UNIVERSAL SELECTIVE HARMONIC ELEMINATION METHOD FOR HIGH POWER SYSTEM

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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 it also includes the 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 the power quality a lot. How harmonic reduction will improve the power quality is explained in detail.

Introduction

As always, the main objective of the power system would be generation of electrical energy to the end user. Also, associated with power system generation is the term power quality. So much emphasis has been given to power quality that it is considered as a separate area of power engineering. There are many reasons for the importance given to the power quality. One of the main reason is, the consumers are well informed about the power quality issues like interruptions, sagging and switching transients. Also, many power systems are internally connected into a network. Due to this integration if a failure exists in any one of the internal network it would result into unfavourable consequences to the whole power system. In addition to all this, with the microprocessor based controls, protective devices become more sensitive towards power quality variation than were the past generation protective devices.

Following are some of the disturbances which are common in affecting the power system.

Transients:

In terms of power system, the transients can be defined as an action or a situation in power system with variations in power system and which is not desirable in nature. A general understanding of transient is considered to be an oscillatory transient which is damped due to the RLC network. A person who is new to the power system also uses the term "surge" to define transient. A surge may be analyzed as a transient which is resulting from the stroke of lightening where protection is done by using a surge arrester. A person who is more groomed in the field of power engineering would avoid to use the term "surge" unless it is specified as to what exactly the term "surge" refers to. Transient can be divided into two categories i.e. the oscillatory transient and the impulsive transient. [1][3]

Oscillatory Transient :

A voltage or a current whose values change polarity rapidly are part of oscillatory transient. In case of a steady state of voltage and current when there is a sudden non-power frequency change or when there is a non-power frequency change in positive and negative polarity values, such a change is termed as an oscillatory transient. [2][3]

Impulsive Transient :

Impulsive transients are mostly caused due to lightning. Unlike the oscillatory transient, the impulsive transient is such a condition when there is sudden change of non-power frequency in a steady state condition of voltages and currents that is unidirectional in polarity. Impulsive transients also have the ability to produce oscillatory transients by exciting the natural frequency of a power system. [2][3]

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.

There is also a third type of filter which is used i.e. The Hybrid Filter. Hybrid filters are composed of the passive and active filters both. [3]

Passive Filters :

As explained earlier, 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 there by 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. Figure 1 shows a single phase representation of distribution system with the nonlinear load and passive shunt filter.

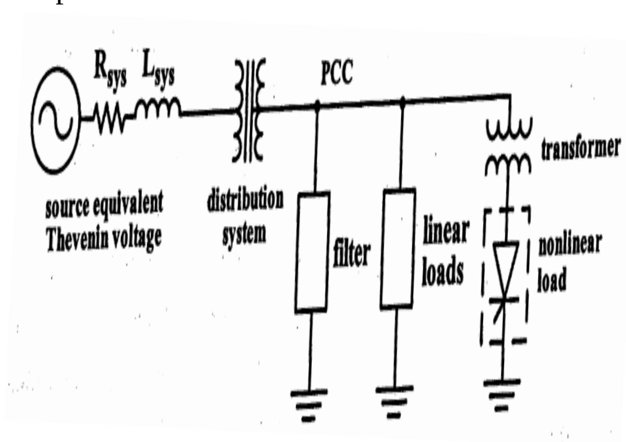

Figure 1 : Single Phase Representation of Non Linear load and Passive Shunt filter [3]

One of the most important aspect in installing the passive filters in the power system is that they should be installed based on the order of the harmonics that are supposed to be filtered. For example, in order to install a filter for the 3rd order of harmonics, it is required that the filter of 1st order of harmonics is already installed.

In order to reduce the harmonic effect, the passive filters create a resonance frequency. This resonance frequency is kept away from the nonlinear load's harmonic distortion. Also, the passive filters are caliberated at a point which is a bit lower than the point at which the harmonics is supposed to be reduced so that, if there is any change in the parameters there is still margin for improvement. If this is not done, then there might be a condition in power system due to capacitance and inductance of filter that the resonance is shifted causing unfavourable conditions in the power system.

DC-AC Inverter :

DC to AC inverters are those devices which are used to produce inversion by converting a direct current into an alternating current. If the output of a circuit is AC then depending on the input i.e. either AC or DC, the devices are called as AC-AC cycloconverters or DC-AC inverters. DC to AC inverters are such devices whose AC output has magnitude and frequency which is either fixed or variable. In case of DC to AC inverters the output AC voltage can be either single phase or three phase. Also, the magnitude of the AC voltage is from the range of 110-380 VAC while the frequencies are either 50Hz, 60Hz or 400Hz.

Some of the basic applications of inverters would be an UPS (uninterruptible power supply). When the main power is not available UPS uses batteries and inverter to supply AC power. A rectifier is used to recharge the batteries used when the main power is back. Other applications of an inverter included Variable frequency drives. The variable frequency drives controls the frequency and voltage of power supplied to the motor, thus controlling the speed of AC motor. An inverter is used in the variable frequency drives to provide controller power. An inverter is also used in an induction motor to regulate the speed by changing the frequency of AC output. [6][7]

Block Diagram of DC-AC Inverter:

As explained in earlier chapters, the harmonics can be present in any system. Similarly, the harmonics are present in a system where inverters are used as well. Ideally, the main aim of using an inverter is to produce an ac output from the dc source. Theoretically the output voltage waveform is expected to be sinusoidal, but in practical terms there is definitely going to be distortions due to harmonics present in the system which results into distorted output waveforms. As a result of this, inverters are used in a system in order to produce output waveforms which are purely sinusoidal and distortion free.

Figure 10 shows a circuit showing DC-AC inverter along with filters which are used to reduce the effect of harmonics to provide distortion free output ac signal. The front part of the circuit consists of AC to DC converters. These AC to DC converters has one ac frequency i.e. the line frequency and it relies on line communication for switching. The system also consists of DC to AC inverters which are used to turn on or off the power switches. Unlike AC to DC converters in DC to AC inverters, the ac frequency is not the line frequency. The figure also shows a voltage control where variable frequency drives are used to control the speed of motors and provide variable output voltage. Due to this complex structure, the inverter circuits require proper control signals to produce the expected ac output voltage. The figure also shows a filter circuit which is used to reduce the harmonics in the system to produce clean sinusoidal output ac voltage. A comparator circuit is also employed which compares the output ac voltage with the reference ac voltage. If he output ac voltage is more distorted as compared to the reference ac voltage then filter circuits are used again to produce the desired clean sinusoidal AC voltage.[6][7]

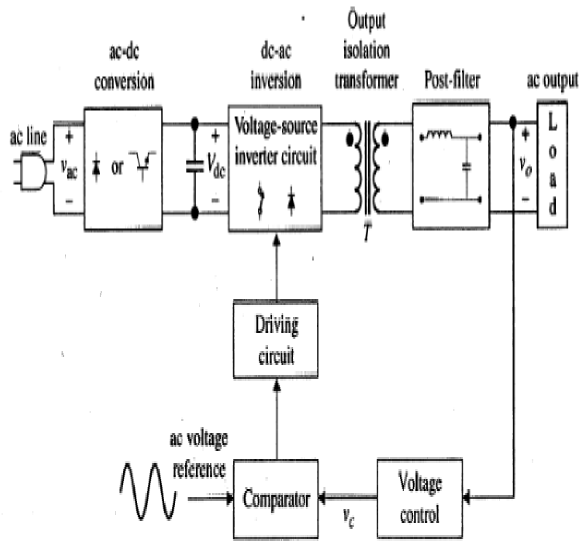

Figure 2: Power Electronic Circuit with DC-AC inverter.

Conclusion

This chapter shows how harmonic elimination is done in Inverter by Pulse Width Modulation technique by solving the non linear equations. Equations are used to determine switching angles of an Inverter. Switching angles play an important role to produce the desired output by eliminating selected harmonics.

In order to form the equation set, fundamental component is given desired output value and all other harmonics are equated to zero. In my simulation I find the switching angles for the 5^{th}, 7^{th} and 11^{th} harmonics. [9]

The equation which is derived for Total Harmonic Distortation of the the output voltage of an inverter is used in order to reduce the harmonics that are produced in the inverter.

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