ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com

International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 3, Issue 2, February 2016

Novel Hybrid Random PWM Scheme for VSI Fed Three Phase Induction Motor

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Abstract: This paper presents a new hybrid random PWM algorithm for spreading the harmonic power of VSI fed Induction motor drives. The harmonic spread reduces the acoustical noise of three phase induction motor. The PWM pulses are obtained by the logical comparison of pseudorandom binary sequence (PRBS) bits with the PWM pulses corresponding to two carriers with two different frequencies. One end is fed with triangular carrier and other with inverted carrier of the same frequency. Hence, the PWM pulses exhibit the hybrid characteristics of both the random pulse position PWM and the random carrier frequency PWM. Simulation results show the capability of the proposed scheme in reducing the harmonic content compared to conventional RPWM techniques.

Keywords: Hybrid Random PWM, Total Harmonic Distortion, Harmonic Spread Factor, Acoustic noise, Voltage Source Inverter

I. INTRODUCTION

Advancements in power electronic devices, reliable and cost effective control of induction motor. Inverter plays a crucial role in the control of industrial motor drives. Apart of this VSI is the very familiar for control of induction motor drives. With increased demand for VSI has its root in the advantages like low total harmonic distortion (THD), characteristics which are near to sinusoidal, etc.

The motors generate an unpleasant acoustic switching noise due to the deterministic frequency PWM switching of the inverters. The main feature of random PWM is that its output harmonic spectra are dispersed and continuously distributed, thus reducing the acoustic noise.

A hybrid random pulse width modulation (PWM) scheme based on a TMS320LF2407 DSP is proposed in [1] in order to disperse the acoustic switching noise spectra of an induction motor drive. PWM algorithm is proposed that modifies the time duration of application of vector by using a factor μ by which various switching sequences can be derived. The suitable sequence is selected by comparing the instantaneous ripples in each sampling time interval, thus resulting in minimum current ripple [2]. A hybrid random PWM algorithm for direct torque controlled induction motor drive for reduced acoustical noise and harmonic distortion is presented in [3]. A hybrid random space vector PWM strategy is proposed in [4]. The strategy is controlled by two random variables, one control the duration time partitioning method to two zero-vectors, the other controls the pulse positioning method. A space vector based hybrid random pulse width modulation algorithm for direct torque controlled AC drives to achieve good waveform quality with reduced acoustical noise and vibrations. The pulse width modulation (PWM) algorithm that uses instantaneous sampled reference phase voltages to calculate the actual switching times of the devices is introduced in [5], to reduce the complexity of the conventional space vector approach. A Space Vector based Random Pulse Width Modulation technique (RPWM) for a 3-level inverter is proposed in [6]. Here, the randomization is achieved by random placement of active vectors in fixed switching time period.

A simplified hybrid random PWM algorithm for direct torque controlled induction motor drive for reduced acoustical noise and harmonic distortion [7]. In order to minimize the complexity involved in the classical space vector approach, the proposed PWM algorithm uses the notion of imaginary switching times.Three different hybrid modulation strategies are proposed in [8] for single-phase voltage source inverter. The method is formulated by using fundamental switching and carrier based pulse width modulation methods. The main aim is to optimize a specific performance criterion, such as minimization of the total harmonic distortion (THD), lower order harmonics,

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switching losses, and heat losses. Yet another hybrid random PWM for VSI fed induction motor drive is proposed in [9].

II. Hybrid Random PWM

The proposed hybrid random PWM scheme is shown in Fig.1. The random bit generator consists of a shift register and XOR gates. A shift register with m-bits is clocked at fixed frequency f_{clock}. The EXCLUSIVE-OR gate generates the input signal from EXCLUSIVE-OR combination of feedback bits of the shift register. A set of states is generated and repeated after K-clock pulses. The maximum number of conceivable states of an m-bits register is K = 2m − 1. The random variable PRBS, which is used to decide the pulses position, is obtained by the output of the EXCLUSIVE-OR gate.

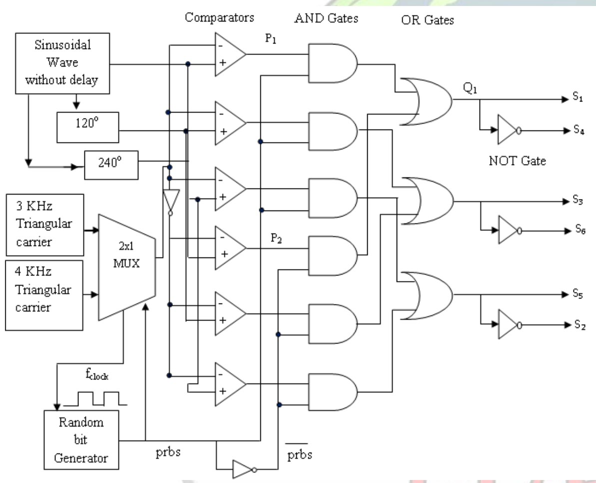

Fig. 1. Proposed Hybrid Random PWM Scheme

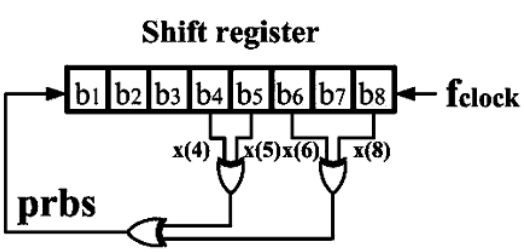

Fig. 2. 8-bit PRBS generation

The PRBS bits of the random bits generator, is given as follows

$$PRBS = a(4) \oplus a(5) \oplus a(6) \oplus a(8) \quad (1)$$

where ⊕ means an EXCLUSIVE-OR (XOR) operator and x(i) means the i^{th} bit of the register. p1 and p2 are determined by comparing the triangular carrier f_c with reference signal. The PRBS (Fig.3) is logically compared to p1 and p2. p1 is obtained by comparison of the carrier f_c+ with the reference signal. Similarly, p2 can be obtained through comparison of the 180o shifted carrier f_c− with the reference signal. The PRBS signal and p1 or p2 are logically compared using AND gates. The output signals of each AND gates are logically compared using OR gates and a random PWM signal q is generated.

The resulting carrier wave and the frequency of the random variable generator are generated. The PRBS bits of the random bits generator, is given as follows

$$PRBS = x(4) \oplus x(5) \oplus x(6) \oplus x(8) \quad (2)$$

The resultant pulse q is expressed as

$$q = (PRBS)\, p1 + (1 - PRBS)\, p2. \quad (3)$$

The random characteristics are yielded by using not only the carrier frequency randomization but also the PRBS bits synchronized by the random frequency carrier. This characteristic makes more continuous distribution of its power spectra, as compared to the conventional schemes.

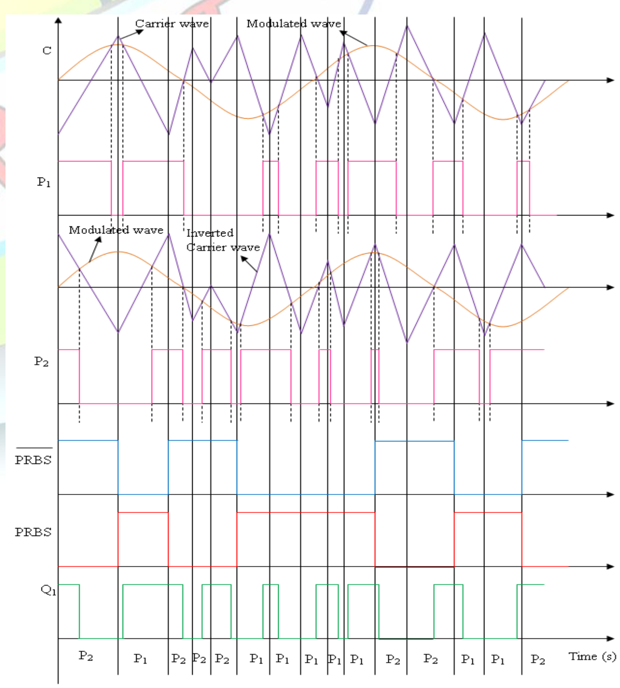

Fig. 3. Carrier Waveforms and the corresponding pulses of the proposed scheme

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III. Simulation Results

The simulation study is performed in MATLAB/Simulink software. A three phase VSI inverter with three phase, 0.75 kW Squirrel Cage Induction Motor is considered.

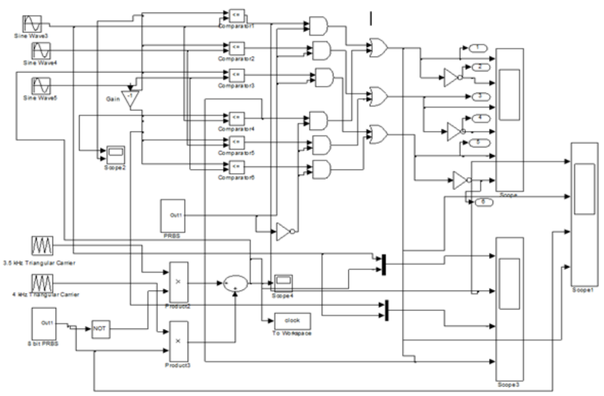

Fig. 4. Simulink implementation of the proposed scheme

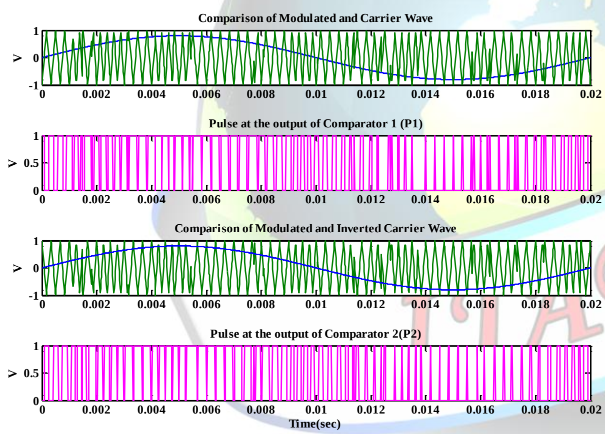

Fig. 5. Carrier Waveforms and the corresponding six pulses

TABLE I
Results of Hybrid RPWM

Ma	Hybrid		
	Fundamental Component of Output Voltage	Total Harmonic Distortion	Harmonic Spread Factor
0.2	71	239	5.4
0.4	111	161	5.1
0.6	189	113	4.9
0.8	212	90	4.12
1.0	244	67	3.9
1.2	317	59	3.6

IV. Conclusion

A novel hybrid random PWM scheme with a two triangular carriers with a random frequency was proposed. It was developed with the aim of distributing the harmonic spectra spreading effect. The proposed scheme possesses the characteristics of the random pulse position and random carrier frequency scheme, hence the name hybrid. Simulations are carried out on a 0.75kW, three-phase induction motor drive under the fundamental frequency f = 50 Hz and for various modulation indexes. Simulation results demonstrate that the low order harmonics was considerably reduced. From the results, the proposed scheme possesses an excellent harmonic spectra spreading capability. HSF of the proposed scheme was improved about 35% as compared with that of the conventional scheme.

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BIOGRAPHY

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