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Three Phase Induction Motor Drive Using Boost Converter and 3 Level Inverter Fed From Photovoltaic Panel

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ABSTRACT: This paper proposes a topology of induction motor drive system integrating a boost converter and a three-phase 3 level inverter using solar photovoltaic panel. The motor is driven with the available power at the moment. To match impedance between the solar panel and motor load and to step up the panel voltage, a boost dc-dc converter topology is employed. Maximum power point tracking algorithm is implemented to extract maximum power from the PV panel. A 3 level inverter is used to drive the induction motor. To obtain optimum motor performance and to reduce THD of the inverter output waveform, we employed 3 level diode clamped inverter. The proposed system is simulated and results are discussed.

KEYWORDS: THD total harmonic distortion, MPPT Maximum power point tracking.

I.INTRODUCTION

The power electronic device plays an important role in the PV fed drive system for the improvement of efficiency. The maximum power point tracking is use to extract maximum power from the PV panel [1]. There are more than 30 algorithms to track maximum power point. MPPT algorithm is use in order to match load side impedance with source, so power flow is maximum. Perturbation and observation algorithm is used in the paper [2-3]. Different duty cycles are calculated from the algorithm with varying irradiation.

The pulses are generated from corresponding duty cycles, which is given to a DC-DC converter. There are different types of DC-DC converters. Boost DC-DC converter is most commonly used [3].

Sinusoidal pulse width (SPWM) modulation is commonly used in the inverter switching, since it is considered as the traditional switching techniques. The paper discusses the generation of 3 level voltage technique so as reduce the THD and to obtain a better switching pulse.[4].

Here an induction motor is driven using 3 level inverter and Boost DC-DC converter. Induction motor is the most popular motor in the market. The proposed system can be used for water plumping, and other drive system.

Fig.1 gives the overall block diagram of the proposed system.

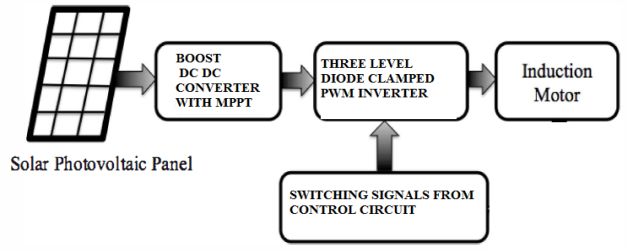

Fig.1. Overall block diagram

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II. LITEARTURE SURVEY

Photovoltaic power provides an environment friendly green source of electricity, of which the fuel is sunshine, a renewable energy. power electronics interface like dc-dc converter merge with a dc-ac three-phase inverter, it is possible to transfer the power efficiently from the panel to the machine useable sinusoidal ac with the help of Maximum Power Point Tracking (MPPT), where MPPT works by changing the parameters of the power electronics components in order to obtain the maximum power available at that moment of the panel. Pulse Width Modulation (PWM) technique is used for inverter switching and controlling of induction motor. However these techniques are suffered from several drawbacks such as low fundamental output voltage, excessive amount of harmonic element, and higher value of Total harmonic Distortion (THD), which is harmful and resulting poor performance of induction motor. To overcome this problem a three level inverter is used here.

III. MODELING OF PHOTOVOLTIC SYSTEM

A solar cell is basically a semiconductor, p-n junction fabricated in a thin wafer of semiconductor which converts sunlight into electrical energy. The electromagnetic radiation of solar energy can be directly converted to electricity through photovoltaic effect. The power on the PV depends on solar irradiance, panel temperature and operating voltage and current. The current-voltage relationship is called as the I-V characteristic which is a complex and non linear function [5-6].

Fig 2 shows the equivalent diagram of a PV cell.

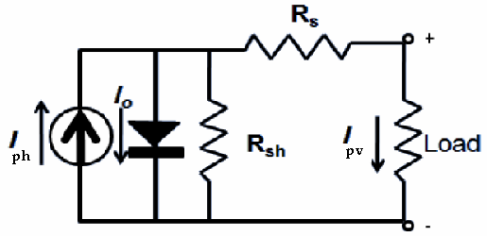

Fig. 2. Equivalent model of a PV cell

PV cells are grouped in larger units called PV modules which are further interconnected in a parallel-series configuration to form PV arrays.

The photovoltaic panel is modeled according to the mathematically equation as given below.

$$I_{ph} = I_{scr} + K_i(T - 298) * {}^{\lambda}/_{1000} \qquad (1)$$

Equ (1) gives the module current.

$$I_{rs} = {}^{I_{scr}}/_{[\exp\left(\frac{qV_{oc}}{N_s kAT}\right) - 1]} \qquad (2)$$

Equ (2) gives the reverse saturation current.

$$I_o = I_{rs}\left(\frac{T}{T_r}\right)^3 \exp[\frac{q*E_{go}}{Bk}\left(\frac{1}{T_r} - \frac{1}{T}\right)] \qquad (3)$$

Equ (3) gives the module saturation current I0 which varies with the cell temperature.

$$I_{pv} = N_p * I_{pv} - N_p * I_o[\exp\left\{\frac{q*(V_{pv} + I_{pv} R_s)}{N_s AkT}\right\} - 1] \quad (4)$$

Equ (4) gives the PV module current output IPV.

Required amount of Power is generated by connecting the PV panel in series and parallel combination.

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IV. MAXIMUM POWER POINT TRACKING

MPPT is an algorithm to find the maximum power point of the PV panel at different irradiation. Since the P-V curve of the solar panel is non linear, when variable load like motor is connected to the system, it is not necessary that the load will absorb maximum power from the solar panel. As per Maximum Power Transfer theorem, the output power flow is maximum between sources to load side when the Thevenin impedance of the source matches with the load impedance. This matching of impedance is done using the MPPT algorithm..

Perturbation And Observation Algorithm

There are many control algorithms for MPPT with basic aim of extracting maximum power from the panel. There are certain requirements that need to be satisfied by MPPT techniques while. P&O method is frequently used tracking algorithm since it has simple structure, low cost of implementation and requires only a few input parameters for its working.

The P&O as its name suggests it works on the principle based on the observation of the panel output power, and on perturbation i.e. incrementing or decrementing the power based on the increments of the array voltage.

P & O algorithm is explained below with the help of a flow chart fig.3 :

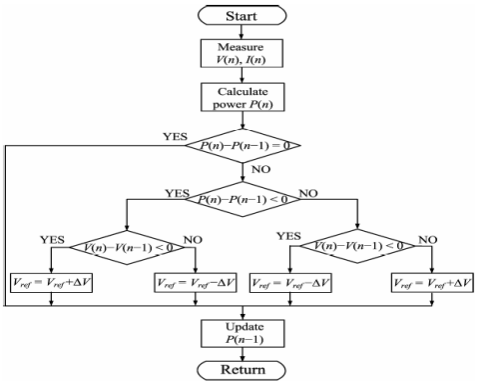

Fig.3. Flow chart of P&O Method

If change in power is positive then the operating voltage is incremented in same direction as that of the panel power. If change in power is negative that means the previous power P (n-1) is greater than P (n) then the system operating power point moves away from maximum power point (MPP). To achieve MPP, the operating voltage needs to be moved in the direction opposite to the direction of the incremented power.

V. BOOST CONVERTER

The boost is a called step up DC-DC converter since its output voltage is stepped to a higher value. To achieve MPPT of the PV panel, the dc-dc boost converter topology is used. The pulse generated from the MPPT algorithm is fed to the switch of the converter. Thus the impedance between the supply side and load side is kept equal, hence maximum power flow happens.

Boost circuit consist of a inductor, high frequency switching MOSFET, diode and a filter across load.

The relation between the load and supply voltage are shown below:

$$V_o = \frac{V_s}{(1-D)} \qquad (5)$$

$$D = \frac{T_{ON}}{T} \qquad (6)$$

The output voltage of the boost converter depends on the source voltage and duty cycle.

Where, V_o, D= duty cycle and T_{ON} =total time interval.

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VI. THREE LEVEL INVERTER

Diode Clamped 3 Level Inverter

Three level diode clamped inverter consists of twelve switches and six fast recovery diodes with two dc-link capacitors. To produce n levels of phase voltage, an n level diode clamped inverter needs (n-1) capacitors on the dc bus.

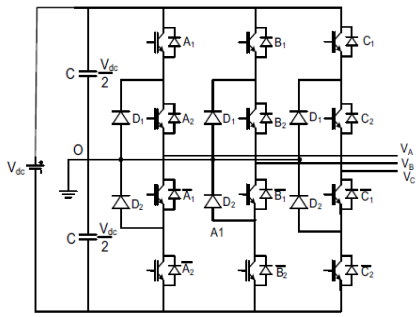

Fig.4. 3 Level Inverter

The sinusoidal PWM technique is popular in industrial converters. The general principle of pulse generation, where an isosceles triangle of carrier wave of frequency fc is compared with the fundamental frequency of the sinusoidal modulating wave, the point of intersection determine the switching point of the IGBT.

In this SPWM technique sine wave is taken as the modulating signal (50Hz) and it is compared with the two high frequency carrier signals (4KHz) and the resultant gate pulse is produced which is given to the corresponding switches of the inverter to produce the three level waveform. Table 1 below shows the switching states.

Sl. No.	Switching States				Switching State	Output Phase Voltage(Vao)
	Sa1	Sa2	S'a1	S'a2		
1	1	1	0	0	+	+(V/2)
2	0	1	1	0	0	0
3	0	0	1	1	-	-(V/2)

Table 1

VII. INDUCTION MOTOR

Induction motor is one of the most commonly used motor. About 90 % of motor produced in market is induction motor and cost is moderate. The synchronous speed of the motor can be control by using controlling the frequency of the stator voltage.

VIII. SIMULATION RESULT

The fig.5 shows the MATLAB model of boost converter with solar panel.

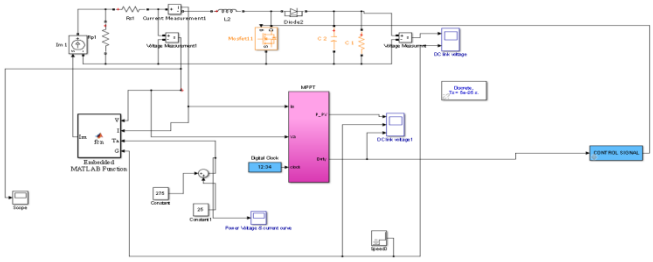

Fig.5. MATLAB model of dc converter with PV panel.

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The fig.6 shows the variation of output voltage of the DC-DC converter with respect to the change in irradiation. As irradiation increases, the output voltage increases.

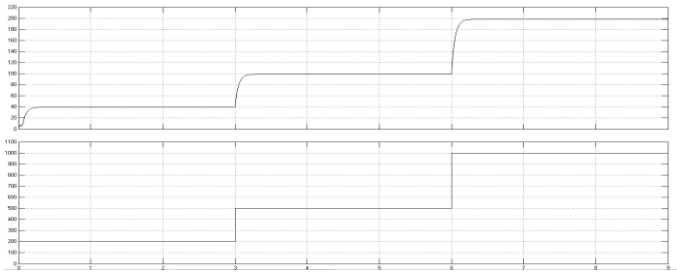

Fig.6. Change in voltage Vs change in irradiation.

The fig.7 shows the MATLAB model of 3 level inverter.

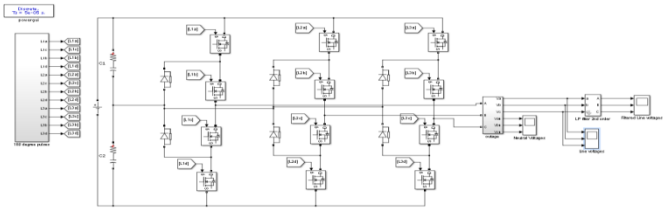

Fig.7. MATLAB model of 3 level inverter.

The fig.8 shows output voltage of the 3 level inverter.

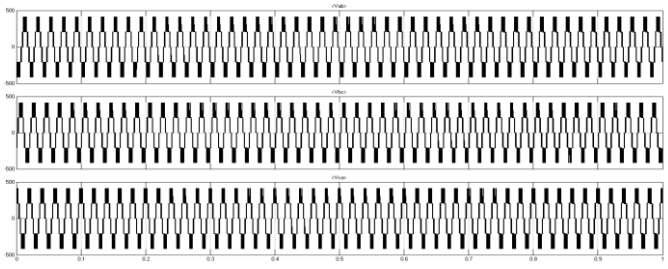

Fig.8. Output voltage of inverter.

The fig.9 shows MATLAB model of proposed system.

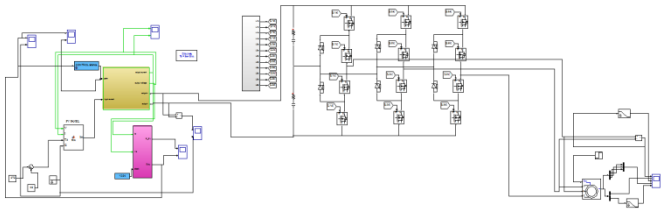

Fig.9. Overall MATLAB model

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The fig.10 shows change in dc link voltage of converter. As irradiation decreases the output voltage also reduces(as irradiation changes from 800 to 200W/sq.m, the voltage reduces from 390 to 310V)

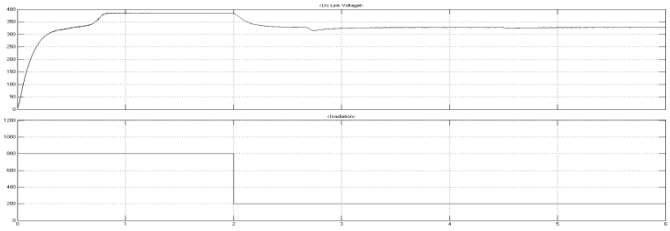

Fig.10. Change in dc link voltage with respect to irradiation.

The fig.11 shows the change in speed of the motor with respect to the irradiation. The fig.11(c) and fig.11(a) shows the output voltage across the motor terminal with and without filter. As irradiation changes the speed of the motor also changes. Here the speed of the motor is reduced to 150rps (at 2 sec) from157rps due to decrease in irradiation.

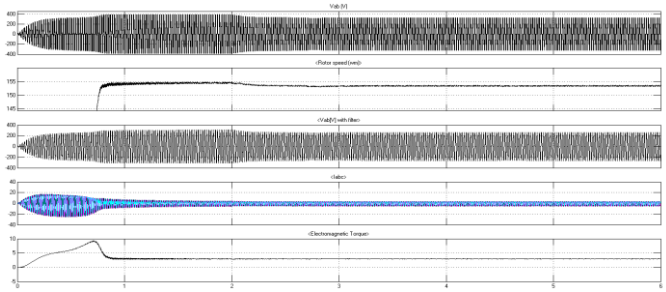

Fig.11. Variation of speed of the motor with change in irradiation

The fig.12 shows loading of motor. Here motor is loaded to 6Nm at 1 sec. As the loading is done, the speed of the motor reduces.

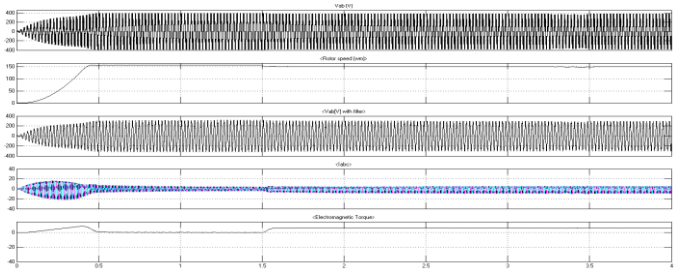

Fig.12. Loading of induction motor with constant irradiation(800W/sq-m)

The fig.13 shows the THD, which is found to be 2.52%.

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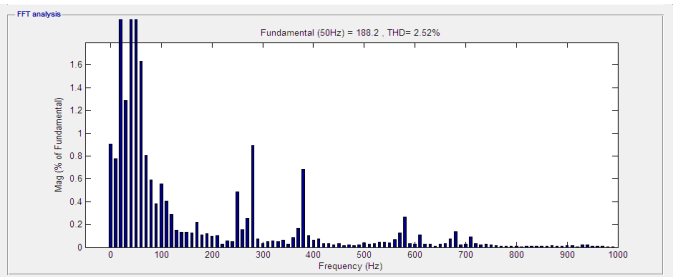

Fig.13. THD analysis.

IX.CONCLUSION

The simulation is carried out in MATLAB and results are studied. The P&O algorithm is implemented so as to extract the maximum power from the PV panel. A DC-DC converter is used to match the impedance between the load and source. The matching of the impedance of both side helps in attaining the maximum power flow. Here a 3 level inverter is used to drive the induction motor. The THD of the 3 level inverter is analyzed which is found to be less than 5%. Thus the overall efficiency of the system is increased.

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