Coordinated Voltage Control in Electrical Power Systems

Mohammad Moradzadeh
SYSTeMS Research Group
Departement of EESA
University of Ghent
Technologiepark - Zwijnaarde 914
B-9052 Zwijnaarde, Belgium
Email: Mohammad.Moradzadeh@UGent.be

René Boel
SYSTeMS Research Group
Departement of EESA
University of Ghent
Technologiepark - Zwijnaarde 914
B-9052 Zwijnaarde, Belgium
Email: René.Boel@UGent.be

Abstract

Over the last two decades power systems have been operated under much more stressed conditions than were usual in the past due to environmental pressures on generation and transmission expansion, competitive markets, and unpredictability of renewable energy sources. Under these stressed conditions, voltage instabilities result from the attempt of loads to draw more power than can be delivered by the transmission and generation system. Components such as generators and loads drive the continuous dynamic behavior. On the other hand, discrete events such as threshold reached by over excitation limiters (OXLs) and logical controllers such as load tap-changing transformers (LTCs) and switched capacitor banks (CBs) actions lead to discrete state dynamics. So, the behavior of power systems is characterized by the complex interactions between continuous dynamics of the power system and many hybrid automata representing the logical controllers, i.e. power systems exhibit complex hybrid behavior.

LTCs and CBs can locally maintain the voltage but many voltage collapse incidents have been caused by uncoordinated interactions of LTCs following a major disturbance that locally causes a strong decrease in the voltages. Current practice disables some of those controllers such as LTCs in order to prevent additional problems resulting from their interaction and up to now there has been relatively little attention paid to devising a true coordinated voltage control using message exchange between discrete event controllers by applying distributed control theory and taking discrete events into account.

So, we aim at voltage stability enhancement by using coordinated control actions of the discrete event controllers by using message exchange between the different local control agents (e.g. one control agent per bus). A hybrid system model for investigating the quality of these distributed controllers has been implemented in Simulink using also (SymPowerSystem & Stateflow) which allows reliable simulation of the behavior of both the continuous and the logical components of 12 bus power system with 3 LTCs and 3 CBs. Various approaches for coordinating local controllers (e.g. distributed model predictive controllers) can be investigated using this simulator.

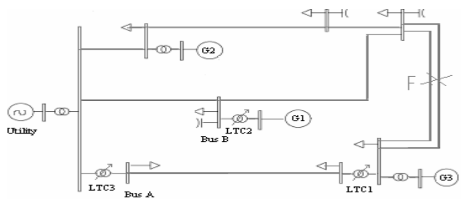

Figure 1: 12-bus IEEE standard power system.

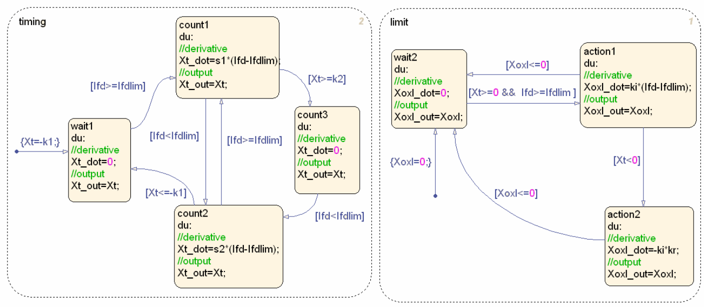

Figure 2: Hybrid system model for OXL.

References

[1] Van Cutsem, T, and Vournas, C, Voltage stability of electric power systems. Power electronics and power systems series, Kluwer academic publisher, 1998.

[2] Larsson, M, Coordinated voltage control in electric power systems. Ph.D. thesis, Industrial electrical engineering and automation, Lund university, Sweden, 2000a.

[3] Ian A. Hiskens, Power system modeling for inverse problems, IEEE transaction on circuits and systems, Vol. 51, No. 3, March 2004.