

Implementation of an SF6 Monitoring System for High Voltage Equipment

Jay Popham – BEng Electrical and Electronic Engineering

ACCA6020



1.Introduction

This project aims to develop a real-time gas monitoring system for sulphur hexafluoride (SF₆), which is used in high-voltage gas-insulated switchgear (GIS). The system is designed to detect any drop in gas density that could indicate a leak, thereby improving operational safety and ensuring compliance with environmental regulations. Key objectives include:

- Researching current technologies.
- Designing a PLC-based system.
- Designing a Prototype using Siemens TIA Portal.
- Integrating high-accuracy sensors.
- Implementing alarm logic and HMI feedback.
- Validating the prototype through testing.

2.Background

SF₆ is widely used in substations due to its excellent insulating and arc-quenching properties. However, it is also a potent greenhouse gas, with a Global Warming Potential (GWP) 23,500 times greater than carbon dioxide. Regulations such as the EU F-Gas Regulation require real-time leak detection and maintenance logs for any equipment containing SF₆. Substations that use SF₆ rely on these systems to ensure both safety and environmental responsibility[1].

3. Literature Review –Key Insights

Research into industry practices revealed the limitations of existing tools such as DILO’s handheld devices and Quoitrol systems, which often lack integration with automation platforms. Trafag’s 8773 sensors proved to be reliable components due to their 6.5–20 mA analogue output, ideal for continuous PLC input, while also offering a mechanical switch for back up feedback signals. Artificial intelligence (AI) techniques, such as YOLOv4 are emerging in predictive maintenance[2]. Alternatives to SF₆, including g³ and AirPlus, show promise but face early-stage implementation barriers[3]. These findings helped inform the system’s focus on compliance, integration, and practical implementation.

4.System Design

The system architecture consists of Trafag gas density sensors feeding analogue signals into a Schneider Eco – Struxure Software , which processes the data and communicates alarm states to a local HMI and a remote Substation Control System (SCS) . The PLC continuously compares input values to predefined thresholds. If these are breached, digital outputs trigger alarms and activate visual indicators on the HMI. Operators can then acknowledge and reset alarms as required. The modular design also allows the system to be expanded for larger installations.

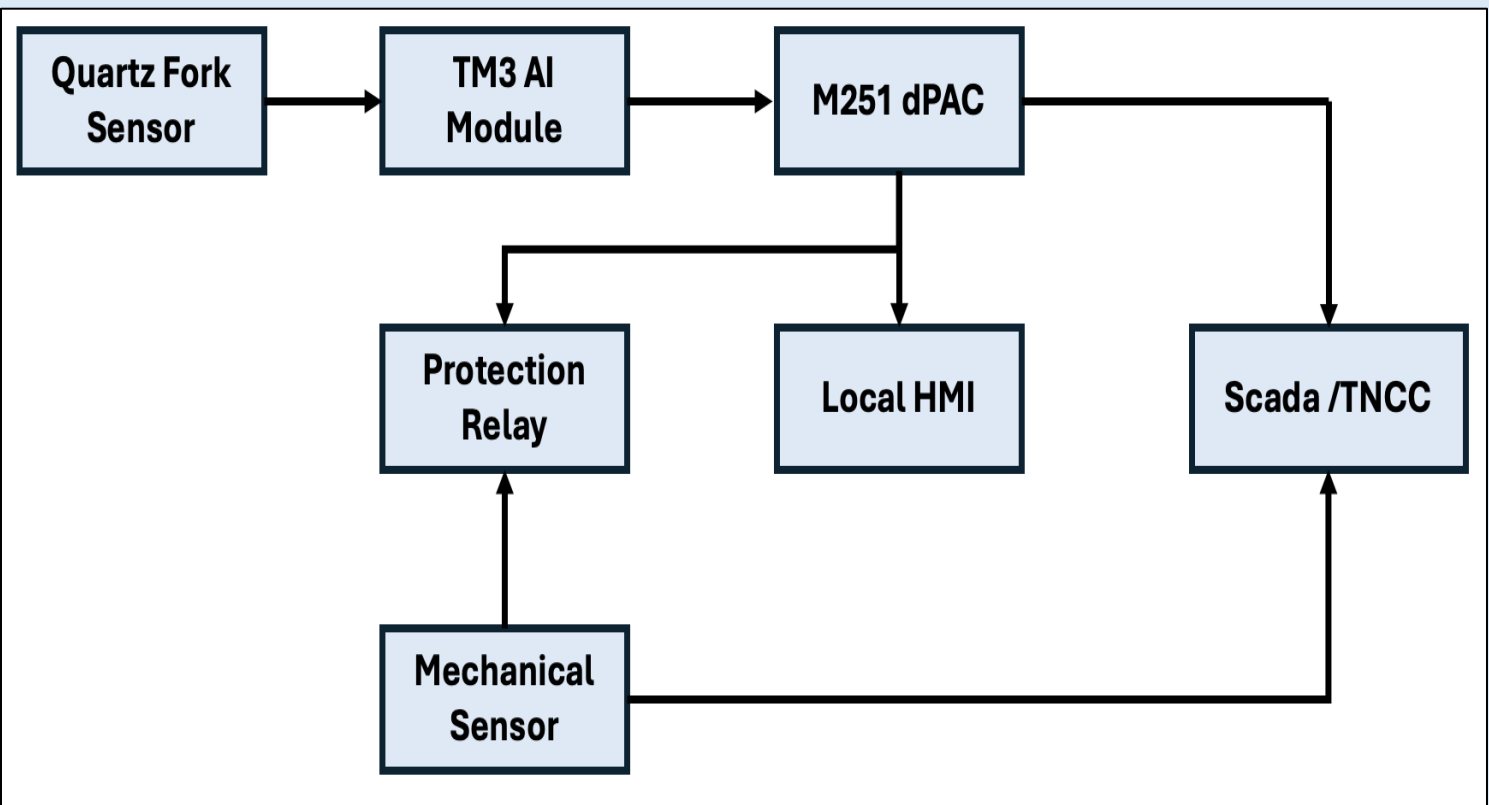


Figure 1: Block Diagram of Proposed Gas Density Monitoring system

5.Implementation

The prototype was developed using Siemens TIA Portal V16. Sensor inputs were scaled and interpreted using ladder logic, and HMI screens were created to provide real-time monitoring, alarm indication, and manual reset capabilities. Alarms are latched for safety and only clear once the fault condition has been resolved. Testing was conducted using simulated 0-10VDC input via a voltage regulator and potentiometer to verify the alarm logic, HMI functionality, and communication with SCADA .

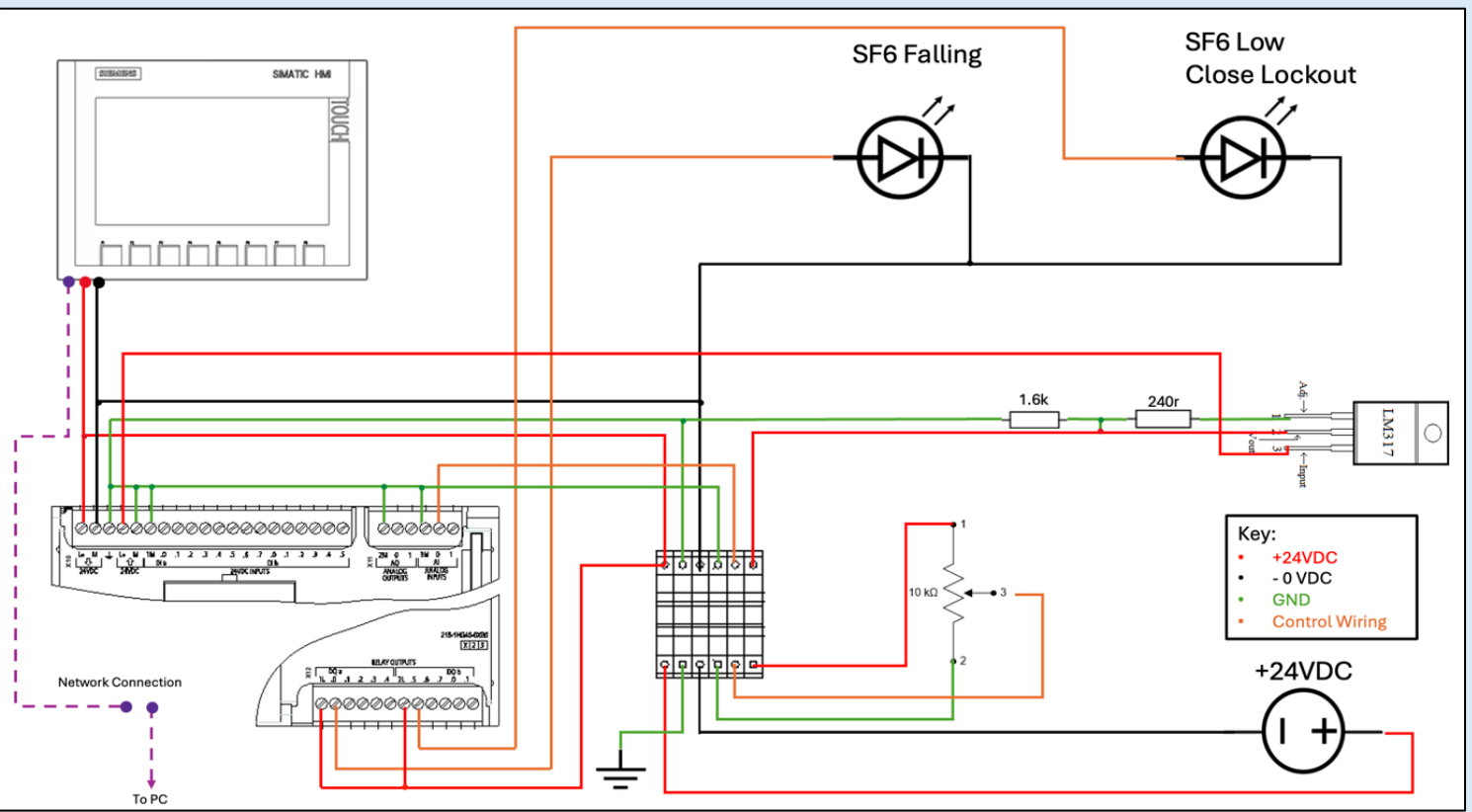


Figure 3: Prototype Wiring Diagram

6. Results & Testing

Testing was carried out using simulated inputs to replicate both normal and fault conditions. The PLC successfully triggered alarms when thresholds were crossed and activated the correct outputs and indicators. The reset function only cleared the alarms when sensor inputs returned to safe levels, as designed. The results demonstrate that the system is accurate, responsive, and suitable for both monitoring and compliance applications.

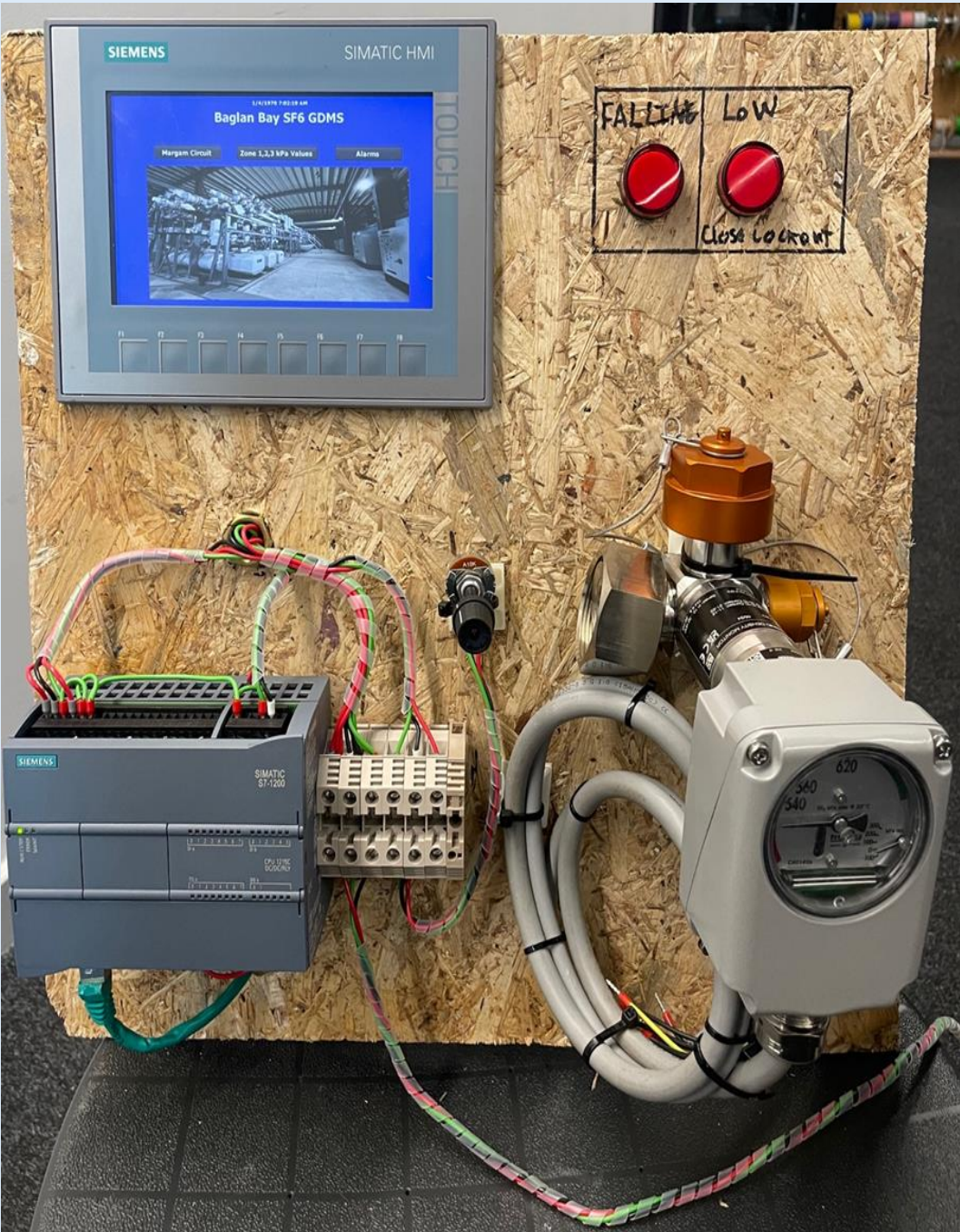


Figure 6: Overall view of Prototype Build



Figure 2: Trafag C40149/48

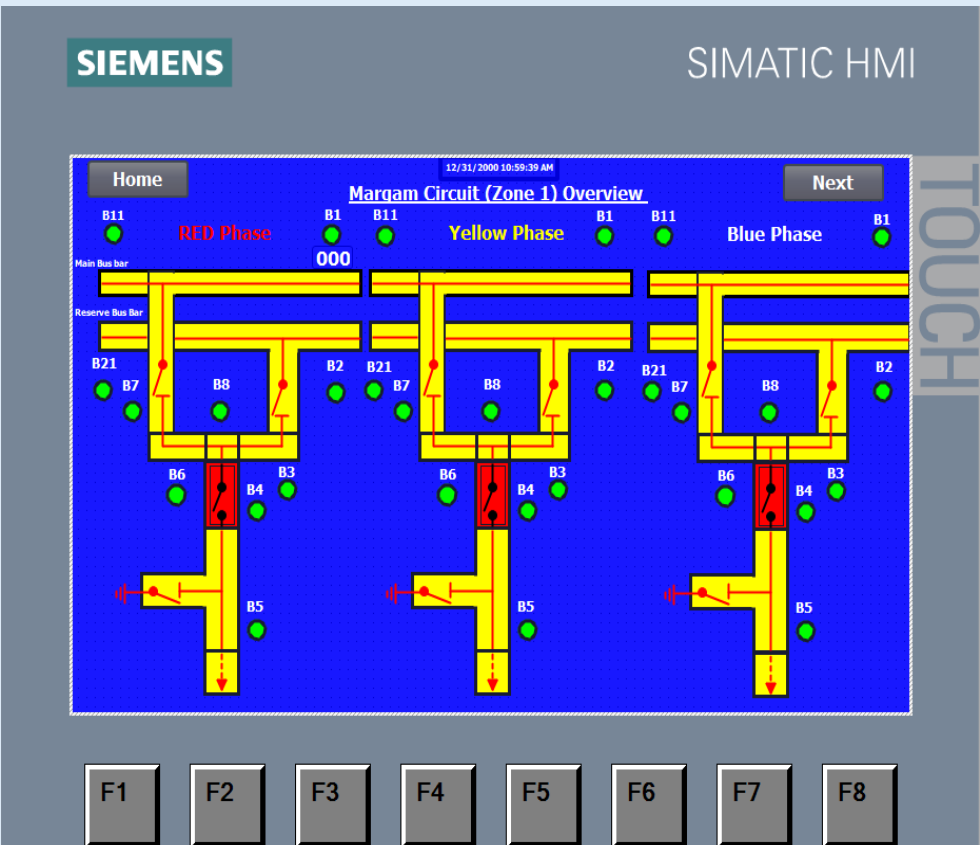


Figure 4:HMI Circuit Overview Screen

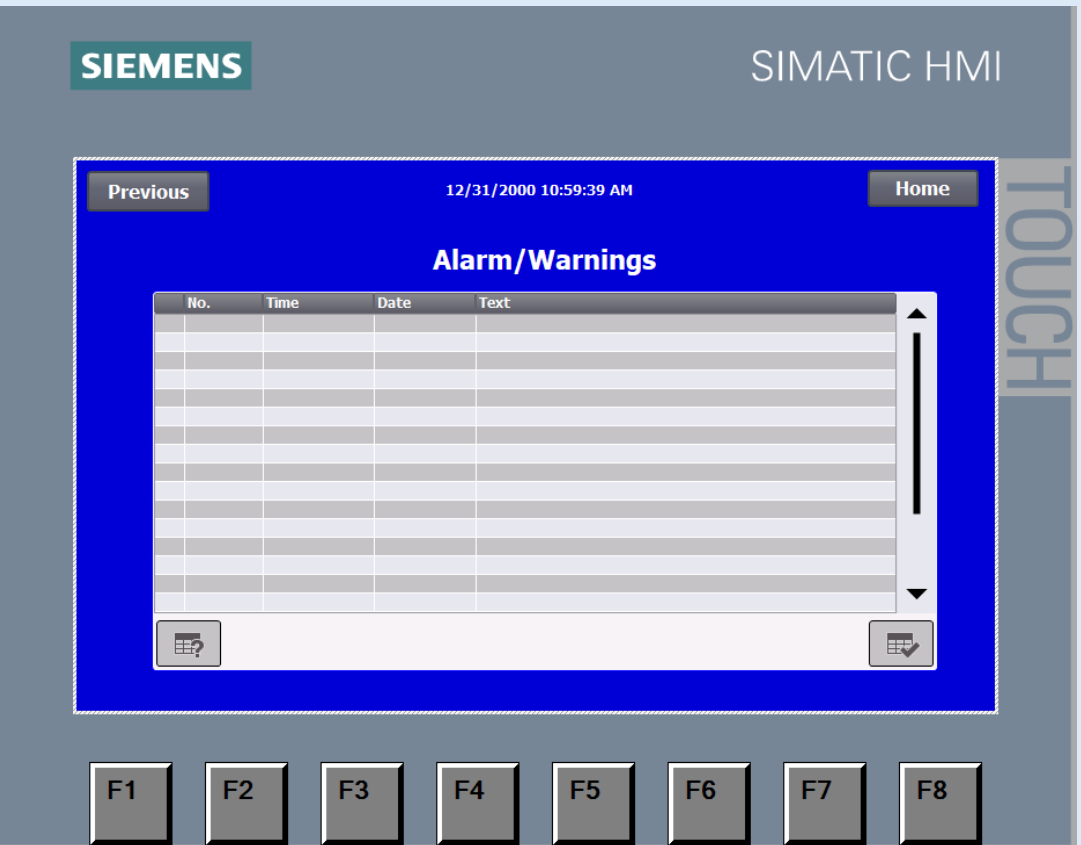


Figure 5 : Alarm View Screen

References

[1] DEFRA, “F gas regulation in Great Britain,” UK Government, 2022.
[2] B. C. C. X. Y. W. Jing Huang, “Research on Intelligent Detection of Sulphur Hexafluoride Gas Leakage in Confined Spaces,” ICEPE-ST, 2022.
[3] M. Eves, “A Literature Review on SF6 Gas Alternatives for use on the Distribution Network,” Western Power Distribution, 2018.

7. Conclusion & Future Work

The project successfully delivered a working prototype capable of monitoring SF₆ gas density in real time, raising alarms, and providing clear feedback via an HMI. The system aligns with current industry regulations and demonstrates that such solutions can be developed cost-effectively using commercial components. Future developments may include AI-based fault prediction, sensor redundancy, and live integration into actual substation environments.