SOLAR TRACKING SYSTEM

NUR KHUZAIRY BIN JAMALUDIN

This thesis is submitted as partial fulfillment of the requirement for the Award of the Bachelor Degree of Electrical Engineering (Electronic)

Faculty of Electrical & Electronic Engineering
University Malaysia Pahang

NOVEMBER 2008

DECLARATION

"All the trademark and copyrights use herein are property of their respective owner. References of information from other sources are quoted accordingly, otherwise the Information presented in this report is solely work of the author".

Signature : ______________________________

Author : NUR KHUZAIRY BIN JAMALUDIN.

Date : 17 NOVEMBER 2008.

DEDICATION

Special dedicated to

To my beloved family, lecturer, friend and those people who have guided and inspired me throughout my journey of education

ACKNOWLEDGEMENT

First and foremost, I am very grateful to the almighty ALLAH S.W.T for giving me the key and opportunity to accomplish my Final Year Project.

In particular, I wish to express my sincere appreciation to my supervisor, En. Fairuz Rizal Mohamad Rashidi for encouragement, guidance, suggestions, critics and friendship throughout finishing this project.

Secondly, I wish to thank lecturers, staff and technicians, for their cooperation, indirect or directly contribution in finishing my project. My sincere appreciation also to all my friends who have involved and helped me in this project.

Most importantly, I wish my gratitude to my parents for their support, encouragement, understanding, sacrifice and love.

ABSTRACT

As we can see now, the earth becomes hot effect of the global warming. Here we can take an advantage from the effect of the global warming. We can use solar energy as an electrical energy to operate an electrical appliance. The problem that we can see now is most of the solar panel that had been use by a user just only in a static direction. If the solar panel located at east and the sun is located at west, the solar panel cannot be charging. So, the project that wants to develop here is called "Solar Tracking System". Solar tracking system is the project that used PIC16F877A microcontroller as a brain to control the whole system. The LDR (Light Dependant Resistor) had been used to sense the intensity of light at 30 degree each or 180 degree total and sent the data to the microcontroller. This microcontroller will compare the data and rotate a stepper motor to the right direction. The stepper motor will rotate the solar panel based on the highest intensity of light.

ABSTRAK

Seperti yang kita ketahui sekarang, bumi menjadi semakin panas kesan daripada pemanasan bumi. Kita boleh mengambil kelebihan daripada kesan pemanasan bumi yang sedang kita hadapi sekarang. Kita boleh menggunakan matahari untuk menghasilkan tenaga elektrik bagi menggerakkan perkakas elektrik. Tetapi masalah yang dihadapi sekarang ialah solar panel hanya berada dlm keadaan satu arah sahaja(statik). Oleh itu, projek yang hendak dihasilkan di sini dipanggil "Solar Tracking System". projek ini menggunakan mikropengawal PIC16F877A sebagai otak untuk mengawal keseluruhan projek ini. LDR (Light Dependant Resistor) digunakan sebagai pengesan untuk mengesan keamatan cahaya pada 30° setiap pengesan atau 180°(30°X6 pengesan) keseluruhannya dan menghantar maklumat ke mikropengawal. Mikropengawal akan membandingkan data tersebut dan menggerakkan motor stepper ke arah keamatan cahaya yang tertinggi.

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOL

I/O	-	Input Output
RAM	-	Random Access Memory
ROM	-	Read Only Memory
PROM	-	Programmable Read Only Memory
EPROM	-	Erasable Programmable Read Only Memory
IC	-	Integrated Circuit
R	-	Resistor
LED	-	Light Emitter Diode
k	-	kilo
V	-	volt
mA	-	mili ampere
LDR	-	Light Dependant Resistor
PCB	-	Printed Circuit Board

CHAPTER 1

INTRODUCTION

1.1 OVERVIEW

As we know, sun is a one of the most important component in this world. Without sun, it is impossible for a human or living creature to live in this world. Humans nowadays feel uncomforted about the global warming situation. Even this kind of situation bring a lot of negative perception, they should have to think it through the positive way. One of the way to reduce the global warming is to reduce the utilizing of electrical voltage and change to a natural voltage source like wind, rain, tides, sunlight and geothermal heats. So, the engineers try to create a new device that can convert the natural energy to an electrical energy like solar panel for sunlight energy, wind turbines for wind energy, water turbines. The problem that still exists now is the device that invests by an engineer. For example, the solar panel that many of the users use is only in a one way direction. If the sun located at the direction that is not perpendicular to the solar panel, the power that can be generate is low compare to the when the sun located exactly perpendicular to the solar panel. The sun is rotate from east to west but the highest power that can be generate by the solar panel is when location of sun is perpendicular to the solar panel. So the power that can be use in the night day is quite short.

So, the project that I will do is called ‘Solar tracking System’. This is because the sunlight can generate a clean and free power. This project helps for power generation by setting the equipment to get maximum sunlight automatically. This project will use a six sensor in a six direction to sense the direction of maximum intensity of light. Each sensor will face 30°. So, the total angle that this system can sense is 180°. This system will detect the maximum intensity of light. When there is decrease in intensity of light, this system will automatically change it direction using a motor to get a maximum intensity of light. This system will use a PIC 16F877A Microcontroller as a brain to operate this system and a stepper motor to rotate the solar panel. The angle/direction of solar panel will be shown in the Liquid Crystal Display (LCD).

This system is suitable to be used in home or small factories that want to save their budget for a long term.

1.2 OBJECTIVE OF THE PROJECT

Below are the main objectives of "Solar Tracking System" projects.

1. To design a project that can detect and compare the intensity of light and
2. To design a project that able to move a stepper motor based on the intensity of light and show the direction/angle of solar panel on LCD.

1.3 PROJECT SCOPE

This project is focused to design and build the prototype of solar tracking system that would be a starting point to build the realistic solar tracking system. Therefore, this prototype will cover the scope as followed.

- Move 30° each and total movement that this system can do is 180°
- Using microcontroller (16F877A).
- Using stepper motor (bipolar 5 pin).
- Using Light Dependant Resistor (LDR) or Photoresistor as a sensor.
- Using 6 sensors (photoresistor) to detect and compare the solar intensity of light.
- Using LCD to show the direction/angle of solar panel.

1.4 PROBLEM STATEMENT

As we can see, there are many problems that occur in the previous type of solar tracking system. The problem that we can see here is the solar panel that is use is only in one way direction. Because of this problem, the power that can be generated is low. The second problem is the price for the solar tracking system is very expensive for the family that use more power than usual because they need to install more than one solar panel to produce enough power.

So, this project is to fix the problem that occurs here. This solar tracking system can detect a 180 degree of rotation. So, the solar panel that can be generating here is very high compare to when the solar panel can only stay in one direction. So, the families don’t have to install more than one solar panel to generate enough power. One solar panel is enough to produce a lot of power.

1.5 THESIS ORGANIZATION

This thesis consists of seven chapters. This chapter discuss about overview of project, objective research, project scope, problem statement and thesis organization.

Chapter 2 contains a detailed description of solar tracking system. It will explain about the concept of solar tracking system, the application of this system and the involved component in this project.

Chapter 3 includes the project methodology. It will explain how the project is organized and the flow of process in completing this project. Also in this topic discusses the methodology of the system, circuit design, software design and the mechanical design.

Chapter 4 contained detailed description about hardware development.

It will explain more detail about the electronic component that had been used and the method used to develop hardware.

Chapter 5 includes the software methodology. This will discuss more about the software that had been use to design a programming for the whole project and the software that had been used to design a Printed Circuit Board (PCB).

Chapter 6 will discuss more about the result and discussion. This chapter will show the result of this project step by step.

The last chapter contained the detailed description about conclusion and recommendation. This chapter will conclude the whole project and give a future recommendation to make this project perfect.

CHAPTER 2

LITERATURE REVIEW

2.1 OVERVIEW

Solar tracking system project had been widely employed by the other giant company like BP Solar, Yingli Green Energy, Kyocera, Q-Cells, Sanyo, Sharp Solar, Solar World, Sun Power, and Suntech. Now, many people use solar energy or photovoltaic energy as an alternative power because it's free and renewable. As we can see now, the payment charge for an electricity had been risen rapidly because the increasing of gas price. Many researchers have tried to find the alternative energy to replace the gas. One of the alternative energy that we can use is photovoltaic energy. Photovoltaic energy is the most promising and popular form of solar energy. In solar photovoltaic's, sunlight is actually converted into electricity. This is very different from a conventional understanding of solar power as only a way of heating water. Photovoltaic, now the biggest usage of solar energy around the world, is briefly explained below:

Sunlight is made of photons, small particles of energy. These photons are absorbed by and pass through the material of a solar cell or solar photovoltaic panel. The photons 'agitate' the electrons found in the material of the photovoltaic cell. As they begin to move (or are dislodged), these are 'routed' into a current. This, technically, is electricity - the movement of electrons along a path. Solar panels made of silicon to convert sunlight into electricity. Solar photovoltaic are used in a number of ways, primarily to power homes that are inter-tied or interconnected with the grid.

Wire conducts these electrons, either to batteries or to the regular electrical system of the house, to be used by appliances and other household electrical items. In many solar energy systems, the battery stores energy for later use. This is especially true when the sun is shining strongly.

2.1.1 Applications of Photovoltaic Power

Here are the examples of application of photovoltaic power or solar power.

1. **Photovoltaic in transport**

   Photovoltaic power has traditionally been used for auxiliary power in space. Photovoltaic power is rarely used to provide motive power in transport applications, but is being used increasingly to provide auxiliary power in boats and cars.

2. **Photovoltaic power in standalone devices**

Photovoltaic power has been used for many years to power calculators and novelty devices. Improvements in integrated circuits and low power LCD displays make it possible to power a calculator for several years between battery changes, making solar calculators less common. In contrast, solar powered remote fixed devices have seen increasing use recently, due to increasing cost of labour for connection of mains electricity or a regular maintenance programmed. For examples are parking meters, emergency telephones, and temporary traffic signs.

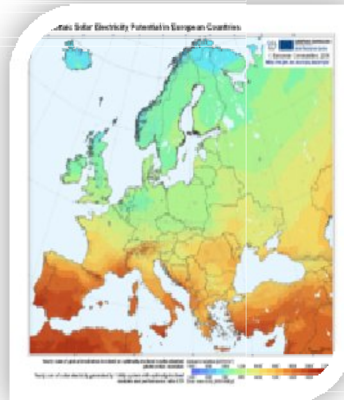
2.1.2 Advantages of solar electricity

- The 89 petawatts of sunlight reaching the earth's surface is plentiful - almost 6,000 times more - compared to the 15 terawatts of average power consumed by humans. Additionally, solar electric generation has the highest power density (global mean of 170 W/m^2) among renewable energies.
- Solar power is pollution free during use. Production end wastes and emissions are manageable using existing pollution controls. End-of-use recycling technologies are under development.
- Facilities can operate with little maintenance or intervention after initial setup.
- Solar electric generation is economically superior where grid connection or fuel transport is difficult, costly or impossible. Examples include satellites, island communities, remote locations and ocean vessels.
- When grid-connected, solar electric generation can displace the highest cost electricity during times of peak demand (in most climatic regions), can reduce grid loading, and can eliminate the need for local battery power for use in times of darkness and high local demand; such application is encouraged by net metering. Time-of-use net metering can be highly favourable to small photovoltaic systems.
- Grid-connected solar electricity can be used locally thus reducing transmission/distribution losses (transmission losses were approximately 7.2% in 1995).
- Once the initial capital cost of building a solar power plant has been spent, operating costs are extremely low compared to existing power technologies.

2.1.3 Disadvantages of solar electricity

- Solar electricity is almost always more expensive than electricity generated by other sources.
- Solar electricity is not available at night and is less available in cloudy weather conditions. Therefore, a storage or complementary power system is required.
- Limited power density: Average daily isolation in the contiguous U.S. is 3-7 kW·h/m^2 and on average lower in Europe.
- Solar cells produce DC which must be converted to AC (using a grid tie inverter) when used in currently existing distribution grids. This incurs an energy loss of 4-12%.

Photovoltaic 'tree' potential in Europe



Map of solar electricity

Solar powered parking meter.

Photovoltaic solar panels on roof.

2.2 PIC MICROCONTROLLER

For this project, the controller for the movement is PIC microcontroller. We will describe about the PIC microcontroller and at the same time, it will give more understanding for me to employ this controller. Almost all type of PIC microcontroller is included in a class of 8-bit microcontrollers of RISC architecture. Basically, the PIC architecture is minimized to be a simpler item but it still operates at the same function. The Harvard architecture is a newer concept than von-Neumann. It was designed as a response for the need to speed up the work of a microcontroller. In Harvard architecture, data bus and address bus are separate. Thus, the data will flow directly through the central processing unit and the address bus is neglected. This greater flow of data will impact for a greater speed of work. Besides that, the architecture will involve for a small number of a fixed length instruction. It means the instruction is not to have to be 8-bit words but it can uses 14 bits for instructions which allows for all instruction to be one word instructions. Microcontrollers with Harvard architecture are called "RISC microcontrollers". RISC is a short form for Reduced Instruction Set Computer. Microcontrollers with von-Neumann's architecture are called 'CISC microcontrollers'. CISC is a short form for Complex Instruction Set Computer. Same as discussion before, RISC microcontroller has a reduced set of instructions, maybe 35 instructions for one cycle. If we compared it with Intel's and Motorola's microcontroller, it has over hundred instructions.

As a simplified point, we can say that the features of PIC microcontroller are:

(i) Separate code and data spaces (Harvard architecture).
(ii) A small number of fixed length instructions.
(iii) Most instructions are single cycle execution (4 clock cycles), with single delay cycles upon branches and skips.
(iv) All RAM locations function as registers as both source and/or destination of math and other functions.
(v) A hardware stack for storing return addresses.
(vi) A fairly small amount of addressable data space (typically 256 bytes), extended through banking.
(vii) Data space mapped CPU, port and peripheral registers.

(viii) The program counter is also mapped into the data space and writable.

So, the result for PIC microcontroller reach of 2:1 in code compression and 4:1 in speed in relation to other 8-bit microcontrollers in its class. Generally, PIC microprocessor divides to 6 parts. Those are program memory, EEPROM, RAM, PORTA and PORTB, free-run timer and central processing unit.

Furthermore, I will use PIC16877 for the microcontroller. In general, the characteristic of PIC16877 are same as explained before but the difference is amount of number pin. PIC16877 has a total of 40 pins.

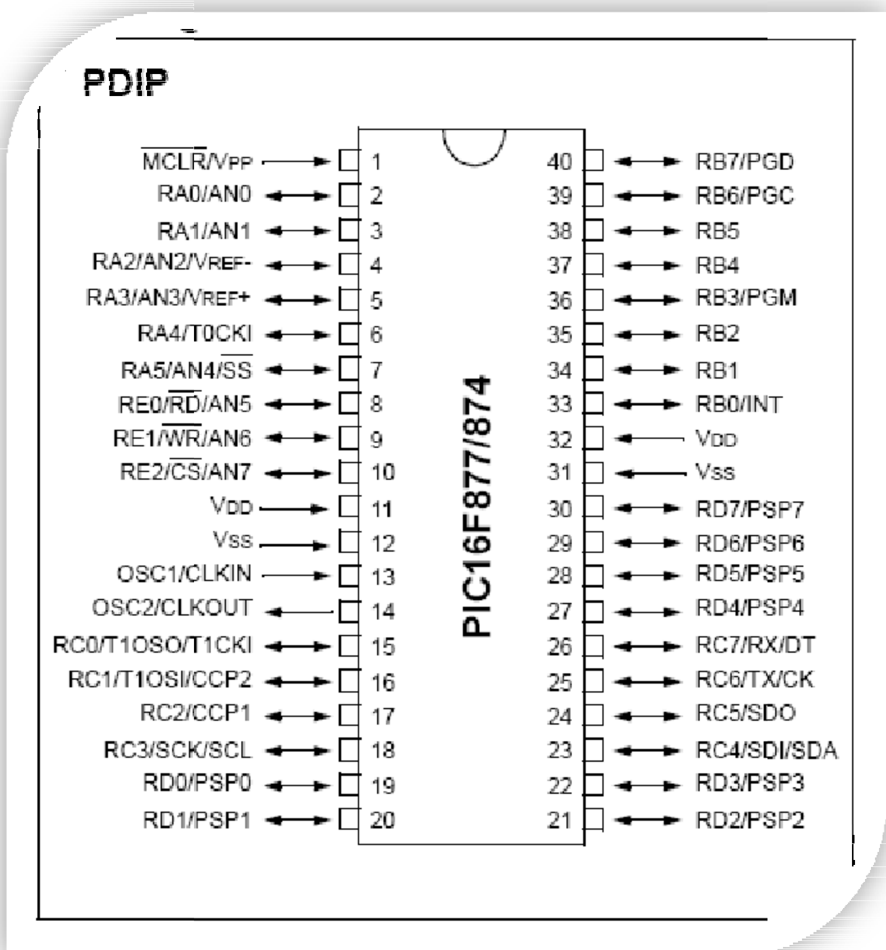


Figure 2.1: Pin diagram

Refer to figure 2.1, each pins has its meaning. But I only want to justify for the common pins where it will be function. For pin no. 1 (V_{PP}), pin no. 11 (V_{DD}), pin no.

32 (V_{DD}), these pins will be connecting to the 5V voltage. For pin no. 12 (V_{SS}), pin no. 31 (V_{SS}), these pins will be connecting to the ground (GND). For pin no. 13 (OSC1) and pin no. 14 (OSC2), these pins will be connecting to the oscillator. For other pins, we take point for the input and output. As example, for pin no. 2 (RA0/AN0), this pin is zero pin on port A. For pin no. 33 (RB0/INT), this pin is zero on port B. We can select or program to give command either port A or port B to be input or output.

The most important part is how to program this PIC16877 microcontroller. For this project, the PICBasic is the preferred compiler to build program for the microcontroller. For PIC microcontroller, we found that we can use two options that are assembly language and PicBasic programming. It is easier and quicker if we use PicBasic programming than the use of assembly language programming. The English Basic language is much easier to read and write down quickly than microchip assembly language. PPICBASIC is a micro-controller developed by COMFILE Technology and is programmed in a form of the BASIC language. Mostly, PICBasic use the basic language such as MOVE, LOW, HIGH, GOTO, GOSUB and others. PICBASIC has BASIC interpreter inside of a microcontroller on board so that you can program micro controller in a form of the BASIC language with ease. We will program the microcontroller by copy the command to the PIC microcontroller (EEPROM).

2.3 STEPPER MOTOR

Stepper motors are special motors that are used when motion and position have to be precisely controlled. The stepper motor is closely related in design to three-phase AC synchronous motors where an internal rotor containing permanent magnets or a large iron core with salient poles is controlled by a set of external magnets that are switched electronically. A stepper motor may also be thought of as a cross between a DC electric motor and a solenoid. As each coil is energized in turn, the rotor aligns itself with the magnetic field produced by the energized field winding. Unlike a synchronous motor, in its application, the motor may not rotate continuously; instead, it "steps" from one position to the next as field windings are energized and de-energized in sequence. Depending on the sequence, the rotor may turn forwards or backwards.

Simple stepper motor drivers entirely energize or entirely de-energize the field windings, leading the rotor to "cog" to a limited number of positions; more sophisticated drivers can proportionally control the power to the field windings, allowing the rotors to position "between" the "cog" points and thereby rotate extremely smoothly. Computer controlled stepper motors are one of the most versatile forms of positioning systems, particularly when part of a digital servo-controlled system.

Stepper motors can be rotated to a specific angle with ease, and hence stepper motors are used in computer disk drives, where the high precision they offer is necessary for the correct functioning of, for example, a hard disk drive or CD drive. Only very old hard drives (from the pre-gigabyte era) use stepper motors; newer drives use systems based on voice coils.

Stepper motors were upscale to be used in electric vehicles under the term SRM (switched reluctance machine). The stepper motor is turned one step at a time or can turn at a specific rate (specified by the speed in which the steps are executed). In term of hardware interface, the stepper motor requires a bit more complex to wire and more current. But this motor has more advantages in software control. A stepper motor can be controlled by stepper-motor controlled chips, such as the UC1517.

2.4 PREVIOUS PROJECT

I had been studied about the previous project. The previous project also called "Solar Tracking System. Figure 2.2 show the detail about the previous project. The previous current had some disadvantage compared to the current project. The main disadvantage that we can see here is the previous project only used 2 sensors to sense the intensity of light compared to the current project that use 6 sensor to sense the intensity of light. So the rotation of solar panel in the current project is more precise compared to the previous project. Refer table 2.1 for a more detail about comparison between previous project and current project.

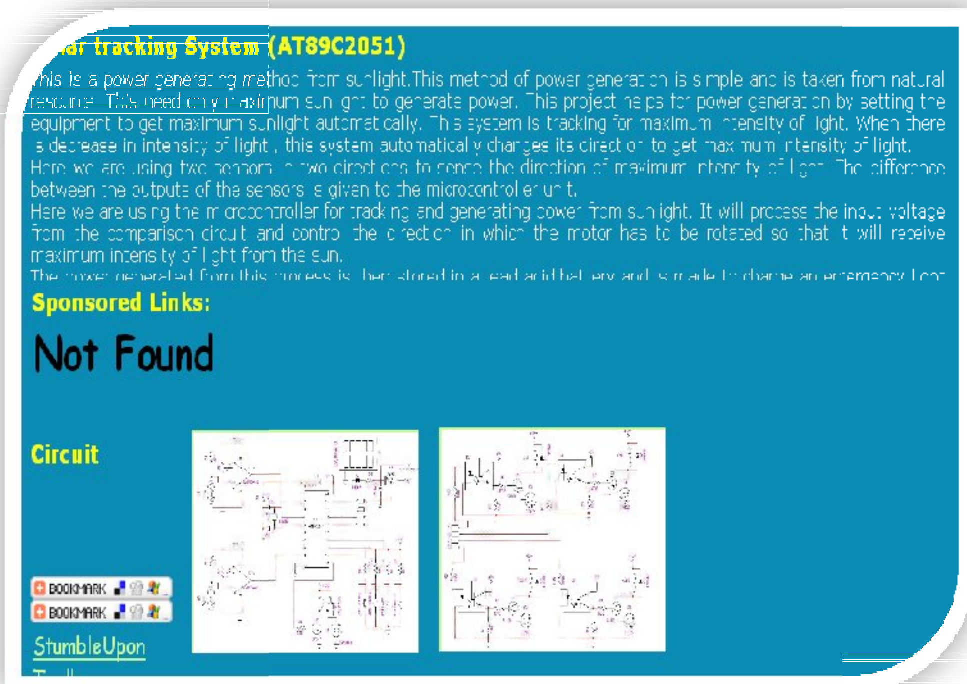


Figure 2.2: Previous project

Table 2.1: Current Project VS Previous Project

Description	Current Project	Previous Project
Type of Microcontroller	PIC16F877A Microcontroller	Intel 8051 Microcontroller
Total sensor use	6 sensor	only 2 sensor
Direction of sensor	30° from east to west(180° total)	45° from east or 45° from west
Type of circuit	Simple	Complex
Energy stored	no	Yes