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Effective Vector Control to Reduce Induction Motor Harmonic

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***Abstract*— Induction motors have many usages in industrial application. Today, generally three-phase induction motors with variable frequency and voltage are fed with variable speed drives.one of the most important concern for electrical engineering is the quality of power, and the harmonic is one of the power quality problem. In this paper the effective method to reduce harmonic of induction motor based on Pulse Width Modulation (PWM) technique is presented. The switching angle for the pulse is selected in such way to reduce the harmonic distortion. The simulations are done by using MATLAB/SIMULINK. At the end, simulation result shows the effect of proposed approach.**

***Index Terms*—** harmonic, induction motor, PWM

I. INTRODUCTION

One of the most common motor that used in industrial motion control is AC induction motors. The three-phase induction motor, also called an asynchronous motor. This kind of motor has many advantages such as simple and rugged design, low-cost and direct connection to an AC power source. They have no brushes and require minimum maintenance. In particular, the squirrel-cage design is the most widely used electric motor in industrial applications. We would find induction motors mostly in applications such as water pumps, compressors, fans and air-conditioning systems [1-3].

The control problem of induction motors is the most disadvantage of this kind of system and it is crossed off by development of power electronics and signal processing systems. With modern techniques of field-oriented vector control, the task of variable-speed control of induction machines is no longer a disadvantage [4, 5].

The deterioration of power quality is caused by intensive use of power electronic converters and nonlinear loads. This distortion in the waveform is measured in term of index known as Total Harmonics Distortion (THD). According to equation 1, the THD may be described as the ratio of the square root of the sum of squares of the rms value of harmonic component to the rms value of the fundamental component [6].

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$$I_{THD} = \frac{\sqrt{\sum_{n=2}^{\infty} I_n^2}}{I_1} \qquad (1)$$

According to IEEE 519 standard, The THD level for current harmonics should be less than 5%.

II. Sinusoidal PWM (SPWM) & Space Vector PWM (SVPWM)

At this part, two kind of PWM technique will be explained in details. At first Sinusoidal PWM (SPWM) is explained and after that the Space Vector PWM (SVPWM) is presented.

A. Sinusoidal PWM (SPWM)

The ac output voltage is showed in figure 1. In this technique the modulating signal V_c is sinusoidal. Its frequency and amplitude are f_c and $\overline{V_c}$ respectively, furthermore the triangular signal V_Δ has f_Δ as its frequency and its amplitude is $\overline{V_\Delta}$. m_a as its modulation index and the normalized carrier frequency m_f are presented in equations 2 and 3 respectively [7]:

$$m_a = \frac{\overline{V_C}}{V_\Delta} \qquad (2)$$

$$m_f = \frac{f_\Delta}{f_C} \qquad (3)$$

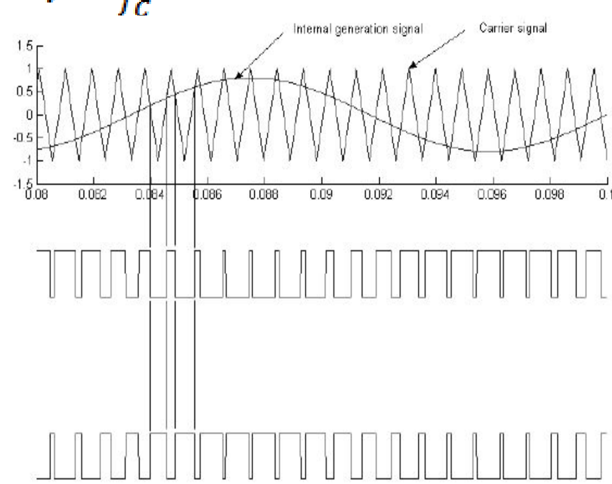

Fig.1: Gating signal production of Sinusoidal PWM

B. Space Vector PWM (SVPWM)

SVPWM method was developed as a vector approach to pulse width modulation. The SVPWM technique is mostly used in vector controlled applications. Obtain minimum harmonics is the main goal of using the SVPWM. In figure 2, the basic concept of SVPWM using a three-phase inverter is presented [8-10].

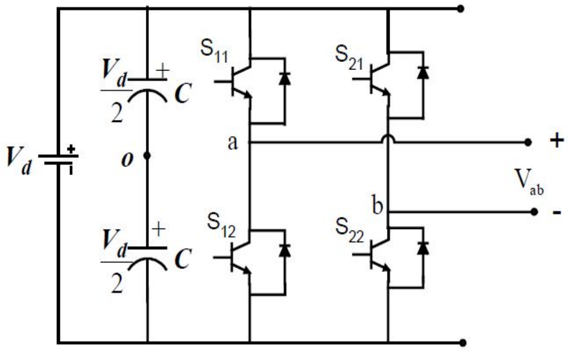

Fig.2: Power circuit of a three-phase VSI

In SVPWM technique, it is possible to transfer equation from abc frame to dq reference frame. Figure 3 shows this reference frame.

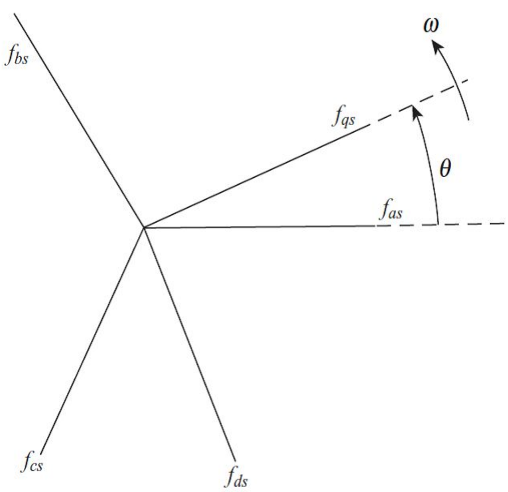

Fig.3: abc and dq Reference Frame

$$f_{dqo} = K_s f_{abc} \qquad (4)$$

Where:

$$K_s = \frac{2}{3}\begin{bmatrix} 1 & -1/2 & -1/2 \\ 0 & -\sqrt{3}/2 & -\sqrt{3}/2 \\ 1/2 & 1/2 & 1/2 \end{bmatrix} \qquad (5)$$

$$f_{dqo} = [f_d f_q f_0]^T, f_{abc} = [f_a f_b f_c]^T \qquad (6)$$

And f can be voltage or current.

Because of many advantages, the SVPWM is more popular than other methods. The most advantage of SVPWM which is very important is the lower total harmonic distortion so that it used to achieve the minimal harmonic. In next pat, the simulation result shows the effect of this method.

III. Simulation results

In this part the simulation results for SPWM and SVPWM are presented. At first the SPWM ad after that the SVPMW is simulated.

a) SPWM simulation

Figure 4, 5 and 6 shows the rotor speed, torque and the harmonic for SPWM technique.

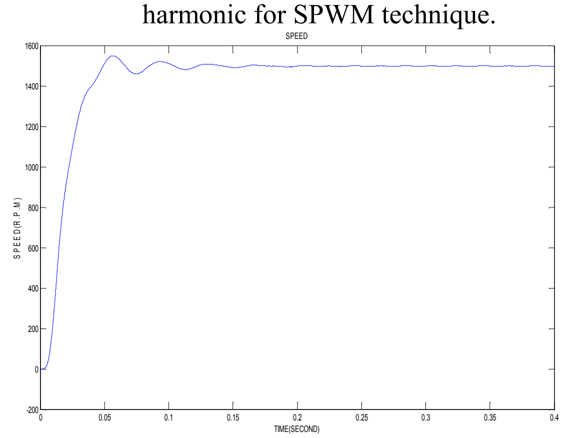

Fig.3: rotor speed of SPWM

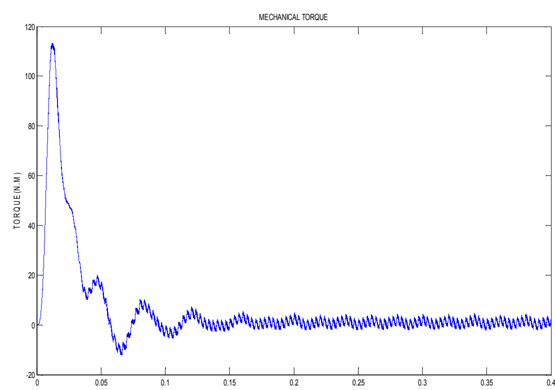

Fig.4: torque in SPWM

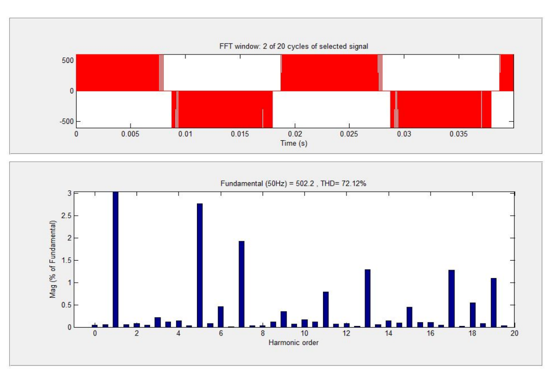

Fig.5: THD for SPWM with modulation index=1

b) SVPWM simulation

Similar to the SPWM, the rotor speed, torque and the harmonic for SVPWM is presented in figures 7, 8 and 9 respectively.

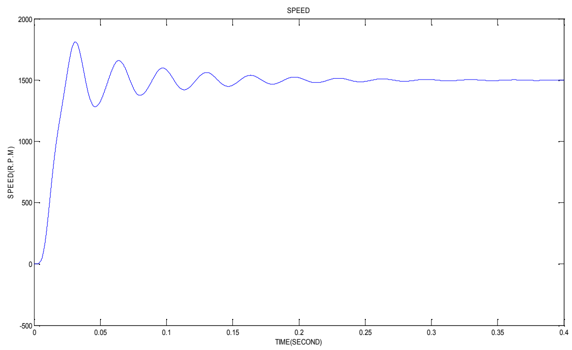

Fig.6: rotor speed of SVPWM

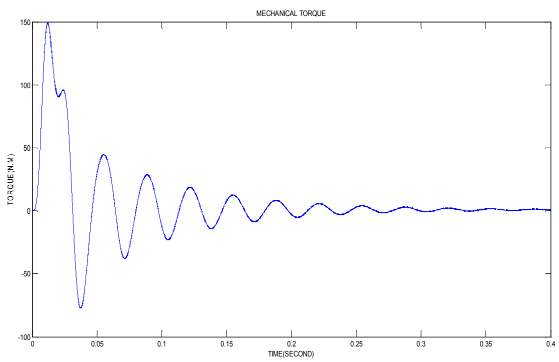

Fig.5: torque in SVPWM

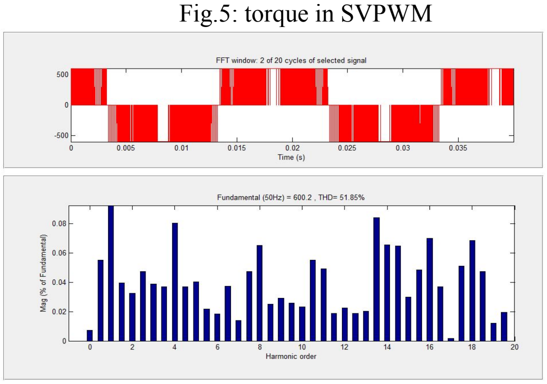

Fig.6: THD for SVPWM with modulation index=1

As it's clear from the simulations, the THD is reduced from 72.22% in SPWM technique to 52.27% in SVPWM technique. It shows the effect of proposed method.

Conclusion

Induction motors are the most common motor that used in industry. The control problem of induction motors is the most disadvantage of this kind of system so in this paper two kind of PMW technique is simulated by using MATLAB/SIMULINK to control output voltage with minimal harmonic. Simulation shows to achieve minimal harmonic of output voltage, the space vector PWM has better effect to compare with sinusoidal PWM. On other hand, the torque of motor is improved in SVPWM method due to the reduction of harmonic.

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