International Journal for Research in Engineering Application & Management (IJREAM)
ISSN : 2454-9150 Vol-04, Issue-10, Jan 2019

Harmonics Compensation in Current Source Type of Non-Linear Load by HBCC Technique

[1]Dinesh Chandra, [2]Krishan Kumar

[1,2]Department of Electrical Engineering, MIT, Bikaner, India.

[1]prajapat73@gmail.com, [2]krishankaler@gmail.com

Abstract - This work presents a study on the use of a shunt active power filter using Hysteresis band current control technique, where the voltages are unbalanced due to non linear load. In modern industrial applications, due to use of non linear load, increase complexity of the system and also make it difficult to harmonics free and results the instabilities of the systems in terms of voltage and frequency. This paper concentrate the design of two different control strategies for shunt Active power filter to improve power quality in distribution system. A detail analysis has been carried out on shunt active power filter on non linear load. Simulations and analysis are carried out in MATLAB/SIMULINK with this control method for proposed systems. The experimental result can be easily extended to other possible system on similar lines.

Keywords: Shunt active power filter, non linear load, Hysteresis band current control, etc

I. INTRODUCTION

Power Quality (PQ) related issues are of most concern nowadays. The widespread use of electronic equipment, such as information technology equipment, power electronics such as adjustable speed drives (ASD), programmable logic controllers (PLC), energy-efficient lighting, led to a complete change of electric loads nature. These loads are simultaneously the major causers and the major victims of power quality problems. Due to their non-linearity, all these loads cause disturbances in the voltage waveform. Along with technology advance, the organization of the worldwide economy has evolved towards globalisation and the profit margins of many activities tend to decrease. The increased sensitivity of the vast majority of processes (industrial, services and even residential) to PQ problems turns the availability of electric power with quality a crucial factor for competitiveness in every activity sector. The most critical areas are the continuous process industry and the information technology services.

1.1 Shunt Active Power Filter

Active power filters were proposed by Sasaki and Machida for removing current harmonics in 1971[1].At that time this technology was theoretical only. Then advances in power semiconductor devices and development in DSP processor lead to more improvement in Active power filter technology. Because of these fast switching semiconductor technology Active power filter installed in power system. Active power filter gives excellent performance in filtering of harmonics; size of active filter is small and very flexible as compared with passive filter. Active power filters are broadly classified as Series and Shunt filter. These series and shunt filter can work in same system together or individually. Sometime active and passive filter both acts together in system. Active power filter for three-phase system, which can be used for current harmonics and power factor correction. Same time load balancing, reduction of current in neutral wire can also be achieved [2].

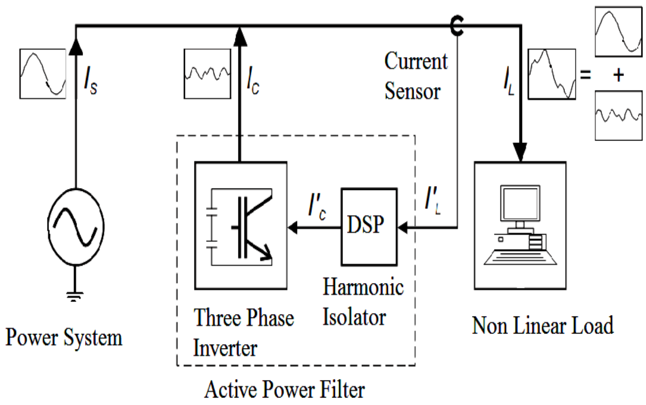


Fig. 1.1 Single Line Diagram of Active Power Filter (APF)

Problem of resonance can take place in series active filter. To solve problem of resonance shunt active filter proposed [3], [4]. Usually connected at load sites, it offers low impedance path to harmonic currents. Cost of shunt Active filter is less than series active filter. Size of shunt active filter is less than passive filter. Shunt active filter draw very less current from the system. Shunt active filter mainly used for current harmonic filtering, Reactive current compensation, Current unbalance, Voltage flicker.

A lot of topology of shunt active power filter has been proposed in [5], [6], and [7]. For highly non-linear load, shunt active power filter based on current controlled

 DOI : 10.18231/2454-9150.2018.1318

voltage source converter has been proved very effective [8], [9]. There is resonance on between the line inductor and capacitor installed for power factor correction, this phenomenon is called harmonic propagation. A shunt active power filter behaving like resistor for harmonic frequencies work as harmonic damper is used in [10]. When shunt active power filter is connected between renewable energy source and grid, it injects active power to the grid [11]. For improving the power quality at PCC, Shunt APF is used to mitigate line current harmonics and the neutral current [12].

1.2 Current Source Type Nonlinear Load

Current source type nonlinear load contains an inductor in series with resistance. Whenever there is inductor in series with the DC voltage, it will produce constant current and behave as constant current source [13-14]. In DC, side of rectifier output voltage is pulsating in nature. When inductor is in series with the resistance is connected at DC side of rectifier as shown in Fig.1.2 then inductor will try to make current constant. Because of pulsating DC current, will not pure constant it will have current ripple. Current source type load is simulated in Matlab/simulink environment response of this type load shown in Fig.1.3

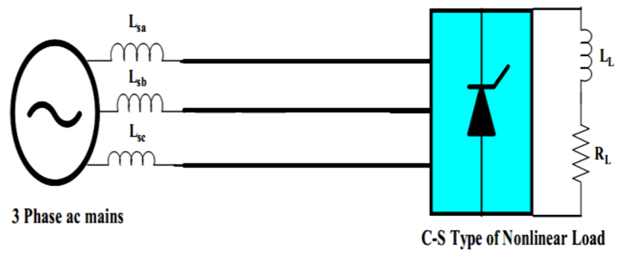


Fig. 1.2 Current Source Type Nonlinear Load

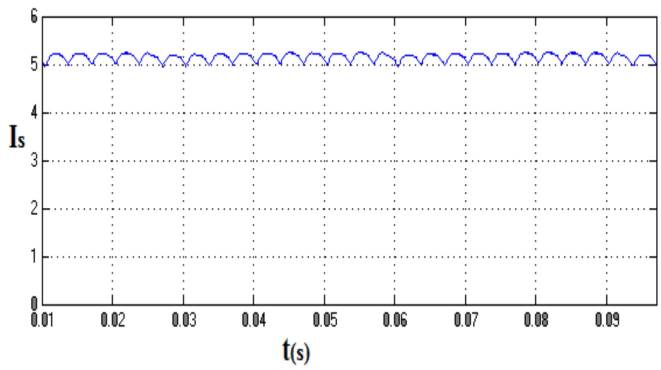


Fig.1.3 Output of Current of the Current Source Type Load

It can be seen that current is not purely constant, it has current ripple. By increasing value of inductor, current ripple can be reduced. This type of load gives almost constant current at DC side of rectifier i.e. known as current source type load.

Simulation models have been designed to verify the working of Shunt Active Power Filter (SAPF). A four leg SAPF is used for Power Quality (PQ) improvement. A model of shunt active power filter using active current component theory and Synchronous Reference Frame theory (SRFT) are develop in MATLAB. Set of load is modelled and applied on system to verify the whether SAPF is able to improve power quality in non linear load conditions.

Load Set is compostions of following different loads:-

1. A three phase balanced current source type controlled nonlinear load
2. A single phase current source type uncontrolled nonlinear load connected between phase 'c' and neutral.
3. A linear RL load connected between phase 'a' and neutral.

A three phase supply voltage with neutral is consider as supply grid which is also called as three phase four wire system. There are loads connected between phase and neutral so there will be neutral current hence it will make the system unbalance. So work of APF is to balanced the supply current so that neutral current becomes zero, and inject harmonic current in phase opposition so that source current become harmonics free.

Table 1.1: Specification of Parameters

Phase voltage and frequency V	60 V,60 Hz
Supply /line inductance ,resistance	7mH,.8 Ω
Coupling inductance	2mH
For CS Type Load resistance, load inductance	26.66 Ω,10 mH
For CS Single phase b/w c and n	36.66 Ω,10mH
Single phase linear load b/w a and n	60 Ω,10mH
Inverter DC(bus voltage and capacitance	90 V, 3000µF
Controller Parameter	K_p=0.5,K_i=10, K_p=0.8,K_i=12,

2.1 Power Quality Improvement for non linear Load

2.1.1 Source Current without Compensation

When three four wire system is feeding power to group of nolinear and linear load, then there will be harmonics in source current. Source current shown in Fig.2.1

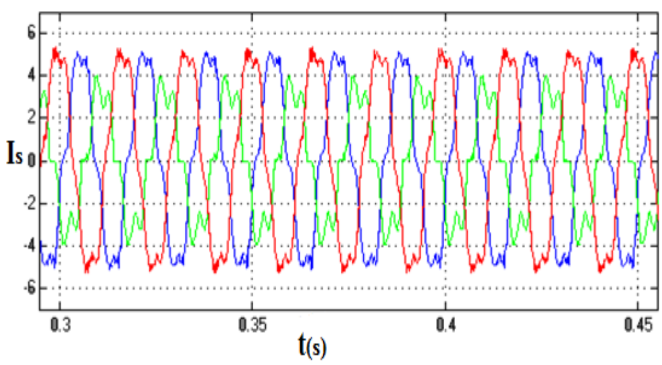


Fig.2.1. Souce Current Waveform without Compensation

It can be seen in Fig.2.1 that source current is unbalance and contains harmonics. FFT analysis done for finding their

 DOI : 10.18231/2454-9150.2018.1318

THDs of each phase.THD of each phase shown in Fig.2.2, 2.3 and 2.4.

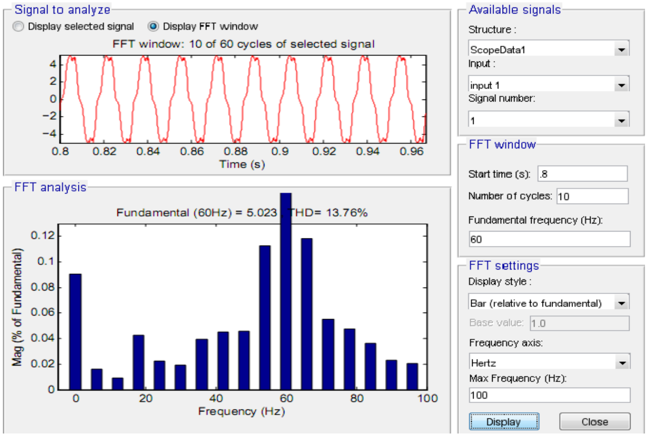


Fig.2.2 THD of Phase ‘a’ Before Compensation

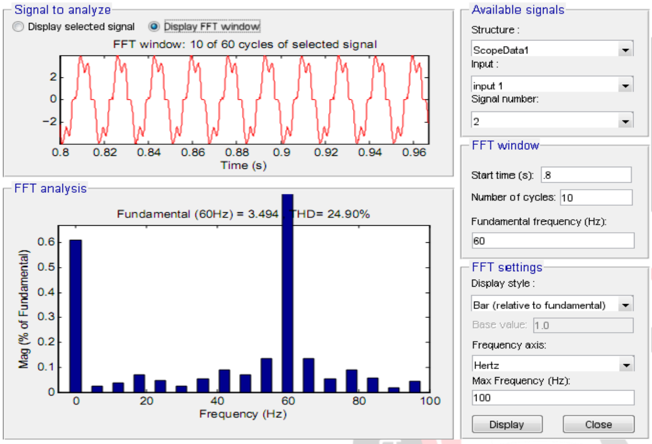


Fig.2.3 THD Of Phase ‘b’ Before Compensation

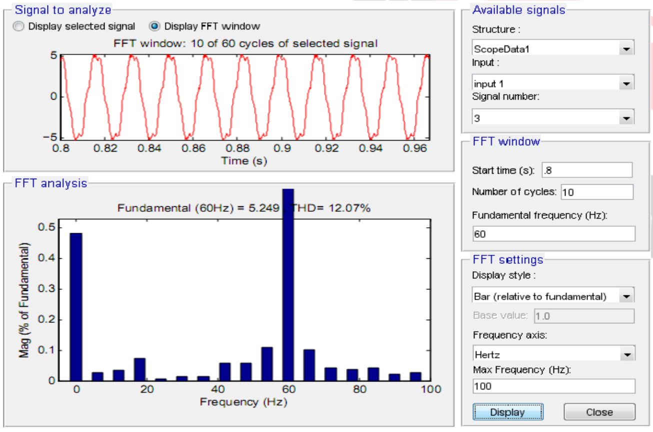


Fig.2.4 THD of Phase ‘c’ Before Compensation

It can be seen that THD of phase ‘a’ is 13.76 %, phase ‘b’ 24.90 % and for phase ‘c’ 12.07 %. Current of each phase is highly polluted and unbalanced. For reducing the THD (improving power quality), shunt active power filter is connected with the system using two different control strategies.

2.1.2 Source Current Compensation using different Techniques

Source current is compensated with the both techniques. Source current waveform after compensation using active current component theory shown in Fig.2.5 Source current waveform after compensation using synchronous reference frame theory shown in Fig.2.6

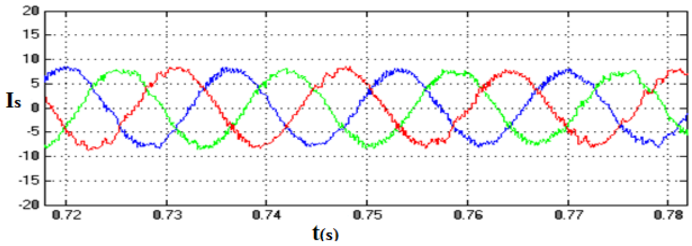


Fig.2.5 Compensated Source Current Using Active Current Component Theory

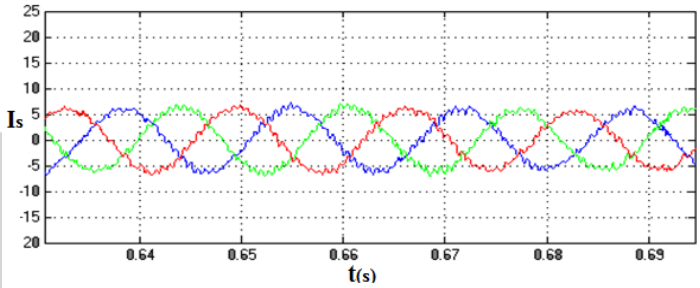


Fig.2.6 Compensated Source Current Using SRFT

It can be seen that harmonic contents in the source current is reduced. Source current become almost balanced after compensation. FFT analysis is done for finding THDs of each phase. THD of each phase is shown in Fig.2.7, 2.8, 2.9, 210, 2.11 and 2.12.

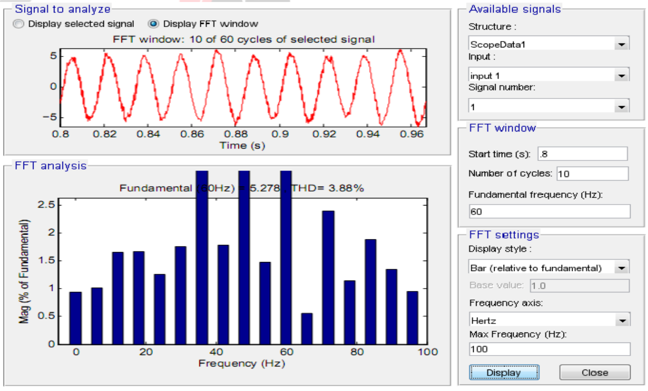


Fig.2.7 THD of Phase ‘a’ Using Active Current Component Theory

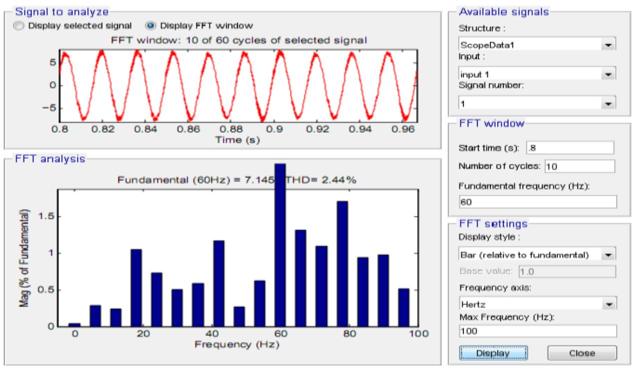


Fig.2.8 THD of Phase ‘a’ Using SRFT

 DOI : 10.18231/2454-9150.2018.1318

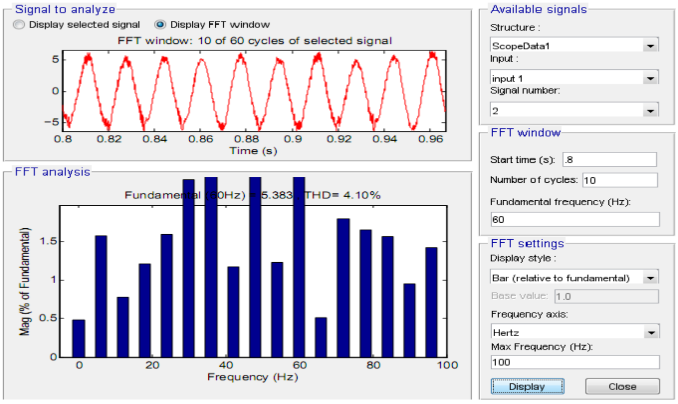


Fig.2.9 THD of Phase 'b' Using Active Current Component Theory

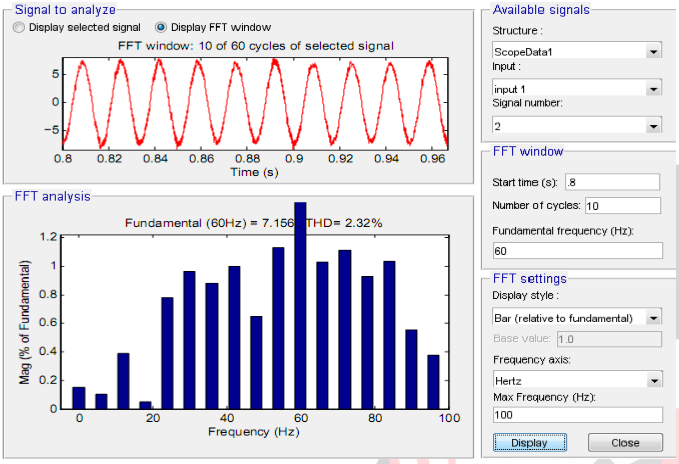


Fig.2.10 THD of Phase 'b' Using SRFT

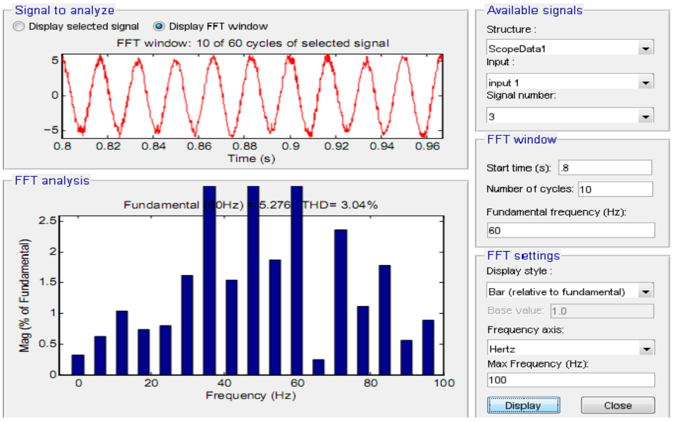
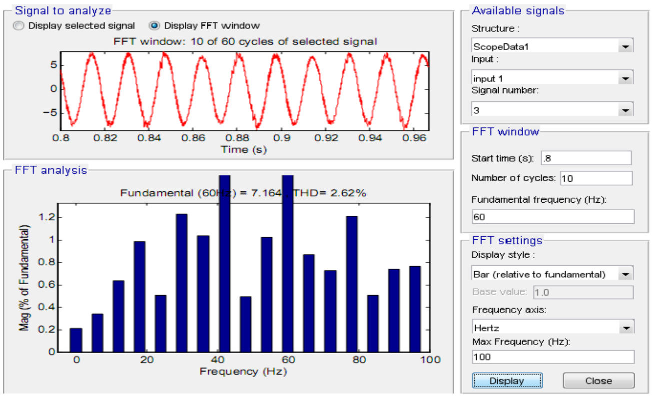


Fig.2.11 THD of Phase 'c' using Active Current Component Theory



Fog.2.12 THD of Phase 'c' Using SRFT

THD of phase 'a' using active current component theory and synchronous reference frame theory shown in Fig.6.27& 6.28. Before compensation, THD of phase 'a' was 13.76 %. Using active current component theory THD reduced to 3.88 % and by using synchronous reference frame theory THD reduced to 2.44%. Therefore, both techniques are able to improve the power quality.

THD of phase 'b' using active current component theory and synchronous reference frame theory shown in Fig.6.29, 6.30. Before compensation, THD of phase 'a' was 24.90 %. Using active current component theory THD reduced to 4.10 % and by using synchronous reference frame theory THD reduced to 2.32 %. Therefore, both techniques are able to improve the power quality.

THD of phase 'c' using active current component theory and synchronous reference frame theory shown in Fig.6.31, 6.32. Before compensation, THD of phase 'a' was 12.07%. Using active current component theory THD reduced to 3.04 % and by using synchronous reference frame theory THD reduced to 2.62 %. Therefore, both techniques are able to improve the power quality.

It can be seen from above discussion that synchronous reference frame theory is improving power quality better than active current component theory.

Table 2.1: Current Source Type of Non-Linear Load

Currents	THD(%) before compensation	THD(%) after compensation	
		Active Current Component Theory	Synchronous Reference Frame Theory
Phase a	13.76	3.88	2..44
Phase b	24.90	4.10	2.32
Phase c	12.07	3.04	2.62

Hence, the simulation results for different control strategies for different loads were obtained. For current source type nonlinear load, the THD of phase 'b' is compensated from 24.90 to 4.10 by Active Current Component Theory and 2.32 by synchronous reference frame theory. SRFT is better response than Active Current Component Theory.

HBCC technique used for the switching pulse generation was found to be effective and its validity is proved based on simulation results. Thus Active Current Component Theory and SRFT have been proved to be effective to keep the harmonic content in power lines within the permissible limit of IEEE standards.

II. Conclusion

HBCC technique used for the switching pulse generation was found to be effective and its validity is proved based on simulation results. Thus Active Current Component Theory and SRFT have been proved to be effective to keep the

 DOI : 10.18231/2454-9150.2018.1318

harmonic content in power lines within the permissible limit of IEEE standards.

REFERENCES

[1] A New Method to Eliminate AC Harmonic Currents by Magnetic Flux Compensation Considerations on Basic Design. IEEE Transactions on Power Apparatus and Systems, PAS 90, 2009-2019.

[2] J. W. Dixon, J. J. Garcia, and L. A. Moran, "Control system for three-phase Active power filter which simultaneously compensates power factor and Unbalanced loads," IEEE Trans. Ind. Electron., Vol. 42, pp. 636–641, Dec. 1995.

[3] Duke, R.M., Round, S.D., "The Steady-State Performance of a Controlled Current Active Filter", IEEE Transactions on Power Electronics, 8,pp.140-146,1993.

[4] Enio R. Ribeiroand Ivo Barbi, "Harmonic Voltage Reduction Using a Series Active Filter under Different Load Conditions" IEEE Transactions on Power Electronics, Vol. 21, No. 5, September2006.

[5] Juan W. Dixon, Gustavo Venegas, and Luis A. Mor´ an,"A Series Active Power Filter Based on a Sinusoidal Current-Controlled Voltage-Source Inverter" IEEE Transactions on Industrial Electronics, Vol. 44, No. 5, October 1997.

[6] H. Akagi, A. Nabae, and S. Atoh, "Control strategy of Active power filters using Multiple-voltage source PWM converters," IEEE Trans. Ind. Applicant., Vol. IA-20, pp. 460–465, May/June 1986.

[7] J. Nastran, R. Cajhen, M. Seliger, and P. Jereb, "Active power filters for nonlinear AC loads," IEEE Trans. Power Electron. Vol. 9, pp. 92–96, Jan. 1994.

[8] W. M. Grady, M. J. Samotyj, and A. H. Noyola, "Survey of Active power line Conditioning methodologies," IEEE Transactions on Power Delivery, Vol.5, No.3, pp. 1536–1542, Jul. 1990.

[9] S. Jain, P. Agarwal, and H. O. Gupta, "Design simulation and experimental Investigations on a shunt Active power filter for harmonics and reactive power Compensation," Electrical Power Components and Systems, Vol. 32, No. 7, pp. 671–692,Jul. 2003.

[10] B. Singh, A. Chandra, and K. Al-Haddad, "A review of Active filters for power Quality improvement," IEEE Transactions on Industrial Electronics, Vol.46, No. 5, pp.1-12,Oct 1999.

[11] ShyhJier Huang and Jinn-Chang Wu, "A control algorithm for three-faze three Wired Active power filters under non ideal mains voltages," IEEE Transactions on Power Electronics, Vol. 14, No. 4,pp. 753-760, July 1999.

[12] J.W.Dixon, J.J.Garcia & L.Morgan, "Control system for three phase Active power Filter which simultaneously compensates power factor and unbalanced loads, "IEEE Transactions on Industrial Electronics, Vol.42, No.6, pp. 636-641,1995.

[13]J. P. Pinto, R. Pregitzer, L. F. C. Monteiro, and J. L. Afonso, "3-phase 4-wireshunt Active power filter with renewable energy interface," presented at the Conf. IEEE Renewable Energy & Power Quality, Seville, Spain, 2007.

[14] C. Dinesh, and K. Krishan, "Comparison of Different Control Strategies for Shunt Active Power Filters using HBCC Technique" International Journal of Electrical Electronics & Computer Science Engineering Vol 5, Issue 3 June, 2018.

[15] K. Krishan, and C. Dinesh, "Compensation for voltage sag in line to line fault using silicon oxide fuel cell based D-STATCOM " International Journal of Management Technology & Engineering Vol 9, Issue 1, January, 2019.

[16] K. Krishan, and C. Dinesh, "A novel approach for power quality enhancement using silicon oxide fuel cell based D-STATCOM " International Journal of Electrical Engineering and Technology, Volume 9, Issue 2, March-April, 2018

AUTHOR'S BIOGRAPHY

Dinesh Chandra S/o Sh. Bhanwar lal Prajapat was born on 22-05-1987. He completed his B. E. in Electrical Engineering from University of Rajasthan, Jaipur, Rajasthan, India in year 2009, M. Tech. (Hons.) in Power System from Rajasthan Technical University, Kota, Rajasthan, India in year 2015.Presently he is working as Assistant Professor at Manda Institute of Technology, Bikaner. His area of interests includes Electrical Power Generation, Power System Analysis, Power Electronics, Network Systems, PLCC and SCADA and emerging technologies.He has guided several projects and dissertations in B. Tech. He has actively organized numerous National Conferences/Seminars/Workshops in the field of Electrical Engineering, Applied Sciences, Energy.

Krishan Kumar S/o Sh. Hanumana Ram was born on 17-09-1987. He completed his B. E. in Electrical Engineering from University of Rajasthan, Jaipur, Rajasthan, India in year 2009, M. Tech. (Hons.) in Power System from Rajasthan Technical University, Kota, Rajasthan, India in year 2015. Presently he is heading the Department of Electrical Engineering at Manda Institute of Technology, Bikaner. His area of interests includes Electrical machines (AC/DC), Power Systems, Power System Stability Power Electronics, Embedded Systems, PLCC and SCADA and new emerging technologies.He has been actively engaged in research work and had guided many B. Tech. projects. He has successfully taken many grants from DST for B. tech projects, Conferences etc. He has convened National Conferences / Seminars/ Workshops in Electrical Engineering, Energy and Environment.

DOI : 10.18231/2454-9150.2018.1318