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ROLE OF SWITCH IN MULTILEVEL INVERTER DESIGNING

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ABSTRACT

An Inverter arrangement consists of power semiconductor switches. These switches having their different characteristics due to which performance of inverter has changes according to switch. Various power semiconductor switches can be used in inverter arrangement. In this paper performance of switch in multilevel inverter designing has been studied. MATLAB/SIMULINK software is used for designing and simulation purpose. In this performance of inverter has been studied using three semiconductor switches MOSFET, IGBT and GTO. First of all three multilevel inverter models are design and after simulation performance of inverter are compared.

Key Words—Multilevel inverter, IGBT, GTO, MOSFET, MATLAB/SIMULINK.

I. INTRODUCTION

Inverters become the need of today's world due to the change in the use of drives, equipments, devices, gadgets etc. from industries to houses. At the same the efficient semiconductor switches are responsible for the loss component during the triggering actions. In inverter voltage control is an important issue to maintain a fixed output voltage when the dc input voltage regulation is poor, or to control power to a load. The inverter and its output can be single-phase, three-phase or multi-phase. Variable output frequency may be required for ac motor speed control where, in conjunction with voltage or current control, constant motor flux can be maintained. Inverter output waveforms (either voltage or current) are usually rectilinear in nature and as such contain harmonics which may lead to reduced load efficiency and performance. Load harmonic reduction can be achieved by either filtering, selected harmonic-reduction chopping or pulse-width modulation. The quality of an inverter output is normally evaluated in terms of its harmonic factor, ρ, distortion factor, μ, and total harmonic distortion, THD [1]-[5].

Two-level inverter produces more harmonics which results in increasing losses. Indirectly decreases efficiency and results in poor power quality [5]. To reduce these harmonics multilevel inverter is design, number of input dc voltage of multilevel inverter depends upon the output voltage levels of inverter, as level increases harmonics reduces. A multilevel inverter (directly or indirectly) divides the dc rail, so that the output of the leg can be more than two levels. In this way, the output quality is improved because both pulse width modulation and amplitude modulation can be used. The output pole is made from more than two series connected switches, so the total dc rail can be the sum of the voltage rating of the individual switches. Very high output voltages can be achieved, where

each device does not experience a voltage in excess of its individual rating. Thus due to the use of both pulse width and amplitude modulation multilevel inverter allows higher output voltages with low distortion [3].

The design of inverter and role of switches therefore are the prime factor in academic pursuits of the graduate level students. Hence the aim of this paper has set to demonstrate and perform a comparative study of the behavior of the output of single phase multi level inverter by changing semiconductor switches for triggering purpose. In this paper inverter has been designed and simulated using soft tool i.e. MATLAB / SIMULINK.

II. MULTILEVEL INVERTER

The concept of multilevel inverter has been introduced since 1975. Using only one power semiconductor switch directly made some trouble for medium voltage grid. To overcome this limitation multilevel power inverter structure has been introduced as an alternative in high power and medium voltage situation; it decreases the harmonic distortion in output waveform. Three types of multilevel inverter are reported in literature until now. [1] Cascaded H-bridge inverter, diode clamped (neutral- clamped) and flying capacitor (capacitor clamped). Cascaded multilevel inverter needs less number of components comparative to diode-clamped or capacitor clamped, so the price and the weight of the inverter is less than these two types. Multilevel inverter having important phenomenon that as the level of inverter increases from three-level, five-level to so on, and harmonics reduces which increases the efficiency and as efficiency increases voltage quality or power quality is improved [3].

III. SEMICONDUCTOR SWITCHES

Power semiconductor device is the heart of modern power electronics. Power electronics system plays important role in making efficient use of electric power in many applications, both in industries and in houses. Power semiconductor devices are used as switching devices in many power electronics devices such as inverter, converters, and so on. A power electronic converter is made up of some power semiconductor devices controlled by integrated circuits. The switching characteristics of power semiconductor devices permit a power electronic converter to shape the input power of one form to output power of some other form. It operates as a switch when the device conducts; it behaves as an ordinary closed switch. Therefore, ideally no voltage drop occurs across the device and the supply voltage applies to the load. Similarly, when the device does not conduct, it behaves as opened switch and offers ideally infinite impedance. The silicon material is widely used for the fabrication of power semiconductors. It will take long way to replace silicon when the technology of these materials advances.

A. MOSFET

The Power MOSFET (Metal Oxide Semiconductor Field Effect Transistor) was evolved from integrated circuit
technology in response to the need to develop power transistors that can be controlled using much lower gate drive
power levels as compared to the existing power transistors. A power MOSFET is a unipolar voltage controlled device and requires very small gate current for its turn on.

B. IGBT

An IGBT is basically a hybrid MOS-gated turn on/off bipolar transistor that combines the attributes of a MOSFET, BJT and thyristor. The device was commercially introduced in 1983. The device is also known as a metal oxide semiconductor insulated gate transistor (MOSIGT), conductivity-modulated FET (COMFET) or gain-modulated FET (GEMFET), and was originally called insulated gate transistor (IGT) or insulated gate rectifier (IGR) [8]. It is used for medium power application.

C. GTO

A gate turn-off thyristor (GTO), as the name indicates, is basically a thyristor-type device that can be turned on by a positive gate current pulse and turn off by a negative gate current pulse. It is also used for medium power application. It has high efficiency and high power handling capability but requires a large gate power source (negative) to turn it OFF.

IV. PULSE WIDTH MODULATION (PWM)

Pulse width modulation techniques are used to achieve voltage control in an inverter and to reduce the harmonic contents in the output voltage of an inverter. The main aim of the modulation strategy of multilevel inverters is to synthesize the output voltage as close as possible to the sinusoidal

waveform. Many modulation techniques have been developed for harmonic reduction and switching loss minimization. The modulation methods used in multilevel inverters can be classified according to switching frequency. Switching techniques of pulse width modulation (PWM) have been popular in the area of power electronics and drive systems. PWM is commonly used in applications like motor speed control, converters audio amplifiers etc. PWM is used to adjust voltage applied to the motor. There is no single PWM method which can suite for all applications. As per the advanced technology in solid state power electronic devices and microprocessors, various pulse-width modulation (PWM) techniques have been developed for different industrial applications. For the above reasons, the PWM techniques have been the subject of intensive research since 1970s. The pulse width modulation (PWM) techniques are mainly used for voltage control. These techniques are most efficient and they control the drives of the switching devices. The different PWM techniques are Single pulse width modulation, Multiple pulse width modulation, Phase displacement control, Sinusoidal pulse width modulation, Harmonic Injection modulation, Space Vector pulse width modulation, Hysteresis (Delta) pulse width modulation, Selective Harmonic Elimination and Current Controlled pulse width modulation. Hysteresis controller is used for Current source inverter and all the remaining PWM techniques are used for Voltage source inverter. Sinusoidal and Space Vector PWM techniques are most widely used. They control the output voltage as well as reduce the harmonics.

V. MATLAB/SIMULINK MODEL

Five-level cascaded H-bridge inverter is design using soft tool MATLAB/SIMULINK. Discrete PWM generator is used for triggering semiconductor switches giving suitable phase shift angle. Using different semiconductor switches such as MOSFET, IGBT and GTO simulation is carried out in MATLAB/SIMULINK. After simulation THD of multilevel inverter using different switches are compared by increasing modulation index from 0.4 to 1.

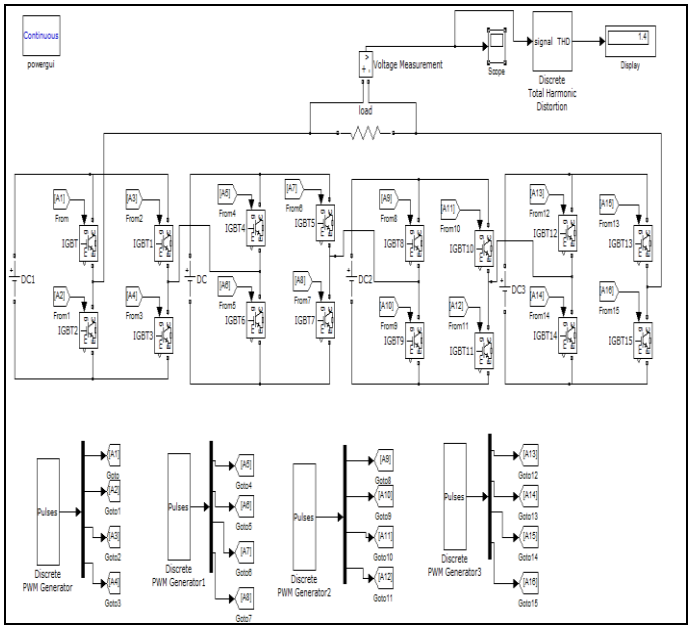

Figure.1. Five-level IGBT based inverter

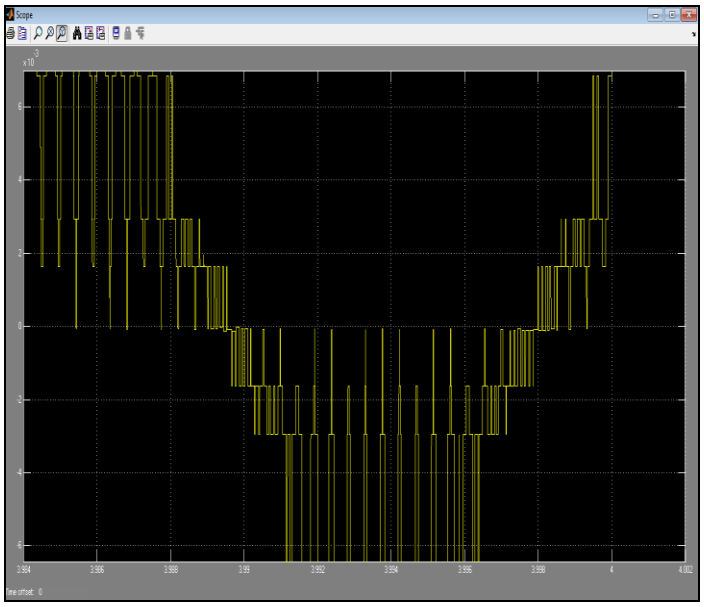

Figure.2. Output waveform of IGBT based multilevel inverter.

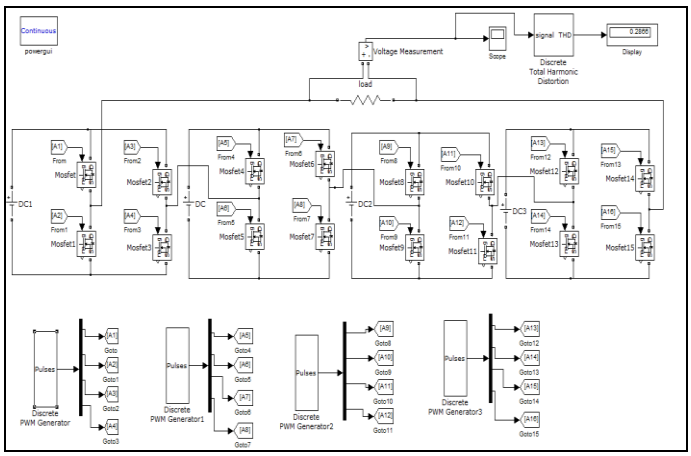

Figure.3. Five level MOSFET based inverter.

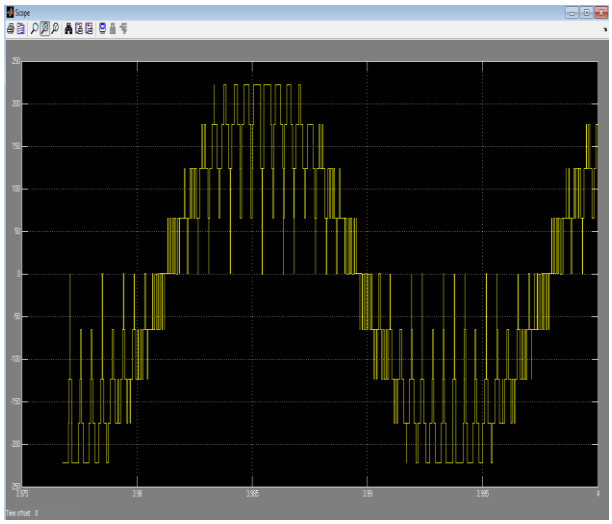

Figure.4. Output waveform of MOSFET based multilevel inverter.

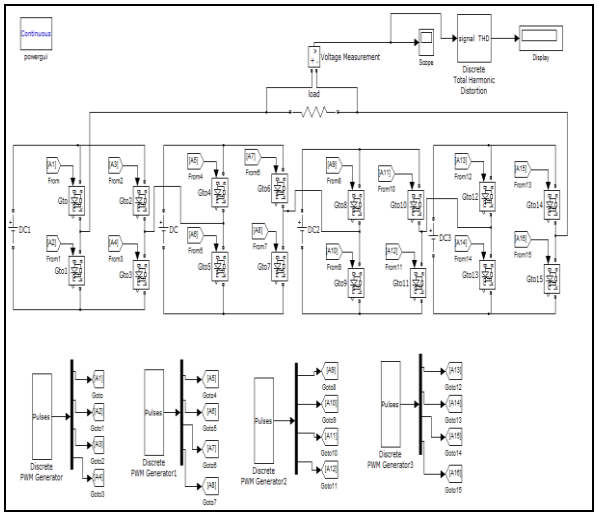

Figure.5. Five level GTO based inverter.

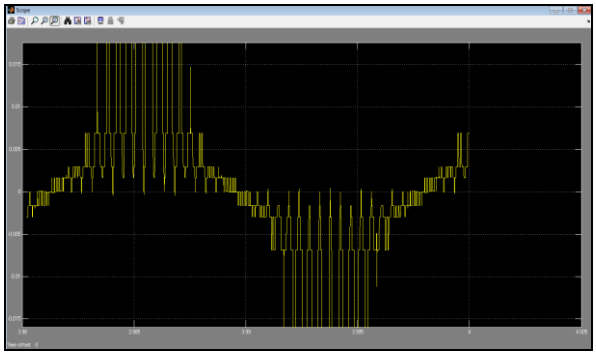

Figure.6. Output waveform of GTO based multilevel inverter.

VI. RESULTS

By increasing modulation index from 0.4 to 1, THD % is noted for IGBT, MOSFET and GTO.

Modulation index (m)	Total harmonic distortion (THD) Vo %
0.4	131.7
0.5	109.8
0.6	90.63
0.7	74.43
0.8	59.8
0.9	46.86
1	28.66

Table.1. for IGBT

Modulation index (m)	Total harmonic distortion (THD) Vo %
0.4	134.6
0.5	112.8
0.6	98.76
0.7	79.24
0.8	61.02
0.9	49.05
1	32.42

Table.2. for MOSFET

Modulation index (m)	Total harmonic distortion (THD) Vo %
0.4	138.23
0.5	121.64
0.6	101.01
0.7	82.76
0.8	64.76
0.9	52.08
1	39.43

Table.3. for GTO

VII. CONCLUSION

By observing above tables it is concluded that THD is less in IGBT as compare to other switches. So it is better to select IGBT switch for designing inverter, as THD is less, efficiency increases and power quality of inverter get improved. This paper will help to select proper switch for designing inverter.

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REFERENCES

[1] Bindeshwar Singh, Nupur Mittal, Dr.K.S.Verma, Dr.Deependra Singh, S.P. Singh, Rahul, "Multilevel Inverter: A literature survey on topologies and control strategies", International

Journal of Reviews in Computing, volume 10 , 31st July 2012.

[2] Rajesh Kr Ahuja, Lalit Aggrawal, Pankaj Kumar, "Simulation of single phase multilevel inverters with simple control strategy using MATLAB", International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering, volume 2, Issue 10,October 2013.

[3] .Vinod Kumar, Ch.Santosh Kumar and K.Ramesh Reddy, "Single phase cascaded multilevel inverter using multicarrier PWM technique", ARPN Journal of engineering and applied sciences, volume 8 no.10, October 2013.

[4] Gobinath.K, mahendran.S, Gnanambal.I, "New Cascaded H-Bridge Multilevel Inverter with Improved Efficiency", International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering, volume 2, Issue 4,April 2013.

[5] Ersoy Besery, Birol Arifoglu, Sabri Camur, and Esra Kandemir Beser, "Design and Application of a Single Phase Multilevel Inverter Suitable for using as a Voltage Harmonic Source", Journal of Power Electronics, Volume. 10, No. 2, March 2010.

[6] G.Gopal, B.Shankaraiah, M.Chinnalal, K.Lakshmi Ganesh, G.Satyanarayana, D.Sreenivasa Naik, "A New topology of Single-Phase Seven-Level Inverter with Less Number of Power Elements for Grid Connection", International Journal of Innovative Technology and Exploring Engineering (IJITEE) ISSN: 2278-3075, Volume-3, Issue-4, September 2013.

[7] T.Prathiba, P.Renuga, "A comparative study of Total Harmonic Distortion in Multilevel inverter topologies", Journal of Information Engineering and Applications, Vol 2, No.3, 2012.

[8] Bimal K. Bose, Fellow, IEEE, "Evaluation of modern power semiconductor devices and future trends of converters", IEEE transactions industry application, Vol .28, No.2, March/April 1992.

[9] Vitezslav Benda, "Power semiconductors – state of the art and future trends", Global Journal of Technology and Optimization, volume 2, 2011.

[10] B. Jayant Baliga, "The Future of Power Semiconductor Device Technology", Proceeding of the IEEE, Vol. 89, No.6, June 2001.

[11] Jawad Faiz and Ghazanfar Shahgholian, "Modeling and Simulation of a Three-Phase Inverter with Rectifier-Type Nonlinear Loads", Armenian Journal of Physics, 2009, vol. 2, issue 4, pp. 307-316.

[12] M.Murugesan, R.Sakthivel, E.Muthukumaran and R.Sivakumar, "Sinusoidal PWM Based Modified Cascaded Multilevel Inverter", International Journal of Computational Engineering Research / ISSN: 2250-3005.

[13] Shazly A. Mohammed, Abdel-Moamen M. A, B. Hasanin, "A Review of the State-Of-The-Art of Power Electronics for Power System Applications", Quest Journals Journal of Electronics and Communication Engineering Research Volume1 -Issue1 (2013) pp: 43-52.

[14] Abhijit Kundu, Maitreyi Ray Kanjilal, M.Mukherjee, Damayanti Ghosh, "Switching Characteristics of P-I-N Diode Using Different Semiconductor Materials", International Journal of Advanced Technology & Engineering Research (IJATER).

[15] Meenakshi mataray, "Modern Power Semiconductor Devices" (A Review), International Journal of Computer Science and Information Technologies, Vol. 3, 2012.

[16] Sneha Bhavsar, Dr.Hina Chandwani, "Topological Advancements in Matrix Converter Technology: A Review Paper", International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering, Vol. 2, Issue 12, December 2013.

[17] Lee Empringham, Member, Johann W. Kolar, Jose Rodriguez, Pat W. Wheeler and Jon C. Clare, "Technological Issues and Industrial Application of Matrix Converters: A Review", IEEE Transactions on Industrial Electronics, Vol. 60, No. 10, October 2013