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Remote Fault Monitoring of Substation Primary Equipment Using Embedded Technology

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Abstract: *We know that due to huge demand of electricity the size and complexity of distribution network has grown & because of that automation of substation becomes very important to increase its efficiency as well as to improve the quality of power being delivered at users end. So, our prototype will monitor the real time parameters like voltage, temperature, current, power of substation with Micro-controller unit & if any faults occur in distribution transformer it will gives indication during fault condition and immediately relay operates. The data of measured parameters will be available on smartphone/ desktop. This allows us to save time and money at the substation by reducing labour cost. Also, the functioning effectiveness, efficiency and power quality will undoubtedly improve with this approach.*

Keywords: Substation, Automation, Micro-controller, Embedded Technology, Monitoring, Relay.

I. Introduction

Electricity is very much convenient and one of the most useful form of energy. It plays a very important as well as major role in our todays modern industrialized & automated society. These systems are typically enormous, very non-linear, and have incredibly complicated networks. These electric power systems are combined for cost savings, operational efficiency, and greater reliability.

These systems are a vital part of both national and global infrastructure and communities. When these systems fail, it has serious direct and indirect consequences for the economy and national security. Transmission lines, transformers, generators, loads, switchgear devices, and various compensators are all part of these systems. Modern power systems are frequently configured with widely spread power sources and loads. Even today, because of a lack of automation in the system, poor analysis electricity suffers from power outages and blackouts. [3]

With the help of different sensors, it will allow us collecting all the data from the different sub-systems of the grid.[1][2] According to the user sensor node will decide its work to send information or to slightly delay its notification. As a result, we can implement automation in the substation with the help of various sensors and controllers in order to maximize power efficiency and improve the power quality.

II. System Architecture

2.1 Block Diagram

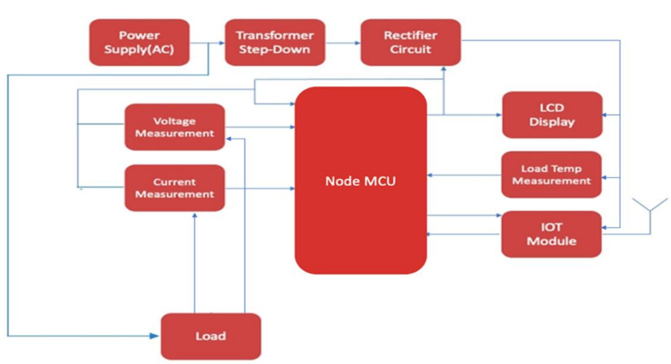

Figure 1: Block Diagram of proposed system

2.2. Algorithm

Our goal is to protect unknown parameters such as voltage and current, as well as physical parameters such as temperature and to transmit these real-time data of different parameters via IOT-based monitoring system with the present temperature at the power plant. This system is also designed to protect the electrical hardware by activating a Relay. When the electrical parameters (Voltage, Current) and physical parameters (Temperature) cross the predefined values, this Relay is activated. The Relay can also be used to activate a Circuit Breaker, which will switch off the main electrical supply. [4] The client can utilise IOT to submit commands to examine remote electrical parameters.

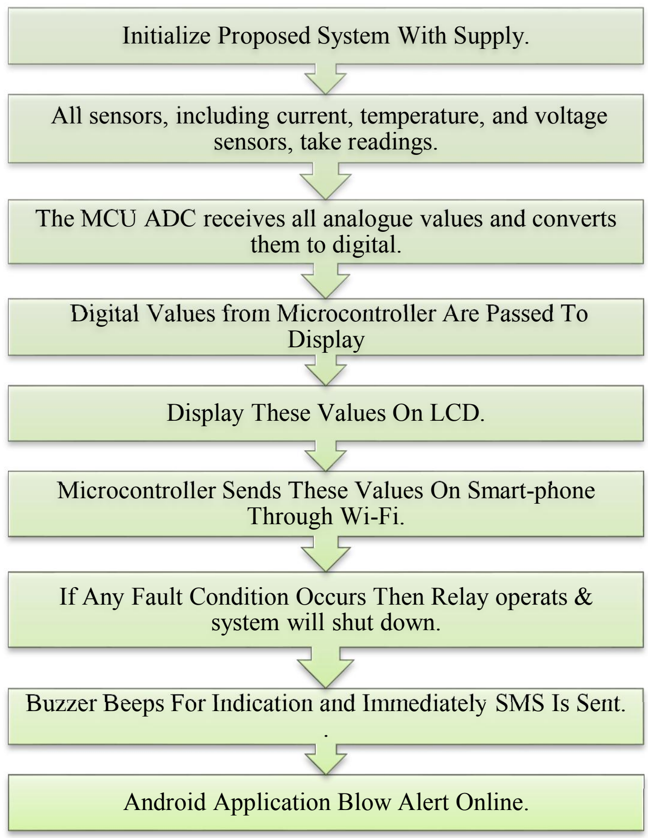

Figure 2: Algorithm

2.3 Procedure (Steps)

1. Implementation of "IOT" in Hardware:
   The Node Micro Controller Unit has ESP8266 which includes a RAM, CPU, Wi-Fi connectivity for networking, and even a current operating system and SDK.
2. Implementation of "Android Application" on Smartphone
3. Interfacing of Android Application with Microcontroller to Monitoring Parameters of Substation through Smartphone
4. Implementation of "Automatic Fault Alarm System.
   - **a.** Buzzer System: In Buzzer System a Buzzer is connected to the microcontroller, when the substation parameters crossed its rated values then relay operates and buzzer will be turned on which indicates fault condition & works as physical alarm system.
   - **b.** Direct Messaging System: In case of Direct messaging system If any emergency/fault condition occurs then immediately alert SMS is sent to smartphone present over there

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III. Hardware Implementation

3.1 Circuit Diagram

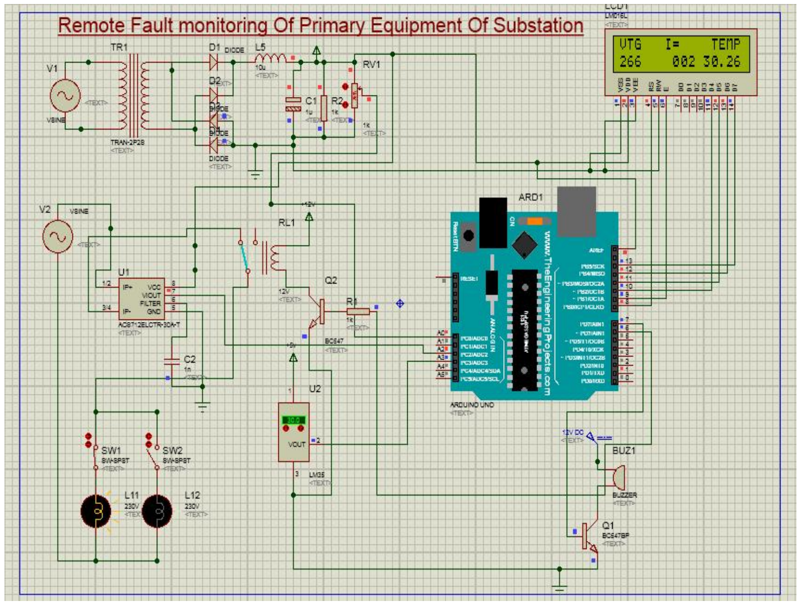

Figure 3: Circuit Diagram

3.2 Components Required

Our Component Part is Mainly Divided into total 5 parts as follows,

1. Primary Microcontroller (Node MCU) Unit
2. Power Supply and its Processing Unit
3. Current Measurement (ACS712) Unit
4. Relay Unit (5V Avr low trigger)
5. Display unit (I2C LCD)

A. Primary Microcontroller Unit

Node MCU:

The Node MCU (Node Micro Controller Unit) has ESP8266 which is System-on-a-Chip (SoC). It is an inexpensive open source software as well as hardware development environment. Espressif Systems invented and manufactured the ESP8266, which includes all of the essential components of a modern computer. Which includes a RAM, CPU, Wi-Fi connectivity for networking, and even a current operating system and software development kit. The ESP8266 is only Rs 399 per piece so it's a great fit for IoT projects.

Figure 4: Mode MCU

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B. Power Supply Processing Unit

It has one 230V to 12V step-down transformer, a bridge rectifier (consisting of four diodes of 1N4007 as rectification unit, one Voltage Regulator (IC7805), and two Film Capacitors of 0.1 Microfarad).

This converts a single phase 230 V, 50Hz AC supply to 12 V, 50Hz AC supply, which is then delivered to a bridge rectifier, this rectification unit converts it to pulsing 12 Volt DC. As a result, we send it through the filter circuit, which includes a 470 micro farad capacitor that converts the pulsing DC to a smooth DC supply. Many components, including the primary micro farad require 5V DC, therefore we passed this 12 V smooth DC to the IC7805 voltage regulator, which subsequently converted the 12V DC to 5V DC.

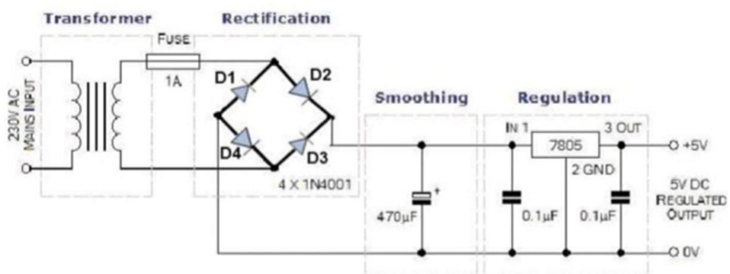

Figure 5: Power Supply Processing Unit

C. Current Measurement Unit

ACS712 Current Sensor

The ACS712 measures current and delivers cost-effective and precise AC and DC current sensing solutions. The popular ACS712 integrated circuit is used for the measurement. The Hall Effect theory is used to measure current. For wire passage, the ACS712 module has two phoenix terminal connectors with mounting screws. There are three pins as well. The first is Vcc which is connected to the +5 V supply and the second is ground, which is connected to the µC's ground connection. The third signal is analogue voltage, which is generated by the ACS712 module and accessed using any analogue pin on the controller.

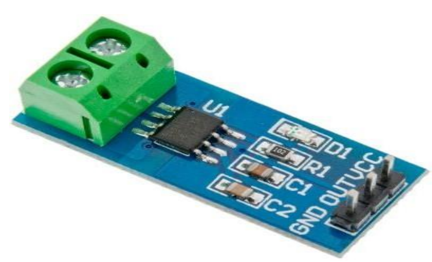

Figure 6: ACS712 Current Sensor

D. Relay Unit

The Relay Module is a channel relay interface board with a screw terminal that can be operated easily and directly by a variety of microcontrollers, including Arduino, AVR, PIC, ARM, and others. It contains a high-quality relay that can easily manage a maximum current of 15 amps at 125 volts and 10 amps at 250 volts. Relay has three connections – 1. Common - C, 2. Normally 3. Open-NO, Normally Closed which is NC brought out to 3 pin terminals which makes connection very easy to do and remove. The module has a power indication LED and a relay status LED for debugging. Relay control and Power input signals are brought to header pins on the board. Which makes the board easy to interface with the development boards using jumper wires.

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Figure 7: Relay

E. Display Unit

An LCD has a liquid crystal which is used to produce a visible image. It is an electronic display module which use 6×2 which means 16 characters in each line in 2 such kind of lines. In this display device each letter will be displayed in a pixel of 5×7 matrix.

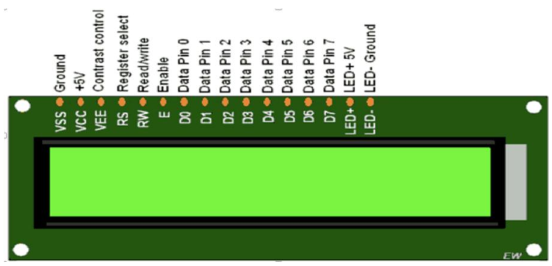

Figure 8: L2C LCD Display

IV. Hardware Prototype

The hardware prototype is implemented as referring the circuit diagram. Fig. 3 shows hardware prototype system. The final results of project are described here. However, the main focus is on monitoring the parameters of substation.

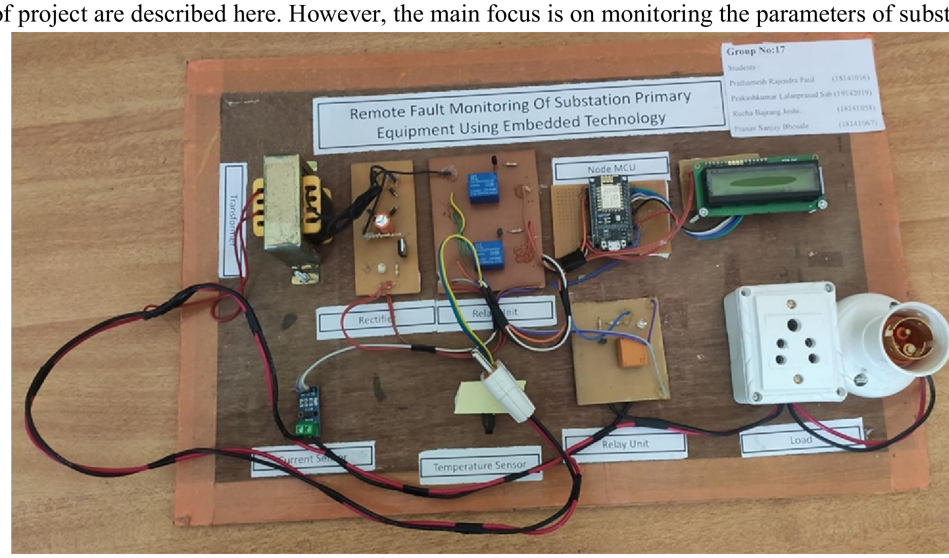

Figure 9: Hardware prototype

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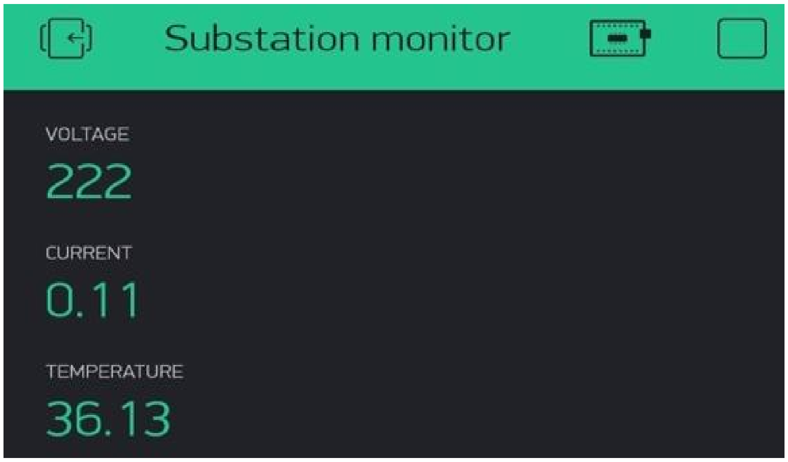

Figure 10: Parameters obtained on smart-phone

V. Results & Discussion:

Sr. No	Voltage (V)	Current (A)	Temperature (^{0}C)	Fault
1)	233	3.05	33	No Fault
2)	239	6.2	34.5	Over Current
3)	235	1.02	36	Under Current
4)	315	3.5	34	Over Voltage
5)	174	3.9	34.8	Under Voltage
6)	233	3.8	74	High Temp

Table 1: Results

Above table shows the values of voltage, current and temperature that are obtained through hardware. We have set a range of 2A to 5A for current, 180V to 280V for voltage and 650 C for temperature. If any of the measured parameter not fall in their range of limit then fault will be detected. At that time relay gets operated & message containing fault type and values of all measured parameters is send to user.

5.1 Advantages

1. Helpful for Fault Management
2. Reduced hazards
3. Real time monitoring
4. Remote Access
5. Error free data
6. Personalized alert over fault

VI. Conclusion

This proposed system is created and built specifically for monitoring the real-time condition of substation transformers located in various locations. The obtained data can be used to analyse the transformer's status and to plan or schedule maintenance to control the system by reducing direct contact between humans and high-voltage equipment. Monitoring multiple metrics by appointing a person at various locations is very expensive and laborious, and the data produced will also contain errors if the monitoring is done manually. When data is collected manually, the biggest challenge is having all of the transformers' data in one place. All of the concerns mentioned above can be mitigated to some extent by our project.

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