INTERNATIONAL RESEARCH JOURNAL IN ADVANCED ENGINEERING AND TECHNOLOGY (IRJAET) E - ISSN: 2454-4752 P - ISSN : 2454-4744
VOL 2 ISSUE 2 (2016) PAGES 757-766
RECEIVED : 25/03/2016. PUBLISHED : 01/04/2016
April 1, 2016

Design of High-speed Induction Motor Controllers using Space vector Pulse Width Modulation

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ABSTRACT: Induction Machines, the most widely used motor in industry, have been traditionally used in open-loop control applications, for reasons of cost, size, reliability, ruggedness, simplicity, efficiency, less maintenance, ease of manufacture and its ability to operate in dirty or explosive conditions. However, induction machine suffers with the requirement of more complex control methods. With developments in Microcontroller, Micro-processors/DSPs, power electronics and control theory, the induction machine can now be used in high performance variable-speed applications. Voltage source inverter (VSI) fed induction motors are widely used in variable speed applications. Space Vector Pulse Width Modulation (SVPWM) has become the successful techniques to construct three phase sine wave Voltage Source Inverter (VSI).
VSI fed induction motor produces a pulsating torque due to the application of non-sinusoidal voltages produced by the conventional PWM techniques. Among the various modulation strategies Space Vector pulse width Modulation Technique is the efficient one because it has better performance and output voltage is more closed to sinusoidal. The close loop V/f control of induction motor with SVPWM shows better reduction in torque ripples when compared with conventional PWM technique.

KEYWORDS: V/F, Space Vector Pulse width modulation, Voltage source inverter

I. INTRODUCTION

In this system the pulse width modulation technique plays a vital role for investigated decades. It has two types i. sinusoidal pulse width modulation ii. Space vector pulse width modulation. Sinusoidal pulse width modulation has disadvantages like more total harmonic distortion, unable to use fully utilize the available Dc supply voltage. In space vector pulse width modulation is a more important technique for generating sine wave that provides a higher voltage to motor with low harmonic distortion. It gives higher output voltage, lower switching losses, increased utilization of DC supply 15% more than sinusoidal pulse width modulation and the performance of the harmonics is better. The main aim of the pulse width modulation technique is to obtain variable output having a maximum fundamental component with minimum harmonics. The space vector pulse width modulation techniqueis more popular than conventionaltechnique because of its features like higher efficiency andoptimizes harmonics etc.

II. V/F CONTROL OF INDUCTION MOTOR DRIVE

V/F means variable voltage and variable frequency by using this we are controlling the speed of the induction motor.There are various methods for the speed control of an Induction Motor. They are: i. Pole Changing
ii. Variable Supply Frequency Control iii. Variable Supply Voltage Control iv. Variable Rotor Resistance Control v. V/f Controlvi. Slip Recovery vii. Vector Control Of the above mentioned methods, V/f Control is the most popular and has found widespread use in industrial and domestic applications because of its ease-of-implementation. However, it has inferior dynamic performance compared to vector control. Thus in areas where precision is required, V/f Control are not used. The various advantages of V/f Control are as follows: i. It provides good range of speed. ii. It gives good running and transient performance. iii. It

has low starting current requirement. iv. It has a wider stable operating region. v. Voltage and frequencies reach rated values at base speed. vi. The acceleration can be controlled by controlling the rate of change of supply frequency. vii. It is cheap and easy to implement. The main objective of the project is to develop a model or models to implement V/f control of an induction motor. In order to do that, one must be familiar withthe PWM Inverter which drives the induction motor. Hence, PWM signal generation, and Inverter topologies are also studied and simulated. Scope of the Thesis i. Development Simulink models for a PWM Inverter. ii. Using the developed PWM Inverter Simulink model to run an Induction Motor, and obtain its uncontrolled speed, torque, and current characteristics. iii. Development of a V/f Control scheme for controlling the Induction motor- both Open Loop and Closed Loop using MATLAB.

III. INDUCTION MOTOR

Induction motors are the most widely used motors in domestic appliances, industrial control, and automation. Hence they are often called the workhorse of the motion industry. They are robust, reliable, and durable. When power is supplied to an induction motor, it runs at its rated speed. However, many applications need variable speed operations. For example, a washing machine may use different speeds for each wash cycle. Historically, mechanical gear systems were used to obtained variable speed. Recently, power electronics and control systems have matured to allow these components to be used for motor control in place of mechanical gears.

BASIC OPERATION:

When the rated AC supply is applied to the stator windings, it generates magnetic flux of constant magnitude, rotating at synchronous speed. The flux passes through the air gap, sweeps past the rotor surface and through the stationary rotor conductors. An electromotive force (EMF) is induced in the rotor conductors due to the relative speed difference between the rotating flux and stationary conductors. The frequency of the induced EMF is the same as the supply frequency. Its magnitude is proportional to the relative velocity between the flux and the conductors. Since the rotor bars are shorted at the ends, the EMF induced produces a current in the rotor conductors. The direction of the rotor current opposes the relative velocity between rotating flux produced by stator and stationary rotor conductors. To reduce the relative speed, the rotor starts rotating in the same direction as that of flux and tries to catch up with the rotating flux. But in practice, the rotor never succeeds in catching up to the stator field. So, the rotor runs slower than the speed of the stator field. This difference in speed is called slip speed. This slip speed depends upon the mechanical load on the motor shaft. The frequency and speed of the motor, with respect to the input supply, is called the synchronous frequency and synchronous speed. Synchronous speed is directly proportional to the ratio of supply frequency and number of poles in the motor. Synchronous speed of an induction motor is shown in the equation

$$\text{SYNCHRONOUS SPEED } N_s = \frac{120 f}{p}$$

Where f = rated frequency of the motor

p= number of poles in the motor

Synchronous speed is the speed at which the stator flux rotates. Rotor flux rotates slower than synchronous speed by the slip speed. This speed is called the base speed. The speed listed on the motor nameplate is the base speed. Some manufactures also provide the slip as a percentage of synchronous speed.

IV.SPACE VECTOR PULSE WIDTH MODULATION

(SVPWM) generates the appropriate gate drive waveform for each PWM cycle. The inverter is treated as one single unit and can combine different switching states (number of switching states depends on levels). The SVPWM provides unique switching.The topology of a three-leg voltage source inverter is shown in Fig. 4.1Becauseof the constraint that the input lines must never be shorted and the output current mustalways be continuous a voltage source inverter can assume only eight distinct topologies.These topologies are shown on Fig.4.1Six out of these eight topologies produce a non-zerooutput voltage and are known as non-zero switching states and the remaining twotopologies produce zero output voltage and are known as zeroswitchingstates.

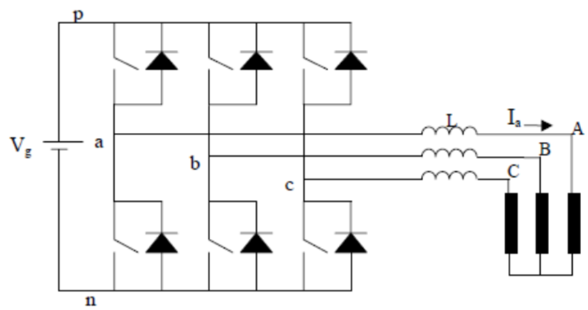

FIG 4.1 Three leg voltage source inverter

V.SPACE VECTOR MODULATION:

The desired three phase voltages at the output of the inverter could be represented by an equivalent vector V rotating in the counter clock wise direction as shown in Fig. 5.1. The magnitude of this vector is related to the magnitude of the output voltage Fig. 5.2 and the time this vector takes to complete one revolution is the same as the fundamental time period of the output voltage.

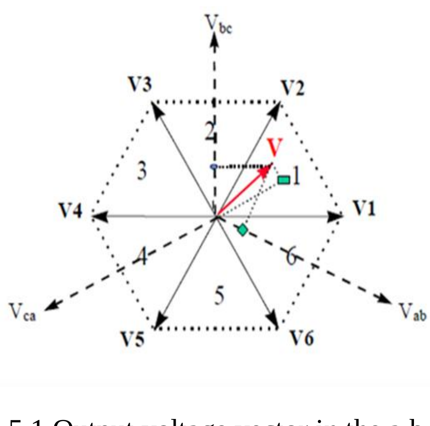

Fig 5.1 Output voltage vector in the a,b plane.

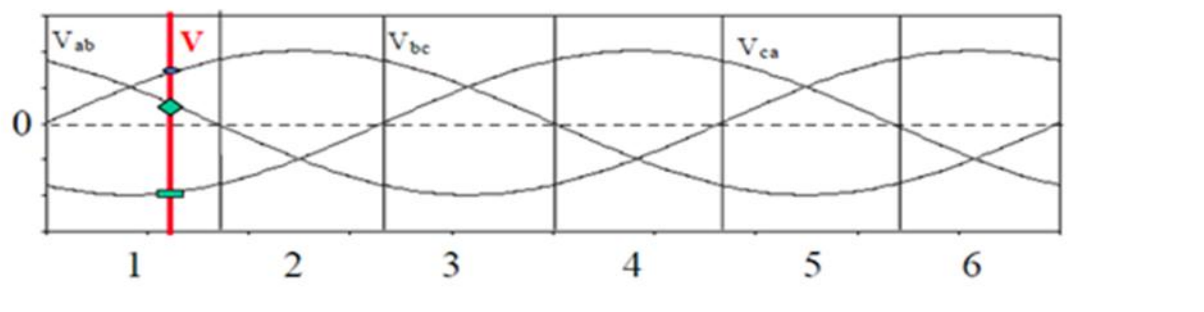

Fig 5.2Output line voltages in time domain.

Let us consider the situation when the desired line-to-line output voltage vector Vis in sector 1 as shown in Fig. 2.7. This vector could be synthesized by the pulse-width modulation (PWM) of the two adjacent SSV's V1(pnn) and V2 (ppn), the duty cycle of each being d1 and d2, respectively, and the zero vector (V7(nnn) / V8(ppp)) of duty cycle d0 [1]:

$$d_1 \boldsymbol{V_1} + d_2 \boldsymbol{V_2} = \boldsymbol{V} = m\, V_g\, e^{j\theta}$$

$$d_1 + d_2 + d_0 = 1$$

where, 0 £ m £ 0.866, is the modulation index. This would correspond to a maximum line-to-line voltage of 1.0Vg, which is 15% more than conventional sinusoidal PWM .

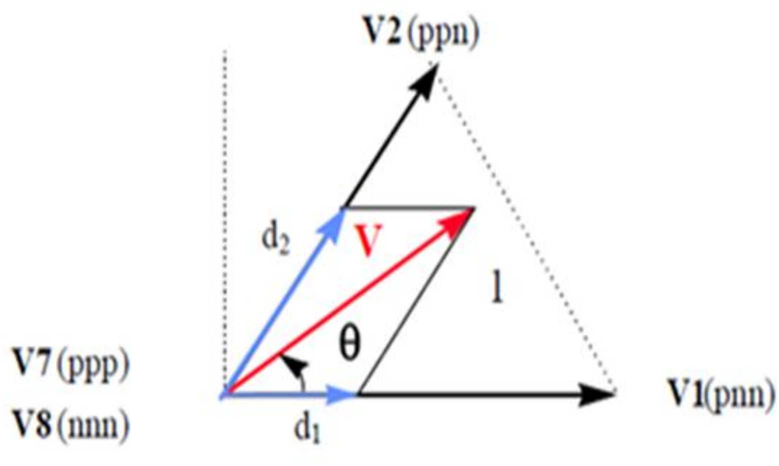

Fig. 2.7. Synthesis of the required output voltage vector in sector 1.

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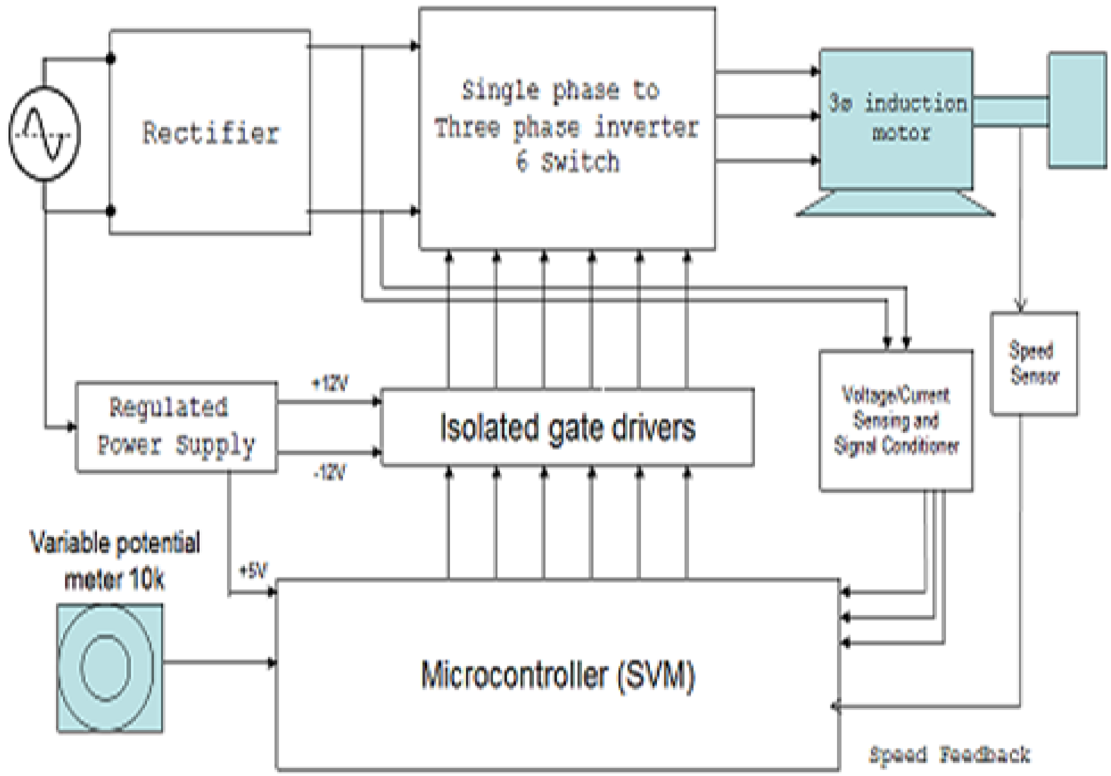
PROPOSED SYSTEM:

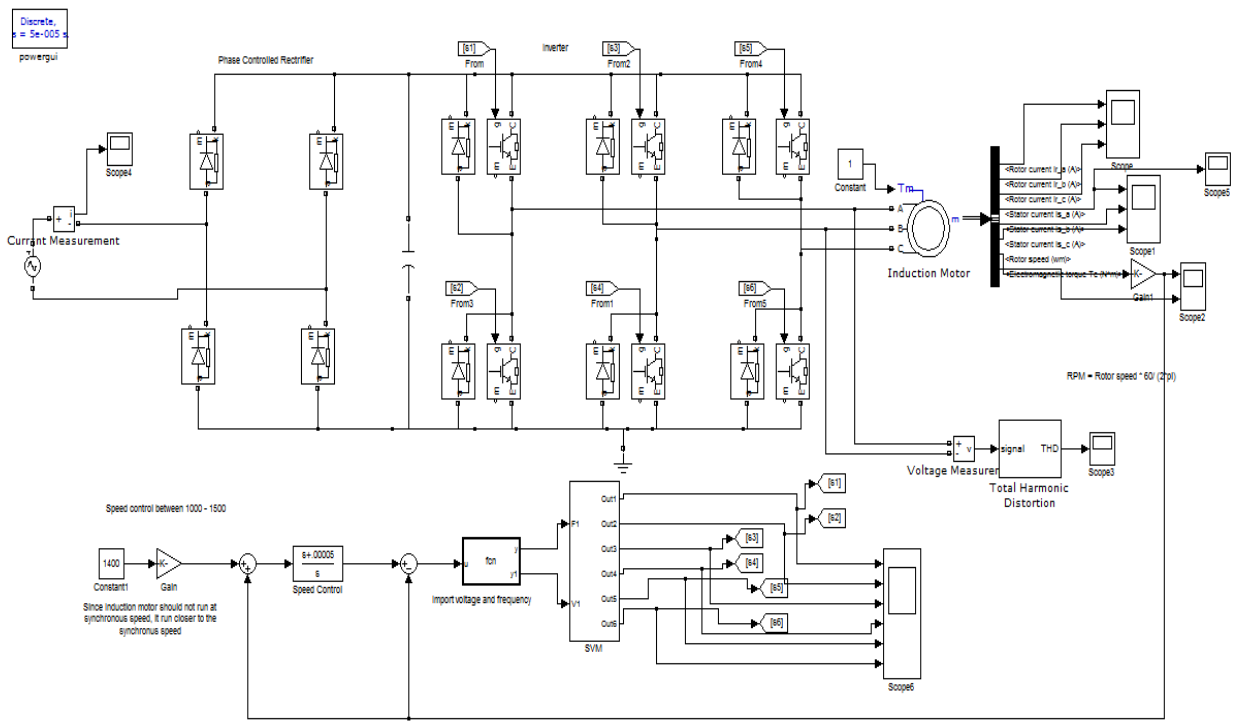


DESCRIPTION OF PROPOSED SYSTEM:

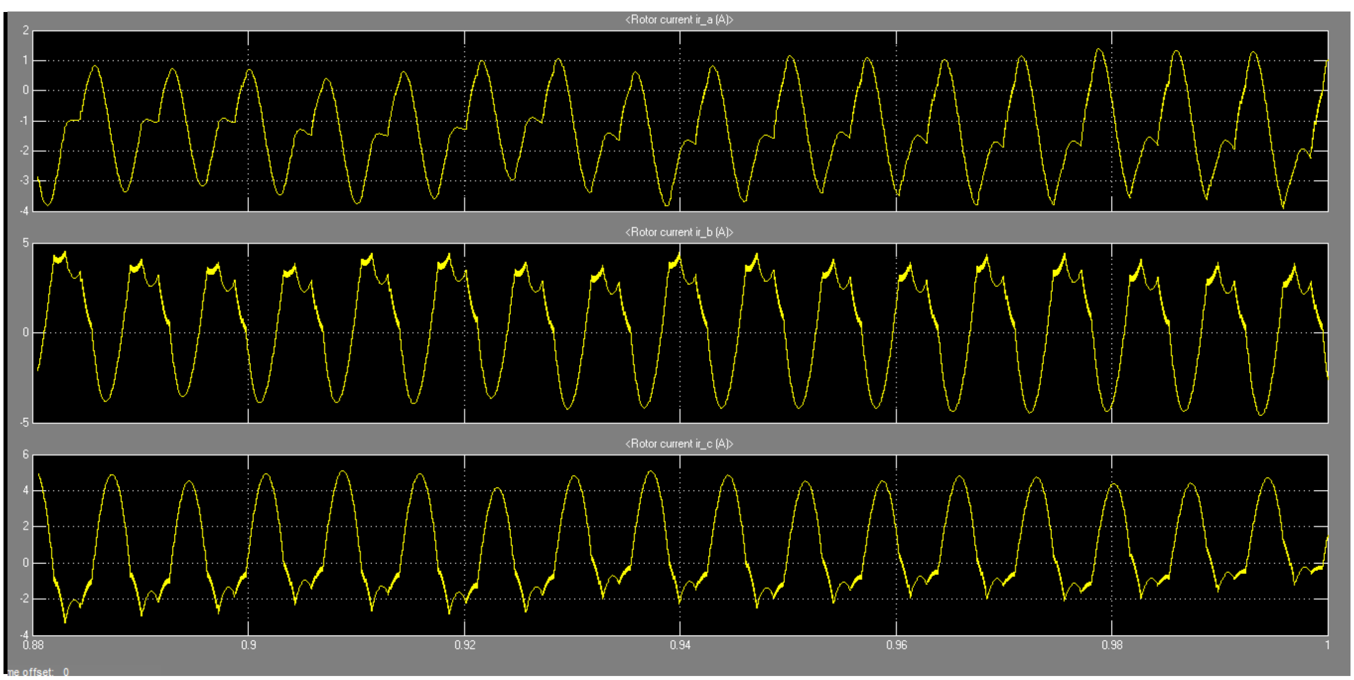
The figure shows the block diagram of v/f based closed loop control of elevator in this system the first four blocks act as a power block here we are giving single phase. Ac supply to the system. This single phase 230v ac supply can be converted in to dc by using the controlled rectifier block. Then the output of the controlled rectifier signal is fed to the three phase inverter block this block isused to convert single phase dc supply in to three phase ac voltage. Now the output of the three phase inverter signal is three ac voltages is given to the induction motor.

Then the induction motor starts to run with the three phase ac supply voltage. The next three blocks act as a control blocks are given below. Zero crossing detect gate driver circuit control system the zero crossing detector blocks and gate driver circuit as connecting in the control system. The microcontroller as used in the control system. The gate driver circuit as connecting in control rectifier and three faze inverter the control rectifier as connecting in zero crossing detectors. The regulated power supply as a main block in the circuit. The all the block function as the regulated power supply as used the final blocks are simulation blocks are using reference speed simulated load and input mode operation.

SIMULATION RESULT:



ROTOR CURRENT:



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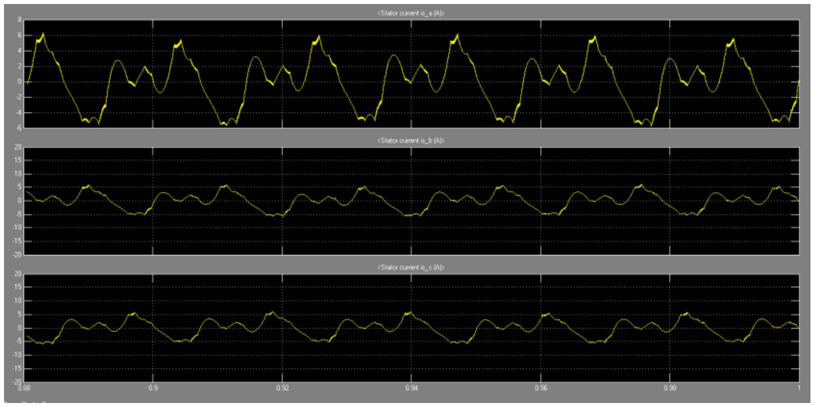
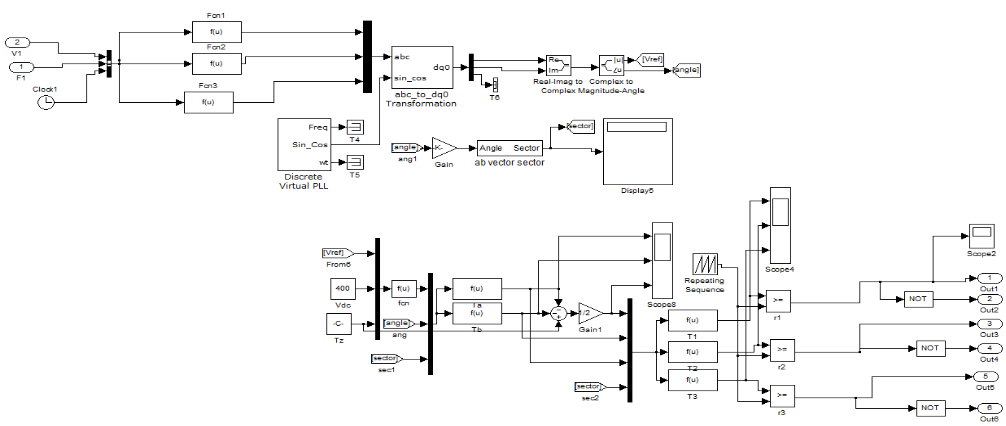
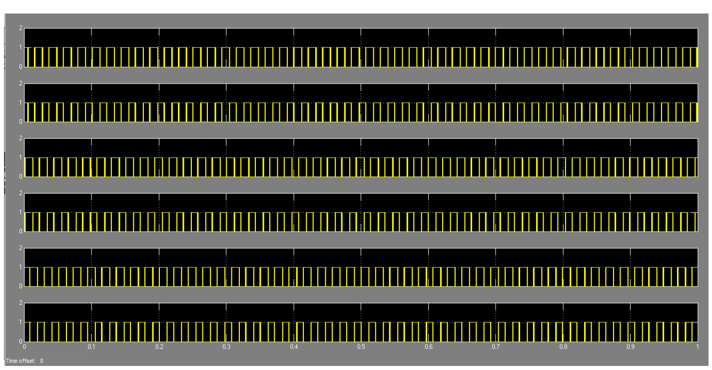
STATOR CURRENT:



SPACE VECTOR MODULATION:



PULSE OF INVERTER:



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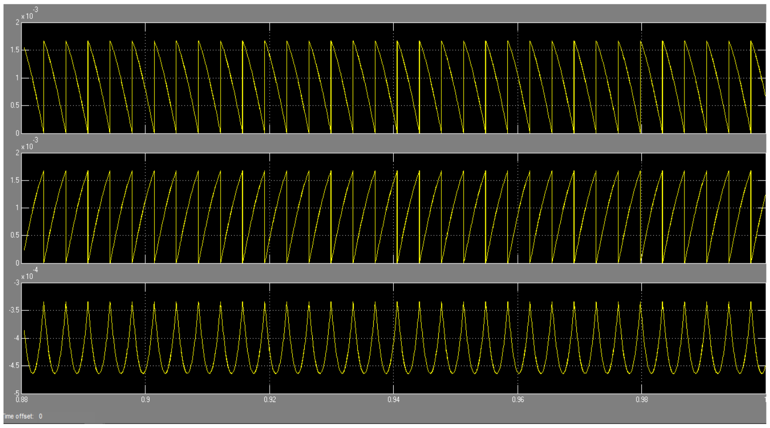
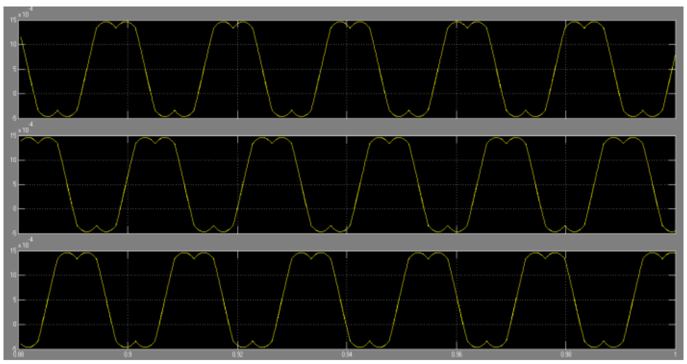
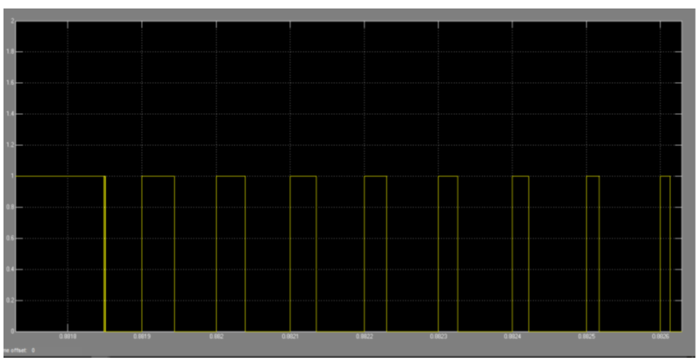
CARRIERWAVE:



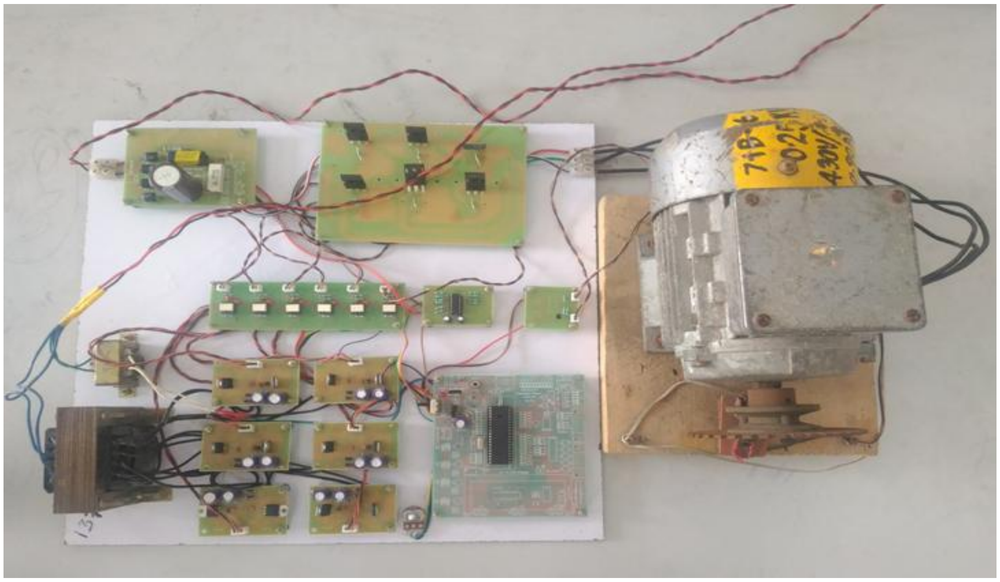
REFERRENCE WAVE:



PULSE OF SVM:



HARDWARE SETUP:



CONCLUSION:

In this project we have successfully implemented the close loop operation for Induction Motor. Which provide more smooth and jerk free operation of motor for numerous Industrial Application's. With good performances and reduced torque ripple and improve the performances of the drive. High reliable control of V/F drive is achieved through SVPWM techniques

REFERENCES

1. K. Basu, "Minimization of torque ripple in space vector PWM based induction motor drives," (Apr 2013). Keliang Zhou and Daniel Wang, "Relationship between Space Vector Modulation and three phase Carrier-Based PWM, A Comprehensive Analysis" (February 2010)

2. Decomposition," IEEE Trans. Ind Appl., vol. 31, no. 5, pp. 1100– 1109, Sep./Oct. 1995G. Narayanan and V. T. Ranganathan, "Analytical evaluation of harmonic distortion in PWM ac drives using the notion of stator flux ripple," (Mar. 2014).

3.S.R. Bowes and Y.S. Lai, "The relationship between space vector modulation and regular-sampled PWM" (March 2011) [4] V. S. S. P. K. Hari and G. Narayanan, "Space-vector-based hybrid pulse width modulation technique to reduce line current distortion in induction motor drives", IET Power Electron., vol. 5(8) , pp. 1463-1471, September 2012.

4. K. Basu, J. S. S. Prasad and G. Narayanan, H. K. Krishnamurthy and R. Ayyanar, "Reduction of torque ripple in induction motor drives using an advanced hybrid PWM technique", IEEE Trans. Ind. Electron., vol. 57(6), pp. 2085-2091, June 2010.

5.G. Narayanan, Di Zhao, H. K. Krishnamurthy, R. Ayyanar and V. T. Ranganathan, "Space vector based hybrid PWM techniques for reduced current ripple", IEEE Trans Industrial Electronics, vol. 55(4), pp. 1614- 1627, April 2008

6.A. C. Binojkumar, J. S. Siva Prasad, and G. Narayanan, “Experimental Investigation on the Effect of Advanced Bus-Clamping Pulse width Modulation on Motor Acoustic Noise”IEEE TRANSACTIONS ON INDUSTRIAL ELECTRONICS, VOL. 60, NO. 2, FEBRUARY 2013

7. B.V. S. S. Pavan Kumar, D. Hari, “Space-Vector-Based Hybrid PWM Technique to Reduce Peak-to-Peak Torque Ripple in Induction Motor Drives” (March 2010)

8. Bimal K.Bose (1982), “Adjustable Speed Ac Drive-A Technology Status Review”, IEEE Proceedings, Vol.70, pp.2-6, Feb.

9. Boys J.T., S.J.Walton (1988), “Scalar Control: An Alternate Ac Drive Philosophy”, IEE proceedings, Vol.135, pp.151-158, May.

10. Edward Randolph Collins (1992),” Torque and Slip Behavior of Single Phase Induction Motor Driven from Variable Frequency Supplies”, IEEE Transactions on Industry Applications, Vol.28, pp.310-315, May/June.

11. Gordon R.Slemon (1989), “Modeling of Induction Machines for Electric Drives” IEEE Transactions on Industry Application, Vol 25, pp.36-39, Nov.

12. Iordanis Kioskeridis and Nikos Margaris (1996), “Loss Minimization in Induction Motor Adjustable – Speed Drives”, IEEE Transactions on Industrial Electronics, Vol.43, No.1, Feb.

13. Sun Jin, Zhenga (2004),” One Novel Scalar Control Scheme For Induction Motor”, IEEE Industrial Electronics Society, pp. 2-6, Nov.

14. Technical details of induction motor and control –www.microchip.com.

15. Werner Leonardo (1988),”Adjustable Speed Ac Drives” IEEE Proceedings, Vol.76, No.4, pp.455-470, April.

16. Zhao and T. A. Lipo, “Space Vector PWM Control of Dual Three-phase Induction Machine using Vector Space