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IOT Based Distribution Transformer Health Monitoring System

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Abstract – *Transformer is an important device in electrical field that used to transfer electricity from one circuit to another with changing the voltage level. The transformer will be having a problem such as increasing in temperature and make a lot of noise. Typical transformer measurement system will take time for testing and less accurate. The aim of this project is to design the IoT system for monitoring and evaluate the performance of the transformer current, sound and temperature. The Arduino microcontroller is used by the system to collect data and send it to a cloud-based server. A variety of sensors are used to gather vital indicators of transformer health, such as temperature, oil level, and current. A web-based interface is used to evaluate and visualize the gathered data, giving remote access to the transformer's status. In order to improve the longevity and dependability of power distribution networks, this Internet of Things (IoT)-based monitoring system provides an economical and effective means of proactive maintenance and early identification of any defects in distribution transformers*

1. INTRODUCTION

In power system, a distribution transformer is an electrical device that provides the final voltage transition in the electrical power distribution side that stepping down the voltage used in distribution lines to the voltage that will use by the consumers. A distribution transformer is a complex piece of equipment with a complex electromagnetic circuit inside of it. The selection of specific transformer auxiliaries, as well as the proper design of a magnetic circuit, structure and insulation system makes transformer more reliable equipment.

The key causes of a transformer's health degradation are problems such as overburdening and insufficient heating.

Gathering data from transformer is very important to monitor and control the entire of the transformer in efficiently and reliably. The health and safe operation of transformer in electrical distribution is important due to unexpected fault that will occur. Therefore, transformer health monitoring and accurate fault diagnosis are beneficial in reducing equipment harm economic loss and impacts on the reliability of electric power systems. The transformer monitoring for problem before may help avoid expensive repairs and a reduction in service life. This method allows to track the transformer's health on a regular basis and take the appropriate steps to ensure that it is properly maintained.

Wireless monitoring system by using Internet of Things (IoT) has been around for a while and mostly used in industry to track key performance from remote locations. It provides useful information about the health of the distribution transformer and will facilitate the services of the transformer and increase the lifetime of a transformer. The output data is stored in a database after processing so that the report can be viewed using mobile applications. As a result, an online measurement device is used to collect and analyse various types of data from sensors over time.

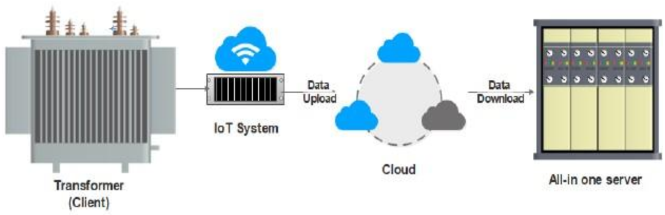

Figure 1. An overview of proposed system

Manual monitoring of transformer conditions, such as temperature rise, load current, oil level, and voltage, can be complex and lacks insights into critical issues like occasional overloads or overheating of the oil and temperature. To address this, an IoT-based system has been proposed. This system collects key operational data from transformers, helping utility companies optimize their performance and extend their lifespan.

By identifying problems early, the system prevents minor issues from escalating into major ones, ultimately enhancing transformer durability. It works by comparing real-time data with the transformer's rated values. If any monitored parameters exceed the acceptable limits, the Arduino in the system is programmed to take preventive measures. Additionally, it displays the collected data on a remote computer, making it easier to monitor and respond effectively.

2. PROPOSED SYSTEM

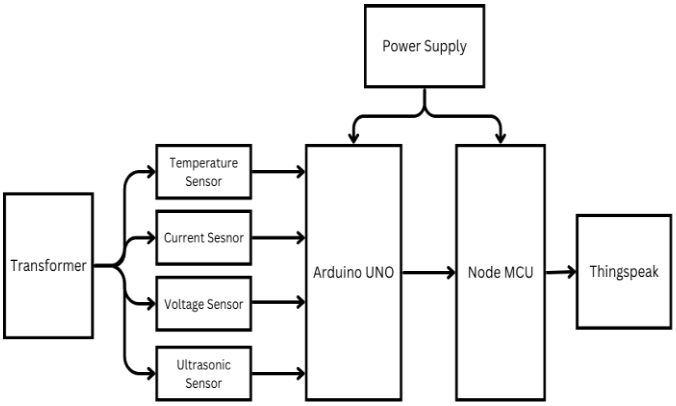

Figure 2. Block Diagram of the Proposed System

2.1 METHODOLOGY

2.1.1 Cloud Server

In this system, the ThingSpeak platform is utilized for data analytics and processing. ThingSpeak collects data from devices in the form of compact messages using the HTTP protocol over the Internet. It offers real-time visualization of the uploaded data, along with features like location tracking and integration with social media platforms. Additionally, ThingSpeak provides a MATLAB tool for advanced data analysis, either through the cloud or via a dedicated all-in-one server. In the proposed system, data is transmitted to ThingSpeak at intervals of 15 seconds, with a payload size of 3000 bytes per transmission.

2.1.2 Workflow of the Proposed System

Workflow of system is completed in following steps:

a) Collect sensor-based data
b) Deploy data to cloud and data visualization
c) Develop health index algorithm

2.2 WORKING

This technology is designed for online parameter monitoring of distribution transformers, enabling utilities to maximize the efficiency of their transformers and extend their operational lifespan. The system employs four key sensors: a temperature sensor, a voltage sensor, a current sensor, and a level sensor. These sensors are powered alongside the Arduino UNO and Wi-Fi modem using a dedicated power source. Data captured by the sensors is transmitted via the Wi-Fi module to the user at a specified IP address, as per the programmed configuration. The readings are also displayed on an LCD screen. By detecting anomalies or insecure data, the system allows for timely preventive actions to avoid transformer failures.

3. HARDWARE COMPONENTS

The project is designed to emit a reduced size and maximum efficiency. The components used are Arduino, temperature sensor, current sensor, voltage sensor circuit and Node MCU.

3.1 TEMPERATURE SENSOR-LM 35

Temperature sensor is used to sense the current temperature status of a transformer or generator. It has three pins as shown in fig 4. The output obtained from the temperature sensor is proportionally dependent on the temperature in degree Celsius sensed. The operating temperature ranges from -55^0 C to 150^0 C. It draws about 60 micro amperes from the supply and has reduced self-heating. It does not tend to possess a temperature rise more than 0.1 ^{0}C in still air. For every ^{0} C rise or fall in temperature the output response will be10mV variation. This LM35 operates from 4V to 30V. It has + 1 / 4^0 C of typical nonlinearity. Pin description is as shown in the table.1.

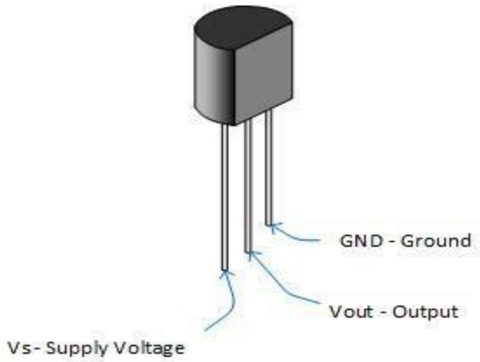

Figure 3. LM 35 Temperature Sensor

Table 1. Pin description of temperature sensor LM-35

Pin no	Pin name	Description
1	Vcc	Input supply voltage: +5V
2	Analog output Voltage	Usually, +6 V to -1 V.
3	Ground	Ground: 0V

3.2 CURRENT SENSOR

ACS712 current sensor produces an analog output voltage proportional to the current sensed by the terminals. The current sensor can operate from an voltage of 5V. Even high AC mains current can be measured. The sensors are based on the Allegro ACS712ELC chip. These sensors are available full scale reading of 5A, 20A and 30A. For a 30A sensor the output sensitivity s 66mV/A and it can measure a current from 30MA-to-30A range.

ACS712 consists of a low offset, precise linear Hall effect sensor circuit having a copper conduction path around the die surface. The hall effect circuit convert the electromagnetic field produced during current flow through the copper part to output voltage.

3.3 VOLTAGE SENSOR

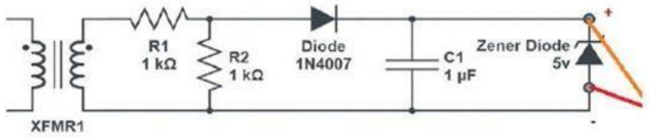

Figure 4. Voltage Measurement Circuit

It is a combination of IN4007 diode, a step-down transformer, variable resistor 47K Ω, capacitor 1microF 25V, 5V Zennor diode. Usually, 5V output is obtained during 250V. variable resistance is adjusted to get the output. AC Voltage = (230/1024) * ADC_ Value

3.4 ULTRASONIC SENSOR HC-SR04

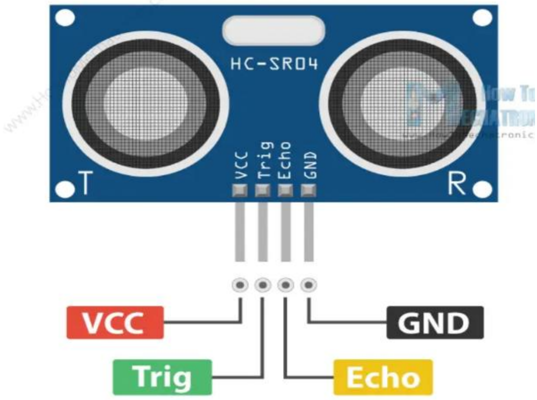

Figure 5. Ultrasonic Sensor HC-SR04

Ultrasonic sensors are based on the principle of sound waves, which are emitted by a transducer and then reflected when they encounter an obstacle. These reflected waves are then detected by the sensor and used to determine the distance and direction of the obstacle. The frequency range of ultrasonic sensors typically falls between 20 kHz and 200 kHz.

3.5 NODE MCU V3

Node MCU is an open source IoT platform. It includes firmware which runs on the ESP8266 Wi-Fi SoC from Espressif Systems, and hardware which is based on the ESP -12 module. This is a single board microcontroller. The operating system is XTOS. This is version 3 and it is based on ESP - 12E. Multiple GPIO pins on the board allow us to connect the board with other peripherals and are capable of generating PWM, I2C, SPI, and UART serial communications. USB to UART converter is added on the module that helps in converting USB data to UART data which mainly understands the language of serial communication. Instead of the regular USB port, MicroUSB port is included in the module that connects it with the computer for programming and powering up the board as shown in fig 5 . LED blinks giving the current status of the module if it is running properly when connected with the computer. The power voltage for USB be kept around 5 V. It has a memory of about 128kBytes. Storage is about 4Mbytes.

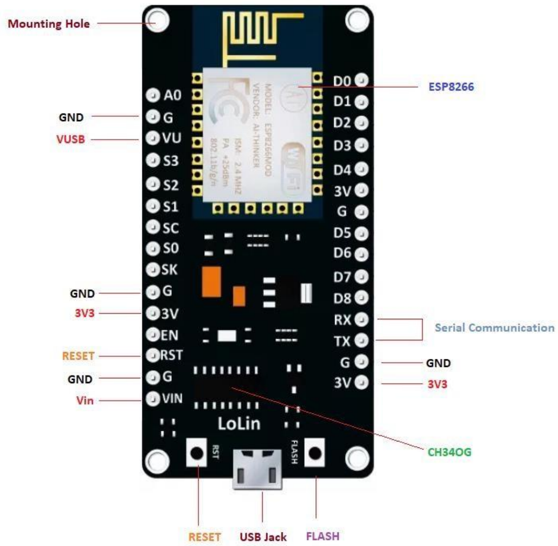

Figure 6. Node MCU v3

The Arduino nano and Node MCU exchange data through serial communication. The Node MCU will be treated as master and Arduino nano act as slave during this communication. Arduino acts according to the instructions given by Node MCU.

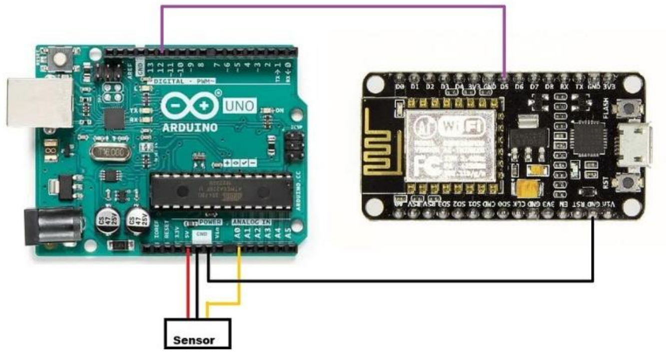

Figure 7. Interconnection of Arduino Nano and Node MCU

3.6 ARDUINIO UNO

Arduino UNO is a microcontroller board based on the **ATmega328P**. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header and a reset button.

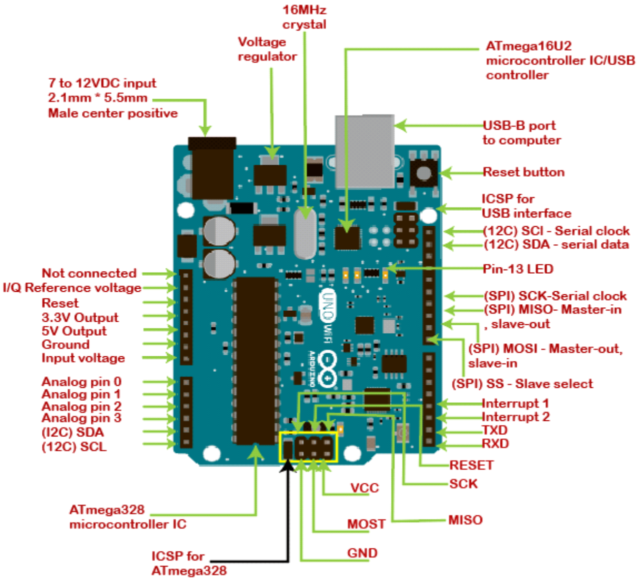

Figure 8. Arduino UNO

3.6.1 Specification of Arduino UNO

Category	**Specification**
Name	Arduino UNO R3
SKU	A000066
Microcontroller	ATmega328P
USB Connector	USB-B
Pins	
Built-in LED Pin	13
Digital I/O Pins	14
Analog Input Pins	6
PWM Pins	6
Communication	
UART	Yes
I2C	Yes
SPI	Yes
Power	
I/O Voltage	5V
Input Voltage (Nominal)	7-12V
DC Current per I/O Pin	20 mA
Power Supply Connector	Barrel Plug
Clock Speed	
Main Processor	ATmega328P 16 MHz
USB-Serial Processor	ATmega16U2 16 MHz
Memory	
ATmega328P	2KB SRAM, 32KB FLASH, 1KB EEPROM
Dimensions	
Weight	25 g
Width	53.4 mm
Length	68.6 mm

4. ADVANTAGES

- Easy to use
- Remote monitoring using IOT
- No men power required
- LCD for local monitoring
- Cost Effective
- Auto switch off
- Multi fault

5. LIMITATIONS

- Complex Hardware
- One system required for one transformer

6. FUTURE SCOPE

In further work, we may create a database with all of the distribution transformer's parameters, all of which are located in separate locations. By installing the suggested system modules at each transformer, we can obtain all the information. Both an Ethernet shield and a WiFi module can be used to transmit data. We may use an Ethernet shield to store data on a webpage or website and use a remote terminal device as a server. A WiFi module joins a neighbouring network and transmits data to a monitoring node.

7. CONCLUSION

The proposed system not only the increase the reliability and stability but also save the time of maintenance of the transformer, energy and also reduce the effort. With the help of the kit, we can not only monitor the transformer condition but also collect the data so that we can manufacture the transformer in such a way that fault condition can be reduced. Another advantage of the kit is that we can monitor the transformer condition from remote location also, so no need to visit the site on regular interval. If we increase the sensor the some more reading also collected form the transformer. By using this type of monitoring system, it increases the life of transformer.

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