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Low Cost Solar Tracker with High Efficiency Charging Technique

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Abstract : The solar energy can be better received using intelligent tracking system with lowest energy for tracking. An excellent charging technique can be employed using power electronic component MOSFET known as high efficiency charging. A state of art embedded technology can be used for multilevel and multibattery charging system. Embedded controller is the whole system behind this scheme, because it accepts data interacts with mechanical model, collecting the data from position transducers, directing the power from photovoltaic to charging system, controlling the MOSFET and relays with appropriate threshold level.

Keywords : Intelligent Tracking System, Embedded Controller, High Frequency Charging, MOSFET, Multilevel Charging System.

I.INTRODUCTION

Solar power is going to be the need of future generation. We are very less dependent on conventional sources of energy and we will need renewable energy resources to meet the future energy demand needs. Solar power will be the best form of renewable energy resources since the source for sun's energy is completely natural and there is no need for investment in source produced for solar energy. Although where we lack in technology is that we are unable to capture sun's energy to the fullest and we do not have an efficient way to utilize sun's energy with minimum of cost.

In this paper we have proposed a new model of low cost solar tracking system with a high efficiency charger. It is been a well-known fact that the maximum utilization of solar energy could be done between the time of 10.00 AM to 2.00 PM. But sun's energy can be captured from other time also. The major disadvantage of why previous technologies couldn't capture maximum power of sun is due to the changing position of sun. There aren't many technologies available that could capture the maximum power of sun with respect to its changes in its positions. Here we have proposed a solar tracking system which could utilize the sun's energy efficiently and does not vary its power capturing capacity even with varying position of sun. We have implemented an efficient tracking system which could sense sun's position and move the panels accordingly to capture maximum power of sun. We have done this with the help of a Embedded Controller, Stepper motor, Sun position tracking sensors and stepper motor drives.

We have also proposed a system which is highly efficient in charging batteries. We have prepared a module of an efficient tracking system.

II.SOLAR TRACKING SYSTEM

A. *Embedded Controller*

This is the heart of our project which is the core collects the data, passes to the computer takes control action. To perform the various operations and conversions required to switch, control and monitor the devices a processor is needed. In this scheme an embedded controller has been preferred because of its industrial advantages in power electronics like built in ADC, RAM, ROM, ports, USART, DAC. This leads to lesser space occupation by the circuit and also the speed of embedded controllers are more compared to other processors.

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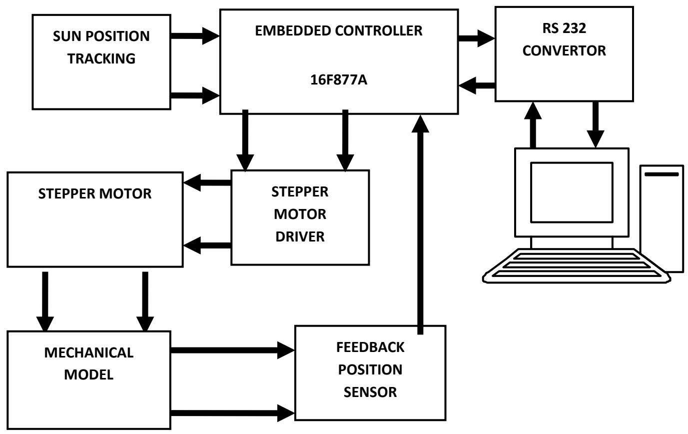

Fig 1. Block Diagram of Solar tracking system

B. *Stepper Motor*

Stepper motor is a bipolar, electronically driven, can be controlled by all types of Technologies, various types & sizes are available. Economical, high efficiency, smaller in size.It has a very small rotational angle and better efficiency. It has better position sensing and good repetitive action. It can 360 degree of rotation.The highest limitation of the stepper motor usage in electrical circuit is back emf during turn OFF stage. That can be eliminated using optical isolation to save the embedded controller and computer. Optocouplers are made up of two opposite nature transducers coupled together for single objective called electrical isolation. In a simple conclusion, optocouplers are optically coupled and electrically isolated.

C. *RS 232 Converter*

It is a serial port connection given to the computer interface.

D. *Sun Position Tracking*

According to the scheme without any human's interference, the collector will be positioned automatically to the appropriate sun direction. In this scheme, sun direction from 0º to 180º is divided into 5 known positions (180/5) the collectors has to be set to one direction for that whenever we give a fresh switching, it will go to the appropriate directions by intelligent pulse counting technique.

E. *Computer Interface*

With the use of computer, we can able to introduce record making a database for peak light (voltage) identification to see the exact position of sun. With the help of computer, we can easily analyze the accuracy of our project and accuracy can be proved.

Brief explanation of block diagram

The sun position tracking sensor will sense the position of sun and give the signals to controller. The controller then will give the command to the stepper motor where it will turn or rotate the solar panel as in position where it can capture maximum solar energy.

Drawback

In this tracking method the battery charging voltage and PV panel voltage are mismatched. So the battery life is reduced and complete utilization of energy is not achieved. These drawbacks are eliminated in the proposed system.

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III.PROPOSED SOLAR TRACKING SYSTEM

A. *Parabolic light collector*

A semicircle plastic box is used for this application and it is divided by 6 equal portions and LDR's are fixed. It must be placed East-West position to track sun position from morning to evening. In particular, direction is very important i.e. sensor1 must be placed always in the East direction, the last sensor must be kept on the West direction. The intermediate sensors must be connected increment angles of 30°.(180/6=30 deg). Similarly for 16-channel and 32-channel, the angles must be calculated for number of sensors plus 1 equal position.

B. *LDR*

LDR is the sensor used for cheaper cost with good reliability. LDR's are passive transducers accept light and convert them into resistance. Resistance across LDR's is directly proportional to the light offered to it. At bright sunlight, the resistance is very negligible where it is infinite while dark. The Light Vs Resistance characteristics are very narrow in LDR. Converting resistance into voltage is possible by two ways (a) Wheatstone bridge, (b) potential divider.

We are implementing potential divider for our application. Since they are very suitable for huge change in resistance and good sensitivity systems like thermistors, LDR's etc. It is well known that, LDR creates huge change in resistance for the applied variable light.. LDR's can be easily interfaced with ADC using simple potential divider, which can be calibrated for known value output voltage. And low profile photovoltaic cells are better replacement in future.

C. *Filters*

Generally, filters are necessary to keep the values constant for short time. We need low pass filters to remove unwanted and fast response signals. Low pass filters are generally a capacitor placed on the output in parallel to the ground with appropriate polarity.

D. *PV Modules*

Our module is the photovoltaic active transducer which produces electrical energy for the received light energy. This has a greater life, accepts and produces voltage for the any given light, the only precaution to be carried out is the photovoltaic outer glass cover to be dust free to avoid shadow on it, where shadow will reduce the output voltage. It is made up of amorphous silicon. It is a native transducer, which can be used in earth (or) at satellite. In satellite, it plays vital role.

E. *V/I Protection*

This is to avoid high voltage entering into the embedded and high current drawn by the embedded. To avoid high voltage entering into embedded controller, we can use 5 Volt Zener diode, because our embedded controller will accept maximum of 5. 1KΩ resistor in series to the embedded controller, will allow only current upto 5mA.

F. *Signal Conditioner Volt/Current*

The Signals received from the field may not be suitable directly for ADC and further processing. In such case, the signal may need amplification to improve sensitivity, remove unwanted frequencies, and allow frequencies of specified range. Finally signal should also have Dynamic Response Range.

G. *MOSFET Modules*

MOSFET's are advanced transistors which eliminates loss of current while switching and improves excellent switching characteristics. MOSFET's are power electronics components designed for high voltage, high current, and high frequencies.

MOSFET's can be used as a linear system as well as logical system according to the usage. In our project, MOSFET is used as a switch to charge the battery to achieve MPPT. The MOSFET is driven by an astable multivibrator. The multivibrator output is connected to gate of the MOSFET.

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H. *Oscillators*

Oscillators are very important to generate constant pulses and can be varied by proper RC network. Oscillator plays vital role for charging. In our scheme, we have used astable multivibrator to produce pulses to activate MOSFET base to switch the PV output to battery.

In this module, the voltage obtained from the module will be connected to the battery through a MOSFET which is driven by an astable multivibrator whose frequency & duty cycle can be altered externally. The highest advantage of this system is pulsed charging, pulsed charging provides an advantage that the voltage is not flowing continuously there by failure of module will not happen. Because of the high frequency and duty cycle the momentum of power applied to the storage system will be like hammering & charging, so that the charging will be possible even if the battery is fully discharged. It is advisable that the battery should be charged by pulsating only instead of continuous voltage.

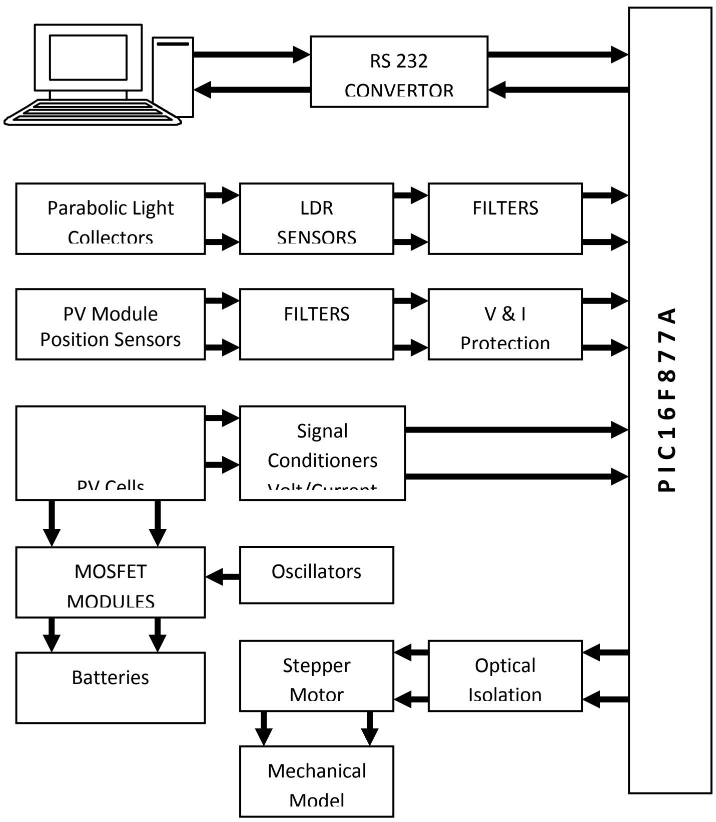

Fig 2. 6 Channel Tracking System

IV. CHARGING METHODS

A battery is a reservoir, which is used for storing energy. The energy in the battery is stored as chemical energy, and it is charged and drained from the battery in the form of electricity. The battery used in this scheme is a Sealed Lead Acid (SLA) battery. The battery goes through two phases of charging,

- First phase: High efficiency charging mode.
- Second phase: TRICKLE and BOOST charging mode.

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A. *High Efficiency Charging Mode*

During early in the morning and late in the evening, sunlight will not be much bright, similarly when the battery is fully empty irrespective of the generated voltage photovoltaic will be loaded in result which may fail. To avoid the above said problem, an oscillator is used with predetermined frequency where charging will be intermittent (discontinuous). So the loading effect of the photovoltaic is fully eliminated.

B. *TRICKLE* and BOOST *Charging mode*

The SLA battery have comparatively high self discharge rate, which could lead to sulfilation and over gassing of the battery. This problem is eliminated by this charging mode. Trickle means slow charging, boost means high charging. Trickle charge avoids failure of charging devices as well as photovoltaic cells. But in worst conditions, boost charge is essential during bright sun light.

C. *Multiple Charging Systems.*

Depends on the voltage received from the photovoltaic cell, appropriate batteries will be selected for charging, which enables us to charge more numbers of batteries.

V.MECHANICAL MODEL

Our Mechanical model is made up of fabric hylam sheet, which has following features. It consists of 4:1 gear ratio

1. Greater life.
2. Less weight.
3. Cost effective.
4. Does not require any surface finishing.
5. Does not require painting.
6. Withstand high temperature.
7. Any mechanical work can be carried for getting the required shape.
8. 11KV electrical isolation.

A. *Real Type Mechanical Model*

In this prototype project, we have used mechanical grade fabric hylam to construct rotation model. The model consists of motor, gear, bearings & shaft recruited for movement.

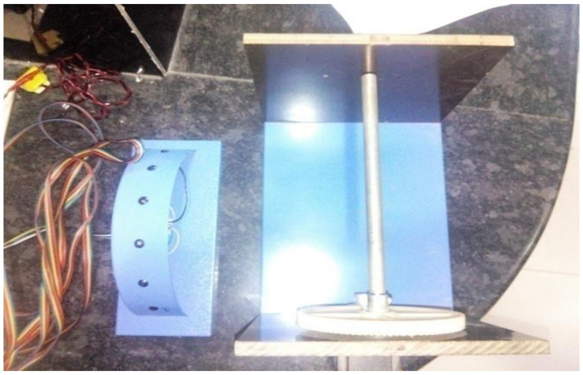

Fig 3. Mechanical model

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B. *Industry Standard Solar Cell*

A high profile amorphous Silicon photovoltaic cell is employed with glass cover and fully enclosed in an aluminum body for non-corrosion. We have used 6W photovoltaic cell, whose voltages are 12V and 0.5 Amps (500 mA). The voltage may go up to 35V at peak sunlight when no load, whose full load voltage will be approximately 15V at bright sunlight.

Fig 4. Solar panel

C. *High Frequency Charging*

During early in the morning and late in the evening, sunlight will not be much bright, similarly when the battery is fully empty irrespective of the generated voltage photovoltaic will be loaded in result which may fail. To avoid the above said problem, an oscillator is used with predetermined frequency where charging will be intermittent (discontinuous). So the loading effect of the photovoltaic is fully eliminated.

D. *Auto Cut off during Low Lights*

During evening to night times, the output of the photovoltaic will be to less to charge, so the connections to be removed automatically to avoid back feeding.

E. *Positioning Sensors*

This is to identify and locate the sun position from 0°. (Home position sensed). Now we have used infrared emitter and detector to identify the position of the collector. But in real time, inductive proximity sensor can be better replacement.

F. *Recording of all parameters in real time*

Figure 5 shows a plot of an average light where the sun is brighter after 8.45AM and continued till 6.0PM after it is moderate, at 6.45 PM it was completely dark. Approximately 40 readings are registered in one database. The database consists of time, tracking voltage, non-tracking voltage, fields respectively.

The average tracking voltage as per the calculations is 16.51V against 12.09V on non-tracking. This proves tracking enhances energy production.

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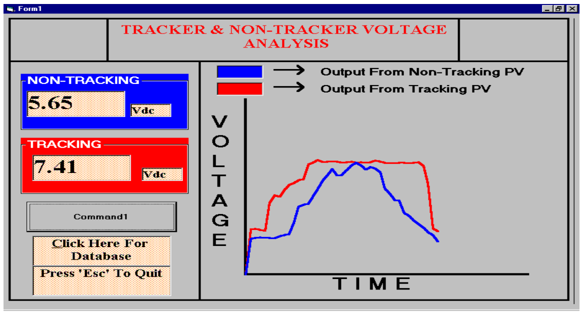

Fig 5.Comparison Plot Between Tracking And Non-Tracking System

This will be very much useful for future diagnostic application. The user can easily analyze light Vs voltage, light Vs current, light Vs power and time with light. This may enhance the research people knowledge towards sunlight Vs photovoltaic cell. This is a complete solution for forecasting the sunlight.

VI.CONCLUSION

This scheme improves the life of the battery by complete utilization of the battery life cycle and also prevents it from fully discharged state. Therefore efficiency is improved considerably when compared with the MPPT charging technique without any additional cost to the existing system. Further the accuracy can be obtained by increasing the number of channels i.e. upto 64 channels in large scale.

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