SVPWM Based Multi Level Indirect Matrix Converter for Nonlinear Loads

Suhail Belal[1], Prof. Pramod Kumar Rathore[2], Prof. Ashok Jhala[3]

[1]Mtech. Scholar, [2]Guide, [3]HOD

Department of Electrical Engineering, RKDF College of Engineering, Bhopal

Abstract - The occurrence of Harmonics in power is the unwanted outcome of non-linear loads and industrial electronic devices. The output waveform contains various different waveforms holding assorted frequencies since the current which is taken from supply is no more simply sinusoidal. As a result of the thorough usage of power converters and comparable nonlinear loads in various sectors for different purposes, combined decrease in the voltage waveforms as well as current waveforms has been observed. The current conveyed by a nonlinear load can never be free from harmonics it always contains harmonics in certain amount. Distortion of load voltage is the unfavourable result of voltage dropping non-linearly which is caused by none other than the line current harmonics. The current carried by the linear load becoming non-sinusoidal is caused by the distortion in load voltage. To overcome power quality and harmonic issue a SVPWM based multi level indirect matrix converter for nonlinear loads has proposed in this work. The implementation and simulation of proposed work has done on Matlab Simulink. The obtained results are observed and compared with existing results. It is found that the proposed work has better performance as compared to existing work.

Keywords- SVPWM, Matrix Converter, Nonlinear Loads, Harmonic generation, Power Quality Improvement, THD.

I. INTRODUCTION

Three phase voltage-fed PWM inverters are recently showing growing popularity for multi-megawatt industrial drive applications. The main reasons for this popularity are easy sharing of large voltage between the series devices and the improvement of the harmonic quality at the output as compared to a two level inverter. In the lower end of power, GTO devices are being replaced by IGBTs because of their rapid evolution in voltage and current ratings and higher switching frequency. The Space Vector Pulse Width Modulation of a three level inverter provides the additional advantage of superior harmonic quality and larger under-modulation range that extends the modulation factor to 90.7% from the traditional value of 78.5% in Sinusoidal Pulse Width Modulation.

Pulse Width Modulation variable speed drives are increasingly applied in many new industrial applications that require superior performance. Recently, developments in power electronics and semiconductor technology have lead improvements in power electronic systems. Hence, different circuit configurations namely multilevel inverters have become popular and considerable interest by researcher are given on them. Variable voltage and frequency supply to drives is invariably obtained from a three-phase voltage source inverter. A number of Pulse width modulation (PWM) schemes are used to obtain variable voltage and frequency supply. The most widely used PWM schemes for three-phase voltage source inverters are carrier-based sinusoidal PWM and space vector PWM (SVPWM). There is an increasing trend of using space vector PWM (SVPWM) because of their easier digital realization and better dc bus utilization.

A noteworthy role is played by Pulse Width Modulation (PWM) inverters concerning power electronics.

The most prevalent pulse width modulation scheme which is conceivably the most efficient one among all other PWM techniques is Space Vector Modulated PWM (SVPWM) since it manages to produce high voltages accompanied with less total harmonic distortion as well as toils splendidly field oriented structures to achieve motor control.

Elimination of a number of small order harmonics by implementing an appropriate harmonic elimination methodology can lead to an excellent quality spectrum of output.

SVPWM signifies an exceptional switching scheme of six semiconductor switches of a 3- phase converter.

SVPWM has turned out to be a standard and prevalent PWM technique in some purposes like induction motor and synchronous motor control for 3-phase voltage-source inverters

SVPWM is well known for its efficient modulation technique as compared to other methods as it causes reduced harmonic distortion in output voltage as well as current which is applied to the ac motor phases. This in turn makes the most efficient use of the supply voltage when compared to other modulation schemes.

The switching frequency can be regulated with great ease in the case of SVPWM as it enables a steady unvarying switching frequency.

II. MATRIX CONVERTERS

Basically, a matrix converter (MC) is composed by 9 bidirectional switches, as shown in Fig. 1.1, where each dot of the grid represents a connection between the output and the input terminals.

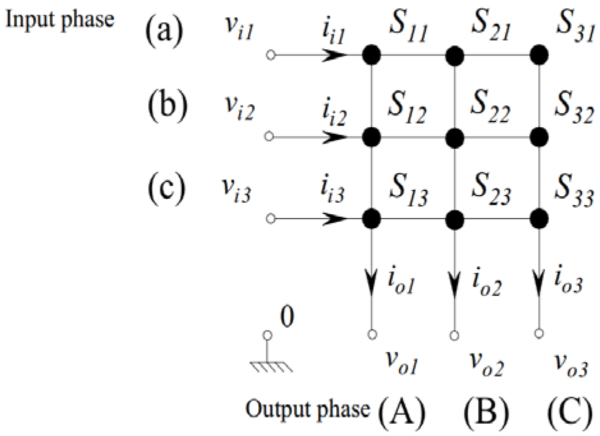

Figure 2.1 Basic Scheme of matrix converter.

The converter is usually fed at the input side by a three phase voltage source and it is connected to an inductive load at the output side.

The schematic circuit of a matrix converter feeding a passive load is shown in Fig. 2.2. The system is composed by the voltage supply, an L-C input filter, and the MC and load impedance.

a. Input Filter

The input filter is generally needed to smooth the input currents and to satisfy the EMI requirements. A reactive current flows through the input filter capacitor, leading to a reduction of the power factor, especially at low output power.

b. Bidirectional Switches

The MC requires bidirectional switches with the capability to block the voltage and to conduct the current in both directions. There are two main topologies for bi-directional switches, namely the common emitter anti- parallel IGBT configuration and the common collector anti-parallel IGBT configuration.

c. Current Commutation

Matrix converters have not free-wheeling diodes, unlike traditional voltage source inverters. This makes the current commutation between switches a difficult task, because the commutation has to be continuously controlled.

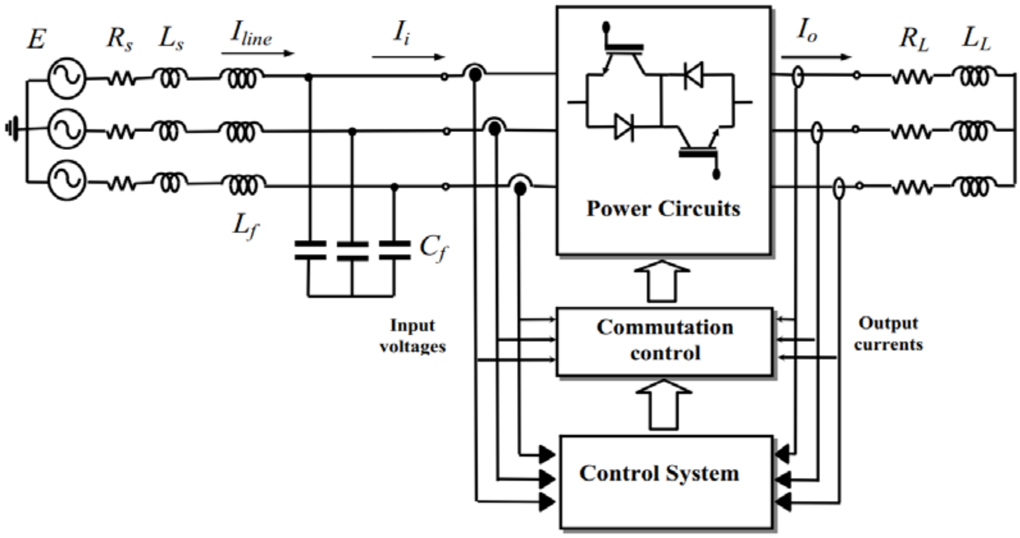

Figure 2.2 Schematic of Matrix Converter System

The switches have to be turned on and turned off in such a way as to avoid short circuits and sudden current interruptions.

d. Converter Protections

Due to the lack of free-wheeling paths for the currents, a number of protection strategies should be adopted to prevent the damage of the converter. Protections against over-load short-circuit and over-voltage are usually implemented. The over-load protection is performed directly by the control logic that turns off all the switches when the load current is greater than the rated one.

III. PROPOSED SYSTEM

A matrix converter based on SVPWM has been modelled in this work on MATLAB Simulink. Matrix convertres enables some interesting features, for example, conservativeness and sinusoidal waveform of the input and output streams. The intricacy of the matrix converter topology makes the investigation and the assurance of suitable modulation methodologies has carried out in this work. A Space Vector Modulation (SVM) approach has used in this work proposed System SIMULINK Circuit has shown in Figure 3.1.

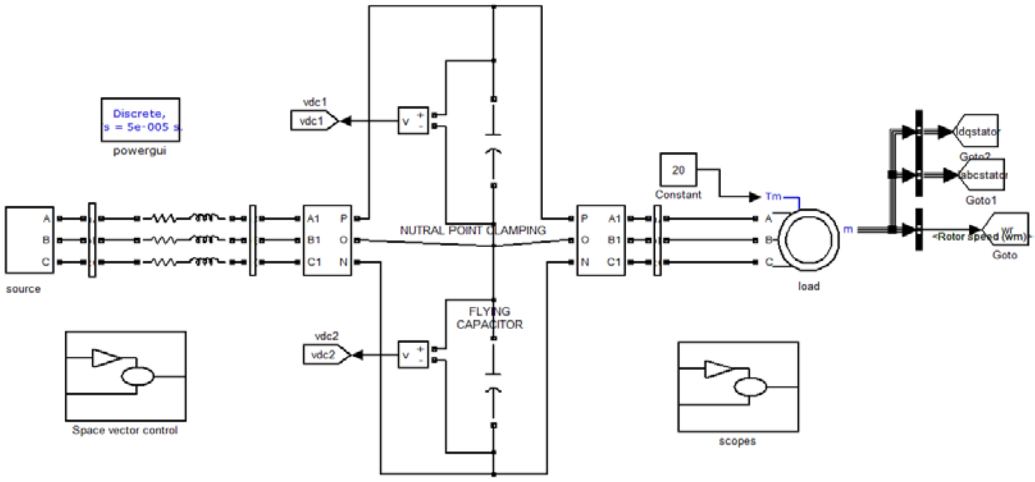

Figure 3.1 Proposed System SIMULINK Circuit.

The SVPWM approach, at first used to control just the output voltages has been progressively created with a specific end goal to completely abuse the possibility of matrix converters to control the input power factor in any case the output power factor, to completely use the input voltages, and to diminish the quantity of switch compensations in each cycle period. Moreover, this methodology permits a prompt comprehension of the modulation process, without the requirement for an imaginary DC interface, and avoiding the addition of the third harmonic elements. Figure 3.2 demonstrates the SIMULINK model of Proposed Indirect Matrix Converter network. The Space Vector modulation Approach is depends on the immediate space vector representation of input and output voltages and currents. Space Vector Control network of proposed system has been shown in figure 3.3. The SVM algorithm for matrix converters displayed in this work has the inherent ability to accomplish the full control of both output voltage vector and immediate input current displacement angle.

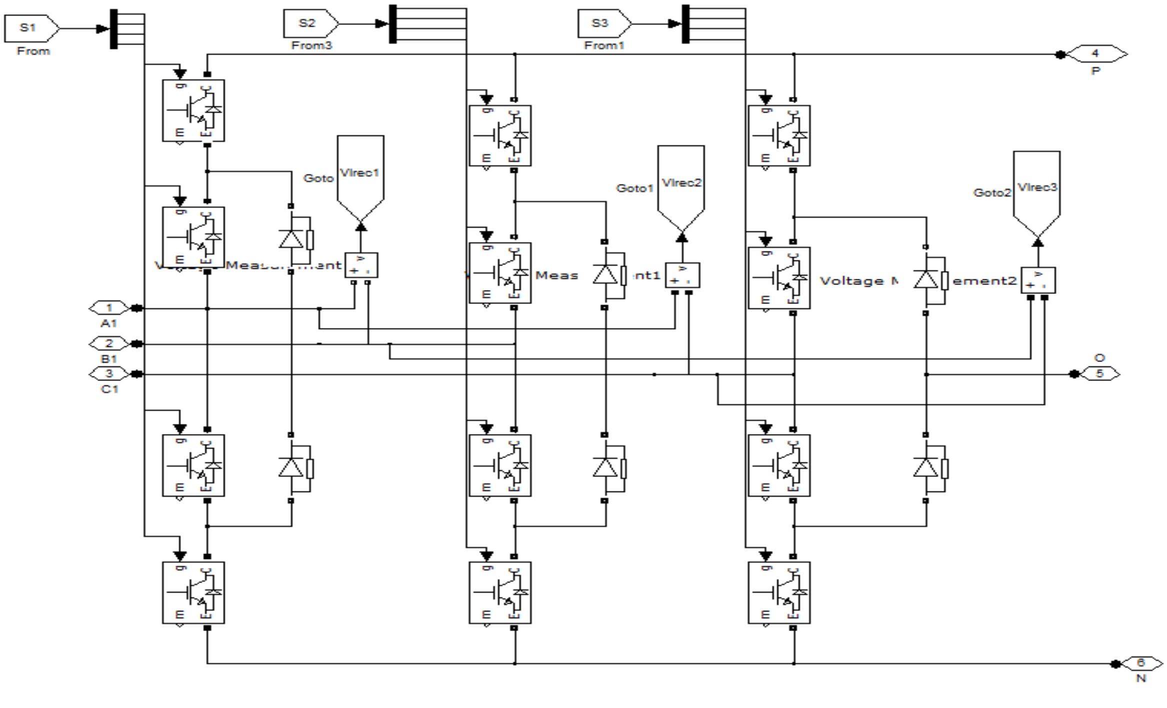

Figure 3.2 Proposed Indirect Matrix Converter Circuit.

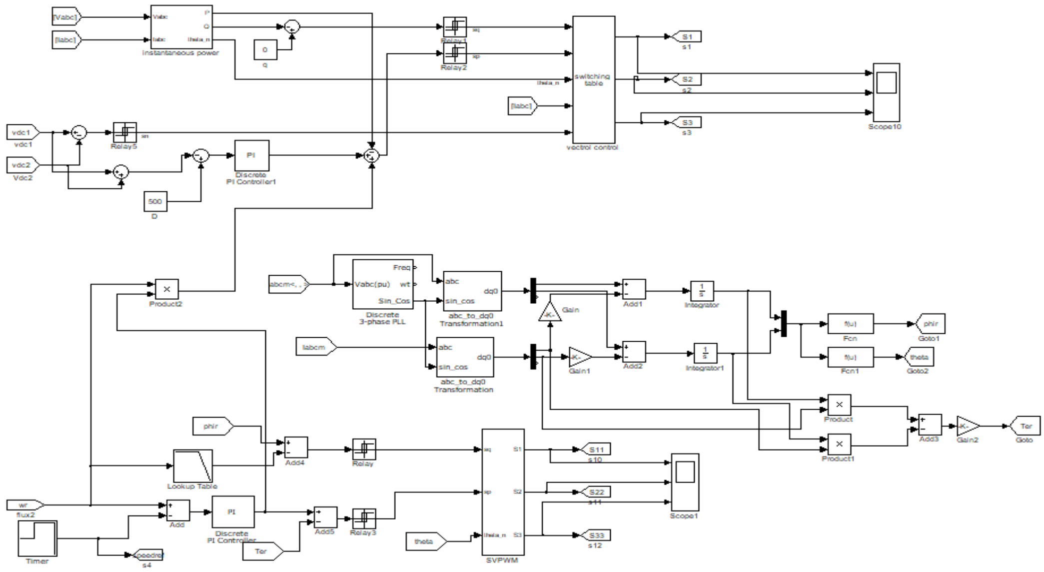

Figure 3.3 Space Vector Control Circuit.

IV. SIMULATION RESULTS

SVPWM based multi level indirect matrix converter for nonlinear loads has been implemented on MATLAB SIMULINK. To verify the performance of proposed system Simulation of proposed work has done on MATLAB SIMULINK. The performance of proposed work has evaluated based on input output currents and voltage waveforms. Input waveform of Three Phase Voltage has shown in Figure 4.1. The Level Voltage Va, Vb and Vc waveform has been shown in Figure 4.2. Figure 4.3 shows the Level Voltage and Phase Voltage. The characteristics of the proposed SVPWM technique have been also compared with existing strategy.

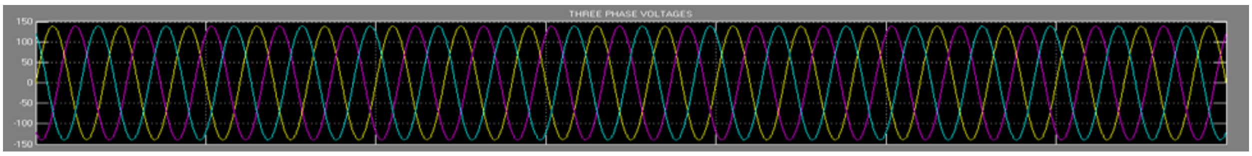

Figure 4.1 Three Phase Voltage.

Figure 4.4 shows the THD Analysis in fist experiment based on simulation the evaluated THD is 1.86% at 50Hz. For accurate evaluation the experiment has repeated two more times as shown in Figure 4.5 and figure 4.6. As shown in Figure 4.5 THD Analysis tests 2 the obtained THD=1.17% at frequency 50Hz. In Figure 4.6 THD Analysis test 3 the THD evaluated is THD=1.09% at frequency 50Hz.

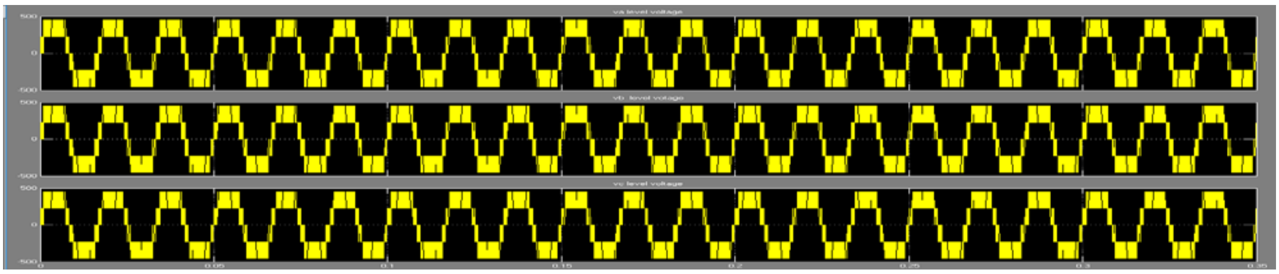

Figure 4.2 Level Voltage Va, Vb and Vc.

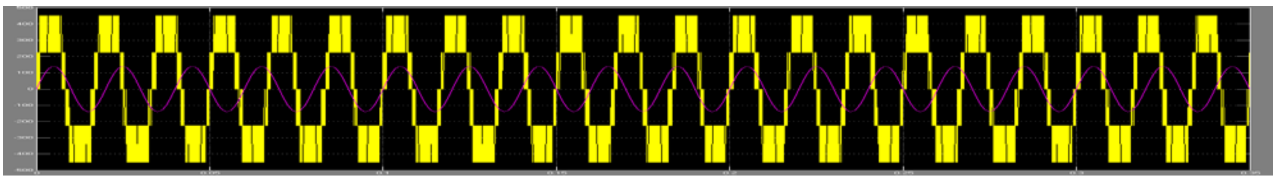

Figure 4.3 Level Voltage and Phase Voltage.

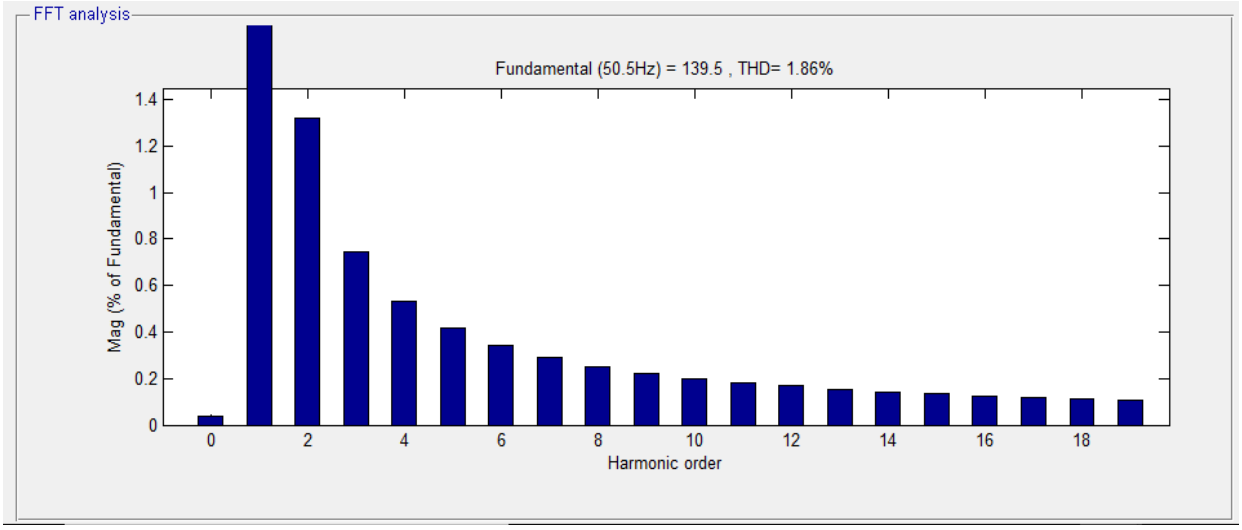

Figure 4.4 THD Analysis test 1.

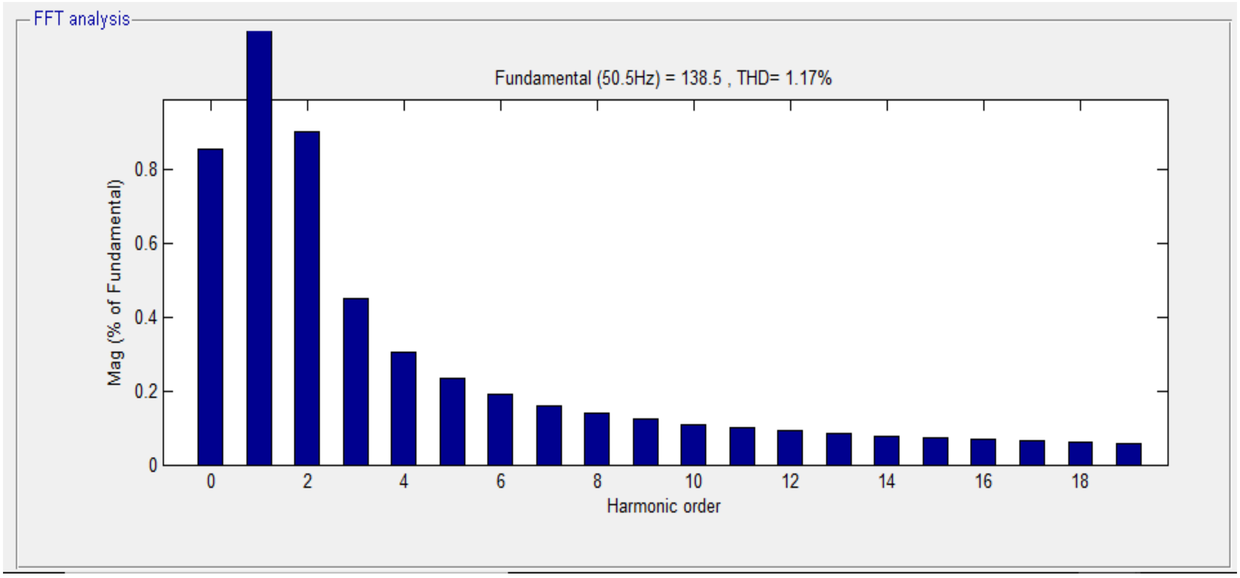

Figure 4.5 THD Analysis tests 2.

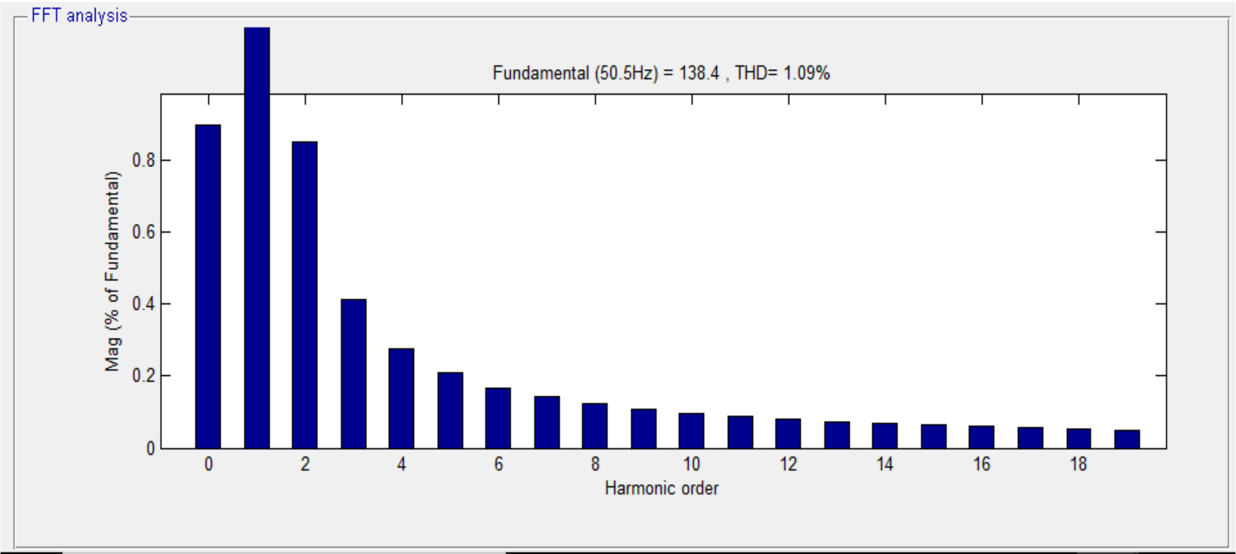

Figure 4.6 THD Analysis test 3.

V. CONCLUSION

This work presents a SVPWM based multi level indirect matrix converter for nonlinear loads. SVPWM is more complex and intricate than other methods of harmonics elimination, it may be executed with great ease involving recent digital signal processing based control mechanism. Vector theory allows through a simple and direct geometrical representation, an immediate comprehension of the modulation basic principles. The performance of the proposed strategy and of the existing, in terms of THD of input and output quantities, has been analyzed by means of realistic numerical simulations. The comparison has been carried out assuming either the same cycle period or the same switching frequency. The obtained results clearly emphasize the effectiveness of the proposed approach through THD analysis. The total harmonic distortion SVPWM based multi level indirect matrix converter for nonlinear loads is 1.86 %, 1.17% and 1.09%. Here, is it clearly visible that % THD is less in case of SVPWM as compare existing approach. Hence, it can be easily conclude that the proposed Technique is more efficient in eliminating harmonics.

REFERENCES

[1]. M. B. Ghat and A. Shukla, "A New H-Bridge Hybrid Modular Converter (HBHMC) for HVDC Application: Operating Modes, Control and Voltage Balancing," in IEEE Transactions on Power Electronics, vol. PP, no. 99, pp. 1-1..

[2]. M. A. Abdel-Moamen, S. A. Shaaban and F. Jurado, "France-Spain HVDC transmission system with hybrid modular multilevel converter and alternate-arm converter," 2017 Innovations in Power and Advanced Computing Technologies (i-PACT), Vellore, 2017, pp. 1-6

[3]. Shahu, T. Bandaru, T. Bhattacharya and D. Chatterjee, "Control of hybrid modular multilevel converter based HVDC system under DC short circuit faults," IECON 2017 - 43rd Annual Conference of the IEEE Industrial Electronics Society, Beijing, 2017, pp. 171-176.

[4]. M. Lu, J. Hu, L. Lin and K. Xu, "Zero DC voltage ride through of a hybrid modular multilevel converter in HVDC systems," in IET Renewable Power Generation, vol. 11, no. 1, pp. 35-43, 1 11 2017

[5]. K. Xu, J. Hu and M. Miao, "Analysis and control of hybrid modular multilevel converter with scheduled DC voltage reducing in a HVDC system," 12th IET International Conference on AC and DC Power Transmission (ACDC 2016), Beijing, 2016, pp. 1-6.

[6]. Rui Li, Jing Wu, Liangzhong Yao, Yan Li and B. Williams, "Hybrid modular multilevel converter with reduced three-level cells in HVDC transmission system," 2016 IEEE 8th International Power Electronics and Motion Control Conference (IPEMC-ECCE Asia), Hefei, 2016, pp. 708-712.

[7]. R. Li, G. P. Adam, D. Holliday, J. E. Fletcher and B. W. Williams, "Hybrid Cascaded Modular Multilevel Converter With DC Fault Ride-Through Capability for the HVDC Transmission System," in IEEE Transactions on Power Delivery, vol. 30, no. 4, pp. 1853-1862, Aug. 2015.

[8]. J. Qin and M. Saeedifard, "A Zero-Sequence Voltage Injection-Based Control Strategy for a Parallel Hybrid Modular Multilevel HVDC Converter System," in IEEE Transactions on Power Delivery, vol. 30, no. 2, pp. 728-736, April 2015.

[9]. Akagi, H., "Modern active filters and traditional passive filters"; Bulletin of The Polish Academy of Sciences Technical Sciences; Vol. 54, No. 3, pp. 255- 269; 2006.

[10]. Akagi, H., "New trends in active filters for improving power quality", in Proc. of the International Conference on Power Electronics, Drives and Energy Systems for Industrial Growth, 1996,Vol. 1, Issue 8-11, Jan. 1996, pp. - 425.

[11]. A. Iqbal, A. Lamine, I. Ashraf, and Mohibullah, "Matlab/simulink model of space vector pwm for three-phase voltage source inverter," in Universities Power Engineering Conference, 2006. UPEC '06. Proceedings of the 41st International, vol. 3, pp. 1096–1100. 2006.

[12]. H. Van der Broeck, H.-C. Skudelny, and G. Stanke, "Analysis and realization of a pulse width modulator based on voltage space vectors,"Industry Applications, IEEE Transactions on, vol. 24, no. 1, pp. 142–150, 1988.

[13]. J.W. Dixon, J. J. Garcia, and L. Moran, ―Control system for three-phase active power filter which simultaneously compensates power-factor and unbalanced loads,‖ IEEE Trans. Ind. Electron., vol. 42, pp. 636–641,Dec. 1995.