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MULTILEVEL CONTROL STRATEGY FOR INDUCTION MOTOR USING PV-BATTERY STANDALONE SYSTEM

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ABSTRACT

The paper presents a scheme that is used to enhance the capacity of the PV cell along with standalone battery used to feed the induction motor drive. The power capacity is increased by using 9-level inverter and its is almost equal for the cases of Neutral Point Clamped Multi level inverter and Cascade –H –Bridge inverter. Since the power level remains same for the above mentioned topologies, here main focus is on the THD content for the different topologies.

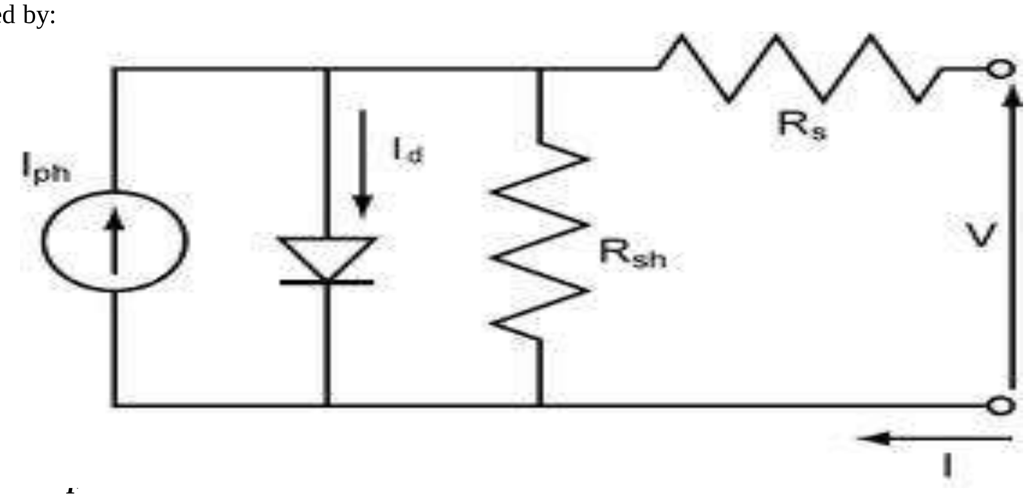
KEYWORDS: Energy management, Induction motor, Multi level inverter, Multi level SPWM, PV Battery, and THD.

I. INTRODUCTION

Solar power is the abundantly available source which has no noise and pollution during its production compared with conventional energy sources hence the solar power is the upcoming source of energy for future needs. Solar Energy is trapped and converted in to electricity with the help of PV cells. PV cells are more useful for remote areas where conventional energy sources are not reachable. Rapid evolution in semiconductor devices has revolutionized the industry for increasing in the production of high-power applications. The above mentioned reasons lead to the development of multilevel inverter. Difficulties of commutation failure, harmonics and total input voltage problems are minimized as the level of inverter is increased.

Different Control Algorithms are used by the multi level inverter [2-4] of which Sinusoidal Pulse Width Modulation (SPWM) appears most suitable. In multi level inverter as the level increases the THD decreases, also the output signals will have good spectral quality. Multi level inverters are mostly suited for high power applications [3-6].Disadvantage of multi level inverter design of control circuit is much complex and due to which it is not widely used for industrial applications [7-8].

Photovoltaic System: Photovoltaic cell characteristics are strongly nonlinear and the pv cell performance is characterized by:



ig.1. Equivalent circuit of solar PV

As shown in the fig-1, I_{Ph} is the short circuit current of PV cell and R_S is the series resistance, R_{Sh} is the shunt resistance, I_d is the diode current. The operation of PV cell is characterized by the fallowing equation

$$I=I_{Ph}-I_0[e^{\frac{qV+IR_S}{AKT}}-1]-\frac{V+IR_S}{R_{Sh}} \quad \rightarrow (1)$$

Where,

I_{Ph}= Photo-generated current (A)
I= Cell output current (A)
I_0=Diode Saturation Current (A)
V=Cell Output Voltage (V)
Rs=Series Resistor (Ω)
e= Electron Charge 1.6×10-19 (coul)
K=Boltzmann Constant (j/K)
T=cell temperature

Due to the robustness and the satisfactory performance of the three phase induction motor it is widely used in various kinds of industrial applications. Whatever the research work done main focus was on the development of Control Algorithm. Cost, Simplicity and flexibility of the drive was not given much importance. This paper gives a new approach so that the cost and flexibility of the drive are taken into picture during the design process of the induction motor drive.

II. MATERIALS AND METHODS

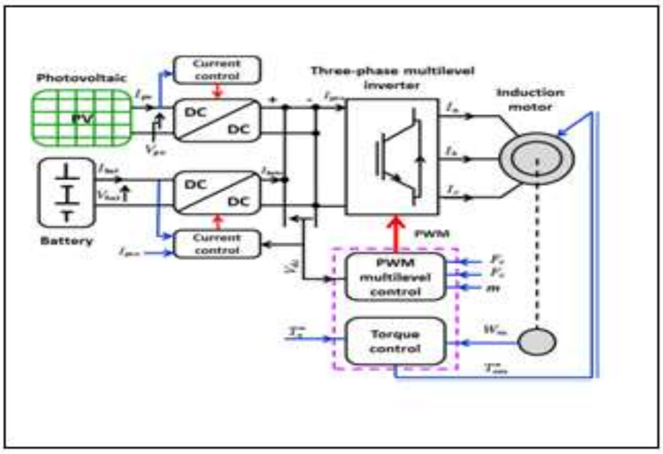


fig. 2: Induction motor driven by PV-batteries standalone system using a controlled multilevel inverter

MULTILEVEL INVERTER CONTROL STRATEGIES

The three-level inverter control strategy:

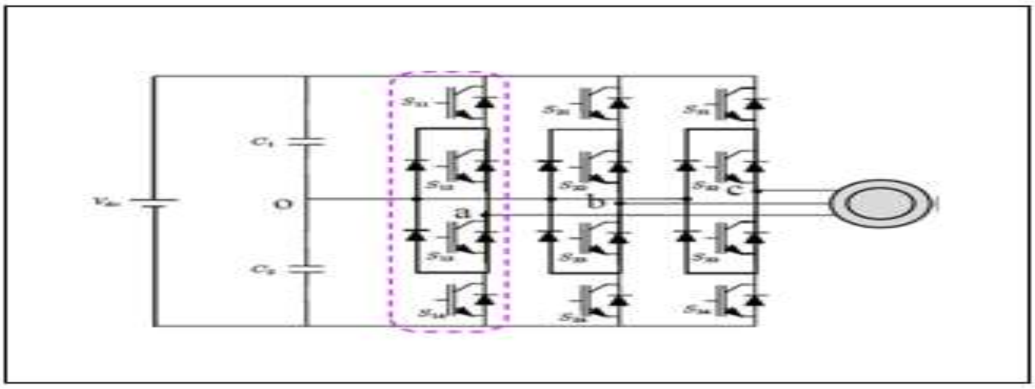


Fig. 3: Three-level three phase inverter

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Fig (3) shows a three phase three level inverter.V_{ao} is the phase voltage between phase a and neutral 'o'.The three level NPC inverter is used [10] for medium voltage, high power application.

Sequence	Switches State		Output phase(v_{ao}) voltage
	ON	OFF	
1	S_{11},S_{12}	S_{13}, S_{14}	$+v_{dc}/2$
2	S_{12},S_{13}	S_{11}, S_{14}	0
3	S_{13}, S_{14}	S_{11},S_{12}	$-v_{dc}/2$

These '3' sequences are applied periodically.9 level NPC multi level technique is used. In SPWM technique the modulating wave is compared with reference waves both in the +ve and –ve halves. The comparator output is sent to the switches to generate phase output voltages

CASCADED H-BRIDGE INVERTER:

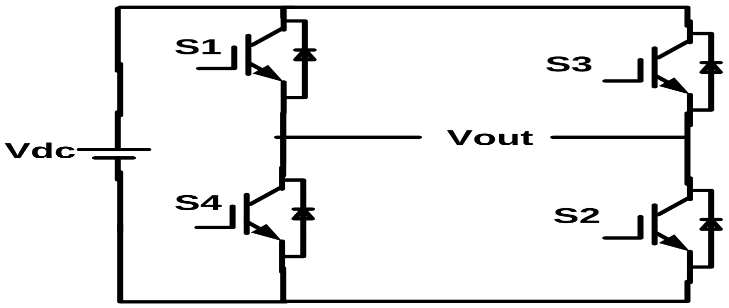


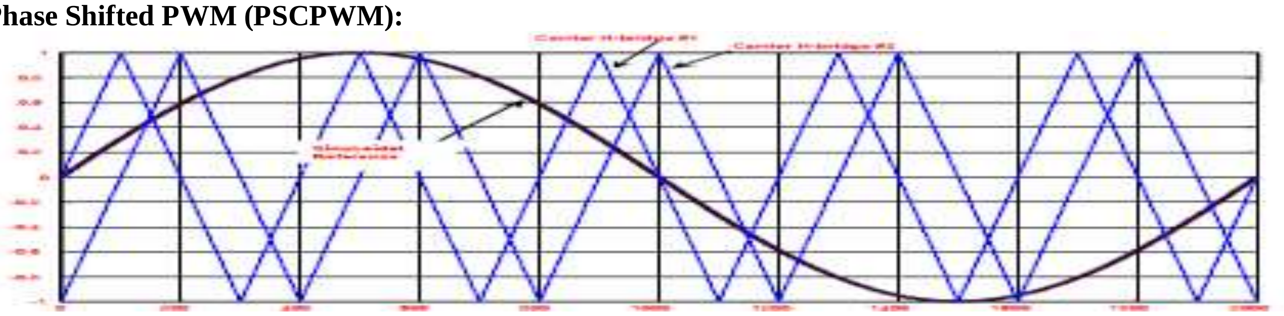
Fig. 4 Circuit of the single cascaded H-Bridge Inverter

For the above single phase three level inverter the switch positions and the output voltages are as fallows
In the cascaded H-bridge inverter
Output voltage level=2x+1

Switches		Voltage Level
ON state	OFF state	
S1,S2	S3,S4	+Vdc
S3,S4	S1,S2	-Vdc
S4,D2	S3,D1	0

Voltage step of each level=Vdc/(2x)
Where x=no of cascaded H-bridges
The selection scheme of 5 level CHB and the output voltages are as follows:
The available PWM techniques for CHB inverter are
(1)Phase Shifted PWM (PSCPWM)
(2)Level shifted PWM (LSCPWM)

Phase Shifted PWM (PSCPWM):



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For Y voltage levels (Y-1) carrier signal required and they are phase shifted with an angle θ=(360°/Y-1).The gate signals are generated with proper comparison of carrier wave and modulating signal

Level shifted PWM (LSCPWM :
For carriers signals, the time values of each carrier waves are set to [0 1/600 1/300] while the outputs values are set according to the disposition of carrier waves. After comparing, the output signals of comparator are transmitted to the IGBT
This technique is divided into 3 types

(i) In phase disposition :

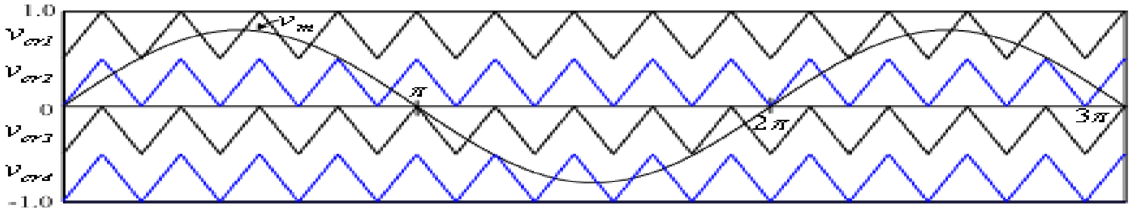

Fig-6 Level shifted carrier PWM (IPD)

All carrier signals are in phase.

(i) Alternative phase opposition :

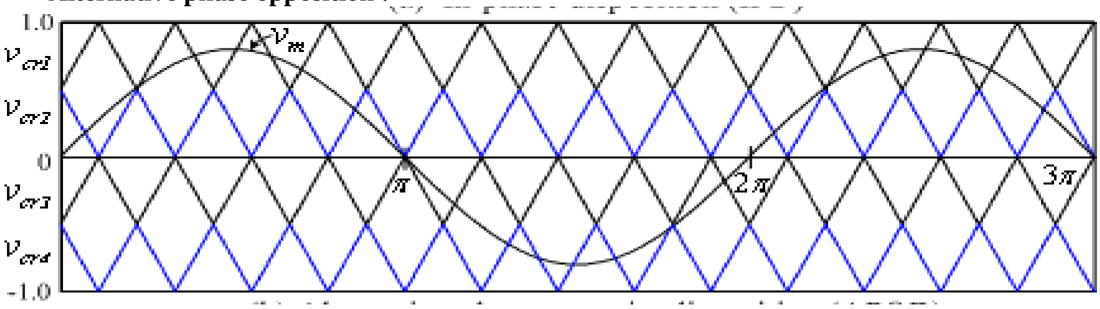

Fig. 7 Alternative Phase Opposite Disposition (APOD)

Switches at on stage	Diodes at ON stage	Voltage level
S1,S2	-	+Vdc
S1,S2,S5,S6	-	+2 Vdc
S4,S8	D2,D6	0
S3,S4	-	-Vdc
S3,S4,S7,S1	-	-2 Vdc

All carrier signals are alternatively phase opposite disposition.

Phase opposite disposition :

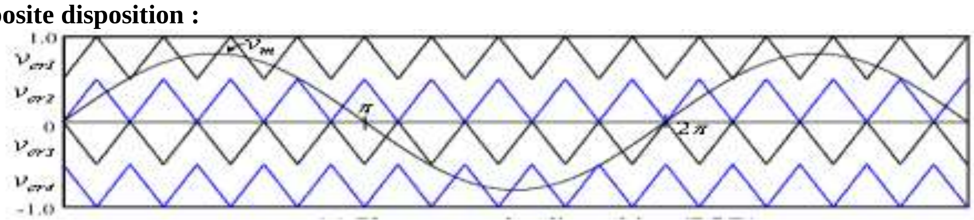

FIG. 8 Phase opposite Disposition (POD)

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All carriers above zero reference are phase but in opposition with those below the zero references. Among the above 3 cases, IPD give better harmonic performance.

III. RESULTS AND DISCUSSION

Here simulation is carried out in two different configurations, 1). Implementation of Proposed Concept using Neutral Clamped Type Multilevel Inverter. 2).
Implementation of Proposed Concept using Cascaded H-Bridge Multilevel Type Inverter.
Case 1: Implementation of Proposed Concept using Neutral Clamped Type Multilevel Inverter.

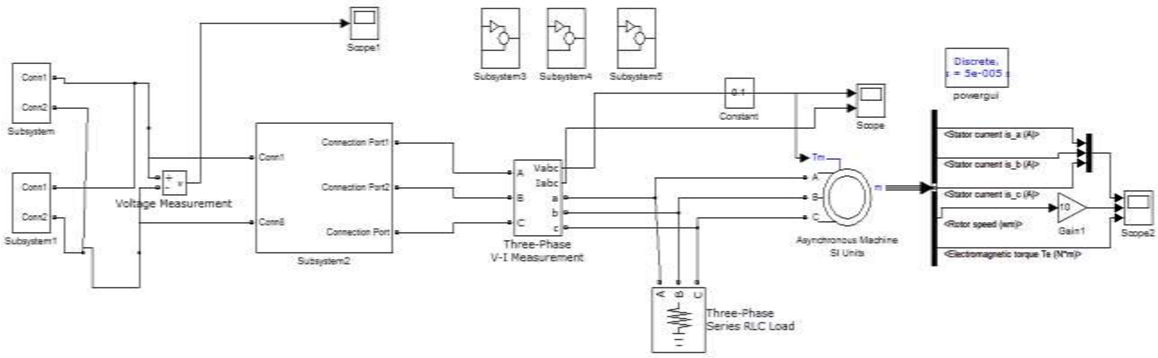

Fig. 9 Matlab/Simulink Model of Proposed NPC Converter with Induction Machine Drive

Fig.9 shows the Matlab/Simulink Model of Proposed NPC Converter with Induction Machine Drive.

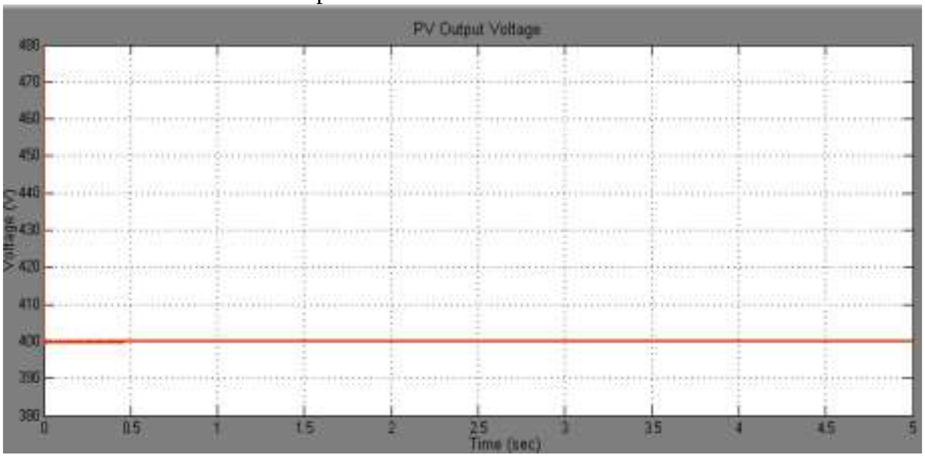

Fig.10 PV Output Voltage

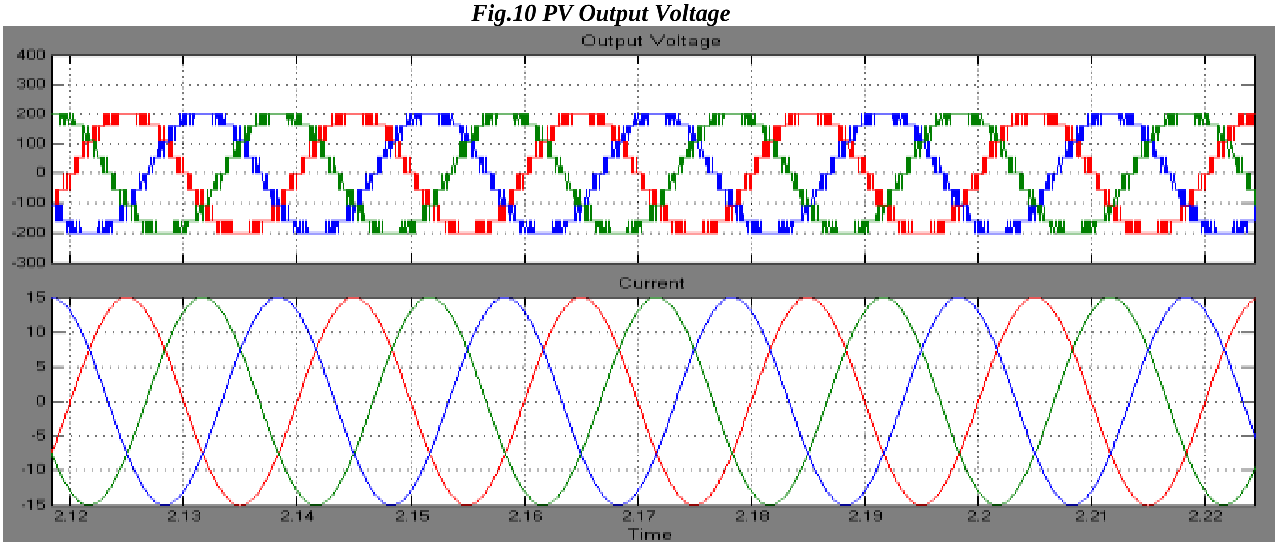

Fig.11 Level Output Voltage and Current

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Fig. 11 shows the 9-Level Output Voltage and current coming from the proposed NPC multilevel inverter.

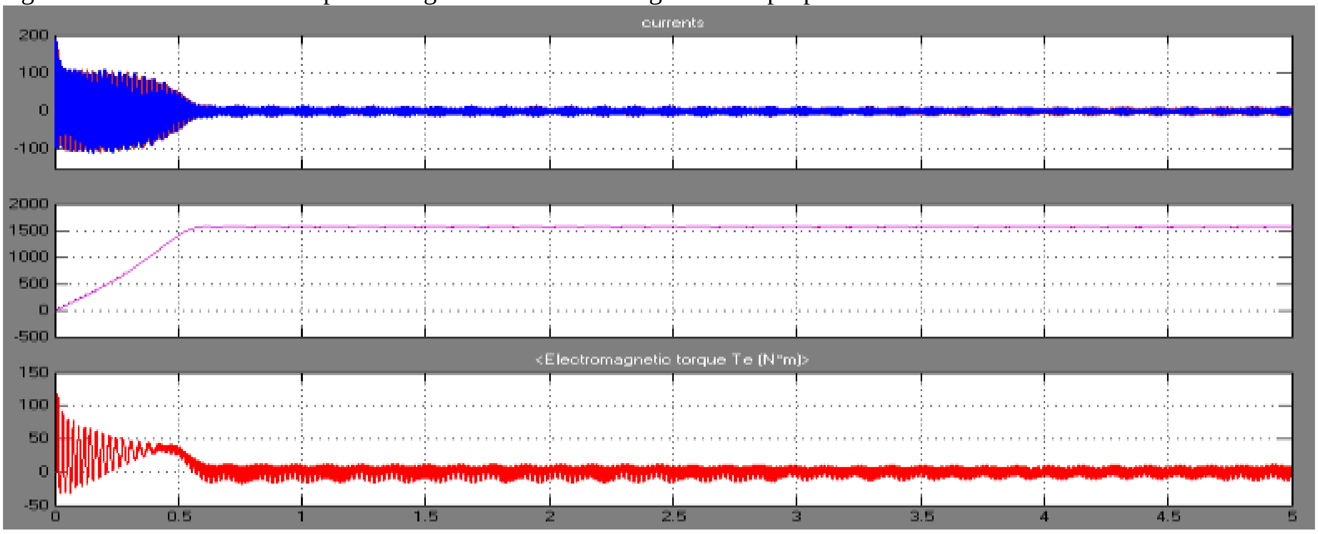

Fig.12 Stator Currents, Speed, Electromagnetic Torque

Fig.12 shows the Stator Currents, Speed, and Electromagnetic Torque of the proposed NPC Strategy Controlled Drive Performance Characteristics.

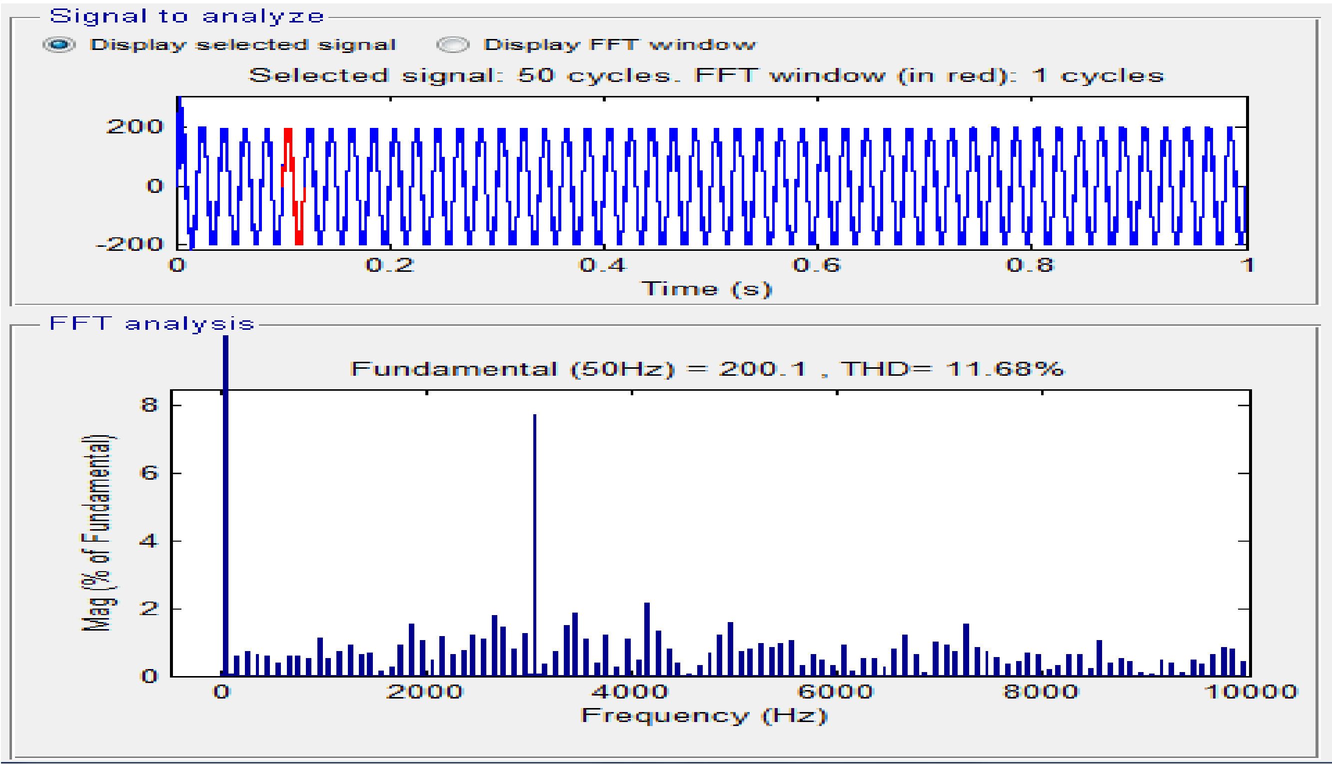

Fig. 13 FFT Analysis of Proposed NPC Converter Output

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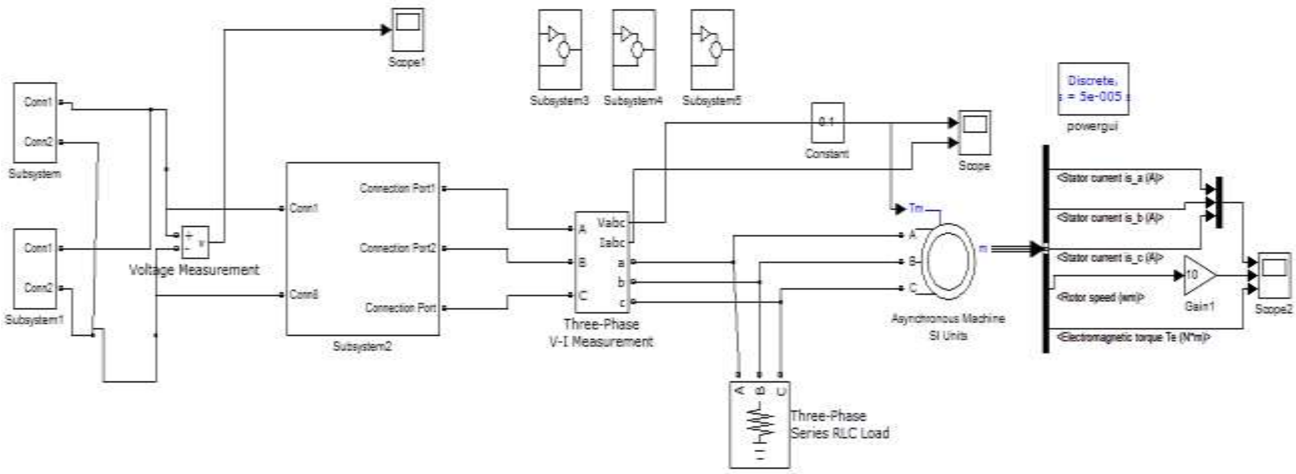

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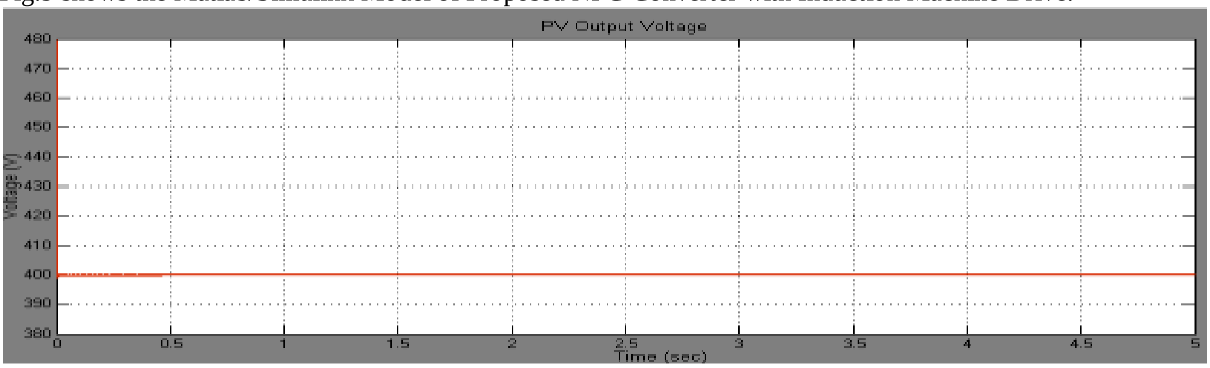
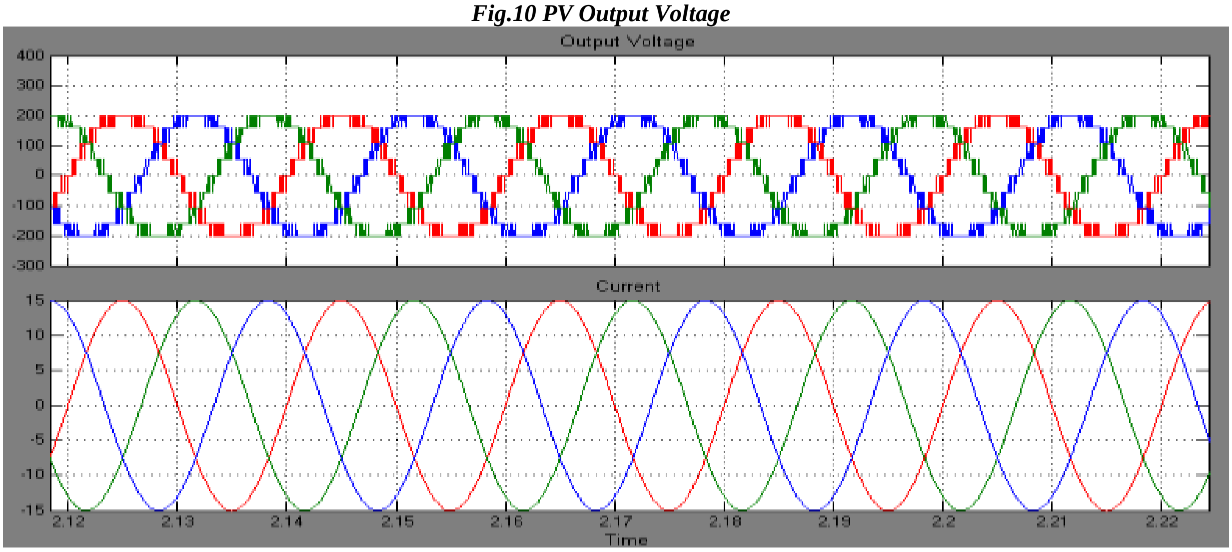


Fig.10 PV Output Voltage



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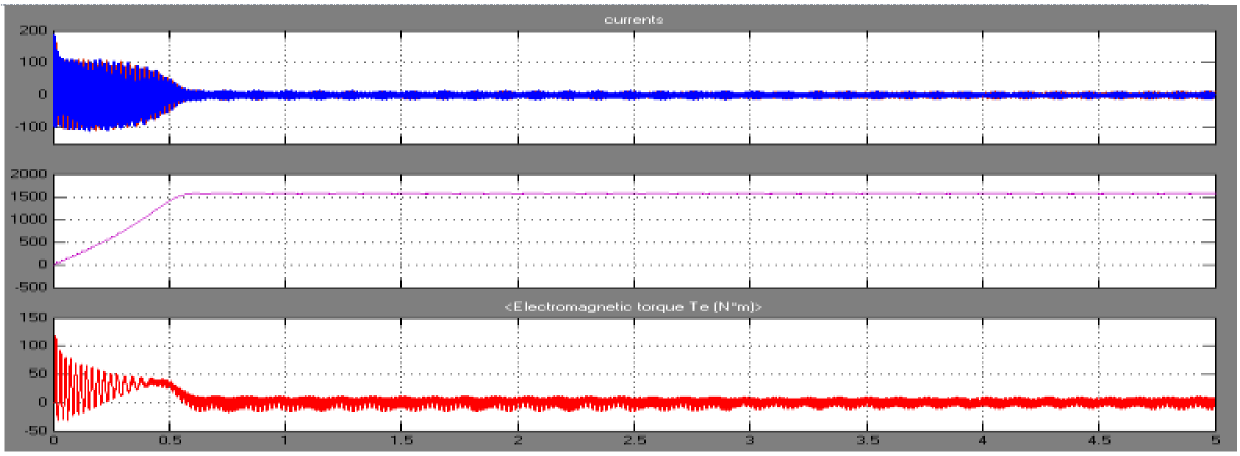

Fig.12 Stator Currents, Speed, Electromagnetic Torque

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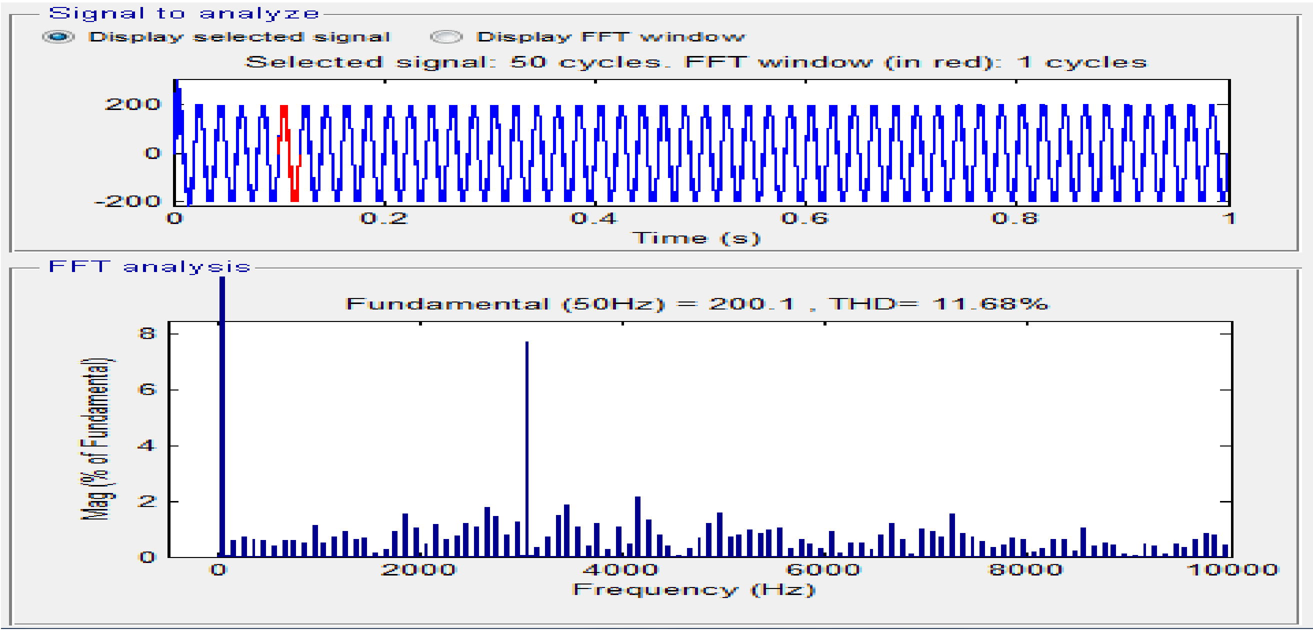

Fig. 13 FFT Analysis of Proposed NPC Converter Output

Fig. 13 shows the FFT Analysis of Proposed NPC Converter Output Voltage, we get 15.18% no need of any filter we get this value.

Case 2: Implementation of Proposed Concept using Cascaded H-Bridge Multilevel Type Inverter

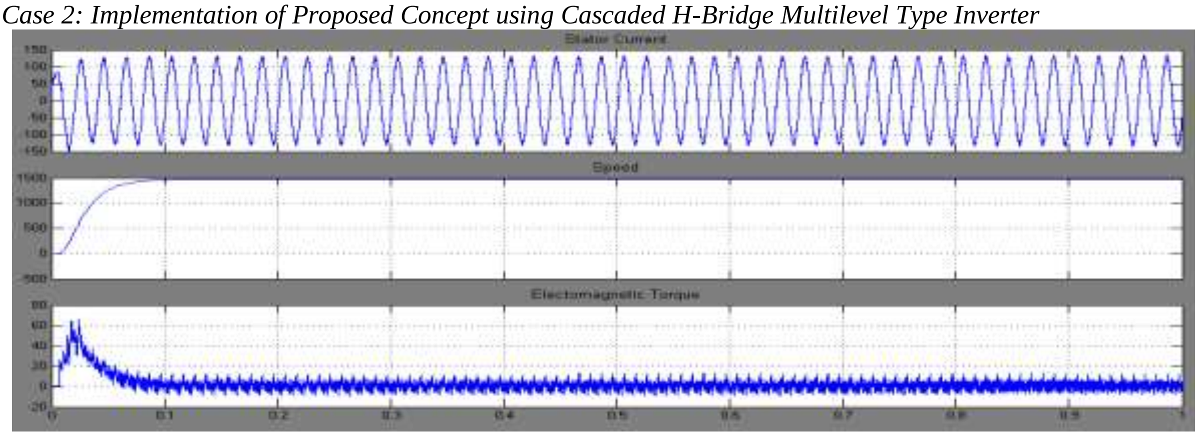

Fig.14 Stator Currents, Speed, Electromagnetic Torque

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Fig.14 shows the Stator Currents, Speed, and Electromagnetic Torque of the proposed CHB Multilevel Inverter to Controlled Drive Performance Characteristics.

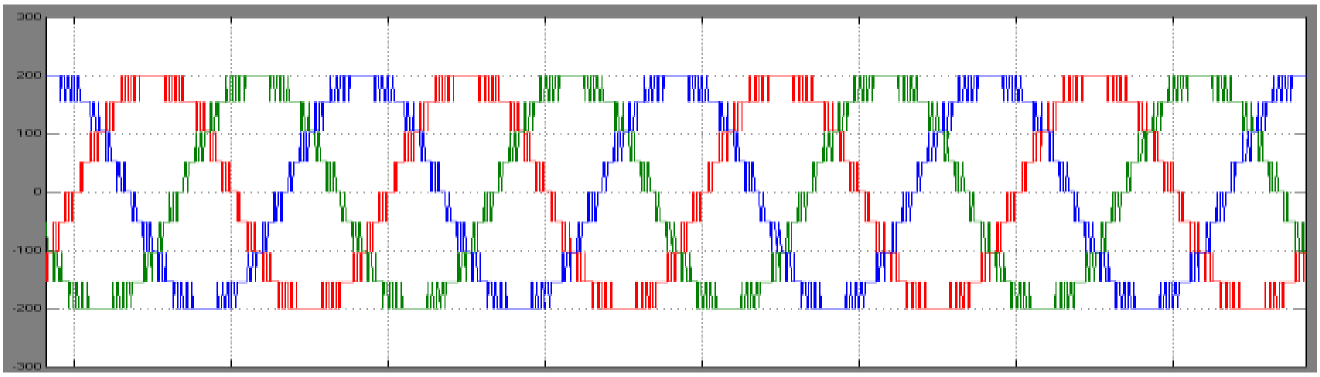

Fig. 15: 9- Level Output Voltage

Fig. 15 shows the 9-Level Output Voltage and coming from the proposed CHB Multilevel Inverter.

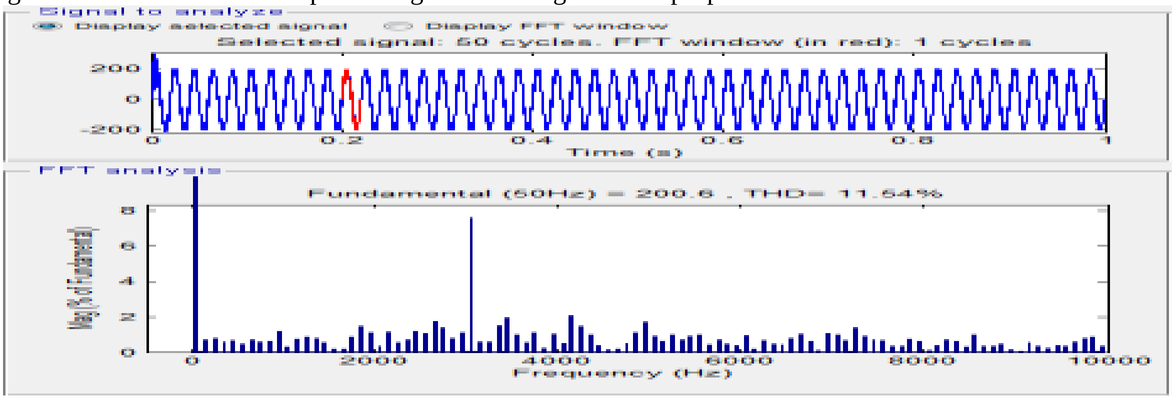

Fig. 16 FFT Analysis of Proposed CHB Multilevel Converter Output Voltage

Fig. 16 shows the FFT Analysis of Proposed CHB Multilevel Converter Output Voltage, we get 15.18% no need of any filter we get this value.

In this paper, modeling and simulation of a multilevel inverter using Neutral-Point-Clamped (NPC) inverters have been performed with motor load using Simulink/MATLAB program.

The modeling and the Maximum Power Point Tracking (MPPT) control strategy for a PV system are developed the control strategy that is presented is based only on the measurement of the PV current to track the maximum power

IV. CONCLUSION

In this paper, a general multilevel SPWM control algorithm for *9-level* inverter has been modelled and simulated using Matlab®/Simulink with different topologies. This algorithm can generate automatically SPWM pulses for any level of inverter by changing only a parameter *n* which is the number of inverter level. Simulation of nine level inverter of NPC topology and CHB Multilevel Converter is connected to induction motor has been performed and the generated signals THD is analysed. The system is supplied by a PV panel and batteries bank. That gives energy autonomy to the system. Simulation results give a better quality of stator current in terms of low harmonics, thus reducing the adverse effects on of the machine life and eventually the electrical network which supplies it, and reduces the switch count, low switching losses, etc.

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