COMPARATIVE STUDY BETWEEN TWO AND THREE LEVEL CONVERTER FOR ELECTRIC APPLICATION

Tejaswini Honade, Sonali Udapure, Sneha Timande, Sneha Rodge,
Vaishnavee Burde, Sayali Gudadhe
Smt. Rajshree Mulak College of Engineering for Woman, Nagpur, Maharashtra, India

ABSTRACT
The conventional two level inverter has many limitations for high voltage and high power application. Multilevel inverter becomes very popular for high voltage and high power application. The multilevel began with the three level converters. The elementary concept of a multilevel converter to achieve higher power to use a series of power semiconductor switches with several lower voltage dc source to perform the power conversion by synthesizing a staircase voltage waveform. However, the output voltage is smoother with a three level converter, in which the output voltage has three possible values. This result in smaller harmonics, but on the other hand it has more components and is more complex to control. In this paper, we study the comparison between the two-level and three-level converter and a controlling device microcontroller.

KEYWORD- *two-level, three-level, converter, output, voltage, frequency, switching, triggering*.

I. INTRODUCTION

The converters which produce an output voltage or a current with levels either 0 or +- V are known as two level converter. In high power and high voltage application, these two level inverters have some limitations in operating at high frequency mainly due to switching losses and constraints of device rating. The three level converter produces output voltage or a current with three levels. The unique structure of three level voltage source converters allows them to reach high voltages with low harmonics without the use of transformer. This results in smaller harmonics. As compare to two level converters, three level converters have smaller output voltage. In addition, the output waveform provides an effective switching frequency twice that of actual switching frequency. In two levels converter total harmonic distortion is poor while in three levels it is better. Power losses in two level converter is more than that of three level converter. Efficiency of three level converters at full load is better than two level converter which is dominate by rectifier losses. Cost of three level converter. The cost of the converter is 40% higher than two level converter. The cost of the converter is mainly dependent on the IGBT and other component used in circuit. Pulse Width Modulation (PWM) technique here used to obtain variable output voltage by varying the gain of the inverter if the dc input voltage is fixed and it is not controllable. The inverter gain may be the ratio of ac output voltage to dc input voltage. This paper presents the most important topologies like diode- clamped inverter (neutral-point clamped), capacitor-clamped (flying capacitor), and cascaded multilevel with separate dc sources. Multilevel inverter is based on the fact that sine wave can be approximated to a stepped waveform having large number of steps. The steps being supplied from different DC levels supported by series connected batteries or capacitors.

II. TWO-LEVEL CONVERTER

The converters which produce an output voltage or current with level either zero or +ve /-ve are known as two level converteres.In high power and high voltage applications this two level inverter however have some limitations in operating at high frequency mainly due to switching losses and constraints of device rating.

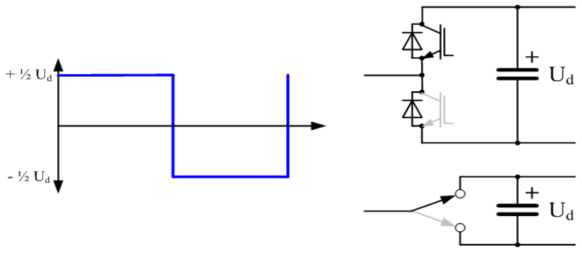

Figure 1. Two-level converter

Table1. Two-level converter switching table

IGBT	$V_{out}= V_p$	$V_{out}=V_n$
Q1	ON	OFF
Q2	OFF	ON

III. THREE-LEVEL CONVERTER

The unique structure of three level voltage source converters allows them to reach high voltages with low harmonics without the use of transformers or series-co. The harmonic content of the output voltage waveform decreases significantly. As compared to two level inverters, three level inverters have smaller output voltage. In addition, the output waveform provides an effective switching frequency twice that of the actual switching frequency.

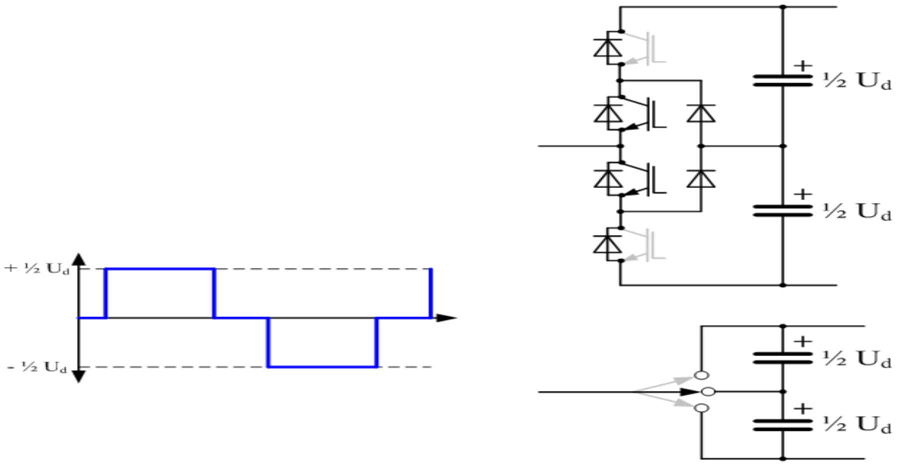

Figure2. Three-level converter

Table2: Three-level converter switching table

IGBT	$V_{out}= V_p$	$V_{out}= V_0$	$V_{out}=V_n$
Q1	On	Off	Off
Q2	On	On	Off
Q3	Off	On	On
Q4	Off	Off	On

IV. Types Of Three Level Converter

Three Level Inverter Topology:

The basic three types of multilevel topologies used are:

i. Diode clamped multilevel inverters
ii. Flying capacitors multilevel inverter or capacitor clamped multilevel inverter.
iii. Cascaded inverter with separate DC sources.

i. Diode Clamped Inverter

The diode clamped multilevel inverter uses capacitors in series to divide the dc bus voltage into a set of voltage levels. To produce n levels of the phase voltage, an n level diode clamp inverter needs (n-1) capacitors on the dc bus.

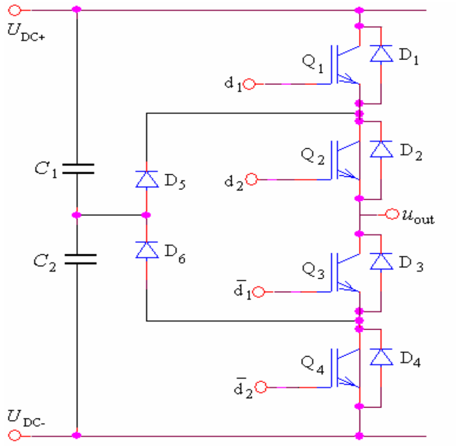

Figure3. Diode Clamped Inverter

In this paper, diode clamped multilevel inverters topology is
Used shown in fig 3

ii. Flying Capacitor Multilevel Inverter:

It uses ladder structures of dc side capacitors where the voltage on each capacitor differs from that of the next capacitor. To generate n- level staircase output voltage, (n-1) capacitors in the dc bus are needed. The size of the voltage increment between two capacitors determines the size of the voltage levels in the output wave.

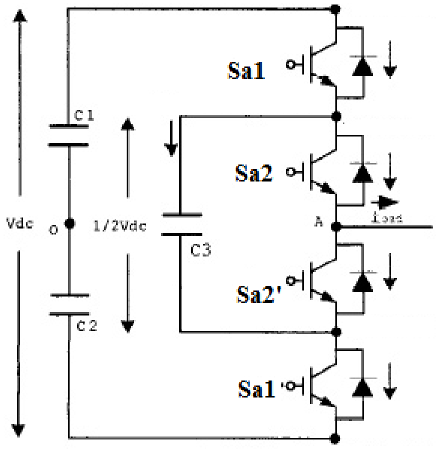

Figure 4. Flying Capacitor Multilevel Inverter

In this paper, flying capacitor multilevel inverters topology is
Used shown in fig 4.

iii. Cascaded Inverters with Separate DC Source:

This inverter is nothing but the series connection of single connection of single phase inverters with separate dc source. This inverter can be avoiding the extra clamping diodes or voltage balancing capacitors.

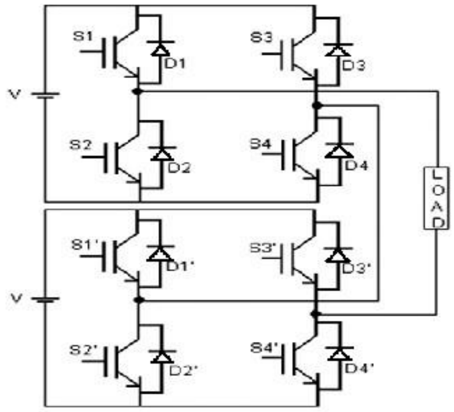

Figure5. Cascaded Inverter

In this paper, cascaded multilevel inverters topology is used shown in fig 5

Table3. Comparison of different Multilevel Inverter Topologies

S.No.	Topology	Diode Clamped	Flying Capacitor	Cascaded
1	Power semi conductor switches	2(m-1)	2(m-1)	2(m-1)
2	Clamping diodes per phase	(m-1)(m-2)	0	0
3	DC bus capacitors	(m-1)	(m-1)	(m-1)/2
4	Balancing capacitors per phase	0	(m-1)(m-2)/2	0
5	Voltage unbalancing	Average	High	very small
6	Applications	Motor drive system, STATCOM	Motor drive system, STATCOM	Motor drive system, PV, fuel cells, battery system

V. SIMULATION RESULTS

Simulation of various inverters was carried with the help of "MATLAB R2013".Simulation was carried out to observe the improvement in the line voltage THD and Line current THD for RL load as the inverter level increases from 2-level and 3-level. Following quantities have been observed:

1. Line voltage waveform
2. Line current and Line voltage waveform for RL load for two level inverter.
3. Line current and Line voltage waveform for RL load for three level inverter.

We study two level Converter in MATLAB and their parameters are following:

1. DC Voltage Source – 400v – 1no.
2. Resistance - 1ohm – 1no.
3. Inductor - 5mH -1no.

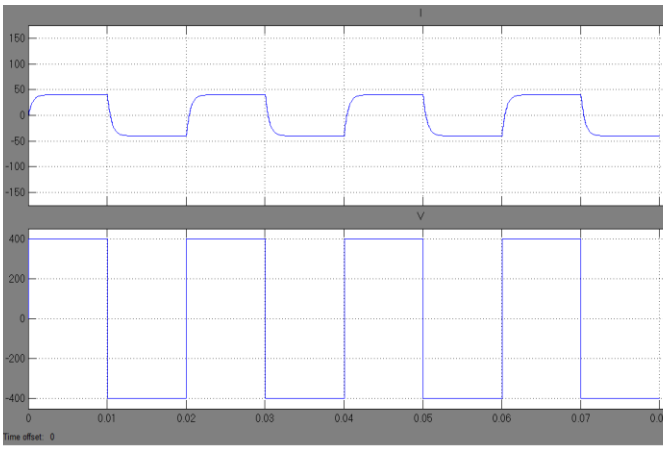

Figure6. MATLAB simulation for two level converter

We study two level Converter in MATLAB and their parameters are following

1. DC Voltage Source – 400v – 1 no.
2. Resistance - 1ohm – 1no
3. Inductor - 5mH -1no

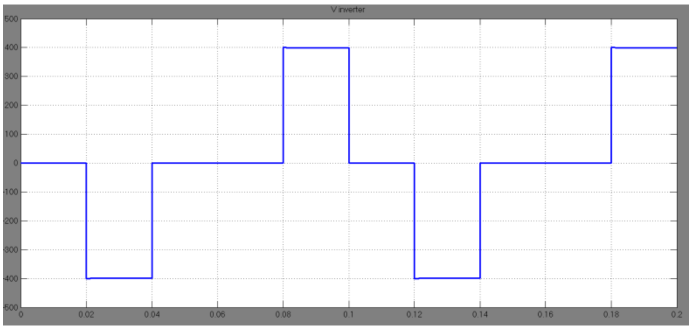

Figure7. MATLAB simulation for three level converter

VI. HARDWARE IMPLEMENTATION

System overview

To achieve the goal, the following additional technical arrangements are implemented in the system. Multiple devices are controlled and processed by micro-controller. Gate drive is used to access the selected mode of the IGBTs. Micro-controller is used to control the IGBTs switching operation. IGBTs uses gate drive to perform the switching process through which it gives desired output.

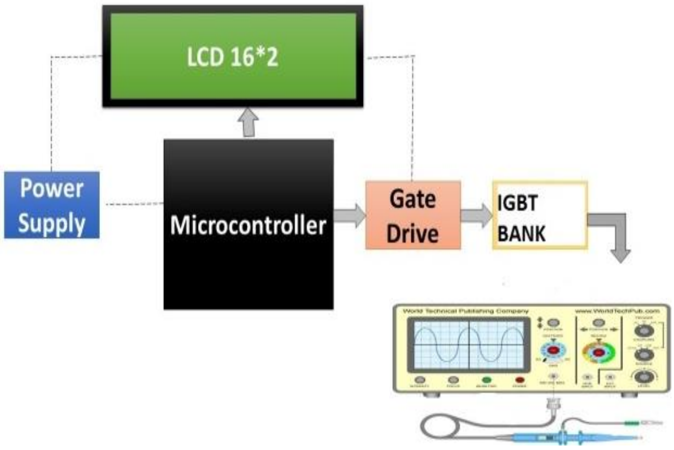

Figure 8. System Functional Diagram

The main steps which are followed while implementation of hardware is explain as below:

i. CONTROL CIRCUIT
ii. DRIVER CIRCUIT
iii. POWER CIRCUIT

VII. MICROCONTROLLER AT89S51

The AT89S51 is a low-power, high-performance CMOS 8-bit microcontroller with 4K bytes of In-System Programmable Flash memory. The device is manufactured using Atmel's high-density nonvolatile memory technology and is compatible with the industry-standard 80C51 instruction set and pin out. The on-chip Flash allows the program memory to be reprogrammed in-system or by a conventional nonvolatile memory programmer. By combining a versatile 8-bit CPU with In-System Programmable Flash on a monolithic chip, the Atmel AT89S51 is a powerful microcontroller which provides a highly-flexible and cost-effective solution to many embedded control applications

Features:

- 4K Bytes of In-System Programmable (ISP) Flash Memory – Endurance: 10,000 Write/Erase Cycles
- 4.0V to 5.5V Operating Range
- Fully Static Operation: 0 Hz to 33 MHz
- Three-level Program Memory Lock
- 128 x 8-bit Internal RAM
- 32 Programmable I/O Lines
- Two 16-bit Timer/Counters
- Six Interrupt Sources
- Full Duplex UART Serial Channel
- Low-power Idle and Power-down Modes
- Interrupt Recovery from Power-down Mode
- Watchdog Timer
- Dual Data Pointer
- Power-off Flag
- Fast Programming Time

VIII. POWER CIRCUIT

The microcontrollers that are used frequently for developing many embedded systems used in real-time applications. These microcontrollers require a 5V DC supply, so the AC 230V needs to be converted into 5V DC using the step-down converter in their power supply circuit. The circuit consisting of a 12V step down transformer, voltage regulator IC (7805) and some capacitors, used for filtering purpose.

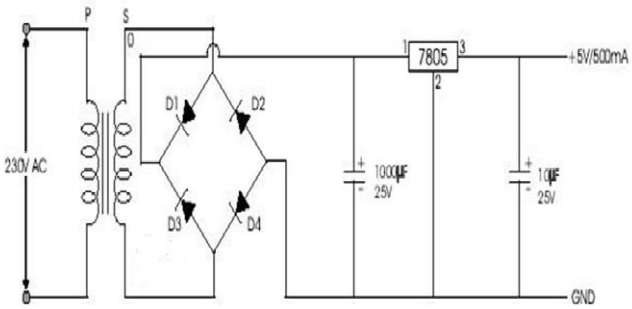

Figure9. Block diagram for power supply

IX. IGBT

The Insulated Gate Bipolar Transistor (IGBT) is a minority-carrier device with high input impedance and large bipolar current-carrying capability. Many designers view IGBT as a device with MOS input characteristics and bipolar output characteristic that is a voltage-controlled bipolar device. To make use of the advantages of both Power MOSFET and BJT, the IGBT has been introduced. It's a functional integration of Power MOSFET and BJT devices in monolithic form.

X. LIQUID CRYSTAL DISPLAY

LCD stands for **L**iquid **C**rystal **D**isplay. LCD is finding wide spread use replacing LEDs (seven segment LEDs or other multi segment LEDs) because of the following reasons:

1. The declining prices of LCDs.
2. The ability to display numbers, characters and graphics. This is in contrast to LEDs, which are limited to numbers and a few characters.
3. Incorporation of a refreshing controller into the LCD, thereby relieving the CPU of the task of refreshing the LCD. In contrast, the LED must be refreshed by the CPU to keep displaying the data.
4. Ease of programming for characters and graphics.

These components are "specialized" for being used with the microcontrollers, which means that they cannot be activated by standard IC circuits. They are used for writing different messages on a miniature LCD.

XI. COMPARISON OF THE 2-LEVEL AND MULTILEVEL INVERTERS

In 2-level inverter output voltage waveform is produced by using with two voltage levels. This causes the output voltage and current to be distorted and the THD of the voltage is poor. In 3-level inverter output voltage and current is much more sinusoidal and the THD is better.

In 2-level inverter the efficiency of the whole system is dominated by the rectifier losses in light loads. In 3-level inverter the efficiency at full load is better than in 2-level inverter. This means better energy capture of the system. Better efficiency at rated power means also smaller heat sink and better reliability.

Efficiency of the 3-level inverter at small power is also improved. The value of P/Pmax is reduced at the knee by 50%.

- **Cost Comparison**

In the determination of inverter configuration, usually the cost comparison of different configurations has to be executed. The cost of inverter is affected mainly by the DC-link capacitor, IGBT and the filtering components, while the rest electronics have quite insignificant affects good estimation of inverter costs can be done comparing the costs of capacitor and IGBT. The impact of filtering cost can be significant.

REFERENCE

[1]. Muhammad H. Rashid, "Power electronic circuits, devices and applications", 3rd edition 2003, Pearson Education Inc., chapter 9, pp 406-430.

[2]. Nagrath G. Hingorani Laszlo Gyugyi, Understanding FACTS concept and technology of flexible AC transmission system (Page no. 69 to 71 , 87 to 91)

[3]. M D Singh, K B Khanchandani, Power Electronics Electrical and Electronics Engineering series, second addition (Page no. 535 to 657)

[4]. Semikronapplication manual. Web-document. Available at http://www.semikron.com/internet/index.jsp?sekId=13 (reference SKM 145GB123D datasheet.

[5]. SKM 145GB123D datasheet available athttp://www.semikron.com/internet/ds.jsp?file=33.html(references) 10.9.2005) d 14SKM 145GB123Ddatasheet

[6]. Multilevel Inverter 3 level available at www.academia.edu/7896 2 level and 3 level HVDC converter circuit at Wikipedia.org/wiki/HVDCconverter.

[7]. T.Prathiba, P.Renuga "A comparative study of Total Harmonic Distortion in Multilevel inverter topologies in the paper" Journal of Information Engineering and Applications ISSN 2224-5782 (print) ISSN 2225-0506 (online) Volume- 2, No.3.

[8]. PradyumnChaturvedi, Shailendra Jain and Pramod Agrawal, "Modeling, Simulation andAnalysis of Three-Level Neutral Point Clamped Inverter Using Matlab/Simulink/PowerSystem Block set", Eighth

International Conference on1223-122727-29 Sept. 2005International Journal of Innovative Research and StudiesPage 402April, 2013, 2012, pp.26-36.

AUTHORS BIOGRAPHIES

Tejaswini Honade Born on 11June 1995 in Maharastra India, Recived BE Degree in Electrical Engineering from Rastrasant Tukadoji Maharaj Nagpur University , India in 2016

Sonali Udapure Born on25April 1995 in Maharastra India, Recived BE Degree in Electrical Engineering from Rastrasant Tukadoji Maharaj Nagpur University , India in 2016

Sneha Rodge Born on 5April 1995 in Maharastra India, Recived BE Degree in Electrical Engineering from Rastrasant Tukadoji Maharaj Nagpur University , India in 2016

Sneha Timande Born on 26February 1995 in Maharastra India, Recived BE Degree in Electrical Engineering from Rastrasant Tukadoji Maharaj Nagpur University , India in 2016.

Vaishnavee Burde Born on 14 May 1995 in Maharastra India, Recived BE Degree in Electrical Engineering from Rastrasant Tukadoji Maharaj Nagpur University , India in 2016.

Sayali Gudadhe Born on 15October 1986 in Maharastra India, Recived BE Degree in Electrical Engineering from Rastrasant Tukadoji Maharaj Nagpur University , India in 2007 , Master of Technology Degree in Electrical Power System feom Government College Of Engineering and Technology Amravati , India in 2009.assistant professor in government college of engineering Amravati , India since 2008 to2010