

**DESIGN AND IMPLEMENTATION OF VOLTAGE STABILIZER  
USING DC MOTOR**

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*Submitted to the APJ Abdul Kalam Technological University in partial  
fulfilment of the requirements for the award of degree*

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*in*

*Electrical and Electronics Engineering*

*by*

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**CERTIFICATE**

This is to certify that this project report entitled **DESIGN AND IMPLEMENTATION OF VOLTAGE STABILIZER USING DC MOTOR** submitted by **ANUPAMA REJY (PTA21EE03)** to the APJ Abdul Kalam Technological University in partial fulfilment of the B. Tech degree in Electrical and Electronics Engineering is a bonafide record of the project work carried out by them under our supervision. This report has not been submitted to any other University or Institution for any purpose.

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# **ABSTRACT**

This project focuses on the design, development and use of a voltage stabilizer, a crucial component required to keep voltage levels of electrical systems constant. Voltage variations can cause malfunctions, decrease efficiency, and even damage delicate items as our reliance on electronic machinery and equipment grows. This problem is solved by the voltage stabilizer, which automatically adjusts the voltage to keep the output steady despite changes in the input. To manage voltage levels in real time, the project uses a Dc voltage motor, control circuits, and a feedback system. Incorporating sensing devices for voltage detection, a DC motor for accurate adjustments, and an algorithm for smooth operation are important components of the implementation. The stabilizer functionality was examined under various voltage circumstances to guarantee accuracy, efficiency, and dependability. The result illustrates how voltage stabilizers may improve the robustness and efficiency of electrical and electronic systems. This paper provides important information on the real-world implementation of voltage stabilizers in industrial and residential settings by highlighting the technological approach, design concerns, and project outcomes.

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## **LIST OF ABBREVIATIONS**

<b>AVR</b>	: AUTOMATIC VOLTAGE REGULATOR
<b>CVT</b>	: CONSTANT VOLTAGE TRANSFORMER
<b>UPS</b>	: UNINTERRUPTIBLE POWER SUPPLY
<b>EV</b>	: ELECTRIC VEHICLE
<b>PWM</b>	: PULSE WIDTH MODULATION

# **CHAPTER 1**

## **INTRODUCTION**

The objective of this system is to design, develop, and evaluate a voltage stabilizer that effectively regulates the output voltage by dynamically compensating for fluctuations in input voltage. This stabilizer ensures the safe and reliable operation of connected electrical equipment. The system works by dynamically adjusting the output voltage through the use of a DC motor and an autotransformer.

For sensitive electronic gadgets and industrial machinery to operate properly in modern electrical systems, a steady voltage must be maintained. Voltage fluctuations are a prevalent problem in power supply systems that can seriously harm electrical gadgets and lower their working efficiency. In regions with unstable power grids, variations which include both voltage surges and voltage dips are frequent and can result in equipment failures, shorter lifespans, and safety risks.

To guarantee that the connected devices receive the proper quantity of power, a voltage stabilizer is a device made to control and stabilize the voltage to a steady level. A voltage motor mechanism is used to modify the output voltage, continually in reaction to input voltage variations. Voltage stabilizers are perfect for a variety of applications, such as residential dwellings, industrial sectors, and medical facilities, because of their ability to adapt in real-time, which enables them to handle both high and low voltage circumstances effectively.

Devices that are frequently vulnerable to voltage fluctuations, such computers, air conditioners, refrigerators, and medical equipment may malfunction or even burn out. For example, low voltage can result in equipment operating poorly or shutting down completely, while excessive voltage can cause overheating and destroy internal components. In these situations, voltage stabilizers are crucial for protecting electrical equipment since they keep the voltage within a safe and useful range.

DC voltage motor is used in the stabilizer to change the voltage in real time by adjusting the tap of a transformer. In order to account for changes and provide a constant output voltage, the system continually checks the input voltage and moves the transformer tappings using the DC voltage motor. Compared to static stabilizers, which are constrained by set voltage thresholds, this kind of stabilizer is more effective and particularly useful for managing large voltage

variations.

Designing and implementing a voltage-controlled voltage stabilizer that can produce a steady output voltage and shield electrical appliances from the destructive effects of voltage instability is the main goal of this project. Choosing the right parts for this project, such control circuits, voltage motors, and auto transformers, and then incorporating them into a stabilizer system that works. To make sure the system efficiently stabilizes the output and safeguards linked devices, it will be tested under a range of voltage circumstances.

We want to get a better knowledge of the voltage motor mechanism, voltage regulation techniques, and their usefulness in power systems via this research. By avoiding waste that may result from voltage fluctuations, the system will not only protect delicate equipment but also promote energy efficiency. The research also offers important insights into the integration of feedback loops and electrical circuit design, both of which are critical to system stability.

This project is intended to increase the dependability and effectiveness of electrical equipment by concentrating on the design and implementation of a servo stabilizer, decrease downtime and prolong sensitive gadgets' useful lives. Additionally, the research will advance knowledge of DC voltage motor applications in power systems and voltage regulation techniques, which may be useful to other domains including automation, robotics, and industrial control systems. In the end, the use of these stabilizers may improve the general robustness and safety of electronic systems in both commercial and residential settings.

## CHAPTER 2

### BLOCK DIAGRAM REPRESENTATION

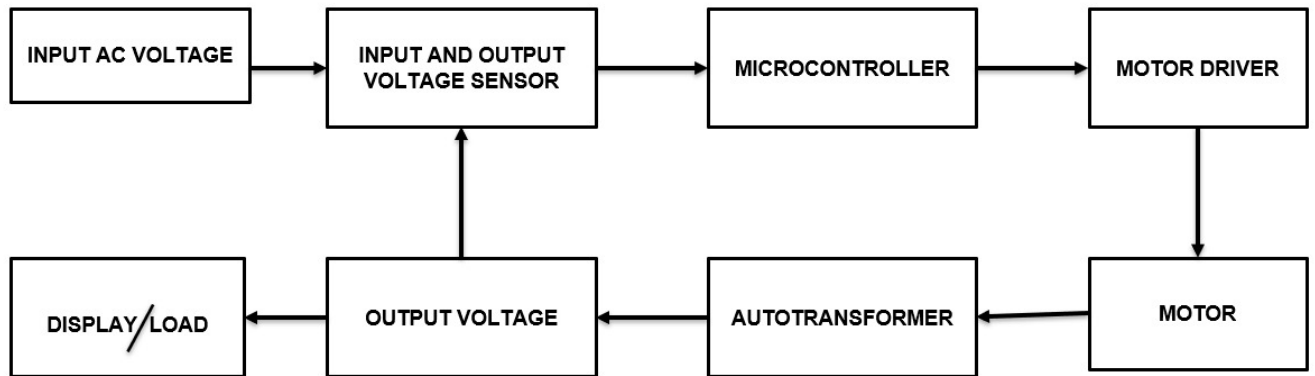


Fig 2.1: Block Diagram of the voltage stabilizer for DC voltage motor

### 2.1 DESCRIPTION OF EACH BLOCK

#### 2.1.1 Input Voltage

The input AC voltage is the primary power source for the system. It is typically obtained from the electrical grid or another AC power supply. This AC voltage is unstable and may vary in magnitude, which is why voltage stabilization is needed for sensitive equipment, such as the DC voltage motor in this case.

#### 2.1.2 Voltage Sensor

The Voltage Sensor is responsible for monitoring the input AC voltage in real-time. It continuously detects fluctuations and provides feedback to the microcontroller, allowing the system to adjust the output accordingly. The voltage sensor ensures that the microcontroller receives accurate data about the input voltage to make the necessary adjustments.

#### 2.1.3 Microcontroller

The Microcontroller is the central processing unit (CPU) of the system. It receives data from the voltage sensor and processes it to control other system components. The microcontroller makes decisions regarding how to stabilize the voltage and adjusts the motor driver to control

the DC voltage motor. It processes the feedback signals to ensure that the motor operates smoothly and responds to varying voltage conditions.



Fig 2.2: Microcontroller (ARDUINO ATMEGA 328p)

#### **2.1.4 Driver of DC Motor**

The Motor Driver interprets the signals from the microcontroller and powers the DC voltage motor. Based on the microcontroller's instructions, the driver regulates the voltage and current supplied to the motor. The driver controls the motor's performance by adjusting its speed, torque, and direction, allowing for precise control of the voltage motor's movement.

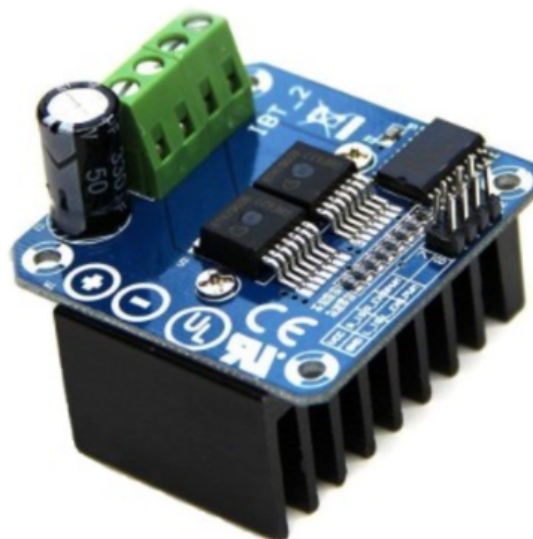


Fig 2.3: Motor Driver (BTS7960)

### **2.1.5 DC Motor**

The DC voltage motor is the actuator that converts electrical energy into mechanical motion. The performance of the DC voltage motor depends on the stability and quality of the input voltage. The motor operates in response to the output provided by the motor driver. In the voltage stabilizer system, the DC voltage motor is used for applications such as automated positioning, speed control, or motion tasks

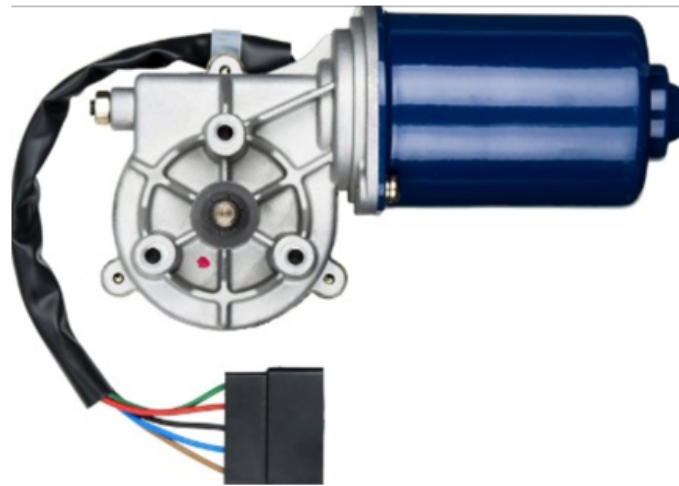


Fig 2.4: Motor (12V DC)

### **2.1.6 Auto Transformer**

The Auto transformer is an essential component in voltage regulation. It adjusts the input AC voltage to a level suitable for the DC voltage motor and reduces any potential strain caused by voltage fluctuations. The auto transformer helps to achieve better efficiency and stability by stepping up or stepping down the voltage, ensuring that the DC voltage motor receives a consistent and reliable voltage.

### **2.1.7 Output Voltage**

The Output Voltage represents the stabilized voltage delivered to the DC voltage motor. The output voltage ensures that the DC voltage motor operates optimally, free from the disturbances caused by input voltage fluctuations. The goal of the voltage stabilizer system is to maintain a constant output voltage, irrespective of changes in the input AC supply.



## **2.2 SYSTEM WORKFLOW**

The system is powered by an AC supply, which serves as the primary input source, initiating the process of voltage regulation and motor control. To ensure the stability of the system, a voltage sensor continuously monitors the incoming AC voltage, detecting even minor fluctuations or variations. This is critical, as unstable or fluctuating voltages can potentially harm connected equipment or cause malfunctions. The voltage data collected by the sensor is then sent to the microcontroller, which acts as the brain of the system. The microcontroller processes this data and determines whether any adjustments need to be made. If the input voltage is found to be too high or low, the microcontroller analyzes the situation and decides on the necessary corrective actions, such as adjusting the voltage or modifying the motor's performance to restore stability. At this stage, the autotransformer steps in, adjusting the incoming AC voltage based on instructions from the microcontroller. By manipulating the position of transformer tapings, it ensures that the voltage is optimized, neither too high nor too low, to provide a consistent and stable power supply to the DC voltage motor. This stable voltage is crucial, as fluctuations can lead to inefficiency or wear on the motor. The motor driver, which is connected to the DC voltage motor, receives control signals from the microcontroller, dictating the motor's speed, torque, and direction according to the system's needs. For example, the microcontroller may increase the motor's torque or adjust its speed to meet higher load demands. Finally, after voltage regulation and motor adjustments, the stabilized output voltage is delivered to the DC voltage motor, ensuring smooth and efficient operation. This well-regulated output voltage not only maintains optimal motor performance but also helps extend the longevity of both the motor and the system as a whole, guaranteeing reliable and efficient operation throughout its lifespan.

## **CHAPTER 3**

### **SYSTEM DESIGN AND COMPONENTS**

The design focuses on integrating a voltage motor, autotransformer, sensor, control circuit, and feedback mechanism into a functional unit that ensures stable voltage regulation under varying power supply conditions. Here, we will discuss the individual components, their specifications, and how they work together to maintain the desired output voltage.

#### **3.1 OVERVIEW OF SYSTEM DESIGN**

The voltage stabilizer system is designed to maintain a constant output voltage regardless of fluctuations in the input voltage. The system is composed of several interconnected components: The system consists of several key components working together to regulate voltage. A voltage motor is used to adjust the voltage by controlling the tapping positions of the transformer, while the transformer itself steps up or steps down the voltage as needed based on the system's requirements. The control circuit monitors and regulates the system's performance by processing feedback from the voltage sensors. These sensors detect both the input and output voltage, providing critical data as required. The feedback mechanism ensures that the voltage motor adjusts the voltage accordingly, based on real-time information from the sensors, allowing for precise voltage control.

Each of these components plays a vital role in the stability and performance of the voltage stabilizer, ensuring that electrical equipment connected to the system operates under safe and regulated voltage conditions.

#### **3.2 DC MOTOR**

The DC voltage motor is the actuator that makes adjustments to the transformer tap, regulating the output voltage in real-time. The precision of the DC voltage motor is key in maintaining the stability of the output voltage.

Type of Motors: Motors come in AC (alternating current) and DC (direct current) types. In voltage stabilizers, AC voltage motors are commonly preferred due to their higher durability, capability to handle larger loads, and more efficient performance over time. However, DC voltage motors are also used in smaller or more specific applications due to their precision and

control in low-power systems.

The DC voltage motor operates by adjusting the transformer's variable tap to step up or step down the voltage based on input changes. The DC voltage motor's position is controlled by the control circuit, which processes the voltage signals received from the voltage sensing unit. The key parts of a voltage motor include:

The DC voltage motor in a stabilizer consists of several key components, including the armature (rotor), which is the rotating part that receives power, and the stator, the stationary part that creates a magnetic field to induce motion in the armature. A feedback mechanism within the motor monitors the armature's position, ensuring that the system knows when the required position is reached. Characteristics such as Torque and speed aids in the process of delivering our purpose. Torque, which determines the amount of force the motor can apply to move the transformer tap, and speed, which dictates how quickly the motor responds to voltage fluctuations, ensuring it can handle voltage spikes or dips. Additionally, accuracy is crucial, as the motor must make small, incremental adjustments to the transformer tap to maintain precise voltage control. The motor is typically controlled using methods like pulse-width modulation (PWM), which adjusts the voltage to the motor, enabling fine control over its movements.

### **3.3 TRANSFORMER**

The transformer in the voltage stabilizer is responsible for stepping up or stepping down the voltage supplied by the power source, making it suitable for the connected load.

#### **3.3.1 Role of the Transformer:**

The transformer works by adjusting the output voltage. It can be a step-up transformer or a step-down transformer based on the requirement. In a voltage stabilizer, a variable transformer is typically used. This transformer has a variable tapping mechanism that can be adjusted to change the output voltage. The DC voltage motor controls this tap to increase or decrease the voltage.

#### **3.3.2 Construction and Design of Transformer:**

The primary coil is connected to the input power supply, while the secondary coil is linked to the load, providing a stabilized output voltage. The variable tap is a section of the transformer that allows the voltage motor to adjust the voltage.

### **3.3.3 Selection Criteria:**

When selecting a transformer, several key factors must be considered. The power rating should match the total load of the devices being protected, ensuring the transformer can handle the required power without any loss of efficiency. The voltage rating is equally important, as the transformer must be capable of providing the desired output voltage to maintain the proper operation of the devices. The impedance of the transformer must also align with the load requirements, as this helps minimize losses during operation. Finally, efficiency is a crucial consideration; the transformer should operate with minimal core and copper losses to ensure optimal performance and energy conservation.

### **3.3.4 Types of Power Transformers:**

Autotransformers are commonly used in voltage stabilizers due to their design, which features a single winding that functions as both the primary and secondary winding. This configuration allows for energy savings in specific applications, as it reduces the amount of copper required and provides more efficient voltage conversion. On the other hand, toroidal transformers are favored in high-frequency voltage stabilizers for their compact size and low electromagnetic interference (EMI). Their circular design reduces the amount of stray magnetic field, making them ideal for applications where space is limited and minimal EMI is critical for performance. Both transformer types offer unique advantages depending on the specific needs of the stabilizer and the application.

## **3.4 CONTROL CIRCUITS**

The control circuit is the brain of the voltage stabilizer. It continuously monitors both the input voltage and the output voltage to ensure that the system provides a stable output.

### **3.4.1 Key Functions of Control Circuit:**

The system is designed to continuously monitor and adjust voltage levels for optimal performance. Voltage monitoring is carried out by sensors that constantly check the input voltage. The control circuit processes these voltage readings and determines whether the output voltage needs to be increased or decreased. If adjustments are needed, the circuit sends signals to the voltage motor to adjust the transformer tap, compensating for any voltage fluctuations. Additionally, the system includes protection and safety features to safeguard both the system and

connected devices. If unsafe voltage levels are detected, the system triggers alarms or cuts off the output to prevent damage.

### **3.4.2 Components of the Control Circuit:**

**Microcontroller:** This is the core component, responsible for processing the input voltage and driving the voltage motor. Popular microcontrollers like Arduino, PLC, or AVR microcontrollers are commonly used. **Voltage Sensors:** These sensors detect the input and output voltage and send this information to the control circuit. Common sensors include resistor-dividers, op-amps, or digital potentiometers. **Relay/ TRIAC Circuit:** Used for switching the voltage motor on or off based on control signals. Relays are typically used for DC circuits, while TRIACs are preferred for AC systems.

### **3.4.3 Design Considerations:**

**Programming:** If using a micro controller, software algorithms will need to be developed to calculate the necessary adjustment for the voltage motor. **Response Time:** The control system needs to be fast enough to make adjustments quickly when voltage fluctuates. **Reliability:** The control circuit must be robust and able to handle various operational conditions, including high currents or unexpected faults.

## **3.5 VOLTAGE SENSING UNIT**

The voltage sensing unit plays a critical role in monitoring and maintaining the stability of the electrical system by detecting fluctuations in both the input and output voltages. It continuously sends real-time data to the control circuit, enabling the system to react instantly to any voltage variations. This immediate feedback is crucial for ensuring that the system adjusts the output voltage in a timely manner, maintaining stability and preventing damage to sensitive equipment. The sensing unit operates by identifying any deviations from the desired reference voltage, whether it's higher or lower than expected. Once these deviations are detected, the voltage sensing unit communicates the information to the control circuit. The control system then processes this data and instructs the voltage motor to make precise adjustments to the output voltage. This dynamic communication ensures that the voltage remains within a stable range, tailored to the load's requirements. For the adjustments to be accurate, the sensors must be of high precision. If the sensors have even a slight margin of error, the system's adjustments

may not be correct. This could result in either over-voltage or under-voltage conditions, which can lead to malfunction or potential damage to sensitive devices that rely on stable voltage inputs. Therefore, using highly accurate voltage sensors is crucial to the overall functionality and protection of the system. To further ensure accurate and timely voltage regulation, a continuous feedback loop is maintained between the sensors and the control system. This loop continuously monitors the voltage levels, and if any discrepancies arise, the sensors relay the updated data to the control circuit, which adjusts the voltage as needed. This process ensures that the voltage remains within safe operational limits. In terms of accuracy, the voltage sensors need to have a very low error margin to ensure that any adjustments made are precise. Even small errors in voltage measurement can lead to significant problems, such as incorrect voltage adjustments, potentially causing harm to the connected equipment or failing to protect it adequately. As such, the sensors play a vital role in ensuring the system is both efficient and safe. The program used in the project plays a key role in managing these processes, by integrating the sensors with the control system and ensuring real-time monitoring and adjustments. The program allows the control circuit to interpret the sensor data, activate the voltage motor for voltage correction, and maintain a constant, safe voltage output. Through precise management and efficient communication between components, the system operates seamlessly to provide stable voltage regulation for sensitive devices.

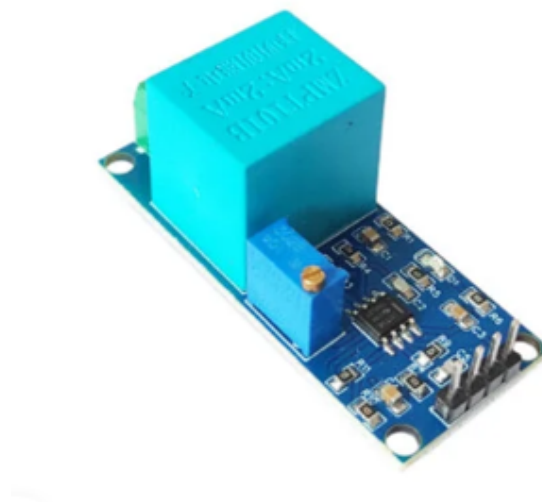


Fig 3.1: Voltage Sensor (ZMPT101B)

### **3.6 EC11 ROTARY ENCODER**

The EC11 Rotary Encoder is a type of electromechanical sensor used to measure rotational position. It consists of a rotating shaft and two output pins (A and B) that generate signals to determine the direction and amount of rotation. The EC11 encoder is commonly used for controlling volume knobs, adjusting settings, and tracking position in various devices. The key features are The encoder typically features two output pins, A and B, which provide signals that are in quadrature, meaning they are out of phase with each other by 90 degrees. This configuration allows the Arduino to detect both the direction and speed of rotation. Some EC11 encoders also come with an integrated push button, located on the encoder's shaft, which can be used for selecting options or confirming actions. Additionally, the encoder usually includes mechanical detents that provide tactile feedback for each step or increment of rotation. These encoders are commonly used in a variety of applications, such as volume control in audio devices like speakers and amplifiers, where they help adjust volume levels smoothly. They are also found in user interface navigation, used in devices like cameras and industrial equipment for menu selection, zooming, or scrolling. In robotics and CNC machines, encoders enable precise motor positioning and movement control. They are integrated into systems like thermostats or light dimmers to allow for easy adjustment of settings through rotational input. Encoders are also used in gaming controllers, such as game pads or arcade machines, to control actions like speed or movement direction, and in machinery and measurement systems to track rotational counts or process cycles. The key advantages of these encoders include precise control, offering accurate rotational feedback for fine adjustments in systems like volume control or motor positioning. They are also highly durable, with mechanical detents providing tactile feedback, making them robust for frequent use in consumer electronics and industrial equipment. Their compact size makes them ideal for integration into space-constrained devices and projects, and they operate with low power consumption, making them beneficial for battery-operated systems. Furthermore, these encoders are versatile, suitable for a wide range of applications, including volume control, menu navigation, robotics, and machinery, and they are easily integrated with microcontrollers like Arduino, making them accessible for DIY projects and prototypes.



Fig 3.2: EC11 Rotary Encoder

### **3.7 FRAME**

The frame serves as the foundation that houses and supports the various components, ensuring stability, protection, and efficient functioning of the system. The frame is designed with outer dimensions of 12 inches in length, 8 inches in breadth, and 9 inches in height, providing ample space for the integration of essential parts such as the voltage motor, control circuit, transformer, and wiring. The structure is constructed using durable materials such as mild steel or aluminum to ensure both strength and lightweight properties, which are critical for maintaining the stability of the stabilizer. The design focuses on providing ease of access for maintenance, adequate ventilation to prevent overheating, and secure mounting for each component to reduce vibrations during operation. The frame is meticulously designed to ensure durability, stability, and optimal performance of the stabilizer system. Its robust construction from materials like mild steel or aluminum guarantees strength while remaining lightweight. The thoughtful layout prioritizes accessibility for maintenance, effective ventilation, and secure component mounting to minimize vibrations. In essence, the frame forms the backbone of the stabilizer, seamlessly integrating and safeguarding all critical components for reliable operation.





Fig 3.3: Frame

### **3.8 FEEDBACK MECHANISM**

The feedback mechanism in a voltage stabilizer system plays a crucial role by ensuring that the system reacts continuously to any voltage fluctuations in real-time, forming an essential part of the closed-loop control system. This mechanism works by continuously monitoring the output voltage and comparing it to the desired voltage. If there is any deviation from the desired level, the control system sends a command to the voltage motor to adjust the transformer tap, bringing the voltage back into the specified range. This process repeats continuously, maintaining a stable voltage output. There are different types of feedback systems, including analog feedback, which is commonly used in traditional voltage stabilizers, where the voltage signal is continuously fed back to the control circuit to adjust the transformer tap. Modern designs, on the other hand, often utilize digital feedback, where voltage values are converted into digital signals for more precise control, typically involving microcontrollers. The feedback system is also responsible for error detection, identifying issues such as under-voltage or over-voltage, and adjusting the system accordingly. This ensures that the voltage motor responds swiftly to changes in input voltage, effectively minimizing any potential damage to the connected devices.

### **3.9 SYSTEM INTEGRATION**

The successful operation of a voltage stabilizer relies on the seamless integration of all its components, including the voltage motor, transformer, control circuit, and feedback loop, which must work together harmoniously. However, there are several integration challenges to address, such as ensuring that the system can handle sudden voltage spikes, preventing overshoot and undershoot during voltage adjustments, and synchronizing all components to respond in real time. To overcome these challenges, system tuning is essential, with each component needing careful calibration to ensure the stabilizer responds accurately to voltage fluctuations. Tuning the control circuit and feedback system is particularly crucial for minimizing errors and optimizing performance. Ultimately, the goal is to ensure efficient operation, reliable voltage regulation, and protection of electrical equipment, maintaining a stable environment for all connected devices. To achieve this, regular maintenance and monitoring are necessary to detect and address any component wear or performance degradation over time. Additionally, incorporating advanced algorithms and adaptive control techniques can further enhance the stabilizer's responsiveness to dynamic load conditions. By prioritizing precision and reliability in both design and operation, the voltage stabilizer can deliver consistent performance, safeguarding sensitive electronics and ensuring uninterrupted power supply.

## **CHAPTER 4**

### **WORKING PRINCIPLE OF VOLTAGE STABILIZER**

#### **4.1 WORKING PRINCIPLE**

A voltage stabilizer is an essential device that stabilizes the output voltage by automatically regulating fluctuating input voltage, ensuring a steady supply to electrical equipment. It uses a voltage motor to adjust the voltage according to the incoming power, keeping sensitive equipment safe from damage caused by voltage surges, sags, or imbalances. The working principle involves detecting fluctuations in the input voltage, adjusting it to a stable level using a variable transformer, and continuously monitoring the output to ensure it remains within a desired range.

##### **4.1.1 Voltage Sensing and Detection:**

The process begins by detecting the input voltage that enters the stabilizer. The stabilizer is equipped with a voltage sensing circuit that constantly monitors the fluctuations in the input voltage. It checks whether the incoming voltage is within the acceptable range. If the voltage is stable, the stabilizer bypasses any adjustments. However, if there's a deviation (i.e., the voltage is too high or too low), the stabilizer springs into action to restore the voltage to the required level.

##### **4.1.2 Control Mechanism (voltage Motor):**

The primary mechanism for correcting voltage fluctuations is a voltage motor, which is linked to a variac transformer (a type of adjustable transformer). The voltage motor is controlled by the sensing circuit. When voltage deviations occur, the sensing circuit sends a signal to the voltage motor, instructing it to adjust the position of the transformer's tapping point. This adjustment either increases or decreases the output voltage, depending on whether the input is too high or too low. The voltage motor rotates the transformer's shaft, which changes the output voltage smoothly and continuously.

##### **4.1.3 Feedback System:**

The stabilizer also has a feedback loop that ensures real-time monitoring and adjustment of the output voltage. Once the voltage motor has made adjustments to the transformer, the sensing

circuit compares the adjusted output with the set voltage. If the output voltage is still not at the required level, the feedback system continuously signals the voltage motor to make fine adjustments. This real-time correction guarantees that the voltage stays within a stable range, preventing equipment from being exposed to damaging voltage fluctuations.

#### **4.1.4 Regulation of Output Voltage:**

As the system continuously monitors and adjusts, it ensures that the output voltage remains constant despite variations in the input supply. This is crucial in protecting sensitive equipment, which can malfunction or get damaged if exposed to voltage irregularities. If the input voltage is too low, the voltage motor will adjust the transformer to increase the output voltage to the desired level. Similarly, if the input voltage is too high, the voltage motor will reduce the output voltage to prevent overvoltage conditions.

#### **4.1.5 Additional Protection Features:**

**Time Delay Mechanism:** To avoid frequent adjustments for transient voltage spikes, many voltage stabilizers have a time delay function. This function helps to delay the correction action until it's certain that the fluctuation is not temporary.

**Overload Protection:** The stabilizer is often equipped with an overload protection feature that disconnects the power supply when there is excessive current or a short circuit, safeguarding both the stabilizer and the connected equipment.

**Indicator Panel:** A display panel may also be present to provide real-time information about the input and output voltage levels, as well as operational status, enabling easy monitoring.

#### **4.1.6 Final Output:**

Once the voltage motor has adjusted the transformer to the correct position, the stabilized output voltage is sent to the connected load, such as machinery, home appliances, or sensitive electronic devices. The result is a continuous, steady voltage supply that prevents equipment from being affected by power surges or dips.

## CHAPTER 5

### SCHEMATIC DIAGRAM

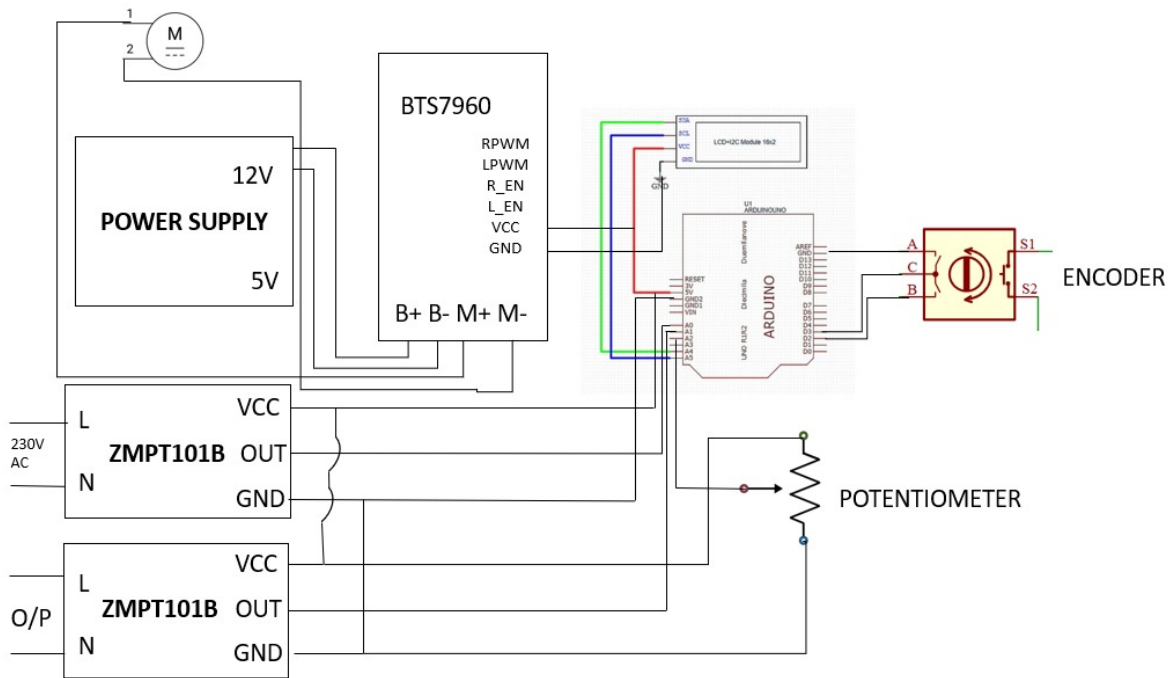


Fig 5.1: Schematic representation of components

The Arduino controls a DC motor using a motor driver (BTS7960), which receives direction signals from the Arduino's digital pins. The voltage sensor is connected to an analog input pin on the Arduino, allowing it to monitor the system's voltage. The LCD display is connected via I2C (SDA and SCL) to show real-time data such as voltage levels and motor status. The Arduino processes sensor readings and controls the motor based on the voltage, displaying relevant information on the LCD. The wiring ensures seamless communication between all components for effective system control and monitoring. This integrated setup ensures efficient motor control, real-time voltage monitoring, and clear data visualization for optimal system performance.

## CHAPTER 6

### SIMULATION

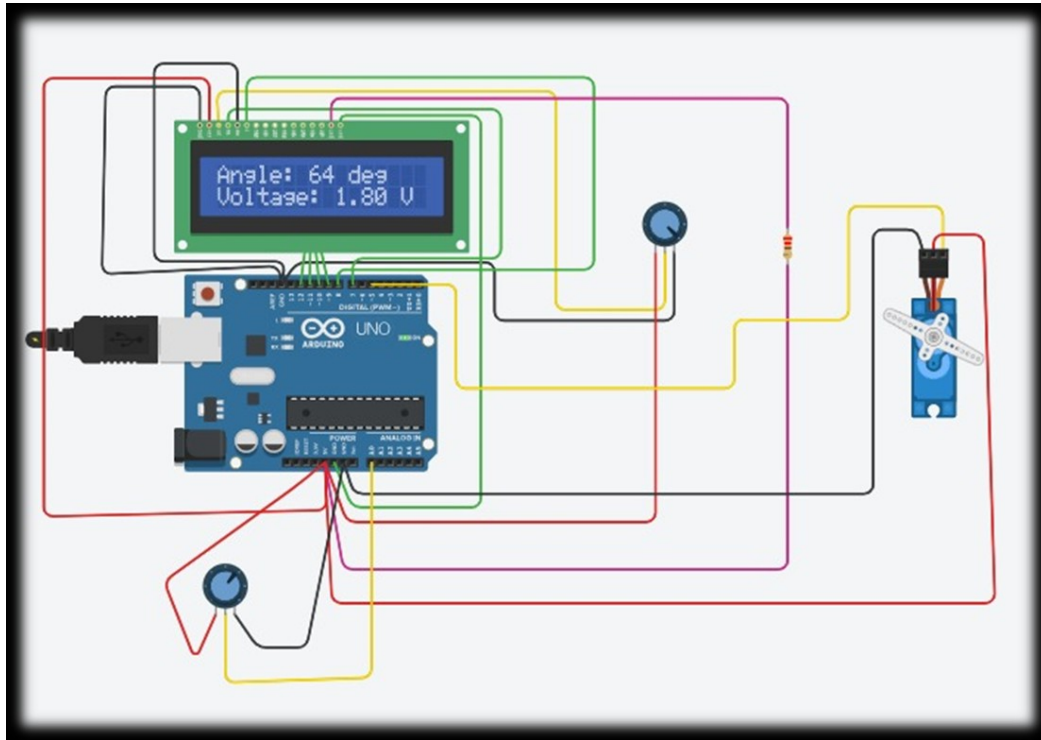


Fig 6.1: Simulation setup

The simulation results showed that the voltage stabilizer efficiently maintained a stable output voltage, even in the face of varying input voltages. Despite fluctuations, the system effectively corrected any deviations, ensuring the output remained within the specified range. This demonstrates the stabilizer's reliability in providing consistent voltage, which is crucial for protecting sensitive equipment from the harmful effects of power surges or drops. Additionally, these results highlight the stabilizer's robust performance and suitability for applications requiring precise voltage regulation under dynamic conditions.

## **CHAPTER 7**

### **METHODOLOGY**

The methodology or approach that was followed to implement the voltage stabilizer project. This chapter describes the systematic process involved, covering component selection, system design, circuit design, assembly and integration, and programming of the stabilizer. Each of these steps is essential to ensure the final system is functional, efficient, and reliable.

#### **7.1 SYSTEM DESIGN**

In designing the voltage stabilizer, careful consideration was given to creating an architecture that is both efficient and easy to troubleshoot. The design process followed key principles such as a Closed-Loop Feedback System, a Modular Design, and the inclusion of essential Safety Mechanisms. A closed-loop feedback system is at the heart of the voltage stabilizer. This approach ensures that the output voltage is constantly adjusted and regulated according to fluctuations in the input voltage. The essential features of a closed-loop system include continuous voltage monitoring, real-time data processing, control signals to the voltage motor, and continuous adjustment. The voltage sensor is responsible for continuously measuring the input voltage, providing real-time data to the microcontroller, which acts as the brain of the system. In an ideal scenario, the input voltage should always match the desired output voltage; however, fluctuations can occur due to various reasons, such as power surges, load changes, or other external factors. The microcontroller processes the data coming from the voltage sensor and determines whether the input voltage is within the required range. If not, it calculates the difference (the error) and generates control signals to correct it. Based on this error, the microcontroller sends control signals, typically in the form of Pulse Width Modulation (PWM), to the voltage motor, which then adjusts the position of the variac transformer. The variac transformer has multiple taps, and by adjusting these taps, the output voltage is regulated. If the input voltage is too high, the system reduces the output voltage by adjusting the tap position, and if it is too low, the system increases the output voltage. The system continuously compares the desired output voltage with the actual output voltage, and if there is any discrepancy, the microcontroller makes further adjustments, sending more control signals to the voltage motor, which then moves the transformer tap to bring the output voltage closer to the desired level.

This feedback loop works continuously, ensuring that the output voltage is always maintained within the acceptable range, even if the input voltage fluctuates. The advantages of this closed-loop system are its accuracy, stability, and adaptability. The system is highly accurate in maintaining the desired voltage since it makes real-time adjustments based on feedback. It offers stable performance even when there are significant fluctuations in the input voltage, making it ideal for applications that require a consistent voltage. As the input voltage fluctuates over time, the system can adapt by making continuous small adjustments, ensuring that the output voltage remains within the set limits.

## **7.2 MODULAR DESIGN**

The voltage stabilizer's system architecture is designed with a modular structure, meaning the entire system is divided into three core functional blocks: Power Supply, Control Circuit, and Output Regulation. Each block is designed independently but works in conjunction with the others to form a complete system. This modular approach offers several benefits, such as ease of troubleshooting, scalability, and flexibility. The power supply module is responsible for providing electrical power to the system, ensuring that all components, including the control circuit and the voltage motor, have a reliable and regulated power source. The power supply is divided into two sections: the AC input supply, which feeds power from the grid to the variac transformer, and the DC supply for the control circuit, which provides stable power to the microcontroller and voltage sensors. The control circuit consists of a microcontroller that processes input voltage data and generates control signals for the voltage motor. Its primary functions include constantly reading voltage data from the sensors, comparing the actual input voltage with the desired output voltage, and sending appropriate control signals to adjust the transformer's tap to maintain stable output voltage. The output regulation module consists of the voltage motor and the variac transformer. The voltage motor adjusts the position of the transformer's tap, regulating the output voltage, while the variac transformer provides a smooth, continuously adjustable voltage output by changing its tap positions. The modular design of the system simplifies troubleshooting, as any issues can be isolated to specific blocks, making it easier to address problems without affecting other parts. Additionally, this structure allows for scalability, enabling future enhancements like adding more sensors or integrating smart features without major redesigns. The modular approach also offers flexibility, as each module can be independently tested, allowing for more efficient development and integration.



of the system.

### **7.3 SAFETY MECHANISMS**

Ensuring the safety of the system and preventing damage to the equipment are key considerations in the design of the voltage stabilizer. Several safety mechanisms were incorporated to provide both operational safety and protection from electrical hazards. The fuse protection system is a common safety feature used in electrical systems, where fuses are included in both the AC input circuit, protecting the transformer, and the control circuit, protecting the microcontroller and other sensitive components. These fuses prevent damage caused by overcurrent conditions, such as power surges or short circuits. Overload protection monitors the system's power consumption, detecting when the load is too high, such as when too many devices are connected to the stabilizer's output. If this occurs, the system can disconnect the load or limit the output voltage. This is achieved through current sensing circuitry that continuously monitors the current drawn by the load, and if it exceeds the safe limit, the control circuit triggers a protective action, such as turning off the system or sounding an alarm. Overvoltage protection ensures the system does not deliver a voltage that could potentially damage connected devices. The control circuit monitors the output voltage, and if it exceeds a certain limit, the system will shut down or switch to a fail-safe mode, preventing damage to sensitive equipment. Safety monitoring is another key aspect, with the microcontroller continuously monitoring the system's performance. If any unsafe conditions, such as overload, overcurrent, or overvoltage, are detected, the microcontroller takes appropriate actions like disconnecting the load, activating alarms or warnings, and automatically restoring normal operation once the fault is cleared. The system may also include a manual reset feature, allowing users to reset the system after addressing a fault condition. Grounding and isolation techniques are employed to further enhance safety. Proper grounding of the transformer and voltage motor helps protect users and components from electrical shocks, while isolation methods, such as optocouplers and transformers, separate high-voltage circuits from low-voltage control circuits, preventing accidental electrical shock and reducing the risk of damage to the control circuit. In conclusion, the system architecture of the voltage stabilizer follows three key principles: the closed-loop feedback system, which ensures continuous monitoring and adjustment of output voltage in response to input fluctuations; the modular design, which divides the system into independent sections for easier testing, troubleshooting, and modification; and safety mechanisms, including fuse

protection, overload protection, and overvoltage protection, ensuring safe operation of the stabilizer and protection of sensitive components. Together, these principles form the foundation of a reliable, safe, and efficient voltage stabilizer capable of maintaining stable output voltage under fluctuating input conditions.

## **7.4 CIRCUIT DESIGN**

The circuit design step involves designing the electrical circuits that connect the selected components and ensure the system functions as intended. The power supply circuit begins with the AC main supply, which is connected to the variac transformer that adjusts the voltage. A regulated DC power supply is also used to power the control circuit, including the microcontroller and sensors. In the control circuit, the voltage sensors are connected to the analog-to-digital converter (ADC) input pins of the microcontroller (e.g., Arduino). These sensors continuously monitor the input voltage and provide the data to the microcontroller. The microcontroller processes the voltage data and compares it to the desired output voltage. If the input voltage is not within the desired range, the microcontroller sends control signals to the voltage motor. These control signals are typically PWM (Pulse Width Modulation) signals, which control the voltage motor's position. The voltage motor control circuit receives the PWM signals from the microcontroller, which adjusts the motor's position to regulate the voltage. The voltage motor moves the transformer's tapping point, thereby changing the output voltage. A feedback loop is established where the microcontroller receives continuous data from the voltage sensors to ensure the output voltage is regulated. The voltage regulation circuit relies on the variac transformer, which is the core of the regulation process. The voltage motor adjusts the tap of the transformer based on the control signals received from the microcontroller, and the output voltage is smoothly adjusted by the transformer. The voltage sensors provide real-time data to the microcontroller for continuous regulation. In terms of safety and protection, the circuit includes overvoltage protection, which disconnects the load or triggers an alarm if the voltage exceeds a certain limit, and overload protection, which ensures that if the load exceeds a safe limit, the system shuts down or adjusts to prevent damage.

## **CHAPTER 8**

### **GEAR DESIGN**

#### **8.1 GEAR DESIGN TERMINOLOGY**

Module definition:  $m = \frac{D}{N}$  (pitch diameter/number of teeth, in mm)

Number of teeth ( $N$ ) : Total teeth forming gear circumference

Pressure angle :  $20^\circ$  (angle between line of action and pitch circle tangent)

Face width : 10mm (axial tooth width)

Clearance : 0.2mm (tip-root gap)

Pitch diameter :  $D = m \times N$

Addendum :  $a = 1 \times m$  (tooth height above pitch circle)

Dedendum :  $d = 1.25 \times m$  (tooth depth below pitch circle)

Root diameter :  $D_{\text{root}} = D - 2.5 \times m$

Material : PLA/ASA for 3D printing

Bore diameter : Shaft mounting hole dimension

Example calculation ( $m = 2\text{mm}$ ,  $N = 10$ ):

$$D = 2 \times 10 = 20\text{mm}$$

$$a = 2\text{mm}, \quad d = 2.5\text{mm}$$

$$D_{\text{root}} = 20 - 5 = 15\text{mm}$$

The gear module (pitch diameter/tooth count in mm) determines tooth size, with tooth count affecting compatibility. The pressure angle ( $20^\circ$ ) governs load distribution. Key dimensions include: face width (tooth length), clearance (tooth gap), pitch diameter (contact circle), addendum ( $1 \times \text{module height}$ ), dedendum ( $1.25 \times \text{module depth}$ ), and root diameter (pitch diameter -  $2.5 \times \text{module}$ ). PLA/ASA materials suit 3D-printed gears, while the bore diameter enables shaft mounting.

## **8.2 GEAR CALCULATION**

### **Input parameters:**

Input speed = 60rpm (motor)

Output speed = 6rpm (auto transformer)

Torque output = 5 Nm (assumed)

$$\text{Gear ratio (GR)} = \frac{\text{Input speed}}{\text{Output speed}} = \frac{60}{6} = 10 \Rightarrow 10 : 1 \text{ reduction}$$

$$\text{GR} = \frac{T_2}{T_1} \quad (\text{Assume } T_1 = 10 \text{ teeth})$$

$$T_2 = \text{GR} \times T_1 = 10 \times 10 = 100 \text{ teeth}$$

$$\text{Gear module (m)} = 2 \text{ mm} = \frac{\text{Diameter}}{\text{Number of teeth}}$$

$$\text{Pitch diameter of } T_1 = m \times T_1 = 2 \times 10 = 20 \text{ mm}$$

$$\text{Pitch diameter of } T_2 = m \times T_2 = 2 \times 100 = 200 \text{ mm}$$

$$\text{Centre distance} = \frac{20 + 200}{2} = 110 \text{ mm}$$

$$\text{Torque of driver} = \frac{5}{10} = 0.5 \text{ Nm}$$

### **DRIVER GEAR (SPUR GEAR):**

Module = 2 mm, Teeth = 10, Pressure angle = 20°

Face width = 10 mm, Clearance = 0.2 mm

Pitch diameter = 20 mm, Addendum = 2 mm

Dedendum = 2.5 mm, Root diameter = 15 mm

Material = Nylon, Bore = 8.3 mm

### **DRIVEN GEAR (SPUR GEAR):**

Module = 2 mm, Teeth = 100, Pressure angle = 20°

Face width = 10 mm, Clearance = 0.2 mm

Pitch diameter = 200 mm, Addendum = 2 mm

Dedendum = 2.5 mm, Root diameter = 195 mm

Material = Nylon, Bore = 10 mm

## **CHAPTER 9**

# **VOLTAGE STABILIZER SYSTEM ASSEMBLY AND TESTING**

### **9.1 ASSEMBLY AND INTEGRATION**

The assembly and integration phase is a critical part of the voltage stabilizer project. This phase involves physically assembling the components, ensuring that they are securely mounted and connected according to the design specifications, followed by initial testing to confirm that each part functions as expected before full system integration. Below is an in-depth explanation of this phase, which includes mounting components, wiring, and initial testing.

#### **9.1.1 Mounting Components**

Once the components were selected and the circuit designs were finalized, the next step was to mount the components onto a chassis. The mounting process ensures that each component is securely positioned, reducing the risk of mechanical failures, vibrations, and ensuring safe operation during the system's use.

#### **9.1.2 Selection of the Chassis**

A metal or plastic chassis was chosen based on the project's requirements. The chassis acts as the backbone of the system, providing a stable and robust frame to mount the components. A metal chassis is preferred in many cases because it provides enhanced strength and can also help in dissipating any heat generated by the system. Size and accessibility were also considered during the selection of the chassis. There had to be enough space for the voltage motor, transformer, control circuit, sensors, and other components. Additionally, the components should be placed in positions where they can be easily accessed for maintenance and troubleshooting.

#### **9.1.3 Placement of Components**

The voltage motor was positioned where it could easily connect to the variac transformer, which is critical for adjusting the transformer tap to regulate the output voltage. It also needed to be placed in a location where it could operate freely without interference from other components. The variac transformer was placed securely within the chassis, ensuring its position allowed

for the smooth movement of the voltage motor to adjust the transformer's tap position. Additionally, it had to be accessible for both wiring and cooling, as transformers can generate heat during operation. The control circuit, which includes the microcontroller and associated components, was mounted in a location where it could easily connect to sensors and the voltage motor. This control circuit is central to the system's operation, as it reads the input voltage from the sensors and sends control signals to the voltage motor based on that data.

#### **9.1.4 Safety Measures During Mounting**

All components were mounted securely using screws, bolts, or fasteners, depending on the component's size and weight, to prevent any movement during operation, which could lead to component failure or interference. A grounding point was incorporated into the chassis to protect the system from electrical shocks in case of fault conditions. Proper grounding is particularly important in high-voltage circuits to ensure both user and system safety. Components that generate heat, such as the transformer or voltage motor, were mounted in locations that allow for adequate ventilation, and if necessary, heat sinks or fans could be incorporated into the chassis to assist with cooling. Once all the components were securely mounted, the next step was to wire them according to the finalized circuit design. Wiring is one of the most crucial aspects of assembly, as improper wiring can result in malfunction, system instability, or even failure of components.

#### **9.1.5 AC Power Connections for the Transformer**

AC power was supplied to the variac transformer. The transformer is the component responsible for regulating the output voltage, so it needs to be connected to the AC power source. The connections were made using heavy-duty, insulated wires rated for high voltage to avoid any accidents or shorts. AC input wiring was carefully routed to prevent interference with other signal or low-voltage wires. Wire clips or cable ties were used to keep the AC wiring secure and in place, avoiding strain on the connections.

#### **9.1.6 DC Power Connections for the Control Circuit and Sensors**

The control circuit and sensors required DC power to function. A regulated DC power supply was used to provide stable voltage to components such as the microcontroller, voltage sensors, and other low-voltage devices. DC power connections were made with properly rated wires and connectors to avoid loose or unreliable connections, which could cause the system to mal-

function. Voltage regulators were used where necessary to ensure that the correct DC voltage is supplied to sensitive components, especially to the microcontroller, which typically operates on 3.3V or 5V.

#### **9.1.7 Signal Wiring Between Sensors, Microcontroller, and voltage Motor**

The voltage sensors were connected to the microcontroller to provide input data about the input and output voltage levels. These sensors need to send continuous data to the microcontroller so that the system can react and adjust the output voltage as needed. Signal wiring was done with low-voltage, shielded cables to avoid interference from high-power cables. Proper insulation was used to ensure there was no risk of short circuits or signal degradation. The voltage motor was connected to the microcontroller via a PWM (Pulse Width Modulation) signal. The microcontroller generates PWM signals based on the input voltage data, and the voltage motor uses these signals to adjust the transformer's position.

#### **9.1.8 Insulation and Safety Precautions**

To prevent electrical hazards, proper insulation was used throughout the system. For AC connections, high-voltage rated insulation was used to cover the wires and connectors. Insulating tapes and heat shrink tubing were applied to areas where wires were exposed or at risk of rubbing against other components, ensuring that no part of the wiring could cause a short circuit or electrical shock. Special attention was given to ensuring that all wiring was kept well-organized, and cable ties were used to secure wires in place and avoid tangling or strain on the connections. This also prevents overheating and ensures the system runs smoothly.

#### **9.1.9 Initial testing**

After all components were mounted and the wiring was completed, the next important step was initial testing. This phase allows for individual verification of each component's functionality and ensures that the system works as expected before full integration. Initial testing was carried out in three key steps: testing the control circuit, testing the voltage motor, and checking signal integrity.

#### **9.1.10 Testing the Control Circuit:**

The first component to be tested was the control circuit, primarily the microcontroller. The microcontroller was powered on, and a basic test program was loaded onto it to verify that

it could correctly read input data from the voltage sensors. The microcontroller's analog-to-digital converter (ADC) was tested by checking if it could accurately measure the input voltage and convert it into a usable signal. The test program also checked if the microcontroller could send control signals to the voltage motor by generating PWM signals. The response of the microcontroller to various input voltage conditions was tested, simulating fluctuations to verify that the system would react accordingly.

#### **9.1.11 Testing the voltage Motor Response:**

The voltage motor was tested independently to ensure it was working correctly. The motor was activated using the PWM signals generated by the microcontroller to ensure it moved in response. The motor's movement was monitored to check for smooth operation and accurate positioning of the variac transformer's tap. If the voltage motor was not responding as expected, troubleshooting was carried out to determine whether the issue was with the motor, the control circuit, or the wiring. Load testing of the voltage motor was also performed, where different input voltages were simulated, and the system was observed to see if the voltage motor adjusted the transformer tap position appropriately.

#### **9.1.12 Verifying Signal Transmission:**

The signal connections between the microcontroller, sensors, and the voltage motor were thoroughly tested. Using an oscilloscope or multimeter, the signals were checked for continuity, proper voltage levels, and accuracy. It was important to ensure that the PWM signal from the microcontroller was transmitted properly to the voltage motor, and that the sensor signals were accurately relayed back to the control circuit.

#### **9.1.13 Simulating Input Voltage Fluctuations:**

A variable AC power supply was used to simulate different input voltage conditions. The response of the system to both under-voltage and over-voltage was monitored, ensuring the stabilizer could adjust the output voltage accordingly. The system's ability to handle rapid changes in input voltage was tested to ensure the voltage motor and transformer responded quickly enough to maintain a stable output voltage.



## **CHAPTER 10**

### **ALGORITHM**

The implementation of a voltage stabilizer involves monitoring and regulating the output voltage by adjusting the position of a variac transformer through a voltage motor. This process requires continuous feedback from the voltage sensor to the Arduino, which then controls the voltage motor via a voltage driver to adjust the transformer tap. The following algorithm outlines the system operation in detail:

#### **10.1 STEP I**

Initialize the system: Begin by initializing the Arduino, voltage sensor, encoder, and voltage motor driver to prepare the system for operation.

#### **10.2 STEP II**

Monitor input voltage: Continuously measure the input voltage using the voltage sensor to track any fluctuations or changes in the supply voltage.

#### **10.3 STEP III**

Compare input voltage with desired voltage: The system compares the input voltage with the desired output voltage. If the input voltage is lower than the target value, the voltage motor will be adjusted to increase the output voltage. If the input voltage is higher, the voltage motor will adjust to decrease the output voltage.

#### **10.4 STEP IV**

Adjust voltage motor position: Using the voltage motor driver, control the movement of the voltage motor based on the voltage comparison. The voltage motor will adjust the transformer tap to regulate the output voltage according to the desired level.

#### **10.5 STEP V**

Monitor voltage motor position using encoder: Continuously check the encoder feedback to ensure that the voltage motor reaches and maintains the target position. This ensures accurate

adjustments in the transformer tap.

## **10.6 STEP VI**

Safety mechanisms: The system includes safety checks to detect over-voltage, overcurrent, or voltage motor limits. If any of these conditions are detected, the system will trigger an alarm or stop the motor to protect the system from damage.

## **10.7 STEP VII**

Maintain output voltage: The system will continually monitor the input voltage and make real-time adjustments to the voltage motor to maintain the desired output voltage, ensuring stable operation.

## **10.8 STEP VIII**

Shutdown (if necessary): In the case of an emergency or if a critical failure is detected, the system will safely stop the voltage motor and disconnect the power to prevent any potential damage.

# CHAPTER 11

## CODE

```

1 #include <Encoder.h>
2 #include <Filters.h>
3 #include <Wire.h>
4 #include <LiquidCrystal_I2C.h>
5
6 // Rotary Encoder Setup
7 Encoder myEnc(2, 4);
8 float scalingFactor = 360.0 / (20 * 4);
9 long oldPosition = -999;
10 float currentAngle = 0.0;
11
12 // LCD Configuration
13 LiquidCrystal_I2C lcd(0x27, 16, 3);
14
15 // RMS Measurement Configuration
16 float testFrequency = 50; // 50Hz for standard AC
17 float windowLength = 0.04; // 2 cycles of 50Hz (40ms)
18
19 // Sensor Pins
20 int SensorInput = A0;
21 int SensorOutput = A1;
22 byte sensorPin = A2;
23
24 // Calibration Parameters (for RMS values)
25 float interceptInput = -0.04, slopeInput = 0.0405;
26 float interceptOutput = -0.03, slopeOutput = 0.041;
27
28 // Motor Control Pins
29 int motorEnablePin = 9; // Must be PWM capable pin
30 int motorForwardPin = 6;
31 int motorBackwardPin = 5;
32
33 // Voltage Variables
34 float rmsVoltageInput = 0.0;
35 float rmsVoltageOutput = 0.0;
36 float desiredVoltage = 0.0;
37 float tolerance = 3; // Reduced from 5.0
38
39 // New Filtering Variables
40 const int SAMPLES_PER_UPDATE = 50; // Increased from 10
41 const float MOVING_AVG_ALPHA = 0.1; // Moving average factor
42 float filteredInputVoltage = 0.0;
43 float filteredOutputVoltage = 0.0;
44
45 // Timing Variables
46 unsigned long encoderUpdateTime = 0, sensorUpdateTime = 0,
47 motorControlTime = 0, displayUpdateTime = 0;
48 const unsigned long encoderInterval = 10; // 10ms
49 const unsigned long sensorInterval = 100; // 100ms for RMS
50 // → calculations
51 const unsigned long motorInterval = 50; // 50ms
52 const unsigned long displayInterval = 500; // 500ms

```

```
52
53 // Angle Limits
54 float minAngle = 1.0;
55 float maxAngle = 329.0;
56
57 // RMS calculation objects
58 RunningStatistics inputStats;
59 RunningStatistics outputStats;
60
61 void setup() {
62     Serial.begin(9600);
63
64     // LCD Initialization
65     lcd.init();
66     lcd.backlight();
67     lcd.setCursor(0, 0);
68     lcd.print("Initializing...");
69     delay(2000);
70     lcd.clear();
71
72     // Motor Pins Configuration
73     pinMode(motorEnablePin, OUTPUT);
74     pinMode(motorForwardPin, OUTPUT);
75     pinMode(motorBackwardPin, OUTPUT);
76
77     // Stop motor initially
78     digitalWrite(motorEnablePin, LOW);
79     digitalWrite(motorForwardPin, LOW);
80     digitalWrite(motorBackwardPin, LOW);
81
82     // Initialize RMS calculation
83     inputStats.setWindowSecs(windowLength);
84     outputStats.setWindowSecs(windowLength);
85
86     // Initialize filtered values
87     filteredInputVoltage = 0.0;
88     filteredOutputVoltage = 0.0;
89 }
90
91 void loop() {
92     unsigned long currentMillis = millis();
93
94     // Update encoder
95     if (currentMillis - encoderUpdateTime >= encoderInterval) {
96         updateEncoder();
97         encoderUpdateTime = currentMillis;
98     }
99
100    // Update RMS measurements
101    if (currentMillis - sensorUpdateTime >= sensorInterval) {
102        updateRMSMeasurements();
103        sensorUpdateTime = currentMillis;
104    }
105
106    // Motor Control
107    if (currentMillis - motorControlTime >= motorInterval) {
108        controlMotor();
109        motorControlTime = currentMillis;
```

```

110     }
111
112     // Display Update
113     if (currentMillis - displayUpdateTime >= displayInterval) {
114         updateDisplay();
115         displayUpdateTime = currentMillis;
116     }
117 }
118
119 void updateEncoder() {
120     long newPosition = myEnc.read();
121     if (newPosition != oldPosition) {
122         currentAngle = fmod(newPosition * scalingFactor, 360.0);
123         if (currentAngle < 0) currentAngle += 360.0;
124         currentAngle = constrain(currentAngle, minAngle, maxAngle);
125         oldPosition = newPosition;
126     }
127 }
128
129 void updateRMSMeasurements() {
130     // Take more samples for better RMS calculation
131     float sumInput = 0.0;
132     float sumOutput = 0.0;
133
134     for(int i = 0; i < SAMPLES_PER_UPDATE; i++) {
135         inputStats.input(analogRead(SensorInput));
136         outputStats.input(analogRead(SensorOutput));
137         delay(2); // Increased delay between samples
138     }
139
140     // Calculate RMS values with moving average filter
141     float newInputVoltage = (interceptInput + slopeInput *
142                             inputStats.sigma()) * 40.3231;
143     float newOutputVoltage = (interceptOutput + slopeOutput *
144                              outputStats.sigma()) * 40.3231;
145
146     // Apply moving average filter
147     filteredInputVoltage = (MOVING_AVG_ALPHA * newInputVoltage) +
148                            ((1 - MOVING_AVG_ALPHA) * filteredInputVoltage
149                             ↪ );
150     filteredOutputVoltage = (MOVING_AVG_ALPHA * newOutputVoltage) +
151                             ((1 - MOVING_AVG_ALPHA) *
152                              ↪ filteredOutputVoltage);
153
154     rmsVoltageInput = filteredInputVoltage;
155     rmsVoltageOutput = filteredOutputVoltage;
156
157     // Smooth desired voltage reading with multiple samples
158     float sumDesired = 0.0;
159     for(int i = 0; i < 5; i++) {
160         sumDesired += analogRead(sensorPin);
161         delay(1);
162     }
163     float avgPotValue = sumDesired / 5.0;
164     desiredVoltage = (avgPotValue * (5.0 / 1023.0)) * 46;
165
166     // Debug output
167     Serial.print("RMS␣Input:␣");

```

```

166     Serial.print(rmsVoltageInput);
167     Serial.print("V, RMS Output: ");
168     Serial.print(rmsVoltageOutput);
169     Serial.print("V, Desired: ");
170     Serial.println(desiredVoltage);
171 }
172
173 void controlMotor() {
174     float error = desiredVoltage - rmsVoltageOutput;
175
176     if (abs(error) <= tolerance) {
177         // Stop Motor
178         digitalWrite(motorEnablePin, LOW);
179         digitalWrite(motorForwardPin, LOW);
180         digitalWrite(motorBackwardPin, LOW);
181         return;
182     }
183
184     // Calculate PWM value based on error
185     int pwmValue = min(255, abs(error) * 50); // Proportional control
186
187     analogWrite(motorEnablePin, pwmValue);
188
189     if (error > 0 && currentAngle < maxAngle) {
190         // Forward
191         digitalWrite(motorForwardPin, HIGH);
192         digitalWrite(motorBackwardPin, LOW);
193     } else if (error < 0 && currentAngle > minAngle) {
194         // Backward
195         digitalWrite(motorForwardPin, LOW);
196         digitalWrite(motorBackwardPin, HIGH);
197     } else {
198         // Stop at limits
199         digitalWrite(motorEnablePin, LOW);
200         digitalWrite(motorForwardPin, LOW);
201         digitalWrite(motorBackwardPin, LOW);
202     }
203 }
204
205 void updateDisplay() {
206     lcd.clear();
207
208     // First row: Angle and Input RMS
209     lcd.setCursor(0, 0);
210     lcd.print("A:");
211     lcd.print(currentAngle, 1);
212     lcd.print(" I:");
213     lcd.print(rmsVoltageInput, 1);
214
215     // Second row: Output RMS and Desired
216     lcd.setCursor(0, 1);
217     lcd.print("O:");
218     lcd.print(rmsVoltageOutput, 1);
219     lcd.print(" D:");
220     lcd.print(desiredVoltage, 1);
221 }

```

## **CHAPTER 12**

### **ADVANTAGES OF VOLTAGE STABILIZER**

#### **12.1 PRECISE VOLTAGE REGULATION**

voltage stabilizers provide accurate and continuous voltage regulation, adjusting to fluctuating input voltages to ensure a stable and consistent output voltage. They are capable of stabilizing voltage with very tight tolerance levels, making them ideal for sensitive equipment such as computers, medical devices, and industrial machinery, where precise voltage control is crucial for proper operation and safety.

#### **12.2 PROTECTION FOR SENSITIVE EQUIPMENT**

voltage stabilizers protect electrical equipment from potential damage caused by under-voltage or over-voltage conditions. Fluctuating voltages can lead to excessive wear and tear or even burn out electronic circuits, but voltage stabilizers prevent such damage. By maintaining a steady and regulated output voltage, they help extend the lifespan of appliances, machinery, and electronic devices, ensuring more reliable and long-lasting performance.

#### **12.3 WIDE INPUT VOLTAGE RANGE**

voltage stabilizers can effectively handle a broad range of input voltages, accommodating significant fluctuations (e.g., from 150V to 270V or beyond). This makes them suitable for regions with unstable power supply systems.

#### **12.4 IMPROVED EFFICIENCY**

Unlike traditional stabilizers, which often use transformers with relays or capacitors to step down the voltage, voltage stabilizers can adjust the voltage efficiently, minimizing energy loss and resulting in better overall efficiency. The stabilization process ensures that equipment operates optimally without overusing power, which contributes to energy savings in the long run, making voltage stabilizers a more energy-efficient solution for maintaining stable voltage levels.

## **12.5 AUTOMATIC OPERATION**

voltage stabilizers automatically adjust the output voltage based on input fluctuations without requiring manual intervention. The voltage motor mechanism ensures seamless operation, making them ideal for unattended use. Once installed, the stabilizer operates autonomously, providing peace of mind to users, especially in critical applications where constant monitoring is not feasible, ensuring consistent voltage regulation without the need for ongoing supervision.

## **12.6 DURABILITY AND LONGEVITY**

voltage stabilizers are built with solid, robust construction, ensuring a long service life and the ability to withstand harsh operating conditions such as high temperatures, dust, and humidity, making them suitable for both residential and industrial use. The use of voltage motors, instead of relays or switching components, further reduces mechanical wear and tear, leading to a more durable and reliable device that requires less maintenance and is better equipped to handle continuous operation over time.

## **12.7 FAST RESPONSE TIME**

voltage stabilizers quickly respond to voltage fluctuations, adjusting the output within seconds to stabilize the power supply. This rapid response is crucial in preventing damage to sensitive electronics that require constant voltage.

## **12.8 LOW MAINTENANCE**

voltage stabilizers have a simple design with fewer moving parts compared to other types of stabilizers, which means they require less maintenance. The absence of mechanical switches or relays significantly reduces the chances of failure, enhancing their reliability. Additionally, components like the voltage motor and transformer are built to last, reducing the need for frequent repairs or replacements, further contributing to the stabilizer's long-term performance and cost-effectiveness.

## **12.9 COMPACT DESIGN**

voltage stabilizers are often compact and can be easily installed in confined spaces, whether in homes, offices, or factories. Their small footprint makes them less intrusive compared to other types of voltage stabilizers



## **12.10 HIGH LOAD CARRYING CAPACITY**

voltage stabilizers are capable of handling a wide range of load capacities, from small domestic appliances to large industrial machines, without compromising on performance. They can efficiently stabilize voltage for heavy equipment and high-power systems.

## **12.11 NOISE-FREE OPERATION**

voltage stabilizers operate quietly, unlike some other stabilizers that generate noise due to mechanical switching or relays. This feature is particularly useful in environments where noise is a concern, such as offices or hospitals.

## **12.12 COST-EFFECTIVE IN THE LONG RUN**

Although voltage stabilizers may have a higher upfront cost compared to some other stabilizers, their longevity, efficiency, and minimal maintenance requirements make them cost-effective in the long term. By safeguarding sensitive equipment from voltage fluctuations, they help prevent costly repairs or replacements that might otherwise occur due to power surges or under-voltage situations. This makes voltage stabilizers a wise investment, offering substantial savings by reducing the likelihood of equipment damage and the need for frequent servicing.

## **12.13 ENHANCED SAFETY FEATURES**

voltage stabilizers often come with surge protection features that prevent damage from sudden spikes in voltage, ensuring the safety of connected equipment. Additionally, some models are equipped with overload protection, which safeguards the system from damage when the power load exceeds its capacity, providing an added layer of security and reliability for both sensitive and high-power equipment.

## **CHAPTER 13**

### **APPLICATIONS OF VOLTAGE STABILIZERS**

#### **13.1 INDUSTRIAL APPLICATIONS**

voltage stabilizers play a crucial role in protecting industrial machinery and automated systems, which often require a stable voltage supply to function efficiently. Voltage fluctuations can damage sensitive components, leading to production delays and higher maintenance costs, but voltage stabilizers ensure that equipment receives a constant and regulated voltage. In large industrial setups, HVAC systems also depend on stable voltage for smooth operation, and voltage stabilizers protect these systems from voltage spikes or dips that could damage compressors, motors, and other electrical components. Additionally, voltage stabilizers help safeguard control systems, programmable logic controllers (PLCs), and industrial computers, which require stable voltage to ensure accurate data processing and reliable system control.

#### **13.2 COMMERCIAL APPLICATIONS**

voltage stabilizers are essential in offices and commercial buildings with sensitive electronics, such as computers, printers, and communication equipment, as they ensure a stable power supply, preventing downtime or damage to these devices. In data centers, where high-value equipment like servers and storage devices require uninterrupted and stable power, voltage stabilizers are crucial to prevent voltage fluctuations that could lead to system crashes or data loss, maintaining operational integrity. Similarly, in retail stores, voltage stabilizers protect point-of-sale (POS) systems, digital signage, and other electronic devices, ensuring smooth customer transactions and enhancing the reliability of the systems.

#### **13.3 RESIDENTIAL APPLICATIONS**

In households, appliances such as refrigerators, air conditioners, washing machines, and microwaves are sensitive to voltage fluctuations, and a voltage stabilizer ensures these devices operate efficiently and last longer by maintaining a constant voltage supply. Similarly, home entertainment systems, including TVs, audio systems, and gaming consoles, can suffer from voltage instability, but voltage stabilizers protect these devices from potential damage while enhancing their performance. For domestic water pumps and other small motors, voltage stabi-

lizers ensure the motor operates within the recommended voltage range, extending the equipment's lifespan and preventing performance issues.

### **13.4 HEALTHCARE AND MEDICAL EQUIPMENT**

Critical medical equipment such as X-ray machines, ECG monitors, ventilators, and laboratory devices require stable power for accurate operation, and voltage stabilizers play a vital role in preventing voltage fluctuations from affecting the performance or safety of these devices. Hospitals, particularly in areas like operation theaters, intensive care units (ICUs), and emergency rooms, rely on a consistent power supply to maintain operations, and voltage stabilizers ensure that sensitive medical equipment operates without interruptions, even in areas prone to power issues, safeguarding both patient care and equipment functionality.

### **13.5 TELECOMMUNICATION**

Telecommunication towers and base stations rely on stable power to maintain constant communication, and voltage stabilizers ensure that voltage fluctuations do not disrupt signal transmission, allowing for seamless communication. Similarly, broadcasting studios and transmission equipment, including radio and television stations, require a consistent power supply for high-quality signal transmission. Voltage stabilizers help prevent interruptions or equipment damage due to unstable voltage, ensuring reliable operation and optimal performance of broadcasting systems.

### **13.6 LABORATORIES AND RESEARCH FACILITIES**

Laboratories often use sensitive equipment like microscopes, spectrometers, and other analytical instruments that require stable and precise voltage to function correctly. Voltage stabilizers protect these instruments from voltage fluctuations that could affect results or lead to equipment failure. Additionally, researchers working on experiments that demand consistent power, such as those involving electronic circuits or sensitive sensors, rely on voltage stabilizers to prevent voltage variations from interfering with their work, ensuring accurate and reliable results.

### **13.7 AGRICULTURE AND IRRIGATION SYSTEMS**

Voltage stabilizers are commonly used in agricultural setups to stabilize the voltage supplied to irrigation pumps, ensuring a consistent water supply and preventing pump failure due to fluctu-

ating voltages. In addition, cold storage units that store perishable products require precise temperature control, and voltage stabilizers ensure that refrigeration systems continue to operate effectively despite power fluctuations, protecting the integrity of stored goods and maintaining optimal conditions.

### **13.8 ELECTRIC VEHICLE (EV) CHARGING STATIONS**

As electric vehicles (EVs) become more popular, the infrastructure for charging stations must be reliable. voltage stabilizers ensure that the voltage supplied to EV charging stations is stable, reducing the risk of charging errors or damage to EV batteries.

### **13.9 RENEWABLE ENERGY SYSTEMS**

Renewable energy systems, such as solar power installations and wind turbines, are increasingly being used as sustainable sources of electricity. However, these systems can be prone to voltage instability due to their inherent reliance on natural energy sources, which are often variable and unpredictable. The output from solar panels can fluctuate depending on sunlight intensity, while wind turbines depend on wind speed and direction. This variability can cause voltage surges or drops, potentially damaging sensitive electrical equipment and affecting the overall efficiency of the system. When combined with energy storage devices like batteries, these fluctuations can become even more pronounced. Batteries are essential for storing excess energy produced during periods of high generation and discharging it when energy demand exceeds supply. However, fluctuations in voltage can harm the batteries, reducing their efficiency, lifespan, and overall performance. In this context, voltage stabilizers play a vital role in ensuring that both the energy generation and storage systems operate smoothly. By stabilizing the voltage, voltage stabilizers ensure that the voltage remains within a safe, optimal range, regardless of changes in the input from renewable sources. systems such as solar power installations or battery storage solutions, voltage stabilizers play a crucial role in protecting the core components, including inverters and batteries, from damage caused by voltage fluctuations during charging or discharging cycles. In solar power systems, the inverter is responsible for converting the direct current (DC) from the solar panels into alternating current (AC), which can be used by household appliances or fed into the electrical grid. However, inverters are highly sensitive to fluctuations in input voltage, which can result in inefficient performance or even component failure if not regulated properly.

### **13.10 UPS (UNINTERRUPTIBLE POWER SUPPLY)SYSTEMS**

voltage stabilizers are integral components in enhancing the performance and reliability of Uninterruptible Power Supply (UPS) systems, especially in environments where power fluctuations are common. These stabilizers work by continuously monitoring and adjusting the incoming voltage to maintain a steady and optimal level, protecting sensitive electronic devices and equipment. When paired with a UPS, the voltage stabilizer ensures that the UPS functions at its highest efficiency, by delivering a consistent voltage supply even when the main electrical supply is unstable or fluctuating. This consistent voltage input allows the UPS to respond effectively to power outages, providing uninterrupted power to critical systems.

## **CHAPTER 14**

### **COMPARISON OF VOLTAGE STABILIZER WITH OTHER VOLTAGE REGULATION DEVICES**

The voltage stabilizer is particularly suited for applications that require high precision and real-time voltage regulation, making it the ideal choice for sensitive equipment that depends on a stable voltage supply for optimal performance. This includes critical devices such as medical machinery, laboratory instruments, and industrial systems, where even slight fluctuations in voltage can lead to malfunction or permanent damage. By offering real-time adjustments through its voltage motor mechanism, the voltage stabilizer ensures that the output voltage remains consistent, protecting these vital pieces of equipment. In contrast, Automatic Voltage Regulators (AVRs) and Constant Voltage Transformers (CVTs) offer more cost-effective and simpler solutions for general voltage stabilization, but they are typically less precise. AVRs stabilize voltage within a fixed range using electronic components, making them suitable for general appliances and office equipment that don't require the same level of precision. CVTs, while effective in industrial plants where moderate voltage fluctuations occur, offer continuous voltage regulation but with less precision than voltage stabilizers. On the other hand, isolation transformers excel in providing electrical isolation to protect equipment from electrical surges or noise but do not regulate voltage. This makes them an effective solution for safeguarding sensitive equipment from potential damage caused by sudden power spikes, but they do not offer the same level of voltage regulation as a voltage stabilizer. Therefore, while isolation transformers are useful for protecting against electrical disturbances, they are not a substitute for equipment that requires stable, regulated voltage for consistent performance. In summary, for environments where consistent and stable voltage is essential to the reliable operation of sensitive and critical equipment, the voltage stabilizer remains the best choice. Its ability to provide superior regulation, real-time adjustments, and protection from voltage fluctuations makes it the ideal solution for high-stakes applications, offering better protection and ensuring the longevity and functionality of valuable equipment. In comparison, AVRs, CVTs, and isolation transformers offer more affordable options but are typically more suited for less demanding environments where absolute precision is not as crucial.

## **CHAPTER 15**

### **RESULT**

The objective has been achieved by designing and developing a voltage stabilizer that effectively regulates output voltage, compensating for input voltage fluctuations. The system ensures the safe and reliable operation of connected equipment by dynamically adjusting the voltage using a DC motor and an autotransformer. Through this approach, consistent and stable voltage is maintained, safeguarding electrical devices from potential damage caused by voltage instability.

Here we had provided an in-depth discussion of the voltage stabilizer's performance, with a particular focus on its voltage regulation capabilities. Voltage regulation is a critical feature of any stabilizer, as it determines the system's ability to maintain a constant output despite fluctuations in the input voltage. The voltage stabilizer was subjected to a series of tests where the input voltage was varied across a range of conditions, including both lower and higher voltage scenarios, which are commonly encountered in real-world applications. These fluctuations simulate the kind of electrical disturbances that could affect sensitive equipment and machinery.

The results of these tests were analyzed in detail, providing insights into the stabilizer's overall performance and reliability in real-world conditions. By comparing the stabilizer's response to expected voltage variations with its actual performance, we can assess how well it meets its primary objective: to maintain a constant and stable voltage output. This section will conclude by highlighting the key findings and providing recommendations for situations where the voltage stabilizer is most effective in maintaining operational stability, protecting equipment, and ensuring long-term durability of sensitive systems.

Figure 14.2 presents a tabular representation of input voltage, obtained output voltage, desired voltage, and the corresponding angle of rotation for a voltage stabilizer system. The obtained output voltage values remain close to the desired voltage of 110V, with slight variations within an acceptable tolerance of five percentage. As the input voltage decreases, the angle of rotation increases, indicating the control system's response to compensate for voltage fluctuations. This suggests that the stabilizer effectively regulates the output voltage by adjusting the angle of rotation.

INPUT VOLTAGE (V)	OBTAINED VOLATGE (V)	DESIRED VOLTAGE (V)	ANGLE (°)
230	113	110	90
220	111	110	114
200	110	110	157
150	107	110	207
100	106	110	319

Table 15.1: Voltage stabilization performance (5% tolerance)

Figure 14.3 is a graphical representation of the same data. It plots input supply voltage against output voltage, desired voltage, and angle of rotation. The desired voltage (110V) remains nearly constant, as expected. The obtained output voltage follows a similar trend with minor deviations. However, the angle of rotation increases significantly as the input voltage decreases, showing an inverse relationship between input voltage and angle. This confirms that the stabilizer compensates for voltage fluctuations by increasing its corrective action.

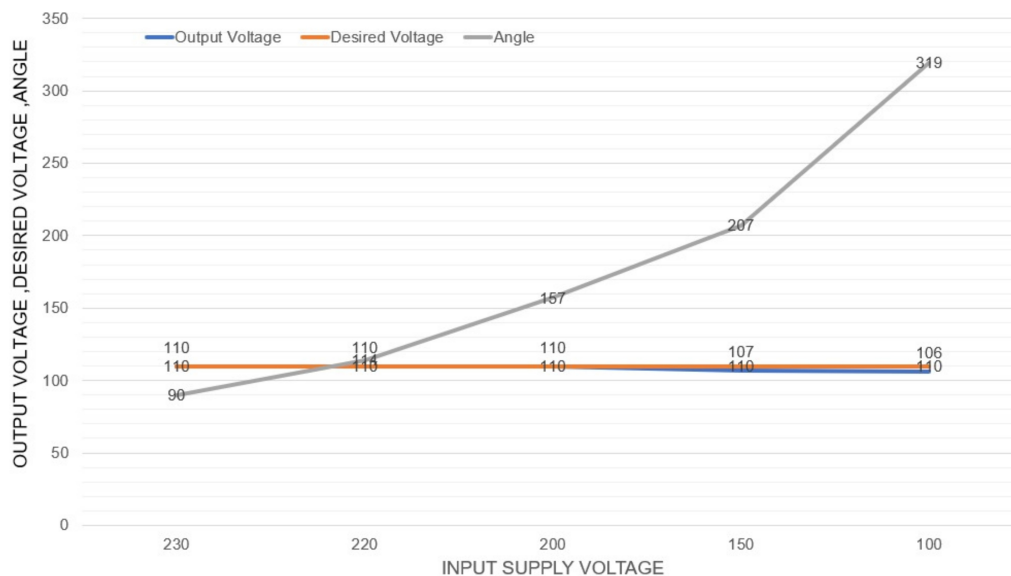


Fig 15.1: Plotting of significant voltages ( inclusive of respective angles )

Table 1 represents manual readings taken during the operation of a voltage stabilizer, it provides real-time observations of how the stabilizer responds to varying input voltages. The "Observed Output Voltage" column records actual measured values, while the "Desired Output Voltage" remains constant at 110V, indicating the intended regulation. The "Angle of Rotation" represents the corrective adjustment applied by the stabilizer to maintain the output voltage within an acceptable range.

From the data, when the input voltage is 230V, the stabilizer achieves perfect regulation,



maintaining 110V output with no corrective rotation. As the input voltage decreases, the observed output voltage begins to deviate from the desired value, requiring an increasing angle of rotation. However, at significantly lower input voltages (e.g., 150V and 100V), the stabilizer struggles to maintain the desired voltage, as indicated by the large deviations in observed output voltage (82V and 64V, respectively). This suggests that the stabilizer has a limited range of correction, beyond which it cannot fully compensate for voltage fluctuations.

These manual readings provide valuable insight into the real-world performance of the stabilizer, highlighting its effectiveness within certain operational limits and its inefficiencies when input voltage drops too low.

<b>INPUT VOLTAGE (V)</b>	<b>OBSERVED OUTPUT VOLTAGE (V)</b>	<b>DESIRED OUTPUT VOLTAGE (V)</b>	<b>ANGLE OF ROTATION (°)</b>
230	110	110	0
210	101	110	13.89
200	104	110	22.5
150	82	110	77
100	64	110	227.4

Table 15.2: Manual Readings and Calculations

## **15.1 CHALLENGES AND LIMITATIONS**

During the design and implementation of the voltage stabilizer, several challenges were encountered. One of the main difficulties was calibrating the voltage motor to ensure precise adjustments to the transformer tap. Wiring complexity also posed challenges, as careful attention was needed to ensure proper connections and prevent electrical interference. The system faced certain constraints, such as a limited input voltage range, which might prevent optimal functioning in environments with extreme variations. Additionally, under extreme conditions, the system's response could be slower, and frequent calibration was needed to maintain precision. To improve the system, upgrades such as implementing more precise feedback systems and faster control circuits could enhance performance and reduce response time, making the system more reliable in wider applications.

## **CHAPTER 16**

### **COST ESTIMATION**

#### **16.1 COST BREAKDOWN OF OUR VOLTAGE STABILIZER COMPONENTS**

<b>COMPONENTS</b>	<b>COST</b>
Arduino Uno	1089
Driver and Motor	1183
Voltage Sensor	73
Display	499
Jumper Cables	38
Adapter Module	40
Rotary Encoder	137
<b>Total</b>	<b>3059</b>

Table 16.1: Cost Breakdown of Components

This cost breakdown outlines the expenses for all critical components in the voltage stabilizer system, including voltage sensors, microcontrollers, encoders, and other essential hardware. The analysis focuses on industrial-grade parts selected for reliability during continuous operation, with costs optimized through competitive vendor comparisons while meeting technical specifications. By providing transparent pricing for each element, it enables accurate budgeting during construction and future upgrades, ensuring the system delivers stable performance without compromising affordability. The total reflects a balance between durability and cost-efficiency for long-term operation.

#### **16.2 PRICING OF EXISTING VOLTAGE STABILIZER SYSTEM COMPONENTS**

This cost comparison analysis examines the pricing structure of components used in conventional voltage stabilizer systems versus our proposed design, highlighting key cost differentials across essential hardware elements. The breakdown quantifies expenditure variations for critical parts like voltage sensors, control modules, and power regulation components, demonstrating how the proposed system achieves cost efficiencies through optimized material selection while maintaining performance standards. By presenting these comparative figures, the analy-

sis provides valuable insights for budget planning and identifies potential savings opportunities in system implementation and upgrades.

<b>COMPONENTS</b>	<b>COST</b>
Servo Motor	4,000
Variable Transformer	6,000
Carbon Brushes	500
Buck/Boost Converter	3,500
Control and Sensing Circuit	4,500
Circuit Breaker (Overload Protection)	800
Meters and Indicators	1,000
Enclosure	1,500
<b>Total</b>	<b>21,800</b>

Table 16.2: Cost Breakdown of power components

The standard voltage stabilizer costs Rs.21,800 to manufacture, using expensive parts like servo motors and complex control circuits. Our version achieves the same performance at just Rs.3,059 by using smart alternatives - an Arduino microcontroller and affordable sensors, delivering an incredible 85% cost reduction. This proves that intelligent design and modern electronics can create powerful yet budget-friendly solutions.

Our voltage stabilizer uses simple, durable designs to provide basic power protection at lower prices. The system works for small households and shops that need straightforward solutions without advanced features. By focusing on essential functions, we keep production and maintenance costs down while still offering core stabilization. This approach makes the technology an option for budgets that couldn't consider commercial stabilizers before.

## **CHAPTER 17**

### **FUTURE SCOPE**

The future scope of the voltage Stabilizer project offers numerous opportunities for enhancement and expansion. Integration with renewable energy systems, such as solar and wind power, could improve the stability of fluctuating energy supplies, ensuring a consistent output. Additionally, integrating the stabilizer with smart grids and IoT technology would enable real-time monitoring and more efficient voltage regulation, benefiting both residential and industrial sectors. There is also potential to develop stabilizers with higher power ratings to cater to larger industrial or commercial applications. Enhancements in efficiency, faster response times, and automation using microcontroller-based systems or artificial intelligence could make the stabilizer even more intelligent and adaptable. Future developments could also focus on providing comprehensive protection against both overvoltage and undervoltage, ensuring greater safety for sensitive equipment. Mobile and remote monitoring features, along with improvements in miniaturization and cost reduction, would make voltage stabilizers more accessible to a broader audience. Furthermore, incorporating environmentally friendly materials and energy-efficient designs could make these systems more sustainable. Finally, customization for specific industries, such as telecommunications, automotive, or healthcare, would open new avenues for precise and specialized applications. Overall, the future of the voltage stabilizer is promising, with a range of potential improvements and innovations that could make it an even more vital component in modern electrical systems.

## **CHAPTER 18**

### **CONCLUSION**

In conclusion, the Implementation of a Voltage Stabilizer successfully addressed the critical issue of voltage fluctuations, which can cause significant damage to electrical appliances and equipment. The project demonstrated the practicality and effectiveness of employing a voltage motor-driven mechanism to regulate and stabilize the input voltage, thereby ensuring a consistent and reliable output. Through the meticulous design and integration of crucial components such as the voltage motor, voltage sensing circuit, transformer, and control system, the voltage stabilizer was able to deliver precise and real-time voltage correction. The testing phase confirmed that the stabilizer effectively mitigated the adverse effects of voltage fluctuations, protecting sensitive devices from potential damage, enhancing their lifespan, and improving overall performance. This project not only underscores the importance of voltage regulation in both residential and industrial sectors but also provides a robust solution to safeguard various systems, from home appliances to critical infrastructure like medical equipment and communication systems. By stabilizing the voltage supply, the voltage stabilizer plays a pivotal role in preventing equipment malfunctions and ensuring operational reliability. Looking ahead, future improvements could include refining the control mechanism for even quicker response times, optimizing energy efficiency, and expanding the system's capability to handle higher power ratings or more complex environments. Additionally, integrating the stabilizer with renewable energy sources and smart grid technology could open up new possibilities for energy management. Overall, this project highlights the vital role of voltage stabilizers in modern electrical systems, offering both protection and efficiency for a wide range of applications.

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## **APPENDIX**

### **DATASHEET OF ARDUINO ATMEGA 328P**

#### **Overview:**

The Atmel® ATmega328P is a low-power CMOS 8-bit microcontroller based on the AVR® enhanced RISC architecture. By executing powerful instructions in a single clock cycle, the ATmega328P achieves throughputs approaching 1MIPS per MHz allowing the system designer to optimize power consumption versus processing speed.

#### **Features**

High performance, low power AVR® 8-bit microcontroller

Advanced RISC architecture

131 powerful instructions – most single clock cycle execution

32 8 general purpose working registers

Fully static operation

Up to 16MIPS throughput at 16MHz

On-chip 2-cycle multiplier High endurance non-volatile memory segments

32K bytes of in-system self-programmable flash program memory

1Kbytes EEPROM

2Kbytes internal SRAM

Write/erase cycles: 10,000 flash/100,000 EEPROM

Optional boot code section with independent lock bits

In-system programming by on-chip boot program

True read-while-write operation

Programming lock for software security

Peripheral features

Two 8-bit Timer/Counters with separate prescaler and compare mode

One 16-bit Timer/Counter with separate prescaler, compare mode, and capture mode

Real time counter with separate oscillator

Six PWM channels

8-channel 10-bit ADC in TQFP and QFN/MLF package

Temperature measurement

Programmable serial USART

Master/slave SPI serial interface

Byte-oriented 2-wire serial interface (Phillips I2C compatible)

Programmable watchdog timer with separate on-chip oscillator

On-chip analog comparator

Interrupt and wake-up on pin change

Special microcontroller features

Power-on reset and programmable brown-out detection Internal calibrated oscillator

External and internal interrupt sources

Six sleep modes: Idle, ADC noise reduction, power-save, power-down, standby, and extended standby

I/O and packages

23 programmable I/O lines

32-lead TQFP, and 32-pad QFN/MLF

Operating voltage: 2.7V to 5.5V for ATmega328P

Temperature range: Automotive temperature range:  $-40^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$

Speed grade:

0 to 8MHz at 2.7 to 5.5V (automotive temperature range:  $-40^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$ )

0 to 16MHz at 4.5 to 5.5V (automotive temperature range:  $-40^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$ )

Low power consumption Active mode: 1.5mA at 3V - 4MHz

Power-down mode:  $1\mu\text{A}$  a



## PIN DIAGRAM OF ARDUINO ATMEGA 328P

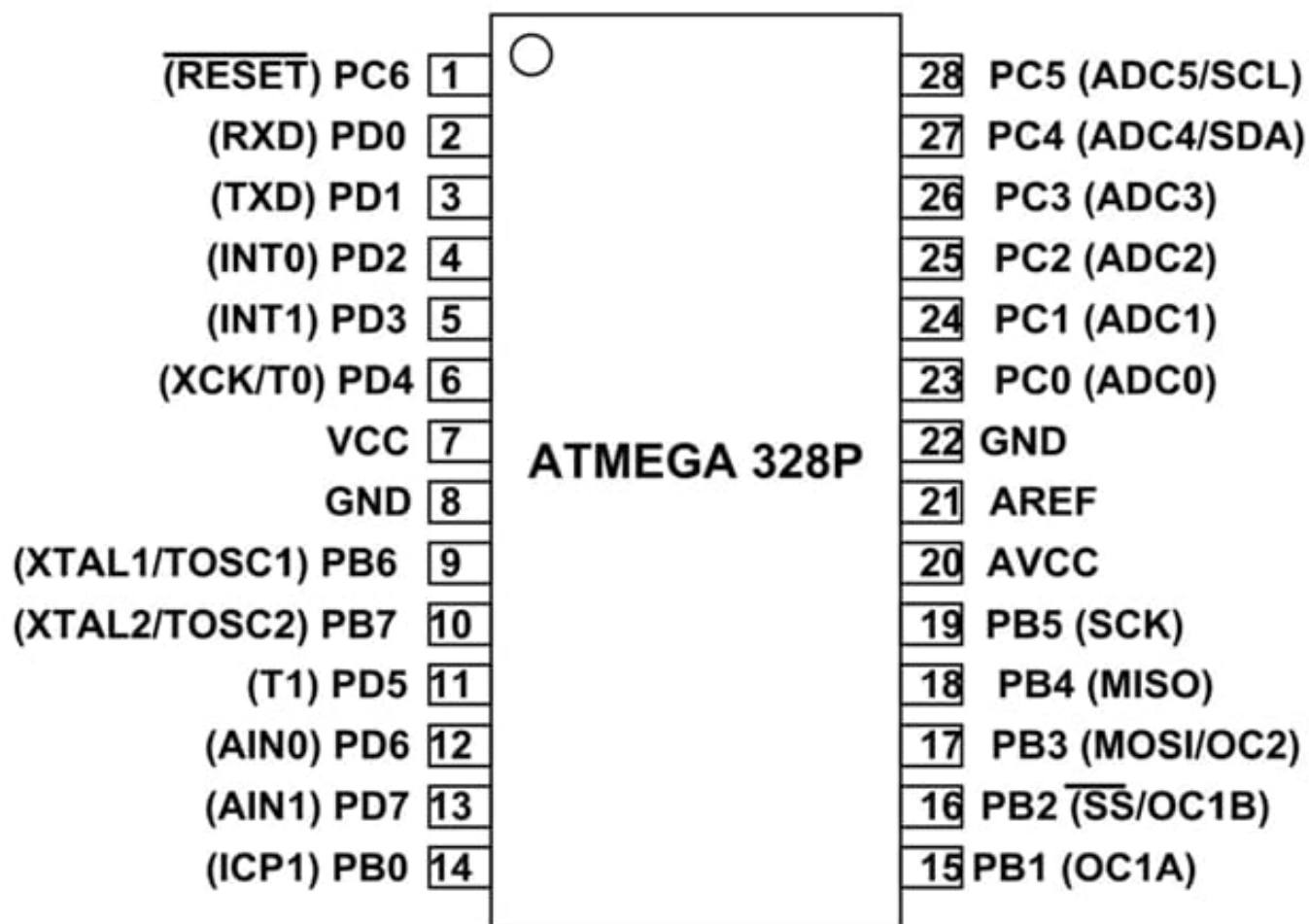


Fig 18.1: Pin diagram

Parameters	Value
Motor Type	Wiper Motor
Operational Voltage	12V
No Load Current	2A
Stall Current	10A
Stall Torque	45 kg-cm
Motor Power	120W
Shaft diameter	10 mm
Shaft dimension	29 mm
Weight	1280 g
Speed	55 RPM

Table 18.3: DC Motor Specification

<b>Features</b>	<b>Value</b>
Operating Voltage	5.5V to 27V DC
Continuous Output Current	43A (with proper cooling)
PWM Capability	Up to 25 kHz with active freewheeling
Path Resistance (High Side + Low Side)	Typ. 16 milli ohm at 25°C
Overcurrent Protection	Switched mode current limitation - Type 43
Current Sense Capability	Yes

Table 18.4: Motor Driver (BTS7960) Important Specifications