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BORANG PENGESAHAN STATUS TESIS◆

JUDUL: AUTOMATIC TEMPERATURE CONTROL SYSTEM FOR AQUAPONIC GREEN HOUSE

SESI PENGAJIAN: 2012/2013

Saya, **AMIN KHAIRI BIN ROSLI (890214-01-5839)**
(HURUF BESAR)

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Alamat Tetap:
NO 1, JALAN ANGGERIK 6
TAMAN ANGGERIK,
86000 KLUANG,
JOHOR.

Prof. Ir. Dr. Hj. Yusoff bin Ali
(Nama Penyelia)

Tarikh: **17 JUNE 2013** Tarikh: **17 JUNE 2013**

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AUTOMATIC TEMPERATURE CONTROL SYSTEM

AMIN KHAIRI BIN ROSLI

Report submitted in partial fulfilment of the requirements
For the award of Bachelor of Mechanical Engineering

Faculty of Mechanical Engineering
UNIVERSITI MALAYSIA PAHANG

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FACULTY OF MECHANICAL ENGINEERING

I certify that the project entitled "*Automatic Temperature Control System for Aquaponic Green House*" is written by *AMIN KHAIRI BIN ROSLI*. I have examined the final copy of this report and in my opinion, it is fully adequate in terms of language standard, and report formatting requirement for the award of the degree of the Mechanical Engineering. I herewith recommend that it be accepted in partial fulfilment of the requirements for the degree of Bachelor of Mechanical Engineering.

PROF. DATO.DR. ROSLI ABU BAKAR

Examiner Signature

SUPERVISOR'S DECLARATION

I hereby declare that I have checked this project report and in my opinion this project is satisfactory in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering with "specialization".

Signature	:
Name of Supervisor	: PROF. IR. DR. HJ. YUSOFF BIN ALI
Position	: PROFESSOR
Date	: 17 JUNE 2013

STUDENT'S DECLARATION

I hereby declare that the work in this report is my own except for quotations and summaries which have been duly acknowledged. The report has not been accepted for any degree and is not concurrently submitted for award of other degree.

Signature :
Name : AMIN KHAIRI BIN ROSLI
ID Number : MA10105
Date : 17 JUNE 2013

Dedicated to my father, Mr. Rosli Bin Dolah my beloved mother, Mrs. Jumilah Binti Hj Shafie, and last but not least to all my fellow friends

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ABSTRACT

The objective of this thesis is to design an automatic temperature control system in the aquaponic house. This project focuses on the design of control systems using the concepts of temperature control using PIC and low cost. The purpose of this project is to overcome the problems occurred in the heat of the house aquaponic to control the flow of ventilation as a cooling agent. In this project, PIC16F876A is used as the brain for the prototype. PIC controls were selected as a control because it has a faster response when compared with conventional control on-off. The components required in this project can be divided into two groups, electric components and mechanical components. Some electrical components used are actuator, switches, relays and PIC controller. Mechanical components used were as bolts and nuts as well as the mechanical structure. The system completed and tested to control the temperature constant 30°C.

ABSTRAK

Objektif tesis ini adalah untuk merekabentuk sistem kawalan suhu automatik di dalam rumah aquaponik. Projek ini menumpukan kepada rekaan sistem kawalan suhu dengan menggunakan konsep kawalan PIC dan menggunakan kos yang rendah. Tujuan projek ini adalah untuk mengatasi masalah kepanasan berlaku didalam rumah aquaponik dengan mengawal aliran pengudaraan sebagai agen penyejuk. Didalam projek ini, PIC16F876A digunakan sebagai otak untuk prototaip. Kawalan PIC telah dipilih sebagai kawalan kerana memiliki respon lebih cepat jika dibandingkan dengan kawalan konvensional secara buka-tutup. Komponen-komponen yang diperlukan dalam projek ini boleh dibahagikan kepada dua kumpulan iaitu komponen electrik dan juga komponen mekanikal Antara komponen-komponen elektrik yang digunakan termasuk actuator, suis, relays dan juga PIC controller. Komponen-komponen mekanikal yang digunakan pula adalah seperti bolt dan nut dan juga struktur mekanikal tersebut. Sistem ini telah disiapkan dan dicuba untuk mengawal suhu pada 30°C secara kosisten.

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LIST OF SYMBOLS

v	Voltage
N	Newton
Vss	Supply Voltage
°C	Degree Celsius
Mv	millivolt
µA	microampere
CO^2	Carbon Dioxide
mA	miliampere
pc	Personal computer
A	ampere
W	watt
mm	millimetres
s	second
RM	Ringgit malaysia

LIST OF ABBREVIATIONS

PIC	Programmable Interface Controller
LED	Light Emitting diode
RAM	Random Access Memory
ROM	Read Only Memory
CPU	Central processing Unit
I/C	Integrated Circuit
I/O	Input / Output
EPROM	erasable programmable read only memory
IRL	International Rectifie
PV	Photovoltaic
DC	direct current
AC	Alternative current
VRLA	valve regulated lead acid
MIG	Metal Inert Gas
ICSP	in circuit serial programming

CHAPTER 1

INTRODUCTION

1.1 GENERAL INTRODUCTION

Aquaponic is a closed system agriculture that combine with hydroponic and aquaculture. This farming system is combine fish and plants together in a one place. Fish produce wastes that turn into nitrates and ammonia. Too much nitrates and ammonia aren't good for the fish, but they are great fertilizer for the plants. As the plants suck up these nutrients, they purify the water, which is good for the fish. Many cultures have made use of this cycle to grow better crops and nurture the fish as an additional food source.

Modern aquaponic is slightly more high technology, but it's still an efficient and environmentally friendly way to produce food. Fish are kept in large tanks and the plants are grown hydroponically. They are plant in beds with a little gravel or clay and their roots hang down into the water. The water is cycled through the system, so that it collects the waste from the fish and then its pump to the plant beds, where it is filtered naturally by the plants and can then be returned to the fish tanks.

In aquaponic good ventilation is essential for healthy plant growth. In fact, it is one of the most important factors that need to consider because it will effect to the plants and plant struggle to live. Ventilation is about controlling the quality of air, CO^2, heat and humidity in the aquaponic house. To achieve a high quality of air in aquaponic house we need to ensure that there is a sufficient amount of air exchange. The amount of air exchange required will vary according to the temperature outside.

To achieve sufficient air exchange the great way is to use extractor fan. Basically, an extractor fan will help to achieve the ideal growing environment in aquaponic house. By circulating and exchanging air, an extractor fan will give a greater degree of control heat and humidity.

1.2 PROJECT OBJECTIVE

The purpose of this project is to design and fabricate aquaponic house with temperature control system powered by solar power.

1.3 PROJECT SCOPE

This project focuses on the following points:

i. To control temperature in the aquaponic house at 30°C
ii. Using PIC to control the motion of linear actuator

1.4 PROBLEM STATEMENT

Ventilation system refers to the system of exchange of indoor and outdoor air. Without proper ventilation, airtight house will contain harmful pollutants, such as carbon monoxide, and moisture that can damage the air quality in the house. This project is to design a system of removing the hot air and significantly improve air. This project is eco-friendly because it use solar energy and can save cost of electricity.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

This chapter will provide the detail description literature review done according to the title of design and fabricate aquaponic house with automatic opening and closing of the roof. Automatic open and close roof act using the actuator system and provide motion in order to open or closed the roof. Basically this automatic roof opening system ventilates and improves the overall efficiency of a greenhouse. Cooling is critical in the agriculture environment and is most commonly achieved using passive roof ventilation. The movement of hot air up and out of the roof vents pulls in cooler air.

2.2 TEMPERATURE SENSOR

2.2.1 Measurement of Temperature

Temperature has significant effects on the materials and process at the molecular level. Temperature is defined as a specific degree of hotness or coldness as referenced to a specific scale. It can also be defined as the amount of heat energy in an object or systems. Temperature sensor usually can detect a change in physical parameter such as resistance or output voltage that corresponds to a temperature change. Temperature has two basic types of temperature sensing:

i. Contact: Temperature sensing requires the sensor to be in direct physical contact with the medium or object being sensed. It can be used to monitor the temperature different type of medium such as solids, liquids, or gases. Basically this type of sensor has a wide range of measurement.

ii. Non-contact: Measurement interprets the radiant energy release by a heat source in form energy emitted in the infrared portion of the electromagnetic spectrum. This method usually used to monitor non reflective solids and liquids but not effective with gases due to natural transparency

2.2.2 Comparison between 4 Types of Temperature Sensor

In market there various types of temperature sensors for selection. In selecting temperature sensor there are a few conditions and situation might be considered depending on the requirement and specification of the project. The table below might describes the difference between 4 types temperature sensor that available in the market. The 4 temperature sensors are thermocouple, resistance thermo detector, thermistor and I.C sensor. (Voda, A. A. and I. D. Landau 1995)

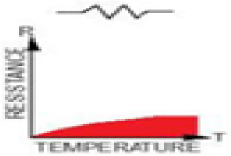
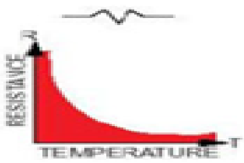
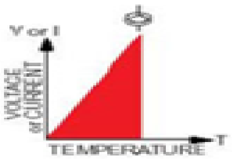
Type	Advantages	Disadvantages
Thermocouple 	• Self powered (active sensor) • Simple • Rugged • Inexpensive or economical • Wide range of temperature.	• Non-linear • Low voltage output • Reference point is required • Least sensitive and least stable.
Resistance Thermo Detector (RTD) 	• Most stable temperature sensor available • Accurate • Has more linearity output rather than thermocouple	• Expensive • Passive sensors • Small resistance change if temperature is changing • Self heated
Thermistor 	• Fast response over narrow temperature range • Good sensitivity in NTC region • Small size and economical	• Have non linear graph • Limited temperature range • Fragile • Passive sensor • Self heated
I.C sensor 	Most linear graph of Voltage or current versus temperature • Highest output of voltage or current • Inexpensive (economical	Measurement range below than 200°C • Power supply is required (passive sensors) • Slow

Figure 2.1: Comparison between Different Types of Temperature Sensor

Source: Emerging Technologies 1995

2.2.3 Temperature Sensor LM35

Temperature sensor LM35 is one of the most accurate integrated circuit temperature sensors which available in the market. The output of voltage is linearly proportional to the temperature in degree Celsius. The LM35 doesn't require any calibration to provide accuracies. It has good temperature range reading for electronic and electric purpose since its cover temperature from -55°C to 150°C. Lm35 has low output impedance, linear output which this requirement fulfils some application specification. In the market, LM35 is one of the cheap and economical temperature sensors compare to the other types of temperature sensors. Below are some of the features of LM35.

i. Calibrated directly in °Celsius and centigrade
ii. Linear a 10.0 mV/°C scale factor
iii. 0.5°C accuracy guarantee
iv. Rated for full 55°C to 150°C range
v. Suitable for remote application.
vi. Low cost due to wafer level trimming
vii. Operates at 4V to 30V of voltages.
viii. Low self-heated.
ix. Low impedance output, 0.1O for 1mA load.

Figure 2.2: Plastic Package Bottom View of LM35 Microcontroller

Source: Microcontroller-Kits 2012

A microcontroller chip is a computer on a chip. Microcontroller is one of the microchip that emphasizes self-sufficiency and cost effectiveness, in contrast to a general purpose microcontroller (usually found in PC) . Microcontroller contains all the memories and interfaces needed for a simple application, whereas a general purpose microprocessor requires additional chips to provide this function. Commonly microprocessor has the following specification features. (Balhara, S. and S. Srivastava 1995).

i. Input/ output interfaces such as peripheral interfaces.
ii. Peripheral such as timers and watchdog circuit and signal conversion circuit RAM for data storage.
iii. ROM, EPROM, FLASH MEMORY for program storage.

iv. Clock generator such as oscillator and quartz timing crystal, resonator and RC circuit.

Microcontrollers are programmed in assembly language or in C programming language. Some of the microcontroller today is built into high level programming language interpreter for greater ease of use. Microcontrollers trade speed and flexibility against ease of equipment design and economical.

2.3 PIC16F876A

PIC16F876A is one type of the PIC16 microcontroller families, it has a few advantages. PIC16F876A has high computational performance at an economical price, high endurance, and enhanced flash memory. Due to the good performance showed by PIC16F876A microcontroller, it always chooses as logical devices for many high performance and power sensitive application. This powerful (200 nanosecond instruction execution) yet easy-to-program (only 35 single word instructions) CMOS FLASH-based 8-bit microcontroller packs Microchip's powerful PIC architecture into a 28-pin package.

2.3.1 Pin I/O Description

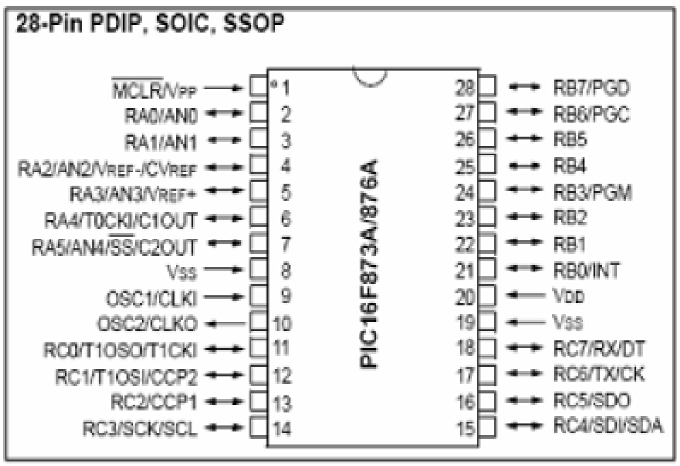


Figure 2.3: I/O pin for PIC16F876A

Source: Abhaynayak 2012

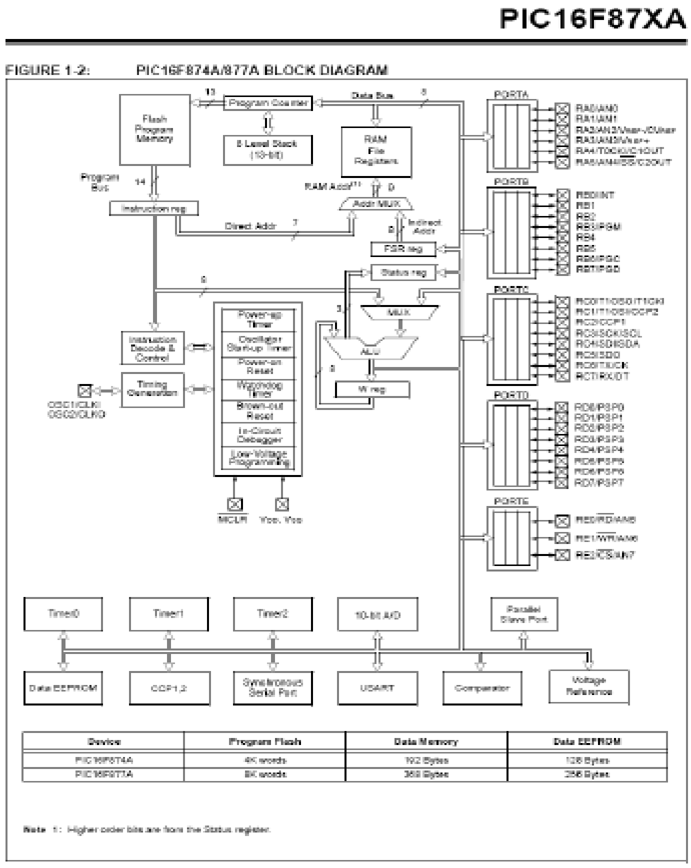


Figure 2.4: Block diagram for PIC16F876A

Source: Oysgroup 2008

2.3.2 PIC16F876A Advantages

PIC16F876A has many advantages if PIC16F876A is compared to other family of microcontroller. The following data are the advantages of PIC16F876A.

i. 256 bytes of EEPROM data memory.

ii. Self-Programmability: PIC16F876A has an ability to write its own program memory spaces under internal software control. Using boot loader routine located in the protected Boot Block at the top of program memory, it is possible to create application which can update itself in the field.

iii. Has 2 capture/compare/PWM functions that suitable to use in PID process

iv. All features make PIC16F876A ideal for more advanced level A/D applications in automotive, industrial, appliances and consumer applications.

2.4 LCD (2X16) FOR USER INTERFACE

For the user interface while reading the temperature reading activity LCD type JHD162A was used. The special characteristic about this type of LCD is green backlight and it easy for the user to read.

Figure 2.5: LCD for User Interface

Source: Pantechsolutions 2012

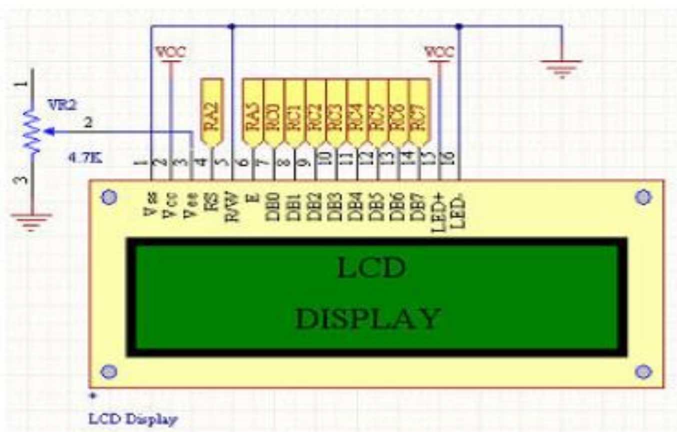


Figure 2.6: LCD Schematic diagram

Source: Electronics-Diy 2002

2.5 IRL1004 N-MOSFET

IRL1004 is one type of a relay, it has fast switching speed and ruggedized device design that HEXFET power Mosfets are well known for. IRL1004 suitable is a good replacement for mechanical relay which has limited switch speed.

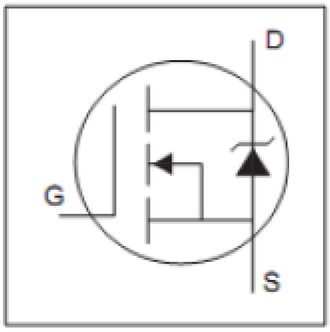


Figure 2.7: IRL1004

Source: Datasheetdir 2000

IRL1004 is a package is universally preferred for all commercial-industrial applications at power dissipation levels to approximately 50watts. The low thermal resistance and low package cost of IRL1004 contribute to its wide acceptance throughout the industry. IRL1004 is also suitable for PWM module which use in PID output

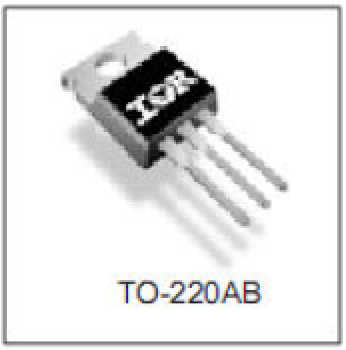


Figure 2.8: N-Mosfets outlook

Source: Electronic Products 2011

2.6 SOLAR POWER

Photovoltaic comes from the words *photo,* meaning light, and *volt*, a measurement of electricity. Sometimes photovoltaic cells are called PV cells or solar cells for short. You are probably familiar with photovoltaic cells. Solar-powered toys, calculators, and roadside telephone call boxes all use solar cells to convert sunlight into electricity. Solar cells are made up of silicon, the same substance that makes up sand. Silicon is the second most common substance on Earth. Solar cells can supply energy to anything that is powered by batteries or electrical power. Electricity is produced when sunlight strikes the solar cell, causing the electrons to move around. The action of the electrons starts an electric current. The conversion of sunlight into electricity takes place silently and instantly. There are no mechanical parts to wear out.

Photovoltaic (PV) systems convert sunlight directly to electricity. They work any time the sun is shining, but more electricity is produced when the sunlight is more intense and strikes the PV modules directly (as when rays of sunlight are perpendicular to the PV modules). Solar energy is free, and its supplies are unlimited. It does not pollute or otherwise damage the environment. It cannot be controlled by any one nation or industry. If we can improve the technology to harness the sun's enormous power, we may never face energy shortages again.

The solar panel is composed of solar cells that collect solar radiation and transform it into electrical energy. This part of the system is sometimes referred to as a solar module or photovoltaic generator. Solar panel arrays can be made by connecting a set of panels in series and/or parallel in order to provide the necessary energy for a given load. The electrical current supplied by a solar panel varies proportionally to the solar radiation. This will vary according to climatologically conditions, the hour of the day, and the time of the year. Several technologies are used in the manufacturing of solar cells. (Govinda R. Timilsina, October 2011)

Basic photovoltaic system consists of four main components which is solar panel, batteries, regulator and the load. The panels are responsible for collecting the energy from the sun and generating electricity from it. The battery stores the electrical energy for the later use. The regulator ensures that panel and battery are working together in an optimal fashion. The load refers to any device that requires electrical power, and is the sum of the consumption of all electrical equipment connected to the system. Something important that should be take note that solar panel and the batteries use the direct current (DC).

The equipment that use the different DC voltage then the one that supplied by the battery, it will need to use a dc/dc converter. For the equipment that use the alternate current (AC), then it need to use a DC/AC converter, also known as inverter. The battery and the equipment will have the range of operational voltage that did not fit with each other, so it will need to include some type of converter.

Solar Inverter converts DC power from battery, charged from PV source, to AC power compatible with the utility and AC loads. This unit consists of solar inverter cum charge controller with intelligent logic which controls the charging of battery from solar or mains or both with solar as priority in sharing mode. This system monitors the battery charging status and accordingly decides to charge the battery either from solar or from mains or both in sharing mode.

The battery stores the energy produced by the panels that is not immediately consumed by the load. This stored energy can then be used during periods of low solar irradiation. Batteries store electricity in the form of chemical energy. The most common type of batteries used in solar applications are maintenance-free lead-acid batteries, also called recombinant or VRLA (valve regulated lead acid) batteries.
When designing the system, first consideration is realistic estimate of the maximum consumption. Once the installation is in place, the established maximum consumption must be respected in order to avoid frequent power failures.

2.7 RECHARGEABLE BATTERY

In this system, maintenance-free battery with valve regulated sealed is strongly recommended. This is because it will never require water. Even though lead-acid batteries are commonly used for this system, but nickel-cadmium batteries are also used in some special circumstances. In the term of economy, the nickel cadmium batteries are more expensive compare to the lead-acid type. The important features of these batteries are designed especially for deep cycle and low self-discharge as need for this solar application. The lead acid battery was the most commonly used of the group, due to its low cost, and the efficiency of charging and discharging is 90%.

Temperature affects the performance of the battery by changing the internal resistance of the cells. There are two types of lead acid batteries, standard and gel filled. The standard batteries have a limited range in the amount that can be discharged; the higher the daily discharge, the lower the number of recharging cycles the battery will have in its lifetime. Lead acid gel batteries are designed to handle discharges down to 20% before serious damage occurs, and are able to handle the daily long-term needs. Nickel Cadmium batteries have a lower efficiency of 85%, and are more expensive than lead acid types, but have a wider temperature range and are less susceptible to overcharging.

FIGURE 2.9: Rechargeable Battery

Source: Solat Industry 2000

To operate equipment 24 hours a day requires an energy source that comes in the form of a battery, fuel cell, or connection to a power grid. To supplement for this weakness, energy collected in the daylight hours must be transformed from flowing electrons into a chemical compound that retains the energy. The standard solar powered system uses batteries with voltages of 4V, 6V, 8V, or 12V. All batteries had to be a heavy-duty deep-cycle battery with the longest warranty. The standard batteries were rated for up to five years. Solar panels can charge the rechargeable battery voltage directly because using direct current (DC). Solar panel voltage must be higher than the rechargeable battery so that battery can be charged quickly.

2.8 LINEAR ACTUATOR

A linear actuator is a mechanical device that converts energy (power from air, electricity or liquid) to create motion in a straight line; contrasted with circular motion of a conventional electric motor. It can also be used to apply a force. Types of motion include: blocking, clamping, ejecting, lifting, descending, pushing or pulling.

Many variations on the basic linear actuator design have been created throughout time. Most focus on providing general improvements such as a higher mechanical efficiency, speed, or load capacity. There is also a large engineering movement towards linear actuator miniaturization. It is seen by some manufacturers that the smaller the linear actuator, the better. This does not necessary equate to a cost-savings, rather, it is desirable for reducing the overall size and weight of a linear actuator motion control system.

i. Rotary to Linear Motion - Some linear actuators use straight sections of a cogged belt or roller drive chain in a lengthwise circuit between two pulleys or sprockets. This type of linear actuator system is widely used in garage door openers. Other linear actuators also use standard rotational electric motors (such as Stepper, DC Brush, DC Brushless and AC motors) with mechanical conversion for steering systems, or crankshafts in sewing machines, and many other uses.

ii. Specialized Linear Actuators - Highly specialized linear actuators are used in critical applications, such as hydraulically actuated flight control surfaces on large aircraft, in ultra-fine machining equipment requiring precise positioning to tenths of thousandths, as well as tiny servo motors and cog belts, and for minute movements in medical procedures such as eye surgery. Even inexpensive stepper motor-driven linear actuator used in home computer printers has resolution down to single pixel size.

iii. Motion, Position, Velocity, and Force Combinations - Designers integrating linear actuators into equipment must examine their application carefully to determine whether motion, force, position, or velocity is the primary operational requirement, or whether the application requires some combination of all of them. For example: printer head skewing systems must be able to position the heads precisely across a long stroke, while braking cylinders must provide very large forces through relatively short strokes against the brake discs that limit their motion. The hydraulic cylinders on large excavators used in construction must be able to provide tens of thousands of pounds of force over many feet of stroke, with a degree of precision of an inch or two being considered adequate. Electronically controlled linear actuators used in circuit board assembly move at blinding speed as microchips are inserted into precise positions. Therefore, complex linear actuator applications will often incorporate position, force and velocity feedback sensors connected into programmable machine control systems to assure that all linear actuator performance is achieved consistently.

iv. Electromechanical Linear Actuator Designs: Most electromechanical designs incorporate a lead screw and lead nut, while some use a ball screw and ball nut. In either case, the screw may be connected to a motor or manual control knob either directly or through a series of gears. Gears are typically used to allow a smaller, weaker motor, rotating at a higher RPM to be geared down to provide the torque necessary to rotate the screw under a heavier load than the motor would otherwise be capable of driving directly. Generally speaking, this approach effectively sacrifices linear actuator speed in favour of increased actuator thrust. In some applications the use of a worm gear is common, as this approach allows a smaller built-in dimension, while allowing for greater travel length.

2.9 SPECIFIC TYPES OF LINEAR ACTUATORS

2.9.1 Mechanical Linear Actuators

Mechanical linear actuators typically operate by the conversion of rotary motion into linear motion (motion in a straight line). Mechanical linear actuators convert rotary motion of a control knob or handle into linear displacement using screws and/or gears to which the knob or handle is attached. A jackscrew or car jack is a familiar mechanical linear actuator.

Another type of linear actuator is based on the segmented spindle. Rotation of the jack handle is converted mechanically into the linear motion of the jack head. Mechanical linear actuators are also frequently used in the field of lasers and optics to manipulate the position of linear stages, rotary stages, mirror mounts, goniometers and other positioning instruments. For accurate and repeatable positioning, index marks may be used on control knobs. Some linear actuator designs include an encoder and digital position readout. These are similar to the adjustment knobs used on micrometers, except that their purpose is position adjustment rather than position measurement. Conversion is typically made using a few simple mechanisms:

- **Screws:** lead screw, screw jack, ball screw and roller screw linear actuators all operate on the principles and functions of a simple screw. By rotating the actuator's nut, the screw shaft moves in a straight line.
- **Wheel and axle:** Hoist, winch, rack and pinion, chain drive, belt drive, rigid chain and rigid belt linear actuators operate on the principles and functions of the wheel and axle, wherein a rotating wheel moves a cable, rack, chain or belt to produce linear motion.

- **Cam:** Cam linear actuators function on a principle similar to that of the wedge, but provide relatively limited travel. As a wheel-like cam rotates, its eccentric shape provides thrust at the base of a shaft.

Some mechanical linear actuators only pull (such as hoists, chain drive and belt drives), while other types only push (such as a cam actuator). Pneumatic and hydraulic cylinders, or lead screw linear actuators can be designed to provide force in both directions. The selection of the linear actuator is dependent upon the application and budget.

2.9.2 Hydraulic Linear Actuators

Hydraulic linear actuators sometimes referred to as or hydraulic cylinders, typically involve a hollow cylinder with a piston inserted into it. An unbalanced pressure applied to the piston provides the necessary force that moves an external object. Since liquids are nearly incompressible, a hydraulic cylinder can provide controlled precise linear displacement of the piston. The displacement is only along the axis of the piston. Although the term "hydraulic actuator" refers to a device controlled by a hydraulic pump, an example of a manually operated hydraulic linear actuator is a simple hydraulic car jack.

2.9.3 Pneumatic Linear Actuators

Pneumatic linear actuators, sometimes referred to as pneumatic cylinders, are similar to hydraulic linear actuators except they use compressed gas to provide pressure, rather than of a liquid force.

2.9.4 Piezoelectric Linear Actuators

The piezoelectric effect is a property of certain materials in which the application of a voltage to the material causes it to expand. Very high voltages correspond to only tiny expansions. As a result, piezoelectric linear actuators can achieve extremely fine positioning resolution. The downside to the piezoelectric linear actuator is that it has a very short range of motion. In addition, piezoelectric materials exhibit hysteresis, which makes it difficult to control its expansion in a repeatable manner.

2.9.5 Electromechanical Linear Actuators

A miniature electromechanical linear actuator is a design wherein the lead nut is part of the motor. The lead screw does not rotate; the lead nut is rotated by the motor and the lead screw is extended or retracted. Electromechanical linear actuators are similar to mechanical actuators, the only difference being the control knob or handle is replaced with an electric motor. Rotary motion of the motor is converted into linear displacement of the actuator. There are many designs of modern linear actuators. Every linear actuator manufacturer has their own proprietary methods and designs, making it difficult to cross parts from one manufacturer to another, for a given application. The following is a generalized description of a very simple electromechanical linear actuator.

Typically, an electric motor is mechanically connected to rotate a lead screw. A lead screw has a continuous helical thread machined on its circumference running along the length (similar to the thread on a bolt). Threaded onto the lead screw is a lead nut or ball nut with corresponding helical threads. The nut is prevented from rotating with the lead screw (typically the nut interlocks with a non-rotating part of the actuator body). Therefore, when the lead screw is rotated, the nut is driven along the threads. The direction of motion of the nut will depend on the direction of rotation of the lead screw. By connecting to the nut, the motion can be converted to usable linear displacement.

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

First of all, the design processes need a draft idea as a brainstorm for making a problem solving become more effective. Designers can make references from many sources, such as internet, article and engineering journal. Product design is required to be realistic and acceptable to manufacture it. For this project, it required a material selection process, because the product can be manufactured of different material like steel, wood and plasticThis chapter consists about the conceptual design, concept selection, and selection of the final design. It also explained about the method of fabricate such as the cutting of the material, drilling, welding, fastening and grinding. I also will explain about the design that had been chosen to be as the final idea to be produced or fabricate. All the fabrication process in this project is going to be explained in details.

3.2 PROCESS FLOW

Figure 3.1 shows below the process flow of the design and fabricate aquaponics solar house with system that control temperature by opening and closing of a roof window. The manufacturing process consists of 7 phases.

a) Phase 1 - Determine the objective, problem and the scope
b) Phase 2 - Find the related information about this project
c) Phase 3 - Sketch manually on the A4 and design in solid work.
d) Phase 4 - Fabricate the aquaponics structure and ventilation system
e) Phase 5 - Analysis and Testing
f) Phase 6 - Making the overall overview
g) Phase 7 - Result the research

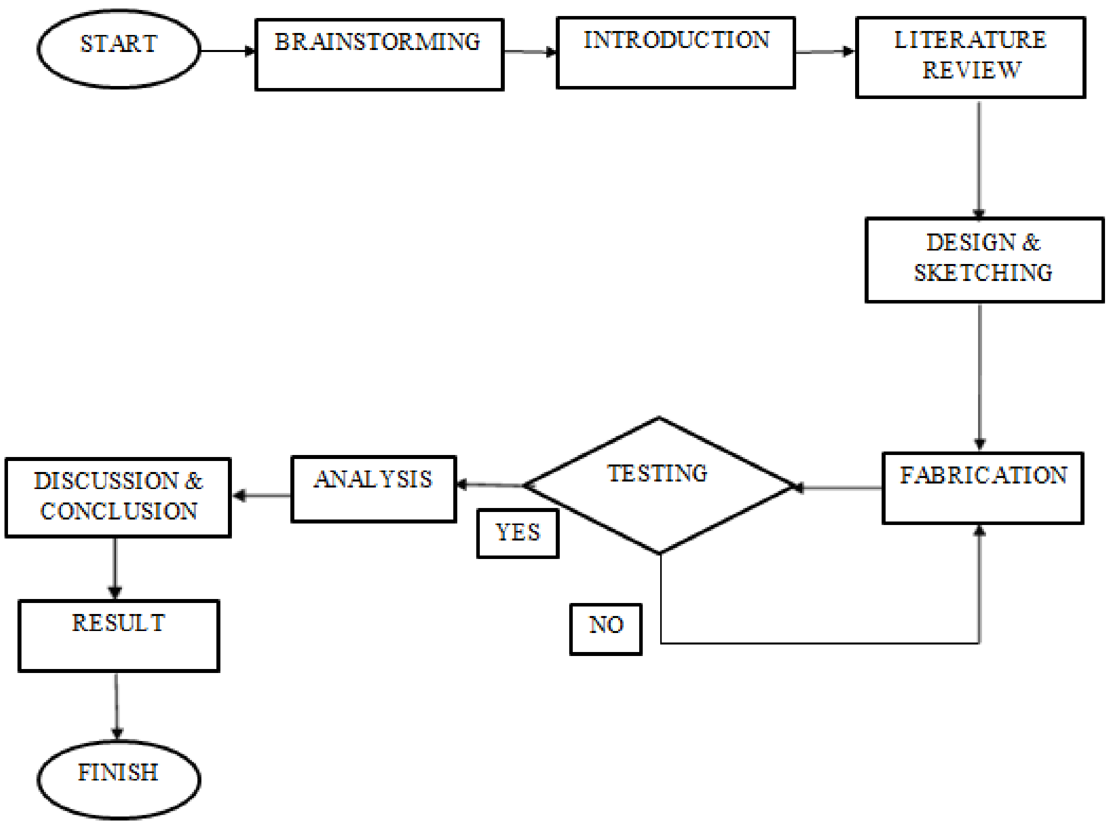


Figure 3.1: Flow Chart of Methodology

From the flow chart in Figure 3.1, this project started with the brainstorming idea and research about the title. The main important of the project is a determination the objective. Then, study and make a lot of research about the automatic opening and closing the roof. These tasks have been done through research on the internet, books and others sources.

Then the information has been collect and gather, after that, the project will be continuing with the design process. In this stage, the knowledge and lessons that have studied will be applied in sketching. The manual sketching is on the A4 it is to make a suitable design for the project. After several design sketched, design consideration have been made and one of the design have been chosen. The selected sketch will be transfer to engineering drawing by using Solid works program.

After all the drawing finished, the drawing was used as a reference for the next process, which it is fabrication stage. This process is consists fabricate all the parts that have design before by following all the dimension using various type of manufacturing process. The manufacturing process included in this process is welding by using MIG, cutting by using disc cutter, drilling and others. For the structure we used the circular hollow steel to make a high strength and light frame.

Next is the installation of the roof to the structure of aquaponics solar house. This system of opening and closing the roof will control using PIC. Temperature sensor is used to determine and control the temperature in the house.

Testing stage has been implementing after fabrication stage. The testing is to gathered information about strength of the truss frame and ventilation system in the aquaponics solar house. During the testing, if a problem occur such as the structure crack, broke or the ventilation system can’t function the process step back to previous process, which is a design back the circuit of automatic temperature roof. If the structure strong and ventilation system function, the project will be declaring success.

Then, all the process mentioned above is done and all the material for report writing is gathered. The report writing process will be guided by the UMP final year project report writing. This process also, preparation for presentation slides for the final presentation for this project. The project ended after the submission of the report and the slide presentation has been present.

3.3 CONCEPT GENERATION

After brainstorming to generate a few designs of automatic roof, the concept will come out with three design of roof. All the concepts must go through concept selection to determine which one is the best design to be fabricated among all the three design of the automatic roof.

3.4 SKETCHING CONCEPT

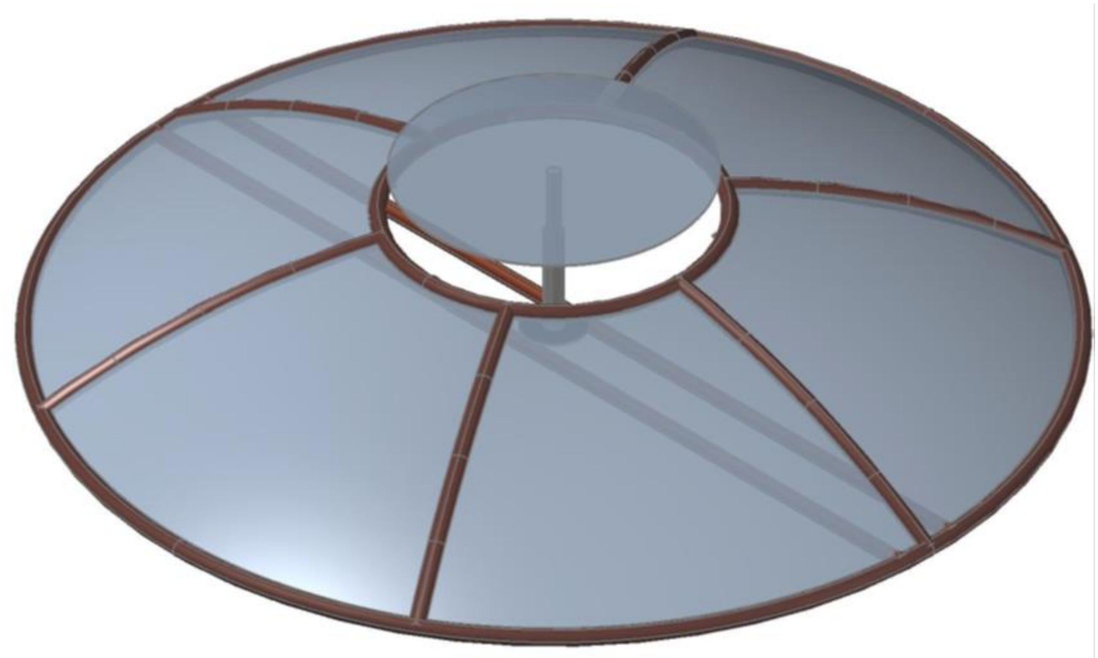


Figure 3.2: Concept A

Concept A design has a few advantages which are simple mechanism, use single actuator and less power usage. Besides that, it also has few disadvantages that are the mechanism design is low ventilation system.

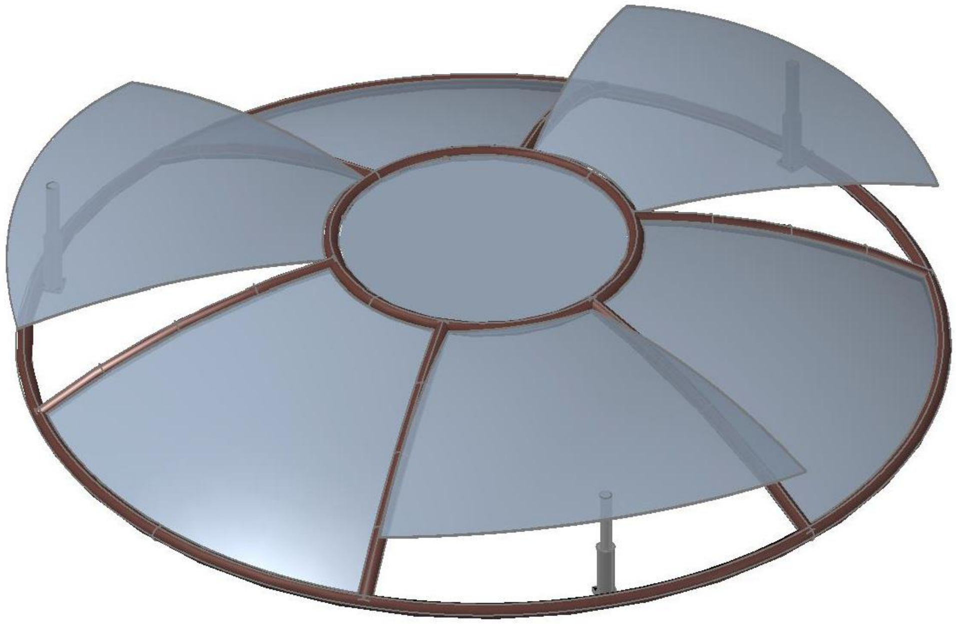


Figure 3.3: Concept B

Concept B design has a few advantages which are easy to fabricate, can control 3 roof at the same time and high ventilation system. Besides that, it also has few disadvantages with is very expensive and high power usage.

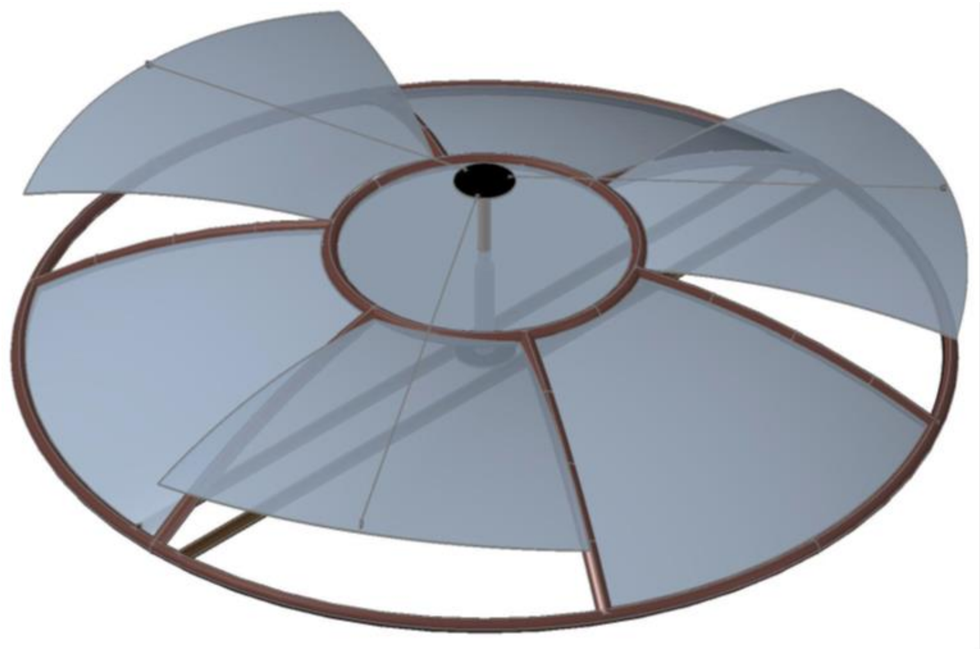


Figure 3.4: Concept C

For concept C, its advantages are it has less power usage, use only single actuator, high ventilation system and it can control 3 roofs at the same time. But, this concept difficult to fabricate and complicated mechanism design.

3.5 CONCEPT SELECTION

In order to determine which design is the best to be fabricated, all of the concept must undergo concept selection (Pugh Method). The result of the selection is as shown in the table below.

Table 3.1: Concept Selection Table

Selection Criteria	**Concepts Variants**		
	A(Datum)	**B**	**C**
Simple mechanism	+	-	-
Less actuator uses	+	-	+
Less power usage	+	-	+
High ventilation system	-	+	+
Easy to fabricate	+	+	-
Can control 3 roof at same time	-	+	+
Low Cost	+	-	+
Plusses	5	3	5
Same	0	0	0
Minuses	2	4	2
Net	3	-1	3
Rank	2	3	1
Continue	√	X	√

Note :
+ = Better than
- = Worse than
0 = Same as

From the table 3.1, the Concept A and Concept C get the highest net score and then the lowest net scores is Concept B. Due to that, Concept C is chose as the concept to be fabricated in this project.

3.6 FINAL CONCEPT

After go through the concept selection, the final concept that is going to be fabricated which is Concept C will be drawn by using AutoCAD.

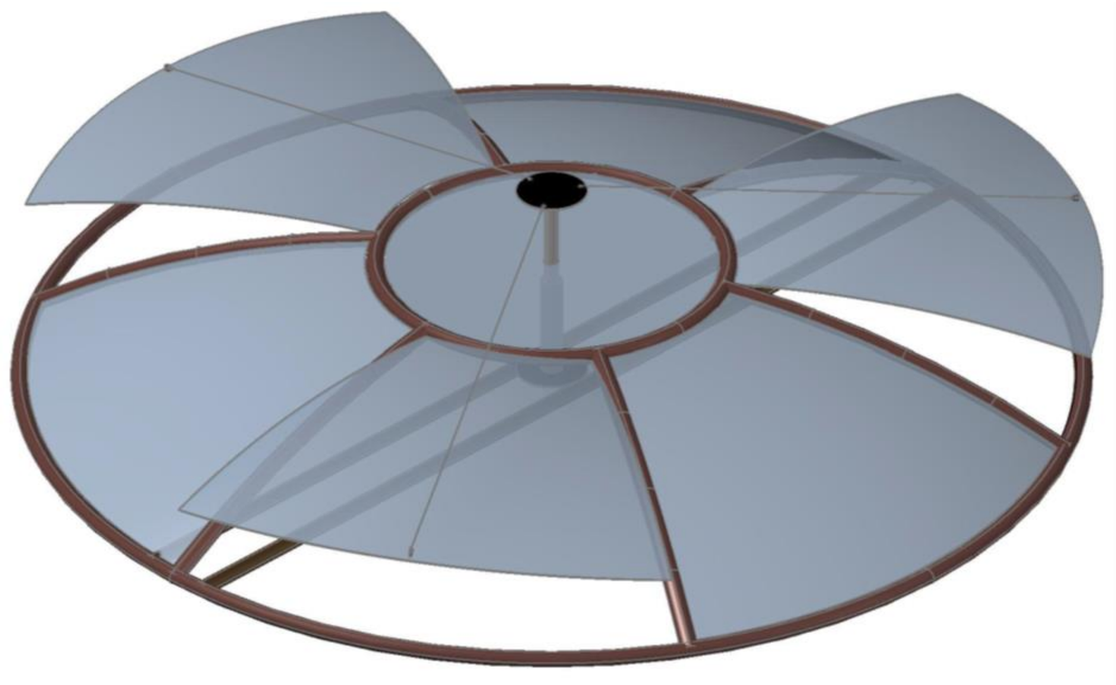


Figure 3.5: Final Concept (Concept C)

This design is use a single actuator but it can control 3 roofs at the same time. So it can minimize the power usage. Beside that this design has good ventilation system because it can open the roof very large.

3.7 MATERIAL PREPARATION

After we get the final design, we need to prepare all of the material that we need to fabricate of aquaponic roof. Below are all the parts that are needed

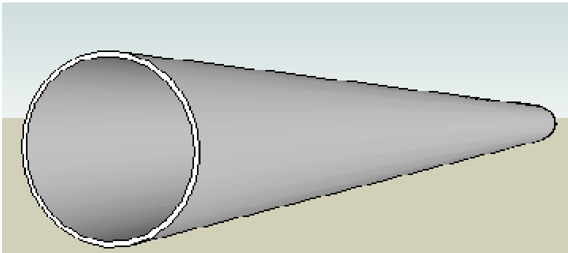


Figure 3.6: Circular Hollow Steel

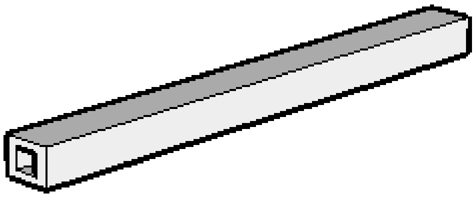


Figure 3.7: Square Hollow Steel

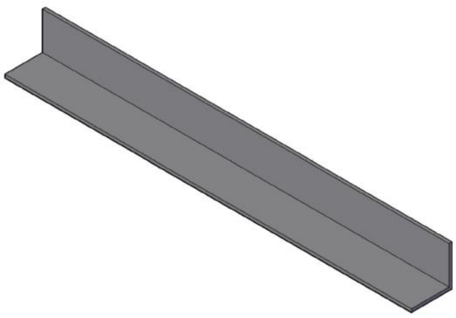


Figure 3.8: Angle Bar

Figure 3.9: Resin

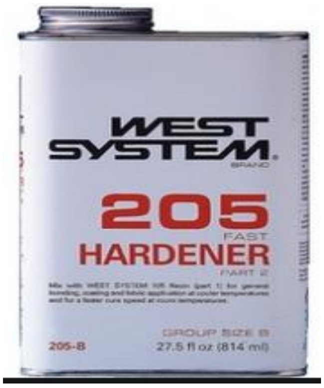


Figure 3.10: Hardener

Figure 3.11: Fiber Glass

Figure 3.12: Wire Mesh

Figure 3.13: Sun Shade Plastic

3.8 FABRICATION PROCESS

After the designing phase, here comes the fabrication process. This process is about using the material selection and makes the product base on the design and by followed the design dimension from the drawing. Many methods will be used to fabricate the product such as measuring and marking, cutting, drilling, joining and finishing. Fabrication process is difference from manufacturing process in term of production quantity. Fabrication process is a process to make only one product rather than manufacturing process that focus to large scale production. As there are a lot of processes of fabrication, there also need a lot of machines and tools to perform the processes.

3.8.1 Measuring and Marking

Before we cut the material to the dimension we want, we need to measure and mark the material first. This is to ensure the precision of the material's length which is quite important in the fabrication process. It is also to avoid the waste of the material because we undersize while cutting it.

To perform this process, we will need a measuring tape to measure the work piece and to get the precise measurement.

Figure 3.14: Marking Process

3.8.2 Rolling

Rolling machine is used to roll the circular hollow steel depends on the size of circle. The rolling machine consists of 3-roller asymmetrical structure with the upper roller as the main drive and the 2 lower roller function to clamp the steel materials tight. The rollers have size that must be match with the size of circular hollow steel that will be rolled. Circular hollow steel will be used to make the aquaphonic house casing. Round hollow rod will going bending process using rolling machine. It is to make aquaphonic house shape which is a dome shape. The circular hollow steel being bending in 3 different diameters and rod will be check using jig that have been make.

Figure 3.15: Rolling Machine

3.8.3 Cutting

In this process, hand saw and grinder will be used to cut the materials according to the measuring that have been marked. After the bending processes have finish. That rod will going for cutting process follow as dimension in the design.

Figure 3.16: Using Floor Cutting Disc

3.8.4 Joining

As the parts are cut, the joining process will take place to join all the parts. There are two process uses to join the parts which are welding and fastening. The machines use for welding process is Metal Inert Gas (MIG) welding. The joining must be strong enough to support the load.

Figure 3.17: Welding Process Using MIG

3.8.5 Fastening

A fastener is device that mechanically joins or affixes two or more objects together. To install the frame, the aluminum and casing will be drill and rivet process will take place to assembly it.

Figure 3.18: Fastening Process Using Rivet

3.8.6 Chassis Assembly

Chassis assembly show the way how the structure of aquaponic house will be fabricated. The assembly started with bending. This pictures below show the fabrication process of aquaponic house.

The circular hollow steel is used to make aquaponic structure. This hollow steel will be bending using rolling machine. There are 3 different diameters that we used to make aquaponic structure.

The bended shape of circular hollow steel will be check using the jig that has been made. To get the precise diameter, the method that use is try and error method.

After all circular hollow steel has been banded; the hollow steel will be cut follow by the drawing of aquaponic structure.

This aquaponic structure welded using MIG welding. The defect after welded can cause the fragile structure.

In order to make sure the structure stable, the several part of the structure will be fixing to the ground to ensure the structure can support the grow bed that containing the water. After the pole has been concrete, brick will be stacking for aquaponic base.

	For the grow bed, the material will be use is fiber glass. This grow bed shaped is U shaped. The wall and the base of grow bed will be fabricate separately and will be combine to become a tank.
	The frame of aquaponic house will be installing both sides to make easier when install the wire mesh. The aluminum has been chosen as a frame because of there is light weight, not rust and easy to shape.
	Wire mesh will be installed to the casing after the entire frame already. Wire mesh will go drilling process to fix it with the frame. Wire mesh being installing to the entire casing wall.

Figure 3.19: Fabrication of Aquaponic House

3.8.7 Roof Fabrication

For the roof fabrication, the first thing that should do is make the roof mold using wood. Then the brick will put at the bottom of the mold in order to strengthen the mold base. Figure 3.19 shows the step of mold fabrication using brick.

Figure 3.20: Mould Fabrication

After the bottom of the mould is finish, the mould will be cover using sand to make sure that the shape of the roof very smooth. Then, the roof mould will cover using cement. This is the important part to be done and must be sure that the surface is smooth. Surface that not smooth will affect the roof surfaces. Figure 3.19 shows the mold after finish fabricates.

Figure 3.21: Roof Mould

Roof being fabricate using fiber glass. Fiber glass is easier to fabricate follow the dome shaped of the roof. Then the roofs being cut follow the roof dimension. The dirty at the roof surface being clean using wire brush. After the roof finish fabricated, the roof panel will be install to the structure of aquaponic house.

Figure 3.22: Roof after Cutting Process

3.8.8 Solar Panel Installation

There are 3 solar panel will be install at the roof. This solar panel is use to absorb the heat from the sun. . To receive maximum energy, the solar panel should be situated in an area that will receive direct sunshine the entire day. The figure 3.22 show the installation of solar panel at the 3 fix roof.

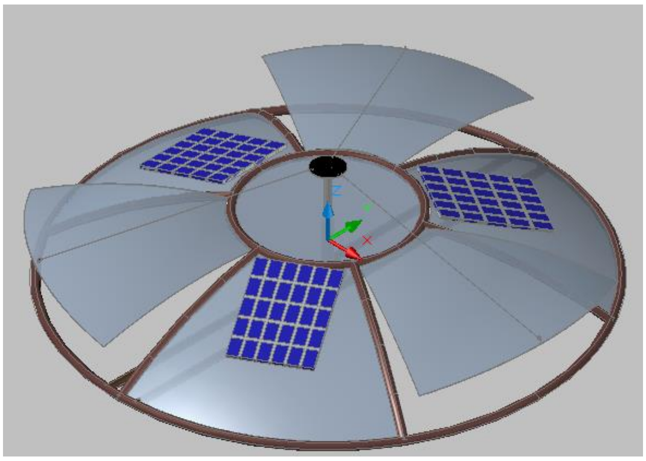


Figure 3.23: Solar Panel Installation

CHAPTER 4

RESULTS AND DISCUSSION

4.1 INTRODUCTION

The final result to design and fabricate aquaponics house with temperature control system powered by solar power is done from only limited times due to several problems occur to the project. In this chapter will discuss mainly about the result of the project, analysis about the project and all problems encountered during the whole project was been carried out.

4.2 RESULT

After finish the fabrication of structure of aquaponic house, the result shown as the figure below:

Figure 4.1: Aquaponic House Structure

Figure 4.2: Aquaponic Roof

Figure 4.3: Actuator Holder

Figure 4.4: Roof Mechanism

4.3 PRODUCT SPECIFICATION

This is another example of analysis process. The product specification is shown on the table below:

Table 4.1: Linear Actuator Specification

CATEGORIES	RESULT
Voltage	24V
Power	45W
Current	3A (Max)
Speed	20mm/s
Maximum Thrust	750N
Extendable length	200mm

4.4 COST ANALYSIS

Some of the material that need to be purchased such as the thing that not available in mechanical laboratory:

Table 4.2: Cost Analysis

PART	PRICE	QUANTITY	TOTAL
Electric component	RM 6.00	2	RM 90.70
Linear actuator	RM 350.00	1	RM 350.00
Power supply 10v 6a	RM 60.00	1	RM 60.00
Board casing	RM 16.00	1	RM 16.00
PCB board	RM 50.00	1	RM 50.00

4.5 ELECTRONIC PART AND FUNCTION

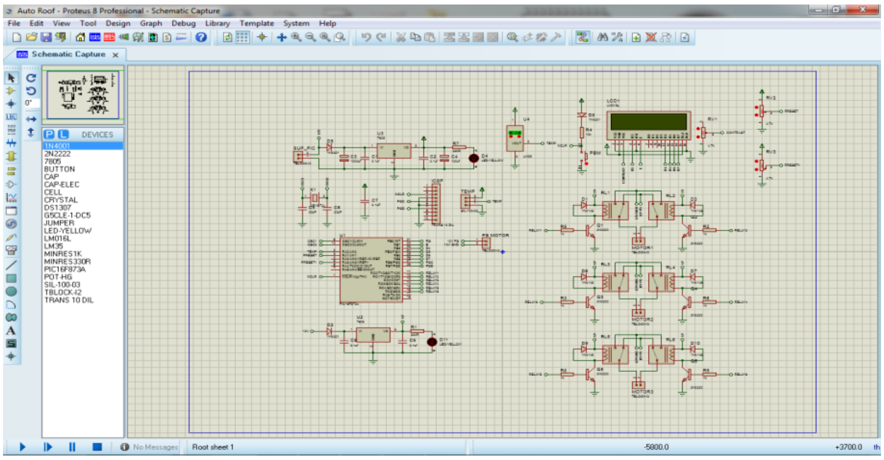


Figure 4.5: Electronic Part on the Board

From the figure 4.5, it is shown the circuit design of PIC temperature controller. The circuit above was designed using Proteus 8 software which allowed us to simulate whether the circuit design working or not. To simulate the circuit above we need to include hex which contain machine code that can operate PIC16F873A

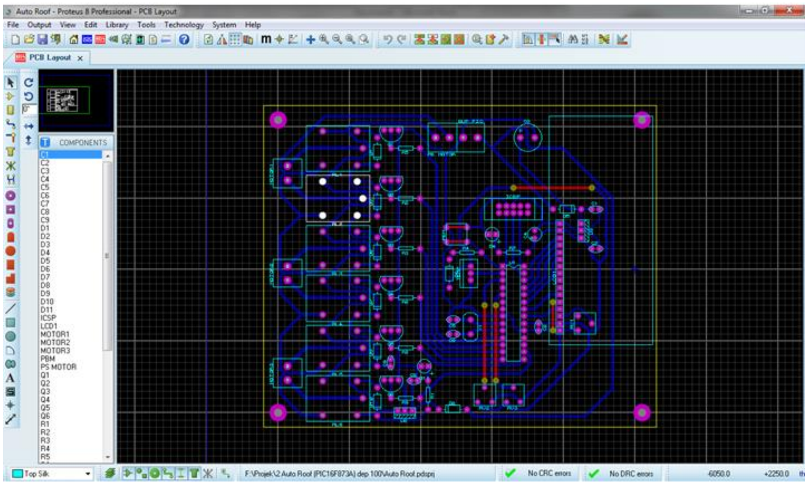


Figure 4.6: Printed Circuit Board (PCB)

Figure 4.6 show the simulation flow of the board that will connect between the electronic parts. This process will make the installation of the electronic part will easier and can reduce mistake. The blue color shows where the flow of current will go and contact with the electronic part. The pink color shows the location of electronic part will be installing.

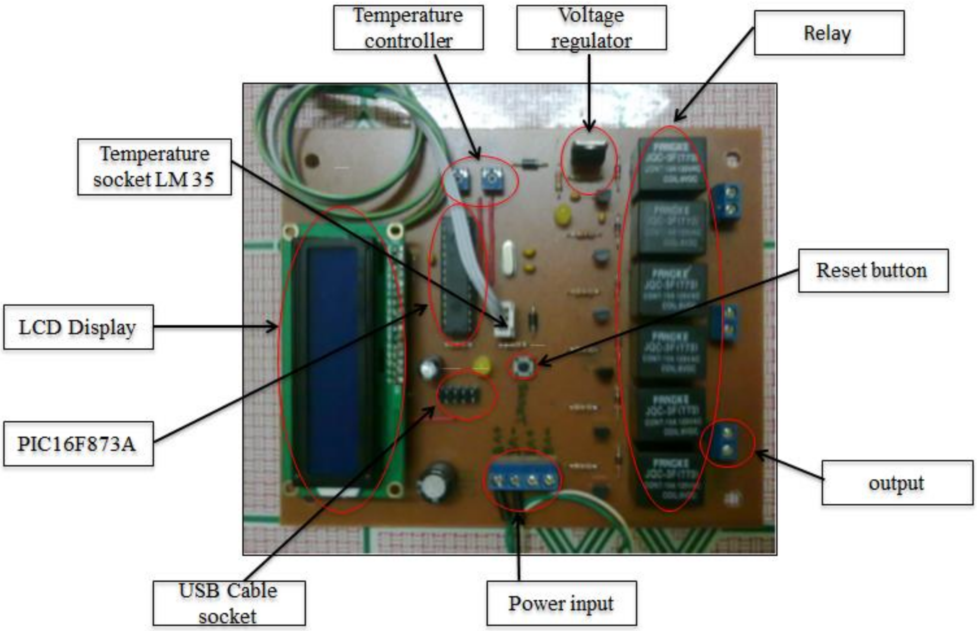
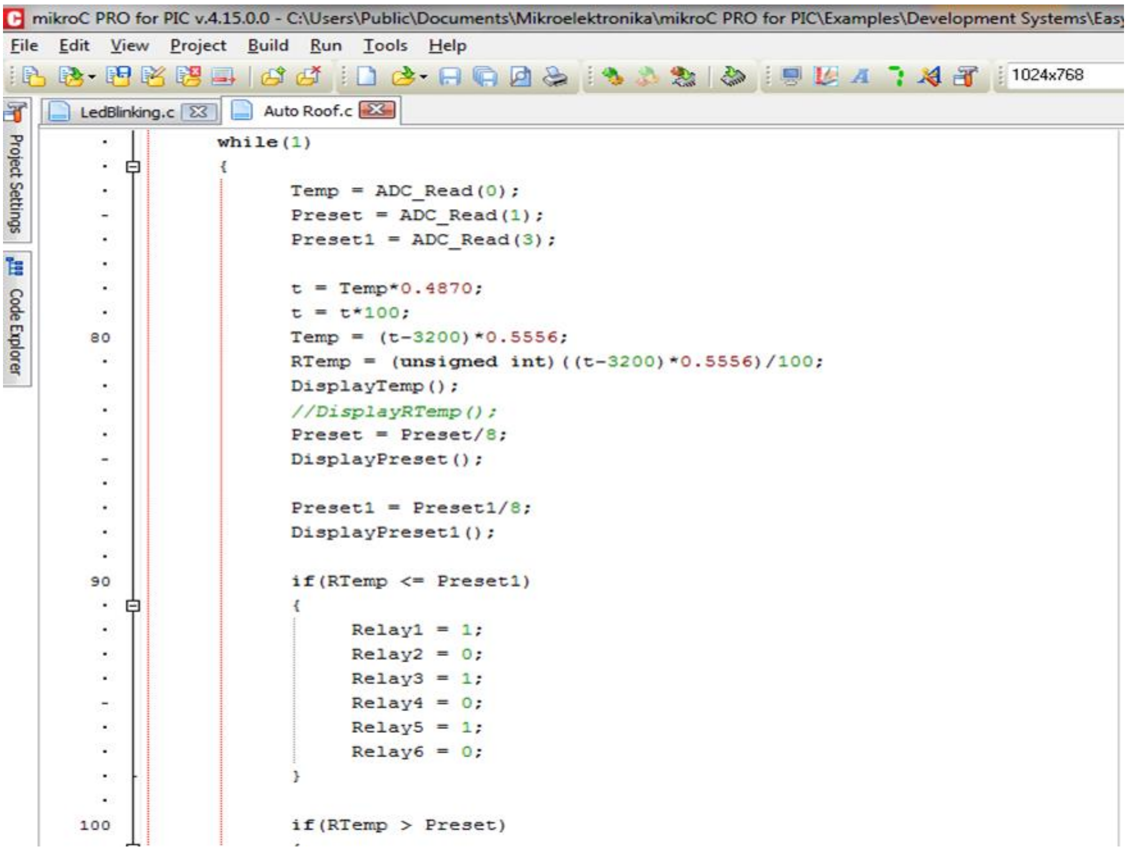


Figure 4.7: Component Labeling

Figure 4.7 shows the function of the button and the place where the input and output power delivery. All the button that being shown will be used to set the time for each session of the feeding time. The function of the button us limited to reset the session time and to create new session time for the feeding. The feeding time for each session is only set in the programming that has been done using PIC.




```
while(1)
{
        Temp = ADC_Read(0);
        Preset = ADC_Read(1);
        Preset1 = ADC_Read(3);

        t = Temp*0.4870;
        t = t*100;
        Temp = (t-3200)*0.5556;
        RTemp = (unsigned int)((t-3200)*0.5556)/100;
        DisplayTemp();
        //DisplayRTemp();
        Preset = Preset/8;
        DisplayPreset();

        Preset1 = Preset1/8;
        DisplayPreset1();

        if(RTemp <= Preset1)
        {
            Relay1 = 1;
            Relay2 = 0;
            Relay3 = 1;
            Relay4 = 0;
            Relay5 = 1;
            Relay6 = 0;
        }

        if(RTemp > Preset)
```

Figure 4.8: PIC code used in Microcontroller

Software implementation is the important part of this project and takes the longest period of analysis and research. The software used in this project is MicroC with to write MicroC language program. The software will convert the MicroC Pro language to HEX file that can be read by the microcontroller. This project used PIC16F873A as a microcontroller

4.6 DISCUSSION

In this project, several observations have been done with respect to the fabrication of aquponic house. The outcome design and fabricate of aquaponic house was achieve the objective of this project. The temperature of aquaponic house can function in good condition for examples the actuator can be move up and down follow by the temperature.

During fabrication process, there are so many things happen such as defect. This defect happens because lacks of skill to operate a machine such as when handling MIG welding machine. Although this problem happened, it can give an experience to avoid the same problem to be repeated again at the future.

This project successfully programmed into the microcontroller, PIC16F873A can control LM35DZ as an input, control the output such as LCD 16x2, LED and actuator. This project also successfully displayed the environment temperature value and also displayed the desired temperature set point so the user can monitor the different between desired temperatures with current temperature read by a sensor.

For the circuit, the first thing that must do is to analyse all the sensor circuit to get the sensor characteristic using proto board and multi meter .After the entire sensor has been analysed, the project proceeds to the next stage.

The next stage is software development. Based on the analysis, the project programming can be designed. After designed the project programming, the programming was tested by using MICROC software. This method used to test either the program is successfully built or not. If there are any errors in the programming, the MICROC software will locate the errors, and then the error can be fixed either directly or by checking the problem using help library.

After successfully build and compile the project programming, the project proceeds to the next stage which the programming was tested on the microcontroller PIC16F873A. The hex file was created by MICROC and downloaded into the

PIC16F873A using PIC kit2 v2.55 software. The USB ICSP PIC programmer used as interface between PIC16F873A with the software PIC kit2 v2.55.

The PIC16F873A that already downloaded with the hex file was tested using proto board and multi meter. The microcontroller will interface with sensor, LCD and the relay circuit to test either the project programming practically successful or not.

After the circuit on the proto board successfully process the data from the sensor circuit and can control the output, the circuits are ready to be soldered on the PCB board. After the circuit was soldered, once again all the circuit will be tested.

If the circuit has a problem, the circuit will be troubleshooting by using multimeter. The project is successfully done when all the sensor work properly based on characteristic and fully functioning without a problem.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 INTRODUCTION

This final chapter represents about conclusion and recommendation for the project. In this chapter will discuss mainly about the conclusion of the project, concluding all the process that involved. Besides that this chapter also contains recommendation about the project. So for this recommendation it can make improvement about the project in the future.

5.2 CONCLUSION

The objectives of this project to design and fabricate aquaponic house with temperature control system powered by solar power are successfully done and achieved. The mechanism system to open and close the roof is work smoothly. Besides that, the temperature control system successfully designed and been implemented to control the temperature about 30°C. The LCD screen displayed the environment temperature and desired set point of temperature value using the LCD 16x2.Although there are a lot of obstacles, the project can finish within the given time. There are many things throughout this project such as skill and knowledge that we can get especially during fabrication process. These valuable experiences get will be useful in the future.

This project also generates capabilities as a responsibility person. This is because we need to take care and take a look the project. Finally, we can conclude that final year project is very important because we can learn a lot of things that are important for us to use them while we are working in the future.

5.3 RECOMMENDATION

For future improvement, there are few suggestion to make this project more efficient and marketable. This project still needs lot of effort to be improved. For future works, some recommendations are listed as follows:

5.3.1 Temperature – the different outside and inside temperature very small because of velocity the wind flow very slow. So we can use exhaust fan to suck out the hot air inside aquaponic house. Exhaust fan is a must device as a cooling system in a aquaponic house.

5.3.2 Roof Design – the design of the roof we can change from 3 panels to 6 panel roof can be open**.** So the hot and fresh air easy to change then the aquaponic house will stay cool at day and night.

5.3.3 Controller – to get the faster response PID controller need to be use because it has faster response than the conventional on-off controller. Besides that, PID controller can calculate error to make the linear actuator extend follow the actual temperature.

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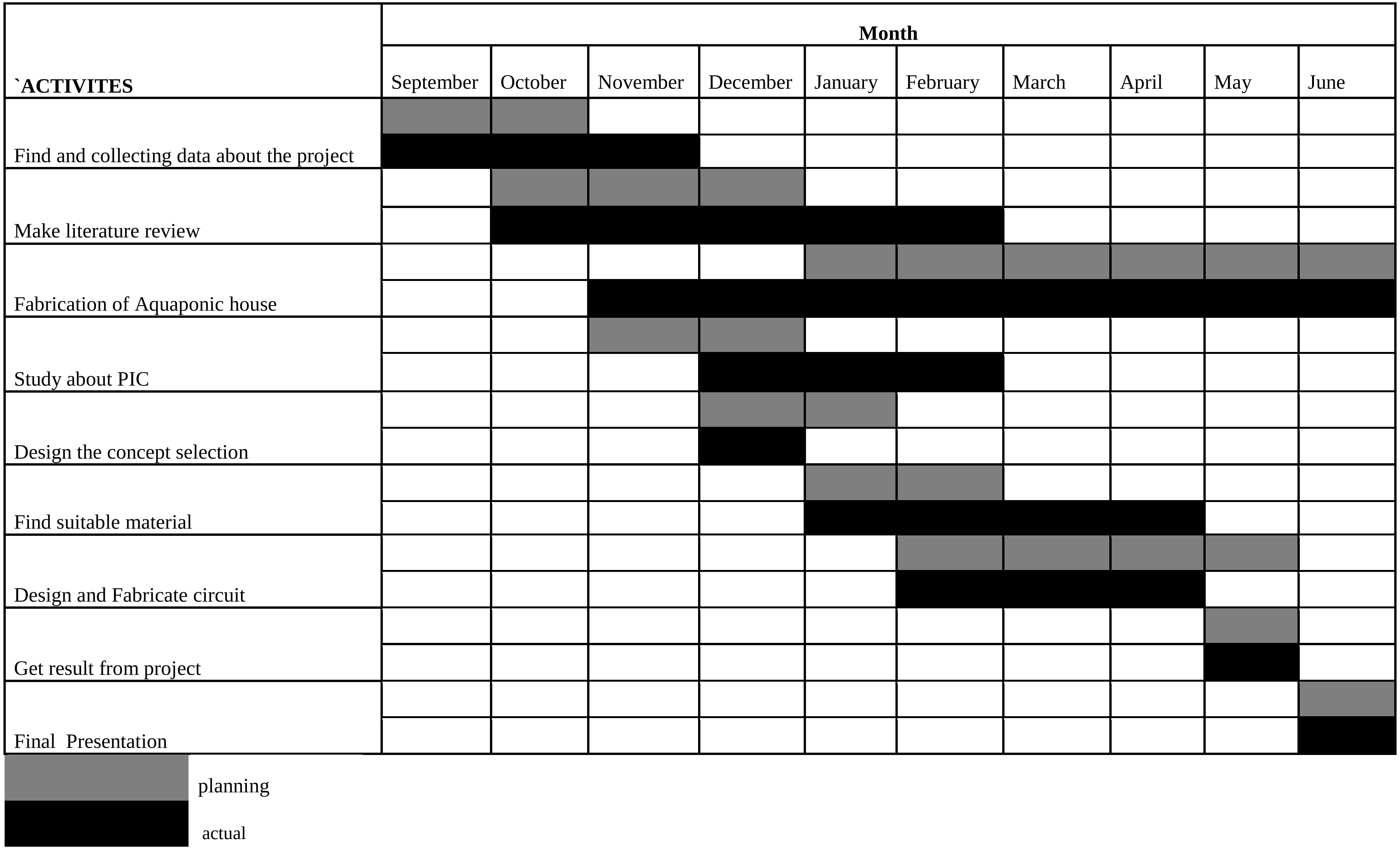
APPENDIX A

GANTT CHART


`ACTIVITES
Month
September
October
November
December
January
February
March
April
May
June
Find and collecting data about the project
Make literature review
Fabrication of Aquaponic house
Study about PIC
Design the concept selection
Find suitable material
Design and Fabricate circuit
Get result from project
Final Presentation
planning
actual

APPENDIX B

PROGRAM DEVELOPMENT

```
// LCD module connections
sbit LCD_RS at RB0_bit;
sbit LCD_EN at RB1_bit;
sbit LCD_D4 at RB2_bit;
sbit LCD_D5 at RB3_bit;
sbit LCD_D6 at RB4_bit;
sbit LCD_D7 at RB5_bit;

sbit LCD_RS_Direction at TRISB0_bit;
sbit LCD_EN_Direction at TRISB1_bit;
sbit LCD_D4_Direction at TRISB2_bit;
sbit LCD_D5_Direction at TRISB3_bit;
sbit LCD_D6_Direction at TRISB4_bit;
sbit LCD_D7_Direction at TRISB5_bit;
// End LCD module connections

sbit Relay1 at RC0_bit;
sbit Relay2 at RC1_bit;
sbit Relay3 at RC2_bit;
sbit Relay4 at RC3_bit;
sbit Relay5 at RC4_bit;
sbit Relay6 at RC5_bit;

unsigned int Temp, RTemp, Preset, Preset1;
float t;

void DisplayTemp (void)
{
   Lcd_Chr(2,1,('0'+(Temp/1000)%10));
   Lcd_Chr(2,2,('0'+(Temp/100)%10));
   Lcd_Chr(2,3,'.');
   Lcd_Chr(2,4,('0'+(Temp/10)%10));
   Lcd_Chr(2,5,('0'+(Temp/1)%10));
```

```
}

void DisplayRTemp (void)
{
   Lcd_Chr(1,5,('0'+(RTemp/1000)%10));
   Lcd_Chr(1,6,('0'+(RTemp/100)%10));
   Lcd_Chr(1,7,'.');
   Lcd_Chr(1,8,('0'+(RTemp/10)%10));
   Lcd_Chr(1,9,('0'+(RTemp/1)%10));
}

void DisplayPreset (void)
{
   Lcd_Chr(1,14,('0'+(Preset/100)%10));
   Lcd_Chr(1,15,('0'+(Preset/10)%10));
   Lcd_Chr(1,16,('0'+(Preset/1)%10));
}
void DisplayPreset1 (void)
{
   Lcd_Chr(2,14,('0'+(Preset1/100)%10));
   Lcd_Chr(2,15,('0'+(Preset1/10)%10));
   Lcd_Chr(2,16,('0'+(Preset1/1)%10));
}

void main()
{

     ADCON1 = 4;
     TRISC = 0;
     PORTC = 0;

     Lcd_Init();                    // Initialize LCD
     Lcd_Cmd(_LCD_CLEAR);           // Clear display
```

```
Lcd_Cmd(_LCD_CURSOR_OFF);          // Cursor off
Lcd_Out(1,5,"Auto Roof");                  // Write text in first row
Delay_ms(500);
Lcd_Out(1,1,"Temp     OFF ");                  // Write text in first row
Lcd_Out(2,1,"          ON  ");                  // Write text in first row
while(1)
{
     Temp = ADC_Read(0);
     Preset = ADC_Read(1);
     Preset1 = ADC_Read(3);

     t = Temp*0.4870;
     t = t*100;
     Temp = (t-3200)*0.5556;
     RTemp = (unsigned int)((t-3200)*0.5556)/100;
     DisplayTemp();
     //DisplayRTemp();
     Preset = Preset/8;
     DisplayPreset();

     Preset1 = Preset1/8;
     DisplayPreset1();

     if(RTemp <= Preset1)
     {
         Relay1 = 1;
         Relay2 = 0;
         Relay3 = 1;
         Relay4 = 0;
         Relay5 = 1;
         Relay6 = 0;
     }
```

```
        if(RTemp > Preset)
        {
            Relay1 = 0;
            Relay2 = 1;
            Relay3 = 0;
            Relay4 = 1;
            Relay5 = 0;
            Relay6 = 1;
        }

    }
}
```