Vector Controller based Speed Control of Induction Motor Drive with 3-Level SVPWM based Inverter

G. Subba Reddy

ABSTRACT: Vector control is becoming the industrial standard for induction motor control. The vector control technique decouples the two components of stator current space vector: one providing the control of flux and the other providing the control of torque. The two components are defined in the synchronously rotating reference frame. With the help of this control technique the induction motor can replace a separately excited dc motor. The DC motor needs time to time maintenance of commutator, brushes and brush holders. The main effort is to replace DC motor by an induction motor and merge the advantages of both the motors together into variable speed brushless motor drive and eliminate the associated problems. The squirrel cage induction motor being simple, rugged, and cheap and requiring less maintenance, has been widely used motor for fixed speed application. So with the implementation of vector control, induction motor replaces the separately excited dc motor. The vector control technique is therefore a better solution so that the control on flux and torque become independent from each other and the induction motor is transformed from a non-linear to linear control plant. With the advent of field oriented control; the induction motor has become an attractive option. In this report we will come to know the concept of vector control and different types of vector control techniques available. And finally we will be able to compare them.

Keywords : Induction Motor, SVPWM, Vectorl, 3-level Inverter.

1. INTRODUCTION

Now a day's more than 60% of all the electrical energy generated in the world is used by cage induction machines have been mostly used at fixed speed for more than a century. An induction motor (IM) is a type of asynchronous AC motor where power is supplied to the rotating device by means of electromagnetic induction On the other hand, D.C machines have been used for variable speed applications. Induction motors are widely used, especially polyphase induction motors, which are frequently used in industrial drives.

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In DC machines mmf axis is established at 90° electrical to the main field axis. The electromagnetic torque is proportional to the product of field flux and armature current. Field flux is proportional to the field current and is unaffected by the armature current because of orthogonal orientation between armature mmf and field mmf .Therefore in a separately excited DC machine , with a constant value of field flux the torque s directly proportional to the armature current. Hence direct control of armature current gives direct control of torque and fast response. Hence they are simple in control and offer better dynamic response inherently. Numerous economical reasons, for instance high initial cost, high maintenance cost for commutators, brushes and brush holders of DC motors call for a substitute which is capable of eliminating the persisting problems in dc motors. Freedom from regular maintenance and a brushless robust structure of the three phase squirrel cage induction motor are among the prime reasons, which brings it forward as a good substitute. The history of electrical motors goes back as far as 1820, when Hans Christian Oersted discovered the magnetic effect of an electric current. One year later, Michael Faraday discovered the electromagnetic rotation and built the first primitive D.C. motor. Faraday went on to discover electromagnetic induction in 1831, but it was not until 1883 that Tesla invented the A.C. asynchronous motor [1]. Currently, the main types of electric motors are still the same, DC, AC asynchronous and synchronous, all based on Oested, Faraday and Tesla's theories developed and discovered more than a hundred years ago.

An induction motor (IM) is a type of asynchronous AC motor where power is supplied to the rotating device by means of electromagnetic induction [2, 3]. Induction motors are widely used, especially polyphase induction motors, which are frequently used in industrial drives. These facts are due to the induction motors advantages over the rest of the motors. Most of the industrial motor applications use AC induction motors. The reasons for this include high robustness, reliability, low price and high efficiency [2-4].

1.1. APPLICATIONS

A wide variety of induction motors are available and are currently in use throughout a range of industrial applications. Single phase induction motors are widely used, due to their simplicity, strength and high performance. They are used in household appliances, such as refrigerators, air conditioners, hermetic compressors, washing machines, pumps, fans, as well as in some industrial applications. Before the days of power electronics, a limited speed control of IM was achieved by switching the three-stator windings from delta connection to star connection, allowing the voltage at the motor windings to be reduced [1-6].

1.2. VARIABLE-FREQUENCY DRIVES (VFD)

A VFD can easily start a motor at a lower frequency than the AC line, as well as a lower voltage, so that the motor starts with full rated torque and with no inrush of current. The rotor circuit's impedance increases with slip frequency, which is equal to supply frequency for a stationary rotor, so running at a lower frequency actually increases torque [7]. Industries have many applications, where variable operating speed is a prime requirement. Principal benefits of variable speed drives in industrial applications are that they allow the drive speed and torque to be adjusted to suit the process requirements. In many applications, operating the plant at a reduced speed when full output is not needed produces a further important benefit: energy savings and reduced cost [7]. Whereas infinitely variable speed drives with good performances for DC motors already existed. These drives not only permitted the operation in four quadrants but also covered a wide power range. Moreover, they had a good efficiency, and with a suitable control even a good dynamic response. Its main drawback was the compulsory requirement of brushes [4].

Scalar controllers: Despite the fact that "Voltage-Frequency" (V/F) is the simplest controller, it is the most widespread, being in the majority of the industrial applications [2]. It is known as a scalar control and acts by imposing a constant relation between voltage and frequency, so as to give nearly constant flux over wide range of speed variation [3]. More over Constant voltage/hertz control keeps the stator flux linkage constant in steady state without maintaining decoupling between the flux and torque [2]. However, this controller does not achieve a good accuracy in both speed and torque responses, mainly due to the fact that the stator flux and torque are not directly controlled. Even though, as long as the parameters are identified, the accuracy in the speed can be 2% (expect in a very low speed), and the dynamic response can be approximately around 50ms [2, 3].

2. INDUCTION MOTOR MATHMATICAL MODEL

The steady-state model and equivalent circuit are useful for studying the performance of machine in steady state. This implies that all electrical transients are neglected during load changes and stator frequency variations. The dynamic model of IM is derived by using a two-phase motor in direct and quadrature axes [16]. This approach is desirable because of the conceptual simplicity obtained with the two sets of the windings, one on the stator and the other on the rotor.

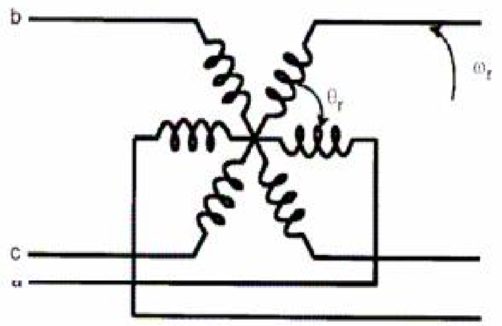
The equivalence between the three-phase and two-phase machine models is derived from the simple observation. The concept of power invariance is introduced [2, 3, 8]. The reference frames are chosen to arbitrary and particular cases such as stationary, rotor, and synchronous reference frames, are simple instances of the general case. The space-phasor model is derived from the dynamic model in direct and quadrature axes [16].

2.1 DYNAMIC d-q MODEL

The assumptions are made to derive the dynamic model as uniform air gap, balanced rotor and stator windings, with sinusoidal distributed mmf, inductance vs. rotor position in sinusoidal, and Saturation and parameter changes are neglected.

The dynamic performance of an AC machine is somewhat complex because the three-phase rotor windings move with respect to the three-phase stator windings as shown in Fig 1(a). Basically, it can be looked on as a transformer with a moving secondary, where the coupling coefficients between the stator and rotor phases change continuously with the change of rotor position θ_r correspond to rotor direct and quadrature axes [2-4, 7, 8]. Note that a three-phase machine can be represented by an equivalent two-phase machine as shown in Fig 1(b), where ds ~ qs correspond to stator direct and quadrature axes, and d r ~q r is corresponding to rotor.

Although it is somewhat simple, the problem of time-varying parameters still remains. R.H. Park, in the 1920s, proposed a new theory of electric machine analysis to solve this problem. Essentially, he transformed or referred, the stator variables to a synchronously rotating reference frame fixed in the rotor [17]. With such a transformation (called Park's transformation), he showed that all the time-varying inductances that occur due to an electric circuit in relative motion and electric circuits with varying magnetic reluctances can be eliminated [3,7]. Later, in the 1930s, H. C. Stanley showed that time- varying inductances in the voltage equations of an induction machine due to electric circuits in relative motion can be eliminated by transforming the rotor variables to variables associated with fictitious stationary windings. Later, G. Kron proposed a transformation of both stator and rotor variables to a synchronously rotating reference frame that moves with the rotating magnetic field. D. S. Brereton proposed a transformation of stator variables to a rotating reference frame that is fixed on the rotor. In fact, it was shown later by Krause and Thomas that time-varying inductances can be eliminated by referring the stator and rotor variables to a common reference frame which may rotate at any speed.



(a)

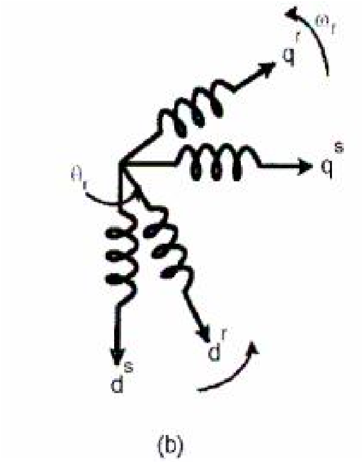


Fig 1: (a) Coupling effect in three-phase stator and rotor windings of motor; (b) Equivalent two-phase machine.

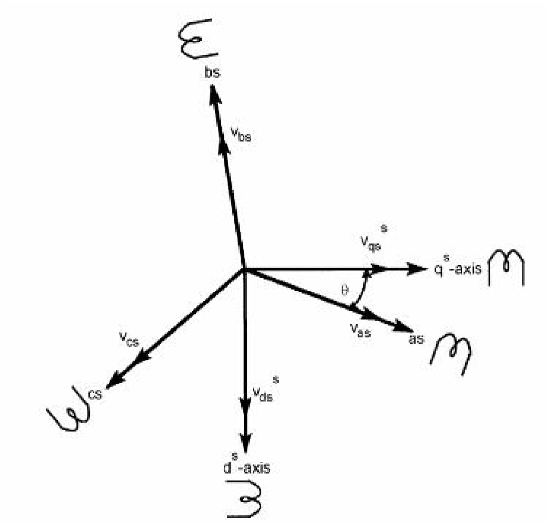


Fig 2. Stationary frame a~b~c to d^s~q^s axes transformation.

2.2. AXES TRANSFORMATION

Consider a symmetrical three-phase induction machine with stationary as-bs-cs axes at 2π/3-angle apart, as shown in Fig 2. Our goal is to transform the three-phase stationary reference frame (as-bs -cs) variables into two-phase stationary reference frame (ds~qs) variables and then transform these to synchronously rotating reference frame (de ~ qe), and vice-versa [3, 17]. Assume that the de– qe. Axes are oriented at θ angle, as shown in Fig 2. The voltages V_{ds}^s and V_{qs}^s can be resolved into as-bs-cs components and can be represented in the matrix form as

$$\begin{bmatrix} V_{as} \\ V_{bs} \\ V_{cs} \end{bmatrix} = \begin{bmatrix} \cos\theta & \sin\theta & 1 \\ \cos(\theta-120^0) & \sin(\theta-120^0) & 1 \\ \cos(\theta+120^0) & \sin(\theta+120^0) & 1 \end{bmatrix} \begin{bmatrix} V_{qs}^s \\ V_{ds}^s \\ V_{os}^s \end{bmatrix} \quad (1)$$

The corresponding inverse relation is.

$$\begin{bmatrix} V_{qs}^s \\ V_{ds}^s \\ V_{os}^s \end{bmatrix} = \frac{2}{3} \begin{bmatrix} \cos\theta & \cos(\theta-120^0) & \cos(\theta+120^0) \\ \sin\theta & \sin(\theta-120^0) & \sin(\theta+120^0) \\ 0.5 & 0.5 & 0.5 \end{bmatrix} \begin{bmatrix} V_{as} \\ V_{bs} \\ V_{cs} \end{bmatrix} \quad (2)$$

Where V_{os}^s is added as the zero sequence component, which may or may not be present. The current and flux linkages can be transformed by similar equations. It is convenient to set θ = 0, so that the qs axis is aligned with the as-axis, the transformation relations can be simplified by ignoring zero sequence. Fig 3 shows the synchronously rotating de- q e, which rotates at synchronous speed ω_e with respect to the ds-qs axes and the angle $\theta_e = \omega_e t.$ the two-phase de- qs windings are transformed into the hypothetical windings mounted on the de-qe axes [3]. The voltages on the ds-qs axes can be converted (or resolved) into the de-qe frame as follows:

$$V_{qs} = V_{qs}^s \cos\theta_e - V_{ds}^s \sin\theta_e \quad (3)$$

$$V_{ds} = V_{qs}^s \sin\theta_e + V_{ds}^s \cos\theta_e \quad (4)$$

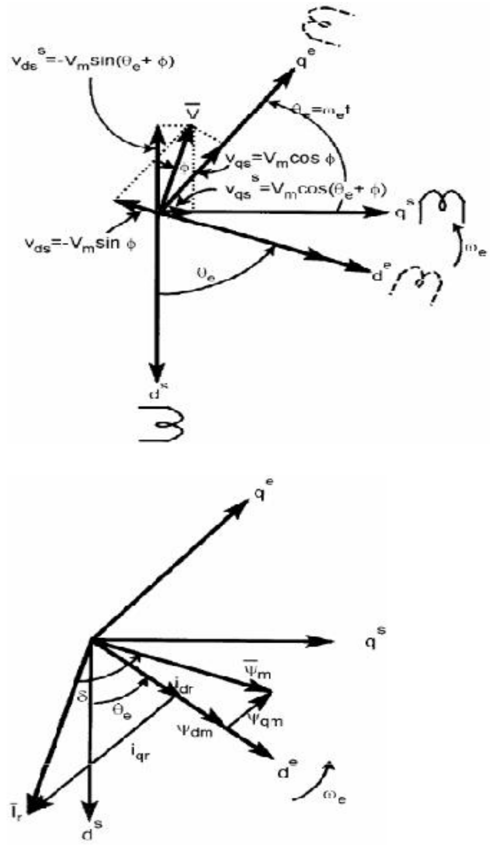


Fig.3: (a) Stationary frame d^s - q^s to rotating frame de - q^e ; (b) Flux and current vectors d^e - q^e.

For convenience, the superscript e has been dropped from now on from the synchronously rotating frame parameters. Again, resolving the rotating frame parameters into a stationary frame, the relations are.

$$V_{qs}^{s} = V_{qs} \cos\theta_e + V_{ds} \sin\theta_e \quad (5)$$

$$V_{ds}^{s} = -V_{qs} \sin\theta_e + V_{ds} \cos\theta_e \quad (6)$$

The qe -de components can also be combined into a vector form:

$$V_{qds}^{e} = V_{qs} - jV_{ds} = (V_{qs}^{s}\cos\theta_e - V_{ds}^{s}\sin\theta_e) - j(V_{qs}^{s}\sin\theta_e + V_{ds}^{s}\cos\theta_e)$$
$$= (V_{qs}^{s} - jV_{ds}^{s})e^{-j\theta_e} = \overline{V}e^{-j\theta_e}$$

(7)

Or inversely

$$\overline{V} = V_{qs}^{s} - jV_{ds}^{s} = (V_{qs} - jV_{ds})e^{+j\theta_e} \quad (8)$$

Note that the vector magnitudes in stationary and rotating frames are equal, that is,

$$\left|\overline{V}\right| = \hat{V}_m = \sqrt{V_{qs}^2 + V_{ds}^2} \quad (9)$$

In Equation (7), $e^{-j\theta_e}$ is defined as the inverse vector rotator that converts ds -qs variables into de - qe variables. The vector V and its components projected on rotating and stationary axes are shown in Fig 3. The as-bs-cs variables can also be expressed in vector form. And also:

$$\overline{V} = V_{qs}^{s} - jV_{ds}^{s}$$
$$= \left(\frac{2}{3}V_{as} - \frac{1}{3}V_{bs} - \frac{1}{3}V_{cs}\right) - j\left(-\frac{1}{\sqrt{3}}V_{bs} + \frac{1}{\sqrt{3}}V_{cs}\right)$$
$$= \frac{2}{3}\left[V_{as} + aV_{bs} + a^2V_{cs}\right] \quad (10)$$

Where a=e j 2∏ / 3. The parameters a and a^2 can be interpreted as unit vectors. Similar transformations can be made for rotor circuit variables also [3, 8, 17].

2.3. SYNCHRONOUSLY ROTATING REFERENCE FRAME - DYNAMIC MODEL.

For the two-phase machine shown in Fig 3, we need to represent both ds -qs and dr – qr circuits and their variables in a synchronously rotating de -qe frame. We can write the following stator circuit equations:

$$V_{qs}^{s} = R_s I_{qs}^{s} + \frac{d}{dt}\psi_{qs}^{s} \quad (11)$$

$$V_{ds}^{s} = R_s I_{ds}^{s} + \frac{d}{dt}\psi_{ds}^{s} \quad (12)$$

Where ψ_{qs}^{s} and ψ_{ds}^{s} are q- axis and d-axis stator flux linkages, respectively. When these equations are converted to de -qe frame, the following equations can be written:

$$V_{qs} = R_s I_{qs} + \frac{d}{dt}\psi_{qs} + \omega_e\psi_{ds} \quad (13)$$

$$V_{ds} = R_s I_{ds} + \frac{d}{dt}\psi_{ds} - \omega_e\psi_{qs} \quad (14)$$

If the rotor is not moving, that is, $\omega_r = 0$, the rotor equations for a doubly fed wound-rotor machine will be similar to Equations (13) - (14):

$$V_{qr} = R_r i_{qr} + \frac{d}{dt}\psi_{qr} + \omega_e\psi_{dr} \quad (15)$$

$$V_{dr} = R_r i_{dr} + \frac{d}{dt}\psi_{dr} - \omega_e\psi_{qr} \quad (16)$$

The rotor actually moves at speed ω_r , the d - q axes fixed on the rotor move at a speed $\omega_e - \omega_r$ relative to the synchronously rotating frame. Therefore, rotor equations should be modified as.

$$V_{qr} = R_r i_{qr} + \frac{d}{dt}\psi_{qr} + (\omega_e - \omega_r)\psi_{dr} \quad (17)$$

$$V_{dr} = R_r i_{dr} + \frac{d}{dt}\psi_{dr} - (\omega_e - \omega_r)\psi_{qr} \quad (18)$$

The de -qe dynamic model equivalent circuits that satisfy Equations (13), (14) and (17), (18). A special advantage of the de -qe dynamic model of the machine is that all the sinusoidal variables in stationary frame appear as dc quantities in synchronous frame. The flux linkage expressions in terms of the currents can be written from Fig 3(b) as follows:

$$\psi_{qs} = L_{ls}i_{qs} + L_m(i_{qs} + i_{qr}) \quad (19)$$

$$\psi_{qr} = L_{lr}i_{qr} + L_m(i_{qs} + i_{qr}) \quad (20)$$

$$\psi_{qm} = L_m(i_{qs} + i_{qr}) \quad (21)$$

$$\psi_{ds} = L_{ls}i_{ds} + L_m(i_{ds} + i_{dr}) \quad (22)$$

$$\psi_{dr} = L_{lr}i_{dr} + L_m(i_{ds} + i_{dr}) \quad (23)$$

$$\psi_{dm} = L_m(i_{ds} + i_{dr}) \quad (24)$$

Combining the above expressions with Equations (13), (14), (17) and (18), the electrical transient model in terms of voltages and currents can be given in matrix form as

$$\begin{bmatrix} V_{qs} \\ V_{ds} \\ V_{qr} \\ V_{dr} \end{bmatrix} = \begin{bmatrix} R_s + SL_s & \omega_e L_s & SL_m & \omega_e L_m \\ -\omega_e L_s & R_s + SL_s & -\omega_e L_m & SL_m \\ SL_m & (\omega_e - \omega_r) L_m & R_r + SL_r & (\omega_e - \omega_r) L_r \\ -(\omega_e - \omega_r) L_m & SL_m & -(\omega_e - \omega_r) L_r & R_r + SL_r \end{bmatrix} \begin{bmatrix} i_{qs} \\ i_{ds} \\ i_{qr} \\ i_{dr} \end{bmatrix}$$

(25).

Where S is Laplace operator. For a cage motor, Vrq=Vdr= 0. If the speed ω_r is considered constant. Then, knowing the inputs Vsq, Vsd and ω_e, the currents iqs, ids, iqr and idr can be solved from Equation (25). If the machine is fed by current source, iqs, ids and ω_e are independent. Then the dependent variables Vsq,Vsd, iqr and idr can be solved from Equation (25). The speed ω_r in Equation (25) cannot normally be treated as a constant. It can be related to the torques as

$$T_e = T_L + J\frac{d\omega_m}{dt} = T_L + \frac{2}{P}J\frac{d\omega_r}{dt} \tag{26}$$

Where TL = load torque, J = rotor inertia, and ω_m = mechanical speed. Often, for compact representation, the machine model and equivalent circuits are expressed in complex form [3]. Multiplying Equation (14) by –j and adding with Equation (13) gives.

$$V_{qs} - jV_{ds} = R_s(i_{qs} - ji_{ds}) + \frac{d}{dt}(\psi_{qs} - j\psi_{ds}) + j\omega_e(\psi_{qs} - j\psi_{ds}) \tag{27}$$

Or

$$V_{qds} = R_s i_{qds} + \frac{d}{dt}\psi_{qds} + j(\omega_e - \omega_r)\psi_{qds} \tag{28}$$

Similarly, the rotor equations (17)-(18) can be combined to represent

$$V_{qdr} = R_r i_{qdr} + \frac{d}{dt}\psi_{qdr} + j(\omega_e - \omega_r)\psi_{qdr} \tag{29}$$

Where Vqdr=0. Therefore, the steady-state equations can be derived as

$$V_s = R_s I_s + j\omega_e \psi_s \tag{30}$$

$$0 = \frac{R_r}{S} I_r + j\omega_e \psi_r \tag{31}$$

If the parameter Rm is neglected. We know that

$$T_e = \frac{3}{2}\left(\frac{P}{2}\right)\overline{\psi}_m \bar{I}_r \sin\delta \tag{32}$$

From Equation (32), the torque can be generally expressed in the vector form as

$$T_e = \frac{3}{2}\left(\frac{P}{2}\right)\overline{\psi}_m x \bar{I}_r \tag{33}$$

$$T_e = \frac{3}{2}\left(\frac{P}{2}\right)\psi_{dm} i_{qr} - \psi_{qm} I_{dr} \tag{34}$$

Some other torque expressions can be derived easily as follows:

$$T_e = \frac{3}{2}\left(\frac{P}{2}\right)\psi_{dm} i_{qs} - \psi_{qm} I_{ds} \tag{35}$$

$$T_e = \frac{3}{2}\left(\frac{P}{2}\right)\psi_{ds} i_{qs} - \psi_{qs} I_{ds} \tag{36}$$

$$T_e = \frac{3}{2}\left(\frac{P}{2}\right)L_m(i_{qs} i_{dr} - i_{ds} i_{qr}) \tag{37}$$

$$T_e = \frac{3}{2}\left(\frac{P}{2}\right)(\psi_{dr} i_{qr} - \psi_{qr} I_{dr}) \tag{38}$$

Equations (25), (26), and (37) give the complete model of the electro-mechanical dynamics of an IM in synchronous frame. Fig 4 shows the block diagram of the machine model along with input voltage & output current transformation [2, 8] and resolving variables into dqe components.

3. 3-LEVEL INVERTER

Three-level inverters have attracted the attention of researchers since their introduction by Nabae et al. [27] in 1981. Though simple and elegant, neutral-clamped circuit topology has a few disadvantages. Neutral point fluctuation is commonly encountered as the capacitors connected to DC-bus carry load currents. Also, there is ambiguity regarding the voltage rating of the semiconductor devices, which are connected to the neutral point. This calls for a conservative selection of devices for reliable operation, which, however, increases cost. H-bridge topology [28, 29] eliminates the problem of neutral fluctuation, but requires three isolated power supplies. Diode clamped inverter method alleviates the problem but does not eliminate it. Three-Ievel inversion may also be achieved with two 2-level inverters, driving an open-end winding induction motor from either end [5], [6]. The inverters in this case require isolated power supplies to eliminate the harmonic currents of the triple order in the individual motor phases.

While two level-shifted triangular carrier waves are generally employed to compare the modulating sine wave to generate PWM signals for a 3-level Inverter [28], one bipolar triangular carrier wave is sufficient for a 2-level inverter, As mentioned earlier, one of the important advantages of the proposed 3-level inverter is that it can be operated as a 2-level inverter in the lower output voltage range. This is accomplished by comparing the modulating sine wave with only one triangular carrier wave for the generation of PWM signals in the lower output voltage range and with two triangular carrier waves in the higher output voltage range. To get a clear picture to facilitate the explanation of the proposed SPWM strategy, the frequency of the triangular carrier wave was chosen to be only 11 times that of the frequency of the modulating sine wave. Also, to simplify the illustration of the concept of the proposed SPWM strategy, it is assumed that the frequency of the modulating sine wave is constant. But, in reality, it is varied by the speed controller as in V/f control or the vector control. Also, the frequency of the triangular carrier wave will be significantly higher in practice.

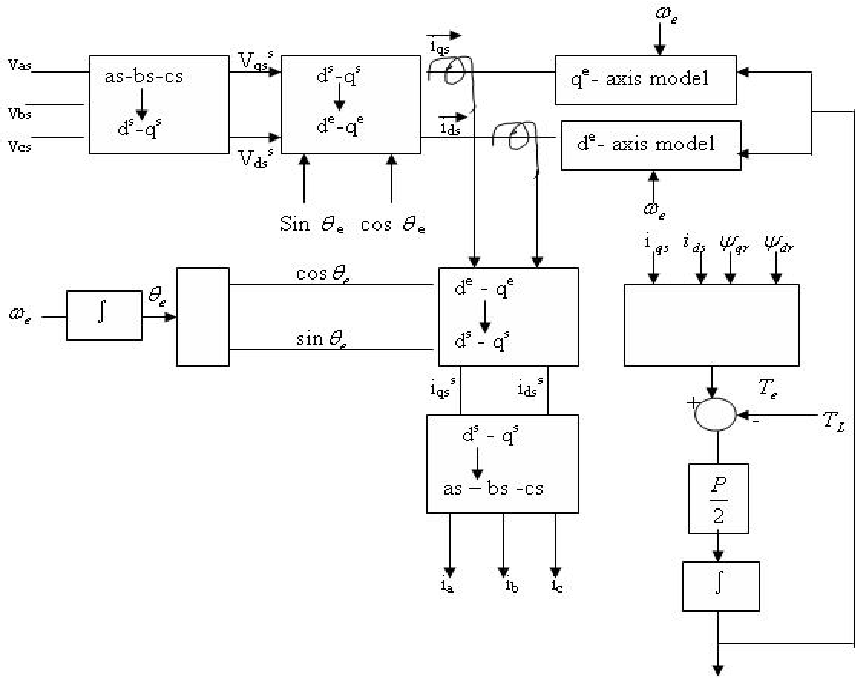


Fig 4. Synchronously rotating frame machine models with input voltage and output current transformations.

In this paper, a sine-triangle PWM scheme is also proposed for the inverter scheme. The scheme does not require look-up tables to realize the switching sequences as in the case of space vector modulation. Also, the switching criterion that there should be only one switching of the power devices of the constituent inverters during the subinterval of the sampling time period is automatically ensured in the sine-triangle PWM scheme [29]. The salient features of the proposed scheme are

(i) A new 3-level voltage source inverter, obtained by cascading two 2-level inverters, is proposed in this paper. The DC link capacitors of individual inverters carry only the ripple currents and not the load current. Hence the voltage fluctuations of the neutral point are avoided in the proposed scheme. However, three switches in the proposed scheme must be rated to block the entire DC bus voltage. .In the lower range of output voltage, 2-level inversion can be achieved by switching only one inverter and therefore the switching losses are lower when compared to a conventional 3-level inverter.

(ii) A modified sine-triangle-based PWM is also presented in this paper. The scheme is capable of ensuring a smooth changeover from 2- to 3-level inversion mode and vice versa.

(iii) Simulation results indicate that the proposed inverter scheme is capable of rendering good performance in closed loop applications also.

(iv) This scheme may be extended to higher number of levels also.

This Application Note reviews three level inverter topology, often referred to as Neutral Point Clamped (NPC) inverter. The three level inverter offers several advantages over the more common two level inverter. As compared to two level inverters, three level inverters have smaller output voltage steps that mitigate motor issues due to long power cables between the inverter and the motor. These issues include surge voltages and rate of voltage rise at the motor terminals and motor shaft bearing currents. In addition, the cleaner output waveform provides an effective switching frequency twice that of the actual switching frequency. Should an output filter be required, the components will be smaller and less costly than for an equivalent rated two level inverter. Most often the NPC inverter is used for higher voltage inverters. Because the IGBTs are only subjected to half of the bus voltage, lower voltage IGBT modules can be used. Moreover, SVPWM of three level is different from 2 level. Fig. 5 shows the SVM strategy for two level inverter, in this method 6 active pulses are generated for 6 switches in 2-level inverter. The detailed block diagram of SVM method for 2 level inverter is shown in Fig. 6(a) and (b). here delta terms represents the change in corresponding parameter.

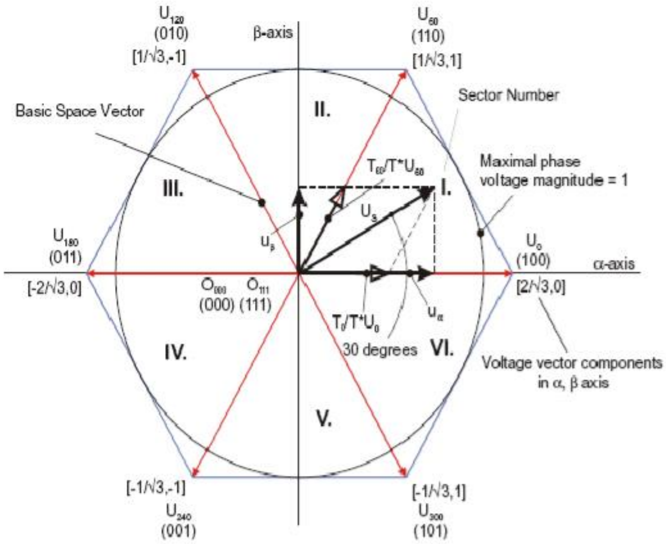


Fig. 5: SVM and different possible switching voltage vectors

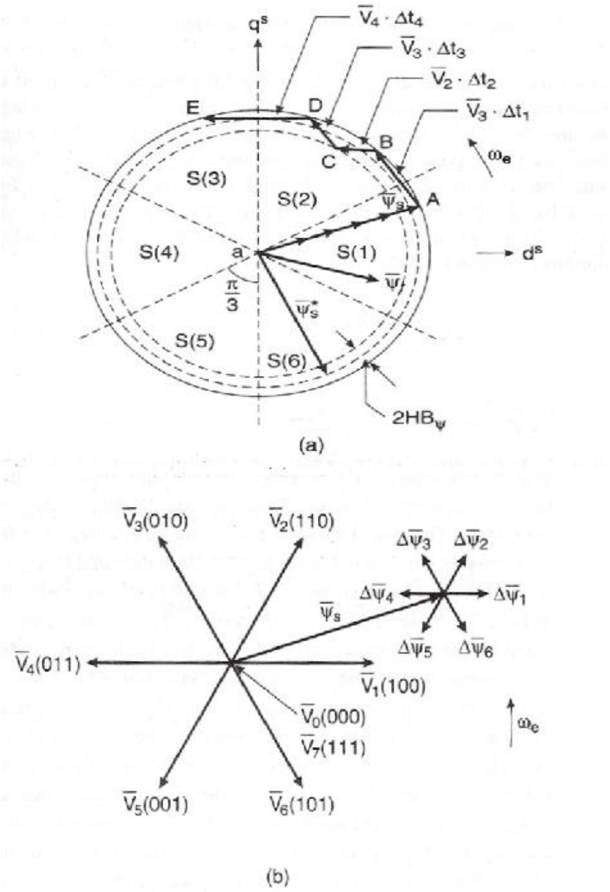
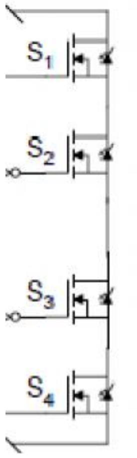


Fig 6: In principle the DTC method selects one of the six nonzero and two zero voltage

The 3-level inverter diagram (1-leg) is shown in Fig. 7. The corresponding switching vectors are shown in Fig. 8. Here 24 non-zero (active) vectors are present and 3-zero vector or null vectors are present.



	PWM Input		Switching Device			
	A	$\overline{A}$	S_1	S_2	S_3	S_4
Logic State	1	0	1	1	0	0
	0	0	0	1	1	0
	0	1	0	0	1	1

Fig. 7: 1-leg of 3-level inverter and corresponding switching patteren.

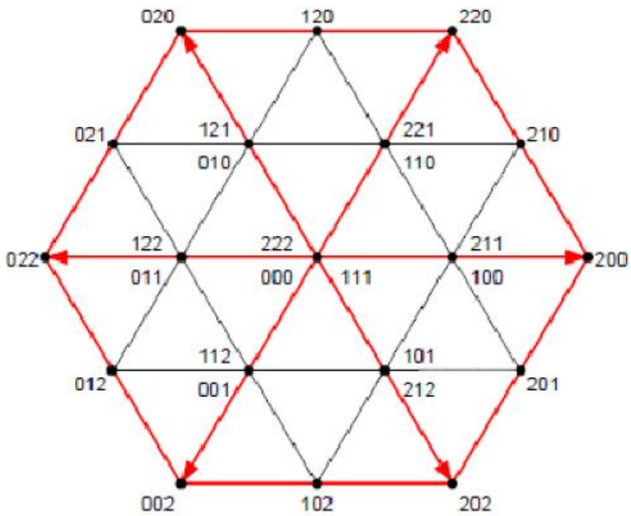


Fig 8: Inverter voltage vectors and corresponding stator flux variation in time Δt.

The digital simulation is performed using mat lab version 7.6/simulink software environment. The basic building block of the 3-phase A. C. Induction motor vector control is implemented using MATLAB / simulink software. The control process is based on a DC coupled voltage controlled strategy using both direct and quadrate current components of the induction motor. Pulses are also produces using currents. The speed is varying with currents. So we use references currents, those are produces by SVM technique. These references currents are club with main currents and produce six none zero pulse currents. These pulses are fed to IGBT based 3-phase inverter. This IGBT based inverter out puts are ac voltages (but not a sinusoidal. Because filters are not use in this model).

4. RESULTS

The performance of the designed induction motor drive is evaluated by using the Matlab / Simulink In this section, simulation results are presented, and the Matlab block diagram of the proposed drive system is shown in Fig. 9 and the parameters of induction motor as shown in Tab. 1.

Caes-1: Change in load torque:

In this case, the load on the motor is changed from 1 Nm to 4 Nm at t=1sec. due to proposed control, there is no change in speed. It seems that the drive can operate at constant speed at different values of load torque. The corresponding torque generated by motor (electromagnetic torque), dc-link voltage and speed of induction motor are shown in Fig. 10 (a), (b) and (c) respectively.

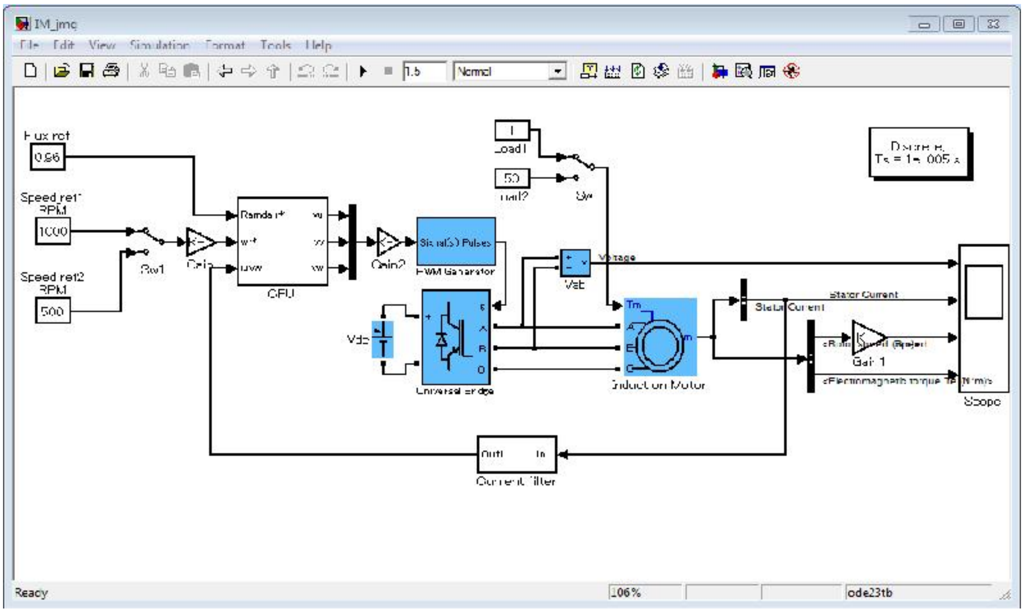


Fig. 9: Matlab block diagram of proposed model.

Parameters of Induction Motor:

Parameter	Value
Stator Resistance (Rs)	7.83 Ω
Rotor Resistance(Rr)	7.55 Ω
Stator Inductance (Ls)	0.4751 H
Rotor Inductance (Lr)	0.4751 H
Mutual Inductance (M)	0.4535 H
Number of poles (p)	4
Inertia (J)	0.07
Friction (B)	0.001
DC Link Voltage (V_{dc})	310V

Table:1 parameters of induction motor.

Case-2: changing in reference speed.

In this case, reducing the reference speed of induction motor from 157 to 130 rps at t=3 sec. in this case, up to t=3 sec. drive is operated at 130 rps speed and after t=3 sec. controllers reduce the speed of induction motor to 130 rps. The corresponding speed, dc link voltage and stator currents are showing in Fig. 11 (a), (b) and (c) respectively. According to currents, it seems that motor is operating at constant load at before and after t=3 sec.

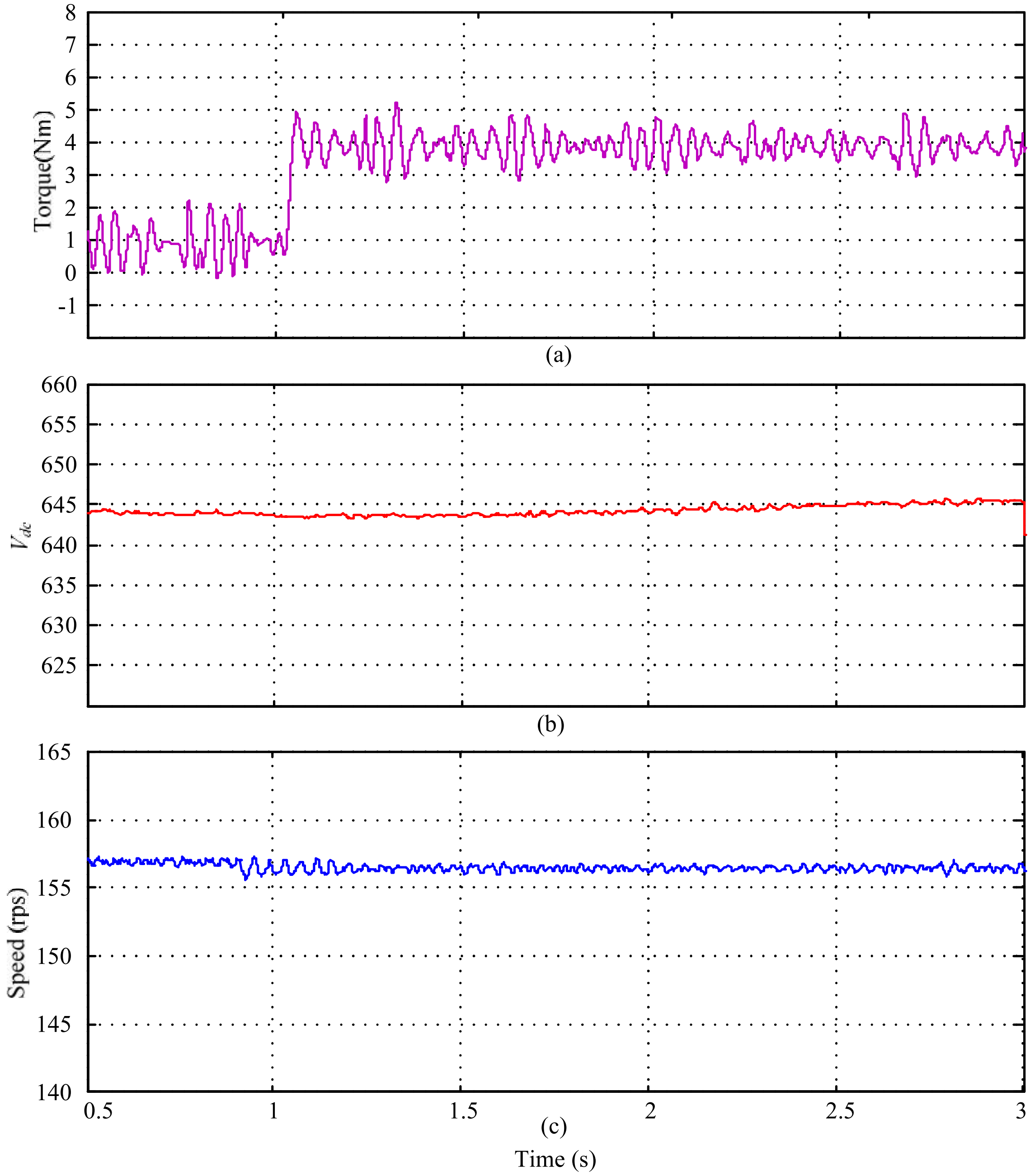


Fig. 10: (a) Electromagnetic torque, (b) dc-link voltage, (c) Speed of induction motor.

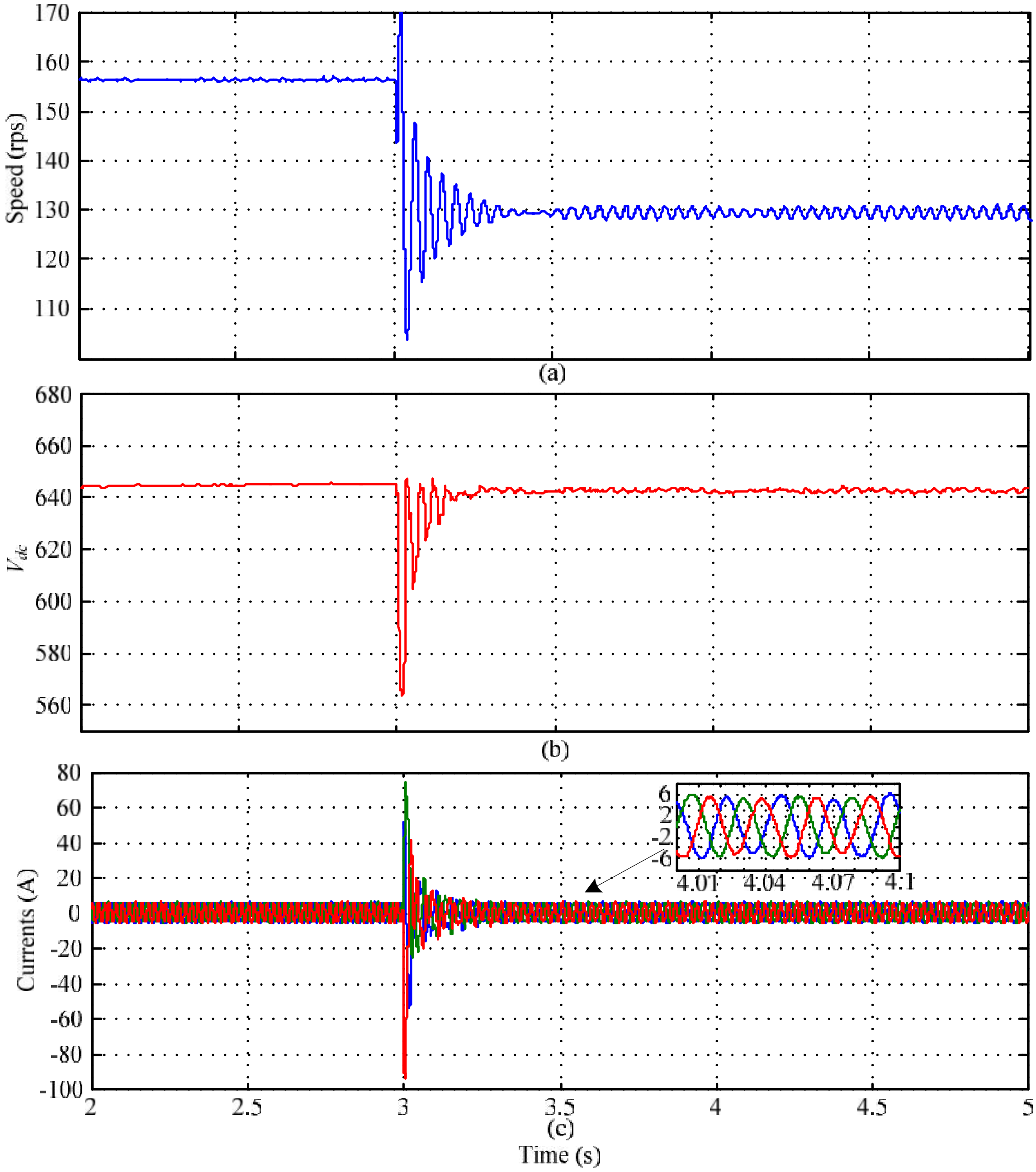


Fig. 11: (a) Speed of induction motor, (b) dc link voltage, (c) stator currents.

5. CONCLUSION

This paper presented Space vector pulse width modulation based 3 level inverter for vector controller based induction motor drive. The main advantage in this proposed method is incorporated vector control based induction motor control with multi level inverter. So that the advantages in 3-level with SVPWM as increased the performance and life time of drive. Extensive simulation results are presented with different case studies. These advantages allow implementing controllers for electric vehicles; because, mainly electric vehicles need high starting torque so this is produce the required torque with minimum torque ripples and in electric vehicles, operation of drive is depends on variable torque with constant speed applications as well as variable speed with constant torque application. These two types of application we are discussed in case-1 and case-2.

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