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Design of Smart Filter for Cancellation of Current and Voltage Harmonics in Three phase System

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Abstract -*The new way of cancellation of current and voltage harmonics in three phase system was introduced in this paper. Wide use of non-linear load, results in current harmonics causes frequent problems such as overheating of building wiring, overheating of transformer units and failure in electronics equipment. The desired aim is to reduce current and voltage harmonics to improve the power quality. A new filter having a combination of PI and Fuzzy controllers which eliminates maximum amount of harmonics.*

Key Words: power filters, hybrid power filters, passive power filters, power system harmonics.

1. INTRODUCTION

Current and voltage harmonics in power distribution system are generated by non-linear loads such as UPS, inverters, adjustable speed drives and other power electronic equipment which causes power quality issues such as over neutral current, reactive power problem, unbalanced current and low efficiency[1]. In four wire distribution system, due to delta connected primary, the triplen harmonic currents (3rd, 9th, and 15th) can only circulate in primary delta winding of transformer causing overheating. Excessive heating can reduce the bearing lubrication which collapse the bearing. Power cables carrying harmonic loads has a harmful effect on televisions, telephones, control systems and other equipment. The range 540 Hz to 1200 Hz (9th harmonic to 20th harmonic at 50 Hz fundamental) can be troublesome [2].

IEEE guidelines are suggested to limit the power quality problems created by harmonics. Thus many harmonic mitigation techniques with various passive filter configurations were developed to provide suitable impedance to harmonics such as shunt, or series or their combination. Passive filters have some shortcomings; those are fixed compensation, resonance, bulky size etc. This problem can be evaded by using active filters. Active filters are switch mode power electronic converter which supplies distortion free current. But large VA rating of active convertor.

1.1FBS Hybrid Power Filter

FBS filter topology use only single phase inductances and capacitors, without using any transformer or special electromagnetic device. This FBS filter can work as a passive filter when passive component are employed or as a hybrid filter to improve its efficiency. A FBS power filter has two different resonance frequency one for pn-seq such as 5th, 7th,11th and 13th order harmonics and another one for z-seq such as 3rd,9thand 15th order current harmonics.[3]

The diagram of FBS Filter is as shown in figure 1.The pn-seq

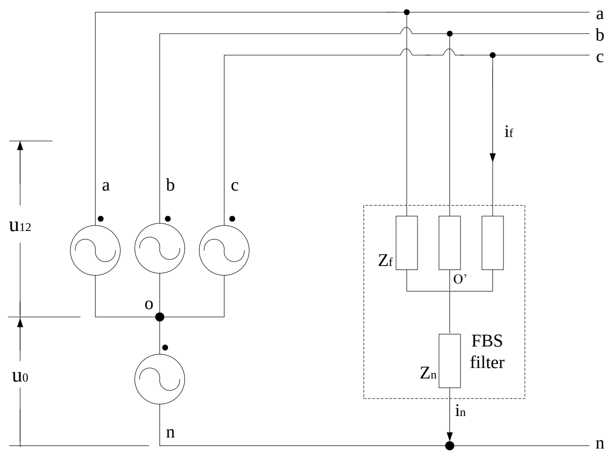

Fig -1: FBS Power Filter with impedance

and z-seq voltage components of the 3 phase network that the filter is connected to are also shown in figure 1 [4].The FBS filter consist of 3 phase branches with 3 identical single phase impedances Zf and one neutral branch impedance Zn

$\vec{Z}_{12} = \frac{V_{12}}{I_{12}}$ (1)

Where V_{12} is pn-seq voltage and I_{12} is pn-seq current.

The z-seq impedances

$\vec{Z}_0 = \frac{V_0}{I_0}$ (2)

V_0 is Z seq voltage component and I_0 is Z seq current component.

FBS Power filter with simple LC resonant cell is as shown in figure 2.

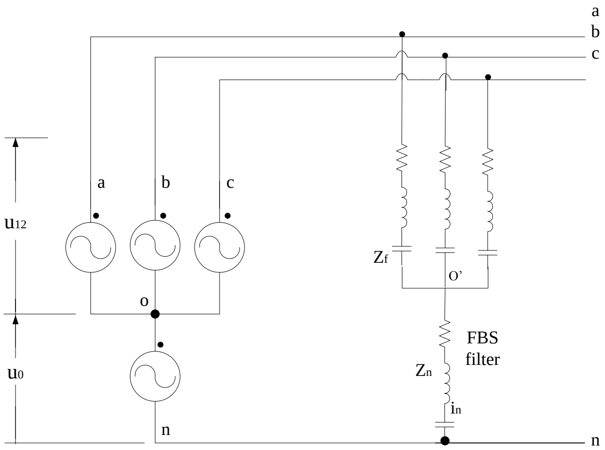

Fig -2: FBS Power Filter with LC resonant cells

The phase and neutral branch impedance are given by,

$$\vec{Z}_f = R_f + j(L_{f\omega} - \frac{1}{C_{f\omega}}) \quad (3)$$

$$\vec{Z}_n = R_n + j(L_{n\omega} - \frac{1}{C_{n\omega}}) \quad (4)$$

Following filtering parameter can be calculated by,
F_{12}=frequency of pn-seq component
Q_{12} =Quality factor for pn-seq component
F_0 =frequency of z-seq component
Q_0=Quality factor for z-seq component
These parameters are determined by,

$$F_{12} = \frac{1}{2\pi}\frac{1}{\sqrt{L_f C_f}} (5)$$

$$Q12 = \frac{1}{R_f}\sqrt{\frac{L_f}{C_f}} (6)$$

$$f_0 = \frac{1}{2\pi}\frac{1}{\sqrt{(L_f + 3L_n)\left(\frac{C_f C_n}{C_n + 3C_f}\right)}} (7)$$

$$Q_0 = \frac{1}{(R_f + 3R_n)}\sqrt{\frac{(L_f + 3L_n)(C_f + 3C_n)}{C_f C_n}} (8)$$

2. BLOCK DIAGRAM OF FBS HYBRID POWER FILTER

The control system of the FBS hybrid power filter is constituted of four main blocks shown in figure 3.

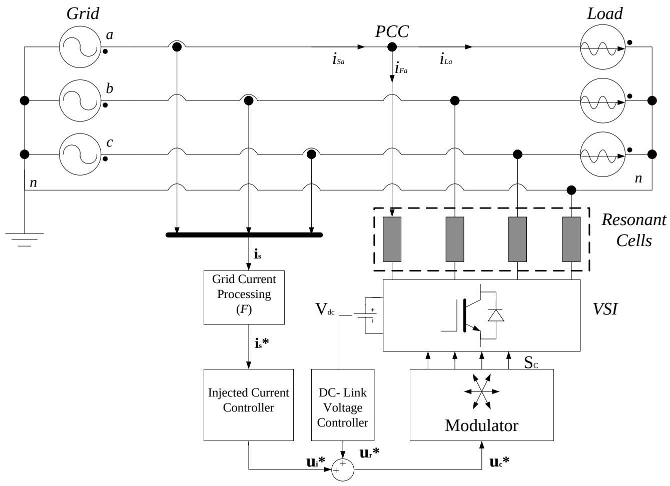

Fig -3: FBS Hybrid Power Filter

Grid current processing block (F):-It is use to select harmonics from the controlled grid current [5].
Injected current controller: - It is use to sets a reference voltage for the VSI (u_i)in order to cancel out the selected current harmonics;
Dc-link voltage controller: -It is use for modification of the original reference voltage of the VSI.
Modulator: - It is use to generates the switching signals of the VSI [6].
Figure 4 shows Simulation model for smart Filter in which we use combination of PI and Fuzzy controller [7]. Due to combination of PI and Fuzzy performance are improved than previous one. Figure 5 shows generating side of filter which consist of grid and which supply power to any type of load. In figure 5 we use VI measurement for taking reading of voltage and current.Figure6 shows Load side of Smart Filter which is shown by L. Figure 7 shows Smart Filter which is shown by F. Filter consist of Grid current processing block, injected current controller Discrete PWM Generator, IGBT Switches, Capacitance, Inductance [8].

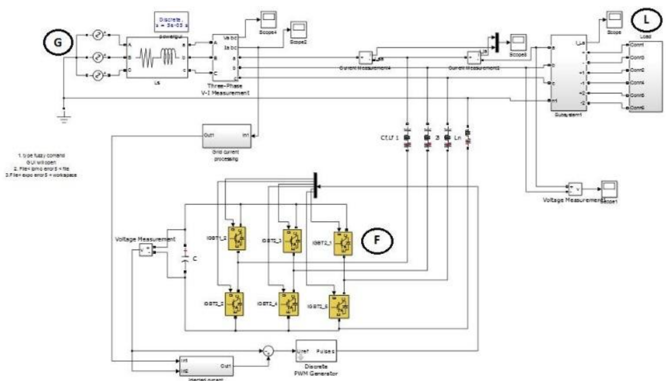

Fig -4: Simulation model of smart filter with combination of pi and fuzzy controller

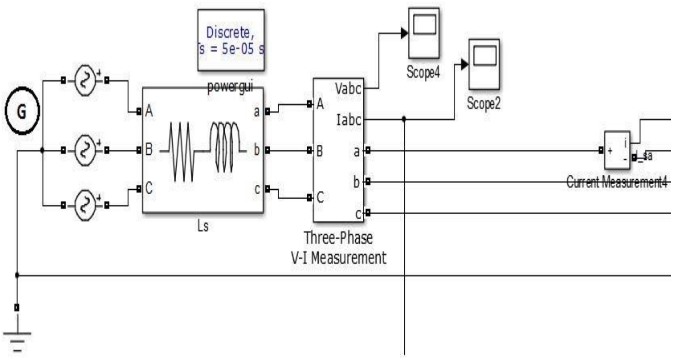

Fig -5: Grid part of Simulation model of smart Filter topology with combination of pi and fuzzy controller

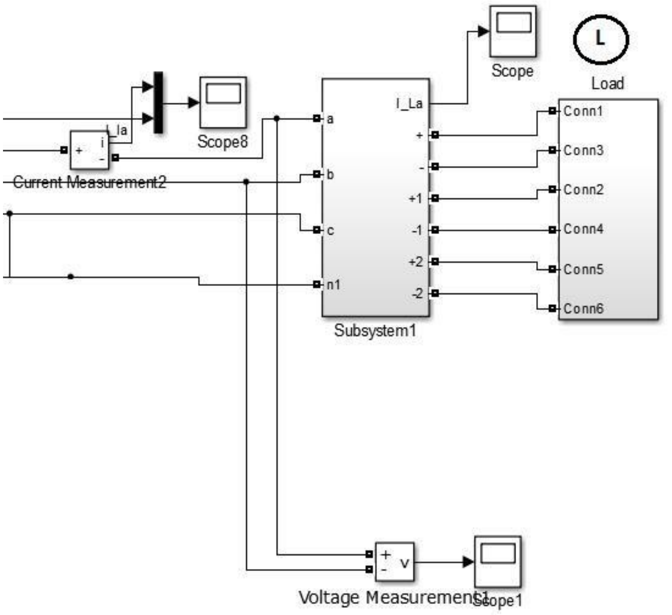

Fig -6: Load part of Simulation model of smart Filter topology with combination of pi and fuzzy controller

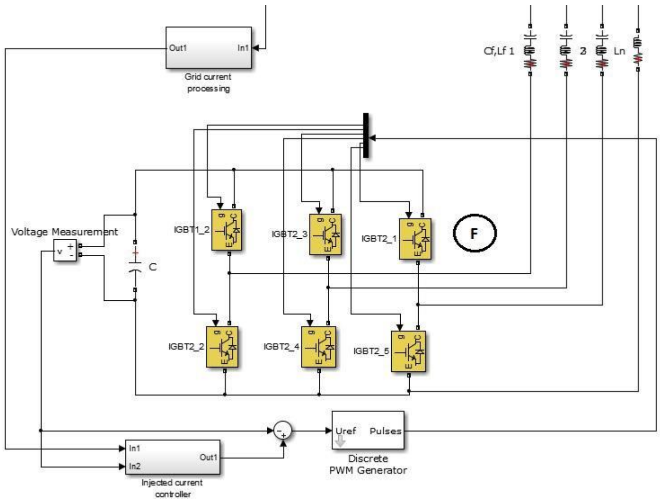

Fig -7: Filter part of Simulation model of smart Filter topology with combination of pi and fuzzy controller

3. EXPERIMENT RESULTS

Table -1: Grid Parameter

Sr. No	Parameter	Value
1	Line voltage	400V
2	Line Resistance	240m
3	Line Inductance	3:2mH
4	Frequency	50Hz

Table -2: Load Parameter

Sr. No.	Parameter	Value
1	Load Resistance	200ohm
2	Load Inductance	0.1H
3	Load	1KW

Table -3: Input Parameters of Smart Filter

Sr. No.	Parameter	Value
1	Filter phase branch inductance	8:5mH
2	Filter phase branch resistance	244m-ohm
3	Filter phase branch capacitance	33:5 F
4	Filter phase branch inductance	8:5mH
5	Filter phase branch resistance	244m-ohm
6	Nominal DC link voltage	45v
7	DC link capacitor	14100 F
8	Switching Frequency	14:4kHz

Table -4: Comparison between PI and combination of PI and Fuzzy Controller

Sr. No.	Component	THD with PI Controller	THD with combination of PI and Fuzzy Controller
1	Is	10.42	2.43
2	IL	9.96	0.22
3	Is-L	10.46	2.43
4	Vs	0.61	0.15
5	VL	0.92	0.22

Following figures shows FFT analysis of THD of combination of PI and fuzzy controller.

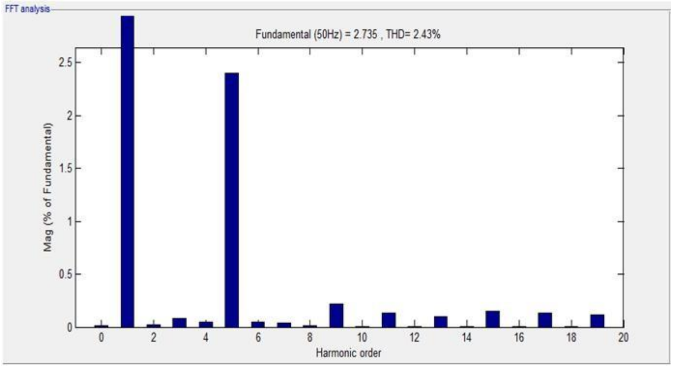

Fig -8: FFT analysis for source current

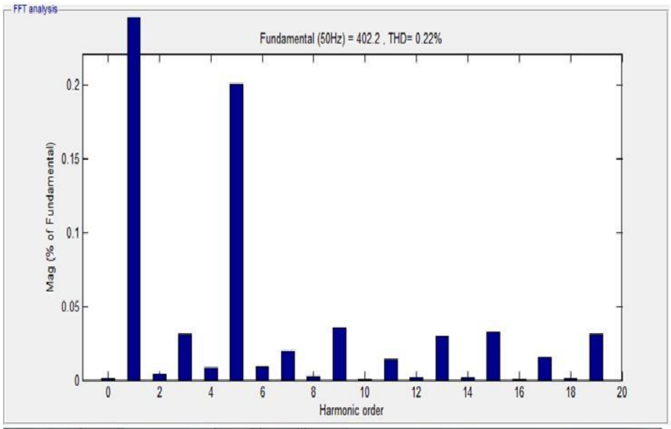

Fig -9: FFT analysis for load current

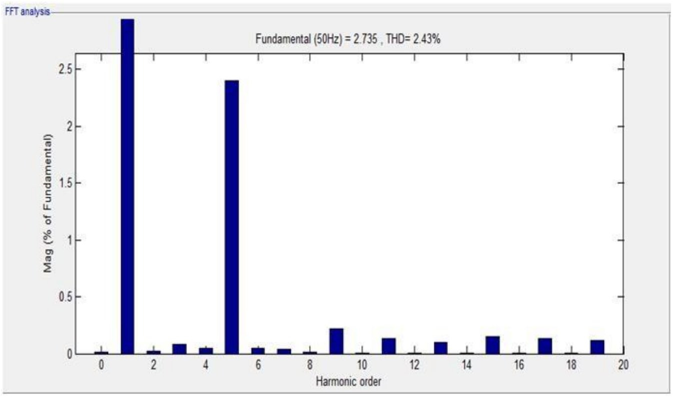

Fig -10: FFT analysis for source-Load current

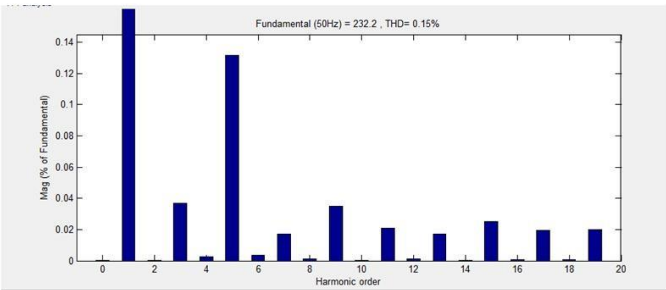

Fig -11: FFT analysis of Source voltage

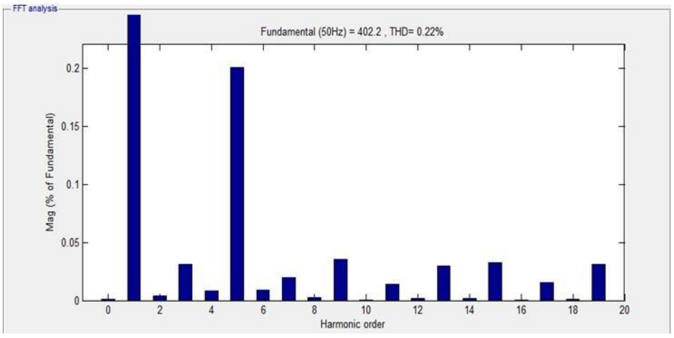

Fig -12: FFT analysis of Load voltage

4. CONCLUSIONS

In this Smart Filter two controllers are developed and verified with three phase four wire system. Even though both controllers are capable to compensate the current and voltages harmonics in the 3 phase 4-wire system, it is observed that the fuzzy controller shows more dynamic performance over conventional PI controller. Source voltage and current THD is satisfactorily reduced by using Smart filter which are checked by simulink / matlab software.

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