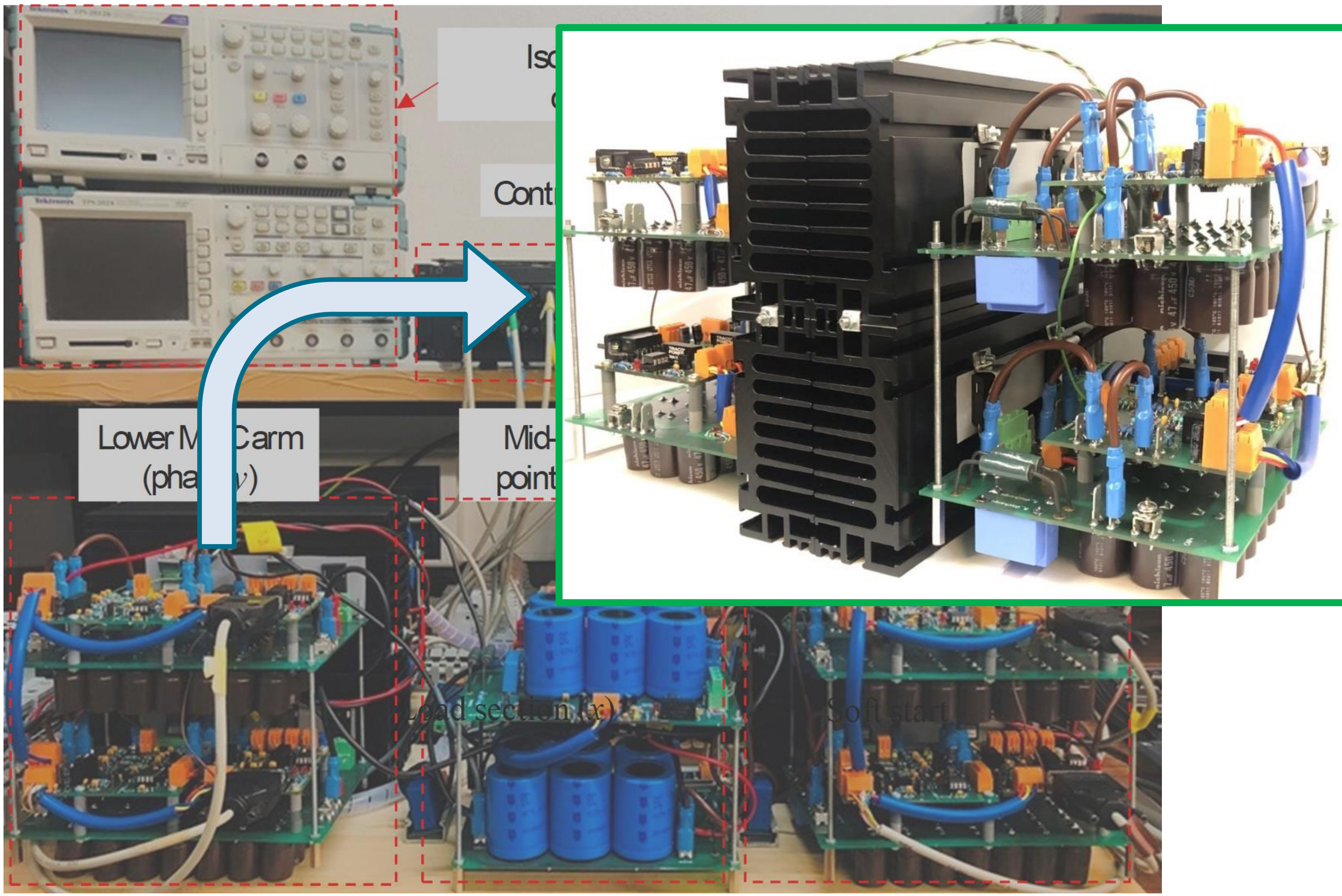
Power Electronics for Railway Systems

Rail Power Conditioner Based on Modular Multilevel Converter for AC Railway Power Grids

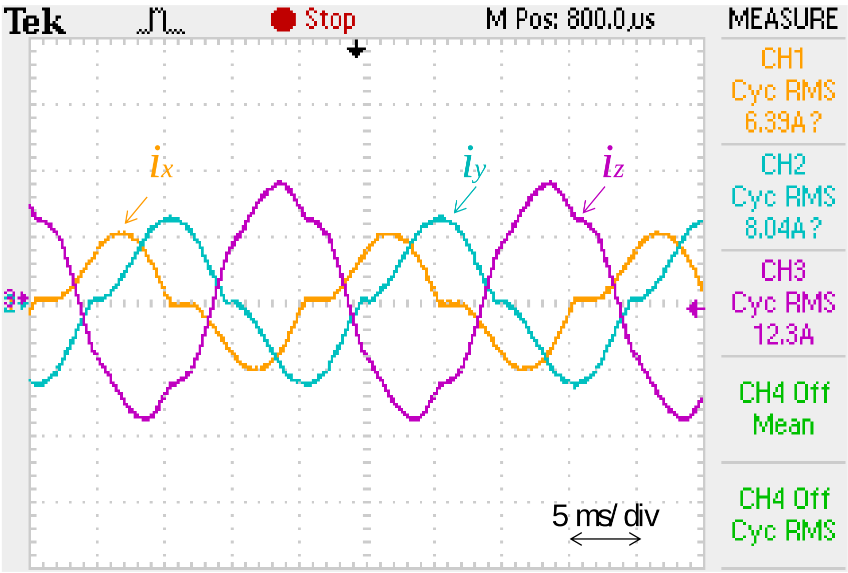


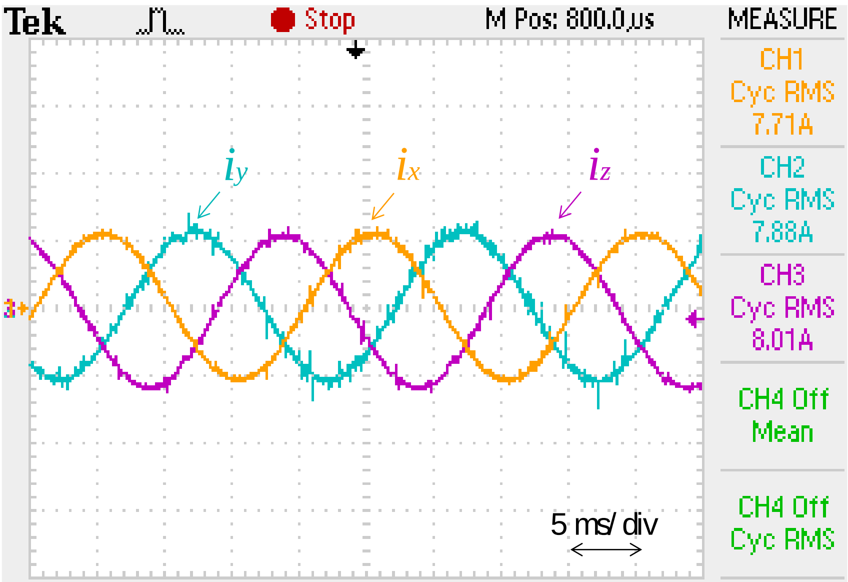
Mohamed Tanta, José Cunha, Luís A. M. Barros, Vítor Monteiro, J. G. Pinto, Antonio P. Martins, João L. Afonso, "***Experimental Validation of a Reduced Scale Rail Power Conditioner Based on Modular Multilevel Converter for AC Railway Power Grids***", MDPI Energies, vol.14, no.2, pp.1-27, Jan. 2021.

Workbench with the developed MMC.



Experimental validation of the developed MMC.





Experimental results when two load sections are loaded:
(a) Before compensation; (b) After compensation. Phase *x* current (i_x: 10 A/div); phase *y* current (i_y: 10 A/div); phase *z* current (i_z: 10 A/div).

section #11

Conclusions

- Nowadays, the EV is considered the main alternative for replacing the traditional polluting vehicles with internal combustion engines.
- This is an important contribution; however, the EV can also emerge in the future smart grids and smart homes with a set of new features.
- Power electronics technologies play an essential role and can be contextualized in different purposes to support the full adoption of electric mobility.
- Innovative operating modes that enable the dynamic integration of electric mobility into the power grids targeting smart grids were presented.
- Along the presentation, several experimental results were presented, showing that the EV represent an added value to the power grids.

Thank you for your attention.

POWER ELECTRONICS TECHNOLOGIES FOR ELECTRIC MOBILITY

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