UEC2201

Fundamentals of Electronic Devices and Circuits

Mini Project Report on

BATTERY ELIMINATOR USING ZENER DIODE

II Semester

B.E. (ECE – B)

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Faculty In-charge

ABSTRACT

This paper explores the design and application of a battery eliminator using a Zener diode for voltage regulation. The device aims to replace traditional batteries in low-power electronic devices by converting AC mains electricity into a stable DC voltage. The primary components of this battery eliminator include a transformer, rectifier, filter, and Zener diode for voltage regulation.

The transformer steps down the AC voltage to a suitable lower level, which is then converted to DC using a bridge rectifier. The resulting pulsating DC voltage is smoothed by a filter capacitor to reduce ripple. A Zener diode is employed to maintain a stable output voltage, leveraging its ability to maintain a constant voltage over a wide range of load currents, thus providing effective voltage regulation.

Current going across the terminals in reverse bias (backward) is called the Zener effect. When voltage potential is met, this causes the Zener voltage / breakdown voltage. This is the minimum voltage that causes a portion of an insulator to experience a breakdown and become electrically conductive.

This study concludes that using a Zener diode for voltage regulation in battery eliminators is an efficient and economical approach. Future enhancements could involve integrating additional features such as overcurrent protection, thermal management, and variable output voltage to broaden the range of applications and improve device robustness.

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CHAPTER 1

INTRODUCTION

What is battery eliminator?

A battery eliminator is a device that supplies electrical power to equipment in place of a battery. The primary function of a battery eliminator is to convert an available power source, typically an AC mains supply, into a suitable DC voltage and current that the battery-powered device requires.

Why do we use Zener-diode in battery eliminator?

➞Voltage Regulation:

• Zener diodes are excellent voltage regulators. They maintain a constant voltage across them, even when the current varies.

• In a battery eliminator, Zener diodes help stabilize the output voltage, ensuring consistent power supply to connected devices.

➞Preventing Overcharging:

• In solar power systems, Zener diodes are used in charge controllers to prevent battery overcharging.

• By shunting excess voltage, Zener diodes protect batteries from damage due to overcharging.

➞Low Voltage Cut-Off:

• However, using a Zener diode directly as a low voltage cut-off isn't ideal.

The diode won't cut off precisely at the desired voltage; it will slightly conduct and produce heat over time.

• Instead, a better approach is to set a lower reference voltage (e.g., 9 volts) and compare it with a fraction of the battery voltage (e.g., 9/10ths). This ensures a more reliable cut-off point.

CHAPTER 2

LITERATURE REVIEW

Description:

Battery eliminators were popular accessories for early radios, allowing them to operate directly from AC power mains. While B+ and C- supplies were relatively straightforward, the A+ supply (heaters) posed challenges.

Zener diodes were used to regulate the A+ supply voltage, ensuring stable operation. Battery eliminators are used in vintage radios, clocks, and other

devices. Zener diodes play a crucial role in voltage regulation within these eliminators.

Identification of Gaps:

Zener diodes can play a role in voltage regulation, achieving precise battery cutoffs often requires additional components and careful design. Using a precision reference and addressing hysteresis can improve the overall performance of your battery eliminator.

Significance:

- Voltage Regulation: Zener diodes maintain a stable output voltage, even when the current varies.
- Battery Replacement: Battery eliminators using Zener diodes allow devices to operate directly from AC power sources, eliminating the need for batteries.
- Widespread Use: Zener diodes are widely used in voltage regulation tasks due to their robustness and reliability.

Limitations:

- Inaccurate Cutoff Voltage: Zener diodes may not cut off precisely at the desired voltage. There's a slight conduction and heat production near the cutoff point.
- Zener Impedance: Zener diodes have some impedance, limiting their ideal voltage regulation range.
- Wasted Power: In battery eliminators, Zener diodes act as shunt regulators, wasting power by burning off excess current when the load takes none.

Impact:

- Reliable Voltage Regulation: Zener diodes ensure stable output voltages, making them valuable in various electronic circuits.
- Efficient Battery Elimination: By replacing batteries, Zener-based battery eliminators improve convenience and reduce environmental impact.

METHODOLOGY

Theory on the Problem Statement:

Context:

In many electronic devices, the need for continuous and reliable power is critical. Traditional batteries, while convenient, have several drawbacks, including frequent replacements, environmental impact, and inconsistent power supply as they discharge. To address these issues, a battery eliminator can provide a more sustainable and reliable power solution. Specifically, incorporating a Zener diode into the design of a battery eliminator can enhance voltage regulation and stability, ensuring that the device receives a consistent power supply.

Problem:

Traditional battery-powered devices face several challenges:Frequent Battery Replacements: Batteries need to be replaced or recharged regularly, leading to interruptions in device operation.

Environmental Impact: Discarded batteries contribute to environmental pollution and resource depletion.

Inconsistent Power Supply: As batteries discharge, the voltage they provide drops, potentially causing device malfunction or suboptimal performance.

Maintenance Hassles: Constant monitoring and replacement of batteries add to maintenance efforts and costs.

Evidence of the Problem:

Operational Interruptions: Devices frequently experience downtime due to dead batteries, impacting productivity and user experience.

Cost Implications: The cumulative cost of purchasing and disposing of batteries over time is significant.

Environmental Concerns: Increased awareness of environmental issues has highlighted the need to reduce battery waste.

Performance Issues: Fluctuating voltage levels from discharging batteries can lead to erratic device performance.

Impact of the Problem:

The aforementioned issues have several adverse effects:

Reduced Productivity: Frequent interruptions for battery changes disrupt workflows and reduce efficiency.

Higher Costs: Long-term expenses related to battery purchases and disposals add up.

Environmental Harm: Improperly disposed batteries contribute to soil and water pollution, harming ecosystems.

Device Reliability: Inconsistent power supply affects the reliability and lifespan of electronic devices.

Desired Outcome:

The goal is to develop a battery eliminator using a Zener diode that provides a stable and reliable power supply, eliminating the need for traditional batteries. The desired outcomes include:

Continuous Power Supply: Ensuring devices operate without interruption.

Cost Savings: Reducing or eliminating the need for battery purchases and disposals.

Environmental Benefits: Minimizing battery waste and its associated environmental impact.

Enhanced Device Performance: Providing a consistent voltage to improve device reliability and performance.

Scope of the Project:

This project will focus on designing and implementing a battery eliminator circuit incorporating a Zener diode for voltage regulation.

The scope includes:

- Design and Testing: Creating and testing the battery eliminator circuit to ensure it provides stable power.
- Integration: Ensuring compatibility with various devices currently using traditional batteries.
- Cost Analysis: Evaluating the cost-effectiveness of the solution compared to ongoing battery use.
- Environmental Impact Assessment: Analysing the environmental benefits of reducing battery waste.

In many electronic devices, the need for continuous and reliable power is critical. Traditional batteries, while convenient, have several drawbacks, including frequent replacements, environmental impact, and inconsistent power

supply as they discharge. The devices frequently experience downtime due to dead batteries, leading to reduced productivity, higher costs, and environmental harm.

Additionally, fluctuating voltage levels from discharging batteries can cause erratic device performance. The goal is to develop a battery eliminator using a Zener diode that provides a stable and reliable power supply, eliminating the need for traditional batteries.

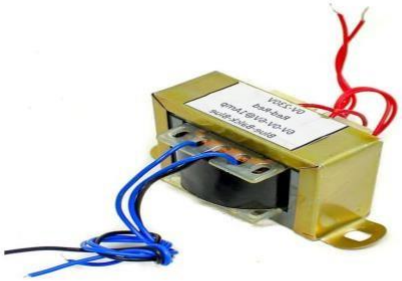
This solution aims to ensure continuous device operation, reduce costs, minimize environmental impact, and enhance device performance. The project will focus on designing and testing a battery eliminator circuit with a Zener diode for voltage regulation, ensuring compatibility with various devices, and evaluating the cost-effectiveness and environmental benefits of the solution.

Components with Description:

The Components required for designing a Battery Eliminator Using Zener Diode are:

S. No	COMPONENTS	RANGE	QUANTITY
1.	Step-down transformer	(9-0-9) V	1
2.	PN Junction Diode	IN-4007	4
3.	Capacitor	100 μF	1
4.	Resistor	1k ohm	2
5.	Zener diode	5.5 V	1

Step-down transformer:



A step-down transformer is an electrical device that converts high voltage (HV) and low current from the primary side of the transformer to low voltage (LV) and high current on the secondary side. Essentially, it “steps down” the voltage. When an alternating current (AC) voltage is applied to the primary winding, it generates a fluctuating magnetic field in the iron core. This changing magnetic flux induces an electromotive force (emf) in the secondary coil, which has a lower voltage than the primary coil.

Bridge Rectifier: (IN4007 diode - 4)

A bridge rectifier is a type of full-wave rectifier that efficiently converts alternating current (AC) to direct current (DC). It achieves this by using four or more diodes arranged in a bridge circuit configuration. Unlike half-wave rectifiers, which use only one diode, bridge rectifiers rectify both the positive and negative halves of an AC waveform. The output waveform generated by a bridge rectifier is of the same polarity regardless of the input polarity.

Capacitor:

A capacitor is an electrical device that stores energy by accumulating electric charges on two closely spaced surfaces, which are insulated from each other. When a voltage is applied across the capacitor's terminals, an electric field develops across the dielectric, resulting in a net positive charge on one plate and a net negative charge on the other. Capacitors are widely used in electronic circuits for various purposes, including smoothing power supply outputs and blocking direct current (DC) while allowing alternating current (AC) to pass.

Resistor:

A resistor is a passive two-terminal electrical component that implements electrical resistance in a circuit.

Resistors are used to:

- Reduce current flow.
- Adjust signal levels.
- Divide voltages.
- Bias active elements
- Terminate transmission lines.

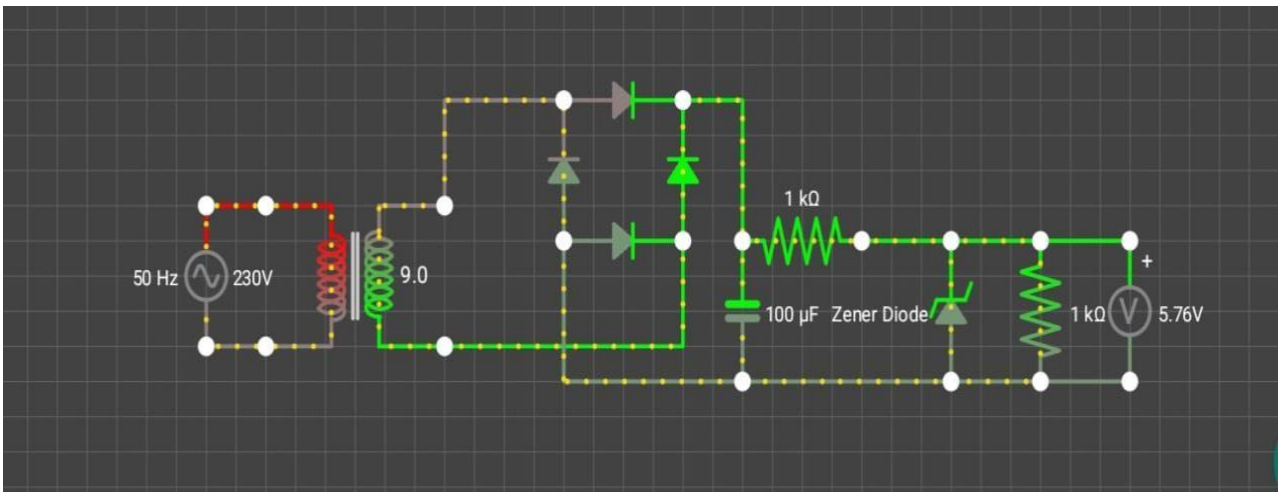
Zener diode:

A Zener diode is a specialized semiconductor device designed to allow current to flow in the reverse direction (inverted polarity) when a certain set reverse voltage, known as the Zener voltage, is reached. These diodes come in various Zener voltages, and some are even adjustable. The Zener effect, named after physicist Clarence Zener, explains their behaviour. At lower voltages, the Zener effect predominates, while at higher voltages, avalanche breakdown occurs. Zener diodes are used for generating reference voltages, voltage

stabilization, and protecting circuits from overvoltage, including electrostatic discharge.

SOFTWARE IMPLEMENTATION / INTERIM RESULTS OF THE PROPOSED CIRCUIT

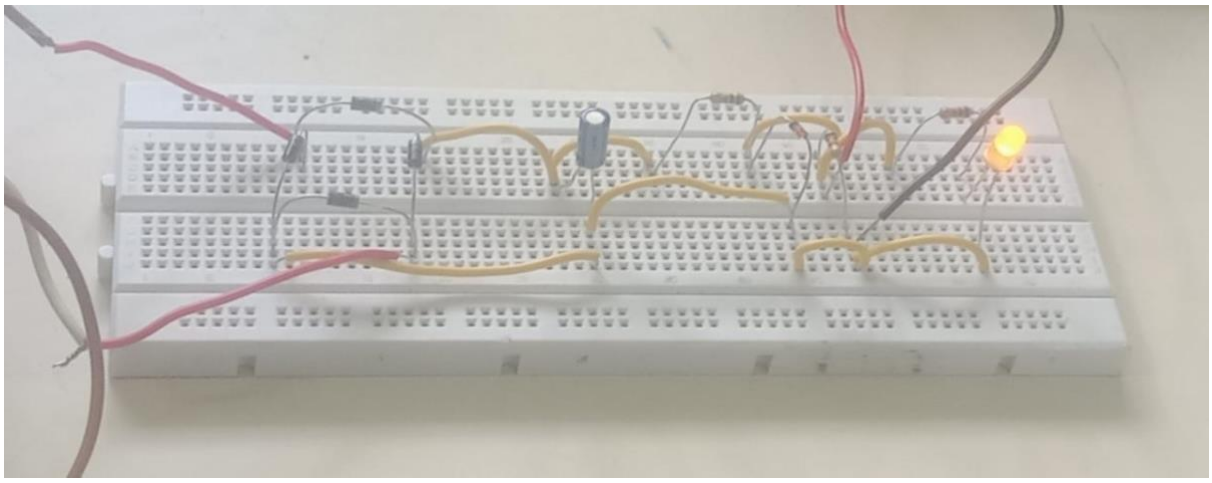
1. Simulation snapshots:

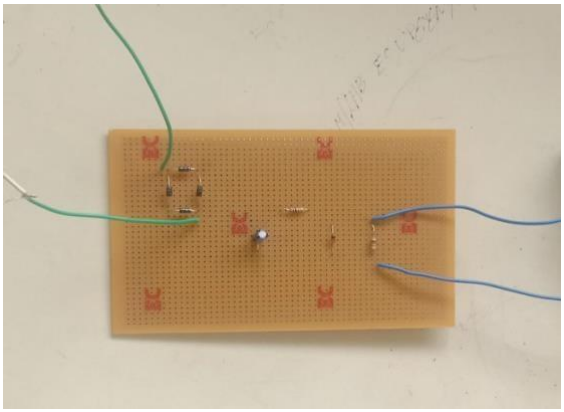


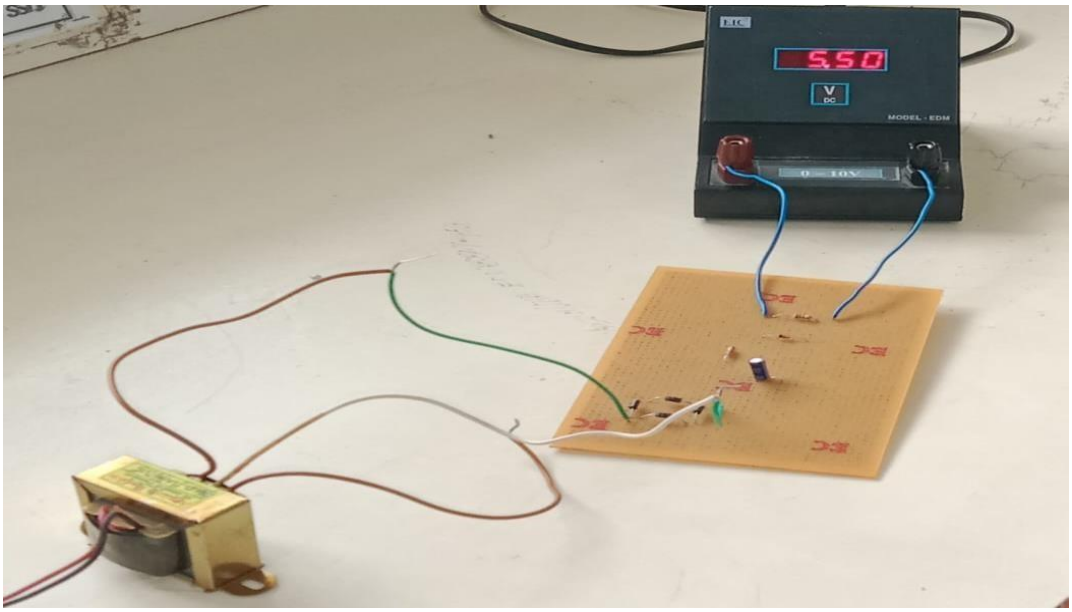
Simulation software used: Voltsim.

Simulation link:
https://www.voltsimulator.com/dl?id=HQ6iPrYoTx0JDKNv4TIM

2. Hardware Implementation of Proposed Circuit:







CONCLUSION AND FUTURE WORK

Conclusion:

Zener Diodes in Battery Eliminators:

- Zener diodes are commonly used for voltage regulation in battery eliminators.
- However, using them as a precise low-voltage cutoff has limitations due to their wide voltage tolerance.

Challenges:

- Zener diodes don't cut off precisely at the desired voltage; they slightly conduct and produce heat.
- After the cutoff, the battery remains unloaded, potentially causing stress on the system.

Recommended Approach:

- Consider using a comparator with hysteresis to achieve more accurate cutoff points.

- Explore alternative voltage references like the TL431 for better performance.

Future work:

Explore alternative voltage references, such as precision references like the TL431, which provide more accurate cutoff points.

Consider using a combination of Zener diodes and other components to achieve better performance in battery eliminators.

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