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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Date of submission:28/5/2024

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Objectives:

1) To create a model and develop an electronic device switching and regulating system, comprising a water pump, a fan, and two lights, all powered by semiconductors.
2) To comprehend the fundamentals of power electronics, circuit design abilities, and acquire competence with simulation using Multisim program.

Introduction:

In modern residential environments, the efficient management and regulation of electrical devices are crucial for both convenience and energy conservation. This project focuses on the design and simulation of an advanced electronic system for the switching and regulation of various electrical devices within an apartment. The primary objective of this project is to develop a robust and efficient control system that ensures optimal performance and safety of all connected electrical devices. This includes implementing precise switching mechanisms, speed regulation for motor-based devices like fans. Furthermore, the project aims to enhance the understanding of power electronics principles and improve circuit design skills through practical application and simulation using Multisim software.

Theory:

The project is based on the principles of power electronics, which involve the control and conversion of electrical power using semiconductor devices. Key theoretical concepts relevant to this project include the operation and application of power semiconductors such as Silicon Controlled Rectifiers (SCRs), DIACs, TRIACs.

Power Semiconductors

1. **Silicon Controlled Rectifier (SCR):**

   - **Structure:** An SCR is a four-layer, three-junction semiconductor device composed of alternating P and N materials (PNPN).
   - **Operation:**

    - **Off-State:** In the absence of a gate signal, the SCR remains in the off-state (blocking state), allowing only a small leakage current to flow.
    - **On-State:** When a gate signal is applied and the anode is positive relative to the cathode, the SCR switches to the on-state (conducting state), permitting current flow from anode to cathode.
    - **Latching:** Once triggered by the gate signal, the SCR continues to conduct even if the gate signal is removed, as long as the current remains above the holding current.

2. **DIAC (Diode for Alternating Current):**
    - **Structure:** A DIAC is a two-terminal, three-layer device (PNP or NPN).
    - **Operation:**
        - **Breakover Voltage:** The DIAC remains non-conductive until the applied voltage exceeds its breakover voltage in either direction.
        - **Conduction:** Upon exceeding the breakover voltage, the DIAC switches to a low-resistance state, allowing current to flow.
    - **Applications:** DIACs are primarily used to trigger TRIACs in phase control applications such as light dimmers and motor speed controls.

3. **TRIAC (Triode for Alternating Current):**
    - **Structure:** A TRIAC is a bidirectional thyristor with five layers of semiconductor material and three junctions (PNPNP). It has three terminals: MT1 (Main Terminal 1), MT2 (Main Terminal 2), and Gate.
    - **Operation:**
        - **Gate Triggering:** A gate pulse triggers the TRIAC into conduction, irrespective of the polarity of the voltage across MT1 and MT2.
        - **Bidirectional Conduction:** Once triggered, the TRIAC can conduct current in both directions.
    - **Applications:** TRIACs are used in AC power control applications such as light dimmers, motor speed controllers, and heater controls, as well as in AC switching applications requiring bidirectional control.

Circuit Diagram:

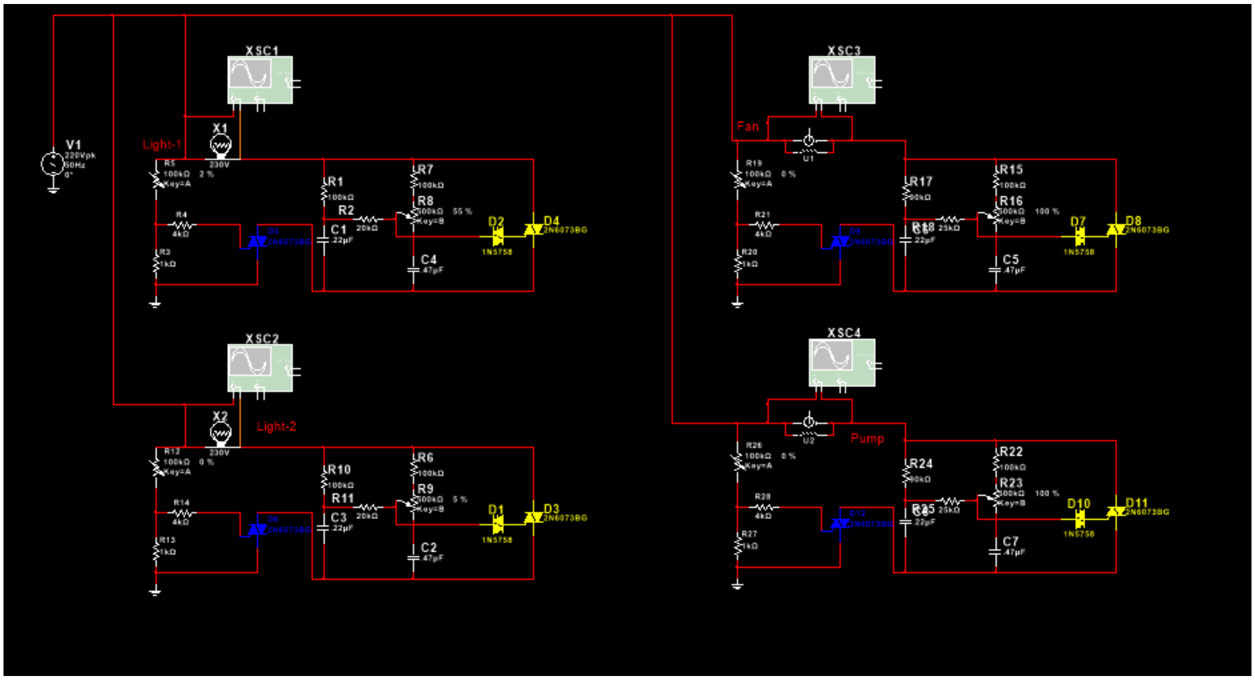


Fig: Diagram of our designed circuit

Triac as a Switch:

A triac can be turned on (triggered) by applying a small current or voltage to its gate terminal.

Once triggered, the triac will continue to conduct current until the main current passes through zero (zero-crossing).

At the zero-crossing point, the triac will automatically turn off if the gate signal is removed.

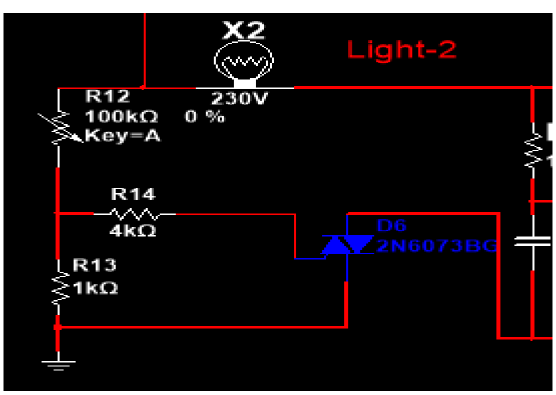


Fig: Diagram of Triac as a Switch

AC power control circuit: By controlling the triggering of the triac using the diac, we can regulate the amount of power delivered to the load.

Varying the firing angle of the triac, which is the point in the AC cycle when the triac is triggered, allows for control over the RMS (Root Mean Square) voltage and power delivered to the load. The combination of a diac and a triac provides a simple and cost-effective way to control and regulate the power in AC-based applications, making it a widely used solution in various industries and consumer products.

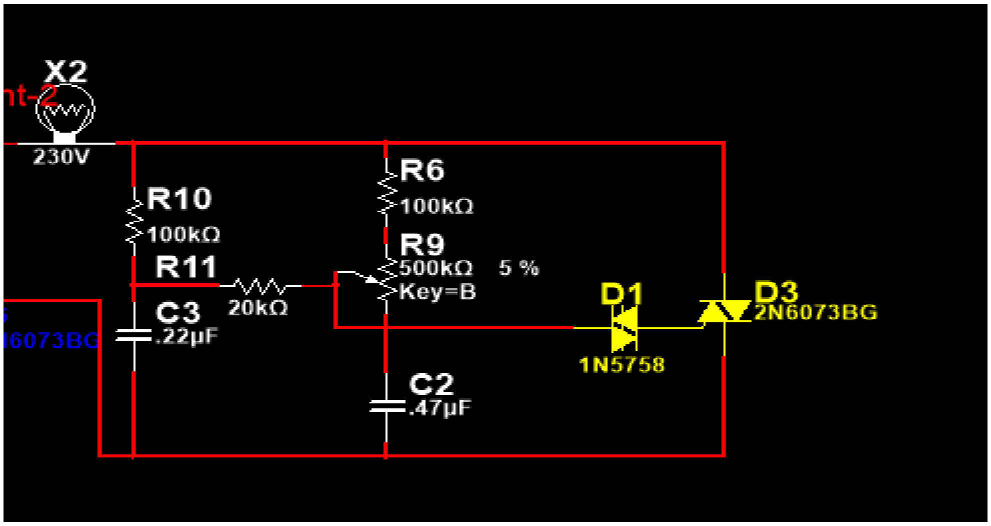


Fig: Diagram of diac and triac as a power regulator

Experimental Data:

Max power state:

Power:12.9 W

Voltage:159V

Current:929mA

Min power state:

Power: 5.17mW

Voltage:32V

Current:1.71mA

Result Analysis:

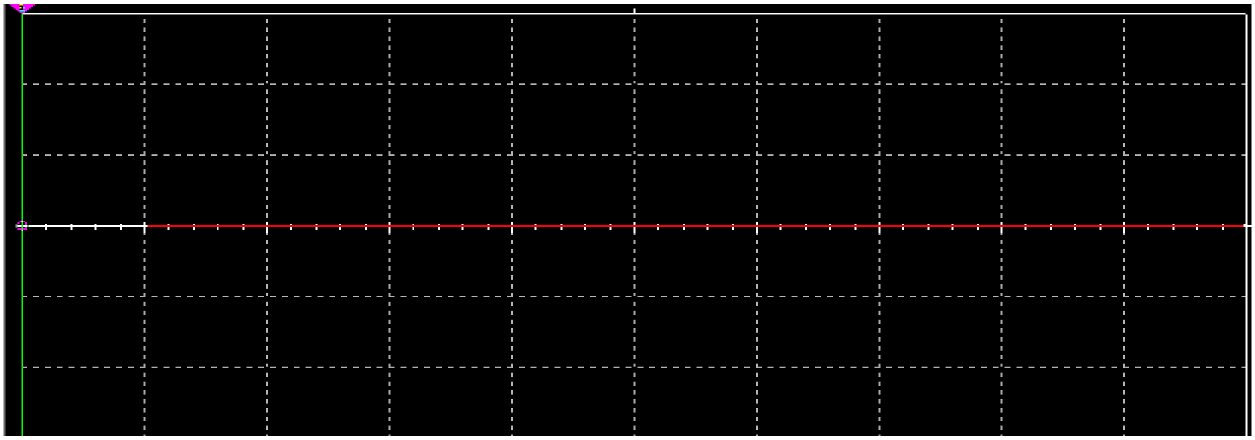
In this project we design an electronics system that can switching and regulate of all electronic devices. We use triac for making switch. We use DIAC and TRIAC for regulate the fan and control the speed of dc motor.

Waveform:

Case1:

When R=0%;

Light off

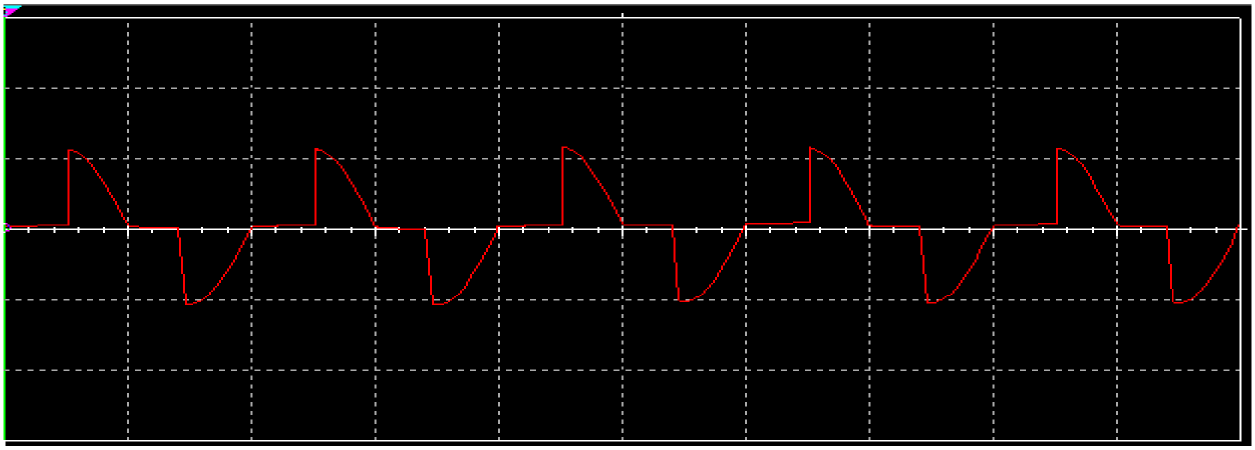


Case2:

When R=25%;

Firing angle=90

Conduction angle=90

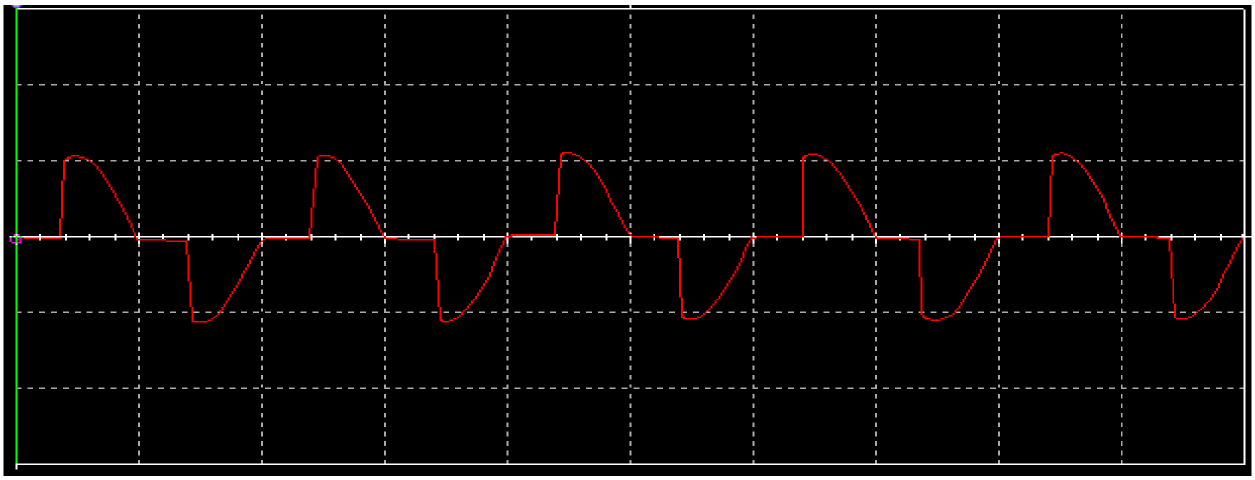


Case3:

When R=50%;

Firing angle=72

Conduction angle=108

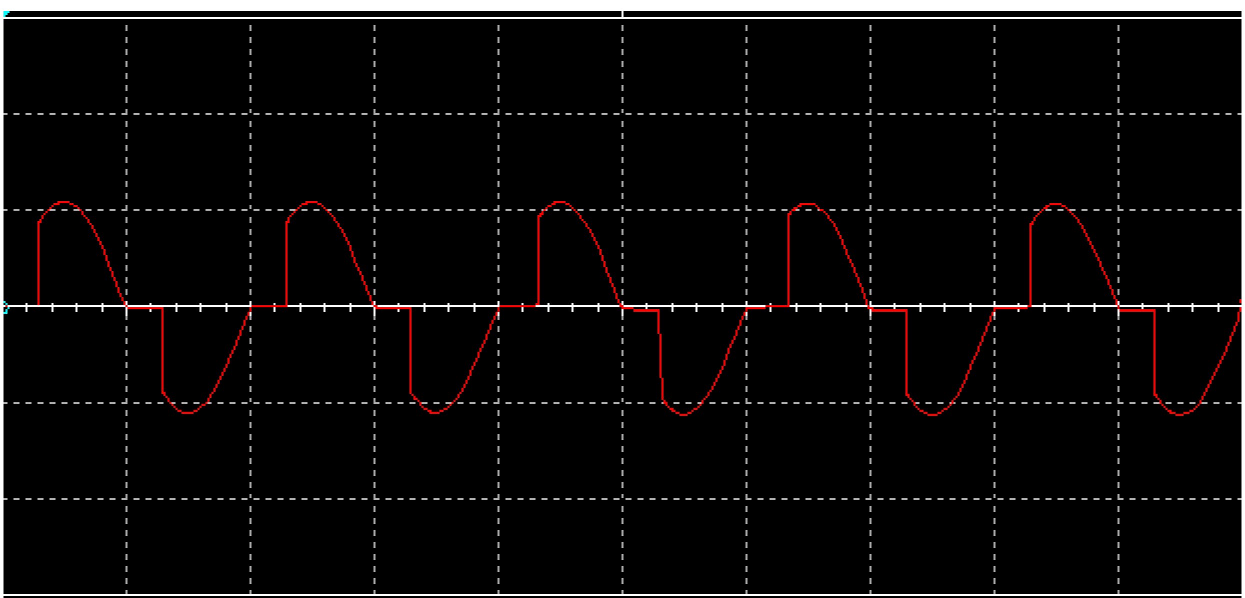


Case4:

When R=75%;

Firing angle=54

Conduction angle=126

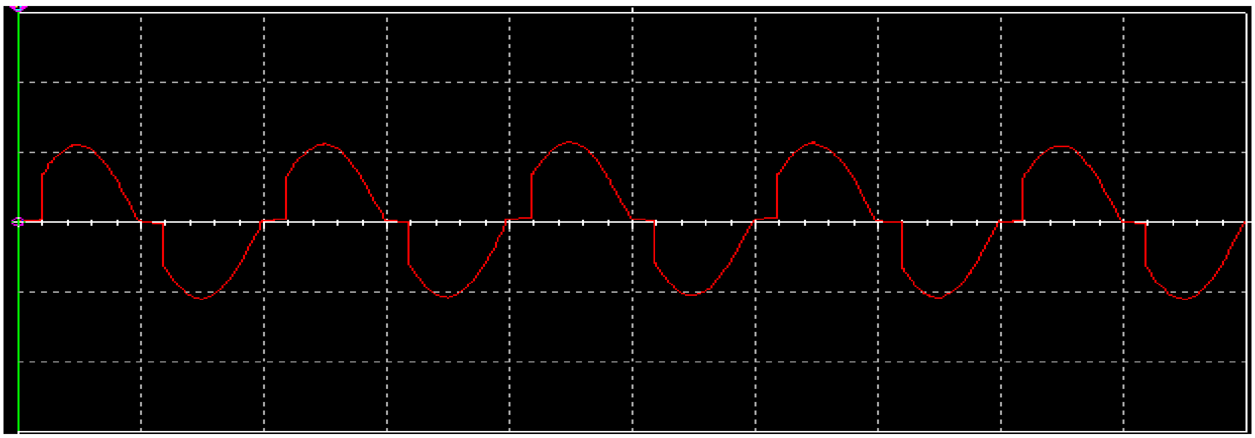


Case5:

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/