SOFT SWICHTING CONVERTER FOR REDUCED OUTPUT FILTER FOR HIGH VOLTAGE APPLICATIONS

[1]G Gnaneshwar Kumar, [2]Dr. K Bhaskar
[1]Research Scholar, [2]Assistant Professor
[1&2]School of Electrical & Communication Engineering
[1&2]Vel Tech Rangarajan Dr. Sagunthala R&D Institute of Science and Technology, Avadi, Chennai, India

Abstract: In this Paper, we analyzed a switched resonant power converter for solar power applications. A solar fed cascaded multilevel inverter is used to reduce the number of semiconductor Switches. This circuit topology integrates a switched resonant Converter with zero-voltage switching (ZVS). Hence to obtain a 15-level inverter, the conventional method requires 28 switches.In binary mode 7 switches are needed for resonant converters. The basic requirements of resonant converters are their small size and high efficiency. A high switching frequency is required to achieve small size. To solve the problems due to the switching losses, some soft-switching approaches must be used at high switching frequencies such as Zero voltage switching (ZVS).Switching losses are reduced less voltage stress and less current distortion. High efficiency and high voltage regulation. This work is to analyses a switched highly efficient resonant converter with ZVS topology based on the traditional ZVS concept for solar power generation applications. The advantage of these three designs is in the reduction of total harmonic distortion by increasing the levels. Simulations are carried out in MATLAB/Simulink and comparisons were made.

I. INTRODUCTION

Multilevel converter provides a suitable solution for medium and high power systems to synthesize an output voltage which allows a reduction of harmonic content in voltage and current waveforms. Renewable energy power supplied into the utility grid has been paid much attention due to increase in fossil fuel prices, environmental pollution and energy demand boom. Among various renewable energy resources such as solar, wind, tidal, geothermal, biomass etc., the solar photovoltaic system being more attractive and promising green resource. The solar photovoltaic (PV) modules directly converts the light energy into the electrical energy, but energy obtained from the PV module acts as low voltage DC source and has relatively low conversion efficiency. In order to improve the efficiency and convert low voltage DC source into usable DC source, the power electronics converters are used . The simulation results presented in this paper verifies the operation of proposed Converter topology.

SOFT SWITCHING:

Soft switching is a possible way of reducing losses in power electronics switches. The expression “soft switching” actually refers to the operation of power electronics switches as Zero Voltage Switching (ZVS) or Zero Current Switching (ZCS).The many different converter circuits that working according to these pinciples are generally assind to resonance or quasi resonance technology

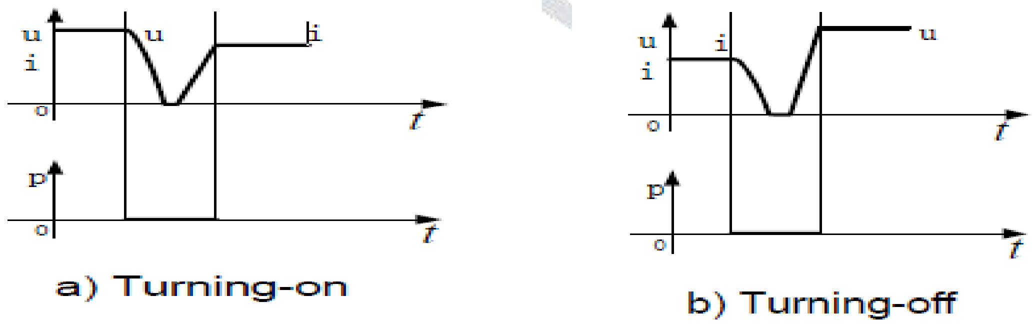

Fig. 1 .Switching of resonant converter (soft switching).

ZERO VOLTAGE SWITCHING:

The voltage across the device is reduced to zero before the current increases or device turns ON

ZERO CURRENT SWITCHING:

The current flowing through the device is reduced to zero before the voltage increases or device turns OFF

CHARACTERISTICS:

Resonant converters are extensively utilized in the application of renewable energy generation systems. The basic requirements of resonant converters are their small size and high efficiency. A high switching frequency is required to achieve small size. However, the switching loss increases with the switching frequency, reducing the efficiency of the resonant converters. To solve this problem, some soft-switching approaches must be used at high switching frequencies. Zero voltage switching (ZVS) and zero-current switching (ZCS) techniques are two commonly used soft-switching methods.

This project proposes a dc power supply system to give high power factor and low current distortion on the rectifier side and provide stable dc voltage on the isolated dc/dc converter side. The proposed dc power supply system uses a new zero-voltage switching (ZVS) strategy to get ZVS function. Besides operating at high switching frequency, all semiconductor devices operate at soft switching. A significant reduction in the conduction losses is achieved, since the circulating current for the soft-switching flows only through the auxiliary circuit and a minimum number of switching devices are involved in the circulating current path and the rectifier in the proposed dc power supply system uses a single converter instead of the conventional configuration composed of a four-diode front-end rectifier followed by a boost converter. An average current-mode control is employed in proposed dc power supply system to detect the transition time and synthesize a suitable low harmonics sinusoidal waveform for the input current.

II. LITERATURE SURVERY

A Half-Bridge LLC Resonant Converter Adopting Boost PWM Control Scheme Of Hold-Up State Operation

The paper titled ‘A Half-Bridge LLC Resonant Converter Adopting Boost PWM Control Scheme Of Hold-Up State Operation’ by In-Ho Cho, Young-Do Kim, and Gun-Woo Moon, Members, IEEE, in the IEEE transactions on power electronics, vol. 29, no. 2, February 2014. An LLC resonant converter shows the maximum efficiency in the nominal condition, when the converter is operated at the resonant frequency. However, the switching frequency becomes reduced and growing apart from the resonant switching point as the input voltage decreases. This frequency change becomes a considerable issue under a wide input variation condition. It makes LLC resonant converters have difficulty in magnetic design, and it also decreases nominal efficiency of the converters.

A Bidirectional-Switch-Based Wide-Input Range High-Efficiency

The IEEE transactions on power electronics, vol. 29, no. 7, July 2014. Modular photovoltaic (PV) power conditioning systems (PCSs) require a high-efficiency dc–dc converter stage capable of regulation over a wide input voltage range for maximum power point tracking. This paper presents a novel, isolated topology that is able to meet the high efficiency over a wide input voltage range requirement. This topology yields high efficiency through low circulating currents, zero-voltage switching (ZVS) and low-current switching of the primary side devices.

A New LLC Series Resonant Converter with a Narrow Switching Frequency Variation and Reduced Conduction Losses

The paper titled ‘A New LLC Series Resonant Converter with a Narrow Switching Frequency Variation and Reduced Conduction Losses’ by Jong-Woo Kim, and Gun-Woo Moon, Members, IEEE, in the IEEE Transactions on Power Electronics, Vol. 29, No. 8, August 2014. A new LLC series resonant converter that has a narrow switching frequency variation and reduced conduction losses is proposed, the proposed converter can obtain a reduced conduction loss in its secondary side rectifiers. Because the proposed converter operates with a narrow switching frequency variation, a small transformer core can be selected, which results in a decreased core size and loss.

Analysis of a Fifth-Order Resonant Converter for High-Voltage DC Power Supplies

This paper titled ‘Analysis of a Fifth-Order Resonant Converter for High-Voltage DC Power Supplies’ by Navid Shafiei, Majid Pahlevaninezhad, Hosein Farzanehfard, Alireza Bakhshai and Praveen Jain Fellow, Members, IEEE, in the IEEE transactions on power electronics, vol. 28, no. 1, January 2013. This paper presents a precise analysis of a fifth-order resonant converter which has incorporated the resonant circuit into the transformer. The proposed fifth-order resonant converter is able to effectively reduce the range of phase-shift angle from no load to full load for a fixed-frequency phase-shift control approach. Therefore, the converter is able to operate under zero voltage switching during entire load range with a fixed-frequency control method. Also, the proposed converter offers a high gain which leads to a lower transformer turns ratio.

A Step-up Resonant Converter for Grid-Connected Renewable Energy Sources

This paper titled ‘A Step-up Resonant Converter for Grid-Connected Renewable Energy Sources’ by Wu Chen, Xiao gang Wu, Liangzhong Yao, Senior Member, IEEE, Wei Jiang and Renjie Hu, Members, IEEE, in the IEEE transactions on power electronics, vol. 30, no. 6, June 2014. The high-power, high-voltage step-up dc–dc converters are the key equipment to transmit the electrical energy. This paper proposes a resonant converter which is suitable for grid-connected renewable energy sources.

The converter can achieve high voltage gain using an LC parallel resonant tank. It is characterized by zero-voltage-switching (ZVS) turn-on and nearly ZVS turn-off of main switches as well as zero-current-switching turn-off of rectifier diodes; moreover, the equivalent voltage stress of the semiconductor devices is lower than other resonant step-up converters.

III. SYSTEM ANALYSIS

This existing system presents a new form of MMC for high-voltage step-down unidirectional dc–dc conversion. The proposed converter has inherent-balancing of each capacitor voltage. High step-down voltage conversion ratios can be achieved by using large numbers of submodules. With phase-shifted pulse width-modulation (PWM), higher operating frequency can also be achieved, which is equivalent to the product of the number of submodules and the switching frequency. Moreover, the converter operates with two resonant frequencies where zero voltage- switching (ZVS) and/or zero-current-switching (ZCS) become possible. The proposed converters are more suitable for low-power dc–dc applications as it has the feature of modularity, simplicity, and flexibility. The detailed configuration and operation principle are presented, and verified by experimental results from bench-scale prototype tests.

These converters provide more than two levels which can be adjusted by changing the number of modular cells. Cells with a fault can also be bypassed while keeping the converters operating. High reliability and modularity are the main features of MMCs. However, all these MMCs require a complicated balancing control to maintain the voltage levels. Even though a requirement is placed on the tolerance of the cell capacitors, measuring capacitor voltages for balancing control is indispensable. Moreover, the operating frequency of the conventional control for MMCs is not higher than the switching frequency. High switching frequencies are used to reduce the sizes of passive components. Tradeoffs between switch ratings and converter size should be made, but it is hard to find a good solution for high-voltage, high-step-down ratio, and low-power applications.

Dc power supplies have been widely used in industrial equipments, such as dc uninterruptible power supply and telecommunications power supply, and high power factor and low input-current harmonics are mandatory performances of the dc power supplies for satisfied agency standards such as EN61000–3-2.The size of low-frequency inductors and capacitors will result in the dc power supplies, which are very bulky and heavy.

The passive filter approach to PFC is limited to applications where the size and weight of the converter are not major concerns. For overcoming this problem, a boost power-factor-corrected (PFC) front-end converter followed by a transformer-isolated dc–dc converter is the most extensively employed in offline power supplies, and full-bridge transformer-isolated dc/dc converter is the most extensively applied in medium-to-high power dc/dc power conversion.

Thus, a boost PFC front-end converter followed by a full-bridge transformer-isolated dc/dc converter is the most popularly used in offline dc power supplies. For solving the problem that the boost rectifier and the full-bridge transformer-isolated dc/dc converter must use individual soft-switching techniques to reduce their switching losses, a simple ZVS strategy is also proposed in this paper using solar power.

BLOCK DIAGRAM:

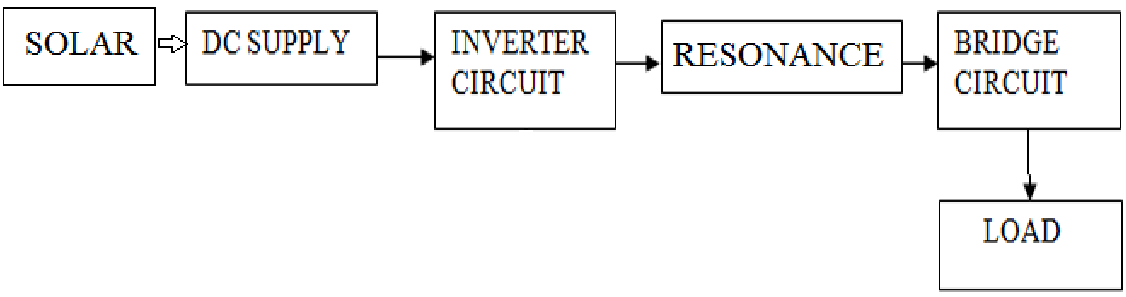

Fig 2: Proposed block diagram

In this block diagram, switches in the inverter circuit are triggered by the gate pulses. Four MOSFET switches are used in the inverter circuit. The gate pulses are given to the switches from the drive circuit. Using micro-controller 89s52 , drive circuit is actuated to give trigger pulses which will make the switches to conduct. DC supply is given to the inverter circuit so that the AC output of inverter is given to a Ferrite core transformer and then to the bridge rectifier.

The boosted up voltage is supplied to the load finally. The voltage is boosted up using resonant switching at very high frequencies say 20 kHz.

SOLAR ENERGY:

Solar energy is quite simply the energy produced directly by the sun and collected elsewhere, normally the Earth. The sun creates its energy through a thermonuclear process that converts about 650,000,000 tons of hydrogen to helium every second. The process creates heat and electromagnetic radiation. Due to the nature of solar energy, two components are required to have a functional solar energy generator. These two components are a collector and a storage unit. The collector simply collects the radiation that falls on it and converts a fraction of it to other forms of energy. The storage unit is required because of the non-constant nature of solar energy; at certain times only a very small amount of radiation will be received. In general, there are three types of collectors and many forms of storage units.

In today's climate of growing energy needs and increasing environmental concern, alternatives to the use of non-renewable and polluting fossil fuels have to be investigated. One such alternative is solar energy.

Focusing collectors are essentially flat-plane collectors with optical devices arranged to maximize the radiation falling on the focus of the collector. These are currently used only in a few scattered areas. Solar furnaces are examples of this type of collector. Although they can produce far greater amounts of energy at a single point than the flat-plane collectors can, they lose some of the radiation that the flat-plane panels do not. Radiation reflected off the ground will be used by flat- plane panels but usually will be ignored by focusing collectors (in snow covered regions, this reflected radiation can be significant).

Passive collectors are completely different from the other two types of collectors. The passive collectors absorb radiation and convert it to heat naturally, without being designed and built to do so. All objects have this property to some extent, but only some objects (like walls) will be able to produce enough heat to make it worthwhile. Often their natural ability to convert radiation to heat is enhanced in some way or another (by being painted black, for example) and a system for transferring the heat to a different location is generally added.

These passive collectors can take a few different forms. The most basic type is the incidental heat trap. The idea behind the heat trap is fairly simple. Allow the maximum amount of light possible inside through a window (The window should be facing towards the equator for this to be achieved) and allow it to fall on a floor made of stone or another heat holding material.

Another major form of passive collector is thermos phoning walls and/or roof. With this passive collector, the heat normally absorbed and wasted in the walls and roof is re-routed into the area that needs to be heated.

The last major form of passive collector is the solar pond. This is very similar to the solar heated pool described above, but the emphasis is different. With swimming pools, the desired result is a warm pool. With the solar pond, the whole purpose of the pond is to serve as an energy regulator for a building. The pond is placed either adjacent to or on the building, and it will absorb solar energy and convert it to heat during the day

Besides being used for heating and cooling, solar energy can be directly converted to electricity. Most of our tools are designed to be driven by electricity, so if you can create electricity through solar power, you can run almost anything with solar power. The solar collectors that convert radiation into electricity can be either flat- plane collectors or focusing collectors, and the silicon components of these collectors are photovoltaic cells.

Most of the photovoltaic cells on the market today operate at an efficiency of less than 15% that is, of all the radiation that falls upon them, less than 15% of it is converted to electricity. The maximum theoretical efficiency for a photovoltaic cell is only 32.3%, but at this efficiency, solar electricity is very economical. Most of our other forms of electricity generation are at a lower efficiency than this.

Of the main types of energy usage, the least suited to solar power is transportation. While large, relatively slow vehicles like ships could power themselves with large onboard solar panels, small constantly turning vehicles like cars could not.

The only possible way a car could be completely solar powered would be through the use of battery that was charged by solar power at some stationary point and then later loaded into the car. Electric cars that are partially powered by solar energy are available now, but it is unlikely that solar power will provide the world's transportation costs in the near future.

While the burning of fossil fuels introduces many harmful pollutants into the atmosphere and contributes to environmental problems like global warming and acid rain, solar energy is completely non-polluting. While many acres of land must be destroyed to feed a fossil fuel energy plant its required fuel, the only land that must be destroyed for a solar energy plant is the land that it stands on.

As the primary element of construction of solar panels, silicon, is the second most common element on the planet, there is very little environmental disturbance caused by the creation of solar panels. In fact, solar energy only causes environmental disruption if it is centralized and produced on a gigantic scale. Solar power certainly can be produced on a gigantic scale, too.

Unfortunately, at this scale, the production of solar energy would have some unpredictable negative environmental effects. If all the solar collectors were placed in one or just a few areas, they would probably have large effects on the local environment, and possibly have large effects on the world environment.

Of all the energy sources available, solar has perhaps the most promise. Numerically, it is capable of producing the raw power required to satisfy the entire planet's energy needs. Environmentally, it is one of the least destructive of all the sources of energy. Practically, it can be adjusted to power nearly everything except transportation with very little adjustment, and even transportation with some modest modifications to the current general system of travel.

MULTILEVEL INVERTER

A tool for component sizing for MMCs has been developed and tested through simulations in PLECS. The steady-state behavior under grid frequency deviations - interesting for offshore wind farm connections - has been analyzed, providing insights in MMC characteristics and further testing the proposed tool.

SWITCHING STRATEGIES

In conventional approach, PWM techniques are used by the comparison of reference and carrier signals to provide the required gating signals for the inverter switches.

The number of output voltage levels obtained from this approach is given in the following equation:

$$m = 2Ns + 1$$

where m denotes the output voltage levels and Ns is the individual inverter stages. The number of switches (l) required to achieve m levels is given in the following equation:

$$l = 2(m - 1)$$

For the implementation of 15-level CMLI, the number of switches required is 28 with seven individual inverter stages. In addition to the 28 switches, 182 clamping diodes in case of NPC or diode clamped multilevel inverter and 91 balancing capacitors in case of FC type multilevel inverter along with 14 DC bus capacitors are needed to achieve 15-level output. The proposed paper deals with the following topologies for the reduction of switches. Increasing the number of levels will subsequently reduce the harmonic distortion which in turn improves the power quality.

MMC OPERATION

The modification is realized in control circuit of CMLI to achieve 15 and 27 levels with three inverter stages. In this approach, the modification is made in both control circuit and predominately in power circuit to obtain 31 levels with only eight switches. The addition of diode and capacitor (1 nF) is to normalize the output within the given interval. Based on the table, the inverter circuit (T1–T4) is in ON condition at all the levels, but the input switches (S1–S3) are controlled in such a way that to obtain the required output voltage. Let the PV array inputs be V1–V3. During the level 1, V1 alone is given as input to the inverter and V2, V3 in OFF condition. Similarly the 15 level is achieved by controlling the ON/OFF status of the input voltages. The remaining 15 level from the truth table will be obtained by controlling the sequence in reverse direction.

The cascaded multilevel inverter consists of a series connection of single phase full bridge inverter units. Each full bridge units known as ‘stages’ can generate three different voltages output: +Vpv, 0, -Vpv. For the seven stage inverter the output waveform is illustrated. Where m is the number of levels and Ns is the number of inverter stages. By using Fourier series the staircase output of multilevel inverter with non-equal input sources is described.

The number of harmonics which can be eliminated by the multilevel inverter is (m-1). For a seven stage inverter, six numbers of harmonic orders can be minimized or eliminated. The elimination of triple harmonics for the three-phase power system applications is not necessary, because these harmonics are automatically eliminated from the line-line voltage. Switching losses can also be minimized by turning the switch on and off only once per cycle.

DIODE BRIDGE RECTIFIER

The diodes are used to convert AC into DC these are used as half wave rectifier or full wave rectifier.
Three points must he kept in mind while using any type of diode.

- Maximum forward current capacity
- Maximum reverse voltage capacity
- Maximum forward voltage capacity

In this project the diode rectifier is used in the main circuit. Usually all the power electronics circuits are provided with a diode rectifier. This helps to convert the 12V AC voltage to DC voltage. They are connected at the output of input filters.

The ac input from the main supply is stepped down using a 230 /30V step down transformer. The stepped down AC voltage is converted into dc voltage using a diode bridge rectifier. The diode bridge rectifier consists of four diodes arranged in two legs. The diodes are connected to the stepped down AC voltage. For positive half cycle of the ac voltage, the diodes D1 and D4 are forward biased . For negative half cycles diodes D2 and D3 are forward biased. Thus dc voltage is produced to provide input supply to the DC-DC Converter.

DESIGN OVERVIEW

The control strategy used in resonant converter switching is explained. Soft switching technique is used in this proposed method which helps in reducing the switching losses. The circuit is operated with ZVS topology and the measured energy conversion is about 11% more than conventional method.

Simulation results and discussion are explained. . The results are explained as waveform and compared with the conventional method for efficiency. Thus in proposed method the efficiency is increased

The proposed dc power supply system must control both the input current and the output voltage. The input current of proposed dc power supply system must be programmed to follow line input voltage and to be the shape offline input voltage. Thus, the average-current mode is used to control the input current. The output voltage is controlled by changing the average amplitude of the current-programming signal.

The block diagram of the proposed soft switching single-phase dc power supply system with average current mode . The controller can prescribe the shape and the frequency of the input current due to its inherently synchronous feedback loop.

In order to obtain almost unity power factor, the synchronous signal must be sensed from a rectified line input voltage. The analog multiplier creates the current programming signal by multiplying the rectified line voltage with the error output voltage between the feedback voltage and the reference voltage Vref so that the current-programming signal has the shape of the line input voltage and an average amplitude to control the output voltage. The error output voltage between the feedback voltage and reference voltage V_{ref} is divided by square of the average input voltage before it is multiplied by the rectified input voltage signal. It can keep the gain of the voltage loop composed.

IV. SYSTEM ANALYSIS AND IMPLEMENTATION

Existing Binary 15 Level MMC Dc Converter

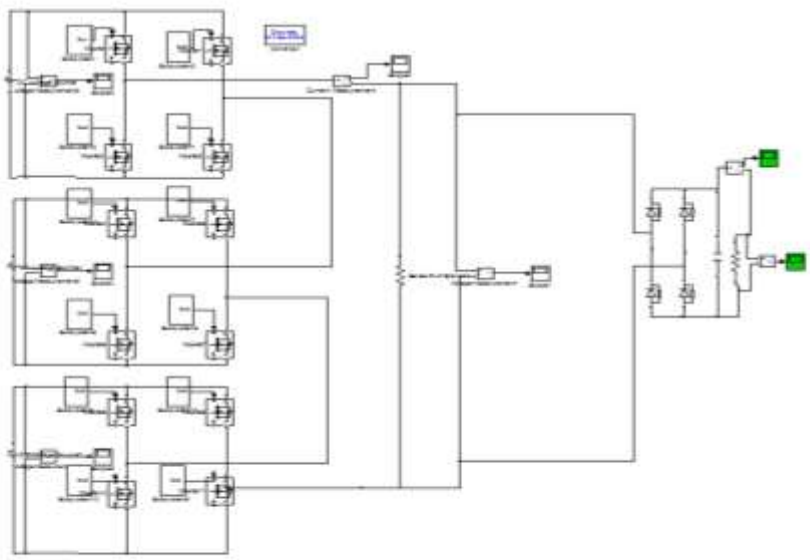

Fig 3: Binary 15 Level MMC Dc Converter JRDSM

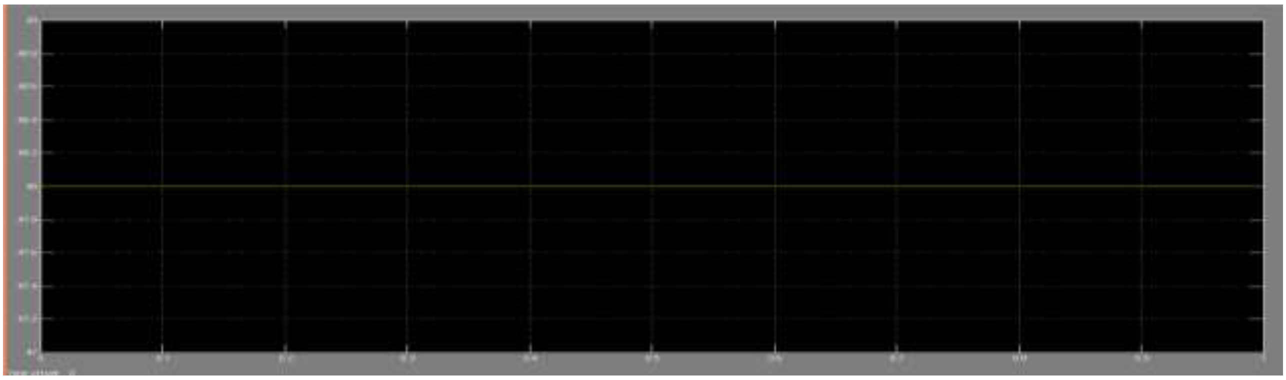

Fig 4. Input voltage vo1 waveform

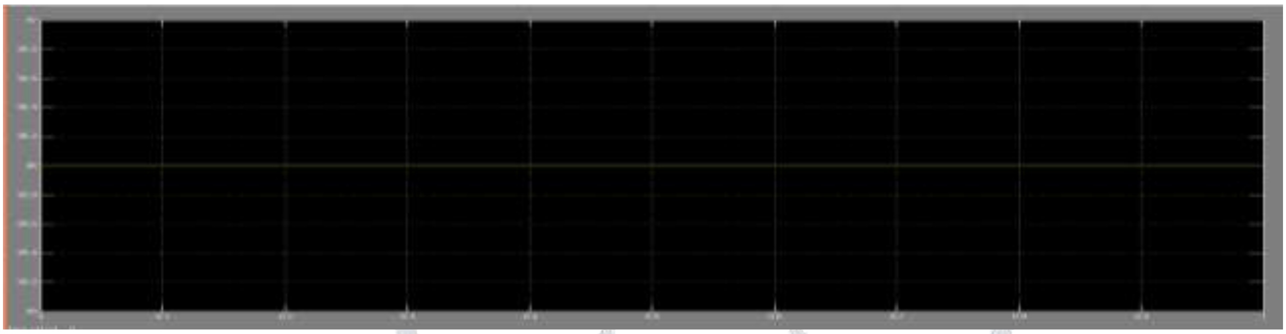

Fig 5. Input voltage vo2 waveform

Fig 6. Input voltage vo3 waveform

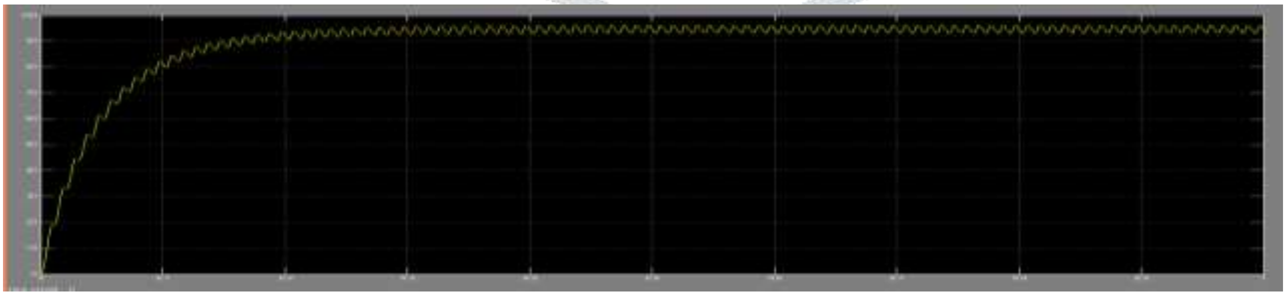

Fig 7. Out put current of converter waveform

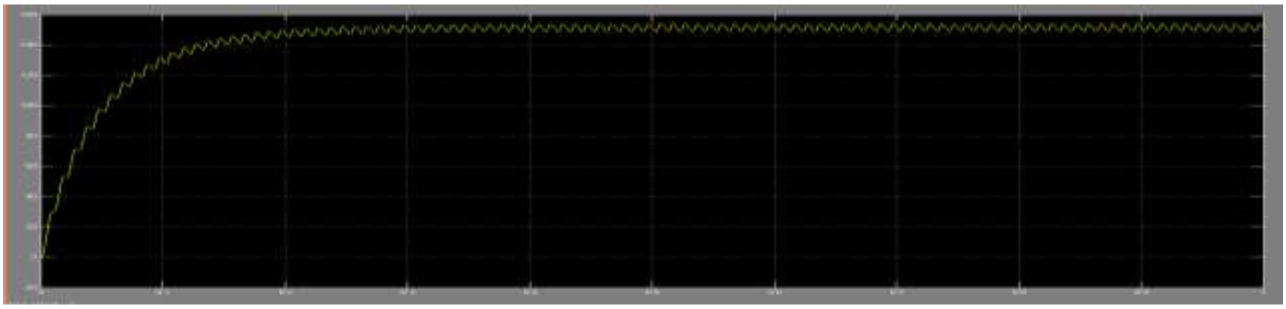

Fig 8. Out put voltage of converter waveform

Proposed Circuit Of 15 Level Resonant MMC Dc Converter

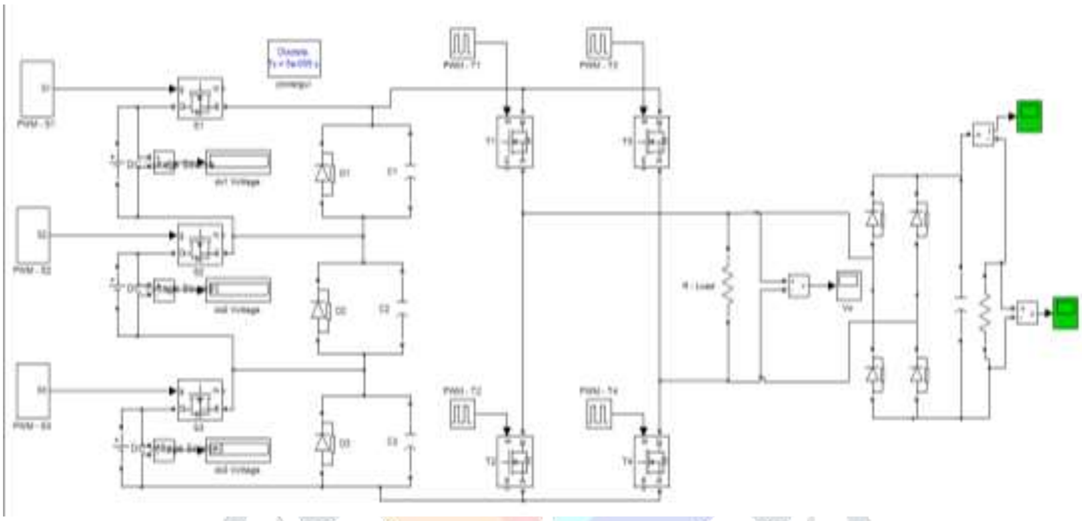

Fig 9. Simulation circuit of 15 level resonant mmc dc converter

V. CONCLUSION

The proposed work demonstrated the state of art switched resonant converter technology. A novel method for soft switching was investigated in order to improve the efficiency of PV systems. The design and simulation of a ZVS based switched resonant converter was proposed using MATLAB. The proposed method has very good performances, fast responses with no overshoot and less fluctuation in the steady state. These controllers are able to attain an increase in the output voltage level based on the increase in the switching frequency which would drastically improve the performance of the system.

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AUTHORS PROFILE

[1]G Gnaneshwar Kumar, received B.Tech degree in Electrical and Electronics Engineering from JNTUH, Telangana in 2005 and M.Tech degree in Electrical Power Systems from JNTUH, Telangana in 2011. Persuing Ph.D (Part Time) in Vel Tech Rangarajan Dr. Sagunthala R&D Institute of Science and Technology, Avadi, Chennai, India. Currently working as a Assistant Professor in Department of Electrical Engineering, Khader Memorial College of Engineering & Technology, Devarakonda, Nalgonda Dist, Telangana, India. Research interests include Electrical Power Systems, Renewable Energy Sources. He has total 12 years teaching experience.

[2]Dr. K Bhasker is working as a Assistant Professor in department of School Of Electrical & Communications at Vel Tech Rangarajan Dr. Sagunthala R&D Institute of Science and Technology, Avadi, Chennai, India, his Interest Areas Power Electronics and Electrical Power Systems, he has total Experience 15 years.