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SIMULATION AND ANALYSIS OF FOC OF INDUCTION MACHINE USING SPWM TECHNIQUES

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Abstract- **Pulse Width Modulation variable speed drives are used in so many industrial applications in which higher performance is required. Low power loss, ease of implementation and control, no temperature variation are few advantages of PWM based switching. Improvements in power electronics system is due to the development of power electronics and semiconductor technology. A 3-phase voltage source inverter provides variable voltage and frequency which is supplied to ac drives. In ac motor drives, it is possible to control both magnitude and frequency of current and voltage which are applied to the motor is only due to SPWM inverters. Hence PWM inverters fed motor drives are more variable and offer a wide range of better efficiency and provides higher performance when compared to fixed frequency drives. Here open loop simulation and analysis of PWM inverter fed induction motor is carried out.**

Keywords - Matlab, SPWM, Thyristor, Induction Motor.

I. Introduction

Induction motors are used widely in industrial control and many other applications by converting electrical power into mechanical. Household applications, steel mill, hoist drives are few applications of Induction motor and are most commonly used because they provide better performance than ac drives. 3-phase induction motor are most reliable, robust, durable, require less maintenance and can be manufactured with the characteristics to meet most of the industrial requirements and hence are most widely used in industries.

Generally the output voltage of the inverter is required to be controlled for the constant voltage/frequency (V/F) control of an induction motor. The best method of controlling the output voltage of an induction motor is to give a PWM based firing of inverter. In this inverter is fed by a fixed DC voltage and by adjusting the on-off period of inverter devices a controlled AC output voltage is obtained.

Among the various PWM techniques the sinusoidal PWM is the most popular one which provides a smooth changeover of VI, harmonic elimination etc. in both open and closed loop applications

Field orient control is a variable frequency drive (VFD) control method that is used to control speed and torque of the motor by changing input of the motor that is frequency and voltage which are fed as input to the motor. In Field orient control stator currents are visualized with a vector in two orthogonal components. One component will represent Magnetic flux and the other will represent torque of the motor.

II. Pulse Width Modulation

Pulse width modulation is used for encoding a message into pulse signals that isPulse width modulation signals are pulse trains which have fixed magnitude and frequency but has variable pulse width. Although Pulse width modulation can be used to encode information for transformation but its main use is to control the power which is supplied to electrical devices especially to the motor with inertial loads. The average value of voltage which is fed to the load can be controlled by turning on and off switch at a fast rate between load and supply. The longer the switch will be on, higher will be the total power supplied to load.

Pulse width modulation signal's frequency should be much higher than the modulating signal. Pulse width modulation gives better results than an external control method as it is an internal control method. There are two types of Pulse width modulating signals, symmetric signal and asymmetric signal as shown in fig 1.

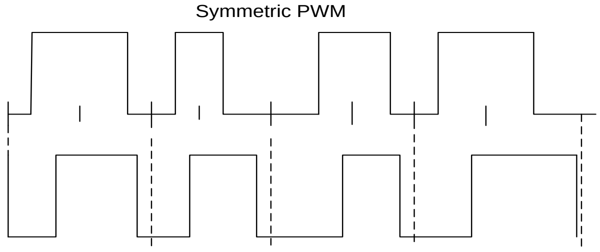

Fig 1 – Different types of PWM signals

The pulses of a symmetric PWM are always symmetric with respect to the centre of each PWM period. But in the asymmetric PWM pulses have same side aligned with one end of each PWM period. Symmetric PWM signals generate less harmonics in the output voltages and currents. Main advantage of PWM is that there is very less power loss in the switching device as when the switch is in off state practically there is no current and when the switch is on then the power is being transferred to the load hence there is almost zero voltage drop across the switch.

For variable frequency VSI inverters there are no. of PWM techniques. A suitable PWM technique has to be employed in order to get the required voltage output of the inverter.

III. Sinusoidal Pulse Width Modulation

Sinusoidal PWM is also known as triangulation method and is very popular in industrial applications. In SPWM several pulses per half cycle are used but the pulse width is a sinusoidal function of the angular position of pulse. For realizing SPWM, a triangular carrier wave is compared with a sinusoidal reference wave note that the frequency of the carrier wave should be greater than reference wave. The intersection both waves will determine the switching instants and the commutation of the modulated pulse. As shown in fig 2 the carrier and reference waves are mixed in a comparator. When the reference wave have higher magnitude than the carrier wave, the comparator output will be high otherwise it will be low. The comparator output is fed in the trigger pulse generator in such a way that the pulse width of the output voltage wave of the inverter is in agreement with the output pulse width of the comparator.

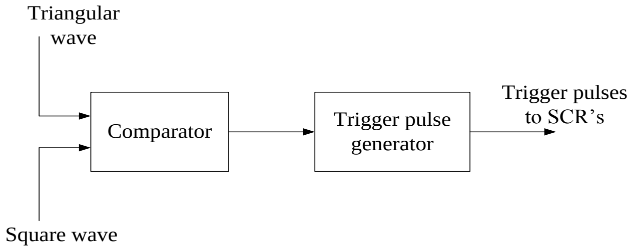

Fig – 2 Block diagram of SPWM

When reference signal is of amplitude A_m and carrier wave amplitude is A_c, then modulation index i is defined as $i = \frac{A_m}{A_c}$. Amplitude of the applied voltage can be controlled by controlling the modulation index i.Modulation index $i$can never be more than unity.

For variations in speed of drives, frequency of AC voltage which is applied needs to be varied. The harmonic content of the inverter output can be reduced by employing PWM. Few constraints for slow varying sinusoidal voltage be considered as modulating signal are –

1. Peak magnitude of reference signal should be less than or equal to the peak magnitude of carrier signal. This will make sure that the instantaneous magnitude of modulating signal will never exceed the peak magnitude of carrier signal.
2. Frequency of modulating signal should be less than the frequency of carrier signal by several orders such that the magnitude of modulating signal will be constant over any time period of carrier signal under high frequency ratio's.
3. A 3-phase sine PWM inverter will require a set of 3 sinusoidal modulating signal along a triangular carrier signal which is of high frequency.

IV. Field Oriented Control

Vector control is mentioned for both phase and magnitude control. Vector control of current and voltage results in altitudinal orientation control of electro-magnetic field in machine which leads to field orientation. 90˚ orientation is generally anticipated between MMF due to armature field and control.

With the increase in slip, torque can be increased and flux will tend to decrease. Variation of flux is always lumpish. The flux decrease is then reimbursed by lumpish flux control loop which is feeding additional voltage. The changeable flux reduces the sensitivity of torque with respect to slipand will increase the response time. Vector control is used to solve the above problems and it do decoupling that is flux and torque are not affected from each other.

Now transformation from 3 phase to 2 phase is done that is terminal phase currents $i_a, i_b and i_c$ of the machine are converted into $i_{ds}{}^s$and $i_{qs}{}^s$which are further converted into synchronous rotating frame using unit components of unit vector that is $cos\theta_e andsin\theta_e$ before implementing them to $d^e - q^e$ machine model.

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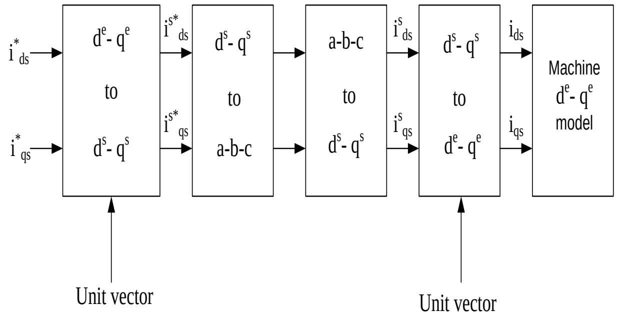

Fig -3 Vector Control principle

There are two stages of inverse transformation in controller such that control currents $i_{ds}{}^{*}$and $i_{qs}{}^{*}$ are identical to the machine currents i_{ds} and i_{qs} respectively.

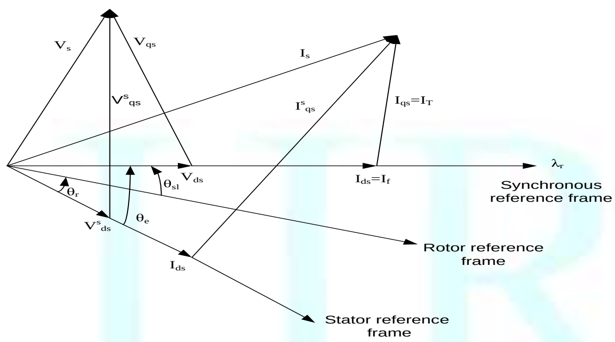

Fig -4 Phasor diagram of Induction machine

The electric torque equation from induction machine is -

$$T_e = \frac{3P}{4} . \frac{L_m}{L_r} . (\lambda_{dr} I_{qs} - \lambda_{qr} I_{ds})$$

V. SIMULATION AND RESULTS

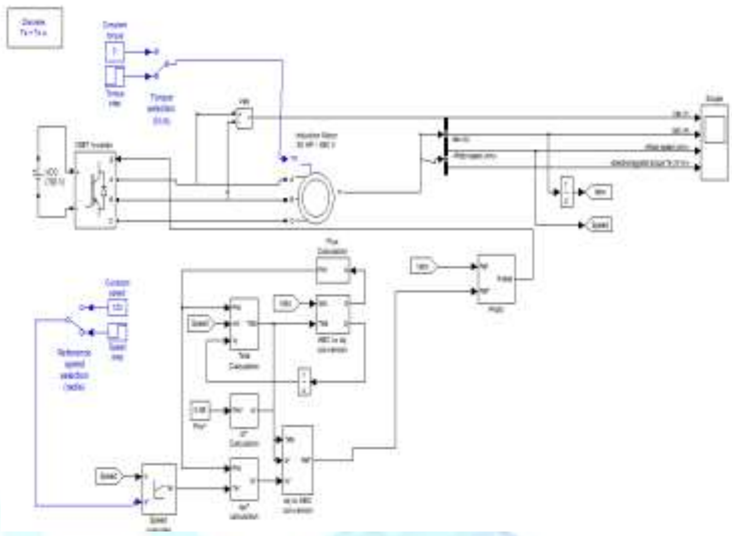

Fig- 5 Block diagram of FOC of Induction Motor using PWM techniques

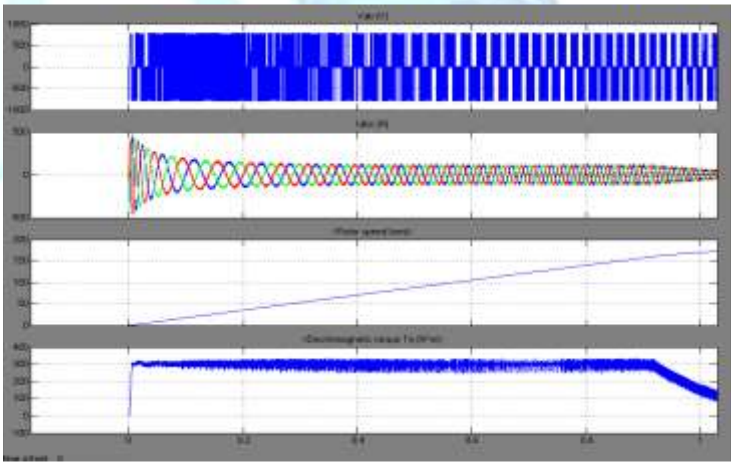

Fig- 6 Layout and simulation results

VI. CONCLUSION

From above results we can see clearly that motor will run smoothly after using Field oriented control. In this SPWM technique is also used by which results are smoother.

References

1. *Fang Zheng Peng et al.," A multilevel voltage source inverter with separate DC sources for static SAR generation", IEEE Trans. On Industry Applications, VOL. 32, NO. 5, PP. 1130-1138, September/October 1996.*

2. *B.K.Bose, Modern Power Electrics and AC Drives: Prentice-Hall, 2002.*

3. *B.K. Bose," An adaptive hysteresis band current control technique of a voltage-fed PWM inverter for machine drive system", IEEE Trans. On industrial electronics, VOL. 37, NO. 5, PP. 402-408, 1990.*

4. *M. Lafor and I.J. Iglesias," A novel double hysteresis band current control for a three - level voltage source inverter", 1st Annual Power Ele"ies Specialist Conference, VOL. 1, P. 21.*

5. *J.Y. Lee and Y.Y. Sun," A new SPWM inverter with minimum filter requirement", International Journal of electronics, VOL. 64, NO. 5, PP. 815-826, 1988.*

6. *Sandeep Kumar Singh et al.," A survey and study of different types of PWM techniques used in Induction Motor drive", IJESAT VOL. 4, Issue – 1, ISSN : 2250-3676.*

7. *P.S. Joshi, Prof. A.M. Jain, " Wireless speed control of an Induction motor using PWM technique with GSM", IOSR-JEEE VOL. 6, Issue 2, PP. 01-05.*

8. *C.S. Sharma and TaliNagwani," Simulation and analysis of PWM inverter fed induction motor drive" IJSETR VOL. 2, Issue 2, ISSN : 2278-7798.*

9. *RaduBojoi et al., " Digital Field – Oriented Control for dual three-phase Induction Motor drives", IEEE Trans. On Industrial Applications, VOL. 39, NO. 3, May/June 2003.*

10. *DomenicoCasadei et al.," FOC and DTC : two variable schemes for Induction Machine torque control", IEEE Trans. On power electronics, VOL. 17, NO. 5, September 2002.*

11. *Rajesh Thinga et al.," Field - Oriented Control of single phase Induction Machine", IJETAE VOL. 4, Issue 8, ISSN : 2250-2459, August 2014.*

12. *Alberti L et al.," Field – Oriented control of Induction Motor : A direct analysis using finite elements", IEEE Trans. On Industrial Electronics, 34th Annual Conference of IEEE, Nov. 2008.*