International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 02 Issue: 07 | Oct-2015 www.irjet.net p-ISSN: 2395-0072

EXPERIMENTATION AND TESTING OF AN OP-AMP OPERATED SOLAR TRACKING MECHANISM

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Abstract* – Amount of solar energy captured by a solar collector determines the output power generated for thermal applications. Hence, accurate solar tracking systems have an important role in the performance of solar collecting technologies. The unique feature of the proposed system is that instead of taking the earth as its reference, it takes the sun as a guiding source. The light dependent resistors (LDR) is used to sense the change in the position of the sun which is dealt by the respective change in the solar trough position by switching on and off the geared motor controlled by op-amp. The developed structure, by eliminating expensive computing systems, allows closed loop solar tracking as simple, low cost with minimal configuration. It is found that the motor will move the solar trough according to the light intensity of the sun.

Keywords: *Solar Tracking mechanism, Light Dependent Resistor in solar system, Op-amp.*

1. INTRODUCTION

In recent years, the need for energy is increasing in many fields, while the reserves of conventional energy are getting depleted at a rapid pace. To meet this growing demand for energy, harnessing of non-conventional / renewable energy becomes a necessity. Solar energy is the most abundant and uniformly distributed from among all the available non-conventional sources. Even though technology for trapping solar energy is already in existence, the process can be further improved to increase its efficiency [1], thereby making it more cost effective. Solar energy is freely available, needs no fuel and produces no waste or causes any pollution. Moreover solar power is renewable. The sun will keep on shining anyway, so it makes sense to utilize it.

The sun has an apparent motion with respect to a particular orientation of a plane on the earth, which can be described in terms of angles [2]. The first angle goes from east to west and it is called azimuth angle, the second angle is the sun elevation or complementary angle called the zenith angle. A solar tracking system must orientate the solar collector moving its collecting surface in these two angles. Because of these movements a solar collector will not have fixed position [3]. A solar tracking system plays an important role in solar collectors since the maximum received solar radiation depends on its precision and accuracy [4].

2. SOLAR TRACKING METHODOLOGY

The proposed system automatically provides best alignment of solar collector with the sun, to get maximum output. The change in sun position is monitored and the position of the collector is maintained always at normal to the direction of the sun. By doing so, maximum irradiation from the sun takes place [5]. The elevation angle of the sun remains almost invariant during a month and varies little (latitude ± 10°) in a year [6]. The proposed system uses a single axis position control scheme which is sufficient for the collection of solar energy. The proposed automatic solar tracking system is shown in fig.1.

Fig.1: General layout of solar tracking system

At ideal condition shadow of vacuum tube remain at centre of solar trough. This shadow moves as the sun position changes from east to west. We are chasing this shadow by Light Dependent Resistor (LDR). The Light Dependent Resistor (LDR) senses the change in the sun position and gives signal to the control circuit in order to tackle the change in the position of the solar collector. The control circuit gives signal to run the motor in forward direction.

3. SOLAR TRACKING MECHANISM ASSEMBLY

Assembly is made up of solar collector attached to frame and motor as shown in fig.2. One end of solar collector is attached to a plate connected with motor. Desired speed ratio is kept by chain and sprocket assembly. For solar collector aluminum reflective sheet is used of 4ft × 4ft dimension. Sheet is placed on wooden frame which are opposite to each other and connected by PVC pipe and wooden rib. Solar collector has length of 4ft, width is 3ft and depth is 1ft.The frame for solar unit is made of box shape mild steel rod 20mm × 20 mm. The motor is connected to shaft which is placed on frame by means of bearing. Input to motor is given by battery and control by control unit. One vacuum tube of 1.5 m length and 47 mm outer diameter is used.

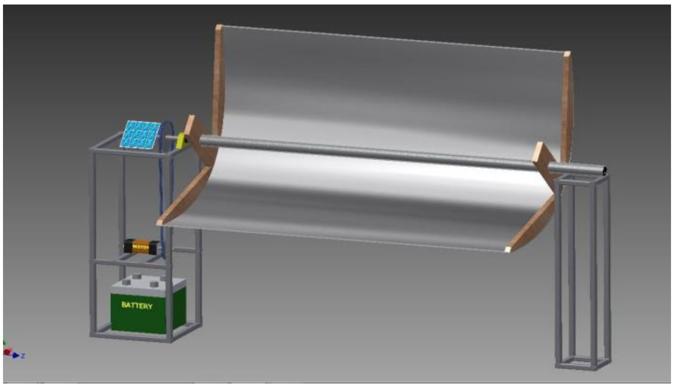

Fig. 2: Solar Tracking Mechanism Assembly

3.1. Rotating Mechanism

The solar collector will be fixed in a frame which is attached to the rotatable shaft. The shaft is connected with the chain and sprocket that is coupled with the PMDC geared motor. When the motor is ON the shaft rotates and that makes the solar collector to rotate. The collector frame is fixed with the shaft which is mounted on the either sides of the stand using roller bearings in order to make the rotation smooth and free. The shaft is attached to the gearbox which is coupled with the motor as shown in fig. 3.

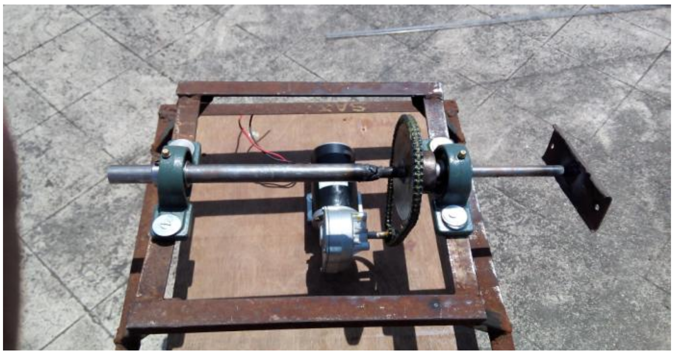

Fig. 3: Rotating mechanism

3.1.1. Geared Motor

The motor chosen for the proposed system is a PMDC geared motor with a power of 40 watts coupled with a worm gear. Table 1 shows the specification of PMDC motor.

Table -1: Specification of Motor

Parameter	Values	Units
Power	60	Watts
Speed	2000	RPM
Voltage(DC)	12/24	V
current	5.2/2.6	Amp.
Reduction ratio	55	-
Output speed	35	RPM
Torque	57	Kg-cm
Weight	1.8	Kg

3.1.2. Chain and sprocket assembly

Dimensions of chain and sprocket assembly is given in Table 2. Chain used in assembly is roller chain with 6 mm pitch.

Table -2: Chain and sprocket Dimensions

	No. of teeth	Pitch (mm)
Sprocket 1	60	6
Sprocket 2	12	6

3.1.3. Bearing

Two roller bearings of foot mounting type are selected for 20 mm shaft diameter.

3.2. Controlling Unit

LDR as shown in fig. 4 is used as a controlling unit in solar tracking mechanism.

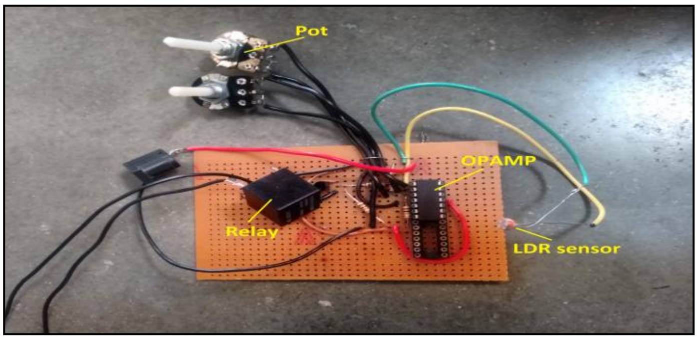

Fig. 4 Controlling Unit

4. RESULTS AND TESTING

Controlling unit that acts as a light-activated switch which turns the output relay either "ON" or "OFF" as the light level detected by the LDR resistor exceeds or falls below some pre-set value. A circuit diagram of a controlling unit as shown in fig. 5. A fixed voltage reference is applied to the non-inverting input terminal of the op-amp via the R_1 – R_2 voltage divider network. The voltage value at V_1 sets the op-amp's trip point with a feedback potentiometer, VR_2 used to set the switching hysteresis. That is the difference between the light level for "ON" and the light level for "OFF".

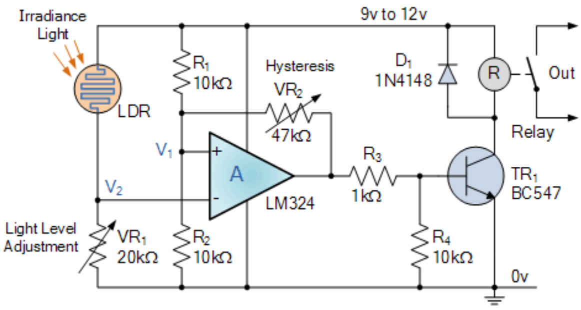

Fig. 5: Circuit diagram of controlling Unit

The second leg of the differential amplifier consists of a standard light dependent resistor, also known as a LDR, photo resistive sensor that changes its resistive value with the amount of light on its cell as their resistive value is a function of illumination. The LDR can be any standard type of cadmium-disulphide (cdS) photoconductive cell such as the common $NORP_{12}$ that has a resistive range of between about 500Ω in sunlight to about 20kΩ's or more in the dark. The $NORP_{12}$ photoconductive cell has a spectral response similar to that of the human eye making it ideal for use in lighting control type applications. The photocell resistance is proportional to the light level and falls with increasing light intensity so therefore the voltage level at V_2 will also change above or below the switching point which can be determined by the position of VR_1.

Then by adjusting the light level trip or set position using potentiometer VR_1 and the switching hysteresis using potentiometer VR_2 and precision light-sensitive switch can be made. Depending upon the application, the output from the op-amp can switch the load directly, or use a transistor switch to control a relay or the lamps themselves.

Figure 6 shows the resistance in ohms during 10 am to 6 pm of LDR in sunlight and tube shadow on parabolic trough.

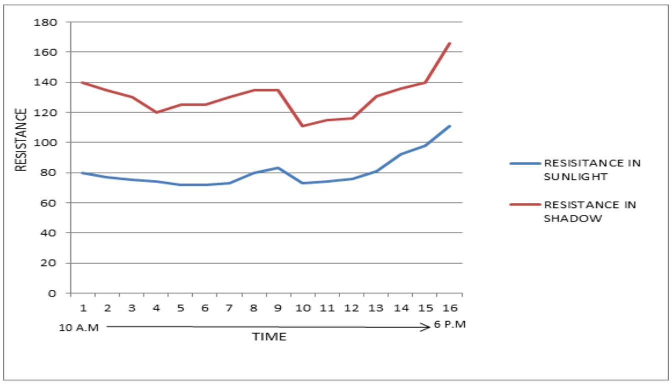

Fig. 6: Graph of variation in Resistance

By testing our solar tracking mechanism for one complete day we have found that our trough moves by 14.4° per hour. Testing specifications and results are as follows

Testing duration is from 10am to 5:30pm
Total no of teeth moved on bigger sprocket= 18
Total no of teeth present on sprocket = 60
Angle moved during testing = 108^0
Angle moved per hour = 14.4^0
Parabolic trough resolution = 20mins
Solar hour angel is 15^0

5. CONCLUSIONS

OP-AMP operated solar tracking mechanism with low cost, is developed and tested successfully to improve the efficiency of solar energy conversion system.

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