Conclusion. The transmitssibility results obtained under random vibration excitation (0–1600 Hz) revealed a generally low transmission ratio, with all values remaining below unity. This confirms that the system effectively attenuates dynamic forces rather than amplifying them. Notably, 17 discrete frequencies exhibited close agreement between longitudinal and transversal transmissibility, implying near-isotropic dynamic behavior at those points. These frequencies likely represent common structural response modes where energy distribution is balanced between directions. Beyond these points, differences between the two directions became more pronounced, reflecting the inherent anisotropy of the dynamometer and mounting configuration. Overall, the results provide a strong experimental basis for developing a transmissibility law characterizing the directional dependence of vibration transmission within the system.

References

1. Mupona, M. I. Modal analysis of a milling dynamometer considered as 1DOF system / M. I. Mupona, I. C. Roșca // Vibroengineering Procedia. – 2022. – Vol. 46. – P. 54–60.
2. Kim, D. H. A design and calibration of a three-component dynamometer for milling process / D. H. Kim, C. M. Lee // Journal of Mechanical Science and Technology. – 2014. – Vol. 28, № 1. – P. 4–12.
3. Design, development and testing of a four-component milling dynamometer for the measurement of cutting force and torque / S. Yaldiz [et al.] // Mechanical Systems and Signal Processing. – 2007. – № 1. – P. 3–22.
4. Park, S. S. Dynamic compensation of spindle-integrated force sensors / S. S. Park, Y. Altintas // CIRP Annals. – 2004. – Vol. 53, № 1. – P. 305–308.
5. A methodology for the dynamic calibration of force transducers / A. Mondelin [et al.] // Mechanical Systems and Signal Processing. – 2012. – Vol. 26. – P. 1–16.
6. Inman, D. J. Engineering Vibration / D. J. Inman. – 4th ed. – London: Pearson, 2014. – 688 p.
7. Stein, G. J. On the dynamic behavior of force transducers / G. J. Stein, P. Mucka // Measurement. – 2005. – Vol. 38, № 3. – P. 183–196.
8. Bendat, J. S. Random Data: Analysis and Measurement Procedures / J. S. Bendat, A. G. Piersol. – 4th ed. – Hoboken: Wiley, 2010. – 640 p.
9. Pereira, J. M. Evaluation of the cross-talk in a three-component force dynamometer / J. M. Pereira, M. F. S. F. de Moura // Experimental Mechanics. – 2005. – Vol. 45, № 5. – P. 1–8.
10. Yoshioka, T. A method for the dynamic calibration of force transducers using a vibration exciter / T. Yoshioka, Y. Yabe // Measurement Science and Technology. – 2011. – Vol. 22, № 5. – Art. 055101.
11. Design of a Quality Management System to enhance reliability in Remote Monitoring with Control for ZETDC Bulk Supply points DC Supplies focusing on Telecommunications and Protection DC systems.

UDC 681

DESIGN OF A QUALITY MANAGEMENT SYSTEM TO ENHANCE RELIABILITY IN REMOTE MONITORING WITH CONTROL FOR ZETDC BULK SUPPLY POINTS DC SUPPLIES FOCUSING ON TELECOMMUNICATIONS AND PROTECTION DC SYSTEMS

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Abstract. High voltage substations depend heavily on reliable DC power supplies to ensure the continuous operation of protection relays, telecommunications systems, and control equipment. This paper presents the design of a Quality Management System (QMS) aimed at remotely monitoring and controlling these DC supply systems, with particular emphasis on battery banks and chargers supporting telecom and protection infrastructure. The proposed system ensures compliance with reliability standards, enhances real-time visibility, and enables predictive maintenance, thereby improving operational efficiency and system resilience. A new standard by the international Electro technical commission (IEC) which is IEC 61850 communication system in substations which is primarily used to eliminate the problem of interoperability between IEDs supplied by different vendors. Currently existing systems used only give an indication of a failure of DC supplies but do not offer ways to control the DC supply system so that it functions well. This paper looks into that and also proposes a way to monitor and control the DC supply system.

Keywords: quality management system, remote monitoring, protection systems, telecommunication batteries, battery chargers, predictive maintenance.

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Introduction. Modern power systems rely on high voltage substations for the transmission and distribution of electricity. Within these substations, reliable DC power is essential to maintain critical systems such as protection relays, automation equipment, and telecommunications. Failure in DC supply systems can lead to malfunctions in protection schemes, delayed fault clearing, or even blackouts. Therefore, ensuring the health and reliability of batteries and chargers in substations is a matter of significant operational importance.

Substation DC systems generally include:

Battery banks (typically VRLA or Ni-Cd types),

Battery chargers (rectifiers with float and boost charging), Distribution panels with circuit breakers and monitoring devices and Remote Terminal Units (RTUs) or intelligent electronic devices (IEDs).

The proposed system architecture shall include:

Sensors and IEDs to monitor voltage, current, temperature, electrolyte levels, and charger output.

Data Acquisition Units (DAUs) integrated with existing RTUs or PLCs.Communication Interfaces using secure protocols (e.g., IEC 61850, DNP3, Modbus TCP/IP). Cloud or Local Server Platforms for data storage and visualization. User Interface Dashboards for operators and maintenance personnel.

Alarm and Event Management System integrated with the SCADA/HMI.The SCADA system shall also be used for quality control of the system ensuring that it performs as intended.

Design of the Quality Management System (QMS). Quality Objectives. Ensure battery voltage and temperature within specified limits. Maintain charger output regulation and health. Early detection of battery degradation (for example sulfation, cell imbalance). Timely alarm on low charge/discharge events.

Key Features. Automated Reporting on battery state of health (SoH) and state of charge (SoC). Trend Analysis of parameters to forecast maintenance. Alarm Hierarchies based on severity. Self-test Routines scheduled to minimize false alarms.

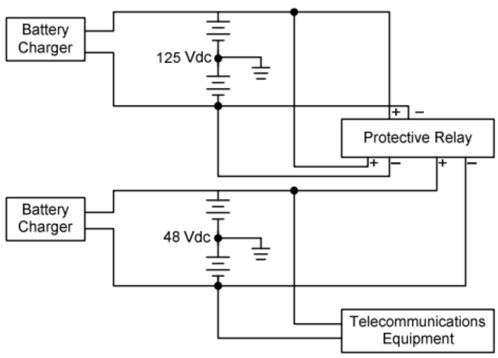

Figure 1 – DC supply system in a substation

Implementation and Monitoring.

Implementation. Implementation and monitoring will include, Baseline Survey of existing equipment, Gap Analysis to determine integration needs. Selection of Remote Monitoring Devices compatible with substation standards. System Integration Testing with existing SCADA/EMS platforms. Staff Training and procedure development, Deployment and Commissioning and Ongoing monitoring includes real-time dashboards, monthly performance reports, and quarterly audits. AI-powered analytics may be employed for anomaly detection and lifecycle prediction.

There are various benefits of this system which include improving uptime of protection and telecom systems. Data-driven maintenance and lifecycle management. Enhanced safety through early fault detection.

Disadvantages are also found in such systems and these include Integration with legacy systems.

Cybersecurity concerns with remote access.

Initial capital cost and training requirements.

DC Battery Systems. The dc auxiliary service of a substation is responsible for supplying dc current for all devices. It is composed basically of a rectifier, a battery charger, and a bank of batteries for each level of dc voltage required. The proper operation of the dc battery system and the source of ac is essential for the operation of the control and protection systems of a substation. However, not all the rectifiers and battery chargers have auto diagnostic mechanisms, and those that have them only signal to indicate alarm situations.

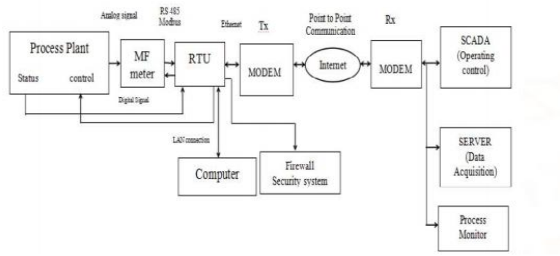

Figure 2 – Remote monitoring system for a substation

Quality control. This shall be achieved through ensuring system design meets IEC standards, SCADA operator training, designing user friendly HMI, simulation of the system before testing it in the real world, design drawings shall be reviewed including program flow charts and system back up archived. Access control and cybersecurity protocols shall also be implemented for system protection from unauthorized users.

References

1. Kimura, S. Applying IEC 61850 to Real Life: Modernization Project for 30 Electrical Substations / S. Kimura, A. Rotta, R. Abboud [et al.] // Proceedings of the 10th Annual Western Power Delivery Automation Conference, Spokane, WA, April 2008. – 2008. – P. 1–12.

2. Ayers, L. Using Dynamic Real-Time Substation Information to Reinvent Asset Management / L. Ayers, D. Dolezilek // Proceedings of the 3rd Annual Western Power Delivery Automation Conference, Spokane, WA, April 2001. – 2001. – P. 1–8.

3. Dolezilek, D. Understanding, Predicting, and Enhancing the Power System Through Equipment Monitoring and Analysis / D. Dolezilek // Proceedings of the 2nd Annual Western Power Delivery Automation Conference, Spokane, WA, April 2000. – 2000. – P. 1–7.

4. Bernardes, R. PQMS – Power Quality Monitoring System: Improve Power Systems Through IEDs / R. Bernardes, F. Ayello // Proceedings of the 20th Annual International Conference on Electricity Distribution, Prague, Czech Republic, June 2009. – 2009. – P. 1–6.

5. Sidhu, T. S. Implementation Issues with IEC 61850 based substation automation systems / T. S. Sidhu, M. G. Kanabar, P. P. Parikh // National Power Systems Conference, Bombay, December 2008. – 2008. – P. 473–478.

6. Li, H. Research on technologies in smart substation / H. Li, K. Wang // ICSGCE 2011: Energy Procedia. – 2011. – Vol. 12. – P. 113–119.

7. Satheyamoorthy, K. P. Role of controlling of substation using PLC and SCADA / K. P. Satheyamoorthy // Journal of Automation and System Engineering. – 2015. – Vol. 9, № 3. – P. 194–201.

8. Cyber security analysis of substation automation system / A. U. J [et al.] // International Research Journal of Engineering and Technology. – 2016. – № 7. – P. 301–304.