Co-Simulation of Power- and Communication-Networks for Low Voltage Smart Grid Control

Abstract — The present passive operation in the electricity network is able to handle only limited amount of distributed generation. To avoid extension of grid capacity an intelligent infrastructure and smart grid control is proposed which will guarantee the compliance of limits given by EN50160. For this reason, the different components of the grid have to communicate with the grid controlling unit to transfer real-time voltage measurements and commands. To assess the mutual influences between the electrical power grid and power system, a co-simulation architecture was developed. The methodology in which the components of communication and power simulation are coupled along with some first emulation results are presented in this paper.

Why Co-Simulation of electrical power grid and communication network?

- Necessary in the development of algorithms for active voltage control. The grid active components need measurements of network voltages to take correct decisions.
- For the evaluation of the control loop, properties of the communication channel(s) matter and verification of the control algorithms have to be done before implementation.

System architecture

Power Grid Simulation

- To perform steady state and transient analysis the software PowerFactory will be used. Transient simulation can be synchronized to real time (necessary for emulation mode).
- In simulation mode the power flow analysis can be time synchronized with the simulation controller. Below are the implemented interfaces.

Adapter: integrates the heterogenous simulation components, stand-alone, minimalistic, efficiently handles data traffic between simulation clients.

Emulation: Grid simulation, communication model and grid control are linked via adapters. The packets flow top-down experiencing a delay in the simulation controller. Reply packets go the opposite way.

Simulation: Adds event queue and synchronizer to the chain via a third adapter. The transport layer is not fixed TCP/IP socket. It can be an arbitrary component with a compatible interface.

Communication Simulation

- Protocol used is the Power line Communication (PLC) also used in AMIS smart meters. Master: the data concentrator (DC) / Slave: Smart meter.
- Every node receiving a packet repeats it simultaneously for a defined (master) number of times. Retransmissions create hop layers. Also not directly reachable nodes can be addressed via repeating intermediate nodes.

Emulation Results

Grid model: 50 household customers in a star topology. A single-phase 5 kW photovoltaik with E0 profile is assumed to be on every house. Load model: A probabilistic model generates household-like behaviour based on three main groups of signal forms:

1. A base load, that varies over the day
2. A small number of ripple processes that have a nearly constant duty-cycle
3. High-amplitude peaks, occurring without fixed frequency at certain times during the day.

The parameters are set so that the sum profile of the households will converge to a synthetic H0 profile. When adding them up, again a near-H0 shape is achieved.

Voltage control approach: The tap changer transformer is used as the active control element and it has five steps with a step size of 2.5 % of the nominal voltage. At five critical nodes three-phase voltage measurements are performed. If the limits are exceeded, the tap changer reacts.

Outlook: The results show a proof of concept of the co-simulation in the emulation mode. However the use of the adapter has turned out to cause performance issues. In next version, a better intermediary element will be developed and for the grid model, Powerfactory will be used.