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Matlab/Simulink Modeling of Novel Hybrid H-Bridge Multilevel Inverter for PV Application

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***Abstract*- This paper presents a single-phase multistring Multi-level photovoltaic (PV) inverter topology for grid-connected PV systems with a novel hybrid H- bridge inverter. The proposed novel cascaded Hybrid H-bridge produces higher voltage levels with less number of devices. This will reduce the number of gate drivers and protection circuits requirement, this inurn reduces the cost increase the reliability. Design Procedure for various components of single Hybrid H- bridge cell is given. A cascaded Grid connected PV topology is proposed. Finally a Matlab/Simulink based model is developed and simulation results are presented.**

Keywords- *PV system, Multilevel Inverter, Cascaded H-Bridge.*

I. INTRODUCTION

As the PV system is clean and large enough in the natural quantity available, it has been spotlighted as the future energy sources of promising potentiality, due to the stable supply of the energy and alternative method of responding to the problem of the earth environment followed by the increase of the demand for the electric power supply. Solar-electric-energy demand has grown consistently by 20%–25% per annum over the past 20 years, which is mainly due to the decreasing costs and prices. This decline has been driven by the following: 1) an increasing efficiency of solar cells; 2) manufacturing-technology improvements; and 3) economies of scale [2]. A PV inverter, which is an important element in the PV system, is used to convert dc power from the solar modules into ac power to be fed into the grid. A general overview of different types of PV inverters is given in [3] and [4].

In recent years, multilevel converters have shown some significant advantages over traditional two-level converters, especially for high power and high voltage applications.In addition to their superior output voltage quality. They can also reduce voltage stress across switching devices. Since the output voltages have multiple levels, lower d*v/dt is achieved, which greatly alleviates electromagnetic* interference problems due to high frequency switching. Over the years most research work has focused on converters with three to five voltage levels, although topologies with very high number of voltage levels were also proposed. In general, the more voltage levels a converter has the less harmonic and better power quality. However, the increase in converter complexity and number of switching devices is a major concern for multilevel converter. There are several topologies available, being the Neutral Point Clamped [5], Flying Capacitor [6] and Cascaded H-bridge inverter [7] the most studied and used. In recent years many variations and combinations of these topologies have been reported, one of them is the cascaded H-bridge [7-10].

II.HIGH POWER CONVERTERS CLASSIFICATIONS

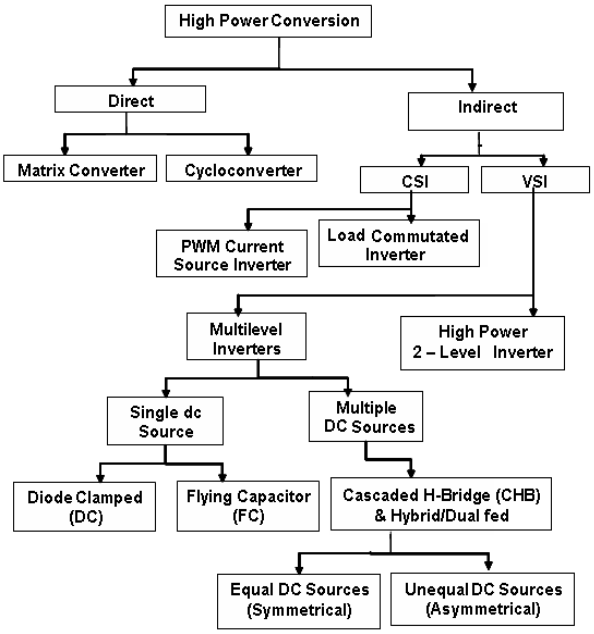

Figure 1 Classification of High power Converters

Fig.1 shows the classification of high power converters. Out of all converters Cascaded bridge configuration is more popular. Cascaded bridge configuration is again classified into 2 types 1) Cascaded Half Bridge 2) Cascaded Full Bridge or Cascaded H-Bridge. In this paper a novel cascaded hybrid H-Bridge topology is proposed for PV application.

A Half H-Bridge

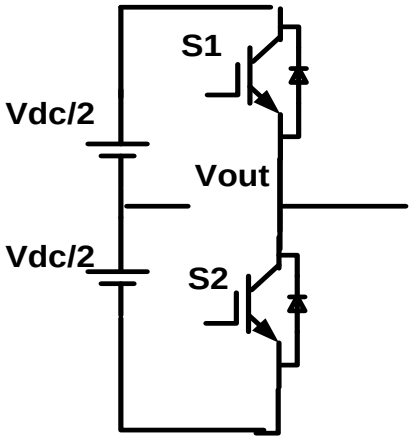

Figure 2 Half Bridge

Fig.2 shows the Half H-Bridge Configuration. By using single Half H-Bridge we can get 2 voltage levels. The switching table is given in Table 1.

Table 1. Switching table for Half Bridge

Switches Turn ON	Voltage Level
S2	Vdc/2
S1	-Vdc/2

B Full H-Bridge

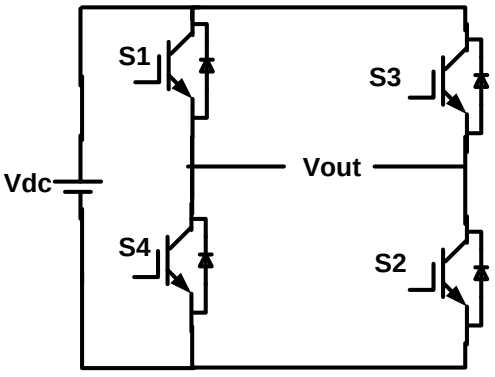

Figure. 3 Full H-Bridge

Fig.3 shows the Full H-Bridge Configuration. By using single H-Bridge we can get 3 voltage levels. The number output voltage levels of cascaded Full H-Bridge are given by 2n+1 and voltage step of each level is given by Vdc/n. Where n is number of H-bridges connected in cascaded. The switching table is given in Table2.

Table 2. Switching table for Full H-Bridge

Switches Turn ON	Voltage Level
S1,S2	Vdc
S3,S4	-Vdc
S4,D2	0

C Hybrid H-Bridge

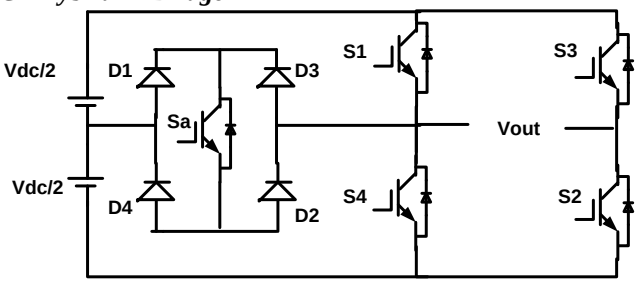

Figure. 4 Hybrid H-Bridges

Fig. 4 shows the Hybrid H-Bridge configuration. By using single Hybrid H-Bridge we can get 5 voltage levels. The 13 number output voltage levels of cascaded Hybrid H-Bridge are given by 4n+1 and voltage step of each level is given by Vdc/2n. Where n is number of H-bridges connected in cascaded. The switching table of Hybrid H-Bridge is given in Table 3.

Table 3. Switching table for Hybrid H-Bridge

Switches Turn On	Voltage Level
Sa, S1	Vdc/2
S1,S2	Vdc
S4,D2	0
Sa,S3	-Vdc/2
S3,S4	-Vdc

D Cascaded Hybrid H-Bridge

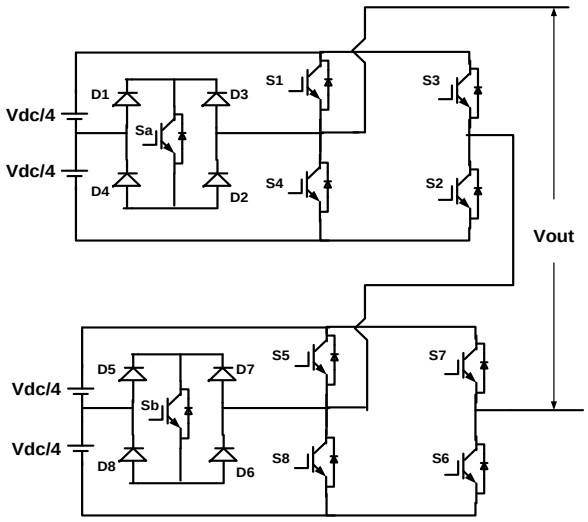

Figure 5. Cascaded Hybrid H-Bridges

Table 4 Switching table for Cascaded Hybrid H-Bridge

Switches Turn On	Voltage Level
Sa,S2,S8,D6	Vdc/4
S1.S2,S8,D6	2Vdc/4
S1,S2,Sb,S6	3Vdc/4
S1,S2,S5,S6	Vdc
S4,D2,S8,D6	0
Sa,S3,S8,D6	-Vdc/4
S3,S4,S8,D6	-2Vdc/4
S3,S4,Sb,S7	-3Vdc/4
S3,S4,S7,S8	-Vdc

The proposed Cascaded Hybrid H-Bridge (CHHB) uses less number of switches to produce more voltage levels. This will reduce Gate Drivers and protection circuit requirement thus it reduce cost and complexity of the circuit. For example for 9 level output the proposed converter uses 10 switches but cascaded H- Bridge converter uses 12 switches. This difference increases as the number of output voltage levels increases.

III. PROPOSED PV SYSTEM

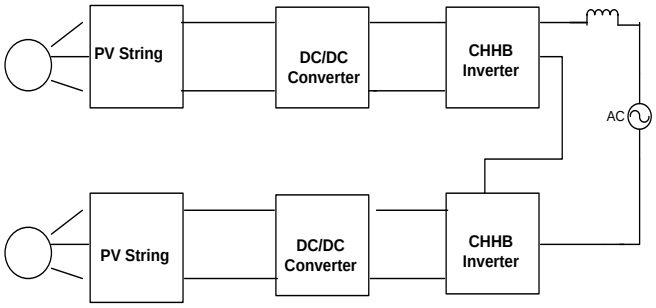

Figure. 6. Grid Connected PV System

The general block diagram of PV system is shown in fig.6.The PV string converters solar radiation into DC. Here we are using DC/DC Boost converter to increase the output voltage. The output inverter converts DC into AC and feeding into the grid. The proposed system uses small PV array cascading to produce higher voltage output. This system reduces overall cost and complexity. The Fig.6 shows the proposed PV configuration.

IV. MATLAB/SIMULINK MODELING AND SIMULATION RESULTS

A. Single Hybrid H-Bridge System

Fig. 7 Shows the Matlab/Simulink model of complete PV system. It consists of PV array block, DC/DC converter Block, Hybrid H-Bridge Block.

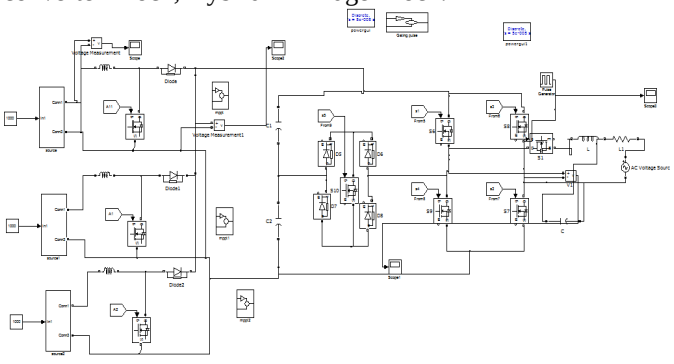

Figure. 7 Matlab/Simulink model of Hybrid H-bridge

Fig. 8 shows the inverter input DC voltage and Multilevel AC output voltage. Fig. 9 Shows the five level output of the Hybrid H-Bridge. Fig. 10 shows the grid voltage and current wave forms.

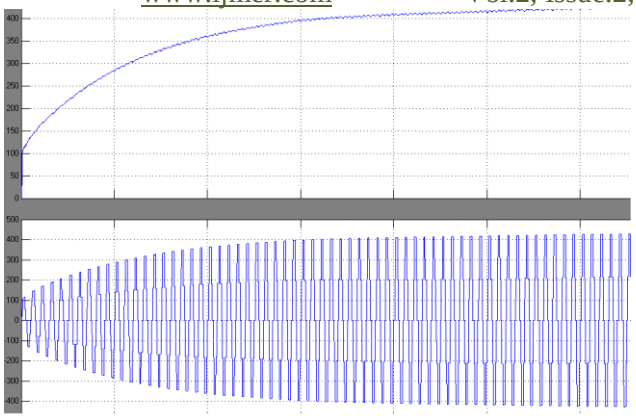

Figure.8 Inverter Input and Output

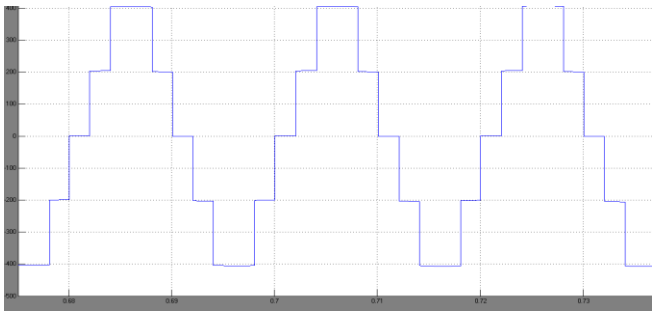

Figure. 9 Five level output of H-bridge

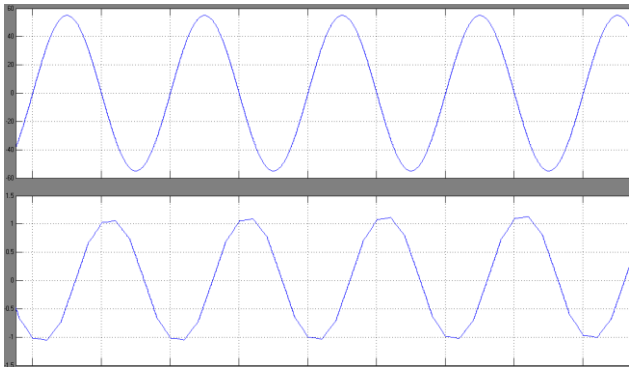

Figure10 Grid voltage and Grid current

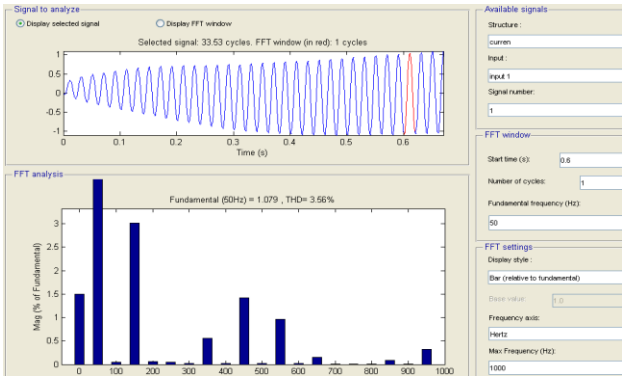

Figure11 FFT of grid current

Fig. 11 shows the FFT analyses of grid current. From the figure it is clear that the total THD is 3.2 %.

B. Proposed Cascaded Hybrid H-Bridge System

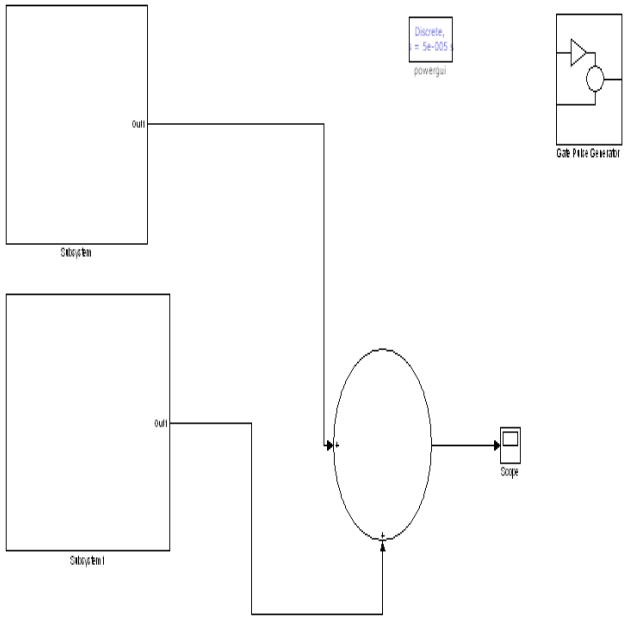

Fig. 12 Cascaded Hybrid H-Bridge

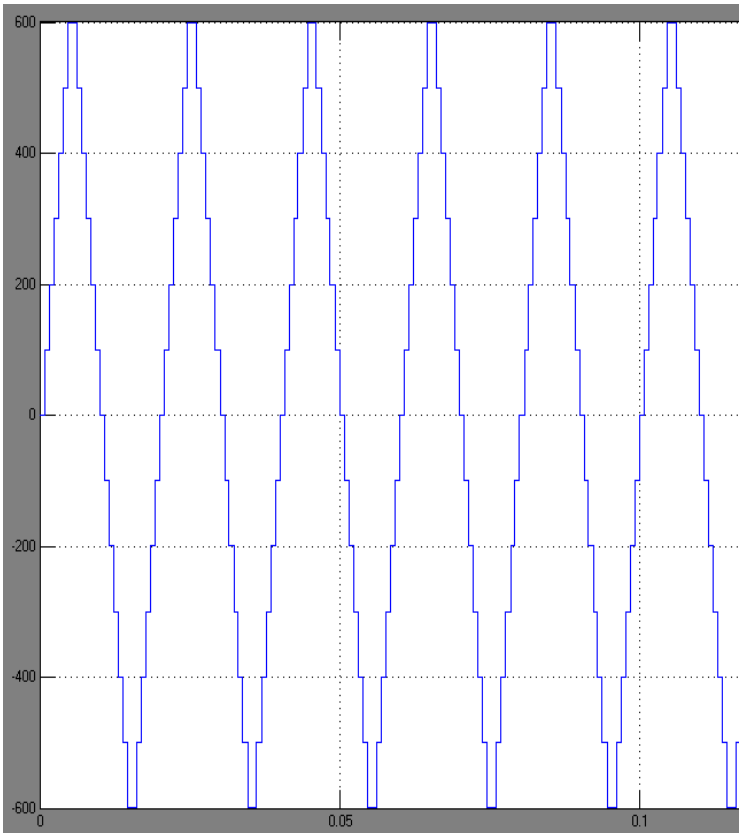

Fig. 13 Eleven level Hybrid H-Bridge

V.CONCLUSION

This paper presents a single-phase multistring Multi-level photovoltaic (PV) inverter topology for grid-connected PV systems with a novel hybrid H- bridge inverter. The proposed novel cascaded Hybrid H-bridge produces higher voltage levels with less number of devices. This will reduce the number of gate drivers and protection circuits requirement. This inurn reduces the cost & increase the reliability. Design Procedure for various components of single Hybrid H- bridge cell is given. A cascaded Grid connected PV topology is proposed. Finally a Matlab/Simulink based model is developed and simulation results are presented.

VI. REFERENCES

[1] N. A. Rahim and S. Mekhilef, "Implementation of three-phase grid connected inverter for photovoltaic solar power generation system," in *Proc. IEEE PowerCon*, Oct. 2002, vol. 1, pp. 570–573.

[2] J. M. Carrasco, L. G. Franquelo, J. T. Bialasiewicz, E. Galvan, R. C. PortilloGuisado, M. A. M. Prats, J. I. Leon, and N.Moreno-Alfonso,"Power-electronic systems for the grid integration of renewable energy sources: A survey," *IEEE Trans. Ind. Electron.*, vol. 53, no. 4, pp. 1002–1016, Aug. 2006.

[3] S. B. Kjaer, J. K. Pedersen, and F. Blaabjerg, "A review of single-phase grid connected inverters for photovoltaic modules," *IEEE Trans. Ind. Appl.*, vol. 41, no. 5, pp. 1292–1306, Sep./Oct. 2005.

[4] S. Daher, J. Schmid, and F. L.M. Antunes, "Multilevel inverter topologies for stand-alone PV systems," *IEEE Trans. Ind. Electron.*, vol. 55, no. 7, pp. 2703–2712, Jul. 2008.

[5] M. Meinhardt and G. Cramer, "Past, present and future of grid-connected photovoltaic- and hybrid-power-systems," in *Proc. IEEE-PES Summer Meeting*, Jul. 2000, vol. 2, pp. 1283–1288.

[6] S. Kouro, J. Rebolledo, and J. Rodriguez, "Reduced switching-frequency modulation algorithm for high-power multilevel inverters," *IEEE Trans.Ind. Electron.*, vol. 54, no. 5, pp. 2894–2901, Oct. 2007.

[7] S. J. Park, F. S. Kang, M. H. Lee, and C. U. Kim, "A new single-phase fivelevel PWM inverter employing a deadbeat control scheme," *IEEE Trans. Power Electron.*, vol. 18, no. 18, pp. 831–843, May 2003.

[8] L. M. Tolbert and T. G. Habetler, "Novel multilevel inverter carrier-based PWM method," *IEEE Trans. Ind. Appl.*, vol. 35, no. 5, pp. 1098–1107, Sep./Oct. 1999.

[9] Y. Liu, H. Hong, and A. Q. Huang, "Real-time calculation of switching angles minimizing THD for multilevel inverters with step modulation," *IEEE Trans. Ind. Electron.*, vol. 56, no. 2, pp. 285–293, Feb. 2009.

[10] N. S. Choi, J. G. Cho, and G. H. Cho, "A general circuit topology of multilevel inverter," in *Proc. IEEE 22th Annu. PESC*, Jun. 24–27, 1991, pp. 96–103.

[9] L.M.Tolber, T.G.Habetler, "Novel Multi level inverter Carrier based PWM Method," IEEE Ind.Appli., vol.35. pp.1098-1107. Sep/Oct 1999.

[10] Holmes, D. G. and Lipo, T. A., Pulse width modulation for power converters: principles and practice, IEEE.

[11] T.H.Barton, "Pulse Width Modulation Waveforms – The Bessel Approximatilon", *IEEE-IAS Conference Record*,