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Harmonic Compensation using different Passive Filter Configurations

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Abstract---Harmonics are a menace to electric power systems with disastrous consequences. Line current harmonics cause increase in losses, instability, and also voltage distortion. Both passive and active filters have been used near harmonic producing loads or at the point of common coupling to block current harmonics. Shunt filters still dominate the harmonic compensation at medium/high voltage level, whereas active filters have been proclaimed for low/medium voltage ratings. With diverse applications involving reactive power together with harmonic compensation passive filtering has been preferred for harmonic compensation in distribution systems due to low cost, simplicity, reliability, and control less operation. The main emphasis of this investigation has been on a compactness of configurations, simplicity in control, reduction in rating of components, thus finally leading to saving in overall cost. Based on thesis considerations, a wide range of configurations of power quality mitigators are developed, which is expected to provide detailed exposure to design engineers to choose a particular configuration for a specific application under the given constraints of economy and desired performance. For bidirectional power flow applications, the current source converter is designed and simulated with R-L load. The necessary modeling and simulations are carried out in MATLAB environment using SIMULINK and power system block set toolboxes. The behavior of different configurations of passive tuned filters on power quality is studied.

I. INTRODUCTION

The harmonic produce in the system is minimized by the use of various filter configurations that are referring basically as ACTIVE FILTER & PASSIVE FILTER. Passive filters use passive components such as resistors, inductors, and capacitors. A combination of passive components is tuned to the harmonic frequency that is to be filtered. Fig.1 is a typical series-tuned filter. Here the values of the inductor and the capacitor are chosen to present low impedance to the harmonic frequency that is to be filtered out. Due to the lower impedance of the filter in comparison to the impedance of the source, the harmonic frequency current will circulate between the load and the filter. This keeps the harmonic current of the desired frequency away from the source and other loads in the power system. If other harmonic frequencies are to be filtered out, additional tuned filters are applied in parallel. Applications such as arc furnaces require multiple harmonic filters, as they generate large quantities of harmonic currents at several frequencies. As a first step in the computer simulation, the power system is modelled to indicate the locations of the harmonic sources, then hypothetical harmonic filters are placed in the model and the response of the power system to the filter is examined. If unacceptable results are obtained, the location and values of the filter parameters are changed until the results are satisfactory.

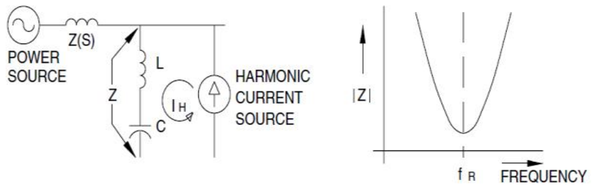

Fig. 1: Series-tuned filter and filter frequency response.

Active filters use active conditioning to compensate for harmonic currents in a power system. Fig.2 shows an active filter applied in a harmonic environment. The filter samples the distorted current and, using power electronic switching devices, draws a current from the source of such magnitude, frequency composition, and phase shift to cancel the harmonics in the load. The result is that the current drawn from the source is free of harmonics. An advantage of active filters over passive filters is that the active filters can respond to changing load and harmonic conditions, whereas passive filters are fixed in their harmonic response. As we saw earlier, application of passive filters requires careful analysis. Active filters have no serious ill effects associated with them. However, active filters are expensive and not suited for application in small facilities.

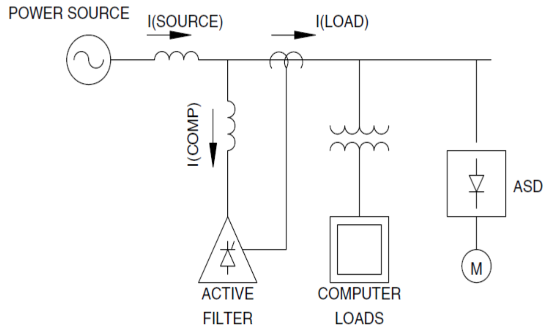

Fig. 2: Active filter to cancel harmonic current.

II. CLASSIFICATION OF PASSIVE FILTER

The classification of passive filter is done on the type of harmonic generation component source present in the system and passive component resistor inductor and capacitor connected in the system and are given as

A. *PASSIVE SERIES FILTER*

Fig.3 shows the schematic diagram of a passive

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series filter connected at input ac mains. For voltage source type of harmonic loads (such as diode rectifier with R-L load filter), passive series filter is considered as a potential remedy for harmonic mitigation. Here, the different tuned branches of passive filters are connected in series with the supply and the diode rectifier. It consists of a set of low block tuned shunt filter tuned at 5th and 7th harmonic frequencies and high block tuned filter for 11th harmonic frequency. These passive filters blocks most dominant 5th, 7th and other higher order harmonics and thus prevents them from flowing into ac mains. Here, the performance of the series filter is not much dependent on the source impedance. However, it results in reduction in dc bus voltage due to voltage drop across filter components.

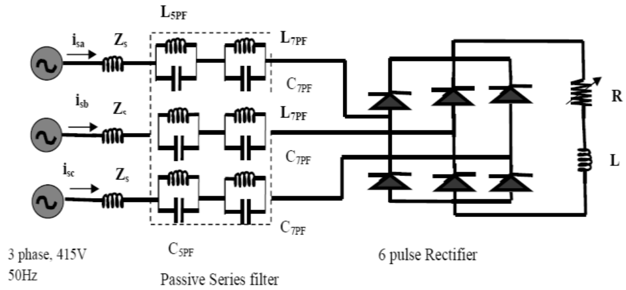

Fig. 3: Series connected passive filter with six pulse rectifier.

B. PASSIVE SHUNT FILTER

Fig.4 shows the schematic diagram of a passive shunt filter connected at input ac mains of six pulse ac-dc converter with R-L load. This is the most commonly used configuration of passive filters. In this configuration different branches of passive tuned filters (low pass and high pass) tuned for the more dominant harmonics are connected in parallel with the diode rectifier with RL load. It consists of a set of low pass tuned shunt filters tuned at 5th and 7th harmonic frequencies and high pass tuned for 11th harmonic frequency. This passive filter scheme helps in sinking the more dominant 5th and 7th and other higher order harmonics and thus prevents them from flowing into ac mains. The diversion of harmonic current in the passive filter is primarily governed by the source impedance available in the system. The higher value of source impedance offers better performance of the passive filter.

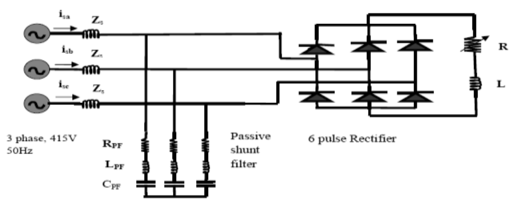

Fig. 4: Shunt connected passive filter with six pulse rectifier.

C. C. PASSIVE HYBRID FILTER

Fig.5 shows passive hybrid filter .The use of passive shunt filter creates the problem of voltage regulation at light loads. It also increases the dc voltage ripple and ac peak current of the rectifier. On the other hand, passive series filter suffers from lagging power factor operation as well as the voltage drop across the filter components both at fundamental frequency as well as harmonic frequencies. To overcome these drawbacks, a combination of both these configurations is presented as passive hybrid filter. This configuration is able to supplement the shortfalls of both these passive filters and simultaneously it results in improvement in harmonic compensation characteristics for varying load condition even under stiff and distorted ac mains voltage.

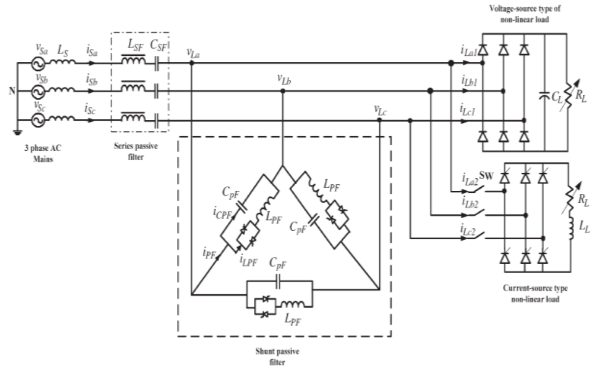

Fig. 5: PASSIVE HYBRID FILTER

III. SIMULATIONS AND RESULT

The simulation results are obtained through Power System toolboxes in SIMULINK by taking system parameter as given in table.1.

Components	Specifications
AC Source	Vs=415v, f=50 Hz
Nonlinear Load	RL=40(Ω) L=50(mH)
Passive Filter	LPF=16(mH),RPF=0.83(Ω),CPF=25(µF)

Table.1: System parameters

To demonstrate the performance of these passive filters feeding a three-phase converter with R-L load, these passive filters are modelled in MATLAB environment along with SIMULINK and power system block set toolboxes. Different components of these converters such as low pass filter with R-L load are simulated in MATLAB/SIMULINK.

A. PASSIVE SHUNT FILTER BASED CONVERTER WITH R-L LOAD.

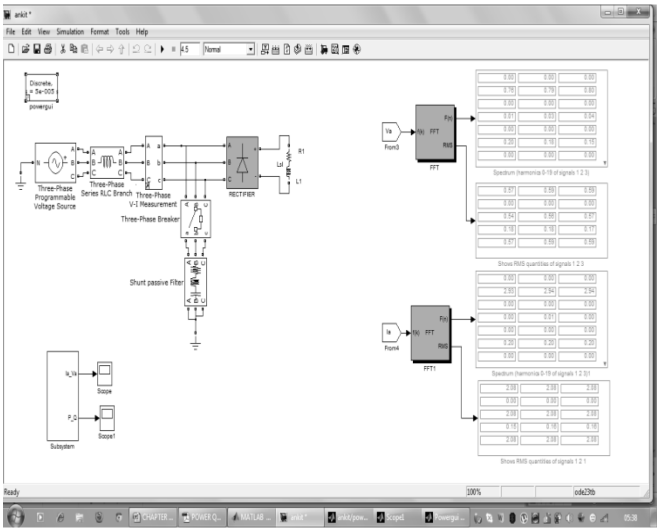

Fig.6 MATLAB based model of a six pulse ac-dc converter R-L load without passive filter.

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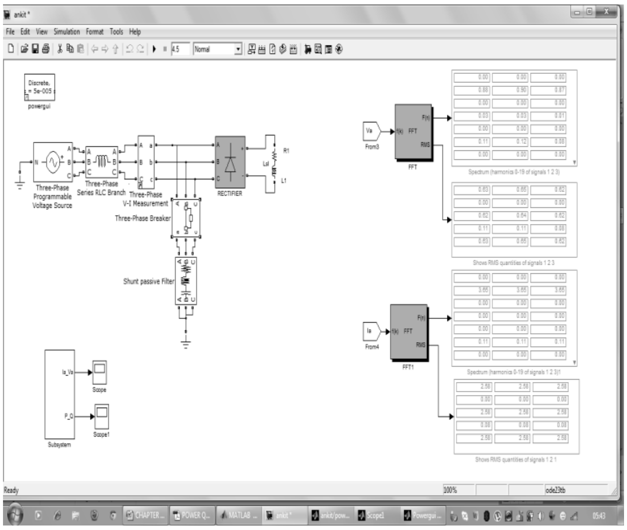

Fig. 7: MATLAB based model of a six pulse ac-dc converter R-L load with passive shunt filter.

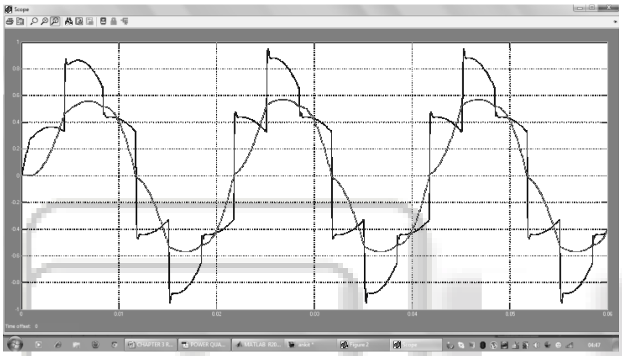

Fig. 8: AC mains V & I response for R-L load without passive shunt filter.

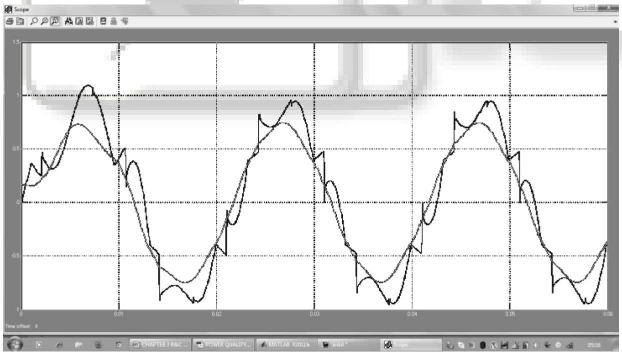

Fig. 9: AC mains V & I responses for R-L load with passive shunt filter.

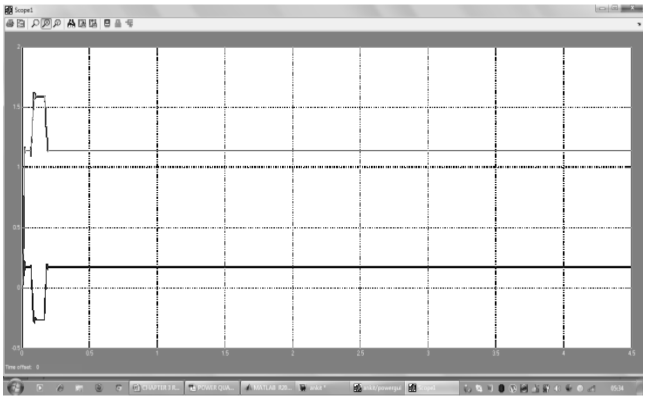

Fig. 10: AC mains Active and Reactive power response for R-L load without passive shunt filter

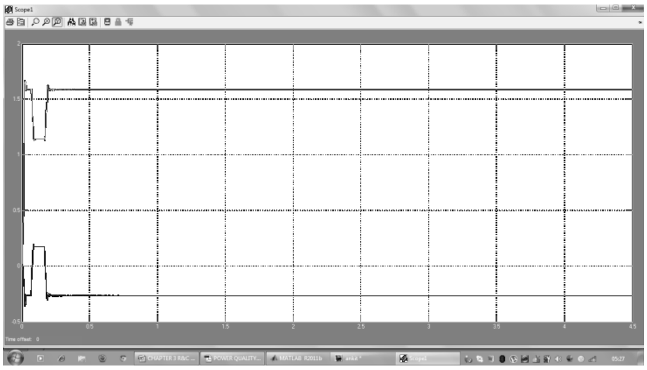

Fig.11 AC mains Active and Reactive power response for R-L load with passive shunt filter.

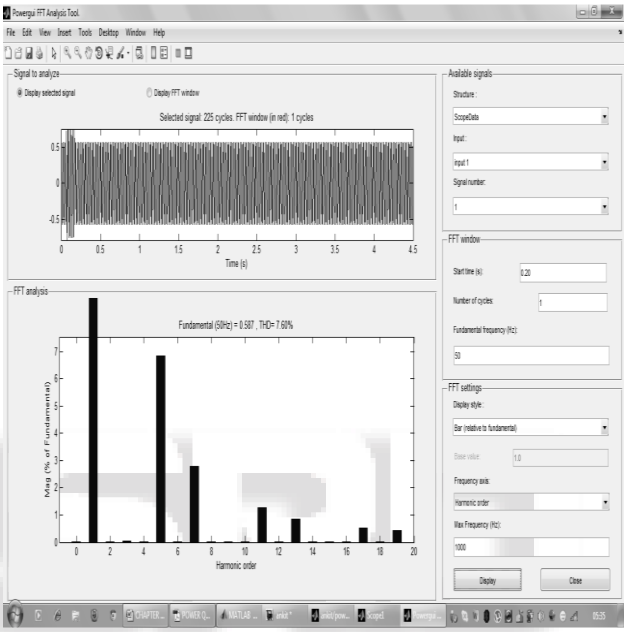

Fig. 12: AC mains I response with %THD for R-L load without passive shunt filter.

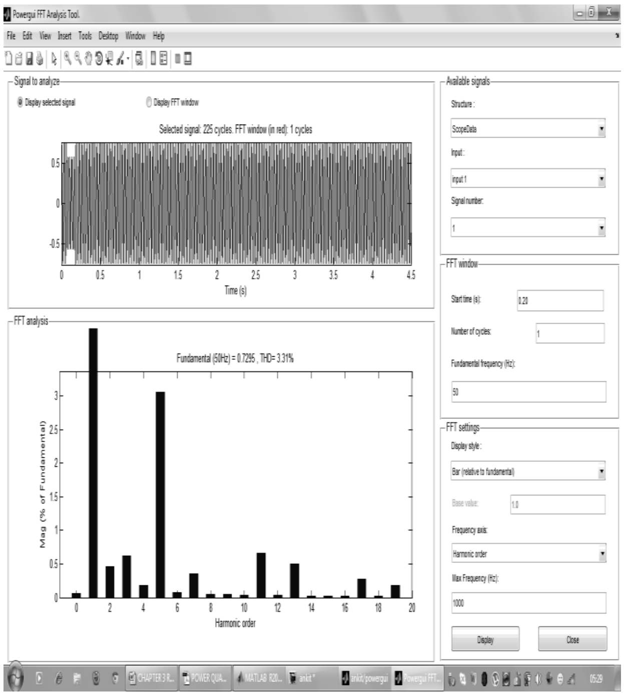

Fig. 13: AC mains I response with %THD for R-L load with passive shunt filter.

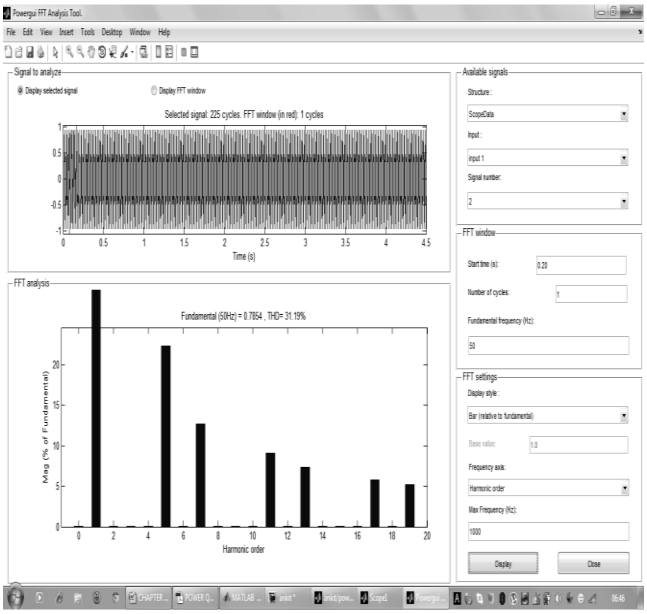

Fig. 14: AC mains V response with %THD for R-L load without passive shunt filter.

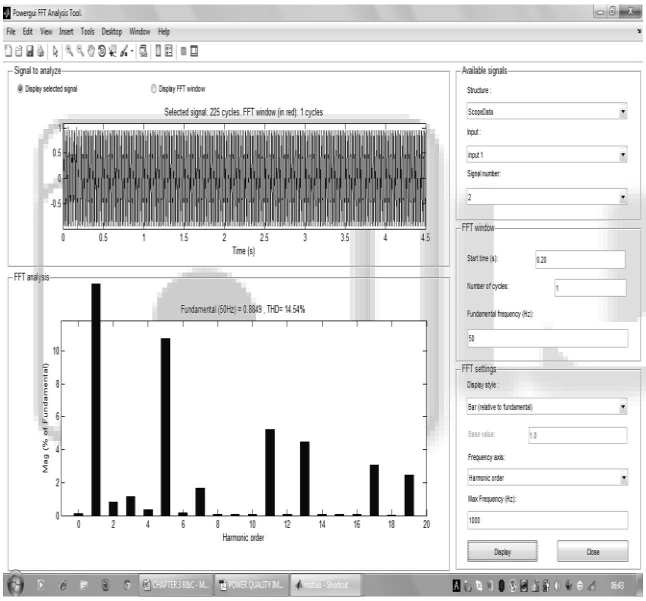

Fig. 15: AC mains V response with %THD for R-L loads with passive shunt filter.

IV. CONCLUSION

The configuration of passive shunt filter has been simulated and developed for six pulse ac-dc converter with R-L load. The simulated and test results of with passive shunt filter and without passive shunt filter configurations are presented here.Table 2 shows that by using passive filter we may reduce the Voltage and Current THD.

Simulink Model	Current THD%	Voltage THD%
Without Passive Filter	7.60	31.19
With Passive Filter	3.31	14.54

Table 2

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