Enhancing DPDC SCADA Communication System.

An Independent Study Report

Submitted to the Department of Computer Science and Engineering

Of

BRAC University.

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Declaration

I hereby declare that this independent study work is carried out by me. Materials of work found by other researchers are mentioned in the reference. This study work had not been previously carried out and submitted by anyone for any degree.

Signature of the Supervisor. Signature of Author.

Acknowledgement

I would like to express my deep gratitude to many people who helped and encouraged me throughout the time of my study.

First and foremost, I would like to express my heartiest gratitude to my supervisor Dr. Azad AKM. I am I in debt to him for his support, guidance and the valuable impact he left on my approach on this independent study.

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BRAC University, 2009.

Abstract

SCADA is an acronym that stands for Supervisory Control and Data Acquisition. It is a decentralized control system used extensively in power industry for monitoring and controlling plant equipment, processes as well as resources in industry such as energy, water/wastewater, petrochemical and manufacturing. To assist in the management and control of the country's critical infrastructures SCADA were developed and implemented–complete with remote communications. SCADA communication plays a vital role in the functioning of this supervisory control system. Reliability of SCADA system is therefore much dependent on the SCADA communication sector. As such a communication technology should be used that the reliability of SCADA system does not need to be compromised. SCADA had been in use in Dhaka Power Distribution Company since 1998. It was then developed by ABB. Ever since its introduction the communication sector of DPDC hardly went any improvement. At present the SCADA Communication sector is facing many problems that are rendering the whole structure obsolete. The communication structure is based on microwave links and this paper intends to propose a new communication technology named Free Space optical Communication to enhance system reliability. Free Space Optics (FSO) or Optical Wireless, refers to the transmission of modulated visible or infrared (IR) beams through the air to obtain optical communications. Like fiber, Free Space Optics (FSO) uses lasers to transmit data, but instead of enclosing the data stream in a glass fiber, it is transmitted through the air. It is a secure, cost-effective alternative to other wireless connectivity options.

Key words: DPDC, SCADA, RTU, FSO Communication, Modulation, LOS.

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CHAPTER 1

1. Introduction

SCADA is a decentralized system used extensively in power industry for monitoring and controlling plant equipment, processes as well as resources in industry such as energy, water/wastewater, petrochemical and manufacturing. Such control can be automatic or manually initiated by operator commands. The control capability that SCADA system provide is essential for the safe and efficient operation of the power machines. The system-wide monitoring and control functions provided by SCADA system may have shortcomings that may reduce the system's effectiveness. A typical SCADA system consists of three main components, named Remote Terminal Units, master control and telecommunication network. Failure of any one of these components will disable the whole system. The master control takes part in controlling the entire network which is expected to be compact with the addition of sophisticated equipment and at the same time to be highly sensitive with respect to time in order to be more efficient in transmitting instructions to its target for the execution of a particular function.

Modern power system is characterized by the presence of sophisticated and at the same time physically huge machines that are in continuous operation generating huge amount of electricity. So it is a matter of great importance of keeping these machines working without breaking apart and causing casualties and huge losses in terms of power production. The level of reliability with which the power systems are working is solely due to the tribute to the sophistication built into them. As communication system is an important aspect of the power industry, the choice for Distribution Automation (DA) has to be such that it meets the requirements set by the intended functions. The aspects that satisfy the communication requirements include load control, power and service quality monitoring feeder status monitoring, feeder switch control and monitoring, supervisory monitoring and control of feeder automation systems. Each of these services has its own communication technology requirements. SCADA communications are interconnected to every part of the utility. SCADA systems have a diverse amount of functionality such as identifying and isolating faults, circuit breaker and recloser control, voltage control and load management. It is therefore a matter of great importance that SCADA system is free of errors and this requires a reliable communication system. The choice of a Communications system for Distribution Automation (DA) is uniquely driven by requirements determined by the desired business functions to be filled. DA communication requirements are driven by a utility's business requirements and include things as diverse as customer meter reading, customer load control, power and service quality monitoring, feeder status monitoring, feeder switch control and monitoring, supervisory monitoring and control of feeder automation systems (SCADA functionality), and provision of peer-to-peer communication functions for feeder automation systems. Each of these functional requirements drives a corresponding communication requirement and, in turn, drives the selection of the appropriate communication technology for any particular utility application.

CHAPTER 2

2. Fundamental principles of modern SCADA systems

In modern manufacturing and industrial processes, mining industries, public and private utilities, leisure and security industries telemetry is often needed to connect equipment and systems separated by large distances. This can range from a few meters to thousands of kilometers. Telemetry is used to send commands, programs and receives monitoring information from these remote locations. SCADA refers to the combination of telemetry and data acquisition. SCADA encompasses the collecting of the information, transferring it back to the central site, carrying out any necessary analysis and control and then displaying that information on a number of operator screens or displays. The required control actions are then conveyed back to the process. In the early days of data acquisition, relay logic was used to control production and plant systems. With the advent of the CPU and other electronic devices, manufacturers incorporated digital electronics into relay logic equipment. The PLC or programmable logic controller is still one of the most widely used control systems in industry. As need to monitor and control more devices in the plant grew, the PLCs were distributed and the systems became more intelligent and smaller in size. The advantages of the PLC / DCS SCADA system are:

- The computer can record and store a very large amount of data.
- The data can be displayed in any way the user requires.
- Thousands of sensors over a wide area can be connected to the system.
- The operator can incorporate real data simulations into the system.
- Many types of data can be collected from the RTUs.
- The data can be viewed from anywhere, not just on site.

As the requirement for smaller and smarter systems grew, sensors were designed with the intelligence of PLCs and DCSs. These devices are known as IEDs (intelligent electronic devices). The IEDs are connected on a fieldbus, such as Profibus, Devicenet or Foundation Fieldbus to the PC. They include enough intelligence to acquire data, communicate to other devices, and hold their part of the overall program. Each of these super smart sensors can have more than one sensor on-board. Typically, an IED could combine an analog input sensor, analog output, PID control, communication system and program memory in one device. The advantages of the PC to IED fieldbus system are:

- All devices are plug and play, so installation and replacement is easy
- Smaller devices means less physical space for the data acquisition system
- Minimal wiring is needed
- The operator can see down to the sensor level

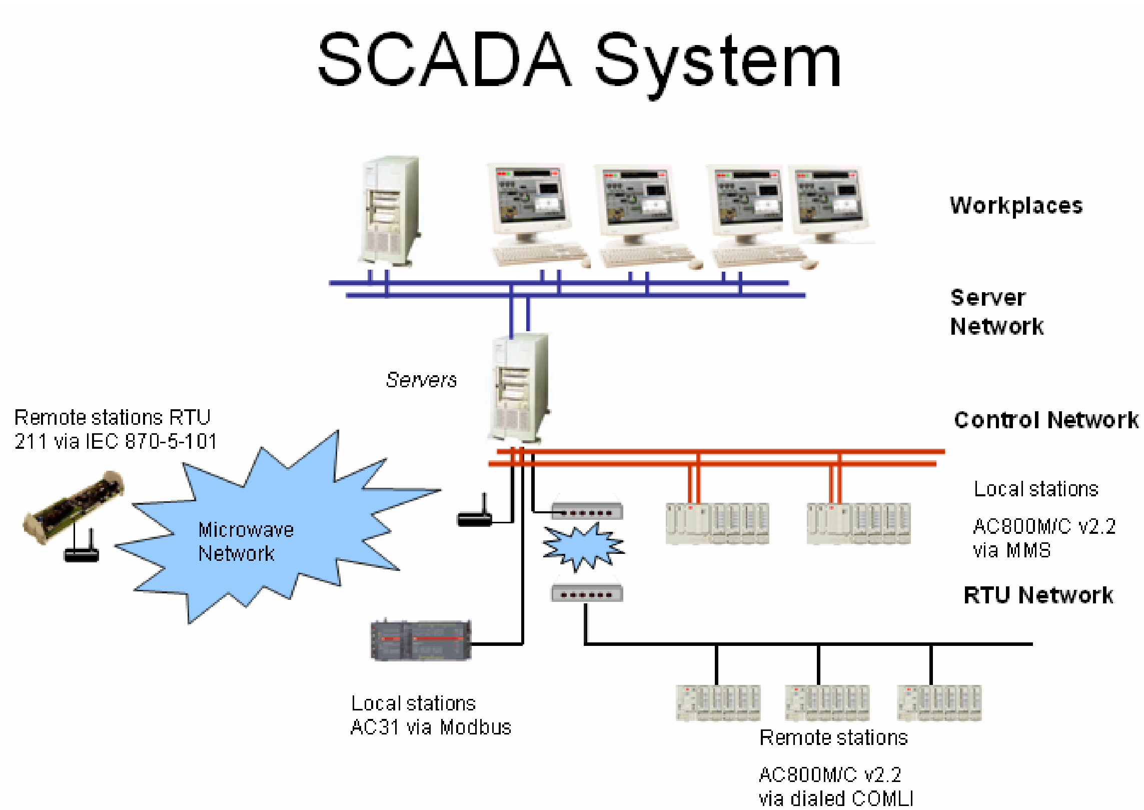


Figure 2.1. SCADA System

CHAPTER 3

DHAKA POWER DISTRIBUTION COMPANY (DPDC)

3.1 DPDC- SCADA SYSTEM

When it comes to conserve energy and save money that would have been otherwise spent in power distribution, electric network management is a system worth considering about. Ever since this management technique has been introduced in Bangladesh, crores of taka was saved every month. Improving the quality and the security would further help the nation in saving money in the power sector. A system like that of SCADA gives the overview of the entire network and update view of the voltage levels. Such control systems enable to have a window into electrical network through computer station.

SCADA system had been introduced in the DHAKA POWER DISTRIBUTION COMPANY a decade ago and is been in operation since then. It was developed by ABB and so far hardly any development been made to the communication sector of the system to make it more reliable. At the very beginning stage DPDC SCADA system faced some problems and solutions to those problems were proposed by ABB. However newer problems had now made those propositions obsolete. DPDC SCADA system is now in need of technological development to overcome the newer problems and retain its reliability. As SCADA communications are interconnected to every part of an utility and the system gives a overview of the network and update view of voltage levels and equipment states making them instantly aware from anything happening over a wide area, it improves the quality and the security of power distribution. This is worthwhile for

Bangladesh as it will help in saving huge amount of money every month. Below is the diagram illustrating the power communication network of SCADA system. The Remote Terminal Units (RTU) are positioned some distance away from the Master control unit. The communication is maintained via microwave communication having a bandwidth of 7-7.8 GHz.

3.2 SCADA Monitoring

For remote control and PLC applications SCADA is the ABB's Human System Interface. It enables the operators and engineers to get access to all process control information in real time. Since it is simple, reliable and robust, SCADA portal enhances the efficiency.

3.3 DPDC SCADA COMMUNICATION NETWORK.

The DPDC SCADA communication network comprises of cells that are positioned in a manner that gives rise to a ring network. Attached with these cells are the receiver and antenna for microwave communication. The ring topology is built in such a way that communication can occur in either direction i.e. data transfer can be carried out in clockwise manner and also in counter-clockwise manner. This is done in order to prevent unscheduled communication interruption. If there happens to be case that one direction of communication is blocked then the other direction will be in use thus enabling communication to be in progress. The communication will be taking place by selecting the shortest path to the intended RTU. The longest path will only be in operation if there is a link missing corresponding to the shortest distance to the destination RTU. The communication method is based on point to point communication. The receivers and the transmitters are placed high above the ground to assist Line of Sight (LOS) communication. The figure below illustrates the communication ring used by DPDC SCADA.

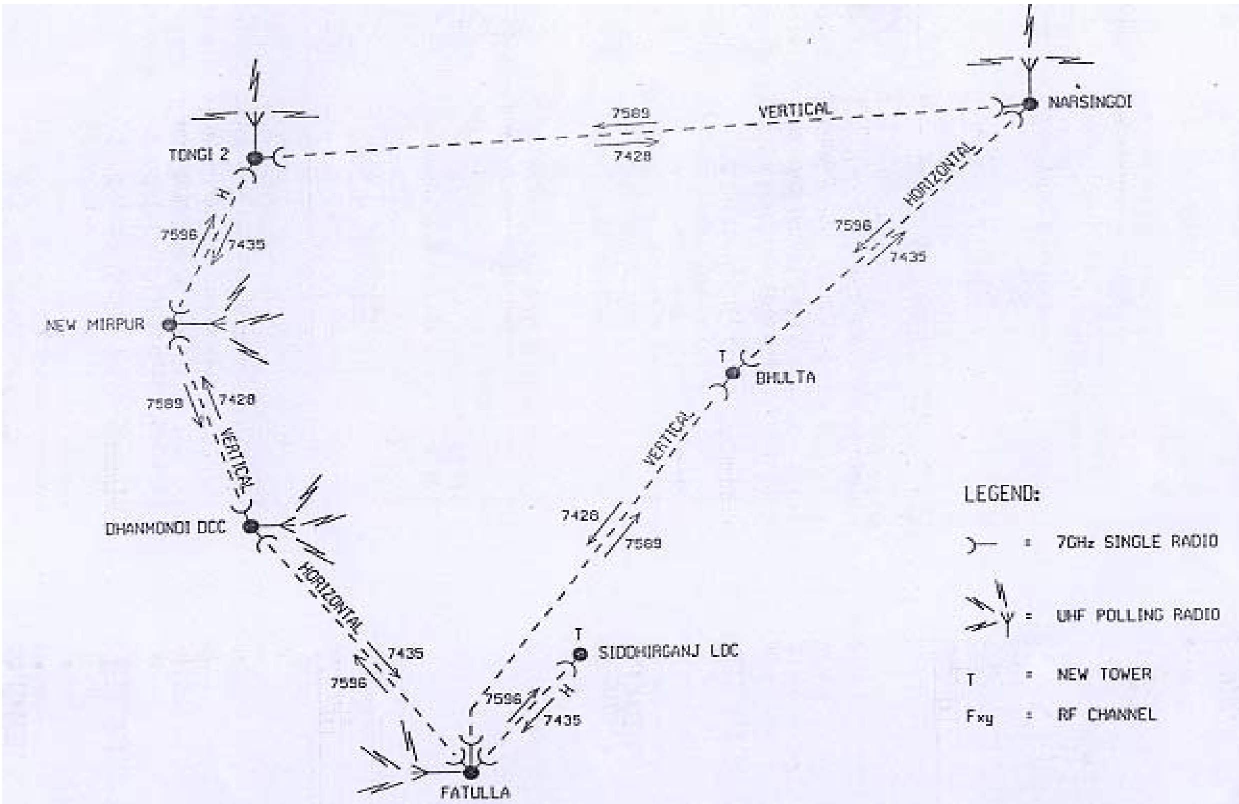
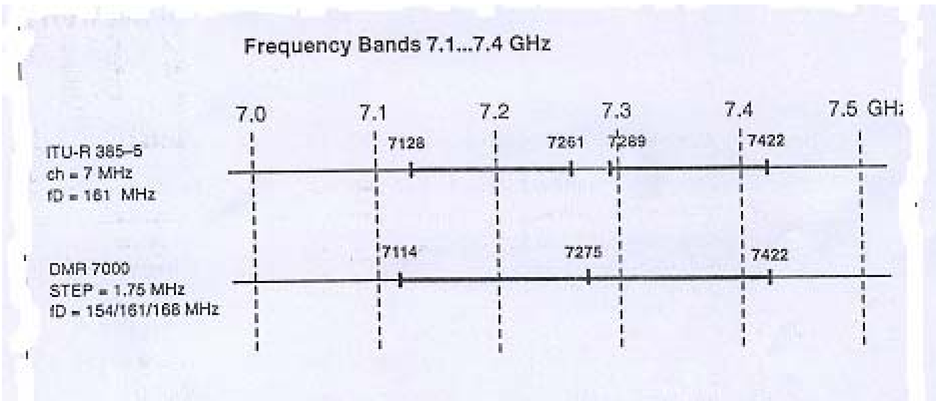


Figure 3.1 DPDC SCADA Ring Communication Network.

The diagram above illustrates the communication ring currently used by DPDC SCADA Communication network. The base stations are using simplex channels and the frequencies used are labeled. The base stations that are connected to the Remote Terminal Units (RTU) have UHF Polling Radio. The base stations are connected via different frequencies. However the same frequencies are being re-used at different cells. Dhanmondi DCC is using 7435 and 7596 to connected to Fatulla. The same pair of frequencies are being used to New Mirpur and Tongi2. This reuse of frequency is done to make efficient use of the allocated frequencies. Apart from the microwave link, Ultra High Frequency(UHF) are being used to connect the RTUs with the base stations. The radio relay equipment used operates in the 7.3GHz frequency band. The equipment named DMR 7000 can transmit two, four, eight or sixteen 2Mbps signals or one 34Mbps signal. The use of the radio frequency spectrum has been optimized at all transmission capacities. The diagram below illustrates the frequency allocation of the DMR 7000 frequency bands.



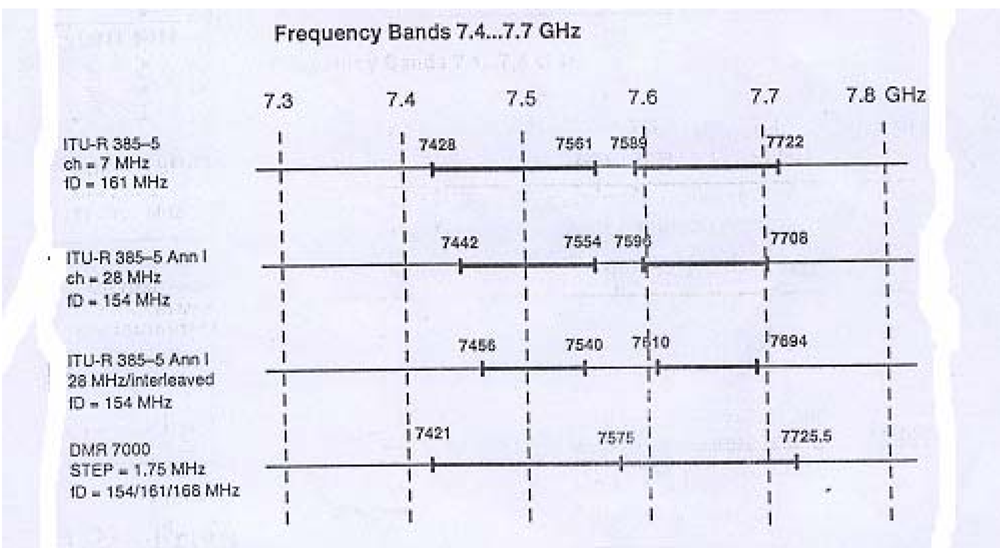


Figure 3.2 Frequency allocation

CHAPTER 4

SCADA COMMUNICATION STRUCTURE

4.1 Communication architectures

Point-to-point (two stations)

This is the simplest configuration where data is exchanged between two stations. One station can be setup as the master and one as the slave. It is possible for both stations to communicate in full duplex mode (transmitting and receiving on two separate frequencies) or simplex with only one frequency.

Point-to-point (two station)

Multipoint (or multiple stations)

In this configuration, there is generally one master and multiple slaves. Generally data points are efficiently passed between the master and each of the slaves. If two slaves need to transfer data between each other they would do so through the master who would act as arbitrator or moderator. Alternatively, it is possible for all the stations to act in a peer-to-peer communications manner with each other. This is a more complex arrangement requiring sophisticated protocols to handle collisions between two different stations wanting to transmit at the same time.

Store and forward relay operation

This can be a component of the other approaches discussed above where one station retransmits messages onto another station out of the range of the master station. This is often called a store and forward relay station. There is no simultaneous transmission of the message by the store and forward station. It retransmits the message at the same frequency as it received it after the message has been received from the master station. This approach is slower than a talk through repeater as each message has to be sent twice. The advantages are considerable savings in mast heights and costs.

Talk through repeaters

This is the generally preferred way of increasing the radio system's range. This retransmits a radio signal received simultaneously on another frequency. It is normally situated on a geographically high point. The repeater receives on one frequency and retransmits on another frequency simultaneously. This means that all the stations it is repeating the signal to must receive and transmit on the opposite frequencies. It is important that all stations communicate through the talk through repeater. It must be a common link for all stations and thus have a radio mast high enough to access all RTU sites. IT is a strategic link in the communication system; failure would wreak havoc with the entire system. The antenna must receive on one frequency and transmit on a different frequency. This means that the system must be specifically designed for this application with special filters attached to the antennas. There is still a slight time delay in transmission of data with a repeater. The protocol must be designed with this in mind with sufficient lead time for the repeater's receiver and transmitter to commence operation.

4.2 Communication philosophies

There are two main communication philosophies possible. These are; polled (or master slave) and carrier sense multiple access/collision detection (CSMA/CD). The one notable method for reducing the amount of data that needs to be transferred from one point to another (and to improve the overall system response times) is to use exception reporting which is discussed later. With radio systems, exception reporting is normally associated with the CSMA/CD philosophy but there is no theoretical reason why it cannot be applied to RTUs where there is a significant amount of data to be transferred to the master station.

Polled (or master slave)

This can be used in a point to point or multipoint configuration and is the simplest philosophy to use. The master is in total control of the communication system and makes regular requests for data and to transfer data, to and from each one of a number of slaves. The slaves do not initiate the transaction but rely on the master. It is essentially a half-duplex approach where the slave only responds on a request from the master. If a slave does not respond in a defined time, the master then retries (typically up to three times) and then marks the slave as unserviceable and then tries the next slave node in the sequence. It is possible to retry the unserviceable slave again on the next cycle of polling.

CSMA/CD system (peer-to-peer)

In a situation where an RTU wants to communicate with another, a solution would be to respond to a poll by the master station having a message with a destination address other than that of the master station's. The master station will then examine the destination address field of the message received from the RTU and if it does not, mark its own, retransmit onto the appropriate remote station. This approach can be used in a master slave network or a group of stations all with equal status. It is similar to the operation of Ethernet discussed in section 2.4.1. The only attempt to avoid collisions is to listen to the medium before transmitting. The systems rely on recovery methods to handle collision problems. Typically these systems are very effective at low capacity rates, as soon as the traffic rises to over 30% of the channel capacity there is an avalanche collapse of the system and communications become unreliable and erratic. The initial experiments with radio transmission between multiple stations (on a peer to peer basis) used CSMA/CD. This technique is used solely on networks where all nodes have access to the same media (within radio range or on a common cable link). All data is transmitted by the transmitting node first encapsulating the data in a frame with the required destination node address at the head of the frame. All nodes will read this frame and the node which identifies its address at the head of the frame will then continue reading the data and respond appropriately.

CHAPTER 5

COMMUNICATION SYSTEM FOR DISTRIBUTION AUTOMATION

5.1 COMMUNICATIONS SYSTEM FUNCTIONAL REQUIREMENTS

Functional requirements capture the intended behavior of the system. This behavior may be expressed as services, tasks or functions the system is required to perform. In the case of Distribution SCADA it will contain such information as system status points to be monitored, desired control points, analog quantities to be monitored, and

identification of customer metering and control points. It will also include identification of acceptable delays between when an event happens and when it is reported, required precision for analog quantities, and acceptable reliability levels. The functional requirements analysis will also include a determination of the number of remote points to be monitored and controlled. It should also include identification of all communication stakeholders. These might include (for Distribution Automation) the control center, the customer billing office, and technical support and planning personnel. It may also include stakeholders as diverse as the customer himself if services such as Internet-accessible meter reading and power quality information are to be offered. The functional requirements analysis should also include a formal recognition of the physical, electrical, communications, and security environment in which the communications is expected to operate. Considerations here include recognizing the possible (likely) existence of electromagnetic interference from nearby power systems, identifying available communications facilities, identifying functionally the locations between which communication is expected to take place, and identifying communication security threats which might be presented to the system.

5.2 COMMUNICATION REQUIREMENTS

Communication requirements include those elements which must be included in order to meet the functional requirements. Some elements of the communication requirements include []:

- Identification of communication traffic flows –
- source/destination/quantity
- Overall system topology – e.g., star, mesh
- Identification of end system locations
- Device/Processor Capabilities
- Communication Session/Dialog Characteristics
- Device Addressing schemes
- Communication Network Traffic Characteristics
- Performance Requirements
- Timing Issues
- Reliability/Backup/Failover
- Application Service Requirements
- Application Data Formats
- Operational Requirements (Directory, Security, and Management of the network).

5.3 DISTRIBUTION AUTOMATION COMMUNICATION REQUIREMENTS

Distribution Automation communication requirements are driven by business functional requirements which may include the following []:

- Feeder status monitoring
- Feeder voltage quality monitoring
- Reactive power monitoring (capacitor bank monitoring)
- Managing reactive compensation (capacitor bank switching)
- Feeder switch control
- Feeder sectionalized and recloser control
- Supervisory control of feeder fault isolation schemes
- Provide communication channels for fault isolation schemes
- Monitor customer power quality
- Read customer meters for total usage
- Read customer time-of-use usage
- Control end-use loads according to predetermined schedules
- Control end-use loads according to system conditions, such as peak load periods.

CHAPTER 6

COMMUNICATIONS MEDIA

This section discusses several data communication systems which can be used for various utility applications. In order to show the breadth of communication systems which are offered for utility use and also to allow this reference to be applied as technologies mature and their economic applications broaden, this list deliberately includes some technologies which are not presently considered suitable for distribution automation application.

6.1 ARDIS (Advanced Radio Data Information Service)

ARDIS is optimized for short message applications which are relatively insensitive to transmission delay. ARDIS uses connection-oriented protocols that are well suited for host/terminal applications. With typical response times exceeding four seconds, interactive sessions generally are not practical over ARDIS. As a radio-based service, ARDIS can be expected to be immune to most of the EMC issues associated with substations. It provides either 4800 bps or 19.2 kbps service using a 25 KHz channel in the 800 MHz band.

6.2 Digital Microwave

Digital microwave systems are licensed systems operating in several bands ranging from 900 MHz to 38 GHz. They have wide bandwidths ranging up to 40 MHz per channel and are designed to interface directly to wired and fiber data channels such as ATM, Ethernet, SONET and T1 derived from high-speed networking and telephony practice. Digital microwave systems can provide support for large numbers of both data and voice circuits. This can be provided either as multiples of DS3 (1xDS3 = 672 voice circuits) signals or DS1 (1xDS1 = 24 voice circuits) signals, where each voice circuit is equivalent to 64Kbps of data or (increasingly) as ATM or 100 Mbps Fast Ethernet, with direct RJ-45, Category 5 cable connections. They can also link directly into fiber optic networks using SONET/SDH. Digital microwave is costly for individual substation installations but might be considered as a high performance medium for establishing a backbone communications infrastructure that can meet the utility's operational needs.

6.3 Fiber Optics

Fiber optic cables offer at the same time high bandwidth and inherent immunity from electromagnetic interference. Large amounts of data as high as gigabytes per second can be transmitted over the fiber. The fiber cable is made up of varying numbers of either single- or multi-mode fibers, with a strength member in the center of the cable and additional outer layers to provide support and protection against physical damage to the cable during installation and to protect against effects of the elements over long periods of time. The fiber cable is connected to terminal equipment that allows slower speed data streams to be combined and then transmitted over the optical cable as a high-speed data stream. Fiber cables can be connected in intersecting rings to provide self-healing capabilities to protect against equipment damage or failure. Although it is very costly to build an infrastructure, fiber networks are highly resistant to undetected physical intrusion associated with the security concerns outlined above. Some of the infrastructure costs can be recovered by joint ventures with or bandwidth sales to communication common carriers. Optical fiber networks can provide a robust communications backbone for meeting a utility's present and future needs.

6.4 Satellite Systems

Satellite systems which offer high-speed data service have been deployed in two different forms, broadly categorized by their orbits. Because of the large distances to the satellite, GEO systems require relatively large parabolic antennas in order to keep satellite transponder power levels to a manageable level. Because of the distances involved, each trip from earth to satellite and back requires ¼ second of time. Some satellite configurations require all data to pass through an earth station on each hop to or from the end user, thereby doubling this time before a packet is delivered to the end device. If a communications protocol is used which requires link-layer acknowledgements for each packet (typical of most legacy SCADA protocols), this can add as much as one second to each poll/response cycle. This can be unacceptably large and have a significant impact on system throughput, so careful protocol matching is appropriate if a GEO satellite link is being considered. This long delay characteristic also makes GEO satellites undesirable for two-way telephone links. A second satellite technology which is gaining popularity is the “low earth orbit” (LEO) satellite. LEO’s operate at much lower altitudes of 500 to 2000 kilometers. Because of the lower altitude, the satellites are in constant motion (think of a swarm of bees), so a fixed highly directional antenna cannot be used. But compensating for this is the fact that the smaller distances require lower power levels, so if there are a sufficient number of satellites in orbit and if their operation is properly coordinated, LEO’s can provide ubiquitous high-speed data or quality voice service anywhere on the face of the earth. LEO systems can be quickly deployed using relatively small earth stations.

CHAPTER 7

FREE SPACE OPTICAL COMMUNICATION

7.1 GENERAL OVERVIEW

Free Space Optics communications, also called Free Space Photonics or Optical Wireless, refers to the transmission of modulated visible or infrared beams through the atmosphere to obtain optical communications. Like fiber, Free Space Optics uses lasers to transmit data, but instead of enclosing the data stream in a glass fiber, it is transmitted through the air. Free Space Optics (FSO) works on the same basic principle as Infrared television remote controls, wireless keyboards or wireless Palm devices. Free Space Optics (FSO) transmits invisible, eye-safe light beams from one "telescope" to another using low power infrared lasers in the THz spectrum. The beams of light in Free Space Optics (FSO) systems are transmitted by laser light focused on highly sensitive photon detector receivers. These receivers are telescopic lenses able to collect the photon stream and transmit digital data containing a mix of Internet messages, video images, radio signals or computer files. The bandwidth of the optical wireless is 10,000 times higher than the highest frequencies used by RF technologies. Furthermore, 1000 independent data channels can be grouped into the air on a single optical beam using wavelength division multiplexing thus providing a potential bandwidth ten million times that of any RF solution. Commercially available systems offer capacities in the range of 100 Mbps to 2.5 Gbps, and demonstration systems report data rates as high as 160 Gbps. Free Space Optics (FSO) systems can function over distances of several kilometers.

7.2 **Advantages of Free Space Optical Communication**

Unlike radio and microwave systems, Free Space Optics (FSO) is an optical technology and no spectrum licensing or frequency coordination with other users is required, interference from or to other systems or equipment is not a concern, and the point-to-point laser signal is extremely difficult to intercept, and therefore secure. Data rates comparable to optical fiber transmission can be carried by Free Space Optics (FSO) systems with very low error rates, while the extremely narrow laser beam widths ensure that there is almost no practical limit to the number of separate Free Space Optics (FSO) links that can be installed in a given location. FSO's freedom from licensing and regulation translates into ease, speed and low cost of deployment. Since Free Space Optics (FSO) transceivers can transmit and receive through windows, it is possible to mount Free Space Optics (FSO) systems inside buildings, reducing the need to compete for roof space, simplifying wiring and cabling, and permitting Free Space Optics (FSO) equipment to operate in a very favorable environment. The major advantages of FSO are summarized below []:

- There are no licensing requirements.
- No tariffs are required for its utilization.
- There are no radiofrequency (RF) radiation hazards (eye-safe power levels are maintained if required).
- It has a large bandwidth, which enables very high data rates.
- It is small, light, and compact.
- It has low power consumption.
- Reusability – Enables use of same communication equipments and wavelengths by nearby systems.
- Cannot be intercepted easily.
- Cannot be interpreted with spectrum analyzers or RF meters.

7.3 Major problems of FSO and their solution.

One of the major problem of FSO is the method of propagation it uses for transmission. FSO works best if there is Line of Sight (LoS). However, in an industrial area this method of propagation is difficult to carry out since the presence of high rise buildings or other huge establishment blocks the path. To overcome this problem a method known as diffusion method is used. FSO can rely on the diffused system technique where LOS is not necessary. In diffused system, a base station is attached at an elevated point. A wide angle of source emits beams that are allowed to reflect off within the cell. Terminal receivers have wide angle that cover the whole plane. In order to reduce multipath dispersions multibeam transmitters can be used. This method relies in the use of multiple narrow beam transmitter and multi-branch-angle-diversity-receiver. This diffused system of transmission enables a number of servers in the master station to be updated continuously. Similar to microwave FSO is susceptible to atmospheric turbulences. However design methods are been proposed to overcome this problem. One such method is the use of fractal modulation.. Signals are transmitted over time varying channels where the spectral efficiency remains unchanged over a broad range of rate-bandwidth ratios using a fixed transmitter configuration. The data are embedded in the optical –ultra short pulses, which are shaped like wavelets by using fractal modulation. These wavelets are generated and separated using holographic techniques. Scintillation is another problem that FSO is likely to face. This can be overcome by the usage of larger photodiodes. This ensures that signals are never lost and so the wave front distortion due to scintillation is minimized. At higher frequency scintillation has very little effect. For the DPDC SCADA communication network, a 1550nm wavelength will work fine as the 1550nm systems are entirely eye-safe and more resilient to adverse weather. This communication technology achieves the same speed as that provided by optical fiber. Therefore the system response would be much faster and this will play a vital role in minimizing the delay that occurs between tripping and execution of a particular command. Unlike optical fiber this method of communication is cost effective.

CHAPTER 8

PROPOSED DPDC COMMUNICATION SYSTEM

8.1 SCADA MICROWAVE COMMUNICATION

The DPDC SCADA communication relies on Line of Sight topology [LOS]. This however presents a problem. The LOS communication will be affected badly if a obstruction such as a high rise building appears in the path. Therefore the architecture of the whole DPDC SCADA system communication network needs to be deeply evaluated. Apart from the architecture the media also presents some problems. In case of microwave communication the radiation gets affected by the atmosphere and is also prone to undesirable interference from outside source. The radiation which is in use in microwave communication has the disadvantage of getting absorbed by the oxygen and the moisture present in the atmosphere and at the same time has the susceptibility of undergoing scattering by rainfall. There had been cases when this communication network suffered interferences from the base band frequencies used by the Bangladesh military and US Embassy. This unwanted interference from the outside sources breaches the security of communication and puts the monitored functions in risk. Apart from the microwave link, Ultra High Frequency (UHF) is being used to connect the RTUs with the base stations. These UHF are adversely affected by the weather and are also susceptible to interferences. Based on these observations a new communication technology is therefore needed to overcome atmospheric impacts and undesirable interference in order to have a reliable data transmission.

8.2 FSO for DPDC SCADA COMMUNICATION

The primary functions of DPDC SCADA system is to control and monitor equipment used for data acquisition and power distribution. Reliability is therefore a condition worth not compromising. However the communication media used undergoes certain problems that present a situation for compromising. Since this is unwanted the communication network needs to be replaced and FSO communication is just the right solution. As mentioned earlier DPDC SCADA communication relies on microwave transmission. The substitution of this mode of communication with FSO technology increases security and error less date transmission. The wavelength used in FSO ranges from .7 μm to 10 μm making the FSO spectrum virtually unlimited. The windows used for FSO transmission are 780-980nm, 1520-1600nm and 10000nm. The significance of the first window is being in the fact that at 780nm cheap CD lasers are available and at 850nm silicon APD. Components used in the second window are generally expensive but once incorporated in the fiber based industry, the cost would much be reduced. The last window has the advantage of being less affected by fog [11]. Unlike microwave, FSO is less susceptible to suffer from unwanted intrusion. It is immune from electromagnetic interference. Therefore tapping FSO is practically impossible as no form of waves having either electric field or magnetic field or both be able to interact with it. So chances of it interfering with baseband frequencies of other entities such as military frequency are nil. As such the security in FSO communication is better. The topology implemented by the microwave communication is based on point to point communication. This also happens to be one of the topologies of FSO. However FSO can operate without the existence of LOS. It can rely on the diffused system technique where LOS is not necessary [2]. In diffused system, a base station is attached at an elevated point. A wide angle of source emits beams that are allowed to reflect off within the cell. Terminal receivers have wide angle that cover the whole plane. In order to reduce multipath dispersions multibeam transmitters can be used. This method relies in the use of multiple narrow beam transmitter and multi-branch-angle-diversity-receiver. This diffused system of transmission enables a number of servers in the master station to be updated all at a time.

Similar to microwave FSO is susceptible to atmospheric turbulences. However design methods are been proposed to overcome this problem. One such method is the use of fractal modulation.[2]. Signals are transmitted over time varying channels where the spectral efficiency remains unchanged over a broad range of rate-bandwidth ratios using a fixed transmitter configuration. The data are to be embedded in the optical –ultra short pulses, which are shaped like wavelets by using fractal modulation. These wavelets are generated and separated using holographic techniques. Scintillation is another problem that FSO is likely to face. This can be overcome by the usage of larger photodiodes. This ensures that signals are never lost and so the wave front distortion due to scintillation is minimized. At higher frequency scintillation has very little effect. Optical carrier frequencies in the order of 200 THz (1550 nm) or 350 THz (850 nm) are free of any license requirements worldwide and cannot interfere with Satellite or other RF equipment. For the DPDC SCADA communication network, a 1550nm wavelength is suitable as the 1550nm systems are entirely eye-safe and more resilient to adverse weather. The bandwidth used by optical wireless communication is potentially huge. 1000 independent data channels can be multiplexed into the air. The characteristics provided by the free space optic channel and the presence of the large bandwidth allows the transmission of any 2-state digital modulation formation the same base band This communication technology achieves the same speed as that provided by optical fiber. Therefore the system response would be much faster and this will play a vital role in minimizing the delay that occurs between tripping and execution of a particular command. A part of this huge bandwidth can be used for establishing a communication network within DPDC and also can be allocated as a rent for business purpose. Unlike that of microwave this method of communication is cost effective as the major development of optoelectronic technology has led to the cheap manufacturing of the components of FSO network. In case of microwave communication, the equipment needed such as antenna, transceiver is costly. This makes the setting up of a microwave backbone on a new site expensive. Moreover this equipment are larger in size. This is a drawback of microwave communication network. With FSO, the equipment such as transceivers has small dimensions and low power consumption facilitating their installation in buildings, post signs, etc. For easy and quick setting up, FSO systems operating in the near infrared region can be used for connections through glass. Thermally isolating windows with surfaces coated by thin metal layers attenuate light much less than longer wavelengths.

CHAPTER 9

CONCLUSION

As power industry enters the new century, powerful driving forces, uncertainties and new functions are compelling electric utilities to make dramatic changes in their information communication infrastructure. Expanding network services such as real time measurement and monitoring are also driving the need for more bandwidth in the communication network and reliable communication infrastructure. These needs will grow further as new remote real-time protection and control applications become more feasible and pervasive. Information embedded power system via wide area network is the solution to accommodate the growing demand of wide area monitoring, protection and control. Successful operation of electric power systems and Distribution Automation are strongly dependent on communication technologies. As we have seen in this discussion, a careful analysis of the resultant communication requirements is a prerequisite to making good choices of communication technologies for DA. There is a large and growing list of communication technologies available to serve the needs of utility Distribution Automation systems. The goal of this independent study was to identify the problems faced by DPDC SCADA communication and then come up with an appropriate solution. FSO , as discussed, with all its drawbacks solved happens to be ideal replacement for the existing microwave communication within DPDC. This will develop the performance of the decentralized control system.

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APPENDIX A

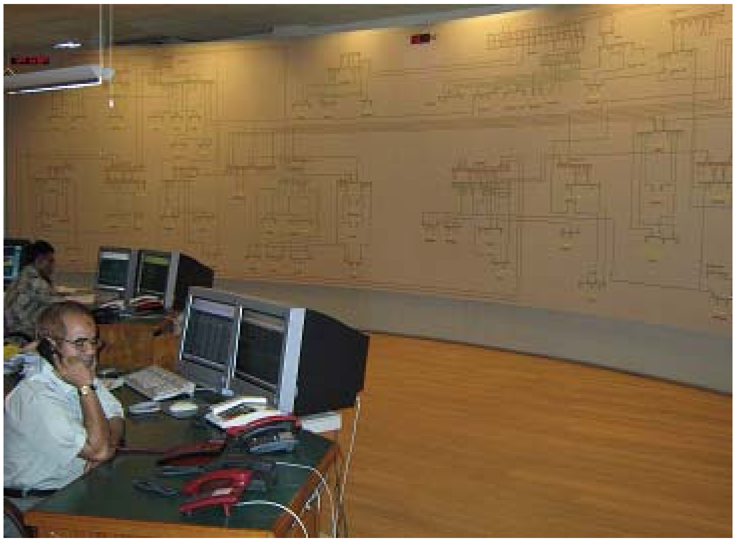

Figure1 Control Panel.

Figure 2 Remote Terminal Unit.

Figure 3 Communication Equipment

Figure 4 Power Lines.