ALGORITHAM BASED SPEED CONTROL OF THREE PHASE INDUCTION MOTOR USING SPACE VECTOR PULSE WIDTH MODULATION

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Abstract- **The 3-phase alternating current (AC) induction motors are lower in cost per horsepower than DC motors and capable of more torque and efficiency than single-phase AC motors. supply of variable voltage and frequency to ac drives is invariably obtained from a 3 phase voltage source inverter .A number of pulse width modulation scheme is used to obtain variable voltage and frequency supply. The most widely used PWM schemes for 3 phases VSI are carrier based sinusoidal PWM and Space vector PWM. The trend of using space vector PWM is increased because of their easier digital realization and better DC bus utilization. A 3-phase AC induction motor can be controlled by varying its inputs according to a mathematical model of the rotor flux field in a complex vector space (vector control). This method provides efficient and accurate control of the motor's speed and torque. This drive application allows vector control of the AC induction motor running in a closed-speed loop with the speed / position sensor coupled to the shaft. The application serves as an example of AC induction vector control drive design using a controller with power electronics support.**

Keywords – Voltage Source Inverter(VSI),Pulse Width Modulation(PWM) ,Alternating Current(AC),Induction Motor(IM)

I. INTRODUCTION

Three phase voltage-fed PWM inverters are recently showing growing popularity for multi-megawatt industrial drive applications. The main reasons for this popularity are easy sharing of large voltage between the series devices and the improvement of the harmonic quality at the output as compared to a two level inverter. In the lower end of power, GTO devices are being replaced by IGBTs because of their rapid evolution in voltage and current ratings and higher switching frequency. The Space Vector Pulse Width Modulation of a three level inverter provides the additional advantage of superior harmonic quality and larger under-modulation range that extends the modulation factor to 90.7% from the traditional value of 78.5% in Sinusoidal Pulse Width Modulation. A variable speed drive is a device used to provide continuous range process speed control (as compared to discrete speed control as in gearboxes or multi-speed motors) and is capable of adjusting both speed and torque from an induction motor.Adjustable speed drives are the most efficient (98% at full load) types of drives. They are used to control the speeds of both AC and DC motors. They include variable frequency/voltage AC motor controllers for squirrel-cage motors, DC motor controllers for DC motors, eddy current clutches for AC motors (less efficient), wound-rotor motor controllers for wound-rotor AC motors (less efficient) and cycloconverters (less efficient). Pulse Width Modulation variable speed drives are increasingly applied in many new industrial applications that require superior performance. Recently, developments in power electronics and semiconductor technology have lead improvements in power electronic systems. Hence, different circuit configurations namely multilevel inverters have become popular and considerable interest by researcher are given on them. Variable voltage and frequency supply to A.C drives is invariably obtained from a three-phase voltage source inverter. A number of Pulse width modulation (PWM) schemes are used to obtain variable voltage and frequency supply. The most widely used PWM schemes for three-phase voltage source inverters are carrier-based sinusoidal PWM and space vector PWM (SVPWM). There is an increasing trend of using space vector PWM (SVPWM) because of their easier digital realization and better dc bus utilization. SPWM only reaches to 78 percent of square-wave operation, but the amplitude of maximum possible voltage is 90 percent of square-wave in the case of space vector PWM. The maximum phase-to-center voltage by sinusoidal and space vector PWM are respectively

$$Vmax = Vdc/2 \qquad (1) \text{ for Sinusoidal PWM}$$

$$Vmax = Vdc/\sqrt{3} \qquad (2) \text{ for Space Vector PWM}$$

This means that Space Vector PWM can produce about 15 percent higher than Sinusoidal PWM in output voltage.SVPWM algorithm used in three-level inverters is more complex because of large number of inverter switching states.

II. PROPOSED ALGORITHM

Implementation of this paper on a three-phase AC Induction motor, needs a three-phase inverter with the required DC link and driving circuits, and a digital processor that supplies the PWM signals based on a selected control algorithm. Here assuming that a three-phase switching power inverter with the necessary driving circuits and DC link is available and focus on algorithm and software implementation issues. A 3-phase AC induction motor control algorithm based on the discussed constant V/Hz principle and the space vector PWM technique generally contains the following steps:

1) Configure the timers and compare units to generate PWM outputs.

2) Input the desired speed, and it is used as the set speed.

3) The motor speed is measured and is used as feedback.

4) Command frequency is obtained with a speed controller.

5) The magnitude of reference voltage vector Vout is obtained based on V/Hz profile

6) The phase of V_{out} based on command frequency is determined.

7) The sector of V_{out} is determined.

8) V_{out} is decomposed to obtain T1, T2 and T0.

9) The switching pattern or sequence to be used is determined and the calculated compare values is loaded into the corresponding compare registers. The above procedure requires a digital signal processor having all the needed timers and compare units with associated PWM outputs. The controller dsPIC30F4011 is fulfilling all the above requirements hence it is used in this implementation.

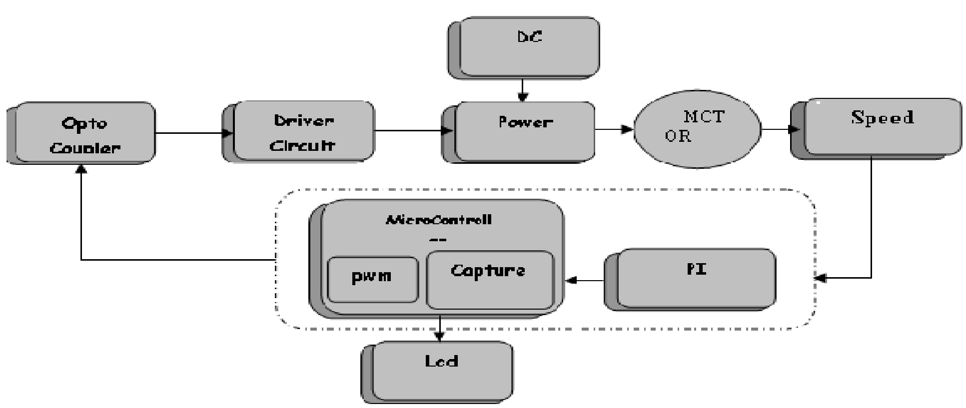

Figure1: Block Diagram

The implementation of the paper is shown in block diagram in Figure 1. DC supply is applied to microcontroller. DSPIC controller is programmed to generate a sinusoidal PWM pulses. Totally six number of pulses are generated. Three-phase inverter is used to get the three-phase output. In this inverter three branches are available. Each branch belongs to each phase. Each branch has two devices. The output of three-phase inverter having variable voltage and variable frequency. Speed control is done by varying the frequency of the system. The speed of the three-phase motor varies. If we change the frequency alone it will affect the torque of the motor. To avoid this we will change the voltage proportional to the frequency changes. This type of control maintains the motor speed constantly. The PWM pulses are given to input of optocoupler. Optocoupler is used to isolate between control circuit and power circuit. DC supply is applied to power circuit. Optocoupler output signal is inverted from original PWM input signal. Optocoupler output is given to driver circuit through NOT gate (NOT gate output signal same as the original input signal). Load is connected to across the power circuit terminals A. the PI controller is used to maintain the constant dc motor speed and motor speed is display to LCD.

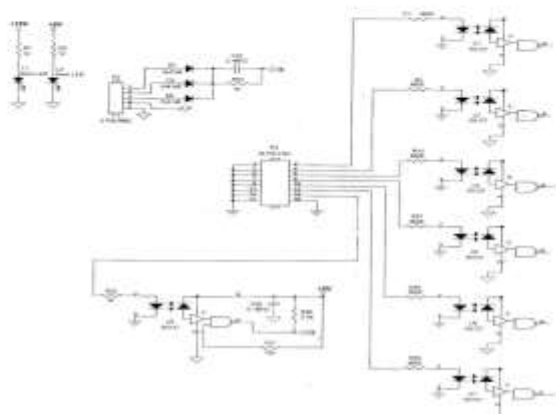

Figure 2: PWM INTERFACE THRO OPTOCOUPLE

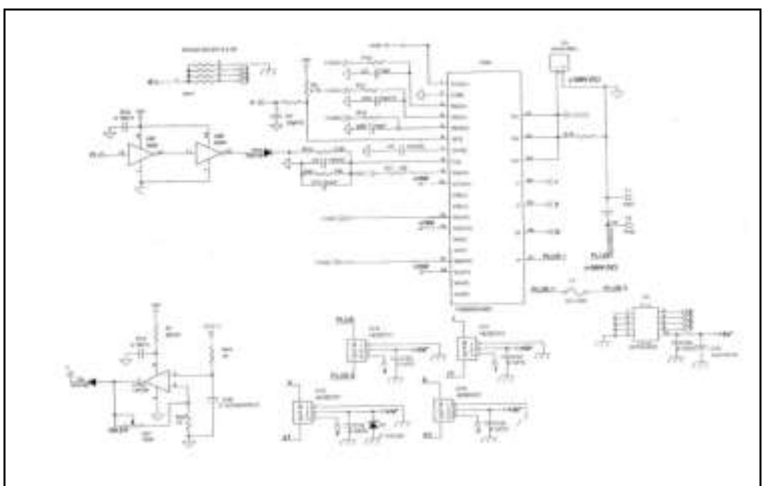

Figure 3: CIRCUIT DIAGRAM OF SWITCHING MODULE

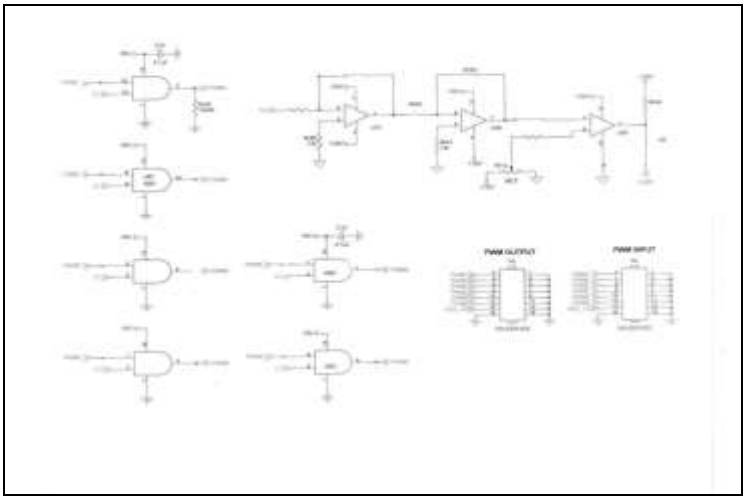

Figure 4: PWM THRO NOT GATE

Figure 5: Overall Setup

III.CONCLUSION

From above discussion Space Vector PWM is superior as compared to Sinusoidal pulse width modulation in many aspects like:

1) The Modulation Index is higher for SVPWM as compared to SPWM.
2) The output voltage is about 15% more in case of SVPWM as compared to SPWM.
3) The current and torque harmonics produced are much less in case of SVPWM.

However despite all the above mentioned advantages that SVPWM enjoys over SPWM, SVPWM algorithm used in three-level inverters is more complex because of large number of inverter switching states.

REFERENCES

[1] O. Ogasaw.vector theory," in Proc. EPE European Conf. Power Electronics and Applications, 1989, pp. 1197–1202.

[2] M. Depenbrock, "Pulse width control of a 3-phase inverter with non sinusoidal phase voltages," in Proc. IEEE-IAS Int. Semiconductor Power Conversion Conf., Orlando, FL,1975, pp. 389–398.

[3] A. C. Binojkumar, B. Saritha and G. Narayanan, "Acoustic Noise Characterization of Space-Vector Modulated Induction Motor Drives-An Experimental Approach", *IEEE Transactions on Industrial Electronics*, vol. 62.6, 2015.

[4] G. Narayanan, Di Zhao, Harish and K. Krishnamurthy, "Space Vector Based Hybrid PWM Techniques for Reduced Current Ripple", *IEEE Trans. on Ind. Electron*, vol. 55, no. 4, pp. 1614-1627, April 2008.

[5] K Zhou and D. Wang, "Relationship between space-vector modulation and Three phase carrier-based PWM: a comprehensive analysis", *IEEE Trans. Ind. Appl.*, vol. 49, no. 1, pp. 186-96, 2002.

[6] C. Charumit and V. Kinnares, "Discontinuous SVPWM techniques of three-leg VSI-fed balanced two-phase loads for reduced switching losses and current ripple", *IEEE Trans. Power Electron.*, vol. 30, no. 4, pp. 2191-2204, Apr. 2015.

[7] J. H. Seo, C. H. Choi, and D. S. Hyun, "A new simplified spacevector PWM method for three-level inverters," IEEE Transactions on Power Electronics, vol. 16, no. 4, pp. 545-550, 2001.

[8] C. Lin, X. Zhang, and Q. Jiang, "Research on SVPWM inverter output control technology," in Proc. Fifth International Conference on Measuring Technology and Mechatronics Automation, Hong Kong, 2013, pp. 927-929.

[9] Z. Zhang, M. Zhou, M. Xiang, and Y. Liu, "PSCAD/EMTDC based SVPWM inverter simulation," in Proc. International Conference on Sustainable Power Generation and Supply, Hangzhou, 2012, pp. 1-5.

[10] Texas Instruments, "Scalar (V/f) control of 3-phase induction motors," Application report SPRABQ, July 8, 2013.