FLOOD PROTECTION GARAGE SYSTEM

By

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FINAL PROJECT REPORT

Submitted to the Electrical & Electronics Engineering Programme
in Partial Fulfillment of the Requirements
for the Degree
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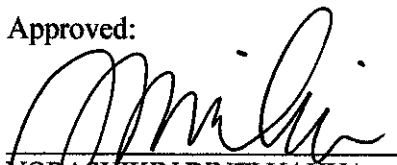Perak Darul Ridzuan

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CERTIFICATION OF APPROVAL

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Mohd Fariz Ikram Bin Mohd Nor @ Abdullah

A project dissertation submitted to the
Electrical & Electronics Engineering Programme
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JUNE 2008

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

Mohd Fariz Ikram Bin Mohd Nor @ Abdullah

ABSTRACT

This project is focus on the development of a flood protection garage system (FPGS) in order to protect vehicle and other valuable things inside the garage from flooding water. When flood happens, the water level detector circuit inside the garage will sense the existence of water in the respective level of the sensor. This sensor will send signal to the microcontroller to control motor operation in order to drive the jack and lift up the garage floor. The floor of the garage can also be lower down when the water level inside the garage decreases. Meanwhile, the signal will also be sent to the receiver via radio frequency transmission to alert the car owner about the flooding. The sensor, microcontroller and the wireless transmission are the main components of FPGS.

ACKNOWLEDGEMENTS

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LIST OF ABBREVIATIONS

PIC	PERIPHERAL INTERFACE CONTROLLER
FPGS	FLOOD PROTECTION GARAGE SYSTEM
DC	DIRECT CURRENT
IC	INTEGRATED CIRCUIT
V	VOLTAGE
V_S	VOLTAGE SUPPLY
LED	LIGHT EMITTING DIODE
IR	INFRA RED
RF	RADIO FREQUENCY
CPU	CENTRAL PROCESSING UNIT
I/O	INPUT OUTPUT
EEPROM	ELECTRICALLY ERASABLE PROGRAMMABLE READ-ONLY MEMORY
ICSP	IN CIRCUIT SERIAL PROGRAMMING
CAD	COMPUTER AIDED DESIGN
HP	HORSE POWER
RAM	RANDOM ACCESS MEMORY
PCB	PRINTED CIRCUIT BOARD

CHAPTER 1

INTRODUCTION

1.1   Background of Study

Malaysia has equatorial climate with constant high temperatures and relatively high humidity. The climate is influenced by the northeast and southwest monsoons. The former, prevailing between November and February, brings heavy rainfall (as much as 600 mm in 24 hours in extreme cases) predominantly to the east coast of Peninsular Malaysia and to Sabah and Sarawak. The annual average rainfall is 2420 mm for Peninsular Malaysia, 2630 mm for Sabah and 3830 mm for Sarawak. Due to these heavy rainfalls in Malaysia, several major flood and flash flood have been experienced in the last few years. For examples in 2003, a severe flood with heavy winds was experienced in the east coast of peninsular Malaysia especially in Kelantan resulting in extensive damages to property, road systems and agricultural land and crops. The latest incidents occur in last year where heavy rain in the vicinity of Kuala Lumpur on the afternoon of 10 June 2007 caused flash flood over many areas [1]. A lot of valuable properties were lost and damaged, and this tragedy had a huge economic impact to Malaysia. These flood occurrences seem to be getting more frequent in recent years. Realizing this, the idea of protecting vehicles or any other valuable properties at home is relevant by introducing the flood protection garage system. This Final year project is believed to be very useful and marketable, because it can be expanded to basement installation to prevent water flooding from destroying valuable properties stored in the basement.

1.2   Problem Statement

Flood are regular natural disaster in Malaysia which happen nearly every year during the monsoon season. When the flood occur, a lot of valuable properties such as vehicles get damage or even lost. Therefore, in order to provide protection to the valuable things such as vehicles from water flooding, an automated garage system is needed. The main concept of the automated garage system is to adjust the height of the garage floor depending on the water level. The ground will be lift up when the water level in the garage increases and will be lowered when water level decreases. This system is an automated system which will handle all the above works by itself. It will be power up by batteries, so it still functioning when there is power outage. The design system will also utilize wireless radio frequency transmission to send signal to the receiver which is use to alert the owner of the garage about the water level in their garage.

1.3   Objective and Scope of Study

The main goal on this project is to build a system to protect vehicle inside the garage from water flooding. The design is to adjust the height of the garage floor depending on the water level. The system will use a water level detection circuit as a sensor to detect the water level and send out digital signals to the microcontroller. The microcontroller will then activate the motor to drive the jack which will raise the garage floor. When water goes down, the motor will operate in the opposite direction to lower the floor. This automated system is controlled by the programmable microcontroller. At the same time the microcontroller will trigger the radio frequency transmitter to send signal to alert the owner of the garage about the flooding water so that the owner will take appropriate action to save other valuable properties at home.

The scope of study is mostly on designing the sensor circuit and programming the microcontroller which will be the brain for this project. Further studies about designing the radio frequency transmitting and receiving circuit is also needed in order to have a wireless transmission to alert the user about the flooding.

CHAPTER 2

LITERATURE REVIEW

The scope of study for this project mostly on the designing the power supply module, the sensor in detecting the water level, the wireless transmission system and also the programming of the Peripheral Interface Controller (PIC) as well as the motor driver circuit. These project components will be described detailed in subsequent sections.

2.1   Power Supply Module

For the Flood Protection Garage System project (FPGS), three different values of DC voltages are needed to power up the system. 12V DC supply will be used for power window motor, 9V DC supply for water level sensor circuits and 5V DC for PIC and for the transmitter circuit. Therefore, 12V DC power supply from car battery need to be converted to 9V and 5V in order to operates the system. This can be achieved by using the voltage regulator to step the voltage down to 9V and 5V. In addition, this module also providing circuit protection against incorrect setup and voltage spikes.

2.1.1   Voltage Regulator

Voltage regulators are used to produce a stable power supply voltage (+Vs) from a higher (varying) DC voltage and to limit the current supply. Some electronic systems require a stable voltage supply. A varying input voltage can be converted to a stable DC voltage by using a voltage regulator as illustrated in Figure 1.

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Figure 1: Voltage Regulator Operations

LM78L05 and LM7809 can be used to produce output voltages closed to 5 Volt and 9 Volt respectively. The voltage regulators will accept input voltages that vary anywhere in the range 7.5V to 35V. Voltage regulators provide protection to prevent the current drawn from input voltage source exceeding these limits. This can be useful in preventing excessive current being drawn from rechargeable batteries and also protects against accidental reverse connection of the input voltage source [2].

As stated in PICbasic Project by Dogan [3], a voltage regulator circuit is used to convert the 12V voltage to 5V, independent of the current drawn from the supply. A basic voltage regulator circuit consists of a regulator integrated circuit (IC) and filter capacitor. Figure 2 shows the low-cost voltage regulator circuit using LM78L05 IC with two filter capacitors. LM78LXX is a 3-pin IC with a maximum current capacity of 100mA [4]. The input pins of the LM78LXX need to be connected to the +V terminal of the battery in parallel with a 0.33 μF capacitor while the ground pin is connected to the –V terminal of the battery. The third pin of LM78L09 which provides the output of 9V will be connected to the water level sensor circuits and LM78L05 which provides the 5V output will be connected to the microcontroller and transmitter circuit. Figure 3 and Figure 4 shows the pin mapping for LM78L05 voltage regulator.

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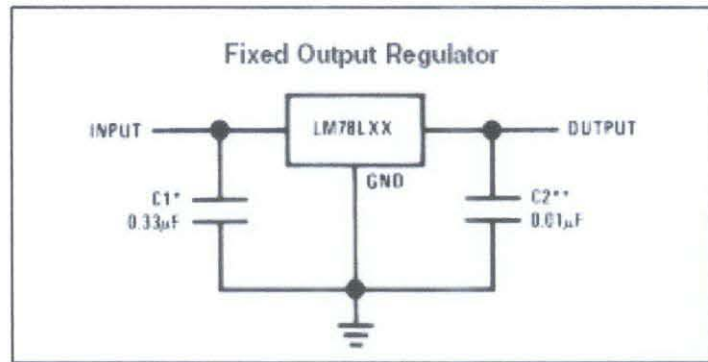
Figure 2: Circuit Diagram of the Voltage Regulator [4]
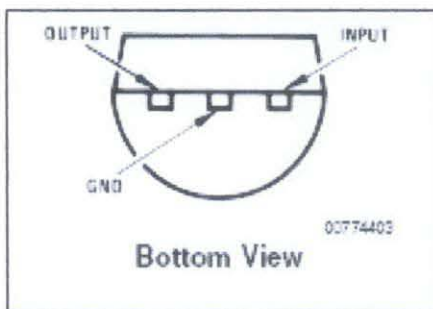
Figure 3: LM78L05 Bottom View [4]
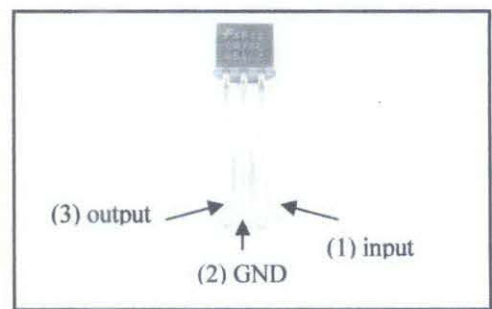
Figure 4: LM78L05 Voltage Regulator [3]

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2.2   Water Level Sensor System

Throughout the research about the possible type of sensor that can be used for this project, it was found that there are three possible types of sensor circuit which are:

1. Infra red transmitter & detector circuit.
2. Infrared LED & Photo detector circuit.
3. Water level detector circuit.

After consider about pros and cons of all three possible types of sensors, the water level detector circuit has been chosen as the sensor circuit instead of the other two. Since this project dealing with flooding water, the infra red transmitter & detector circuit and infra red LED & photo detector circuit is not quite suitable. When using these two circuits, the circuit must be in line with the water level and the problem occurs when the sensor circuit gets immersed in the flood where the circuit will be short and malfunction. This problem can be overcomed by using the water level detector circuit since we only put the sensor pad inside the flooding water and the rest of the circuit is on the secure level inside the garage. The other advantage of using the water level detector circuit is that the sensor is not dependent on light unlike the other two sensors which are very sensitive to light sources [5].

2.3   Wireless Transmission System

For the wireless transmission system, there are three possible ways in doing the project. The three ways are using the Bluetooth technology, infra red technology and radio frequency technology. Based on range of transmitting and cost effective, the radio frequency system has been chosen as a wireless transmission system.

For the Bluetooth system, even though the range of the transmitting is quite good and it is also user friendly where it is portable and it has no side impact to our health, but the cost the system is very high and it is also need a software to be installed.

For the infra red (IR) system, unlike radio-frequency (RF), IR wireless cannot pass through walls. Therefore, IR communications or control is generally not possible between the garage and house.

For the radio frequency system, it is the most suitable system in doing this project since it has longer transmission range since its frequency is between 30M hertz to 1G hertz [6]. The radio frequency signal also can pass through closed door and even through wall. The cost for the circuit is also low compared to the other two systems described before.

2.4   PIC 16F877 Microcontroller

Microcontrollers are single-chip computer consisting of CPU (central processing unit), data and program memory, serial and parallel I/O (input/output), timers, external and internal interrupts, all integrated into a single chip that is very cheap in the market. Most microcontrollers operate with the standard logic voltage of +5V. Since this project will be using the existing 12V car battery, a voltage regulator needs to be used to reduce the voltage to 5V to supply the microcontroller [3].

Intelligence of the robot lies in the complex and lengthy algorithm uses in microcontroller. It is not easy to implement such algorithm if there is no good support from programming side. In PIC Microcontroller Project Book by Iovine J. [7] has listed down the advantages of using microcontroller. Some of it are microcontroller is widely used because of its inexpensive and work as brain of the robot. Apart from that, microcontroller is capable to store and run program. Microcontroller also has the ability to perform math and logic function, which allow it to understand the sophisticated logic and electronics circuits. In the book "PIC Microcontroller for beginners, too!" [8] stated that microcontroller have memories which functions to store data. The microcontroller is the component that makes the robot intelligent. It also accepts high level programming language such as C.

In this project, the microcontroller module will take inputs from water level sensors. The output of the microcontroller will be sent to the relay to control the power

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window motor. The microcontroller will act as the brain of the system and it will be programmed by using C language. The time of power window motor to run and the logic flow will be programmed in this microcontroller. The possible microcontroller that can be used for this project is PIC 16F877

PIC16F877 is one of the most popular PIC microcontrollers for a very long time. It's consist of 40 pin device and offers 8k x 14 words Flash Program Memory, 368 bytes RAM and 256 bytes EEPROM. There are 33 I/O pins where each pin can source or sink 25 mA current. Additionally, the device contains of 3 timers with internal oscillator [9]. Other features of the PIC16F877 have been simplified in the Table 1 and Table 2 shows the pin description of the PIC16F877 and Figure 5 shows the PIC16F877 pin configuration.

Table 1: Features of Microcontroller, PIC16F877 [9]

Key Features PICmicro™ Mid-Range Reference Manual (DS33023)	PIC16F877
Operating Frequency	DC - 20 MHz
FLASH Program Memory (14-bit words)	8K
RAM Data Memory (bytes)	368
EEPROM Data Memory (bytes)	256
Interrupts Capability	14 Source
I/O Ports	Ports A,B,C,D,E
I/O Pins	33
Timers	3
Serial Communications	MSSP, USART
Parallel Communications	PSP
Operating Voltage Range	2.0V to 5.5V
High Sink / Source Current	25 mA

Table 2: Microcontroller PIC16F877 Pin Description [9]

Pin	Description	Pin	Description
1	MCLR – Master clear	40	RB7 – PORT B bit 7
2	RA0 – PORT A bit 0	39	RB6 – PORT B bit 6
3	RA1 – PORT A bit 1	38	RB5 – PORT B bit 5
4	RA2 – PORT A bit 2	37	RB4 – PORT B bit 4
5	RA3 – PORT A bit 3	36	RB3 – PORT B bit 3
6	RA4/T0CK1 – PORTA bit 4/ Counter clk	35	RB2 – PORT B bit 2
7	RA5 – PORT A bit 5	34	RB1 – PORT B bit 1
8	RE0 – PORT E bit 0	33	RB0/INT – PORT B bit 0
9	RE1 – PORT E bit 1	32	Vdd - + V supply
10	RE2 – PORT E bit 2	31	Vss – Gnd
11	Vdd - + V supply	30	RD7 – PORT D bit 7
12	Vss – Gnd	29	RD6 – PORT D bit 6
13	OSC1 / CLK IN	28	RD5 – PORT D bit 5
14	OSC2 / CLK OUT	27	RD4 – PORT D bit 4
15	RC0 – PORT C bit 0	26	RC7 – PORT C bit 7
16	RC1 – PORT C bit 1	25	RC6 – PORT C bit 6
17	RC2 – PORT C bit 2	24	RC5 – PORT C bit 5
18	RC3 – PORT C bit 3	23	RC4 – PORT C bit 4
19	RD0 – PORT D bit 0	22	RD3 – PORT D bit 3
20	RD1 – PORT D bit 1	21	RD2 – PORT D bit 2
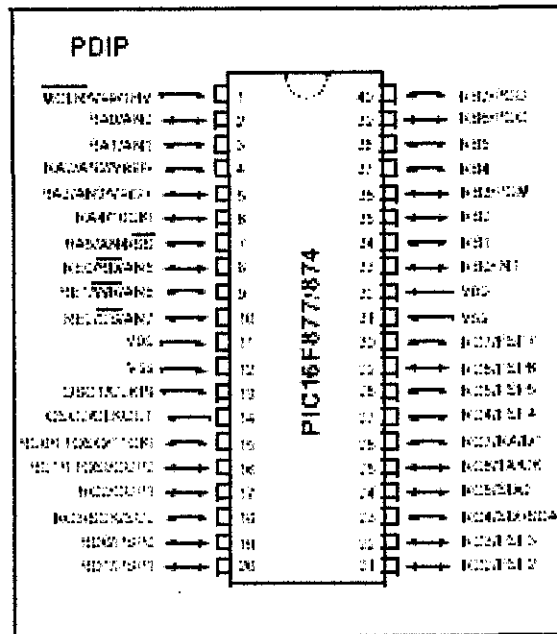
Figure 5: Microcontroller PIC16F877 Pin Configuration [9]

2.5   PIC Programmer Module

Programmers are traditionally used to get program code into the target PIC [10]. In computer hardware, the term programmer refers to a hardware device that configures programmable non-volatile circuits such as EEPROM or programmable logic circuits.

Nowadays, there are many programmers for PIC microcontrollers ranging from the extremely simple designs which rely on ICSP (In Circuit Serial Programming) to allow direct download of code from a host computer, to intelligent programmers that can verify the device at several supply voltages. Many of these complex programmers use a pre-programmed PIC themselves to send the programming commands to the PIC that is to be programmed [10].

These are some common programmer types:
1. Simple serial port ICSP programmers
   - Generally rely on driving the PIC's Vss line negative to get the necessary voltage differences from programming. Hence they are compact and cheap but great care is needed if using them for in circuit programming [10].
2. Simple parallel port ICSP programmers
   - Simple to understand but often have much higher part counts and generally require external power supplies [10].
3. Intelligent programmers
   - Generally faster and more reliable (especially on laptops which tend to have idiosyncrasies in the way they implement their ports) but far more complex to build (in particular they tend to use a PIC in the programmer which must itself be programmed somehow) [10].

For FPGS project, CYTRON SK40A which provided by Cytron Enterprise will be used as the PIC Programmer. SK40A have onboard voltage regulator, 7805 which will provide stable 5V output to PIC and other application. However, the maximum current of this regulator is only1A, thus if higher current is needed, an additional

voltage regulator is required. SK40A is ready with a protection diode to avoid damage to circuit if the Power Input polarity is connected wrongly. Once power is connected to Power Input, Power On LED will light up. If the LED does not light after power is connected, it might be caused by wrong polarity of power or no power from battery. SK40A also capable to accept the input voltage that range from 7V to 30V [11]. Figure 6 and Figure 7 shows the CYTRON SK40A PIC Programmer and the schematic diagram for CYTRON SK40A PIC Programmer respectively.
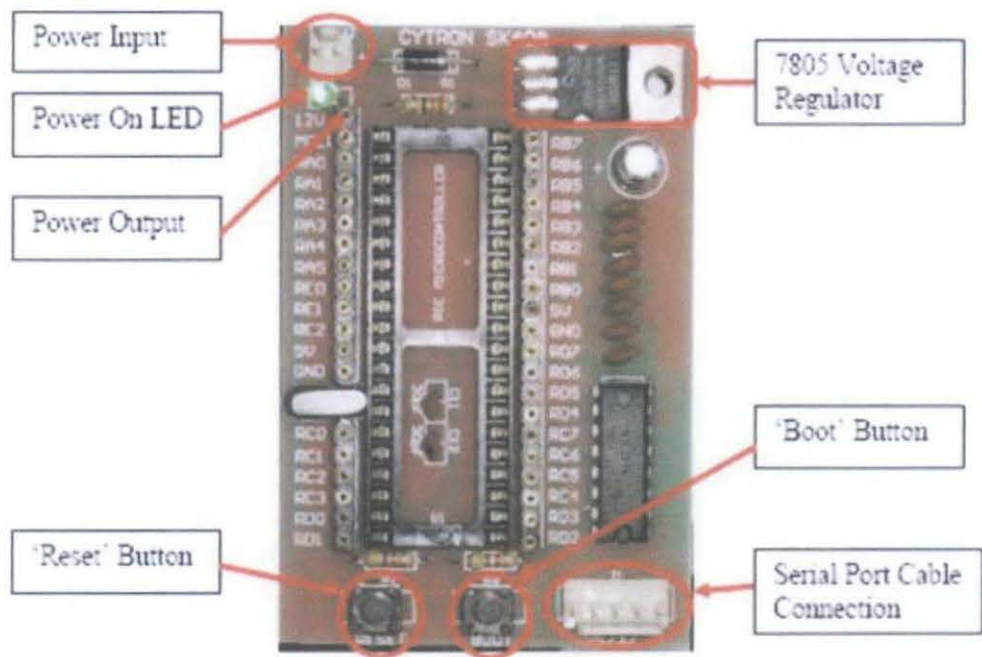
Figure 6: CYTRON SK40A PIC Programmer [11]

Figure 7: Schematic Diagram of SK40A PIC Programmer [11]

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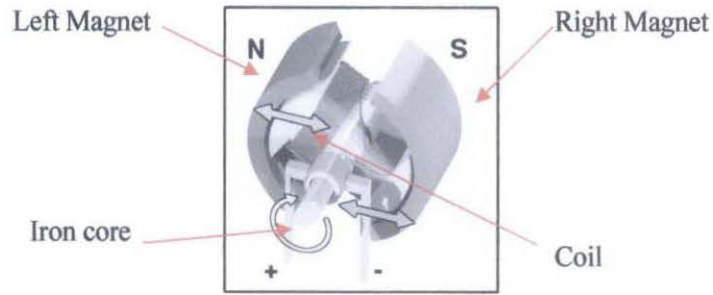
2.6   DC Motor

Figure 8:   Two Poles DC Motor[12]

A 12 Volt power window motor is one type of a standard DC motor. A DC motor is an internally commutated which designed to be run with existence of DC power source. When the coil is powered, a magnetic field is generated around the armature. The left side of the armature is pushed away from the left magnet and drawn toward the right, causing rotation. When a current passes through the coil wound around a soft iron core, the side of the positive pole is acted upon by an upwards force, while the other side is acted upon by a downward force [12]. Figure 8 shows the Two poles DC Motor Operations diagram.

According to Fleming's left hand rule, the forces cause a turning effect on the coil, making it rotate. To make the motor rotate in a constant direction, "direct current" commutators make the current reverse in direction every half a cycle thus causing the motor to rotate in the same direction [12].

2.6.1   Motor and Jack Specification

In order to ensure that the lifting system will work as expected, the calculation for the energy needed to lift up the expected load and the power of the motor was done. This calculation is made to guarantee that the chosen 12 Volt power window motor is capable to lift up the load. In the small scale prototype, it is expected that the system should be able to lift the load up to 10 kilogram including the weight of the garage floor.

The power needed for a motor to lift up a load of M kg by distance d m is given by

$$P = \frac{Mgd}{t}$$

P = Power motor needed

M = Total mass of the load

g = Gravitational force, $9.81 ms^{-2}$

d = Lifting distance

t = Time taken

where g is gravitational force with value equal to 9.81 ms^{-2} and t is the time taken to lift up the load. If it is required to lift up the load of 10 kg through a distance of 0.1m, in 10 s, then the chosen motor must have 1.315×10^{-3} hp. So for the prototype, it can be concluded that the power for 12 V power window motor which is equal to 31.2 Watt or 4.1×10^{-2} Hp is sufficient enough to drive the jack and lift the 10kg load up to 10 cm.

In real life application, considering total weight of Proton Wira car and garage floor is 2370 kg, then to lift up the car by 1 m in 200 s would require a motor with 0.156 hp. However the factors such as friction of the jack, environmental conditions (for example, water condition) in the garage should be taking into account. Therefore, a motor with much bigger horsepower is needed in order to run the system.

2.7   Limit switch

Mechanical limit switches are contact sensors widely used for detecting the presence or position of objects in industrial environments. These products offer high precision in terms of accuracy and repeatability, due to the fact that physical contact is made with the target. Limit switches can be modular, with a variety of interchangeable components, or a self-contained, single-piece switch. In addition, this switch is easy to connect to microcontroller because they are either off or on, making them digital. Limit switch can be set up to turn on when the switch button is depressed and turn off when the button is released, or set it up the opposite way. It has three pin out which are Normally Close (NC), Normally Open (NO) and Common (C). The limit switch for this project will be mounted directly on top of the power window frame and it is activated when the window glass strikes the switch to stop the motor. Figure 9 shows a typical circuit for a limit switch connection. The resistor is important because it holds the signal line at ground while the switch is off. Without it, the signal line is effectively floating because there is nothing connected to it, and may cause unreliable readings as the processor tries to decide if the line is on or off. The limit switch connection diagram shown in figure 9.
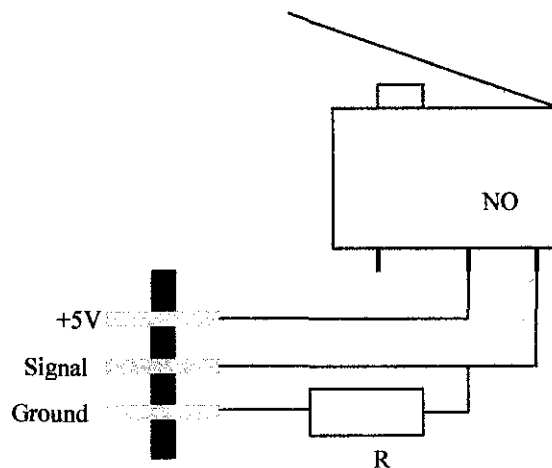
Figure 9: Limit switch connection diagram

2.8 PIC Programming

Programming process will involve 6 steps which are;

1. Analyze the Problem
2. Develop an Algorithm
3. Document the Program
4. Write Code for the Program
5. Run the Program
6. Test the Results

As stated in Structured Programming Approach Using C by Behrouz and Gilberg, a program is a set of step-by-step instructions that directs the computer to do the desired tasks and produce the results. A programmer must know what information will go into the software, how it will process the information, and what will result. All software must work with three concepts to be successful:

- Input: Information that comes from an external source and enters the software.
- Processing: Manages information according to a piece of software's logic. Processing is what the software does to the input it receives.
- Output: The information software produces after it has processed input. Output can appear on a computer screen, in a printout, or in records in a database.

Therefore, a logic flowchart has been produced for this project after analyzing the problems. The next steps that will be taken are producing the pseudo code, algorithm, document the program, write the code and test the program. After that, the code produced will be programmed in the PIC 16F877 before it can be implemented to the whole system.

Micro C program is used to write the code in C language to control the movement of stepper motor. The program is written to receive different inputs from the two water level detector circuits and the limit switch. The advantage of using C language rather than using Assembly Language is that no requirement needed to program each memory allocation while in assembly language, each memory allocation needs to be

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defined. Complete PIC code for Microcontroller can be found at Appendix D & E. The flowchart on how to program a microcontroller is shown in Figure 10.
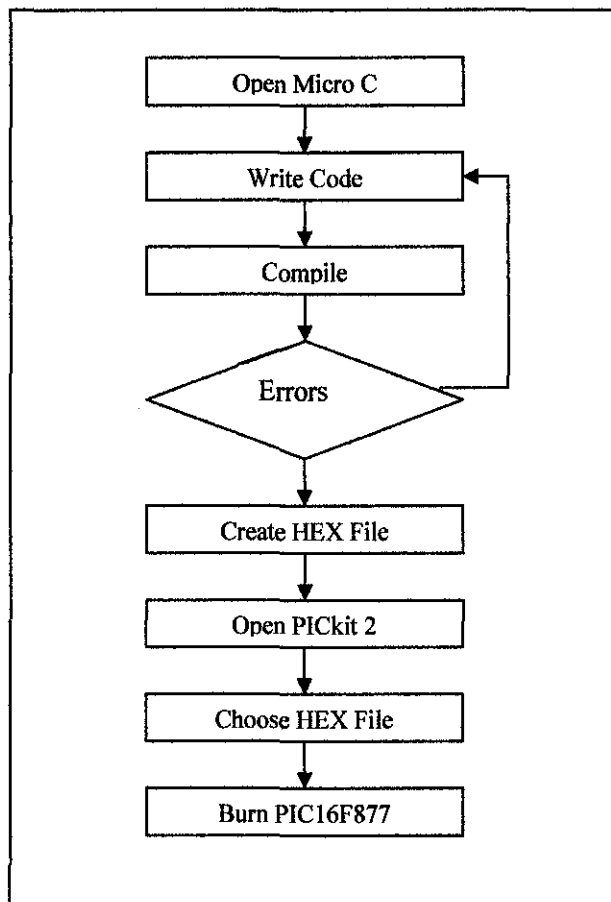
Figure 10: Flow Chart to Program the Microcontroller

For FPGS project, the programming flowchart is shown in figure 11.
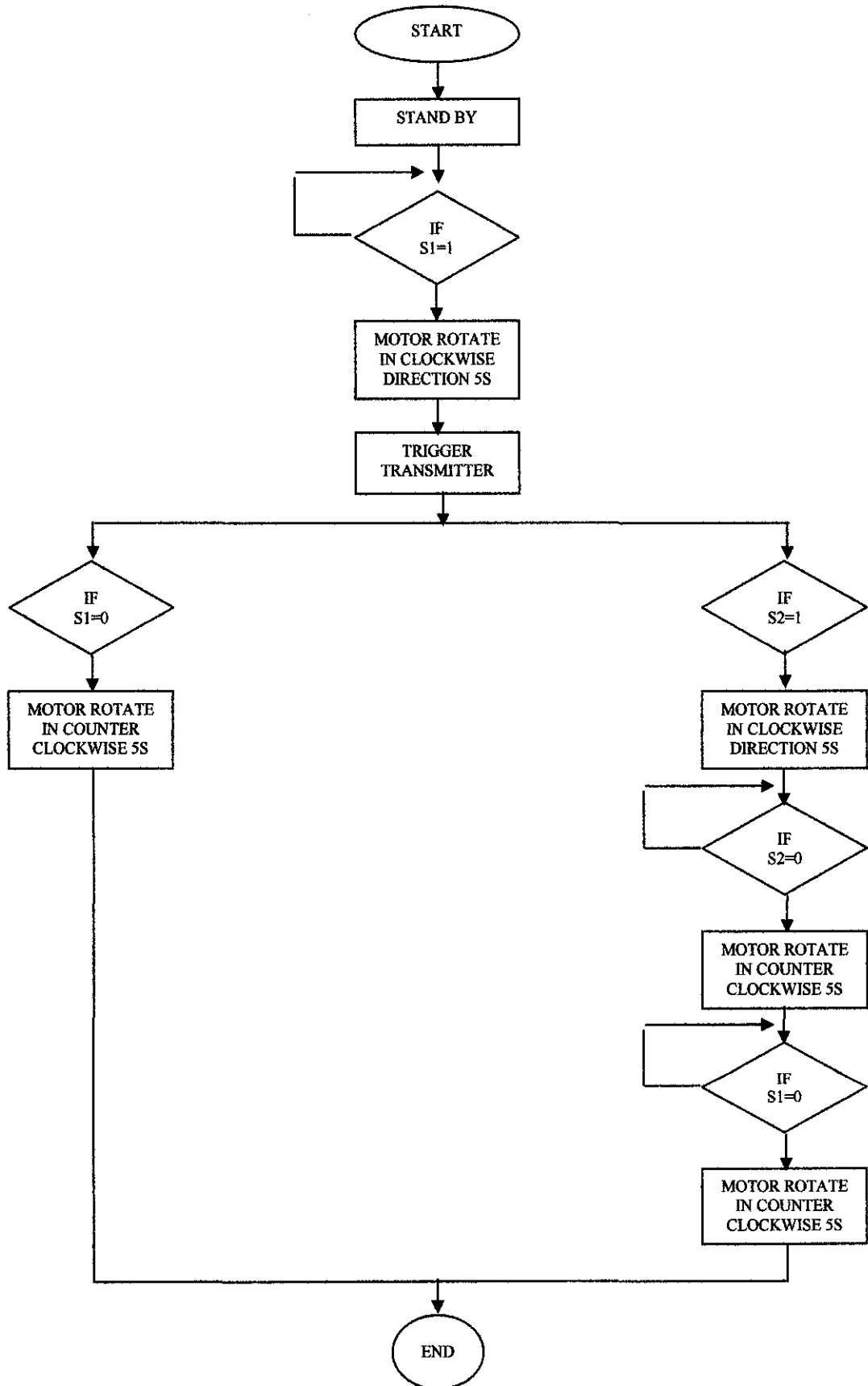
Figure 11 : FPGS Programming Flow Chart

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At the beginning, the system will be at standby mode. Then the system will check the condition of sensor 1. If sensor 1 is activated, the system will trigger the motor to rotate in clockwise direction for 5 second. At the same time, RF transmitter will send signal to the receiver to activate the LCD circuit. The system then will check the condition of sensor 1 and sensor 2 whether the flood level is increase or decrease. If flood level is increase, sensor 2 will activated and the motor will rotate in clockwise direction for another 5 second but if sensor 1 is deactivated, motor will rotate in counter clockwise direction for 5 second and back to standby mode. At the maximum high level, the system will keep on checking the condition of sensor 2 whether the flood is decreased or not. If sensor 2 is deactivated motor will rotate in counter clockwise direction for 5 second to level 1 and when sensor 1 also deactivated, means that the flood is over, motor will rotate another 5 second in counter clockwise direction and back to the standby mode.

2.9   Radio Frequency Module

Since FPGS project is dealing with a RF transmission, the 315 MHz RF transmitter and receiver module are use to trigger the output of this system. In this case, the low cost RF transmitter receiver module from Cytron technology is used to transmit signal up to 100 meters (the antenna design, working environment and supply voltage will seriously impact the effective distance). This transmitter is good for short distance with benefits of:

• Wide input supply (2.5V-12V)
• Easy to integrate (Data, Vcc and GND)
• Device in deep sleep mode when Data pin is grounded
• Very small dimension

Figure 12 shows the 315 MHz Cytron Transmitter module and Table 3 shows in details the specification of 315 MHz transmitter module.
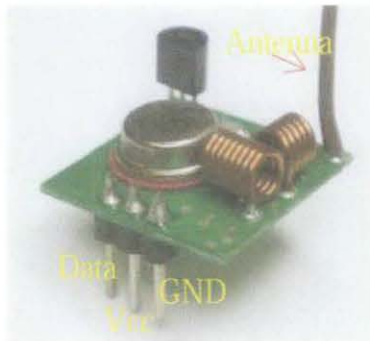
Figure 12: 315 MHz Transmitter Module

Table 3: Specification of 315 MHz Transmitter Module

Operating Voltage	2.5 V to 12 V
Operating Current	4mA @ 5V, 15mA @ 9V
Quiescent Current	10uA
Operating Temperature	-10°C – 60°C
Modulation	ASK
Max Data Rate	9.6K
Data Input	TTL
RF Power	20mW @ 5V

For the receiver part, the 315 MHZ RF receiver module is used to receive signal from 315MHz transmitter. This receiver is equipped with super regeneration design to ensure that it will still receive the signal even the signal is weak. Figure 13 shows the 315 RF receiver module and Table 4 shows in detail the specification of the 315 RF receiver module.

Figure 13: 315 MHz Receiver Module

Table 4: Specification of 315 MHz Receiver Module

Operating Voltage	4.5 V to 5.5 V
Operating Current	4mA @ 5V
Operating Temperature	-10°C – 60°C
Sensitivity	-10dBm
Max Data Rate	4.8K
Data Output	TTL

2.10   Available Product

There are some flood protection products available in the market today such as The Door Flood Barrier System [13] and the Flood Guard System [14]. These two systems utilize the concept of preventing the water from entering the houses by installing a barrier on the front door or on the airbrick on the wall of the houses.

Figure 14: Flood Guard System

The easy installation has made these products marketable in the United Kingdom market but these products can only be fitted into modern houses and it is not suitable for the wooden houses since the water can still passes through the gaps in the wooden houses. The other thing is these products have been designed to protect the houses during the flash flood, means that these product can only prevent the water from entering the house for short period of time and it is not suitable if the flood event took more than a day which is always happened in Malaysia. Unlike These two available products, the FPGS is suitable for both wooden structures and the brick structures because the concept of the system is not to prevent the water from entering the garage but to protect the valuable things inside the garage. This system is also expected to run continuously for a longer period of time without changing the batteries.

CHAPTER 3

METHODOLOGY
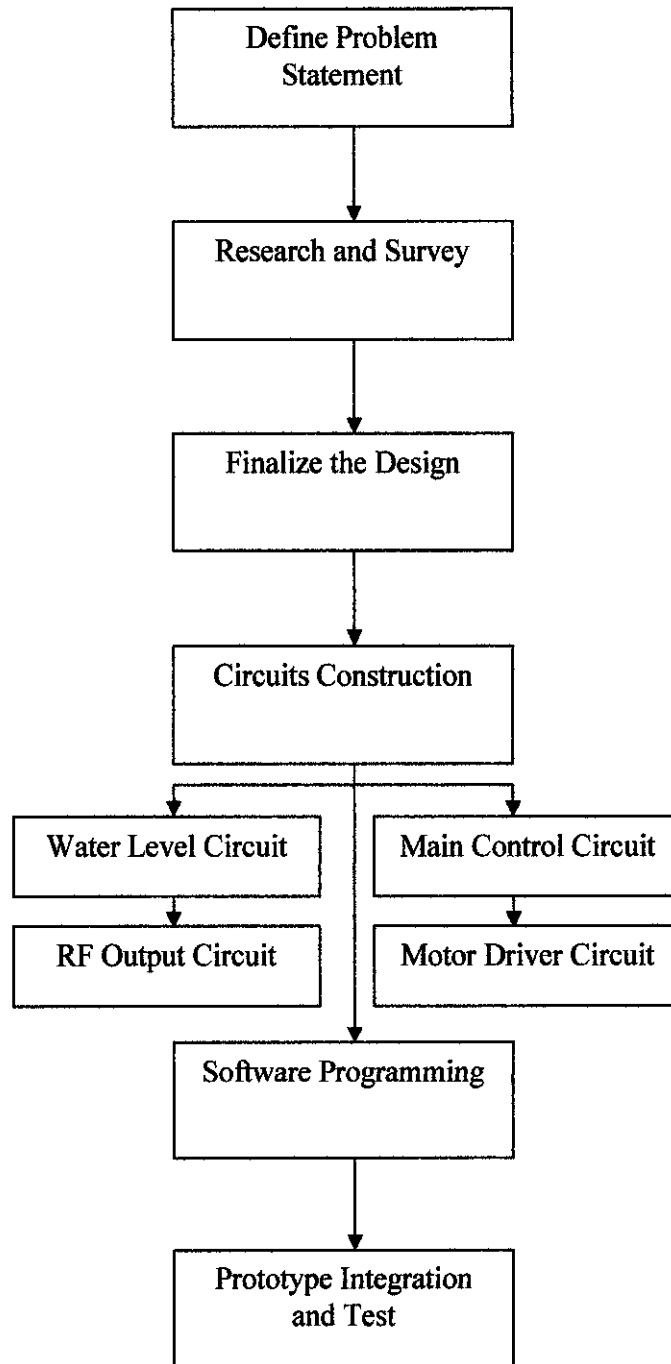
Figure 15: Project Workflow

The next paragraph will describe detailed about the FPGS project workflow according to Figure 15.

Define problem Statement

In order to begin the project, the most important things is to define the problem statement. It is because, with the problem statement, the objectives of the project are defined. This objective will be the solution for the problems.

Research and Survey

The research and survey is to be done to ensure the best project solution. The research and survey include the hardware, the software and the cost of the materials and components that are going to be used.

Finalize the Design

After the problem statement has been clearly defined and the research and survey have been conducted, the design will be finalized. This will include the calculation for design parameters as well as design of the garage prototype.

Circuit Construction

For this stage, the designed circuit will be drawn and simulated in the PSpice software and then constructed on the breadboard. The circuits that need to be constructed are two water level detector circuits, main control circuit, RF output (LCD) circuit as well as motor driver circuit. When the circuits have been constructed, those circuits will be tested to run individually before creating Gerber file for making printed circuit board (PCB)

Software Programming

For the software programming stage, the components are assembled and the PIC which is the brain of this project will be programme to control the rotation of the motor to drive the jack and lift up the garage floor and also trigger the transmitter. In this project, C coding will be used as the source code to program the PIC.

Prototype Integration and Testing

This stage combines all the systems as a working prototype. The test will be conducted so that the design programming is match with the hardware. The modification will also be made at this stage to ensure the prototype is more effective, efficient and working properly.

3.1 Tools Required

For the implementation of the project, several tools are required to be used to attain the goals.

Hardware

- Water level sensor circuit
- PIC Microcontroller
- Jack
- 12V DC motor to drive jack
- Motor driver
- Wireless radio frequency transmission

Software

- PSpise software
  - To draw and simulate the designed circuit
- MicroC software
  - C language software for programming the PIC Microcontroller
- SK40A PIC Programmer
  - The burner to burn the PIC Microcontroller
- Eagle Layout Editor
  - Schematic drawings and Gerber files creation to design the printed circuit board (PCB)

CHAPTER 4

RESULT & DISCUSSION

4.1   Project Architecture

The specific architecture of FPGS is similar to the block diagram shown in figure 16 where it start with two level sensor which will sense the presence of water then it will send signal to the main control circuit to process the instruction sets.
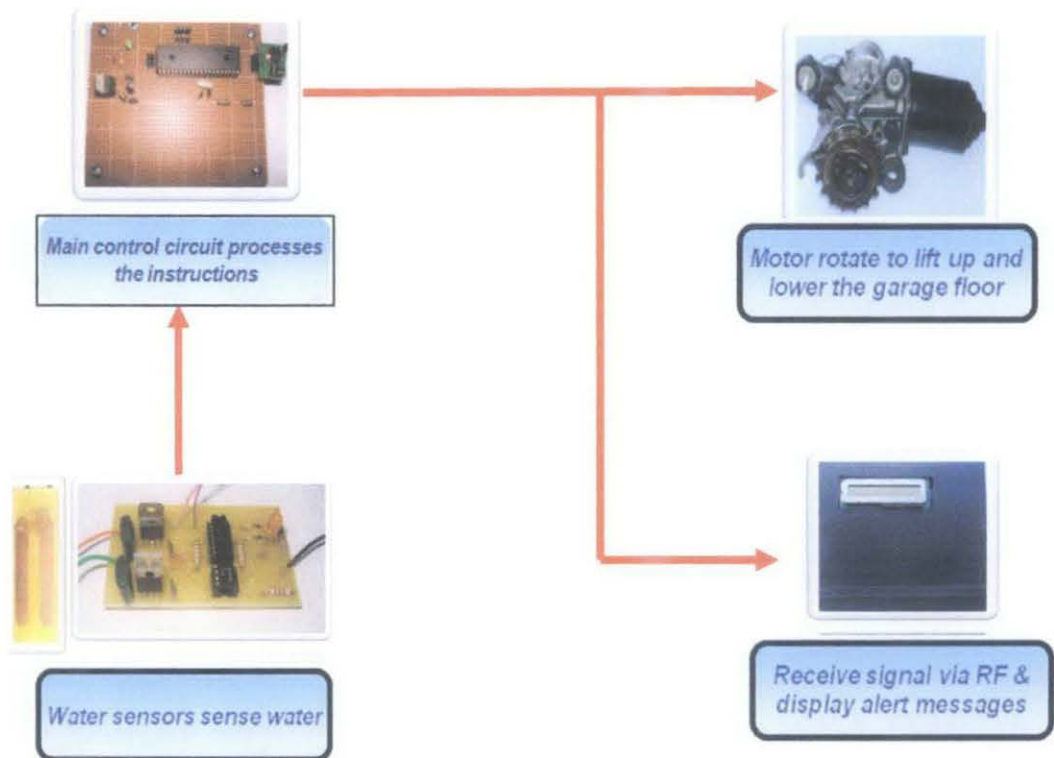
Figure 16: Project Architecture

When the signal is received, the control circuit will rotate the motor either in clockwise or anti clockwise direction depending on the water level sensor. In FPGS project, the sensor 1 is placed on the ground level where sensor 2 is 4 cm above the ground level. If water level is at level 1, the garage floor will be lift up to 5 cm and while the water increased to level 2, the garage floor will be lift up for another 5 cm. At the same time, the microcontroller will trigger the RF transmitter to transmit signal to the RF receiver and the output of the receiver will be the alert messages in order to inform owner of the garage about flood.

4.2   Water Level Sensor Circuit Construction
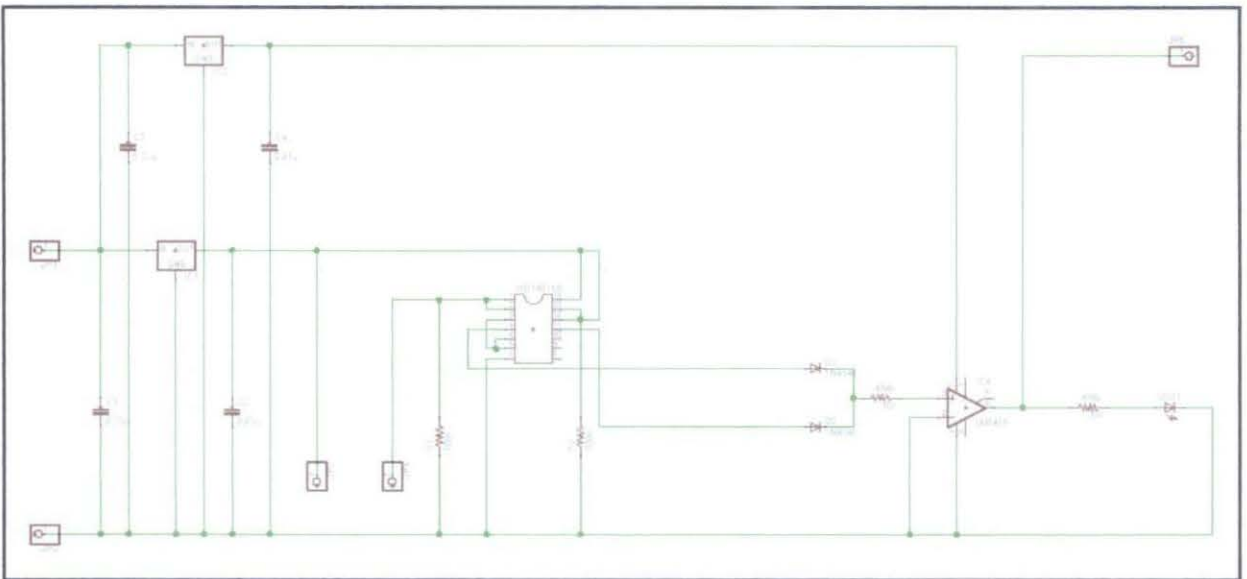
Figure 17: Schematic Diagram for Water Level Sensor

The water sensor circuit has been constructed based on the schematic in Figure 17. This sensor circuit used 12 Volt source as an input signal and the LED as the output. When both sensor cables are immersed in water, the water as conductor will closed the circuit thus making a complete sensor circuit and LED will light up as the output. When the sensor cables are removed from the water, the connections is break off and turn off the LED. The sensor circuit constructed on breadboard is shown in Figure 18.

31
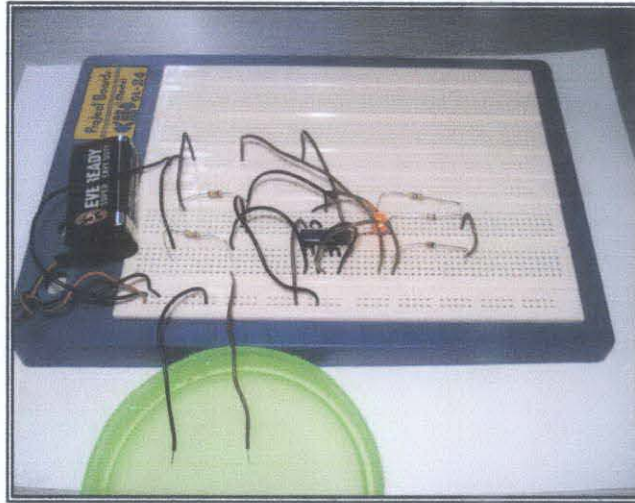
Figure 18: Constructed Water Level Sensor

4.2.1 Creation of Gerber File

A Gerber File is a standard file format used by printed circuit board (PCB) fabrication houses that contains information necessary for computer controlled machines to draw exact patterns for circuit boards The software, EAGLE 4.13 is use to create schematics and Gerber files. When making an actual printed circuit board based on data made from Computer Aided Design (CAD), the data of Gerber form are used in many cases. Gerber data are the data formats which a photograph plotter maker's Gerber Scientific Instrument Company created. All the information (the position of holes, size, thickness of lines and etc) for automating manufacture of a printed circuit board is numerically expressed with Gerber data.

Gerber form is standardized as CAD output data of a printed circuit board. The printed circuit board data created by EAGLE are the form only for EAGLE. It is not Gerber form. Figure 19 shows the Gerber file layout of the water level sensor circuits. Those entire layouts were designed by using a single layer routing which means that the wire pattern is printed only on a bottom layer of the PCB.
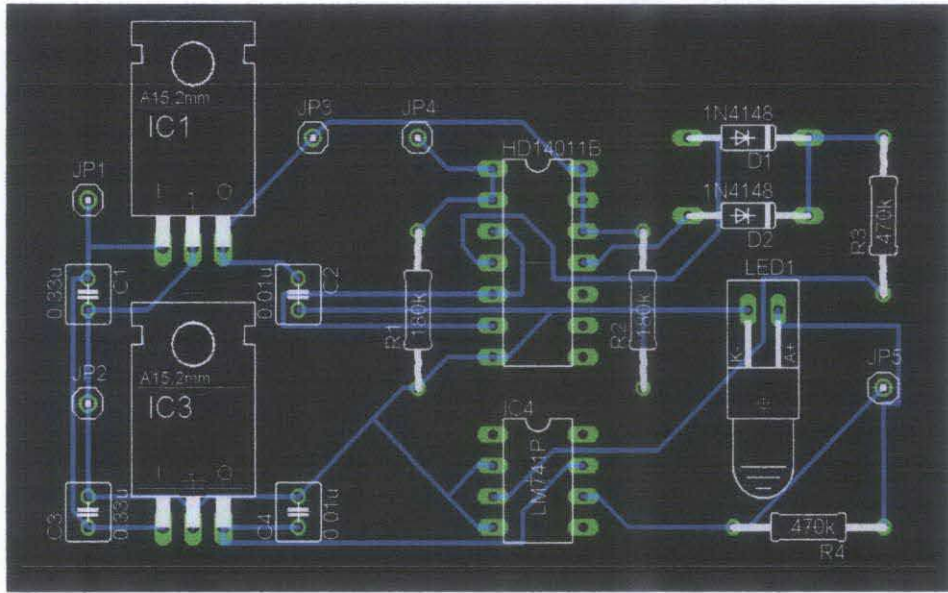
Figure 19: PCB Layout for Water Level Sensor Circuit

4.2.2 Construction of Circuits on PCB

From the Gerber that has been created, the PCB's have been designed from the Gerber files using CAM processor function in Eagle software, the complete circuits are then constructed on those PCB's. Figure 20 shows the constructed Water Level detector circuits on PCB.
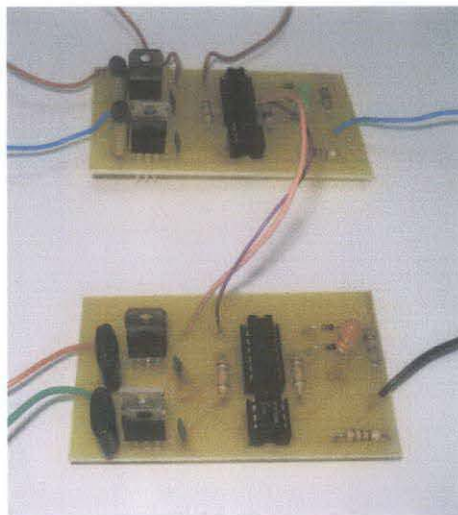
Figure 20: Constructed Water Level Sensor Circuits on PCB

4.2.3   *Water Sensor Output Test*

In order to ensure that the water sensor will sense the presence of water even with difference concentration, a test is conducted by measuring the output voltage and the resistance of three different concentration of water. Three type of water that was tested are plain water, salty water and muddy water. This test is conducted to ensure that the sensor can work in the worst case scenario. The salty water represents the sea water and the muddy water represents the sludge of the flood. The resistance values and output voltages of different type of water are shown in Table 5.

Table 5 : Measured Output Voltage for Different Type of Water

No	Type of Water	Resistance of Water	Output voltage
1.	Plain water	5.09 MOhm	4.25 Volt
2.	Salty water	5.28 MOhm	4.25 Volt
3.	Muddy water	15.05 MOhm	4.25 Volt

Table 5 shows that with different type of water having different value of resistance, the output of the circuit still maintain at 4.25V. Thus it can be concluded that the output of the circuit is not dependent to the resistance of the water. As long as there is continuity in the water, the circuit will function well. According to the PIC16F877 specification datasheet, approximately 2 V is needed to detect a signal as the input of the controller [9] so, by having the output voltage maintain at 4.25V, this sensor circuit is believed to work even in the worst case conditions.

4.3   Voltage Regulator Circuit
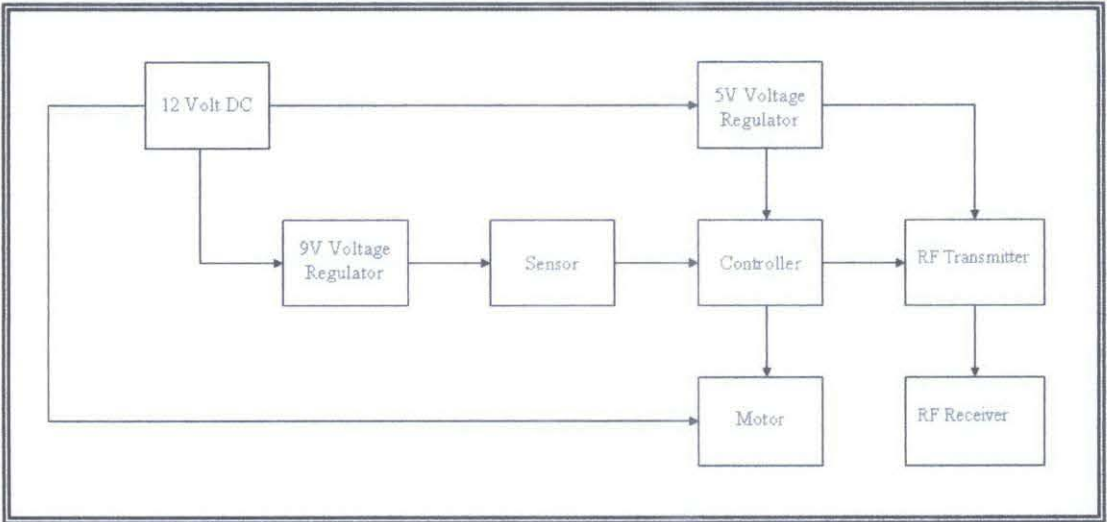
Figure 21: Block Diagram of FPGS

Referring to the block diagram of FPGS in Figure 21, the voltage regulator is needed to convert 12 Volt DC supply to 9 Volt DC for water level sensor circuits and 5 Volt DC for PIC and transmitter circuit. In order to convert 12 Volt DC to 9Volt DC and 5Volt DC, two voltage regulator circuits have been constructed using two different type of voltage regulator IC. Figure 22 shows the circuit diagram for 9 Volt voltage regulator circuit using LM78L09 and figure 23 shows the circuit diagram for 5 Volt voltage regulator circuit using LM78L05.
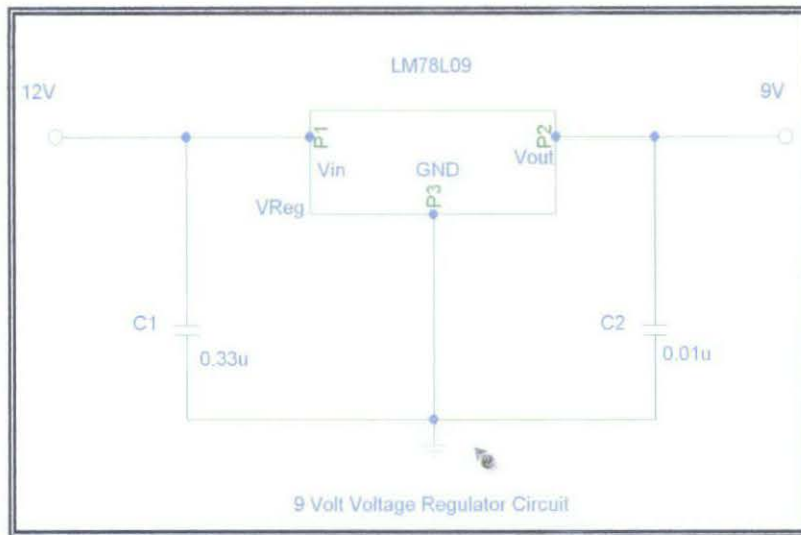
Figure 22: 9 Volt Voltage Regulator Circuit
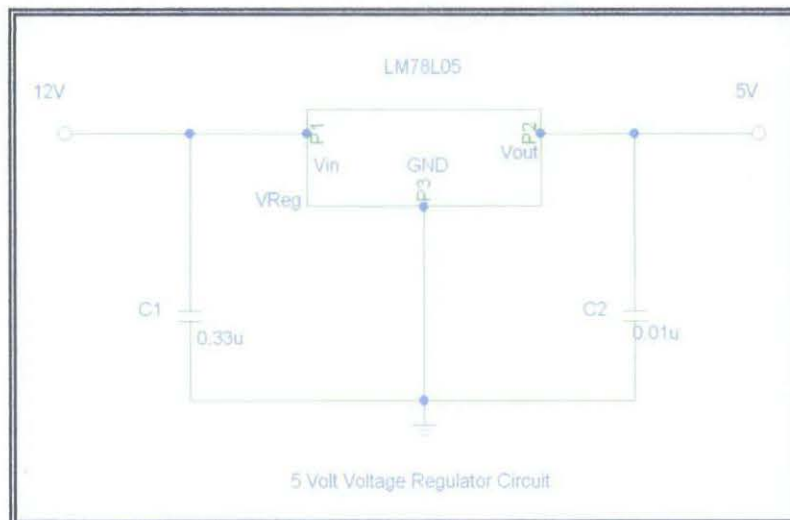
Figure 23: 5 Volt Voltage Regulator Circuit

4.3.1 Voltage Regulator Functional Test
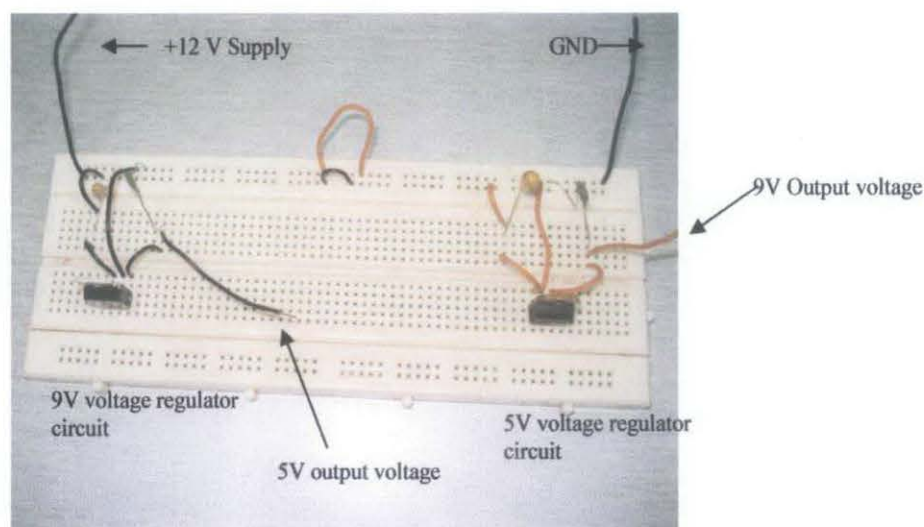
Figure 24: Constructed 9V and 5V Voltage Regulator Circuits

A functional test was conducted for voltage regulator circuits as shown in Figure 24. Here, the 12 Volt supply from car battery is connected parallel to the input of the 9 Volt voltage regulator circuit and 5 Volt voltage regulator circuits to ensure that both circuits will have the same supply input which is 12 Volt. Results on the test are shown in table 6.

Table 6: Expected and Measured Output Voltage for Voltage Regulator Circuits

No	Type	Expected Output Voltage	Measured Output Voltage
1.	9 Volt voltage regulator	9.0 Volt	8.89 Volt
2.	5 Volt voltage regulator	5.0 Volt	5.0 Volt

According to the table 6, it shows that the constructed voltage regulator circuits have been able to produce 9 Volt and 5 Volt output voltage from 12 Volt DC supply as expected but, further test will be conducted to ensure that the output current is sufficient to power up the water level sensor circuits, PIC and also for transmitter circuit.

4.4   Main Control Circuit Construction

A main control circuit is the brain of this project which consists of PIC circuit and motor driver circuit. The motor driver circuit is used to control the left and right motors respectively. The PIC will send the output signal to the motor's input to drive the motor. The H-Bridge circuit is supplied by 12 Volt external voltage as a microprocessor cannot drive a motor directly due to insufficient current.

Although, the PIC can be used as current sinking or current supplying, but it is more efficient in current sinking. Therefore all water level sensors are connected to PIC as external input which supplies the current. If the sensor is triggered, the PIC will detect the received signal and take action based on the programming code. Figure 25 shows the schematic diagram for the main control circuit and figure 26 shows the constructed main control circuit on veroboard.
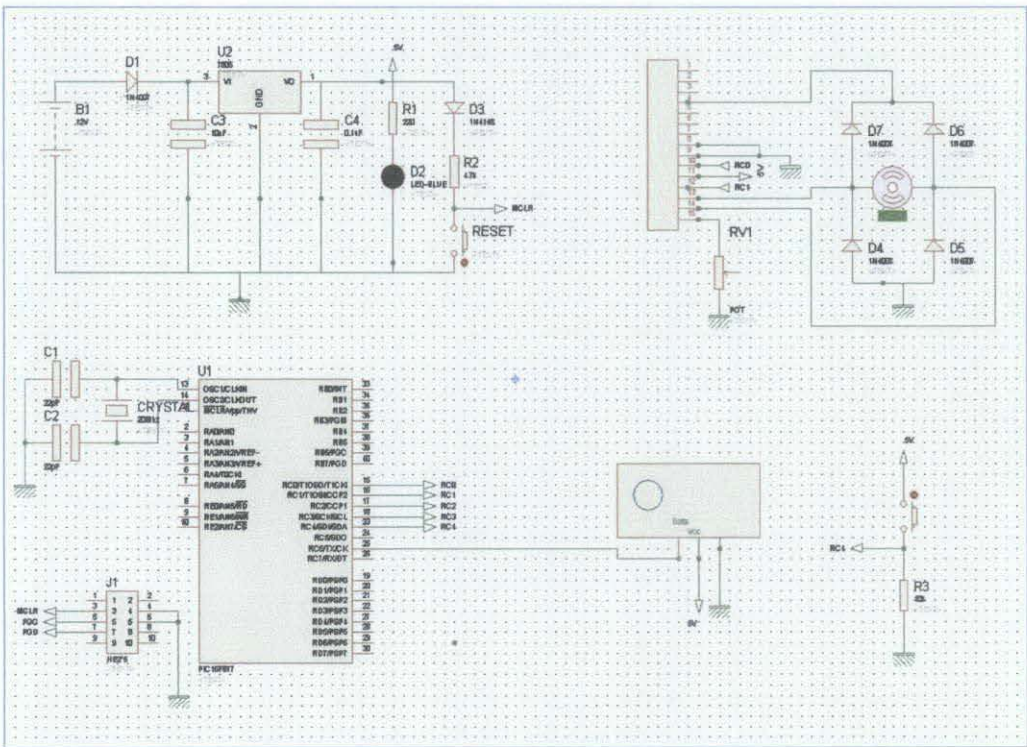
Figure 25: Schematic Diagram of Main Control Circuit
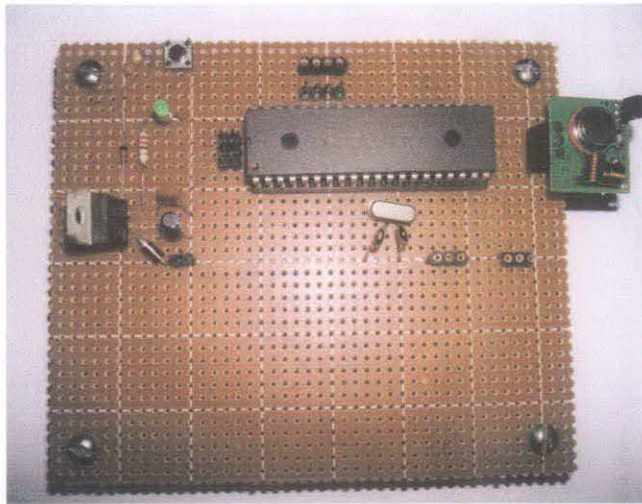
Figure 26: Constructed Main Control Circuit

4.5   LCD Output Circuit Constructions

As been discussed previously in the objective and scope of study section, one of the objective of this project is to have the output of the system that can be used to alert the owner about water flooding. To achieve this objective, the output circuit has been constructed. This circuit will have the LCD as a text display to inform the owner of the garage about the water level. This output circuit is controlled by the PIC to display the text. When the RF receiver receives signals from the RF transmitter circuit, it will trigger the PIC to process the instruction as in the output programming code. Figure 27 shows the schematic diagram for LCD output circuit and figure 28 shows the constructed LCD output circuit.
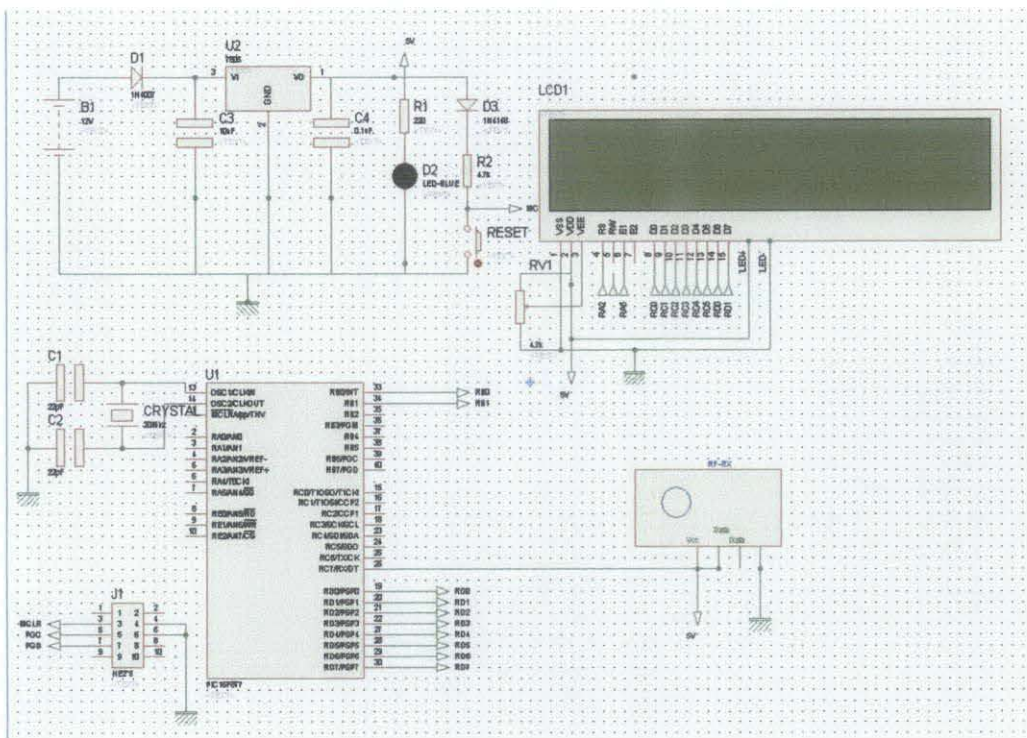
Figure 27: Schematic Diagram for LCD Output Circuit
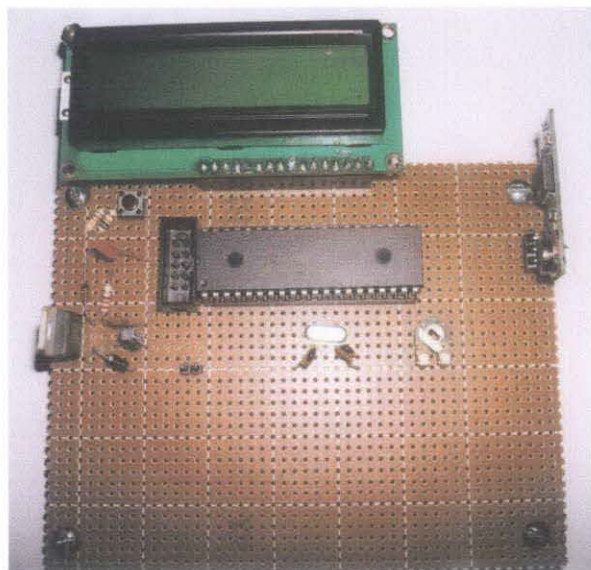
Figure 28: Constructed LCD Output Circuit

4.6 Motor Driver Circuit Construction

A motor driver is an electronic circuit which enables DC electric motors to be run forwards or backwards. These circuits are often used in robotics. These drivers are available as integrated circuits, or can be built from separate components. In this project, L293B driver is used to drive the 12V dc motor either to be forward or reverse operation. Two enable inputs are provided to enable or disable the motor independently of the input signals. These two inputs are droved by the signal from the microcontroller as to enable the changes of the power window motor direction. Figure 29 shows the constructed L293B motor driver circuit.
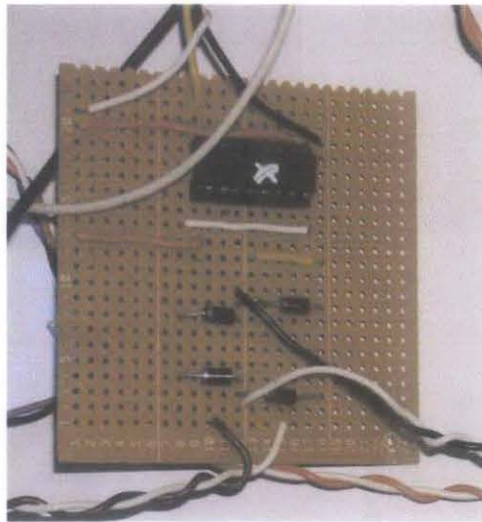
Figure 29: Constructed Motor Driver Circuit

4.7 Construction of Garage Prototype

Based on the project drawing in Appendix A, a garage prototype for FPGS is constructed using carbon type of steel. The construction stage is divided into two stages. The first stage is a construction of the garage floor with jack only. For this stage the jack is constructed and tested to lift the load manually. At this stage, the garage floor can be lift up an down as expected by turning the jack shaft clockwise to lower down the garage floor and vice versa. Figure 29 shows the first stage of garage prototype construction and Figure 30 shows the second stage of garage prototype construction.

Figure 30: First Stage of Garage Prototype Construction

The second stage is a construction of the base for the motor and the control circuit. At this stage, the power window motor is mounted to the garage prototype and the motorcycle chain's has been used to attach the motor to the jack's shaft. This prototype was tested to run with 12 V power window motor and as a result, this 31 Watt power window motor is capable to lift up the garage floor up to 20 cm. The circuits' slot is also designed on the garage prototype in order to place the control circuits.

Control circuits slot
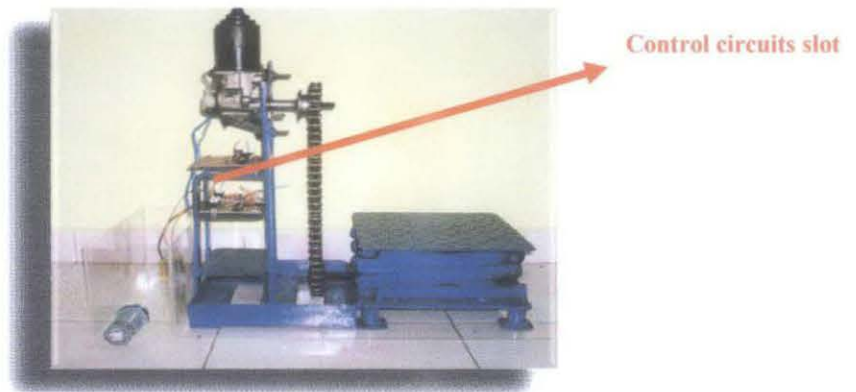
Figure 30: Second Stage of Garage Prototype Construction

4.8   Problem Identification

Throughout the circuits' construction, all constructed circuits have been tested individually. From the test, all circuits were able to give the expected output. For example, the main control circuit was able to give the output of 4.84 Volt which is sufficient enough to trigger the motor driver circuit which needs approximately 4 to 5 Volts. The motor driver circuit also gives the expected output which is around 11V to 12V to drive motor when the input of PIC has been triggered. Figure 31 shows the result of the main control circuit output test and Figure 32 shows the motor driver circuit output test.
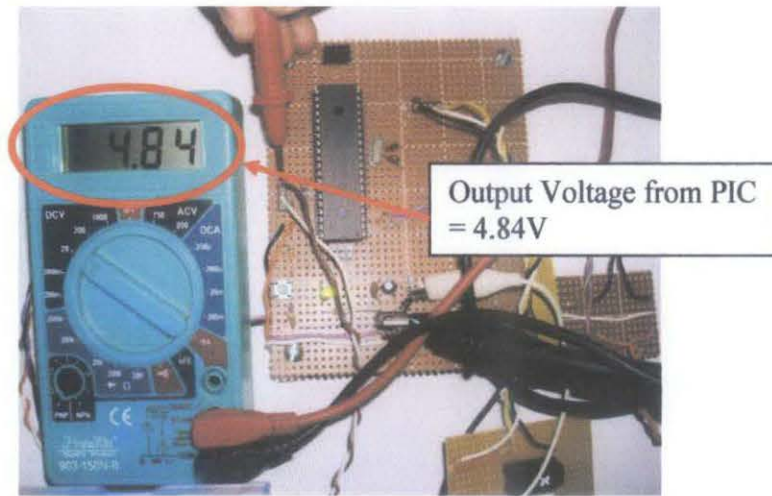
Figure 31: Main Control Circuit Output Voltage
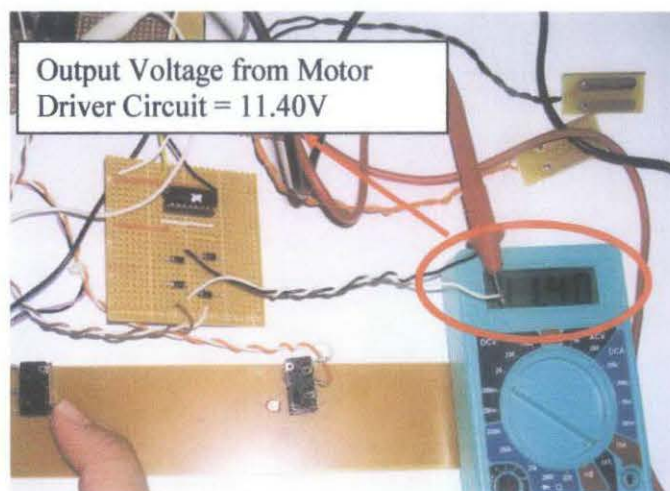
Figure 32: Motor Driver Circuit Output Voltage

The problem occur when its come to the hardware and software integration and test stage where the current flow through the motor driver circuit is very high which is equal to 2.2 A. The maximum allowable current limit for the L293B is 2.0A. So, by having current that exceed the maximum allowable limit of the motor driver L293B has caused the motor driver IC became overheat and burn. So as a solution to this problem, it is proposed to add the 5V relay circuit as a driver circuits triggered by L293B motor driver circuit. This is means that the output of L293B motor driver circuit will be used to trigger the relay circuit to drive the motor. By using this method, the problem of high current flow through the L293B motor driver circuit will be eliminate since only minimum current will be used to trigger the relay circuit.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

The implementation of Flood Protection Garage system is completed. Through all development stages and organized planning, the project has partially met its objective to protect vehicle and other valuable properties inside the garage from water flooding. The constructed circuits were able to give the expected output when its tested individually but the problem occur when its come to the hardware and software integration and test stage where the current flow through the motor driver circuit is exceed the maximum allowable limit thus damage the motor driver IC. The RF receiver also give the expected output but some modification need to be done to ensure that FPGS system will fully utilize the LCD function to meet the objective which to alert the owner of the garage about flood so that appropriate action can be taken in order to safe valuable properties as well as to safe their life in case of the flood became worst.

From the prototype testing, the system is able to lift the load of 2 kg by distance of 10 cm. this is due to the heavy weight of the jack itself which is 15kg. The heavy load has increased the friction of the jack thus more power is needed to raise the garage floor. So In real world application, even though through calculation, the power of power motor needed to raise the garage floor with load of 2370 kg up to 1 m is only 31.2W, but taking into account about factors such as friction of the jack and environmental conditions (for example, water condition) in the garage, a motor with much bigger horsepower is needed in order to run the system for better efficiency. So FPGS is believed to be implemented in the real world and it will work

even in a worst case conditions. Besides it will also be marketable since this system can be expanded to the basement installation.

As a whole, it can be concluded that the FPGS project has partially reach its objective but it is admitted that this prototype still has its own deficiency and still lack of some good aspects. Some recommended features can be added in this system to make the project more reliable, effective and secured. Instead of using pulley and chain, it is recommended that in a real world application the hydraulic jack to be used for better efficiency, safety as well as ease of maintenance. The ways the system alerts the owner regarding the flood can also be improved by utilizing short messaging system (SMS). This may ensure that the owner can still receive the information even if he or she is not at home.

REFERENCES

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2007

APPENDICES

Flood Protection Garage System
Project Drawing

Motor

Sensor and
Controller
Circuits

Garage
Floor

Jack

Water
Detection
Pad

Pulley &
Chain
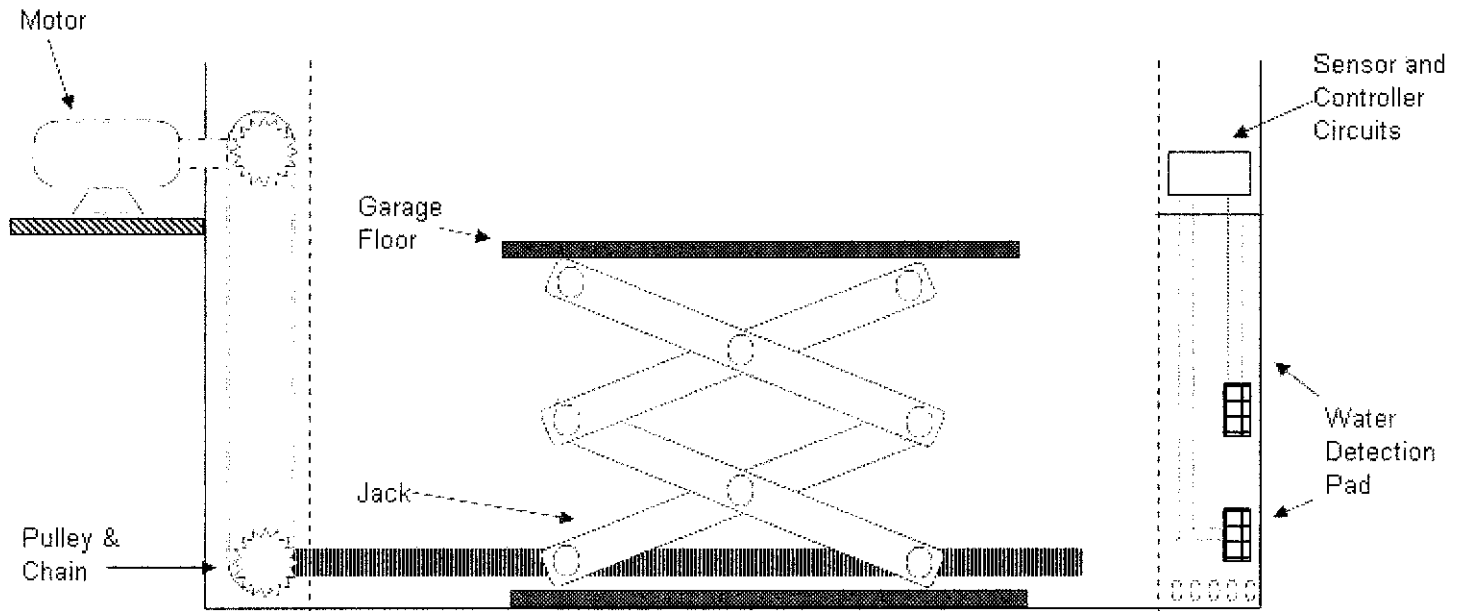
APPENDIX B: FYPI GANTT CHART

No.	Detail/Week	1	2	3	4	5	6	7	8	9	10	11	12	Mid-Semester Break	13	14
1	Selection of Project Topic	■	■													
2	Preliminary Research Work		■	■	■											
	2.1 Introduction															
	2.1.1 Background of Project		▓	▓												
	2.1.2 Define Problems Statement		▓	▓												
	2.1.3 Identify the Objectives		▓	▓												
	2.2 Literature Review		■	■	■											
	2.2.1 Available Product		▓													
	2.2.2 Sensor System		▓	▓												
	2.2.3 Wireless Transmission System			▓	▓											
	2.2.4 Microcontroller Module			▓	▓											
	2.3 Project Methodology				■											
3	Submission of Preliminary Report				■											
4	Seminar 1 (Optional)					■	■	■								
5	Project Work					■	■	■								
	5.1 Data Gathering and Lab Work					■	■									
	5.1.1 Sensor Circuit Construction					▓	▓									
	5.1.2 PIC chip research					▓	▓									
	5.1.3 Analyze the Programming					▓	▓									
	5.1.4 Motor and Jack Specification					▓	▓									
	5.2 Project Analysis						■	■	■							
6	Submission of Progress Report								■							
7	Seminar 2 (Compulsory)										■	■	■			
8	Project Work Continues								■	■	■	■	■			
	8.1 Voltage Regulator Construction								■	■	■	■	■			
	8.1.1 Construct and Test										▓	▓	▓			
9	Submission of Interim Report Final Draft (soft bound)												■			
10	Oral Presentation															■

APPENDIX C: FYPII GANTT CHART

NO	DETAILS	WEEKS															
		2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1	Sensors Circuits Construction	▓	▓														
2	Main Board Construction			▓	▓	▓	▓										
3	Programming							▓									
4	Program the PIC									▓							
5	Finalize Garage prototype										▓	▓					
6	Assemble and Troubleshooting												▓	▓			
7	Progress Report 1 (15/2/08)			●													
8	Progress Report 2 (21/3/08)							●									
9	Draft Report (17/4/08)											●					
10	Final Report & Technical Report (5/5/08)													●			
11	Oral Presentation (2-6/6/08)														●		
12	Final Report (20/6/08)																●

APPENDIX D: PIC PROGRAMMING FOR MAIN CIRCUIT

```
/*
 * Project name:
   Flood Protection Garage System
 * Done by:
   Mohd Fariz Ikram bin Mohd Nor @ Abdullah 5954
 * Description:
   The code demonstrates using library function for USART library
   to communication, Lcd8 library to LCD display and using the
   sensor to detect water
 * Test configuration:
   MCU:         P16F877A
   Dev.Board:   PICkit 2
   Oscillator:  HS, 20.0000 MHz
   Ext. Modules:   x
   SW:          mikroC v 2.1.0.0
*/




#define  motor_left     PORTB.F0
#define  motor_right    PORTB.F1
#define  sensor_level_1 PORTB.F2
#define  sensor_level_2 PORTB.F3
#define  limit          PORTB.F4

//--------------function prototype--------------------
void motor_up1();
void motor_up2();
void motor_down1();
void motor_down2();



//--------------main program-------------------------
unsigned int i;


void main()
{
TRISB.F0 = 0;
TRISB.F1 = 0;
TRISB.F2 = 1;
TRISB.F3 = 1;
```

```
  USART_Init(19200);              // Initalize USART (19200 baud rate, 1 stop bit, no
parity...)

  do {
   if (sensor_level_1 ==1)
       { motor_up1();              // motor up to level 1
         i = 1;                    // sent data to inform sensor level 1 now
       }
       else if((sensor_level_1 ==1) && (sensor_level_2 ==1))
       { motor_up2();              // motor up to level 2
         i = 2;                    // sent data to inform sensor level 2 now
       }
       else if((sensor_level_1 ==1) && (sensor_level_2 ==0))
       { motor_down1();            // motor down to level 1
         i = 3;                    // sent data to inform sensor level 1 now
       }

       else
       { while(limit == 0)
           {motor_down2();}        // motor down to level 0
         i = 4;                    // sent data to inform all in safe condition
       }


   USART_Write(i);                 // Send i reading as byte
   Delay_ms(100);
  } while (1);                     // endless loop
}




//-------------motor_up1-----------------------------------------

void motor_up1()
{
int i;
while( i < 100)

{ motor_right = 1;
  motor_left = 0;
  i =0 ;
  i++ ;
}
```

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```
}
//---------------motor_up2-----------------------------------
void motor_up2()
{
int j;
while( j < 100)
{motor_right = 1;
 motor_left = 0;
 j = 0 ;
 j++ ;
}


}
//----------------motor down1-------------------------------
void motor_down1()
{
int a;
while( a < 100)
{motor_right = 0;
 motor_right = 1;
 a = 0;
 a++;
}


}
//----------------motor down2-------------------------------
void motor_down2()
{
int a;
while( a < 100)
{motor_right = 0;
 motor_right = 1;
 a = 0;
 a++;
}
}
```

APPENDIX E: PIC PROGRAMMING FOR LCD OUTPUT CIRCUIT

```c
/*
 * Project name:
   Flood Protection Garage System
 * Done by:
   Mohd Fariz Ikram bin Mohd Nor @ Abdullah 5954
 * Description:
   The code demonstrates using library function for USART library
   to communication, Lcd8 library to LCD display and using the
   sensor to detect water

 * Test configuration:
   MCU:          P16F877A
   Dev.Board:    PICkit 2
   Oscillator:   HS, 20.0000 MHz
   Ext. Modules: x
   SW:           mikroC v 2.1.0.0
*/

unsigned short i;
char *text_1 = " LEVEL 1";
char *text_2 = " LEVEL 2";
char *text_3 = " LEVEL 3";
char *text_4 = " FPGS";

void main()

{

  TRISB = 0;
  TRISD = 0;

  USART_init(9600);              // initialize USART module
                                 // (8 bit, 9600 baud rate, no parity bit...
  Lcd8_Init(PORTB);              // Initialize LCD connected to PORTB

  while (1) {
    if (USART_Data_Ready())      // if data is received
    {
    i = USART_Read();            // read the received data
     if ( i == 1)
       { Lcd8_Cmd(LCD_CLEAR);              // Clear display
         Lcd8_Cmd(LCD_CURSOR_OFF);  // Turn cursor off
         Lcd8_Out(1,1, text_4);             // Print text to LCD, 1st row, 1st column
```

```
        Lcd8_Out(1,2, text_1);}              // Print text to LCD, 2nd row, 1st column

   else if ( i == 2)
   { Lcd8_Cmd(LCD_CLEAR);              // Clear display
     Lcd8_Cmd(LCD_CURSOR_OFF); // Turn cursor off
     Lcd8_Out(1,1, text_4);              // Print text to LCD, 1st row, 1st column
     Lcd8_Out(1,2, text_2);}            // Print text to LCD, 2nd row, 1st column

   else
   { Lcd8_Cmd(LCD_CLEAR);              // Clear display
     Lcd8_Cmd(LCD_CURSOR_OFF); // Turn cursor off
     Lcd8_Out(1,1, text_4);              // Print text to LCD, 1st row, 1st column
     Lcd8_Out(1,2, text_3);}            // Print text to LCD, 2nd row, 1st column


   }
   }
}
```

MICROCHIP

PIC16F87X

28/40-pin 8-Bit CMOS FLASH Microcontrollers

Devices Included in this Data Sheet:

- PIC16F873
- PIC16F876
- PIC16F874
- 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 and Industrial temperature ranges
- Low-power consumption:
  - < 2 mA typical @ 5V, 4 MHz
  - 20 µA typical @ 3V, 32 kHz
  - < 1 µA typical standby current

Pin Diagram
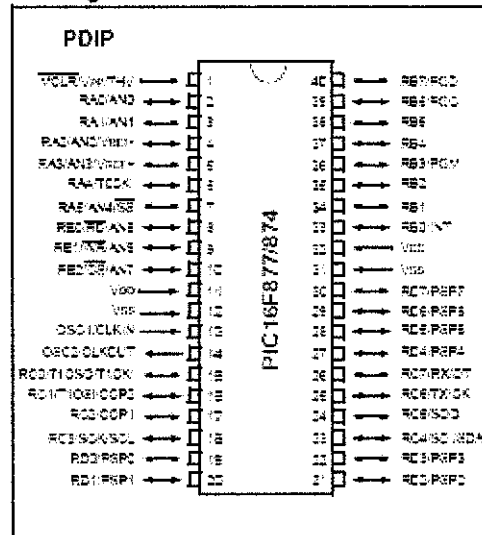
Peripheral Features:

- 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)

PIC16F87X

Pin Diagrams

DIP, SOIC

PLCC

QFP
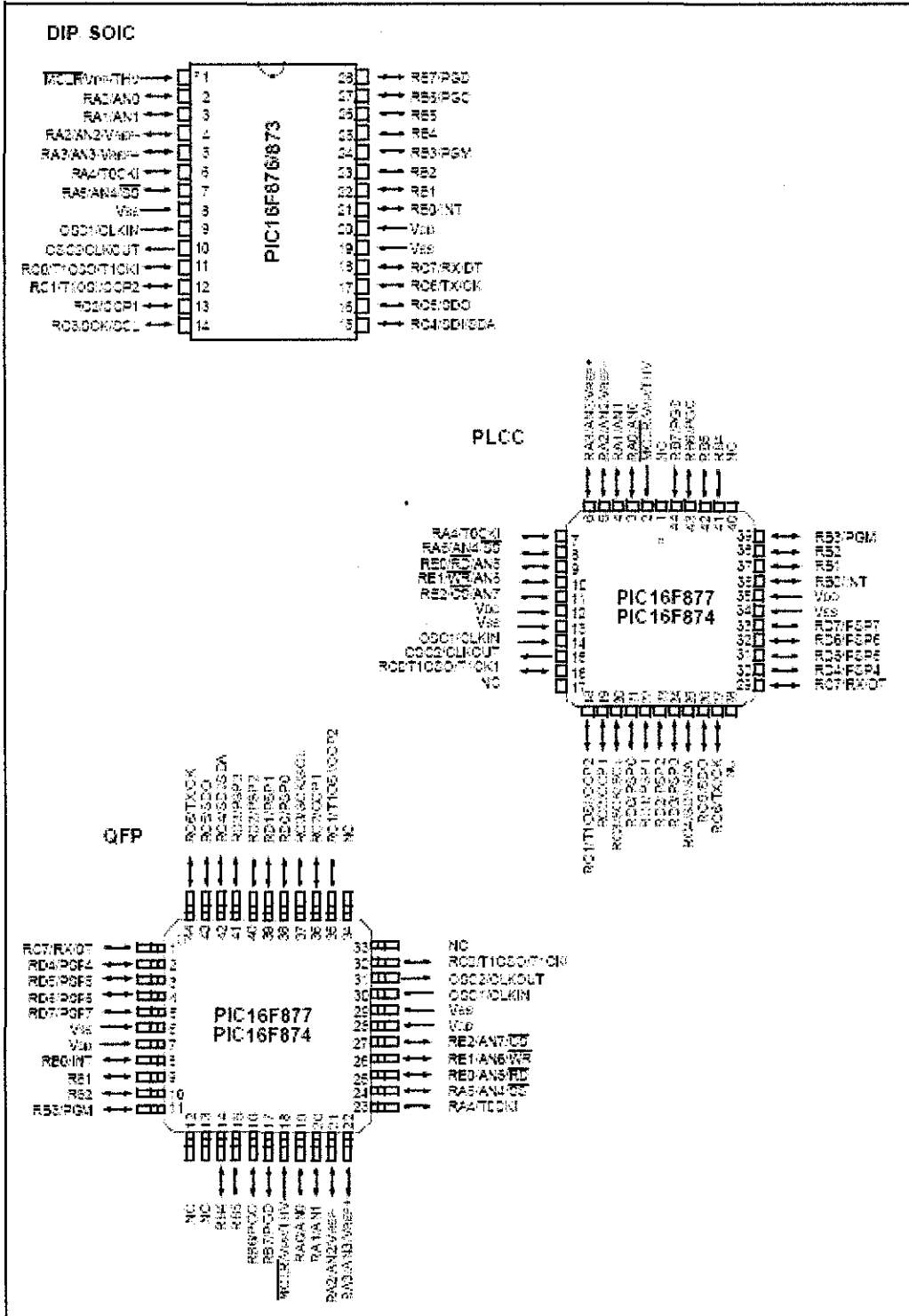
Key Features PICmicro™ Mid-Range Reference Manual (DS33023)	PIC16F873	PIC16F874	PIC16F876	PIC16F877
Operating Frequency	DC - 20 MHz	DC - 20 MHz	DC - 20 MHz	DC - 20 MHz
Resets (and Delays)	POR, BOR (PWRT, OST)	POR, BOR (PWRT, OST)	POR, BOR (PWRT, OST)	POR, BOR (PWRT, OST)
FLASH Program Memory (14-bit 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

60
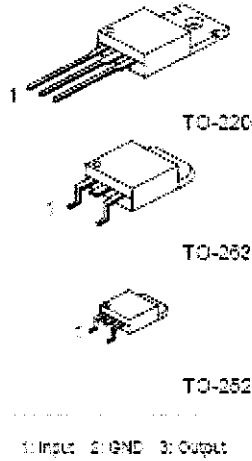
UTC LM78XX   LINEAR INTEGRATED CIRCUIT

## 3-TERMINAL 1A POSITIVE VOLTAGE REGULATOR

DESCRIPTION
The UTC 78XX family is monolithic fixed voltage regulator integrated circuit. They are suitable for applications that required supply current up to 1 A.

FEATURES
* Output current up to 1.5 A
* Fixed output voltage of 5V, 6V, 6V, 9V, 10V, 12V, 15V, 18V and 24V available
* Thermal overload shutdown protection
* Short circuit current limiting
* Output transistor SOA protection

TO-220

TO-263

TO-252

1: Input 2: GND 3: Output

TEST CIRCUIT
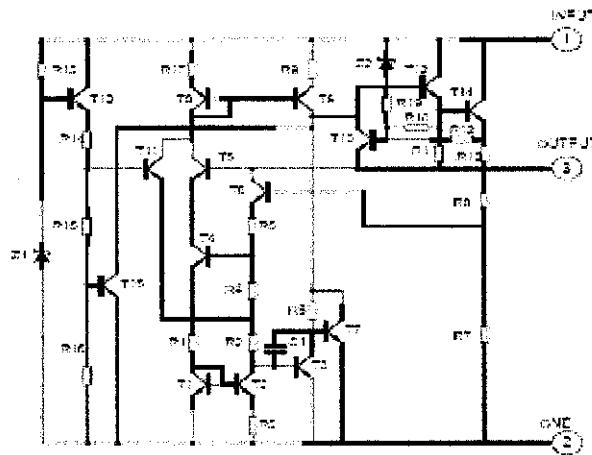
UTC LM78XX   LINEAR INTEGRATED CIRCUIT

ABSOLUTE MAXIMUM RATINGS

Operating temperature range applies unless otherwise specified :

PARAMETER	SYMBOL	RATING		UNIT
Input voltage(for Vo=5~18V)	Vi		35	V
(for Vo=24V)	Vi		40	V
Output Current	Io	-		A
Power Dissipation	PD	Internally Limited		W
Operating Junction Temperature Range	TOPR	-20	+150	°C
Storage Temperature Range	TSTG	-65	+150	°C

UTC LM7805 ELECTRICAL CHARACTERISTICS

(Vi=10V, Io=0.5A, Tj=0°C~125°C, C1=0.33μF, Co=0.1μF, unless otherwise specified (Note 1)

PARAMETER	SYMBOL	TEST CONDITIONS	MIN	TYP	MAX	UNIT
Output voltage	Vo	Tj=25°C, Io=5mA~1.0A	4.80	5.0	5.20	V
		Vi=7.5V to 20V,	4.75		5.25	V
		Io=5mA~1.0A,PD=15W				
Load Regulation	ΔVo	T=25°C, Io=5mA~1.5A			50	mV
		T=25°C, Io=0.25A~0.75A			25	mV
Line regulation	ΔVo	Vi=7V to 25V,Tj=25°C			50	mV
		Vi=7.5V to 20V,T=25°C,Io=1A			50	mV
Quiescent Current	Iq	T=25°C, Io=1A			6.0	mA
Quiescent Current Change	ΔIq	Vi=7.5V to 20V			1.0	mA
	ΔIq	Io=5mA~1.0A			0.5	mA
Output Noise Voltage	VN	f=10Hz~f=100kHz		40		μV
Temperature coefficient of Vo	ΔVo/ΔT	Io=5mA		-0.6		mV/°C
Ripple Rejection	RR	Vi=8V~18V,f=120Hz,Tj=25°C	62	80		dB
Peak Output Current		T=25°C		1.5		A
Short-Circuit Current		Vi=35V, T=25°C		250		mA
Dropout Voltage	Vo	T=25°C		2.0		V

UTC LM7806 ELECTRICAL CHARACTERISTICS

(Vi=11V, Io=0.5A, Tj=0°C~125°C, C1=0.33μF, Co=0.1μF, unless otherwise specified (Note 1)

PARAMETER	SYMBOL	TEST CONDITIONS	MIN	TYP	MAX	UNIT
Output voltage	Vo	Tj=25°C, Io=5mA~1.0A	5.76	6.0	6.24	V
		Vi=8.5V to 21V,	5.70		6.30	V
		Io=5mA~1.0A, PD=15W				
Load Regulation	ΔVo	T=25°C, Io=5mA~1.5A			50	mV
		T=25°C, Io=0.25A~0.75A			30	mV
Line regulation	ΔVo	Vi=8V to 25V,Tj=25°C			50	mV
		Vi=8.5V to 21V,T=25°C,Io=1A			50	mV
Quiescent Current	Iq	T=25°C, Io=1A			6.0	mA
Quiescent Current Change	ΔIq	Vi=8.5V to 21V			1.0	mA
	ΔIq	Io=5mA~1.0A			0.5	mA
Output Noise Voltage	VN	f=10Hz~f=100kHz		45		μV
Temperature coefficient of Vo	ΔVo/ΔT	Io=5mA		-0.7		mV/°C
Ripple Rejection	RR	Vi=9V~19V,f=120Hz,Tj=25°C	59	75		dB

UTC LM78XX   LINEAR INTEGRATED CIRCUIT

PARAMETER	SYMBOL	TEST CONDITIONS	MIN	TYP	MAX	UNIT
Peak Output Current	Ipk	Tj=25°C		1.5		A
Short-Circuit Current	Isc	Vi=35V, Tj=25°C		250		mA
Dropout Voltage	Vc	Tj=25°C		2.0		V

UTC LM78C9 ELECTRICAL CHARACTERISTICS
(Vi=14V, Io=0.5A, Tj=0°C - 125°C, C1=0.33uF, Co=0.1uF, unless otherwise specified) (Note 1)

PARAMETER	SYMBOL	TEST CONDITIONS	MIN	TYP	MAX	UNIT
Output Voltage	Vo	Tj=25°C, Io=5mA - 1.0A	7.55	8.0	8.32	V
		Vi =10.5V to 23V, Io=5mA - 1.0A, PD<15W	7.50		8.40	V
Load Regulation	ΔVo	Tj=25°C, Io=5mA - 1.5A			50	mV
		Tj=25°C, Io=0.25A - 0.75A			40	mV
Line regulation	ΔVo	Vi = 10.5V to 23V, Tj=25°C			50	mV
		Vi = 10.5V to 23V, Tj=25°C, Io=1A			50	mV
Quiescent Current	Iq	Tj=25°C, Io=<1A			8.0	mA
Quiescent Current Change	ΔIc	Vi =10.5V to 23V			1.0	mA
	ΔIc	Io=5mA - 1.0A			0.5	mA
Output Noise Voltage	VN	10Hz<=f<=100kHz		58		μV
Temperature coefficient of Vo	ΔVo/ΔT	Io=5mA		-0.9		mV/°C
Ripple Rejection	RR	Vi = 11.5V to 21.5V, f=120Hz, Tj=25°C	56	72		dB
Peak Output Current	Ipk	Tj=25°C		1.5		A
Short-Circuit Current	Isc	Vi=35V, Tj=25°C		250		mA
Dropout Voltage	Vc	Tj=25°C		2.0		V

UTC LM78C9 ELECTRICAL CHARACTERISTICS
(Vi=15V, Io=0.5A, Tj=0°C - 125°C, C1=0.33uF, Co=0.1uF, unless otherwise specified) (Note 1)

PARAMETER	SYMBOL	TEST CONDITIONS	MIN	TYP	MAX	UNIT
Output Voltage	Vo	Tj=25°C, Io=5mA - 1.0A	8.54	9.0	9.35	V
		Vi = 11.5V to 24V, Io=5mA - 1.0A, PD<15W	8.55		9.45	V
Load Regulation	ΔVo	Tj=25°C, Io=5mA - 1.5A			90	mV
		Tj=25°C, Io=0.25A - 0.75A			45	mV
Line regulation	ΔVo	Vi = 11.5V to 25V, Tj=25°C, PD<15W			90	mV
		Vi = 11.5V to 24V, Tj=25°C, Io<=1A			90	mV
Quiescent Current	Iq	Tj=25°C, Io=<1A			8.0	mA
Quiescent Current Change	ΔIc	Vi = 11.5V to 24V			1.0	mA
	ΔIc	Io=5mA - 1.0A			0.5	mA
Output Noise Voltage	VN	10Hz<=f<=100kHz		58		μV
Temperature coefficient of Vo	ΔVo/ΔT	Io=5mA		-1.1		mV/°C
Ripple Rejection	RR	Vi = 12.5V to 22.5V, f=120Hz, Tj=25°C	56	72		dB
Peak Output Current	Ipk	Tj=25°C		1.5		A
Short-Circuit Current	Isc	Vi=35V, Tj=25°C		250		mA
Dropout Voltage	Vc	Tj=25°C		2.0		V

UTC UNISONIC TECHNOLOGIES CO., LTD.   2

APPENDIX H: L293 MOTOR DRIVER DATASHEET

SLRS008B – SEPTEMBER 1986 – REVISED JUNE 2002

- Featuring Unitrode L293 and L293D Products Now From Texas Instruments
- Wide Supply-Voltage Range: 4.5 V to 36 V
- Separate Input-Logic Supply
- Internal ESD Protection
- Thermal Shutdown
- High-Noise-Immunity Inputs
- Functional Replacements for SGS L293 and SGS L293D
- Output Current 1 A Per Channel (600 mA for L293D)
- Peak Output Current 2 A Per Channel (1.2 A for L293D)
- Output Clamp Diodes for Inductive Transient Suppression (L293D)

N, NE PACKAGE
(TOP VIEW)

```
1,2EN  [ 1      16 ]  Vcc1
  1A   [ 2      15 ]  4A
  1Y   [ 3      14 ]  4Y
HEAT SINK AND  ⌠ 4   13 ⌠  HEAT SINK AND
   GROUND      ⌡ 5   12 ⌡  GROUND
  2Y   [ 6      11 ]  3Y
  2A   [ 7      10 ]  3A
 Vcc2  [ 8       9 ]  3,4EN
```

DWP PACKAGE
(TOP VIEW)

```
1,2EN  [ 1      28 ]  Vcc1
  1A   [ 2      27 ]  4A
  1Y   [ 3      26 ]  4Y
  NC   [ 4      25 ]  NC
  NC   [ 5      24 ]  NC
  NC   [ 6      23 ]  NC
HEAT SINK AND  ⌠ 7   22 ⌠  HEAT SINK AND
   GROUND      ⌡ 8   21 ⌡  GROUND
            ⌡ 9   20
  NC   [ 10     19 ]  NC
  NC   [ 11     18 ]  NC
  2Y   [ 12     17 ]  3Y
  2A   [ 13     16 ]  3A
 Vcc2  [ 14     15 ]  3,4EN
```
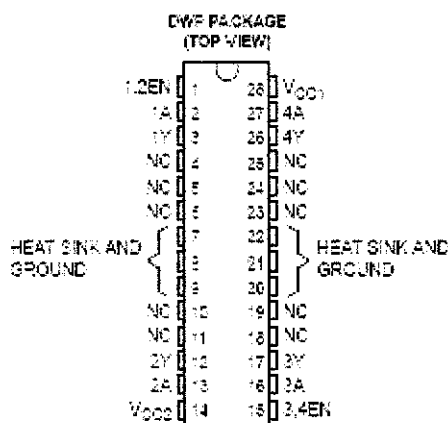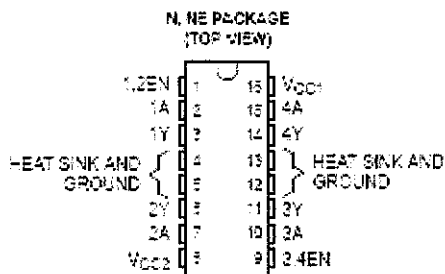
description

The L293 and L293D are quadruple high-current half-H drivers. The L293 is designed to provide bidirectional drive currents of up to 1 A at voltages from 4.5 V to 36 V. The L293D is designed to provide bidirectional drive currents of up to 600-mA at voltages from 4.5 V to 36 V. Both devices are designed to drive inductive loads such as relays, solenoids, dc and bipolar stepping motors, as well as other high-current/high-voltage loads in positive-supply applications.

All inputs are TTL compatible. Each output is a complete totem-pole drive circuit, with a Darlington transistor sink and a pseudo-Darlington source. Drivers are enabled in pairs, with drivers 1 and 2 enabled by 1,2EN and drivers 3 and 4 enabled by 3,4EN. When an enable input is high, the associated drivers are enabled and their outputs are active and in phase with their inputs. When the enable input is low, those drivers are disabled and their outputs are off and in the high-impedance state. With the proper data inputs, each pair of drivers forms a full-H (or bridge) reversible drive suitable for solenoid or motor applications.

On the L293, external high-speed output clamp diodes should be used for inductive transient suppression.

A Vcc1 terminal, separate from Vcc2, is provided for the logic inputs to minimize device power dissipation.

The L293 and L293D are characterized for operation from 0°C to 70°C.

TEXAS INSTRUMENTS

POST OFFICE BOX 655303 ● DALLAS, TEXAS 75265

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block diagram
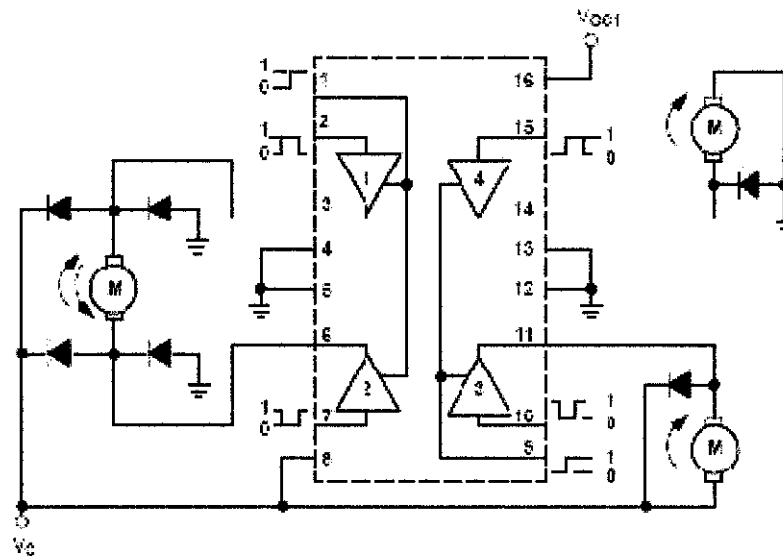
NOTE: Output diodes are internal in L293D.

TEXAS INSTRUMENTS
AVAILABLE OPTIONS

	PACKAGE
T_A	PLASTIC DIP (NE)
0°C to 70°C	L293NE L293DNE

Unitrode Products
from Texas Instruments
AVAILABLE OPTIONS

	PACKAGED DEVICES	
T_A	SMALL OUTLINE (DWP)	PLASTIC DIP (N)
0°C to 70°C	L293DWP L293DDWP	L293N L293DN

The DWP package is available taped and reeled. Add the suffix TR to device type (e.g., L293DWPTR).

2

FUNCTION TABLE
(each driver)

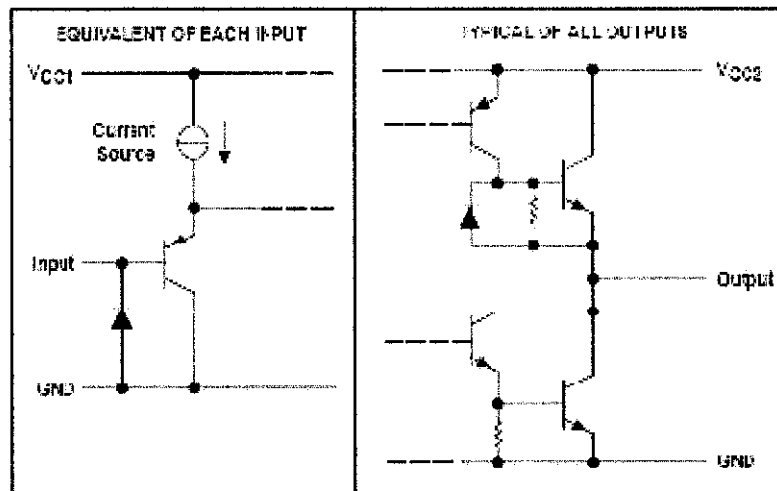| INPUTS† | | OUTPUT |
A	EN	Y
H	H	H
L	H	L
X	L	Z

H = high level, L = low level, X = irrelevant,
Z = high impedance (off)

† In the thermal shutdown mode, the output is
in the high-impedance state, regardless of
the input levels.

logic diagram
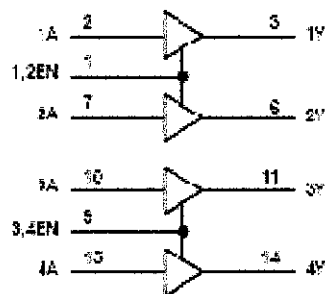
schematics of inputs and outputs (L293)

5

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