AUTOMATIC TESTER DEVICE FOR EARTH LEAKAGE CIRCUIT BREAKER

MOHD AZRAIE B SUARIN

UNIVERSITI MALAYSIA PAHANG

UNIVERSITI MALAYSIA PAHANG

BORANG PENGESAHAN STATUS TESIS♦

JUDUL: **AUTOMATIC TESTER DEVICE FOR EARTH LEAKAGE CIRCUIT BREAKER**

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AUTOMATIC TESTER DEVICE FOR EARTH LEAKAGE CIRCUIT BREAKER (ELCB)

MOHD AZRAIE B SUARIN

This thesis is submitted as partial fulfillment of the requirement for the award of the Bachelor Degree of Electrical Engineering (Power System)

Faculty of Electrical & Electronic Engineering
University Malaysia Pahang
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Specially dedicated to

My beloved parent

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ABSTRACT

Power system protection plays important role for the safety of humans and electrical equipments in houses or buildings. Besides it also becomes a precondition of the system for obtaining capability and continuous power supply. Earth leakage circuit breaker (ELCB) is an important protection device especially for houses and buildings. The ELCB's spring trap will trip to isolate the fault from the system when line to ground fault occurs. So the good condition of the ELCB is very important to run the duty as a power system protector. This project is designed to test the earth leakage circuit breaker (ELCB) automatically every month by detecting current through it when it is in off condition. Microcontroller will be use in this project to make the ELCB automatically tested with programmed it for month. During test period, a current detector which is connected series with the ELCB will detect any current that flow through it. When the detector detect currents, mean that the ELCB does not function properly and LED or buzzer will be ON as an indicator for occupant, so that ELCB can be change immediately. The ELCB is in good condition and can function properly when no current detected and DC motor will be used to switch ON the ELCB's spring trap. Actually this project can improve the ELCB application and also will enhance the safety for occupant of houses and buildings.

ABSTRAK

Perlindungan sistem kuasa memainkan peranan yang penting dalam menjaga keselamatan penghuni serta peralatan elektrik sesebuah premis. Selain itu ia juga menjadi salah satu syarat yang harus dipenuhi bagi mendapatkan keupayaan sistem kuasa yang berterusan. Litar pemutus kebocoran arus kebumi (Earth Leakage Circuit Breaker / ELCB) ialah alat perlindungan yang sangat penting terutamanya untuk kegunaan rumah dan bangunan. Belantik pada litar pemutus kebocoran arus kebumi akan terbelantik untuk memisahkan kerosakkan didalam sistem kuasa apabila berlaku kebocoran arus. Oleh itu ELCB mestilah dalam keadaan yang baik supaya dapat menjalankan tugasnya sebagai pelindung terhadap sistem kuasa. Projek ini direka untuk menguji ELCB secara automatik setiap bulan dengan mengesan arus yang mengalir melaluinya semasa ia dalam keadaan tidak hidup. Mikropengawal akan digunakan didalam projek ini supaya ELCB dapat diuji secara automatik dengan mengaturcara untuk masa sebulan. Semasa dalam ujian, satu pengesan arus yang telah disambungkan secara sesiri dengan ELCB akan mengesan sebarang arus yang mengalir melaluinya. Jika pengesan arus dapat mengesan arus yang mengalir melalui ELCB, ini bermakna ELCB itu tidak berada didalam keadaan yang baik dan LED atau bazer akan di hidupkan sebagai penunjuk kepada penghuni rumah atau bangunan supaya ELCB dapat ditukarkan dengan segera. ELCB didalam keadaan yang baik sekiranya tiada arus yang dapat dikesan dan motor arus terus (DC motor) akan digunakan untuk menolak semula belantik pada ELCB. Sebenarnya projek ini dapat meningkatkan penggunaan ELCB serta dapat meningkatkan keselamatan terhadap penghuni rumah dan bangunan.

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LIST OF ABBREVIATIONS

ELCB	-	Earth Leakage Circuit Breaker
RCCB	-	Residual Current Circuit Breaker
DC	-	Direct Current
AC	-	Alternate Current
UPS	-	Uninterruptible Power Supply
EHV	-	Extra High Voltage
VAC	-	Voltage Alternate Current
VDC	-	Voltage Direct Current
PIC	-	Programmable Integrated Circuit
LED	-	Light Emitting Diode
SPST	-	Single Pole Single Throw

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CHAPTER 1

INTRODUCTION

1.1 Background

This chapter explains about the information of circuit breaker and also explains about identification of automatic tester device for ELCB, problem statement, objective of the project and project scope.

1.1.1 Circuit breaker

Circuit breaker is an automatically operated electrical switch designed to protect an electrical circuit from damage caused by overload or short circuit. Circuit breaker can be reset (manually) to resume normal operation. Basically, circuit breaker is implemented using a solenoid (electromagnet) that's pulling force increase with the current. There are many different technologies used in circuit breaker such as:

i. Miniature Circuit Breaker (MCB)

- Rated current not more than 100A.
- Trip characteristics normally not adjustable.

ii. Moulded Case Circuit Breaker (MCCB)

- Rated current up to 1000A.
- Thermal or thermal magnetic operation.
- Trip current may be adjustable.

iii. Residual Current Device (RCD)

- Known as a Residual Current Circuit Breaker (RCCB).
- Detects current imbalance.

iv. Earth Leakage Circuit Breaker (ELCB)

- This detects earth current directly rather than detecting imbalance.

v. Residual Current Breaker with Overcurrent Protection (RCBO)

- Combines the function of RCD and an MCB in one package.

1.1.2 Automatic tester device for ELCB

In this project, basically have 3 main circuits. First circuit is to make the ELCB trip automatically. Second’s circuit is to checks current flow through the ELCB. Last circuit is to switch ON automatically the ELCB’s spring trap using a dc motor. All the circuits controlled by microcontroller, PIC 16F877A so that the operation of this project operates with directive and fluent.

1.1.3 Automatic ELCB’s trip.

Application of this circuit basically for replace the function of test button ’T’ at the ELCB which is use for trip the ELCB when it pushed manually. This circuit will trip the ELCB every month, so the microcontroller is programmed with timer program for a month and will send signal to relay when the timer has been counted for a month. Normally open at the relay connection connected with life wire (L) and neutral wire (N) from power supply. When the relay received signal from microcontroller, PIC16F877A, it will energized and short the normally open’s connection. Basically ELCB will trip instantaneous when the life wire (L) and the neutral wire (N) are shorted because fault is created.

1.1.4 ELCB’s current detector.

After the ELCB trip, it is in off condition, so to ensure it is in good condition or not, current detector will be use. If the current detector detects no current flows through the ELCB, microcontroller, PIC16F877A, will send signal to relays for control a DC motor to push back the ELCB’s spring trap and the ELCB is in good condition. Otherwise, if it detects current, the ELCB’s is not in good condition and microcontroller, PIC16F877A, will send signal to ON LED or Buzzer as an indicator.

1.1.5 Automatic switch on ELCB's spring trap.

The ELCB's spring trap actually will be pushed by a DC motor but with order from microcontroller, PIC16F877A. Microcontroller will ensure the ELCB is in good condition before it sends signaling to control a DC motor to push back the ELCB's spring trap.

1.2 Problem statement.

Normally ELCB should be tested monthly to ensure it is well functioning or not and the good condition of the ELCB make it's operating fluently as an earth leakage circuit breaker when fault occurs but the problems are:

i. The ELCB is test manually using the test button 'T' on it.

ii. Cannot ensure the good condition of the ELCB and cannot detect current flow through it.

iii. After test period has been done, ELCB's spring trap should be push up manually.

1.3 Project objectives.

The overall of this project is to test the ELCB every month automatically using microcontroller, PIC16F877A.This project has three main objectives to achieve such as:

i. Trip ELCB automatically every month.

ii. Ensure the good condition of the ELCB with current detector.

iii. Switch ON back the ELCB's spring trap automatically.

1.4 Project scope.

The scope of this project is:

i. To design a hardware that can take duty only for test and turn on back the ELCB and at the same time ensure the good condition of the ELCB by using current detector. This project did not function during fault situation and when the ELCB detect leakage current and trip, the spring trap must turn on back manually after that.

ii. To design and simulate program that will be use to setting time and date for every month as input to trip the ELCB and for controlling a DC motor for turn on back ELCB after test period.

iii. Does not have any back up circuit when the ELCB in test progress because it is difficult for make appropriate back up circuit to take ELCB duty and the suitable circuit that can be use for back up is UPS (uninterruptible power supply) which is complicated to design.

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 residual current circuit breaker (RCCB). 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 (120V or 220V). 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 can not 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]

Figure 2.1: Single phase system.

2.1.2 Circuit breakers.

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 energize or disenergize 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 SF_6 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 SF_6 circuit breakers, the same principle is employed, with SF_6 as the medium instead of air. In the “puffer” SF_6 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 SF_6 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]

2.1.3 Circuit breaker operation.

Circuit breaker is implemented using a solenoid (electromagnet) that’s pulling force increases with the current. The circuit breaker's contacts are held closed by a latch and, as the current in the solenoid increases beyond the rating of the circuit breaker, the solenoid's 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]

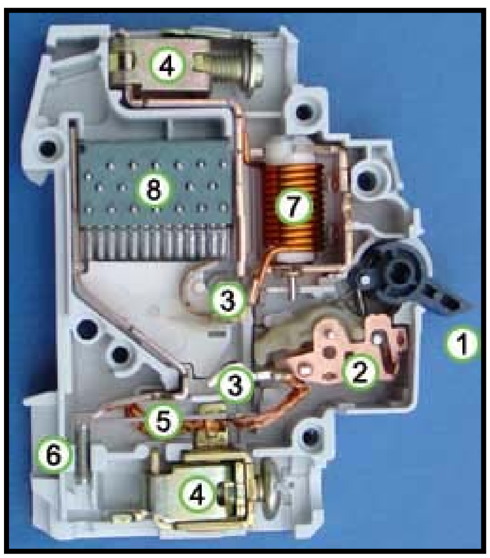


Figure 2.2: Internal of circuit breaker

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, residual current circuit breaker (RCCB) is chosen because RCCB have several important characteristic as table the table below:

Table 2.1: Characteristic of residual current circuit breaker (RCCB).

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

2.1.4 Residual current circuit breaker (RCCB)

Residual current circuit breaker (RCCB) 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 as shown in Figure 2.3. 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. RCCB is designed to disconnect quickly enough to prevent such as shock. [4]

Figure 2.3: Residual current circuit breaker (RCCB)

2.1.5 RCCB operation.

RCCB 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). RCCB 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, RCCB 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 RCCB is use to protect the electrical circuit and electrical equipment are allowed to trip as high as 30 milliamps of current. [4]

2.1.6 Principal operation of RCCB.

ELCB (earth leakage circuit breaker) or also known as RCCB (residual current circuit breaker) 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 2.4 below:

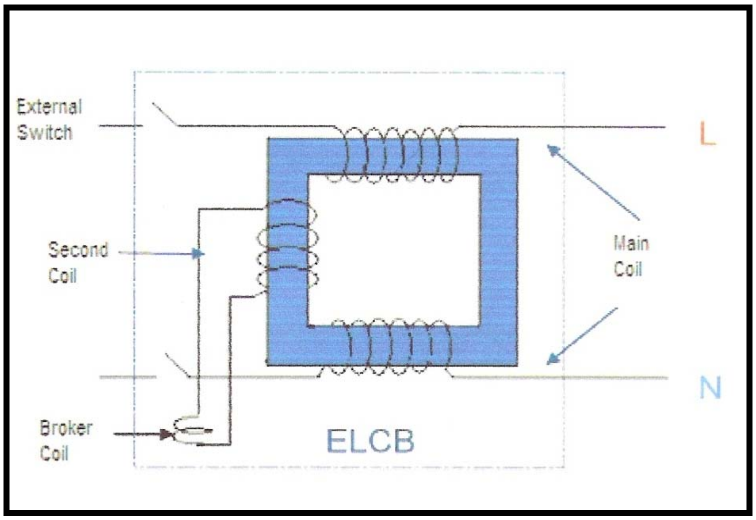


Figure 2.4: Principal operation of ELCB

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 others 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.

RCCB 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. RCCB are intended to operate within 25 milliseconds. [5]

2.1.7 Flow operation of RCCB.

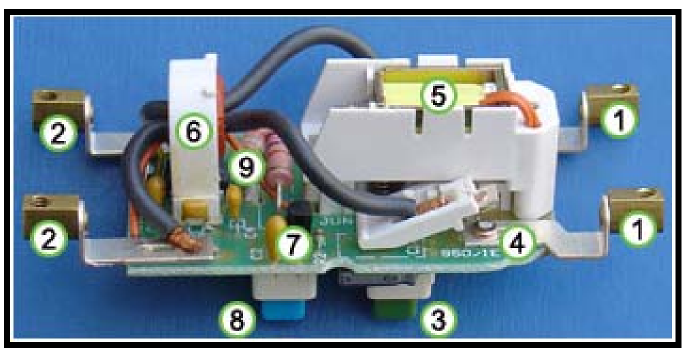


Figure 2.5: Internal mechanism of RCCB

The Figure 2.5 above is internal mechanism of RCCB. The device 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. Function for each terminal is described in Table 2.2.

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 2.2: Portion each terminal of RCCB

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. [4]

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 Microcontroller (PIC 16F877A).

PIC is a family of Harvard architecture microcontrollers made by Microchip Technology, derived from the PIC1650 originally developed by General Instrument's Microelectronics Division. The name PIC was originally an acronym for "Programmable Intelligent Computer".

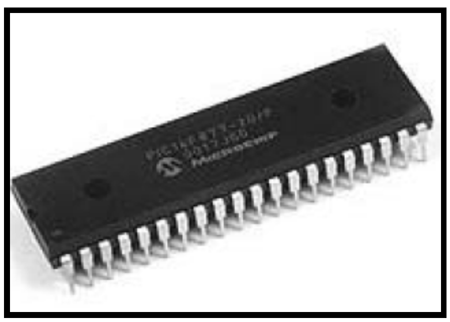


Figure 2.6: PIC16F8777A

In this project, a microcontroller; PIC16F877a (Figure 2.4.1 (a)) is use to control the output. The reason for use microcontroller is the PIC architecture is distinctively minimalist. It is characterized by the following features:

i. separate code and data spaces
ii. a small number of fixed length instructions
iii. most instructions are single cycle execution (4 clock cycles), with single delay cycles upon branches and skips
iv. a single accumulator (W), the use of which (as source operand) is implied

v. All RAM locations function as registers as both source and/or destination of math and other functions.

vi. data space mapped CPU, port, and peripheral registers

vii. the program counter is also mapped into the data space and writable (this is used to synthesize indirect jumps)

viii. 10-bit multi-channel Analog-to-Digital converter

ix. Has 33 input or output ports (see Figure 2.7).

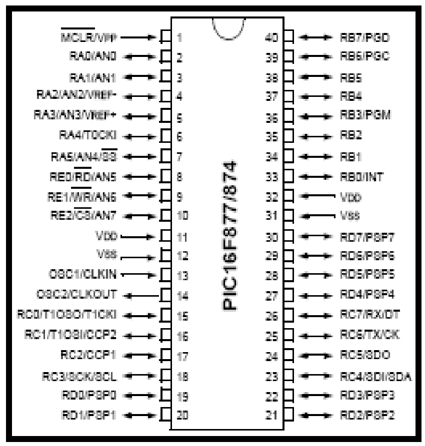


Figure 2.7: PIC 16F877A schematic

Unlike most other CPUs, there is no distinction between "memory" and "register" space because the ram serves the job of both memory and registers, and the ram is usually just referred to as the register file or simply as the registers.

PIC microcontroller have a very small set of instructions (only 35 instruction), leading some to consider them as RISC devices, however many salient features of RISC CPU's are not reflected in the PIC architecture. For example:

i. it does not have load-store architecture, as memory is directly referenced in arithmetic and logic operations

ii. it has a singleton working register, whereas most modern architectures have significantly more

PIC have a set of register files that function as general purpose RAM, special purpose control registers for on-chip hardware resources are also mapped into the data space. The addressability of memory varies depending on device series, and all PIC devices have some banking mechanism to extend the addressing to additional memory. Later series of devices feature move instructions which can cover the whole addressable space, independent of the selected bank. In earlier devices (ie. the baseline and mid-range cores), any register move had to be through the accumulator.

To synthesize indirect addressing, a "file select register" (FSR) and "indirect register" (INDF) are used: A read or write to INDF will be to the memory pointed to by FSR. Later devices extended this concept with post and pre increment/decrement for greater efficiency in accessing sequentially stored data. This also allows FSR to be treated like a stack pointer.

All PICs feature Harvard architecture, so the code space and the data space are separate. PIC code space is generally implemented as EPROM, ROM, or FLASH ROM. In general, external code memory is not directly addressable due to the lack of an external memory interface.

The PIC architecture has no (or very meager) hardware support for saving processor state when servicing interrupts. The 18 series improved this situation by implementing shadow registers which save several important registers during an interrupt.

.

The PIC architecture may be criticized on a few important points.

i. The few instructions, limited addressing modes, code obfuscations due to the "skip" instruction and accumulator register passing makes it difficult to program in assembly language, and resulting code difficult to comprehend. This drawback has been alleviated by the increasing availability of high level language compilers.
ii. Data stored in program memory is space inefficient and/or time consuming to access, as it is not directly addressable.[6]

2.2.2 Voltage regulator circuit.

When the 9V through voltage regulator, the supply will be fixing to 5V and divide it to switch ON the PIC 16F877A and relays. The type of the voltage regulator is LM 7805 like Figure 2.8 and Figure 2.9. The features of LM 7805 are shown in data sheet at appendix.[7]

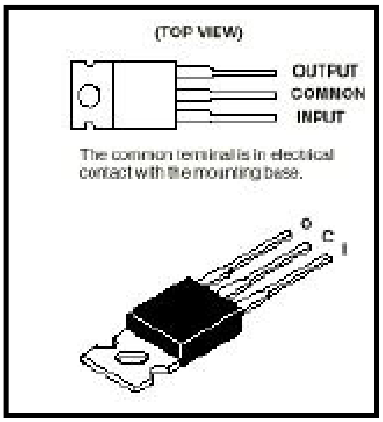


Figure 2.8: LM 7805

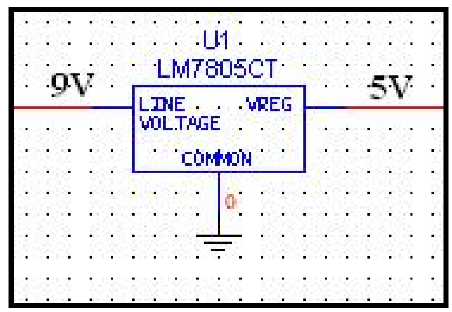


Figure 2.9: LM 7805 circuit

2.2.3 Relay

A relay is an electrical switch that opens and closes under the control of another electrical circuit. In the original form, the switch is operated by an electromagnet to open or close one or many sets of contacts. Because a relay is able to control an output circuit of higher power than the input circuit, it can be considered, in a broad sense, to be a form of an electrical amplifier. Current flowing through the coil of the relay creates a magnetic field which attracts a lever and changes the switch contacts.

The coil current can be on or off so relays have two switch positions and they are double throw (changeover) switches. Usually this is a spring, but gravity is also used commonly in industrial motor starters. Most relays are manufactured to operate quickly. In a low voltage application, this is to reduce noise. In a high voltage or high current application, this is to reduce arcing. The symbol circuit of relay and the relay are shown in figure 2.10 below: [6]

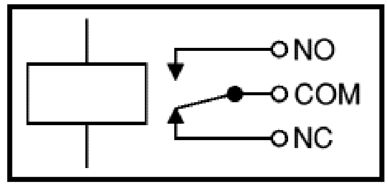


Figure 2.10: Relay and symbol circuit.

2.2.4 Darlington transistor array (ULN 20003A)

ULN 20003A is a high-voltage, high-current of Darlington transistor arrays. Each consists of seven npn Darlington pairs that feature high-voltage outputs with common-cathode clamp diodes for switching inductive loads. The collector-current rating of a single Darlington pair is 500 mA. The Darlington pairs can be paralleled for higher current capability. Applications include relay drivers, hammer drivers, lamp drivers, display drivers (LED and gas discharge), line drivers, and logic buffers. Figure 2.11 and Figure 2.12 show the ULN2003A IC and logic diagram. Figure 2.13 show the circuit of Darlington arrays in the ULN2003A.[7]

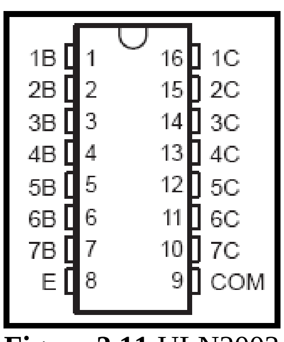


Figure 2.11:ULN2003A

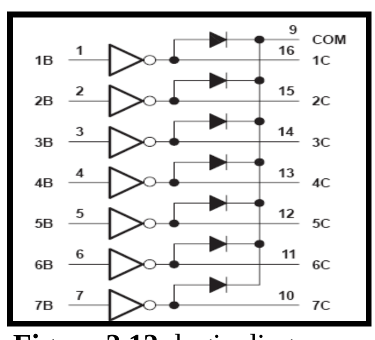


Figure 2.12: logic diagram

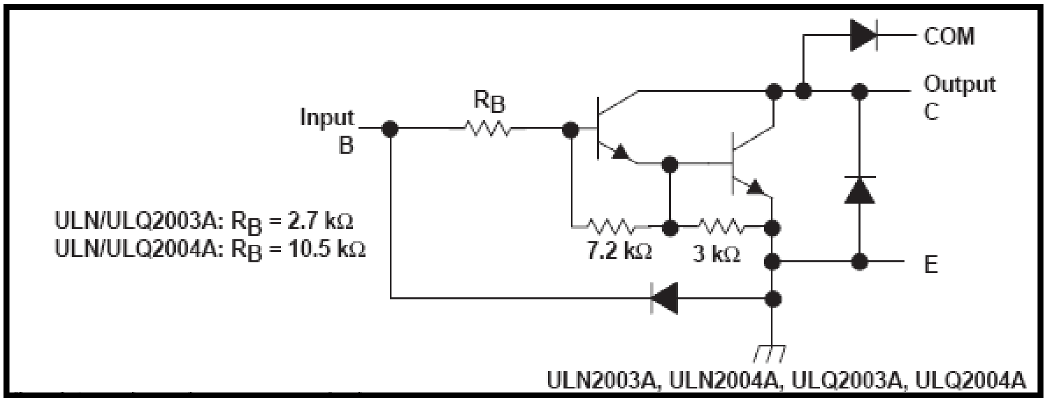


Figure 2.13: Darlington transistor circuit.

2.2.5 DC motor (automotive power window motor).

Motor will be use in this project for push back ELCB's spring trap and the spring trap actually very hard to push although by hand, so selection of motor 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 make this happen is an automotive power window motor as shown in Figure 2.14 which is a DC motor type. Below are the specifications of the motor:

i. Working voltage: 12V DC
ii. No-load speed: 92rpm
iii. No-load current: 1.30A
iv. Stall torque: 9Nm
v. Stall current: 24A
vi. Water-resistant construction.[8]

Figure 2.14.: Automotive power window motor.

2.2.6 Current detectors.

There are several types of current detector such as current transducer, transtronics current detector and current transformer which are use for detected current by sensing the AC current. Figure 2.15 below is an example of current detector:

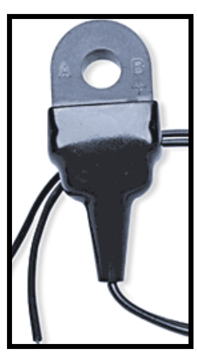


Figure 2.15: Current detector

Basically it gives us positive feedback whether the ELCB has current or not flow through it when it is in OFF condition. In this part the current detector that use is not like the example above but it function for detect current same as the current detector and actually it is a power supply which are use to step down the AC voltage then convert it to 5VDC voltage. Circuit diagram of it is on the appendix.

The power supply that use in this project as shown in figure above use a flyback converter and a bridge rectifier. The Flyback converter is a DC to DC converter with a galvanic isolation between the input and the output(s). More precisely, the flyback converter is a buck-boost converter with the inductor split to form a transformer, so that the voltage ratios are multiplied with an additional advantage of isolation. When driving for example a plasma lamp or a voltage multiplier the rectifying diode of the Buck-Boost converter is left out and the device is called a flyback transformer. This flyback transformer was apply to the 5VDC power supply as a transformer. Due to intrinsic limitations, this converter is only used in low power applications (up to about 250 W). Figure 2.16 below is a schematic diagram for flyback converter:

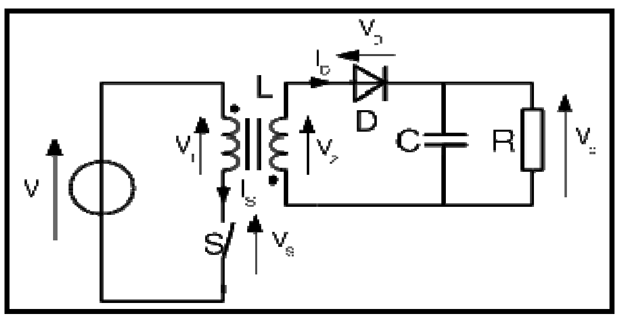


Figure 2.16: Schematic of flyback converter.

The bridge rectifier makes use of four diodes in a bridge arrangement to achieve full-wave rectification in the power supply. This is a widely used configuration, both with individual diodes wired and with single component bridges where the diode bridge is wired internally. Figure 2.17 below is a figure of full bridge rectifier:[9]

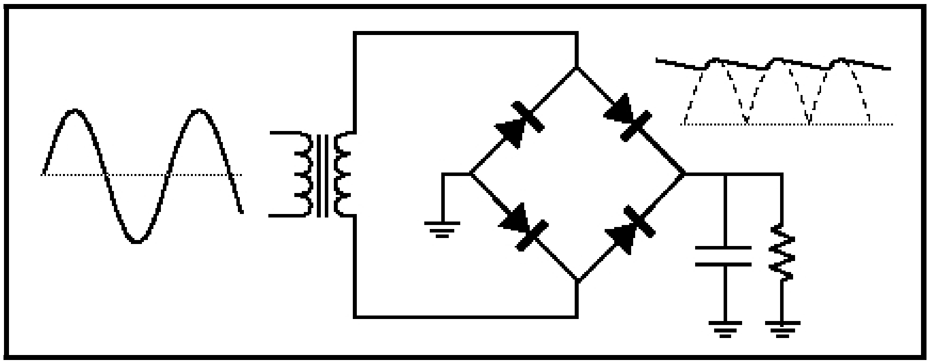


Figure 2.17: Full bridge rectifier circuit.

Current would be detected if there has a voltage from TNB power supply to a load, so based from the voltage law, if current want to be detected, thus I= V/R. The 5VDC power supply almost like a cell phone charger which is produce 5VDC and current 500mA.It would be connected series with the life wire from TNB then the output, 5VDC would be connected to microcontroller, PIC16F877A as an input.

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. Actually there are three software assist to make this project:

i. ISIS PROFESSIONAL (designing simulating circuit).

ii. PCW C COMPILER (PIC programming for C language).

iii. MELABS PROGRAMMER (PIC program’s burner)

2.3.1 ISIS PROFESIONAL software

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 been created with this in mind and Figure 2.18 shows the Proteus ISIS window. It 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 now - with PROTEUS VSM - interactive 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.

For the educational user and engineering author, ISIS also excels at producing attractive schematics like you see in the magazines. 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.
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.

For the 'power user', ISIS incorporates a number of features which aid in the management of large designs. Indeed, a number of our customers have used it to produce designs containing many thousands of components.

i. Hierarchical design with support for parameterized component values on sub-circuits.
ii. Design Global Annotation allowing multiple instances of a sub-circuit to have different component references.
iii. Automatic Annotation - the ability to number the components automatically.ASCII Data Import - .this facility provides the means to automatically bring component stock codes and costs into ISIS design or library files where they can then be incorporated or even totaled up in the Bill of Materials report.

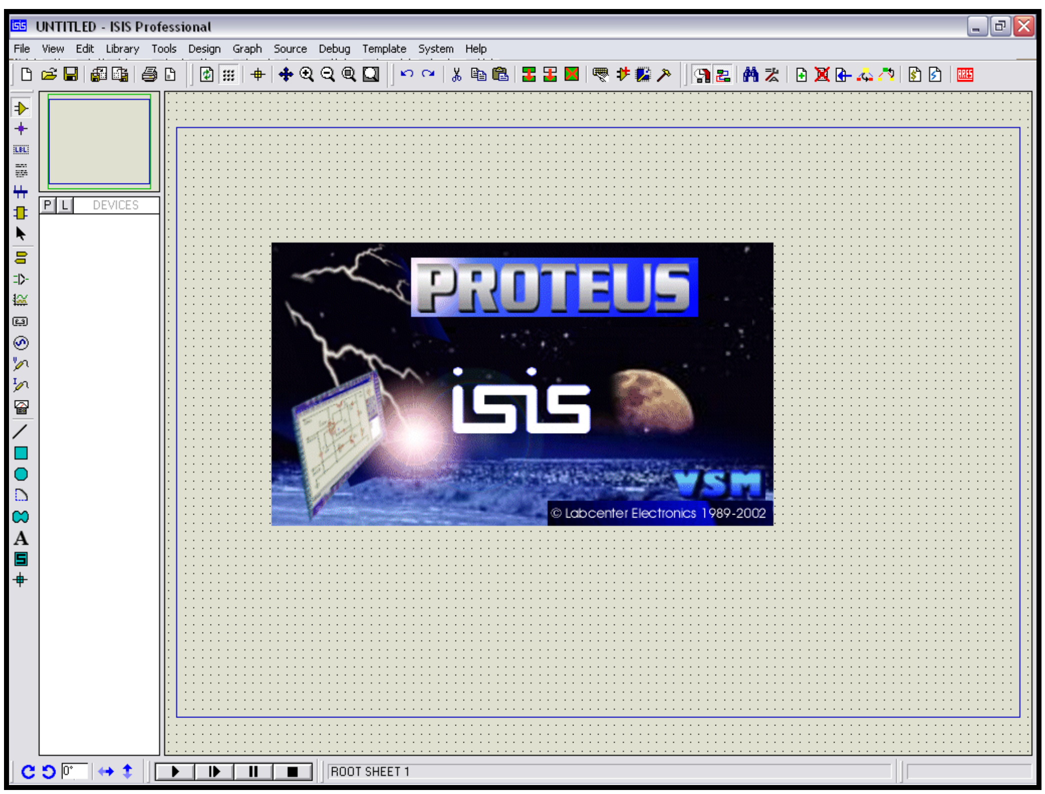


Figure 2.18: Window of ISIS PROFESSIONAL software

2.3.2 PCW C compiler software.

The PCB, PCM and PCH are separate compilers. Figure 2.19 show the window of PCW C compiler. PCB is for 12 bit opcodes, PCM is for 14 bit opcodes and PCH is for the 16 and 18 bit PICmicro® MCU. Since much is in common between the compilers both are covered in this reference manual. Features and limitations that apply to only specific controllers are indicated within. These compilers are specially designed to meet the special needs of the PICmicro® MCU controllers. These tools allow developers to quickly design application software for these controllers in a highly readable high-level language.

The compilers have some limitations when compared to a more traditional C compiler. The hardware limitations make many traditional C compilers ineffective. As an example of the limitations, the compilers will not permit pointers to constant arrays. This is due to the separate code/data segments in the PICmicro® MCU hardware and the inability to treat ROM areas as data. On the other hand, the compilers have knowledge about the hardware limitations and do the work of deciding how to best implement your algorithms. The compilers can implement very efficiently normal C constructs, as well as input/output operations and bit twiddling operations and Figure 2.20 show the compiler result of your C construct.

2.3.3 MELABS programmer.

The melabs Programmer can program most PIC® microcontrollers (MCUs) either in-circuit or in an optional ZIF, surface-mount or PLCC adapter. It will not program the base-line PIC16C5x parts or the high-end PIC17C4x parts. The melabs EPIC™ Programmer and melabs Serial Programmer are powered from an AC adapter, available separately. A 16VDC, 500ma, center pin positive AC adapter is recommended. A suitable AC adapter is available from us. The melabs USB Programmer and melabs U2 Programmer are powered from the USB port. The melabs EPIC™ Programmer connects to a PC compatible parallel printer port. The melabs Serial Programmer connects to a PC compatible serial port. The melabs USB Programmer and melabs U2 Programmer connect to a PC USB port or powered USB hub. Each programmer may be controlled by the melabs Programmer software.

HEX files may be programmed into a PIC® MCU using the melabs Programmer software and Figure 2.21 show the window of it.The software runs under Windows 98/ME/NT/2000/XP.Start the melabs Programmer software by double-clicking on the melabs Programmer icon on the desktop or selecting melabs Programmer from the Start menu. All the melabs Programmer files must be in the same directory MEPROG.EXE resides in and the melabs Programmer directory should be in your path so that Windows can find the device drivers.

Once the programming tool-bar is displayed, select the LPT port the melabs EPIC™ Programmer is connected to or the serial COM port the melabs Serial Programmer is connected to or the USB port the melabs USB / U2 Programmer is connected to on the File|Port menu. Next, select the device type you wish to program using the drop-down device selector box.Click the Open button or File|Open with the mouse to open your object (.HEX) file. Double-click on the appropriate file to load it. Once the file has been loaded, make sure the proper device characteristics are selected in the Configuration window. See the Microchip data book for the device for information on the configuration fuses. Figure 2.22 shows the ZIF (zero insertion force) connection for PIC 40 pins which is use for loaded the HEX file program inti PIC.

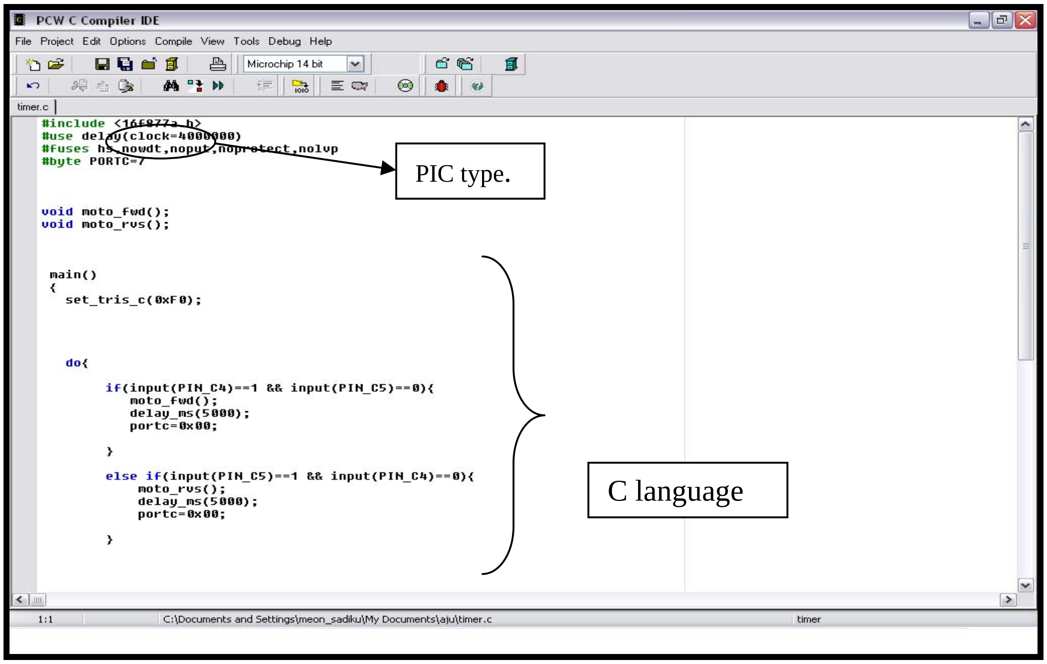


Figure 2.19: Window for PCW C compiler.

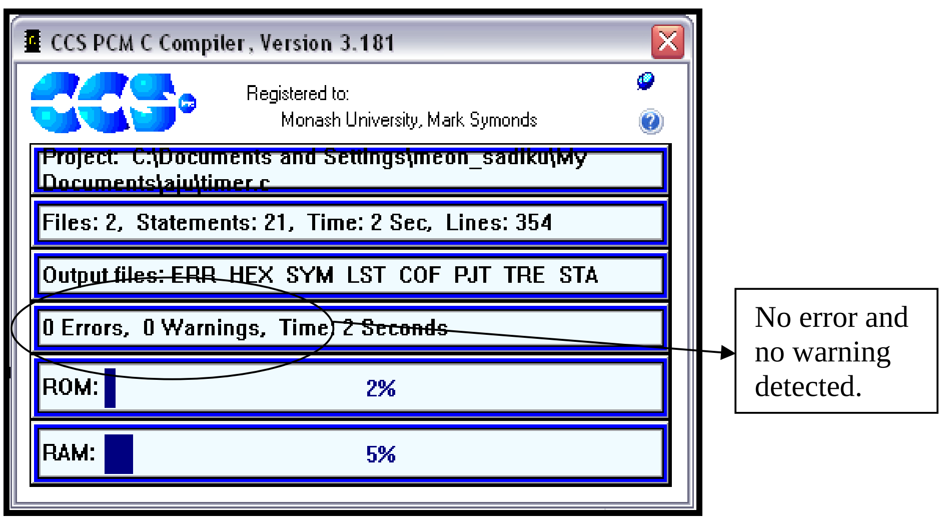


Figure 2.20: Compile result

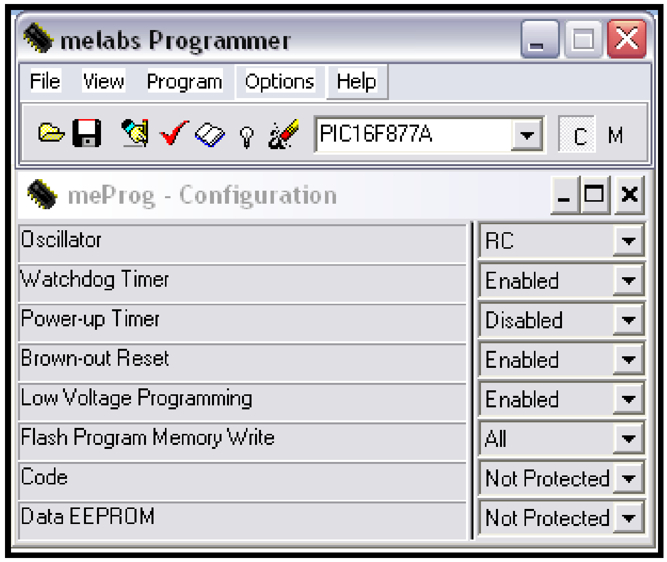


Figure 2.21: Windows for MELABS programmer

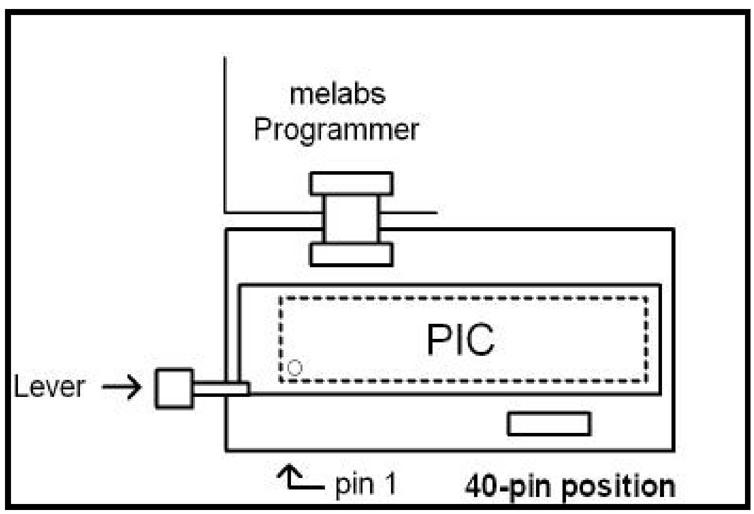


Figure 2.22: ZIF (zero insertion force) connection for PIC 40 pins

CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter explains about hardware design include ELCB's trip, current detector and a DC motor design. This chapter also explains the software design that use to programmed microcontroller, PIC 16F877A and the complete operation of the project system.

Before looking at the detail of all methods using, it is best to begin with brief review the correlation of all methods. The Figure 3.1 below show the correlation of all methods in this project and the small box in right of the figure is the tester device.

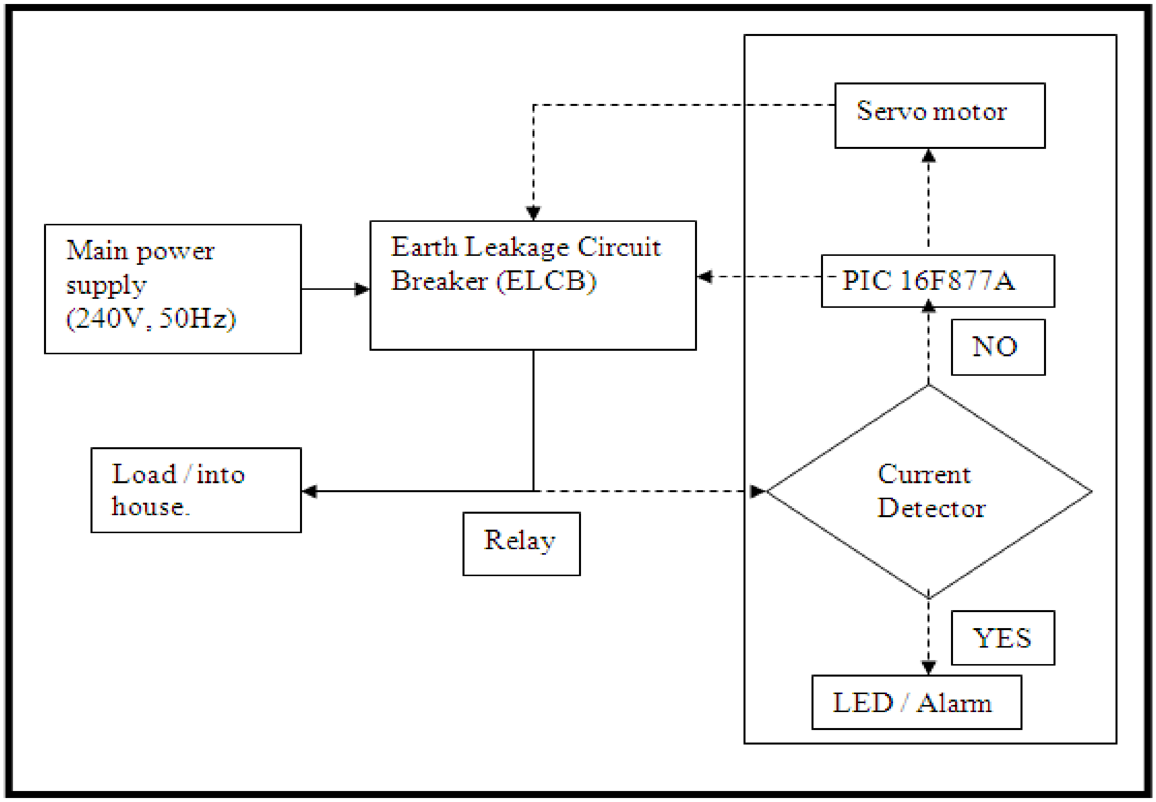


Figure 3.1: Design flow for automatic tester device for ELCB.

3.2 Overall system design

The system of this project actually based on directives from microcontroller, PIC 16F877A. It starts with timer that has been programmed in microcontroller which would count until reached 30 days. Then microcontroller send signal to trip ELCB .For ensure the ELCB is in good condition, the connection for life wire would be shifted to a current detector and it would be used to check current that flows through the OFF ELCB. In this condition, microcontroller has two situations to control but it must choose only one at a time.

First situation, if the current detector detects current from the OFF ELCB, microcontroller would ON the indicator (LED / Buzzer). Second situation, if the current detector detect no current, microcontroller would send signal to control a DC motor, so that the ELCB's spring trap could be pushed to ON back the ELCB and the ELCB would run its duty normally, then this system would be reset and repeated all over again.

3.3 Hardware design.

The hardware designs are divided into 3parts:

i. The controller circuit design
ii. Current detector design
iii. DC motor controller design.

All this hardware parts are depends on the software design which has been programmed into microcontroller, PIC16F877A and Figure 3.2 below show the complete hardware of the Automatic tester device for ELCB.

3.3.1 Controller circuit design.

In this part, the controller circuit is the main circuit which has PIC16F877A, relays, Darlington arrays and voltage regulator. This circuit uses a 9V battery for power supply for 6V relays and microcontroller, PIC16F877A.The voltage regulator (LM7805) is used for regulates and stabilizes voltage from the 9V battery which is for input voltage for the circuit. Actually this circuit would be used as a timer counter then to energize relays for trip ELCB, change life wire (L) connection from TNB power supply(240 VAC) either to load or current detector and lastly for controlled DC motor. The figure of controller circuit is shown in figure 3.3.

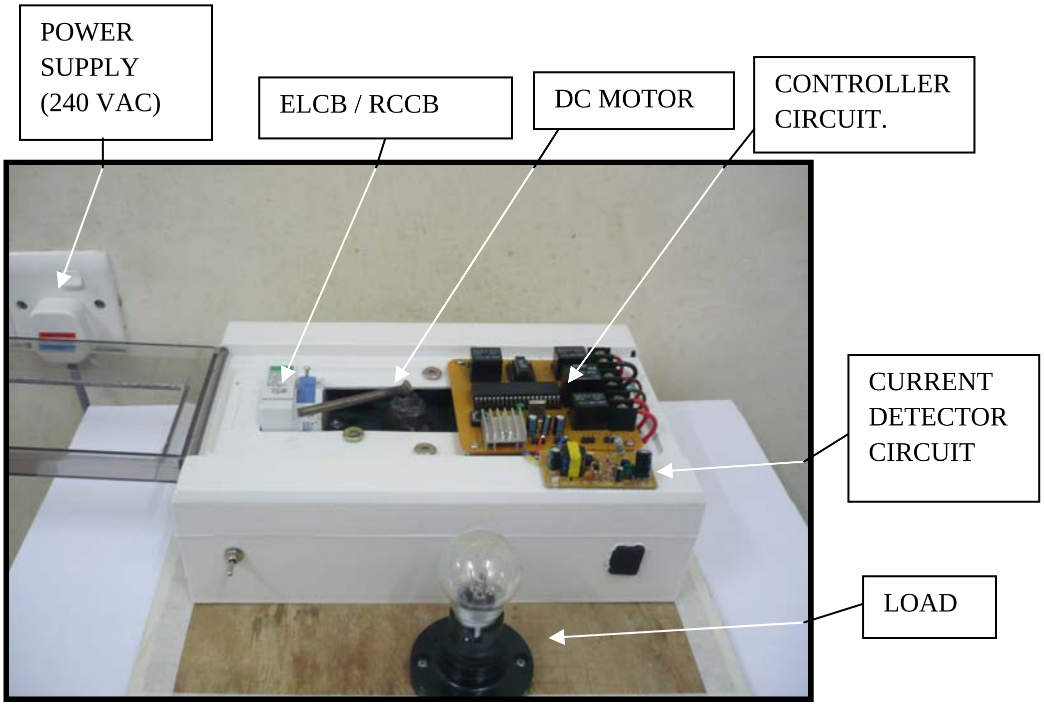


Figure 3.2: Automatic tester device for ELCB hardware**.**

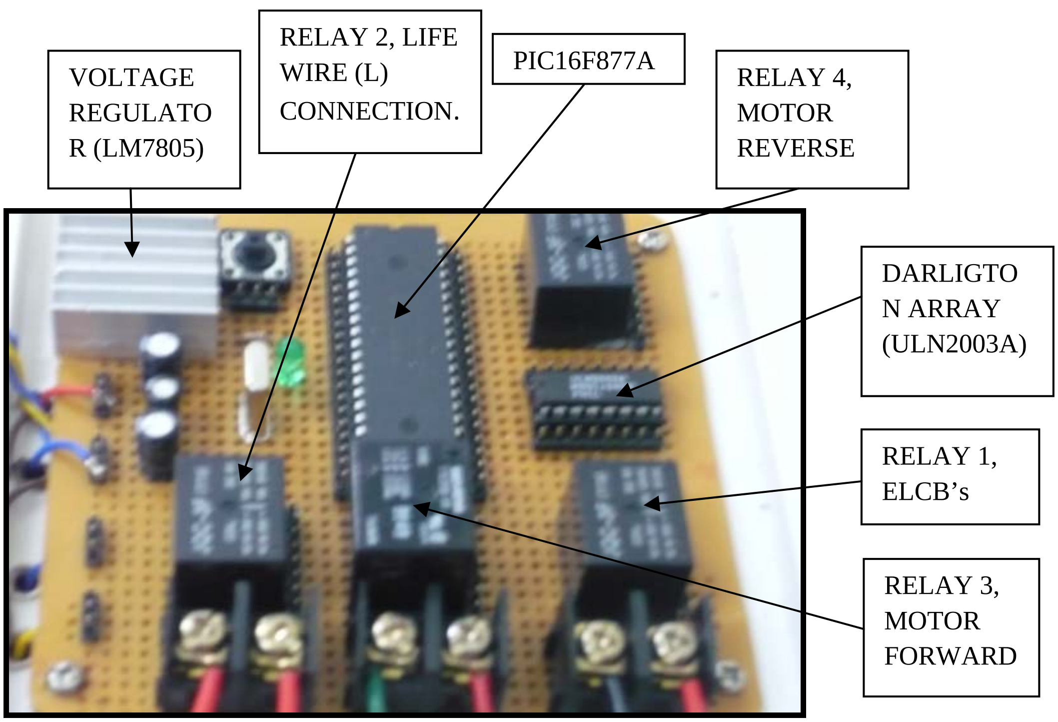


Figure 3.3: Controller circuit

3.3.2 Current detector design

The current detector is a device that uses to detect current. Basically it is a 5 VDC power supply which are consist a rectifier and a transformer as the main part which would be use to convert current and step down it from 240 VAC to 5 VDC. Current would be detected if there is a voltage obtained, it happen when the voltage that carried current connected to resistor or load. It based on voltage law $V = IR$, so if the current want to be detected, thus $I = V/R$. This basic principal of voltage actually applied to this project to detect current from ELCB and it is important because when the ELCB has been tripped it will disconnect power supply to load but if current detected while it is in OFF condition, that's mean the ELCB's contact was damaged or the ELCB's spring trap was loosed and the new ELCB must be replace.

In normal condition, TNB life wire would be connected to loads and in test condition it must be shifted to this current detector, so when the ELCB has been tripped, then relay would be use for shifted this connection. The PIC16F877A would be program so that if it received 5VDC from current detector it will ON indicator and if it received 0V, it will run DC motor for push back the ELCB's spring trap. With this positive feedback, the condition of the ELCB could be known either there is current or not when the ELCB in test progress. The circuit of the 5VDC power supply is shown on Figure 3.4 below.

3.3.3 DC motor controller.

In this project, the DC motor will be use to on back the ELCB, after the current detector has check current through the ELCB .Microcontroller, PIC16F877A will receive signal from the current detector and if there is no current detected, it will control relay to control the DC motor. In this project, 2 relays are uses for change the polarities of motor's wires so that when relay3 energized it would ON motor to forward direction then when relay4 energized it would ON the motor with opposite polarities of wire to reverse direction. For controlling angle of the motor, delay should be put in the control motor program which is for 45 degrees the delay is 100ms.The circuit of the relays for control motor is on Figure 3.3 and Figure 3.5 below is the DC motor.

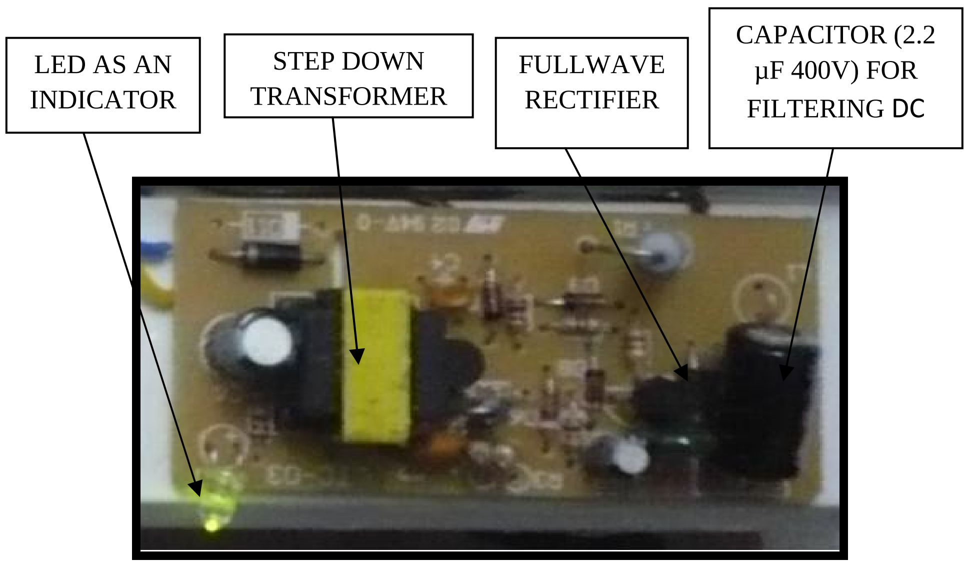


Figure 3.4: Current detector circuit

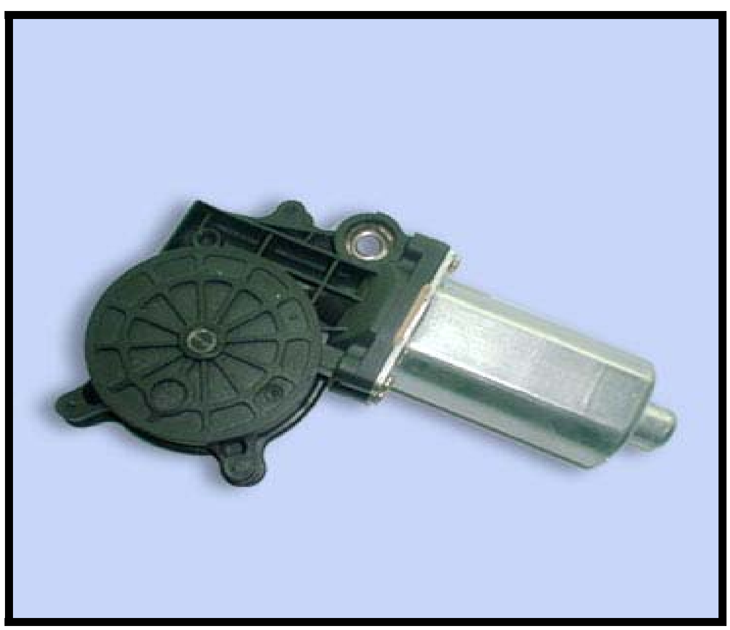


Figure 3.5: DC motor / power window motor.

3.4 Software design.

This project use two software programming and simulation, which are:

i. ISIS PROFESIONAL – for design and simulate circuit.

ii. PCW C COMPILER IDE – for PIC C language programming

Overall of this project is depending on software part which is:

i. For timer counter.

ii. To control relay for ELCB's trip.

iii. To control relay for shift the life wire connection from load to current detector.

iv. To control relays to change DC motor directions.

v. To send input to ON indicator (LED / buzzer).

The program start with timer that would count until 30 days then after that it send output to energize relay1 which for trip ELCB. Once the ELCB tripped, it would disconnect power supply into load then the program continue with send output to energize relay2 which is shift the life wire connection from load to the current detector. In this part, the program has two conditions to run.

First condition, it receives input high from current detector which means the current detector had detected current flow through the ELCB then it would send output to ON indicators. Second condition, it receives input low from the current detector which means no current was detected from the ELCB then it would send input to energize relay3 for forward the DC motor and after that it send input to energize relay4 for reverse the motor to initial condition. When the entire program has been run, it would clear all input and output for resetting then it would repeat all over again. Figure 3.6 below is the flow chart of the software design.

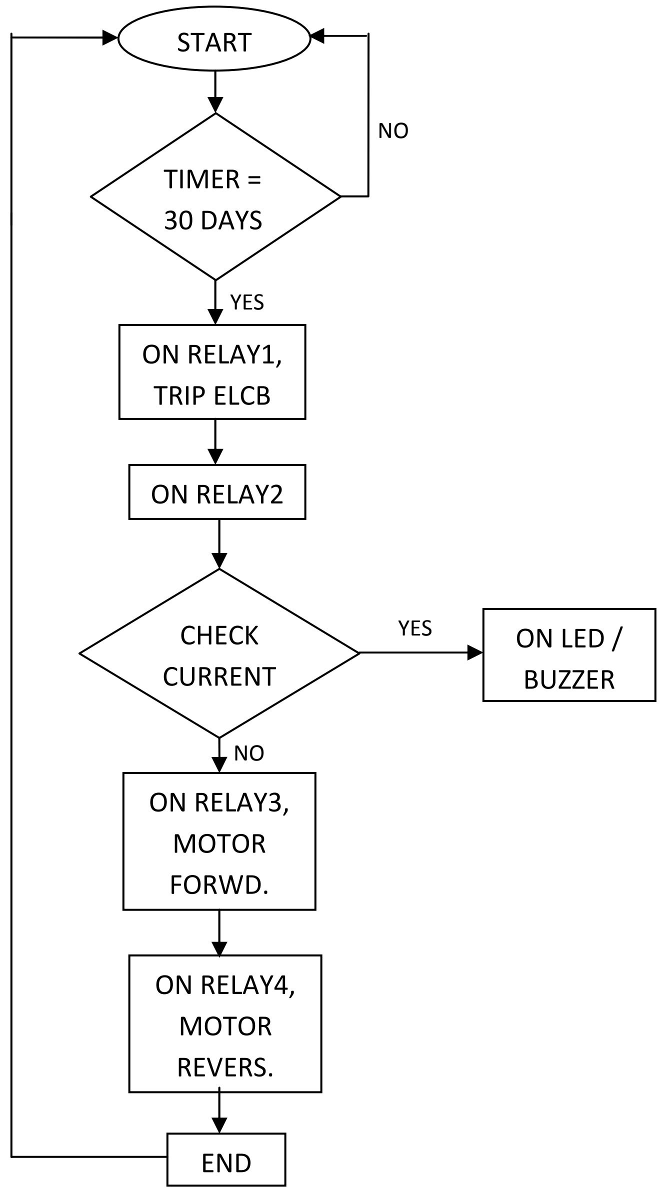


Figure 3.6: Flow chart for software design

3.4.1 ISIS PROFESIONAL

This software actually facilitates the project's progress especially in designing and simulating circuit. Before the real hardware of this project could be making up, it must design first then simulate. The microcontroller in the circuit that has been designing could interact with a program which has been compiling to a HEX file. When the circuit simulated, the output and the input that display on it can be known and the program could edited for improvement. Figure 3.7 below is the circuit of this project which has been designed and simulated.

3.4.2 PCW C compiler IDE.

This is a software for program design which is use C language and the program that has been designed could compiled to HEX file. The microcontroller only can read a HEX file program which would be burn into it using MELAB burner. With used this software, the program design more easy and it could detect error on the program created. Program that has been created using this software and it based on flow chart shown in figure 3.6 above are shown appendix.

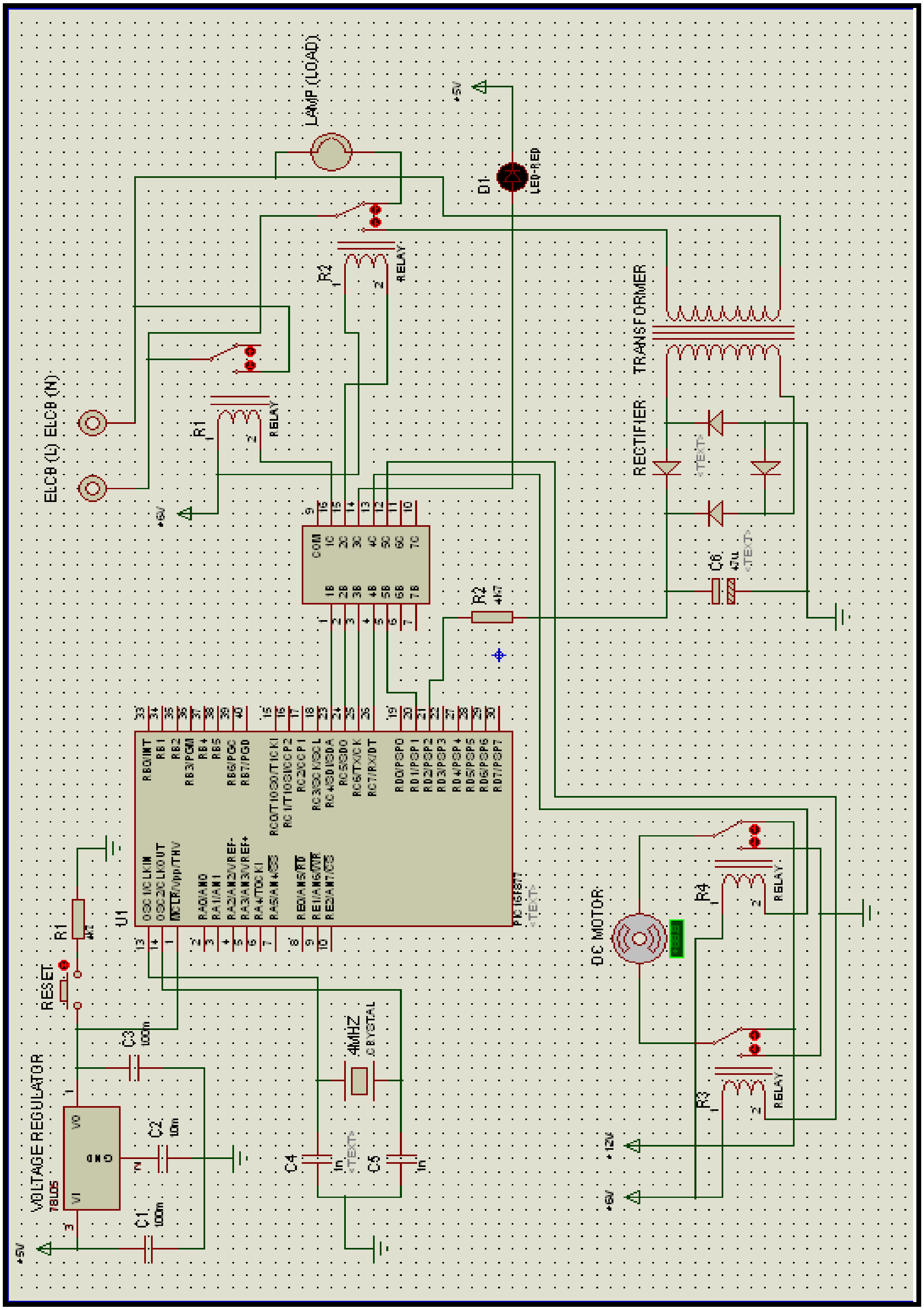


Figure 3.7: Circuit diagram for hardware design

CHAPTER 4

RESULT, ANALYSIS AND DISCUSSION

4.1 Introduction

After completing the project, the result obtain is so impressive where all expected result are achieved. The ELCB was trip based on program setting then the current detector do its work to detect current through the ELCB whiles it in test condition. The PIC16F877A successfully control the circuit based on the programming that has been setting on it and the DC motor successfully can push on back the ELCB's spring trap.

4.2 Result of the three main part of the hardware.

Figure 4.1 below show the combination of the three main part of the project. The three main parts are:

i. The controller circuit.
ii. Current detector.
iii. DC motor controller

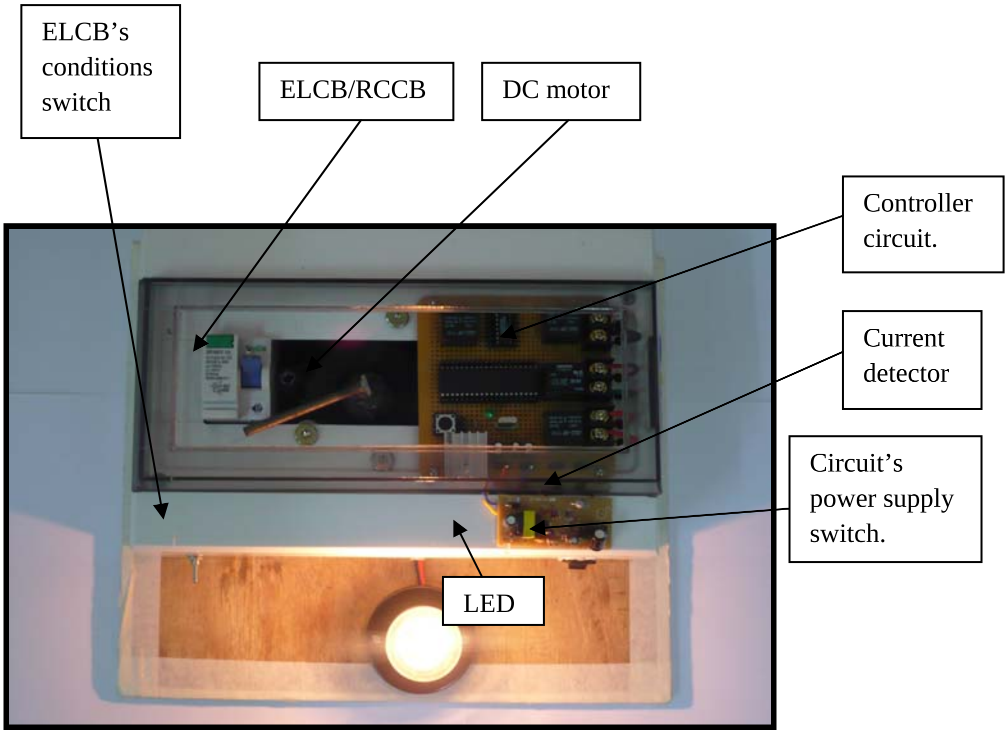


Figure 4.1: Overall hardware of automatic tester device for ELCB

The automatic tester device for ELCB that shown above has two switch, the right switch for the controller circuit power supply which is use a battery 9V and the left switch is the ELCB condition where for first condition, switch ON, to show damaged ELCB and the second one, switch OFF, to show undamaged ELCB or the good condition of it.

4.2.1 **Result of controller circuit**.

The controller circuit for this project can give output for energizes relay1 after 10 second delay then trip the ELCB. From figure 4.1(a) below, before 10 second the ELCB is in normal condition and figure 4.1(b) after 10 second, PIC16F877A give output high at port C4 for energizes relay1.When relay1 energized it would short life wire from TNB power supply with neutral wire which is connect to ELCB then the ELCB would be tripped and power supply would shut down. The power supply can be connect again just by ON back the ELCB's spring trap because the life wire and neutral wire are shorted at short time but the ELCB condition did not know either it is in good condition or not, so the current detector would be use for that.

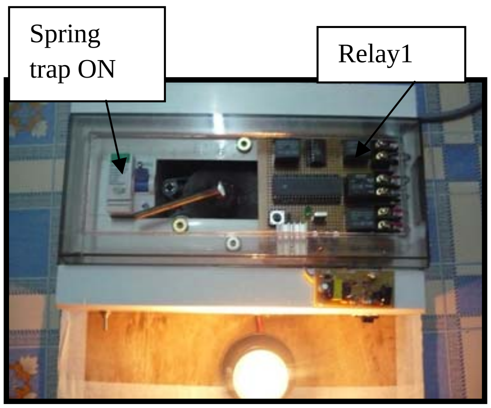


Figure 4.1(a): Result before 10 second timer counter

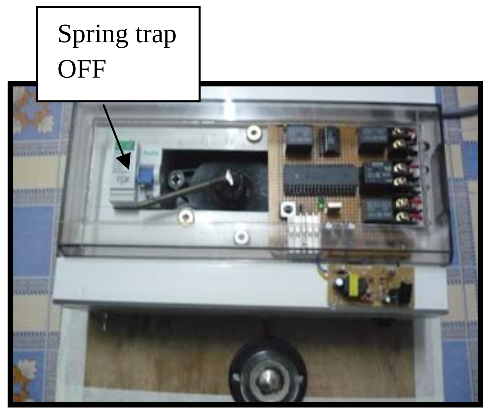


Figure 4.1(b): Result after 10 second timer counter

4.2.2 Result of current detector circuit.

This part show how the current detector's function for detect current through the ELCB. To make the current detector operated either for damaged ELCB or undamaged ELCB, this project must use two ELCB but it is difficult to change and make another connection to other ELCB. So this project only uses one ELCB which is in good condition and for showed the damaged ELCB, this project use a single pole single throw (SPST) switch. When switch ON, it would disconnect neutral wire connection from ELCB to relay1, so if the relay1 energized, life wire cannot be shorted with the neutral wire and the ELCB did not trip. This situation of switch show the real damaged of ELCB which is come from its own contact or spring trap that has been loosed.

4.2.2.1 Result of damaged ELCB.

Figure below show the simulation of the damaged ELCB when the SPST switch is on and when the timer has count until 10 second, the relay1would energized but the ELCB's spring trap did not trip as shown in Figure 4.2 (a). After relay1 disenergized, relay2 would be energized for shifted connection of life wire from TNB power supply to current detector circuit. Current detector would operated its function for check current through the ELCB and for this case of damaged ELCB, it detect current and ON LED as an indicator like Figure 4.2 (b) shown above. The other situation is the ELCB's spring trap would trip when relay1 energized but there has current through the ELCB and after the current has been detected and ON indicator, DC motor wouldn't be controlled to ON back the spring trap.

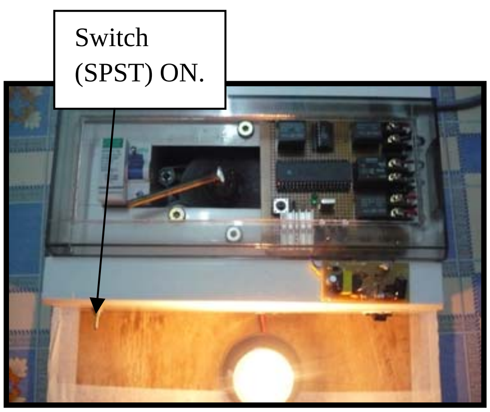


Figure 4.2 (a): Result for ELCB. did not trip

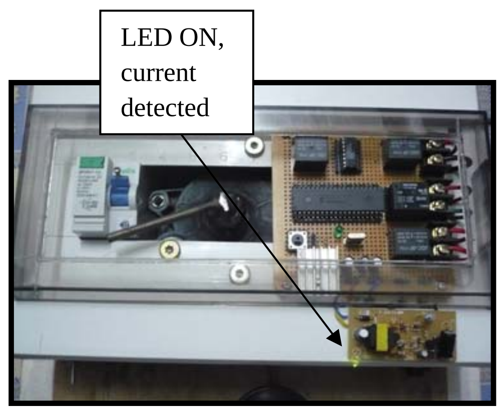


Figure 4.2 (b): Result for Current detector detects current .

4.2.2.2 Result of undamaged ELCB.

Figure below show the undamaged ELCB which is tripped when relay1 energized after 10 second delay like figure 4.3 (a), then current detector would operate its function for check current through the ELCB which has been OFF. Figure 4.3(b) shows that no current detected and input to PIC16F877A is 0V. The PIC16F877A has been programmed so that when it received 0V, it did not ON LED but it would energize relay3 and relay4 for controlled the DC motor to push back the ELCB's spring trap. Next subtopic will show the result of the DC motor. Figure below show the undamaged ELCB when the SPST switch is OFF.

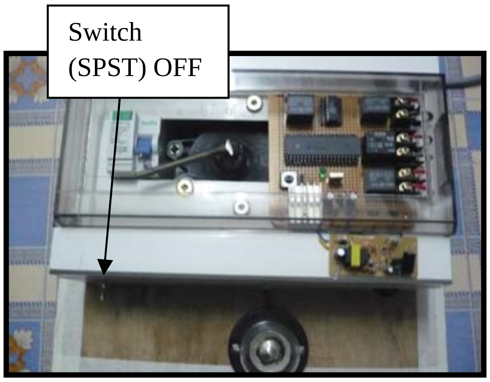


Figure 4.3(a): Result for ELCB's trip

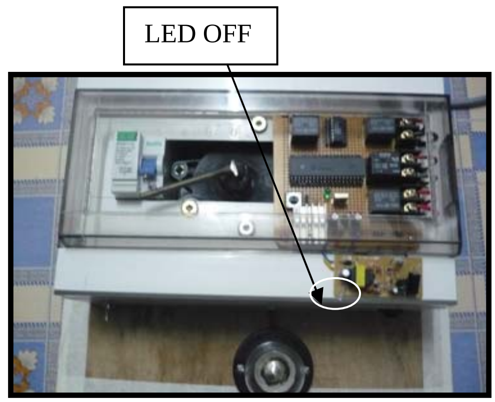


Figure 4.3(b): Result for Current detector detects no current.

4.2.3 Results for DC motor control.

This project use a motor for push back the ELCB's spring trap but the motor that would be used must very strong to push it, so the power window motor or DC motor had been choose to operate it. The power window motor has high torque which is strongly enough to push the ELCB's spring trap.

After the current detector has done for check current and no current detected, PIC16F877A would receive 0V as input and it would give output to energized relay3 for ON the DC motor to forward and push the spring trap as a Figure 4.4(a) below. Then after delay, the PIC16F877A would energize relay4 for ON the DC motor to reverse or to initial condition of the motor as a Figure 4.4(b) below.

Figure 4.4(a): Result for motor forward

Figure 4.4(b): Result for motor reverse

4.3 Result from software simulation.

This project need to simulate first for obtain the output desired, so the software ISIS professional has been used. The circuit which are being simulate does not fully complete like the actual project's circuit because its use to get output from the microcontroller and this output actually would be applied to real hardware.

4.3.1 Simulation result of controller circuit

This result would show the timer that has been program in the PIC16F877A which is successfully count for 10 second and then energized relay1 (RL1) as shown in Figure 4.5 (a) below. Relay1 is used for tripped ELCB then after delay, relay1 would disenergized. After that, PIC 16F877A would energized relay2 (RL2) which is used for shifted connection of life wire from TNB power supply to current detector for detecting current flow through ELCB and Figure 4.5 (b) shows the result of relay2.

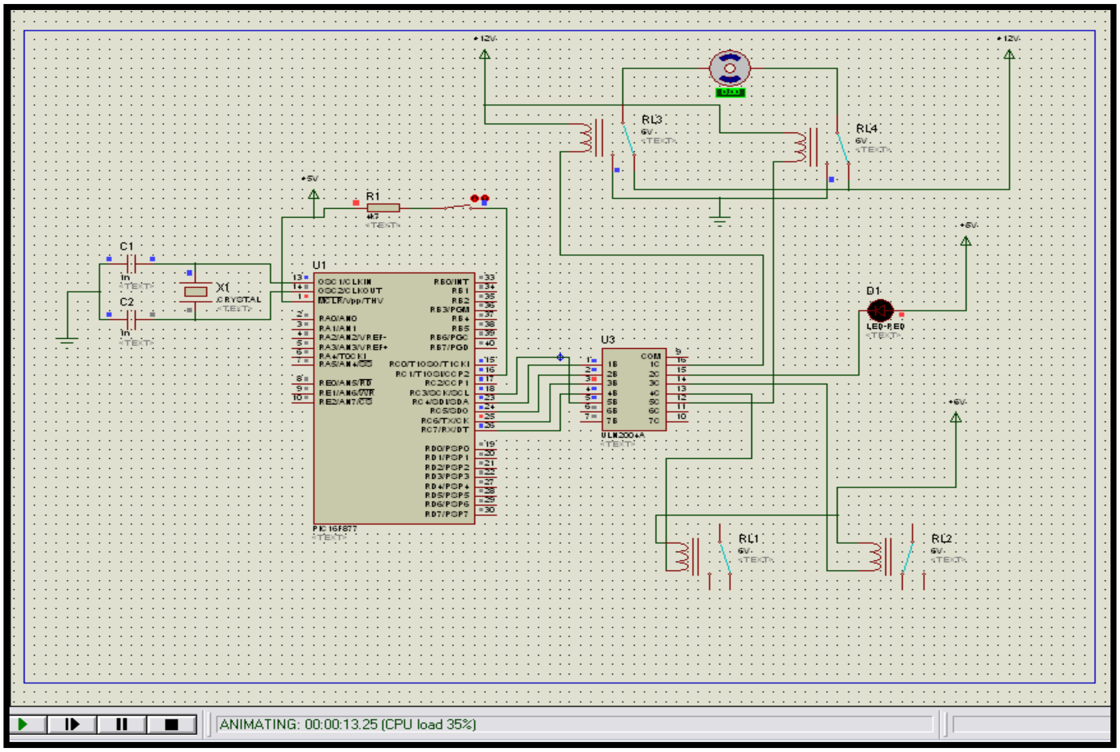


Figure 4.5 (a): Simulation result of timer and relay1 (RL1)

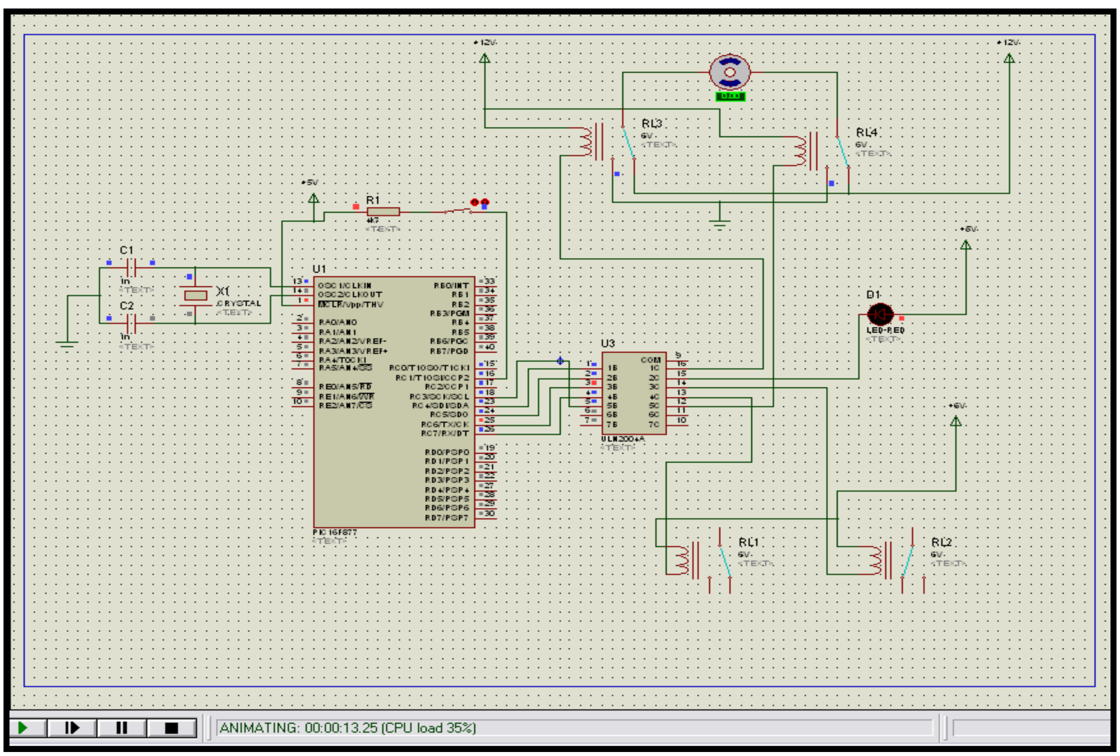


Figure 4.5 (b): Simulation result of relay2 (RL2)

4.3.2 Simulation result of current detector

This simulation wants to compare the result between two condition of ELCB which are damaged and undamaged condition when SWITCH1 on the simulation circuit is ON. In this simulation the switch is used as input to PIC16F877A and to show when current flows through ELCB which is similarly function as current detector. Figure 4.6 (a) show the result when the switch1 is OFF and show that no current would be detected which mean that the ELCB is in good condition. Figure 4.6 (b) shows the result when SWITCH1 is ON and current would be detected. When PIC16F877A received high input from SWITCH1 then it would ON LED to notify that the ELCB is in damaged condition.

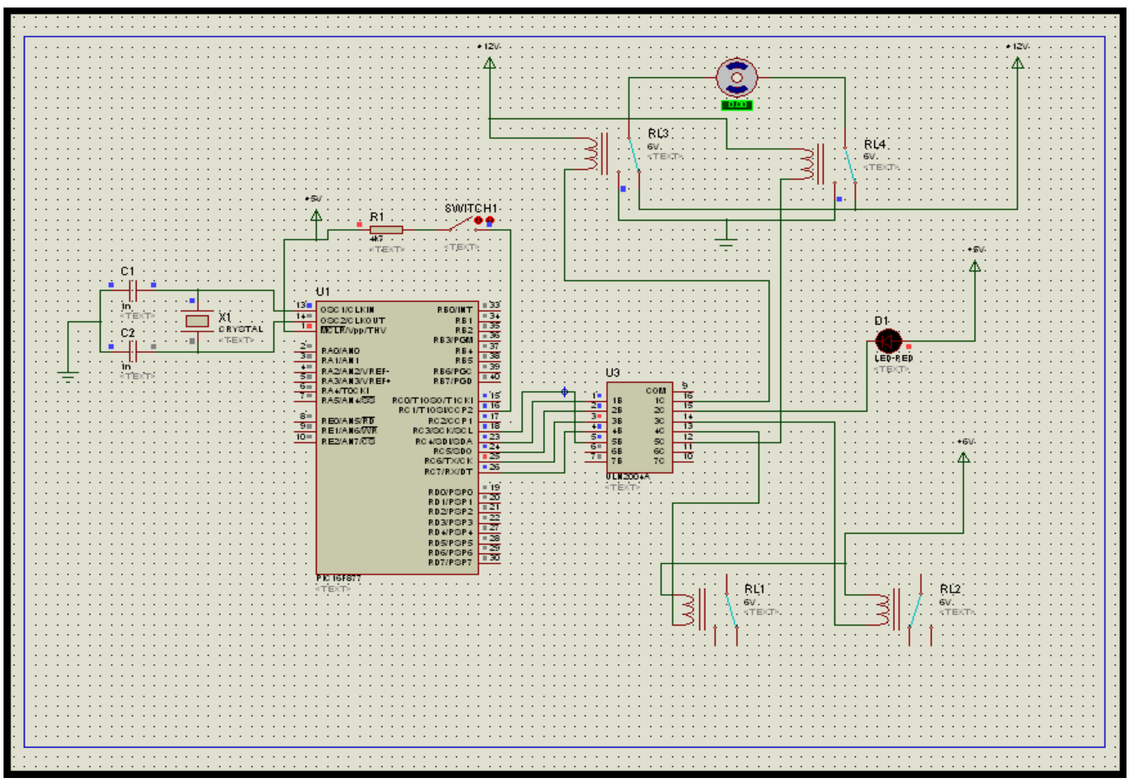


Figure 4.6 (a): Simulation result when SWITCH1 OFF

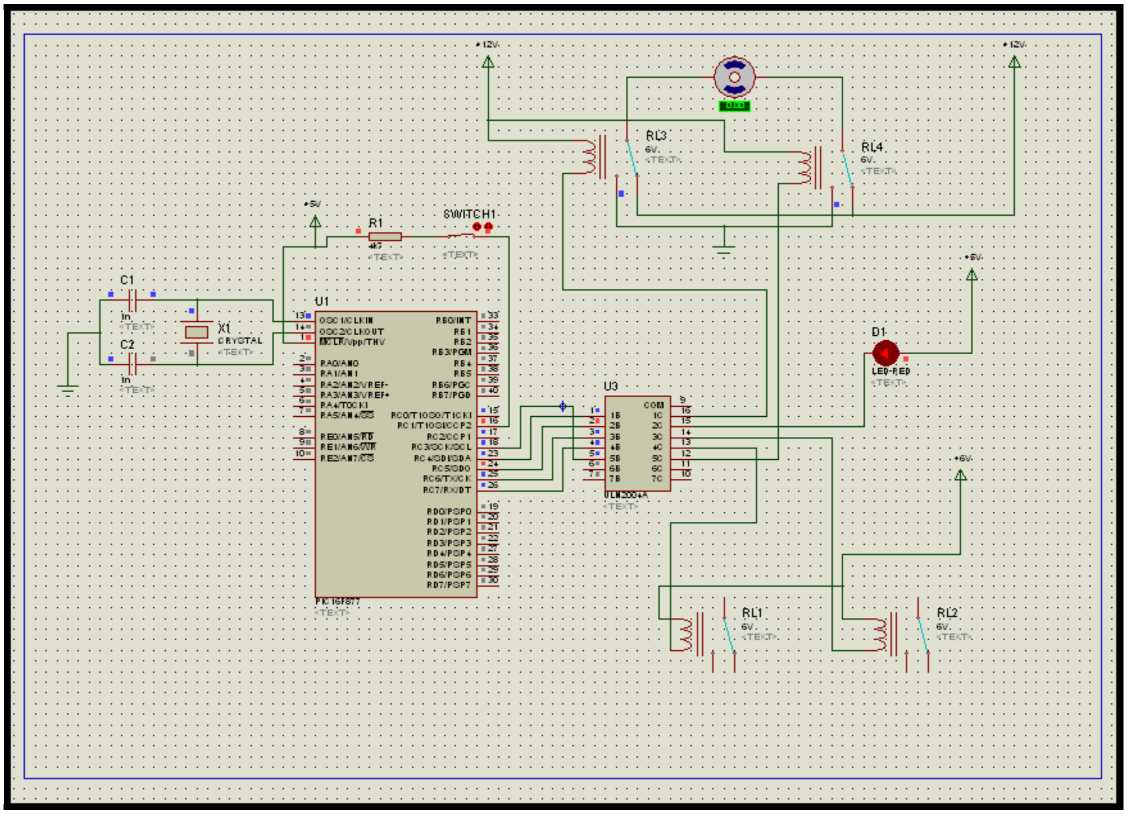


Figure 4.6 (b): Simulation result when SWITCH1 ON

4.3.3 Simulation result of DC motor control.

When there is no current detected or the SWITCH1 is OFF, PIC16F877A would received low input from the switch and would energized relay3 (RL3) for forward motor in 100ms delay as shown in Figure 4.7 (a) and then it would energized relay4 (RL4) for reverse motor in 100ms delay too as shown in Figure 4.7 (b). This simulation wants to show that this project use relay and delay for controlling circuit where when relay3 energized, it would ground the motor connection then the motor would run forward in delay time that was set. After delay, the relay3 would disenergized and relay4 would energized and change the motor connection polarities so that it would run reverse to initial condition.

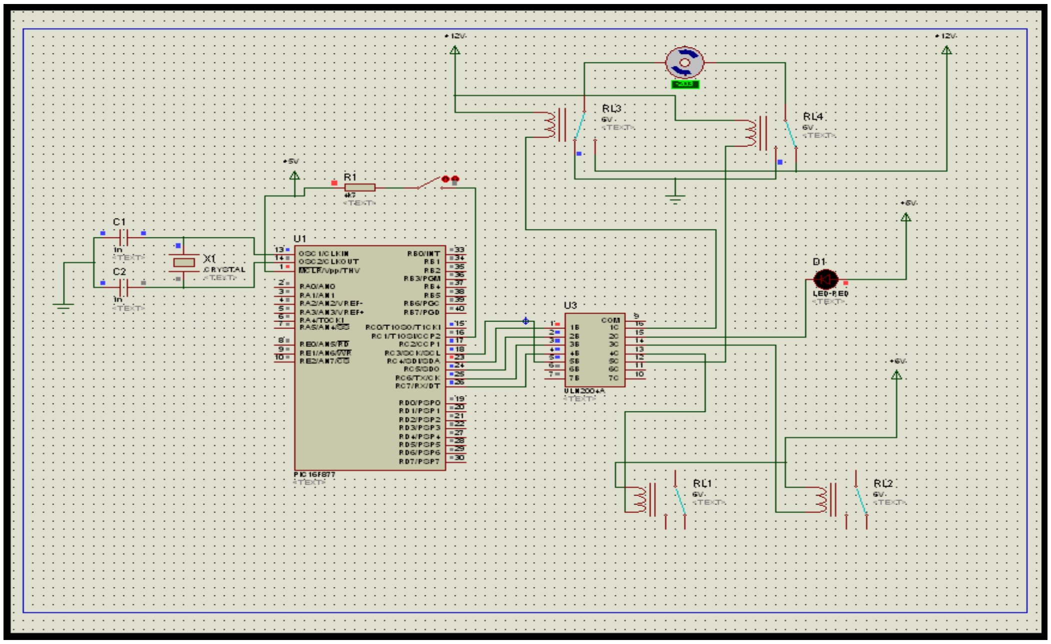


Figure 4.7 (a): Simulation result for motor forward when relay3 (RL3) ON.

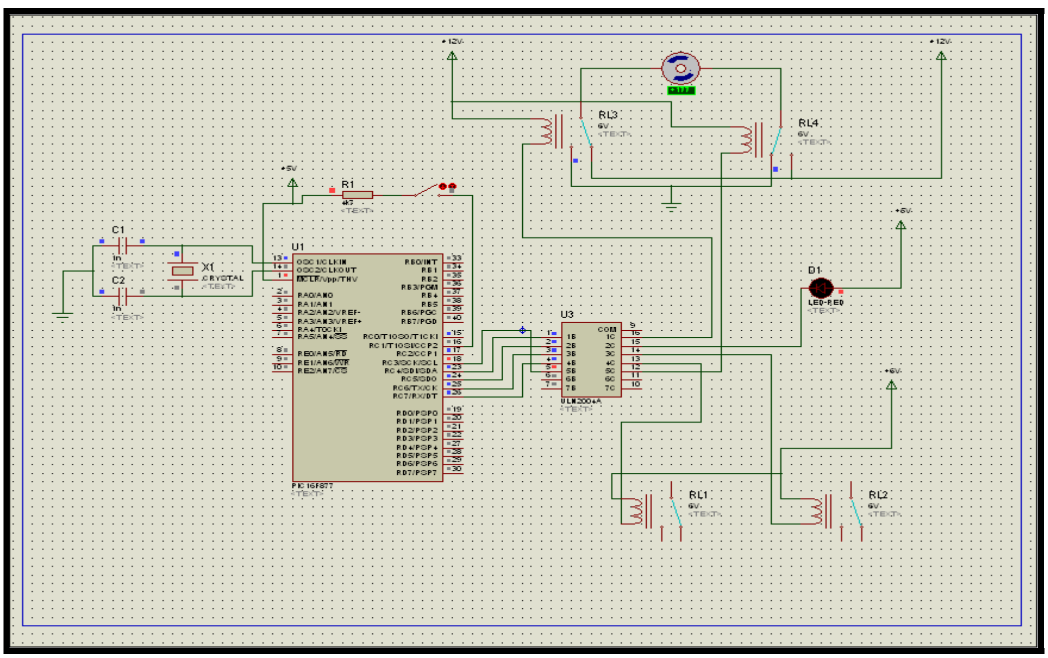


Figure 4.7 (b): Simulation result for motor reverse when relay4 (RL4) ON

4.4 Analysis and discussion.

This part shows the comparison between the result of the project and the real result that should be gain. Actually the real results are based on simulation and real case which are happen in our daily life.

4.4.1 The controller circuit.

Result above show the controller circuit which has been setting with 10 second of timer, so for made it count for 30 days, the microcontroller should be uses must has big enough of memory for store every second, minute and hour for one day and enough for store 30 days counter, it also could store the program for controlled relays. This project actually just wants to show the function of the timer so that’s why it only uses PIC16F877A.

4.4.2 Current detector.

Actually in real case of ELCB, it has four damaged condition when it tripped manually or automatically which we could detected or undetected such as:

i. Spring trap drop but power supply did not cut OFF.

ii. Spring trap drop and power supply cut OFF but there is current flow in small amount.

iii. Spring trap drop but could not pushed ON back after tested.

iv. Spring trap does not drop and power supply did not cut OFF.

Table 4.1: Results of ELCB

ELCB condition.	ELCB trip	Spring trap drop	Current detected	Control motor	ON LED	Power supply after tested.
Normal	No	No	No	No	No	ON
Undamaged	Yes	Yes	No	Yes	No	ON
Damaged (a)	Yes	Yes	Yes	No	Yes	ON
Damaged (b)	Yes	Yes	Yes	No	Yes	OFF
Damaged (c)	Yes	Yes	No	Yes	No	OFF
Damaged (d)	Yes	No	Yes	No	Yes	ON

Table 4.1 above show the overall result of ELCB, normally we could detect the damaged of the ELCB when test button was pushed and the damaged of it could be known when spring trap was pushed ON back. From there we could know either the contactor doesn't function or spring trap has loosed. We could not know if there is current flow through it just by push the test button, so current detector was put in the project for detecting current which flow through the ELCB while it is in test condition.

From result that obtains above, it only shows one condition of damaged ELCB which is condition (d) where when the ELCB was tripped, the spring trap does not drop and power supply did not cut OFF. The current detector detects current flow through the ELCB then microcontroller does not controlled motor for pushed ON back the spring trap but ON indicator (LED) for show the ELCB does not function well or not in good condition and should be change immediately.

4.4.3 DC motor control.

After compared between stepper motor and DC motor for push up the ELCB's spring trap, finally I choose to use DC motor or Power window motor which has strongly enough for push it. The motor actually has high torque and 2 wires input, positive and negative. This would make the motor easy for controlling because for change direction of the motor, just change opposite polarities of motor's wire. Different with the stepper motor which are used 6 wires input where 2 wires for windings of stator and the other 4 wires are for polarities. For controlling this motor actually used programming which is one output for one step of rotating and each rotating is 7.5 degree. Control the motor is not being a problem but the problem is with the motor's torque which is not strong enough to push up the spring trap.

Result above show that the DC motor successfully pushed back the ELCB spring trap and 2 relays are uses for change the polarities of motor's wires so that when relay3 energized it would ON motor to forward direction then when relay4 energized it would ON the motor with opposite polarities of wire to reverse direction. For controlling angle of the motor, delay should be put in the control motor program which is 100ms for 45 degrees of rotation.

CHAPTER 5

CONCLUSION

5.1 Summary of project.

There are many type of circuit breaker could be use for human life and equipments protections especially in houses or buildings but there is no one of it could be durable if no supervision on it. Almost of the circuit breaker are designed with tester button which is use for ensure the good condition of it and should be tested manually every month. The test button actually is for tripped the ELCB or RCCB when it pushed and power supply would be cut OFF and if this happen, that's mean it is in good condition.

For the damaged case of ELCB, it does not tripped because the ELCB's contactor does not work and the other damaged case, the ELCB tripped but could not be pushed ON again because the spring trap has been loosed. Beside that, there is a damaged case of ELCB could not be detected. The case are when the test button pushed, the ELCB tripped but power supply did not cut OFF and the other one is the power supply OFF but there is current flow through it.

From the damaged case that mention above, we could know if the ELCB's contactor does not work or spring trap has been loosed but we could not know if there is current flow through the ELCB when it is tripped, so it could be dangerous for human life and equipment if the ELCB not really ensure in good condition because it cannot function well when leakage current occur.

This project has been designed so that it could really ensure the good condition of the ELCB. Actually this project has solved the ELCB's problems and there is no need to concern for test it monthly because it could test automatically. The main parts of this project are timer which is for trip monthly, current detector and DC motor. This project works for tripped the ELCB and current checked through it then advanced with automatic switch ON by pushed the ELCB's spring trap using a DC motor if it is in good condition.

This project use microcontroller so that it can interact with program which would control input and output of current detector and DC motor beside timer could be setting for make this project automatically.

5.2 Conclusion

As the conclusion, this project successfully achieved the objective and can be improve for make the ELCB's application more efficient. This project also give opportunity to learn knowledge about the microcontroller, C language programming and about the motor controlled. It also conscious us about important of ensure the good condition of ELCB or circuit breaker for avoid hazard and the objective that has been achieved are:

i. Could test the ELCB automatically every month on the right time and date.

ii. Current detector function well for detecting current which is flow through ELCB while it is in test condition.

iii. DC motor successfully could push the ELCB’s spring trap after the current detector has ensured the ELCB is in good condition.

5.3 Recommendation.

For future development and enhancement of this project, there are some improvement should be put in such as:

i. Diversity the application of ELCB beside it detects earth leakage it also can detect unstable voltage.

ii. Put LCD screen on project so that it can display the time and date for test the ELCB and occupants of houses or buildings could be prepare for shut down equipment for avoid damage of it.

iii. Back up circuit should be place on this project for avoid damage of sensitive equipment like computer or others and works which are uses electrical equipment could not be interrupt.

5.3.1 Costing and Commercialization

Costing of this project is stated in table shown below:

Table 5.1: Cost of controller circuit.

No	Component	Quantity	Cost (RM)
1.	Voltage regulator (LM7805)	1	2.00
2.	Capacitor (various value)	5	3.00
3	Resistor (various value)	5	2.00

4.	Relay (6V)	4	10.00
5.	ULN 2003A	1	4.00
6.	PIC 16F877A	1	35.00
7.	Crystal (4MHz)	1	8.00
Total			**RM64.00**

Table 5.2: Cost of current detector circuit

No	Component	Quantity	Cost (RM)
1.	Zener diod	2	2.00
2	Power diod	5	5.00
3.	Resistor (Various value)	5	1.00
4.	Capacitor (Various value)	2	2.00
5.	Flyback transformer	1	7.00
6.	Transistor (Various type and value)	2	5.00
7.	LED	1	0.50
Total			**RM22.50**

Table 5.3: Total cost of project

No	Item	Quantity	Cost (RM)
1.	Cost of controller circuit	1	64.00
2.	Cost of current detector circuit	1	22.50
3.	DC motor (Power window motor)	1	40.00
Total			**RM126.50**

This project has high potential to be commercialize and marketable especially in residential power system as a tester for circuit breaker and this can increase safety value and avoid hazard. Beside it can be developing for industrial power system which is can reduce maintenance cost for circuit breaker checking.

REFERENCES

1. William D. Stevenson, Jr. Elements of Power System Analysis Third Edition,McGraw-Hill, New York (1975) ISBN.

2. Schneider Electric (2000). “ELCB Circuit Breaker with Earth Leakage Circuit Interrupter.” Instruction Bulletin, Bulletin No. 48840-079-01, Cedar Rapids, IA, USA 9/00.

3. Tom Harris “Introduction to How Circuit Breakers Work”,from http://en.wikipedia.org/wiki/cicrcuit breaker.

4. L. W. Brittian (2003): “*Electrical Circuit Breakers*” British Standard Institute.

5. Raja Mohd Taufika Bin Raja Ismail (2004). “Peranti Pengesan Voltan Litar Bocor ke Bumi.” Universiti Malaysia Pahang.

6. Data Catalog (1977), Micro Electronics from General Instrument Corporation

7 Vladimir Gurevich "Electrical Relays: Principles and Applications", CRC Press (Taylor & Francis group) http://en.wikipedia.org/wiki/Relay

8. Floyd (2005). “Electronic Devices.” United State of America.

9. Theodore Wildi. “Electrical Machine, Drive and Power System.”

10. R. Nave “Hyper Physics Electricity and mechanism electronic”.

REFERENCES

1. William D. Stevenson, Jr. Elements of Power System Analysis Third Edition,McGraw-Hill, New York (1975) ISBN.

2. Schneider Electric (2000). “ELCB Circuit Breaker with Earth Leakage Circuit Interrupter.” Instruction Bulletin, Bulletin No. 48840-079-01, Cedar Rapids, IA, USA 9/00.

3. Tom Harris “Introduction to How Circuit Breakers Work”,from http://en.wikipedia.org/wiki/cicrcuit breaker.

4. L. W. Brittian (2003): “*Electrical Circuit Breakers*” British Standard Institute.

5. Raja Mohd Taufika Bin Raja Ismail (2004). “Peranti Pengesan Voltan Litar Bocor ke Bumi.” Universiti Malaysia Pahang.

6. Data Catalog (1977), Micro Electronics from General Instrument Corporation

7 Vladimir Gurevich "Electrical Relays: Principles and Applications", CRC Press (Taylor & Francis group) http://en.wikipedia.org/wiki/Relay

8. Floyd (2005). “Electronic Devices.” United State of America.

9. Theodore Wildi. “Electrical Machine, Drive and Power System.”

10. R. Nave “Hyper Physics Electricity and mechanism electronic”.

APPENDIX A

CIRCUIT DESIGN

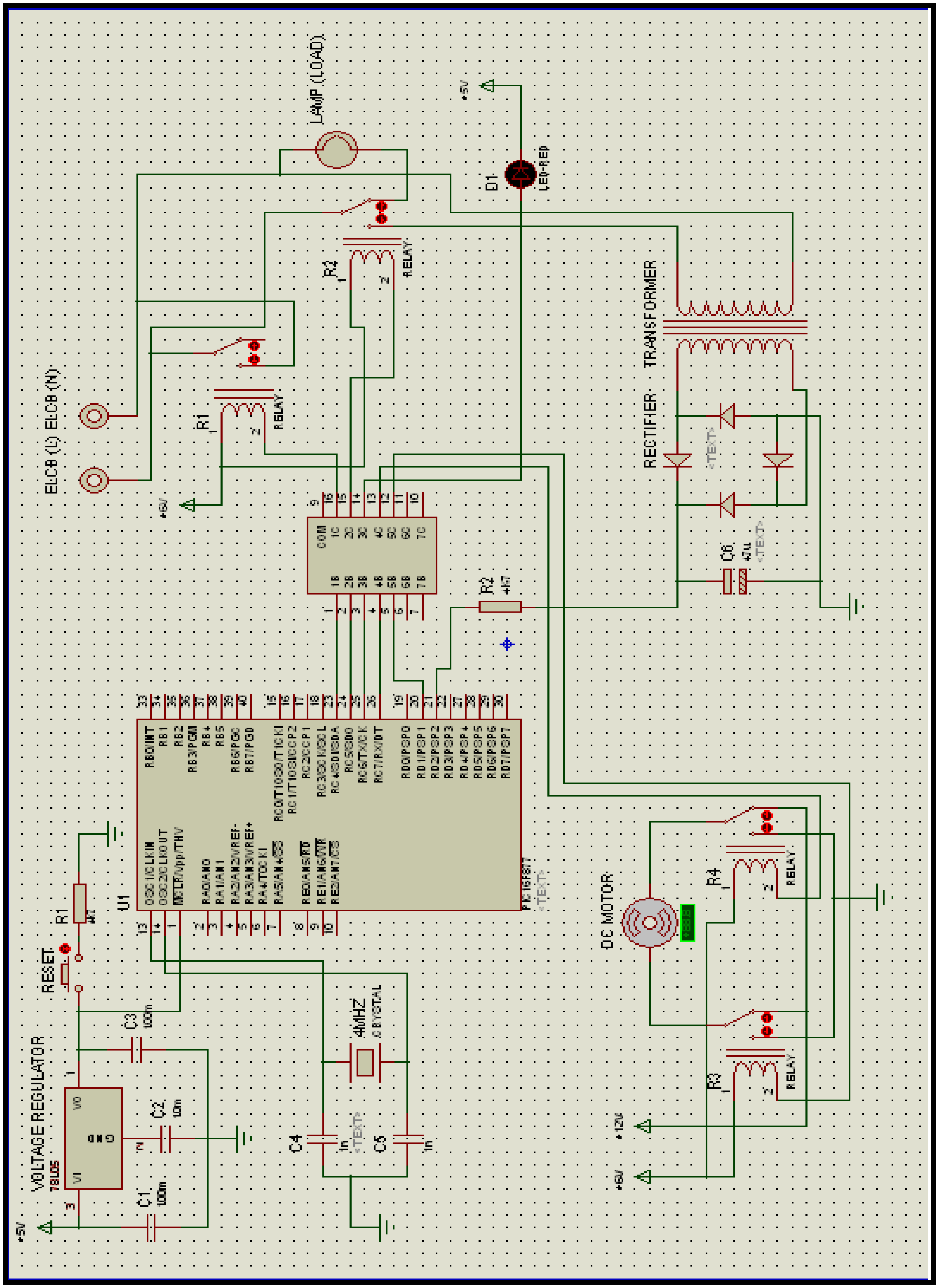


Figure 1: Circuit diagram of project

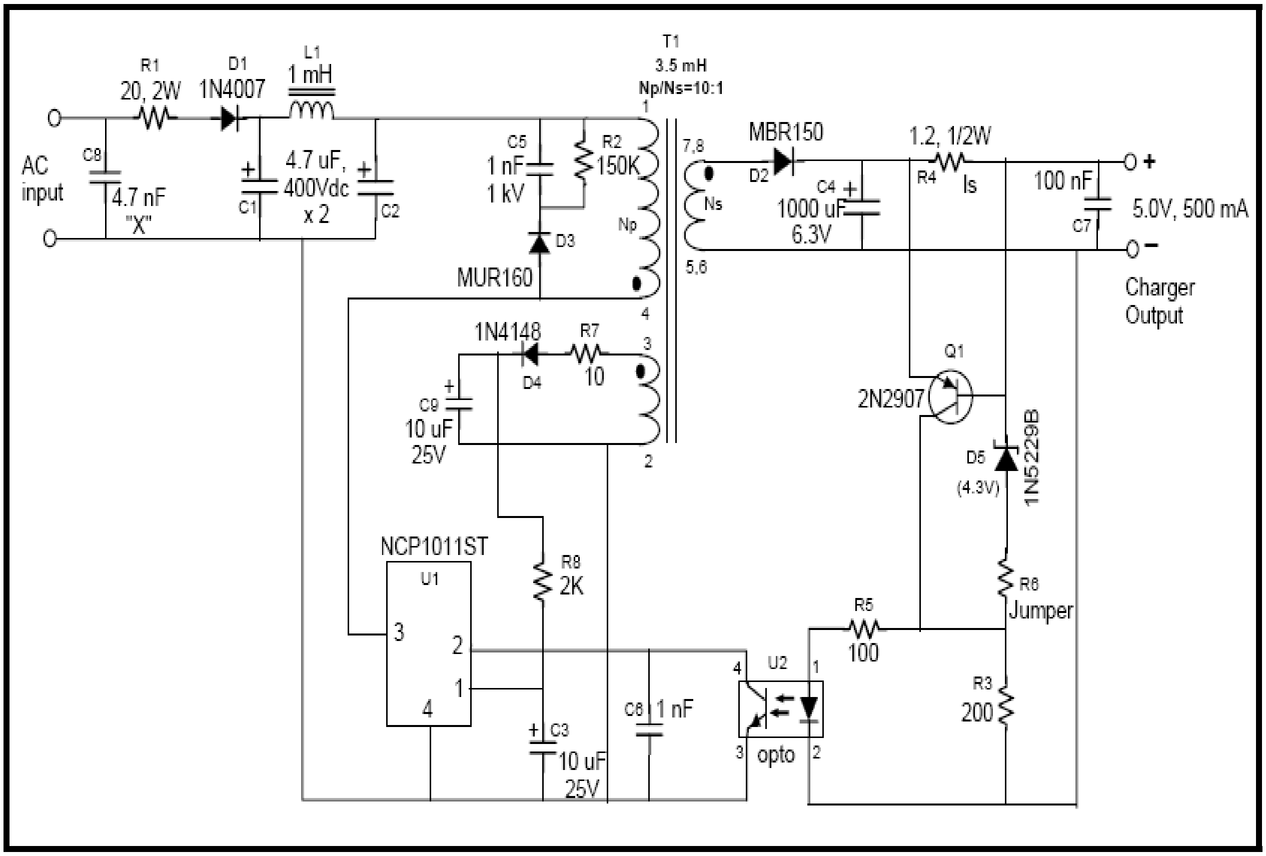


Figure 2: Circuit diagram of cell phone charger

APPENDIX B

SOFTWARE DESIGN

```
#include <16f877a.h>
#use delay(clock=4000000)
#fuses hs,nowdt,noput,noprotect,nolvp
#byte PORTC=7

int i;
long timer_cnt1;
int timer_cnt2;
int time_sec;
void trip();
void check();
void moto_fwd();
void moto_rvs();
void LED();

#int_rtcc
  clock_isr()
 {
          timer_cnt1++;
          if(timer_cnt1>=977){ //1.024ms x977 = 1s
          timer_cnt1=0;
          time_sec++;
  }
 }
```

```
main()
 {set_tris_c(0x01);
   set_rtcc(0);   //Timer0 setup
   setup_counters(RTCC_INTERNAL,RTCC_DIV_4);
   enable_interrupts(int_rtcc);
   enable_interrupts(GLOBAL);

   set_tris_c(0);
   time_sec=0;
   timer_cnt1=0;

   do {
      if(time_sec>=10){
            time_sec=0;
            trip();
            check();
      if(input(PIN_C1)==0){
            moto_fwd();
            delay_ms(5000);
            moto_rvs();
            delay_ms(5000);
        }
        else
            {LED ();
        }
     }while (1);
}
```

```
void trip()
        { portc=0x80;
        delay_ms(2500);
        portc=0x00; }

void check()
        { portc=0x40;
        delay_ms(5000);
        portc=0x00;}

void moto_fwd()
        { portc=0x10;
        delay_ms(100);
        portc=0x00;}

void moto_rvs()
        {portc=0x08;
        delay_ms(100);
        portc=0x00;}

void LED()
        { portc=0x20;
        delay_ms(5000);}
```

APPENDIX C

DATA SHEET

PIC16F87X Data Sheet

28/40-Pin 8-Bit CMOS FLASH Microcontrollers

MICROCHIP

PIC16F87X

28/40-Pin 8-Bit CMOS FLASH Microcontrollers

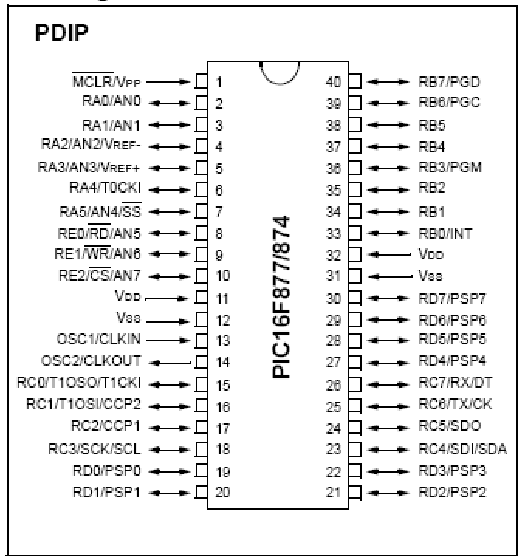
Devices Included in this Data Sheet:

- PIC16F873
- PIC16F874
- PIC16F876
- PIC16F877

Microcontroller Core Features:

- High performance RISC CPU
- Only 35 single word instructions to learn
- All single cycle instructions except for program branches which are two cycle
- Operating speed: DC - 20 MHz clock input
  DC - 200 ns instruction cycle
- Up to 8K x 14 words of FLASH Program Memory,
  Up to 368 x 8 bytes of Data Memory (RAM)
  Up to 256 x 8 bytes of EEPROM Data Memory
- Pinout compatible to the PIC16C73B/74B/76/77
- Interrupt capability (up to 14 sources)
- Eight level deep hardware stack
- Direct, indirect and relative addressing modes
- Power-on Reset (POR)
- Power-up Timer (PWRT) and Oscillator Start-up Timer (OST)
- Watchdog Timer (WDT) with its own on-chip RC oscillator for reliable operation
- Programmable code protection
- Power saving SLEEP mode
- Selectable oscillator options
- Low power, high speed CMOS FLASH/EEPROM technology
- Fully static design
- In-Circuit Serial Programming™ (ICSP) via two pins
- Single 5V In-Circuit Serial Programming capability
- In-Circuit Debugging via two pins
- Processor read/write access to program memory
- Wide operating voltage range: 2.0V to 5.5V
- High Sink/Source Current: 25 mA
- Commercial, Industrial and Extended temperature ranges
- Low-power consumption:
  - < 0.6 mA typical @ 3V, 4 MHz
  - 20 µA typical @ 3V, 32 kHz
  - < 1 µA typical standby current

Pin Diagram



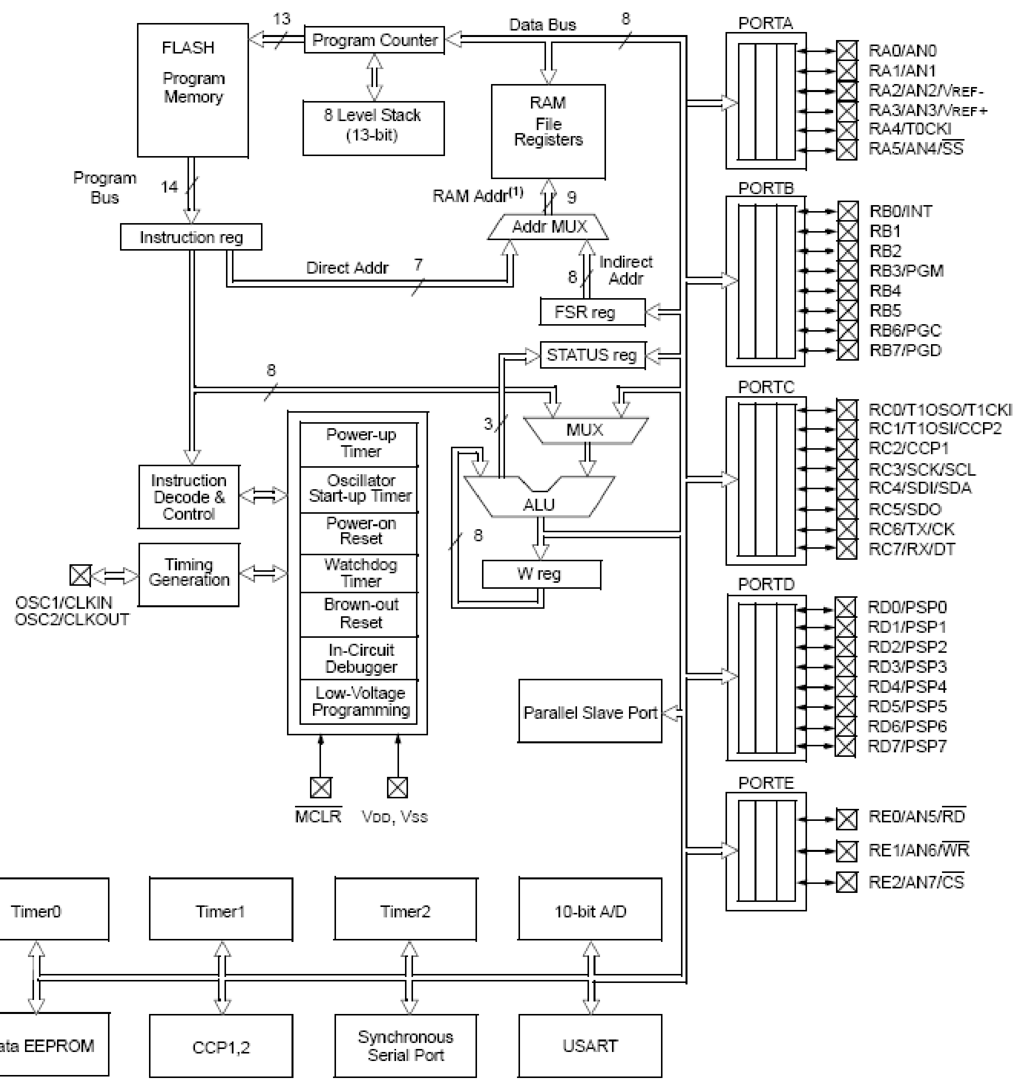
Peripheral Features:

- Timer0: 8-bit timer/counter with 8-bit prescaler
- Timer1: 16-bit timer/counter with prescaler, can be incremented during SLEEP via external crystal/clock
- Timer2: 8-bit timer/counter with 8-bit period register, prescaler and postscaler
- Two Capture, Compare, PWM modules
  - Capture is 16-bit, max. resolution is 12.5 ns
  - Compare is 16-bit, max. resolution is 200 ns
  - PWM max. resolution is 10-bit
- 10-bit multi-channel Analog-to-Digital converter
- Synchronous Serial Port (SSP) with SPI™ (Master mode) and I²C™ (Master/Slave)
- Universal Synchronous Asynchronous Receiver Transmitter (USART/SCI) with 9-bit address detection
- Parallel Slave Port (PSP) 8-bits wide, with external RD, WR and CS controls (40/44-pin only)
- Brown-out detection circuitry for Brown-out Reset (BOR)

Key Features PICmicro™ Mid-Range Reference Manual (DS33023)	PIC16F873	PIC16F874	PIC16F876	PIC16F877
Operating Frequency	DC - 20 MHz	DC - 20 MHz	DC - 20 MHz	DC - 20 MHz
RESETS (and Delays)	POR, BOR (PWRT, OST)	POR, BOR (PWRT, OST)	POR, BOR (PWRT, OST)	POR, BOR (PWRT, OST)
FLASH Program Memory (14-bit words)	4K	4K	8K	8K
Data Memory (bytes)	192	192	368	368
EEPROM Data Memory	128	128	256	256
Interrupts	13	14	13	14
I/O Ports	Ports A,B,C	Ports A,B,C,D,E	Ports A,B,C	Ports A,B,C,D,E
Timers	3	3	3	3
Capture/Compare/PWM Modules	2	2	2	2
Serial Communications	MSSP, USART	MSSP, USART	MSSP, USART	MSSP, USART
Parallel Communications	—	PSP	—	PSP
10-bit Analog-to-Digital Module	5 input channels	8 input channels	5 input channels	8 input channels
Instruction Set	35 instructions	35 instructions	35 instructions	35 instructions

FIGURE 1-2: PIC16F874 AND PIC16F877 BLOCK DIAGRAM

Device	Program FLASH	Data Memory	Data EEPROM
PIC16F874	4K	192 Bytes	128 Bytes
PIC16F877	8K	368 Bytes	256 Bytes



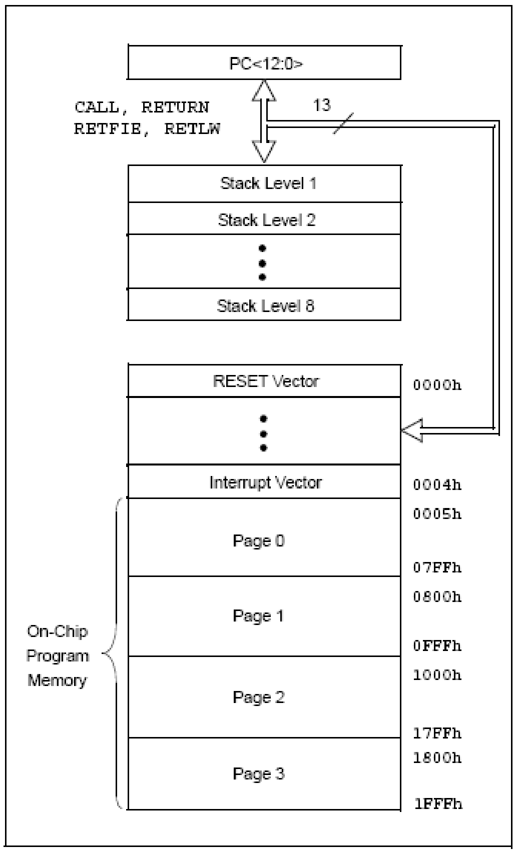
Note 1: Higher order bits are from the STATUS register.

2.0 MEMORY ORGANIZATION

There are three memory blocks in each of the PIC16F87X MCUs. The Program Memory and Data Memory have separate buses so that concurrent access can occur and is detailed in this section. The EEPROM data memory block is detailed in Section 4.0.

Additional information on device memory may be found in the PICmicro™ Mid-Range Reference Manual, (DS33023).

FIGURE 2-1: PIC16F877/876 PROGRAM MEMORY MAP AND STACK



2.1 Program Memory Organization

The PIC16F87X devices have a 13-bit program counter capable of addressing an 8K x 14 program memory space. The PIC16F877/876 devices have 8K x 14 words of FLASH program memory, and the PIC16F873/874 devices have 4K x 14. Accessing a location above the physically implemented address will cause a wraparound.

The RESET vector is at 0000h and the interrupt vector is at 0004h.

FIGURE 2-2: PIC16F874/873 PROGRAM MEMORY MAP AND STACK

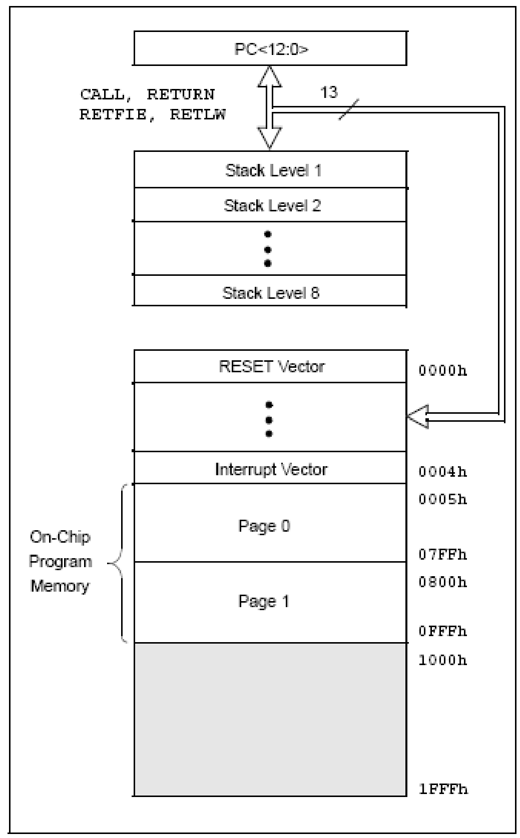


FIGURE 2-3: PIC16F877/876 REGISTER FILE MAP

Bank 0	File Address	Bank 1	File Address	Bank 2	File Address	Bank 3	File Address
Indirect addr.(*)	00h	Indirect addr.(*)	80h	Indirect addr.(*)	100h	Indirect addr.(*)	180h
TMR0	01h	OPTION_REG	81h	TMR0	101h	OPTION_REG	181h
PCL	02h	PCL	82h	PCL	102h	PCL	182h
STATUS	03h	STATUS	83h	STATUS	103h	STATUS	183h
FSR	04h	FSR	84h	FSR	104h	FSR	184h
PORTA	05h	TRISA	85h		105h		185h
PORTB	06h	TRISB	86h	PORTB	106h	TRISB	186h
PORTC	07h	TRISC	87h		107h		187h
PORTD(1)	08h	TRISD(1)	88h		108h		188h
PORTE(1)	09h	TRISE(1)	89h		109h		189h
PCLATH	0Ah	PCLATH	8Ah	PCLATH	10Ah	PCLATH	18Ah
INTCON	0Bh	INTCON	8Bh	INTCON	10Bh	INTCON	18Bh
PIR1	0Ch	PIE1	8Ch	EEDATA	10Ch	EECON1	18Ch
PIR2	0Dh	PIE2	8Dh	EEADR	10Dh	EECON2	18Dh
TMR1L	0Eh	PCON	8Eh	EEDATH	10Eh	Reserved(2)	18Eh
TMR1H	0Fh		8Fh	EEADRH	10Fh	Reserved(2)	18Fh
T1CON	10h		90h	General Purpose Register 16 Bytes	110h	General Purpose Register 16 Bytes	190h
TMR2	11h	SSPCON2	91h		111h		191h
T2CON	12h	PR2	92h		112h		192h
SSPBUF	13h	SSPADD	93h		113h		193h
SSPCON	14h	SSPSTAT	94h		114h		194h
CCPR1L	15h		95h		115h		195h
CCPR1H	16h		96h		116h		196h
CCP1CON	17h		97h		117h		197h
RCSTA	18h	TXSTA	98h		118h		198h
TXREG	19h	SPBRG	99h		119h		199h
RCREG	1Ah		9Ah		11Ah		19Ah
CCPR2L	1Bh		9Bh		11Bh		19Bh
CCPR2H	1Ch		9Ch		11Ch		19Ch
CCP2CON	1Dh		9Dh		11Dh		19Dh
ADRESH	1Eh	ADRESL	9Eh		11Eh		19Eh
ADCON0	1Fh	ADCON1	9Fh		11Fh		19Fh
General Purpose Register 96 Bytes	20h	General Purpose Register 80 Bytes	A0h	General Purpose Register 80 Bytes	120h	General Purpose Register 80 Bytes	1A0h
			EFh		16Fh		1EFh
		accesses 70h-7Fh	F0h	accesses 70h-7Fh	170h	accesses 70h - 7Fh	1F0h
	7Fh		FFh		17Fh		1FFh

Unimplemented data memory locations, read as '0'.

* Not a physical register.

Note 1: These registers are not implemented on the PIC16F876.

2: These registers are reserved, maintain these registers clear.

3.3 PORTC and the TRISC Register

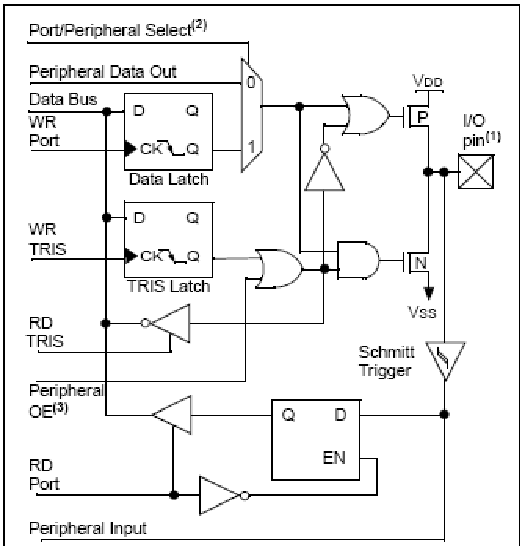
PORTC is an 8-bit wide, bi-directional port. The corresponding data direction register is TRISC. Setting a TRISC bit (= 1) will make the corresponding PORTC pin an input (i.e., put the corresponding output driver in a Hi-Impedance mode). Clearing a TRISC bit (= 0) will make the corresponding PORTC pin an output (i.e., put the contents of the output latch on the selected pin).

PORTC is multiplexed with several peripheral functions (Table 3-5). PORTC pins have Schmitt Trigger input buffers.

When the I^{2}C module is enabled, the PORTC<4:3> pins can be configured with normal I^{2}C levels, or with SMBus levels by using the CKE bit (SSPSTAT<6>).

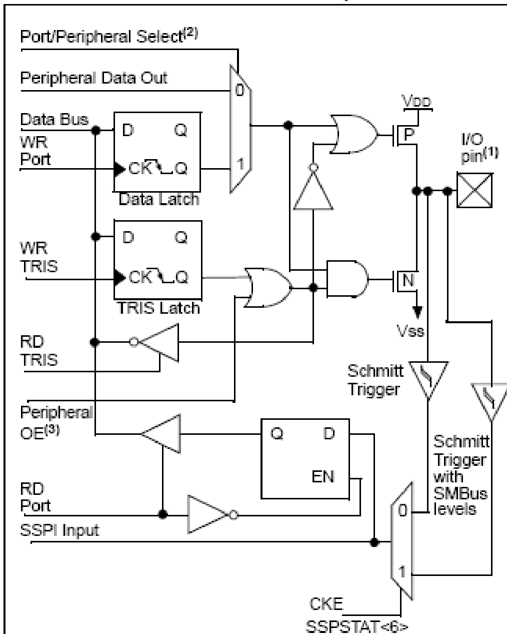
When enabling peripheral functions, care should be taken in defining TRIS bits for each PORTC pin. Some peripherals override the TRIS bit to make a pin an output, while other peripherals override the TRIS bit to make a pin an input. Since the TRIS bit override is in effect while the peripheral is enabled, read-modify-write instructions (`BSF`, `BCF`, `XORWF`) with TRISC as destination, should be avoided. The user should refer to the corresponding peripheral section for the correct TRIS bit settings.

FIGURE 3-5: PORTC BLOCK DIAGRAM (PERIPHERAL OUTPUT OVERRIDE) RC<2:0>, RC<7:5>



Note 1: I/O pins have diode protection to VDD and Vss.
2: Port/Peripheral select signal selects between port data and peripheral output.
3: Peripheral OE (output enable) is only activated if peripheral select is active.

FIGURE 3-6: PORTC BLOCK DIAGRAM (PERIPHERAL OUTPUT OVERRIDE) RC<4:3>



Note 1: I/O pins have diode protection to VDD and Vss.
2: Port/Peripheral select signal selects between port data and peripheral output.
3: Peripheral OE (output enable) is only activated if peripheral select is active.

TABLE 3-5: PORTC FUNCTIONS

Name	Bit#	Buffer Type	Function
RC0/T1OSO/T1CKI	bit0	ST	Input/output port pin or Timer1 oscillator output/Timer1 clock input.
RC1/T1OSI/CCP2	bit1	ST	Input/output port pin or Timer1 oscillator input or Capture2 input/ Compare2 output/PWM2 output.
RC2/CCP1	bit2	ST	Input/output port pin or Capture1 input/Compare1 output/ PWM1 output.
RC3/SCK/SCL	bit3	ST	RC3 can also be the synchronous serial clock for both SPI and I^2C modes.
RC4/SDI/SDA	bit4	ST	RC4 can also be the SPI Data In (SPI mode) or data I/O (I^2C mode).
RC5/SDO	bit5	ST	Input/output port pin or Synchronous Serial Port data output.
RC6/TX/CK	bit6	ST	Input/output port pin or USART Asynchronous Transmit or Synchronous Clock.
RC7/RX/DT	bit7	ST	Input/output port pin or USART Asynchronous Receive or Synchronous Data.

Legend: ST = Schmitt Trigger input

TABLE 3-6: SUMMARY OF REGISTERS ASSOCIATED WITH PORTC

Address	Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	Value on: POR, BOR	Value on all other RESETS
07h	PORTC	RC7	RC6	RC5	RC4	RC3	RC2	RC1	RC0	xxxx xxxx	uuuu uuuu
87h	TRISC	PORTC Data Direction Register								1111 1111	1111 1111

Legend: x = unknown, u = unchanged

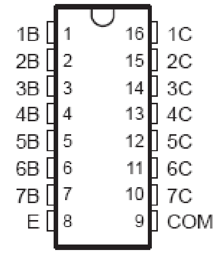
ULN2001A, ULN2002A, ULN2003A, ULN2004A, ULQ2003A, ULQ2004A
HIGH-VOLTAGE HIGH-CURRENT DARLINGTON TRANSISTOR ARRAY

SLRS027G – DECEMBER 1976 – REVISED JUNE 2004

The ULN2001A is obsolete and is no longer supplied.

- **500-mA-Rated Collector Current (Single Output)**
- **High-Voltage Outputs . . . 50 V**
- **Output Clamp Diodes**
- **Inputs Compatible With Various Types of Logic**
- **Relay-Driver Applications**

ULN2001A . . . D OR N PACKAGE
ULN2002A . . . N PACKAGE
ULN2003A . . . D, N, NS, OR PW PACKAGE
ULN2004A . . . D, N, OR NS PACKAGE
ULQ2003A, ULQ2004A . . . D OR N PACKAGE
(TOP VIEW)



description/ordering information

The ULN2001A, ULN2002A, ULN2003A, ULN2004A, ULQ2003A, and ULQ2004A are high-voltage, high-current Darlington transistor arrays. Each consists of seven npn Darlington pairs that feature high-voltage outputs with common-cathode clamp diodes for switching inductive loads. The collector-current rating of a single Darlington pair is 500 mA. The Darlington pairs can be paralleled for higher current capability. Applications include relay drivers, hammer drivers, lamp drivers, display drivers (LED and gas discharge), line drivers, and logic buffers. For 100-V (otherwise interchangeable) versions of the ULN2003A and ULN2004A, see the SN75468 and SN75469, respectively.

ORDERING INFORMATION

T_A	PACKAGE†		ORDERABLE PART NUMBER	TOP-SIDE MARKING
−20°C to 70°C	PDIP (N)	Tube of 25	ULN2002AN	ULN2002AN
			ULN2003AN	ULN2003AN
			ULN2004AN	ULN2004AN
	SOIC (D)	Tube of 40	ULN2003AD	ULN2003A
		Reel of 2500	ULN2003ADR	
		Tube of 40	ULN2004AD	ULN2004A
		Reel of 2500	ULN2004ADR	
	SOP (NS)	Reel of 2000	ULN2003ANSR	ULN2003A
			ULN2004ANSR	ULN2004A
	TSSOP (PW)	Tube of 90	ULN2003APW	UN2003A
		Reel of 2000	ULN2003APWR	
−40°C to 85°C	PDIP (N)	Tube of 25	ULQ2003AN	ULQ2003A
			ULQ2004AN	ULQ2004AN
	SOIC (D)	Tube of 40	ULQ2003AD	ULQ2003A
		Reel of 2500	ULQ2003ADR	ULQ2003A
		Tube of 40	ULQ2004AD	ULQ2004A
		Reel of 2500	ULQ2004ADR	ULQ2004A

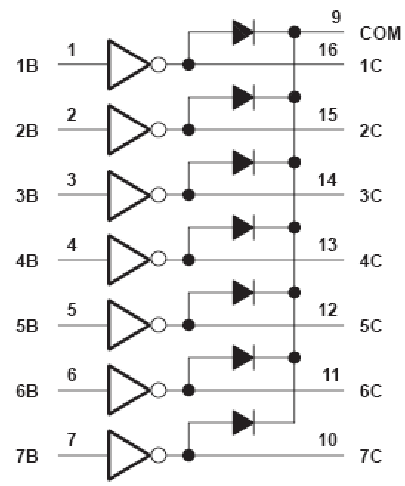
† Package drawings, standard packing quantities, thermal data, symbolization, and PCB design guidelines are available at www.ti.com/sc/package.

The ULN2001A is obsolete and is no longer supplied.

description/ordering information (continued)

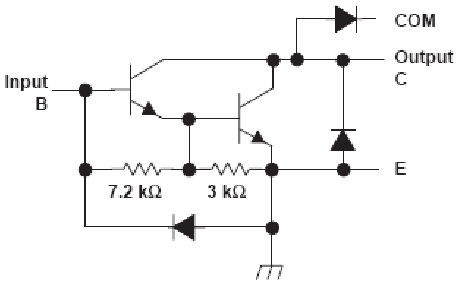
The ULN2001A is a general-purpose array and can be used with TTL and CMOS technologies. The ULN2002A is designed specifically for use with 14-V to 25-V PMOS devices. Each input of this device has a Zener diode and resistor in series to control the input current to a safe limit. The ULN2003A and ULQ2003A have a 2.7-kΩ series base resistor for each Darlington pair for operation directly with TTL or 5-V CMOS devices. The ULN2004A and ULQ2004A have a 10.5-kΩ series base resistor to allow operation directly from CMOS devices that use supply voltages of 6 V to 15 V. The required input current of the ULN/ULQ2004A is below that of the ULN/ULQ2003A, and the required voltage is less than that required by the ULN2002A.

logic diagram

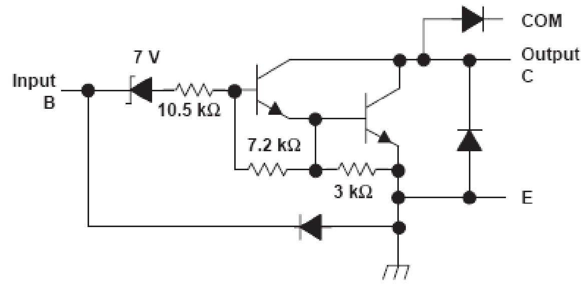


The ULN2001A is obsolete
and is no longer supplied.

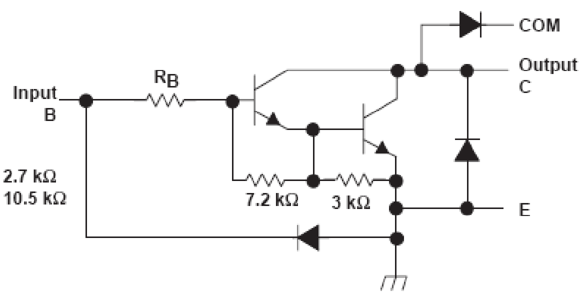
schematics (each Darlington pair)



ULN2001A



ULN2002A



ULN/ULQ2003A: R_B = 2.7 kΩ
ULN/ULQ2004A: R_B = 10.5 kΩ

ULN2003A, ULN2004A, ULQ2003A, ULQ2004A

All resistor values shown are nominal.

The ULN2001A is obsolete and is no longer supplied.

PARAMETER MEASUREMENT INFORMATION

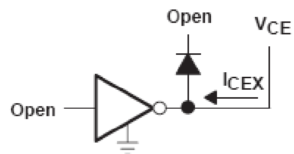


Figure 1. I_{CEX} Test Circuit

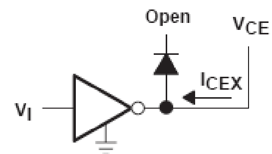


Figure 2. I_{CEX} Test Circuit

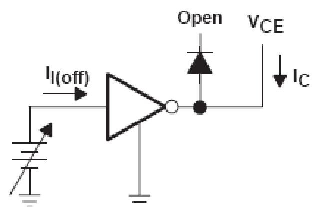


Figure 3. $I_{I(off)}$ Test Circuit

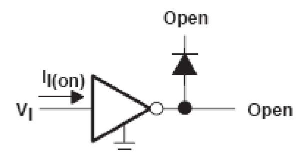
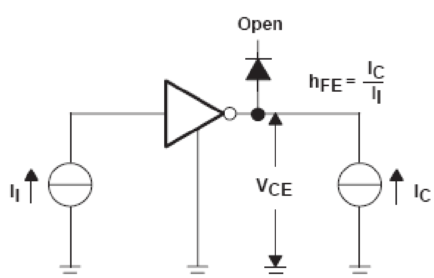


Figure 4. I_I Test Circuit



NOTE: I_I is fixed for measuring $V_{CE(sat)}$, variable for measuring h_{FE}.

Figure 5. h_{FE}, $V_{CE(sat)}$ Test Circuit

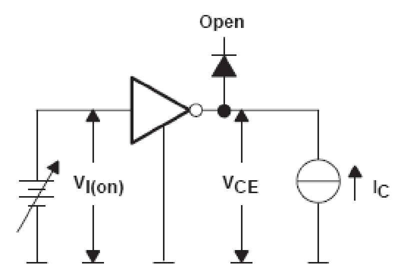


Figure 6. $V_{I(on)}$ Test Circuit

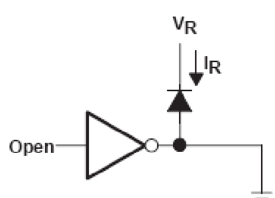


Figure 7. I_R Test Circuit

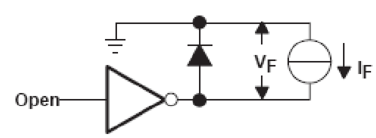
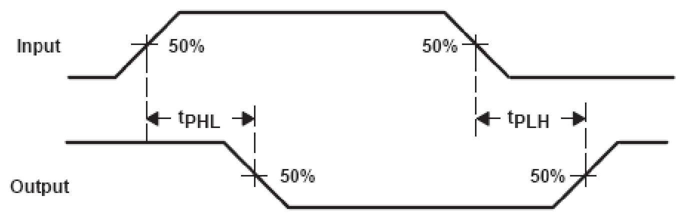


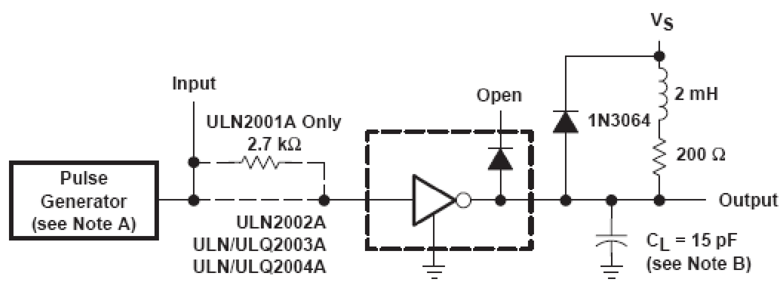
Figure 8. V_F Test Circuit

PARAMETER MEASUREMENT INFORMATION

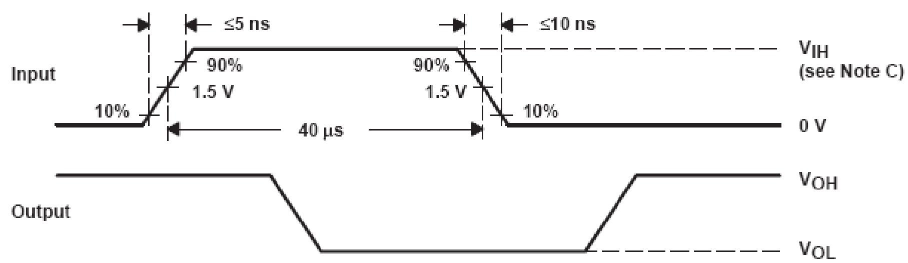


VOLTAGE WAVEFORMS

Figure 9. Propagation Delay-Time Waveforms



TEST CIRCUIT



VOLTAGE WAVEFORMS

NOTES: A. The pulse generator has the following characteristics: PRR = 12.5 kHz, Z_O = 50 Ω.
B. C_L includes probe and jig capacitance.
C. For testing the ULN2001A, the ULN2003A, and the ULQ2003A, V_{IH} = 3 V; for the ULN2002A, V_{IH} = 13 V; for the ULN2004A and the ULQ2004A, V_{IH} = 8 V.

Figure 10. Latch-Up Test Circuit and Voltage Waveforms

KEC
KOREA ELECTRONICS CO.,LTD.

SEMICONDUCTOR
TECHNICAL DATA

KIA7805AP/API~ KIA7824AP/API

BIPOLAR LINEAR INTEGRATED CIRCUIT

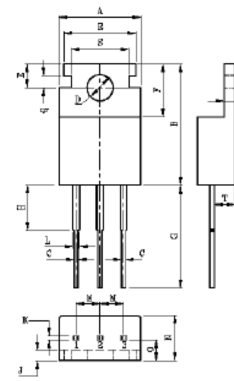
THREE TERMINAL POSITIVE VOLTAGE REGULATORS
5V, 6V, 8V, 9V, 10V, 12V, 15V, 18V, 20V, 24V.

FEATURES

- Suitable for C-MOS, TTL, the Other Digital IC's Power Supply.
- Internal Thermal Overload Protection.
- Internal Short Circuit Current Limiting.
- Output Current in Excess of 1A.
- Satisfies IEC-65 Specification. (International Electronical Commission).

MAXIMUM RATINGS (Ta=25℃)

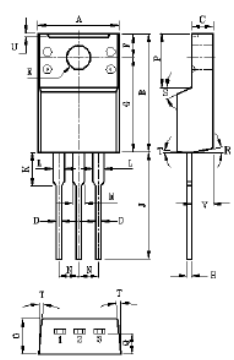
CHARACTERISTIC		SYMBOL	RATING	UNIT
Input Voltage	KIA7805AP/API~ KIA7815AP/API	V_{IN}	35	V
	KIA7818AP/API~ KIA7824AP/API		40	
Power Dissipation (Tc=25℃)		P_D	20.8	W
Power Dissipation (Without Heatsink)	KIA7805API~ KIA7824API	P_D	2.0	W
Operating Junction Temperature		T_j	-30~150	℃
Storage Temperature		T_{stg}	-55~150	℃



DIM	MILLIMETERS
A	10.50 MAX
B	15.50 MAX
C	9.80
D	ϕ3.60±0.20
E	3.00
F	6.70 MAX
G	13.60±0.50
H	5.60 MAX
J	1.37 MAX
K	0.50
L	1.80 MAX
M	2.54
N	4.70 MAX
O	2.60
P	1.50 MAX
Q	1.50
R	9.50±0.20
S	8.00±0.20
T	2.90 MAX

1. INPUT
2. COMMON(CASE)
3. OUTPUT

TO-220AB



DIM	MILLIMETERS
A	10.30 MAX
B	15.30 MAX
C	2.70±0.30
D	0.85 MAX
E	ϕ3.20±0.20
F	3.00±0.30
G	12.30 MAX
H	0.75 MAX
J	13.60±0.50
K	3.90 MAX
L	1.30
M	1.30
N	2.54
O	4.50±0.20
P	6.80
Q	2.60±0.20
R	10°
S	25°
T	5°
U	0.6
V	2.60±0.15

1. INPUT
2. COMMON
3. OUTPUT

TO-220IS

ON Semiconductor

Design Note – DN06009/D

5 W, CCCV Cell Phone Battery Charger

Device	Application	Input Voltage	Output Power	Topology	I/O Isolation
NCP1014	Cell Phone Charger	90 to 270 Vac	5 W	Flyback	Isolated

Other Specifications				
	Output 1	Output 2	Output 3	Output 4
Output Voltage	5.0 V	N/A	N/A	N/A
Ripple	200 mV p/p	N/A	N/A	N/A
Nominal Current	1.0 A	N/A	N/A	N/A
Max Current	1.1 A	N/A	N/A	N/A
Min Current	zero	N/A	N/A	N/A

PFC (Yes/No)	No
Minimum Efficiency	65%
Operating Temp. Range	0 to +60°C
Cooling Method/Supply Orientation	Convection

Others	CCCV (Constant Current – Constant Voltage) output load profile for typical battery charger.

Circuit Description

This circuit presents a very simple, low cost, yet highly effective 5 watt, off-line constant current – constant voltage battery charger for cell phones or similar applications. The circuit is designed around ON's NCP1014 integrated controller with internal mosfet in a discontinuous mode flyback topology. Current and voltage feedback are accomplished with a single optocoupler as well as providing ac mains isolation. The circuit provides a respectable output V/I load-line characteristic for battery charging over typical temperature variations. The use of an auxiliary Vcc winding on T1, although not required because of the 1014's DSS circuitry, guarantees very low standby (no load) power consumption (< 300 mW). For maximum simplicity a half-wave input rectifier (D1) is utilized and a conducted EMI filter is provided by C1 and L1. If there are very low output line frequency ripple and/or low ac input constraints, a full bridge input rectifier is recommended. The T1 flyback transformer design is compliant enough for output voltage requirements from 4 to 6.5 volts.

Key Features

- Extremely simple yet effective off-line battery charger circuit.
- Constant current – constant voltage output load line profile.
- Less than 300 mW standby (no load) input power if auxiliary winding is used.
- Conducted EMI input filter.
- Adjustable output voltage and current with resistors.
- Monolithic, integrated current mode controller with inherent over-current, over-temperature, and over-voltage protection.

The fault current during 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 leakage currents and disconnects the circuit 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 to 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 5 kW.
- Luminous Tube Installations.
- X-Ray machines .

2 Pole

Used for Single phase electrical connections, mostly for domestic purposes.

4 Pole

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

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

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.

Precautions 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.
- 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's 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_E) With Max. Permissible Touch Voltage (U_T)

Touch Voltage (U_T) (V)	Earth Resistance R_E (?) Sensitivity $I_{\Delta n}$ (mA)		
	30	100	300
25 50 65	833 1666 2160	250 500 650	83 166 216

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

U_T = 25V R_E = 83 Ohm U_T = 50V R_E = 166 Ohm U_T = 65V R_E = 216 Ohm