Test bench validation of an excitation booster for enhancement of fault ride through capability of synchronous generators

Luis Rouco

3 November 2016

Contents

- Introduction
- An ultracapacitor based excitation booster for bus fed excitation systems
- Test bench
- Results
- Conclusions

Introduction

- Fault Ride Through Capability (FRTC) refers to the ability of generators to remain connected to the grid in case of grid faults.

- GE Power (formely Alstom Power) patented an ultracapacitor-based Excitation Booster (EB) aimed at improving the FRTC of synchronous generators equipped with bus fed static excitation systems.

- In other words, the EB allows synchronous generators to withstand longer faults without losing synchronism.

Introduction

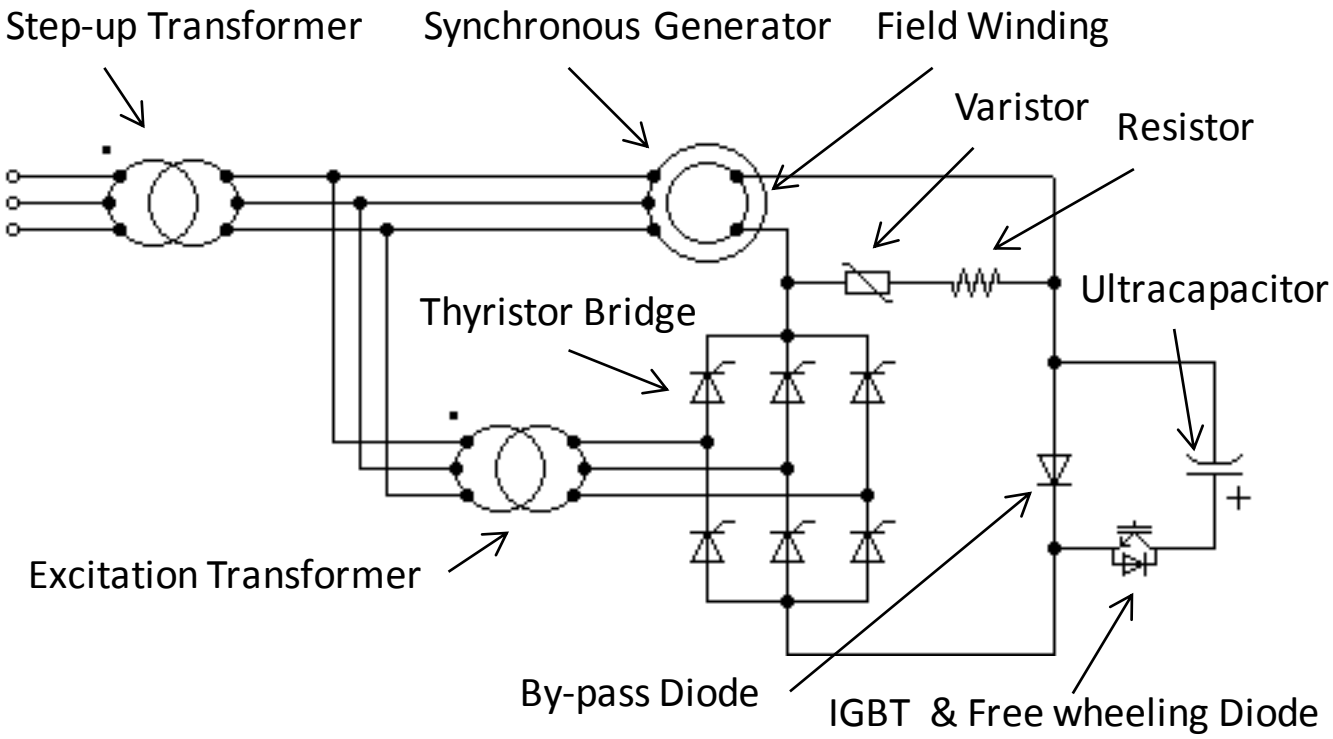
- GE commissioned Comillas University the experimental validation of the EB concept together with its modeling, sizing and controller design.

- Although the value of the concept has been checked by transient stability simulations, the test bench validation is intended to check aspects that are not shown by such simulations.

- This paper describes a small-scale (10 kVA) test bench developed for the experimental validation of the EB concept.

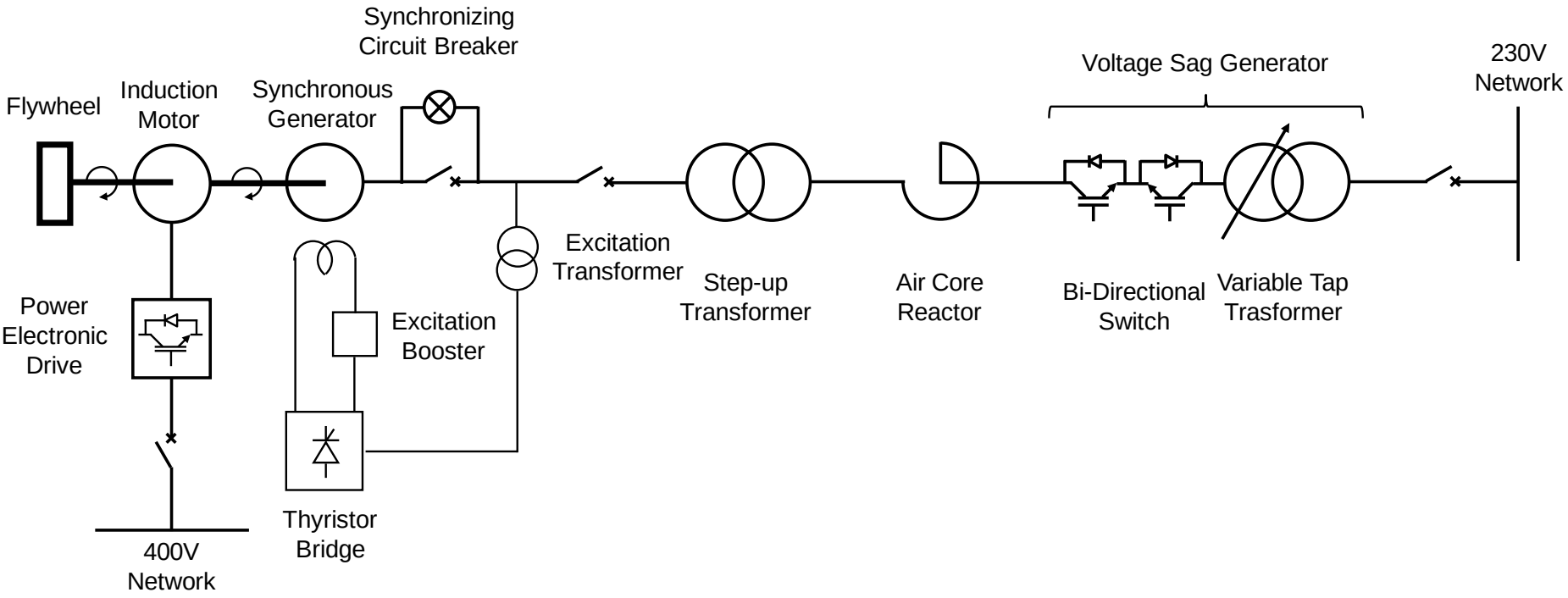
- Moreover, it investigates the feasibility and performance of EB control algorithms in a real environment.

An ultracapacitor based excitation booster for bus fed excitation systems



Test bench

- Single line diagram

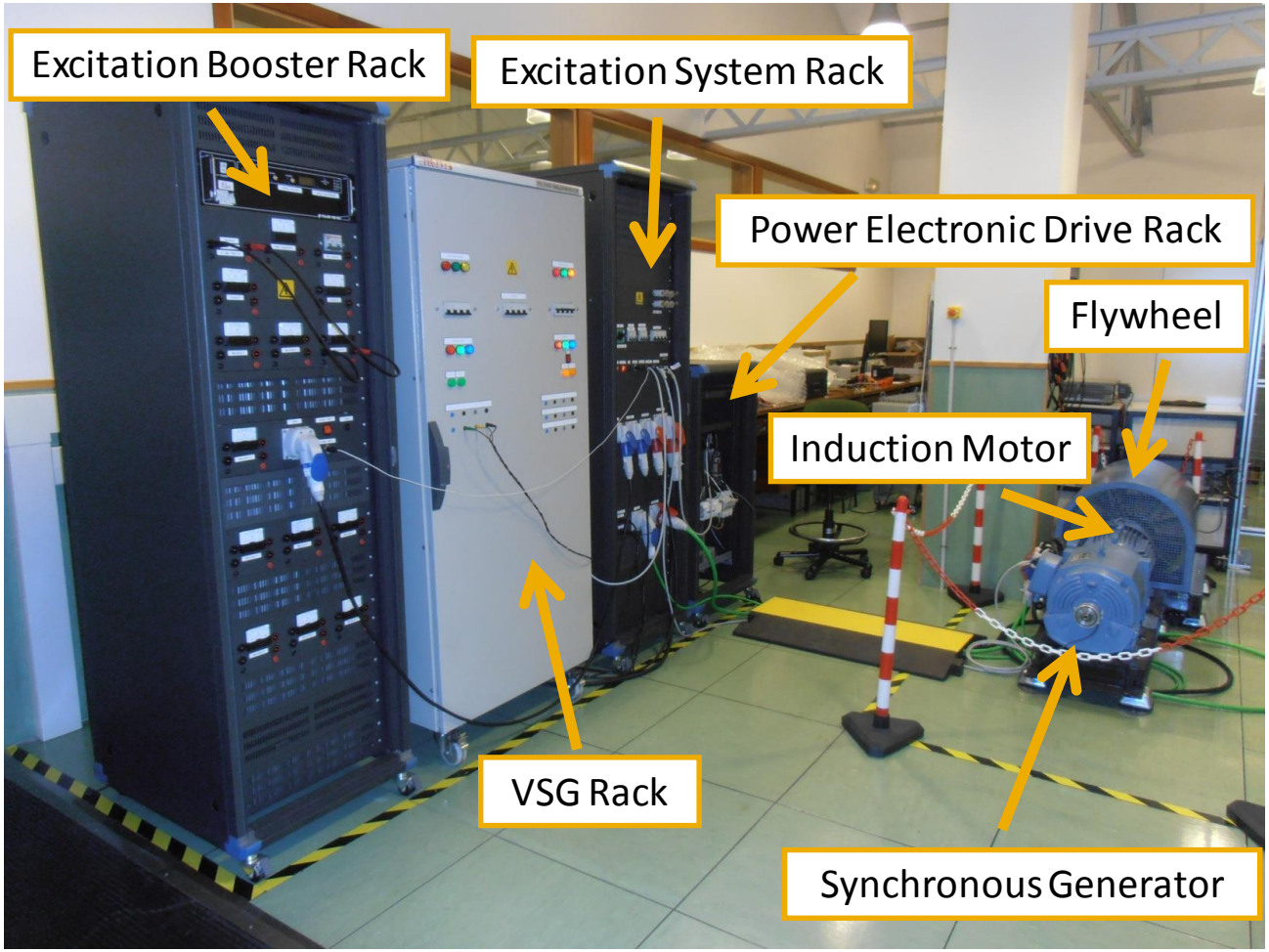


Test bench

- Components
  - Prime mover
    - Power electronic drive
    - Induction machine
  - Synchronous machine
  - Flywheel
  - Synchronous machine excitation system
    - Excitation transformer
    - Thyristor bridge
    - Automatic Voltage Regulator (AVR)
    - Excitation booster (DEM)
  - Voltage Sag Generator (VSG)
  - SCADA system

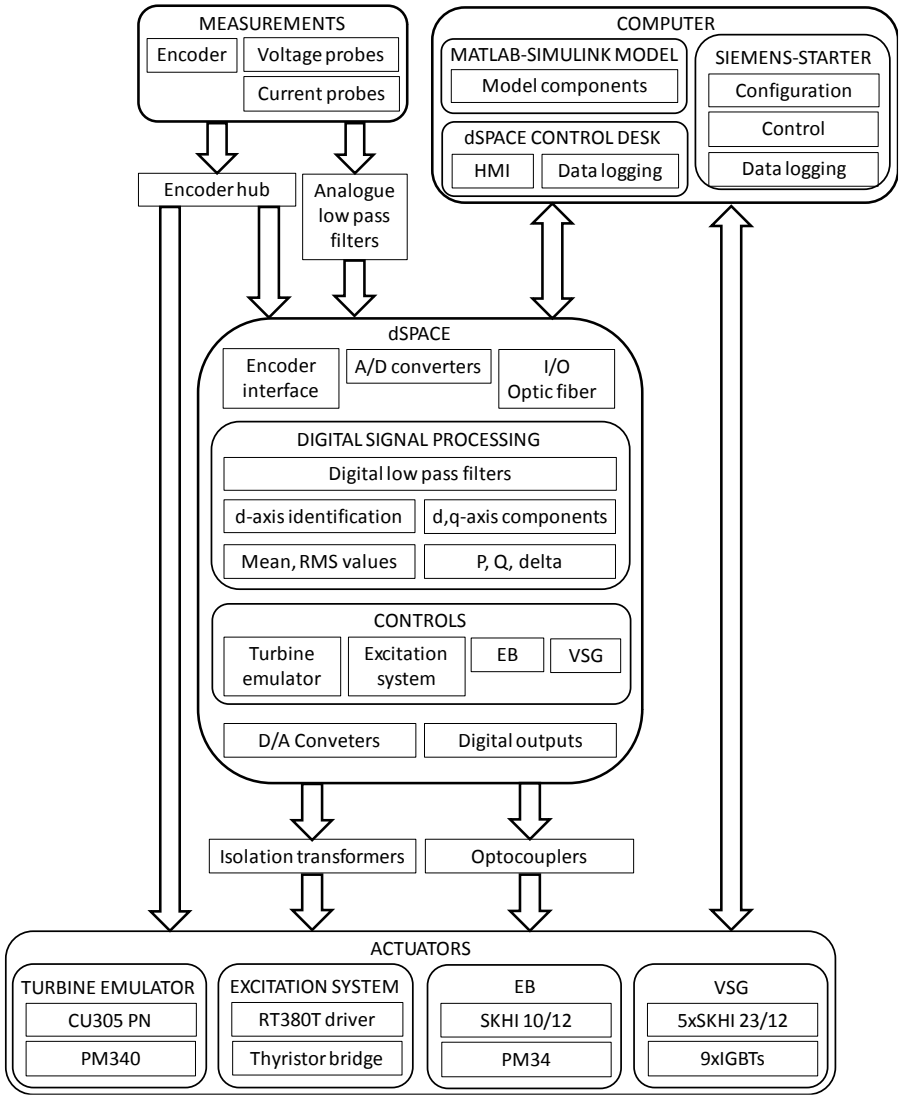
Test bench

- Overview



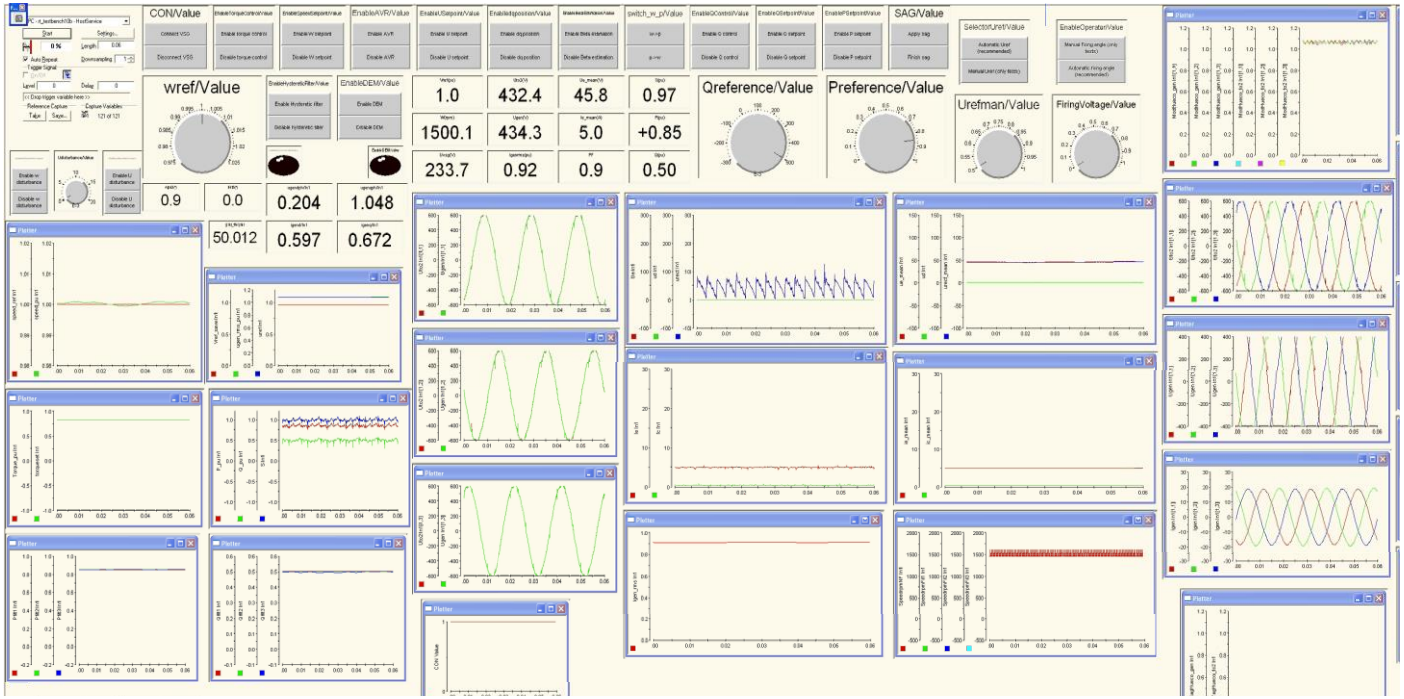
Test bench

- SCADA



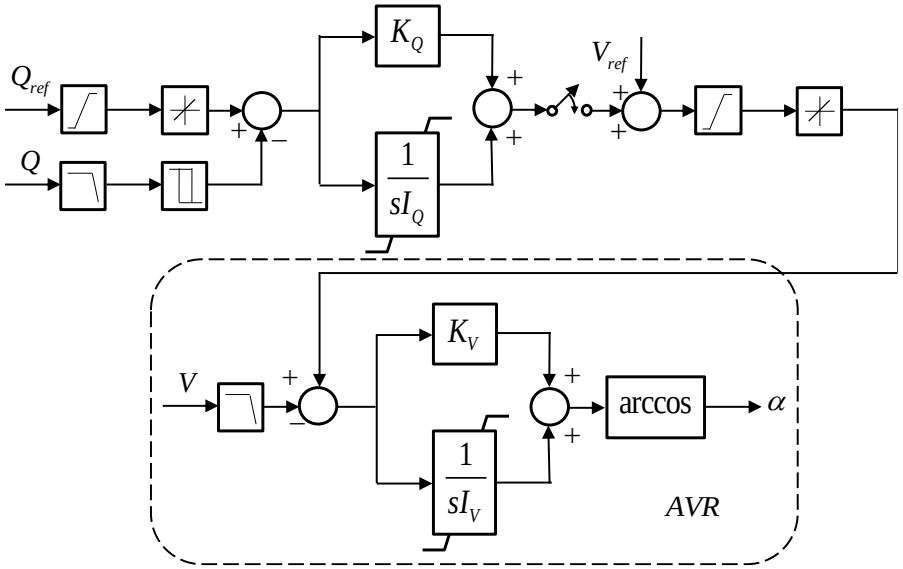
Test bench

Man-Machine Interface

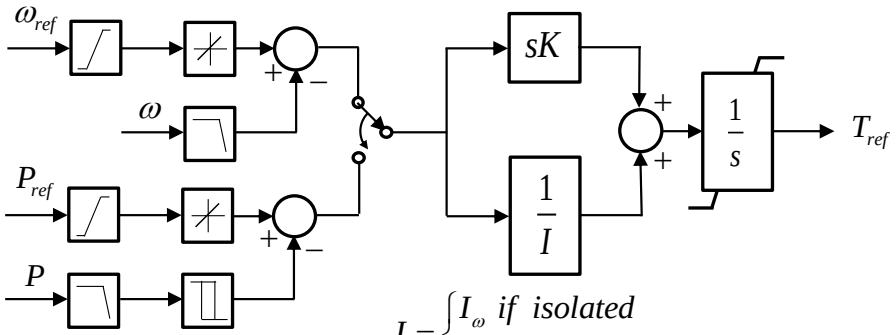


Test bench

- Controls



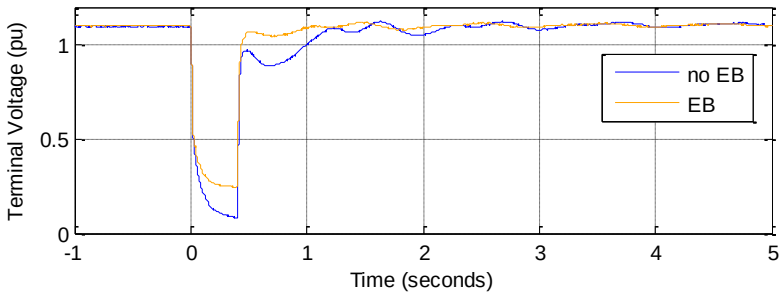
$$K = \begin{cases} K_\omega \ if \ isolated \\ K_P \ if \ synchronised \end{cases}$$

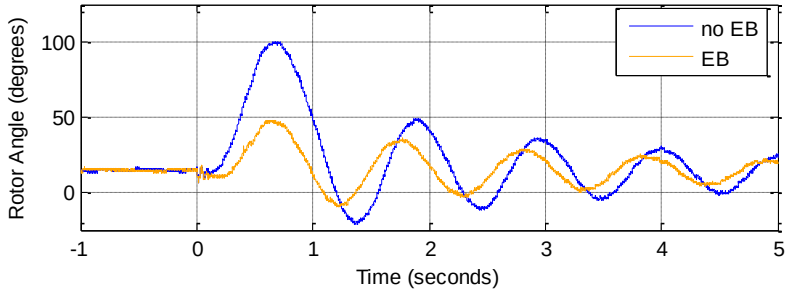


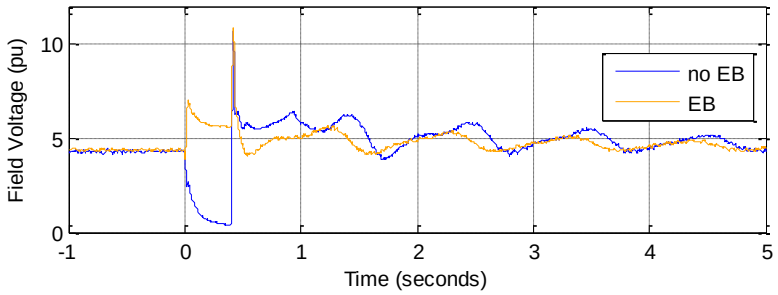
$$I = \begin{cases} I_\omega \ if \ isolated \\ I_P \ if \ synchronised \end{cases}$$

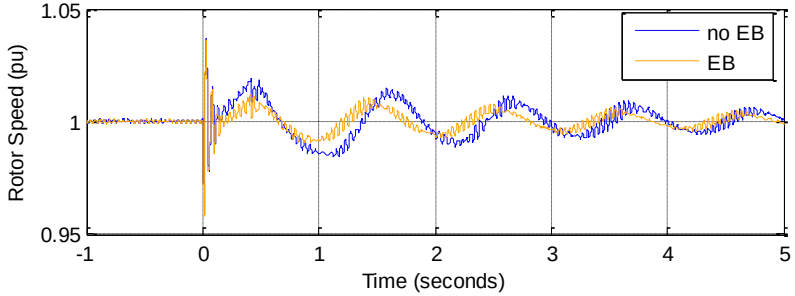
Results

- No EB versus EB
  - 400 ms three-phase solid fault



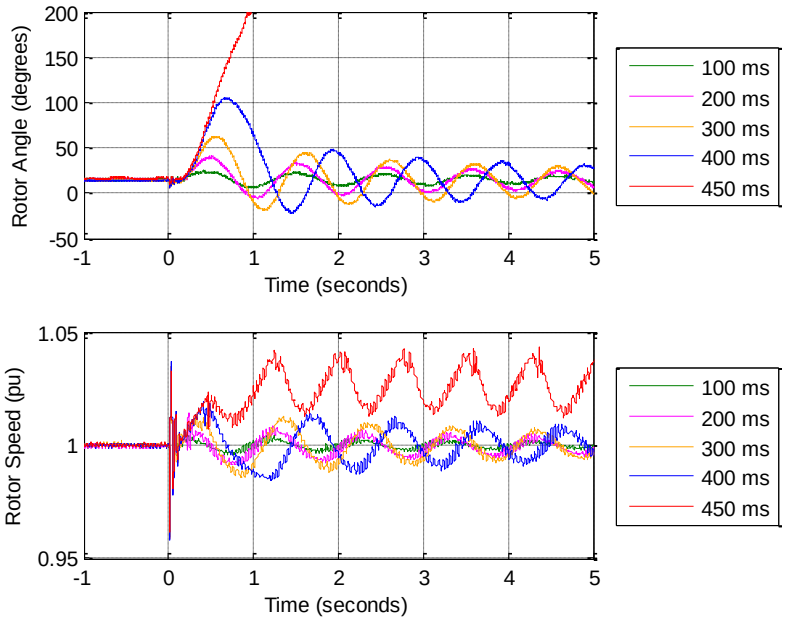




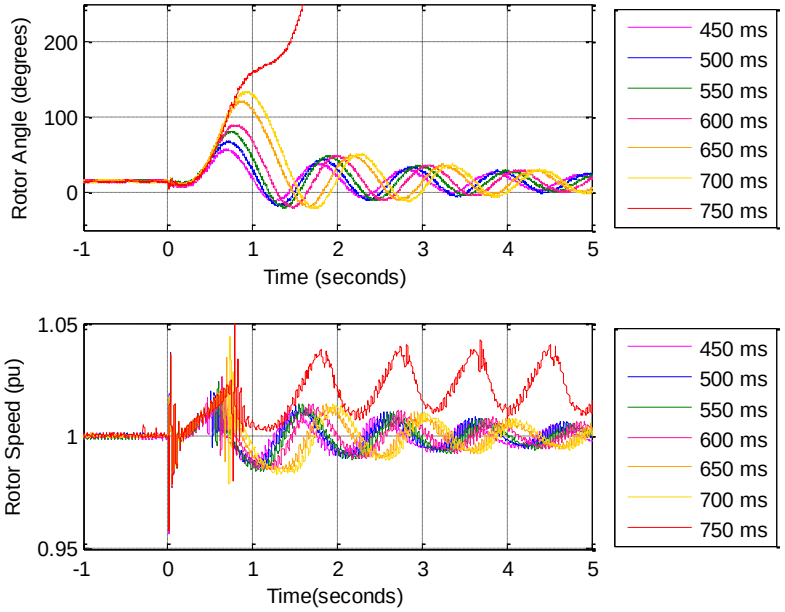


Results

- No EB versus EB
  - Critical clearing time experimental calculation



No EB: 400 ms



EB: 700 ms

Conclusions

- A 10 kVA test bench that reproduces the relevant behavior of a synchronous generating unit in case of voltage sags has been developed and assembled to test the EB concept patented by GE.

- The tests have proved the value of the EB concept to enhance the fault ride through capability of synchronous generating unit equipped with bus fed excitation system for generator's transient stability, solving some of the limitations of the bus fed static excitation system.

Instituto de Investigación Tecnológica
Santa Cruz de Marcenado, 26
28015 Madrid
Tel +34 91 542 28 00
Fax + 34 91 542 31 76
info@iit.upcomillas.es

UNIVERSIDAD PONTIFICIA ICAI ICADE COMILLAS MADRID