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ijirset@gmail.com



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A Smart High Gain DC-DC SEPIC Converter for Solar PV Applications

G.KARTHIGA, M.PADMAVATHI,

ME Power Electronics and Drives, Gnanamani College of Technology, NH-7, A.K.Samuthiram, Pachal-PO,

Namakkal, Tamilnadu, India

Assistant Professor, Power Electronics and Drives, Gnanamani College of Technology, NH-7, A.K.Samuthiram,

Pachal-PO, Namakkal, Tamilnadu, India

ABSTRACT: Multilevel voltage source inverter (VSI) has been recognized to be very attractive in high voltage dc to ac conversion. It offers several advantages compared to the conventional two-level inverter, namely reduced switching losses and better harmonic performance. This work proposed a new switching strategy for a particular multilevel topology, known as the modular structured multilevel inverter (MSMI). The proposed scheme is based on symmetric regular sampled unipolar PWM technique. Unlike other techniques proposed by other researchers, this method uses multiple modulating waveforms with a single carrier. Mathematical equations that define the PWM switching instants are derived. The derived equations are verified by computer simulation. To justify the merits of the proposed modulation scheme, prediction on the output voltage harmonics using Fourier analysis is carried out. An experimental five-level MSMI test-rig is built to implement the proposed algorithm. Using this set-up, it was found that the derived equations could be easily implemented by a low-cost fixed-point microcontroller. Several tests to quantify the performance of the inverter under the proposed modulation scheme are carried out. The results obtained from these tests agree well with theoretical prediction.

KEYWORDS--Photovoltaic (PV) systems, multi-string systems, multilevel inverters, stand-alone, battery converters.

I. INTRODUCTION

The continuous economic development of many countries and the environmental issues (gas emissions and the greenhouse effect) observed in the last decades forced an intense research in renewable energy sources [1]. Hydro, photovoltaic (PV) and wind energy conversion are the most explored technologies due to their considerable advantages among these energy sources the PV is pointed out as one of the most modular and environmentally friendly technologies [2]. The output of photovoltaic (PV) is in DC form. Therefore, it requires sophisticated conversion techniques to make them usable because the power utilization is mostly in AC form. This conversion can be done by using inverter that converts DC input into AC output. The inverter is a critical component responsible for the control of electricity flow between the modules, battery and loads in any PV based system.[2] This paper is classified into five section [3]. Recently, the need of renewable energy has become important contribution in energy consumed such as solar, wind, biomass and geothermal. Among them, solar energy is one of the important renewable energy sources because it is inexhaustible. Besides, its conversion free from the emission of air or water pollutions or the generation of solid waste [4]. The time interval between OFF and ON may be small but it is enough to cause the output of Transistor to dissipate power. However, this slope can be used to cause a delay. So, there is a moment of pause between the two Transistors ON time and this will avoid overlap [5]. Multilevel inverter as compared to single level inverter has advantages like minimum harmonic distortion and can operate on several voltage level inverters. A key component in this project is the DC to AC nine level multilevel inverter. The DC source feeding the multilevel inverter is considered to be varying in time and the switching angle is adapted to the dc source variation [6]. A new approach for modulation of a 7-level cascade multilevel inverter using selective harmonic elimination is presented. The dc sources feeding the multilevel inverter are considered to be varying in time, and the switching angles are adapted to the dc source variation. This method uses genetic algorithms to obtain switching angles offline for different dc source value [7].

II. METHOD AND MATERIALS

1.1 Photovoltaic System

Energy from our sun is one such example. Technically, the sunlight will fade in about 5 billion years, but for all practical purposes and human timescales, this is a continuous and infinite resource. Solar Panels use arrays of solar PV cells to convert photons into usable electricity. Installing solar panels with a synchronous or multifunctional solar inverter allows us to use city electricity in emergency times. Photovoltaic Operation is the direct conversion of light into electricity at the atomic level. Some materials exhibit a property known as the photoelectric effect that causes them to absorb photons of light and release electrons. When these free electrons are captured, electric current results that can be used as electricity. For solar cells, a thin semiconductor wafer is specially treated to form an electric field, positive on one side and negative on the other. When light energy strikes the solar cell, it produces an electric power which can be fed to the desired load.

1.2 Solar Energy System

It is a new topology; the H Bridge is constructed using MOSFET and a switch. The output of the inverter has three levels; the load current ripple is very small. Although in this case the frequency of current is equal to the switching frequency, leakage current is small due to parasitic capacitance. The configuration is compact and uses lesser components. Only one (undivided) PV source and one buck-boost inductor are used and shared between the two half cycles, which prevents asymmetrical operation and parameter mismatch problems. Total harmonic distortion and DC component of the current supplied to the grid is low, compared to existing topologies and conform to standards like IEEE 1547. Design and analysis of the inverter in discontinuous conduction mode is carried out. Simulation and experimental results are presented.

Here in the photovoltaic inverter technology we use these topologies in order to acquire higher efficiencies combining with very low ground leakage current. In this project, a new topology, based on the H-bridge with a new ac bypass circuit consisting of a diode rectifier and a switch with clamping to the dc midpoint, is proposed. In case the transformer is omitted, the efficiency of the whole PV system can be increased with an extra 1%–2%.

The most important advantages of This PV systems can be observed. This PV inverters use different solutions to minimize the leakage ground current and improve the efficiency of the whole system.

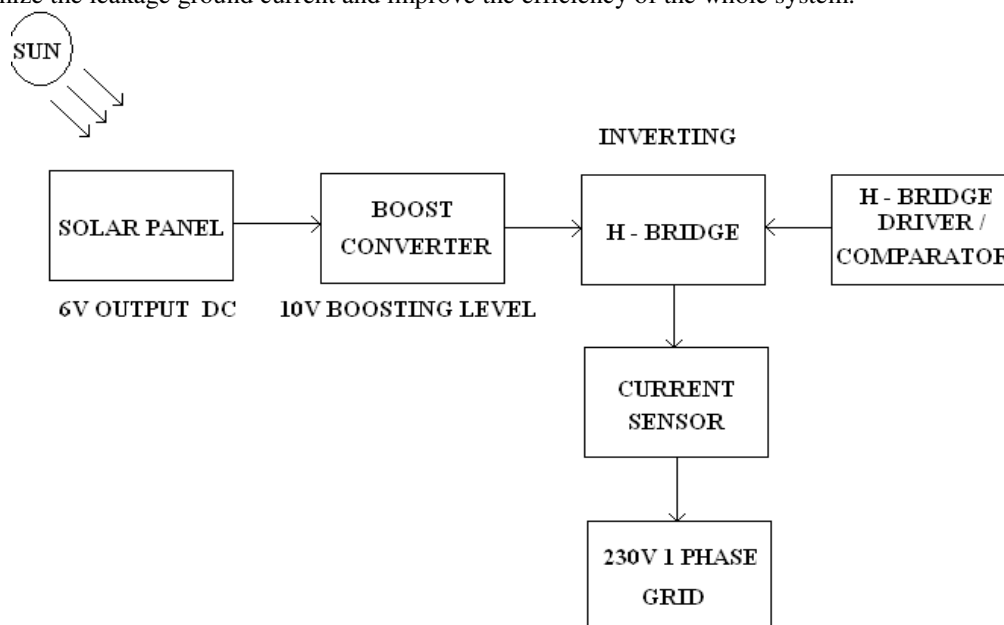


Fig: 1 Block Diagram solar panel

One of them is to connect the midpoint of the dc-link capacitors to the neutral of the grid, like the half-bridge, neutral point clamped (NPC), or three-phase full bridge with a split capacitor topology, thereby continuously clamping the PV array to the neutral connector of the utility grid. Half-bridge and NPC type of converters have very high efficiency, above 97%. Furthermore, the topology proposed in here reduces the dc current injection, which is an important issue in the case of these topologies and is limited by different standards.

The main advantage of the HB inverter with unipolar switching is that the output voltage has three levels and the frequency of the output voltage is the double of the switching frequency, thereby increasing the efficiency of the inverter and decreasing the size of the output filter. The non-injection of dc current into the grid is topologically guaranteed by adding a second capacitive divider to which the neutral terminal of the grid is connected.

1.3 Advantages

- This inverter offers a better efficiency, compared to those inverters that have a galvanic isolation.
- HB-ZVR is that the HERIC topology, with the implemented PWM strategy, ideal for PV systems that supply the grid with active power
- Power factor is maintained at unity
- These PV inverters are current controlled, injecting only active power into the utility grid
- Decreasing the size of the output filter.

2.4 CUK Boost Converter

A boost converter (step-up converter) is a DC-to-DC power converter with an output voltage greater than its input voltage. It is a class of switched-mode power supply (SMPS) containing at least two semiconductor switches (a diode and a transistor) and at least one energy storage element, a capacitor, inductor, or the two in combination. Filters made of capacitors (sometimes in combination with inductors) are normally added to the output of the converter to reduce output voltage ripple.

2.4.1 Inverting

2.4.1.1 H – Bridge

An H bridge is an electronic circuit that enables a voltage to be applied across a load in either direction. These circuits are often used in robotics and other applications to allow DC motors to run forwards and backwards. H bridges are available as integrated circuits, or can be built from discrete components.

2.4.1.2 Sensing and Feedback

Sensing is a device that detects electrical current (AC or DC) in a wire, and generates a signal proportional to it. The generated signal could be analog voltage or current or even digital output. It can be then utilized to display the measured current in an ammeter or can be stored for further analysis in a data acquisition system or can be utilized for control purpose. The sensed current and the output signal can be:

AC current input,

- analogy output, which duplicates the wave shape of the sensed current
- BIPOLAR output, which duplicates the wave shape of the sensed current
- unipolar output, which is proportional to the average or RMS value of the sensed current

DC current input,

- unipolar, with a unipolar output, which duplicates the wave shape of the sensed current
- digital output, which switches when the sensed current exceeds a certain threshold

2.4.1.3 Single Phase Grid

An electrical grid is an interconnected network for delivering electricity from suppliers to consumers. It consists of three main components: 1) power stations that produce electricity from combustible fuels (coal, gas, biomass) or non-combustible fuels (wind, solar, nuclear, hydro power); 2) transmission lines that carry electricity from power plants to demand centers; and 3) transformers that reduce voltage so distribution lines carry power for final delivery.

In the power industry, electrical grid is a term used for an electricity network which includes the following three distinct operations:

- Electricity generation - Generating plants are usually located near a source of water, and away from heavily populated areas. They are usually quite large to take advantage of the economies of scale. The electric power which is generated is stepped up to a higher voltage-at which it connects to the transmission network.
- Electric power transmission - The transmission network will move (wheel) the power long distances—often across state lines, and sometimes across international boundaries, until it reaches its wholesale customer (usually the company that owns the local distribution network).

Electricity distribution - Upon arrival at the substation, the power will be stepped down in voltage from a transmission level voltage to a distribution level voltage. As it exits the substation, it enters the distribution wiring. Finally, upon arrival at the service location, the power is stepped down again from the distribution voltage to the required service voltage(s).

2. Working

Solar cells are composed of various semiconducting materials. Semiconductors are materials, which become electrically conductive when supplied with light or heat, but which operate as insulators at low temperatures.

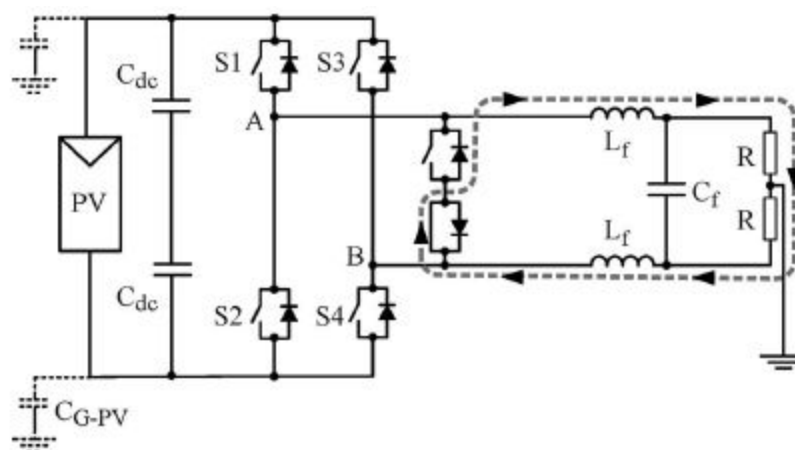


Fig: 2 Topology: Zero vector applied to load, using S6 during positive half-wave

Over 95% of all the solar cells produced worldwide are composed of the semiconductor material Silicon (Si). As the second most abundant element in earth's crust, silicon has the advantage, of being available in sufficient quantities, and additionally processing the material does not burden the environment. To produce a solar cell, the semiconductor is contaminated or "doped". "Doping" is the intentional introduction of chemical elements, with which one can obtain a surplus of either positive charge carriers (p-conducting semiconductor layer) or negative charge carriers (n-conducting semiconductor layer) from the semiconductor material. If two differently contaminated semiconductor layers are combined, then a so-called p-n-junction results on the boundary of the layers.

At this junction, an interior electric field is built up which leads to the separation of the charge carriers that are released by light. Through metal contacts, an electric charge can be tapped. If the outer circuit is closed, meaning a consumer is connected, and then direct current flows. Silicon cells are approximately 10 cm by 10 cm large (recently also 15 cm by 15 cm).

A transparent anti-reflection film protects the cell and decreases reflective loss on the cell surface. Photovoltaic: Solar Electricity and Solar Cells in Theory and Practice the word Photovoltaic is a combination of the Greek word for Light and the name of the physicist Alexandra Volta. It identifies the direct conversion of sunlight into energy by means of solar cells. The conversion process is based on the photoelectric effect discovered by Alexander Becquerel in 1839. The photoelectric effect describes the release of positive and negative charge carriers in a solid state when light strikes its surface.

III. METHOD

3.1 Photovoltaic Cell Construction

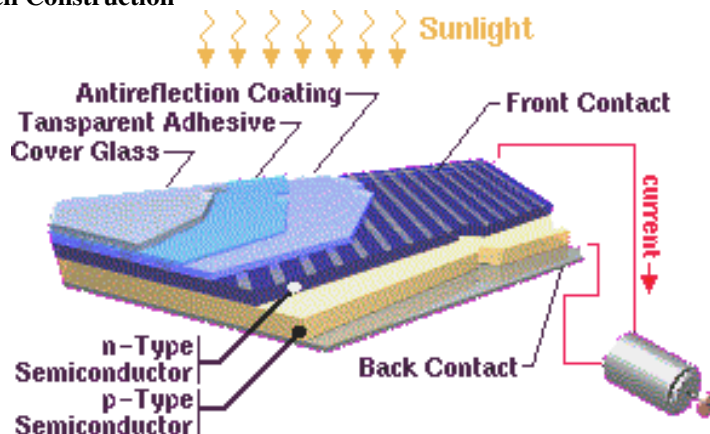


Fig: 3PV Constructions

3.2 Characteristics of a Solar Cell

The usable voltage from solar cells depends on the semiconductor material. In silicon it amounts to approximately 0.5 V. Terminal voltages is only weakly dependent on light radiation, while the current intensity increases with higher luminosity. A 100 cm² silicon cell, for example, reaches a maximum current intensity of approximately 2 A when radiated by 1000 W/m².

The output (product of electricity and voltage) of a solar cell is temperature dependent. Higher cell temperatures lead to lower output, and hence to lower efficiency. The level of efficiency indicates how much of the radiated quantity of light is converted into useable electrical energy.

IV. MATLAB & IMPLEMENTATION

4.1 Implementation

This Project has Solar Energy Systems. These Energy is boosted to regulate the AC loads that are interlinked to Supply power. The process is executed by storing the Energy in a battery Station and converting the DC to DC and transmitting to the Inductive Flux Transformer. Solar power is drawn and converted from DC to DC by adding Single Switch IGBT based closed loop DC to DC CUK convertor and the Voltage is monitored such that a closed loop system follows the output voltage variation of solar power because of variation in sun light intensity will cause power fluctuations from solar. This variation is controlled by boosting the output accordingly by monitoring with closed loop control system.

The renewable energy from solar station is obtained and converted as an Alternating source. The Source voltage is converted to low voltage DC to high voltage DC by rectification process and fed to Transformer linked Inverter devices. This is done by a single phase full wave rectifier bridge. The storage energy is again converted to sinusoidal form and distributed top Load sides. The above Topology is studied and simulated and output results are obtained using MATLAB.

4.2 Results

Partial Simulation 1

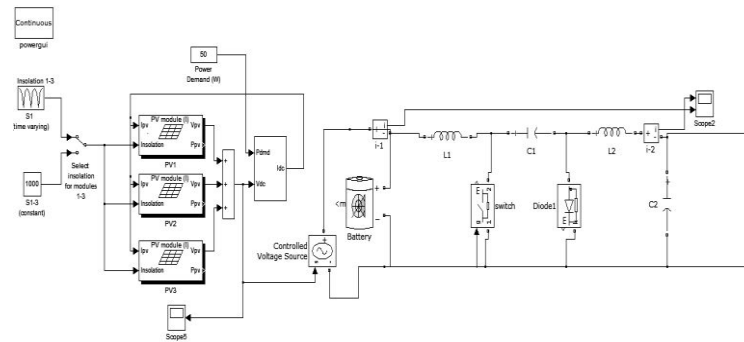
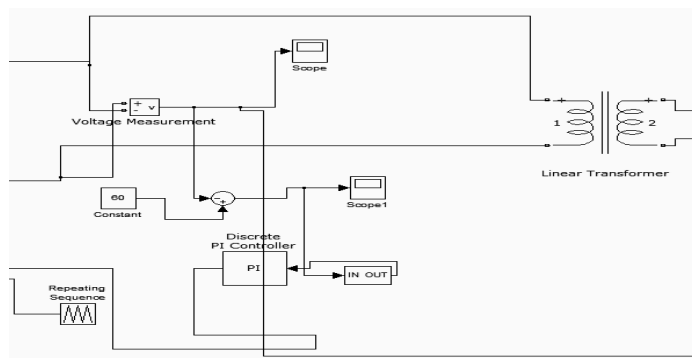


Fig: 4(a) circuit Diagram of Solar Panel and CUK Converter

Partial Simulation 2



MATLAB Results & Waveforms

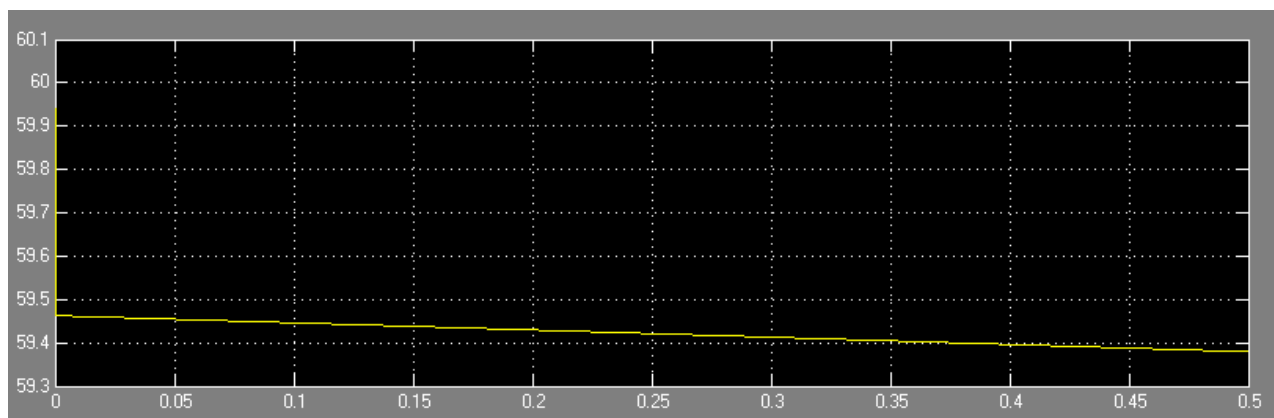


Fig: 5 Solar DC Voltge at Source

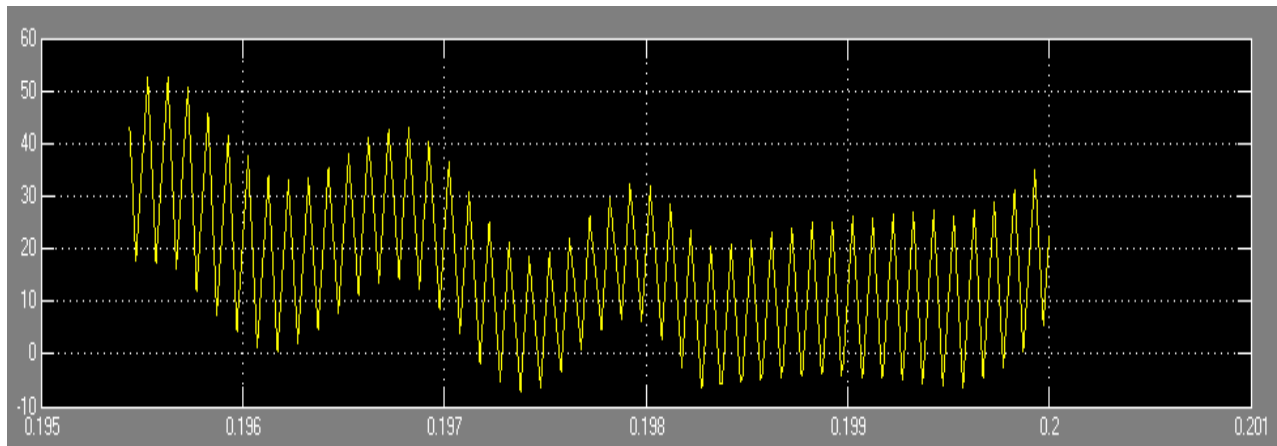


Fig: 6 DC Current at CUK converter

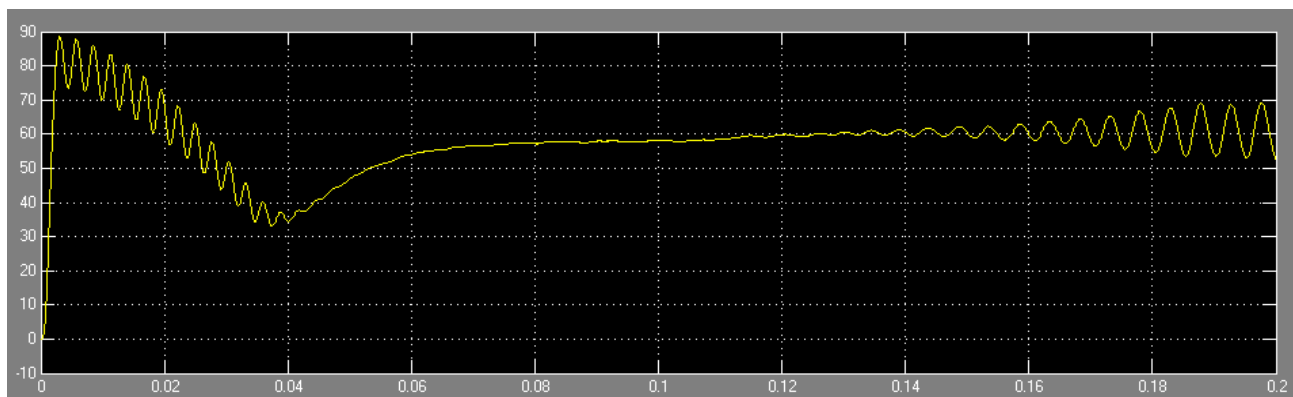


Fig: 7 DC Voltage Boosted at CUK Converter

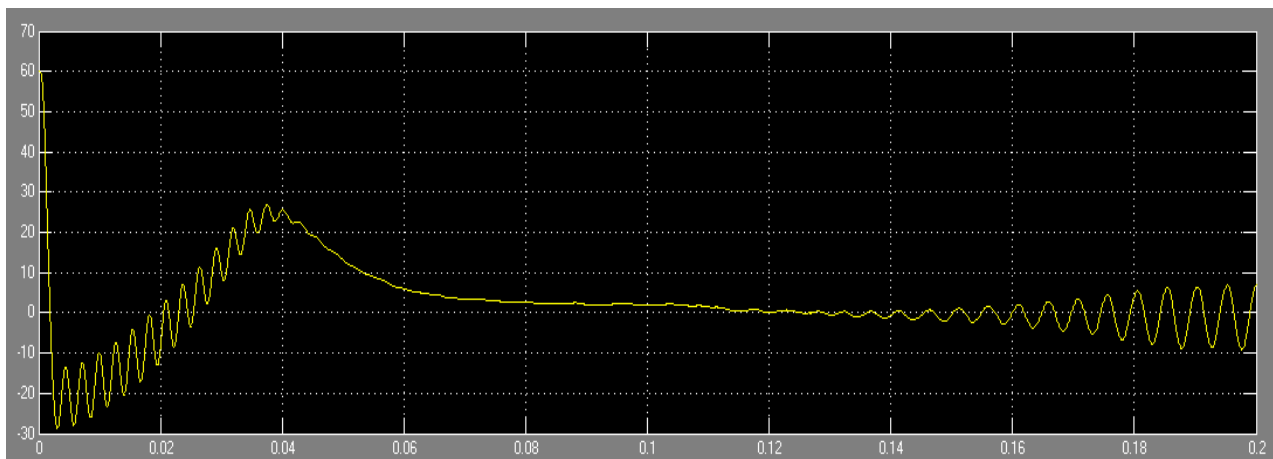


Fig: 8 DC Voltage Reference at PI Controller



V.CONCLUSION

The proposed converter allows the reduction of the voltage stress across active switches, being capable of reaching a high level of efficiency. This inverter offers a better efficiency, compared to those inverters that have a galvanic isolation. On the other hand, in case the generated common-mode behaviour of the inverter topology greatly influences the ground leakage current through the parasitic capacitance of the PV. By using unipolar PWM modulation, the output of the converter will have three levels; the generated common-mode voltage will have high-frequency components, which will lead to very high ground leakage currents. This topology is an alternative solution for the bidirectional switch, used to generate the zero-voltage state. The constant common-mode voltage of the HB-ZVR topology and its high efficiency make it an attractive solution for This PV applications.

Future Enhancements

Future work will be to compare these topologies with special respect to the induced ground-leakage currents by simulation and measurements on an experimental setup. Experimental measurements are important, because parasitic effects, which are difficult to understand only by simulation, play a role for the paths of the leakage currents at higher frequencies.

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