Tutorial

FREQUENCY REGULATION SUPPORT BY LOADS AND RENEWABLE ENERGY SOURCES

Organised by:

Francesco Conte, University of Genova (IT)
fr.conte@unige.it

During last years, a wide installation of renewable energy sources (RESs) into the power system has been promoted. In this scenario, the control of the grid frequency is becoming highly complex. Indeed, RESs are distributed, extremely variable, not programmable, and they do not contribute to the frequency regulation. Moreover, the spread of RESs is associated to the displacement of large-scale traditional and fully controllable generation units, which today mainly operate the frequency control. This means that the frequency control power reserve is decreasing as well as the rotational inertia of the power systems, which is also becoming markedly time-variant and non-uniformly distributed within the grid. Potentially, this leads to frequency instability phenomena compromising the overall power system stability.

The Transmission System Operators (TSOs) and the scientific and industrial communities are tackling the problem proposing new paradigms of control. One of the main ideas is to involve into the frequency regulation flexible customer loads with Demand Side Response (DSR) programs and/or the same renewable energy generation units.

After an analysis of the frequency control state-of-the-art, this tutorial will present three control strategies designed to allow loads or RES to participate to the grid frequency control:

1. ***Power system dynamics and controls in the presence of large penetration***. Presented by **Dr. Giorgio Maria Giannuzzi, TERNA RETE ITALIA S.p.A**.

2. ***Wind farm participation to frequency regulation*** **[1]:** a model-based control technique to provide the contribution of a set of wind power generators to primary frequency regulation. Presented by Francesco Conte.

3. ***Frequency regulation support by domestic thermostatically controlled devices*** **[2]:** analysis of the impact of a distributed control strategy proposed by the European Network of Transmission System Operators for Electricity (ENTSO-E) applied to domestic refrigerators and water heaters in the scenario of a regional power system. Presented by **Diego Cirio, Ricerca Sistema Energetico, S.p.A.**

4. ***Frequency control services by building cooling system aggregates*** **[3]:** a control strategy for managing an aggregate of commercial buildings equipped with Space Cooling Systems (SCSs), called to provide frequency control services to the main grid. Presented by Francesco Conte.

[1] F. Baccino, F. Conte, S. Massucco, S. Grillo, and F. Silvestro, "An Optimal Model-Based Control Technique to Improve Wind Farm Participation to Frequency Regulation," IEEE Transactions on Sustainable Energy, vol. 6, no. 3, pp. 993–1003, 2015.
[2] F. Conte, S. Massucco, F. Silvestro, E. Ciapessoni, and D. Cirio, "Stochastic modelling of aggregated thermal loads for impact analysis of demand side frequency regulation in the case of Sardinia in 2020," International Journal of Electrical Power & Energy Systems., vol. 93, pp. 291–307, 2017.
[3] F. Conte, S. Massucco, and F. Silvestro, "Frequency control services by a building cooling system aggregate," Electric Power Systems Research, vol. 141, pp. 137–146, 2016.

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Francesco Conte is assistant professor at the Department of Electrical, Electronics and Telecommunication Engineering and Naval Architecture of University of Genova (Italy). He received the master degree in computer science and automatic engineering and the Ph.D. degree in electrical and information engineering from the University of L'Aquila (Italy), in 2009 and 2013, respectively. His areas of interest include power system modelling and control, analysis and control of stochastic, nonlinear, and/or delayed dynamical systems. He is co-author of more than 15 peer-reviewed publications in international journals and 25 international conferences.

Diego Cirio received the M.Sc. degree (1999) and Ph.D. degree (2003) in Electrical Engineering from University of Genoa, Italy. He leads the Grid Development and Security Research Group at "Ricerca sul Sistema Energetico - RSE S.p.A." (Milano, Italy). He is active in EU and national research projects on system adequacy, operational risk, security, resilience, and new system services, also supporting Italian public institutions on planning and operation issues within the research group he coordinates. He acted as co-Operating Agent in the IEA Implementing Agreement ENARD Annex IV "Transmission systems" and he is currently involved in IEA ISGAN Annex 6 "Power Transmission and Distribution Systems". He contributed to CIGRE WG C4.601 on Power system security assessment and he is member of CIGRE WG C4.47 on power system resilience. He has been IEEE Senior Member since 2013.

Giorgio Giannuzzi (1967) received his Electric Engineering degree from the University of Rome. Until December 2000 he worked for ABB, where he was in charge of network studies, protection and control applications, with special reference to RTU apparatus and data engineering issues. Since 2001 he works for TERNA as expert in defense plans/systems, dynamic studies, protection, telecontrol and substation automation. Between years 2004 and 2011 he coordinated the study, design and activation of Wide Area Defence system (including Interruptible Customers System) and Wide Area Monitoring System. In addition under his guidance were designed and coded the main security Energy Management Systems actually in use at National Control Centre (Optimal Power Flow security and market constrained, Optimal Reactive Power Flow, Dynamic Security Assessment tool, Dynamic and Static security verification software, Operator Training Simulator) and revision of main Italian Grid Code technical enclosures (Primary and Secondary frequency regulation, Load Shedding, Protection and Automation, Defence Plans).
Until 2009 he was a member of a UCTE Expert Group on Power System Stability. In 2010 he joined ENTSO-E System Protection and Dynamics Group and starting from 2014 is the Convenor, coordinating the European evaluation over Dispersed Generation impact on system security and load shedding guidelines. Currently is responsible of the Engineering Department of National Dispatching Centre.