PLC and SCADA Based Smart Distribution System

Submitted in partial fulfillment of the requirement of the degree of

BACHELOR OF ENGINEERING

in

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by

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Under the guidance of

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(Affiliated to University of Mumbai)

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Affectionately Dedicated

To My Beloved

Family,

Professors

&

Friends

Who Always Sacrifies Their Happiness

To Make Me Happy

CERTIFICATE

This is to certify that **Mr.Shaikh Mohammed Hamza (11EE43)**has satisfactorily carried out the dissertation work entitled **“PLC and SCADA based Smart Distribution System”** and submitted in the partial fulfillment of the requirement for the award of the degree of **Bachelor of Engineering** in **Electrical**to the **University of Mumbai.**

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DECLERATION

I declare that this written submission represents my ideas in my own words and where others' ideas or words have been included, I have adequately cited and referenced the original sources. I also declare that I have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in my submission. I understand that any violation of the above will be cause for disciplinary action by the Institute and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

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ABSTRACT

In today's world most of the systems are operate on automation. Because of that the automotive systems are most efficient. Automation means use of Programmable Logic Controller (PLC) & Supervisory Control And Data Acquisition (SCADA) instead of electromechanical devices. PLC & SCADA based distribution monitoring & control means use of automotive system in electrical distribution system for monitoring the electrical parameters (like voltage, current, power factor, etc) & controlling if any fault occurs in electrical system with the help of personal computer (PC).

Electric power distribution system is an important part of electrical power systems in delivery of electricity to consumers. Automation in the distribution field allows utilities to implement flexible control of distribution systems, which can be used to enhance efficiency, reliability, and quality of electric service. Presently, worldwide research and development efforts are focused in the areas of communication technologies revolution and application of IEC 61850 protocol in the distribution automation to make distribution automation more intelligent, efficient and cost effective.

This report has proposed a model that illuminates the categories of data, functionality, and interdependencies present in a SCADA system. Main concept of the project is data acquisition and controlling by using SCADA software PLC. Here PLC is a medium between electrical system and Personal Computer for SCADA to take input and output bits.By using the parameters, we can easily control any load in our system to improve system operation, system reliability, etc. alternatively, SCADA and PLC communication system make it possible to integrate protection control and monitoring electrical parameter together for maximum benefit. It also discusses about the present implantation philosophies and current challenges in the distribution system automation. Further, EPRI 'IntelliGrid' project is discussed as an example of advance distribution system automation. Finally, communication aided advanced distribution system automation and its advantages are explained in detail.

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Abbreviations

AC	Alternating Current
ALS	Automatic Load Shedding
AMR	Automatic Meter Reading
DMS	Demand Side Management
DAS	Distribution Automation System
ADA	Advanced Distribution Automation
QoS	Quality of Service
GM	General Motor
LT	Low Tension
CPU	Central Processing Unit
CB	Circuit Breaker
DC	Direct Current
EEPROM	Electrically Erasable Programmable Read Only Memory
kV	kilo Volt
DA	Distribution Automation
I/O	Input / Output
ms	milli second
P2P	Peer-to-Peer
VDC	Direct Current Voltage
VAC	Alternating Current Voltage
EMS	Energy Management System
GUI	Graphical User Interfaces
GSM	Global System for Mobile Communications
GPRS	General Packet Radio Service
HMI	Human-Machine Interface
MMI	Man-Machine Interface
GUI	Graphical User Interface
HTML	Hyper Text Markup Language
IED	Intelligent Electronic Device
IEC	International Electro-technical Commission
ISO	Isolator
IAP	Intelligent Alarm Processors
ISC	Industrial Control System
LabVIEW	Laboratory Virtual Instrument Engineering Workbench
LED	Light Emitting Diode
LTC	Load Tap Changer
MMI	Man-Machine Interfaces
PLC	Programmable Logic Controllers

PDF	Portable Document Format
PC	Personal Computer
PCSProcess Control System	
PCB	Printed Circuit Board
RTU	Remote Terminal Units
RLL	Relay Ladder Logic
RAM	Random Access Memory
ROM	Read Only Memory
SCADA	Supervisory Control And Data Acquisition
SMPS	Switched-Mode Power Supply
TTL	Transistor–Transistor logic
VSAT	Very Small Aperture Terminal
WAN	Wide Area Network
TREND	Towards Real Energy Efficient Network design

Chapter 1

Introduction

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. Application of automation in distribution power system level can be define as automatically monitoring, protecting and controlling switching operations through intelligent electronic devices to restore power service during fault by sequential events and maintain better operating conditions back to normal operations.

Power management is an important constraint in the design of various loads in industries for automation. So if power consumption increases then the substation monitoring is very important for the purpose of controlling the hardware and software optimization with the help of PLC ladder logic system and SCADA were used. This technique in order to reach strong conclusion about their actual impact on the power grid monitoring and control without manpower. In Distribution System many relays and circuit breakers are used. Whenever there is less power generation because of the problems, we can monitor and control through SCADA windows. In power distribution management project, the computer is used for assigning the priority for various loads. The signals are given to the computer of the electricity board where there is the electronic control unit which controls the sequence of disconnecting the load. On basis of controls from the computer the relays or breakers are managed and in computer the SCADA system is installed which is used for monitoring and control. If there any problem occurs in plant, we can easily identify which part is under fault. After that we can troubleshoot the problem through manpower and monitor the substation.

The purpose of the project is to develop an (ALS) Automatic Load Shedding management system. This will ensure that the load shedding will not affect the activities which have high priority. Thus the devices are programmed to function based on their priorities whenever there is less power generation.

Chapter 2

Literature Review

There have been so many researches done in the theoretical and application field of PLC, SCADA and Distribution System which are briefly discussed in this chapter.

In [1], D.Gruenemeyerexplained the definition of distribution automation system, three different zones in which distribution automation is implemented and advantages of automation system inApr. 1991

In [2], A. Pahwa explained the limitation of present automation techniques used in the field, challenges of implementing new technologies is discussed. Implementation and benefits of Distribution Automation is also discussed in detail.

In [3], As the technology advances, there are possible solutions to develop advanced distribution automation system. The requirements and implementation of Advanced Distribution Automation (ADA) is explained.

In [4], V.K. Mehta, Rohit Mehta, PRINCIPLES OF POWER SYSTEM, presented in his book regarding requirements of distribution system and its objectives.

In [5], Matthaias Seitz explained the basics of Programmable Logic Controller, its features and functions.

In [6], Wang Huazhong explained the basics of Supervisory Control and Data Acquisition (SCADA) system, its features, functions and application.

In [7],Warren C. New presented the idea of load shedding management using Solid State and Electromechanical Underfrequency Relays.

In [8], The principle operation of PLC and its applications in various field are explained in details by John W. Webb

In [9], The present philosophies of the EPRI's IntelliGrid Project based on distribution automation system are explained.

In [10], Shalini Sunil Kumar presented the research paper on "Working Phases of SCADA System for Power Distribution Networks".

In [11], Khin Thu Zar Win 1, Hla Myo Tun 2 presented the International journal of advanced research on "Design And Implementation Of SCADA System Based Power Distribution For Primary Substation".

In [12], Santhosh B.Belekar, presented the multidisciplinary journal of research on "PLC and SCADA based distribution monitoring and control".

In [13], Prof. Sachchidanand of IIT Kanpur presented the research paper on "Electrical Distribution System" in 1999.

In [14], K. Ghoshal explained the importance of SCADA in Distribution Automation and presented the research paper on the same in January1997.

In [15], Complete theory of Programmable Logic Controller (PLC), its advantages and applications are explained in detail.

In [16], Complete theory of Supervisory Control And Data Acquisition (SCADA) system, its advantages and applications are explained in detail.

In [17], PLC programming software "SELPRO" is explained in detail.

In [18], SCADA software "NI LabView" used in the implantation of project is explained in detail.

In [19], Specifications and dimensions of the PLC module used in the project are given.

From the reading of the above literatures it was found that PLC and SCADA based Smart Distribution System are not guaranteed to find the global optimum solution to a problem, but they are generally good at finding acceptably good solutions to problems acceptably quickly.

Chapter 3

Programmable Logic Controller

In this Chapter we have discussed the basics of PLC, it's Block Diagram and features. The PLC module of our Project is also described in brief.

Fig. 3.1: Programmable Logic Controller

A **programmable logic controller**, **PLC**, or **programmable controller** is a digital computer used for automation of typically industrial electromechanical processes, such as control of machinery on factory assembly lines, amusement rides, or light fixtures. PLCs are used in many machines, in many industries. PLCs are designed for multiple arrangements of digital and analog inputs and outputs, extended temperature ranges, immunity to electrical noise, and resistance to vibration and impact. Programs to control machine operation are typically stored in battery-backed-up or non-volatile memory. A PLC is an example of a "hard" real-time system since output results must be produced in response to input conditions within a limited time, otherwise unintended operation will result.[15]

3.1 Features

- ✓ Compact PLC
- ✓ Configurable LED display
- ✓ Window based software
- ✓ program for configuration
- ✓ **Size:** 48mm*96mm [19]

Control panel with PLC (grey elements in the center). The unit consists of separate elements, from left to right; power supply, controller, relay units for in- and output

The main difference from other computers is that PLCs are armored for severe conditions (such as dust, moisture, heat, cold), and have the facility for extensive input/output (I/O) arrangements. These connect the PLC to sensors and actuators. PLCs read limit switches, analog process variables (such as temperature and pressure), and the positions of complex positioning systems. Some use machine vision. [1] On the actuator side, PLCs operate electric motors, pneumatic or hydraulic cylinders, magnetic relays, solenoids, or analog outputs. The input/output arrangements may be built into a simple PLC, or the PLC may have external I/O modules attached to a computer network that plugs into the PLC.[19]

Scan time:

A PLC program is generally executed repeatedly as long as the controlled system is running. The status of physical input points is copied to an area of memory accessible to the processor, sometimes called the "I/O Image Table". The program is then run from its first instruction rung down to the last rung. It takes some time for the processor of the PLC to evaluate all the rungs and update the I/O image table with the status of outputs.[19] This scan time may be a few milliseconds for a small program or on a fast processor, but older PLCs running very large programs could take much longer (say, up to 100 ms) to execute the program. If the scan time were too long, the response of the PLC to process conditions would be too slow to be useful.

As PLCs became more advanced, methods were developed to change the sequence of ladder execution, and subroutines were implemented. [19] This simplified programming could be used to save scan time for high-speed processes; for example, parts of the program used only for setting up the machine could be segregated from those parts required to operate at higher speed.

Special-purpose I/O modules may be used where the scan time of the PLC is too long to allow predictable performance. Precision timing modules, or counter modules for use with shaft encoders, are used where the scan time would be too long to reliably count pulses or detect the sense of rotation of an encoder. The relatively slow PLC can still interpret the counted values to control a machine, but the accumulation of pulses is done by a dedicated module that is unaffected by the speed of the program execution.

System scale:

A small PLC will have a fixed number of connections built in for inputs and outputs. Typically, expansions are available if the base model has insufficient I/O.

Modular PLCs have a chassis (also called a rack) into which are placed modules with different functions. The processor and selection of I/O modules are customized for the particular application. Several racks can be administered by a single processor, and may have thousands of inputs and outputs. A special high-speed serial I/O link is used so that racks can be distributed away from the processor, reducing the wiring costs for large plants.[19]

User interface:

PLCs may need to interact with people for the purpose of configuration, alarm reporting, or everyday control. A human-machine interface (HMI) is employed for this purpose. HMIs are also referred to as man-machine interfaces (MMIs) and graphical user interfaces (GUIs). A simple system may use buttons and lights to interact with the user. Text displays are available as well as graphical touch screens. More complex systems use programming and monitoring software installed on a computer, with the PLC connected via a communication interface. [19]

Communications:

PLCs have built-in communications ports, usually 9-pin RS-232, but optionally EIA-485 or Ethernet. Modbus, BACnet, or DF1 is usually included as one of the communications protocols. Other options include various fieldbuses such as DeviceNet or Profibus. Other communications protocols that may be used are listed in the List of automation protocols.

Most modern PLCs can communicate over a network to some other system, such as a computer running a SCADA (Supervisory Control And Data Acquisition) system or web browser.

PLCs used in larger I/O systems may have peer-to-peer (P2P) communication between processors. This allows separate parts of a complex process to have individual control while allowing the subsystems to co-ordinate over the communication link. These communication links are also often used for HMI devices such as keypads or PC-type workstations.[19]

Formerly, some manufacturers offered dedicated communication modules as an add-on function where the processor had no network connection built-in.

Programming

PLC programs are typically written in a special application on a personal computer, then downloaded by a direct-connection cable or over a network to the PLC. The program is stored in the PLC either in battery-backed-up RAM or some other non-volatile flash memory. Often, a single PLC can be programmed to replace thousands of relays. [19]

3.2 Block Diagram of PLC:

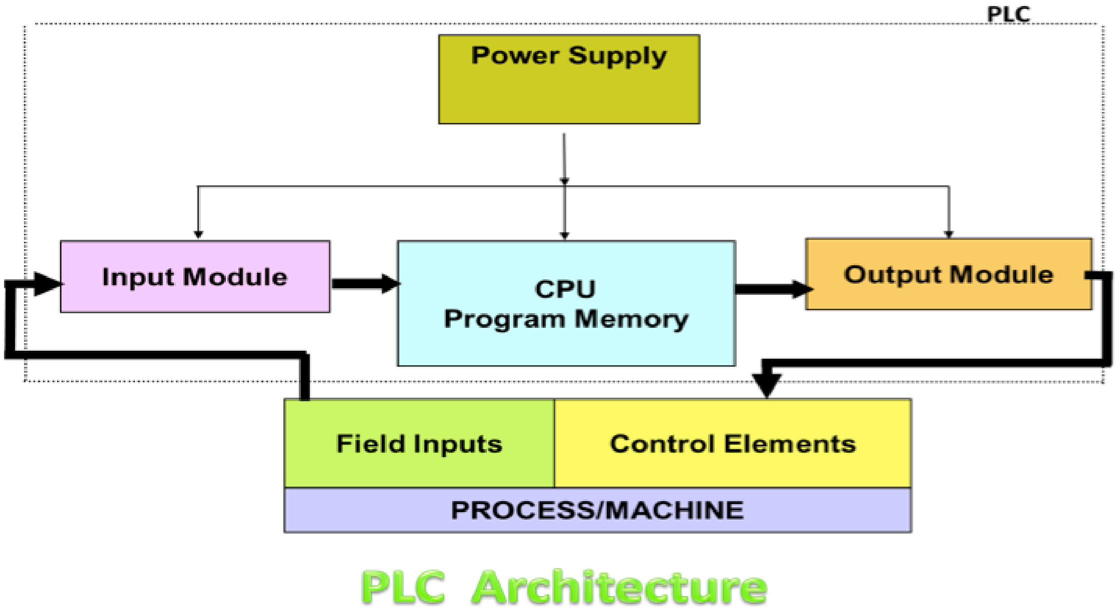


Fig. 3.2:PLC Architecture

A Programmable Controller is a **specialized computer**. Since it is a computer, it has all the basic component parts that any other computer has a Central Processing Unit, Memory, Input Interfacing and Output Interfacing.[8] A typical programmable controller block diagram is shown below:

- **The Central Processing Unit (CPU)** is the control portion of the PLC.
  1. It interprets the program commands retrieved from memory and acts on those commands.
  2. In present day PLC's this unit is a microprocessor based system.
  3. The CPU is housed in the processor module of modularized systems.

- **Memory** in the system is generally of two types: ROM and RAM.

  1. The ROM memory contains the program information that allows the CPU to interpret and act on the Ladder Logic program stored in the RAM memory.
  2. RAM memory is generally kept alive with an on-board battery so that ladder programming is not lost when the system power is removed.
  3. This battery can be a standard dry cell or rechargeable nickel-cadmium type.

4. Newer PLC units are now available with Electrically Erasable Programmable Read Only Memory (EEPROM) which does not require a battery.
5. Memory is also housed in the processor module in modular systems.[8]

- **Input units** can be any of several different types depending on input signals expected as described:

1. The input section can accept discrete or analog signals of various voltage and current levels.
2. Present day controllers offer discrete signal inputs of both AC and DC voltages from TTL to 250 VDC and from 5 to 250 VAC.
3. Analog input units can accept input levels such as ±10 VDC, ±5 VDC and 4-20 ma. Current loop values.
4. Discrete input units present each input to the CPU as a single 1 or 0 while analog input units contain analog to digital conversion circuitry and present the input voltage to the CPU as binary number normalized to the maximum count available from the unit.
5. The number of bits representing the input voltage or current depends upon the resolution of the unit.
6. This number generally contains a defined number of magnitude bits and a sign bit.

- **Output units** operate much the same as the input units with the exception that the unit is either sinking (supplying a ground) or sourcing (providing a voltage) discrete voltages or sourcing analog voltage or current.

1. These output signals are presented as directed by the CPU. The output circuit of discrete units can be transistors for TTL and higher DC voltage or Triacs for AC voltage outputs.
2. For higher current applications and situations where a physical contact closure is required, mechanical relay contacts are available.
3. These higher currents, however, are generally limited to about 2-3 amperes.
4. The analog output units have internal circuitry which performs the digital to analog conversion and generates the variable voltage or current output. [8]

Extending PLC:

- Every PLC controller has a limited number of input/output lines.
- If needed this number can be increased through certain additional modules by system extension through extension lines.
- Each module can contain extension both of input and output lines.
- Also, extension modules can have inputs and outputs of a different nature from those on the PLC controller (ex. in case relay outputs are on a controller, transistor outputs can be on an extension module) [8]

3.3Terminal Connections and Features of PLC used in Project

PLC

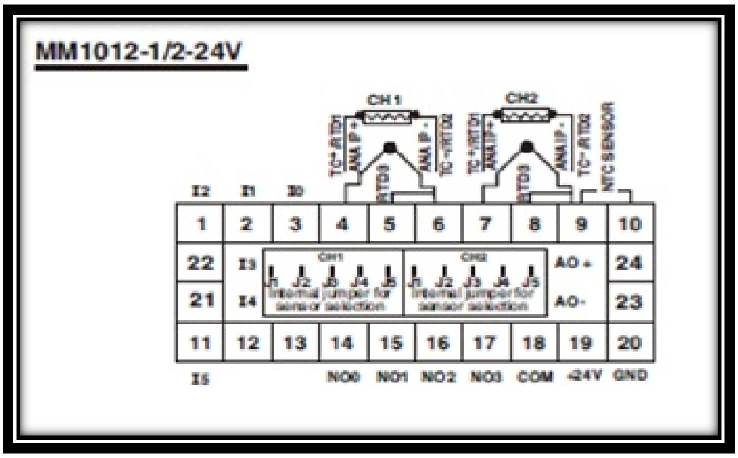


Fig. 3.3: Terminal Connections of PLC [19]

Functional Features

Timer Operational Modes	On Delay, Off Delay, Pulse, Special [Up/Down] Timer
Timer Resolution	1 ms (Accurate only for 1 msec Timer block)
Timer Display Format	Sec, Min, Hr, Day, Min.Sec, Hr.Min, Day.Hr.
Counter	Up Counter, Down Counter, Up/Down Counter, Special Up Down Counter
Other Blocks	PID Control with Autotune, Analog input, Rampsoak, FTC, Analog Output, Hysterisis, Scaling.
Memory Retention	10 years (4k memory)
RTC	No

Supply Voltage

Supply Voltage [As per product selection]	180 - 270V AC, 50Hz 18 - 30V DC

Environmental Specifications

Temperature	Operating : 0 to 50 °C Storage : -20 to 60 °C
Humidity (non-condensing)	95% RH
Weight	258gms

Output Specifications

Digital Output - Relay		
Contact Rating	NO type :	3A resistive @ 230V AC [For MM101X-24V] 5A resistive @ 230V AC
Isolation	2.5kV	
Analog Output		
Output Type	**Current** - 0-20mA **Voltage** - 0-10V	
Resolution	14.5 bits	
Conversion time	20 msec	
Linearity error	0.1%	

Functional Specifications:

Programming Method	Windows based software for ladder programming and HMI configuration.
Memory	Data memory: 16 kbytes Code memory: 223 kbytes
Max. no. of Objects	5000 (As per memory)
Minimum Scan Time	200 µsec
Typical Scan Time	1 ms

Communication:

Communication Ports	RS485 port [slave]
Communication Protocol	MODBUS RTU

Fig. 3.4: PLC Specifications [19]

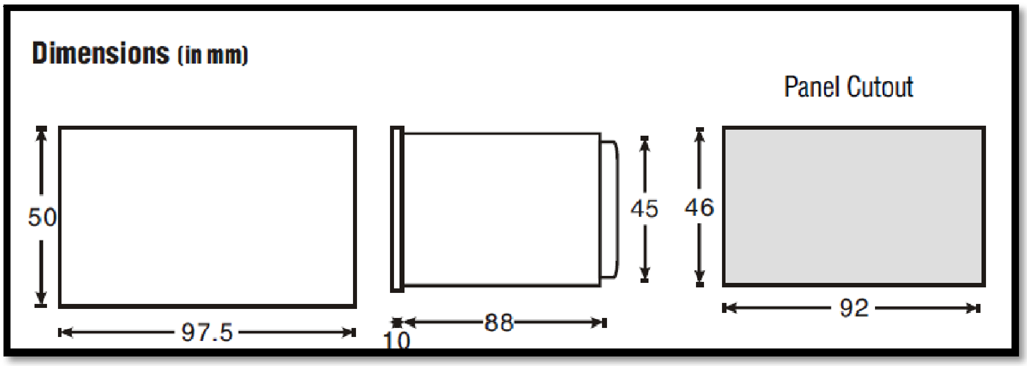


Fig. 3.5: PLC Dimensions [19]

Chapter 4

Supervisory Control And Data Acquisition

In this Chapter we have discussed the basics of SCADA, it's Block Diagram and features. The design example of our project is also described in brief.

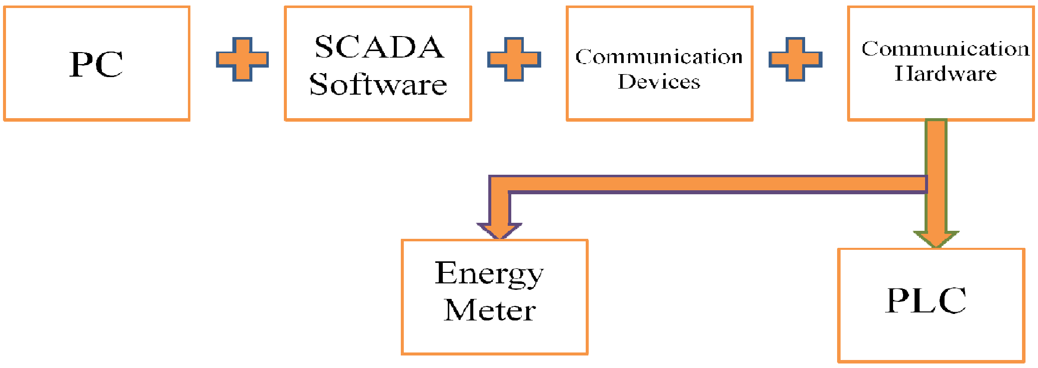


Fig. 4.1Simple SCADA Block Diagram

SUPERVISORY CONTROL AND DATA ACQUISITION – we more frequently call it as SCADA. As the name implies SCADA system supervises, acquires and control data received from a distant data source from the control center. SCADA system is located in the control center and is operated in the scanning mode, communicating between the CONTROL CENTER and the REMOTE STATION by means of two-way communication channels. Such a supervisory control and data acquisition system is intended to facilitate the work of operator by acquiring and compiling information as well as locating, identifying and reporting faults. On the basis of information received, the operator makes necessary decisions via the control system he can then perform different control operations in power stations or influence the processing of the information acquired. The main task of a modern day power system is to ensure quality and reliable power at an economic rate. Hence the system is to be updated at a very fast rate (real time mode/management), which helps to control the complex system effectively without any loss of time.[16]

4.1Two-Way Communication Channels Between The Master Control Centre And Remote Control Centre

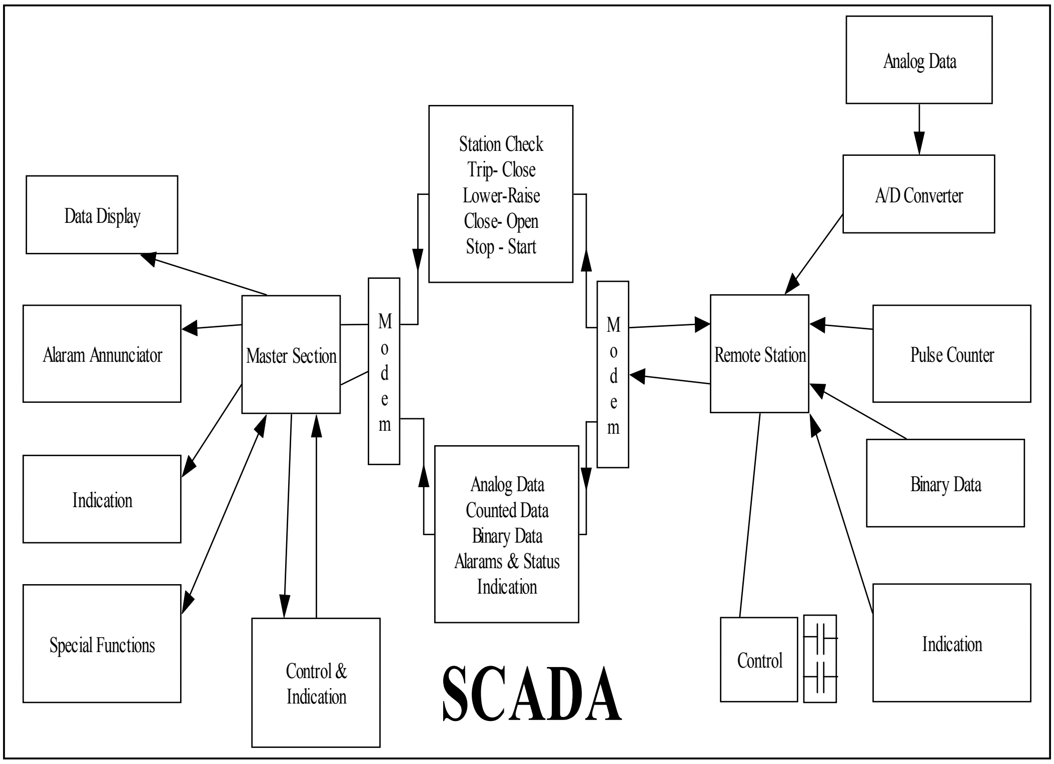


Fig: 4.2 Two Way Communication Channel

Traditionally, the SCADA systems were used for scanning mode, providing data regarding generating stations, generating units, transformer sub-stations etc. Traditional hard wired SCADA systems were arranged to perform several functions to supplement Automatic Control and Protection Systems.

Now a day's protective relays, control relays and control systems are used for automatic control of generating stations and transmission systems along with SCADA. Only initiating devices may be different or omitted with fully automatic SCADA control. For example, tap changing may be initiated either by the sub-section control room operator or by the automatic voltage control relays connected in the protection panel of the transformer.[16]

Controls systems were arranged to keep the values of controlled quantities within target limits. Protection equipments were arranged for sounding alarms and for tripping circuit-breakers. With the recent revolution in microprocessor technology, the size, performance and cost of digital automation systems have become acceptable in commercial installation. SCADA provides integrated approach to power system protection, operation control and monitoring, automatically with least intervention of the control room operator.[16]

The microprocessors located in the master station, generating stations, transmission sub-stations and distribution sub-stations provide control and protection decisions locally where the data is located. The action is reported to the operator "by exception". The operator retains the option of taking intervening action of overriding or initiating of his own. All these microprocessor based systems are connected through the GLOBAL POSITIONING SYSTEM. The functions and architecture of SCADA system is selected in accordance with the functional requirements and size of the power system.

4.2 Features of SCADA

Tracker Option: This feature provides collection and storage of variety pertaining to the serialized items such as time stamps, quality measurements, temperature, humidity, pressure, sub- assembly part number etc through various automated sensors and readers like bar code readers, radio frequency tags, mechanical tag based system. This information is used for over viewing the flow of serialized items and the location of materials through the system which helps in isolating the defective items from the perfect ones. For example boxes or containers over a specified weight limit may be routed to different storage area.[6]

Simulator option: SCADA system contains in it the simulator option, which allows the operator to have a hand-on experience in dealing with the day-to-day problem occurring in the plant by creating the environs similar to that of the main process. The operators can be trained in this artificial fault environment, which helps in understanding the plant operation in better version.

Data import/export function: This feature allows the transfer of all the point configuration data via a 'comma separated variable' file. Points are the representation of actual field parameters; these are the variables in which the actual incoming data is stored. Similarly point configuration can be sent to other SCADA system for their use over their. This is made possible through data import/export facility. Data management is possible using MS EXCEL, MS ACCESS etc.

Flexibility: This feature provides tools by which an existing system could be tailored according to the changes taking place. Thus the user can mould the system according to the demands thus making it more flexible.

Forecasting: Forecasting is the ability to predict future state of the system by studying previously collected data. Forecasting feature of SCADA system allows the operator to visualize the state of the system well in advance, hence the operator has enough time to manage the system properly. This feature of SCADA finds a huge application in Energy Management System

Job Management: Using SCADA all the tasks can be properly sequenced and executed to allow the most efficient task scheduling for proper utilization of man and machinery of plant. Thus ensuring the most optimum utilization of the resources. And hence, the conformance to international standards of safety and security of the plant and personnel is also ensured.[6]

The present day Supervisory Control and Data Acquisition (SCADA) systems consisting of SCADA hosts, Remote Terminal Units (RTUs) and field devices monitor and control process equipment and systems from multiple locations and exchange data from various distributed control systems along the local and wide area networks.

Main concept of our project is “Data Acquisition and Control using PC". We are going to read the electrical data by the use of PLC and SCADA. Then the entire data will be displayed on SCADA. According to the readings controlling actions will be taken by the operator.

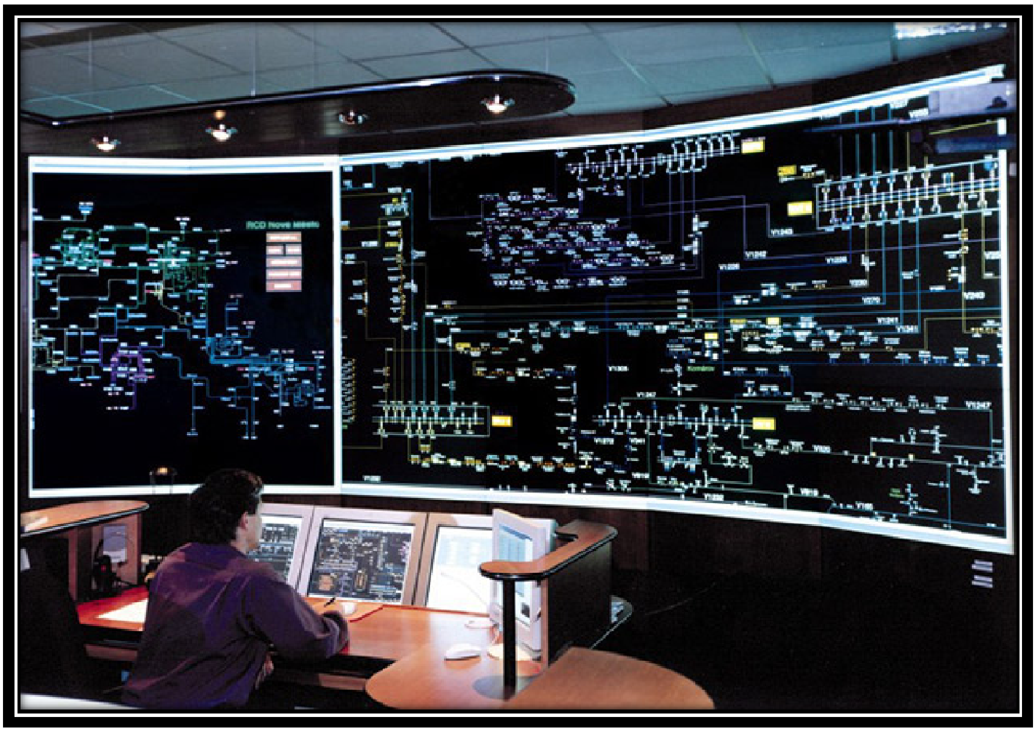


Fig: 4.3 SCADA as a heart of Distribution management System

4.3 Functions of SCADA

- **Data Acquisition-**Furnishes status information & measured data to operator.
- **Control -**Allows the operator to control the devices e.g. circuit breakers, Transformer tap changer etc. from a remote centralised location.
- **Data Processing -**Includes data quality & integrity check, limit check, analog value processing etc.
- **Tagging-** Operator identifies any specific device & subjects to specific operating restrictions to prevent from unauthorized operation.
- **Alarms -**Alerts the operator of unplanned events & undesirable operating conditions in the order.
- **Logging-**Logs all operator entries, alarms &selected entries.
- **Trending-**Plots measurements on selected scale to give information on the trends e.g. one minute, one hour etc.
- **Historical Reporting -**To save & analyze the historical data for reporting, typically for a period of 2 or more years & to archive.[6]

4.4Functional Units of SCADA

Following equipments perform the above functions;

1. *Data collection equipment.*
2. *Data transmission / telemetric equipment.*
3. *Remote terminal unit.*
4. *Data loggers.*
5. *Data presentation equipments.*

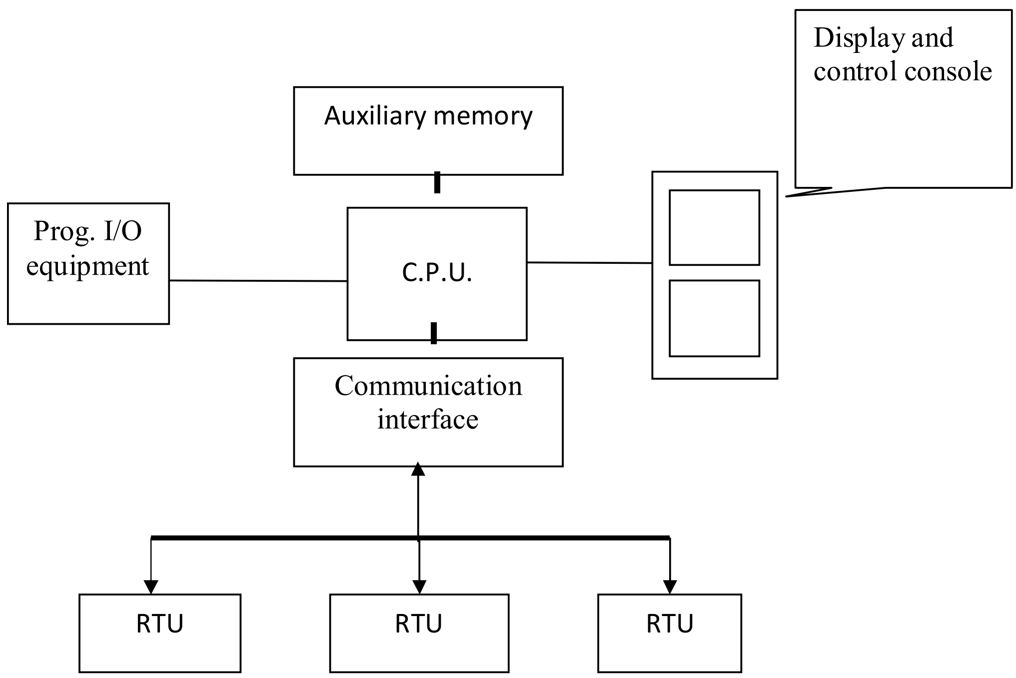


Fig: 4.4 Simple SCADA system with single computer

The figure shown below represents the simplest SCADA configuration employing single computer; Computer receives data from RTUs via the communication interface.

Operators control base one or more CRT terminals for display. With this, terminal it is possible to execute supervisory control commands and request the display of data in alpha-numerical formats arranged by geographical location and of type. The programming input/output is used for modifying the supervisory software. In the basic SCADA system, all the programs and the data is stored in the main memory. The more sophisticated version of SCADA has additional auxiliary memories in the form of magnetic disc units.[6]

4.4.1 Common system components

A SCADA system usually consists of the following subsystems:

- **Remote terminal units (RTUs)** connect to sensors in the process and convert sensor signals to digital data. They have telemetry hardware capable of sending digital data to the supervisory system, as well as receiving digital commands from the supervisory system. RTUs often have embedded control capabilities such as ladder logic in order to accomplish boolean logic operations.
- **Programmable logic controller (PLCs)** connect to sensors in the process and convert sensor signals to digital data. PLCs have more sophisticated embedded control capabilities (typically one or more IEC 61131-3 programming languages) than RTUs. PLCs do not have telemetry hardware, although this functionality is typically installed alongside them. PLCs are sometimes used in place of RTUs as field devices because they are more economical, versatile, flexible, and configurable.
- **A telemetry system** is typically used to connect PLCs and RTUs with control centers, data warehouses, and the enterprise. Examples of wired telemetry media used in SCADA systems include leased telephone lines and WAN circuits. Examples of wireless telemetry media used in SCADA systems include satellite (VSAT), licensed and unlicensed radio, cellular and microwave.
- **A data acquisition server** is a software service which uses industrial protocols to connect software services, via telemetry, with field devices such as RTUs and PLCs. It allows clients to access data from these field devices using standard protocols.
- **A human–machine interface** or **HMI** is the apparatus or device which presents processed data to a human operator, and through this, the human operator monitors and interacts with the process. The HMI is a client that requests data from a data acquisition server.
- **A Historian** is a software service which accumulates time-stamped data, boolean events, and boolean alarms in a database which can be queried or used to populate graphic trends in the HMI. The historian is a client that requests data from a data acquisition server.
- **A supervisory (computer) system**, gathering (acquiring) data on the process and sending commands (control) to the SCADA system.[6]

4.5 System Description (Simulation Tools)

4.5.1 User Friendly Software

Software Screens are very user friendly.

All Screens will be customized as per plants requirement.[6]

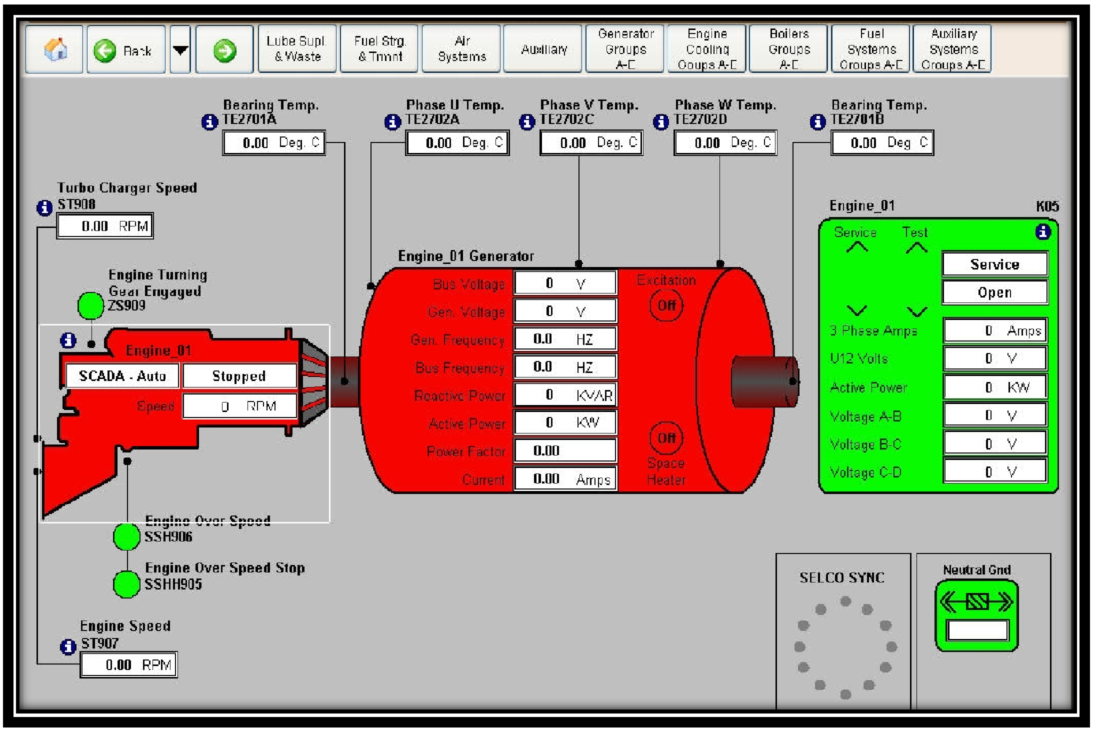


Fig. 4.5 SCADA software screen user friendly

4.5.2 Data Acquisition of full range of parameters

All Parameters which are being measured will be stored in Configured Database.

Parameters may be Line voltage, Line current, Line Frequency, power factor, KW, V-THD, I-THD,KVA,KWH etc.

ID_SAGE_ORG	kconv1	kconv2	NPORG	NPDST
PA10IB--ZRDRE----Fail	1	0	27772	27772
PA10IB--ZZCPP----InFl	1	0	27773	27773
PA10IB--0ZCPP----CmFl	1	0	27774	27774
PA10IB--0ZCPP----InFl	1	0	27775	27775
PA10TR1--PDIF----Fail	1	0	27776	27776
PA10TR1-ZZCPP----CmFl	1	0	27777	27777
PA10TR1-ZZCPP----InFl	1	0	27778	27778
PA10TR1-0ZCPP----CmFl	1	0	27779	27779
PA10TR1-0ZCPP----InFl	1	0	27780	27780
PA10TR3--PDIF----CmFl	1	0	27781	27781
PA10TR3--PDIF----Fail	1	0	27782	27782
PA10TR3-ZZCPP----CmFl	1	0	27783	27783
PA10TR3-ZZCPP----InFl	1	0	27784	27784
PA10UTRX-ZTCO----Locl	1	0	27785	27785
PA10UTRX-ZTCO----Remt	1	0	27786	27786
PA10UTRX-ZUTR----CmFl	1	0	27787	27787
PA10UTRX-ZUTR----Fail	1	0	27788	27788
PA10UTRX-ZUTR--02Fail	1	0	27789	27789
PA10UTRX-ZUTR--02Rsrv	1	0	27790	27790
PA10UTRX-ZUTR--01Fail	1	0	27791	27791
PA10UTRX-ZUTR--01Rsrv	1	0	27792	27792

Fig. 4.5 SCADA software screen data acquisition

4.5.3 Real Time Trends

All Parameters which are being measured can be monitored in real time trends.

Trends can be standard as well as customized.

Data can be exported to various formats.

User can select parameters to be displayed in live trend for monitoring.

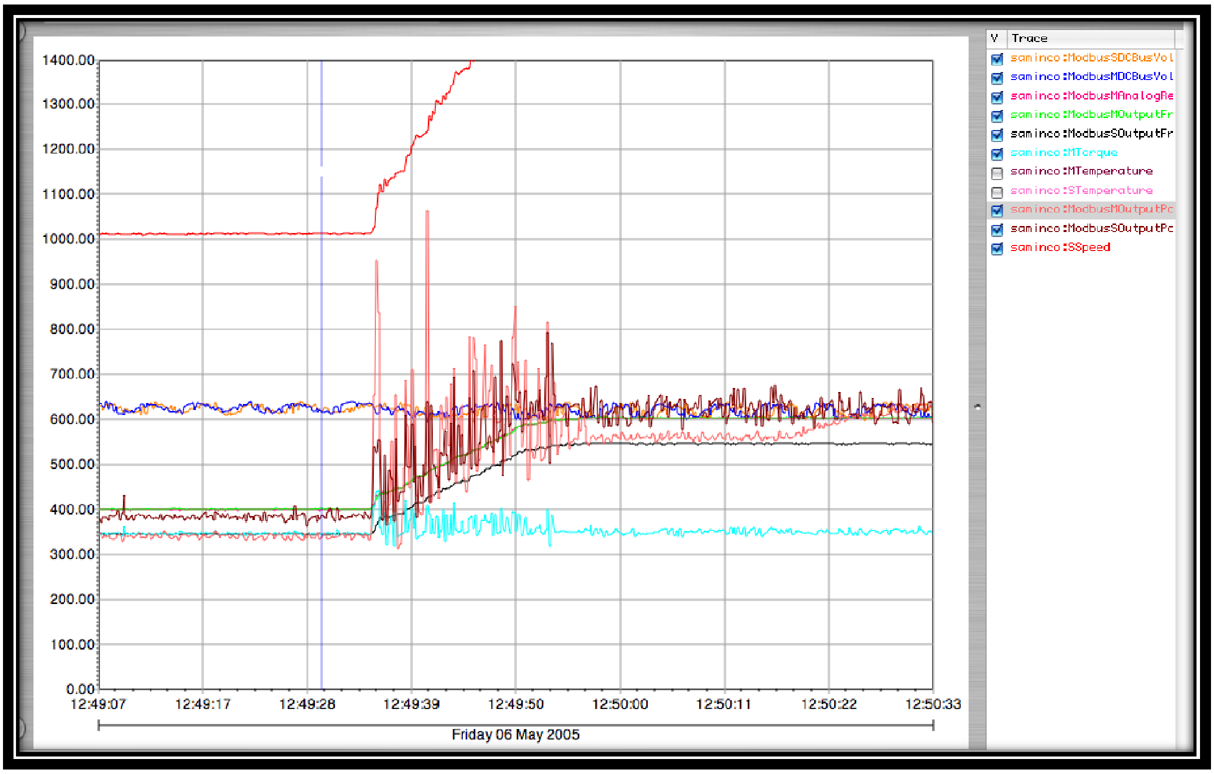


Fig. 4.6 SCADA software screen real time trends

4.5.4 Historical Trends

Historical Data for all parameters can be monitored in Historical trends.

Data can be exported to various formats.

User can select parameters to be displayed in live trend for monitoring.

Fig. 4.7 Historical Trends

4.5.5 Alarms

If any parameter exceeds normal range of value then alarm will be generated.

User can select low and high set point of alarms and customize alarm.

Fig. 4.8 Buzzer Alarm

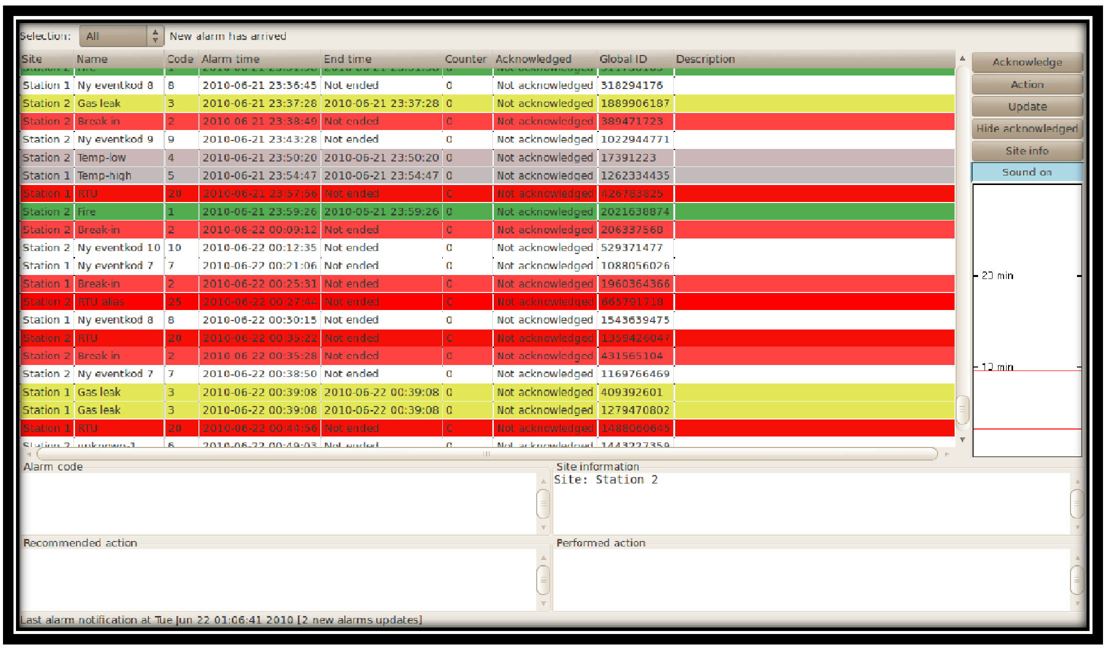


Fig. 4.9 SCADA software screen Alarm

4.5.6 Security

There will be multiple levels of security for different types of operations.

Complete data is fully secured by High level of encryption technology.

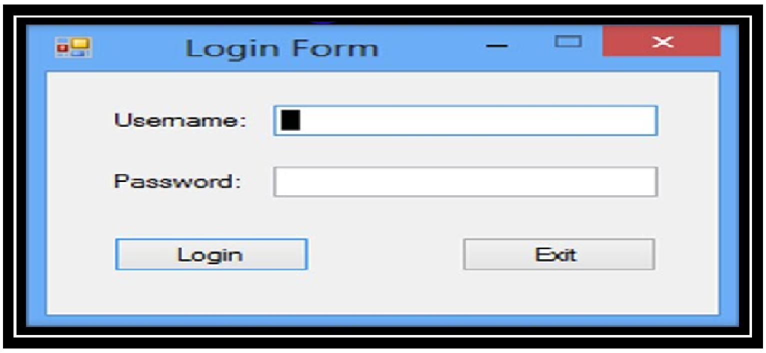


Fig. 4.10 SCADA software screen security

4.5.7 Detailed Reporting

Reports can be generated for selected parameters or for group of parameters.

Reports can be used for observation of Losses considerations.

All Reports can also be exported to various formats including Excel, Word, PDF, HTML etc.

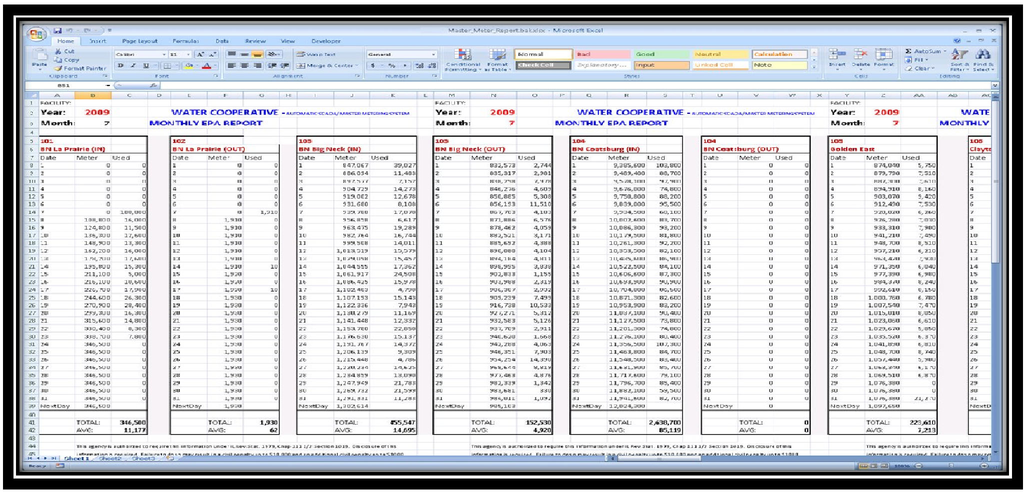


Fig. 4.11 SCADA software screen detailed reporting

4.6 SCADA role in Distribution System

Total plant is monitoring their operation in control room itself. High/Low Alarm is update frequently with respect to the measuring equipments. The graphs are run in the trend window. In this trend we can get the old data for yearly auditing purpose. In any emergency condition, we can shut down the total system. By using this SCADA, we can reduce the man power and time delay of operation.[14]

Advantage Of Proposed Method

- Reduced manpower.
- Time delay is reduced.
- In control room itself monitor the plant and give commands through user.
- Economical and safe operation
- Is there any modification and future extension, we can easily update in PLC & SCADA.
- In substation and Distribution System, many switches are used, if there any one of the switch is trip means we can easily identify the particular area.

Chapter 5

Distribution Automation System

This chapter explains current philosophies for the distribution automation system implementation. Further this chapter also discuss the EPRI's IntelliGrid Project based on distribution automation system.

5.1 Need for Automation in Power Distribution

The demand for electrical energy is ever increasing. Today over 21% (theft apart) of the total electrical energy generated in India is lost in transmission (4-6%) and distribution (15-18%). The electrical power deficit in the country is currently about 18%. Clearly, reduction in distribution losses can reduce this deficit significantly. It is possible to bring down the distribution losses to a 6-8 % level in India with the help of newer technological options (including information technology) in the electrical power distribution sector which will enable better monitoring and control.[13]

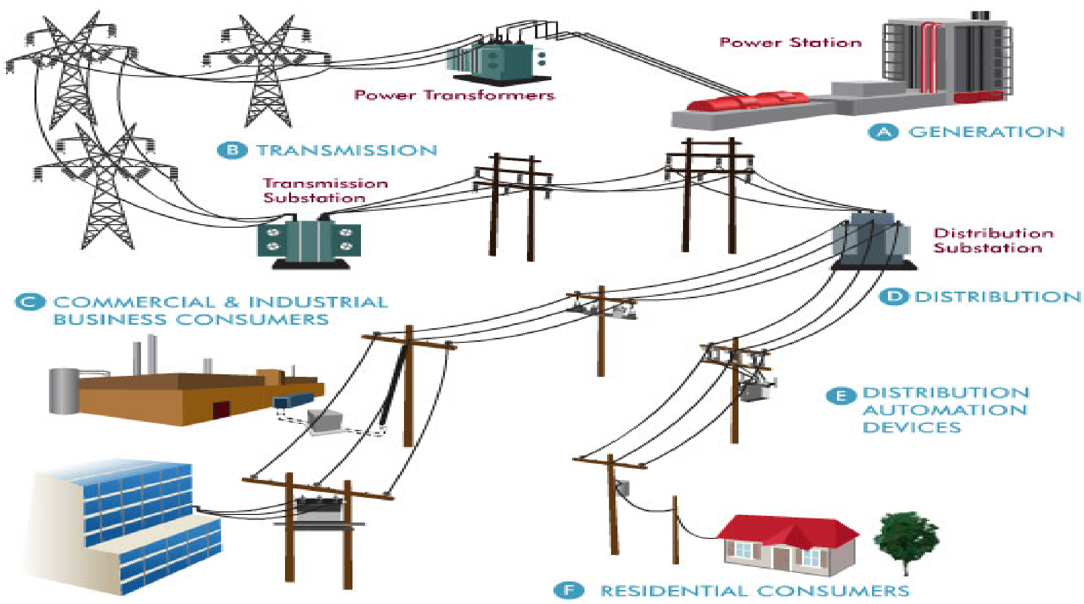


Fig: 5.1 Basic Distribution System

Conventional Load Shedding Approach

This section is a review of load shedding techniques that have been devised over a number of years each having its own set of applications and drawbacks. [7]

A. Breaker Interlock Load Shedding :

This is the simplest method of carrying out load shedding. For this scheme, the circuit breaker interdependencies are arranged to operate based on hardwired trip signals from an intertie circuit breaker or a generator trip. This method is often used when the speed of the load shedding is critical. Even though, the execution of this scheme is fast, breaker interlock load shedding possesses a number of inherent drawbacks:

Load shedding based on worst-case scenario Only one stage of load shedding Almost always, more load is shed than required Modifications to the system are costly

B. Under-Frequency Relay (81) Load Shedding :

Guidelines for setting up a frequency load shedding are common to both large and small systems. The design methodology considers fixed load reduction at fixed system frequency levels. Upon reaching the frequency set point and expiration of pre-specified time delay, the frequency relay trips one or more load breakers. This cycle is repeated until the system frequency is recovered, e.g., 10% load reduction for every 0.5% frequency reduction. Since this method of load shedding can be totally independent of the system dynamics, total loss of the system is an assumed possibility. Additional drawbacks of this scheme are described below. [7]

1) Slow Response Time :

In addition to the time it takes for the frequency to reach the pre-defined settings, there is an intentional time delay setting to prevent nuisance tripping during frequency spikes. Time delay may be further prolonged due to the over-frequency condition that can occur during the fault.

Upon detection of frequency decay and expiration of set time delay, the frequency relay initiates the first stage of load shedding. If the amount of load shed was insufficient, the frequency continues to decay, activating the next stage of load shedding. Each additional stage introduces further delays in the load shedding process.

2) Incorrect / Excessive Load Shedding :

The setting of each frequency relay is usually determined based on the most severe disturbance conditions, and most conservative generation and loading levels. This means excessive load shedding for the majority of conditions that are not as severe.

In response to a dip or rate-of-change in frequency, frequency relays operate a set of fixed circuit breakers, independent of their actual operating load. Some breakers might have a load that may be quite different than the value considered in the studies. Additionally, the sequence of operation of the breakers may not be correct and/or optimal.

3) Analysis Knowledge Is Always Lost :

To determine the frequency relay settings requires simulation of hundreds of transient stability studies. The objective of this analysis is to find the minimum fault clearing time and determine the minimum required load shedding by trial and error methods. The engineer performing the study learns the behavior of the system and can intuitively predict the response of the system under various operating conditions. However, the only study result utilized by the load shedding system is a set of frequency relay settings. All other pertinent analysis results, along with the engineer's knowledge of the system, are lost.

C. Programmable Logic Controller-Based Load Shedding :

With a Programmable Logic Controller (PLC) scheme, load shedding is initiated based on the total load versus the number of generators online and/or detection of under-frequency conditions. Each substation PLC is programmed to initiate a trip signal to the appropriate feeder breakers to shed a preset sequence of loads. This static sequence is continued until the frequency returns to a normal, stable level.

A PLC-based load shedding scheme offers many advantages such as the use of a distributed network via the power management system, as well as an automated means of load relief. However, in such applications monitoring of the power system is limited to a portion of the network with the acquisition of scattered data. This drawback is further compounded by the implementation of pre-defined load priority tables at the PLC level that are executed sequentially to curtail blocks of load regardless of the dynamic changes in the system loading, generation, or operating configuration. The system-wide operating condition is often missing from the decision-making process resulting in insufficient or excessive load shedding. In addition, response time (time between the detection of the need for load shedding and action by the circuit breakers) during transient disturbances is often too long requiring even more load to be dropped.[7]

5.2 Benefits of Distribution Automation System 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 [2]

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

5.3Areas of Distribution Automation System Implementation

The area distribution automation system can be divided into two areas:

A: Distribution Substation and Feeder Automation:

Usually the distribution automation on substation and feeder are integrated to share common monitoring and controlling equipment and devices. Distribution substation automation includes supervisory control of circuit breakers, load tap changers (LTCs), regulators, reclosers, sectionalizers, switches and substation capacitor banks. Remote data acquisition is required in order to achieve effective use of the supervisor control function.[2]

B: Consumer Location Automation:

Automation at the consumer's location includes the ability to remotely: read meters, program time-of-use (TOU) meters, connect/disconnect services, and control consumer loads.

5.4 Distribution Automation System Implementation Philosophies

Implementation philosophies at distribution substation and feeder; and at consumer locations are described as follows:

5.4.1 Distribution Substation and Feeder Automation:

It is generally applied to that element of the distribution system which operates at voltages above 22 kV. Distribution substation and feeder automation also referred to as Primary Distribution automation. Different functions of Primary Automation Technique are listed below. [2]

1) Transformer Load Balancing: Transformer load balance monitoring provides remote access to near real-time information concerning the overall operation of the distribution system. This information can be used on a daily basis to verify the effects of other down line events such as capacitor switching, residential load control, and recloser operations. It is also useful on a periodic basis to fine tune the efficiency of the Utility's power distribution configuration.

2) Voltage Regulation: This feature of DAS offers utility personnel the ability to reduce line voltage during peak demand times by remotely taking control of the Load Tap Changer. It also facilitates the remotely boosting of line voltages above the local LTC settings in case of emergency situations such as back-feeding.

3) Fault Isolation and Sectionalizing: Remote monitoring of the recloser operation to the melting of a fuse link, utilities can detect the fault very fast and can take quick action to clear that fault. Even during the outage of the power supplies distribution automation devices on that line can report the data remotely. By correlating the last voltage or current measured before an outage from several points along the distribution system, an indication of the nature of the fault as well as its approximate location can be obtained.

4) Remote Interconnect Switching: Distribution automation systems can be deployed to drive remotely interconnected switches that separate different portion of the utility distribution feeders. By the use of remote interconnect switching utilities can manipulate their distribution system to provide the most efficient configuration and also will able to remotely restore power to as many consumers as possible during the time of multiple faults.

6) Voltage Monitoring: By monitoring the feeder voltage remotely utility personal gets advance notification about the line voltage drop due to high usage. Also recorded data of feeder voltages will give snapshot of the actual usage patterns.

5.4.2 Consumer Location Automation:

Consumer location is the most challenging application area for the distribution automation system as large numbers of installation points are required and all the points should be economically viable.[2]

1)Load Management: Load management is achieved by local appliance control. It consists of a utility activated relay that interrupts the power consumed by non-critical loads such as water heaters, air conditioners, electrical heaters, pool pumps, etc.

2) Automatic Meter Reading (AMR): For utilities, AMR is one of the cost effective way to read the residential kilowatt-hour meters. The AMR device can be initially programmed to report back to the utility based on a schedule or some pre-set usage level. Modern AMR devices incorporate the capability of remote reconfiguration of operating parameters and schedules.

3) Demand Side Management (DSM): An extension of automatic meter reading technology is the DSM application using Real Time Pricing. This application includes the functionality of monitoring the power usage during specific periods of the day as well as the control functionality of notifying the customer of the change of periods and the new rate for that period. For some utilities, this option is not cost effective.

4) Quality of Service (QoS) Monitoring: Quality of service is different things to different utilities. The most comprehensive definition includes monitoring power outages and its duration, the track record of power disturbances (such as voltage blinks, harmonics and voltage sags), and monitoring voltage wave-form distortions.

5.5 EPRI's IntelliGrid Project: Advanced Distribution Automation

Project Objective: The objective of Advanced Distribution Automation Function is to enhance the reliability of power system service, power quality, and power system efficiency, by automating the following three processes of distribution operation control: data preparation in near-real-time; optimal decision-making; and the control of distribution operations in coordination with transmission and generation systems operations [9].

Scope of the Project: The ADA Function performs following functions:

1. Data gathering, along with data consistency checking and correcting
2. Integrity checking of the distribution power system model
3. Periodic and event-driven system modeling and analysis
4. Contingency analysis
5. Coordinated Volt / VAR optimization
6. Fault location, isolation, and service restoration
7. Multi-level feeder reconfiguration
8. Logging and reporting

These processes are performed through direct interfaces with different databases and systems, comprehensive near real-time simulations of operating conditions, near real-time predictive optimization, and actual real-time control of distribution operations.

Status of the Project: The methodology and specification of the Function for current power system conditions have been developed, and prototype (pilot) and system-wide project in several North-American utilities have been implemented by Utility Consulting International and its client utilities prior to IntelliGrid Architecture project [9].

Chapter 6

Implementation of Project

In this Chapter we have discussed the detailed description of project including circuit diagram, components used and working of Project.

6.1 Circuit Diagram of Project

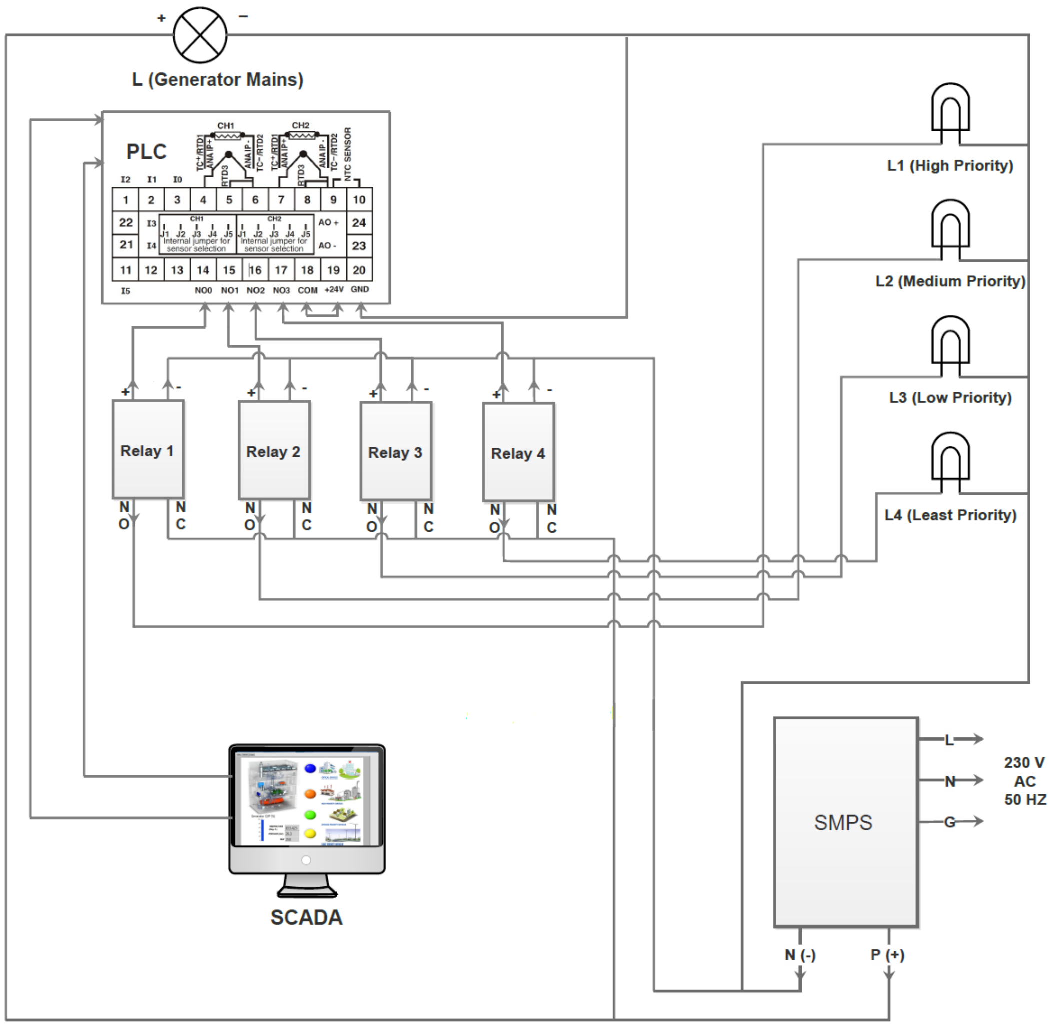


Fig. 6.1 Circuit diagram of project

6.2System Architecture of Project

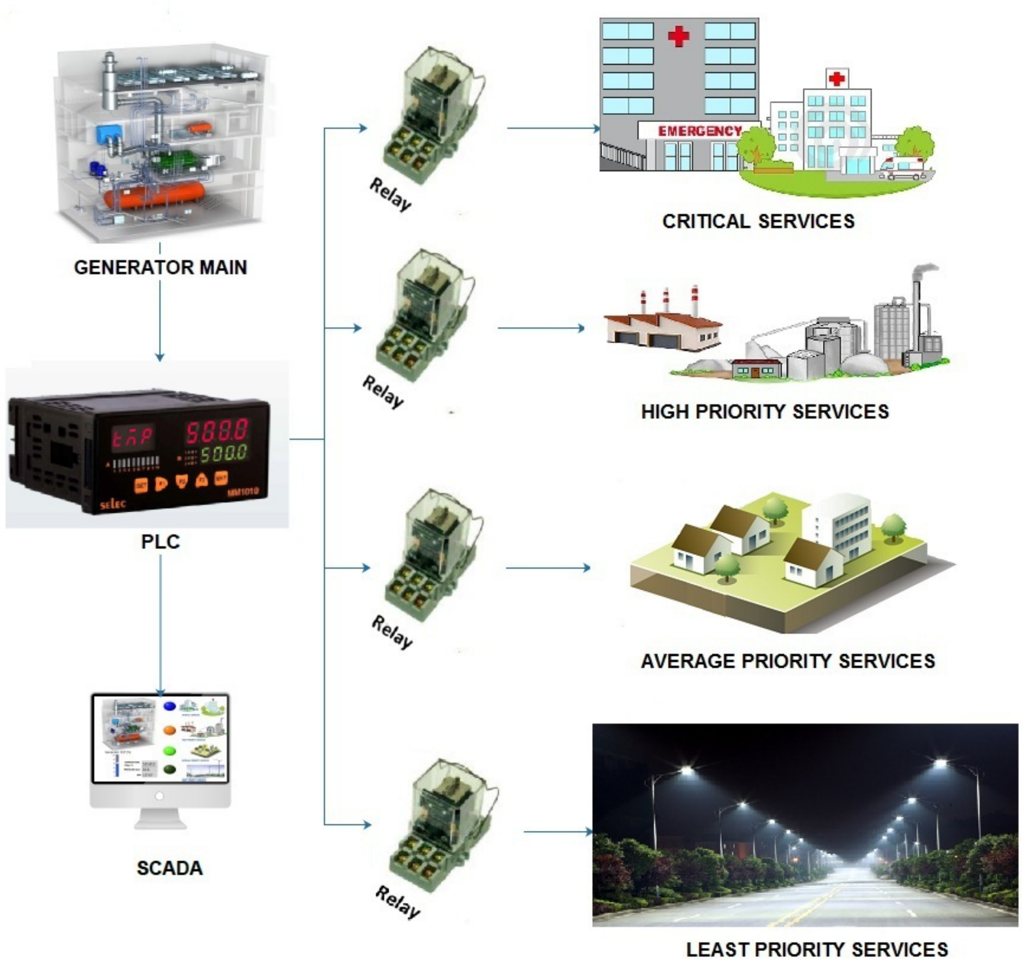


Fig. 6.2 System Architecture of project

In our Project we have considered a prtical area to be supplied by electrical power. This area consists of hospitals, industries, residential areas and street. The electrical power is supplied to the devices connected in an area based on their priorities. Here we have given the highest priority to the hospitals, High priority to the industries, average priority to the residential areas and the least priority to the streetlight.

6.3 Working of the Project

Energymeter measures the power generated by the power generator. Whenever less power is generated, the lower priority devices of a specific area are cut off instead of switching off the whole supply for the area. The power cut off is not according to area but according to the devices which have lower priorities. The switching devices connected in this area are programmed by PLC based on their priorities and monitored by SCADA. Thus according to the power generated the load shedding occurs. The power generation is done by simulation in SCADA.

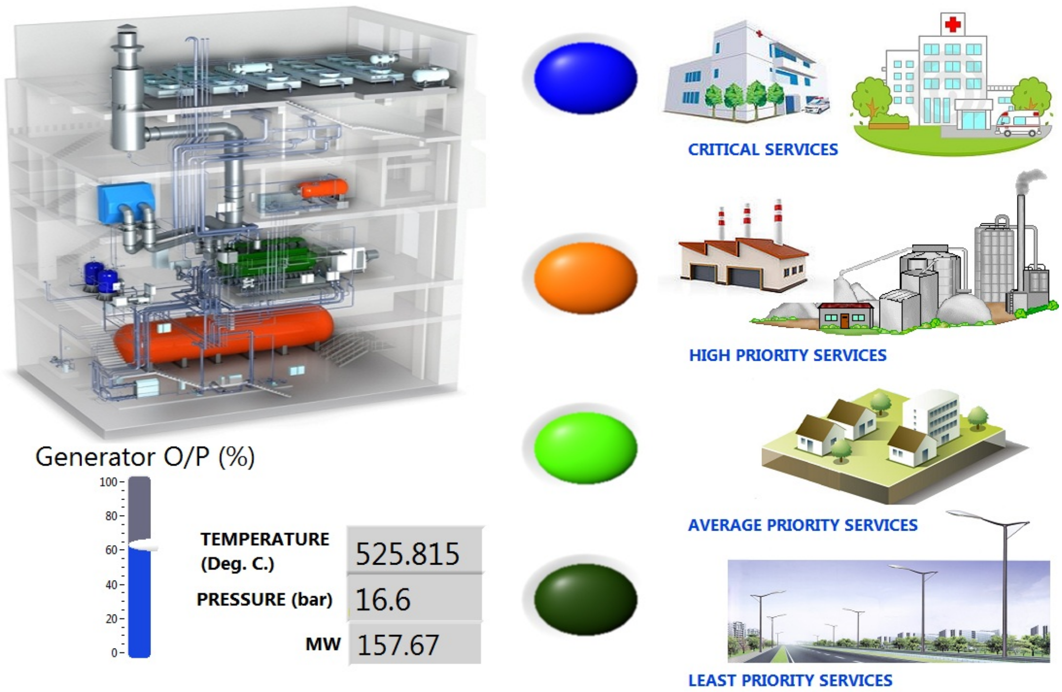


Fig. 6.3 SCADA control window

Project Model Working Steps:

Step1: When the energy generation is 100% and above 75% then all the areas will get power supply (all LED glows).

Step2: When the energy generation is below 75% and above 50% then the power supply will be cut off for the least priority area (LED 4 gets switched off).

Step 3: When the energy generation is below 50% and above 25% then the power supply will be cut off for the least priority and average priority areas (LED 4 and LED 3 gets switched off).

Step 4: When the energy generation is below25% and above 0%then the power supply will be available only for the critical or highest priority area (only LED 1 glows).

Thus the power supply will always be available for the critical area until the energy generation is 0%

6.4 Advantages of Project:

- No need of Human Being required for changing the load
- All kinds of human errors and mistakes are minimized
- No continuous attention is required for monitoring the system
- No need of Site visits by Personnel for inspection
- Reduced Space
- Economical and Energy Saving
- Greater Life and Reliability through Automation
- Tremendous Flexibility
- Automation protects workers by enabling problem areas to be detected and addressed automatically
- Alarms and system-wide monitoring enable operators to quickly address problems
- Historians provides the ability to view data in various ways to improve efficiency

6.5Components Used in Project

6.5.1 Relay Module:

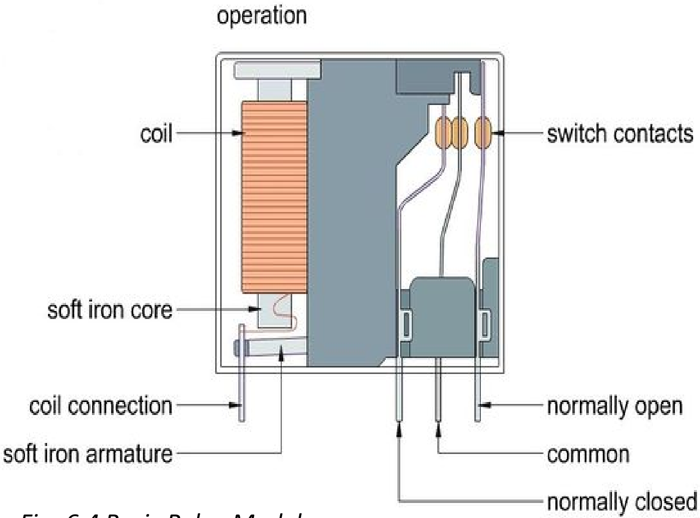


Fig. 6.4 Basic Relay Module

A **relay** is an electrically operated switch. Many relays use an electromagnet to mechanically operate a switch, but other operating principles are also used, such as solid-state relays. Relays are used where it is necessary to control a circuit by a low-power signal (with complete electrical isolation between control and controlled circuits), or where several circuits must be controlled by one signal.

A type of relay that can handle the high power required to directly control an electric motor or other loads is called a contactor. Solid-state relays control power circuits with no moving parts, instead using a semiconductor device to perform switching. Relays with calibrated operating characteristics and sometimes multiple operating coils are used to protect electrical circuits from overload or faults; in modern electric power systems these functions are performed by digital instruments still called "protective relays".

Chapter 6

Basic design and operation

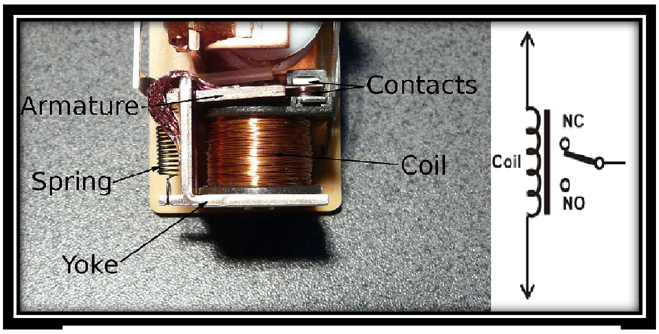


Fig. 6.5 Basic design and symbol of relay

A simple electromagnetic relay consists of a coil of wire wrapped around a soft iron core, an iron yoke which provides a low reluctance path for magnetic flux, a movable iron armature, and one or more sets of contacts (there are two in the relay pictured). The armature is hinged to the yoke and mechanically linked to one or more sets of moving contacts. It is held in place by a spring so that when the relay is de-energized there is an air gap in the magnetic circuit. In this condition, one of the two sets of contacts in the relay pictured is closed, and the other set is open. Other relays may have more or fewer sets of contacts depending on their function. The relay in the picture also has a wire connecting the armature to the yoke. This ensures continuity of the circuit between the moving contacts on the armature, and the circuit track on the printed circuit board (PCB) via the yoke, which is soldered to the PCB.

When an electric current is passed through the coil it generates a magnetic field that activates the armature, and the consequent movement of the movable contact(s) either makes or breaks (depending upon construction) a connection with a fixed contact. If the set of contacts was closed when the relay was de-energized, then the movement opens the contacts and breaks the connection, and vice versa if the contacts were open. When the current to the coil is switched off, the armature is returned by a force, approximately half as strong as the magnetic force, to its relaxed position. Usually this force is provided by a spring, but gravity is also used commonly in industrial motor starters. Most relays are manufactured to operate quickly. In a low-voltage application this reduces noise; in a high voltage or current application it reduces.

Relay Module Used in Project

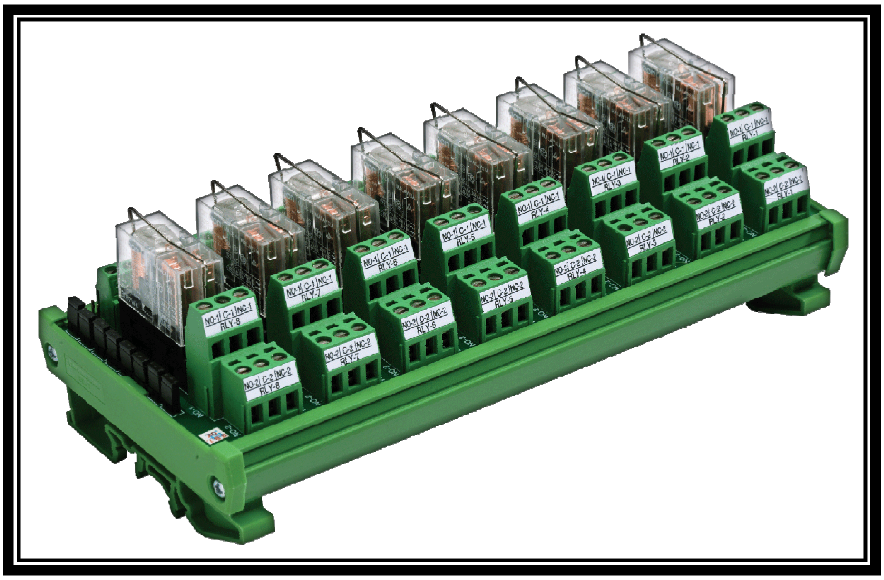


Fig: 6.6 Relay Module Used in Project

FEATURES	LED & Free wheeling diode across coil Reverse Polarity blocking diode					
CONTACT CONFIGURATION	2C/O					
NO. OF CHANNELS	1, 2, 4, 8, 12, 16					
RELAY	NOMINAL COIL VOLTAGE	5VDC	6VDC	12VDC	24VDC	48VDC
	MUST OPERATE VOLTAGE	4.7VDC	5.5VDC	10.3VDC	19.9VDC	39.1VDC
	MUST RELEASE VOLTAGE	1.7VDC	1.9VDC	3.1VDC	5.5VDC	10.3VDC
	MAX. COIL VOLTAGE	5.5VDC	6.6VDC	13.2 VDC	26.4VDC	52.8VDC
	COIL CURRENT PER CHANNEL (1)	110mA	95mA	50mA	25mA	15mA
	OPERATE (SET) TIME	15ms max.				
	RELEASE (RESET) TIME	20ms max.				
	ENDURANCE	Electrical : 100,000 operations min. (at 1,800 operations/hr)				
	MAX. OPERATING FREQUENCY	Mechanical : 18,000 operations/hr Electrical : 1,800 operations/hr				
DIELECTRIC STRENGTH	1. Coil to coil (when isolated) : 100VAC , 50/60 Hz for 1 minute 2. Coil to contact : 2KVAC , 50/60 Hz for 1 minute 3. Contacts of different polarity : 1KVAC , 50/60 Hz for 1 minute 4. Contacts of same polarity : 1KVAC , 50/60 Hz for 1 minute 5. Contacts - channel to channel : 1.5KVC, 50/60 Hz for 1 minute					
CONTACT RATING	RELAY	5A@28VDC/230VAC				
	ON BOARD	5A@28VDC/230VAC				
OPERATING AMBIENT	0~55°C, 85% RH					
STORAGE AMBIENT	-20°C to 85°C					
TERMINATIONS	COIL TERMINATION	Screw type, for 1.5mm sq. wire				
	CONTACT TERMINATION	Screw type, for 2.5mm sq. wire				
MOUNTING	35 mm DIN rail					

Fig: 6.7 Relay Features

6.5.2 SMPS

Fig. 6.8 SMPS

A **switched-mode power supply** (**switching-mode power supply**, **SMPS**, or **switcher**) is an electronic power supply that incorporates a switching regulator to convert electrical power efficiently. Like other power supplies, an SMPS transfers power from a source, like mains power, to a load, such as a personal computer, while converting voltage and current characteristics. Unlike a linear power supply, the pass transistor of a switching-mode supply continually switches between low-dissipation, full-on and full-off states, and spends very little time in the high dissipation transitions, which minimizes wasted energy. Ideally, a switched-mode power supply dissipates no power. Voltage regulation is achieved by varying the ratio of on-to-off time. In contrast, a linear power supply regulates the output voltage by continually dissipating power in the pass transistor. This higher power conversion efficiency is an important advantage of a switched-mode power supply. Switched-mode power supplies may also be substantially smaller and lighter than a linear supply due to the smaller transformer size and weight.

Switching regulators are used as replacements for linear regulators when higher efficiency, smaller size or lighter weight are required. They are, however, more complicated; their switching currents can cause electrical noise problems if not carefully suppressed, and simple designs may have a poor power factor

Features

- ✓ Single Phase Input
- ✓ Built In Transient protector & EMI filter
- ✓ Protection against short circuit, overload & overvoltage
- ✓ Low ripple & noise
- ✓ Cooling by free air convection
- ✓ Power OK indication, terminations, output set control & rating details on front
- ✓ 100% full load burn in tested
- ✓ Low cost
- ✓ High reliability
- ✓ Compact [17]

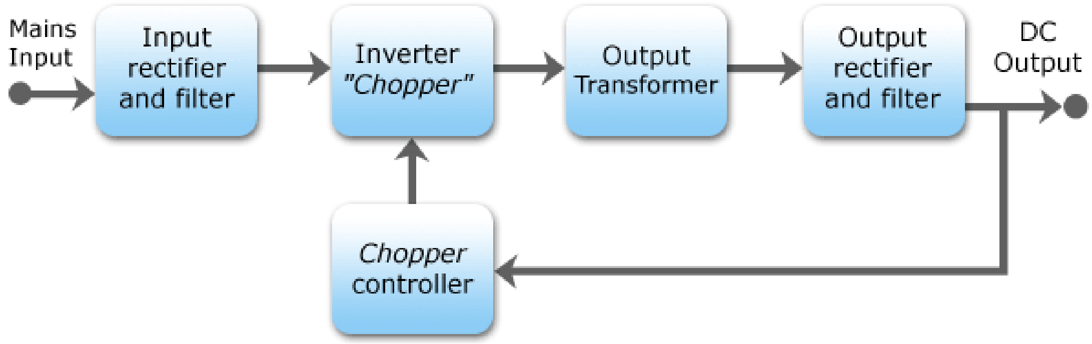


Fig: 6.9 Block diagram of a mains operated AC/DC SMPS with output voltage regulation

Advantages and Disadvantages

The main advantage of the switching power supply is greater efficiency because the switching transistor dissipates little power when acting as a switch. Other advantages include smaller size and lighter weight from the elimination of heavy line-frequency transformers, and lower heat generation due to higher efficiency. Disadvantages include greater complexity, the generation of high-amplitude, high-frequency energy.

6.5.3 Panel LED Indicator

Fig. 6.10 Panel LED lighting

Light Emitting Diodes are great for projects because they provide visual entertainment. LEDs use a special material which emits light when current flows through it. Unlike light bulbs, LEDs never burn out unless their current limit is passed. A current of 0.02 Amps (20 mA) to 0.04 Amps (40 mA) is a good range for LEDs. They have a positive leg and a negative leg just like regular diodes. To find the positive side of an LED, look for a line in the metal inside the LED. It may be difficult to see the line. This line is closest to the positive side of the LED. Another way of finding the positive side is to find a flat spot on the edge of the LED. This flat spot is on the negative side.

When current is flowing through an LED the voltage on the positive leg is about 1.4 volts higher than the voltage on the negative side. Remember that there is no resistance to limit the current so a resistor must be used in series with the LED to avoid destroying it. It has high brightness panel led indicators light in various colors like red, green, yellow, blue, white. Various volt range in led indicators lights. Long life working. Different Volt is available 24v, 110v, 220v,

Features

- ✓ Power: 24V
- ✓ Colour: Green,Yellow,Red,Blue
- ✓ Multi segment
- ✓ Long life: 30,000 hours
- ✓ 24V & 110V AC/DC
- ✓ 230V AC
- ✓ Complete with locking nut
- ✓ Current rating: 20mA

Fig. 6.14 LED lights

Inputs & Outputs use in PLC

Inputs – Positive Supply and Ground

Outputs –Relay 4 nos.

R1, R2, R3, R4.

Chapter 7

Software Used In Project

This chapter provides a detail of Software used in implementation of Project.

7.1 PLC Software:

Software Name: SELPRO

Fig: 7.1 SELPRO software

Selec's SELPRO is integrated with an HMI calibration facility, and a ladder editor that complies with international IEC61131-3 standards. This programming system features an exhaustive function and function block library, an auto-declared variable that represents physical I/O of the selected structure, and an auto-read and auto-save facility. It also sports an extensive hardware compatibility, modified protocol support (MM3010, MM3030-2) and an on-line and off-line simulation capability.[17]

Software Features

- ✓ User friendly ladder editor on lines of IEC61131-3
- ✓ Built-in HMI configuration facility
- ✓ On-line and Off-line simulation possible
- ✓ Exhaustive function and function block library
- ✓ Auto read and Auto save facility
- ✓ Auto declared variable to represent physical IO of selected configuration
- ✓ Project upload from target
- ✓ Editable passwords for download, upload and project
- ✓ Facility to set debounce time for physical inputs
- ✓ Hardware compatibility - Facility to download applications into the previous versions of bootloader by selecting respective hardware version.
- ✓ Customized protocol support (MM3010, MM3030-2) [17]

Programming Language: Ladder Logic Diagram

Ladder logic was originally a written method to document the design and construction of relay racks as used in manufacturing and process control. Each device in the relay rack would be represented by a symbol on the ladder diagram with connections between those devices shown. In addition, other items external to the relay rack such as pumps, heaters, and so forth would also be shown on the ladder diagram. See relay logic.Ladder logic has evolved into a programming language that represents a program by a graphical diagram based on the circuit diagrams of relay logic hardware. Ladder logic is used to develop software for programmable logic controllers (PLCs) used in industrial control applications. The name is based on the observation that programs in this language resemble ladders, with two vertical rails and a series of horizontal rungs between them. While ladder diagrams were once the only available notation for recording programmable controller programs, today other forms are standardized in IEC 61131-3.

Overview

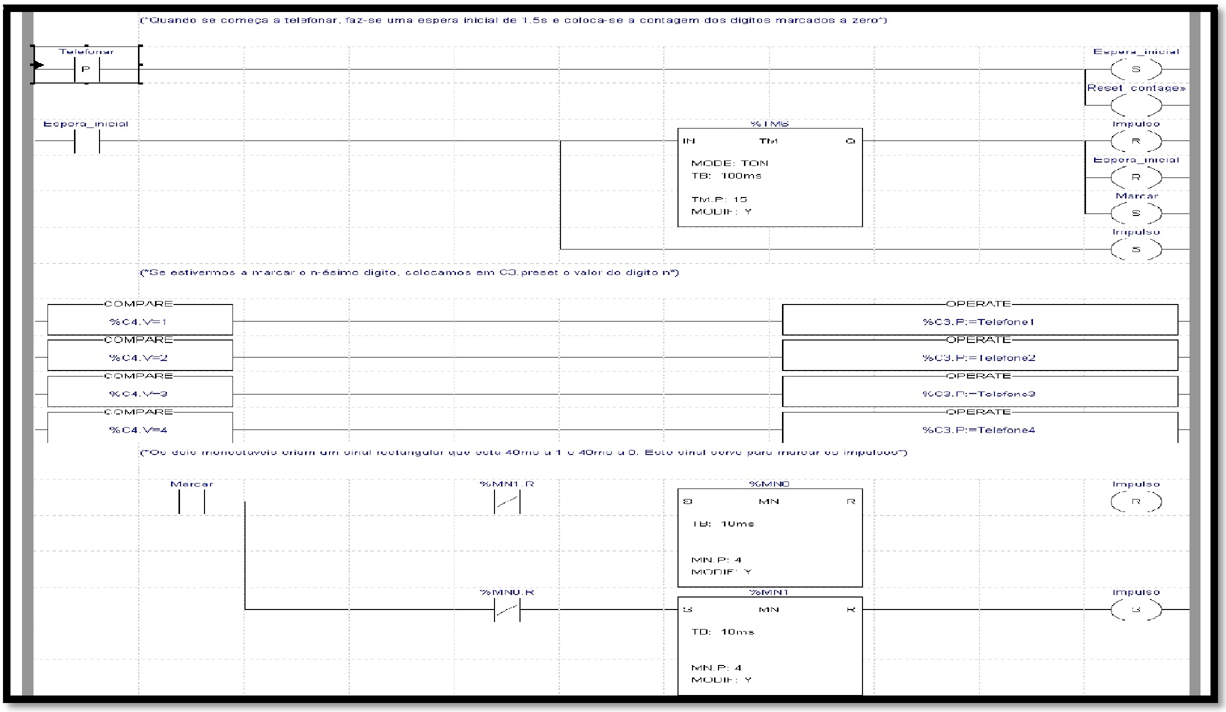


Fig: 7.2 Part of ladder diagram

Part of a ladder diagram, including contacts and coils, compares, timers and monostablemultivibrators

Ladder logic is widely used to program PLCs, where sequential control of a process or manufacturing operation is required. Ladder logic is useful for simple but critical control systems or for reworking old hardwired relay circuits. As programmable logic controllers became more sophisticated it has also been used in very complex automation systems. Often the ladder logic program is used in conjunction with an HMI program operating on a computer workstation.[17]

The motivation for representing sequential control logic in a ladder diagram was to allow factory engineers and technicians to develop software without additional training to learn a language such as FORTRAN or other general purpose computer language. Development, and maintenance, was simplified because of the resemblance to familiar relay hardware systems. Implementations of ladder logic have characteristics, such as sequential execution and support for control flow features, that make the analogy to hardware somewhat inaccurate. This argument has become less relevant given that most ladder logic programmers have a software background in more conventional programming languages.

Manufacturers of programmable logic controllers generally also provide associated ladder logic programming systems. Typically the ladder logic languages from two manufacturers will not be completely compatible; ladder logic is better thought of as a set of closely related programming languages rather than one language. (The IEC 61131-3 standard has helped to reduce unnecessary differences, but translating programs between systems still requires significant work.) Even different models of programmable controllers within the same family may have different ladder notation such that programs cannot be seamlessly interchanged between models.

Ladder logic can be thought of as a rule-based language rather than a procedural language. A "rung" in the ladder represents a rule. When implemented with relays and other electromechanical devices, the various rules "execute" simultaneously and immediately. When implemented in a programmable logic controller, the rules are typically executed sequentially by software, in a continuous loop (scan). By executing the loop fast enough, typically many times per second, the effect of simultaneous and immediate execution is achieved, if considering intervals greater than the "scan time" required to execute all the rungs of the program. Proper use of programmable controllers requires understanding the limitations of the execution order of rungs. [17]

7.2 SCADA Software:

Name of Software: LabVIEW

What Is LabVIEW?

1. What Makes Up LabVIEW?
2. Benefits of LabVIEW
3. LabVIEW – More Than Just Software
4. Productivity and Empowerment with LabVIEW

NI LabVIEW software is used for a wide variety of applications and industries, which can make it challenging to answer the question: "What is LabVIEW?" I have heard many conflicting opinions and debates over the years, so I thought it would be appropriate to take this opportunity to discuss what LabVIEW is.

LabVIEW is a highly productive development environment for creating custom applications that interact with real-world data or signals in fields such as science and engineering.

The net result of using a tool such as LabVIEW is that higher quality projects can be completed in less time with fewer people involved.So productivity is the key benefit, but that is a broad and general statement. To understand what this really means, consider the reasons that have attracted engineers and scientists to the product since 1986. At the end of the day, engineers and scientists have a job to do – they have to get something done, they have to show the results of what they did, and they need tools that help them do that. Across different industries, the tools and components they need to succeed vary widely, and it can be a daunting challenge to find and use all these disparate items together. LabVIEW is unique because it makes this wide variety of tools available in a single environment, ensuring that compatibility is as simple as drawing wires between functions.[18]

What Makes Up LabVIEW?

LabVIEW itself is a software development environment that contains numerous components, several of which are required for any type of test, measurement, or control application.

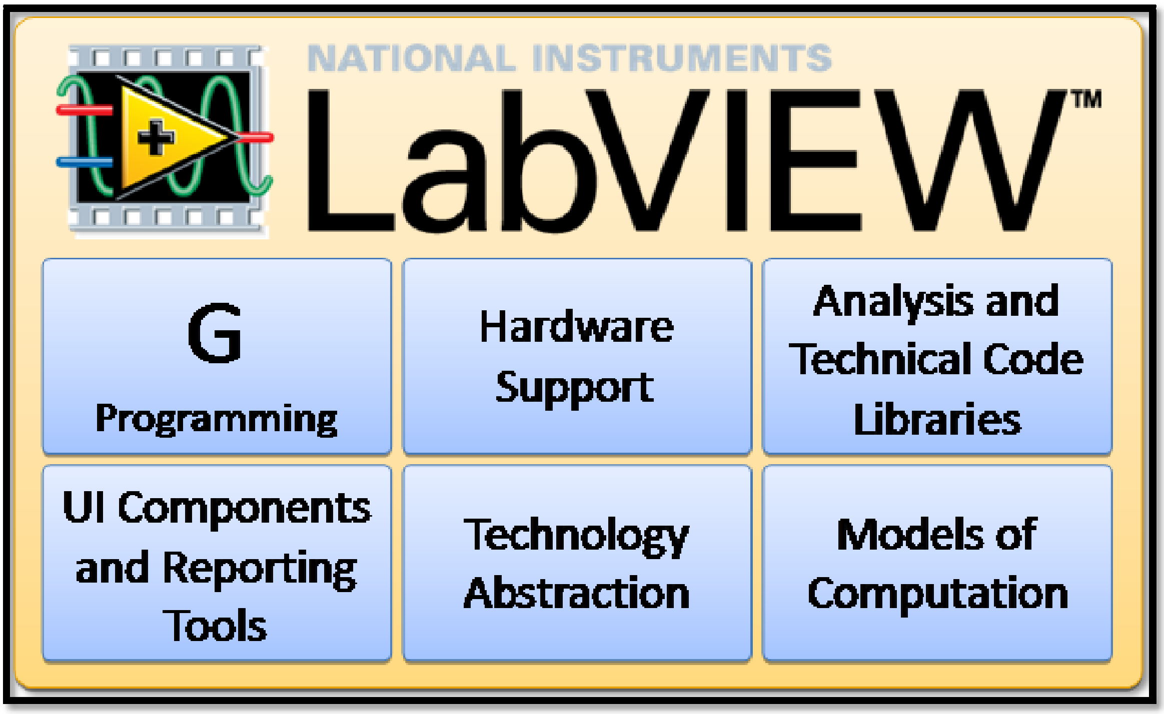


Fig: 7.3 LabVIEW contains several valuable components.

To quote one of our software developers, “We write low-level code so you don’t have to.” Our global team of developers continually works on the six areas called out in Figure 1 to free you, the LabVIEW user, up to focus on the bigger problems and tasks you are trying to solve.

G Programming Language

- Intuitive, flowchart-like dataflow programming model
- Shorter learning curve than traditional text-based programming
- Naturally represents data-driven applications with timing and parallelism

The G programming language is central to LabVIEW; so much so that it is often called "LabVIEW programming." Using it, you can quickly tie together data acquisition, analysis, and logical operations and understand how data is being modified. From a technical standpoint, G is a graphical dataflow language in which nodes (operations or functions) operate on data as soon as it becomes available, rather than in the sequential line-by-line manner that most programming languages employ. You lay out the "flow" of data through the application graphically with wires connecting the output of one node to the input of another.

The practical benefit of the graphical approach is that it puts more focus on data and the operations being performed on that data, and abstracts much of the administrative complexity of computer programming such as memory allocation and language syntax. New programmers typically report shorter learning curves with G than with other programming languages because they can relate G code to flow charts and other familiar visual representations of processes. Seasoned programmers can also take advantage of the productivity gains by working at a higher level of abstraction while still employing advanced programming practices such as object-oriented design, encapsulation, and code profiling.

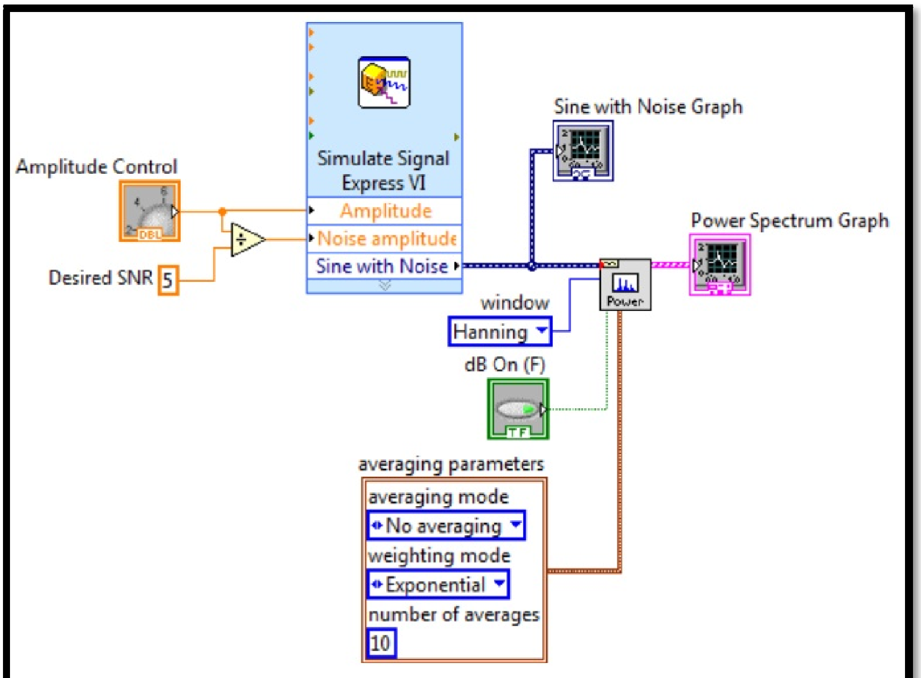


Figure 2. This block diagram shows shows self-documenting G code.

Fig: 7.4 Block diagram of self-documenting G code

LabVIEW contains a powerful optimizing compiler that examines your block diagram and directly generates efficient machine code, avoiding the performance penalty associated with interpreted or cross-compiled languages. The compiler can also identify segments of code with no data dependencies (that is, no wires connecting them) and automatically split your application into multiple threads that can run in parallel on multicore processors, yielding significantly faster analysis and more responsive control compared to a single-threaded, sequential application.

With the debugging tools in LabVIEW, you can slow down execution and see the data flow through your diagram, or you can use common tools such as breakpoints and data probes to step through your program node-by-node. The combination of working with higher-level building blocks and improved visibility into your application's execution results in far less time spent tracking down bugs in your code.[18]

Hardware Support

- Support for thousands of hardware devices, including:
    - Scientific instruments
    - Data acquisition devices
    - Sensors
    - Cameras
    - Motors and actuators
- Familiar programming model for all hardware devices
- Portable code that supports several deployment targets

Typically, integrating different hardware devices can be a major pain point when automating any test, measurement, or control system. Worse yet, not integrating the different hardware pieces leads to the hugely inefficient and error-prone process of manually taking individual measurements and then trying to correlate, process, and tabulate data by hand.

Fig: 7.5 LabVIEW connects to almost any hardware device.

LabVIEW makes the process of integrating hardware much easier by using a consistent programming approach no matter what hardware you are using. The same initialize-configure-read/write-close pattern is repeated for a wide variety of hardware devices, data is always returned in a format compatible with the analysis and reporting functions, and you are not forced to dig into instrument programming manuals to find low-level message and register-based communication protocols unless you specifically need to.

LabVIEW has freely available drivers for thousands of NI and third-party hardware. In the rare case that a LabVIEW driver does not already exist, you have tools to create your own, reuse a DLL or other driver not related to LabVIEW, or use low-level communication mechanisms to operate hardware without a driver. Chances are if the hardware can be connected to a PC, LabVIEW can talk to it.

The cross-platform nature of LabVIEW also allows you to deploy your code to many different computing platforms. In addition to the popular desktop OSs (Windows, Mac, and Linux), LabVIEW can target embedded real-time controllers, ARM microprocessors, and field-programmable gate arrays (FPGAs), so you can quickly prototype and deploy to the most appropriate hardware platform without having to learn new toolchains.[18]

Analysis and Technical Code Libraries

- Libraries of signal processing, analysis, and control algorithms
- Libraries of communication, file I/O, and connectivity

- Library functions that consume data in the same format as the hardware drivers return it

LabVIEW tailors the G programming language to engineering and scientific use by incorporating hundreds of specialized functions and algorithms that are not typically included with general-purpose programming languages.

In addition to the standard programming language constructs, LabVIEW contains functions for:

- String, array, and waveform manipulation
- Signal processing, including filters, windowing, spectral analysis, and transforms
- Mathematical analysis, including curve fitting, statistics, differential equations, linear algebra, and interpolation.
- Communication, including high-level communication protocols, HTTP, SMTP, FTP, TCP, UDP, Serial, and Bluetooth
- Report generation, file I/O, and database connectivity
- Add-on packages supplement the core functionality for more specialized disciplines, such as:

- ➢ Control design and simulation
- ➢ Sound and vibration analysis
- ➢ Machine vision and image processing
- ➢ RF and communication

With the comprehensive analysis capabilities of LabVIEW, you can perform all the signal processing you need without wasting any time moving data between incompatible tools or resorting to writing your own analysis routines. All of the included functions in LabVIEW work seamlessly with the data you acquire from your hardware so you do not need to worry about converting and passing data. When you do have specific file format or communication protocol needs, LabVIEW can help you get the data into the right format.

UI Components and Reporting Tools

- Interactive controls such as graphs, gauges, and tables to view your acquired data
- Tools to save data to file or databases, or automatically generate reports

Every LabVIEW block diagram also has an associated front panel, which is the user interface of your application. On the front panel you can place generic controls and indicators such as strings, numbers, and buttons or technical controls and indicators such as graphs, charts, tables, thermometers, dials, and scales. All LabVIEW controls and indicators are designed for engineering use, meaning you can enter SI units such as 4M instead of 4,000,000, change the scale of a graph by clicking on it and typing a new end point, export data to tools such as NI DIAdem and Microsoft Excel by right-clicking on it, and so on.

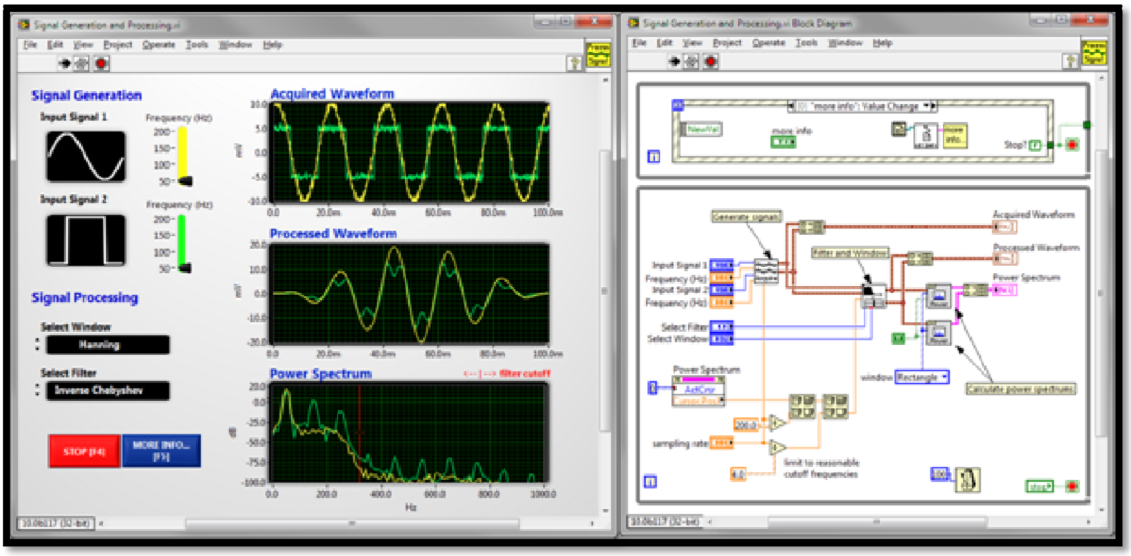


Fig: 7.6 LabVIEW block diagram has an associated front panel, such as this signal generation example with custom UI.

Controls and indicators are customizable. You can add them either from a palette of controls on the front panel or by right-clicking on a data wire on the block diagram and selecting “Create Control” or “Create Indicator.”

In addition to displaying data as your application is running, LabVIEW also contains several options for generating reports from your test or acquired data. You can send simple reports directly to a printer or HTML file, programmatically generate Microsoft Office documents, or integrate with NI DIAdem for more advanced reporting. Remote front panels and Web service support allow you to publish data over the Internet with the built-in Web server.

Technology Abstraction

- Harness emerging technologies such as FPGAs, multicore CPUs, and virtualization without painful relearning and additional development effort
- Use common protocols and platforms without getting bogged down by details

Technology advances at a rapid pace and the pressure to keep current and take advantage of state-of-the-art performance is rarely matched with enough time and training to learn and implement emerging technologies. LabVIEW addresses this problem by quickly adopting advances in personal and embedded computing in such a way that you get the new capabilities without having to learn significant new paradigms. Examples of this approach include how LabVIEW is able to automatically generate multithreaded code for execution on multicore processors or program FPGAs to gain the speed and reliability of custom hardware chips without the LabVIEW user needing to learn the underlying details of multithreading or the hardware description languages typically required to use FPGAs.

The same applies to new OSs, networking protocols, and more. LabVIEW moves with the industry and our engineers work diligently to ensure that applications created with LabVIEW are able to easily move with it. If you do not use LabVIEW, the responsibility of moving to a new or updated OS or other computer standard is on you.

Models of Computation

- Simulation syntax, textual math, statecharts, component-level IP (CLIP) nodes, DLL calls, and other models are available for whenever G is not the most natural representation of the solution.
- Incorporate and reuse existing code and IP to minimize development effort

When LabVIEW was first released, G was the only way to define the functionality you needed. Much has changed since then. With LabVIEW, you can now pick the most efficient approach to solve the problem at hand. Examine the following considerations:

- Graphical data flow is the default model of computation for LabVIEW.
- Statecharts provide a higher level of abstraction for state-based applications.
- Formula Node puts simple mathematical formulas in line with your G code.
- LabVIEW MathScript is math-oriented, textual programming for LabVIEW that you can use to call .m files without the need for extra software.
- CLIP and IP integration nodes import FPGA intellectual property so you can use VHDL.

These flexible models of computation allow you to pick the right tool for the particular problem you are trying to solve. In any given application you will likely want to use more than one approach, and LabVIEW is the perfect tool to quickly tie everything together.

Benefits of LabVIEW

As Complex As You Need It to Be

One of the reasons LabVIEW makes you successful is its ability to scale to meet the needs of a given application. Picking the right software is all too often a balancing act between ease of use and learning curve on one side and power and flexibility on the other.Full-fledged programming, on the other hand, is powerful and flexible but comes at the cost of increased training and development time.

LabVIEW addresses this problem by providing several ways to accomplish similar tasks, so you can make the trade-off between simplicity and customization yourself on a task-by-task basis.

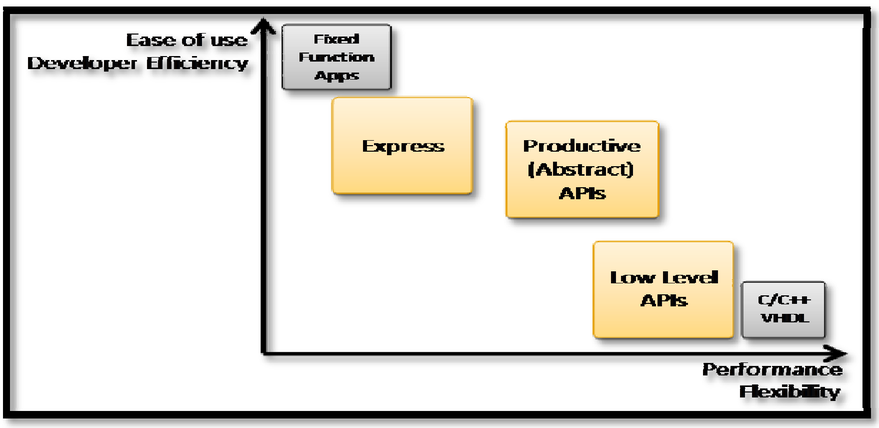


Fig: 7.7 LabVIEW gives you the freedom to choose between ease of use and low-level flexibility.

Express VIs

- Quick and easy, but limited
- Similar to other fixed-function/configurable, non programming tools

Express VIs are normally the quickest and easiest way to perform a task in LabVIEW. You choose the settings you want for a given operation, such as acquiring from an NI data acquisition (DAQ) device or saving data to a file, from a configuration window with several options and settings. When you click the OK button, LabVIEW configures the underlying code for you and just relies on you defining the flow of data between Express blocks (or Express VIs, as they are called in LabVIEW).[18]

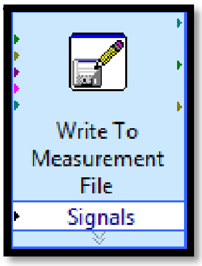


Fig: 7.8 Express VIs provide common functionality with configuration dialog simplicity.

Productive (Abstract) APIs

- High degree of customization
- Require application expertise, but abstract many programming complexities

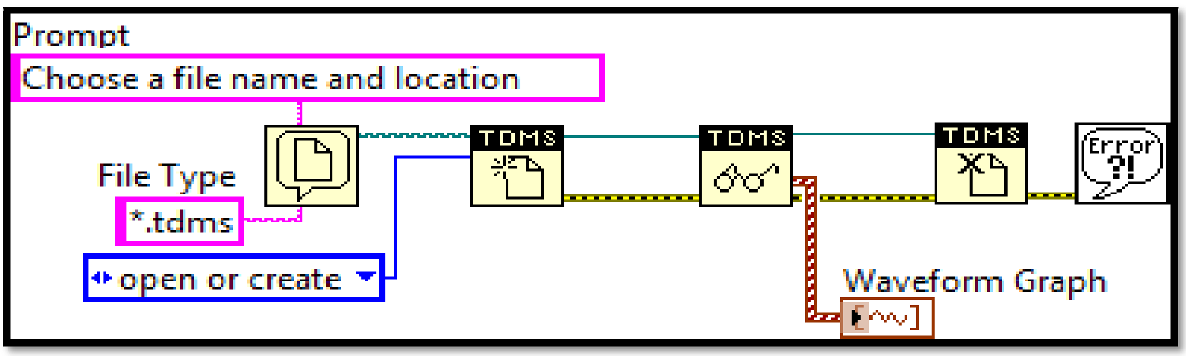


Fig: 7.9 The TDMS file API exposes only the functionality and not the complexity

.

The most common way to program in LabVIEW is using high-level functions that strike a balance between abstracting the unnecessary administrative tasks such as memory management and format conversion, but keep the flexibility of being able to customize almost every aspect of whatever task you need to accomplish.

Most of these APIs implement a specific technology, such as working with the TDMS file format (shown in Figure 7), talking to an instrument (the NI-VISA API), or manipulating and processing waveform data (any of the Wfm functions). Each API gives you full control of the actual process involved but does not require you to deal with all of the intricacies of implementing the minutia of the protocol. These APIs save you time by eliminating the steps that you do not need to define – whether it be calculating the number of bytes to read and byte order for file I/O when all you care about is reading in the previous day's measurements or implementing all of the intermediate math operations when you need only the fundamental frequency of a waveform.

Low-Level APIs

- Powerful, but require both application and programming expertise and development time
- Similar to C or other multipurpose programming languages/tools

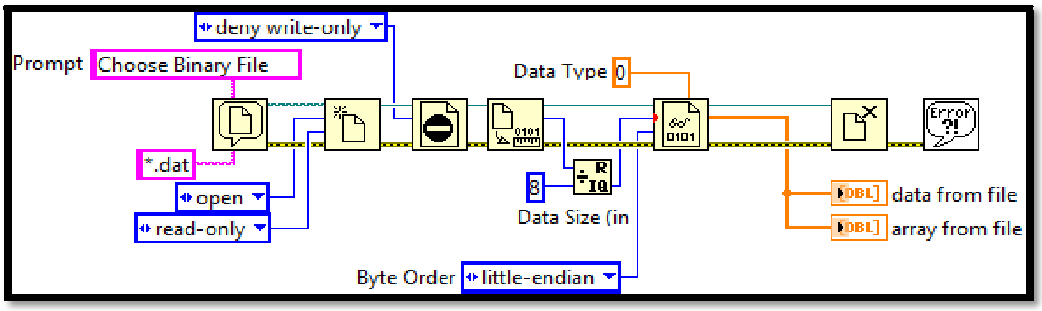


Fig: 7.10 Low-level access gives you complete freedom to implement custom solutions.

When you need to be able to completely define every detail of your task, LabVIEW offers the same low level access as you would get in traditional programming languages. LabVIEW can support any file type or any communication protocol because in the worst-case scenario you can implement them yourself, forming whichever headers or packets you need and sending raw binary data. For example, if your company uses a proprietary file format for which LabVIEW does not have a built-in function, you can use the low-level file I/O VIs to describe exactly how your data should be written to file – right down to the individual bits on the disk if you need to.

LabVIEW – More Than Just Software

We have discussed what the LabVIEW product is, but in reality, LabVIEW is more than just what we develop and you install on your computer. LabVIEW has a thriving ecosystem of products, services, and people around it that continue to drive adoption and ensure success.

Fig: 7.11An ecosystem of products, services, and people make LabVIEW more than just a product.

NI Support and Services

National Instruments stands behind LabVIEW with comprehensive support, training, and certification options. You can contact our applications engineers via phone and e-mail to help you get up and running, troubleshoot issues, and ensure that you are successful with LabVIEW.

Certification allows individuals to provide proof of their capabilities and for organizations to recognize and distinguish expertise among employees and make potential outsourcing decisions.

Beyond NI

In addition to NI support and services, there is a substantial community of users and professionals with expertise and products that extend the reach of LabVIEW. The NI Discussion Forums and LAVA are large, active message boards for LabVIEW discussion where developers of varying experience ask questions and help each other out. Another way to interact with other LabVIEW users is through user groups in both physical and virtual meetings where users share presentations, advice, and best practices.

The LabVIEW Tools Network houses code reuse libraries, architectures, and toolkits from NI and third parties to further enhance the capabilities of LabVIEW for specific applications.

When you need extra assistance solving a problem, the National Instruments Alliance Partner program is a worldwide network of more than 600 consultants, system integrators, developers, channel partners, and industry experts who partner with NI to provide complete, high-quality virtual instrumentation solutions to customers.[18]

Chapter 8

Results and Discussions

In this Chapter we have discussed the various results obtained in our project. As our project makes use of PLC and SCADA as the Controlling Unit we will first display the window corresponding to PLC and SCADA.

Total plant is monitoring their operation in control room itself. High/Low Alarm is update frequently with respect to the measuring equipments. The graphs are run in the trend window. In this trend we can get the old data for yearly auditing purpose. In any emergency condition, we can shut down the total system. By using this SCADA, we can reduce the manpower and time delay of operation.

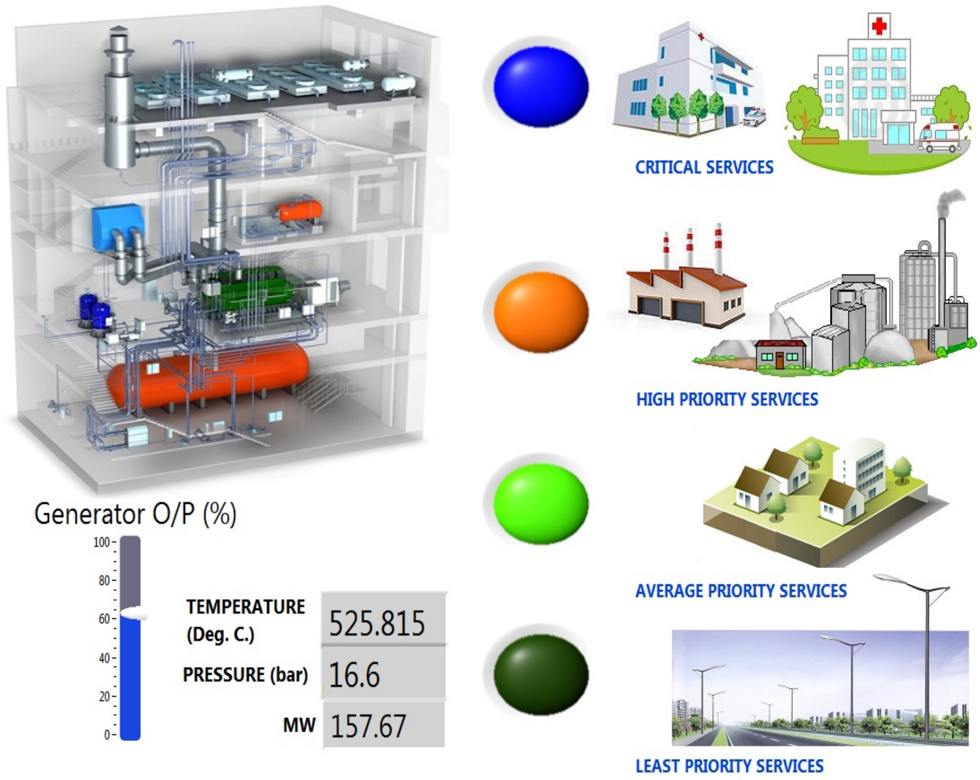


fig. 8.1: Control Window

TREND meter is based on standard measurements and data export methods. The TREND meter provides you with easy to read, graphed energy consumption and load information of each measured device. The TREND meter represents the starting point towards a more complex tool able to monitor a network infrastructure and to trigger energy saving techniques when traffic conditions change. Our tool has been developed inside the context of the European project TREND (Towards Real Energy Efficient Network design), which actually supported this work. The main goal of the TREND meter is to collect measurements of power and utilization from a variety of devices located in the Internet. The idea is to build a centralized server which collects the measurements from the devices. As second goal, the TREND meter aims at consolidating these measurements together to study whether there aresimilarities or not in the patterns of power and utilization of the devices. Additionally, the TREND meter aims at making publicly available the collected data to the community, and to easily show this information with a graphical representation. The design of TREND meter architecture had to face a complex and very heterogeneous scenario.

The SCADA trend window of our project is shown below:

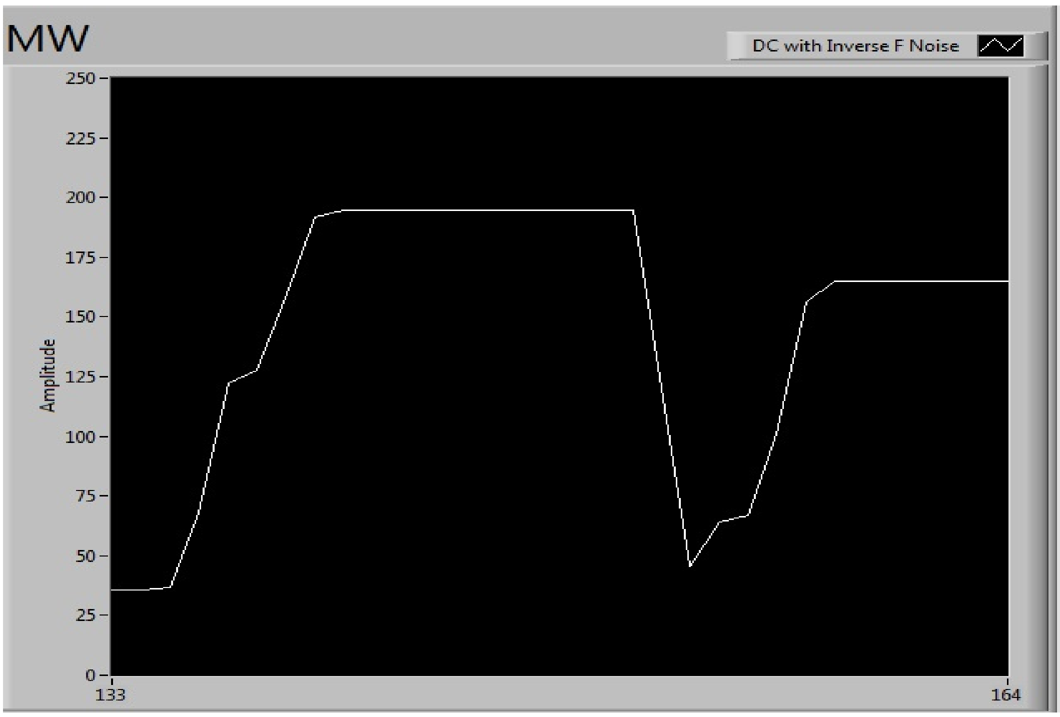


Fig. 8.1: SCADA trends MW v/s time

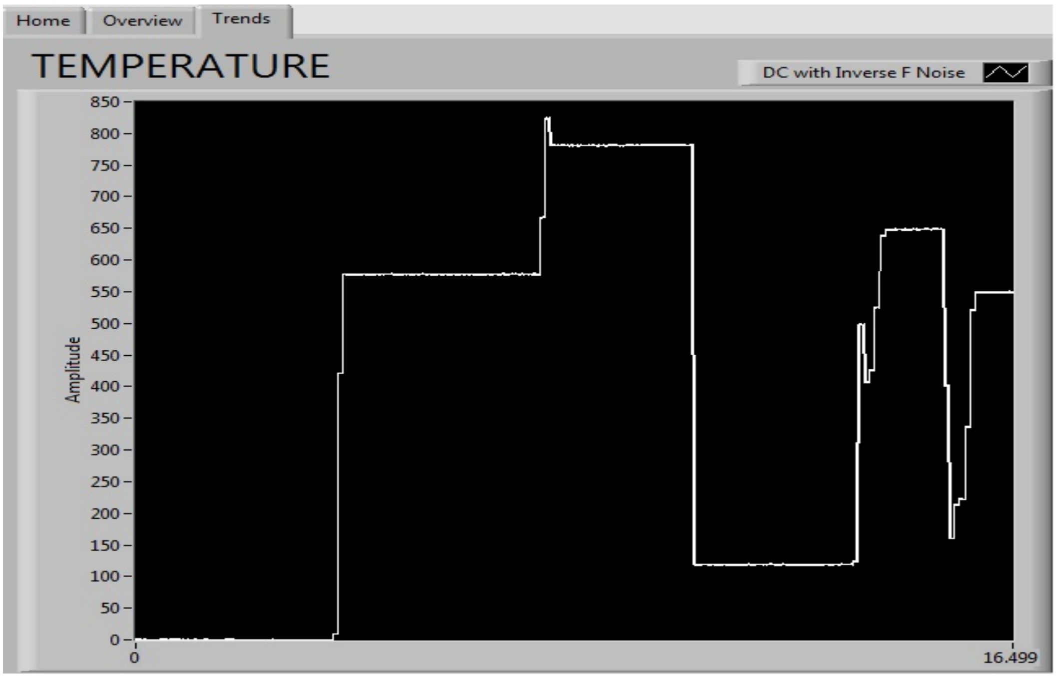


Fig. 8.2: SCADA trend Temperature v/s time

Load shedding in industrial power systems serves as the ultimate guard that protects the system from an overload induced collapse. This critical load preservation is normally done with the use of circuit breaker interlocks, under frequency relaying and other manual scheme. Common drawbacks of these schemes include lack of detailed pre- and post-disturbance data, real-time system configuration, type and duration of the disturbances, as well as other important information. This paper has introduced an intelligent optimal and fast load shedding technology referred to as 'PLC and SCADA based Smart Distribution System'. It combines system online data, equipment ratings, user-defined control parameters, a knowledge base obtained from offline system simulations, system dependencies, and continually updated dynamic load shed tables. This system can perform load shedding in less than 100 milliseconds from the initial occurrence of a disturbance. This technology has been successfully installed and operational at industrial facilities.

The purpose of the project is to develop an automatic load shedding management system. This will ensure that the load shedding will not affect the activities which have high priority. Thus the devices are programmed to function based on their priorities whenever there is less power generation.

8.2 Application of Project:

Due to reliability and flexibility the 'PLC and SCADA based Smart Distribution System' can be installed in places where Automatic Load shedding management is required. It can be installed for:

- Particular City or District
- Library
- College building
- Residential Towers
- Industries
- Hospital Building
- Airport
- Street Lighting System, etc.

Fig: 6.3 SCADA Layout

8.3 Future Scope:

- Although the project takes care of all the three performance specifications i.e. Automatic Load Shedding Management, Elimination of Human Intervention, Elimination of Conventional System still we cannot guarantee a two degree of freedom structure since the design and the programming of project is not taken care of by the actual distribution system in this project. In future we can propose techiques to control and Monitor the Distribution System more efficiently.
- In future we can propose more practical objective functions for Automatic Load Shedding management so that the design is more mature.
- New techniques can be introduced in future which provides control of Distribution System more precisely
- Modern Techniques like Substation Automation could be used in combination with Distribution Automation in order to provide better optimization.

Chapter 9

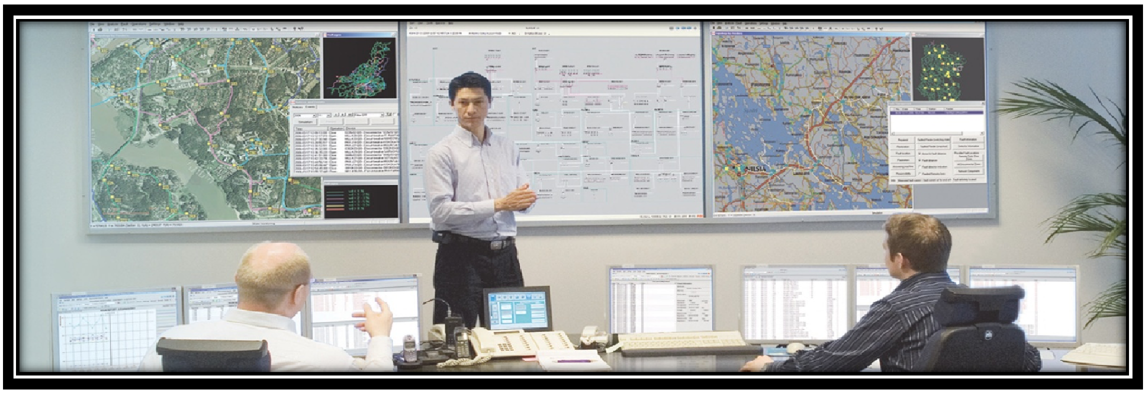
Conclusion

This chapter provides a summary of finding of the project study whichhas been done so far.

9.1 Conclusion:

SCADA provides management with real-time data on production operations, an implement more efficient control paradigms, improves plant and personnel safety, and reduces costs of operation. The proposed model that illuminates the categories of data, functionality, and interdependencies present in a SCADA. The model serves as a foundation for further research on how to best apply technical controls in substation and domestic distribution areas.

This report identifies the advantages of automation application at distribution level. Distribution automation enhances the efficiency and productivity of a utility, and also provides quality and reliable supply to the consumers. Commercially available products for distribution automation application are also discussed. Later part of the report discusses the challenges faced by current distribution automation system and need for advanced distribution automation.



Chapter 10

Appendices

10.1 Appendix I: Flow Chart For Plc Program Execution:

The ladder program is then executed rung-by-rung. Scanning the program and solving the logic of various ladder. determine the outputs states & the output values held in memory are used to set and reset the physical output of plc ,simultaneously at the end of program scan, the software monitors the real time electrical parameters (like voltage, current, power factor, etc) with the help of PLC and SCADA.[8]

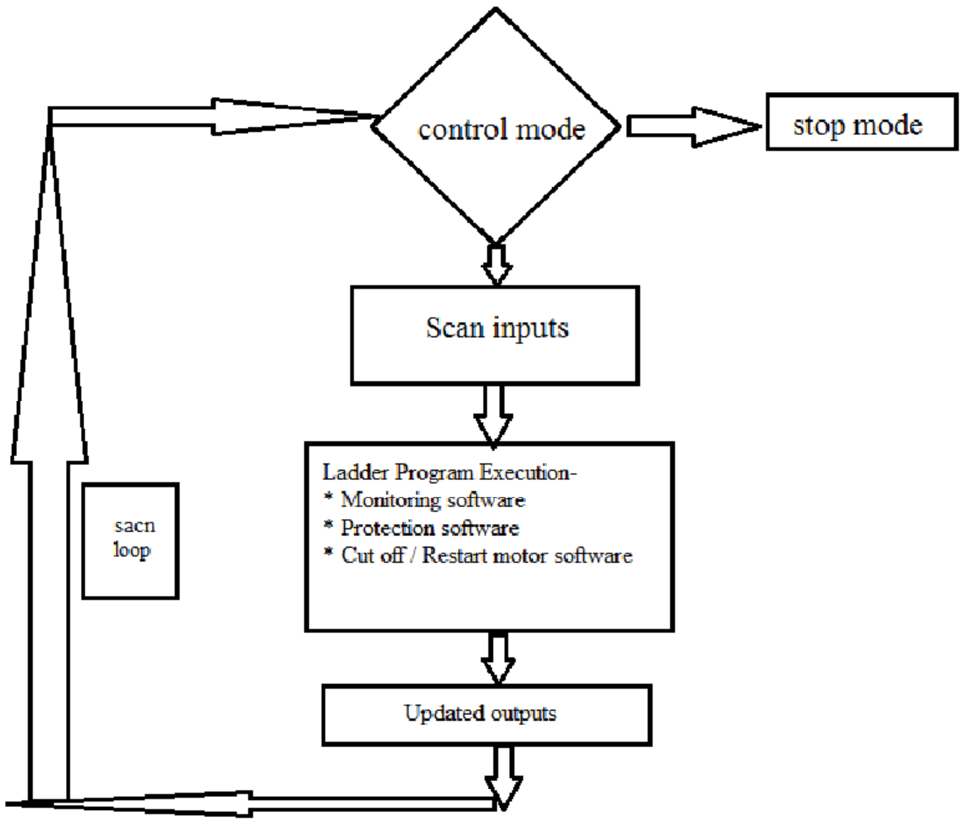


Fig. 10.1: Flowchart of the Main Block Diagram

10.2 Appendix II: PLC interfacing with SCADA:

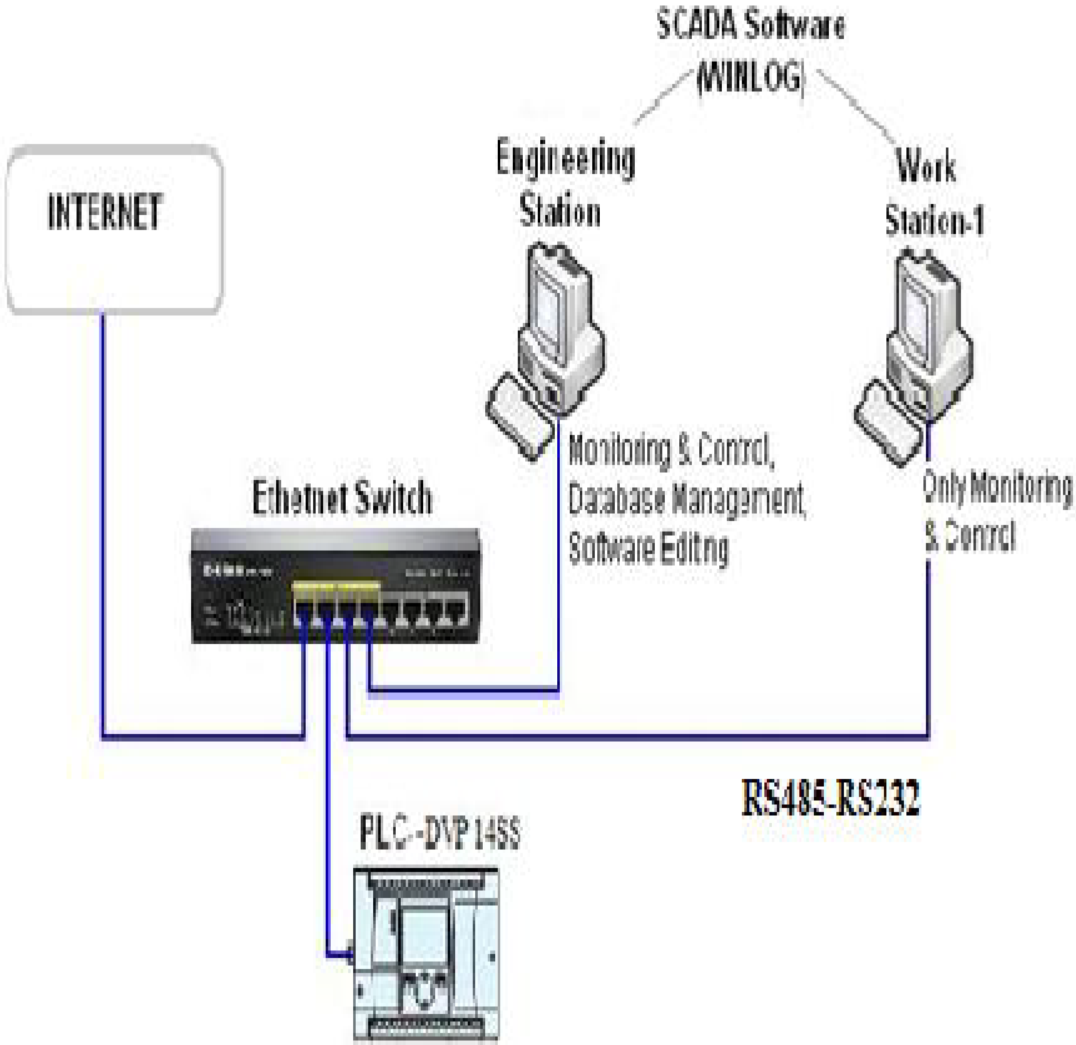


Fig. 10.2: Interfacing of PLC with SCADA [8]

10.3 Appendix III: Ladder Diagram Logic Of The Project:

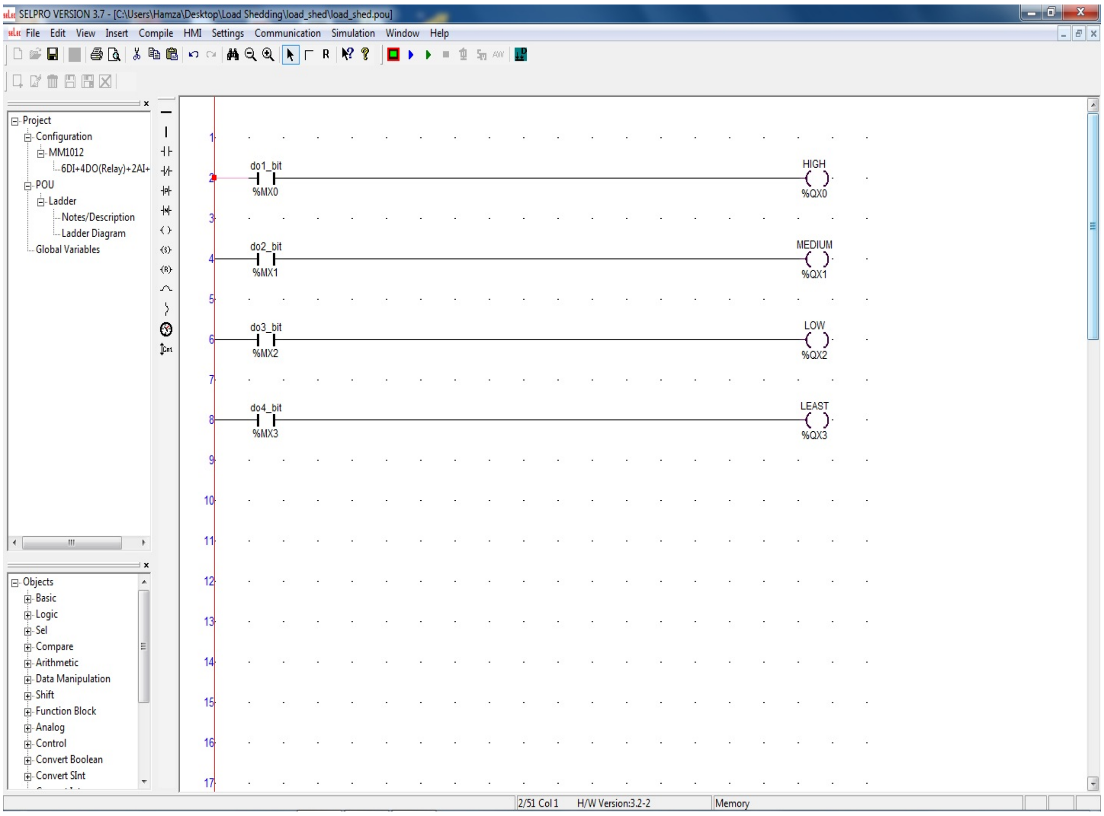


Fig. 10.3: Ladder Diagram Logic

10.4 Appendix IV: Logic Of The Project Using Lab View:

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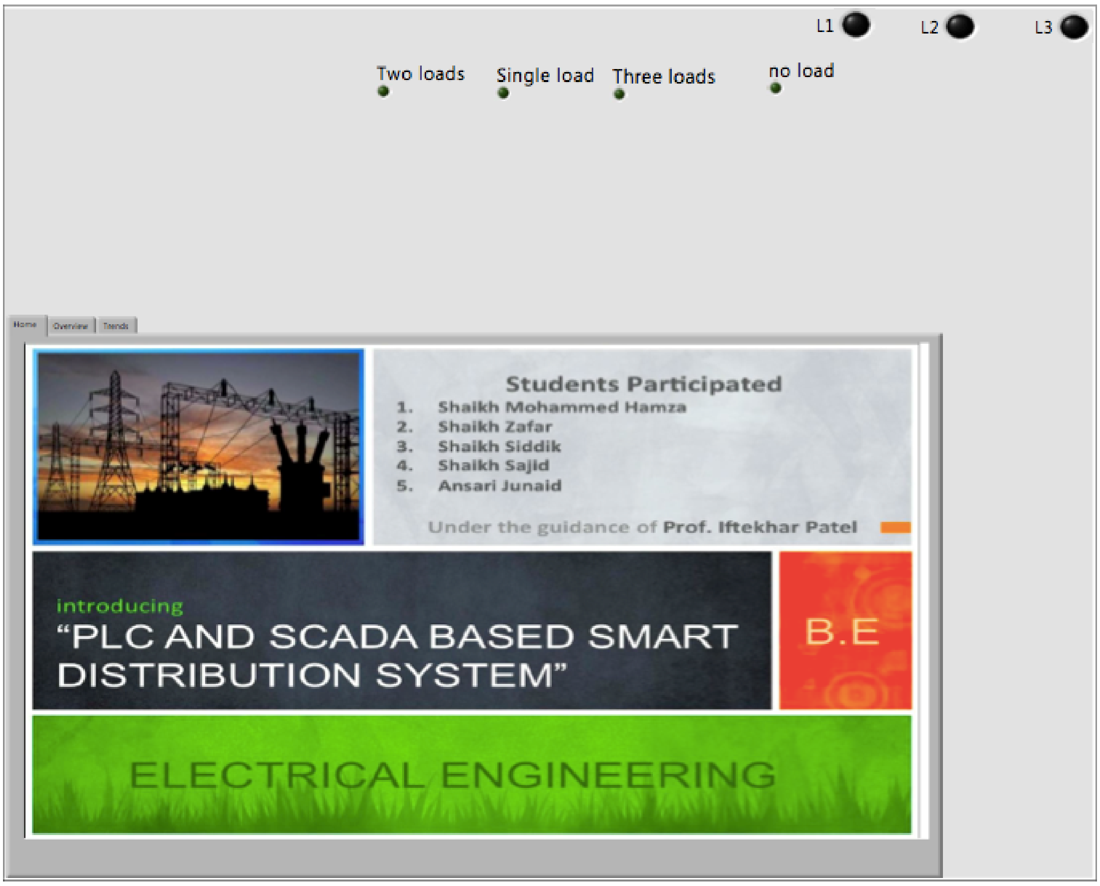

Generator O/P (%)

Fig. 10.4: Project SCADA software program logic screenshot 1

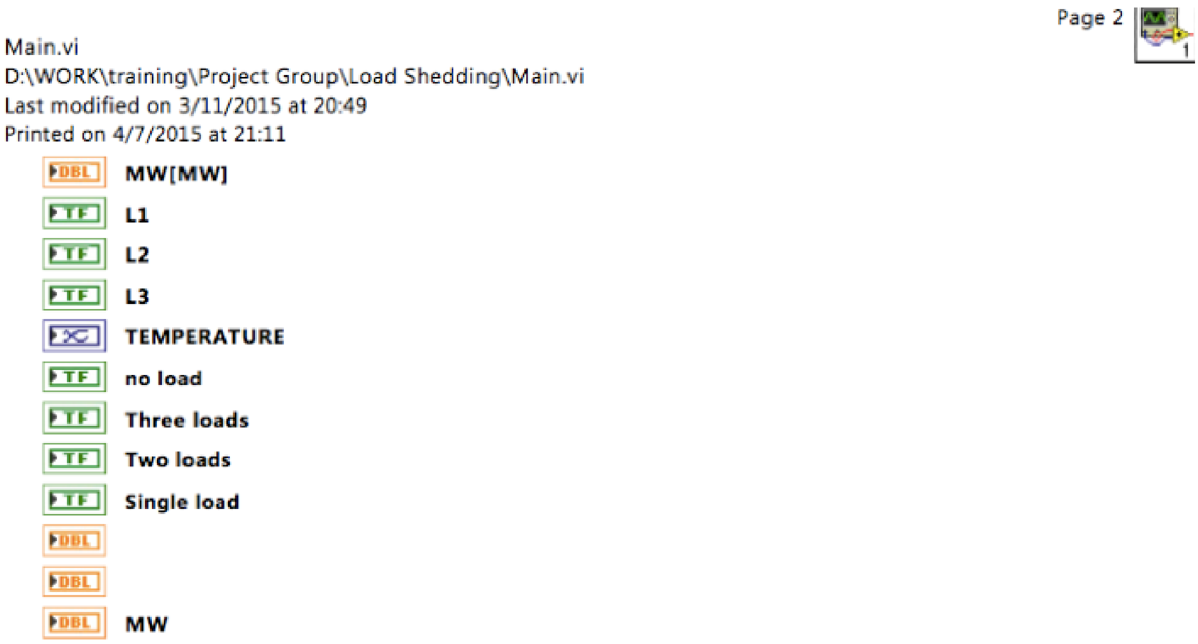

Fig. 10.5: Project SCADA software program logic screenshot 2

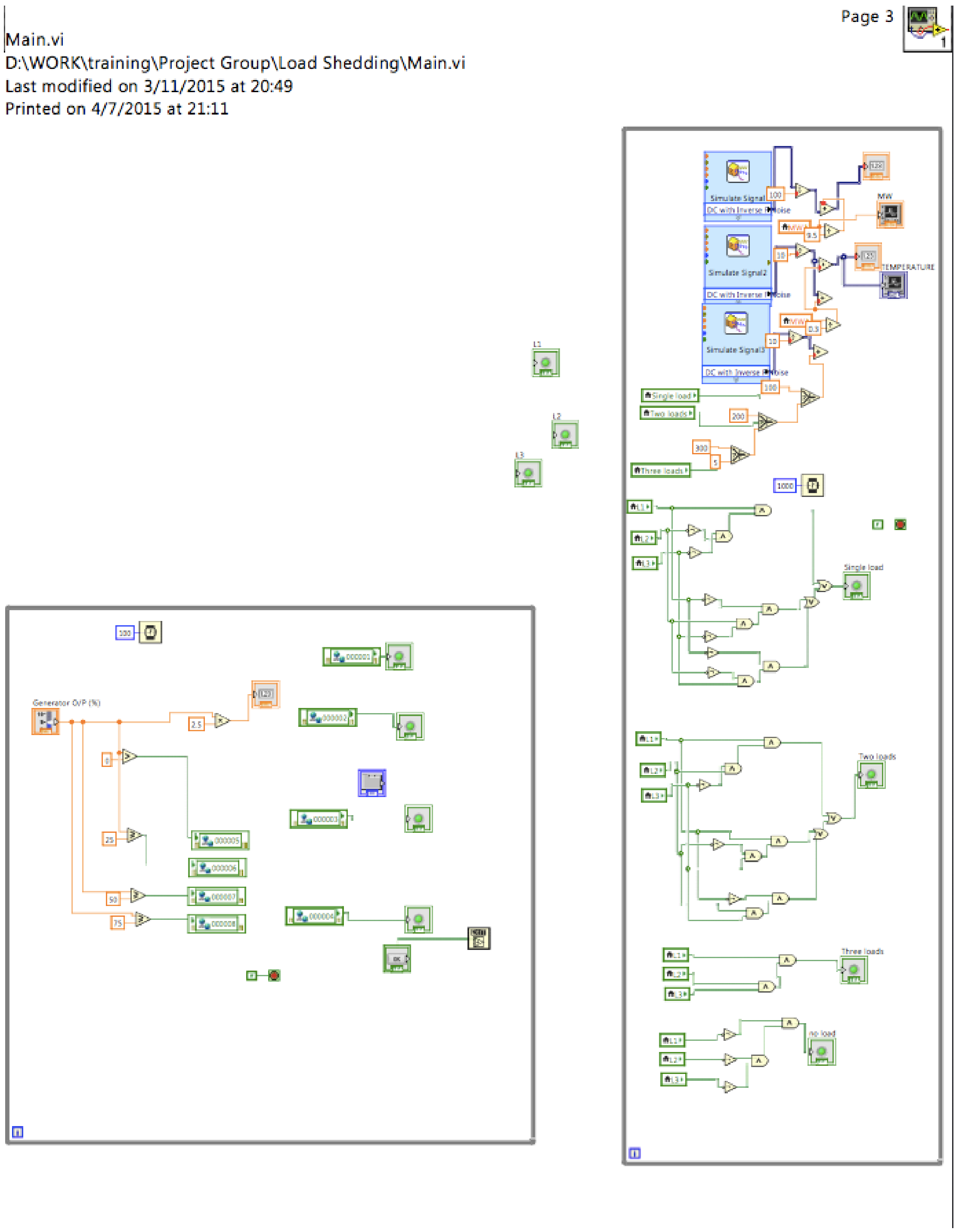

Fig. 10.6: Project SCADA software program logic screenshot 3

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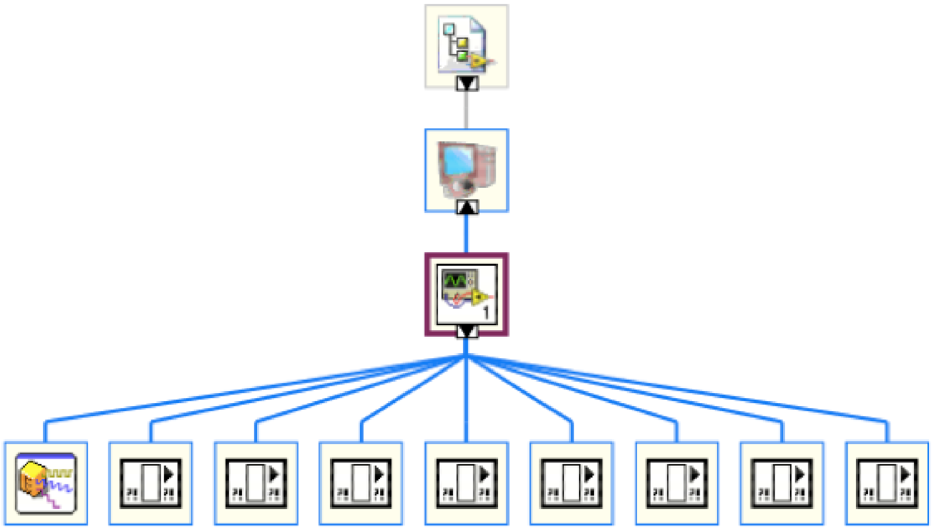

subSigGeneratorBlock.vi
C:\Program Files (x86)\National Instruments\LabVIEW 2014\vi.lib\express\express input\SimulateSignalBlock.llb\subSigGeneratorBlock.vi

"Main.vi History"
Current Revision: 27

Fig. 10.7: Project SCADA software program logic screenshot 4

10.5 Appendix V: Project SCADA Screen View

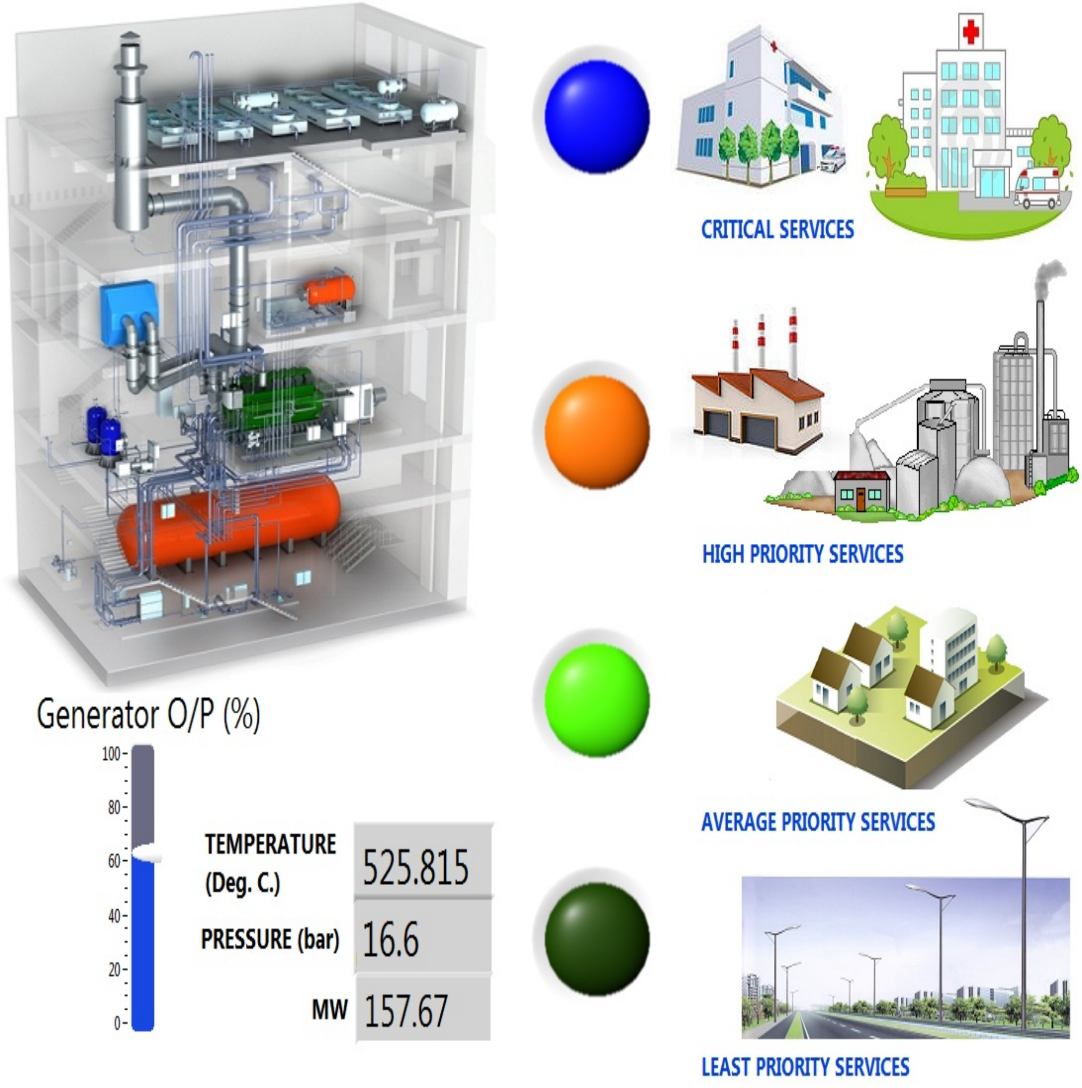

Fig. 10.8: Project SCADA Screen View

10.6 Appendix VI: List of Components used in Project

Sr. No.	Component	Rating/Size	No. of Units	Price ()
01	PLC	12V	1	6000
02	Relay Module	230V	4	800
03	SMPS	24V	1	1000
04	Indicator LED	24V	10	200
05	Panel Board	2*2.5 ft^2	1	150
06	DIN Rail	1 ft	1	200
07	Terminal Block	-	As required	50
08	Nut & Bolt	-	As required	10
09	Layout Sticker	-	1	200
10	Wooden Stand	-	2	150
11	Connecting Wire	10 A /0.5 mm^2	As required	75
12	Other Accessories	-	As required	150
13	Guidance Charge	-	-	6000
Total				**14985/-**

Table. 10.1 Component list

Chapter 11

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