Relay demonstration on board for final year student

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Abstract. The present invention relates to a relay demonstration board, characterized by a microcontroller, numbers of relays are connected to the microcontroller by a plurality of switches, wherein the first relay is connected to a light bulb for controlling the lighting of the bulb and the second and third relay are connected to a DC motor for controlling the rotational direction of the motor. Accordingly, these objectives may be achieved by following the teachings of the present invention. This invention relates to a relay demonstration board for teaching and learning purpose. An electrical relay is an electromagnetic switch operated by a relatively small electric current that can control a much bigger current and thus enable both circuits to be electrically isolated from each other. Relays have been used in wide variety of applications such as home appliances, digital computers and automation system due to its simplicity, long life and high reliability. The project present invention relates to a relay demonstration board. It is developed to allow students to understand the function of relay and how to connect relay in circuit. The major components include three relays, one light bulb and one direct current (DC) motor. The relays are used for control purpose while the light bulb and DC motor are used as the output. Furthermore, the light can be connected in alternating current (AC) or DC circuit to show students how to connect AC circuit and DC circuit. Besides, this tool are invention can be connected to an external microcontroller such as an Arduino board to provide input and or signal to the circuit.

1 Introduction

Relays operate mechanical switching mechanisms using an electromagnet as its basic operating principle. They are used to control circuits with low-power signals and to provide electrical isolation between the controlled circuit and the actuator [1]. Due to their simplicity, longevity, and great reliability, relays are utilized in a wide range of applications, including home automation systems, industrial and automotive applications [2].

Relay is utilized to operate lights, appliances, and other devices in home automation systems. With the help of the internet-based smart home system, it is simple to operate

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the house from a distance and automate routine tasks without the need for physical labour. Some basic functions in the house, such as automatic switching states of lights in the presence or absence of any human in the room and automatic switching of monitoring lights during the day and at night, can be remotely accessed with a simple mobile phone, while focusing on energy conservation [3–5]. For example, Sri et al. in Chinnasamy et al. [6] design home automation system using four key components which are the Arduino, Bluetooth module, Relay drivers, and Android application. The Arduino is linked to the Rx and Tx pins of the Bluetooth module, which transmits data to the microcontroller. The information is read by the microcontroller and sent to the relay drivers, which serve as switches. They upload the program to the Arduino according to the specifications, and it then does various logical and mathematical operations to control the relay drivers. Application for Android are linked to the Arduino Bluetooth (HC-05).

Next, the industrial relays also used in industrial applications to operate machinery, process controls, and other pieces of equipment. Other industrial applications for relay include lighting control and the operation of alarm or security systems [7]. Besides that, relay can be used as a protective relay to avoid equipment damage by detecting electrical faults such as overcurrent, undercurrent, overloads, and reverse current. Therefore, a lot of researchers are doing extensively development of power system relay protection technology. The most fundamental requirements for an electric power system relay protection device include smooth operation, successful system operating status monitoring, automatic correction of electric power system faults, etc. Second, due to the widespread use of modern network monitoring technology and its rapid development, the relay protection device must be able to work in conjunction with the network monitoring system to achieve power system automation. This has led to specific requirements for the relay protection device. Power system applications frequently utilize protection to the relay protection device of capacitor protection, main transformer protection, bus coupler protection, and line protection, among other duties [8–10].

Relay also are commonly utilized in automotive applications. The starter motor, turn signals, and other components are all under the control of the automobile relay. Many additional vehicle circuits, such as those that control remote starters or theft alarms, also use a car relay module [11]. In Konatham et al. [12], the authors design the vehicle safety and security. It involves using a fingerprint reader to read the owner's fingerprint sample to help in lowering vehicle thefts. Besides that, driving while intoxicated is a common reason for accidents. To ascertain whether the driver has taken alcohol, the alcohol sensor is employed. If the driver is found to have ingested alcohol, the car won't start.

Based on its advantages, relay has widely used in most application as stated above. Therefore, most students use relays as main component for their Final Year Projects (Project 1 and Project 2). Final Year Project is required for all Polytechnic students to obtain their Diploma. At the early stages, students are still confused and need more time to understand and apply relays in their projects. Thus, Demonstration Relay Board (DRB) can help students quickly and concisely understand how to connect the relay pin for each project output. This innovation tool is able to display in a real connection. In addition, DRB also displays light output from AC and DC outputs. Direct connectivity of DC motors is also shown in this innovation tool. Therefore, this direct picture based on schematic layout can help students more practically how this relay is applied to their project.

1.1 Objectives

It is an objective of the present invention to provide an effective relay demonstration board with simple circuit layout.

It is also an objective of the present invention to provide a relay demonstration board which is user-friendly and easy for learning. Accordingly, these objectives may be achieved by following the teachings of the present invention.

The current work relates to a relay demonstration board, which includes a microcontroller, multiple relays connected to the microcontroller by multiple switches, first relay connected to a light bulb to control lighting, second and third relay connected to a DC motor to control rotation direction of the motor.

1.2 Problem statement

The teaching and learning process for technical fields is more focused on two parts which is theory and practical. These two parts play an important role for students to ensure that they really understand what has been taught by the lecturer. For the Project 1 and Project 2 courses, their imagination and the way they think affect their level of understanding either verbally, in writing or in practical work.

Students are having difficulties in mastering and developing Project 1 and Project 2 courses because they do not understand the circuit, lack of communication and interaction during teaching session, difficult to understand the concepts and principles of operations, lack of problem solving and project development skill.

One way to overcome this problem is to develop a Relay Demonstration Board. The Relay Demonstration Board that was developed so that students could clearly see how to connect the circuit described by the lecturer, can be used to solve the delivery issue. This relay demonstration board can also save time because lecturers can use it to display to all students and to construct final projects without having to explain everything again.

2 Hardware design

The present invention will now be described with reference to Figure 1. The present invention relates to a relay demonstration board, characterized by: a microcontroller; a plurality of relays are connected to the microcontroller by a plurality of switches; wherein the first relay is connected to a light bulb for controlling the lighting of the bulb; and the second and third relay are connected to a DC motor for controlling the rotational direction of the motor.

Figure 2 is the final prototype of the relay demonstration board from which the advantages of the present invention may be more readily understood. It is to be understood referring to Relay demonstration board circuit. This prototype model can be shown directly by the connection between Relay 1, Relay 2 and Relay 3. When Switch 1 is pressed, that means relay 1 is active and the bulb ON in DC or AC input. If using a

Microcontroller, switch 1 is not used and the microcontroller will activate the output based on the program instructions created. Relay 2 and Relay 3 for motor forward reverse rotation. Switch 2 and switch 3 are used to rotate the motor. The microcontroller can also be used to control the movement of the motor based on the program instructions created instead of using the switch.

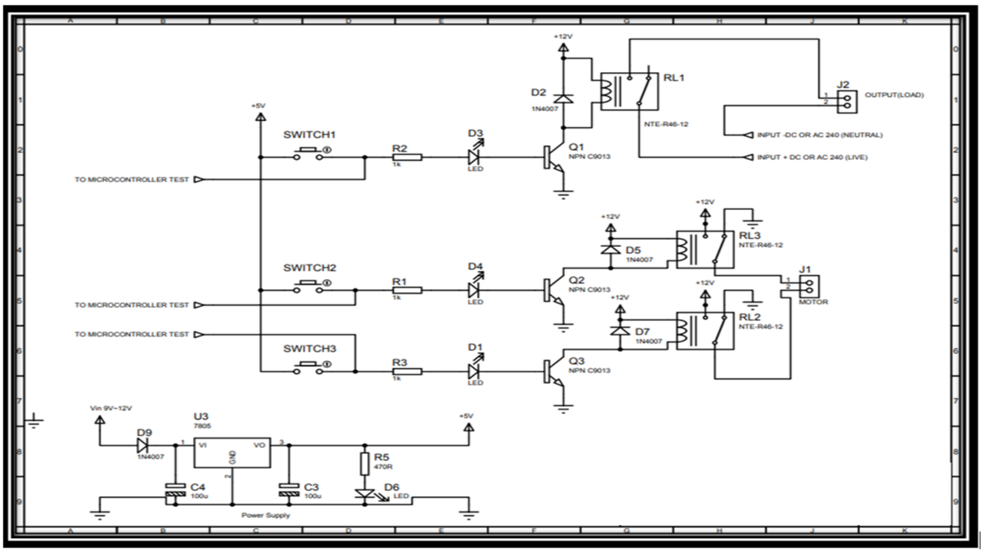

Fig. 1. Relay demonstration board circuit.

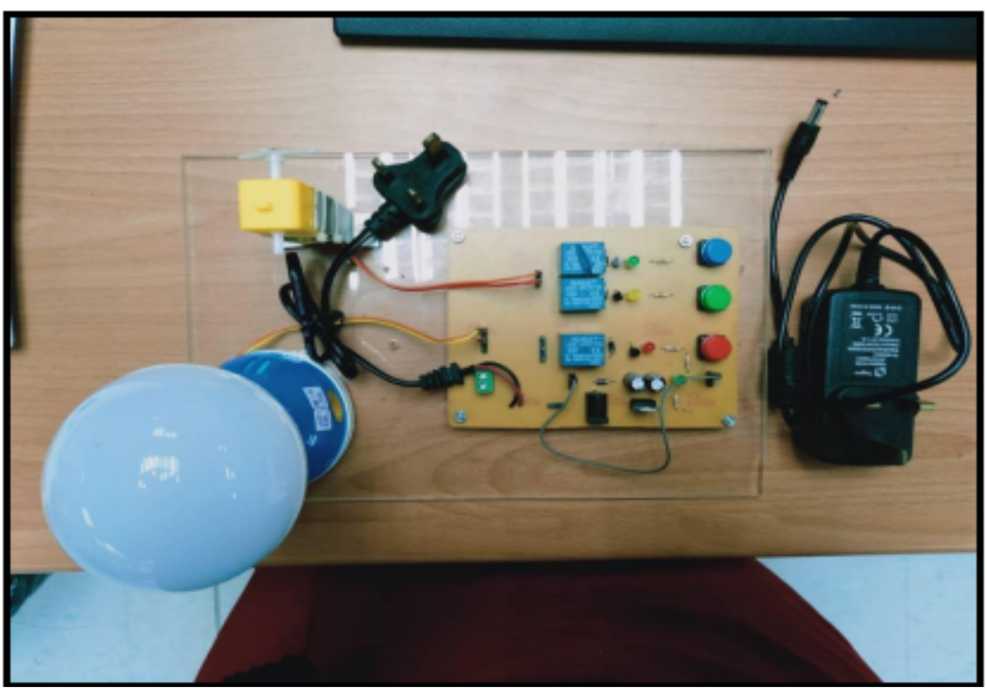

Fig. 2. Final prototype setup.

3 Experimental results

In the present invention, a relay demonstration board is developed to enable students to understand the function of the relay and the connection of the relay in circuit. Referring to Figure 1, the major components of the relay demonstration board comprise a plurality of relays, a light bulb and a DC motor. The relays are used for controlling purpose while the light bulb and DC motor are used as an output. Furthermore, the light bulb is connected to alternating current (AC) or DC circuit to show students how to connect AC circuit and DC circuit. Besides, we can directly connect to an external microcontroller such as an Arduino board instead of switches to provide input or signal to the circuit.

The light bulb control comprises two circuits which is a light bulb circuit and a relay circuit. The first relay is used to turn on the high-power light bulb circuit by a low power signal. When the first switch is turned on or receiving input from the microcontroller, the first relay will be activated electromagnetically and move from NC position to NO position. When the relay is in NO position, the light bulb circuit is closed and thus the light bulb will light up using AC or DC power supply. On the contrary, if the first switch is turned off or there is no input from the microcontroller, the first relay will be deactivated and stay in NC position. When the relay is in NC position, the light bulb circuit is open and thus the light bulb will not light up.

In the DC motor control, the second and third relays are used to control the rotational direction of DC motor. When the second switch is turned on and the third switch is turned off, the second relay will be activated electromagnetically and move from NC position to NO position. When the second relay is in NO position, power supply is connected to the DC motor via the second relay and creates a closed circuit. Consequently, current will flow from the second relay to the third relay and causes the DC motor to rotate in clockwise direction.

When the third switch is turned on and the second switch is turned off, the third relay will be activated electromagnetically and move from NC position to NO position while the second relay will stay at NC position. When the third relay is in NO position, power supply is connected to the DC motor via the third relay and creates a closed circuit. Consequently, current will flow from the third relay to the second relay and causes the DC motor to rotate in anticlockwise direction.

The DC Motor speed controller design using a microcontroller-based network system. The reference speed was set to around 4.5V to test the system (about 50 percent D) [13]. Using the HyperTerminal program, the motor speed was then displayed on a desktop computer and transmitted to microcontroller M2. The embedded controller software in M2 determines the necessary duty cycle needed to keep the motor speed at the desired constant value. The input set point and the actual output voltage waveform are displayed in Figure 3. The software tools DAvE and Vision2 were used to generate the codes. C was the language used to create the software.

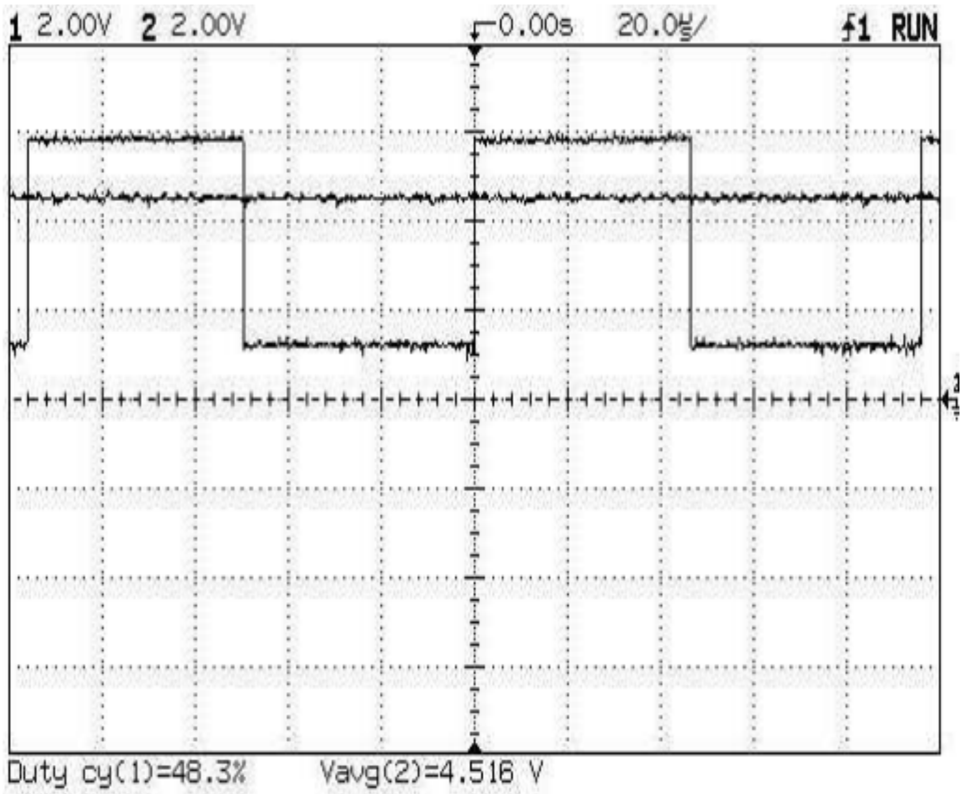

Fig. 3. Final prototype setup.

The suggested design makes use of a useful DC motor model and a Dearborn Protocol Adapter II (DPA-II) to monitor the CAN system bus. The simulation results for a change in the speed value and the motor speed corresponding to the above change are shown in Figures 4 and 5. As illustrated in Figure 4, a potentiometer is used to continually feed a speed change of between 1.5 and 1.7 rps. Based on the DC motor model, the remote controller has been implemented in the forward loop, and each time the motor input is made using the CAN bus, the updated value of the controller is used. It is possible to see how the speed varies at each instant and how the controller is acting. It was observed that the motor output is within the 14.5 and 15.5 rps range of the set point speed. Therefore, the controller's activity is successful since throughout the 1-second snapshot period, the actual speed should decrease to 13.3–13.5 rps without the controller. The controller response during this time is also shown in Figure 5.

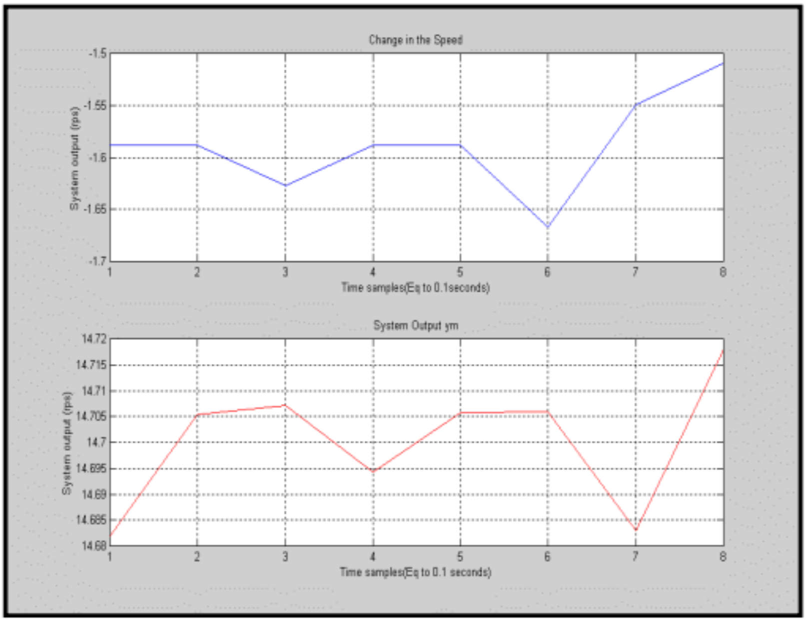

Fig. 4. Motor speed changes.

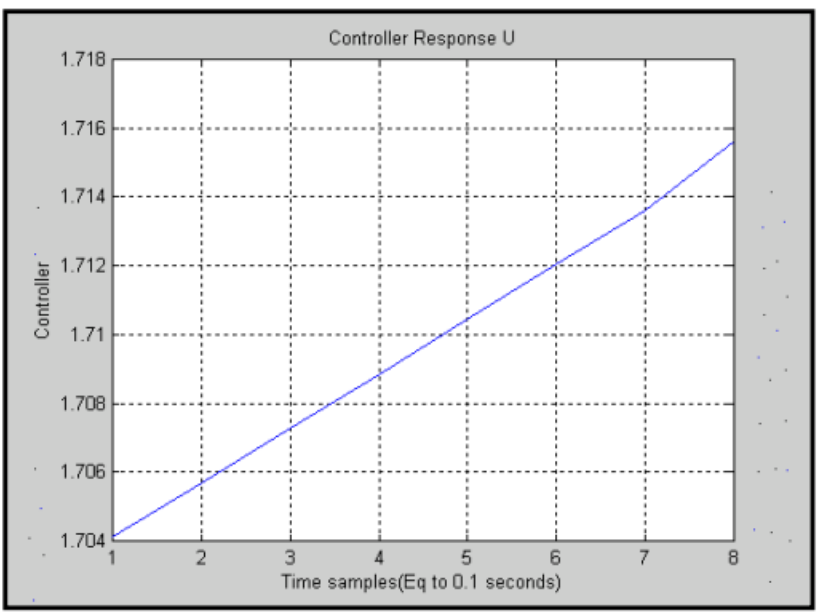

Fig. 5. Controller response.

Meanwhile, although AC power management is already a part of our daily lives, there are significant technological restrictions on it, such as the inability of some AC power control devices to be controlled remotely and their limited power regulating range. A phase control technique was used in a study to manage the amount of power given to AC loads utilizing TRIAC in order to advance presence power control technology [14].

The step input varies, which changes the rms voltage of the AC load. Two graphs of load rms voltage vs. step percentage for realistic and ideal circumstances are shown in Figure 6. Each stage input is divided by 64 to obtain the percentage because this study uses 64 steps. The plots demonstrate how, in both situations, a rise in AC load rms voltage led to a step increase. Equation (1)'s TRIAC output voltage formula is used to calculate the ideal case data using 240V as the supply voltage. In a real-world application, the load rms voltage is measured using a digital oscilloscope in accordance with the approach, and Equations (1) and (2) are applied to the measured voltage supply of 243V. As an illustration, the delay period in Figure 5 is 6.4 ms, the delay angle is 115.2°, and the load rms voltage is 118.4V.

$$V_{L(RMS)} = V_S\sqrt{\frac{1}{\pi}(\pi-\alpha)+\frac{sin2\alpha}{2}} \qquad (1)$$

where: $V_{L(rms)}$ = TRIAC ms output voltage
V_s = supply voltage
α = delay angle, in radian

$$\text{Delay angle, } \alpha = \frac{time\ delay,t}{10\ ms} \text{ x } 180 \qquad (2)$$

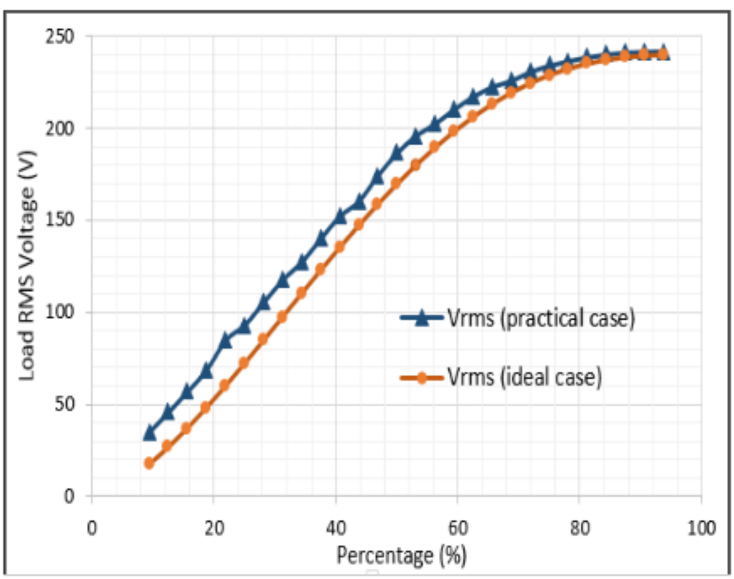

Fig. 6. Load RMS voltage vs percentage.

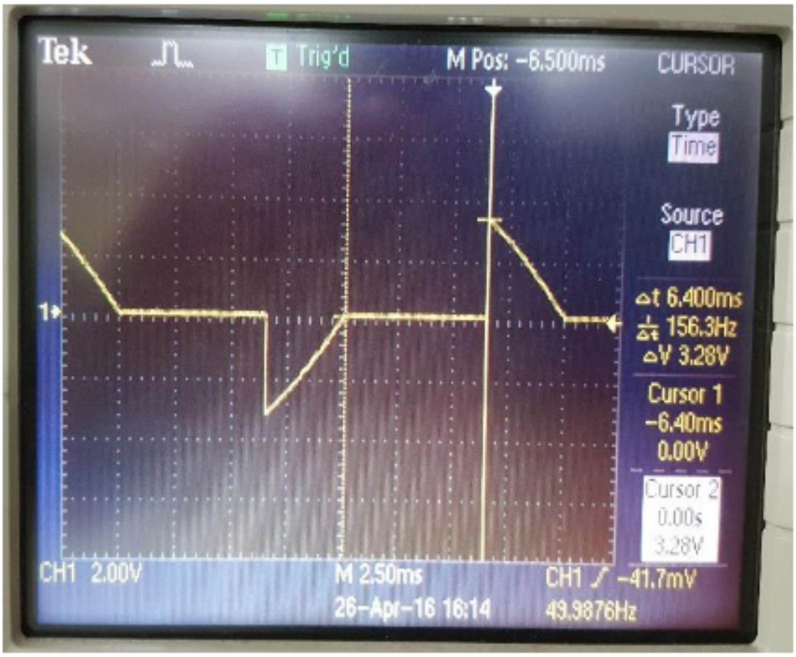

Fig. 7. Measuring exact delay time using oscilloscope.

Figure 6 demonstrates that, for the same step percentage and practical load, the rms voltage is somewhat greater than in the ideal situation, even if both examples exhibit the same increasing trend.

The most important component of estimating the needed time delay for transmitting triggering pulses to TRIAC following the zero-crossing is depicted in Figure 7 on a oscilloscope screen. According to the Bluetooth Serial input, the delayed time is calculated. The frequency of the supply voltage must first be understood in order to calculate the time delay. This paper uses a 50 Hz supply voltage, which means that the supply voltage will cross zero point every 10 milliseconds. Every step takes about 150 milliseconds due to the 64-step step resolution that is being employed. As a result, 150 s of total delay time are needed, multiplied by Bluetooth serial input (1 to 64). To prevent strange results, it is necessary to confirm that the Bluetooth serial input is a number and falls within the range of 0 to 64 before triggering the TRIAC (such like flickering on lamp load). The TRIAC must be stopped after 10 seconds, according to the flowchart's final step. In actuality, the TRIAC just has to have the triggering signal removed; after that, it will continue to conduct current until the next zero-crossing point. To ensure that no TRIAC is accidentally ignited before the delay time in the following cycle, the triggering signal must be removed.

4 Conclusion

The present invention relates to a relay demonstration board, characterized by: a microcontroller; a plurality of relays are connected to the microcontroller by a plurality of switches; wherein the first relay is connected to a light bulb for controlling the lighting of the bulb; and the second and third relay are connected to a DC motor for controlling the rotational direction of the motor. The Relay Demonstration Board (RDB) was produced to improve students' understanding of the PROJECT 1 and PROJECT 2 courses, particularly in the Department of Electrical Engineering, Kuching Sarawak Polytechnic. This RDB is suitable to be used as a teaching tool to make it easier for students to understand the concept of relay circuits as well as relay applications in basic electronic circuits.

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