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Ardunio controller based spherical sun power generator for photovoltaic energy

Bekir Cirak

Abstract
In this study, the reflection of the sun rays directly on the spherical lens and its focusing in this lens is examined. Energy collection efficiency of such a spherical surface has been analyzed. Compared with traditional sun fixed panel and sun tracker panel. An experimental device is made to test the solar intake from all directions, including scattering and reflections from spherical lenses. In order to obtain maximum energy from spherical lens, a microcontroller based spherical lens system has been developed that takes into account both solar azimuth and altitude angles. Thus, the sun was monitored on the spherical lens based on real time data. The control unit used in this study was the ARDUINO UNO and L293D Motor Driver with real time clock. A program that instantly calculates the sun's movements (azimuth and elevation angles) using the solar geometry throughout the day and year was loaded on the ARDUINO. The angle values calculated by this program were converted into pulse width modulation signals and the spherical lens system was controlled using these signals. As a result of the experiments, it was observed that more energy was obtained by using a microcontroller-based spherical lens system. In addition, a low cost and easily programmed control system has been obtained that monitors the sun in real time, ensures stable operation of the system and consumes very little energy.

Keywords: Spherical lens, Ardunio controller, photosensitive, renewable energy

Introduction
Solar energy is the most energy source in the world. The sun is the world's main energy source. Most renewable energy sources, such as wind and ocean waves, are caused by the sun. Currently, photovoltaic (PV) based solar panels have been in commercial use for some time. PV module formation started with hard silicon solar cells. For this reason, there are technological advantages and innovations in the production and installation of flat panel solar panels. In the early 2000s, futurist Ray Kurzweil stated that with solar technology, it can meet all energy needs of the world in 20 years. He said that the amount of energy the Earth received in just one hour would be enough to make people's lives easier for a year.

German architect Andre Broessel, who thinks a lot about the insufficiency of the sun, invented a model, spherical lens device, designed to overcome the existing bottlenecks of technology. Basically, the Spherical lens concept is not a radical move from other panel technologies. Because it says solar cells are used to collect sunlight and more juice can be squeezed from the sun. It is the biggest sustainable energy source of the sun in the world. For more than 40 years, energy studies have been working to bring this resource to the first place. The problem is low efficiency: 80% of PV panels installed worldwide have up to 15% performance; however, if the panels do not watch the sun, the average annual slope losses increase by 70%.

According to Broessel, the conversion of light into energy can be optimized all year round, even in bad weather. It is unrealistic to think that energy efficiency can be doubled in a year. The conversion of light into energy can be optimized year-round, even in bad weather. Today, solar panels have revealed the need for designs that will reduce the cost of the system, facilitate the control of the system and increase the amount of electrical energy obtained from the system. some studies on the subject can be mentioned in the literature; Al-Mohammad presented a solar tracking design so that the motion of a photovoltaic module was controlled to track solar radiation using a programmable logic controller (PLC) unit [1].

Abdallah and Nijmeh have developed an PLC controlled open loop type solar tracking system [2]. Barakat et al. has designed a two-axis solar tracking system that operates with a closed circuit system and controlled by electronic circuits [3].

Chong and Wonga presented the most general form of sun-tracking formula that embraces all the possible on-axis tracking methods. The general sun-tracking formula not only can provide a general mathematical solution, but more significantly it can improve the sun-tracking accuracy by tackling the installation error of the solar collector [4].

Wang et al. presented an electromechanical, two axes sun tracking system based on single chip microcomputer (MCU) [5].

Abu-Khader et al. carried out an experimental investigation on the effect of using multi-axes sun-tracking systems on the electrical generation of a flat photovoltaic system (FPVS) in Jordan. In this study, multi-axes (N–S, E–W, vertical) electromechanical sun-tracking system was designed and constructed. The measured variables were compared with that at fixed axis. It was found that there was an overall increase of about 30–45% in the output power for the North–South axes (N–S)-tracking system compared to the fixed PV system [6].

Rubio et al. presented a control application of a sun tracker that is able to follow the sun with high accuracy without the necessity of either a precise procedure of installation or recalibration. A hybrid tracking system that consists of a combination of open loop tracking strategies based on solar movement models and closed loop strategies using a dynamic feedback controller is presented. Energy saving factors are taken into account, which implies that, among other factors, the sun is not constantly tracked with the same accuracy, to prevent energy overconsumption by the motors. Simulation and experimental results with a low cost two axes solar tracker are exposed, including a comparison between a classical open loop tracking strategy and the proposed hybrid one [7].

Khalifa performed an experimental study to investigate the effect of using a two-axes sun-tracking system on the thermal performance of compound parabolic concentrators (CPCs). The tracking CPC collector showed a better performance with an increase in the collected energy of up to 75% compared with an identical fixed collector [8].

Oner et al. conducted a study on a two-axes sun tracking system and obtained a higher performance [9].

Sungur implemented a single-axis (azimuth angle) sun tracking system with PLC control and obtained 32.5% more energy from the PV panels which track the sun compared to the PV panels at fixed positions [10]. Also a PLC controlled system which tracks the sun on both axes according to azimuth and altitude angles was developed and it was observed that 42.6% more energy was obtained in the two-axes sun tracking system when compared to the fixed system [11].

In the present study, a arduino controller -based two-axes sun tracking system which tracks the sun on both azimuth and altitude angles and which does not require photo sensors or pyranometers was developed in order to obtain the maximum energy from the sun. The azimuth and altitude angles were calculated by the arduino controller using the data on the latitude and longitude of the location of the PV panel. PWM signals that change based on the values of these angles were produced and used in order to control the actuator motors. The study aims to present information about PV panels and spherical lens systems. Detailed information about the arduino controller and the program which control the system is presented in the third section. The experimental results obtained through the suggested system are presented.

Photovoltaic Energy

Photovoltaic cells are devices that generate electricity from direct solar energy, which is among the renewable energy sources. They are produced in different sizes and different strengths. The power available is increased by connecting the panels in series or in parallel. The most important reason to prefer solar cells is that they benefit from a source that can be considered as infinite and do not create waste materials. However, filling these cells with full capacity is also an important issue, since the angle of incidence of solar rays in fixed panels is not always 90 degrees. In Sun tracker panels, maintenance and sensitivity of device elements may not be provided completely. As the spherical lens has the feature of focusing and concentrating the sun rays, it produces % 40 more energy than the sun tracker system and % 70 more than the fixed system [12].

Solar angles

The Earth has two different movements; it revolves around its own axis and revolves around the sun. Due to these movements, the sun's rays come to the earth at two different angles. These are called the azimuth angle and altitude angle [13].

Solar azimuth angle (a_s)

The angle of the sun's rays with the surface of the earth, from sunrise to sunset, is called the surface azimuth angle (equation1). The azimuth angle is calculated mathematically for each month, day and hour of the year as follows [14].

$$\cos(a_s) = \frac{\sin(\alpha)\sin(L) - \sin(\delta)}{\cos(\alpha)\cos(L)} \tag{1}$$

Where L is the local latitude (°), a_s the solar azimuth angle (°), δ the solar declination angle (°), and α the solar altitude angle (°).In the Northern hemisphere, the largest solar azimuth angle occurs as 232° on 4nd July. The smallest solar azimuth angle in the Northern hemisphere occurs as 26° on 4nd July.

Solar altitude angle (α)

The solar altitude angle (α) is defined as the angle between the horizontal plane of the earth's field and a point on the earth (Figure 1). In any period between sunrise and sunset, the solar altitude angle is calculated for each day of the year (Equation (2)). The sun altitude angle at sunrise and sunset time is 0 degrees. The maximum value of the solar altitude angle is the noon hours in all seasons. The solar altitude angle is calculated as follows [15].

$$\alpha = \sin^{-1}\left[\left[\cos(L)\cos(\delta)\cos(h_s)\right] + \left[\sin(L)\sin(\delta)\right]\right] \tag{2}$$

Where α is the solar altitude angle (°), L the local latitude (°), δ the solar declination angle (°) and h_s the hour angle (°). According to the calculations, in the Northern hemisphere in Siirt / Turkey, where the experiment was conducted, the highest value of the solar altitude angle is 68° in the summer months (4 July). The highest value of the solar altitude angle is 42 in the winter months (December 27).

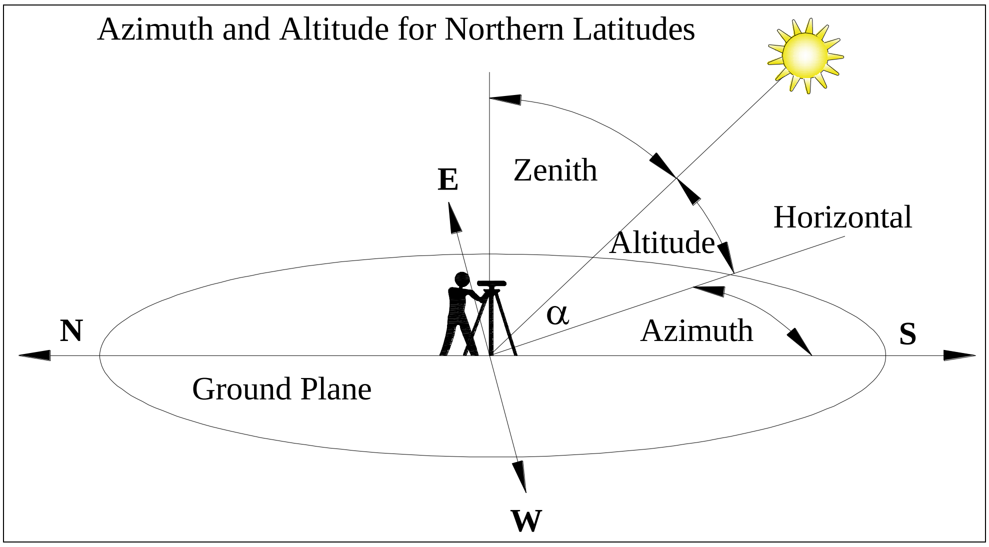


Fig 1: Solar azimuth and altitude angles [15]

Spherical Sun Power Generator

A spherical solar power generator, called spherical lens, was invented. It will produce twice the efficiency of a conventional solar panel in a much smaller surface area. At the same time, this spherical lens incorporates a hybrid collector to convert it into daily electricity and thermal energy. Developed by German architect Andre Broessel, this system charges and stores energy during the day, and can even collect energy from the moon and ambient lights at night. this system used a highly efficient multi-splicing cell. It reduced the surface of the cell to 1% compared to a conventional silicon cell, provided that it was the most appropriate and equal power output. The system produces twice the efficiency of a conventional panel. It has smaller cell area and lower carbon footprint. Because its production requires less valuable semiconductor or other building materials. Multi-link cells made of multiple materials respond to multiple light wavelengths, and some of the energy to be lost may be captured and transformed. Multi-articular cells can only work with condensing systems. Photovoltaic solar panels are 20-30 percent efficient. Solar radiation is 1000 watts / m^2. It has been shown by experiments that the panels that constantly turn to the sun will be more efficient if they are in the form of spheres. It is claimed that it produces 5-6 times more energy because of lensing in spherical lenses. More Light energy falls on the glass or lens surface in the Spherical lens system [16-17].

Through the movement of the frame following the sun, the sun's rays enter and focus on the spherical lens. Following the focus, the solar panel generates intense solar energy and sends it to the battery. The frame that follows the sun and the solar panel that follows the focus make these movements by means of sensors 1 and 2 - DC 1 motor and 2. Pinion gear is reflected on the solar panel by following the focused rays by rolling on the rack gear. As shown in Fig. 2.

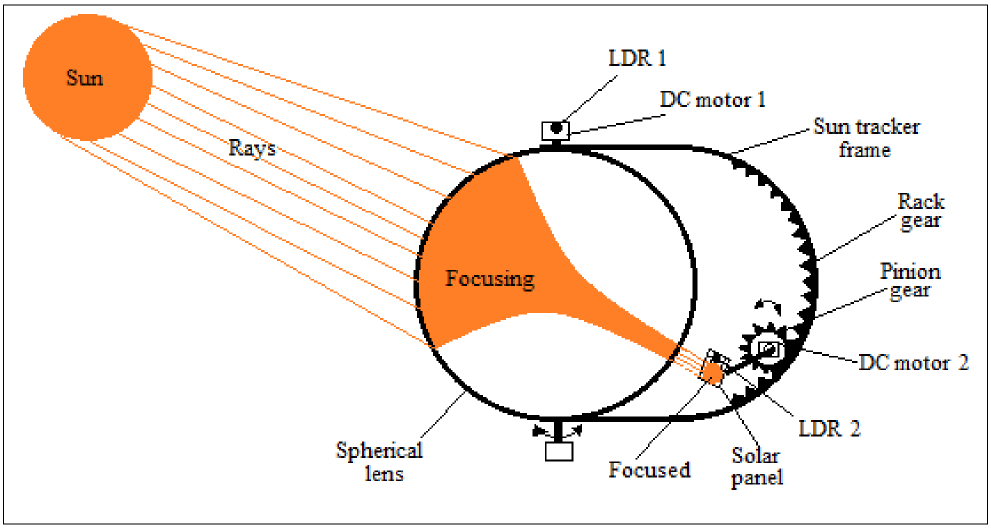


Fig 2: Parts and working principles of spherical sun power generator

The spherical lens power generator converts the rays received from the sun in the daytime to the electrical energy at night, from the ambient lights and from the moon. Thus, the conversion of light into energy can be optimized all year round, even in bad weather.

Spherical sun power system

In order to obtain maximum energy from the spherical lens, the sun's rays must fall vertically on the panel. For this purpose, spherical lens systems have been developed. Spherical lens systems consist of three main parts:

1. Sensors that detect the position of the sun or determine

the position of the sun by calculating the solar geometry
2. Control systems that produce the necessary control signals by evaluating the signals or calculation results from the sensors
3. Motor providing the necessary mechanical power to the drive circuits of the sphere frame following the focus and the sun following the sun.

Various disruptors occur during the application of these systems. Photosensor monitoring systems require the use of 2 different photosensors for biaxial monitoring applications. Also, instability occurs when one of the sensors is blocked or the weather is partly cloudy.

Different control elements are used in control systems such as PIC, PLC and other similar elements. Each of these control elements has specific programming methods. In mechanical systems, the drive is selected based on the motor type (DC motor, Step motor). The working principles of the motors used in the system prevent to obtain maximum energy from the sun. For example, in step motors, movement takes place in steps. Although solar rays initially fall vertically onto the panel, maximum energy cannot be obtained from step motorized systems because the solar azimuth angle changes during the time until step changes occur. In DC motors, a separate circuit must be used to change the direction [18-19].

Due to the negative aspects and results presented above, an actuator motor that can monitor instant changes in the angles of the sun and change the position and angle of the system according to the control signals is used in this study.

Depending on the movement and direction of rays in the morning and afternoon, the frame performs the motive 1 of the spherical lens. Depending on the focus of the rails, the focused viewer moves from the motion of the rack gear with the rack gear. This situation is shown in Figure 3

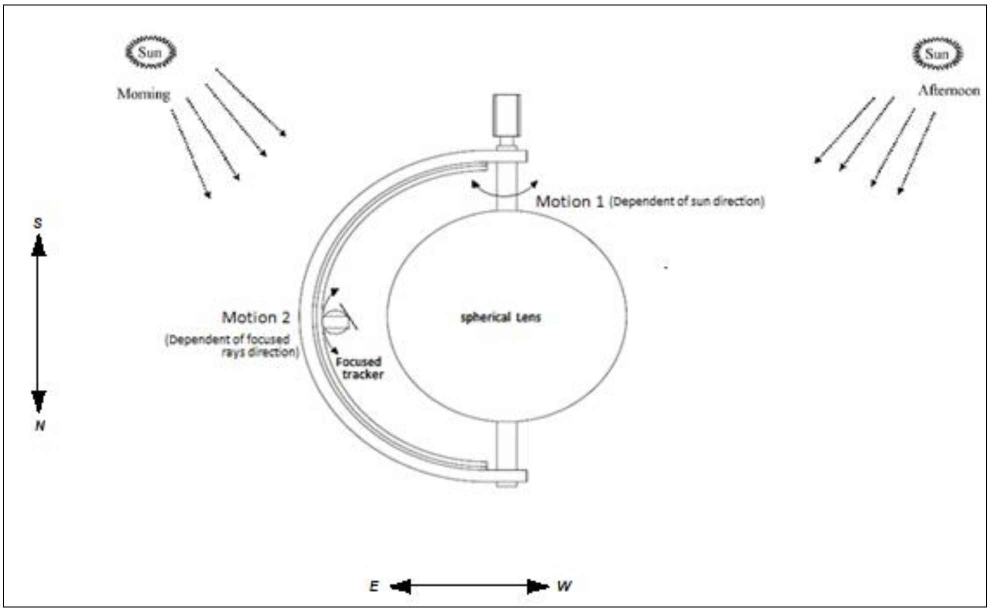


Fig 3: Motions and position of spherical sun power system in the morning and afternoon

Spherical Material

In this study, used spherical lense specification by model: optical ball lens, material:glass (none coating), shape:ball, structure: spherical, diameter : 0.5-150 mm. Fig.4 shows spherical lens.

Fig 4: Spherical Ball Lens [20].

Ball lenses are great optical components for improving signal coupling between fibers, emitters and detectors.They are also used in endoscopy, bar code scanning, ball pre-forms for aspheric lenses and sensor applications. Ball lenses are manufactured from a single substrate of glass and can focus or collimate light,depending upon the geometry oh the input source.They are commonly used for laser collimating and focusing, laser to fiber coupling, fiber to fiber coupling and fiber to detector coupling. Larger spheres are easier to handle ease the sensitivity of translational alingment. However smaller spheres has the benefit of fitting into smaller packages [20-21].

Spherical cells

More Light energy falls on the glass or lens surface in the Spherical lens system. Rawlemon mini cells are only % 1 the size of a conventional pv module. This situation is shown in Fig.5.

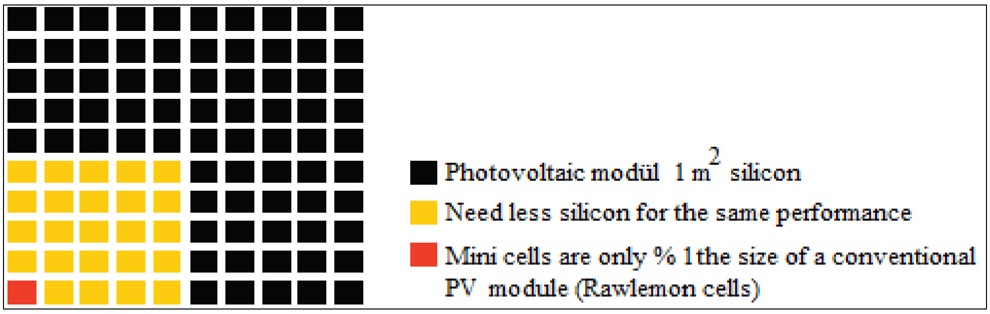


Fig 5: Comporasion spherical cell bettween conventional cells

Control Circuits

Arduino with L293D Motor Driver is used to control DC motors with Arduino. The L293D motor driver is capable of controlling both the speed and direction of rotation of two DC motors. Materials to be used for DC Motor Starting and Controlling Project with Arduino:

1. Arduino Uno R3
2. DC Motor
3. L293D Motor Driver
4. Breadboard
5. Jumper Cable
6. Power Supply (Battery etc.)
7. LDR
8. Resistor

To have full control over the DC motor, its speed and direction of rotation should be checked. Two techniques are used for this: PWM - for speed control, H-Bridge - for control of the direction of rotation (direction, forward - reverse, position).

DC motor speed control with PWM – Arduino

The speed of a DC motor can be controlled by changing the input voltage. To do this, a common technique PWM (Pulse Width Modulation) is used. PWM is a technique in which the average value of the input voltage is set by sending a series of ON-OFF triggers. Average voltage is proportional to the width of the pulses known as Duty Cycle. The higher the duty cycle, the higher the voltage applied to the dc motor (High Speed), and the lower the duty cycle, the lower the average voltage applied to the dc motor (Low Speed). Fig.6 shows the PWM technique with various work cycles and average voltages.

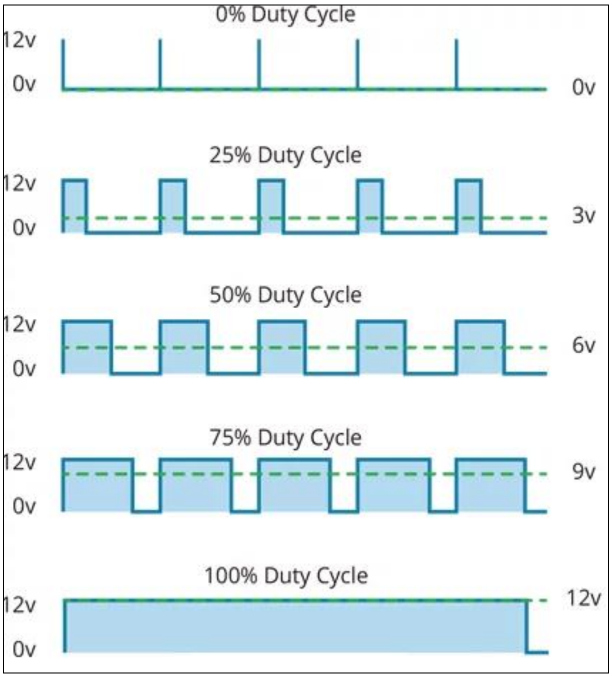


Fig 6: Working technique of PWM

DC motor speed control with H-Bridge – Arduino

The direction of rotation of the DC motor can be controlled by changing the polarity of the input voltage. A common technique for doing this is to use H-Bridge. An H-Bridge circuit contains four switches that form an H-like arrangement in the motor center. Turning off the two private switches simultaneously reverses the polarity of the voltage applied to the motor. This causes a change in the direction of rotation of the motor. Fig.7. Shows the operation of the H-Bridge circuit.

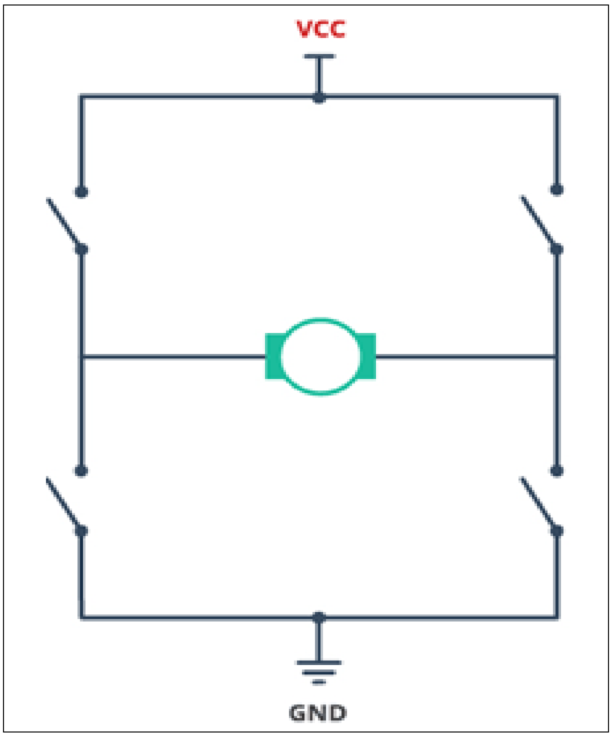


Fig 7: Working technique of H-Bridge

Using L293D motor driver with Arduino

The L293D motor driver is a dual channel H-Bridge motor driver that can use a dual DC motor or a stepper motor. With the L293D, two DC or stepper motor systems can be driven. Both can be driven by coding differently for the motor. L293D Motor Drive Energy Pin It is shown in Fig.8.

Where, GND 4, GMD 5, VCC1 16, VCC2 8, GND 13, GND 12 pins are the power connection pins of the L293D motor driver. The L293D motor driver actually has two power input pins. These are Vcc1 and Vcc2. Vcc1 is used to drive the internal logic circuit, which should be 5V.The transmitter Vcc2 pin transmits the required motor power from 4.5V to 36V with H-Bridge connection and both are connected to the GND pin.

The output pins for the L293D motor driver to transmit data to A and B motors are OUT1, OUT2 and OUT3, OUT4 pins respectively. These pins transmit voltage between 4.5V and 36V to two DC motors. Each pin on the motor drive can transmit electric current up to a maximum of 600 mA in DC motors. However, the amount of current supplied to the motor depends on the system's power supply (adapter, lipo battery, etc.)

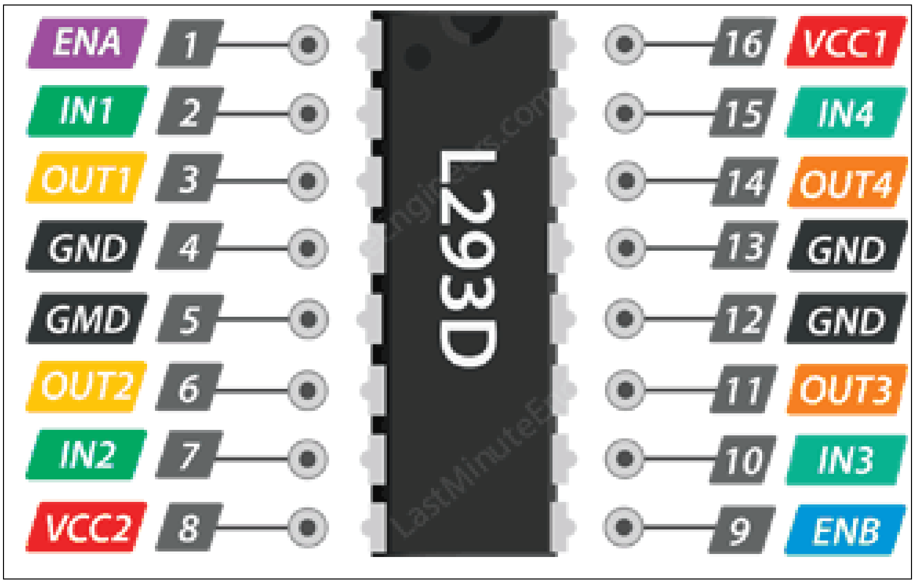


Fig 8: Connecting pins of L293 motor driver

There are two types of control pins for each of the L293D motor driver pins, which enable us to control the speed and rotation direction of DC motors simultaneously; Directional control pins and speed control pins. Using the directional control pins, it is possible to control whether the motor moves forward or backward. The position pins actually control the switches of the H-Bridge circuit inside the L293D motor driver. The L293d motor driver has two directional control, ie motion pins, for each channel. While IN1, IN2 pins control the movement and speed of the 1st dc motor, IN3, IN4 control the speed and movement, ie directional activity of the 2nd dc motor. Table 1shows how this is done.

Table 1: Effect of input pins on the motor

IN 1	IN 2	Motor Moves
Low (0)	Low (0)	Closed
High (1)	Low (0)	Forward
Low (0)	High (1)	Reverse
High (1)	High (1)	Closed

cxSpeed control pins are ENA and ENB. Speeds of 2 dc motor control are made with these pins. It controls the ENAA motor, the ENBB motor. The HIGH code applied to these pins enables the movement, that is, the rotation of the motors, while the LOW ensures that the motors stop. However, motor speed control can be achieved with Pulse Width Modulation (PWM).

In this study, arduino dc motors (Yellow TT motor) are used. The 9V power supply is connected to the Vcc2 pin. 5 Volts are then required for the L293D's logic circuit. The Vcc1 pin is connected to the 5V output in Arduino.L293D IC's input and enable pins (ENA, IN1, IN2, IN3, IN4 and ENB) are connected to six Arduino digital output pins (9, 8, 7, 5, 4 and 3). It is active for PWM (motor speed control) of both Arduino output pins 9 and 3.Finally, connect one motor (for Frame) to OUT1, OUT2 and the other motor (for Pinion gear) to OUT3, OUT4. Connections of your motor can be changed as left or right. The total connection and Arduino circuit of these experimental studies are shown in Fig.9.

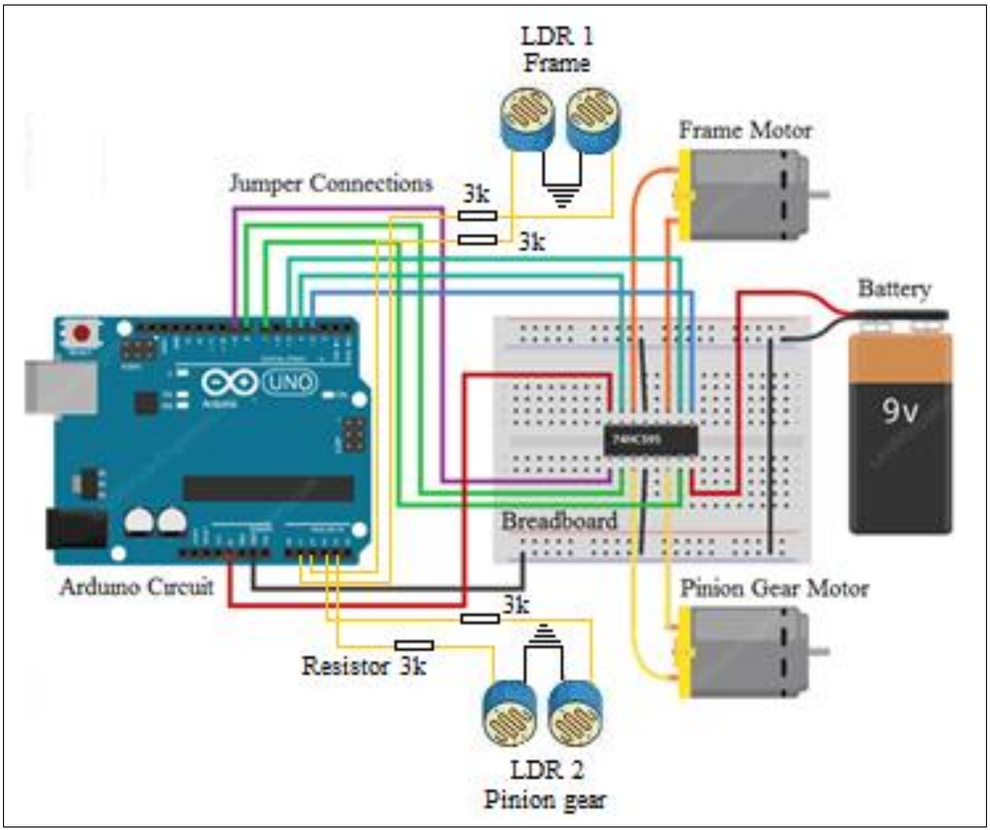


Fig 9: DC Motor Connection with Arduino and L293D Motor Driver

Arduıno software

The following programs and codes are used to control the speed and direction of rotation of a DC motor with the L293D motor driver.

Programs / Codes

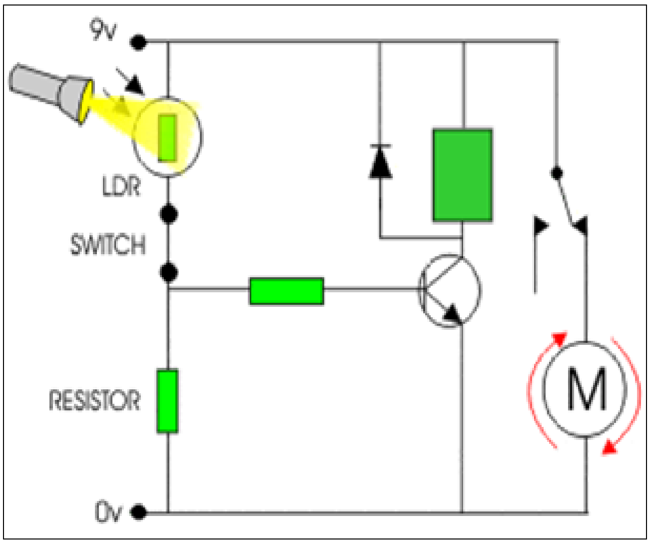
```
#include <Servo.f> //Servo libraries
//writed by Bekir Cirak
Servo frame;
int servof = 90;
int servofLimitHigh = 180;
int servofLimitLow = 10;
//motor pinleri
#define top 10
#define down 9
#define left 8
#define right 7
#define framespeed 12
#define pinionspeed 11
int dtime = 200;
int tol = 150;
int godown =50;
int gotop=10;
int servov = 90;
int servopLimitHigh = 175;
int servopLimitLow = 25;
// LDR pin connections
// name = analogpin;
```

```
int ldrlt = 2; //LDR frame left
int ldrrt = 3; //LDR frame right
int ldrtop = 1; //LDR pinion top
int ldrdn = 0; //LDR pinion down
void setup()
{
 Serial.begin(9600);
 // servo connections
 // name.attacht(pin);
pinMode(top, OUTPUT);
pinMode(down, OUTPUT);
pinMode(left, OUTPUT);
pinMode(right, OUTPUT);
pinMode(10, OUTPUT);
pinMode(9, OUTPUT);
pinMode(8, OUTPUT);
pinMode(7, OUTPUT);
pinMode(12, OUTPUT);
pinMode(11, OUTPUT);
/*frame.attach(11); // frame
pinion.attach(10); // pinion
frame.write(90);
pinion.write(90);*/
delay(2000);
}
void loop()
{
digitalWrite(11,HIGH);
digitalWrite(12,HIGH);
int lt = analogRead(ldrlt); // frame left
int rt = analogRead(ldrrt); // frame right
int ld = analogRead(ldrld); // pinion down
int rd = analogRead(ldrrd); // pinion top
// int tol = analogRead(0) / 4;
//int dtime = analogRead(5) / 4;
int dtime = 10;
int tol = 20;
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 dpinion = avt - avd; // check the diffirence of top and
down
int dframe = avl - avr;// check the diffirence og left and rigt
int ldrlt = 3; //LDR frame left
int ldrld = 4; //LDR frame right
int ldrrt = 2; //LDR pinion top
int ldrrd = 1; //LDR pinion down
Serial.print("lefttop= "); Serial.print(lt);
Serial.print(" ");
Serial.print("righttop= "); Serial.print(rt);
Serial.print(" ");
Serial.print("leftdown= "); Serial.print(ld);
Serial.print(" ");
Serial.print("rigtdown= "); Serial.println(rd); Serial.print("
");
Serial.print("time= "); Serial.print(dtime);
Serial.print(" ");
Serial.print("has.= "); Serial.print(tol);
Serial.println(" ");
if (-1 * tol > dpinion || dpinion > tol)
{
if (avt > avd)
{
Serial.println("top");
digitalWrite(top, LOW);
digitalWrite(down, HIGH);
digitalWrite(left, LOW);
digitalWrite(right, LOW);
delay(gotop);
}
else if (avt < avd)
{
Serial.println("down");
digitalWrite(top,HIGH);
digitalWrite(down, LOW);
digitalWrite(left, LOW);
digitalWrite(right, LOW);
delay(gotop);
}
}
if (-1 * tol > dframe || dframe > tol)
{
if (avl > avr)
{
Serial.println("toright");
digitalWrite(top, LOW);
digitalWrite(down, LOW);
digitalWrite(left, LOW);
digitalWrite(right, HIGH);
delay(20);
}
else if (avl < avr) {
Serial.println("to left");
digitalWrite(top, LOW);
digitalWrite(down, LOW);
digitalWrite(left, HIGH);
digitalWrite(right, LOW);
delay(godown);
}
else if (avl = avr)
 // nothing
}
}
digitalWrite(top, LOW);
digitalWrite(down, LOW);
digitalWrite(left, LOW);
digitalWrite(right, LOW);
delay(10);
```

The codes begin by defining the Arduino pins to which the control pins of the L293D are connected. In the setup section of the code, all motor control pins define digital OUTPUT, both motors as LOW or OFF. In the loop section of the code, two user-defined code functions are used at one-second intervals. directionControl () - This function functions to rotate forward at maximum speed for two seconds for 2 dc motor control. It then reverses the direction of rotation of the motor and rotates for two more seconds. Eventually it turns the engines off. speedControl () - This function generates PWM signals using the analogWrite () function, accelerates both motors from zero to maximum speed, then returns to zero again. Eventually it turns the engines off.

Ldr: Ldr is a light sensitive circuit element. It has a working principle inversely proportional with the light intensity falling on it. As the light intensity decreases, its resistance value decreases and as the light intensity

decreases, the resistance value increases. Ldr act as a switch by changing their resistance values. If we look at it from another angle, they also function as an optical sensor. They deteriorate under extreme temperatures (Maximum: 65 °C). The control of the M motor with Ldr is shown in Figure 10.
Although Ldr is a kind of resistance, it is also a passive sensor. It controls the ambient light and triggers the electrical circuit to which it is connected. If Ldr is used in a circuit or system, it should be understood that a photosensitive response has occurred or the light level has been checked. The Ldr initial principle is presented in Fig. 11 [24-25].



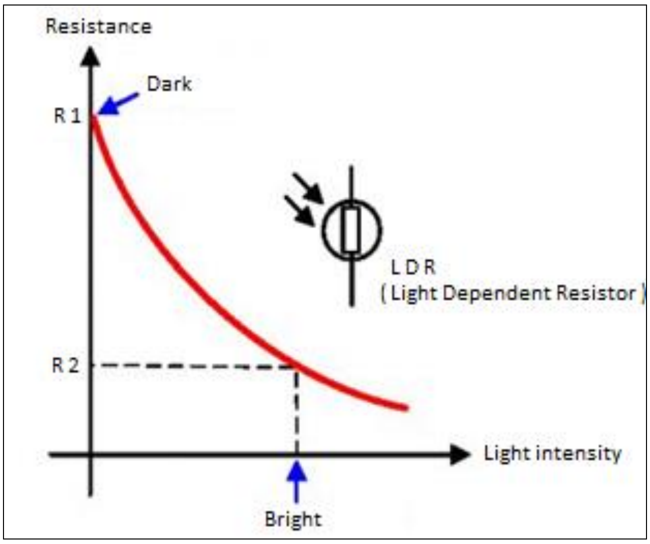


Fig 10: Control of M motor with Ldr Fig. 11 Ldr runing principle

Experimental Results

The spherical lenses designed in this study, 41.7 ° latitude in the northern hemisphere was tested in Turkey's Siirt. Calculations were made for the province of Siirt. The average amount of energy obtained from all three systems in Siirt and the power usage times during the day hours are shown in Figure 12. In this graph, it is seen that the province of Siirt uses solar energy for an average period of 10 hours. Since solar energy cannot be collected from the PV panel after this 10 hour period, the PV panels of the fixed and sun tracker systems are brought to zero position and the system goes into standby mode until the sun rises. In this way, it is aimed to save energy and reduce mechanical fatigue and wear. However, the situation of the spherical lens system is different here. Because the spherical lens system receives energy from the moon and ambient lights at night. And it charges the battery as focused and concentrated energy. For this reason, there is no standby mode in the spherical lens.
The voltage and power change values obtained as a result of the movement of the PV panel with the sensor-based classical method and the voltage and power change values obtained by rotating the panel were compared by calculating the azimuth and slope angles without the need for sensors. Also, the total voltage and power change values of the day and night obtained from the spherical lens are included in this comparison. In Fig. 12, it can be seen that using the spherical lens system, more voltage is generated and more power is obtained than the conventional two systems. Under equal conditions, the fixed system converts the energy from the sun to 55 w and the Sun tracker system to 65 w, while the spherical system generates 80 w.

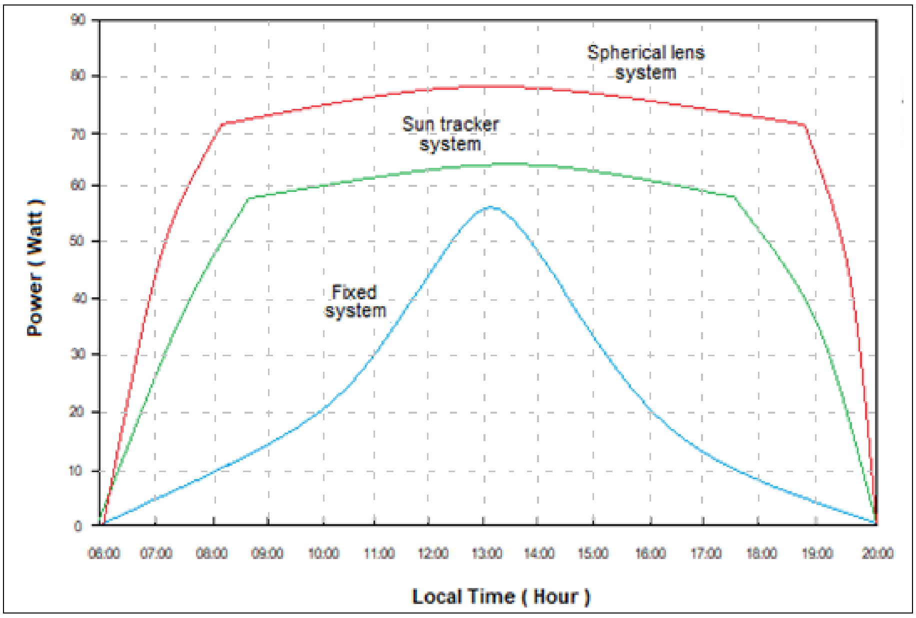


Fig 12: Energy comparison of fixed - sun tracker - spherical lens systems

Comparison of power values between fixed sytem, sun tracker and spherical lens sytem is shown in Fig 12. In the city of Siirt in Turkey, data were collected from the sun between the hours of 06:00 and 20:00 on July 4, 2020. These data were taken for fixed, sun tracker and spherical lens systems. Data were read in 3 systems at the same time. and the graph curve ie the comparison curve Fig.12. It was formed. In this study, controlling the spherical lens system with micro controller constituted the main study. The comparison of power values between fixed sytem, sun tracker and spherical lens sytem is shown in Fig 12. In the city of Siirt in Turkey, data were collected from the sun between the hours of 06:00 and 20:00 on July 4, 2020. These data were taken for fixed, sun tracker and spherical lens systems. Data were read in 3 systems at the same time. and the graph curve ie the comparison curve Fig.13. It was formed. In this study, controlling the spherical lens system with a micro controller constituted the main study.

Conclusion

In this study, a spherical solar generator system has been developed that monitors the sun in real time at both azimuth and altitude angles and does not require photo sensors. Developed as a system microcontroller based spherical solar generator system, tested in the Turkey's Siirt and the sun with the developed spherical lens system, according to a fixed system and a tracker system has been shown to obtain more energy. Using the system developed in this study, the sun was monitored in real time, regardless of whether the weather was clear or cloudy, day and night. Under the same conditions, for each of the three systems, between the hours of 06:00 and 20:00 on July 4, 2020, each system has its own measurement. Since the monitoring was carried out in real time, no change in the energy obtained was observed. Spherical system, on the other hand, produced more power than sun tracker system.Compared to the stationary system that produces 55 watts of energy, the solar tracking system produced 65 watts of energy. This redundancy is that it absorbs rays from the sun up to 90º using the alpha angle perpendicular to the sun. The spherical system produced more power than the solar tracking system. This value is 80 watts. The reason for this excess is that it takes intense focus by focusing on the rays coming from the sun. When proportional calculation is made here, it is seen that the spherical lens system achieves 70% more energy than the fixed system and 20% more energy than the sun tracker system.

Nomenclature

a_s solar azimuth angle
α solar altitude angle
L local altitude
δ solar declination angle
h_s hour angle
E irradiation
T temperature
V voltage
A current
Wp peak watt

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