Norway
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Three-level ANPC converter at medium voltage – control scheme and experimental results

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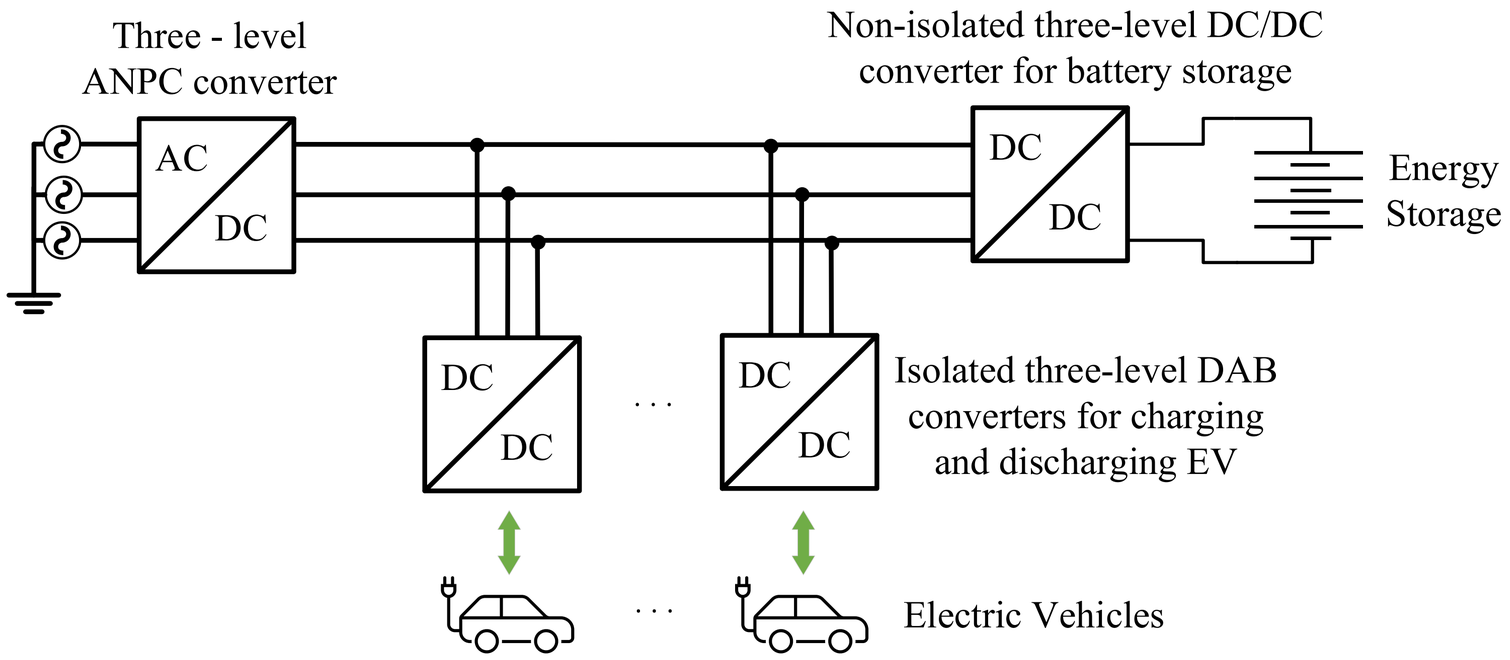
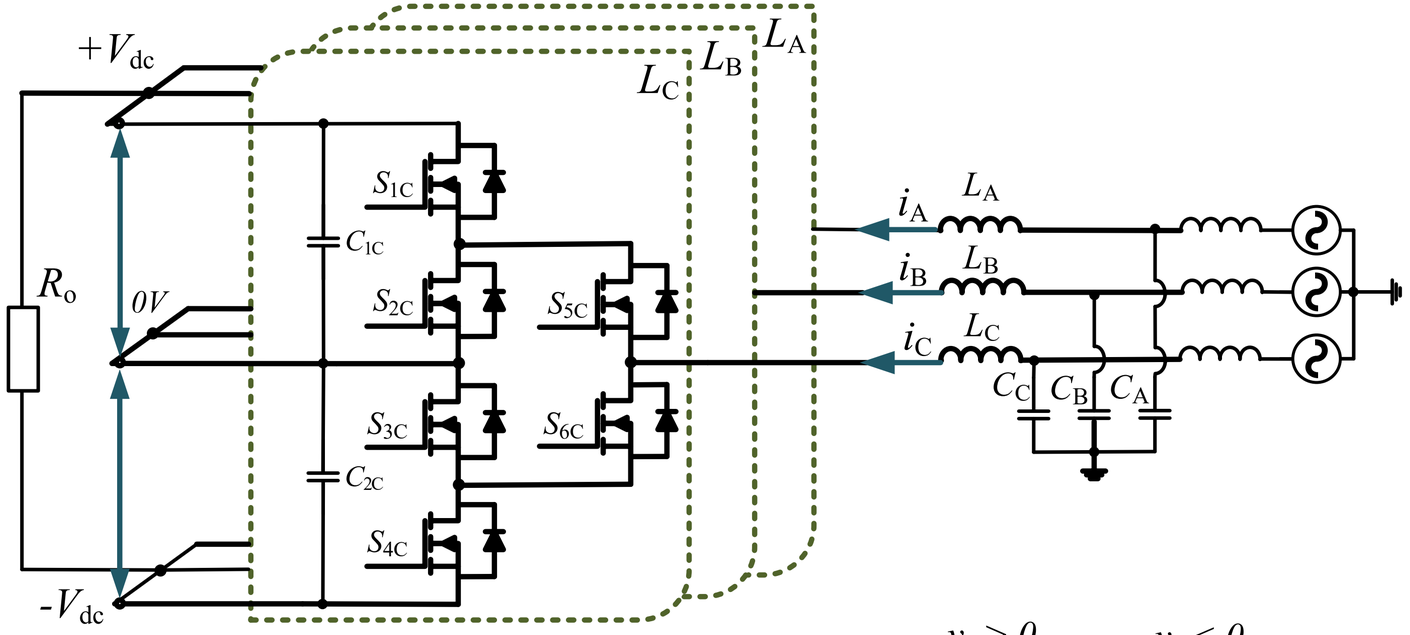
Advanced charging system with bipolar DC-link and energy storage

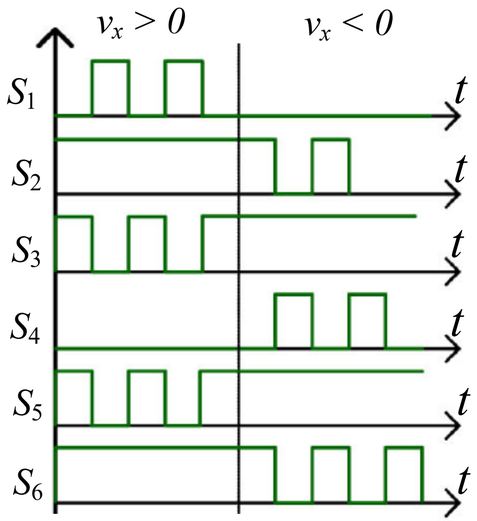


- The project is carried out under MoReSiC system (Modularized, Reconfigurable and Bidirectional Charging Infrastructure for Electric Vehicles with Silicon Carbide Power Electronics)
- **One type of three-level power module used in each converter**
- 1.5 kV dc-link voltage

ANPC converter – control strategy

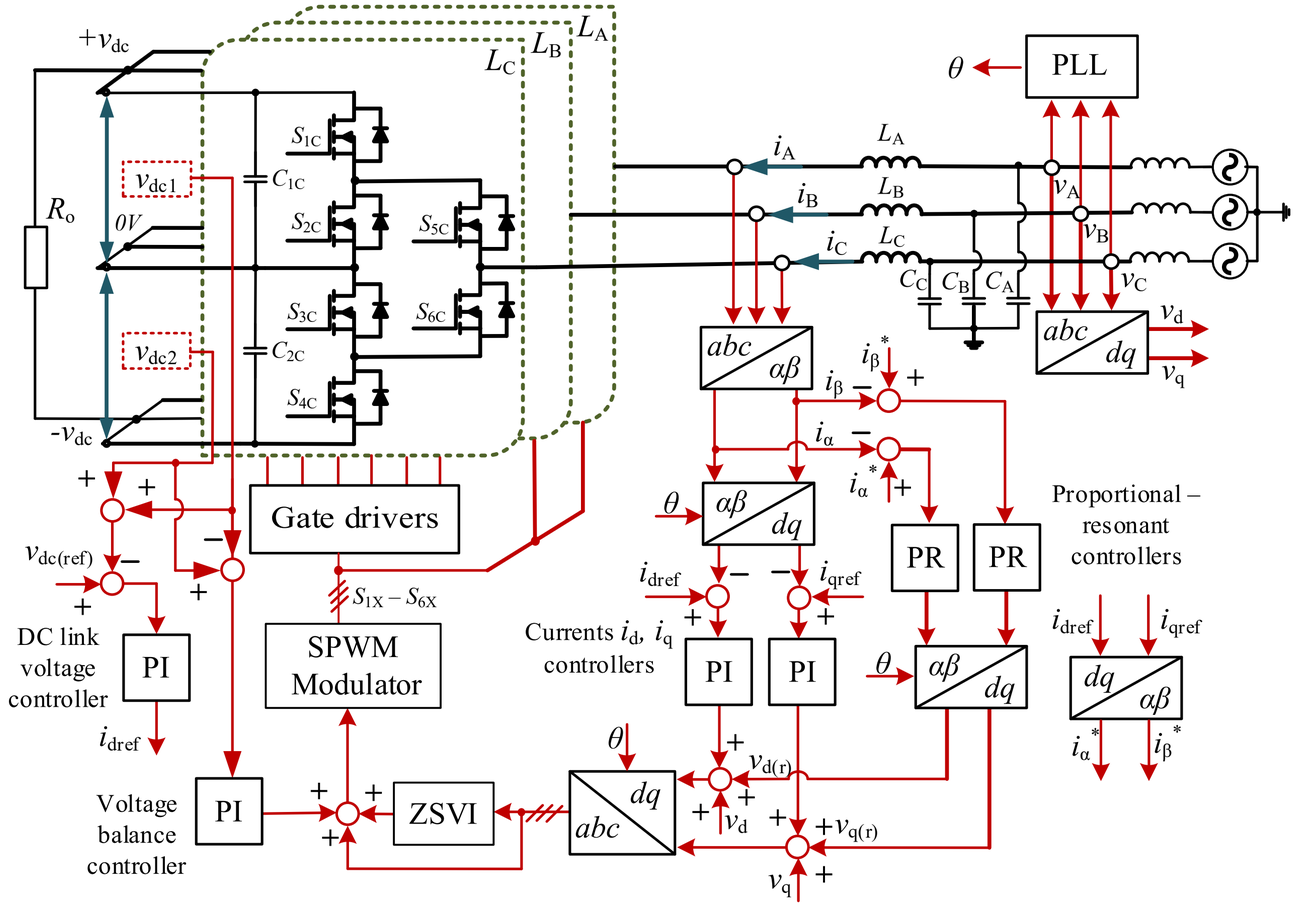


switch \ state	$-V_{dc}$	0 V	$+V_{dc}$
S_1	0	0	1
S_2	0	1	1
S_3	1	1	0
S_4	1	0	0
S_5	1	1	0
S_6	0	1	1



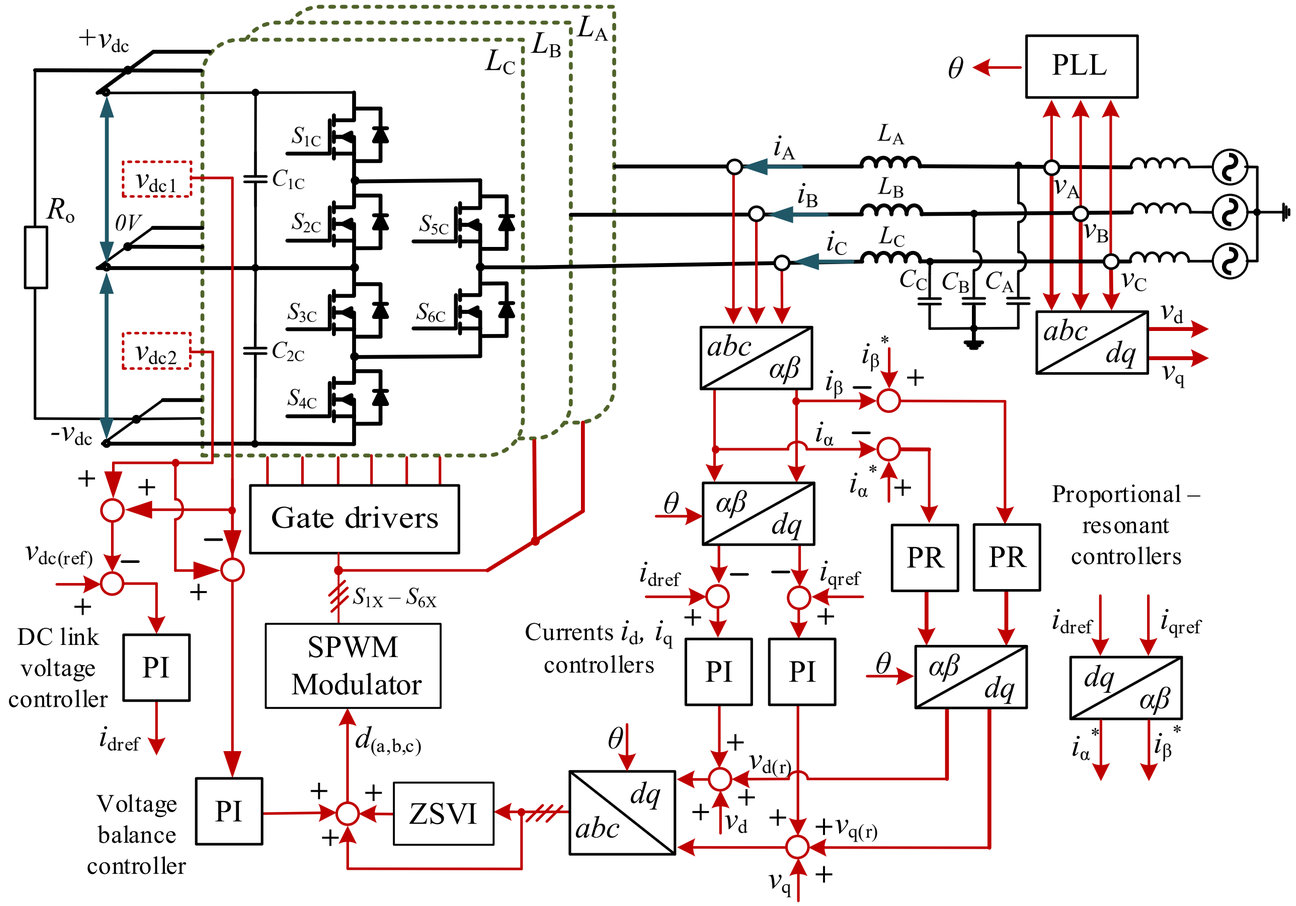
- Utilization a three-level structure allow to use input filter with lower volume, improve efficiency and reduce maximum voltage on transistors
- SiC with breakdown voltage 1.2 kV and dc-link 1.5 kV
- LC filters
- All transistors (SiC) are switched with high frequency

ANPC converter – control strategy



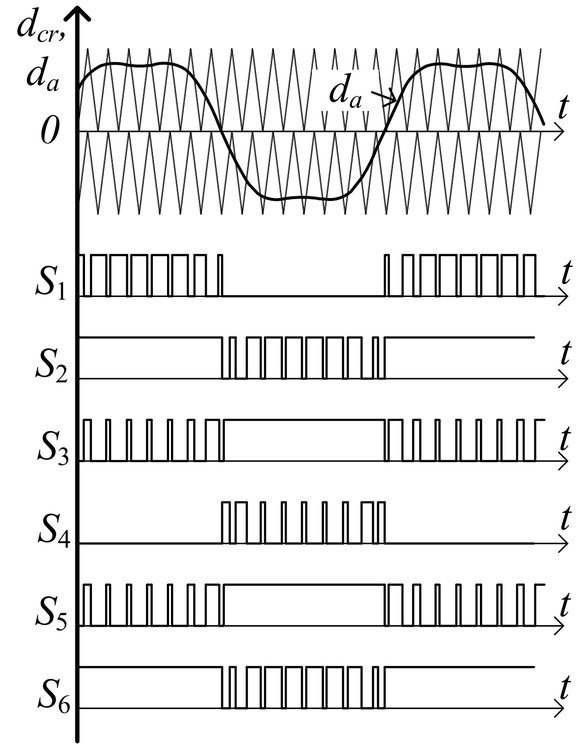
- SPWM (sinusoidal pulse width modulation) with ZSVI (zero sequence voltage injection) modulation
- PR (proportional – resonant) controllers for 5th, 7th, 11th and 13th harmonic of fundamental frequency
- PI controller for balance voltages on dc-link capacitors

ANPC converter – SPWM + ZSVI



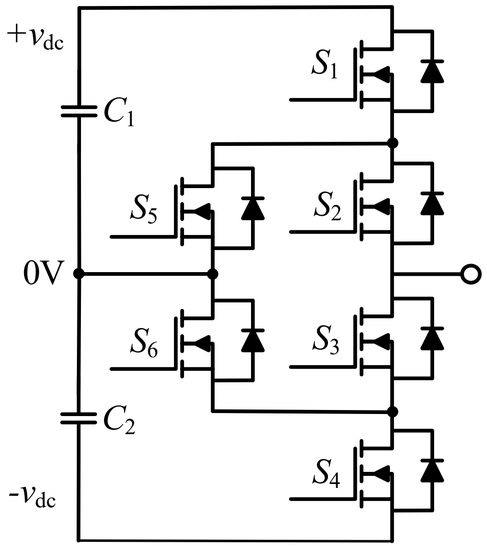
- SPWM (sinusoidal pulse width modulation) with ZSVI (zero sequence voltage injection) modulation

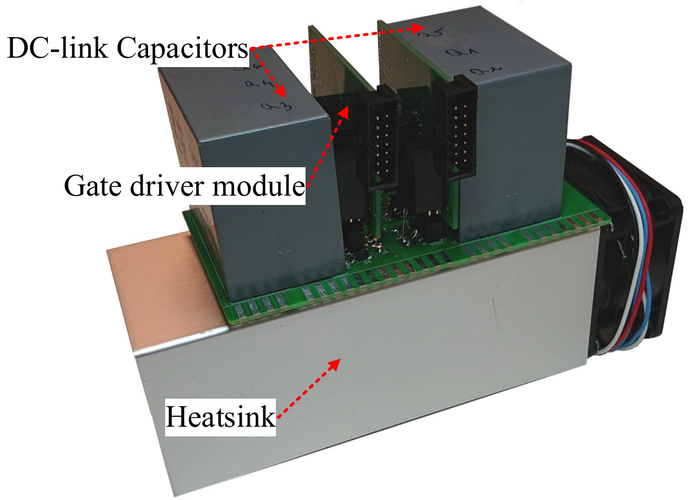
$$d_a = M\left[\cos(\omega_m t) + \frac{\cos(3\omega_m t)}{3}\right]$$



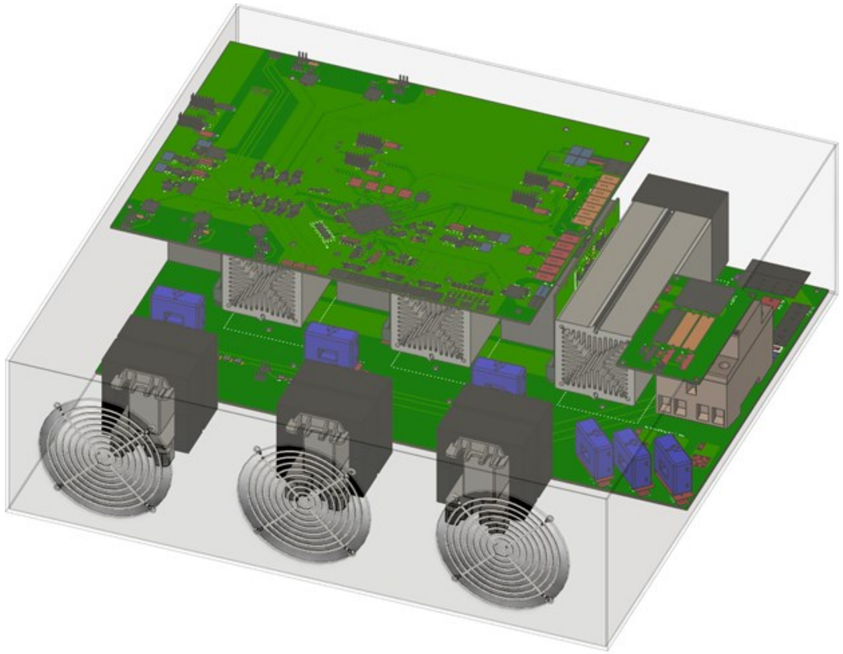
MoReSiC system – power submodule

- One power leg conssit six SiC transistors, two dc-link capacitors, heatsink and gate drivers
- NTH4L040N120SC1 SiC transistors
- **One type of three-level power module used in each converter (three modules are needed in ANPC)**





Experimental research of the ANPC - parameters

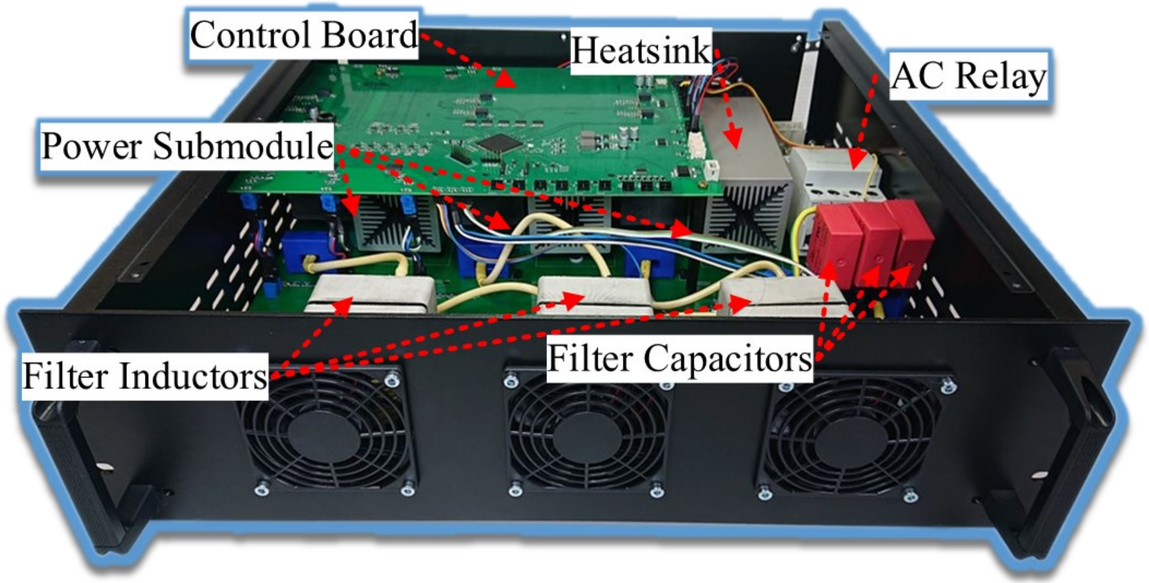


AC side parameters	3 x 230 VAC, 50Hz
Output voltage	1.5 kV DC
Switching frequency	62.5 kHz
Filter inductors	3 x 330 µH
Filter capacitors	3 x 4.7 µF
DC-link capacitors	6 x 60 µF
Power transistors	18 x NTH4L040N120SC1
Nominal output power	20 kW

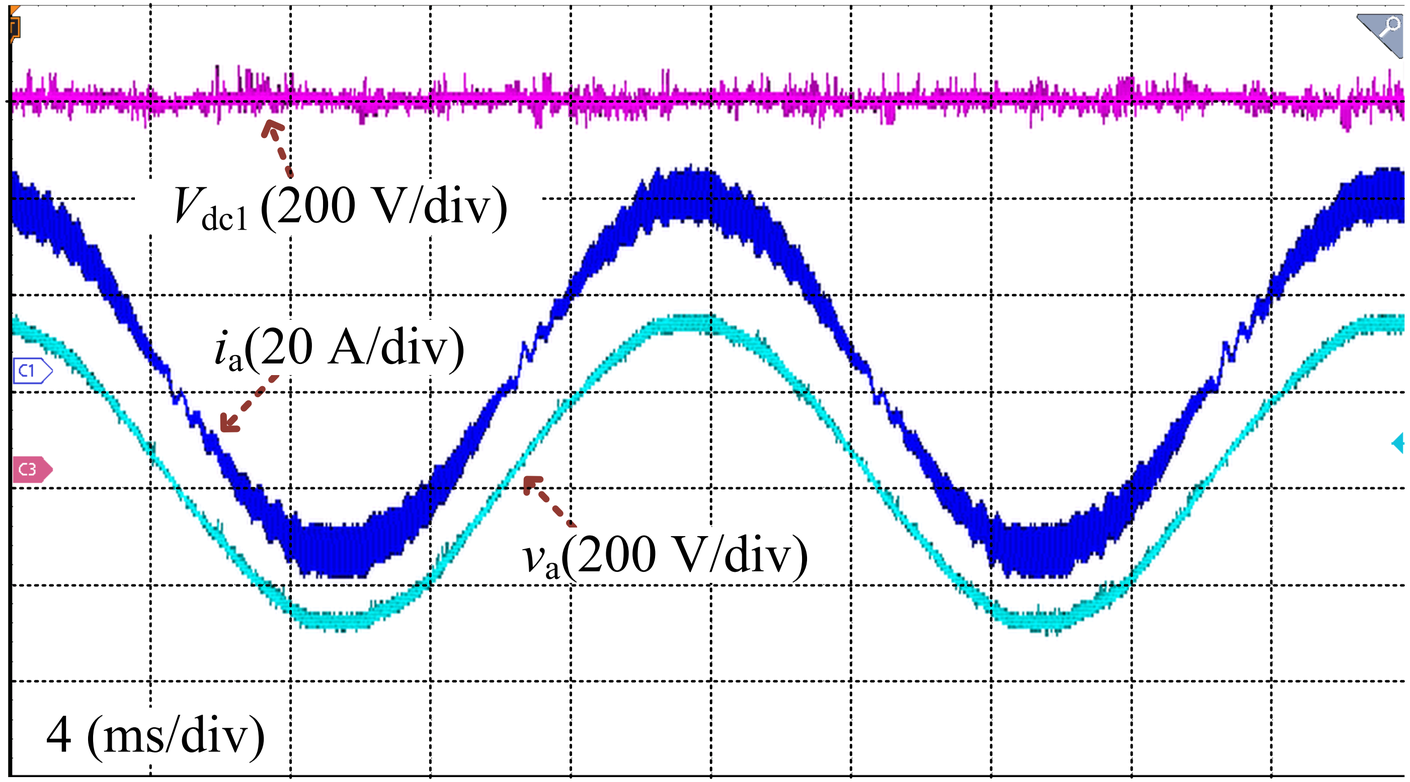
Experimental research of the MoReSiC system - ANPC

- All components are within rack 3U case (133 mm x 428 mm x 450 mm)

- ANPC consists, among others: three power submodules, control board with TMS320F28388DPTPS DSP, relays for precharging and enable AC grid, AC filter inductors and capacitors

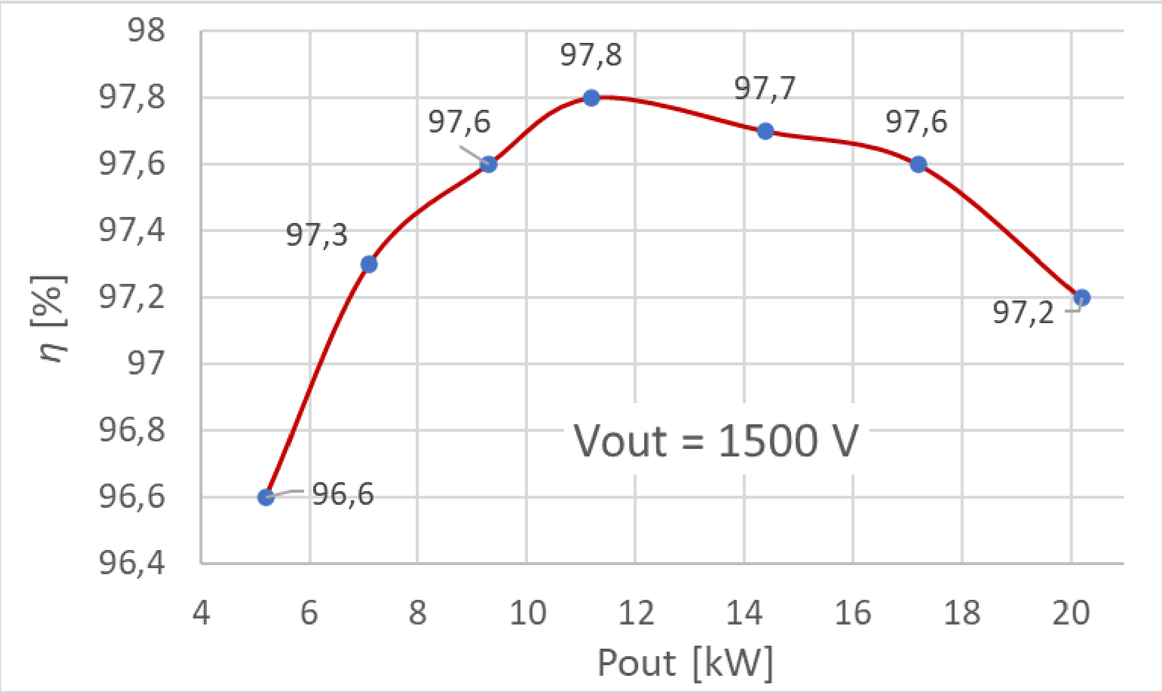


Experimental research of the ANPC - waveforms



- iTHD is equal to 3,1%
- Inductance of input filter is below 200 µH at peak input current
- Voltage ripples on output voltage are below 3%

Experimental research of the ANPC - efficiency



- Peak efficiency 97.8% at 11.2 kW
- Efficiency at nominal output power (20 kW) is 97,2%
- Efficiency in entire measuring output power range is above 96,6%

Norway grants

Thank you!

1st Workshop on Advanced Charging Systems

Gdynia 2022

moresic-project

https://www.ee.pw.edu.pl/moresic-project/

Warsaw University of Technology

NTNU Norwegian University of Science and Technology

MARKEL energoelektronika to nasza pasja

AREX GRUPA WB