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INTERNET OF THINGS (IOT) – WIRELESS SENSOR NETWORK SYSTEM SUPPORTING ELECTRICAL POWER SUBSTATION

FOREWORD

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JTC1-SC41/163/FDIS	JTC1-SC41/176/RVD

Full information on the voting for the approval of this International Standard can be found in the report on voting indicated in the above table.

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

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INTRODUCTION

The data collected from various types of electrical equipment is sparsely located, and on-line transmission of the data helps to collaboratively aggregate and analyse them in real-time. Transitioning to the smart electrical power substation using wireless communication among the sensor nodes – i.e. wireless sensor network (WSN) – requires systems architecture provisioning automated data collection from the electrical equipment, which allows collaborative data processing, sends automatic alerts, provides preventive actions, and potentially takes corrective actions for certain situations.

Electrical power substation communications should be designed to support scalability, interoperability, autonomous fault correction, and other key attributes. The intelligent wireless sensor network (iWSN) is inherently flexible and scalable in its capabilities and in operations including in the size of its converge areas; however, depending on the geographical (e.g. urban, suburban, remote location) and structural (both natural and man-made) situations, the installation architecture should ensure the fidelity of all sensor nodes' wireless connectivity. Furthermore, the WSNs can support either distributed or decentralized network architecture. The wired substation network typically uses high-availability seamless ring (HSR) and parallel redundancy protocol (PRP) protocols (see IEC 62439-3, IEC 61850-8-1 and IEC 61850-9-2) to provide seamless failover against failure of any network component. For the iWSN, it is also important to have the key iWSN network components (e.g. sensor nodes) from data communication failure. Therefore it is important to select wireless sensor network architecture for a substation which overcomes the potential issue of a single point of failure in the wireless sensor network, for example, by installation architecture, the use of PRP to improve packet loss and timing behaviour in wireless network, or a combination of these.

This document introduces iWSN as a system which helps to make the power substation smarter, which is compatible with IEC 61850. In the past, wireless communication was thought to be unreliable and ineffective over long distances. With the advancements in communication technologies in the last decade, the wireless communications have given rise not only to wireless meshed systems, multi-hop and self-healing networks, but also to various low-power protocols having high network/communication security standards. Additionally, different network topologies with effective wireless signal routing algorithms have improved range and reduced power consumption while minimizing frequency of communication channel error. These improvements can be leveraged to form a highly reliable communication network for the electrical power substation.

The existing applications of the WSNs in smart grid include, but are not limited to, automatic meter reading, remote system monitoring and control, equipment fault diagnostics, distribution automation, outage detection, line fault and electronic fault detection, underground cable system monitoring, towers and poles monitoring, conductor temperature and dynamic thermal rating. However, the realization of these existing and envisioned WSN-based smart grid applications is hindered by not having uniform sensing data formats, data interfaces, etc. Although some sensor communication systems are not compatible with the devices from different equipment manufacturers, most intelligent electronic devices used in electrical power substations are interoperable, through the use of standard protocols, for example, IEC 61850 GOOSE, TCP, UDP, etc., and standards related to the common information model (CIM) defined by IEC 61970 and IEC 61968. For cases where new types of sensors (either existing or newly developed) have not adopted IEC 61850, they may be used with an intelligent wireless sensor network (iWSN) system^{1,2} because the iWSN system interfaces can act as an adaptor for the sensors and the rest of the systems.

¹ Wireless technology in general is not suitable for the transmission of mission critical data such as sampled measured values according to IEC 61850-9-2 or trip signals for circuit breakers due to the possible interference of electromagnetic radiation caused by arc-flashes (e.g. in case of an internal fault or switching operations inside a substation) with the radio signals of wireless sensors.

² Any data commonly sent over layer 2 broadcast (e.g. GOOSE) are not suitable for transmission over wireless networks due to the unavailability of corresponding broadcast features.

The main purpose of wireless sensor network applications for electrical power substations is to improve the capability of acquiring, monitoring, processing, and maintaining the data and information from the power equipment. A wireless sensor network (WSN) is characterized by flexible deployment, device collaboration and low-cost implementation, and WSN realizes efficient monitoring of the smart grid systems and subsystems. By enabling the monitoring and controlling capabilities by installing wireless sensor nodes on critical power grid equipment, reliable and real-time online management of this equipment can be accomplished.

Electrical power substation is one of the most important building blocks of the smart grid. The monitoring and control systems in electrical power substations acquire current, voltage, status and other parameters from their primary equipment, and also data from their environment. The information from the measurement systems provides the basis for integrated applications, enabling the transformation of a conventional electrical power substation to a smart electrical power substation, especially when considering the use of the IEC 61850 series, iWSN and other information technologies. In addition to the substation equipment's (wired) connectivity, which is likely based on the IEC 61850 series, the iWSN system will provide additional benefits to collect, process, and transmit data/information about power substation equipment and its environment. An effective and efficient sensing system can be achieved by an iWSN system which takes the role of a data/information measurement and collection system. The concept of the iWSN system provides functions, such as automatic data collection and aggregation, collaborative information processing (e.g. data/information fusion), data analysis, and alarming, and other functional applications that enable the intelligence or smartness of the system that the iWSN system is monitoring.

The information collected in an electrical power substation about the equipment state and the flow of electricity provides the electricity providers with a clearer view and better control over the electrical power substation. Among the many add-values that the iWSN brings compared to the wired installation, one of them is the migration to the no-wire installation as all the sensor nodes are powered by batteries and the data is transmitted via the wireless communication links of the iWSN. A wireless sensor network, that is able to communicate with the utility provider's control system by sharing the collected information with the existing networks becomes an attractive technology to deploy in an electrical power substation in order to collect required and critical information.

This document is built upon ISO/IEC 29182 (Sensor Network Reference Architecture) and ISO/IEC 30101 (sensor network and its interfaces for smart grid systems), IEC 61850 (communication networks and systems for power utility automation), and ETSI's and NIST's work in smart grid, and extends ISO/IEC 29182 and ISO/IEC 30101 to the application standard of the sensor network that supports the electrical power substations.

The iWSN system uses wireless sensor networks for power substations including substation, equipment, facility, environment, etc. The existing communication protocols specified in IEC 61850-8-1 and IEC 61850-9-2 can be used within power substation, or IEC 61850-8-2 can be used over public network. This document provides the iWSN system's infrastructure from System and Communications Views and also specifies the iWSN system's technical requirements to realize and support the smart electrical power substation. Electrical power substations with sensor networks use advanced information and communication technologies in order to improve the efficiency, reliability, and security of their components and services.

INTERNET OF THINGS (IOT) – WIRELESS SENSOR NETWORK SYSTEM SUPPORTING ELECTRICAL POWER SUBSTATION

1 Scope

This document specifies

- intelligent wireless sensor network (iWSN) from the perspectives of iWSN's system infrastructure and communications internal and external to the infrastructure, and
- technical requirements for iWSN to realize smart electrical power substations.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 61000-4-39, *Electromagnetic compatibility (EMC) – Part 4-39: Testing and measurement techniques – Radiated fields in close proximity – Immunity test*

IEC 61326-1, *Electrical equipment for measurement, control and laboratory use – EMC requirements – Part 1: General requirements*

IEC 61850-3, *Communication networks and systems for power utility automation – Part 3: General requirements*