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Development of Random Pulse Width Modulation in Power Electronics Converter

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Abstract:- *With the new advancement in Power Electronic devices the high frequency system can often causes acoustic noise, mechanical vibration, EMI related problems in inverter-fed AC machine due to harmonics content in voltage and current waveforms which makes operator feel uncomfortable to work. Proposed work deals with one of the Pulse Modulation Technique, RPWM, Random Pulse Width Modulation, which is a new and effective technique to let the inverter-fed ac motor drive possess low acoustic noise and mechanical vibration when lower switching frequency is chosen. In this paper the conventional SPWM and RCPWM is compared in MATLAB/simulink to measure the THD and IHD of voltage and current waveforms.*

Keywords-*Random Pulse Width Modulation (RPWM);THD analysis; IHD; SPWM; Voltage Source Inverter; Induction Motor;Harmonic reduction*

I. INTRODUCTION

In power electronic systems Pulse-Width Modulation (PWM) techniques have been widely used. Pulse width modulation is a technique in which a fixed input dc voltage is given to the inverter and a controlled ac output voltage is obtained by adjusting the on and off periods of the inverter components [1]. This is most popular method of controlling the output voltage and this method is termed as pulse width modulation technique. PWM is an internal control method and it gives better result than an external control methods [6].

PWM techniques generally operate with a fixed switching frequency causing power spectrum to be concentrated at multiples of the switching frequency. This gives rise to the harmonic spikes and can produce unwanted effects in the power converter such as acoustic noise, torque ripple, and electromagnetic interference (EMI) [1].

This undesirable effects can be mitigates by using the new established technique Random Pulse Width Modulation. It is the most effective method to Randomizing the switching frequency. The chief reason is that the harmonic spectrum of a RPWM inverter can be dispersedly and continuously distributed. So it is increasingly attracted much attention in practical applications. The key spirit of RPWM is to let the time positions of switching signals for inverter switches be randomly varied [4].There are three types of RPWM (1)Randomized Switching Frequency,(2) Randomized Pulse Position(3) Random Switching[1,4]. These random PWM methods have the advantage of spreading the harmonic cluster to adjacent frequencies, and thereby reducing EMI filter size or removing it. However, random PWM techniques result in the increase of switching counts and thereby increasing the switching losses [3].This paper investigated and compared new RCPWM with conventional SPWM method by MATLAB/simulink. Moreover, this new random PWM technique significantly reduce the .harmonic intensity without effecting the efficiency [3]

This paper organized as follows :(I) Introduction (II) Random Carrier PWM Scheme(III) Matlab/simulink of proposed scheme in inverter-fed AC machine and its results (IV) Comparison between SPWM and RCPWM (V) Measured results.

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II. RANDOM CARRIER PULSE WIDTH MODULATION

A. Conventional SPWM and RCPWM schemes

A Sinusoidal Pulse Width Modulation technique is also known as the triangulation, sub oscillation, sub harmonic method which is very popular in industrial applications [6]. In this technique a high frequency triangular carrier wave is compared with the sinusoidal reference wave determines the switching instant as shown in Figure 1

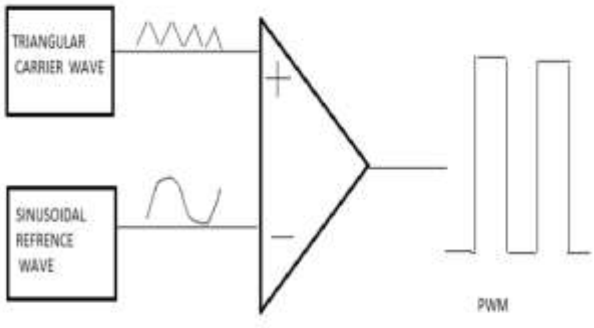

Figure:1 Operation of SPWM

Since past three decades Sinusoidal PWM (SPWM) is used to reduce the lower order harmonics while varying the output Voltage. Some of the following constraints for slow varying sinusoidal voltage be considered as the modulating signal are [6].

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1) The peak magnitude of the sinusoidal signal is less than or equal to the peak magnitude of the carrier signal. This ensures that the instantaneous magnitude of the modulating signal never exceeds the peak magnitude of the carrier signal.
2) The frequency of the modulating signal is several orders lower than the frequency of the carrier signal. For example 50 Hz for the modulating signal and 20 KHz for the carrier signal. Under such high frequency ratio's the magnitude of the modulating signal will be virtually constant over any particular carrier signal time period.
3) A three phase Sine-PWM inverter would require a balanced set of three sinusoidal modulating signals along with a triangular carrier signal of high frequency.

Random Carrier PWM is similar to Sinusoidal PWM, while it uses two different triangular carriers. The Pseudo random carrier modulation scheme is most commonly used for the random triangular frequency generation. A simple concept of randomly modulated carrier PWM is illustrated in the Figure 2

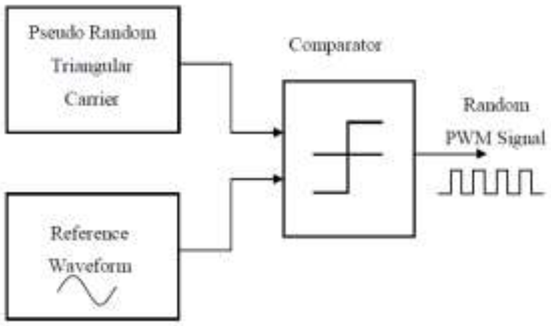


Figure 2 Random Carrier PWM Signal Generation

B. Performance Evaluation of Random PWM

The three-phase VSI with random carrier PWM has been simulated using MATLAB/Simulink software with the input dc voltage (Vdc) of 400V. The random carrier is generated from a triangular waves of 2 kHZ and 3 kHz. The load is 3 kW three-phase Squirrel Cage Induction Motor. The Simulink model for this set-up is shown in Fig.3 and the triggering pulses for the inverter are shown in Fig. 4

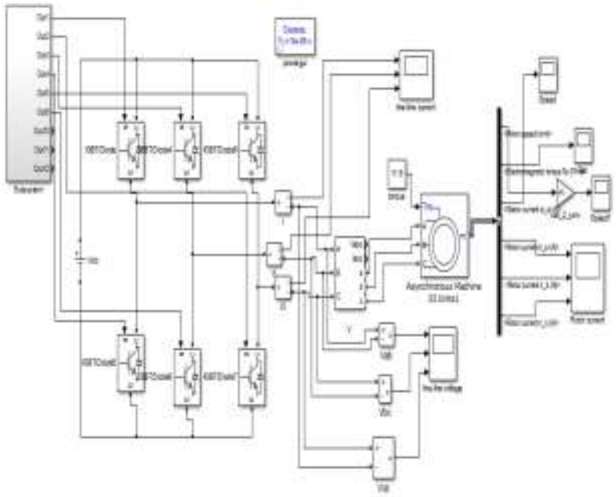


Figure: 3 Simulink Model for Random Carrier PWM

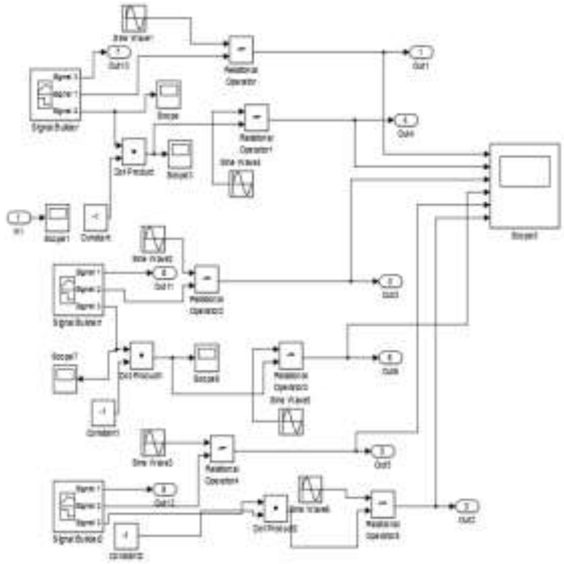
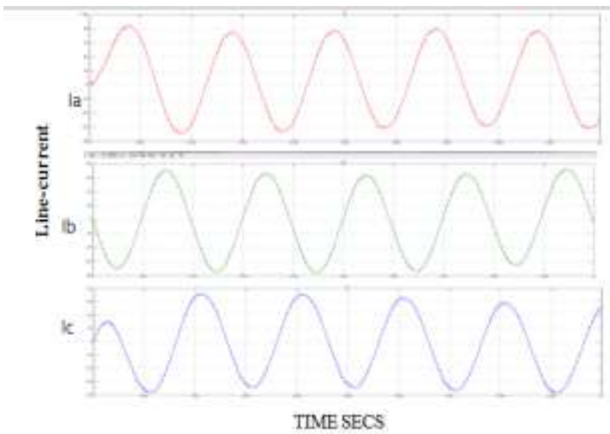


Figure: 4 Triggering pulses of Random carrier PWM for 2 khz and 3 khz

III. SIMULATION AND COMPARISON RESULTS

Here the line-currents, line-voltages waveforms, THD and IHD of SPWM and RCPWM are compared and depicted in Fig:5(a)and (b),6(a) and (b),7,8.



(a)

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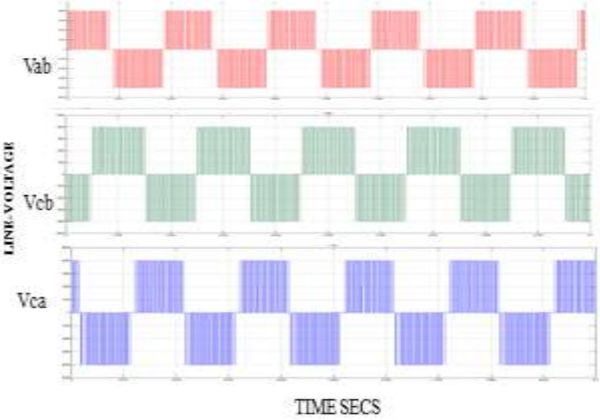
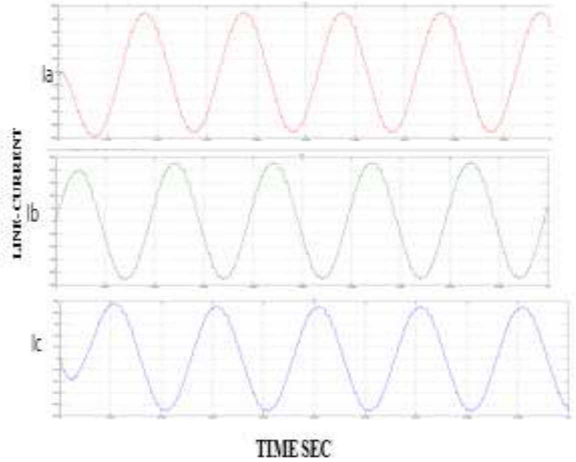
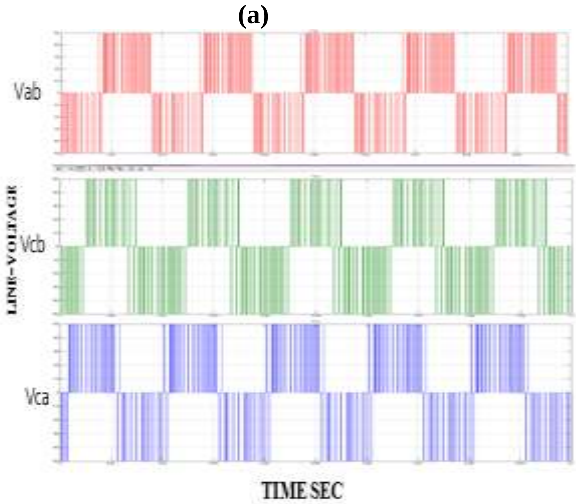


(b)

Figure: 5 (a)line-line current waveforms (b) line-line voltage waveforms of SPWM



(a)



(b)

Figure:6(a) line-line currents waveforms (b) line-line voltages waveforms of Random Carrier PWM

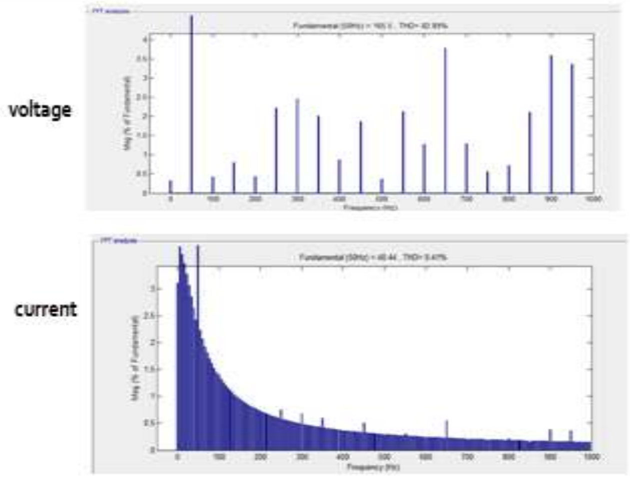


Figure:7 THD analysis of voltage and current waveforms of SPWM for n=5

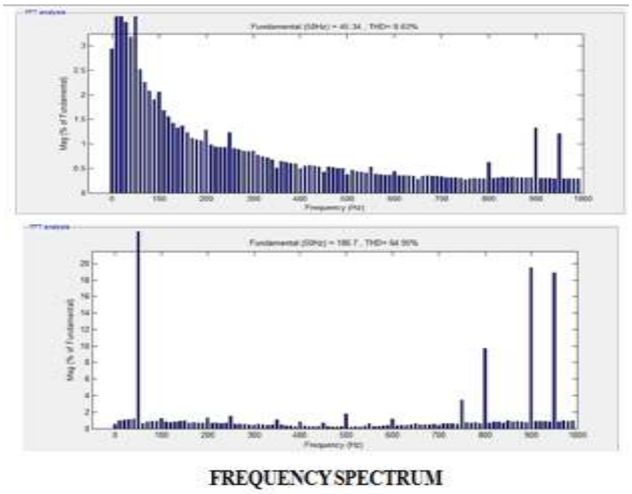


Figure:8 THD analysis of voltage and current waveforms of RCPWM for n=5

IV. COMPARISON OF IHD OF SPWM AND RCPWM

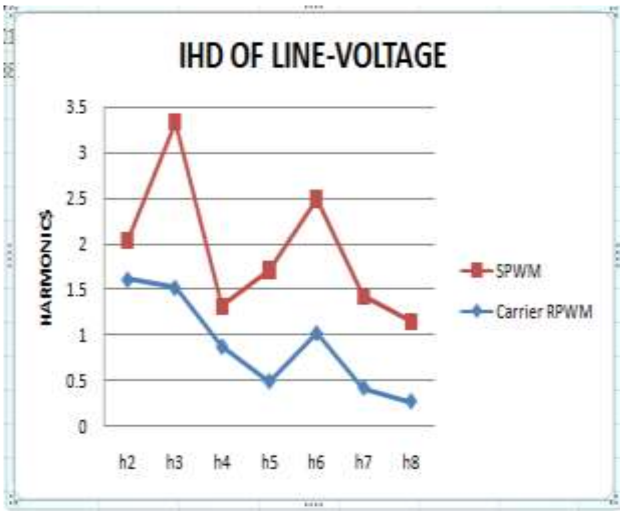


Figure: 9 comparison of voltage line-line voltage

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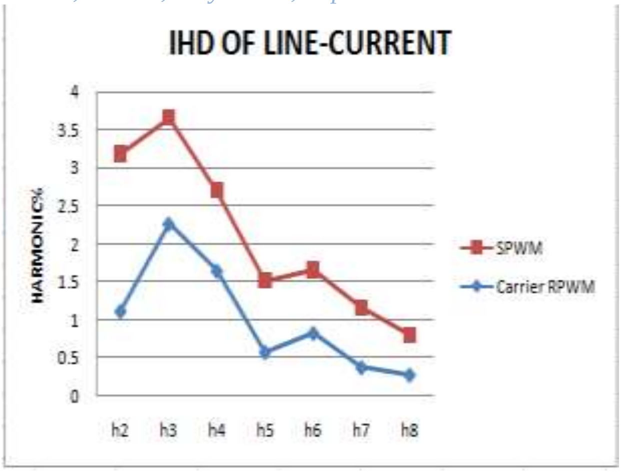

Figure: 10 Comparion of IHD of line-line current

TABLE 1.THD Comparison Of SPWM And RCPWM For Voltage And Current Waveforms

SCHEME	VOLTAGE%	CURRENT%
SPWM	82.89	8.41
RCPWM	68.19	5.65

V. MEASURED RESULTS

Having tested and compared the SPWM and proposed RPWM by simulink/MATLAB the results are created that harmonic THD,IHD content is low in line-line voltage and current waveforms by using the proposed scheme and the current waves came almost sinusoidal as shown in fig:6(a) and (b). Due to this the harmonic spikes, EMI problems, and acoustic noise are reduced from inverter-fed ac motor. Fig:9 and 10 shows the IHD analysis of volatage and current of SPWM and RCPWM which shows that harmonic peak is low by using RCPWM. Harmonic peak is another important factor in PWM.Table 1. Shows the THD analysis of SPWM and the proposed scheme which shows that THD voltage and current is low in the proposed scheme.

VI. CONCLUSION

In this paper the conventional SPWM and the new method RCPWM is compared in 3-ph inverter-fed induction machine. By comparison it is concluded that the THD and IHD of line-line voltage and current waveforms is less in RCPWM as compared than SPWM. The proposed scheme could be useful to reduces harmonic from voltage and current of AC machines and also from the V/F drive as well. In this paper two different frequencies of carrier wave is being used (2 and 3 khz). In future more than these frequency could be used.

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