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Indian Institute of Information Technology Design & Manufacturing
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Solar Tarcker (Dual Axis)

Report as a Part of PR201
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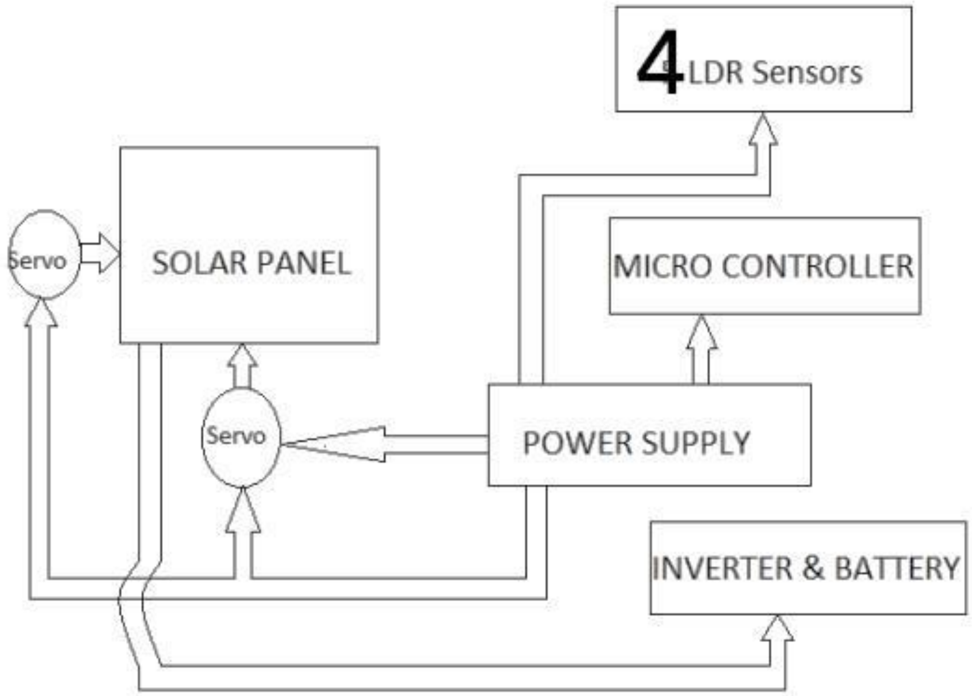
ABSTRACT:

Solar energy is rapidly gaining notoriety as an important means of expanding renewable energy resources. As such, it is vital that those in engineering fields understand the technologies associated with this area. Our project will include the design and construction of a microcontroller-based solar panel tracking system. Solar tracking allows more energy to be produced because the solar array is able to remain aligned to the sun. This system builds upon topics learned in this course. A working system will ultimately be demonstrated to validate the design. Problems and possible improvements will also be presented.

The main aspects of programming for an Solar tracker or Orientable Solar Panel System–OSPS prototype are summarized. The prototype has both elevation and azimuth motions. Four photo-resistors that are separated by the proposed design are used to evaluate the perpendicularity of the light ray incidence pairwise. Signals are sent to an Arduino microcontroller, where data are compared against light threshold values (or range of light threshold values). The servomotor is then ordered to turn until the light ray intensity (bit number) on each photo-resistor has reached the same value. Four sensors, each one with four photo-resistors, were used in the OSPS lab model. Programming required a main program and three routines: turning sense, elevation motion and azimuth motion. Extreme light intensities (thresholds) for the sensors were established by exposing them to different light types and incidence angles.

1 INTRODUCTION:

Orientable Solar Panel Systems–OSPS are mechanical devices combined with sensors, actuators and a processing unit to maintain the solar panel perpendicular to the incidence sunrays. Electric generation output has been proved greater in Orientable Solar Panel Systems-OSPS with perpendicular incidence of the sun rays to the panel surface. Reported studies between fixed and OSPS with both azimuth and elevation motion capability suggest that OSPS are 20% to 40% more efficient. Figure 1 shows the two motions, elevation and azimuth, that an OSPS must be able of describing. An increase in panel efficiency of up to 90% with respect to the efficiency with no tracking was reported . Its tracking algorithm used peak power tracking based on the topology of continuous pulses with maximum power extraction by constantly monitoring voltage and current values.A prototype of an OSPS for both azimuth and elevation motion is equipped with four low cost Light Depending Resistor-LDR or light changing resistance. The prototype is an active follower that it is activated depending only on the sensors' signals. The sensors were arranged to allow comparison of the intensity of light along each axis of motion. The movement is achieved through two servomotors commanded with an Arduino UNO microcontroller. The light thresholds were stipulated for the purpose of calibrating the light sensors, thus allowing the comparison of light intensities in the sensors. BLOCK DIAGRAM



Block Diagram of overall system

FIGURE 1

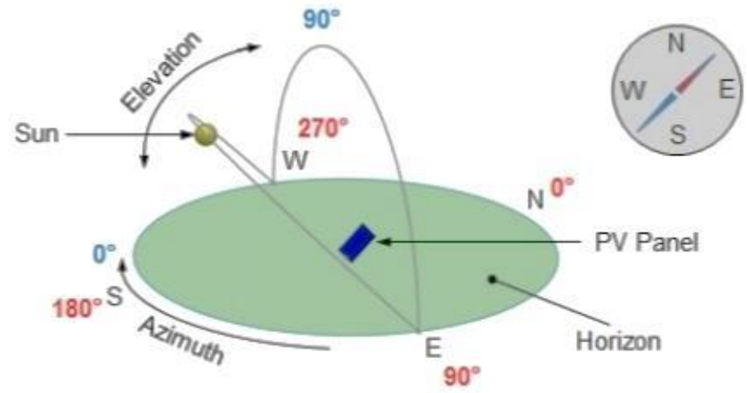
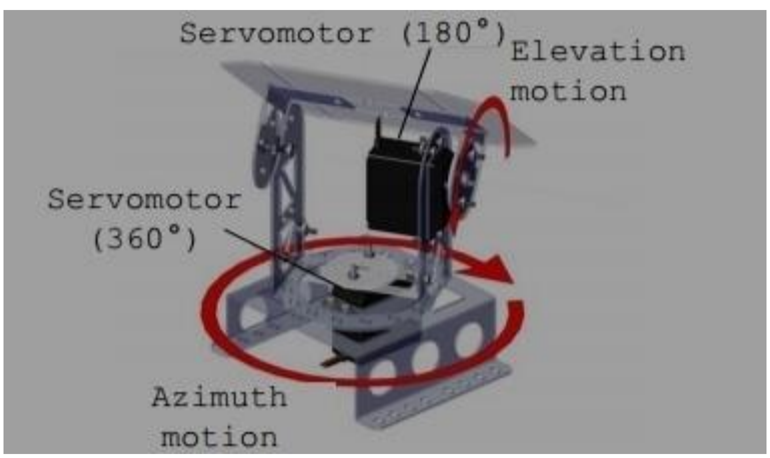


Figure 1. Azimuth and elevation motions of a photovoltaic-PV panel in an OSPS

2 Materials and Methods:

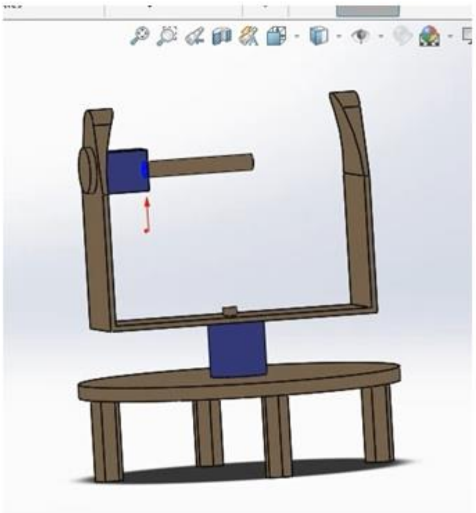
2.1. Prototype Description

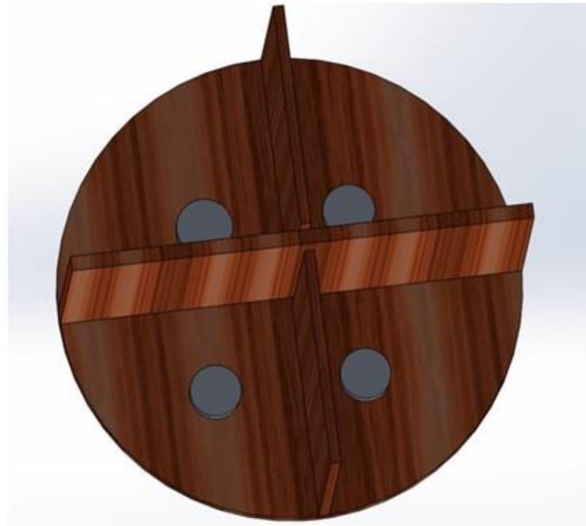


(Figure:-2)

It consists of light sensors arranged in the solar cell with actuators. Below figures shows a CAD scheme of the system and presents the final prototype of LDR sensor mounting. The main components are: light sensors, servomotors (actuators), wiring and electronic components, and structural and fastening elements. Two 9G servomotors were used to execute the azimuth and elevation motions, with 360° and 180° motion ranges, respectively. As for the light sensors, a photo-resistor element that works as a variable resistance is integrated. It decreases its resistance value when perceiving an increase in light intensity.

CAD Model



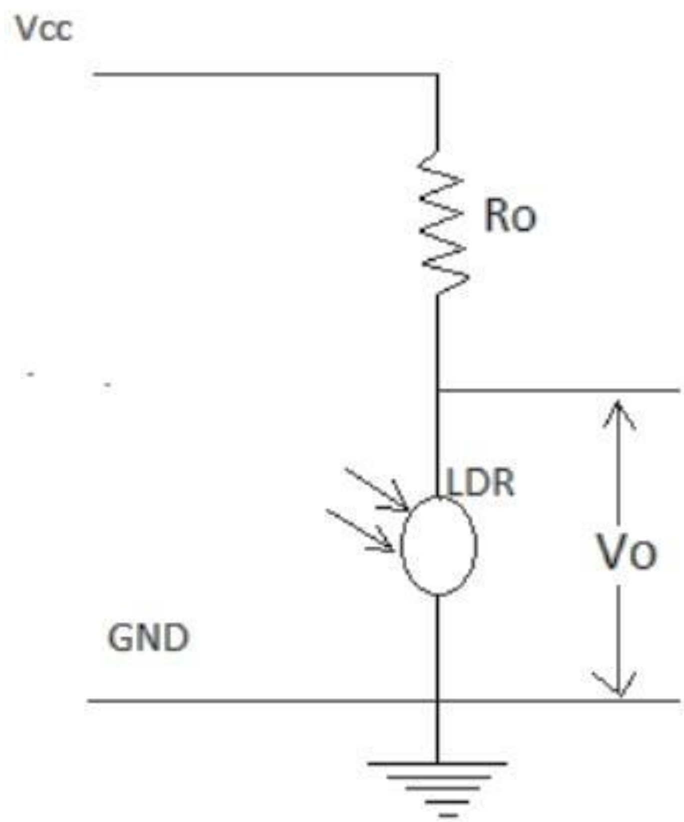


LDR sensor mounting

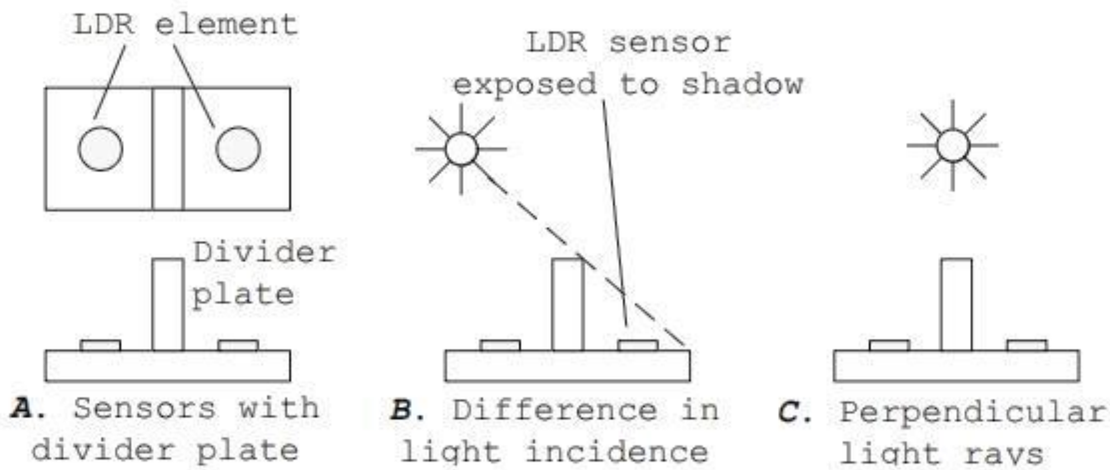
2.2 . Sensors

We are using Four Light Dependent Resistor’s as a sensor. They sense the higher density area of sun light. The solar panel moves to the high light density area through servo motors.Each LDR is connected to power supply forming a potential devider. Thus any change in light density is proportional to the change in voltage across the LDR’s.

LDR is a passive transducer hence we will use potential divider circuit to obtain corresponding voltage value from the resistance of LDR. LDRs resistance is inversely proportional to the intensity of light falling on it i.e. Higher the intensity or brightness of light the Lower the resistance and vice versa.



The output voltage, Vo, for sensors is given by Vo = {RLDR/(RLDR + Ro)}*Vcc, where RLDR is the photo-resistors and Vcc is the input continuous voltage. The circuits are integrated to the physical sensor with a divider plate, Figure 4.A. The plate allows evaluating the perpendicularity of the light rays that affect the LDR circuit. If one of the two photo-resistive elements is exposed to shadow, Figure 4.B, the sensor signals will be different. Both sensors must generate the same signal to establish the perpendicularity of the cell with the light ray



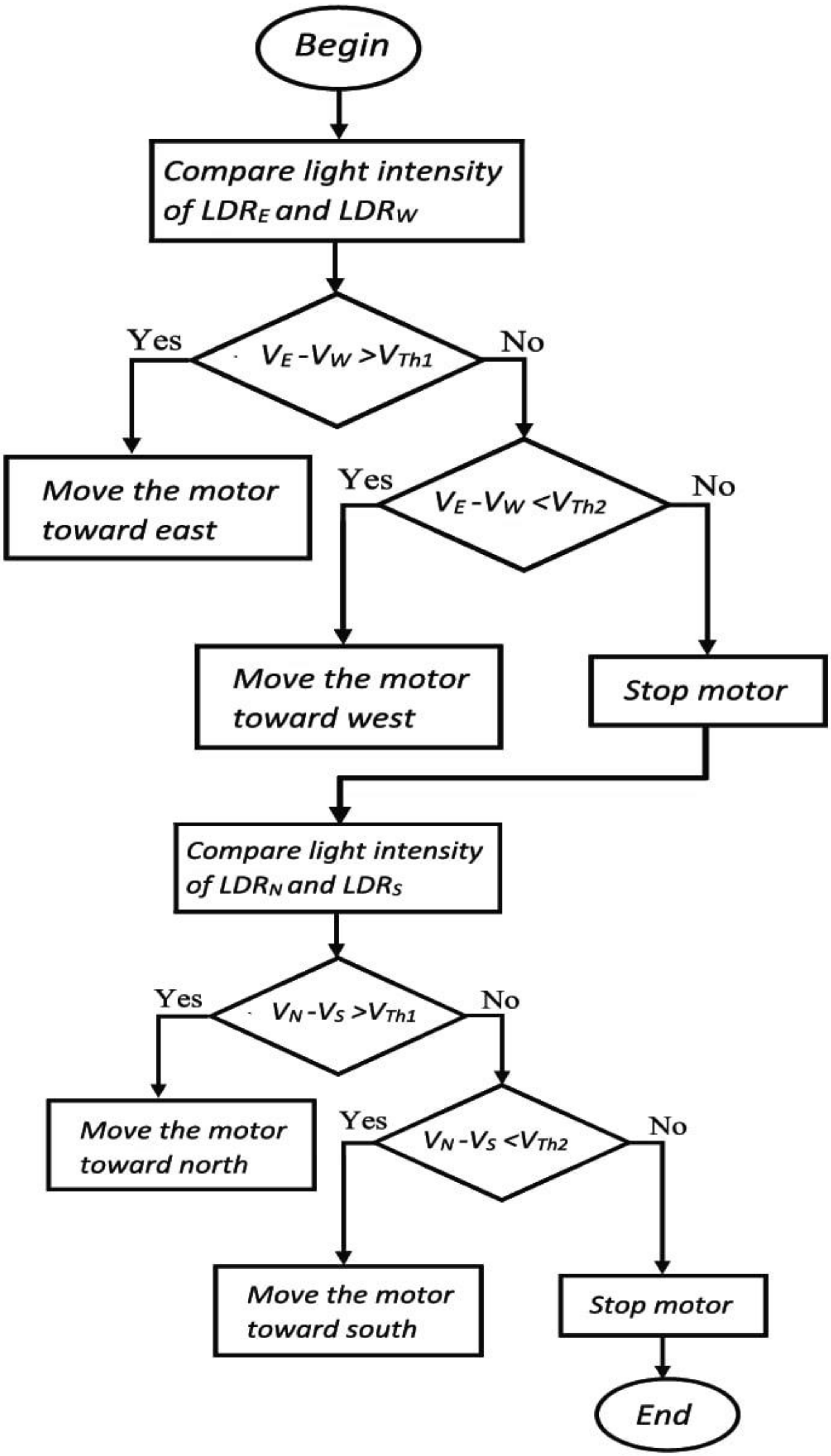
(LDR Disposition)

2.3 .Input(ADC)

Arduino has an inbuilt 10-bit Analog to Digital converter(ADC), hence it can provide Digital values from 0-1023.(since 2^10=1024). We can also set the ADC reference voltage in arduino, but here we'll let it use default value. LDR's has two pins, and to get voltage value from it we use potential divider circuit. In potential divider we get Vout corresponding to resistance of LDR which in turn is a function of Light falling on LDR. The higher the intensity of light, lower the LDR resistance and hence lower the Output voltage (Vout) And lower the light intensity, higher the LDR resistance and hence higher the Vout.

2.4 .Output(PWM)

Arduino has a 8-bit PWM generator, so we can get up to 256 distinct PWM signal. To drive a servo we need to get a PWM signal from the board, this is usually accomplished using timer function of the microcontroller but arduino makes it very easy. Arduino provides a servo library in which we have to only assign servo angle (0-1800) and the servo rotates by that angle, all the PWM calculations are handled by the servo library and we get a neat PWM signal according to the desired angle.


Begin
Compare light intensity of LDRE and LDRW
Yes
VE-VW >VTh1
No
Move the motor toward east
Yes
VE-VW <VTh2
No
Move the motor toward west
Stop motor
Compare light intensity of LDRN and LDRS
Yes
VN-VS >VTh1
No
Move the motor toward north
Yes
VN-VS <VTh2
No
Move the motor toward south
Stop motor
End

(CONTROL ALGORITHM)

```
#include <Servo.h> // include Servo library

// 180 horizontal MAX
Servo horizontal; // horizontal servo
int servoh = 90;    // stand horizontal servo

int servohLimitHigh = 175;
int servohLimitLow = 5;

// 65 degrees MAX
Servo vertical;   // vertical servo
int servov = 45;   // stand vertical servo

int servovLimitHigh = 80;
int servovLimitLow = 15;


// LDR pin connections
//  name  = analogpin;
int ldrlt = A1; //LDR top left
int ldrrt = A3; //LDR top rigt
int ldrld = A0; //LDR down left
int ldrrd = A2; //ldr down rigt

void setup()
{
```

```
 Serial.begin(9600);
// servo connections
 horizontal.attach(9);
 vertical.attach(10);
 horizontal.write(180);
 vertical.write(45);
 delay(3000);
}

void loop()
{
 int lt = analogRead(ldrlt); // top left
 int rt = analogRead(ldrrt); // top right
 int ld = analogRead(ldrld); // down left
 int rd = analogRead(ldrrd); // down rigt

 int dtime = 10;
//****** int tol = 1;

 int avt = (lt + rt) / 2; // average value top
 int avd = (ld + rd) / 2; // average value down
 int avl = (lt + ld) / 2; // average value left
 int avr = (rt + rd) / 2; // average value right

 int dvert = avt - avd; // diffirence of up and down
 int dhoriz = avl - avr;// diffirence og left and rigt


 Serial.print(avt);
```

```
 Serial.print(" ");
 Serial.print(avd);
 Serial.print(" ");
 Serial.print(avl);
 Serial.print(" ");
 Serial.print(avr);
 Serial.print("   ");
 Serial.print(dtime);
 Serial.print("   ");
//****** Serial.print(tol);
 Serial.println(" ");


//****** if (-1*tol > dvert || dvert > tol) // check if the diffirence is in the tolerance else change vertical angle
 {
 if (avt > avd)
 {
   servov = ++servov;
    if (servov > servovLimitHigh)
    {
     servov = servovLimitHigh;
    }
 }
 else if (avt < avd)
 {
   servov= --servov;
   if (servov < servovLimitLow)
 {
```

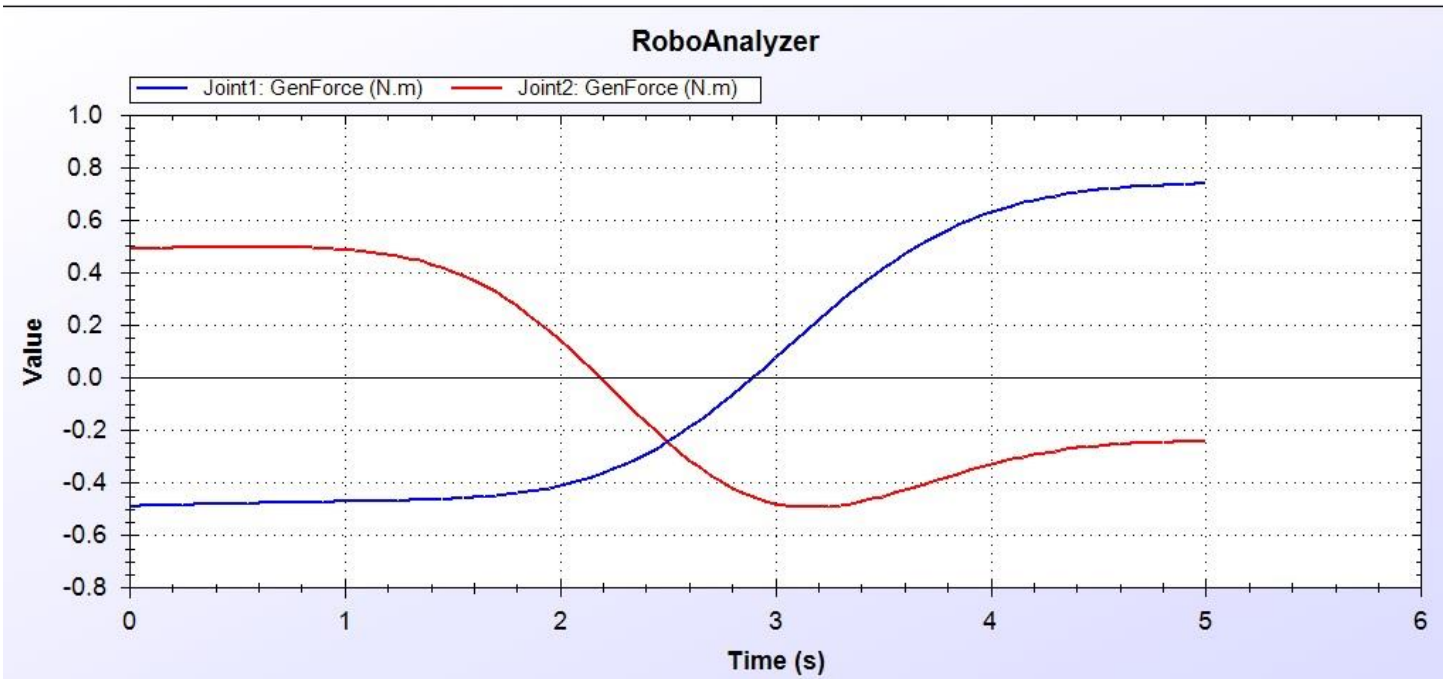
```
  servov = servovLimitLow;
 }
 }
 vertical.write(servov);
 }

//****** if (-1*tol > dhoriz || dhoriz > tol) // check if the diffirence is in the tolerance else change horizontal angle
 {
 if (avl > avr)
 {
  servoh = --servoh;
  if (servoh < servohLimitLow)
  {
  servoh = servohLimitLow;
  }
 }
 else if (avl < avr)
 {
  servoh = ++servoh;
   if (servoh > servohLimitHigh)
   {
   servoh = servohLimitHigh;
   }
 }
 else if (avl = avr)
 {
  // nothing
 }
```

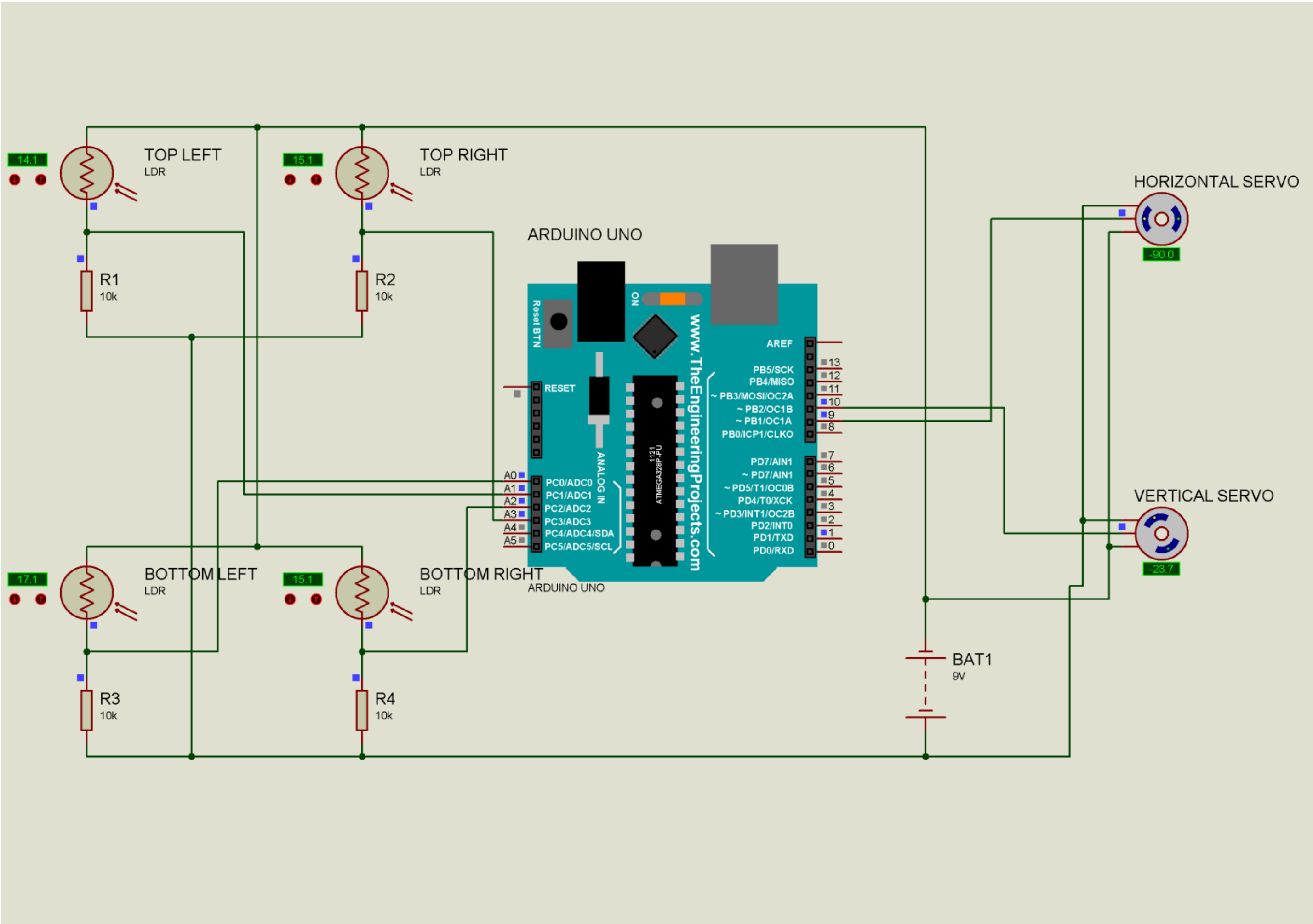
```
 horizontal.write(servoh);
 }
  delay(dtime);

}
```

(Code)



STATIC ANALYSIS



CIRCUIT SIMULATION AND DESIGN)

CONCLUSION:

It was presented the sensors programming of a two degrees-of-freedom azimuth and altitude OSPS prototype comprised by an Arduino microcontroller, two servomotors, and four light sensors (LDR in potentiometer configuration). The built light sensors were based on the voltage division principle that allows the shadow perception by one (or both) photo-resistors. The sensors emit the change in voltage that is perceived, and according to the algorithm, it is executed the comparison and decision making to send the commands to the servomotors, thus achieving the task of tracking the change in light intensity. Before being integrated into the prototype, arbitrary thresholds and saturation values of the sensors were found by exposing each sensor to light intensity (LED: regular light bulb, and ambient light) at different inclination angles of incidence. Later, the sensors were integrated into the tracker prototype and new light thresholds were established for the sensors. These values will be used by the microcontroller to assess the perpendicularity of the solar panel to the light rays. Before the lack of a lux meter instrument, the used method was an alternative for setting limits and values for sensor equations. To obtain better results when tracking the light rays using LDR sensors, a calibration process is recommended that follows the steps described according to the work environment. Later, they must be compared against a lux meter instrument to obtain a sensor equation associated with an uncertainty, the result of a calibration.

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