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Substation Automation Using PLCand SCADA

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***Abstract*-The role is of substation is become more important in power system. The generating stations, transmission lines and distribution systems are the main components in substation system transmission lines switching, parameter measurement, fault detection and storing of historical data are carried out in each of the substation. Previously these activities was carried out manually, as complexity of system increase the role of substation become crucial and we need to move towards the use of IEDs and Automation. Activities carried out at substation are categorized in to three terms. supervision, control and Data acquisition. In an automated substation these are will be done using Programmable Logic controller and SCADA. For system monitoring or supervision data is given to controllers from RTU. Control command according to system parameter is produced by PLC and SCADA provide human machine interference. Substation automation systems make their control and monitoring possible in real time control and availability, reliability and security of the system.**

***Keywords*-Substation, PLC, SCADA, RTU.**

I.INTRODUCTION

Substations form a very important mode in the transmission and th distribution of electrical power systems. Substation is the most important part of the power system, and also needs automation.

The main function of substation is to receive energy transmitted at high voltage from the generating station to a value appropriate for local distribution and provide facilities for switching [1]. A substation is the convenient place for setting up the synchronous condenser at the end of the transmission line for the purpose of power factor improvement. The combination of all the equipment which is used to change the characteristics (e.g. voltage, frequency, p.f, etc.) of electrical supply is known as substation [2].

Automation is the process of automatically controlling the process parameters in the plant with the help of automation devices. In the beginning, the process at the plants was supervised manually based on the instrument installed in fields. The rest of the paper is organized as follows [3].The hardware component description to implement the project is explained in Section II.

The software description to implement the project is presented in Section III. Experimental Set up is described in Section IV and paper is concluded in Section V.[4,5] presented in Section III. Experimental Set up is described in Section IV and paper is concluded in Section V.

II.HARDWARECOMPONENT DESCRIPTION

Proposed SCADA based system is a small working model of substation automation. The main aim of our project is to detect the fault within no time and to improve productivity, efficiency of power distribution system. After the process of power transmission (stepping up and stepping down for neglecting losses) we are using circuit breakers. To detect the type of fault we are using over current relay, under voltage relay and phase failure relay and earth fault relay.

Then the supply is distributed to different loads. All the relays are connected to the PLC which is programmed to sense and detect the type of fault and controls the operation of the relays. This whole system is monitored by using SCADA on which we can check the faults and operation of the system. The different hardware components used in the project are listed as follows. The block diagram of the project is shown in Figure. 1.

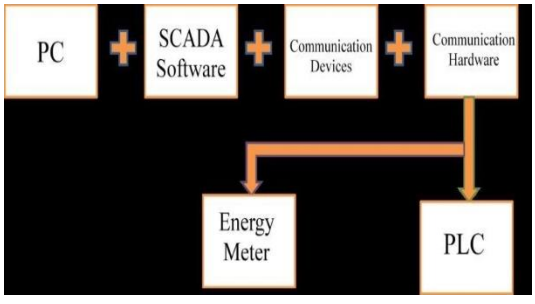

Figure.1 Block Diagram

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1. PLC

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".

2. Supervisory Control & Data Acquisition (SCADA)

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) connects to sensors in the process and converts 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 data acquisition server is a software service which usesindustrial 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 supervisory (computer) system, gathering (acquiring) data on the process and sending commands (control) to the SCADA are increasingly being used with VFDs for variable speed applications. is shown in Figure 2.

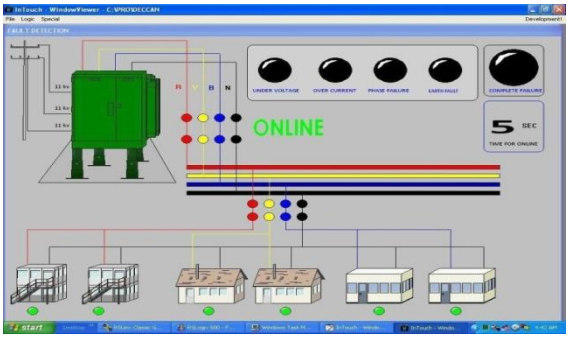

Figure .2 Block diagram of SCADA

3. Remote Terminal Unit (RTU)

Means a microprocessor to connect data input streams to data output streams. RTU may include a battery or charger circuitry. It is accomplished by using an isolated voltage or current source. In SCADA system, RTU is a device that collects data, codes the data into a format that is from the master device and implements processes that are directly by the master. RTUs are equipped with input channels for sensing or metering, output channels for control.

4. Master Terminal Unit (MTU)

Allows operators to view the state of any part of the plant equipment and drives most operator interaction with the by alarms.

5. Intelligent Electronic Devices (IEDs)

Includes electronic meters, relays and controls on specific substation equipment. It has the capabilities to support serial communications to a SCADA sever and reports to modern RTU via communication channels. It performs all functions of protection, control, monitoring, metering and communication. SCADA systems used for monitoring and controlling the power. Traditionally, SCADA systems have made use of the Public Switched Network (PSN) for monitoring purposes.

In SCADA system transmit & receives logic or data from any events of controls metering measuring do monitoring of process devices for example electric equipment, instrumentation devices, telecommunication on industrial applications. It is also used for safety or protection purpose. In power system by using SCADA entire power plant can be controlled remotely over long-distance communication links. SCADA also be used for remote switching, telemetering of grids like showing voltage, current, power, direction, consumption in KWH, even automatic synchronization is used in some power systems. SCADA could be comprising an operator work station (OWS) with a local human machine interface for displaying station of switch position of equipment current\voltage of equipment is used to it. It also used for communication purpose with a network control centre (NCC) with other station also with the generating stations.

6. Interfacing Allows

Communications equipment from different manufacturers to be connected together. The RS- 232 or RS-485 interface is designed for the connection of two devices. Two devices called: DTE (Data Terminal Equipment) communicates with a DCE device and transmits data and receives data and DCE (Data communications Equipment) transmits data between the DTE and a physical data communications link.

7. Contactor

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A contactor has three components. The contacts are the current-carrying part of the contactor. This includes power contacts, auxiliary contacts, and contact springs. The electromagnetic coil provides the driving force to close the contacts. The enclosure is a frame housing the contacts and the electromagnet. The enclosures are made of insulating materials such as Bakelite, Nylon 6, and thermosetting plastics to protect and insulate the contacts and to provide some measure of protection against personnel touching the contacts.

8. Miniature Circuit Breaker (MCB)

The MCB is an electromagnetic device that embodies complete enclosure in a molded insulating material. The main function of an MCB is to switch the circuit, i.e., to open the circuit (which has been connected to it) automatically when the current passing through it (MCB) exceeds the value for which it is set. It can be manually switched ON and OFF as similar to normal switch if necessary. MCBs are of time delay tripping devices, to which the magnitude of over current controls the operating time. This means these get operated whenever overload exists long enough to create a danger to the circuit being protected. Therefore, MCBs don't respond to transient loads such as switches surges and motor starting currents Generally, these are designed to operate at less than2.5 milliseconds during short circuit faults and 2 seconds to 2 minutes in case of overloads (depending on the level of current).

III. SOFTWARE DESCRIPTION

1. PLC Software

Programmable logic controllers (PLCs) used in industrial control applications.Each device in the relay rack would be represented by a symbol on the ladder diagram with connections between those devices shown.

Figure.3 PLC Communication.

2. Lab VIEW

Lab-VIEW 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.

3. Ladder Logic

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

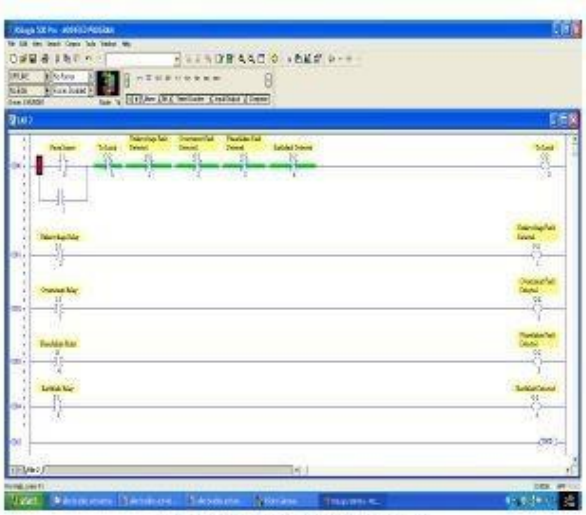

Figure.3 Ladder Logic of PLC Program

IV. EXPERIMENTAL SETUP

As per the discussion of the hardware components our main objective is to main aim is to detect the fault within no time and to improve productivity, efficiency of power distribution system. After the process of power transmission (stepping up and stepping down for neglecting losses) we are using circuit breakers. To detect the type of fault we are using over current relay, under voltage relay and phase failure relay and earth fault relay. Then the supply is distributed to different loads.

All the relays are connected to the PLC which is programmed to sense and detect the type of fault and control the operation of the relays. This whole system is monitored by using to the SCADA monitoring system through RS-232 cable. For the transfer of data, the driver needs to be configured. The required series of steps as per the software are to be followed for the configuration of the PLC. A ladder diagram for monitoring four analog signals is developed. Among them, three analog signals are from current transformers of outgoing feeders and one analog signal is from potential transformer of low voltage side bus.

The major faults that occur in most substations are symmetrical faults, unsymmetrical faults, over-voltage,

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over current and overloading etc. Practically these currents did not meet the required current ratings of the PLC. Hence these faults were not implemented in the constructed model of the substation.Overvoltage and overloading decrease the efficiency and damage the insulation of the system. Hence, necessary actions are taken at any substation in order to mitigate these faults. The built substation prototype is equipped with SCADA control system that can clear the over-voltage and overloading faults automatically.

1. 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

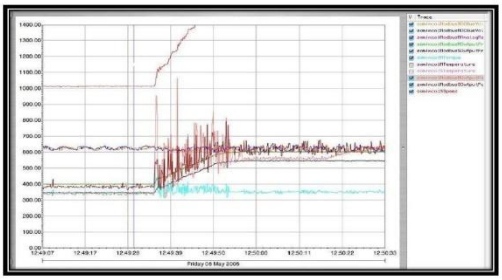

Figure.5 Real Time Trends

2. 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

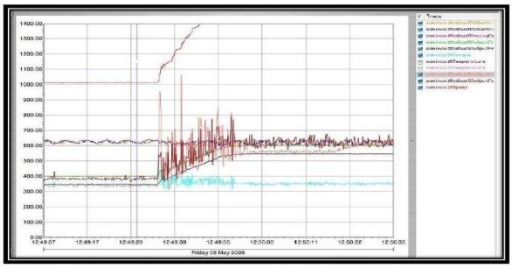

Figure.6Historical Trends

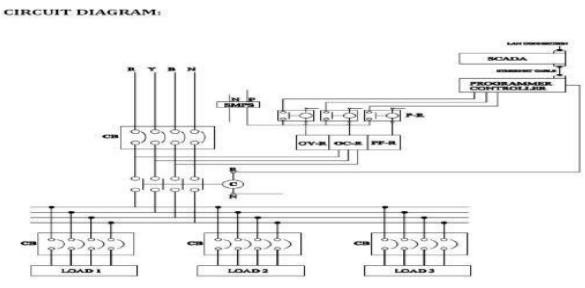

Figure.7 Experimental Setup.

VI. CONCLUSION

With the help of Substation Automation we can improve reliability, power quality & power handling and distribution capacity/management.

The implementation of automation is very costly & complex procedure with increasing use of power electronics & electronics equipment, for implementation in practical existing field. After investing more equity for automation we can achieve a lot from the system. Total 60% to 65% of existing substation's age is more than 25 years. According to its age government has started renovating and improving towards system automation. This improvement should be IEC 61850 instead of distinctive Substation Automation. At present in INDIA knowledge of IEC 61850 & implementation technology is only with private sectors. This standard is worldwide accepted. So, government should try to train engineers to get enhanced output.

We can see from above discussions of Substation Automation t has become an essential part in designing a Substation. Automation removes human errors & provides accuracy to the system efficiently and moreover at intellectual electronic faster devices. The Automation Demonstration involved all kind of real time existing equipment required work properly and understand the actual automotive structure of modern substations. The modern substations are well equipped with SCADA, IEDs , PLC & RTU. These are popular now-a-days which provide an excellent human machine-interface unparalleled with the existing machineries.

VII. ACKNOWLEDGMENT

It is indeed a matter of great pleasure and proud privilege to be able to present this paper on "Substation Automation Using PLC and SCADA".This paper and the research behind it would not have been possible without the exceptional support of my supervisor.

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