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A Novel Ten Switch Single Phase Fifteen Level Inverter Using Single Dc Source For Ac Drives

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ABSTRACT—*The multilevel voltage source inverter is recently applied in many industrial application such as ac power supplies, static VAR compensators, drive systems, etc. One of the significant advantages of multilevel configuration is harmonic reduction in the output waveform without increasing switching frequency or decreasing the inverter output. The output voltage waveform of a multilevel inverter is composed of the number of levels of voltages, typically obtained from capacitor voltage sources. As the number of levels reach infinity, the output THD approaches zero.*

Keywords—H-Bridge, Bi-directional switches, split capacitors.

1, INTRODUCTION

Nowadays, non-linear components such as diodes/ thyristors, current/voltage source converters, switched mode power supplies and motor drives are very popular in power systems. They generate lots of harmonics and reactive power which greatly degrade power quality. In addition, the presence of large industrial unbalanced loads such as single phase traction systems, electrical furnaces and welding machines can also produce significant current and voltage distortion in power system. There are several deleterious effects of high distortion in the current or voltage waveform and a poor power factor. They increase power loss, cause vibrations and noise in motors and malfunction and failure of sensitive equipment’s etc. Harmonic currents may also cause resonance between the shunt capacitor and the series inductance of the distribution and transmission lines. Traditionally, passive filters have been used to compensate harmonics and reactive power, but passive filters are large in size, have aging problems and may resonate with the supply impedance. On the other hand, as more industrial and commercial applications need medium and high voltages, such as the superfast charging station, the implementation of passive filters become harder. Due to these reasons, multilevel inverter based active power filters, which have the ability to synthesize high voltage with low voltage components, have been designed to compensate harmonics and suppress reactive power simultaneously and numerous control techniques. According to the current reference's generation methods, these control methods of multilevel inverter based APFs can be categorized into ABC frame current reference generation, DQ-frame current reference generation and prediction based current reference generation. ABC-frame reference current generation obtains the reference current based on the currents and voltages in the ABC-frame. DQ-frame current reference generation transforms the ABC-frame current and voltage into the DQ-frame and acquires current reference based on D component and Q component of currents, which is a linear algorithm and is easier to model than the ABC-frame. The prediction based current reference generation proposed can eliminate the delay inherent in the previous two current reference identification schemes which is caused by performing the digital control algorithm and sampling the measurement signal. While these control techniques can compensate harmonics and reactive power to some extent, they suffer from several drawbacks. The first one is they can only reduce overall harmonics and reactive power, but have no control on specific order of harmonics. The second one is only at high switching frequency, can the performance of these control methods be ensured. However, a high switching frequency will increase switching loss and complicate thermal management of the system, especially in high voltage and high power density applications. Additionally, while most of these techniques can compensate harmonics and reactive power simultaneously, few of them can also balance unbalanced loads at the same time.

This paper proposes a new control strategy to control the firing angle and conduction angle of each H-bridge of multilevel inverters. Instead of working in the time domain, this technique works in the frequency domain. Based on the active, reactive and individual harmonic currents drawn by the loads, the firing angle and conduction angle of each H-bridge of multilevel inverters can be derived. By working in the frequency domain, this new technique can control specific order of harmonics to ensure they are in accordance with standards. Also, compared with conventional methods, this new technique can achieve the same compensation effect with a much lower switching frequency, which will greatly reduce switching loss of multilevel inverters. Additionally, unbalanced load can also be balanced with this novel control strategy.

2, DIRECT ASYMMETRIC SWITCHING ANGLE CONTROL OF MULTILEVEL INVERTER

The different topologies presented in the literature as a multilevel inverter show a number of characteristics in common. The main disadvantage associated with the multilevel inverter configuration is their circuit complexity, requiring a high number of power switches. When we are entering the simplified H-Bridge multilevel inverter, power devices will be reduction and circuit complexity also reduction so circuit losses also reducing. Even taking into account the technological tendency to lower the prize at which multilevel inverter can compete with standard configuration.

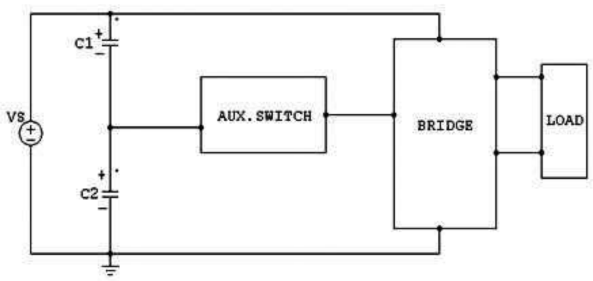

Figure. 1 Simplified block diagram of 15 level inverter

As contribution to solve this twin Problem (cumbersome power stage and complex firing control circuit) this work proposes a new converter topology. This topology includes an H-Bridge stage with an auxiliary bidirectional switch, drastically reducing the power circuit complexity, and a modulator and firing control circuit developed using a controller these two Concepts used in the design of the seven level bridge converters presented below. The new converter topology used in the power stage offers an important improvement in term of lower component count and reduced layout complexity, when compared with the nine level converters presented in the literature. The simplified H-bridge multilevel inverter achieves a reduction in the number of main switch required and uses no more diodes and capacitors that the second best topology, the asymmetric cascade configuration .In the modulator circuit, The FPGA can perform all required modulation functions providing another important reduction in cost and circuit complexity.

3, PROPOSED WORKING METHOD

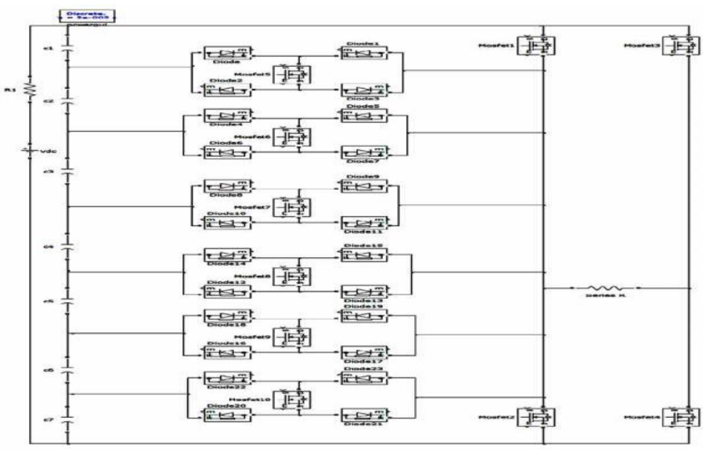

Figure. 2 Circuit diagram

The new control strategy is used to control the firing angle and conduction angle of each H-bridge of multilevel inverters. Instead of working in the time domain, this technique works in the frequency domain. Based on the active, reactive and individual harmonic currents drawn by the loads, the firing angle and conduction angle of each H-bridge of multilevel inverters can be 24 derived. By working in the frequency domain, this new technique can control specific order of harmonics to ensure they are in accordance with standards. Also, compared with conventional methods, this new technique can achieve the same compensation effect with a much lower switching frequency, which will greatly reduce switching loss of multilevel inverters.

Additionally, unbalanced load can also be balanced with this novel control strategy. The fifteen level can be achieved by about ten switches. The voltage can be balanced through split capacitors. Here bidirectional switches are used it conducts both positive and negative. The harmonics are reduced by this proposed method.

3.1 Circuit Configuration:

The block diagram of simplified H-bridge multilevel inverter shows the 3- level simplified H-bridge multilevel inverter. The H-bridge is formed by four main power devices, S1 to S4. For 15 level output voltage, six auxiliary switches, four main switches and six capacitor are required.

3.2 Stage Advantages:

To prove the reduction in component numbers achieved by this simplified H-bridge multilevel inverter configuration, the number of component required to implement a 13 level inverter using simplified H- bridge multilevel inverter and three previously defined ones: the two that considered as the standard multi level stages, the diode clamped and the capacitor clamped configuration, and a new and highly improved multi level stage with reduced switches.

3.3 Main Power Switches:

The new topology achieves a around 40% reduction in the number of main switches required, using only nine controlled power switches instead of twelve required in any of the other three configurations. The auxiliary switch voltage and current rating are lower than the once required by the main controlled switches.

3.4 Auxiliary Devices:

The new configuration reduces the number of diodes and capacitors, when compared with diode clamped configuration. The new configuration reduces the number of capacitors, when compared with the capacitor clamped configuration. The new configuration uses no more diodes or capacitors.

4, SIMULATION RESULT

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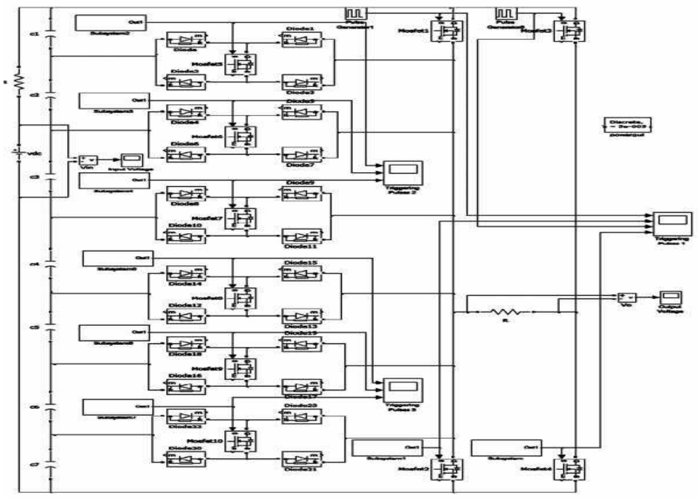

Figure. 3 Simulation circuit diagram of 15 level inverter

The above diagram shows the modified fifteen level inverter. The fifteen level can be achieved by using ten switches. The voltage can be balanced through split capacitors. Here bidirectional switches are used it conducts both positive and negative. The harmonics are reduced by this proposed method.

4.1 Input Voltage:

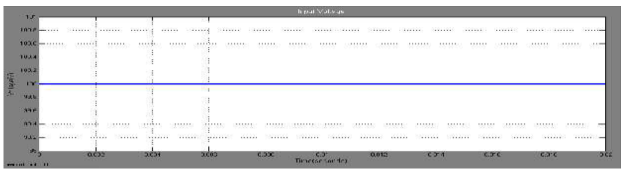

Figure. 4 Input voltage

When you measure a current using a Current Measurement block, the positive direction of current is indicated on the block icon (positive current flowing from + terminal to – terminal). Similarly, when you measure a voltage using a Voltage Measurement block, the measured voltage is the voltage of the + terminal with respect to the – terminal. However, when voltages and currents of blocks from the Elements library are measured using the Multimeter block, the voltage and current polarities are not immediately obvious because blocks might have been rotated and there are no signs indicating polarities on the block icons.

4.2 Output Voltage:

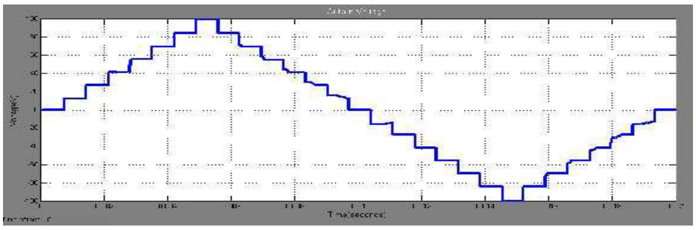

Figure. 5 Output voltage

The voltage waveform is shown in the above fig 5. The step level is increased to 15 level and the harmonics is reduced and the nearby sinusoidal waveform is getting instantly.

4.3 THD Level:

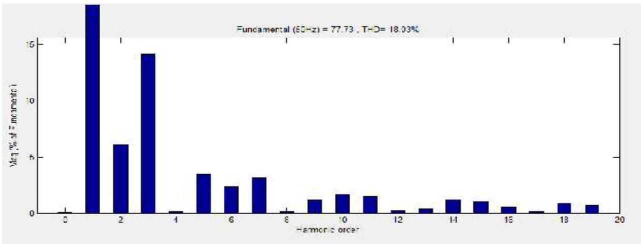

Figure. 6 Total harmonic distortion for modified circuit in simulation

The active power filter used is also a four H- bridge cascaded multilevel inverter and the switching frequency is also 60Hz. it can be seen that this method can only reduce THD to 9.46%. Additionally, the amplitude of the grid current is increased greatly and triple-n-orders of harmonics are induced, which will cause more power losses actually. As for the displacement power factor, it is reduced to 0.773, which means the reactive current is actually be increased rather than decreased. In conclusion, the conventional techniques are not suitable to work at low switching frequency, especially when the number of cascaded H-bridges is small. These simulation results are in accordance with our analysis that the conventional control techniques need high switching frequency to have good performance, which, however, will increase switching loss.

5, CONCLUSION

A multilevel inverter with individual dc sources has been proposed for use in large electric drives. Simulation and experimental results have shown that with a control strategy operates the switches at the fundamental frequency, these converters have low output voltage THD and high efficiency and power factor. In summery the main advantages of using multilevel converters for large electric drives are, They are suitable for large volt-ampere rated and /or high voltage motor drives. These multilevel converters systems have higher efficiency because the devices can be switched at minimum frequency. Power factor is close to unity for multilevel inverters used as a rectifier to convert generated ac to dc, No EMI problem or common mode voltage/current problem exists, No charge unbalance problem results when the converters are in higher charge mode or drive mode.

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