Khulna University of Engineering & Technology

Department of Electronics & Communication Engineering

Project Report

Course No: ECE 3102

Project Name: Design and simulate an electronic system for the switching and regulation of all the electric devices for a typical apartment

Submitted by	Project supervisors
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Objectives:

1. Develop a model and electronic device control system to manage a water pump, fan, and two lights using semiconductors.
2. Understand power electronics basics, enhance circuit design skills, and gain proficiency in simulation using Multisim software.

Introduction:

Effective management and regulation of electrical devices in modern homes are essential for convenience and energy efficiency. This project aims to design and simulate a sophisticated electronic system to control and regulate various electrical devices in an apartment. The main goal is to create a reliable and efficient control system to ensure the optimal performance and safety of all connected devices, including precise switching mechanisms and motor speed regulation for fans. Additionally, the project seeks to deepen the understanding of power electronics and improve circuit design skills through practical application and Multisim software simulation.

Theory:

Power electronics involves controlling and converting electrical power using semiconductor devices. This project uses Silicon Controlled Rectifiers (SCRs), DIACs, and TRIACs to design a switching and regulation system for household electrical devices.

Key Components and Their Functions

1. Silicon Controlled Rectifier (SCR)
    - Structure: Four layers of alternating P and N materials (PNPN) with three junctions.
    - Operation:
        - Off-State: Blocks current without a gate signal.
        - On-State: Conducts current from anode to cathode when a gate signal is

applied.
    - Latching: Continues conducting even if the gate signal is removed, as long as current exceeds the holding current.
2. DIAC (Diode for Alternating Current)
    - Structure: Two-terminal, three-layer device (PNP or NPN).
    - Operation: Conducts current when voltage exceeds its breakover voltage.
    - Applications: Triggers TRIACs in phase control applications like light dimmers and motor speed controls.
3. TRIAC (Triode for Alternating Current)
    - Structure: Five layers forming three junctions (PNPNP) with three terminals: MT1, MT2, and Gate.
    - Operation: Conducts current bidirectionally when triggered by a gate pulse.
    - Applications: Used in AC power control for light dimmers, motor speed controllers, and heater controls.

Circuit Diagram:

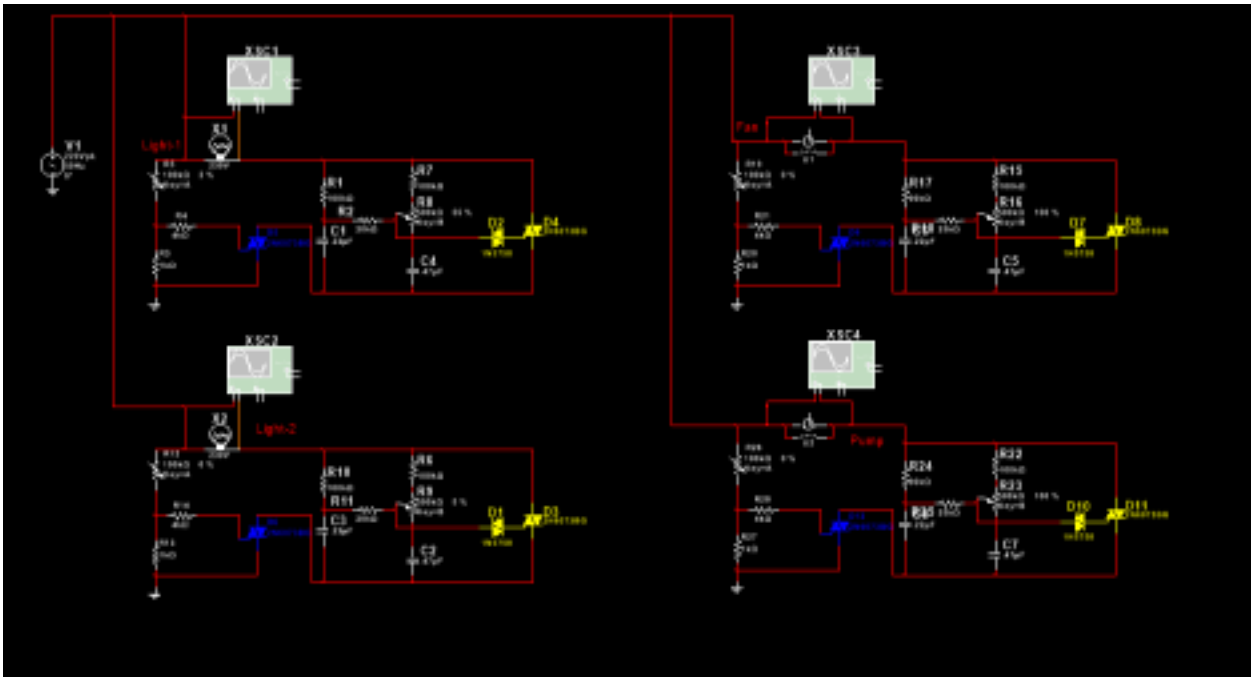


Fig: Diagram of our designed circuit

Practical Application in Circuit Design

Circuit Functionality: The TRIAC acts as a switch, conducting current when a gate signal is applied and stopping when the main current crosses zero if the gate signal is removed.

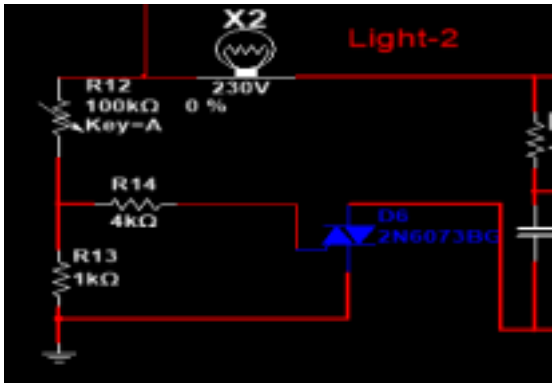


Fig: Diagram of Triac as a Switch

AC Power Regulation: The firing angle of the TRIAC, controlled by a DIAC, regulates the power delivered to the load. Adjusting the firing angle controls the RMS voltage and power delivered.

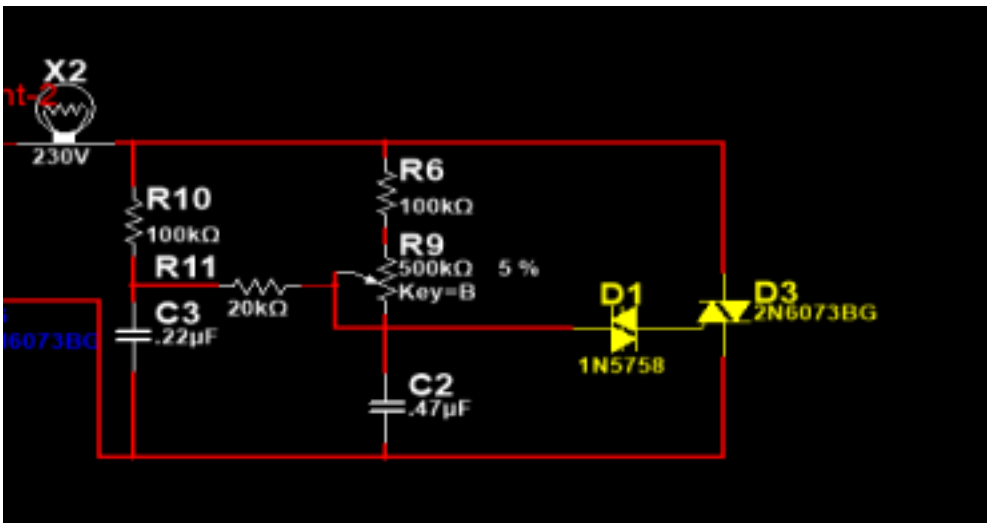


Fig: Diagram of diac and triac as a power regulator **Experimental**

Experimental Observations

Performance Data:

- Maximum Power State: Power: 12.9 W, Voltage: 159V, Current: 929mA
- Minimum Power State: Power: 5.17mW, Voltage: 32V, Current: 1.71mA

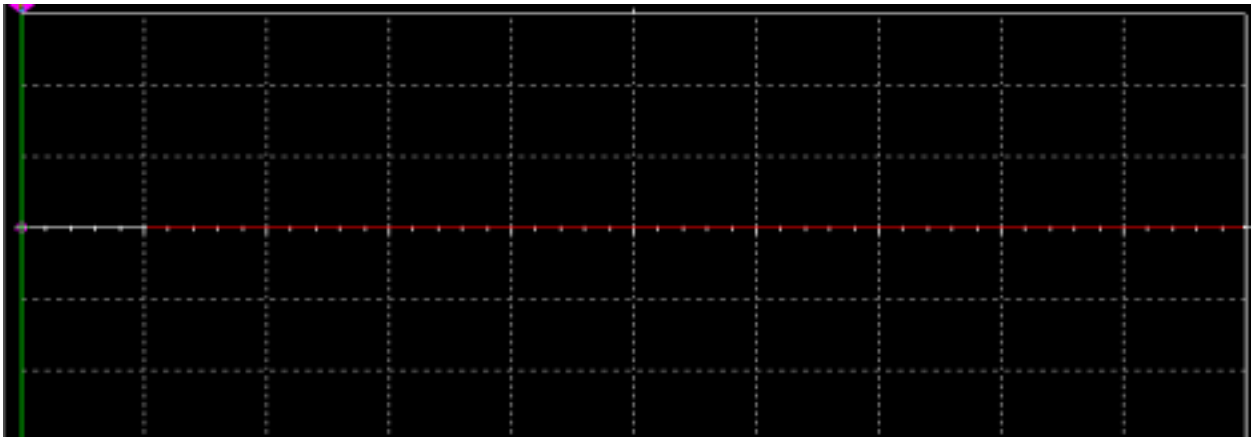
Result Analysis:

The project successfully designed an electronic system capable of switching and regulating various electrical devices. A TRIAC was employed for switching, while both DIAC and TRIAC

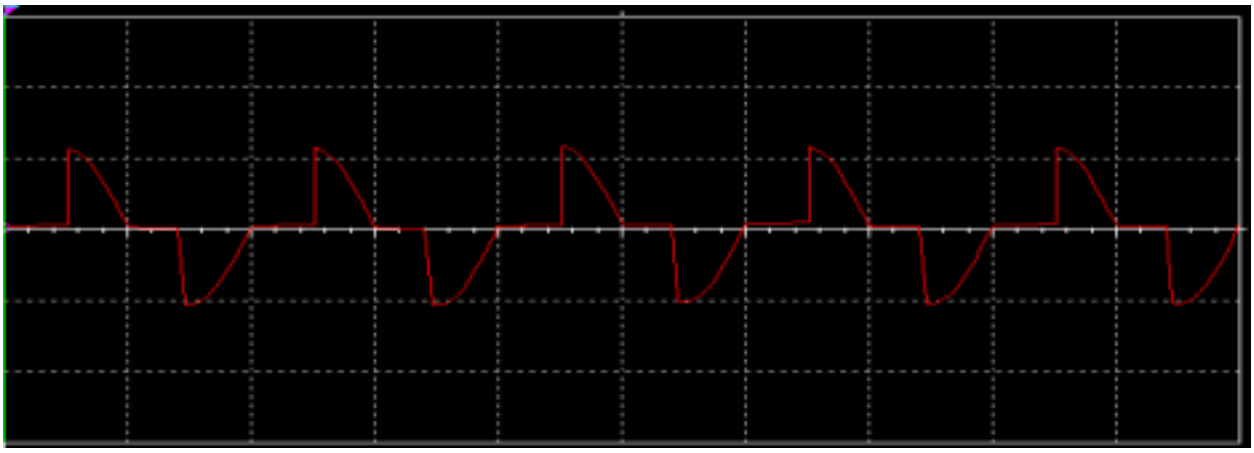
were utilized for fan regulation and motor speed control.

Waveform Analysis:

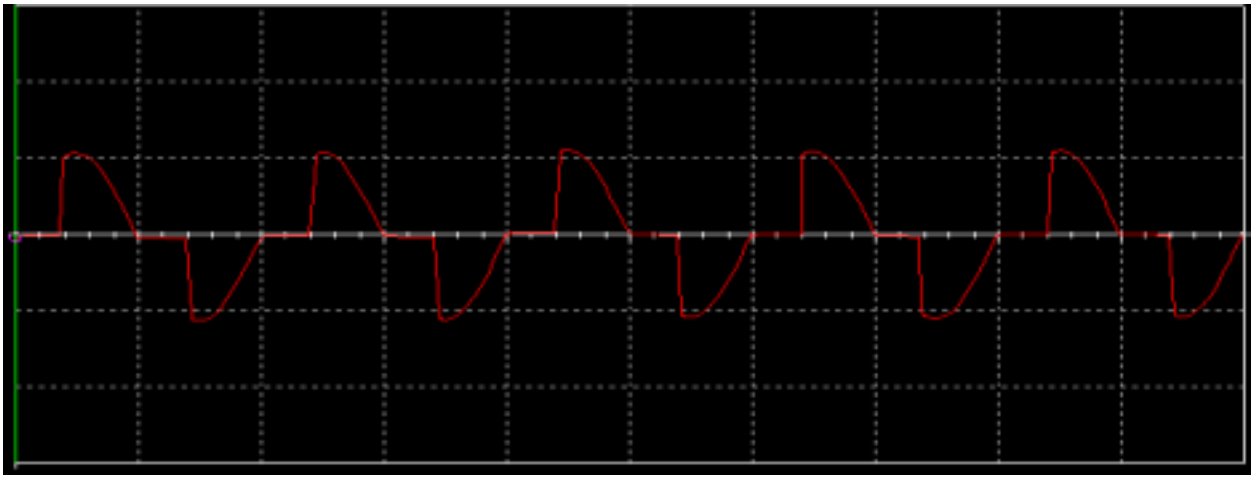
- Case 1: R = 0% - Light off



Case 2: R = 25% - Firing an



- Case 3: R = 50% - Firing angle = 72°, Conduction angle = 108°

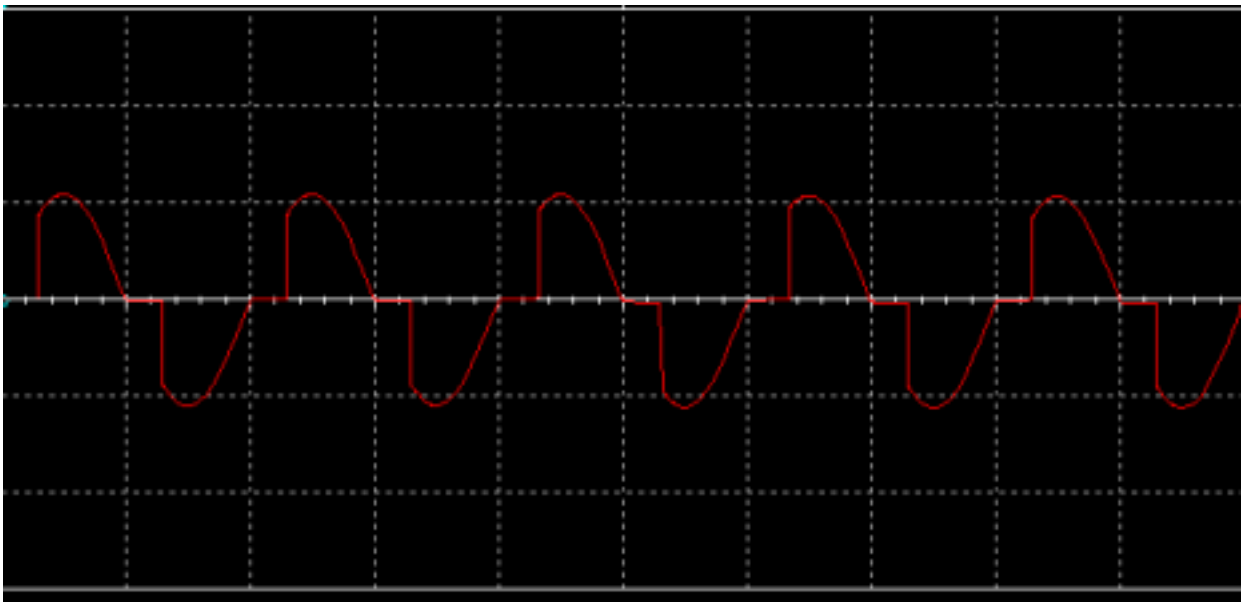


Case4:

When R=75%;

Firing angle=54

Conduction angle=126

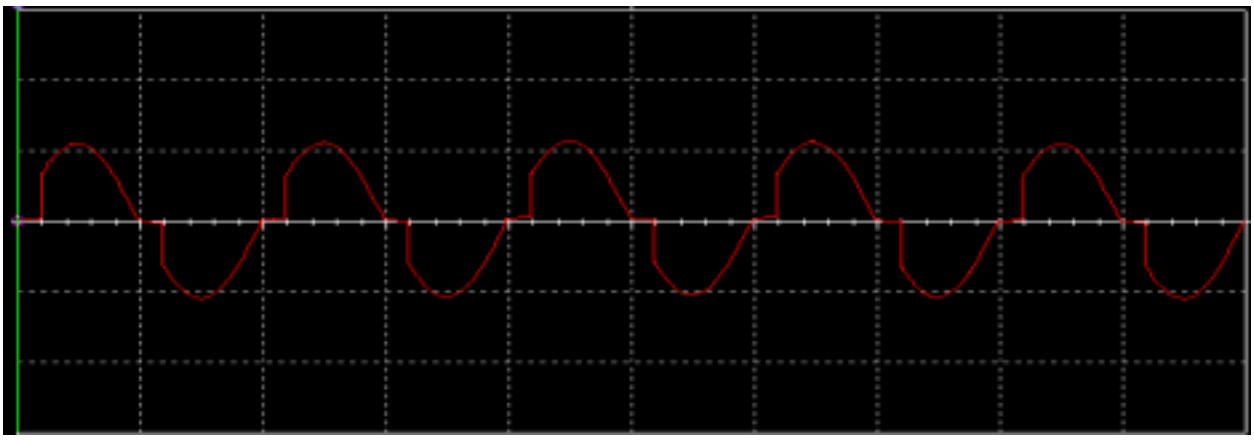


Case5:

When R=100%;

Firing angle=32.4

Conduction angle=147.6



Discussion:

In this project, we designed an electronic system that functions both as a switch and a regulator for various devices. Specifically, we implemented a light dimmer circuit to control the speed of a motor. The project aimed to leverage power electronics principles to achieve efficient and reliable control of electrical loads in a residential setting.

During the design and simulation phases, we encountered several challenges. The primary issue was the unavailability of a water pump in the Multisim simulation library, so we use motor as a pump. While this workaround allowed us to proceed with our project, it introduced some limitations in accurately simulating the behavior of an AC motor
controlled circuit

Another significant challenge was the performance of the simulation software. This issue was particularly problematic when running the simulations, as it caused delays and occasionally distorted the waveforms. These distortions made it more difficult to analyze the results accurately and required us to spend additional time troubleshooting and verifying the circuit behavior.

Despite these obstacles, we successfully completed our project. The final circuit design met our initial objectives and demonstrated the capability to switch and regulate electrical devices effectively.

Conclusions:

In conclusion, this project successfully demonstrated the design and simulation of an electronic system capable of switching and regulating electrical devices using power electronics principles. Despite facing challenges related to component availability and software performance, we were able to achieve our objectives.

Reference:

1) https://www.androiderode.com/lamp-dimmer-using-triac-and-diac/ 2)

https://www.homemade-circuits.com/how-to-make-simplest-triac-flasher/