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Speed Control of Three Phase Induction Motor using Space Vector PWM Method

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ABSTRACT: This method is used to control the speed of the induction motor .The speed control by this method is simple and can be made economical by using different methods to control the operation of cycloconverter which in turn controls the performance of motor. In this method the frequency changing device ,with change in voltage is cycloconverter. A cycloconverter is a power electronic device used to convert constant voltage constant Frequency AC power to adjustable voltage adjustable frequency AC power without a DC link. In among all the methods this method is simple, reliable and economical. The various speed of induction motor is obtained by volt hertz method.

KEYWORDS: Space Vector, Pulse Width Modulation, V/f, Three Phase Induction Motor.

I.INTRODUCTION

In such a developing era there are large numbers of variable speed three phase induction motor drives. These drives are used to serve the various industrial expectations esaly, efficiently and economically. There is various methods of speed control of induction motor but in this paper we have used constant V/f method. If only frequency is changed and stator voltage kept constant, the stator flux will not be at its rated value. The operation with flux above or below the rated value is not desirable. For constant flux operation it is necessary that the induced emf increases or decreases linearly with applied frequency. At higher voltage and higher frequency operation stator drops are very small and thus constant flux operation obtained by keeping V/f ratio constant. The relation between voltage and frequency is shown in fallowing fig.

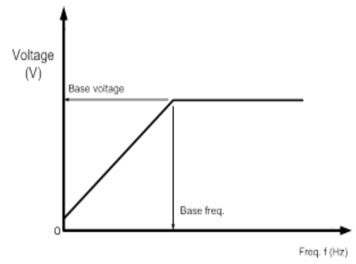

Fig. 1. voltage and frequency variation

The variable voltage and variable frequency can be obtained from pulse width modulation method. In this paper we have discussed about the SVPWM method.

Space vector PWM refers to a special switching scheme of the six power semiconductor switches of a three phase power converter. Space vector PWM (SVPWM) has become a popular PWM technique for three-phase voltage-source inverters in applications such as control of induction and permanent magnet synchronous motors. The mentioned drawbacks of the sinusoidal PWM and hysteresis-band current control are reduced using this technique. Instead of using a separate modulator for each of the three phases (as in the previous techniques), the complex reference voltage vector s processed as a whole. Therefore, the interaction between the three motor phases is considered. It has been shown, that SVPWM generates less harmonic distortion in both output voltage and current applied to the phases of an ac motor and provides a more efficient use of the supply voltage in comparison with sinusoidal modulation techniques.

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SVPWM provides a constant switching frequency and therefore the switching frequency can be adjusted easily. Although SVPWM is more complicated than sinusoidal PWM and hysterisis band current control, it may be implemented easily with modern DSP-based control systems.

In this paper, it proposes efficient communication between CR nodes and spectrum utilization. Secondly the security concerns of spectrum sensing to ensure trustworthiness. It uses two selection schemes called node selection scheme (NSS) and channel selection scheme (CSS). The aim of NSS is to allow each node to check its gain in copying a message to a relay while examining its transmission effort. Using NSS, each node decides which paths should be used in order to provide minimum energy consumption without sacrificing end-to-end delay performance. Based on CSS, each node decides and switches to a licensed channel to maximize spectrum utilization while keeping the interference in a minimum level. This eventually enables CR-Networks nodes to determine optimum path nodes and channels for an efficient communication in CR-Networks. The CR technology allows Secondary Users (SUs) to seek and utilize "spectrum holes" in a time and location-varying radio environment without causing harmful interference to Primary Users (PUs). This opportunistic use of the spectrum leads to new challenges to the varying available spectrum. Using a Trust-Worthy algorithm, it improves the trustworthiness of the Spectrum sensing in CR-Networks.

II. PRINCIPLE OF SPACE VECTOR PULSE WIDTH MODULATION

Eight possible combinations of on and off patterns may be achieved. The on and off states of the lower switches are the inverted states of the upper ones .The phase voltages corresponding to the eight combinations of switching patterns can be calculated and then converted into the stator two phase (αβ) reference frames. This transformation results in six non-zero voltage vectors and two zero vectors. The non-zero vectors form the axes of a hexagon containing six sectors ($V_1 - V_6$) as shown in Fig. 4The angle between any adjacent two non-zero vectors is 60 electrical degrees. The zero vectors are at the origin and apply a zero voltage vector to the motor. The envelope of the hexagon formed by the non-zero vectors is the locus of the maximum output voltage. The maximum output phase voltage and line-to-line voltage that can be achieved by applying SVPWM.

The maximum output phase voltage and line-to-line voltage that can be achieved by applying SVPWM are:

$$V_{ph\,max} = \frac{V_{dc}}{\sqrt{3}} \qquad V_{llmax} = V_{dc}$$

And the r.m.s. output phase voltage and line-to-line voltage are:

$$V_{ph\,max} = \frac{V_{dc}}{\sqrt{6}} \qquad V_{11\,max} = \frac{V_{dc}}{\sqrt{2}}$$

Therefore the dc voltage V_{dc} for a given motor r.m.s. voltage V_{ph} rms is $V_{dc} = \sqrt{6} * V_{ph\,rms}$

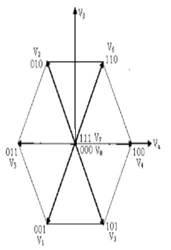

Fig. 4 Non-zero vectors forming a hexagon and zero vectors.

Practically, only two adjacent non-zero voltage vectors Vx and Vx+60 and the zero vectors should be used. Depending on the reference voltages V_α and V_β, the corresponding sector is firstly determined.

Space Vector Modulation (SVM) is one of the popular real- time Pulse Width Modulation (PWM) techniques and is widely used for digital control of Voltage Source I nverters (VSI). The operating status of all the switches in a two level inverter can be represented as Switching State '+' which denotes that the upper switch in inverter leg is ON and the inverter voltage (VAN, VBN, VCN) is +Vdc while '-' indicates that the inverter terminal voltage is zero due to the conduction of lower switch. There are eight possible combinations of switching states in two level inverters. For

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example, the switching state ‘1’ (+--) corresponds to the conduction of switches S1, S6 and S2 in the legs A, B and C respectively. Among the eight switching states ‘7’ (+++) and ‘8’ (---) are zero states and others are active states.

Table -1:Space Vector Switching States

Space Vector		Switching States	ON-state Switch	Vector Definition
Zero Vectors, V_O		7(+++) 8(- - -)	S_1, S_3, S_5 S_2, S_4, S_6	$V_O = 0$
Active Vectors	V_1	1 (+--)	S_1, S_6, S_2	$V_1 = (2/3)V_d\, e^{j0}$
	V_2	2 (++-)	S_1, S_3, S_2	$V_2 = (2/3)V_d\, e^{j\pi/3}$
	V_3	3 (-+-)	S_4, S_3, S_2	$V_3 = (2/3)V_d\, e^{j2\pi/3}$
	V_4	4 (-++)	S_4, S_3, S_5	$V_4 = (2/3)V_d\, e^{j3\pi/3}$
	V_5	5 (--+)	S_4, S_6, S_5	$V_5 = (2/3)V_d\, e^{j4\pi/3}$
	V_6	6 (+-+)	S_1, S_6, S_5	$V_6 = (2/3)V_d\, e^{j5\pi/3}$

The active states and zero states are denoted by their respective space vectors, where the six active vectors V1to V6 form a regular hexagon with six equal sectors (1-6).

III. THREE PHASE INDUCTION MOTOR

The relationship between synchronous speed, rotor speed and the slip is given by

$$S = \frac{N_S - N_r}{N_S}$$

Or, $N_r = N_s(1-S)$

□ Rotor speed $N_r = 120f/P(1-s)$

Thus, the speed of an induction motor depends on slip S, frequency of the stator supply f and the number of poles for which the windings are wound. The ability of varying any one of the above three quantities will provide methods of speed control of an induction motor. Constant V/F method is commonly used for constant and variable speed control of induction motor. The torque developed by the motor is directly proportional to the magnetic field produced by the stator. So, the voltage applied to the stator is directly proportional to the product of stator flux and angular velocity. This makes the flux produced by the stator proportional to the ratio of applied voltage and frequency of supply. Therefore by varying the voltage and frequency by the same ratio, the torque can be kept constant throughout the speed range. The below relations justify the above explanation.

Stator Voltage (V) ∝ [Stator Flux(ϕ)] x [Angular Velocity (ω)]

$$V \propto \phi \times 2\pi f$$

$$\phi \propto V/f$$

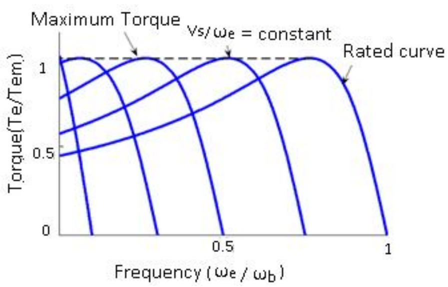

Figure 3. Torque-speed characteristics of the induction motor

This makes constant V/F is the most common speed control of an induction motor. The torque developed by the

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induction motor is directly proportional to the V/F ratio. If we vary the voltage and frequency, keeping their ratio constant, then the torque produced by induction motor will remain constant for all the speed range.
Since the torque developed by the induction motor is directly
proportional to the V/F ratio will not remain constant throughout the speed.
Other than the variation in speed, the torque-speed characteristics of the V/F control reveal the following:
1) The starting current is low.
2) The stable operating region of the motor is increased. Instead of simply running at its base/ rated speed (NB), the motor can be run typically from 5% of the synchronous speed (NS) up to the base speed. The torque generated by the motor can be kept constant throughout this region.
3) Since almost constant rated torque is available over the entire operating range, the speed range of the motor becomes wider. User can set the speed as per the load requirement, thereby achieving the higher efficiency.
Because of above reasons V/F control method is used in this work.

IV. SIMULATION RESULT

In this paper we have discussed about speed control of three phase induction using PWM technique, the figure 4 given below shows the rotor speed variation against constant V/f ratio.

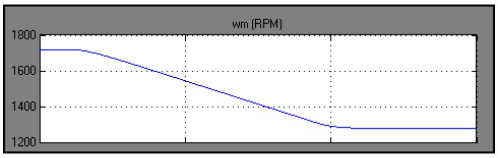

Fig4 rotor speed variation with constant V/f ratio

Figure 5 shows the change in applied voltage and corresponding change in frequency shown in figure 5, both the waveforms describes constant V/f ratio.

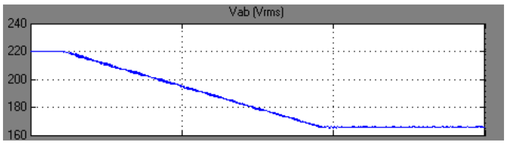

Fig.5 change in voltage

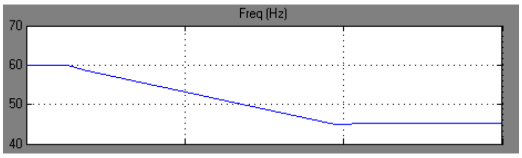

Fig.6 change in freq

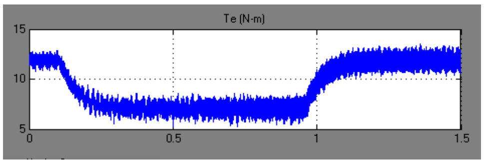

Fig.7 variation in torque

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VI. CONLUSION

The variation of stator voltage and frequency is done proportionally, such that V/F ratio is constant. From this work and result analysis, it is observed that speed of an induction motor can be efficiently controlled by using SVPWM. In the present work, the simulation of speed control of motor by volt/hertz method using SVPWM is simulated and waveforms are discussed.

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