



MONTREAL 16TH/17TH JUNE 2026 KAI PIETILAEINEN, MARTIN BRUHA, JOHN ECKERLE,

GRID FRIENDLY TEST BENCH

8th International Workshop on Grid Simulator Testing of
Energy Systems and Inverter-Based Resources

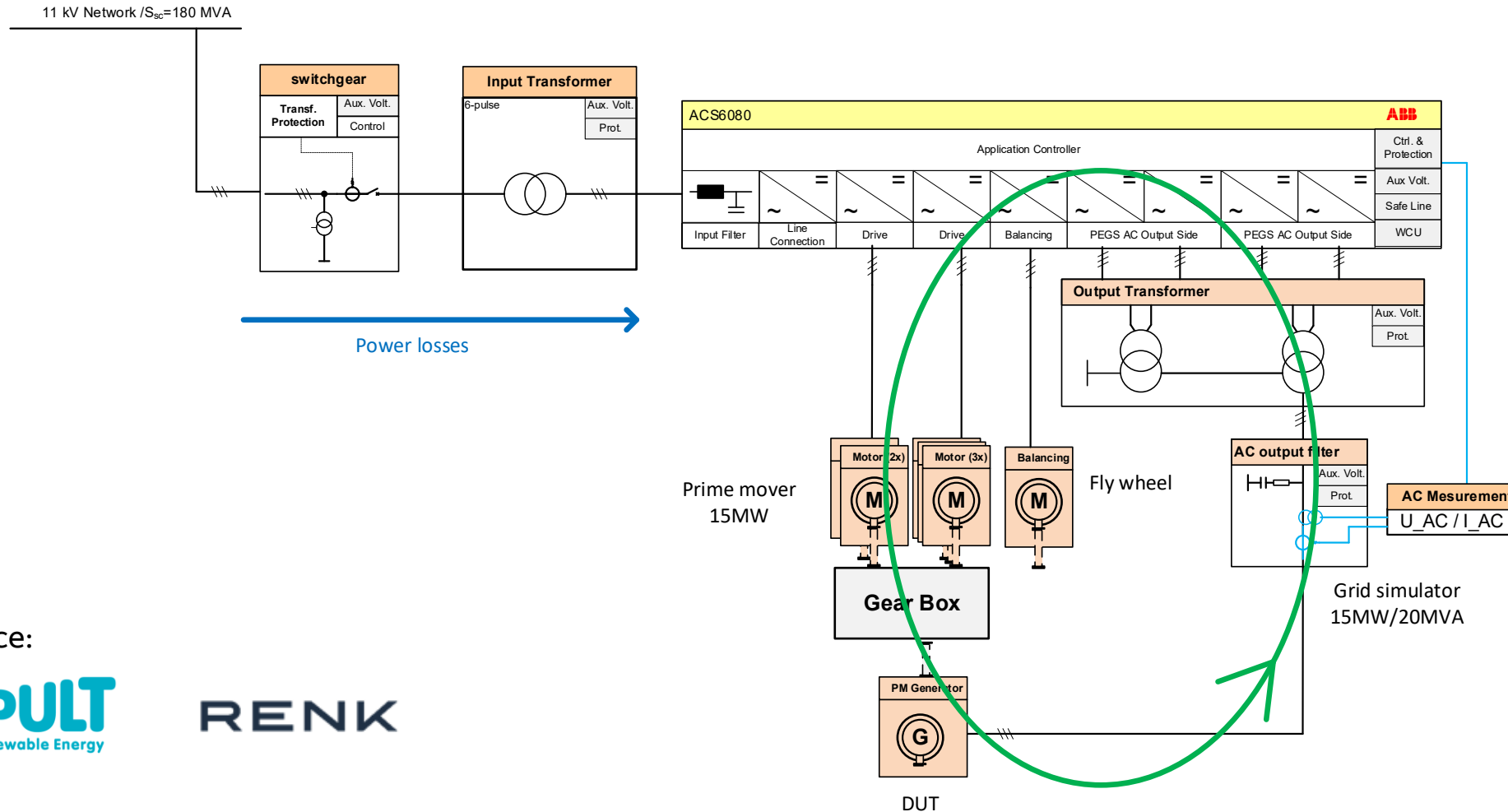
ENGINEERED
TO OUTFIT

1

INTRODUCTION

Overview diagram of one line-up (power in the loop configuration)

Full installation is a series connection of the output transformer



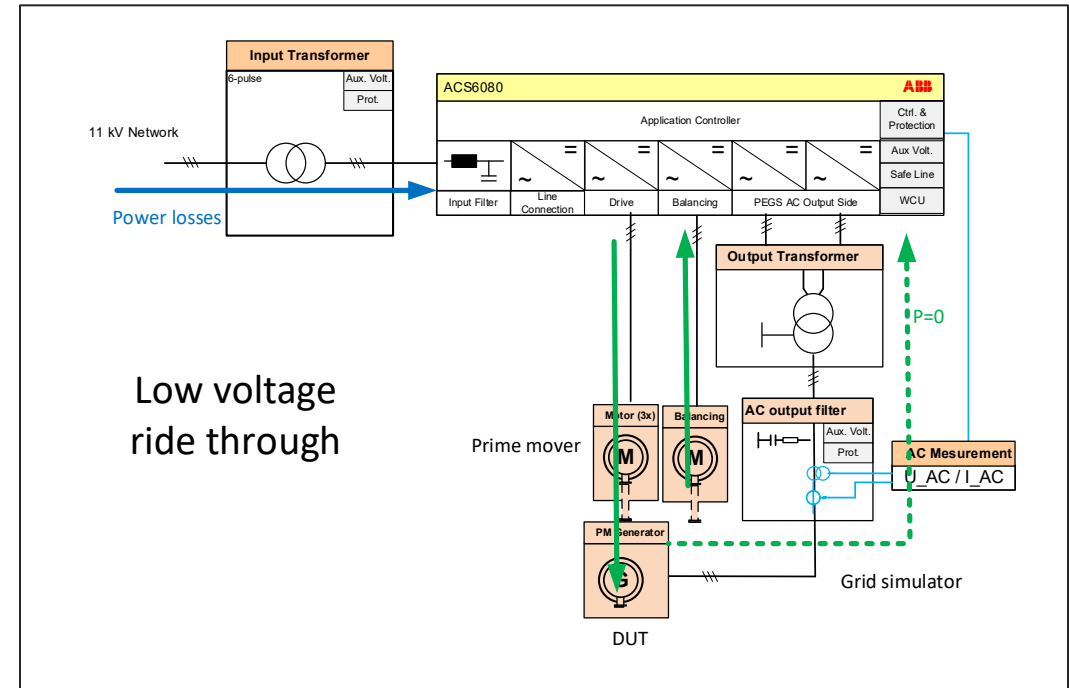
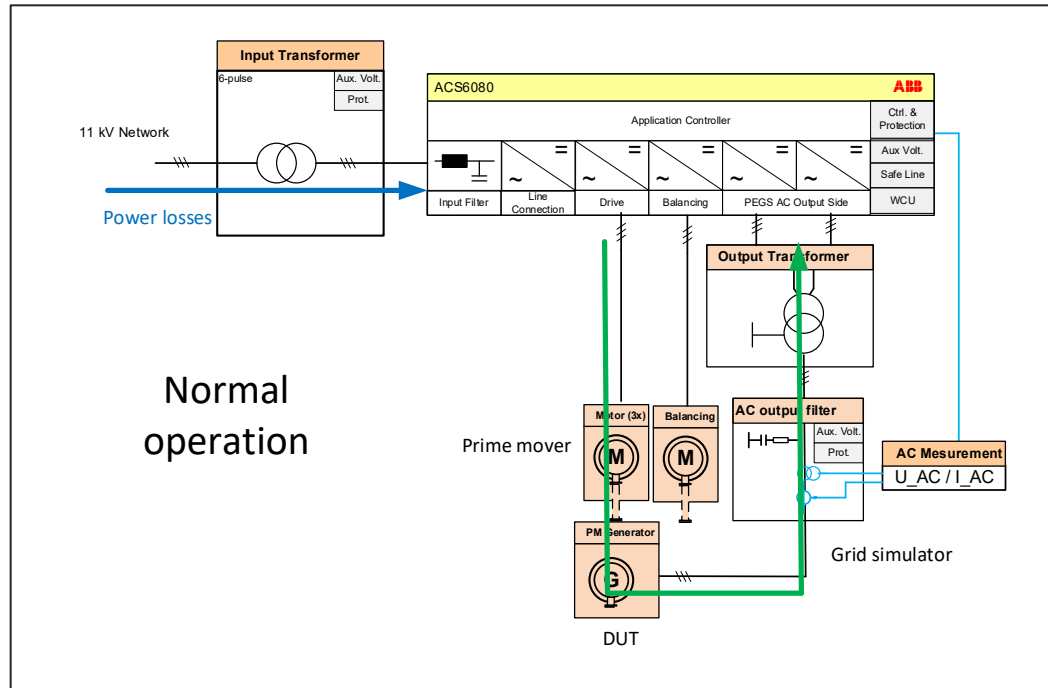
Reference:

CATAPULT
Offshore Renewable Energy

RENK

LVRT topic

No voltage fluctuation ($\Delta u < 3\%$) on 11kV grid during LVRT, limited power consumption



Topic / Simulation parameter

Special grid connection requirement

Special grid connection requirement

- No energy feedback to grid allowed
- Maximum 10 MVA_{cont} and 12 MVA_{peak} power consuming for 30 MW/40 MVA application
- Maximum voltage fluctuation of 3% (30MW, two-line-up)

Simulation parameter

- Scaled down case: Nominal power of 7 MW, reducing the number of converter module for faster simulation
- DUT is a PM generator (emulating of a grid forming converter)
- Grid short circuit power for the simulation model: 180 MVA
- Maximum 2.3 MVA_{cont} and 2.8 MVA_{peak} power consuming
- Maximum voltage fluctuation of 0.7% scaled fluctuation

Solution

- Using fly wheel machine as energy storage
- Fast power management control (PC-MC)
- Stable of PLL regulator
- Fast ARU current control

Verification

- Using EMT simulation model with original converter software

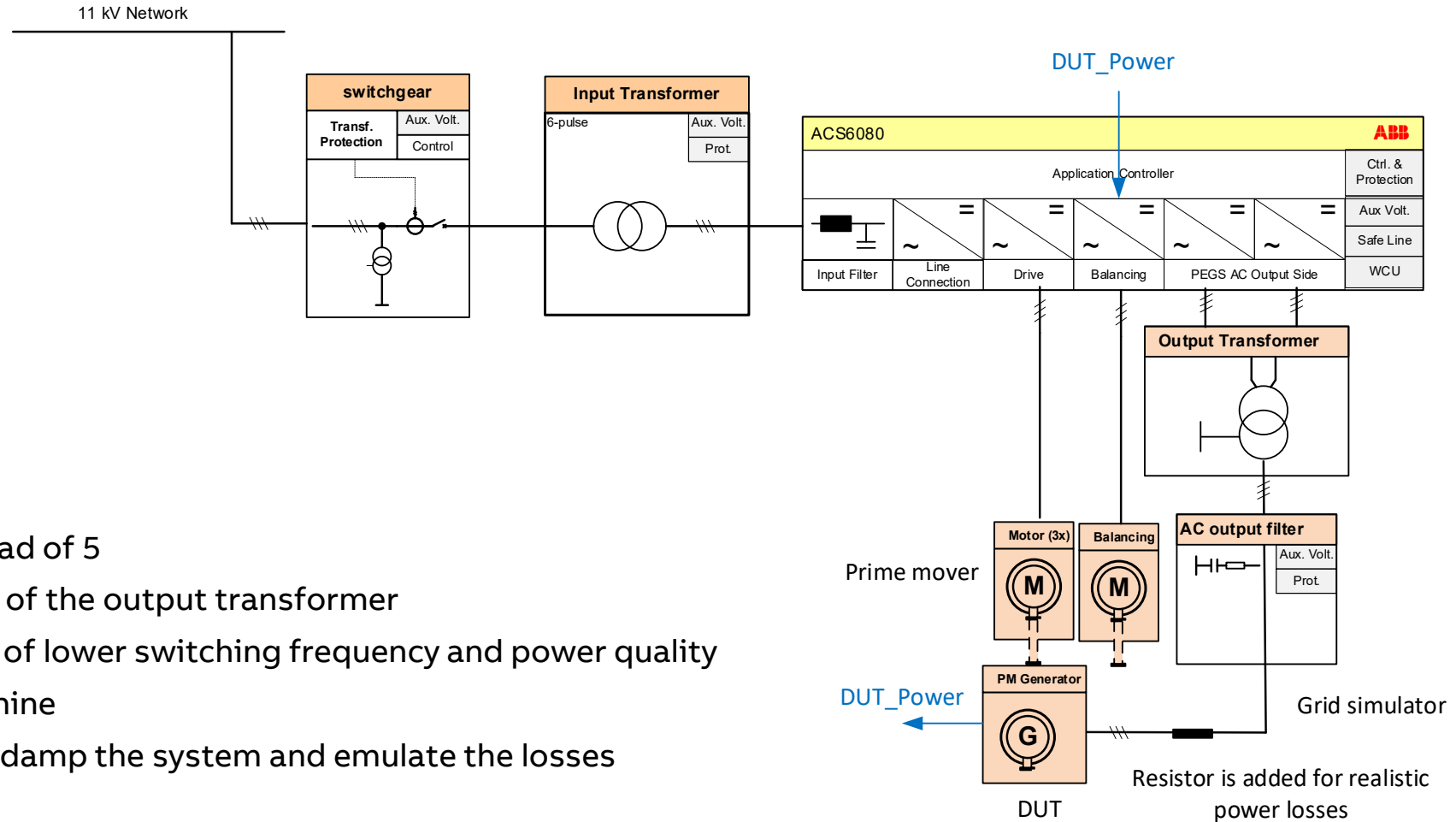
ACS6080 converter is prepared for this application

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SIMULATION

Simulation (Power in the loop configuration)

Simplified simulation model (reduced scope of supply, lower power)

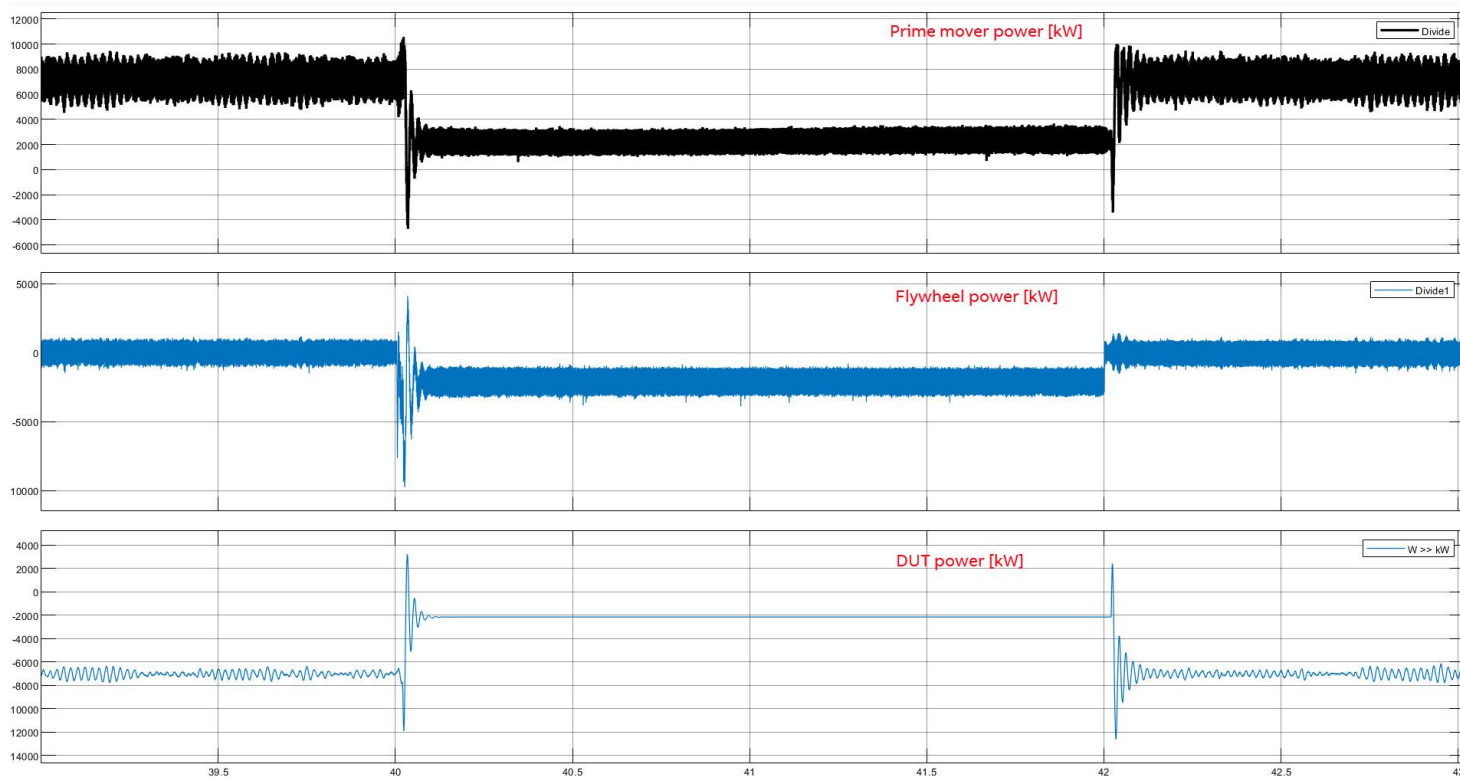


Adaption:

- One prime mover instead of 5
- Smaller nominal power of the output transformer
- Adapted filter because of lower switching frequency and power quality
- Smaller balancing machine
- Introduce a resistor to damp the system and emulate the losses

Simulation result with flywheel

LVRT Operation, Load



Before LVRT:

- DUT: 7MW
- Prime Mover: 7.5MW
- Flywheel: 0 MW
- ARU: 1.1 MW

During LVRT:

- DUT: 2 MW
(zero power to the grid simulator)
- Prime Mover: 2.3 MW
- Flywheel: 2 MW
- ARU: 0.6 MW

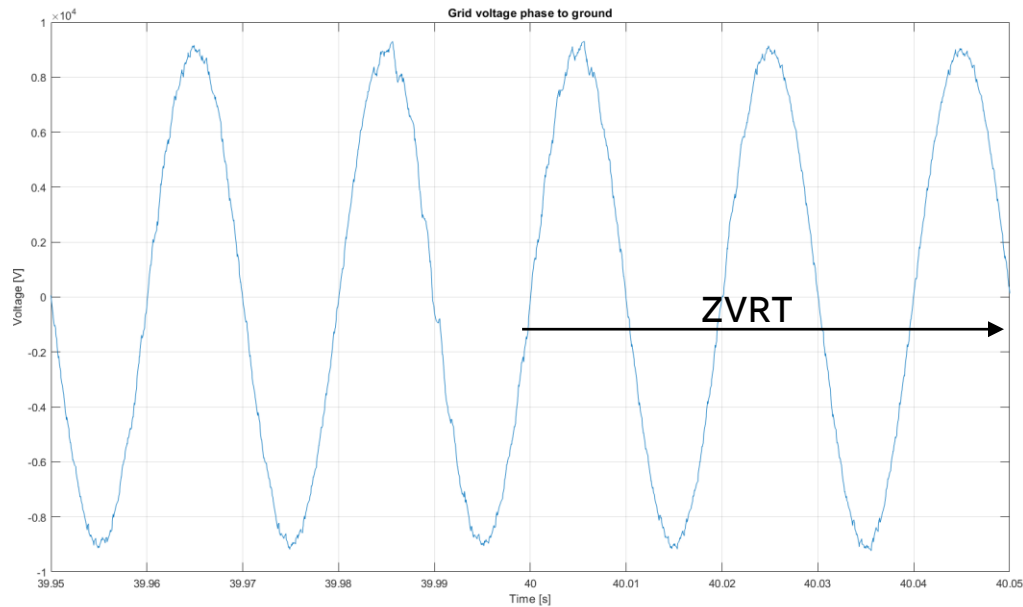
After LVRT:

- DUT: 7 MW
- Prime Mover: 7.5 MW
- Flywheel: 0 MW
- ARU: 1.1 MW

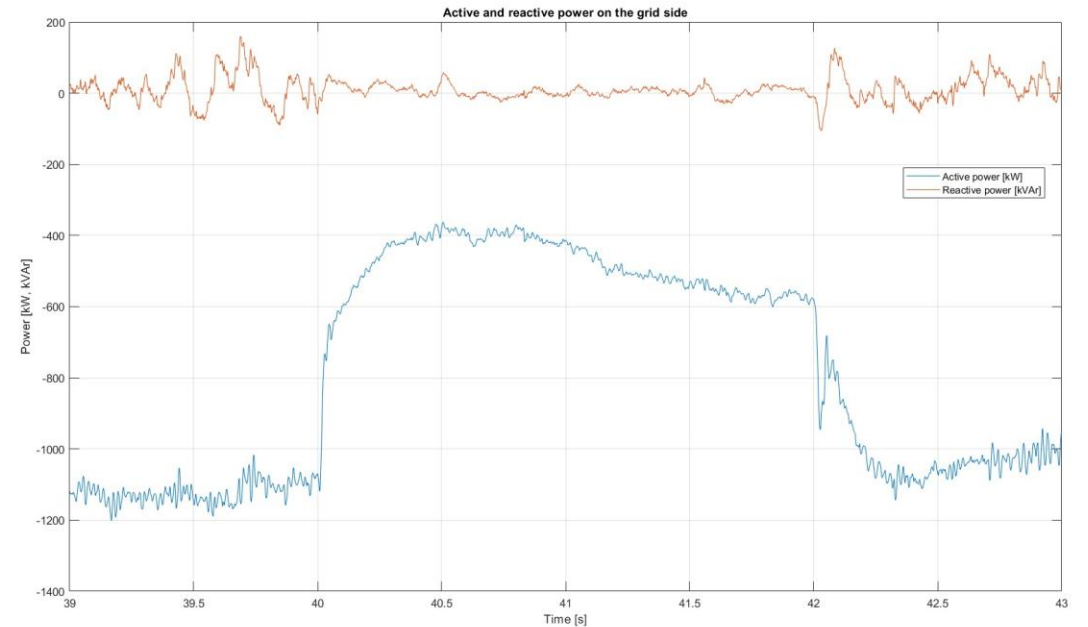
Simulation result with flywheel

LVRT Operation, grid-side converter (ARU)

Voltage wave form at PCC



Active and reactive current at PCC

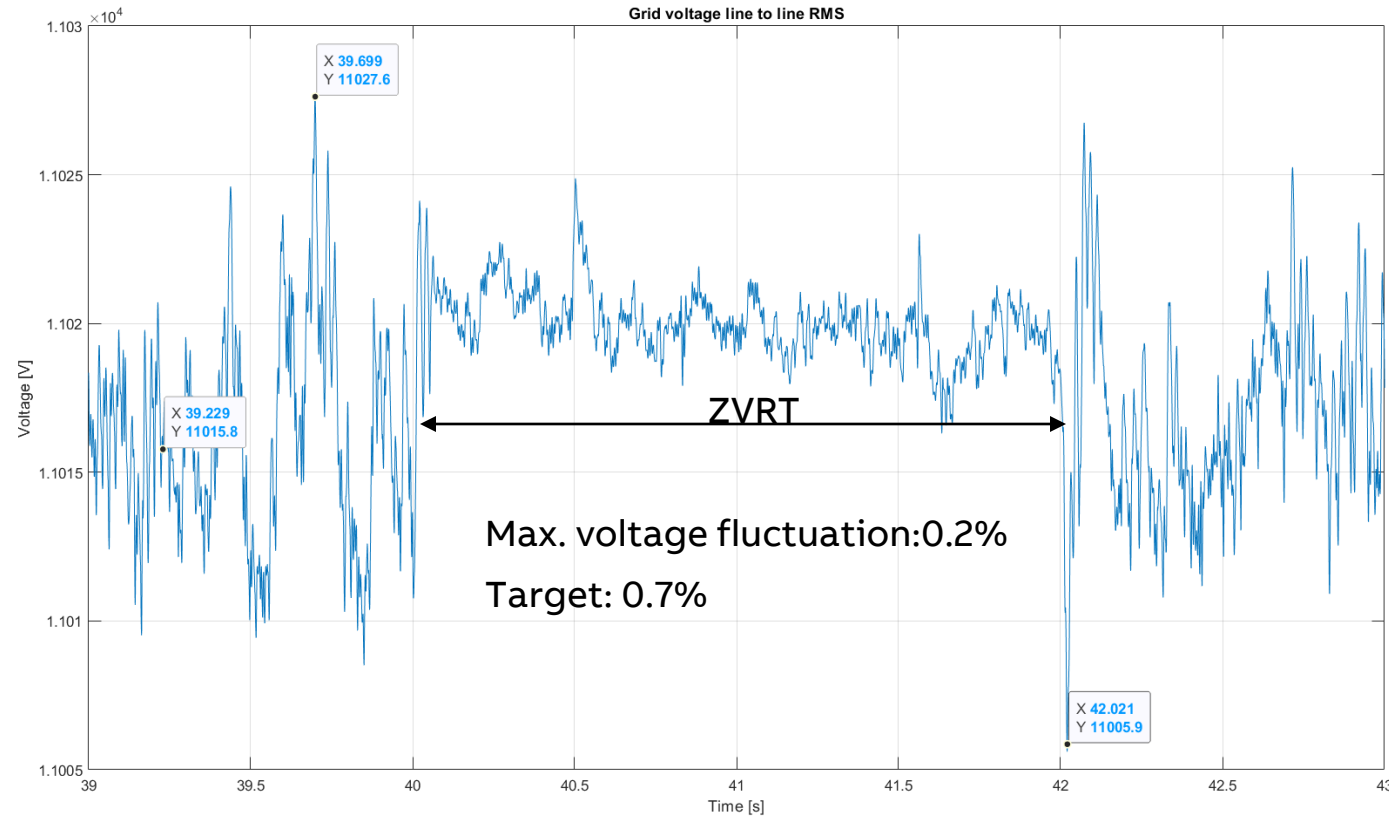


No power to the grid

Low reactive power fluctuation

Simulation result with flywheel

LVRT Operation, grid connection, fluctuation



The target of max. 0.7% voltage deviation is fulfilled

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SUMMARY

Conclusion/Next steps

The EMT simulation results fulfills the expectations

Model

- DUT with full power absorption during LVRT (constant prime mover power)
- Full configuration (5 motors)
- Nominal output power (15MW)

Control

- Implementing of final flywheel control

Conclusion

- Voltage fluctuation is within the limits
Margin is more than 200%
- Active current control is robust and fast enough
- Flywheel control is fast enough

ABB