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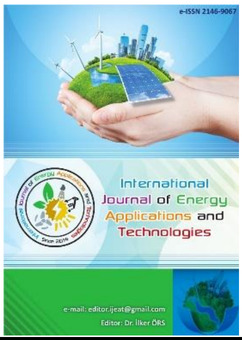

Original Research Article

The design of biaxial solar tracking with a smart house model

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ABSTRACT

In this study, it is aimed to determine and reveal a viable two-axis solar monitoring system that produces higher voltage output than a fixed panel. After intensive research, a small-scale solar panel, servo motors, arduino processor as controller, and a two-axis solar tracker using a transmitter wirelessly transmitting voltage feedback were carried out.
In addition, a 'Smart House' model that makes our current lives safer and more practical has been investigated. Remote control of the smart home system has been analyzed. For remote control of the smart home model, the IoT (Internet of Things) structure uses the MQTT Protocol, NodeMCU (ESP8266) Control Card and sensors of different features to build this structure. Signals from sensors are directed to MQTT Broker with the help of the NodeMCU (ESP8266) Control Card. Phone control is provided through the mobile app, which is written using QML and C++ languages in the QT Creator IDE.

Keywords: Solar house; Biaxial; Smart house; Internet; Sensors

1. Introduction

Solar power stands out as the most reliable source of renewable energy sources. With reliability, the fact that the sun releases and transmits 10,000 times the energy consumed in the world at any time makes solar energy more interesting [1].
About 30% of the energy emitted from the sun is reflected in the atmosphere, while 20% are spent in the atmosphere and 50% reach the earth. The ratio of energy directly to the earth's surface may change due to weather conditions. In a closed air, the sun's rays are more exposed to clouds and weaken energy as they are exposed to scattering, but in open air the rays will have higher energy for the direct future. Weather conditions are therefore of great importance in systems using solar energy [2].
As mentioned above, the integrated use of solar energy with the grid is a new and emerging issue. For this reason, it is more frequently encountered with network-independent and mostly mobile applications [3].
Photovoltaic (PV) effect; electrical potential between the common function of two different materials exposed to solar radiation. The PV cell converts light directly to electricity with this effect. This effect was found by French physicist Becquerel in 1839. Solar cells can be used in any application where electrical energy is required [4]. Solar cell modules depending on the application; accumulators, firefighters, battery charging control devices and various electronic support circuits to form a solar cell system (photovoltaic system). These systems are used especially in areas away from settlements, without electricity grids, where it is difficult and expensive to transport fuel to the generator [5].
In addition, it is possible to use it as a hybrid with diesel generators or other power systems. A photovoltaic system converts solar energy into electrical energy to feed the load that works with the correct current (DC) or alternative current

(AC). The electricity produced is DC. From here, a load that works with the right current can be fed. Since the sun's radiation is not continuous and stable, there may be situations where the load is inadequate in feeding. It can also occur when the energy produced is greater than the system needs [6]. This surplus energy can be stored in batteries, providing energy for time zones where solar radiation is inadequate. The load requested to run may be running with the alternative current. In this case, an inverter is used to convert the correct current into an alternative current. Photovoltaic systems can be built independently of the local power grid to feed electrical loads located in remote locations. However, photovoltaic systems located close to the local power grid can be arranged so that they can transfer energy to the grid [7].

2. Materials and Method

In this study, solar cells, Arduino UNO, MG 996-R Servo Motor (2 Grain), Photo resistance (LDR) (4 Grain), 10K Ohm resistance (4 Grain), 12V 7A Accumulator (optional), 2 Axis pan tilt (servo motor kit), Jumper cables, LM-2596 DC-DC converter and Miscellaneous project equipment were used.

2.1. Servo motor

Servo is defined as a drive system that performs angular-linear position, speed and acceleration control in an error-free manner in the mechanisms. So it's a movement control device. Servo motors are the most widely used engine variety in robot technologies, but are also used in RC (Radio Control) applications. RC Servo Motors were first used in remote-controlled model vehicles. The servos are designed to take the desired position and not change the position it is in unless a new command is received [11].

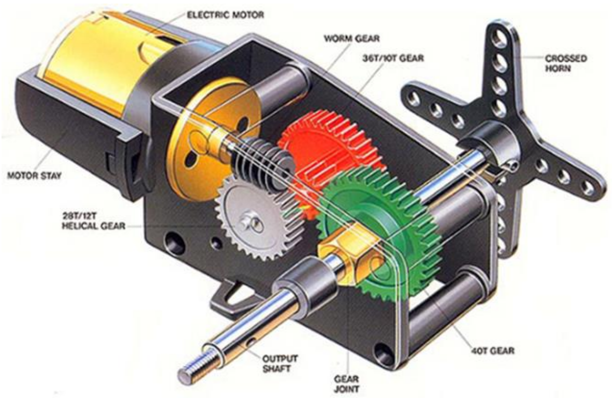

Fig. 1. Servo motor structure [11]

Servo motors have a DC engine that allows the engine to move. Outside this engine there is a gear mechanism, a potentialacymeter and an engine drive circuit. The potentialanion measures the rotation amount of the motor shaft. As the DC engine in the servo moves, the potentialacymeter rotates and the control circuit compares the position of the engine with the desired position and performs the engine riding process. In other words, servos operate without the need for an external engine driver like other engines. Generally, operating angles are limited to 180 degrees, but there are also special purpose servo motors with a working angle of 360 degrees. Servos usually operate with a voltage of 4.8-6V. There are also 7.4V and higher voltage-operated servos (Figure 1) [12].

2.2. Two axis pan tilt

Slope support kit for SG90 servo motors. The slope support, where two servos can be added, consists of mounting table and adjustment screws. Camera position control can be used in applications including sensor control and radio control applications for robotics. Horizontal rotation range: 180º Tilt range: 135º (Figure 2) [13].

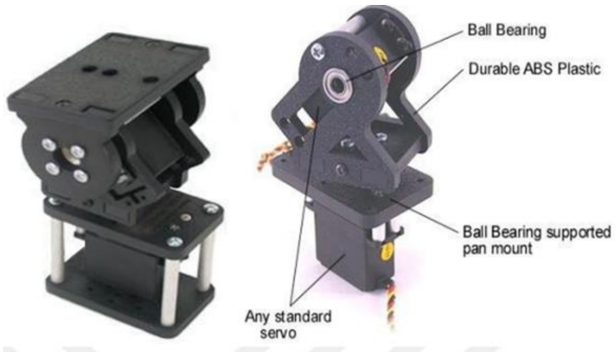

Fig. 2. Axis pan tilt [13]

2.3. Application

First, solid modeling was drawn with the Solidworks program by reducing the size of a normal house at a scale of 1:10 (5000*6000*3000 mm) with Solidworks program (Figure 3).

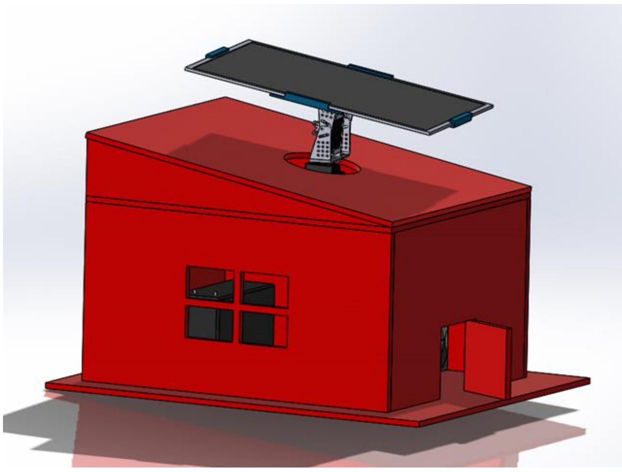

Fig. 3. Solid model of the solar house drawn with Solidworks

MDF chipboard parts were cut for household material by taking measurements from the drawn parts.

The bottom part of the house and the ceiling part were glued with fast glue. In order to avoid image pollution, electronic circuit elements Arduino UNO and LM 2596 DC-DC converter are fixed on top of the roof. The solar panel holder M3, which is specially made to the top of the pan tilt, which is installed, is connected with bolts and nuts. A bow is attached to the front of the house to ensure the ease of vertical movement. The light dependent resistor (ldr) separator is mounted on the top of the holder and placed inside the solar panel holder (Figure 4).

Fig. 4. Two-axis pan tilt and solar panel assembly

After this process, light dependent resistor (ldr) are placed on the holder. The reason for the use of differentials between ldr is because it can better detect light (Figure 5).

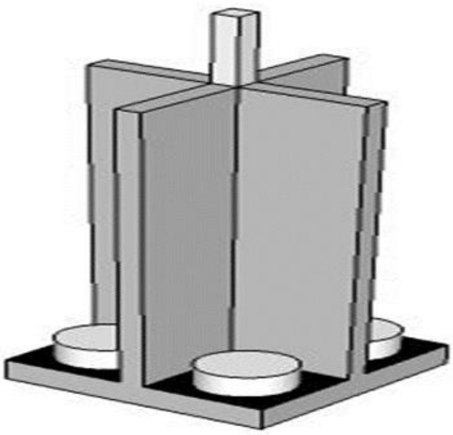

Fig. 5. Light dependent resistor

After the mechanical process of the project is finished, the electronics section is switched. Cable connections are made according to the electrical circuit diagram. In addition, we connect the + and – ends of servo motors to the LM2596 DC-DC converter, which is due to the fact that the card we use cannot provide enough electrical power. As mentioned in the Arduino issue, the card is fed with a 5 volt voltage, while 6 volt voltage is required for the servo motor, so we connect the power inputs to the converter when connecting the servo motor's info pin to the ardunio. The inputs of the converter are also directly linked to the battery (Figure 6).
Finally, arduino's codes were written and the final version of our solar house project appears in Figure 7.

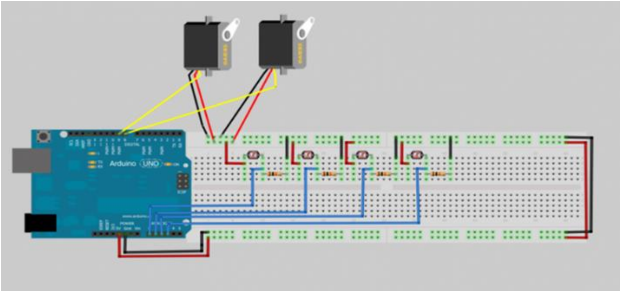

Fig. 6. Electrical circuit diagram

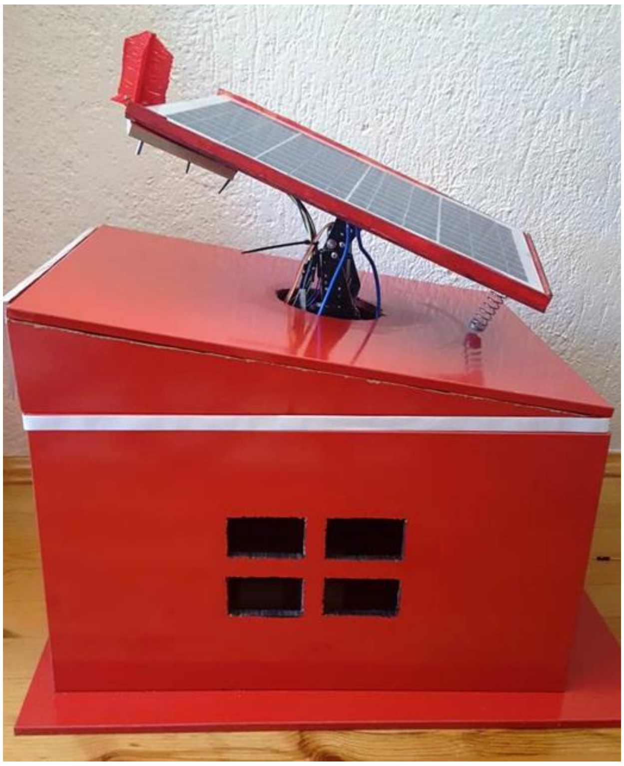

Fig. 7. The final version of the solar house

2.4. Analysis applications

The house, which was designed according to the measurements of 600*300*500 mm in the SolidWorks program, was magnified at a scale of 100:1 and brought to 60000*30000*50000 (Figure 8). In other sizes, it was multiplied by 10. Pre-preparations were made for analysis by transferring to spaceclaim program. After the operations were completed, analysis of 4 bolts connected to the pan tilt base was analyzed with the Ansys program, analysis of the holes that were affected by the moment on the pan tilt, and pan tilt strain analyses in general.

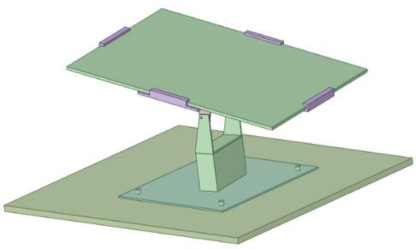

Fig. 8. Spaceclaim screenshot

In order to avoid any weight that does not load on them, the discharged holes, servo motors and servo motor holders were canceled and the analysis was planned to be done in a shorter time (Figure 9 and 10). The following are the strain distributions that come upon pan tilt and holes.

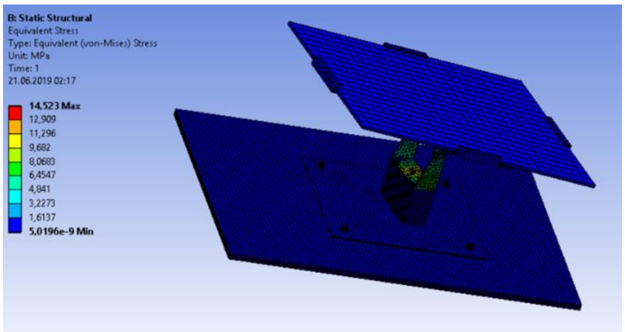

Fig. 9. Stress distribution

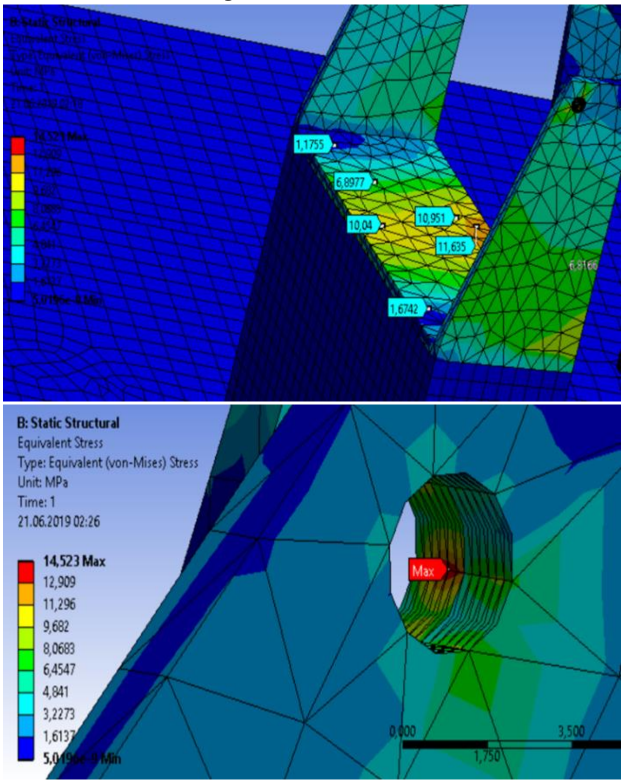

Fig. 10. Stress-intensive regions (N/mm^2)

The load voltage on the bolt, the load voltage, graph and table that come on to the bolt axis are given below (Figure 11-13).

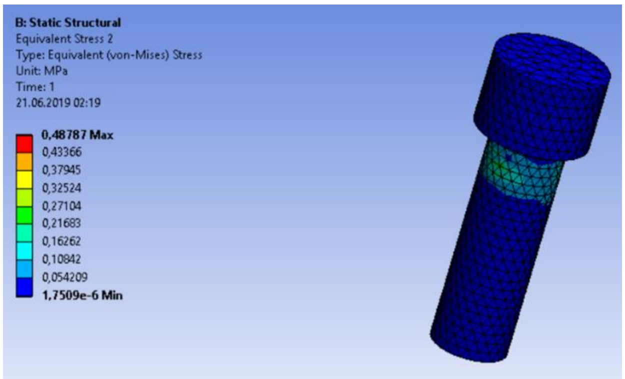

Fig. 11. Stress distribution at the bolt

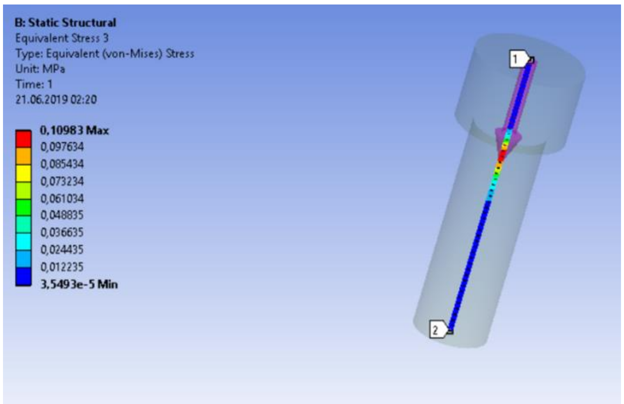

Fig. 12. Stress distribution in the axis of the bolt

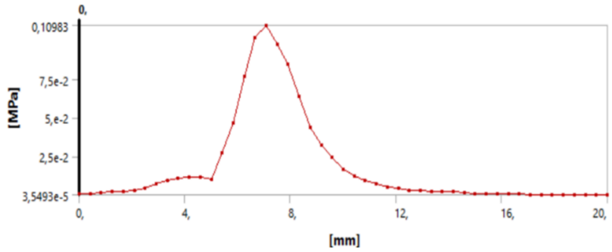

Fig. 13. Stress distribution graph on the axis of the bolt

The servo motor, which provides vertical movement, has a 20º angle and an 80º angle for the servo motor that provides horizontal movement. Within these limitations, strain analysis was carried out in areas with servo motor connections with pan tilt. The forces that come after the horizontal movement servo motor can make 80º angles are given below (Figure 14).

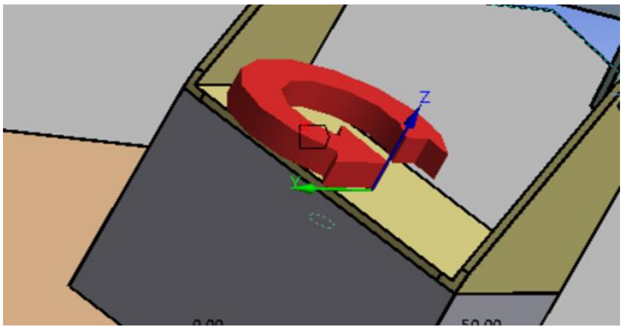

Fig. 14. Forces on axes for horizontal servo motor

The following are the forces that come after the vertical lyo motor can make 20º angles (Figure 15).

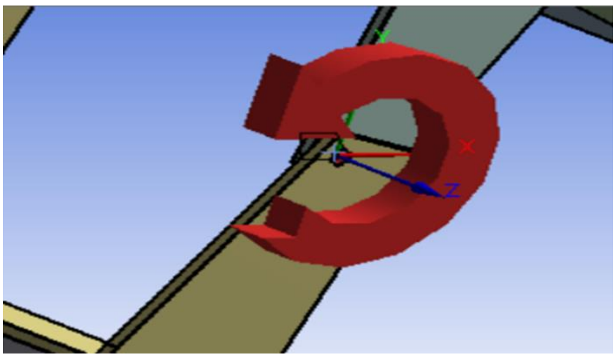

Fig. 15. Forces on axes for vertical servo motor

As noticed, the Z axis for the horizontal servo motor is more than enough force to the Y-axis in the vertical servo motor. Because these axes are parallel to the incoming force, their values are high.
Finally, the following are the terms of the limit used in the analysis (Figure 16).

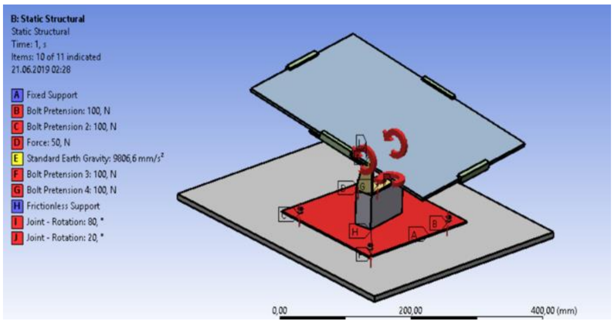

Fig. 16. Boundary conditions

In terms of analysis, we based the pan tilt and other parts we designed as if they were a completely full piece by filling the holes we had emptied to avoid making weights when preparing them for analysis in the cad program spaceclaim, and we canceled the radiates and accepted them as sharp corners, and the reason we did it was preferred to ensure that the analysis was finished in less time. That prevented him from giving us the exact optimum result. If we want to achieve the optimum result, it will be to analyze the piece we designed as one-on-one. For this, you need to have a very high-level computer with features. A multi-featured computer also means a very costly computer. However, our analysis is also within the acceptable limit. In real life, the safety coefficient is assigned in manual calculations and made available for unsuitable conditions by the engineer who designed it. For this reason, our static analysis is considered appropriate.

3. Adapting to The Smart Home Model

3.1. What is IoT?

The Internet of Things (IoT) is defined as a worldwide network of objects that are uniquely addressable among themselves, and objects on that network are in contact with each other with a specific protocol". Also this concept is rough; It is also possible to identify each other as a system of devices that communicate with each other and connect together and create a smart network by sharing information through various communication protocols [14].

3.2. What is the MQTT protocol?

Message Queuing Telemetry Transport is a communication protocol used to send the MQTT message to the other side (Figure 17). The administrator who controls this communication traffic is called BROKER, PUBLISH to the message publication, and subscribe to this message publication [15].

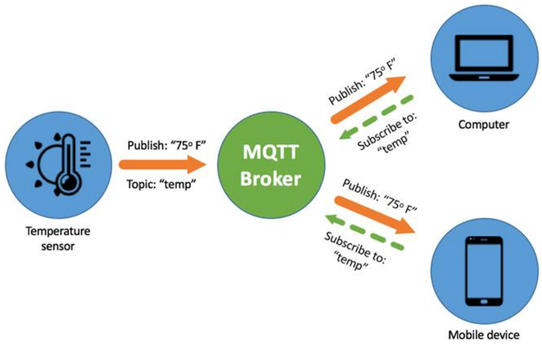

Fig. 17. MQTT Work Logic Chart

3.3. What is NodeMCU (ESP8266)?

NodeMCU (Figure 18) is an open source control unit. The unit, which has a large area of use; It solves many problems by using what we call the "internet of things". It is a control unit that is required to provide a data transfer between individuals and objects over the Internet [16].
NodeMCU, a micro chip; The ESP8266 type is located on a microchip set. NodeMCU with sizes up to a coin; contains software in it. Thanks to this software, it becomes smart, so it becomes able to process. NodeMCU; in a sense, it's like a microcomputer (Figure 19). Of course, it does much simpler things than a computer, but it is imperative for an object to become smart by transferring data, i.e. to have the Internet [14].


Fig. 18. NodeMCU

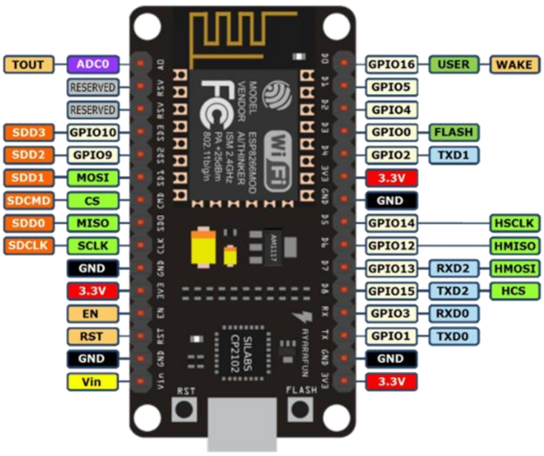

Fig. 19. NodeMCU Pins

3.4. Programming the NodeMCU control card

Sensors are integrated into the NodeMCU Control Card using jumper cables and resistors. Programming was developed using C language in the Arduino IDE environment.

3.5. Designing mobile application

A hybrid mobile app has been written to run on Android and IOS using QML and C++ languages in qt environment for remote control of the home model with internet connection and sensors (Figure 20 and 21). This application has been developed to work in parallel with the software of the NodeMCU card [17].

Fig. 20. Login Screen

Fig. 21. Home page

As soon as the button on the Home Screen is pressed, the home is connected and the home opens 4 different features of the house to be checked separately. These 4 features include:

- Temperature and humidity status of the house
- Lighting and extinguishing the lights of the house
- Opening and closing of the door
- Automatic or manual control of the solar panel.

When the panel is taken to Manual Mode, lds (light sensors) on the roof are deactive and the panel can perform right-left and up-and-down movements under the user's control.

When the panel is taken to Auto Mode, the LDS (light sensors) on the roof are active, and the panel now automatically begins to move to the angle at which the sun comes from.

In this system, the energy provided from the sun is stored in the battery with the help of the Panel. The energy stored in the battery is used to measure the lights of the house, the opening and closing of the door, the movement of the panel and the temperature of the house.

4. Results and Discussion

In this study, the two-axis solar monitoring system allows it to use solar energy more effectively. Although costly according to fixed mechanisms, it appears to be a project that can pay itself off soon after it is being used.

Unlike similar studies, the servo motor kits were examined, thinking that the pan tilt would take up much space inside the house, and the appropriate servo motor kit was reverse engineered and designed to be compatible with the servo motor MG 996-R, which we will use.

The goal of doing this study was to test whether it would succeed in a real house 10 times the size of the house we built. Considering multiple mechanisms, the appropriate mechanism for a solar panel of this size has been selected. In choosing the mechanism, it was our priority to shrink and fit their size into the roof using little material. It was a disadvantage like the cost to us. We had to use material with better tensile, flow and rupture values in the selection of materials. As a result of computer-media analysis and observations, it was concluded that the project was appropriate. However, in real life, such reasons as natural phenomena and the increased wind as height increased, such a system was not considered appropriate to be used unless necessary.

This system may be suitable for projects that will be used by fixing more places. The advantage of the two-axis solar monitoring system was that it achieved a yield increase of around 30-40% according to a fixed mechanism. The disadvantage of the system is that it is costly according to the fixed mechanism. However, it should be remembered that the servo motor and cards used in the two-axis solar monitoring system consume energy. Optimum engine and card selection should be made. The energy that the system will provide us should be more than the fixed mechanism.

Finally, in our country; Projects should be developed in terms of clean and cheap renewable energy systems and technological developments in response to the ever-increasing energy needs and to spread these projects with the support of the state by providing the necessary support and taking into account the economic and social structure.

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