Development of a Control System for Islanded Power Systems based on Intelligent Agents Technology

Diploma Thesis

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ABSTRACT

This diploma thesis deals with the development of a control system for power systems. Specifically, the structure of a microgrid and the intelligent agents' technology are being studied. The main objectives of this thesis are the design of an intelligent load controller as well as the implementation of machine learning in order to enable the controller to learn through his environment.

The microgrid is a new form of a power system, part of the wider concept of smartgrids. It can be considered as a small-scale electricity grid in low voltage – or even in medium voltage – and it is consisted of loads and microsources such as renewable energy sources, combined heat and power units, fuel cells, among others. An important characteristic of the microgrid is that it interacts with the main grid as one entity, absorbing or supplying power to the grid.

The intelligent agents' technology is a new approach to the control of power systems, which mainly focuses on distributed control. The control units are given a degree of autonomy and are able to interact in order to achieve best performance. The intelligent agents are characterized from intelligence and sociability. Thus, they are able to take decisions locally, in order to control one unit, but they can also interact with other agents in order to accomplish goals set for the whole system, such as power availability in case of islanded operation.

The expected boost in small production units – and most possibly in microgrids – after the liberalization of the energy market will increase the complexity of the grid control. Distributed control, realized in the form of intelligent agents, might prove to be an effective solution.

Within this context, the design and the construction of an intelligent load controller, which will be implemented in the pilot microgrid of Kythnos, is initially studied. The algorithms developed are described. Main objectives have been to enable the interaction among the agents, the coordination of their actions as well as to achieve an effective behavior of the agents in emergency situations such as voltage sag, overvoltage or overcurrent events. Optimized load allocation is required, so that the power supply provided from the photovoltaics and the batteries can be maximized, while the use of the diesel genset will be minimized. To this end, the intelligent load controller is equipped with electronic switches, which in case of emergency cut the power in non-important loads. It should be noted that this is the first worldwide field test of the intelligent agents' technology in a microgrid.

Additionally, an algorithm for the optimization of the economic operation of a microgrid in a liberalized energy market is developed. Based on machine learning, and specifically Q-learning, our objective is to enable the agent to learn through his environment. The agents, who control the system, are required to determine a set of actions (buying or selling electric power to the grid) which will maximize their profit. The Q-learning technique, the algorithm developed as well as an example of its implementation with real data of buying/selling prices are presented.

Keywords: microgrid, intelligent agents, multi-agent systems, Kythnos, intelligent load controller, machine learning, Q-learning

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