GREEN HOUSE FERTIGATION SYSTEM

by

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CERTIFICATION OF APPROVAL

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A project dissertation submitted to the
Electrical & Electronics Engineering Programme
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in partial fulfillment of the requirement for the
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Approved by,

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UNIVERSITI TEKNOLOGI PETRONAS
TRONOH, PERAK
May 2011

CERTIFICATION OF ORIGINALITY

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

(NOR SYAFIQAH BT SYAFRUDDIN)

ABSTRACT

The project is about Green House Fertigation System which the main focus is on watering and fertilizing. The project is meant to efficiently improve the distribution of water and fertilizer inside the green house. It is an intelligent and advanced system where the nutrients (water and fertilizer) can be controlled and distributed based on the time set. The proportion of fertilizer and water used for this project is in 1 : 100 ratio. PIC 16F877A microcontroller is used as the control unit. The microcontroller will monitor the inputs and as a result the program would turn outputs on and off. The input of this system is the time setting while the output is the water pump that will distribute the nutrient to the plants.

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CHAPTER 1
INTRODUCTION

1.1 Background of Study

A greenhouse is a building where plants are grown. It protects crops from over temperature, shield plants from dust storms and help to keep out pests. The idea of growing plants in environmentally controlled areas has existed since Roman times. As the technology is getting modern over the centuries, a completely closed system allowing the gardener control the plants while using less energy is applied. The closed environment of a greenhouse has its own unique requirements where extremes of heat and humidity have to be controlled and irrigation is necessary to provide water [1].

This project is about designing and implementing a fertigation system inside the greenhouse. Words fertigation came from the combination of fertilization and irrigation. The project is targeted to improve the irrigation water management as well as the fertilizer distribution.

Plants depend on water and being in the greenhouse, there will be no rainfall to supply water naturally. The added warmth can make the soil dry out quickly, thus, some form of artificial watering or irrigation system inevitably become essential.

Fertilizer injector is used for fertilizer distribution. It is a mechanical devices used to deliver the water-soluble fertilizers. They are a vital part of modern greenhouse operation [2]. Since the fertilizer is in the liquid form, it can be distributed together with irrigation water. This is what is called "fertigation" which implements the simultaneous use of irrigation and fertilization. In the simplest word, fertilization and watering systems can be done at the same time.

This fertigation idea can increase the efficiency of the greenhouse because the crops can get food and water at the same time. It is a precise application of the nutrients according to the crop requirements. Plants that are given a continuous supply of nutrients tend to develop stronger root systems that are able to take in water more effectively so they stay green and healthy with less water [3]. In addition, this system can save the usage of water.

1.2 Problem Statement

1.2.1 Problem Identification

To water a large scale agriculture area can be a major task, especially if it has to be done manually as it can be very time-consuming and laborious. The traditional irrigation method which uses watering-cans or barrels is an ineffective way as they are particularly useful in providing very specific and only targeted watering for individual plant. Many gardeners overcome this problem by using a hosepipe instead, but this approach is not suitable, chiefly in terms of delivering the right amount of water needed. Also, these two approaches can lead to over irrigation.

According to the prediction, it shows that by 2025, one quarter of the world population will face water shortage [4]. Because agriculture is the main consumer of fresh water, increasing irrigation efficiency seems to be the most practical way to save water.

In addition, over fertilization which affects the growth of the plant often occurs in agriculture. Over application of fertilizer kills the plants by effectively burning them. Hence, to overcome this problem, an auto system for fertilizer application is concerned throughout this project.

1.2.2 Significant of the Project

In Malaysia, agriculture remains an important sector of Malaysia economy, contributing 12 percent to the national gross domestic partner and providing employment for 16 percent of the population [5]. Greenhouse is one of the systems used for agriculture which can save energy and has many advantages. Therefore, by upgrading the greenhouse system, this project will significantly help the country in such a way. Through a proper system of fertilization and watering, the greenhouse is expected to produce good crops which are economically feasible in future.

1.3 Objective

A set of objectives has been identified as the guidelines for what should be achieved throughout this project. The followings are the objectives of this project:

- To design a system that can control the distribution of water and fertilizer inside the greenhouse.
- To construct the proposed fertigation system by integration of hardware device and software programming

1.4 Scope of Study

The scope of study for this project embraces type of plants to be used and the optimum amount of water and fertilizer needed for plant to grow. In order to achieve the project objectives, the understanding of the matters below are taken into account:

- The number of times the plants need fertilizer per day
- The volume of the nutrient (water + fertilizer) required for each plant per day
- Distance of each plant

The operation of piping, pump, PIC microcontroller and other electronics equipment are studied for the hardware connection for this project. It is important to understand these operations as the flow of water and fertilizer depends on this system.

1.5 Project Relevancy and Feasibility

The project is relevant since knowledge of Instrumentation and Control; and Computer System will be applied in the construction of the system. The control unit involves programming and hardware connection of a microcontroller, namely PIC. With the timeframe of two semesters, the works regarding the project such as components acquisition, circuit construction and programming microcontroller can be carried out, as success of these processes ensure smooth project progress.

CHAPTER 2
LITERATURE REVIEW

2.1 Overview

In recent years, agriculture has played a very important role as one of the major economic incomes of our country. In 2009, high value agriculture, including organics fruits and vegetables contributed about 1 % to the national gross domestic partner (GDP). During the tenth Malaysian plan, these high value agriculture activities will be given special focus such that the contribution to GDP increases to 2% by 2015 [6].

Fertigation increases proportionally with the increased of irrigation system. Because of this, fertigation itself has increased dramatically in the past 15 years particularly due to the improvement in the sprinkler and drip systems. This will continue to grow since such systems result in less water usage and better uniformity.

2.2 Watering System

There are several watering systems that can be applied in the greenhouse including mister, sprinkler systems and drip irrigation. If large numbers of seeds or cuttings require watering, misters may well be the best option. It fills the greenhouse with a fine spray of water which gradually moistens the soil without disturbing it [7].

Sprinkler systems are also commonly used in greenhouses. It is the suitable method in providing water which resembles the natural rainfall. Water is distributed through a system of pipes usually by pumping. It is then sprayed into the air through sprinklers so that it will break up into small water drops. However, the delivery to match the needs of individual plants is not easy to achieve.

Drip irrigation system is fast catching on as a far more efficient method of irrigating. It allows water to drip slowly to the roots of plant, either onto the soil surface or directly onto the root zone [8]. This system was chosen because it can deliver moisture directly to the roots of the plants so there is less water lost to evaporation and wind drift. In addition, all plants will get the same amount of water. Figure 1 shows the example of drip irrigation system that has been practiced by MARDI.

Figure 1 : Drip Irrigation System in MARDI

2.3 Growing Systems

There are two ways in growing the crops which are in open-field soil and soilless culture. A major problem in growing crops in soil is the presence of soil pathogens that may lead to soil-borne diseases. Growing plants continuously without crop rotation or interruption in production as .in open field production can lead to an excessive build up of soil pathogens [9].

Soilless culture is a way to grow plants with artificial medium. For greenhouse, soilless culture is possibly the most intensive method of crop production. It is highly productive, conservative of water and land, and protective of the environment. Virtually this system in temperate regions of the world are enclosed in greenhouse-type structures to provide temperature control, reduce evaporative water loss, reduce disease and pest infestations, and protect crops against the elements of weather such as wind and rain. The latter considerations are especially valid in tropical regions such as Malaysia.

Coco peat or also known as coir dust is used as the artificial medium for this project. Coco peat holds water rather than shedding it and it can retain moisture up to eight times of its volume. It has the ability to store and release nutrient to plants for extended periods of time. [10].

2.4 Fertilization

The common case of indoor plant is over fertilization. Fertilizer intake of plant is directly proportional to the rate of plant growth especially in the presence of light and temperature.

Fertigation is the answer for over fertilization problem. It is the technique of supplying dissolved fertilizer to crops through an irrigation system. This system works by injecting treatments into water pipes and delivered right to the plants that need them. Small applications of soluble nutrients saves labour, reduces compaction in the coco peat, thereby enhancing productivity. Because these nutrients are dissolved in water, the plants will readily absorb what they need to thrive.

Table 1 shows the chemical substances that made up the liquid fertilizer. The ratio of fertilizer and water is 1 : 100. For example, one tank of fertilizer solution must consist of 98 liters of water, 1 liters of solution A and 1 liters of solution B.

Table 1 : Chemical Substance in Liquid Fertilizer

Solution	Chemical Substance
A	Calcium Nitrate, $Ca(NO3)_2$
	Iron Chelate, FeEDTA
B	Potassium Nitrate, KNO_3
	Monobasic Potassium Phosphate, KH_2PO_4
	Magnesium Sulphate, $MgSO_4$
	Mangan Sulphate, $MnSO_4$
	Hibor
	Zinc Sulphate, $ZnSO_4$
	Copper Sulphate, $CUSO_4$
	Sodium Molybdate, Na_2MoO_4

2.5 System Control Unit

A controller is the brain of the system. The intelligence of the system lies on the ability to execute process when certain conditions are interpreted by the control unit. For this project, the situation is to distribute the nutrients to the plant everytime when needed.

PIC 16F877A microcontroller is used for this project. It has a set of serial ports built in, which are used to transfer data to and from other devices, as well as analogue inputs. The features offered by this particular microcontroller are vast, thus making it attractive to be used for this project. Most of the pins in PIC are for input and output, and arranged as 5 ports : A(5), B(8), C(8), D(8) and E(3), giving a total of 32 I/O pins. They are configurable through software programming, analog-to-digital converter (A/D) module, large programming memory and multiprogramming language that can support the device [11].

2.6 Irrigation Scheduling

By definition, irrigation scheduling is a planning and decision-making process used by the farmers to improve the efficiency of water usage and to raise yields. This in turn will lead to higher income. Besides that, it can also bring a positive effect on the quality of soil and ground water. This decision-making process determines when and how much water to apply to a growing crop to meet specific management objectives.

A common method that farmers use to determine when their crops need watering is by observing the amount of time has elapsed since the last irrigation cycle. This manual process typically causes farmers to over-irrigate the crops. In fact, over-irrigation can give significant effect to plant and cause environmental problems. Excessive use of water leads to a range of environmental problems such as water logging, nutrient leaching, ground water pollution and salinization.

The solution for this problem is to automate the irrigation system and water management process to decide when to irrigate the crop and how much water to apply. In this project, we upgrade the system by introducing fertigation system inside the irrigation scheduling. The system will work by replacing the irrigation water with nutrients needed by the plant which are water and fertilizer. This system has been practiced by MARDI (Malaysian Agricultural Research and Development Institute)

The nutrient is distributed to the plants based on the real timer that will be set earlier. For example; the plant requires 200ml of nutrient, two times per day, thus, the system must be intelligent enough to distribute 200ml of nutrient to each plant without exceeding the amount. As for the plant inside the greenhouse itself, it is important to make sure that each plant will get similar amount of nutrient.

CHAPTER 3
METHODOLOGY

3.1 Project Procedure Identification

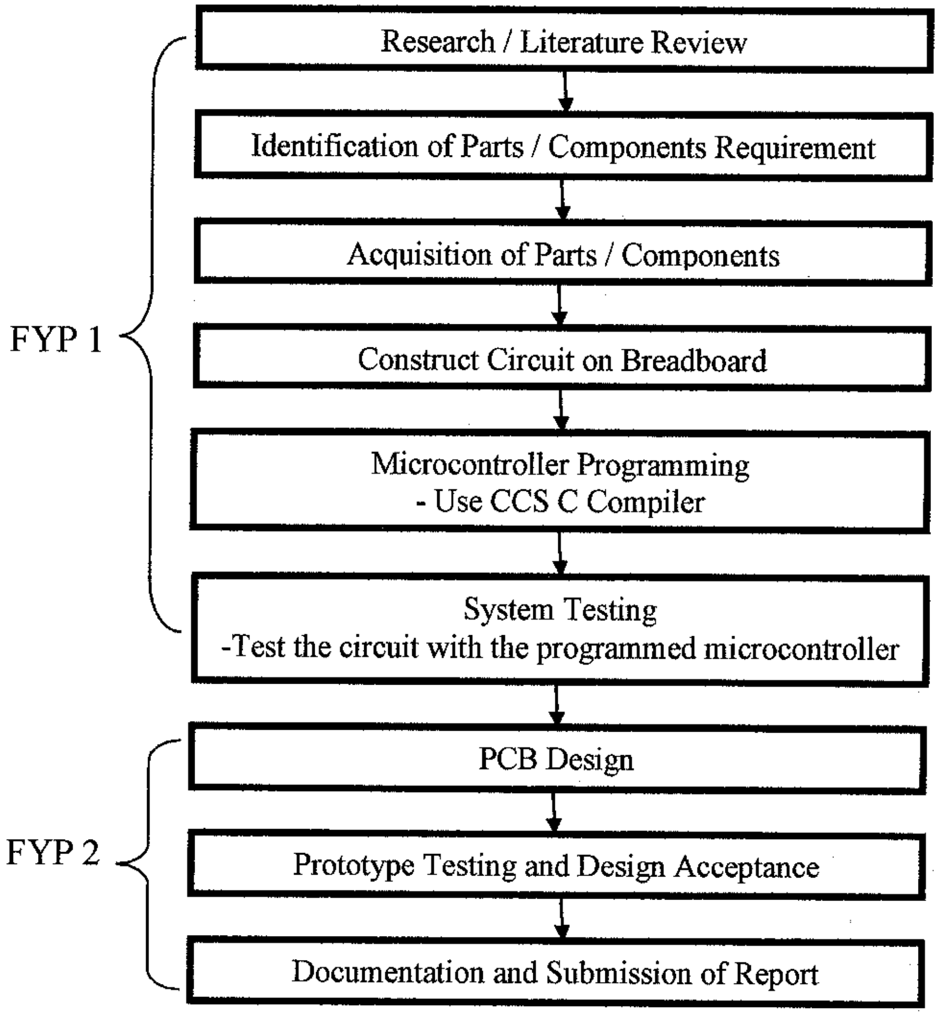


Figure 2 : Project Procedure Identification

3.2 Project Activities

The methodology is divided into two sections which are FYP1 and FYP2. All steps and procedures performed throughout this project will be clarified in step by step. This section briefly shows the path for accomplishing the project from the beginning until end.

During the initial stage of this project, some research and literature review was done to know and understand in details about green house fertigation system. A proper planning is needed to schedule the tasks and ensure all progress can be completed in the desired time.

After that, the designing stage began according to the main objective of this project. Many factors need to be considered and require further analysis before implementing the project. These include the output of this project, the calculation, the construction and all the components needed throughout this project.

The construction of the system started after all the materials and devices were obtained. All information regarding the fertigation were evaluated and analyzed in order to select the best equipment to be implemented for the system. The prototype was constructed according to the design. The prototype was tested to ensure the functionality of the system and the modifications were made to increase the quality of the model.

3.3 Information Gathering

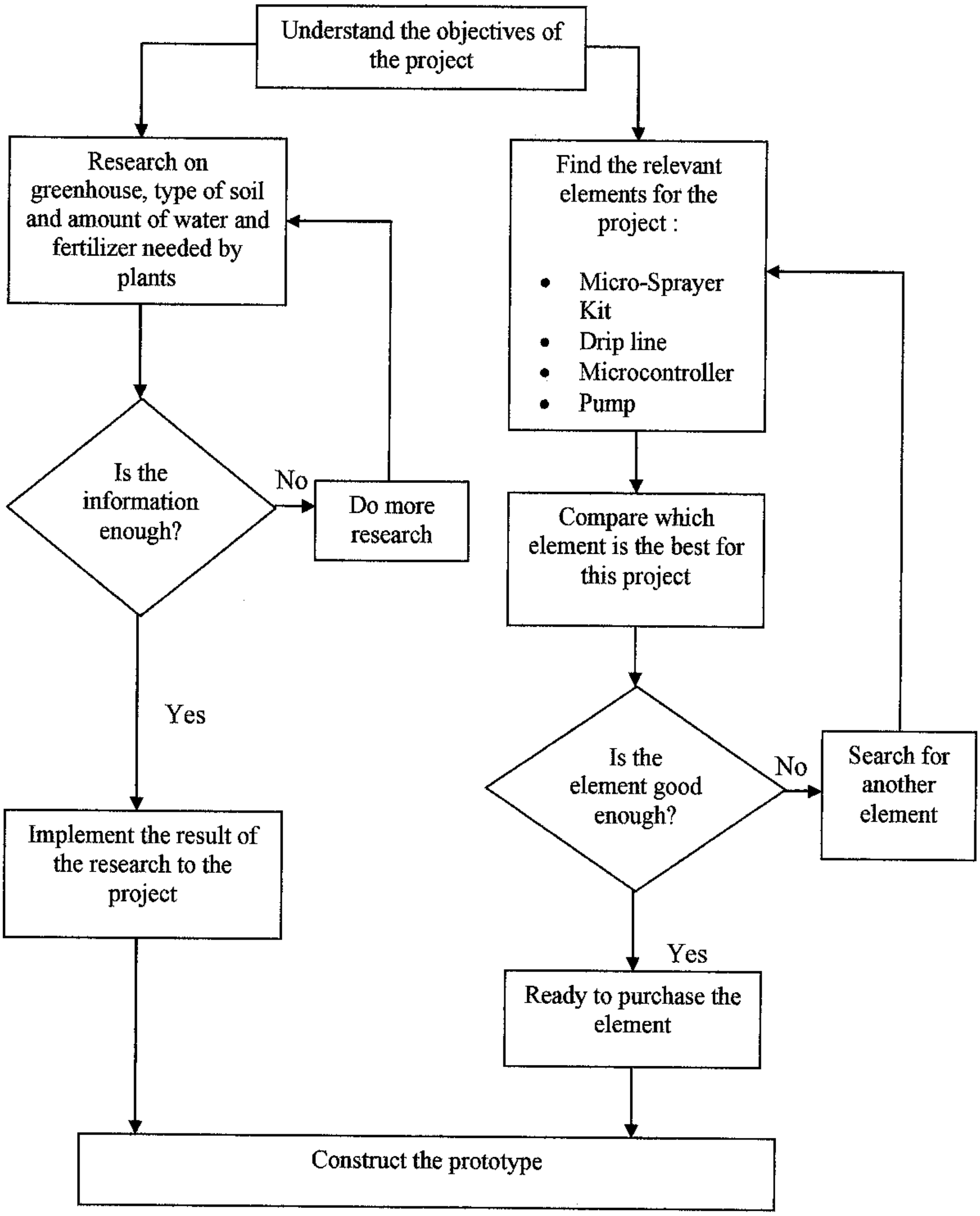


Figure 3 : Method of Information Gathering

3.4 Functional Block Diagram

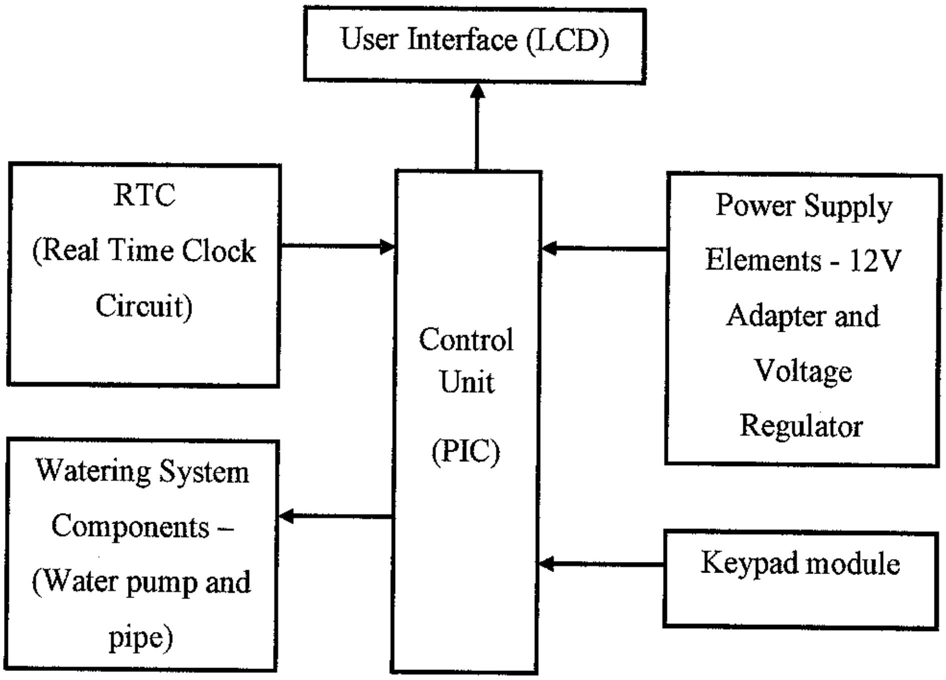


Figure 4 : Functional Block Diagram

The functional block diagram of the system clearly indicates the components and modules that made up the project. By identifying these components and modules, the system can be properly constructed.

3.5 Components and Specification

3.5.1 Project Schematic Diagram

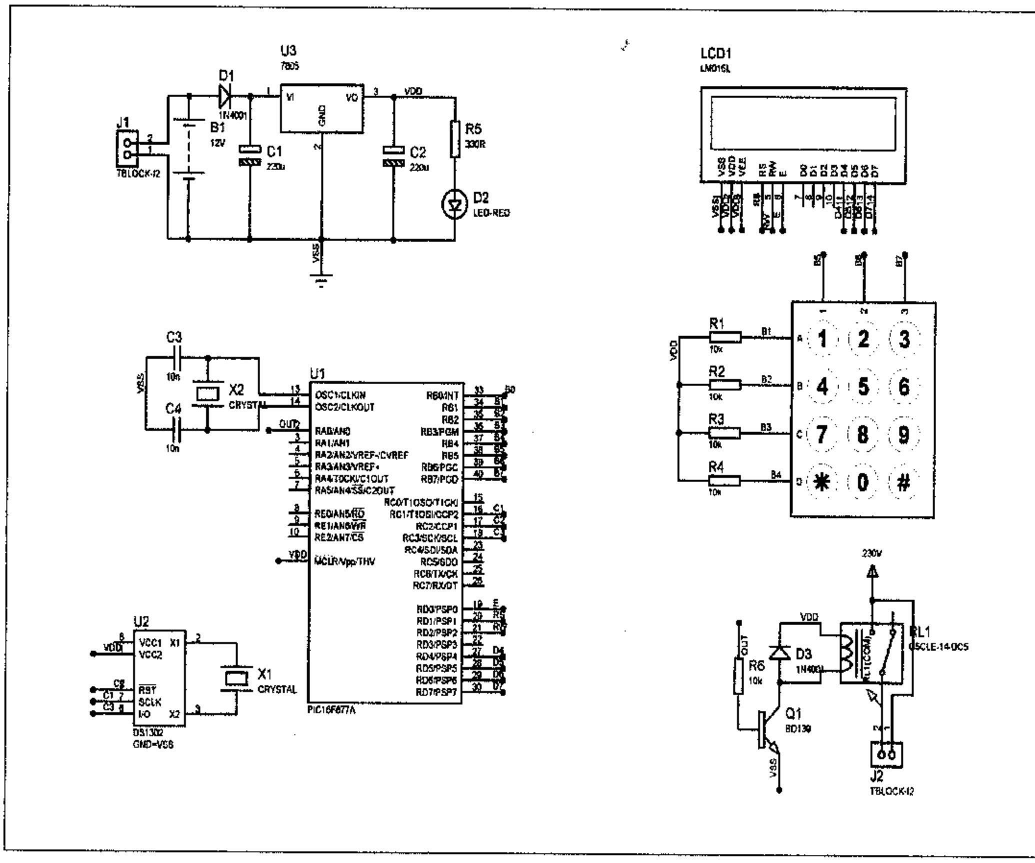


Figure 5 : Circuit Schematic Diagram

Figure 5 gives the overall view of the devices and components connection between each other. The circuit diagram shown is used to control the fertigation system inside the greenhouse. This diagram can be separated into six modules which are voltage regulator circuit, real time clock (RTC) circuit, control unit (PIC), keypad module, LCD module and AC circuit relay motor driver.

3.5.2 Voltage Regulator Circuit / Power Supply Module

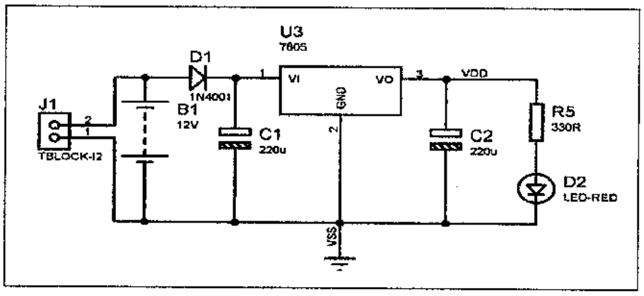


Figure 6 : Power Supply Module

With the use of constructed independent circuit, AC – DC adapter is an essential component to deliver the power requirement of the system and to ensure the supply is constant. After the AC voltage is converted by the adapter, voltage regulator is used to ensure that certain voltage level can flow through the system. This means that the risk and possibility of using the wrong voltage value to operate the system is reduced, thus enhance the safety of the system.

3.5.3 Real Time Clock Circuit

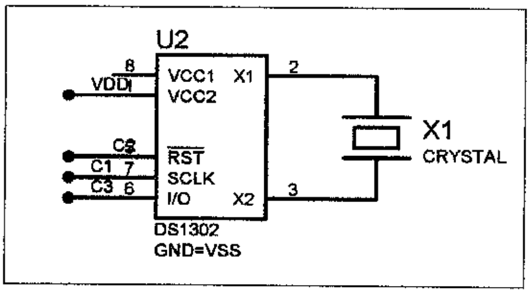


Figure 7 : RTC Module

Real time clock (RTC) circuit is part of the system that keeps track of the current time. The circuit is an essential component for this system as it can provide a real-time clock value indicating. The clock signal that is generated is used to synchronize the operation of the other components and circuits in the system.

3.5.4 Control Unit (PIC)

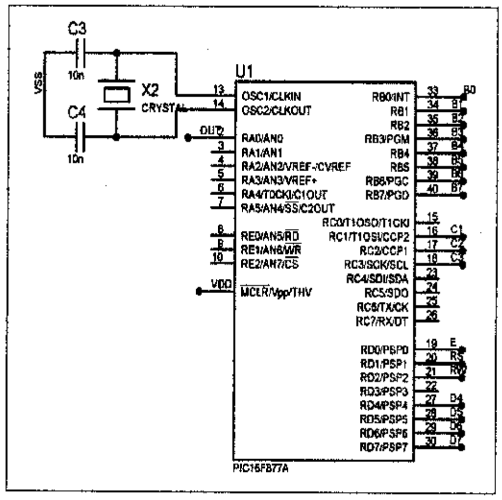


Figure 8 : PIC Module

The main component of the system would be the control unit. This is where the system operation is programmed and the external devices are governed by it. The intelligence of the system lies on the ability to execute the process when certain conditions are interpreted or detected by the control unit.

3.5.5 Keypad Module

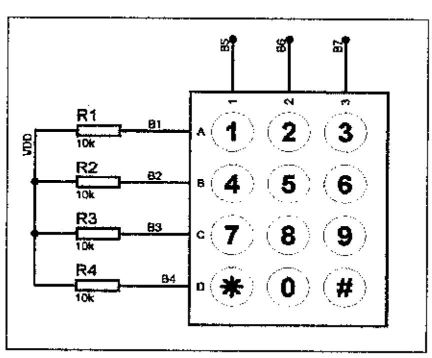


Figure 9 : Keypad Module

Keypad module acts as the user interface for this system. For example, if we want to set the system to operate at 9am, the data must be installed to the system by using the keypad module.

3.5.6 *Liquid Crystal Display (LCD)*

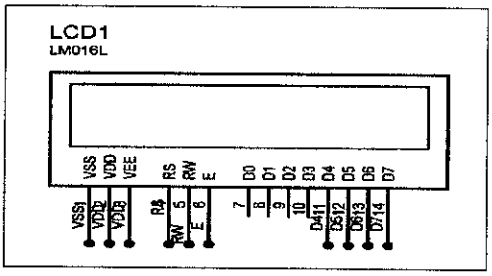


Figure 10 : LCD Module

LCD is the mean of user interface. It is the particular subsystem that is responsible to give feedback and information to the user regarding the status and operation of the system. For this project, LCD is used to show the real timer setting for the pump to operate.

3.5.7 *AC Circuit Relay Motor Driver*

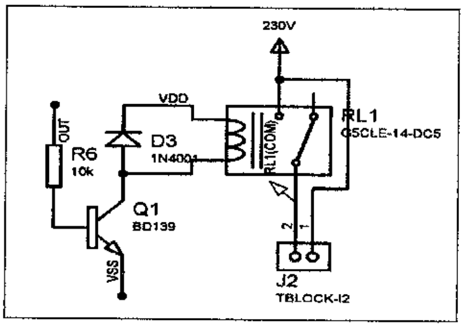


Figure 11 : AC Motor Driver

This module consists of relay and water pump. Relay is essential as the voltage required to operate the pump differs from other components. It provides switching interface between the PIC and the pump. This is because PIC can only provides signal as high as 5V and low current. Therefore, the relay is used to allow the PIC to trigger the pump as programmed.

3.6 Tools and Equipment Used

The tools and equipment used throughout the duration of this project are as follows :

Table 2 : List of Tools / Hardware Used

Tools / Hardware	**Description**
Power Supply Elements	The device used to supply the required amount of electricity. It also regulates the voltage to avoid spikes and surges.
Drip set and Pump	The watering device that is used to distribute nutrients to the plants
Indoor Plant	This is for experiment purpose of the proposed fertigation system. Evaluation of system performance and plant growth is required in order to meet the project requirement
Tank	To store the irrigation water

Table 3 : List of Software Used

Software	**Description**
PSPICE Schematic	The software used to simulate the circuitry designed for the device. It can be used for error checking to identify week points of the circuit.
AutoCAD	This program is particularly important for the design of the device. The initial design should be done using this software to get a visual representation of how the final product should look like.
CCS C Compiler	The C language that is used for PIC programming. It is chosen due to its robustness and functionality that the language offers.

3.7 Fertigation Experiment

3.7.1 Plant Setup

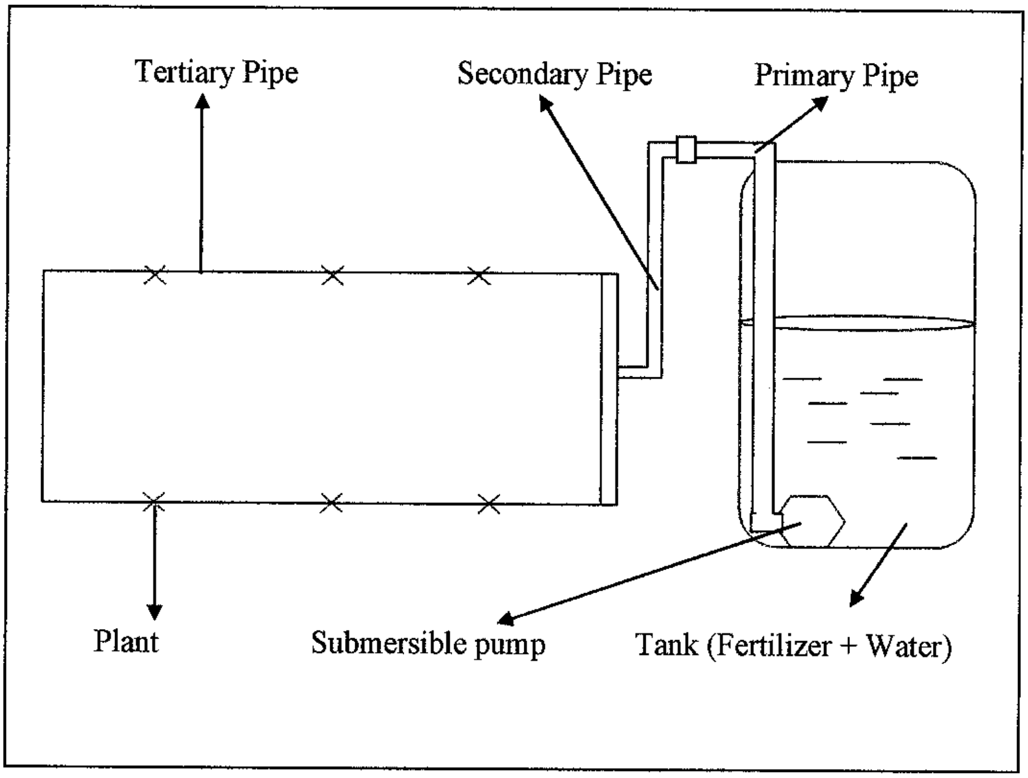


Figure 12 : Structure for Fertigation System

The purpose of conducting experiment on "plant setup" is to study the relationship between distance of the plant and amount of nutrient that can be absorbed by each plant. Basically, there are more than one plant inside the greenhouse and it is important to ensure that each plant is separated in equal distance so that they can get similar amount of nutrient. In order to achieve this objective, all the plants must be organized in a circular structure as shown in Figure 12. The structure can facilitate the nutrient circulation to all plants uniformly. This experiment is expected to determine the optimum distance that can make all plants get the needed amount of nutrient. The experiment can be summarized as shown in Table 4.

Table 4 : Summary of Plant Setup Experiment

Constant Variable	Manipulated Variable	Responding Variable
Volume of nutrient	Distance of each plant	Amount of nutrient absorbed by each plant

The result of this experiment is shown in Chapter 4, page 24.

3.7.2 Timing Setup

"Timing setup" is another critical factor that will ensure the efficiency of this system. Timer must be first set before the system can fully operate. However, in order to set the timer, a basic experiment to determine the optimum time for the system to operate must be performed. For example, if the plant requires 200ml of nutrient, we have to determine how long the pump should be working in order to distribute 200ml of nutrient to the plant. This experiment can be summarized as shown in Table 5. Next section will show the operation flow diagram for the whole system

Table 5 : Summary of Timing Setup Experiment

Constant Variable	Manipulated Variable	Responding Variable
Volume of nutrient	Timing setup	Amount of nutrient absorbed by each plant

The result of this experiment is shown in Chapter 4, page 25.

3.8 Operation flow Diagram

After all the information are gathered, the next step which is prototyping can be done. All the results obtained from the fertigation experiment will be used to construct the whole prototype. Figure 13 shows the complete operation of this system.

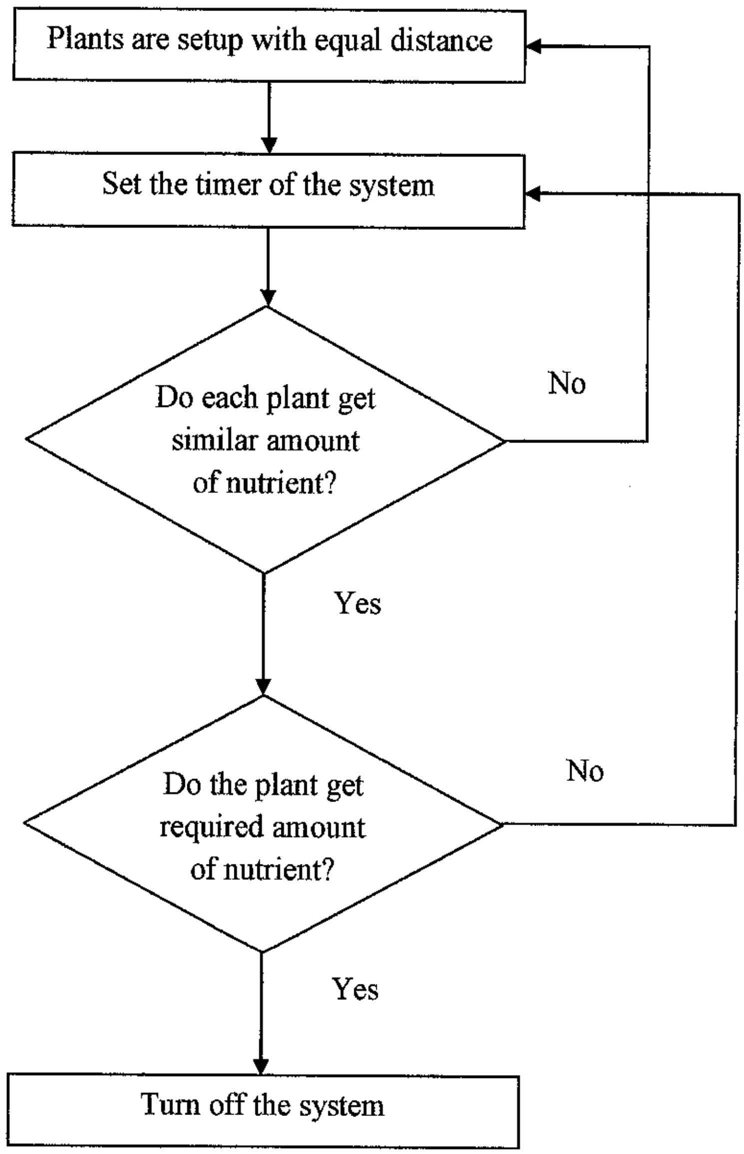


Figure 13 : Operation Flow Diagram of Fertigation System

CHAPTER 4
RESULTS AND DISCUSSIONS

4.1 Experimental Result

In this section, we performed two experiments; the plant setup and timing setup experiments. According to the fertigation department at MARDI, plant needs 200ml of nutrients per day and this is very critical for healthy growth. Here comes the objective and significance of these experiments where to control the fertigation so that the plants will get the needed amount of nutrients.

4.1.1 Plant Setup Experiment

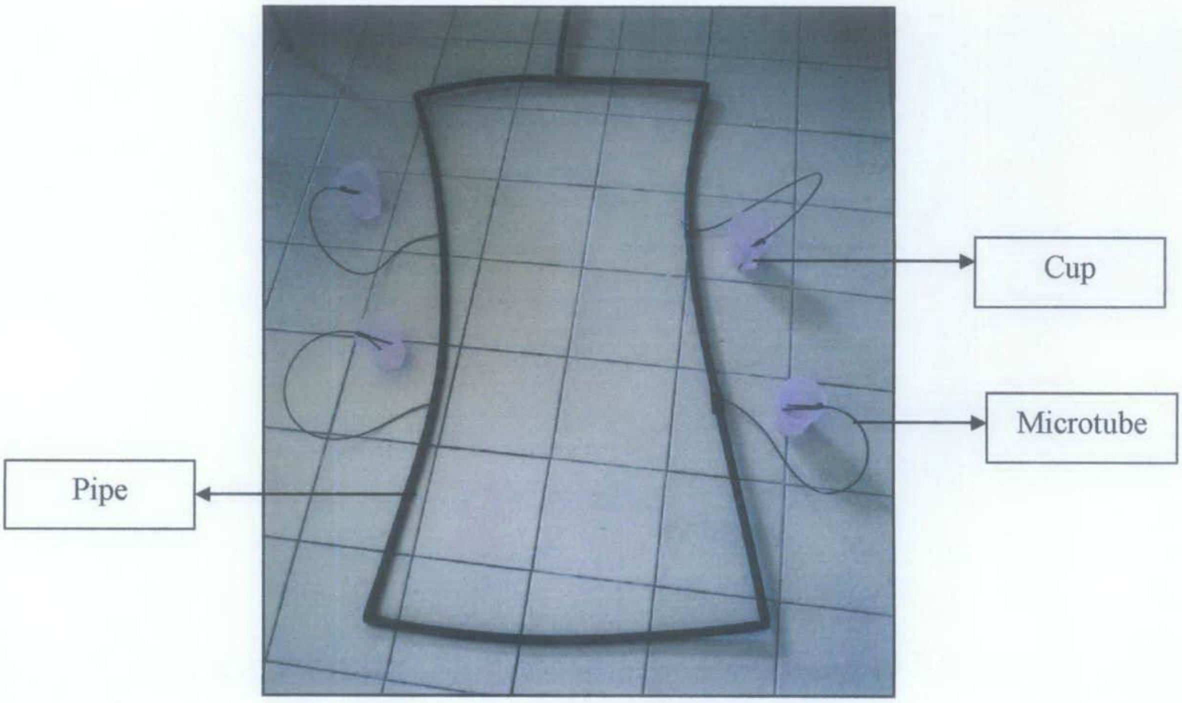


Figure 14 : Plant Setup Experiment

Figure 14 shows the setting for the plant setup experiment. In this experiment, the plant is replaced with a cup so that the outflow water from the pipe can be measured. Four cups were used and set in equal distance. Throughout the experiment, it is found that each cup can get similar amount of water with distance of 37cm. Thus, for this project, the distance chosen is 37cm.

Figure 15 : Water Measurement in Each Cup

Figure 15 shows water measured by each cup during the plant setup experiment. From the figure, we observe that each cup contains equals / similar amount of water.

4.1.2 Timing Setup Experiment

The purpose of conducting this experiment is to determine the optimum pumping time that will distribute the desired amount of nutrients which is 200ml.

There is a limitation for this system which it only allows the pump to operate for 60 seconds. Thus, in order to achieve the desired amount of nutrient, we decided to distribute 50ml of nutrient four times per day. This experiment is conducted by using trial and error method. Table 6 shows the data collection during the experiment. By referring to Table 6 below, the optimum time for the pump to operate is 58 seconds.

Table 6 : Volume of Nutrient Distributed with Different Time Points

Time (s)	**Volume of nutrient (ml)**
50	42
52	44
54	46
56	48
58	50

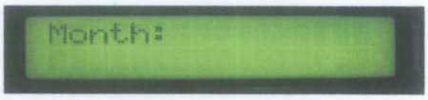
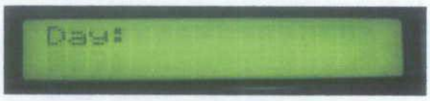
There is a limitation for this system which it only allows the pump to operate for 60 seconds. Thus, in order to achieve the desired amount of nutrient, we decided to distribute 50ml of nutrient four times per day. By referring to Table 6 above, the optimum time for the pump to operate is 58 seconds.

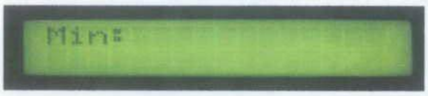
4.2 Circuit Construction

Figure 16 : Circuit Diagram

Figure 16 shows the complete circuit diagram that is used to control the system. There are several "setting-up" steps to be performed before the pump is fully functioning. The steps are summarized in Table 7 below.

Table 7 : Circuit Description

LCD Display	Description
	1. Set time and alarm by choosing option #1
	2. Set the year (ex : 11 means 2011)
	3. Set the month (ex : 04 for April)
	4. Set the day (ex : 06)

	5. Set the hour in 24 hour format (ex : 23 for 11pm)
	6. Set the minute (ex : 45)
	7. Set the required number of alarms per day (maximum : 9 alarms)
	8. Set the hour for 1st alarm
	9. Set the minute for 1st alarm
	10. Set the duration/time for the pump to operate (maximum : 60 seconds)
	11. Display the real time clock and alarm that have been set
	12. Pump will turn on based on the duration set in step 10. For this situation, the duration set is 9 seconds

4.3 Discussion

This system can be classified as an automated system because the proportion of fertilizer and water distributed are set as per the PIC programming. By installing this system in the agriculture area, it controls and allows the right distribution of water and fertilizer, and most importantly it get rids the classical problems that are associated with irrigation and fertilization such as water wasting and over fertilization Besides that, fertigation system is not focusing on the water delivery only, but it helps the plants to get the exact amount of water and nutrient as required.

There are two basic requirements needed for this system to function successfully which are plant setup and timing setup. The objective of having the plant setup in fertigation system is to ensure that each plant in the greenhouse will get the same amount of nutrient. In order to achieve this requirement, all plants must be separated in equal distance and organized in circular structure. Throughout this project, it was determined that the distance of 37 cm between the plants works the best for this project.

Besides that, the main purpose of timing setup is to determine how long the pump should be working in order to distribute 200ml of nutrients to the plant. Because of the limitation for this system which it only allows the pump to operate for 60 seconds, we decided to distribute 50ml of nutrients four times per day. From several experiments that have been done, the optimum time required is 58 seconds.

CHAPTER 5
CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusion

A project's conclusion is basically related with the project's objectives. This project demonstrates the importance and significance of agriculture in our country. The agriculture through greenhouse is the best way as it can save energy and also eco-friendly. Fertigation is introduced for this project as it is a smart way to water and fertilize the plants inside the greenhouse.

The constructed system, hardware and software alike has managed to perform well according to the requirement set for this project, which is to distribute water and fertilizer to the plants based on the time set. Although many obstacles were encountered, the project managed to complete and operate according to the requirement.

In a conclusion, this system can be implemented in Malaysia because the irrigation scheduling in Malaysia normally practices the traditional irrigation method, which can be very time-consuming. However, before actual implementation in the field for big scale, the system must be furtherly tested. This irrigation system which has been upgraded to fertigation system will lead to higher income and bring out positive effect on the quality of soil and ground water in the greenhouse. It can help to prevent over irrigation and over fertilization as it will distribute the exact amount of nutrient required directly to the root zone of the plant.

5.2 Recommendation

It is an understatement that in any systems or projects, continuous improvement is necessary. This is to ensure the systems or projects can produce better result and reduced the problems existed. The system would certainly provide benefits from improvement of additional components and features. The suggested additions could certainly improve the credibility of the system as an all-rounded intelligent system that can monitor the plant growth requirements. Temperature measurement and light intensity detection are several examples of such additional features to enhance the system. The key to greenhouse gardening is to keep all of these factors in optimum balance so can maximize plant growth.

Another recommendation is for the programming part in the control unit. The maximum time for the pump to operate should be modified up to 60 minutes so that the system can distribute 200ml of nutrient in one cycle only instead of having 50ml of nutrients distributed in four times per day.

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APPENDIX A

Gantt Chart for FYP 1

NO	ACTIVITIES	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	FYP Briefing	■														
2	Selection of Project Title	■														
3	Preliminary Research Work		■	■	■											
4	Submission of Preliminary Report				■											
5	Research Work Continues					■										
6	Design						■	■	■							
7	Submission of Progress Report								■							
8	Seminar									■	■					
9	Material & Software Selection										■					
10	Circuit Construction & testing											■	■			
11	Submission of Draft Report													■		
12	Submission of Interim Report														■	
13	Oral Presentation															■

APPENDIX B

GANTT CHART FOR FYP II

No.	ACTIVITIES	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	Project Work Continue															
2	Submission of Progress Report															
3	Project Work Continue															
4	Submission of Draft Report															
5	Project Work Continue							Mid-								
6	Poster Exhibition							Sem								
7	Submission of Dissertation (soft bound)							Break								
8	Submission of Technical Paper															
9	Oral Presentation															
10	Submission of Project Dissertation (Hard Bound)															

APPENDIX C
PROTOTYPE DESIGN

The Constructed Laboratory Model Fertigation System

Close up View of Drip Irrigation inside the Coco Peat

APPENDIX D

CONTROL UNIT PROGRAMMING

```
//Programming by Nor Syafiqah Bt Syafruddin 9948
//Final Year Project Green House Fertigation System

#include <16F877a.h>          //include pic16f877a file header
#include <stdio.h>            //include standard input/output header file
#fuses hs,noprotect,nowdt,nolvp,NOBROWNOUT,PUT     //internal fuses for this
                                                   //type of PIC
#use delay(clock=20000000) //set clock frequency/oscillator (20MHz)

#define use_portb_kbd TRUE        //define port b for keypad

#include <ds1302.c>           //include source file for RTC ic
#include <lcd.c>              //include source file for lcd 16x2
#include <kbd.c>              //include source file for phone keypad

#byte porta=5                 //define address for each port
#byte portb=6
#byte portc=7
#byte portd=8

int hour,n,min,sec,on,current,i;      //define type of general variables
int status=0;          //define and initialize value for status of alarm counter

int get_number() {    //function to get two digit no int first,second;

 do {                              //for 1st digit
  first=kbd_getc();
 } while ((first<'0') || (first>'9'));
 lcd_putc(first);
```

```
  first-='0';
  do {                              //for 2nd digit
   second=kbd_getc();
  } while ((second<'0') || (second>'9'));
  lcd_putc(second);
  second-='0';
  delay_ms(1000);

  return((first*10)+second);        //return the value when this function was called
}

void set_clock(){                   //function for clock setting
  int day,mth,year,hour,min;

  lcd_putc("\fYear 20: ");
  year=get_number();      //call function get_number and store to variable year
  lcd_putc("\fMonth: ");
  mth=get_number();       //call function get_number and store to variable month
  lcd_putc("\fDay: ");
  day=get_number();       //call function get_number and store to variable day
  lcd_putc("\fHour: ");
  hour=get_number();      //call function get_number and store to variable hour
  lcd_putc("\fMin: ");
  min=get_number();       //call function get_number and store to variable minutes

  rtc_set_datetime(day,mth,year,0,hour,min);      //set RTC by using all variable
                                                  //earlier
}

void set_alarm(){                   //function alarm setting
    int i,set1,set2;                //set1 for hour, set2 for minutes
```

```
    lcd_putc("\fAlarms/day \n(max=9): ");
    do {                              //set no of alarms ( maximum 9)
      n=kbd_getc();
    } while ((n<'0') || (n>'9'));
    lcd_putc(n);
    n-='0';
    delay_ms(1000);
    write_eeprom(0,n);                //store no of alarms

    for(i=2;i<=n+1;i++)
    {
      printf(lcd_putc,"\fSet Alarm %u \nHour: ",i-1);
      set1=get_number();
      write_eeprom(i,set1);           //store set1 in memory address i
      printf(lcd_putc,"\fSet Alarm %u \nMinutes: ",i-1);
      set2=get_number();
      write_eeprom(i+9,set2);         //store set1 in memory address i+9
    }

    lcd_putc("\fON time(minutes) \n(max=59): ");

    on=get_number();
    write_eeprom(24,on);                 //store no of alarms

}


void alarm()                          //function for alarm status checking
{
  rtc_get_time( hour, min, sec );     //read real time clock data
  write_eeprom(1,status);             //store curent count of alarm in address 1
```

```
  if (status<=read_eeprom(0))                  //check if current status less than no of
                                                //alarms set
  {
    if
(read_eeprom(status+2)==hour&&read_eeprom(status+11)==min&&sec==0)
//compare the clock and current alarm
    {
      lcd_putc('\f');                          //clear LCD
      printf(lcd_putc,"ON     for     %u     minute     \nEnd     at
%u",read_eeprom(24),read_eeprom(status+11)+read_eeprom(24));

      while (min!=(read_eeprom(status+11)+read_eeprom(24)))
      {
        rtc_get_time( hour, min, sec );        //read real time clock data
        output_high(pin_a0);                   //turn ON relay
      }

      status=status+1;
      write_eeprom(1,status);                  //store curent count of alarm
    }
    else
    {
      output_low(pin_a0);                      //turn OFF relay
      status=status;                           //stay on current status
      current=0;
    }
  }
  else
  {
    status=0;                                  //if current status greater than no of
alarms,                                        //reset status
  }
```

```
}

void main() {
  char cmd;
  int hour,min,sec,curent,hour_alarms,min_alarms;

  set_tris_a(0x00);                        //set port A as output

  rtc_init();
  lcd_init();
  kbd_init();

  for(i=2;i<=21+1;i++)                     //reset alarm memory
  {
    write_eeprom(i,0);
  }

  lcd_putc("\f1:Set Time&Alarm\n2:Set Alarm");

  do {
    cmd=kbd_getc();                        //choose mode
  } while ((cmd!='1')&&(cmd!='2'));

  if(cmd=='1')
   set_clock();                            //call function to set clock
   set_alarm();                            //call function to set alarms

  while (true) {

     lcd_putc('\f');
     rtc_get_time( hour, min, sec );       //read real time clock
```

```
    alarm();                                   //call function alarms to check
                                               //status alarm
    curent=read_eeprom(1);                     //read status no of alarm
    hour_alarms=read_eeprom(curent+2);         //read hour of alarm
    min_alarms=read_eeprom(curent+11);         //read minutes of alarm
    printf(lcd_putc,"TIME=%d:%d:%d\nAlarm at%u: %u", hour, min, sec,
    hour_alarms, min_alarms);
    delay_ms(250);

  }
}
```

APPENDIX E

PIC 16F877A DATASHEET

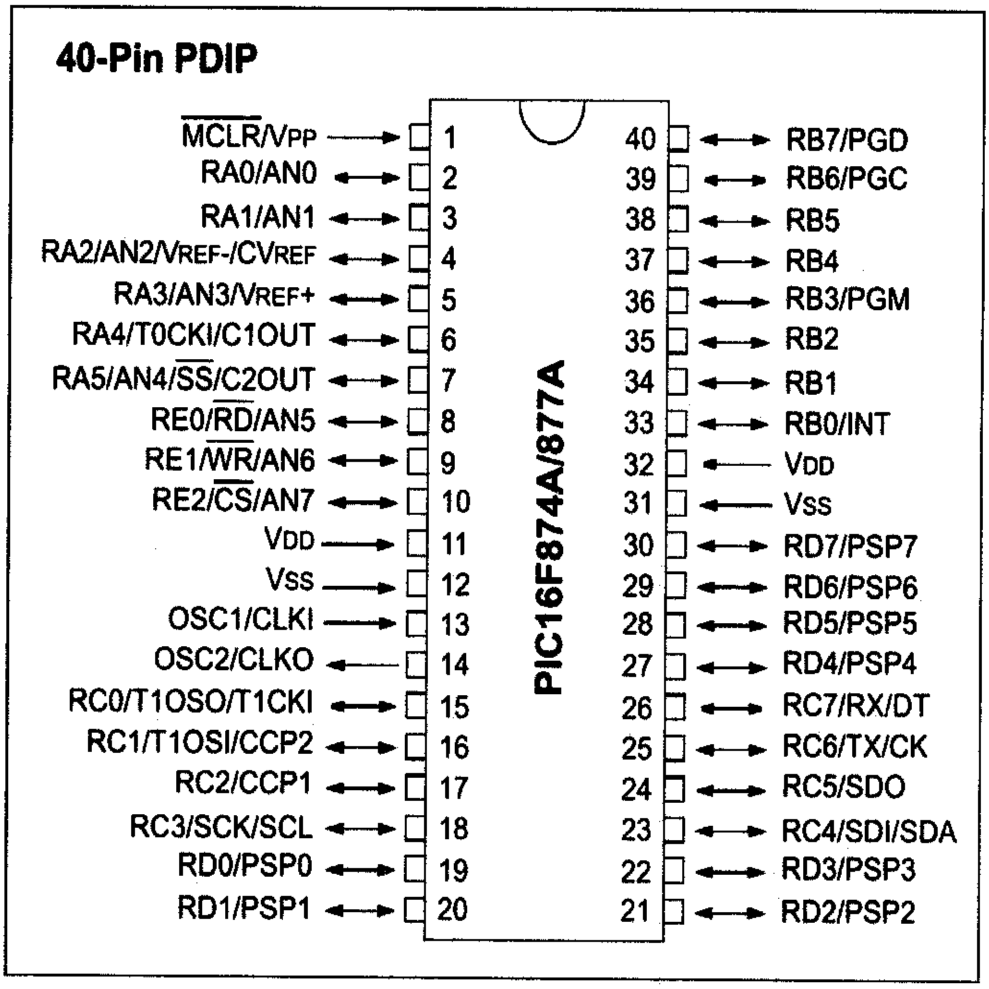


TABLE 1-3: PIC16F874A/877A PINOUT DESCRIPTION

Pin Name	PDIP Pin#	PLCC Pin#	TQFP Pin#	QFN Pin#	I/O/P Type	Buffer Type	Description
OSC1/CLKI	13	14	30	32		ST/CMOS(4)	Oscillator crystal or external clock input.
OSC1					I		Oscillator crystal input or external clock source input. ST buffer when configured in RC mode; otherwise CMOS.
CLKI					I		External clock source input. Always associated with pin function OSC1 (see OSC1/CLKI, OSC2/CLKO pins).
OSC2/CLKO	14	15	31	33		—	Oscillator crystal or clock output.
OSC2					O		Oscillator crystal output. Connects to crystal or resonator in Crystal Oscillator mode.
CLKO					O		In RC mode, OSC2 pin outputs CLKO, which has 1/4 the frequency of OSC1 and denotes the instruction cycle rate.
$\overline{MCLR}/V_{PP}$	1	2	18	18		ST	Master Clear (input) or programming voltage (output).
$\overline{MCLR}$					I		Master Clear (Reset) input. This pin is an active low Reset to the device.
V_{PP}					P		Programming voltage input.
							PORTA is a bidirectional I/O port.
RA0/AN0	2	3	19	19		TTL	
RA0					I/O		Digital I/O.
AN0					I		Analog input 0.
RA1/AN1	3	4	20	20		TTL	
RA1					I/O		Digital I/O.
AN1					I		Analog input 1.
RA2/AN2/V_{REF-}/CV_{REF}	4	5	21	21		TTL	
RA2					I/O		Digital I/O.
AN2					I		Analog input 2.
V_{REF-}					I		A/D reference voltage (Low) input.
CV_{REF}					O		Comparator V_{REF} output.
RA3/AN3/V_{REF+}	5	6	22	22		TTL	
RA3					I/O		Digital I/O.
AN3					I		Analog input 3.
V_{REF+}					I		A/D reference voltage (High) input.
RA4/T0CKI/C1OUT	6	7	23	23		ST	
RA4					I/O		Digital I/O – Open-drain when configured as output.
T0CKI					I		Timer0 external clock input.
C1OUT					O		Comparator 1 output.
RA5/AN4/$\overline{SS}$/C2OUT	7	8	24	24		TTL	
RA5					I/O		Digital I/O.
AN4					I		Analog input 4.
$\overline{SS}$					I		SPI slave select input.
C2OUT					O		Comparator 2 output.

Legend: I = input O = output I/O = input/output P = power
— = Not used TTL = TTL input ST = Schmitt Trigger input

Note 1: This buffer is a Schmitt Trigger input when configured as the external interrupt.
2: This buffer is a Schmitt Trigger input when used in Serial Programming mode.
3: This buffer is a Schmitt Trigger input when configured in RC Oscillator mode and a CMOS input otherwise.

TABLE 1-3: PIC16F874A/877A PINOUT DESCRIPTION (CONTINUED)

Pin Name	PDIP Pin#	PLCC Pin#	TQFP Pin#	QFN Pin#	I/O/P Type	Buffer Type	Description
							PORTB is a bidirectional I/O port. PORTB can be software programmed for internal weak pull-up on all inputs.
RB0/INT	33	36	8	9		TTL/ST(1)	
RB0					I/O		Digital I/O.
INT					I		External interrupt.
RB1	34	37	9	10	I/O	TTL	Digital I/O.
RB2	35	38	10	11	I/O	TTL	Digital I/O.
RB3/PGM	36	39	11	12		TTL	
RB3					I/O		Digital I/O.
PGM					I		Low-voltage ICSP programming enable pin.
RB4	37	41	14	14	I/O	TTL	Digital I/O.
RB5	38	42	15	15	I/O	TTL	Digital I/O.
RB6/PGC	39	43	16	16		TTL/ST(2)	
RB6					I/O		Digital I/O.
PGC					I		In-circuit debugger and ICSP programming clock.
RB7/PGD	40	44	17	17		TTL/ST(2)	
RB7					I/O		Digital I/O.
PGD					I/O		In-circuit debugger and ICSP programming data.

Legend: I = input O = output I/O = input/output P = power
— = Not used TTL = TTL input ST = Schmitt Trigger input

Note 1: This buffer is a Schmitt Trigger input when configured as the external interrupt.
2: This buffer is a Schmitt Trigger input when used in Serial Programming mode.
3: This buffer is a Schmitt Trigger input when configured in RC Oscillator mode and a CMOS input otherwise.

TABLE 1-3: PIC16F874A/877A PINOUT DESCRIPTION (CONTINUED)

Pin Name	PDIP Pin#	PLCC Pin#	TQFP Pin#	QFN Pin#	I/O/P Type	Buffer Type	Description
							PORTC is a bidirectional I/O port.
RC0/T1OSO/T1CKI	15	16	32	34		ST	
RC0					I/O		Digital I/O.
T1OSO					O		Timer1 oscillator output.
T1CKI					I		Timer1 external clock input.
RC1/T1OSI/CCP2	16	18	35	35		ST	
RC1					I/O		Digital I/O.
T1OSI					I		Timer1 oscillator input.
CCP2					I/O		Capture2 input, Compare2 output, PWM2 output.
RC2/CCP1	17	19	36	36		ST	
RC2					I/O		Digital I/O.
CCP1					I/O		Capture1 input, Compare1 output, PWM1 output.
RC3/SCK/SCL	18	20	37	37		ST	
RC3					I/O		Digital I/O.
SCK					I/O		Synchronous serial clock input/output for SPI mode.
SCL					I/O		Synchronous serial clock input/output for I²C mode.
RC4/SDI/SDA	23	25	42	42		ST	
RC4					I/O		Digital I/O.
SDI					I		SPI data in.
SDA					I/O		I²C data I/O.
RC5/SDO	24	26	43	43		ST	
RC5					I/O		Digital I/O.
SDO					O		SPI data out.
RC6/TX/CK	25	27	44	44		ST	
RC6					I/O		Digital I/O.
TX					O		USART asynchronous transmit.
CK					I/O		USART1 synchronous clock.
RC7/RX/DT	26	29	1	1		ST	
RC7					I/O		Digital I/O.
RX					I		USART asynchronous receive.
DT					I/O		USART synchronous data.

Legend: I = input O = output I/O = input/output P = power
— = Not used TTL = TTL input ST = Schmitt Trigger input

Note 1: This buffer is a Schmitt Trigger input when configured as the external interrupt.
2: This buffer is a Schmitt Trigger input when used in Serial Programming mode.
3: This buffer is a Schmitt Trigger input when configured in RC Oscillator mode and a CMOS input otherwise.

TABLE 1-3: PIC16F874A/877A PINOUT DESCRIPTION (CONTINUED)

Pin Name	PDIP Pin#	PLCC Pin#	TQFP Pin#	QFN Pin#	I/O/P Type	Buffer Type	Description
							PORTD is a bidirectional I/O port or Parallel Slave Port when interfacing to a microprocessor bus.
RD0/PSP0	19	21	38	38		ST/TTL(3)	
RD0					I/O		Digital I/O.
PSP0					I/O		Parallel Slave Port data.
RD1/PSP1	20	22	39	39		ST/TTL(3)	
RD1					I/O		Digital I/O.
PSP1					I/O		Parallel Slave Port data.
RD2/PSP2	21	23	40	40		ST/TTL(3)	
RD2					I/O		Digital I/O.
PSP2					I/O		Parallel Slave Port data.
RD3/PSP3	22	24	41	41		ST/TTL(3)	
RD3					I/O		Digital I/O.
PSP3					I/O		Parallel Slave Port data.
RD4/PSP4	27	30	2	2		ST/TTL(3)	
RD4					I/O		Digital I/O.
PSP4					I/O		Parallel Slave Port data.
RD5/PSP5	28	31	3	3		ST/TTL(3)	
RD5					I/O		Digital I/O.
PSP5					I/O		Parallel Slave Port data.
RD6/PSP6	29	32	4	4		ST/TTL(3)	
RD6					I/O		Digital I/O.
PSP6					I/O		Parallel Slave Port data.
RD7/PSP7	30	33	5	5		ST/TTL(3)	
RD7					I/O		Digital I/O.
PSP7					I/O		Parallel Slave Port data.
							PORTE is a bidirectional I/O port.
RE0/$\overline{RD}$/AN5	8	9	25	25		ST/TTL(3)	
RE0					I/O		Digital I/O.
$\overline{RD}$					I		Read control for Parallel Slave Port.
AN5					I		Analog input 5.
RE1/$\overline{WR}$/AN6	9	10	26	26		ST/TTL(3)	
RE1					I/O		Digital I/O.
$\overline{WR}$					I		Write control for Parallel Slave Port.
AN6					I		Analog input 6.
RE2/$\overline{CS}$/AN7	10	11	27	27		ST/TTL(3)	
RE2					I/O		Digital I/O.
$\overline{CS}$					I		Chip select control for Parallel Slave Port.
AN7					I		Analog input 7.
V_{SS}	12, 31	13, 34	6, 29	6, 30, 31	P	—	Ground reference for logic and I/O pins.
V_{DD}	11, 32	12, 35	7, 28	7, 8, 28, 29	P	—	Positive supply for logic and I/O pins.
NC	—	1, 17, 28, 40	12, 13, 33, 34	13	—	—	These pins are not internally connected. These pins should be left unconnected.

Legend: I = input O = output I/O = input/output P = power
— = Not used TTL = TTL input ST = Schmitt Trigger input

Note 1: This buffer is a Schmitt Trigger input when configured as the external interrupt.
2: This buffer is a Schmitt Trigger input when used in Serial Programming mode.
3: This buffer is a Schmitt Trigger input when configured in RC Oscillator mode and a CMOS input otherwise.

APPENDIX F

REAL TIME CLOCK DS 1302 DATASHEET

DALLAS SEMICONDUCTOR

DS1302

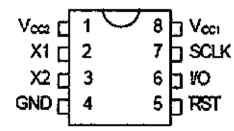
Trickle Charge Timekeeping Chip

www.dalsemi.com

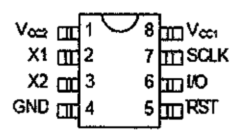
FEATURES

- Real time clock counts seconds, minutes, hours, date of the month, month, day of the week, and year with leap year compensation valid up to 2100
- 31 x 8 RAM for scratchpad data storage
- Serial I/O for minimum pin count
- 2.0–5.5 volt full operation
- Uses less than 300 nA at 2.0 volts
- Single–byte or multiple–byte (burst mode) data transfer for read or write of clock or RAM data
- 8–pin DIP or optional 8–pin SOICs for surface mount
- Simple 3–wire interface
- TTL–compatible (V_{CC} = 5V)
- Optional industrial temperature range –40°C to +85°C
- DS1202 compatible
- Added features over DS1202
  - Optional trickle charge capability to V_{CC1}
  - Dual power supply pins for primary and backup power supplies
  - Backup power supply pin can be used for battery or super cap input
  - Additional scratchpad memory (7 bytes)

PIN ASSIGNMENT



DS1302
8-Pin DIP (300-Mil)



DS1302S 8-Pin SOIC (200-Mil)
DS1302Z 8-Pin SOIC (150-Mil)

PIN DESCRIPTION

X1, X2	– 32.768 kHz Crystal Pins
GND	– Ground
$\overline{RST}$	– Reset
I/O	– Data Input/Output
SCLK	– Serial Clock
V_{CC1}, V_{CC2}	– Power Supply Pins

ORDERING INFORMATION

PART #	DESCRIPTION
DS1302	Serial Timekeeping Chip; 8–pin DIP
DS1302S	Serial Timekeeping Chip; 8–pin SOIC (200-mil)
DS1302Z	Serial Timekeeping Chip; 8–pin SOIC (150-mil)

DESCRIPTION

The DS1302 Trickle Charge Timekeeping Chip contains a real time clock/calendar and 31 bytes of static RAM. It communicates with a microprocessor via a simple serial interface. The real time clock/calendar provides seconds, minutes, hours, day, date, month, and year information. The end of the month date is automatically adjusted for months with less than 31 days, including corrections for leap year. The clock operates in either the 24–hour or 12–hour format with an AM/PM indicator.

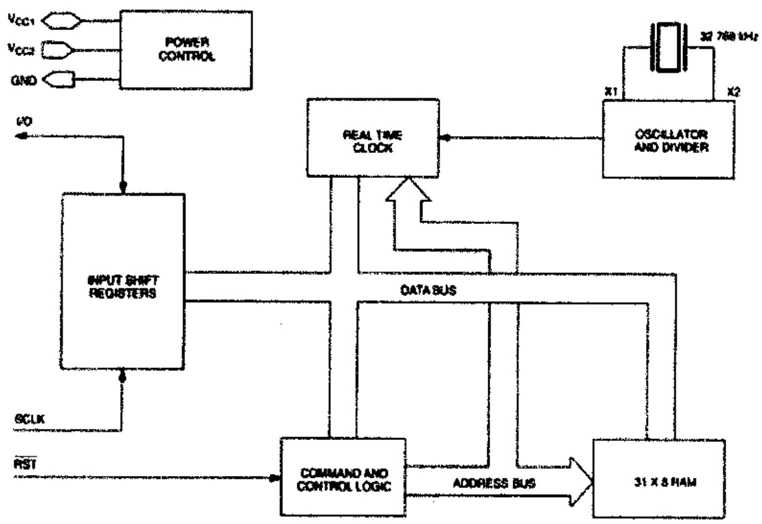
Interfacing the DS1302 with a microprocessor is simplified by using synchronous serial communication. Only three wires are required to communicate with the clock/RAM: (1) $\overline{RST}$ (Reset), (2) I/O (Data line), and (3) SCLK (Serial clock). Data can be transferred to and from the clock/RAM 1 byte at a time or in a burst of up to 31 bytes. The DS1302 is designed to operate on very low power and retain data and clock information on less than 1 microwatt.

The DS1302 is the successor to the DS1202. In addition to the basic timekeeping functions of the DS1202, the DS1302 has the additional features of dual power pins for primary and back-up power supplies, programmable trickle charger for V_{CC1}, and seven additional bytes of scratchpad memory.

OPERATION

The main elements of the Serial Timekeeper are shown in Figure 1: shift register, control logic, oscillator, real time clock, and RAM. To initiate any transfer of data, $\overline{RST}$ is taken high and 8 bits are loaded into the shift register providing both address and command information. Data is serially input on the rising edge of the SCLK. The first 8 bits specify which of 40 bytes will be accessed, whether a read or write cycle will take place, and whether a byte or burst mode transfer is to occur. After the first eight clock cycles have loaded the command word into the shift register, additional clocks will output data for a read or input data for a write. The number of clock pulses equals 8 plus 8 for byte mode or 8 plus up to 248 for burst mode.

DS1302 BLOCK DIAGRAM Figure 1



APPENDIX G
PCB LAYOUT