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Improvement of Power Quality Using Advanced Series Active Power Filters

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Abstract: This paper presents the various issues of power quality. The typical loads in the commercial buildings comprise of many loads. These loads are highly sensitive for any input voltage. The performance of the electrical equipment weakens if they are supplied with polluted voltage. Advanced series active power filters are present in this paper which carried out in MATLAB/SIMULINK.
Keywords: Power quality, voltage Swell, voltage sag, series active power filters.

I. INTRODUCTION

The waveform of the supply voltage from sinusoidal waveform at rated frequency for all three phase Power quality phenomena include all possible situations[1].Voltage dips cause tripping sensitive in industries and low quality of the current drawn by the load[8][2][3]. The compensating devices are used for load balancing, active filtering, voltage regulation and power factor improvement [4].This paper presents that any fluctuation caused in the supply voltage will result in the damage to the electrical equipment [8]. Series Active power filters have been developed to overcome these problems.

II. POWER QUALITY

The Power Quality(PQ) issue is defined as “any occurrence occurred in V,I,f deviations that results in damage, upset, failure of equipment”. The problem can solved on the type of issue involved such as Lamp flicker, Frequent blackouts , interference and Overheated elements and equipment[2]. Conventionally, harmonic problems are eliminated by passive filters. This filter consists of common devices such as inductance and capacitance[10].There are two approaches to the solve power quality problems. Load conditioning, ensures the equipment which is made less sensitive to power disturbances even under significant voltage distortion [5]. The other is line-conditioning systems which counteract the power system disturbances.

III. MODELING OF SERIES ACTIVE POWER FILTER

The series active filter (SAF) injects a voltage component in series with the supply voltage and therefore can be regarded as a controlled voltage source (CVS), compensating voltage sags and swells on the load side[4].

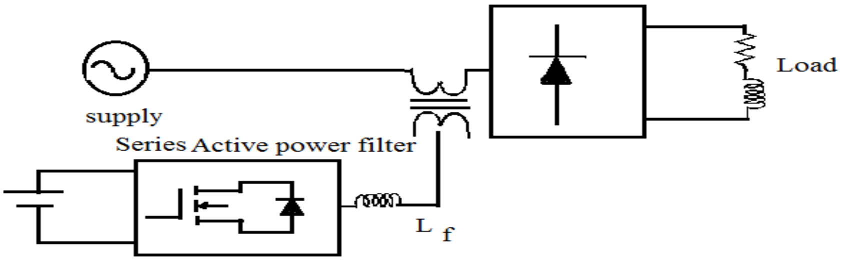

Fig.3.1: Block Diagram of Series APF

The main advantage of this scheme is that the rated power of the series active filter(SAF) is a small fraction of the load. However, the apparent power(AP) rating of the series active power(SAF) filter may increase in case of voltage compensation [6]. The main function of a series active power filter(SAF) to protect sensitive loads from supply voltage sags, swells and harmonics.

3.1CONTROL SCHEME OF SERIES FILTER

A simple algorithm is developed to control the shunt and series filters [8]. The control strategy for the series AF is shown in Fig. 3.2.

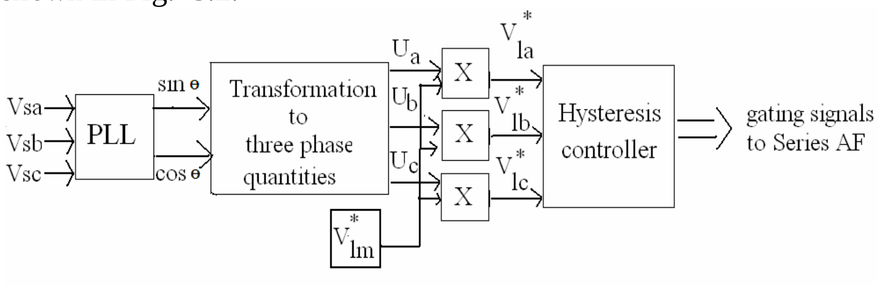

Fig.3.2: Control Scheme of Series APF

3.2 REFERENCE VOLTAGE GENERATION

The in-phase sine and cosine outputs from the Phase Locked Loop are used to compute the supply in phase, 120^0 displaced in three unit vectors (u_a,u_b,u_c) using eqn.(3.1) as

$$\begin{bmatrix} u_a \\ u_b \\ u_c \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ -\frac{1}{2} & -\frac{\sqrt{3}}{2} \\ -\frac{1}{2} & \frac{\sqrt{3}}{2} \end{bmatrix} \times \begin{bmatrix} Sin\theta \\ Cos\theta \end{bmatrix} \qquad (3.1)$$

The computed three in-phase unit vectors are then combined with the desired peak value of the PCC phase voltage (V^*_{in}), which become the three phase reference PCC voltages as

$$\begin{pmatrix} V_{la}^* \\ V_{lb}^* \\ V_{lc}^* \end{pmatrix} = V_{lm}^* \begin{pmatrix} u_a \\ u_b \\ u_c \end{pmatrix} \qquad (3.2)$$

IV. ADVANCED SERIES ACTIVE POWER FILTER

The advanced series active power filter (ASAPF) is used to compensate the source side disturbances such as voltage sags, swells and also harmonic distortions [6]. In this configuration, the filters are connected in series with the line being compensated. Therefore the configurations referred as an advanced series active filter.

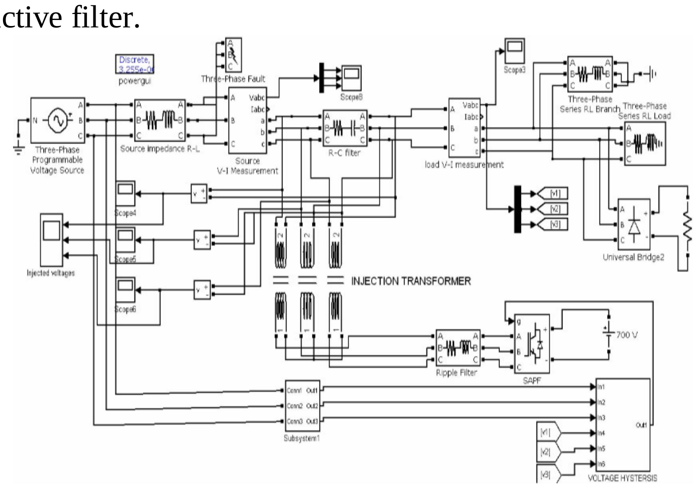

Fig. 4.1 MATLAB/Simulink model of advanced Series active power filter

Utility Source	Phase voltage= 415 V(RMS) Frequency = 50 Hz Source resistance = 0.1 Ω Source inductance= 0.5 mH L-G Fault on Phase A (case 3) L-L fault on Phase B & C (case 4)
Series Active Power Filter	Ripple filter parameters= 3.35mH, 0.1Ω; Injection transformer= 1.5 KVA& 7KVA DC voltage source = 700 V RC filter= 6 Ω, 6 μF
Load	R=10 ohms and L=1 mH. R=50 ohms and L=10 mH. Inductive load of P.F 0.894 lag. Three phase Diode bridge rectifier.

Table 4.1 System parameters for Series APF

Fig. 4.3 shows the source voltage with 1p.u voltage in phase A from 0 to 0.5 seconds (no distortion) , Line to Line Fault in phase B & C from 0.1 to 0.25 seconds, the rest is free from distortions. Due to this fault the Line to Line voltage between B&C lines is zero The load is R=10 ohms and L=1 mH, a three phase diode rectifier bridge ,an inductive load of 0.894 lag (active power =1000W and reactive power = 500W).

Time(seconds)	Voltage (p.u)	Phase	Load
0 to 0.5	1	A	R=10 Ω &L=1mH, three phase diode rectifier, inductive load of power factor (p.f) 0.894 lag
0 to 0.1	1	A,B & C	
0.1 to 0.25	L-L fault	B & C	
0.25 to 0.5	1	A,B&C	

Table 4.2 Source Voltage parameters 3-phase (line-Ground)

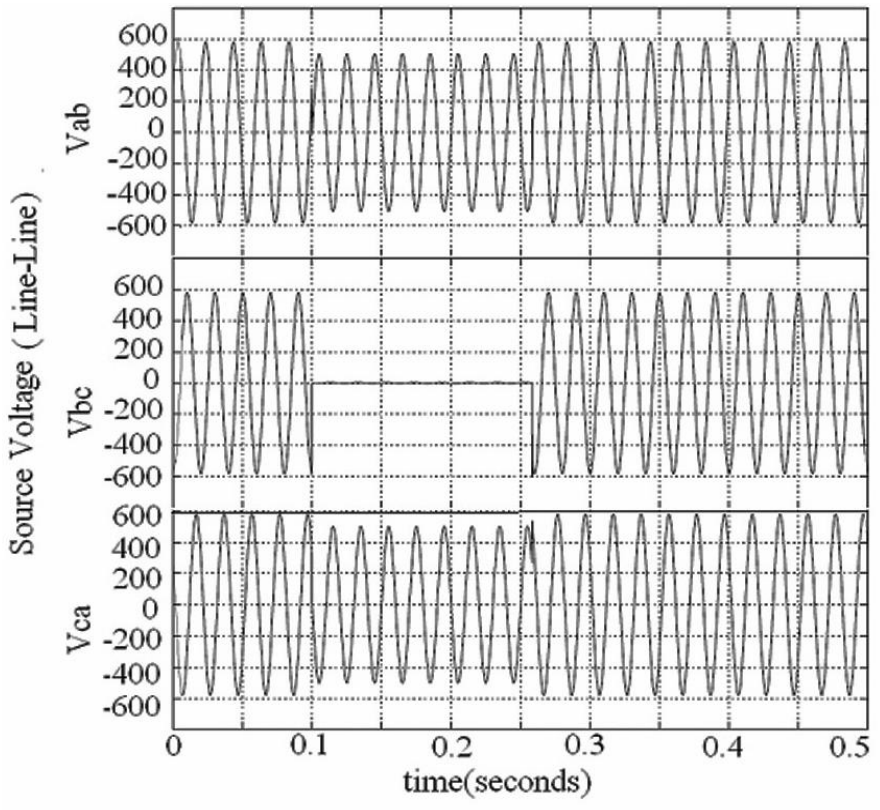

Fig. 4.3 Source Voltage (line to line voltages)

Fig. 4.4 shows the compensated voltage injected by each phases to cancel the source side disturbances present in the system.

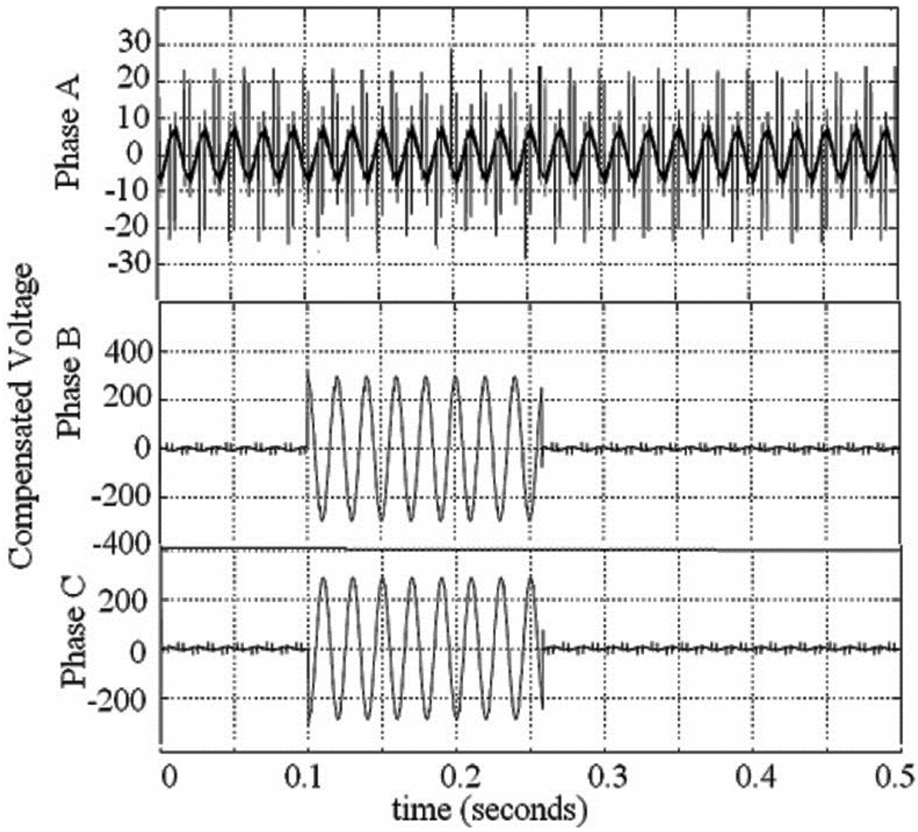

Fig. 4.4 Compensated voltages injected for each phases

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Due to the inject of the above voltages through the injection transformer in series with the line the load voltage is sinusoidal as shown in the Fig. 4.5

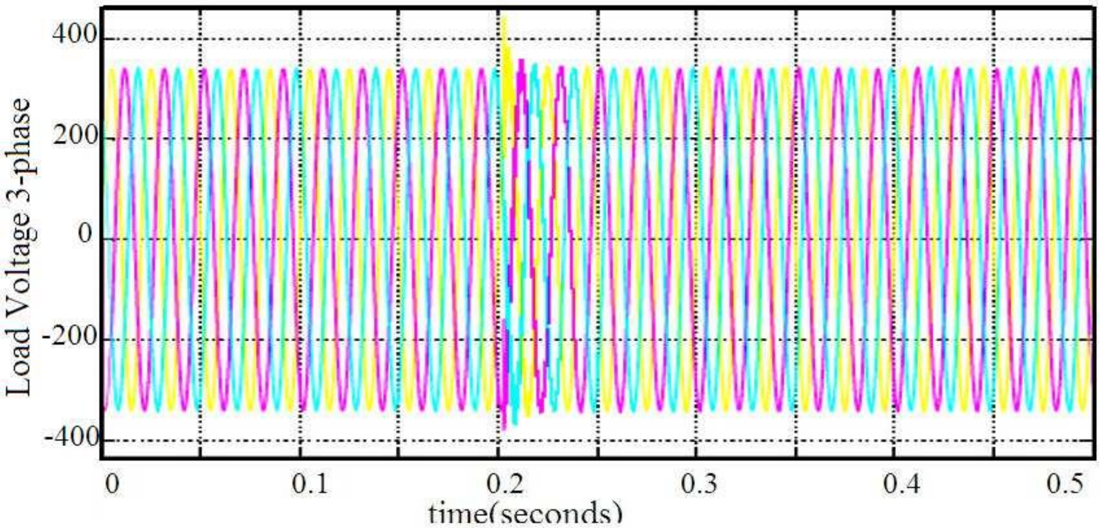

Fig. 4.5 3-Phase load voltage (Line-Ground)

Table 4.6 gives the THD magnitude & percentage at Source & Load.

	Source Voltage peak (Phase A)		Load Voltage peak (Phase A)	
Frequency	Voltage(Peak)	%THD	Voltage(Peak)	%THD
0	1.19	0.22	0.02	0.01
50	**531.46**	**-**	**338.02**	**-**
100	2.29	0.43	0.02	0.01
150	2.14	0.4	0.15	0.05
200	1.95	0.37	0.03	0.01
250	1.87	0.35	0.8	0.24
300	1.45	0.27	0.04	0.01
350	1.30	0.24	0.74	0.22
400	0.88	0.17	0.02	0
450	0.56	0.11	0.11	0.03
	%THD = 1.32%		**%THD= 0.66%**	

Table 4.6 Peak values of Source & Load Voltages per phase

The Total harmonic distortion of source voltage is 1.32% and load voltage is 0.66 % as shown in Fig. 4.7 & Fig. 4.8 Respectively.

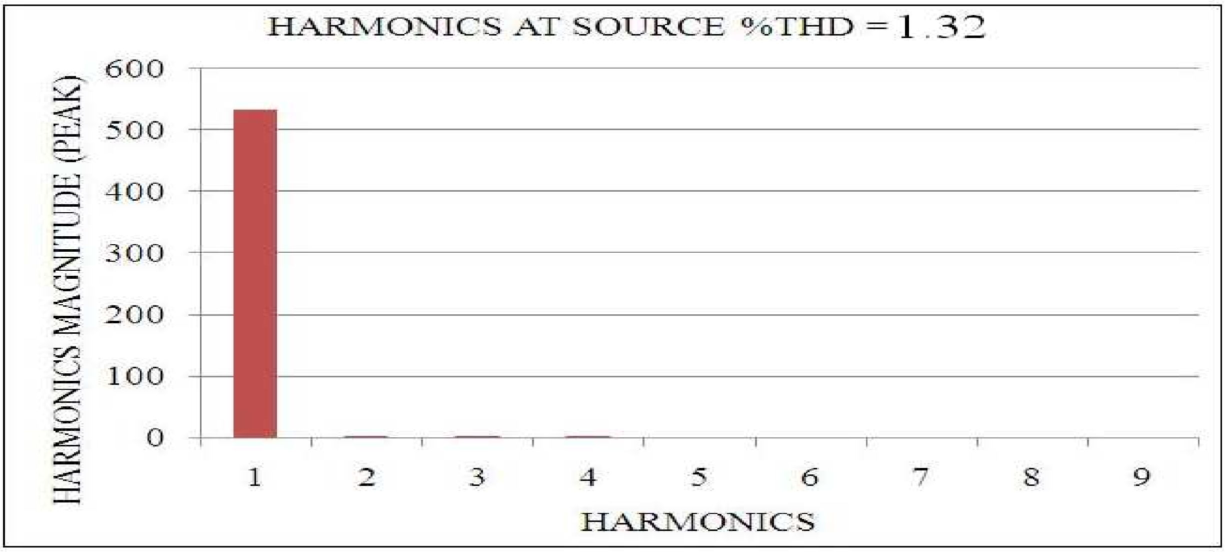

Fig. 4.7 Source voltage harmonic spectrum

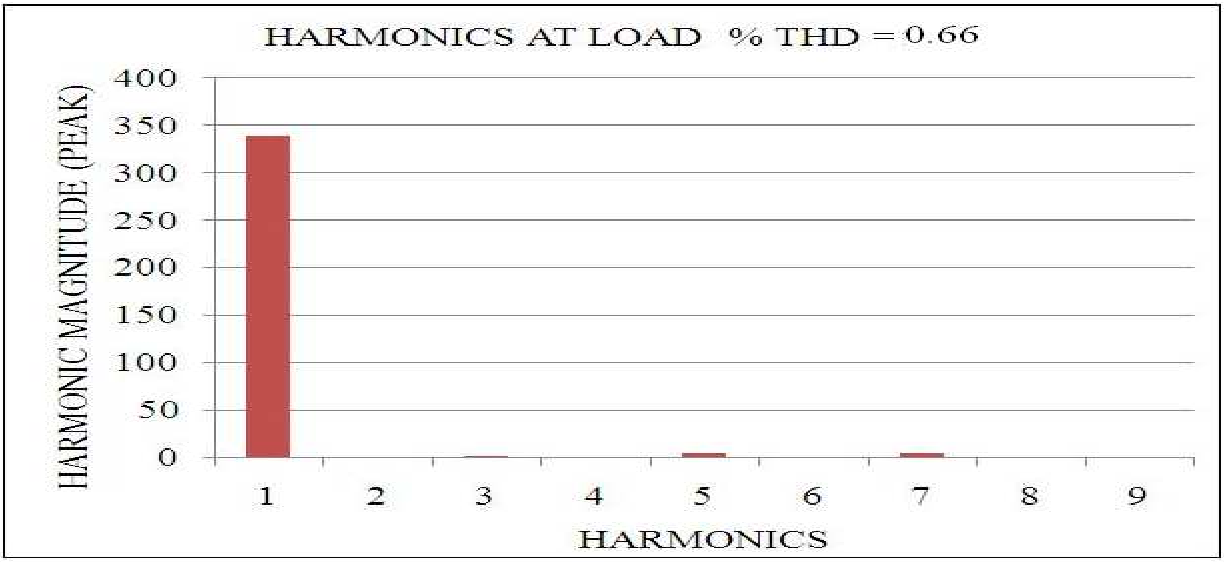

Fig. 4.8 load voltage harmonic spectrum

V. CONCLUSION & FUTURE SCOPE

For harmonic and voltage distortion compensation of the non-linear load SAPF is implemented. The simulation for is even done for the abnormal faults like L-L and L-G.The performance of the above mentioned Hysteresis controller based Series active filter(SAF) can be improved by fuzzy logic controller.

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