

EFFICIENT DUAL AXIS SOLAR TRACKER WITH H-BRIDGE INVERTER

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ABSTRACT

This paper concerns the design and realization of a solar tracking system oriented to the PV conversion panels. The proposed dual axis solar tracking system offers optimal energy conversion process of solar energy into electricity through appropriately orienting the PV panel in accordance with the real position of the sun. The mechanism of the experiment is based on a servo motor which is intelligently controlled by Arduino micro controller that moves prototype according to the inputs received from RTC clock. This project proposes a new single-phase H-Bridge transformerless inverter with common ground for grid connected photovoltaic systems (hereafter it is called 'Siwakoti-H' inverter). The inverter works on the principle of flying capacitor and consists of only four power switches (two reverse blocking IGBT's (RB-IGBT) and two MOSFET's), a capacitor and a small filter at the output stage.

Keywords: Siwakoti Inverter, Arduino, RTC, Dual Axis Solar Tracker, Servo Motor

I. INTRODUCTION

Global warming and energy policies have become a hot topic on the international agenda in the last years. Developed countries are trying to reduce their greenhouse gas emissions. For example, the EU has committed to reduce the emissions of greenhouse gas to at least 20% below 1990 levels and to produce no less than 20% of its energy consumption from renewable sources by 2020. In this context, photovoltaic (PV) power generation has an important role to play due to the fact that it is a green source.

In their lifetime, which is around 25 years, PV panels produce more energy than that for their manufacturing. Also they can be installed in places with no other use, such as roofs and deserts, or they can produce electricity for remote locations, where there is no electricity network. The latter type of installations is known as off-grid facilities and sometimes they are the most economical alternative to provide electricity in isolated areas. However, most of the PV power generation comes from grid-connected installations, where the power is fed in the electricity network.

In this project a dual axis solar tracker system by having a servo motor which is intelligently controlled by Arduino micro controller that moves prototype according to the inputs received from RTC clock. A new single-phase H-Bridge transformer less inverter with common ground for grid connected photovoltaic systems (hereafter it is called 'Siwakoti-H' inverter). In below content consist of the construction, operation, advantages and disadvantages of a dual axis solar tracker and H-bridge Siwakoti inverter. Finally, simulation result of a Siwakoti inverter and the conclusion are drawn in last section

POWER GENERATION IN SOLAR PANEL

Solar photo voltaic system uses solar cells to convert light into electricity. A PV system consists of PV modules. Solar radiation is sufficient to generate required electricity. To run the elevator efficiently. The standard equivalent circuit of the PV cell is shown in Fig.1.

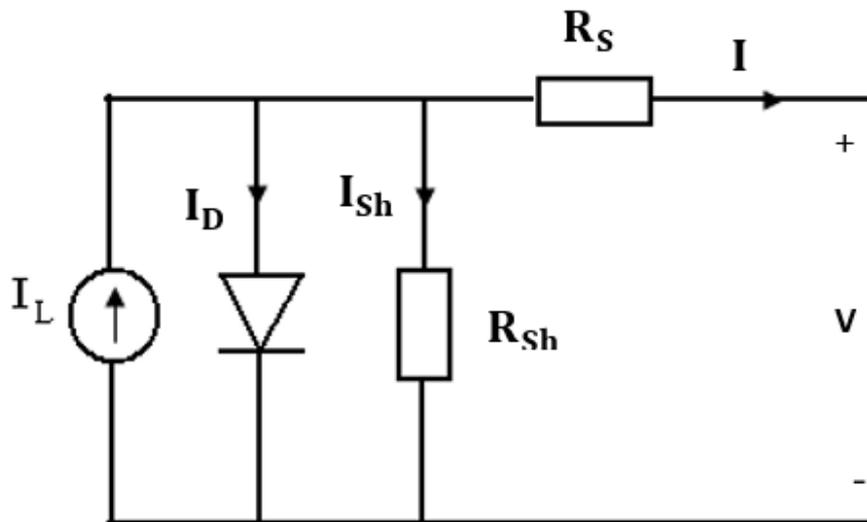


Fig 1.1 power generation in solar panel

The basic equation that describes the I-V Characteristics of the PV model is given by the following equation:

$$I = I_L - I_0 \left(e^{\frac{q(v+IR_s)}{KT}} - 1 \right) - \frac{v + IR_s}{R_{Sh}}$$

Where:

- I - Cell Current (A).
- I_L - Light Generated Current (A).
- I_0 - Diode Saturation Current.
- Q - Charge of Electron = 1.6×10^{-19} (Coul).
- K - Boltzmann Constant (J/K)
- V - Cell Output Voltage (V)
- R_s , R_{sh} - Cell Series and Shunt Resistance (Ohms).

In this tracking methodology servo motor is intelligently controlled by Arduino micro controller that moves prototype according to the inputs received from LDR sensor. The motor drive is used to give a sufficient input supply for servo motor operation.

The required output from the PV panel is given to a 12V regulator for a constant supply of 12V power to the battery. From the battery the power is distributed to siwakoti inverter, driver circuit and pulse generating unit. Siwakoti inverter has two MOSFT and RB-IGBT in order to give a external pulse a pulse generating unit is used. The obtained pulse from the pulse generating unit is not required to operate the MOSFET and IGBT so a driver circuit is included in the circuit.

II. PROPOSED SYSTEM

The solar tracking methodology is based on a servo motor which is intelligently controlled by Arduino micro controller that moves prototype according to the inputs received from LDR sensors.

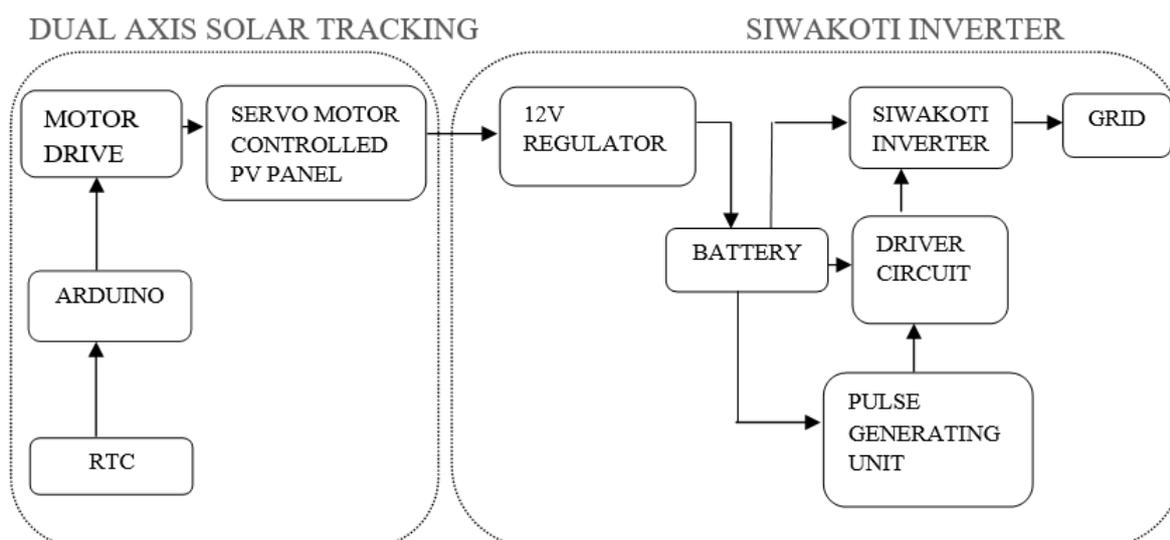


Fig.2 Block diagram

REAL TIME CLOCK (RTC)

A real-time clock is a computer clock (most often in form of an integrated circuit) that keeps track of the current time. In our system RTC is used to give the input signal to Arduino. The solar panel is tilted according to the time period fed into the Arduino. The solar panel's first axis starts the tilting process from the east to west direction as of the sun's direction. According to India for first six months sun will appear at one corner and it gradually moves to next corner. Then for the next six months sun will appear on another corner. So the time period for the other axis will be changed for every six months.

ARDUINO MICRO CONTROLLER

The signal from the LDR sensor is given as the input to the Arduino micro controller. This micro controller as the prototype based on the input signal from the sensor and it gives the signal to the servo motor

SERVO MOTOR

Servo motor is used as the tilting medium in this tracking system. The servo motor has controlled by an intelligent controller called an Arduino controller. This controller feed with a prototype language by the signal from the LDR sensor.

SIWAKOTI INVERTER

A new single-phase H-Bridge transformerless inverter with common ground for grid connected photovoltaic systems (hereafter it is called 'Siwakoti-H' inverter). The inverter works on the principle of flying capacitor and consists of only four power switches (two reverse blocking IGBT's (RB-IGBT) and two MOSFET's), a capacitor and a small filter at the output stage. The proposed topology share a common ground with the grid and the PV source. A Unipolar Sinusoidal Pulse- Width Modulation (SPWM) technique is used to modulate the inverter to minimize switching loss, output current ripple and filter requirements. The main advantages of the new inverter topology are the elimination of the leakage current and ability to provide reactive power to the grid. Further, the peak of output ac voltage is equal to input dc voltage (unlike NPC and ANPC type which requires two times of the peak ac-voltage magnitude). Simulation as well as experimental results from a 1 kW prototype are presented at the end of the paper to prove the concept and also the theoretical analysis presented.

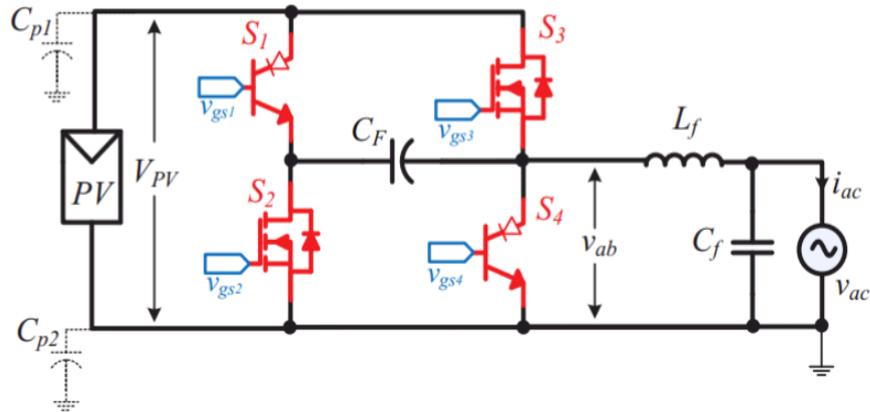


Fig.3 siwakoti inverter

III. WORKING AND MODES OF OPERATION

OPERATION MODES

STATES	S ₁	S ₂	S ₃	S ₄
Positive (Active)	0	0	1	0
Zero	1	0	0	1
Negative (Active)	0	1	0	0

POSITIVE CYCLE

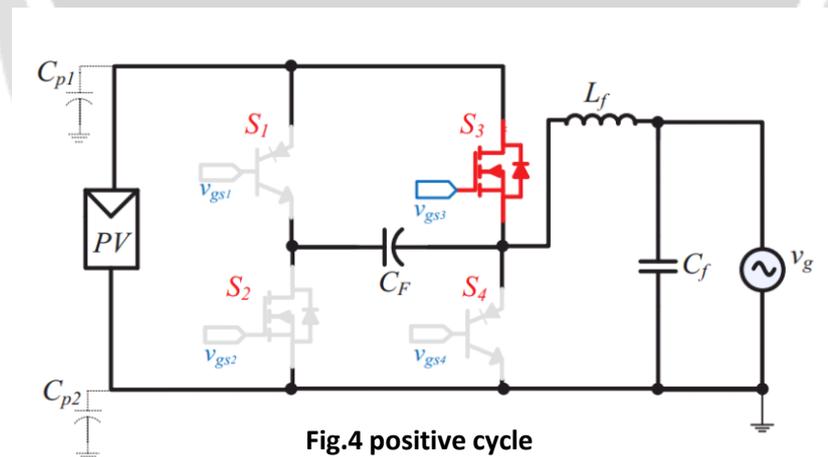
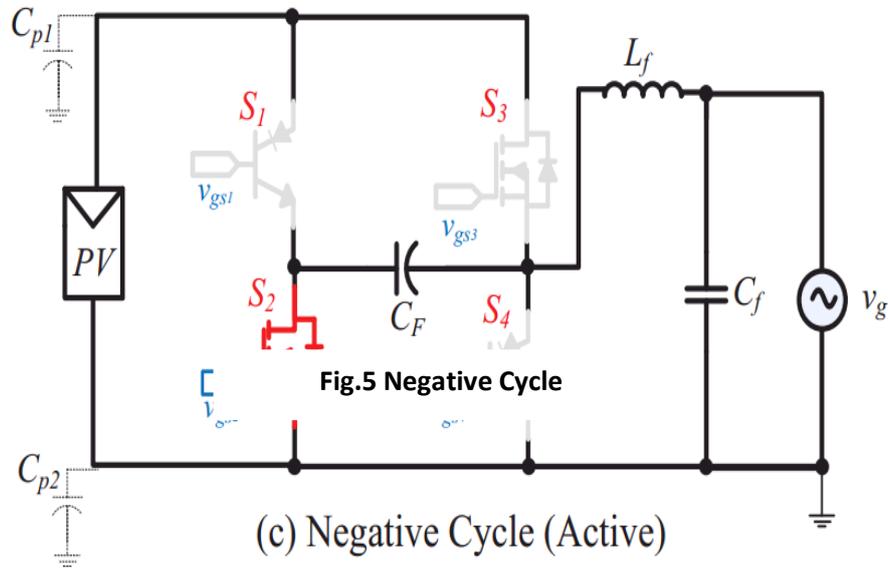


Fig.4 positive cycle

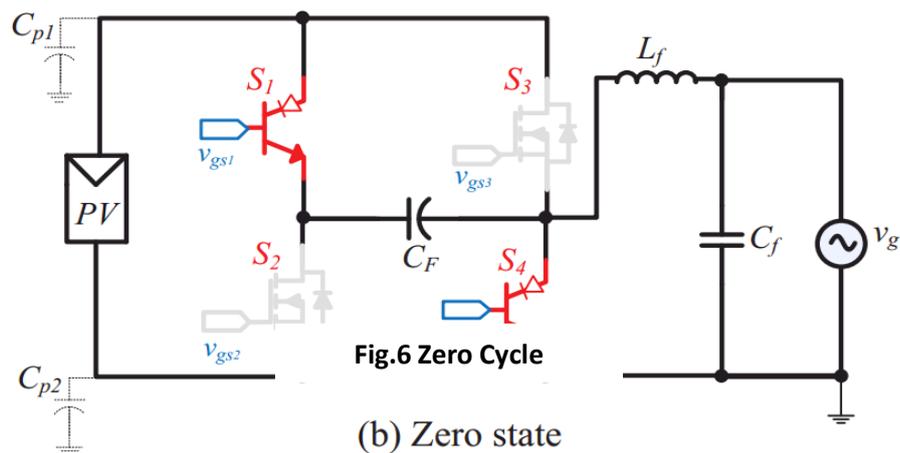
The positive modulating signal is compared with a triangular waveform to create the correct switching pulse for the switch S3, which creates unipolar positive voltage at the filter. Switches S1 and S4 are off during this state; while, S2 also remains off for the whole positive cycle.

NEGATIVE CYCLE



The negative modulating signal is compared with a triangular waveform to create the correct switching pulse for the switch S_2 . The flying capacitor which charges in each zero state (both positive and negative cycle) acts as a virtual dc-bus for the inverter to create a unipolar negative voltage at the filter. Switches S_1 and S_4 are off during this state; while, S_3 also remains off for the whole positive cycle. Only the switch S_2 remains on and the other switches will be turned off. Even in negative cycle operation the grid gets a constant supply from the PV connected system. The virtual dc-bus plays an important role in the power supply from the PV panel to the grid.

ZERO CYCLE



Following the above positive and negative active state, switch S_4 turns ON to create zero state in the circuit. In the same state, switch S_1 also turns ON, which charges the capacitor through S_4 . This shows that the capacitor charges in every switching cycle despite of polarity of the power cycle. This helps to reduce the size of the capacitor with the switching frequency.

IV. SIMULATION OUTPUT

Circuit diagram

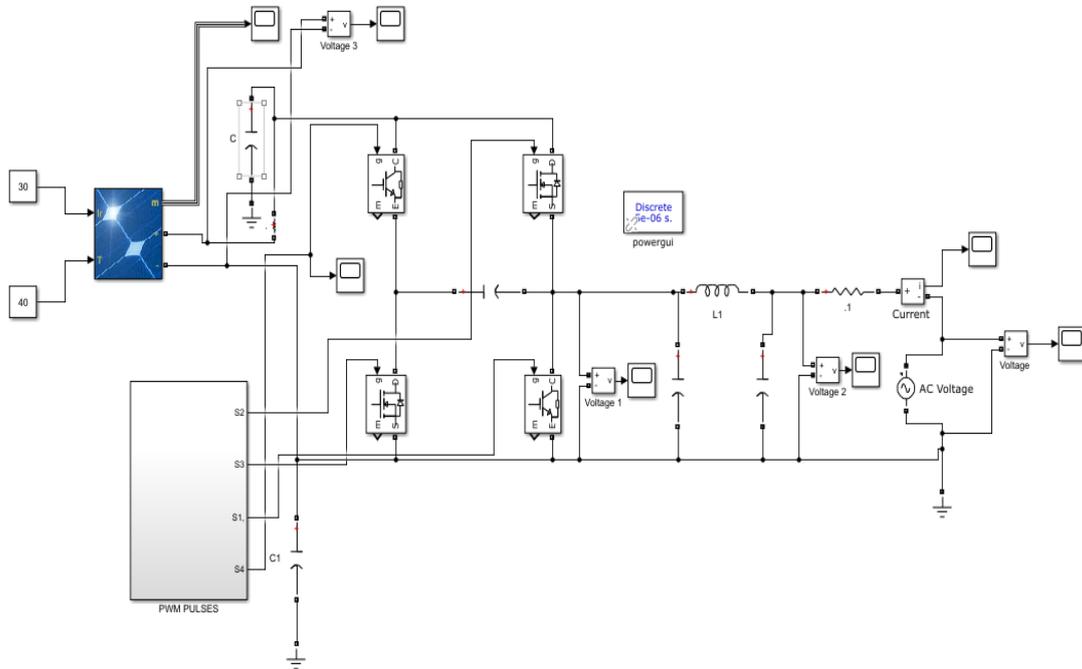
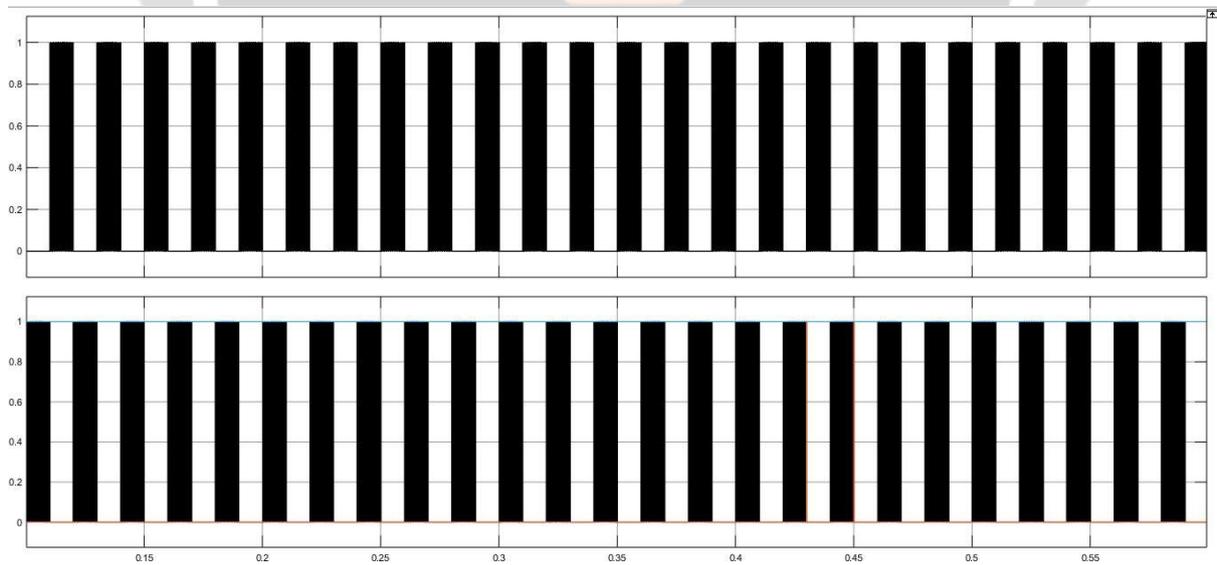


Fig.7 Simulation Circuit

Switching pulse



The switching pulse is given for MOSFET and IGBT to switch ON the electronic devices like MOSFET and IGBT.

Solar Panel Parameters

- Green – Temperature
- Red – Irradiance
- Blue – Output Voltage

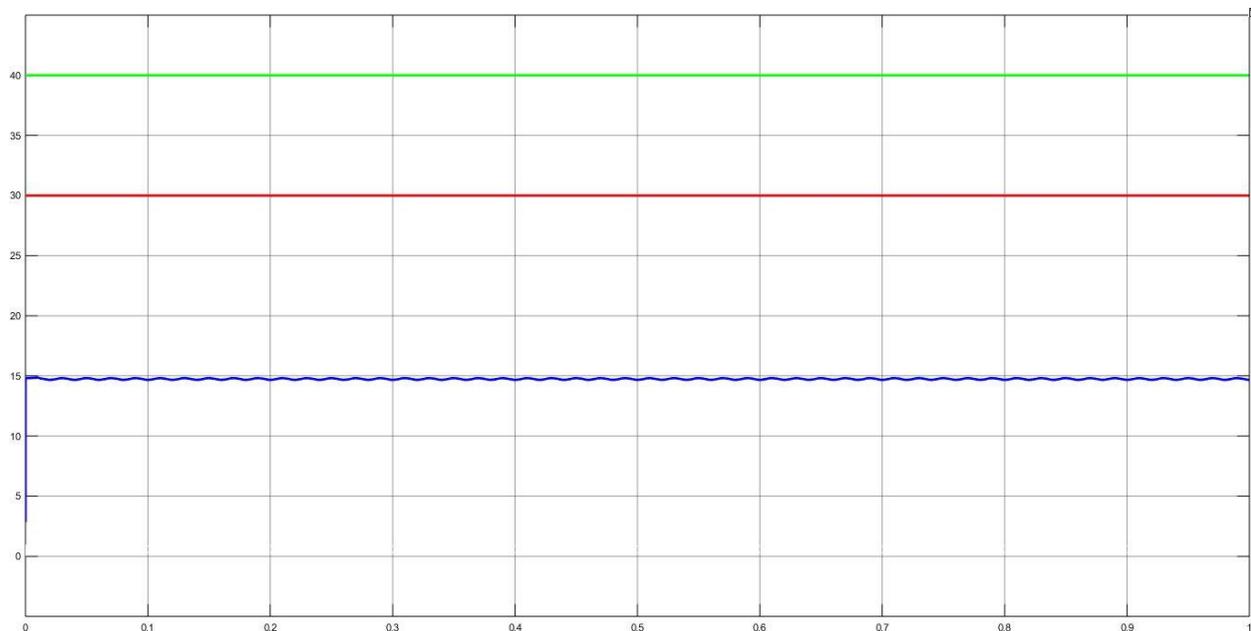


Fig.8 Solar Panel Parameters

OUTPUT VOLTAGE

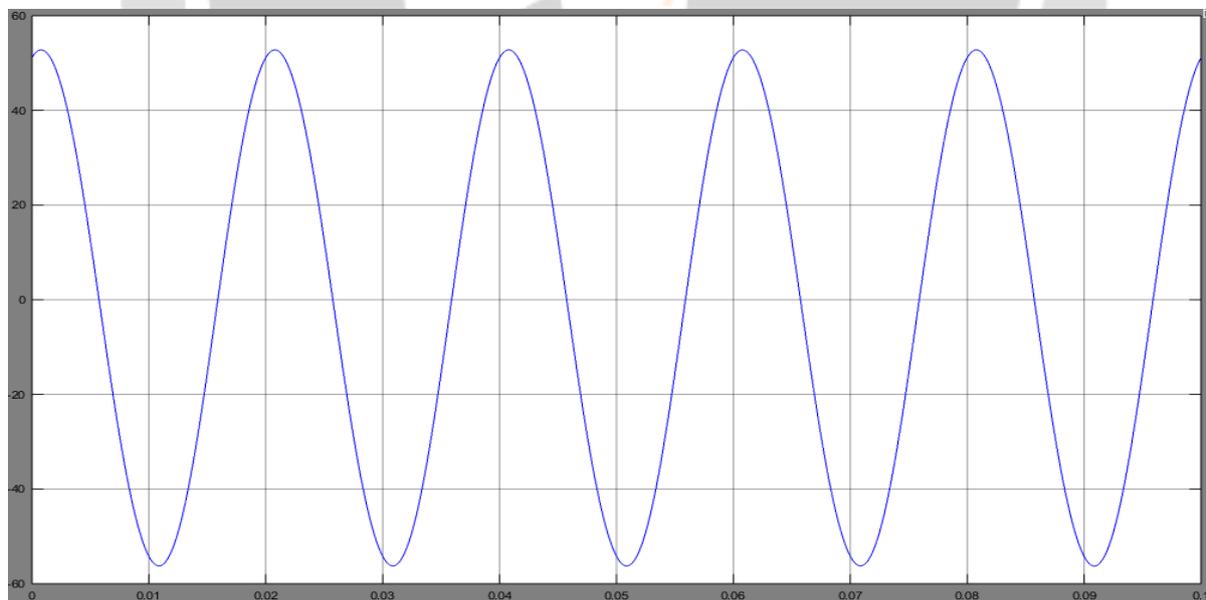


Fig.9 Output Voltage Waveform

The above Fig.9 describes the output voltage waveform from the Siwakoti inverter. The output voltage from the siwakoti inverter is around 50V whereas the input voltage for the inverter is 12V without using the transformer. This inverter is also called as transformerless inverter.

OUTPUT CURRENT

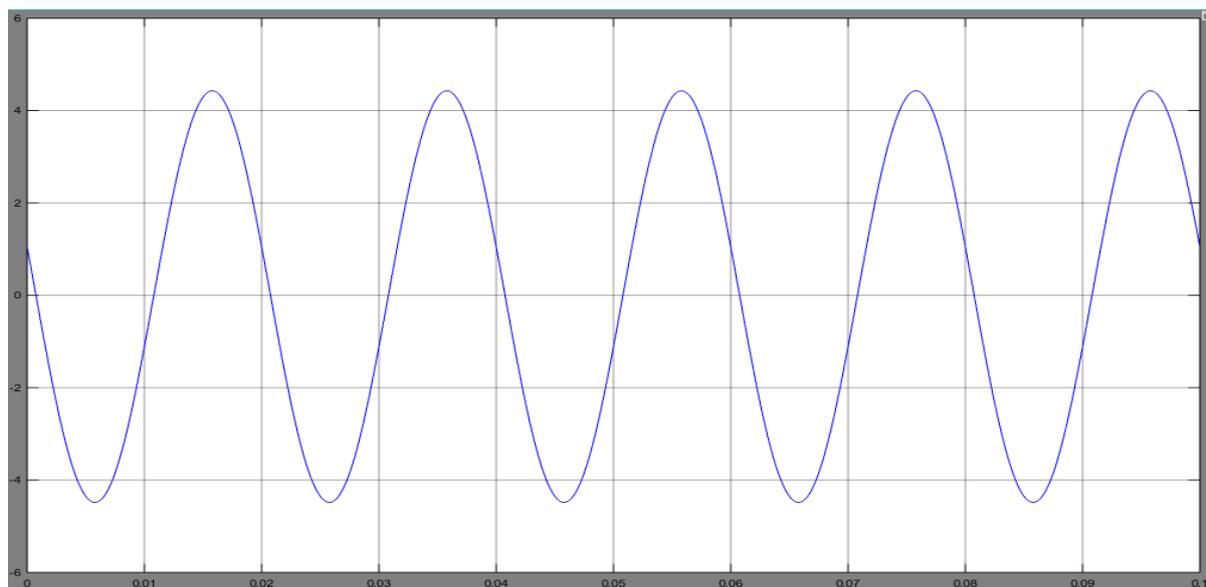


Fig.10 Output Current Waveform

The above Fig.9 describes the output current waveform from the siwakoti inverter. In this circuit the reverse leakage current is reduced by having a RB-IGBT (Reverse blocking IGBT) this IGBT blocks the reverse current from the circuit and safeguard the PV panel.

V. HARDWARE IMPLEMENTATION

Power Supply

It is the power source unit, it can be produce 5V and 12V ranges. This power supply units are

- a) Step down transformer
- b) Rectifier
- c) Pulse generator
- d) Inverter
- e) Filter
- f) Zero crossing detector

Step Down Transformer

When AC 230V 50Hz supply is applied to the primary winding of the transformer. It can be step down into 230V to 12v ranges. The output voltage will be pick up by the secondary winding of the transformer. This step down voltage will be applied to the rectifier section.

Rectifier

This is the full wave bridge type rectifier. Bridge is constructed by four diodes. It is used to convert from AC form to DC form. This DC output is given to pulse generator circuit.

Pulse Generator

A pulse generating unit is an electronic circuit or a piece of electronic test equipment used to generate rectangular pulses. In this circuit pulse generator unit is used to give input pulse to the MOSFET and IGBT of the Siwakoti inverter.

Inverter

Inverter is the circuit which is used to convert DC supply to AC supply. In this circuit the DC output from the solar panel is converted to AC supply by having a H-Bridge Siwakoti inverter.

Filter

Filter used in this circuit is LC filter which is used to reduce the ripples from the output voltage of Siwakoti inverter.

Zero crossing detector

A zero crossing detector or ZCD is a one type of voltage comparator, used to detect a sine waveform transition from positive and negative, that coincides when the input crosses the zero voltage condition.

HARDWARE SETUP OF THE SYSTEM

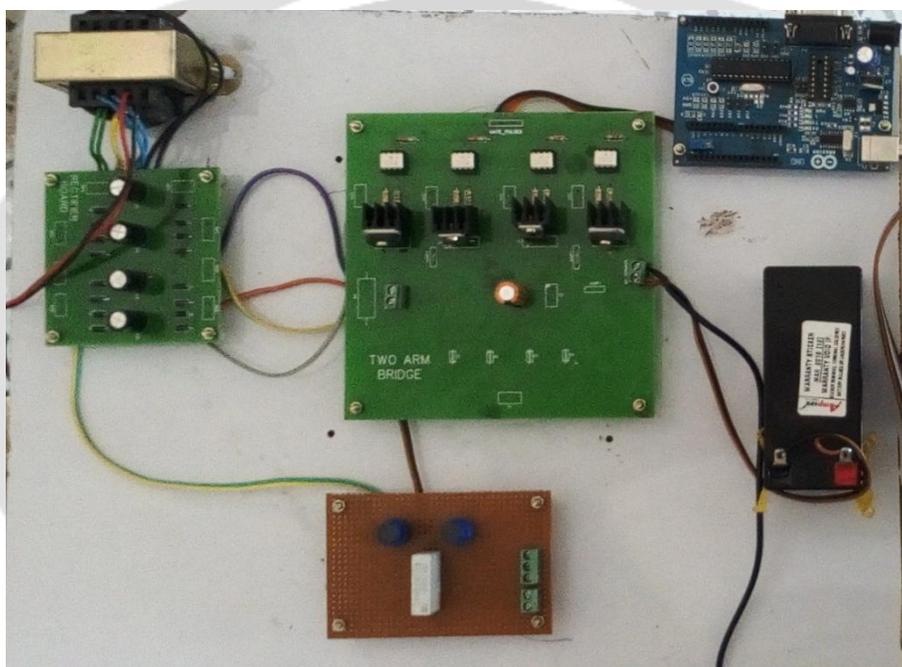


Fig.11 Snapshot of Siwakoti hardware setup

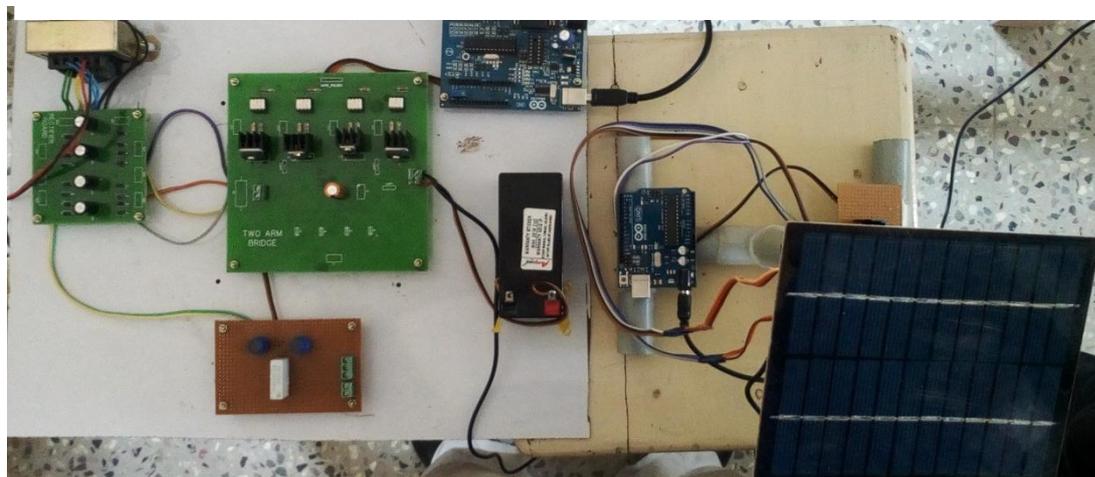


Fig.13 Snapshot of hardware model

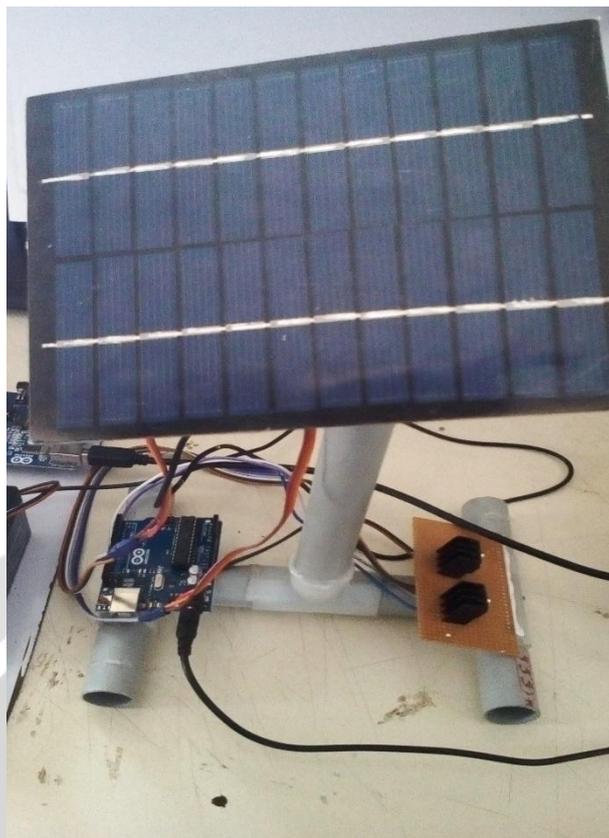


Fig.12 Snapshot of solar panel tilting method

VI. CONCLUSION

This paper has presented a novel and a simple control implementation of a Sun tracker that employed a dual axis tracker with a H-Bridge Siwakoti inverter. This inverter does both the operation of inverter and step up operation so it is also known as transformerless inverter. This type of tracking methodology is more efficient for our seasonal condition to have a better harvest in solar energy.

VII. FUTURE ENHANCEMENT

This system can be further be used in all over the world for the generation of electric power so our environment is safeguard from the pollution issues. This solar tracking system could be more advanced in future for the betterment of generation in electric power.

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