Green House Management System

by

Loh Jui Boon

Dissertation submitted in partial fulfilment of
the requirements for the
Bachelor of Engineering (Hons)
(Electrical and Electronic Engineering)

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Universiti Teknologi PETRONAS
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CERTIFICATION OF APPROVAL

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Tronoh, Perak

May 2011

CERTIFICATION OF ORIGINALITY

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

LOH JUI BOON

ABSTRACT

Heat management control and the exposure of light intensity towards the plants are studied and analyzed for three months from January 2011 to March 2011. Due to the variety of considerations of the greenhouse management, the scope study is limited only to the heat management control and light intensity exposure. The main objective of the project study is to satisfy the basic needs of the plants to survive besides reduce the risk of capital investment loss. Therefore, the system is designated and applied in the project study where it must be able to fulfill the condition where the plants are able to perform their daily activities in a much efficient way. The heat sensor and light sensor is applied in the system to correspond with the variation in heat detection and light intensity respectively. The room temperature is maintain at the standard condition in managing heat control while the light is turned on while the brightness of the light is low. When the basic needs of the plants are satisfied as well as manipulation of the greenhouse environmental factor, the rate of productivity increases. Thus, with the increase in production rate and controlled surrounding, the return of profit almost becomes a guarantee and reduce the risk of investment greatly.

ACKNOWLEDGEMENT

First of all, I would like to thank god for giving me the strength and health to do this project work until it done. Next I would like to express my greatest gratitude to my supervisor, AP DR Josefina. Without her assistance and guidance throughout the project, it is not possible for me to complete the project. We do face lots of difficulties during these two semesters, however, she patiently discuss the arising problems with me and give a clear vision for my project.

Besides that, I would like to thank my family member for providing me the support especially the crucial time of the project. For example, I really appreciate my father's help in buying the raw material of the prototype as well as the construction of the prototype. Their support and encouragement inspired me to complete the project in a much better way.

Last but not least, not forgotten my friends who were helping me in this project. We brainstormed and designed the circuit together. They were helpful that when we discussed together, the problems became easily solved. Thank you to all of you for helping me throughout the tough period of the project.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1
INTRODUCTION

1.1 Background Study

Green house's main function is to provide a protective environment for crop production while allowing natural light transmission [1]. Thus, green house management helps to control the temperature level, light intensity, and humidity level of the surrounding, to protect the crops from being exposed to harsh climate change directly. Green house technology is also applicable in our country and the most common one is located in Cameron Highlands Agrotechnology Park [2]. The crops which are planted there are strawberries, apples, pears, persimmons, roses, tomatoes, citrus fruits and others. Due to high humidity and hot weather around the year in Malaysia, it makes us hard to plant crops like strawberries, grapes, roses and tomatoes under the normal condition. Thus, green house management is certainly required to those plants in Malaysia. Meanwhile, the green house management technology is much more common in four-seasonal countries due to the insufficient of light energy. For example, the lilac bushes that are grown in Netherland use the green house management to increase the output efficiency periodically during winter [3].

Green technology is on everyone's lips nowadays, more and more corporation are taking steps to reduce the depletion of Earth's resources by finding alternatives like using renewable energy. For example, Wal-Mart has targeted to double the fuel efficiency of its truck fleets in 10 years by spending USD 500 million to reduce the production of greenhouse gases up to 20% in seven years while Marriot hotel group has replaced the light bulbs with fluorescent lights, installing low-flow shower-heads and toilets, and introducing linen reuse programmes to increase the efficiency of electricity usage [4].

Furthermore, the GreenTech (Green Technology Corporation) Malaysia has been actively involved in promoting the concept of green technology like conducting awareness road shows and International GreenTech & Eco Products Exhibition & Conference Malaysia (IGEM) 2010, which brought green technology business to Malaysia [4]. Therefore, the management of green house in my project goes along with the government policy to promote on green technology concept. In the project, we are trying to advocate the awareness of green technology so that we could encourage more green activities in Malaysia.

Since 1990, there is a great change in greenhouse firms world widely, large investors have increased the productivity of plants in term of size to meet the huge demands of the market. It has led to the plant factories where they are able to mass produce the plants with a lower product prices [5]. However, it doesn't leave out the smaller investors, they came up with a new strategy, which is a mix of growing, retailing and customer services. In spite of all the change in the plants industry, it is a great opportunity time to be involved in the greenhouse production business. A certain understanding of greenhouse operation and growing crops knowledge are vital for the project to go on to reduce the losses.

In green house management, we are able to control the climate change inside the room environment. In other words, once the environmental factor is in our hands, it makes it easier to monitor the crops' growth activities. Besides, out-of-season plants can be grown inside a greenhouse regardless of the external weather factor. The other advantages of green house management are reducing the risk of capital investment, increasing the productivity growth, and increasing the job opportunities in agriculture industry. The major disadvantage of the green house is the disease can be easily spread if one of the plants has been infected among the plants [6]. Besides, the price of the plants from the green house is usually more expensive and smaller in size since it requires experts to handle the management of greenhouse operation. Next, the construction of the green house for a large scale of plantation demands a huge cost, which makes it as one of the disadvantages for the investor if there is no return of their capitals.

1.2 Problem Statements

The main problem arises in this project is narrowing down the scope of greenhouse management criteria that involved in green house management. Since there are a lot of features or criteria that we need to consider in green house management likes condensation and cooling problem, heat loss, temperature, water quality management, pH and soil monitoring, chemical growth regulations, fertilizer formulations and methods of applications, pest controls, light intensity and quality, radiation, climate control, and others as well [7], it would be very difficult to monitor all of the aspects of the green house management in the project. Therefore, the management in heat control as well as light intensity exposure have been chosen as the main scope of study for my project.

Besides, controlling the crops growth in a large scale of plantation is a difficult task since the area involved is very large and there is no guarantee that the investor will get a 100% profit return from the crops. To reduce the risk of losing capital investment, the green house management study is introduced. In the study of the project, we use a small region of area to construct the green house to represent the commercial green house management system since the period of the project is limited to two semesters. The other issue in the project is the efficiency of the project's material cost. Since the light system will be turned on at nights to increase the crops yield rate, it increases the electrical cost. Besides, the air-conditioned or cooling system requires the electricity for activation to control the room temperature gives additional costs to the budget of the project. Besides the electricity's cost, the material used to construct the greenhouse wall structure and the consideration of how much penetration of the light intensity into the greenhouse are the issues arises in greenhouse business. Thus, choosing the appropriate materials is also one of the highlights of the project.

1.3 Objectives

The objectives of the project are:

(a) To study the criteria of green house management, which are the heat management control and light intensity exposure

(b) To understand the basic idea of the operation behind the green house management

(c) To introduce the concept of green technology and create the awareness to promote more green and environmental friendly activities or projects

1.4 Scope of Study

(a) Heat management control

Heat management control is one of the important aspects since the heat or the temperature level inside the green house will affect the plant growth. The requirement for heating is defined as the rate of adding heat at which it is lost. The same goes with the concept of cooling, the temperature inside the greenhouse drops at the same rate of the rate of temperature rise. The light rays that penetrated through the greenhouse wall will be trapped inside the greenhouse structure usually due to the characteristics of greenhouse structure. Therefore, inappropriate management in heat control will bring the excessive heat inside the room and deteriorate the plant growth eventually. Thus, we will design an electronic system that will monitor the temperature or heat level inside the room. The system will trigger the cooling system to be activated if the temperature is higher than normal condition or activate the heating system if the room temperature lower than normal condition.

(b) Light intensity exposure

The light exposure is very important for plants to carry out the photosynthesis process. However, there are different types of wavelength in the light spectrum. These different wavelengths or frequencies of the light rays will affect the plant growth differently. And these different light rays in this context are referred as the light intensity. Therefore, in the project, we will conduct the experiment on how does different light intensity affects the plant growth and determine the suitable range of light intensity for the plants.

1.5 Limitation of the project

The limitations of the green house project are listed below:

(a) Duration of the project

The period for final year project is very limited which is two semesters. Thus, the plant selection is limited to those plants that are fast-matured and easy to be planted. Fast matured plants enable the monitoring activity easier since there will be changes in the plant physical appearance like growth while the easy-planted plants are preferable since we can re-planted them if anything goes wrong.

(b) Factors of green house management

There are lots of features or criteria that we should consider in green house management. A single change in the plant growth can be defined in many ways since there are so many criteria involved in the green house management. Thus, it becomes very hard to find out the real cause of the changes in plant growth activity in order to reverse the effects.

(c) Devices applied in the project

Since the project is only a represented version of the real commercialised greenhouse structure. The heating system and the cooling system in the project will be represented by the heat system and the cooling fan respectively. The heat system consists of a LED, when LED is on, it indicates the heat system is initiated. When the cooling system is initiated, the cooling fan will be turned on and another LED will light to indicate the output.

1.6 Benefits of the project

(a) To be able to control the heat management changing inside the green house of the project

(b) To be able to determine how intense of the light should be exposed to the plants

(c) It is an environmental friendly project since it does not produce any waste that brings harm to the nature and goes along with the government policy in encouraging the involvement in green technology activities.

CHAPTER 2
LITERATURE REVIEW

2.1 Theory

"Greenhouse" means a structure used to cover the ground for growing crops that will return profit to the owner whom risking their time and capital investment [7]. Therefore, green house management means the methods that are used in controlling the factors or the considerations that will affect the growth of the crops either directly or indirectly. The green house management is the research study to improve agriculture industry. As discussed earlier, there are lots of features in the green house management. Thus, when all these features are supervised and being controlled, we can say that we have control the effects of environmental factors and this is how we can guarantee the 100% return from the crops.

The main aim of the project is to satisfy the needs of the plants inside the greenhouse, which are the heat and light intensity regulation, the light exposure is vital for the plants to do photosynthesis process, while the suitable heat of the environment allows the plants to survive for respiration process or seeds germination. Therefore, the project's purpose is served by designing or applying the system that will satisfy the needs of the plants. The system will be able to control or maintain the temperature level inside the greenhouse surrounding as well as expose the appropriate level of light intensity to the plants. In this context, the three aspects that have to be considered are the light intensity exposure, the heat management control and the sensors or components that are used in the project.

2.1.1 Heat Management Control

Normally the temperature maintained on daytime is different compared to temperature falls at night. Besides, it varies with the condition of the weather itself either it is cloudy or sunny day. This assumes that the temperature at which the plants grown can actually be controlled. In heat management control, the heating and the cooling system are required to add heat if there is a heat loss or reduce the heat if there is an excessive heat respectively. The heat is lost due to air conduction mostly through the wall of green house and the rate of heat loss greatly depends on the material that constructs the greenhouse's wall. Besides, the heat lost can be occurred by air infiltration [3]. The term here means that the air that flows into the greenhouse environment from the atmosphere has cooled down the inner room temperature. Therefore, besides putting the heater system device, we can try to modify the greenhouse structure so that it can trap more heat and improve its ventilation of air flow at the same time.

For cooling system, it is used for cooling purposes especially on the summer season which the temperature may rise to maximum and the plants can be suffered from heat scorch or desiccation [8]. This condition happens when the plants cannot supply water fast enough to its tissues and causing death. Besides that, the air ventilation during the cooling process can exchange the greenhouse air from the outside to renew the supply of the carbon dioxide for photosynthesis process. The third purpose of the cooling process is to reduce the air humidity level in the greenhouse atmosphere as one of the regulation method to control and prevent high rate disease spread inside the greenhouse [1]. Depending on the countries' climate, the cooling system machines serve different purposes. For summer cooling system, passive ventilator cooling and active fan-and-pad system are being used [3]. The radiator and fans in the machine will absorb the heat and cool down the temperature momentarily. However, the cooling system will be much more expensive to be used in a hot and wet country like Malaysia. Therefore, water spray cooling system with fan with a simple construction might work for the project.

2.1.2 Light Intensity Exposure

Under the scope study of light intensity exposure, we examine and determine the suitable level of light intensity that should be exposed to the plants. Light intensity means the level of the light brightness or the level of radiant energy that it carries. Irradiance is the measure of how we determine the light intensity [9]. It is a general term for how much radiant energy that is received by the object per unit area per unit time.

Light varies in intensity or brightness, duration or length of daytime, and its quality or the colour of light spectrum [10]. Green plants react varies in different ways to each of these factors. The plants are dependent on solar radiant energy (light) to produce carbohydrates as a source of energy for respiration and health. Meanwhile, the spectral quality and wavelength of the light period modifies the plant development in terms of growth, flowering, seed germination, and other morphological traits [11]. Therefore, it is important to study on how the properties of light energy affect the plants. The light quality or the spectrum can be divided into seven different colour layers as shown below.

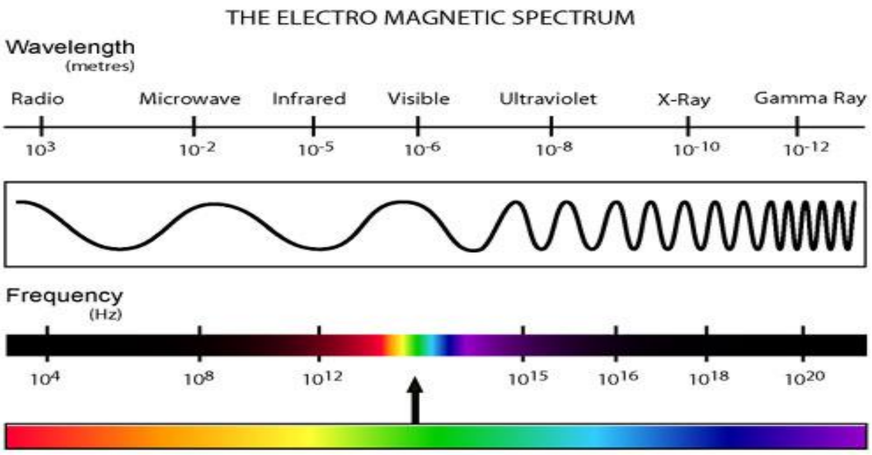

Figure 1: The light spectrum and its wavelength [12]

Table 1: The approximate wavelength of light spectrum[13]

Types of colour light	Approximate Wavelength (nm)
Violet	400
Indigo	445
Blue	475
Green	510
Yellow	570
Orange	590
Red	650

Each wavelength of light can cause chemical and thermal response to the plants that may influence its various phases of growth. For instance, white light is composure of seven colour lights and its wavelength ranges from 400 to 700 nm. Ultraviolet light is invisible due to its shorter wavelength, which ranges from 200 to 400 nm. The infrared light is also invisible light due to longer wavelength than human visibility wavelength. Its wavelength is greater than 750 nm. Photosynthetic light is the light that is being absorbed by the plants for photosynthesis. Generally, there are two forms of chlorophyll, which is chlorophyll a and chlorophyll b. Chlorophyll a absorbs most of the light radiant energy at 430 and 662 nm while chlorophyll b absorbs most of the light radiant energy at range of 453 to 642 nm [1]. Thus, most of the colour lights that are absorbed in that range are green and yellow light. Therefore, the green light is giving the plants their characteristic green colour. Plants that are exposed to the UV light will have tissue death or sun scald (sunburn). The type of exposure may cause the plant to mutate itself and halt the growing. The exposure of infrared radiation has a higher heat effect on plants. The plants give mostly red colour since it is in the range and the greatest effect of red visible light is preventing the flower response [1].

2.1.3 Sensors and Special Electronic Components Used

2.1.3.1 1-Wire Digital Thermometer

1-Wire digital thermometer is also known as DS18B20 Digital thermometer. The sensor used in the project is TO-92 since it is a 3-pin package. The sensor provides 9 to 12-bit centigrade temperature measurement digitally. The sensor itself has an non-volatile user programmable upper and lower trigger points. The term non-volatile means the sensor will remember the setup point even after the power is off. It can operate within the temperature range of -55^{o}C to 125^{o}C where its accuracy is within $\pm$ 0.5^{o}C over the range of -10^{o}C to 85^{o}C. With digital measurement, it can works with the microprocessor to control many applications like temperature monitoring system inside buildings, equipment or machinery, process monitoring and in control systems. For further information, please refer to Appendix B of the component datasheet.

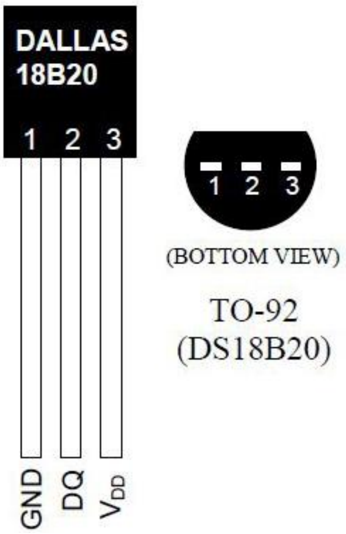

Figure 2: The pin assignment of DS18B20 Digital Thermometer

2.1.3.2 Light Dependent Resistor (LDR)

Figure 3: Illustrated diagram of light dependent resistor [14]

The above figure shows the illustration of a light dependent resistor or also known as LDR. LDR is a light sensitive resistor which its resistance decreases with the increase of the light intensity [14]. In other words, the resistance of LDR becomes nearly zero during daytime and increases to several mega ohms at night. The LDR component is used in the project to initiate the light system of the green house to turn on the light at night to allow the photosynthesis process of the plants.

2.1.3.3 SPDT Relay

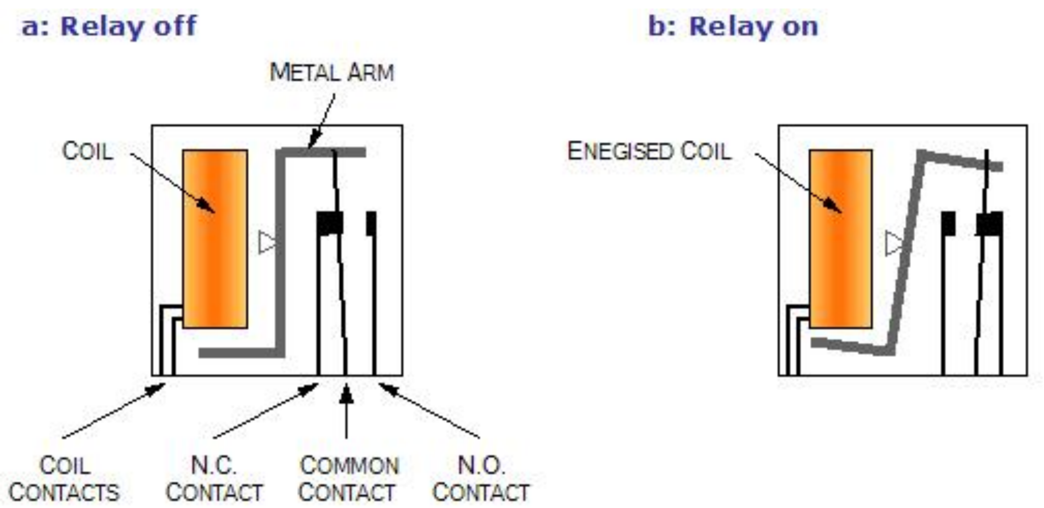

Figure 4: Mechanical operation of SPDT relay [15]

Figure 4 in the previous page shows the mechanical operation of a SPDT relay. A SPDT relay stands for Single Pole Double Throw relay [15]. It is an electromagnetic switch which consist of a coil, a common terminal (COM), a normally open terminal (NO) and a normally closed terminal (NC). The principal operation of a SPDT relay can be explained with the illustration help of Figure 4. When the relay is off or in rest condition, the metal arm is not attached to the coil and common terminal is in contact with the normally closed terminal. However, when the relay is triggered or on, the magnetic field resulted from the current passing will attract the metal arm and let the common terminal to be connected with the normally open terminal. The operation of relay will be applied in the heat management system so that when there is a detection in temperature change will trigger the system to take action by using relay.

2.1.3.3 AT89C2051 8-bit Microcontroller

The AT89C2051 is an integrated circuit (IC) designed with a high performance CMOS of 8-bit microprocessor and 2 KB of flash programmable and erasable read only memory (PEROM). It can be operated using a low voltage and works well with the DS18B20 digital sensor. Thus, the low power consumption can be accommodated in many applications without high power loss of the circuitry. The IC contains 128 bytes of RAM, on chip oscillator and clock circuitry. Therefore, the clock cycle can be set or pre-determined using the IC. The IC works with the digital sensor 18B20 to displays the temperature reading on the 7 segment displays. Since the 7 segment displays and the digital temperature sensor operates with the coding in hexadecimal, the chip reads the instructions from the sensor and executes it on the 7 segment displays. For further information on the AT89C2051 8-bit microcontroller, please refer to Appendix C.

CHAPTER 3

METHODOLOGY

3.1 Procedure Identification

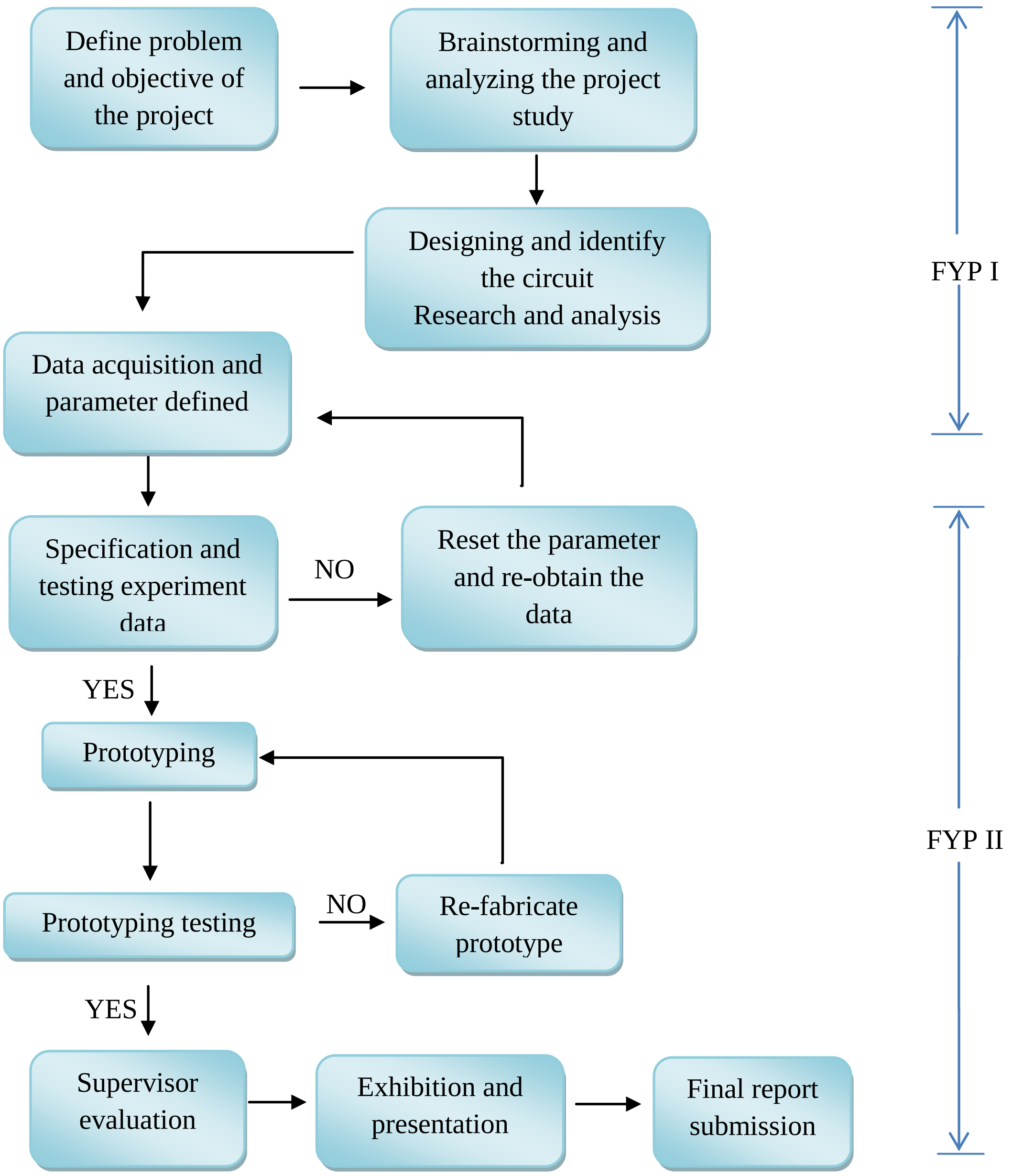

Figure 5: The work flow of the project prototype

3.2 Tools and Equipment Used

Firstly, I have to consider on the construction of greenhouse structure. There are several different types of green houses like even span, uneven span, Quonset, Gothic arch, vinery, hill slide, slant-side, A-frame and dome shaped as figure shown below. Different types of greenhouse structure may affect the plants growth varies in different ways. Therefore, choosing the correct structure of greenhouse depends greatly on the geographic location, climate impact changes, the types of crops, and also cost of construction. Besides, the material used to cover the wall like plastic and glass have to be taken into account since it determine how much the light will be reflected or penetrated which will affect the plants growth indirectly.

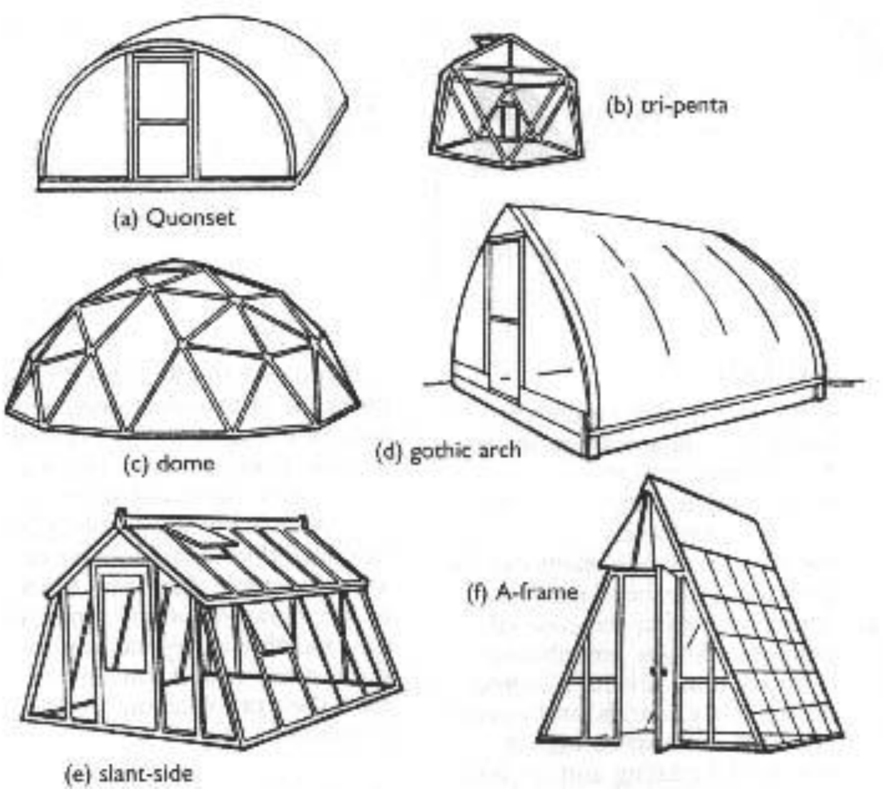

Figure 6: The types of greenhouse structure [16]

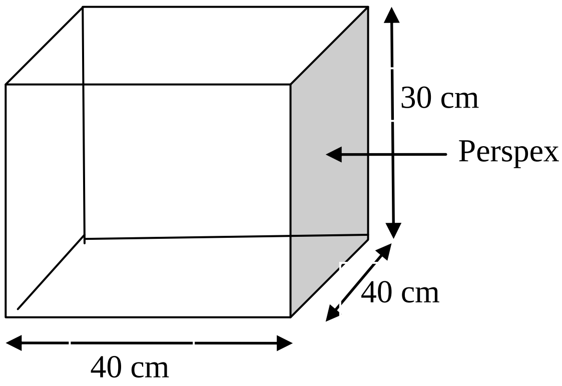

Figure 7: The drawing of greenhouse prototype dimension

In the project, the prototype of the green house project is designed and constructed based on selection choice of greenhouse structure from Figure 6. Since the plants that are grown in the project is small, the square shape with a small dimension of the prototype is taken into consideration. The prototype is constructed by Perspex, a transparent thermoplastic acrylic resin to improve the penetration of light intensity through the greenhouse's wall. The dimension of the prototype is 40 cm x 40 cm x 30 cm (refer to Figure 7), a small medium suitable for the growth of the plants for the experiment. The bottom of the prototype is made by a waterproofed three-ply board so that the wood won't be destroyed by the water throughout the experiment time. Besides that, the plants are harmful to the ultraviolet ray radiation by being exposed to the sunlight, Thus, choosing the correct material in constructing the green house is one of the consideration of the project so that it can filter the UV light.

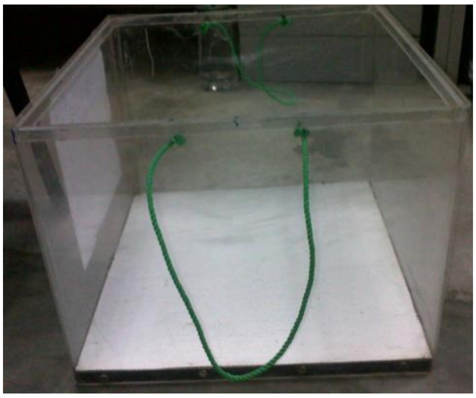

Figure 8: The greenhouse prototype of the project

The plants that are grown throughout the experiment is mixture of several crops, which includes the tomato, chilli, and wild flowers. Due to the limitation of project period, the plants choice does not really play an important role for the project. The purpose of growing the crop is to observe and examine the changes of the plant growth response towards different light intensity during the experimentation. The experiment is conducted for three months from January 2011 to March 2011. In the experiment, same types of plant is selected and placed in three different environment. The first plant is placed in normal condition, the second plant is placed under very bright condition while the third plant is placed in very dim condition.

The term 'normal' is defined as the environment where the plant is exposed to suitable sunlight during daytime and appropriate fluorescent light at night. Meanwhile, in very bright condition, the plant is exposed to very bright light bulb (high wattage) for the whole time of the experiment. Next, in very dim surrounding, the plants are kept in dark with little exposure of sunlight during daytime or light bulb at night. Other parameters are set to be constant to improve the accuracy of the results. For example, same amount of water is given to the plants three times per day and same type of soil is used as the plant's medium. Besides studying the varies of light intensities, the temperature of the medium is measured as well during daytime and at night to determine how does the variation of temperature may affect the plant growth.

Last but not least, the system is made up of a digital heat sensor and a simple light dependent resistor (LDR) sensor. Both of the components help to maintain the temperature level to normal condition and detect the level of the light brightness so that the light will be turned on when it is dark respectively. The system is power up by DC supply and collaborated with the outputs so that when the it meets the conditions, it will trigger and activate the output.

3.2.1 Hardware

Table 3: The hardware used in the green house project

Components or hardware	Functions/purposes
LDR	Used to determine the level of the light brightness or the intensity
DS18B20	Used as the temperature sensor to detect the variation of atmospheric temperature in the greenhouse
7-Segment Display	Used to display the temperature reading inside the prototype digitally
Light bulb/fluorescent	Used as the light system in green house and acts as the sun to radiate light rays to plants for photosynthesis at night
SPDT Relay	Used as the switch to turn on the cooling system or heating system if there is a variation in temperature
LED	Represents the heater system, when it is on, it indicates the heater is activated to warm up the environment
Fan	Used to cool down the temperature in the greenhouse and improve the air flow inside the greenhouse
Perspex	Used to construct the roof as well as the wall of the greenhouse prototype
Bottle	Used to grow the plants
DC Supply	Used as the main power source to activate the system

3.2.2 Raw material

Table 4: The raw materials used for the project

Raw materials	Functions/purposes
Seeds	Tomato seed or other preferable seed will be used, mix crop is also an available option
Soils	As the main medium for the plant to grow
Water	Used to water the crops and cool down the temperature inside the green house

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Heat Management Control

In heat management control of the greenhouse, we have to consider the heat loss, the minimum heat requirement of the plants, the heat conservation for the plants and types of heating system that are suitable to the project. Besides that, the cooling system and ventilation system play an important role in controlling the heat inside the greenhouse. Similar to the heat control, we have to consider the cooling system effects, the type of ventilation system, the cost of the construction and low temperature condition to determine the type of ventilation system and the cooling system that should be used for the project.

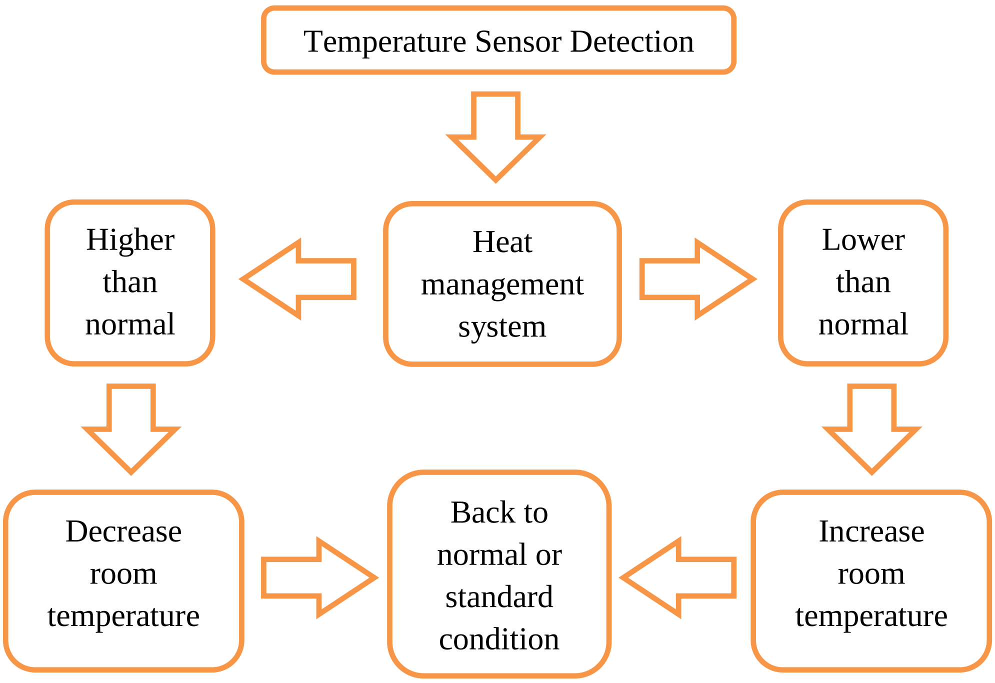

Figure 9: The flow chart of heat/temperature variation detection

The above figure identifies the process involved in the heat management control system. Using a temperature sensor like DS18B20 to detect the changes of temperature in the green house, the system then will compare the value with the temperature that have been predetermined. For example, if we set the normal temperature to be 25^{o}C, then the system will compare the current temperature with 25^{o}C, if the detection is higher than normal, it will acknowledge the system to drop the temperature. Else, if the temperature is lower than 25^{o}C (pre-set point), it will trigger the heater to warm up the room.

Once the detection output gives a ‘high’ it means that the current room temperature is greater than normal condition and it will go to the cooling system or the fan to drop temperature level. Thus, it will turn on the fan to drop the temperature level. However, if the detection output gives a ‘low’ output, it means the current temperature of the room is lower than the reference temperature or no change in temperature. Thus, it will turn on the LED, which represent the heater system in order to increase back the temperature. Further improvement is needed to differentiate the temperature lower than reference point and current temperature equal to the reference point so that the system will only turn on the heater when room temperature is low and become idle when the room temperature is equal to reference temperature. The picture below shows heat management system that is applied in the prototype.

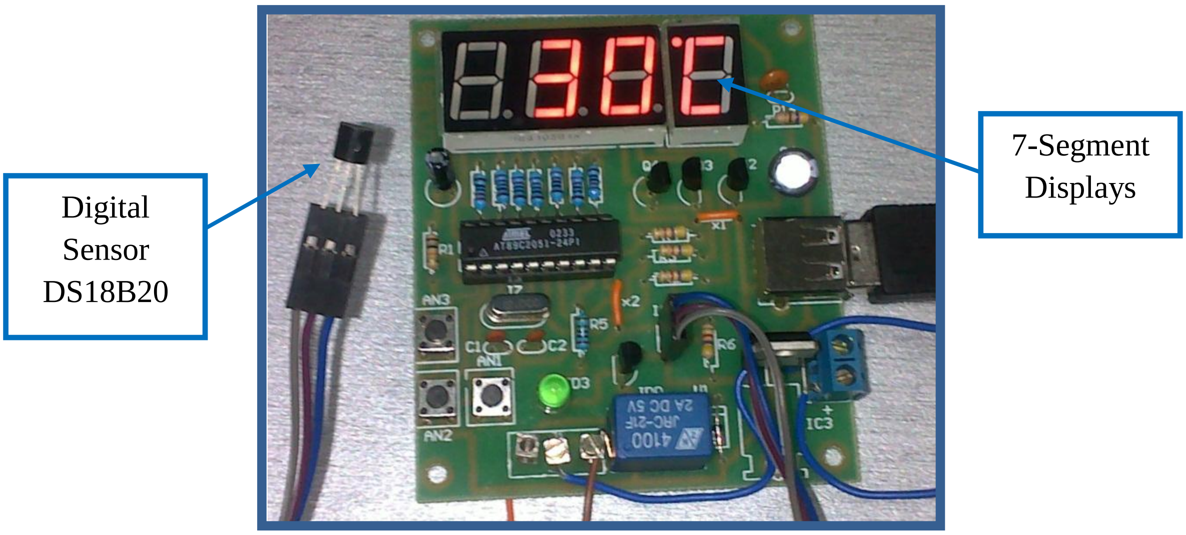

Figure 10: The prototype circuit of heat management system

In the project, as mentioned earlier, the heat system is powered up by Direct Current (DC) source and the output of the system is connected to the fan (cooler) and LED (heater). From Figure 10, the system can be power up either from the battery of 9 to 12V, DC power source or USB connector from computer. When the power is on, the Celsius unit will be shown by the 7-segment display, by pressing the tact switch into normal mode, it shows the room temperature's reading or what is detected by DS18B20. When the temperature reading more than the reference point or the pre-set point, the LED will on and trigger the exhaust fan to be turned on. In order to set the reference temperature point, press the tact switch again until the temperature reading blinks, then press the other two switches to increase or decrease the value of the temperature point. Meanwhile, if the temperature reading is lower than the reference point, the system will trigger another LED to turn on to indicate the heater system is activated to warm up the room temperature.

In the project, the daytime temperature measure ranges from $30^{o}C$ to $34^{o}C$ while $24^{o}C$ to $29^{o}C$ at night during the period of the experiment. Depends on the weather, the temperature at night may reach to $33^{o}C$ if the sky is very clear. Thus, additional tools like ice will be used so that the temperature will drop to $26^{o}C$. It is found that the suitable temperature range for the plants to grow healthy falls within the range of $24^{o}C$ to $28^{o}C$. The ice cubes are put inside the closed bottles and will be placed around the four corner of the prototype as seen from the figure below. Due to the hot weather in Malaysia, there is no need to use the heater system throughout the experiment of the project.

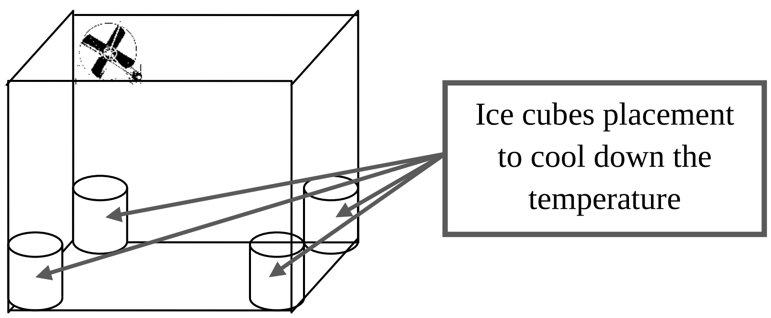

Figure 11: The illustration of the ice cubes placement during hot weather

Refer to the Appendix D, it shows the schematic circuit diagram of the digital sensor DS18B20 with AT89C2051 IC component. The crystal oscillator is used as the clock frequency signal so that the IC keeps track with the sensor detection and displays on the 7-segment displays. Therefore, the heat detection and reading display is using the flip flop circuit as well as the clock frequency signal to make the detection reading a real time application. Since it is a real time application, the IC keeps update the temperature reading from the digital thermometer though there may not be any changes in temperature for time being. When there is a variation in heat detection, it immediately shows the changes in temperature reading.

DS18B20 is a digital sensor which measures the temperature in hexadecimal format. Refer to the Table 2 of Appendix B – Digital Sensor part III, it lists out the hexadecimal value of digital outputs registered from the sensor, thus it works well with 7-segment displays since it requires hexadecimal format to turn on each different 8-pins (segments) of single 7-segment display. From the Appendix C of AT89C2051 part II, where it shows the operation of the IC in simple block diagram. The flash memory of works with the sensor to keep track of the temperature records while the non-volatile memory of the component remember the setup point even after the power is off. The ALU block diagram stands for Arithmetic Logic Unit, where it performs all sort of arithmetic and logical operation like adding, subtracting, bitwise logic operation (AND, OR, XOR, etc.) and others. This is how the temperature detected compared with the reference temperature as well as allowing the interrupt or reset point to occur to more the circuit more flexible.

4.2 Light Intensity Exposure

Light intensity exposure or the radiation exposure will harm the living organisms in long term period. Thus, in this project, we will determine the suitable or the appropriate level of the sunlight that should be exposed to the plants. The determination of how much light energy is suitable for the growth of the plant will be carried out through some experiment. Firstly, the plants will be planted inside the greenhouse, with the environmental condition is manipulated to increase the accuracy of the data analysis. Besides, the plant growth activity is also being observed and monitored to notice the changes. The experiment is carried out by comparing few sets of same plant that are being exposed to different level of light intensity.

For the analysis of light intensity of the plants, it is conducted by observing the changes of plant growth towards different kinds of light intensity. In the experiment, the plants are grown in different types of environment, which are normal condition, very bright condition and very dim condition. As mentioned earlier, the different types of environment have been predefined and the response of plant growth is observed throughout the three months experiment. The picture below shows the condition of the plants before the experiment is conducted. It is the initial condition where the plants are growing healthy and flourishing.

Figure 12: The initial condition of the plants before conducting the experiment

Table 5: The table below illustrates the response of the plant growth activity towards different types of light intensities environment

Environment condition	Observation and results
Normal 	Under the normal condition, the plant grows healthy and prosperous as indicated from the picture displayed besides.
Very bright 	Under very bright condition, the plants looks like dehydrated. There are lots of yellow spots appear on the leaves of the plant.
Very dim 	Under the very dim condition, the plant doesn't receive enough sunlight and the plant is wilted and its condition is very similar to the plant that is exposed to the very bright surrounding.

The LDR circuit is used to turn on the light at night. Refer to the schematic diagram below, it shows the dark relay circuit where it is used to turn on the light system when it detects there is a ‘low’ light or little presence of light. Thus, it will turn on the light system inside the green house to provide the conditions for the plants to enable the photosynthesis process. In the experiment, the circuit is applied as the switch to turn on the light bulbs at night or when it detects little presence of light during daytime.

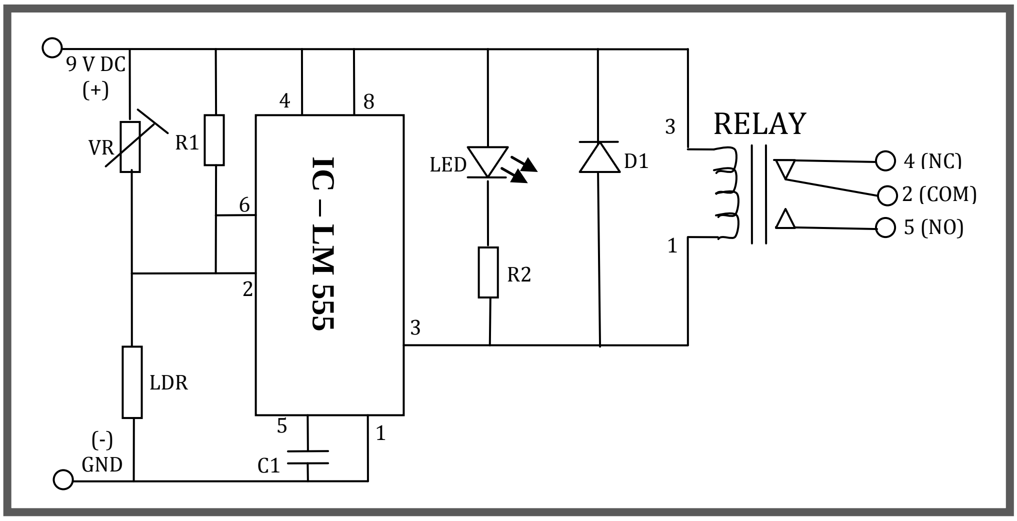

Figure 13 : Schematic Diagram of Automatic Light Activation at night

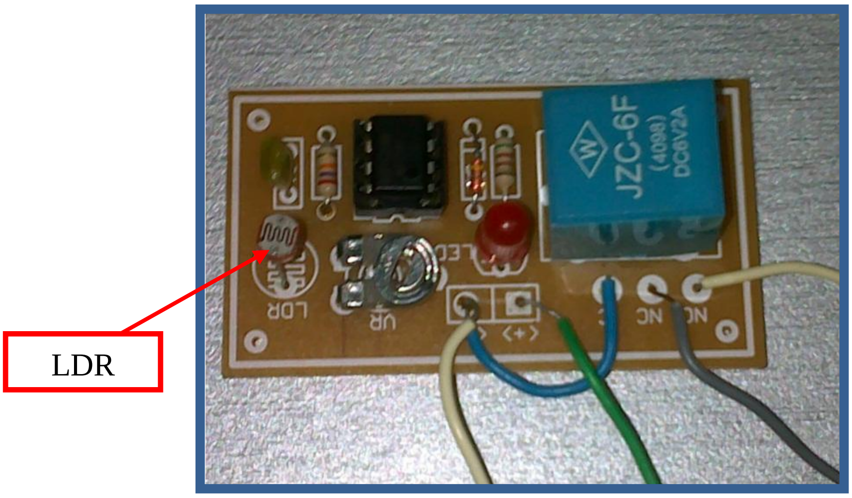

Figure 14: The LDR circuit in the prototype

The above figure shows the schematic circuit of the LDR operation. Refer to Appendix E of LM555 Timer Datasheet, it explains how does the circuit works. At daytime, the resistance of the LDR is very low, thus it is a high at pin 2 of LM555 IC, gives no result of the comparator since both pins are high, thus the output is not triggered. However at night, the resistance of LDR becomes very high, thus giving a low to pin 2. When the trigger pin 2 is low, the comparator gives a high output and triggers the flip flop to gives a high to the output. Therefore, this explains the basic operation of the circuit to turn on the light at night.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

Green house management is a very important step that we should look into to develop and grow the industry of agricultural. With the correct investment in the greenhouse technology, it is possible to return the profit without risking the investor's capital investment. One of the purpose of the green house management project is to reduce the capital cost while promising the same profit return. In order to achieve the objective of the project, it is possible to manipulate and control the environmental factor inside the greenhouse. Therefore, by applying the concept of greenhouse management, we are able to reach another objective of the project which is to reduce the risk of capital loss since we are able to maximize the productivity of crops with the control of the of the greenhouse's surrounding.

The scope study of the project is narrowed down to the heat management control and light intensity exposure due to the variety of greenhouse management considerations. The heat control management helps to control or maintain the temperature changes inside the greenhouse and improve the ventilation of the air flow around the room. Next, the exposure of light affects the plant growth directly since the high level of irradiance or the radiation energy of the light will harm the plants and result in tissue damage or dehydrated symptoms. These two features of management are very important aspects that should not be neglected in green house management.

In greenhouse management, it is designated to control the environment inside the greenhouse so that the plants can do their normal activities like respiration, photosynthesis, and others in a much better way. Therefore, when the above conditions are met, the system is said to be able to satisfy the basic needs of the plants thus it improves and maximizes the productivity rate of the plants.

5.2 Recommendation

The recommendations are as following:

(a) Heat management control

The heat management circuit currently is able to response when the detected temperature is lower or higher than the reference temperature point. However, we are not able to differentiate the condition since the heater will be turned on either the temperature is lower than or equal to the reference point. So the improvement of the circuit that can be done is to list out another condition where the system becomes idle when temperature detected is equivalent to the pre-set point. Next, instead of configuring one point, we should set two points, which the upper point stands for the maximum temperature that the plant can sustain, while the lower point is the minimum temperature. Thus, we are able to set the ranges of temperature suitable for the plants to live since it is very hard to say that the plant will be living healthy forever only at one particular temperature point.

(b) Light intensity exposure

Besides having the light activation circuit at night time, experiments on light intensity exposure on the plants which are planted inside the green house will be conducted. In the coming days, the plants will be further observed to notice the plants growth towards different type of environment. The types of plant and the environmental factors like water quality and atmospheric temperature become the constant variable in the experiment, so the experiment is planned by testing the different types of light intensity exposure on the greenhouse plants.

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APPENDICES

APPENDIX A

GANTT CHART OF FYP I

WEEK NUMBER / MILESTONES	1	2	3	4	5	6	7		8	9	10	11	12	13	14
BRIEFING AND TITLE SELECTION								HARI RAYA / SEMESTER BREAK							
DEFINE PROBLEM															
BRAINSTORMING AND ANALYZING															
DESIGNING AND IDENTIFYING CIRCUIT															
RESEARCH AND DATA ANALYSIS															
DATA ACQUISITION AND PARAMETER TESTING															
SEMINAR															
FINAL REPORT DRAFT															
FINAL REPORT SUBMISSION AND ORAL PRESENTATION															

GANTT CHART OF FYP II

WEEK NUMBER / MILESTONES	1	2	3	4	5	6	7		8	9	10	11	12	13	14
SPECIFICATION AND TESTING DATA								SEMESTER BREAK							
PROJECT WORK															
PROTOTYPING															
PROGRESS REPORT II SUBMISSION															
PROTOTYPING TESTING															
SUPERVISOR EVALUATION															
EXHIBITION AND PRESENTATION															
FINAL REPORT SUBMISSION															

Appendix B

DS18B20 Digital Thermometer Datasheet – Part I

DALLAS SEMICONDUCTOR MAXIM

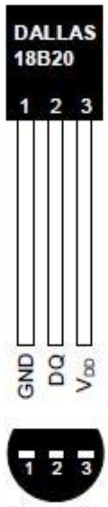
DS18B20
Programmable Resolution 1-Wire Digital Thermometer

www.maxim-ic.com

FEATURES

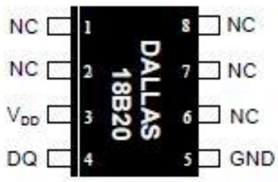
- Unique 1-Wire® interface requires only one port pin for communication
- Each device has a unique 64-bit serial code stored in an onboard ROM
- Multidrop capability simplifies distributed temperature sensing applications
- Requires no external components
- Can be powered from data line. Power supply range is 3.0V to 5.5V
- Measures temperatures from –55°C to +125°C (–67°F to +257°F)
- ±0.5°C accuracy from –10°C to +85°C
- Thermometer resolution is user-selectable from 9 to 12 bits
- Converts temperature to 12-bit digital word in 750ms (max.)
- User-definable nonvolatile (NV) alarm settings
- Alarm search command identifies and addresses devices whose temperature is outside of programmed limits (temperature alarm condition)
- Available in 8-pin SO (150mil), 8-pin μSOP, and 3-pin TO-92 packages
- Software compatible with the DS1822
- Applications include thermostatic controls, industrial systems, consumer products, thermometers, or any thermally sensitive system

PIN ASSIGNMENT

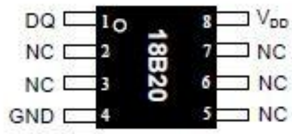


(BOTTOM VIEW)

TO-92
(DS18B20)



8-Pin 150mil SO
(DS18B20Z)



8-Pin μSOP
(DS18B20U)

PIN DESCRIPTION

GND	- Ground
DQ	- Data In/Out
V_{DD}	- Power Supply Voltage
NC	- No Connect

DESCRIPTION

The DS18B20 Digital Thermometer provides 9 to 12–bit centigrade temperature measurements and has an alarm function with nonvolatile user-programmable upper and lower trigger points. The DS18B20 communicates over a 1-Wire bus that by definition requires only one data line (and ground) for communication with a central microprocessor. It has an operating temperature range of –55°C to +125°C and is accurate to ±0.5°C over the range of –10°C to +85°C. In addition, the DS18B20 can derive power directly from the data line ("parasite power"), eliminating the need for an external power supply.

Each DS18B20 has a unique 64-bit serial code, which allows multiple DS18B20s to function on the same 1–wire bus; thus, it is simple to use one microprocessor to control many DS18B20s distributed over a large area. Applications that can benefit from this feature include HVAC environmental controls, temperature monitoring systems inside buildings, equipment or machinery, and process monitoring and control systems.

Appendix B

DS18B20 Digital Thermometer Datasheet – Part II

DETAILED PIN DESCRIPTIONS Table 1

SO*	μSOP*	TO-92	SYMBOL	DESCRIPTION
5	4	1	GND	**Ground.**
4	1	2	DQ	**Data Input/Output pin.** Open-drain 1-Wire interface pin. Also provides power to the device when used in parasite power mode (see "Parasite Power" section.)
3	8	3	V_{DD}	**Optional V_{DD} pin.** V_{DD} must be grounded for operation in parasite power mode.

*All pins not specified in this table are "No Connect" pins.

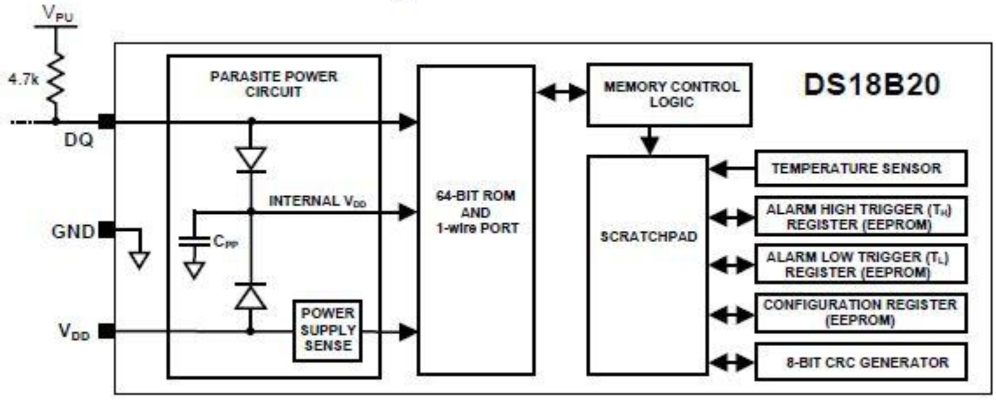
OVERVIEW

Figure 1 shows a block diagram of the DS18B20, and pin descriptions are given in Table 1. The 64-bit ROM stores the device's unique serial code. The scratchpad memory contains the 2-byte temperature register that stores the digital output from the temperature sensor. In addition, the scratchpad provides access to the 1-byte upper and lower alarm trigger registers (T_H and T_L), and the 1-byte configuration register. The configuration register allows the user to set the resolution of the temperature-to-digital conversion to 9, 10, 11, or 12 bits. The T_H, T_L and configuration registers are nonvolatile (EEPROM), so they will retain data when the device is powered down.

The DS18B20 uses Dallas' exclusive 1-Wire bus protocol that implements bus communication using one control signal. The control line requires a weak pullup resistor since all devices are linked to the bus via a 3-state or open-drain port (the DQ pin in the case of the DS18B20). In this bus system, the microprocessor (the master device) identifies and addresses devices on the bus using each device's unique 64-bit code. Because each device has a unique code, the number of devices that can be addressed on one bus is virtually unlimited. The 1-Wire bus protocol, including detailed explanations of the commands and "time slots," is covered in the *1-WIRE BUS SYSTEM* section of this datasheet.

Another feature of the DS18B20 is the ability to operate without an external power supply. Power is instead supplied through the 1-Wire pullup resistor via the DQ pin when the bus is high. The high bus signal also charges an internal capacitor (C_{PP}), which then supplies power to the device when the bus is low. This method of deriving power from the 1-Wire bus is referred to as "parasite power." As an alternative, the DS18B20 may also be powered by an external supply on V_{DD}.

DS18B20 BLOCK DIAGRAM Figure 1



Appendix B

DS18B20 Digital Thermometer Datasheet – Part III

OPERATION — MEASURING TEMPERATURE

The core functionality of the DS18B20 is its direct-to-digital temperature sensor. The resolution of the temperature sensor is user-configurable to 9, 10, 11, or 12 bits, corresponding to increments of 0.5°C, 0.25°C, 0.125°C, and 0.0625°C, respectively. The default resolution at power-up is 12-bit. The DS18B20 powers-up in a low-power idle state; to initiate a temperature measurement and A-to-D conversion, the master must issue a Convert T [44h] command. Following the conversion, the resulting thermal data is stored in the 2-byte temperature register in the scratchpad memory and the DS18B20 returns to its idle state. If the DS18B20 is powered by an external supply, the master can issue "read time slots" (see the *1-WIRE BUS SYSTEM* section) after the Convert T command and the DS18B20 will respond by transmitting 0 while the temperature conversion is in progress and 1 when the conversion is done. If the DS18B20 is powered with parasite power, this notification technique cannot be used since the bus must be pulled high by a strong pullup during the entire temperature conversion. The bus requirements for parasite power are explained in detail in the *POWERING THE DS18B20* section of this datasheet.

The DS18B20 output temperature data is calibrated in degrees centigrade; for Fahrenheit applications, a lookup table or conversion routine must be used. The temperature data is stored as a 16-bit sign-extended two's complement number in the temperature register (see Figure 2). The sign bits (S) indicate if the temperature is positive or negative: for positive numbers S = 0 and for negative numbers S = 1. If the DS18B20 is configured for 12-bit resolution, all bits in the temperature register will contain valid data. For 11-bit resolution, bit 0 is undefined. For 10-bit resolution, bits 1 and 0 are undefined, and for 9-bit resolution bits 2, 1 and 0 are undefined. Table 2 gives examples of digital output data and the corresponding temperature reading for 12-bit resolution conversions.

TEMPERATURE REGISTER FORMAT Figure 2

	bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0
LS Byte	2^3	2^2	2^1	2^0	2^{-1}	2^{-2}	2^{-3}	2^{-4}

	bit 15	bit 14	bit 13	bit 12	bit 11	bit 10	bit 9	bit 8
MS Byte	S	S	S	S	S	2^6	2^5	2^4

TEMPERATURE/DATA RELATIONSHIP Table 2

TEMPERATURE	DIGITAL OUTPUT (Binary)	DIGITAL OUTPUT (Hex)
+125°C	0000 0111 1101 0000	07D0h
+85°C*	0000 0101 0101 0000	0550h
+25.0625°C	0000 0001 1001 0001	0191h
+10.125°C	0000 0000 1010 0010	00A2h
+0.5°C	0000 0000 0000 1000	0008h
0°C	0000 0000 0000 0000	0000h
-0.5°C	1111 1111 1111 1000	FFF8h
-10.125°C	1111 1111 0101 1110	FF5Eh
-25.0625°C	1111 1110 0110 1111	FE6Fh
-55°C	1111 1100 1001 0000	FC90h

*The power-on reset value of the temperature register is +85°C

Appendix B

DS18B20 Digital Thermometer Datasheet – Part IV

TRANSACTION SEQUENCE

The transaction sequence for accessing the DS18B20 is as follows:

Step 1. Initialization

Step 2. ROM Command (followed by any required data exchange)

Step 3. DS18B20 Function Command (followed by any required data exchange)

It is very important to follow this sequence every time the DS18B20 is accessed, as the DS18B20 will not respond if any steps in the sequence are missing or out of order. Exceptions to this rule are the Search ROM [F0h] and Alarm Search [ECh] commands. After issuing either of these ROM commands, the master must return to Step 1 in the sequence.

INITIALIZATION

All transactions on the 1-Wire bus begin with an initialization sequence. The initialization sequence consists of a reset pulse transmitted by the bus master followed by presence pulse(s) transmitted by the slave(s). The presence pulse lets the bus master know that slave devices (such as the DS18B20) are on the bus and are ready to operate. Timing for the reset and presence pulses is detailed in the *1-WIRE SIGNALING* section.

ROM COMMANDS

After the bus master has detected a presence pulse, it can issue a ROM command. These commands operate on the unique 64-bit ROM codes of each slave device and allow the master to single out a specific device if many are present on the 1-Wire bus. These commands also allow the master to determine how many and what types of devices are present on the bus or if any device has experienced an alarm condition. There are five ROM commands, and each command is 8 bits long. The master device must issue an appropriate ROM command before issuing a DS18B20 function command. A flowchart for operation of the ROM commands is shown in Figure 11.

SEARCH ROM [F0h]

When a system is initially powered up, the master must identify the ROM codes of all slave devices on the bus, which allows the master to determine the number of slaves and their device types. The master learns the ROM codes through a process of elimination that requires the master to perform a Search ROM cycle (i.e., Search ROM command followed by data exchange) as many times as necessary to identify all of the slave devices. If there is only one slave on the bus, the simpler Read ROM command (see below) can be used in place of the Search ROM process. For a detailed explanation of the Search ROM procedure, refer to the *iButton® Book of Standards* at www.ibutton.com/ibuttons/standard.pdf. After every Search ROM cycle, the bus master must return to Step 1 (Initialization) in the transaction sequence.

READ ROM [33h]

This command can only be used when there is one slave on the bus. It allows the bus master to read the slave's 64-bit ROM code without using the Search ROM procedure. If this command is used when there is more than one slave present on the bus, a data collision will occur when all the slaves attempt to respond at the same time.

MATCH ROM [55h]

The match ROM command followed by a 64-bit ROM code sequence allows the bus master to address a specific slave device on a multidrop or single-drop bus. Only the slave that exactly matches the 64-bit ROM code sequence will respond to the function command issued by the master; all other slaves on the bus will wait for a reset pulse.

Appendix B

DS18B20 Digital Thermometer Datasheet – Part V

SKIP ROM [CCh]

The master can use this command to address all devices on the bus simultaneously without sending out any ROM code information. For example, the master can make all DS18B20s on the bus perform simultaneous temperature conversions by issuing a Skip ROM command followed by a Convert T [44h] command.

Note that the Read Scratchpad [BEh] command can follow the Skip ROM command only if there is a single slave device on the bus. In this case time is saved by allowing the master to read from the slave without sending the device's 64-bit ROM code. A Skip ROM command followed by a Read Scratchpad command will cause a data collision on the bus if there is more than one slave since multiple devices will attempt to transmit data simultaneously.

ALARM SEARCH [ECh]

The operation of this command is identical to the operation of the Search ROM command except that only slaves with a set alarm flag will respond. This command allows the master device to determine if any DS18B20s experienced an alarm condition during the most recent temperature conversion. After every Alarm Search cycle (i.e., Alarm Search command followed by data exchange), the bus master must return to Step 1 (Initialization) in the transaction sequence. Refer to the *OPERATION — ALARM SIGNALING* section for an explanation of alarm flag operation.

DS18B20 FUNCTION COMMANDS

After the bus master has used a ROM command to address the DS18B20 with which it wishes to communicate, the master can issue one of the DS18B20 function commands. These commands allow the master to write to and read from the DS18B20's scratchpad memory, initiate temperature conversions and determine the power supply mode. The DS18B20 function commands, which are described below, are summarized in Table 4 and illustrated by the flowchart in Figure 12.

CONVERT T [44h]

This command initiates a single temperature conversion. Following the conversion, the resulting thermal data is stored in the 2-byte temperature register in the scratchpad memory and the DS18B20 returns to its low-power idle state. If the device is being used in parasite power mode, within 10μs (max) after this command is issued the master must enable a strong pullup on the 1-Wire bus for the duration of the conversion (t_{conv}) as described in the *POWERING THE DS18B20* section. If the DS18B20 is powered by an external supply, the master can issue read time slots after the Convert T command and the DS18B20 will respond by transmitting a 0 while the temperature conversion is in progress and a 1 when the conversion is done. In parasite power mode this notification technique cannot be used since the bus is pulled high by the strong pullup during the conversion.

WRITE SCRATCHPAD [4Eh]

This command allows the master to write 3 bytes of data to the DS18B20's scratchpad. The first data byte is written into the T_H register (byte 2 of the scratchpad), the second byte is written into the T_L register (byte 3), and the third byte is written into the configuration register (byte 4). Data must be transmitted least significant bit first. All three bytes MUST be written before the master issues a reset, or the data may be corrupted.

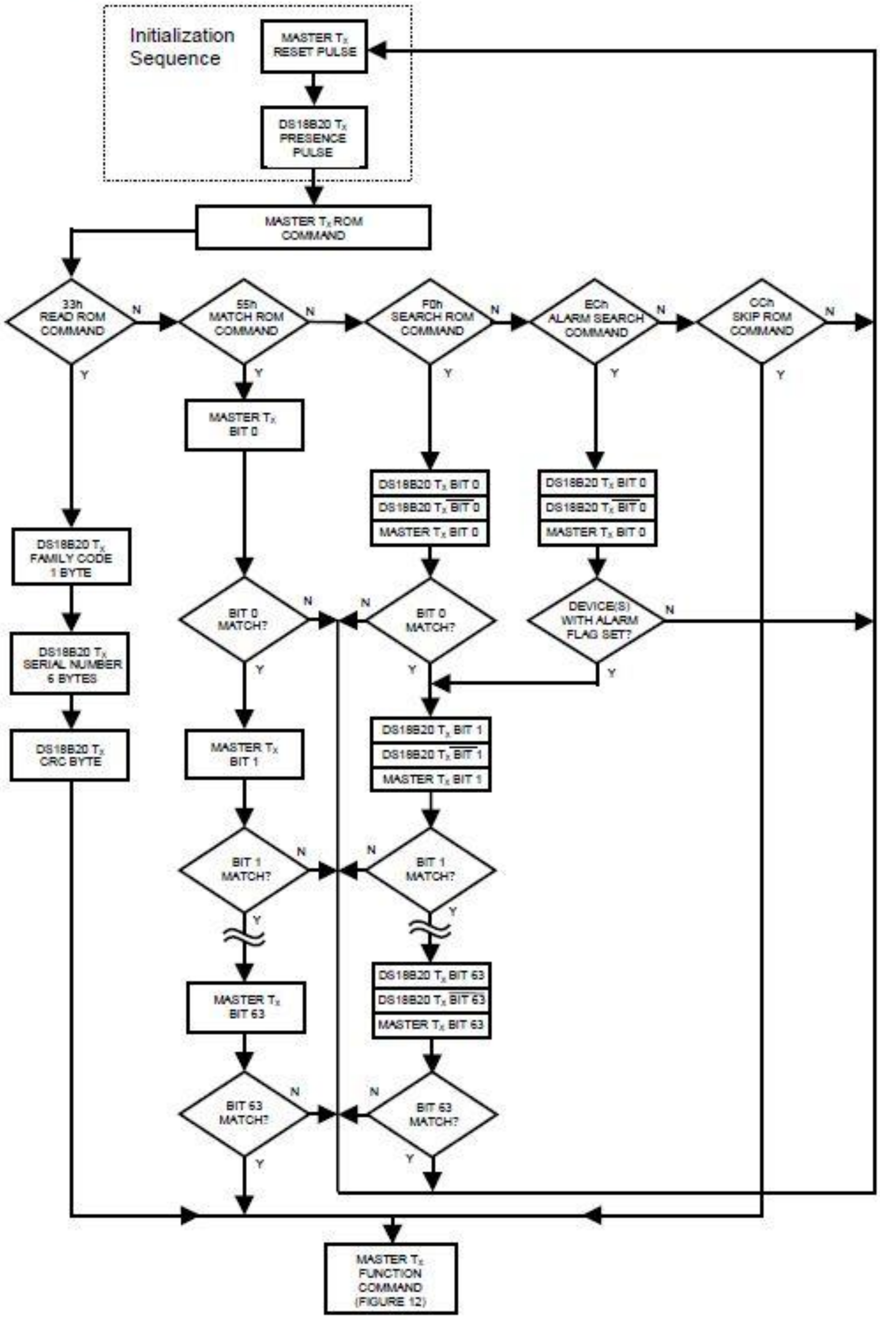
READ SCRATCHPAD [BEh]

This command allows the master to read the contents of the scratchpad. The data transfer starts with the least significant bit of byte 0 and continues through the scratchpad until the 9^{th} byte (byte 8 – CRC) is read. The master may issue a reset to terminate reading at any time if only part of the scratchpad data is needed.

Appendix B

DS18B20 Digital Thermometer Datasheet – Part VI

ROM COMMANDS FLOW CHART Figure 11

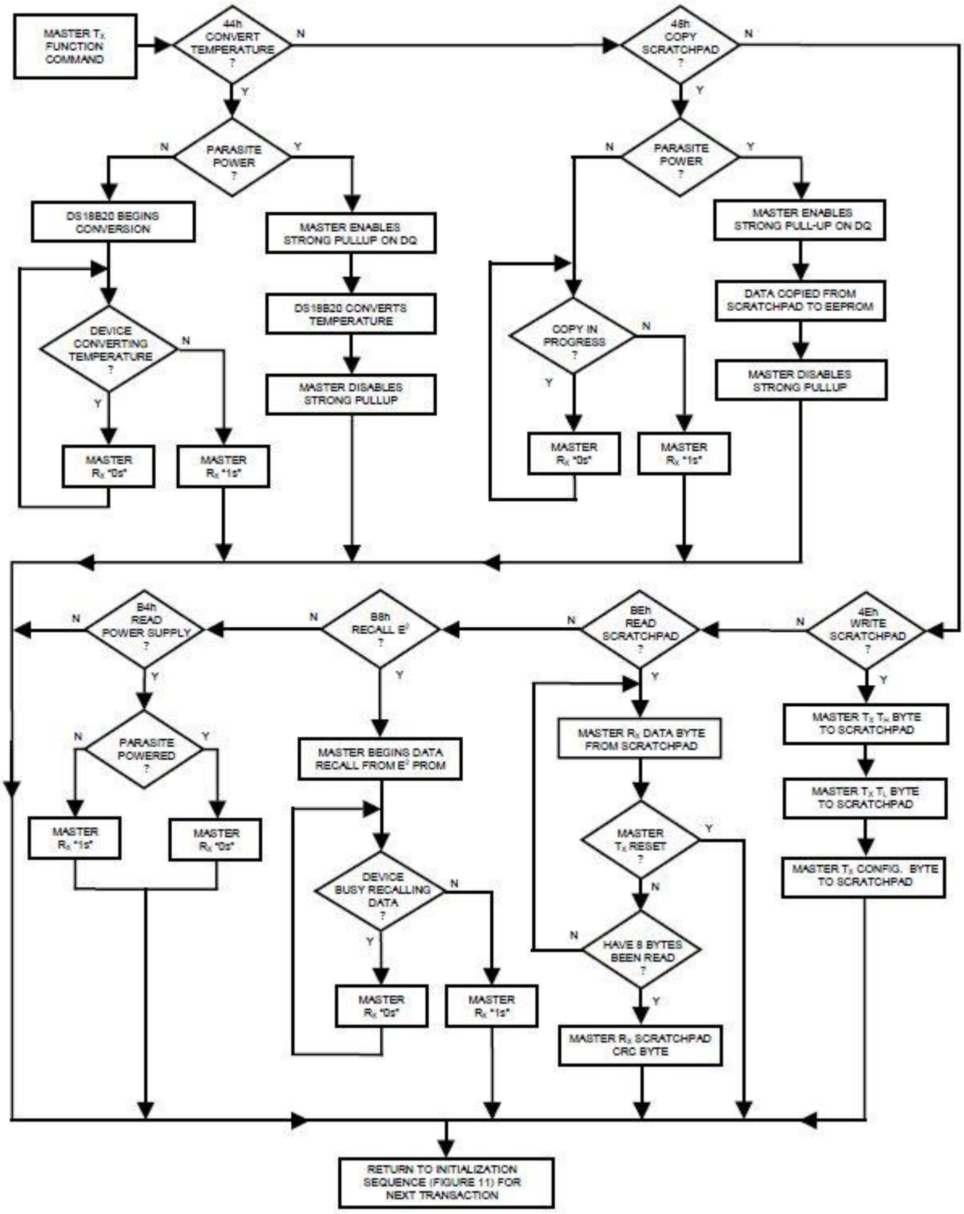


Appendix B

DS18B20 Digital Thermometer Datasheet – Part VII

DS18B20

DS18B20 FUNCTION COMMANDS FLOW CHART Figure 12



Appendix C

AT89C2051 8-bit Microcontroller Datasheet – Part I

Features

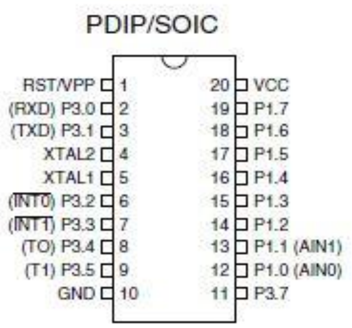
- Compatible with MCS-51™ Products
- 2K Bytes of Reprogrammable Flash Memory
  - Endurance: 1,000 Write/Erase Cycles
- 2.7V to 6V Operating Range
- Fully Static Operation: 0 Hz to 24 MHz
- Two-level Program Memory Lock
- 128 x 8-bit Internal RAM
- 15 Programmable I/O Lines
- Two 16-bit Timer/Counters
- Six Interrupt Sources
- Programmable Serial UART Channel
- Direct LED Drive Outputs
- On-chip Analog Comparator
- Low-power Idle and Power-down Modes

Description

The AT89C2051 is a low-voltage, high-performance CMOS 8-bit microcomputer with 2K bytes of Flash programmable and erasable read only memory (PEROM). The device is manufactured using Atmel's high-density nonvolatile memory technology and is compatible with the industry-standard MCS-51 instruction set. By combining a versatile 8-bit CPU with Flash on a monolithic chip, the Atmel AT89C2051 is a powerful microcomputer which provides a highly-flexible and cost-effective solution to many embedded control applications.

The AT89C2051 provides the following standard features: 2K bytes of Flash, 128 bytes of RAM, 15 I/O lines, two 16-bit timer/counters, a five vector two-level interrupt architecture, a full duplex serial port, a precision analog comparator, on-chip oscillator and clock circuitry. In addition, the AT89C2051 is designed with static logic for operation down to zero frequency and supports two software selectable power saving modes. The Idle Mode stops the CPU while allowing the RAM, timer/counters, serial port and interrupt system to continue functioning. The power-down mode saves the RAM contents but freezes the oscillator disabling all other chip functions until the next hardware reset.

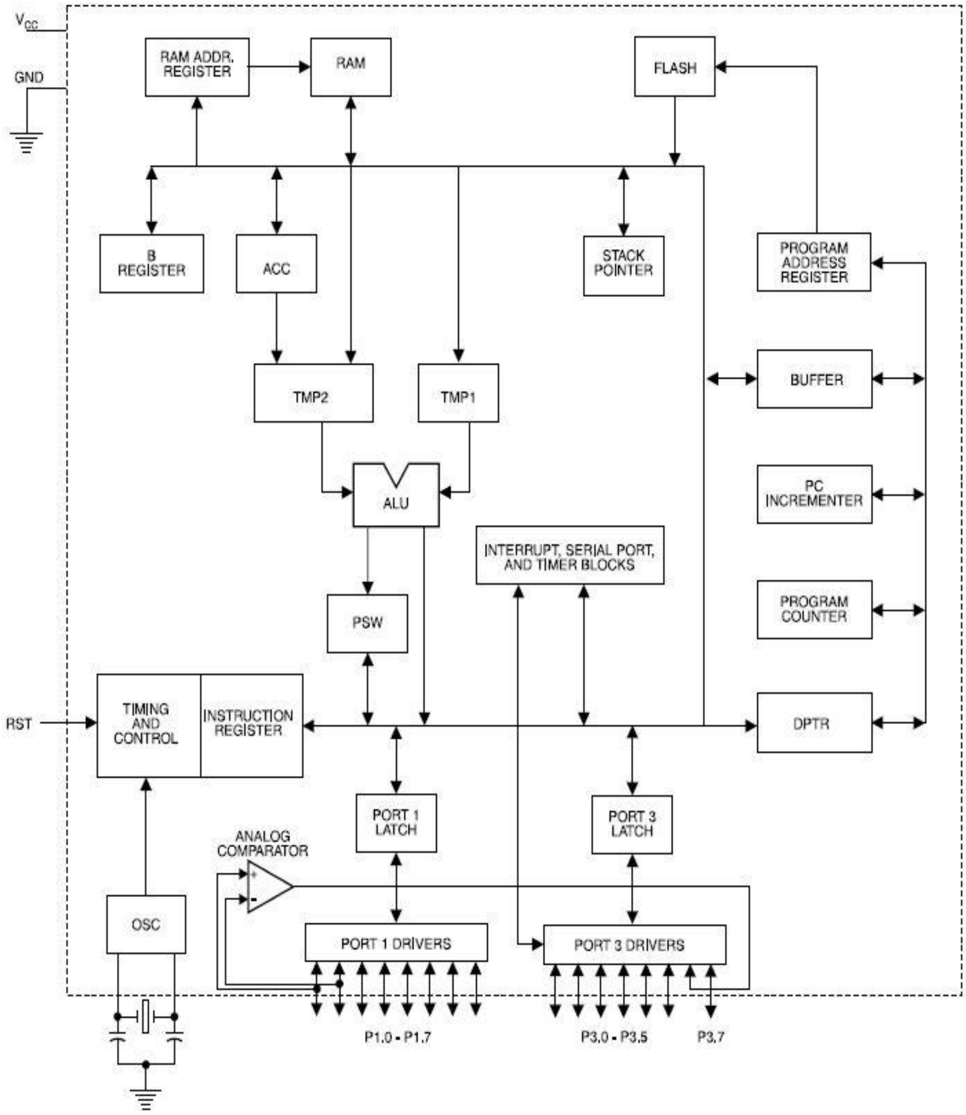
Pin Configuration



Appendix C

AT89C2051 8-bit Microcontroller Datasheet – Part II

Block Diagram



Appendix C

AT89C2051 8-bit Microcontroller Datasheet – Part III

Pin Description

VCC

Supply voltage.

GND

Ground.

Port 1

Port 1 is an 8-bit bi-irectional I/O port. Port pins P1.2 to P1.7 provide internal pullups. P1.0 and P1.1 require external pullups. P1.0 and P1.1 also serve as the positive input (AIN0) and the negative input (AIN1), respectively, of the on-chip precision analog comparator. The Port 1 output buffers can sink 20 mA and can drive LED displays directly. When 1s are written to Port 1 pins, they can be used as inputs. When pins P1.2 to P1.7 are used as inputs and are externally pulled low, they will source current (I_{IL}) because of the internal pullups.

Port 1 also receives code data during Flash programming and verification.

Port 3

Port 3 pins P3.0 to P3.5, P3.7 are seven bi-irectional I/O pins with internal pullups. P3.6 is hard-wired as an input to the output of the on-chip comparator and is not accessible as a general purpose I/O pin. The Port 3 output buffers can sink 20 mA. When 1s are written to Port 3 pins they are pulled high by the internal pullups and can be used as inputs. As inputs, Port 3 pins that are externally being pulled low will source current (I_{IL}) because of the pullups.

Port 3 also serves the functions of various special features of the AT89C2051 as listed below:

Port Pin	Alternate Functions
P3.0	RXD (serial input port)
P3.1	TXD (serial output port)
P3.2	$\overline{\text{INT0}}$ (external interrupt 0)
P3.3	$\overline{\text{INT1}}$ (external interrupt 1)
P3.4	T0 (timer 0 external input)
P3.5	T1 (timer 1 external input)

Port 3 also receives some control signals for Flash programming and verification.

RST

Reset input. All I/O pins are reset to 1s as soon as RST goes high. Holding the RST pin high for two machine cycles while the oscillator is running resets the device.

Each machine cycle takes 12 oscillator or clock cycles.

XTAL1

Input to the inverting oscillator amplifier and input to the internal clock operating circuit.

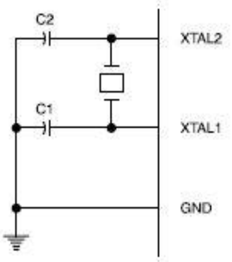
XTAL2

Output from the inverting oscillator amplifier.

Oscillator Characteristics

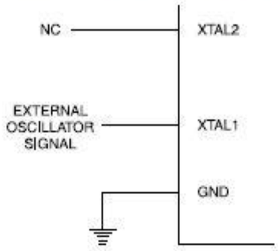
XTAL1 and XTAL2 are the input and output, respectively, of an inverting amplifier which can be configured for use as an on-chip oscillator, as shown in Figure 1. Either a quartz crystal or ceramic resonator may be used. To drive the device from an external clock source, XTAL2 should be left unconnected while XTAL1 is driven as shown in Figure 2. There are no requirements on the duty cycle of the external clock signal, since the input to the internal clocking circuitry is through a divide-by-two flip-flop, but minimum and maximum voltage high and low time specifications must be observed.

Figure 1. Oscillator Connections



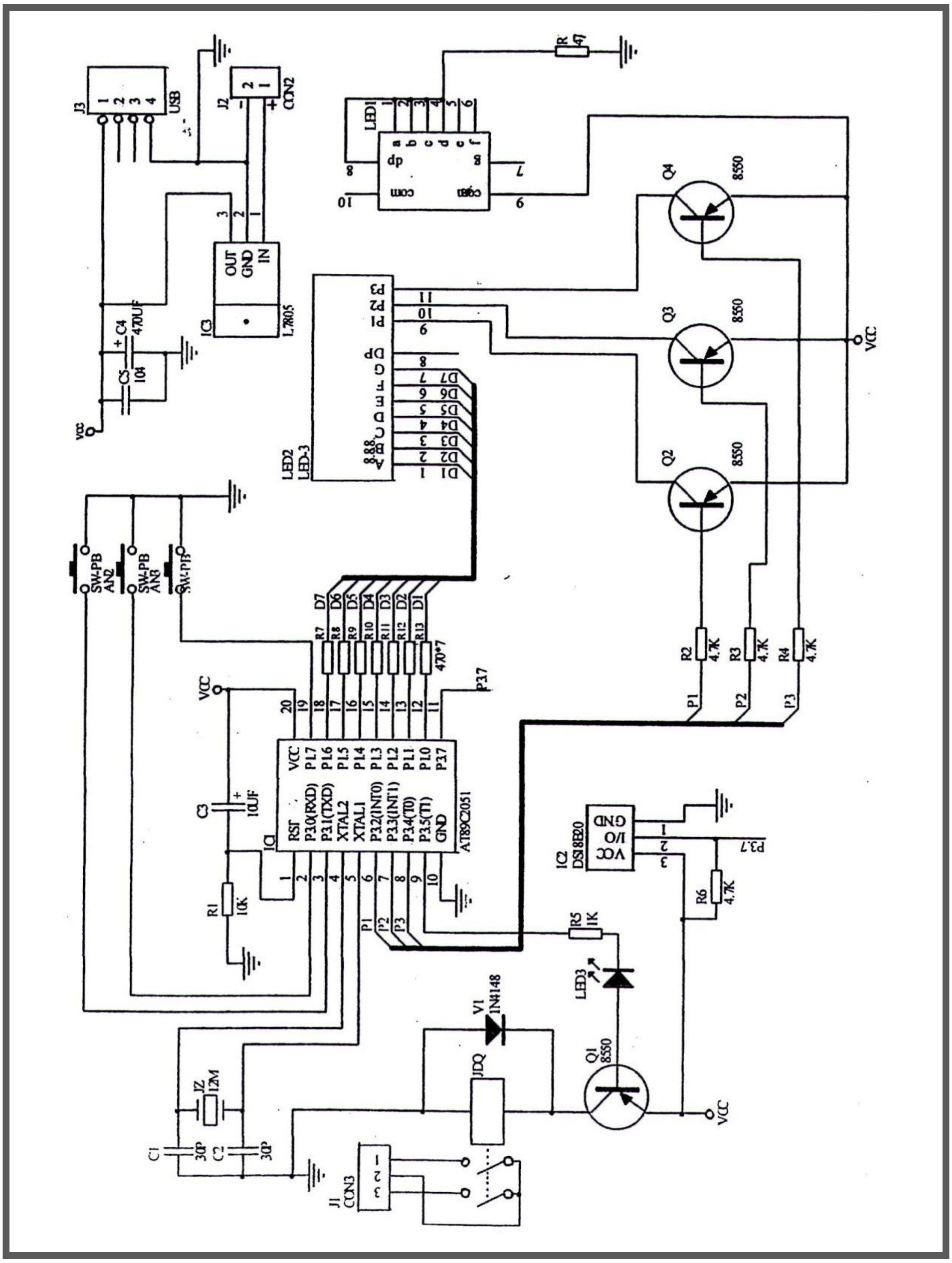
Note: C1, C2 = 30 pF ± 10 pF for Crystals
= 40 pF ± 10 pF for Ceramic Resonators

Figure 2. External Clock Drive Configuration



Appendix D

Schematic Diagram of the Heat Management System



Appendix E

LM555 Timer Datasheet

FAIRCHILD SEMICONDUCTOR®

www.fairchildsemi.com

LM555/NE555/SA555

Single Timer

Features

- High Current Drive Capability (200mA)
- Adjustable Duty Cycle
- Temperature Stability of 0.005%/°C
- Timing From µSec to Hours
- Turn off Time Less Than 2µSec

Applications

- Precision Timing
- Pulse Generation
- Time Delay Generation
- Sequential Timing

Description

The LM555/NE555/SA555 is a highly stable controller capable of producing accurate timing pulses. With monostable operation, the time delay is controlled by one external resistor and one capacitor. With astable operation, the frequency and duty cycle are accurately controlled with two external resistors and one capacitor.

Internal Block Diagram