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A Literature Survey on Multilevel Inverter and its Parameter

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***Abstract*— Multi Level Inverters (MLI) are today used in medium and large power applications. Here are three major topologies of multilevel inverters; they are capacitor clamped, diode camped and cascaded. In literature it is found that these topologies have been used by several researchers. This paper presents a brief review of various inverter techniques. Here main objective of this review paper is to focus on multilevel inverters. We conclude various multilevel inverter techniques also review previously done work.**

***Index Terms*—Inverter, Multilevel Inverter, Power Electronics, PWM, AC, DC.**

I. INTRODUCTION

Inverters plays vital role in routine life. In each field wherever electricity is needed inverters are going to be used there. The main function of the inverter is to convert DC input voltage to an AC output voltage of the specified magnitude. The output voltage waveforms of the ideal inverters ought to be sinusoidal, but the wave form of the practical inverters are non-sinusoidal and contains completely different harmonics. Square wave or quasi-square-wave voltages are acceptable only for low and medium power applications; except for high power applications low distorted sinusoidal waveforms are needed. By using high speed power semi-conductor devices and by using completely different switching techniques we can reduce the harmonic content in output voltage. Inverters are widely utilized in industrial applications (e.g., variable speed AC motors, induction heating, standby power supplies and uninterruptible power supplies). Inverters are broadly classified in to two type's single section inverters and three phase inverters. Every type will use controlled turn on and turn off devices. These inverters usually use pulse width modulation control signals to produce an AC output signal.Power electronic converters, especially dc/ac PWM inverters have been extending. Their range of use in trade because they supply reduced energy consumption and higher system efficiency, then improved the quality of product these maintenance are good, and so on.

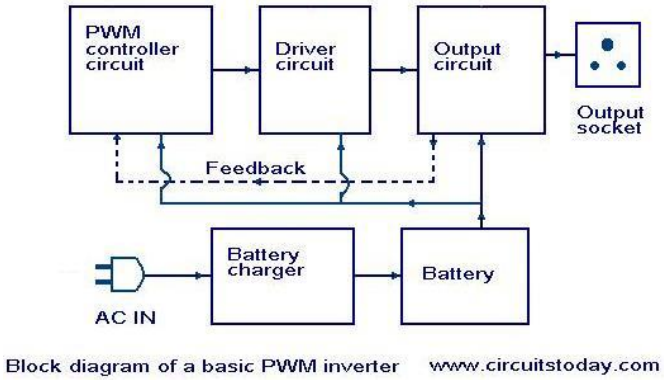

Fig. 1.1 Typical Inverter

For a medium voltage grid, it's difficult to connect only one power semiconductors are switches directly. [1,2,3]. As a result, the multilevel power converter structure has been introduced as another in high power and medium voltage situations like laminators, mills, conveyors, fans, blowers, compressors, pumps, etc. As a cost effective solution on a multilevel converter not solely achieves high power ratings, and additionally enables the utilization of low power application in renewable energy sources like wind cells, photovoltaic cells, and fuel cells, which may be the simply interfaced to multilevel converters system for a high power application.

II. TYPES OF INVERTERS

An electrical power device used for converting direct current (DC) into alternating current (AC) is known as

inverter. Primarily inverters are simply opposite to Rectifiers. Rectifiers are used to convert alternating current (AC) into direct current (DC). We can get AC at any required frequency and voltage by using few control circuits and switches. Different kinds of inverters are accessible now a day, some of principally used are as follows:

1. Multilevel inverters
2. Square wave inverters
3. Pure sine wave inverters
4. Modified sine wave inverters
5. Resonant inverters
6. Grid tie inverters
7. Synchronous inverters
8. Stand-alone inverters
9. Solar inverters

III. MULTILEVEL INVERTER

Now a day's several industrial applications have begun to need high power. Some appliances within the industries however require medium or low power for their operation. Using a high power supply for all industrial loads might prove useful to some motors requiring high power, whereas it should damage the other loads. Some medium voltage motor drives and utility applications need medium voltage. The multi-level inverter has been introduced since 1975 as alternative in high power and medium voltage situations. The Multi-level inverter is like an inverter and it's used for industrial applications as various in high power and medium voltage situations. The necessity of multilevel converter is to provide a high output power from medium voltage supply. Sources like batteries, super capacitors, solar panel are medium voltage sources. The multi-level inverter consists of many switches. Within the multi-level inverter the arrangement switches' angles are vital. Multilevel inverters are three types.

1. Diode clamped multilevel inverter
2. Flying capacitors multilevel inverter
3. Cascaded H- bridge multilevel inverter

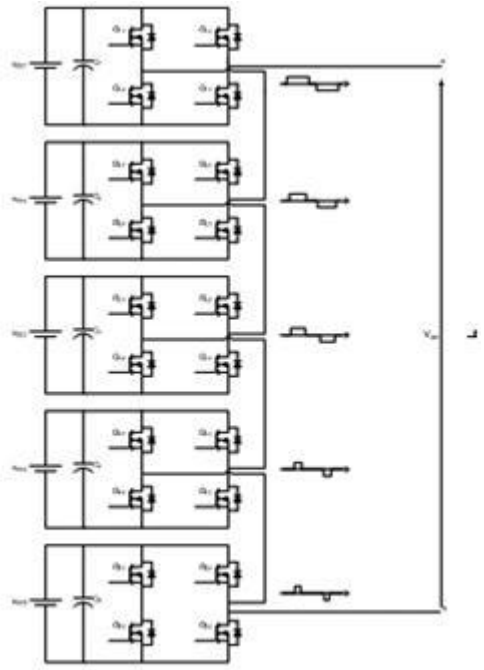

Fig. 1.3 5-H- Bridge Multilevel Invertert6

IV. LITERATURE SURVEY

A. Bharath. K, R. J. Satputaley, Single Phase Asymmetrical Cascaded Multilevel Inverter Design for Induction Motor, 2013

Summary- This paper presents an asymmetric cascaded 7 level multilevel inverter using fixed frequency level shifted carrier based pulse width modulation technique. This new control scheme is applied to 7-level asymmetric cascaded inverter design for induction motor load. Different firing angle control schemes in LSCPWM for 7-level asymmetric cascaded multilevel inverter are compared. In asymmetric cascaded MLI by using only 2-H bridges with 8 switches we can get 7 level output voltage where as in symmetric cascaded MLI 7 level output voltage is obtained by using 3- H bridges with 12 switches.

In asymmetrical topology the output voltage is seven level by using only 2 bridges (8 switches) whereas symmetrical topology uses 3 bridges (12 switches).therefore the number of switches are reduced in asymmetrical topology compared to Symmetrical topology for the same no of levels. The THD of the voltage of asymmetrical CMLI is studied under different modulation techniques such as PD, APOD, POD and the less THD is observed for APOD technique. [1]

B. Mariusz Malinowski, K. Gopakumar, Jose Rodriguez, and Marcelo A. Perez"A Survey on Cascaded Multilevel Inverters", 2010

Summary- Cascaded multilevel inverters synthesize a medium-voltage output based on a series connection of power cells which use standard low-voltage component configurations. This characteristic allows one to achieve high-quality output voltages and input currents and also outstanding availability due to their intrinsic component

redundancy. Due to these features, the cascaded multilevel inverter has been recognized as an important alternative in the medium-voltage inverter market. This paper presents a survey of different topologies, control strategies and modulation techniques used by these inverters. Regenerative and advanced topologies are also discussed. Applications where the mentioned features play a key role are shown. Finally, future developments are addressed. [2]

C. *Ruderman, Alex Schlosberg, Sam, "A Hybrid asymmetric cascaded multilevel inverter comprising high resolution and symmetric low resolution parts", 2008*

Summary- To reduce output voltage waveform distortion and associated harmonic loss, multilevel converter voltage levels count must be increased. While for symmetric cascaded converter levels count increases linearly with modules count, for asymmetric converter levels count grows exponentially. However, a symmetric converter is modular and it is possible to stabilize its voltage levels by charge balance control methods while asymmetric converter modules are different and voltage levels stabilization is not possible. To set up a compromise between converter levels count and its modularity and voltage levels stability, it is suggested to use a hybrid asymmetric converter comprised of a low resolution symmetric and high resolution-symmetric or asymmetric-parts. Utilization of full dynamic range of a high resolution part for each low resolution level provides the increased levels count, reduced and uniform high resolution part power consumption at the expense of increased high resolution part switching frequency. [3]

D. *Zhong Du; Tolbert. L.M.; Chiasson. J.N.; Ozpineci. B," A cascade multilevel inverter using a single DC source", 2006*

Summary- A method is presented showing that a cascade multilevel inverter can be implemented using only a single DC power source and capacitors. A standard cascade multilevel inverter requires n DC sources for 2n + 1 levels. Without requiring transformers, the scheme proposed here allows the use of a single DC power source (e.g., a battery or a fuel cell stack) with the remaining n−1 DC sources being capacitors. It is shown that one can simultaneously maintain the DC voltage level of the capacitors and choose a fundamental frequency switching pattern to produce a nearly sinusoidal output.

A cascade multilevel inverter topology has been proposed that requires only a single DC power source. Subject to specified constraints, it was shown that the voltage level of the capacitors can be controlled while at the same time choosing the switching angles to achieve a specified modulation index and eliminate harmonics in the output waveform. [4]

E. *Azli, N.A. Choong. Y.C., "Analysis on the Performance of a Three-phase Cascaded H-Bridge Multilevel Inverter", 2006*

Summary- In recent years, multilevel inverters are becoming increasingly popular for high power applications due to its improved harmonic profile and increased power ratings. Works on the aspect of topology, control techniques and applications of multilevel inverters have been reported in literatures. However, there are no concrete findings that actually discuss or evaluate the performance of a three-phase multilevel inverter. This paper presents some analysis on the performance of a 5-level cascaded H-bridge multilevel inverter (CHMI) based on a multi-carrier sinusoidal pulse width modulation (MSPWM) control technique. Performance analysis are made based on the results of a simulation study conducted on the operation of the CHMI using MATLAB/Simulink. The performance parameters chosen in the work include the waveform pattern, harmonic spectrum, fundamental value, and total harmonic distortion (THD) of the three-phase CHMI output voltage. From the results of the simulation study and the analysis conducted, several distinct features of the three-phase 5-level CHMI employing the MSPWM control scheme, in particular the phase disposition (PD) type of the carrier disposition (CD) method from the aspect of line voltage have been identified. [5]

F. *Calais, M.; Borle, L.J.; Agelidis, V.G., Analysis of multicarrier PWM methods for a single-phase five level inverter, 2001*

Summary- This paper investigates and analyses different multicarrier PWM methods for a single phase five level cascaded inverter. Carrier disposition methods, phase shifted and a hybrid method are discussed with respect to resulting switching frequencies, complexity of implementation, spectrum of the output waveform, and the use of inverter state redundancies to perform additional application specific control tasks, such as power flow control from each DC source. A concept of separating the wave shaping function from the switch selection is explored and selected experimental results are presented. [6]

G. *Johnson Uthayakumar R., Natarajan S.P., Bensraj R., "A Carrier Overlapping PWM Technique for Seven Level Asymmetrical Multilevel Inverter with various References", 2012*

Summary- This paper presents the use of Control Freedom Degree (CFD) combination to evaluate the performance of single phase seven level Asymmetrical Multilevel Inverter (AMLI) fed with resistive load. The effectiveness of the Pulse Width Modulation (PWM) strategies developed using CFD are demonstrated by simulation. The results are compared for sine, trapezoidal and Trapezoidal Amalgamated Reference (TAR) references in the Carrier Over Lapping (COPWM) strategy. By the different pattern of overlapping it is classified as carrier overlapping, Type-A, Type-B and Type-C. The Total Harmonic Distortion (THD) the Root Mean Square (RMS) value and Form Factor (FF) of output voltage are analyzed for modulation indices 0.7-1. The simulation results indicate that the use of CFD combination is an important clue to realize high performance multilevel inverters.

Single phase seven level cascaded asymmetrical multilevel inverter employing different multi carrier offset modulation schemes have been investigated. It is found that the DC bus utilization is high in COPWM-C modulation strategy with all references. The THD is less in COPWM-C with sine and TAR references. [7]

H. Radha Sree.K, ISivapathi.K, IYardhaman. Y Dr. R.Seyezhai, "Asymmetric Cascaded Multilevel Inverter for Electric Vehicles," 2012

Summary- Multilevel Inverter (MLI) is the advanced power electronic inverter circuit which is most commonly used for producing higher output voltage levels for the drive system applications. Different topologies of multilevel inverter have been reported in the literature, but this paper mainly focuses on the asymmetrical cascaded multilevel inverter circuit with reduced number of input DC sources. This paper presents the application of a novel Carrier Phase shift Pulse Width Modulation (CPSPWM) technique for producing seven level inverter output with reduced Total Harmonic Distortion (THD) with a single phase induction motor load. The simulation of the proposed topology along with its control circuit is done using MATLAB/SIMULINK. [8]

I. A.K.Verma, P.R.Thakura, K.C.Jana and G.Buja, "Cascaded Multilevel Inverter for Hybrid Electric Vehicles," 2011

Summary- Hybrid Electric Vehicle (HEV) is an emerging technology in the modern world because of the fact that it mitigates environmental pollutions and at the same time increases fuel efficiency of the vehicles. Multilevel inverter controls electric drive of HEV of high power and enhances its performance which is the reflection of the fact that it can generate sinusoidal voltages with only fundamental switching frequency and have almost no electromagnetic interference. This paper describes precisely various topology of HEVs and presents transformer less multilevel converter for high voltage and high current HEV. The cascaded inverter is IGBT based and it is fired in a sequence. It is natural fit for HEV as it uses separate level of dc sources which are in form of batteries or fuel cells. Simulation has been done in PSEVI as well as MATLAB and its responses match the theoretical concept of multilevel inverter. [9]

J. Leon M.Tolbert, Fang Zheng Peng, Thomas G. Habet Jer, "Multilevel Converters for Large Electric Drives," 1999

Summary- This paper presents transformer less multilevel converters as an application for high-power and/or high-voltage electric motor drives. Multilevel converters: 1) can generate near sinusoidal voltages with only fundamental frequency switching; 2) have almost no electromagnetic interference or common-mode voltage; and 3) are suitable for large volt-ampere-rated motor drives and high voltages. The cascade inverter is a natural fit for large automotive all-electric drives because it uses several levels of dc voltage sources, which would be available from batteries or fuel cells. The back-to-back diode-clamped converter is ideal where a source of ac voltage is available, such as in a hybrid electric vehicle. Simulation and experimental results show the superiority of these two converters over two-level pulse width modulation-based drives. [11]

V. CONCLUSION

This paper presents a brief review of various inverter techniques. Here main objective of this review paper is to focus on multilevel inverters. We conclude various multilevel inverter techniques also review previously done work.

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