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Harmonics Reduction using Multilevel Inverter

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Abstract:
The main aim of this project is to explain the effects of Harmonics in the Power System and steps to reduce the effects of Harmonics. This project will also explain how Harmonic distortion is one of the most important problems associated with power quality and creates several disturbances to the Power System. It includes the Harmonic reduction techniques to improve the power quality and simulation for the same. In an inverter DC voltage is converted into an AC output. During this transformation from DC to AC, harmonics affect the power quality a lot. How harmonic reduction will improve the power quality is explained in detail.

Keywords: Harmonics, filters, Inverters.

I. INTRODUCTION

The term harmonics referred to Power quality in ideal world would mean how pure the voltage is, how pure the current waveform is in its sinusoidal form. Power quality is very important to commercial and industrial power system designs. Ideally, the electrical supply should be a perfect sinusoidal waveform without any kind of distortion. If the current or voltage waveforms are distorted from its ideal form it will be termed as harmonic distortion. This harmonic distortion could result because of many reasons. In today's world, prime importance is given by the engineers to derive a method to reduce the harmonic distortion. Harmonic distortion was very less in the past when the designs of power systems were very simple and conservative. But, nowadays with the use of complex designs in the industry harmonic distortion has increased as well. This project explains the effects of Harmonics in the Power System and steps to reduce the effects of Harmonics and also explain how Harmonic distortion is one of the most important problems associated with power quality and creates several disturbances to the Power System. Cascade Multilevel Inverter (CMLI) is one of the most important topology in the family of multilevel inverters. It requires least number of components with compare to diode-clamped and flying capacitors type multilevel inverters Following are some of the disturbances which are common in affecting the power system.

1.)Transients
2.)Sagging
3.)Variations in voltage
4 .)Harmonics

Harmonics:
Harmonics are one of the major concerns in a power system. Harmonics cause distortion in current and voltage waveforms resulting into deterioration of the power system. The first step for harmonic analysis is the harmonics from non-linear loads. The results of such analysis are complex. Over many years, much importance is given to the methods of analysis and control of harmonics. Harmonics present in power system also has non-integer multiples of the fundamental frequency and have aperiodic waveform. The harmonics are generated in a power system from two distinct types of loads .First category of loads are described as linear loads. The linear time-invariant loads are characterized such that application of sinusoidal voltage results in sinusoidal flow of current. A constant steady-impedance is displayed from these loads during the applied sinusoidal voltage. As the voltage and current are directly proportional to each other, if voltage is increased it will also result into increase in the current. An example of such a load is incandescent lighting. Even if the flux wave in air gap of rotating machine is not sinusoidal, under normal loading conditions transformers and rotation machines pretty much meet this definition. Also, in a transformer the current contains odd and even harmonics including a dc component. More and more use of magnetic circuits over a period of time may get saturated and result into generation of harmonics. In power systems, synchronous generators produce sinusoidal voltages and the loads draw sinusoidal currents. In this case, the harmonic distortion is produced because of the linear load types for sinusoidal voltage is small. Non-linear loads are considered as the second category of loads. The application of sinusoidal voltage does not result in a sinusoidal flow applied sinusoidal voltage for a non-linear devices. The non-linear loads draw a current that may be discontinuous. Harmonic current is isolated by using harmonic filters in order to protect the electrical equipment from getting damaged due to harmonic voltage distortion. They can also be used to improve the power factor. The harmful and damaging effects of harmonic distortion can be evident in many different ways such as electronics miss-timings, increased heating effect in electrical equipment, capacitor overloads, etc. There can be two types of filters that are used in order to reduce the harmonic distortion i.e. the active filters and the passive filters. Active harmonic filters are electronic devices that eliminate the undesirable harmonics on the network by inserting negative harmonics into the network. The active filters are normally available for low voltage networks. The active filters consist of active components such as IGBT-transistors and eliminate many different harmonic frequencies. The signal types can be single phase AC, three phase AC. On the other hand, passive harmonic filters consist of passive components such as resistors, inductors and capacitors. Unlike the active filters which are used only for low voltages, the passive filters are commonly used and are available for different voltage levels.

There are two types of filters are used
1.Active filter.
2.Passive filter.
3.Hybrid filter

Active filter is used for low level voltage and passve filter is used for different voltage level. where hybrid filter is the combination of the both Capacitors are frequently used in the Active and Passive filters for harmonics reduction. The Passive filters are used in order to protect the power system by restricting the harmonic current to enter the power system by providing a low impedance path. Passive filters consist of resistors, inductors and capacitors. The Active filters are mostly used in distribution networks for sagging in voltage, flickering, where there are harmonics in current and voltages, etc. Using the filter would result into a better quality of power.

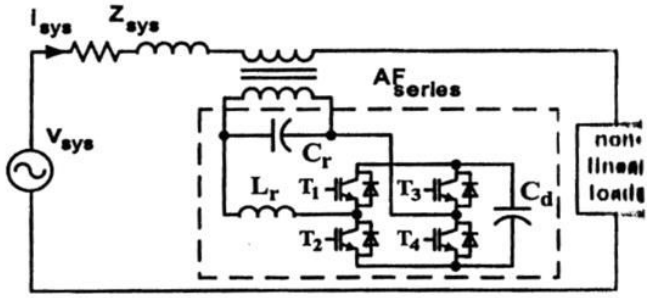

Figure.1. Active filter

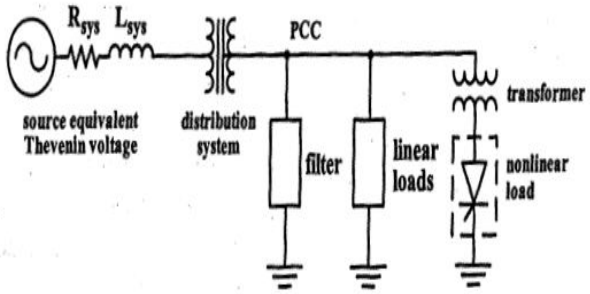

Figure.2. Passive filter

Active Filters:
Active filters are a perfect alternative to the passive filters. The active filters are used in a condition where the harmonic orders change in terms of magnitudes and the phase angles. In such conditions it is feasible to use the active elements instead of passive ones in order to provide dynamic compensation. The active filters are used in nonlinear load conditions where the harmonics are dependent on the time.

Passive Filters:
passive filters consists of resistors, inductors and capacitors. They are not expensive and are often used to restrict the harmonic currents from entering the power system thereby minimizing the effect of harmonics due to nonlinear loads. Also, the passive filters are kept close to the source of harmonic generation i.e. the nonlinear loads. Doing so, the passive filters produce better results in reducing the harmonic effect

II. HARMONIC REDUCTION IN INVERTERS

Methods for Harmonic Reduction in Inverters:
As explained earlier, one of the most important aspect of a system is the reduction of harmonics that are present in the system. In case of an inverter, it is very important to remove the harmonics from the ac output. The harmonics present in a dc to ac inverter are very much obvious compared to the harmonics that can be present in an AC to DC converter. This is because of the output of dc to ac inverter being ac. Thus, the filters that are used in dc to ac inverter have different designs compared to the filters used in ac to dc converters. In case of ac to dc converters, the main objective is to improve the output voltage ripple. Thus, passive filters can be easily used in order to improve the output of an AC to DC converter. While, in case of dc to ac inverter, the harmonic reduction is harder and it also includes the use of active filters. As the output of dc to ac inverters is alternating, it is very important to produce sinusoidal output waveforms. In order to produce such sinusoidal waveforms, filters are implemented which reduce the harmonic effect by removing the third and higher harmonics from the system. The filters used to remove the harmonics from the inverters are more complex and consists of large number of inductors and capacitors to remove the harmonics of higher order. This also results into more costly filters to remove harmonics from the inverter. Thus, in order to avoid the cost of such expensive and complex filters controlling the width or reducing the number of pulses may result into reduction of harmonics. One such technique is explained below

Pulse Width Modulation Technique:
Figure 14 shows a single phase inverter block diagram with a high frequency filter that is used in order to remove the harmonics from the output waveform. Here, vo is the ac output while vin is the input dc voltage

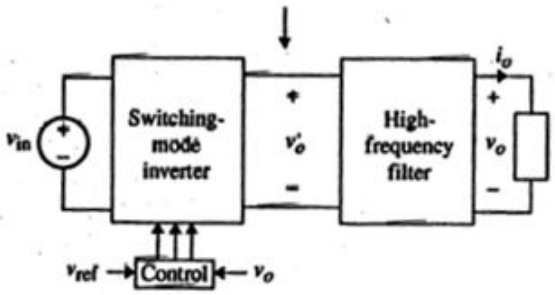

Figure.3. Single phase inverter with filter

In a single phase inverter, the varying width of the output pulse is used to control the output voltage.Thus, this process of controlling the output voltage of inverter in order to reduce the harmonics is known as Pulse Width Modulation The Pulse Width Modulation is classified into two techniques.

- Non sinusoidal Pulse Width Modulation
- Sinusoidal Pulse Width Modulation

4.3.2 Non Sinusoidal Pulse Width Modulation:
In case of Non sinusoidal pulse width modulation, all the pulses that have same pulse width are modulated together. The pulse widths of pulses are adjusted together in same proportion on order to remove the harmonics from the system.

Sinusoidal Pulse Width Modulation
Sinusoidal Pulse Width Modulation is a bit different compared to the Sinusoidal Pulse Width Modulation. In case of sinusoidal pulse width modulation, all the pulses are modulated individually. Each and every pulse is compared to a reference sinusoidal pulse and then they are modulated accordingly to produce a waveform which is equal to the reference sinusoidal waveform. Thus, sinusoidal pulse width modulation modulates the pulse width sinusoidal.

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