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Modelling and Simulation of Single Phase Seven Level Inverter fed from Renewable Energy Sources

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ABSTRACT

This work deals with the simulation of conventional cascaded H-bridge five-level inverter and proposed cascaded H-bridge seven level inverter systems. The open loop system is modelled and simulated. The results of the simulation are compared with respect to output current harmonics. The simulation results indicate that the THD with 7-level MLI is less than that of 5- level MLI. To simulate proposed PV and Battery based buck boost converter (BBC) with 7-level inverter system.

KEYWORDS: Renewable Energy Sources1, Multi level Inverter2,Buck boost converter3

1. INTRODUCTION

Power electronic converters, especially dc/ac PWM inverters have been extending their range of use in industry because they provide reduced energy consumption, better system efficiency, improved quality of product, good maintenance, and so on.

For a medium voltage grid, it is troublesome to connect only one power semiconductor switches directly [1, 2, 3]. As a result, a multilevel power converter structure has been introduced as an alternative in high power and medium voltage situations such as laminators, mills, conveyors, pumps, fans, blowers, compressors, and so on. As a cost effective solution, multilevel converter not only achieves high power ratings, but also enables the use of low power application in renewable energy sources such as photovoltaic, wind, and fuel cells which can be easily interfaced to a multilevel converter system for a high power application.

The most common initial application of multilevel converters has been in traction, both in locomotives and track-side static converters [4]. More recent applications have been for power system converters for VAR compensation and stability enhancement [5], active filtering [6], high-voltage motor drive [3], high-voltage dc transmission [7], and most recently for medium voltage induction motor variable speed drives [8]. Many multilevel converter applications focus on industrial medium-voltage motor drives [3, 9], utility interface for renewable energy systems [10], flexible AC transmission system (FACTS) [11], and traction drive systems [12]. The inverters in such application areas as stated above should be able to handle high voltage and large power. For this reason, two-level high-voltage and large-power inverters have been designed with series connection of switching power devices such as gate-turn-off thyristors (GTOs),

integrated gate commutated transistors (IGCTs), and integrated gate bipolar transistors (IGBTs), because the series connection allows reaching much higher voltages. However, the series connection of switching power devices has big problems [13], namely, non equal distribution of applied device voltage across series-connected devices that may make the applied voltage of individual devices much higher than blocking voltage of the devices during transient and steady-state switching operation of devices.

2. MULTILEVEL INVERTER

The principal function of the inverters is to generate an ac voltage from a dc source voltage. If the dc voltage is composed by many small voltage sources connected in series, it becomes possible to generate an output voltage with several steps. Multilevel inverters include an arrangement of semiconductors and dc voltage sources required to generate a staircase output voltage waveform. Fig. 2.1 shows the schematic diagram of voltage source-inverters with a different number of levels.

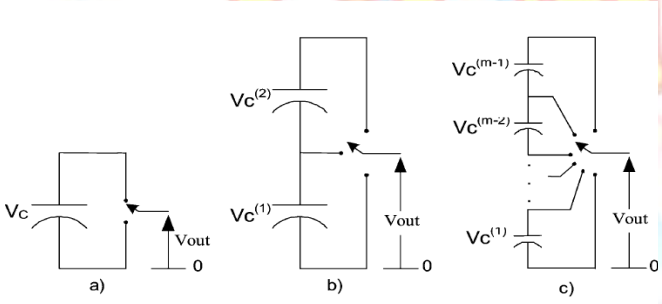

Fig. 1 Basic Multilevel Inverters (a) Two levels, (b) Three levels, and (c)m Levels.

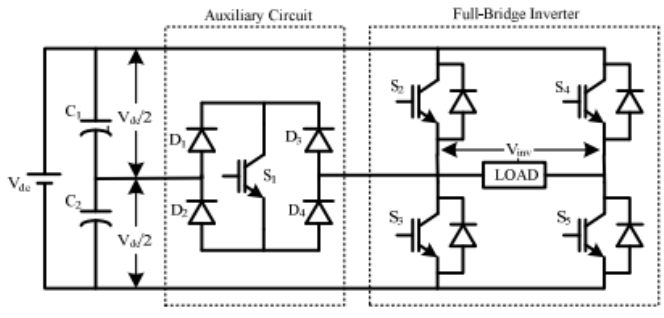

Fig 2.2 Conventional circuit diagram

The fig 2 shows the Conventional circuit diagram. The fig 3 shows the Proposed Circuit Diagram.

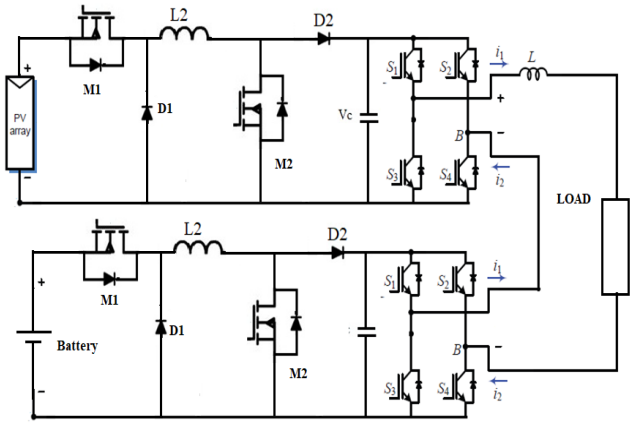

Fig. 3 Circuit Diagram of Proposed MLI

3. PRINCIPLE OPERATION OF MLI

The phase output voltage is synthesized by the sum of two inverter outputs. Each inverter bridge is capable of generating three different levels of voltage outputs. The main bridge can generate +3Vdc, 0, -3Vdc and the auxiliary bridge can generate +Vdc, 0, -Vdc. By using appropriate combinations of switching devices many voltage levels are obtained. When the positive group switches are turned on the voltage across that particular bridge is positive. When the negative group switches are turned on the voltage across that particular bridge is negative. When S1, S2 are turned on the voltage across the main bridge is +3Vdc. When S3, S4 are turned on the voltage across the main bridge is -3Vdc.When S5, S6 are turned on the voltage across the auxiliary bridge is +Vdc. When S7, S8 are turned on the voltage across the auxiliary bridge is -Vdc. To obtain +2Vdc the switch combinations S1, S2, S7& S8 are turned on.. To obtain -2Vdc the switch combinations S3, S4, S5& S6 are turned on. are turned on. The following table shows the switching strategy of transistors at each level. The status of the switch is '0', that switch is in OFF condition. The status of the switch is '1', that switch is in ON condition.

S_1	S_2	S_3	S_4	S_5	S6	S7	V_{inv}
0	1	0	0	1	0	0	V_{dc}
1	0	0	0	1	1	0	$V_{dc}/2$
0	1	0	1	0	0	1	0
0	0	1	0	1	0	0	
1	0	0	1	0	1	0	$-V_{dc}/2$
0	0	1	1	0	0	1	$-V_{dc}$

Table 1 Switching Strategies Of Transistors At Each Level.

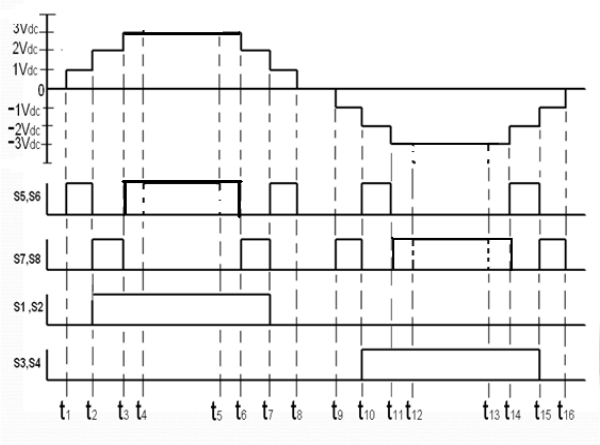

Fig 4 Switching Strategies of Transistors at Each Level

4. SIMULATION AND DISCUSSION

Circuit diagram of 5-level inverter with RL load is shown in Figure 5. Voltage across PV is shown in Figure 6 and its value is 15 volts. Switching pulse for M1,M3 is appeared in Figure 7 and its value is 1 volts. Output voltage across RL-load is shown in Figure 8 and its value is 15 Volts. Output current through RL-load is appeared in Figure 9 and its value is 0.3 Amp. The Output current THD is appeared in Figure 10 and its value is 28.25%. Output power is appeared in Figure 11 and its value is 1.9W.

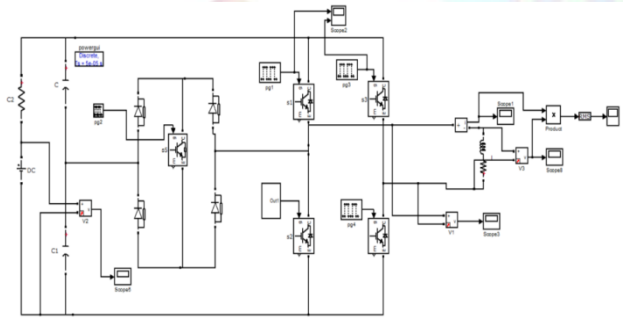

Figure 5 Circuit diagram of 5-level inverter with RL load

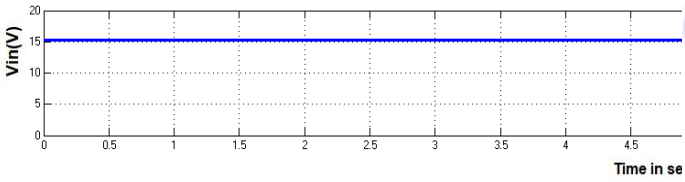

Figure 6 Voltage across PV

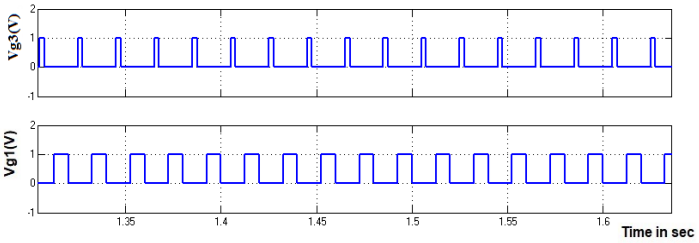

Figure 7 Switching pulse for M1,M3

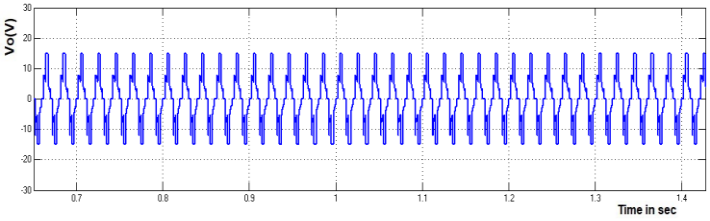

Figure 8 Output voltage across RL load

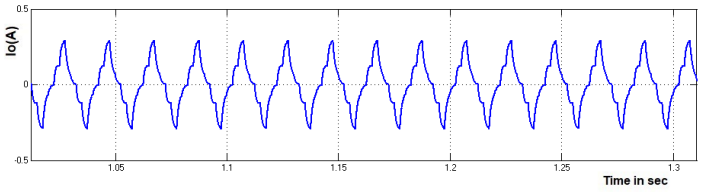

Figure 9 Output current through RL-load

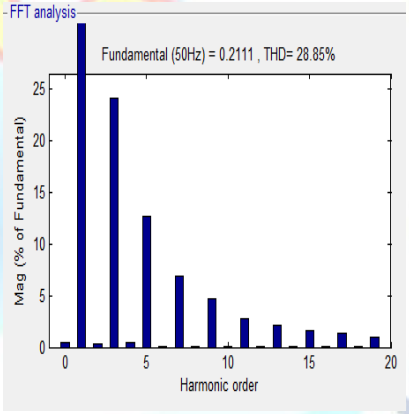

Figure 10 Output current THD

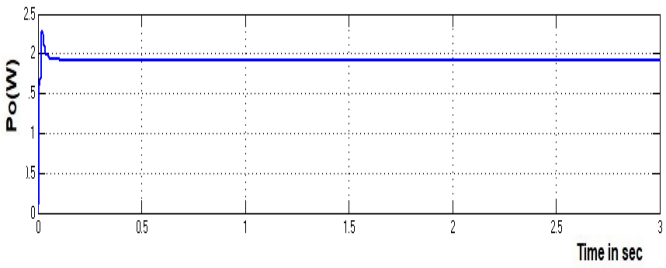

Figure 11 Output power

Circuit diagram of Modified H-Bridge7-level inverter with RL-loadis appeared in Figure 12. The Voltage across PV is appeared in Fig 13 and its value is 15 Volts.

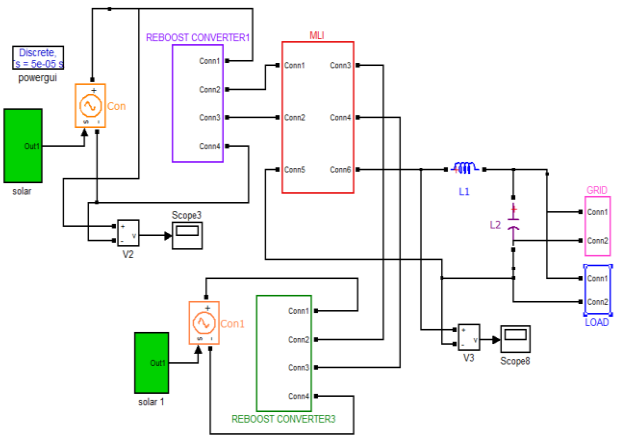

Figure 12 Circuit diagram of Modified H-Bridge7-level inverter with RL-load

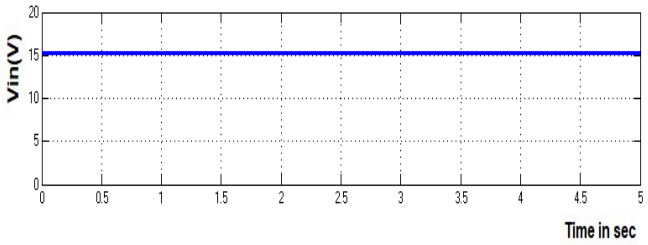

Figure 13 Voltage across PV

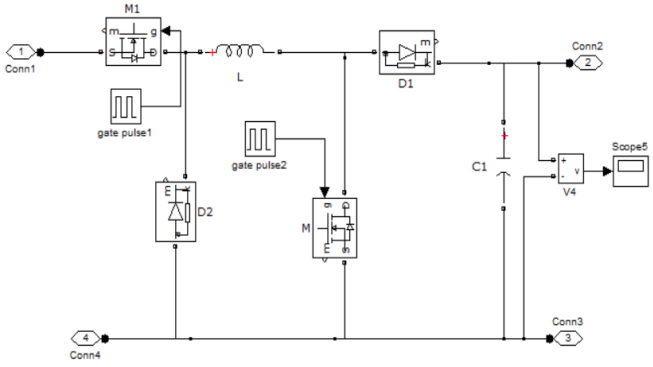

Figure 14 Circuit diagram of Buck Boost converter

Voltage across buck boost converter S1 is appeared in Fig 14 and its value is 50 Volts. Switching pulse of for buck-boost converter S1is appeared in Fig 15 and its value is 1 Volts.

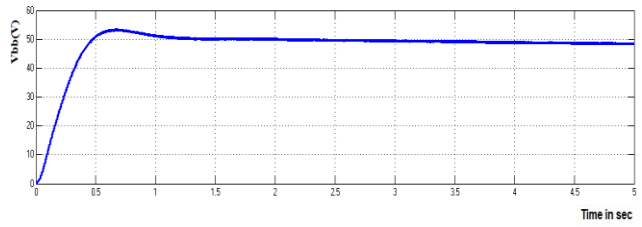

Figure 15 Voltage across buck boost converter

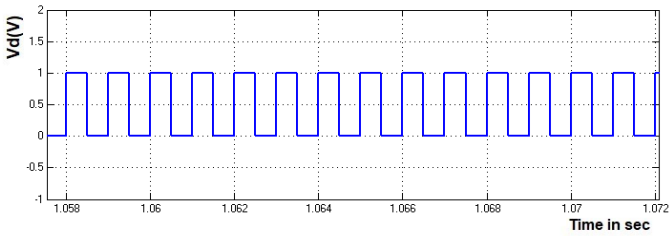

Figure 16 Switching pulse for buck-boost converter S1

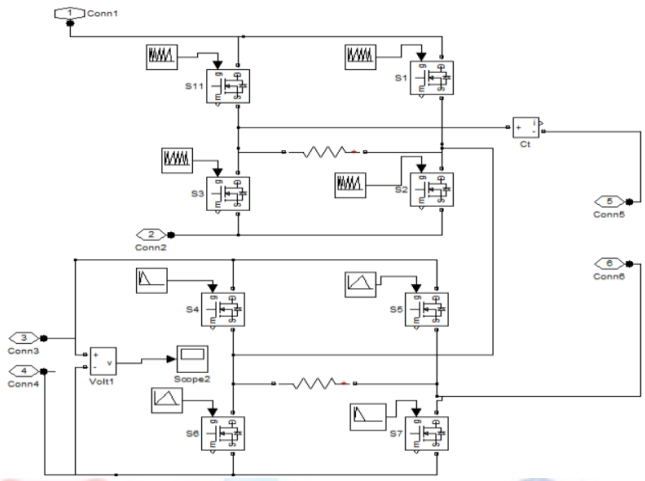

Figure 17 Circuit diagram of 7-level inverter

Circuit diagram of 7-level inverter is appeared in figure 16. Switching pulse for inverter M1,M3is appeared in figure 17 and its value is 1V. Voltage across RL-load is shown in Fig 18 and its value is 60 Volts.

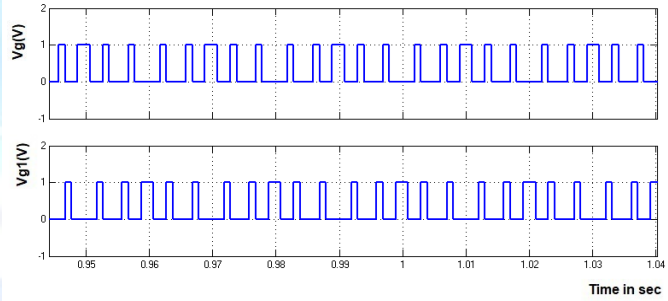

Figure 18 Switching pulse for inverter M1,M3

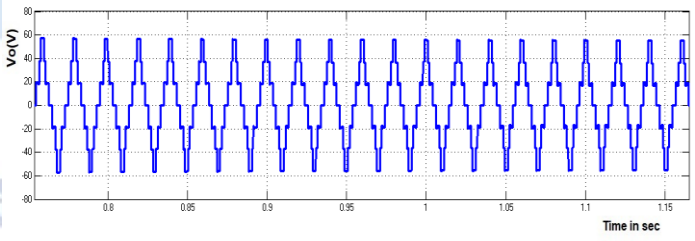

Figure 19 Output voltage across RL load

Output current Through RL-load is shown in Fig 19 and its value is 0.3A. Output current THD is shown in Fig 20 and its value is 8.62%. Output power is shown in Fig 21 and its value is 5.5W.

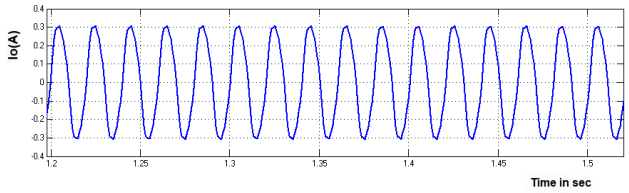

Figure 20 Output current Through R-load

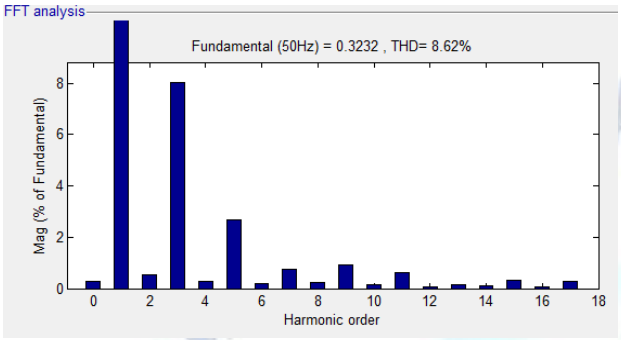

Figure 21 Output current THD

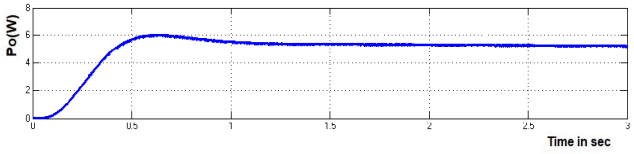

Figure 22 Output power

Table 1 Comparison of output current THD

MLI	output current THD
5-level-RL-load	28.85%
7-level-RL-load	8.62%

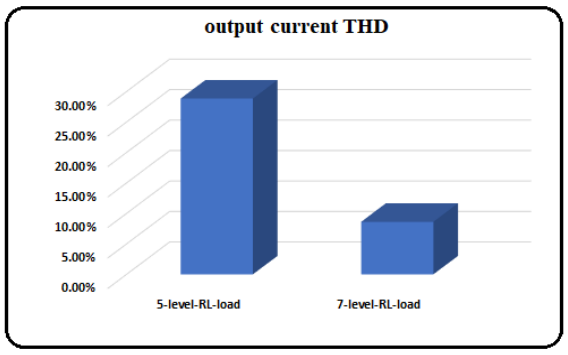

Figure 23 Bar chart Comparison of Current THD

The table 1 shows the Comparison of output current THD for 5 level and 7 level with RL in MLI system. The fig 23 shows the bar chart Comparison of output current THD for 5 level and & level with RL in MLI system. By using 7 level with RL load MLI system, The output current total harmonic distortion of reduced from 28.85% to 8.62%; The output voltage total harmonic distortion of reduced from 44.79% to 28.86%.

5. CONCLUSION

Single-phase five level inverter inverter system is simulated.Single-phase Buck boost converter with seven –level inverter system is simulated. Above systems compared. Circuit diagram of Modified H-Bridge7-level inverter with source disturbance is simulated. By using 7 level with RL load MLI system, The output current total harmonic distortion of reduced from 28.85% to 8.62%; The output voltage total harmonic distortion of reduced from 44.79% to 28.86%.

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

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