Survey of Communication System for DG's and Microgrid in Electrical Power Grid

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Abstract— Different distributed generation (DG) units form a Microgrid in electrical power grid. Microgrid contains two or more distributed generation unit such as wind power, photovoltaic cell, solar panel, fuel cell etc. Each DG unit converts physical quantity (wind, solar, fuel cell etc.) into electrical power. The role of inverter, in DG, is to convert DC Power into 3 phase power and supplied to power grid to cater load demand. For this purpose DG's are need to work in synchronization. Each DG has to communicate the status of frequency, phase and voltage with other DG's working in Microgrid to maintain synchronization with the power grid. A communication between DG's may be wired or wireless. A communications system is the key component of the Microgrid infrastructure. Different communications technologies are supported by wired and wireless communications media. The DG acquires information about synchronization parameters using a wireless or wired network (such as a WiFi, ZigBee, and/or cellular communication network, PLC, Ethernet etc.). The information contains phase voltage, phase current, frequency and phase angle between DG's output voltage and grid voltage. This paper presents different communication technologies suitable for inverter based DG's and Microgrid to access and control data from/to each DG as a node. The main objective of this paper is to survey the communication channels and protocols suitable for Microgrid in electrical power grid.

Index Terms- *Microgrid, DG node, wireless network, communication channel*

I. INTRODUCTION

Renewable energy sources such as wind, solar, fuel cell etc. are forming distributed generation sources in a Microgrid. Microgrid interconnects a group of DG units and loads at a distribution voltage level in a local area such as homes or a residential community. An important task of Microgrid is to share the load demand using multiple Distributed Generation (DG) units.

Microgrid needs resynchronization for smooth reconnection to utility, which means that a Microgrid not only can disconnect from the utility when grid fault is detected, but also reconnect to the utility when the fault is cleared. This transition should not cause negative effects on the utility and critical loads. So the control strategy is used for the parallel operation of inverters in a Microgrid. The power sharing according to the capacity of individual DG can be achieved through communication network, so the communication is the key part of the Microgrid [1-2].

Communication network will help us to measure and monitor different parameters such as current, voltage, phase, frequency, power etc. at DG node. Basically power is the product of voltage and current. When voltage and current are not in phase, there are two components, real or active power and reactive power. DGs in Microgrid share the power to connected load as active power and reactive power. Normally DGs connected in Microgrid are sufficient to cater the load in Microgrid. Temporary excess loads or any short fall can be supplied by main grid. When more than two DGs are in Microgrid sharing of active and reactive power is an important issue. The communication network can play important role to control power flow from Microgrid to main grid and vice versa [3].

To control and monitor various parameters like voltage, current, frequency etc. of multiple DGs in Microgrid needs a communication channel. Communication channels are either wired or wireless. Out of that wireless network uses IEEE 802.15.4 standard for communication purpose. Hence implementation of network for communication between DGs and Microgrid in grid system will help us to measure and control power flow in a grid system [4]. In this paper, survey of communication channels and protocols suitable for Microgrid is presented.

This paper is organized as follows; section II describes the Microgrid architecture. Section III descries role of communication in Microgrid. Methods and technology available for Microgrid system is presented in section IV. The communication standards are studied in section V. Finally this paper is concluded in section VI.

II. MICROGRID ARCHITECTURE

An electrical grid (also referred to as an electricity grid or electric grid) is an interconnected network for delivering electricity from suppliers to consumers. It consists of generating stations that produce electrical power, high-voltage transmission lines that carry power from distant sources to demand centres, and distribution lines that connect individual customers. A power station (also referred to as a generating station, power plant, powerhouse or generating plant) is an industrial facility for the generation of electric power .The electric power generated is stepped up to a higher voltage at which it connects to the transmission network. The term grid usually refers to a network. Grid may also be used to refer to an entire continent's electrical network, a regional transmission network or may be used to describe a sub network such as a local utility's transmission grid or distribution grid [4] [5]. The electricity generation, transmission, distribution and control networks make up the electrical grid. Smaller grids have a radial structure with supply lines branching out from a large centralised electricity supplier.

A Microgrid is defined as an aggregator of several micro generation units, storage devices and loads operating as a single system that provides electricity. Microgrid is a concept that combines distributed generation sources, including distributed energy resources (DER) and distribution storage. Microgrid operates in an islanded mode or grid connected mode. The term synchronization means a connection of Microgrid with main grid. The synchronization of generator with grid by traditional synchronizer is easy. The synchronization of Microgrid with main grid is very difficult because Microgrid operates with multiple DG's that produced electrical power together and critical loads that's cannot be controllable by traditional synchronizer. To overcome this problem it is needed to control multiple generators and energy storage system in coordinated way for the Microgid synchronization. Generator generates electrical power having some parameters such as voltage, current, frequency etc. and the importance of these parameters is to produce active and reactive power depends on phase between voltage and current. To manage DG's parameters (Voltage, current, frequency etc.) a network of communication system need to be implemented in Microgrid with necessary communication protocols [6].

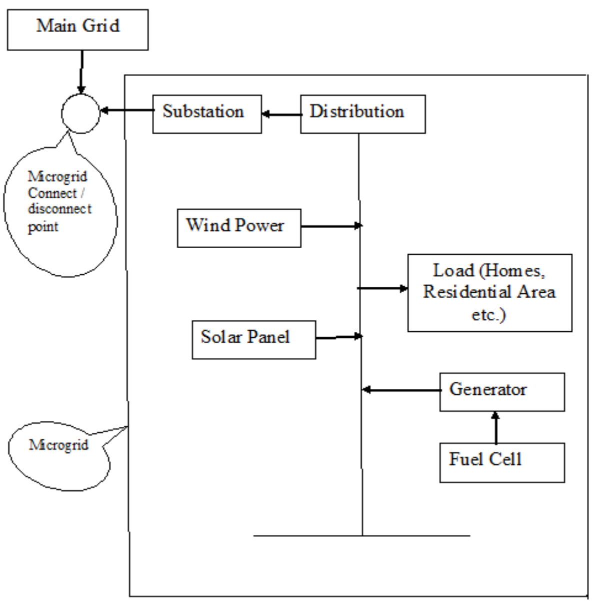

Figure1 Microgrid Architecture

The architecture of communication network can be centralized or hierarchical. Figure 1 shows the basic architecture of Microgrid. Microgrid may range in size from a tiny residential load to small city. The Microgrid is small scale flexible reliable source of electricity and can operate in grid-connected or stand-alone mode. Two methods are used in Microgrid to manage the power of a Microgrid: the centralized operation that concentrates information in node and decentralized operation which uses local information and provides more autonomy to the DER units [7]. While smart grid is a modernized electrical grid that uses information and communications technology together and act on information, such as information about the behaviours of suppliers and consumers, in an automated fashion to improve the efficiency, reliability, economics, and sustainability of the production and distribution of electricity [8] . A system containing different DG's & loads in Microgrid is presented in Figure 1. Each DG will generate its own electrical energy; and supplies active and reactive power for sharing the power at specified voltage and phase. It is necessary to get status of other DG's working in grid through communication channel [9][10]. Next section describes the role of communication in Microgrid to improve the reliability in power grid.

III. ROLE OF COMMUNICATION IN MICROGRID

As mentioned in section I, there are two communication technics available in Microgrid, one is wired and second one is wireless. In Microgrid system, DG's are connected to different load (homes, residential area etc.) and main power grid through distribution network. It is necessary to know the information about current, voltage, phase, power etc. at each DG unit to main control unit through proper communication channel. So it is very easy to monitor and control all the parameters on main central control unit; hence the role of communication in Microgrid is more important. [11].

The role of communication is one of the major factors in Microgrid that are converting the traditional grid into a set of micro-grids. An important purpose of communication in Microgrid is that they have variations in their power generation. This will cause the two primary issues for the power distribution operation, i.e. voltage control and power flow management. As an example of Solar panel generation, power output can increase or decrease in solar photovoltaic farms from milliseconds to few seconds as the cloud coverage changes. Similarly, power output for a wind farm can be completely lost on the order of minutes. Similar instabilities can occur, e.g. a fault current can be introduced and it can affect the stability of the micro-grid. Excess power produced by DGs has to be stored or shared with other distribution networks, this issue will be solved by power flow management and it requires bidirectional power flow with communication.

Therefore, for safe operation in Microgrid and to maintain power system stability, we need advanced control techniques combined with effective communication techniques. The information such as voltage, current, phase etc. and communication technology (wired or wireless) infrastructure in a Microgrid needs to be reliable, highly available, secure and easy to manage.

Figure 2 shows communication in Microgrid, the communication infrastructure of the Microgrid should provide continuous connection with all units in the Microgrid. In central control scheme a central controller must interact with all units to manage the Microgrid [12]. A local data concentrator is commonly used to collect data from several groups of node and send the data to the central controller through communication channel. The selection of a communication technology and network topology is not limited in Microgrid. Numerous technologies or channels for communication can be considered in Microgrid [13]. To achieve a safe and stable operation in Microgrid needs a good communication technology. Next section describes details about communication methods and technologies available for Microgrid. This is helpful to understand different communication channels suitable for communication in Microgrid, according to spectrum, data rate, coverage range etc.

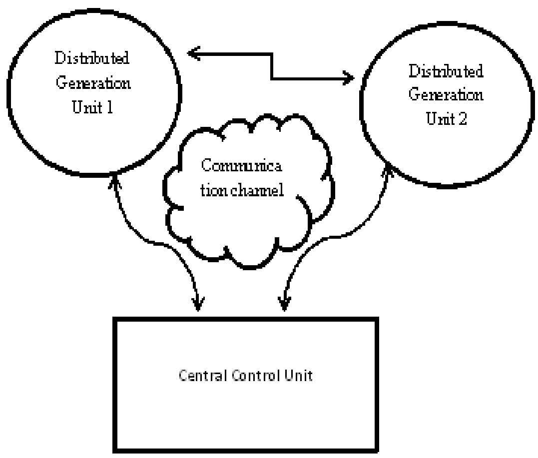

Figure 2 Centralized communications network in Microgrid

IV. COMMUNICATION METHODS AND TECHNOLOGIES AVAILABLE FOR MICROGRID SYSTEM

For protection and power control in Microgrid communication systems are very important. The basic communication methods used in the existing Microgrid are: power-line carrier, broadband over power line, leased telephone line, global system for mobile (GSM) communication, LAN / WAN / Internet (TCP/IP), wireless radio communication, optic fiber, WiFi 802.11b, WiMAX 802.16 and ZigBee / IEEE 802.15.4. These are the method used for communication in Microgrid [14][15].

The communication system in Microgrid may use of multiple technologies such as wireless, Ethernet, fiber and power line communications. There are two basic communication channels are used in Microgrid such as Wired and Wireless. The details of wired technologies suitable for Microgrid are as follows:

A. Power line Communication

Power line communication (PLC) is a technique that uses the existing power lines to transmit high-speed (2–3 Mb/s) data signals from one device to the other. PLC has been the first choice for communication with the electricity meter due to the direct connection with the meter [16][17]. In a typical PLC network, Microgrids are connected to the data concentrator through power lines and data is transferred to the data centre via cellular network technologies. PLC technology is chosen for data communication between DG's and the data concentrator, while GPRS technology is used for transferring the data from the data concentrator to the utility's data canter [18].

Table I
Classification of PLC by frequency band

Classification	Frequency band	Data Rate	Application
Ultra Narrowband PLC (UNB PLC)	~ 3 KHz	100 bps	Control, AMR
Narrowband PLC (NB PLC)	~ 500 KHz	500 Kbps	Control, smart metering
Broadband PLC	1.8 ~ 250 MHz	Over 1 Mbps	Data and multimedia communication

Power Line Communication (PLC) which uses power cable as communication media has received attention as a candidate communication technology for smart power system. PLC is not a new technology. Utility companies have used PLC for monitoring and control of applications for several decades. PLC which has been used for this purpose has few bps of data rate and used a narrow band frequency. PLC is only a wire technology which can compete with wireless technologies economically because cost for cable deployment is not necessary. Also PLC can support ubiquitous solution with distributed power grid. PLC can be classified in three types through the use of frequency band. Table I shows summary of these three types of PLC [18].

1) Advantages: PLC can be considered as a promising technology for Microgrid applications due to the fact that the existing infrastructure decreases the installation cost of the communications infrastructure. The standardization efforts on PLC networks, the cost-effective, ubiquitous nature, and widely available infrastructure of PLC, can be the reasons for its strength and popularity. Data transmissions are broadcast in nature for PLC; hence, the security aspects are critical. Confidentiality, authentication, integrity, and user intervention are some of the critical issues in Microgrid communications. Moreover, PLC technology can be well suited to urban areas for micro grid applications, such as, monitoring and control applications.

2) Disadvantages: There are some technical challenges due to the nature of the powerline networks. The powerline transmission medium is a harsh and noisy environment that makes the channel difficult to be modelled. Furthermore, the network topology, the number and type of the devices connected to the power lines, wiring distance between transmitter and receiver, adversely affect the quality of signal that is transmitted over the power lines. The sensitivity of PLC to disturbances and dependency on the quality of signal are the disadvantages that make PLC technology not suited for data transmission. However, there have been some hybrid solutions in which PLC technology is combined with other technologies, i.e., GPRS or GSM, to provide full-connectivity not possible by PLC technology.

Table II shows some communication technologies suitable for Microgrid and their classification according to spectrum, data rate, coverage range, application and limitations. Out of these communication technologies, wireless communications have some advantages over wired technologies, such as low-cost infrastructure and ease of connection to unreachable areas. On the other hand, wired communications do not have interference problems and their functions are not dependent on batteries, as wireless communications often do. Basically, two types of information infrastructure are needed for information flow in a Microgrid system. The first flow is from sensor to slave controller; the second is between slave controller and the utility's data canters i.e. at master controller. The communication system between the Microgrid components is mostly based on the structure of Microgrid and its control system. Generally, there are two approaches for communication system in a micro-grid. It can be centralized, i.e. there is a main controller in the Microgrid that collects the required data from DG nodes and performs necessary actions, or it can be decentralized, where every DG node has its own microcontroller that will take actions according to their policies [19][20].

Table II
Microgrid Communication Technologies

Technology	Spectrum	Data Rate	Coverage Range	Application	Limitations
PLC	1-30 MHz	2-3 Mbps	1-3 Km	AMI, Fraud Detection	Harsh, Noisy Channel environment
ZigBee	2.4 GHz, 868-915 MHz	250 Kbps	30-50 m	AMI, HAN	Low data rate, short range
GSM	900-1800 MHz	Up to 14.4 Kbps	1-10 Km	AMI, HAN	Low data rate
WiMAX	2.4 GHz, 3.5 GHz, 5.8 GHz	Up to 75 Mbps	10-50 Km	AMI, Demand Response	Not Widespread

The details of wireless technologies suitable for Microgrid are as follows:

A. ZigBee

ZigBee is a Wireless communications technology that is relatively low in power usage, data rate, complexity, and cost of deployment. It is an ideal technology for smart lightning, energy monitoring, home automation, and automatic meter reading, Microgrid etc. The communication between DG's, as well as among intelligent Microgrids is very important. ZigBee is one of the newest technologies developed by ZigBee Alliance; enabling Wireless Personal Area works (WPAN). ZigBee is the name of a specification for a suite of high level communication protocols using small, low-power digital radios based on the IEEE 802.15.4 standard. Networking plays a very important role in ZigBee core technologies. There are basically two type routing algorithms used in the ZigBee network AODV and the Tree Based Routing Algorithm [21]

1) Advantages: ZigBee has 16 channels in the 2.4 GHz band, each with 5 MHz of bandwidth. 0 dBm (1 mW) is the maximum output power of the radios with a transmission range between 1 and 100 m with a 250 Kb/s data rate and OQPSK modulation [19]. ZigBee is a Wireless communications technology based on the IEEE 802.15.4 standard.

2) Disadvantages: There are some limitations on ZigBee for practical implementations, such as low processing capabilities, small memory size, small delay requirements and most important issue is to interference with other

appliances, which share the same transmission medium, license-free industrial, scientific and medical (ISM) frequency band ranging from IEEE 802.11 wireless local area networks (WLANs), WiFi, Bluetooth and Microwave. Hence, due to that there is possibility of corrupting the entire communications channel due to the interference of 802.11/b/g in the vicinity of ZigBee. This is the disadvantages of ZigBee protocol.

From the above discussion on ZigBee now concluded as, ZigBee is considered as a good option for communication between DG's in Microgrid along with its simplicity, mobility, robustness, low bandwidth requirements, low cost of deployment, its operation within an unlicensed spectrum, easy network implementation, being a standardized protocol based on the IEEE 802.15.4 standard as compared to wired technology.

B. Wireless Mesh

A mesh network is a flexible network consisting of a group of nodes, where new nodes can join the group and each node can act as an independent router. The self-healing characteristic of the network enables the communication signals to find another route via the active nodes, if any node should drop out of the network. Especially, in North America, RF mesh-based systems are very popular. A private company, SkyPilot Networks uses mesh networking for smart grid applications due to the redundancy and high availability features of mesh technology [22] [23].

In the traditional power grid, energy generation facilities are generally developed with wired sensors which are located only at a few critical places. This is due to the high cost of installation and maintenance of those sensors. Wireless Networks having low cost sensors that can communicate via wireless links hence have flexible deployment opportunities. In fact, the utilization of Wireless Networks becomes even more essential with the increasing number of renewable energy sites in the energy generation cycle. These renewable energy generation facilities can be in remote areas, and operate in harsh environments where fault-tolerance of Wireless Networks makes them an ideal candidate for such applications.

These varying ambient conditions cause intermittent power generation which makes renewable resources hard to integrate to the power grid. For those reasons, WSNs can offer solutions for renewable energy generation sites, such as solar (PV) farms or wind farms. Figure 3 shows wireless mesh network in power grid.

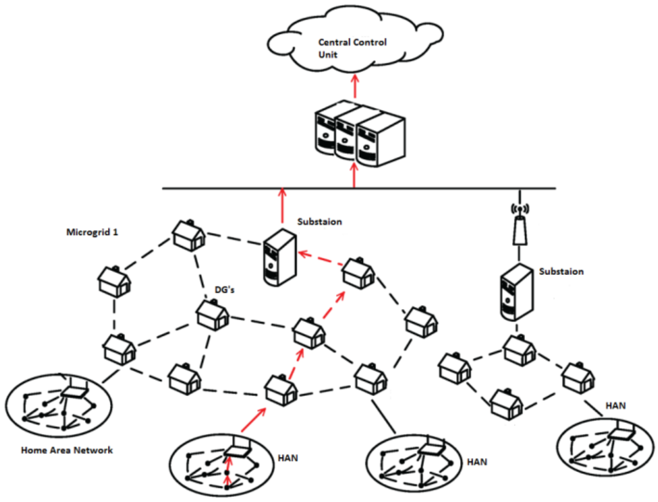

Figure 3 Wireless Mesh Network

1) Advantages: Mesh networking is a cost effective solution with dynamic self-organization, self-healing, self-configuration, high scalability services, which provide many advantages, such as improving the network performance, balancing the load on the network, extending the network coverage range. Good coverage can be provided in urban and suburban areas with the ability of multi hop routing.

2) Disadvantages: Network capacity, fading and interference can be counted as the major challenges of wireless mesh networking systems. In addition, while data packets travel around many neighbours, there can be loop problems causing additional overheads in the communications channel that would result in a reduction of the available bandwidth.

C. Cellular Network Communication

Existing cellular networks can be a good option for communicating between DG's and the utility and between far nodes. The existing communications infrastructure avoids utilities from spending operational costs and additional time for building a dedicated communications infrastructure. Cellular network solutions also enable DG's deployments spreading to a wide area environment. 2G, 2.5G, 3G, WiMAX, are the cellular communication technologies available to utilities for DG's deployments. Cellular communication infrastructure are the another communication technology used for the communication between DG's and Microgrid. [24]

Since GSM network will handle all the communication requirements of the DG's network, there is no need for an investment of a new dedicated communications network by utilities. Telenor, Airtel, Idea, Vodafone etc. have also available to put their GSM network into service for data flow of DG's communications. Code-division multiple-access (CDMA), wideband code-division multiple-access (WCDMA), and Universal Mobile Telecommunications

System (UMTS) wireless technologies are also used in Microgrid projects [24].

1) Advantages: Cellular networks already exist. Therefore, a utility does not need to spend extra cost for building the communications infrastructure required for a Microgrid. Widespread and cost-effective benefits make cellular communication one of the leading communications technologies in the market. When security comes into discussion, cellular networks are ready to secure the data transmissions with strong security controls. In addition, GSM technology performs up to 14.4 Kb/s, GPRS performs up to 170 Kb/s and they both support AMI, Demand Response, Home Area Network (HAN) applications. Anonymity, authentication, signalling protection and user data protection security services are the security strengths of GSM technology. Lower cost, better coverage, lower maintenance costs, and fast installation features highlight why cellular networks can be the best candidate as a Microgrid communications technology for the applications, such as demand response management, advanced metering infrastructures, Home Area Network, outage management, etc.

2) Disadvantages: Some power grid applications needs continuous availability of communications. However, the services of cellular networks are shared by customer market and this may result in network congestion or decrease in network performance in emergency situations. Hence, these cases utilities need to build their own private communications network. In abnormal situations, such as a wind storm, cellular network providers may not provide guarantee service. Compared to public networks, private networks may handle these kinds of situations better due to the usage of a variety of technologies and spectrum bands.

As we discussed above, different communication channels are available in Microgrid for communication between DG's and Microgrid. Communication plays important role in Microgrid system. Out of these wired and wireless communication technologies, wireless communication is more effective over wired communication, such as easy to deploy in urban and rural area, low cost, low complex, easy to troubleshoot etc. Next section we will discussed on communication standards or protocol suitable for Microgrid system. There are different communication protocols such as IEC 61850 protocols, IEEE1547 etc. are available in Microgrid to monitor, control, and measure power utilities.

V. COMMUNICATION STANDARDS

A Microgrid system based on the IEC 61850 protocol, it consists of a Microgrid monitoring system, a protocol converter that transforms serial data to IEC 61850 data and distributed energy Resource controllers for varied distributed energy resources nodes. The IEC 61850 has been adopted as an international communication protocol to monitor, control, and measure power utilities. The IEC 61850-7-420 has been chosen to interact with the Microgrid [25] [26].

Distributed energy resources (DER) vendors need communication capability because they interconnect to the micro grid. DER vendors have used their own proprietary communication protocols due to the short of standards. The distributed energy resources logical nodes data model for DER are standardized under the basic communication structure fixed in the communication networks and systems for power helpfulness automation introduced in the IEC 61850-7- 420 [27].

A. Micro Grid System Based IEC 61850

DER nodes, i.e., wind power generator, photovoltaic system, fuel cells, and energy storage are shown in figure 4 that have dedicated controllers for each DER unit. Each controller sends measured and status data that are encoded with their own proprietary protocol to the dedicated gateway using a serial communication link. The gateways convert received measured values and status information to those prescribed by the IEC 61850 data model and sends them to the micro grid monitoring system through a 100 Mbps. Ethernet interface using services defined in IEC 61850. The micro grid monitoring system works as a small Energy Management System (EMS), which sends control command to the DER controller via the gateway as required. Each component of the deployed micro system is described in a top-down manner [28].

1) Gateway

The gateway plays two roles: as the master node of the Distributed energy resources control unit over the serial link and as an IEC 61850 server for the micro grid monitoring system over the Ethernet link. 24Different IEC 61850 servers are implement for different DER control units. The Gateway has two communication interfaces. The serial Interface and the Ethernet interface. The gateway receives data from a DER controller using the serial link with the proprietary protocol developed in the present work, after which it transfers data to the micro grid monitoring system using the Ethernet with the IEC 61850 protocol. As long as data mapping between the proprietary protocol and the IEC 61850 data model is possible [29].

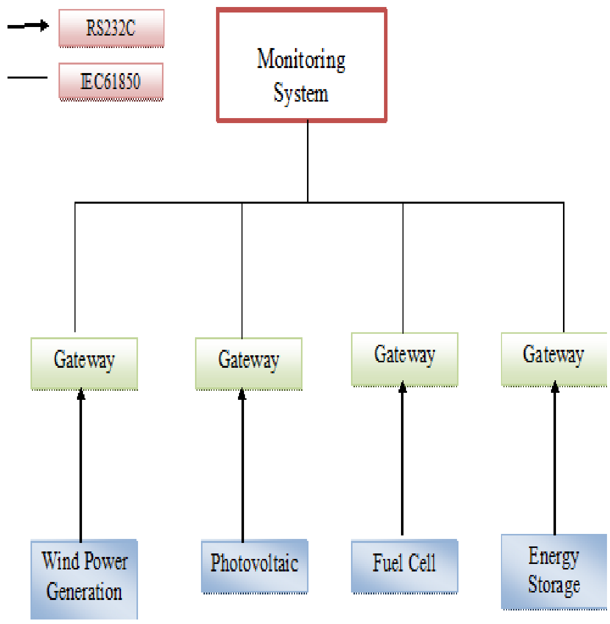

Figure 4 Microgrid communications Architecture

B. IEEE 1547

EEE 1547TM 2003 Standard for Interconnecting Distributed Resources with Electric Power Systems is the primary interconnection standard and auxiliary standards for testing, applications, and communications are under improvement by IEEE work groups. The 1547 standard is the only systems-level technical standard of consistent necessities and specifications universally needed to interconnect DR with the grid.

Distributed generation (DG) not only provides local benefits to its owner, but it also offers new options for utilities. These options range from a physical hedge alongside purchased power to alternatives to transmission and distribution system upgrades or construction. Understanding how DG systems are designed, interconnected, and operated is key to understanding the effect of DG on electric power systems and on utilities, goals of maintaining system and supply source reliability. Interconnecting DG to electric power systems can involve system engineering, safety, and reliability considerations [28] [29].

C. IEC 61400-25

Wind power plants have through the years steadily gained a bigger and more dominant Position in the power generation industry. Each vendor has their proprietary solutions on controlling and monitoring of the products supplied. In today's ever changing and rapidly growing energy market, monitoring and easy communication is essential. Through this communication the current state of the individual power plant can be controlled and monitored when required, and counter measurements can be enforced if needed in order to supply the demand for energy and keep the stability of the distribution system. It is vital that the overall dispatching systems are able to control the energy generation from a wind farm on demand in order to meet the fluctuations in the energy consumption [30].

A common way to achieve this is a vendor independent approach. IEC 61400-25, Wind Plant Communications, and Expected Output: based on IEC 61850. The IEC 61400-25 series defines communication for monitoring and control of wind power plants. The modelling approach of the IEC 61400-25 series has been selected to provide definitions of classes and services such that the specifications are independent of specific protocol stacks, implementations, and operating systems [30] [31]. IEC 61400-25 defines protocols for communication, control, and monitoring of wind power plants (WPP). This standard includes a wide range of mandatory and optional elements, ranging from security, communications interface, and system speed. This enables control and monitoring to be handle communication in a standardized and secure way. An analysis \focusing on isolating the necessary requirements of IEC61400-25 has been carried out to create a generic prototype which can be used by WPP vendors where main communications interface of the prototype utilizes web services.

The prototype is comprised of several independent modules to allow the possibility of choosing a fully customizable setup by the end user. Configuration of the system need to be done in an easy way, ensuring a flexible and reusable system, where different choices for the system can be added or left out depending on user specifications. From the requirements a prototype with the purpose of examining the key aspects of these definitions has been elaborated The mapping of these classes and services to a specific communication profile is not within the scope of this 27part of the IEC 61400-25 series but within the scope of future IEC 61400-25-41 [31]. To reach interoperability, all data in the information model need a strong definition with observe to syntax and semantics. The semantics of the data is mostly provided by names assigned to logical nodes and data they contain, as defined in this part of the IEC 61400-25 series.

Interoperability is easiest if as much as possible of the data are defined as mandatory. It should be noted that data with full semantics is only one of the elements required to achieve interoperability. Since data and services are hosted by devices (IED), a proper device model is needed along with compatible domain specific services (see IEC 61400-25-3).This part is used to specify the definitions of a logical device class, logical node classes, data classes, and abstract common data classes. These abstract definitions are mapped into concrete object definitions that are to be used for a particular protocol. The compatible logical node name and data name definitions found in this part and the associated semantics are fixed.

IEC 61400-25 series implementations are application specific. The IEC 61400-25 series does not guarantee a certain level of performance. This is beyond the scope of the IEC 61400-25 series. However, there is no underlying limitation in the communications technology to prevent high speed application (millisecond level responses) [32].

D. Powerline Networking

1) Home Plug: Home Plug is a powerline technology and the existing home electricity is used to connect the smart appliances to HAN (Home Area Network); Home Plug Command and Control (HPCC) version is designed for low-cost applications. Home Plug is a promising technology to create a reliable HAN between electric appliances and a smart meter.
2) PRIME: PRIME is an open, global powerline standard that provides multivendor interoperability and welcomes several entities to its body. Advanced Digital Design, CURRENT Group, Landis+Gyr, STMicroelectronics, uSyscom and ZIV Medida are some of the current companies that have extensive experience in PLC technology.
3) G3-PLC: G3-PLC is a powerline communications specification launched by ERDF and Maxim that aims to provide interoperability, cyber security and robustness and reduce infrastructure costs in smart grid implementations worldwide.

E. Home Area Network Device Communication Measurement and Control

ZigBee (WPAN)	Bluetooth (WLAN/WPAN)	Wi-Fi (WLAN)
802.15.4 standard	802.15.1 standard	802.11 standard
250 kbps	1 Mbps	Up to 54 Mbps
TX: 35 mA	TX: 40 mA	TX: 400+ mA
Standby: 3 uA	Standby: 200 uA	Standby: 20 mA
32-60 KB memory	100+ KB memory	100+KB memory
Lighting, sensors, RC peripherals	Telecom audio, cable replacement	Enterprise, home access points
Mesh networking	Point to multi-point	Point to multi-point

U-SNAP: There have been a variety of incompatible standards for Home Area Network (HAN). This lack of standardization in HAN Utility has driven major AMI suppliers and product manufacturers to develop a solution, namely Utility Smart Network Access Port (U-SNAP). The main requirement is the existence of an interface to connect any type of product to a HAN. U-SNAP basically enables the standardization of a connector and serial interface and identifies the hardware interface, physical dimensions, data transfer, message contents and protocol specifics for HAN devices to provide many communication protocols to connect HAN devices to smart meters.

1) IEEE P1901: The IEEE P1901 Working Group (WG) under the sponsorship of the IEEE Communications Society developed the IEEE P1901 standard for high-speed powerline communications to meet in-home multimedia, utility and smart grid application requirements [32].

   Access control and physical layer specifications for broadband over powerline networks are analyzed in detail and the access system with cell structure is defined by the IEEE P1901 Working Group [32]. The IEEE P1901 standard has an important effect on communications technology by integrating powerline communications into wireless networks with extensive features, such as high-speed, walls-penetration, etc.

2) IEEE 802.15.4: The term ZigBee is used to describe a standardized wireless protocol for personal area networking, or "WPAN." ZigBee is different from other wireless standards in that it has been designed to serve a diverse market of applications that require low cost, low power wireless connectivity with more sophistication than previously available at the target price. The standard focuses on low data rate, low duty cycle connectivity, a market segment not serviced well by existing standards. ZigBee is hardware and software standard built on the recently ratified IEEE 802.15.4 standard. This important standard defines the hardware and software, which is described in networking terms as the physical (PHY), and Medium Access Control (MAC) layers.

   ZigBee is implemented in either the globally assigned 2.4 GHz unlicensed band or one of the 900 MHz regional bands. Unlicensed radio spectrum is designated by international agreement and puts the burden of specification adherence on the equipment manufacturer.

Table III Comparison between ZigBee standard with other standard

There are many wireless options available to designers. Let's compare ZigBee with some of the more popular standards which share the unlicensed 2.4 GHz band. The parameters listed in the chart include the governing MAC standard, maximum over the air data rate, typical transmit and standby currents, memory requirements for a typical device, target applications and networking options. Table III shows comparison between ZigBee standard with other standard.

3) Z-Wave: Z-Wave is an alternative solution to ZigBee that handles the interference with 802.11/b/g since it operates in the 800 MHz range. Z-Wave is not an open standard and developed by The Z-Wave Alliance, an international consortium of manufacturers. The simple, modular and low-cost features make Z-Wave one of the leading wireless technologies in home automation. Z-Wave can be easily embedded to consumer electronic appliances, such as lighting, remote control, security systems that require low-bandwidth data operations [32].

VI. CONCLUSION

In this paper, we discussed the microgrid concept, microgrid architecture, communication technique, communication standards in grid system. Microgrid system consists of different DG's. Distributed generation (DG) systems are presented as a suitable form to offer high reliable electrical power supply. The concept is particularly interesting when different kinds of energy resources are available, such as photovoltaic panels, fuel cells, or speed wind turbines. The main objective is to study Microgrid architecture consists of different Distributed Generation (DG) units and each DG will consider as a node. DG's are needed to communicate with each other through proper communication media or channel. So the survey of different communication channels for Microgrid system is more important in power grid. This paper is presenting overall communication technologies suitable for Microgrid. Out of that wireless have some advantages over wired technology because of low cost infrastructure, less complex, good data rate, configure in different topologies etc.

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