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Generation and Analysis of Harmonic for Various Combinations of Non-linear Load

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Abstract

This paper refers to a comparative study of the harmonics generated by non-linear loads like compact fluorescent lamps (CFL). This work is carried out by measuring the frequency across the supply line by using CFL along with a resistive load. Here CFL are used as they are non-linear loads and generate frequencies of very high value. We have used three CFL of different ratings such as 5Watt, 14Watt and 20Watt.

Keywords: *harmonics, neutral line, non-linear load*

1. Introduction

The mathematical definition of harmonics, generally mean when we use the integral orders of fundamental frequencies. In power system harmonics: the currents or the voltages are having with frequencies that are integer multiples (h=0, 1, 2…N) of the fundamental power frequency [1-2]. When a switching power supply distorts the current, harmonics at multiples of the power line frequency are generated. Two significant consequences arise as a result of harmonic generation. First, because of finite impedances of power lines, voltage variations are generated that other equipment on the line must tolerate. Second, when generated in a three-phase system [3-6], harmonics may cause overheating of neutral lines, because neutral lines are not fused or protected by circuit breakers.Thus overheating of neutral conductors in a three-phase line can cause a significant safety hazard and damage the total electrical network [4-6]. Such damaging occurrences are usually attributable to the use of single-phase loads attached to three-phase or single-phase wiring systems. Excessive neutral current is caused by the existence of "triplen" harmonics [2-6], which add in series in the neutral line.

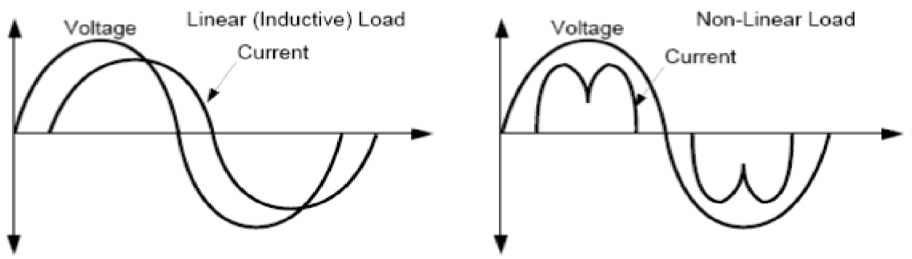

Figure 1. Current and Voltage Waveforms for Non-linear Load

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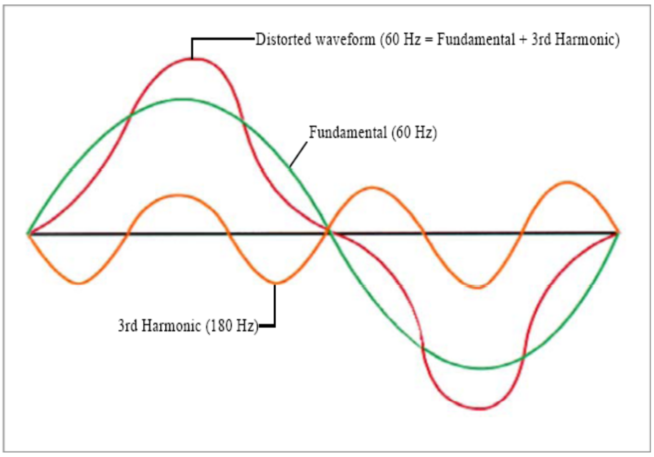

Figure 2. Fundamental and 3rd Harmonics

It is found that the current distortions are related to the rectifier voltage gain M, which is defined as:

$$M = \frac{V_o}{V_{lp}}$$

Where, V_0 is rectifier output voltage and V_{lp} is input line-line peak voltage. The higher the M is, the lower the harmonics become. A larger M means a high output voltage, yielding a high voltage stress on the devices.

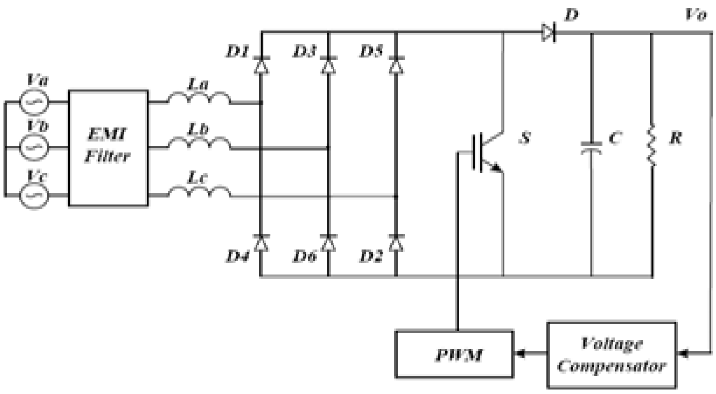

Figure 3. A Single-switch Three-phase Boost Rectifier

2. Triplen Harmonics

Triplen harmonics are those harmonics that are odd multiple of three times the fundamental, i.e., 3rd , 9th , 15th , 21st harmonics etc.In low-voltage distribution line of the three-phase four-wire system [3-6], the neutral conductor current increases by the current mainly on third harmonic wave which does not have the phase rotation under the condition while balance of the load is removed, at the time of the harmonic generation equipment is contained for the load. The increase of such current in neutral conductor is made to increase the waveform distortion of receiving end voltage, and due to this various waveform interferences are arising.

3. Experimental Setup

Table 1. Auto-transformer without Load

Sl. No.	Line Voltage (in volt)	Frequency (in KHz)
1	220	4.72-4.84
2	230	5.85-6.32
3	240	7.45-7.65

Table 2. Auto-transformer with a 14 watt CFL Lamp

Sl. No.	Line Voltage (in volt)	Frequency (in KHz)
1	220	0.050
2	230	0.110-0.204
3	240	0.144-0.182

Table 3. Connected with Auto-transformer with 20 watt CFL Lamp

Sl. No.	Line Voltage (in volt)	Frequency (in Hz)
1	70	50
2	110	52
3	120	54-60
4	140	63-90
5	160	97-103
6	170	96-111
7	200	103-122
8	220	101-139
9	230	109-147
10	240	109-168

Table 4. Connected with Auto-transformer with 5 watt and 20 watt CFL Lamp in Parallel

Sl. No.	Line Voltage (in volt)	Frequency (in Hz)
1	70	50
2	110	50
3	120	50
4	140	50
5	160	50
6	170	50
7	200	50
8	220	50
9	230	50
10	240	55

Figure 4. Experimental Setup for Observing Harmonics Generation with a Non-linear Load (20 watt CFL)

Figure 5. Experimental Setup for Observing Harmonics Generation with a Non-linear Load (parallel CFL for 5 watt & 20 watt)

4. Results and Discussion

The Comparative study between the different non-linear loads along with the different line voltages are done in Electrical Machine Laboratory in NSHM Knowledge Campus, Durgapur, West Bengal, India & IMPS College of Engineering & Technology,Malda, West Bengal, India. All frequencies are measured with the help of a digital multimeter.

It was found that, in no load, the line frequency will be 4.72-7.65KHz for a line voltage of ac 220-240V.After connecting 14 watt CFL, the line frequency increases from 0.050KHz-0.182KHz.

For connecting 20 watt CFL, the line frequency increases from 50Hz-168Hz for a supply voltage ranges from ac 70V-240V.It was also observed that, for connecting two CFL of 5 watt and 20 watt, the line frequency more or less constant with a voltage variation of ac 70V- 240V. Table 1 to Table 4 identifies all these variations.

5. Conclusion

The harmonic distortion principally occurs from nonlinear type loads. The application of power electronics is causing increased level of harmonics due to switching phenomena. Harmonic distortion can cause serious failure, accident and damaging problems to the circuit. Thus harmonics are important aspect of power operation that requires mitigation and minimizing solution. In future we will sort out different aspects in circuit design for optimizing harmonic affects.

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