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Innovation Action

flexitranstore

An Integrated Platform for Increased FLEXIbility in smart TRANSmission grids with STORage Entities and large penetration of Renewable Energy Sources

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D10.3 Design of the virtual power system for the ADN demonstrator and WPP active substation			
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Executive summary

1.1 Scope of deliverable

This report describes the detailed design of a real-time hardware-in-the-loop power system simulation platform called Computing and Control Laboratory to evaluate commercial Battery Energy Storage System (BESS) controllers. The main goal for the computing and control lab is to establish a demonstration and evaluation platform for testing proposed first, second and third level controllers of BESS using any system topology.

The objective of the laboratory is the simulation of the BESS-integrated active substations. The design of the laboratory to simulate the active substations(active distribution node-BESS in Cyprus and wind power plant-BESS in Greece) are oriented both to work autonomously (by distributed control) and with system operators (by centralized control) in order to monitor the system and control the active substations by assigning appropriate set points.

Main part of the computation area of the lab is the computing equipment and intelligent algorithms. The control area of the lab takes advantage of power system simulation and measurement equipment such as OPAL RT, phasor measurement unit and remote terminal unit, which obtain the data from the grid to the computation area and transfer the outcomes back to the grid after the computation is performed. Execution of experiments, assignment of appropriate set points, display of the status of the systems on the screen, status monitoring, and maintenance tasks are some of the tasks carried out in the lab. Lastly, this developed ‘‘virtual power system’’ will be used during the demonstration phase of the project, comparing the operational magnitudes and indicators of the remotely monitored demonstrators with the ones resulting from the virtual laboratory environment.

1.2 Concept and methodology

This report provide the results of the “Virtual power system programing (HI simulator programming)”, whose implementations, outcomes and retrieved guidelines will support the realisation of the demonstrators in WP5 and WP6 in the project.

Specifically, in this deliverable, we lay the structure and provide information for developing a virtual power system for active distribution and wind power plant substation nodes in the context of Flexitranstore project. The developed virtual power system with its defined sections will be used to carry out case studies with characteristics of the real power systems in this project. Firstly, we arrange the configuration for the considered virtual power system with all the main blocks. Detailed link among the blocks and type of link with the corresponding required data communications are discussed. Next, a description of the hardware-in-the-loop is given, which accounts for the physical and real-time simulation platforms. The information regarding the real-time simulation platform is mentioned after this. To select the appropriate platform, multiple studies from various perspectives are performed. Due to provisional availability of electrical grid in different simulation formats, a procedure is explained on how to transfer the models to the real-time simulation platform, while mentioning the challenges and issues in this process. In line with the objectives of the project, we enumerate the steps to move from a full system implementation to a reduced area. In this regard, we explain the overall philosophy of reducing a network and mention various techniques with different features. The process starts by identifying the area of influence where the focus is on operation of the BESS. In other words, the area that BESS can have defined impact is recognized. Then, the rest of the grid should be reduced and entered into the calculation as a reduced network with specific characteristics. The implementation of the reduced power systems in the real-time simulation platforms is also described in the complete document. It includes the reduced networks of Cyprus and Greece by accounting for the characteristics of each network. In order to complete the virtual power systems with the active substations designed in Flexitranstore project, each substation is individually modelled. As BESS is one part of the active substations, the detailed model of the BESS is presented. Then, the BESS model is also transferred into the real-time simulation platform with the rest of the modelled reduced power systems. One other aspect of a virtual power system is demand consumption, production by renewable sources and electricity market. Therefore, three emulators are developed to address there important aspects. While the demand emulator provides the required information from the demand side in order to operate a power system, the weather emulator provides availability of renewable sources (e.g. wind and solar). The electricity market emulator in this part of the project is focused on representation of outcomes of a market. After development of the reduced networks in the real-time simulators, several processes are undertaken to validate the accuracy of the models. In the end, the digital communication among various parts of the hardware-in-the-loop lab is detailed.

1.3 Key activities

1st-level controller communications in the lab are operational and working. Tests including, including communications, have already been performed, in order to program the 1st-level controller algorithms (frequency droop, virtual synchronous power, power smoothing). The state machine is operational. Activities focusing on programing the final version of the 1st-level controller have been developed.

For starting up the 2nd-level controller and the communications, tests have been conducted and it is being refined. Algorithms are already programmed.

The 3rd-level controller structure and the communication with FEG has already been defined. Algorithms are designed and the final version is currently working.

1.4 Key results/Main findings

Main results of tasks related to WT 10.3 is the HIL simulation platform development. This platform could be uses to support the development of embedded systems in power systems activities involving the development of subsystems, integration of real and virtual subsystems, and systems tests. The platform will be used to evaluate operation of commercial grid interactive BESS trough hierarchical controllers. Main results of the developed virtual environment of power systems are:

- Reproducing hybrid simulation environment of the grids in demonstration sites using reduced but accurate models for the transmissions and distribution networks.
- Emulating other contour magnitudes of active substations, such as behaviour of the renewable energy resources, behaviour of the demand, and the evolution of electricity markets.
- Establishing appropriate communication of different blocks of the virtual power systems
- Ability to connect new devices in the system under study without interrupting the simulation of the system.
- Ability to provide animation and visualization of any device in the system under study to the response of the system.

Finally, all the communication interfaces are properly linked to real-time model of grids in order to communicate with the substation and overall system control platform, which hosts all the algorithms of the system operation and active substation's hierarchical control system. The communication structure deployed in the HIL-Lab reproduces the actual communication networks installed in the actual demonstrators.