DEVELOPMENT OF 2-AXIS SOLAR PANEL FOR SOIL MOISTURE DETECTOR AT 4 SEASONS COUNTRIES

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CHAPTER1

INTRODUCTION

1.1 Background

This chapter explains the overview on 2-axis solar tracker and the significance of solar tracker. This overview will be briefly explains on what is the solar tracker and the functions of this solar tracker. It also explains on the significance of solar tracker for the user and why the solar tracker invented.

1.2 Overview of 2-Axis Solar Tracker

Solar panel or also known as photovoltaic module is a most effective thing of way to produce the electricity. Extracting useable electricity from the sun was made possible by the discovery of the photoelectric mechanism and subsequent development of the solar cell (a semiconductive material that converts visible light into a direct current). By using solar arrays, a series of solar cells electrically connected, a DC voltage is generated which can be physically used on a load. Solar arrays or panels are

CHAPTER 2

LITERATURE REVIEW

2.1 Solar Power History

Ancient Egyptians built places to live that allowed stored energy from the sun during the day, and a heat release during the night. This kind of architecture heated homes at night while keeping the temperature low during the day. Egyptians also used the sun as part of their mummification process, using the sun to dry dead bodies. The Egyptians used a form of passive solar power.

In 3rd Century B.C., Greek soldiers with the help of Archimedes, focused light on a Roman fleet by using mirrors. The Romans were invading a port city that did not have defenses ready for the attack. The mirrors were used to concentrate the energy of the sun, and cause the fleet's sails to burn. The Romans retreated and the Greeks were able to prevent the invasion. The Greeks used passive solar power.

In 100 A.D. a historical writer by the name of Pliny the Younger built a house in the northern part of Italy that had mica windows in one room. This one particular room demonstrated solar heating in that it's mica windows stored heat, and later gave it off. This room was useful because the added heat it generated lessened the amount of wood that had to be burnt. For the roman bath houses, it a had famous south facing windows that heated the rooms. Other than that, Native Americans also built houses that used passive solar power. Houses were built into the side of cliffs or hills to allow storage of heat during the day, and a release of heat at night.

In 1767, the world's first solar collector was built by Swiss scientist Horace de Saussare. And 1839, a physicist from France, Edmond Becquerei observes the photoelectric effect. It is continue with 1880's, where visible light converting photovoltaic cells made of selenium were built and had 1- 2% efficiency. In 1891 the first commercial solar water heater was patented by the father of American solar energy, Clarence Kemp.

William J. Bailley of the Carnegie Steel Company in 1908 invented a solar collector with copper coils and an insulated box and a book published by the Libbey-Owens-Ford Glass Company in 1947 showcased the fourty-nine greatest American solar architects. By the early 1950's, A process for producing crystalline silicon of high purity was developed, called the Czochralski meter and it’s continue with the Bell Telephone Laboratories in 1954 which is produced a 4% efficiency silicon PV cell, and later accomplished 11% efficiency.

During the mid-1950's, the first solar water heated office building was built by architect Frank Bridgers. In 1958, A small satelitte of US Vanguard was powered by a less than one watt power solar cell. From the 1960's to the present oil prices play an important part of the economics of solar power and other alternative energy forms. In the 1960's cheap imported oil was the main energy competitor to solar power and restricted the overall solar technology market. During 1973 - 1974 the oil embargo allowed opportunity for solar power to flourish. The US Department of Energy funded the Federal Photovoltaic Utilization Program that began installation and testing of over 3,000 PV systems.

In the mid 1980's incentive for business led to around 150 businesses for manufacturing industry with annual sales of $0.8 billion. Gulf War of 1990 renewed interest in solar power as an alternative to oil and petroleum products. Mid-1990's have few tax credits and incentives for solar electric homes or heating systems, yet approximately 1.2 million buildings in the US are solar heated. International markets and foreign investments especially from Germany and Japan took off in 1970, but continue to be major factors in the solar energy market. [1]

2.2 Photovoltaic Technology

Photovoltaic are best known as a method for generating electric power by using solar cells to convert energy from the sun into electricity. The photovoltaic effect refers to photons of light knocking electrons into a higher state of energy to create electricity. The term photovoltaic denotes the unbiased operating mode of a photodiode in which current through the device is entirely due to the transduced light energy. Virtually all photovoltaic devices are some type of photodiode.

Solar cells produce direct current electricity from sun light, which can be used to power equipment or to recharge a battery. The first practical application of photovoltaic was to power orbiting satellites and other spacecraft, but today the majority of photovoltaic modules are used for grid connected power generation. In this case an inverter is required to convert the DC to AC. There is a smaller market for off-grid power for remote dwellings, boats, recreational vehicles, electric cars, roadside emergency telephones, remote sensing, and cathode protection of pipelines.

Cells require protection from the environment and are usually packaged tightly behind a glass sheet. When more power is required than a single cell can deliver, cells are electrically connected together to form photovoltaic modules, or solar panels.

2.3 Solar Panel

In the field of photovoltaic, a photovoltaic module or photovoltaic panel is packaged interconnected assembly of photovoltaic cells, also known as solar cells. An installation of photovoltaic modules or panels is known as a photovoltaic array. Photovoltaic cells typically require protection from the environment. For cost and practicality reasons a number of cells are connected electrically and packaged in a photovoltaic module, while a collection of these modules that are mechanically fastened together, wired, and designed to be a field-installable unit, sometimes with a glass covering and a frame and backing made of metal, plastic or fiberglass, are known as a photovoltaic panel or simply solar panel.

2.4 Solar Tracker

The solar tracker is a device that keeps photovoltaic or photo thermal panel in an optimum position perpendicularly to the solar radiation during daylight hours, can increase the collected energy by up to 50%. Commercially, single-axis and two-axis tracking mechanisms are available. Usually the single-axis tracker follows the sun's East-West movement, while two-axis tracker follows also the sun's changing altitude angle. Sun tracking system have been studied with different application to improve the efficiency of solar system by adding the tracking equipment to these systems through various methods. A tracking system must be able to follow the sun with a certain degree of accuracy, return the collector to its original position at the end of the day and also track during periods of cloud over.

The aim of this solar tracker project is to design a microcontroller operate two-axis Sun Tracker which works efficiently in all weather conditions regardless of presence of clouds for sun tracking systems on the electrical generation of a flat photovoltaic system.

2.5 Polar

Polar trackers have one axis aligned to be roughly parallel to the axis of rotation of the earth around the north and south poles-- hence the name polar. (With telecopes, this is called an equatorial mount.) Single axis tracking is often used when combined with time-of-use metering, since strong afternoon performance is particularly desirable for grid-tied photovoltaic systems, as production at this time will match the peak demand time for summer season air-conditioning. A fixed system oriented to optimize this limited time performance will have a relatively low annual production. The polar axis should be angled towards due north, and the angle between this axis and the vertical should be equal to your latitude. Simple polar trackers with single axis tracking may also have an adjustment along a second axis: the angle of declination. It might be set with manual or automated adjustments, depending on your polar-tracking device. If one is not planning on adjusting this angle of declination at all during the year, it is normally set to zero degrees, facing your panel straight out perpendicular to the polar axis, as that is where the mean path of the sun is found. Occasional or continuous adjustments to the declination compensate for the northward and southward shift in the sun's path through the sky as it moves through the seasons (and around the ecliptic) over the course of the year.

Figure2.1 Polar tracker

2.6 Overview of current driver tracker types

Solar trackers can be divided into three main types depending on the type of drive and sensing or positioning system that they incorporate. Passive trackers use the suns radiation to heat gasses that move the tracker across the sky. Active trackers use electric or hydraulic drives and some type of gearing or actuator to move the tracker. Open loop trackers use no sensing but instead determine the position of the sun through pre recorded data for a particular site.

2.7 Gas Trackers (Passive Trackers)

Passive trackers use a compressed gas fluid as a means of tilting the panel. A canister on the sun side of the tracker is heated causing gas pressure to increase and liquid to be pushed from one side of the tracker to the other. This affects the balance of the tracker and caused it to tilt. This system is very reliable and needs little maintenance. Although reliable and almost maintenance free, the passive gas tracker will very rarely point the solar modules directly towards the sun. This is due to the fact that temperature varies from day to day and the system can not take into account this variable. Overcast days are also a problem when the sun appears and disappears behind clouds causing the gas in the liquid in the holding cylinders to expand and contract resulting in erratic movement of the device. Passive trackers are however an effective and relatively low cost way of increasing the power output of a solar array. The tracker begins the day facing west. As the sun rises in the east, it heats the unshaded west-side canister, forcing liquid into the shaded east-side canister. The liquid that is forced into the east side canister changes the balance of the tracker and it swings to the east. It can take over an hour to accomplish the move from west to east. The heating of the liquid is controlled by the aluminum shadow plates. When one canister is exposed to the sun more than the other, its vapor pressure increases, forcing liquid to the cooler, shaded side. The shifting weight of the liquid causes the rack to rotate until the canisters are equally shaded. The rack completes its daily cycle facing west. It remains in this position overnight until it is "awakened" by the rising sun the following morning. [1]

Figure 2.2 Passive tracker

2.8 Active Trackers

Active trackers measure the light intensity from the sun to determine where the solar modules should be pointing. Light sensors are positioned on the tracker at various locations or in specially shaped holders. If the sun is not facing the tracker directly there will be a difference in light intensity on one light sensor compared to another and this difference can be used to determine in which direction the tracker has to tilt in order to be facing the sun. [1]

Figure 2.3 Active solar tracker

2.9 Chronological Tracker

A chronological tracker counteracts the earth's rotation by turning at an equal rate as the earth, but in the opposite direction. Actually the rates aren't quite equal, because as the earth goes around the sun, the position of the sun changes with respect to the earth by 360° every year or 365.24 days. A chronological tracker is a very simple yet potentially a very accurate solar tracker specifically for use with a polar mount (see above). The drive method may be as simple as a gear motor that rotates at a very slow average rate of one revolution per day (15 degrees per hour). In theory the tracker may rotate completely, assuming there is enough clearance for a complete rotation, and assuming that twisting wires are not an issue, such as with a solar concentrator or the tracker may be reset each day to avoid these issues. Alternatively, an electronic controller may be used, with a real time clock that is used to infer the "solar time" (hour angle). Tracking adjustments can be made incrementally or continuously.[1]

2.10 The Backtracking Strategy

Development and implementation of Backtracking one-axis tracking systems which overcomes the shading losses of conventional tracking and reduces the balance of system (BOS) costs. This strategy, known as backtracking, employs a microprocessor-based controller which commands the PV arrays to move such that no inter-array beam shading occurs. This is accomplished by flattening out the arrays in the morning and afternoon hours (i.e., zero tilt angle), using the precise control achievable with a microprocessor-based system. The algorithm can be easily developed for any location using well-established sun position equations in conjunction with site and system-specific dimensions. For this reason, extension of the backtrack concept to two-axis tracker systems is also possible.

To illustrate the effect of the backtrack strategy on panel tilt angle, The arrays begin each day in the horizontal position (facing the sky), then gradually rotate toward the east at a rate which does not produce any inter-array shadows. At some hour of the morning, depending upon season and location, the trackers will reverse direction and rotate west to minimize the incidence angle. Thus, during midday hours, the backtrack strategy is equivalent to the conventional strategy. When the low afternoon sun angle causes inter-array shading to begin, the array again reverses direction (toward the east this time) and gradually returns to the horizontal position.[2]

2.11 The Scarlet Light Concentrating Solar Array

As power levels increase spacecraft system level trades often indicate the use of a high-efficiency solar array system especially in applications that encounter aerodynamic drag'. If standard silicon cell rigid array technologies are employed, array mass, stowed volume, and deployed area may quickly erode the system cost benefits. Standard bus designs were developed with silicon cell technologies for standard launch vehicles with standard faring shroud sizes. When power levels are roughly doubled, the twice-as-big solar array on such a standard bus seriously erodes launch vehicle mass and volume margins. This trend will serve to limit spacecraft power levels. To maintain standard spacecraft sizes, systems (ACS, station-keeping fuel usage, etc.), and manufacturing lines, higher cell photovoltaic conversion efficiency is required to maintain a reasonable array size. High performance, light concentrating solar arrays offer spacecraft users these cost and performance benefits especially when high-efficiency solar cells are indicated by system-level trades.

Simply stated, concentrator technology allows arrays to have much lower cell area for a given power level. For instance, a concentrator array with a 10:1 geometric concentration ratio requires about 10% of the active solar cell area of a traditional planar array. This equates to a approximate 90% reduction in solar cell material costs which are a large component of total array costs. Additionally, since only 10% of the total area needs to be populated, high-efficiency multifunction cells can be more economically employed to field a reduced area array as indicated by system-level trades. The mission benefits of reduced area arrays have also been well documented.

The naturally occurring radiation environment is a concern for various constellation designs. A key technical barrier to employing satellites in such high radiation missions is degradation of cell energy conversion efficiency due to electron and proton impingement. In a planar array, compensating for cell degradation requires the use of larger, more costly arrays due to excessive cell usage (a high BOL to EOL power ratio). Alternately, system costs will be driven by unreasonably massive radiation protection over the entire cell area, front side and backside. In such missions the SCARLET array will provide significant mass savings because only 10% of the array's area need be protected with mass shielding. This mass savings can technically and financially enable certain missions.[3]

CHAPTER 3

METHODOLOGY

3.1 Introduction

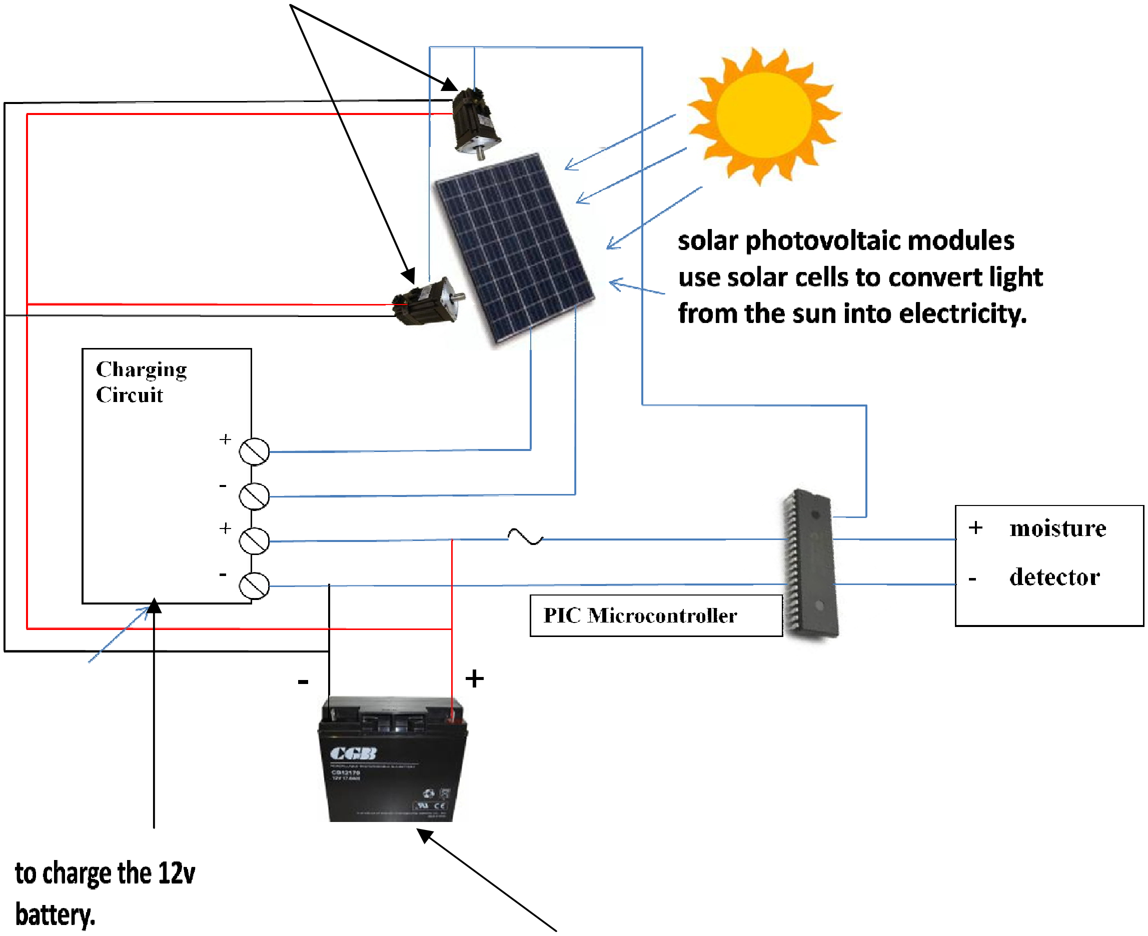
In designing and installing the electrical part of this project, a flow of methods had to be used to design and complete the model. First of all, a process planning had to be charted out. This acts as a guideline to be followed so that, the final model meets the requirement and time could be managed. This would determine the efficiency of the project to be done. Regulating and analyzing these steps are very important as each of it has its own criteria to be followed. The designing process is the backbone of the model, therefore using appropriate the precise method is imperative to this project. Intense study of the designing phase proved to be essential for the next step. Only with this determination on the designing procedure to be successful, then the circuit installation development of the project can be carried out. The circuit installation process carried out has to be accurate with the design first. Once this is established, modification grounds can be made triumph during testing of the 2-axis solar panel system. During testing, the experiment criteria are validated to suite the performance of the system and understanding. Finally, the analysis of the whole project can be concluded in the next chapter.

3.1.1 Block Diagram

Move the solar panel in 2-axis

That is 180^{o} up and down and

360^{o} rotation around.



solar photovoltaic modules use solar cells to convert light from the sun into electricity.

to charge the 12v battery.

supply to PIC microcontroller (PIC18F14K50) that connected to moisture sensor to and the result will be display at the LCD display.supply to motor.

Figure 3.1: Block Diagram of the System

3.1.2 Hardware Design

Figure 3.2: Hardware Design

3.1.3 Flow Chart

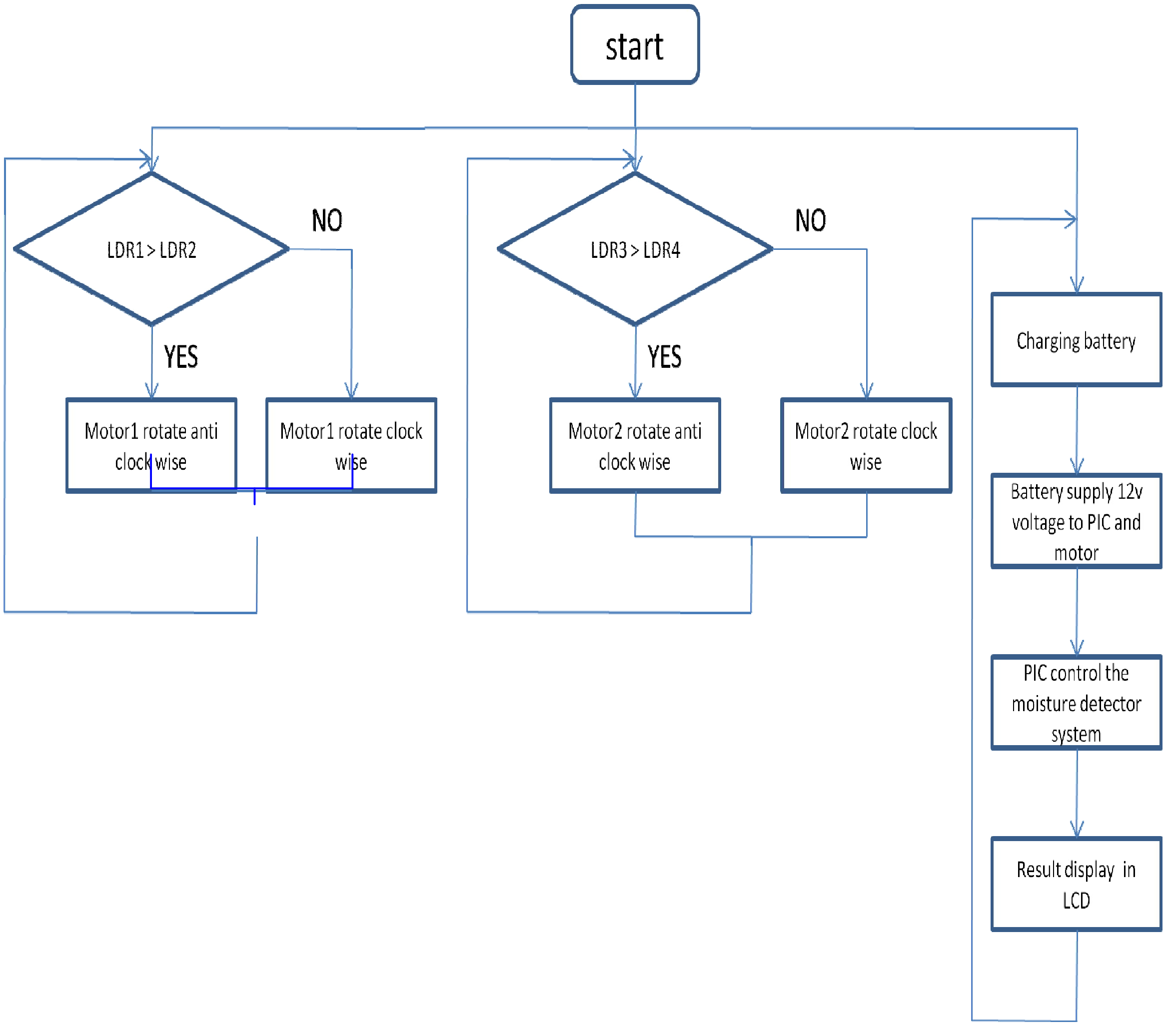


Figure 3.3: Flow chart of the System

3.1.4 Description

In this project, all the function run at the same time. There are 3 main part in this project, it is solar panel rotation at 180^o , rotation at 360^o around and lastly the charging part. For the 180^o rotation part, it consist LDR1 and LDR2. When LDR1>LDR2 or LDR1 receive more voltage from the sunlight than LDR2 , motor will be rotate anti-clock wise or rotate to the left and on the other hand if LDR2>LDR1. For the 360^o rotation part, it consist LDR3 and LDR4. When LDR3>LDR4 or LDR3 receive more voltage from the sunlight than LDR4 , motor will be rotate anti-clock wise or rotate to the left around until solar panel get the highest voltage and on the other hand if LDR2>LDR1. Lastly. For the charging part, when the solar panel get the highest voltage, it will charging the 12V battery through charging circuit. This battery will be supply voltage for the power window motor and the PIC circuit. PIC circuit will be controlled the movement of power window motor and the soil moisture detector system.

3.2 Hardware Implementation

3.2.1 Design Decision

The design of 2-axis solar panel for soil moisture detector (electrical part) must be compliance to several aspects. The aspect that must be considered in designing the electrical part of the system is operating mechanism, cost, ease of design, and performance of the system.

3.2.2 Solar Charging System

For solar charging system in this project, it has 3 main component. It is 12V, 10W solar panel, 12V 5A solar charger (controller) and 12V sealed lead acid battery. The connection of this 3 component like below.

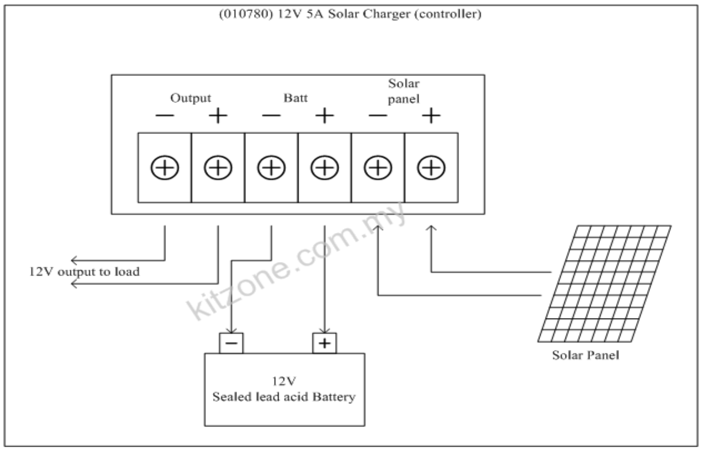


Figure 3.4: Connection of Solar Charging Circuit

The solar charger will be charging the battery automatically. Where it automatically ON when the sun rises and shut down at night and it charging cut-off at 14.7V and recharge when battery falls below 14.6V.[5]

Figure 3.5: Solar Charging Circuit

3.2.4 Soil Moisture Sensor

I use Soil moisture sensors to measure the water content in soil. This soil moisture sensor is low cost sensor probes, low cost irrigation systems and solutions and is sensitive and accurate enough to be used in research grade instrumentation.

Figure 3.6: Vegetronix Moisture Sensor Probe

3.2.5 PIC 18F4550 Microcontroller

In this project, I used PIC18F4550 that is because PIC18F4550 is an ideal for low power (nanoWatt) and connectivity applications that benefit from the availability of three serial ports: FS-USB(12Mbit/s), I²C™ and SPI™ (up to 10 Mbit/s) and an asynchronous (LIN capable) serial port (EUSART). It has Large amounts of RAM memory for buffering and Enhanced Flash program memory make it ideal for embedded control and monitoring applications that require periodic connection with a (legacy free) personal computer via USB for data upload/download and/or firmware updates. [6]

Figure 3.7: PIC18F4550

This PIC contains 40-pin with 16K of code space, 10-bit A/D converters, 34 I/O pins, full speed USB module, 48MHz operation, and many other features. This features are very useful for my project where in my project, I used many analogue input and output port. This PIC became a best choice for us due to their low cost, wide availability, large user base, extensive collection of application notes, availability of low cost or free development tools, and serial programming (and re-programming with flash memory) capability.[6]

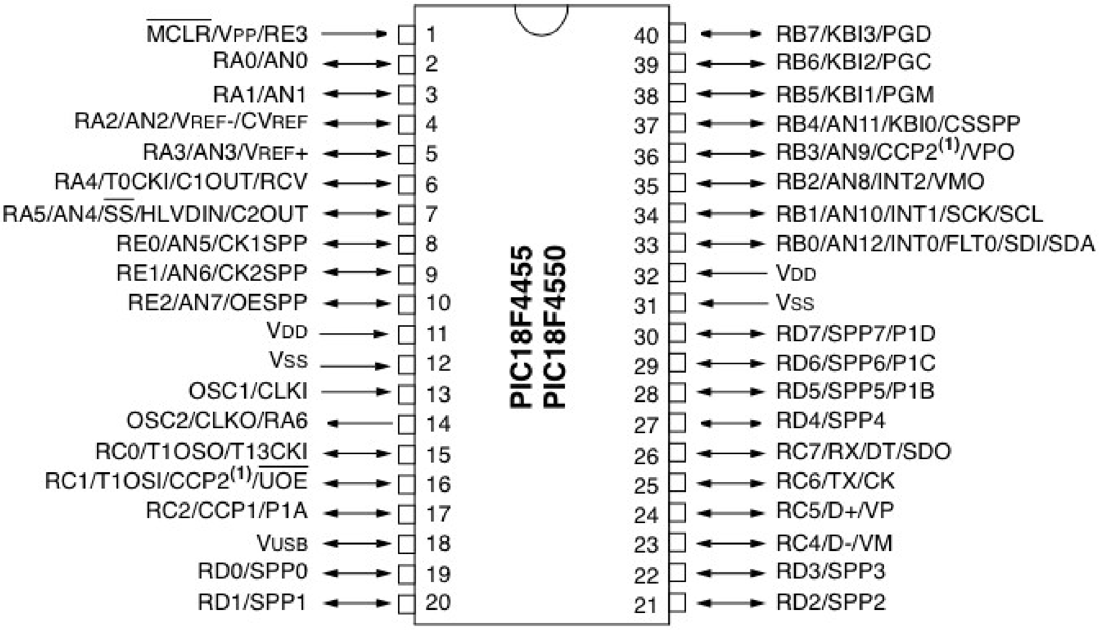


Figure 3.8: PIC18F4550 I/O Ports

3.2.5.1 nanoWatt TECHNOLOGY

All of the devices in the PIC18F4550 family incorporate a range of features that can significantly reduce power consumption during operation. Key items include:

- **Alternate Run Modes:** By clocking the controller from the Timer1 source or the internal oscillator block, power consumption during code execution can be reduced by as much as 90%.

- **Multiple Idle Modes:** The controller can also run with its CPU core disabled but the peripherals still active. In these states, power consumption can be reduced even further, to as little as 4% of normal operation requirements.

- **On-the-fly Mode Switching:** The power-managed modes are invoked by user code during operation, allowing the user to incorporate power-saving ideas into their application's software design.

- **Low Consumption in Key Modules:** The power requirements for both Timer1 and the Watchdog Timer are minimized.

3.2.5.2 Universal Serial Bus (USB)

Devices in the PIC18F2455/2550/4455/4550 family incorporate a fully featured Universal Serial Bus communications module that is compliant with the USB Specification Revision 2.0. The module supports both low-speed and full speed communication for all supported data transfer types. It also incorporates its own on-chip transceiver and 3.3V regulator and supports the use of external transceivers and voltage regulators.[6]

3.2.6 LDR - Light Dependent Resistor

A light sensor is the most common electronic component which can be easily found. The simplest optical sensor is a photo resistor or photocell which is a light sensitive resistor these are made of two types, cadmium sulfide (CdS) and gallium arsenide (GaAs) [4], The sun tracker system designed here uses the cadmium sulfide (CdS) photocell for sensing the light. This photocell is a passive component whose resistance is inversely proportional to the amount of light intensity directed towards it. It is connected in series with capacitor. The photocell to be used for the tracker is based on its dark resistance and light saturation resistance. The term light saturation means that further increasing the light intensity to the CdS cells will not decrease its resistance any further. [4, 5], Figure 1 shows the dimensions of the light dependent resistor. Light intensity is measured in Lux, the illumination of sunlight is approximately 30,000 lux, Figure 1 shows how a typical light dependent resistor behaves in terms of its resistance with changes to light intensity. From the graph shown in figure 2 it can be clearly seen that the resistance of the LDR is inversely proportional to the light intensity that as the light intensity increases the resistance of the LDR decreases [5].

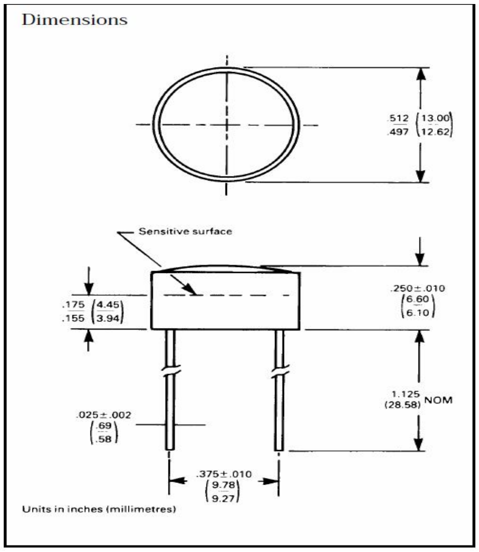


Figure 3.9: Dimension of LDR

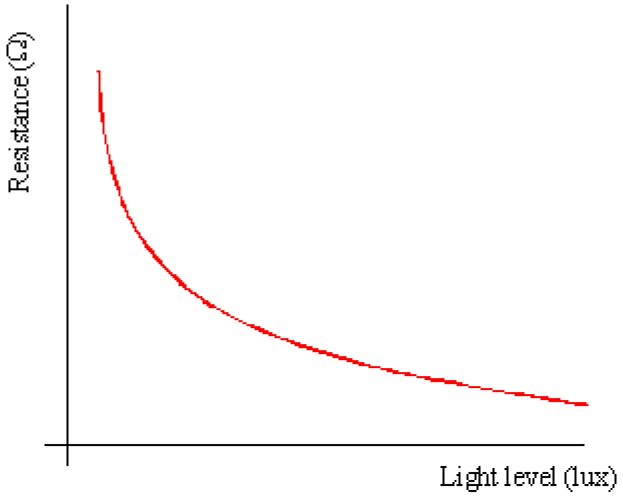


Figure 3.10: LDR Characteristic

An LDR is a Light Dependent Resistor and its resistance varies with the amount of light falling on it. Resistance becomes lower as the light falling on the LDR increases. When the amount of light decreases the resistance of the LDR increases. In this project, I used four LDR as an input for the two motors. LDR1 and LDR2 will be control the motor1 whereas LDR3 and LDR4 will be control motor2. Motor will moving until both LDR received same voltage or light falling on it. Why I used LDR in my project but not a Phototransistor because LDR is low cost component, easy to find and easy to implement to the circuit.

3.2.7 Voltage Regulator

Voltage Regulator is a small device or circuit that regulates the voltage fed to the microprocessor. The power supply of most PCs generates power at 5 volts but most microprocessors require a voltage below 3.5 volts. The voltage regulator's job is to reduce the 5 volt signal to the lower voltage required by the microprocessor. Typically, voltage regulators are surrounded by heat sinks because they generate significant heat.

Voltage Regulator (regulator), usually having three legs, converts varying input voltage and produces a constant regulated output voltage. They are available in a variety of outputs.

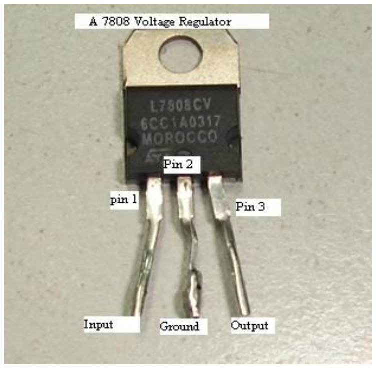


Figure 3.11: Voltage Regulator

3.2.8 Power Window Motor

There are 2 power window motor will be used in this project. This power windows used to moving the solar panel in 2-axis. I choose this type of motor because power window has more power to carry a heavy load like solar panel. Other than that, the movement of power window quite slow and it is good for my project because my sun tracker need the slow movement to follow the sun. The voltage that needed for power window also small, it is only 12V.

Figure 3.12: Power Window Motor

3.3 Software Development

3.3.1 Proteus 7 Professional

Proteus 7 Professional are used to simulated the circuit before we apply it on the circuit board. It is very wonderful software because it is software for microprocessor simulation, schematic capture, and printed circuit board (PCB) design. Other than that, it produce animation where it easy to me see the simulation or result for my project and easy to program the PIC in the simulation circuit.

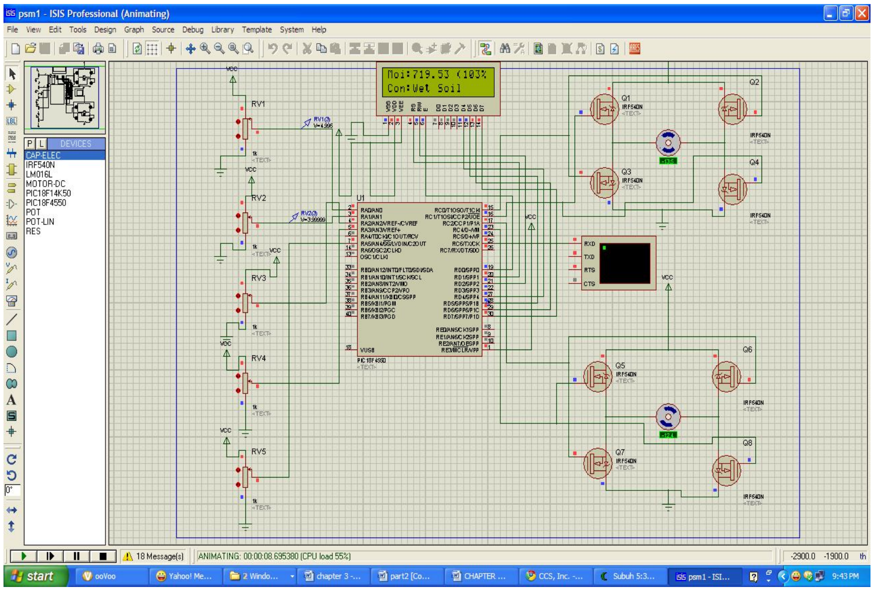


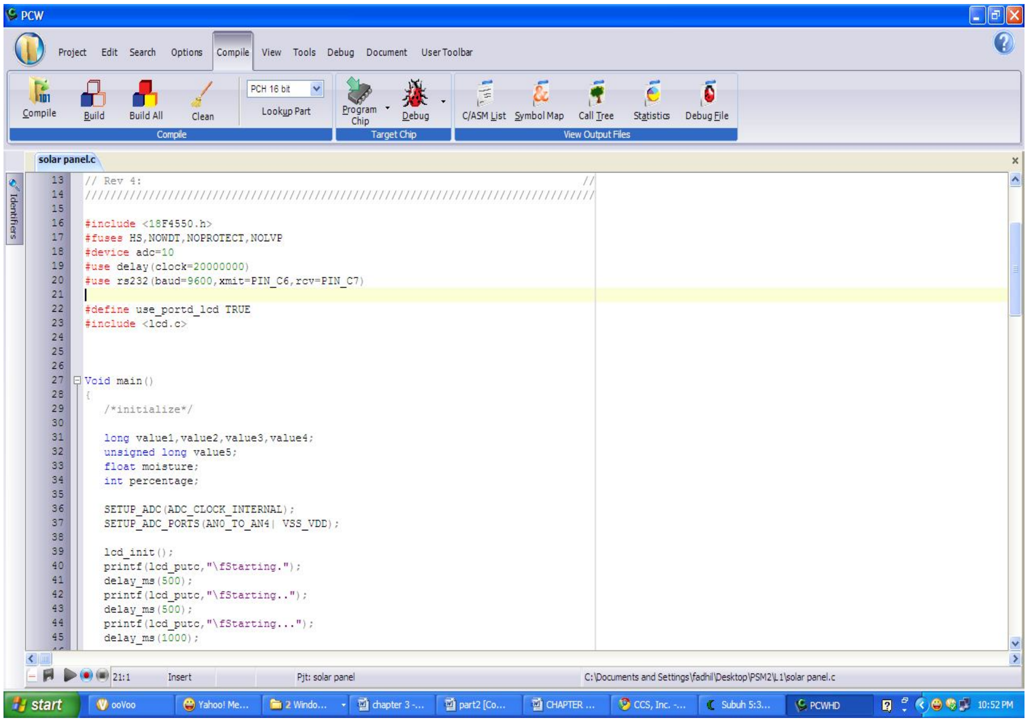
Figure 3.13 : Proteus 7 Professional

3.3.2 PIC-C Compiler

PIC-C Compiler is a computer program (or set of programs) that transforms source code written in a computer language (the source language) into another computer language (the target language, often having a binary form known as object code). The most common reason for wanting to transform source code is to create an executable program.

It's provides a complete integrated tool suite for developing and debugging embedded applications running on Microchip PIC® MCUs and dsPIC® DSCs. The heart of this development tools suite is the CCS intelligent code optimizing C compiler which frees developers to concentrate on design functionality instead of having to become an MCU architecture expert. [8]

- Maximize code reuse by easily porting from one MCU to another. Device Support
- Minimize lines of new code with CCS provided peripheral drivers, built-in functions andstandard C operators
- Built-in functions are specific to PIC® MCU registers, allowing access to hardware features directly from C



```c
// Rev 4:                                                                     //
////////////////////////////////////////////////////////////////////////////////

#include <18F4550.h>
#fuses HS,NOWDT,NOPROTECT,NOLVP
#device adc=10
#use delay(clock=20000000)
#use rs232(baud=9600,xmit=PIN_C6,rcv=PIN_C7)

#define use_portd_lcd TRUE
#include <lcd.c>



Void main()
{
   /*initialize*/

   long value1,value2,value3,value4;
   unsigned long value5;
   float moisture;
   int percentage;

   SETUP_ADC(ADC_CLOCK_INTERNAL);
   SETUP_ADC_PORTS(AN0_TO_AN4| VSS_VDD);

   lcd_init();
   printf(lcd_putc,"\fStarting.");
   delay_ms(500);
   printf(lcd_putc,"\fStarting..");
   delay_ms(500);
   printf(lcd_putc,"\fStarting...");
   delay_ms(1000);
```

Figure 3.14: PIC-C Compiler

3.3.3 Program Development

For this project, I used C-Language to write my project coding. I used C-language because it is easy to write and easy to understand. Here is some coding from my project.

```
SETUP_ADC(ADC_CLOCK_INTERNAL);
SETUP_ADC_PORTS(AN0_TO_AN4| VSS_VDD);
                              :
                              :
                              :
```

```
set_adc_channel(0);
value1=read_adc();
delay_ms(500);

set_adc_channel(1);
value2=READ_ADC();
delay_ms(500);

set_adc_channel(2);
value3=READ_ADC();
delay_ms(500);

set_adc_channel(3);
value4=READ_ADC();
delay_ms(500);

set_adc_channel(4);
value5=Read_ADC();
moisture=(float)value5/0x400*100;
percentage=moisture;
```

Coding above is about how to initialize the analog input by using ADC function because the PIC can’t the read the analog input but it can only read digital input (0 or 1).

```
if (value1>value2)
{
  output_high(PIN_C0);
  output_low(PIN_C1);
}
else
{
  output_high(PIN_C1);
  output_low(PIN_C0);
}



if (value1==value2)
{
  output_low(PIN_C0);
  output_low(PIN_C1);
}

delay_ms(200);

if (value3>value4)
{
  output_high(PIN_C2);
  output_low(PIN_C4);
}
```

```
 else

 {

   output_high(PIN_C4);

   output_low(PIN_C2);

 }


 if (value3==value4)

 {

   output_high(PIN_C2);

   output_high(PIN_C4);

 }

 delay_ms(200);
```

Coding above is shows how to control the output (motor) from the analog input. Value1 until value4 is a analog input(LDR). Output_high means the output port is logic1 (5V) and output_low means the output port is logic 0 (0V).

```
if (moisture>79)

{

  printf(lcd_putc,"\fMoi:%f (%i%%) \nCon:Wet Soil",moisture,percentage);

}

else if (moisture>59)

{

  printf(lcd_putc,"\fMoi:%f (%i%%) \nCon:Balence Soil",moisture,percentage);

}

else if (moisture>5)

{

  printf(lcd_putc,"\fMoi:%f (%i%%) \nCon:Dry Soil",moisture,percentage);

}

else if (moisture<5)

{

  printf(lcd_putc,"\fMoi:%f (%i%%) \nCon:",moisture,percentage);

}

delay_ms(100);

}
```

Lastly is coding for LCD. Like the coding shows above, the coding for LCD is very simple. We must add the input of the LCD where this input must be initialize first. To display on LCD, we just write printf(lcd_putc, and follow with the word that we want to display.

CHAPTER 4

RESULT AND DISCUSSION

4.1 Introduction

This chapter is focused on the comparison between the fixed solar panel and 2-axis solar tracking. It shows on the effect of solar tracker in producing maximum output and achieve the objectives of 2-axis solar tracker. In this chapter, its including the hardware implementation and how this hardware produce a result. Besides comparison between fixed solar panel and 2-axis solar tracking, this chapter also shows the result of soil moisture detector, where this soil moisture detector only the application of the 2-axis solar tracking system.

4.2 Complete Hardware

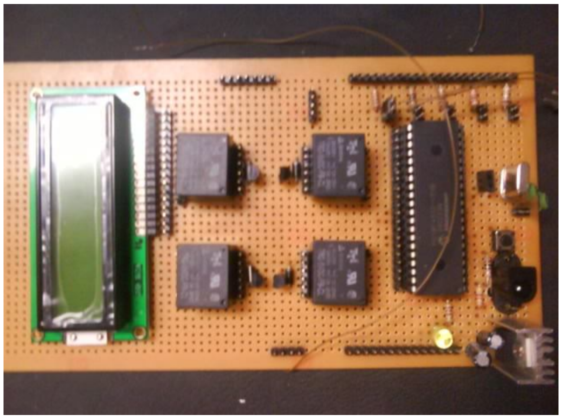


Figure 4.1 Complete Circuit

The figure above show the complete circuit of the system. Figure 4.1 shows the hardware of the DC motor controller circuit and sensor circuit.

4.3 The Implementation of Hardware To Solar Tracker

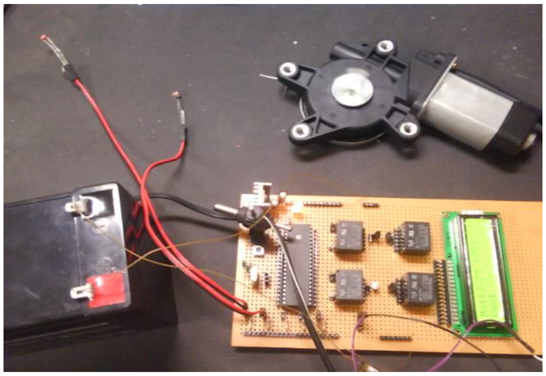


Figure 4.2 Implemented Hardware

Figure 4.2 above shows the circuit being implemented as hardware to the 2-axis solar tracker. The power window motor used to move the solar panel and the solar panel will charge the 12V battery where this battery used as a supply to the circuit.

4.4 Construction of the solar tracker prototype

Figure 4.3 below is the model of Solar-Tracker prototype. As illustrated the solar tracker prototype accommodates both degrees of freedom: azimuth and vertical. Note that two LDR sensors module and thus two identical control circuits are implemented in both degrees of freedom. The two photocells will be positioned on a small straight piece of wood or plastic. Another piece will be mounted perpendicular to the straight piece, thereby dividing both the sensors. The concept is that if both the photocells are equally illuminated by the sun, their resistance level will be the same. As long as the resistance is the same with an error margin of ±10 points, the PIC will analyze this data and thus will not generate any signal to actuate the motor. Whereas in the case if one of the sensors comes under a shadow, then the PIC will detect this change and thus it will actuate the motor to move the sensor module to a position where equal light is being illuminated on both of them. The PIC is programmed so that it can obtain its resistance data from the two LDRs and to move motor either clock wise or anti clock wise depending on which LDR is under shadow.

Figure 4.3: Solar Tracker Prototype

4.5 The System Can Produce Maximum Voltage Output

From the table 4.0 below, the 2-axis solar tracker produce more output then fixed solar panel. The voltage are measure every one hour from 7.30a.m until 6.30p.m. That is from the sun rise until the sun set.

Table 4.0 Comparison between 2-axis tracker and fixed panel

Time	2-axis Solar Tracker Voltage(V)	Fixed Solar Panel Voltage(V)
7.30a.m	7.5	5.5
8.30a.m	8.0	6.7
9.30a.m	9.2	7.5
10.30a.m	10.1	8.4
11.30a.m	11.5	10.2
12.30p.m	12.0	12.0
1.30p.m	12.0	11.8
2.30p.m	12.0	11.2
3.30p.m	11.8	10.8
4.30p.m	10.5	8.2
5.30p.m	9.2	7.3
6.30p.m	8.3	5.8

The table proves that 2-axis solar tracker produce more output voltage than fixed solar panel. 2-axis solar tracker will always make sure that solar panel has maximum concentrated sunlight. Hence, the voltage output is much higher than fixed solar panel and it shows that solar tracker is more reliable than fixed solar panel. The 2-axis solar tracker has low output voltage in the morning and evening because of the low capacity of sunlight from the sun. But it has maximum concentrated sunlight around 12p.m to 2p.m because of high capacity of sunlight.

4.6 Solar tracker verification and testing

The first step in testing the solar tracker design is to verify whether the LDRs are working properly. The light intensity directed onto the LDR increases, its resistance therefore decreases. The next step is to use the digital oscilloscope in order to test the signals generated by the LDR and then sent to the PIC. Oscilloscope is a digital graph displaying device; it draws a graph of an electrical signal. In most applications, the graph shows how signals change over time [7].

Figure 4.4 shows the result when one of the Two LDRs is covered. Channel 1 and 2 represent the RA0 and RA1 on the PIC respectively. The signal represented by channel 1 illustrates that LRD1 is under shadow. The signal shown in the figure is sent to the motor drive from the PIC18F4550. The motor is therefore actuated, and it runs until the resistance on both LDRs is the same.

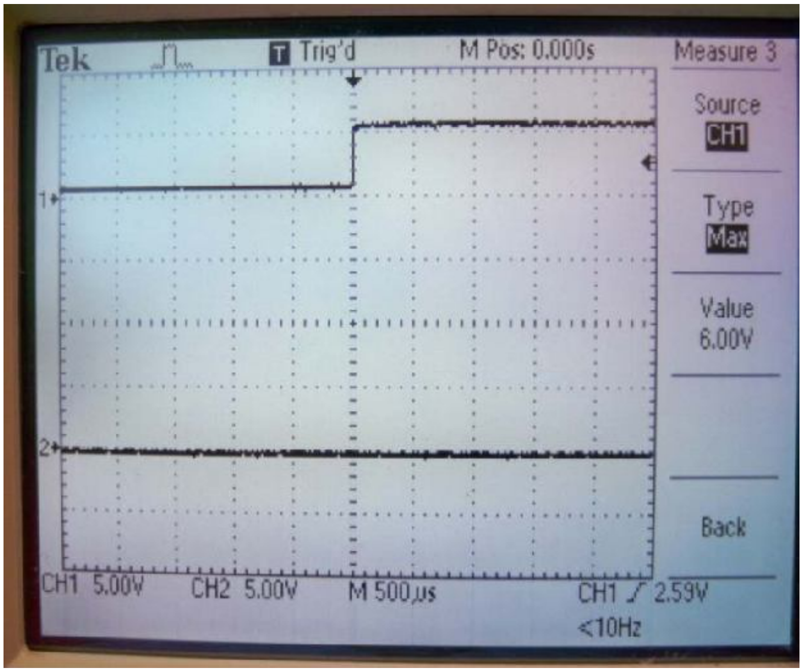


Figure 4.4: Signal generated when one LDR is under shadow

Figure 4.5 illustrates the result when both the LDRs are covered. The signal is sent to PIC18F4550 to be analyzed. In this case PIC does not send any signal to the motor drive as the resistance value on both LDRs is the same.

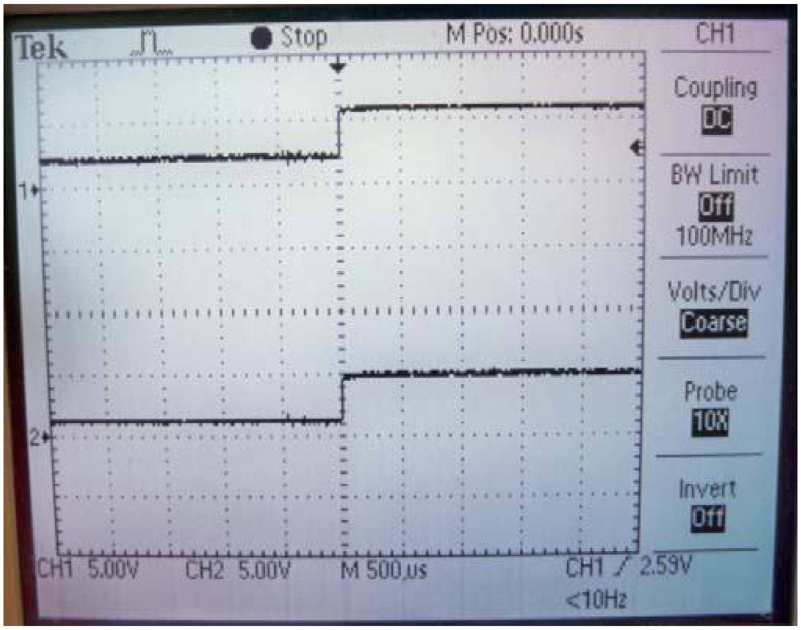


Figure 4.5: Signal generated when both LDRs are under shadow

4.7 Soil Moisture Detector Results

For soil moisture detector, it will detect the percentage of soil moisture by using soil moisture sensor and display it on the LCD. It is just an application of solar tracker and to show that 2-axis solar tracker can charge the battery maximally. If the battery can't received a maximum voltage, this soil moisture application cannot run very well.

The figures during testing the soil moisture on the hardware are shown below:-

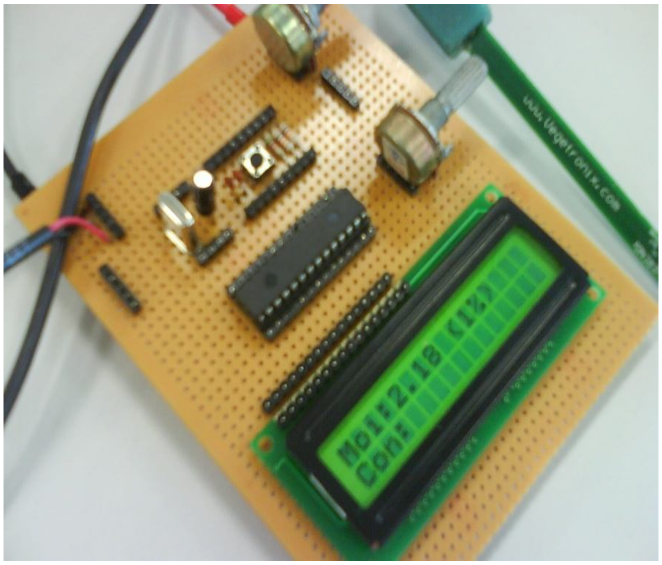
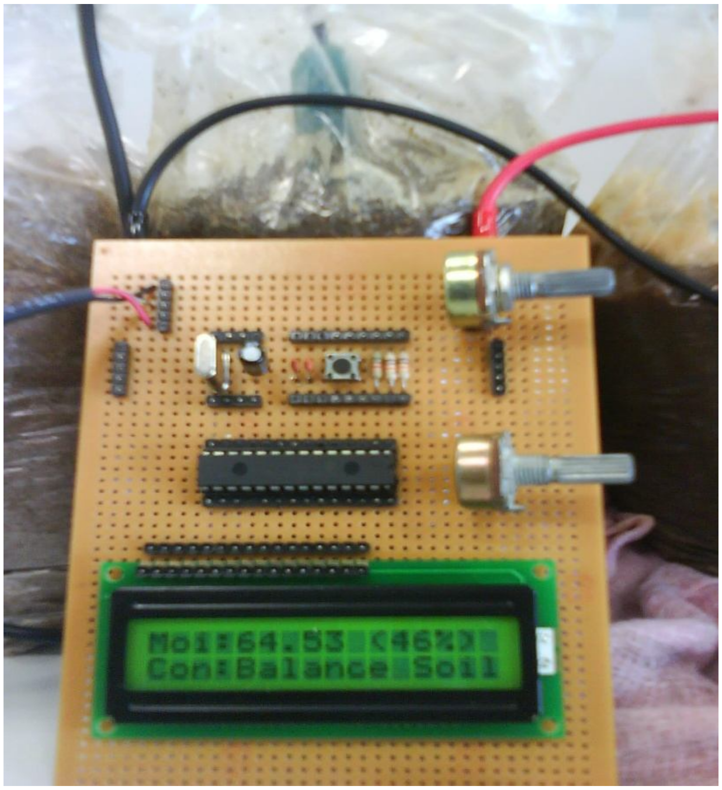


Figure 4.6: Value on LCD screen when tested no soil

The figure 4.6 shows the result of the soil condition on LCD when the sensor is not tested in any soil.

Figure 4.7: Value on LCD screen when tested with dry soil

The figure 4.7 shows the result of the soil moisture and the soil condition on LCD when the sensor is tested in dry soil.



```
Moi:64.53 (46%)
Con:Balance Soil
```

Figure 4.8: Value on LCD screen when tested with balanced soil

The figure 4.8 shows the result of the soil moisture and the soil condition on LCD when the sensor is tested in balanced soil.

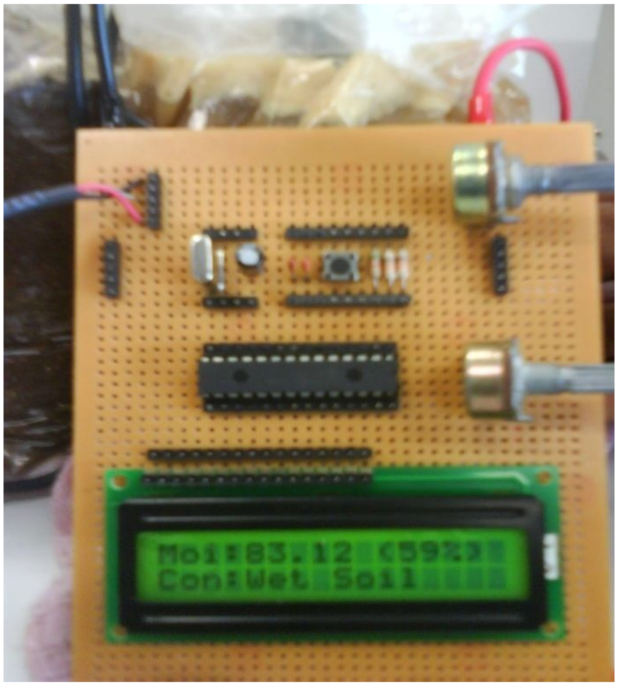


Figure 4.9: Value on LCD screen when tested with wet soil

The figure 4.9 shows the result of the soil moisture and the soil condition on LCD when the sensor is tested in wet soil.

The stimulation figures during testing the soil moisture on the software are shown below:-

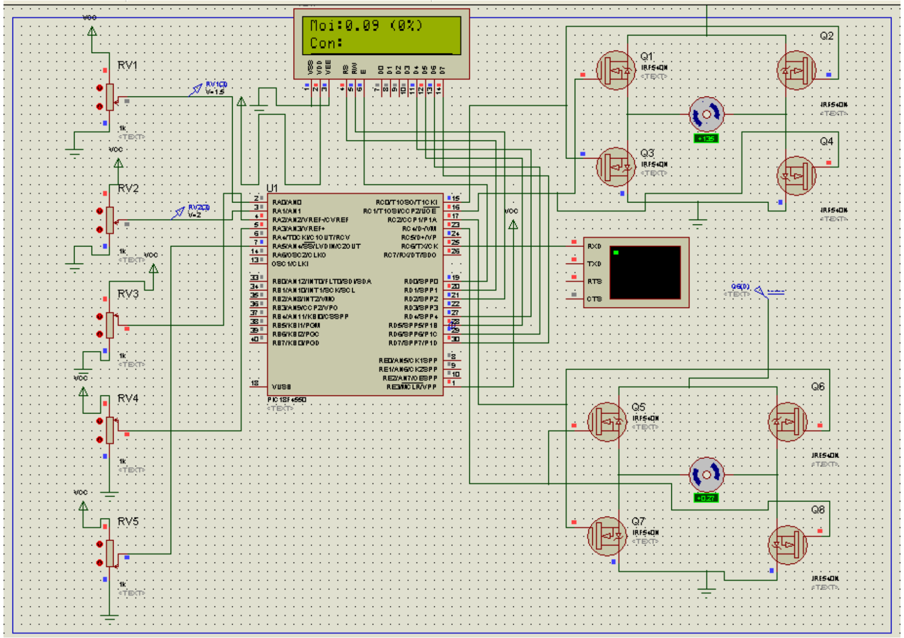


Figure 4.10: Value on LCD screen after simulation (no soil)

The figure 4.10 shows the result of the soil condition on LCD when the sensor is not tested in any soil.

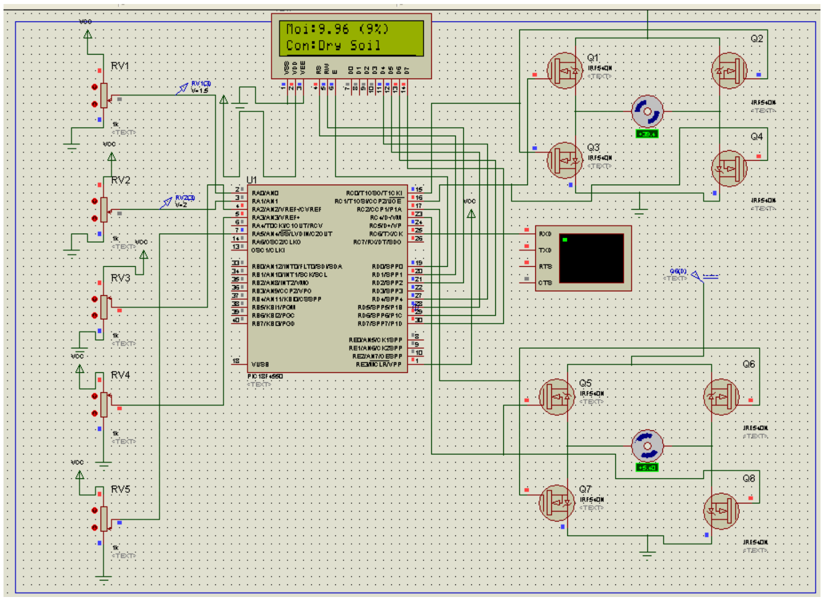


Figure 4.11: Value on LCD screen after simulation (dry soil)

The figure 4.11 shows the result of the soil moisture and the soil condition on LCD when the sensor is tested in dry soil.

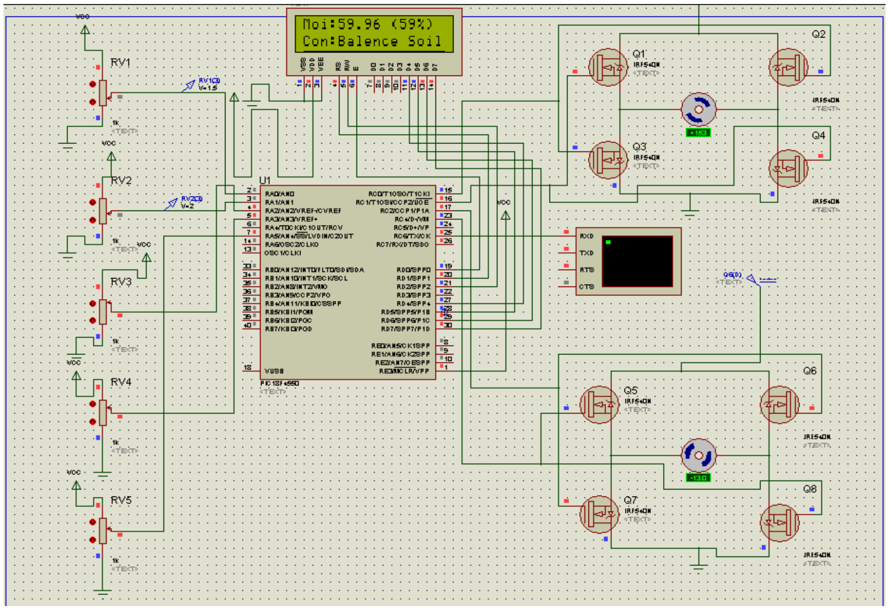


Figure 4.12: Value on LCD screen after simulation (balanced soil)

The figure 4.12 shows the result of the soil moisture and the soil condition on LCD when the sensor is tested in balanced soil.

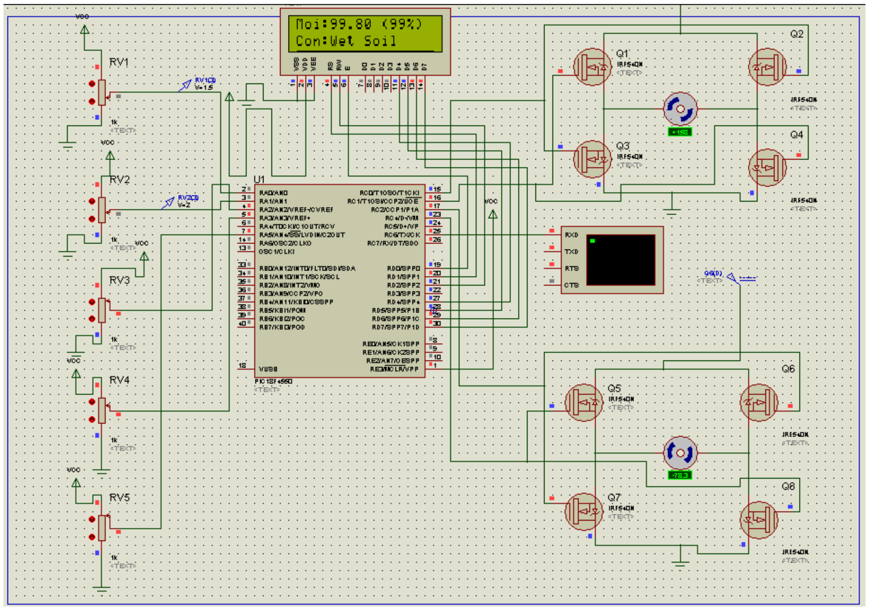


Figure 4.13: Value on LCD screen after simulation (wet soil)

The figure 4.13 shows the result of the soil moisture and the soil condition on LCD when the sensor is tested in wet soil.

Table 4.1: Results of soil moisture on different soil condition

Tested soil type	Measured soil moisture value (range)	Soil condition displayed on LCD	Percentage of soil moisture (%)
No condition	(<5)	-	0 - 2
Dry	(≥5,<59)	Dry soil	2 - 29
Balance	(≥59,<79)	Balance soil	30 - 39
Wet	(≥79,<200)	Wet soil	40 - 100

CHAPTER 5

CONCLUSION

5.1 Conclusion

From this project, it has been proven that by using 2-axis solar tracking system it can increase the voltage output by more than 40%, whereas the tracking system with single axis freedom can increase the output by approximately 20%. Therefore this project will be implementing by using four LDR as a sensor to make sure the solar panel received the maximum voltage. All of the LDR will be programmed by PIC18F4550 where LDR1 and LDR2 must be get same voltage all the time and it similarly with LDR3 and LDR4. All this 4 input will be controlled the movement of two power window motor where it is act as an output.

After many setbacks in testing of the solar tracker, a lot of time was needed to be set aside for verification and testing due to the unpredictability of the weather and debugging of errors. The tracking implementation is successfully achieved with complete design of two degree of freedom using the PIC microcontroller. Suitable components and gear dc motors are used for the prototype model, which exhibit a clear, stable and precise movement to face the sun.

5.2 Future Recommendation

From the beginning this project focuses to developed solar tracking system from single axis to double axis system. This idea is to produce a maximum voltage where this voltage can be used to many applications. This project can be used for multipurpose in much application not only for soil moisture detector especially in 4 season’s countries. This 2-axis solar panel can produce maximum voltage or power aside can save our cost effectively.

REFFERENCE

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[2] http://en.academic.ru/dic.nsf/enwiki/2056385

[3] David Panico , Paul Garviron, Howard Wenger & Daniel Shugar (1991). Backtracking: A novel strategy for tracking PV systems. Photovoltaic Specialists Conference, 1991. 668 - 673 vol.1.

[4] Douglas M. Allen, P. Alan Jones and David M. Murphy & Micheal F. Piszczor (1996). The SCARLET Light Concentrating Solar Array. Photovoltaic Specialists Conference, 1996. 353 – 356.

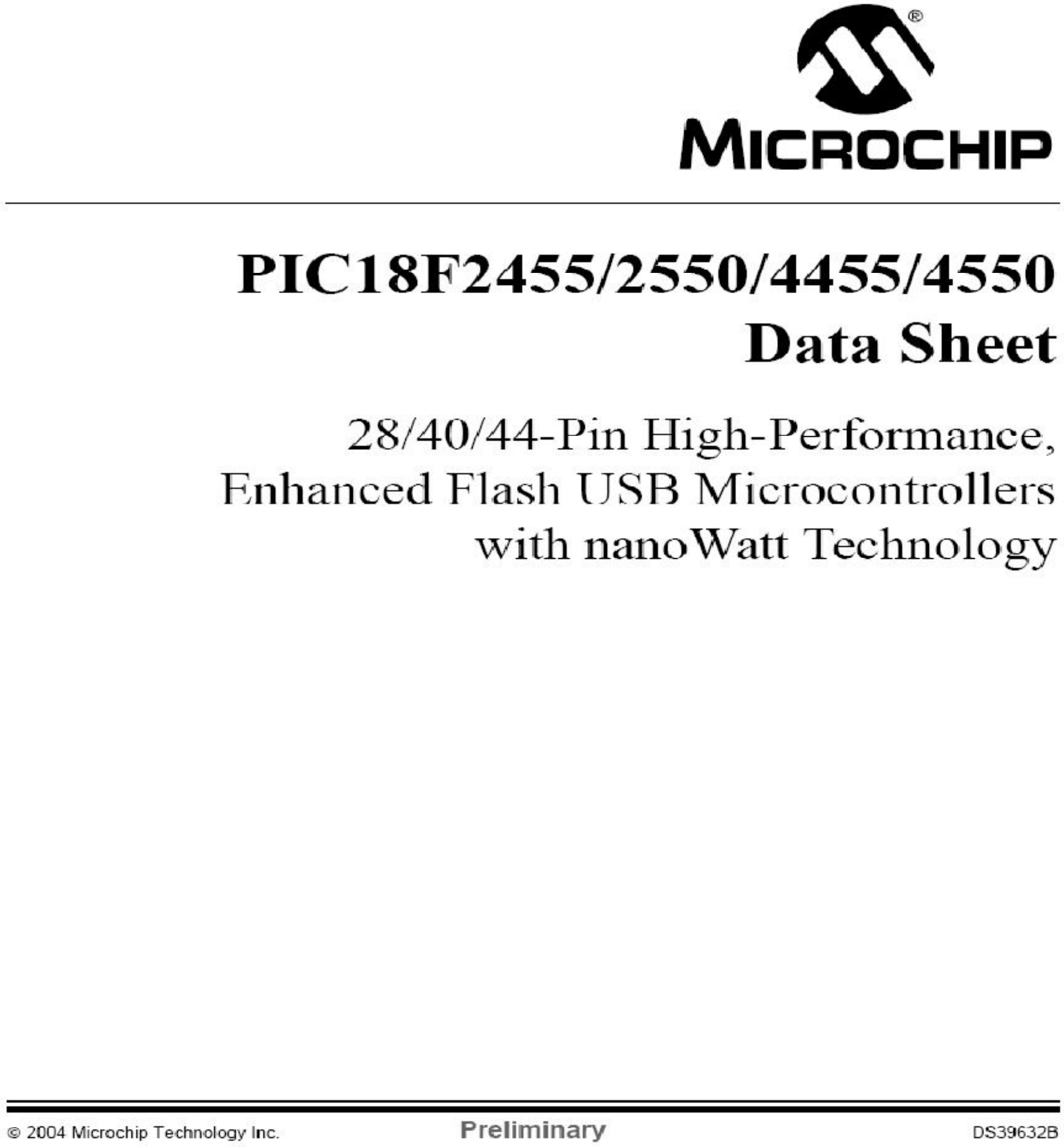
[5] Iovine, John. (2000). PIC Microcontroller Project Book, 1st edition. Ch. 3, pg 35. McGraw-Hill.

[6] Microchip Technology Incorporated (2001). PIC18F4550, 18-pin Enhanced FLASH/EEPROM 8-Bit Microcontroller, PIC16F84A Data Sheet

[7] Wilmshurst, Tim. (2007). Designing Embedded Systems with PIC Microcontrollers, Ch.2, pg25-30, Elsevier

[8] Custom Computer Services(CCS). (2010). CCS C Compiler. Retrieved August 21,2010, from http://www.ccsinfo.com/content.php?page=compilers

APPENDIX A

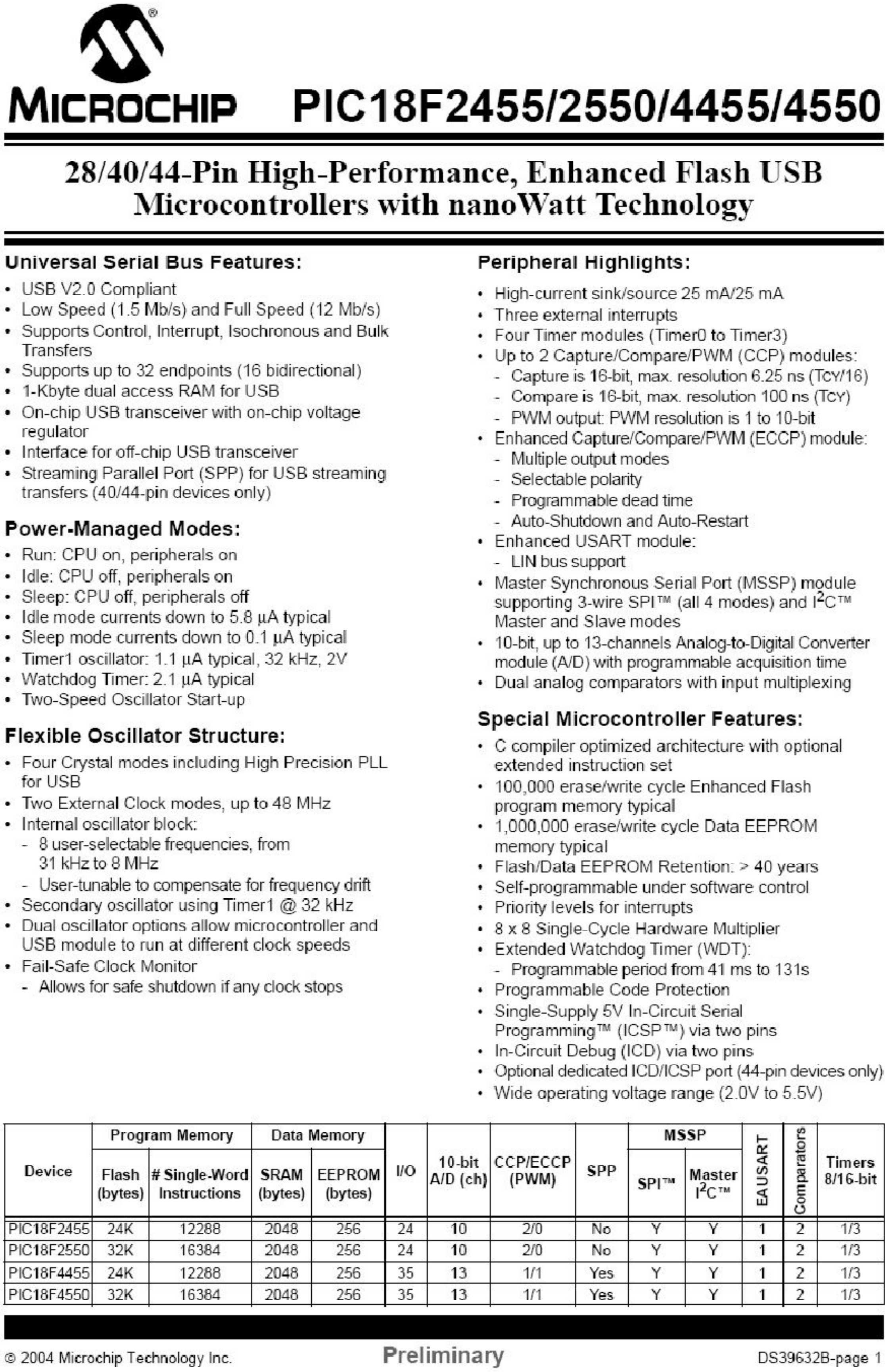


MICROCHIP

PIC18F2455/2550/4455/4550 Data Sheet

28/40/44-Pin High-Performance, Enhanced Flash USB Microcontrollers with nanoWatt Technology

Preliminary DS39632B



MICROCHIP PIC18F2455/2550/4455/4550

28/40/44-Pin High-Performance, Enhanced Flash USB Microcontrollers with nanoWatt Technology

Universal Serial Bus Features:

- USB V2.0 Compliant
- Low Speed (1.5 Mb/s) and Full Speed (12 Mb/s)
- Supports Control, Interrupt, Isochronous and Bulk Transfers
- Supports up to 32 endpoints (16 bidirectional)
- 1-Kbyte dual access RAM for USB
- On-chip USB transceiver with on-chip voltage regulator
- Interface for off-chip USB transceiver
- Streaming Parallel Port (SPP) for USB streaming transfers (40/44-pin devices only)

Power-Managed Modes:

- Run: CPU on, peripherals on
- Idle: CPU off, peripherals on
- Sleep: CPU off, peripherals off
- Idle mode currents down to 5.8 µA typical
- Sleep mode currents down to 0.1 µA typical
- Timer1 oscillator: 1.1 µA typical, 32 kHz, 2V
- Watchdog Timer: 2.1 µA typical
- Two-Speed Oscillator Start-up

Flexible Oscillator Structure:

- Four Crystal modes including High Precision PLL for USB
- Two External Clock modes, up to 48 MHz
- Internal oscillator block:
  - 8 user-selectable frequencies, from 31 kHz to 8 MHz
  - User-tunable to compensate for frequency drift
- Secondary oscillator using Timer1 @ 32 kHz
- Dual oscillator options allow microcontroller and USB module to run at different clock speeds
- Fail-Safe Clock Monitor
  - Allows for safe shutdown if any clock stops

Peripheral Highlights:

- High-current sink/source 25 mA/25 mA
- Three external interrupts
- Four Timer modules (Timer0 to Timer3)
- Up to 2 Capture/Compare/PWM (CCP) modules:
  - Capture is 16-bit, max. resolution 6.25 ns (TCY/16)
  - Compare is 16-bit, max. resolution 100 ns (TCY)
  - PWM output: PWM resolution is 1 to 10-bit
- Enhanced Capture/Compare/PWM (ECCP) module:
  - Multiple output modes
  - Selectable polarity
  - Programmable dead time
  - Auto-Shutdown and Auto-Restart
- Enhanced USART module:
  - LIN bus support
- Master Synchronous Serial Port (MSSP) module supporting 3-wire SPI™ (all 4 modes) and I^2C™ Master and Slave modes
- 10-bit, up to 13-channels Analog-to-Digital Converter module (A/D) with programmable acquisition time
- Dual analog comparators with input multiplexing

Special Microcontroller Features:

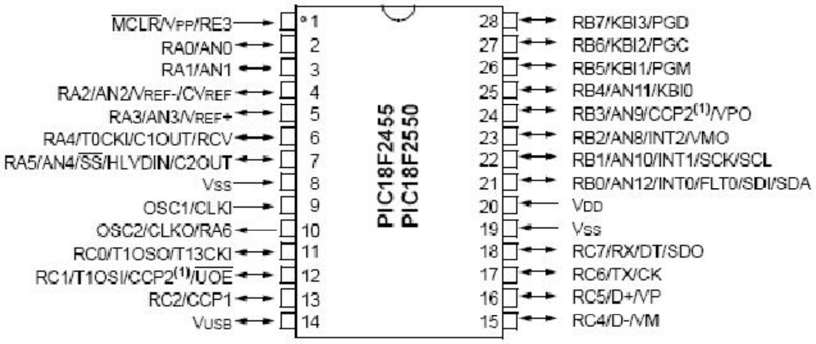
- C compiler optimized architecture with optional extended instruction set
- 100,000 erase/write cycle Enhanced Flash program memory typical
- 1,000,000 erase/write cycle Data EEPROM memory typical
- Flash/Data EEPROM Retention: > 40 years
- Self-programmable under software control
- Priority levels for interrupts
- 8 x 8 Single-Cycle Hardware Multiplier
- Extended Watchdog Timer (WDT):
  - Programmable period from 41 ms to 131s
- Programmable Code Protection
- Single-Supply 5V In-Circuit Serial Programming™ (ICSP™) via two pins
- In-Circuit Debug (ICD) via two pins
- Optional dedicated ICD/ICSP port (44-pin devices only)
- Wide operating voltage range (2.0V to 5.5V)

Device	Program Memory		Data Memory		I/O	10-bit A/D (ch)	CCP/ECCP (PWM)	SPP	MSSP		EAUSART	Comparators	Timers 8/16-bit
	Flash (bytes)	# Single-Word Instructions	SRAM (bytes)	EEPROM (bytes)					SPI™	Master I^2C™			
PIC18F2455	24K	12288	2048	256	24	10	2/0	No	Y	Y	1	2	1/3
PIC18F2550	32K	16384	2048	256	24	10	2/0	No	Y	Y	1	2	1/3
PIC18F4455	24K	12288	2048	256	35	13	1/1	Yes	Y	Y	1	2	1/3
PIC18F4550	32K	16384	2048	256	35	13	1/1	Yes	Y	Y	1	2	1/3

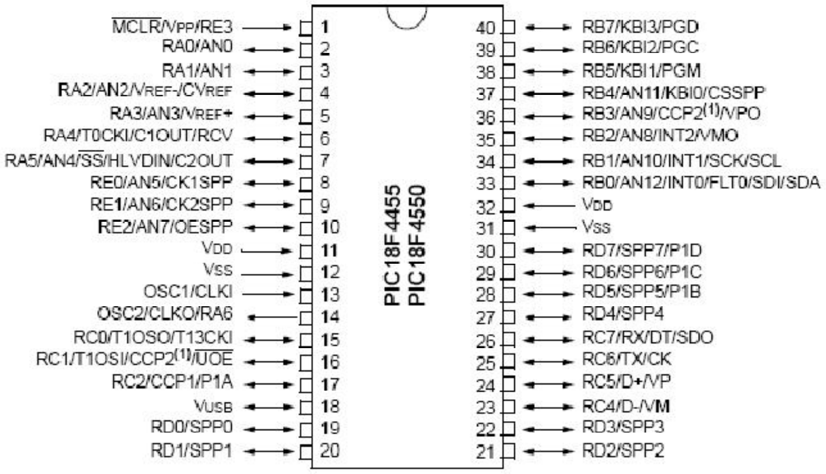
PIC18F2455/2550/4455/4550

Pin Diagrams

28-Pin PDIP, SOIC



40-Pin PDIP

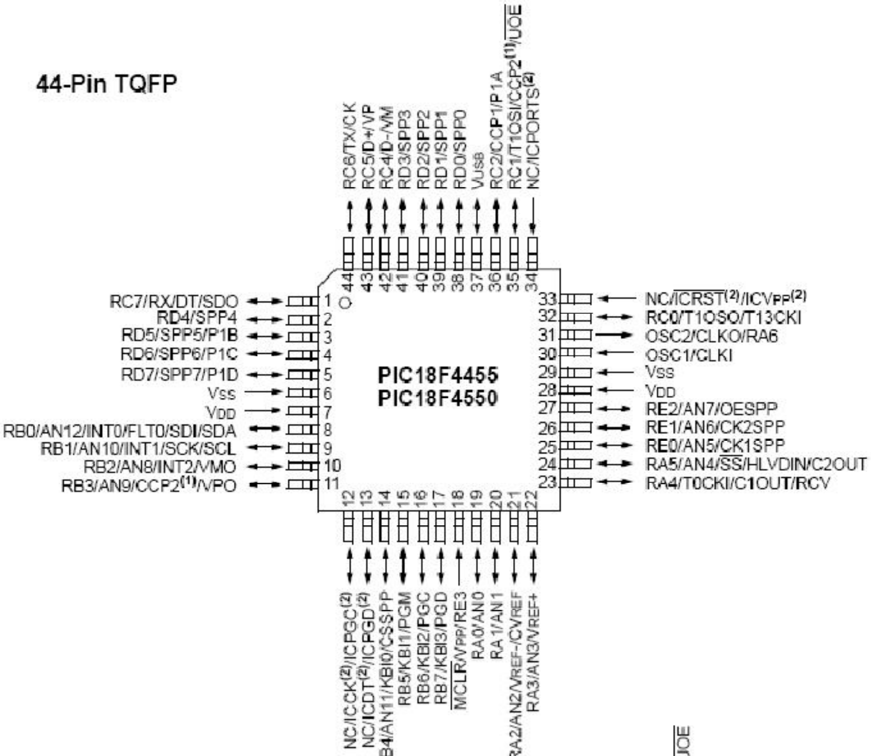


Note 1: RB3 is the alternate pin for CCP2 multiplexing.

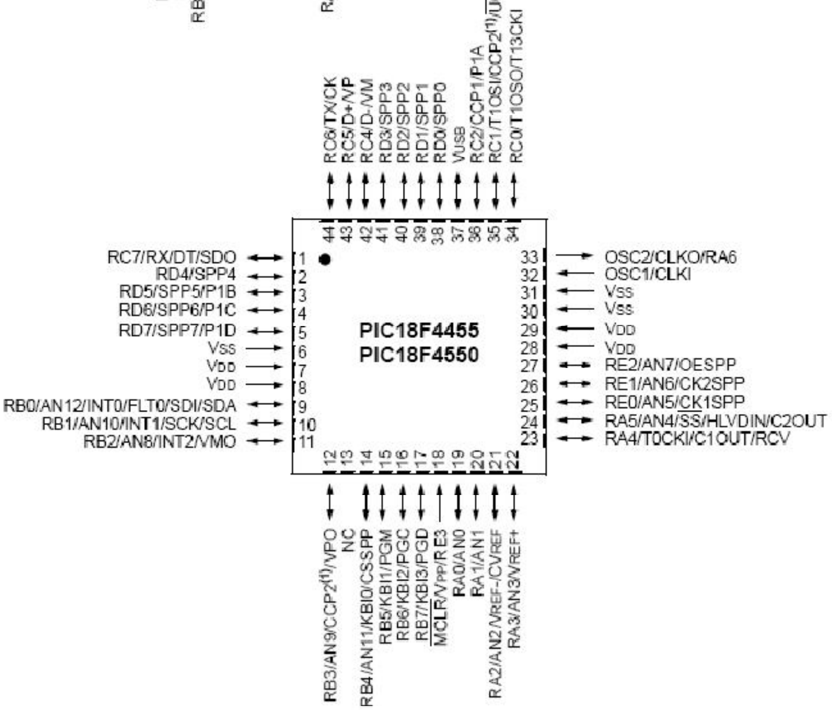
DS39632B-page 2 **Preliminary**

Pin Diagrams (Continued)

44-Pin TQFP



44-Pin QFN



Note 1: RB3 is the alternate pin for CCP2 multiplexing.

2: Special ICPORTS features available in select circumstances. See **Section 25.9 "Special ICPORT Features (Designated Packages Only)"** for more information.

APPENDIX B

SGS-THOMSON
MICROELECTRONICS

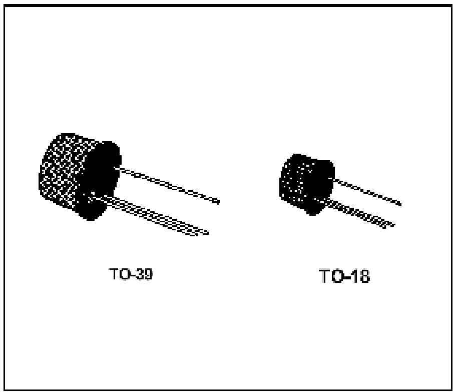
2N2218-2N2219
2N2221-2N2222

HIGH-SPEED SWITCHES

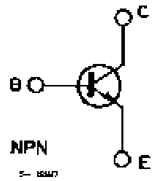
DESCRIPTION

The 2N2218, 2N2219, 2N2221 and 2N2222 are silicon planar epitaxial NPN transistors in Jedec TO-39 (for 2N2218 and 2N2219) and in Jedec TO-18 (for 2N2221 and 2N2222) metal cases. They are designed for high-speed switching applications at collector currents up to 500 mA, and feature useful current gain over a wide range of collector current, low leakage currents and low saturation voltages.

- 2N2218/2N2219 approved to CECC 50002-100, 2N2221/2N2222 approved to CECC 50002-101 available on request.



INTERNAL SCHEMATIC DIAGRAM

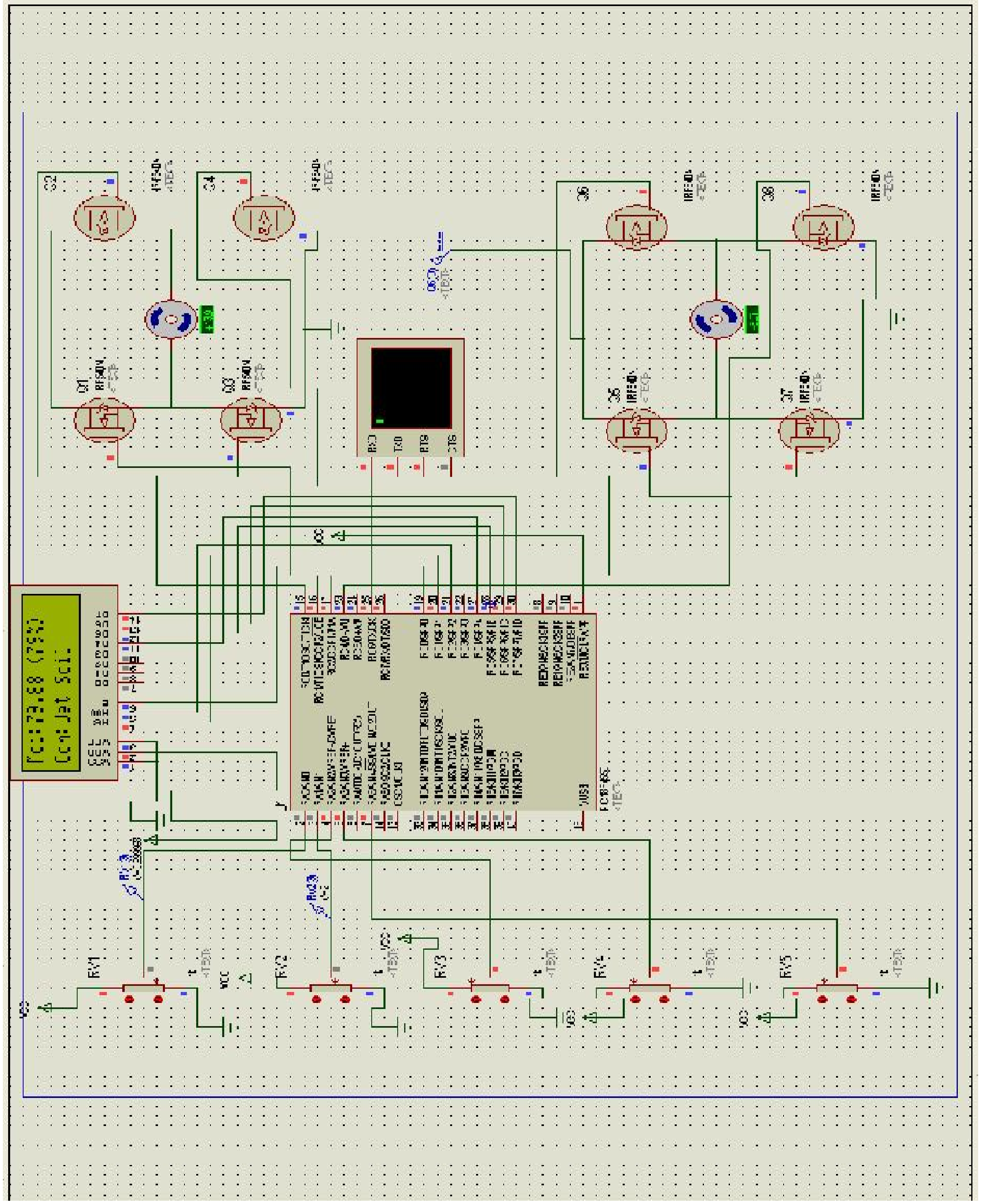


ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_{CBO}	Collector-base Voltage ($I_E = 0$)	60	V
V_{CEO}	Collector-emitter Voltage ($I_B = 0$)	30	V
V_{EBO}	Emitter-base Voltage ($I_C = 0$)	5	V
I_C	Collector Current	0.8	A
P_{tot}	Total Power Dissipation at $T_{amb} \le 25$ °C		
	for **2N2218** and **2N2219**	0.8	W
	for **2N2221** and **2N2222**	0.5	W
	at $T_{case} \le 25$ °C		
	for **2N2218** and **2N2219**	3	W
	for **2N2221** and **2N2222**	1.8	W
T_{stg}	Storage Temperature	– 65 to 200	°C
T_j	Junction Temperature	175	°C

APPENDIX C

Simulation Circuit



being used increasingly as efficiencies reach higher levels, and are especially popular in remote areas where placement of electricity lines is not economically viable.

A solar collector or photo-voltaic module receives the maximum solar-radiation when the Sun rays strike it at right angles. Tilting it from being perpendicular to the Sun will result in less solar energy collection by the collector or the module. Therefore, the optimal tilt angle for a solar energy system depends on both the site latitude and the application for which it is to be used. With a peak laboratory efficiency of 32% and average efficiency of 15-20%[1-4], it is necessary to recover as much energy as possible from a solar power system. From this background, we see the need to maintain the maximum power output from the panel by maintaining an angle of incidence as close to 0° as possible. By tilting the solar panel to continuously face the sun, this can be achieved. This process of sensing and following the position of the sun is known as Solar Tracking. It was resolved that real-time tracking would be necessary to follow the sun effectively, so that no external data would be required in operation. The 2-axis solar panel is very efficiency used in 4 seasons countries because in 4 seasons countries the sun rise and set in different angle for every seasons.

1.3 Problem Statement

In 4 seasons countries, the sun rise and set in different angle for every seasons. So, it’s difficult to get the high voltage from the sun light when we used solar energy as our supply. If we used a fixed solar panel, it cannot received maximum voltage when solar panel collect the solar radiation and number of solar cells required on a fixed flat panel to get the higher voltage. Other than that, by using fixed solar panel, the size of such a system can be unusable requiring heavy structural frames and supports to provide adequate load carrying capabilities in view of the weight such units as well as wind and snow load.

1.4 Objective

This project aim is to developed portable dynamic solar tracking system and provides the maximum voltage from this 2 axis solar panel. It will be done by using software or programming where this programming will be control the movement of motor while LDR as the input. This maximum voltage that provide from solar panel will be charged the 12V battery through charging circuit.

For the second objective of this project, it is to measure soil moisture by using soil moisture detector system. This is only additional application of this project and it just want to see whether the solar can produce a maximum voltage for used in that application.

1.5 Scope Of Project

To developed solar panel with:-

i. Move it in 2-axis.
ii. Can get higher voltage from the sun light.

iii. It will be able charge the battery with 12V DC.

Utilize solar energy to powered soiled system and to detect soil moisture for different type of soil condition, (dry, balanced, wet).

1.6 Thesis Outline

Chapter 1 is discussing about overview on solar tracker. It explain about the problem statement, objective and scope of the project.

Chapter 2 is discussing about the literature review. It explains the development of photovoltaic technology, the history of solar cell, and overview on the tracker types. Overall, it is about the basic knowledge on solar tracker.

Chapter 3 is discussing about the methodology that involves in designing the project. There are two sections. The first section discusses about the hardware implementation and the second section discuss about software development.

Chapter 4 is discussing about the result and discussion obtain from the testing the project. The result basically on the operation of solar tracker and the prove that 2-axis solar tracker can provide maximum voltage output.

Chapter 5 is discussing about the conclusion of the project. There are future recommendations of the project and the costing and commercialization of the project.

UNIVERSITI MALAYSIA PAHANG

BORANG PENGESAHAN STATUS TESIS♦

JUDUL: DEVELOPMENT OF 2-AXIS SOLAR PANEL FOR SOIL MOISTURE DETECTOR AT 4 SEASONS COUNTRIES

SESI PENGAJIAN: **2010/2011**

Saya **MOHD FADZIL BIN MAT ISA (860816-38-5549)**
(HURUF BESAR)

mengaku membenarkan tesis (Sarjana Muda/~~Sarjana~~ /~~Doktor Falsafah~~)* ini disimpan di Perpustakaan dengan syarat-syarat kegunaan seperti berikut:

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3. Perpustakaan dibenarkan membuat salinan tesis ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. **Sila tandakan (√)

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____________________________	____________________________
(TANDATANGAN PENULIS)	(TANDATANGAN PENYELIA)

Alamat Tetap:

NO,60 KAMPUNG TUALANG TUJUH,
31300, KAMPUNG KEPAYANG,
IPOH, PERAK.

MOHD ZAMRI BIN IBRAHIM

(Nama Penyelia)

Tarikh: **29 NOVEMBER 2010**

Tarikh: : **29 NOVEMBER 2010**

CATATAN:

* Potong yang tidak berkenaan.

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Signature : ______________________________

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Date :

DEDICATION

Specially dedicated to
My beloved family, and those who have guided and inspired me
Throughout my journey of learning

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Mohd Fadzil Bin Mat Isa

ABSTRACT

Photovoltaic (PV), is a technology in which light is converted into electrical power. One of the applications of PV is in solar tracker. Commercially, single-axis and two axis tracking mechanisms are available. Usually, the single axis tracker follows the Sun’s East-West movement, while the two-axis tracker follows the Sun’s changing altitude angle. To control the two axis solar panel so that it will always face the sun, the circuit will be programmed with 4 Light Dependent Resistor (LDR) as an input and 2 motor as an output. Both motor will be moved East-West and rotate around until both pair of LDR get the same percent of sunlight. It will move along the day follow to the sun. When the solar panel face directly to the sun and has maximum concentrated sunlight to the solar panel, the maximum power output will produce. The two axis solar tracker is design as active tracker and to make sure it can be used as a power supply especially in 4 seasons countries because in 4 seasons countries the sun rise and set in different angle for every seasons. It moves according to the sun movement and controlled by microcontroller. Besides that, solar tracker used to make sure have enough demand electricity, if not more photovoltaic module is needed where it is really expensive.

ABSTRAK

Fotovolta (PV), adalah teknologi dimana cahaya ditukarkan kepada tenaga elektrik. Salah-satu daripada aplikasi PV adalah pengesan suria. Secara komersialnya, satu-paksi dan dua-paksi mekanisme pengesan boleh didapati. Biasanya pengesan satu-paksi mengikut pergerakan Timur-Barat matahari, manakala pengesan dua-paksi mengikut perubahan sudut altitude matahari. Untuk mengawal pengesan dua-paksi supaya ia akan sentiasa menghadap matahari, litar akan diprogramkan dengan 4 Perintang Bergantung Cahaya (LDR) sebagai masukan dan 2 motor sebagai keluaran. Kedua-dua motor akan bergerak Timur-Barat dan pusingan keliling sehingga kedua-dua pasang LDR mendapat peratus cahaya matahari yang sama. Ia akan bergerak sepanjang hari mengikut matahari. Apabila panel suria menghadap tepat kea rah matahari dan mempunyai penumpuan yang maksimum kepada panel suria, kuasa keluaran maksimum akan dihasilkan. Pengesan suria dua-paksi direka sebagai pengesan aktif dan untuk memastikan ianya boleh digunakan sebagai bekalan kuasa terutamanya di Negara 4 musim kerana di Negara 4 musim matahari terbit dan terbenam pada paksi yang berbeza setiap musim. Ianya bergerak berdasarkan pergerakan matahari dan dikawal oleh pengawal mikro. Selain itu, pengesan suria digunakan untuk memastikan mempunyai permintaan elektrik yang cukup, jika tidak lebih banyak modul fotovolta diperlukan dimana ianya terlalu mahal.

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