

## WORKSHOP

# Frequency Control and Inertial Response Schemes for the Future Power Networks

### 1. Abstract

Future power networks face several challenges: (i) the high penetration level of renewable energy from highly variable generators connected over power converters, (ii) several technologies for energy storage with very different time constants -some of them using power converters as an interface to the grid, (iii) A pan-European transmission network facilitating the integration of large-scale renewable energy sources and the balancing and transportation of electricity based on underwater multi-terminal high voltage direct current transmission. All of them have an element in common, high power converters that decouple the new energy sources from the pre-existent ac power systems. During a system frequency disturbance the system frequency will change at a rate initially determined by the total system inertia. The inertial response of the system might be negatively affected with devastating consequences for system security and reliability. The aim of this tutorial is to introduce the frequency control and inertia response schemes for the future power networks.

### 2. Outline

1. **Introduction:** Electromechanical concepts and frequency control
2. **A Vision of Future Electrical Power Systems.**
3. **System Frequency Response in Power Systems**
4. **Synthetic or Artificial Inertia:** Concepts and implementations.
5. **Frequency Response of Wind Turbines/Farms.**
6. **Enabling the HVDC systems to deliver frequency response.**

### 3. Duration

One hour and thirty minutes.

#### 4. Instructor Affiliation

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#### 5. Instructor Biography

**Francisco M. Gonzalez-Longatt** is currently a Lecturer in Electrical Engineering in the Faculty of Engineering and Computing, University of Coventry and he is Vice-President of Venezuelan Wind Energy Association. His academic qualifications include first Class Electrical Engineering of Instituto Universitario Politécnico de la Fuerza Armada Nacional, Venezuela (1994), Master of Business Administration (Honors) of Universidad Bicentennial de Aragua, Venezuela (1999) and PhD in Electrical Power Engineering from the Universidad Central de Venezuela (2008). He is former associate professor on Electrical engineering Department of Universidad Nacional Politécnico de la Fuerza Armada Nacional, Venezuela (1995-2009). He was formerly with the School of Electrical and Electronic Engineering, The University of Manchester as Postdoctoral Research Associate (2009-2011). His main area of interest is integration of intermittent renewable energy resources into future power system and smart grids.

## 6. List of Relevant Publications in this Area by the Instructor:

- [1] **F. Gonzalez-Longatt**, P. Regulski, H. Novanda, V. Terzija "Impact of Shaft Stiffness on Inertial Response of Fixed Speed Wind Turbines" *Automation of Electric Power Systems*, Vol 8, No 8, April 2012. (DOI: 10.3969/j.j.issn.1000-1026.2012.08.001).
- [2] **F. Gonzalez-Longatt**, J. Roldan, M. Burgos-Payán, V. Terzija. "Implications of the DC Voltage Control Strategy on the Dynamic Behavior of Multi-terminal HVDC following a Converter Outage". *UK and European T&D Network Solutions to the challenge of increasing level of renewable generation*. Newcastle-under-Lyme, Staffordshire UK, marc 14-15, 2012.
- [3] **F. Gonzalez-Longatt**, "Impact of Synthetic Inertia from Wind Power on the Protection/Control Schemes of Future Power Systems: Simulation Study". *DPSP 2012 - Protecting the Smart Grid, The 11th International Conference on Developments in Power System Protection*, 23-26 April 2012, Birmingham, UK. ACCEPTED
- [4] **F. González-Longatt**, P. Regulski, P. Wall, V. Terzija. "Induction Generator Model Parameter Estimation using Improved Particle Swarm Optimization and On-Line Response to a Change in Frequency". *IEEE PES General Meeting 2011*, 24 – 29 July 2011, Detroit, USA. (Available online DOI: 10.1109/PES.2011.6039373)
- [5] **F. González-Longatt**, P. Regulski, V. Terzija. "Procedure for Estimation of Equivalent Model Parameters for a Wind Farm using Post-Disturbance On-line Measurement Data". *IEEE PES: European conference and exhibition on Innovative Smart Grid Technologies (ISGT-EUROPE 2011)*, 11-13 October 2011, Manchester, UK.
- [6] **F. González-Longatt**, P. Regulski, P. Wall, V. Terzija. "Fixed Speed Wind Generator Model Parameter Estimation using Improved Particle Swarm Optimization and System Frequency Disturbances". *IET Renewable Power Generation Conference 2011*, 6 - 8 September 2011, Edinburgh, UK.
- [7] **F. González-Longatt**, P. Wall, V. Terzija. "Impact of the shaft stiffness in the inertia response of Fixed speed wind turbines based on single cage induction generator". *Advanced Power System Automation and Protection (APAP2011)*. 16-20 October 2011. Beijing, China. (ISBN: 978-1-4244-9619-8)