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Analysis of Electric Circuit Harmonics and its Disadvantage, Effect of Harmonics on Efficiency

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ABSTRACT: The quality of power has been improving year by year with the internationalization of every industry. For now, technology is moving to digital electrical equipment, and compared to digital equipment, their need is minimal. Yet electrical harmonics or disruption grabs engineers' attention to it. Harmonics is something that can minimize or impact the performance of the electrical network, so power engineers are concerned with harmonics and harmonics reduction techniques. Applications of control systems have been improved in everyday life and are also responsible for the development of harmonics through the use of power electronics and power electronics. Two forms of load present in the electrical circuit are nonlinear load and linear load in which nonlinear load is responsible for zero sequence current, also known as harmonic current, and which generates harmonic current in the neutral conductor that can influence the circuit's voltage and current level, which disturbs its waveform. Harmonics is a big issue that can be minimized by using proper filters, voltage current ratings, etc. In certain places in the electrical network, filters such as LC filters are used, which can neutralize the zero sequence harmonics but also some more harmonics present in the system, and this can also boost the power factor value. This paper provides details about the distortion of harmonics and their technique of reduction.

KEYWORDS: Fault, Power system, Power electronics, Harmonics, Level of harmonics, Filter, LC filter, Power, Voltage, Current, linear and nonlinear load.

I. INTRODUCTION

The presence of harmonics in electrical systems means that current and voltage are distorted and deviate from sinusoidal waveforms. Harmonic currents are caused by non-linear loads connected to the distribution system. A load is said to be non-linear when the current it draws does not have the same waveform as the supply voltage. The flow of harmonic currents through system impedances in turn creates voltage harmonics, which distort the supply voltage. The Fourier theorem states that all non-sinusoidal periodic functions can be represented as the sum of terms (i.e. a series) made up of:

- A sinusoidal term at the fundamental frequency,
- Sinusoidal terms (harmonics) whose frequencies are whole multiples of the fundamental frequency,
- A DC component, where applicable.

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The harmonic of order h (commonly referred to as simply the h th harmonic) in a signal is the sinusoidal component with a frequency that is h times the fundamental frequency. The equation for the harmonic expansion of a periodic function $y(t)$ is presented below:

Where:

- Y_0 : value of the DC component, generally zero and considered as such hereinafter,
- Y_h : r.m.s. value of the harmonic of order h ,
- ω : angular frequency of the fundamental frequency,
- ϕ_h : displacement of the harmonic component at $t = 0$.

Figure1 shows an example of a current wave affected by harmonic distortion on a 50Hz electrical distribution system. The distorted signal is the sum of a number of superimposed harmonics:

- The value of the fundamental frequency (or first order harmonic) is 50 Hz,
- The 3rd order harmonic has a frequency of 150 Hz,
- The 5th order harmonic has a frequency of 250 Hz,

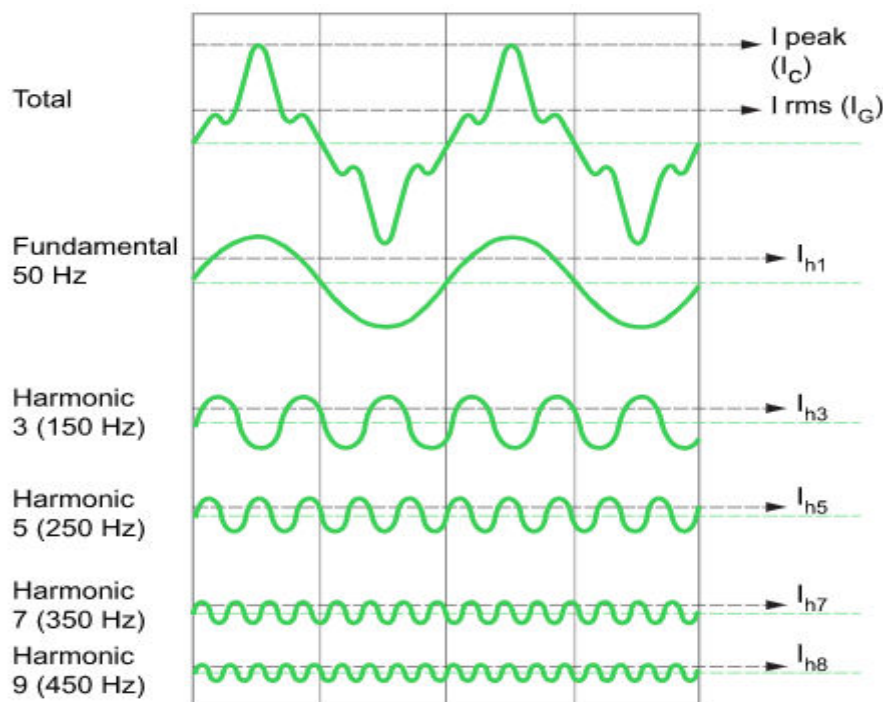


Figure 1: Harmonic Wave Forms

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In power systems, harmonics are mainly due to the sudden increase of non-linear loads, especially in AC reasons, and this is due to some devices that change their value when some disruption such as a variable frequency drive starts in the circuit. This is when everything goes to digital because of developments in technology, so the use of digital equipment creates these issues with harmonics, technical advances such as the use of circuits and systems for power electronics. Electronics such as microprocessors, Arduino microcontrollers, etc. are responsible for generating differences in performance due to their highly sensitive existence[1]. In AC/DC transmission links or load either load is heavy or low, it is controlled by a power system using power electronics elements which creates harmonics in the whole system. Harmonics are classified into three part

- a) Domestic load
- b) Industrial load
- c) Control device

Harmonics cases are created due to nonlinear load and nonlinear load due to none complying with the ohm law, when harmonic current or voltage has distorted waveform so that the effect of non-sinusoidal wave on it is reduced or normalised by a compensator. A compensator can only be used when all the electrical circuit components are able to operate accurately and have a relation between the loads[2].

How to measure Harmonics?

Measurement of harmonics of a circuit is by harmonics analyzer or digital storage oscilloscope. Oscilloscope is of two type analog and digital so it is used to measure the amount of distortion in the sinusoidal wave. Each harmonic frequency (f_n) is given by the equation $f_n = n \cdot f_1$ where n is the harmonic number and f_1 is the frequency of the first harmonic[3].

Effects of Harmonics?

Any electrical and electronics system can be affected by harmonics because sudden increase in current can lead to heating problems and low voltage can cause speed problems in the device[4].

The transformer effect of harmonics is also a static device used to convert voltage from lower to higher or from higher to lower called as step-up transformer and step-down transformer. Transformer is a nonlinear device which means that when voltage begins to fluctuate, its resistive value shifts[5]. The heat losses are the main impact of the harmonics on the transformer, and the heat loss is an additional loss caused by the harmonic current. Due to harmonics such as resonance between transformer inductance and device insulation, capacitance, mechanical insulation and stresses due to transformer core (iron core) vibration and temperature increase, several more problems associated with transformers. These losses can be caused by harmonics in transformers in different types of losses in which heat loss, iron loss, copper loss, hysteresis loss and humming loss are present, which means that harmonics eddy current loss in the transformer increases as a result of which transformer performance decreases[6].

Harmonics for any circuit is the sum of excessive frequency wave increase that is superimposed on and skewed by the input wave that causes many electrical circuit equipment failures and losses[7]. Harmonics can be calculated by $n \cdot f$, where f is India's basic frequency (50Hz). Each equipment is sufficient to generate a signal producing harmonics of even/ODD some of the equipment generated harmonics of either odd or even.

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II. LITERATURE REVIEW

Many papers have been published in the field of harmonics and research is still going on in this field to reduce harmonic distortion and make circuit efficient, one research paper among many research papers titled “harmonics in power system and its mitigation technique” by A.J. Mehta and K.L. Mokariya. The harmonics and their cause and prevention were discussed. LC circuits are often used for decreasing harmonics and rising the power factor in electrical networks. There are two types of techniques for normalising harmonics in the circuit: active filtering and passive filtering, effects of harmonics on transformers and other machinery, effects of harmonics on loads. Electrical circuit simulation on MATLAB to detect voltage and current behavioural waveform. Influence of harmonics on load and system influencing load rupture (abnormal operation), insulation stress (voltage effects), and thermal stress (current effect). Active and passive filter design, single frequency tuned filter analysis for the 5th, and current filter waveform has also been shown in this paper[1].

A case study by Ritesh Dash, Aradhana Pradhan, Manas Ranjan Sarang, Pratik Ranjan Behera, is a research paper entitled Fundamental of harmonics and its effect on the power system. In this paper, they discussed the principle of fourier transformation and how it can help reduce harmonics, MATLAB simulation also studies various load types, such as linear load, inductive load, capacitive load, etc. Linear load is a type of load that fully transforms the electrical energy into another form of energy; it has 100% active power and 0% reactive power. Linear load is never responsible for harmonic output. The basics of harmonics were also discussed in this paper[8].

III. CONCLUSION

Harmonics in the power system are due to nonlinear load that changes its resistive value to adjust the voltage value, harmonics in it can be generated in nonlinear equipment such as variable frequency drive etc. used in electrical circuits. Linear loads have only active power and zero reactive power because when voltage is changed, there is no difference in resistance. Active power in any circuit is either in the form of light energy or heat energy, the modified form of electrical energy, so active power is the amount of energy used by the circuit, and reactive power is the amount of energy passed through the circuit or the amount of energy returned. Harmonics is the sum of waste of energy when distorting current and voltage waveforms. The use of large electronic power equipment will trigger harmonic effects and a specially switched power supply mode in digital equipment. The higher to lower rating transmission line is designed to take care of these forms of distortion current caused by harmonics, short circuit effects and other causes. In order to minimize the harmonic effect of the LC circuit filter used by engineers to supply the circuit with reactive power, filters such as the active filter and the passive filter were used to demonstrate the system's improved performance.

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