



Role of SCADA in Hydro Power Plant AUTOMATION

Sukhmeet Kaur¹, Namita Kathpal², Nitika Munjal³

Asst. Prof, Dept. of ECE, Manav Rachna University, Faridabad, India¹

Asst. Prof, Dept. of ECE, Manav Rachna University, Faridabad, India²

Asst. Prof, Dept. of ECE, Manav Rachna University, Faridabad, India³

ABSTRACT: Automation is the use of control systems, intelligent electronic devices, instruments and new communication technologies to enhance the quality of work, better monitoring and controlling of the system to reduce the human interface with system. Automation plays an increasingly important role in the world economy. Automation has had a notable impact on power sector beyond manufacturing industries also. Now a day's Power plant control systems have evolved from SCADA-centered platforms to communicate with industry standard hardware and software, and then to integrate power plant automation systems with almost unlimited connectivity. The system will embrace the latest information and communication technologies (ICT), and multiple communication channels (some traditional and some personal, such as instant messaging).

Interoperation of various control system in power house and substation automation system from SCADA was a challenge in past decades, but with the development of IEC 60870 - 5 - 103/104 and IEC 61850 interoperation of various automation systems is possible.

IEC 60870 standard is used for telecontrol in electrical power system such systems are used for controlling electrical transmission grids, power house control system like turbine controller, Protection system, Excitation System and other geographically widespread control system.

This paper describes a SCADA System for hydro power plant automation in compliance with the various IEC standard and interfacing protocols to ensure interoperability among the various devices.

KEYWORDS: SCADA, PLC, Intelligent Electronic devices, Interfacing protocol, MODBUS, IEC 60870

I.INTRODUCTION

Supervision consists of commanding a process and supervising its working. 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 [1].

The main objective of a supervisory system is to give the means to the human operator to control and to command a highly automated process. So, the supervision of industrial processes includes a set of tasks aimed at controlling a process and supervising its operation [2]

SCADA system supervises, controls, optimizes and manages generation and transmission systems. The main component of these systems are RTUs (Remote Terminal Units) that collect data automatically and are connected directly to sensors, meters, loggers or process equipment[3]. They are located near the monitored process and they transfer data to the controller unit when requested. They often include integral software, data logging capabilities, a real-time clock (RTC) and a battery backup. Most of the RTUs are time redundant. These devices are complete remote terminal units that contain all of the transceivers, encoders, and processors needed for proper functioning in the event that a primary RTU stops working. Meter readings and equipment status reports can also be performed by PLCs (Programmable Logic Controllers).

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II. AUTOMATION FOR HYDROPOWER STATION

Before the existence of the automation, qualified personnel operated the equipment manually. This was called Manual System, The qualified personnel, to operate manually the complete hydropower plant equipments (Turbine, Generator, Breakers etc), must first take into account the situation of the equipment. Next, depending on the situation, the operator can undertake certain correction to modify on the situation that they have recognized as deficient on the equipment. This approach requests full time supervision by the operators.

The same applies to the automatic system. The automatic system also reads the information on the equipment status operation, and then activates commands to various equipment of power plant and responsible for Auto sequencing. However, this type of system will also need specialized personnel. The operator of the automatic system will still have to make the necessary changes to the commands or controls, based on the needs or production demands from time to time.

A system for managing, controlling & protecting a hydropower plant operation as shown in Fig 1. It is realized by obtaining information in real time, by providing powerful local & remote control system and advance protection system. An automation system consists of Following as shown in fig 1.

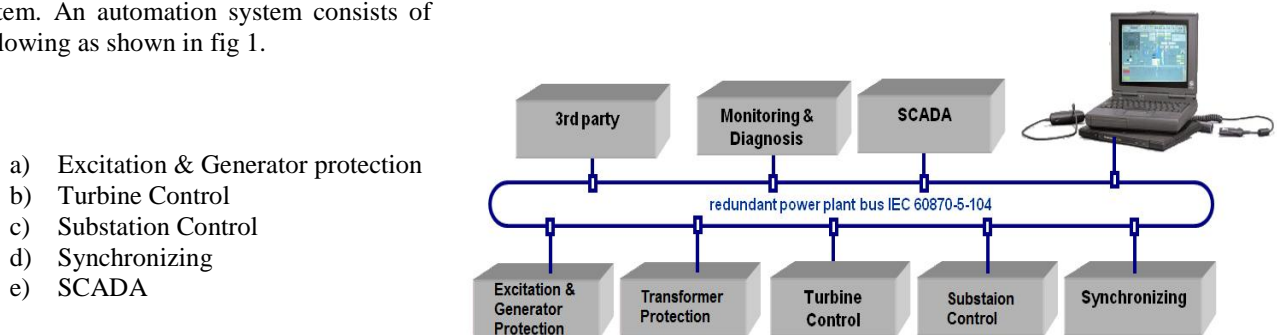


Fig 1: Automation System for hydropower plant Station

III. PLC AN IMPORTANT TOOL FOR AUTOMATION

The objective of automation of hydropower plant is to automate the complete plant process. Such an operation will typically involve many operations and steps. Some of these steps would occur in series and some would occur in parallel. Some events may involve discrete setting of states in the plant like valves open or closed, accessories on or off, and so on. Other events may involve regulation of some continuous variable over time or duration of operation. For example it is very important to maintain constant speed of one machine to remain in synchronization with other machine. So operation of hydropower plant is a combination of discrete as well as continuous processes.

In early days of development, microprocessor was an important mean to do these tasks but the number of relays was unaffected. But with help of PLC, use of hardwired relays is minimized. A large PLC has enough number of relays to do all the operations. The advantages of these relays are that these are digital, so minimum damage to the system, cost reduction and less maintenance is involved in their use. If there is any need to change the control system, only the program is to be changed and it can be done easily without any cost involvement.

PLC is able to perform these operations very effectively. 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[5]. PLC is best suited for discrete control system. The PLC[8] is connected to the SCADA (Supervisory Control And Data Acquisition) which monitors the process. Where the sequence of events are programmed to form a ladder diagram. For example the sequence of events in starting up of a machine involves discrete state control, like sensing of pressure switches, limit switches etc. Other events are purely continuous or may be combination of both discrete and continuous process.



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(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 10, October 2015

In continuous processes we may need to convert the analog signal to the acceptable value to the PLC and then with A/D converter it is converted to digital input to processor. A control algorithm is to be developed to get a control signal to control the variable. There is always a set value to which the variable is taken. By calculating the error, algorithm can be applied to get a control signal. This control signal is the converted to analog signal and then amplified to control the variable.

For precise control a PID algorithm can be developed. With help of (IEC 61131) functional block diagram programming language it is very easy to design a PID controller. Depending on the control action, speed and accuracy of system response, the error signal may be amplified using any or combination of proportional, integral or derivative action they can be combined with each other to get desired control action. For all continuous controls such as governor control, load control, level control, flow control and kV AR or power factor control etc. a PID algorithm can be developed.

Programmable Logic Controller (PLC) type plant controller combined with PC based SCADA systems are used for plant control and data acquisition. This makes the system economically viable and thus can be suitable for many hydropower plants for generation control and automatic. It is considered that dedicated digital control systems with interface with digital P.C., for redundancy as well data acquisition and storage can perform all functions of governing, unit control and protection as well as for data storage and also provide redundancy and are more economical, dependable and are easily available. These systems with redundancy and back up manual control facility of speed and unit control in emergency can be low cost option.

In this way almost each and every control requirement of control can be integrated into PLC for auto operation. In this way, unit control and data recording becomes very easy. Thus a supervisory control and data acquisition can also be achieved with PLC and supervisory computer. Following are the Major Role of PLC in Automation of hydropower plant.

- (a) Automatic Start Sequence
- (b) Automatic Shutdown (Normal, Emergency).
- (c) Digital Governing using PLC
- (d) Speed Governing
- (e) Position Control
- (f) Excitation Control with PLC
- (g) Protection System with PLC
- (h) Alarm and Annunciation using PLC

IV. SCADA SYSTEM FOR HYDROPOWER PLANT

SCADA stands for supervisory control and data acquisition [9] which generally refers to industrial control systems: computer system that monitor and control industrial. A SCADA control center performs centralized monitoring and control for field sites over long-distance communications networks, including monitoring alarms and processing status. The PLC type plant controller combined with PC based SCADA [10] systems are used for plant control and data acquisition. This makes the system economically viable and thus can be suitable for many small hydroelectric power plants [11] for generation, control and automation. Based on information received from remote stations, automated or operator-driven supervisory commands can be pushed to remote station control devices, which are often referred to as field devices.

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Figure 2 shows a typical SCADA system of a hydropower plant. We can see that in this diagram there are different sections which required for operation & monitoring.

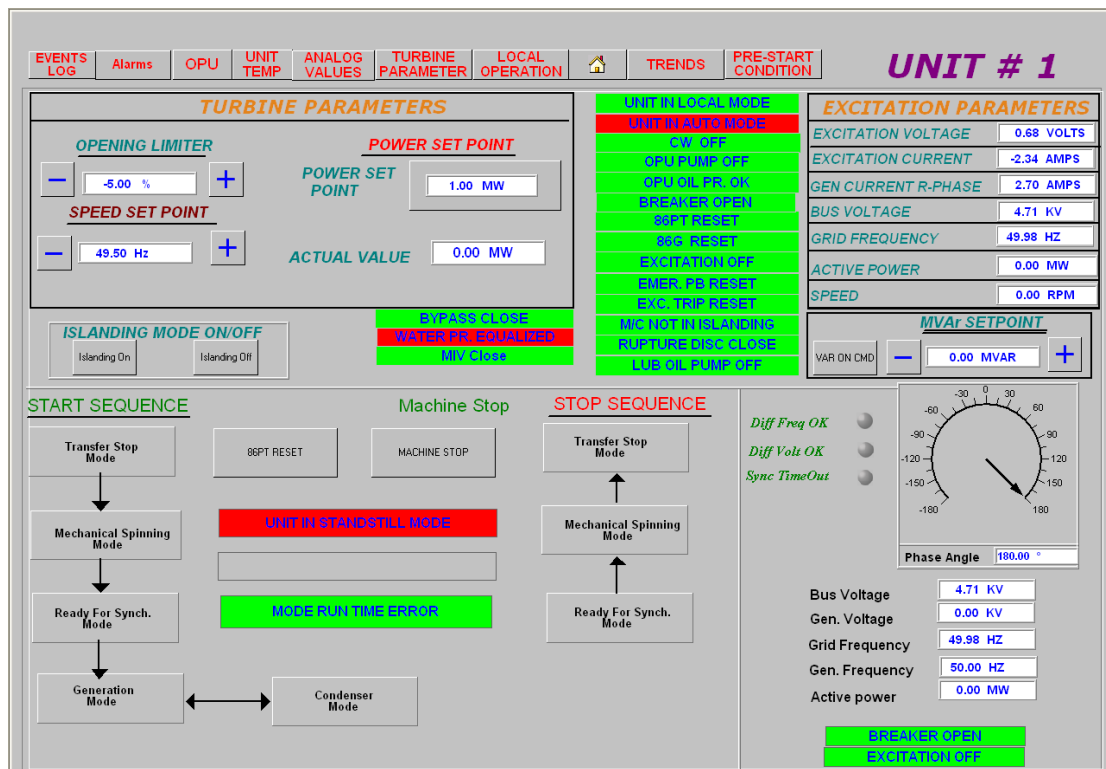


Figure 2: SCADA screen of hydropower plant

As shown in fig 2, the SCADA screen is divided into following 5 sections.

Section 1: Turbine parameter

From this section operator can monitor and change turbine parameters.

Section 2: Status display

This section displays the status of machine.

Section 3: Excitation Parameters

From this section operator can monitor analog value of important excitation parameters

Section 4: Command Section

This section is used to issue start and stop command for machine.

Section 5: Synchronizing section

From this section operator can monitor synchronizing condition of machine as well as related imp electrical parameter.

SYSTEM OPERATOR

Few other requirements of operator are, [4]:

- Probabilistic approach for network management;
- Control of centralized units;
- Compensation plan for voltage regulation;



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Vol. 4, Issue 10, October 2015

V. INTELLIGENT ELECTRONICS DEVICES

An IED, such as a protective relay, may communicate directly to the SCADA Server, or a local Remote Terminal Unit (RTU) may poll the IEDs (Intelligent Electronic Devices) to collect the data and pass it to the SCADA Server. IEDs (Intelligent Electronic Devices) provide a direct interface to control and monitor equipment and sensors.

IEDs may be directly polled and controlled by the SCADA Server and in most cases have local programming that allows for the IED to act without direct instructions from the SCADA control center. SCADA systems are usually designed to be fault-tolerant systems with significant redundancy built into the system architecture.

VI. FIELD INSTRUMENT

An instrument is a device that measures and/or regulates physical quantity/process variables such as flow, temperature, level, or pressure. These instruments are installed at various remote locations for measurement in a power plant. i.e flow sensor for measurement of flow in penstock or at reservoir of power plant. Output instrumentation includes devices such as solenoids, valves, regulators, circuit breakers, and relays. These devices control a desired output variable, and provide either remote or automated control capabilities. These are often referred to as final control elements when controlled remotely or by a control system.

Transmitters are devices that produce an output signal, often in the form of a 4–20 mA electrical current signal, although many other options using voltage, frequency, pressure are possible. This signal will be used for informational purposes, or it can be sent to a PLC, SCADA system for control and monitoring

VII. COMMUNICATION PROTOCOL

Communication protocols are required for interfacing of various control and protection system with SCADA. Standard and proprietary communication protocols running over serial communications are used to transport information between the control center and field sites using telemetry techniques such as telephone line, cable, fiber, and radio frequency such as broadcast, microwave and satellite.

Mainly used communication protocols are following.

- **Modbus**

Modbus is a kind of communication protocol which is promoted by Modicon Corporation. It is widely used in the industrial automation and has become the actual industrial standard[6]. The point-to-point Modbus protocol has become a virtual standard for RTU and PLC communications. During communication on a Modbus network, the protocol determines how each controller will know device address, recognize a message addressed to it determine the action to be taken and extract any information / data attached to it. There are a number of expansions to fix these shortcomings.

- **DNP (Distributed Network Protocol)**

Distributed Network Protocol Version 3 (DNP3) is an open and optimized protocol developed for the Supervisory Control and Data Acquisition (SCADA) Systems supporting the utilities industries[7]. A member restricted protocol, used in some Electric Power systems. The DNP protocol has gone through various iterations. Presently it is up to version 3.0. The DNP association has rules, which tend to restrict the use of the protocol, and major SCADA software suppliers have been slow in implementing the protocol.

- **IEC 60870**

IEC 60870, is a collection of open standards written by the International Electrotechnical Commission (IEC) regarding the transmission of SCADA telemetry control and information[4]. This protocol is mostly used in power transmission and distribution systems IEC 60870-5-101 is an International Communications Protocol Standard for the Telecontrol of Electric Power transmission systems, which is being widely adopted in many countries throughout the world.

IEC 60870 part 5 provides a communication profile for sending basic telecontrol messages between two systems, which uses permanent directly connected data circuits between the systems. The IEC TC 57 WG3 have developed a protocol standard for telecontrol, teleprotection, and associated telecommunications for electric power systems. The result of this work is IEC 60870-5. Five documents specify the base IEC 60870-5:

IEC 60870-5-1 Transmission Frame Formats

IEC 60870-5-2 Data Link Transmission Services

IEC 60870-5-3 General Structure of Application Data



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Vol. 4, Issue 10, October 2015

IEC 60870-5-4 Definition and Coding of Information Elements

IEC 60870-5-5 Basic Application Functions

The IEC TC 57 has also generated companion standards:

IEC 60870-5-101 Transmission Protocols, companion standards especially for basic telecontrol tasks

IEC 60870-5-102 Companion standard for the transmission of integrated totals in electric power systems (this standard is not widely used)

IEC 60870-5-103 Transmission Protocols, Companion standard for the informative interface of protection equipment

IEC 60870-5-104 Transmission Protocols, Network access for IEC 60870-5-101 using standard transport profiles

IEC 60870-5-101/102/103/104 are companion standards generated for basic telecontrol tasks, transmission of integrated totals, data exchange from protection equipment & network access of IEC101 respectively.

VIII. CONCLUSION

Hence we conclude that, the SCADA system is used for monitoring and controlling of various processes from remote areas in a Hydro power plant. It allows an operator to make a set point changes on remote controllers, to open/close valves/switches, to monitor alarms and to gather instrument information from a local process to a widely distributed process(SCADA) of Hydropower Plant. In the context of SCADA, it refers to the response of the control system to changes in the process and makes them similar to real-time control system in the virtual environment.

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