Effect of Electromagnetic Interference on Smart Grid

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Abstract - Smart grid was introduced in an attempt to create an upgraded and increasingly dependable electric power network. Smart grid is a dynamic and independent framework, which will in general be dependable and adaptable, therefore improving the electric framework. It has some innovative difficulties, one of which is the electromagnetic compatibility issue. This paper sketches out the impact of electromagnetic interference on smart grid by showing the origins of interference and the defenseless system in the grid network. Simulations were performed to show the activity of a basic PLC transmission interface, and flexible ac transmission system.

Keywords: Smart grid, power line communication (PLC), power electronic interface, flexible alternating current system (FACTS), electromagnetic interference (EMI).

1 Introduction

The production of electric power and its conveyance to the customer is a crucial part of the society. The development and improvement of the general public because of its innovative headway presently requests uninterruptible power supply. Considering the setbacks and limitations the existing power system faces, a new and more reliable network system is needed to meet the requirement for a sustainable and uninterruptible power supply [1], [2]. An innovative approach to address this shortcoming brought about the concept of smart grid. Smart grid is a self-sufficient electrical grid with the integration of several technologies which include sustainable energy resources, smart devices, information and communication technologies and other energy efficient resources planned to manage the activity of electric power grid [3], [4]. Since the reception of this innovative grid system, there have been difficulties confronting its activity, which has been a noteworthy concern and difficulty in the task and power conveyance [5]. In the midst of these difficulties (financial issues, and strategies), electromagnetic interference has been a major setback to the effectiveness of smart grid operation, as it represents a risk because of the rising reception of new and cutting-edge innovations [5].

2 Major technology in smart grid

This innovative concept requires integration of several technologies. The key technologies in smart grid include power electronic interface, smart meter, power line technology, flexible ac transmission system and other communication technologies [5]-[7].

2.1 Power electronic interface

Before the incorporation of sustainable power sources, the current energy sources were nuclear, hydro and other non-renewable energy sources. To create clean energy and decrease the negative effect of the conventional energy sources in the earth, sustainable energy sources (solar, wind, geothermal energy) were introduced [8]. The energy obtained from these sources cannot be directly integrated into the power grid because of their varying output characteristics. An interfacing technology is needed to regulate and stabilize the output of these distributed energy sources before it is being used by the power grid. This interfacing technology is referred to as the power electronic interface [8], [9].

The power electronic interface employs a power converter or multiple converters in carrying out this task. This could be a DC/DC or DC/AC. The choice of converter depends on the need or function required. A DC/DC converter is used to regulate the frequency and load voltage, and can be used to step up or step down the dc voltage source. A DC/AC converter, also known as an inverter, is used to change a dc power into a fixed frequency ac power [8], [9].

2.2 Smart meters

Smart meters (SMs) are fundamentally digital meters that read remotely over a secure wireless network. Prior to the introduction of the smart meter, to charge an end client for utilities, the utilization is being estimated by a meter which must be read physically by an individual [10], [11]. The smart meter being an advanced measurement instrument automatically sends usage information back to the utility companies. It is a fundamental part of the smart grid which enables a two-way communication between the end users and utility companies. It also provides end user with the data essential for proficient utilization of their appliances [10], [11].

2.3 Power line technology and other communication technology

Real time data transfer between the end users and utility companies is enabled by the communication infrastructure which is an essential part of the smart grid operation. It is crucial to continuously monitor, oversee and gather exact energy status at the customer’s end of the grid to ensure effective feedback to fault events and to keep up the steady quality and viability of the system energy. This communication technologies can be commonly categorized into wired and wireless communication. The wired technique consists of fiber optics and power line
communication (PLC). The wireless mechanism includes cellular communication, ZigBee, Wi-fi, WiMAX and Bluetooth [6], [12].

Fiber optics, regardless of its preferences, has a mind-boggling expense of establishment which may demoralize its general use. The wireless technologies have lower cost and its coverage and accessible information spurs it uses. The power line communication utilizes existing electrical cables that are utilized for power transmission to transfer data [12]. This procedure is done by superimposing the data or voice signals onto the line carrier signal by utilizing a proper communication technology. This adds a modulated carrier signal to the wiring system. PLC technology ensures information exchange utilizing diverse frequency band scale technologies which can be narrowband (NB) or broadband (BB) [6], [12].

2.4 Flexible ac transmission system

The smart grid will turn out to be very complex to operate, control and keep up considering the association of various distributed energy sources in the grid, fast responses to power demands and interchange operations, and multi-path control streams [13]. To optimize the activity of the smart grid, reasonable control of power flow and its stability must be guaranteed. Considering the setback and limitations with the conventional way of transmission such as delayed response characteristics and mechanical wear and tear, an alternative technology to improve the response characteristics was suggested. Semiconductor devices due to its fast response characteristics was employed. Environmental and efficiency guidelines expanded the need to utilize these technologies. Flexible alternating current transmission systems (FACTS) depends on the use of power electronic parts in power systems [13].

The advancement in power electronic switches, insulated gate bipolar transistors, voltage source converters with the application of gate turn-off led to a new generation of FACTS devices which include static synchronous compensator, unified power flow controller, static synchronous series compensator, and the super conducting magnetic energy storage unit [13], [14].

3 Electromagnetic compatibility issues in smart grid

With the quick improvement in present day innovation and its combination in the smart grid, there has been progressively mind-boggling electromagnetic condition causing degradation which prompts inefficient activity of systems or framework breakdown [5], [6], [15], [16].

3.1 EMI in power electronic interface

Since sustainable energy sources were integrated into the grid, an interfacing technology is needed to regulate the output before it goes into the grid. Power electronic interface plays this role employing the use of power converters which could be DC/DC, AC/DC OR DC/AC. However, quick changes in the electric field or the magnetic field are a typical characteristic of EMI. In switching power converters, high proficiency is accomplished by influencing the power transistors to work either in their cut-off or saturation districts [17].

3.2 EMI in power line communication

Power line which traditionally is used in transmission and distribution utilizing electrical cables often at a 50/60 Hz. It is now being modeled as a communication infrastructure [18]. Despite the advantage of this infrastructure, there has been increment in the level of electromagnetic interference created from high frequency based electrical systems, thus acquainting disturbance with Power Line Communications [19]. There are also noises being generated within the power line communication which makes it a source and also a victim of interference [19].

3.3 EMI in flexible ac transmission system

There is an extended usage of new FACTS-based apparatus in power systems for high versatility and wide flexibility to load assortment by controlling the reactive power and maintenance to and from the transmission frameworks [13]. FACTS devices are based on the application of solid-state device, which are practically semiconductors. There has been increased utilization of electronic units in the grid technologies, which can be vulnerable to electromagnetic interference created by the FACTS devices, causing breakdowns or even damage.

4 Simulations

To investigate the interfering mechanism, simulations were done to show the activity of a flexible ac transmission system (FACTS) and a power line communication (PLC).

A simulation model was used to explore the key reason for conducted interference in FACTS devices utilizing an SVC (static var compensator) introduced in substations. Figure 1 shows the model of SVC unit in a substation.

![Figure 1. Model of SVC unit in a substation.](image-url)
on and turn-off strategy are the genuine explanation behind interference in FACTS gadgets.

Figure 2. Transient current in TSC1.

Also, a simulation of a simple power line with a voltage source as the signal transmitter was used to investigate the loss in power line due to electromagnetic interference. Figure 3 shows a model of a power line that was tested to show the insertion loss which causes attenuation and leads to transmission or data loss.

Figure 3. Simulation model of a power line.

Figure 4 reveals the consequence of the S21 parameter for the 12m link interface with derivation set at 2m which causes high attenuation at 7.75 MHz and 22.9 MHz. These fading frequencies are altogether caused by impedance mismatch at the termination across the line network set at 2m.

Figure 4. S21 parameter for the 12m cable with derivation.

5 Conclusion

The importance of smart grid cannot be overemphasized. However, these daunting challenges if not dealt with could affect the successful operation of the smart grid or even cause system failure which would lead to the grid breakdown.

This paper discussed the effect of electromagnetic interference in technologies incorporated in smart grid. The interfering mechanism stated in this paper and further research would be essential in providing solutions by mitigating interference and other immunity measures.

References


