

# IOT-BASED TRANSFORMER MONITORING SYSTEM

<sup>1</sup>CHAITANYA SHINDE, <sup>2</sup>CHAITANYA SAHANE, <sup>3</sup>UMESH LATAPTE <sup>4</sup>SOMESHWAR GUTTE <sup>5</sup>HARSHDA NANDE <sup>6</sup>NIKITA PATIL

<sup>1</sup> UG Scholar, Electrical Dept. JSPM's Bhivrabai Sawant polytechnic, Wagholi

<sup>2</sup> UG Scholar, Electrical Dept. JSPM's Bhivrabai Sawant polytechnic, Wagholi

<sup>3</sup> UG Scholar, Electrical Dept. JSPM's Bhivrabai Sawant polytechnic, Wagholi

<sup>4</sup> UG Scholar, Electrical Dept. JSPM's Bhivrabai Sawant polytechnic, Wagholi

<sup>5</sup> UG Scholar, Electrical Dept. JSPM's Bhivrabai Sawant polytechnic, Wagholi

<sup>6</sup>Asst. Prof. Electrical Dept. JSPM's Bhivrabai Sawant polytechnic, Wagholi

**ABSTRACT:** Power transformers are one of the most important and expensive components in an electrical power system. Transformer failure leads to power interruption, financial loss, and safety hazards. Traditional monitoring methods are manual and periodic, which cannot detect faults in real time. The IoT-Based Transformer Monitoring System is designed to continuously monitor transformer operating parameters such as temperature, oil level, load current, and voltage using sensors. These parameters are processed by a microcontroller and transmitted to a cloud platform through IoT communication technologies like Wi-Fi or GSM. The system provides real-time monitoring, data logging, and automatic alert generation during abnormal conditions. This project improves transformer reliability, reduces maintenance cost, and supports smart grid infrastructure.

## I. INTRODUCTION

Electrical energy plays a very important role in the development of any country. The power system mainly consists of generation, transmission, and distribution. Among these, distribution transformers are the most critical and widely used equipment, as they supply electricity directly to residential, commercial, and industrial consumers. Any transformer malfunction can result in widespread power outages, financial losses, and public annoyance. Because of overloading, varying loads, environmental factors, and aged insulation, transformers are constantly exposed to mechanical, thermal, and electrical stressors. Overheating, overloading, decreased oil levels, insulation failure, and unusual voltage or current circumstances are common reasons why transformers fail. In conventional systems, transformer monitoring is mostly done manually or through periodic inspections. Such methods are time-consuming, less accurate, and unable to detect sudden faults in real time. With the rapid advancement in Internet of Things (IoT) technology, it has become possible to monitor electrical equipment remotely and continuously. IoT enables interconnection of sensors, controllers, and communication networks to collect real-time data and transmit it to cloud platforms for analysis and visualization.

Transformer health characteristics can be continuously monitored without human intervention by utilizing IoT. Using a variety of sensors, the Internet of Things-based Transformer Monitoring System is intended to continuously monitor critical transformer parameters like temperature, voltage,

---

current, and load conditions. These sensors are interfaced with a microcontroller, which processes the data and sends it to an IoT cloud server through a wireless communication module. The collected data can be accessed from anywhere using a web dashboard or mobile application.

This system helps in early detection of abnormal operating conditions and provides timely alerts to maintenance personnel. As a result, preventive maintenance can be carried out before a major failure occurs. This not only improves transformer reliability and lifespan but also reduces maintenance cost and power outages. IoT-based monitoring is essential for enhancing efficiency, safety, and dependability in contemporary power distribution systems and smart grids. As a result, this project offers a clever, dependable, and affordable transformer monitoring solution that is ideal for modern electrical power systems.

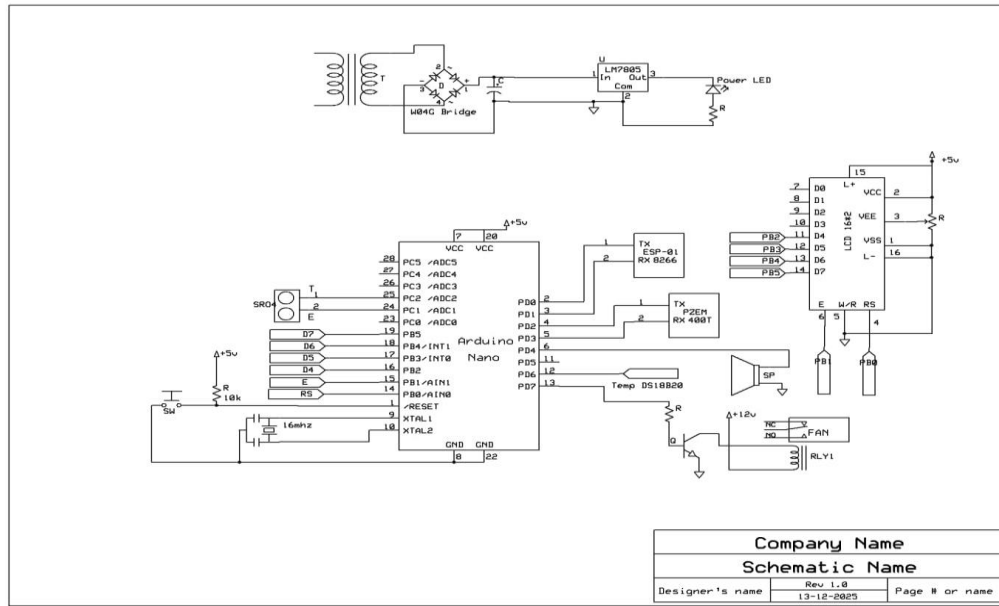
## II. SYSTEM DESCRIPTION

Real-time monitoring of an electrical transformer's health and operational state is the goal of the Internet of Things-based Transformer Monitoring System. Transformers are essential parts of the power distribution system, and their failure can result in both financial losses and power disruptions. Thus, ongoing observation is crucial. This system uses different sensors to measure important transformer parameters such as temperature, voltage, and current. These parameters indicate the operating condition of the transformer. The sensors are connected to a microcontroller such as Arduino or ESP32, which acts as the main processing unit of the system.

The microcontroller collects sensor data, processes it, and compares it with predefined safe limits. If any parameter exceeds the safe limit, the system identifies it as an abnormal condition. The processed data is then transmitted to an IoT cloud platform using a Wi-Fi module. The data is stored on the cloud platform and shown as graphs and numerical numbers. Through a mobile application or web dashboard, users can access this data from a distance. When issues like overheating or overloading happen, alerts are produced. This system helps in early fault detection, preventive maintenance, reduced downtime, and improved transformer life. It provides a smart, reliable, and cost-effective solution for modern power distribution systems. The IoT-based Transformer Monitoring System is a smart embedded system designed to continuously monitor the health and operating conditions of an electrical transformer in real time. The system integrates sensors, a microcontroller, and IoT communication technology to collect, process, transmit, and display transformer parameters remotely.

.

Circuit Diagram:



The system consists of sensors connected to a microcontroller. The microcontroller collects data from sensors and sends it to the cloud using an IoT communication module. The user can monitor transformer parameters through a web dashboard or mobile application.

### III. WORKING

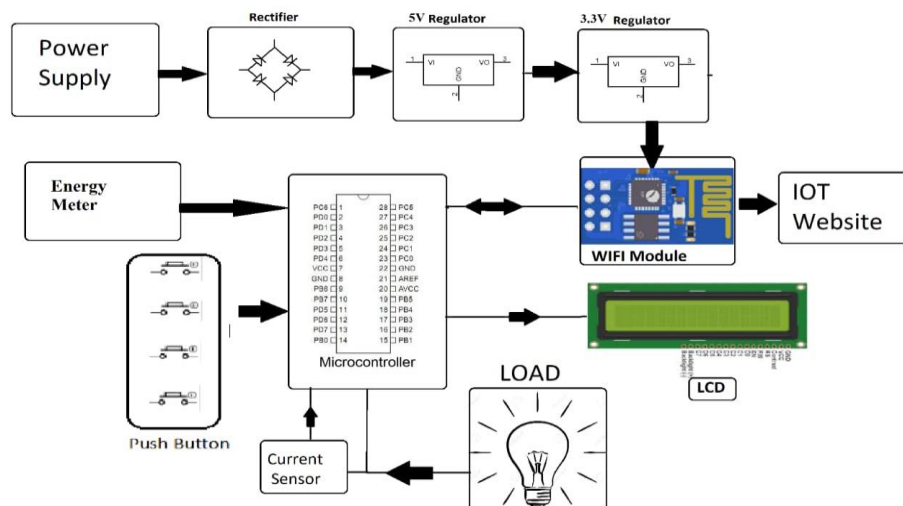
The IoT-based Transformer Monitoring System operates by continuously monitoring important operating parameters of an electrical transformer and transmitting this information to a remote monitoring platform through the internet. The main objective of the system is to detect abnormal conditions at an early stage and prevent transformer failures. Initially, various sensors such as temperature sensors, voltage sensors, and current sensors are installed on the transformer. These sensors continuously sense real-time physical and electrical parameters. One important sign of overheating is the transformer oil or winding temperature, which is measured by the temperature sensor. While the voltage sensor keeps an eye on changes in voltage, the current sensor analyzes the load current to identify overloading situations. The output of these sensors is fed to the microcontroller, which acts as the central control unit of the system. The microcontroller's integrated Analog-to-Digital Converter (ADC) transforms analog signals into digital form after reading sensor data on a regular basis. After then, the gathered data is processed and compared to predetermined safe operating limits that are kept in the program memory. Under normal operating conditions, the system continuously monitors the transformer and sends real-time data to the IoT cloud platform.

If any parameter exceeds its safe limit, such as excessive temperature or overcurrent, the microcontroller immediately identifies it as a fault condition. In such cases, the system generates alerts and uploads the abnormal data to the cloud server. The transformer data is sent to the cloud platform via IoT connection technology (Wi-Fi), where it is saved and shown in numerical and graphical ways. This data can be accessed remotely by authorized persons via a mobile application or

web browser. This makes it possible to continuously monitor the transformer site without being physically present. As a result, the system guarantees early defect identification, minimizes downtime, and permits preventive maintenance.

### Hardware Requirements

- Microcontroller (Arduino / ESP8266 / ESP32)
- Temperature Sensor (LM35 / DHT11 / DS18B20)
- Current Sensor (ACS712)
- Voltage Sensor Module
- Oil Level Sensor (optional)
- Wi-Fi Module (inbuilt or external)
- Power Supply Unit
- Transformer (prototype or model)



### Software Requirements

- Arduino IDE
- Embedded C / C++
- IoT Cloud Platform (ThingSpeak / Blynk / Firebase)
- Web browser or mobile application

### Technical Specification

#### 1. System Type

- Real-time embedded monitoring system
- IoT-enabled transformer health monitoring

#### 2. Controller Specification

- **Microcontroller:** ESP32 / ESP8266 / Arduino Uno
- **Operating Voltage:** 5 V DC (Arduino) / 3.3 V DC (ESP)
- **Clock Frequency:**
  - Arduino Uno: 16 MHz
  - ESP32: up to 240 MHz
- **ADC Resolution:** 10-bit / 12-bit

- **Communication Interfaces:** UART, I2C, SPI

### **3. Sensor Specifications**

#### **a) Temperature Sensor**

- Type: LM35 / DS18B20
- Measuring Range:  $-55^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$
- Accuracy:  $\pm 0.5^{\circ}\text{C}$
- Output Type: Analog / Digital

#### **b) Current Sensor**

- Type: ACS712
- Measuring Range: 0–30 A
- Sensitivity: 66–185 mV/A
- Isolation: Yes

#### **c) Voltage Sensor**

- Type: Voltage Divider Module
- Input Range: 0–230 V AC (scaled)
- Output Range: 0–5 V DC

#### **d) Oil Level Sensor**

- Type: Float / Ultrasonic Sensor
- Output: Digital / Analog
- Function: Detects low oil level

### **4. Communication Specification**

- **IoT Technology:** Wi-Fi / GSM
- **Wi-Fi Module:** ESP8266 (802.11 b/g/n)
- **GSM Module:** SIM800
- **Data Transmission:** Real-time cloud upload
- **Alert Mode:** SMS / App Notification

### **5. Cloud & Data Handling**

- **IoT Platform:** ThingSpeak / Blynk / Firebase
- **Data Type:** Voltage, Current, Temperature, Oil Level
- **Update Interval:** 5–10 seconds
- **Data Storage:** Cloud database
- **Visualization:** Graphs and numeric display

### **6. Power Supply Specification**

- Input: 230 V AC
- Step-Down Transformer: 230 V / 12 V
- Rectifier: Bridge Rectifier
- Regulator: 7805 / Buck Converter
- Output: 5 V DC regulated

### **7. Software Specification**

- **Programming Language:** Embedded C / C++
-

- **IDE:** Arduino IDE
- **Operating System:** None (Bare-metal embedded)
- **Communication Protocol:** HTTP / MQTT

### **8. System Performance Parameters**

- Response Time: < 2 seconds
- Data Accuracy: > 95%
- System Availability: 24×7 operation
- Fault Detection: Real-time

### **9. Safety & Protection**

- Low-voltage electronics isolation
- Over-current protection via sensor limits
- Safe threshold-based alert system

### **10. Environmental Specification**

- Operating Temperature: 0°C to 50°C
- Humidity: Up to 90% (non-condensing)
- Suitable for outdoor transformer installation

### **11. Output Specification**

- Real-time transformer parameter display
- Alert message during abnormal condition
- Cloud-based historical data

### **12. Reliability & Maintainability**

- Continuous monitoring
- Easy sensor replacement

## **IV. CONCLUSION**

For real-time transformer health monitoring, the IoT-based Transformer Monitoring System offers a clever and effective solution. The system helps prevent significant failures, minimizes downtime, and enhances the overall reliability of the power distribution network by continually monitoring crucial parameters and sending timely alarms. This project is ideal for contemporary smart grid applications..

## **REFERENCES**

- Power System Protection and Switchgear textbooks
  - IoT and Embedded Systems reference materials
  - Research papers on smart transformer monitoring
-