International Journal of Electrical and Electronics Research ISSN 2348-6988 (online)
Vol. 3, Issue 2, pp: (586-593), Month: April - June 2015, Available at: www.researchpublish.com

Design of Five Level T-Type Neutral-Point Clamped Inverter Using Cool-MOSFET for Solar Energy System

[1]G.Karthick, [2]E.Prasanna Kumar

[1] M.E Power Electronics and Drives, Jayshriram Group of Institutions, Tirupur, India
[2]M.E Asst.Professor, Jayshriram Group of Insititutions Tirupur, India

***Abstract*: The conventional I- and T-type three level neutral-point-clamped (3L-NPC) inverter for low-voltage renewable energy systems is generally used in this paper. Three-level low-voltage 1-phase inverters used over the last years. For high switching frequencies, converter efficiency suffers and can be kept high only by employing cost intensive switch technology such as MOSFET switches therefore, conventional IGBT technology still prevails. In this paper, the alternative of using five-level converters for low voltage applications is addressed. The performance and the competitiveness of the five-level T-type NPC Inverter is analyzed in detail. The 5L NPC inverter basically combines the positive aspects of the five-level inverter such as low conduction losses, small part count and a simple operation principle with the advantages of the five-level converter such as low switching losses and superior output voltage quality. It is, therefore considered to be a real alternative to three-level inverters for certain low voltage applications. Here Cool MOSFET replaced for IGBT+Diode middle bidirectional switch. Therefore, it can reduce the current path in the zero vector conduction due to replacing Cool MOSFET.It has low on state resistance so voltage drop soundly reduced. Increasing the voltage level MOSFET upto five levels for getting lower Harmonics distortion.**

***Keywords*: NPC–Neutral point clamp, IGBT-Insulated gate bipolar transistor, and MOSFET-metal oxide semiconductor field effect transistor.**

I. INTRODUCTION

Over the past two or three decades, multilevel inverters, such as the neutral-point-clamped (NPC) inverter, the flying capacitor inverter, and the cascaded multilevel converter, has been increasingly studied and widely applied. Multilevel inverters are basically composed by an array of power components and dc voltage supplies which can produce stepped voltage waveforms. Among them, the NPC inverter is the most widely known and adopted multilevel topology for its low current distortion and high efficiency. In the low-voltage renewable energy systems, the five level NPC (5L-NPC) inverter has been the centre of numerous research studies and applications.

In this paper, the state of the art of 5L-NPC inverters applied in the low-voltage renewable energy systems is investigated thoroughly. Moreover, the 5L-NPC inverters are divided into I- and T-types according to their leg shapes. The competitiveness of those two types for low-voltage renewable energy systems is then discussed. This paper shows that the T-type 5L-NPC improves the conduction loss of the nonzero-vector current path of T-type 5L-NPC. However, the zero-vector current path's conduction losses are the same. In both I- and T-type's zero vectors, there are one diode and one metal oxide semiconductor field effect transistor (MOSFET) involved in the current path.

Therefore, there is at least 2-V total conduction voltage due to MOSFET + diode structure according to the MOSFET and diode datasheets. Moreover, this conduction voltage causes high power losses, particularly in low and medium power ranges of a renewable energy system. Moreover, this paper theoretically proves that the zero vectors duty time or its conduction loss is almost equal to the sum of the other positive and negative nonzero vectors.

Our primary source of clean, abundant energy is the sun. The sun deposits 120,000 TW of radiation on the surface of the Earth, far exceeding human needs even in the most aggressive energy demand scenarios. The sun is Earth's natural power source, driving the circulation of global wind and ocean currents, the cycle of water evaporation and condensation that creates rivers and lakes, and the biological cycles of photosynthesis and life. Covering 0.16% of the land on Earth with 10% efficient solar conversion systems would provide 20 TW of power, nearly twice the world's consumption rate of fossil energy and the equivalent 20,000 1-GWe nuclear fission plants. These comparisons illustrate the impressive magnitude of the solar resource, providing an energy stream far more potent than present-day human technology can achieve.

All routes for utilizing solar energy exploit the functional steps of capture, conversion, and storage. The sun's energy arrives on Earth as radiation distributed across the colour spectrum from infrared to ultraviolet. The energy of this radiation must be captured as excited electron- hole pairs in a semiconductor, a dye, or a chromophore, or as heat in a thermal storage medium. Excited electrons and holes can be tapped off for immediate conversion to electrical power, or transferred to biological or chemical molecules for conversion to fuel.

Natural photosynthesis produces fuel in the form of sugars and other carbohydrates derived from the reduction of CO_2 in the atmosphere and used to power the growth of plants. In addition to electric and chemical conversion routes, solar radiation can be converted to heat energy. Solar concentrators focus sunlight collected over a large area to a line or spot where heat is collected in an absorber. Temperatures as high as 3,000°C can be generated to drive chemical reactions, or heat can be collected at lower temperatures and transferred to a thermal storage medium like water for distributed space heating or steam to drive an engine.

Effective storage of solar energy as heat requires developing thermal storage media that accumulate heat efficiently during sunny periods and release heat slowly during dark or cloudy periods. Heat is one of the most versatile forms of energy, the common link in nearly all our energy networks. Solar thermal conversion can replace much of the heat now supplied by fossil fuel.

The silicon solar cell gives output voltage of around 0.7 V under open circuit condition. To get a higher output voltage many such cells are connected in series. The typical characteristic curve of a PV solar cell is shown below. The characteristic of a PV module is non-linear which makes it difficult to determine the maximum power point. In order to extract maximum power from the PV module, it must always be operated at or very close to where the power is highest. This point is referred to as Maximum power point (MPP) and it is located around the bend or knee of the IV characteristic.

II. CONVENTIONAL 5L I-TYPE NPC INVERTER

A novel highly efficient stacked 5L-NPC inverter is proposed in to provide the paralleled current paths. Based on the work in, the authors in proposed an active clamped 5L-SNPC to further distribute power losses evenly. The aforementioned literature covers the different perspectives of I-type 5L-NPC. However, all hardware topologies are based on or derived from the fundamental I-type 5L-NPC leg, as shown in Therefore, they have common or similar features, as described in the following. The current paths with the leg switch statuses of 1100, 0110, and 0011. As aforementioned, 1100 and 0011 are defined as nonzero vectors with the output voltage being equal to Vdc/2, and 0110 is defined as a zero vector with output equal to zero. It is shown in Fig. 2 that, in both zero vector and nonzero vector, the current paths include two power devices. These long current paths imply the high conduction loss. Second, higher stray inductance, due to the long current paths, results in higher power loss and turns off over voltages. Moreover, Fig. 3 shows the reactive power generation of the conventional I-type 5L-NPC. In the blue and red regions of Fig. 3, when the switching sequence changes from 1100 to 0110, or from 0011 to 0110, the current commutates through a long commutation path from D1, D2 to S1c, Dnpc2 or from D1c, D2c to S2, Dnpc1. Therefore, four devices are involved in the current commutation. The longer commutation paths consisting of four devices cause higher power transition loss as well as the higher conduction loss. Having the same arguments with the aforementioned long current path, the long commutation path increases the stray inductance. More importantly, there are three diodes involved when a zero vector is commutating with a nonzero vector. It causes higher diode reverse recovery losses and worse electromagnetic interference issues.

It is worthy of noting that the renewable energy system is usually operating in a much lower power range than the rated power. Moreover, the foregoing discussed drawbacks of I-type 5L-NPC seem more prominent because of the MOSFET and diode relatively larger state voltage/current ratio at the low and medium powers. Based on the foregoing recognitions, the T-type 5L-NPC, as shown in Fig. 4, is being studied increasingly to improve the system efficiency. The authors in evaluated the power loss and control scheme of T-type 5L-NPC applied in the low voltage renewable energy system. The authors in applied T-type 5L-NPC in a solar system to avoid the high conduction loss. As shown in Fig. in the T-type 5L-NPC, the long current paths of nonzero vectors are shortened with only one device conducting. Therefore, the conduction loss of the T-type 5L-NPC in states shown is smaller than that of the I-Type.

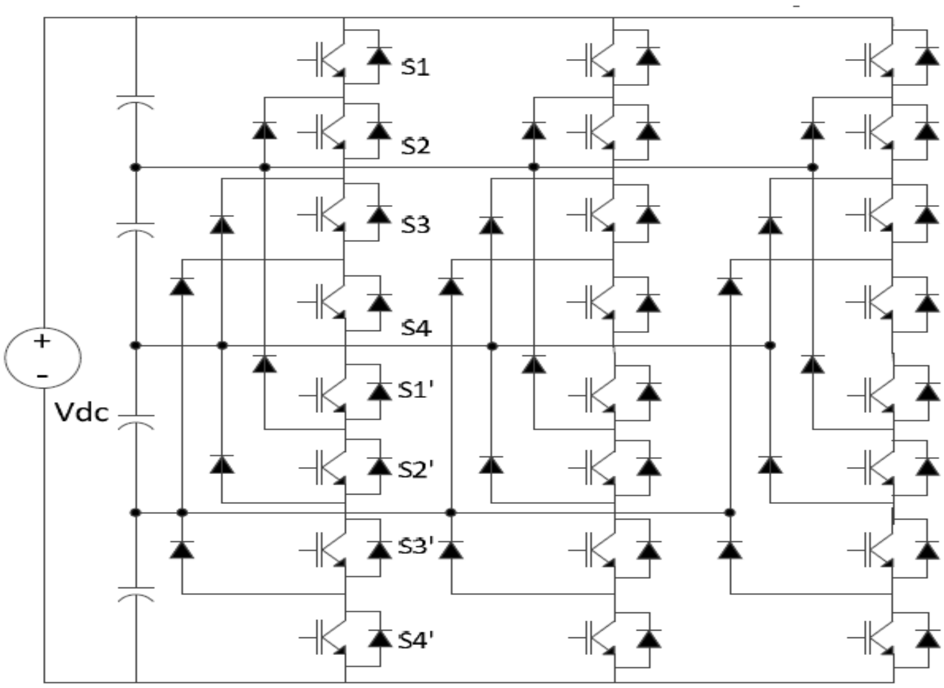

Fig.1 Conventional I type 5 level NPC inverter

The high ON-state voltage can cause the same high conduction loss as the I-type 5L-NPC shown in Fig. 2(b), particularly in low and medium power ranges. More importantly, it should be emphasized that, in Figs. 2 and 5, the zero vector in (b) occurs about as much as the sum of the nonzero vectors in (a) and (c), as aforementioned. Therefore, the zero vectors dominate the conduction loss more than the nonzero vector. From this point of view, the improvement of T-type 5L-NPC over I-type 5L-NPC is much limited.

III. PROPOSED 5L T-TYPE NPC INVERTER USING COOLMOS

In order to solve the problems in I-type five-level inverter, a topology was proposed in photovoltaic and fuel cell modules which offers smaller filter size, lower EMI and THD. It can be also seen as variations of that in. To standardize this kind of topology, it is redrawn in and named T-type five-level inverter, which can be taken as a T-type three-level topology with an additional bridge on the right side. So these topologies present similar characteristics as the T-type three-level topology. The T-type five-level inverter alleviates the problem of large conduction loss and long commutation path is I-type inverter. However, since S1 and S2c need to block the whole DC link voltage, the voltage stress of them is twice of that in I-type inverter. As for solar system, S1 and S2 are 1200V MOSFET. Moreover, these two high voltage MOSFETs operate with high switching frequency; therefore, they lead to large switching power loss. The higher the switching frequency, the larger the switching loss is According to the aforementioned analysis, we can draw a conclusion that although the T-type five-level inverter has higher efficiency.

Here are used Cool-MOSFET for low on state power loss .The Cool-MOSFET are generally replace for General MOSFET due to their On state resistance is very less. so the conduction loss and switching loss should less than conventional MOSFET. Implementation of this Cool-MOSFET in these photovoltaic energy systems especially in the low voltage renewable system are increased their whole system efficiency.

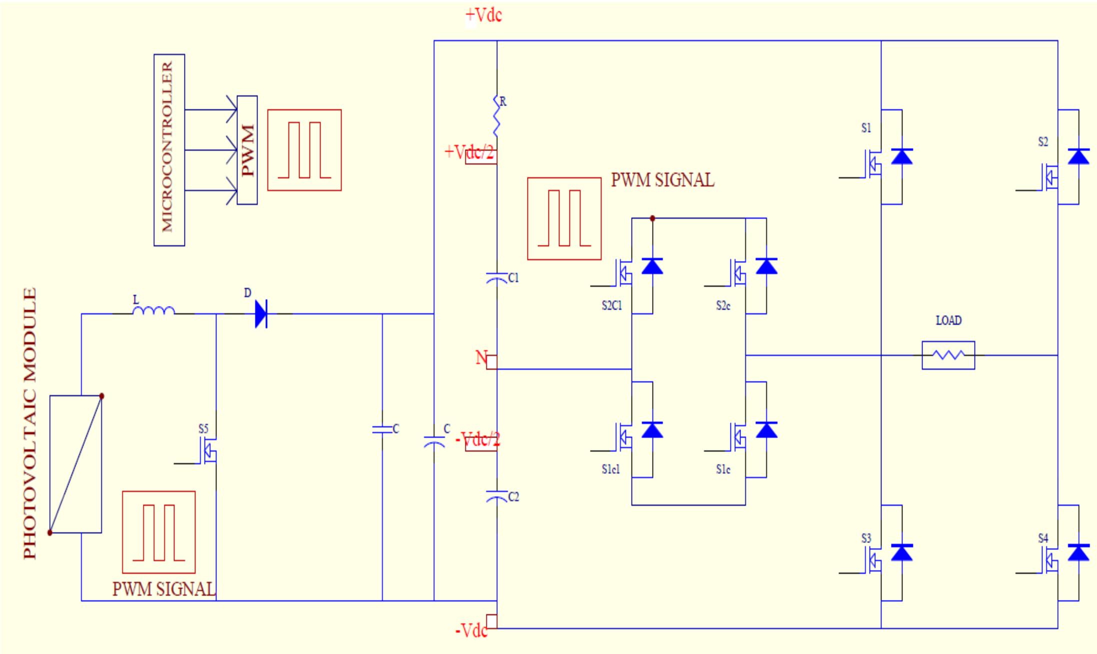

Fig.2 Five level T-Type NPC inverter using COOLMOS

The proposed five-level inverter is based on the T-type inverter, with two additional devices connected in the midpoint of the two bidirectional switches. These two additional devices (S1c&S2c) are Cool MOSFETS instead of IGBTs. The idea is to eliminate the switching losses of S1 and S2 and The new five-level inverter can not only solve the contradiction between frequency and efficiency in T-type five-level inverter, but balance the power loss between inner and outer devices as well. Two PWM modes are proposed in this paper to implement according to the operation condition of the solar system, a self-adaptive multi-mode PWM strategy is proposed to achieve the highest efficiency In the positive half cycle, when the output voltage changes between +Vdc and +1/2Vdc, the current flows through S1/s1c or the middle switch as shown in the transition between current is mainly conducting through 1200V Power MOSFET S1. During the transition, S1 turns off a little bit ahead of S1-aux. When this happens, the of S1 is almost zero, namely ZVS turn-off, since S1-aux is still conducting current. Therefore, the switching loss of high voltage Power MOSFET is transferred to the 600V Cool mosfet, which has a much lower switching energy loss per switch. Similarly, when the output changes from +1/2Vdc to +Vdc, namely changes from state to state, S1-aux turns on a little bit ahead of S1, the transition state is also state.

After A1-auxis turned on, S1 turns on with all the current flowing throughA1-aux, namely a ZCS turn-on. When the output obtained the full output voltage +Vdc by switching on the s1 and s4 switch at same time. So the current passed through S1 and Load then S2. So the output voltage getting positive voltage. Then second level voltage will obtained by switching on the four Cool-MOSFET located in the bidirectional swichs.The Cool-MOSFET will swill switched on the simultaneously because it has low ON state resistance .When conducting start from Cool-MOSFET the current flow through the parallel connected Cool-MOSFET It has low conduction losses. On state resistance have low resistance. Also current flow through the S4 we have obtained half of the peak voltage

IV. MICROCONTROLLER BASED PULSE WIDTH MODULATION

Pulse-width modulation (**PWM**), or **pulse-duration modulation** (**PDM**), is a technique used to encode a message into a pulsing signal. It is a type of modulation. Although this modulation technique can be used to encode information for transmission, its main use is to allow the control of the power supplied to electrical devices, especially to inertial loads such as motors. In addition, PWM is one of the two principal algorithms used in photovoltaic solar battery chargers, the other being MPPT.

The average value of voltage (and current) fed to the load is controlled by turning the switch between supply and load on and off at a fast rate. The longer the switch is on compared to the off periods, the higher the total power supplied to the load. The PWM switching frequency has to be much higher than what would affect the load (the device that uses the power), which is to say that the resultant waveform perceived by the load must be as smooth as possible. Typically switching has to be done several times a minute in an electric stove, 120 Hz in a lamp dimmer, from few kilohertz (kHz) to tens of kHz for a motor drive and well into the tens or hundreds of kHz in audio amplifiers and computer power supplies.

The term duty cycle describes the proportion of 'on' time to the regular interval or 'period' of time; a low duty cycle corresponds to low power, because the power is off for most of the time. Duty cycle is expressed in percent, 100% being fully on. The main advantage of PWM is that power loss in the switching devices is very low. When a switch is off there is practically no current, and when it is on and power is being transferred to the load, there is almost no voltage drop across the switch. Power loss, being the product of voltage and current, is thus in both cases close to zero. PWM also works well with digital controls, which, because of their on/off nature, can easily set the needed duty cycle. PWM has also been used in certain communication systems where its duty cycle has been used to convey information over a communications channel.

8-bit PIC16F877A microcontroller was chosen to obtain the pulses for the FSTPI to drive the multilevel inverter. This Microcontroller has a 25 MHz processor, 33 input/output (I/O) pins, interrupts, counters, timers, I/O ports, RAM, and ROM/EPROM. The peripheral interface controllers (PICs) are the integrated circuits based on CMOS technology. The main components of a PIC are RAM, EPROM, EEPROM, and Peripheral Interface Adaptor (PIA).

These components are inserted in the same integrated circuit to reduce the size, the cost of the system and make design of the system easier. The address bus, the data bus and the control bus connecting the components are placed in the PIC circuit by the manufacturer. Because of these advantages, PICs have been preferred devices in practical control applications. PIC16F877A used in this work operates at 20 MHz clock frequency and runs each instruction as fast as 200 ns.

Flash Program Memory is up to 8K×14 words. Data memory is partitioned into four banks which contain the General Purpose Registers and the Special Function Registers. Bits RP1 and RP0 are the bank select bits. Each bank extends up to 7Fh (128 bytes). It contains 1 K EEPROM as a program memory.

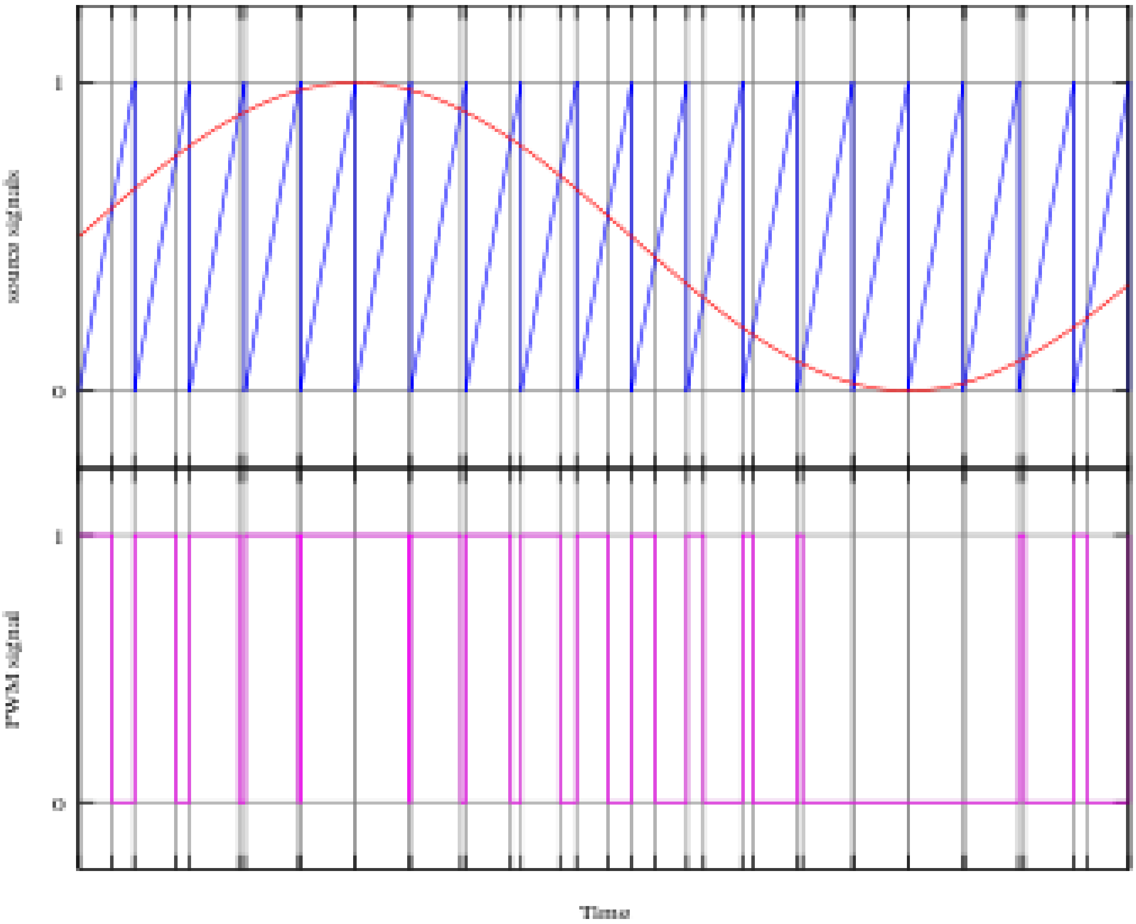

Fig.3 A simple method to generate the PWM pulse train

V. SWITCHING STRATERGY

Table.1 Switching Strategy

Output	S1	S2	S3	S4	S1C	S1C1	S2C	S2C1
Vdc	on	off	off	On	Off	Off	Off	Off
Vdc/2	off	off	off	On	On	On	On	On
Vo = 0	off	off	on	On	Off	Off	Off	Off
-Vdc/2	off	on	off	Off	On	On	On	On
- Vdc	off	on	on	Off	Off	Off	Off	Off

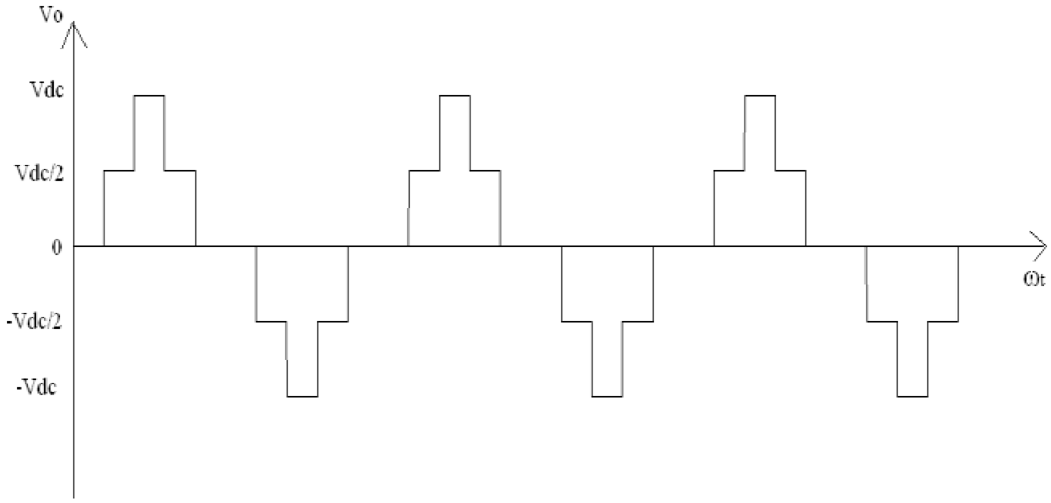

Fig.4 Five level T-Type NPC output waveform

VI. SIMULATION RESULTS

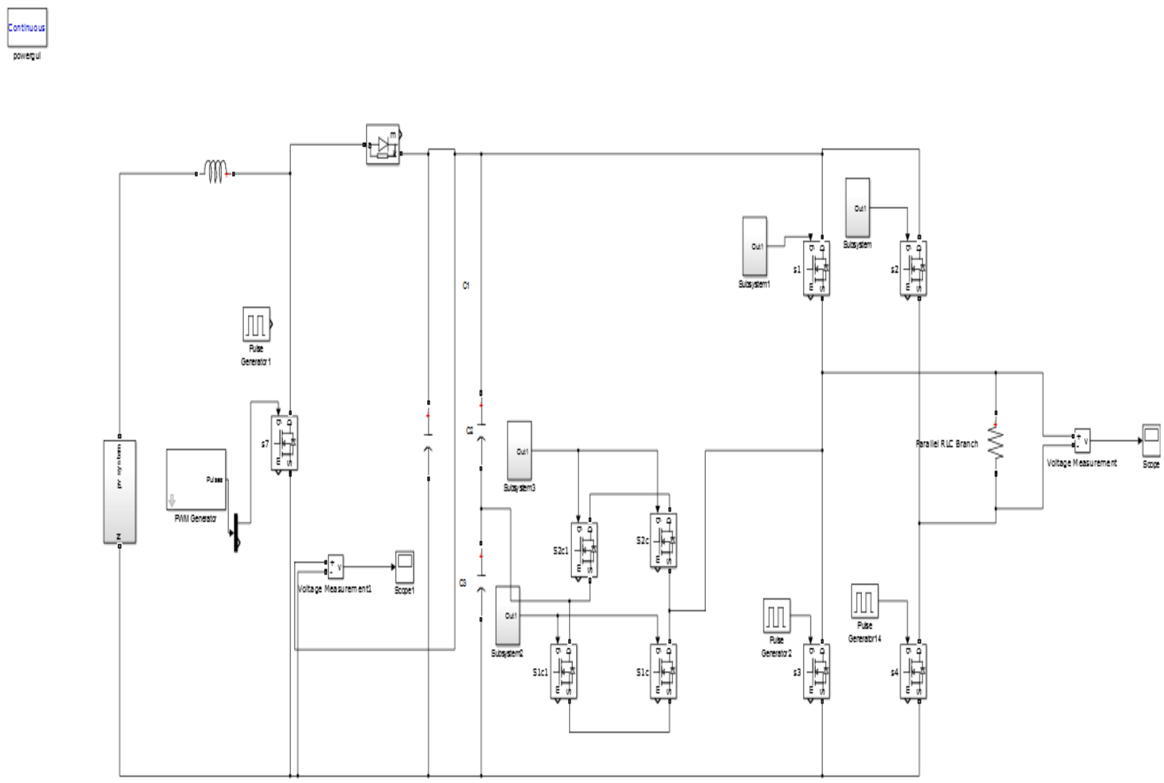

Fig .5 Simulation circuit of Proposed Model

The model developed in this work has been built in the Mat Lab/Simulink Environment. It integrates different parts of the building from energy production systems to energy consumption specifications.The simulation doing in the mat lab shown in the fig 6. Dc voltage obtained from the Solar Panel is given as input to the Γ source network.The voltage from the energy source (dc) is also focused to the MPPT .The MPPT deduct the maximum voltage and maximum current during the maximum power for to get the maximum power generation from the solar source of energy. After that the finite step predictive control strategy used to generating the control signal for to control the inverter output with the help of pulse generation.

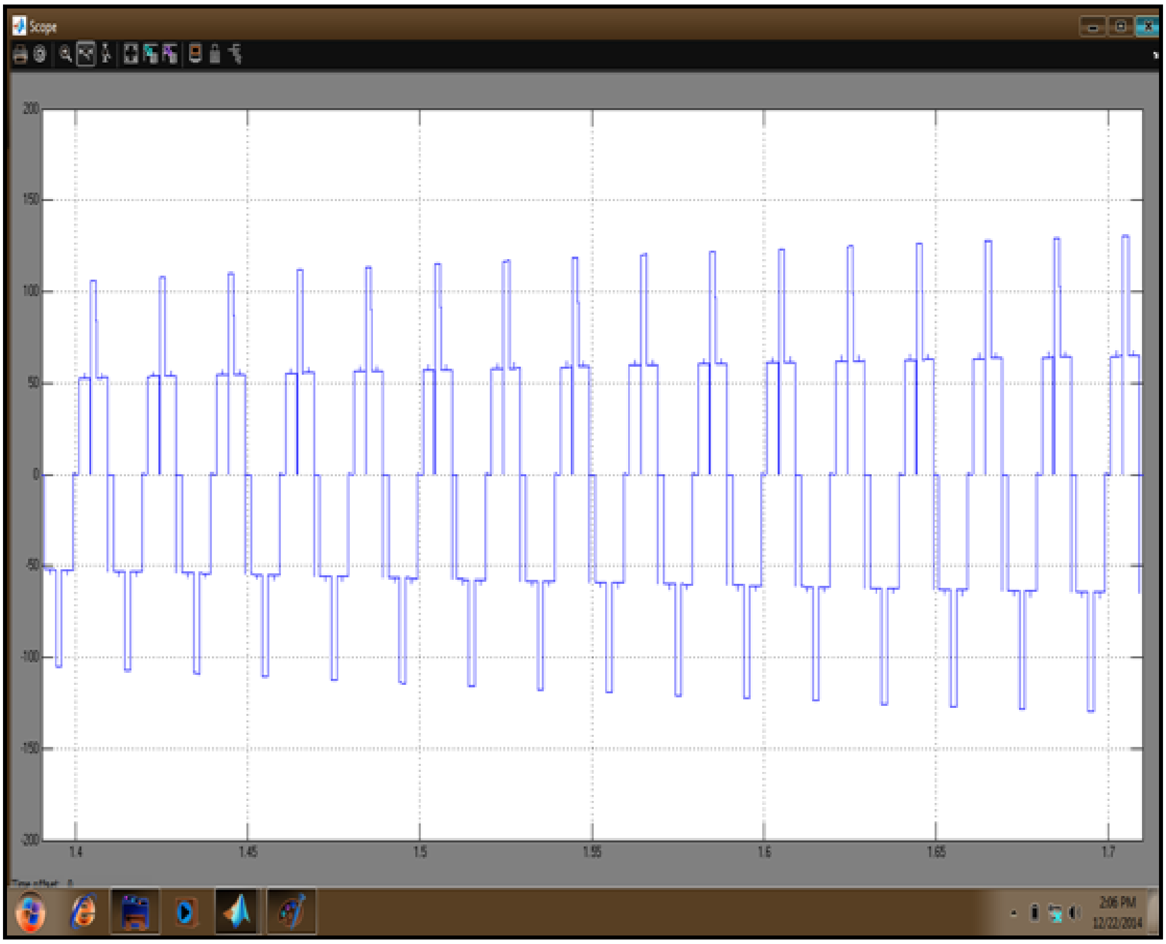

Fig .6 inverter output voltage

Based on the implementation steps of FSMPC. With FSMPC's ability of multisystem variables regulation, load current regulations, impedance network inductor current as well as capacitor voltage an all be regulated as subjecting to constraints of this control method. minimizing the cost function, proper current or voltage vector can be gained and corresponding switching state can be gained.we get the constant output at the inverter side by controlling the inverter switches with the help of Γsource network.This system of solar based Γsource inverter is proposed for to eliminate the battery usage.

VII. CONCULSION

In this paper, the five level Neutral point clamped inverter using Cool-Mosfet for a high-efficiency low-voltage application was presented. It is an alternative to the three-level VSC for medium switching frequency applications and is very efficient in the range of 4–30 kHz. The main advantage comes from the halved commutation voltage which reduces the switching losses compared to the three-level topology. The implementation of the bidirectional switch to the midpoint of the dc-link with two anti-parallel 600-V IGBTs in common-emitter or common-collector configuration was discussed and benefits concerning the additional isolated gate drive supplies have been shown for the common-collector configuration.

REFERENCES

[1] Bhattacharya, S. Mascarella, D. Boulet, B. Joos, G.Interleaved PWM control for neutral point balancing in dual 3-level traction drives. Energy Conversion Congress and Exposition (ECCE), 2014 IEEE.

[2] C. Cecati, F. Ciancetta, and P. Siano, “A multilevel inverter for photovoltaic systems with fuzzy logic control,” IEEE Trans. Ind. Electron., vol. 57, no. 12, pp. 4115–4125, Dec. 2010.

[3] Corcau, J.-I. ; Dinca, L. Experimental tests regarding the functionality of a DC toDC Boost Converter Power Electronics, Electrical Drives, Automation and Motion (SPEEDAM), 2014

[4] Corcau, J.-I. ; Dinca, L.Numerical modeling of a Dc to Dc boost converter Applied and Theoretical Electricity (ICATE), 2014.

[5] D. Floricau, G. Gateau, and A. Leredde, “New active stacked NPC multilevel converter: Operation and features,” IEEE Trans. Ind. Electron., vol. 57, no. 7, pp. 2272–2278, Jul. 2010.

[6] F. Z. Peng and J. S. Lai, “Multilevel cascade voltage source inverter with separate dc sources,” U.S. Patent 5 642 275, Jun. 24, 1997.

[7] F. Kieferndorf, M. Basler, L. A. Serpa, J.-H. Fabian, A. Coccia, G. A. ScheuerA New Medium Voltage Drive System Based on ANPC-5L Technology978-1-4244-5697-0/10/$25.00 ©2010 IEEE.

[8] Jayant J. Mane, Shubhada P. Muley, Mohan V. Aware Mohan. Performance of 5-level NPC inverter with Multi-Multicarrier Multi-Modulation technique Dec 2012.

[9] K. Ma, M. Liserre, and F. Blaabjerg, “Operating and loading conditions of three-level neutral-point-clamped wind power converter under various grid faults,” IEEE Trans. Ind. Appl., vol. 50, no. 1, pp. 520–530,Jan/Feb. 2014.

[10] Mario Schweizer,Johann W. Kolar Design and Implementation of a Highly Efficient Three-Level T-Type Converter for Low-Voltage Applications IEEE transactions on power electronics, vol. 28, no. 2, february 2013.

[11] M. Calais and V. Agelidis, “Multilevel converters for single-phase grid connected photovoltaic systems—An overview,” in Proc. IEEE Int. Symp. Ind. Electron., Jul. 1998, pp. 224–229.

[12] Nashiren Farzilah Mailah, Sh. Sakinah Tuan Othman, Hanamoto Tsuyoshi, Yamada Hiroaki. Harmonics Reduction of Three Phase Five-Level Neutral-Point-Clamped Multilevel