Development of a Time Controlled Based Solar Radiation Tracking System

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DEVELOPMENT OF A TIME CONTROLLED BASED SOLAR RADIATION TRACKING SYSTEM

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Abstract
The increase in daily use of electricity with limited in the amount of fossil fuel necessitated researchers to explore other methods of producing energy. Many renewable sources of electricity are in existence, one of the cheapest, free and the most abundant renewable source of energy is the electricity generated from the sun. Electricity from solar radiation is environmentally friendly as it poses no harmful hazard to the surrounding. Today, radiation from the sun can be harnessed with the use of the photovoltaic material like the solar panel. It was observed that the sun direction keeps changing during the day as a result of the rotation of the earth and obtaining maximum amount of solar energy from a fixed solar panel cannot be totally achieved throughout the day. To this extend, a time controlled base solar radiation tracking system was developed. The developed system is capable of continuously changing the direction of sun module as the sun transverse the sky with the use of an intelligent fuzzy rules base on input variations. The performance of the tracking system when compared with the fixed solar device gave an output of 19.54% increase in voltage output.

Keywords: Sun, Energy, Radiation, Tracking, Time, Panel

Introduction
Energy is the prime factor in the development of a nation. An enormous amount of energy is extracted, distributed, converted, and consumed in the global society daily. About 85% of energy production is dependent on fossil fuels. The resources of fossil fuels are limited and their use results in global warming due to emission of greenhouse gases (Rajan *et al*,2016). Worldwide shape adjustment and the energy crisis promotes the improvement of renewable energy. Solar electricity has gained a lot greater cognizance because of infinite and green capabilities (Xiaoshan *et al*, 2013).

Nowadays, the improvement of the electricity industry keeps changing with time. The change in methods of generating the power pushes the energy producing industry to a new level of using different means of energy generation from the earth surface and this also prompt mankind continually looked for environmental friendly kind of electric powered energy for sustenance (Shyngs *et al*, 2013). Today, it is closely observed that most of the energy from the sun is absorbed when the panels surface is perpendicular to the sun. Desk bound mounted PV (Photovoltaic) panel are usually perpendicular to the sun once a day and the principal research it is always to get maximum amount of energy base on motion from sun direction (Sharad *et al*, 2015). The apparent motion of the sun is shown in Figure 1. Solar energy is likewise a radiant light and heat from the sun harnessed the use of a variety of ever-evolving technology consisting of sun heating, photovoltaic solar thermal energy and artificial photosynthesis (Sivasakthi *et al*, 2016).

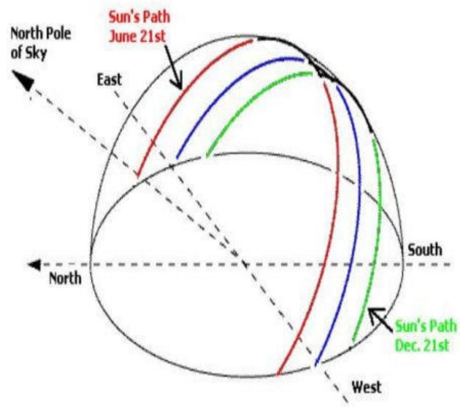

Figure 1: Sun's apparent motion (Narendrasinh, 2015)

Photovoltaic system is one of the most promising and active technology in the continuous development of an easy and dependable energy source with a totally low preservation rate, minimal ecological effect and nearly inexhaustible. PV conversion is not always new but enhancing its performance is still a top precedence in lots of academic and business studies companies all over the globe (Tudorache & Kreindler, 2010). In an effort to attain solar energy production, the performance of PV device is also a point of focus in the field of engineering. There are three (3) strategies to determine the performance of PV systems. The first technique is to obtain the efficiency of sun cells. The second is related to the energy conservation system consisting of maximum energy factor monitoring (MPPT) a manageable set of rules and the third method is to adopt sun monitoring gadget to obtain maximum energy from the sun (Gagari & Arijit, 2012).

Methodology

The use of Photovoltaic panels is to harness sun electricity by way of changing it to electric power thereby assembly the growing call for alternative energy resources by preserving the PV-panels perpendicular to the sun's radiation maximizes the output. The efficiency of the solar panel may be maximized if it can be aligned to constantly to face the sun direction, by means of so doing, the energy output might be maximized. To maximise strength output from the solar panels, a way of monitoring the sun's motion is essential. The systems which can be applied for this movement are called solar trackers and the technique of aligning the photovoltaic module to constantly face the solar is called solar tracking. The system block diagram of the actuation unit is shown in figure 2.

For tracking to take place, two conditions should be met; RTC (Real Time Clocking) time must suit with tabled cost and the sensor input from the solar radiation must be greater than the threshold value from the photo resistor. If these two conditions are met, motor can rotates to manipulate sun panel.

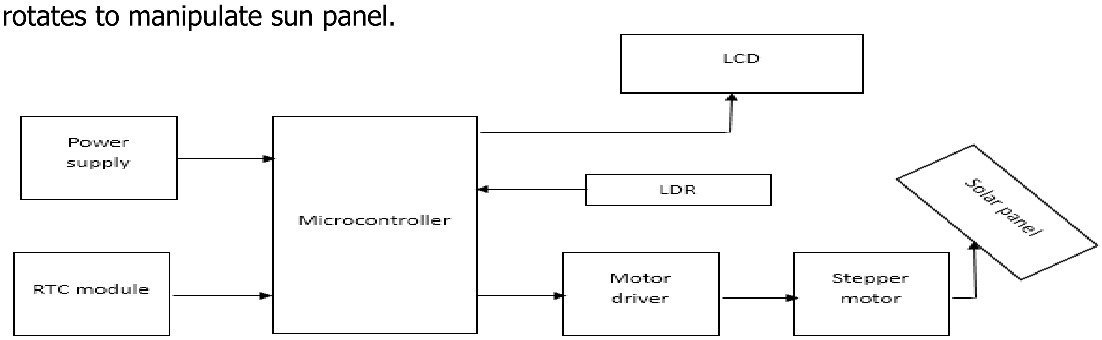

Figure 2: Actuation unit block diagram

Generally, the actuation unit is responsible for the alignment of the solar panel when a control signal is sent from the microcontroller. The 2N222 transistor is used as a switch, the base terminal of the transistor is connected to the microcontroller, this transistor is unable to drive the stepper motor because it has a small collector current. Therefore, the current is amplified by passing it to the base of a bigger transistor (TIP41C) and then it is used to power the MOSFET (*Metal Oxide Semiconductor Field Effect Transistor).*

The stepper motor used in this research is 2-phase 6-wire, 1.8A unipolar stepper motor. The two wires at the centre of the motor were connected to 12V supply and the remaining wires are connected to the source terminal of the MOSFETS as shown in Figure 2.8. The microcontroller is the main processing unit of the whole system upon which every other component depends. The microcontroller chip used in this research is the AT89S52 microcontroller. The processing unit consist of : 8KB of flash, 32 I/O lines, two data pointers, 256ytes of RAM, watchdog timer, three 16-bit timer/counters a full duplex serial port, and an on-chip oscillator.

Real time clock as the name implies, is a clock module. The RTC chip used in this research is DS1307. It is available in form of integrated circuits (ICs), it supervises timing like a normal clock and operates dates like a calendar. The RTC chip can operate in either 12 or 24 hour format. The chip has an in-built battery which serves as a backup power supply when the power failure occurs. The 555 timer IC is used in a variety of applications like timing function, pulse generation and oscillation applications. The 555 timer is configured in a bi-stable mode of configuration which acts like a flip-flop.

The microcontroller performs movement of the tracking system. The 11.0592MHz crystal is used in the microcontroller to help in the operation of the internal oscillator. LDR is connected to pin 2 (Trigger) of the 555 timer. When light falling on the LDR is of high intensity, the resistance of the LDR drops which increases the voltage going into the trigger pin and consequently results in a low output of pin 3. Conversely, when light falling on the LDR is of low intensity, a high resistance is developed in the LDR.

The fuzzy logic input for time and position with rules is develop to provide orientation and communication between the sun and solar panel which is shown in Figure 2.2, Figure 2.3, Figure 2.4, Figure 2.5 and Figure 2.6 respectively.

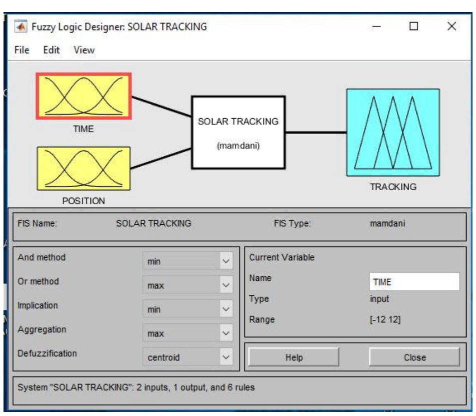

Figure 2.2: Fuzzy logic system

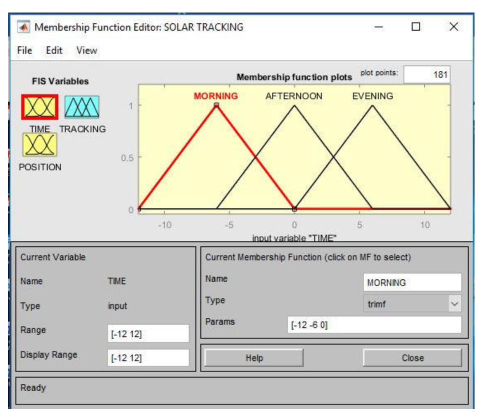

Figure 2.3: Time membership function

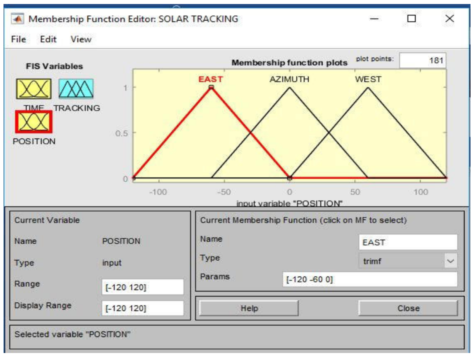

Figure 2.4: Position membership function

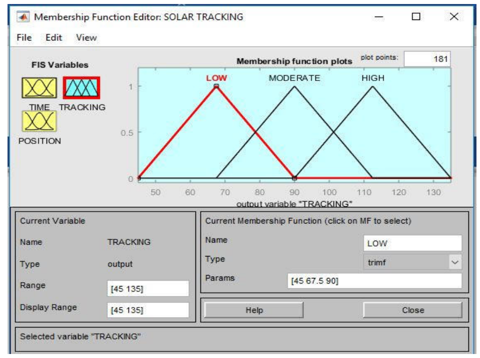

Figure 2.5: Tracking membership function

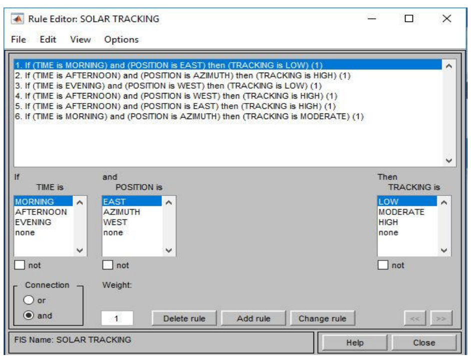

Figure 2.6: Fuzzy rules

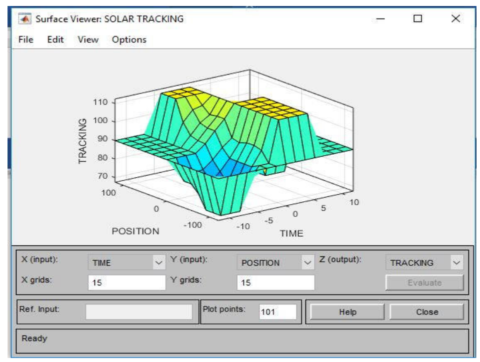

Figure 2.7: Output relationship

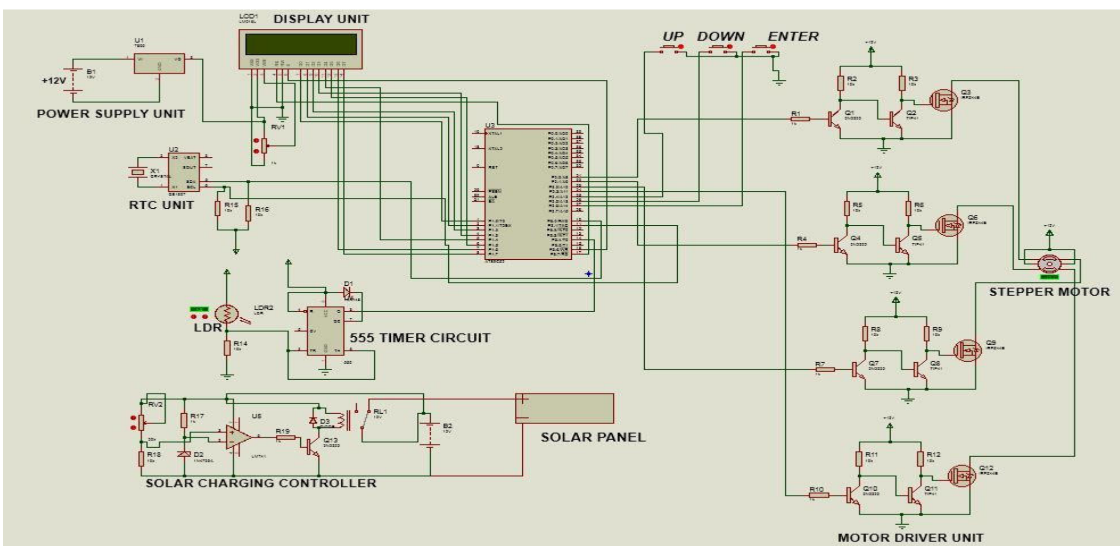

Figure 2.7: System circuit diagram

From the develop membership function of fuzzy logic in Figure 2.3, the negative values represent AM (Ante Meridiem) and the positive values represent the PM (Post Meridiem). The membership function for the position of the sun is develop with the negative values representing the east position of the sun and the positive value represent the west position of the sun as shown in Figure 2.4. The tracking movement of the solar panel from the fuzzy system from low, moderate and high angular position is shown Figure 2.5 together with the rules in Figure 2.6. The output relationship between time and position is also shown in Figure 2.6.

The display unit consists of a 16x2 Liquid Crystal Display (LCD). The 16x2 LCD is capable of displaying only 16 characters on two lines at a time. The purpose of LCD in this research is to display the tracking time at different tilt time.

Results and Discussion

The initial position is set to 8.00 AM in the morning which is achieved from the membership function time interval and the final time to reverse back to the initial position is 6.00 PM in the evening as shown in table 3.1. The voltage level output of the solar panel both the tracking and fixed system was recorded at different times of the day under the same atmospheric condition. Voltage measurement was taken on 26th January, 2017, 27th January, 2017 and 28th January, 2017.

Table 3.1: Voltage values for fixed and tracking mode of solar radiation system

S/N	Time	26th January, 2017		27th January, 2017		28th January, 2017	
		Fixed Mode (V)	Tracking Mode (V)	Fixed Mode (V)	Tracking Mode (V)	Fixed Mode (V)	Tracking Mode (V)
1	8:00 AM	12.3	17.6	12.1	16.4	12.0	17.3
2	9:00 AM	13.1	18.7	13.4	17.2	13.6	18.7
3	10:00 AM	16.4	21.9	16.0	20.5	17.0	21.8
4	11:00 AM	18.1	22.2	18.6	21.5	19.8	21.7
5	12:00 PM	23.3	23.5	23.4	23.6	22.4	22.9
6	1:00 PM	23.1	23.2	23.1	23.2	23.0	23.3
7	2:00 PM	18.4	21.1	18.0	20.2	19.2	21.8
8	3:00 PM	17.0	19.8	17.1	18.4	17.0	19.9
9	4:00 PM	13.0	17.1	13.4	17.2	13.4	16.8
10	5:00 PM	12.2	15.4	11.4	15.4	11.2	15.6
11	6:00PM	10.5	13.9	8.9	12.8	9.0	13.5

Average increase in output Voltage = $\frac{20.86 + 17.67 + 20.10}{3}$ = 19.54%

The relationship time with respect to voltage measurement taken in fixed and tracking mode for three different days are shown figure 3.1, figure 3.2 and figure 3.3. The overall assessment of the graphs shows that the voltage gain in tracking mode is higher than the fixed mode.

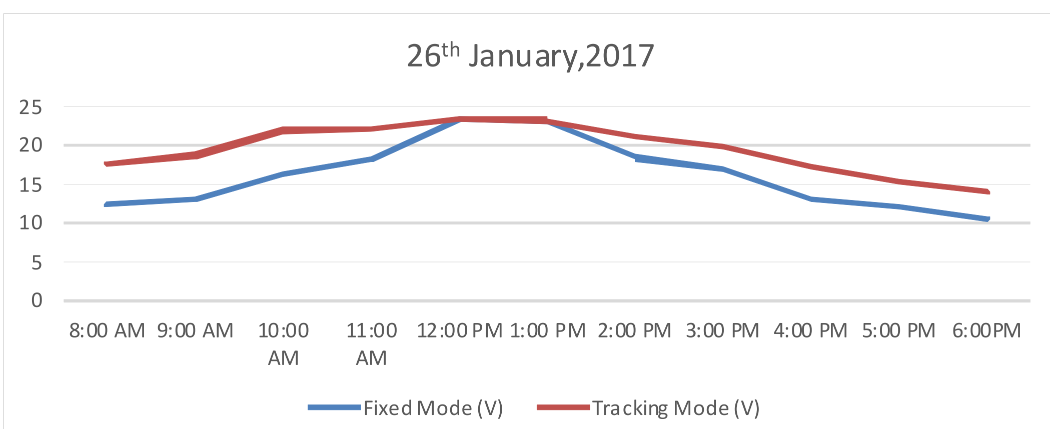

Figure 3.1: Time and voltage measurement for 26th January, 2017

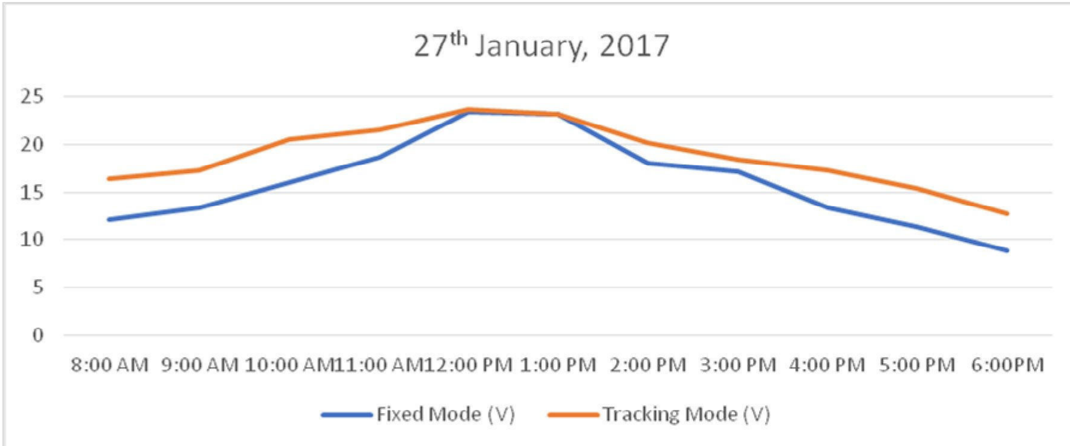

Figure 3.2: Time and voltage measurement voltage measurement for 27th January, 2017

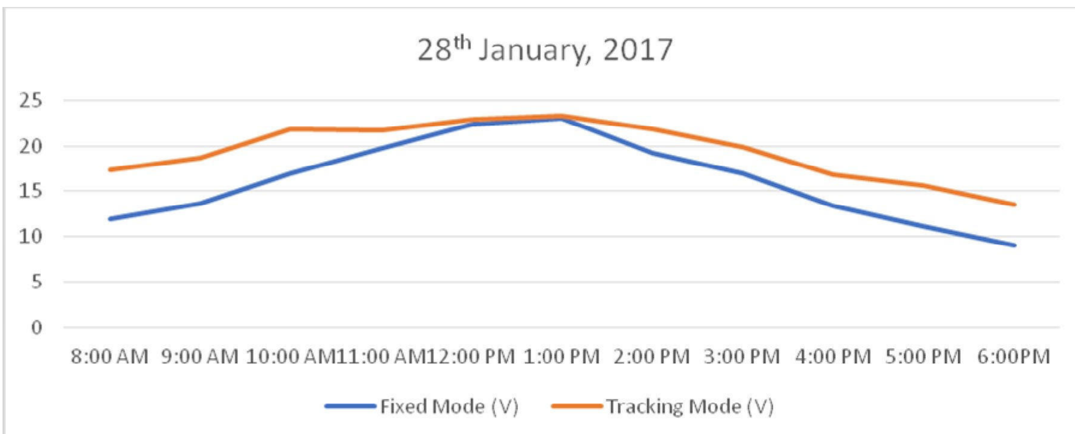

Figure 3.3: Time and voltage measurement voltage measurement for 28th January, 2017

The physical structure of the developed system is shown in figure 3.4 and the testing mode of motor driver that rotate the panel is shown in figure 3.5.

Figure 3.4: Solar tracking system

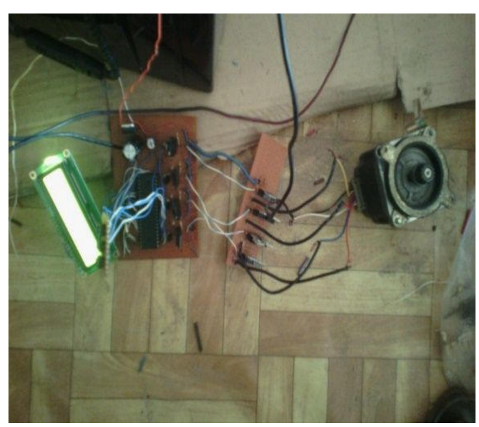

Figure 3.5: Testing the motor driver

Conclusion

This research provides a cost-effective means of harnessing the amount of sun radiation to be converted to electrical energy thereby meeting the excessive demand of electricity. The development of this system will continue to reduces the total dependence on fossil fuels for electricity delivery and lower the quantity of emission of gases like carbon monoxide which poses critical environmental threats. The precise steps required to constantly align solar modules to the course of maximum radiation of daylight have been carried out. The performance assessment of the device became completed through comparing the solar panel voltage output of the monitoring tracking system with the constant solar panel. After the assessment, there was 19.54% increase in the voltage output.

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