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Analysis & Hardware Implementation of Three-Phase Voltage Source Inverter

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***Abstract*: -- With advances in solid-state power electronic devices and microprocessors, various pulse-width-modulation (PWM) techniques have been developed for industrial applications. For example, PWM-based three-phase voltage source inverters (VSI) convert DC power to AC power with variable voltage magnitude and variable frequency. This paper discusses three PWM techniques: the sinusoidal PWM (SPWM) technique, third-harmonic-injection PWM (THIPWM) technique & Digital PWM (DPWM) technique along with the analysis of Sensor less close-loop vector control of Induction motor drive. These PWM methods are compared by discussing their ease of implementation and by analyzing the output harmonic spectra of various output voltages and their total harmonic distortion (THD). The simulation results show that THIPWM techniques have lower total harmonic distortion than the SPWM & DPWM techniques & hardware implementation scheme for SPWM Inverter is discussed. The simulation results for Sensorless vector control are also discussed.**

***Keywords*: - SPWM Inverter; Sensor less Indirect vector control; Third harmonic injection; Three-Phase.**

I. INTRODUCTION

Pulse Width Modulated (PWM) voltage source inverters (VSI‟s) are widely utilized in ac motor drive application. Many PWM-VSI drives employ carrier based PWM methods due to fixed-switching frequency, low ripple current & well-defined harmonic spectrum characteristics. But a pulse width modulated inverter employing pure sinusoidal modulation cannot supply sufficient voltage to enable a standard motor to operate at rated power and rated speed. Sufficient voltage can be obtained from the inverter by over modulating, but this produces distortion of the output waveform [1]-[2]. In recent past, Third-Harmonic injection Pulse Width Modulation (THIPWM) switching technique is developed and widely used for three phase PWM inverter and the multilevel inverters [3]. It has been generally reported that third-harmonic injected modulation strategies offer superior performance compared to regular sampled pulse width modulation, in terms of reduced harmonic current ripple, optimized switching sequence and increased voltage transfer ratios. The voltage can be generally increased by harmonic suppression for the rectifiers as well as inverters. This can be mainly done by injecting the third harmonic component with fundamental in balanced three phase loads. At present, induction motors are the dominant drives in various industries. In recent years, demand for power converters that operate in high switching speed, low voltage with high power efficiency has become very high. The aim of this paper is to develop a vector controlled induction motor drive operating without a speed or position sensor but having a dynamic performance comparable to a sensored vector drive. Vector control of induction motor is based upon the field-oriented co-ordinates aligned in the direction of the rotor m.m.f. However, there is no direct means of measuring the rotor flux linkage position Ψ and therefore an observer is needed to estimate Ψ for the implementation of sensorless vector control. With the help of synchronous reference frame model the indirect field oriented vector control, which is very popular and convenient method in real time implementation was developed.

II. GENERAL THEORY OF VOLTAGE SOURCE INVERTER

Voltage source inverters as the name indicate, it receives dc voltage at one side and convert it to ac voltage on other side. According to the type of ac output waveform, these topologies can be considered as voltage source inverters (VSIs), where the independently controlled ac output is a voltage waveform. The ac voltage and the frequency may be variable or constant depending on the application. A voltage fed inverter should have a stiff voltage source at the input i.e. its Thevenin impedance should be ideally zero. A large capacitor can be connected at the input if the source is not stiff. Three phase bridge inverter are widely used for ac motor drives and general purpose ac supplies. Fig 1 shows the inverter circuit suppling a star connected load. The circuit consist of three half bridge, which are mutually phase shifted by 2π/3 angle to generate the three phase voltage waves.

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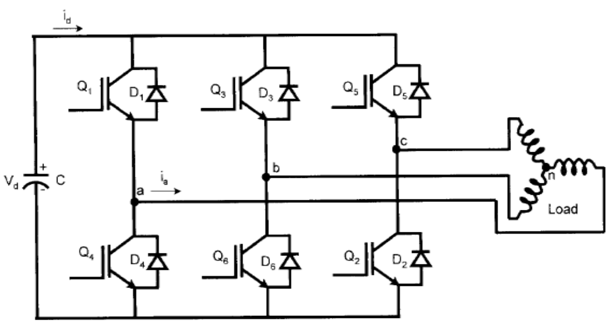

Fig 1: Circuit configuration of VSI.

The three phase bridge inverter is basically a six step bridge inverter. A step means firing of next SCR in the sequence. Thus in a cycle (360°), firing of six SCRs in a particular sequence forms six steps. Therefore, each firing is delayed by 60° from earlier firing. It means that the SCRs are fired at regular interval of 60º in a particular sequence to synthesize three phase voltage at the output terminals. The diodes used in the circuit are feedback diodes. The capacitor at input terminals helps to maintain constant dc supply voltage to inverter. This capacitor also helps to suppress harmonics resulting from inverter operation and prevent them from reaching to DC source. The three phase load connected at output terminals a, b, c is assumed to be a star or delta connected purely resistive load.

III. DIFFERENT PULSE-WIDTH MODULATION TECHNIQUES

Up to date, due to the improvement of fast-switching power semiconductor devices and machine control algorithm, more precise PWM (Pulse Width Modulation) method finds particularly growing interest. The used PWM techniques are:

1 Sinusoidal pulse width modulation (SPWM)

2. Third Harmonic Injection pulse width modulation (THIPWM)

3. Digital pulse width modulation (DPWM)

4. Sensorless Indirect Vector Control of Induction motor drive

3.1 Sinusoidal Pulse Width Modulation

The sinusoidal pulse-width modulation (SPWM) technique produces a sinusoidal waveform by filtering an output pulse waveform with varying width. A high switching frequency leads to a better filtered sinusoidal output waveform. The variations in the amplitude and frequency of the reference voltage change the pulse-width patterns of the output voltage but keep the sinusoidal modulation. As shown in Figure 2, a low-frequency sinusoidal modulating waveform is compared with a high-frequency triangular waveform, which is called the carrier waveform. The switching state is changed when the sine waveform intersects the triangular waveform. The crossing positions determine the variable switching times between states.

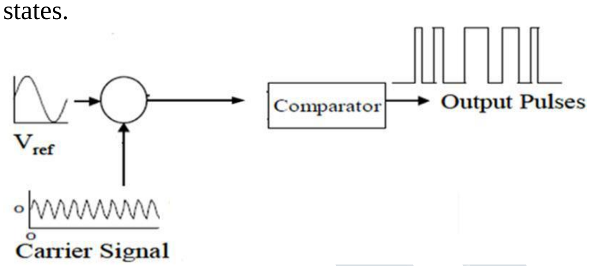

Fig 2: Block diagram for generation of SPWM pulses

The gating signals can be generated using unidirectional triangular carrier wave as shown in the figure 3. But a pulse width modulated inverter employing pure sinusoidal modulation cannot supply sufficient voltage to enable a standard motor to operate at rated power and rated speed. Sufficient voltage can be obtained from the inverter by over modulating, but this produces distortion of the output waveform. The linear output range of SPWM is restricted to 0.785 compared with six step inverter. The non-linear region operation (over-modulation) is leading to large amounts of sub carrier frequency harmonic currents, reduction in fundamental voltage gain and switching device gate pulse dropping.

3.2 Third-Harmonic Injection Pulse Width Modulation

The third – harmonic PWM is similar to the selected harmonic injection method & it is implemented in the same manner as sinusoidal PWM. The difference is that the reference ac waveform is not sinusoidal but consists of both a fundamental component and a third-harmonic component. As a result, the peak-to-peak amplitude of the resulting reference function does not exceed the DC supply voltage Vs, but the fundamental component is higher than the available supply Vs. The block diagram for Third Harmonic Injection is shown below in figure 4.

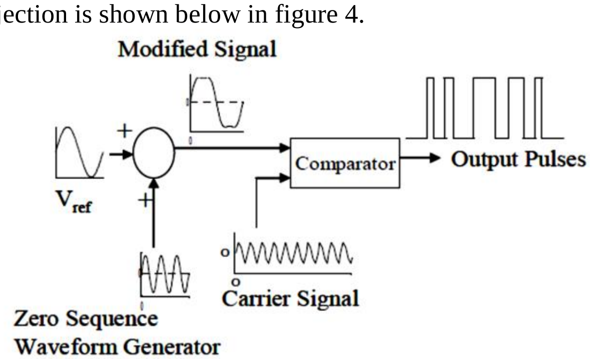

Fig 4: Block diagram for generation of THIPWM pulses

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The reference voltage Vref is added with signal having frequency three times of fundamental frequency and the magnitude is 1/6th of the fundamental amplitude. The resultant is then passed through comparator which compares the modified signal with the carrier signal of frequency 2 KHz. The presence of exactly the same third-harmonic component in each phase results in an effective cancellation of the third harmonic component in the neutral terminal, and the line-to-neutral phase voltages are all sinusoidal with the peak amplitude. By injecting the third harmonic into the reference voltage signal, the fundamental of the phase voltage can be increased. The voltage can be increased by harmonic suppression for the rectifiers as well as inverters. This can be mainly done by injecting the third harmonic.

3.3 Digital Pulse Width Modulation

In recent years, the interest on digital control for switching power converters has grown considerably. In order to reduce limit cycle oscillations, high resolution digital pulse width modular (DPWM) is mandatory for the system implementation especially for the applications with high switching frequency and tight output regulation.

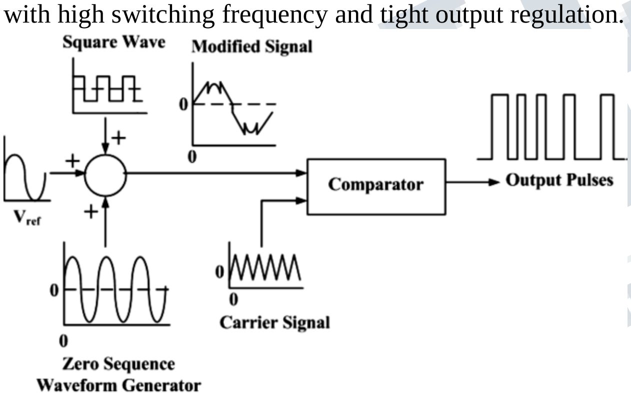

Fig 6: Block diagram for generation of DPWM pulses

DPWM scheme is used to improve resolution while keeping relative low cost. For the method of dithering DPWM, it increases the resolution by averaging several adjacent switching periods‟ duty cycle values;
hence, a large magnitude output ripple is resulted although the limit-cycle oscillation could be reduced.

3.4 Sensor less Indirect Vector Control of Induction Motor Drive

Sensor less vector control induction motor drive essentially means vector control without any speed sensor. A speed signal is also required in indirect vector control in the whole speed range and in direct vector control for the low speed range, including the zero speed start up operation. Speed encoders undesirable in a drive because it adds cost and reliability problems, besides the need for a shaft extension and mounting arrangement. Controlled induction motor drives without mechanical speed sensors at the motor shaft have the attractions of low cost and high reliability. To reduce total hardware complexity, costs and to increase mechanical robustness, it is desirable to eliminate speed and position sensors in vector-controlled drives. To replace the sensor the information on the rotor speed is extracted from measured stator voltages and currents at the motor terminals. The operation of speed controlled ac drives without mechanical speed or position sensors requires the estimation of internal state variables of the machine. The assessment is based exclusively on measured terminal voltages and currents. Speed estimation is an issue of particular interest with induction motor drives where the mechanical speed of the rotor is generally different from the speed of the revolving magnetic field.

IV. CONCLUSION

The Voltage source inverter operation with SPWM, THIPWM & DPWM is simulated and their performance has been presented. The effectiveness of THIPWM technique in this operation improves the inverter output rms voltage for a given DC bus voltages as compare to SPWM & DPWM. Thus it gives effective utilization of the inverter and enhancement of rms content of the output voltage. From the simulation results of Indirect vector control of Induction motor drive, it can be observed that, in steady state there are ripples in torque wave and also the starting current is high. The main results obtained from the Simulation, the following observations are made.
i) The transient response of the drive is fast, i.e. we are attaining steady state very quickly.
ii) The speed response is same for both vector control and Sensor less control.
iii) By using Indirect vector control, we are estimating the speed, which is same as that of reference speed of induction motor.
Thus by using sensor less control we can get the same results as that of vector control without shaft encoder. Hence by using this proposed technique, we can reduce the cost of drive i.e. shaft encoder‟s cost, we can also increase the ruggedness of the motor as well as fast dynamic response can be achieved.

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REFERENCES

[1] Mr. JOBY JOSE, Prof. G.N.GOYAL and Dr. M.V.AWARE "Improved Inverter Utilization Using Third Harmonic Injection".

[2] Srinivasa Rao Maturu* and Avinash VujjiDing, "SVPWM Based Speed Control of Induction Motor Drive with Using V/F Control Based 3-Level Inverter" VSRD-IJEECE, Vol. 2 (7), 2012, 421- 437

[3] Prof. G.N.GOYAL and Dr. M.V.AWARE "A Comparative Performance of Six-Phase Nine Switch Inverter Operation with SPWM and SVPWM"

[4] Yang Qiu, Jian Li, Ming Xu, Dong S. Ha, Fred C. Lee "Proposed DPWM Scheme with Improved Resolution for Switching Power Converters" at Center for Power Electronics Systems Virginia Polytechnic Institute and State University Blacksburg, VA 24061 USA

[5] Yunxiang Wu, Mohsin A. Shafi, Andrew M. Knight and Richard A. McMahon "Comparison of the Effects of Continuous and Discontinuous PWM Schemes on Power Losses of Voltage-Sourced Inverters for Induction Motor Drives", IEEE TRANSACTIONS ON POWER ELECTRONICS, VOL. 26, NO. 1, JANUARY 2011

[6] Cristian Aghion, Mihai Lucanu, Ovidiu Ursaru "Gh. ASACHI" Technical University of Iasi Faculty of Electronics, Telecommunications and Information Technology, "DPWM-S3 Software Control for Three-phase Inverters" .

[7] Lu-Sheng Ge, Zong-Xiang Chen, Zhi-Jie Chen and Yan-Fei Liu1, (Senior Member, IEEE) "Design and Implementation of A High Resolution DPWM Based on A Low-Cost FPGA"

[8] Pardasani Hitendra K. Arora Kapildev N. "Simulation of Three Level Inverter Using Sinusoidal Pulse Width Modulation Technique by MATLAB," National Conference on Recent Trends in Engineering & Technology

[9] Mahrous E. Ahmed & Saad Mekhilef "Three-Phase Three-Level Nine Switches Inverter Employing Space Vector Modulation".

[10]Sharad.S.Patil, R.M.Holmukhe , P.S.Chaudhari "Steady state analysis of PWM inverter fed cage induction motor drive" Proceedings of International Conference on Energy Optimization and Control (ICEOC-2010) December 28 - 30.2010. Aurangabad, Maharashtra, India

[11] Bimal K.Bose „Modern Power Electronics and AC Drives‟ Pearson Education, Singapore.2003

[12] M.H.Rashid, „Power Electronics: Circuits, Devices and Applications‟, Pearson Education, 2004

