Integrated chargers for EVs

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The FUTURE and VESI seminar
Shard, London
14th January 2015

Presentation outline:

- Introduction
- Demonstrator 3 aims
- Three-phase charging
- Single-phase charging

1) Introduction

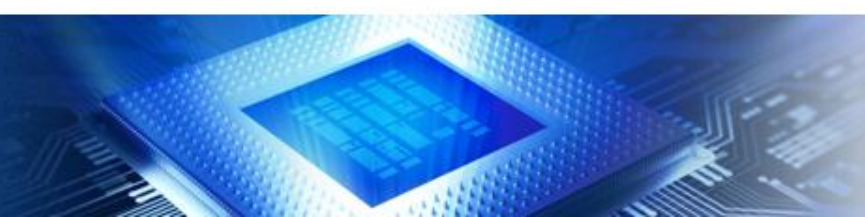machine   ac/dc   battery

1) Introduction

charger

battery

machine

ac/dc

1) Introduction
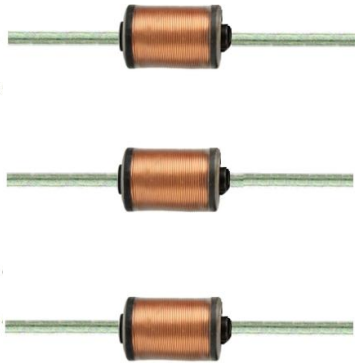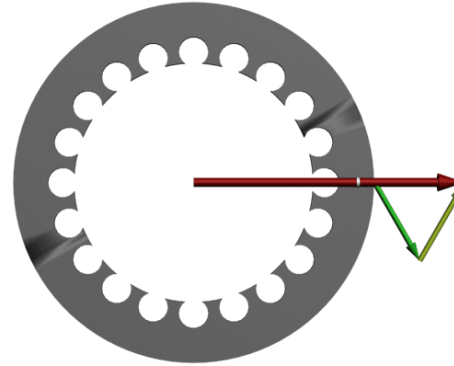

machine   ac/dc   battery

1) Introduction

machine

ac/dc
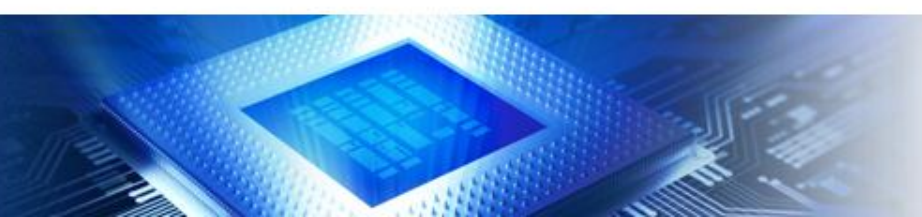
battery

2) Demonstrator 3 aims

9-phase machine

battery

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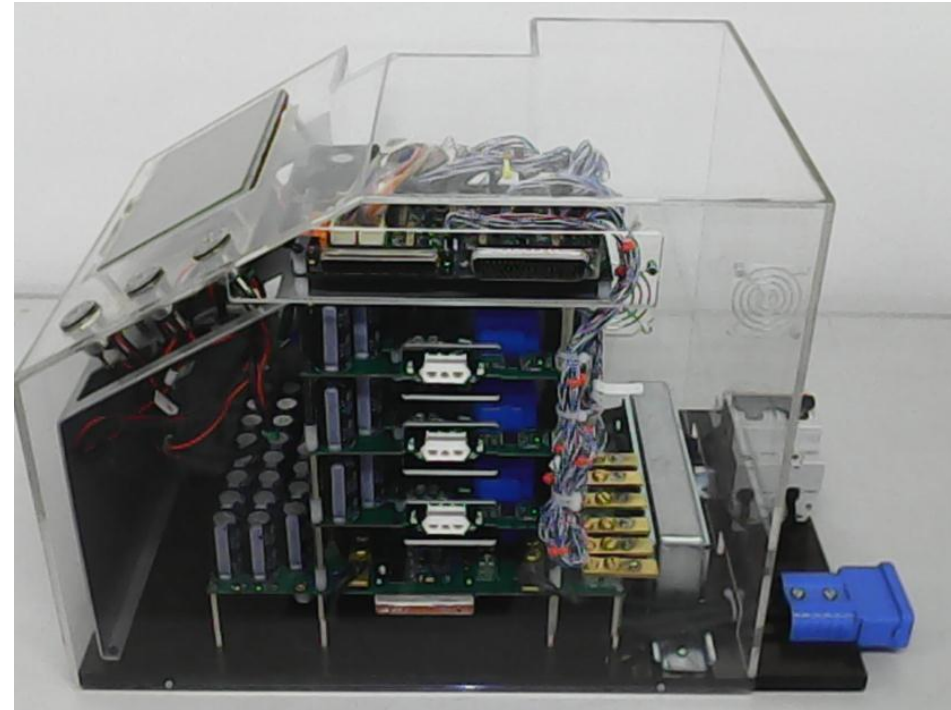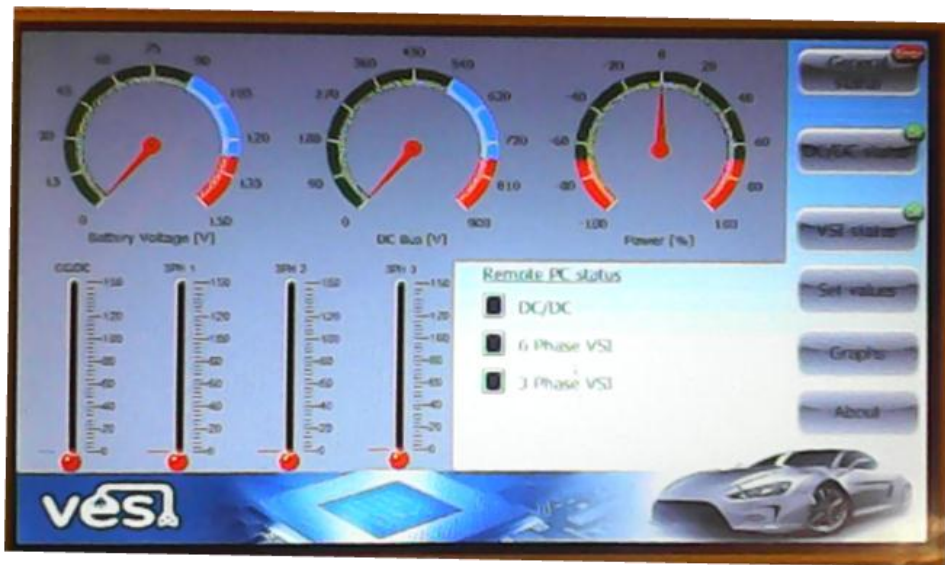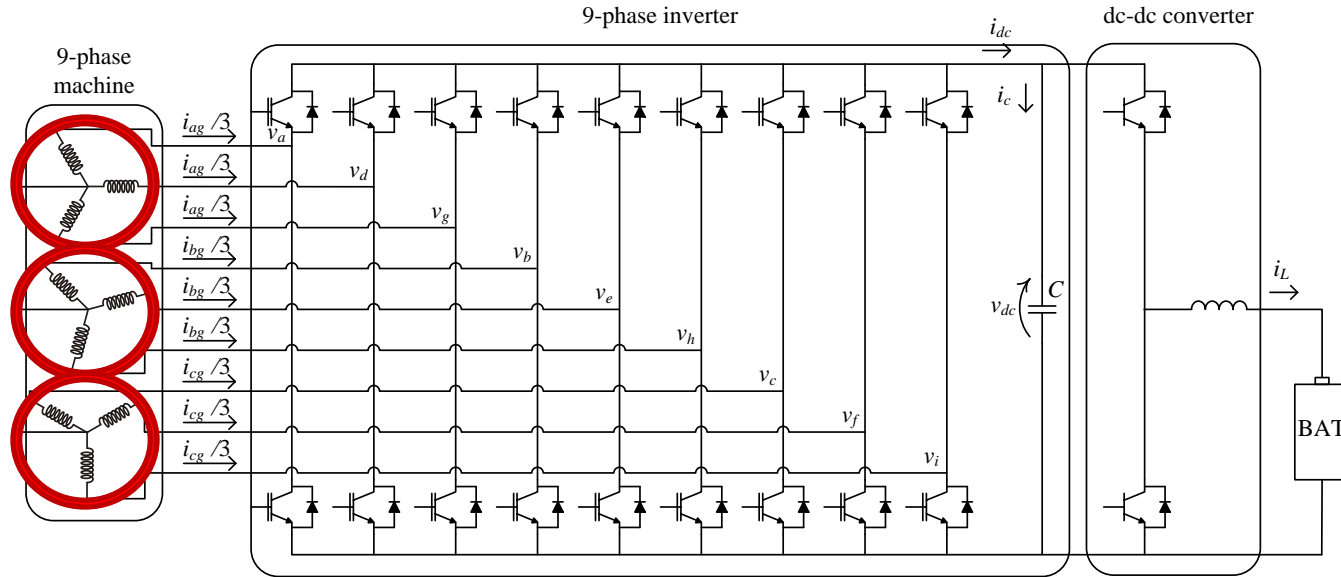

9-phase converter

control panel

UNIVERSITY OF
Southampton

microcontroler unit

GUI

3) Three-phase charging

9-phase machine

9-phase inverter

dc-dc converter

$i_{ag}/3$, $i_{ag}/3$, $i_{ag}/3$, $i_{bg}/3$, $i_{bg}/3$, $i_{bg}/3$, $i_{cg}/3$, $i_{cg}/3$, $i_{cg}/3$

v_a, v_d, v_g, v_b, v_e, v_h, v_c, v_f, v_i

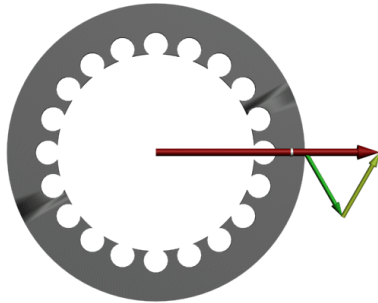i_{dc}, i_c, v_{dc}, C, i_L, BAT
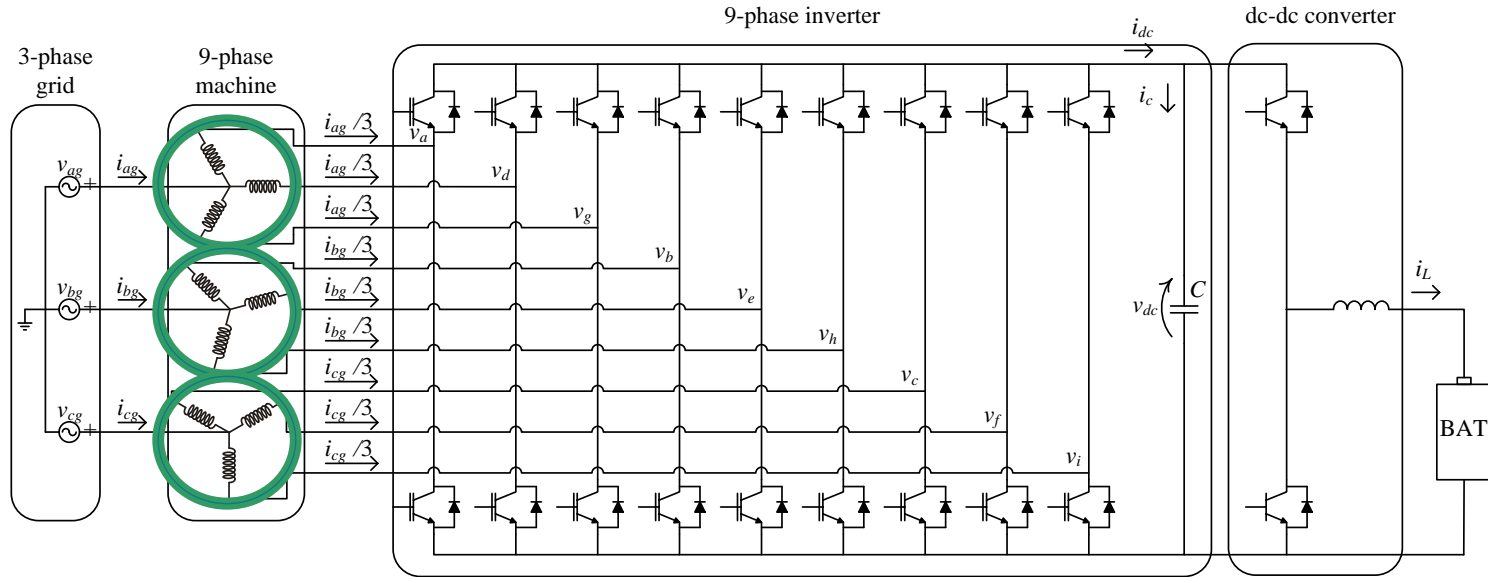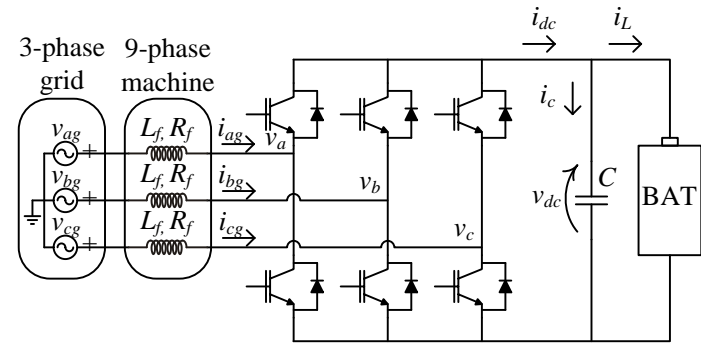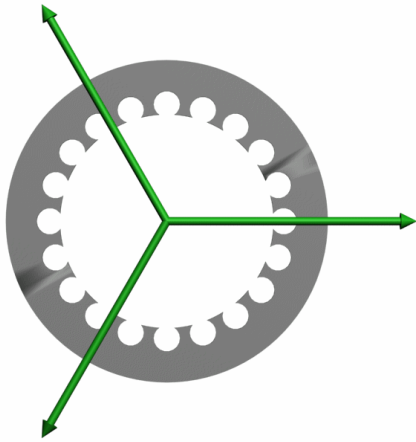
Integrated propulsion/charging topology

3) Three-phase charging
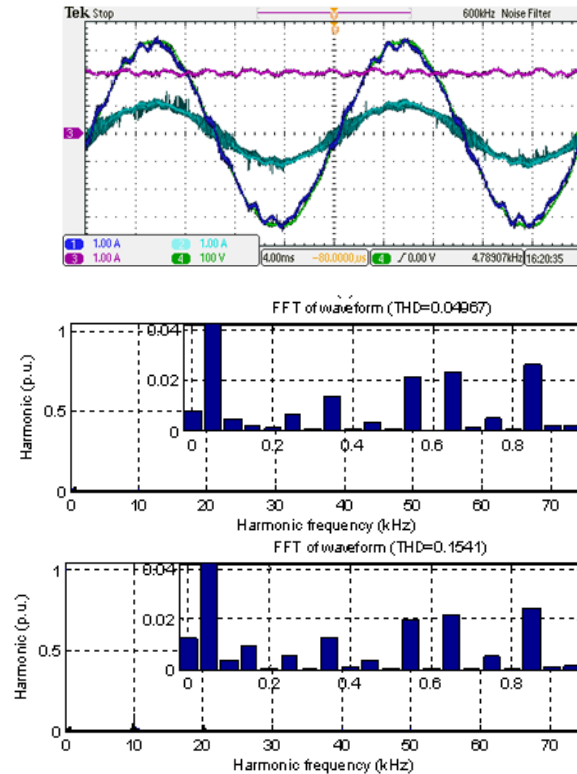

Integrated propulsion/charging topology
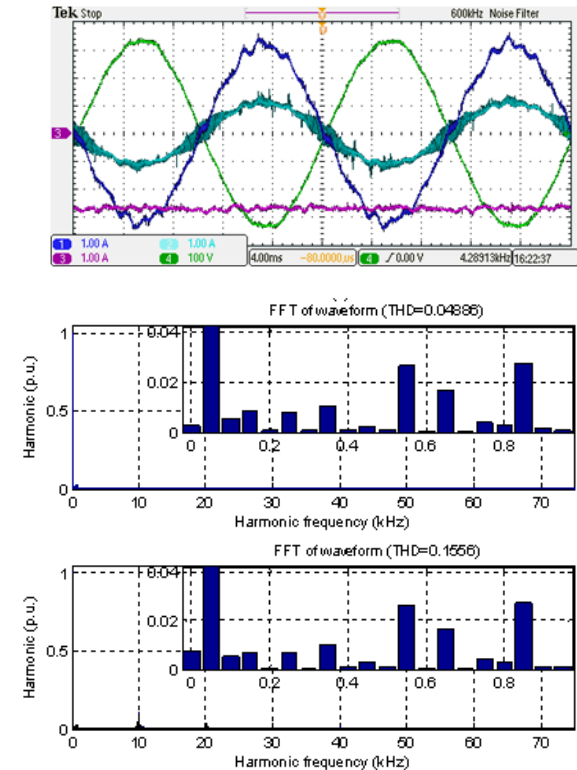

equiv. circuit

3) Three-phase charging

- In charging mode it can be seen that the current is in phase with the grid voltage, which confirms unity power factor operation.

- Spectrums of grid and machine current show very small low-order harmonics in both charigng and V2G mode.
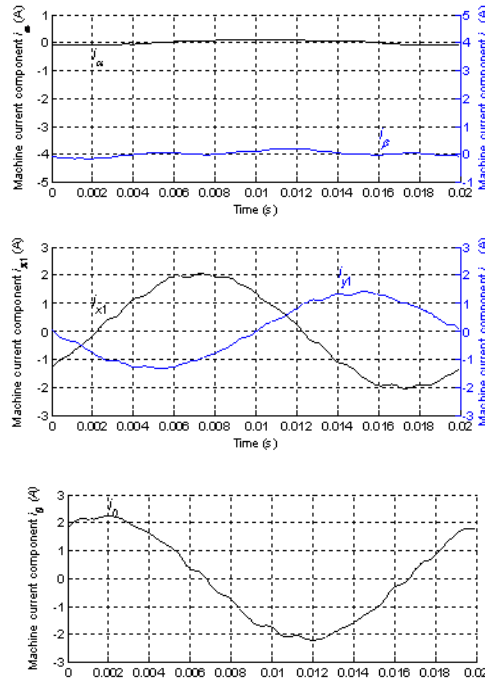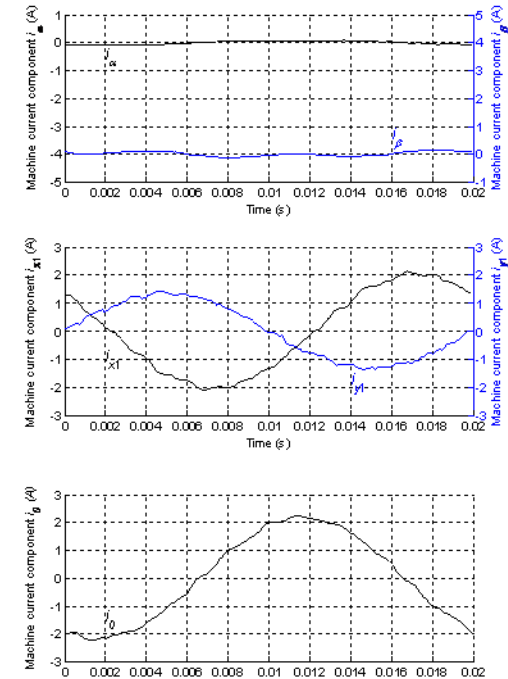
Charging mode

V2G mode

3) Three-phase charging

Charging mode V2G mode

- There is no excitation in the first plane of the machine, which confirms that a torque is not produced during the charging/V2G process.

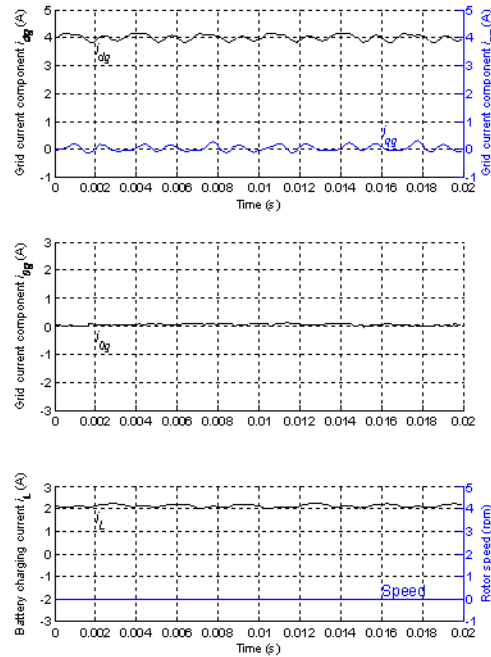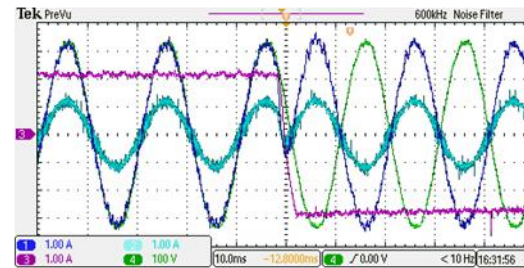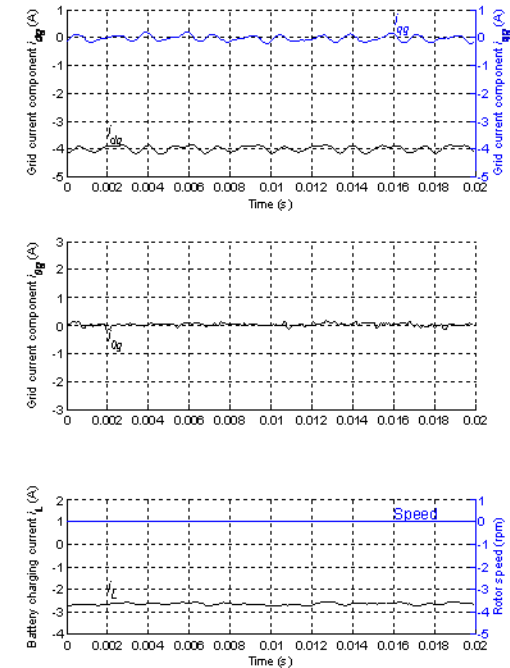- Excitation maps into the second plane and in zero-sequence.

3) Three-phase charging

- The grid current q-component is kept at zero, while the d-component is used for energy transfer.

- Machine does not rotate during the charging/V2G process.

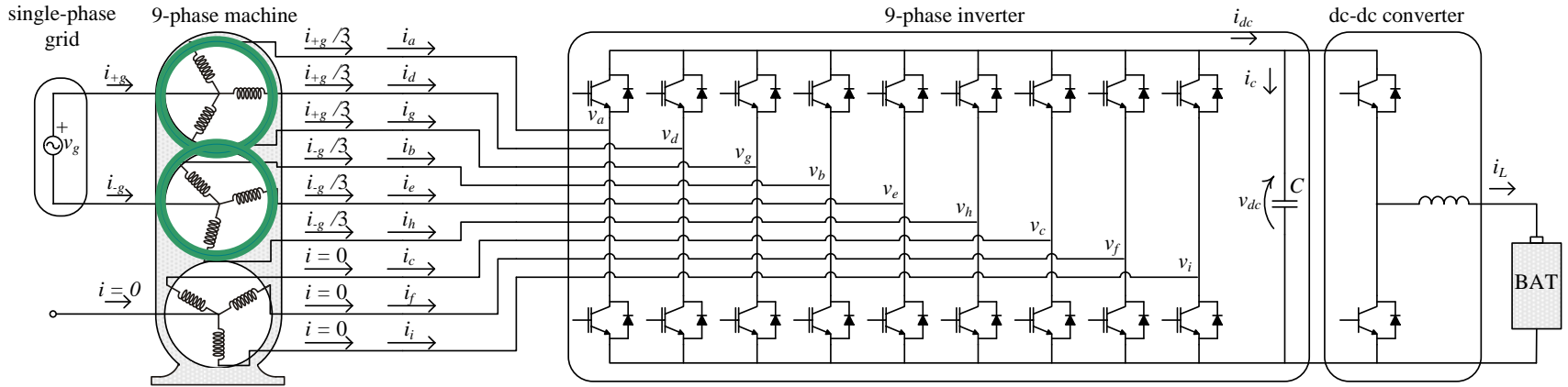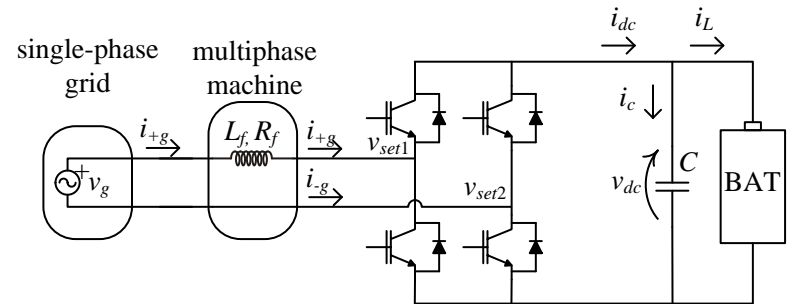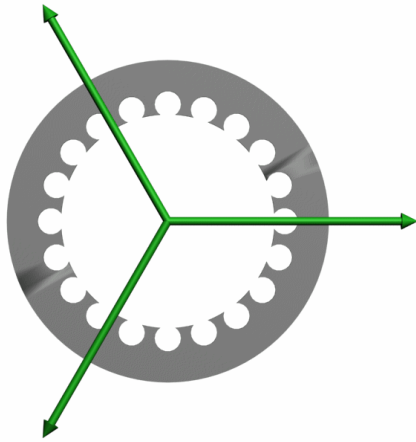- Transient from charging into V2G mode of operation is fast.

Charging mode

V2G mode

4) Single-phase charging

Integrated propulsion/charging topology

equiv. circuit

4) Single-phase charging

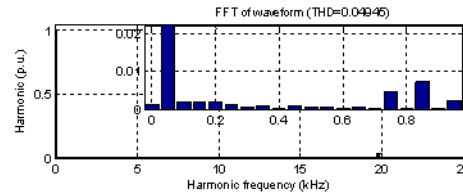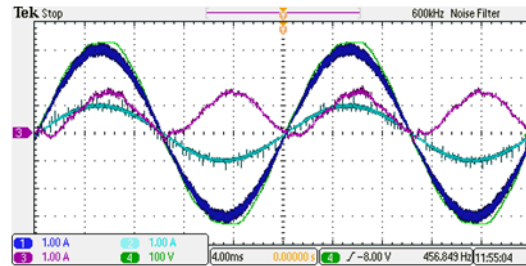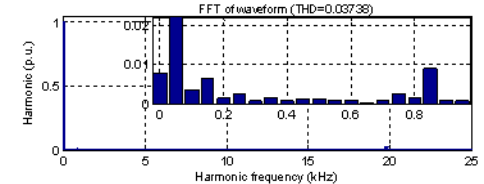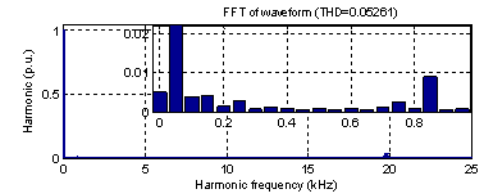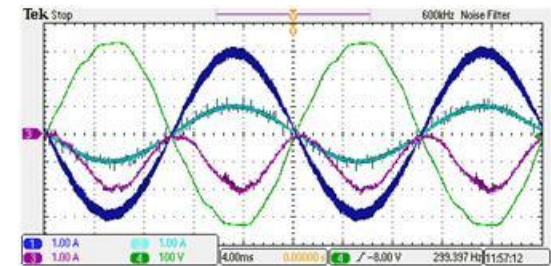- Again unity power factor is accomplished in both charging and V2G mode.

- Grid and machine curents spectrums demonstrate excellent current quality with low order harmonics below 1% of the fundamental.

Charging mode
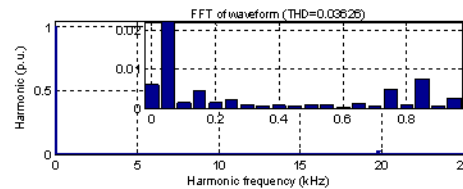
V2G mode

4) Single-phase charging

- It can be seen that the interleaving process singnificantly reduces grid current ripple.

- On the other hand, interleaving process increases machine current ripple

- Transient from V2G into the charging mode is almost instantaneous.

V2G mode with interleaving
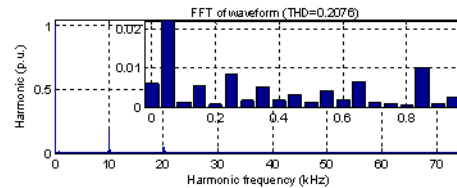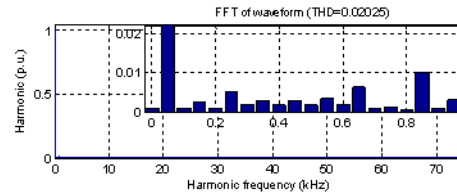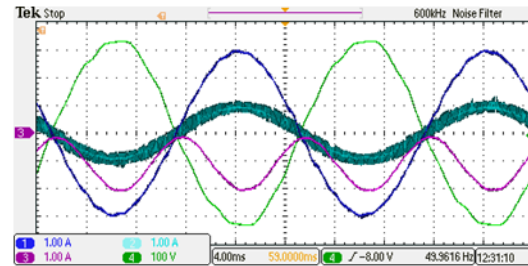
V2G mode

Experimental rig

grid   9-phase machine   9-phase converter   dc voltage source   resistor load   dSPACE
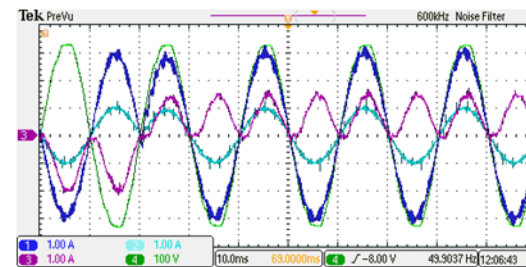
Conclusions

- Since in EVs propulsion and charging power-electronics components are never used simultaneously they can be replaced with a single component that is capable of performing both functions. The process is called integration and it has many benefits.
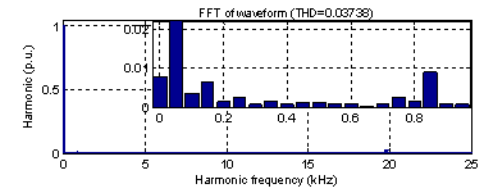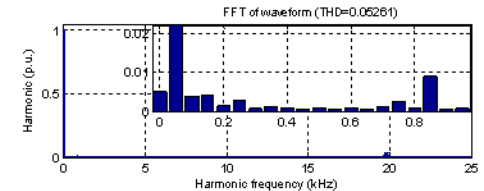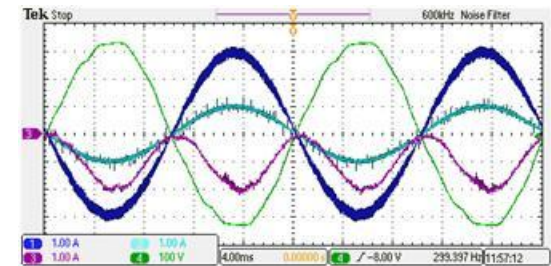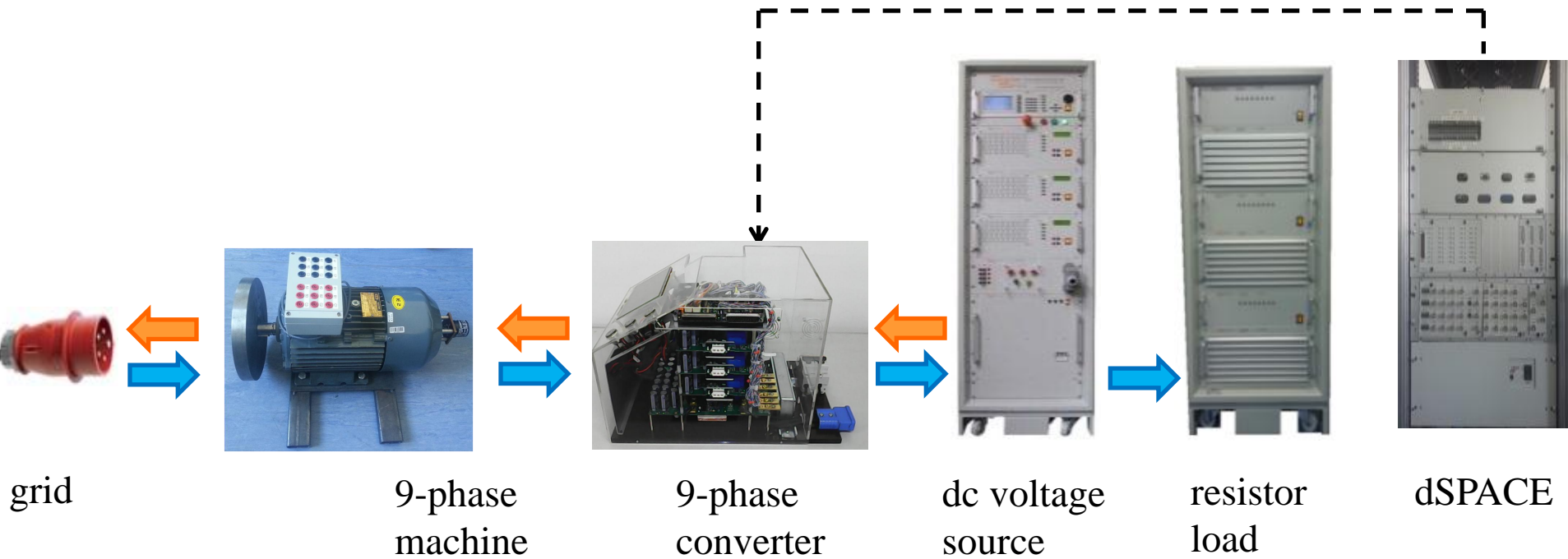
- The major obstacle against integration of a three-phase machine is torque production. Demonstrator 3 presents fully integrated nine-phase topology that does not have torque production during the charging/V2G mode. Moreover, it does not require any hardware reconfiguration between charging/V2G and propulsion mode of operation. It is capable of charging from both three-phase and single-phase grid.

- Experimental rig is developed. Preliminary experimental results demonstrate unity power factor operation in both three-phase and single-phase charging/V2G mode. Control achieves currents with excellent quality. A torque is not produced in the machine during the experiments.

Thank you

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