

Development of a Self-Activate RCCB For Single Phase Domestic Wiring System Using Arduino Uno

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Abstract

Residual Current Circuit breaker (RCCB) is a safety device to detect and trip against electrical leakage currents. RCCB is one of the main protection devices that monitor input current from power line and interfacing the signals to the mechanical switch to trip the circuit breaker. The conventional system will force RCCB to trip if a disturbance or a fault occurs in the protected area. The main drawback of the conventional system is that it cannot turn on the power supply back to the normal operation condition even if only a short disturbance occurs. To turn the power back to normal operation, consumers need to do it manually. To overcome this problem, a self-activated RCCB system has been developed. This device has been designed to reactivate the RCCB protection system in the event of a fault. This report presents the development of the self-activated RCCB system. It discusses the solution that has been done to make self-activated RCCB function safely without user intervention. To achieve this objective, microcontroller has been utilized in designing the proper program to completely control the operation of RCCB. Selection of the proper mechanisms has also been done to overcome the issues of high thrust force at RCCB switch. Servo motor has been chosen as the DC motor is easier to control. Servo motors have an advantage over higher thrust than its compact size. In addition, it can work well with Arduino. This project is expected to provide greater benefits to those consumers who will leave their residence for a period. The weakness for this prototype is the system is unable to determine the differentiation between permanent and temporary fault. At the same time, the system is unable to identify and inform the user which part of the wiring system is damaged. In addition, this project uses a Power Bank and a 9V adapter as the main power supply to an Arduino board and servo motor. In the event of a power supply failure, there is no available power supply support to operate the system.

Key Words: circuit, breaker, self-activate, domestic, servo, Arduino

1.0 Introduction

When implementing electrical protection, one of the most prevalent strategies is to promptly isolate the affected section by cutting off the power supply upon detecting a fault, ensuring that healthy parts of the system remain operational (Wikipedia, 2024). Safety always remains the highest priority, even though consumers, especially critical infrastructures, production processes, or low-maintenance services, cannot afford indefinite power interruptions; hence, electrical protection systems must balance fault isolation with continuity of service (Thomas, 2022). Whenever the circuit was decided by the Residual Current Circuit Breaker (RCCB) to trip because of a fault either temporarily or permanently, consumers must ensure consistent electricity supply in continuous operation at the same time confirming electrical protection. These conditions make it essential to use an intelligent and self-activate protection device. This implies the consumers require a device that guarantees protection that triggered only when the problem is real and has the capability to establish again the electric supply under the reclosing conditions required by the consumer, which can be activated or programmed. This project is related to a method used to ensure the electricity supply system remains operational after experiencing a fault by modifying an RCCB to self-activate without compromising the safety of the circuit or residential consumers. In conclusion, when there is any disruption or damage to the electrical wiring system, whether temporary or permanent, the RCCB typically detects leakage current and immediately disconnects the power supply to protect users and equipment (Wikipedia, 2024). Moreover, advanced RCCBs equipped with auto-reclosing functions can reset themselves and restore power after temporary faults without requiring manual intervention, thus reducing downtime while maintaining safety (CJE Group, 2023). The electricity supply will not be reconnected automatically if the user does not manually activate the RCCB. This innovation is related to the method that will be used to

ensure that the electricity supply system is back in operation after the system experiences disruption or damage by transforming the RCCB into an automatic device that can be activated and programmed without neglecting the safety aspects of the circuit operation and users in the home.

2.0 Materials and Methods

2.1 Methodology

A microcontroller is the most appropriate tool to control RCCB system because the desired output can be varied in accordance with the programmer's requirements. The Arduino board is highly suitable as it is open-source electronics prototyping platform built around easy-to-use hardware and software, and it interfaces seamlessly with microcontrollers to read inputs and control outputs (Arduino Foundation, 2025). The C language is used to write the coding program that is used to control the movement towards the servo motor. It is also used to determine the output of the LCD display and as well as to activate the warning light and buzzer. The inputs can be in analogue or digital signals while the output is in digital signals. Output signal in digital form will simplify the process of analysis and troubleshooting. Each progress must be carefully planned so that each parameter can be utilized optimally. The research is adopting to modify the hardware approach involving design, development and testing to achieve the project's objectives. The project methodology is conducting in four phase's bases as follows:

Phase 1 include Literature review on previous work or project. Literature studies on the project that have been made by another inventor or any other similar project with this project must be performed. The study can also be made for any product that has been available on the market if it has a near or similar characteristics to a project that will be implemented.

Phase 2 include Project block diagram and flowcharts. The block diagram and flowcharts are a visual tool that represent of a system, process, or workflow. Block diagrams focus on the overall structure and connections of a system, while flowcharts emphasize the step-by-step flow of a process.

Phase 3 include Design and testing which is Software that will be used as follows:

- i. ARDUINO software is used to design and test the self-RCCB controller system.
- ii. SketchUp 2014 software is used to sketch the project prototype in 3D.
- iii. Proteus 7 Professional software is used in schematics drawing and to simulate the circuit.

Phase 4 include Developing the prototype. In this final phase, every prototype model that was drawn in 3D will be made to the actual model. Each mechanical part involved will be installed. The circuit was simulated to be generated into the PCB circuit.

2.2 Requirements Analysis

All project requirements were thoroughly analyzed and compiled into a specification document. A usability analysis was also conducted to validate these requirements. During the initial investigation phase, key elements such as the problem statement, project scope, Gantt chart, and development planning strategies were established. All potential system requirements were identified and systematically documented in the requirements specification.

2.3 System Design

The C language is commonly employed to program servo motor control due to its efficiency, low-level hardware access, and ability to manage precise timing-sensitive tasks (Lee, 2025). It also used to determine the output of the LCD display and as well as to activate the warning light and buzzer. Each progress must be carefully planned so that each parameter can be utilized optimally. The program codes that have been written need to be tested first before making further progress. This is to ensure that the desired output is achieved. Every code written program will be tested for breadboard at first. Once satisfied with the output, the process is forwarded to the next level. Hardware development involves all components associated with the project. The scheme was developed based on the component being studied which included Arduino UNO R3, infrared switches, circuit servo motor, LCD display, warning light and buzzer, circuit wiring of single-phase and others. The circuit should be implemented into the printed circuit board (PCB) fabrication when the simulation is successful. Project prototype has been prepared to use SketchUp 2014. The illustration was drawn to visualize the mechanical device construction. every prototype model that was drawn in 3D will be made to the actual model. Each mechanical part involved will be installed. The circuit was simulated to be generated into the PCB circuit. All parts involved will be included to ensure the success of this project.

2.3.1 Logical Design

Block diagrams and flowcharts are essential tools in engineering and software development; they should be developed incrementally stage by stage to clarify each process and function in precise detail (Tech Schematic, 2024). Block diagram gives an overview of the project. Flowchart gives a more detailed description of each process. Figure 1 displays the block diagram for the RCCB systems. Figure 2 shows the flowchart of RCCB self-activate system. Figure 3 shows the flowchart of the motor controller.

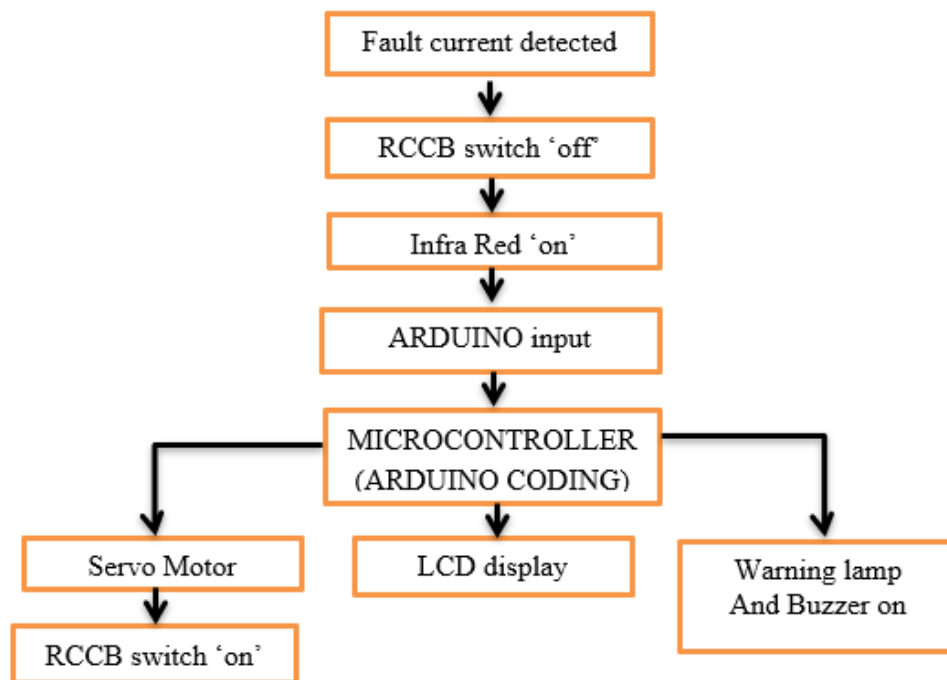


Figure 1: The Block Diagram for The RCCB Systems.

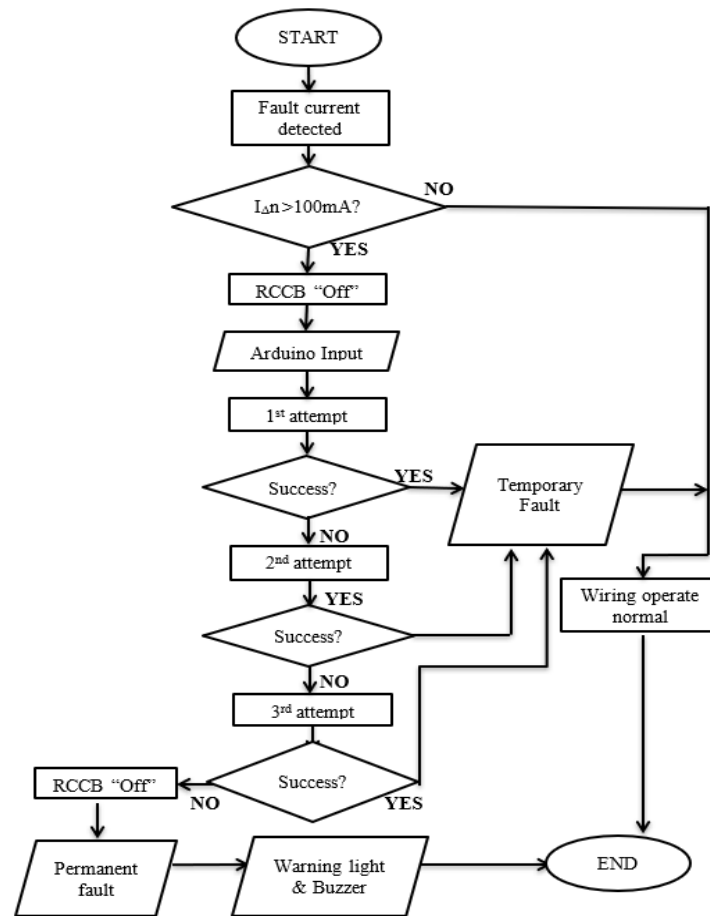


Figure 2: Flowchart of RCCB Self-activate System.

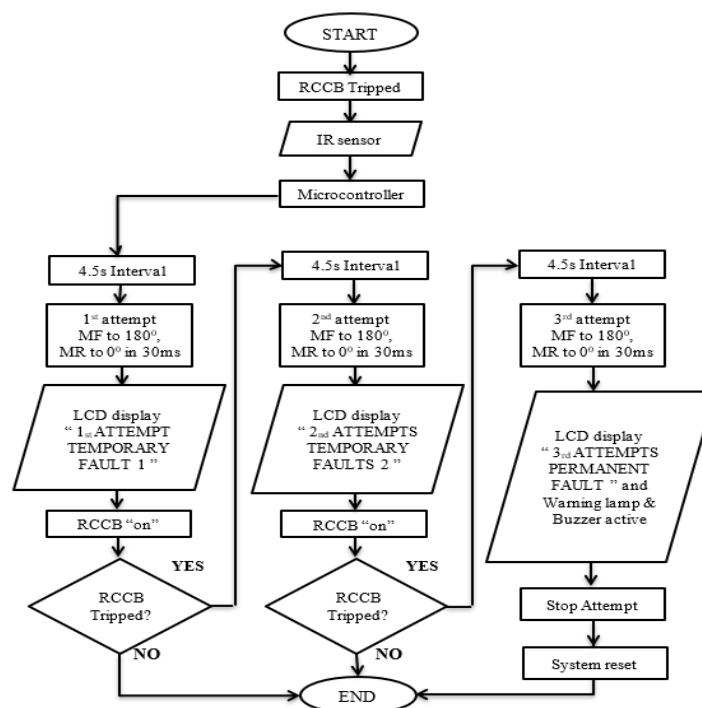


Figure 3: Flowchart Of Motor Controller.

2.3.2 Physical Design

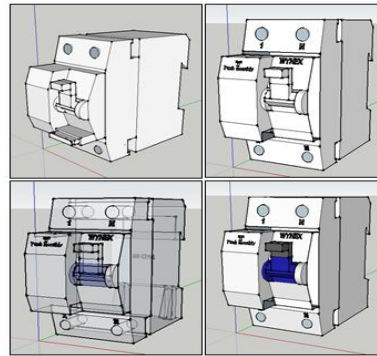


Figure 4: The progress of drawing design for self-activate RCCB

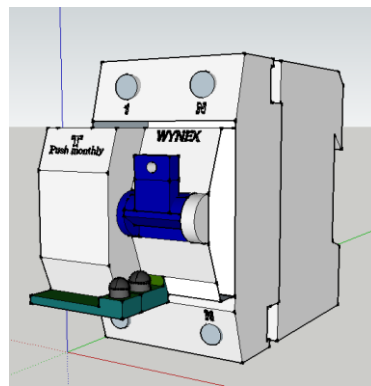


Figure 5: IR sensor is attached on RCCB

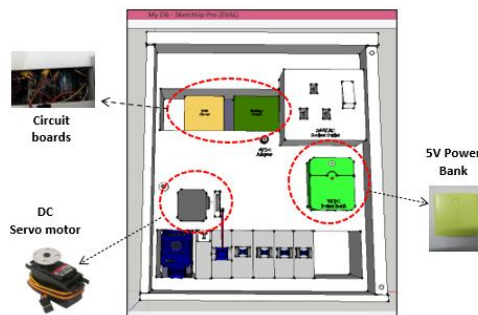


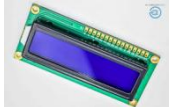
Figure 6: The illustration of the entire project's prototype

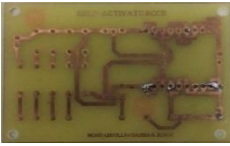
2.3.3 Instrument

The tools and technologies required to develop the Self-Activate RCCB For Single Phase Domestic Wiring System Using Arduino Uno are shown in Table 1.

Table 1: List of instruments.

Parts	Main Function
Infrared Sensor	To detect and measure infrared radiation
	

Parts	Main Function
<i>Home RCCB with housing</i> 	Monitoring the current flow in the live and neutral wires of an electrical circuit.
<i>Jumper Wires</i> 	Create temporary connections in circuits, especially during prototyping and testing.
<i>Arduino Uno</i> 	A platform for building interactive electronic projects.
<i>Mini DC servo motor</i> 	To convert electrical energy into precise mechanical motion
<i>Breadboard</i> 	To build and test electronic circuits.
<i>Power bank</i> 	Source of energy
<i>Buzzer</i> 	To produce an audible sound, typically as an alert or warning signal.
<i>LCD Display</i> 	To modulate light and display images.

Parts	Main Function
<i>PVC mcb box</i> 	As a protective enclosure for electrical components.
<i>Light bulb and bulb holder</i> 	As an indicator that the RCCB is active
<i>Light-emitting diode (LED)</i> 	To emit light when an electric current passes through it
<i>Oscilloscope</i> 	To analyze signal characteristics
<i>Printed circuit board</i> 	As an electrical connection for electronic components.
<i>Resistor</i> 	To limit or regulate the flow of electric current within a circuit
<i>DC Adaptor</i> DC12V 2A 	Converts alternating current (AC) from a wall outlet into direct current (DC) that electronic devices can use
<i>Miniature circuit breaker</i> 	To protects a circuit from damage caused by overcurrent or short circuits.

3.0 Results and Discussions

3.1 Result

Analysis has been conducted on the output waveform of all stages. The waves have been analyzed in terms of voltages and frequency when the system is operating. Analysis has been conducted on every attempt to see if there are any changes in the resulting waveform for each trial. The results obtained from RCCB function tests are shown in the following figures and the summary of analysis in Table 2.

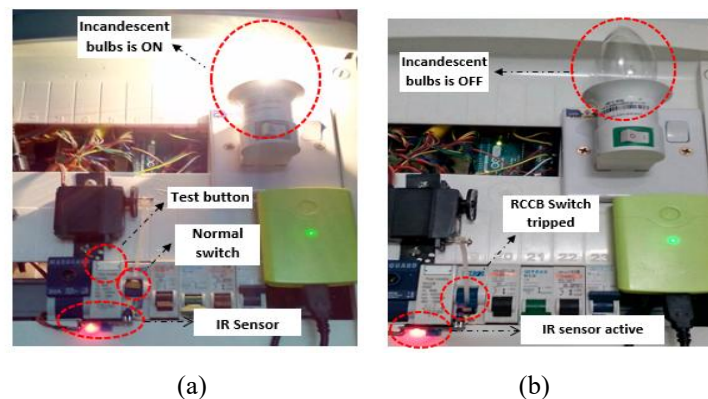
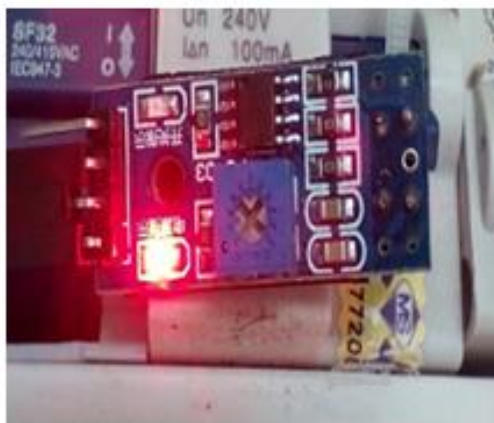


Figure 7: RCCB- (a) Function Normally, (b) Tripped RCCB

Table 2. Summary of Analysis.

No	Condition	First Attempt	Second Attempt	Third Attempt
1	Temporary Fault (Motor will attempt 2 times)	4.5 seconds after trip motor will on, turn 180° and push the RCCB back to its normal position. First LED (red) as an output is on (active HIGH). $V_{rms} = 13.2mV$ LED not active at LOW. $V_{rms} = 1.07V$ LED active at HIGH - Motor reversed to 0° immediately after 1st attempt. - LCD will display “1st ATTEMPT TEMPORARY FAULT 1” - IR Obstacle Avoidance Sensor before and after its	4.5 seconds after trip motor will on, turn 180° and push the RCCB back to its normal position. - Second LED (blue) is on. Then both red and blue LED is on. - Motor reversed to 0° immediately after 2nd attempt. - LCD will display “2nd ATTEMPT TEMPORARY FAULT 2”	None

		active. Testing during first attempt.		
		Vrms = 5.16V IR not active at HIGH Vrms= 204mV IR active at LOW		
2	Permanent Fault (Motor will attempt 3 times)	4.5 seconds after trip motor will on, turn 180° and push the RCCB back to its normal position. - First LED (red) is on. - Motor reversed to 0° immediately after 1st attempt. - LCD will display “ 1st ATTEMPT TEMPORARY FAULT 1 ”	4.5 seconds after trip motor will on, turn 180° and push the RCCB back to its normal position. - Second LED (blue) is on. Then both red and blue LED is on. - Motor reversed to 0° immediately after 2nd attempt. - LCD will display “ 2nd ATTEMPT TEMPORARY FAULT 2 ”	4.5 seconds after trip motor will on, turn 180° and push the RCCB back to its normal position. •Third LED is on. Then all LED's is on and blinking. The buzzer is on. - Motor reversed to 0° immediately after 3rd attempt and back to normal position. RCCB trip again. - STOP the process. - LCD will display “ 3rd ATTEMPTS PERMANENT FAULT ” . - RCCB assumed to trip for the last time. When it happen LCD will display “LAST ATTEMPTS !!!WARNING!!!”



(a)



(b)

Figure 8: IR Testing During First Attempt - (a)IR Before Active, (b) IR After Active

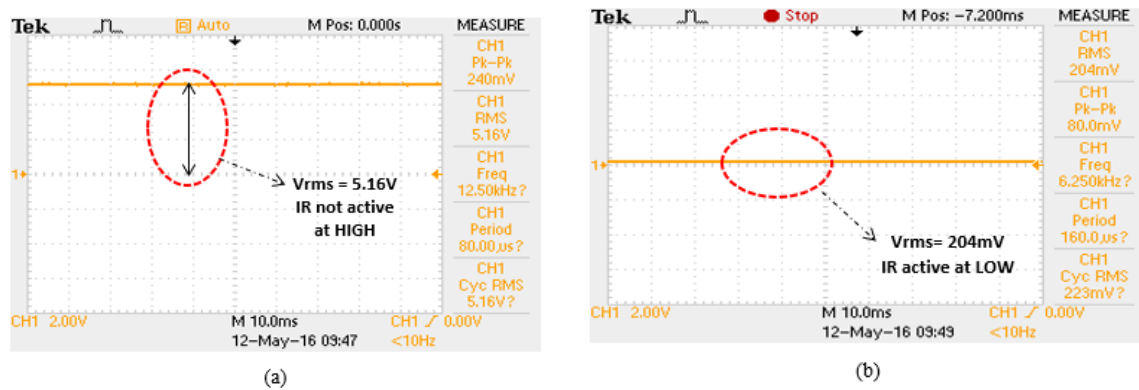


Figure 9: IR Waveforms for Both Conditions - (a)IR Before Active, (b) IR After Active



Figure 10: The Red LED - (a)Before Active, (b)After Active

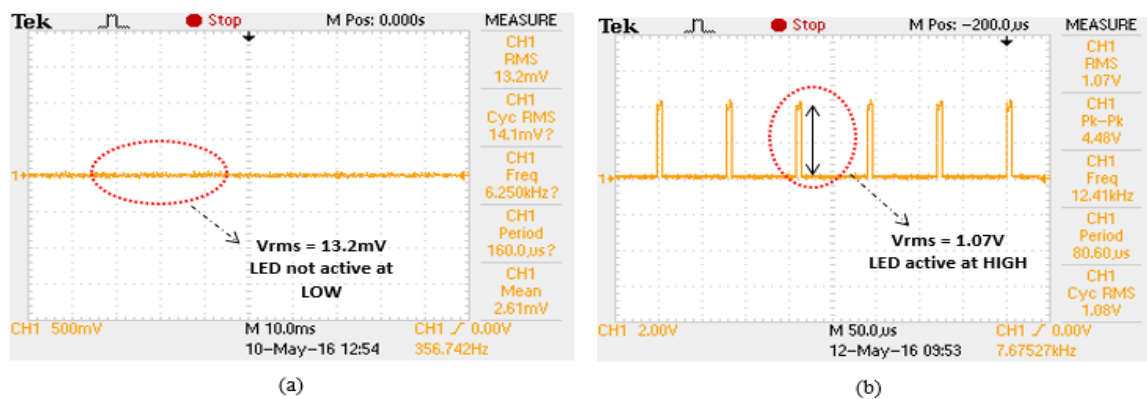


Figure 11: The Waveforms Red LED - (a)Before Active, (b)After Active

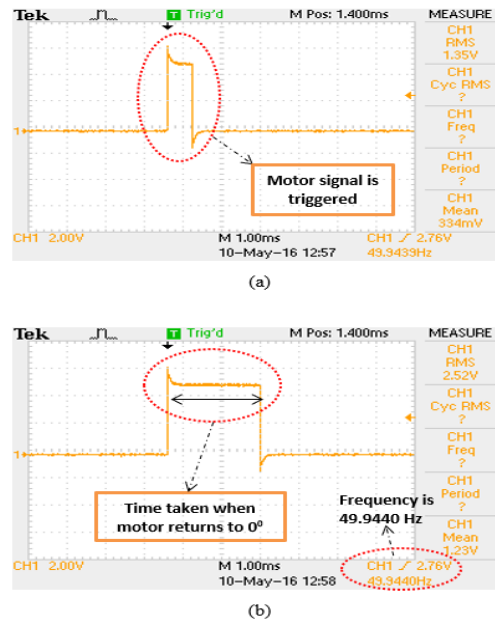


Figure 12: The resulting waveform signal during servo motor doing the rotation. (a). Motor signal when rotate to 180^0 , (b). Motor signal when turning back to 0^0

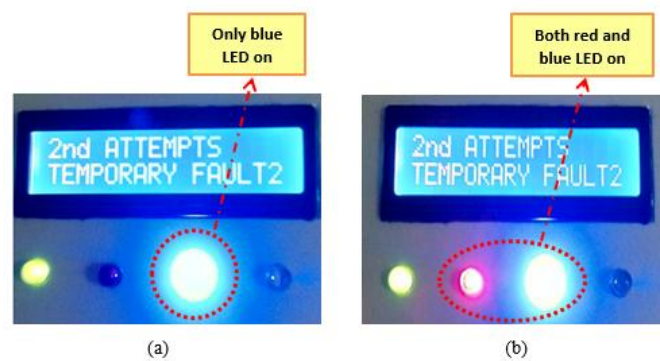


Figure 13: LEDs Function During Second Attempt - (a) Blue LED is Lit up 4.5 seconds after IR Active, (b) Both LEDs Activated

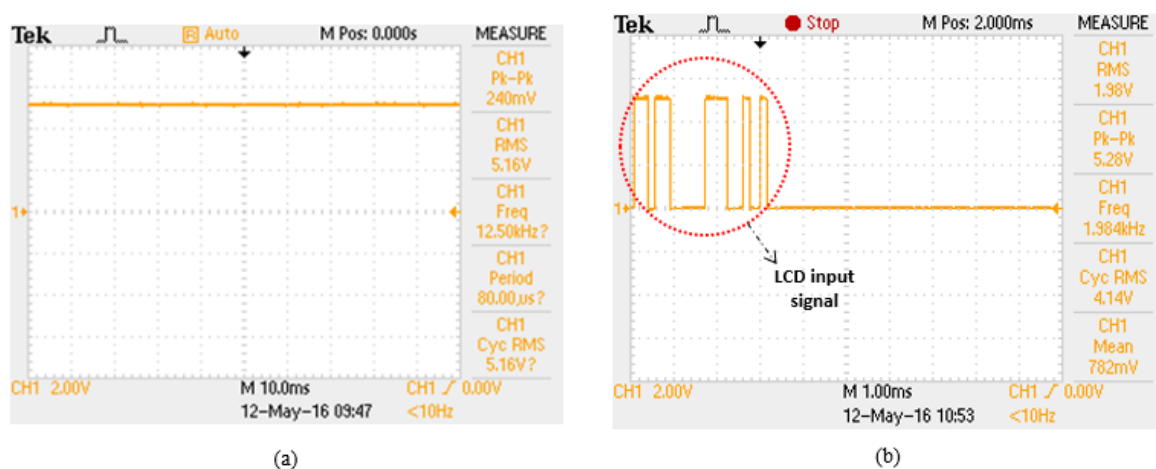


Figure 14: LCD Waveforms on Second Attempt - (a) Before Second Attempt Occurred, (b) After Second Attempt Occurred.

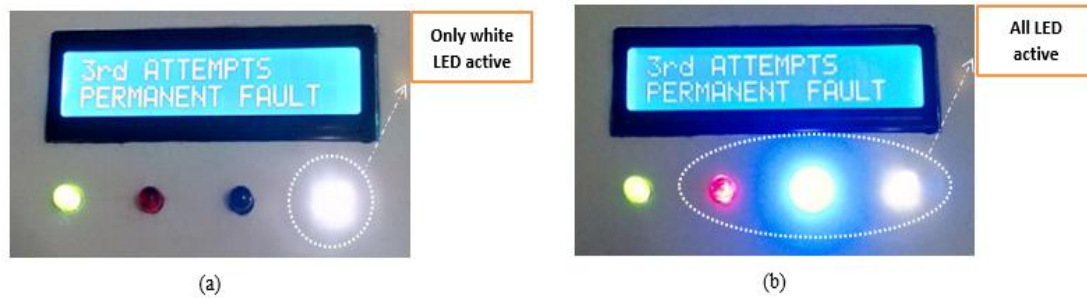


Figure 15: LED Function Third Attempt - (a) White LED is Lit up 4.5 Seconds After IR Active, (b) All LED Activated.

3.2 Discussions

Microcontroller is used to create many applications based on tasks and program that need to be developed. Arduino board is the most suitable to use because it is open-source electronics prototyping board that can interact very well with microcontroller. It is based on easy-to-use, flexible hardware and software. This project can be upgraded to make it more effective and increase functionality. Currently, the determination of whether a fault is temporary or permanent is based on the reclosure attempt that was made. However, this approach carries operational risks, particularly the possibility of a false reclose during permanent faults, which may lead to equipment damage, safety hazards, or system instability. Therefore, mitigation strategies such as implementing fault type discrimination algorithms, integrating current and voltage sensing for accurate fault classification, and setting a maximum limit for reclosure attempts should be considered to enhance system protection and operational safety. For improvement in the future, it is better if the system can understand and determine what kind of differentiation between permanent and temporary faults. At the same time the system can identify and inform the user which part of the wiring system is damaged. For that reason, the designing of the additional circuit is important to match the voltage and current values so that it is suitable for control element and the devices could work together. To make the system more accurate and better, the new PIC controller microcontroller which is more advanced is required to be used as a control element. The appropriate model is MC68HC11AI MOTOROLA Microprocessor or PIC 16F877A microcontroller. PIC controller can identify the fault, act accordingly, display the fault and self-activate the RCCB back to normal. The controller will determine the unbalanced current between Life and Neutral line by doing monitoring and measuring. When unbalanced current occurs, it will isolate the load from power line of the shortest time possible without harming any other electrical devices

4.0 Conclusion

Based on this research, in conclusion this prototype is successfully achieving its objectives. This prototype is one of the solutions to turn on or to reconnect the power outage caused by lightning or earth leakage current have been introduced. The finishing product of this project is expected to provide more convenience to the user. It also expected a new level of convenience to consumers without compromising security outlined by the authorities. In addition to the fault caused by lightning and permanent fault, the supply also can cut off abruptly because of the problem of nuisances tripping. Although the issue of nuisance tripping cannot be eliminated, it is anticipated that upon completion of this project, such problems will be mitigated as the RCCB will be capable of self-activation in the event of any disturbance occurrence. Moreover, the system holds potential for integration with IoT-

based monitoring to further enhance its intelligence, enabling real-time status tracking, predictive maintenance, and improved operational reliability. Overall, the deeper study of this technology must be developed further so that its use continues to be expanded upon the future to facilitate human life.

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