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# Maximum Solar Energy Saving For Sterling Dish with Solar Tracker Control System

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## ABSTRACT

Solar tracking allows more energy to be produced because the solar tracking control system is able to keep equipment like sun dish and photovoltaic cell align with sun. The output power produced by high-concentration solar thermal and sun dish systems is directly related to the amount of solar energy acquired by the system. It is therefore necessary to track the sun's position with a high degree of accuracy .There are actually several solutions to solve this problem. Accordingly, this project will include the design and construction of a microcontroller-based solar dish tracking system and commences by providing a high level overview of the sun tracking system field and then describes some of the more significant proposals for closed-loop and open-loop types of sun tracking systems and finally Thermal energy produced by sun dish can be used for one cycle of sterling motor and cooker and absorption chiller to generate electricity.

**KEYWORDS**: Microcontroller, Sun dish, Sun position, Sterling motor, Thermal energy, IR sensor.

## 1. INTRODUCTION

Renewable energy solutions are becoming increasingly popular. Solar energy systems have emerged as a viable source of renewable energy over the past two or three decades, and are now widely used for a variety of industrial and domestic applications. Such systems are based on a solar collector, solar dish, designed to collect the sun's energy and to convert it into either electrical power or thermal energy. As such, it is vital that those in engineering fields understand the technologies associated with this area. In order to maximize power output from the solar panels, one needs to keep the sun dish aligned with the sun. Such as, a means of tracking the sun is required.

In general, the power developed in such applications depends fundamentally upon the amount of solar energy captured by the collector, and thus the problem of developing tracking schemes capable of following the trajectory of the sun throughout the course of the day on a year-round basis has received significant coverage in the literature. For example, various schemes have been proposed for optimizing the tilt angle and orientation of solar collectors designed for different geographical Latitudes or possible utilization periods In general, the results showed that by using mathematical models to optimize the tilt angle and orientation of the solar collector, a yearly gain of more than 20-60%could be obtained in the captured solar radiation compared to the case in which the collector was fixed on a horizontal surface.

This project will include the design and construction of a microcontroller-based solar dish tracking system and commences by providing a high level overview of the sun tracking system field and then describes some of the more significant proposals for closed-loop and Open-loop types of sun tracking systems and finally Thermal energy produced by sun dish can be used for one cycle of sterling motor to generate electricity and cooker and absorption chillers (A.K. Saxena and V. Dutta, 1990 ).

## METHODOLOGY AND DESIGN

### *Closed-loop for Sun Tracking System*

Closed-loop types of sun tracking systems are based on feedback control principles. As shown in (*Fig. 1*),after turning on the control system, first system check the Auto/Manual switch, if it's state is high(it means auto mode),the control system start searching function to follow the sun light . To accomplish this, there are 4 IR sensors are used to find the sun position. Sensors output will transfer to micro controller in continue micro controller (AT Mega 32), reads light sensors value a compares them and then positioning motors to align with the greatest value which corresponds to the sun's position.

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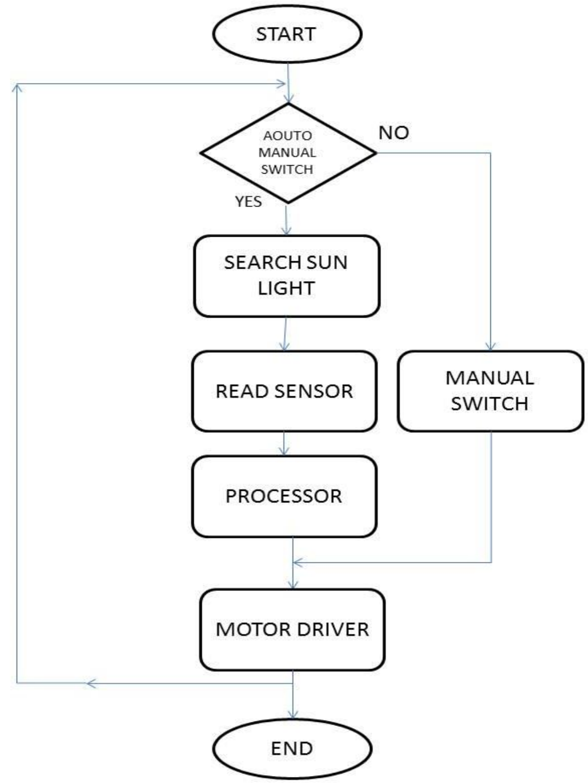


***Figure 1**: overall sun tracking control system flowchart*

Finally as shown in (*Fig. 1*), the thermal energy that produced by sun dish can drive the sterling motor as hot cylinder to generate electricity.

### *Open-loop for Sun Tracking System*

According to discusses in closed loop sun tracking control system if the auto / manual switch became low manual function will be run. In this mode operator will be able to control sun dish with orientation release to achieve maximum amount of sun light.

***Figure 2**: installed sterling motor upon sun dish*

## Motor and motor drive design

### *Stepper Motor and Driver Theory*

Stepper motors are commonly used for precision positioning control applications (R. Condit and D. W. Jones, 2004). All stepper motors possess five common characteristics which make them ideal for this Application. Namely, they are brushless, load independent; have open loop positioning Capability, good holding torque, and excellent response characteristics. There are three types of stepper motors: permanent magnet, variable reluctance, and hybrid. The Arrangement of windings on the stator is the main distinguishing factor between the three types. Permanent magnet motors may be wound either with unipolar or bipolar windings. The sun tracker uses a unipolar step motor. As such, discussion will be limited to this type of stepper motor. Unipolar motors have two windings with each having a center tap as shown in *(Fig. 3)*.

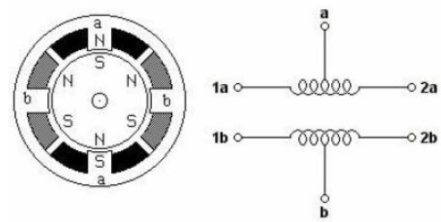


***Figure 3*****:** *Unipolar Stepper Motor Coils*

The center taps are connected to a positive voltage while the coil ends are alternately grounded to cause a reversal of the field direction in that winding. (*Fig. 3)* shows 4-phase motor. The number of phases is equal to two times the number of coils. The motor is rotated by applying power to the windings in a sequence as shown in Table 1.

***Table 1:*** *Standard Drive Sequence Example*

Clockwise Rotation

| Index | 1a | 1b | 2a | 2b |
|---|---|---|---|---|
| 1 | 1 | 0 | 0 | 0 |
| 2 | 0 | 1 | 0 | 0 |
| 3 | 0 | 0 | 1 | 0 |
| 4 | 0 | 0 | 0 | 1 |
| 5 | 1 | 0 | 0 | 0 |
| 6 | 0 | 1 | 0 | 0 |
| 7 | 0 | 0 | 1 | 0 |
| 8 | 0 | 0 | 0 | 1 |

The motor may also be half-stepped. Half-stepping is achieved by first energizing one

Coil, then two coils, then one coil, etc. The motor specifically used in the project was a 5 volt, 7.5 degree-per-step, 4 Phase, unipolar motor. It was decided to half-step the motor in order to provide greater positioning accuracy. This results in 3.75 degrees-per-step. The drive sequence used in this design is shown in Table 2. Lastly, a control circuit is needed to drive the stepper motor. The basic control circuit for a unipolar stepper motor is shown in *(Fig 4)*.

***Table 2:*** *Actual Half-Step Sequence Utilized*

| Index Position | Y2 | Y1 | X2 | X1 |
|---|---|---|---|---|
| 1 | 0 | 1 | 0 | 1 |
| 2 | 0 | 0 | 0 | 1 |
| 3 | 1 | 0 | 0 | 1 |
| 4 | 1 | 0 | 0 | 0 |
| 5 | 1 | 0 | 1 | 0 |
| 6 | 0 | 0 | 1 | 0 |
| 7 | 0 | 1 | 1 | 0 |
| 8 | 0 | 1 | 0 | 0 |

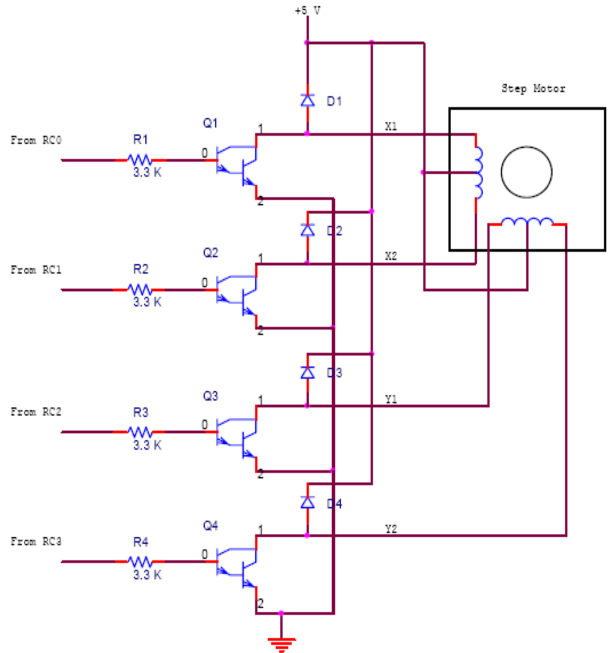


***Figure 4:*** *Motor Drive Circuit*

### Microcontroller

The microcontroller selected for this project had to be able to convert the analog IR sensor voltage into digital values and also provide four output channels to control stepper motor rotation. The AVR (at mega32) was selected as it satisfies these requirements. A 8 MHz crystal oscillator was also used in conjunction with the AVR to provide the necessary clock input. This speed is sufficient for the application. A pin diagram of the AVR is provided in *Fig 5*. The LCD is used to show functions result.

### IR Sensor Design

As presented above, the sun tracker uses IR sensors photocell for sun IR detection. Also the complete schematic of sun tracking control system presented in *Fig 6* (T.A. Papalias and M. Wong,2006 ). In this project an lm324 op-amp and a 5 kΩ multi turn were used for infrared sensors bias. In this operation the infrared sensors, change the solar ray into voltage regarding to the circuit, then the produced voltage is given to the negative pin of op-amp. A variable voltage is given to positive pin with the use of multi turn. The op-amp with comparison of these two pins considers the status of the output in in positive saturation and negative saturation and this means that if the sun was found with the sensors the logical 1 output and otherwise logical 0 is taken.

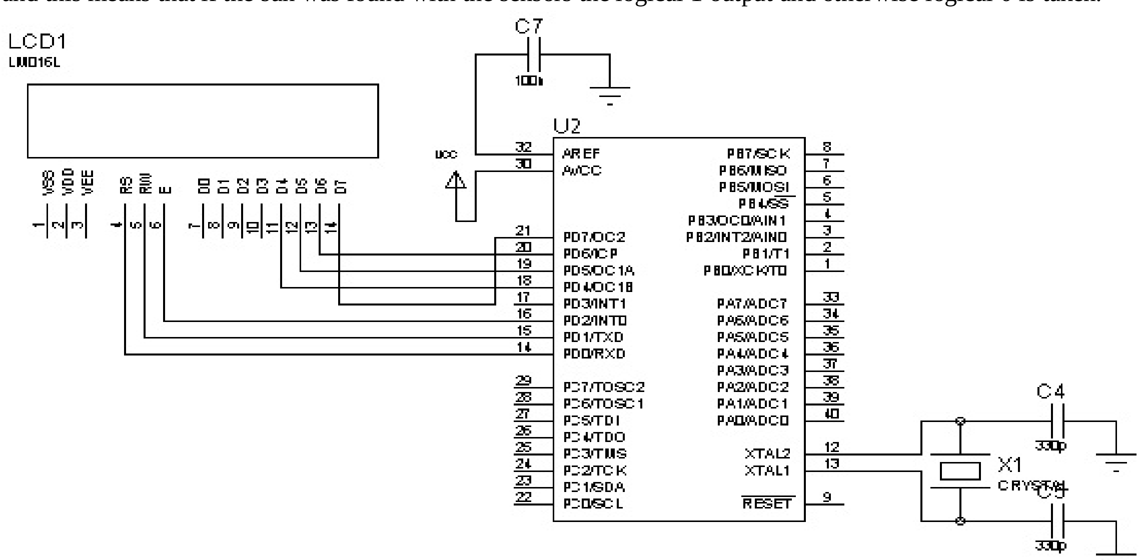


***Figure 5:*** *AT mega32 pin diagram*

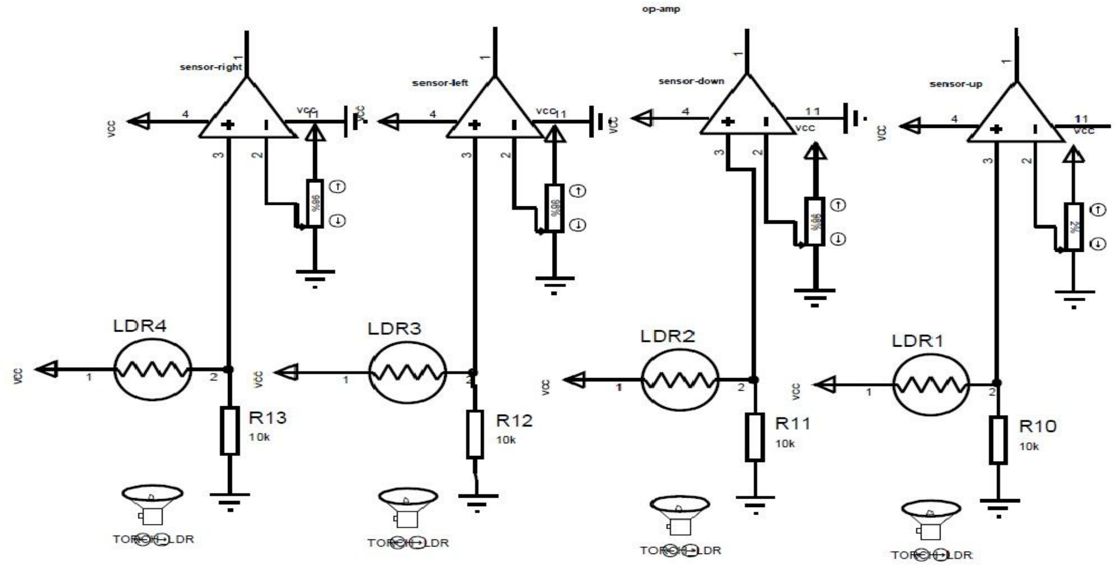


***Figure 6:*** *IR sensor bias circuit*

Four sensors for finding the sun are installed in front of the dish and in the focal distance. The fifth sensor in the back of the dish is used for recognizing the day and night. The placing of the sensors is in the *Fig 7*. With placing a circular plate on the sensors plate and setting it, the sun movement could be appeared *Fig 8*. The placement of the plate should be in the manner that when the dish is toward the sun all sensors placed in the shadow of the above plate and logical 0 appeared in the op-amp output. And with the sun movement the shining angle on the sensors change and the sensors coming out from the above plate shadow and logical 1 for each sensor coming out from the shadow is appeared.

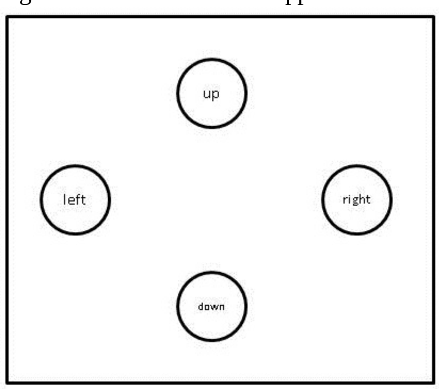


***Figure 7:*** *The placing of the sensors*

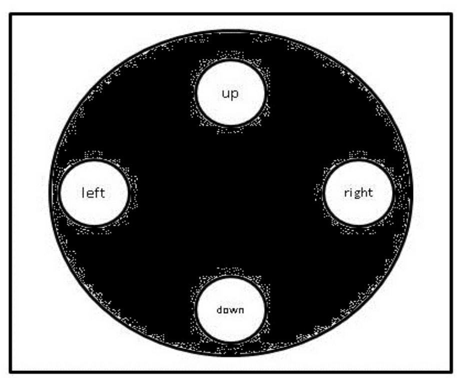


***Figure 8:*** *placing a circular plate on the sensors*

As it can be seen from the *Fig 9* the right side sensor has come out form the above plate shadow and it means that the sun is shining from the left side of the dish and for the dish to be vertical to the light it should be turned to the left side till all four sensors be under the above plate shadow.

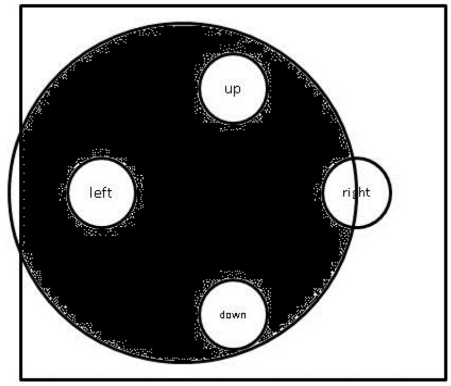


***Figure 9:*** *Right side sensors come out*

**Motors placement method**

For the dish to be toward the sun at least two motors are needed which one of them change the horizontal status of the dish and the other one changes the vertical status. The *Fig 10* obviously shows how the motors cause the turning of the dish. (S. J. Hamilton,1999)

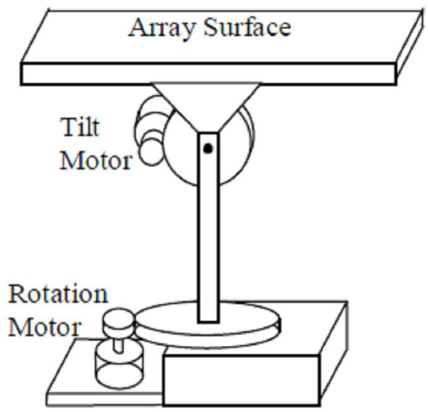


***Figure 10:*** *Motors placement*

## CONCLUSION

With the tests have been done it is obviously distinguished that this completely smart design can place the dish in front of the sun in the manner that the sun ray shines vertically to the dish and has the maximum efficiency. With the tests have been done in Mahshahr , Khoozestan on the dish with the width of 90 cm with the use of designed control system the heat concentrated in the focal distance has been measured approximately 600 ℃ which is very suitable for starting the sterling motor *Fig 11*.

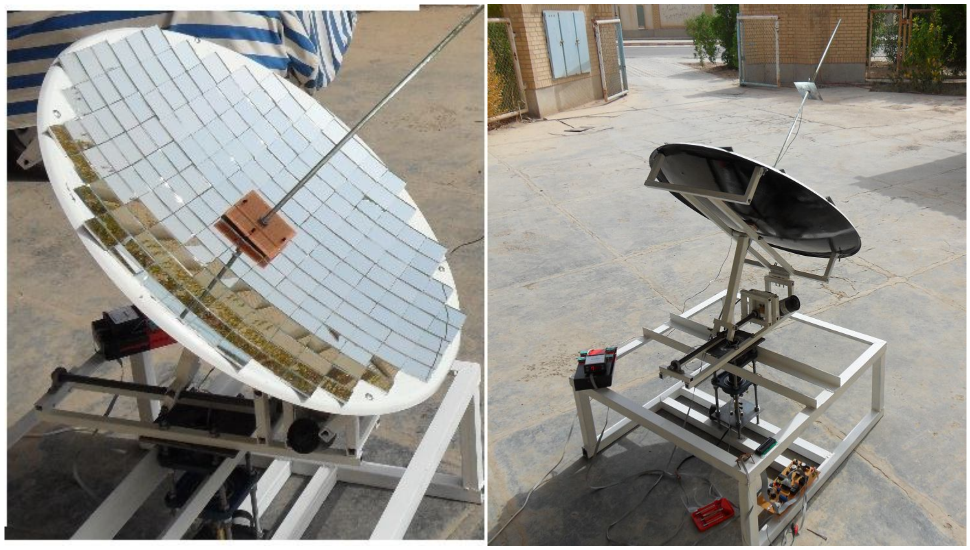

***Figure 11:*** *sterling dish in Mahshar,Khoozestan,Iran*

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