SCADA – BASED MONITORING & CONTROL SYSTEM OF NSHES

S Asha Kiranmai*[1] | P Lohitha[2] | J Sriya Deepthi[3] | Humera Nazeer[4]

1 Associate Professor, EEE Department, Bhoj Reddy Engineering College for Women, Hyderabad, Telangana, India.

2, 3&4 Undergraduate Students, Bhoj Reddy Engineering College for Women, Hyderabad, Telangana, India.

Abstract:

The Nagarjuna Sagar Hydro Electric Station (NSHES) is one of the largest hydroelectric power plants in India, providing renewable energy to the region. This paper focuses on implementing a Supervisory Control and Data Acquisition (SCADA) system to enable real-time monitoring and control of the NSHES plant operations. The SCADA system integrates Programmable Logic Controllers (PLCs), Remote Terminal Units (RTUs), sensors, and Human-Machine Interfaces (HMIs) to monitor key parameters such as water flow, turbine speed, generator output, and control commands. The system enhances operational efficiency, fault detection, and automation by providing a centralized control platform. The SCADA system is implemented using Plant Studio software and supports remote supervisory control, data logging, and alarm management, thus improving the reliability and safety of the power plant.

Keywords: *NSHES, SCADA, RTU, PLC, AVEVA, Hydro Power, Monitoring, Automation*

1. INTRODUCTION

Hydroelectric power stations like NSHES play a vital role in generating clean and sustainable energy. The integration of SCADA systems in such plants allows for automated and efficient control of plant equipment, improved monitoring, and timely fault detection. NSHES uses eight generating units with an installed capacity of 816 MW. The SCADA system facilitates centralized monitoring of the units, gate controls, transformers, and auxiliaries, providing operators with real-time data and control capabilities to optimize power generation and plant safety. Several studies have explored SCADA advancements in hydroelectric plants, focusing on efficiency and intelligent monitoring.

N. Mayadevi proposed an intelligent support system that integrates SCADA with artificial intelligence for predictive maintenance. The system utilized associative data mining techniques with the Tertius algorithm and a Multi-Layer Perceptron (MLP) neural network to detect and forecast equipment failures. This work demonstrated the role of AI in improving SCADA-based fault diagnosis in power plants [1].

M.N. Lakhoua detailed the implementation of SCADA systems in hydro-generator monitoring, focusing on Citect SCADA software. His study emphasized modular architecture and adaptability,

proving the viability of SCADA for both small and large-scale hydroelectric installations. This work is particularly relevant for plants like NSHES, where both flexibility and scalability are critical [2].
Rajeev Kumar Chauhan analyzed the role of SCADA in modern power systems, underlining its applications in load balancing, real-time monitoring, and predictive diagnostics. The study further explored communication protocols such as Modbus and IEC 60870 for efficient data transfer, reinforcing the necessity of robust connectivity in complex power stations like NSHES [3].
M. Elamin in his paper "Fundamentals of Hydro Power Generation" provided a foundational overview of hydroelectric generation principles, system components, and operational characteristics. His insights are crucial for understanding the integration of automation systems like SCADA into hydroelectric facilities, particularly in contexts demanding high efficiency and real-time control [4].
Most existing studies on SCADA in power systems focus on simulation or partial implementations, lacking real-world application in large-scale hydroelectric stations like NSHES. They do not address full integration of hardware and software or coordination with grid-level operations. This paper addresses the gap by implementing a comprehensive SCADA system at NSHES using AVEVA Plant SCADA, RTUs, PLCs and field sensors. It enables real-time monitoring, centralized control, automated fault response, and grid synchronization, offering a robust, field-tested model for efficient hydroelectric plant operation.

2. OVER VIEW OF NSHES

NSHES located on the Krishna River in Telangana, is one of India's largest and oldest hydroelectric power stations. Operated by TGGENCO, NSHES has a total installed capacity of

Fig.1.Power house of NSHES

816 MW, comprising eight generating units—seven rated at 100.8 MW and one at 110 MW. These units utilize vertical Francis turbines coupled with synchronous generators, and are fed by penstocks embedded in the dam structure.

The power generated is stepped up via transformers and integrated into the Southern Grid. In addition to electricity generation, NSHES also serves critical roles in irrigation, flood control, and drinking water supply, supported by the Left (Lal Bahadur) and Right (Jawahar) Bank Canal systems. The reservoir has a gross storage capacity of over 11.5 billion cubic meters, making it vital for both energy production and agricultural support.

SCADA integration at NSHES provides centralized control, real-time monitoring, and remote operation of generating units and auxiliaries, significantly improving operational efficiency, system safety, and maintenance responsiveness.

3. SCADA System

Supervisory Control and Data Acquisition systems are essential in industrial automation, enabling centralized monitoring, control, and data acquisition for critical infrastructure such as power plants, water treatment facilities, and manufacturing systems.

3.1 PRINCIPLE OF OPERATION

A SCADA system operates by collecting real-time data from sensors and field instruments, transmitting it via a communication network to a centralized control station, and displaying the information through HMI. Operators can observe system conditions, respond to alarms, and remotely control field devices, ensuring responsive and efficient system management.

3.2 SYSTEM COMPONENTS

1. Field Layer (Bottom Layer)

- Components: Sensors & Actuators (temperature, pressure, flow, motors, switches, etc.)
- Function: Directly interface with the physical environment to measure and influence system parameters.
- Connectivity: Linked via electrical wiring and fieldbus protocols to controllers.

2. Local Control Layer

- Components: PLC (Programmable Logic Controller), RTU (Remote Terminal Unit), HMI (Human-Machine Interface)
- Function:
    - PLCs/RTUs execute control logic, such as starting/stopping equipment.
    - HMI displays real-time data for local operators to monitor or control equipment.
- Communication: Uses *PROFINET* or similar protocols to interface with sensors/actuators.

3. Communication Layer

- Technologies: GPRS, Internet, Radio, Satellite, OPC, VPN
- Function: Facilitates data transfer between field devices and higher supervisory systems.
- Connectivity: Supports both *wired and wireless* methods for flexibility in deployment

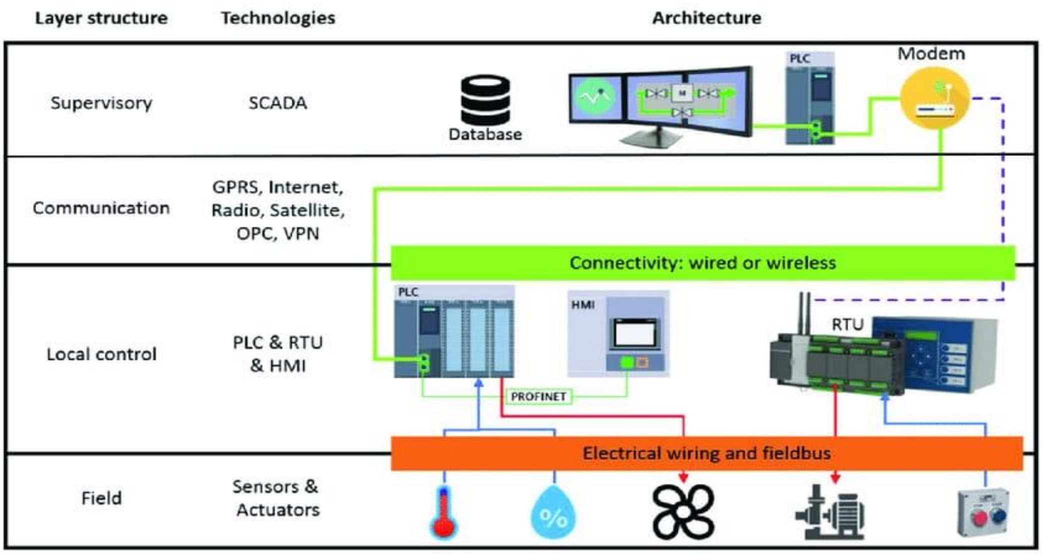

Fig.2. Components of SCADA

4. Supervisory Layer (Top Layer)

- Components: SCADA software, Database, Control Monitors, Modem
- Function:
  - Centralized data acquisition and visualization
  - System-wide monitoring and control via SCADA
  - Alarm generation, data logging, report generation
- Modem: Used to interface with external networks for remote monitoring or cloud-based SCADA systems.

This architecture shows how data flows upward from physical sensors to high-level decision-making tools, while commands flow downward from SCADA software to field devices. It represents a standard automation model used in power plants, including hydroelectric stations like NSHES, for efficient, scalable, and secure operation.

3.4 SCADA HARDWARE

SCADA systems rely on integrated hardware for real-time control and monitoring in hydro plants.

- **RTUs:** Collect and transmit field data, offer local control during communication failure.
- **PLCs:** Perform automation tasks like turbine control; support redundancy and modular I/O.
- **Field Devices:** Sensors and actuators measure and control parameters like pressure and flow.
- **Servers & Networking:** Manage data processing, HMI, alarms; use redundant servers for reliability.

These components ensure seamless, safe, and efficient plant operation.

3.5 SOFTWARE SYSTEM

SCADA software used to monitor and control industrial processes automatically. SCADA is like the "brain and eyes" of big systems. It watches what's happening in real time and allows operators to control machines and processes from a central location. There are different types of SCADA Software's:

- AVEVA SCADA (earlier Wonderware)
- Siemens WinCC
- Schneider Electric EcoStruxure
- AVEVA Plant SCADA

AVEVA Plant SCADA is used mostly for SCADA, which is a crucial component of modern hydropower plant automation. This system, formerly known as Citect SCADA, helps in monitoring, controlling, and optimizing various aspects of the plant's operations, including power generation, water management, and overall performance.

4. IMPLEMENTATION OF SCADA AT NSHES

The Nagarjuna Sagar Hydro Electric Station utilizes a SCADA-based control system to enhance the efficiency, safety, and automation of its power generation process. SCADA integrates field devices like sensors, RTUs, and PLCs with centralized servers and HMI for real-time data monitoring and control.

Each generating unit is equipped with Unit Control Boards that interface with the Central Control Room (CCR). The system supports remote and local control, enabling operators to monitor critical parameters such as turbine speed, generator output, pressure, and temperature. Automated start/stop sequences, synchronization, and alarm systems ensure safe and stable operations.

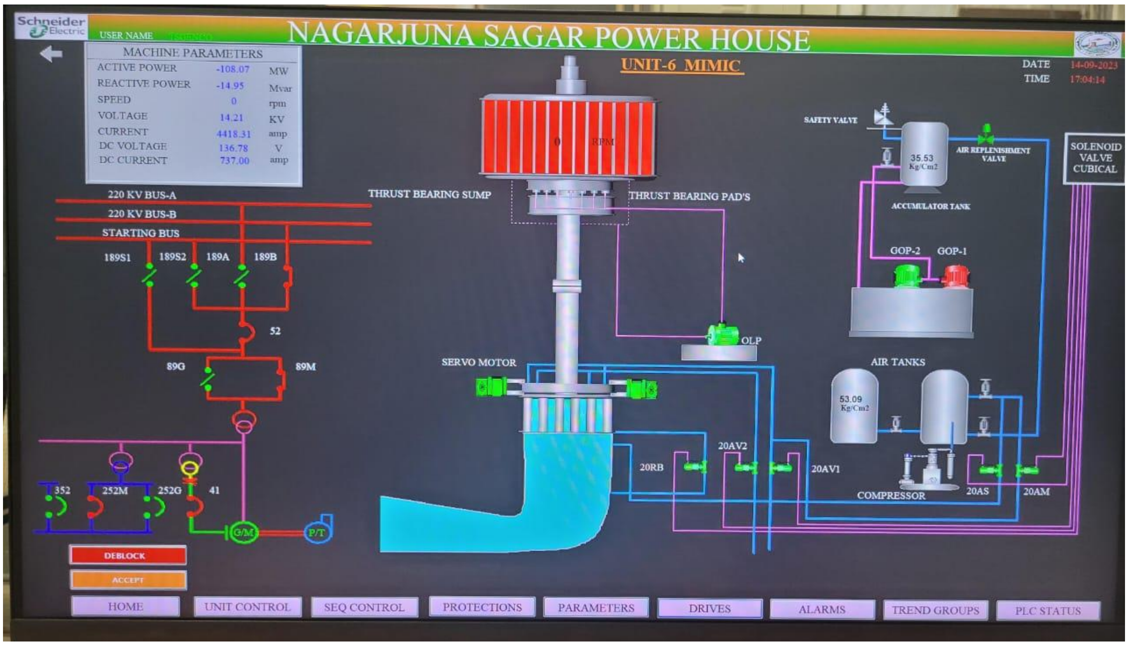

Fig.3. SCADA system at NSHES

SCADA enables real-time visualization, alarm handling, and historical data logging. It also facilitates remote supervisory control via integration with the Southern Regional Load Dispatch Centre (SRLDC), contributing to efficient grid coordination, frequency regulation, and demand-based generation. It continuously collects real-time data from a wide range of field instruments and sensors installed on turbines, generators, transformers, and other vital equipment. This data is transmitted via reliable communication networks to a central control room, where it is processed and visualized through user-friendly interfaces. Operators can monitor key parameters such as water flow, pressure, temperature, and electrical output to ensure the plant operates within safe and optimal limits.

The system also enables remote control of equipment, allowing operators to quickly respond to changing conditions or faults. SCADA's ability to generate alarms and alerts helps in early fault detection, reducing downtime and maintenance costs. Additionally, the system logs all operational data, facilitating detailed performance analysis, predictive maintenance, and regulatory reporting. The implementation of SCADA at NSHES significantly enhances operational efficiency, reliability, and safety by automating routine tasks and providing real-time insights into plant performance.

BENEFITS OF SCADA IMPLEMENTATION AT NSHES

The implementation of SCADA at the NSHES offers numerous advantages that significantly enhance plant performance, safety, and operational management:

Improved operational efficiency

SCADA enhances operational efficiency by automating control tasks, reducing errors, and improving response times.

Enhanced safety and fault prevention

SCADA ensures safety by detecting faults in real time and triggering automatic protective actions to prevent accidents and damage.

Comprehensive data collection and analysis

SCADA stores extensive operational data for performance analysis, maintenance planning, and regulatory compliance.

5. CASE STUDY

5.1 SYSTEM SETUP

NSHES is equipped with a comprehensive SCADA system designed to monitor and control its 8 hydro turbine-generator units and associated auxiliary equipment. The SCADA system enables centralized data acquisition, remote control, and real-time status visualization. Twelve RTUs collect data from sensors measuring key parameters like voltage, speed, and gate positions. A fiber-optic network with MODBUS and IEC protocols ensures fast, reliable communication. Operators use AVEVA SCADA HMIs in the control room to monitor real-time status and alarms. Data is stored in a historian database for trend analysis and preventive maintenance.

5.2 OPERATION WORKFLOW

The SCADA system at NSHES provides continuous real-time monitoring of key parameters such as generator output, turbine status, water levels, and gate positions through constant data polling from RTUs. Operators can remotely control the start and stop of generating units, adjust wicket gate openings, and operate spillway gates using HMI controls, with support for both manual and automated control sequences. Additionally, the system actively monitors parameter values against preset thresholds, triggering visual and audible alarms when limits are exceeded enabling prompt operator response to potential issues.

5.3 CASE INCIDENTS

Case 1: Unit-5 Overload Alarm

- On March 13, 2025, at approximately 2:46 AM, the SCADA system at Nagarjuna Sagar Hydro Electric Station detected an abnormal condition on Unit-5, where the electrical current surged beyond 110% of its rated load capacity.
- This triggered an immediate overload alarm, which was displayed prominently on the control room operator screens accompanied by an audible siren to alert the staff. Upon receiving the alarm, operators promptly accessed real-time data including current measurements and vibration trends from the SCADA interface to assess the situation.

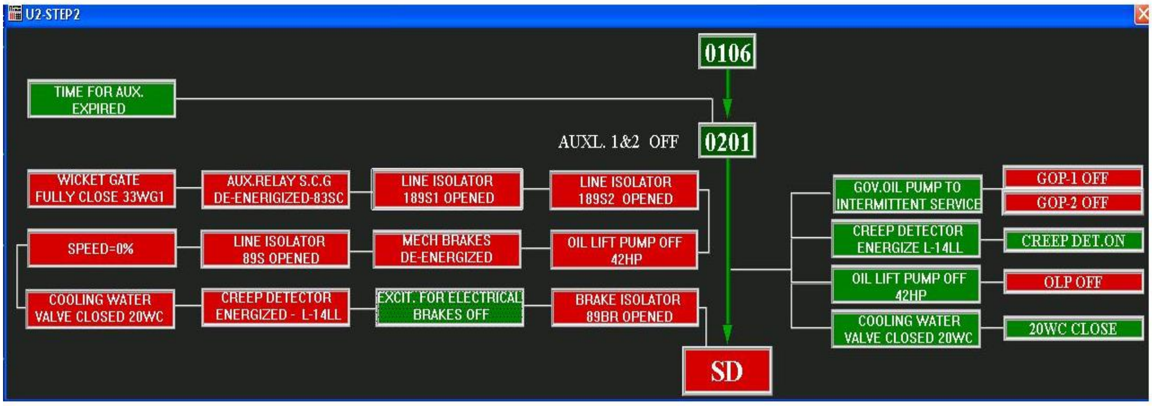

Fig. Wicket gate control sequence

- Their analysis confirmed that while the electrical load was exceeding safe limits, there were no signs of mechanical faults or abnormal vibrations in the turbine or generator units.

Acting swiftly, the operators used the SCADA system's remote control functionality to partially close the wicket gates, thereby reducing the flow of water into the turbine and consequently lowering the electrical load.

Their analysis confirmed that while the electrical load was exceeding safe limits, there were no signs of mechanical faults or abnormal vibrations in the turbine or generator units.

Case 2: Spillway Gate Automation During High Inflow

On July 9, 2024, the Nagarjuna Sagar Hydro Electric Station experienced an unusually high water inflow due to intense upstream rainfall. As a result, the reservoir level rose rapidly and crossed the critical threshold of 589 feet.

To prevent overflow and potential structural damage, the SCADA system automatically activated the spillway gate controls. The gates were progressively opened to release excess water safely downstream, ensuring the reservoir level was maintained within safe limits. This automated response helped avoid manual intervention delays and minimized the risk of flooding downstream.

Throughout the event, real-time monitoring provided operators with continuous updates on water levels, gate positions, and discharge rates. The system also triggered alarms to notify the control room of the high inflow situation, enabling readiness for any emergency actions if needed.

6. CONCLUSION

The implementation of a SCADA-based monitoring and control system for the NSHES has demonstrated the immense potential of automation in enhancing the safety of hydroelectric power generation. Through the integration of real-time data acquisition, remote monitoring, and automated control, the system offers a comprehensive solution for managing complex plant operations with minimal human intervention.

This project has illustrated how SCADA systems enable proactive decision-making by providing operators with accurate, real-time insights into the performance of various subsystems such as turbines, generators, and switchgear. It also ensures quick response to faults and anomalies, thereby minimizing downtime and preventing equipment damage.

Overall, this work not only underlines the value of SCADA technology in modern hydroelectric power plants but also serves as a foundational step toward smarter, more sustainable power infrastructure.

7. ACKNOWLEDGMENT

The authors are thankful to the officials of Department of Electrical and Electronics Engineering, Bhoj Reddy Engineering College for Women, Hyderabad, India, for providing facilities required to carry out this work.

REFERENCES

1. Mayadevi, N., Ushakumari, S., and Vinodchandra, S.S., “SCADA-based Operator Support System for Power Plant Equipment Fault Forecasting,” *Journal of The Institution of Engineers (India): Series B*, Vol. 95, Issue 4, pp. 369–376, October–December 2014.
2. Lakhoua, M.N., “Application of Functional Analysis on a SCADA System of a Thermal Power Plant,” *Advances in Electrical and Computer Engineering*, Vol. 9, Issue 2, pp. 90–98, June 2009.
3. Rajeev Kumar, M.L. Dewal, and Kalpana Saini, “Utility of SCADA in Power Generation and Distribution System,” *International Journal of Engineering Research and Applications (IJERA)*, Vol. 2, Issue 2, pp. 1234–1239, April 2012.

4. M. Elamin, “Fundamentals of Hydro Power Generation,” *International Journal of Engineering and Advanced Scientific Technology (IJEAST)*, vol. 5, no. 6, pp. 111–115, Oct. 2020.
5. A. K. Sharma and S. Kumar, "SCADA Based Monitoring and Control of Hydropower Plant," *International Journal of Electrical Engineering & Technology (IJEET)*, vol. 8, no. 3, pp. 25–32, Mar. 2017.
6. R. Singh, P. K. Tiwari, and S. Singh, "Design and Implementation of SCADA for Hydroelectric Power Plant," *International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering*, vol. 6, no. 9, pp. 6548–6554, Sept. 2017.
7. J. M. Pérez, L. A. Gómez, and F. Rodríguez, "Implementation of a SCADA System for Hydropower Plants," *Journal of Renewable Energy*, vol. 2021, Article ID 6618273, 10 pages, 2021.
8. OverviewofNSHEShttps://en.wikipedia.org/wiki/Telangana_Power_Generation_Corporation_Limited