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AUTOMATIC FAULT DETECTION SYSTEM IN SWITCH YARD USING PLC/SCADA

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Abstract: Automation means Delegation of human control to machine. A PLC (Programmable Logic Controller) is a device that was invented to replace the necessary sequential relay circuits for machine control. A SCADA (Supervisory Control & Data Acquisition System) is used to control the process where person cannot go or stay for longer period. The aim of tis paper is to provide information about electricity can be generated from Renewable sources & how its transmission done using automation system. Renewable Energy consists of energy generated from natural and unlimited sources, which include wind, solar, biomass and hydroelectricity. Programmable logic controllers (PLC) can be used for control & automation in Distribution of Energy. The main reason for this is cost effectiveness. Various functions and controls can be achieved by programming the PLC.They can be used for full plant automation including governing of auto operation includes speed control, load control, excitation control, and level control automatic start/stop sequencing, gate control, start/stop of auxiliary systems, and protection requirement etc. Functions other than control like continuous monitoring, data recording, instrumentation and protections can also be performed. For remote operation, communication with PLC can be performed. For continuous monitoring purpose, a personal computer can be interfaced with PLC and continuous data can be recorded regularly. In this paper I used different methods for generation of electricity like wind, PV (photovoltaic), hydro, biogas & distributed using PLC & controlling using SCADA.

Key Terms: PLC (programmable Logic Controller), SCADA (Supervisory Control & Data Acquisition System), PV (Photovoltaic).

I. INTRODUCTION

Supply disruptions have been caused by factors such as overloading that causes fuses to blow, lightning, poor workmanship of materials and equipment, incorrect operations, relay failures and inadequate maintenance. Without distribution automation system, these problems always cause failures anywhere in the service substations and would result in power outage for an entire area. If all diagnosis and repairs are handled manually, teams of technicians have to isolate and repair the faulty sections. Power failures can last for extended periods, causing much inconvenience and financial losses to the customers and to the utilities.

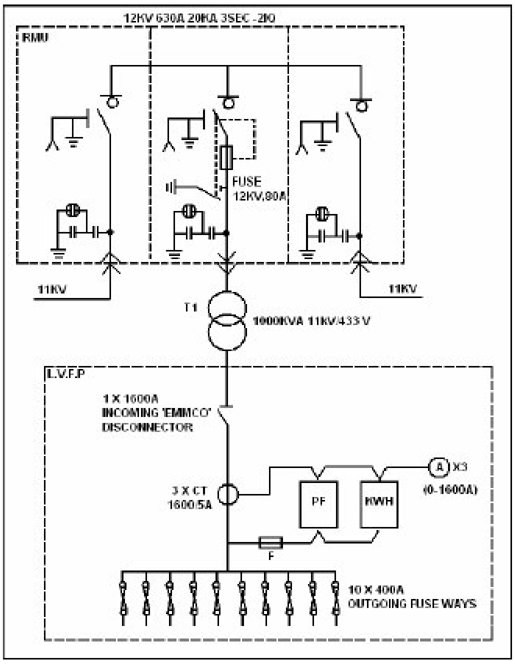

fig.1 Service substation panel

The SCADA remote monitoring and control system is in demand to provide a fast fault restoration with minimum cost and shorter time consuming.

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SCADA can be used to handle the tasks which are currently handled by the people and can reduce frequency of these visits substantially. No researches have been done in the service substation side of the downstream distribution systems. This is probably due to the limited degree of damages at the downstream. Faults occur in the substations and distribution substations are more severe and affect wider area compared to faults which occur in the service substations. Although, the faults are considered as minor in the service substations, they are handled by equipment which is very close to customers. Some minor fault might jeopardize continuous electricity supply to customers.

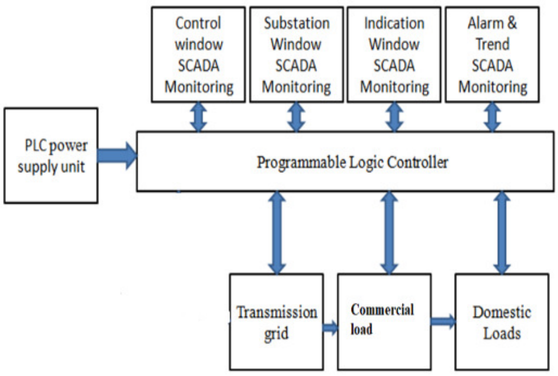

Fig.2 Proposed System

Power management is an important constraint in the design of various loads in industrial for automation. So if power consumption increases then the substation monitoring is very important so for the purpose of controlling the hardware and software there are various factors which causes faults in switchyard and transmission systems. These factors include over voltage, over current, frequency. Relays and circuit breakers are used to protect the systems when these faults occur. In our project we are controlling the relays with the help of software called PLC and SCADA. This reduces the fault occurring time of relay. We use Allen Bradley Programmable Logic Controller and In touch for SCADA. The ladder logic program is used to control the operation of substation by interfacing with SCADA. The program uses comparison of values to protect the system. The comparison is done in such a way that the instant values of voltages and current with their respective preset values. If the values exceed the limit, the respective area will shut down and an alarm is given.

This research is based on open loop distribution system which means that the loads are connected to two feeders and any section of the feeder can be isolated without interruption. Thus, the average outage time is reduced to the time required to locate the fault and do the necessary switching to restore the service. In this research, the switching can be performed either automatically or manually.

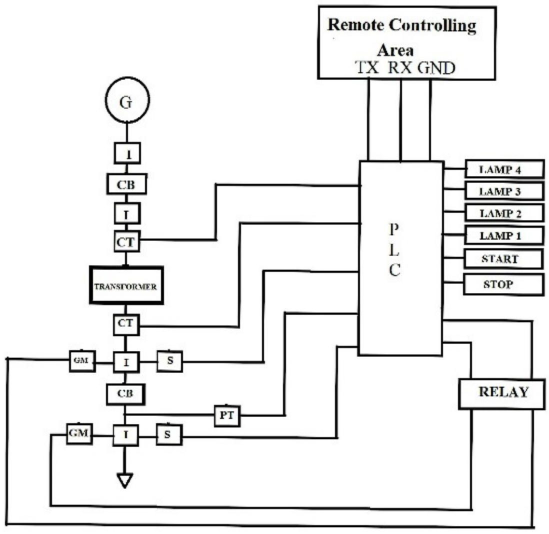

Fig.3 System Block diagram

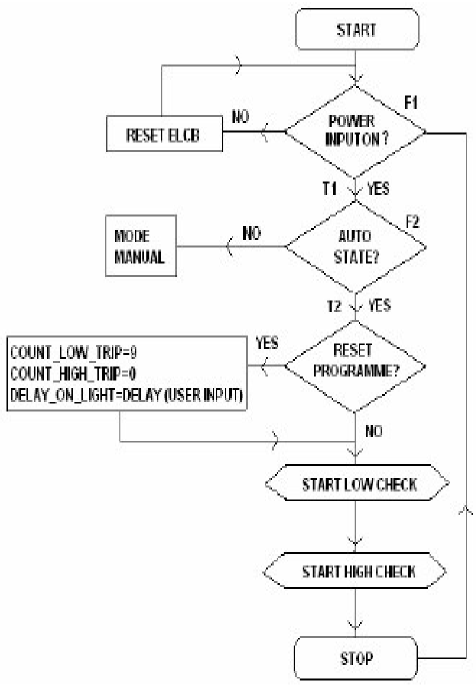

Fig.4 Algorithm for fault isolation method

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The developed logic programming is based on the flowchart described. By using a flowchart, the sequences of operations were determined. Based on the flowchart, there are five major actions which are the status of 'power input', mode state, the status of 'reset program', execute 'start low check' and execute 'start high check'.

First step is to check the power input whether it is turned on or turned off. The power input is referring to relay output of Earth Leakage Circuit Breaker (ELCB) with over current relay protection. Earth leakage relays work in much the same way as the Residual Current Circuit Breaker (RCCB) and as such, must be accompanied by a circuit breaker or fuse. So basically it will only break the circuit when there is a leakage current flowing from phase line to the earth. If no faulty condition is detected by ELCB, power input is turned on (Normally Close (NC)). When ELCB detects the fault condition, power input is turned off (Normally Open (NO)). In this case, the ELCB is reset by using a delay timer and power input is turned on automatically. There are two modes of operations, i.e. manual and automatic modes. If automatic mode is selected, when fault occurs, the fault point is isolated automatically by activating the 'start low check' and 'start high check'. The 'start low check' and 'start high check' are executed only when the fault point is isolated and the unaffected points are operated as normal condition. Once the fault point is operated as normal, the 'reset program' button is pressed. These button resets back the counter to initial values and execute the 'start low check' and 'start high check' again. 'Start low check' checks the low side which is from the left to right while 'start high check' checks the high side which is from the right to the left. This is illustrated. If the manual mode is switched on, when fault occurs, the checking is done manually by the operator. The developed Graphical User Interface (GUI) provides buttons to control the switching of the loads.

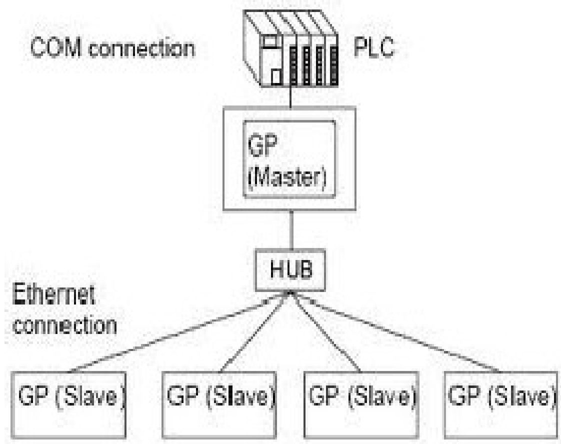

Fig.5 System control using PLC & SCADA

PLC is used for centralized management. It is a Master PLC. Many Slave PLCs are connected to Master PLC. SCADA is used for outer loop management. In each power unit there exists a slave PLC, which is connected to the master PLC through a Profibus network. This power unit PLC monitors and controls the on-line power delivery to the electric grid. Similarly each ESS has a slave PLC controlling the income/outcome energy in the system. Each PLC hosts several control programs whose selection is made either locally, via an HMI (Human Machine Interface) or remotely, via the Master PLC. The Master PLC is connected to the server PC, via RS232/ MPI Siemens protocol, where the SCADA application is running.

The server PC is simultaneous a SCADA server and an internet server, as the implemented SCADA application is web enabled. All process variables are available at the SCADA PC as these variables are on-line available through a Profibus/ DP connection protocol (Siemens,2001a).

The four slave PLCs for wind farm, PV, Hydro & Biomass respectively. A Supervisory Control and Data Acquisition (SCADA) System is used as an application development tool that enables system integrators to create sophisticated supervisory and control applications for a variety of technological domains, mainly in the industry field. The main feature of a SCADA system is its ability to communicate with control equipment in the field, through the PLC network. As the equipment is monitored and data is recorded, a SCADA

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application responds according to system logic requirements or operator requests. In the developed control strategy, the SCADA application performs the outer control loop of the energy plant system. At this outer loop several complex control structures can be used to manage the overall system dynamics.

II. DEVELOPED MAIN SCADA SCREEN

Main screen displays both panels which are service substation panel and customer service substation panel. Each symbol created is assigned to a tag that is already issued to certain network address that linked to the variable downloaded to the RTU. The symbols changed to red color to indicate false status and green color to indicate true status. The displayed data on the screen consists of alarm screen, event screen, graph screen and table screen.

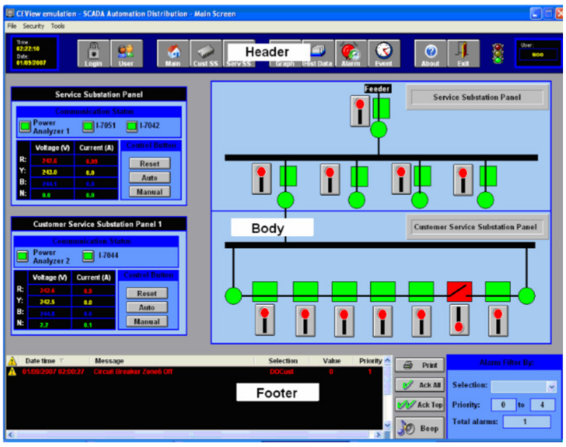

Fig.6 GUI of SCADA

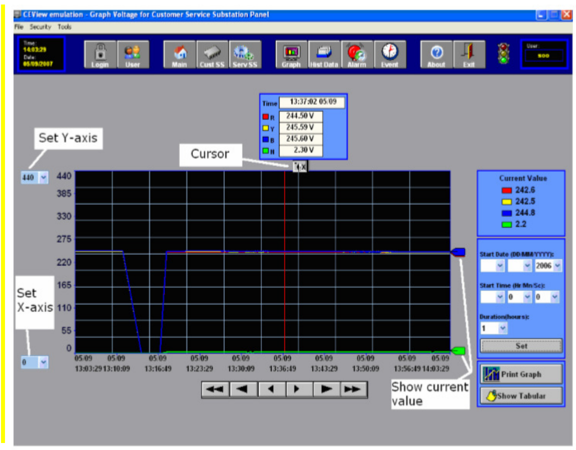

Fig.7 Voltage of Customer Service Substation Panel

This provides on-line data of voltage and current from the power analyzer. "Cursor" a button at the top of the graph can be dragged to know the value along a certain position of the graph. X-axis and Y-axis can be set to the user preferences. A combo box on the left side of the graph is to change the x-axis and y-axis. Start Date, Start Time and duration are to set the x-axis. By clicking on the "Show Tabular" button, screen shown in Fig. 13 will be displayed. This screen is to display the graph data in a table form. The value is archived from the graph shown in the trending screen. "Reload" button is to update the table based on the graph.

III. SOFTWARE & HARDWARE REQUIREMENTS

Software requirements:

The software used for the PLC programming was the Allen Bradley SLC 500 The Scada system was developed over the platform Wonderware (INTOUCH).

PLC properties:

- PLC Company : Allen Bradley PLCs (AB)
- PLC Prog. Language :LADDER DIAGRAM
- PLC Model :SLC5/038k mem.
- TYPE : Slot
- Power Supply : 230v AC
- I/P rating : 24v DC
- O/P rating : 24v DC & 230v AC (Relay Type)
- Max I/o's : 4096 (Digital)
- Protocol : RS 232, DH 485
- Prog. S/W : RS Logix 500
- Communication S/W: RS Linx

SCADA properties:

- SCADA Company : Wonderware
- SCADA Prog. Language :Assembly Language
- SCADA S/W : IN Touch 9.5v
- SCADA/PLC Interface :(DDE/OPC) server
- NO. of Tags : 64000 (I/o's) but used Tags 117

IV. HARDWARE REQUIREMENTS

Referring hardware characteristics each PLC (Master and Slaves) was composed by the following Siemens modules: Slot1 = Power supply PS 307-2A Slot2 = Processor CPU 315-2DP Slot4 = Communication module CP 342 -5 Slot5 = Digital card DI8/DO8xDC24V/0,5A Slot6 = Digital card DI8/DO8xDC24V/0,5A Slot7 = Analogue card AI4/AO2x8/ 8bit. Additionally, the Master PLC has a modem for GSM communication that provides the system capacity to communicate through the mobile phone network. The sensors used to monitor the generated and consumed electric power/current are a set of AC/DC current transducers, coupled to

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energy analysers, with Profibus communication. In our case the energy meters used were the family Siemens SIMEAS P. The power generation of the considered RES units, was simulated through 2 DC-power supplies, and 1 AC-Power supply, which simulated the power output from the DC converters and the AC-generator illustrated in fig 6. The power amplitude was externally changed.

Hardware cost analysis:

- SLC 5103 PLC (AB) = 42,000
- SCADA INTOUCH (9.5V) =4Lakhs
- 24V DC 3amps Power Supply (RPS) = 550
- 8 Channel Glass Relay = 2400
- 22m Green (8) & Red (2) Lamp = 800
- 22m Push Button (3) = 240
- Rail (30cm) = 100
- Connectors = 200
- Ply wood = 150
- Connecting wires = 150

Equipment ratings:

- PLC (Power Supply)= 230V AC
- I/P Rating = 24V DC [Transistor I/P]
- O/P Rating = 24V DC [Transistor O/P]

Glass relay:

- Relay (I/P) = 24V DC [Max- 230V AC]
- Relay (O/P) = 24V DC [60 Amps]

Push Buttons:

- (I/P) = 24V DC
- (O/P) = 24V DC

Lamps:

- 24V DC = 0.3mA

V. RESULTS & DISCUSSIONS

The SCADA system used to implement this monitoring and control strategy permits the selective access to the application, depending on the user's responsibility degree. In this paper we developed three user levels: Operators, Supervisors and Administrators. Several SCADA menus were built. The main characteristic of a SCADA Menu is to be simple, explicit and quick on transmitting the information to the operator or to the System Administrator. Power Plant Production (PV unit, Biomass unit, Wind Unit & Consumption).The on-line available information, referring actual data from each power unit is: actual values and maximal daily values for Voltage, Current, Power and efficiency ratio (actual Value/Max.Value).

VI. CONCLUSION

The Energy Management System in this paper consists of PLC for inner loop controlling & SCADA for outer loop controlling. PLC is centralized PLC having four slave PLC for different processes like wind energy, hydro power, photovoltaic & biomass respectively. Due to Energy Management System using PLC & SCADA operational cost decreases & also easy to handle. Online monitoring & distribution of energy is possible due to this developed Energy Management System.

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