East West University

INTERNSHIP REPORT

ON

SCADA Communication System of Dhaka Power Distribution Company (DPDC)

SUPERVISED BY:

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Submitted by:

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AN INTERNSHIP REPORT PRESENTED TO THE FACULTY OF ECE IN PARTIAL FULFILLMENTOF THE REQUIREMENT FOR THE DEGREE OF B.SC. IN ETE

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Lastly, I am really 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 hereby declare that I am the author of this independent study paper. The reference includes materials discovered by other researchers. This research work had not previously been completed or submitted by anyone for any degree.

Signature of the Supervisor.   Signature of Author

Abstract

Supervisory Control and Data Acquisition (SCADA) is an acronym that stands for Supervisory Control and Data Acquisition. It is a centralized control system that is widely used in the power industry to monitor and regulate plant equipment, processes, and resources such as energy, water/wastewater, petrochemical, and manufacturing. SCADA was created and implemented to aid in the management and control of the country's essential infrastructure, complete with remote communications. SCADA communication is critical to the operation of this supervisory control system. The reliability of the SCADA system is thus heavily reliant on the SCADA communication sector. As a result, communication technology should be employed so that the reliability of the SCADA system is not jeopardized. Since 1998. ABB went on to develop it. Since its inception, the DPDC's communication sector has seen little progress. At the moment, the SCADA Communication sector is plagued by numerous issues that are rendering the entire structure obsolete. The communication structure is based on microwave links, and the purpose of this work is to propose a new communication technology known as Free Space optical Communication to improve system reliability. The transmission of modulated visible or infrared (IR) beams via the air to achieve optical communications is referred to as free space optics (FSO) or optical wireless. Free Space Optics (FSO) employs lasers to transfer data in the same way that fiber does, except instead of containing the data stream in a glass fiber, it is transmitted over the air. It provides a safe and cost-effective alternative to conventional wireless technologies.

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

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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

CHAPTER 1 - Introduction

1.1 Introduction

SCADA is a decentralized system that is widely used in the power industry to monitor and control plant equipment, processes, and resources such as energy, water/wastewater, petrochemical, and manufacturing. Such control can be automatic or activated manually by operator commands. The control capabilities provided by SCADA systems is critical for the safe and efficient operation of power machines. The SCADA system's system-wide monitoring and control capabilities may contain flaws that diminish the system's efficacy. A typical SCADA system is made up of three major components: Remote Terminal Units, master control, and a telecommunication network. If any of these components fails, the entire system will be rendered inoperable. The master control participates in the overall control of the network, which is expected to be compact with the addition of sophisticated equipment while also being highly sensitive to time in order to be more efficient in transmitting instructions to its target for the execution of a specific function.

The existence of intricate, physically large, and continuously producing massive amounts of electricity defines the contemporary power system. As a result, keeping this equipment in good operating order is critical to avoiding disasters, fatalities, and substantial losses in power output. The only factor influencing the dependability of power systems is their sophistication. Because communication systems are an integral aspect of the power industry, Distribution Automation (DA) must be selected in a way that fits the requirements outlined by the desired functions. 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 meet communication requirements are all included. There are specific communication technology requirements for each of these services. SCADA communications link every component of the utility. SCADA systems have a wide range of capabilities, including load management, voltage regulation, fault isolation, and control over circuit breakers and reclosers.

As a result, it is critical that the SCADA system work without mistakes, necessitating the use of a dependable communication system. The criteria established by the needed business functions to be filled have an unique influence on the selection of a communications system for distribution automation (DA). 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 are some of the various things that fall under the general heading of DA communication requirements that are motivated by a utility's business requirements. Each of these functional requirements creates a corresponding communication requirement for any given utility application, which drives the selection of the optimum communication technology.

CHAPTER 2 - Fundamental principles of modern SCADA systems

2.1Fundamental principles of modern SCADA systems

Telemetry is commonly used in modern manufacturing and industrial processes, mining sectors, public and private utilities, leisure and security organizations to connect equipment and systems that are separated by considerable distances. This can range from a few meters to thousands of kilometers. Telemetry is used to interface with these remote locations by sending commands, running programs, and receiving monitoring data. SCADA combines data acquisition and telemetry. SCADA entails acquiring data, transmitting it to a central location, executing any necessary analysis and control, and finally displaying that data on a variety of operator screens or displays. The process is then notified of the required control actions. In the early days of data collection, relay logic was used to manage production and plant systems. When the CPU and other electronic devices were introduced, manufacturers integrated digital electronics into relay logic equipment. The PLC, or programmed logic controller, is a popular business control system. As the demand to monitor and operate additional equipment in the plant expanded, the PLCs were distributed, the systems became more sophisticated, and their size shrank.

The benefits of the PLC / DCS SCADA system are:

The computer can record and store massive amounts of data.
• The data can be shown in any manner desired by the user.
• The system can connect thousands of sensors spread across a large area.
• The operator has the ability to incorporate real-world data simulations into the system.
• The RTUs can capture a wide range of data.
• The data can be accessed from any location, not only the site.

As the demand for more compact and intelligent systems grew, sensors with the same level of intelligence as PLCs and DCSs were developed. These devices are known as IEDs (intelligent electronic devices). A fieldbus, such as Profibus, Device net, or Foundation Fieldbus, connects the RTU to the IEDs. They have enough intelligence to collect data, communicate with other devices, and stay in their place within the bigger program. Each of these incredibly sophisticated sensors can accommodate a large number of sensors. An IED would typically have a program memory, a communication system, PID control, an analog input sensor, and an analog output.

The following are the benefits of the PC to IED fieldbus system:

- All devices are plug and play, making installation and replacement simple.
- Less physical space is required for the data collecting system due to smaller components
- Minimal wiring is required
- The operator can see all the way down to the sensor level

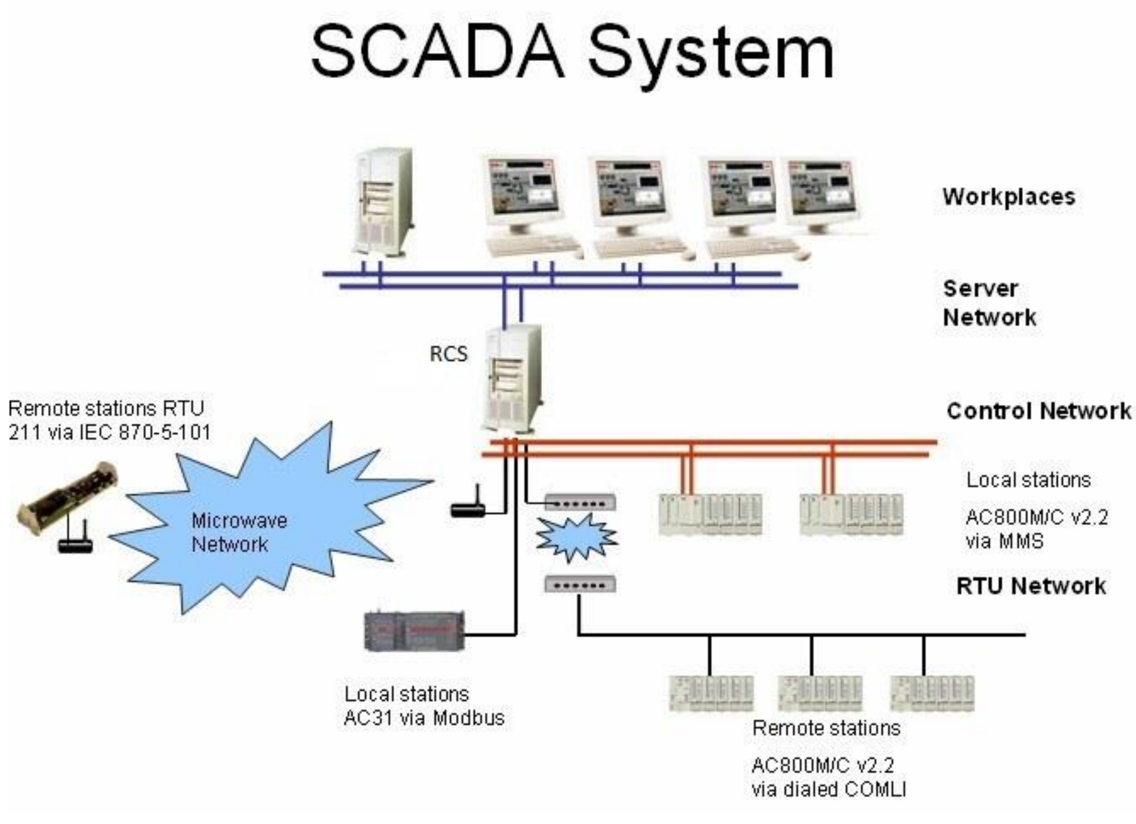


Figure 2.1. SCADA System

CHAPTER 3 - DHAKA POWER DISTRIBUTION COMPANY (DPDC)

3.1 DPDC- SCADA SYSTEM

When it comes to conserving energy and saving money on power distribution, electric network management is a solution worth investigating. Every month since this management strategy was implemented in Bangladesh, crores of taka have been saved. Improving quality and security will also help the government save money in the power sector. SCADA systems provide an overview of the complete network as well as an up-to-date view of the voltage levels. Such control systems provide access to the electrical network via a computer station.

The SCADA system was implemented in the DHAKA POWER DISTRIBUTION COMPANY a decade ago and has been in use since. It was created by ABB, and little progress has been made in the system's communication sector to make it more reliable. ABB suggested answers to several problems that arose during the early stages of the DPDC SCADA system. However, additional issues had rendered those suggestions obsolete. To overcome emerging difficulties and maintain reliability, the DPDC SCADA system requires technological advancement. SCADA communications are linked from the master station to the distant outstation

In 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

ABB's Human System Interface for remote control and PLC applications is SCADA. It provides operators and engineers with real-time access to all process control information. SCADA portal improves efficiency since it is easy, reliable, and robust.

3.3 DPDC SCADA COMMUNICATION NETWORK.

The DPDC SCADA communication network is made up of cells that are arranged in a ring network configuration. The receiver and antenna for microwave communication are attached to these cells. The ring topology is designed in such a way that communication can occur in either direction, i.e. data transfer can occur in both clockwise and counter-clockwise directions. This is done to avoid unplanned communication interruptions. In the event that one way of communication is blocked, the other direction will be used, allowing communication to continue. The communication will occur by choosing the quickest way to the intended RTU. The longest way will only be operational if a radio link is missing, depending on the frequency bandwidth, or if optical fiber is used to avoid problems. To aid with Line of Sight (LOS) communication, the receivers and transmitters are located high above the ground. The communication ring utilized by DPDC SCADA is seen in the figure below.

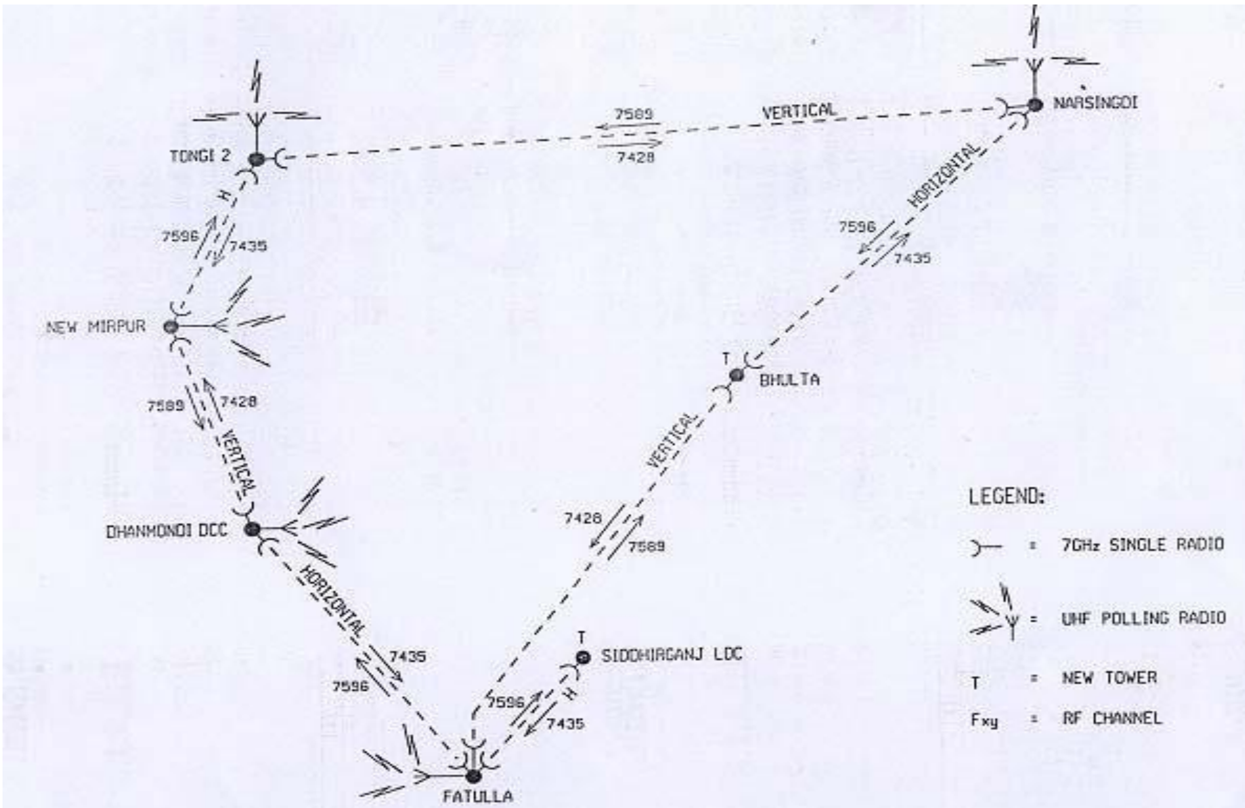
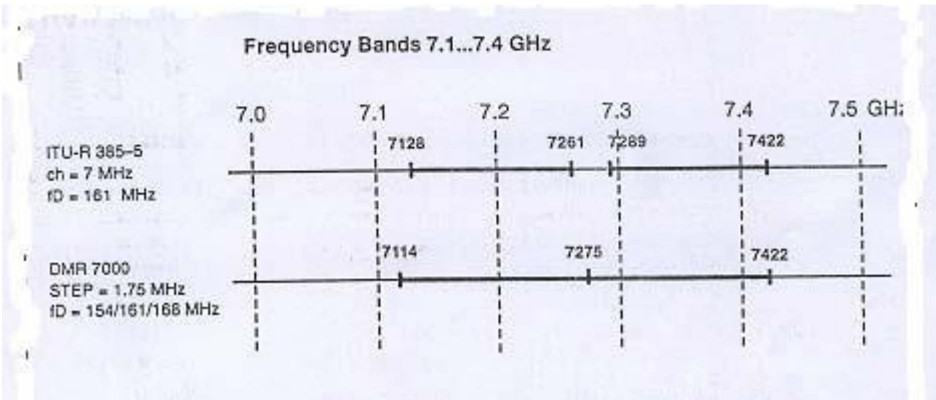


Figure 3.1 DPDC SCADA Ring Communication Network.

The diagram above depicts the current communication ring utilized by the DPDC SCADA Communication network. The base stations operate on simplex channels with indicated frequencies. UHF Polling Radio is used by base stations that are linked to Remote Terminal Units (RTU). The base stations communicate using separate frequencies. The same frequencies, however, are reused at various cells. Dhanmondi DCC connects to Fatulla via 7435 and 7596. The same frequency pair is used for New Mirpur and Tongi2. This frequency reuse is done to make better use of the assigned frequencies. Aside from the microwave link, Ultra High Frequency (UHF) is utilized to connect RTUs to base stations. The radio relay equipment employed works at a frequency of 7.3GHz. The DMR 7000 equipment may send two, four, eight, or sixteen 2Mbps signals. This is a 42 Mbps frame in a DPDC system. The radio frequency spectrum has been optimized for all transmissions capacities.

The diagram below illustrates the frequency allocation of the DMR 7000frequency bands.



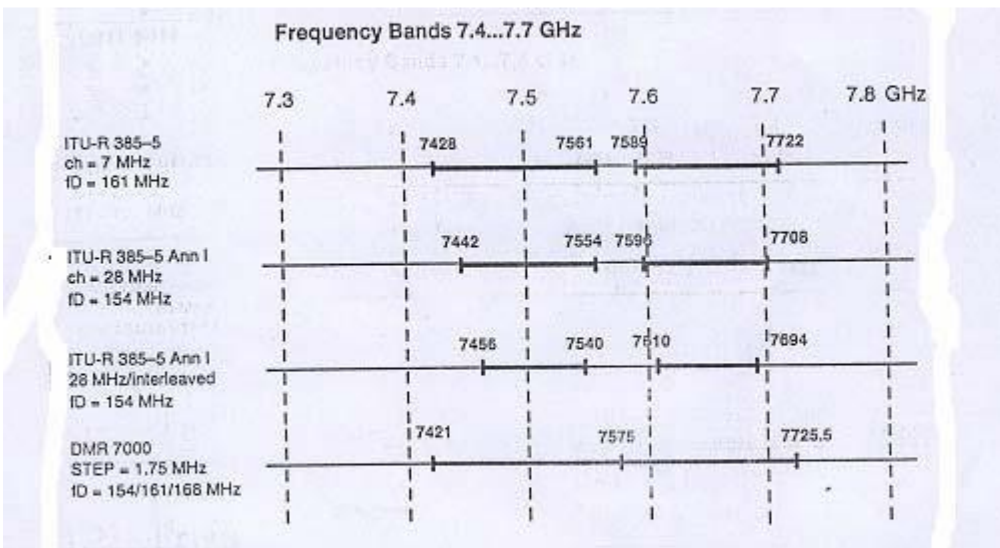


Figure 3.2 Frequency allocation

CHAPTER 4 - SCADA COMPONENTS & ARCHITECTURE

4.1 SCADA system components

The key components include:

1.The field devices

Field devices are input devices such as sensors, valves, and actuators that collect data from the process being monitored or controlled. Both devices are controlled and monitored by field controllers.

2.Field controllers

The control room operator interface equipment allows the operator to view process data and issue commands to the field devices. Controllers use algorithms to process data from field devices and make decisions on how to control operations in the field.
Two types of controllers are there.

2.1Remote terminal units (RTUs)

Physical objects in the SCADA systems are interfaced with the microprocessor controlled electronic devices called as Remote Terminal Units (RTUs). These units are used to transmit telemetry data to the supervisory system and receive the messages from the master system for controlling the connected objects. Hence, these are also called as Remote Telemetry Units.

2.2Supervisory computer

Supervisory system is used as server for communicating between the equipment of the SCADA system such as RTUs, PLCs and sensors, etc., and the HMI software used in the control room workstations. Master station or supervisory station comprises a single PC in smaller SCADA systems and, in case of larger SCADA systems, supervisory system comprises distributed software applications, disaster recovery sites and multiple servers. These multiple servers are configured in a hot-standby formation or dual-redundant, which continuously controls and monitors in case of a server failure for increasing the integrity of the system.

3.Human-machine interface (HMI)

It is an input-output device that presents the process data to be controlled by a human operator. It is used by linking to the SCADA system's software programs and databases for providing the management information, including the scheduled maintenance procedures, detailed schematics, logistic information, trending and diagnostic data for a specific sensor or machine. HMI systems facilitate the operating personnel to see the information graphically.

4.PLCs (Programmable Logic Controllers)

The term PLC stands for programmable logic controllers which are used in SCADA systems with the help of sensors. These controllers are connected to the sensors for converting the output signal of the sensor into digital data. As compared with RTUs, these are used due to their flexibility, configuration, versatility & affordability.

5.Communication infrastructure

Generally the combination of radio and direct wired connections is used for SCADA systems, but in case of large systems like power stations and railways SONET/SDH are frequently used. Among the very compact SCADA protocols used in SCADA systems – a few communication protocols, which are standardized and recognized by SCADA vendors – send information only when the supervisory station polls the RTUs.

6.SCADA Programming

In HMI otherwise master station, SCADA programming is mainly used to make maps, diagrams to provide very important information throughout progression otherwise when event failure occurs. Most of the commercial SCADA systems utilize consistent interfaces in C programming language otherwise derived programming language can also be used.

4.2 SCADA system architecture

Generally, the SCADA system is a centralized system that monitors and controls the entire area. It is a pure software package that is positioned on top of the hardware. A supervisory system gathers data on the process and sends the commands control to the process. The SCADA is a remote terminal unit which is also known as RTU.

Most control actions are automatically performed by RTUs or PLCs. The RTUs consists of the programmable logic converter which can be set to specific requirement. For example, in the thermal power plant, the water flow can be set to a specific value or it can be changed according to the requirement.

The SCADA system allows operators to change the set point for the flow, and enable alarm conditions in case of loss of flow and high temperature, and the condition is displayed and recorded. The SCADA system monitors the overall performance of the loop. The SCADA system is a centralized system to communicate with both wired and wireless technology to Clint devices. The SCADA system controls can run completely all kinds of the industrial process.

For example, if too much pressure is building up in a gas pipeline the SCADA system can automatically open a release valve.

Hardware Architecture

The generally SCADA system can be classified into two parts:

1.Client layer
2.Data server layer

The Clint layer caters to the man-machine interaction.

The data server layer handles most of the process of data activities.

The SCADA station refers to the servers and it is composed of a single PC. The data servers communicate with devices in the field through process controllers like PLCs or RTUs. The PLCs are connected to the data servers either directly or via networks or buses. The SCADA system utilizes a WAN and LAN networks, the WAN and LAN consist of internet protocols used for communication between the master station and devices.

The physical equipment like sensors connected to the PLCs or RTUs. The RTUs convert the sensor signals to digital data and sends digital data to the master. According to the master feedback received by the RTU, it applies the electrical signal to relays. Most of the monitoring and control operations are performed by RTUs or PLCs

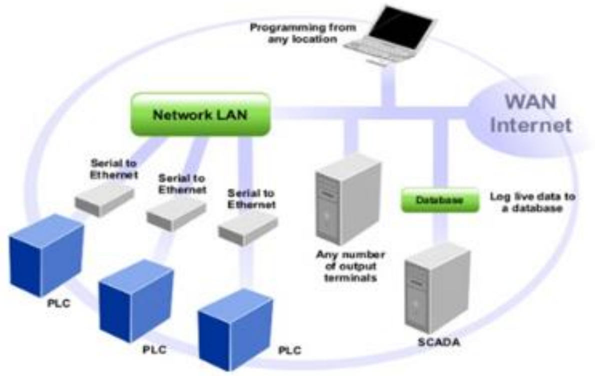


Fig 4.1 SCADA system hardware architecture

<u>Software Architecture</u>

Most of the servers are used for multitasking and real-time database. The servers are responsible for data gathering and handling. The SCADA system consists of a software program to provide trending, diagnostic data, and manage information such as scheduled maintenance procedures, logistic information, detailed schematics for a particular sensor or machine, and expert-system troubleshooting guides. This means the operator can see a schematic representation of the plant being controlled.
Examples are alarm checking, calculations, logging, and archiving; polling controllers on a set of parameters, those are typically connected to the server.

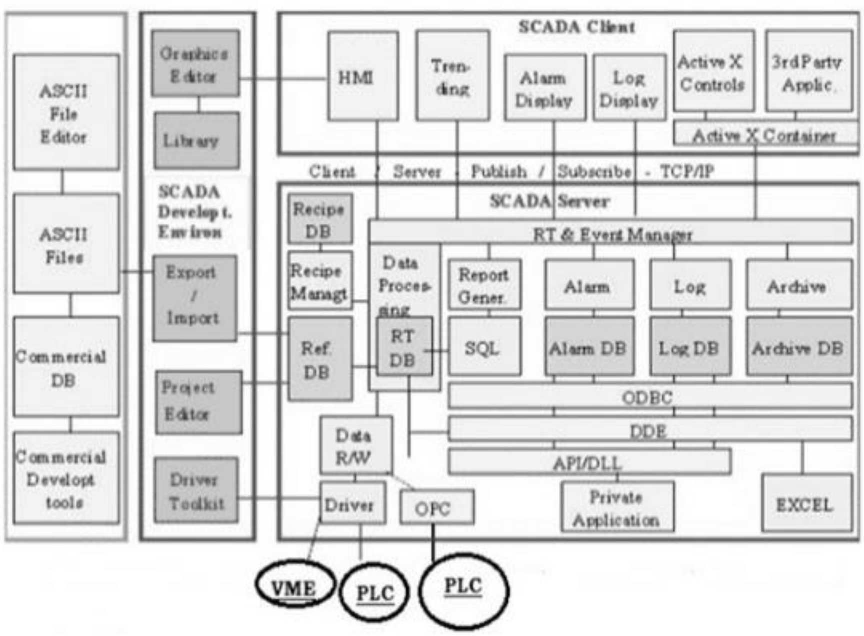


Fig 4.2 software architecture of SCADA

CHAPTER 5 - DISTRIBUTION AUTOMATION SYSTEM

5.1 APPLICATION OF DISTRIBUTION AUTOMATION

The word Automation means doing the particular task automatically in a sequence with faster operation rate. This requires the use of microprocessor together with communication network and some relevant software programming. The application of automation in distribution power system level can be define as automatically monitoring, protecting and controlling switching operations through intelligent electronic devices to locate and isolate the fault and then restore the service. Now days due to advancement in the communication technology, distribution automation system (DAS) is not just a remote control and operation of substation and feeder equipment but it results into a highly reliable, self-healing power system that responds rapidly to real-time events with appropriate actions. Hence, automation does not just replace manual procedures; it permits the power system to operate in best optimal way, based on accurate information provided in a timely manner to the decision-making applications and devices.

There are several reasons to use (DAS). Until now, the electric power industry has made remarkable progress in both quantity and quality of supplying electrical power. But, it is expected that the social demand for better services would be requested. Now, distribution automation has to address enhancements in efficiency as well as reliability and quality of power distribution. Today (DAS) are more concerned about improving reliability to achieve the required performance and improving power quality.

Adding more capabilities for distribution automation system by extend supervisory control and data acquisition) SCADA and communicate the infrastructure is required. The success or failure of an automation program depends on proper selection of communication’s equipments to integrate into the control room. With the latest high speed communication technology there has never been a better time to extend the Distribution automation ensures providing effective management minute by minute and continuous operation of a distribution system. It represents a tool to achieve a maximum utilization of the utility and to provide the highest quality of service to customers. Obviously, both the utility and customers are beneficiaries of successful distribution designing a wide range distribution automation applications and systems, such as applications that include automatic sectionalizing and SCADA controlled switching.

5.2 EQUIPMENTS

The equipments (either fixed wired or/and programmable), which are used for distribution automation, include:

(i)Data collection equipment.

(ii) Data transmission (telemetering) equipment.

(iii) Data monitoring equipment.

(iv) Data processing equipment.

(v) Man-machine interface.

All the above equipments are integrated through distribution SCADA system.

Distribution SCADA involves collecting and analyzing information to take decisions and then implementing them and finally verifying whether desired results are achieved.

A SCADA system for a power distribution application is a typically a personal computer based (PC) software package. Data is collected from the electrical distribution system, with most of the data originating at substations. Depending on its size and complexity, a substation will have a varying number of controllers and operator interface points. In a typical configuration, a substation is controlled and monitored in real time by a programmable logic controller (PLC) and by certain specialized devices such as circuit breakers and power monitors. Data from the PLC and the devices is then transmitted to a PC-based SCADA node located at the substation. One or more PCs are located at various centralized control and monitoring points. The links between the substation PCs and the central station PCs are generally Ethernet-based and are implemented via the internet, an internet and/or some version of cloud computing. In addition to data collecting, SCADA systems typically allow commands to be issued from central control and monitoring points to substations. If desired and as circumstances allows these commands can enable full remote control.

5.3BENEFITS OF DISTRIBUTION AUTOMATION IMPLEMENTATION

The benefits of distribution automation system implementation can be classified in three major areas are as follows:

Operational & Maintenance benefits

1. Improved reliability by reducing outage duration using auto restoration scheme
2. Improved voltage control by means of automatic VAR control
3. Reduced man hour and man power
4. Accurate and useful planning and operational data information
5. Better fault detection and diagnostic analysis
6. Better management of system and component loading

Financial benefits

1. Increased revenue due to quick restoration
2. Improved utilization of system capacity
3. Customer retention for improved quality of supply

Customer related benefits

1. Better service reliability
2. Reduce interruption cost for Industrial/Commercial customers
3. Better quality of supply

CHAPTER 6 - COMMUNICATIONS MEDIA

This section covers a variety of data transmission technologies that can be used for a variety of utility purposes. This list includes some technologies that are not currently considered suitable for distribution automation application in order to demonstrate the breadth of communication systems available for utility use, as well as to allow this reference to be applied as technologies mature and their economic applications broaden.

6.1 ARDIS (Advanced Radio Data Information Service)

ARDIS is designed for short message applications that are insensitive to transmission delays. ARDIS employs connection-oriented protocols, which are ideal for host/terminal applications. With normal response times surpassing four seconds, interactive sessions over ARDIS are often impractical. ARDIS, as a radio-based service, should be immune to the majority of the EMC concerns connected with substations. It uses a 25 KHz channel in the 800 MHz spectrum to provide either 4800 bps or 19.2 kbps service.

6.2 Digital Microwave

Digital microwave systems are licensed systems that operate in a variety of frequencies ranging from 900 MHz to 38 GHz. They offer broad bandwidths of up to 40 MHz per channel and are meant to connect directly to wired and fiber data channels generated from high-speed networking and telephony practice, such as ATM, Ethernet, SONET, and T1. Digital microwave systems can accommodate a huge number of data and voice circuits. This can be given as DS3 (1xDS3 = 672 voice circuits) or DS1 (1xDS1 = 24 voice circuits) signals, with each voice circuit corresponding to 64Kbps of data, or (increasingly) as ATM or 100 Mbps Fast Ethernet, with direct RJ-45, Category 5 cable connections. They can also connect to fiber optic networks directly using SONET/SDH. Although digital microwave is expensive for individual substation installations, it might be viewed as a high-performance medium for constructing a backbone communications infrastructure that can meet the utility's operating needs.

6.3 Fiber Optics

Fiber optic connections provide tremendous bandwidth while also being immune to electromagnetic interference. The fiber can transfer large volumes of data at speeds of up to terabytes per second. The fiber cable is made up of varying numbers of single-mode or multi-mode fibers, with a strength member in the center and additional outer layers to provide support and protection against physical damage to the cable during installation as well as protection against the effects of the elements over long periods of time. The fiber cable is connected to terminal equipment that permits slower speed data streams to be merged and then transferred as a high-speed data stream across the optical connection. To defend against equipment damage or failure, fiber cables can be joined in overlapping rings to give self-healing capabilities. Although building an infrastructure is expensive, fiber networks are highly resistant to detectable physical penetration related with the security concerns discussed above. Some infrastructure expenditures can be recovered through joint ventures with or sales of bandwidth to communication common carriers. Optical fiber networks can provide a reliable communications backbone for utilities' current and future demands..

6.4 Satellite Systems

Satellite systems that provide high-speed data services have been implemented in two distinct types, which are broadly classified by their orbits. Because of the long distances between the satellite and the ground, GEO systems require rather large parabolic antennas to keep satellite transponder power levels tolerable. Due to the distances involved, each transit from Earth to Satellite and back takes 14 seconds. Some satellite setups require all data to pass through an earth station on each hop to or from the end user, doubling the time it takes to send a packet to the end deviceIf a communications protocol that requires link-layer acknowledgements for each packet is employed (as is common with most legacy SCADA systems), this can add up to one second to each poll/response cycle. This can be unreasonably huge and have a major influence on system throughput, so if a GEO satellite link is being considered, rigorous protocol matching is required. GEO satellites are likewise unsuitable for two-way telephone communications due to their considerable delay. The "low earth orbit" (LEO) satellite is a second satellite technology that is gaining prominence. LEOs fly at substantially lower altitudes ranging from 500 to 2000 kilometers. Because the satellites are in constant motion due to their lower altitude (like a swarm of bees), a fixed highly directed antenna cannot be employed. However, because shorter distances demand lower power levels, if there are a sufficient number of satellites in orbit and their operation is correctly coordinated, LEO's can provide ubiquitous high-speed data or excellent voice communication anywhere on the planet. LEO systems may be swiftly deployed thanks to the use of tiny earth stations.

CHAPTER 7 - FREE SPACE OPTICAL COMMUNICATION

7.1 GENERAL OVERVIEW

The transmission of modulated visible or infrared beams through the atmosphere to get optical communications is referred to as free space optics communications, also known as free space photonics or Optical Wireless. Free Space Optics, like fiber, employs lasers to transfer data, but instead of containing the data stream in a glass fiber, the data stream is transmitted over the air. FSO operates on the same basic idea as infrared television remote controls, wireless keyboards, and wireless Palm devices. Free Space Optics (FSO) uses low power infrared lasers in the THz range to transmit invisible, eye-safe light beams from one "telescope" to another. Laser light focused on highly sensitive photon detector receivers transmits light beams in Free Space Optics (FSO) devices. These receivers are telescopic lenses that catch photon streams and send digital data that may include Internet communications, video images, radio signals, or computer files. The optical wireless bandwidth is 10,000 times greater than the highest frequencies employed by RF technology. Furthermore, utilizing wavelength division multiplexing, 1000 independent data channels can be grouped into the air on a single optical beam, providing a potential bandwidth ten million times that of any RF system. Commercially available systems range in capacity from 100 Mbps to 2.5 Gbps, with demonstration systems reporting data speeds of up to 160 Gbps. Free Space Optics (FSO) systems can communicate across long distances.

7.2 Advantages of Free Space Optical Communication

Unlike radio link systems and microwave systems, Free Space Optics (FSO) is an optical technology that requires no spectrum licensing or frequency coordination with other users, no interference from or to other systems or equipment, and the point-to-point laser signal is extremely difficult to intercept and thus secure. Free Space Optics (FSO) systems can carry data rates comparable to optical fiber transmission with very low error rates, and 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. The lack of license and regulation for FSOs translates into convenience, speed, and inexpensive deployment costs. Because Free Space Optics (FSO) transceivers can transmit and receive through windows, Free Space Optics (FSO) systems can be mounted inside buildings, reducing the need for roof space, simplifying wiring and cabling, and allowing Free Space Optics (FSO) equipment to operate in an extremely favorable environment. The primary benefits of FSO are summarized here []:

• There is no need for a license.
• No tariffs are necessary for its use.
• There are no risks from radiofrequency (RF) radiation (eye-safe power levels are maintained if required).
• It has a huge bandwidth, allowing for extremely high data speeds.
• It's small, light, and portable.
• It consumes little power.
• Reusability enables neighbouring systems to use the same communication equipment and wavelengths.
• Cannot be readily intercepted.

7.3 Major problems of FSO and their solution.

One of the primary issues with FSO is the mode of transmission it employs. However, in an industrial location, this form of propagation is difficult to implement since high rise buildings or other large establishments impede the way. To address this issue, the diffusion method is employed. Where LOS is not required, FSO can rely on the diffused system technique. A base station is attached to an elevated location in a dispersed system. A wide-angle source emits beams that can be reflected within the cell. Terminal receivers have a wide field of view that covers the entire plane. Multibeam transmitters can be used to reduce multipath dispersions. This approach makes use of a multi-branch-angle-diversity-receiver and numerous narrow beam transmitters. This dispersed transmission technology allows a few servers in the master station to be continuously updated. FSO, like microwave, is sensitive to air turbulence. However, design solutions have been offered to address this issue. The use of fractal modulation is one such way. Signals are sent through time-varying channels with a fixed transmitter configuration, where the spectral efficiency remains constant across a wide variety of rate-bandwidth ratios. The data are encoded in optical ultrashort pulses that are fractal modulated to seem like wavelets. Holographic techniques are used to produce and separate these wavelets. Scintillation is another issue that FSO is likely to encounter. This can be avoided by using larger photodiodes. This ensures that communications are never lost and that scintillation-induced wave front distortion is minimized. Scintillation has less effect at higher frequencies. A 1550nm wavelength will suffice for the DPDC SCADA communication network since 1550nm systems are completely eye-safe and more resistant to harsh weather. This communication technique provides the same speed as optical fiber. As a result, the system reaction will be substantially faster, which will be critical in decreasing the delay that occurs between tripping and command execution. This type of communication is less expensive than optical fiber.

CHAPTER 8 - PROPOSED DPDC COMMUNICATION SYSTEM

8.1 SCADA MICROWAVE COMMUNICATION

Line of Sight [LOS] topology is used for DPDC SCADA communication. This, however, creates an issue. If an impediment, such as a high-rise building, emerges in the way, the LOS communication suffers greatly. As a result, the architecture of the entire DPDC SCADA system communication network must be thoroughly analyzed. Aside from architecture, the media provides several issues. In the case of microwave transmission, the radiation is influenced by the atmosphere and is also susceptible to unwanted interference from outside sources. The radiation used in microwave communication has the disadvantage of being absorbed by the oxygen and moisture present in the environment, as well as being susceptible to scattering by rains. This communication network has experienced interference from the base band frequencies used by the Bangladesh military and the US Embassy in the past. This unwelcome interference from outside sources compromises communication security and jeopardizes the monitored functions. In addition to the microwave link, Ultra High Frequency (UHF) is utilized to connect RTUs to base stations. These UHF frequencies are impacted by weather and are prone to interference. Based on these findings, a new communication method is required to overcome atmospheric effects and unwanted interference in order to ensure reliable data transfer.

8.2 FSO for DPDC SCADA COMMUNICATION

The basic responsibilities of the DPDC SCADA system are to control and monitor data acquisition and power distribution devices. As a result, dependability is a condition that should not be compromised. However, the communication media used encounters issues that create a position for compromise. Because this is undesirable, the communication network must be replaced, and FSO communication is the ideal answer. As previously stated, DPDC SCADA communication is based on microwave transmission. The use of FSO technology instead of this style of communication improves security and error-free data transfer. FSO wavelengths extend from.7 m to 10 m, making the FSO spectrum almost limitless. FSO transmission windows are 780-980nm, 1520-1600nm, and 10000nm. The relevance of the first window stems from the availability of low-cost CD lasers at 780nm and silicon APD at 850nm. Components utilized in the second window are normally expensive, but their cost would be much lowered if they were absorbed into the fiber-based industry. The final window benefits from being less impacted by fog [11]. Unlike microwave, FSO is less vulnerable to unwanted intrusion. It is not affected by electromagnetic interference. As a result, tapping FSO is essentially impossible because no waves with either an electric or magnetic field, or both, can interact with it. As a result, the possibilities of it interfering with other entities' baseband frequencies, such as military frequencies, are nil. As a result, the security of FSO communication is improved. The microwave communication topology is based on point-to-point communication. This also happens to be one of the FSO topologies. However, FSO can operate in the absence of LOS. Where LOS is not required, it can rely on the diffused system technique [2]. A base station is attached to an elevated location in a dispersed system. A wide angle source emits beams that can be reflected within the cell. Terminal receivers have a wide field of view that covers the entire plane. Multibeam transmitters can be used to reduce multipath dispersions. This approach employs numerous narrow beam transmitters and a multi-branch-angle-diversity-receiver. This dispersed transmission technology allows a number of servers in the master station to be updated all at once.

FSO, like microwave, is sensitive to air turbulence. However, design solutions have been offered to address this issue. The use of fractal modulation is one such way. [2]. Signals are sent through time-varying channels with a fixed transmitter configuration, where the spectral efficiency remains constant across a wide variety of rate-bandwidth ratios. The data will be contained in optical ultrashort pulses that have been fractal modulated to seem like wavelets. Holographic techniques are used to produce and separate these wavelets. Scintillation is another issue that FSO is likely to encounter. This can be solved by using larger photodiodes. This ensures that communications are never lost and that scintillation-induced wave front distortion is minimized. Scintillation has less effect at higher frequencies. Optical carrier frequencies in the range of 200 THz (1550 nm) or 350 THz (850 nm) are not subject to any licensing requirements and do not interact with satellite or other RF equipment. A 1550nm wavelength is appropriate for the DPDC SCADA communication network since 1550nm systems are completely eye-safe and more resistant to harsh weather. The bandwidth used by optical wireless communication has the potential to be enormous. In the air, 1000 distinct data channels can be multiplexed. Because of the properties of the free space optic channel and the availability of a huge bandwidth, any 2-state digital modulation forming the same base band can be sent. This communication technique provides the same speed as optical fiber. As a result, the system reaction will be substantially faster, which will be critical in decreasing the delay that occurs between tripping and command execution. A portion of this massive bandwidth can be used to construct a communication network within DPDC and can also be rented out for business purposes. Unlike microwave, this type of communication is less expensive since considerable advances in optoelectronic technology have resulted in the low cost of producing FSO network components. The equipment required for microwave transmission, such as an antenna and a transceiver, is expensive. This makes establishing a microwave backbone on a new site costly. Furthermore, this equipment is larger in size. This is a disadvantage of the microwave communication network. FSO equipment, such as transceivers, has modest dimensions and low power consumption, making installation in buildings, post signs, and so on easier. FSO systems operating in the near infrared area can be used for connections through glass enabling simple and quick setup. Thermally isolating windows with thin metal coatings on their surfaces attenuate light much less than longer wavelengths.

CHAPTER 9

CONCLUSION

As the power business enters the twenty-first century, significant driving factors, uncertainties, and new functions drive electric utilities to make dramatic modifications to their information communication infrastructure. Expansion of network services such as real-time measurement and monitoring is also pushing the need for additional bandwidth in communication networks and dependable communication infrastructure. These requirements will increase as new remote real-time protection and control applications become more feasible and widespread. The solution to the growing demand for wide area monitoring, protection, and control is an information embedded power system via wide area network. Communication technologies are critical to the successful operation of electric power networks and distribution automation. As we have shown in this talk, establishing excellent choices of communication technologies for DA requires a comprehensive examination of the resulting communication requirements. To meet the needs of utility Distribution Automation systems, there is a broad and growing list of communication technologies available. The purpose of this independent study was to identify the issues with DPDC SCADA connectivity and then provide a remedy. As previously discussed, FSO, with all of its problems addressed, is a perfect alternative for the existing microwave communication within DPDC. This will improve the performance of the DPDC's existing control system, the SCADA.

REFERENCE

[1] Ahmed Mahdy and Jitender S. Deogun " Wireless optical communications : A survey", Wireless Communications and Networking Conference, 2004 WCNC, IEEE.

[2] Salahuddin Qazi, "Challenges In Indoor and Outdoor Optical Wireless Communications", US-Pakistan Internation Workshop on High Capacity Optical Networks and Enabling Technologies.

[3] Daniel E. Nordell, P.E., "Communication Systems for Distribution Automation" Transmission and Distribution Conference and Exposition 2008. T&D. IEEE/PES.

[4] A G Bruce, "Reliability Analysis of Electric Utility SCADA System", Power Industry Computer Applications.,1997. 20th International Conference on 11-16 May 1997.

[5] Edward Chikuni, Maxwell Dondo, "Investigating the security of electrical power systems SCADA", AFRICON 2007.

[6] C. M. I. Hussain, M. Alam and A. M. Azad, "Performance Improvement of DPDC SCADA System Using Hard Real-Time OS", CIM 2009.

[7] David Bailey, Edwin Wright, "Practical SCADA for Industry".

[8] ABB Utility Vice President of export sales "Bangladesh can save more money in power sector using SCADA system", Daily star .April11 2003.

[9] http:// www.desa.com.bd.

[10] http://www.free-space-optics.org/.

[11] M. Gebhart, P. Schrotter, U. Birnbacher, E. Leitgeb, Department of Communications and Wave Propagation (INW), Graz University of Technology (TUG), Satellite Communications, Free Space Optics and Wireless LAN combined: Worldwide broadband wireless access independent of terrestrial infrastructure.

[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

INTERNSHIP LETTER

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তারিখ: ৩০/০৮/২০২২ খ্রি.

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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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06	Md. Abu Sayem Rishad	B.Sc in ECE	2019-1-55-026	01521572297	
07	Maimanah Binte Jahangir	B.Sc in ECE	2019-1-55-027	01780234185	
08	Ahnaf Muttaque	B.Sc in ECE	2019-2-55-009	01719695456	

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।
(খ) ডিপিডিসি'তে বিদ্যুৎ সরবরাহ ব্যবস্থা।
(গ) ডিপিডিসি'তে নেটওয়ার্ক অপারেশন ও কাস্টমার সার্ভিস (এনওসিএস) কার্যক্রম।
(ঘ) এনওসিএস এর সহায়ক অফিসসমূহের (যেমন- এইচ.আর, ফিন্যান্স, আইসিটি, অডিট, পরিকল্পনা, উন্নয়ন, মিটারিং, সিস্টেম প্রটেকশন, গ্রীড, ট্যারিফ এন্ড এনার্জি অডিট) কার্যক্রম।
(ঙ) ডিপিডিসি'র প্রশিক্ষণ ও উন্নয়ন দপ্তরের কার্যক্রম।
(চ) ১৩২/৩৩ কেভি জিআইএস উপকেন্দ্র ও ৩৩/১১ কেভি উপকেন্দ্র পরিদর্শন।
(ছ) ডিপিডিসি'র স্ক্যাডা সিস্টেম, ওয়ার্কশপ, মিটার টেস্টিং ল্যাব, কেন্দ্রীয় ভান্ডার, মেডিকেল সেন্টার পরিদর্শন।

শিক্ষার্থীদের উত্তরোত্তর সাফল্য কামনায়,

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

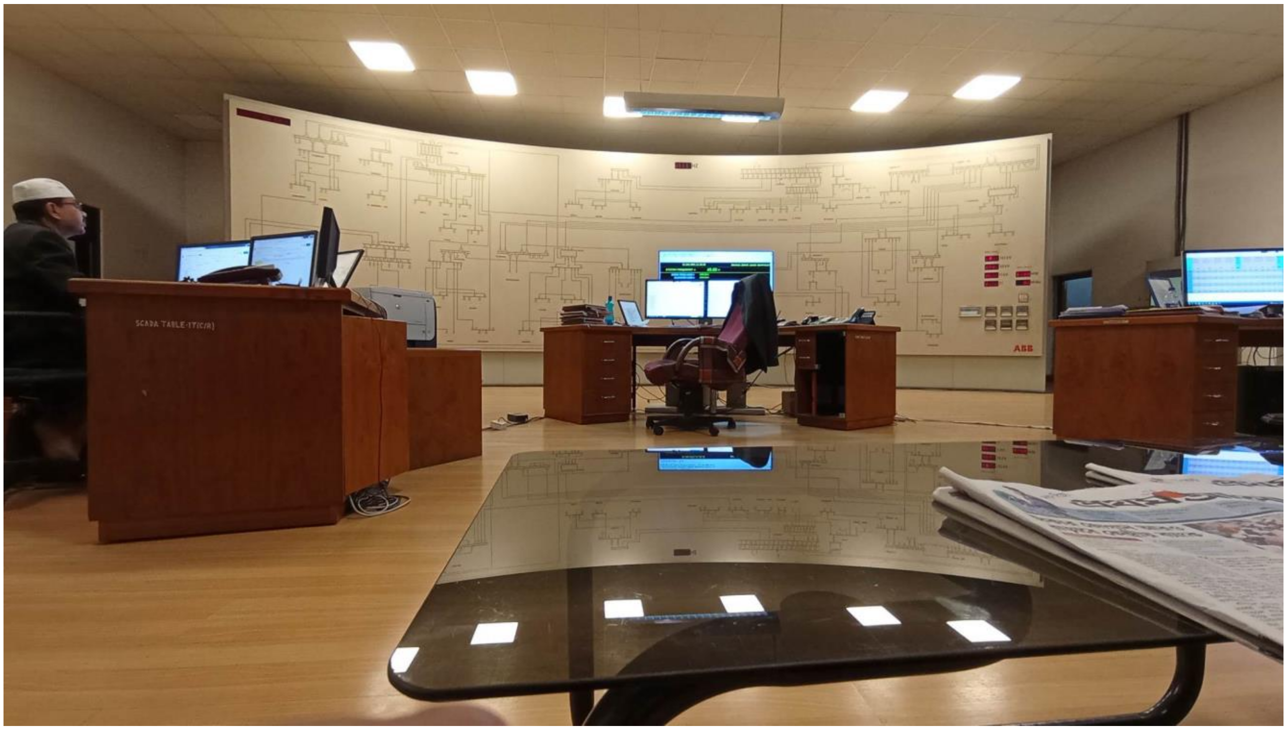

Figure-1 : SCADA panel of DPDC

Figure-2 : Remote Terminal Unit (RTU)

Figure-3 : SCADA Communication Equipment

Figure-4: **SCADA Communication Equipment**

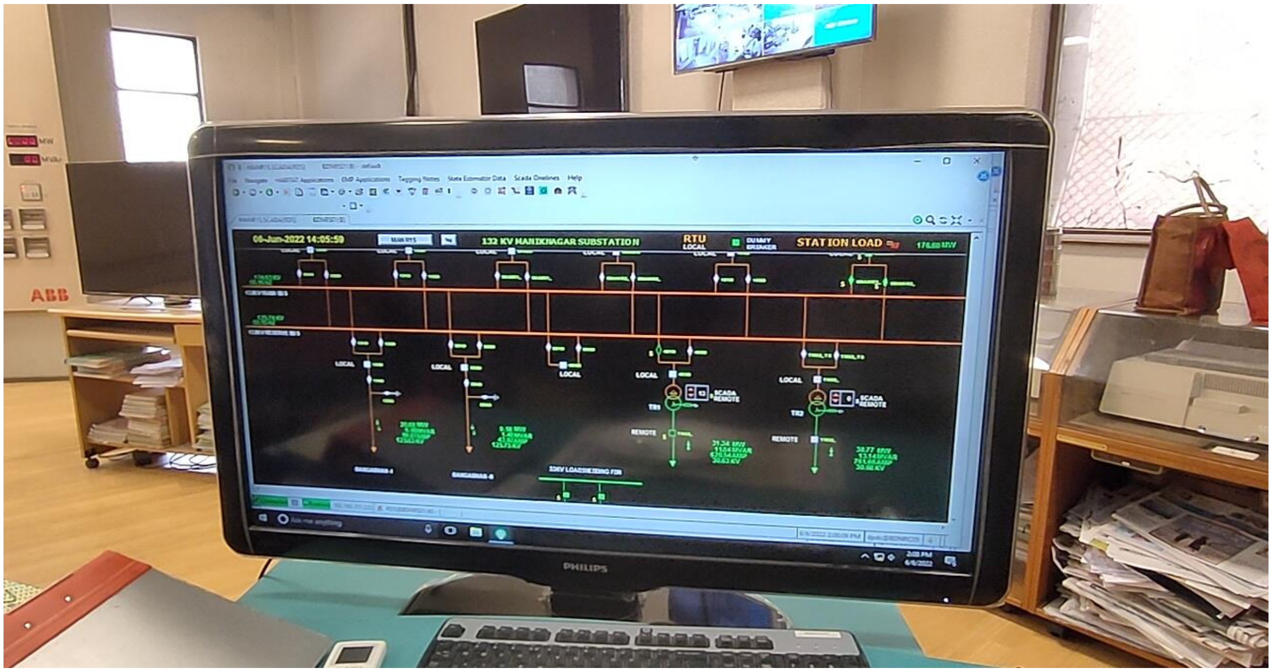

Figure-5 : **Power Lines.**

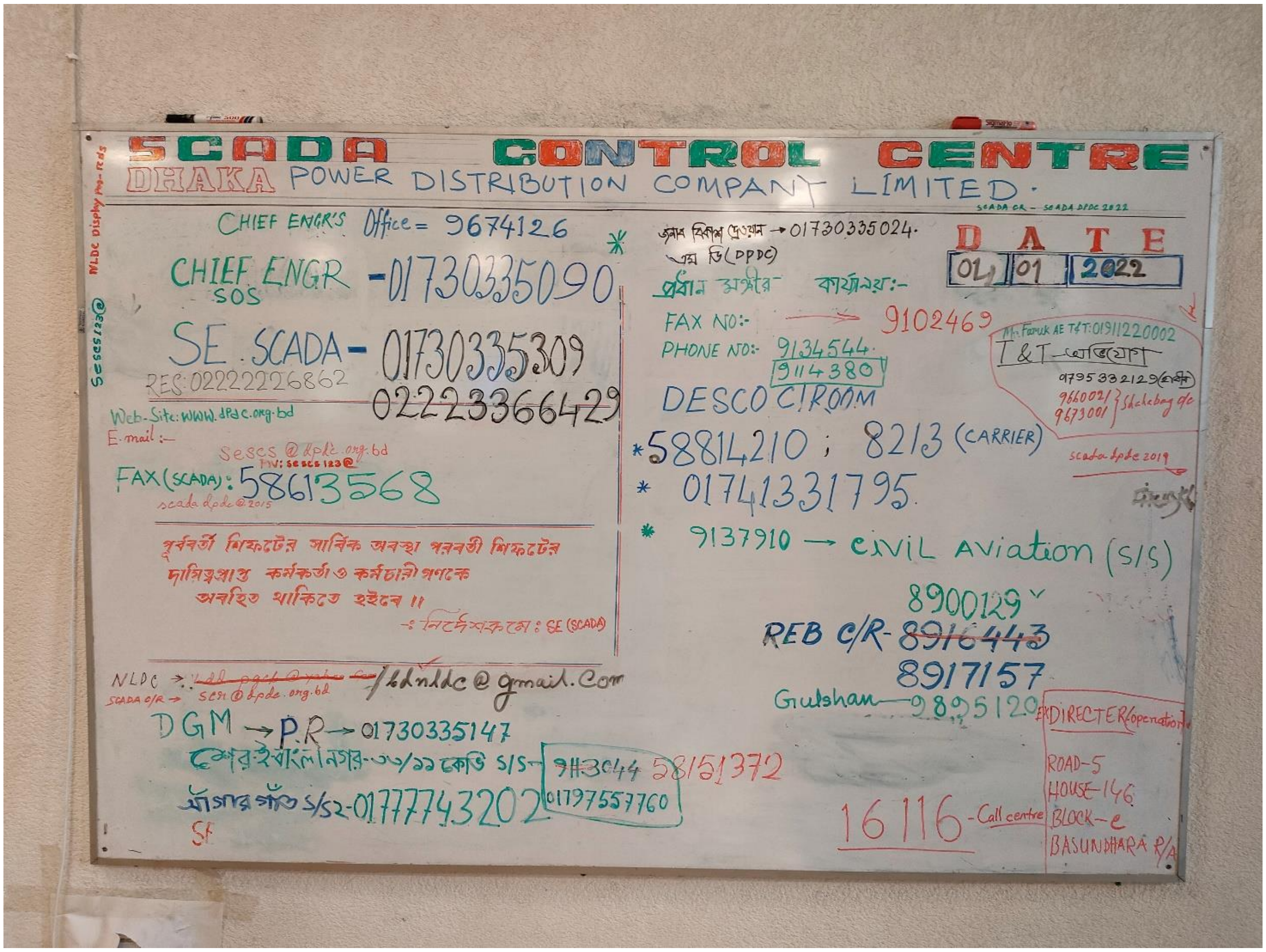

Fig-6: SCADA data table