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H6 Inverter For Solar Power Generation With Automatic Tracking System

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Abstract— Solar power is one of the most powerful renewable energy. Renewable energy is rapidly gaining importance an alternative energy resource since fossil fuel are depleting and their prices are fluctuating. The unique feature of the proposed method is the use of H6 type inverters instead of PWM inverters which eliminates the common mode voltage error thus reducing the transient oscillations, noise, etc.The microcontroller(PIC16F887A) is provided with tracking panel with automatic control, stepper motor and driver circuit.The microcontroller is used to control the solar panel. Opto isolation circuit is used to protect microcontroller and control circuit from power circuit. Isolated gate driver circuit and signal conditioning circuit are used for amplification and other purpose.

Keywords: Common mode voltage error, H6 inverter, light dependent resistor, maximum powerpoint tracking (MPPT), microcontroller, , opto-isolation, reduced instruction set compiler (RISC) stepper motor, Solar energy, solar tracker.

I . INTRODUCTION

Renewable energy sources plays an essential role in electricity generation.Various renewable energy sources like wind, solar, geothermal, ocean thermal, and biomass can be used for electricity generation and for meeting our daily energy needs. But the solar energy i.e., energy from the sun is the best choice for electric power generation as it is easily available and pollution free. One hour of sun light falling on the earth periphery is identical with the total energy we use the whole year globally. This solar energy is being popular because of its non-contaminated property. The energy from the sun is converted into electrical energy for further use. This transformation is done by using photo-voltaic conversion.

The main objective of the paper is to use H6 inverter instead of single phase PWM inverter with MPPT system in order to increase efficiency of solar power generation. Maximization of power from a solar photo voltaic module (SPV) is of special interest as the efficiency of the SPV module is very less. A power tracker is used for obtaining the maximum power from the SPV module .The present work describes the maximum power point tracker (MPPT) for the SPV module connected to a load. A good tracking system must be able to follow the sun with a certain degree of accuracy, return the collector to its original starting position at the end of the day and also track during periods of cloud over and winter season. Though this energy is very small we use this energy in our life every day. It is clean and free to all and we will never face the scarcity of solar energy like any other energy.

II. EXISTING SYSTEM

In an exixting system single phase PWM inverter is used along with MPPT system. The traditional full-bridge inverter with four active switches i.e., single phase PWM inverters is simple and has a good tradeoff between efficiency, complexity, and price. The parasitic capacitor between the PV array and the ground also plays an important role in a common mode voltage or ground leakage current issue. The Common mode voltage across the capacitor generates a ground leakage current, which may results in electromagnetic interference (EMI) problem, grid current distortion, and additional losses in the system, etc. The stray capacitor depends on many factors, such as the solar panel and the frame structure, the surface occupied by the cells, the distance between

International Innovative Research Journal of Engineering and Technology
ISSN NO: 2456-1983

cells, the module frame, the weather conditions, the humidity and the dust covering the PV panel, etc

The technique of converting the dc power from the photovoltaic cells to a single phase ac power using an traditional pulse width modulated inverter. In photovoltaic power generation system, it is needed to use a simple single phase and special quality inverter for residential and small scale industrial applications especially in rural areas. The existing type of multi- step PWM inverter has unique features such that it can be connected conveniently to separate solar cell modules that contribute to an easy implementation of the photovoltaic power generation system. In thisexisting system, single phase PWM Inverter for a solar power generation system with automatic tracking system is employed.

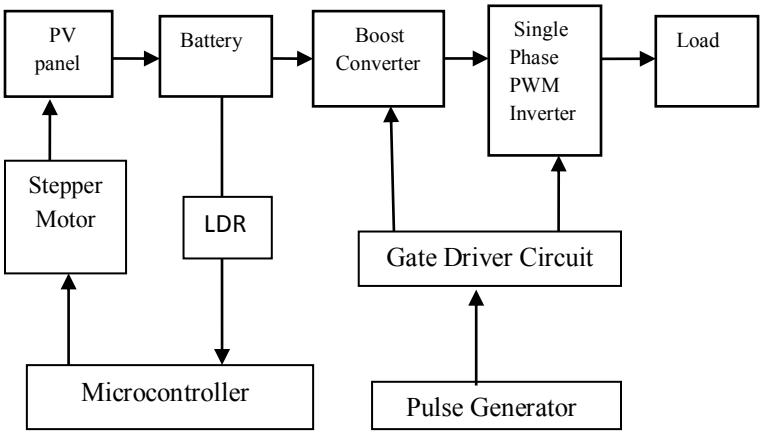


Figure 1: Existing Block diagram for Single phase PWM inverter for Automatic Solar Tracking System.

The existing block diagram for single phase PWM inverter for Automatic tracking system is shown above.The PWM inverter is placed between the boost converter and load. For the Pulse generation, Pulse generator and gate driver circuit is connected to PWM inverter. The amount of dc power, which varies with solar light intensity and temperature is converted to a single-phase 50hz ac using an type of a pulse width modulation inverter. This inverter meets most of the specifications required in the residential system such as small size and light load applications, high reliability, high efficiency and low cost performance. In the shown figure(figure 2) is the circuit diagram for the single phase PWM inverter. In this inverter four MOSFET switches are used. Two diodes are connected in between four switches. This inverter coverts different level of DC voltage into AC voltage. The DM inductor is connected between the four

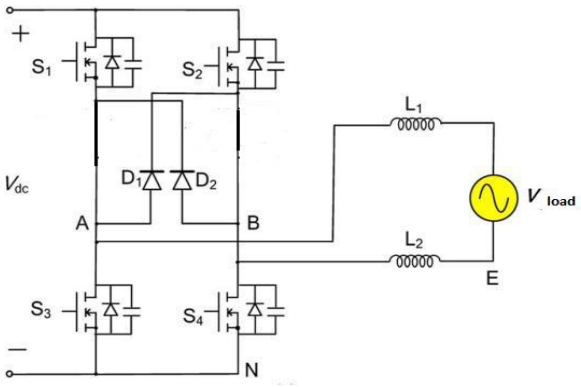
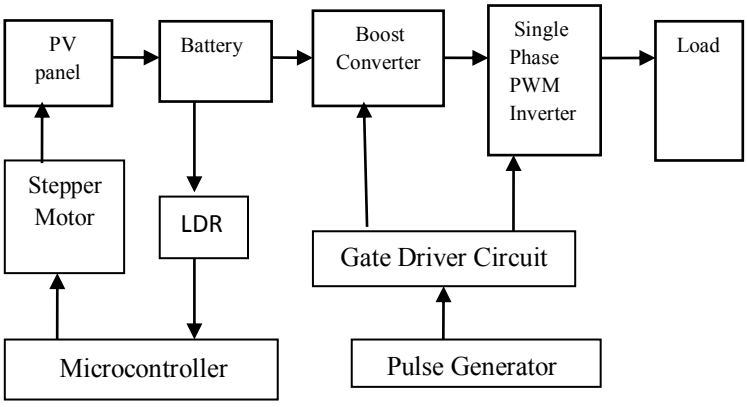


Figure 2: Circuit Diagram for Single phase PWM inverter

switches and load. The load is connected to the output of the single phase PWM inverter. With the more active switches added to the H4 topology with the modified PWM methods, the objectives of high efficiency and low leakage current are both achieved.

III. PROPOSED SYSTEM

The main contribution of this paper is the existing high-performance inverters with H6-type configuration, which makes novel topologies possible. In addition, a novel high-efficiency single-phase transformerless photovoltaic inverter with modulation method is also proposed and evaluated as an example. Without input split capacitors, common-mode voltage and leakage current problems in a non-isolated system with H6-type configuration are avoided, and the feature of a three-level output voltage in the inverter bridge's middle point helps inductors and power quality is increased. The detailed operation principles with combined modulation strategy with unipolar and bipolar pulse width modulation schemes are presented



International Innovative Research Journal of Engineering and Technology
ISSN NO: 2456-1983

Figure 3:Proposed block Diagram for H6 inverter with Automatic solar tracking system.

III.H6-INVERTER

A novel high-efficiency single-phase transformer-less inverter (H6 topology) is proposed. This hybrid modulation method features both bipolar and unipolar .Figure 4:Circuit

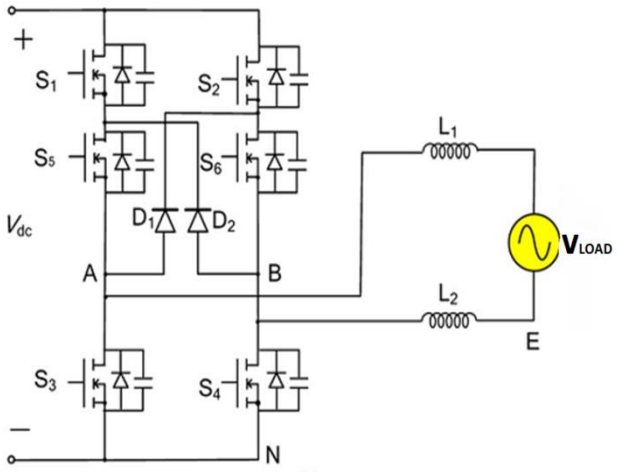
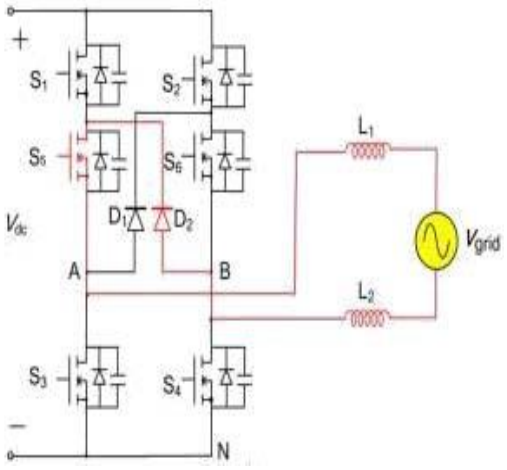


Figure 4 for H6 inverter inverter.

modulation, which was proposed for the H6 inverter. It consist of six MOSFET switches. There are four different modes of operation in H6 inverter

Mode 1:

In the grid positive half-cycle,S5 is alwayson,where S1, S4 are active. The input voltage applied to the inductors L1 and L2 is the difference between the input and load voltages; thus, the current is charging.



addition,D2 commutates at the PWM switching frequency. By discharging the grid voltage , a freewheeling path to maintain an inductor current is provided. At this time, the input voltage is shared between parasitic capacitors of switches S1 and S3 because the discharging process of these parasitic capacitors is blocked by the large impedance of inactive switches blocks .

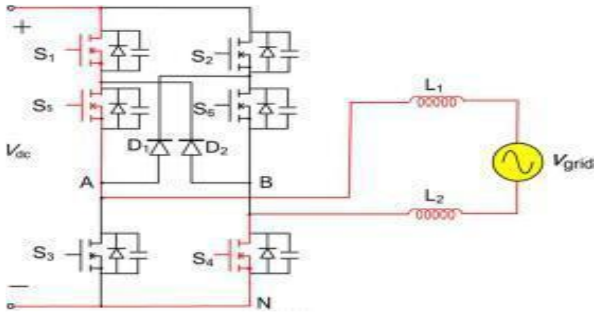


Figure 6: Mode 2 operation of H6 inverter.

Mode 3 and Mode 4:

Similarly change during the grid negative half-cycle where VDM changes in between 0 and−Vdc/2, according to the conditions of Modes 1–4 illustrated, CM voltage is denoted as VCM keeps an almost constant value of half input voltage Vdc/2. It means that the H6 inverter with hybrid modulation method has a high performance in Common Mode noise elimination. In addition, parasitic capacitors of switches are used instead of input split capacitors, there is no need to e

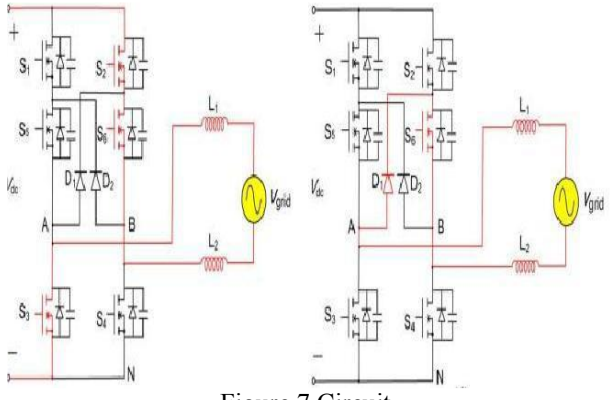


Figure.7 Circuit.

International Innovative Research Journal of Engineering and Technology
ISSN NO: 2456-1983

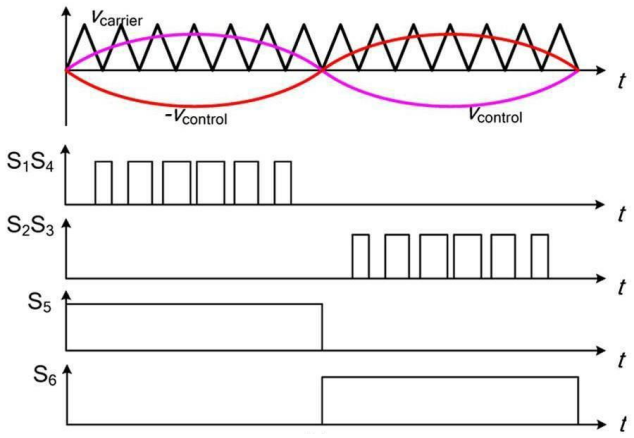


Figure 8: Waveform obtain in H6 inverter.

Isolated Gate Driver:

Gate driver is a power amplifier that accepts a low power input from a controller IC and produces the appropriate high current gate drive for a power MOSFET. They can also be integrated within a controller. The main purpose of gate driver circuit is

1. Isolation purpose (MCT2E) – 6 pin IC.
2. Efficient driving (PUSH-PULL amplifier).
3. PWM protector.
4. To provide isolation between MOSFET and controller.
5. To drive the MOSFET Effectively.

Opto-isolation circuit:

Since the MOSFETs are used to switch the capacitor voltage into supply line there will be switching transients produced by them. These switching transients in turn will affect the pulses developed by the PIC16F887A and by time the microcontroller itself. So in order to protect the microcontroller and the control circuit from power circuit we are providing isolation circuit.

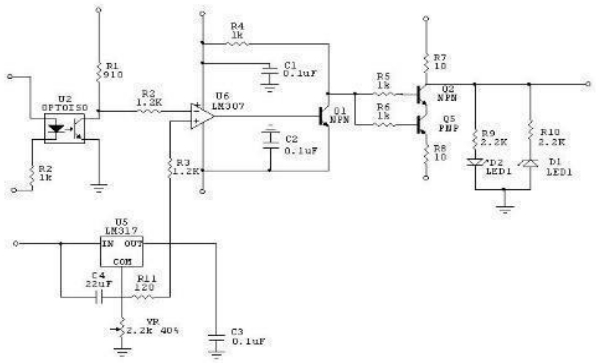


Figure 9: Opto-isolation circuit.

BOOST CONVERTER

A boost converter is a DC_DC power converters, with the output voltage is always greater than the input voltage.DC_DC converters have a wide range of uses today,It is the DC equivalent of the transformer. Filter capacitors are used to reduce the ripple from the output voltage. It consists of Switched More Power Supply unit.

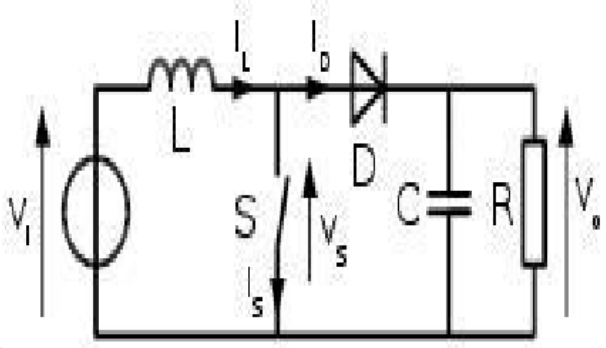


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Figure 10: Circuit diagram for boost converter.

Mode 1:

when switch (S) is closed the current flows through the inductor in clockwise direction.Hence the polarity of the inductor is positive.

Mode 2:

when switch (s) is open .current is reduced as the impedance is higher. Therefore a change or reduction of current will opposed by the inductor..hence the polarity of the inductor will be reversed.

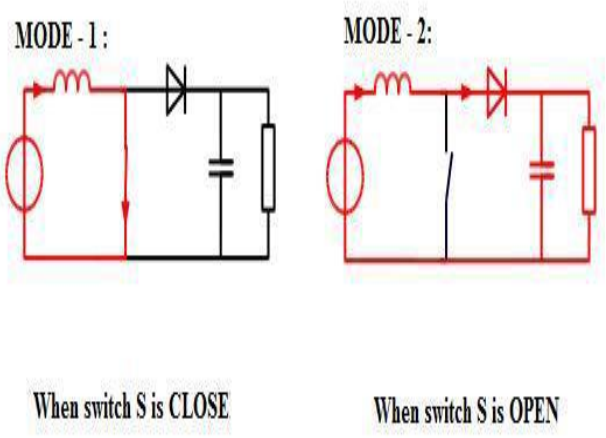

Figure 11:Operation of boost converter.

SOLAR TRACKER

Solar tracker is a device that tracks the position of the sun as it revolves from east to west during daytime. Generally solar tracker can be classified into two group i.e.,

i)Single axis solar tracker
ii) Dual axis solar tracker.

For a specific longitude the sun moves from east to west along a fixed solar path everyday. But during seasonal changes the sun moves at an angle of 460 degree north and south . A dual axis solar tracker can be suitable for both the daily changes and seasonal changes of the sun. So a dual axis solar tracker is more effective than that of single axis solar tracker. In our proposed model we used microcontroller (PIC16F887) based azimuth-altitude dual axis solar tracking system. The azimuth-altitude dual axis solar tracker pivots the solar panel in which the position of the sun is perpendicular to the panel i.e the angle of incidence of sun beam will be 0°. Light dependent resistors (LDR) are used for sensing the positional change of the sun. This sensor is used to moniter continuously the solar radiation and this data are transferred to the stepper motor through microcontroller. The stepper motor moves the panel where the intensity of light is maximum. Our aim is to reduce the power consumption and boost up the solar energy generation. In existing system, dual axis solar tracker is uses two stepper motor simultaneously. It is the disadvantage of using dual axis solar tracking system. Because it needs more power to operate two motors. In the proposed model we do not use two stepper motors at same time. At the initial condition , two stepper motors start running. Since the sun changes its position for every four minutes the sensor detects the location of the sun where it is moved. The first stepper motor is responsible for movement of the sun from east to west .The second stepper motor is responsible for the movement of sun from north to south or viceversa. If the first stepper motor operates , second stepper motor will be at rest . If the second stepper motor operates , first stepper will stop working. The azimuth and altitude angle is taken as a reference for the vertical and horizontal movement of the solar panel and the exact position of the sun is estimated by these two angles. The vertical angle located between the horizontal and the line connecting to the sun is called solar altitude angle . At sunset or sunrise altitude angle is 0° and when the sun is at the zenith the altitude angle remains 90°. The proper solar tracker is needed for this system in order to measure the efficiency of the H6 inverter. This dual axis tracking system with azimuth and altitude angle is suitable to increase efficiency of solar power generation with H6 inverter.

IV. MICROCONTROLLER

The microcontroller used is PIC16F887. This features include 256 bytes of EEPROM datamemory, self-programming, an ICD, 2 Comparators, 14 channels of 10-bit analog-to-digital (A/D) converter , a synchronous serial port that can be configured as either 3-wire Serial Peripheral Interface (SPI) or the 2-wire Inter-Integrated Circuit (I^2C) bus and an Enhanced Universal Asynchronous Receiver Transmitter (EUSART). Because of its low price, wide range of applications, high quality and ease of availability this PIC microcontroller is widely used for experimental and modem applications. It is better for machine control applications, measurement devices, study purpose and so on. PIC16F887 devices have a Watchdog Timer, which can be turn-off only through configuration bits. It runs off its own RC oscillator for reliability purpose. There are two timers that offer necessary delays on power-up. One is the Oscillator Start-up Timer (OST), intended to maintain the chip in RESET mode until the crystal oscillator is stable. The other is the Power-up Timer (PWRT), which is used to provide a fixed delay of 72ms (nominal) on power-up only. It is designed to keep the part in RESET while the power supply stabilizes. With these two timers onchip, most applications need no external RESET circuitry.

International Innovative Research Journal of Engineering and Technology
ISSN NO: 2456-1983

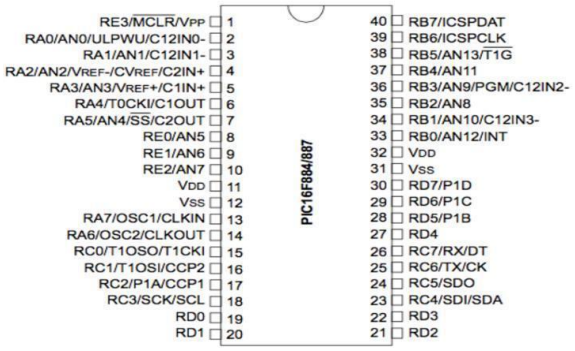

Figure 12: Pin Configuration of microcontroller

The PIC 16F887 basically have three timer modules. These timer module terminals are multiplexed with other functions for handling alternate functions. These timer modules are usually denoted by the symbols TIMER-0, TIMER-1, and TIMER- 2.These modules are help to functions the various timing and counting functions inside the chip. The INDF register is not a physical register. Addressing the INDF register will result in indirect addressing. Indirect addressing is applicable by using the INDF register. Any instruction using the INDF register actually accesses the register pointed to by the File Select Register, FSR.

LCD (Liquid Crystal Display) screen is an electronic device with display module and find a wide variety of applications. A 16x2 LCD display is very basic version and is very commonly used in many devices and circuits. These modules are suitable than the seven segments and other multi segment LEDs. The LCD used in this microcontroller because it is economical , easily programmable , no limitations in displaying special and customs characters (unlike in seven segment) , animations and so on. A **16x2 LCD** denoted that it can display 16 characters per line and there are 2 such lines. In this LCD each character is displayedin 5x7 pixel matrix.

PORT NAME	**REGISTERS**	**LENGTH**
PORT-A	RA-0 to RA-5	6 bit wide
PORT-B	RB-0 to RA-7	8 bit wide
PORT-C	RC-0 to RA-7	8 bit wide
PORT-D	RD-0 to RD-7	8 bit wide
PORT-E	RE-0 to RE-2	8 bit wide

Table 1:Port Details of Microcontroller(PIC16F887).

Microcontroller with steppers drivers can be used to obtain very high rotation speeds in stepper motors. It is possible to have extreme control over exactly how each individual coil is energized inside the Motor by using a microcontroller. This is absolutely necessary to achieve high speeds because when the speed increases, timing of the coils firing must be perfectly in sync. In order to handle higher current than what the microprocessor can allow, the controller needs to use full H-bridge chips. Normally, an H-bridge is used for controlling a plain old DC-motor but in this case, the H-bridge chips are used for exactly controlling the amount of electricity that goes to each individual coil on the stepper motor. Thus, for bipolar stepper motors, it needs 2 chips per motor.

V. SOFTWARE REQUIREMENTS

MATLAB is briefly known as Matrix laboratory. It is used to verify and analyse the given input data and to check whether the proper output is obtained.. It is also called as computer algebra system. It is a high-performance language for technical computing. It is used to integrates computation, visualization, and programming in an easy-to-use environment where problems and solutions are expressed in familiar mathematic alnotation. MATLAB was originally written to It is used to provide easy access to matrix software developed by the LINPACK and EISPACK projects. Nowdays, MATLAB systems incorporate the LAPACK and BLAS libraries, including the state of the art in software for matrix computation. MATLAB is a high level language and interactive environment that enables to perform computationally concentrated tasks faster than with traditional programming languages such as C, C++, and Fortran. Simulation is an platform for multi-domain simulation and Model-Based Design for dynamic and IOT systems. It provides an interactive graphical environment and a customizable set of block libraries that let you design, simulate, implement, and test a variety of time-varying systems, including communications, controls, signal processing, video processing, and image processing.

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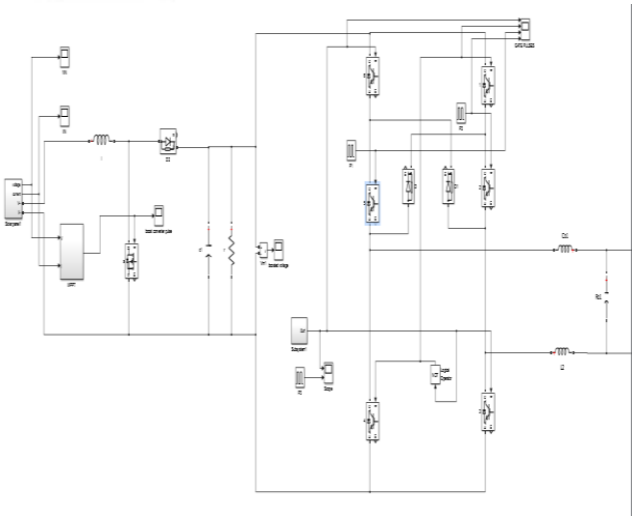

Figure 13a: Input side of the circuit diagram for matlab simulation.

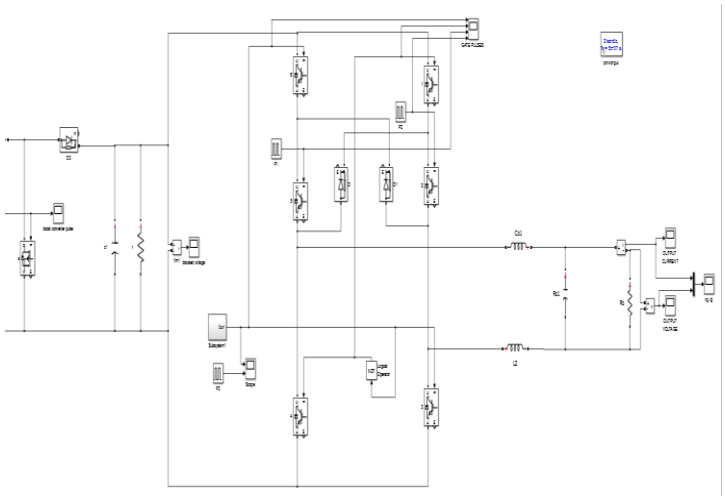

Figure 13 b: Output side of the circuit diagram for the matlab simulation .

VI. SIMULATION RESULT

After designing the circuit diagram the simulink graph is obtain for the boosted voltage , output voltage and output current.

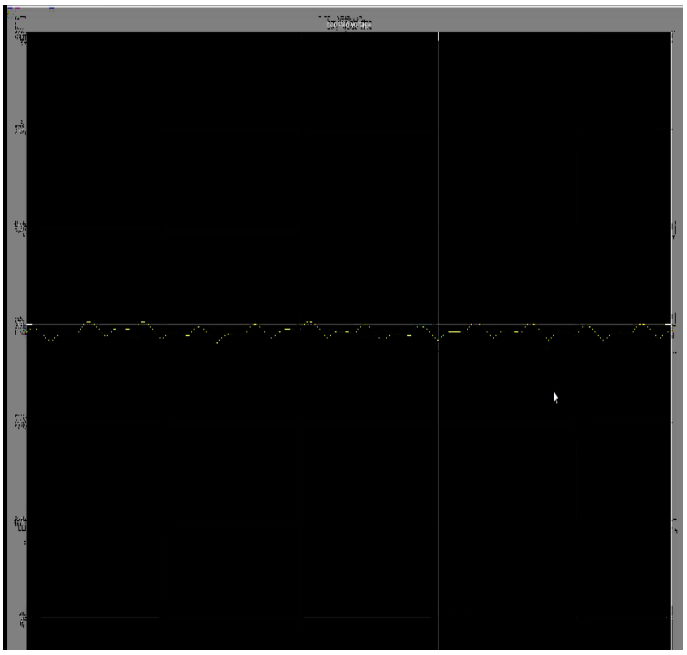

Figure 14 a:Waveform of the boosted voltage.

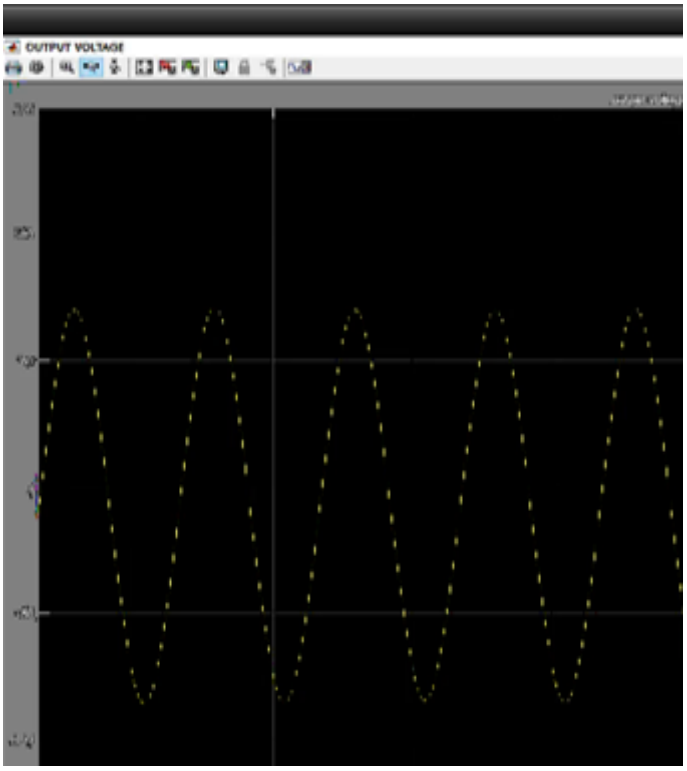

Figure 14 b :Waveform of the output voltage.

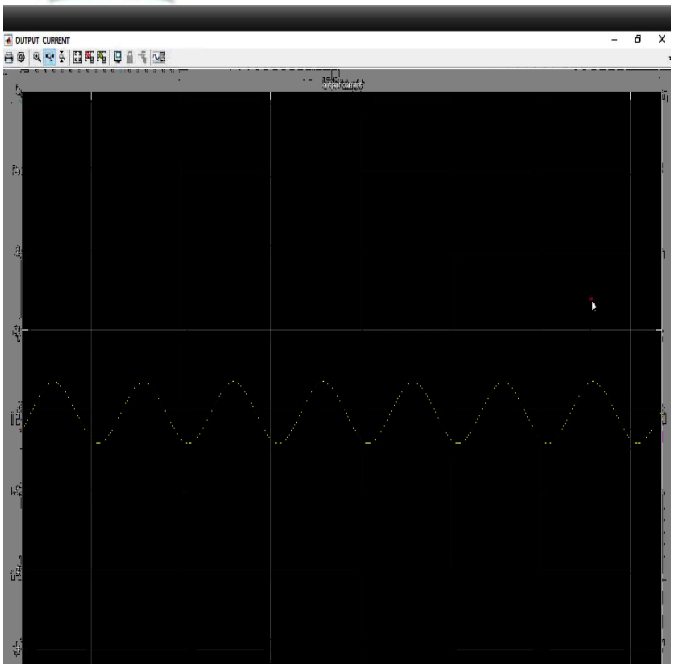

Figure 14 c:Waveform for output current.

VII. RESULT

It is observed that the solar panel rotates for about 360° along with the axis of rotation of sunlight based on the intensity of light falling on the solar panel according to the principle of MPPT. The output thus obtained from the panel (DC voltage) is then passed to the boost converter to step-up the voltage to a higher level in-order to withstand losses and ripples. This DC voltage is then made to pass through the H6 inverter in which the implementation of anti-parallel diodes and six MOSFET switches allows for the prevention of COMMON MODE VOLTAGE ERROR unlike other PWM inverters. The isolated gate driver isolates the microcontroller and rest of the circuit in terms of supply voltage required according to the specific function it performs. The microcontroller establishes a complete control over the panel in tilting it according to the intensity of light which is directly proportional to the power flow in the panel by controlling the stepper motors. The microcontroller also controls the converter and inverter by generating the pulses which are required for the proper working of these components. It also has a built in ADC which is used to obtain digital value of amount of voltage, power generated in the output terminal in accordance with the input analog voltage.

Table 2: Comparision between the single phase PWM inverter and H6 inverter.

VIII. CONCLUSION

For a dual axis solar tracking system, an efficient method of tracking has been developed and applied to 10W, 12V solar panel implemented through a H6 inverter coupled to it. The output voltage and current ripple can be greatly reduced with the proposed H6 inverter and filters. By the implementation of this method, the efficiency can be improved by 35-40% when compared to the existing system.

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