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A Survey on Sinusoidal PWM Technique for VSI Fed To Induction Motor

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ABSTRACT

In this project, sinusoidal pulsewidth modulation (SPWM) technique for Voltage Source Inverter (VSI) to induction motor or with different load is proposed. The Voltage Source Inverters(VSI) using the proposed SPWM technique can generate output voltage & current waveform for the different load.

In the medium voltage adjustable speed drive market, the various topologies have evolved with various components, design, and reliability. The two major types of drives are known as voltage source inverter (VSI) and current source inverter (CSI). In industrial markets, the VSI design has proven to be more efficient, have higher reliability and faster dynamic response, and be capable of running motors without de-rating.

Medium voltage adjustable speed drive (MV-ASD) systems offer significant advantages in fan, pump and many process control applications with higher efficiencies combined with energy savings over a wide range of speed settings. MV-ASD systems continue to grow at a steady rate of 9% and find expanding applications. Commercial MV-ASD systems are both current source inverter (CSI) and voltage source inverter (VSI).

Voltage source inverter (VSI) is to convert a fixed dc voltage to a three phase ac voltage with variable magnitude and frequency. This project focus on pulsewidth modulation (PWM) schemes for high power two level inverter , where the device switching frequency is normally below or equal to 1KHz.

In this project, sinusoidal pulsewidth modulation (SPWM) technique for Voltage Source Inverter (VSI) to induction motor or with different load is proposed. The Voltage Source Inverters(VSI) using the proposed SPWM technique can generate output voltage & current waveform for the different load.

Keywords: Sinusoidal pulsewidth modulation (SPWM), voltage source inverter (VSI), Induction Motor, different load(L, R & C load).

I. INTRODUCTION

Due to various aspect in starting of motors in this project are studied the different load and aspects to other simulation [1] In this hybrid PMW technic reduction of torque ripple in voltage source inverter fed induction motor drives [2]in this PWM technique for nth harmonic injection for n-phase VSIs. The simulation results are obtained for 5, 7 and 9-phase VSIs [3]in this proposed for detecting

IGBT open circuit faults. The method is an extension of the traditional three-phase average current method.[4] Random PWM with saw tooth carrier is proposed in the paper. Compared to sinusoidal PWM, the performance of saw tooth carrier based RPWM is improved in terms of fundamental voltage and Total Harmonic Distortion.[5] Traditional voltage source inverter (VSI) used to drive a three phase induction motor (IM) is a two level inverter. Various control techniques are employed to improve the DC-link utilization and to reduce the DC-link voltage. Lower DC-link voltage reduces the voltage stress across active switches and passive elements, thereby increasing the inverter reliability

II. VOLTAGE SOURCE INVERTER

The VSI that transforms the input dc lick voltage into the three phase balanced ac output voltages required by the load. the use of voltage source type inverters with (PWM) of the line voltages for improved performance. In addition to these advantages, the voltage source approach offers improved system reliability and capability of sustained regeneration. The main downside of VSI lies in its narrow dynamic concert. The effect varies with changes in working conditions and system parameters, causing the design of a wide-bandwidth controller with fast dynamic response to be difficult.

An idealized PWM VSI is in Figure 2.1. the converter is cucumed of six IGBT switches. The inverter produces a defined PWM output voltage. On the DC side of the converter is an ideal dc voltage source Vd. The voltage source inverter normally required a 3ᶲ capacitor at its output to help the commutation of the switching devices. The capacitor provides a current track for the energy hugged in, it also work as a harmonics filter, advanced the load current and voltage sinusoidal form. The new IGBT VSI with sinusoidal PWM control techniques is put ahead, for the purpose of supplying both the alternating turnout voltage and current to the motor. The resonance current is reduced by the addition of PWM control.

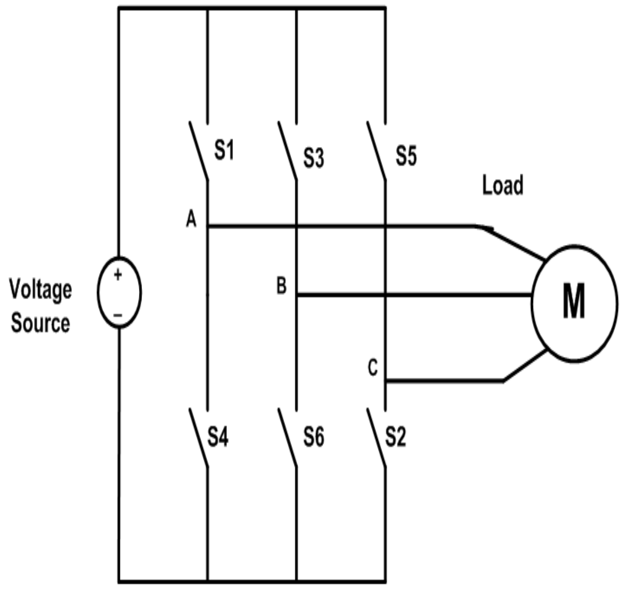

Figure 1. PWM Voltage Source Inverter

Above inverter comprises a constant dc power supply, an inverter section to convert the dc power to the variable voltage variable frequency ac power and an induction motor at the load side. Moreover, three capacitors are connected to the ac output terminals to absorb the over voltages which occur when the current is cutoff.

2.2. COMPARISION BETWEEN VSI & CSI

The following Table 2.1 shows the comparison between VSI & CSI

VSI	CSI

(1) Input voltage is maintained constant & input current may or may not be constant. (2) The amplitude of output voltage does not depend on the load. However, he amplitude and waveform of output current depends upon the load. (3) The misfiring of switching devices may cause short circuit across the source and create serious problem. (4) VSI create serious problem against a short circuit across motor terminals. (5) VSI is less reliable.	(1) Input current is maintained constant& input voltage may change with load. (2) The amplitude of output current is independent of load. However, the amplitude and waveform of output voltage depends upon load. (3) Input current is maintained constant, misfiring switching devices or short circuit across source would not be a serious problem (4) CSI gives inherent protection against a short circuit across motor terminals. (5) CSI is more reliable than VSI.

2.3. VOLTAGE CONTROL IN INVERTERS

The voltage control in the inverter is essential due to the following reasons;

(1) In VSI, the output AC voltage depends upon the input voltage.

(2) Voltage control is essential, to compensates the variation in input dc voltage, so as to provides fixed ac output voltage.

(3) Voltage control is essential, for voltage regulation of the inverter under the various loading condition.

(4) If, the inverter supplies induction motor, the voltage to frequency ratio must be maintained constant at the motor terminal, therefore the voltage control is essential.

The control over the O/P voltage of the converter can be acquired by following two ways:

(i) External Control

(a) Outward controlling the AC O/P voltage

(b) Outward controlling the DC I/P PD

(ii) Intramural Control

2.3.1 OUTWARD CONTROLLING THE AC O/P VOLTAGE

In this technique, an alternating current voltage controller is used between inverter and load, as in figure 2. An inverter is supplied with constant dc voltage, output ac voltage of the converter is fed to ac controller and output voltage of ac controller, which is a controlled ac voltage is fed to load.

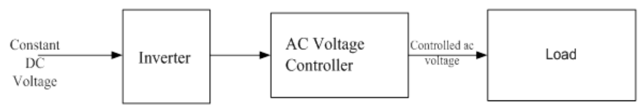

Figure 2. Externally Controlling Ac Output Voltage Of Inverter.

In ac controller, by phase angle control, the voltage is controlled. When output voltage required to be low, this control gives rise to higher harmonics content in output voltage, hence this method is rarely employed in high power application . However, this method is accepted in low power application.

2.3.2 EXTERNALLY CONTROLLING THE DC INPUT VOLTAGE

For Acquiring control over output potential difference of inverter, the input dc voltage of inverter is steer by following methods, as in figure 2.

(1) Obtaining controlled dc supply for inverter from fully controlled rectifier and filter (Figure 2.a)

(2) Obtaining steer dc supply for converter from uncontrolled rectifier, chopper and filter. (Figure 2.b)

(3) Obtaining controlled dc supply for inverter from AC voltage controller, uncontrolled rectifier and filter.(Figure 2.c)

(4) Obtaining controlled dc supply for inverter from chopper and filter. (Figure 2.d)

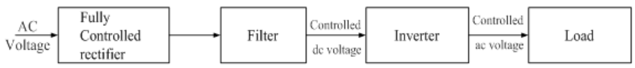

Figure 2.a

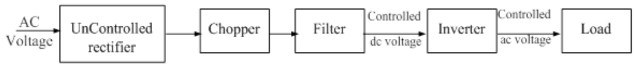

Figure 2.b

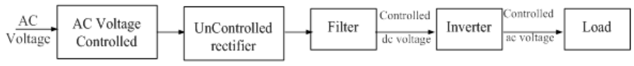

Figure 2.c

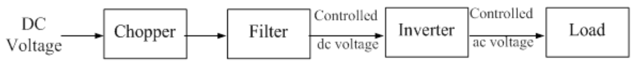

Figure 2.d

Figure 2. Externally controlling dc input voltage to inverter.

These method have an advantage that the harmonics content and output voltage waveform are not affected appreciably, as the output voltage is not directly controlled. It is controlled through the control over input dc voltage.

2.3.3 INTERNAL CONTROL

The O/P voltage of an inverter can be steer by the operation of inverter itself. The control is inside the inverter itself. The most methodical steer of controlling the O/P voltage is used PWM inside the inverter. In this technique, the ON & OFF periods are adjusted to control the output voltage.

2.4 CHARACTERISTICS OF A PWM VOLTAGE SOURCE INVERTER

Simple Converter Topology: The IGBT devices used in the inverter are of symmetrical type, which do not require anti-parallel freewheeling diodes.

Motor Friendly Waveforms: The voltage source inverter produces a three phase PWM voltage instead of PWM current as in CSI. With the filter capacitor installed at the inverter output , the load current & voltage waveform are close to sinusoidal. The high dv/dt problem associated with the VSI does not exist in CSI.

Reliable Short-Circuit Protection: In case of a short circuit at the inverter output terminals, the rate of rise of the dc voltage is limited by the dc choke, allowing sufficient time for the protection circuit to function.

III. PULSEWIDTH-MODULATION TECHNIQUES

The available PWM techniques can be categorized into two kinds: one is an on-line generation technique and the other is an off-line generation technique. The pre-calculated off-line PWM switching patterns are usually optimized to eliminate a certain order of harmonics. But, the trade off is slow dynamic response and imprecise control of the ac line current.

For the online generated PWM switching patterns, two types can be realized: the carrier-based PWM and space vector (SV)-based PWM. The carrier-based Pulse Width Modu is produce by comparison of triangle carrier wave and sine modulating wave. This method is easy to apply by analog circuitry. The SV-based PWM utilizes the space vector concept, and it can easily be apply by a microprocessor or a digital signal processor.

In most applications, “carrier-based PWM technique” is used to steer the inverter switches due to its low-harmonic distortion characteristics and constant switching frequency. This technique employs “the per-carrier cycle volt-second balance principle” to generate a desired inverter output voltage. As the principle, in a PWM period, the Avg value of the O/P rectangular voltage pulses is same to the desirable voltage value . Sinusoidal PWM (SPWM), which is the simplest PWM method, has been used for many decades. However, in 3ϕ, 3-wire inverter applications such as AC motor drives, the inverter staging can be significantly improved by modification of the SPWM pulse pattern.

While this enlarge switching frequency reduces harmonics, emerge in a lower THD by which high excellent O/P voltage waveforms of desired fundamental r.m.s value and frequency which are as close as possible to sinusoidal wave. There are divers PWM methods proffer in the belles-letters which differ in idiom of their voltage linearity range, DC bus and AC output current ripple, switching losses, high frequency CMV.

3.1 DIFFERENT PWM TECHNIQUES

- ✓ Single Pulse-Width-Modulation.
- ✓ Multiple Pulse-Width-Modulation.
- ✓ Sinusoidal Pulse-Width-Modulation.
- ✓ Space Vector Pulse-Width-Modulation.
- ✓ Phase-displacement control.
- ✓ Ramp Type Pulse-Width-Modulation.
- ✓ Trapezoidal Pulse-Width-Modulation.
- ✓ Selective Harmonics Elimination Pulse-Width-Modulation.
- ✓ Random Pulse-Width-Modulation.

IV. SINUSOIDAL PWM TECHNIQUES

4.1. Sinusoidal PWM Concept

The sinusoidal SPWM technique generate a sinusoidal waveform by riddle an O/P pulse waveform with alter width. A high redirect frequency leads to a better riddle sinusoidal O/P waveform. The covet O/P voltage is achieved by alter the frequency and peak of a aludance or modulating voltage. The changes in the peak and frequency of the ref voltage change the PW patterns of the O/P voltage but keep the sinusoidal modulat.

As shown in Figure 3, a low-frequency sinusoidal transmogrify oviform is corelated with a high-frequency triangular oviform, which is called the carrier oviform. The switching state is retoted when the sine oviform intercross the triangular oviform. The crossing tract determine the iffy switching times between states.

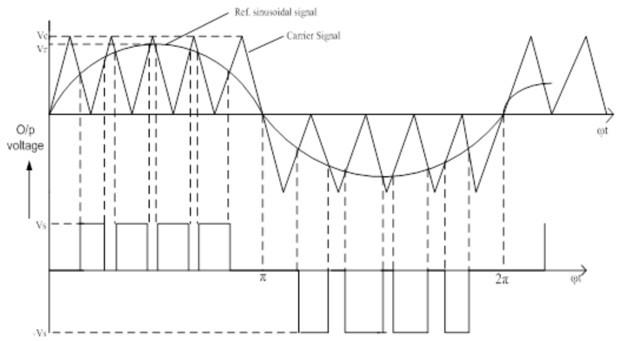

Figure 3. Sinusoidal Pulse-Width Modulation (Spwm).

Figure 5.1.shows reference sinusoidal modulating wave V_r and the triangular carrier wave V_c. The fundamental frequency inherent in the inverter O/P voltage can be steer by Amplitude modulation index, m_a.

$$m_a = \frac{V_r}{V_c}$$

The amplitude modulation index m_a is usually adjusted by varying Vc while keeping Vr fixed. The frequency modulation index is defined by m_f,

$$m_f = \frac{f_c}{f_r}$$

Where f_c and f_r are the frequencies of carrier & reference waves.

The operation of switching is determined by comparing the reference modulating waves with the carrier wave . when$V_r \geq V_c$ the upper switch in inverter leg is turned on. The lower switch operates in a complementary way and thus is switch off. When $V_r < V_c$, lower switch is off, Since the waveform has only two level, the inverter familiar as a 2-level inverter. It should be recognized that to elude possible S.C during veer transient of the upper and lower devices in an inverter leg, a blanking time should be put in effect, during which both veer are turned off.

The magnitude and frequency of can be independently steer by m_a and f_r respectively. The converting frequency of the active veer in the two level converter can be found from,

$$f_{sw} = f_c = f_r \times m_f$$

4.1.1 HARMONIC ANALYSIS

With the help of Sine PWM scheme the harmonic analysis of the following observation can made:

The distortion aspects is significantly decrees compared to that of diverse pulse modulation.

All harmonics less than or equal to 2p-1 are eliminated.

For modulation index M<1, the imperious harmonics are of the order of 2p±1.

For modulation index M>1, since pulse-width is formerly a sinusoidal role of the angular locus of pulse, the lower order harmonic appear.

Higher no. of pulses per 1/2 cycle p, minimizes the filtering requirement, but result in high switching frequency, high switching losses and low inverter efficiency.

4.2STUDY & SIMULATION OF SPWM VOLTAGE SOURCE INVERTER

The given fig shows Voltage Source Inverter with sinusoidal PWM Techniques. The O/P Voltage of an inverter can be steer by controlling the activity of inverter itself. The most valuable method of steer the O/P voltage is use PWM technique within the inverter.

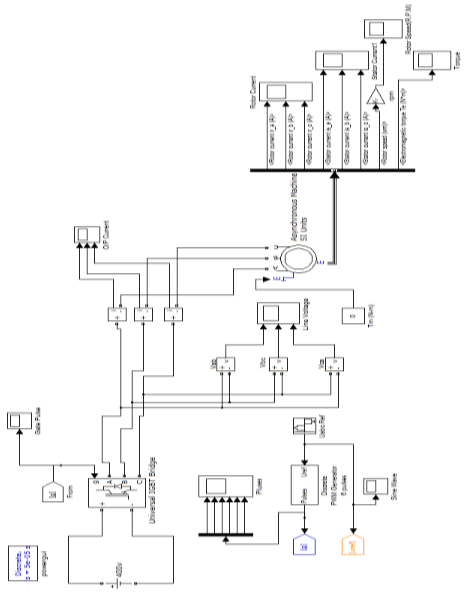

Figure 4. Simulated Model Of VoltageSource Inverter Fed To A Induction Motor With SPWM.

In a given simulated model, the main system block is the VSI that transforms the input dc lick voltage into the three phase balanced ac output voltage appropriate by the motor load. To improve the attainment characteristics of the VSI, the traditional six-step voltage control method has been replaced with the optimum PWM method with sinusoidal pulse width modulation, asshown in Figure 5.2. The resulting VSI structure yields input dc lick voltage and output voltage & current waveforms which do not contain low order harmonics. These features, in turn, result in proportional size reductions for the inverter I/P and O/P filters. Moreover, since the inverter line currents contain only high-frequency harmonic components which are subsequently filtered (i.e bypassed) the voltage accentuation on the inverter components have been minimized.

The proposed PWM VSI supplies variable amplitude variable frequency sinusoidal voltage and contributes to the absence of harmonic copper/core losses, torque pulsations, acoustic noise associated with typical PWM voltage fed machines.

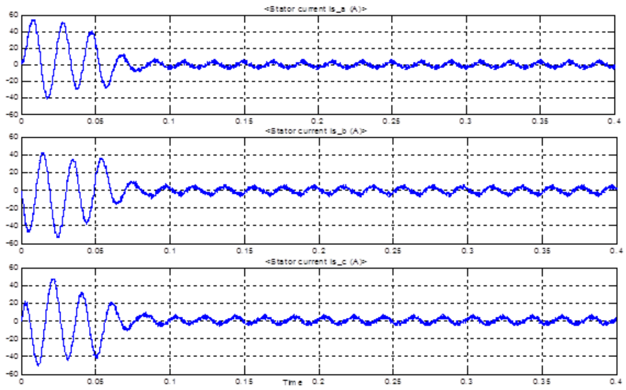

Figure 5. Simulated Stator Current Of A SPWM VSI Fed To A Induction Motor.

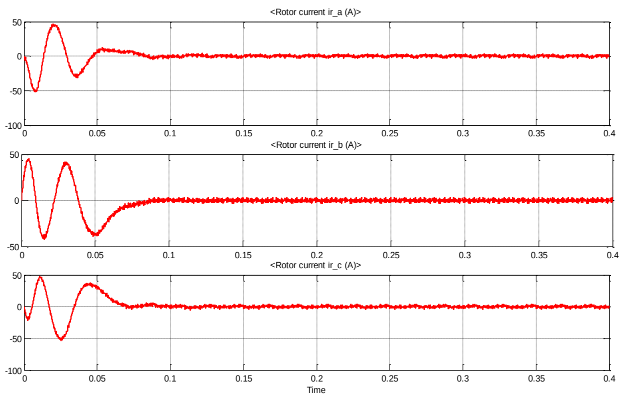

Figure 6. Simulate Rotor Current Of A SPWM VSI Fed To A Induction Motor.

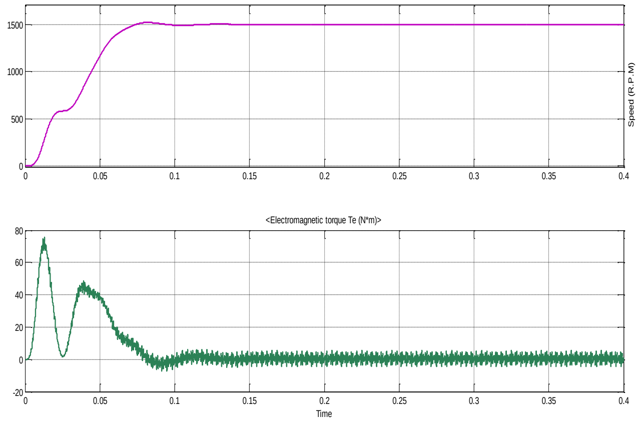

Figure 7. Simulation Speed& Torque Characteristics Of SPWM VSI Fed To Induction Motor Load

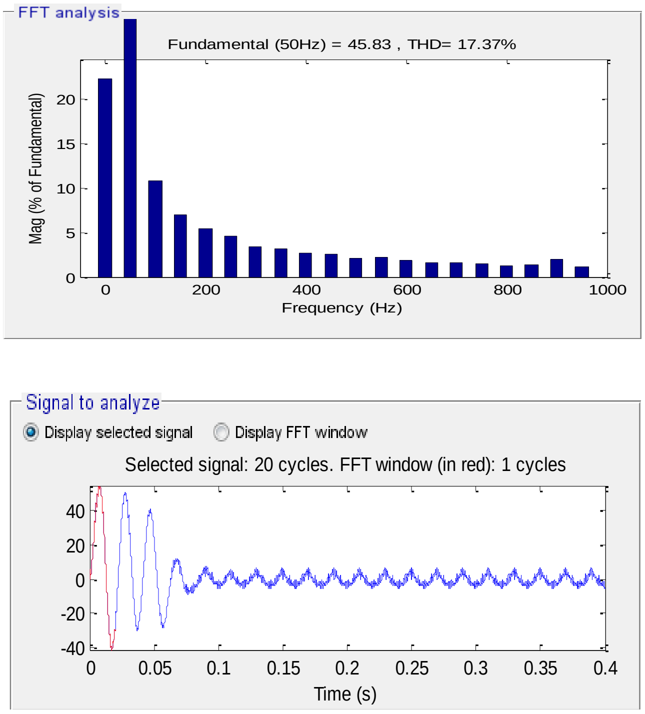

Figure 8. FFT Analysis Of A SPWM Voltage Source Inverter

V. CONCLUSION

- ✓ Short-circuit protection, the output voltage being bound by the governed dc-bus current.
- ✓ Low output voltage , resulting from the filtering effect of the output capacitor.

- ✓ High converter constancy, due to the unidirectional traits of the swap and the inherent short-circuit protection.
- ✓ Utilization the SPWM technique, which has fast dynamic respond and stability.
- ✓ The proposed steer scheme analyz the calculation process of the Sinusoidal PWM, which cause it possible to be put into effect in low cost processors.
- ✓ The collecting signals are directly generated by the Sinusoidal PWM.
- ✓ The stresses on power swap and the overall losses are always reduced.
- ✓ Due to the firm inverter modulation index service, the motor voltage harmonic distortion is firm, which reduces the induction motor losses.
- ✓ These features make the VSI drive an interesting alternative to VSI-based drives operating at similar switching frequency, when the requested fundamental reactive power could be disregarded with respect to output power.
- ✓ The PWM -VSI has simple converter topology, motor friendly waveform, & reliable short-circuit protection.

These features make the VSI drive an alluring alternative to VSI-based drives performing at similar swap frequency, when the requested basic reactive power could be disregarded with respect to O/P power.

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