Politecnico di Torino

Power Electronics Innovation Center

Control of a Microgrid based on Virtual Synchronous Machine Technology

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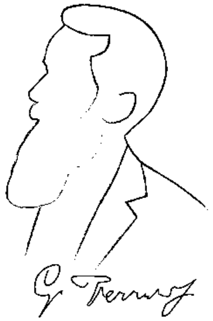

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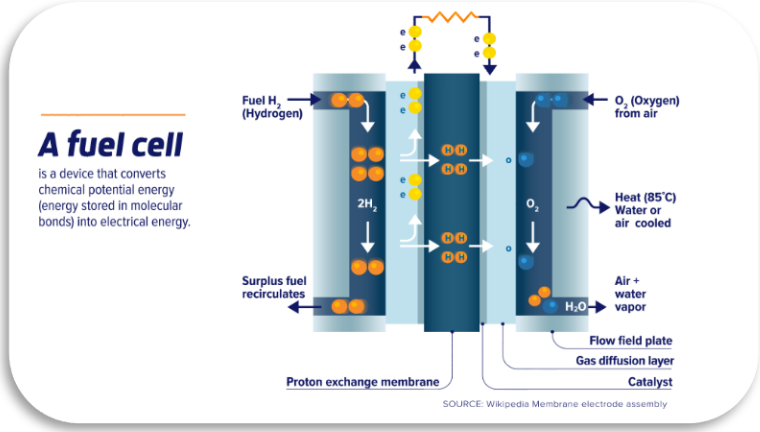
Outline

- Context
- Objective of the Study
- S-VSC
- Experimental Validation
- Islanding
- Conclusions

Context

Renewable energy sources and storage systems are interfaced to the grid through power electronic converters



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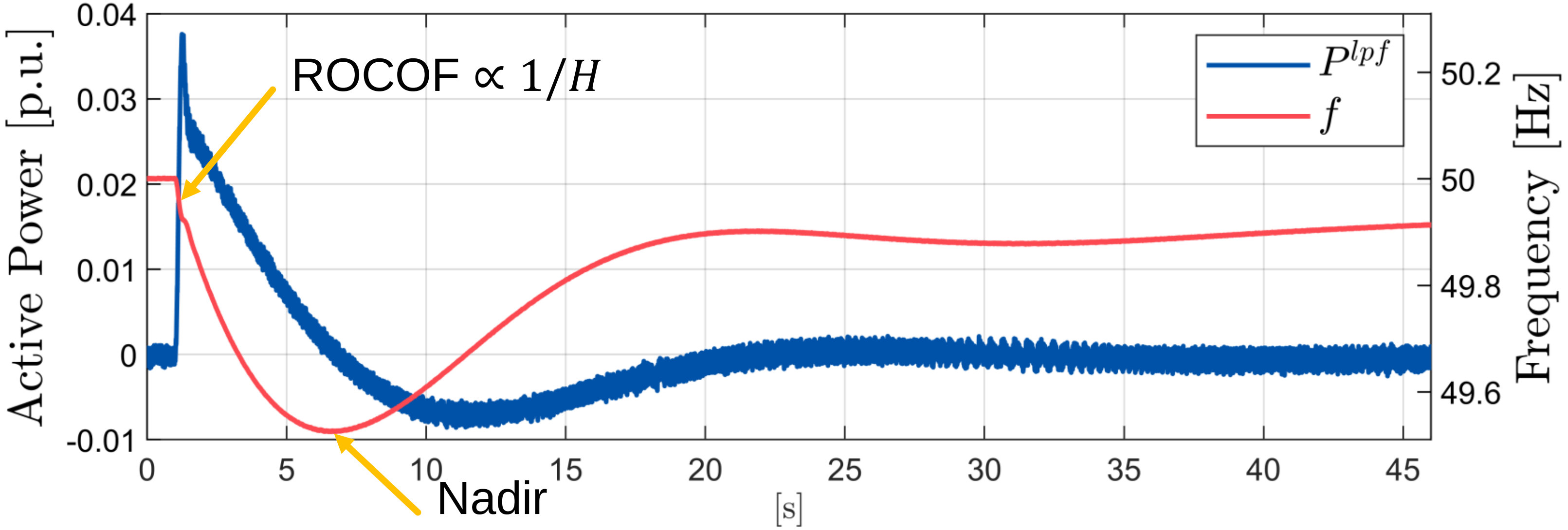
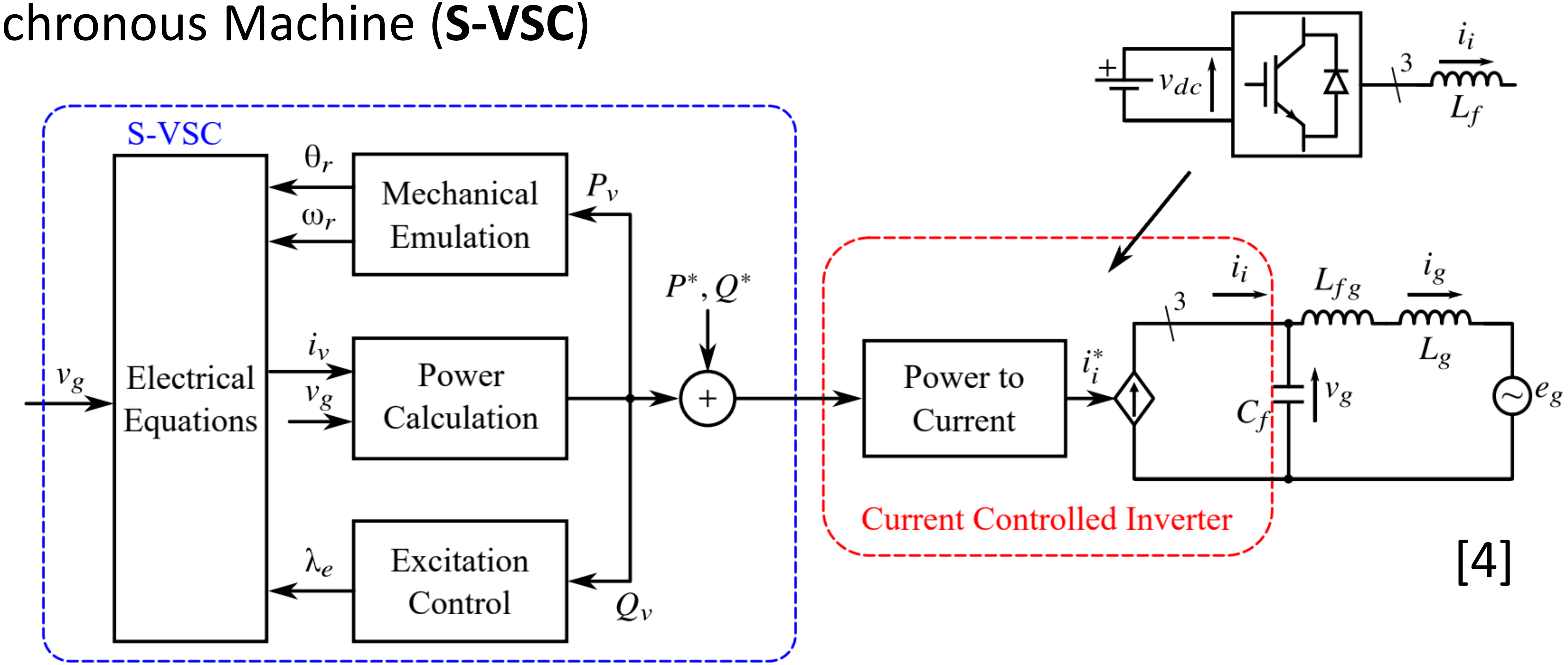
Traditional grid following inverters operate in Maximum Power Point Tracking (**MPPT**) and do not provide any ancillary service

Context

- Synchronous generators (SGs) of traditional power plants guarantee the stability of the grid by providing ancillary services (e.g., inertial behavior)
- The concept of Virtual Synchronous Machine (**VSM**) is a method to make grid converters able to provide ancillary services: it controls the converter to mimic the behavior of SGs



The VSM algorithm investigated in this thesis is the Simplified - Virtual Synchronous Machine (**S-VSC**)



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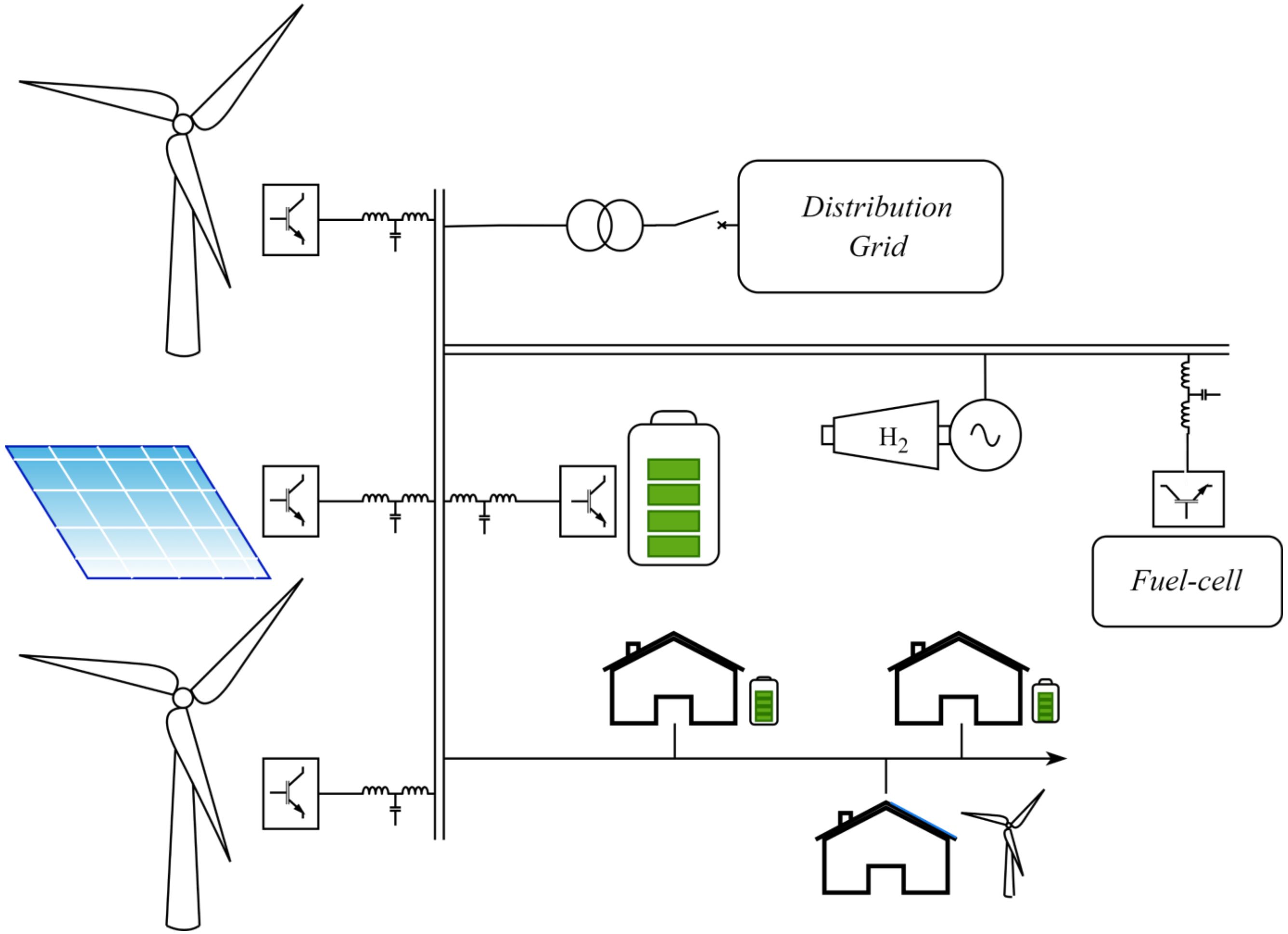
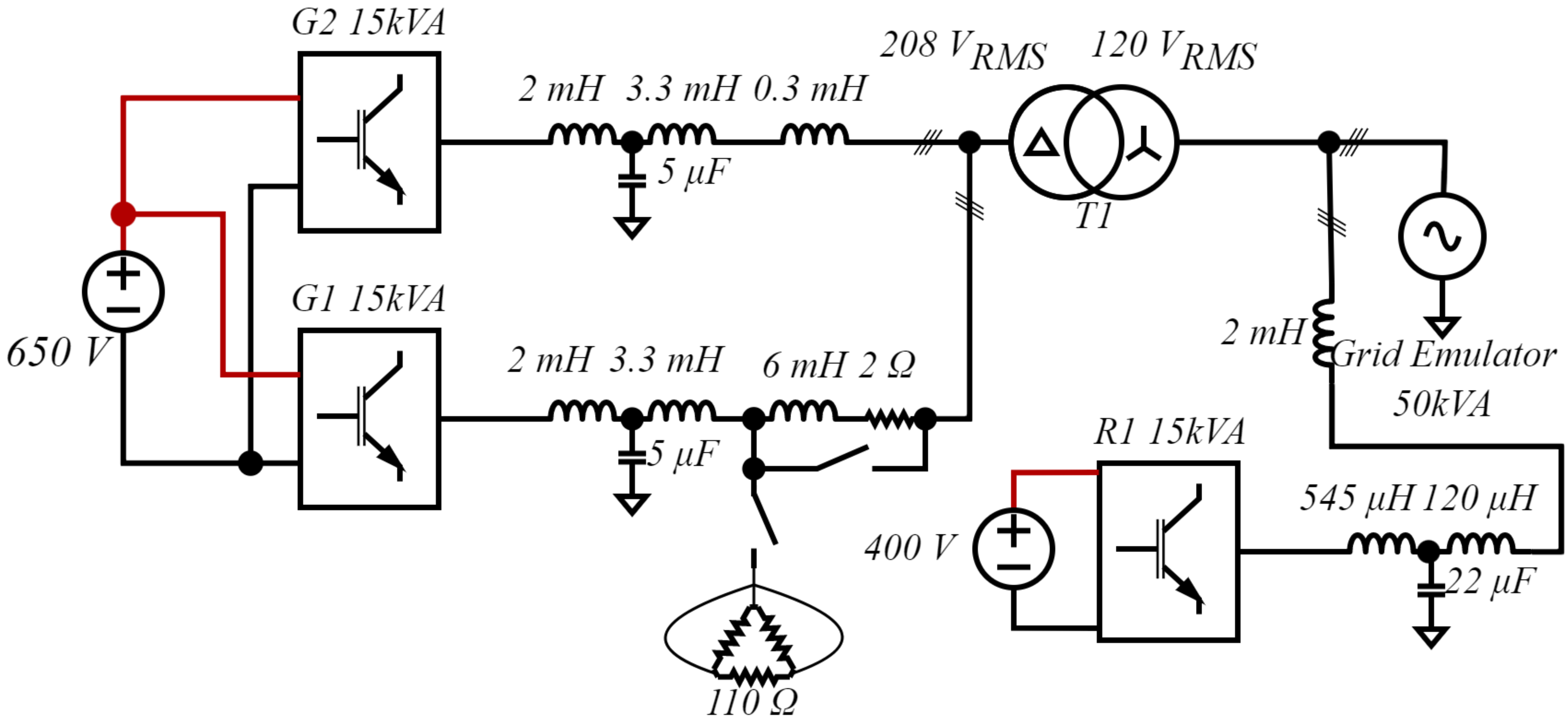
Microgrids

The converter can either be directly connected to the grid or be part of a **microgrid**

The term **microgrid** refers to a portion of the network that can also operate independently in **island** configuration



Microgrid under study



Objective of the Study

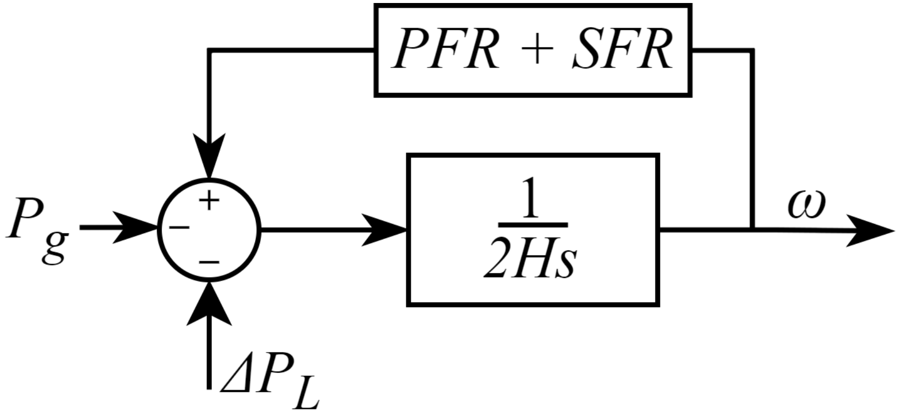
- The **objective** of the thesis is to **compare** the inertial contribution of **traditional** controls vs. that of **S-VSCs**

- To achieve this goal, the grid emulator must modify its frequency based on the active power injections

- This need brought forward the model of a **dynamic grid** which uses the exchanged power as feedback

Dynamic Grid

A **dynamic model** of the grid using the **swing equation**

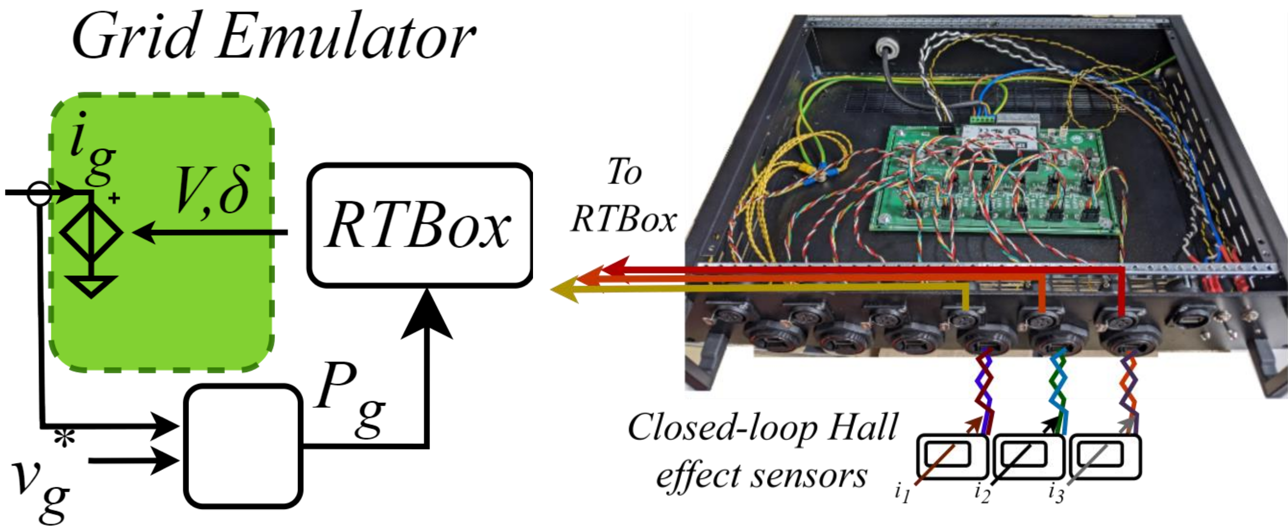


PFR + SFR: Primary and Secondary regulation

P_g: measured interface power

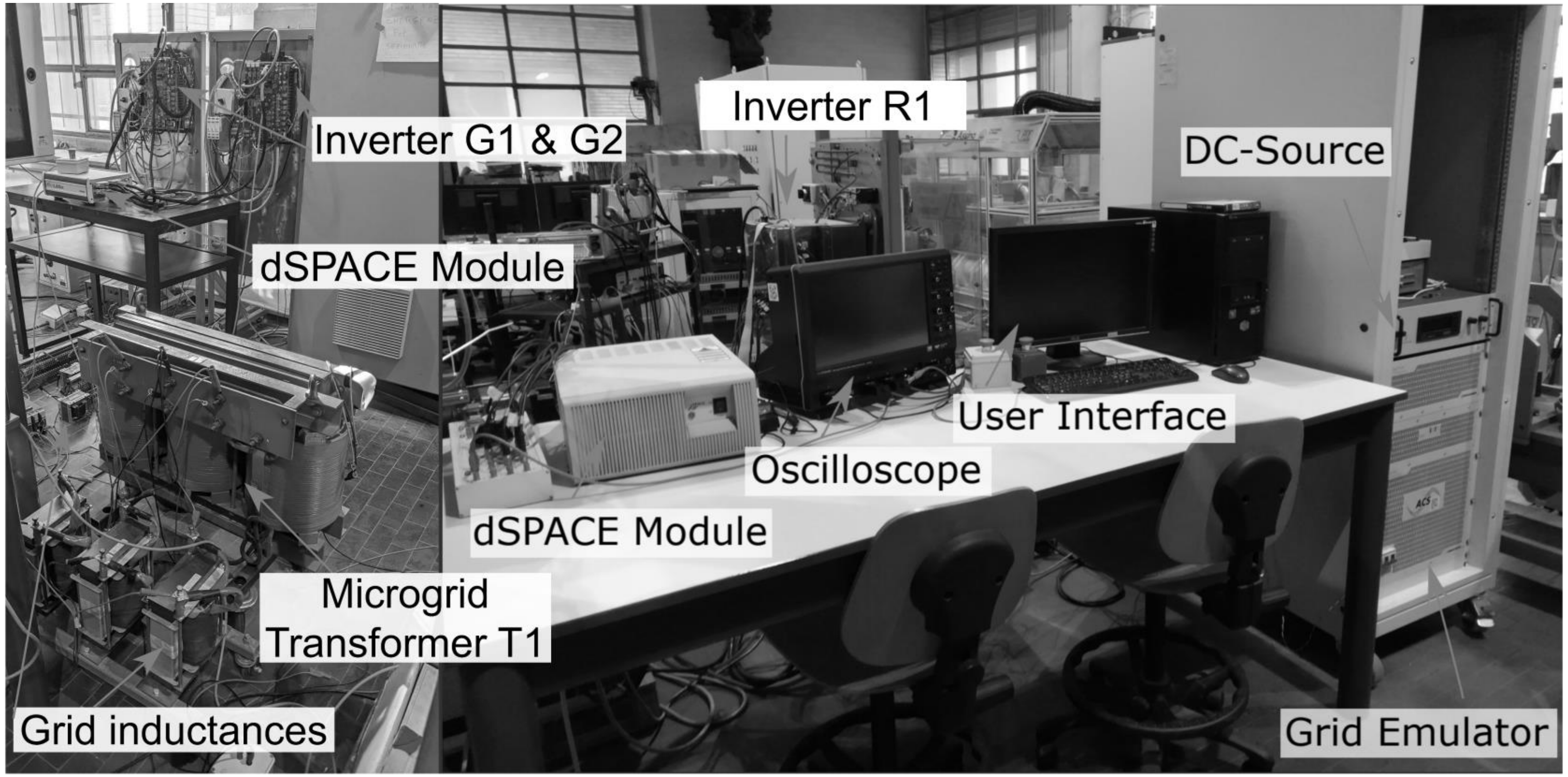
ΔP_L: load imbalance stimulus

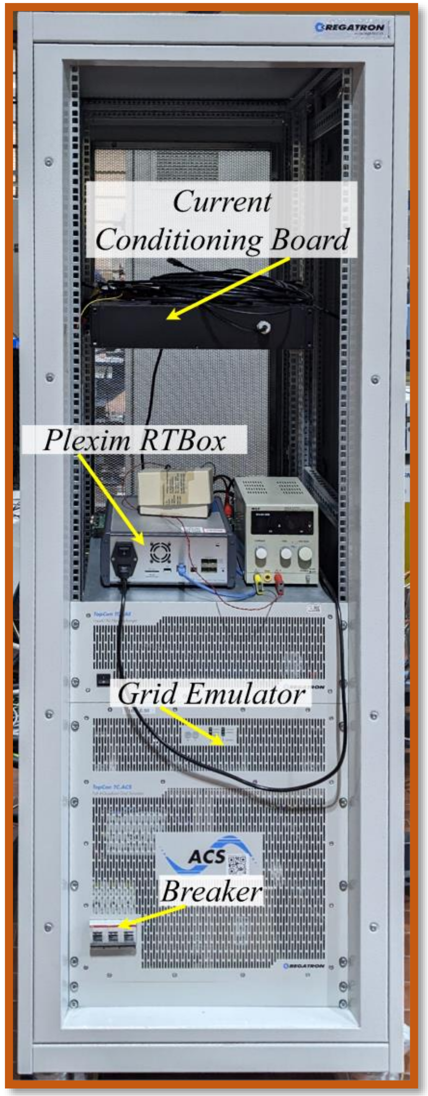
A current conditioning board to **measure** the current $\boldsymbol{i_g}$ and **estimate** the exchanged active power $\boldsymbol{P_g}$



Experimental Setup

- <u>Grid emulator</u>
- Microgrid





Experimental Setup

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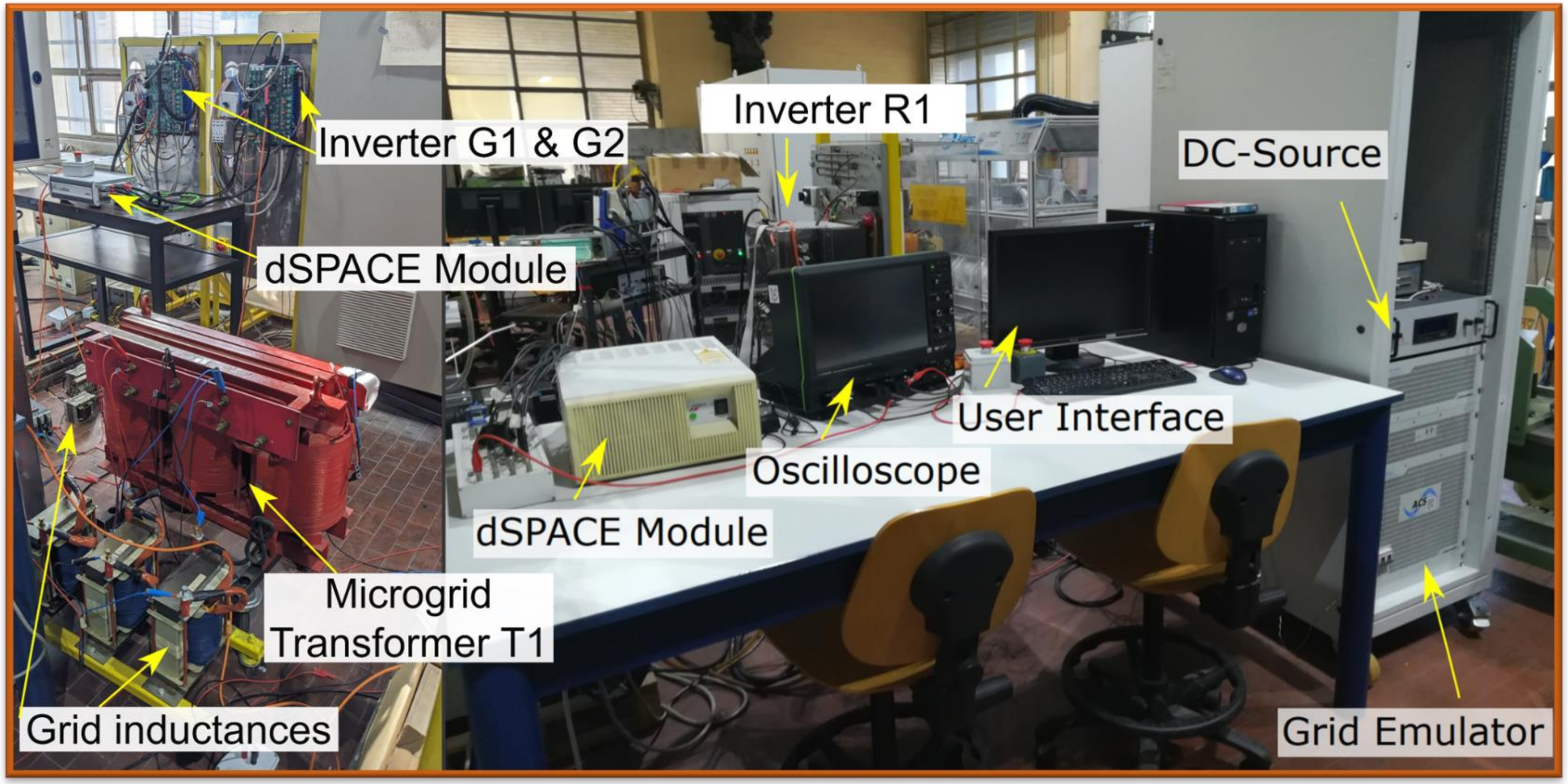
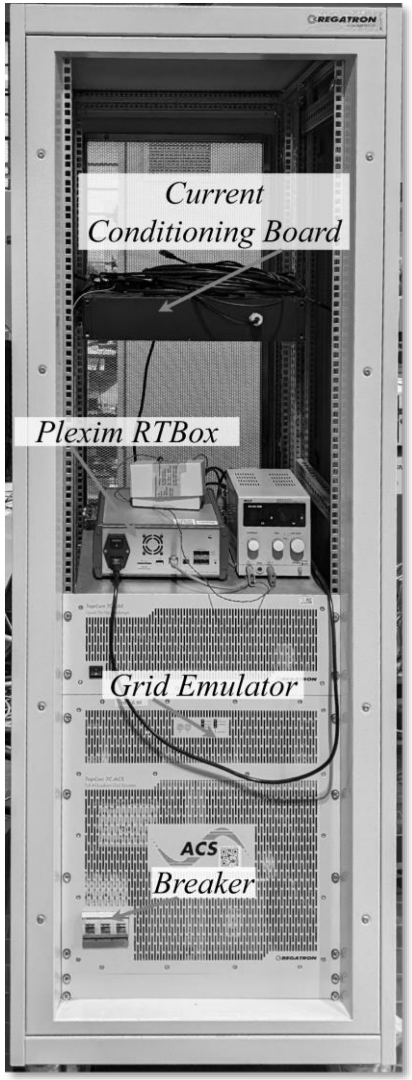
- Microgrid





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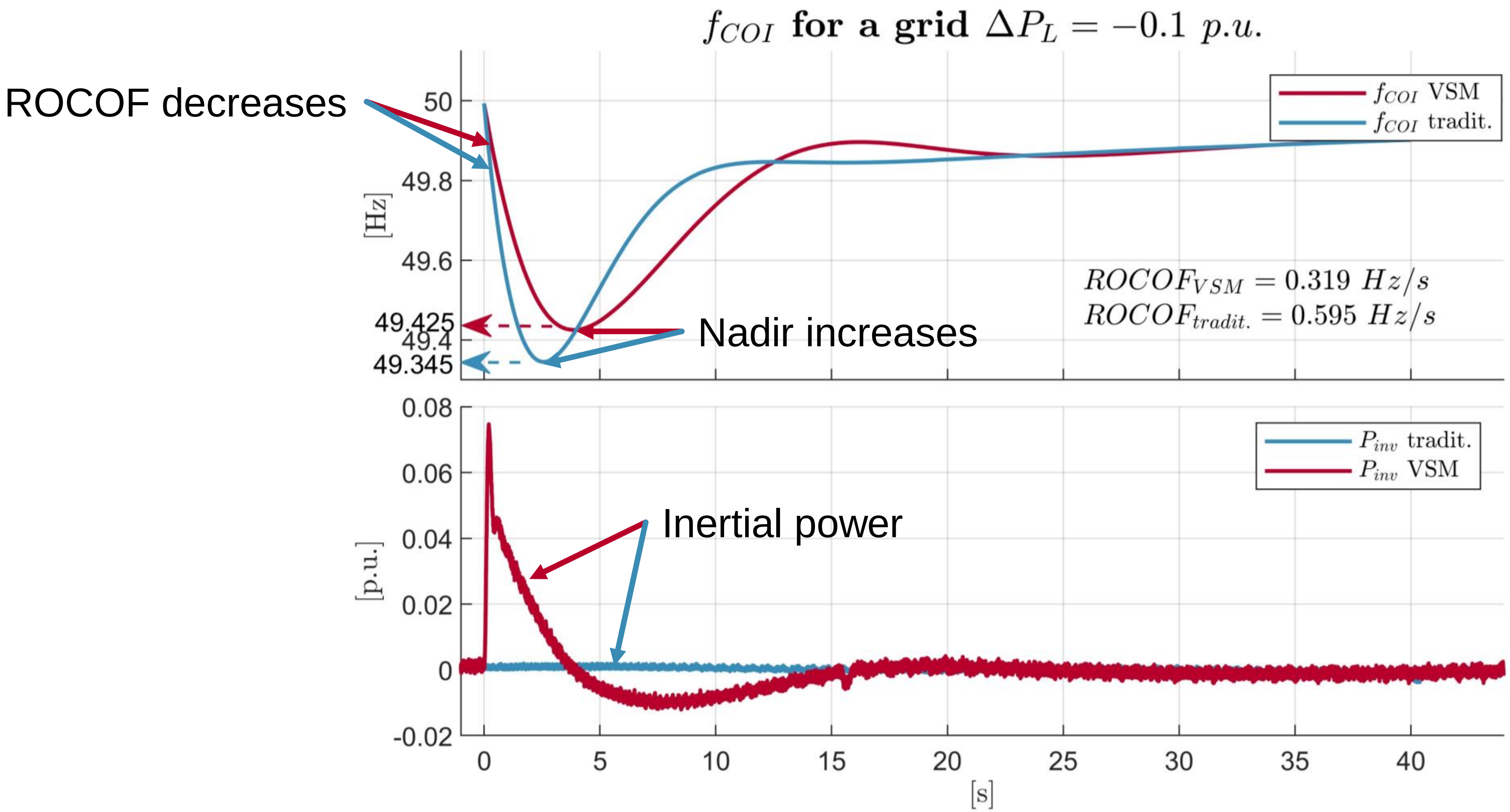
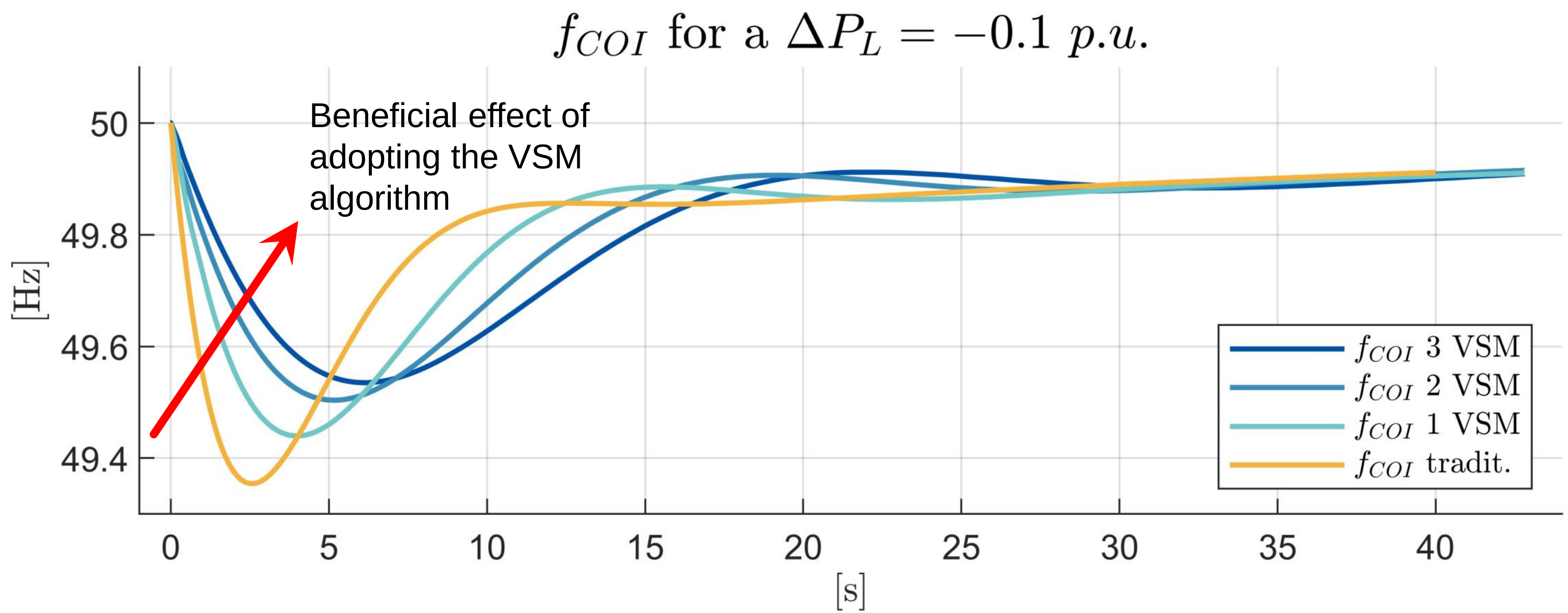
S-VSC vs. **traditional** (Grid Following): inertial behavior



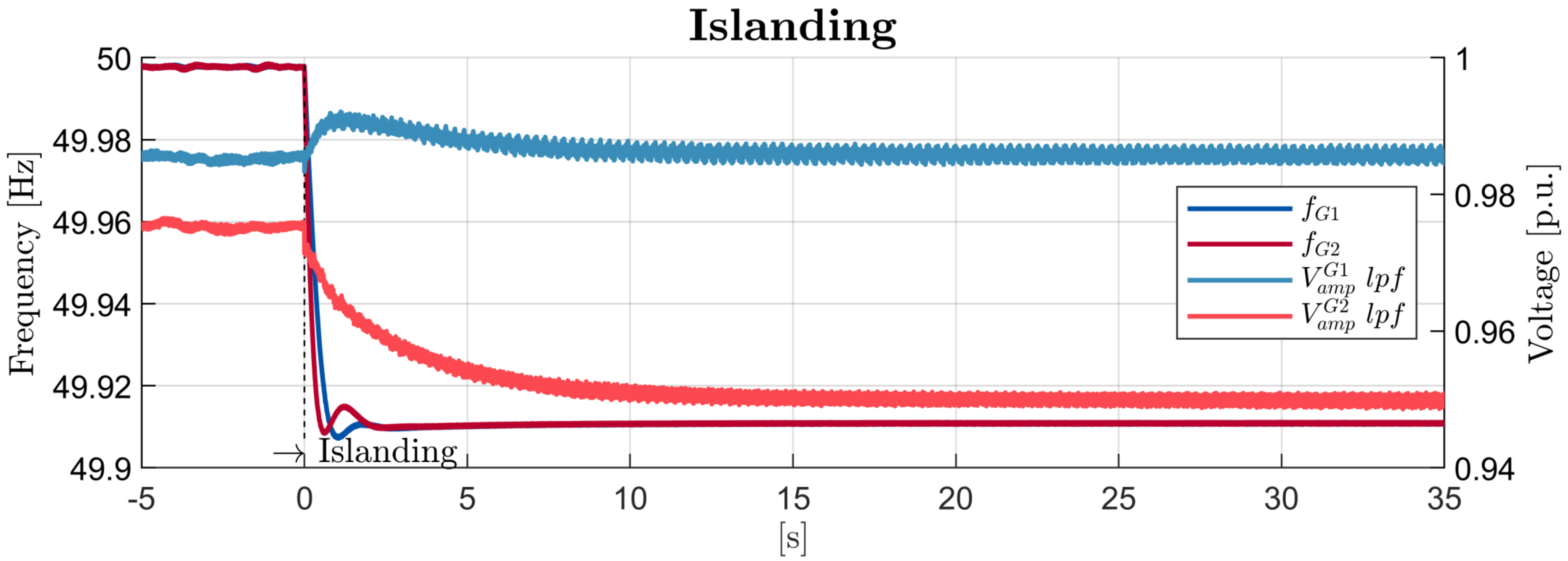
Final results of the Microgrid Tests

The results show how during the same **contingency**, for an increasing amount of VSMs in the grid, the frequency variations and ROCOF decrease



Transitioning from grid connected to island

- The control remains **stable** and the microgrid loads are supplied
- Steady state error could be eliminated by **secondary regulation**

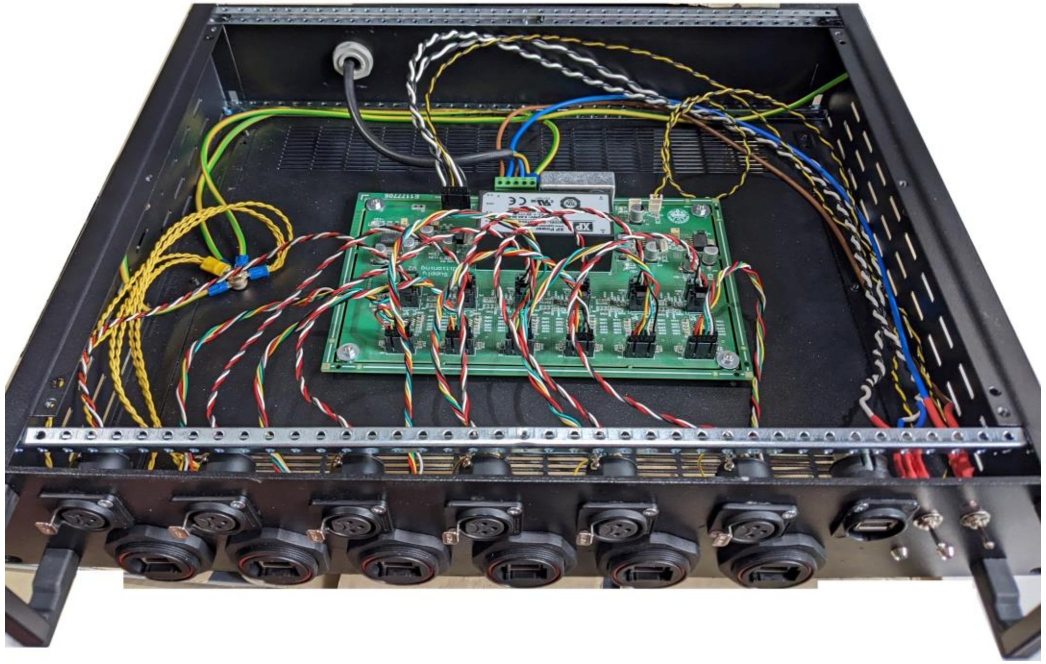


Conclusions

- The **S-VSC** is a suitable algorithm to provide inertial support to the grid
- Thanks to the dynamic model and the current board the grid emulator can interact with neighbour converters
- The **islanding** manoeuvre proved succesful
- The setup assembled allows for new tests, to further understand the behavior of **VSMs** in supporting the grid

Personal Contributions

- Assembling and testing of a current conditioning board for the grid emulator
- Implementation of the **dynamic grid** in the grid emulator control
- Refurbishment of the analog and digital cabling of the inverters G1 & G2
- Implementation of a **digital control** able to handle **two S-VSM** in parallel



Thank you for the attention!

References

[1] CHFCA

[2] AZOM

[3] ENELX

[4] Mandrile Fabio. “Next Generation Inverters Equipped with Virtual Synchronous Compensators for Grid Services and Grid Support”.