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Research Article

Smart SCADA and Automation System in Power Plants

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Abstract

SCADA is an acronym that denotes Supervisory Control and Data Acquisition. SCADA is a control system with applications in managing large-scale, automated industrial operations. Factories and plants, water supply systems, nuclear and conventional power generator systems etc are a few examples. The SCADA system consists of one Central Terminal (which could be several kilometers away from the site of operations) and one or several remote sensor terminals close to the site of operations. The sensor units send data to the central terminal which monitors and manages this data. Communication devices, a user interface and the software to make it all work together complete the picture of what makes a SCADA system. Automation systems in a power utility are required for generation, transmission, distribution and management of power in order to increase the efficiency of a power utility

Keywords: *power utility, SCADA, RTU, HMI, PLC, MTU.*

1. Introduction

The goal for any power utility is to maximize their profits and have customer satisfaction. This can be achieved through continuous 24x7 supply of power, cheap, safe and reliable power which should not damage any appliances of the customer .This can be achieved by efficient ,automated power production and distribution and having less power system breakdowns which is achieved by using SCADA systems and automated systems.

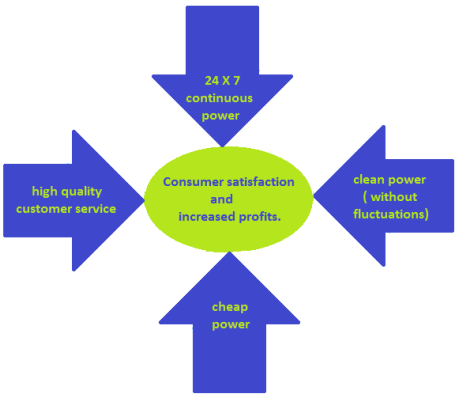

Fig.1 An illustration of how a utility can attain maximum profit.

2. SCADA

SCADA stands for supervisory control and data acquisition is a system operating with coded signals over communication channels so as to provide control of remote equipment. It is an open loop system. The supervisory system may be combined with a data acquisition system by adding the use of coded signals over communication channels to acquire information about the status of the remote equipment for display or for recording functions. SCADA system is used for real time control and monitoring of electrical network from the remote location. The components present in a SCADA system are divided into two units control room and remote station.

3. Remote Station

Remote Station consists of sensors and actuators that are directly interfaced to the generation plant or equipment's. The components present in a remote station are:

3.1 Remote Terminal Unit (RTU)

Remote Terminal unit acts as an interface between the field and the SCADA master (D. Bailey *et al*, 2003; http:// www.ndpl.com/ profile.html ;Rajeev Kumar Chandra). It supports control and monitoring of digital and analog data. The RTU panels consist of a power supply card and DO cards, processor, and memory communication card. The RTU panel is powered at 48V.The digital inputs are used to provide the status of switchyard equipment and station auxiliaries. The digital outputs are used for breaker and isolator commands and relay reset commands. There are also junction boxes which are present along with the equipment in order constantly. The general specifications of RTUs are:

- RTU has two TCP/IP Ethernet ports for communication with Master station(s) using IEC 60870-5-104.

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- Minimum 15 analog values (including 4 energy values) to be considered per energy meter
- The RTU shall be designed to connect maximum 5 Master stations
- RTU shall be capable of acquiring analog values through transducers having output as 4-20 mA, 0-10 mA, 0-+10 mA or +/- 5 volts using analog input modules.
- Support for IEC 60870-5-103, IEC 61850 protocols & ability to act as a gateway for Numerical relays may have to be interfaced in future with numerical relays with future vision of Smart grid
- RTU should have Capability of time synchronisation with GPS receiver which may be required future at the time of SMART GRID.

3.2 Bay Control Unit (BCU)

It is a De-centralized architecture. It is an interface between the field and the SCADA master;it supports the control and monitoring of digital and analog data. BCU has memory unit, DI/DO modules, processor unit, communication unit, power supply unit.

3.3 Gateway

The SCADA Gateway is a Windows application used by System Integrators and Utilities to collect data from OPC (Originating Point Codes), IEC(International Electro technical Commission) 60870-6 , IEC 61850, IEC 60870-5, DNP3, or Modbus Server/Slave devices and then supplies this data to other control systems supporting OPC. Gateways are used to interface with other systems . The functions of gateway is to translate between protocol

3.4Multifunction Meter (MFM)

It is an energy meter which communicates on MODBUS/TCP/IP. It gives various parameters like 3 phase voltages, currents. It requires less space and can replace conventional meters.

4. Control Room

Control room consists of computers which monitor, control real time data received from the remote station. Man power is required to monitor and control the real time data. The components present in the control room are.

4.1HMI- Human Machine Interface

HMI is the apparatus which presents process data to a human operator, and through this, the human operator monitors and controls the process (Sunil Kumar J *et al*; White paper from InduSoft). A human–machine interface or HMI is the apparatus which presents process data to a human operator, and through which the human operator controls the process. An HMI is usually linked to the SCADA system's databases and software programs, to provide trending, diagnostic data, and management information such as scheduled maintenance procedures, logistic information, detailed schematics for a particular sensor or machine, and expert-system troubleshooting guides. The HMI system usually presents the information to the operating personnel graphically, in the form of a mimic diagram. This means that the operator can see a schematic representation of the plant being controlled. For example, a picture of a pump connected to a pipe can show the operator that the pump is running and how much fluid it is pumping through the pipe at the moment. The operator can then switch the pump off. The HMI software will show the flow rate of the fluid in the pipe decrease in real time. Mimic diagrams may consist of line graphics and schematic symbols to represent process elements, or may consist of digital photographs of the process equipment overlain with animated symbols.

4.2Communication Network

Any media capable of supporting serial binary signaling, including the following may provide the necessary communications facility between SCADA system master and remote terminals:

- Copper cables
- Coaxial cables
- Fiber optic Cables
- VHF/UHF
- Satellite

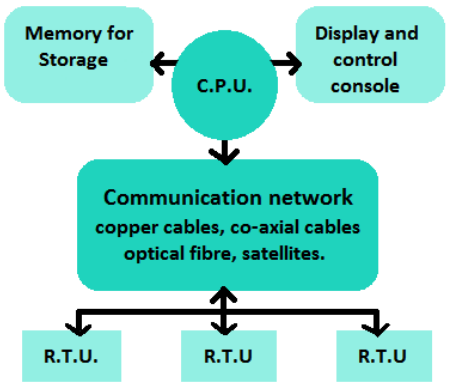

Fig.2 Basic architecture of SCADA systems

5. Application of SCADA systems in power plants

5.1 Fault location, Isolation and Service Restoration

This function helps the utility in detecting faults in the the transmission line isolating it from the other grids in order not to affect the flow of power in the neighboring grid. SCADA systems are also responsible to restore the fault area back into service.

5.2 Load Balancing

This function distributes the system total load among the available transformers and the feeders in proportion to their capacities.

5.3 Load Control

Practically the demand for power is always more as compared to generation. The demand for power also varies with seasons from month to month. In order to bridge the gap between demand and generation load shedding is carried out on a rotational bases so as to provide power to all consumers. The algorithm of which area will shed load and when is decided by SCADA systems.

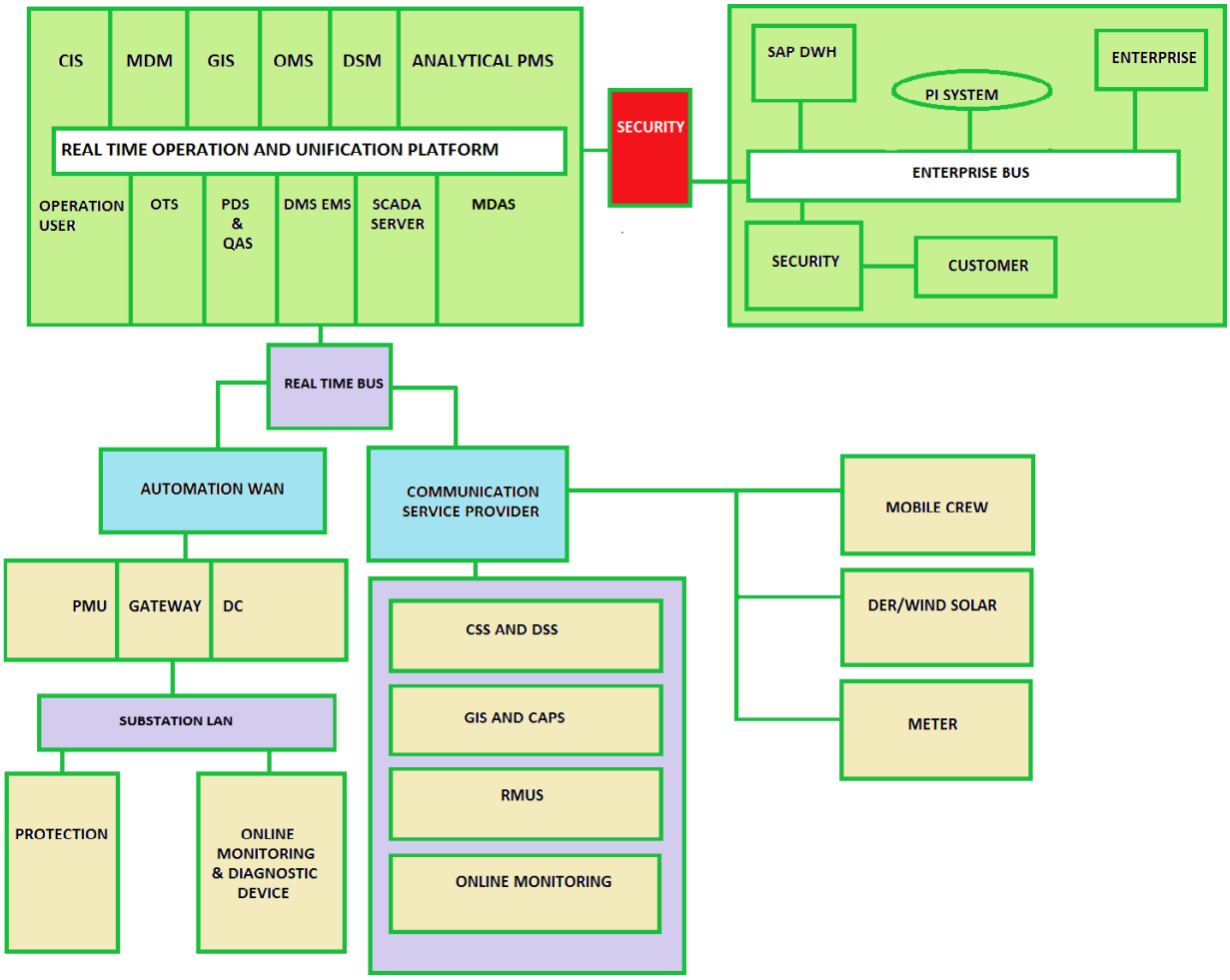

Fig.3 Basic functional block diagram of the automation vision in power plants

5.4 Remote Metering

The function of remote metering is to read data from the meters and to provide information to the operator of the consumption. Remote metering makes the consumer aware about his real time consumption which would make the consumer more conscious and conserve energy.

5.5 Energy Accounting

This function helps in arriving at the systems load patterns which helps in planning expansion. It also helps in detecting abnormal energy consumption patterns of the consumers and identifying high-loss areas. Processing the data obtained by the remote metering function and the data obtained from the substation does this.

6. Automation Systems in a Power Plant

6.1Consumer Information system (CIS)

CIS is a web based application which allows the user to track his/her electric consumption. CIS allows a consumer to update his/her details, pay bills and view his or her recent activity. It aims at keeping a record of the all consumers- like their meter number, name etc. Also, in case the supplier utility is going to have a power cut due to load shedding it can inform all its consumers in advance.

6.2 Meter Data Management (MDM)

It deals with the management of meter data. The current revenue can be checked and it is capable of communicating with the operator.

6.3 Geographical Information System (GIS)

It gives the geographical location of the equipments on field. This information is made available on real time basis on the screen with latitudes and longitudes which helps in faster decision making. Furthermore the operation engineer shall come to know in which geographical area the asset or equipment has been damaged. This allows fast correction of the fault and faster re-commissioning of the faulty line which would ultimately decrease the losses to the utility.

GS - Generating station
RS - Receiving station
RSS - Receiving sub station
DSS - Distributing sub station
CSS - Consumer sub station

Fig.4 Basic distribution block diagram

6.4 Outage Management System (OMS)

The Outage management system works in combination with the mobile crew or with DMS. The maintenance crew is deployed or directed to place along with the right equipment and spares to repair the fault .Commissioned activity information is displayed and this information can be given to the consumer if a complaint is registered. Giving the consumer this information would increase the trust and faith the consumer will have in the utility.

6.5 Demand Side Management & Analytics (DMS)

It is the modification of consumer demand for energy through various methods such as financial incentives and education. Usually, the goal of demand side management is to encourage the consumer to use less energy during peak hours, or to move the time of energy use to off-peak times such as night time and weekends. The peak demand management does not necessarily decrease total energy consumption, but could be expected to reduce the need for investments in networks and/or power plants for meeting peak demands. DMS would increase the availability of power to consumers and make power within the reach all consumers.

6.6 Analysis and Performance Management System (PMS).

It handles the analysis of data collected from different systems in order to monitor the system performance. KPI(Key performance indicator) is one kind of key indicator of the system performance. There are indicators that show the performance of the utility. Example: How many times the consumer was affected and the number of times the corrective action was taken.

6.7 Operator Training Simulator (OTS)

For any city, country a power utility is a very critical organization. Power has to be produced 24X7. The Operator controlling and monitoring various equipment need to be highly trained and skilled thus OTS is needed which is an offline simulator which is used to train new employees.

6.8 Program Development System & Quality Assurance System (PDS&QAS)

This systems ensures that there is a throughout availability of the online system. The program or database that has been developed is checked for errors and then after successfully running it, it gets online.

6.9 Energy Management System (EMS)

An energy management system is a system of computer-aided tools used by operators of electric utility grids to monitor, control, and optimize the performance of the generation and/or transmission system. The computer technology is also referred to as SCADA/EMS or EMS/SCADA. In these respects, the terminology EMS then excludes the monitoring and control functions, but more specifically refers to the collective suite of power network applications and to the generation control and scheduling applications.

6.10 Meter Data Acquisition System (MDAS)

The meters are provided by the service providers. This system is managed by the Automated meter infrastructure and also by the Automated Meter readings. MDAS provide long term data storage and management of large quantities of data received by metering systems

6.11 Security

It is basically a firewall, it provides protection from the occurrence of any kind of hacking It also protects the system from viruses and prevents unauthorized access.

6.12 Management Information System (MIS)

It gives real time information which is used for financial analysis and operational improvement.

6.13 Plant Information System (PI)

The PI System is a software product that is used for data collection, historicizing, finding, analysing, delivering, and visualizing. It is marketed as an enterprise infrastructure for management of real-time data and events. Data can be automatically collected from many different sources (Control systems, Lab equipment, Calculations, Manual Entry, and/or Custom software). Most information is gathered using one of the many OSIsoft and third party PI Interfaces. Users can then access this information using a common set of tools (Excel, web browser, PI Process Book) and look for correlations.

6.14 Data Warehouse (DW)

It is used for storing data for a longer time period. It is observed that each system, example CIS MDM GIS etc may all use an operating system which is open platform so that the application designed may run on any system.

6.15 Distribution Energy Resources (DER)

Table.1 Power generation from different sources in India (http://powermin.nic.in/indian_electricity_scenario/introduction.htm)

Fuel	MW	%
Coal	134388	58.75
Gas	20380	8.31
Oil	1199	0.52
Hydro	39778	17.32
Nuclear	4780	2.08
Biomass power, wind power, Solar power	28184	12.32

This is present as there is a huge cost involved in setting up any renewable energy generation plant. At least 5%

generation should be from renewable resources. It is preferred for pollution control. The Indian scenario of power distribution is show in the table1.

6.16 Distributed Generation (DG)

Working with Customers to conserve electricity by encouraging customers to use solar panels and by encouraging the use of non-critical appliances at non-peak hours.

6.17 Meters

They are used in order to detect change in direction of the power flow like generation and consumption. Changes in the meter and adjustment if power is transmitted or purchased from the customer can be handled with ease.

6.18 Online Monitoring and Diagnostic Device

It is done for equipment that is frequently used data obtained is further sent to PMS. It monitors the health of the equipments on a real time basis. This device is placed on the equipments and this information is used for analysis and decision making

6.19 Phasor Management Unit (PMU)

A phasor measurement unit (PMU) is a device which measures the electrical waves on an electricity grid; PMUs are one of the most important measuring devices in the future of power systems. PMU can measure 50/60 Hz AC waveforms voltages and currents typically at a rate of 48 samples per cycle (2880 samples per second). The analog AC waveforms are digitized by an Analog to Digital converter for each phase. A phase-lock oscillator along with a Global Positioning System (GPS) reference source provides the needed high-speed synchronized sampling with 1 microsecond accuracy. PMU increase reliability of power and also the quality of power

7. Advantages of SCADA Systems

SCADA system is a real time system in which the information is time stamped along with the event SCADA system provides faster analysis of real time data which allows the operator to make faster decisions with the help of different alarms on the panels.

SCADA systems reduces human error (that occurs while taking readings mostly) making the system more efficient and reliable. It keeps a record of the data and analysis of the past years which can be easily accessed. The real time data can be accessed by different users in the organization such as the operating engineer, CEOs Used for the purpose of load forecasting which means that it can predict the usage based on the availability of resource. SCADA systems provide safety to the workers as the workers are not in the vicinity of the hazardous plant site

8. Future Scope

The large territories and huge volumes of data SCADA can handle form a formidable combination. Today's SCADA systems can manage anything from a few thousands to one million of input/output channels. The technology is still evolving in terms of sophistication as well. SCADA systems as they are now can perform a large variety of tasks and some systems have artificial intelligence built into them. They are also more network-enabled, thus paving the way for voice-data-control data convergence. With proper planning and a custom-made installation, a SCADA system becomes a valuable asset.

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References

D. Bailey and E. Wright (2003), Practical SCADA for Industry, Elsevier

Sunil Kumar J, BirtukanTeshome, Samrawit Bitewlgn Muluneh, Bitseat Tadesse Aragaw, Working phases of scada system for power distribution networks International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

A White Paper from InduSoft SCADA Systems Automate Electrical Distribution

http://www.ndpl.com/profile.html

Rajeev Kumar Chandra, Utility of SCADA in Power Generation and Distribution system Research gate

http://powermin.nic.in/indian_electricity_scenario/introduction.htm