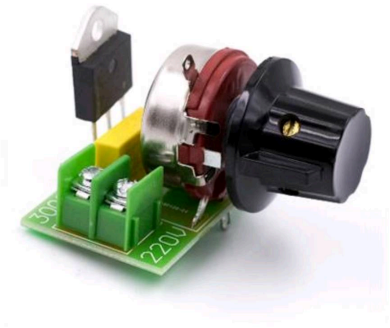
NATIONAL INSTUTUTE OF TECHNOLOGY AGARTALA

SESSION: 2023-24

Topic: AC VOLATGE REGULATOR



SUBMITTED BY:

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Certificate

This is to certify that the mentioned students of 3rd year,5th semester have successfully completed their group project work on the topic of "AC Voltage Regulator" during the academic session 2023-24 under my supervision. They have taken proper care and have shown utmost sincerity in the completion of this project.

I certify that this project is up to my expectations and as per the guidelines. I have gone through their project report and it is assessed that no work has been done in this topic so far. They have worked hard towards the completion of this project and I wish them success.

Signature of the supervisor

Acknowledgement

We would like to express our sincere gratitude to **Sir Debabrata Bhattacharjee** for his invaluable guidance and support throughout the development of this project.

Additionally, we extend our thanks to **Sir Bikram Das** for his valuable contributions and assistance, which greatly enriched the project's quality and outcomes. Your expertise and mentorship have been instrumental in our success.

We would also like to thank all who have directly or indirectly contributed to the successful completion of our project.

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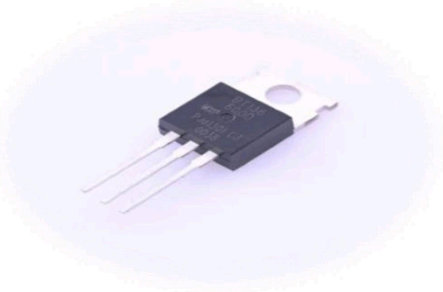
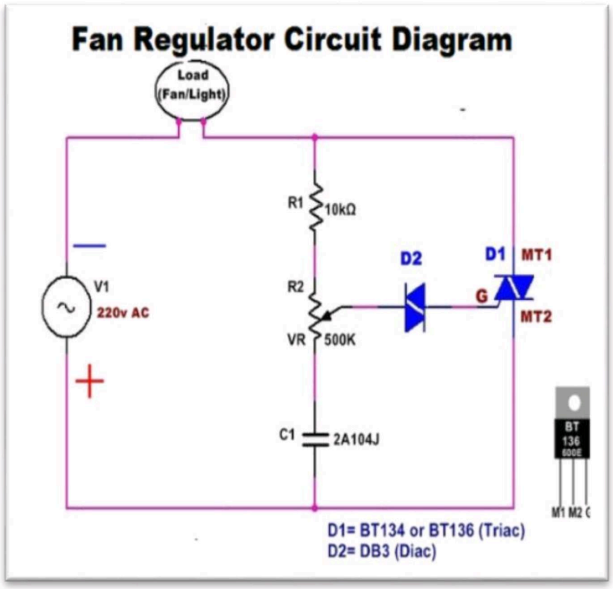
6. INCANDESCENT LIGHT BULB	25W



WORKING PRINCIPLE

This circuit serves as a precise voltage regulator for controlling lamp brightness. The fundamental operation revolves around the manipulation of the voltage supplied to the lamp. When the voltage is elevated, the lamp exhibits increased luminance, whereas voltage reduction results in gradual dimming, with maximum brilliance occurring near the 240-volt threshold.



Here's a detailed breakdown of the underlying processes:

1. Voltage Variation Control:

The core objective of this circuit is the thorough regulation of the voltage supplied to the lamp, enabling precise control over its brightness.

Elevating the voltage levels effectively results in augmenting the lamp's luminosity, while decreasing voltage levels lead to gradual dimming.

2. BT136 TRIAC Functionality:

The central component for voltage regulation in this circuit is the BT136 TRIAC, a solid-state semiconductor device proficient in managing the flow of AC voltage to the lamp.

3. Precision Timing with DB3 DIAC:

To ensure precise timing of the TRIAC's activation and deactivation, we employ the DB3 DIAC. It plays an integral role in triggering the TRIAC at highly specific points within each AC cycle.

4. Polyester Capacitor Filtering:

The polyester capacitor (104K, 400V) serves a dual purpose within the circuit.

It functions primarily as a highly effective AC voltage filter, effectively reducing voltage fluctuations and providing voltage stabilization to the lamp.

Additionally, the capacitor operates as a phase-shifting component, actively participating in the precise timing of the TRIAC's conduction events.

5. Variable Resistor Control:

The variable resistor, featuring impressive 512K ohms of resistance, assumes a central and influential role within the circuit's design.

By adjusting this resistor, the operator gains the capability to finely tune the firing angle of the BT136 TRIAC, effectively dictating when it enters its conducting phase.

6. Lamp Illumination Control:

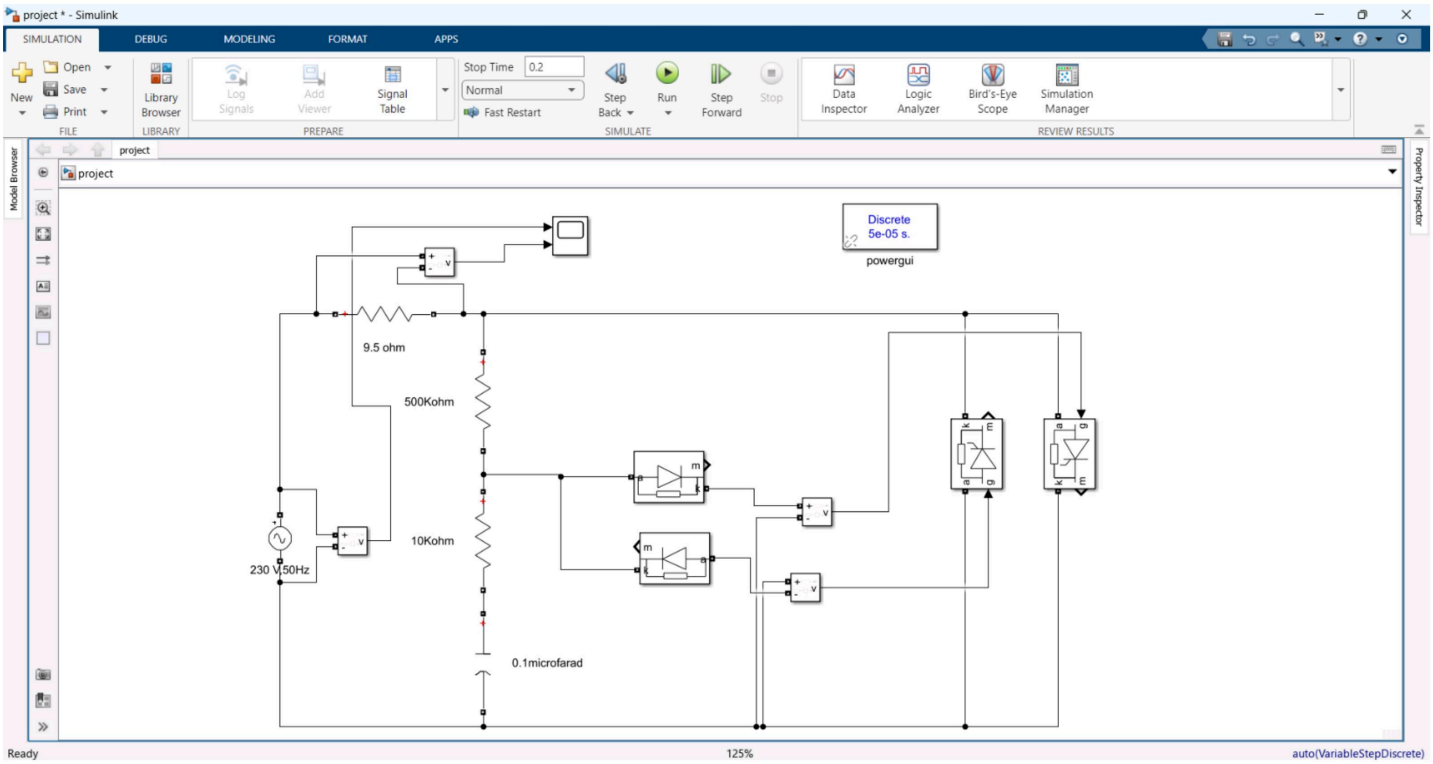
The lamp is seamlessly integrated with the TRIAC, serving as the primary load.

When the TRIAC conducts, it facilitates the flow of voltage to the lamp, resulting in its illumination.

Notably, the rate of the TRIAC's on-off cycles, under the control of the variable resistor, modulates the average voltage delivered to the lamp.

CIRCUIT DIAGRAM

MATLAB Simulink



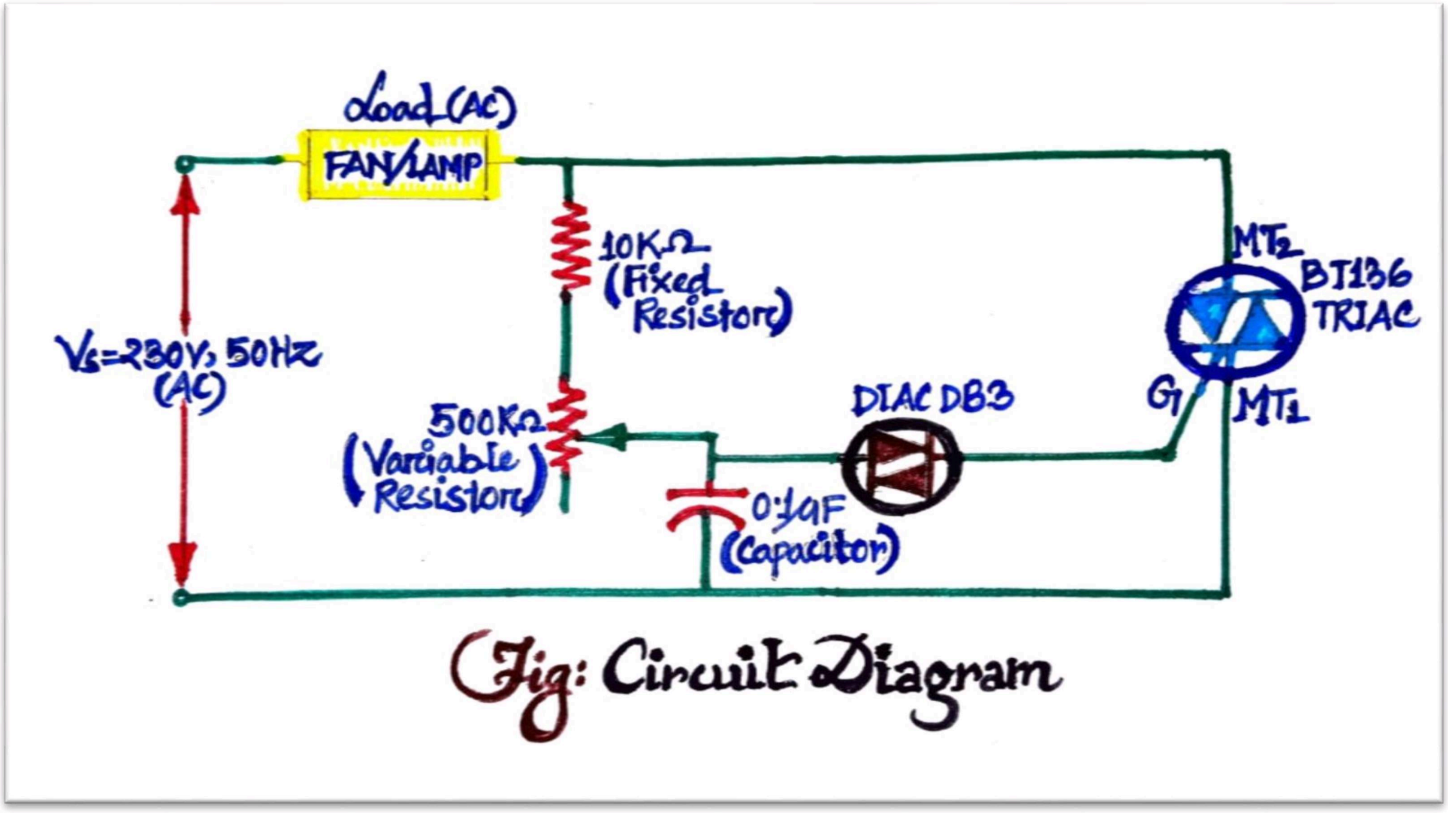
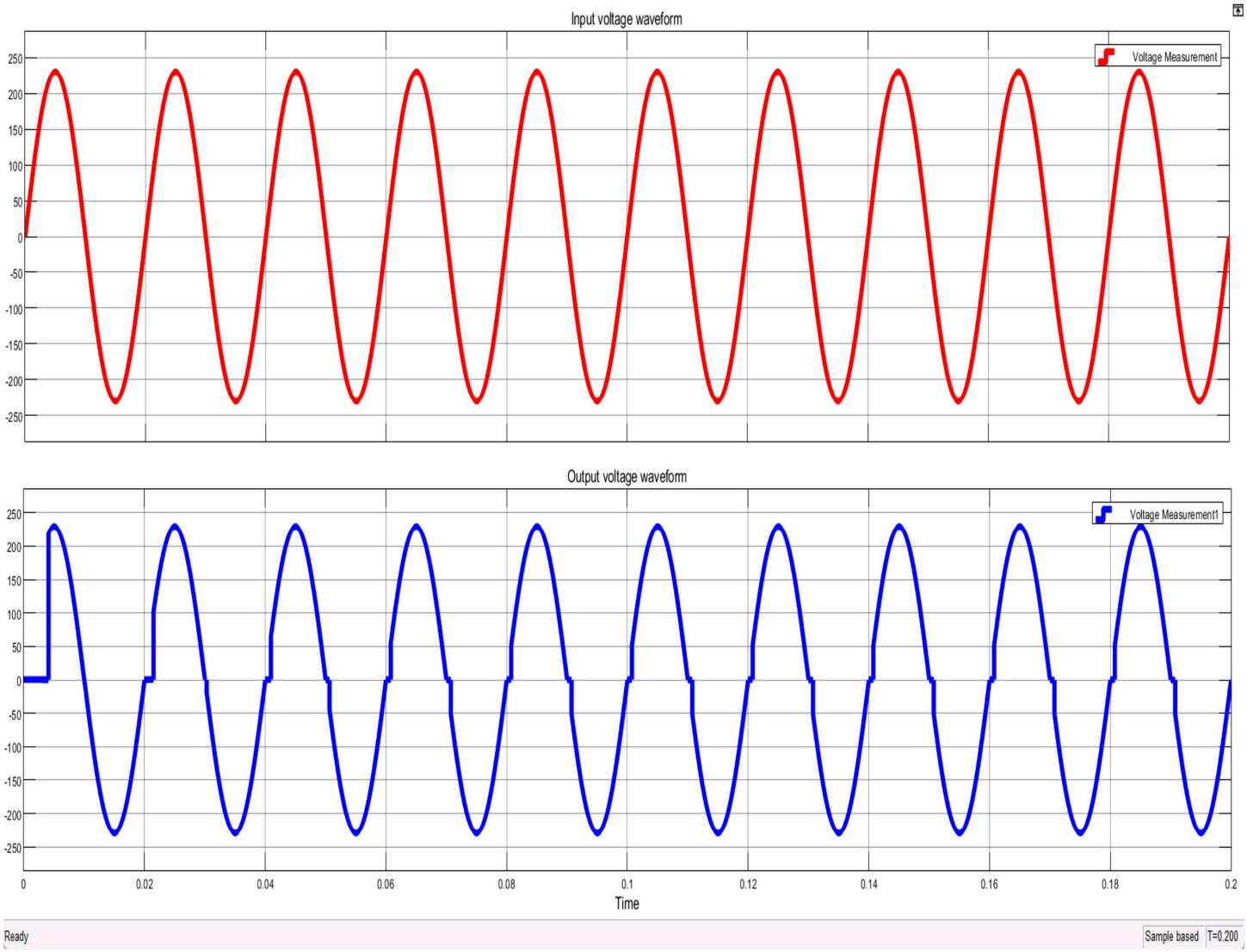


Fig: Circuit Diagram

WAVEFORM


Input voltage waveform
Voltage Measurement
250
200
150
100
50
0
-50
-100
-150
-200
-250
Output voltage waveform
Voltage Measurement1
0
0.02
0.04
0.06
0.08
0.1
0.12
0.14
0.16
0.18
0.2
Time
Ready
Sample based
T=0.200

DIAC DB3

Introduction to DIAC DB3

DIAC stands for **Diode for Alternating Current**. As the name implies, a DIAC is a semiconductor diode for conducting alternating current. Basically, it is a power electronic bidirectional semiconductor uncontrolled switch that is capable of conducting the electric current in both directions. This device functions as a trigger diode with a fixed voltage reference and can be used in conjunction with TRIAC for simplified gate control circuits and as a starting element in fluorescent lamp ballasts.

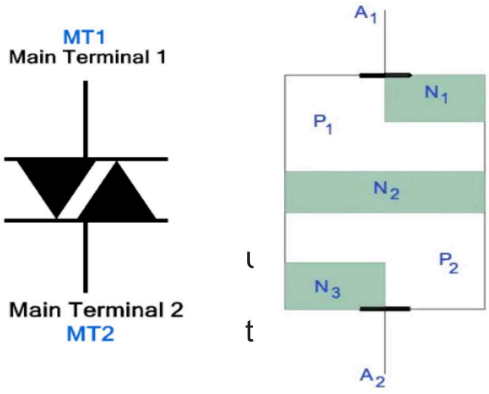
Specifications-

Maximum Breakover Current	0.05mA
Maximum Breakover Voltage	36V

Applications:

- Light Dimmers – Triggers TRIAC.
- Phase Controlled Circuits.
- Rectifier Circuits.

Depiction:



Advantages:

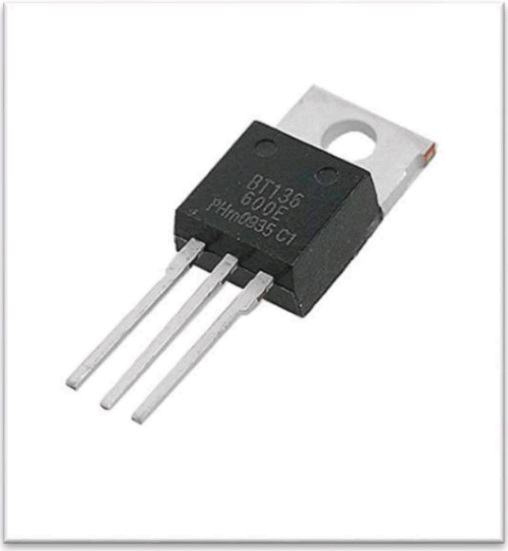
- Smooth control of Power and Current is achieved DIAC.
- The device can be turned on or off by decreasing voltage level.
- Harmonics is reduced to a great extent as the device equalizes the switching characteristics.

Role in AC Voltage Regulator Circuit:

DIAC is the component that is controlling the conducting phase of a TRIAC through its Gate terminal. The DIAC only gets to its conducting stage once it crosses a barrier voltage (VBO) which is roughly around 36V but differs with different component models.

Initially, DIAC is a device that has a higher resistance but after a continual increase in the voltage level, at the point of VBO, the resistance decreases drastically and it starts conducting which results in an increase in the current. The DIAC stays in its conducting state till the current drawn from it decreases to a level called 'holding current'. Once the current drawn drops below the holding current, the DIAC becomes non conducting again.

BT 136 TRIAC



Introduction to BT 136 TRIAC

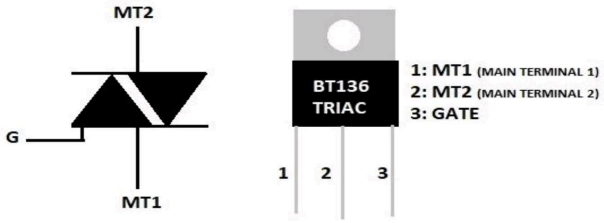
A **TRIAC**, short for "**Triode for Alternating Current**," is a three-terminal semiconductor device used for various purposes. It is a bidirectional switching device that can control the flow of current in both directions, making it suitable for AC applications. The **BT136 TRIAC** is a widely used semiconductor device that plays a crucial role in controlling power to AC (alternating current) loads. It can conduct current in both directions through its main terminals (MT1 and MT2) when triggered by a gate current. This bidirectional capability makes it suitable for applications involving AC power.

Symbol and Pin Configuration:

The BT136 has three main terminals:

- MT1 (Main Terminal 1)
- MT2 (Main Terminal 2)
- G (Gate)

Depiction:

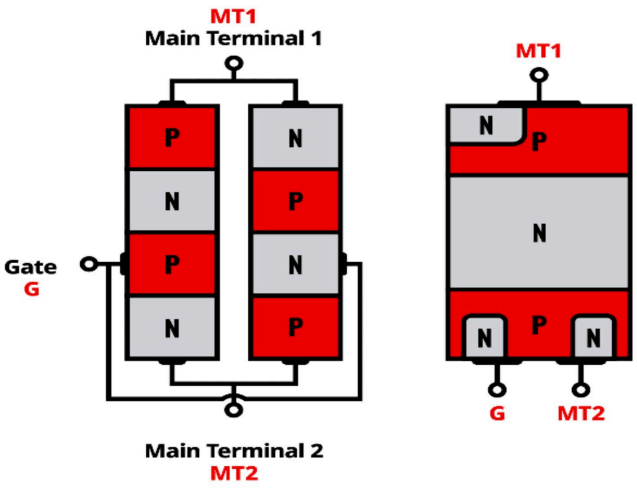


Specifications:

Maximum Terminal current	4A
On-state Gate voltage	1.4V
Gate trigger current	10mA
Maximum Terminal Voltage	600V
Holding current	2.2mA
Latching current	4mA

Applications:

- **Light Dimming:** Controlling the intensity of incandescent or dimmable LED/CFL lights.
- **Motor Speed Control:** Regulating the speed of AC motors in appliances like fans and blenders.
- **Heating Control:** Managing the power supplied to resistive heating elements like those in ovens and stovetops.



- **Power Control:** In various power regulation scenarios for AC loads.

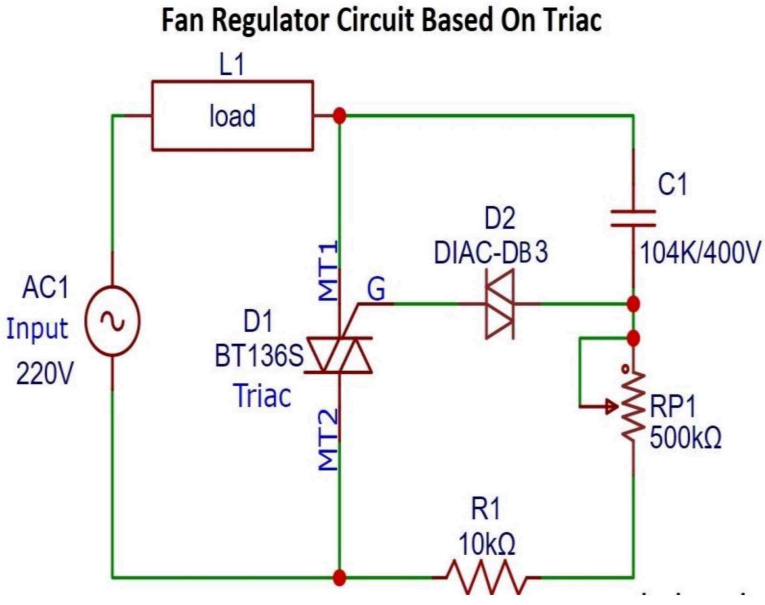
Advantages:

- **Bidirectional and Precise Control:** TRIACs like the BT136 are capable of controlling current in both directions, making them suitable for AC power applications. It can be triggered with a gate current, allowing for precise control over the timing and duration of the switching action. TRIAC can be triggered with positive or negative polarity voltages.
- **Compact Size:** Being relatively compact semiconductor devices makes them suitable for integration into various electronic circuits and applications without taking up much space. A TRIAC needs a single fuse for protection which also simplifies construction.
- **Occupies less space:** A TRIAC needs a single heat sink of slightly larger size, whereas anti- parallel thyristor pair needs two heat sinks of slightly smaller sizes, but due to the clearance total space required is more for thyristors.
- **Zero-Crossing Detection:** TRIACs are often used in conjunction with zero-crossing detection circuits to ensure that they switch on and off at points where the AC voltage waveform crosses zero.
- **Cost-Effective:** TRIACs are generally cost-effective components, making them suitable for use in a wide range of consumer and industrial products.

Role in AC Voltage Regulator Circuit:

TRIACs are used in voltage regulation to give full wave control between zero and full power. The bidirectionality of TRIACs makes them convenient switches for alternating-current (AC).

Here, in each power line half-cycle, the R-C network applies a variable phase-delayed version of the half-cycle to the TRIAC gate via the diac, and when the C1 voltage rises to a certain value, the DIAC fires and delivers a voltage trigger pulse (from C1) into the TRIAC gate, thus turning the TRIAC on and simultaneously applying power to the L1 load and removing the drive from the R-C network. The mean power to the load (integrated over a full half-cycle period) is thus fully variable from near-zero to maximum via RP1.



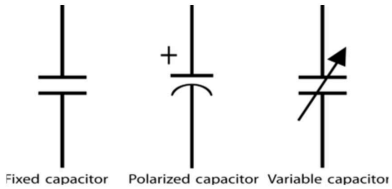
Many industries face problems like voltage sags and extended under voltage and thus it could cause a negative impact on productivity. For this we need to install voltage controllers to control the voltage.

CAPACITOR

Introduction to Capacitors:

A **capacitor** is a device in which electrical energy can be stored. It is an arrangement of two conductors, generally carrying charges of equal magnitudes and opposite signs, and separated by an insulating medium. The non-conductive region can either be an electric insulator or vacuum, such as glass, paper or air, or a semi-conductor called a dielectric.

Specifications: 1)104k, 400 volts, 0.1uF



Application of capacitors:

- They are used in power supply circuits to smooth out voltage fluctuations.
- In electronic filters to remove or separate AC and DC components of a signal.
- In oscillator circuits to generate periodic signals.

Advantages of capacitors:

- They can store and release energy fast, making them useful for quick charge and discharge applications.
- They reduce losses, free up capacity, and reduce voltage drop in distribution systems, improving system performance and efficiency.
- They have low losses, no maintenance required, long service life, simple method of operation, and relatively cheap cost, making them reliable and versatile components.
- They can work with both AC and DC currents, making them more compatible

Role in AC Voltage Regulation Circuit

- After turning the power supply of the circuit, we observe whether the fan is in standstill condition or not. We Vary the potentiometer position slowly so that the capacitor starts charging at the time constant determined by the values of resistances
- Once the voltage across the capacitor is more than the break over voltage of the DIAC, DIAC starts conducting. Thus, the capacitor starts discharging towards the gate terminal of TRIAC through DIAC.
- Therefore, TRIAC starts conducting and hence the main current starts flowing into the fan through the closed path formed by TRIAC.
- The rate at which capacitor is going to be charged get varied this means that if the resistance is less, the capacitor will charge at a faster rate so the earlier will be the conduction of TRIAC.

INCANDESCENT LIGHT/ REFRIGERATOR BULB

Introduction to incandescent light bulb:

The **incandescent lamp** or light or bulb is an electric light source that works through the incandescence phenomenon that means the light emission can be caused by filament heating. These lamps are available in different sizes with different voltages and wattages. The first inventor of an incandescent lamp is "**Thomas Edison**"Incandescent lamps are the most frequently used bulbs at a reasonable cost. These lamps will glow once electrical current flows throughout a filament then they generate high brightness that is matched through large energy utilization.They have a light expectancy of approximately 800 hours.

Specifications:

Operating Voltage: 230 Volts

Power Consumption : 15 Watts

Dimmable : Yes

Lighting Technology: Incandescent

Lifetime : 1000 Hour(s)

Advantages:

These lamps are cheap and easily available. Their light output is high and can be easily dimmed by using rheostats. In winter, they help in increasing room temp.

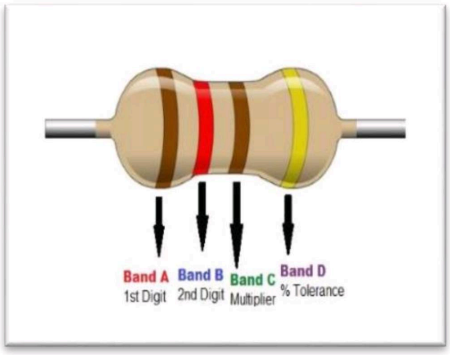
Applications:

These lamps are normally used in table lamps, desk lamps, hallway lighting, accent lighting, chandeliers, closets, etc. 95% of the energy consumed by these bulbs are dissipated as heat. So, these are rather used as heat sources.

Role in AC Voltage Regulator Circuit:

It indicates the operation of the regulator.

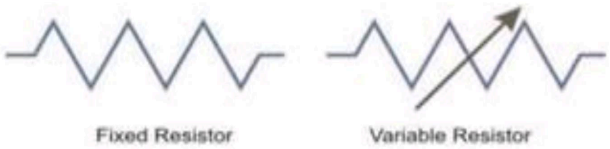
RESISTOR



Introduction to Resistor:

A **Resistor** is a passive electrical component with two terminals that are used for either limiting or regulating the flow of electric current in electrical circuits. The main purpose of resistor is to reduce the current flow and to lower the voltage in any particular portion of the circuit. It is made of copper wires which are coiled around a ceramic rod and the outer part of the resistor is coated with an insulating point.

Specifications: 1)10k



Application of Resistor:

- Resistors are used for controlling temperature and voltmeter.
- Resistors are used in digital multi-meter, amplifiers, telecommunication, and oscillators.
- They are also used in modulators, demodulators, and transmitters.
- Resistor is used in voltage regulators.
- Resistors is used in power control circuit.

Advantages of Resistor:

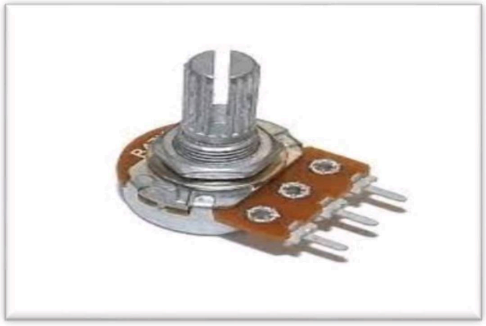
- Resistors are very small. Hence, it is very easy to carry them from one place to another place.
- Resistors are very cheap. Hence, it is easy to replace them.
- Resistors do not depend on the external source of voltage. Hence, external voltage or energy is not needed for operating the resistors.

Role in AC Voltage Regulation Circuit:

- When using pure resistors in AC circuits that have negligible values of inductance or capacitance, the same principles of Ohm's Law, circuit rules for voltage, current and power (and even Kirchhoff 's Laws) apply as they do for Dc resistive circuits the only difference this time is in the use of the instantaneous "peak-to-peak" or "rms" quantities.
- When working with AC alternating voltages and currents it is usual to use only "rms" values to avoid confusion. The rms or "root mean squared" value of an AC waveform is the effective or DC value equivalent for an AC waveform.
- For current limiting, resistors control current flow to avoid damaging excess and can be used in simple to complex circuits, often determining the current limit.
- Resistors are crucial in voltage regulation and current limiting circuits in electronic design.

VARIABLE RESISTOR

Introduction to Variable Resistor



A variable resistor is a resistor of which the electric resistance value can be adjusted. A variable resistor is in essence an electro-mechanical transducer and normally works by sliding a contact (wiper) over a resistive element. When a variable resistor is used as a potential divider by using 3 terminals it is called a potentiometer. When only two terminals are used, it functions as a variable resistance and is called a rheostat. Electronically controlled variable resistors exist, which can be controlled electronically instead of by mechanical action. These resistors are called digital potentiometers.

Specifications:512 Kiloohm

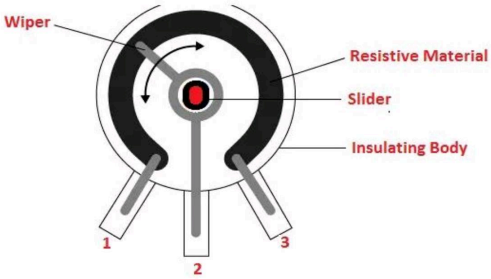
Applications:

- A variable resistor is used in a dimmer switch for light & the knob for volume control on a radio. The resistance values of these resistors mainly include 10Ω, 100Ω,10kΩ & 100KΩ.
- Variable Resistors can be found in:
  - Audio Control
  - Television
  - Motion Control
  - Transducers
- The Variable Resistor will have maximum and minimum value through which it can alter the current.

Advantages:

The advantages of variable resistance are-

- It helps in increasing strength.
- It also helps in increasing power.
- Helps in improving neuromuscular coordination.

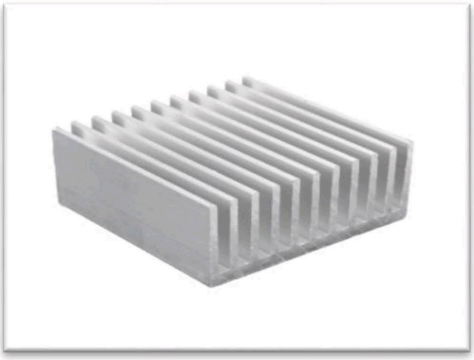


Terminals in a Variable Resistor

Role in Ac voltage regulation circuit:

- Any resistive heating element such as Electric Fires, Toasters, Kettles, Irons, Water Heaters etc. can be classed as a resistive AC circuit and we use resistors in AC circuits to heat our homes and water.
- In a pure ohmic AC Resistance, the current and voltage are both said to be “in-phase” as there is no phase difference between them. The current flowing through the resistor is directly proportional to the voltage across it with this linear relationship in an AC circuit being called Impedance. As with DC circuits, Ohm’s Law can be used when working with resistors in AC circuits to calculate the resistors voltages, currents and power.

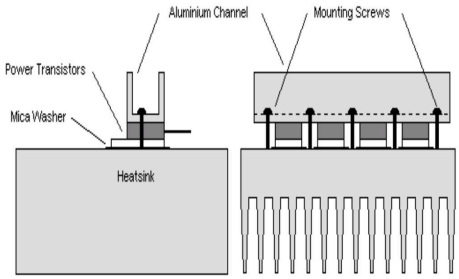
HEAT SINK



Introduction to Heat Sink:

A **heat sink** is a passive heat exchanger that transfers the heat generated by an electronic or a mechanical device to a fluid medium, often air or a liquid coolant, where it is dissipated away from the device, thereby allowing regulation of the device's temperature

Application of Heat Sink:



- Heat sinks are used to cool CPUs, GPUs, and some chipsets and RAM modules in computers
- High-intensity LED lights generate a significant amount of heat. Heat sinks are used to keep the temperature of the LEDs within safe operating limits and extend their life span.
- Heat sink is also used in solar panels where it is employed with the inverter to ensure the inverters performance.
- Heat sinks are also used in medical devices like MRI machines and laser systems to ensure the safe functioning of the devices.
- Heat sink is also used in aerospace and defence equipment.

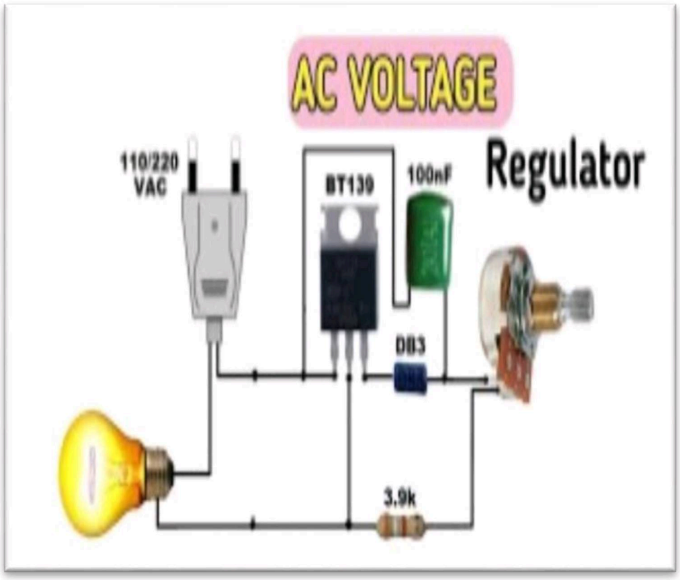
Advantages of Heat Sink:

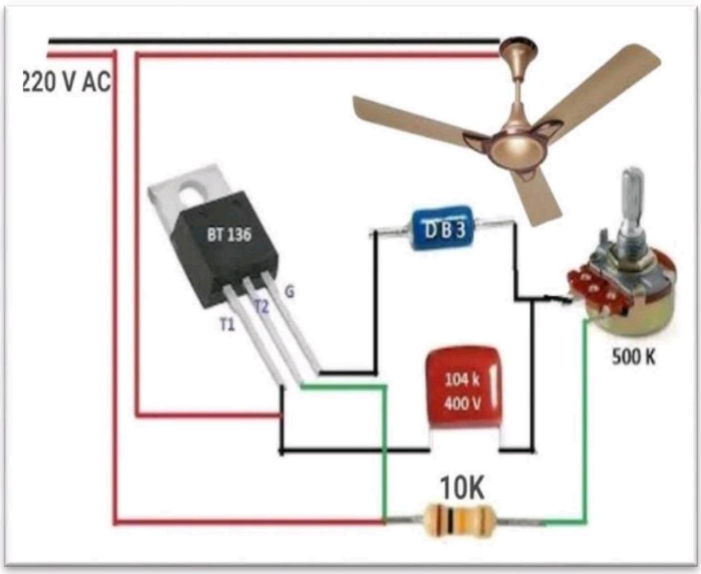
- Heat sinks are generally safer than some other cooling methods, as they don't have.
- Heat sinks are cost effective. Hence, it is easy to replace them.
- Heat sinks do not rely on refrigerants or other potentially harmful substances, making them environment friendly cooling solutions.

Role in AC Voltage Regulation Circuit:

- **Power Semiconductors**: In some AC voltage regulation circuits, power transistors, MOSFETs (Metal-Oxide-Semiconductor Field-Effect Transistors), or thyristors (SCRs - Silicon Controlled Rectifiers) may be used to control the flow of AC power. These devices can generate substantial heat when conducting high current loads. Hence to reduce the heat and for the normal functioning Heat Sink is required.
- **Longevity**: Heat sinks play a crucial role in extending the lifespan of voltage regulators and power semiconductors. Excessive heat can lead to component degradation and premature failure, so effective heat dissipation is essential for long-term reliability.

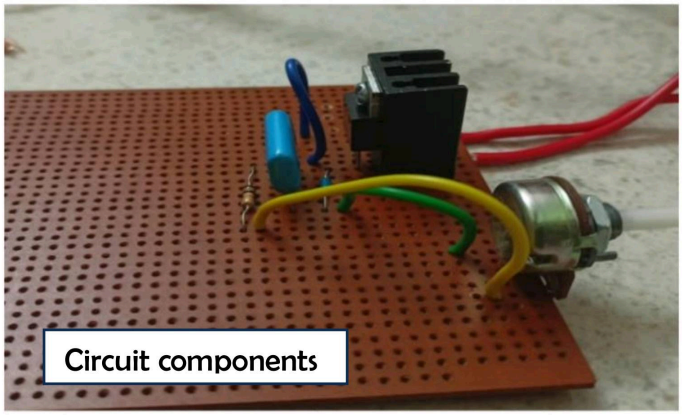
PRECAUTIONS



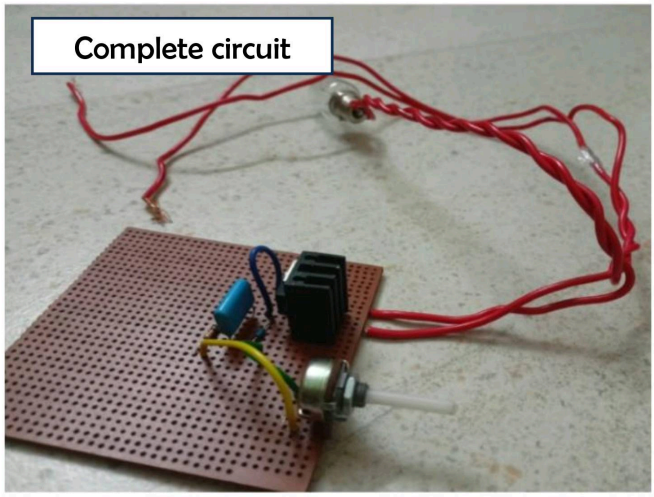


1) Arrange and Secure the Cables properly.
2) The stable power supply must be reliably grounded.
3) Make sure the ground wire power supply is far away from Liquid or Heat.
4) Check for loose connection regularly.
5) Handle the stabilizer with care.
6) Avoid overloading the voltage stabilizer.

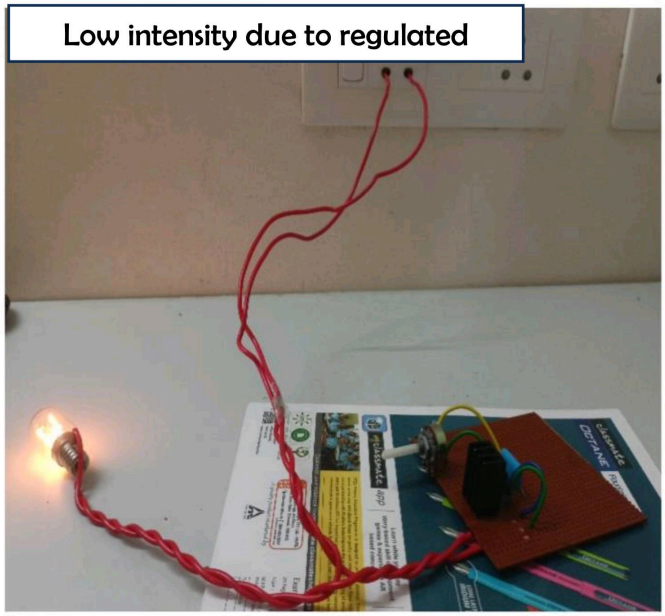
PHOTO ALBUM



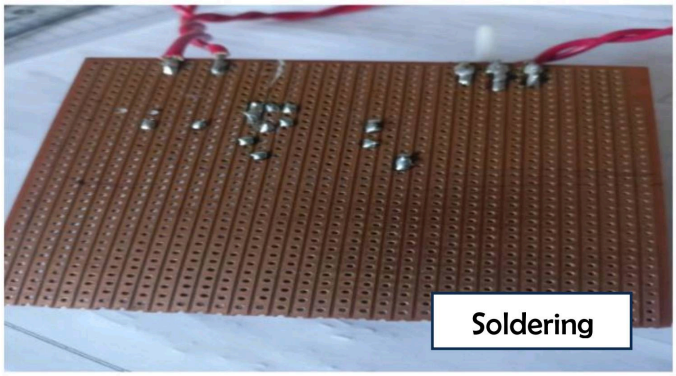
Circuit components



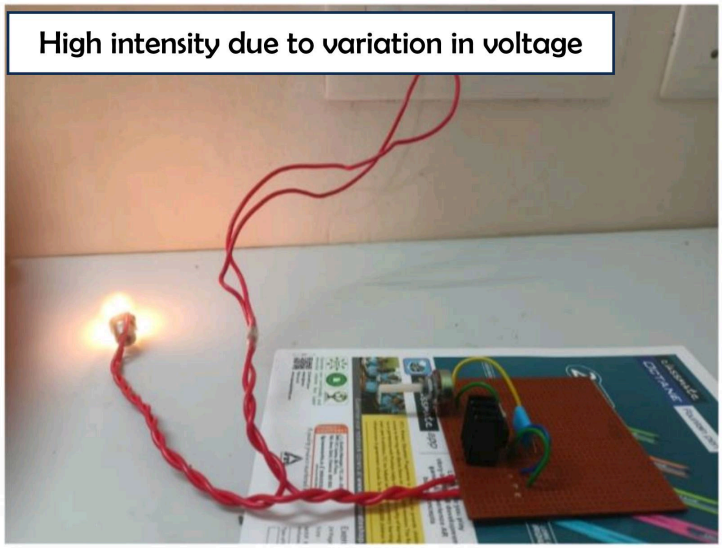
Complete circuit



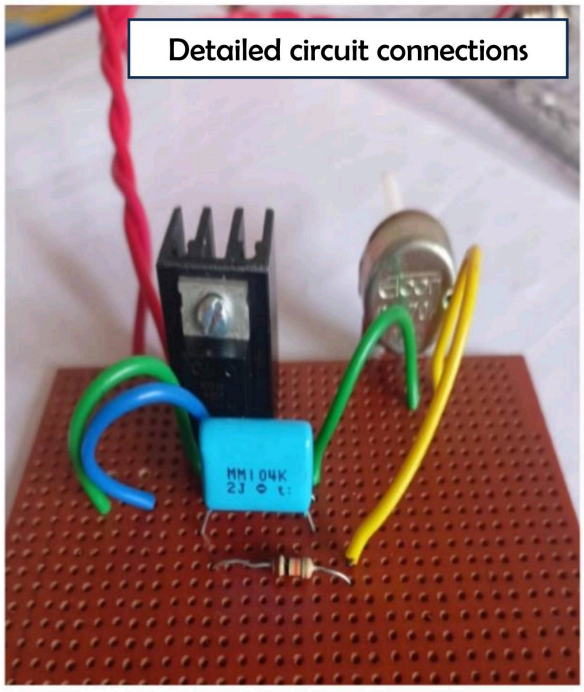
Low intensity due to regulated



Soldering



High intensity due to variation in voltage



Detailed circuit connections

CONCLUSION

Advantages:

1. **Cost Efficiency:** This regulator provides a cost-effective solution for fan speed control, making it accessible for a wide range of applications.
2. **Smooth Speed Control:** It allows for smooth and precise adjustments in fan speed, enhancing user comfort and energy efficiency by providing the desired airflow.

Disadvantages:

1. **Electromagnetic Interference (EMI) and Electrical Noise:** Due to its switching nature, this regulator can introduce electromagnetic interference (EMI) and electrical noise into the electrical system, potentially affecting the performance of nearby electronic devices. Additional filtering or shielding may be necessary to mitigate this issue.
2. **Heat Generation:** DIACS and TRIACS can generate heat during operation, especially when controlling higher loads. This heat can potentially lead to overheating issues if not managed properly, requiring the use of heat sinks or other thermal management solutions to ensure safe and reliable operation.

In summary, while this regulator offers cost-efficient and precise fan speed control, it's essential to address potential issues related to EMI and heat generation when implementing this circuit. By leveraging the characteristics of these semiconductor devices, the project allows for smooth and precise fan speed adjustments, enhancing user comfort and energy efficiency. However, proper safety measures and electrical knowledge are essential when implementing this circuit to ensure safe operation.