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Modeling and Simulation of Shunt Active Filter for Non Linear Load

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ABSTRACT

Uninterrupted power supply, variable speed drives and rectifiers are some of the non linear loads and they produce non sinusoidal current from the network. Shunt active filters connected in parallel to the load act as a current source with opposite phase to harmonic current opposes the current harmonics. This proposed study deals tuning of Shunt Active Filter (SAF) along with Artificial Neural Network (ANN) controller. Shunt active filter recompenses reactive power and improve the power factor. ANN is used for extracting the harmonics' fundamental component in the load current which is used as reference for the mains supply. This reference is compared to actual supply current and then error is given as input to hysteresis current controller, which in turn tunes the SAF. The usage of ANN simplifies the hardware to a great extent.

Key words: Shunt active filter, hysteresis controller, artificial neural network

INTRODUCTION

Power quality (Berbaoui and Benachaiba, 2011) means maintaining the supply voltage at its rated RMS value and the system frequency around a nominal value with least amount of interruption. Power quality (Akagi, 1996; Salam *et al.*, 2006) is becoming important due to non-linear loads for instance diode bridge rectifiers, amendable speed drives; arc furnaces etc., have introduced voltage and current harmonics. The harmonics (Tao *et al.*, 2009) generated by these non-linear loads flow from the load to the source and distort the source (Salam *et al.*, 2006; Singh *et al.*, 1998). This forms a low impedance path to ground, which cause low power factor (Akagi, 2006) and large transmission-cum-distribution-line expiration.

With recent developments in the field of power electronics, more and more power electronic appliances are widely used for meeting industrial, commercial and consumer needs (Salam *et al.*, 2006). In rectifier type of converters, power conversion is achieved by diode bridge rectifiers which are simple and highly reliable where only fixed DC voltages are required. Whenever the DC voltage has to be controlled, thyristors are used in placed of diodes.

In the recent years single phase utility power is increasingly (Singh *et al.*, 1998) brought into play in inhabited heating, venting as well as a/c's. In these applications bridge rectifiers are used at the back end of the power stage. The performance of these converters has significant effect on the power network. The rectifier sops up pulsed current in service line because of their non-linearity, topology and switching operation causing abject power factor, squat efficiency along with soaring rating of switching devices.

Harmonics cause problems like paraphernalia overheating (Chandra *et al.*, 2000), capacitor vaunting, motor pulsation, extreme neutral currents with decreased power factor. Conventional method to allay the harmonics, responsive power compensation is by using passive LC filters (Akagi, 2006) but this method has drawbacks like bigger size, resonance and fixed compensation behavior etc. and becomes ineffective.

The Shunt Active Filter (SAF) provides result to compensate (Jou *et al.*, 2005) for above effects simultaneously by using suitable control algorithms (Chandra *et al.*, 2000; Tey *et al.*, 2002; Lu *et al.*, 2003). Shunt Active Filter (SAF) (Kouzou *et al.*, 2010) is designed based on Artificial Neural Network (ANN) (Rukonuzzaman and Nakaoka, 2001) for stifling harmonic components that are produced via nonlinear loads (Janpong *et al.*, 2011). The SAF is switched based on the hysteresis current control (Buso *et al.*, 2000). For the extraction (Lu *et al.*, 2003) of the fundamental component current from the load current, Artificial Neural Network (ANN) technique is implemented.

The retrieval routine of adaptive neural network (Lu *et al.*, 2003) is used in the approximation of harmonic component (Nouri and Seifi, 2012). Widrow-Hoff learning rule (least mean square LMS algorithm) (Lu *et al.*, 2003) obtains the Weight (W). To modify weight (Rukonuzzaman and Nakaoka, 2001; Lu *et al.*, 2003; George and Agarwal, 2005) the modified Widrow-Hoff learning rule is followed. SAF reference current is generated as per weight estimation founded on neural network.

SINGLE PHASE SHUNT ACTIVE FILTER CONFIGURATION

The schematic representation of SAF is shown in Fig. 1. It spawns actively a harmonic current spectrum in opposite phase to the distorting harmonic current that was measured

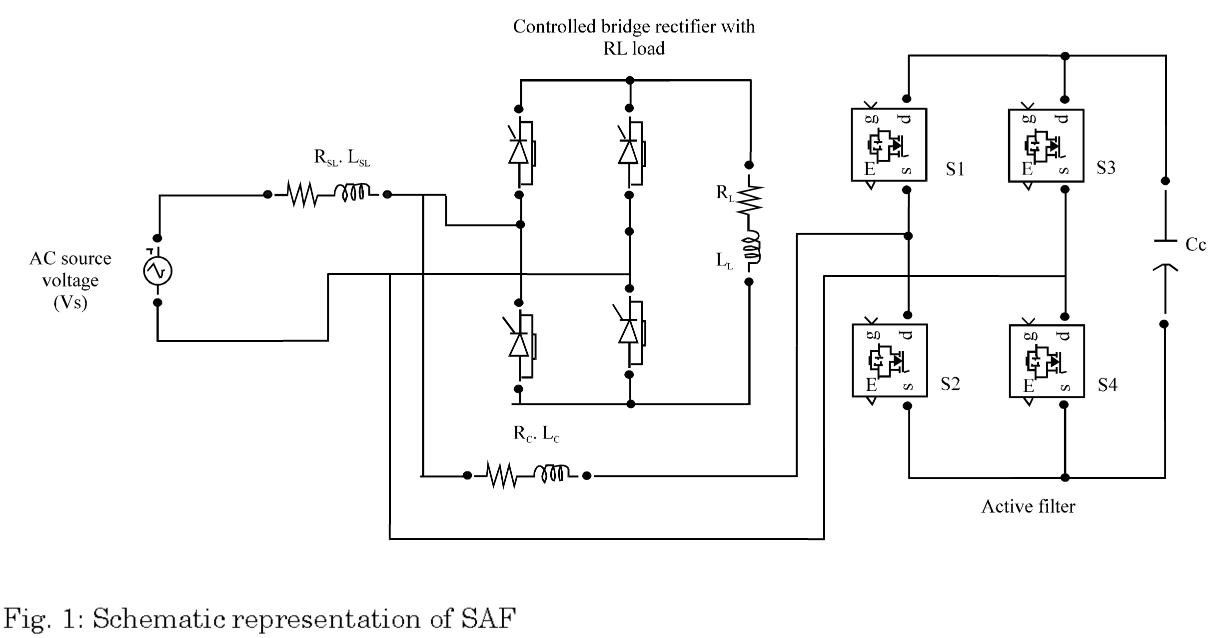

Fig. 1: Schematic representation of SAF

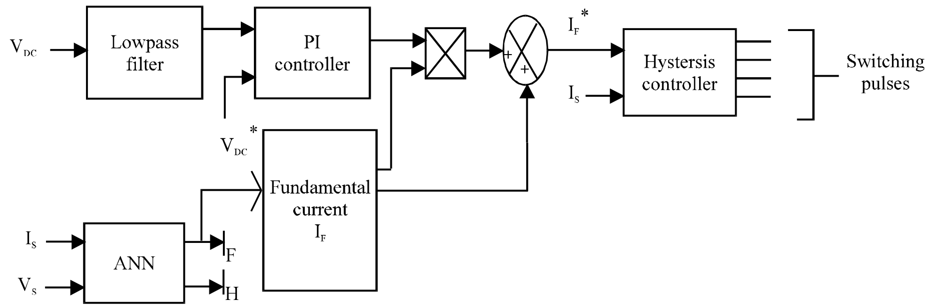

Fig. 2: Block diagram representation of SAF with ANN controller

(Giri *et al*., 2010). The original harmonics are thereby cancelled. The voltage source inverter is used like active filter and current is of same magnitude as load but contrary in phase. The filter's control along with active generation of the compensating current allows for a concept that may not be overloaded. The active filter will operate and reduce all harmonic currents up to its capacity. It can also be noted that the active filter considered here has a parallel topology. Thus, the supply current is free from harmonics; power factor also gets near to unity.

MODELING OF SAF

The schematic representation of SAF shown in Fig. 1 can be modeled using state space method (Giri *et al*., 2010).

Then, the general equation for the above system is given as Eq. 1:

$$\left.\begin{aligned} L_f \frac{di_f}{dt} &= V_s - V_{AB} \\ c_f \frac{dV_{dc}}{dt} &= i_{dc} \end{aligned}\right\} \quad (1)$$

CONTROL STRATEGY

Figure 2 shows control block diagram of SAF. The output of the Proportional Integral (PI) controller which is used to maintain the inverter DC side voltage (V_{DC}) constant. This output is compared with the value of the generated compensating current (I_F*) and difference between the two values are input to the hysteresis controller. The fundamental component current (I_F) is extracted from the total distorted current (I_H) (Dehini *et al*., 2012) by using ANN modified algorithm method (Rukonuzzaman and Nakaoka, 2001; Janpong *et al*., 2011; Lu *et al*., 2003). Tangible supply current (I_S) and its reference counterpart (I_F*) are compared using hysteresis current controller for deriving switching pulses for MOSFET's in active filter.

Hysteresis controller: The hysteresis control (Vahedi, 2012; Abedi and Vahedi, 2013) generates gating signal to MOSFET's thereby controlling inverter output's both phase and magnitude. The inverter device gets switched by comparing actual supply current and its elementary constituent. Hysteresis band controller (Vahedi, 2012; Buso *et al.*, 2000) chooses active filter's switching pattern (Mao *et al.*, 2012) put together as:

- If Is<(IF*-HB)-upper switch-OFF; lower switch-ON if leg "a" (SA = 1)
- If Is>(IF*+HB)-upper switch-ON and lower switch-OFF if leg "a" (SA = 0)

MATLAB simulation: Simulation is done by MATLAB Simulink. Shunt active filter is premeditated through the block, power system. The firing angle α is changed from 18-90°. The design specifications and selection of system parameters used in simulation study are indicated in Table 1.

RESULTS AND DISCUSSION

Simulation upshots are depicted in Fig. 3 and it portrays active filter's response in the company of ANN control method. Waveforms for supply current without and with filter are publicized in Fig. 3a-b. Figure 3c shows supply voltage and supply current with filter. Figure 3d-e presents supply current harmonic spectrum without and with filter behind reimbursing $\alpha = 54°$. Obviously the supply voltage is in same phase as that of supply current. SAF gives power factor nearer to unity and reduces the current harmonics. Table 2 shows the comparison of simulation results with and without SAF. THD for supply current is abridged from 28.33% without AF to 1.94% with AF by using ANN control method.

Unlike conventional methodology where the correction equipment requires comparatively large voltage, current ratings and this scheme requires only a much reduced voltage and current handling capability. This is examined in conjunction with a controlled bridge rectifier load circuit which is a popular method for generating DC power supply. As is well known, converters employing thyristors with RL are non-linear in nature and impose inherent current discontinuity on the supply side leading to higher harmonic content low power factor. Active filter is verified via Matlab simulink. From simulation results, this system gives unity power factor correction and thus reduces harmonics.

Table 1: Design specifications and selection of system parameters for simulation

Parameters	Values
Ac source voltage (V_s) (peak) (V)	100
Load resistor (R_L) (Ω)	20
Load inductor (L_L) (mH)	1
Inverter side inductance (L_c) (mH)	2
Inverter side DC capacitance (C_c) (μF)	1000

Table 2: Comparison of simulation results with and without SAF

	Firing angle ($\alpha = 54°$)			
	Without SAF		With SAF	
Results (supply side)	Power factor	THD (%)	Power factor	THD (%)
Simulation	0.81	28.33	0.99	1.94

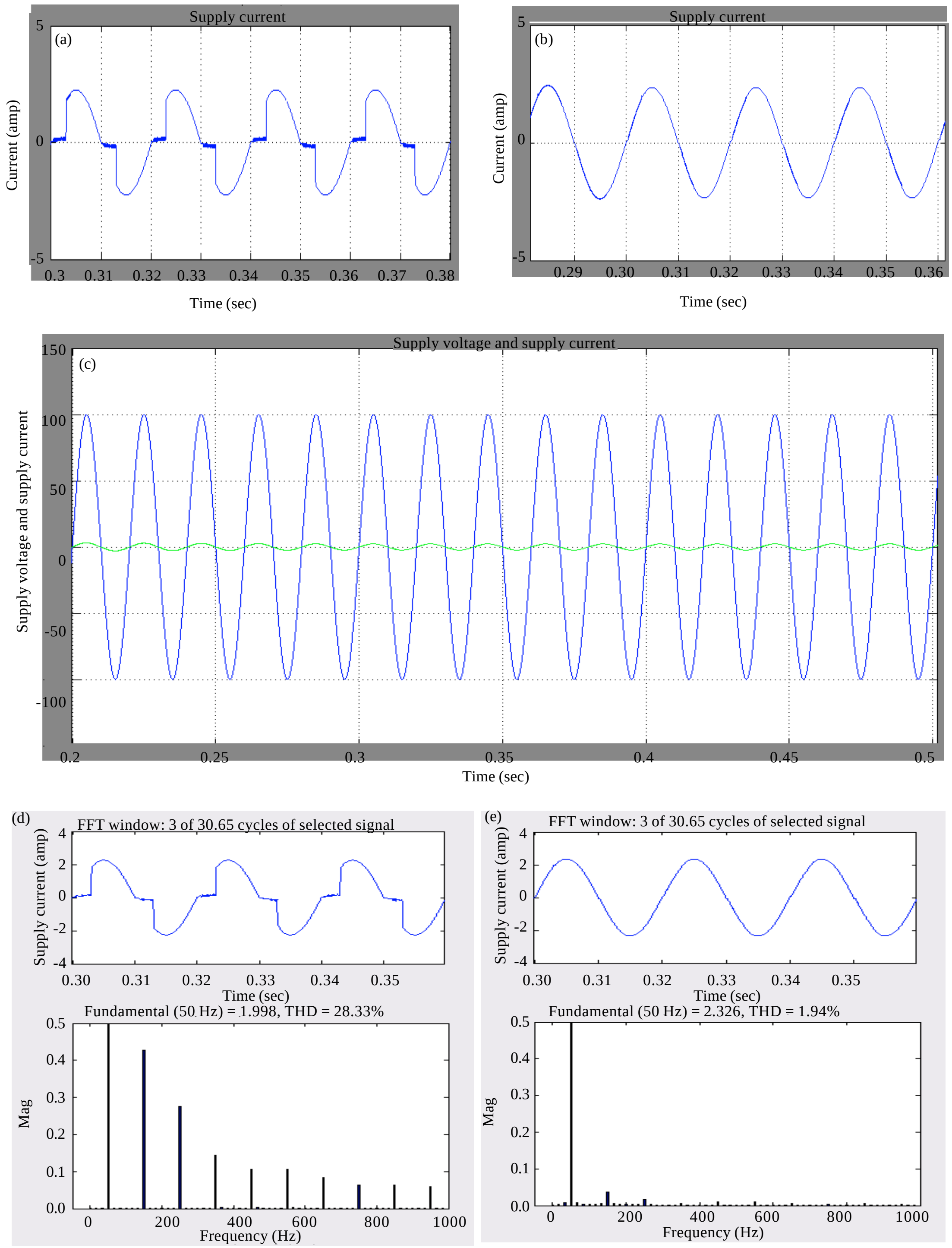

Fig. 3(a-e): Simulation results of proposed SAF, (a) Supply side current waveform without filter, (b) Supply side current waveform with filter, (c) Supply voltage and supply current with filter, (d) Harmonic spectrum of supply current without filter and (e) Harmonic spectrum of supply current with filter

CONCLUSION

This proposed study is concerned with modeling and simulation of Shunt Active Filter (SAF) in support of a novel harmonic correction in addition to reactive power compensation. The results of simulation study of ANN based control technique are found agreeable to reduce supply current harmonics and reactive power compensation. SAF for the compensation of harmonic current in nonlinear load was successful and making the utility supply line current sinusoidal. The validity of this method is to compensate current harmonics and improvement on power factor was proved based on simulated results. The progression in power factor of 0.99 (original value = 0.81) as well as Total Harmonic Distortion (THD) gets reduced to 1.94 from 28.33%. In future, these design concepts on SAFs to be validated by experimental results. Furthermore, the current analysis and simulation results used as a fundamental step towards designing control circuits for hardware implementation of the active filters.

REFERENCES

Abedi, S.M. and H. Vahedi, 2013. Simplified calculation of adaptive hysteresis current control to be used in active power filter. Trends Applied Sci. Res., 8: 46-54.

Akagi, H., 1996. New trends in active filters for power conditioning. IEEE Trans. Ind. Appl., 32: 1312-1322.

Akagi, H., 2006. Modern active filters and traditional passive filters. Bull. Polish Acad. Tech. Sci., 54: 255-269.

Berbaoui, B. and C. Benachaiba, 2011. Power quality enhancement using shunt active power filter based on particle swarm optimization. J. Applied Sci., 11: 3725-3731.

Buso, S., S. Fasolo, L. Malesani and P. Mattavelli, 2000. A dead beat adaptive hysteresis current control. IEEE Trans. Ind. Appl., 36: 1174-1180.

Chandra, A., B. Singh, B.N. Singh and K. Al-Haddad, 2000. An improved control algorithm of shunt active filter for voltage regulation, harmonic elimination, power factor correction and balancing of nonlinear loads. IEEE Trans. Power Electron., 15: 495-507.

Dehini, R., B. Ferdi and B. Bekkouche, 2012. Fuzzy logic controller optimization based on GA for harmonic mitigation. J. Artif. Intell., 5: 26-36.

George, S. and V. Agarwal, 2005. A novel, DSP based algorithm for optimizing the harmonics and reactive power under non-sinusoidal supply voltage conditions. IEEE Trans. Power Delivery, 20: 2526-2534.

Giri, F., A. Abouloifa and I. Lachkar and F.Z. Chaoui, 2010. Formal framework for nonlinear control of PWM AC/DC boost rectifiers-controller design and average performance analysis. IEEE Trans. Control Syst. Technol., 18: 323-335.

Janpong, S., K.L. Areerak and K.N. Areerak, 2011. A literature survey of neural network applications for shunt active power filters. World Acad. Sci. Eng. Technol., 60: 392-398.

Jou, H.L., J.C. Wu, Y.J. Chang and Y.T. Feng, 2005. A novel active power filter for harmonic suppression. IEEE Trans. Power Delivery, 20: 1507-1513.

Kouzou, A., M.O. Mahmoudi and M.S. Boucherit, 2010. Apparent power ratio of the shunt active power filter under balanced power system voltages. Asian J. Applied Sci., 3: 363-382.

Lu, C., B. Shi and L. Chen, 2003. An expandable on-chip back propagation learning neural network chip. Int. J. Electr., 90: 331-340.

Mao, H., X. Yang, Z. Chen and Z. Wang, 2012. A hysteresis current controller for single-phase three-level voltage source inverters. IEEE Trans. Power Electron., 27: 3330-3339.

Nouri, M.A. and A.R. Seifi, 2012. A new reinforcement learning optimization method for capacitor allocation considering variable load. Trends Applied Sci Res., 7: 210-220.

Rukonuzzaman, M. and M. Nakaoka, 2001. Adaptive neural network based harmonic current compensation in active power filter. Proceedings of the International Joint Conference on Neural Networks, Volume 3, July 15-19, 2001, Washington, DC., USA., pp: 2281-2286.

Salam, Z., P.C. Tan and A. Jusoh, 2006. Harmonics mitigation using active power filter: A technological review. Fac. Electrical Eng., 8: 17-26.

Singh, B., K. Al-Haddad and A. Chandra, 1998. A universal active power filter for single-phase reactive power and harmonic compensation. Power Qual., 18: 81-87.

Tao, G., L. Baoshen and Z. Jin, 2009. A high precision selective harmonic compensation scheme for active power filters. Inform. Technol. J., 8: 89-94.

Tey, L.H., P.L. So and Y.C. Chu, 2002. Neural network-controlled unified power quality conditioner for system harmonics compensation. Proceedings of the Transmission and Distribution Conference and Exhibition, Volume 2, October 6-10, 2002, Yokohama, Japan, pp: 1038-1043.

Vahedi, H., 2012. Double band adaptive hysteresis current control employed in active power filter. Trends Applied Sci. Res., 7: 151-159.