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# Multilevel Inverter Topology for Renewable Energy Grid Integration

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**ABSTRACT:** In this paper, three-phase parallel grid connected multilevel inverter (MLI) topologies with a novel switching strategy are proposed. This Inverter is intended to feed amicrogrid from renewable energy sources (RES) to overcome theproblem of the polluted sinusoidal output in classical invertersand to reduce component count, particularly for generating amultilevel waveform with a large number of levels. In the proposedtopology, both voltage pulse width and height are modulated andpre-calculated by using a pulse width and height modulation(PWHM) so as to reduce the number of switching states and the total harmonic distortion (THD).The topology is investigated through simulations and validatedexperimentally with a laboratory prototype.

**KEYWORDS:** Multilevel inverter, Pulse width and height modulation, Total harmonic distortion.

## I.INTRODUCTION

At present, here are over 300 GW of wind power generation and over 110 GW photovoltaic generationsinstalled worldwide. Renewable power plants of more than10 MW in capacity become a reality [1]. However, therenewable energy sources have highly variable daily andseasonal patterns, and consumer power demand requirementsare also extremely variable in nature [2]. Therefore, it isdifficult to operate a stand-alone power system supplied fromonly one type of renewable energy source unless appropriateenergy storage facilities. If enough energy storage capacity isnot available, especially in medium to large-scale systems, agrid-connected renewable power generation may be the onlypractical solution [3].For grid integration, the use of simple conventional inverter,two level, produces a square wave which is not suitable formost of the intricate applications. In such cases, a pure sinusoidal wave is desired. Even more, the traditional convertersrating power are limited to the rated power of the used semiconductor devices and the allowed switching frequencies [4].Conventional inverters based on power-frequency transformersoperating at 50 or 60 Hz and AC filters are generally used inrenewable power generation systems to step up the voltageto the grid voltage levels of 6–36 kV and to reduce thevoltage THD respectively. High investment and installationcosts are required because of its heavy weight and largesize [5].

## II.PROPOSED WORK

The generalized three-phase multilevel invertertopology is shown in Fig.1. It consists of n renewable sources (n DC sources)feeding microgrid. In general, the DC voltage sources canhave different values. However, in order to optimize the totalharmonic order of the multilevel output waveform, they areconsidered to be optimized, and regulated through DC-DC orAC-DC converters. The multilevel inverter consists of  $2n^2+2n$ power switches, so  $4n^2 + 4n$  insulated gate bipolar transistors(IGBT) with antiparallel diodes  $S_{i;j}$  ( $1 < i < 2n$  ;  $1 < j < (n + 1)$ ). For instance, when  $S_{11}$  and  $S_{22}$  are turned ON, theoutput voltage  $U_{ab}$  is equal to  $E_1$ , when  $S_{11}$ ;  $S_{24}$ ,  $S_{34}$ ,  $S_{43}$ ,  $S_{53}$  and  $S_{62}$  are turned ON the output voltages  $U_{ab}$ ,  $U_{bc}$  and  $U_{ca}$  are  $E_1 + E_2 + E_3$ ,  $-E_3$  and  $-E_2 - E_1$  respectively.As  $U_{ab} + U_{bc} + U_{ca} = 0$  for each switching state, so abalanced system is obtained. Following the same combination, $n^2 + 2(n - 1)$  possible levels ( $E_1$ ;  $E_2$ ;  $(E_1 + E_2)$ ;  $E_3 : E_n$ )for the output waveform are obtained. Therefore, the switcheshave to withstand both positive and negative voltages. Inaddition, the switches have to conduct backward current thatis a result of the grid inductive nature. It can be concludedthat the switches must be bidirectional. There are severalcircuit configurations for bidirectional switches In this study,the common emitter topology is used as it, requires only onegate driver per switch. Table I shows the states of the switchesfor each output voltage value, 1 corresponds to the switchON state, 0 corresponds to the OFF state and k is variableaccording to the switching state.

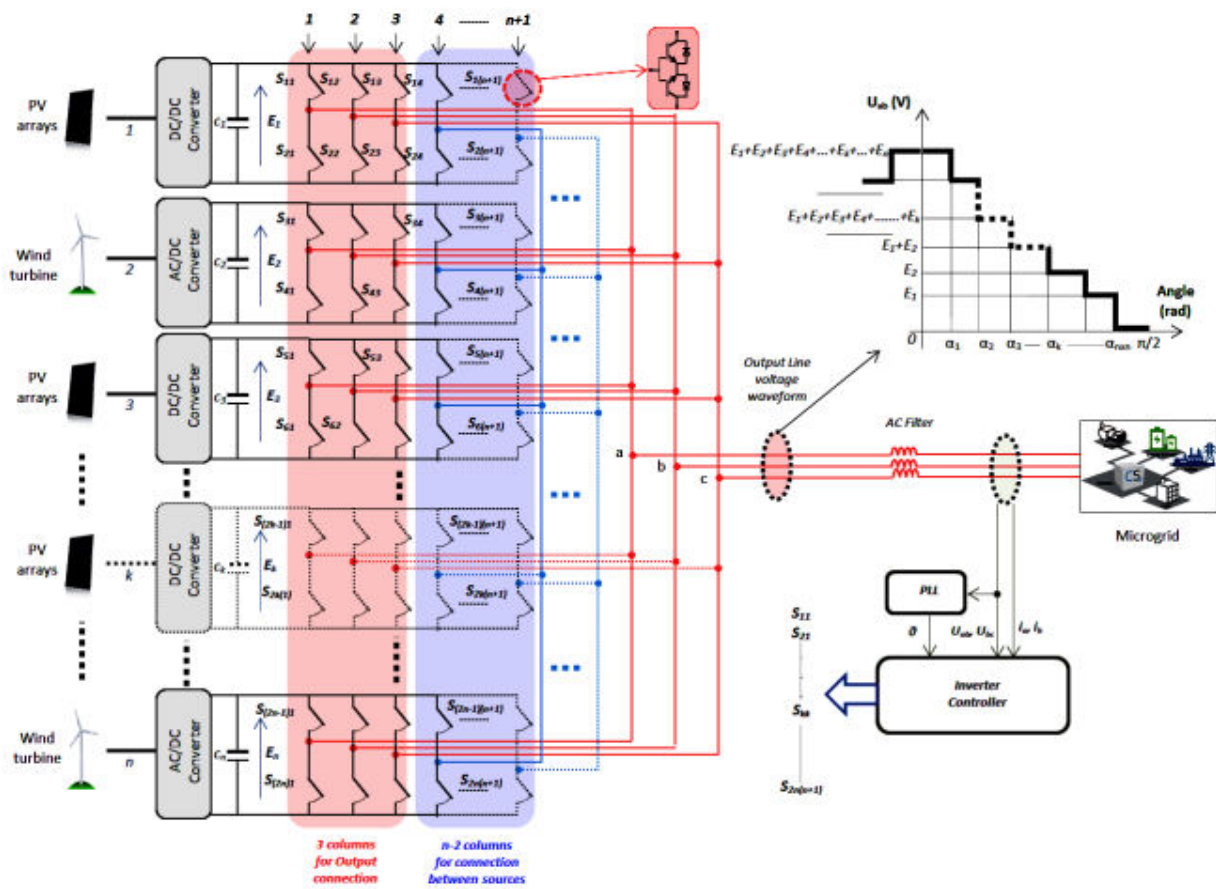


Fig.1. Proposed generalized multilevel inverter topology

### III. OPERATION PRINCIPLE

Fig.2 shows the proposed topology, The required six phase-to-phase voltage output levels ( $\pm E_1$ ;  $\pm E_2 \pm (E = E_1 + E_2)$ ) are generated as follows:

- 1) When turning ON the switches  $S_{13}$ ;  $S_{22}$ ;  $S_{31}$  and  $S_{43}$  during the first cycle  $[0; \alpha_1]$ , three levels are generated for the three phase-to-phase voltages i.e.,  $U_{ab} = E_1 + E_2$ ,  $U_{bc} = -E_1$  and  $U_{ca} = -E_2$ . Fig.3 (left) shows the current path for this mode.
- 2) When turning ON the switches  $S_{12}$ ;  $S_{23}$ ;  $S_{31}$  and  $S_{42}$  during the second cycle  $[\alpha_1; \alpha_2]$ , three levels are generated.
- 3) When turning ON the switches  $S_{11}$ ;  $S_{22}$ ;  $S_{32}$  and  $S_{43}$  during the third cycle  $[\alpha_2; \alpha_3]$ , three levels are generated for the three phase-to-phase voltages i.e.,  $U_{ab} = E_1$ ,  $U_{bc} = E_2$  and  $U_{ca} = -E_1 - E_2$ . Fig.4 (left) shows the current path for this mode.
- 4) When turning ON the switches  $S_{12}$ ;  $S_{21}$ ;  $S_{31}$  and  $S_{43}$  during the fourth cycle  $[\alpha_3; \alpha_4]$ , three levels are generated for the three phase-to-phase voltages i.e.,  $U_{ab} = -E_1$ ,  $U_{bc} = E_1 + E_2$  and  $U_{ca} = -E_2$ . Fig.4 (right) shows the current path for this mode.
- 5) When turning ON the switches  $S_{12}$ ;  $S_{23}$ ;  $S_{32}$  and  $S_{41}$  during the fifth cycle  $[\alpha_4; \alpha_5]$ , three levels are generated for the three phase-to-phase voltages i.e.,  $U_{ab} = -E_2$ ,  $U_{bc} = E_1 + E_2$  and  $U_{ca} = -E_1$ . Fig.5 (left) shows the current path for this mode.
- 6) When turning ON the switches  $S_{13}$ ;  $S_{21}$ ;  $S_{32}$  and  $S_{43}$  during the sixth cycle  $[\alpha_5; \alpha_6]$ , three levels are generated for the three phase-to-phase voltages i.e.,  $U_{ab} = -E_1 - E_2$ ,  $U_{bc} = -E_2$  and  $U_{ca} = E_1$ . Fig.5 (right) shows the current path for this mode.



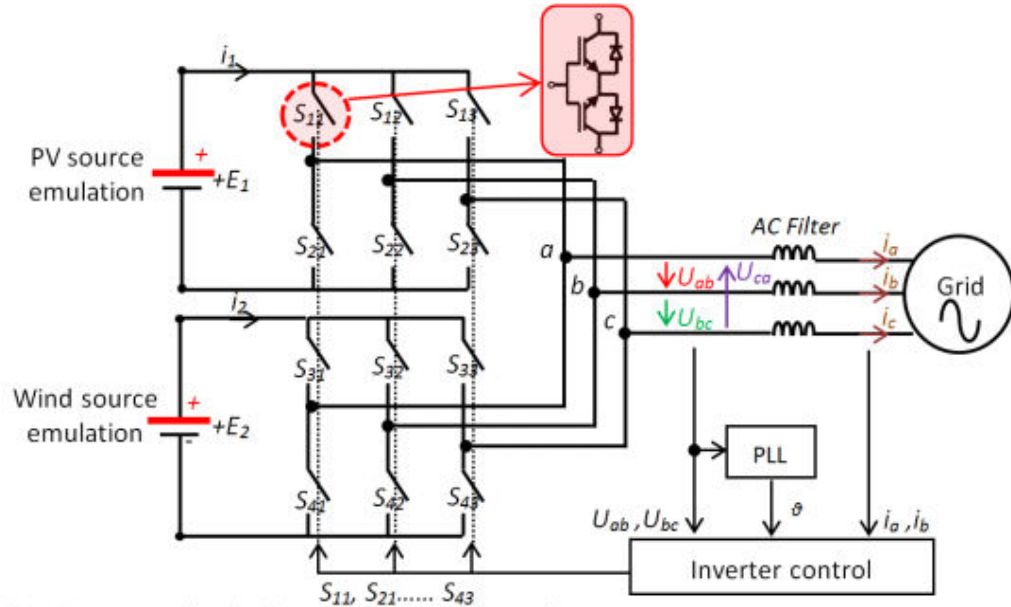


Fig. 2. Proposed six-level inverter topology

IV.SIMULATION AND EXPERIMENTAL VALIDATIONS

To examine the performance of the proposed MLI, simulations are carried out by using Matlab/Simulink and a prototype is implemented based on dSP ACE I'-1103 card(Fig.13). The circuit uses twelve bidirectional power switches S11; S12; S13; S21; S22; S23 fed by E1 and S31; S32; S33; S41; S42; S43 fed by E2. The power IGBT module from SEMIKRON: SKM145-GB123D, with built-in freewheeling diodes (1200V; 100A) is used. From (2), a twelve-gate driverboard is built using opto-couplers CNY 17-4. The DC voltage inputs of the topology were provided by laboratory regulated DC voltage supplies to emulate renewable energy sources(Wind or Solar)

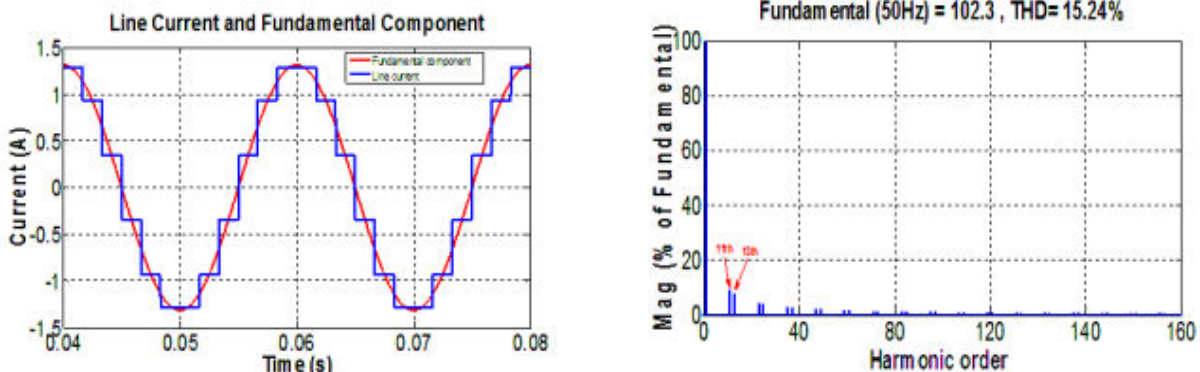


Fig.3. Line current waveforms and its harmonic spectrum with a star resistorload

V. CONCLUSION

The proposed multilevel inverter topology can be a good solution to feed microgrid from renewable energy sources. A six-level inverter was considered and controlled by using a PWHM technique, requiring only twelve switching states per period. Simulations studies have been performed on a six-level inverter based on the proposed structure and have been validated experimentally. The obtained simulation and experimental results have shown a 15 % voltage THD rate, zeroed successive harmonics from 2th to 10th orders. The first non-canceled harmonic is 11th order with 9 % of



the fundamental magnitude. The proposed configuration gives a compact and low cost system with both minimum numbers of switches and less number of switching states.

#### REFERENCES

1. M. R. Islam, Y. Guo, and J. Zhu, "A High-Frequency Link Multilevel Cascaded Medium-Voltage Converter for Direct Grid Integration of Renewable Energy Systems," *IEEE Trans. Power Electron.*, vol. 29, no.8, pp. 4167-4182, Aug. 2014.
2. M. Manojkumar, K. Porkumaran, and C. Kathirvel, "Power electronics interface for hybrid renewable energy system — A survey," in *Proc.Int. Conf. Green Computing Communication and Electrical Engineering, Coimbatore, India*, pp. 1-9, Mar. 2014.
3. T. Adefarati, and R. C. Bansal, "Integration of renewable distributed generators into the distribution system: a review," *IET Renew. Power Gener.*, vol. 10, no. 7, pp. 873-884, Jul. 2016..
4. S. Dasgupta, S. N. Mohan, S. K. Sahoo, and S. K. Panda, "Application of Four-Switch-Based Three-Phase Grid-Connected Inverter to Connect Renewable Energy Source to a Generalized Unbalanced Microgrid System," *IEEE Trans. Ind. Electron.*, vol. 60, no. 3, pp. 1204-1215, Mar. 2013.
5. E. Solas, G. Abad, J. A. Barrena, S. Aurtenetxea, A. Cárcar and, L. Zajac, "Modular Multilevel Converter With Different Submodule Concepts—Part I: Capacitor Voltage Balancing Method," *IEEE Trans. Ind. Electron.*, vol. 60, no. 10, pp. 4525-4535, Oct. 2013
6. F. Z Peng., M. Shen and Z. M. Qian, "Maximum Boost Control of the Z-source Inverter," *IEEE Trans. Power Electron.*, vol. 20, no. 4, pp. 833-838, Jul./Aug. 2005.
7. P. C. Loh, D. M. Vilathgamuwa, Y. S. Lai, G. T. Chua, and Y. W. Li, "Pulse-Width Modulation of Z-source Inverters," in *Rec., 39th IAS Annual Meeting, 2004*, pp. 148-155.
8. Y. Tang, S. J. Xie, C. H. Zhang and Z. G. Xu, "Improved Z-Source Inverter with Reduced Z-Source Capacitor Voltage Stress and Soft-start Capability," *IEEE Trans. Power Electron.*, vol. 24, no. 2, pp. 409-415, Feb. 2009.
9. Y. Li, S. Jiang, J. G. Cintron-Rivera and F. Z. Peng, "Modeling and Control of Quasi-Z-Source Inverter for Distributed Generation Applications," *IEEE Trans. Ind. Electron.*, vol. 60, no. 4, pp. 1532-1541, Apr. 2013.
10. D. Li, F. Gao, P. C. Loh, M. Zhu, and F. Blaabjerg, "Hybrid-source Impedance Networks: Layouts and Generalized Cascading Concepts," *IEEE Trans. Power Electron.*, vol. 26, no. 7, pp. 2028-2040, Jul. 2011.
11. D. Cao and F. Z. Peng, "A family of Z-source and Quasi-Z-source dc-dc converter", in *Proc. IEEE Applied Power Electronics Conf 2009*, pp. 1097-1101, Feb. 2009.
12. V. P. Galigekere and Marian K. Kazimierczuk, "Analysis of PWM Z-source dc-dc converter in CCM for steady state", *IEEE Trans. Circuits and Syst. Regul. Pap.*, vol. 59, no. 4, pp. 854-863, Apr., 2012.



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