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Smart Substation Management

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Abstract: *A smart substation management system is an advanced system that utilizes modern technologies such as sensors, node mcu, communication networks, and intelligent algorithms to monitor, control and optimize the operation of power substations. A substation is a critical component of the power grid that transforms high voltage electricity from power plants into lower voltage electricity that can be distributed to homes and businesses. A smart substation management system can enhance the reliability, efficiency, and safety of the power grid.*

Keywords: node mcu. substation, sensor, smart

I. INTRODUCTION

The purpose of a substation is to ‘step down’ high voltage electricity from the transmission system to lower voltage electricity so it can be easily supplied to homes and businesses through our distribution lines. ENMAX Power Corporation operates 40 high voltage electrical substations and three lower voltage distribution substations, located in all parts of Calgary and our surrounding service area. Managing the environmental aspects of our substations is an important part of environmental stewardship at ENMAX Power. As the City of Calgary continues to grow, so does the need for electricity. As a result, ENMAX Power is proposing to build and operate new substations in Calgary. A substation consists of high voltage electrical equipment such as transformers, switch gear, and circuit breakers. The purpose of a substation is to 'step down' high voltage electricity from the transmission system to lower voltage electricity so it can be easily supplied to homes and businesses in the area through lower voltage distribution lines

Fig 1.1: substation

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1.1 What Is Substation Automation?

A substation automation system is a collection of hardware and software components that are used to monitor and control an electrical system, both locally and remotely. A substation automation system also automates some repetitive, tedious and error-prone activities to increase the overall efficiency and productivity of the system.

High availability and constant operation of an electrical substation has always been the focus of an electrical company. More faults mean more interruption of service to clients and it translates to less revenue that is not desirable to any company. From the early age of electrical systems, engineers and operators have always been interested in collecting useful information on different devices in a substation so they can better evaluate the health of their system, predict potential problems and – in case of a fault – to analyze and troubleshoot the problem as soon as possible to protect their high values assets and to improve their continuous service to their clients

Early substations consisted of mechanical relays and meters that barely supported recording and had no means of communication. Fault recorders were capturing information mainly in the form of paper charts, so reading and analyzing the information was not a straightforward process.

Lack of communication caused any maintenance or troubleshooting to be costly and lengthy because personnel had to be sent to substations that were often far away and hard to reach.

Fig 1.2: step down outdoor substation

With the introduction of microprocessor technology, digital protection and control devices became more intelligent. New intelligent electronic devices (IEDs) can collect and record information on many different parameters of a system, process them based on complex logic in a fraction of a second and make decisions on abnormal situations to send control commands to switches and breakers to clear the fault.

In addition to their superior processing capability, modern substation devices can also hold information in their internal storage for a certain period and transfer this information to third-party applications for further study and analysis. IEDs can now send information to a local or remote user via different types of communication. This gives operators more flexibility on how and when to process the information to provide a fast recovery time from an interruption in the substation.

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With more information remotely available, new supervisory systems were developed to facilitate the task of a system administrator in the control center. A Supervisory Control and Data Acquisition (SCADA) system can collect information from various IEDs in an electrical system via different methods of communication and then control and monitor them using various visualizing technologies – even automating the supervision task based on predefined parameters and algorithms.

A Human Machine Interface (HMI) is deployed in each substation to provide operators with the local control and monitoring capabilities that are often necessary during the configuration, commissioning or maintenance of the substation.

1.2 Objective

A smart substation management system is an advanced system that utilizes modern technologies such as sensors, communication networks, and intelligent algorithms to monitor, control and optimize the operation of power substations. A substation is a critical component of the power grid that transforms high voltage electricity from power plants into lower voltage electricity that can be distributed to homes and businesses. A smart substation management system can enhance the reliability, efficiency, and safety of the power grid. Here are some key features and benefits of a smart substation management system:

1. Monitoring and control: The system can monitor various parameters such as voltage, current, temperature, and humidity in real-time and provide operators with timely information to detect and address any issues.
2. Staff Attendance : The system can monitor and maintain staff attendance records. While will help the admin for payment structures.
3. Security: The system can enhance the security of the substation by detecting and responding to security threats such as cyber-attacks and physical intrusions.
4. Complaints :- The system can increase the complaints resolution speed by tracking and tracing each ticket individually.

Overall, a smart substation management system can provide utilities with a comprehensive solution to manage their substation assets efficiently and effectively.

1.3 Motivation

The motivation behind developing a substation management system using NodeMCU is to improve the efficiency, reliability, and safety of electrical substations. Electrical substations are critical infrastructure components that play a vital role in delivering electricity from power generation sources to end-users. However, these substations are often located in remote areas and are difficult to access, making it challenging to monitor and manage them effectively. Traditionally, substation monitoring and management have been carried out manually or through dedicated monitoring systems, which can be expensive and require specialized equipment and personnel. Moreover, manual monitoring and management can be prone to errors and may not be able to detect issues in real-time. By using NodeMCU-based systems for substation monitoring and management, it is possible to collect real-time data on various parameters such as voltage, current, temperature, and humidity, which can help in identifying issues before they become major problems. The use of cloud-based systems and web servers for data storage and visualization can enable remote access to the data, allowing for quick and informed decision-making. Additionally, these systems can be cost-effective and scalable, making them accessible to smaller utilities and substations. Overall, the motivation behind developing a substation management system using NodeMCU is to enhance the safety, reliability, and efficiency of electrical substations while reducing costs and improving accessibility.

II. LITERATURE SURVEY

A literature survey on substation management systems using NodeMCU reveals that the use of NodeMCU is gaining popularity in the field of electrical engineering due to its low cost, small form factor, and WiFi capabilities. One of the earliest studies in this field was conducted by N. N. Liu et al. (2017) who proposed a smart substation monitoring system based on NodeMCU, which was used to monitor voltage, current, and temperature in real-time. They used a cloud-based system for data analysis and visualization. Another study by S. S. Rathore et al. (2018) developed a

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substation monitoring system using NodeMCU and ESP8266 which monitored the power parameters such as voltage, current, and power factor. They used MQTT protocol for data transfer and a web server to display the data. A study by A. Kumar et al. (2019) proposed a substation monitoring system using NodeMCU and ESP32 which monitored power parameters, temperature, and humidity. They used Firebase for real-time data storage and visualization. A study by S. S. Priyadarshini et al. (2020) developed a substation monitoring system using NodeMCU, which monitored various parameters such as voltage, current, frequency, and power factor. They used Thing speak for data storage and a web server for data visualization. Another study by S. S. Sahu et al. (2021) proposed a substation monitoring system using NodeMCU and ESP32 which monitored voltage, current, frequency, and power factor. They used a cloud-based system for data storage and visualization. Overall, these studies demonstrate the potential of using NodeMCU-based systems for substation monitoring and management. They offer a cost-effective and scalable solution for real-time monitoring and data analysis, which can help in improving the efficiency and reliability of electrical substations. However, further research is needed to address issues such as security, reliability, and scalability in these systems.

III. MAIN EQUIPMENT RELATED TO PROJECT

3.1 NODE MCU ESP8266

NodeMCU is an open-source Lua based firmware and development board specially targeted for IoT based Applications. It includes firmware that runs on the ESP8266 Wi-Fi SoC from Espressif Systems, and hardware which is based on the ESP-12 module.

The NodeMCU ESP8266 development board comes with the ESP-12E module containing ESP8266 chip having Tensilica Xtensa 32-bit LX106 RISC microprocessor. This microprocessor supports RTOS and operates at 80MHz to 160 MHz adjustable clock frequency. NodeMCU has 128 KB RAM and 4MB of Flash memory to store data and programs. Its high processing power with in-built Wi-Fi / Bluetooth and Deep Sleep Operating features make it ideal for IoT projects.

The NodeMCU Development Board can be easily programmed with Arduino IDE since it is easy to use. NodeMCU can be powered using Micro USB jack and VIN pin (External Supply Pin). It supports UART, SPI, and I2C interface.

Applications of Node MCU

- Prototyping of IoT devices
- Low power battery operated applications
- Network projects
- Projects requiring multiple I/O interfaces with Wi-Fi and Bluetooth functionalities

ESP8266 NodeMCU Pinout

The ESP8266 NodeMCU has total 30 pins that interface it to the outside world. The connections are as follows:

For the sake of simplicity, we had make groups of pins with similar functionalities.

Power Pins There are four power pins viz. one VIN pin & three 3.3V pins. The VIN pin can be used to directly supply the ESP8266 and its peripherals, if you have a regulated 5V voltage source. The 3.3V pins are the output of an on-board voltage regulator. These pins can be used to supply power to external components.

GND is a ground pin of ESP8266 NodeMCU development board.

I2C Pins are used to hook up all sorts of I2C sensors and peripherals in your project. Both I2C Master and I2C Slave are supported. I2C interface functionality can be realized programmatically, and the clock frequency is 100 kHz at a maximum. It should be noted that I2C clock frequency should be higher than the slowest clock frequency of the slave device.

GPIO Pins ESP8266 NodeMCU has 17 GPIO pins which can be assigned to various functions such as I2C, I2S, UART, PWM, IR Remote Control, LED Light and Button programmatically. Each digital enabled GPIO can be configured to internal pull-up or pull-down, or set to high impedance. When configured as an input, it can also be set to edge-trigger or level-trigger to generate CPU interrupts.

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ADC Channel The NodeMCU is embedded with a 10-bit precision SAR ADC. The two functions can be implemented using ADC viz. Testing power supply voltage of VDD3P3 pin and testing input voltage of TOUT pin. However, they cannot be implemented at the same time.

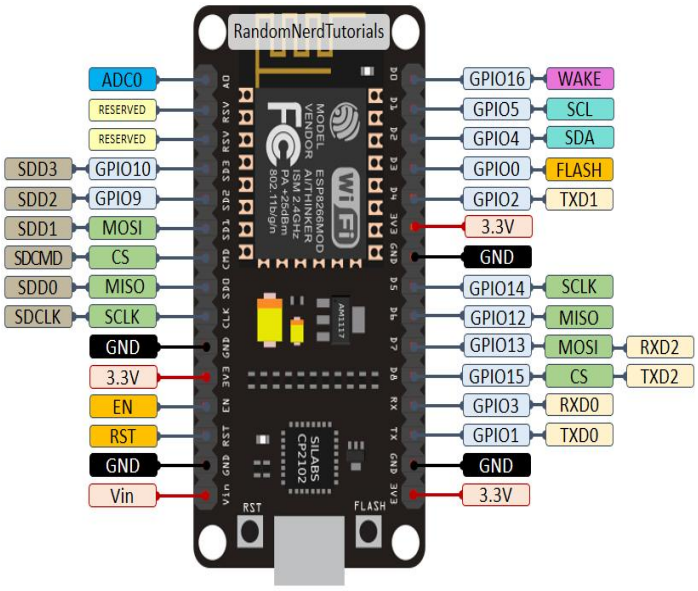

Fig. 3.1: Pinout of Node MCU ESP8266

UART Pins ESP8266 NodeMCU has 2 UART interfaces, i.e. UART0 and UART1, which provide asynchronous communication (RS232 and RS485), and can communicate at up to 4.5 Mbps. UART0 (TXD0, RXD0, RST0 & CTS0 pins) can be used for communication. It supports fluid control. However, UART1 (TXD1 pin) features only data transmit signal so, it is usually used for printing log.

SPI Pins ESP8266 features two SPIs (SPI and HSPI) in slave and master modes. These SPIs also support the following general-purpose SPI features:

- 4 timing modes of the SPI format transfer
- Up to 80 MHz and the divided clocks of 80 MHz
- Up to 64-Byte FIFO

SDIO Pins ESP8266 features Secure Digital Input/Output Interface (SDIO) which is used to directly interface SD cards. 4-bit 25 MHz SDIO v1.1 and 4-bit 50 MHz SDIO v2.0 are supported.

PWM Pins The board has 4 channels of Pulse Width Modulation (PWM). The PWM output can be implemented programmatically and used for driving digital motors and LEDs. PWM frequency range is adjustable from 1000 µs to 10000 µs, i.e., between 100 Hz and 1 kHz.

Control Pins are used to control ESP8266. These pins include Chip Enable pin (EN), Reset pin (RST) and WAKE pin.

EN pin – The ESP8266 chip is enabled when EN pin is pulled HIGH. When pulled LOW the chip works at minimum power.

RST pin – RST pin is used to reset the ESP8266 chip.

WAKE pin – Wake pin is used to wake the chip from deep-sleep.

ESP8266 Development Platforms

There are a variety of development platforms that can be equipped to program the ESP8266. You can go with Espruino – JavaScript SDK and firmware closely emulating Node.js, or use Mongoose OS – An operating system for IoT devices (recommended platform by Espressif Systems and Google Cloud IoT) or use a software development kit (SDK) provided by Espressif or one of the platforms listed on WiKiPedia.

Fortunately, the amazing ESP8266 community took the IDE selection a step further by creating an Arduino add-on.

This ESP8266 add-on for Arduino is based on the amazing work by Ivan Grokhotkov and the rest of the ESP8266 community.

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3.2 Relay 5V

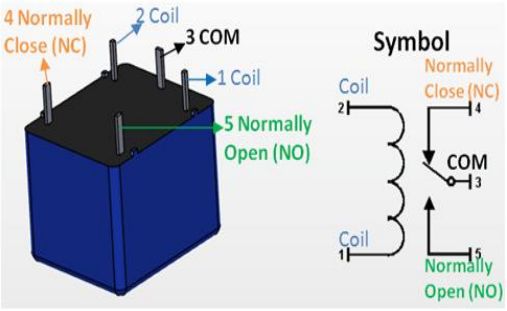

Fig 3.2.1: relay circuit diagram and symbol

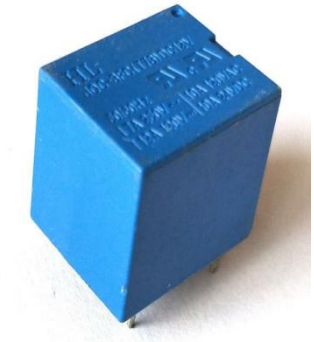

Fig 3.2.2: 5v Relay

Relay Pin Configuration

Pin Number	Pin Name	Description
1	Coil End 1	Used to trigger(On/Off) the Relay, Normally one end is connected to 5V and the other end to ground
2	Coil End 2	Used to trigger(On/Off) the Relay, Normally one end is connected to 5V and the other end to ground
3	Common (COM)	Common is connected to one End of the Load that is to be controlled
4	Normally Close (NC)	The other end of the load is either connected to NO or NC. If connected to NC the load remains connected before trigger
5	Normally Open (NO)	The other end of the load is either connected to NO or NC. If connected to NO the load remains disconnected before trigger

Features of 5-Pin 5V Relay

- Trigger Voltage (Voltage across coil) : 5V DC
- Trigger Current (Nominal current) : 70mA
- Maximum AC load current: 10A @ 250/125V AC
- Maximum DC load current: 10A @ 30/28V DC
- Compact 5-pin configuration with plastic moulding
- Operating time: 10msec Release time: 5msec
- Maximum switching: 300 operating/minute (mechanically)

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Equivalent Relays

3V Relay, 12V Relay, 1-channel Relay module, 4-channel Relay Module.

How to use a Relay

Relays are most commonly used switching device in electronics. Let us learn how to use one in our circuits based on the requirement of our project.

Before we proceed with the circuit to drive the relay we have to consider two important parameter of the relay. Once is the Trigger Voltage, this is the voltage required to turn on the relay that is to change the contact from Common->NC to Common->NO. Our relay here has 5V trigger voltage, but you can also find relays of values 3V, 6V and even 12V so select one based on the available voltage in your project. The other parameter is your Load Voltage & Current, this is the amount of voltage or current that the NC,NO or Common terminal of the relay could withstand, in our case for DC it is maximum of 30V and 10A. Make sure the load you are using falls into this range.

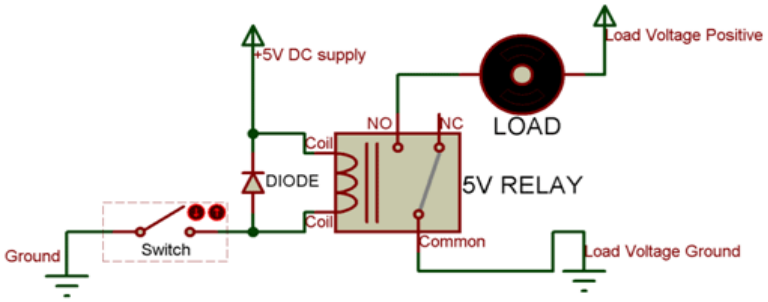


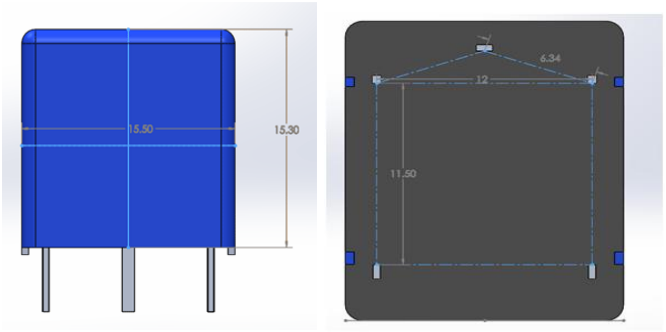
Fig 3.2.3: Schematic circuit diagram

The above circuit shows a bare-minimum concept for a relay to operate. Since the relay has 5V trigger voltage we have used a +5V DC supply to one end of the coil and the other end to ground through a switch. This switch can be anything from a small transistor to a microcontroller or a microprocessor which can perform switching operating. You can also notice a diode connected across the coil of the relay, this diode is called the Fly back Diode. The purpose of the diode is to protect the switch from high voltage spike that can produced by the relay coil. As shown one end of the load can be connected to the Common pin and the other end is either connected to NO or NC. If connected to NO the load remains disconnected before trigger and if connected to NC the load remains connected before trigger

Applications of Relay

- Commonly used in switching circuits.
- For Home Automation projects to switch AC loads
- To Control (On/Off) Heavy loads at a pre-determined time/condition
- Used in safety circuits to disconnect the load from supply in event of failure
- Used in Automobiles electronics for controlling indicators glass motors etc.

2D model of the Relay



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3.3 DHT11(Temperature And Humidity Sensor)

DHT11 Temperature & Humidity Sensor features a temperature & humidity sensor complex with a calibrated digital signal output. By using the exclusive digital-signal-acquisition technique and temperature & humidity sensing technology, it ensures high reliability and excellent long-term stability. This sensor includes a resistive-type humidity measurement component and an NTC temperature measurement component, and connects to a high performance 8-bit microcontroller, offering excellent quality, fast response, anti-interference ability and cost-effectiveness.

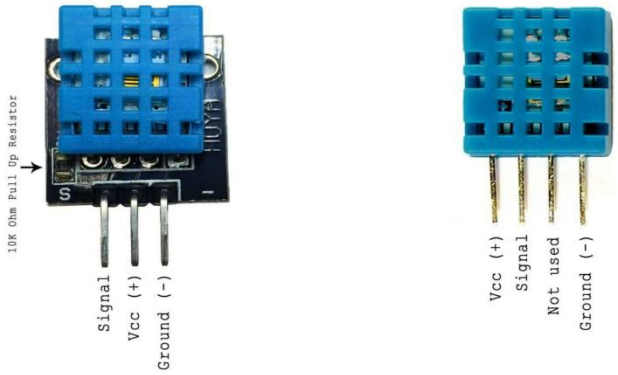

Fig 3.3.1: DHT11 Sensor

Each DHT11 element is strictly calibrated in the laboratory that is extremely accurate on humidity calibration. The calibration coefficients are stored as programmes in the OTP memory, which are used by the sensor's internal signal detecting process. The single-wire serial interface makes system integration quick and easy. Its small size, low power consumption and up-to-20 meter signal transmission making it the best choice for various applications, including those most demanding ones. The component is 4-pin single row pin package. It is convenient to connect and special packages can be provided according to users' request.

TECHNICAL DETAILS:

OVERVIEW:

Item	Measurement Range	Humidity Accuracy	Temperature Accuracy	Resolution	Package
DHT11	20-90%RH 0-50 ℃	±5%RH	±2℃	1	4 Pin Single Row

Detailed Specifications

- Low cost
- 3 to 5V power and I/O
- 2.5mA max current use during conversion (while requesting data)
- Good for 20-80% humidity readings with 5% accuracy
- Good for 0-50°C temperature readings ±2°C accuracy
- No more than 1 Hz sampling rate (once every second)
- Body size 15.5mm x 12mm x 5.5mm
- 4 pins with 0.1" spacing

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Parameters	Conditions	Minimum	Typical	Maximum
Humidity				
Resolution		1%RH	1%RH	1%RH
			8 Bit	
Repeatability			±1%RH	
Accuracy	25℃		±4%RH	
	0-50℃			±5%RH
Interchangeability	Fully Interchangeable			
Measurement Range	0℃	30%RH		90%RH
	25℃	20%RH		90%RH
	50℃	20%RH		80%RH
Response Time (Seconds)	1/e(63%)25℃, 1m/s Air	6 S	10 S	15 S
Hysteresis			±1%RH	
Long-Term Stability	Typical		±1%RH/year	
Temperature				
Resolution		1℃	1℃	1℃
		8 Bit	8 Bit	8 Bit
Repeatability			±1℃	
Accuracy		±1℃		±2℃
Measurement Range		0℃		50℃
Response Time (Seconds)	1/e(63%)	6 S		30 S

3.4 Light Dependent Resistor

A Light Dependent Resistor (LDR) or a photo resistor is a device whose resistivity is a function of the incident electromagnetic radiation. Hence, they are light sensitive devices. They are also called as photo conductors, photo conductive cells or simply photocells.

They are made up of semiconductor materials having high resistance. There are many different symbols used to indicate a LDR, one of the most commonly used symbol is shown in the figure below. The arrow indicates light falling on it.

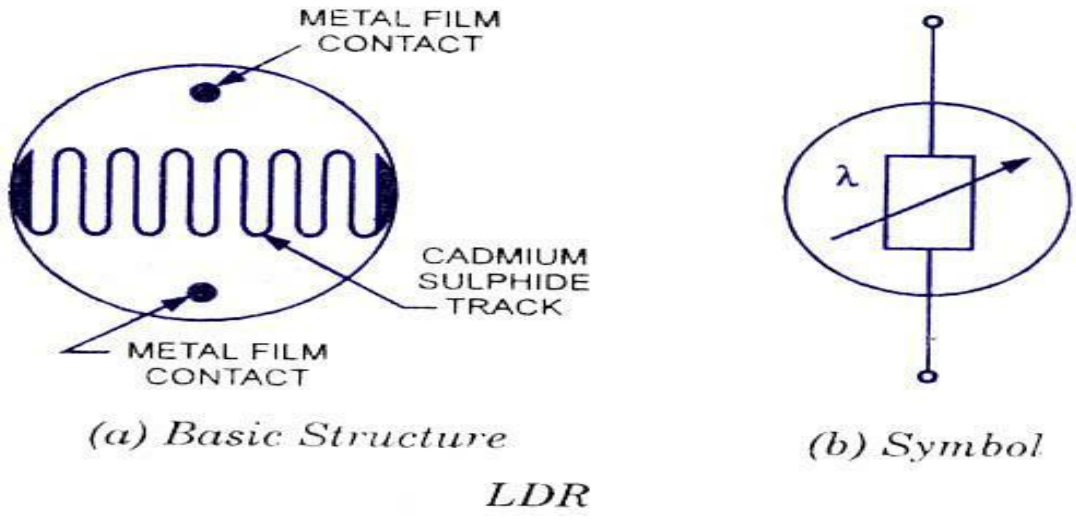

Fig 3.4.1: Light Dependent Resistor

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Working Principle of LDR

A light dependent resistor works on the principle of photo conductivity. Photo conductivity is an optical phenomenon in which the materials conductivity is increased when light is absorbed by the material. When light falls i.e. when the photons fall on the device, the electrons in the valence band of the semiconductor material are excited to the conduction band. These photons in the incident light should have energy greater than the band gap of the semiconductor material to make the electrons jump from the valence band to the conduction band. Hence when light having enough energy strikes on the device, more and more electrons are excited to the conduction band which results in large number of charge carriers. The result of this process is more and more current starts flowing through the device when the circuit is closed and hence it is said that the resistance of the device has been decreased. This is the most common working principle of LDR.

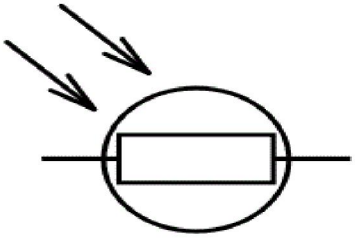

Fig 3.4.2: Symbol of LDR

Characteristics of LDR

LDR's are light dependent devices whose resistance is decreased when light falls on them and that is increased in the dark. When a light dependent resistor is kept in dark, its resistance is very high. This resistance is called as dark resistance. It can be as high as $10^{12}\Omega$ and if the device is allowed to absorb light its resistance will be decreased drastically. If a constant voltage is applied to it and intensity of light is increased the current starts increasing. Figure below shows resistance vs. illumination curve for a particular LDR.

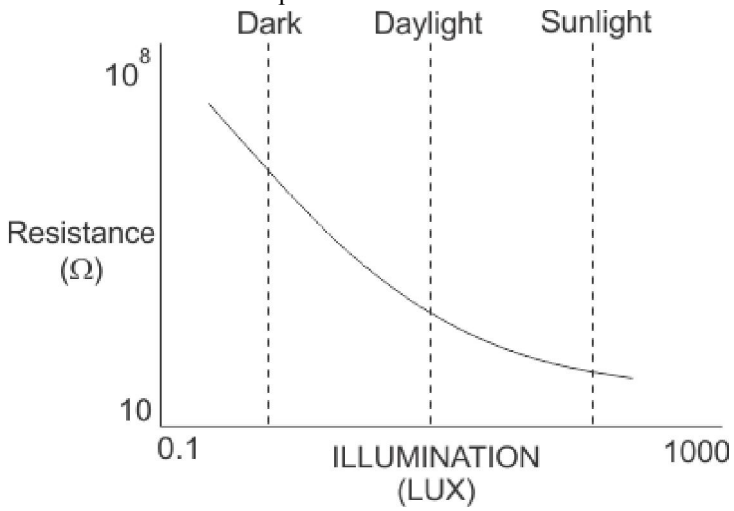

Fig 3.4.3: Characteristics of LDR

Photocells or LDR's are non linear devices. There sensitivity varies with the wavelength of light incident on them. Some photocells might not at all response to a certain range of wavelengths. Based on the material used different cells have different spectral response curves.

When light is incident on a photocell it usually takes about 8 to 12 ms for the change in resistance to take place, while it takes one or more seconds for the resistance to rise back again to its initial value after removal of light. This phenomenon is called as resistance recovery rate. This property is used in audio compressors. Also, LDR's are less sensitive than photo diodes and phototransistor. (A photo diode and a photocell (LDR) are not the same, a photo-diode is a pn junction semiconductor device that converts light to electricity, whereas a photocell is a passive device, there is no pn junction in this nor it "converts" light to electricity).

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Moisture Sensor

The Moisture sensor is used to measure the water content (moisture) of soil. when the soil is having water shortage, the module output is at high level, else the output is at low level. This sensor reminds the user to water their plants and also monitors the moisture content of soil. It has been widely used in agriculture, land irrigation and botanical gardening.

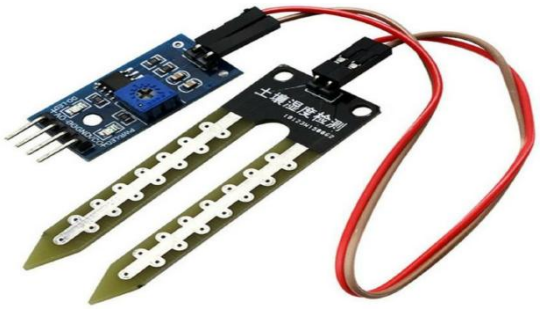

Fig 3.5.1: Moisture Sensor

Specifications

- Working Voltage:**5V**
- Working Current:**<20mA**
- Interface type: **Analog**
- Working Temperature:**10°C~30°C**

Working Principle of Moisture Sensor

The Soil Moisture Sensor uses capacitance to measure dielectric permittivity of the surrounding medium. In soil, dielectric permittivity is a function of the water content. The sensor creates a voltage proportional to the dielectric permittivity, and therefore the water content of the soil. The sensor averages the water content over the entire length of the sensor. There is a 2 cm zone of influence with respect to the flat surface of the sensor, but it has little or no sensitivity at the extreme edges. The Soil Moisture Sensor is used to measure the loss of moisture over time due to evaporation and plant uptake, evaluate optimum soil moisture contents for various species of plants, monitor soil moisture content to control irrigation in greenhouses and enhance bottle biology experiments.

Hardware Connections

The moisture sensor module should be connected to the as follows:

- Vcc to 5V
- GND to GND
- A0 to Analog pin
- D0 to Digital pin

3.6 Rain Sensor

The rain sensor module is an easy tool for rain detection. It can be used as a switch when raindrop falls through the raining board and also for measuring rainfall intensity. The module features, a rain board and
the control board that is separate for more convenience, power indicator LED and an adjustable sensitivity though a potentiometer.

The analog output is used in detection of drops in the amount of rainfall. Connected to 5V power supply, the LED will turn on when induction board has no rain drop, and DO output is high. When dropping a little amount water, DO output is low, the switch indicator will turn on. Brush off the water droplets, and when restored to the initial state, outputs high level.

Specifications:

Adopts high quality of RF-04 double sided material.
Area: 5cm x 4cm nickel plate on side,

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Anti-oxidation, anti-conductivity, with long use time;
Comparator output signal clean waveform is good, driving ability, over 15mA;
Potentiometer adjust the sensitivity;
Working voltage 5V;
Output format: Digital switching output (0 and 1) and analog voltage output AO;
With bolt holes for easy installation;
Small board PCB size: 3.2cm x 1.4cm;
Uses a wide voltage LM393 comparator

Pin Configuration

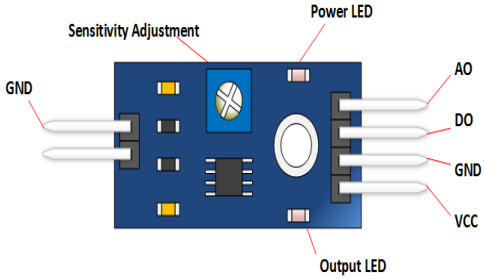

Fig 3.6.1: Rain sensor configuration

1. VCC: 5V DC
2. GND: ground
3. DO: high/low output
4. AO: analog output

IV. SYSTEM DEVELOPMENT

4.1 Components Used

1. NodeMCU Board - It is a low-cost development board based on ESP8266 Wi-Fi module and Lua programming language, which can be used for IoT applications.
2. ESP8266 Wi-Fi module - It is a low-cost Wi-Fi chip with embedded TCP/IP protocol stack, which provides internet connectivity to NodeMCU board.
3. ESP32 Wi-Fi module - It is a low-power Wi-Fi and Bluetooth chip, which can be used for more advanced IoT applications.
4. Sensors - Various sensors can be used to measure parameters such as voltage, current, temperature, and humidity.
5. Relay modules - These modules can be used to control the switching of electrical equipment remotely.
6. Power supply - A power supply unit is needed to provide power to the NodeMCU board and other components.
7. Resistors, capacitors, and other electronic components - These components are needed to build the circuitry for the system.
8. Cloud-based systems - These systems can be used for data storage and analysis, which can be accessed remotely.
9. Web server - A web server can be used to display real-time data and control the system remotely.
10. Mobile application - A mobile application can be developed to provide remote access to the substation management system using NodeMCU.

Overall, these components work together to create a comprehensive substation management system using NodeMCU, which can help in improving the efficiency, reliability, and safety of electrical substations.

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4.2 Working

we can say that, Node MCU is the main component in the whole system. all the other sensors are connected and being controlled by the microcontroller ESP8266.

The ESP8266 Node MCU has total 30 pins that interface it to the outside world. There are 8 digital pins, which are D0,D1,D2,D3,D4,D5,D6,D7

In our project 5v Relay is connected to pin D0

Light dependent resistor is connected to pin D1

Moisture sensor is connected to pin D2

For RFID sensor pins D3,D4,D5 and D6 are engaged

And lastly DHT11 sensor is connected to pin D7

Rain sensor is connected to analog pin A0

This was all about the hardware connections of ESP8266 microcontroller. After successful completion of the hardware connections now its time for programming the stepwise explanations of the code is given

```
#include <SPI.h>
#include <MFRC522.h>
int soilMoisturePin = D1;
#define RAIN_SENSOR_PIN A0
#include <DHT.h>
#define DHTPIN D2 // Define the digital input pin for the DHT11 sensor
#define DHTTYPE DHT11 // Define the DHT11 sensor type
DHT dht(DHTPIN, DHTTYPE);
#include <ESP8266WiFi.h>
#include <ESP8266HTTPClient.h>
#include <WiFiClient.h>
const char* ssid = "admin";
const char* password = "admin@123";
//Your Domain name with URL path or IP address with path
String serverName = "http://bubblecode.in/smart_sub_station/api2.php";
// the following variables are unsigned longs because the time, measured in
// milliseconds, will quickly become a bigger number than can be stored in an int.
unsigned long lastTime = 0;
// Timer set to 10 minutes (600000)
//unsigned long timerDelay = 600000;
// Set timer to 5 seconds (5000)
unsigned long timerDelay = 5000;
constexpr uint8_t RST_PIN = D3; // Configurable, see typical pin layout above
constexpr uint8_t SS_PIN = D4; // Configurable, see typical pin layout above
MFRC522 rfid(SS_PIN, RST_PIN); // Instance of the class
MFRC522::MIFARE_Key key;
String tag;
void setup() {
 Serial.begin(9600);
 SPI.begin(); // Init SPI bus
 rfid.PCD_Init(); // Init MFRC522
 pinMode(RAIN_SENSOR_PIN, INPUT);
 dht.begin();
 pinMode(soilMoisturePin,INPUT);
WiFi.begin(ssid, password);
```

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```
 Serial.println("Connecting");
 while(WiFi.status() != WL_CONNECTED) {
 delay(500);
 Serial.print(".");
 }
 Serial.println("");
 Serial.print("Connected to WiFi network with IP Address: ");
 Serial.println(WiFi.localIP());
}
void loop() {
int rainSensorState = analogRead(RAIN_SENSOR_PIN);
String Rain = "";
  // If the sensor is wet, print "It's raining" to the serial monitor
 if (rainSensorState > 500) {
 Serial.println("It's not raining");
 Rain =0;
 }
 else
 {
 Serial.println("its raining");
 Rain =1;
 }
 String soilsensor = "";
 int soil = digitalRead(soilMoisturePin);
 if(soil==0)
 {
 soilsensor = 1;
 Serial.println("Wet soil");
 }
 else
 {
 soilsensor = 0;
 Serial.println("Dry soil");
 }
// Read the temperature and humidity from the DHT11 sensor
 float temperature = dht.readTemperature();
 float humidity = dht.readHumidity();
 // Print the temperature and humidity to the serial monitor
 Serial.print("Temperature: ");
 Serial.print(temperature);
 Serial.print(" °C\t");
 Serial.print("Humidity: ");
 Serial.print(humidity);
 Serial.println("%");
 // Send an HTTP POST request depending on timerDelay
 if ((millis() - lastTime) > timerDelay) {
 //Check WiFi connection status
 if(WiFi.status()== WL_CONNECTED){
  WiFiClient client;
```

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```
HTTPClient http;
String serverPath = serverName +
"?temp1="+temperature+"&humidity="+humidity+"&rain="+Rain+"&soil="+soilsensor;
 // Your Domain name with URL path or IP address with path
http.begin(client, serverPath.c_str());
int httpResponseCode = http.GET();
 if (httpResponseCode>0) {
Serial.print("HTTP Response code: ");
Serial.println(httpResponseCode);
String payload = http.getString();
Serial.println(payload);
}
else {
Serial.print("Error code: ");
Serial.println(httpResponseCode);
}
 http.end();
}
else {
Serial.println("WiFi Disconnected");
}
lastTime = millis();
}
delay(1000);
if ( ! rfid.PICC_IsNewCardPresent())
return;
if (rfid.PICC_ReadCardSerial()) {
for (byte i = 0; i < 4; i++) {
tag += rfid.uid.uidByte[i];
}
Serial.println("UID No." );
Serial.println(tag);
tag = "";
rfid.PICC_HaltA();
rfid.PCD_StopCrypto1();
}
}
```

We have created a substation management app. Initially, by using HTML for frontend and .php for backend we developed a website and then by using “Gonative” we converted it into a app.

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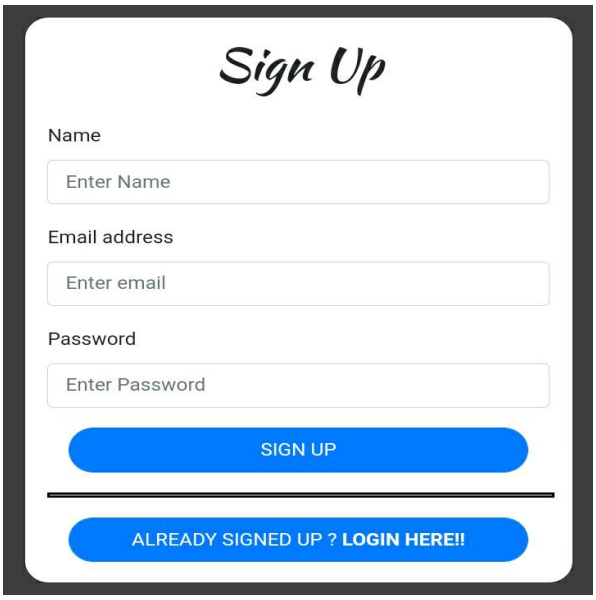

Fig 4.2.1: login up

As the user opens the app the login display is shown up as shown in fig4.2.1. here we have to enter the user name, mail id, password in order to operate the app further.

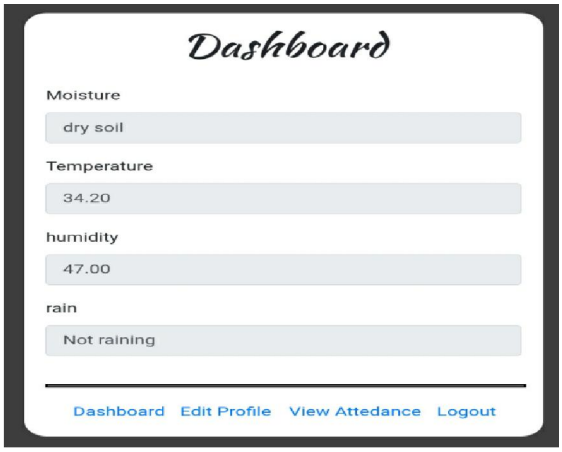

Fig 4.2.2:Dashboard

Dashboard shows the latest measurement of temperature, humidity, soil moisture and the status of the rain

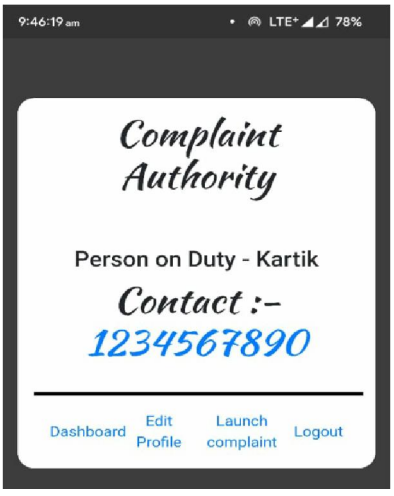

Fig 4.2.3: employee attendance

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We have this interesting feature in our app which allows the end user to check information and contact number of the employee who is on duty at that particular time. If end user experience a fault he/she cam complaint directly to the operator which saves the time and energy on both utility and end users sides.

4.3 Connection Diagram

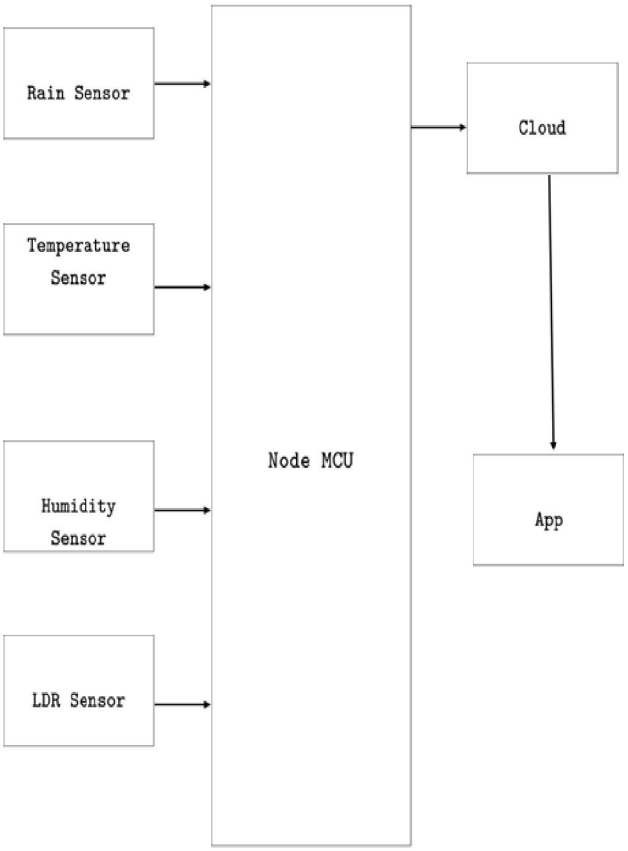

Fig 4.3: connection diagram of our project

4.4 Model Of Project

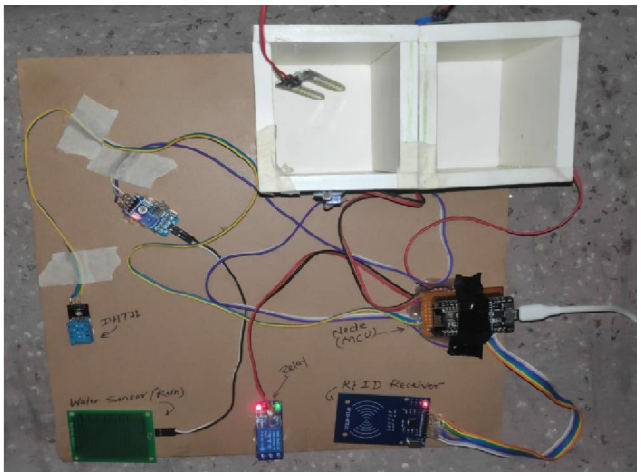

Fig 4.4: model of our project

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4.5 schematic circuit diagram

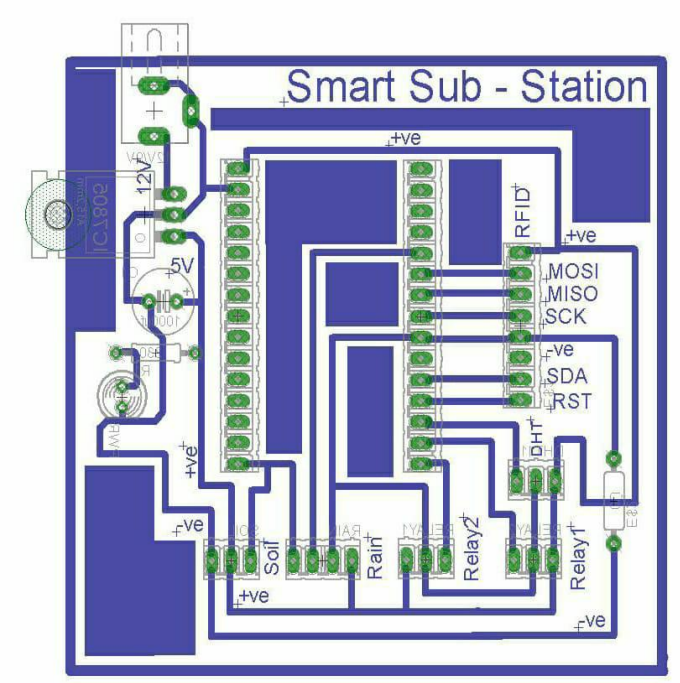

Fig 4.4: schematic diagram

V. Result Analysis And Discussion

The substation management system using NodeMCU can collect real-time data on various parameters such as voltage, current, temperature, and humidity, which can help in identifying issues before they become major problems. The data collected by the system can be analyzed and visualized using cloud-based systems and web servers, which can enable remote access to the data, allowing for quick and informed decision-making.

The system can also be programmed to trigger alarms and notifications in case of any abnormality detected in the substation, enabling the substation personnel to take quick actions to prevent any major issues. The system can also control the switching of electrical equipment remotely through relay modules, which can help in improving the efficiency of the substation.

Furthermore, the use of NodeMCU-based systems can be cost-effective and scalable, making them accessible to smaller utilities and substations. The system can be easily integrated with mobile applications, providing remote access to the substation management system. The challenges & cost pressure in the operation of medium and low voltage networks are increasing.

Unfortunately, network operators at these voltage levels are either “visually impaired” (mid voltage grid) or completely “blind” (low voltage grid). Solutions for digital substations have been on the market for several years, but unfortunately they are usually expensive and/or connected with the exchange of essential components of the substation.

In summary, the substation management system using NodeMCU can provide real-time data collection, analysis, and visualization, remote access, control, and cost-effective solutions to improve the efficiency, reliability, and safety of electrical substations. Further this app can be merge up with maha vitra or many other distribution company app.

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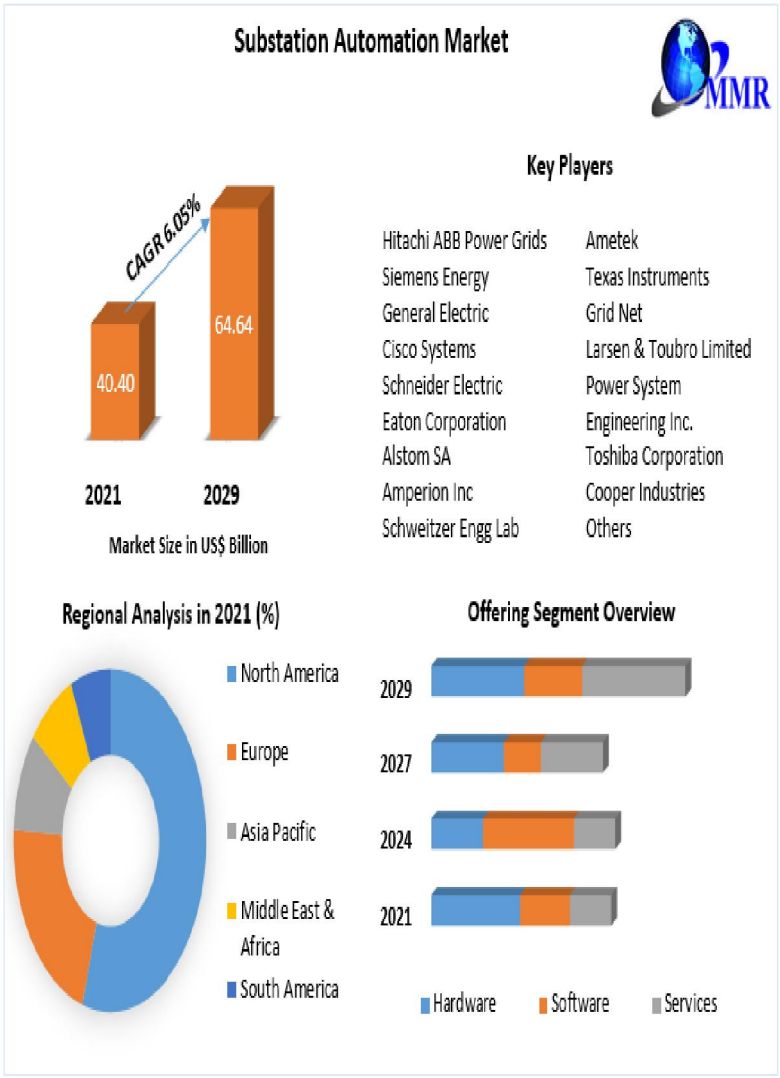

Fig 5.1: substation automation market survey

VI. CONCLUSION

The hardware components are successfully assembled and interfacing the Node_mcu with sensors is achieved. Controlling the substation via webpage as well as from android applet is successfully obtained. Hence the two modules of controlling the substation is successfully tested and demonstrated. Though controlling using Wifi limits the range of distance for communication, a smart and easy means to guide a system is achieved.project cost is not much that and it is very friendly fo users to used also. This project is very reliable and safe for used. Its monitor the temperature ans humidity of atmosphere and its shown in our app.

6.1 Scope of Future Work

A substation management system using NodeMCU is a system that allows for remote monitoring and control of electrical substation equipment. It can provide real-time data on various parameters such as voltage, current, temperature, and humidity, and can be used to detect and alert on any abnormalities or faults in the system. As for the scope of future work, there are several areas that can be explored to enhance the capabilities and functionality of the substation management system using NodeMCU. Here are a few potential avenues to consider:

1. Integration with other systems: The substation management system can be integrated with other systems such as SCADA (Supervisory Control and Data Acquisition), which can provide additional data and control

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capabilities. This integration can also enable advanced analytics and predictive maintenance to optimize the performance of the substation equipment.

2. Enhanced data visualization: The system can be further developed to provide more detailed and interactive visualizations of the data collected from the substation equipment. This can help in identifying patterns and trends that may not be immediately apparent from raw data.
3. Improved communication protocols: The system can be made more robust and reliable by implementing more advanced communication protocols such as MQTT (Message Queuing Telemetry Transport) or CoAP (Constrained Application Protocol). These protocols can provide greater scalability, reliability, and security for the system.
4. Incorporation of machine learning: Machine learning algorithms can be used to analyze the data collected from the substation equipment and identify potential issues before they become major problems. This can help in reducing downtime and improving the overall efficiency of the substation.
5. Implementation of automation: The substation management system can be further developed to enable automated control of the substation equipment. This can help in reducing the workload on human operators and improving the responsiveness of the system to changing conditions.

Overall, there are many areas that can be explored to enhance the capabilities and functionality of a substation management system using NodeMCU. As technology continues to evolve, there will likely be new opportunities to improve the efficiency, reliability, and safety of electrical substations

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