The PLC Based Approach for Automation of Power Distribution in Radar

Ekta Tripathi, Abdul Bari and P.K. Gupta
Bharat Electronics Limited, Ghaziabad

ektatripathi@bel.co.in, abdulbari@bel.co.in, guptapk@bel.co.in

Abstract:

This paper presents a new approach towards power distribution systems in Radars that provides full automation in process control areas vis-a-vis conventional relay type control. This design approach utilizes PAC8000 programmable logic controller (PLC) as the control equipment and Supervisory control and data acquisition (SCADA) system for the remote monitoring and control of various subsystems.

Keywords:
PAC8000, PLC, SCADA, Data Acquisition, Radar System.

I INTRODUCTION

Automation, a Greek word means "self dedicated". Automation is the key to modernization and has been conceptually understood as a way to increase efficiently and to improve productivity.

Programmable Logic controllers are being used extensively in the process and automation industry. For the last few decades, Programmable Logic Controller (PLC) has been widely accepted in various process industries which is a solid state device designed to perform logic functions [1]. PLC has several known features including, flexibility, reliability, low power consumption and ease of expandability. The software abstraction level changes mere requirement in extending and optimizing the control process rather than internal rewiring [2, 3].

While PLCs provide the interfacing facility with the field equipments, **supervision** is required for the process control at the users' end. To achieve this goal, the supervisory system of a process must collect, supervise and record important sources of data linked to the process, to detect the possible loss of functions and alert the human operator.

With the advances of electronic and software technologies, the SCADA systems are widely used in industrial plant automation. It provides an efficient tool to monitor and control equipment in manufacturing processes on-line.

SCADA is the acronym for "Supervisory Control and Data Acquisition". SCADA systems are widely used for supervisory control and data acquisition of diverse kind of processes. Such process can be industrial, infrastructure or facility [4].

SCADA systems became popular to arise the efficient monitoring and control of distributed remote equipment's [5]. PLC can have the communication with SCADA through tags of information [6]. In literature, many reports are found pertinent to successful integration of PLC with SCADA for number of applications [7, 8].

SCADA systems play a vital role providing power related utilities with valuable knowledge and capabilities that are keys to a primary business function - delivering power in a reliable and safe manner. A quality SCADA solution is central to effective operation of a utility's most critical and costly distribution, transmission, and generation assets.

Power distribution in radar systems is a significant area which requires considerable amount of accuracy, efficiency and safety in its design phase. To this date, radar systems power distribution is handled manually due to which remoting, monitoring and maintenance of the system becomes a cumbersome task and is more prone to human errors.

This paper presents the application of PLCs & Supervisory control and data acquisition (SCADA) system in the radar systems particularly Arudhra Radar. The power distribution scheme has been implemented in the form of PLC based Power Distribution Panel. This design mainly uses configuration software to conduct configuration design for the power distribution monitoring and control system. It provides real time data and status display for field equipments and integrates with reports, database, and other functions so as to help query and analyse historical data.

II SYSTEM DESIGN

1 Arudhra System – General Overview and functional description

Arudhra radar major subsystems are Power system (DG, UPS & Rectifier), Pedestal Assembly, Cooling system, Radar Shelter and Operations shelter (OPS). All these subsystems communicate to each other on LAN using Radio / Optical Fiber media as shown in Figure 1 given below.

Each of the major subsystems (DG, Cooling system, Radar, OPS) has individual PLC through which they can be controlled and monitored locally. Apart from that, each of the PLCs can be controlled and monitored from a remote PLC (Radar Shelter or OPS shelter).

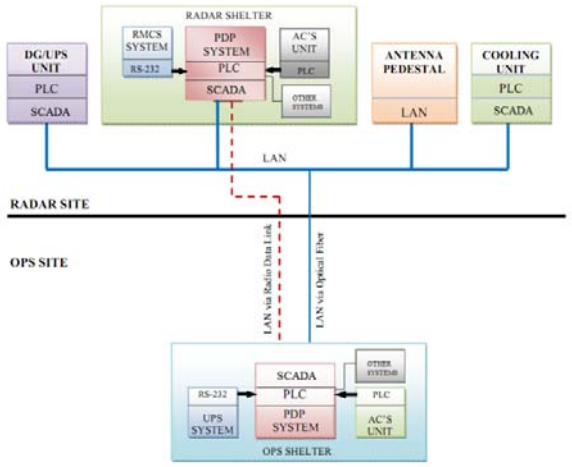

Figure 1: General Overview

This inter-PLC communication provides current status and helps to take immediate decisions in case of any emergency or fault of any subsystem. The facility of alarm logging proves helpful in troubleshooting and digging to the root cause of the faults. The screens are password-protected and master management is available to avoid any ambiguity in the controlling of system.

2 System Architecture

PLC based PDP system used in Arudhra Radar controls and monitors the power distribution in two shelters namely (1) Radar Shelter (2) OPS Shelter.

Each shelter houses a PDP Rack which individually controls and monitors the distribution in that shelter; moreover each shelter can be fully monitored and controlled remotely from other shelter. The architecture of the PDP system is divided into three layers namely, System Monitoring Layer, System Communication Management Layer and Field device Layer.

System Monitoring Layer: Includes Touch Input Panel, Multi Function meter, Sensors, Aspiration Smoke Detectors.

System Communication Management Layer: Includes LAN Switches, Cimplicity SCADA server, PLCs.

Field device Layer: Includes Contactors, MCBs etc.

The monitoring of the system is done through CIMPLICITY SCADA System. Various communication protocols are being used viz, MODBUS TCP/IP, MODBUS RS485. In some scenarios, the scripts are being utilised for communicating on RS232, UDP protocols. The topology is shown in Figure 2.

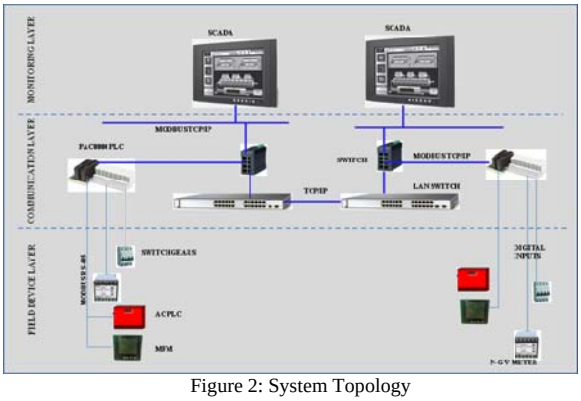

Figure 2: System Topology

III PDP – HARDWARE DESCRIPTION

PDP Rack Dimensions (in mm): H1700*W600*D400
Net weight approximate (in Kg): 300

The PDP hardware comprises of following major equipments:

1) PAC8000 Controller (PLC)
2) Analog and Digital carriers
3) DC Power Supplies
4) Circuit Breakers
5) Contactors, DC Relays
6) Touch Input Display (TID)
7) Sensors (Temp, Humidity, Airflow, Fire/Smoke)
8) Multifunction Meter (RS-485 Interface)
9) Capacitors Bank
10) UPS
11) Battery
12) PHS and N-G Voltage Meters
13) Current Transformers

PAC8000 is the CPU of the whole PDP System. Each PAC8000 node can address up to 64 I/O modules which, depending upon the number of channels per module, can provide up to 1024 I/O points at a single node. A node can consist of a mixture of analog and discrete modules and this gives maximum flexibility to the system designer.

This project uses 32 Digital Inputs, 13 Digital Outputs and 7 Analog Inputs to the PAC controller through the DI, DO and AI cards. All the PLC related modules are powered through UPS for continuous power supply.

The Figure 3 below shows the PDP Rack currently utilised in Arudhra radar.

Figure 3: PDP Rack in Arudhra

IV PDP – SOFTWARE DESCRIPTION

The software module of the project consists of PLC Configuring & programming workbench and Supervisory Control and Data Acquisition software. The specifications of the PLC programming software are PAC8000 workbench and the SCADA software used is HMI Scada Cimplicity Workbench 8.2.

1 PAC8000 Workbench

The commonly used language for PLC's is ladder logic. The ladder logic programming language is an adaptation of an electrical relay-wiring diagram. The input to the PLC can be wired as normally open contact or normally closed contact depending on this when the input is actuated the input relay may turn on or off respectively. The Figure 4 given below shows a snapshot of PAC8000 Workbench.

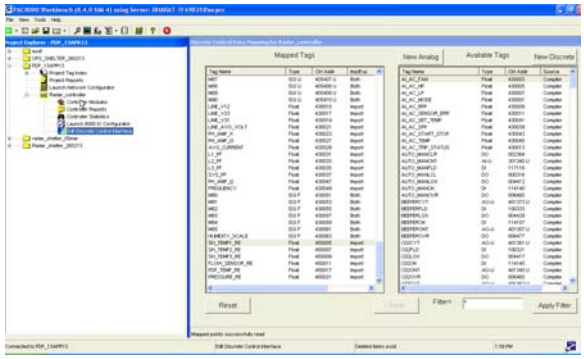

Figure 4: PAC8000 Workbench

1 SCADA Architecture

SCADA architecture supports TCP/IP, UDP or other IP-based communications protocols as well as strictly industrial protocols such as Modbus TCP, Modbus over TCP or Modbus over UDP, all working over private radio, cellular or satellite networks.

A well planned and implemented SCADA system not only helps utilities deliver power reliably and safely to their customers but also helps to lower costs, achieve higher customer satisfaction and retention and enable increased operational and tariff flexibility.

The SCADA system usually consists of the following subsystems [9]:

- A human–machine interface or HMI is the apparatus or device which presents process data to a human operator, and through this, the human operator monitors and controls the process.
- A supervisory (computer) system, gathering (acquiring) data on the process and sending commands (control) to the process.
- Remote terminal units (RTUs) connecting to sensors in the process, converting sensor signals to digital data and sending digital data to the supervisory system.
- Programmable logic controller (PLCs) used as field devices because they are more economical, versatile, flexible, and configurable than special-purpose RTUs.
- Communication infrastructure connecting the supervisory system to the remote terminal units.

The SCADA system used in this project uses HMI Scada Cimplicity Workbench 8.2 as the programming tool. The screens developed are designed so as to monitor and control the power distribution to the whole shelter from a single location. The user accessible GUI is shown in Figure 5 and Figure 6.

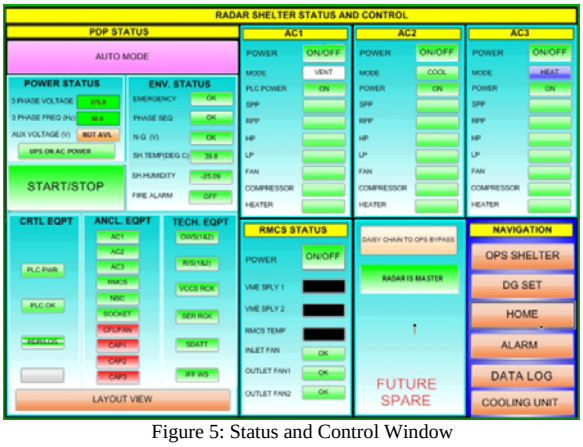

Figure 5: Status and Control Window

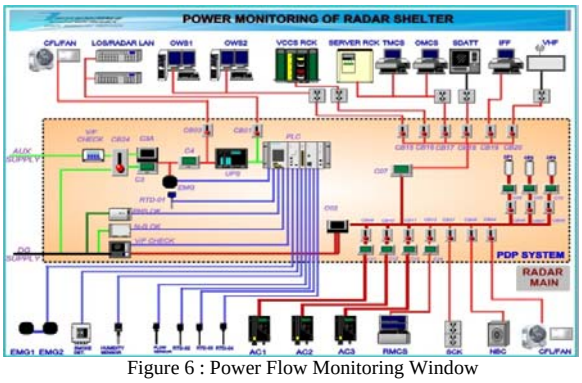

Figure 6 : Power Flow Monitoring Window

V PROCESS DESCRIPTION

The power distribution has two modes of operation in the shelter:

1) Auto Mode: In this mode, the PLC monitors and controls the power distribution according to the logic built in the memory.

2) Manual Mode: In this mode the controlled capability of the PLC is bypassed and SCADA now only monitors the power distribution status. The power distribution is done manually by the operator. This mode is used only in case of emergency conditions when all the environmental checks etc are to be bypassed and the systems need to be kept ON.

The equipments in the shelter are divided into three main domains:

1) Critical Equipment: Power distributions take place if there is no Fire/Smoke or Short Circuit.

2) Ancillary Equipment: Power distributions take place if emergency, phase sequence and Neutral-to-ground voltages are OK along with Voltage and frequency is within specified range.

3) Technical Equipment: - Power distributions take place if shelter temperature and Humidity are within specified range.

The flowchart of the process is given below in Figure 7:

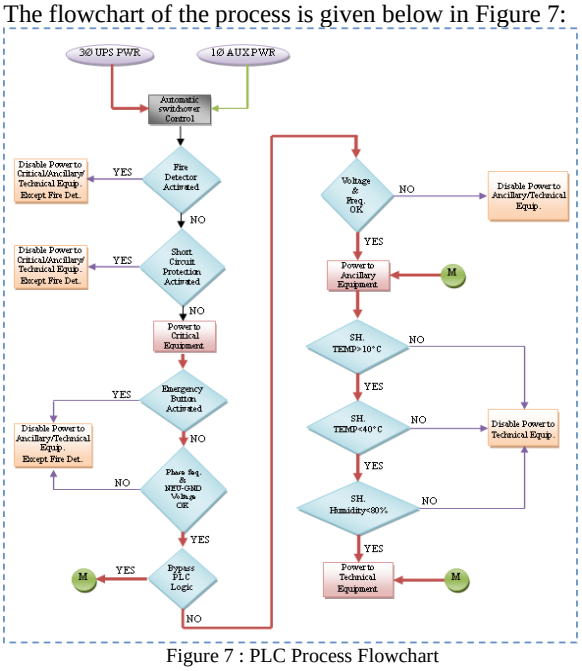

Figure 7 : PLC Process Flowchart

VI COMPARATIVE STUDY

In the conventional relay based power distribution systems, following points were observed:

1) There were too many wiring work in the panel.
2) Modification can be quite difficult.
3) Troubleshooting can be quite troublesome as a skilful person may be required and takes longer time to repair.
4) Power consumption can be quite high as the coil consumes more power.
5) Remote operation & monitoring requires huge cabling and is costlier and more prone to errors due to unavailability of user interface.

As compared with the conventional system, PLC has the following advantages:

1) The wiring of the system usually reduces by 80% compared to the conventional relay control system.
2) The power consumption is greatly reduced as PLC consumes less power.
3) The PLC self diagnostic functions enable easy and fast troubleshoot of the system.
4) Modification of control sequence or application can easily be done by programming through the console or computer software without changing of I/O wiring, if no additional Input or Output devices are required.
5) In PLC System spare parts for relays and hardware timers are greatly reduced as compared to conventional control panel.
6) The machine cycle time is improved tremendously due to the speed of PLC operation is a matter of milliseconds. Thus, productivity increases.
7) The reliability of the PLC is higher than the mechanical relays and timers.

VII SALIENT FEATURES

The salient features of PLC based PDP are summarized below:

- The environmental condition (Temp, Humidity, Smoke, and Airflow) of the shelter is continuously monitored through sensors which send the analog values to PLC System.
- Control of power on basis of Phase sequence and Neutral to ground voltage level Monitoring.
- Auto shutdown in case of Fire detection and/or Short circuit.
- Safety of equipments is inbuilt in case of short circuit or sparking.
- Real time monitoring of Health Status of various subsystems on Cimplicity SCADA.
- Real time monitoring of different parameters (Voltage, Frequency, Temperature, Humidity, Emergency etc) on Cimplicity SCADA TID.
- Automatic Power Factor correction.
- Setting of Alarms at various levels.
- Debug Window for troubleshooting.
- Web-based access of the Cimplicity screens on remote systems on LAN.

VIII CONCLUSION

This paper presents the need of PLC and SCADA in the present electrical industry. The SCADA system is used for monitoring and controlling power industry from remote areas. We presented the importance of PLC & SCADA and the integration of Hardware and Software components to the power distribution areas. Moreover, we proved the importance on using Computer based system for sustainable development in the automation of the power distribution network to improve the customers' service and the reliability of the network. Also the paper outlines the general concepts and required equipments for the automation of such power distribution systems.

ACKNOWLEDGEMENT

We are very grateful to our project team for their constant support and guidance.

REFERENCES

[1] W. Bolton, Programmable logic controllers, Newnes: 2009
[2] James A. Rehg, Glenn J. Sartori, Programmable logic controllers, Prentice Hall: 2007
[3] Frank D. Petruzella, Programmable logic controllers, Tata McGraw-Hill Education: 2005
[4]. D. Bailey and E. Wright, "Practical SCADA for Industry", Elsevier, 2003.
[5] Stuart A. Boyer, SCADA: supervisory control and data acquisition, International Society of Automation: 2009

[6] Adnan Salihbegovica, Vlatko Marinkovica, Zoran Cicoa, Elvedin Karavdicb and Nina Delica, “Web based multilayered distributed SCADA/HMI system in refinery application” Computer Standards & Interfaces, vol. 31, p. 599-612, March 2009

[7] Vinay M. Igure,Sean A. Laughtera, and Ronald D. Williamsa, “Security issues in SCADA networks” Computers & Security, vol. 25, p. 498- 506, October 2006

[8] Cihan Sahina, and Emine Dogru Bolatb, “Development of remote control and monitoring of web-based distributed OPC system”, Computer Standards & Interfaces, vol. 31, p. 984-993, September 2009

[9] G. Clarke, D. Reynders and E. Wright, "Practical Modern SCADA Protocols", Elsevier, 2003

[10] GE Intelligent Platforms, “PAC Systems” reference manuals.

[11] GE Intelligent Platforms, “8000-2/x Series Modular I/O” reference manuals.

[12] Modbus Application Protocol Specification V1.1b, 2006.

BIO DATA OF AUTHOR(S)

Ekta Tripathi graduated in Electronics & Communication Engineering from Uttar Pradesh Technical University in the year 2008. She is currently working as a Deputy Engineer in D&E - Radar department. Her areas of interest in Process control are: Control and Automation, Fuzzy Logic, PLC and SCADA based automation.

Abdul Bari, born in March 1984, graduated in Electronics & Communication Engineering from Uttar Pradesh Technical University in 2006. He is presently working as a Senior Engineer in D&E - Radar department.

His areas of interest are Radar Technologies, Digital/Analog circuit design, Communications System, Control and Automation using PLC/SCADA.

P.K. Gupta, born in Oct 1964, joined BEL in Dec 1986. Presently working in D&E-Radar as Sr.DGM. Experience on radar systems like Indra-I, ASR & MSSR, SRE. Presently working on Arudhra & Mountain radar.