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SIMULINK OF HARMONIC ANALYSIS AND ITS MITIGATION TECHNIQUE IN INDUSTRIAL ENVIRONMENT USING 7% DETUNNED PASSIVE FILTER

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Abstract -Harmonics are the by-products of recent electronic devices. Harmonics play a big role in deteriorating power quality, called harmonic distortion. To mitigate the harmonics, one can install passive or active filters. Though active filters are very effective to compensate harmonic currents and voltages they're still very expensive. Hence, active filters are only installed in large industrial plants while for little installations passive filters are more preferred.
In this paper a case study of design and development of harmonic filter for a typical non- linear load is presented. Different filter topologies are designed supported the introduced methods to suppress a benchmark of harmonics. Harmonic survey indicated a current THD of 5.9%. Then the entire system is simulated with SIMULINK to verify the discussed procedures.

***Key Words*:**Capacitors, Harmonics, Passive filter, Power quality

1. INTRODUCTION

The proliferation of electronic switching devices into modern equipment's has resulted during a significant increase within the amount of harmonic pollution in distribution systems. These harmonics if disregarded or undetected may cause harmonic resonant conditions which could present system operating problems leading to complaints from customers and reduced lifetime of power equipment also as degraded efficiency and performance. Harmonic currents and voltages can cause many unfavorable effects on the facility system itself and therefore the connected loads. Malfunctioning of equipment, capacitor failure, transformer and neutral conductor overheating, excessive heating in rotating machinery are a number of these effects.

Passive filters are widely employed to suppress load harmonics. Topology selection of the filters is predicated on the frequency bandwidth to be suppressed. Among different topologies, single-tuned (ST) and high-pass filters are more popular in power grid applications. There also are some filters to eliminate voltage distortions. However, most of filters are applied to cancel current distortion. For system below 66KV, the THD should be but 5 %.

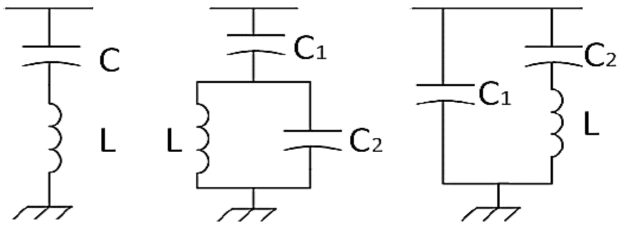


Figure 1: Different Filter Topologies (a) ST Filter (b) C Type Filter (c) CCL Filter [5]

2. CASE STUDY

Harmonic effects of the facility system are often studied for a typical site or load. It involves selecting the location which is usually suffering from harmonics and conducting the harmonic experiment.

2.1 Selection of Site

The location should be such where the presence of harmonic is more. Such quite site or location are generally where, DC Drives, non-linear loads like computers, UPS, electronic ballast, heating furnace, solid state rectifiers charger , etc are more which generate harmonic current within the system. Now a day's computers became an important tool for several activities. Same environment is in the AC-DC substation for long transmission Hence it had been decided to use 6 pulse inverter base AC-DC substantiation .

2.2 Harmonic Survey

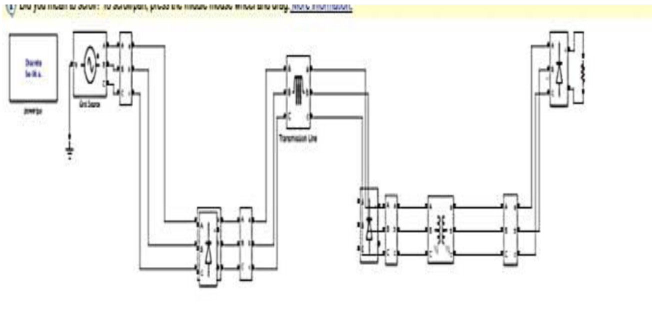


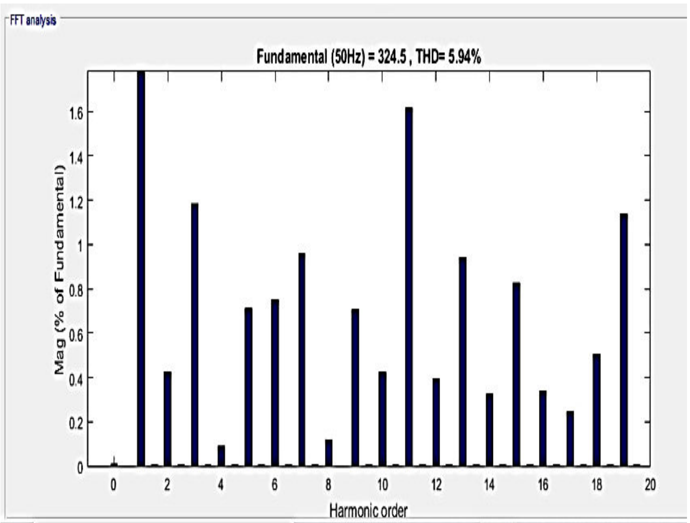
Figure 2: Simulink of AC-DC Substation without Detuned Filter

The Non-Linear is chosen for harmonic experimental study and is tested for its non-linearity. The conditions of the test are as given below.

Line to Neutral voltage: 440 Volts
Current to every phase: 1.5 Amp Frequency: 50 Hz
Power factor: 0.61 lag KVA: 0.338
KW: 102.21
Max current: 60.2 A
Voltage Harmonics – THD: 5.8 %
The following THD is obtained for various order harmonics.

Table 1: Voltage Harmonics for Phase and Neutral

condition	*THD A (%)*
Without Filter	5.94



Filter Elements	*Order of Harmonics*				
	2	3	5	7	9
L (mH)	258.47	114.87	41.35	21.099	12.76
C (µF)	9.8	9.8	9.8	9.8	9.8

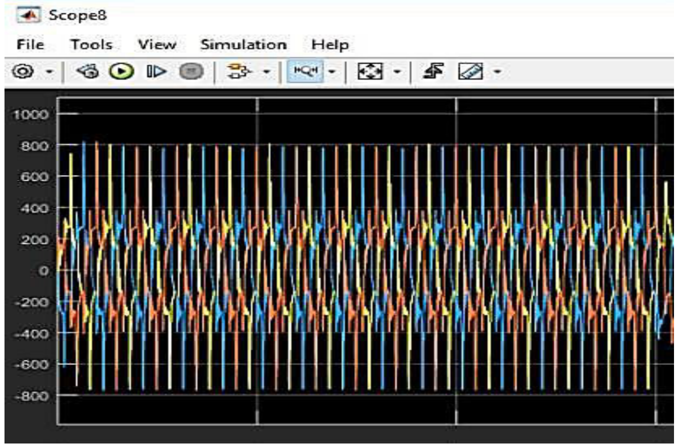


Figure 3: Voltage Harmonics for Phase and Neutral

From the above measurements it are often seen that harmonic is dominant, also power factor is poor at full load. Harmonic distorted current is prevented from flowing back to the facility system by diverting them through the low impedance shunt path called “HARMONIC FILTER”. it's essentially an influence factor correcting capacitor combined with a series reactor. At frequency above tuned point, it behaves as an inductive load. Harmonic filter isn't a capacitive load at frequency above a tuning frequency. Hence the facility system can not resonate at any magnitude of either current of voltage distortion. From the readings it seems very clearly that the presence of harmonic level content is more so as of 3rd harmonic. Hence we'll choose “Detuned Passive Filter” which eliminates the actual order harmonic and can reduce the general average effect of nth order of harmonic.

3. DESIGN OF HARMONIC FILTER

The filter design contains inductor design, capacitor design, other protective equipment and indication devices which indicates the on or off of the filter. The reactor should be of 7% of the system voltage for 3rd harmonic where as for the 5th and better order harmonic of the system voltage.

3.1 Single Detuned Filter

Onedetuned filter may be a capacitor designed to trap a particular harmonic by adding a reactor with at the tuned frequency fn. The steps involved in designing ST filter are as follows:

i. Determine capacitor size Qc in MVAr

ii. Determine capacitor reactance Xc $X_c = \frac{kV^2}{Q_c}$

iii. Determine inductive reactance XL

iv. Determine inductance and capacitance $X_c = \frac{1}{2\pi f_1 C}$

v. L and C are often related as,

Table 3: Designed Values of C Type High Pass Filter

Filter Elements	*Hrmonics*				
L (mH)	36.32	16.14	5.8104	2.9645	1.7933
C_1 (µF)	11.6252	11.6252	11.6252	11.6252	11.6252
C_2 (µF)	58.1262	58.1262	58.1262	58.1262	58.1262

4. SIMULATION RESULT AND ANALYSIS

TheNon-Linear load of is tested for the non-linearity and individual harmonics are simulated in MATLAB SIMULINK software. The source current has a THD of 5.94%.

4.1 Single Detuned Filter

Single detuned filters are designed to wipe out 2nd, 3rd, 4th, 5th, 7th and 9th harmonics. FFT analysis of the source current using ST filter is shown below. THD ampere has reduced from 5.94 % to 4.2 %.

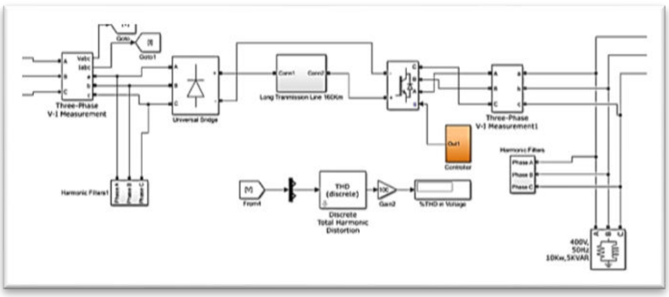
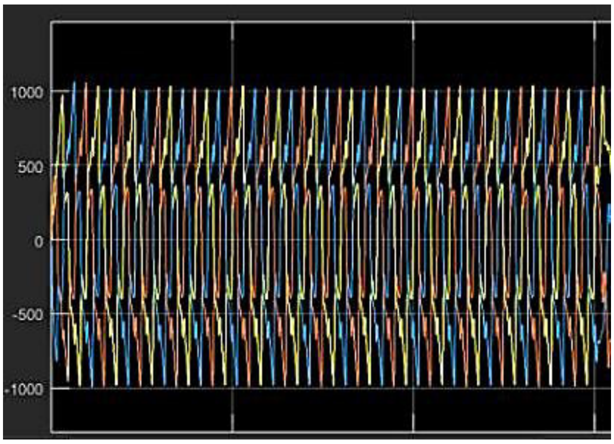


Figure 7: Simulink model of Detuned filter



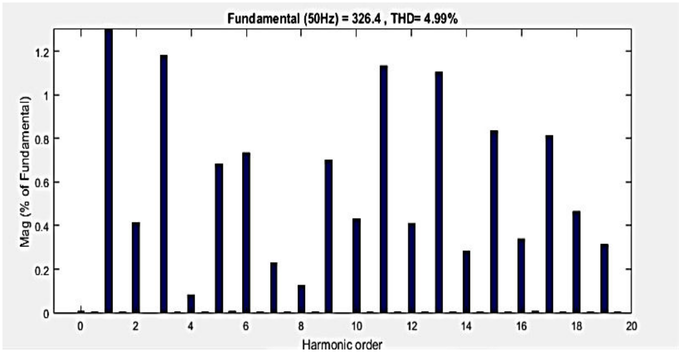


Figure 8: FFT Analysis of source current with Detuned filter

5 CONCLUSION AND FUTURE ENHANCEMENT

This paper has presented the results of the Simulation of AC-DC Substation of a typical non-linear load. Here various harmonic filters are designed for the non- linear load in. Efficient and comprehensive design procedures of single-tuned passive harmonic filters are appropriate for power applications. Detuned filter are often combined with single tuned filter to enhance power factor and to scale back the THD.

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