Solar Tracker and Concentrator (Project Report)

Group: D-14

Supervisor: Prof. Girish Kumar

Project Members: Ashutosh Singh 06D07034

Piyush Mittal 06D07035

Abstract:

The Device could broadly be divided into two main parts:

Solar Tracking: This part involves continuous motion of the Device such that it keeps itself **perpendicular** to the direction of the sun at any given point. The present state of the art devices use photodiodes as sensors and their voltage difference as the criterion for tracking. This kind of technology is heavily dependent on the weather conditions and the surrounding environment, thus making them more prone to errors. In our device tracking is ensured and governed by the predefined equations that relate the **angular movement** of the Device with time, thus immune to the specified errors.

Solar Concentrator: This part is aimed at further enhancement of power by a concentrator. Concentrator is made of two simple **plain mirrors** attached to the device in such fashion that the total **intensity** that falls on the panel is considerably increased.

Design Approach:

Tracking Equations:

From our study of the **sunrise** and **sunset** timings throughout the year, we found that the **longest day** in any year (i.e. around June 21st) is about **13 hrs**, **16 minutes** and approximately **17 seconds** long . While the **shortest day** (i.e. around December 21st) is approximately **10hrs, 59 minutes** and about **32 second**s long . We thus deduced that if the device was to track sun around 21st of June, it had to move by about 180 degrees in approximately 13 hrs and 16 minutes; around 21st of December it should do so in about 11 hours.

Therefore around **21st of June** the amount by which the Device moves is about **13.5 degrees per hour**. Similarly, around **21st of December** the figure comes out to be about **16.7 degrees per hour**. The **difference** between the two angular movements comes out be approximately **3.2 degrees.** Now, if we **assume** here that the sunrise and the sunset timings over a month are approximately constant, we could say that the number of degrees covered by the Device should increase by about **0.5 degrees per hour over a month.**

Considering a **Stepper Motor** with a **step angle** of **1.8 degrees**, the **time interval** for different months could be tabulated as follows:

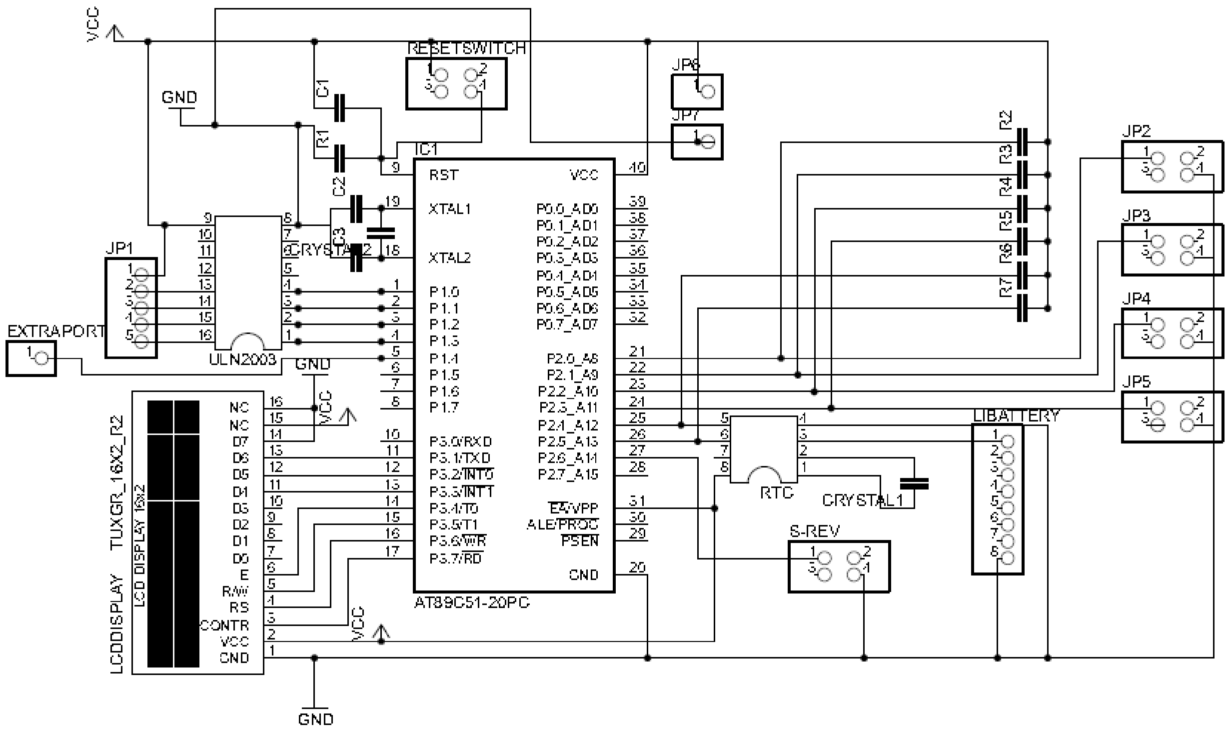
MONTH	Time lag between two steps (in mins)
January	8.0
February	7.7
March	7.5
April	7.2
May	7.0
June	6.5
July	6.5
August	7.0
September	7.2
October	7.5
November	7.7
December	8.0

These calculations done were implemented on circuit using a **Real Time Clock IC (DS 1307), Stepper Motor, and** a standard **Microcontroller (AT 89c51).**

Design of Circuit:

1. **89c51 Microcontroller:** This is simplest available microcontroller that has been used here for controlling the stepper motor. It has been interfaced with an RTC to take the time data. It also interfaced with an LCD Display to show the current time, date and day. It's also interfaced with buttons used to change time setting.
2. **Real Time Clock (DS 1307):** The DS1307 serial real-time clock (RTC) is a low power, full binary-coded decimal (BCD) clock/calendar plus 56 bytes of NV SRAM. Address and data are transferred serially through an I2C, bidirectional bus. The clock/calendar provides seconds, minutes, hours, day, date, month, and year information.
3. **Stepper Motor and Driver (ULN 2003):** Microcontroller itself gives very small current. Therefore a driver IC ULN2003 has been used. The ULN2003 is a monolithic high voltage and high current Darlington transistor arrays. It consists of seven NPN Darlington pairs that feature high-voltage outputs with common-cathode clamp diode for switching inductive loads. The collector-current rating of a single Darlington pair is 500mA.
4. **LCD Display Unit:** This unit displays the time. User can set the initial time by using push buttons.

Circuit Diagram:



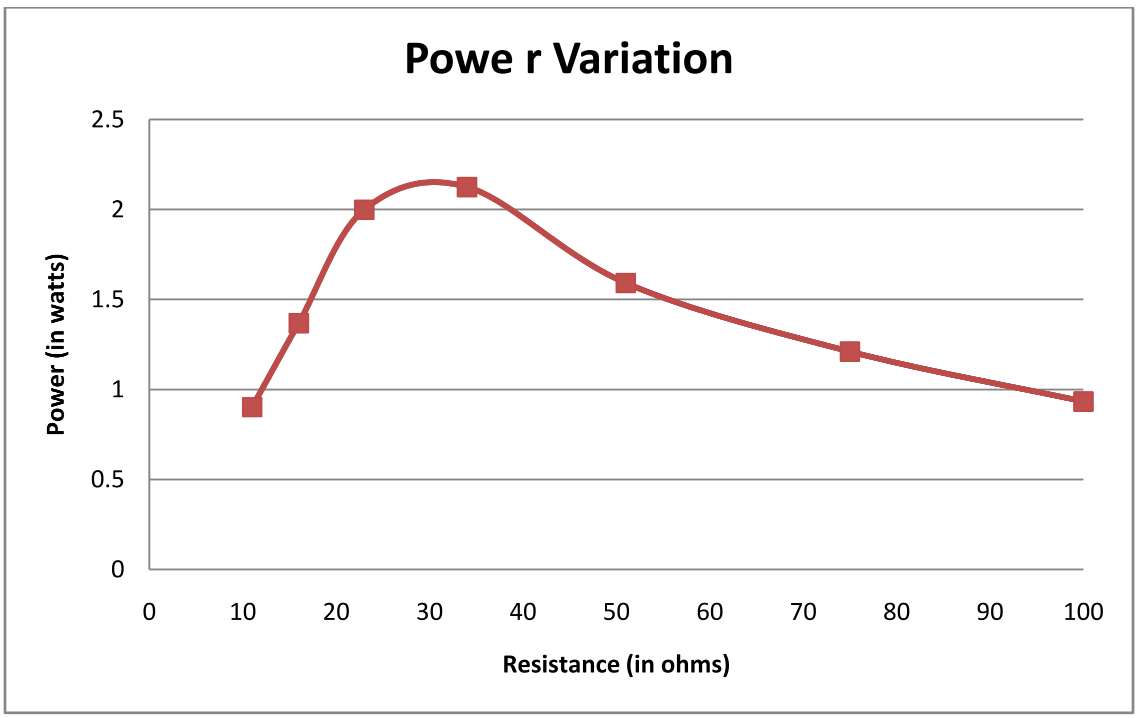
Algorithm Implemented:

The RTC gives the data of the current time continuously to the microcontroller. A program such as that in an alarm has been built inside the microcontroller. We assume alarm time to be the time when the stepper has to be rotated. Now at every instant microcontroller compares the time in RTC with the alarm time stored in its register (alarm time) and if the equal, it rotates the stepper by 1.8deg, and then sets the next alarm time (say adds 8mins). After the end of 100 steps the stepper is returned to its previous position and the next morning's initial time is set.

Test Results:

1. **Variation of Solar Power with load resistance** (taken at 12:00):

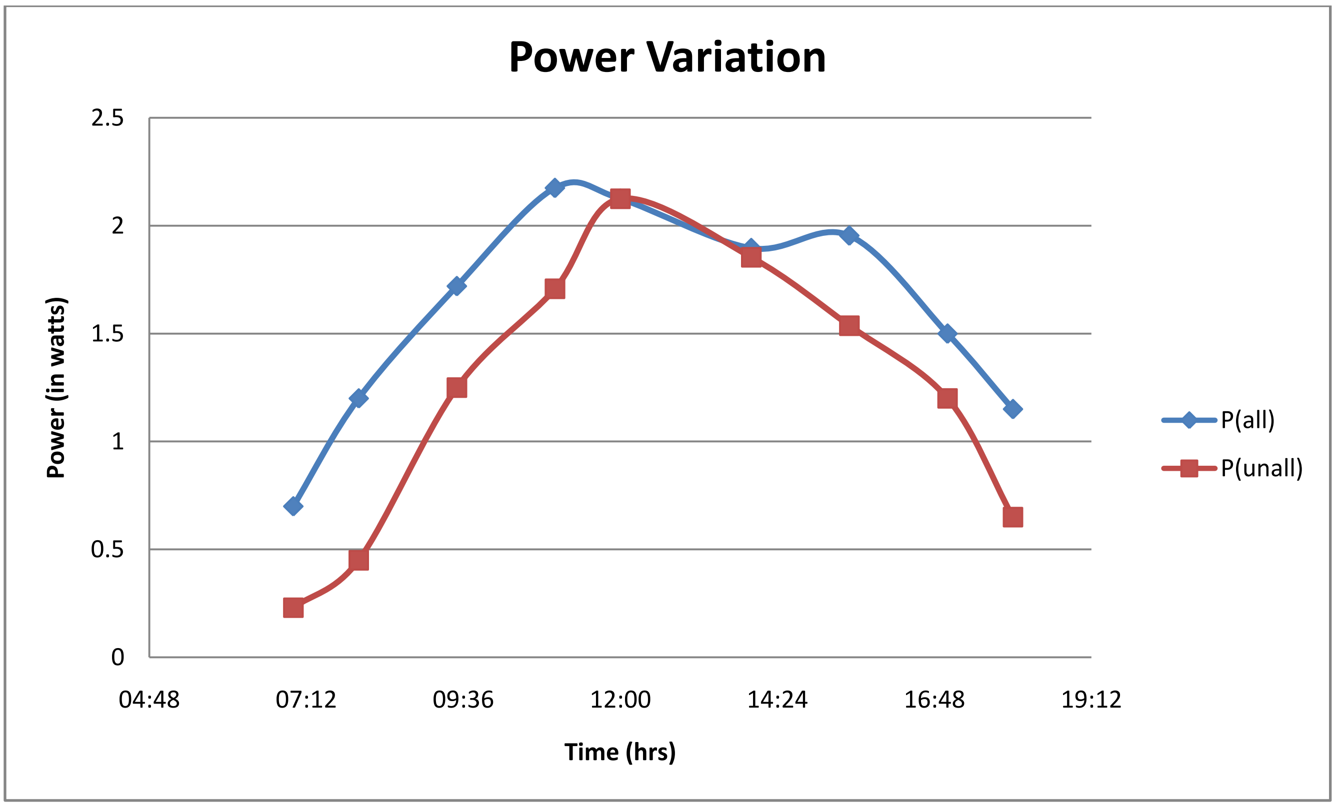
Sno.	R(ohm)	V(unall)	V(all)	I(unall)	I(all)	P(unall)	P(all)
1	11	3.15	3.15	0.286	0.286	0.902	0.902
2	16	4.68	4.68	0.293	0.293	1.369	1.369
3	23	6.78	6.78	0.295	0.295	1.999	1.999
4	34	8.5	8.5	0.25	0.25	2.125	2.125
5	51	9.01	9.01	0.177	0.177	1.592	1.592
6	75	9.53	9.53	0.127	0.127	1.211	1.211
7	100	9.66	9.66	0.097	0.097	0.933	0.933
8	150	9.77	9.77	0.065	0.065	0.636	0.636
9	250	9.86	9.86	0.039	0.039	0.389	0.389
10	1000	9.95	9.95	0.01	0.01	0.099	0.099



The above curve shows that output power of the panel is a function of applied load resistance and has maxima at 34ohms. This is called the maximum power point.

2. Variation of Maximum Power output point with time of the day:

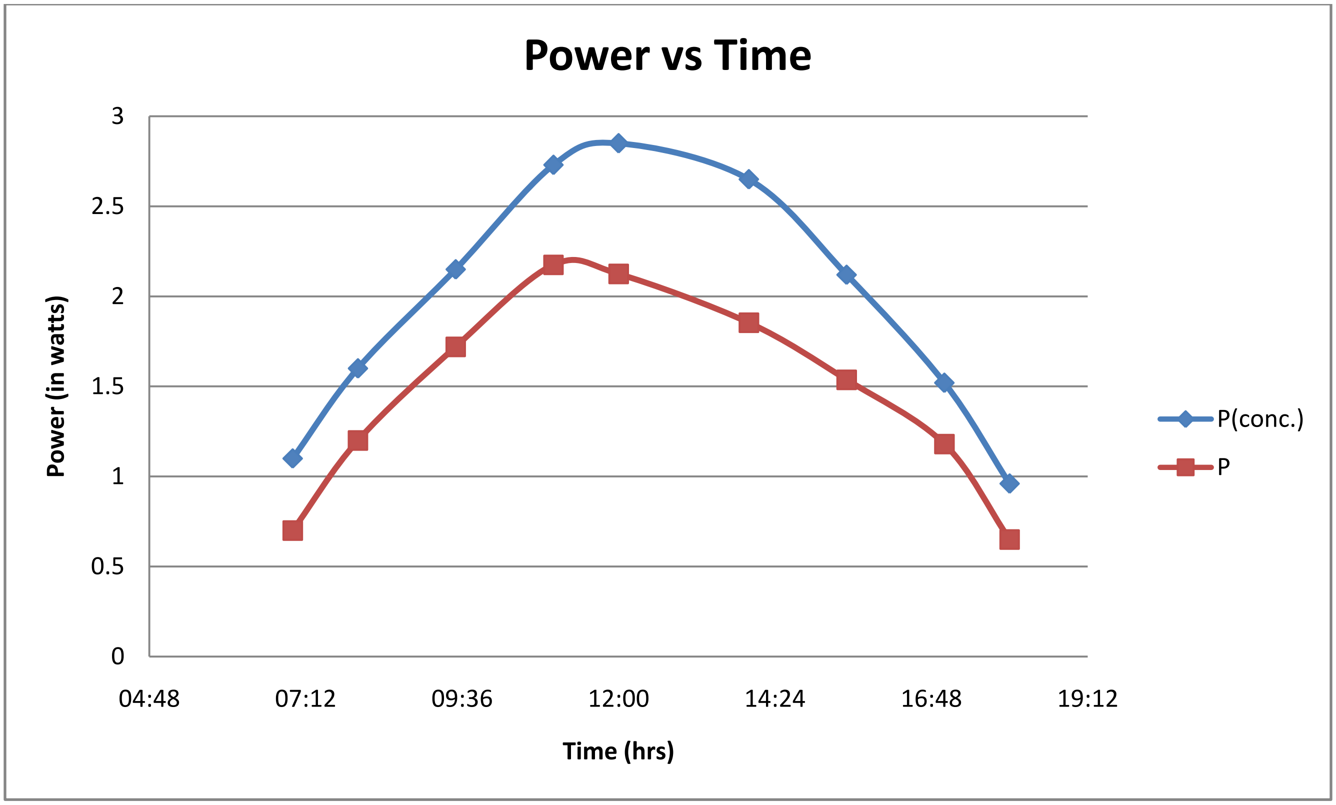
Sno.	Time	P(unall)	P(all)
1	07:00	0.23	0.7
2	08:00	0.45	1.2
3	09:30	1.25	1.72
4	11:00	1.708	2.175
5	12:00	2.125	2.125
6	14:00	1.854	1.896
7	15:30	1.537	1.954
8	17:00	1.2	1.5
9	18:00	0.65	1.15



The variation of power can be seen above for the two cases:
1.) When Panel is aligned perpendicular to sun 2.) When not aligned
One can see that aligned power is much higher than unaligned power. Thus one has achieved an increase in the efficiency.

3. Variation of Maximum Power output with time with tracking and concentrator:

Sno.	Time	P	P(conc.)
1	07:00	0.7	1.1
2	08:00	1.2	1.6
3	09:30	1.72	2.15
4	11:00	2.175	2.73
5	12:00	2.125	2.85
6	14:00	1.854	2.65
7	15:30	1.537	2.12
8	17:00	1.18	1.52
9	18:00	0.65	0.96



From the above curves we can see that there is a net increase in power when concentrating mirrors are used along with the aligning. Power maxima gets shifted upwards

Discussion of the test results:

The MPPT remained constant at approximately at 34ohms almost independent of time.

The energy delivered by the panel when **aligned is 19.2 w-hr**.

The energy delivered by the panel when **unaligned is 14.1 w-hr**.

Thus **% increase in power = 36.2%** by building a single axis tracking device.

Energy delivered by the panel when **concentrator** is used **= 26.83w-hr**

Thus % increase in power = **39.8%**

Net efficiency gained: 90.3 %

Suggestions for further improvement:

As we have shown in our readings that the maximum power point of the panel varies with load resistance. We can add a MPPT (maximum power point tracking) device to our circuit so as to ensure the panel always supplies max power.

Low power consuming microcontrollers can be used.

References:

1. www.google.com
2. http://en.wikipedia.org/wiki/Solar_tracker
3. www.timeanddate.com