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Induction Motor Driving System using Push-Pull Converter and Three Phase Multilevel Inverter

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Abstract: The paper mainly discuss about the study of driving an induction motor by using single photovoltaic panel. In order to drive the induction motor by PV panel, power electronic interface is necessary. Push-pull DC-DC converter topology is used to boost the PV array voltage. By the implementation of push-pull converter topology and 3-Φ multilevel inverter motor can be driven efficiently. Cascade 5 level inverter is employed to improve the efficiency of the system. SPWM technique is employed for switching of the inverter, to control the motor and also to reduce the total harmonic distortion. Perturb and observe MPPT technique is used to extract maximum power by the panel. Ultimately simulation circuits are developed in SIMULINK module and analyze successfully.

Keywords— Solar Photovoltaic Panel, Maximum PowerPoint Tracking, DC-DC Converter, Multilevel Inverter, Sinusoidal Pulse Width Modulation, Induction Motor.

1. INTRODUCTION

Non-conventional is obtained by the natural process which is usually replenished. This comprise of sunlight, geothermal heat, wind, and various forms of biomass. Photovoltaic systems play a crucial role in conserving the electrical energy. The excessive usage of the fossil fuels such as coal, petroleum, diesel etc. leads to changes in climatic conditions and mainly affects the global environment. In order to overcome these drawbacks from fossil fuels renewable energy will come into picture and eliminates these problems effectively. Different technologies are developed to protect the environment. Solar energy is the highly available, clean source of energy and mainly it is environment friendly source. In the proposed work, 3-Φ Induction Motor is driven from the Photovoltaic panel. Power electronics interface is required to match the requirements to operate the Motor from the panel effectively. By the use of Push-Pull converter along with the 3-Φ Multilevel Inverter, the power can be transferred from the PV panel to motor very efficiently. Push-Pull converter topology is implemented to enhance panel DC voltage which is unregulated to the regulated DC voltage level as per the requirement. The output voltage of the converter (V_0) is depended on the turn's ratio of the converter transformer.

2. PROPOSED METHODOLOGY

The proposed technique majorly focuses on the driving arrangement of the three stage acceptance engine coordinated with a push-pull converter and a 5 level inverter utilizing a solitary PV board. To separate most extreme force from the board, Maximum Power Point Tracking (MPPT) procedure is utilized. So as to coordinate the impedance between the engine load and the photovoltaic board, and furthermore to build the PV exhibit voltage, a push-pull converter topology is executed. To control the exchanging of the inverter sinusoidal heartbeat width regulation (SPWM) method is utilized. The SPWM method is useful in diminishing the THD of the inverter yield waveform, and to get the ideal engine execution. SPWM procedure is usually utilized staggered inverter control technique. This requires numerous triangular transporters which are tweaked by sine wave. Gapped Alternate Phase Opposite Disposition (GAPOD) and Alternate Phase Opposite Disposition (APOD), Phase Disposition (PD), are some of the various kinds of SPWM method that are utilized. THD is resolved for the distinctive SPWM exchanging methods.

The MPPT technique is utilized in order to set duty ratio of the push-pull converter. The output of the push-pull converter is 220V and this is achieved by selecting the proper turn's ratio of the transformer in push-pull converter. This 220V from the push-pull converter is then inverted using five-level inverter and the final output at the inverter side is 440V. The inverted 440V is used to drive the induction motor. In this proposed methodology the sinusoidal heartbeat width regulation technique is used for controlling the Inverter The block diagram of this methodology is as shown in Figure.1.[2].

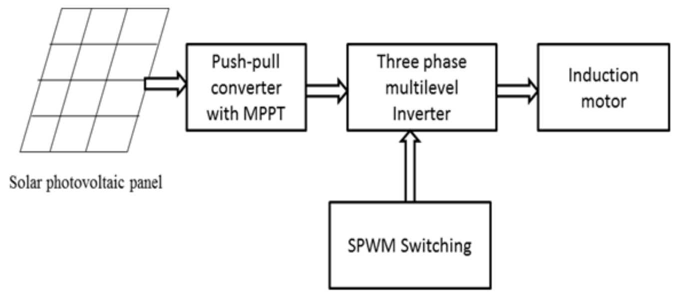

Figure.1: Block diagram of proposed system

The solar intensity and the panel temperature have major impacts on the characteristics of the photovoltaic cells operation. The power supplied by the solar panel is indeed directly proportional to the solar's intensity but any variation in solar intensity has impacts very less effect on the PV panel voltage. The output voltage of the panel is impacted by the temperature of the panel. The output voltage is inversely proportional to the panel temperature. To understand the behavior of the solar panel several mathematical models have been established.. In this paper the output voltage obtained from the panel is 30 V and that is fed to the converter as an input. The graph of voltage Vs current at 25 degree Celsius is as shown in the Fig.2 and the graph of Voltage Vs Power at 25 degree Celsius is as shown in the Fig.3.

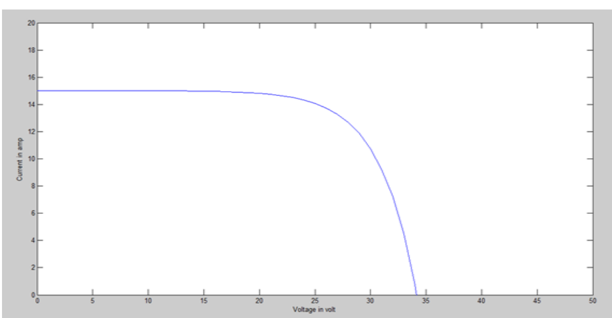

Figure.2: V-I characteristics of the solar panel at 25^{0}C

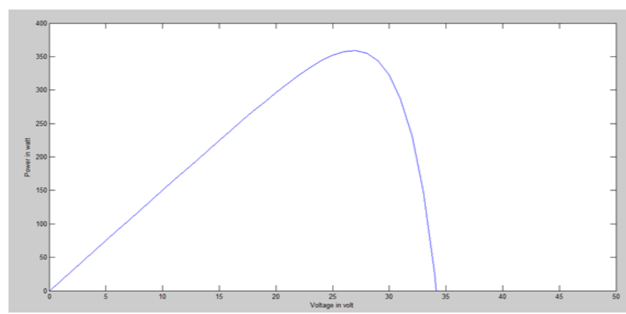

Figure.3: P-V characteristics of the solar panel at 25^{0}C

Maximum Power Point Tracking Technique (MPPT): The solar based Photovoltaic modules work over a wide range of voltages, Electrical circuits are intended to introduce burdens on the PV cells and afterward convert the voltage, flow, or recurrence to suit different gadgets or framework, and MPPT sorts out the issue of selecting the optimal burden that can be introduced to the photovoltaic panels so as to obtain the most appropriate yield. The Maximum Power Point characteristics are as shown in Fig.4. The algorithm of MPPT technique includes V-I parameters as well as power calculation. The flowchart is shown in Figure.5.

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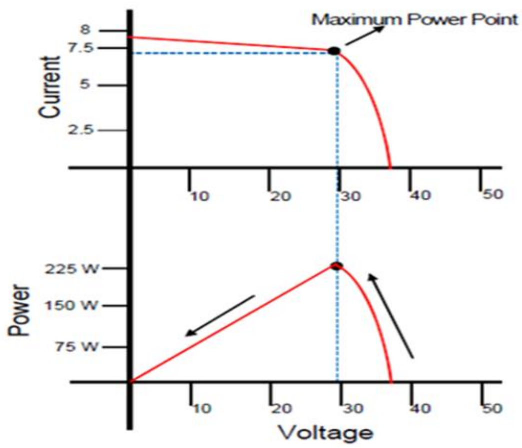

Figure.4: MPPT Characteristics of the solar module

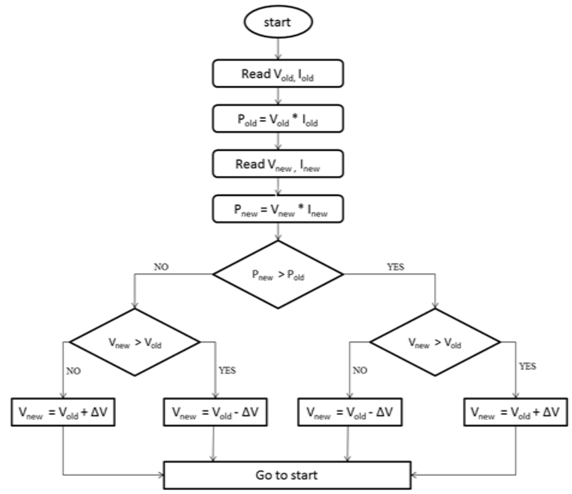

Figure.5: Flow chart of MPPT, P&O method

To achieve Maximum Power Point Tracking Technique of the PV board, the DC to DC push-pull converter is adopted and depicted effortlessly of comprehension. Switch mode DC-DC converters are liable for the transformation of the un-controlled DC gracefully voltage to managed DC effectively. The force thickness and effectiveness of exchanging mode power gracefully is more contrasted with consecutive force flexibly. The transformer turns proportion is 3:22. The converter's V_{in} voltage is same as the Photovoltaic exhibit voltage with MPPT. 'D' is the output voltage of push-pull converter (E) depends on the turn's ratio of frequency of the transformer (n), the supply voltage (v) and the duty cycle (D). The output voltage (E) is related to n, V and D as below,

$$E = \frac{n}{1-D} V \ldots\ldots (1)$$

$$D = \frac{ton}{T} \ldots\ldots\ldots (2)$$

Where,

T_{ON} = Total time interval when both switch conduct.

T – Time interval

Thus, by utilizing the design and implementing this design of DC-DC push-pull converter, a persistent satisfactory result is established that successfully steps-up PV arrays 30V to 220V DC in case of balanced condition of environment. The proposed paper deals with analysis of 3-ɸ five level inverter. The desired output voltage is obtained by MLI from isolated dc source connected to each H-bridge [7]. Sources are batteries and renewable energy sources such as fuel cells and Photovoltaic cells. Number of H-bridge inverter increases with the increase of level. Number of H-bridge inverters to be used for m level is given by (m-1)/2. The 1-Φ 5 levels CHB is shown in Fig.6.

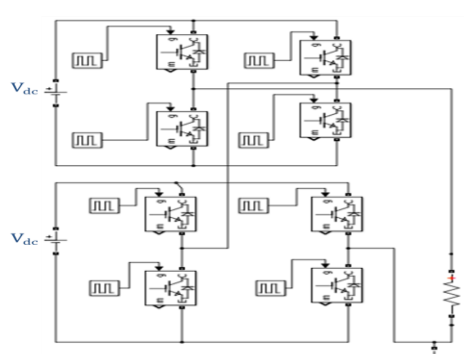

Figure.6:1-Φ 5-level CHB inverter with R load

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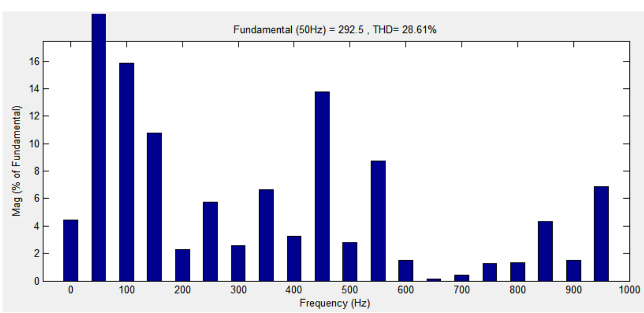
Five levels CHB inverter consists of two H-bridge inverters and require 8 switches. Each H-bridge requires a separate DC source and hence the number of dc sources is same as the number of H-bridge inverters. Each switch operates in the right sequence to obtain stepped output voltage. Switching sequence for 1-Φ 5-level CHB MLI is shown in Table.1.

Table.1: Switching sequence for 1-Φ 5-level CHB MLI

	Q_1	Q_2	Q_3	Q_4	Q_5	Q_6	Q_7	Q_8
0 V_{dc}	0	0	0	0	0	0	0	0
1 V_{dc}	1	0	0	1	0	0	1	1
2 V_{dc}	1	0	0	1	1	0	0	1
1 V_{dc}	1	0	0	1	0	0	1	1
0 V_{dc}	0	0	0	0	0	0	0	0
-1 V_{dc}	0	1	1	0	0	0	1	1
-2 V_{dc}	0	1	1	0	0	1	1	0
-1 V_{dc}	0	1	1	0	0	0	1	1
0 V_{dc}	0	0	0	0	0	0	0	0

SPWM control strategy is adopted that minimizes THD voltage at the output. In multi carrier SPWM technique, modulating signal can be of sinusoidal signal and the carrier signal can be a triangular waveform. As the sinusoidal waveform intersects with the triangular waveform, triggering pulses are accelerated to activate the inverter. For 'm' level of MLI, (m-1) carrier signals are specified.

In multicarrier SPWM, each triangular wave of carrier signal is compared with modulating bipolar wave to access the similarities and differences between the two waves, if the switch concerned to triangular signal, is turned ON. SPWM is often used multilevel inverter control method. Modulating and carrier signal arrangement for the PD-PWM technique with m_a=1 is as shown in Figure.7 along with THD of PD-PWM which is about 28.61% [8].



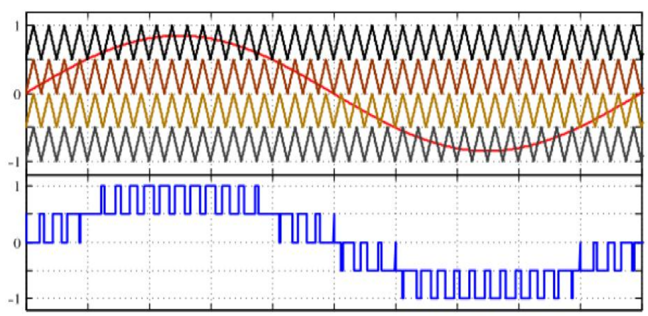


Figure.7:PD-PWM Scheme and THD

In the Alternate phase opposite disposition -PWM technique, the triangular carrier wave as phase shift of 180 degree from its contiguous carrier signal. Modulating and carrier signal arrangement for the above mentioned technique with ma =1is as shown in Figure.8 along with THD. To obtain 'm' level voltage output, (m-1) carriers are required, the peak to peak carrier amplitude VC = ± (m-1)/2 and peak to peak amplitude of the modulating signal VM = ± (m-1)/2, when ma=1. THD obtained in this method is about 21.87%[8].

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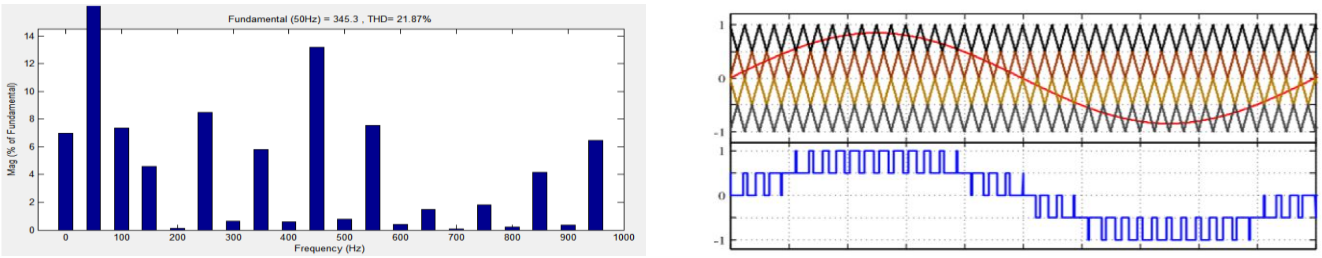


Figure.8: APOD-PWM Scheme and THD

Gapped alternate phase opposite disposition (GAPOD) method is similar in characteristic to APOD arrangement. To secure 'm' level voltage output where, (m-1) carriers are expected. The peak to peak carrier amplitude $V_C = \pm(m-1)$ and Vp-p of modulating signal $V_M = \pm(m-1)$, when ma=1. Carrier signal arrangement and modulating process of the GAPOD-PWM technique with m_a=1is represented as shown in the Figure.9 along with THD. The value of THD of this technique is comparatively very less and it is about 15.77%[8].

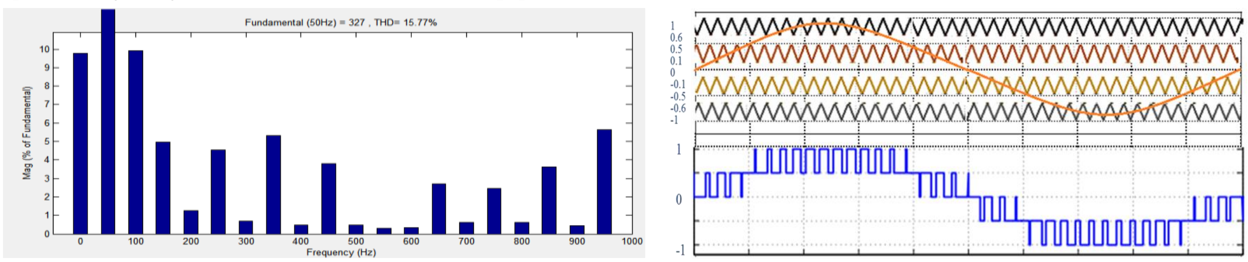


Figure.9: GAPOD-PWM Scheme and THD

3. SIMULATION CIRCUITS AND RESULTS

In the proposed paper, the PV panel is the only source to operate the 3-Φ Induction Motor (IM). In the simulation, the output of the Photovoltaic panel is 30V. And the PV panel output is fed to the push-pull converter. The MPPT techniqueis employed to obtain maximum power from the PV panel and the simulated circuit is shown in Fig.10.

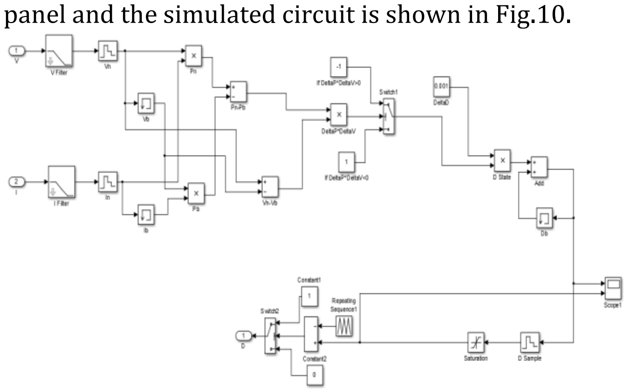


Figure.10: MPPT (P&O) technique developed in SIMULINK

The transformer turns ratio selected in this paper is 3:22; it is selected so as to maintain steady constant output voltage of the converter. The simulated DC-DC push-pull converter integrated with the PV panel and the corresponding is as shown in the Figure.11. Simulated output of the push-pull is 220V is shown in the Figure.12, which is an input to the multilevel inverter.

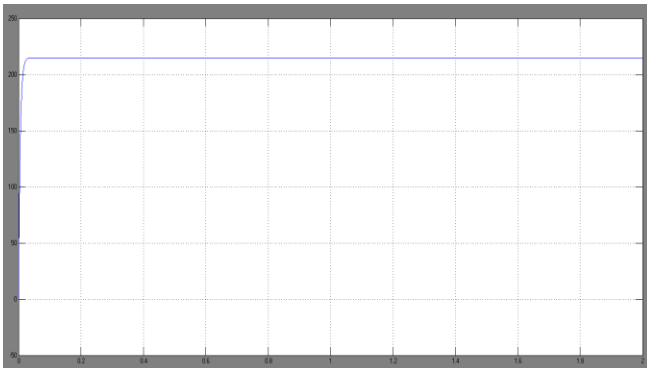


Figure.11:DC-DC push-pull converter

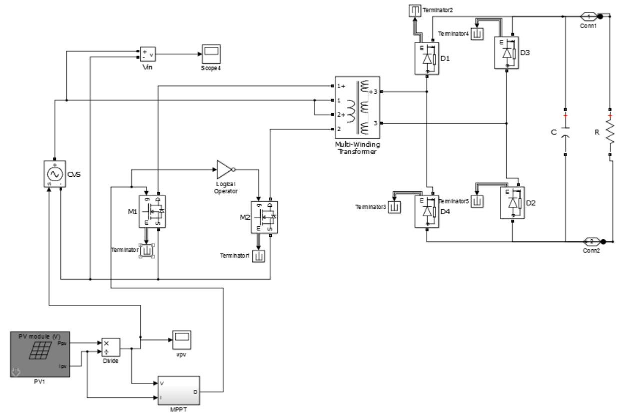


Figure.12:Output voltage of the push-pull converter

The 3-ɸ H bridge inverter with R load is shown in Fig.13, which is interface with the push-pull converter to drive the Induction Motor. For the 5 level inverter Two H Bridges will be connected in series. From the DC to DC push-pull converter, the output voltage is 220V. By using the multilevel inverter the DC voltage $2V_{dc}$ i.e., 440V is obtained at the inverter output which is used to drive the 3-Φ Induction Motor. The phase voltages of the cascaded H-bridge MLI is shown in the Figure.14

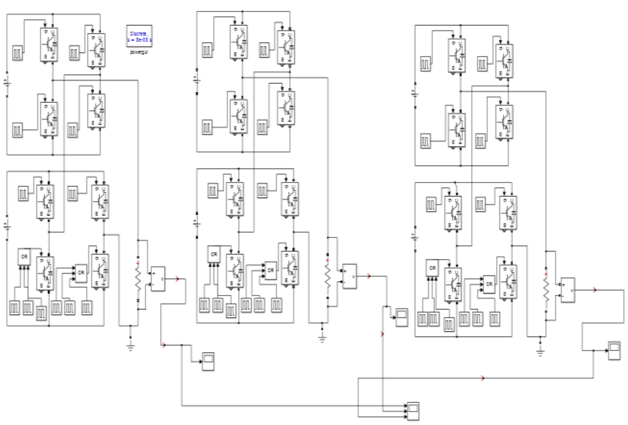


Figure.13: 3-ɸ H bridge MLI

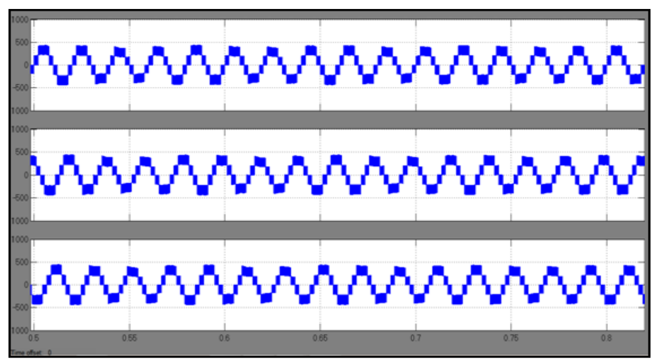
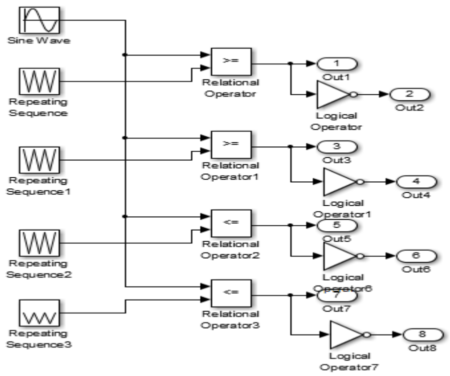


Figure.14: Phase voltages of 5 level inverter

The SPWM Switching for the multilevel inverter is developed in SIMULINK and shown in Figure.15. And also harmonic behavior of different types of Switching can analyze by observing the Waveforms as shown earlier. By controlling the Inverter Switching by using SPWM Technique Induction Motor speed can be controlled. The 5-level Multilevel Inverter with induction Motor is shown in Fig.16.



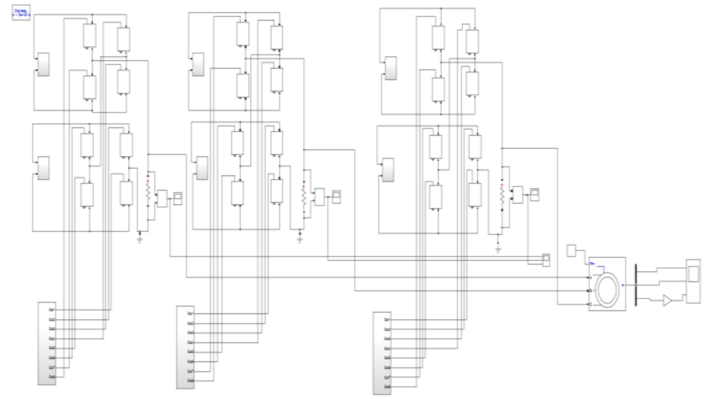


Figure.15: SPWM switching developed in SIMULINK Figure.16:5-level Multilevel Inverter with Induction Motor

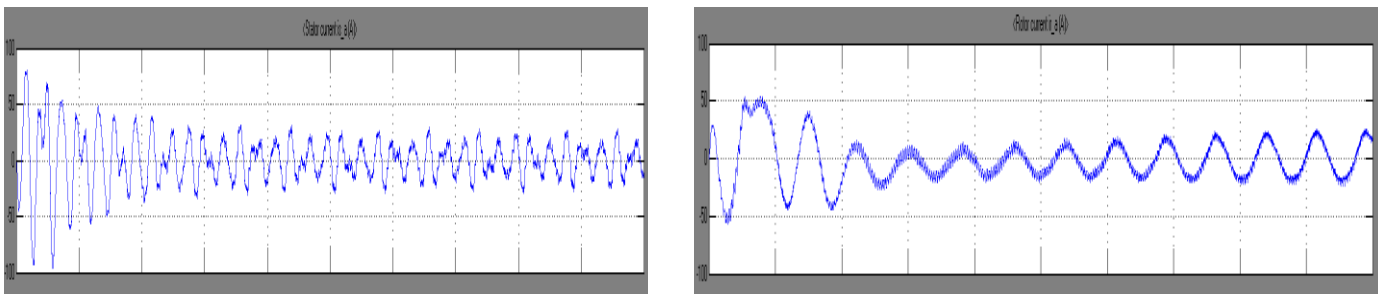


Figure.18: Waveforms of Stator and Rotor current of Induction Motor

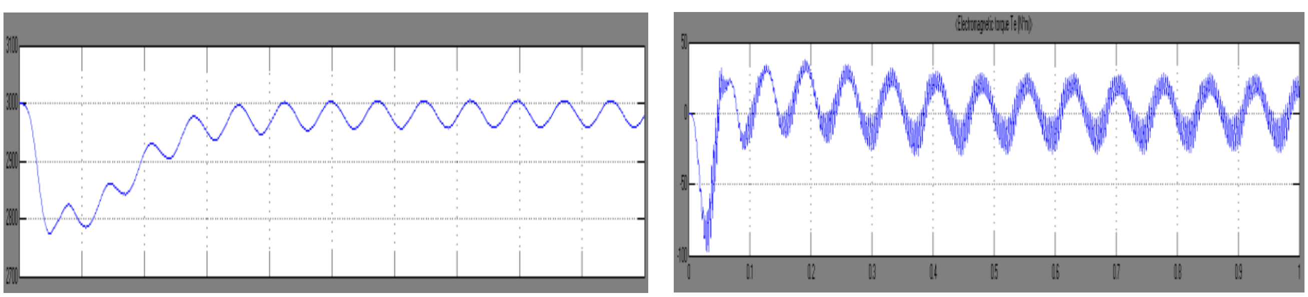


Figure.19: Speed and Torque of Induction Motor

4. CONCLUSION

The proposed paper mainly presents driving of Squirrel Cage Induction Motor by using single Photovoltaic panel. The Induction motor is effectively driven by the Photovoltaic panel. P&O method is widely used to extract maximum power from the panel because of its simplicity and easy for implementation. The power from the photovoltaic panel is extracted effectively by employing MPPT (P&O) Technique. By varying turn ratio of the Push-Pull converter transformer to achieve additional voltage to reach larger voltage levels than single level boost converter topology could. By maintaining V/F ratio constant the speed of the induction motor is controlled in wide range through 3-Φ multilevel inverter (5-level) by using SPWM. The simulation results are obtained and analyzed successfully.

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