East West University

**INTERNSHIP REPORT**

ON

**SCADA Communication System of Dhaka Power Distribution Company (DPDC)**

SUPERVISED BY:

SARWAR JAHAN
ASSISTANT PROFESSOR
DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING
**EAST WEST UNIVERSITY**

SUBMITTED BY:

Md. Abu Sayem Rishad
ID: 2019-1-55-026
MAJOR IN ETE
DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING
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DATE OF SUBMISSION:
January 18, 2023

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## LETTER OF TRANSMITTAL

18th January 2023

Sarwar Jahan
Assistant Professor
Department of Electronics & Communication Engineering
East West University

Subject: Submission of the Internship Report.Dear

Sir,
It is an honor and pleasure for me to present you the internship report on “Enhancing DPDC SCADA Communication System.” as a prerequisite of completing the B.Sc. program. It has been made during the internship period at DPDC based on my practical learning and the information collected from my supervisor, colleagues, staffs, and websites.

This report aims to demonstrate Free Space Optics (FSO) which is more efficient than microwave link in Dhaka Power Distribution Company (DPDC). It was a great pleasure as well as a challenge to work in such a reputed organization in power sector and prepare this report which has helped me significantly to enhance my knowledge and skills.

I, therefore, express my profound gratitude to you for the kind cooperation, supervision, and guidance in successfully preparing this report. I hope you will consider this report and oblige me thereby. I shall be happy to provide any clarification on any relevant matter.

Sincerely yours,

Md.Abu Sayem Rishad
ID: 2019-1-55-026
Major in ETE
Department of Electronics & Communication Engineering
East West University

## ACKNOWLEDGEMENTS

Most importantly, I would like to express my heartiest gratitude to almighty Allah for keeping in good health and giving me the strength, ability, and opportunity to accomplish the report within the schedule time successfully.

I convey my deepest appreciations to my Academic Supervisor Sarwar Jahan, Assistant Professor at Department of ECE, East West University, for his valuable suggestions, advice, support and important guidance while preparing this report. For sure, I am appreciative to all the Faculty Members of Department of ECE, East West University from whom I have been learning and inspired in different courses.

Additionally, my graceful admiration goes to Engr. Akhil Chandra Das, Sub-Divisional Engineer, System Control and SCADA Circle, DPDC who has provided guidance that enabled me to learn the functions of SCADA of DPDC, especially SCADA. Moreover, I am grateful to the Head of Training and Development Md. Mohiul Alam, Superintending Engineer, who paved the way for me to have my internship completed in such a great platform. The experience I have gained here will be a privilege for my future career. A special word of appreciation goes to all the staffs of SCADA & Research Department of DPDC for their generous cooperation and assistance during my entire period of internship.

I would like to thank my family members for their constant support and love in my life that always pushes me forward.

Lastly, I am thankful to them who have shared their views about my work, provided me with necessary information, criticized my work and congratulated me. This page is not enough to tell them how important their opinions are on this report, how indebted I am to them.

# Declaration

I absolutely confirm that I completed my independent study project. The reference lists sources of information discovered by previous researchers. This research work had never been completed and submitted for any degree before.

Signature of the Supervisor. Signature of Author

## 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 notneed to be compromised. SCADA had been in use in Dhaka Power Distribution Company (DPDC) 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.

# Internship Certification


ঢাকা পাওয়ার ডিস্ট্রিবিউশন কোম্পানী লিঃ
**DHAKA POWER DISTRIBUTION COMPANY LTD (DPDC)**
(An Enterprise of the Government of the People's Republic of Bangladesh)
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Office of the
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স্মারক নং: ৮৭.৪১০.৪৫০.০৬.০০.০৭৯.২০২২.১৩৮ তারিখ: ৩০/০৮/২০২২ খ্রি.

Associate Professor & Chairperson
Department of Electronics and Communications Engineering
East West University
Dhaka, Bangladesh

বিষয়: **East West University এর ০৮ জন শিক্ষার্থী ডিপিডিসি'তে ইন্টার্নশীপ ট্রেনিং এ অংশগ্রহণ প্রসঙ্গে।**
Memo No: 87.410.450.06.00.079.2021.994 Date: 16/06/2022

বর্ণিত বিষয়ে জানানো যাচ্ছে যে, East West University এর ECE ডিপার্টমেন্ট এর নিম্নবর্ণিত ০৮ জন শিক্ষার্থী ডিপিডিসি'তে গত ১৯/০৬/২০২২ হতে ৩০/০৮/২০২২খ্রি. পর্যন্ত এটাচমেন্ট ট্রেনিং এ অংশগ্রহণ করেন।

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ইন্টার্নশীপ ট্রেনিং এ নিম্নলিখিত বিষয়ে আলোকপাত করা হয়:

(ক) বিদ্যুৎ সরবরাহের সূচনা, বিদ্যুৎ সেক্টরের রিফর্মের আওতায় সরকার কর্তৃক ক্রমান্বয়ে পিডিবি, আরইবি, ডেসা, ডেসকো ও ডিপিডিসি গঠন।
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শিক্ষার্থীদের উত্তরোত্তর সাফল্য কামনায়,

(মোঃ মহিউল আলম) ৩০/৮/২২
তত্ত্বাবধায়ক প্রকৌশলী
প্রশিক্ষণ ও উন্নয়ন, ডিপিডিসি।
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বিতরণ:
১। নির্বাহী পরিচালক (এডমিন ও এইচ.আর), ডিপিডিসি।
২। সিসিও টু ব্যবস্থাপনা পরিচালক মহোদয়, ডিপিডিসি।

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**LIST OF ABBREVIATIONS**

KGOE : Kilogram Oil Equivalent
KW : Kilowatt
MW : Megawatt
DPDC : Dhaka Power Distribution Company Limited
NOCS : Network Operation and Customer Service
SCADA : Supervisory Control and Data Acquisition
RTU : Remote Terminal Unit
FSO : Free Space Optics
IED : Intelligent electronic devices
DSO : Distribution System Operator
PLC : Power Line Communication
AMR :Automatic Meter Reading
AMI :Advanced Metering Infrastructure
DSM :Demand Side Management
PWM :Pulse Width Modulation
DSL :Digital Subscriber Line
IoT :Internet of Things
NB :Narrowband
HDR :High Data Rate
LDR : Low Data Rate
BB :Broadband
EMI :Electromagnetic Interference
LV : Low Voltage
MV :Medium Voltage
NOCS :Network Operation & Customer Service

## ORIGIN OF THE REPORT

The East West University's internship program is a prerequisite for B.Sc. graduates in order to graduate. This report is one of the requirements for the East West University's B.Sc. internship program. The primary goal of an internship is to expose students to the working world. Being an intern, the biggest challenge was applying the theoretical ideas to real-world situations.

The internship program and the study have following purposes:

- ❖ To get and organize detail knowledge on SCADA Communication system.
- ❖ To experience the real job field.
- ❖ To compare the real scenario with the lessons learned in East West University
- ❖ To fulfill the requirement of B.Sc. Program.

This report, which was produced as part of a three-month internship program at Dhaka Power Distribution Company Limited (DPDC), was created in order to fulfill a requirement for the East West University B.Sc. program. This report must be submitted as a consequence, and it is based on the "SCADA Communication System of Dhaka Power Distribution Company (DPDC)". This report also provides an overview of the company, information on its products and services, and details on the clients it serves.

## OBJECTIVE OF THE REPORT

The objective of the report can be viewed in two forms:

- ❖ General Objective
- ❖ Specific Objective

### General Objective:

This internship report is prepared primarily to fulfill the Bachelor of Science (B.Sc.) degree requirement under the Electronic & Communication Engineering Department of East West University.

Specific Objective:

More specifically, this study entails the following aspects:

- ❖ To give an overview of SCADA Communication system of DPDC.
- ❖ To discuss how SCADA work in Dhaka city.
- ❖ To focus on the Radio link which is used in SCADA communication system.
- ❖ Discuss about using FSO to increase system reliability of SCADA.

## SCOPE OF THE REPORT

The main intention of the report is to identify challenges of Radio link which is used in SCADA and assume the possible solution against that technology which is more reliable for SCADA System

This report covers details about the Radio link of SCADA and their main work. However, the study is mostly related to the Radio link FSO system as I was provided an opportunity to work under this office of DPDC in.

The report's scopes are followed below:

Information for the analysis was collected from the company's internal sources, websites, database, newspapers, research papers & study materials.

Geographic scope of this report is limited to DPDC held area in Dhaka city.

## METHODOLOGY

Starting with the topic selection and ending with the writing of the final report, the study is carried out in a systematic manner. Identification and data collection played a crucial role. Once the important points had been determined, they were systematically categorized, examined, translated, and presented. The overall technique used in the study is described in more detail.

The study's topic was given to me by my supervisor. Before the topic was assigned, it was thoroughly explored to enable the creation of a well-structured internship report.

### Sources of Data

Primary Sources:

Primary Data was derived from the practical deskwork. Moreover, my supervisor at DPDC also helped me to get information directly from the company.

Secondary Sources:

Internal sources: Different documents provided by concerned officers and different circulars, manuals, and files of the organization.

External source: Different websites related to SCADA and online resources.

# CHAPTER 1 - Introduction

## 1.1 Introduction

In the power industry, SCADA, a centralized system, is frequently used to monitor and control plant operations, machinery, and industrial resources like water, energy, petrochemicals, and manufacturing. The operator can issue commands to initiate these controls manually or automatically. The SCADA system's control skills are essential for the power machines to run safely and efficiently. The ability of the SCADA system to monitor and manage the entire system may have downsides that reduce the system's effectiveness. A typical SCADA system is composed of three main components: Remote Terminal Units, Master Control, and Telecommunication Network. If even one of these components malfunctions, the system will be unusable. 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 effective at transmitting instructions to its target for the execution of a specific function.

The modern power system is defined by the presence of intricate, physically big, and continuously producing enormous amounts of electricity. As a result, keeping this equipment in good working order is essential to avoiding mishaps, fatalities, and large losses in power production. The only element affecting the power systems' level of dependability is the sophistication built into them. Since communication systems are an essential part of the power business, Distribution Automation (DA) must be chosen in a way that meets the requirements defined by the intended functions. features include load control, power and service quality monitoring, monitoring and control of feeder automation systems, monitoring and control of feeder switches, and load management of feeders that satisfy the communication requirements. For each of these services, there are communication technology needs. SCADA communications connect every part of the utility. The wide capability of SCADA systems includes load management, voltage regulation, fault isolation, and control over circuit breakers and reclosers.

As a result, it is essential that the SCADA system operate without errors, which calls for a reliable communication system. The criteria set by the required business functions to be filled have a special bearing on the communications system selection for distribution automation (DA). A few of the varied things that fall under the general heading of DA communication requirements that are motivated by a utility's business requirements are 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 needs drives a matching communication requirement for any given utility application., which in turn drives the choice of the best communication technology.

## 1.2 BANGLADESH SCADA SCENARIO

Production, refinement, manufacturing, fabrication, and power generation are all examples of industrial processes, which can operate in batch, continuous, discrete, or recurring modes. Water treatment and distribution, wastewater treatment and collection, electrical power distribution and transmission, gas and oil pipelines, civil defense siren systems, and substantial communication systems are among the infrastructural activities that can be either private or public. Space stations, airports, ships, and buildings have all of the facility processes, whether they are private or public facilities. Access, consumption, HVAC, and energy are all controlled and monitored by these facility operations.

The following subsystems are usually present in the SCADA system:

- The Human-Machine Interface, or HMI, is the device that displays to the human operator all the processed data and allows the human operator to control and observe the operations.
- A monitoring system that gathers all the necessary information about the process and transmits all the necessary directives to the process (commands).
- Remote Terminal Units (RTUs) that are connected to the process's sensors assist in converting the sensor signals into digital data and transmitting that data to the supervisory stream.

# CHAPTER 2 – Introduction of SCADA system

## 2.1 Introduction of modern SCADA systems

Supervisory Control and Data Acquisition, or SCADA. Industrial equipment such as motors, valves, pumps, relays, sensors, and other items are centrally monitored and controlled by real-time industrial process control systems. SCADA stands for Supervisory Control and Data Acquisition.

Previously, industrial processes were totally managed by PLC, CNC, PID, and micro controllers that had been coded in specific languages or codes. These routines lacked any real animation that would have explained how the operation was being carried out and were either written in relay logic or assembly language. If the status of the process is displayed using some animations rather than plain codes, it is always simple to understand. Thus, SCADA software was created, and, thanks to some unique qualities, it was integrated into the automation system.

SCADA consists of both hardware and software. It's a notion. It is a system made up of unique software, hardware, and protocols. SCADA is used to manage operations in chemical plants, oil and gas pipelines, manufacturing facilities, infrastructure for water purification and distribution, and other systems. As an illustration, a PLC can be utilized in a SCADA system to regulate the flow of cooling water as part of an industrial operation. The supervisor can also utilize the Host control feature to adjust the temperature of the water flow at the same time. Additionally, it may include alarms, monitor the temperature of the water flow, and communicate back to The RTUs and PLCs communicate back to the SCADA system and oversee gathering data such as meter readings, equipment status, etc. This information can be watched by a supervisor to take the necessary actions if necessary or recorded in a database for further study.

The distributed database used by SCADA systems is frequently referred to as a tag database and comprises data components called tags or points. A point is an individual input or output value that the system is monitoring or controlling. Points can be "soft" or "hard." A soft point is the outcome of applying logic and math to other hard and soft points, whereas a hard point is a representation of a genuine input or output connected to the system.

Most implementations conceptually eliminate this distinction by making each property a "soft" point (expression) that, in the simplest scenario, can equal a single "hard" point. In most cases, point values are saved as value-timestamp combinations, which include both the value and the time at which the value was calculated or recorded. The history of that point is a set of value-timestamp pairs. Additional metadata, such as the path to a field device and a PLC register, design time comments, and even warning information, are frequently stored with tags.

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 demand for more compact and intelligent systems increased, sensors were created with the same level of intelligence as PLCs and DCSs. IEDs are the name for these gadgets (intelligent electronic devices). The RTU is connected to the IEDs by a fieldbus like Profibus, Device net, or Foundation Fieldbus. They have sufficient intelligence to gather data, communicate with other devices, and maintain their position within the larger program. These extremely intelligent sensors each have the capacity to house many sensors. Typically, an IED would include a program memory, communication system, PID control, analog input sensor, and analog output.

The advantages of the PC to IED fieldbus system are:

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

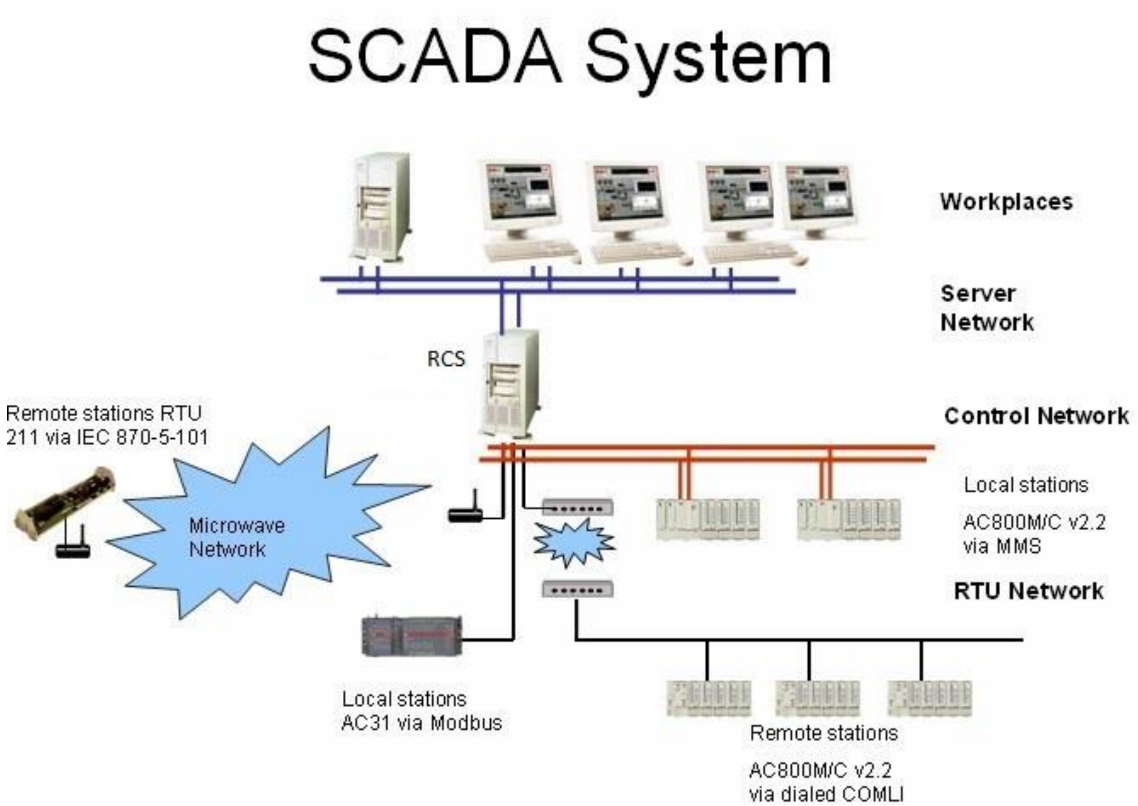



Figure 2.1 SCADA System

## 2.2 What SCADA can do for us

SCADA is a type of application rather than a particular technology. SCADA, which stands for supervisory control and data acquisition, refers to any application that gathers information about a system in order to control it.

A SCADA application has two elements:

- The process/system/machinery we want to monitor a control — this can be a power plant, a water system, a network, a system of traffic lights, or anything else.
- A network of intelligent devices that interfaces with the first system through sensors and control outputs. This network, which is the SCADA system, gives us the ability to measure and control specific elements of the first system.

A SCADA system can be created utilizing a variety of technologies and protocols. This white paper will assist you in weighing your alternatives and selecting the SCADA system that is most suitable for your needs.

## 2.3 Where is SCADA used

SCADA can be used to handle any form of machinery. SCADA systems are typically used to automate intricate industrial processes where human control is unfeasible because there are too many control parameters and too many moving parts for humans to easily handle.

Around the world, SCADA systems control:

- **Electric power generation, transmission, and distribution:** Electric utilities use SCADA systems to detect current flow and line voltage, to monitor the operation of circuit breakers, and to take sections of the power grid online or offline.

- **Water and sewage:** State and municipal water utilities use SCADA to monitor and regulate water flow, reservoir levels, pipe pressure and other factors.
- **Buildings, facilities, and environments:** Facility managers use SCADA to control HVAC, refrigeration units, lighting and entry systems.
- **Manufacturing:** SCADA systems manage parts inventories for just-in-time manufacturing, regulate industrial automation and robots, and monitor process and quality control.
- **Mass transit:** Transit authorities use SCADA to regulate electricity to subways, trams, and trolley buses; to automate traffic signals for rail systems; to track and locate trains and buses; and to control railroad crossing gates.
- **Traffic signals:** SCADA regulates traffic lights, controls traffic flow, and detects out of order signals.

This extremely small list only scratches the surface of all the possible uses for SCADA systems. Every industry and public infrastructure project where automation improves efficiency uses SCADA. Furthermore, the depth and complexity of SCADA data are not demonstrated by these instances. Managers must handle a variety of variables and how they interact in every sector.

SCADA systems offer the computing power and sensing capabilities needed to monitor everything that is important to your operations.

# CHAPTER 3 – USE OF SCADA IN DHAKA POWER DISTRIBUTION COMPANY (DPDC)

## 3.1 DPDC- SCADA SYSTEM

Electric network management is a strategy worth thinking about if you want to save energy and money that would have been spent on power distribution. Every month since this management approach was established in Bangladesh, millions of takas have been saved. The nation might further reduce costs in the power sector by raising the quality and security. A SCADA-style system provides an overview of the complete network as well as an up-to-date picture of the voltage levels. Through a computer station, these control systems allow for a look into the electrical network.

A decade ago, the DHAKA POWER DISTRIBUTION COMPANY installed a SCADA system, which has been in use ever since. It was created by ABB, and the system's communication component hasn't seen any improvement to date in terms of reliability. The DPDC SCADA system initially encountered several issues, and ABB suggested solutions to those issues. However, more recent issues have rendered those ideas obsolete. The DPDC SCADA system presently need technical advancement to address the most recent issues and maintain its dependability. Due to the interconnection of SCADA communications from the master station to the remote out station.

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

SCADA is the Human System Interface used by ABB for applications involving remote control and PLCs. It makes it possible for engineers and operators to have real-time access to all process control data. SCADA portal improves efficiency since it is straightforward, dependable, and strong.

## 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 counterclockwise 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 thereis a Radio link missing depending on the frequency bandqidth or using optical fiber so that no problem will be created. 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.

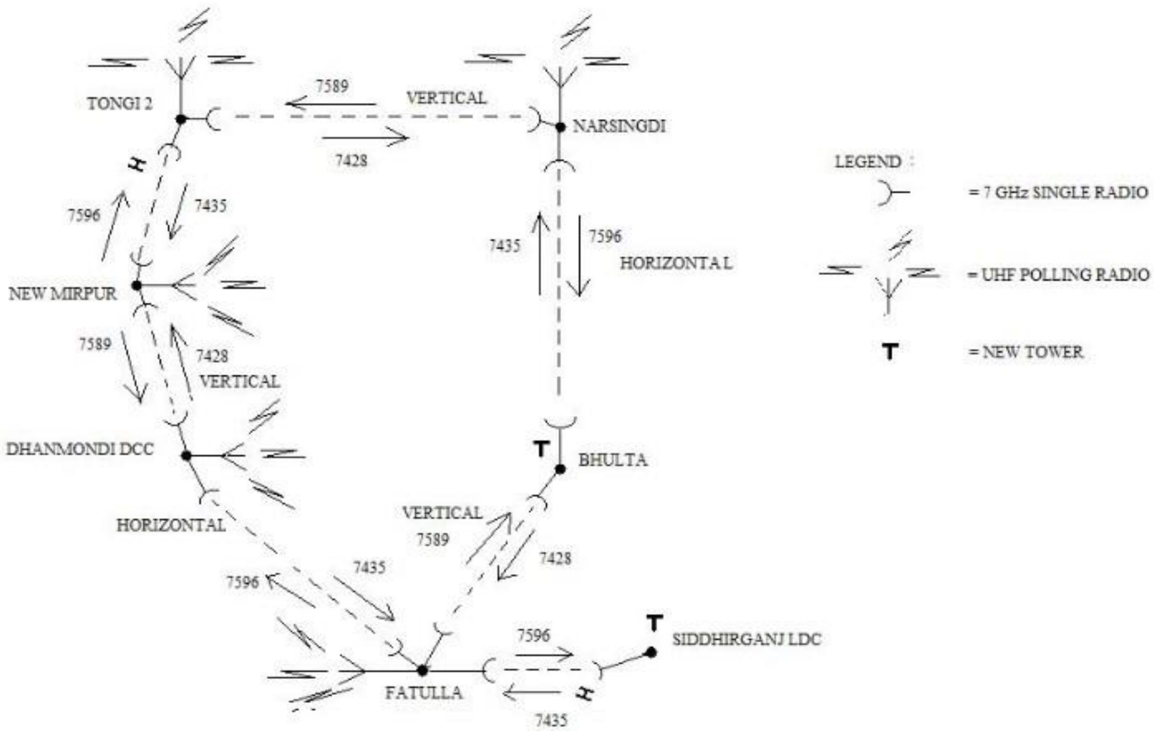



Figure 3.1 DPDC SCADA Ring Communication Network.

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 signal. In DPDC system this is working $4 \times 2$ Mbps frame. 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.

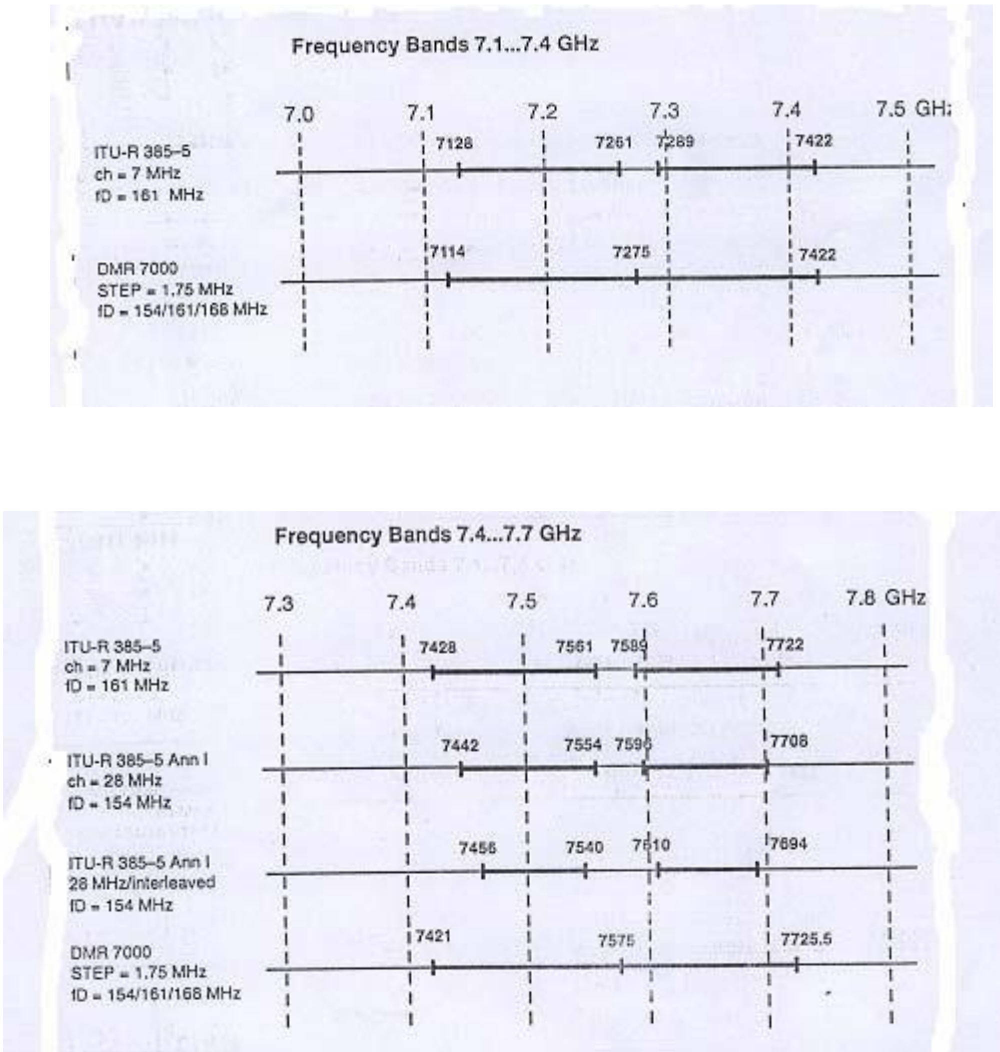



Figure 3.2 Frequency allocation

# 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.

### Multipoint (or multiple stations)

Typically, there is only one master and many slaves in this system. In most cases, data is efficiently sent from the master to each of the slaves. Two slaves that need to exchange data will do so through the master, who will serve as an arbitrator or mediator. As an alternative, all of the stations could interact with one another through peer-to-peer connections. With this more complicated setup, collisions between two separate stations trying to transmit at the same time must be handled by sophisticated procedures.

### Store and forward relay operation

This can be a part of the other strategies mentioned above in which one station relays messages to another station that is outside the master station's range. It's frequently referred to as a store and forward relay station. The store and forward station does not transmit the message at the same time. Once the message has been received from the master station, it is sent out again at the same frequency. Due to the necessity of sending each message twice, this method is slower than a talk through repeater. The benefits include significant cost and mast height savings.

**Talk through repeaters.**

This method of extending the radio system's range is typically recommended. This retransmits a radio signal that was picked up at the same time on a different frequency. It is typically located on a high point in the landscape. The repeater simultaneously receives on one frequency and transmits on a different frequency. As a result, all of the stations that it is repeating the signal to must transmit and receive on different frequencies. Communication between all stations via the talk-through repeater is crucial. All stations must use it, hence it needs to have a radio mast that is tall enough to reach all RTU locations. IT is a crucial component of the communication system, and its collapse would have disastrous effects on the whole thing. The antenna must transmit on one frequency and receive on another. This means that a system with particular filters attached to the antennas must be created especially for this application. With a repeater, data transmission is still slightly delayed. This must be taken into consideration when designing the protocol, allowing enough time for the receiver and transmitter of the repeater to start up.

## 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 to master station through RCS, when master station will send poll to RTU then it will communicate through RCS to master station with required data. There is no RTU will no communicate with another RTU. One particular RTU can communicate with master station. Here is the known as gateway of the SCADA system and another name of the ETU is Front End (FE).

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 like 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 destinationnode 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 CONDITIONS FOR FUNCTIONALITY OF A COMMUNICATIONS SYSTEM

The expected behavior of the system is captured by the functional requirements. The system's required performance of these behaviors may be described as services, tasks, or functions. In the case of Distribution SCADA, this information will include details like the system status points to be monitored, desired control points, analog amounts to be monitored, and customer metering and control point identification. Additionally, it will identify acceptable reliability levels, required precision for analog numbers, and acceptable delays between the time an event occurs and the time it is reported. The quantity of distant points that must be managed and monitored will also be determined as part of the functional requirements analysis. Identification of all parties involved in communication should also be included. These could include the control center, the customer billing office, and the technical support and planning staff (for Distribution Automation). If services like Internet-accessible meter reading and power quality information are to be provided, it may also include stakeholders that are as diverse as the consumer himself. The physical, electrical, communications, and security environments in which the communications are anticipated to operate should also be formally acknowledged as part of the functional requirements study. Here, factors to be taken into account include acknowledging the potential (likely) existence of electromagnetic interference from nearby power systems, identifying the facilities for communications that are available, functionally identifying the locations where communication is anticipated to occur, and identifying communication security threats that may be posed 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, andManagement of the network).

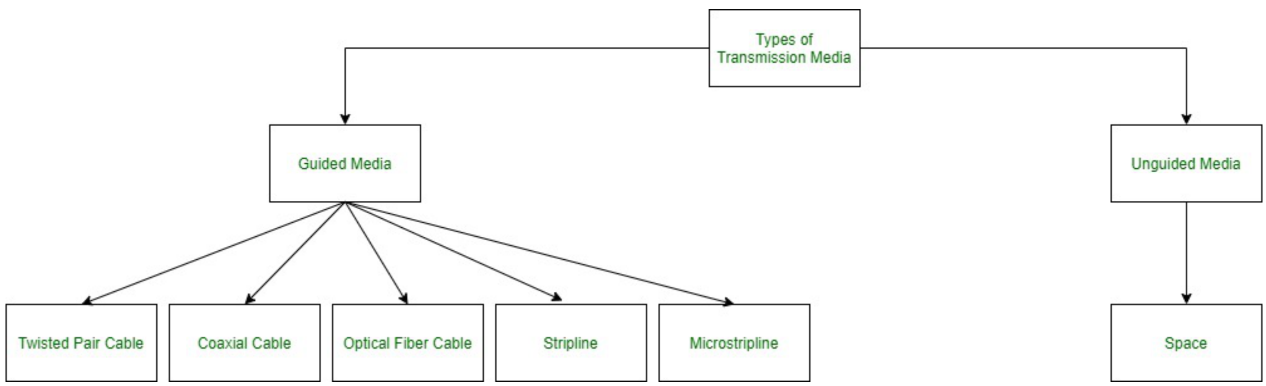
## 5.3 DISTRIBUTION AUTOMATION COMMUNICATION REQUIREMENTS

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

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

# CHAPTER 6 - Types of Transmission Media

A transmission medium, or channel through which data is conveyed from one location to another, is a physical path between the transmitter and the receiver in the context of data communication. The following categories broadly describe the types of transmission media:




## 6.1 Guided Media

Additionally, it is known as wired or bounded transmission media. Physical linkages are used to direct and constrain the signals that are being transmitted along a certain path.

Features:

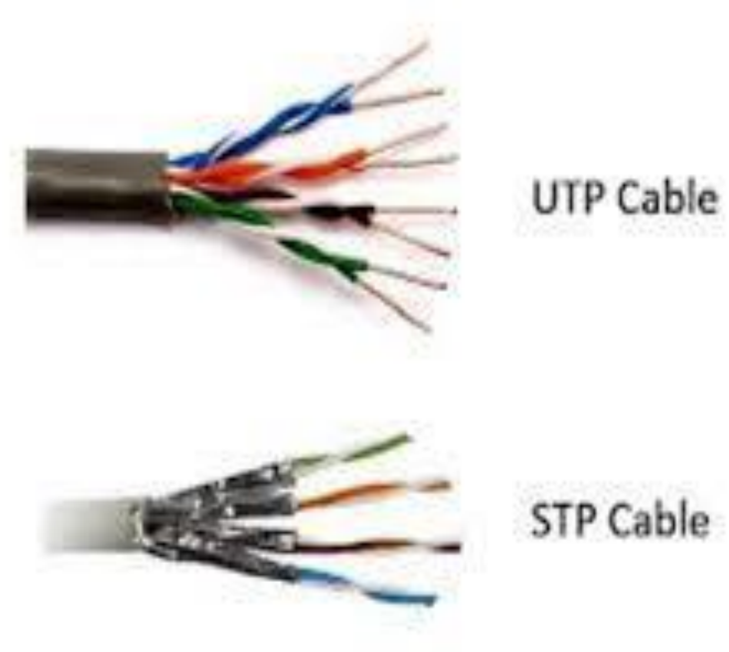
- High Speed
- Secure
- Used for comparatively shorter distances.

### 6.1.1 Twisted Pair Cable

It comprises of two conductor wires that have been twisted around one another. Typically, a protective sheath is used to enclose multiple such pairs. They are the Transmission Media that are used the most. Twisted Pair is of two types:

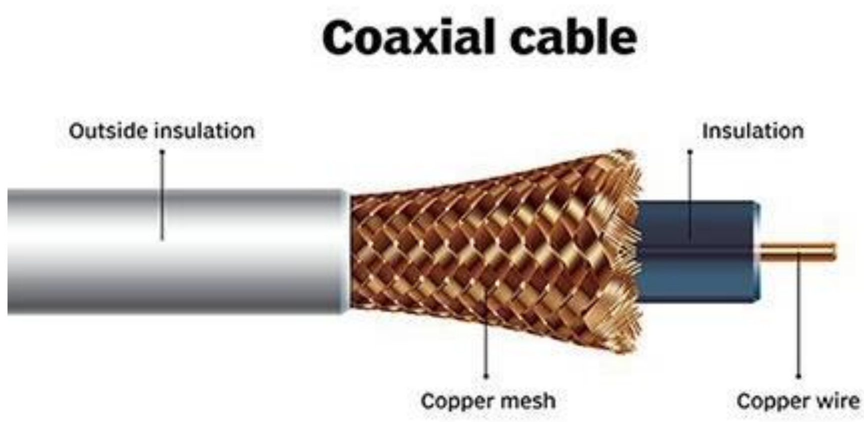
- Unshielded Twisted Pair (UTP): Two insulated copper wires are wound around one another to form UTP. This kind of cable can suppress interference and does not require a physical shield to do so. For telephonic applications, it is employed.

- Shielded Twisted Pair (STP): To prevent outside interference, this type of cable has a protective jacket (a foil shield or a copper braid wrapping). It is utilized in telephone lines' voice and data channels as well as fast-data-rate Ethernet.



### 6.1.2 Coaxial Cable

It has two parallel conductors, each with a separate insulated protection cover, and an exterior plastic covering with an insulating layer composed of PVC or Teflon. Baseband mode (dedicated cable bandwidth) and Broadband mode are the two ways that the coaxial cable sends information (cable bandwidth is split into separate ranges). Coaxial cables are commonly used with cable TVs and analog television networks.




### 6.1.3 Optical Fiber Cable

It makes advantage of the idea of light refraction through a glass or plastic core. The cladding, a less dense layer of glass or plastic, surrounds the core. It is used to transmit massive amounts of data.

Both unidirectional and bidirectional cables are available. Unidirectional and bidirectional modes are supported by the WDM (Wavelength Division Multiplexer).

### 5.1.4 Stripline

A transverse electromagnetic (TEM) transmission line medium called stripline was developed in the 1950s by Robert M. Barrett of the Air Force Cambridge Research Centre. The earliest type of planar transmission line is called a strapline. It is also known as a waveguide because it transmits high-frequency waves using a conducting substance. This conductive substance is positioned in between two ground plane layers that are often shorted to offer EMI immunity.

### 6.1.5 Microstripline

In this, the conducting material is separated from the ground plane by a layer of dielectric.

## 6.2 Unguided Media

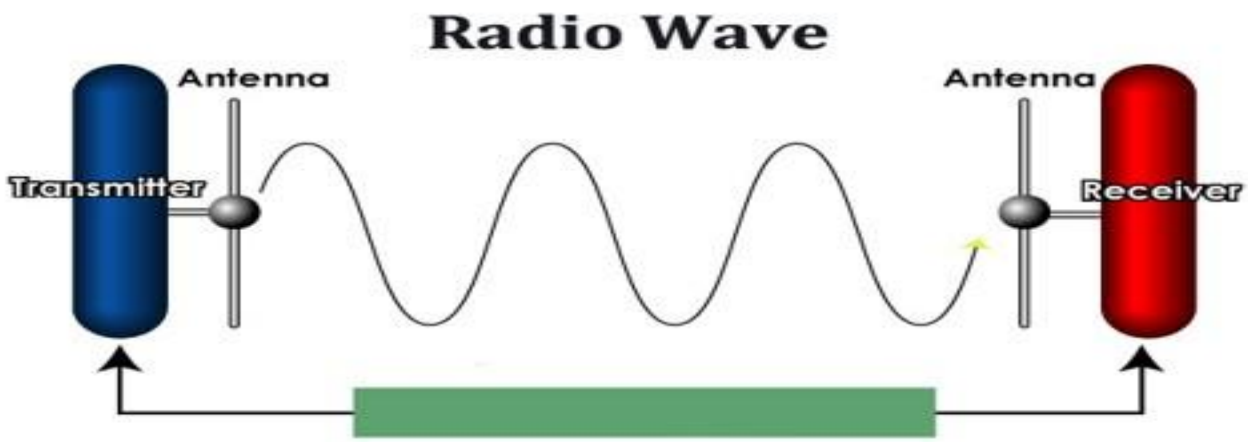
It is also referred to as Wireless or Unbounded transmission media. No physical medium is required for the transmission of electromagnetic signals.

Features:

- The signal is broadcasted through air.
- Less Secure
- Used for larger distances.

**6.2.1 Radio waves**

These may pass through buildings and are simple to produce. It's not necessary to line up the sending and receiving antennas. Range of frequencies: 3 KHz to 1 GHz. Radio waves are used in AM, FM, and cordless phones to transmit information.




**6.2.1 Microwaves**

Since it is a line-of-sight transmission, the sending and receiving antennas must be correctly positioned in relation to one another. The signal's range is directly inversely related to the antenna's height. Range of Frequency: 1 GHz to 300 GHz. These are mostly employed for the dissemination of television and mobile phone communication.

**6.2.2 Infrared**

For extremely short distance communication, infrared wavelengths are used. They are unable to pass through barriers. As a result, system interference is avoided. Range of frequencies: 300GHz to 400THz. The wireless mouse, keyboard, printer, and TV remotes all use it.

# CHAPTER 7 - FREE SPACE OPTICS (FSO): A COMMUNICATION TECHNOLOGY

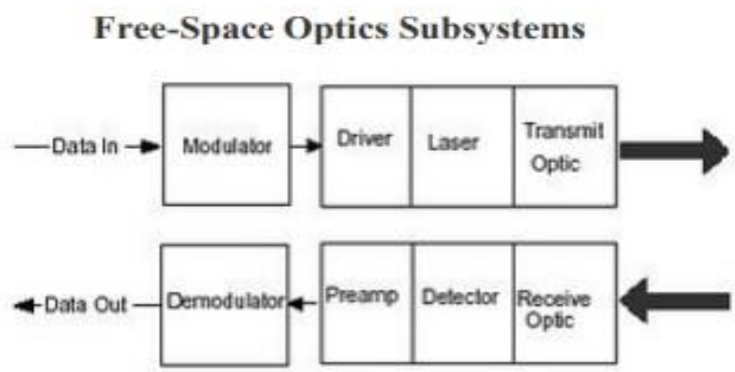
### 7.1 Introduction of FSO

The term "free space optics communications," also known as "free space photonics" or "optical wireless," describes the optical communications achieved by transmitting modulated visible or infrared beams across the atmosphere. FSO uses optical signals as the carrier frequency for point-to-point communication information transmission via the atmosphere. Due to its cost-effectiveness, ease of installation, speedy formation of communication links, particularly in the disaster management scenario, high bandwidth provisioning, and wide variety of applications, it has attracted interest in the telecommunications industry. The frequency spectrum in which it works makes FSO communication license-free. In contrast to the maximum data transfer rates of 622Mbps allowed by RF communication systems, FSO communication allows for maximum data transfer rates up to 2.5 Gbps.

FSO uses air as the transmission medium for the optical transmission of speech, video, and data. Transmission is very easy while using FSO technology. In order to give complete duplex (bi-directional) capabilities, it involves two systems, each of which consists of an optical transceiver, which is made up of a laser transmitter and a receiver. Each FSO system combines a high-power optical source with a telescope that beams light through the atmosphere to a second telescope that collects data. At that moment, an optical fiber connects the receiving telescope to a high-sensitivity receiver.

### 7.2 What is a Free Space Optical Transmission System

A wireless connection system called a free space optical transmission system is made to connect two sites with a clear line of sight. The systems work by transforming a regular data or telecommunications signal to digital form, then sending it through empty space. This signal is transmitted using an infrared carrier that is produced by either a laser diode or a high-power LED. Similar fundamental ideas apply to both signal transmission through open space and signal transmission along a fiber.




### 7.3 FSO Network Applications

There are several uses for free-space optics in telecom networks where there is an optical gap between the network core and the network edge. For businesses and service providers, FSO offers cost-effective optical connectivity and quicker returns on investment (ROI). Although FSO technology adoption is currently growing slowly, it is projected to surpass fiber-optic cable deployment in the future due to increased bandwidth requirements and the need for economically feasible optical solutions.

- ❖ **Telecom network extensions:** FSO can be deployed to extend an existing metro ring or to connect new networks. These links generally do not reach the ultimate end user but are more an application for the core of the network.
- ❖ **Enterprise:** The Flexibility of FSO allows it to be deployed in many enterprise applications such as LAN to LAN connectivity, Storage Area Networks, and intra-company connections.
- ❖ **Last-mile connectivity:** These are the links that reach the end user. They can be deployed in point-to-point, point-to-multipoint, ring or mesh connections.
- ❖ **Fiber Complement:** FSO may also be deployed as a redundant link to back up fiber. Most operators deploying fiber for business applications connect two fibers to secure a reliable service plus backup in the event of outage. Instead of deploying two fiber links, operators could opt to deploy an FSO system as the redundant link.
- ❖ **Access:** FSO can also be deployed in access applications such as gigabit Ethernet access. Service providers can use FSO to provide high-capacity links to businesses.
- ❖ **Backhaul:** FSO can be used for backhauling such as LMDS or cellular backhaul as well as gigabit Ethernet "off-net" to transport network backhaul.
- ❖ DWDM Services: With the integration of WDM and FSO systems, independent players that aim to build their own fiber rings, yet they may own only part of the ring.
- ❖ **Metro network extensions:** FSO may be used to extend existing metropolitan area fiberings to connect new networks from outside. Last mile access FSO can be used in high-speed links to connect end users with ISPs.

### 7.4 Advantages of Free Space Optical Communication

Free Space Optics (FSO) is an optical technology, not a radio link system or microwave system, so there is no need for spectrum licensing or frequency coordination with other users, no need to worry about interference from or to other systems or equipment, and the point-to-point laser signal is very hard to intercept, making it secure. 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, and Free Space Optics (FSO) systems can carry data rates comparable to optical fiber transmission with very low error rates. Due to the lack of licensing requirements and regulations, FSO implementation is simple, quick, and inexpensive. Free Space Optics (FSO) systems can be mounted inside buildings because Free Space Optics (FSO) transceivers can transmit and receive through windows. This eliminates the need to compete for roof space, simplifies wiring and cabling, and enables Free Space Optics (FSO) equipment to operate in a very favorable environment. The following is a summary of the main benefits of FSO,

- 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 equipment’s and wavelengthsby nearby systems.
- Cannot be intercepted easily.

## 7.5 Free Space Optics (FSO): Challenges

When light is transmitted through the air as in optical wireless systems like Free Space Optics (FSO), it must contend with a complex and not always quantifiable subject the atmosphere.

Wireless systems based on Free Space Optics (FSO) technology are not without difficulties. Free space optical communications are fundamentally constrained by the environment they pass in. Snow and rain don't seem to have much of an impact on free space optical. Fog and air turbulence have the potential to significantly impact communication systems.

### 7.5.1 Fog and Free space optics

The biggest difficulty is fog. Few hundred-micron water droplets make up fog, a mist that may either affect the properties of light or entirely block it out by a mixture of absorption, scattering, and reflection. As a result, the transmitted beam's power density may drop, reducing the effective distance of a free space optical link.

### 7.5.2 Scintillation and free space optics

The spatial change in light intensity brought on by turbulence in the atmosphere is known as scintillation. These air pockets have quickly fluctuated densities and, consequently, rapidly changing indices of optical reflection due to wind and temperature gradients. Particularly in the presence of bright sunshine, these air pockets behave like lenses with time-varying features and can cause abrupt increases in the bit-error rates of free space optical communication systems.

### 7.5.3 Beam Wander and free space optics

When turbulent wind currents (eddies) bigger than the transmitted optical beam's diameter induce a slow but significant movement of the transmitted beam, this phenomenon is known as beam wander. Seismic activity that shifts the relative location of the sending laser and the receiving photo detector can also result in beam wander.

### 7.5.4 Free space optics pointing stability: Building sway tower movement

Fixed pointed Free Space Optics (FSO) devices are designed to handle the great amount of movement found in building deployments. The combination of effective beam divergence and a well-matched receiving Field-of-View (FOV) results in an incredibly resilient fixed focused Free Space Optics (FSO) system that is suited for most deployments. Because of their lower cost, fixed-pointed Free Space Optics (FSO) systems are often favored over actively tracked Free Space Optics (FSO) systems.

### 7.5.5 Eye safety and free space optics

With the rise of optical wireless communication equipment that send laser beams into potentially populated areas, laser eye safety is becoming an increasingly important concern for public safety. Such systems should be eye safe, which means they should not endanger persons who meet the transmission beams. This requirement is manifested as upper restrictions on the intensity of the transmitted laser beam.

# 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 has been affected badly if an 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 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.

Like microwave FSO is susceptible to atmospheric turbulences. However, design methods are being 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 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

Electric utilities are being forced to undertake significant modifications to its information communication infrastructure as the power industry enters the new century under the influence of strong driving forces, uncertainties, and new functions. The demand for additional bandwidth in the communication network and dependable communication infrastructure is also being driven by the expansion of network services like real-time measurement and monitoring. As new distant real-time protection and control applications become more practical and widespread, these needs will increase even more. The answer to the growing demand for wide-area monitoring, protection, and control is an information embedded power system via wide-area network. Communication technologies are crucial to the efficient operation of distribution automation systems and electric power systems. Making wise decisions about communication technology for DA requires a detailed understanding of the resulting communication requirements, as we've seen in this discussion. Utility Distribution Automation systems can take advantage of a broad and expanding range of communication technologies. This independent study set out to determine the issues DPDC SCADA connectivity was having before coming up with a workable solution. A perfect substitute for the current microwave communication within DPDC is FSO, as discussed, with all of its problems resolved. This will improve the functionality of the SCADA control system that the DPDC currently uses.

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[12] T. Kamalakis I. Neokosmidis, A. Tsipouras, T. Sphicopoulos, S. Pantazis, I. Andrikopoulos, National and Kapodistrian University of Athens Space Hellas S.A. Athens, Greece Athens, Greece HYBRID FREE SPACE OPTICAL / MILLIMETER WAVE OUTDOOR LINKS FOR BROADBAND WIRELESS ACCESS NETWORKS.

# APPENDIX A

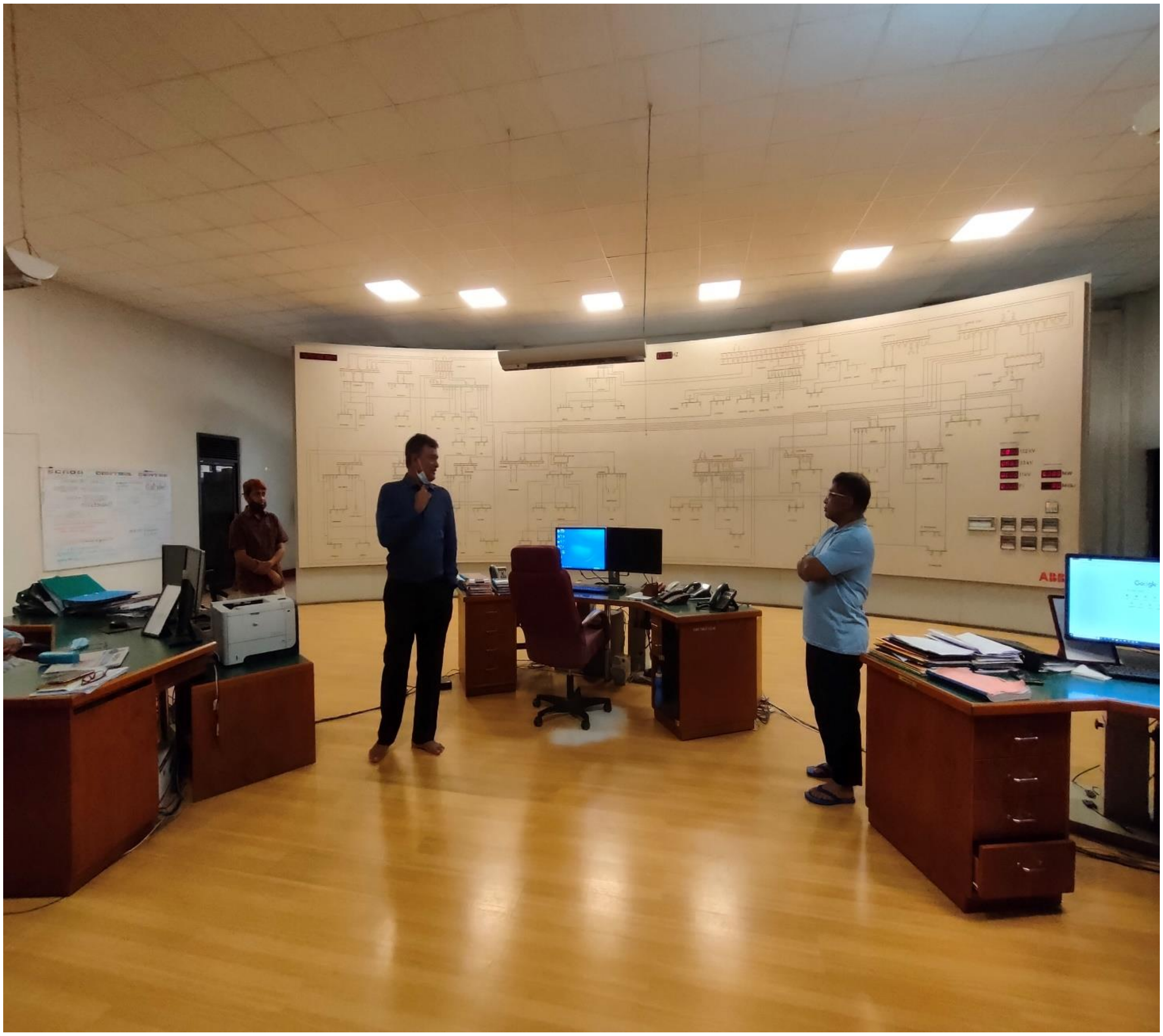

***Figure-1:*** SCADA panel of DPDC

***Figure-2:*** Remote Terminal Unit (RTU)

***Figure-3:*** **Communication Equipment**

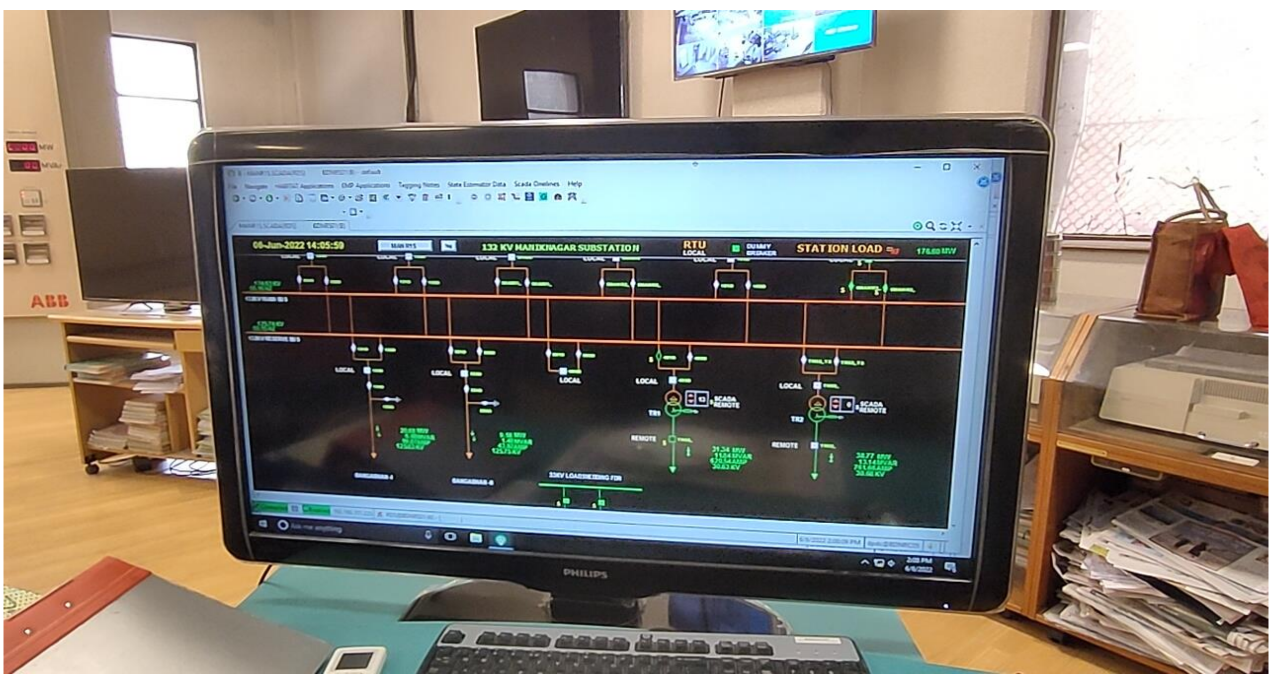


***Figure-4:*** **Power Lines.**