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Arduino-based Internet of Things Distribution Transformer Health Monitoring System with Help of Nodemcu

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ABSTRACT
In order to monitor and analyze distribution transformer metrics in real time, this study suggests an Internet of Things (IoT) based Distribution Transformer Health Monitoring System that uses an Arduino board. 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.
Keywords – *IoT, Arduino, cloud, server, Nodemcu, etc.*

1. INTRODUCTION

The distribution transformer supplies electricity directly to low voltage customers. Therefore, a distribution network's transformer's state of operation is crucial. For the transformers to last a long time, they must be used in rated condition. Throughout the whole working day, this is not feasible. Transformers that are overloaded or have inadequate cooling may suddenly fail, disrupting the supply of electricity to a large number of users. Because incidental parameters cannot be accessible, manual checks of rising voltage, rising ambient temperature, rising load current, etc., tend to be more complicated.

Sensors and actuators are used in the Internet of Things to facilitate interaction between the physical and digital realms. To perceive the specific environment or physical properties, a sensor or network of sensors is employed. Then, with the aid of several network devices, these processed sensor outputs are sent to the primary server or cloud. Anywhere in the globe with an internet connection may access the data. The primary goals of Internet of Things technology are monitoring and regulating. Therefore, it is preferable to use IoT-based monitoring than human monitoring. The transformer characteristics, including voltage, current, and temperature, are monitored in real time by the system. This will assist in locating the issues before a significant breakdown happens.

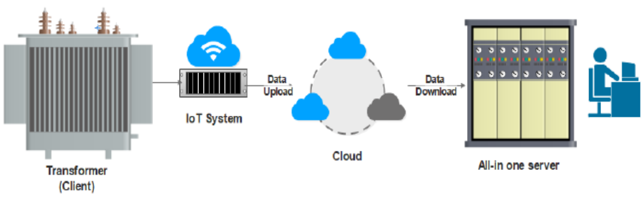

Figure 1. An overview of proposed system

The manual inspection of temperature rise, load current, oil level, voltage rise, etc., is usually more intricate. Information on sporadic overloads and transformer oil and temperature overheating is not available from this manual monitoring. The suggested system, which is based on IOT, gathers crucial transformer operating parameters. This would assist utilities in making the best use of their transformers and prolonging the asset's useful life. Thus, by spotting issues before they become serious, the system prolongs the life of transformers. The rated values of the transformer are compared to the monitored parameters, and if the monitored values are higher than the rated values, the Arduino is configured to take preventative action in addition to displaying the monitored values on a remote PC.

2. PROPOSED SYSTEM

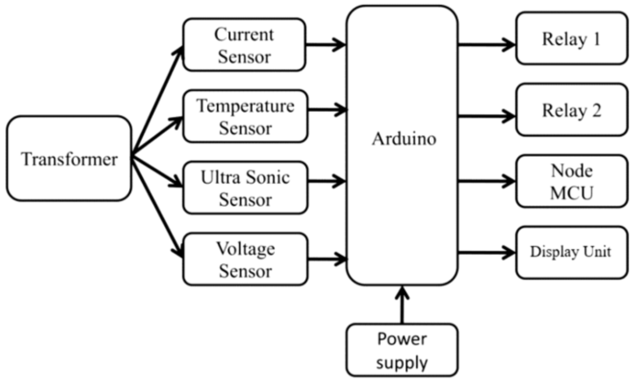

Figure 2. Block Diagram of the Proposed System

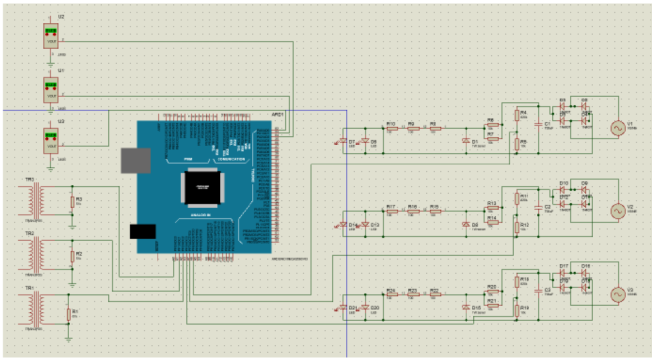

Figure 3. Circuit Diagram of the Proposed System

2.1 Methodology

2.1.1 Cloud Server

In this system, ThingSpeak platform is used for data analytics and processing. ThingSpeak retrieve data from things in the form of small messages through HTTP protocol over Internet. ThingSpeak provide an instant visualization of data uploaded, location tracking and a link with social network. ThingSpeak also provides a MATLAB tool for data processing either over cloud or in our all-in one data server. Proposed system sends data to ThingSpeak at a rate of 3000 bytes per 15 seconds.

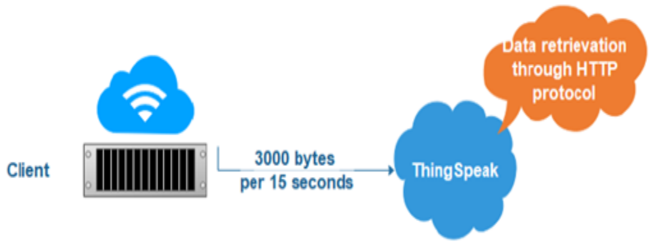

Figure 4. ThingSpeak cloud server

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

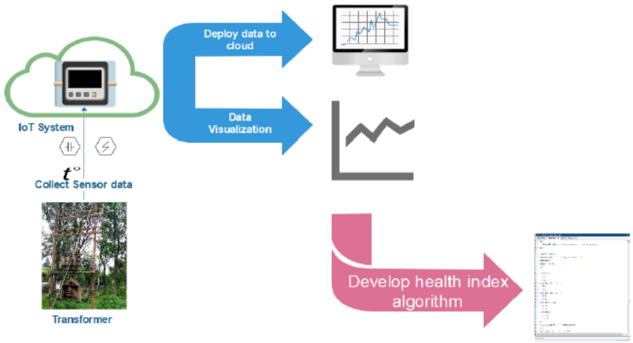

Figure 5. workflow of system

2.2 WORKING

The utilities will be able to make the most use of their transformers and extend the asset's lifespan with the aid of this technology, which is intended for online parameter monitoring of distribution transformers. Four sensors were employed in this system: a temperature sensor, a voltage sensor, a current sensor, and a level sensor. To run the WiFi modem and Arduino UNO, we utilized a power source. Every module's connection is depicted in the above image. The Wi-Fi module transmits the data to the user on the specified IP address in accordance with the program while the sensor senses the data and displays it on the LCD display. If we obtain insecure data, we can prevent system failure.

3. HARDWARE COMPONENTS

The project's goal is to produce the most efficiency at a smaller size. Arduino, temperature sensor, current sensor, voltage sensor circuit, and Node MCU are the parts that are utilized.

3.1 TEMPERATURE SENSOR- LM 35

A transformer current temperature can be detected with a temperature sensor. In following, three pins are visible. The temperature in degrees Celsius that is measured determines how much of an output the temperature sensor produces. The temperature range for operation is -550 to 1500 degrees Celsius. Its self-heating has decreased and it uses around 60 micro-amperes from the supply. In steady air, its temperature seldom rises by more than 0.1 0C. The output response will vary by 10 mV for each 0 C rise or dip in temperature. Operationally, this LM35 is 4V to 30V. Its normal nonlinearity is + 1 / 40 C.

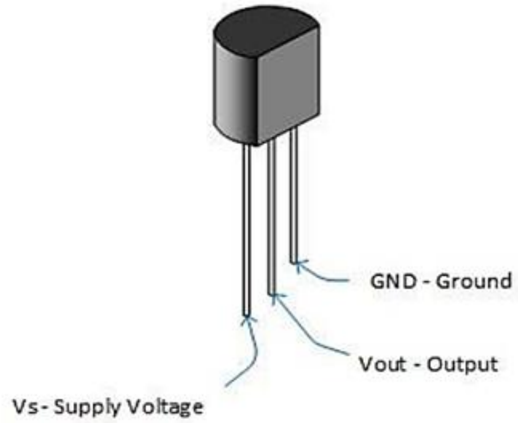

Figure 6. LM 35 temperature sensor

Pin Number	Pin Name	Description
1	Vcc	Input voltage is +5V for typical applications
2	Analog Out	There will be increase in 10mV for raise of every 1°C. Can range from -1V(-55°C) to 6V(150°C)
3	Ground	Connected to ground of circuit

Table 1. LM 35 temperature sensor Pin Description
LM35 Sensor Features

- Minimum and Maximum Input Voltage is 35V and -2V respectively. Typically 5V.
- Can measure temperature ranging from -55°C to 150°C
- Output voltage is directly proportional (Linear) to temperature (i.e.) there will be a rise of 10mV (0.01V) for every 1°C rise in temperature.
- ±0.5°C Accuracy
- Drain current is less than 60uA
- Low cost temperature sensor
- Small and hence suitable for remote applications
- Available in TO-92, TO-220, TO-CAN and SOIC package

3.2 CURRENT SENSOR ACS 712

An analog output voltage proportionate to the current measured by the terminals is produced by the ACS712 current sensor. A voltage of 5V may power the current sensor. It is possible to monitor even high AC mains current. The Allegro ACS712ELC chip serves as the basis for the sensors. There are full scale readings of 5A, 20A, and 30A available for these sensors. The output sensitivity of a 30A sensor is 66mV/A, and its current measurement range is 30mA to - 30A.
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 CIRCUIT

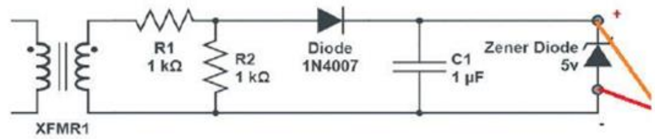

Figure 7. Voltage measurement circuit

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 NODE MCU V3

An open source IoT platform is called Node MCU. It consists of hardware built around the ESP-12 module and firmware running on Espress if Systems' ESP8266 Wi-Fi SoC. This microcontroller is a single board device. XTOS is the operating system. It is based on ESP-12E and is version 3. The board has several GPIO pins that enable us to interface it with other peripherals and generate serial communications such as PWM, I2C, SPI, and UART. The module has a USB to UART converter that aids in translating USB data to UART data, which primarily speaks the serial communication language.
As seen in the image, the module that connects it to the computer for programming and powering up the board has a MicroUSB connector in place of a standard USB port. When the module is linked to the computer and

operating correctly, an LED blinks to indicate its present state. Maintain the USB power voltage at around 5 V. Its memory is around 128k bytes. Four megabytes or so is storage. The arduino and Node MCU exchange data through serial communication. The Node MCU will be treated as master and arduino act as slave during this communication. Arduino acts according to the instructions given by Node MCU.

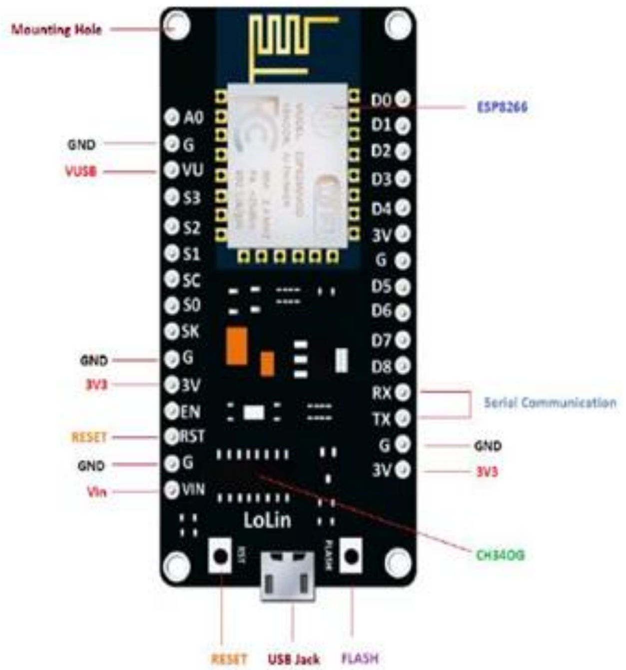

Figure 8. Node MCU v3

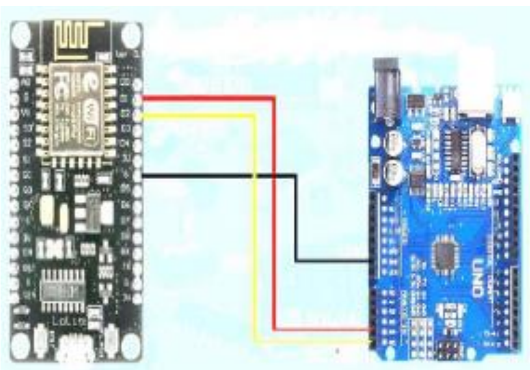

Figure 9. Interconnection of arduino nano and Node MCU

3.5 ARDUINO UNO

The open-source electronics platform Arduino is built on user-friendly hardware and software. Arduino boards have the ability to take inputs, such as a light from a sensor, a finger pressing a button, or a message from Twitter, and convert them into outputs, such as starting a motor, turning on an LED, or posting content to the internet. By giving the board's microcontroller a set of instructions, a message may be delivered telling it what to do. The Arduino Software (IDE) and the Arduino programming language are utilized to do this.

Arduino has been the brains behind hundreds of projects over the years, ranging from simple household items to sophisticated scientific equipment. At the Ivrea Interaction Design Institute, Arduino was created as a simple tool for quick prototyping that was intended for students without any prior experience with electronics or programming.

The Arduino board began to evolve as soon as it became widely available, moving from basic 8-bit boards to devices for wearables, 3D printing, embedded environments, and Internet of Things applications. This was done to meet new demands and overcome obstacles.

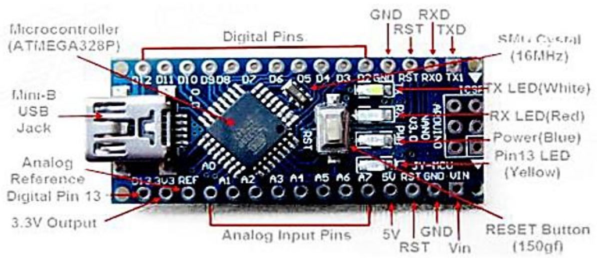

Figure 10. Arduino UNO

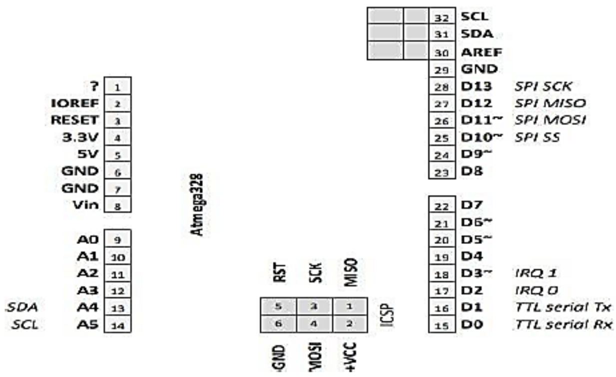

Figure 11. Layout of Arduino UNO

3.5.1 FEATURES OF ARDUINO

- Microcontroller ATmega328.
- Operating Voltage 5V.
- Input Voltage (recommended) 7-12V.
- Input Voltage (limits)

- Digital I/O Pins 14 (of which 6 provide PWM output)
- Analog Input Pins 6.
- DC Current per I/O Pin 40 mA.
- DC Current for 3.3V Pin 50 mA.
- Protocol : USART, SPI & I2C.
- Low Power Consumption 0.3mA/MHz
- Operating Frequency : 20 MHz

4. ADVANTAGES

- **Real-time monitoring:** Makes it possible to track distribution transformer characteristics continuously and instantly.
- **Remote access:** Enables transformer health monitoring and analysis from any location with an internet connection.
- **Economical:** The distribution transformer health may be monitored at a reasonable cost by utilizing the Arduino microcontroller and Internet of Things technologies.
- **Proactive maintenance:** By decreasing downtime and expensive repairs, early identification of anomalies and defects in transformers aids in proactive maintenance.
- **Data analysis:** Based on the gathered data, offers insightful analysis and trends for predictive maintenance and peak performance.

5. LIMITATIONS

- **Unrestricted sensor capabilities:** Certain metrics or fluctuations in transformer health may not be detected by all monitoring sensors.
- **Problems with connectivity:** Relying on the internet to transmit data may cause hiccups or delays in the monitoring process.
- **Security concerns:** Sensitive transformer health data transfer and storage on cloud servers may give rise to data privacy and security problems.
- **Maintenance and calibration:** To guarantee reliable data collection and analysis, regular maintenance and calibration of the sensors as well as the monitoring system itself are necessary.

6. APPLICATION

- **Power distribution networks:** The system may be used to monitor distribution transformer performance and health in real-time within power distribution networks. It contributes to improved network dependability and continuous power delivery.
- **Industrial plants:** By using this approach, industrial facilities that primarily rely on transformers for power distribution may guarantee the smooth operation of their equipment and avoid unplanned downtime brought on by malfunctioning or failing transformers.
- **Smart grids:** By integrating the monitoring system with smart grid technologies, power distribution may be made more reliable and efficient, demand response can be enabled, and energy management can be optimized.
- **Utilities and energy firms:** By using this technology, utilities and energy companies may proactively monitor the condition of distribution transformers, allowing for prompt repair and a reduction in service interruptions.
- **Remote locations:** This system allows for the remote monitoring of distribution transformers situated in difficult areas, such as rural or isolated regions. This eliminates the need for on-site inspections and facilitates the prompt identification and reaction to faults.
- **Renewable energy systems:** This monitoring system can assist maximize the efficiency and dependability of the system in renewable energy systems, where transformers are essential for the conversion and distribution of electricity.

7. CONCLUSION

The suggested method's outcomes demonstrate that the protection strategy operates accurately and with good sensitivity to anomalous and defective situations. Transformer Health Monitoring will assist in seeing or recognizing unforeseen circumstances prior to any major breakdown, resulting in increased dependability and substantial cost savings. We can determine whether a transformer is abnormal from anywhere. The transformer does not require human oversight. When a transformer is in an abnormal condition, the cloud automatically updates with new information about the transformer.

8. 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 neighboring network and transmits data to a monitoring node.

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