NOVATEUR PUBLICATIONS
INTERNATIONAL JOURNAL OF INNOVATIONS IN ENGINEERING RESEARCH AND TECHNOLOGY [IJIERT]
ISSN: 2394-3696
VOLUME 3, ISSUE 10, Oct.-2016

A MULTILEVEL INVERTER BASED ON SWITCHED DC SOURCES

BHARATI S. MATHAPATI
Student, Department of Electrical Engineering. All India Shri Shivaji Memorial Society, Institute of Information Technology, Kennedy Road, Pune
soni.mathapati@gmail.com

PROF. SHUBHANGI S. LANDGE
Professor, Department of Electrical Engineering. All India Shri Shivaji Memorial Society, Institute of Information Technology, Kennedy Road, Pune
shubhangi.landge1@gmail.com

ABSTRACT
Multilevel voltage-source inverters are the best solution for high power dc-to-ac conversion applications. A multilevel inverter is a linkage structure of multiple input dc levels and power semiconductor devices to get a quasisquare waveform. In addition, the multilevel waveform has less harmonic contents as compared to a two-level waveform obtained from conventional inverters. The quality of the multilevel waveform is improved by increasing the number of levels. But, if number of level increases, a large number of power semiconductor devices and gate driver circuits are also increased. So, it will increases system complexity and cost and tends to reduce the system reliability and efficiency. For a high-resolution waveform, therefore, practical considerations necessitate reduction in the number of switches and gate driver circuits. This paper presents a multilevel inverter that has been conceptualized to reduce component count, especially for a large number of output levels. It consists floating input dc sources alternately connected in opposite polarities with one an-other through power switches. Each input dc level appears in the stepped load voltage either individually or in additive combinations with other input levels. This approach results in reduced number of power switches as compared to classical topologies. The working principle of the proposed topology is demonstrated with the help of a single-phase five-level inverter. The topology is investigated through simulations and validated experimentally on a laboratory prototype.

KEYWORDS: Classical topologies, multilevel inverter (MLI), reduced component count, total harmonic distortion.

INTRODUCTION

Multilevel inverter technology has recently as a very important alternative in the area of high-power medium voltage applications. Researchers are going on to improve their capabilities further through optimized control techniques, and to minimize both component count and manufacturing cost. The multilevel inverter has been implemented in various applications, such as motor drives, power conditioning devices, renewable energy generation and distribution. PWM inverters can simultaneously control output voltage, frequency and it can reduce the amount of harmonics in output current which results in better THD content.
Several multilevel topologies have been developed, but increase in number of levels, it also increases the number of switches, number of independent dc sources, switching stresses, losses, voltage unbalancing across capacitors etc. Performances of switched DC sources

inverter and cascaded H-bridge inverter are compared on the basis of structure, working principle, number of switches used and switching losses.

A multilevel inverter consists multiple input DC sources and/or capacitors and power semiconductor devices to produce a quasi square waveform. Quality of output voltage waveform of a MLI indicates how much close in shape the waveform to the required sine wave. Quality of output voltage waveform of a MLI can be improved by increasing the number of levels. However, it results in a large number of power semiconductor devices and gate driver circuits. Therefore, system complexity and cost will be increased. Also, system reliability and efficiency will be reduced. Therefore, for multilevel inverters having higher number of levels in output voltage waveform, practical considerations necessitate reduction in the number of switches and gate driver circuits.

The paper is organized as follows. Section II presents working principle of single phase five level switched DC source inverter. Section III presents simulation and results of switched dc source Inverter. Section IV presents hardware implementation and results of switched dc source inverter. In Section V conclusions are summarized.

STRUCTURE AND WORKING PRINCIPLE OF SWITCHED DC SOURCE INVERTER

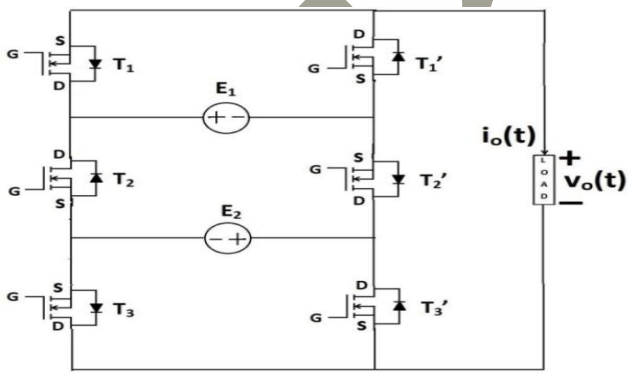

Fig. 2.1: Single phase five level switched DC sources inverter.

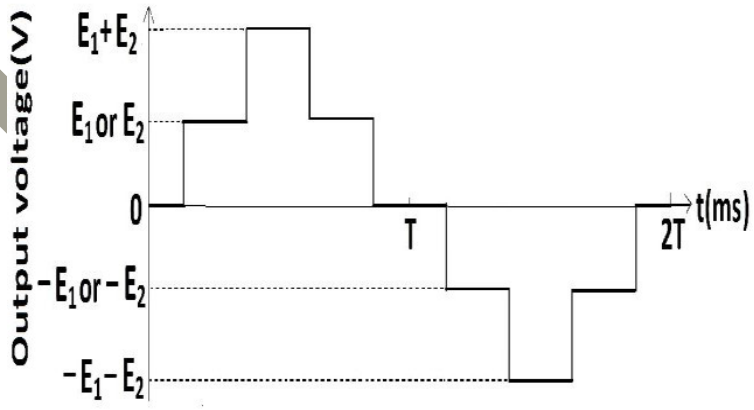

Fig. 2.2: Output voltage waveform of single phase five level switched DC sources inverter

TABLE II: MODES OF OPERATIONS OF SINGLE PHASE FIVE LEVEL SWITCHED DC SOURCES INVERTER

Mode	T1	T2	T3	T1'	T2'	T3'	Output Voltage
1	0	0	0	1	1	1	0
2	1	1	1	0	0	0	0
3	1	0	0	0	1	1	E1
4	0	0	1	1	1	0	E2
5	1	0	1	0	1	0	E1+E2
6	0	1	1	1	0	0	-E1
7	1	1	0	0	0	1	-E2
8	0	1	0	1	0	1	-E1-E2

A Single Phase Five Level Switched DC Sources Inverter is shown in Fig. 2.1. A Single Phase Five Level Switched DC Sources Inverter consist two isolated input DC sources E1and E2 (E1=E2). There are three complementary pairs of power switches (N-Channel MOSFETs) which are denoted by (T1, T1'), (T2, T2') and (T3, T3'). The output voltage across load and load current are denoted by vo(t) and io(t) respectively. The reference polarities of the output voltage vo(t) and reference direction of load current io(t) are shown. The output voltage waveform of a single phase five level switched DC sources inverter when E1=E2 is shown in Fig. 2.2. The output voltage waveform consists of five levels 0, E1 or E2, E1 + E2, -E1 or -E2, -E1-E2. Time period of output voltage is 2T .
There are eight modes of operations for single phase five level switched DC source .Modes of operation are explained below:

MODE 1:
In mode 1, The switches T1', T2' and T3' are turned on. No source is connected to the load. So, Output voltage across load is zero.

MODE 2:
In mode 2, the switches T1, T2 and T3 are turned on. No source is connected to the load. So, Output voltage across load is zero.

MODE 3:
In mode 3,The switches T1, T2' and T3' are turned on. So, Output voltage across load is +E1.

MODE 4:
In mode 4, the switches T1', T2' and T3 are turned on. So, Output voltage across load is +E2.

MODE 5:
In mode 5, switches T1, T2' and T3 are turned on. So, Output voltage across load is E1 + E2.

MODE 6:
In mode 6, switches T1', T2 and T3 are turned on. So, Output voltage across load is -E1.

MODE 7:
In mode 7, the switches T1, T2 and T3' are turned on. So, Output voltage across load is -E2.

MODE 8:
In mode 8, switches T1', T2 and T3' are turned on. So, Output voltage across load is -E1-E2.

SIMULATION AND RESULTS OF SWITCHED DC SOURCE INVERTER

The Simulation of single phase five level switched DC sources inverter with R load using MATLAB/Simulink tool are discussed in this section. The switching sequence for MATLAB simulation is given in Table III.

Table III: Switching sequence for MATLAB simulation ON state of a switch is represented by 1 and OFF state of a switch by 0

Mode	T1	T2	T3	T1'	T2'	T3'	Output Voltage
1	0	0	0	1	1	1	0
3	1	0	0	0	1	1	E1
5	1	0	1	0	1	0	E1+E2
4	0	0	1	1	1	0	E2
2	1	1	1	0	0	0	0
6	0	1	1	1	0	0	-E1
8	0	1	0	1	0	1	-E1-E2
7	1	1	0	0	0	1	-E2

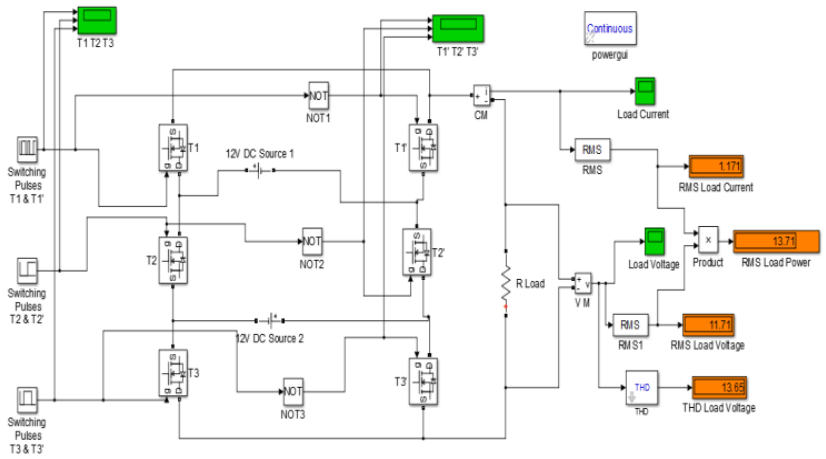

Fig. 3.1: MATLAB simulation diagram for single phase five level switched DC sources inverter with R load

MATLAB simulation diagram for single phase five level switched DC sources inverter with R load is shown in Fig. 3.1. Here input DC source voltages are of 12V and load is resistance of 10Ω.

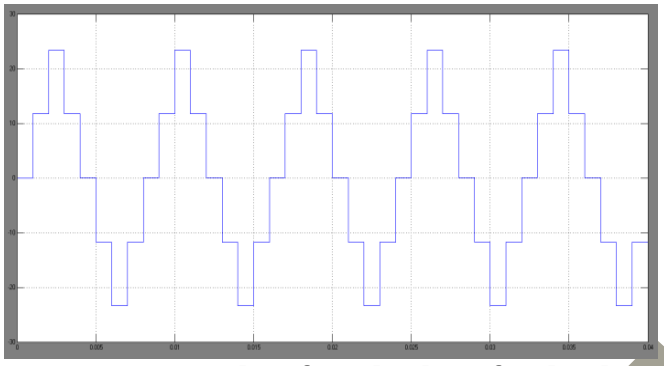

Fig. 3.2: Load voltage verses time plot of single phase five level switched DC sources inverter with R load

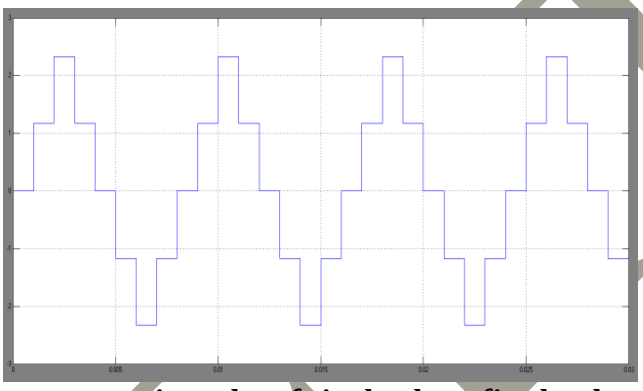

Fig. 3.3: Load current verses time plot of single phase five level switched DC sources inverter with R load

The load voltage versus time is shown in Fig.3.2 has five levels. THD of load voltage is 13.65%. The load current versus time is shown in Fig.3.3.

HARDWARE IMPLEMENTATION AND RESULTS OF SWITCHED DC SOURCE INVERTER

This section discusses about hardware implementation and its results of single phase five level switched DC sources inverter. The schematic diagram of hardware set up for single phase five level switched DC sources inverter is shown in Fig. 4.1. The Input DC sources are E1=12V and E2=12V. Hardware implementation of single phase five level switched DC sources inverter involves implementing control circuit, drive circuit and power circuit. PIC16F877A is used as the controller. TLP250 is used as drive IC. TLP250 converts logic signals generated in PIC18F4550 into power signals. Also, TLP250 is a photo coupler and it isolates power circuit from control circuit. Six TLP250s (one TLP250 for each switch) are required in the drive circuit. Power switches used are MOSFET IRFZ44. A prototype of single phase five level switched DC sources inverter is developed in the laboratory with two isolated input DC voltage sources E1=12V and E2=12V.Load used is RL load. Laboratory prototype of single phase five level switched DC sources inverter is shown in Fig.4.2.The hardware set up is shown in Fig.4.3. The hardware results are shown in Fig.4.4.

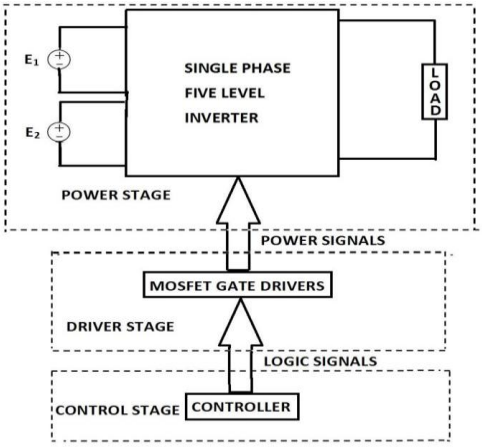

Fig. 4.1: Schematic diagram of single phase five level switched DC sources inverter

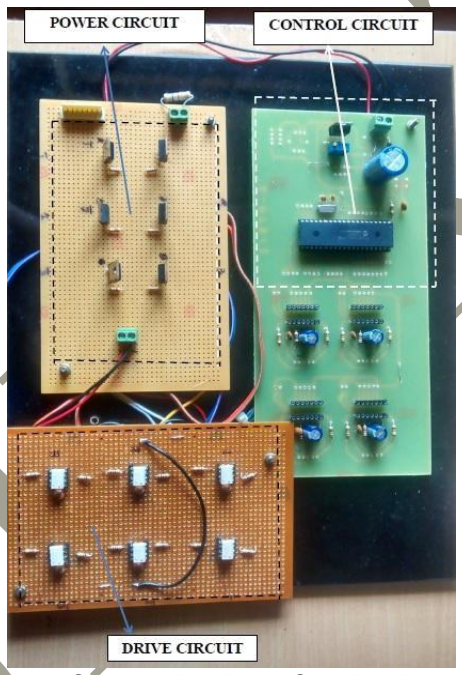

Fig. 4.2: Laboratory prototype for single phase five level switched DC sources inverter

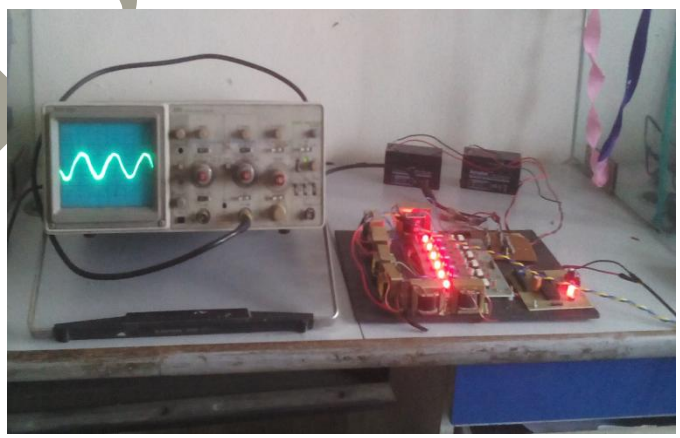

Fig. 4.3: Hardware set up for single phase five level switched DC sources inverter

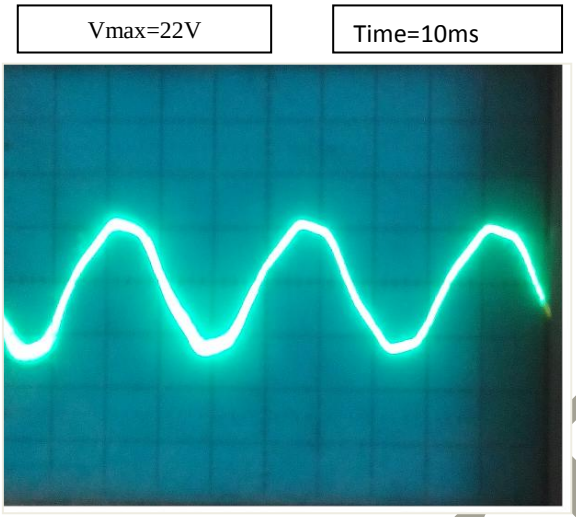

Fig. 4.4: Output voltage waveform with RL load obtained using CRO for single phase five level switched DC sources inverter

CONCLUSION

In this paper the working principle of A Multilevel Inverter based on DC switched sources has been explained. The proposed topology is investigated through simulations and validated experimentally on a laboratory prototype.

REFERENCES

1) Krishna Kumar Gupta, and Shailendra Jain, "*A novel multilevel inverter based on switched DC sources,"IEEE Trans. on Ind. Electron., vol. 61,no.7, pp. 3269-3278, July 2014.*

2) M. Malinowski, K. Gopakumar, J. Rodriguez, and M. A. Pérez, "*A survey on cascaded multilevel inverters," IEEE Trans. Ind. Electron., vol. 57,no. 7, pp. 2197– 2206, Jul. 2010.*

3) J. Ebrahimi, E. Babaei, and G. B. Gharehpetian, "*A new multilevel converter topology with reduced number of power electronic components," IEEE Trans. Ind. Electron., vol. 59, no. 2, pp. 655–667, Feb. 2012.*

4) G. Buticchi, E. Lorenzani, and G. Franceschini, "*A five-level single-phase grid-connected converter for renewable distributed systems," IEEE Trans.Ind. Electron., vol. 60, no. 3, pp. 906–918, Mar. 2013.*

5) Ebrahim Babaei "*A Cascaded Multilevel converter Topology With Reduced Number of Switches", IEEE Trans. Power Electron vol.23,no.6,Nov 2008*

6) K.A.Corzine, M.W. Wielebski, F.Z Peng, and J.Wang, "*Control of cascaded multilevel inverters", IEEE Trans. Power Electron vol.19,no.3 ,pp.732-738,,May 2004*