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I also take this opportunity to thank all teachers who contributed their valuable comments, suggestions and advices and helped to complete the project successfully.

Certificate

This is to certify that the project entitled "Automatic Solar Tracking System" is carried out by Shahriar Shanto, Roll No. : 1604010, under my supervision in the Department of Electronics & Telecommunication Engineering (ETE) in Rajshahi University of Engineering & Technology (RUET).

Signature of the Supervisor:

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Abstract

Energy crisis is the most important issue in today's world. Conventional energy resources are not only limited but also the prime culprit for environmental pollution. Renewable energy resources are getting priorities in the whole world to lessen the dependency on conventional resources. Solar energy is rapidly gaining the focus as an important means of expanding renewable energy uses. Solar cells those convert sun's energy into electrical energy are costly and inefficient. Different mechanisms are applied to increase the efficiency of the solar cell to reduce the cost. Solar tracking system is the most appropriate technology to enhance the efficiency of the solar cells by tracking the sun. A microcontroller based design methodology of an automatic solar tracker is presented in this document. Light dependent resistors are used as the sensors of the solar tracker. The designed tracker has precise control mechanism which will ensure best sun light for the solar panels.

Automatic solar tracker increases the efficiency of the solar panel by keeping the solar panel aligned with the rotating sun. Solar tracking is a mechanized system to track the sun's position that increases power output of solar panel 30% to 60% than the stationary system.

Chapter 1

Introduction

The efficiency of the solar cells can be enhanced by keeping the solar panel aligned with the rotating sun. This way more intense light will be incident directly to the cells.

Solar tracking is a mechanized system to track the sun's position that increases power output of solar panel 30% to 60% than the stationary system.

A microcontroller based design methodology of an automatic solar tracker is presented in this document. Light dependent resistors are used as the sensors of the solar tracker. The designed tracker has precise control mechanism which will ensure best sun light for the solar panels.

The major components are:

- Photo resistor (LDR)
- Microcontroller (ATMEGA 328P)
- Servo motor (SG 90)

Cadmium Sulphide (CdS) photo resistor is used in the designed prototype. The photo resistor is a passive element that has a resistance inversely proportional to the amount of light incident on it. To utilize the photo resistor, it is placed in series with another resistor. A voltage divider is thus formed at the junction between photo resistor and another resistor; the output is taken at the junction point to pass the measured voltage as input to microcontroller.

Microcontroller is the heart of overall system. ATMEGA328P microcontroller requires a 5 volt regulated voltage supply. 'LM 7805'

voltage regulator is used to provide fixed 5 volts supply to the microcontroller.

The micro servo motor SG-90 was chosen for this project as it has enough torque needed to lift a small panel. The servo can go from position at 0 degree to 180 degrees. It requires PWM signal to determine its holding position.

Motivation

Energy crisis in the world and the need of efficient power generation systems motivated me to do this project. Solar cells are the most easy and greenest energy source in the planet. It is very important that we make this technology better through research and engineering. Another motivation to choose this project was to learn about control systems.

Objectives

- To track the sun though sensing sun light
- Rotating the panels using servo motor
- Two-Axis rotation for better alignment
- Low-power solution to minimize power cost
- Reprogrammable solution for control

Chapter 2

Apparatus

List of required components:

- ATmega328P
- Servo (SG90)
- Voltage Regulator (LM 7805)
- Battery (6F22, 9 Volts)
- Battery Connector
- Resistors (1k Ohms)
- Crystal Oscillator (16 MHz)
- Capacitors (22pF)
- Microcontroller Base
- Male Connector Rails

Description of each apparatus:

Microcontroller (ATmega328P)

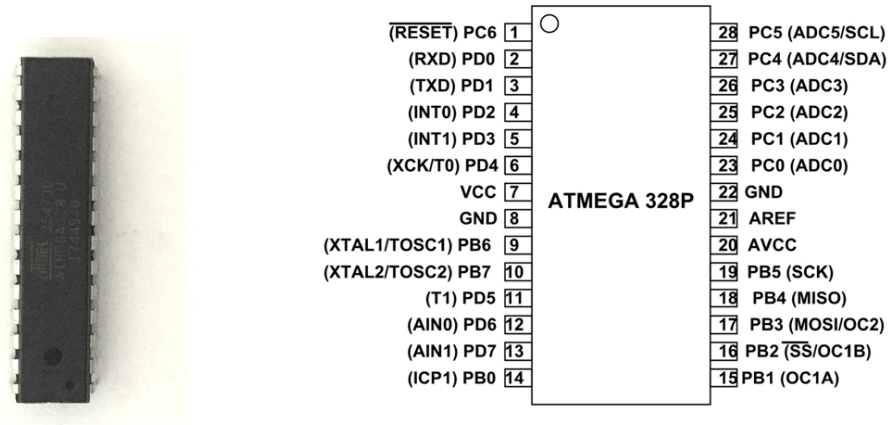

Figure: ATmega328P

ATMEGA328P is high performance, low power controller from Microchip. ATMEGA328P is an 8-bit microcontroller based on AVR RISC architecture. It is the most popular of all AVR controllers as it is used in ARDUINO boards.

Features:

CPU: 8-bit AVR

Number of Pins: 28

Operating Voltage (V): +1.8 V TO +5.5V

Number of programmable I/O lines: 23

ADC Module: 6 channels, 10-bit resolution ADC

Servo Motor (SG90)

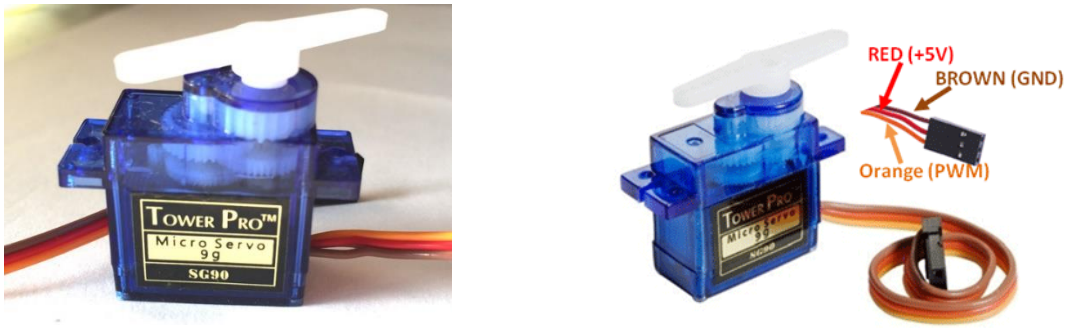

Fig: Servo Motor (SG90)

A servomotor is a rotary actuator or linear actuator that allows for precise control of angular or linear position, velocity and acceleration. It consists of a suitable motor coupled to a sensor for position feedback. It also requires a relatively sophisticated controller, often a dedicated module designed specifically for use with servomotors. It can be controlled by PWM generation in microcontrollers for low-cost approach.

Servomotors are not a specific class of motor although the term servomotor is often used to refer to a motor suitable for use in a closed-loop control system.

Servomotors are used in applications such as robotics, CNC machinery or automated manufacturing.

Specifications:

Weight: 9g
Dimension: 23×12.2x29 mm
Stall torque: 1.8kg/cm (4.8v)
Gear type: POM gear set
Operating speed: 0.12 sec/60 degree (4.8v)
Operating voltage: 4.8v

Temperature range: 0℃ - 55℃
Dead band width: 1us
Power Supply: External Adapter
Servo wire length: 25 cm

Voltage Regulator (LM 7805)

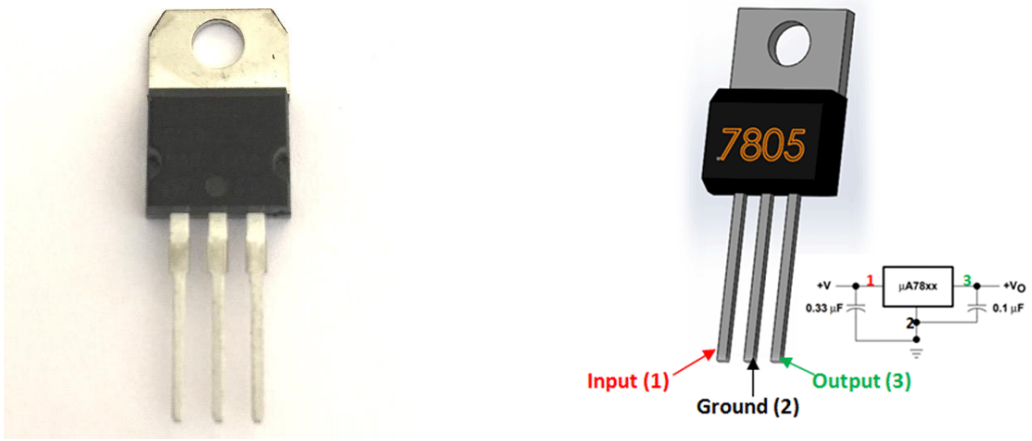

Figure : Voltage Regulator (7805)

Voltage regulators are very common in electronic circuits. They provide a constant output voltage for a varied input voltage. In our case the 7805 IC is an iconic regulator IC that finds its application in most of the projects. The name 7805 signifies two meaning, "78" means that it is a positive voltage regulator and "05" means that it provides 5V as output.

Chapter 3

Automatic Solar Tracking System

Circuit Diagram:

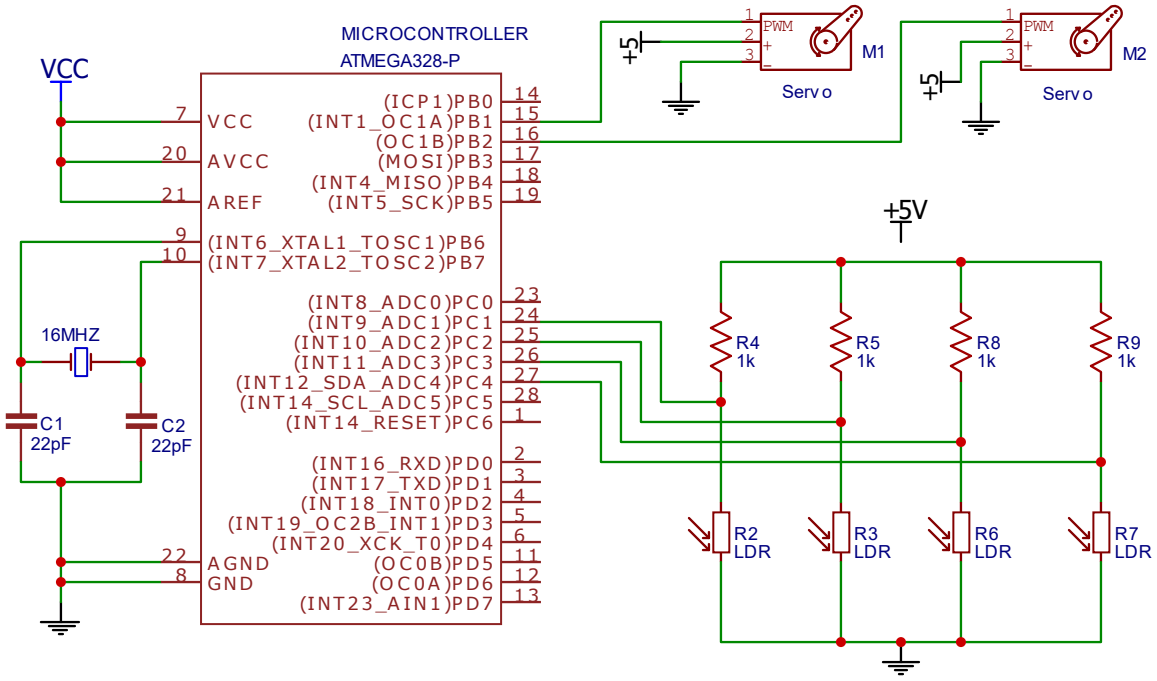

Figure : Circuit Diagram

PCB Design:

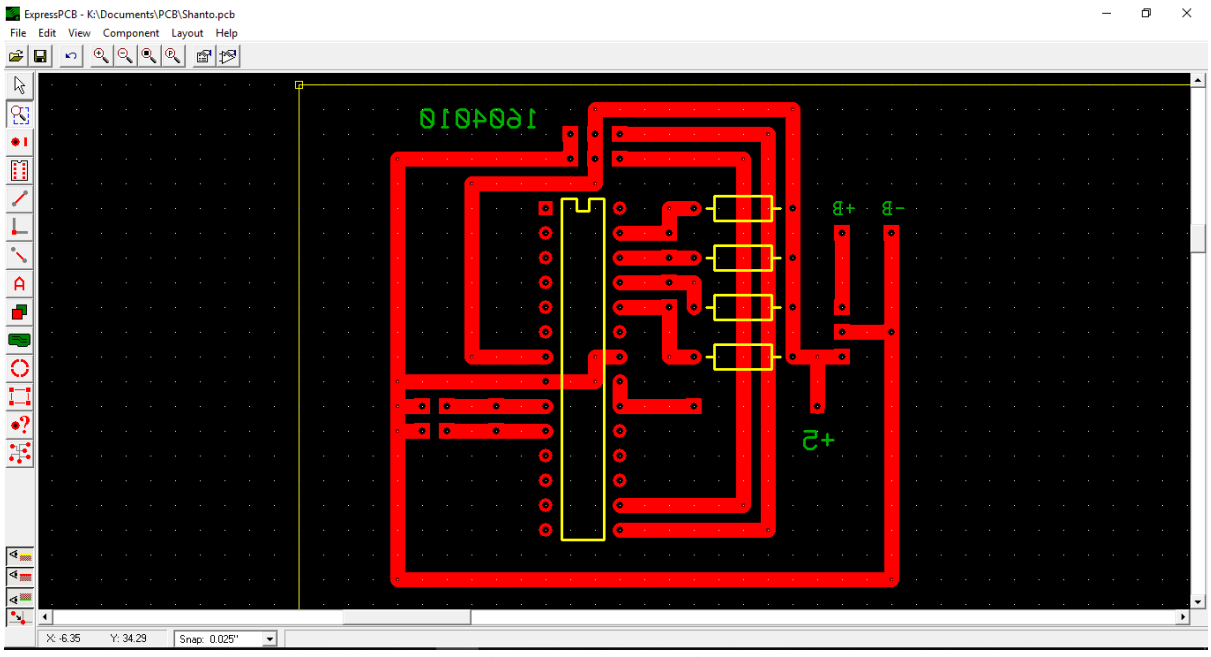

Figure: PCB Design

Chapter 4

Discussion

The most abundant and convenient source of renewable energy is solar energy, which can be harnessed by photovoltaic cells. This document has presented a means of tracking the sun's position with the help of microcontroller. Specially, it demonstrates a working solution for maximizing photovoltaic cell output by positioning a solar panel at the point of maximum light intensity. The attractive feature of the designed solar tracker is simple mechanism to control the system. The solar tracker also provides lucrative solution for third world countries to integrate it into their solar system with a comparatively low cost through software based solution. Though the prototype has limitations in hardware areas as an initial set up, still it provides an opportunity for improvement of the design methodology in future.

Applications:

1. Solar Panels, for best power generation.
2. As a sensor which determines direction of light
3. Other sensors which rely on light
4. Robotics

Limitations:

1. The servo motors used in this project are very small, so the torque is very low. It can lift small panels only.
2. The LDRs are very unreliable. We could use better light sensing component or module for the task.

References:

1. Design and construction of an automatic solar tracking system; Md. Tanvir Arafat Khan, S.M. Shahrear Tanzil, Rifat Rahman, S M Shafiul Alam;

   https://doi.org/10.1109/ICELCE.2010.5700694

2. DIY Miniature Solar Tracker by Great Scott
https://instructables.com/id/DIY-Miniature-Solar-Tracker

Appendix A

Arduino Code

```
#include <Servo.h>
Servo servo1, servo2;
int tl, tr, bl, br, pos1 = 90, pos2 = 90, del = 50;
void setup() {
  servo1.attach(9);
  servo1.write(pos1);
  servo2.attach(10);
  servo2.write(pos2);
}

void loop() {
  tl = analogRead(A1);
  tr = analogRead(A2);
  bl = analogRead(A3);
  br = analogRead(A4);
  if (tl > tr) {
    pos1 = pos1 + 1;
    servo1.write(pos1);
  }
  else {
    pos1 = pos1 - 1;
    servo1.write(pos1);
  }
  if (bl > br) {
```

```
    pos2 = pos2 + 1;
    servo2.write(pos2);
  }
  else {
    pos2 = pos2 - 1;
    servo2.write(pos2);
  }
  if (pos1 > 180) {
    pos1 = 180;
  }
  if (pos2 > 180) {
    pos2 = 180;
  }
  if (pos1 < 0) {
    pos1 = 0;
  }
  if (pos2 < 0) {
    pos2 = 0;
  }
  delay(del);
}
```