C6 - ACTIVE DISTRIBUTION SYSTEMS AND DISTRIBUTED ENERGY RESOURCES
PS 3 - Aggregated DER for Enhancing Resilience, Reliability and Energy Security of Distribution Systems

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Laboratorial testing of island integration of BESS at 5% scale

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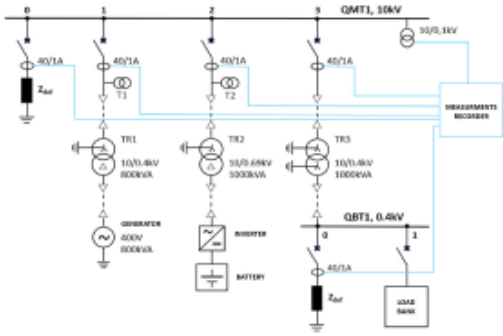
Motivation

- **Increase in energy consumption**
- Dependency of the energy polluting sources
- Increase of CO_2 emissions
- **Result**
- Decentralized generation sources based on Renewable Energy Sources (RES)
- **Impact**
- Intermittency and unpredictable nature of RES
- Introducing of Energy Storage Systems (ESS)
  - Mechanical (pumped hydroelectric, compressed air and flywheels)
  - Electrochemical (conventional batteries BESS)
  - Electromagnetic (capacitors, supercapacitors and superconducting magnetic energy)
  - Chemical (hydrogen with fuel cells)
  - Thermal energy storage (heat)
- **Integration of BESS in the power grid**
- Analysis of the storage system operation in the specific grid
  - Modelling and simulation of the power grid

    First step to obtain previous knowledge on the dynamic performance of the BESS
- Laboratory tests.
  - Necessary to develop a laboratory solution representative of the power system under study, from generation to consumption
  - Replicate the control architecture that will later be implemented in the grid.



Investigation

- To study **BESS performance while operating in a geographical isolated power system**
- **4 main group of tests preformed on the Lab Platform:**
  - **Primary voltage and frequency control** through disturbances in resistive, capacitive and inductive loads. Associated to a transient event and to verify the initial rapid response capacity of BESS to compensate for frequency and voltage deviation in the power grid
  - **Secondary voltage and frequency control** through disturbances of resistive, capacitive and inductive loads. To verify the capacity of BESS to restore the voltage and frequency values to nominal values, ensuring the stability of the power system's operation
  - **Analysis of system performance with faults**. To ensure that the storage system and all equipment (relays and circuit breakers) meet the short-circuit requirements of the power grid. Different types of faults tested: three-phase, phase-phase, phase-earth and phase-phase-earth
  - **Testing BESS black start functionality**. To verify the storage system's capacity to energize the test bench from the de-energized situation to the synchronism of the grid's generators

Approach

- Storage solution to be implemented in the island power grid: **20 batteries of 750 kWh each**
- One battery used to perform the Lab tests
- Lab solution developed represents **5% of the island's power grid**
- Study and test configurations:
  - BESS + Generator + Load bank
  - BESS + Load bank (disconnection of the generator)
  - BESS + Load Bank
  - BESS + Load Bank (reconnection of the generator)
  - Black start + short circuit

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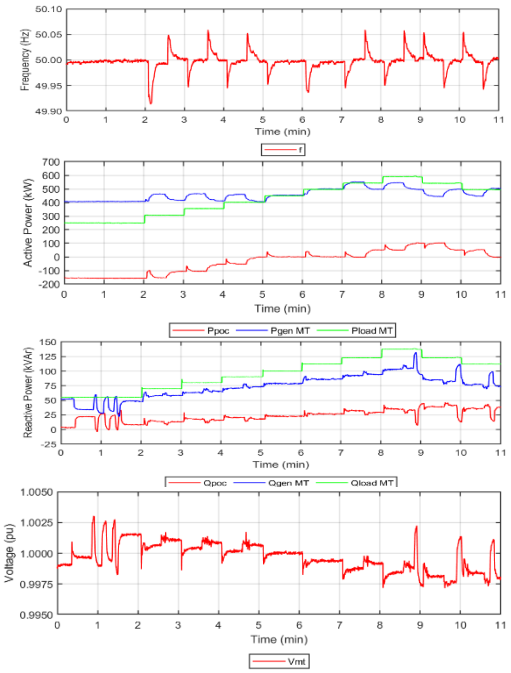
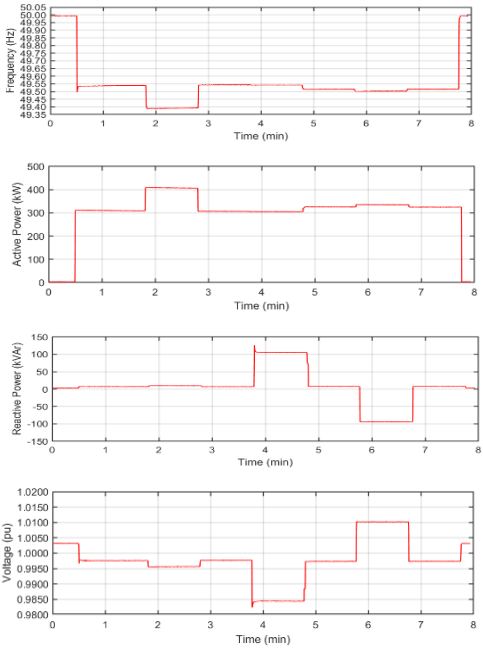
Laboratorial testing of island integration of BESS at 5% scale continued

Experimental setup & test results

- Grid configuration: Bess + Generator + Load bank



- Grid configuration: Bess + Load bank



- 0 to 5 minutes - Generator supplies the load bank + charges the BESS system.
- 5 to 7,5 minutes - BESS system is charged + load bank supplied by the generator
- After 7,5 minutes - Load bank increases + load is balanced to the BESS System
- Frequency variation: 49,92Hz to 50,06 Hz
- Voltage variation: 0,9970 to 1,0028 pu

Discussion

- BESS system handles well the grid fluctuations;
- Voltage and frequency maintained into acceptable limits with load sharing between the power generator (grid) and the BESS system.

Conclusion

- New solutions, as Storage Systems, should be tested in a Laboratory Platform to better analyze its performance and response in a controlled environment.
- The integration of Storage System based in Battery Solutions is a good option to neutralize the variability of the renewables, with principal focus on non-strong networks, like island grids.
- Lab Tests results revealed that BESS integration in the island grid has minimal impact in the system and helps the grid operation.