Synchronization of stand-alone microgrid systems with the utility grid using wireless communication

Abstract

This dissertation focuses on the problems related to ensuring the continuity of maintaining synchronization between the local utility grid and the micro-grid during on/off switching, line change, or loss of galvanic connection between these grids.

The synchronization of the micro-grids with the power grid is crucial for the reliability of energy distribution in dispersed systems. Classic wire synchronization methods, widely known and frequently utilized, ensure a quick and safe adjustment of the instantaneous voltage parameters of the connected power distribution systems. This methodology requires measurements of instantaneous voltages at the point of common coupling of the systems and passing on this information via teleinformatic cables. Because of this requirement, wired solutions are often not economically justified or even impossible to implement due to the limitations of the grid topology, in particular the distances between the synchronized generators. Moreover, the connection points between the grids may be quite distant from the generators. This, in turn, may alter the qualitative parameters of the resulting voltage, possibly becoming a source of instability for the entire system. The need to solve this problem inspired the author of the dissertation to undertake the subject of his doctoral project.

The main purpose of the dissertation is to design an innovative remote synchronization strategy, in which measurements at the point of common coupling of the micro-grid to the utility system were eliminated, but instead wireless communication and innovative proprietary algorithms were implemented. The dissertation formulates a research thesis stipulating that the use of the proprietary method of timestamp-remote synchronization (TS-RS) largely eliminates transient states that may occur during the connection process.

The research methodology presented in the dissertation is based on mathematical models, simulations performed in the MATLAB / Simulink program and real results obtained on the proprietary set-up mapping the micro-grid on to a simulation model. The proposed method of remote synchronization with a timestamp has been tested in laboratory conditions. The research was conducted with the use of generally available transmission media: Wi-Fi and 4G. The experimental results and the times required for correct synchronization were compared with those obtained using the existing cable methods. The advantages of the developed method were confirmed by examining the transient states of the connected micro-sources in the presence of typical mains voltage disturbances.

The results confirmed the proposed hypothesis and indicated a great potential for possible applications.

The results of model considerations, bench and programming tests presented in the dissertation emphasize an innovating aspect of the proposed strategy of remote synchronization, which eliminates the current inconveniences related to the direct measurement of instantaneous grid voltages. The proposed system can be connected to utility grids without location restrictions, which is particularly advantageous in the case of long distances and unsatisfactory voltage quality at the connection point. The proposed method ensures stable operation of the micro-source in the presence of typical voltage disturbances of the mains. The proposed and laboratory-tested method of remote synchronization has a likely large application potential and may provide a key solution for the development of distribution grids of the future, significantly increasing the safety and reliability of the operated systems, especially those with a dispersed structure.

Keywords: The timestamp-remote synchronization, microgrid synchronization, distributed generation, Ethernet, wireless communication, microgrids