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ISLANDING TESTS WITH GRID SIMULATOR

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

ENGINEERED TO OUTRUN

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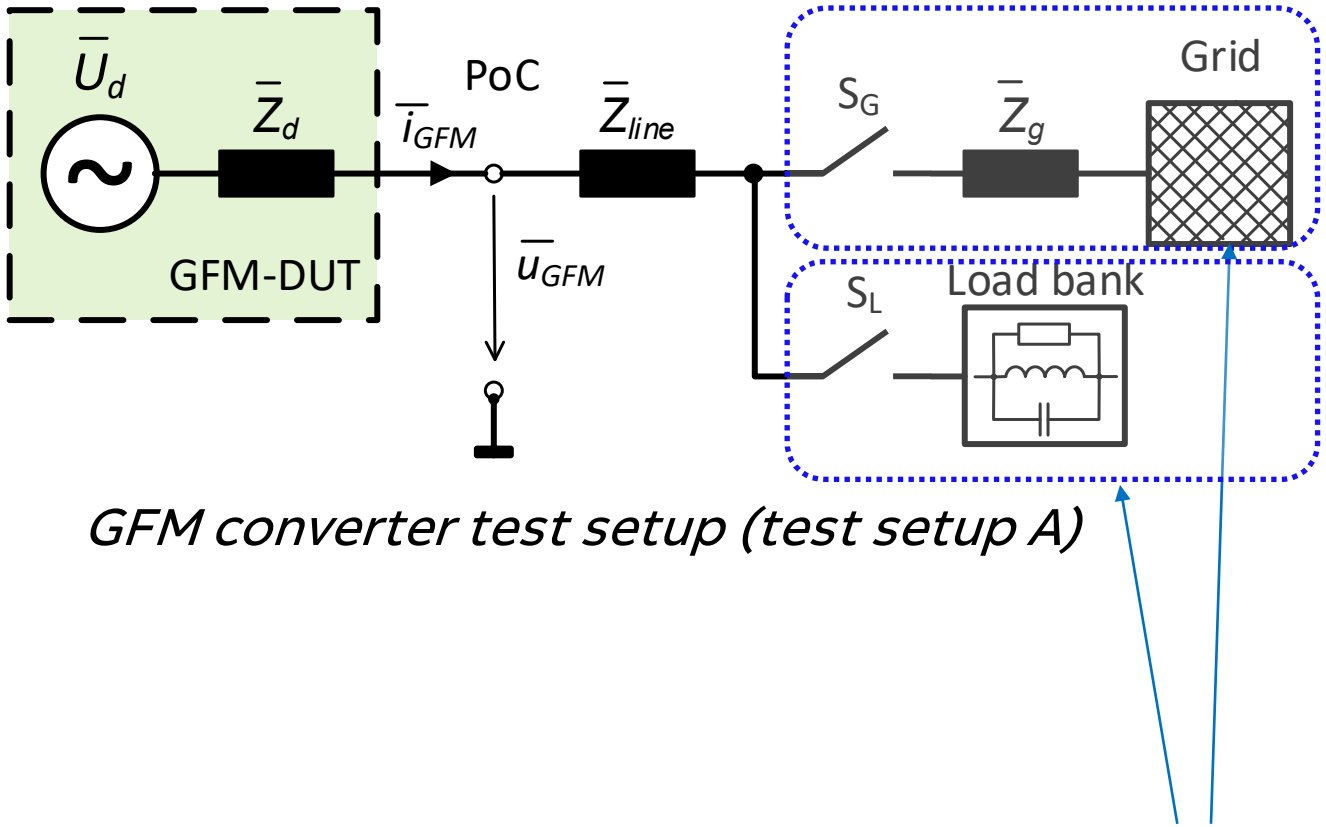
INTRODUCTION

Islanding tests with grid simulator

Conventional test setup



GFM converter test setup (test setup A)

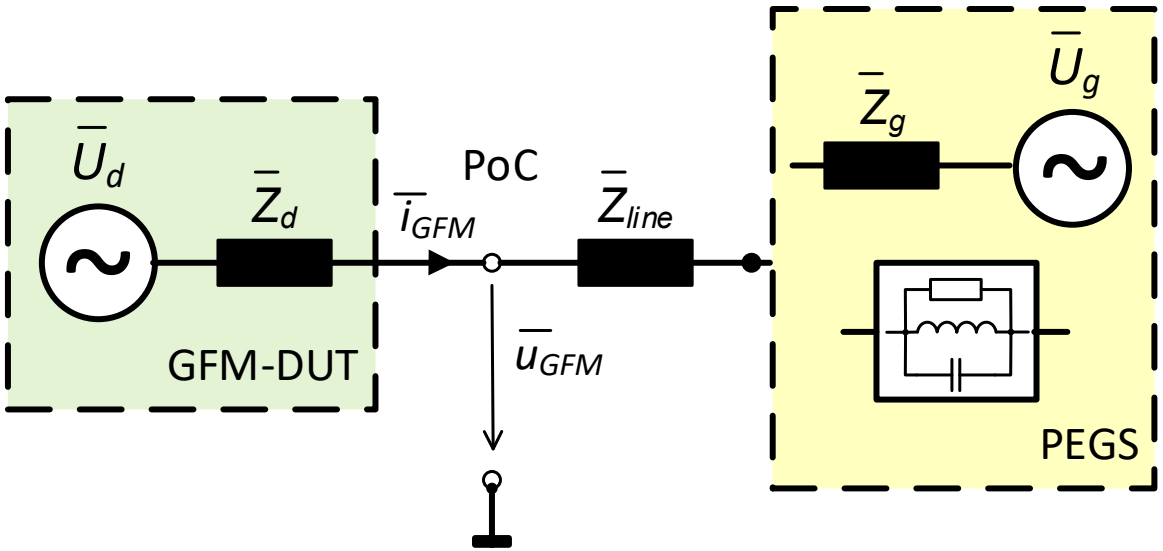
Power hardware configurations:

- GFM-DUT is connected to grid – breaker S_G is closed; breaker S_L is open;
- GFM-DUT is connected to the grid with load – both S_G and S_L are closed;
- GFM-DUT in island mode – S_G open, S_L closed.

It is allowed by guidelines to use emulating devices – grid and/or load emulator(s)

Islanding tests with grid simulator

Concept of GFM converter testing with single emulating device



Test setup with PEGS (test setup B)

PEGS = MV grid emulator solution from ABB

- Single emulating device – offers a practical alternative for conventional test setups
- ABB works towards obtaining substantial background for testing approach to be included in standardized tests
- CENELEC TC 50744-1 in work
- IEEE 1547.1

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CONCEPT

Combined emulating device

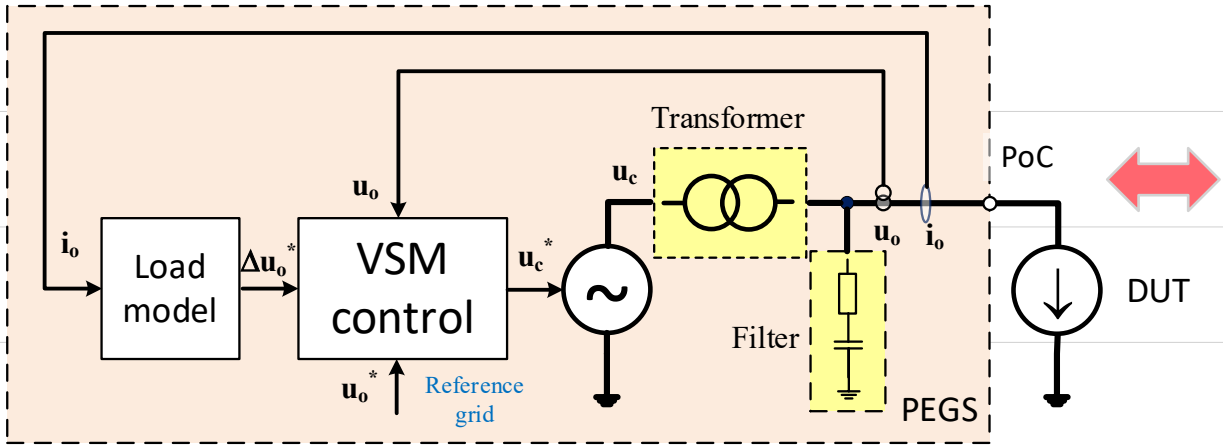
[as presented at 24th Wind & Solar Integration Workshop,
07-10 October 2025, Berlin, Germany]

Islanding tests with grid simulator

Control strategies of PEGS to support testing of GFM converters

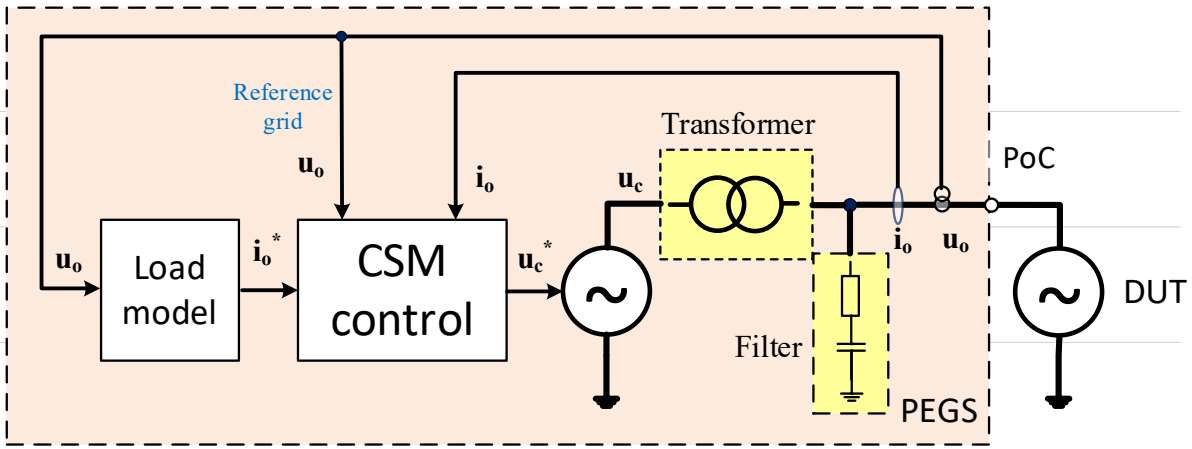
Grid emulation mode based on VSM

PEGS defines test voltage - *reference grid*
GFM-DUT in grid synchronized mode



Load emulation mode based on CSM

PEGS follows *reference grid* - defined by DUT operating in GFM mode

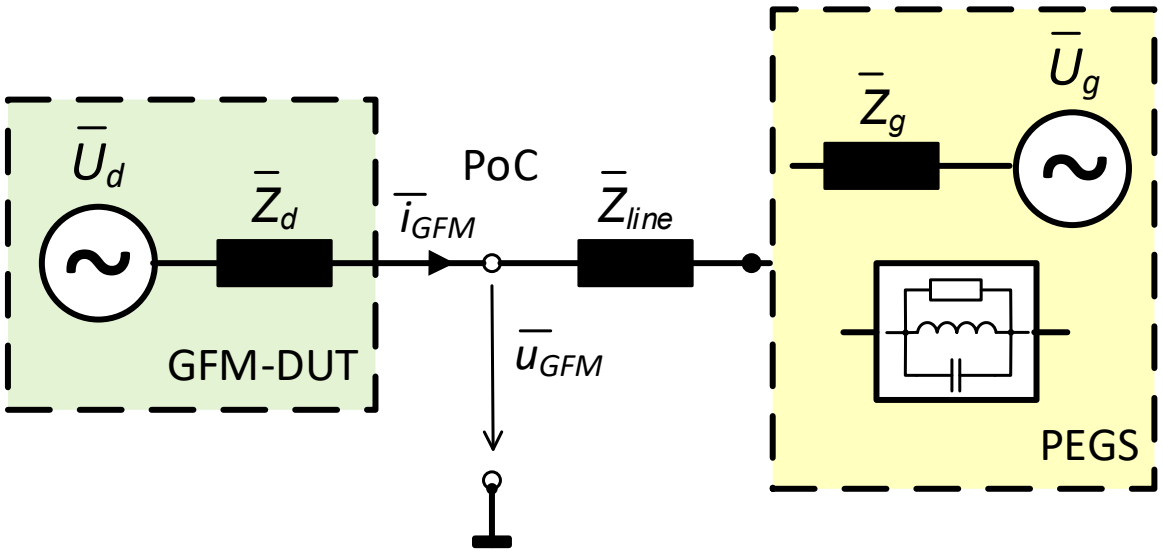


Control aspects:

- Control system design allowing small response time vs. proper stability margin
- Load models' accuracy and computational efficiency
- Fast and seamless transition between emulation modes

Islanding tests with grid simulator

Concept of GFM converter testing with single emulating device



Test setup with PEGS (test setup B)

DUT grid connected:

- Grid without load – PEGS in VSM
- Grid with load – PEGS in VSM

DUT in island mode:

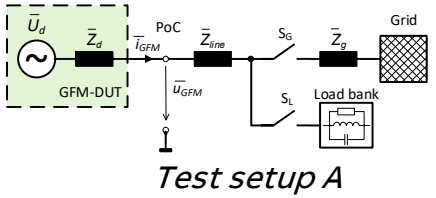
- PEGS in CSM (load emulation).

Test setup B was reconstructed on Controller Hardware-In-The-Loop (C-HIL) stand in ABB PLCTC
GFM-DUT represented with simplified model

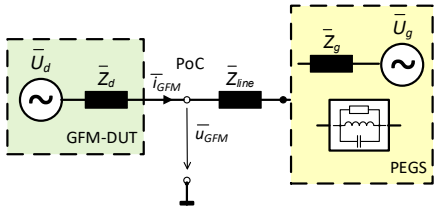
DUT parameter	DUT 0
Rated power	15 MVA
Rated voltage phase-to-phase	33 kV
Internal impedance [pu]	0.03 + 0.15i

Islanding tests with grid simulator

Test of GFM-DUT with switch from grid emulation to load emulation mode



Test setup A

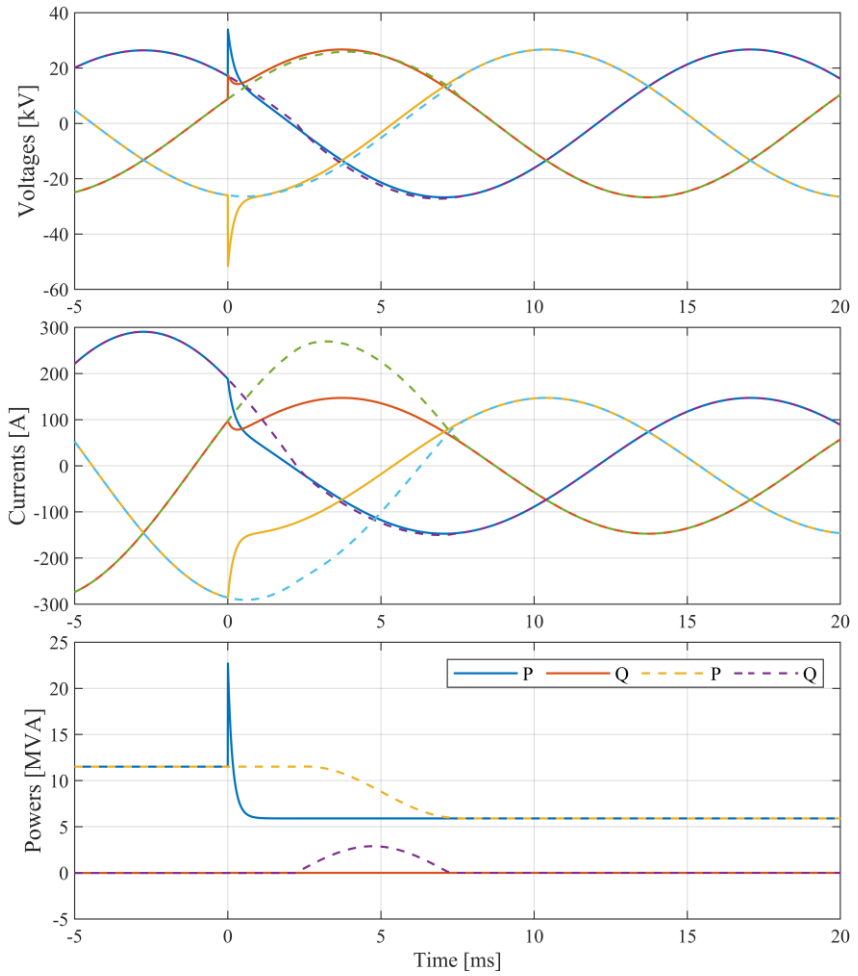


Test setup B

PEGS mode	Active power (towards PEGS)	DUT mode
Voltage	33 kV	
Grid emulation	12 MW	Grid following
Load emulation	6 MW (resistive)	Island mode

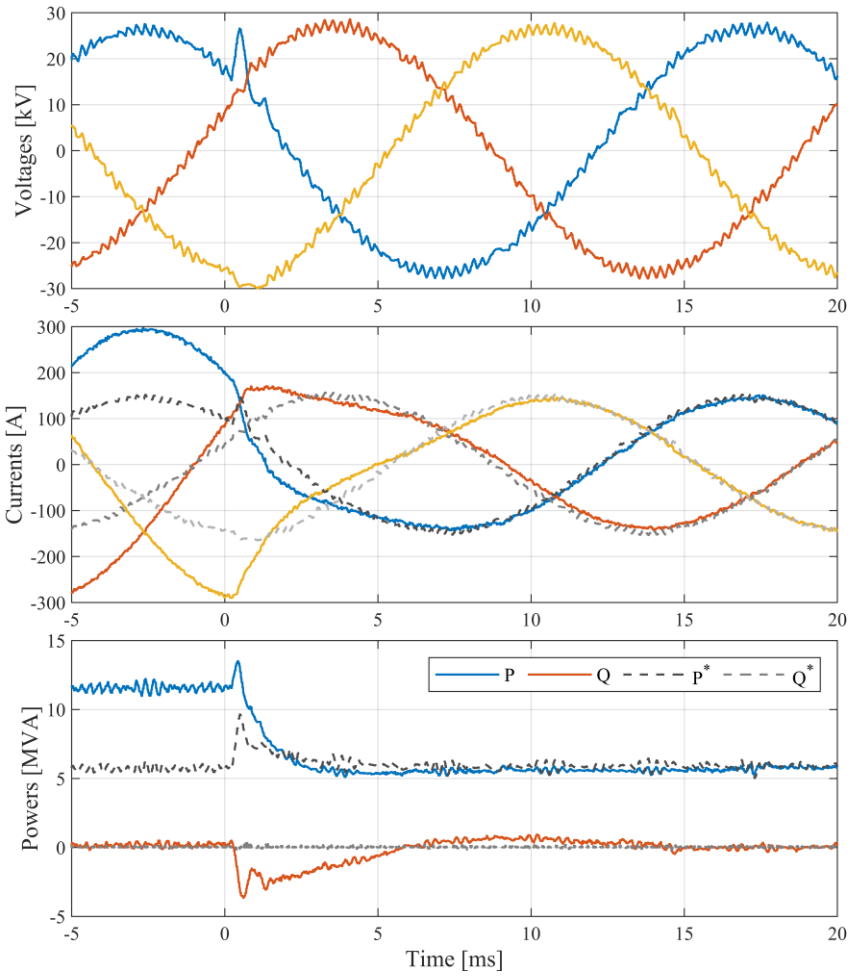
- Similar processes in both setups
- Fast transition between modes

Test setup A (idealized model)



solid – processes in setup with ideal switches (instantaneous)
dashed – processes in setup with realistic switches (zero-crossing)

Test setup B (C-HIL simulation)



solid – measurements from plant simulator outputs
dashed – reference model outputs

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UPDATES AND HIGHLIGHTS

Islanding tests with grid simulator

Current source mode performance

DDSRF-based current control

Target transfer function of each control loop:

$$G_x(s) = \frac{i_x(s)}{i_x^*(s)} = \frac{T_F s + 1}{T_\mu T_D^2 s^3 + K T_D^2 s^2 + 2\xi T_D s + 1}$$

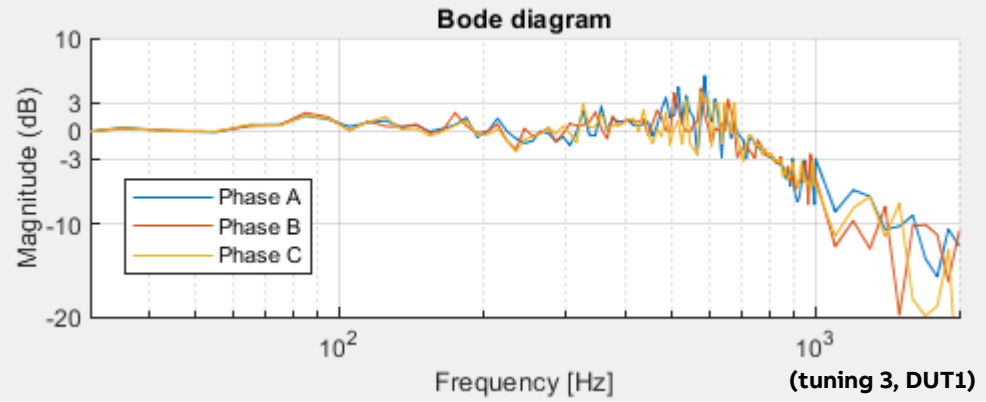
T_F, T_D - adjustable time constants;

T_μ - small non-compensated time constant;

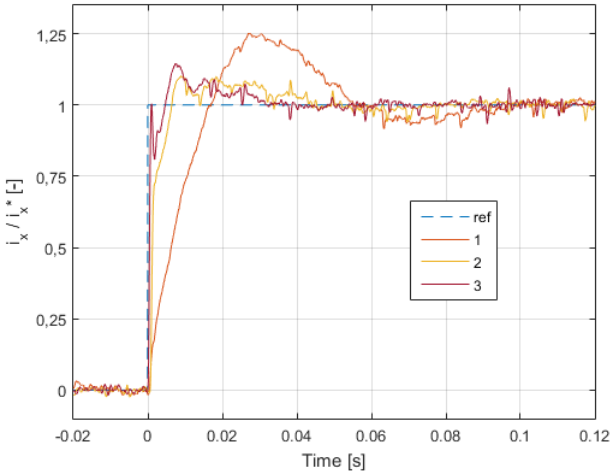
K>1 – gain dependent on plant parameters;

ξ – damping coefficient.

Control bandwidth up to 1kHz (and more)



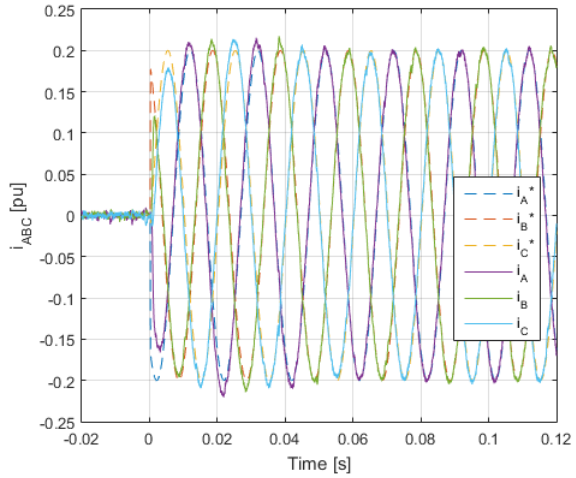
(tuning 3, DUT1)



Control configuration and parameters can be adjusted for the needs of each special application, for example

1 – second-order response (DUT1)

2, 3 – responses for fast transition during islanding (DUT1)



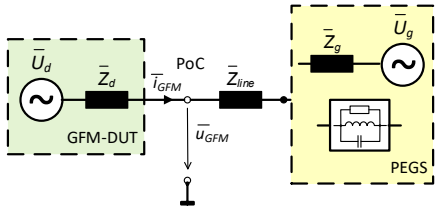
Decoupled control of dq components (positive/negative sequences) allows emulation of various load conditions

Example active current step response (tuning 2, DUT1)

DUT parameter	DUT 1
Rated power	2.5 MVA
Rated voltage phase-to-phase	20 kV
Internal impedance [pu]	0.22 + 0.04i

Islanding tests with grid simulator

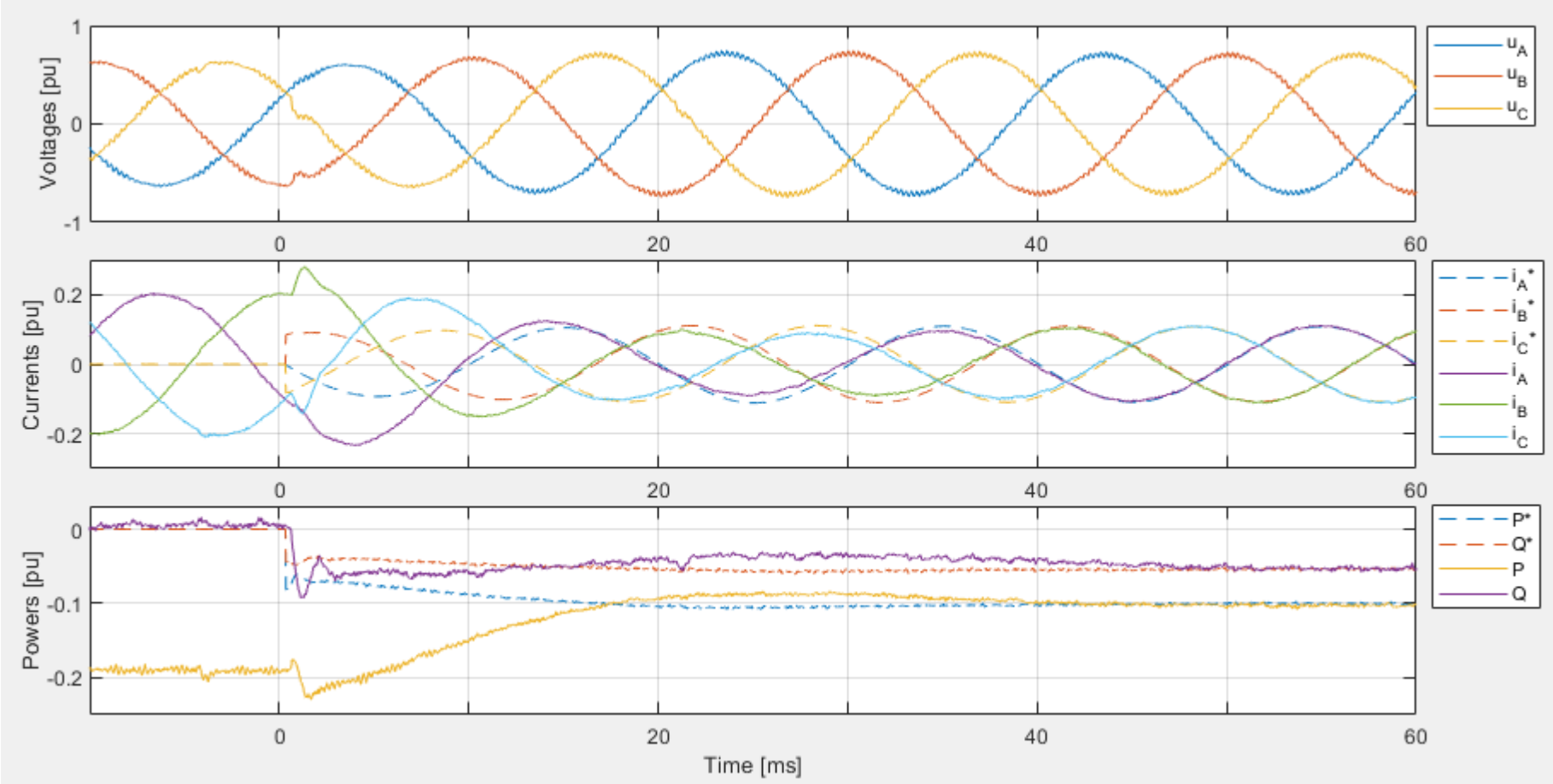
RLC load emulation case (C-HIL simulations)



Test setup B

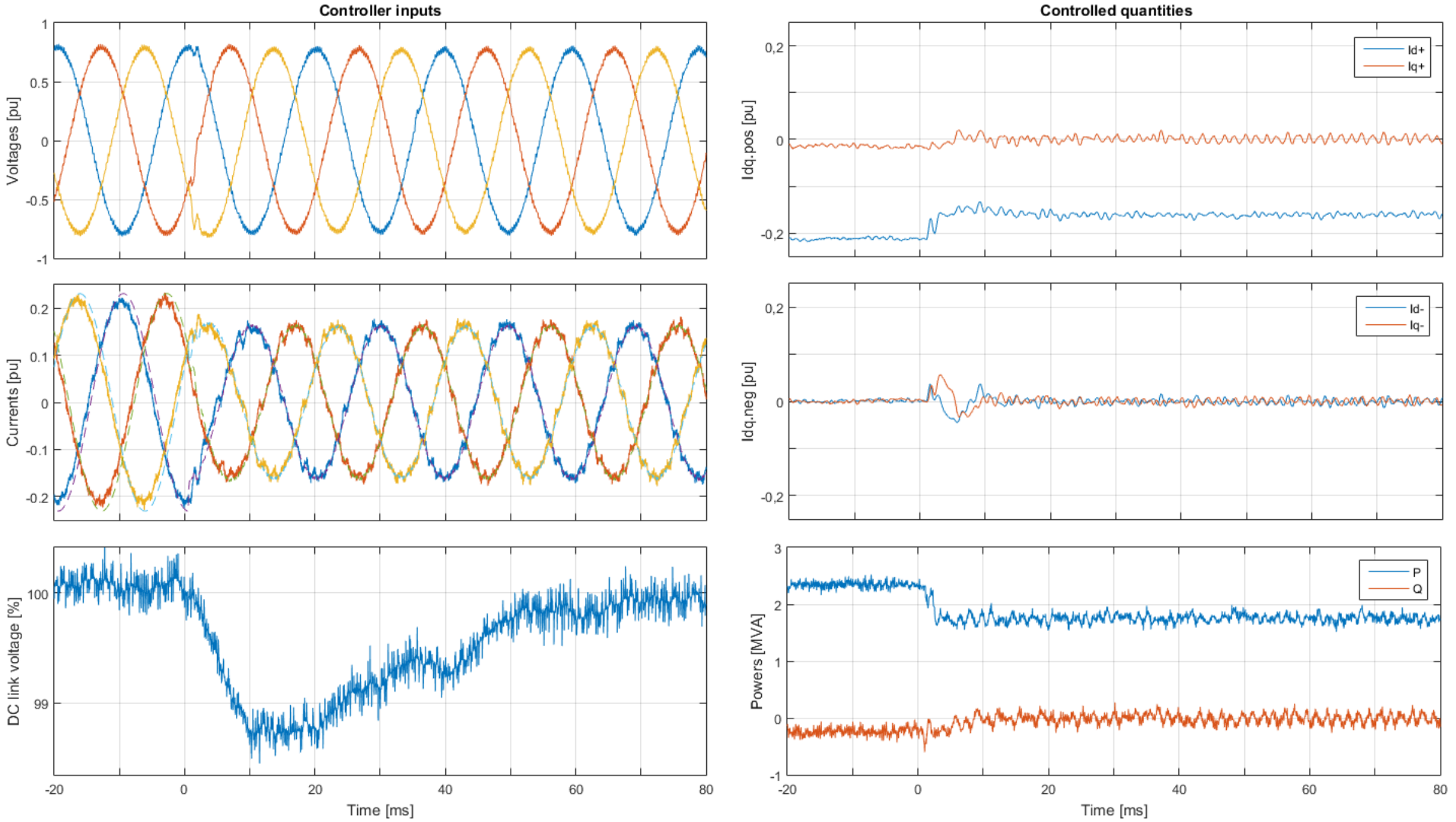
PEGS mode	Active power (towards PEGS)	DUT mode
Voltage	20 kV	
Grid emulation	2 MW	Grid following
Load emulation	1 MW 0.5 MVAr	Island mode

DUT parameter	DUT 1
Rated power	2.5 MVA
Rated voltage phase-to-phase	20 kV
Internal impedance [pu]	0.22 + 0.04i



Islanding field tests at Fraunhofer IWES

Islanding test at field: 2.4 MW grid emulation -> 1.8 MW load emulation



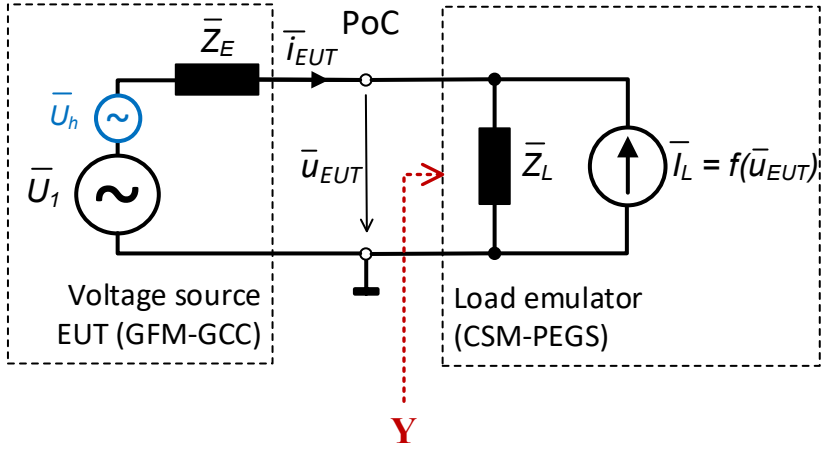
Fraunhofer IWES

[tests performed at Fraunhofer IWES Mobile Grid Simulator, May 2026 with Huawei BESS test specimen]

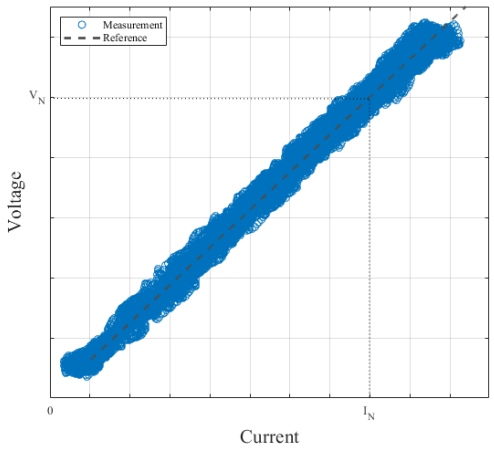
HUAWEI

Load emulator for fundamental frequency

Load emulator is passive for the whole frequency range

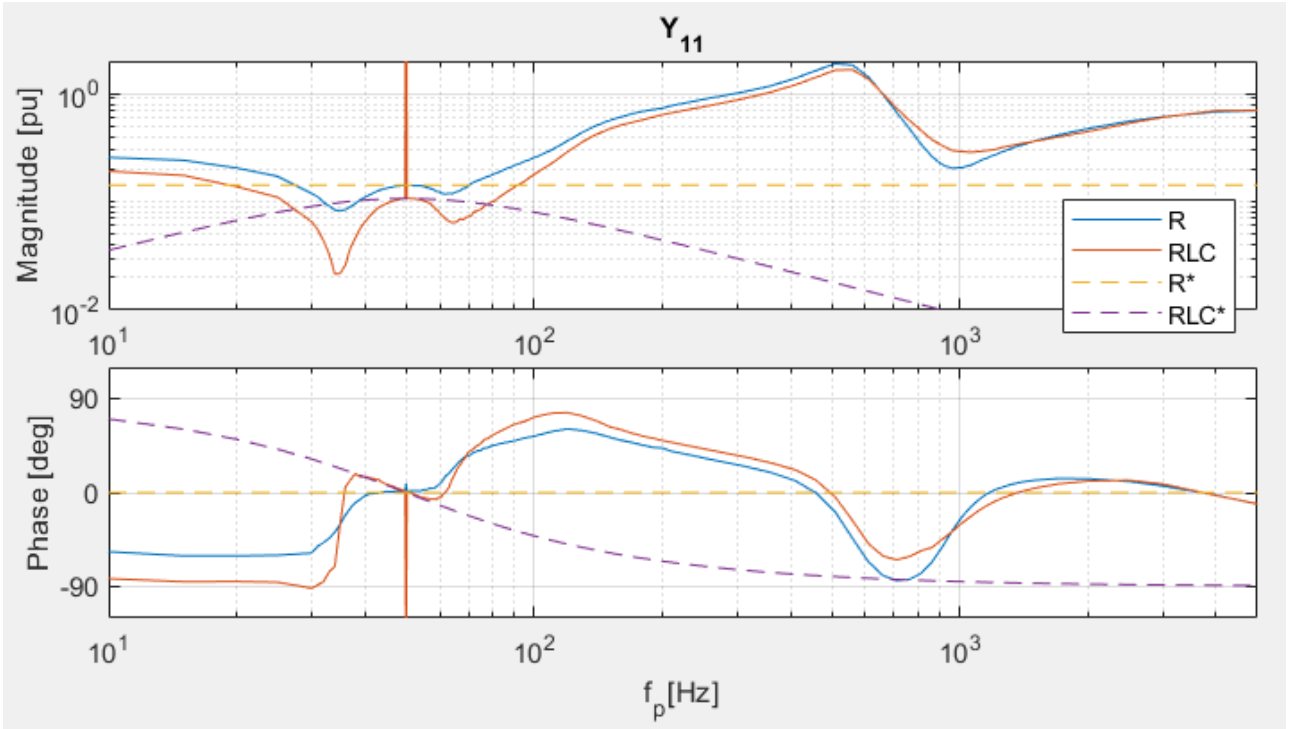


Simulated setup to assess load emulation performance



Example emulated volt-ampere characteristic of the resistive load, reproduced by load emulator

DUT parameter	DUT 1
Rated power	2.5 MVA
Rated voltage phase-to-phase	20 kV
Internal impedance [pu]	0.22 + 0.04i



Example CHIL simulations: Admittance of load emulator seen from the DUT terminals (U=20kV, f1=50Hz), illustrates passive behavior

R - resistive load R=200Ω, P=2MW

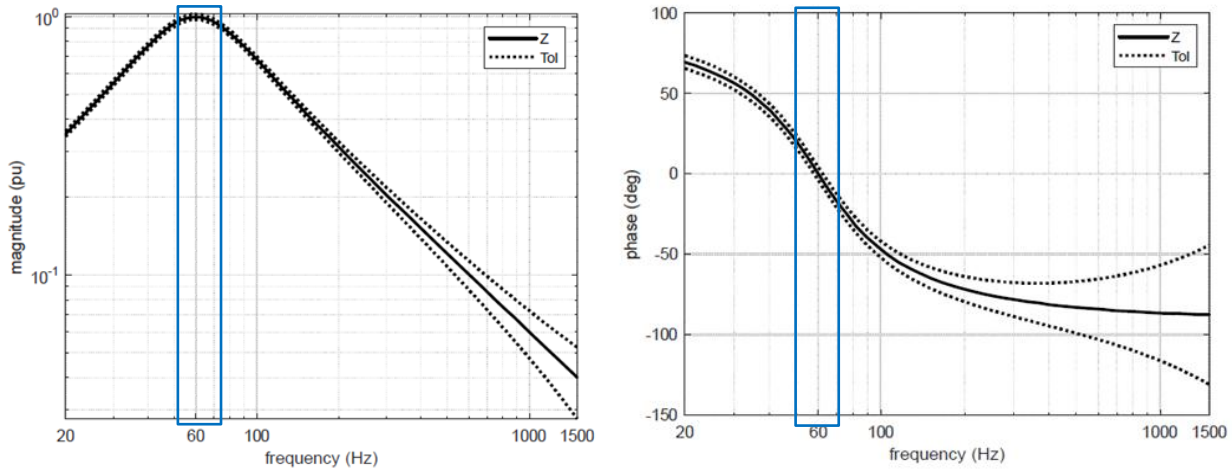
RLC - series RLC branch: R=265 Ohm, L=500mH C=20uF, P=1.5MW @50Hz.

Islanding tests with grid simulator

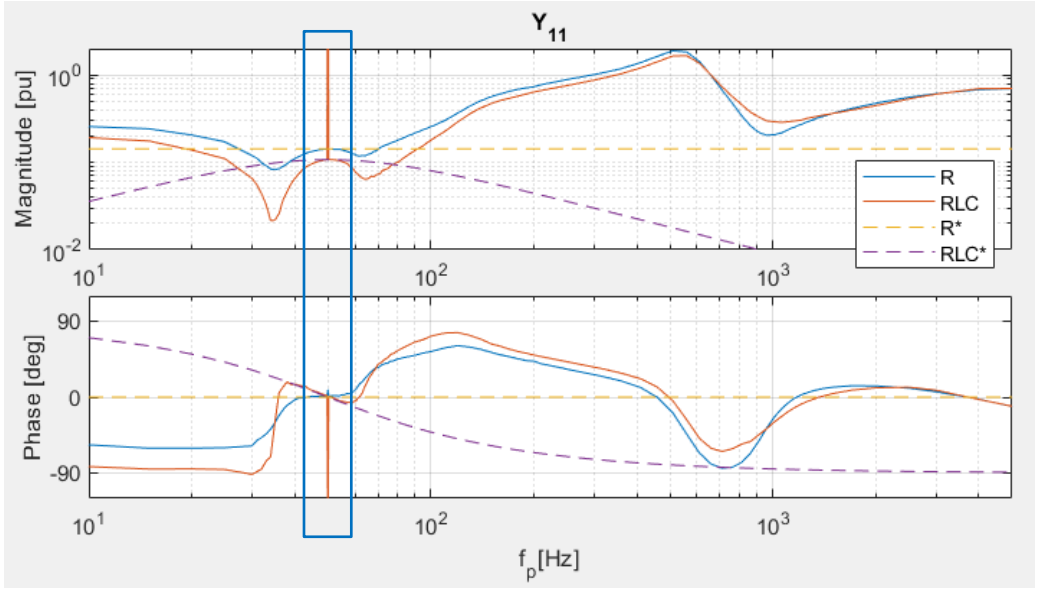
IEEE 1547.1 requirement – requirement acc. 5.10.2.3

IEEE 1547.1 ch. 5.10.2.3 c):
The voltage harmonic magnitude shall be at least 1% of the nominal voltage while operating as a standalone voltage source.
This is a standard function of the ABB Grid Simulator.

Alternative grid simulator test acc. IEEE 1547.1 ch. 5.10.2.3 d):
RLC emulation in voltage source mode:



Actual load emulator is developed for the fundamental frequency



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SUMMARY

Conclusion / Next steps

Islanding tests with grid simulator
Conclusions

- Current source mode of ACS6080-based power electronic grid simulator is enabled to support testing of GFM converters in island operation
- Control solution allows injection of various balanced and unbalanced currents into DUT with high accuracy and small response time
- Seamless transition between emulation modes allow to realize various test scenario
- High load emulation accuracy around fundamental frequency
- Passive behavior in load emulation mode expected to contribute to the stability of test setup

Next steps:

- RLC emulation in voltage source mode acc. IEEE 1547.1 ch. 5.10.2.3 c)
- RLC emulation in current source mode – extend frequency range


ABB