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Renewable Energy Source Applications in Multilevel Inverter Based Induction Motor Drive Using ANN

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Abstract: ***This paper presents optimized multilevel inverter topology is proposed for a four pole induction motor drive. The open-end winding scheme, the Induction Motor windings are fed from both sides with two two-level inverters (with half the dc-link voltage when compared with conventional NPC inverter) to get a three-level inverter topology. With this concept as the number of levels increases, the inverters have to be cascaded or a conventional multi-level inverters have to be used on both the sides of the Induction Motor winding. This topology has developed by using the advantage of two identical voltage profile winding coils per phase in a four pole induction motor drive using Ann. Further the DC source is replaced by a renewable resource such as solar panels, wind power etc. and DC voltage is obtained. Performance characteristics of three-phase asynchronous motor are analyzed with PV array connected. The method can be easily extended to a multilevel inverter. The proposed concept is verified by using Matlab/Simulink software and the corresponding results are presented.***

Keywords: Multilevel inverter, Induction motor, Sine triangle PWM, ANN.

1. Introduction

The voltage source inverters produce a voltage or a current with levels either 0 or ±V dc they are known as two level inverters. In high power and high voltage applications, these two level inverters, however, have some limitations in operating at high frequency mainly due to switching devices should be used in such a manner as to avoid problems associated with their series- parallel combinations that are necessary to obtain capability of handling high voltages and currents. It may be easier to produce a high power, high voltage inverter with the multi-level structure because of the way in which device voltage stresses are controlled in the structure. Cascaded H-bridge MLIs are mostly preferred for high power applications as the regulation of the DC bus is simple. But it requires separate dc sources and also the complexity of the structure is increases as the level predominantly increase. The other alternate topology is open end winding induction motor drive fed with two-level (or multi-level) inverters. Multilevel inverter technology has been widely used for the control of medium and high voltage AC drive applications from the past few decades because of its improved output voltage quality, better harmonic performance, less voltage stress on power electronic devices and etc. Many multilevel inverter configurations are presented to improve the output voltage harmonic spectrum and to reduce the circuit complexity and to reduce the number of switches. Many Pulse Width Modulation (PWM) techniques are proposed to improve the harmonic spectrum of the voltage and currents. In this paper a multilevel inverter topology is proposed for the induction motor drive by using four conventional two-level inverters only, with the advantage of two identical voltage profile winding coils of four pole induction motor. The identical voltage profile winding coils are disconnected and each part of the winding is fed with two two-level inverters from both sides. Thereby four two-level inverters are used to generate five voltage levels on motor phase windings. All two-level inverters are fed with single DC link with the magnitude $V_{DC}/4$. The proposed topology uses sine-triangle PWM to generate the pulses for the switches of each inverter which will also minimize the common mode currents circulating in the motor phase windings because of the common DC link.

2. Mathematical Model of the PV Array

2.1 Simplified Equivalent Circuit:

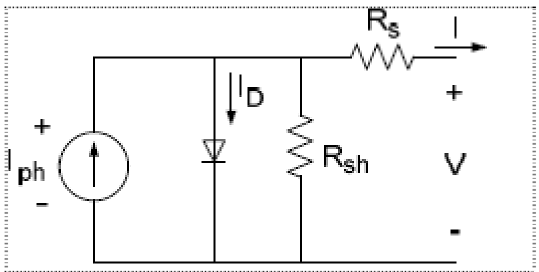


Figure 1: PV cell equivalent circuit

The complex physics of the PV cell can be represented by the equivalent electrical circuit. The circuit parameters are as follows. The current I at the output terminals is equal to the light-generated current I_L, less the diode current I_d and the shunt-leakage current I_{sh}. The series resistance R_s represents the internal resistance to the current flow, and depends on the pn junction depth, impurities, and contact resistance. The shunt resistance R_{sh} is inversely related to the leakage current to ground. In an ideal PV cell, $R_s = 0\Omega$ (no series loss), and $R_{sh} = \infty$(no leakage to ground). In a typical high-quality 1 in.2 silicon cell, Rs varies from 0.05 to 0.10 Ω□and R_{sh} from 200 to 300 Ω. The PV conversion efficiency is sensitive to small variations in Rs, but is insensitive to variations in R_{sh}. A small increase in Rs can decrease the PV output significantly. In the equivalent circuit, the current delivered to the external load equals the current I_L generated by the illumination, less the diode current Id and the shunt leakage current I_{sh}. The open-circuit voltage Voc of the cell is obtained when the load current is zero, i.e., when I = 0, and is given by the following:

$$V_{oc}=V+IR_{sh}$$

The shunt resistance (R_{sh}) is very large and the series resistance (Rs) is very small. Therefore, it is common to neglect these resistances in order to simplify the solar cell model. The resultant ideal voltage-current characteristic of a photovoltaic cell is given by the relation below and illustrated by the figure above.

$$I=I_{ph}-I_D$$

$$I=I_{ph}-I_0\left[\exp\left(\frac{q(V+R_sI)}{Ak_BT}\right)-1\right]-\frac{V+R_sI}{R_{sh}}$$

Where,
I_{ph} = photocurrent,
I_D = diode current,
I_0 = saturation current,
A = ideality factor,
q = electronic charge $1.6\text{x}10^{-9}$,
k_B = Boltzmann's gas constant ($1.38\text{x}10^{-23}$),
T = cell temperature,
R_s = series resistance,
R_{sh} = shunt resistance,
I = cell current,
V = cell voltage
The power output of a solar cell is given by

$$P_{PV} = V_{PV} * I_{PV}$$

Where,
I_{PV} = Output current of solar cell (A).
V_{PV} = Solar cell operating voltage (V).
P_{PV} =Output power of solar cell (W).
The power-voltage (P-V) characteristic of a photovoltaic module operating at a standard irradiance of 1000 W/m^2 and temperature of 25°C is shown below.

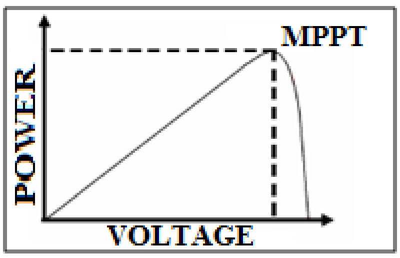


Figure 2: Power-Voltage (PV) Characteristic of a Photovoltaic Module.

3. Induction Motor

In recent years the control of high-performance induction motor drives for general industry applications and production automation has received widespread research interests. Induction machine modeling has continuously attracted the attention of researchers not only because such machines are made and used in largest numbers but also due to their varied modes of operation both under steady and dynamic states. Traditionally, DC motors were the work horses for the Adjustable Speed Drives (ASDs) due to their excellent speed and torque response. But, they have the inherent disadvantage of commutator and mechanical brushes, which undergo wear and tear with the passage of time. In most cases, AC motors are preferred to DC motors, in particular, an induction motor due to its low cost, low maintenance, lower weight, higher efficiency, improved ruggedness and reliability. All these features make the use of induction motors a mandatory in many areas of industrial applications. The advancement in Power electronics and semiconductor technology has triggered the development of high power and high speed semiconductor devices in order to achieve a smooth, continuous and low total harmonics distortion (THD). Three phase induction motors are commonly used in many industries and they have three phase stator and rotor windings. The stator windings are supplied with balanced three phase ac voltages, which produce induced voltages in the rotor windings due to transformer action. It is possible to arrange the distribution of stator windings so that there is an effect of multiple poles, producing several cycles of magneto motive force (mmf) around the air gap. This field establishes a spatially distributed sinusoidal flux density in the air gap. In this paper three phase induction motor as a load. The equivalent circuit for one phase of the rotor is shown in figure. Steady state Equivalent circuit of an induction motor

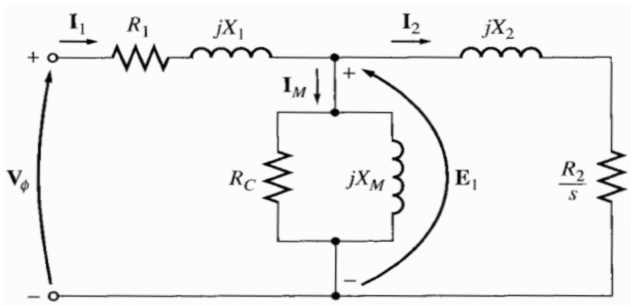


Figure 3: Equivalent circuit refer to stator

The rotor current is

$$Ir = sE_r/Rr + jX_r$$

4. Artificial Neural Network

Once a network has been structured for a particular application, that network is ready to be trained. To start this process the initial weights are chosen randomly. Then, the training, or learning, begins. There are two approaches to training – 'SUPERVISED' and 'UNSUPERVISED'. Supervised training involves a mechanism of providing the network with the desired output either by manually "grading" the network's performance or by providing the desired outputs with the inputs. Unsupervised training is where the network has to make sense of the inputs without outside help. The vast bulk of networks utilize supervised training. Unsupervised training is used to perform some initial Characterization on inputs.

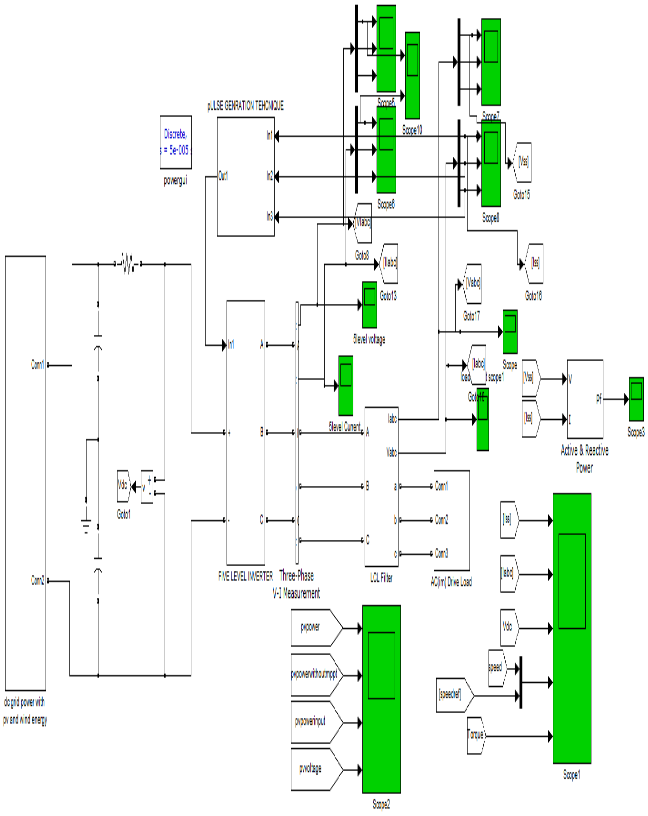
Training can also be classified on basis of how the training pairs are presented to the network. The Mat lab Programming Of ANN Training is as given Below:

```
net=newff(minmax(P),[7,21,3],
{„tansig‟,‟tansig‟,‟purelin‟},‟trainlm‟);
```

```
net.trainParam.show =50;
net.trainParam.lr = .05;
net.trainParam.mc = 0.95;
net.trainParam.lr_inc = 1.9;
net.trainParam.lr_dec = 0.15;
net.trainParam.epochs = 1000;
 net.trainParam.goal = 1e-6;
 [net,tr]=train(net,P,T);
a=sim(net,P);
 gensim(net,-1);
```

The compensator output depends on input and its evolution. The chosen configuration has seven inputs three each for reference load voltage and source current respectively, and one for output of error (PI) controller. The neural network trained for outputting fundamental reference currents. The signals thus obtained are compared in a hysteresis band current controller to give switching signals.

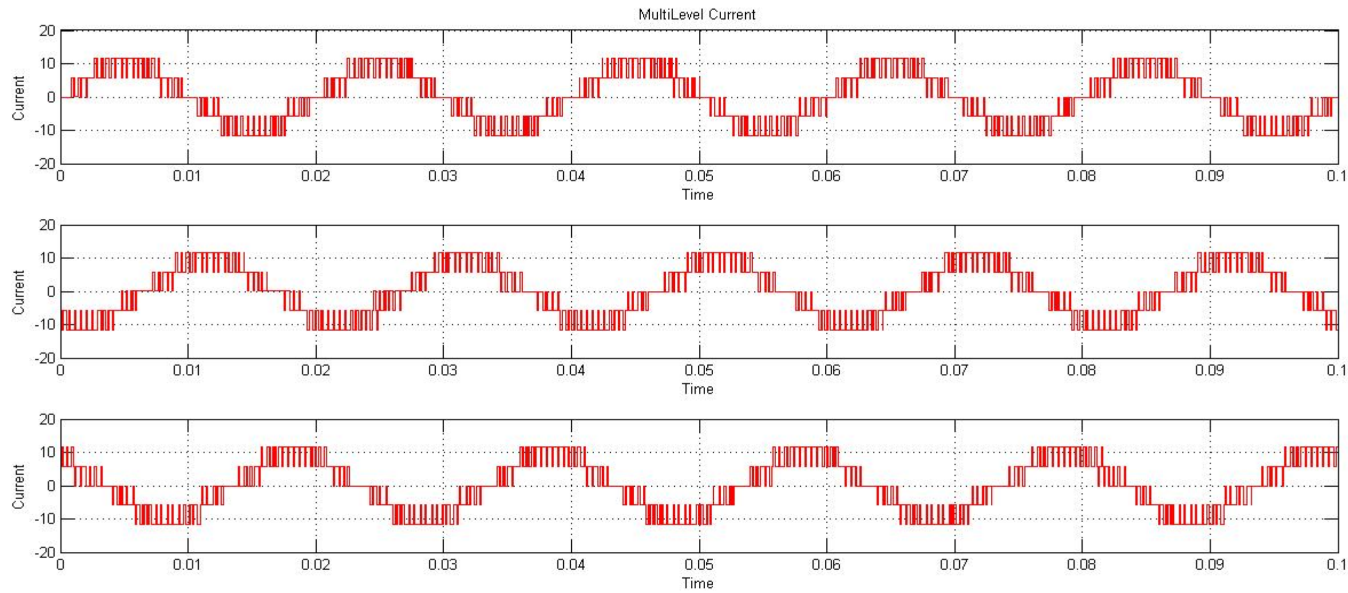
5. Simulation Results and Discussions



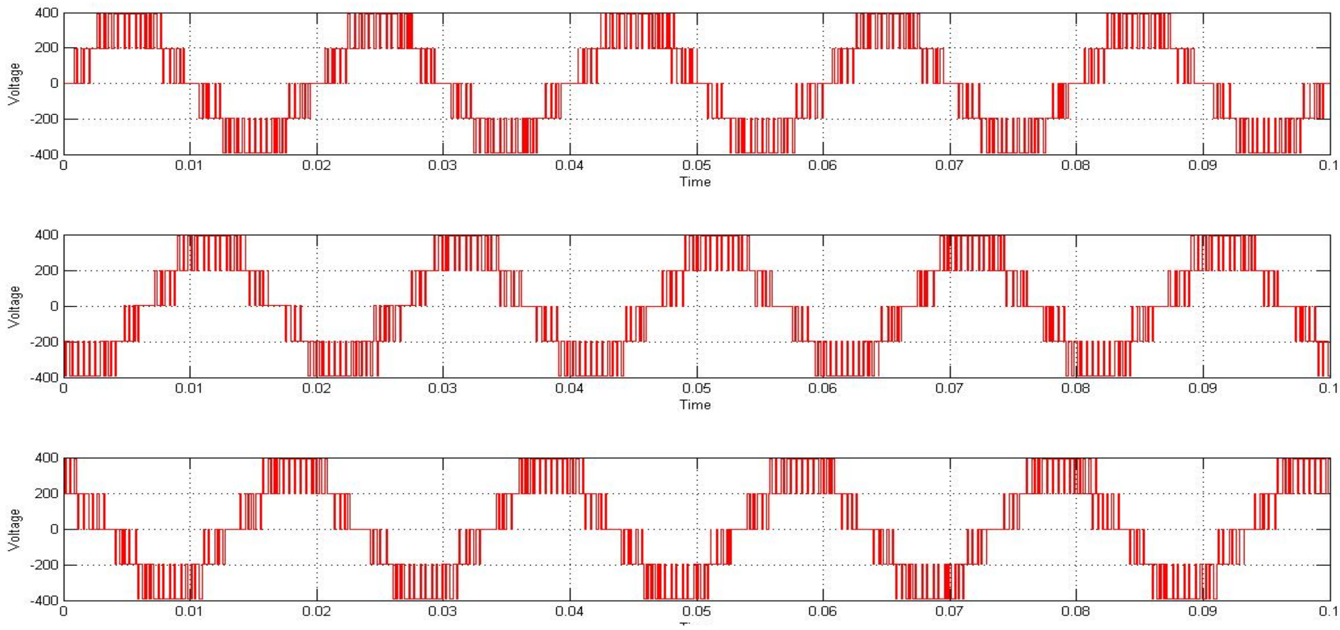
In This paper, the proposed model of multilevel inverter connected to a three phase source feeding dynamic motor loads is developed using Simulink of MATLAB software. Simulated results demonstrate that multi level inverter can be considered as a variable solution for solving such voltage stresses problems. This thesis work aims at developing a multilevel inverter for induction machines with voltage stress and improve the output voltage harmonic spectrum and to reduce the circuit complexity and to reduce the number of switches.

This paper deals with the design and implementation of a multilevel inverter based on three-phase induction motor (IM) under artificial neural network (ANN) technique in a MATLAB/Simulink. Circuit diagram as shown in above fig. This large voltage stress is encountered at the starting of induction motor However, the voltage stress is now within limits as the motor is already started and is drawing normal full rated current, shows the stator current, rotor current, load voltage, speed, torque with respect to time. The multi level inverter helps to reduces switching losses.

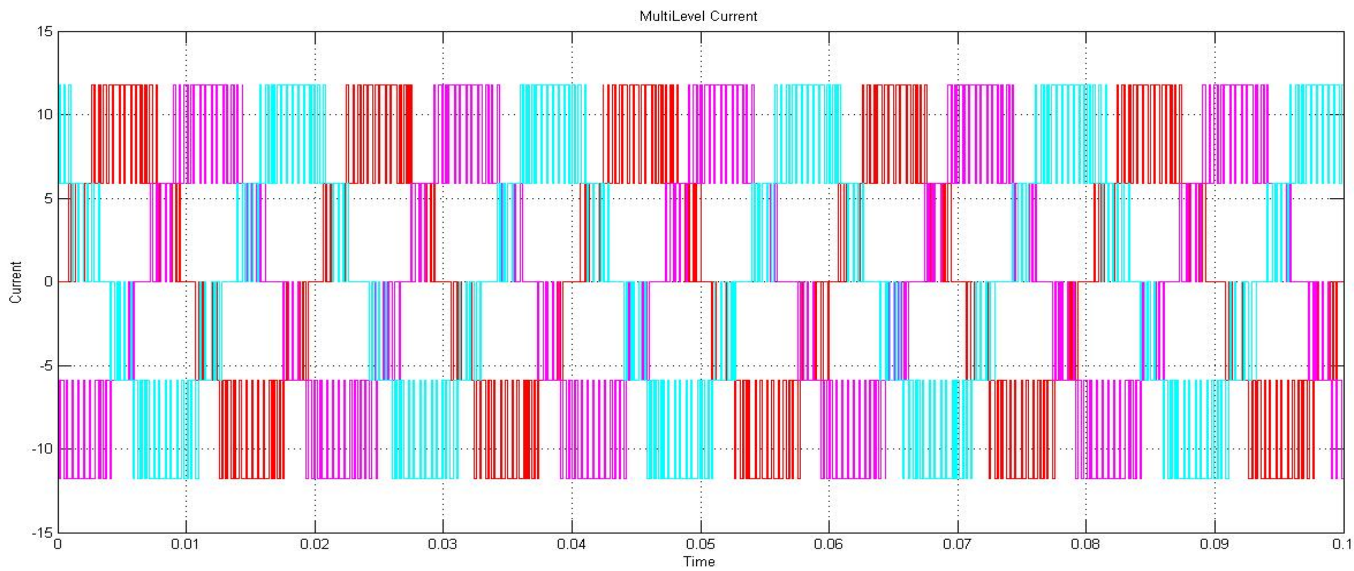
The waveform can be represented multilevel inverter outputs the switches operated in different levels. Waveforms are having switching modules



Multilevel Current



Multilevel Voltage



Three Phase Current

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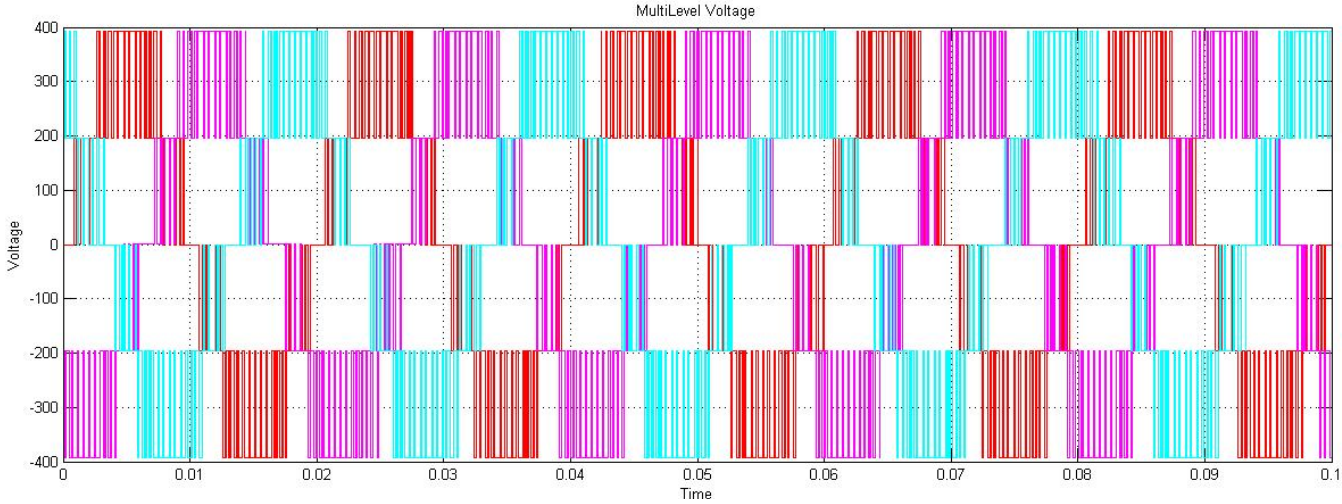
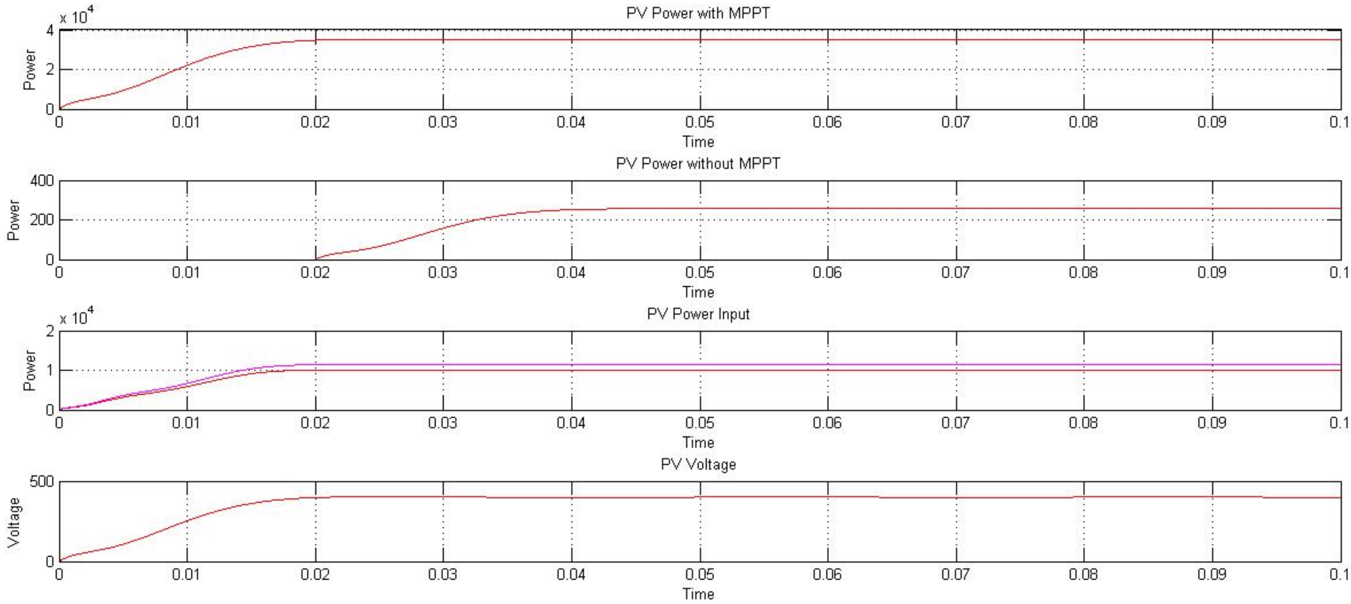


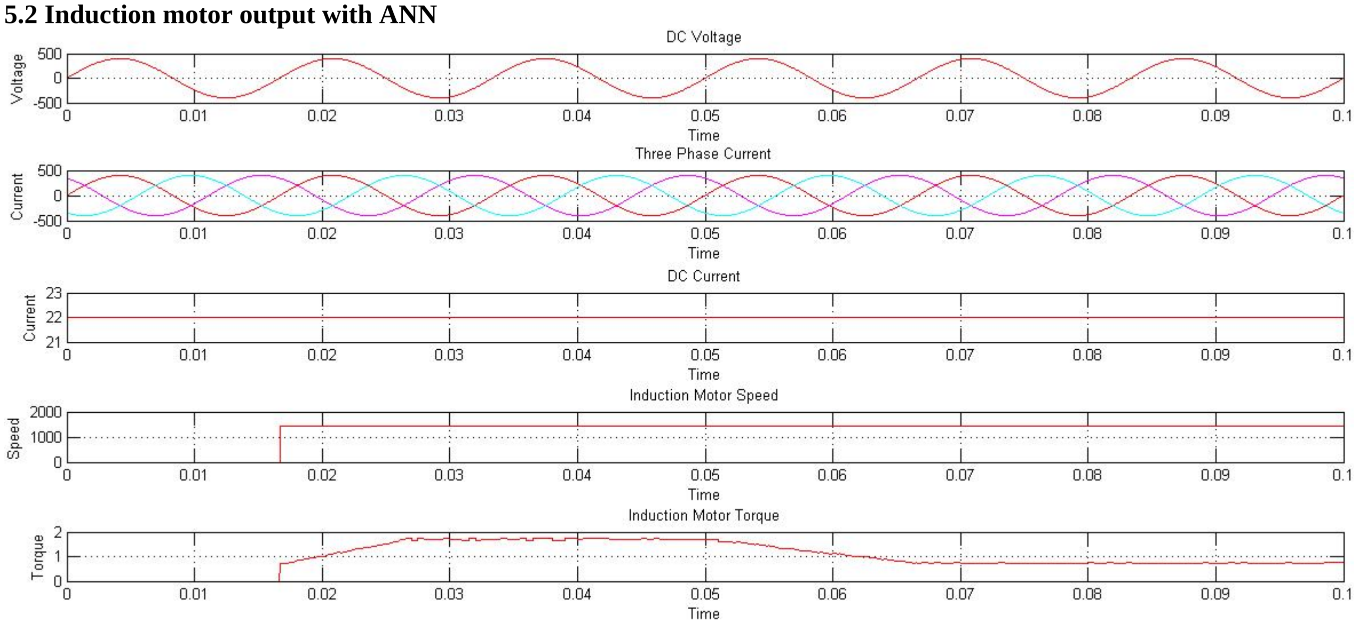
Three Phase voltage

5.1 PV cell input with ANN



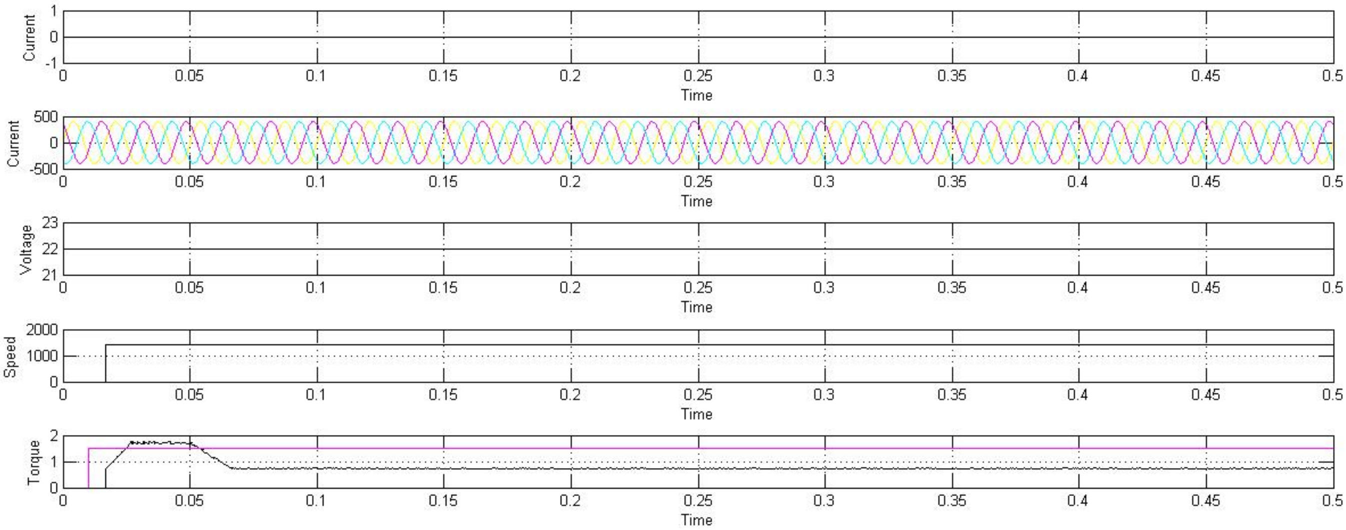
The above waveforms can be represents PV cell input powers with MPPT and without MPPT and Dc voltage. When in this we can use all non conventional energy sources for input of multilevel inverter.

5.2 Induction motor output with ANN



The above waveforms can be represents induction motor stator current, rotor current, load voltage, speed, torque. IM torque with ANN will be better compared to without ANN

5.3 Induction Motor output without ANN



The above waveforms can be represents induction motor stator current, rotor current, load voltage, speed, torque.

6. Conclusion

This paper presented an Three phase Multilevel cascade H-bridge Inverter, which uses single DC source and PV system as DC source and connected to three phase induction motor is used as load to observe the performance characteristics of the motor. The proposed Multilevel Inverter fed Induction Motor can reduce switching losses and circuit complexity. The method can be easily extended to an m-level inverter. The cascaded inverter is subjected to other modulation scheme. Simulations have been carried out in MATLAB–Simulink to study the performance of the proposed prototype.

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