Multilevel Inverter: A study

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ABSTRACT

Multilevel inverters are in favour of academia as well as industry in the recent decade for high-power and medium-voltage applications. In addition, they can synthesize switched waveforms with lower levels of harmonic distortion compared to a two-level converter. Multilevel converters have received increased interest recently as a result of their ability to generate high quality output waveforms with a low switching frequency; the multilevel concept is used to decrease the harmonic distortion in the output waveform without decreasing the inverter power output. This paper presents a review on most important topologies, control techniques of multilevel inverters and also the applications powered by multilevel inverters which are becoming an enabling technology in many industrial and research areas.

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 megawatt power level. For a medium voltage grid, it is troublesome to connect only one power semiconductor switch directly. As a result, a multilevel power converter structure has been introduced as an alternative in high power and medium voltage situations. A multilevel converter 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 converter system for a high power application

Keywords *- Multilevel inverter, different types of inverter, Renewable energy sources, multilevel inverter topologies, power converter*

INTRODUCTION

In recent years, industry has begun to demand higher power equipment, which now reaches the megawatt level. Controlled AC drives in the megawatt range are usually connected to the medium-voltage network. Today, it is hard to connect a single power semiconductor switch directly to medium voltage grids. For these reasons, a new family of multilevel inverters has emerged as the solution for working with higher voltage levels. Depending on voltage levels of the output voltage, the inverters can be classified as two-level inverters and multilevel inverters.

The inverters with voltage level 3 or more are referred as multilevel inverters. Multilevel inverters have become attractive recently particularly because of the increased power ratings, improved harmonic performance and reduced EMI emission that can be achieved with the multiple DC levels that are available for synthesis of the output voltage

An inverter, also named as power inverter, is an electrical power device which is used to convert direct current (DC) into alternating current (AC). Using few control circuits and switches, one can get AC at any required voltage and frequency. Inverter plays exactly the opposite role of rectifiers as rectifiers are used for converting alternating current (AC) into direct current (DC). There are different types of inverters available these days. You should also have a look at Pure Sine wave Inverter Design with code and Modified Sine Wave Inverter Design with code. Few most commonly used inverter types are:

Square wave inverters
Modified sine wave inverters
Multilevel inverters
Pure sine wave inverters
Resonant inverters

Grid tie inverters
Synchronous inverters
Stand-alone inverters
Solar inverters

INTRODUCTION TO MULTILEVEL INVERTER

A multilevel inverter is a power electronic device which is capable of providing desired alternating voltage level at the output using multiple lower level DC voltages as an input. Mostly a two-level inverter is used in order to generate the AC voltage from DC voltage. Now the question arises what's the need of using multilevel inverter when we have two-level inverter. In order to answer this question, first we need to look at the concept of multilevel inverter.

CONCEPT OF MULTILEVEL INVERTER

First take the case of a two-level inverter. A two-level Inverter creates two different voltages for the load i.e. suppose we are providing *Vdc* as an input to a two level inverter then it will provide + *Vdc*/2 and – *Vdc*/2 on output. In order to build an AC voltage, these two newly generated voltages are usually switched. For switching mostly PWM is used, reference wave is shown in dashed blue line. Although this method of creating AC is effective but it has few drawbacks as it creates harmonic distortions in the output voltage and also has a high dv/dt as compared to that of a multilevel inverter. Normally this method works but in few applications it creates problems particularly those where low distortion in the output voltage is required.

The concept of multilevel Inverter (MLI) is kind of modification of two-level inverter. In multilevel inverters we don't deal with the two level voltage instead in order to create a smoother stepped output waveform, more than two voltage levels are combined together and the output waveform obtained in this case has lower dv/dt and also lower harmonic distortions. Smoothness of the waveform is proportional to the voltage levels, as we increase the voltage level the waveform becomes smoother but the complexity of controller circuit and components also increases along with the increased levels. The waveform for the three, five and seven level inverters where we clearly see that as the levels are increasing, waveform becoming smoother.

There are several topologies of multilevel inverters available. The difference lies in the mechanism of switching and the source of input voltage to the multilevel inverters. Three most commonly used multilevel inverter topologies are:
Cascaded H-bridge multilevel inverters
Diode Clamped multilevel inverters
Flying Capacitor multilevel inverters

1. CASCADED H-BRIDGE MULTILEVEL INVERTERS

This inverter uses several H-bridge inverters connected in series to provide a sinusoidal output voltage. Each cell contains one H-bridge and the output voltage generated by this multilevel inverter is actually the sum of all the voltages generated by each cell i.e. if there are k cells in a H-bridge multilevel inverter then number of output voltage levels will be 2k+1. This type of inverter has advantage over the other two as it requires less number of components as compared to the other two types of inverters and so its overall weight and price is also less..
In single phase inverter, each phase is connected to single dc source. Each level generates three voltages which are positive, negative and zero. This can be obtained by connecting the AC source with the DC output and then using different combinations of the four switches. The inverter will remain ON when two switches with the opposite positions will remain ON. It will turn OFF when all the inverters switch ON or OFF. To minimize the total harmonic distortion, switching angles are defined and implemented. The calculations for the measurement of switching angle will remain the same. This inventor can be categorized further into the following types:
5 levels cascaded H Bridge Multilevel Inverter
9 levels cascaded H Bridge Multilevel Inverter
In 5 level cascaded H Bridge Multilevel Inverters, Two H Bridge Inverters are cascaded. It has 5 levels of output and uses 8 switching devices to control whereas in 9 level cascaded H Bridge Multilevel Inverters, Four H Bridge Invertors are cascaded. It has 9 output levels and use and use 16 switching devices

2. DIODE CLAMPED MULTILEVEL INVERTERS

Diode clamped multilevel inverters use clamping diodes in order to limit the voltage stress of power devices. It was first proposed in 1981 by Nabae, Takashi and Akagi and it is also known as neutral point converter.
A *k* level diode clamped inverter needs ($2k - 2$) switching devices, ($k - 1$) input voltage source and ($k - 1$) ($k - 2$) diodes in order to operate. *Vdc* is the voltage present across each diode and the switch.

3. FLYING CAPACITOR MULTILEVEL INVERTERS

The configuration of this inverter topology is quite similar to previous one except the difference that here flying capacitors is used in order to limit the voltage instead of diodes. The input DC voltages are divided by the capacitors here. The voltage over each capacitor and each switch is *Vdc*. A *k* level flying capacitor inverter with (2*k* – 2) switches will use (*k* – 1) number of capacitors in order to operate

CONCLUSION:

In recent years, multilevel inverters have gained popularity with medium and high power ratings. Renewable energy sources such as photovoltaic, wind, and fuel cells can be interfaced to a multilevel converter system. In addition they offer the advantage of less switching stress on each device for high voltage high power application , with a reduced harmonics content at low switching frequency, by means of this paper we studied out multilevel invertor in a broad way

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