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by S S

Chapter 1

Introduction

1.1 Introduction

This project focuses on providing automated control of the existing home appliances by adding a control circuitry to the existing devices. The devices are controlled using wireless communication over the internet by microcontrollers. An app-driven remote control is provided for user interaction. Key Features :

1. Novel Internet of Things (IoT)-enabled modules to attach to a home existing commonly used electric appliances, and connecting these individual appliances with the single board computer(controlling unit).
2. Built-in protection circuitry will trigger initial preventive measures in case of an anomaly.
3. The unique feature about the switch board is that the circuit is isolated using optcouplers at every portion so that the rest of the circuit is unaffected in case of fault.
4. This switch board will allow users to manage individual devices via a remote management application on their smartphones.
5. The development of a user-friendly application facilitating interaction with the system. For instance, the appliances will be accessible via apps developed for mobile devices and laptops.
6. A modular design philosophy will be followed while designing the system. This will enable users to pick and choose the selected functionality they want to add to their house, based on their requirements and monetary capability. The user can also add functionality over an extended span of time.

1.2 Literature Survey

1.2.1 National Status Review

- Archana N. Shewale, **"Renewable Energy Based Home Automation System Using ZigBee"**, International Journal of Computer Technology and Electronics

Engineering (IJCTEE), 2015

Archana N. Shewale describes the methodology of renewable energy based home automation in which two things are consider one is energy consumption and another is energy generation. In this, ZigBee is used for monitoring energy consumption of home equipment and power line communication (PLC) is used to monitoring energy generation.

- S. Anusha, **"Home Automation using ATmega328 Microcontroller and Android application"**, International Research Journal of Engineering and Technology(IRJET), 2015

  S. Anusha describes the design and development of a remote household appliance control system using ATmega328 microcontroller and android mobile through GSM technology.

- J. Chandramohan, **"Intelligent Smart Home Automation and Security System Using Arduino and Wi-Fi"**, International Journal of Engineering and Computer Science, 2017

  J. Chandramohan provides a low cost-effective and flexible home control and monitoring system with the aid of an integrated micro-web server with internet protocol (IP) connectivity for access and to control of equipment and devices remotely using Android-based smartphone application. generation.

1.2.2 International Status Review

- Debraj Basu, **"Wireless Sensor Network Based DSAda Smart Home: Sensor Selection, Deployment and Monitoring"**, IEEE, 2013

  Debraj Basu details the installation and configuration of unobtrusive sensors in an elderly person?s house - a smart home in the making - in a small city in New Zealand. The overall system is envisaged to use machine learning to analyze the data generated by the sensor nodes.

- Byeongkwan Kang, **IoT-based monitoring system using tri-level context making model for smart home services"**, IEEE International Conference, 2015

  Kang discusses about acquisition and analysis of sensor data which are going to be used across smart homes. It proposed an architecture for extracting contextual information by analysing the data acquired from various sensors and provide context aware services.

- Jeya Jeya Padmini, **"Effective Power Utilization and Conservation in Smart Home Using IoT"**, IEEE International Conference, 2015

  Jeya Jeya Padmini discusses about effective power utilization and conservation in smart homes using IoT. It uses cameras for recognizing human activities through image processing techniques.

- Pranay P. Gaikwad, "**A Survey based on Smart Home System Using Internet of Things**", IEEE International Conference, 2015

  Pranay P.Gaikwad discusses about challenges and problems arise in smart home systems using IoT and propose possible solutions.

1.3 Need Analysis

The currently available solution and research exhibit these features

- The existing market solutions provide on/off switching of the devices. The available solutions provide comparatively lower energy efficiency and also require human intervention to achieve desired conditioning of the environment.

- Some of them also use unsuitable technologies like Power Line Communications, Bluetooth and Ethernet etc. From the present analysis of the existing solutions for automating a room environment, the technologies used suffer from a number of drawbacks. So, these protocols are limited in functionalities when used by an end user in real life.

1.4 Aim

The project aims to manage and control existing devices through a Home Automation Unit accessible over the internet.

1.5 Objectives

- To develop driver circuits for controlling the devices inside a room

- To develop software programs for the microcontroller to operate the driver circuits.

- To design mobile applications for users to control the devices over the internet.

1.6 Problem Formulation

In the present day scenario user conform and convenience is the main target for the product developers. The present conventional devices installed and their manual control does not provide benefit for monitoring and controlling them, when a person is away from home. This leads to large power losses due to unnecessary operation of the devices. This can even cause major damages to life and property if not handled properly. Also, existing commercial solutions in the market provide entire new smart devices which requires users to replace the existing devices incurring huge costs.

1.7 Deliverables

- A compact and efficient Smart Switch Board is developed.
- A user-friendly mobile application is developed for operating different appliances installed inside the room.

1.8 Novelty of work

Devices can be controlled over the internet through mobile or desktop applications. Due to the use of Power Electronics devices for the voltage control, there are negligible losses incurred. The switches are formed in a modular fashion providing user to add new devices over time. Higher levels of controllability could be achieved through individual device level control.

Chapter 2

Theory, Standards and Constraints

2.1 Theory

The increasing pollution and degradation of environment due to the conventional energy sources have made it imperative for us to switch to renewable energy sources. But their adoption has not received the fraction it ideally should. India currently fulfils 18.37% of its power needs from renewable sources but plans to increase this share to 40% by 2030. The adoption of these sources has always drawn scepticism from consumers, as one cannot completely rely on them, especially for going completely off-grid.
For such a vision to actually realise, we need to overcome the biggest drawbacks of renewable energy source, its reliability. So this project aims to formulate and implement machine learning methods to predict the generation and optimize the consumption in the household to ensure reliability and increased efficiency of the whole system.

The project will focus on the more efficient domestic use of energy generated from renewable sources. For this, the project will employ a data-driven approach calculating the power consumptions of each and every home appliance and prioritizing the duration and time of usage of each appliance through self-learning algorithms in order to minimize the power requirements at all times of the day also ensuring user convenience. At the moments of peak requirements, some devices could be shut off considering no immediate requirements of the device and they could operate when the load requirements are lower. For instance, the system will ensure a minimum permissible lighting in case of peak power requirements and switch off the remaining lights, also the temperature of the ac could be optimized automatically to an intermediate temperature level where the power consumptions are low so that load is satisfied and also user comfort is ensured. Similar commercial systems currently exist, but are prohibitively expensive and designed for grid-provided power. To remove the entry barrier for customers to the smart-home market, novel Internet of Things (IoT)-enabled modules will be designed which will attach to a house's existing commonly used electric appliances and connect these individual appliances with the local HAS network. These modules will be plug and play setup kits eliminating the need for purchase of special smart devices and also enhance the security in a house. Development of a Machine-Learning (ML)-based demand-response set-up to predict power generation by the off-grid apparatus which will be used by algorithms to optimize device energy consumption to achieve maximum throughput. Renewable energy sources are somewhat cyclical and unpredictable. An accurate demand-prediction model thus developed will enhance the robustness of the system against varying electricity supply. This will increase the longevity of the energy storage systems used in renewable energy systems, by balancing the discharge and recharge cycles. From the analysis of the individual usage of various appliances, the HAS could power down idle devices to save energy. Sensors around the house will monitor variables such as user presence, temperature and illumination, and turn on specific devices to increase convenience and ease of usage, according to predefined and self-evolving algorithms customized for an individual user. The development of a user-friendly application facilitating interaction with the system will be done. For instance, the appliances will be accessible via apps developed for mobile devices and laptops. A touch-screen kiosk will also be designed as an alternative to the conventional switchboards. This kiosk will provide access to the HAS interface in every room, with additional information received by the sensors around the house. An Application Programming Interface (API) will be developed to allow third-party developers to manufacture compatible devices that can be easily integrated with this HAS. This API will a) enable new devices to communicate with other devices and programs on the HAS, by sending and receiving operation parameters, such as readings from other sensors; and b) also make the overall system extensible, and create an ecosystem for additional devices (analogous to the Android SDK for third-party applications on the Android platform). Everything will be designed with a modular design approach, allowing the users to pick and choose the selected functionality they want to add to their house, based on their personal requirements and monetary capability. The users will also be able to add functionality over an extended span of time, enhancing the viability of this project and long-term relevance of the project. This project has the potential to develop a standardised systems framework that will facilitate the adoption of smart technologies (sensors; IoT) in existing domestic situations, which is user-friendly, cost-effective and capable of being controlled from widely-used devices (smartphones). The modular design will allow people to choose from simple power measurement mechanisms and warning system to completely intelligent IoT driven full automation. Depending on the investment capability, the people can move progressively from simplest to most complex system implementation incrementally over few years. Specifically designed to be used in areas where power is generated from off-grid, renewable sources, the project has the potential to be scalable and replicable in other regions of the country. Commercial delivery options will be one of the main project aims. The opportunity of commercialization of the concept will further enhance the scalability of the project work.

2.2 Realistic Constraints

- Although the project will be designed with a modular approach with scope of future expansibility, it will be demonstrated on a much smaller scale, due to a lack of infrastructure and budget.

- Plug and Play modules with fine level of control will be developed only for Lights, Fans due to lack of budget and time. Rest of the devices will be controlled in only an On/Off state.

- Testing of the modules will be limited to the devices available in the institute.

2.3 Technical Standards Used

IEEE802.11 Standard for Wi-Fi

802.11 Standard for Wi-Fi

P2413 Standard for an Architectural Framework for the Internet of Things (IoT)

2755-2017 IEEE guide for terms and concepts in Intelligent Process Automation

IEEE 61850-9-3-2016 International Standard for communication networks and systems for power utility automation

IEEE 802.15.4 Wireless sensor/control networks.

IEEE 1016 Software design description.

Chapter 3

Design Methodology

3.1 Methodology

A. Development of driver circuit To introduce software based control, microcontroller based actuators modules are to be attached in the power supply lines of the devices (fan and lighting system control).
A.1. Study of control methodology The development of actuator modules designed for each device to be automated will be using plug and play methods so as to convert existing devices into smart ones. The actuators will operate and automate the appliances based on the commands received from the microprocessor. **A.2. Actuator circuit design**

- **Incandescent Lamp** The use of pulse width modulated signals that drives a bidirectional control switch i.e., Triac which is connected to the Lamp and thereby with the AC mains. As the width of the PWM is altered the voltage across the lamp will be varied and hence the brightness of the lamp will be controlled.

- **Fans** Speed regulation of fans will be done using the Triac to reduce the energy losses that were occurring by the use of conventional voltage controller. A snubber circuit is connected in parallel with the triac in order to protect it against reverse breakdown.
  Now the designed circuit of actuator modules is designed in such a way that there would be no need to interfere with the existing circuitry of the appliances. The existing switches will be simply upgraded by the smart switch boards providing automated control of each appliance over the internet.

B. Design of the software for the Smart Switch Board The smart switch board needs a central hub for their communication and management. It will receive the inputs from the zero crossing detection circuit and give an optimized output pulse to the switch after processing it using the aforementioned algorithms.
The microcontroller ESP8266 is programmed on NodeMCU platform. The coding is done in C++ language for the microcontroller in order to generate the firing pulses accordingly to operate the driver circuits.
C. Development of a user interface to enable user interaction with the system Applications will be developed for the most common mobile platforms, iOS and Android. A cloud-based web app will also be deployed for users to operate from laptops and

desktops. The user will be able to use these apps to connect directly to the server hosted on the Home Automation Unit in their homes without any middleware services ensuring their security and privacy.
The programming of the Android Application is done in Java XML. The MQTT broker (CloudMQTT.com) is being used for machine-to-machine internet of things connectivity protocol. It works on a publish/subscribe methodology, and is a lightweight messaging protocol.

3.2 Flow Chart

3.3 Mathematical analysis and calculations

3.3.1 Power Supply

$$V_{inp} = 230V = V_{\mathrm{p}}(primary\,voltage) \tag{3.1}$$

$$V_s(secondary\,voltage) = 13.74V \tag{3.2}$$

$$V_{cp}(peak\,capacitor\,voltage) = 13.74 * \sqrt{2} - 2 * 0.7 = 18.03V \tag{3.3}$$

From the data sheet(attached) of Voltage Regulator(7805), the minimum voltage at the Input Terminal must be above 7V.
As we know the discharging equation of capacitor is :

$$V = V_{cp} * e^{\frac{-t}{T}} \tag{3.4}$$

$$7 = 18.03 * e^{\frac{-5*10^{-3}}{T}} \tag{3.5}$$

By Solving,

$$T = 5.28ms \tag{3.6}$$

$$R * C = 5.28ms \tag{3.7}$$

From Diode Bridge Rectifier,

$$V(drop) = 1.4V = I * R \tag{3.8}$$

$$I = 500mA(load\,current) \tag{3.9}$$

By solving,

$$R = 2.8\Omega \tag{3.10}$$

Putting in eqn 3.7,

$$C = 1880\mu F \tag{3.11}$$

So, we have used slightly larger value of capacitor i.e. 2200µF.

3.3.2 Zero Crossing Circuit

From data sheet(attached) of A4N25 Transistor based Octocoupler: For internal Diode to turn ON -

$$I(max.\,permissible\,limit) = 60mA \tag{3.12}$$

$$Rectified\,Voltage, V = 5.21V \tag{3.13}$$

$$R_{connected} = 165\Omega \tag{3.14}$$

$$I_{actual} = \frac{V}{R_{connected}} = 31.57mA \tag{3.15}$$

We have connected two resistors each of 330Ω in parallel for protection purpose.So, power loss across each resistor is :

$$P_L = I^2 * R = (15.78 * 10^{-3})^2 * 330 = 82.22mW < 500mW \tag{3.16}$$

Thus, the resistor will remain safe.

3.3.3 Triac Circuit

From the Triac Circuit,

$$V_{0rms} = \sqrt{\frac{1}{2\pi}(\int_{\alpha}^{\pi}(V_m sin\theta)^2 d\theta + \int_{\alpha+\pi}^{2\pi}(V_m sin\theta)^2 d\theta} \tag{3.17}$$

On solving, the output rms voltage of Triac is:

$$V_{0rms} = \frac{V_m}{\sqrt{2}}[\sqrt{\frac{1}{\pi}((\pi-\alpha)+\frac{sin2\alpha}{2})}] \tag{3.18}$$

Now, for different firing angle, the output voltage across load would be different as: for α=0°

$$V_{orms} = \frac{V_m}{\sqrt{2}} \tag{3.19}$$

for α=30°

$$V_{orms} = \frac{V_m}{\sqrt{2}} * 0.98 \tag{3.20}$$

& so on...

3.3.4 Optocoupler

From datasheet of MOC3041 Optocoupler:

$$I(max.\,permissible\,limit) = 60mA \tag{3.21}$$

Now,

$$Voltage\,applied, V = 3.3V \tag{3.22}$$

Hence,

$$R_{reqd.} = \frac{V}{I} = \frac{3.3V}{60mA} = 55\Omega \tag{3.23}$$

Now, we have connected two resistors(120R, 100R) so that the power rating of resistors do not exceed. Now,

$$P_L(R_1 = 120R) = I^2 * R = (27mA)^2 * 120\Omega = 89.25mW < 500mW \tag{3.24}$$

Similarly,

$$P_L(R_2 = 100R) = I^2 * R = (33mA)^2 * 100\Omega = 108.9mW < 500mW \tag{3.25}$$

So, resistors will remain safe.

3.3.5 Ac Fan

From datasheet(attached) of ac axial fan:

$$L = 3H,\ R = 1.67K\Omega \tag{3.26}$$

So,

$$X_L = w * L = 3 * 2\pi * 50 = 942.477 \tag{3.27}$$

$$tan\theta = \frac{X_L}{R} \tag{3.28}$$

$$\theta = tan^{-1}(\frac{X_L}{R}) \tag{3.29}$$

$$\theta = tan^{-1}(\frac{94204777}{1.67 * 1000}) \tag{3.30}$$

$$\theta = 29.43^\circ \tag{3.31}$$

Now, for the circuit to start operating-

$$Firing\, angle(\alpha) >= \theta \tag{3.32}$$

Hence,

$$\alpha > 29.43^\circ \tag{3.33}$$

3.4 Circuit Diagram

3.5 Hardware Design

3.6 Hardware System

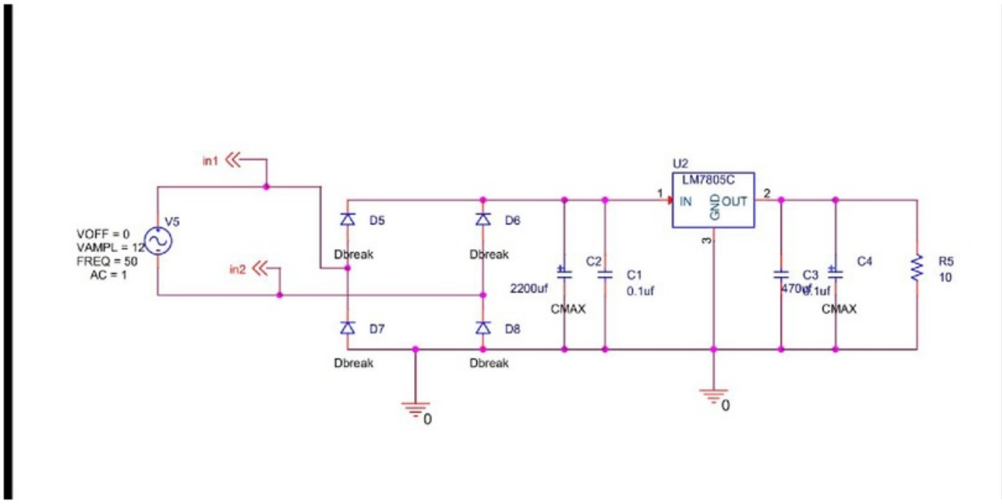

Figure 3.1: 5V DC Power Supply

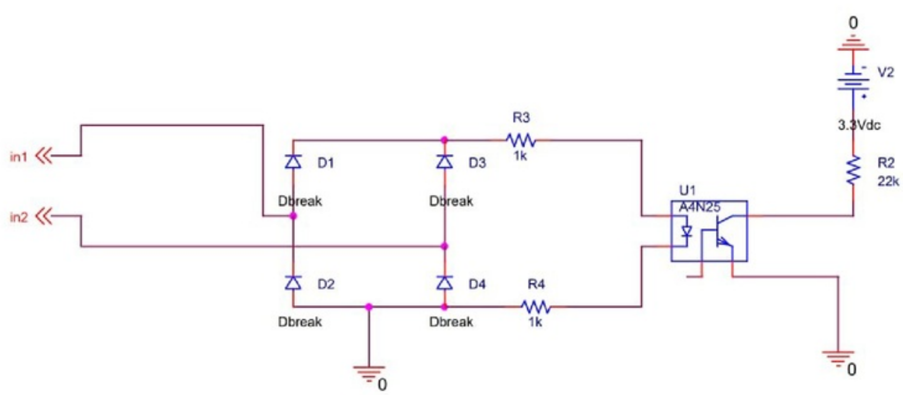

Figure 3.2: Zero Crossing Detection Circuit

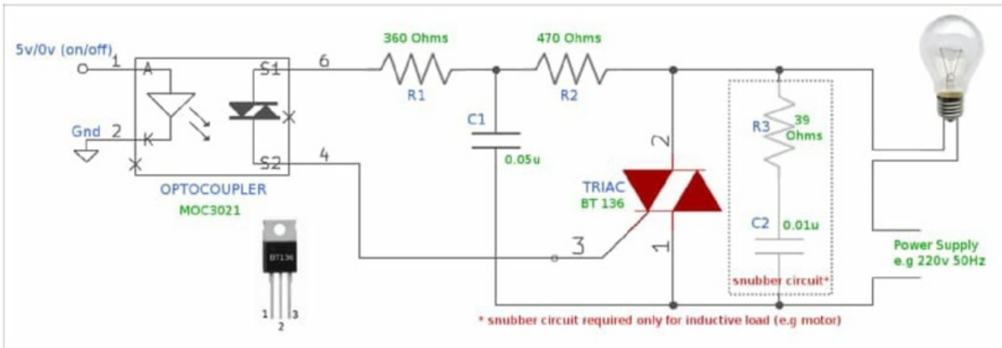

Figure 3.3: Triac based Dimmer Circuit

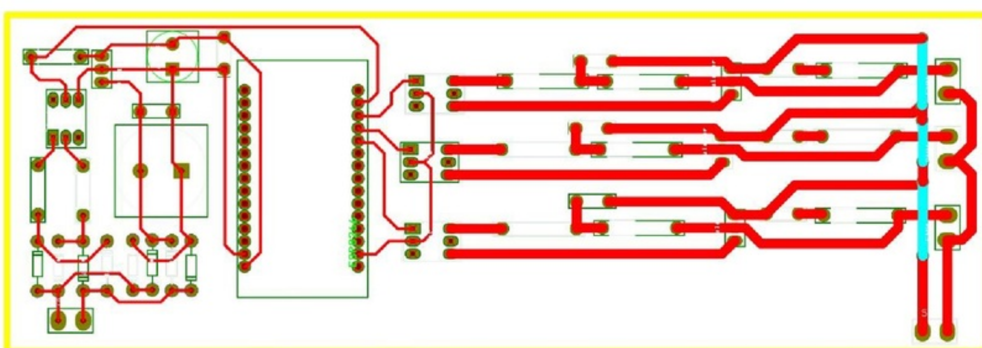

Figure 3.4: PCB Layout for the design

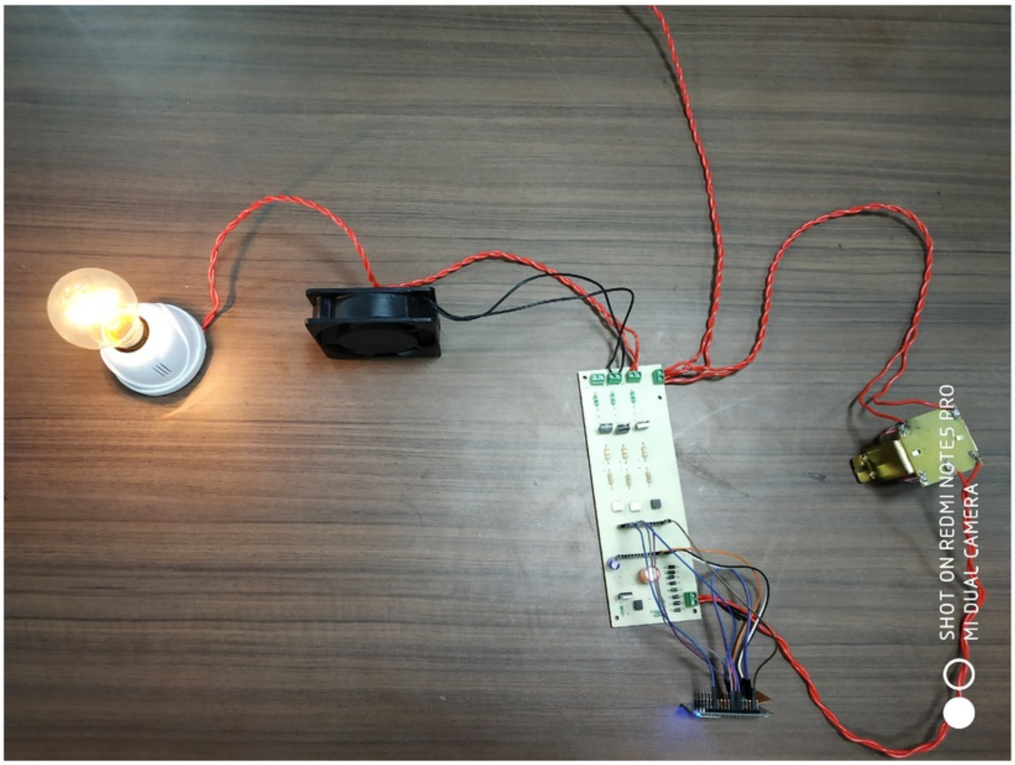

Figure 3.5: Demonstration of the complete project

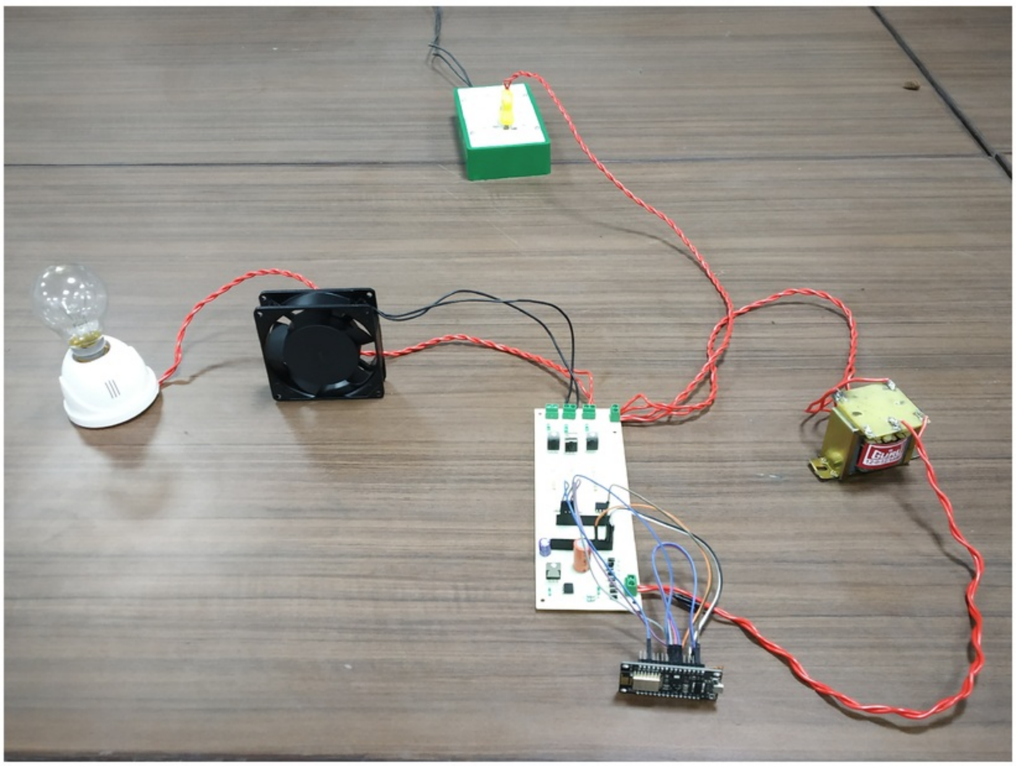

Figure 3.6: Demonstration of the complete project

Chapter 4

Results and Discussion

4.1 Results and Discussion

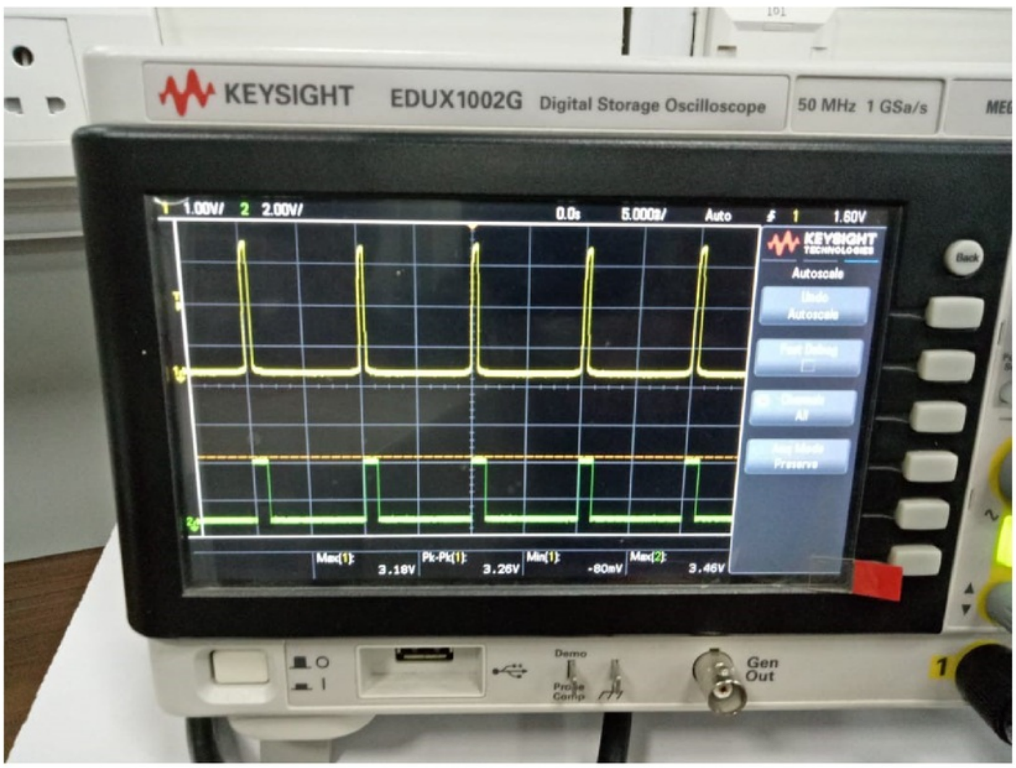

Figure 4.1: Gate signal for the driver circuit

4.2 Justification of objectives achieved

1. With the help of power electronics devices such as triac, optocoupler etc., we designed the control circuitry for controlling the speed of fan, brightness of lights etc.

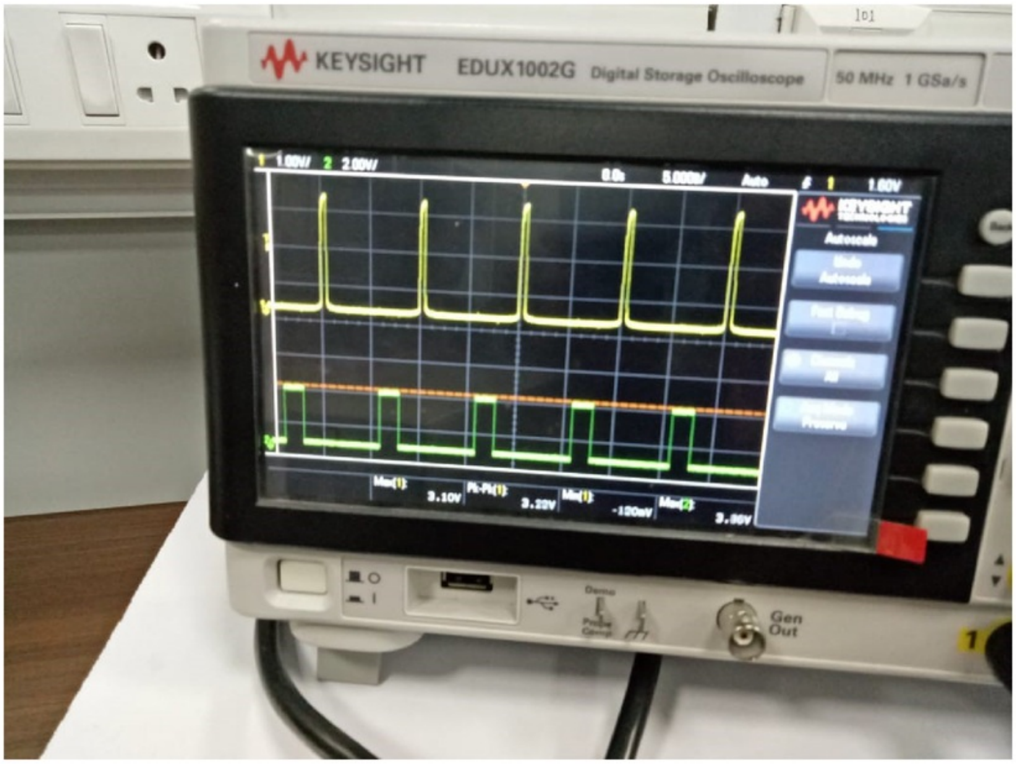

Figure 4.2: Shifted Firing pulses lead to reduced apparent voltage

We have also provided socket (Switch On/Off) for external device connection. A ripple free constant power supply of 5V for power supply of the microcontroller is designed using full bridge rectifier and smoothing capacitors. A zero cross detection circuit is also designed for detection of zero instant of the AC mains so that a reliable firing pulse can be generated from microcontroller in order to control the appliances.

2. Programming of the microcontroller is done on NodeMCU platform. The coding of the microcontroller is done in C++ language. The program formed allows the microcontroller to generate PWM gating pulses based on the user input to achieve the desired output by the user.

3. For the user interaction mobile applications enlisting rooms of each household. The rooms are further divided into lists of appliances which provides control over the devices to the user over the internet. The application is made simple and handy for the user to access easily.

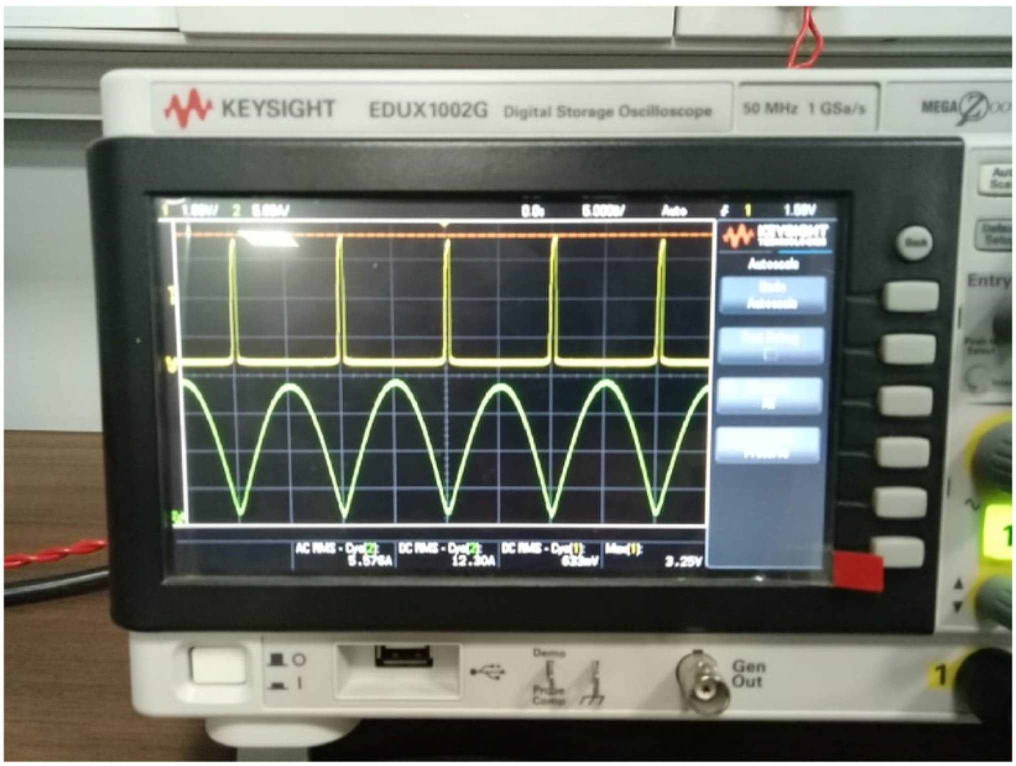

Figure 4.3: Rectified Output for Zero Detection

Chapter 5

Conclusion and Future Work

5.1 Conclusion

We successfully completed the following work areas, including their simulations and hardware representation:

1. 5V Supply for Microcontroller Power Supply.
2. Zero Crossing Circuit for detection of Zero Voltage instant of AC supply.
3. Firing Pulse generation based on Zero Crossing Circuit fed as input to microcontroller.
4. On/Off Control of Lamp using Opto-Isolator and Triac.
5. Android Application Development for managing and control of lamp.

5.2 Future Work

The project will involve further development of-

- Plug and Play modules for Fan, AC and Lights.
- Sensor Aggregator Modules
- Home Automation Software
- Machine Learning based autonomy algorithms.

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ORIGINALITY REPORT

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PRIMARY SOURCES

1	Kumar Mandula, Ramu Parupalli, CH.A.S. Murty, E. Magesh, Rutul Lunagariya. "Mobile based home automation using Internet of Things(IoT)", 2015 International Conference on Control, Instrumentation, Communication and Computational Technologies (ICCICCT), 2015 Publication	2%
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