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A Novel PV Based Three Phase Multilevel Inverter with Reduced Number of Switches Applied to Induction Motor

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Abstract:- In various industrial applications have begin to required higher power apparatus in recent years. Some of the medium voltage motor drives, utility applications requires medium voltage and megawatt power level. For a medium voltage grid, it is worrying to connect one power semiconductor switch in direct. As result, a multilevel converters structure has been introduced as alternative in high power and medium voltage applications. Multilevel converters achieves high power ratings, it enables use of renewable energy sources(RES). Renewable energy sources such as PV system, wind and fuel cells are easily interfaced to multilevel converters for high power applications. The use of PV system is increasing day by day in agriculture and industrial applications, due to their ease of control and flexibility. Multilevel inverters are having attractive features, MLI required least number of components among all other devices of Inverters to achieve same number of voltage levels, there is no EMI problem. The function of multilevel inverters is to get desired voltage from the several DC sources. In this paper mainly focused on reducing number of switches and sources. PV source used as input to the Three phase 25-level inverter and output of inverter connected to Induction motor to find performance characteristics. The simulation results are presented using MATLAB/SIMULINK software.

Keywords:- PV System, H-Bridge Inverter, Multilevel Converter, Symmetrical inverters, Asymmetrical inverters, Induction motor

I. INTRODUCTION

power electronic converters, are especially DC/AC inverters have been extending their range of use in industries because they provides reduced energy consumption, for better system efficiency, improved quality of product and good maintenance[1]-[3]. Multilevel converter structure has introduced as an alternative in high power and low voltage applications such as laminators, mills, conveyors, pumps, fans, compressors etc., The proposed PV based multilevel inverter applied to induction motor shown figure 1. In this paper three phase twenty five multilevel inverter introduced for reducing number of switches and sources.

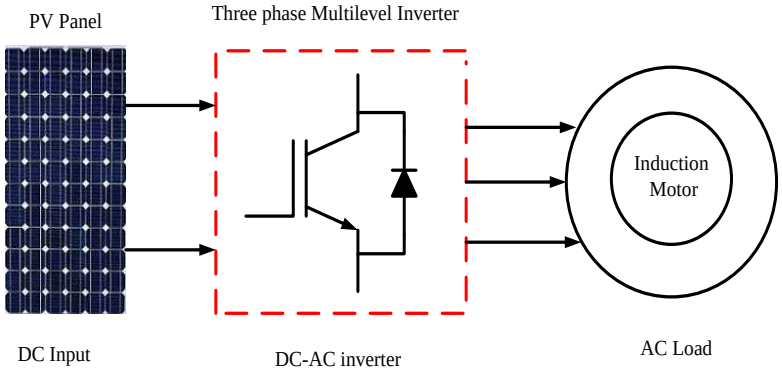

Figure 1.Block Diagram of The proposed converter

Multilevel converters are implemented in many different ways. The easiest techniques is the parallel or series connection of conventional converters to form the multilevel waveforms. More complex structures effectively insert converters within converters. The voltage or current rating of multilevel converter became a multiples of individual switches, and so the power rating of converter can be exceed the limit, imposed by individual switching devices [5].

II. PV SYSTEM

PV cell working on the principle of Photovoltaic effect. A photovoltaic system makes use of one or more solar panel electricity. It consists of various components which include the photovoltaic modules, mechanical and electrical connections and mountings and means of regulating and/or modifying the electrical output. The basic building block of PV arrays is the solar cell, which is basically a p-n junction that directly converts light energy into electricity[12]. The figure 2 shows the equivalent circuit of a PV array with a load.

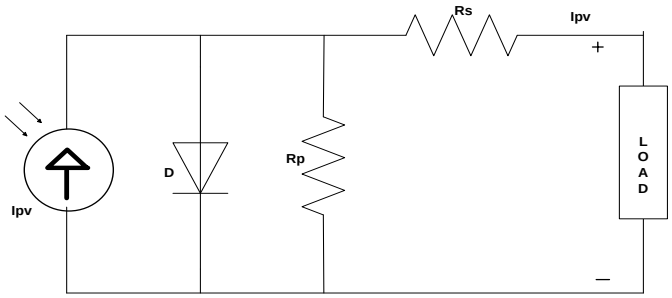

Figure 2 Equivalent circuit of a solar cell

III. MULTILEVEL INVERTER

The voltage level of the inverter is three, it is to be considered as considered as smallest number in multilevel converters. In multilevel inverter bi-directional switches are used, due to this switches Multilevel Voltage source converter(VSC) can be work as in both inverter and rectifier modes. This is because of mostly it can be referred as converter instead of inverter in this context. The multilevel converter switches used in either its input or output nodes or both between multiple or more than two levels of voltage or current [6]. The number of output levels reaches infinity, then the output THD approaches to zero. The number of achievable voltage levels, limited by voltage-imbalance problems, voltage clamping requirements, circuit layout and packaging constraints complexity of the controller, capital and maintenance costs. The main advantage of multilevel inverters are low harmonic distortion obtained due to multiple voltage levels at output and reduced switching stress on the using devices.

In industrial applications Three different types of multilevel converter structures are using, they are: cascaded H-bridge inverter with separate dc sources which is first introduced, followed by diode clamped converter and flying capacitor converters. In this chapter main focus on multilevel inverter structures their types. While each type of the multilevel converters shares the advantages of the multilevel voltage source inverters, they suitable for specific application due to it's structure and drawbacks. The Operation and structure of some important type of multilevel converters are explained in the following sections.

In the multilevel VSI, the dc-link voltage V_{dc} is obtained from any device which can be yield stable dc source. The Series connected capacitors consist of energy tank for inverter providing some nodes to which multilevel inverter can be connected. The series connected capacitors will be assumed to be any voltage sources of the same value. Each capacitor voltage Vc is given by $Vc=V_{dc}/(n-1)$, where n denotes the number of level [8]. Fig.3 shows a representation of one phase leg of inverters with different number of levels, for which the action of the power semiconductors is represented by an ideal switch with several positions. The two-level inverter generates output voltage with two values (levels) with respect to the negative terminal of the capacitor; they are positive and negative levels, whereas the three-level inverter generates three voltages as positive, zero and negative levels for multilevel inverter so on.

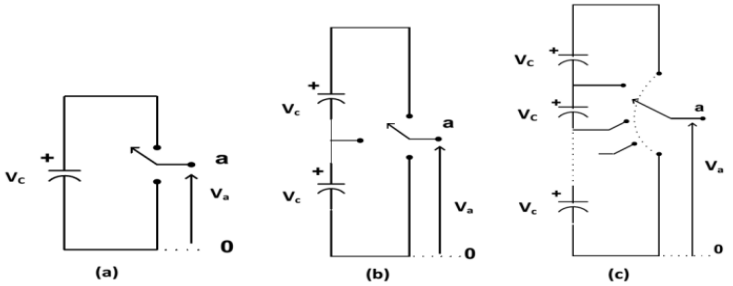

Figure 3: One phase leg of inverter with (a) Two levels (b) Three levels and (c) for n-levels.

H-Bridge inverter generates an output with positive and negative. The circuit diagram H-bridge inverter shown in figure 4.

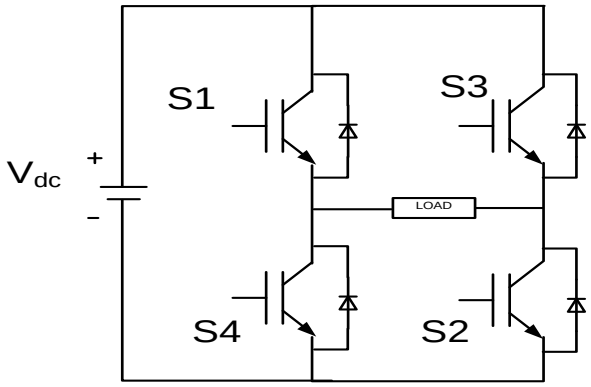

Figure 4: Single phase H-Bridge inverter

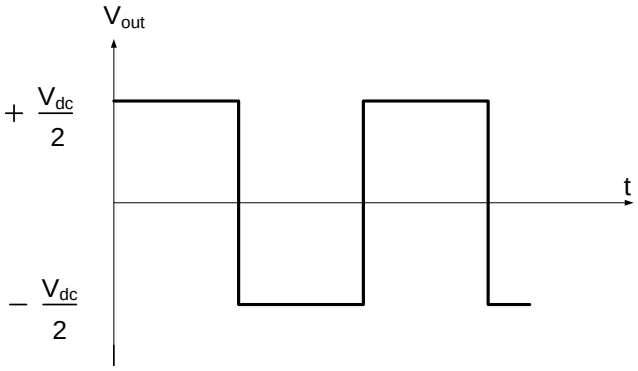

Figure 5: waveform of single phase H-bridge Inverter

IV. TYPES OF CASCADED H-BRIDGE TOPOLOGIES

A. Symmetrical cascaded H-Bridge inverter

All the input sources of an inverter equal in magnitude, it is known as Symmetrical cascaded H-Bridge inverter having voltage sources V_{dc} , V_{dc} as shown in figure 6 and corresponding five level inverter output shown in figure 8. Here both the full bridge inverters are fed with different sources of equal magnitude [9]. Figure 6, shows the cascaded H-bridge multilevel inverter of equal magnitude is connected with a single-phase full-bridge inverter. The output voltages of different level inverters are connected in series with different combinations of H-bridge inverter.

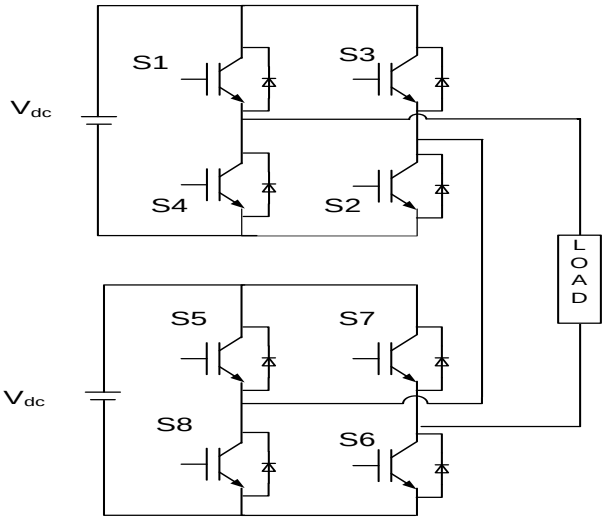

Figure 6: Symmetrical five level Cascaded H-Bridge inverter

B. Asymmetrical multilevel Inverter

The cascaded H-bridge MLI with two separate DC sources with unequal in magnitude is known as asymmetrical cascaded H-Bridge inverter [10].The below figure 7 shows the cascaded H-bridge inverter where it having two unequal DC sources V_{dc}, $2V_{dc}$.

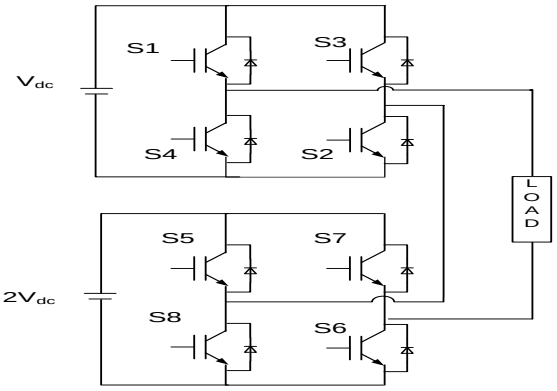

Figure 7: Asymmetrical five level cascaded H-Bridge inverter

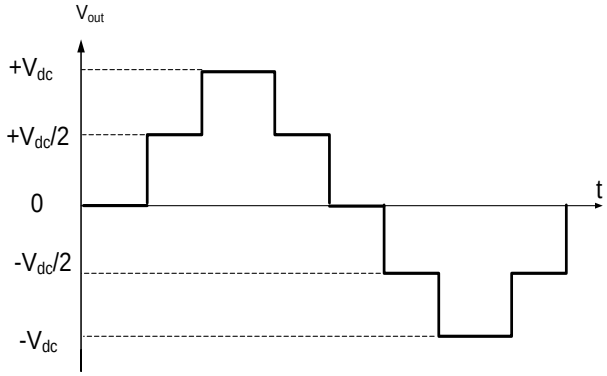

Figure 8: Waveform of five level cascaded H-bridge inverter

V. PROPOSED TOPOLOGY

The proposed circuit consists three single phase inverters as shown in figure 9, Each converter have ten switches to get twenty five level output and to get three phase output, converter connected three phase with phase delay.

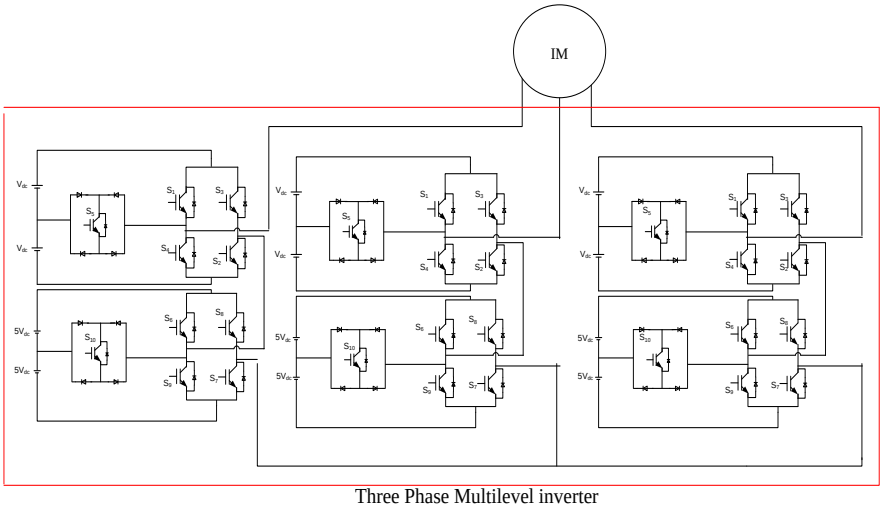

Figure 9: Schematic diagram of the three phase proposed multilevel inverter

Figure 10 shows the single phase converter of the twenty five inverter, In twenty five level multi level inverter the voltage sources are V_{dc}, V_{dc}, $5V_{dc}$ and $5V_{dc}$ total output voltage 1200V. In this proposed topology 10

switches are used to get 25 level, the switching levels shown in table 1 and operation modes for single phase inverter presented.

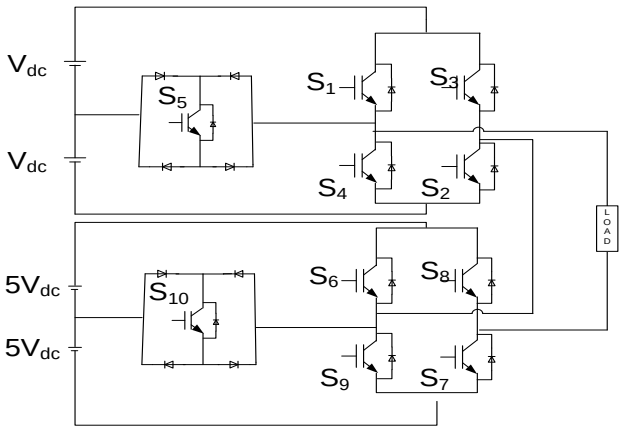

Figure 10: Circuit diagram for 25 levels Asymmetrical multilevel Inverter

The advantages of the topology are:
• Reduced number of dc sources.
• High speed capability
• Low switching loss
• High conversion efficiency.

Table 1 Switching Table for 25 level Asymmetrical multilevel Inverter

Switches ON	Voltage level
S_1, S_2, S_6 and S_7	$+12V_{dc}$
S_2, S_5, S_6 and S_7	$+11V_{dc}$
S_2, S_4, S_6 and S_7	$+10V_{dc}$
S_3, S_5, S_6 and S_7	$+9V_{dc}$
S_3, S_4, S_6 and S_7	$+8V_{dc}$
S_1, S_2, S_7 and S_{10}	$+7V_{dc}$
S_2, S_5, S_7 and S_{10}	$+6V_{dc}$
S_2, S_4, S_7 and S_{10}	$+5V_{dc}$
S_3, S_5, S_7 and S_{10}	$+4V_{dc}$
S_3, S_4, S_7 and S_{10}	$+3V_{dc}$
S_1, S_2, S_7 and S_9	$+2V_{dc}$
S_2, S_5, S_7 and S_9	$+1V_{dc}$
S_3, S_5, S_7 and S_9	$-1V_{dc}$
S_3, S_4, S_7 and S_9	$-2V_{dc}$
S_1, S_2, S_8 and S_{10}	$-3V_{dc}$
S_2, S_5, S_8 and S_{10}	$-4V_{dc}$
S_2, S_4, S_8 and S_{10}	$-5V_{dc}$
S_3, S_5, S_8 and S_{10}	$-6V_{dc}$
S_3, S_4, S_8 and S_{10}	$-7V_{dc}$
S_1, S_2, S_8 and S_9	$-8V_{dc}$
S_2, S_5, S_8 and S_9	$-9V_{dc}$
S_2, S_4, S_8 and S_9	$-10V_{dc}$
S_3, S_5, S_8 and S_9	$-11V_{dc}$
S_3, S_4, S_8 and S_9	$-12V_{dc}$
S_2, S_4, S_7 and S_9	$0V_{dc}$

VI. Modes of Operation

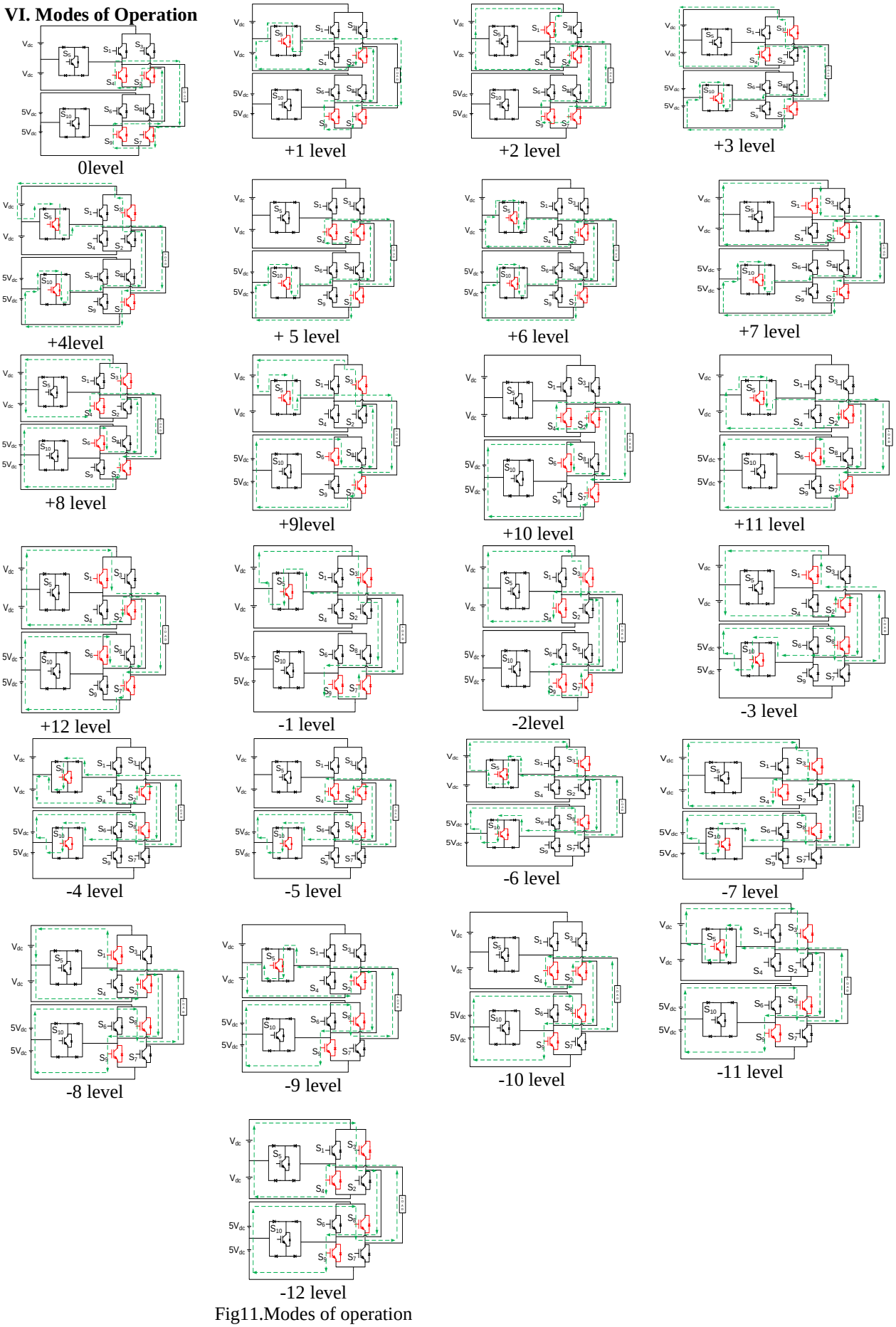

Fig11.Modes of operation

VII. SIMULATION RESULTS

Here Matlab/simulation results are presented for
(i) Single phase Asymmetrical multilevel inverter and
(ii) Proposed PV input Three phase multilevel inverter applied to induction motor .

Case i: Single phase Asymmetrical multilevel Inverter

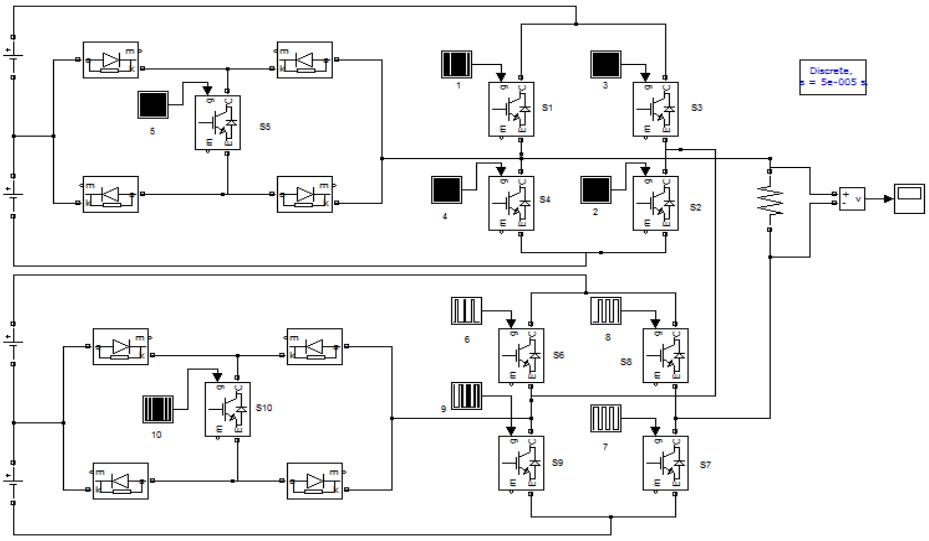

Figure 12: Simulation circuit for 25 level Asymmetrical multilevel Inverter

The above figure shows the single phase twenty five level implemented in Matlab/simulink model, with Resistive Load , in this circuit ten IGBT/Diode switches and four asymmetrical sources are used.

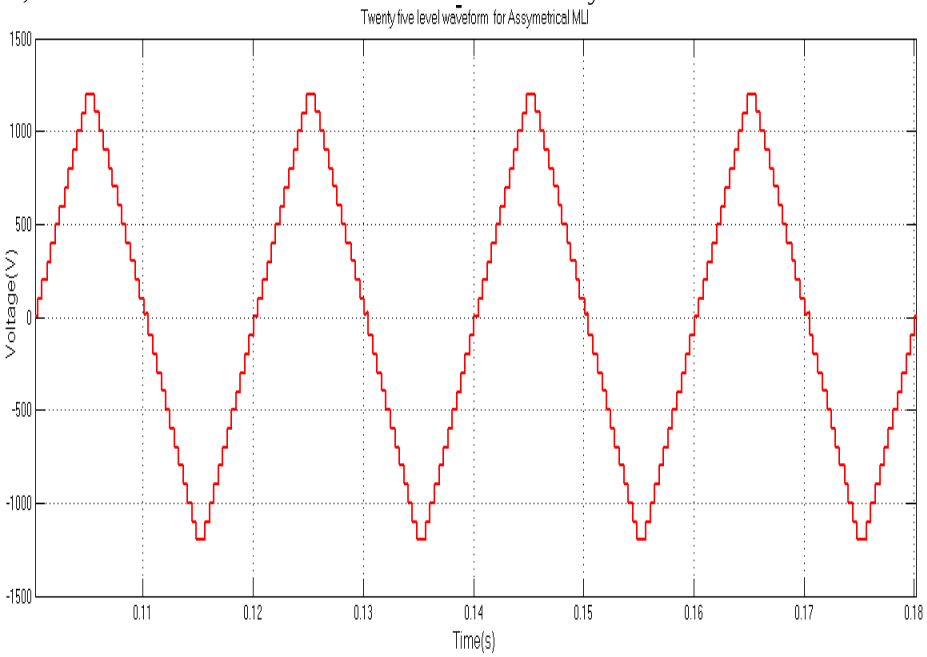

Figure 13: Waveform Twenty five level for Asymmetrical cascaded H-Bridge MLI with output voltage 1200V

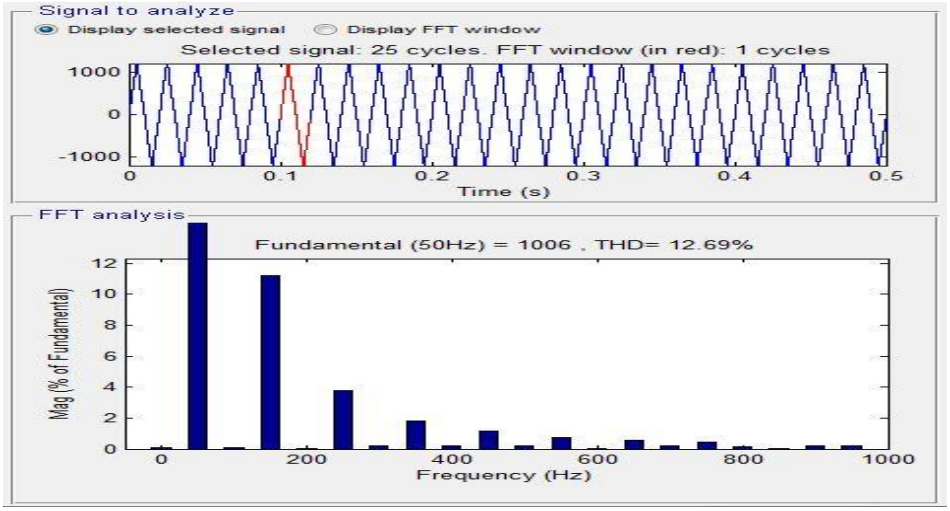

Figure 14: FFT Analysis of Twenty five level for Asymmetrical cascaded H-Bridge MLI

Case ii: Proposed PV input three phase multilevel inverter applied to induction motor

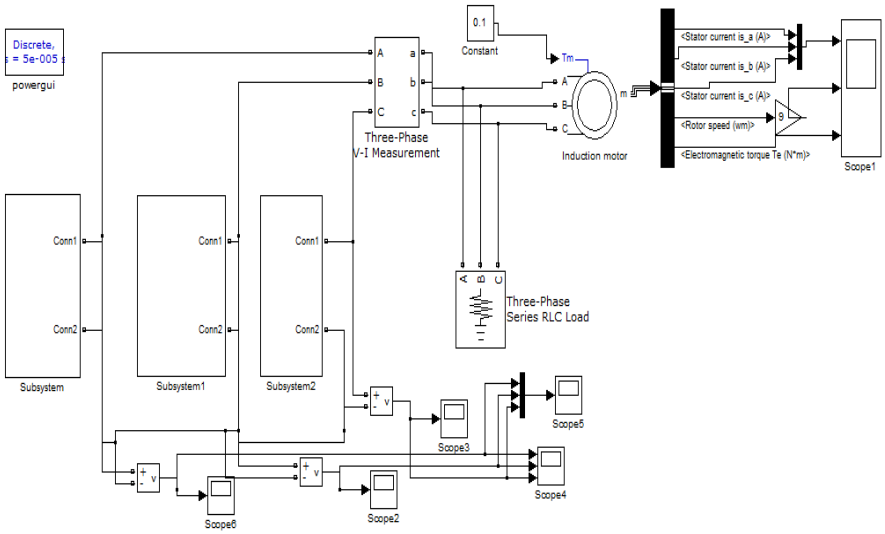

Figure 15: Matlab/simulation model for PV based Three phase MLI applied to Induction motor

In above figure three phase multilevel inverter is used for to converter DC voltage of PV to AC and the output of inverter connected induction motor as industrial apllication

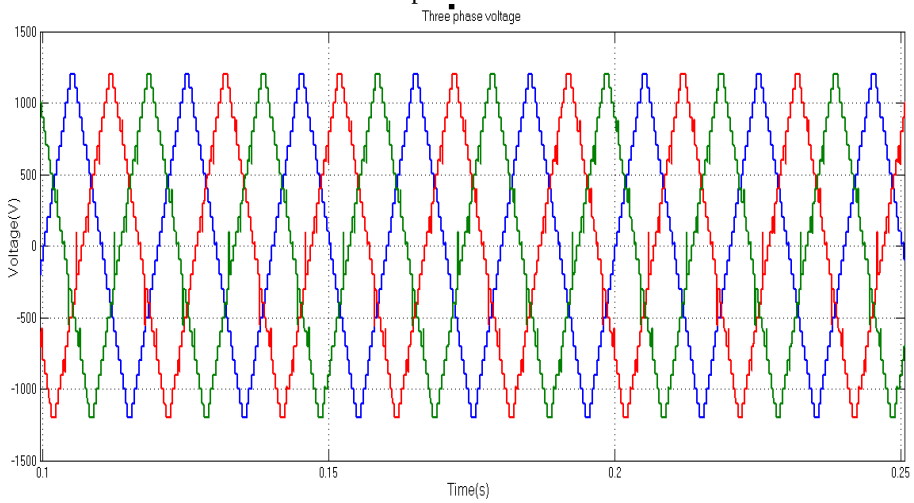

Figure 16: waveform of Three phase output voltage with 1200V

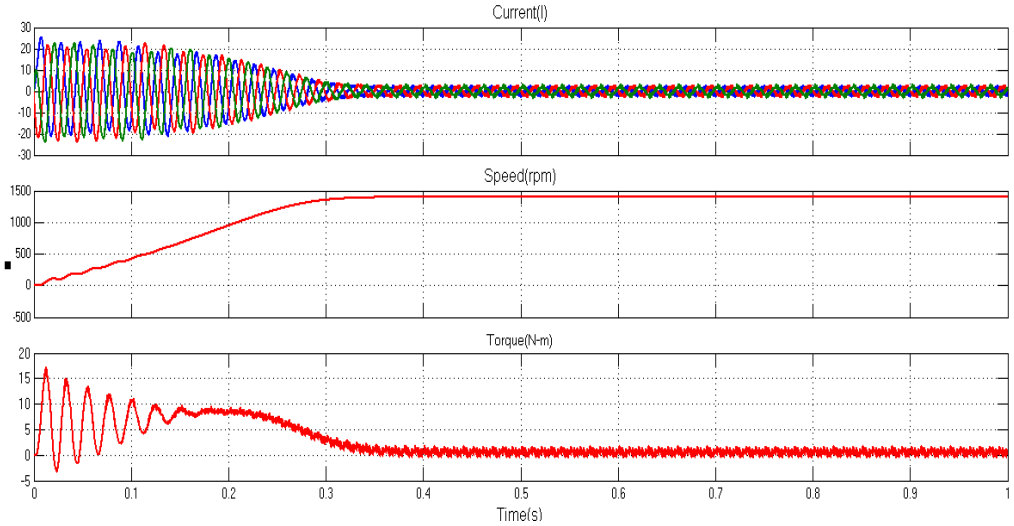

Figure 17: Performance characteristics of Induction motor as Current, Speed and Torque

Figure 17 shows induction motor performance characteristics as stator current, Rotor speed 1500rpm and Electromagnetic torque.

VIII. CONCLUSION

In this paper three phase multilevel inverter with PV source applied induction motor presented. The Three phase converter consists of three single phase asymmetrical inverters. This paper mainly concentrated on reduction of switches and voltage sources. In Asymmetrical cascaded multilevel inverter for twenty five level 10 switches are used with PV cell. Output of the three phase inverter connected to induction motor as industrial application to perform the characteristics of motor. The simulation results are presented by with the help of Matlab/simulink platform.

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