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Hybrid Bidirectional Multilevel Inverter with Less Number of Components

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Abstract—Multilevel inverters performance enhancement is a major topic which has attracted the attention of most of the researchers, to evolve with newer topologies and modulation strategies. In this manuscript two novel hybrid bidirectional multilevel inverter structures which are suitable for bidirectional loads are proposed. An enhancement in the voltage levels and reduction of the component count are achieved for these newly introduced structures. Modular expansion and series cascading are suggested systems for extension of the voltage levels. The prime requirement in most of the industrial drives is a controlled output. VSI fed Induction motor drive satisfies this requirement. The Multicarrier PWM technique has been applied to the basic bidirectional seven level models and nine level model and its performance with induction motor as load has been analyzed for various modulation indices. The simulated results of the proposed structures are verified using MATLAB/SIMULINK platform.

Keywords—*Hybrid bidirectional Multilevel Inverter; cascading; modular expansion; Phase disposition Multicarrier Pulse width Modulation (PDMPWM); Total Harmonic distortion (THD);*

I. INTRODUCTION

The future era of power electronics is focused on energy conservation so as to attain a pollution free environment by adopting energy efficient power modulators for power conversion. Multilevel inverters have become an integral component of the power electronic system. Multilevel inverter has been used in variety of applications which include high speed adjustable drives, Facts devices for reactive power compensation, battery powered vehicles and for grid integration [1-8]. Because of its ever increasing applications the performance improvement of multilevel inverter had been most essential criteria and it attracted many researchers towards introducing newer topologies and control techniques [9-11].

In conventional inverters losses and the output voltage harmonic content were found to be too high so multilevel inverter has emerged as an alternative to address this issue and also to attain high voltage levels. The role of MLI is to synthesize a stepped waveform output voltage with better quality and lesser THD. As the number of stages maximizes, the harmonic content decreases significantly in output voltage step waveform [12].

The three major classical topologies of MLI are clamped diode [13, 14], flying capacitor [15, 16], and cascade type [17, 18]. The requirement of a large number of diodes at neutral point and neutral point voltage balance problems are the draw backs and in flying capacitor the need of many storage capacitors and capacitor voltage balancing issue were the demerits. In case of cascaded H Bridge requirement of many isolated sources has been the major drawback. Inspite of its disadvantage it is more widely used owing to its modularity and its structure is devoid of passive energy storing devices. Increased switch count and its related gate driver circuits and protection circuit were the main disadvantages of multilevel inverters. To overcome these issues many researchers have suggested newer topologies with innovative ideas [19-22]. Many derived structures like Artificial neutral point clamped derived from NPC converter and Packed U cell converter derived from FC with component reduction has been introduced [23]. Several Hybrid topologies which combine two topologies have been emerged. Cascaded Multilevel inverter with sub multilevel inverters and modular multilevel converter were among the emerging structures which has been recently introduced [24]. Hybrid inverters mainly consist of two sub circuits. One basic circuit generates the required positive levels and the other circuit functions as a polarity reversal circuit which is an H- bridge circuit. [25-29].

II. OPERATION OF THE BASIC TOPOLOGY

The basic unit which is a seven level bi directional MLI circuit as given in Figure 1. This structure is capable of supplying inductive loads with bidirectional current. The basic circuit comprises of seven IGBT switches. In that six switches are unidirectional and one switch is bidirectional.

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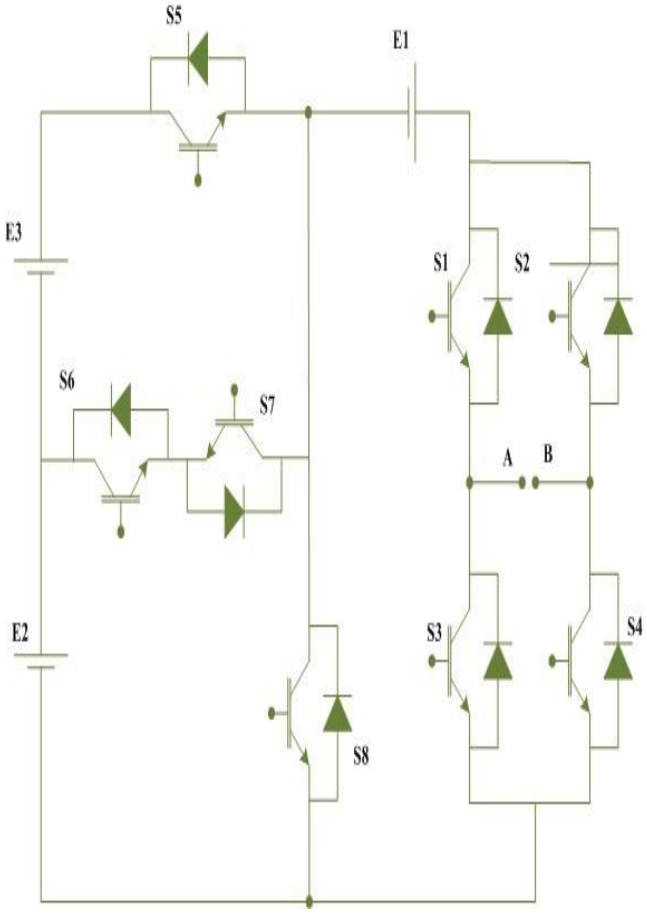

Figure 1 Circuit diagram of seven level bidirectional MLI

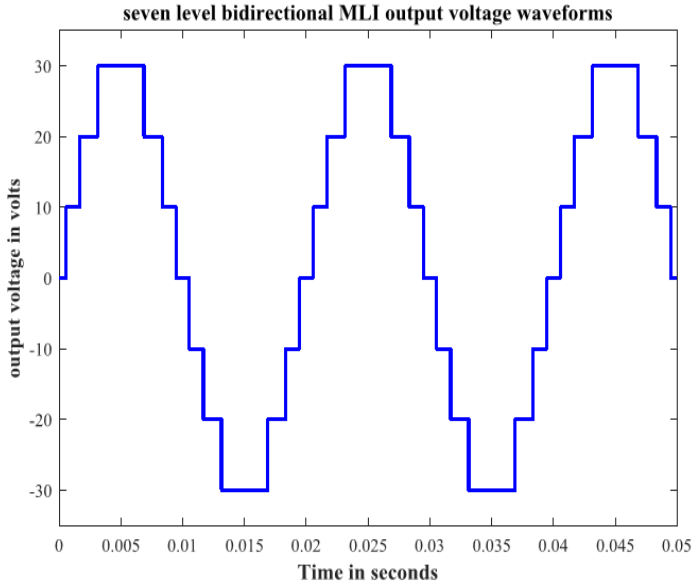

Figure 2 Output voltage waveform for seven level multilevel inverter

Table 1: Switching Sequence of basic 7LBMLI							
S1	S2	S3	S4	S5	S6/S7	S8	Load Voltage $V_{AB}(t)$
1	1	0	0	0	0	0	0
1	0	1	0	1	0	0	vdc
1	0	1	0	0	1	0	2Vdc
1	0	1	0	0	0	1	3Vdc
0	0	1	1	0	0	0	0
0	1	0	1	1	0	0	-Vdc
0	1	0	1	0	1	0	-2Vdc
0	1	0	1	0	0	1	-3Vdc

III. SIMULATION RESULTS

The operation of this circuit is described by a switching table as indicated in table 1 for symmetrical source configuration. When S5 is on and S6/S7 and S8 is off it produces level 1 with E1 as output voltage. When S6 is on and S5 and S8 are off then it produces E1+E2 as output voltage. When S8 is on and S5 and S6/S7 is off it produces E1+E2+E3 as the output voltage. An output voltage waveform for seven level circuits is shown in Figure 1. With a symmetrical voltage selection by suitable relationship of voltages the number of output stages could be extended as nine. Their output voltage waveform is demonstrated at Figure 2.

IV CONCLUSIONS

In this work hybrid bidirectional multilevel inverter fed induction motor drive is presented. The simulated results are obtained for seven level for the proposed structures by series cascading with level doubling network. The simulated results are verified for seven level output, which are synthesized using series cascading method with two similar basic units. All these hybrid BMLI structures produced output with lesser voltage harmonic content. The simulated results obtained by using MATLAB SIMULINK software. This hybrid BMLI structures with increased output voltage levels and minimized THD would be well suited for medium powered AC drive applications.

REFERENCES

[1] J. Lee, A. Rizvi, F. Lin, J. Min, B. Hartaigh and D. Han. 2016. "Fractional Flow Reserve Measurement by Computed Tomography: An Alternative to the Stress Test", *Interventional Cardiology Review*, vol.11, no.2, pp.105, Available: 10.15420/icr.2016:1:2.

[2] L. Franquelo, J. Rodriguez, J. Leon, S. Kouro, R. Portillo and M. Prats. 2008. "The age of multilevel converters arrives", *IEEE Industrial Electronics Magazine*, vol.2, no.2 pp.28-39, Available: 10.1109/mie.2008.923519.

[3] D. Abbott. 2010. "Keeping the Energy Debate Clean: How Do We Supply the World's Energy Needs"?, *Proceedings of the IEEE*, vol.98, no. 1, pp.4266, Available:10.1109/jproc.2009.2035162.

[4] X. Yu, C. Cecati, T. Dillon and M. Simões, 2011. "The New Frontier of Smart Grids", *IEEE Industrial Electronics Magazine*, vol.5, no.3, pp.49-63, Available:10.1109/mie.2011.942176.

[5] S. Mythili, K. Thiyagarajah, P. Rajesh and Shajin FH. 2020. "Ideal position and size selection of unified power flow controllers (UPFCs) to upgrade the dynamic stability of systems: an antlion optimiser and invasive weed optimisation algorithm". *HKIE Trans*, vol.27, no.1, pp.25-37,

[6] P. Rajesh, F. A. Shajin, 2020. "Multi-Objective Hybrid Algorithm for Planning Electrical Distribution System", *European Journal of Electrical Engineering*, vol.22, no.1, pp.224-509,

[7] FH. Shajin, P. Rajesh. 2020. "Trusted secure geographic routing protocol: outsider attack detection in mobile ad hoc networks by adopting trusted secure geographic routing protocol". *International Journal of Pervasive Computing and Communications*.

[8] MK. Thota, FH. Shajin and P. Rajesh. 2020. "Survey on software defect prediction techniques". *International Journal of Applied Science and Engineering*. Vol.17, no.4, pp.331-44,

[9] Y. Liao and C. 2011. Lai. "Newly-Constructed

Simplified Single-Phase Multistring Multilevel Inverter Topology for Distributed Energy Resources", *IEEE Transactions on Power Electronics,* vol.26, no.9 pp.2386-2392, Available: 10.1109/tpel.2011.2157526.

[10] K. Gupta and S. Jain. 2012. "Topology for multilevel inverters to attain maximum number of levels from given DC sources", *IET Power Electronics,* vol.5, no. 4, pp.435, Available: 10.1049/iet-pel.2011.0178.

[11] N. Abd Rahim, M. Mohamad Elias and W. Hew. 2012. "Transistor-Clamped H-Bridge Based Cascaded Multilevel Inverter with New Method of Capacitor Voltage Balancing", *IEEE Transactions on Industrial Electronics*, vol.60, no.8, pp.2943-56.Available: 10.1109/tie.2012.2200213.

[12] J.S. Lai and F.Z. Peng, 1996. "Multilevel converters-a new breed of power converters", *IEEE Transactions on Industry Applications*, vol.32, no.3 pp.509-517, Available: 10.1109/28.502161.

[13] L. Tolbert, J. Chiasson, Z. Du and K. McKenzie. 2005. "Elimination of Harmonics in a Multilevel Converter WithNonequal DC Sources", *IEEE Transactions on Industry Application*s, vol.41, pp.75-82, Available: 10.1109/tia.2004.841162.

[14] A. Nabae, I. Takahashi and H. Akagi. 1981. "A New Neutral-Point-Clamped PWM Inverter", *IEEE Transactions on Industry Applications*, pp.518-523, Available: 10.1109/tia.1981.4503992.

[15] Nabae, I. Takahashi and H. Akagi. 1981. A New Neutral-Point-Clamped PWM Inverter, *IEEE Transactions on Industry Applications*, vol.5, pp.518523, Available: 10.1109/tia.1981.4503992.

[16] T. Meynard and H. Foch. 1992. "Multi-Level Choppers for High Voltage Applications", *EPE Journal*, vol.2, no.1, pp.45-50, Available: 10.1080/09398368.1992.11463285.

[17] J. Myers. 1997. The United States patent and trademark office internet home pages", *World Patent Information*, vol.19, pp.77-78, Available: 10.1016/s01722190(97)82780-9.

[18] P. Hammond. 1997."A new approach to enhance power quality for medium voltage AC drives", *IEEE Transactions on Industry Applications*, vol.33, no.1, pp.202-208, Available: 10.1109/28.567113.