A Review on Multi-Level Inverter Design Methodologies

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Abstract - In this review paper we study Multi-Level Inverter Design Methodologies. Multilevel inverters continue to receive more and more attention because of their high voltage operation capability, low switching losses, high efficiency and low output of Electro Magnetic Interference (EMI). A multilevel inverter is a power electronic device that can provide the required amount of alternating voltage at the output using various reduced level DC voltages as an input. To produce AC voltage from DC voltage, a two-level inverter is mostly used. Thus, the use of a multilevel converter has increased in industrial and renewable energy applications, which require high-voltage and high output quality.

Keywords - Multi-Level Inverter, power electronic device, voltage, multilevel converter, high output quality

I. INTRODUCTION

The multilevel converter can improve efficiency by enabling the use of components with better characteristics due to the reduced voltage stress, and has the advantage of lowering electromagnetic emissions by providing a staircase output voltage. Thus, the use of a multilevel converter has increased in industrial and renewable energy applications, which require high-voltage and high output quality. In recent times, studies of photovoltaic applications with multilevel topologies have made progress in increasing the efficiency and lowering the electromagnetic interference (EMI) and core losses. The multi-level converter has been used mainly in renewable energy systems using high-voltage above kV, but researches are expanding to low-voltage applications to take advantage of the aforementioned merits [1]. MLIs have been drawing growing attention in the recent years especially in the distributed energy resources area because several batteries, fuel cells, solar cells or rectified wind turbines or micro turbines can be connected through a MLI to feed a load or interconnect to the AC grid without voltage balancing problems. The unique structure multilevel VSIs allow them to reach high voltages with low harmonics without the use of transformers. This makes these unique power electronic topologies suitable for FACTS and custom power applications. The unique structure multilevel VSIs allow them to reach high voltages with low harmonics without the use of transformers. This makes these unique power electronic topologies suitable for FACTS and custom power applications [2].

Basically, Inverter is a device that converts DC power to AC power at desired output voltage and frequency. Demerits of inverter are less efficiency, high cost, and high switching losses. To overcome these demerits, we are going to multilevel inverter. The term Multilevel began with the three-level converter [3]. The multi-level inverters are mainly classified as Diode clamped, Flying capacitor inverter and cascaded multi-level inverter. The cascaded multilevel control method is very easy when compare to other multilevel inverter because it doesn't require any clamping diode and flying capacitor. There are two PWM methods mainly used in multilevel inverter control strategy. One is fundamental switching frequency and another one is high switching frequency. For high switching frequency classified as space vector PWM, Selective Harmonics Elimination PWM and SPWM [3].

II. LITERATURE REVIEW

Power electronic device which converts dc power into ac power at desired output voltage and frequency is known as inverter. The inverter producing an output voltage or current with two different levels of +or-V is known as 2 level inverters. This two-level conventional inverter operates at high switching frequency, with high switching losses and rating constraints for high power and voltage applications. It also faces harmonic distortion, EMI and high dv/dt stress. High level of total harmonic distortion is another problem. Because of these problems, it is difficult to interface power electronic switches directly to high and medium voltage grid. Here comes the need for a different topology of multi-level inverter [5]. The photovoltaic applications with multilevel topologies have made progress in increasing the efficiency and lowering the electromagnetic interference (EMI) and core losses. The multi-level converter has been used mainly in renewable energy systems using high-voltage above kV, but researches are expanding to low-voltage applications to take advantage of the aforementioned merits. Among several studies, because isolated direct current (DC) sources are naturally obtained from the photovoltaic (PV) arrays, and can be easily modularized compared to other multilevel converters, a PV generation system with the cascaded H-bridge multilevel inverter topology has been studied. Reference presented a study on the reactive power compensation for the single-phase grid-connected cascaded H-bridge multilevel inverter, but they did not fully suggest the method for designing the controller [1]. The multi-level inverters are mainly classified as Diode clamped, Flying capacitor inverter and cascaded multi-level inverter. The cascaded multilevel control method is very easy when compare to other multilevel inverter because it doesn't require any clamping diode and flying capacitor. There are two PWM methods mainly used in multilevel inverter control strategy. One is fundamental switching frequency and another one is high switching frequency. For high switching frequency classified as space vector PWM, Selective Harmonics Elimination PWM and SPWM[2]. Switched control has gained much attention recently due to its property of being easily implemented, especially in the field of power converters. Power converters play an important role in the field of renewable energy: they are used to connect renewable sources to power grids, optimize the efficiency of solar panels and wind generators. In some topologies, there is however a dramatic increase of the number of switches, which entails an increasing number of degrees of freedom, and complicates the controller design. There is therefore a niche of application for formal methods in order to produce correct-by-design control methods. The general function of a multilevel power converter is to synthesize a desired voltage from several levels of DC voltage. For this reason, multilevel power converters can easily provide the high power required by large electric drive systems [4].

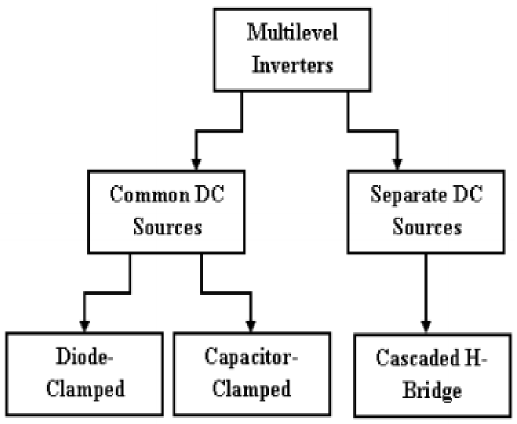

Figure 1: Multilevel Inverter Topologies

Multilevel inverters have an arrangement of power switching devices and capacitor voltage sources. Multilevel inverters are suitable for high-voltage applications because of their ability to synthesize output voltage waveforms with a better harmonic spectrum and attain higher voltages with a limited maximum device rating. Switched control has gained much attention recently due to its property of being easily implemented, especially in the field of power converters [4]. Power converters play an important role in the field of renewable energy: they are used to connect renewable sources to power grids, optimize the efficiency of solar panels and wind generators. In some topologies, there is however a dramatic increase of the number of switches, which entails an increasing number of degrees of freedom, and complicates the controller design. There is therefore a niche of application for formal methods in order to produce correct-by-design control methods. The general function of a multilevel power converter is to synthesize a desired voltage from several levels of DC voltage [5]. However, there is no need to utilize all the switches for generating bipolar levels. This idea has been put into practice by the new topology. This topology is a hybrid multilevel topology which separates the output voltage into two parts. One part is named level generation part and is responsible for level generating in positive polarity. This part requires high-frequency switches to generate the required levels. The switches in this part should have high-switching-frequency capability. The other part is called polarity generation part and is responsible for generating the polarity of the output voltage, which is the low-frequency part operating at line frequency [8]. Numerous industrial applications have begun to require higher power apparatus in recent years. Some medium voltage motor drives and utility applications require medium voltage and MW power level. For a medium voltage grid, it is troublesome to connect one power semiconductor switch directly [9]. The application of ac variable frequency speed regulations are widely popularized, high power and medium voltage inverter has recently become a research focus so far as known there are many problems in conventional two-level inverter in the high-power application. Multilevel inverter has been gained more attention for high power application in recent years which can operate at high switching frequencies while producing lower order harmonic component [10].

III. SEVEN-LEVEL INVERTER IN SINGLE PHASE

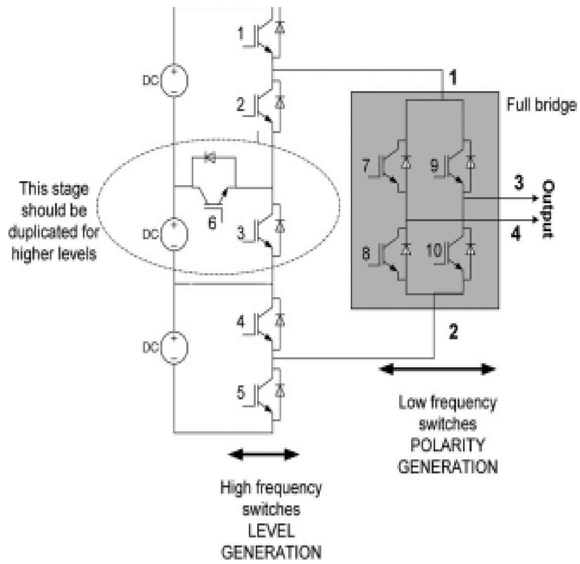

Figure 2: Schematic of a seven-level inverter in single phase

A new multilevel inverter topology named reversing voltage (RV). This topology requires a smaller number of components compared to conventional topologies. It is also more efficient since the inverter has a component which operates the switching power devices at line frequency. Therefore, there is no need for all switches to work in high frequency which leads to simpler and more reliable control of the inverter. A general method of multilevel modulation phase disposition (PD) SPWM is utilized to drive the inverter and can be extended to any number of voltage levels. The simulation and experimental results of the proposed topology are also presented [8]. A multilevel inverter not only achieves high power ratings, but also enables the use of renewable energy sources. Renewable energy sources such as photovoltaic, wind, and fuel cells can be easily interfaced to a multilevel inverter system for a high power application. There are several topologies such as neutral point clamped inverter, flying capacitor based multilevel, cascaded H-bridge multilevel inverter, hybrid H-bridge multilevel inverter and new hybrid H-bridge multilevel inverter [7]. The fundamental methods of pulse-width modulation are divided into the traditional voltage-source and current-regulated methods. Voltage-source methods more easily lend themselves to digital signal processor or programmable logic device implementation. However, current controls typically depend on event scheduling and are therefore analogimplementations which can only be reliably operated up to a certain power level. In discrete current-regulated methods the harmonic performance is not as good as that of voltage-source methods. The carrier-based modulation schemes for multilevel inverters can be generally classified into two categories: phase-shifted and level-shifted modulations. Both modulation schemes can be applied to the cascaded H-bridge inverters [9]. Another disadvantage of multilevel power converter is that the small voltage steps are typically produced by isolated voltage sources or a bank of series capacitors. Isolated voltage sources may not always be readily available, and series capacitors require voltage balancing [2]. To some extent, the voltage balancing can be addressed by using redundant switching states, which exist due to the high number of semiconductor devices. However, for a complete solution to the voltage-balancing problem, another multilevel converter may be required [4]. [6]. Isolated voltage sources may not always be readily available, and series capacitors require voltage balancing [2]. To some extent, the voltage balancing can be addressed by using redundant switching states, which exist due to the high number of semiconductor devices. However, for a complete solution to the voltage-balancing problem, another multilevel converter may be required [5]. The topology combines the two parts (high frequency and low frequency) to generate the multilevel voltage output. In order to generate a complete multilevel output, the positive levels are generated by the high-frequency part (level generation), and then, this part is fed to a full-bridge inverter (polarity generation), which will generate the required polarity for the output. This will eliminate many of the semiconductor switches which were responsible to generate the output voltage levels in positive and negative polarities [7]. Multilevel inversion is a power conversion strategy in which the output voltage is obtained in steps thus bringing the output closer to a sine wave and reduces the total harmonic distortion (THD).Multilevel inverter has drawn tremendous interest in high power applications because it has many advantages: it can realize high voltage and high power output through the use of semiconductor switches without use of transformer and without dynamic voltage balance circuits. When the number of output levels increases, harmonic of the output voltage and current as well as EMI decrease [10].

IV. CONCLUSION

For high voltage and high-power applications, the multilevel inverter is appropriate. Using the modulation method to decrease the amount of switches and discover the performance parameters, Multilevel Inverter provides a fresh class of three phase seven level inverter. However, as the amount of voltage concentrations for the cascaded H-bridge multilevel inverter increases, the amount of active switches decreases. Due to involvement of high number of switches thereby increasing the harmonics, switches losses, cost and the total harmonics distortion the proposed method dramatically reduces the switches for high number of levels. Which will reduce the switching losses, cost and low order harmonics, effectively improves Total harmonics distortion

V. REFERENCES

[1]. Seongjun Lee et al., “Optimized Modelling and Control Strategy of the Single-Phase Photovoltaic Grid-Connected Cascaded H-bridge Multilevel Inverter” 2018, 7, 207; doi:10.3390/electronics7090207

[2]. C.R. Balamurugan et al., “Single Phase Symmetrical Multilevel Inverter Design for Various Loads” An International Journal (ELELIJ) Vol 5, No 2, May 2016

[3]. M. Kavitha et al., “New Cascaded H-Bridge Multilevel Inverter Topology with Reduced Number of Switches and Sources” ISSN: 2278-1676 Volume 2, Issue 6 (Sep-Oct. 2012), PP 26-36

[4]. Gilles Feld et al., “Correct-by-design Control Synthesis for Multilevel Converters using State Space Decomposition” EPTCS 156, 2014, pp. 5–16

[5]. Anjali Krishna R et al., “A Brief Review on Multi Level Inverter Topologies” 2016 International Conference on Circuit

[6]. P. Balapriyan et al., “Design and Analysis Of 7-Level Inverter at Different Modulation Indices with A Closed Loop Control” Volume 119 No. 14 2018, 637-642

[7]. K. Rachel et al., “Design of Seven Level Cascaded H-Bridge Inverter Using MLI with 3 phase DC Source by carrier overlapping” Vol. 3 Issue 4, April – 2014

[8]. Kowstubha.P et al., “Development Of 13 Level Cascaded H Bridge Multilevel Inverter MATLAB Simulation” (2016)

[9]. R.Umamageswari et al., “Design and Development of Multi-Level Inverter” An ISO 3297: 2007 Certified Organization, Volume 3, Special Issue 1, February 2014

[10]. M. Murugesan et al., “Different Types of Multilevel Inverter Topologies – A Technical Review”