RESEARCH ARTICLE OPEN ACCESS

"Investigations on Third Harmonic Injected Control Strategies of Multilevel Inverters for Improved Power Quality"

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Abstract:

Multilevel Inverter has gained popularity in high power and voltage applications such as electrical power transmission and grid integration of renewable energy source. Multilevel inverter is designed to achieve higher voltage level with low harmonics and without requiring higher ratings of individual devices. In this paper, three modulation strategies based on a Multicarrier level shifted PWM and third harmonic Injected reference has been implemented; the aim of this paper is to compare these three strategies to know their effect on the output voltage quality of the inverter. The three modulation strategies are: Third Harmonic Injected reference In Phase Disposition (THI-IPD), Third Harmonic Injected reference Alternative Phase Opposition Disposition (THI-APOD) and Third Harmonic Injected reference Phase Opposition Disposition (THI-POD). These three strategies are applied to 9-levels diode clamped Multilevel inverter under different operation conditions and different Modulation schemes. The study has been implemented via simulation using MATLAB/Simulink

Keywords — **Phase Disposition, Phase Opposition Disposition, Harmonics, Phase Shift PWM, Hybride PWM, Third Harmonic Injected reference.**

I. INTRODUCTION

As discussed in presiding chapter's multilevel inverter are popularly available in three common topologies.

1.diode clamped MLI
2.flying capacitors MLI
3.cascaded h-bridge MLI

Among these topologies the diode clamped MLI is one of the major choices of drive and power electronic industries. While the cascaded h-bridge topologies is mostly preferred by renewable energy application due to its modular approach. Among these three strategies simulation & modeling of these two popular schemes will be validated through Matlab simulation considering the following points and aspects. Furthermore these M.L.I topologies may be investigated on the basis of modulation schemes and is purposed to implement and validate hybrid modulation schemes which will be tested on a diode clamped MLI.

II. MODELLING OF DCMLI (9 LEVEL)

The bellow is the simulink model of the proposed DCMLI. The proposed topology has been designed for a nine level operation with multicarrier based modulation scheme.

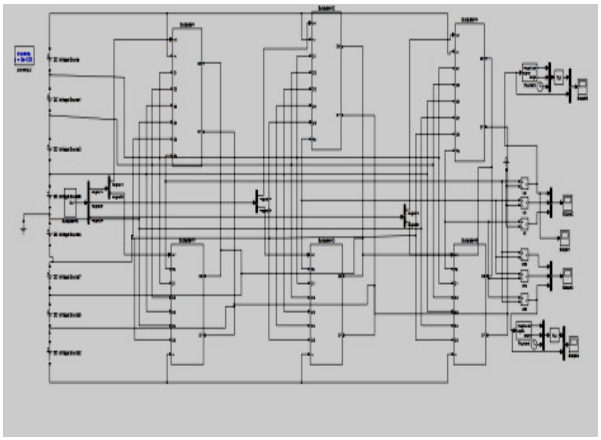

Fig. 1 Simulink model of DCMLI

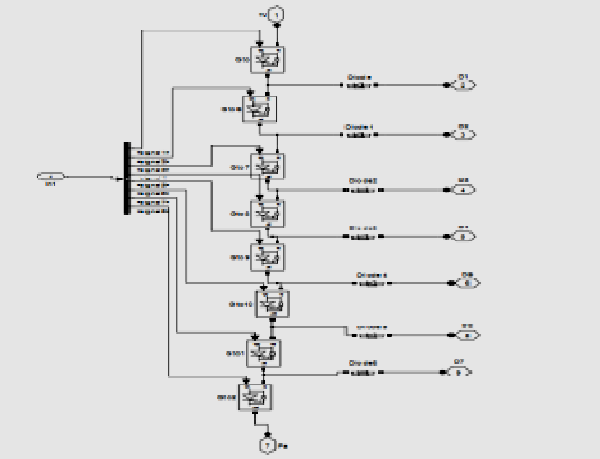

Fig. 2 Subsystem for individual leg of DCMLI

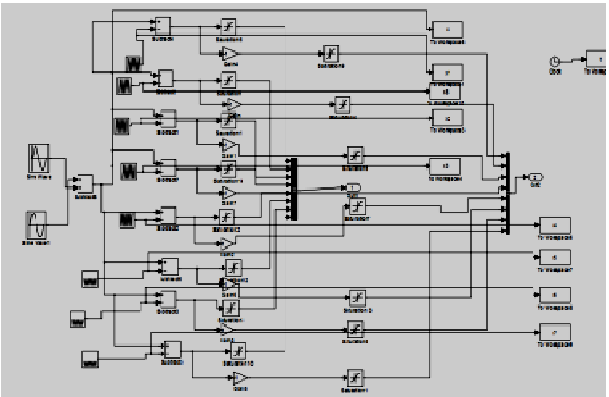

Fig. 3 subsystem for implementation of modulation scheme of of DCMLI

Fig.2 shows the subsystem for one half leg of the proposed scheme, while the subsystem for implementing the different modulation scheme is shown in Fig. 3. in this figure the different carrier based modulation with third harmonics injection is implemented.

III. MODULATION SCHEMES

In this section the different modulation schemes which are commonly prevailed for the control of DCMLI have been discussed. These modulation schemes are based on multicarrier based modulation which are further modified with third harmonic injection.

IV. SINUSOIDAL PULSE WIDTH MODULATION (SPWM) WITH MULTI-CARRIER SCHEMES

In this section the control schemes for implementation of multi carrier modulation schemes with SPWM has been discussed. The following popularly implemented modulation schemes with a minor modification in the carrier wave form is shown below. The first scheme is the Phase disposition PWM Schemes with

1 Triangular Carrier (scheme 2)
2.With 3rdHarmonic Injection (scheme 1)

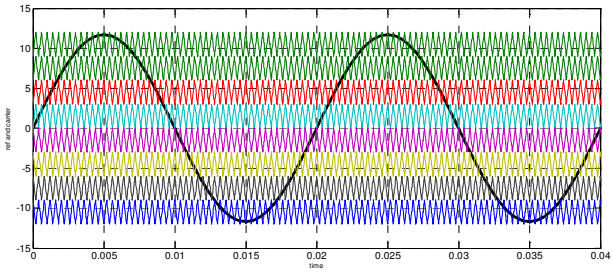

Fig. 4. Carrier and reference wave form for scheme 2

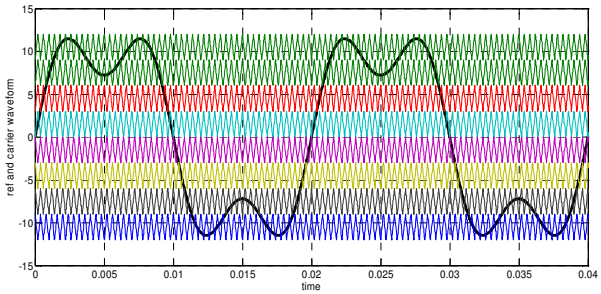

Fig. 4.1 Carrier and reference wave form for scheme 1

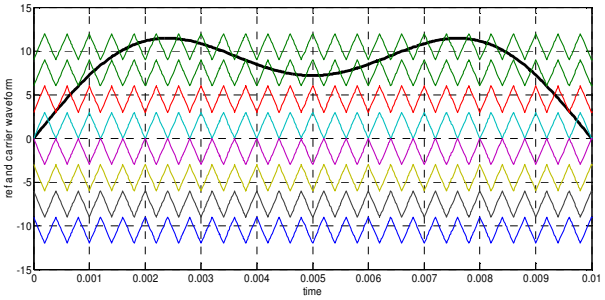

Fig. 4.2 enlarged Carrier and reference wave form for scheme 1

As it can be seen from Fig. 4 that in this modulation scheme sinusoidal multicarrier

modulation with a reference sinusoidal waveform, with third harmonic wave is implemented.

V. VARIABLE AMPLITUDE PHASE DISPOSITION SCHEMES

1.Traingular Carrier (scheme 4)
2.With 3rd Harmonic Injection(scheme 3)

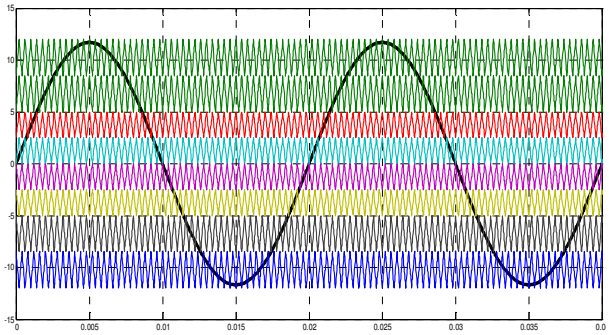

Fig.5 Carrier and reference wave form for scheme 4

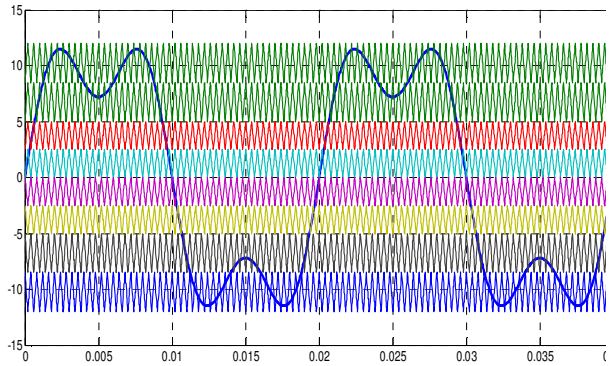

Fig. 5.1 Carrier and reference wave form for scheme 3

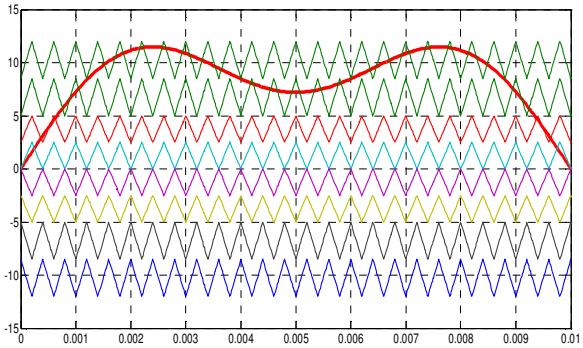

Fig. 5.2. Enlarged Carrier and reference wave form for scheme

VI. PHASE OPPOSITION DISPOSITION PWM SCHEMES

1. Triangular Carrier (scheme 6)
2. With 3rd Harmonic Injection (scheme 5)

As it can be seen from Fig. 10 that in this modulation scheme sinusoidal multicarrier modulation with a reference sinusoidal waveform, with third harmonic wave is implemented. The alternate carrier waveforms are in phase opposition.

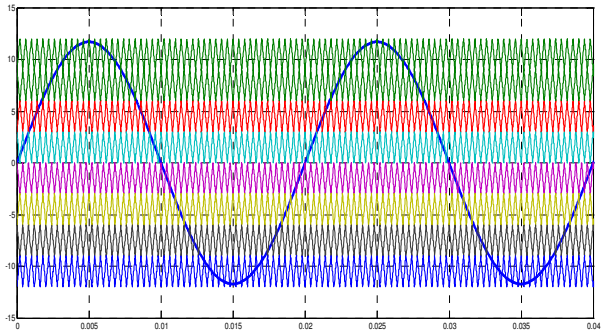

Fig.6 Carrier and reference wave form for scheme 6

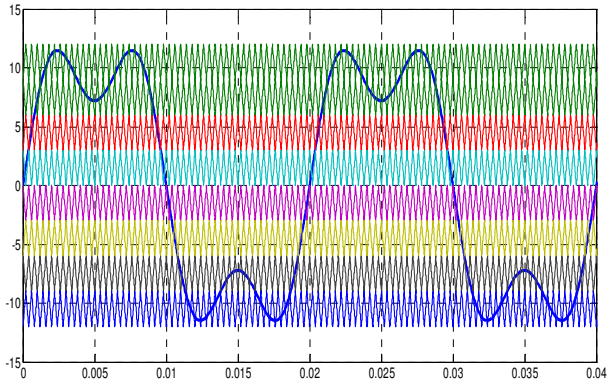

Fig.6.1 Carrier and reference wave form for scheme 5

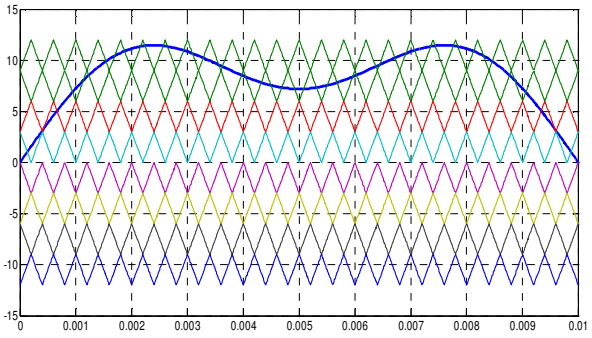

Fig.6.2 enlarged Carrier and reference wave form for scheme 5

VII. VARIABLE AMPLITUDE PHASE OPPOSITION DISPOSITION PWM SCHEMES

1. Triangular Carrier (scheme 8)
2. With 3rd Harmonic Injection(scheme 7)

As it can be seen from Fig. 7 that in this modulation scheme sinusoidal multicarrier modulation with a reference sinusoidal waveform , with third harmonic wave is implemented. The alternate carrier waveforms are in phase opposition and variable in magnitude.

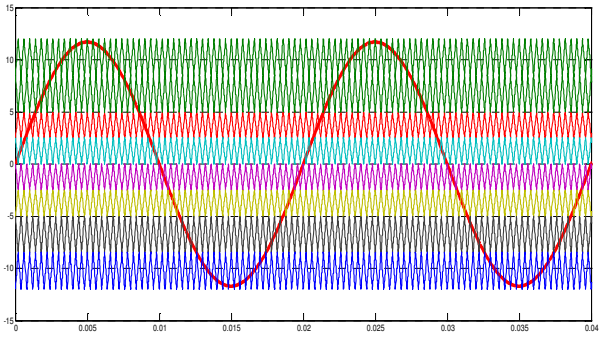

Fig.7 Carrier and reference wave form for scheme 8

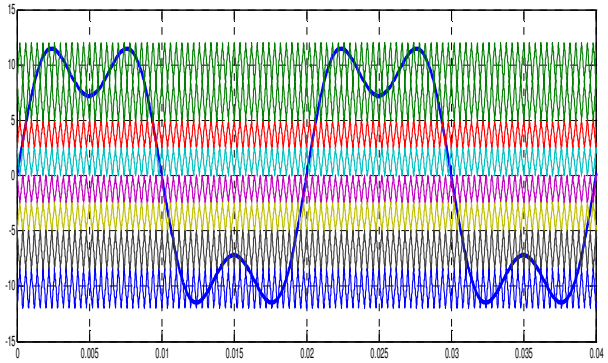

Fig. 7.1 Carrier and reference wave form for scheme 7

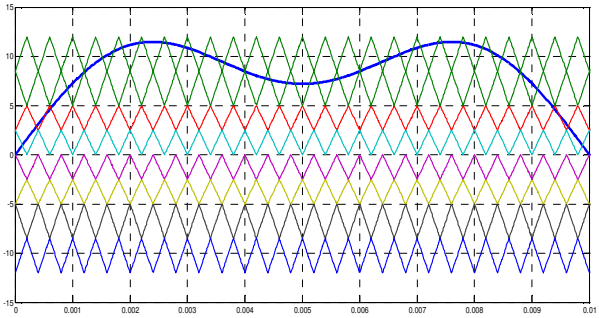

Fig. 7.2. enlarged Carrier and reference wave form for scheme

VIII. VARIABLE FREQUENCY PWM SCHEMES

1. Triangular Carrier (scheme 10)
2. With 3rd Harmonic Injection(scheme 9)

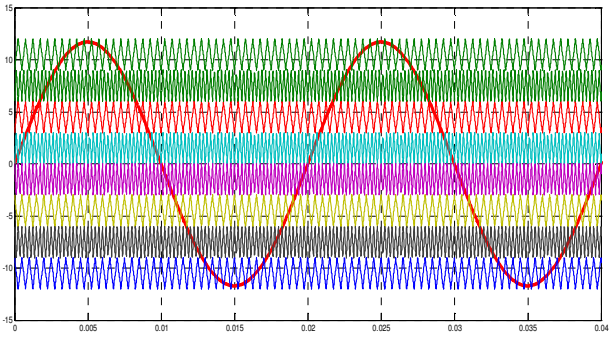

Fig. 8 Carrier and reference wave form for scheme 10

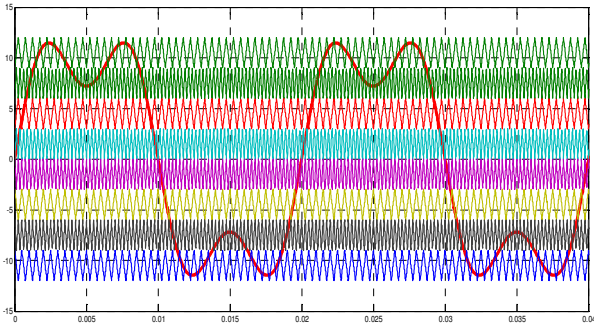

Fig. 8.1 Carrier and reference wave form for scheme 9

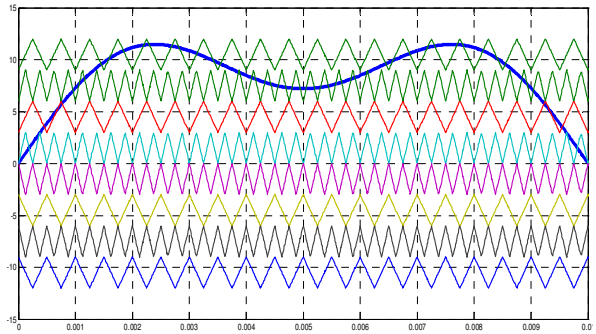

Fig.8.2 enlarged Carrier and reference wave form for scheme 9

As it can be seen from Fig. 8 that in this modulation scheme sinusoidal multicarrier modulation with a reference sinusoidal waveform , with third harmonic wave is implemented. The alternate carrier waveforms are in phase but different in frequencies.

IX. CONCLUSION

In this chapter, a detailed discussion on MLI topologies along with a modulation schemes and this development of simulation models have been carried out.

Furthermore popular carrier waves modulation schemes along with 3rd harmonic injection has also been purposed and simulated.

REFERENCES

[1]S. Jeevananthan, R. Madhavan, T. Suresh Padmanabhan and P.Dananjayan,"State-of-the-art of multi-carrier modulation techniques for seven level inverter: A critical evaluation and novel submissions based on control degree of freedom," Industrial Technology, 2006. ICIT 2006 IEEE International Conference , 2006, pp. 1269-1274.

[2] S. S. Fazel, "Investigation and Comparison of Multi-Level Converters for Medium Voltage Applications," Ph.D. dissertation, Technical Univ of Berlin., Berlin., 2007.

*[3]A. Lega. "Multilevel Converters: Dual Two-Level Inverter Scheme,"
Ph.D. dissertation, Dept. Elect. Eng., Univ of Bologna., Bologna, Italy,2007.*

*[4] Y. Liu, "Advanced Modulation, Control and Application for Multilevel
Inverters, " Ph.D. dissertation, North Carolina State Univ, Raleigh,North Carolina, 2009.*

[5] J. A. Houldsworth and D. A. Grant, "The use of harmonic distortion toincrease the output

voltage of a three-phase PWM inverter," IEEE Trans.Ind. Appl., vol. IA-20, pp. 1224-1228, Sept. 1984.

[6] S. Khomfoi and L. M. Tolbert, "Multilevel Power Converters", in M. H.Rashid, Power Electronics Handbook - Devices, Circuits, and Applications, 3rd ed. Elsevier, 2011, ch.17,pp. 455-484.

[7] Z. Daneshi Far, A. Radan and M. Davari Far, "Introduction and evaluation of novel multi-level carrier-based pwm strategies using,ageneralized lgorithm" ,Power Electronics and Applications 2007European Conference, 2007, pp. 1-10.

[8] M. Tamasas, M. Saleh, M. Shaker, A. Hammoda, "Evaluation of modulation techniques for 5-level inverter based on multicarrier level shift PWM", Proc. IEEE Mediterranean Electrotech. Conf., pp. 17-23, Apr. 2014.