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Harmonic Current Compensation for Power Quality Improvement Using SVPWM based Three Level Converter

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Abstract— *Multilevel converters are widely being used for various high power applications like industrial motor drive, wind farm integration, HVDCtransmission etc. In this paper three-phase diode clamped converter with space vector pulse width modulation (SVPWM) technique has been used to generate the firing pulses. The controller is self-adaptive in nature, and detects the vector, region and sector based on the position of reference voltage vector. This keeps current error space phasor within the prescribed hexagonal boundary. By assuring the switching of only adjacent voltage vectors, the proposed controller is able to eliminate the random switching as observed in case of conventional hysteresis controller.*

Index Terms— PWM, Multilevel Inverter, Neutral Point Clamped Inverter, Total Harmonic Distortion, SVPWM.

1 INTRODUCTION

The IGBT based two-level converters are very common due to their capability in power flow in either direction, which is appriciated by many industrial drives applications and uninterruptable power supply (UPS) etc. [1,2,3]. However, for high-power industrial applications, two-level converters are limited in their use due to high vlotage stress and require higher forward and reverse voltage blocking capacity. The high power and adjustable speed drive requires higher ratings of switches, which puts limitations on switching frequency and cost of the overall system [4]. Multi-level converter as front- end topology offers advantages of bi-directional power flow capability, reduced device rating and lower device stress, which makes them suitable for high-power applications [5]

Most of the high-performance converters employ current controlled PWM techniques for fast dynamic response [6]. Hysteresis current controllers are easy to implement and offers good dynamic response. But on the other hand, this controller suffers from drawbacks as random switching of voltage vectors, limit cycle oscillation, overshoot in current error and random switching of voltage vectors [7,8]. To overcome the said limitations of conventional hysteresis controller, current error space phasor based hysteresis controller is proposed in this paper. A multilevel inverter have the advantages as their level can be easily increased, filtering is not required and as level increases the harmonic contents are reduced considerably.

2. SYSTEM DESCRIPTIONS

2.1. Voltage Source Converters:

A voltage source converter consists of a turn-off device connected in anti-parallel with a diode which has lowest reverse leakage current with the anode of turn-off device connected to the positive side of DC side. In inverter action, turn-off device will conduct and current / power flows from DC side to AC side. In rectifier action, the diode will conduct and current / power flows from AC to DC side. Under inverter operation, current and voltage will be of opposite polarity and under rectifier operation

2.2. Three Level Diode Clamped Converter Topology:

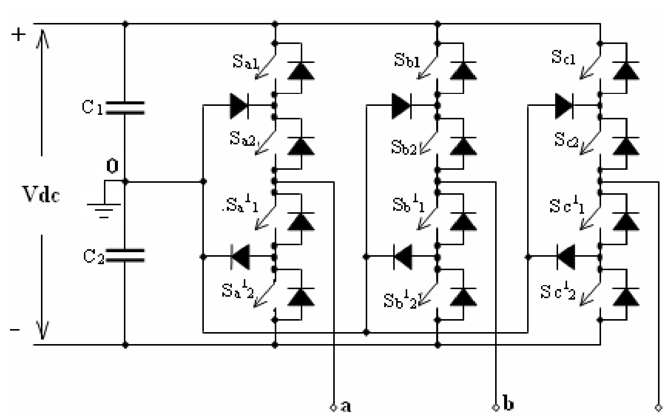

Figure 1 : Three Phase Three Level Diode-Clamped Inverter

The 3 phase 3-level diode-clamped inverter in this paper that shown in Figure 1 came from the neutral point converters (NPC) topology, which was proposed by Nabae, Takahashi, and Akagi [3].

2.3 CONTROL SCHEME:

A carrier-based SVPWM modulation technique [3] is utilized in order to provide an appropriate switching pattern for better output sinusoidal voltage waveform. However, this technique is collaborated with the d-q synchronous reference frame control scheme in order to the generate reference current for control. The algorithm of overall control scheme is as following. When the PLL has detected the frequency and phase from grid system, the phase angle is used to be a reference for the two-phase transformation (abc-dq). These independent parts of signal are being controlled via the PI controller, which are act as current and voltage control, respectively. The controlled signals are re-transformed into 3 phase control signals (dq-abc), and then transformed into controlling signals using a Park's transformation.

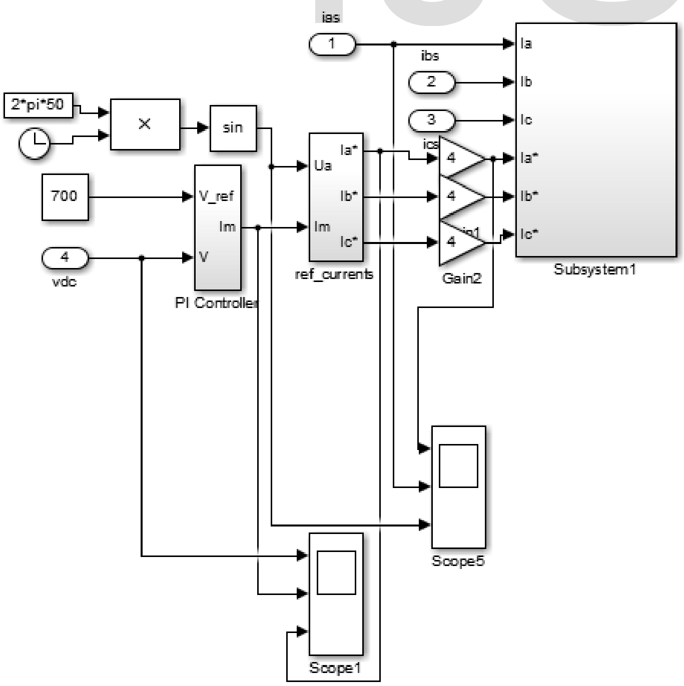

Figure 2: Reference Current Generation

These control signals are suitable to use as a reference signal for the carrier-based SVPWM technique. The reference signal for such technique utilized in this paper is shown in Figure 2.

The relation between 3 phase control signals (abc) to d-q axis and α-β axis can be expresses by the following equations.

$$\begin{bmatrix} Vd \\ Vq \end{bmatrix} = \frac{2}{3}\begin{bmatrix} 1 & -\frac{1}{2} & -\frac{1}{2} \\ 0 & \frac{\sqrt{3}}{2} & -\frac{\sqrt{3}}{2} \end{bmatrix}\begin{bmatrix} Va \\ Vb \\ Vc \end{bmatrix} \quad \text{—— (1)}$$

$$\begin{bmatrix} V\alpha \\ V\beta \end{bmatrix} = \sqrt{\frac{2}{3}}\begin{bmatrix} 1 & -\frac{1}{2} & -\frac{1}{2} \\ 0 & \frac{\sqrt{3}}{2} & -\frac{\sqrt{3}}{2} \end{bmatrix}\begin{bmatrix} Va \\ Vb \\ Vc \end{bmatrix} \quad \text{—— (2)}$$

The illustration of a two-axis is shown in Figure 3, it has 6 sections and 8 voltage vectors, each vector runs from (0 0 0) to (1 1 1). Due to voltage vector V_0 and V_7 are at origin and then there are 6 sectors and 6 voltage vectors.

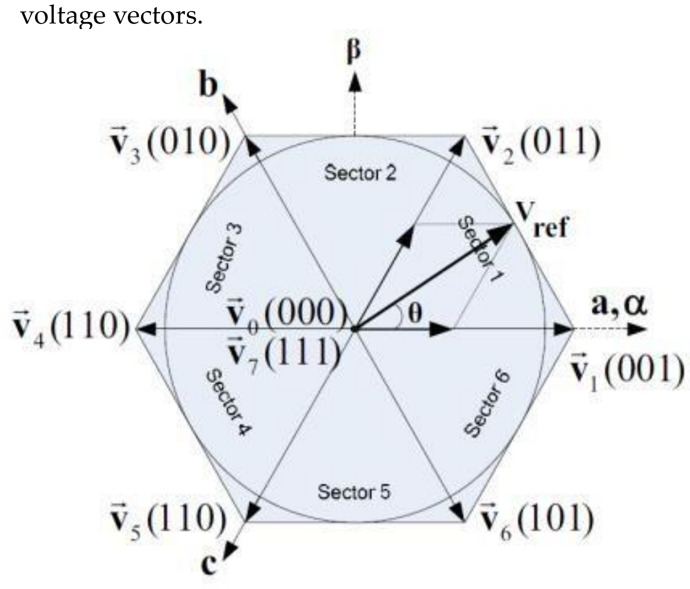

Figure 3 : Illustration of Two axis voltage vector

3. Simulation Model:

The Simulink model of power circuit of 3 - phase 3 - level diode-clamped converter is shown in Figure 4. The simulation parameters of the proposed system are given in Table 1

Table 1. Simulation parameters of the proposed system

Parameters	Specifications
DC-link voltage	700V
Filter inductance (L)	8mH
Filter capacitors (C)	10uF
Phase voltage (V)	220V
Frequency of grid system (f)	50Hz
Switching frequency (f_{SW})	10kHz

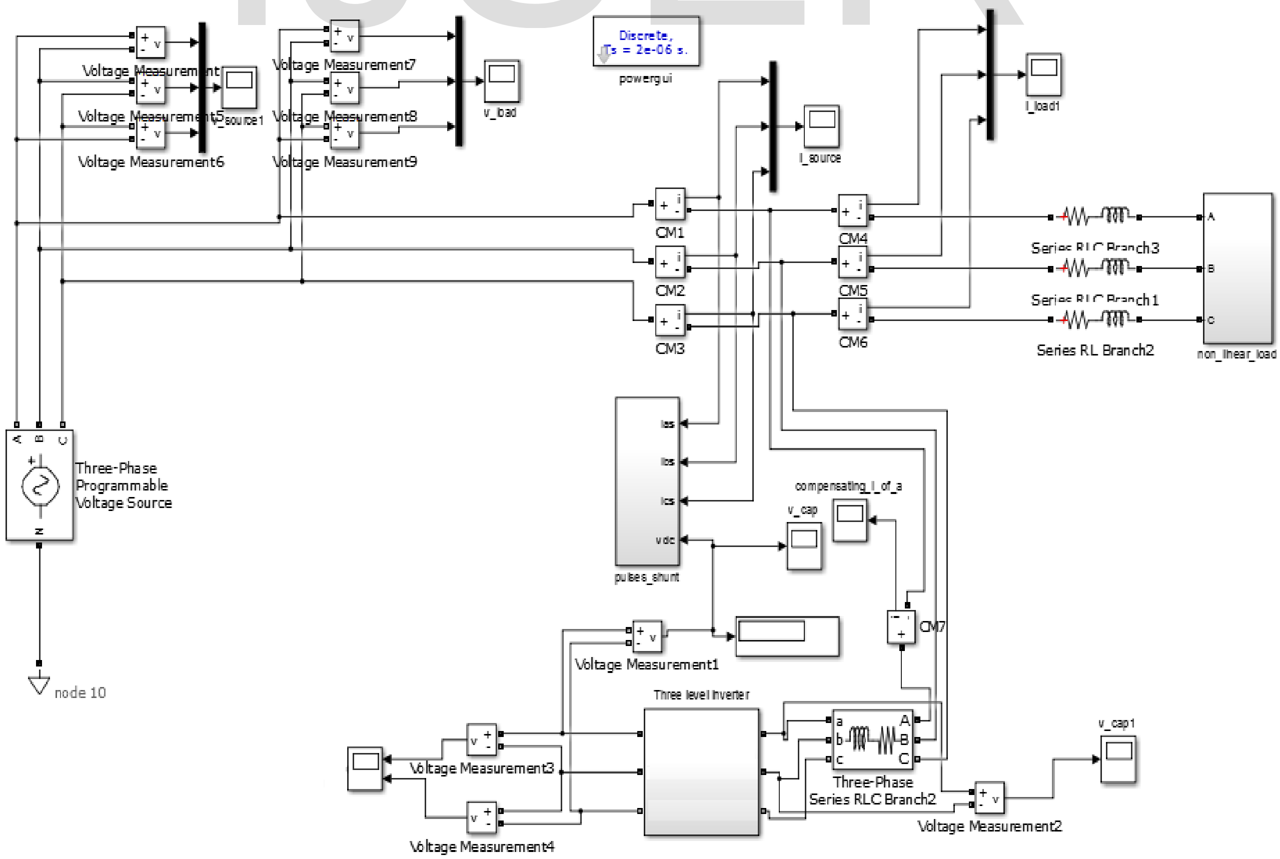

Figure 4: Simulation model

4. RESULTS

In the figure 5, FFT analysis of the Current at non linear load end had been shown which shows total harmonic distortion (THD) of 26.62%.

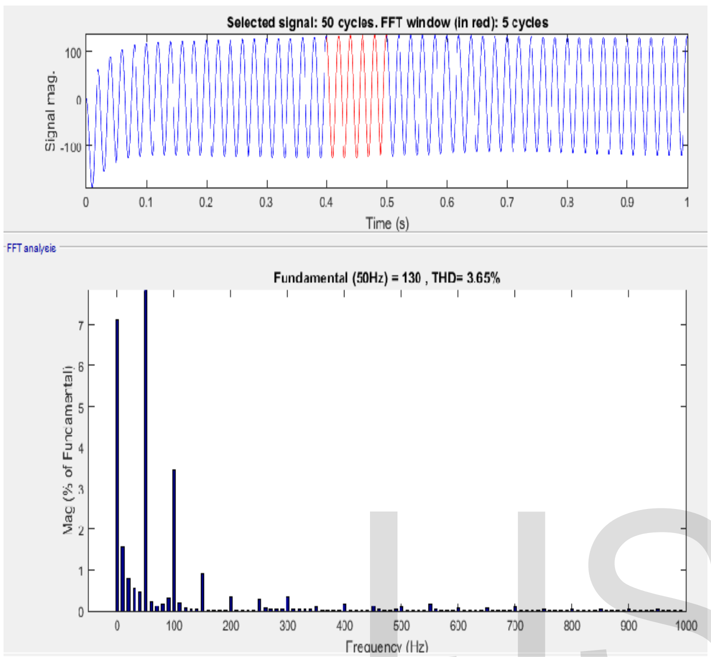

Figure 6: Source Current (THD 3.65%)

In the figure 6, FFT analysis of the source current has been done and this shows that THD after harmonic current compensation through SVPWM three - level converter the THD at source current is reduced to 3.65%.

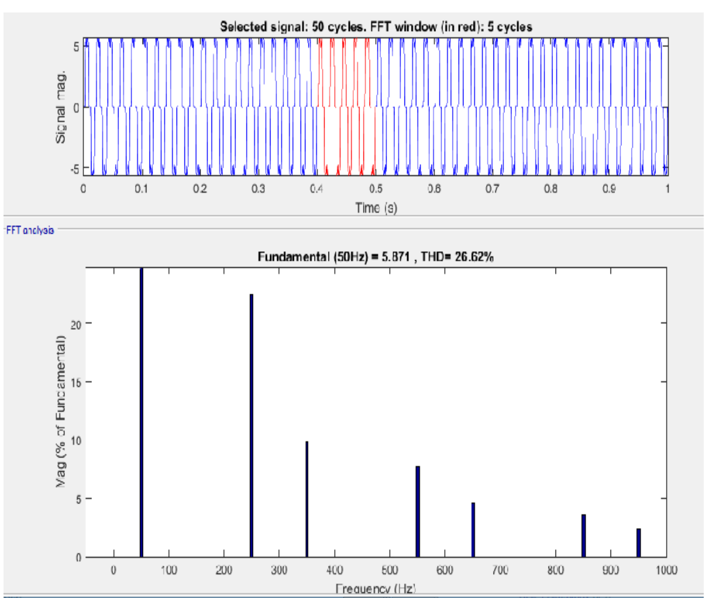

Figure5: Current at Load end (THD 26.62%)

5. CONCLUSION

In this article, the simulation of the 3 phase 3 level diode-clamped converter is carried out using the MATLAB/Simulink program. The proposed converter has a rating on, 400V at PCC and 700 V at DC-link. There are 12 power switches in the 3 phase 3 level diode clamped inverter. The proposed carrier-based SVPWM technique provides a better performance of voltage and grid current waveform at the PCC. However, filter is also associated to ensure the sinusoidal waveform of both voltage and current. By the adjustment of PI controller in the control scheme, the energy can be transferred from inverter. In which, the THDcurrent is at 3.65 % within the IEEE Standard limit.

REFERENCES:

[1] J. Rodriguez, J. S. Lai, and F. Z. Peng, "Multilevel inverters: A survey of topologies, controls, and applications," *IEEE Trans. Ind. Electron.*, vol. 49, no. 4, pp. 724–738, Aug. 2002.

[2] T.Ohnishi and H.Okitsu, "A novel PWM technique for three-phase inverter/converter," *International Power Electronics Conference*, 1983, pp.384-395.

[3] A. Nabae, I. Takahashi, and H. Akagi, "A new neutral-point clamped PWM inverter," *IEEE Trans. Ind. Applicat.*, vol. IA-17, pp. 518–523, Sept./Oct. 1981.

[4] N. Celanovic and D. Boroyevic, "A fast space vector modulation algorithm for multilevel three-phase converters," in *Conf. Rec. IEEE-IAS Annu. Meeting*, Phoenix, AZ, Oct. 1999, pp. 1173–1177.

[5] J. Rodríguez, P. Correa, and L. Morán, "A vector control technique for medium voltage multilevel inverters," in *Proc. IEEE APEC*, Anaheim, CA, Mar. 2001, pp. 173–178.

[6] P. Hammond, "A new approach to enhance power quality for medium voltage ac drives," *IEEE Trans. Ind. Applicat.*, vol. 33, pp. 202–208, Jan./Feb. 1997.

[7] L. Tolbert and T. G. Habetler, "Novel multilevel inverter carrier-based PWM method," *IEEE Trans. Ind. Applicat.*, vol. 35, pp. 1098–1107, Sept./Oct. 1999.

[8] V. G. Agelidis and M. Calais, "Application specific harmonic performance evaluation of multicarrier PWM techniques," in *Proc. IEEE PESC'98*, Fukuoka, Japan, May 1998, pp. 172–178.

[9] W. A. Hill and C. D. Harbourt, "Performance of medium voltage multilevel inverters," in *Conf. Rec. IEEE-IAS Annu. Meeting*, Pheonix, AZ, Oct. 1999, pp. 1186–1192.

[10] Carrara, G.,Gardella, S.G., Archesoni,M., Salutari, R., and Sciutto, G.: 'A new multi-level PWM method: A theoretical analysis', IEEE Trans. Power Electron., 1992, 7, (3), pp. 497–505