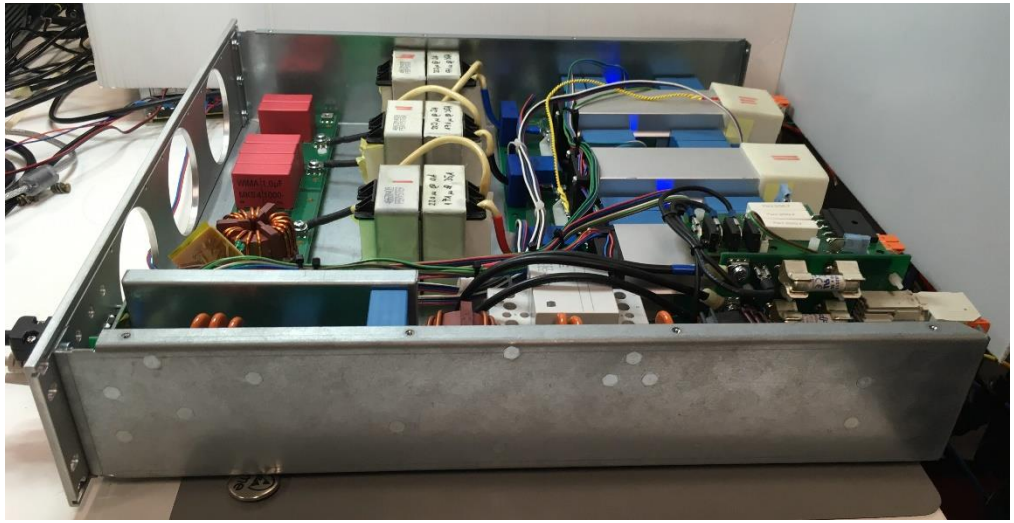
Vienna rectifier as an input stage of the EV charger

mgr inż. **Grzegorz WRONA**



Outline

- Introduction
- EV charging system
  - 20 kVA Vienna rectifier
- System description
- Control algorithm
- Experimental results
  - scope records
  - power losses/efficiency measurements
  - power quality measurement
- Conclusion

Introduction

Developed EV charger

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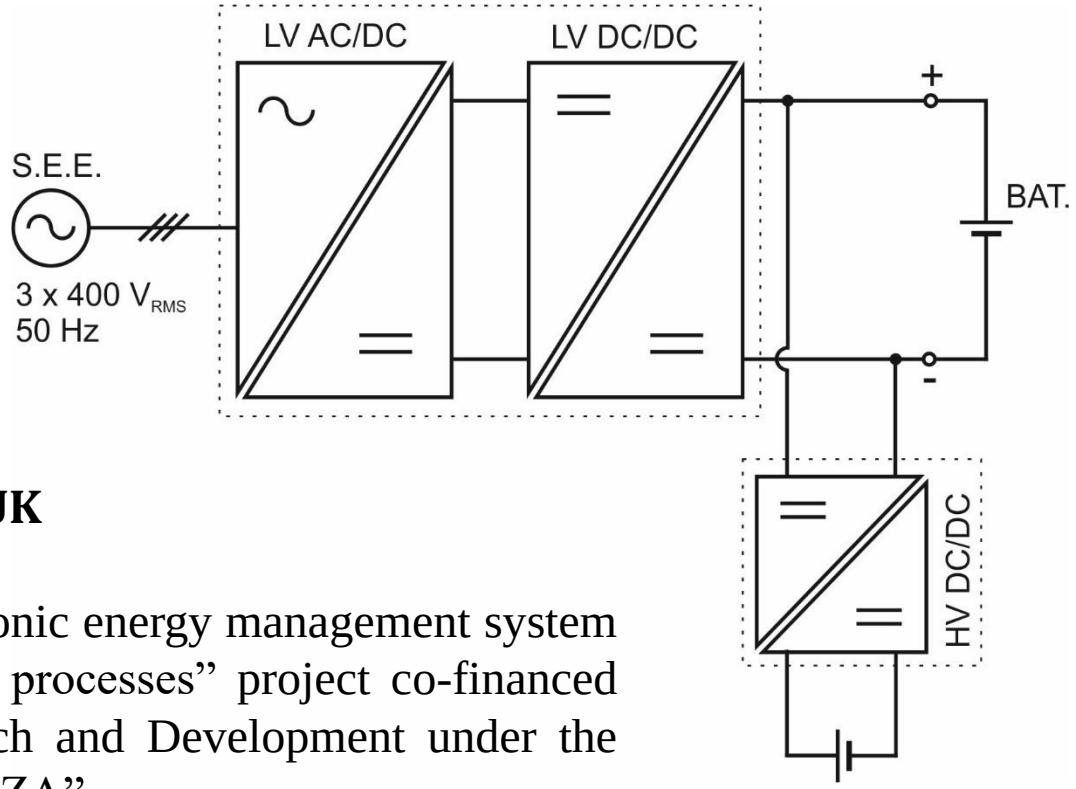

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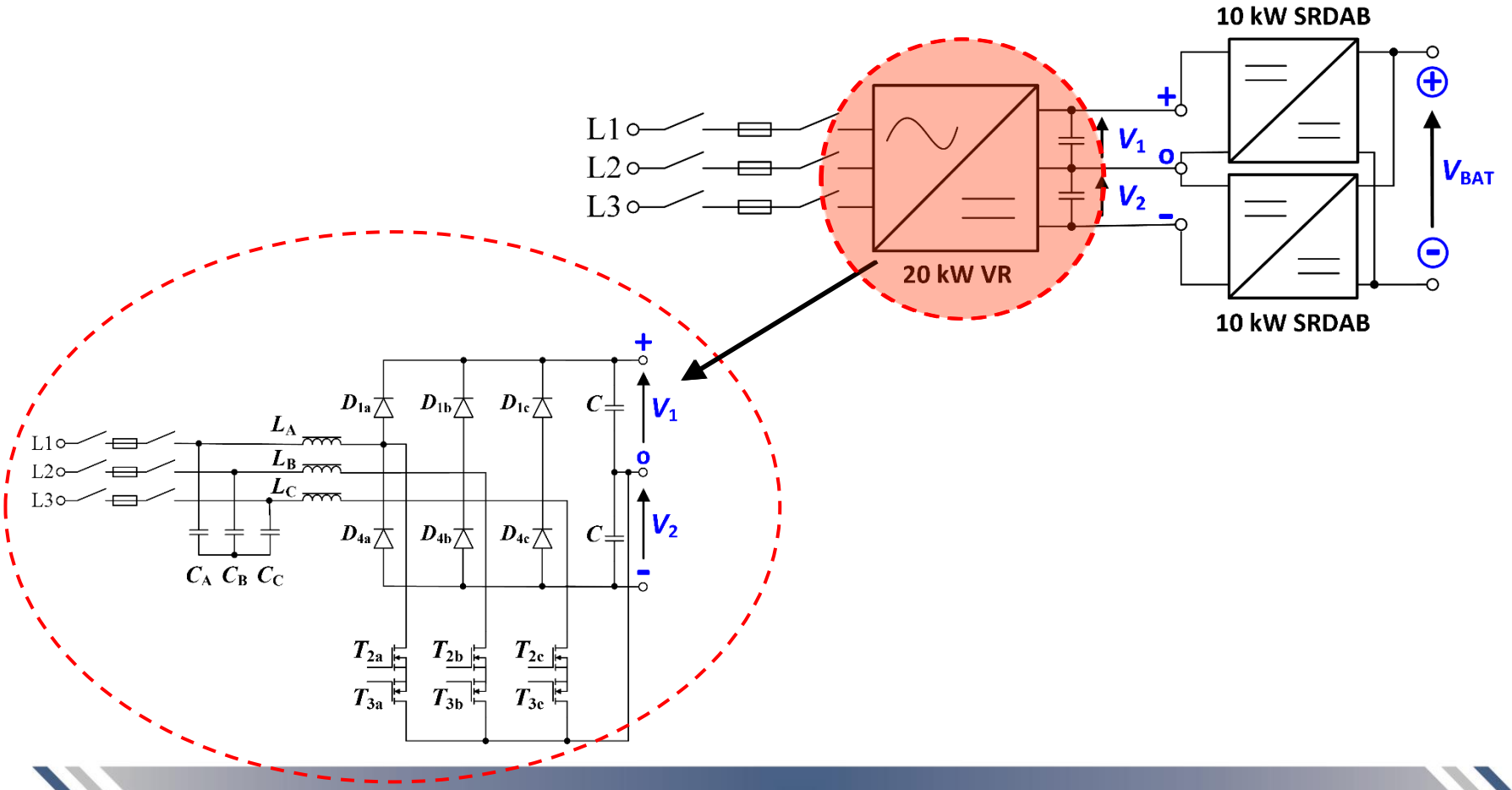
Narodowe Centrum Badań i Rozwoju

MARKEL energoelektronika to nasza pasja

Rzeczpospolita Polska

Introduction

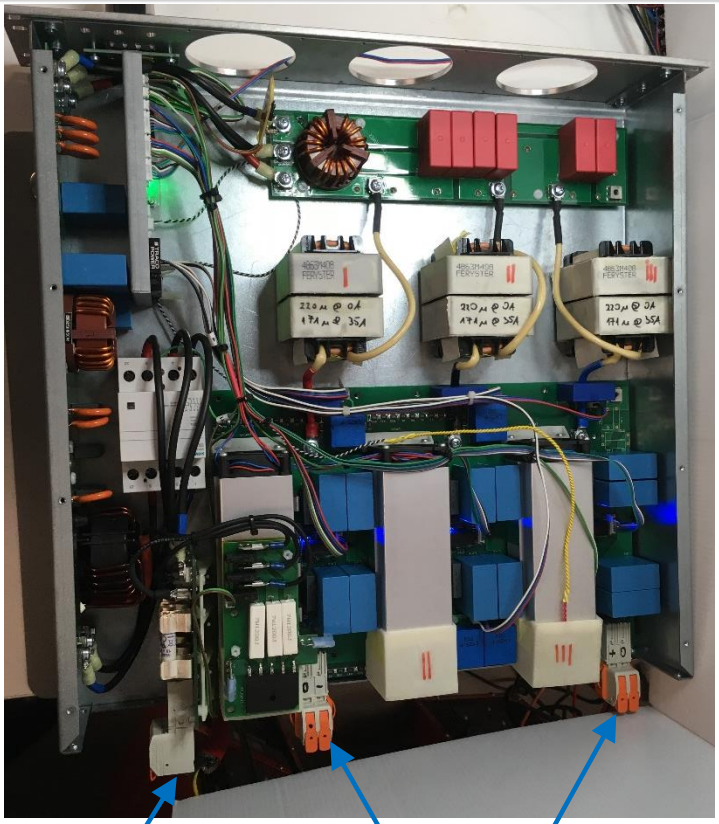
Developed EV charger



Demonstrator

Vienna rectifier

- Three phase, three level topology
- Unity power factor
- Unidirectional power flow
- Low complexity

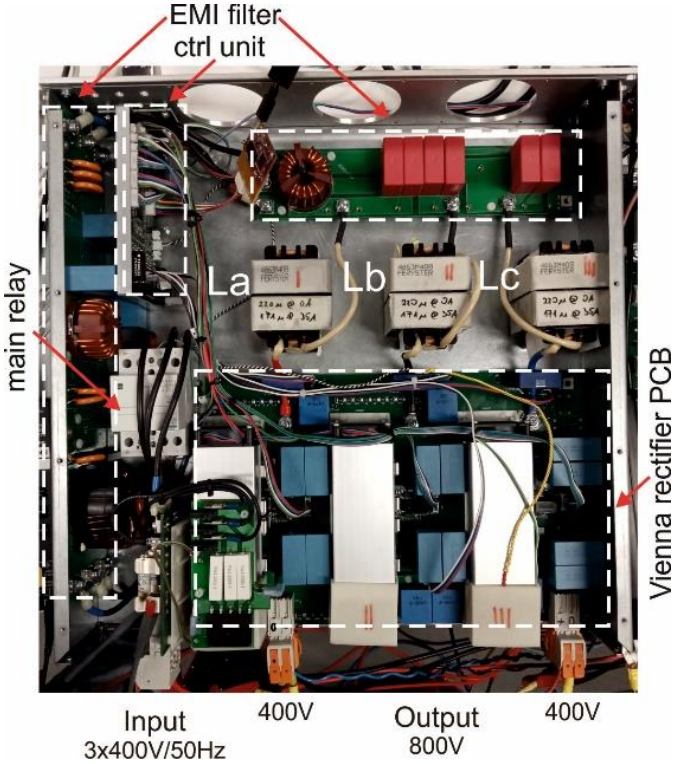


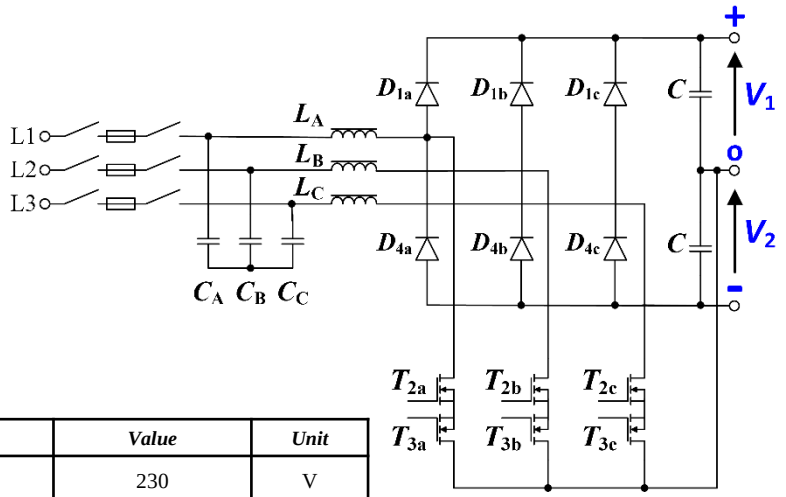
Grid supply
3x400V/50Hz

800 V (2x400V)

Demonstrator

Vienna rectifier



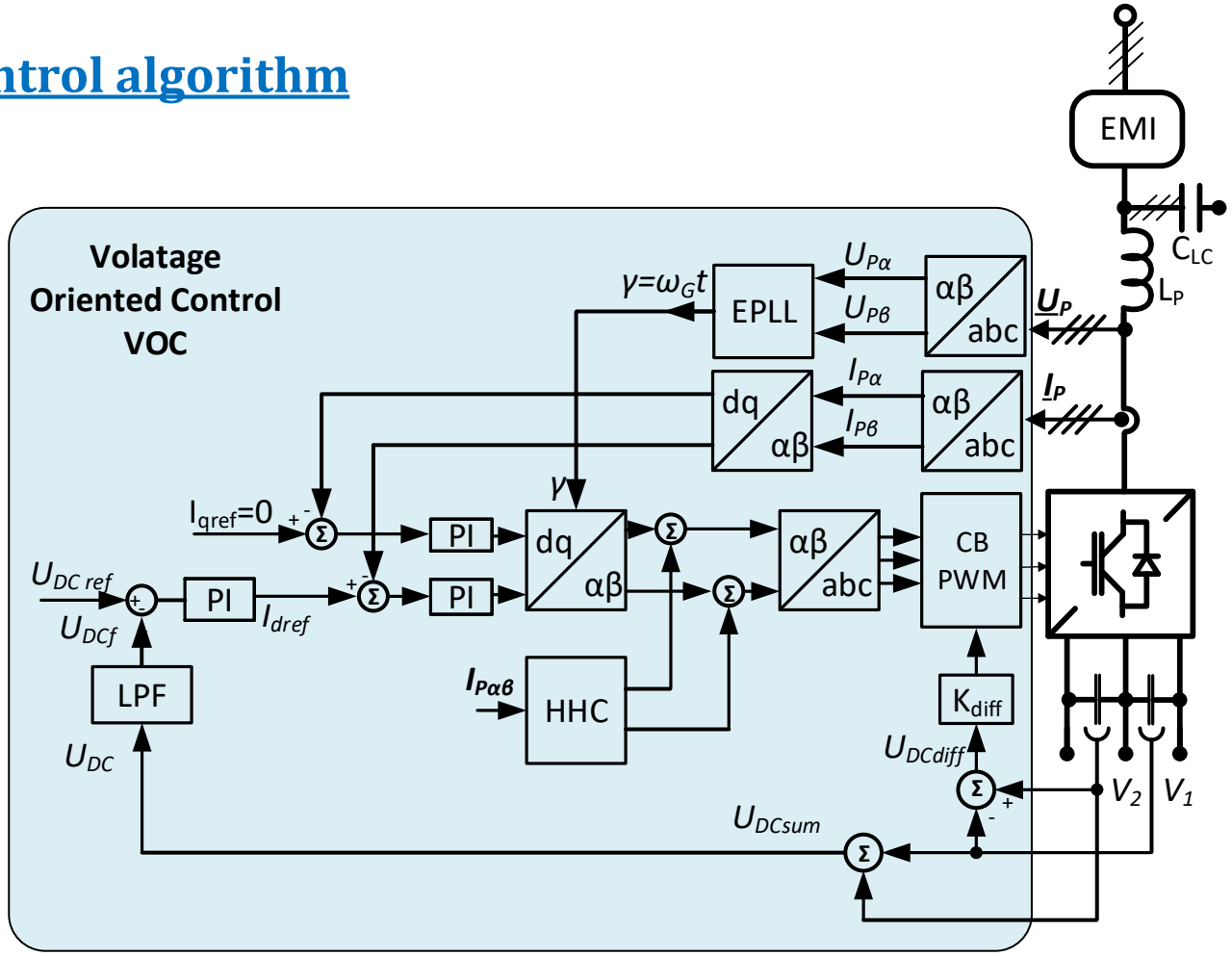


Symbol	*Parameter*	*Value*	*Unit*
L1, L2, L3	Phase voltages	230	V
V_1, V_2	Output voltages	400	V
S_n	Rated power	20	kVA
f_s	Switching frequency	66	kHz
T_{2a}, T_{2b}, T_{2c}, T_{3a}, T_{3b}, T_{3c},	SiC MOSFETs	C3M0030090K	-
D_{1a}, D_{1b}, D_{1c}, D_{4a}, D_{4b}, D_{4c},	Diodes	STPSC20H12	-
L_A, L_B, L_C	Input filter inductors	220	µH
C_A, C_B, C_C	Input filter capacitors	2	µF
C	DC-link capacitors	180	µF

Demonstrator

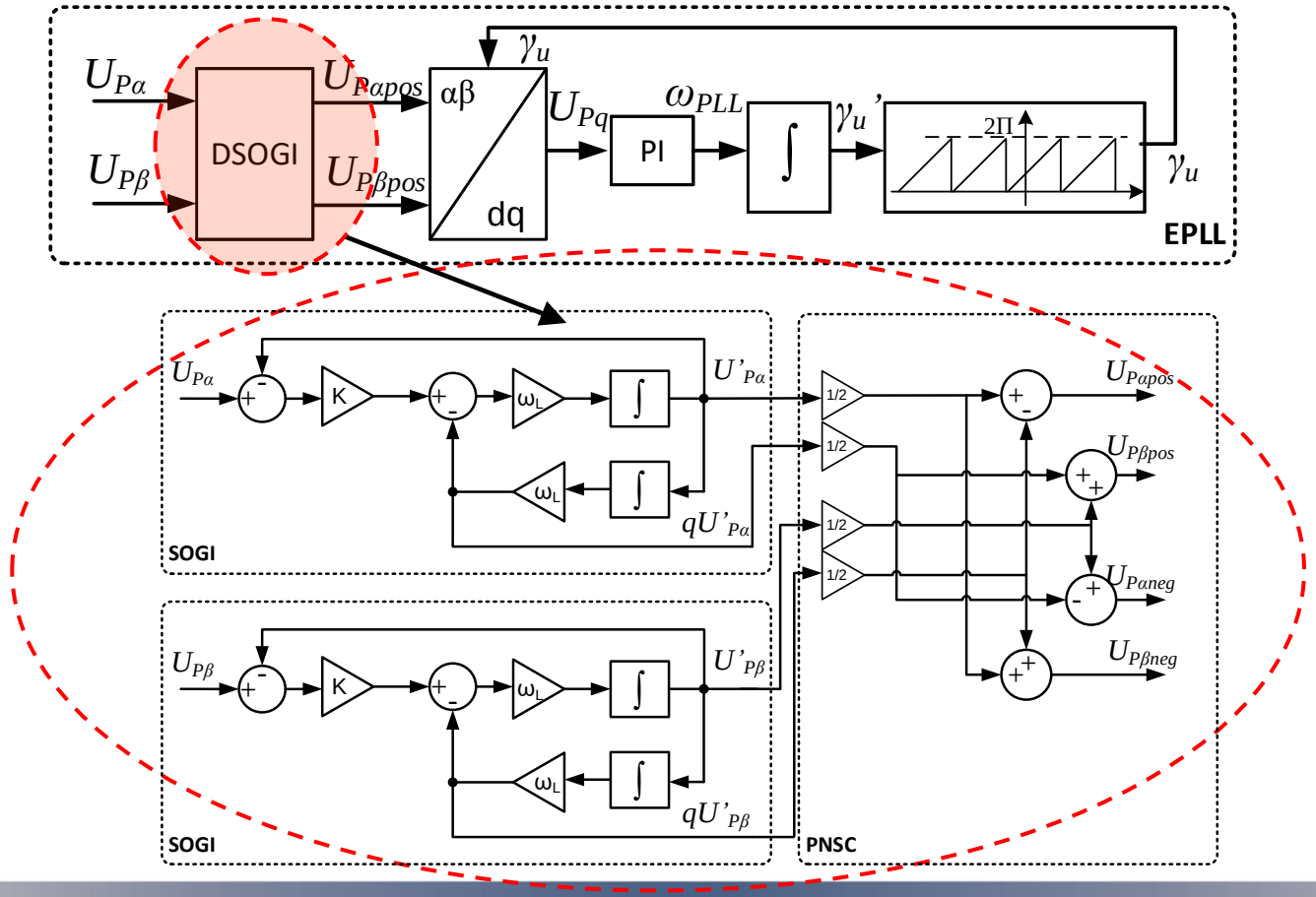
Vienna rectifier – control algorithm

- VOC
- EPLL
- HHC



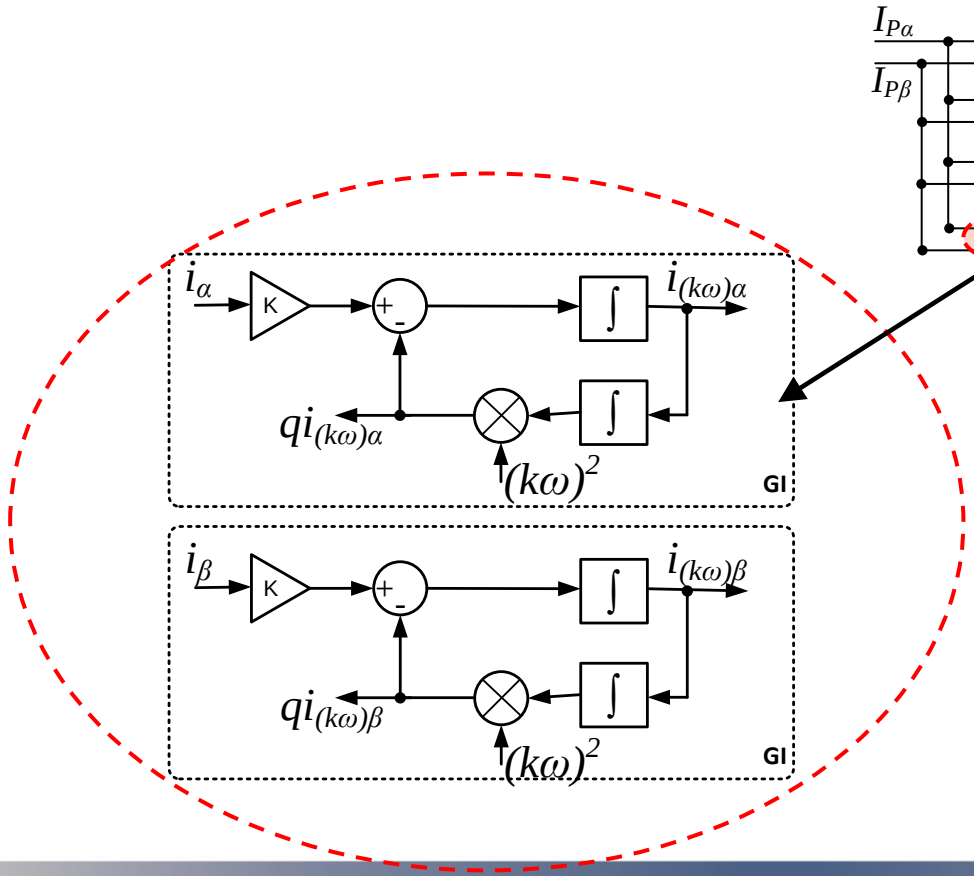
Demonstrator

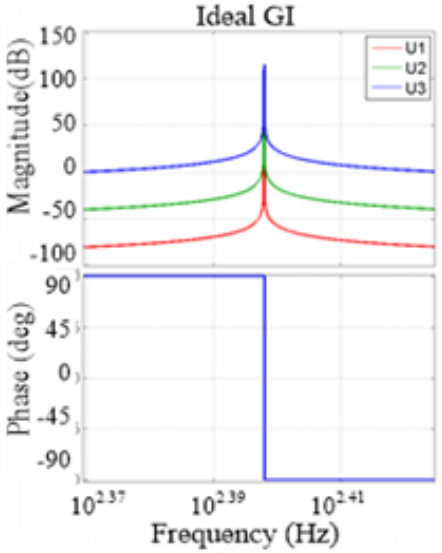
Vienna rectifier – control algorithm – extended phase locked loop EPLL



Demonstrator

Vienna rectifier – control algorithm – higher harmonics compensator HHC





Experiments

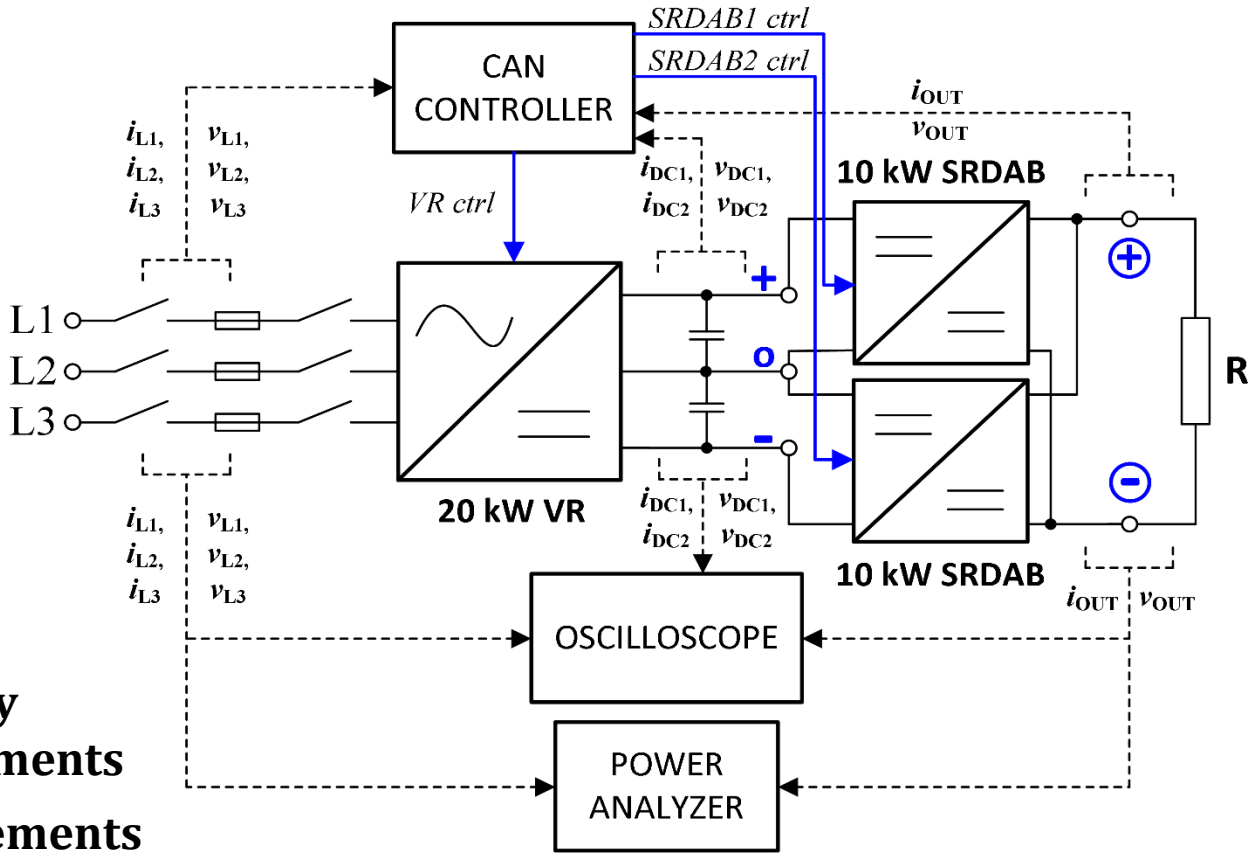
Laboratory setup

Parameters

P_N = 20 kVA

V_{in} = 3x400 Vac/ 50 Hz

V_{out} = 800 Vdc



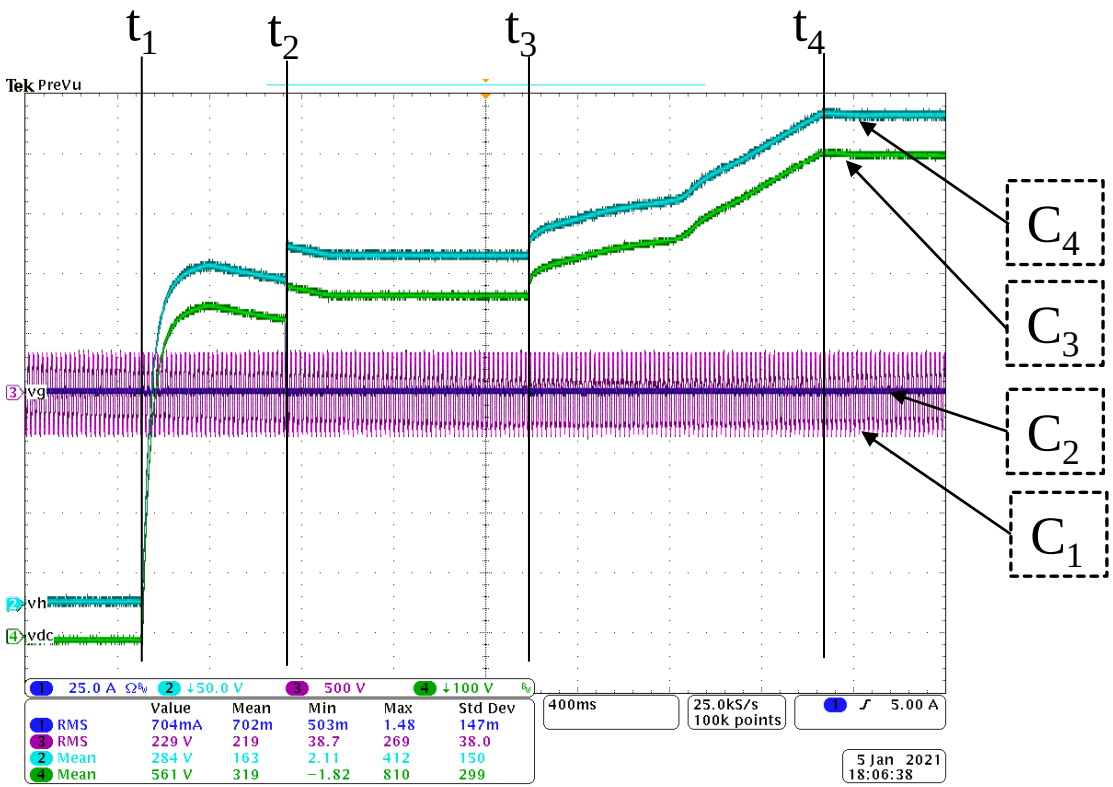
Measurements:

- **scope records**
- **power losses/efficiency measurements**
- **power quality measurements**

Experiments

Scope records

Start-up procedure



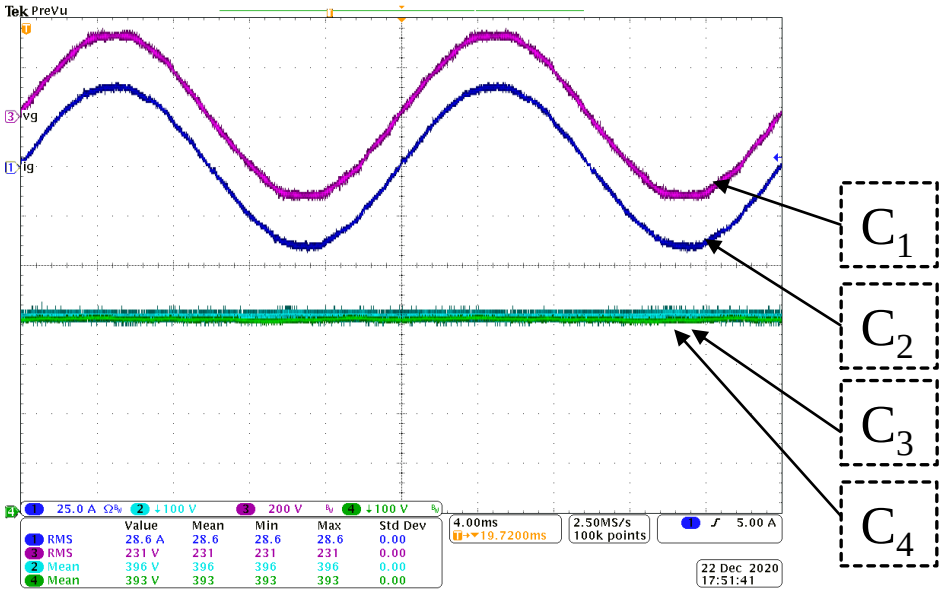
C1 – one of the three-phase grid voltages
C2 – one of the three-phase grid currents
C3, C4 – Vienna rectifier DC-link capacitor voltages

$<t_1$: grid parameters checking
$t_1 \div t_2$: charging capacitors of VR
t_2: the main switch turns ON
$t_3 \div t_4$: start of VR operation (output voltages regulation)
$t_4 \div t_5$: DC link capacitors charging
$>t_5$: rated DC link voltage; end of start-up

Experiments

Scope records

Steady-state operation



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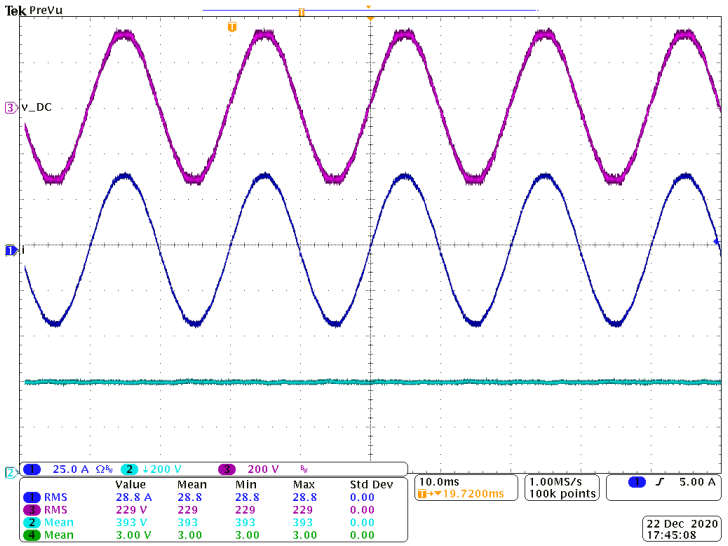
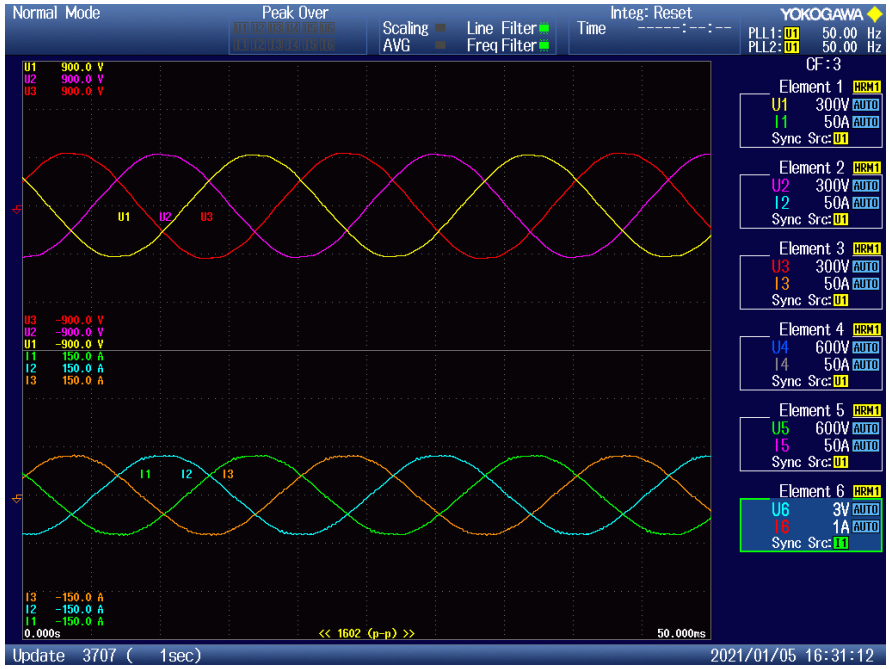


Experiments

Power quality measurements

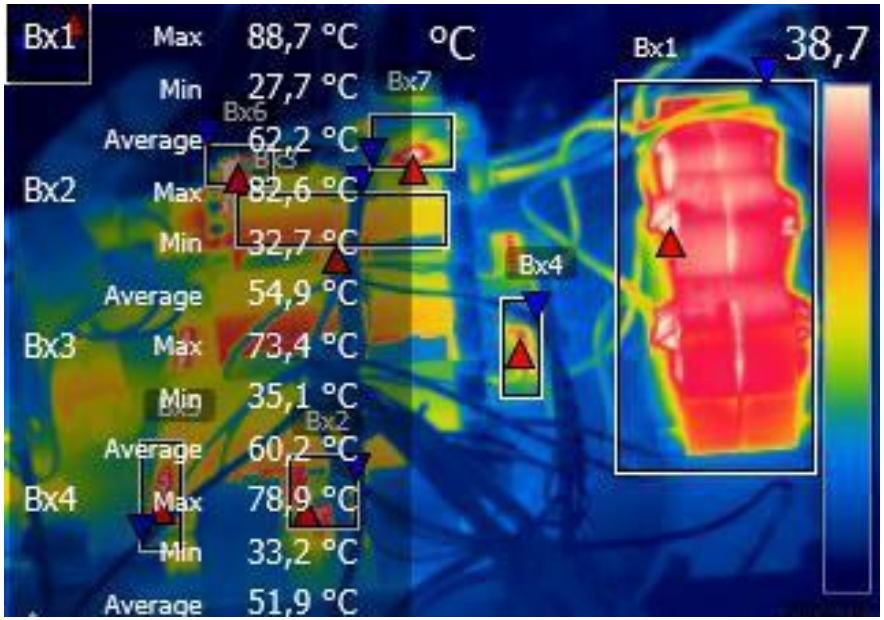
Selected screenshots



Experiments

Thermal measurements /efficiency

Selected screenshots



Conclusion

- experimental validation of a 20 kW rated SiC-based EV charger has been shown:
- Vienna rectifier has been built in 2U rack system
- at the nominal power overall efficiency of the charger was measured at over 98%
- power quality of input waveforms was at an acceptable level reaching about 1.6% of the THD index

… Thank you for your attention.