Data Acquisition, Monitoring & On-Line Controlling using PLC & SCADA for DHABA ESR

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Keywords
WPS-Water Pumping Station, ESR-Elevated Storage Reservoir, PLC-Programmable Logic Controllers, SCADA-Supervisory Control And Data Acquisition, DAS- Data Acquisition System, RTU – Remote Terminal Unit, LAD-Ladder Language, FBD-Functional Block Diagram.

ABSTRACT
In recent times with the ease of technologies, every system is becoming on-line systems, whether it is Banking, Marketing, Trading, Billing etc. Similarly, many services provided are also becoming available as On-Line systems. So, many human intervention systems used previously in industries are also becoming as On-Line systems. Various processes in industries are becoming monitored and controlled through PLC & SCADA systems. These systems are basically used for remote monitoring & controlling and are now becoming web enabled on-line systems. With the web enabled system, it is now possible acquiring the information from the system, monitoring and controlling the processes remotely.

This paper presents automation of water supply system in Nagpur region. It basically presents an approach of integration of automation and web enabled monitoring and controlling of Water Pumping Station at Gorewada. Nagpur NMC has planned to automate all of its water reservoirs and pumping stations.
1. **INTRODUCTION**

NMC has planned to automate all of its Elevated Reservoirs (ESR). The objectives of the project are:

1. To install a real time data monitoring & recording system for each ESRs.
2. To monitor Water flow / discharge from each MBR to various elevated service reservoirs
3. To provide levels data each reservoirs continuously 24 Hrs.
4. To ensure the balance between incoming & outgoing flow at each ESR location.
5. Residual chlorine content in water in each ESRs
6. Monitoring of parameters of pressure, flow, level, water turbidity, water pH, chlorine level at each tank.
7. To make the server data available on WEB for remote monitoring.

This paper basically explains the real time data monitoring & recoding system for DHABA ESR to Gorewada WPS.

![Centralized Monitoring System](image)

**Figure 1:** Centralized Monitoring System

2. **METHODOLOGY**

An ultrasonic level transmitter is operational at ESR DHABA, which gives output through a 4-20mA signal. This analog 4-20mA signal is tapped and split, and further converted to a digital signal before sending it to the WPS Gorewada through a dedicated license free RF Telemetry system. Additionally another 0/24V DC signal is also provided as input signal along with the present 4-20mA analog signal to provide the adequate reinforcement. At the WPS Gorewada, both the signals are captured through a RF antenna and fed into the PLC system. The PLC system deployed controls the water pumping motors and are switched ON and OFF depending upon the water level at ESR.

The output signal of the ultrasonic level transmitter/voltage relay denotes the level of the tank. A 4mA/0VDC denotes that the tank is empty and 20mA/24V DC denotes that the tank is full.

Also, the water quality (pH Level, Turbidity & Chlorine Levels) is monitored and controlled at Gorewada WPS.
3. **DESIGN OF DATA ACQUISITION SYSTEM**

The Data Acquisition System basically includes a RTU (Remote Terminal Unit). The DAS takes the signal from the ultrasonic transmitter, splits the signal into two outputs. One output goes to the automation system and other to the Remote Terminal Unit (RTU) splitter for further conversion to a digital signal and transmits it to the WPS Gorewada. Also another input of 0V DC /24V DC is taken as an input to the RTU. Both the signal determines the level of the ESR and both are used as adequate reinforcement to each other. At WPS Gorewada, an RF antenna receives both the signals and feeds into the input Ethernet port of Ethernet Switch. The communication link is made through a RF Telemetry system using a license free frequency. The communication link is established through a license free frequency which does not entail a recurring cost for a license fee for establishing the required communication. The frequency used is 5.7GHz which is license free under the ISM band.

![Data Acquisition System (DAS)](image)

**Figure 2: DATA ACQUISITION SYSTEM (DAS)**

Lables: 1a-Ultrasonic Level Sensor, 1b-0/24V DC Level Signal, 2-Splitter, 3-Remote Terminal Unit, 4-Ethernet Switch, 5-RF Modem Antenna, 6-PLC, 7-Servo, 8-Motor.

Remote Terminal Unit (RTU) consists of:
- I/O Unit
- Microcontroller Unit
- Power Supply Unit

The I/O unit accepts the 4-20mA analog signal and converts it into the required serial input. It also takes another input of 0/24 VDC as secondary input. The microcontroller unit processes both the signals and converts into the TCP/IP format through its stack. This digital output signal is then fed to the Ethernet port. The RTU operates on 230VAC.

The power supply unit converts the supply voltage into the required DC voltage for the microcontroller operation.

The unit is powered with mains supply with a battery backup so as to inform real time water parameter change to WPS even in case of power failure. The presently available UPS at DHABA is utilized for this backup. The RTU is enclosed in IP65 enclosure.

**RTU Specifications:**
1. Input Port – 4-20mA Analog and OV/24 DC
2. Output Port – Ethernet Port
4. Current Consumption – 70mA
5. Microcontroller – 32bit
6. Enclosure IP65

Enough precaution has been taken for protection against surge and line voltage variation. The RF antennas are provided with lightning arrestors and the aviation lamps.
At WPS Gorewada, the RF antenna is aligned in a proper angle to receive the signal from Dhaba without any attenuation. A reliable and robust link is provided so that the signal is received in any weather and climatic conditions. The received signal is to be fed into the Ethernet port of the Ethernet switch. The signal is taken from the Ethernet switch, and is fed into the PLC controlling the water pumping motors. The same signal & current levels is also made available for the online monitoring.

4. MONITORING & CONTROL SYSTEM

The received data signal from RF antenna at Gorewada WPS is fed to the monitoring & Control System. The monitoring and controlling is done through a PLC & SCADA System. Following figure 2 gives the complete schematic of the system.

![Monitoring & Controlling Schematic](image)

**4.1.1 SIEMENS S7-1200 – PROGRAMMABLE LOGIC CONTROLLER**

The PLC deployed is a Siemens S7-1200. The S7-1200 series is a line of programmable logic controllers (PLCs) that can control a variety of automation applications. Optimized design, cost effective, and a powerful instruction set make the S7-1200 a perfect solution for controlling a wide variety of applications. The S7-1200 models and the Windows-based programming tool provide the flexibility to solve automation problems. The CPU comprises a processor, an integrated power supply, input and output circuits in a compact casing to create a powerful PLC. After downloading the program, the CPU contains the logic required to monitor and control the devices in an application. The CPU monitors the inputs and changes the outputs according to the logic of user program, which can include Boolean expressions, counting & timing, complex math functions and communications with other devices. The CPU has a PROFINET port for communication over a PROFINET network. Modules are available for communicating over RS232 or RS485 networks.

![SIEMENS S7-1200 PLC](image)
Labels: 1-Status LEDs for the on-board I/O, 2-Status LEDs for the operational state of the CPU, 3-PROFINET connector, 4- Memory card slot (under door), 5-Removable user wiring connector

Specifications:
1. Physical Size (mm) – 110 x 100 x 75
2. User Memory – Work Memory: 50Kbytes, Load Memory: 2 Mbytes, Retentive Memory: 2Kbytes
3. Local on-board I/O – Digital: 14 Inputs, 10 Outputs, Analog: 2 Inputs
4. Process image size - 1024 bytes (inputs) and 1024 bytes (outputs)
5. Signal modules expansion - 8
6. Signal board – 1
7. Communication modules – 3 (left-side expansion)
8. PROFINET
9. Ethernet communications port
10. Real math execution speed 18 µs/instruction
11. Boolean execution speed 0.1 µs/instruction

4.1.2 TIA-PORTAL v11 SOFTWARE

The Totally Integrated Automation (TIA) Portal software provides a user-friendly environment for developing, editing, and monitoring the logic needed to control an application. TIA Portal software creates an integrated environment for the development of integrated projects based on a variety of software and hardware components. The TIA Portal provides the tools for managing and configuring all of the devices in a project, such as PLCs and HMI devices. As a component of the TIA Portal, STEP 7 Professional provides programming languages (LAD and FBD) for convenience and efficiency in developing the control program for an application. The TIA Portal also provides the tools for creating and configuring the HMI devices in a project. The Portal view provides a functional view of the project tasks and organizes the functions of the tools according to the tasks to be accomplished, such as creating the configuration of the hardware components and networks. The communication link setup between the S7-1200 and workstation PC is done through the TIA-Portal v11.

4.2 SCADA SYSTEM- TIA-PORTAL v11 WINCC:

SCADA is “Supervisory Control and Data Acquisition” – real time industrial process control systems used to centrally monitor and control remote or local industrial equipment such as motors, valves, pumps, relays, etc. A SCADA system gathers information (such as where a leak on a pipeline), transfers the information back to a central control, then alerts the home station that a leak has occurred. Carry out the necessary analysis and control, such as determining the severity of leakage and displaying the information in an organized fashion. TIA-Portal v11 comes with an integrated package of SIMATIC WinCC SCADA from SIEMENS. It provides a user friendly environment where all plant/project devices, parameters can be monitored with ease.

4.3 MODBUS PROTOCOL

MODBUS protocol is basically used for the data transfer with controllers. The MODBUS protocol is a protocol supporting a single master. The master controls the complete transmission and monitors if possible timeouts occur. The connected devices are slaves and are allowed to send data only on master request. It provides protocols MODBUS/RTU and MODBUS/TCP. Baud rates of 1200, 2400, 4800, 9600 and 19200 are supported by MODBUS/RTU.

MODBUS/TCP Protocol Stack is as shown below:

![MODBUS/TCP Protocol Stack](image-url)
In our project MODBUS is basically used for creating communication link with RF Modem, PLC and Hardware Devices. The communication between the S7-1200 and SCADA on PC is done through Ethernet whereas the communication between PLC and water pumping motors is done through MODBUS Communication link. The data from the RTU is received by the RF antenna and processed by modem is given to the PLC through the MODBUS. The data is monitored on SCADA PC by transferring data between PLC and SCADA PC via Ethernet. The processed data then is monitored on the web.

5.1 LADDER DIAGRAM

![Ladder Diagram](image-url)
5.2. SCADA MONITOR

The following figure 7 gives the overview of water pumping motors at old Gorewada WPS. It shows all the three water pumping motors available at Gorewada WPS. It gives overall view of water pumping being done for DHABA ESR, Seminary Hills and Gorewada Village.

![Figure 6: SCADA Monitor for WPS](image)

The SCADA Monitor is also configured to provide information about the water quality. It provides information about Tank Level, pH Value, Turbidity Value, Chlorine level and Level of DHABA ESR as shown in figure 8 below.

![Figure 7: Water Quality](image)
6. **CONCLUSION**

This paper presents the importance of PLC and SCADA for automation; this allows remote and safe operation and monitoring, flexibility and scalability. A complete control system is made using a PLC as control element and a SCADA system as supervisor software. Efficient control design is achieved in several senses by using proper automation so as to increase productivity, to increase quality, to reduce cost.

7. **REFERENCES:**


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