“Miniature Working Model of 33/11 kV Substation”

A

Project Report

Submitted in the partial fulfillment of the requirements

For the Degree of

Bachelor of Engineering

In

Electrical (Electronics & Power)

By

Ms. Ankita Madiwale

Ms. Gauri Masne

Ms. Sejal Hattel

Ms. Tanuja Wankhede

Ms. Vaishnavi Maharkhede

Under the guidance of

Dr. S. S. Jadhao

DEPARTMENT OF ELECTRICAL ENGINEERING

SHRI SANT GAJANAN MAHARAJ COLLEGE OF ENGINEERING

SHEGAON 444 203 M. S. (INDIA)

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CERTIFICATE

Certified that the project report entitled, **"Miniature Working Model of 33/11 kV Substation"** is a bonafied work done under my guidance by

Ankita Madiwale

Gauri Masne

Sejal Hattel

Tanuja Wankhede

Vaishnavi Maharkhede

In partial fulfillment of the requirements for the award of degree of Bachelor of Engineering in Electrical (Electronics & Power).

Date: 12/05/23

12/05/23

Dr. S. S. Jadhao

Guide

Approved

(Dr. S. R. Paraskar)

Head

Department of Electrical Engg.

(Dr. S. B. Somani)

Principal

E-mail: principal@ssgmce.ac.in

hod_elpo@ssgmce.ac.in

Phone No. 07265-252116, 252216

Fax No. 07265-252346, 253602

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Ms. Ankita Madiwale

Ms. Gauri Masne

Ms. Sejal Hattel

Ms. Tanuja Wankhede

Ms. Vaishnavi Maharkhede

ABSTRACT

The Miniature Working Model of 33/11 kV substation, is actually a replica of a substation located at Nandura Road, MIDC area Khamgaon. As an Electrical Undergrad Substation being a part and parcel of our Studies, we should be able to understand it thoroughly and practically. But due to the busy academic schedule we rarely able to make visits to substation, also during visits as we are in groups faculty can not be able to consider individual doubts. This Fuels the idea of making a Substation model for students where the students can take a look and visualize all the equipments and their working . The main advantage of this model being placed in college campus students can visit it whenever they have studied any new topic and want to learn about how actually it has been placed in a substation.

CONTENT

CHAPTER 1

Introduction

Motivation

In electrical engineering power system plays a vital role, a substation is a part of an electrical power system that transforms voltage levels and distributes electrical power from the transmission system to the distribution system. Substation is nothing but an entity in the power system which distribute power to the consumer and scattered the power to the different load like residential load, commercial load, industrial load, etc. The main function of a substation is to control and regulate the flow of electrical power from the transmission system to the distribution system, which is then supplied to homes and industries. By creating a substation model, you can gain a better understanding of how these facilities work and how they can be optimized to improve power delivery.

Modelling a substation can be a complex task that requires knowledge of electrical engineering, control system, and other technical disciplines. This can make it an exciting and challenging project for us as we want to push our skills and knowledge to limit. Overall, a substation model project proves to be a highly rewarding final year project for us that offers a unique combination of technical challenge, practical application and carrier preparation.

Problem statement

Substation plays an important role in electrical system, but it is difficult to understand the concept and working of each and every component installed at substation thoroughly. Substations are not accessible frequently for study and analysis purpose. Visitors which are not being professional increases the risk of electrical accidents. At the substation, operation of the equipment is not possible whenever desired.

Aim

1. Development of prototype model useful for electrical laboratory.
2. Facilitates Students to learn visually in more effective way than theoretical study.
3. Provide an aid to faculty to effectively deliver the topic.
4. Provides knowledge of switchgear and protection along with the overview of distribution sector.
5. Enabling students to identify other best practices used to improve substation construction and overall project outcomes.

Objectives

The objective of making a substation model is to create a detailed representation of a substation’s physical components and electrical systems. This model can be used for various purposes, such as:

1. **Design and planning**: A substation model can be used for designing and planning new substations, as well as expanding and upgrading existing ones. It helps engineers and planners to visualize the layout of the substation and its components, and to evaluate the performance of the substation under various operating conditions.

2. **Training and Education**: A substation model can be used for training and educating personnel on how to operate and maintain the substation. It provides a safe and realistic environment for trainees to practice their skills and learn about the substation's electrical systems.

3. **Testing and Simulation**: A substation model can be used for testing and simulating various scenarios, such as fault analysis, load flow analysis, and protection coordination. It helps engineers and operators to evaluate the performance of the substation and its protection systems under different operating conditions and contingencies.

4. **Communication and Visualization**: A substation model can be used for communication and visualization purposes. It helps stakeholders to understand the layout and function of the substation and to communicate ideas and plans more effectively.
   Overall, a substation model is a valuable tool for engineers, planners, operators, and other stakeholders involved in the design, construction, operation, and maintenance of substations.

CHAPTER 2

Substation: general information

A substation is a critical component of the power grid that helps to regulate and control the flow of electricity from power plants to consumers. Substations are typically located at strategic points along the transmission and distribution network, and they may be responsible for stepping up or stepping down the voltage of the electricity to ensure it can be transported efficiently. Substations can be complex facilities that consist of a range of electrical equipment, including transformers, circuit breakers, switches, and protection devices. They may also include control and monitoring systems that allow operators to monitor the flow of electricity and respond to any issues that may arise.

Substations can vary in size and complexity, depending on the amount of electricity being transmitted and the number of end-users that are being served. Some substations may be located outdoors, while others may be located indoors in a building. They can also be classified based on their function, such as transmission, distribution, or customer substations. The layout of a substation may vary depending on the location, size, and purpose of the substation. Generally, substations are designed to be compact and efficient, with a layout that allows for easy access to components for maintenance and repairs.

Substations contain high voltage equipment, so safety is a top priority. Substations are typically surrounded by fences, warning signs, and other safety measures to prevent unauthorized access and to protect workers and the public from electrical hazards.

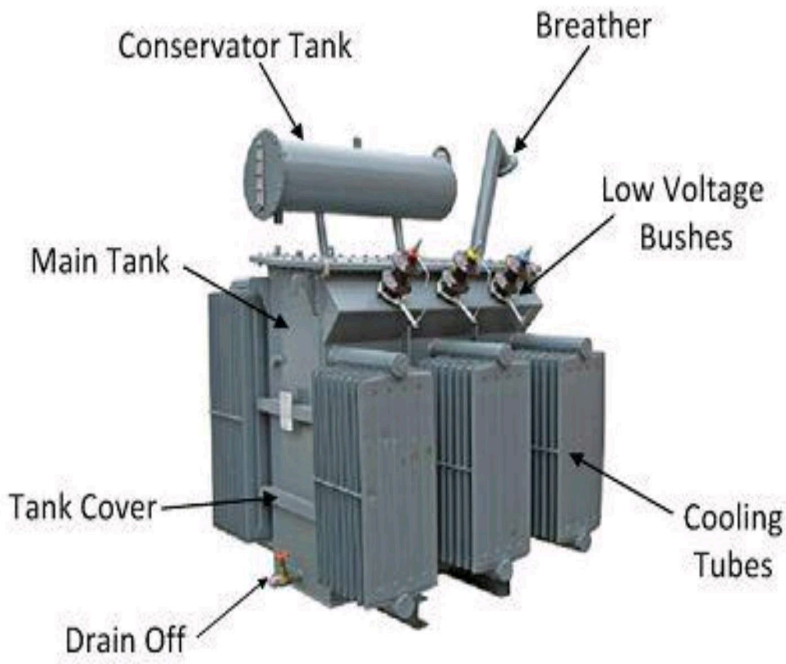
Substations are typically monitored and controlled remotely using a supervisory control and data acquisition (SCADA) system. This allows operators to monitor the performance of the substation and make adjustments as needed to ensure efficient and reliable operation.

Here are some of the key pieces of equipment you might want to consider including in a substation model.

1) Transformer:

An electrical transformer is a device that transfers electrical energy from one circuit to another through the principle of electromagnetic induction. It consists of two coils of wire (the primary and secondary coils) that are wrapped around a common magnetic core. When an alternating current (AC) is passed through the primary coil, it creates a magnetic field around the coil. This magnetic field induces an alternating voltage in the secondary coil, which is proportional to the number of turns in the secondary coil.

Transformers are used to step up or step down the voltage of an alternating current (AC) power supply to match the requirements of the load. Transformers can be used to isolate one part of an electrical system from another, providing protection against electrical faults and improving safety. Transformers are used in power electronics to convert AC power to DC power, or to change the frequency of AC power. Transformers are highly efficient and reliable, with typical efficiencies of around 98-99%.

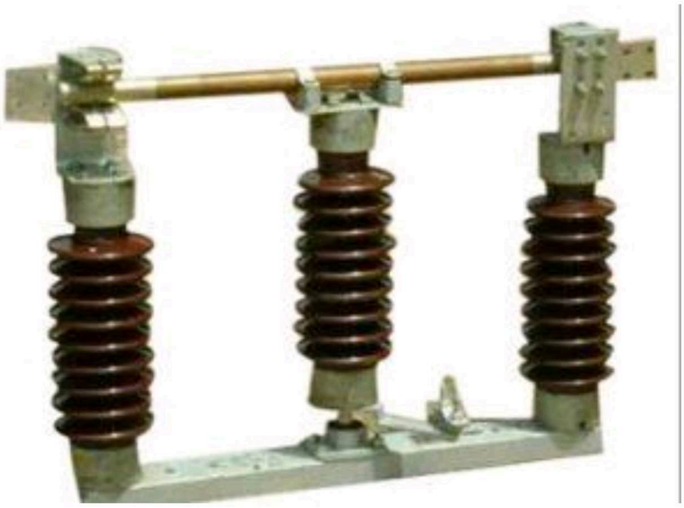


2) Circuit breakers :

Circuit breakers are safety devices that are used to protect the substation and the power grid from damage in the event of an electrical fault or overload. They work by opening and closing circuits automatically to prevent excessive currents from flowing.

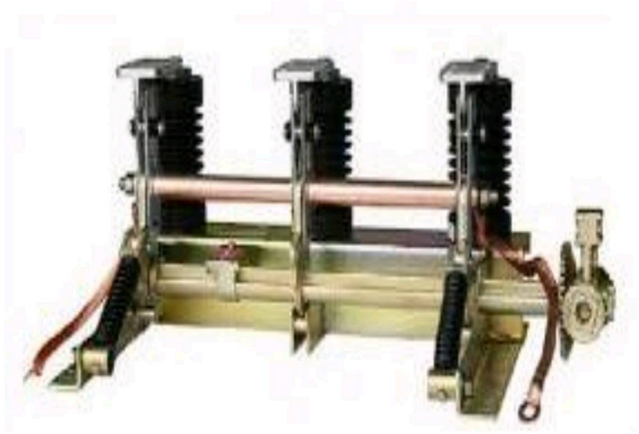
3) Isolator :

Isolator is a manually operated mechanical switch that isolates the faulty section of substation. It is used to separate faulty section for repair from a healthy section in order to avoid the occurrence of severe faults. It is also called disconnector or disconnecting switch.



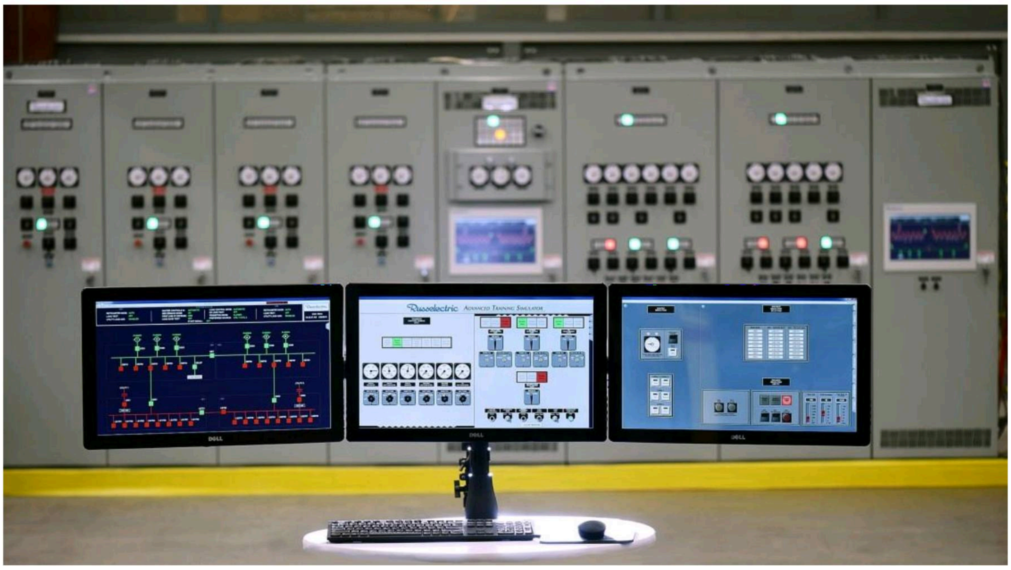
4) Earth switch :

An earth switch is a mechanical switching device for protecting parts of a circuit. It is capable of sustaining currents for a specific time under abnormal conditions such as short circuits. During normal circuit conditions, it doesn't carry any current. It's only called into action when there is an abnormal condition.



5) Control and monitoring systems :

Control and monitoring systems allow operators to monitor the performance of the substation and respond to any issues that may arise. These systems may include supervisory control and data acquisition (SCADA) systems, human-machine interfaces (HMIs), or other control and monitoring devices.



6) Capacitors :

Capacitors are used to regulate voltage and improve power factor within the substation. They may be used to improve the efficiency and reliability of the power grid by reducing power losses and improving power quality. Capacitor banks are mainly used to enhance the electrical supply quality and enhance the power systems efficiency.

7) Current Transformer (C.T.) :

It is a type of “instrument transformer” that is designed to produce an alternating current in its secondary winding which is proportional to the current being measured in its primary. Current transformers reduce high voltage currents to a much lower value and provide a convenient way of safely monitoring the actual electrical current flowing in an AC transmission line using a standard ammeter.

8) Potential Transformer (P.T.) :

Potential transformer is an instrument transformer which is used for the protection and measurement purposes in the power systems. A potential transformer is mainly used to measure high alternating voltage in a power system. Potential transformers are step-down transformers, i.e., they have many turns in the primary winding while the secondary has few turns.

9) Lightening Arrester :

A lightning arrester is a device, essentially an air gap between an electric wire and ground, used on electric power transmission and telecommunication systems to protect the insulation and conductors of the system from the damaging effects of lightning. The typical lightning arrester has a high-voltage terminal and a ground terminal. When a lightning surge travels along the power line to the arrester, the current from the surge is diverted through the arrester, in most cases to earth.

CHAPTER 3

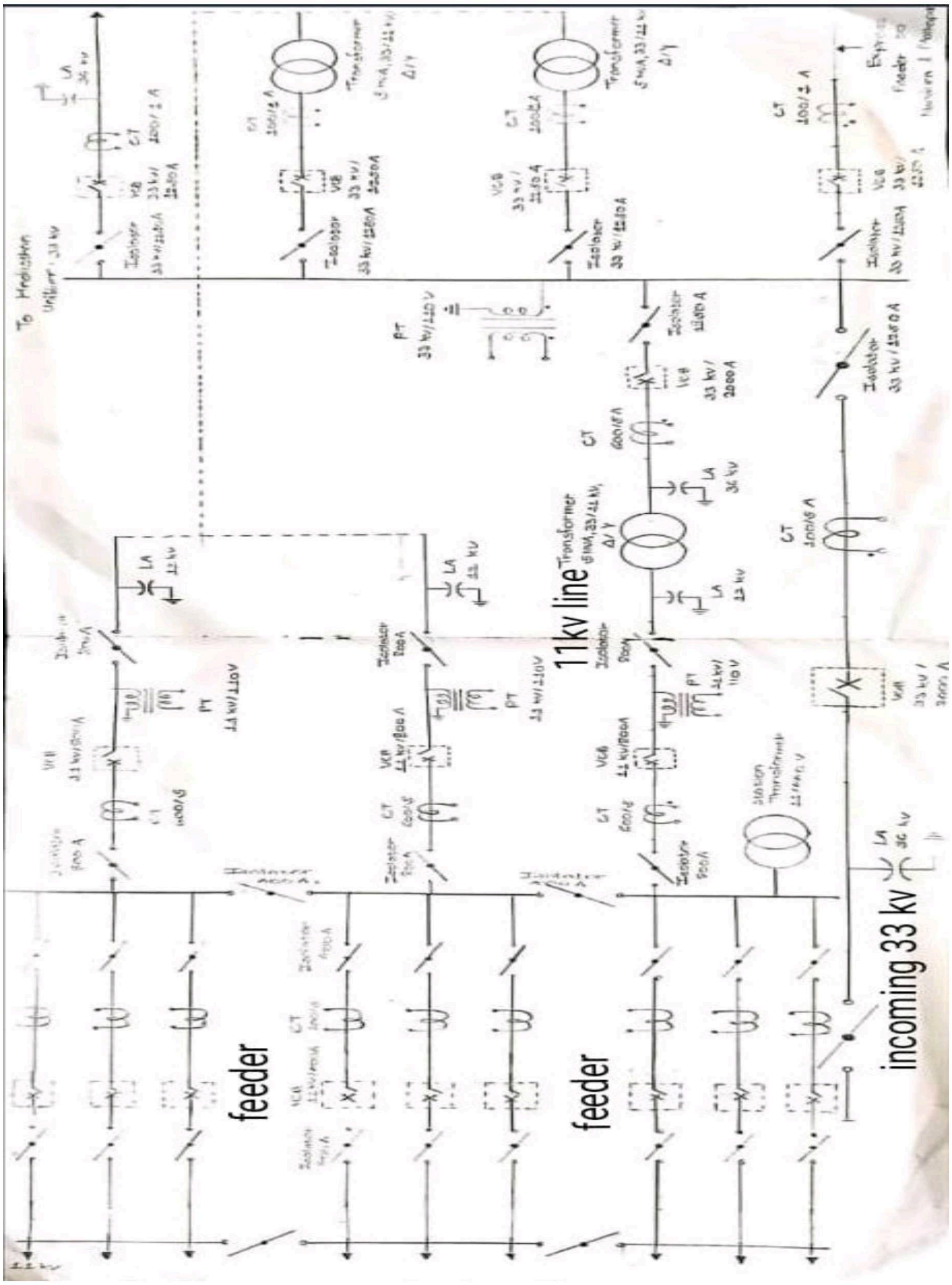
Substation under consideration

The Substation that is taken under consideration as a reference for the making the model of the project is located at the MIDC area of khamgaon city, this substation is a 33\11kV distribution substation where a 33 kV incoming supply is provided by a 132\33 kV substation. The incoming 33kV feeder charges the bus at 33 kV, a 33 kV express feeder line is provided by the 33 kV bus to Nandura substation, also a 33 kV supply line is supplied to a large-scale company located at the MIDC region.

Three circuits are taken out from the bus charged at 33kV, these 33kV supply is stepped down via 33\11kV transformers. The three 11kV outputs of the transformers are then given to charge the 11 kV feeder bus where 9 feeders are connected to the bus (3 feeders from each 11kV output supply. These 9 feeders are then distributed to khamgaon, nearby localities and the MIDC region. A separate 11kV\440 V station transformer is placed at the substation to supply the substation auxiliaries, this 11kV supply for the station transformer is taken by the 11kV feeder bus itself.

A 33/11kV substation is a type of electrical substation that steps down the high voltage of 33 kilovolts (kV) to a lower voltage of 11 kV, which is typically used for distribution to residential, commercial, and industrial customers. The substation may include various components such as transformers, circuit breakers, busbars, isolators, surge arresters, and control systems. The transformers are the most important component, as they are responsible for stepping down the voltage from 33 kV to 11 kV. The substation may also include protection systems to prevent faults and overloads, and monitoring systems to ensure the safe and efficient operation of the substation. Overall, 33/11kV substations play a critical role in the electricity supply chain, as they enable the distribution of power to end-users at a safe and usable voltage. The single line diagram of the substation is provided for the better understanding of the connections and the circuit.

Single Line Diagram of 33/11 kV substation



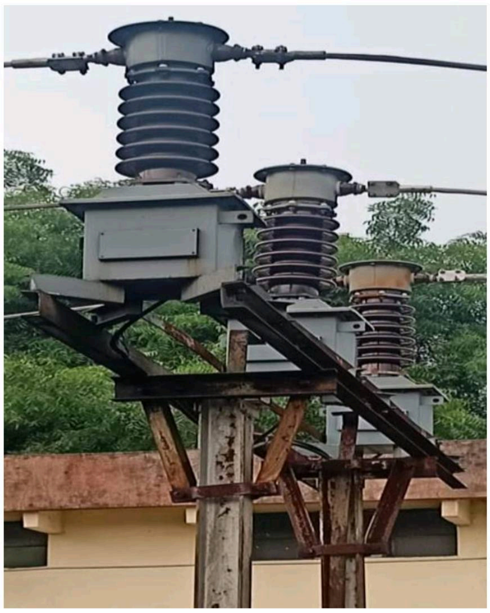
A 33/11kV substation is a crucial component in the power transmission and distribution network. It is responsible for converting high voltage power from the transmission network to a lower voltage suitable for distribution to consumers. Here are some pieces of information that could be useful for your final year project:

1. **Transformer :** The substation contains a transformer that steps down the voltage from 33kV to 11kV. The transformer is usually oil-immersed and has a capacity of several megavolt-amperes(MVA).The Transformer used is a 5 MVA, 33\11kV Rated, Star to Delta connected, It is oil immersed, oil cooling transformer.

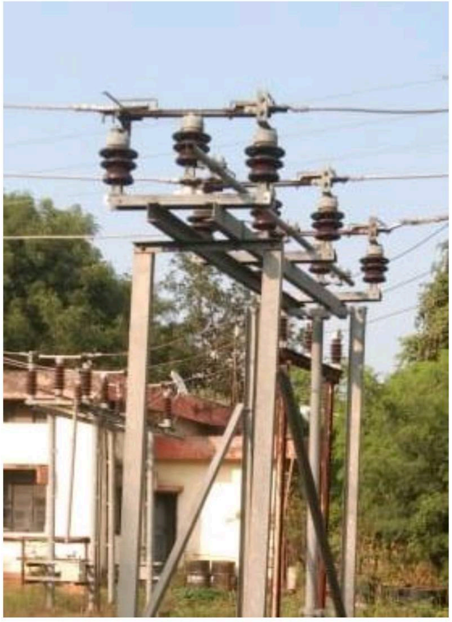
2. **Switchgear :** The substation contains switchgear that allows for the switching and protection of the electrical equipment. The switchgear includes circuit breakers, isolators, and other protective devices.
   Current Transformer rating: 100\1 A, 100\5 A
   Potential Transformer rating: 33kV\110V, 11kV\110V
   Circuit breaker rating: 33kV of current capacity 1250 A,
   11kV of current capacity 800 A and 400 A

Current Transformer

Vacuum Circuit Breaker



3. **Isolator :** Isolator is a manually operated mechanical switch that isolates the faulty section of substation. It is used to separate faulty section for repair from a healthy section in order to avoid the occurrence of severe faults. It is also called disconnector or disconnecting switch.The rating of isolator used at the substation are 33kV, 11kV.

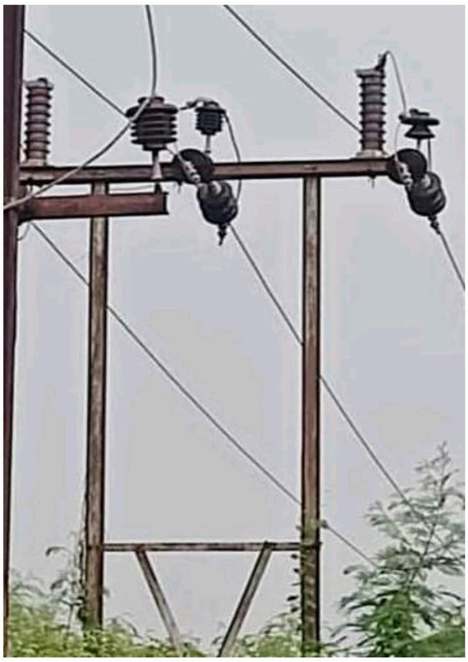


4. **Busbars :** The substation contains busbars that connect the various components of the substation, including the transformer, switchgear, and other equipment. There are two Busbars at the substation 33kV busbar as mentioned above it has three circuits connected and 11kV feeder busbar has 9 feeders connected to it.

5. **Control Room** : The substation has a control room where operators can monitor and control the equipment in the substation. The control room contains various monitoring and control systems, such as (Supervisory Control and data Acquisition System).

6. **Earthing system :** The substation has an earthing system that provides a low-impedance path to earth for fault currents. The earthing system includes earth rods, earth mats, and other components.

7. **Lightning Arrester :** The substation has a lightning protection system that protects the equipment from lightning strikes. The lightning protection system includes lightning arresters, surge arresters, and other components. The lightening arrestors are of rating 12kV for outgoing 11kV side and 36kV for 33kV incoming side of the circuit.



8. **Auxiliary Power Supply :** The substation has an auxiliary power supply that provides power for the substation equipment, such as lighting, heating, and control systems. The auxiliary power supply may be provided by a standby generator or a battery backup system. The supply for auxiliaries are provided by the 11kV feeder busbar to the 11kV\440V, 50 KVA step-down Transformer.

CHAPTER 4

Literature Review

The word substation comes from the days before the distribution system became a grid. As central generation stations became larger, smaller generating plants were converted to distribution stations, receiving their energy supply from a larger plant instead of using their own generators. The first substations were connected to only one power station, where the generators were housed, and were subsidiaries of that power station.

As the demand for electricity increased various power generating stations were interconnected to form a decentralized grid and hence the substations. According to the need various substations came into existence, such as transmission substation, distribution substation, collector substation, converter substation, switching station, railways, there is also a concept called mobile substations.

Early electrical substations required manual switching or adjustment of equipment, and manual collection of data for load, energy consumption, and abnormal events. As the complexity of distribution networks grew, it became economically necessary to automate supervision and control of substations from a centrally attended point, to allow overall coordination in case of emergencies and to reduce operating costs. Early efforts to remote control substations used dedicated communication wires, often run alongside power circuits.

Power-line carrier, microwave radio, fibre optic cables as well as dedicated wired remote control circuits have all been applied to Supervisory Control and Data Acquisition (SCADA) for substations. The development of the microprocessor made for an exponential increase in the number of points that could be economically controlled and monitored. Today, standardized communication protocols such as DNP3, IEC 61850 and Modbus, to list a few, are used to allow multiple intelligent electronic devices to communicate with each other and supervisory control centres. Distributed automatic control at substations is one element of the so-called smart grid.

Power Line carrier communication

AT&T began development of such a system in 1914, inaugurating commercial carrier frequency transmission over telephone lines in 1918. Major Squier termed his carrier technique "wired wireless", and that term began to be used in power line communications, the Power Line carrier Communication (PLCC) has evolved a long way from its earliest use in metering at remote locations to its present-day applications in home automation, high speed internet access, smart grid etc. In the early 20th-century the power companies used telephones as the medium of communication for exchange of voice messages for operational support, maintenance, control etc and as a method of connectivity at remote locations. The telephone lines ran parallel to the power lines. This had so many disadvantages:

- The use of telephone circuits over large distances and at difficult terrains like mountains was very expensive.
- Noise interference due to currents flowing in parallel power lines over the telephone circuits.

- Frequent shut down of telephone cables during harsh weather conditions like snows in winter, storms etc made them less reliable.

This led to the idea of inventing a more robust and less expensive method of communication. The use of power line as a method of telephony was a long thought idea and its first successful test took place in Japan in 1918. And there after its commercialization started during 1930s.

Supervisory Control and Data Acquisition (SCADA)

Nowadays, computer control is one of the most cost-effective solutions for improving reliability, optimum operation, intelligent control and protection of a power system network. Having advanced data collection capabilities, SCADA system plays a significant role in power system operation. Typically, at distribution side SCADA does more than simply collecting data by automating entire distribution network and facilitating remote monitoring, coordinate, control and operating distribution components just like in Smart Grid System. SCADA (Supervisory Control and Data Acquisition) Supervisory Control and Data Acquisition or simply SCADA is one of the solutions available for data acquisition, monitor and control systems covering large geographical areas. It refers to the combination of data acquisition and telemetry. The term “SCADA” was coined in the early 1970s.SCADA systems are mainly used for the implementation of monitoring and control system of an equipment or a plant in several industries like power plants, oil and gas refining, water and waste control, telecommunications, etc.

Flexible AC Transmission Systems (FACTS)

Flexible AC Transmission Systems (FACTS) is comprised of power electronics-based equipment to enhance stability and power transfer capability of the network. Base on the connection and operation of components, there are four categories of FACTS Controllers. Series Controllers, Shunt Controllers, Combined series-series controllers, Combined series-shunt controllers. With the purpose of controlling current and power flow, the series controller which impacts the voltage and power flow directly is several times more powerful than the shunt one. Shunt controller, on the other hand, is better method for controlling voltage around the connection point through injection of reactive current. Since the introduction of FACTS devices for over two decades, they have been in use in many substations around the world. Despite the relatively high cost, they offer some very important benefits to the power systems.

- Power flow can be controlled to meet utilities’ and power systems’ needs
- Loading capability of lines is increased significantly close to their thermal limits.
- System stability and security are increased as they limit fault currents; manage cascading blackout and damp oscillation of the systems.
- Lines’ carrying capacity is enhanced since reactive power flow is reduced. FACTS technology increases power and enhances the capacity of transmission lines by controlling the parameters of the lines.

It is not a substitution for mechanical switches but FACTS is used in combination with other controllers to extend the carrying power of a line to reach closer to its limits. The improvement in power semiconductor technology and the decrease of FACTS controllers’ cost open up the opportunity of applying FACTS technology at a large-scale.

CHAPTER 5

System Requirement

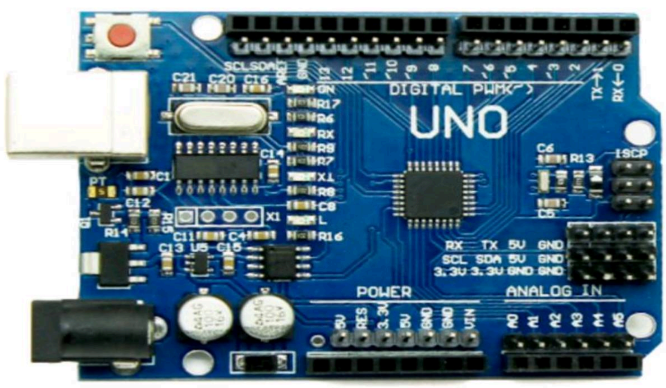
- **Hardware Requirement**

1) Arduino UNO
2) Relay Module
3) Voltage Sensor
4) Adapter
5) LCD Display
6) Contactor

1) Arduino UNO

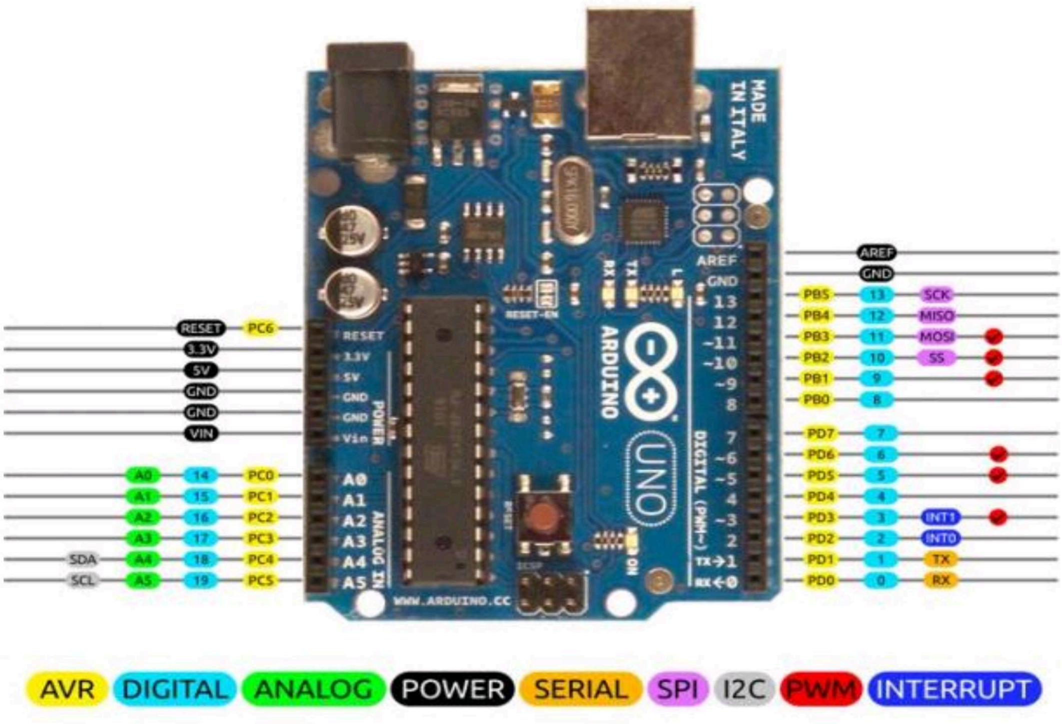
Arduino is an open-source hardware and software platform that enables users to create interactive electronic projects. It consists of a physical computing board and a development environment that can be used to write and upload code to the board. The Arduino board is typically based on a microcontroller, which is a small computer on a single integrated circuit that is used to control and process electronic devices. Arduino Uno is a popular microcontroller development board based on 8-bit ATmega328P microcontroller. Along with ATmega328P MCU IC, it consists other components such as crystal oscillator, serial communication, voltage regulator, etc. to support the microcontroller.

The Arduino board can be programmed using the Arduino programming language, which is a variant of C++. The Arduino development environment provides a simple interface for writing and uploading code to the board, and it includes a number of built-in libraries and examples that can be used to get started with the platform.



- **Arduino UNO Pin Configuration :**

Pin Category	Pin Name	Details
Power	Vin 3.3V 5V GND	1) Vin: Input voltage to Arduino when using an external power source. 2) 5V: Regulated power supply used to power microcontroller and other components on the board. 3) 3.3V: 3.3V supply generated by on-board voltage regulator. Maximum current draw is 50mA. 4) GND: ground pins.
Reset	Reset	Resets the microcontroller
Analog Pins	A0-A5	Used to provide analog input in the range of 0-5V
Input/Output Pins	Digital Pins 0 - 13	Can be used as input or output pins
Serial	0(Rx), 1(Tx)	Used to receive and transmit TTL serial data
External Interrupts	2,3	To trigger an interrupt
PWM	3,5,6,9,11	Provides 8-bit PWM output
SPI	10 (SS), 11 (MOSI), 12 (MISO) and 13 (SCK)	Used for SPI communication
Inbuilt LED	13	To turn on the inbuilt LED
TWI	A4 (SDA), A5 (SCA)	Used for TWI communication
AREF	AREF	To provide reference voltage for input voltage



2) Relay Module

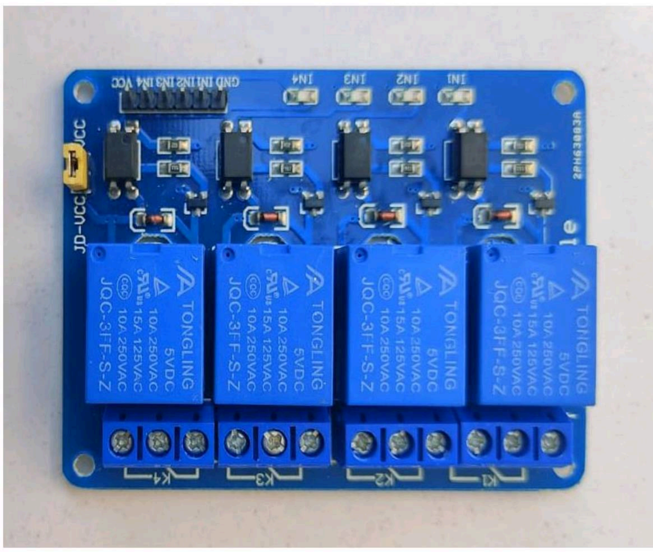
A relay module is an electronic device that is used to switch high-voltage or high-current circuits using a low-voltage or low-current signal. It consists of a relay, which is an electrically operated switch, and a control circuit, which is used to energize or de-energize the relay coil.

The relay module is typically designed to be used with a microcontroller or other digital control circuit, such as an Arduino. The control circuit sends a signal to the relay module, which then switches the high-voltage or high-current circuit on or off.

This is a low level 5V 4-channel relay interface board, and each channel needs a 15-20 mA driver current. It can be used to control various appliances and equipment with large current. It is equipped with high-current relays that work under AC 250V,10A or DC 30V,10A. It has a standard interface that can be controlled directly by microcontroller. This module is optically isolated from high voltage side for safety requirement and also prevent ground loop when interface to microcontroller.

Relay modules are used in a wide range of applications, including industrial automation, home automation, robotics, and automotive electronics. They are commonly used to control motors, lights, solenoids, and other high-power devices.

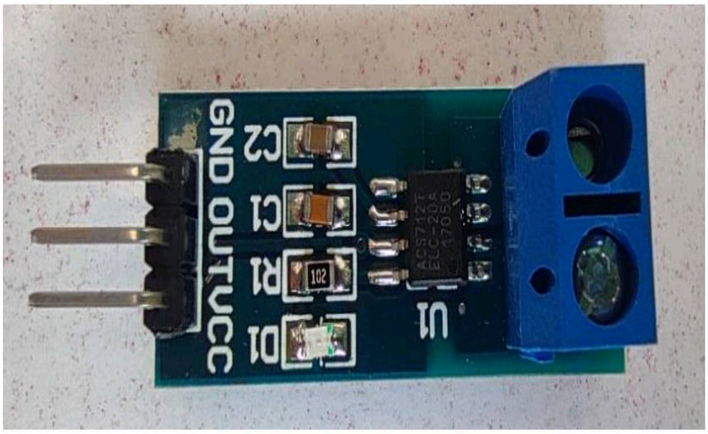
There are many different types of relay modules available, with different specifications and features. Some relay modules are designed to switch AC voltage, while others are designed to switch DC voltage. Some relay modules are designed to switch high-current circuits, while others are designed to switch low-current circuits. Some relay modules include multiple relays, allowing multiple circuits to be controlled independently.



3) Voltage Sensor

A voltage sensor is a device that measures voltage of an electrical circuit. Voltage sensors can measure the voltage in various ways, from measuring high voltages to detecting low current levels. Voltage sensors can detect changes in voltage as well as current, which means they can be used to measure anything from light levels to temperature. This sensor is used to monitor, calculate and determine the voltage supply. This sensor can determine the AC or DC voltage level.

The input of this sensor can be the voltage whereas the output is the switches, analog voltage signal, a current signal, an audible signal, etc. This sensor includes input and output. The input side mainly includes two pins namely positive and negative pins. The two pins of the device can be connected to the positive & negative pins of the sensor. The device positive & negative pins can be connected to the positive & negative pins of the sensor. The output of this sensor mainly includes supply voltage (VCC), ground (GND), analog o/p data. These sensors are essential for many applications, including industrial controls and power systems.



4) Adapter

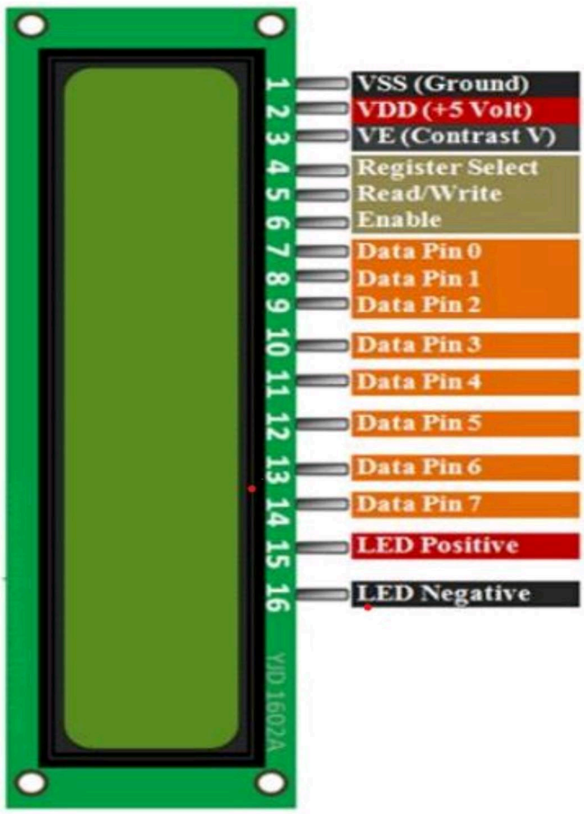
An AC adapter is an external power supply that converts alternating current (AC) from a wall outlet to a direct current (DC) needed by an electronic device. Therefore, it is an AC/DC converter. When it supplies power to a battery-powered device, it is also accurate to describe it as a charger.

5) LCD Display

LCD (Liquid Crystal Display) is a type of flat panel display which uses liquid crystals in its primary form of operation. A display is made up of millions of pixels. The quality of a display commonly refers to the number of pixels; for example, a 4K display is made up of 3840*2160 or 4096*2160 pixels. A pixel is made up of three subpixels; a red, blue and green, commonly called RGB. When the subpixels in a pixel change colour combinations, a different colour can be produced. With all the pixels on a display working together, the display can make millions of different colours. When the pixels are rapidly switched on and off, a picture is created.

- **Technical Specification :**

1) Operating Voltage is 4.7V to 5.3V.
2) Current consumption is 1mA without backlight.
3) Alphanumeric LCD display module, meaning can display alphabets and numbers.
4) Consists of two rows and each row can print 16 characters.
5) Each character is build by a 5×8 pixel box.
6) Can work on both 8-bit and 4-bit mode.
7) It can also display any custom generated characters,
8) Available in green and blue backlight.

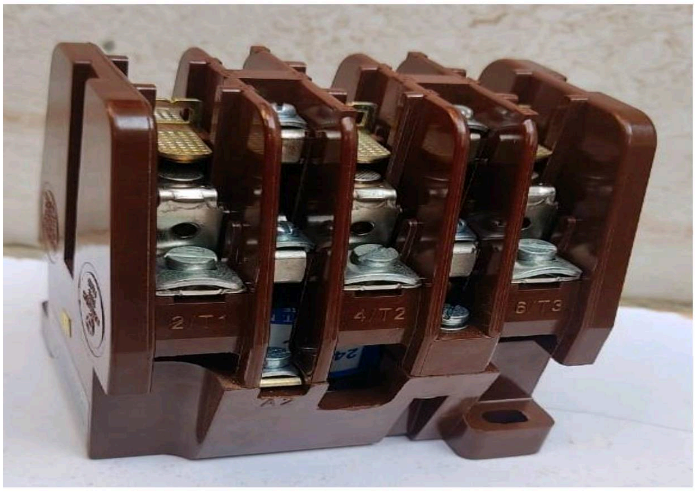


6) Contactor

The contactor is an electromechanical control device that used to make or break the connection between the load and power supply. The use of a contactor is similar to the relay. But the device used for higher current carrying application is known as a contactor and the device used for lower current applications is known as Relay. A contactor has several contacts as per the application and load. Generally, these contacts are normally open (NO) contact. And hence the load is shut off when the coil of the contactor is de-energized.

A contactor is an electrically-controlled switch used for switching an electrical power circuit. A contactor is typically controlled by a circuit which has a much lower power level than the switched circuit, such as a 24-volt coil electromagnet controlling a 230-volt motor switch. Unlike general-purpose relays, contactors are designed to be directly connected to high-current load devices. Relays tend to be of lower capacity and are usually designed for both normally closed and normally open applications. Devices switching more than 15 amperes or in circuits rated more than a few kilowatts are usually called contactors.

Unlike relays, contactors are designed with features to control and suppress the arc produced when interrupting heavy motor currents. Contactors come in many forms with varying capacities and features. Unlike a circuit breaker, a contactor is not intended to interrupt a short circuit current. Contactors range from those having a breaking current of several amperes to thousands of amperes and 24 V DC to many kilovolts.



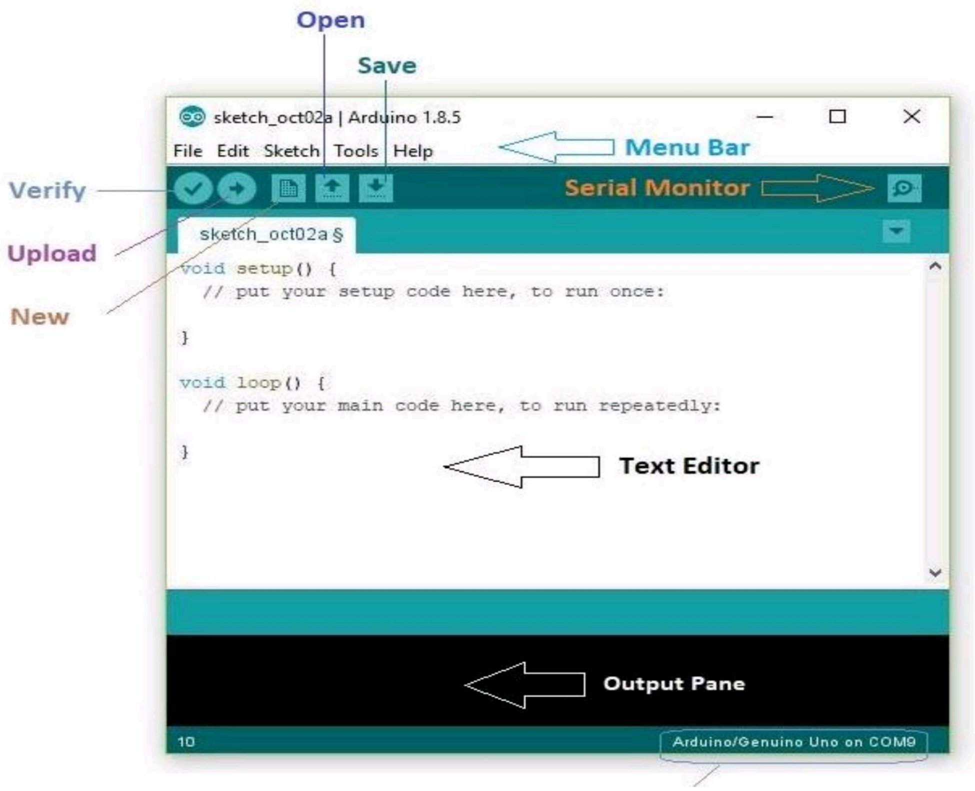
- **Software Requirement**

1) Arduino IDE
2) Proteus

1) Arduino IDE Software :

The Arduino Integrated Development Environment (IDE) is a cross-platform application (for Windows, mac operating system, Linux) that is written in functions from C and C++. It is used to write and upload programs to Arduino compatible boards, but also, with the help of third-party cores, other vendor development boards. Arduino code is written in C++ with an addition of special methods and functions, which we'll mention later on. C++ is a human-readable programming language. When you create a 'sketch' (the name given to Arduino code files), it is processed and compiled to machine language.

The Arduino Integrated Development Environment - or Arduino Software (IDE) - connects to the Arduino boards to upload programs and communicate with them. Programs written using Arduino Software (IDE) are called sketches. These sketches are written in the text editor and are saved with the file extension (.ino).



2) Proteus Simulation design software

The proteus is an electronic circuit design software which includes a schematic capture, simulation and PCB (Printed Circuit Board) layout modules. The proteus design suite is a proprietary software tool suite used primarily for electronic design automation. The software is used mainly by electronic design engineers and technicians to create schematics and electronic prints for manufacturing printed circuit boards.

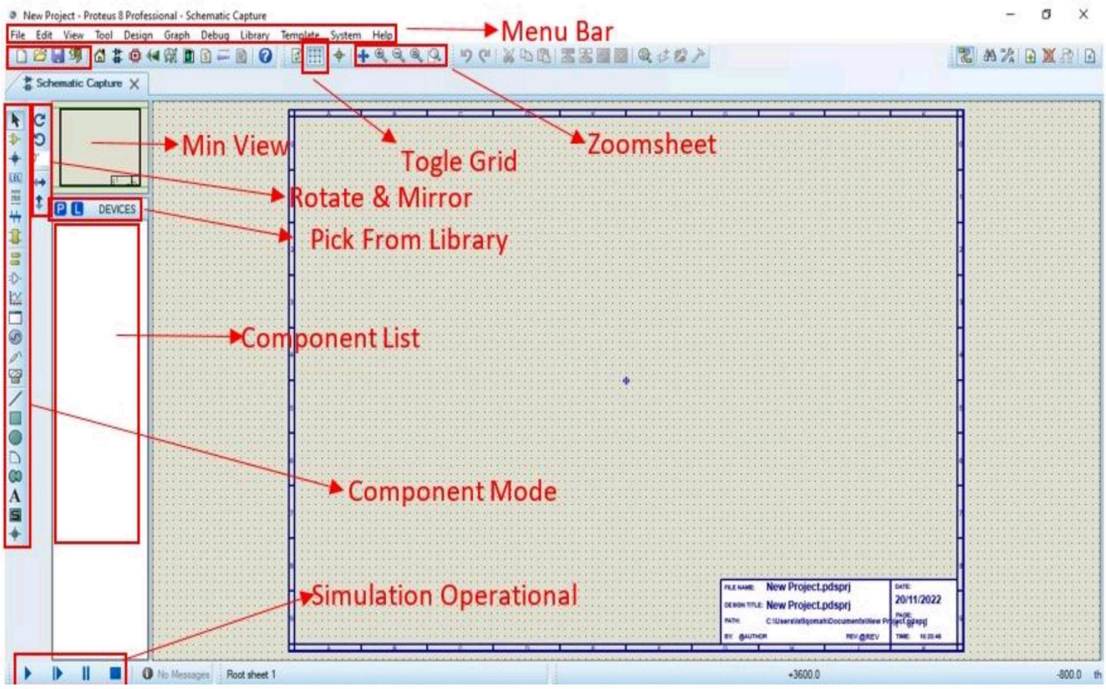
Proteus is a simulation software used to simulate components and is capable of drawing desired circuit. It is being used for fast check-up of code you have written for microcontrollers. Proteus have huge list of components and many libraries available which can be added to include more components.

- **Features of Proteus software :**

1) There are 2 main parts of proteus first is used to design and draw different circuits and the second is for designing of PCB layout.

2) First is ISIS that used to design and simulate circuits and second is ARES that used for designing of a printed circuit board.

3) It also provides features related to the three-dimensional view of design in PCB.



- **Simulation Code**

```
#include <LiquidCrystal.h>


const int rs = 8, en = 9, d4 = 10, d5 = 11, d6 = 12, d7 = 13;
LiquidCrystal lcd(rs, en, d4, d5, d6, d7);

int LINE_1 = A0;
int LINE_2 = A1;
int LINE_3 = A2;
const int A = 2;
const int B = 3;
const int C = 1;
int relay=13;
int a = 0;
int b = 0;
int c = 0;
int A_1 = 0;
int B_1 = 0;
int C_1 = 0;
void setup() {
  lcd.begin(16, 2);
  Serial.begin(9600);
  pinMode(LINE_1, INPUT);
  pinMode(LINE_2, INPUT);
  pinMode(LINE_3, INPUT);
  pinMode(A, INPUT);
  pinMode(B, INPUT);
  pinMode(C, INPUT);
  pinMode(relay,OUTPUT);

}
void loop() {
  a = analogRead(LINE_1);
  b = analogRead(LINE_2);
  c = analogRead(LINE_3);
  A_1 = digitalRead(A);
  B_1 = digitalRead(B);
  C_1 = digitalRead(B);

  if ((a > 10) && (b > 10) && (c > 10))
  {
    lcd.clear();
    lcd.print("PH V:");
    lcd.setCursor(0, 1);
```

```
    lcd.print("Ct:");

    lcd.setCursor(5, 0);
    lcd.print("5V");
    lcd.setCursor(5, 1);
    lcd.print("0.12mA");
b;

    lcd.setCursor(9, 0);
    lcd.print("");
    lcd.setCursor(9, 1);
    lcd.print(" ");


    lcd.setCursor(13, 0);
    lcd.print("");
    lcd.setCursor(13, 1);
    lcd.print(" ");

    delay(1000);
  }
  if ((a < 10) && (b < 10) && (c < 10))
  {
    lcd.clear();
    lcd.print("PH:");
    lcd.setCursor(0, 1);
    lcd.print("FLT:");
    lcd.setCursor(15, 1);
    lcd.print("C");
    lcd.setCursor(5, 0);
    lcd.print("P1");
    lcd.setCursor(5, 1);
    lcd.print(" ");

    lcd.setCursor(8, 0);
    lcd.print("P2");
    lcd.setCursor(8, 1);
    lcd.print("");

    lcd.setCursor(12, 0);
    lcd.print("P3");
    lcd.setCursor(12, 1);
    lcd.print("O ");
    delay(1000);
  }
  if ((a > 10) && (b > 10) && (c < 10))
```

```
{
 lcd.clear();
 lcd.print("PH:");
 lcd.setCursor(0, 1);
 lcd.print("FLT:");
 lcd.setCursor(15, 1);
 lcd.print("C");
 lcd.setCursor(12, 0);
 lcd.print("P3");
 lcd.setCursor(12, 1);
 lcd.print("O");
 delay(1000);
}
if ((a > 10 ) && (b < 10) && (c < 10))
{
 lcd.clear();
 lcd.print("PH:");
 lcd.setCursor(0, 1);
 lcd.print("FLT:");
 lcd.setCursor(15, 1);
 lcd.print("C");
 lcd.setCursor(8, 0);
 lcd.print("P2");
 lcd.setCursor(8, 1);
 lcd.print(" ");
 lcd.setCursor(12, 0);
 lcd.print("P3");
 lcd.setCursor(12, 1);
 lcd.print("O");
 delay(1000);
}
if ((a < 10 ) && (b > 10) && (c > 10))
{
 lcd.clear();
 lcd.print("PH:");
 lcd.setCursor(0, 1);
 lcd.print("FLT:");
 lcd.setCursor(15, 1);
 lcd.print("C");
 lcd.setCursor(5, 0);
 lcd.print("P1");
 lcd.setCursor(5, 1);
 lcd.print("O ");
 delay(1000);
}
if ((a < 10 ) && (b < 10) && (c > 10))
```

```
{
  lcd.clear();
  lcd.print("PH:");
  lcd.setCursor(0, 1);
  lcd.print("FLT:");
  lcd.setCursor(15, 1);
  lcd.print("GO");
  lcd.setCursor(5, 0);
  lcd.print("P1");
  lcd.setCursor(5, 1);
  lcd.print("L ");
  lcd.setCursor(8, 0);
  lcd.print("P2");
  lcd.setCursor(8, 1);
  lcd.print("L ");
  delay(1000);
}
if ((a > 10 ) && (b < 10) && (c > 10))
{
  lcd.clear();
  lcd.print("PH:");
  lcd.setCursor(0, 1);
  lcd.print("FLT:");
  lcd.setCursor(15, 1);
  lcd.print("C");
  lcd.setCursor(8, 0);
  lcd.print("P2");
  lcd.setCursor(8, 1);
  lcd.print("O ");
  delay(1000);
}
if ((a < 10 ) && (b > 10) && (c < 10))
{
  lcd.clear();
  lcd.print("PH:");
  lcd.setCursor(0, 1);
  lcd.print("FLT:");
  lcd.setCursor(15, 1);
  lcd.print("G");
  lcd.setCursor(5, 0);
  lcd.print("P1");
  lcd.setCursor(5, 1);
  lcd.print("L ");
  lcd.setCursor(12, 0);
  lcd.print("P3");
  lcd.setCursor(12, 1);
```

```
    lcd.print("L ");
    delay(1000);
  }
  if (A_1 == HIGH)
  {
    Serial.println("FAULT");
    lcd.clear();
    lcd.print("PH:");
    lcd.setCursor(0, 1);
    lcd.print("SC:");
    lcd.setCursor(15, 1);
    lcd.setCursor(5, 0);
    lcd.print("P1");
    lcd.setCursor(5, 1);
    lcd.print("5mA");
    lcd.setCursor(12, 0);
    lcd.print("P3");
    lcd.setCursor(12, 1);
    lcd.print("5mA");
    delay(5000);

  }
  if (B_1 == HIGH)
  {
    Serial.println("FAULT");
    lcd.clear();
    lcd.print("PH:");
    lcd.setCursor(0, 1);
    lcd.print("SC:");
    lcd.setCursor(15, 1);
    lcd.setCursor(5, 0);
    lcd.print("P2");
    lcd.setCursor(5, 1);
    lcd.print("5mA");
    lcd.setCursor(12, 0);
    lcd.print("P3");
    lcd.setCursor(12, 1);
    lcd.print("5mA");
    delay(5000);

 }
 if (C_1 == HIGH)
{
    Serial.println("FAULT");
    lcd.clear();
    lcd.print("PH:");
```

```
    lcd.setCursor(0, 1);
    lcd.print("SC:");
    lcd.setCursor(15, 1);
    lcd.setCursor(5, 0);
    lcd.print("P1");
    lcd.setCursor(5, 1);
    lcd.print("5mA");
    lcd.setCursor(12, 0);
    lcd.print("P2");
    lcd.setCursor(12, 1);
    lcd.print("5mA");
    delay(5000);

}
}
```

- **Relay Operation Code**

```
const int BUTTON_PIN = 2; // Arduino pin connected to button's pin
const int RELAY_PIN  = 3; // Arduino pin connected to relay's pin

void setup() {
  Serial.begin(9600);                // initialize serial
  pinMode(BUTTON_PIN, INPUT_PULLUP); // set arduino pin to input pull-
up mode
  pinMode(RELAY_PIN, OUTPUT);        // set arduino pin to output mode
}

void loop() {
  int buttonState = digitalRead(BUTTON_PIN); // read new state

  if (buttonState == LOW) {
    Serial.println("The button is being pressed");
    digitalWrite(RELAY_PIN, HIGH); // turn on
  }
  else
  if (buttonState == HIGH) {
    Serial.println("The button is unpressed");
    digitalWrite(RELAY_PIN, LOW);  // turn off
  }
}
```

CHAPTER 6
Working and Circuit Diagram

Working

The project represents a model of 33/11kV substation. Here we have simulated the operations performed at the substation under consideration. In our project, mainly we are showcasing the circuit breaker operation and indication on occurrence of fault to the control room.

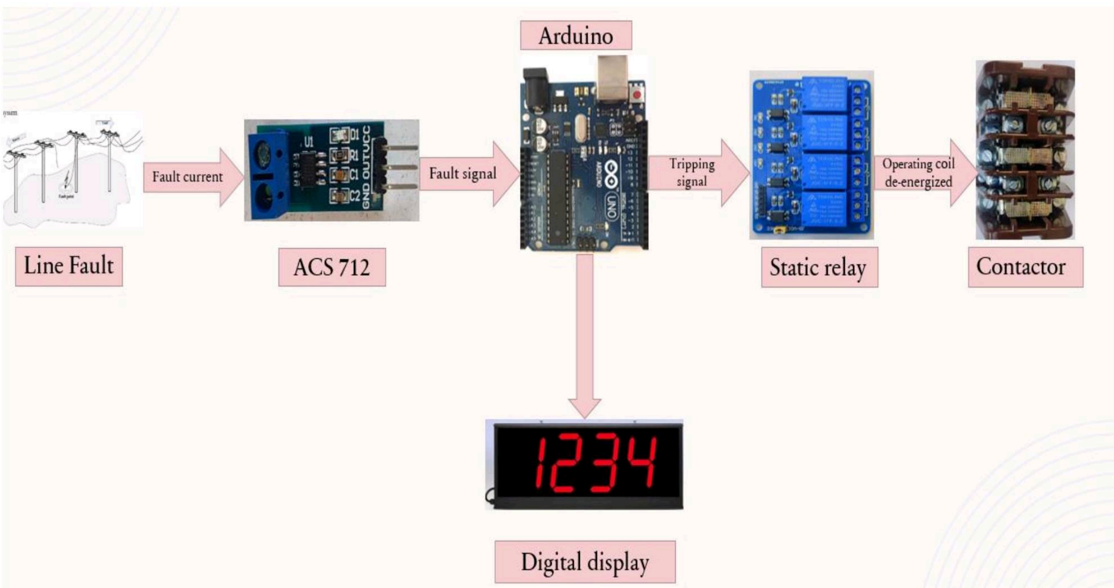
Circuit breaker is a safety device that is used to protect electrical circuits from damage caused by excessive current. It works automatically by interrupting the flow of electricity when a fault or overload occurs. When a fault occurs in the system it is sensed by the relays at the substation whereas in our project the sensing operation is performed by the voltage sensors (ACS) which senses the voltage drop in the circuit when the fault occurs.

For measuring current in a circuit, a sensor is required. ACS712 sensor is the sensor that can be used to measure and calculate the amount of current applied to the conductor without affecting the performance of the system. These voltage sensor's output is given to the relay unit via Arduino.

Here is used to monitor the current flow in the electrical circuit and trip the relay uni. If the current exceeds a certain threshold value the arduino gives a signal to the relay circuit.

The relay unit is coupled with the contactor operating coil, where during normal operation of the circuit the operating coil gets energized by the relay unit and under faulty condition the relay trips and the operating coil of the contactor gets de-energized and the faulty part of the system gets isolated from the healthy part of the system.

At the substation whenever the fault occurs on the system the indication is shown in the control room, same operation has been performed in our project as the faults occurs on the lines like LL and open circuit fault, it is displayed on the LCD.



The project involves the following steps:

Designing the miniature substation model : This includes the designing of fictitious substation equipment like CT, PT, circuit breaker, isolator, lightening arrestor, etc. It also involves the identification of reduction the factor which helps to scaled down the actual magnitude of substation equipment into a smaller dimension and develop the miniature model of substation.

Designing the circuit : This would involve designing a circuit that includes the Arduino microcontroller, a current sensor, and a relay. The current sensor would be used to measure the current flow in the circuit, and the relay would be used to trip the circuit breaker.

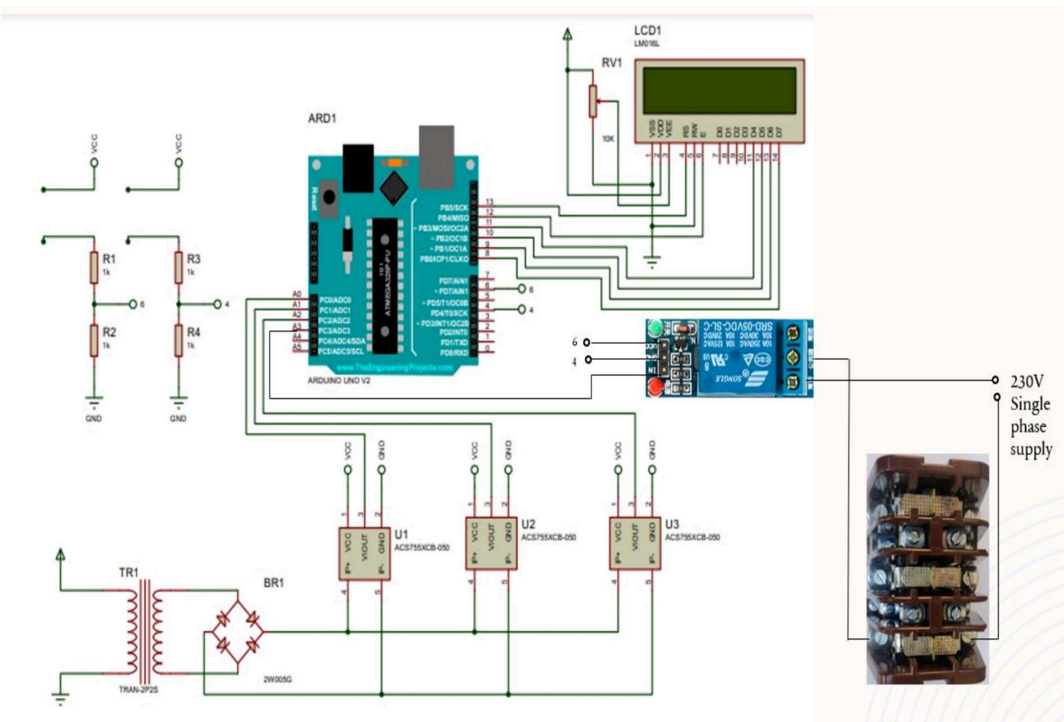
Programming the Arduino : The Arduino would be programmed to read the current sensor data and compare it to a predefined threshold. If the current exceeds the threshold, the Arduino would activate the relay to trip the circuit breaker.

Building the circuit : The designed circuit would be built using breadboards or PCBs. The Arduino and other components would be mounted on the PCB, and the circuit would be tested.

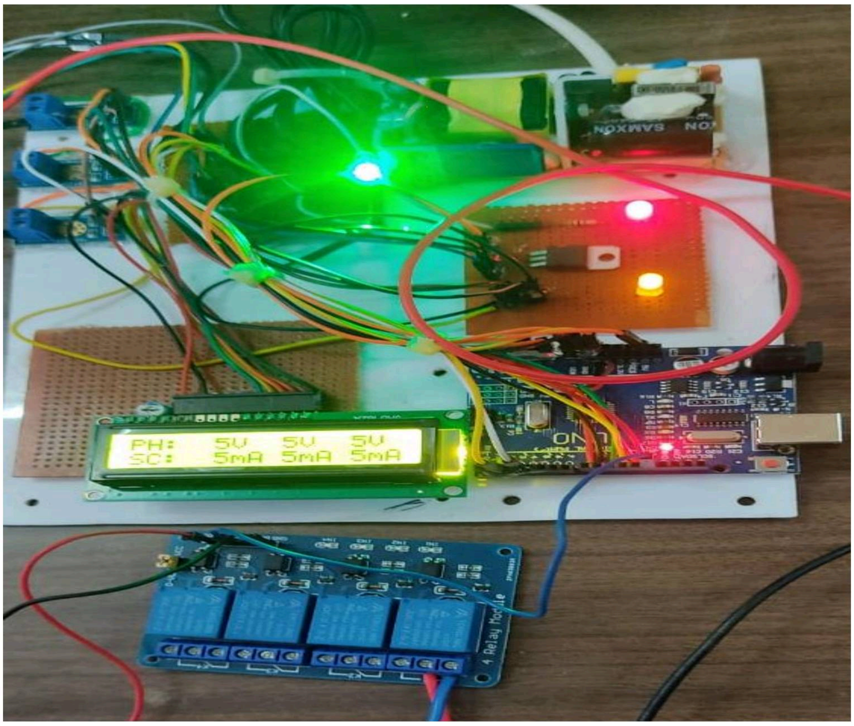
Testing and debugging : The circuit would be tested to ensure that it works as expected. Any issues or errors would be identified and resolved.

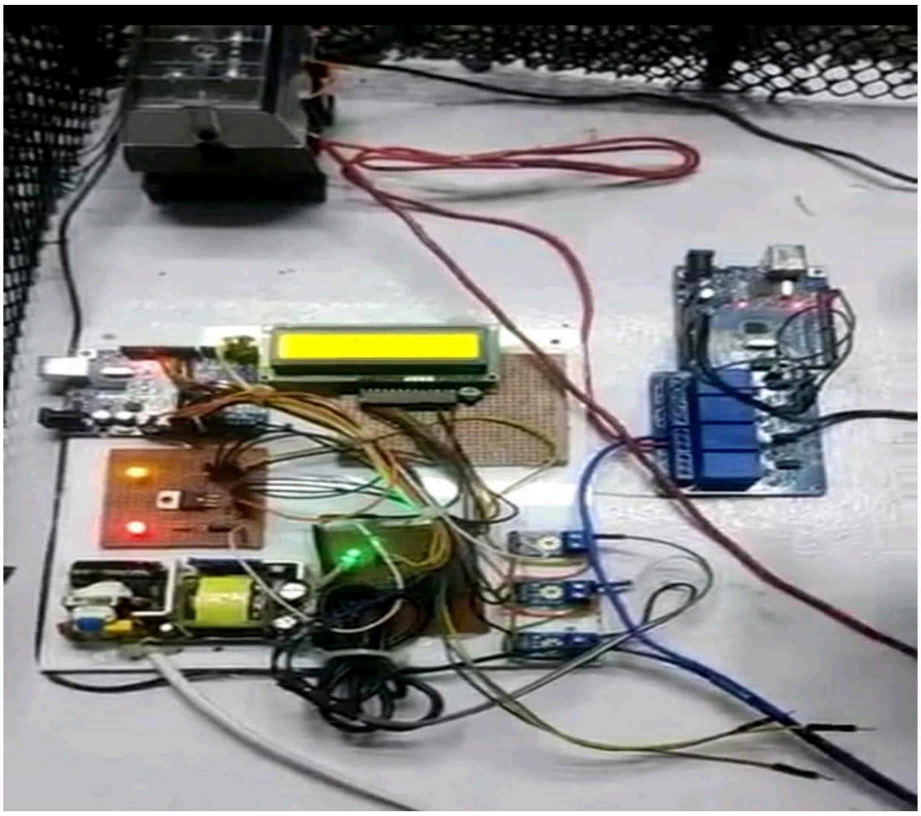
Finalizing the project : Once the circuit is working correctly, the project would be finalized. This would involve documenting the design, implementation, and testing of the circuit.

Circuit Diagram

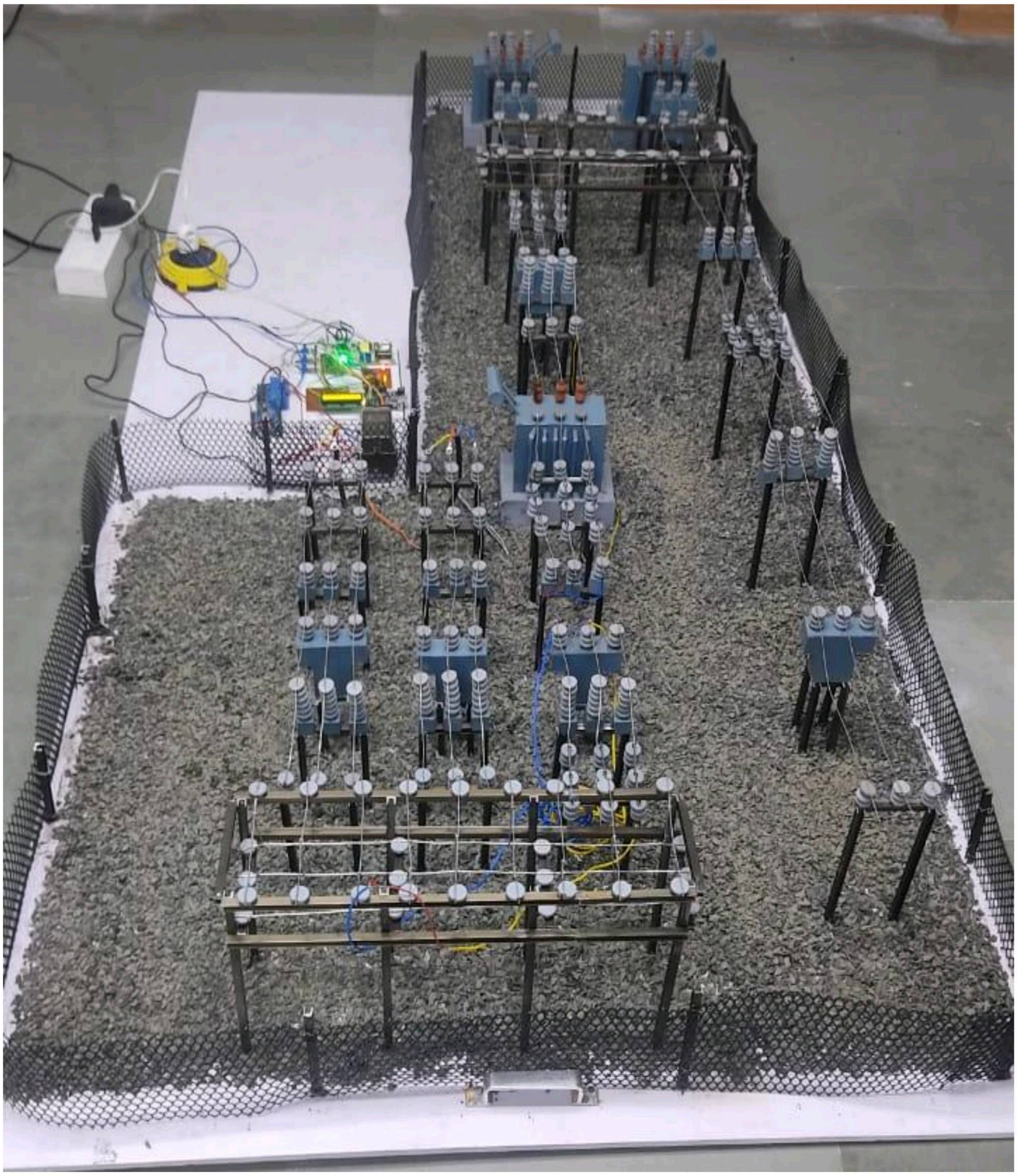


Electronics Circuit





Miniature Working Model of Substation



CHAPTER 7

Future Scope

There are several potential future scopes for a miniature working model of a 33/11 kV substation project, including:

- **Education and Training :** The miniature working model can be used for educational and training purposes. It can be utilized in classrooms or training centers to teach students or professionals about the different components of a substation and how they work together. This can help in enhancing their understanding of power system operations and maintenance.
- **Research and Development :** The miniature working model can be used for research and development purposes. It can be used to simulate different scenarios and test various strategies for improving the efficiency and reliability of the substation. This can help in developing new technologies and techniques for better substation operations.
- **Public Awareness :** The miniature working model can be used for public awareness campaigns. It can be used to demonstrate the importance of substation infrastructure and its role in ensuring uninterrupted power supply. This can help in promoting energy conservation and encouraging the public to be more mindful of their energy usage.
- **Marketing and Sales :** The miniature working model can be used as a marketing and sales tool. It can be showcased in trade shows or conferences to attract potential customers or investors. This can help in generating interest in the substation project and securing funding for future developments.
- **Monitoring and Control :** The miniature working model can be used for monitoring and control purposes. It can be equipped with sensors and control systems to simulate real-time substation operations. This can help in identifying potential issues or inefficiencies and taking corrective actions before they lead to major outages or failures.

CHAPTER 8

Conclusion

In conclusion, our project on the miniature model of a 33/11 kV substation has been successful in achieving its objectives. The model was constructed to showcase the various components and functions of a substation, including transformers, circuit breakers, isolators, and lightning arrestors, and their role in power transmission and distribution.

Through this project, we have gained a better understanding of the complexities involved in designing and constructing a substation, and how different components work together to ensure safe and efficient power distribution. We have also learned about the importance of safety measures and protection schemes in ensuring the reliability and continuity of power supply.

The construction and operation of the model required a combination of electrical, mechanical, and civil engineering principles. We had to carefully plan and design the model, and pay close attention to the details during the construction phase. Our team members worked collaboratively and effectively to complete the project within the given timeline and budget.

Overall, this project has been a great learning experience for all of us, and has helped us to appreciate the importance of substation infrastructure in ensuring reliable and safe power supply. We hope that this project will inspire more young people to pursue careers in engineering and related fields, and contribute to the development of sustainable and resilient power infrastructure in the future.

CHAPTER 9

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Guided by
Dr. Saurabh Jadhao
Team Members -
1. Ankita Madiwale 3. Sejal Hattel
2. Gauri Masne 4. Tanuja Wankhede
5. Vaishnavi Maharkhede
REDMI NOTE 9 PRO
48MP QUAD CAMERA


AI QUAD CAMERA

THANK YOU