Chapter 1

Data and Communication Infrastructure in Smart Grids: State of the Art and Trends

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ABSTRACT

The communication infrastructure constitutes the key element in smart grids. There have been great advances to enhance the way data is communicated among the different smart grid applications. The aim of this chapter is to present the data communication part of the smart grid with some pioneering developments in this topic. A succinct review of the state of art projects to improve the communication link is presented. An illustrative simulation using LABVIEW is included with a proposed idea of introducing some newly technologies involved in the current and future generations of wireless communication systems.

INTRODUCTION

Smart grids incorporate with the electrical grid a data communication infrastructure that gathers and evaluates data in either real- time or offline about power transmission, distribution and consumption (Locke and Gallagher, 2010). The power grid involves four elements: electricity generation plants, transmission substations, distribution substations and customers (Güngör et al., 2011). Power generated from plants from a variety of sources (including classical fossil fuel, solar, wind and nuclear sources) is attenuated to the voltage fit for residential use. Home appliances power utilization is sensed through their electric smart meters (Güngör et al., 2010; Liserre et al., 2010; Hauser et al., 2005). This blend of power levels has to be monitored through the data gathering system. As an example, the power generation can be continually controlled by using the real-time energy consumption of the end users. Similarly, the end

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user can monitor the real-time power usage of the home and can obtain the real-time cost of the power supplied from the service provider (Kim et al., 2015). On the other hand, the users can supply electricity in a smart grid. For example, users having homes equipped with photovoltaic (PV) systems are able to generate electricity and return it to the grid to help balancing the loads by “peak clipping”, i.e., sending power back to the grid when the demand is high. This information exchange between different elements provides the smart grid with predictive information generate recommendations to utilities, their suppliers and their customers on how to manage power in an optimal manner (Hauser et al., 2005).

The new information and communication technologies (ICTs) are becoming progressively integrated within the society. One key area demonstrating this is the next generation of electricity called Smart Grid (SG) or intelligent grid. The Smart Grid adds a two way flow of information, automation and control to the actual power grid. It optimizes energy efficiency through the mutual real time exchange of information between power supplier and consumers through the integration of developed sensors, smart meters and the information technology (IT) (Kuzlu et al, 2014;Park and Kim, 2014).

Due to the importance of the communication infrastructure in the success of smart grid implementation and operation, there has been a variety of research works in the literature focusing on this topic (Saoud and Recioui, 2017). The authors of (Locke and Gallagher, 2010; Yan et al., 2012; Wang et al., 2011; Khan, 2013) provide surveys about the requirements that the smart grid needs from communication perspectives. Smart grid technologies and standards are discussed to provide an overview of the smart grid paradigm and integration of different communication technologies in (Gungor et al., 2011; Fan et al., 2012). Some studies focus on a particular standard or communication technologies such as power line communication (PLC) (Galli et al., 2010) and wireless communication (Pipattanasomporn et al., 2012; Wietfeld et al., 2011). In (Aravinthan et al., 2011), the authors evaluate the network performance for a long-distance distribution line and propose communication architecture for distribution level applications. Furthermore, the appropriate communication technologies for transmission-level applications have been discussed in (Dong and Kezunovic, 2011).

Wide-area monitoring, wide-area control and wide-area protection use Wide Area Networks and have been identified as the next-generation solution to improve power system planning, operation and protection in the smart grid. These applications involve the use of system wide information and selected local information to counteract the propagation of large disturbances (Kuzlu et al, 2014). Wide-area monitoring, control and protection applications offer higher data resolution and shorter response time than classical supervisory control and data acquisition (SCADA) and energy management (EMS) systems. While SCADA/EMS provides a measurement update interval of several seconds or even minutes, wide-area monitoring, control and protection applications provide high-resolution data.

The IEEE Standard for Synchrophasors for Power Systems (IEEE Std.C37.118), defines measurement and data transmission formats for real-time data reporting in electric power systems (IEEE, 2006). For wide-area monitoring applications, a minimum message size containing measurements made by a PMU is 52 bytes. Similar to those for wide-area protection and control applications, the required response time for wide area monitoring applications is also in the range of milliseconds to minutes, and communication system reliability requirement is very high.

While wide-area protection and control applications offer more advanced protection/control systems as compared with traditional power systems, more stringent performance and availability requirements are needed. For example, the required response time for wide-area protection and control applications should be in the range of milliseconds to minutes, and the communication system reliability requirement should be very high. Their typical message size can vary depending upon communication protocols imple-

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