ISSN(Online): 2320-9801
ISSN (Print): 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 7, July 2015

Multilevel Inverter for Eliminating Harmonics in Line To Line Voltage Using Genetic Algorithm

P.Senthilkumar, Gayathri Katuri

Assistant Professor, Department of Electrical and Computer Engineering, College of Engineering and Technology

Mizan-Tepi University, Ethiopia.

Assistant professor, VMKV Engineering College, Chinna Seeragapadi, Periya Seeragapadi, Tamil Nadu, India

ABSTRACT: This paper the total harmonic distortion (THD) minimization of the multilevel inverters output voltage is discussed. The approach in reducing harmonics contents in inverters output voltage is THD elimination. The switching angles are varied with the fundamental frequency so the output THD is minimized. In three-phase applications, the line-voltage harmonics are of the main concern from the load point of view. In this paper, using the genetic algorithm, a THD minimization process is directly applied to the line-to-line voltage of the inverter. Genetic (GA) algorithm allows the determination of the optimized parameters and consequently an optimal operating point of the circuit and a wide pass band with a unity gain is obtained. This paper is based on a 11 level MLI the proposed system also able to obtain an optimal operating point using GA. To verify the simulation a 11 level cascaded-H-bridge-inverter-based simulation is presented.

KEYWORDS: Continuous Genetic Algorithm (CGA); Multi-level Inverters; Optimized Harmonic Stepped Waveform (OHSW); Particle Swarm Optimization (PSO).

I. INTRODUCTION

In the last few years, the necessity of increasing the power quality enhancement in industry has sustained the continuous development of multilevel- inverters due to high efficiency with low switching frequency. The inverters a semiconductor device which is used to convert the variable DC voltage into AC voltage without changing the magnitude. With respect to the switching frequency of multi-level inverters, the switching strategies can be classified into two categories. Methods that work with high switching frequencies, including classic carrier based sinusoidal pulse width modulation (SPWM) and the space vector modulation (SVM)strategy. Methods that work with low switching frequencies, generally equal to fundamental component frequency, and generate a staircase waveform [6]. Representatives of this family are Space Vector Control (SVC), Optimal Minimization of the Total Harmonic Distortion (OMTHD) [7] and Optimized Harmonic Stepped Waveform (OHSW) [12]. OHSW offers controllable low order harmonics and the possibility of the producing sinusoidal waveform by using a filter. The major problem of OHSW is to find a method to solve a set of non-linear equations. However, these equations are not soluble for some operating points, associated with Modulation indices (M). In this regard, presented techniques, published in literatures, can be categorized into two general groups. The first group solves equations. In [8-14] Newton- Raphson (N-R) method is exploited to solve equations. Iterative methods mainly depend on the initial guess and divergence problems are likely to occur, especially for high numbers of inverter levels, and no optimum solution is guaranteed in terms of the total harmonic distortion (THD) as most of the higher order harmonics may strongly exist [8]. Although N-R method is fast, it only can find one set of solutions. Also, [6] attempts to find all the roots using MATLAB function. solves This function is based on Gauss- Newton method with a mixed quadratic and cubic line search method. In addition, [7-13] have used the mathematical theory of resultants. Although this method is complicated and time consuming [8], it finds all possible solutions with the exact range of the M, where solutions exist. Additionally, it should be noted that, for any changes in the voltage level or input dc voltage, new expressions are required [6]. All methods, included in this group, do not suggest any optimum solutions for infeasible Ms, while in many applications working in a continuous range of M is inevitable. Several topologies for multilevel inverts have been proposed over the years the most popular being the diode clamped, flying capacitor and cascaded H-bridge

ISSN(Online): 2320-9801
ISSN (Print): 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 7, July 2015

structures. In [1-4] depicts one aspect which sets the cascaded H-bridge apart from other multilevel inverters is the capability of utilizing different DC voltages on the individual H-bridge cell, which results in splitting the power conversion amongst higher-voltage lower-frequency and lower-voltage higher frequency inverters. An alternate method of cascading inverts involves series connection of two three-phase inverters through the neutral point of the load. An advantage of this approach is that isolated sources are not required for each phase. It should be noted that cascaded inverter system can be considered from a number of different viewpoints. Considering the cascaded inverter to be one unit, it can be seen that a higher number of voltage levels are available for a given number of semiconductor devices. Capacitors batteries and or renewable energy voltage sources can be used as a DC voltage sources. The general function of this multilevel inverter is the same as that of the other two previous inverters. This multilevel inverter using cascaded inverter with SDCS synthesis a desired voltage from several independent sources DC voltages which may be obtained from batteries, fuel cells, all solar cells. This configuration recently becomes very popular in AC power supplies and adjustable speed drive applications. This new inverter can avoid extra clamping ten diodes or voltage balancing capacitors. A single phase m-level configuration of such an inverter is shown in Figure 1. Each SDCS is associated with the single phase full bridge inverter. The AC terminal voltages of different level inverters are connected in series. By different combinations of the four switches, S1-S4, each inverter level can generated three different voltage outputs, +Vdc, -Vdc and zero. The AC output of each of the different level full bridge inverters are connected in series such that the synthesis voltage waveform is the sum of the inverter outputs. In this topology, the number of output phase voltage level is defined by m=2s+1, where s is the number of DC sources.

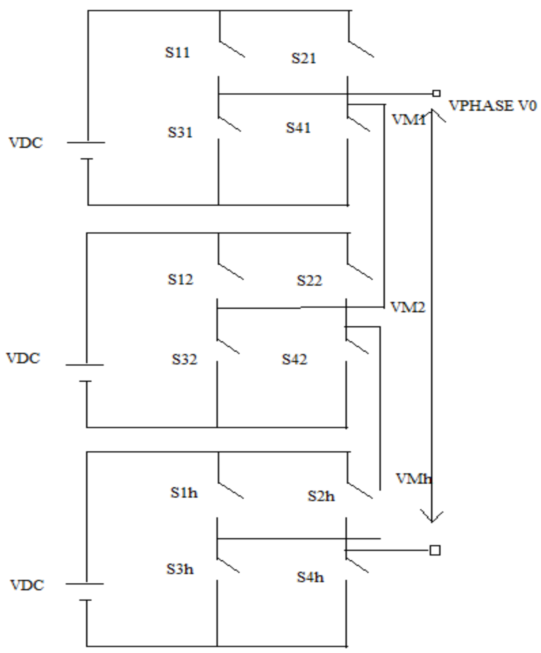

Figure 1 Cascaded Multilevel Inverter

II. HARMONIC REDUCTION TECHNIQUE

If not properly design or rate, electrical equipment will often malfunction when harmonics are present in an electrical system. Most people don't realize that harmonics have been around a long time. Since the first AC generator went online more than 100 years ago, electrical systems have experienced harmonics. The harmonics at that time were minor and had no detrimental effects. In multilevel inverter the Fourier series is used to find the expression for output voltage. The Fourier expression for the output voltage is found because the angles are related with output voltage expression and the output voltage is quarter wave symmetry. So the Fourier series constants a0, an become zero and we have to find only bn

ISSN(Online): 2320-9801
ISSN (Print): 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 7, July 2015

$$Vo(wt)=\{ao+\sum(ancos\ nwt+bnsin\ nwt)\}\sin n\theta \quad (1)$$
$$n=1,2,3...$$

The output voltage expression For five level inverter is found as

$$Vo(wt) =\Sigma\ (4Vdc/n\pi)\ (\cos n\alpha 1 + \cos n\alpha 2 + \cos n\alpha 3+\cos n\alpha 4)\ \text{Sin}\ n\theta \quad (2)$$
$$n=1,3,5$$

Here the angles α1, α2, α3 and α4 are turn on angles for the switches of five level inverter. And these angles are used to reduce the harmonics which are present in output voltage. We can assume these angles to obtain symmetrical output voltage. But the calculated THD of output voltage is high for these angles. If we correctly select these angles, we can reduce THD in output voltage. For that we can use MATHCAD to find these angles. The proposed system analyses the frequency spectrum and Voltage control. In conduction angle control the lower order harmonics are reduced. By adjusting the turn on angle to various levels, it is possible to reduce the lower order harmonics. And the efficiency, power factor is improved. The Fourier expression is also obtained for the output voltage of five-level inverter.

For five level inverter

$$Vo\ (wt) = \Sigma\ (4Vdc/n\pi)\ (\cos n\alpha 1 + \cos n\alpha 2 + \cos n\alpha 3+\cos n\alpha 4)\ \text{Sin}\ n\theta \quad (3)$$
$$n=1,3,5.......$$

Where Vdc is the supply dc voltage.In the above expression there are four angles related to output voltage. So it is possible to reduce four odd harmonic because even harmonics are not present in output voltage. But our aim is to control the output voltage and reduction of harmonics. From the above expression, four equations are formed and the four angles are found. If the no of levels are increased, it is not easy to find the switching angles to remove particular order of harmonics for that ELIMINATION THEORY is used. The modulation index is chosen as 0.8 for low THD. In five level inverter to reduce the LOH from the output voltage, the turn-on angles are calculated from the output voltage equation.

III. GENETIC ALGORITHM

Professor John Holland in 1975 proposed an attractive class of computational models, called Genetic Algorithms (GA), that mimic the biological evolution process for solving problems in a wide domain. Genetic Algorithms has three major applications, namely, intelligent search, optimization and machine learning. Currently, Genetic Algorithms is used along with neural networks and fuzzy logic for solving more complex problems. Because of their joint usage in many problems, these together are often referred to by a generic name: "soft-computing". A Genetic Algorithms operates through a simple cycle of stages:

i. Creation of a ";population" of strings
ii. Evaluation of each string
iii. Selection of best strings and
iv. Genetic manipulation to create new population of strings.

Each cycle in Genetic Algorithms produces a new generation of possible solutions for a given problem. In the first phase, an initial population, describing representatives of the potential solution, is created to initiate the search process. The elements of the population are encoded into bit-strings, called chromosomes. The performance of the strings, often called fitness, is then evaluated with the help of some functions, representing the constraints of the problem. Depending on the fitness of the chromosomes, they are selected for a subsequent genetic manipulation process. It should be noted that the selection process is mainly responsible for assuring survival of the best-fit individuals. After selection of the population strings is over, the genetic manipulation process consisting of two steps is carried out. In the first step, the crossover operation that recombines the bits (genes) of each two selected strings (chromosomes) is executed. Various types of crossover operators are found in the literature. The single point and two points crossover are obtained.

OPTIMIZATION BY GENETIC ALGORITHM

It is inspired by the mechanism of natural selection where stronger individuals would likely be the winners in a competing environment. In this approach, the variables are represented as genes on a chromosome. GAs features a group of candidate solutions (population) on the response surface. Through natural selection and the gene-tic operators, mutation and recombination, chromo-somes with better fitness are found. Natural selection guarantees the recombination operator, the GA com-bines genes from two parent chromosomes to form two chromosomes (children) that have a high probability of having better fitness that their parents. Mutation allows new areas of the response surface to be explored. GAs offer a generational improvement in the fitness of the chromosomes and after many gene-rations will create chromosomes containing the optimized variable settings. The main operations of the genetic algorithm are the selection,

ISSN(Online): 2320-9801
ISSN (Print): 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 7, July 2015

the crossover and the mutation.

IV. SOME COMMON MISTAKES

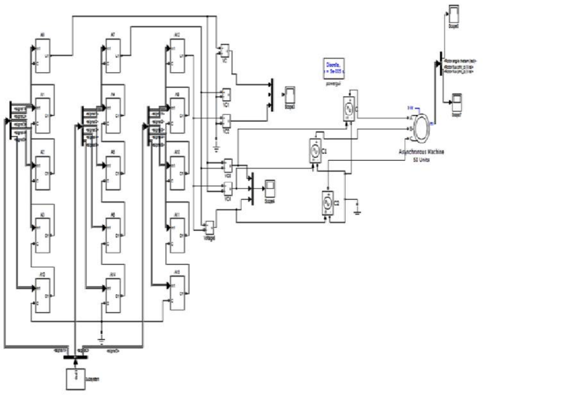

Figure 2.Simulation for 11 levels MLI

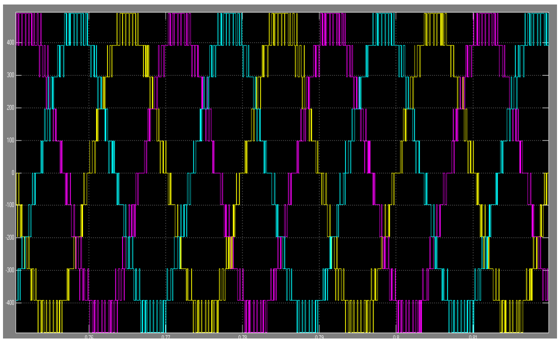

Figure 3 measured phase voltage of MLI output

A. Phase voltage THD

The GA is employed to minimize the objective function for the whole range of fundamental components. The obtained solutions for optimum switching angles are given by SPWM. The corresponding phase-voltage THD is shown in fig.3 Phase-voltage THD, on its own, is of little interest. For a three-phase load, the line-to-line voltage THD is important, since the triple harmonics, present in the phase voltage, are eliminated from the line voltage.

B. Line-Voltage THD Minimization

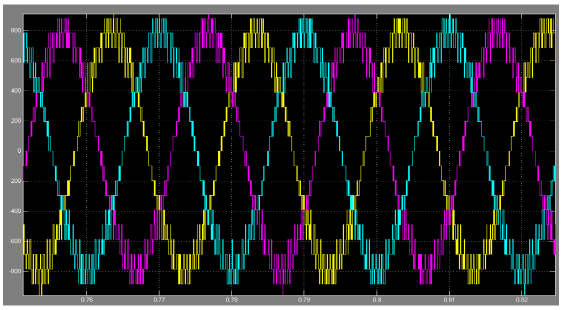

Figure 4 Measured line-to-line voltage waveform

ISSN(Online): 2320-9801
ISSN (Print): 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 7, July 2015

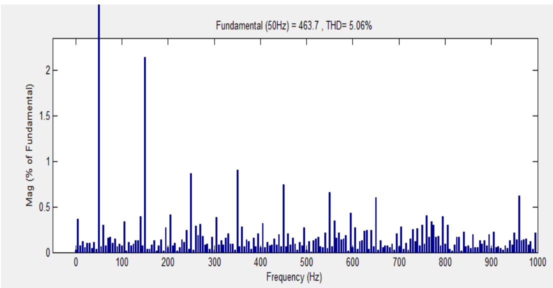

Figure 5 Harmonic spectra analysis of 11 level MLI line voltage

In this approach, the THD minimization algorithm is directly applied to the line-to-line voltage of the inverter. The line-to line voltage waveform is shown in Figure.4. Harmonics spectra analysis is shown in Figure 5

V. CONCLUSION

The disturbances in power electronics equipment are often periodic and rich in higher harmonics. They have been frequencies and are often above the bandwidth of regulators used to control fundamental components. Therefore, the 'regular' control can only partially reduce their effects on the distortion of control variables. The cascade multilevel inverter with unequal DC sources is illustrated and the gate triggering pulse is given by the step modulation Genetic algorithms technique. Here the inverter power device circuit used is IGBT device and it has the better switching frequency and gate control compared to all other semiconductor inverter devices such as power MOSFET, SCR, TRIAC etc., This Genetic algorithms control techniques enables us to obtain better selective harmonic reduction characteristics of the output AC voltage under the utilization ratio of different modulation, and achieve optical control of output waveform by different modulation ratio. Finally, we obtained the output AC voltage waveform and their frequency spectrums. Besides that, it realized better multilevel output and achieved desired results.

REFERENCES

[1] C. Cecati, F. Ciancetta, and P. Siano ,"A multilevel inverter for PV systems with fuzzy logic control," IEEE Trans. Electron., vol. 57, no.12,pp. 4115–4125,2005.
[2]K. El –Naggar , and T.H. Abdelhamid ,"Selective harmonic elimination of new family of multilevel inverters using genetic algorithms," Energy Converters. Manage., vol. 49, no. 1, pp. 89–95,2008.
[3] F. Khoucha, S.M. Lagoun, K. Marouani, A. Kheloui, and M. El Hachemi Benbouzid, "Hybrid cascaded H-Bridge multilevel-inverter induction motor- drive direct torque control for automotive applications," IEEE Trans. Ind. Electron., vol. 57, no. 3, pp. 892–899,2010.
[4] S.H. Fathi. M. G. Hosseini Aghdam , A. zahedi, and G.B. Gharehpetia "Optimum regulation of DC-sources in cascaded multi-level inverters, "COMPEL-Int. J. compute. Math. Elect. Electron. Eng., vol. 28,no.2,pp. 385–395,2009.
[5] L. G. Franquelo, J. Napoles , R.C.P. Guisado , J.I. Leon. , and M.A. Aguirre. , "A flexible selective harmonic mitigation technique to meet grid codes in three-level PWM converters," IEEE Trans. Ind. Electron., vol. 54, no. 6, pp. 3022–3029,2007.
[6]M.G. Hosseini Aghdam, S.H. Fathi, and G.B. Gharehpetian, "Comparison of OMTHD and OHSW harmonic optimization techniques in multilevel voltage-source inverter with non-equal DC sources," in Proc. IEEE 7th ICPE, pp. 587–591,2007.
[7]A.K. Kaviani, S.H. Fathi , N. Farokhnia, and A.J. Ardakani, "PSO, an effective tool for harmonics elimination and optimization in multi-level inverters," in Proc. 4th IEEE ICIEA pp. 2902–2907,2009.
[8]F. Khoucha, S.M. Lagoun. , K. Marouani, A, Kheloui. , and M. El Ha.chemiBenbouzid , "Hybrid cascaded H- multilevel-inverter induction motor-drive direct torque control for automotive applications," IEEE Trans. Ind. Electron., vol. 57, no. 3, pp. 892–899,2010.
[9] S. kouro, M. Malinowski, K. Gopakumar, J. Franquelo, L. G, Pou, L. G. Rodriguez. M.A. J. B.WU,, M.A. Perez, and J.I. Leon. ,"Recent advances and industrial applications of multilevel converters," IEEE Trans. Ind. Electron., vol. 57,no. 8, pp. 2553–2580,2010.
[10] M. Saeedifard, R.Iravani , and J. Pou. "Analysis and control of DC-capacitor-voltage-drift phenomenon of a passive front-end five-level converter," IEEE Trans. Ind. Electron., vol. 54, no. 6, pp. 3255–3266,2007.
[11]Y.shali, and M. K. Fellah , "New approach for the symmetrical multilevel inverters control: Optimal minimization of the total harmonic distortion(OMTHD technique)," in Proc. IEEE ISIE, Ajaccio, France,2004.
[12]Y.sahali, and M. K. Fellah, "Comparison between optimal minimization of total harmonic distortion and harmonic elimination with voltage control candidates for multilevel inverters," J. Elect. Syst., vol. 1, no. 3, pp. 32–46,2005.
[13]Y.Sahali, and M. K. Fellah, "Application of the optimal minimization of the THD technique to the multilevel symmetrical inverters and study of its performance in comparison with the selective harmonic elimination technique," in Proc. IEEE Int. SPEEDAM, pp. 1342–1348,2006.

ISSN(Online): 2320-9801
ISSN (Print): 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 7, July 2015

[14]K.Sivakumar,A.Das,R.Ramchand,C.Patel,andK.Gopakumar,"Afive-level inverter scheme for a four-pole induction motor drive by feeding the identical voltage-profile windings from both sides," IEEE Trans. Ind. Electron., vol. 57, no. 8, pp. 2776–2784,2010
[15]N.Yousefpoor,S.H.Fathi,N.Farokhnia,andS.HSadeghi,"Application of OHSW technique in cascaded multi-level inverter with adjustable DC sources," pp. 1–6,2009.

BIOGRAPHY

P.Senthilkumar received the B.E. degree in electrical and electronics engineering from PSG College of Technology, Coimbatore. He obtained his M.E. degree in the field of Power System from College of Engineering Gundy (CEG), Anna University. Since 2012, he has been with the Department of Electrical and Computer Engineering in Adama Science and Technology University, Ethiopia and continuing his service as Assistant professor inMizan-Tepi University presently. His current research interests include power electronics, electrical machine drives, active filters, flexible ac transmission systems, high-voltage dc andwireless power transmission. He is a member of IEEE, IET and life-member of Indian Society for Technical Education (ISTE). Along with many International Journal publications, he guided funded projects for UG, PG and Ph.D scholars in the field of transistorized drives,induction heating converters and power flow control drives for power system.

Gayathri Katuri obtained the B.E. degree in Electronics and Communication Engineering from Anna University, Chennai in 2008 followed by M.E. in Computer and Communication Engineering in 2013 from Anna University, Guindy, Chennai. Since 2011, She has been working as Assistant professor in VMKV Engineering College. She published several international and national journals and attended many conferences. Her research interest involves in Digital Communication, Cloud Computing, Wireless networks extended up to embedded technologies. She is guiding many projects for Undergraduate and Post graduate students. She is member of IEEE, IET.