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Harmonic Reduction using Passive Filter (reducing electrical pollution)

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Abstract: Now a-days the usage of modern drives are extended, the imbuement of harmonics has been produced rapidly. To reduce the harmonics imbued in the transmission line the filters are used as a piece of the system. The filters are used to diminish the distortion caused by the source and drives. A couple of sorts of filters are accessible; however the passive filter is one of the convincing among them. The passive filter is more feasible in restricting the voltage distortion caused by the nonlinear loads used in the endeavors. Unmistakable decisions for the filter arrangement should be considered for settling on an official decision for filter plans. The layout and execution of the passive filter will be steady of diminishing the current and voltage harmonics. Most of the power quality issues are caused because of the nonlinear loads, induction heater and power equipment devices. These sorts of weights will make the harmonics which will destroy the sinusoidal nature of the AC supply. The most natural approach to diminish harmonics is by introducing passive filter in our system. In this paper we discussed the power philosophies of passive filter which alleviate harmonics and keep up waveform sinusoidal.
Keywords: Harmonics, Passive filter, Transmission line.

I. INTRODUCTION

There is a great emphasis about power quality and particularly the issue of harmonics distortion because of the joining of more non-linear loads in a typical present day plant. Further, power electronic based devices are for the most part being used for inverter, rectification and distinctive applications. Not withstanding the fact that these devices are more suitable they create and imbue harmonics into the power system. For the most part, adequacy examinations in power systems think about without distortion waveforms, that is the voltage and current waveforms are believed to be sinusoidal. A harmonics is a sinusoidal part of an intermittent wave having a frequency that is a vital different of the fundamental frequency. The standard of harmonics in power systems has been the static power converter used as rectifiers, variable speed drives, switched mode supplies, frequency changers for induction heating. Since nonlinear loads speak to a reliably extending level of the total store of a mechanical or modern power system, harmonics examinations have transformed into a basic bit of general system diagram and operation. Fortunately, the accessible programming for harmonics examination has furthermore created.
Guidelines for the acknowledgment of harmonics distortion are particularly characterized in IEEE Standard 519-1992. By showing power system impedances as a component of frequency, an examination can be had to choose the effect of the harmonics. Non-linear loads on the system are the major responsibility for voltages and current harmonics in the power system. The harmonics level gets extended by the utilization of power electronic gadgets.
This prompts the purpose behind minimization in relentless reliability and stability. To beat these issues, it is a need to keep up power quality. These issues rise in view of the electrical unsettling influence. Most of the aggravation depends upon the amplitude or frequency. Harmonics causes overheating of motors, cables, transformers. Moreover reduce the future of various components. With the snappy upgrades and usage of nonlinear loads, the powerling technique is basic over the harmonics. So the passive filter is used to mitigate harmonics.

II. HARMONICS AND ITS TYPES

The integral multiple of the sinusoidal voltage or current having the frequencies at which the supply system is designed (named the key frequency; for the most part 50 or 60 Hz). The distorted waveform can be wrecked into the essential frequency and the harmonics. The distortion occurs generally due to the non-linear characteristics of the drives and loads in a system. Harmonics portion of current order n can be represented as

$$in = I_n \sin 2\pi n f t$$

Where 'In' is the amplitude of the harmonic portion of order n.
Two sorts of harmonics to be particular

A. Odd order

B. Even order

Odd harmonics may be expressed as:

$$in = I_n \sin 2\pi n f t$$

Where n = 3, 5, 7...etc and I_n is the amplitude of harmonic portion of order n.

In fact, even harmonics may be expressed as:

$$in = I_n \sin 2\pi n f t$$

Where n = 2, 4, 6...etc and I_n is the amplitude of harmonic fragment of order n.

The fig 2.1 shows the the distroted wave form of the 3rd order harmonic in a system

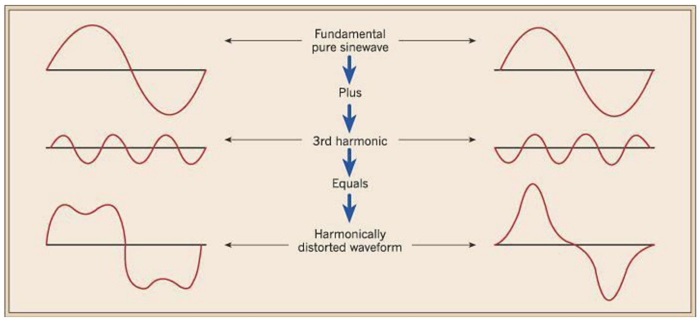

Fig 2.1 3rd order harmonics

C. Impacts of Harmonics

Harmonics are not appealing in numerous applications and operations of electrical power system; thusly it has wide antagonistic impacts on the system. The impacts of harmonics may be classified as:

1) Reverberation and Impact on Capacitor Banks
2) Poor Damping
3) Impacts of Harmonics on rotating Machines
4) Impacts on Transformer
5) Impacts on Transmission Lines
6) Harmonics Interference with Power System Protection
7) Impacts of Harmonics on Consumer equipments

D. Zones of Harmonics

The methodologies used to decrease harmonics distortion issue differs from place to place. To control the harmonics distortion actuated in the distribution feeder and end customer power system, a couple of systems have been used. They are:

1) On Utility Distribution Feeders
2) In End-User Facilities

III. CONTROL METHODS

Filters are used to evacuate the unwanted frequency that actuates due to non-linear characteristics of some electronic devices. Among different approaches to beat the harmonics or keep them inside quite far are by incorporating filter in the system.

There are three sorts of filters.

1) Passive filters
2) Active filters
3) Hybrid filters

Passive filters are used to reduce a particular harmonics frequency, so number of passive filters increase with increase in number of harmonics on the system. They can be characterized into:

4) Passive shunt filter
5) Passive series filter

In our project we are using passive shunt filter. The Fig 3.1 shows the connection of the linear loads in the passive filter.

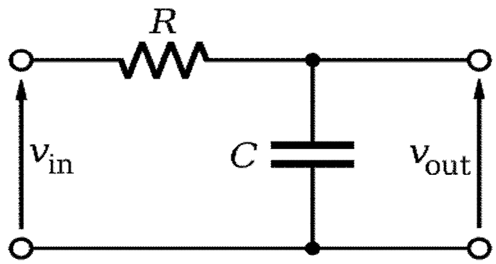

Fig 3.1 Passive filter

IV. PROPOSED SYSTEM

The proposed system to reduce harmonics using passive filter according to IEEE standards and to grow power quality of the system showed up in fig 4.1

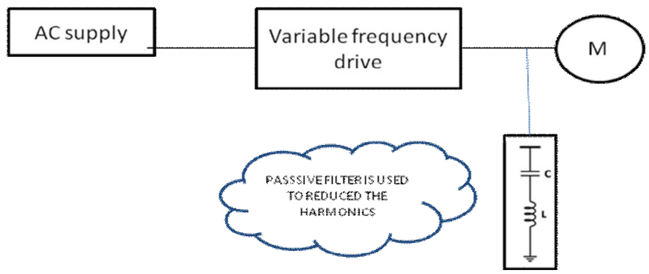

Fig 4.1 Square Layout of Proposed System

A. Hardware Execution

The hardware setup have been shown up in the fig 4.2

Fig 4.2 Hardware setup

B. AC Supply

Three-phase electric power is a normal system for substituting current electric power generation, transmission, and distribution. It is a sort of polyphase system and is the most generally perceived procedure used by electrical lattice worldwide to transfer power.

C. Variable Frequency Drive

Variable frequency drives are known as frequency inverter, AC drives etc. It is an electric gadget to change utility power source to variable frequency to control AC motor operated in variable speed operation.

Two basic concerns:

Many motor and gadgets were not mechanically changed in accordance with work at expanded velocities

VFDs are not fit for extending voltage so as frequency augments more than 60 hertz

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D. AC Motor

An electric motor is an electrical machine that converts electrical energy into mechanical energy. The transform of this is the difference in mechanical energy into electrical energy and is done by an electric generator, which has much in a comparative way as a motor**.**

V. SIMULATION

The introduction of all harmonics examination still depends upon the estimation of amplitude and phase angle of the harmonic components. In this paper, we have used Fast Fourier Transform (FFT) worked in instrument accessible in MATLAB. In fig 5.1 show the system consists of non-linear load which make part to the induce of harmonic in the system which will cause the some damage to the meachines. In fig 5.2 the passive filter is induced in the system which will helps in reducing the harmonic intration in the system.

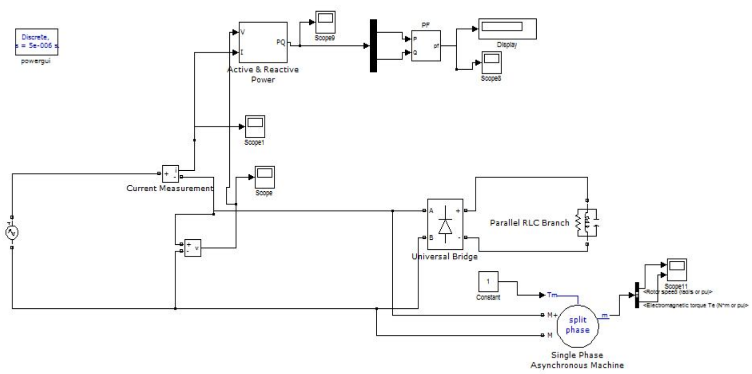

Fig 5.1 Simulation without Filter

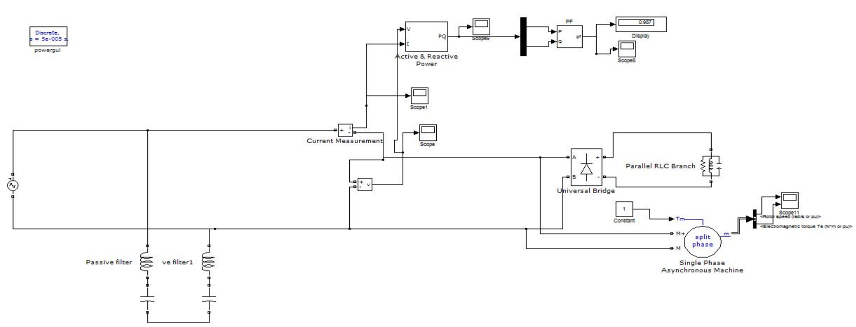

Fig 5.2 Simulation with filter

VI. RESULTS AND DISCUSSION

A. Simulation Result

In the fig 6.1 shows the Total Harmonics Distroction (THD) that occure at the time of using non linear load have been shown with the help of FFT analysis. In fig 6.2 shows the reduction on Total Harmonics Distrotion (THD) by introducing the passive filter in the system.

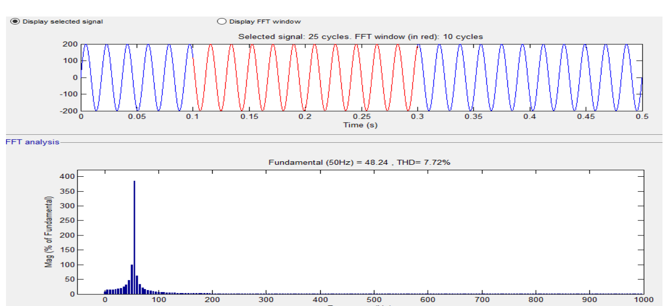

Fig 6.1 FFT analysis without filter

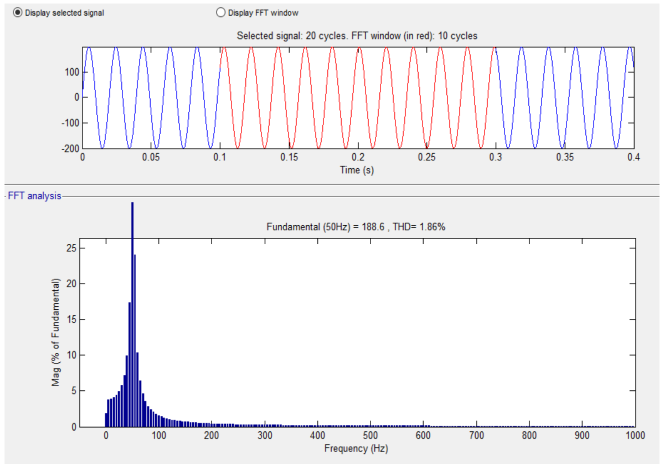

Fig 6.2 FFT analysis with filter

B. Hardware result

The fig 6.3 shows the output of the system when the passive filter is introduced, where the VFD is used. Due to the introducing of the VFD the harmonic is introduced in the system. To reduce the harmonic passive filter is implemented.

Fig 6.3 Hardware result with passive filter

C. Formulae

Let us assume connected load = X KVA

Initial power factor = 0.85

Proposed power factor = 0.98

Reactive power demand at 0.85 PF = Xx sin (arc cos 0.85) =A

Reactive power demand at 0.98 PF = Xx sin (arc cos 0.98) =B

Required compensation from the filter = A-B = C KVAR

For nominal 440 system, the net Y equivalent filter reactance (Capacitive)

$$X_{max} = \frac{KV^2 \text{ x } 1000}{KVAR} = \frac{0.440^2 \text{ x } 1000}{C}$$

X_{filter} is the difference between capacitive reactance and inductive reactance at fundamental frequency

Hence $X_{max} = X_{cap} - X_L$

For tuning at 4.7th Harmonic (h)

$X_{cap} = h^2 X_L = 4.7^2 X_L$

The desired cap reactance

$$X_{cap} = \frac{X_{filter}\, h^2}{h^2 - 1} = D$$

At this point it is not known whether the capacitor is rated for 440V. To achieve this

$$KVAR = \frac{KV^2 \text{ x } 1000}{KVAR} = \frac{0.440^2 \text{ x } 1000}{D}$$

Filter Reactor size

$$X_{L(FUNDS)} = \frac{X_{cap}}{h^2} = \frac{D}{h^2} \text{ ohm}$$

$$L = \frac{X_{L(FUNDS)} \text{ x } 1000}{2pi \text{ x } 50} = E_{mH}$$

D. Calculation

Give us a chance to expect associated stack = 5 HP = 3.73KW
Beginning power factor = 0.8
Proposed power factor = 0.98
Reactive power request at 0.8 PF $= 4.66*\sin(arc\cos 0.85)$
$= 2.7$ KVAR
Reactive power request at 0.98 PF = $4.66*\sin(arc\cos 0.9.8)$
$= 0.932$ KVAR
Required remuneration from the filter = 2.0 KVAR
For ostensible 415 system, the net Y equalent filter reactance (Capacitive)

$$X_{max} = \frac{KV^2 \text{ x } 1000}{KVAR} = \frac{0.415^2 \text{ x } 1000}{2.0}$$

$$= 86.11\omega$$

The coveted capacitive reactance at

$$X_{cap} = \frac{X_{filter} h^2}{h^{2-}1} = \frac{86.11 * 3.7823^2}{3.7823^{2-}1}$$

$$= 92.57\ \omega$$

KVAR at 415V

$$KVAR = \frac{KV^2 \text{ x } 1000}{KVAR} = \frac{0.410^2 \text{ x } 1000}{92.57}$$

$$= 2.0 \text{ KVAR}$$

Filter Reactor estimate

$$X_{L(FUNDS)} = \frac{X_{cap}}{h^2}$$

$$= \frac{92.57}{3.728^2} \text{ ohm}$$

$$= 6.47\ \Omega$$

$$L = \frac{X_{L(FUNDS)} \text{ x } 1000}{2pi \text{ x } 50}$$

$$= \frac{6.47 \text{ x } 1000}{2 \text{ x } \pi \text{ x } 50}$$

$$=20.60 mH$$

E. Tabulations

Fig 7.1 shows the maximum individual frequency voltage harmonics

SCR at PCC	Indidual Frequency Voltage Harmonics (%)
10	2.5% - 3.0%
20	2.0%-2.5%
50	1.0-1.5%
100	0.5%-1.0%
1000	0.05%-0.10%

Fig 7.1 Limitations of voltage harmonic

*SCR: Short circuit ratio
*PCC: Point of common coupling

Fig 7.2 shows the maximum harmonic current distortion in percent of I_L for general distribution systems

Isc/IL	<11	11≤h<17	17≤h<23	23≤h<35	TDD
<20*	4.0	2.0	1.5	0.6	5.0
20<50	7.0	3.5	2.5	1.0	8.0
50<100	10.0	4.5	4.0	1.5	12.0
100<1000	12.0	5.5	5.0	2.0	15.0
>1000	15.0	7.0	6.0	2.5	20.0

Fig 7.2 Lmitations of current harmonics

Even harmonics are limited to 25% of the odd harmonic limits above.

VII.CONCLUSION

The passive harmonics filters are a suitable, linearforward and saving other option to counter the issue of harmonics rising in pretty much nothing and tremendous scale power systems or system including non-direct loads. Versatility in power can't be accomplished using passive filters however in spite of what may be normal power systems are dynamic in nature and thusly there is a prerequisite for versatile and computerized control. However, passive filters are always seen as a possible choice from conservative perspective. Harmonics makes mischief to the electrical systems and now and again be hazardous. Passive filter are effective in constraining voltage and current distortion caused by nonlinear loads. Passive filter gives low impedance route to the harmonics current.

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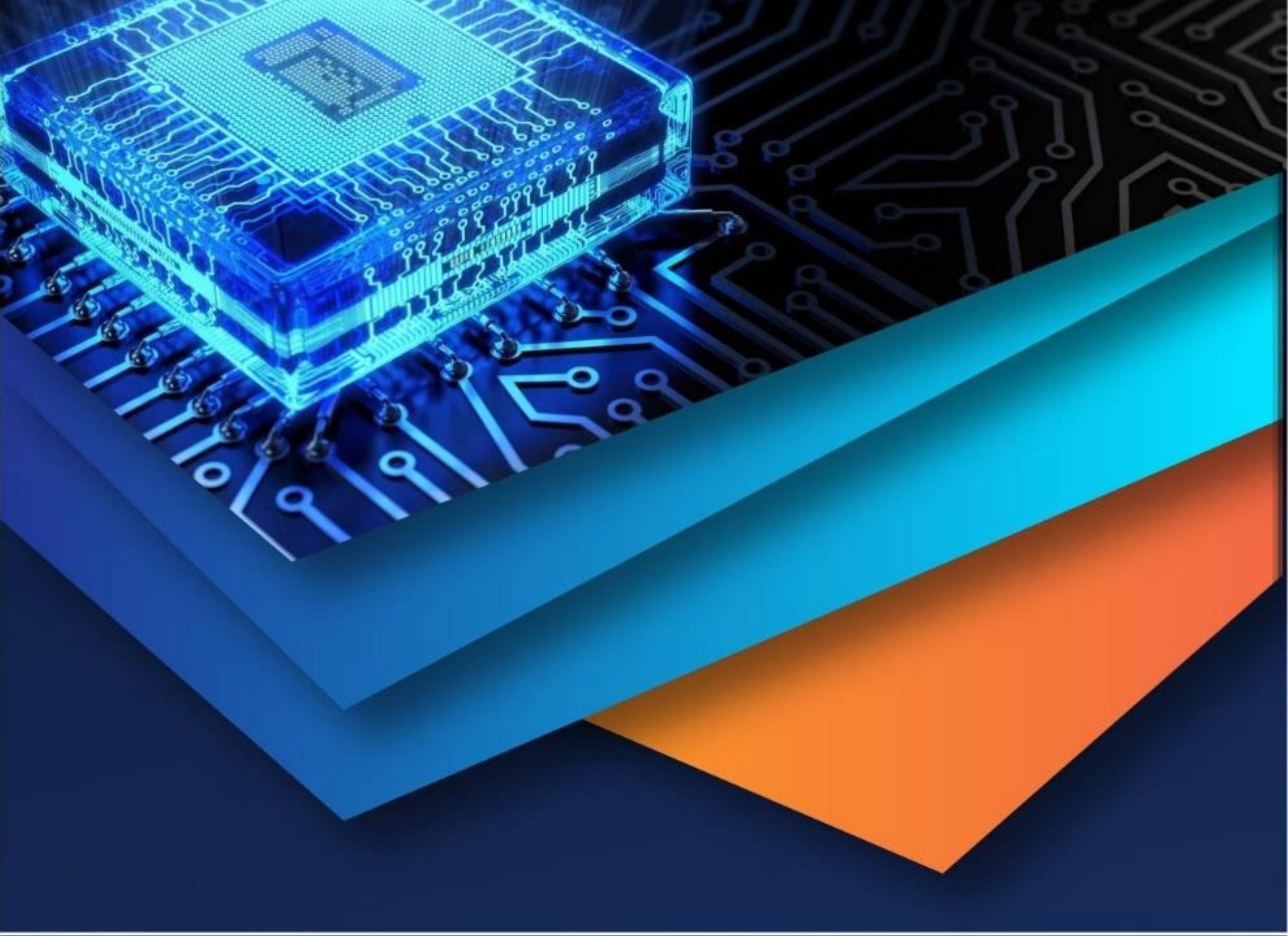

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