Design and Simulation of a Fuzzy Based SVPWM Fed H-Bridge Drive in Hybrid Vehicles

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ABSTRACT

This paper presents a design and simulation of modulation and Fuzzy control strategies are plays main role to minimize THD in Multilevel inverter. These modulation techniques include Sinusoidal Pulse Width Modulation (SPWM) and Selective harmonic Elimination and Space Vector Pulse Width Modulation (SVPWM).Multilevel inverters have tremendous application in the area of high-power and medium-voltage energy control. This paper presents a model simulation of Fuzzy based SVPWM is performed for cascaded H-bridge inverter in hybrid vehicles. The Simulation of various levels of cascaded H bridge inverter with Space vector PWM has been carried out. The Implementation and simulation of SVPWM inverter are presented to realize the validity of the Fuzzy based SVPWM technique.

Key Words: Pulse Width Modulation (PWM), SPWM, Sinusoidal Pulse Width Modulation (SVPWM).

I. INTRODUCTION

Numerous industrial applications require higher power apparatus in recent years. Some medium voltage motor drives and utility applications require medium voltage and megawatt power level. A multilevel power converter structure has been introduced as an alternative in high power and medium voltage situations Subsequently, several multilevel converter topologies have been developed.A multilevel converter not only achieves high power ratings but also enables the use of renewable energy sources. The advantages of three-level Inverter topology over conventional two-level topology are 1)The voltage across the switches is only one half of the DC source voltage 2)The switching frequency can be reduced for the same switching losses 3)The higher output current harmonics are reduced by the same switching frequency.

The cascaded H bridge inverter has the advantage of a reduction in switch count and more effective utilization of the natural switching speed and voltage-blocking characteristics of the different types of power electronic devices that are used. The most common strategy used for the cascaded H bridge inverter is the phase shifted carrier PWM, which provide improved harmonic performance when each single-phase inverter is controlled using three-level modulation [1].Although the cascaded H bridge inverter has an inherent self-balancing capability, because of the losses in circuit component and limited controller resolution, a slight voltage imbalance can occur. The simple control block with PI regulator to adjust the trigger angle and to ensure zero steady-state error between the reference dc voltage and the dc-bus voltage can ensure the dc voltage balance, reactive and harmonic compensations [2].An automatic voltage balance can be achieved by supplying voltage to cascaded H bridge inverter by using a high-frequency link which generates all the isolated dc supplies. Therefore low and constant THD at all operating ranges can be obtained [3]. The cascaded H bridge multilevel inverter can be used for high power applications with novel MMC-based frequency changing conversion scheme [4].The modulation methods used in multilevel inverters can be classified according to switching frequency. The existing system used Space vector PWM contol with less number of sectors whereas in proposed system number of sectors used is more to the THD.

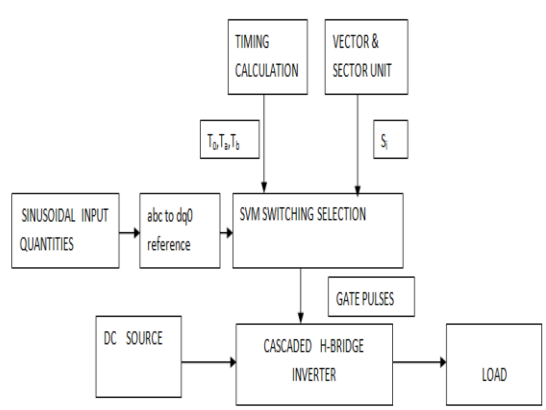


Fig1. Schematic diagram of a proposed Cascaded H-bridge inverter with Space Vector PWM control.

The dc input to the inverter is "chopped" by switching devices in the inverter (bipolar transistors, thyristors, Mosfet, IGBT …etc).The amplitude and harmonic contents of the ac waveform are controlled by controlling the duty cycle of the switches. This is the basic of the pulse width modulation (PWM) techniques. There are several PWM techniques each has its own advantages and also disadvantages. The basic PWM techniques are described briefly in the following subsections. The considered PWM techniques are:

1) Sinusoidal PWM
2) Hysteresis band current control
3) Space-Vector PWM

A. Sinusoidal PWM

The most popular PWM approach is the sinusoidal PWM. In this method a triangular (carrier) wave is compared to a sinusoidal wave of the desired fundamental frequency and the relative levels of the two signals are used to determine the pulse widths and control the switching of devices in each phase leg of the inverter.

II. RELATED WORK

Hysteresis-band current control

In hysteresis-band current control the actual current tracks the form of command current within a hysteresis band. In this approach the reference current wave is compared to the actual current wave thus producing the current error .When the current error exceeds a predefined hysteresis band, the upper switch in the half-bridge is turned off and the lower switch is turned on. As the current error goes below the hysteresis band, the opposite switching takes place. The principle of hysteresis band current control is illustrated in Fig. 3.Hysteresis-band current control is very popular because it is simple to implement, has fast transient response, direct limiting of device peak current and practical insensitivity to machine parameters because of the elimination of any additional current controllers. However, PWM frequency is not fixed which results in non-optimal harmonic ripple in machine current.

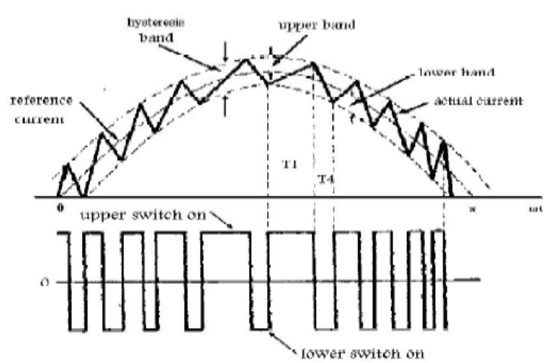


Fig. 3 Principle of hysteresis band current control.

Space vector pulse width modulation

Space vector PWM refers to a special switching scheme of the six power semiconductor switches of a three phase power converter. Space vector PWM (SVPWM) has become a popular PWM technique for three-phase voltage source inverters in applications such as control of induction and permanent magnet synchronous motors.

The mentioned drawbacks of the sinusoidal PWM and hysteresis-band current control are reduced using this technique. Instead of using a separate modulator for each of the three phases the complex reference voltage vectors processed as a whole. Therefore, the interaction between the three motor phases is considered. It has been shown, that SVPWM generates less harmonic distortion in both output voltage and current applied to the phases of an ac motor and provides a more efficient use of the supply voltage in comparison with sinusoidal modulation techniques.

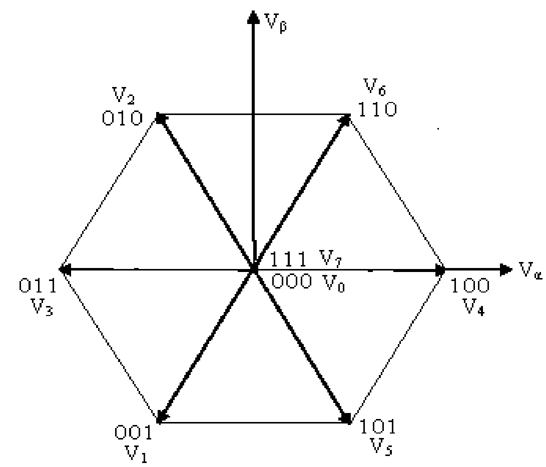


Fig. 4 Non-zero vectors and zeroVectors forming a hexagon

III. SIMULATION RESULTS

The main aim of any modulation technique is to obtain variable output having maximum fundamental component with minimum harmonics. The objective of Pulse Width Modulation techniques is enhancement of fundamental output voltage and reduction of harmonic content in Three Phase Voltage Source Inverters. In this paper Space Vector PWM techniques for different levels are compared in terms of Total Harmonic Distortion (THD).

A Simulation of SVPWM

Space vector PWM is an advanced technique used for variable frequency drive applications. It utilizes dc bus voltage more effectively and generates less THD in the Three Phase Cascaded H bridge inverter. SVPWM utilize a chaotic changing switching frequency to spread the harmonics continuously to a wide band area so that the peak harmonics can be reduced greatly. Simulation has been carried out by varying the modulation index between 0and 1. Finally performance of SVPWM is improved in fivel level with 12 sector when compared to three level inverter with 6 sector.

The Block Diagram of Space Vector Pulse width modulated inverter fed RL load is shown in Figure 5. In SVPWM methods, the voltage reference is provided using a revolving reference vector. In this case magnitude and frequency of the fundamental component in the line side are controlled by the magnitude and frequency, respectively, of the reference voltage vector. Space vector modulation utilizes dc bus voltage more efficiently and generates less harmonic distortion in a three phase voltage source inverter and multi level inverter.

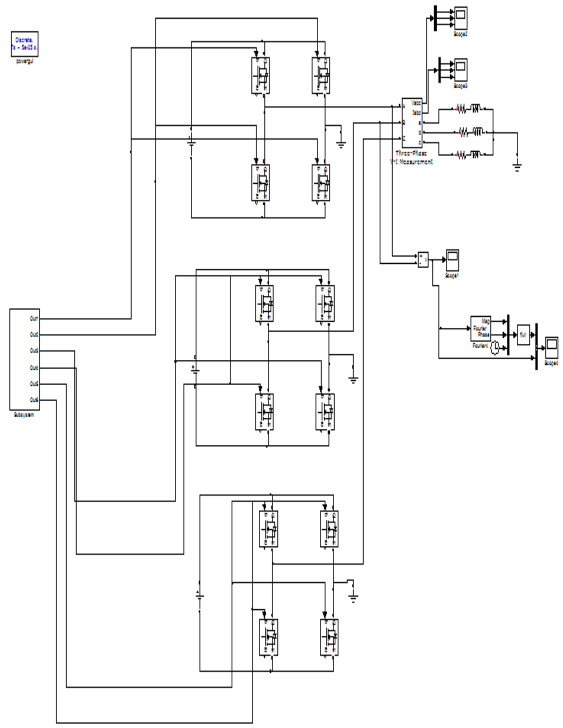


Fig 5.Simulink block diagram of three level Cascaded H Bridge Inverter.

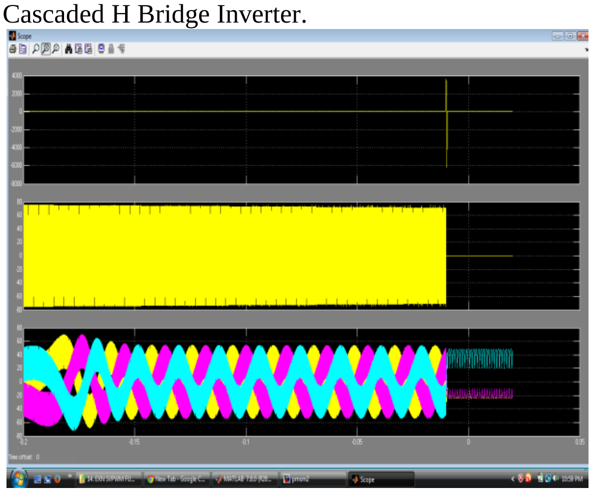
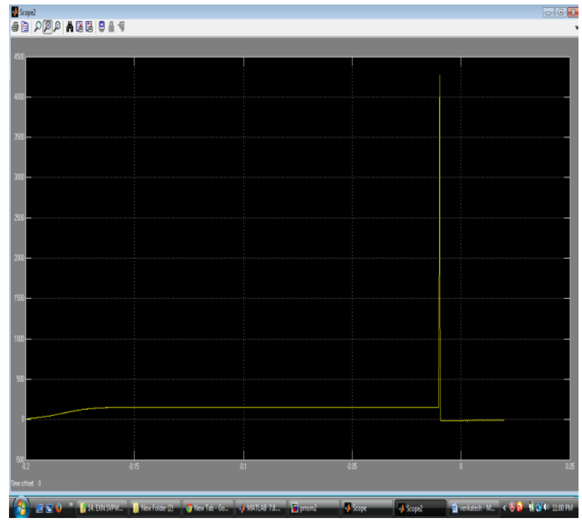


Fig. 6. Zero-sequence current at *T*em = 60 N · m (200 rpm/2000 rpm).



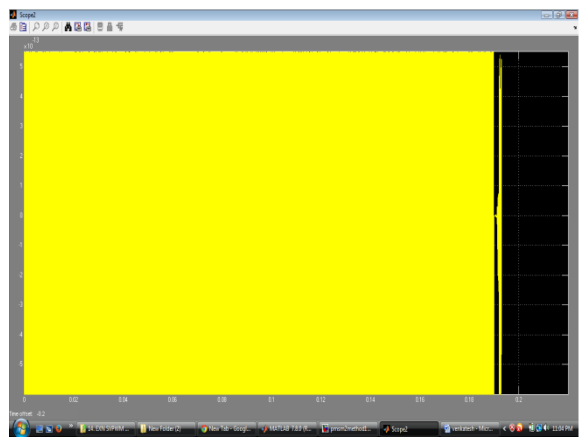


Fig. 7. SVPWM methods comparison in self-control mode.

IV. CONCLUSION

The objective of the Fuzzy based (SVPWM) Space vector Modulation Technique has become the most popular and important PWM technique for Three Phase Voltage Source Inverters for the control of AC Induction Brushless DC Switched Reluctance and Permanent Magnet Synchronous Motors (PMSM). This paper first introduce the comparative analysis of Fuzzy based SVPWM with different sectors is carried out. The model Simulation study reveals that Fuzzy based SVPWM gives 11.58% THD for seven level and 26.4 % for three level cascaded H-bridge inverter enhanced fundamental output with better quality i.e. lesser THD compared to SVPWM. The SVPWM are implemented in MATLAB/SIMULINK software. The proposed Fuzzy based SVPWM utilize a changing carrier frequency to spread the harmonics continuously to a wideband area so that the peak harmonics are reduced.

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