INTELLIGENT EARTH LEAKAGE CIRCUIT BREAKER (I-ELCB) FOR SINGLE-PHASE SYSTEM

by

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Dissertation submitted in partial fulfillment of

the requirements for the

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CERTIFICATION OF APPROVAL

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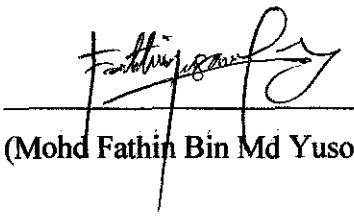
TRONOH, PERAK

May 2011

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in references and acknowledgement or done by unspecified sources or person.



(Mohd Fathin Bin Md Yusof)

Dedicated, in thankful appreciation for support and encouragement to:
My supervisor Dr Nursyarizal Mohd Nor
My beloved family and all my beloved EE course mates batch July 06/07
(especially: Ahmad Nazri Abd Razak, Muhammad Hanif Amaran)

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Last but not least, I offer my regards to those who support me especially all my friends and technicians in Electrical and Electronics Engineering Department for contributing their assistance and ideas for this project.

ABSTRACT

An Earth Leakage Circuit Breaker (ELCB) is an electrical device that disconnects protected circuit whenever it detects unbalance current between the phase conductor and the neutral conductor. Example of the unbalance may caused by current leakage through the body of a person who is grounded when accidentally touching the energized part of the circuit. A lethal shock can result from these conditions. ELCB are designed to disconnect this fault fast enough to mitigate the harm caused by such shocks. Currently, there is no Earth Leakage Circuit Breaker (ELCB) with auto re-closer features in the market. The current ELCB that available in the market is a manual type and cannot differentiate between temporary disturbances and permanent faults, meaning that, if a disturbance or fault occurs on the protected area (house), the protection system will force ELCB to trip. One of the disadvantage of the common ELCB is that, it is cannot turn on the power supply back to the normal operation condition although only a short disturbance occurs. Such disturbance is lightning strike on the transmission line in the distribution site near to the protected area. To turn the power back to normal operation, consumers need to do that manually. To overcome this problem, Intelligent Earth Leakage Circuit Breaker (I-ELCB) has been developed. This device was designed to auto-reset ELCB when short disturbance occur and send alert signal to user if permanent fault occur.

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LIST OF ABBREVIATIONS

I-ELCB	Intelligent Earth Leakage Circuit Breaker
ELCB	Earth Leakage Circuit Breaker

CHAPTER 1
INTRODUCTION

1.1 Background of Study

Power reliability is a critical issue for the power provider since the consumer needs a continuous supply of electricity for their appliances. However at the consumer side, the reliability of the power supply is depending on their electrical system in their residential building from the breaker until the load. Some electrical equipments and appliances need to be turned on even when the occupants leave the building such as alarm system, refrigerator and aquarium ventilation system. Electrical fault may occur in a system that can break the electricity supply. Most of the electrical fault happen in residential area is short disturbance. Auto reset system is designed to make the Earth Leakage Circuit Breaker (ELCB) automatically on after short disturbance occur. The power availability for their appliances should be improved to prevent the property lost.

1.2 Problem Statement

The problems of current Earth Leakage Circuit Breaker (ELCB) that is controlled manually and cannot auto recovery if short disturbance occur. When electricity is not available, operation of critical equipment such as alarm system will be stopped. Loss of electricity supply may also contribute to property lost due to equipment failure such as dying of exotic fish and food damage. This sometimes bring the problems to the consumer who were not at home and do not understand the danger of permanent fault that can cause fatal hazard.

1.3 Objectives

The objectives of this project are:

i. To study and understand on how earth leakage circuit breaker (ELCB) operate.

ii. To improve the ability of earth leakage circuit breaker (ELCB) unit

iii. To develop I-ELCB

1.4 Scope of Project

i. The author needs to understand how the ELCB operate in house application and know about the circuit inside the ELCB.

ii. This project is focused to modify and improve the ability of ELCB where the additional circuit with a system is added to the ELCB and automatically will make ELCB trigger/open when the temporary fault happens and alert the user if permanent fault occur.

CHAPTER 2
LITERATURE REVIEW

2.1 Introduction

This chapter will review about the single phase system, function and principal operation of circuit breaker and also will discuss about application of earth leakage circuit breaker (ELCB). Then it will review about components of hardware and software that will be use to make this project.

2.1.1 Single phase system

Single phase electric power refers to the distribution of electric system using a system in which all the voltage of the supply varies in unison. Standard frequencies are either 50 or 60 Hz.

A single phase load may be powered from a three phase distribution system either by connection between a phase and neutral (120 V or 220 V). On higher voltage system (kilovolt), a single phase transformer is use to supply a low voltage system. Single phase power distribution is used especially in rural area, were the cost of a three phase distribution network is high. Typically, a third conductor is called a ground or earth use for safety, and ordinarily only carries significant current when there is a current fault.

Although the single phase system has safety (earth conductor) but this system cannot perfectly protect the electrical circuit, electrical equipment and also human life from the high voltage. So, the circuit breaker is needed to make more protection [1].

2.1.2 Types of Fault

A fault is any abnormal situation in an electrical system in which the electrical current may or may not flow through the intended parts. Equipment failure attribute to some defect in a circuit (loose connection or insulation failure or short circuit). Types of faults in a distribution network circuit are:

i. Over-load
ii. Line to line fault
iii. Single lines to ground fault
iv. Double line to ground fault

Over-load faults are caused by the unexpected increasing of loads. Faults on electrical equipments are caused by lightning, insulator breakage, product design which is out of specification and improper installations of equipments. Lightning is an example of short disturbance. Meanwhile an example of permanent fault is faults on electrical equipment.

2.1.3 Circuit breaker

The device is use for open or closes an electric power circuit either during normal power system operation or during abnormal conditions. A circuit breaker serves in the course of normal system operation to energized or non-energized loads. During abnormal conditions, when excessive current develops, a circuit breaker opens to protect equipment and surroundings from possible damage due to excess current. These abnormal currents are usually the result of short circuits created by lightning, accidents, deterioration of equipment, or sustained overloads.

Formerly, all circuit breakers were electromechanical devices. In these breakers a mechanism operates one or more pairs of contacts to make or break the

circuit. The mechanism is powered electromagnetically, pneumatically, or hydraulically. The contacts are located in a part termed the interrupter. When the contacts are parted, opening the metallic conductive circuit, an electric arc is created between the contacts. This arc is a high-temperature ionized gas with an electrical conductivity comparable to graphite. Thus the current continues to flow through the arc. The function of the interrupter is to extinguish the arc, completing circuit breaking action [2].

In oil circuit breakers, the arc is drawn in oil. The intense heat of the arc decomposes the oil, generating high pressure that produces a fluid flow through the arc to carry energy away. At transmission voltages below 345 kV, oil breakers used to be popular. They are increasingly losing ground to gas-blast circuit breakers such as air-blast breakers and SF6 circuit breakers.

In air-blast circuit breakers, air is compressed to high pressures. When the contacts part, a blast valve is opened to discharge the high-pressure air to ambient, thus creating a very-high-velocity flow nears the arc to dissipate the energy. In SF6circuit breakers, the same principle is employed, with SF6 as the medium instead of air. In the "puffer" SF6 breaker, the motion of the contacts compresses the gas and forces it to flow through an orifice into the neighborhood of the arc. Both types of SF6 breakers have been developed for EHV (extra high voltage) transmission systems.

Two other types of circuit breakers have been developed. The vacuum breaker, another electromechanical device, uses the rapid dielectric recovery and high dielectric strength of vacuum. A pair of contacts is hermetically sealed in a vacuum envelope. Actuating motion is transmitted through bellows to the movable [3].

2.1.4 Circuit breaker operation

Circuit breaker is implemented using a solenoid (electromagnet) that is pulling force increases with the current. The circuit breakers contacts are held closed by a latch and, as the current in the solenoid increases beyond the rating of the circuit breaker, the solenoids pull releases the latch which then allows the contacts to open by spring action. The core is restrained by a spring until the current exceeds the breaker rating. During an overload, the solenoid pulls the core through the fluid to close the magnetic circuit, which then provides sufficient force to release the latch. Short circuit currents provide sufficient solenoid force to release the latch regardless of core position thus bypassing the delay feature. Ambient temperature affects the time delay but does not affect the current rating of a circuit breaker [4]. Figure 1 below shows the internal part of circuit breaker.

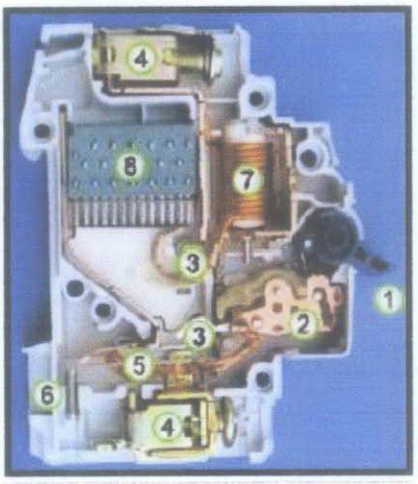


Figure 1: Internal part of circuit breaker

1. Actuator lever - used to manually trip and reset the circuit breaker. Also indicates the status of the circuit breaker (On or Off/tripped). Most breakers are designed so they can still trip even if the lever is held or locked in the on

position. This is sometimes referred to as "free trip" or "positive trip" operation.

2. Actuator mechanism - forces the contacts together or apart.
3. Contacts - Allow current to flow when touching and break the flow of current when moved apart.
4. Terminals.
5. Bimetallic strip.
6. Calibration screw - allows the manufacturer to precisely adjust the trip current of the device after assembly.
7. Solenoid.
8. Arc divider / extinguisher.

In this project, earth leakage circuit breaker (ELCB) is chosen because ELCB have several important characteristic as shown in Table 1.

Table 1: Characteristic of earth leakage circuit breaker (ELCB)

Rated Voltage	230 VAC (2 poles), 400 VAC (4 poles)
Rated Current	25 A, 40 A, 63 A
Rated Residual Operating Current	30 mA, 100 mA, 300 mA, 500 mA
Residual Current off-time	0.1 s
Minimum Value of Rated Making and Breaking Capacity	1 k A
Rated Condition Short Circuit Current	In =25 A or 40 A, Inc =1500 A In = 63 A , Inc = 3000 A

2.1.5 Earth Leakage Circuit Breaker (ELCB)

Earth leakage circuit breaker (ELCB) is an electrical wiring device that disconnects the circuit whenever it detects flow of current is not balance between the phase conductor and the neutral (N) conductor. Figure 2 below shows an example of Earth leakage circuit breaker (ELCB). The presumption is that such as imbalance may represent current leakage through the body of a person who is grounded and accidentally touching the energized part of the circuit. ELCB is designed to disconnect quickly enough to prevent such as shock [4].

Figure 2: Earth Leakage Circuit Breaker (ELCB)

2.1.6 ELCB operation

ELCB operate by measuring the current balance between 2 conductors using a differential current transformer, and opening the device's contact if there is a balance fault (difference in current between the phase conductor and neutral conductor). ELCB operate by detecting a nonzero sum of current must equal zero (within some small tolerance), otherwise there is leakage of current to somewhere else (to ground

or other circuit). Normally, ELCB is use to protect people to interrupt the circuit if the leakage current exceed a range 4 to 6 milliamps of current (the exact trip setting can be chosen by the manufacturer of the device and is typically 5 milliamps) within 25 milliseconds. Also, the ELCB is use to protect the electrical circuit and electrical equipment are allowed to trip as high as 30 milliamps of current [4].

2.1.7 Principal operation of ELCB

ELCB is use to detect leakage current and also provides protection against direct and indirect contact of personnel and livestock and against probable fires. ELCB should be test monthly to ensure it is in good condition or not using ELCB test button. Principal operation of ELCB is in electrical circuit, the incoming current is the same as outgoing current as shown in Figure 3.

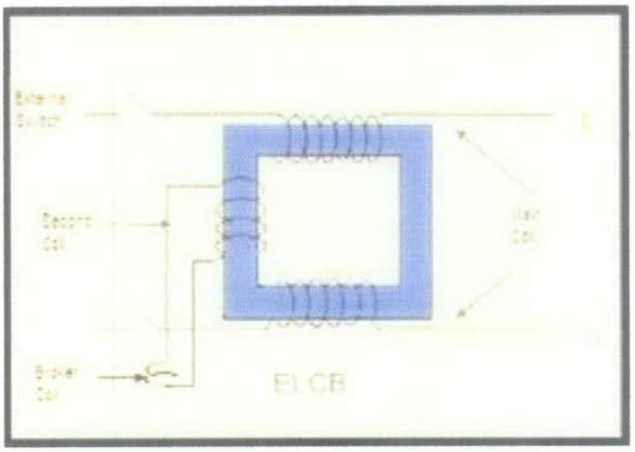


Figure 3: Principal operation of ELCB

Incoming current will flow through in life wire (L) and outgoing current will flow through out neutral wire (N) for make complete circuit. This operation is based on electromagnetic theory where incoming and outgoing current flowed through the wires will have their flux. This ELCB incorporates a core balanced transformer which is having main coil and second coil. The main coils have primary windings for life wire (L) and secondary windings for neutral wire (N) and the second coil which is

connected to relay for instantaneous detection of fault. In faultless situation, the flux which is carried by incoming and outgoing current will cancel each others. There is no magnetic field or flux that could induce a voltage in second coil. During flow of leakage current in the circuit an imbalance current is created because circuit is not complete and no outgoing current at the neutral wire (N) and imbalance flux that carried by the current cannot cancel each other and gives rise to unleakage flux in the core. This unleakage flux will interact with core and produce a magnet at second coil. The magnet at second coil will energize relay or broker coil and trips the external switch thereby disconnecting the supply.

ELCB is designed to prevent electrocution by detecting the leakage current, which can be far smaller (typically 5-6 milliamps) than the trigger current needed to operate conventional circuit breaker, which are typically measure in amperes. ELCB are intended to operate within 25 milliseconds. [5]

2.1.8 Flow operation of ELCB

The internal mechanism of ELCB is shown in Figure 4. ELCB is designed to be wired in line in an appliance flex. It is rated to carry a maximum current is 13 amperes and is designed to trip on a leakage current of 30 amperes.

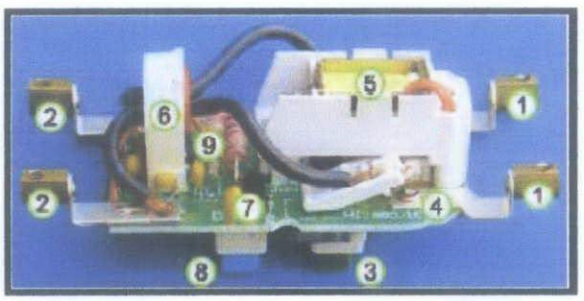


Figure 4: Internal mechanism of ELCB

Function for each terminal is described in Table 2. The incoming supply live and the grounded neutral conductor are connected at terminal 1 and outgoing load conductors are connected at terminal 2. When the reset button at terminal 3 is press the contact at terminal 4, allowing current to pass. The solenoid at terminal 5 keeps the contacts close when the reset button is released. The sense coil at terminal 6 is a differential current transformer which surrounds the live and neutral conductor.

Table 2: Portion each terminal of ELCB

Terminal	Portion
1	Grounded neutral conductor
2	Outgoing load conductor
3	Reset
4	Contact
5	Solenoid
6	Sense Coil
7	Sense Circuitry
8	Test Button
9	Test Wire

In normal operation, all the current flowing down the live conductor returns up the neutral conductor. The current in the 2 conductor are therefore equal and opposite and cancel each other out. When imbalance current flowing in the 2 conductor, this difference causes a current flowing in the sense coil at terminal 6 which is picked up by the sense circuitry at terminal 7. The sense circuitry then remove power from the solenoid at terminal 5 and the contact at terminal 4 are forced part by the spring, cutting off the electricity supply to the appliance. The device is designed so that the current is interrupted in a fraction of a second; greatly reducing the chances of dangerous electric shock being receive.

The test button at terminal 8 allows the correct operation of the device to be verified by passing a small current through the orange test wire at terminal 9. This simulates a fault by creating an imbalance in the sense coil [5].

2.2 Hardware part

This part will discuss about the components that will be use for make the hardware of this project and the components that list below are the main component which will make the hardware successfully run on based the design circuit.

2.2.1 DC Motor

A DC motor works by converting electric power into mechanical work as shown in Figure 5. This is accomplished by forcing current through a coil and producing a magnetic field that spins the motor [6].

Figure 5: DC Motor

So, the torque is proportional to the current through the windings. Given the equation,

$$T = kI \tag{1}$$

where T is the torque, I is the current, and k is a constant

The wire coils have both a resistance, R, and an inductance, L. When the motor is turning, the current is switching, causing a voltage,

$$V = L\, dI/dt \tag{2}$$

This voltage is known as the back-emf(electromotive force), e. If the angular velocity of the motor is w, then,

$$e = kw \tag{3}$$

This voltage, e, is working against the voltage we apply across the terminals, and so,

$$(V - kw) = IR \tag{4}$$

where $I = T/R$, which implies $(V - kw) = (T/k)\, R$

The maximum or stall torque is the torque at which $w = 0$ or $T = kV/R$, and the stall or starting current, $I = V/R$

The no load speed, $w = V/k$, is the maximum speed the motor can run. Given a constant voltage, the motor will settle at a constant speed, just like a terminal velocity. If we plot $w = V/k - (T/k^2)R$, we can get the speed-torque curve as shown in Figure 6.

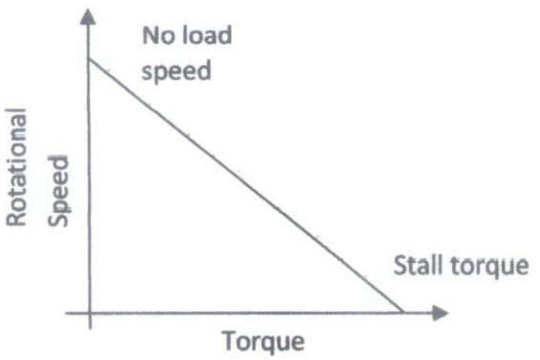


Figure 6: Speed-Torque Curve

2.2.2 Arduino

Arduino is an open-source electronics prototyping platform based on flexible, easy-to-use hardware and software. It is intended for artists, designers, hobbyists, and anyone interested in creating interactive objects or environments.

Arduino can sense the environment by receiving input from a variety of sensors and can affect its surroundings by controlling lights, motors, and other actuators. The microcontroller on the board is programmed using the Arduino programming language and the Arduino development environment [7]. Arduino projects can be stand-alone or they can communicate with software on running on a computer (e.g. Flash, Processing, MaxMSP). There are many model of Arduino, for this project the author used model Arduino Uno as shown in Figure 7.

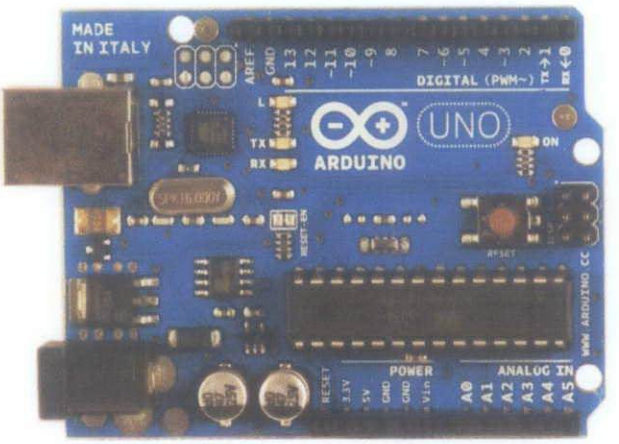


Figure 7: Arduino UNO

The Arduino Uno is a microcontroller board based on the ATmega1280. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, 16 MHz crystal oscillator, USB connection, power jack, ICSP header and reset button. Table 3 tabulated the summary of Arduino UNO.

Table 3: Summary of Aduino Uno

Microcontroller	ATmega328
Operating Voltage	5V
Input Voltage (recommended)	7-12V
Input Voltage (limits)	6-20V
Digital I/O Pins	14 (6 pin provide PWM signal)
Analog Input Pins	6
DC Current per I/O Pin	40 mA
DC Current for 3.3V Pin	50 mA
Flash Memory	32 KB
SRAM8 KB EEPROM	2 KB
Clock Speed	16 MHz

2.3 Software part

Software part will discuss about the software that would be used for designing and simulating circuit of the project and this part is the very important part where it decisive how to start the project. After the designing and simulating the project circuit success, then the real circuit would be made based on it. The author used ISIS PROFESSIONAL and Arduino Development Environment in this project.

2.3.1 ISIS Professional 7

Many CAD users dismiss schematic capture as a necessary evil in the process of creating PCB layout. With PCB layout now offering automation of both component placement and track routing, getting the design into the computer can often be the most time consuming element of the exercise.

ISIS has evolved over twelve year's research and development and has been proven by thousands of users worldwide. The strength of its architecture has allowed us to integrate first conventional graph based simulation and circuit simulation into the design environment. For the first time ever it is possible to draw a complete circuit for a micro-controller based system and then test it interactively, all from within the same piece of software. Meanwhile, ISIS retains a host of features aimed at the PCB designer, so that the same design can be exported for production with ARES or other PCB layout software [8].

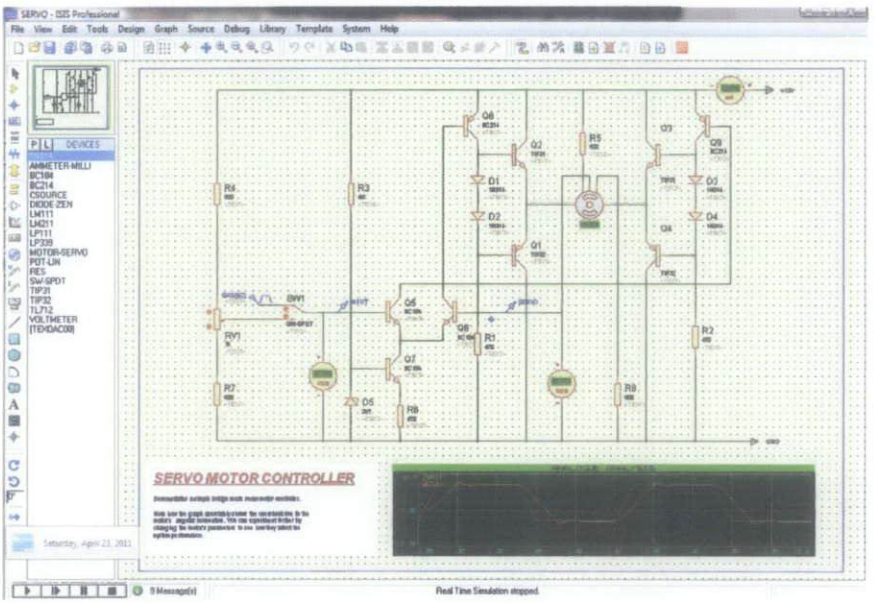


Figure 8: Proteus ISIS window

For the educational user and engineering author, ISIS also excels at producing attractive schematics. It provides total control of drawing appearance in terms of line widths, fill styles, colors and fonts. In addition, a system of templates allows you to define a 'house style' and to copy the appearance of one drawing to another. Figure 8 shows Proteus ISIS window. Other general features include:

i. Runs on Windows 98/Me/2k/XP and later.
ii. Automatic wire routing and dot placement/removal.
iii. Powerful tools for selecting objects and assigning their properties.
iv. Total support for buses including component pins, inter-sheet terminals, module ports and wires.
v. Bill of Materials and Electrical Rules Check reports.
vi. Netlist outputs to suit all popular PCB layout tools.

2.3.2 *Arduino Development Environment*

The Arduino Development Environment is a cross-platform application written in Java and is derived from the IDE for the Processing programming language. It is designed to introduce programming to artists and other newcomers unfamiliar with software development. Arduino Development Environment window is shown in Figure 9. It includes a code editor with features such as syntax highlighting, brace matching, and automatic indentation, and is also capable of compiling and uploading programs to the board with a single click. There is typically no need to edit make files or run programs on the command line.

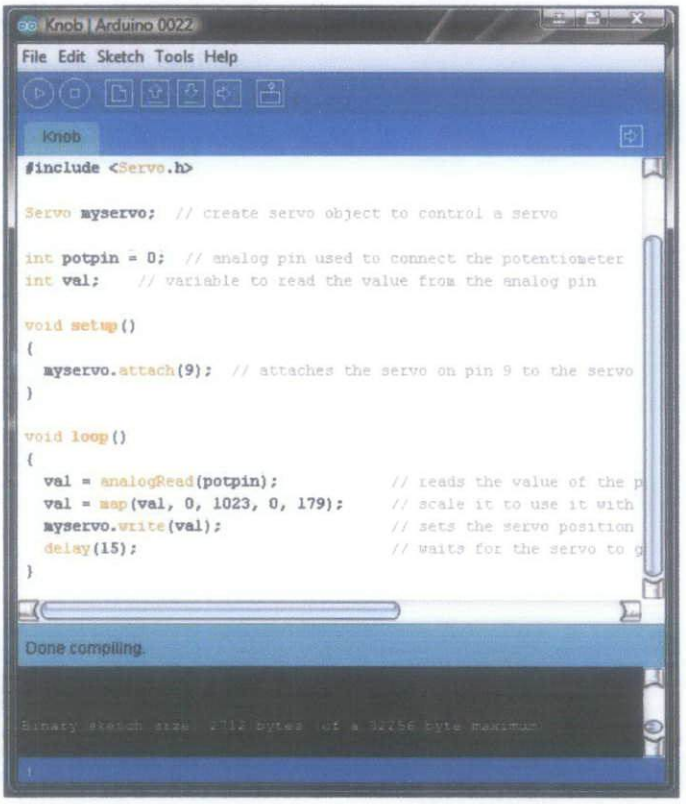


Figure 9: Arduino Development Environment window

CHAPTER 3

METHODOLOGY

3.1 Procedure of project

Planning is the initial phase in this project in order to make sure the progress meet the specified timeline. The sequence of methodology in this project has been illustrated in Figure 10. The project is started with collecting the related data as well as getting the clear understanding on the domestic electrical wiring.

In the Gathering Information phase, the information about breakers used in domestic application such as Earth Leakage Circuit Breaker (ELCB) and Miniature Circuit Breaker (MCB) has been collected. The author also has to understand the operation of each breaker. In this phase, the author collects the data on the other devices involved in this project such as DC motor and microcontroller.

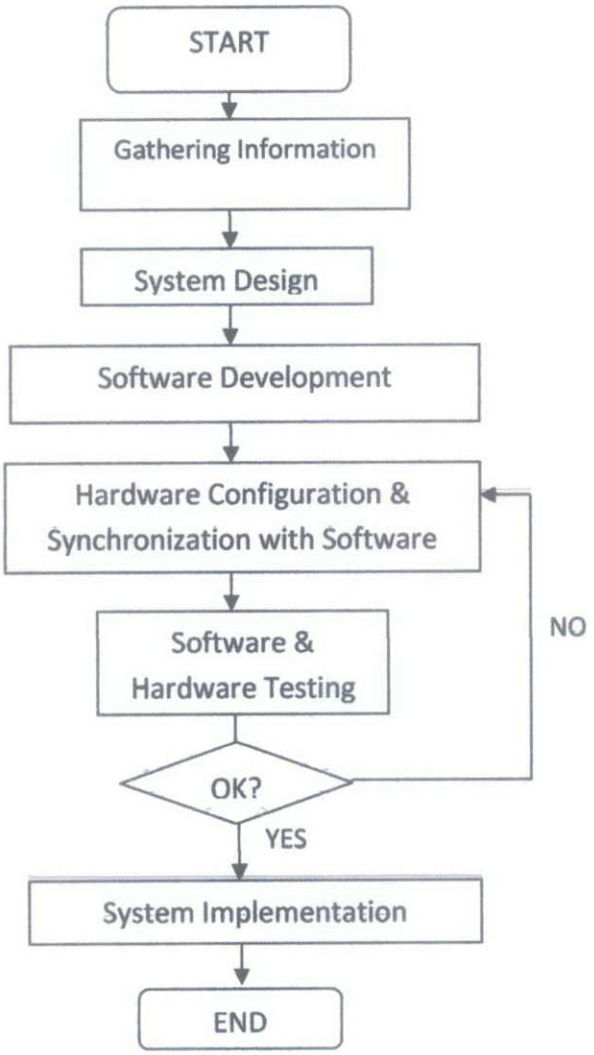


Figure 10: Methodology Flowchart

A program to control the motor will be developed for Software Development. A DC motor is used to reclose the breaker and it will be controlled using Arduino UNO. Then, the hardware and software will be synchronized together to test the functionality of the design and system. If it is passed, the system will be ready to be implemented. If it fails the test, it will be sent back to configuration and synchronization phase for troubleshooting.

3.2 Flow of operation

In System Design phase, a system to auto reset when ELCB and trigger the user if permanent fault has been designed. The system will automatically reclosed the breaker after is tripped. But if it trips for the third time, the possibility of permanent fault occur is high. So, it is dangerous if we try to reclose the ELCB again. Thus system will trigger the cell phone so that the user received a call that indicates his or her home has problem with ELCB. The flow of the system is represented in the Figure 11.

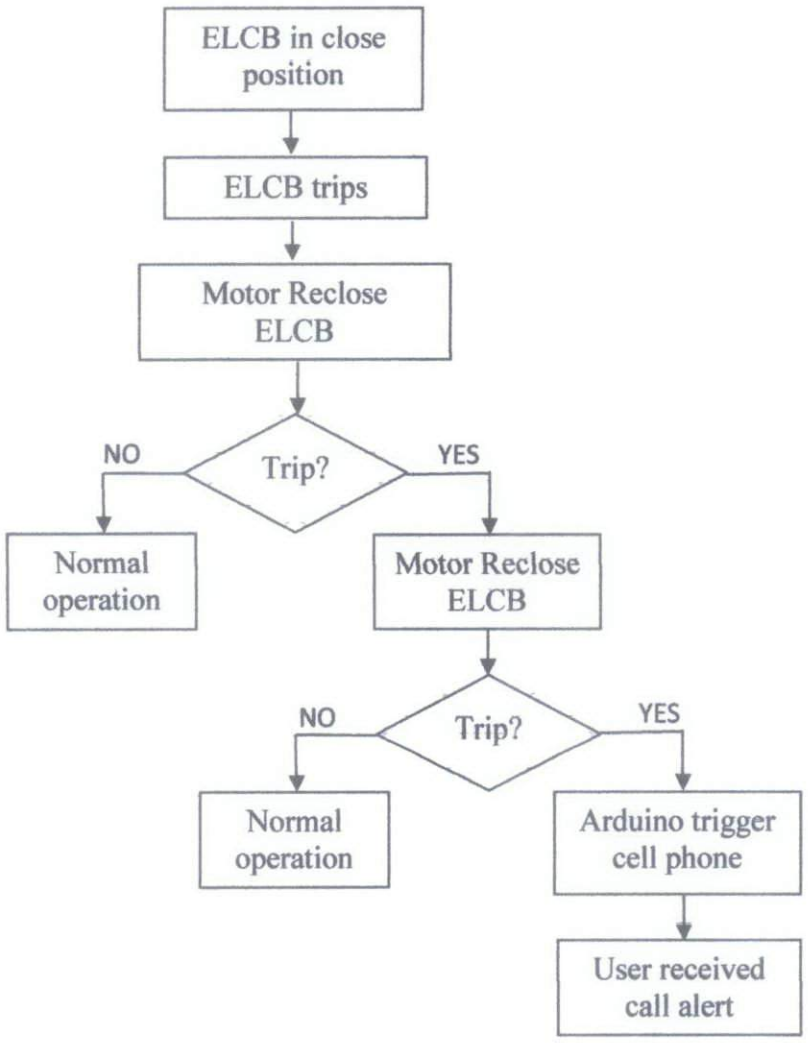


Figure 11: Flow of desired operation

3.3 Tools and equipment required

Table 4: Material and description of hardware

Material	Description
ELCB	Main component of the project
DC Motor 12V	To pull up the ELCB's spring trap
Relay	To operate a switching mechanism mechanically
Arduino UNO	To control the output
Adapter	To step down the voltage from 240V to 9V
Cell phone	To call the user when permanent fault occur
Casing	Material to cover the electrical part

Table 5: Part and software

Part	Software
Documentation	Microsoft Word
Presentation Slides	Microsoft Power Point
Electrical Circuit	ISIS Professional,Arduino Development Environment

3.4 I-ELCB Design

3.4.1 Layout & Auto-Reset Design

Figure 12 shows the layout of this project, the design consists of ELCB, motor, battery and casing. The casing contains electrical part such as relay and cell phone. Motor is powered by the battery.

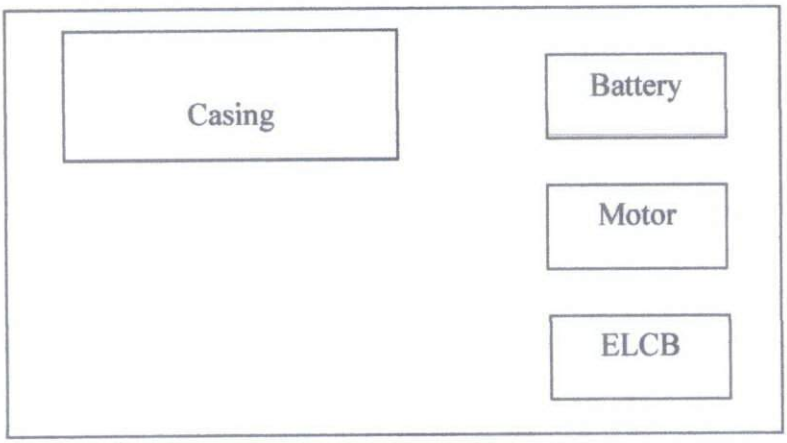


Figure 12: I-ELCB Layout Design

The main feature of this project is to auto-reset ELCB when short disturbance occur. Thus, a mechanism of pulling up the ELCB's spring trap had been design as shown in Figure 13. A tiny hole at ELCB spring trap has been made to insert the cable to pull up the spring trap. When the ELCB trips, relay will trigger the motor to pull up the ELCB's spring trap.

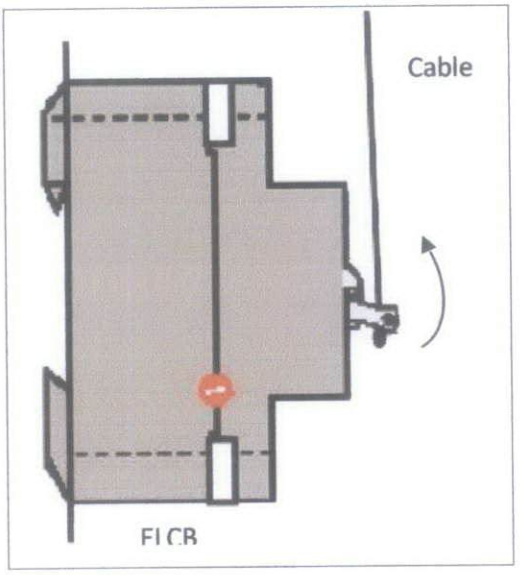


Figure 13: Pull up mechanism design

3.4.2 Main Circuit Design

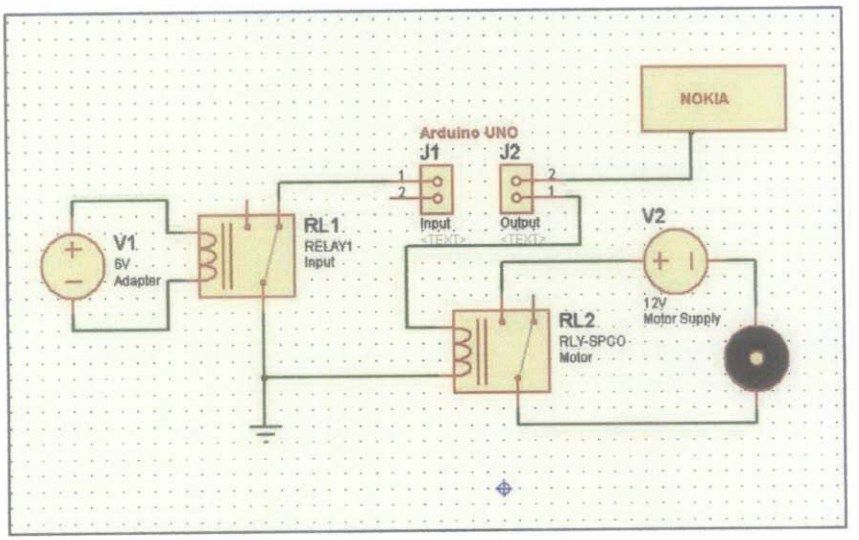


Figure 14: Main Circuit Design

The main circuit design can refer from Figure 14 above. From the adapter (V1), voltage will be step down from 240V to 9V. If fault occur, ELCB will trip and trigger the RL1 to give input to Arduino. After a few seconds, the motor will pull up the ELCB's spring trap to ON back the electricity. If only short disturbance occur, the

system will start back at initial condition. However, if the ELCB trip again, the same process will be repeated to make sure that the type of fault is permanent fault. If the ELCB trip for the third time, Arduino will send the signal to cell phone and make a call to the user to indicates that the there was permanent fault at his/her home. Then, Arduino will shutdown the operation. During this case, the user needs to push reset button at Arduino board manually to reset the operation.

3.4.3 Call Alert

Cell phone is used to call the user to indicate that permanent fault occurs. In order to make the cell phone make a call, the author utilizes speed dial mechanism. First, the contact number of the user must be load in the cell phone and set the speed dial. After that, the selected number pad for speed dial need to be connected with a pair of wire as shown in Figure 15. The speed dial will be trigger after received signal from Arduino when at condition where the ELCB has been reset twice within one minute, and then Arduino will shutdown the operation.

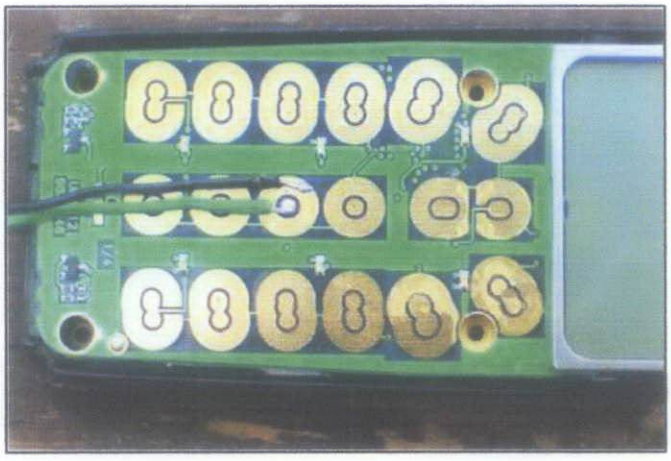


Figure 15: Selected number pad connect with wire

CHAPTER 4

RESULT & DISCUSSION

4.1 Prototype and Circuit Fabrication

In this project, the author designs the I-ELCB prototype for demo purpose. The layout is same as per discuss in Chapter 3. The entire prototype of I-ELCB shows in Figure 16.

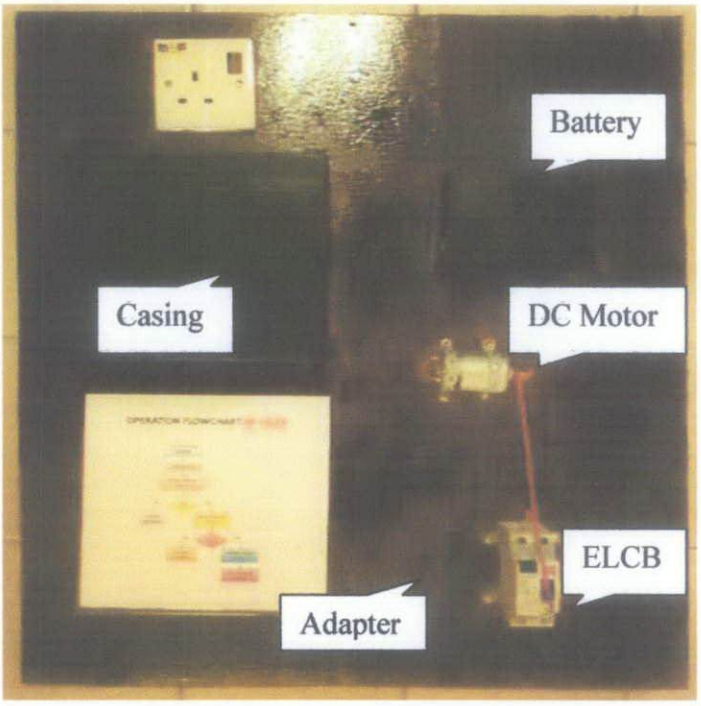


Figure 16: I-ELCB Prototype

Motor is used to pull up ELCB's spring trap and the spring trap actually very hard to push although by hand, so selection of motor is important to make sure the ELCB's spring trap can be on back automatically. The important characteristic that must be highlight is the motor torque and the suitable motor for this project is 12 V DC motor as shown in Figure 17. Below are the specifications of the motor:

- DC12V
- Output Power: 3.4 Watt
- Rated Speed: 17RPM
- Rated Current: 0.9A
- Rated Torque: 1960mN.m

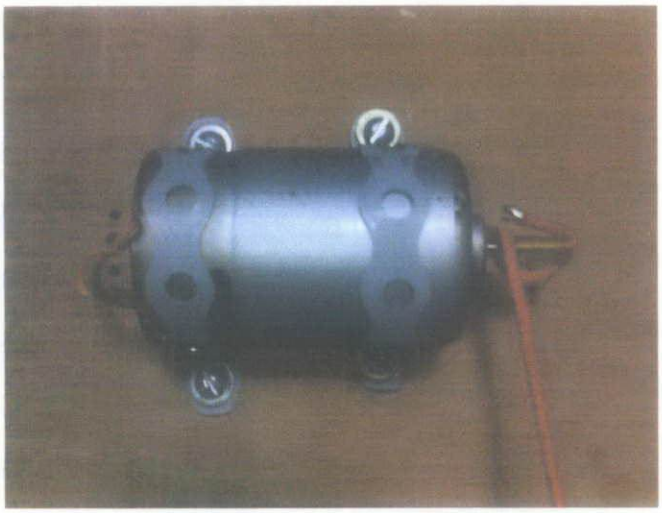


Figure 17: 12V DC Motor

A cable has been attached between ELCB and DC motor for the pull up mechanism as shown in Figure 18. Both the two component are mount tightly to improve reliability of this project. Besides that, the electrical parts such as Arduino board, relays and cell phone are compress together in the casing as shown in Figure 19.

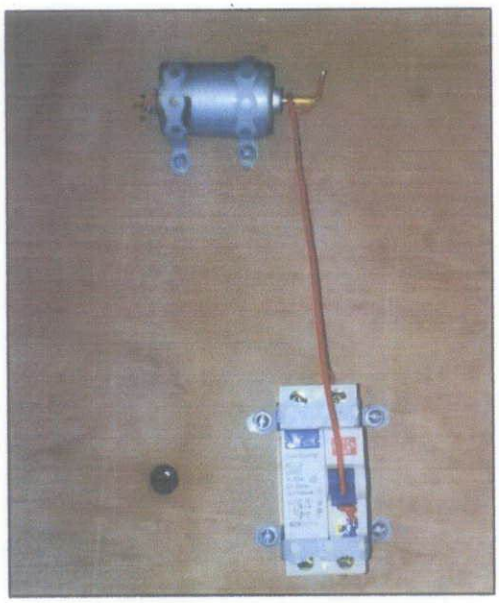


Figure 18: Pull up mechanism

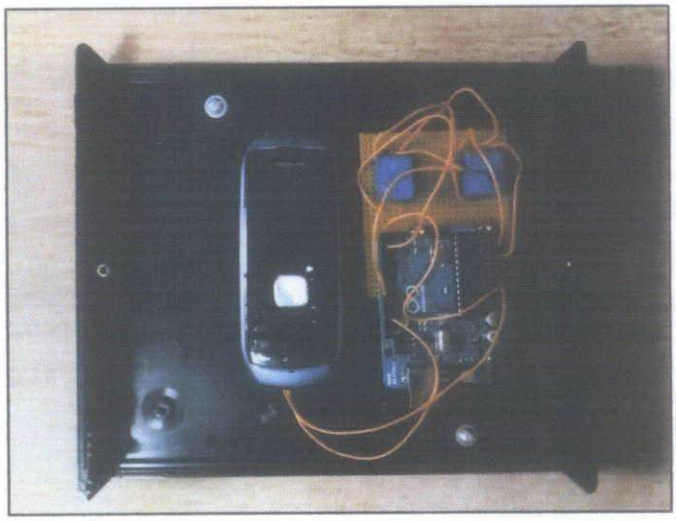


Figure 19: Component inside casing

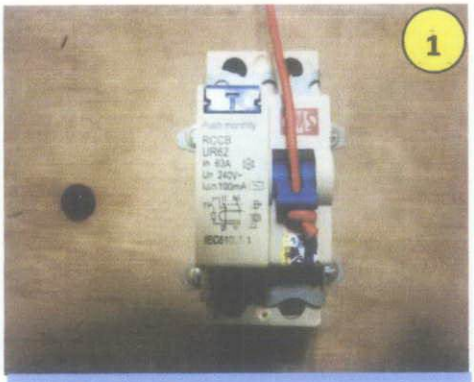
4.2 Result of the operation

In order to prove this project can work on real world, the adapter is connected with the ELCB to indicate that whether it has power supply or not. The desired operation has been explained in Chapter 3. To summarize the full operation of I-ELCB, it can be divided into three cases as shown in Table 6.

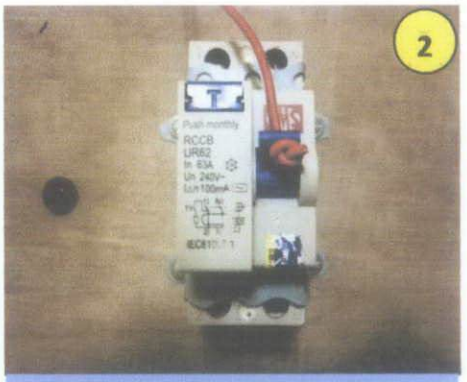
Table 6: Summary of operation

Case 1	ELCB trip first time → motor auto-reset ELCB → electricity ON
Case 2	ELCB trip first time → motor auto-reset ELCB → ELCB trip second time → Motor auto-reset ELCB → electricity ON
Case 3	ELCB trip first time → motor auto-reset ELCB → ELCB trip second time → Motor auto-reset ELCB → ELCB trip third time → Call Alert trigger → Shutdown operation

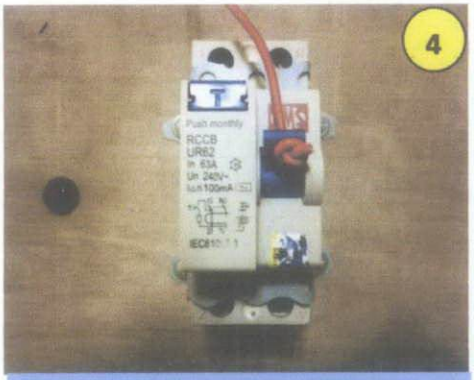
Case 1 and Case 2 are simple operation that involve the DC motor to pull up the ELCB's spring trap if its trips. Meanwhile for Case 3, the system involve cell phone to make a call alert to the user. The visualization for case 3 has been shown in Figure 20.



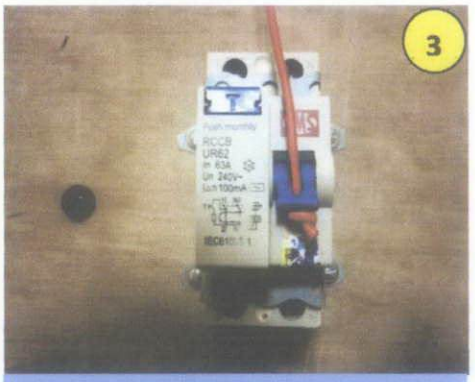
ELCB trip x1.



Motor pull up ELCB spring trap. ELCB in ON condition back.

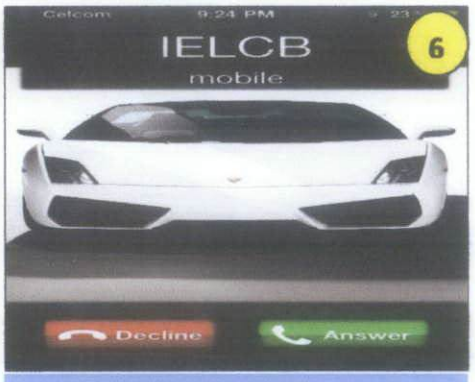


Motor pull up ELCB spring trap. ELCB in ON. If ELCB trip again.



However ELCB trips for second time.

System triggers cell phone to call user.



User received call from I-ELCB to indicated permanent fault occur.

Figure 20: Summary of Case 3

4.3 Market Potential

People in real world need continuous electric supply. Some of them may loss thousands ringgit when no electric supply at their home. This situation also can harm the user who's not aware about permanent fault. Based on the capability of I-ELCB, it is not possible to commercialize it to the market. Besides that, the cost of I-ELCB is reasonable. Table 7 tabulated the summary of total cost of I-ELCB.

Table 7: Total Cost

Part	Cost
Arduino UNO	RM 75.00
Relay 6V x 2	RM 5.00
DC Motor	RM 10.00
Adapter	RM 18.00
Casing Box (18cmx20cmx6cm)	RM 10.00
Casing Box (12cmx8cmx7cm)	RM 5.00
Cell Phone	RM 30.00
TOTAL COST	**RM153.00**

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

As a conclusion, the author had managed to fulfill the objectives of this project. The objectives of this project are to improve the ability of current ELCB and to develop a prototype of Intelligent ELCB. The system was built with an Arduino board as microcontroller circuit to control the operation. The system wills active DC motors to do the resetting task if there is tripping case occur. The system wills also alert the user if permanent fault occur. The objective and the scope of this project have been partially achieved successfully. Finally, this project has provides the author the chance to deal with the concept and the operation of ELCB and the microcontroller. The author also has learned to program the microcontroller with C programming language. Furthermore, the author has trained himself to be positive in tackling the entire problem faced from the early stage until the project finished.

5.2 Recommendation

This project still needs some improvement before it becomes commercialized. The pull up mechanism should be improved in a proper way so that the user didn't need to make a hole at the ELCB's spring trap. Besides that, the space for prototype I-ELCB can be much smaller if the entire component compress together in one box. The cost also can be reduced if this project uses PIC18F452 instead of Arduino board since both of them are microcontroller.

The function of the call alert and programming part for the communication between the modem with the microcontroller should be study further if the system needs to be design for two ways communication since this project just design for one way communication system.

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APPENDICES

APPENDIX A

No.	Detail/ Week	1	2	3	4	5	6	7	MID SEMESTER BREAK	8	9	10	11	12	13	14
1	Project Work Continue	■	■	■												
2	Submission of Progress Report				■											
3	Project Work Continue				■	■	■	■			■	■				
4	Poster Exhibition									■						
6	Submission of Draft Report												■			
7	Submission of Technical Paper													■		
8	Submission of Final Report (soft cover)													■		
9	Oral Presentation														■	
10	Submission of Final Report (hard cover)															■

■ Process

APPENDIX B

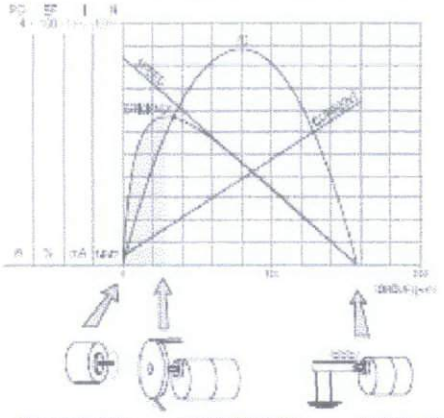
```
// Initialize
int countF = 0; // fault counter
int countS = 0; // state counter

void setup(){
 pinMode(1, INPUT); // input current

 pinMode(9, OUTPUT); // motor
 pinMode(10, OUTPUT); // hp
}

void loop(){

 if(digitalRead(1)==HIGH && countF==0){
  dclay(2000);
  digitalWrite(9, HIGH); // motor is ON
  digitalWritc(10, LOW); // hp is OFF
  delay(4000); // on time motor = 4sec
  digitalWrite(9, LOW); // motor is off
  countF = 1;
 }

 delay(2000);

 if(digitalRead(1)==HIGH && countF==1){
  delay(2000);
  digitalWrite(9, HIGH); // motor is ON
  digitalWrite(10, LOW); // hp is OFF
```

```
  delay(4000); // on time motor = 4sec
  digitalWrite(9, LOW); // motor is OFF
  countF = 2;
 }

 delay(2000);

 if(digitalRead(1)==HIGH && countF==2){
  digitalWrite(10, HIGH); // hp is ON
  delay(3000); // delay 3 seconds
  digitalWrite(10, LOW); // hp is OFF
  countF = 3;
 }

 if(countF==1 || countF==2){
  if(digitalRead(1)==LOW)
  countS++;

  if(countS==15) // reset time, 4sec x countS.
  countF=0;
 }

}
```

APPENDIX C

DC MOTOR SPECIFICATIONS

SPEED AND LOAD CHARACTERISTICS



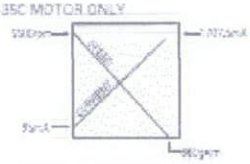
The relationship between torque vs speed and current is linear as shown left, as the load on a motor increases, Speed will decrease.
The graph pictured here represents the characteristics of a typical motor.
As long as the motor is used in the area of high efficiency (as represented by the shaded area) long life and good performance can be expected. However, using the motor outside this range will result in high temperature rises and deterioration of motor parts.
If voltage is continuously applied to a motor in a locked rotor condition, the motor will heat up and fail in a relatively short time. Therefore it is important that there is some form of protection against high temperature rises.
A motor's basic rating point is slightly lower than its maximum efficiency point.
Load torque can be determined by measuring the current drawn when the motor is attached to a machine whose actual load value is known.
We will select the most suitable motor for your application after receiving your information.

AS APPLIED VOLTAGE WILL BE CHANGED

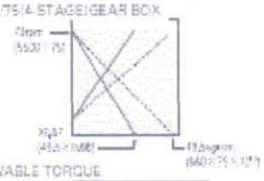
As shown left, if the applied voltage is changed, no load speed and starting torque also change in proportion to the voltage.
Speed charateristics at a given voltage are parallel to those at other voltages.
Thus, a DC motor can be used at a voltage lower than the rated voltage. But, below 1000 rpm, the speed becomes unstable, and the motor will not run smoothly.

CHARACTERISTICS AND RATED PERFORMANCE OF A GEARED MOTOR

Ⓐ ex. TG-35C MOTOR ONLY



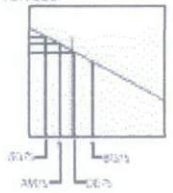
Ⓑ WITH 1/75/4-STAGE GEAR BOX



Speed reduction by means of a gear box results in increased torque.
The reduction/increase is determined by the gear ratio and efficiency of the gear box.

Over all efficiency depends on the number of reduction stages : one average is 90% per stage. Therefore: a two stage reduction gives 90%×90=80%; 3 stages will be 72.9% and a 4-stage reduction 66%.
The above mechanical loss affects the stall torque as shown left.
Stall torque of a geared motor can be calculated using the following formula:
Motor stall torque × gear ratio × efficiency.

Ⓒ ALLOWABLE TORQUE

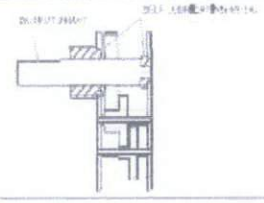


The output loading on a gear box must never exceed the manufacturers "specified rated torque" as this will cause premature gear failure.
It is particularly important to observe this at slow output speeds when the calculated output torque exceeds the specified rated torque.

● GEAR BOX CONSTRUCTION AND FEATURES

INTERMITTENT DUTY
(Suitable for less than 2sec. on & long enough off time)

STANDARD TYPE
AG, SG, BG⇨
VG, VM, LG



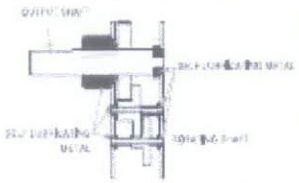
STANDARD GEAR MECHANISM
Other than the output gear, the gears rotate around a shaft that is fixed to the plate.

HEAVY LOAD
—self lubricating metal type

SM, AM, BE, BM⇨

—ballbearing at all stages

AP⇨

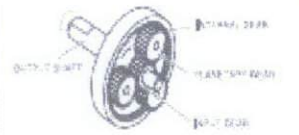


NON-LUBRICATED METAL BEARING GEAR MECHANISM
All gears, including the output gear, are attached to the shaft and supported by non-lubricated metal bearings. This type of mechanism is suitable for medium load applications and continuous duty cycle operation.

LOW COST VERSION—Plastic or sintered metal. EU, RU, LG, VG

COMPACT SIZE TYPE
—Planetary

GU, FU, EU, RU⇨



PLANETARY GEAR MECHANISM
A heavy duty type gear mechanism using 3 mating gears to transmit torque to the output shaft. This type of mechanism is suitable for limited space applications.

Protection against overload and locked rotor

When the rotor is locked and voltage is applied to the motor terminals, the temperature of the motor windings will rise, and eventually short-circuit.
The time until a short-circuit condition appears differs per motor type.
It is recommended that the motor is protected against such an overload by means of a fuse, current limiter or mechanical protection.

Protection against RFI/EMI caused by PWM control

An internally installed suppressor reduces electrical commutation noise caused by the brushes. Depending on the requirements, extra precautions sometimes are recommended such as an external capacitor, or filter circuit.
When driven in PWM at certain Frequencies it may occur that a motor does not start due to the combination of driving frequency and internally fitted capacitive noise suppressor.

Precautions for instantaneous reversing and dynamic braking

When the power supply to the motor is switched off, it is advisable to allow the motor to stop rotating before reversing the supply polarity.
Failure to do this will result in a very high instantaneous current.
It is possible to stop the motor within a few revolutions by applying a short-circuit across the motor terminals immediately after the motor is switched off. This method is very effective but may shorten brush life.

Vertical mounting with shaft up

In some cases when a motor gear is mounted in this position, traces of lubrication oil can contaminate the brushes and commutator thus shortening brush life or causing a short-circuit. Please contact us when vertical mounting is required.

Speed detection and control

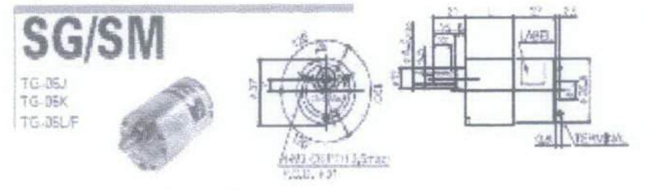
A number of models can be provided with a magnetic or optical encoder.
Please contact us for detailed information and assistance.

TG-05 (1.7~3.6W) ø 36, LONG LIFE, LOW NOISE, COMPACT SIZE, ENCODER CAN BE MOUNTED.

APPLICATION: BANKING MACHINE, VENDING MACHINE, MEDICAL EQUIPMENT, DAMPER, PRINTER. etc

SG/SM

TG-05J
TG-05K
TG-05L/F



SG

GEAR RATIO	L (mm)	STAGE	TORQUE (kg·cm)	WEIGHT (g)
1/5~1/15	20.5	2	1	100
1/22.5~1/30	22	3	2	105
1/36~1/100	23.5	4	3	110
1/120~1/300	25	5	4	115
1/360~1/1000	26.5	6	5	120
1/1500~1/3000	[illegible]	7	6	125

SM

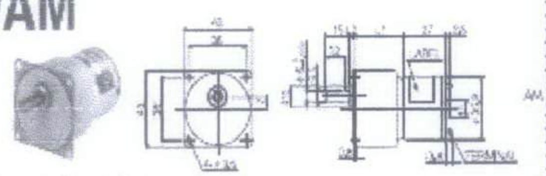
GEAR RATIO	L (mm)	STAGE	TORQUE (kg·cm)	WEIGHT (g)
1/5~1/15	22	2	1	100
1/22.5~1/30	23.5	3	2	105
1/36~1/100	25	4	[illegible]	110
1/120~1/300	26.5	5	[illegible]	115
1/360~1/1000	28	6	[illegible]	120

Allowable torque-speed characteristics

MODEL	GEAR RATIO	1/5	1/10	1/15	1/18	1/25	1/30	1/36	1/50	1/60	1/75	1/100	1/120	1/150	1/200	1/250	1/300	1/500	1/750	1/1000	1/1500
TG-05J-SG (24V)	SPEED(r/min)	982	417	279	231	167	135	112	81.1	67.6	54.1	41.5	33.8	27.2	20.4	16.4	14.1	9.8	6.5	4.4	2.4
	TORQUE(mN·m)	9.8	19.4	28.7	46	73.4	88.3	98	127.3	156.6	196	245	294	343	490	588	588	588	588	588	588
	TORQUE(kg·cm)	0.1	0.2	0.4	0.5	0.8	0.9	1	1.4	1.7	2	2.5	3	3.5	5	6	6	6	6	6	6
TG-05K-SG (24V)	SPEED(r/min)	1271	606	404	335	242	196	164	118	98.3	78.6	60.2	49.3	39.9	29.8	23.9	20.4	12.8	8.8	6.7	4.5
	TORQUE(mN·m)	9.8	19.4	28.2	46	73.4	88.3	98	127.3	156.6	196	245	294	343	490	588	588	588	588	588	588
	TORQUE(kg·cm)	0.1	0.2	0.4	0.5	0.8	0.9	1	1.4	1.7	2	2.5	3	3.5	5	6	6	6	6	6	6
TG-05L-SG (24V)	SPEED(r/min)	1542	831	554	462	330	277	230	165	137	113	83.0	69.4	55.5	41.5	33.5	28.8	17.9	12.5	9.2	6.2
	TORQUE(mN·m)	19.6	39.2	49	58.8	88.2	98	107.8	156.8	186.2	196	294	343	392	539	588	588	588	588	588	588
	TORQUE(kg·cm)	0.2	0.4	0.5	0.6	0.9	1	1.1	1.6	1.9	2	3	3.5	4	5.5	6	6	6	6	6	6
TG-05L-SG (12V)	SPEED(r/min)	603	411	269	231	161	124	110	80.5	65.9	52.4	39.9	33.4	26.7	19.9	16.2	13.4	8.3	5.5	4.5	3
	TORQUE(mN·m)	9.8	19.6	29.4	29.4	49	58.8	68.6	88.2	107.8	137.2	186.2	196	245	343	392	490	588	588	588	588
	TORQUE(kg·cm)	0.1	0.2	0.3	0.3	0.5	0.6	0.7	0.9	1.1	1.4	1.9	2	2.5	3.5	4	5	6	6	6	6
TG-05R-SG (12V)	SPEED(r/min)	1186	565	377	313	226	189	156	113	96.8	74.9	56.2	47.4	37.4	28.1	22.4	18.1	11.9	8.2	6.2	4.2
	TORQUE(mN·m)	9.8	19.6	39.2	49	68.6	78.4	88.2	117.6	147	186.2	245	245	343	441	539	588	588	588	588	588
	TORQUE(kg·cm)	0.1	0.2	0.4	0.5	0.7	0.8	0.9	1.2	1.5	1.9	2.5	2.5	3.5	4.5	5.5	6	6	6	6	6
TG-05J-SM (24V)	SPEED(r/min)	982	417	279	231	167	135	112	81.3	67.6	54.1	41.5	33.8	27.2	20.4	16.4	14.1	9.8	6.5	4.7	
	TORQUE(mN·m)	9.8	19.4	28.7	46	73.4	88.3	98	127.3	156.6	196	245	294	343	490	588	588	588	588	588	
	TORQUE(kg·cm)	0.1	0.2	0.4	0.5	0.8	0.9	1	1.4	1.7	2	2.5	3	3.5	5	6	6	6	6	6	
TG-05K-SM (24V)	SPEED(r/min)	1271	606	404	335	242	196	164	118	98.3	78.6	60.2	49.3	39.9	29.8	23.9	20.4	12.8	8.8	6.6	
	TORQUE(mN·m)	9.8	19.4	28.7	46	73.4	88.3	98	127.3	156.6	196	245	294	343	490	588	588	588	588	588	
	TORQUE(kg·cm)	0.1	0.2	0.4	0.5	0.8	0.9	1	1.4	1.7	2	2.5	3	3.5	5	6	6	6	6	6	
TG-05L-SM (24V)	SPEED(r/min)	1540	831	554	462	330	277	230	165	139	113	83.3	69.4	55.5	41.5	33.8	28.8	17.9	12.5	8.8	
	TORQUE(mN·m)	19.6	39.2	49	58.8	88.2	98	107.8	156.8	186.2	196	294	343	392	539	588	588	588	588	588	-
	TORQUE(kg·cm)	0.2	0.4	0.5	0.6	0.9	1	1.1	1.6	1.9	2	3	3.5	4	5.5	6	6	6	6	6	
TG-05L-SM (12V)	SPEED(r/min)	603	411	269	231	161	124	110	80.5	65.9	52.4	39.9	33.4	26.7	19.9	16.2	13.4	8.3	5.5	4.5	
	TORQUE(mN·m)	9.8	19.6	29.4	29.4	49	58.8	68.6	88.2	107.8	137.2	186.2	196	245	343	392	490	588	588	588	
	TORQUE(kg·cm)	0.1	0.2	0.3	0.3	0.5	0.6	0.7	0.9	1.1	1.4	1.9	2	2.5	3.5	4	5	6	6	6	
TG-05R-SM (12V)	SPEED(r/min)	1186	565	377	313	226	189	156	113	93.8	74.9	56.2	47.4	37.4	28.1	22.6	18.1	11.9	8.2	6.2	
	TORQUE(mN·m)	9.8	19.6	39.2	49	68.6	78.4	88.2	117.6	147	186.2	245	245	343	441	539	588	588	588	588	-
	TORQUE(kg·cm)	0.1	0.2	0.4	0.5	0.7	0.8	0.9	1.2	1.5	1.9	2.5	2.5	3.5	4.5	5.5	6	6	6	6	

AG/AM

TG-05J
TG-05K
TG-05L/F



AG

GEAR RATIO	L1 (mm)	L2 (mm)	STAGE	TORQUE (kg·cm)	WEIGHT (g)
1/5~1/15	26	0.5	2	1	90
1/22.5~1/30	26	3	3	2	95
1/36~1/100	26	5.5	4	3	100
1/120~1/300	31	3	5	4	105
1/360~1/1000	31	5.5	6	5	110
1/1500~1/3000	31	8	7	6	115

AM

GEAR RATIO	L1 (mm)	L2 (mm)	STAGE	TORQUE (kg·cm)	WEIGHT (g)
1/5~1/15	26	4	2	1	115
1/22.5~1/18	26	6.5	3	3.5	115
1/25~1/36	26	6.5	[illegible]	[illegible]	115
1/50~1/75	31	[illegible]	[illegible]	[illegible]	115
1/90~1/150	31	[illegible]	[illegible]	[illegible]	115
1/180~1/500	31	[illegible]	5	[illegible]	125

Allowable torque-speed characteristics

MODEL	GEAR RATIO	1/5	1/10	1/15	1/18	1/25	1/30	1/36	1/50	1/60	1/75	1/100	1/120	1/150	1/200	1/250	1/300	1/500	1/750	1/1000	1/1500
TG-05J-AG (24V)	SPEED(r/min)	982	417	279	231	167	136	112	81.1	67.6	54.1	41.5	33.8	27.2	20.4	16.4	14.1	9.8	6.5	4.7	3.3
	TORQUE(mN·m)	9.8	19.4	28.7	46	73.4	88.2	98	127.3	156.6	196	245	294	343	490	588	588	588	588	588	588
	TORQUE(kg·cm)	0.1	0.2	0.4	0.5	0.8	0.9	1	1.4	1.7	2	2.5	3	3.5	5	6	6	6	6	6	6
TG-05K-AG (24V)	SPEED(r/min)	1271	606	404	335	242	196	164	118	98.3	78.6	60.2	49.3	39.9	29.8	23.9	20.4	12.8	8.8	6.7	4.6
	TORQUE(mN·m)	9.8	19.4	28.2	49	73.4	88.2	98	127.3	156.6	196	245	294	343	490	588	588	588	588	588	588
	TORQUE(kg·cm)	0.1	0.2	0.4	0.5	0.8	0.9	1	1.4	1.7	2	2.5	3	3.5	5	6	6	6	6	6	6
TG-05L-AG (24V)	SPEED(r/min)	1542	831	554	462	330	277	230	165	137	113	83.0	69.4	55.5	41.5	33.4	28.8	17.9	12.5	9.2	6.2
	TORQUE(mN·m)	19.6	39.2	49	58.8	88.2	98	107.8	156.8	186.2	196	294	343	392	539	588	588	588	588	588	588
	TORQUE(kg·cm)	0.2	0.4	0.5	0.6	0.9	1	1.1	1.6	1.9	2	3	3.5	4	5.5	6	6	6	6	6	6
TG-05L-AG (12V)	SPEED(r/min)	603	411	269	231	161	124	110	80.5	65.9	52.4	39.9	33.4	26.7	19.9	16.2	13.4	8.3	5.5	4.5	3
	TORQUE(mN·m)	9.8	19.6	29.4	29.4	49	58.8	68.6	88.2	107.8	137.2	186.2	196	245	343	392	490	588	588	588	588
	TORQUE(kg·cm)	0.1	0.2	0.3	0.3	0.5	0.6	0.7	0.9	1.1	1.4	1.9	2	2.5	3.5	4	5	6	6	6	6
TG-05R-AG (12V)	SPEED(r/min)	1186	565	377	313	226	189	156	113	96.8	74.9	56.2	47.4	37.2	28.1	22.4	18.1	11.9	8.2	6.2	4.2
	TORQUE(mN·m)	9.8	19.6	39.2	49	68.6	78.4	88.2	117.4	147	186.2	245	245	343	441	539	588	588	588	588	588
	TORQUE(kg·cm)	0.1	0.2	0.4	0.5	0.7	0.8	0.9	1.2	1.5	1.9	2.5	2.5	3.5	4.5	5.5	6	6	6	6	6
TG-05J-AM (24V)	SPEED(r/min)	982	417	279	231	167	135	112	81.3	67.6	54.7	41.5	33.8	27.4	20.4	16.2	13.6	9.8	-		
	TORQUE(mN·m)	9.8	19.4	28.7	49	73.4	88.2	107.8	127.2	156.8	196	245	343	392	490	637	686	686			
	TORQUE(kg·cm)	0.1	0.2	0.4	0.5	0.8	0.9	1.1	1.4	1.7	2	2.5	3.5	4	5	6.5	7	7			
TG-05K-AM (24V)	SPEED(r/min)	1271	606	404	335	242	196	164	118	98.3	78.6	59.2	48.8	38.7	29.8	23.1	20	13.8			
	TORQUE(mN·m)	9.8	19.4	28.7	49	73.4	88.2	107.8	127.2	156.8	196	245	343	392	490	637	686	686			
	TORQUE(kg·cm)	0.1	0.2	0.4	0.5	0.8	0.9	1.1	1.4	1.7	2	2.5	3.5	4	5	6.5	7	7			
TG-05L-AM (24V)	SPEED(r/min)	1540	832	554	462	330	277	230	165	137	113	83.3	69.4	55.4	41.5	33.1	28.2	17.9			
	TORQUE(mN·m)	19.6	39.2	49	58.8	88.2	98	117.4	156.8	186.2	196	294	343	441	539	686	686	686			
	TORQUE(kg·cm)	0.2	0.4	0.5	0.6	0.9	1	1.2	1.6	1.9	2	3	3.5	4.5	5.5	7	7	7			
TG-05L-AM (12V)	SPEED(r/min)	603	411	269	231	161	124	110	80.5	65.9	52.4	39.9	34.1	27.1	19.9	16.2	13.4	8.3			
	TORQUE(mN·m)	9.8	19.6	29.4	29.4	49	58.8	68.6	88.2	107.8	137.2	186.2	196	245	343	392	490	588			
	TORQUE(kg·cm)	0.1	0.2	0.3	0.3	0.5	0.6	0.7	0.9	1.1	1.4	1.9	2	2.5	3.5	4	5	6			
TG-05R-AM (12V)	SPEED(r/min)	1186	565	377	313	226	189	156	113	93.8	74.9	56.2	46.9	37.9	28.1	22.5	18.7	11.9			-
	TORQUE(mN·m)	9.8	19.4	39.2	49	68.6	78.4	98	117.4	147	186.2	245	294	343	441	539	686	686			
	TORQUE(kg·cm)	0.1	0.2	0.4	0.5	0.7	0.8	1	1.2	1.5	1.9	2.5	3	3.5	4.5	5.5	7	7			

APPENDIX D

Residual Current Circuit Breaker

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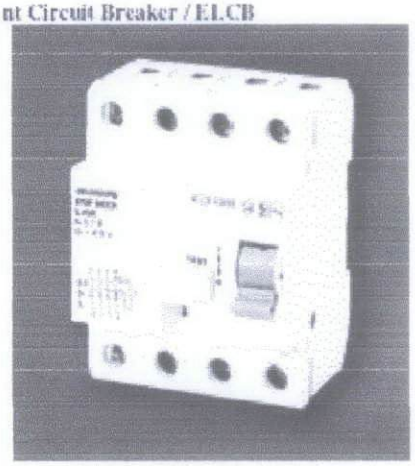
Introduction – Residual Current Circuit Breaker / ELCB

The Fault current overloads and short circuits can be detected by circuit breakers like MCB's MCCB's & HRC Fuses etc. But, Circuit breakers don't detect leakage currents, which are dangerous for humans and livestock and if not detected can lead to fire hazards. We need a solution that detects such leakages currents and disconnects the circuits from the power supply. Here comes the solution in the form of RCCB (Residual Current Circuit Breaker) also known as ELCB (Earth Leakage Circuit Breaker) which provides protection against direct and indirect contact of personnel or livestock and against probable fires.



Product
Stop Shock RCCB's.

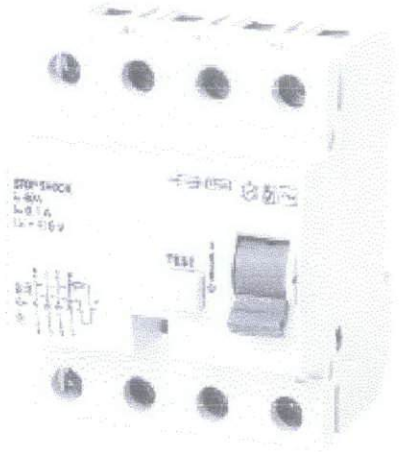
Classification
Domestic and Industrial use Residual Current Circuit Breaker.

Range
Available in 2 Pole and 4 Pole.

Application
Prevents shocks caused by earth leakage which could be fatal.

As per the Rule 61A of the Indian Electricity Rules 1956, the supply of energy of following installations shall be controlled by the earth leakage protective devices so as to disconnect the supply instantly on the occurrence of earth fault or leakage current.

- Installations having load above 5KW.
- Luminous Tube Installations.
- X – Ray Machines.



2 Pole
Used for three phase electrical connections, for industrial and commercial purposes.

As per Government of India Gadget notice, the RCCB's must have ISI mark in India.
Selling of non ISI RCCB's in India is prohibited.

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Salient Features

- Use of special magnetic materials for the toroidal core balance transformer and a specially developed highly sensitive miniature relay ensure positive detection of earth leakage currents as low as 30mA in less than 40 milli seconds thereby acting as a life saver. All the RCCB's are protected from nuisance tripping against transit voltages (lighting, line disturbances...) and transient currents (from high capacitive circuits).
- STOP SHOCK RCCB's are housed in high quality thermoplastic insulating material. The materials used are fire retardant, anti tracking, non-hygroscopic, impact resistant and can withstand high temperatures.
- The moving contacts of the phases are put on a moving arm, actuated by a rugged toggle mechanism. Hence the closing and opening of all the phases occur simultaneously. This also ensures simultaneous opening of all the contact under automatic tripping conditions.
- STOP SHOCK RCCB's incorporate advanced neutral i.e. neutral makes ahead of phases and breaks after phases, which ensures complete discharge of line inductance and capacitance. (It also has safe interrupting clearances as per IS: 13947-1. These two provisions make STOP SHOCK RCCB an ideal selection as main switch.)
- ON & OFF Positions is clearly visible with the help of window provided at the top of housing. The green colour indicates the OFF position and red colour indicates the ON Position.
- Mechanism components are made of plastic which are of high-quality, high-strength, low inertia and self lubricating properties. This results in a very fast opening action of the device under fault conditions. Though the moving components of the mechanism are made of plastic for friction free and smooth operation, load bearing parts of mechanism are made of high-strength steel thus the combination resulting in making the mechanism more sturdy.
- RCCB's relay draws the energy from the residual current which it needs to trip the RCCB that's why it can still operate normally if the mains voltage drops or if the neutral wire is interrupted, even a relatively long period of over voltage resulting from a fault current in the mains can't destroy RCCB or interfere with its normal operations.
- The ever increasing use of rectifies, particularly in the mining industry, requires safety measures against fault current which will also safety detect and respond to AC residual currents with a frequency of 50Hz to smooth DC residual currents. This so-called universal sensitivity which can only be achieved with auxiliary voltage-dependents circuit breakers, i.e 'DI' devices.
  Equipments likely to emit smooth DC residual currents may only be used outside house installations and it may not be operated downstream of 'normal' RCCB's to which other circuits are connected. In the events of a residual DC current arising, the RCCB's operation could be impaired and it might not even trip if a residual current occurs simultaneously at another electrical equipments. In order to be able to ensure selective protection against direct and indirect contact, professional bodies are increasingly demanding that AC-DC sensitive devices be employed. Our devices are designed and constructed to IEC 1008 / IS: 12640 – 2000. They will respond to residual currents from smooth DC currents to 400Hz AC and pulsating currents and provide extremely high operational reliability. These RCCB's are available in selected rating only.

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- RCCB's are provided with an ARC chamber consisting of arc-chute. They arc-chute quenches the arc faster, which further increases electrical contacts life.
- STOP SHOCK RCCB's are life saving devices and hence, incorporate a test button 'T' for periodic checking of the mechanism and function of the RCCB.
- Apart from suitability to copper cables the terminals are suitable for aluminum cables from 1 to 25 Sq.mm.
- STOP SHOCK RCCB can be easily mounted on a standard DIN rail of 35mm. Furthermore, operation of the RCCB is independents of mounting position. Supply connections can be terminated can be terminated either from top or bottom.
- STOP SHOCK RCCB's have been completely type tested at CPRI / ERDA in accordance with IS: 12640-1-2000 and is ISI Marked.

RCCB works on the principle that in an electrical circuit the incoming current is the same as out going current as shown in the Diagram. RCCB incorporates a core balance transformer having primary and secondary windings and a sensitive relay for instantaneous detection of fault signal. The primary winding lies in series with the supply mains and load. Secondary winding is Connected to a very sensitive relay. In a faultless situation, the magnetizing effects of the current carrying conductors cancel each other out. There is no residual magnetic field that could induce a voltage in the secondary. During flow of leakage current in the circuit an imbalance is created in the circuit which gives Rise to leakage flux in the core. This leakage flux generates an electrical signal that is sensed by the relay and it trips the Mechanism thereby disconnecting the supply. When pressing the TEST button 'T', a fault is simulated via the Test resistance & RCCB trips.

To ensure that the RCCB switches off the protected circuit Immediately. If there is an insulation fault causing a short-circuit to an exposed part (frame etc.) of machinery and equipment (protection against indirect contact), the maximum permissible touch voltage U must occur at a residual current greater than or equal to the rated residual operating current I that triggers the ?n RCCB. This condition is met by earthing the exposed part with a Sufficiently low resistance to earth RE.

$$\text{Earth Resistance RE} \quad \leq \frac{\text{Touch Voltage U E T}}{\text{Rated Residual operating current} - \text{I}}$$

The maximum values of R for touch voltages of 25V, 50V & 65V E are given in the specification tables.

To provide extra protection in the event of direct contact with an (unearthed) live part, extremely sensitive RCCB's with a rated residual operating current of 30 mA or less (I = 30 mA) are used instead of more conventional RCCB's with higher residual operating fault currents.

This extra protection is necessary if:
1) The insulation of totally insulated devices or their loads are damaged.
2) The earth wire is interrupted
3) The earth wire and live wire are transposed (accidentally thus rendering line the body of a protection class I device).
4) A component which is live in normal operation is touched during repair work.

In view of this increased range of protection, an RCCB or RCCB/MCB with

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I = 30 mA is must - by law in some European countries - to be used when? Installing machinery of equipment in areas with particularly high accident risk.

I Socket-outlet power circuits in rooms with bath or shower.
I Caravans, boats and yachts and their power supply on camping or berthing Sites
I Electrical appliances in rooms used for medical purposes.

The drawn-in switch-off characteristics of residual current devices with a rated fault current of 10 and 30 mA make it clear that these residual current devices are able to prevent the occurrence of the dangerous heart chamber fibrillation. For this reason, residual current circuit breakers with rated fault currents of 10 mA are used for the protection of particularly exposed individual equipment. Residual current circuit breakers with 30 mA rated fault current are already specified today for many areas (bath, medically utilized rooms, outside areas, agriculture, etc.) in order to ensure the protection of persons.

- Usually no reaction effects.
- Usually no harmful physiological effects.
- Usually no organic damage to be expected. Likelihood of muscular contraction and difficulty of breathing reversible disturbance of formation and conduction of impulses in the heart and transient cardiac arrest without ventricular fibrillation increase with current magnitude and time.
- In addition to the effects of zone 3, increasing with magnitude and time pathy physiological effects such as cardiac arrest, breathing arrest and heavy burns may occur.

Even relatively insensitive RCCB's (I = 300 mA) can be used to provide effective protection against fire caused by earth-leakage faults. With a residual current = 300 mA, the electrical energy released at the location of the earth fault is not sufficient to ignite normal building materials. With larger residual currents, the RCCB switches off the circuit in less than 200 milliseconds, thus limiting the amount of energy released to a harmless level.

Additional Protection Against Pulsating Fault Currents.

While the tripping of residual current circuit breakers with pure alternating fault currents was usual and adequate in the past, these can only be used conditionally in modern electrical installations. With light controls, speed controls etc. pulsating forms of current increasingly occur also as fault currents as a result of the use of electronic components. In order to tackle such pulsating direct fault currents which tend to zero or almost zero within every period of the mains frequency at least for half a period, 'A' type of RCCB's are suitable. Type A is more sensitive than AC type. It covers all requirements of AC type plus it is pulse current sensitive.

Precaution for Installations

- Wiring should be done by a trained & qualified electrician as per the wiring diagram.
- All wiring necessary for operation shall be passed through the RCCB.
- The neutral conductor must be insulated against earth to the same extent as the live conductors.
- All equipments used must be properly earthed.
- To ensure correct functioning care must be taken that the neutral conductor on the load side of the RCCB must not be Connected to earth, otherwise nuisance tripping may occur or tripping may be impaired.
- Suitable device either MCB or HRC fuses shall be used for short circuit and overload protection of the circuit under installation.

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- Don't expose the circuit breaker to direct sunlight, rough weather and keep it away from the influence of magnetic field.

Fault finding when RCCB Trips

Switch OFF all the switches/MCB connected in the circuit downstream the RCCB. Switch ON RCCB and switch ON the Switches one by one. You will find that during switching ON of a particular appliance/switch RCCB trips again and again.
Which shows that this is the faulty circuit/appliance. Isolate the faulty circuit, rectify the fault and switch ON the RCCB.

Permissible Earth Resistance (R) With Max. Permissible Touch Voltage (U)

Therefore the following earth resistance must be guaranteed with 300mA rated fault current of the selective switches :

U = 25V R = 83 Ohm U = 50V R = 166 Ohm U = 65V R = 216 Ohm

Touch Voltage (U) (V)	Earth Resistance R (?) Sensitivity I (mA)		
	30	100	300
25	833	250	83
50	1666	500	166
65	2160	650	216

Sensitivity	Application
30mA	Tripping current designed for additional protection against direct contact, or where specially required by the Indian wiring regulations, the 30 mA RCCB protects against leakage currents and indirect contact with earth loop impedance up to 1667 Ohms; for use as additional protection against direct contact, residual tripping current must not exceed 30 mA.
100mA	Tripping current is suitable for protection against indirect contact and leakage currents for larger installations; the 100 mA RCCB's operate within 30 ms, but do not provide the same level of personal protection as the 30 mA units; the 100 mA RCCB protects against leakage currents and indirect contact with earth loop impedance up to 500 ohms.
300mA	A less sensitive protection suitable for large installations having high levels of leakage current; 300 mA RCCB's protect against leakage current and indirect contact up to 167 ohms earth loop impedance.

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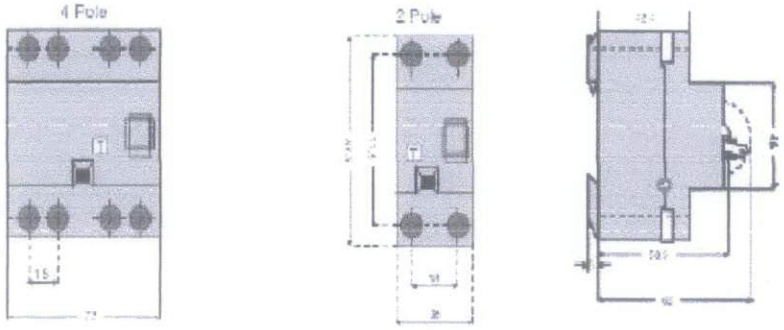
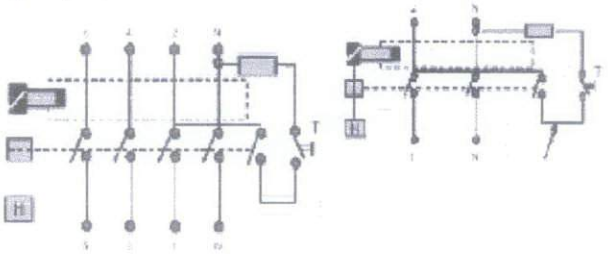
Dimensional Drawing



Wiring Diagram



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