MOBILE PHONE BASED SCADA SYSTEM

By

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DECLARATION

I Commerce Juru (R156247W) as the sole author of this dissertation entitled "Mobile phone based SCADA systems", authorize this documentation at the Midlands State University for academic purposes only.

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APPROVAL

This dissertation entitled “Mobile phone based SCADA system” submitted by Commerce Juru meets the regulations governing the award of the degree of B.Sc. In Applied Physics and Instrumentation of the Midlands State University and this is approved for its contribution to knowledge and literal presentation purposes.

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ABSTRACT

Monitoring is very important in Industrial Automation to bring out reliability and accuracy thus the use of a SCADA system.

SCADA is an acronym for “Supervisory Control and Data Acquisition.” This systems are widely used in industry for supervisory control and data acquisition of industrial processes. A Android-enabled mobile phone can be used as a client in a SCADA application in order to display and supervise an industrial refrigeration system. The project presents an actual implementation of the on-line controlling of the refrigeration system via mobile phone. The wireless communication between the mobile phone and the SCADA server is performed via a 3G Cloud Router. The operator can visualize and modify the plant parameters using his mobile phone, without reaching the site. In this way maintenance costs are reduced and productivity is increased.

DEDICATION

This document is dedicated to my precious daughter Naomi Juru who came after a much awaited time, showing me that nothing is impossible.

ACKNOWLEDGEMENTS

My sincere gratitude is to my Heavenly Father, author and finisher of my life who has granted me in this life time to complete this dissertation. Also acknowledging my great supervisors and friends, Mr. G. Manjengwa and Mr. Mazunga for their great support to make this project come to fruition. Last but not least, to my precious wife Cinderella, my daughter Naomi for their unmeasurable heartfelt support and prayers.

ABBREVIATIONS

SCADA	Supervisory Control and Data Acquisition
RTU	Remote Terminal Unit
PLC	Programmable Logic Controller
HMI	Human Machine Interface
IMT	International Mobile Telecommunication
ITU	International Telecommunication Union
GPRS	General Packet Radio Service
EDGE	Enhanced Data rate GSM Evolution
VPN	Virtual Private Network
PC	Personal Computer
CPU	Central Processing Unit
SPI	Stateful Packet Inspection
TCP	Transmission Control Protocol
RTC	Remote Terminal Connection
NTP	Network Time Protocol
NAT	Network Address Translation
LTE	Long Term Evolution
IP	Internet Protocol
UDP	User Datagram Protocol
DNP	Distributed Network Protocol
SMS	Short Message Service

LIST OF FIGURES

CHAPTER 1: Research Background

1. Introduction

Connectivity provides the lifeline of industrial control. Today, wireless is widely accepted as the technology for connecting sensors, actuators, controllers, computers, and data acquisition systems. In fact, modern factories, process control plants, and similar industrial facilities have been covered with multiple networks, including wireless. Wireless offers significant benefits to industrial connectivity. First, it is time-critical, offering improved response time in some cases over wired solutions. Wireless also eliminates the endless problems with cables and connectors that are common failure points in industrial settings. It is the connection method of choice for hard-to-wire machines, mobile machines, or machines that rotate. It is especially favorable in applications with long cable runs or where wiring is prohibitive. Such a run could cost tens or even hundreds of thousands of dollars and take weeks to install by a union electrician. Wireless devices can usually be installed and provisioned in minutes. And, wireless devices can be easily monitored or controlled via the Internet and cloud. [1]

SCADA (supervisory control and data acquisition) systems, this are computer controlled systems that monitor and control industrial processes. They mainly comprise of computers, controllers, instruments; actuators, networks, and interfaces that manage the control of automated industrial processes and allow analysis of those systems through data collection. These processes include industrial, infrastructure, and facility-based processes, and are used in all types of industries.

Traditionally, SCADA communication took place over radio, modem, or dedicated serial lines. Typical wireless communications for a SCADA system Point-Multipoint with one Master polling multiple remote RTU’s (Remote Terminal Units) or PLC's using RTU or PLC data communication protocols including protocols such as Modbus and DNP3. Each PLC or RTU at the remote site is programmed with a unique system address and those addresses are all configured into the SCADA Host HMI. The SCADA Host then polls these addresses and stores the acquired data into its database. It will perform centralized alarm management, data trending, operator display and control. [2]

1.1 BACKGROUND AND LITERATURE

Recent generation of technology has redefined communication. Majority of people nowadays have access to mobile phones and thus the world indeed has become a global village. Communication to any particular individual can be done with the mobile phone. But the application of mobile

phone cannot just be restricted to sending SMS or starting conversations. Innovations and ideas can be generated from it that can further enhance its capabilities. Technologies such as Infra-red, Bluetooth, which has developed in recent years goes to show the very fact that improvements are in fact possible and these improvements have eased our life and the way we live. Remote

management of industrial equipment is a subject of growing interest and in recent years we have seen many systems providing such controls. These days, apart from supporting voice calls a mobile phone can be used to send text messages as well as multimedia messages (that may contain pictures, graphics, and animations). Instant messaging, as it is also known, allows quick transmission of short messages that allow an individual to share ideas, opinions and other relevant information. The very concept is used to design a system that acts a platform to receive messages which in fact are commands sent to control different equipment and devices connected to the platform. Designed control system is based on the 3G Cloud Router technology that effectively allows control from a remote area to the desired location. The application of suggested system is immense in the ever changing technological world which allows a greater degree of freedom to an individual whether it is controlling any equipment.

The need to be physically present in order to control equipment of a certain location is eliminated with the use of our system. [3] Improvement and developments in the 3G network is its changes in the cellular network with aid of better technologies worldwide. To bring about the changes Japan was the first nation to do so in 2001when it commercially launched 3G. The changes where complete in 2005-2006 period. All this transitions where due to the limited capabilities of the 2G network due to its limited bandwidth and capacity to data transmission and voice calls as well.

This brought the development of 3G due to 2G unsatisfying offers. The International Mobile Telecommunication (IM)-2000 facilitated the growth in bandwidth and diverse applications.

Developments of GPRS (General Packet Radio Service) (2.5G), EDGE (Enhanced Data rates for GSM Evolution) technologies brought about this change to 3G.

1.2 Problem statement

Management of production, process efficiency, real-time plant status and costs have been and still is a stumbling block in business profit making. Thus continuous management of the mentioned pillars will bring about good business through put which definitely leads to profits. Collection of process data in real-time is thus vital to decision making within minimal time space.3G technology provides high data rates and improved call quality, video calling facility and much more. This technology provides huge benefits to mobile users. The major drawbacks are from the regions where 3G is in initial stages of launch. These drawbacks can be minimized when 3G services are used extensively.

1.3 AIM

Remote access of industrial processes using a mobile phone for monitoring and control through the use of a 3G Cloud Router.

1.4 OBJECTIVE

To deliver an uninterrupted output and prevent unplanned downtime.

Reduction in the maintenance cost and to optimize critical monitoring system. Ability to use of mobiles in order to control industrial machineries simultaneously.

To provide necessary data related to industry to a maintenance officer located anywhere at any time and more so reduction in manual cost.

Easiest way for energy auditing process, online energy consumption and maximizing the operational life of the plant.

1.5 JUSTIFICATION

Simple configuration via SMS commands through the internet providing a global range.

Full flexibility with considerable safety to control the machineries at low cost and ease of maintenance.

Industrial automation has grown over time for remote monitoring and also virtual monitoring.

Through surveying recent technology has gotten interest through the use of the internet. Programmable Logic Controller (PLC), Supervisory Control and Data Acquisition (SCADA), Virtual Private Network (VPN) facilitate and are the fundamental to such kind of monitoring.

This kind of optimal control operation maximize the operational life of the plant. Real time data processing, analysis and control through online connection are achievable, so is improved performance.

1.6 SCOPE

The technical design a system which can control multiple processes using SCADA through the use of mobile phone. Connection to the processes and devices in use is wireless aided by the use of a 3G cloud router for remote controlling.

1.7 PROJECT REQUIREMENTS

1.7.1 Hardware Requirements

- 3G CLOUD ROUTER
- Laptop ACER
- Android Phone
- SIEMENS S7-1200 PLC

1.7.2 Software Requirements

- Siemens S7 TIA V13
- DIAview SCADA software
- DIAview and DIAcloud application software
- VNC viewer and server application software

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CHAPTER 2. Theoretical Aspects

2.0 Introduction

Unsatisfying abilities of the 2G network has brought about demands of it growth to accommodate the ever-increasing usage functions flexibility and availability.

This had with it developments of GPRS, EDGE (2.5 G) to make a transition to 3G .

2.1 Features of 3G

Proposal by the ITU (International Telecommunication Union) is for the 3G to come up with enhanced wireless multimedia and communication of high cost efficiency and quality.

The 3G can be divided into two main sections to note, that is security and data rates.

The first point is that the 3G features technologies supports this high data transmission, greater voicing and data carrying capacity at low costs. In addition, the 3G mobiles can also operate on 2G framework.

Its major feature is of security.it does offer better security services than 2G by having protocols like, Network Domain Security, Application Security, and Network Access Security. In addition to the above, 3G is able to make video calls and give reports on traffic for a localized area.

2.2 LITERATURE REVIEW

Evolution of remote communication came about in the 1990s, starting with dial-up connections. Advanced to hard-wired Ethernet/Internet connection with increasing speeds and now wireless technology is being explored.

Plant monitoring abilities has been brought by this cellular technologies which can even match or surpass the hardwired Ethernet connection. It has also come with low cost which is an added advantage.

2.2.1 Benefits of remote monitoring

It has low costs cost when it comes to the initial implementation of the technology. It has an expanded level of people who can monitor the plant processes thus facilitating effective monitoring.

Labor costs are minimized so is the machine life span increased. Less human interference with machinery brings more safety, that's a bonus to hazardous plants. Unplanned downtime is cabbed at its early stages. [5]

Remote monitoring can be a big bit in the right direction but the practical security is of great worry.

2.2.2 Wireless advantages and challenges

Wireless technology has a greater level of being flexible than the hardwired networks. They have an advantage that they can accommodate a larger number of different devices on their networks.

With being in comparison to wires and cable installations, it is the most cost serving which is gradually eliminating the purchasing of this wires and cables. It comes along with ability of fast

and easy installation procedures. Being of sensor installations for a SCADA system it then makes it cheaper.

Though it has this low cost advantage over the wires and cables, great concern has arisen on the issues to do with security. Recently more secure protocols have risen to counter that inefficiency and this has given it a hitch over the wired networks. Nevertheless, though this security measures have grown strong, wireless networks are more venerable that the wired networks. The use of encryption has made the wireless network more secure through the use of standards,IEE.802 protocols, client identification to a network this are kind of acceptable safety measures. [5]

Security maintenance and implementation for this cellular networks require IT knowledge. This can be a drawback to small operation who might not be able to use this kind of security measure. Though less trusted in time past, networking protocols are making it a more viable option in reducing remote maintenance and installation costs.

2.2.3 Remote data access

The web-based access which preceded the PC-based was a big stride in the data acquisition process. This is about the how and where data of the system can be accessed.

Such developments did not only lower the costs but brought about enhanced efficiencies and productivities. This is because of data access which now can be done frequently and easily. In addition to that notable improvements in alarm and alarm response due to this data access. [5]

This time around, simultaneous monitoring of multiple processes through a system facility cannot be over emphasized. In the absence of remote monitoring, quality suffer due to undetected problems, equipment damage and also unscheduled down time occur. Many of the manufacturing companies to this consolidated monitoring models which can cover a wide spectra of manufacturing plants. By this real-time information from the plant, detailed historical data is made available for many to use. [5]

Remotely, parameter changes, troubleshooting and plant shutdown for safety reasons has been made possible. Fast channel of decision making is thus now practical.

Life span for machinery and processes equipment is extend due to the availability of real time visibility being combined with expertise. In addition, determined maintenance, replacement intervals can now be done remotely due to the availability of this historical data and maintenance schedules.

2.2.4 Cellular technology use

Advances in cellular technology have accredited to the ability of smartphones to accommodate maps, calculators, alarm clocks, video recordings, recode devices and more. While others are using mobile devices to communicate information quickly and economically, manufacturing industries or plants have embraced it in a way of remote accessing to their plants this hand-held devices. “One of the main decisions that must be made is how and when to implement browser-based and app-based remote monitoring.” [5]

2.2.5 Web browsers: Pros and cons

Virtual Private Networks (VPN) connection to the plant browser via smartphones can be deemed a logical way of accessing data remotely. Today manufacturers have adopted this kind of remote data access connectivity. The access is through a controller or the Human Machine Interface (HMI), or also to equipment with a web-server capabilities.

This manner of data acquisition is relatively quick and too good when browsing using a Personal Computer (PC), but be of much concern when it comes to smartphones browsers. Scaling is the major problem as it comes to scaling down small screens of hand-held devices because it takes longer to load such information on them.

Remote browsers provide smartphones with access of data and this is a problem considering monitoring the amount of data in conditions were it frequently change. Considering server choosing VPNs and Web servers for two way communication and access is the best since others

offer read-only capabilities when read-write is the best remote controlling and is of great importance. [5]

Accessing Web browsers is almost free but the designing, deploying, maintenance must be well factored in having one.

2.2.6 Using apps for monitoring and control

Smartphone se and also handheld devices for remotely monitoring and controlling operations involve usage of applications (apps) for this devices. The apps are very cheap but they kind of introduce latencies if care is not taken.

Protocols, software, and hardware increase must be done in order to achieve sold networking. Data transfer from automation components must also be done, to remove much frustrations slower and poor network performance.

This app access require more of the VPN than the IT support and they are much less steps in installing in this software.

2.2.7 Security issues

Security is of vital importance when it comes to wireless remote monitoring implementations. This is all due to sensitive information that is being handled via the smartphones. Unauthorized entry to personal data and access to deeper information data must be monitored and controlled.

Therefore this security measures like passwords encryption, authorization and device identification are implemented for remote wireless connection security. The pros and cons of manufacturing plants come along with different monitoring systems. Nevertheless it will become the norm as need to accomplish more security with fewer resources is attainable. [5]

2.3 Remote Monitoring via Smartphones

2.3.1 Web browser/VPN for remote monitoring:

- May provide snapshot, not real-time data
- May be read-only
- Often not designed for small displays
- Security challenges

2.3.2 Smartphone App for Remote Monitoring:

- Very low cost
- Wide range of functionality
- Fast loading of app
- High-speed access
- Seamless upgrades from the supplier
- Designed for small displays
- Security challenges [5]

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CHAPTER 3

RESEARCH METHODS AND TECHNIQUES

3.1 INTRODUCTION

Research methodology generally refers to a systematic and scientific method of enquiry and may include the following; collecting data in an organized and controlled manner so as to arrive at valid decisions and, drawing conclusions and making generalization and making suggestion for future studies.

Thus this chapter takes a look at the hardware and software requirements, analysis and designs required to come up with final project model. A proper analysis of the existing systems has led to a proper design being made of the system.

3.2 SYSTEM DESIGN

The hardware components of the system consist of:

1. SEIMENS PLC S7-1200
2. ACER LAPTOP (PROGRAMMER)
3. SONY SMARTPHONE
4. DELTA DX-2100 3G CLOUD ROUTER
5. ETHERNET SWITCH

Software requirements include:

- DELA DIAview SCADA SOFTWARE
- SIEMENS TIA AUTOMATION SOFTWARE (PROGRAMMING)
- VNC SERVER/VEIWER/ DESKTOP
- DIACom, DIACloud

Below is the block diagram illustrating the connection of the above hardware and software which by being compatible bring the functionality and success of the project.

3.3 SYSTEM BLOCK DIAGRAM

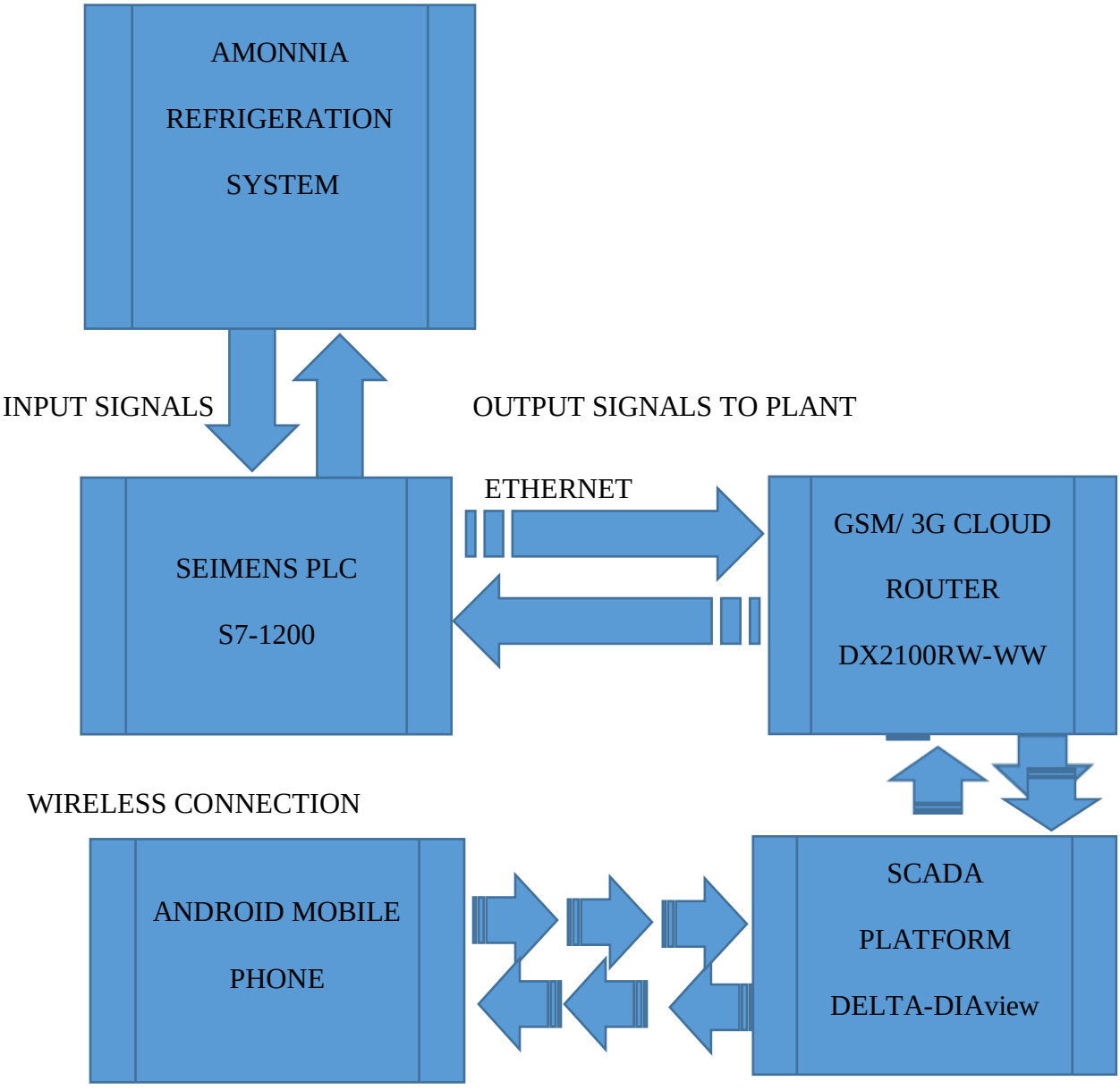

FIG 3.1 showing a system block diagram

3.3.1Hardware components

1. SIEMENS S7-1200 PLC

FIG 3.2 S-1200 SIEMENS PLC

Modular SIMATIC S7-1200 is a simple controller offering a wider range of applications with it being versatile, modular and compact with security investment thus bringing precise automation.

Its CPUs with Safety Integrated can handle safety related tasks and standards. With it comes a compact design with integrated Input/Output, and interfaces meeting the highest industrial standard requirements when it comes to communication and a wider range of powerful integrated technological functions. All this makes S7-1200 CPUS controller an integral part of a comprehensive automation solution. [6]

3.3.2 Delta 3G cloud router (dx 2100rw-ww) GMS modem

FIG 3.5 3G CLOUD ROUTER DX-2100RW-WW

3.3.2.1 Features and benefits

Supports acquisition equipment connected to cloud servers and a robust supporter of two-way data collection channel between the device and the cloud. It also provides secure tunnel between the user and the remote device via the cloud server, without the need of additional VPN server.

It is compatible with MODBUS TCP and MODBUS RTU protocols. In addition, it supports a wide range of bands (800- 2100 MHz), downward compatible with GSM / GPRS / EDGE 2G network and has data transmission rate up to 21.6 Mbps (downlink) / 5.76Mbps (uplink).

Automatic APN parameter matching and connection redial and supports various peripheral interfaces include RS-485, RS-232 and LAN ports. It has got In-built RTC and supports NTP time synchronization over a network. Additionally it supports stateful Packet Inspection (SPI),

Prevent Denial of Service (DoS) attacks, NAT, port triggering, port mapping, IP address filter, MAC address filter, URL filter (firewall functions), TCP/IP, UDP, ICMP, DHCP, HTTP, DNS and SSH protocols. It has an option for job scheduling, Exportation and importation of device configurations, networking failure diagnostics and data flow statistics, PLC-Device interlocking. Alarm conditions with email alerts, Android and iOS devices on-line monitoring support. [7]

3.3.3 Specifications

3.3.3.1 TECHNOLOGY-Standard Compliance

- GSM/GPRS/EDGE/UMTS/HSPA+
- IEEE 802.3 10Base-T
- IEEE 802.3u 100Base-T(X)

3.3.3.2 INTERFACE -3G

- GSM/GPRS/EDGE/UMTS/HSPA+
- **Antennas**
- 1 2.5dBi Omni-directional, SMA(male) connector, cable with magnetic stand
- **Fast Ethernet**
- RJ45 Ports: 1 10/100Base-T(X), auto MDI/MDI-X, auto negotiation
- **Serial Communication**
- Serial Ports : 1 RS-232(DB9 male), 1 RS-485(DB9 female), 15KV isolation protection
- Baud Rate: 2400bps to 115200bps
- Data Bits: 7, 8
- Parity: None, Even, Odd
- Stop Bits: 1, 2
- Flow Control: RTS/CTS(RS-232 only), XON/XOFF
- RS-232: TxD, RxD, RTS, CTS, GND
- RS-485: D+, D-, GND

- **LEDs**
- Device: PWR, SD, Ready, 3G, Signal Strength
- RJ45 Ports: LAN
- Serial Ports: RS-232 RX, RS-232 TX, RS-485 RX, RS-485 TX
- **Reset Button**
- 1set
- **3G RF - Frequency Band**
- GSM/GPRS/EDGE: 850 / 900 / 1800 / 1900 MHz
- **MANAGEMENT - Cloud Service**
- DIACloud
- **Software**
- SSH, DNS, HTTP, TFTP, DHCP Server/Client, Telnet, Syslog, MODBUS TCP, NTP, MODBUS RTU
- **Security**
- MAC/IP/URL filtering, SSH, SPI, Prevent denial of service (DoS) attacks, Port triggering, Port mapping
- **Virtual COM Drivers**
- Windows XP, Windows Vista (32/64 bits), Windows 7 (32/64 bits)
- **Configuration**
- Web Browser, DIACom, Android APP, iOS APP
- **POWER REQUIREMENTS**
- Input Voltage: 12 to 48VDC, 3 pin terminal block input
- Input Current: 1A Max.
- Overload Current Protection: Present, Max. Input current 1.5A
- Reverse Polarity Protection: Not Present
- **PHYSICAL**
- Housing: IP30 metal case
- Dimensions: 111 mm(H) x 77 mm(W) x 26 mm (D)
- Wall mounting installation
- **ENVIRONMENTAL LIMITS**
- Operating Temperature : -20℃ to 70℃

- Storage Temperature: -40℃ to 85℃
- Ambient Relative Humidity: 5% to 95%(non-condensing)
- **APPROVALS**
- Safety: EN 60950-1(DX-2100RW-WW certified)
- EMI: FCC 47 CFR Part 15 Subpart B Class A, EN 55022, EN 301 489-1/7/24 (DX-2100RW-WW certified)
- EMS(EN 301 489-1/7/24, EN 55024): IEC 61000-4-2, IEC 61000-4-3, IEC 61000-4-4, IEC 61000-4-5, IEC 61000-4-6, IEC 61000-4-8 (DX-2100RW-WW certified) [7]

3.3.4 Laptop (programmer)

FIG 3.6 ACER LAPTOP (PROGRAMMER)

3.3.4.1Specification;

Intel Core i5, processor 2.7Hz, 6 GB DDR3 L Memory, 1000 GB HDD.

With Windows 10 , 64 bit operating system.

3.4 Software components

3.4.1. DELTA DIAview SCADA SOFTWARE

Delta's DIAView SCADA (Supervisory Control and Data Acquisition), is an industrial automation management system with a provision for plant efficiency and capacity improvements, information compilation, real-time system control, remote data analysis, monitoring and control, system management implementation and production line visualization. [7]

3.4.1.1FEATURES AND BENEFITS

Stable industrial communication, seamless integration with Delta PLC & other products with WPF technology for intuitive interface. Also has got flexible, versatile variables and parameters and strong friendly graphical demonstration encompassing strong and efficient alarm system, easy-to-learn VBScript language. It carries a reliable user authority management. I/O points: 64, 128, 256, 512, 1000, 1500, 3000 and unlimited and licensing is done via USB hardware key to enable all authorizations [7]

DIAView is a flexible software applicable to various environments, house to factory levels. Real-time monitoring is achievable for both production equipment and factory facilities. For efficient factory alarm functions, Delta provides a complete technical structure for smart factory management. Additionally for equipment data collection, Delta adopts its Industrial Unmanaged Ethernet Switch DVS Series that connects all controllers for the on-site equipment. This collected data is transmitted to the superior controllers, via Ethernet communication protocol. Management can choose to manually give commands via remotely extended Human Machine Interface DOP Series to achieve equipment control. This DVS Series also transmits the collected data to the DIAView SCADA system, which allows the managerial or operator to monitor real-time factory operation and be able to set the threshold variables for the alarm function. For occurring errors, DIAView receives the error-data and deliver alert messages to the responsible managers via a SMS message sending device thus achieving real-time error notification.

Alarm function of Delta's DIAView SCADA system brings the following advantages: [8]

• **Threshold setup for alarm variables**: The DIAView SCADA system provides a highly flexible parameter setting. Offering an interface that can set up an alarm's threshold values for the corresponding on-site machinery in accordance to operation requirements.

• **Real-time and hierarchical SMS dispatch**: Delta's SMS alarm function adopts both real-time message dispatch and a hierarchical delivery function. When an error occurs, it sends to the first manager for response, if not resolved it moves to a next higher level till the error is solved. Bringing up real time error resolving capabilities thus effective factory management.

• Through **Real-time alarm display and log history**: it displays instant alert messages to notify the operator or managers when an error occurs along with historical data collected. The ability to track down events is thus made easier and quicker. Due to this traceability comes better decision making within a minimum period of time.

Delta's **DIAView SCADA system**, due to its ability in increased error response, it has made it successful in risk, hazards and production waste reduction which led to greater industrial competitiveness.

3.4.2 .VNC VIEWER and SERVER

VNC which is an acronym for Virtual Network Computing offers a deceptively simple service. It allows one to view and control remote systems. The compact VNC Server application runs on the system to be controlled. Meanwhile, connecting systems can either run the VNC Viewer application. VNC adapts itself automatically and dynamically to varying conditions, including differing screen contents and network bandwidths. It's an independent platform which can allow Windows system to control a Linux server, or vice versa. [9]

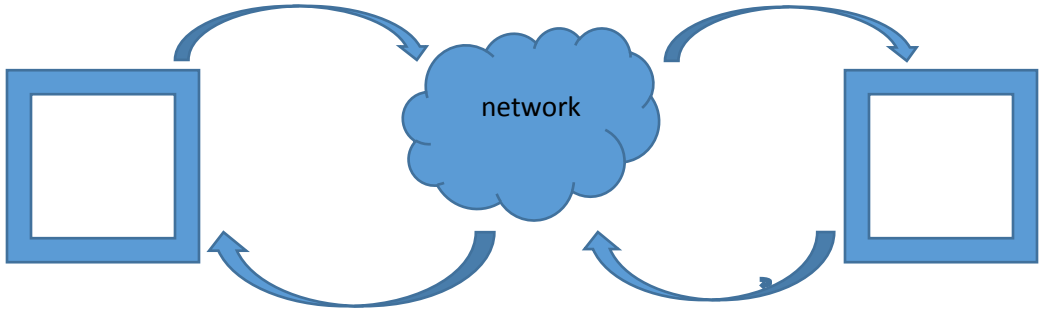

FIG 3.7 VNC COMMUNICATION NETWORK

VNC breaks the Server screen image down into constituent parts and transmits them to the viewer. Controlling mouse components and key press inputs from the Viewer are sent to the server.

3.4.3 SIEMENS TIA V13 (PROGRAMMING SOFTWARE)

Totally Integrated Automation (TIA) offers a common software platform that integrates all components, regardless of of the diversification in applied technology, bringing them into one uniform system. This is bringing all programing functions needs, configurations, operations, data handling, and communications and maintaining control solutions.

During programming and configuring stages, S7 SIMATIC Manger running on PCs or Siemens PGs provides integrated tools which aid up in creation, testing operation and startups to control solutions. While all this is taking place, the Siemens software puts all data processed in a central database for easy access when need be. [10]

3.4.4 DIAcom/DIAcloud SOFTWARE

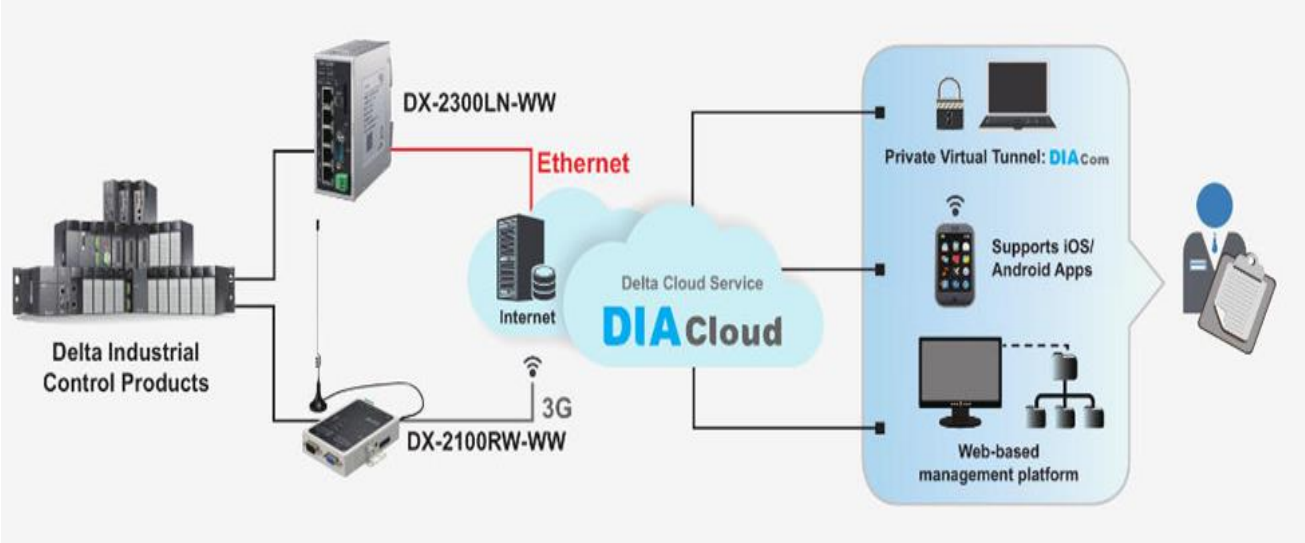

FIG 3.8 SOFTWARE OPERATION

DIACom allows you to create a secure tunnel between your PC and router, making it possible for your PC to communicate remotely with the devices connected to the router. Thus engineers can control, monitor, operate, program and diagnose the device remotely whenever there is internet connectivity. DIACloud provides you with cloud services, including the connected device management, secure tunnel network creation, data upload/download, and directional transmission.

Delta's DIACloud platform cloud-based IoT(Internet of Things) solution provides a concise solution for remote monitoring, maintenance, data collection and data storage. Devices securely communicate as if they are on the same network, allowing users to connect and see device status online or through Delta's DIACloud phone app. The DX-2100 and DX-2300, Delta's enabling hardware products, easily connect legacy and standard non-Delta devices to the platform. SMS and email alarms simplify monitoring, and Delta's worldwide server network eases connectivity. Delta's patented technology for authentication, authorization, and data encryption ensures that the device is secure end-to-end. [11]

3.5 DEVELOPMENT

3.5.1 DIAview SCADA Software

DIAview SCADA software was used to come up with a system diagram for an Ammonia refrigeration cycle. For example, the one illustrated in the diagram below.

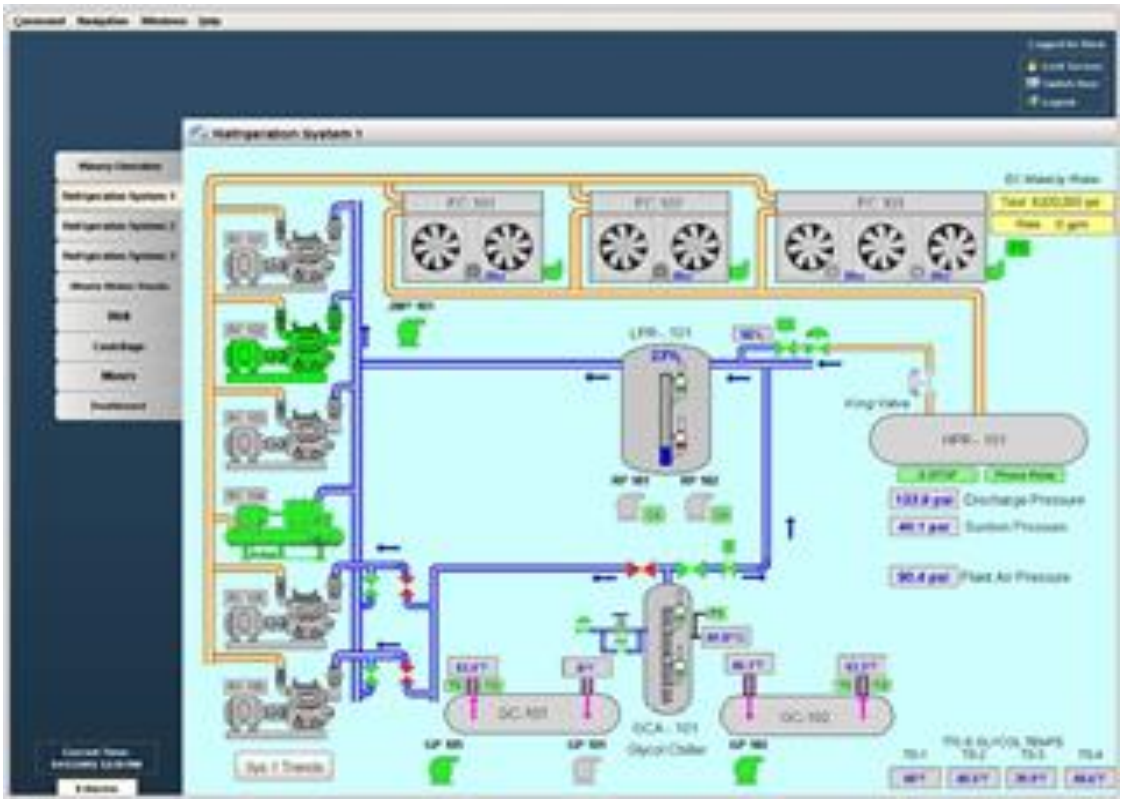

FIG 3.9 DIAview SCADA SCREEN

3.5.2Siemens TIA v13 PLC program

This programming language was used to come with a program on how to run the ammonia refrigeration system on the SCADA. Used to come up with configuration, operation, data handling and communication between SCADA and the PLC-REF system.

3.5.3Delta 3G cloud router

The router was used to make wireless communication between the SCADA system and the mobile phone for remote controlling of the refrigeration system.

3.6 WORKING PRINCIPLE OF THE PROJECT

All physical connections being made, PLC to laptop through Ethernet cabling, 3G Cloud router to laptop through Ethernet, DIAview sends real-time message of the prevailing situation. The VNC server running on the application to be controlled send broken server screen images which are in constituent parts and transmits them to the viewer who has a VNC View application running on his mobile.

Link between the SCADA and the viewer is achieved through the 3G Cloud router which facilitate two way data collection channel between the devices and the cloud. This brings DIAcom and DIAcloud into picture. DIAcom makes secure tunnel communication between PC and router making it possible for PC to communicate remotely with devices connected to the router. DIAcloud facilitates data upload and download and directional transmission.

The viewer now has a remote Human Machine Interface (HMI) on his mobile. He remotely starts the system, and if all conditions are alright for the system to start, all machines come sequentially according to the program and also sending back the system states continuously.

If the program sequences are interrupted, an alarm is raised and sent through the 3G Cloud router to the viewer's mobile phone. Viewer can act accordingly depending on the alarm received, either remotely clearing them and start the system or make physical visit to the plant.

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CHAPTER 4:

Results and Analysis

4.0 Project layout

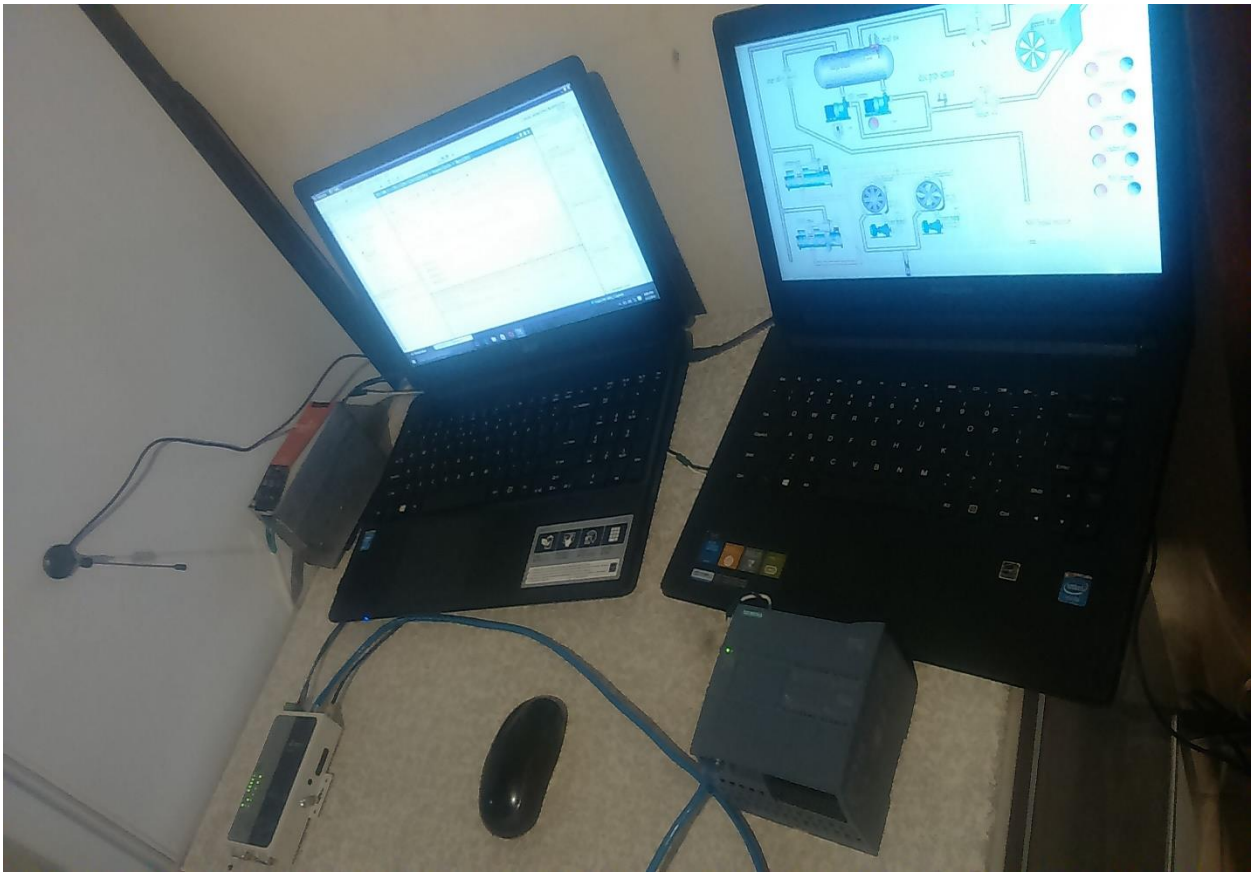

Fig 4.1 Project Layout

4.2 Findings

Managed to start u the system with the 3G Cloud Router managing to connect the devices to the internet.

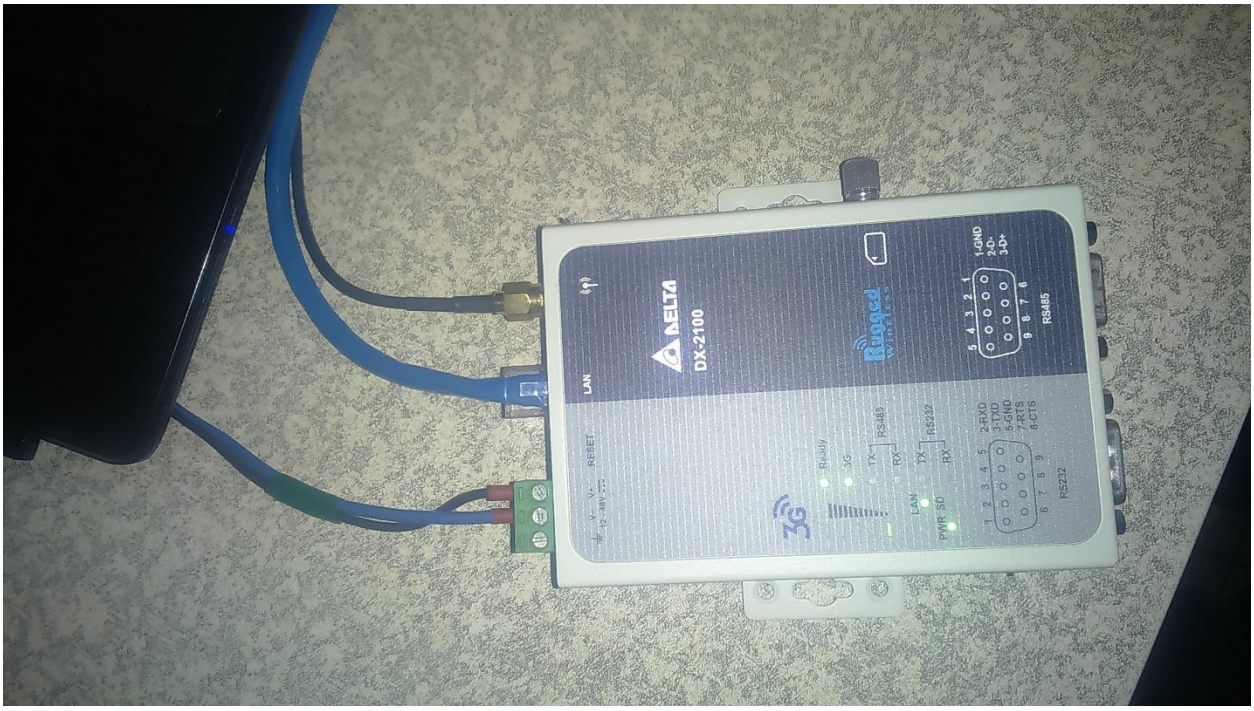

Fig 4.2 3G Cloud Router

Fig 4.3 Powered S7-1200 PLC

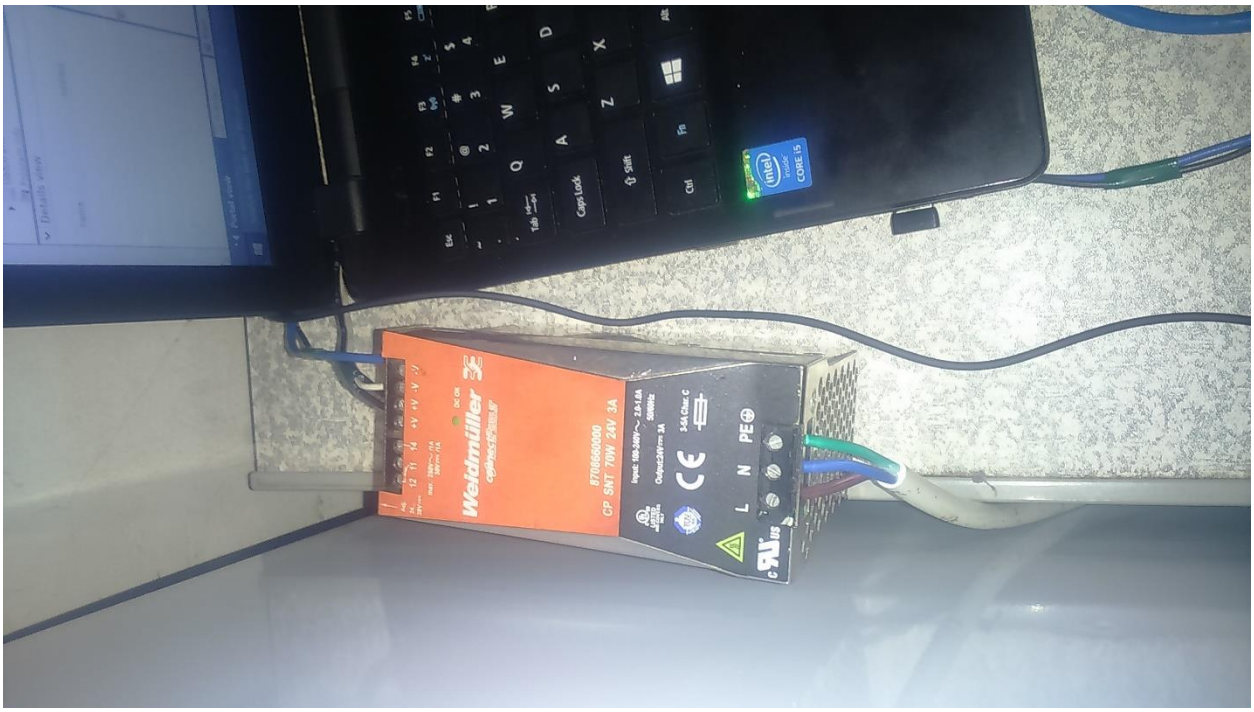

Fig 4.4 12-48 Vdc Power Supply

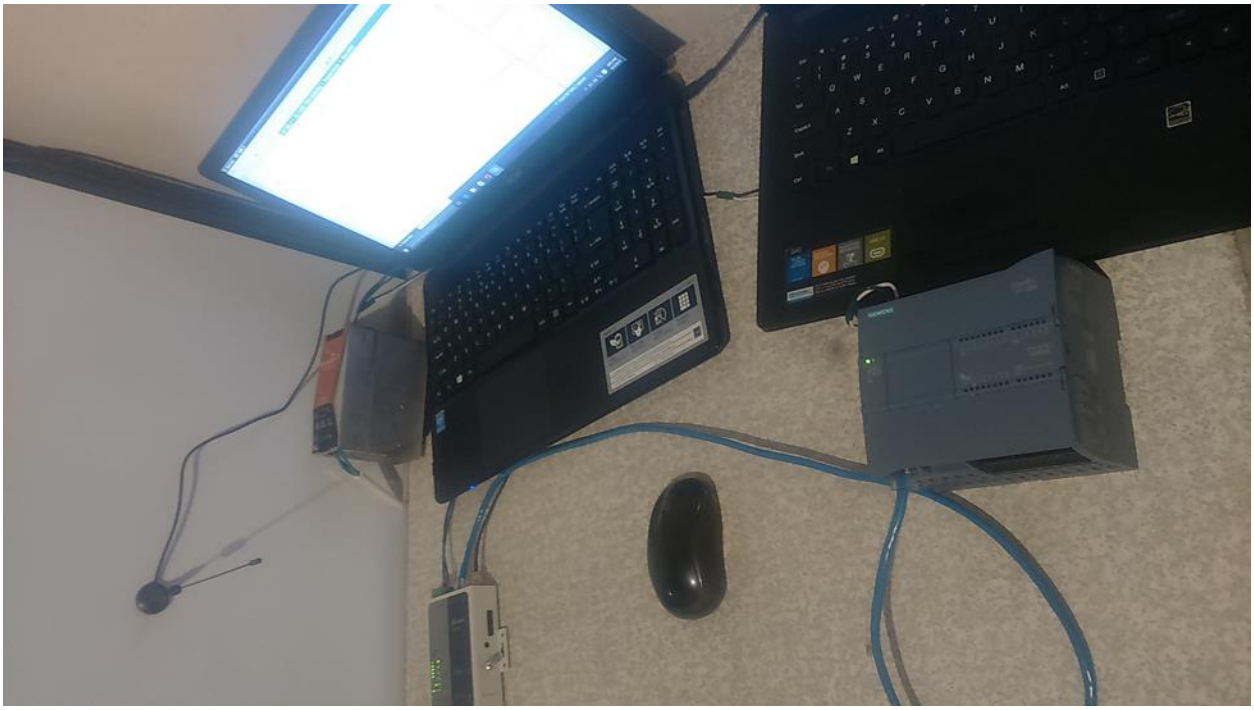

Fig 4.4 Ethernet connection between 3G Cloud Router and S7-1200 PLC

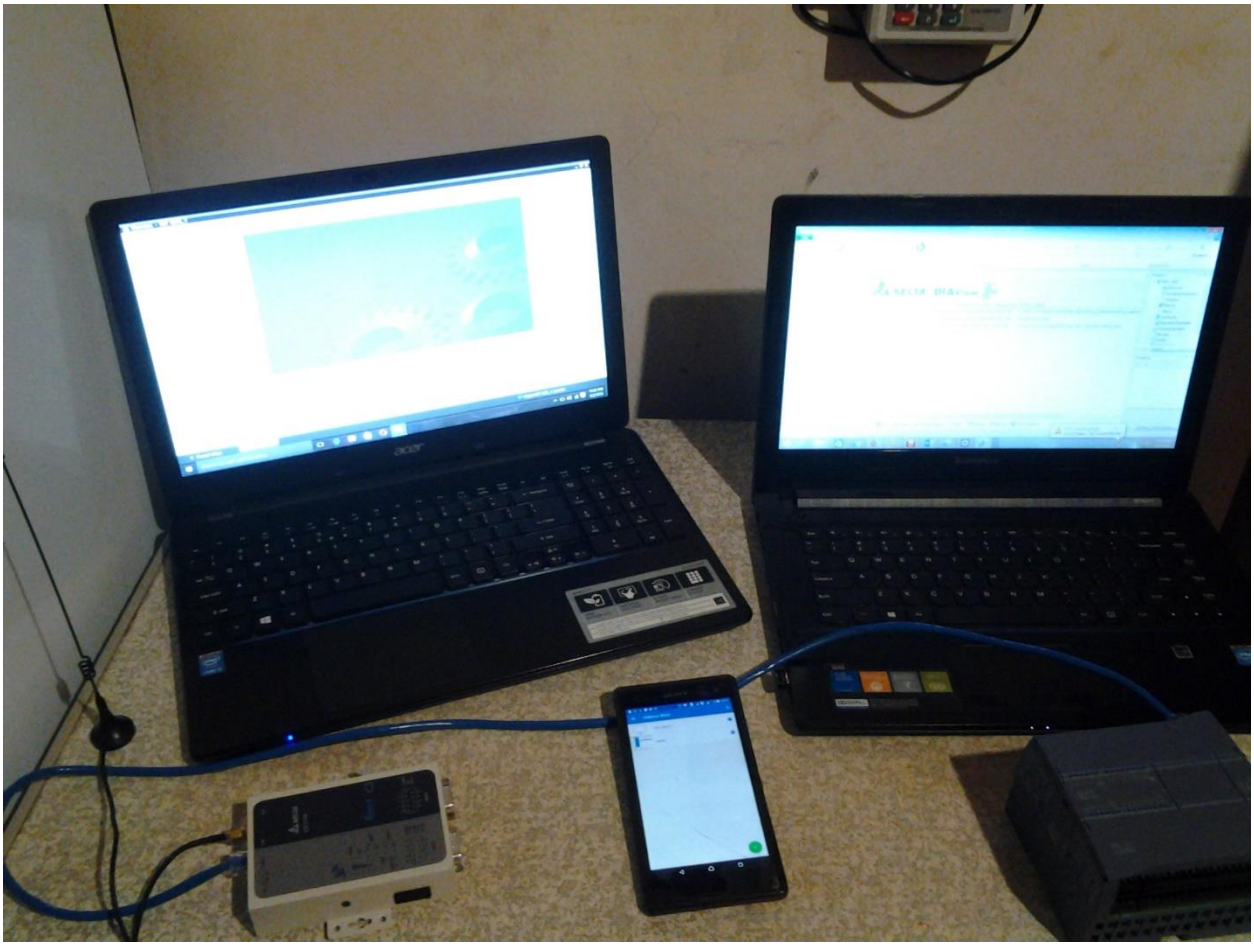

Fig 5.5 Wireless connection between mobile phone, laptops, 3G router with PLC

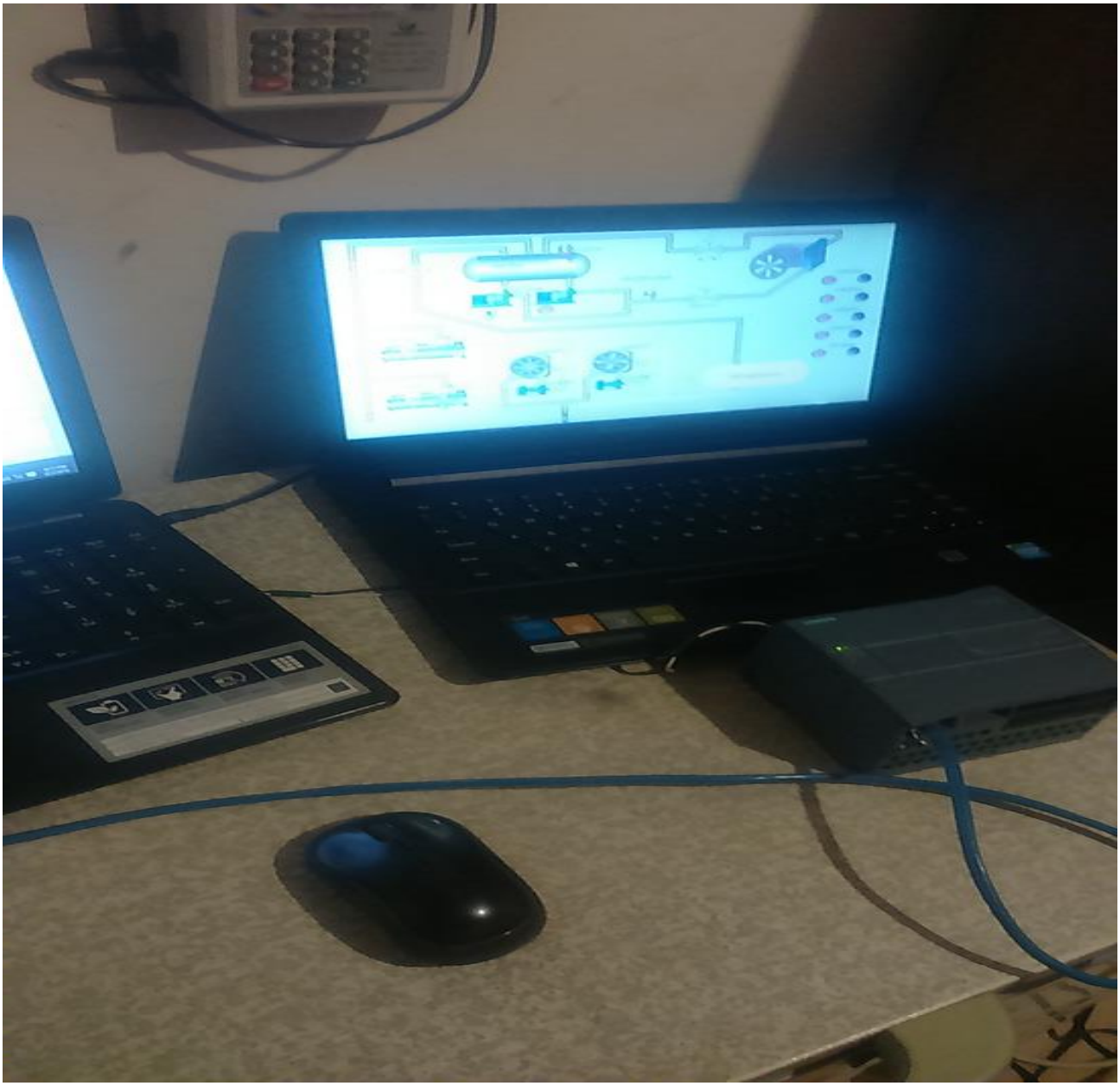

Fig 4.6 Laptop displaying the DIAview SCADA System

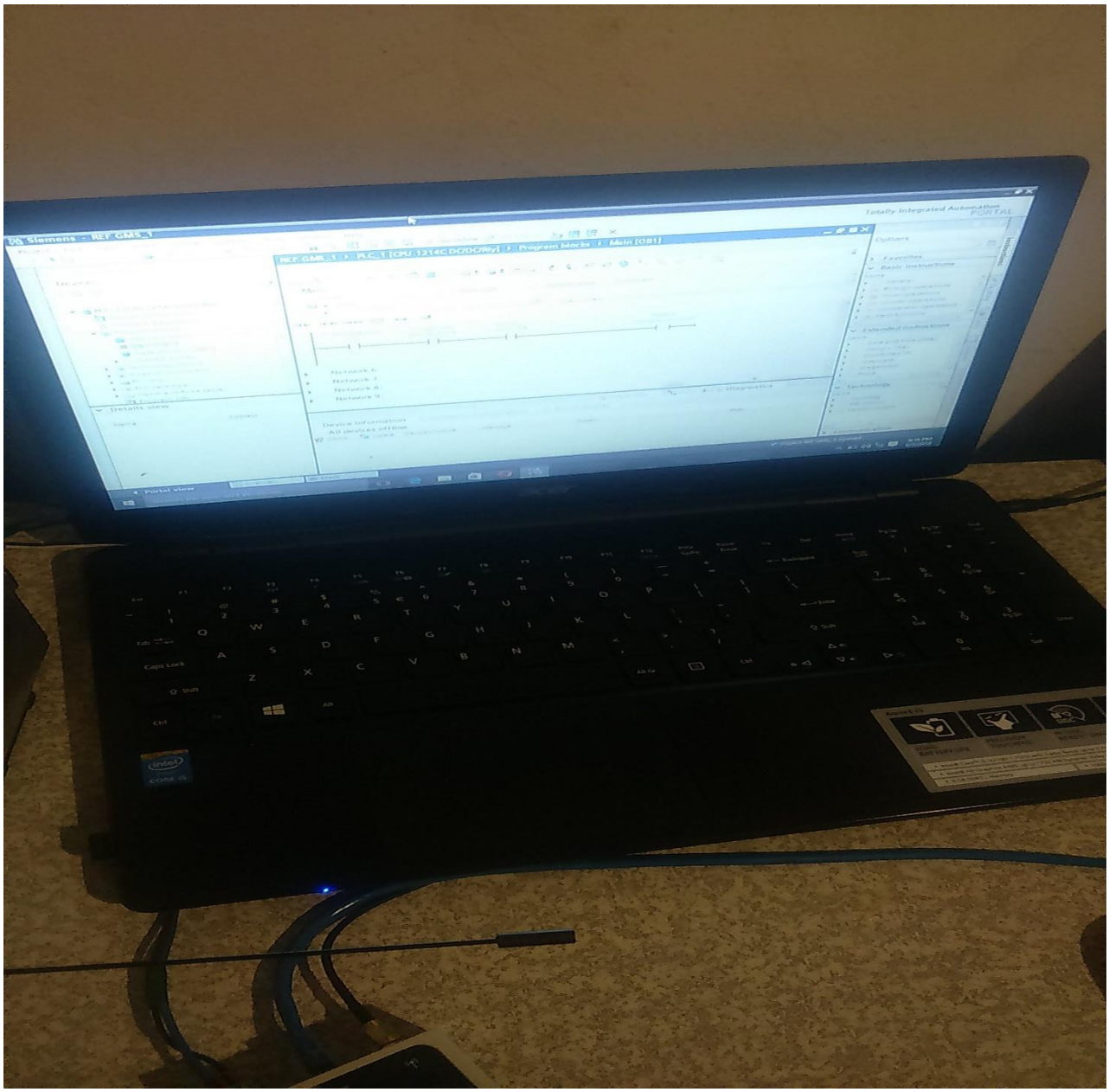

Fig 4.7 Laptop displaying S7-TIA PLC program running on SCADA

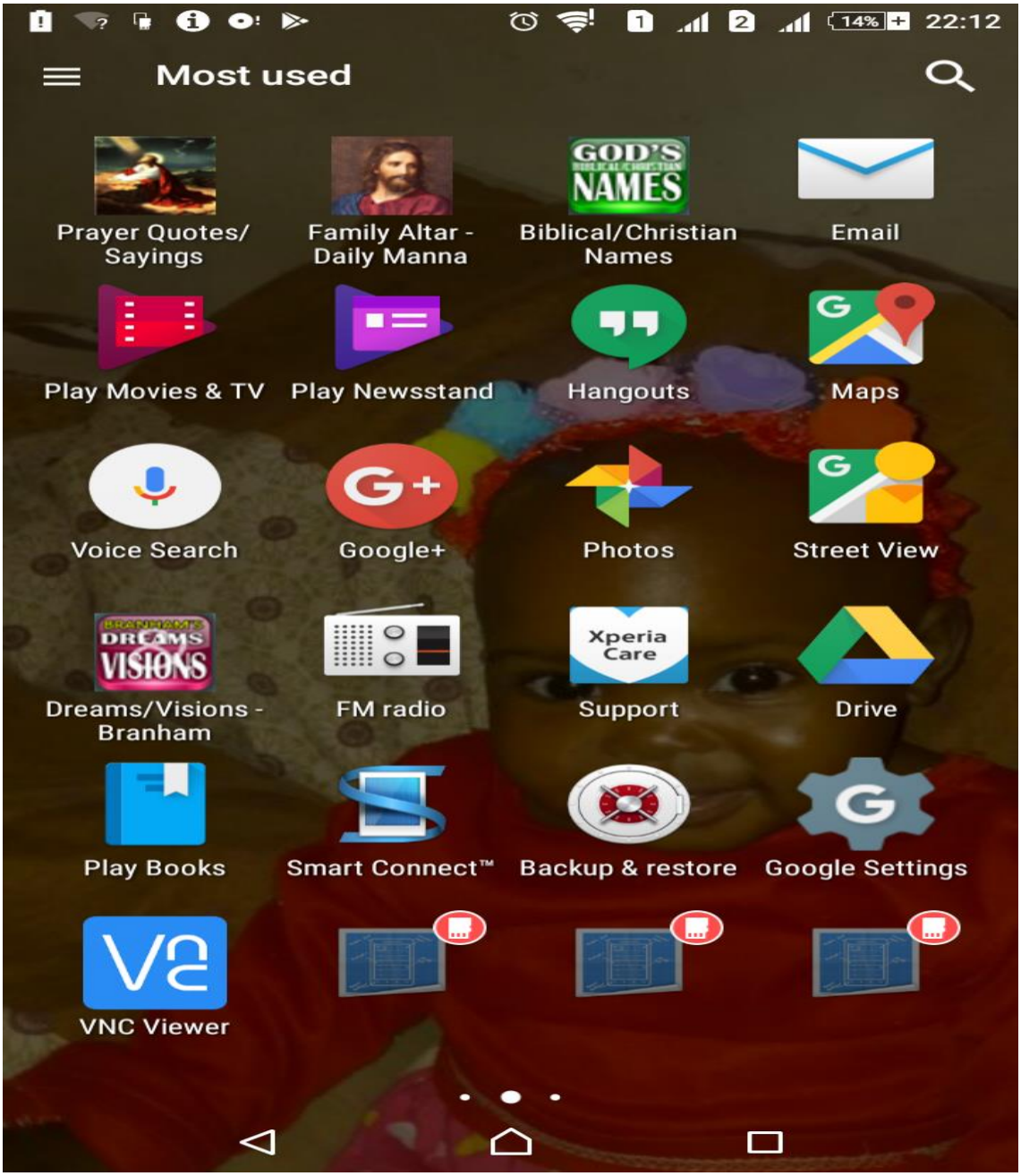

Fig 4.8 VNC Viewer Application on mobile phone

CHAPTER 5: CONCLUSION AND RECOMMENDATIONS

5.1 CONCLUSION

Connection of people to processes and machines though the Internet of Things (IoT) is of paramount importance to all operators and managers. This is achievable through the use of SCADA. Trends, processes variable, alarms and history of alarms, key performance indicators make monitoring and controlling easier.

The increase in distance, and machine processes moving to remote sites has created the need for remote controlling of machinery. This however leads to long range communication technologies to be considered. Cellular kind of remote operation has taken over in recent years. Proper selection of cellular hardware network configurations, data filtering with right protocols have been considered in terms of cost-effectiveness they bring about. [12]

5.2 RECOMMENDATIONS

Cellular communication is facilitated by the use of routers, gateways and cellular modems for remote data collection systems. Their configuration are easily done with gateway having modem functions, Network Address Translations (NAT) router, VPN and modem functionality installed on it. A continuous connection, for gateways is much of a prerequisite to its design. But there is a cellular router which has more managerial functions and capabilities.

In the design of cellular gateways, they must have that ability to stand harsh conditions in industrial environment. The gateways must t have 4G connectivity, encompassed with future-roof designs. There is also need of 2G, 3G capabilities to accommodate remote locations without LTE. Power consumption must be reasonably minimum so as to reduce impacts on power [13]systems.

5.2.1 Secure wireless communications

SCADA security on cellular gateways by use of identification on networks which is the IP network with cyber security features. This features include VPNs and encryption with their ability to run multiple and concurrent VPN sessions. This aid them to control multiple SCADA systems and any other control network system.

Though cellular gateways area good option in presence of cellular service, its data usage must considered wisely.

5.2.2 Transmission reliability and efficiency

Data usage must be limited in cellular but also being efficient at the same time. This helps controlling spiraling of usage costs in data collection for SCADA systems. Use of proper protocols must be taken into account with their efficient use.

Taking into account Transmission Control Protocol (TCP), they are not suitable for SCADA communications which cellular network due to read, confirm and response requirements of the protocol. Such requirements, though they are part of Ethernet services in Windows, they cause retransmission of data several times, mainly if the packet length is long and network is poor. Retransmission therefore causes additional traffic which in turn increases cellular data usage. [12]

A remedy to that is to use (UDP) User Dataram Protocol in place of Transmission Control Protocol. Interestingly UDP is another protocol used by Ethernet to send data via the internet. Though less reliable but faster than TCP, because of the elimination of, confirm or provide error proof delivery of the data packets. User Datagram Protocol sends packets as received without resending action on missed data.

5.2.3 DNP3 protocol reduces data usage

Due to lack of data integrity when using UDP, Distributed Network Protocol V3 (DNP3) is used to reliably data packages. It guarantees full data package delivery. It does this by sending data between server and a remote station through the use of Internet Protocol or serial connections. This protocol is commonly used in industrial networks [12]

An assurance and reliable data delivery is guaranteed by having the local machine verify data received and understanding the Internet Protocol data sent to it. With its introduction of DNP3, data compromise is more inherent to the network. Nevertheless it designed for a more robust network and reliable communication.

It comes with some best protocol abilities and combinations such as time-stamped data, unsolicited reporting, quality alerts and multiple data compatibilities. For its efficiency in data usage, the protocol reads changes in data ‘thus no need to read all the data carried each time changes are reported to the SCADA.

5.2.4 Sends the important data

By using data server protocols, when it comes to the cellular communication, there is need of data filtering. Using a SCADA system, the HMI is equipped with the filters which carry the function of sending vital information. Also SCADA, with the same function can connect to a local historian and compress data for efficient storage in the data base. [12] [5]

For SCADA systems, cellular communication is rendered the best but great consideration on data size for transmission, and by this HMIs are capable of controlling the data size, storage and transmission and making a SCADA system less expensive.

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