IJNRD.ORG ISSN : 2456-4184
INTERNATIONAL JOURNAL OF NOVEL RESEARCH AND DEVELOPMENT (IJNRD) | IJNRD.ORG
An International Open Access, Peer-reviewed, Refereed Journal

Transtect: A Transformer Health Detection System

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Abstract: This study proposes a comprehensive transformer protection system (TPS) that monitors and controls key parameters like faults, oil levels, temperature, and load using sensors. Designed for user-friendliness, it allows real-time access and control through WhatsApp or an App Inventor application on mobile devices. The system detects deviations from normal conditions, such as low oil levels or high temperatures, which could lead to equipment failure, allowing for preventive maintenance. Through continuous data collection, the TPS sends alerts to users for quick intervention and also enables remote adjustments to operational settings, optimizing transformer performance. Ultimately, this solution enhances asset visibility, reliability, and safety in power distribution networks.

Index Terms **- Transformer, Dissolved Gas Analysis, Twillo WhatsApp Sandbox, Node-MCU, Arduino IDE**

1.INTRODUCTION

This research presents an advanced IP-based transformer protection system that monitors voltage, current, oil levels, and temperature without relying on internet connectivity. By allowing real-time monitoring and analysis through a local network, it ensures reliable performance even in remote areas. The system integrates seamlessly with existing infrastructure and uses Twilio's WhatsApp sandbox for alerts, enhancing accessibility for prompt responses. This approach represents a modern, user-friendly solution for transformer management, prioritizing efficiency, reliability, and proactive maintenance.

1.1. PROBLEM STATEMENT

This research addresses the need for reliable transformer monitoring in remote areas with limited internet access by developing an IP-based solution that operates without requiring internet connectivity. By providing real-time defect and load status updates accessible via WhatsApp, this system ensures dependable, user-friendly monitoring. Ultimately, it enhances the accessibility and reliability of transformer management in remote, resource-constrained locations.

2. THE CRITICAL ROLE AND HEALTH OF TRANSFORMERS IN MODERN GRIDS

Transformers play a crucial role in power systems by enabling efficient energy transmission and supporting grid stability, especially with renewable energy integration. Despite their importance, transformers are vulnerable to issues like overheating, insulation breakdown, moisture, and aging, which can lead to failures and reduced efficiency. Proactive maintenance and monitoring are therefore essential to ensure their longevity, maintain grid reliability, and optimize energy efficiency [1]. Figure 1 shows the issues related to the transformer health.

3. SMART DETECTION SYSTEMS FOR TRANSFORMERS

Modern transformer health detection systems enhance reliability by identifying issues early through advanced monitoring techniques. Dissolved Gas Analysis (DGA) detects insulation and overheating problems, while temperature and vibration monitoring reveal thermal and mechanical stresses. Oil quality assessments evaluate cooling efficiency, ensuring optimal operation. Utilizing SCADA and IoT, remote monitoring provides real-time data, enabling centralized oversight and proactive maintenance, significantly boosting transformer reliability [2].

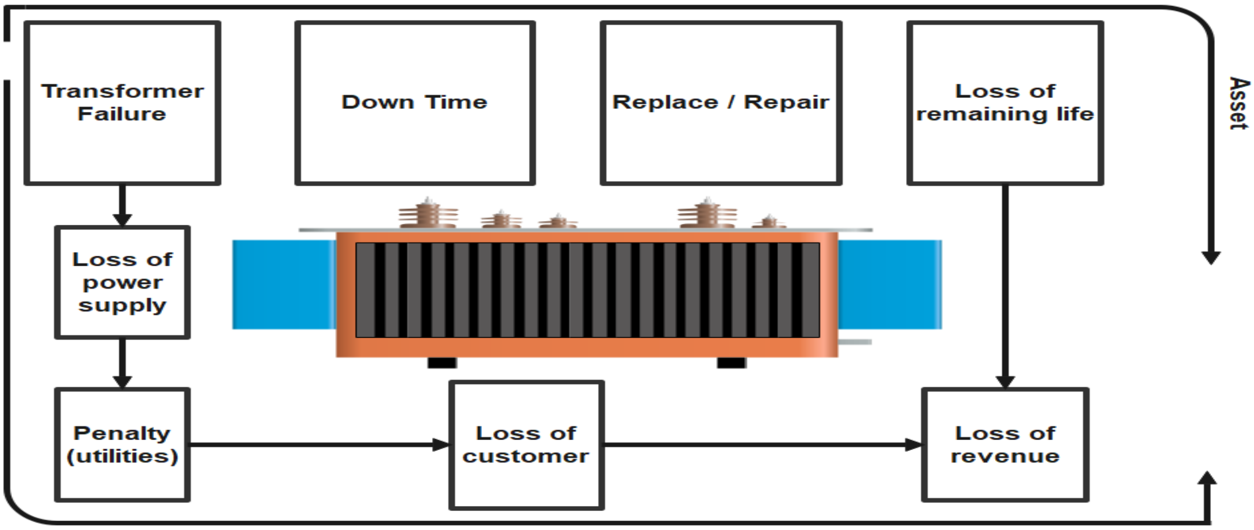
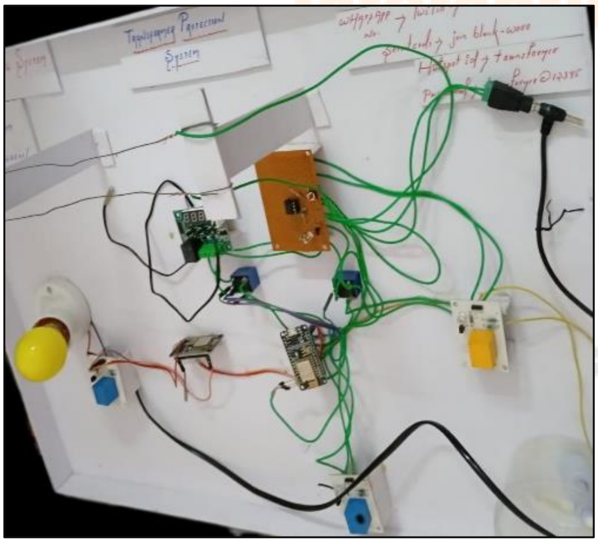


Fig. 1. Issues related to transformers health

4. APPROACH TOWARDS THE RESEARCH

This research will install a transformer monitoring system with temperature monitoring, oil level measurement, and fault detection capabilities. The system will gather data and send out warnings when thresholds are crossed using a Node-MCU (or comparable microcontroller), a number of sensors, and relay drivers [3]. In order to minimize dependence on the internet, notifications will be issued using local systems such as buzzers, lights, or displays. The model of the project is shown in Fig. 2(a).



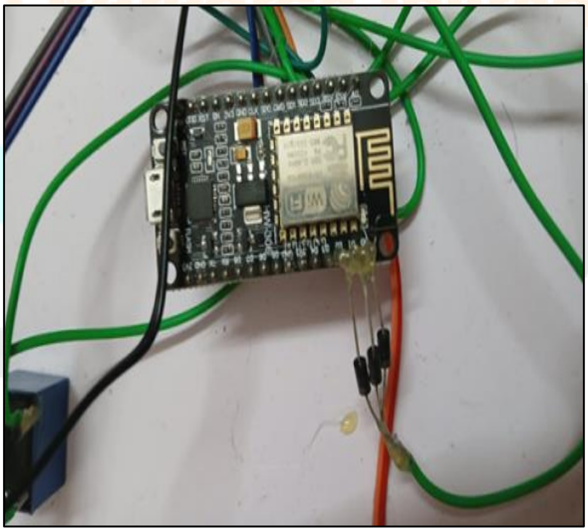


Fig. 2. (a) Model of the circuit. (b) Node-MCU

5. NODE MCU

The system employs a Node-MCU or similar microcontroller as its central unit, integrating relay drivers, temperature and oil level sensors (DS18B20 and magnetic or ultrasonic), and a vibration sensor for effective transformer monitoring. It features alert mechanisms like LEDs for visual notifications and an LCD or OLED display for local status updates [4]. A dedicated power supply powers all components, which are enclosed to protect against environmental factors, ensuring reliable management of transformer health. The Node-MCU hardware is shown in Fig.2(b).

6. **ARDUINO IDE**

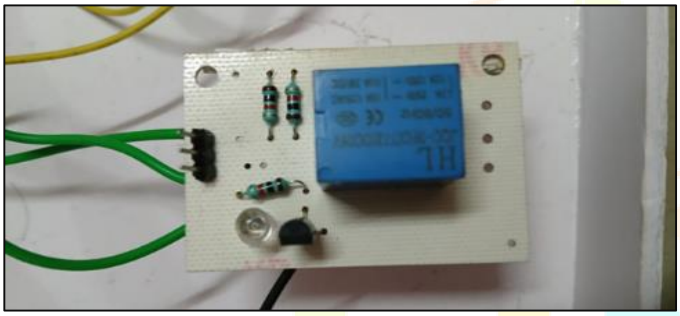
The Arduino IDE is a software tool with a user-friendly interface for programming and managing Arduino boards. It features a central code editor with syntax highlighting and code completion, helping users write and organize their sketches in C/C++. The toolbar offers quick access to essential functions like compiling, uploading, and selecting the board and port. A message console provides real-time feedback on errors and code status, while the status bar displays memory and position information. Key utilities include the Library Manager for adding new functionalities, the Serial Monitor for debugging via serial communication, and the Board Manager for configuring various Arduino-compatible boards. Customizable preferences allow users to adjust font, theme, and language settings, making the IDE flexible and accessible for all levels of Arduino programming [5].

7. **RELAY DRIVERS**

In relay circuits controlled by a transistor, turning off the transistor can lead to an inductive "kickback" effect, causing a harmful voltage spike that may damage the transistor. To prevent this, a diode is connected across the relay coil in reverse polarity. When the transistor is on, the diode is inactive, but when the transistor turns off, the diode becomes forward-biased, allowing current to flow through it and reducing the coil current gradually. This setup shown in Fig.3(a) protects the transistor from high reverse voltages, ensuring circuit stability and preventing damage from inductive kickback [6].

8. **BISTABLE TIMER CIRCUIT**

The 555 timer IC shown in Fig.3(b) operates using two comparators connected to 1/3 Vcc and 2/3 Vcc reference voltages. The comparators are linked to a flip-flop, which changes state based on the comparator outputs. An input signal applied to the trigger pin (below 1/3 Vcc) causes the comparator output to toggle, setting the 555 timer's output high. This output remains stable until a reset signal pulls it to ground, returning the circuit to its original state.



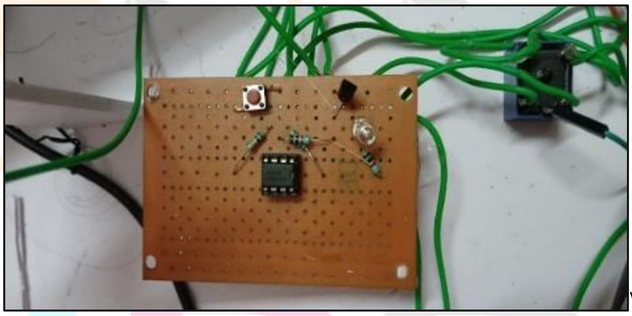


Fig. 3. (a) Relay Driver (b) Bistable timer circuit.

9. **OTHER COMPONENETS**

The Magnetic Float Sensor FS37A shown in Fig.4(a) is a versatile sensor used for liquid level detection in various applications. It operates based on the principle of magnetic field variation caused by the movement of a magnetic float along a sensor shaft. To detect over temperature, for that we need a temperature sensor as a thermistor shown in Fig. 4(b) which is a N.T.C type for sensing the temperature and for comparing the temperature we need an OP-AMP which is configured as an voltage comparator (LM393) which compares the two-input voltage and gives the corresponding outputs according to the temperature. Other components used are like resistors, capacitors, Led, push button, LDR, Transistors (C 547 -npn and BC 557 -pnp) and Voltage regulator.

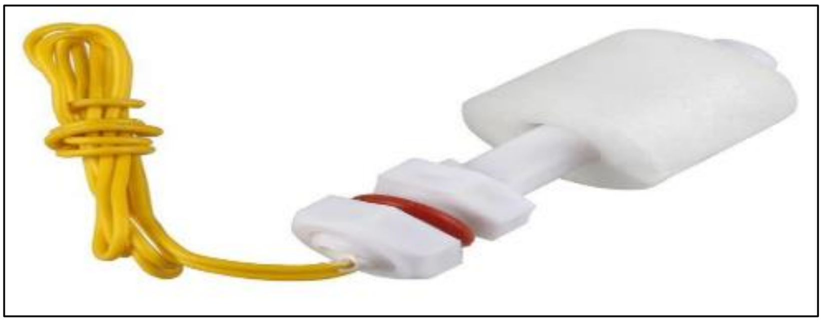
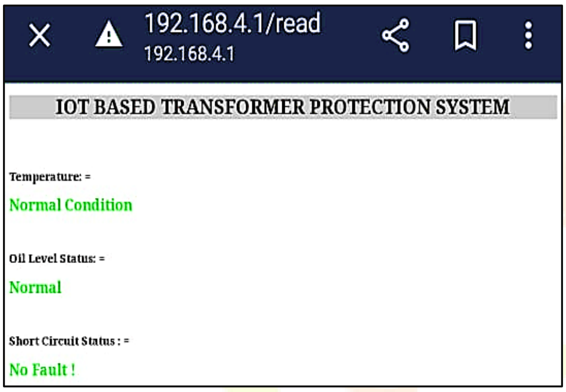
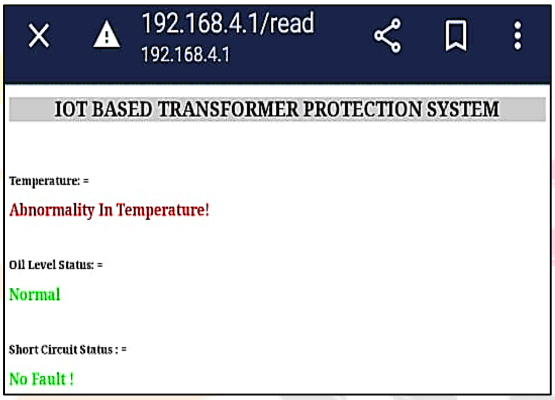


Fig. 4. (a) Magnetic sensor





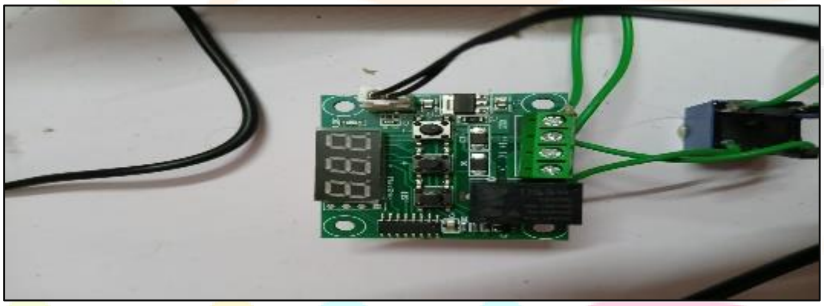


Fig. 4. (b) Over temperature detector

10. RESULTS AND DISCUSSION

10.1. FAULT MONITORING SYSTEM

92.162.4.1/read is the local IP address that the system is set with, which enables remote access to the monitoring dashboard. Users are able to monitor temperature, voltage, current, and other important transformer characteristics with this dashboard.

10.2. LOAD MONITORING SYSTEM

The research's goal is to improve load monitoring operations by integrating a WhatsApp application with a local Twilio sandbox environment. The smooth communication and alerting capabilities made possible by this connection enhance real-time system load monitoring and management.

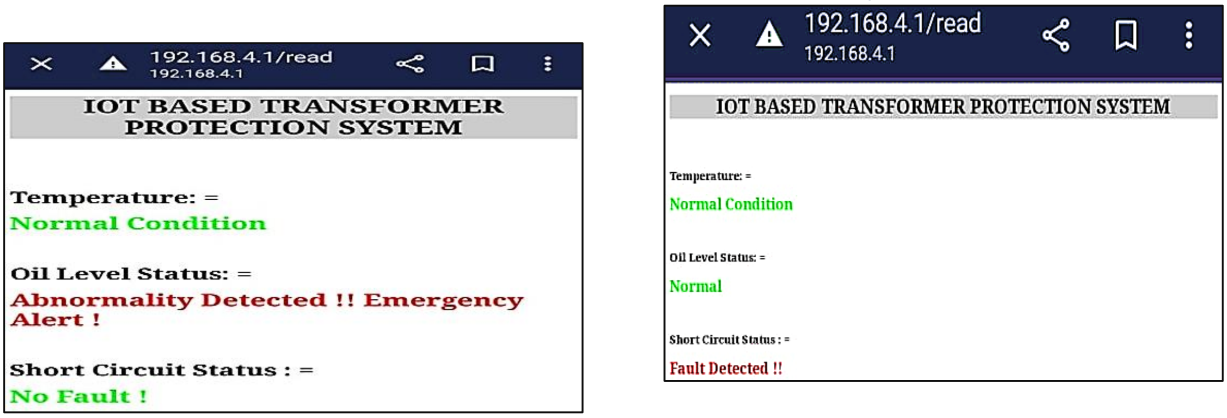


Fig.5. Fault Monitoring System

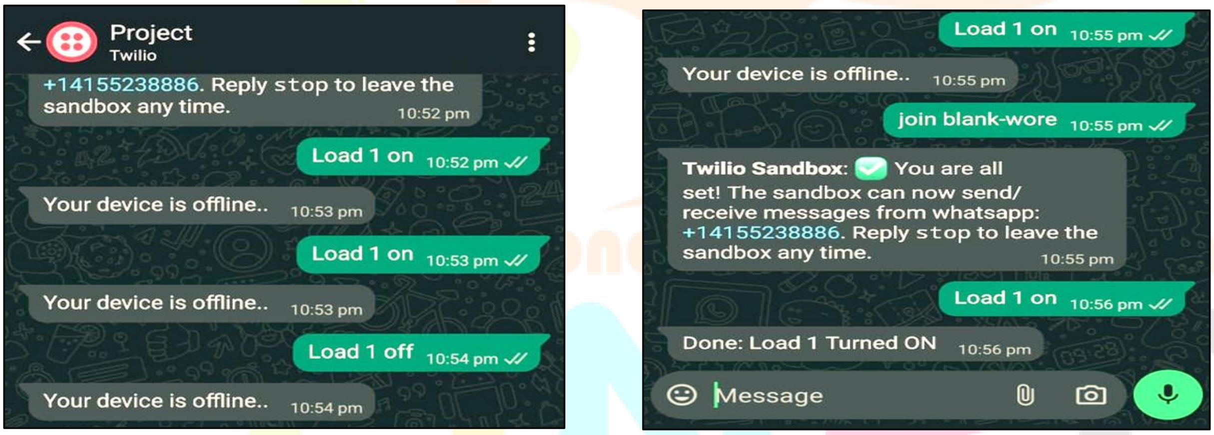


Fig.6. Load Monitoring System

11. CONCLUSION AND FUTURE SCOPE

Using local IP addressing for transformer health monitoring enables robust, real-time condition tracking in remote areas without relying on internet connectivity. This system monitors critical parameters like temperature, oil level, and vibration, allowing for early fault detection and proactive maintenance. By eliminating dependence on external networks, it ensures data continuity and reduces risks of delays or loss, maximizing uptime. Advanced algorithms and machine learning provide actionable insights for predictive maintenance, enhancing transformer reliability and lifespan. With compatibility to industry standards, it integrates seamlessly into existing systems, offering a user-friendly, scalable, and cost-effective solution for optimizing power distribution assets. Utilizing local IP addressing for transformer health monitoring offers enhanced security, as data remains within a private network, reducing the risk of breaches. This approach ensures reliable, real-time monitoring without internet dependency, ideal for remote areas. It supports quick response times, integrates seamlessly with maintenance systems, and allows scalability for multiple transformers. Additionally, predictive analytics and machine learning enable proactive maintenance, and network redundancy boosts reliability, making it a robust and adaptable solution for critical infrastructure.

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