Design and implementation of an 85-kHz Bidirectional Wireless Charger

Wireless charging and V2G market and grid integration

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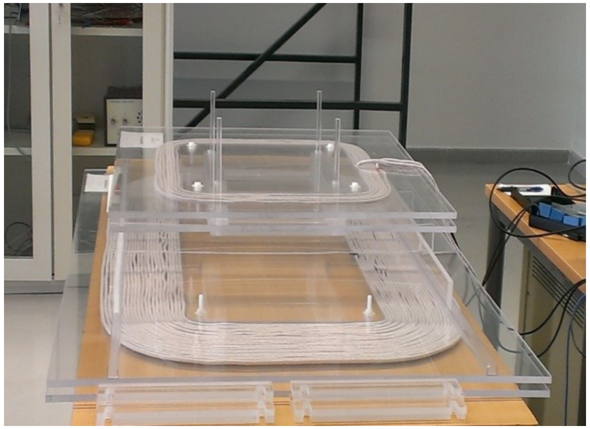
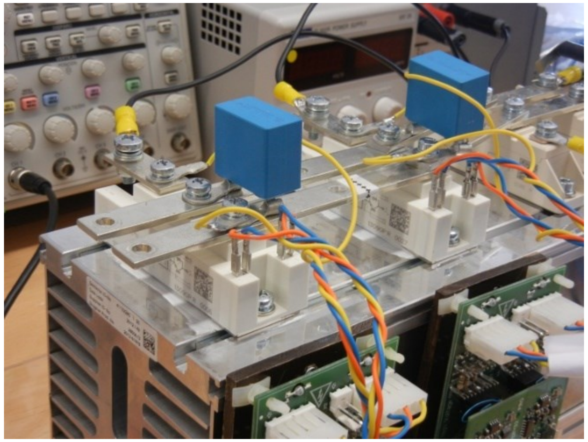
Scenario & Goal:

First WPT prototype (2013-2014)



Litz Wire



IGBTs

Semikron drivers

- Unidirectional
- 20 kHz
- 3.7 kW

ABENGOA

Second WPT prototype (2015-2017)

- Bidirectional
- 85 kHz
- 7 kW

ABENGOA

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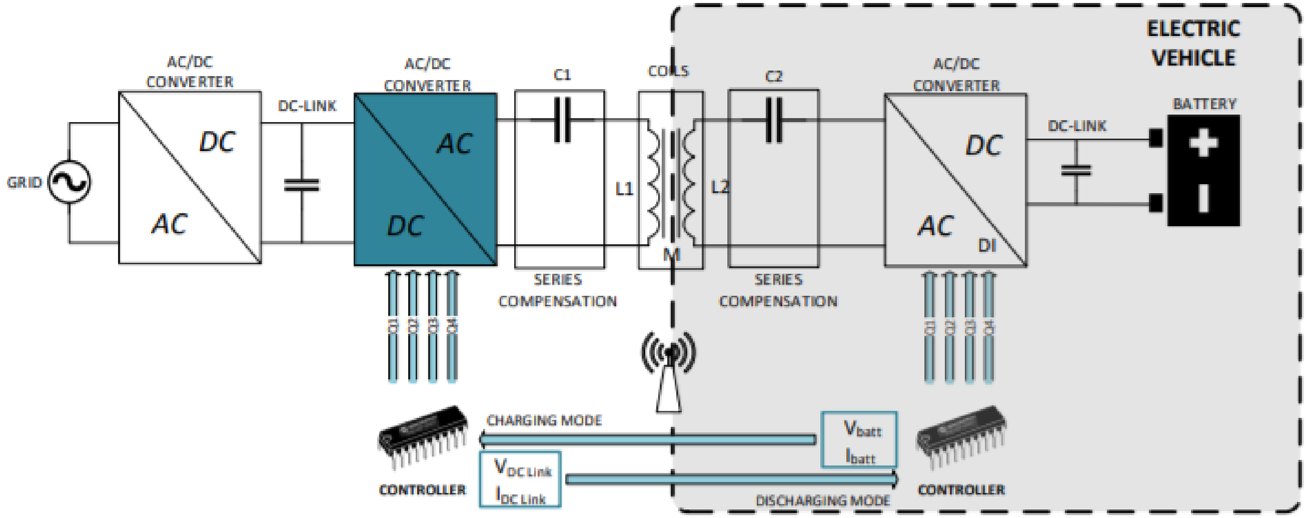
Scheme



- Power Electronics for power transfer at 85 kHz (Recommendations SAE J2954)
- Bidirectional systems.
- Control system

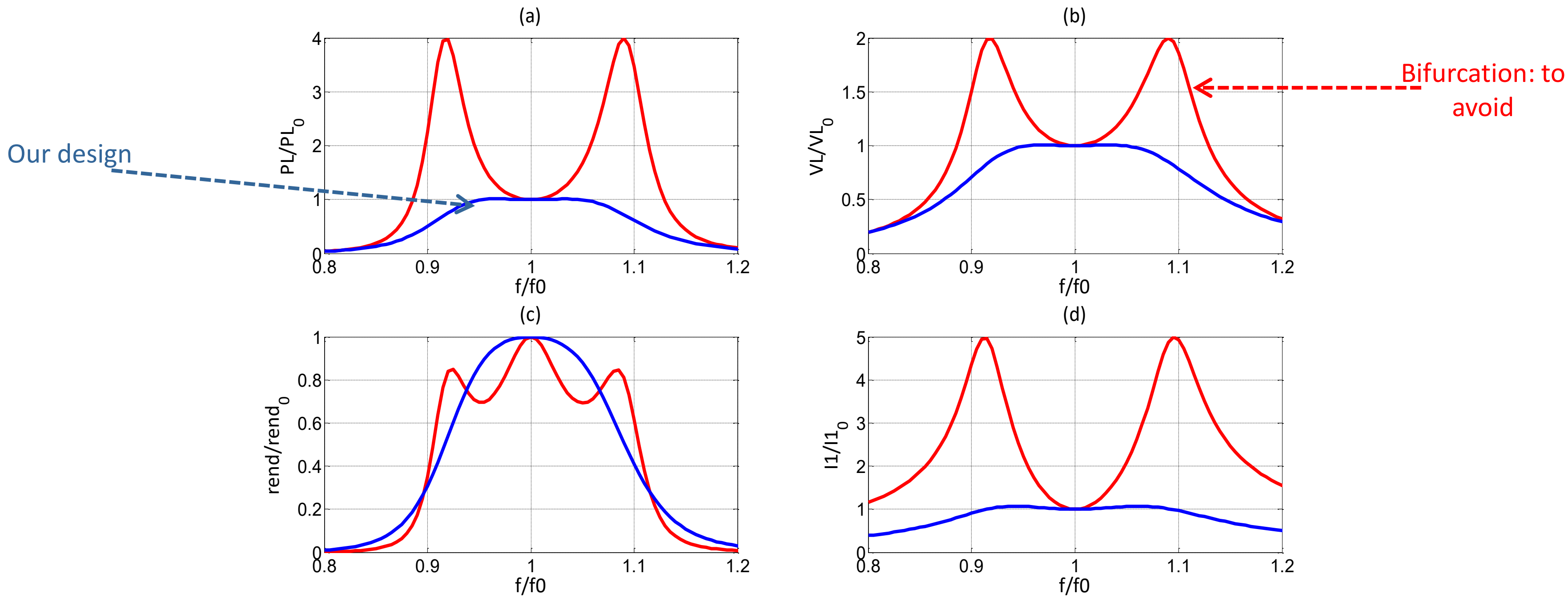
Symmetric compensation topology (Series-Series)

Coil construction

Design based on an iterative algorithm with the main goals:

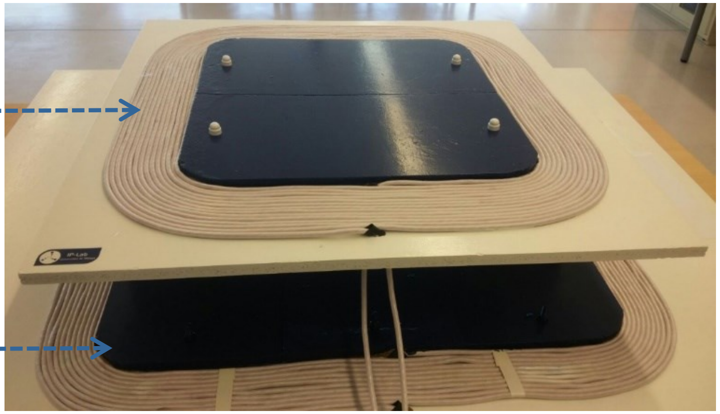
- ❖ Maximize the efficiency of the system
- ❖ Reduce the costs of the Litz wire
- ❖ Avoid bifurcation

} Number of turns primary and secondary coils



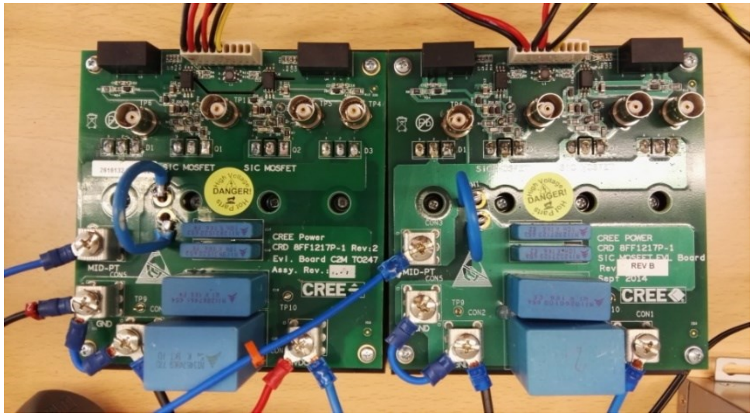
Coil construction

Secondary coil
(0.5x0.5 m^2,
14 turns,
20 mm^2)



Primary coil
(0.75x0.75 m^2 ,
11 turns,
20 mm^2)

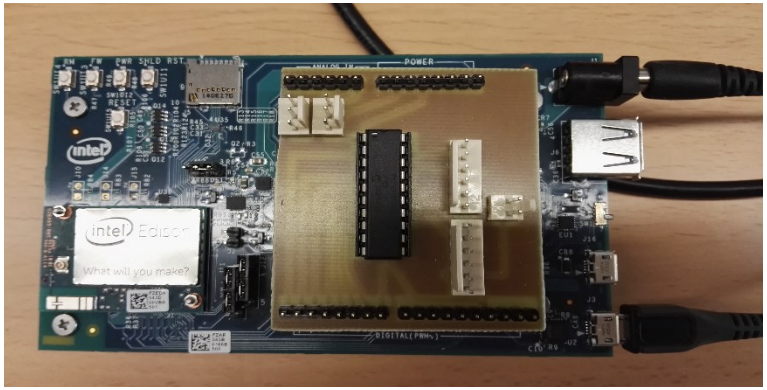
Power electronics



SiC MOSFET

(switching frequency and power)

CREE KIT8020CRD8FF1217P-1 with C2M0080120D

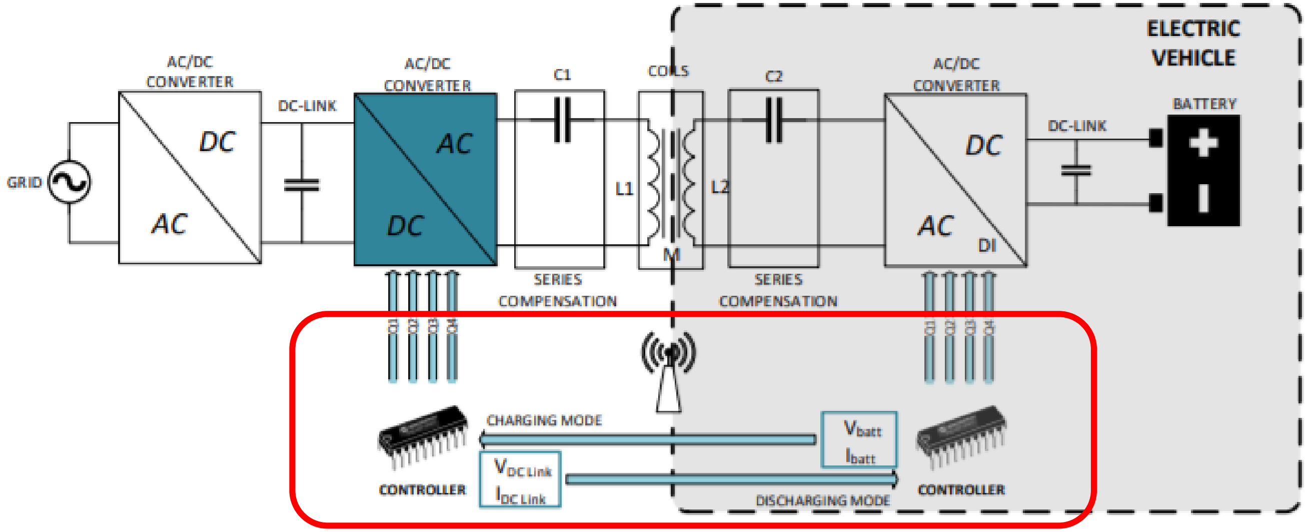


Controller

Intel Edison + PIC16F18344 (Phyton)

Communication system

The controller has a Low Energy Bluetooth module



Maximum distance: 30 m
Communication rate: 24 Mbps

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Experimental Results

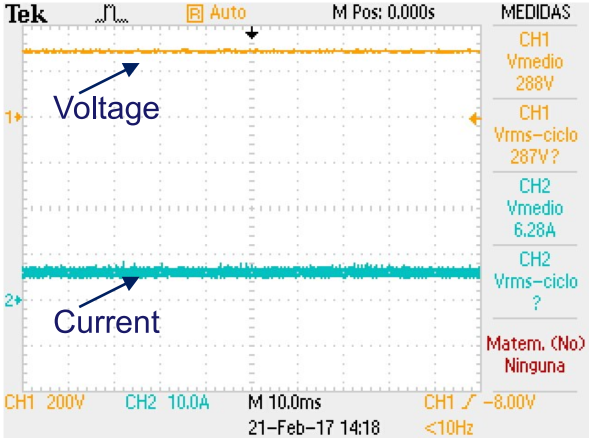
Electrical features of the WPT system

Frequency	85 kHz
Primary coil dimensions	0.75 m × 0.75 m
Cross-sectional area of the primary coil wire	20 mm^2
Resistance of the primary coil (R_1)	195.6 mΩ
Self-inductance of the primary coil (L_1)	240.5 µH
Secondary coil dimensions	0.5 m × 0.5 m
Cross-sectional area of the secondary coil wire	20 mm^2
Resistance of the secondary coil (R_2)	143.1 mΩ
Self-inductance of the secondary coil (L_2)	230.6 µH
Distance between coils assumed in the design (gd)	0.2 m
Compensation topology	Series-Series
Capacitance of the primary side (C_1)	17.05 nF
Capacitance of the secondary side (C_2)	15.88 nF
Load resistance	24 Ω

Experimental results: charging the EV

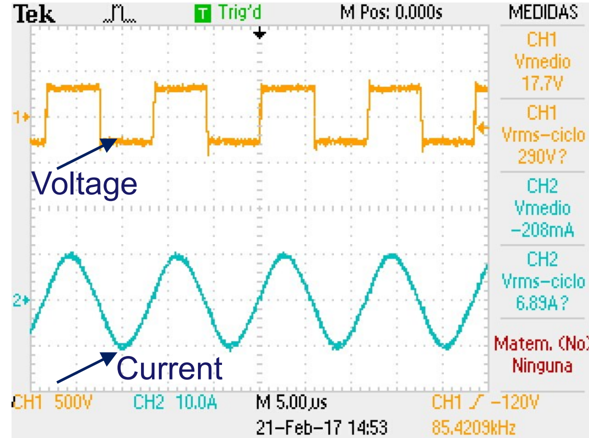
PRIMARY SIDE (GRID)

Inverter input



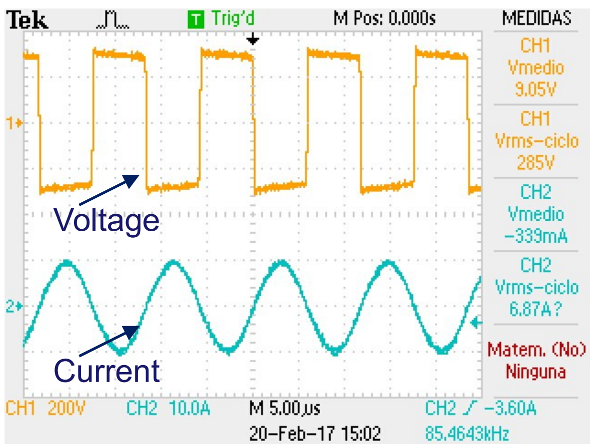
Power: 3.6 kW

Inverter output

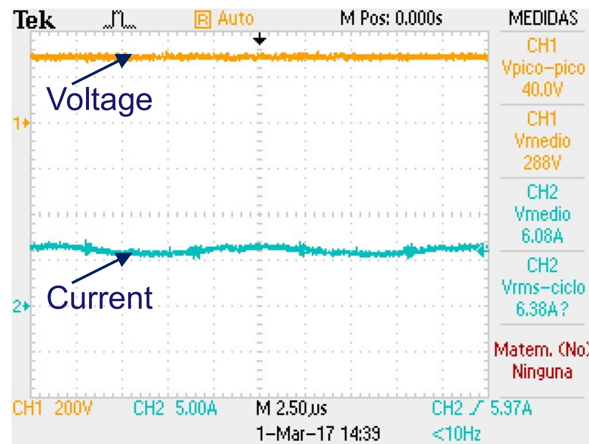


SECONDARY SIDE (EV)

Rectifier input



Battery

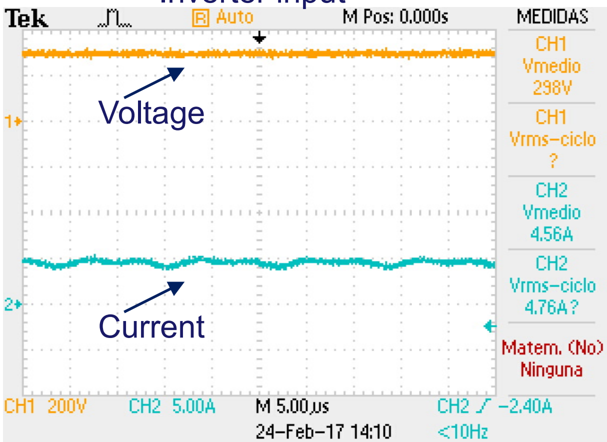


Power: 3.5 kW

Experimental results: discharging the EV – injecting to the grid

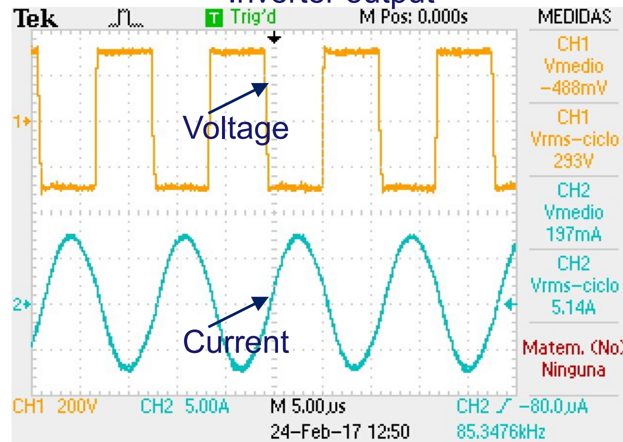
PRIMARY SIDE (EV)

Inverter input



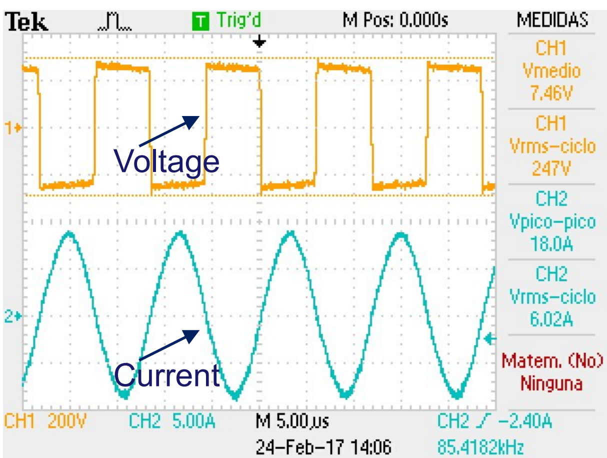
Power: 2.72 kW

Inverter output

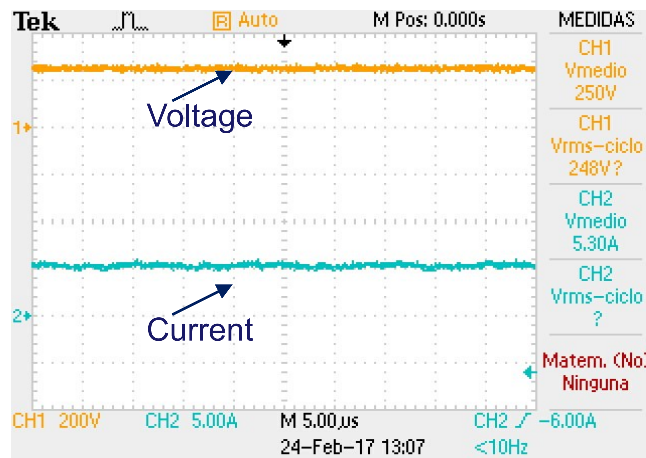


SECONDARY SIDE (GRID)

Rectifier input



DC link



Power: 2.65 kW

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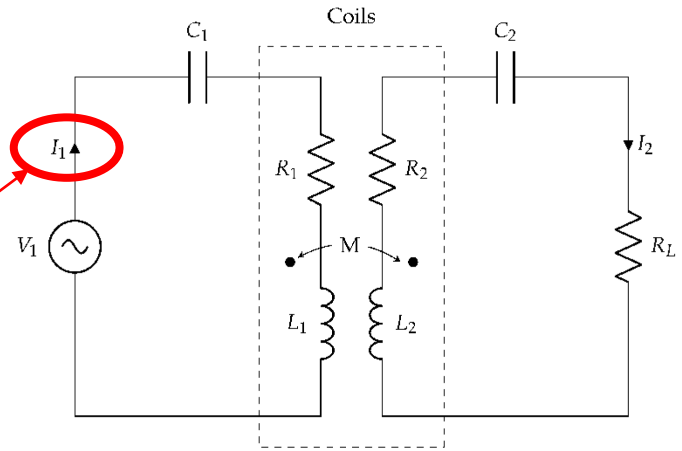
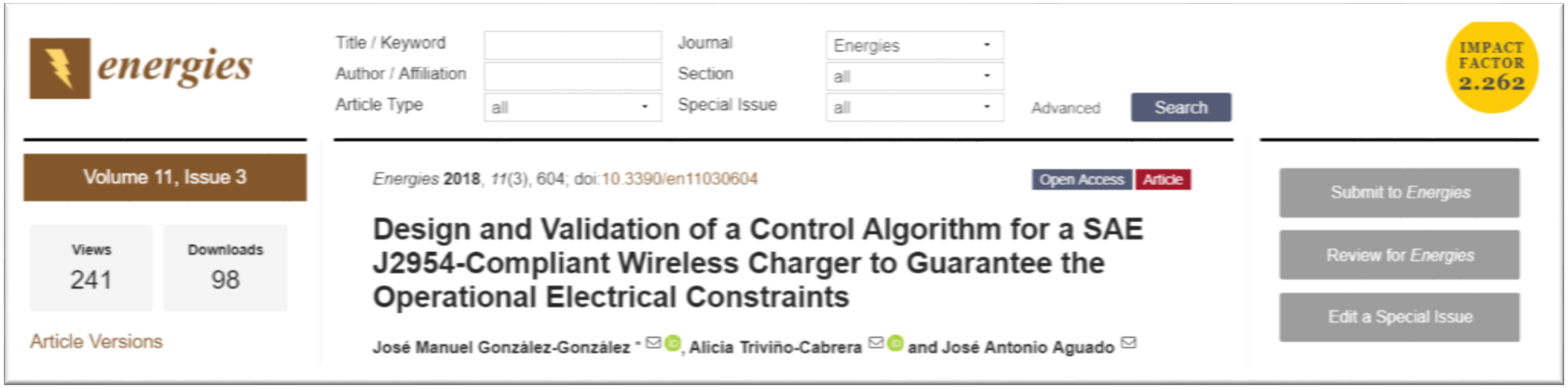
Control algorithm

Goals:

- To control the **power delivered** to the load while **restricting** some other electrical magnitudes.
- To work under **misalignments** conditions.

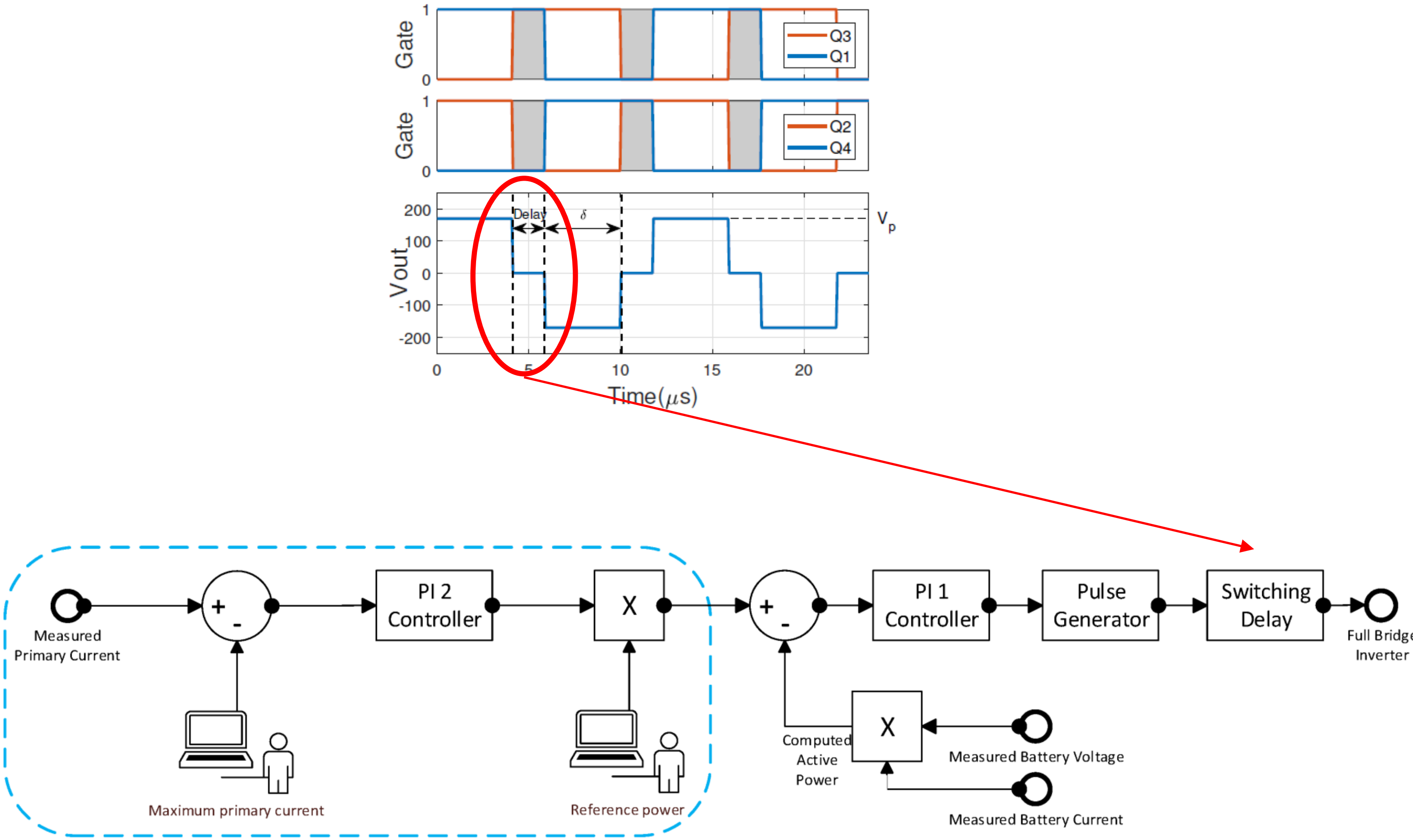
Primary current is clearly affected by misalignment



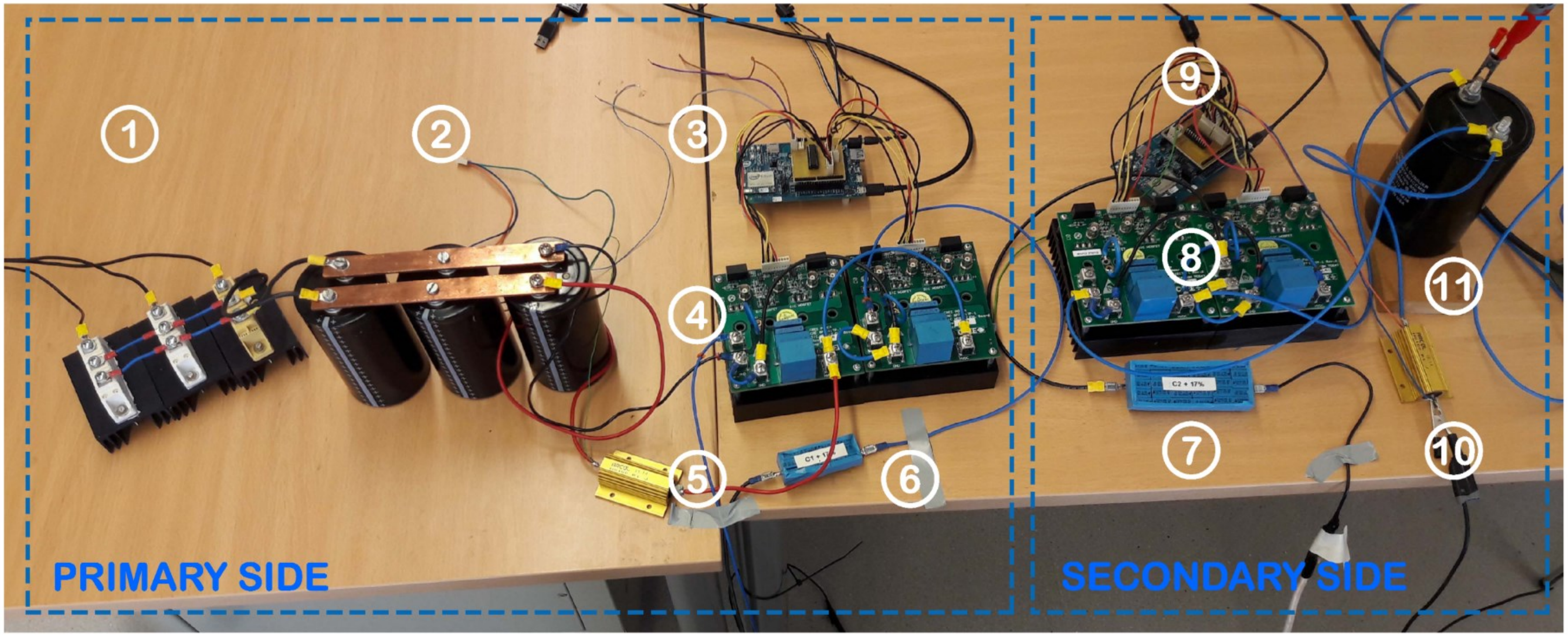


Control algorithm

A phase-shift technique is implemented:

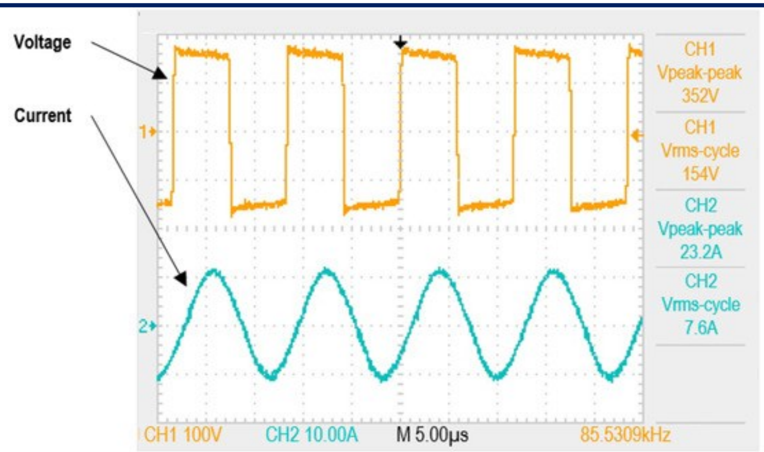


Implementation of the control algorithm



Control algorithm: results

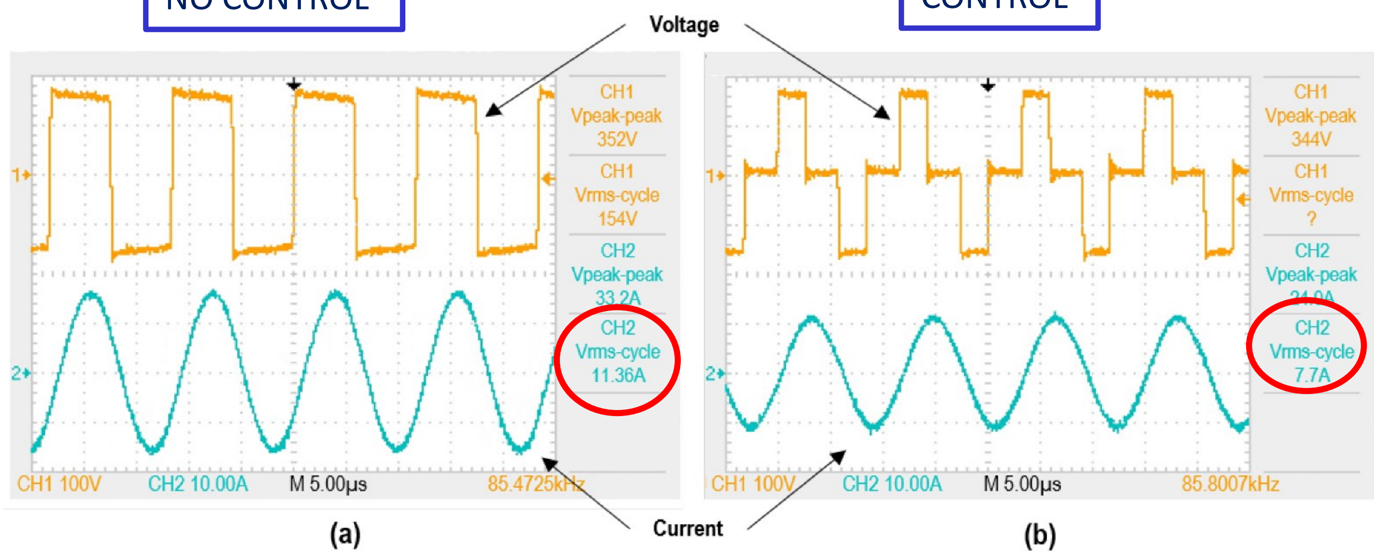
NO MISALIGNMENT



MISALIGNMENT

NO CONTROL

CONTROL



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Conclusions & Future work

- We have built a bidirectional 3.7-kW WPT system operating at 85 kHz (difficulty of the power electronics).
- Future work:
  - Control algorithms (misalignments, V2G services)
  - Communication systems

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