

Optimized she PWM Technique with Odd and Even Values Using GA for Three Phase Voltage Source Inverters

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Abstract

Selective Harmonic Elimination Pulse Width Modulation (SHEPWM) technique is one of the control techniques for inverters. It is mainly used for reducing the harmonic content in single phase and three phase inverters and to improve the power quality. The selection of switching angles for eliminating particular harmonic is difficult. The proposed method uses one of the soft computing techniques Genetic Algorithm(GA) to optimize the switching angle given to the inverter. The bipolar waveform includes both odd and even number of switching angles to eliminate particular harmonics from inverter output. Elimination of selected harmonics is verified using matlab simulation. Optimized SHEPWM technique is compared with standard PWM method using matlab simulation and results are presented.

Index terms—Odd switching angles, Even switching angles, Selective Harmonic Elimination Pulse Width Modulation.

1. Introduction

The improvement of power quality has been the major issue in power electronics. The elimination of specific lower order harmonics improves the performance of voltage source inverter. The main classification of PWM techniques are carrier modulated PWM and Selective Harmonic Elimination based PWM. In that SHE based PWM technique offers best solution. It has been dealt in enormous papers for single and three phase system. This method can provide the highest quality output and offers several advantages compared to many modulation methods including low switching

frequency. It is generally accepted that the performance of an inverter with any switching strategies, can be related to the harmonic contents of its output voltage. Many novel techniques are implemented to reduce the harmonics in output voltage of the inverter.

In the past decade an improved injection current technique is introduced to reduce line current harmonics. The optimal amplitude and phase angle of the injection current for different loads and firing angles have been mathematically determined [2]. A direct minimization of the nonlinear transcendental trigonometric Fourier functions in combination with a random search was obtained [3]. Modified carrier wave is programmed and compared with modified sine wave corresponding to that switching signals are generated [4]. The algorithms for adaptive canceling of selected harmonic components have been well developed in digital signal processing and provide a novel and a systematic design approach for applying signal processing methods as an addition to conventional control [5]. Minimization approach was used to find the solution of generated waveform that takes into a simple harmonic distortion to eliminate first two significant harmonics [7]. The special cases of two and three-level harmonic elimination are presented in detail along with representative solutions for each harmonic control problem. (Quasi square wave symmetry problem)[8]. A genetic algorithm is applied to optimize a carrier frequency of pulse width modulation (PWM) inverter and It is an economical approach to improve the power quality [9]. Some solutions are obtained to eliminate harmonics by using mathematical theory of resultant [10]. The nonlinear equations given by standard mathematical formulation of the problem can be reformulated. Polynomials $P(x)$ associated with the optimal PWM problem can be obtained via simple recursions [12]. The multiple solution equations are Solved and analyzed sequentially by applying a homotopy method and mathematical induction algorithm [13].

So far no techniques are discussed with odd and even number of switching angles given to inverters. In the proposed method genetic algorithm is used to find the optimal solution then it is compared with SPWM technique.

2. Bipolar Switching Pattern

The switching pattern is of unipolar and bipolar type and this includes one level, two levels and three level waveform. For single and three phase inverters bipolar switching pattern shown in fig 1 is used to find the appropriate switching angles that include both odd and even angles. To eliminate $N-1$ harmonics completely from the inverter output waveform N switching angles have to be calculated in quarter period of waveform.

In this paper optimized switching angles are produced to eliminate the lower order harmonics such as 5th, 7th, 11th, 13th. By including both even and odd values of switching angles the harmonic content are much reduced. The output voltage equation of the inverter

$$V_o = \sum_{n=1}^{\infty} a_n + (a_n \cos n\omega t + b_n \sin n\omega t)$$

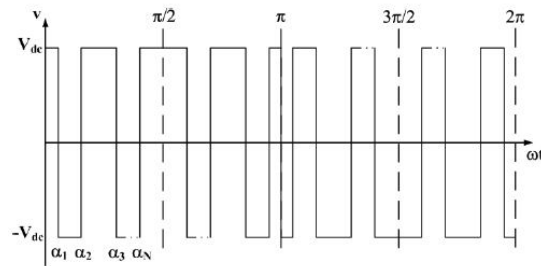


Figure 1: Bipolar waveform.

Whereas a_o is the fundamental component and have to be improved and a_n is the even harmonics that are almost zero and b_n is the odd harmonics have to be eliminated. The range of switching angles should be between 0 to 90 degree.

3. Proposed Technique

The evolutionary computation technique is more suited from the optimization point of view and solves for non-linear problems defined on discrete or continues, constraint or non-constraints. Genetic algorithm is a novel technique for SHEPWM inverter.

3.1 Genetic algorithm for optimization of switching angles

The main procedures in genetic algorithm are initialization of population, fitness calculation, reproduction, cross over, mutation.

3.2 Initialization of Population

The population size represents the number of chromosomes. The number of population represents random number of switching angles from 0 to 90 degree. The nature of problem decides the population size. The GA converges faster for narrow range of values.

3.3 Fitness Calculation

The selected population are used to calculate the objective function. The most fit individuals should have minimum harmonic distortion. Fitness function is the kind of quality measurement for the degree of conformity.

3.4 Reproduction

In reproduction operation the parents are choose to create off springs. The objective function values are calculated for selected off springs. Each object is calculated and an individual is reformed under a flat rule depending on the degree of conformity.

3.5 Cross Over

The most significant part of genetic algorithm is that it creates group of children by exchanging genes among them. So that the cross over operation not only provides new chromosomes but also introduces representation of new chromosomes into the

population to allow further evaluation on optimization. cross over operators is of many techniques and they are selected based on the way of chromosomes encoded.

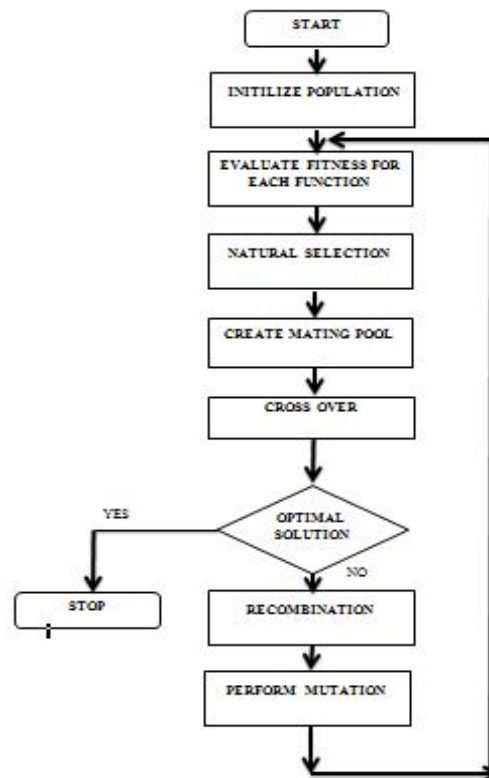


Figure 2: Flowchart.

3.6 Mutation

Mutation works after crossover operation. It is nothing but a sudden change in the chromosome. In this operation, there is a probability that each gene may become mutated when the genes are being copied from the parents to the offspring. This process is repeated, until the optimum of the objective function is reached.

The selected individuals should have minimum harmonic distortion. The number of switching angle should lie between 0 to 90 and $\alpha_1 < \alpha_2 < \dots < \alpha_N < 90$.

GA is performed in matlab software and optimized odd and even switching angles are found. For satisfactory results GA program parameters are

In this algorithm

Initial population size=100

Maximum number of generation=50

Probability of cross over=0.91

Mutation probability=0.01

Performance measure=THD

4. Results And Discussion

The obtained switching angles with three phase inverter are simulated in matlab software. The figure 3 shows the inverter circuit that includes voltage=100, frequency=50HZ, Resistive load=10kΩ. The objective function in GA is written in such a way that it reduces 5th, 7th, 11th, 13th harmonics. From the figure 6 it is clearly shown that the proposed technique offers less harmonic content compared to standard method.

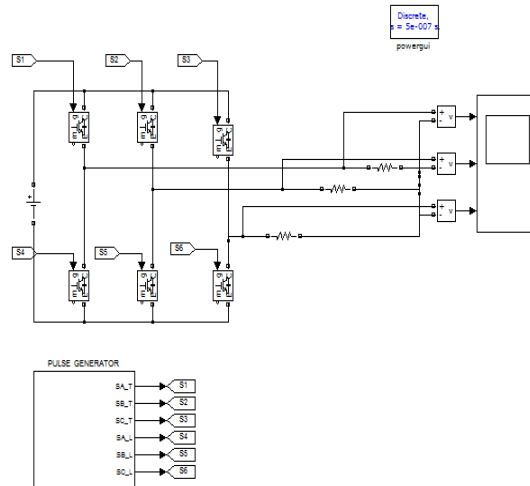


Figure 3: Simulation circuit.

The selected harmonics such as 5th, 7th, 11th and 13th are reduced completely for odd and even values of switching angles is shown in figure 4 and figure 5 respectively. The table 1 shows the harmonic content of odd and even values.

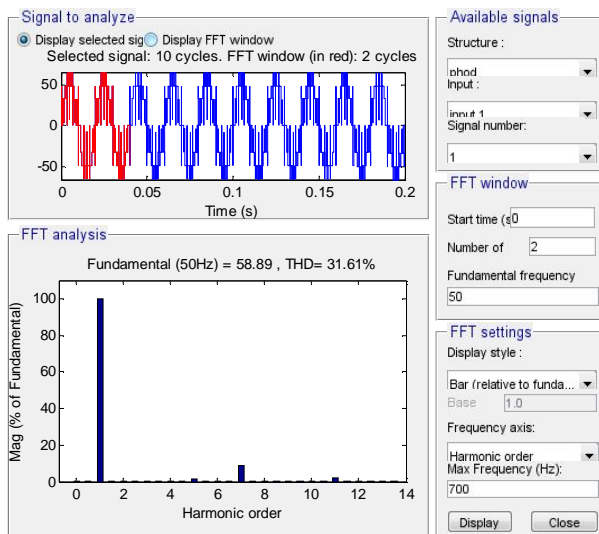


Figure 4: THD values of odd switching angles.

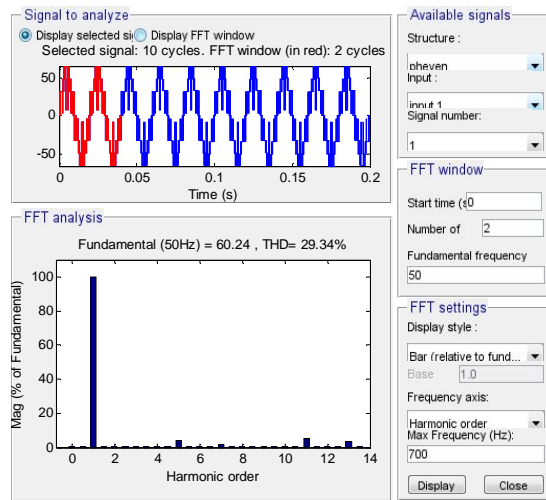


Figure 5: THD values of even switching angles.

Three phase inverter with SPWM technique is simulated using matlab software. THD of this standard method is compared with proposed method and results are shown in figure in figure 6. GA based SHEPWM technique with odd and even values shows reduced THD compared to SPWM technique.

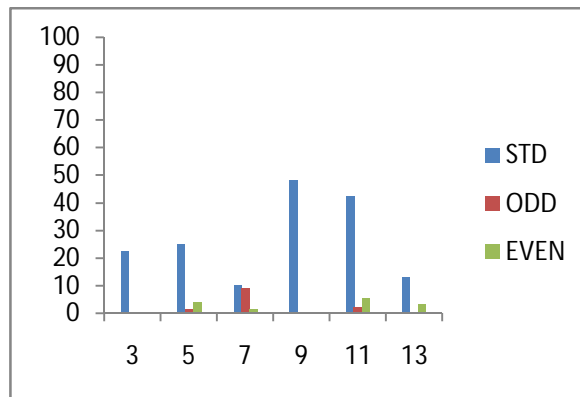


Figure 6: Comparison of THD values.

Table 1: THD values.

Harmonics in output voltage	Harmonic content in %	
	Odd values of switching angle	Even values of switching angle
5th	1.28	4.17
7th	8.99	1.37
11th	2.17	5.36
13th	0.12	3.33

The harmonics affect the performance of the power application. Due to 5th, 11th, 7th, 13th harmonics attempt to drive the motor in reverse direction causing overheating, tripping of over current protection devices, skin effects, destructive heating leads to derating of machine occurs. The proposed method eliminates these particular harmonics by proper selection of odd and even values of switching angles.

Conclusion

A new approach to reduce the lower order harmonics in three phase SHEPWM inverter using GA has been presented. In the drive fields 5th and 11th harmonics create negative sequences and attempt to drive the motor in reverse direction causing overheating, tripping of over current protection devices. Odd numbers of switching angles are selected for eliminating 5th and 11th harmonics completely. The 7th harmonics causes destructive heating and leads to derating of machines like transformer and capacitor bank. Selection of even number of switching angles reduces the 7th harmonics completely. Simulated results has been presented for bipolar waveform and also compared with standard pwm method.

References

- [1] Javier Napoles, Jose, I., Leon, Ramon Portillo, Leopoldo, G., franquelo, and Miguel, A., Aguirre, 2010“ Selective Harmonic Mitigation technique for high power converters,” IEEE transactions on industrial electronics, vol. 57, no. 7.
- [2] Ali, M., Eltamaly, 2008, “A Modified Harmonics Reduction Technique for a Three-Phase Controlled Converter,” IEEE Transactions on Industrial Electronics, vol. 55, no. 3.
- [3] V. G., Agelidis, A., Balouktsis, and C., Cossar, 2008, “On attaining the multiple solutions of selective harmonic elimination PWM three-level waveforms through function minimization,” IEEE Trans. Ind. Electron., vol.55, no. 3, pp. 996–1004.
- [4] Jason, R., Wells, Xin Geng, Patrick, L., Chapman, Philip, T., Krein, and Brett, M., Nee,2007 “Modulation-Based Harmonic Elimination,” IEEE Transactions on power electronics, vol. 22, no. 1.
- [5] V., Blasko, 2007, “A novel method for selective harmonic elimination in power electronic equipment,” IEEE Trans. Power Electron., vol. 22, no. 1, pp. 223–228.
- [6] K., Sundareswaran, K., Jayant, and T. N., Shanavas, 2007 “Inverter Harmonic Elimination through a colony of continuously exploring ants,” IEEE Trans. Ind. Electron., vol. 54, no. 5, pp. 2558–2565.
- [7] Vassilios, G., Agelidis, *Anastasios Balouktsis, Ioannis Balouktsis, and Calum Cossar*, 2006, “Multiple Sets of Solutions for Harmonic Elimination PWM Bipolar Waveforms: Analysis and Experimental Verification,” IEEE transactions on power electronics, vol. 21, no. 2.

- [8] Jason, R., Wells, Brett M., Nee, Patrick, L., Chapman, and Philip, T., Krein, 2005, "Selective Harmonic Control: A General Problem Formulation and Selected Solutions," *IEEE Transactions on Power Electronics*, vol. 20, no. 6.
- [9] K. L., Shi, and H., Li, 2005 "Optimized PWM strategy based on genetic algorithms," *IEEE Trans. Ind. Electron.*, vol. 52, no. 5, pp. 1458–1461.
- [10] John, N. Chiasson, Leon, M., Tolbert, Keith J. Mckenzie, and Zhong du, 2004, "A Complete Solution to the Harmonic Elimination Problem," *IEEE Transactions on Power Electronics*, vol. 19, no. 2.
- [11] kai zhang, yong kang, jian xiong, and jian chen, 2003, "direct repetitive control of spwm inverter for ups purpose," senior member, ieee, *iee transactions on power electronics*, vol. 18, no. 3.
- [12] D., Czarkowski, D.V., Chudnovsky, G. V., Chudnovsky, and I. W., Selesnick, 2002, "Solving the optimal PWM problem for single-phase inverters," *IEEE Trans. Circuits Syst. I*, vol. 49, no. 4, pp. 465–475.
- [13] Toshiji kato, 1999, "Sequential homotopy-based computation of multiple solutions for selected harmonic elimination in pwm inverters," *IEEE transactions on circuits and systems-I: Fundamental Theory and Applications*, vol. 46, no.5.