LMS BASED LOW PASS FILTER FOR IRPT ALGORITHM FOR DSTATCOM

[1] Ganji Vivekananda, [2]Dr.K.Chandra sekhar
[1]Research Scholar, [2]Professor
[1]Department of Electrical and Electronics Engineering
[1] Acharya Nagarjuna University, Guntur, India
[2]RVR&JC Engineering College, Guntur, India.

Abstract: In this paper, voltage source inverter is used is used as a distributed static compensator (DSTATCOM). The voltage source inverter has a advantages of low harmonic distortion and reduced switching losses. The voltage source inverter is used as DSTATCOM elimination of harmonics and reactive power of the nonlinear load. Conventionally, the proportional integral controller is used for control of dc link voltage and current of DSTATCOM. In this paper, least mean algorithm application is extended to estimate the oscillating component of the harmonics active power instead of low pass filter. The tuning or parameter adjustment of the low pass filter is tedious task. The proportional controller requires in detailed mathematical modeling of the overall system and it is tedious process. To overcome aforementioned task interval fuzzy logic controller (FLC) applied for a DSTATCOM. The proposed FLC is used to control the DC voltage as well as current loop to improve the performances of the DSTATCOM. The overall system of DSTATCOM including fuzzy logic controller implemented in MATLAB/Simulink. The simulated response of DSTATCOM found to be improved and better than the conventional PI controller.

Index Terms **-DSTATCOM, FLC, harmonics, reactive power.**

I. INTRODUCTION

The large amount of world energy is processed through power electronics equipment such as variable-frequency drives, computers and electronic ballasts and so on. These loads contribute the enormous harmonics to the utility which are odd multiple of the fundamental frequency. The harmonics cannot contribute the active power and hence, need to be compensated. To eliminate the harmonics, active power filter has been proposed. The active filter is also known as DSTATCOM [1]-[3].

The most of the DSTATCOMs are based on standard two level voltage source inverters (VSI). However, in medium power application two level VSIs are advantages due the lower number of switching devices. Hybrid power filter topologies were used for high power application.

The controller design is the major part of the DSTATCOM for proper tracking the desired response. Conventionally PI controller is used for regulating the DC link voltage of DSTATCOM. However, the parametric value of PI controller requires rigorous mathematic modelling of the system, which is very difficult to obtain parameter of PI controller under uncertainty condition and external load disturbance etc. [5].

In recent times, FLC is generated great deal of interest in most of control system applications. The advantages of the fuzzy logic controller against the PI controller is that the overall modelling and computation of parameter is not require and also handle imprecise input and so on.

In this paper, FLC DSTATCOM based on IRPT algorithm for harmonics and reactive power compensation is proposed. A control theory based on instantaneous reactive power theory is adopted for the reference current generation. The performance of DSTATCOM with FLC is evaluated through computer MATLAB simulation.

.

II. DSTATCOM CONFIGURATION

The schematic diagram of least mean square based LMS algorithm based DSTATCOM is shown in Fig.1. The overall DSTATCOM circuit consists of six insulated gate bipolar transistor, coupling inductors, dc link capacitors and three phase nonlinear load with commutation inductors.

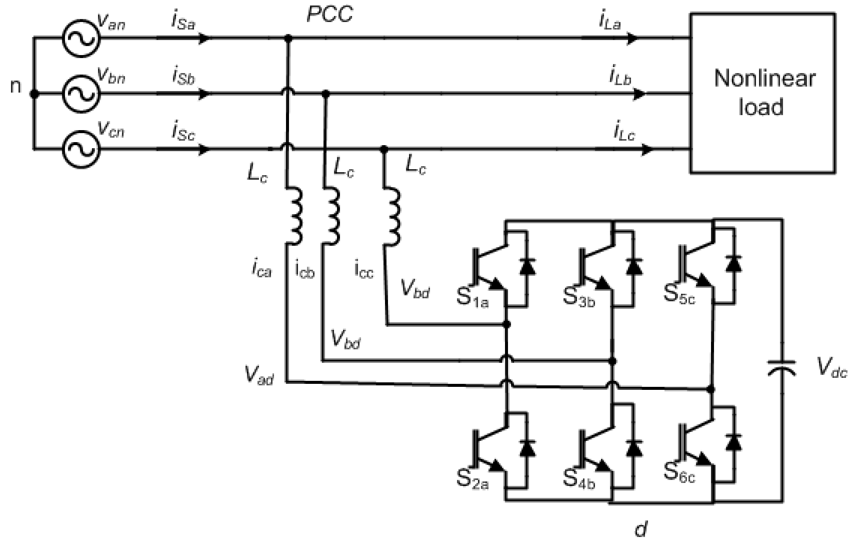

Fig. 1. DSTATCOM configuration for DG set integration.

I. CONTROL SCHEME

In many control schemes are available in literature proposed for efficient extraction of reference current such as synchronous reference frame, power balance, symmetrical component theory and instantaneous reactive power theory etc. [2]-[10]. Among these reference current generations instantaneous reference theory (IRP) most efficient and commonly used. In IRP theory, it involves that conversion of the three phase signals into bi-phase and subsequent computation of the active and reactive power. The calculated active and reactive is used for reference generation and transformed back to three phase. These generated reference current fed to the gate pulse generator to track the source current. The dc voltage regulation is carried out with FLC. The FLC has more freedom for handling uncertainty over conventional type-1 fuzzy logic controller. The individual dc voltage regulation scheme with FLC is shown in Fig. 2. The least mean square (LMS) based low pass filter IRPT is implemented to eliminate the requirement of the low pass filter. The harmonic component is generated with LMS algorithm, which is used to compute the harmonics components of the active power.

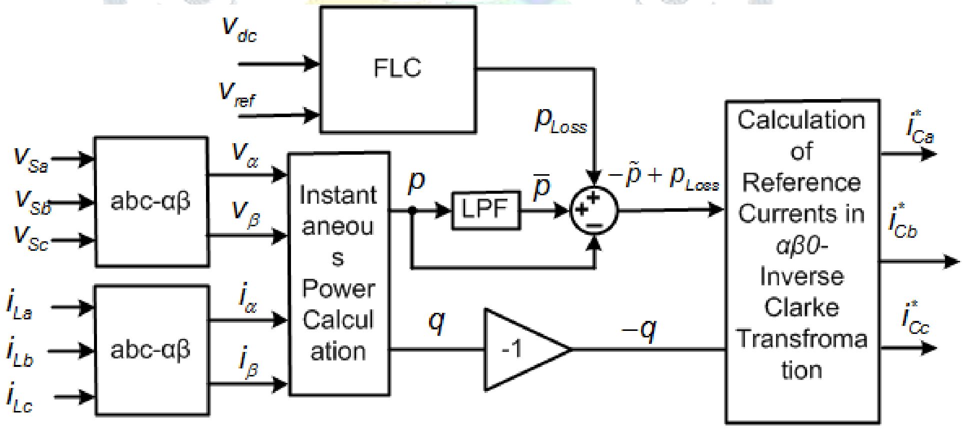

Fig. 2. Instantaneous reactive power theory.

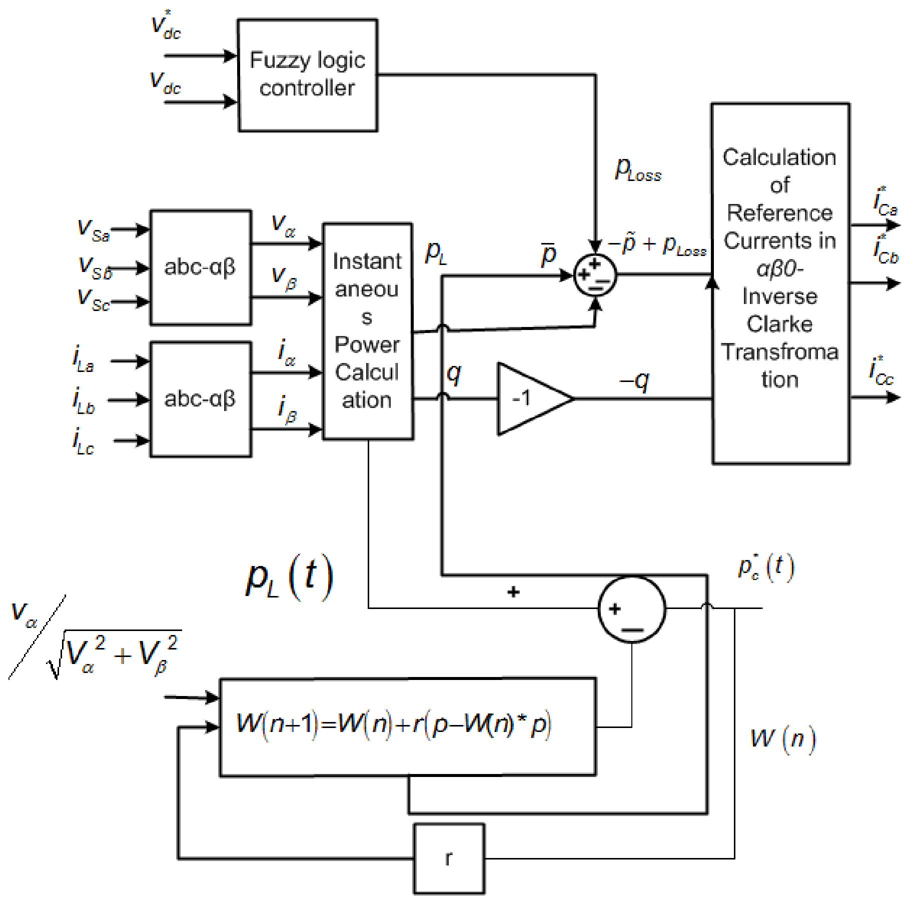

Fig. 3. Least mean square based low pass filter IRPT scheme

III. DC VOLTAGE REGULATION

The dc link voltage of active neutral point converters implemented with FLC. The FLC based controlled outer voltage regulator loop is shown in Fig. 5. The inputs to the FLC are error and change in error with respect to time

$$e_{nA}(n) = \Delta v_{dc_A}(n) = v_{dc_A}^*(n) - v_{dc_A}(n) \qquad (1)$$

$$ce_A(n) = \Delta v_{dc}(n) = v_{dc_A}^*(n) - v_{dc_A}(n-1) \qquad (2)$$

Table I: Fuzzy rule inference

E/CE	ANL	ANM	ANS	AZE	APS	APM	APL
ANL	ANL	NL	ANL	ANL	ANM	ANS	AZE
ANM	ANL	AFNL	AFNL	ANM	ANS	AZE	APS
ANS	ANL	ANL	ANM	ANS	AZE	APS	APM
AZE	ANL	ANM	ANS	AZE	APS	APM	APL
APS	ANM	ANS	AZE	APS	APM	APL	APL
APM	ANS	AZE	APS	APM	APL	APL	APL
APL	ANL	ANM	ANS	AZE	APS	APM	APL

The output of FLC is the change in loss component of active power. The output of FLC at nth and (n-1)th sampling instants are $p_{d_A}(n)$ and $p_{d_A}(n-1)$ respectively. The total output active power at nth sampling is determined by adding the previous value of active loss component of power with current value to the calculated change in loss power component.

$$p_{d_v}(n) = p_{d_v}(n-1) + \delta p_{d_v}(n) \qquad (3)$$

Where n is the sampling time, p_{d_v} is the active loss power of desired reference active power at n[th] sampling time and δ is gain factor of the FLCs. The rule base of the FLC is shown in Table I. The voltage regulator loop for phase-a is shown in Fig. 4. The rue base table type-2 fuzzy logic controller is shown Table I.

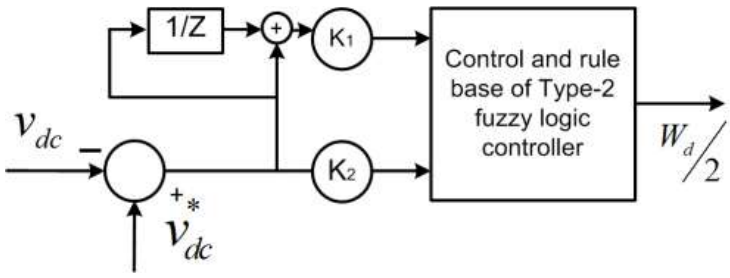

Fig. 4. DC Voltage regulation loop.

IV. RESULTS AND DISCUSSIONS

The simulated response of the DSTATCOM is presented to validate the FLC controller for the DSTATCOM. The simulated response of the DSTATCOM with PI controller is shown in Fig. 5. Before compensation with DSTATCOM, the source current contains multiple of triplen harmonics and reactive component of current. The source current total harmonics distortion before compensation found to be 26.76%. At instant t=0.05sec., when DSTATCOM switched-on source current tend to sinusoidal waveform and in synchronous with source voltage waveform. At same instant, the DSTATCOM voltage gradually increases and settled down at reference value. The settling time required for the voltage to reach reference value is 0.1 sec. the total harmonics distortion source current after compensation with DSTATCOM is 2.13%.

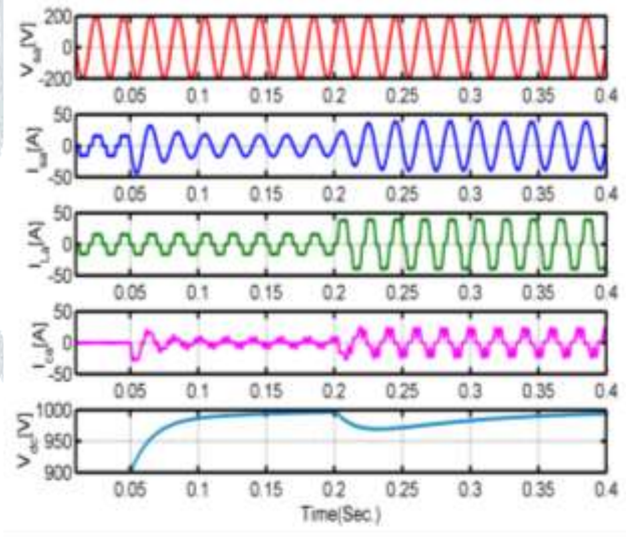

Fig. 5. Simulated waveform with PI controller.

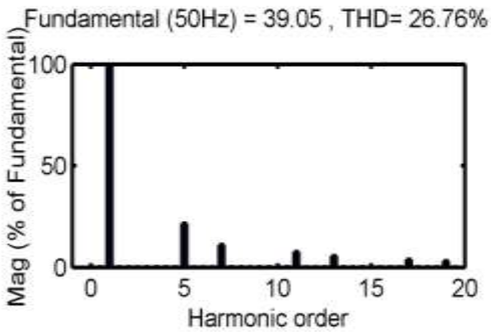

Fig. 6. Source current THD without compensation

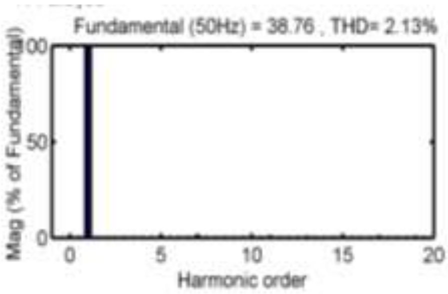

Fig. 7. Source current THD with compensation.

With the step change in the load current, the corresponding changes in load current and compensating current observed. The changes in source current and compensating current restored within 4-6 cycles.

The current and voltage waveforms of DSTATCOM with FLC is shown in Fig. 8. Before compensation with DSTATCOM source current is non-sinusoidal waveforms and shape of waveform in stepped form. When DSTATCOM switched-on at t=0.05sec., the source current is in sinusoidal shape and in phase with source voltage waveform. The source current total harmonics distortion found to be 2.13%. This is within the recommend standard of IEEE standard. The harmonics spectrum is depicted in Fig.4. The dc link voltage gradually increases, when DSTATCOM is connected at t=0.05 sec., and reaches to steady at t=0.05sec. It is evident from the simulation results the dynamics performance of DSTATCOM is better than the coventional IRPT as LMS based low pass filter IRPT.

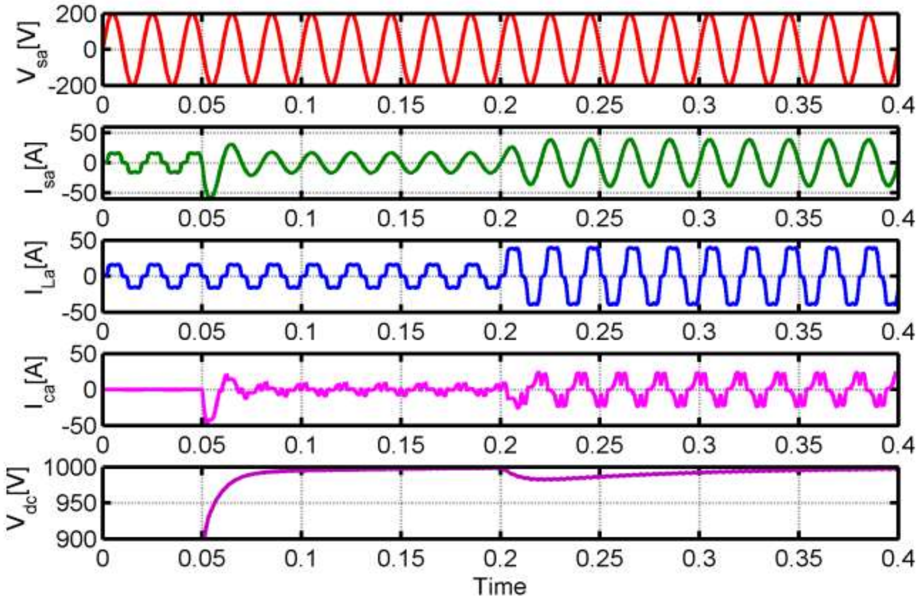

Fig. 8. Simulated waveform

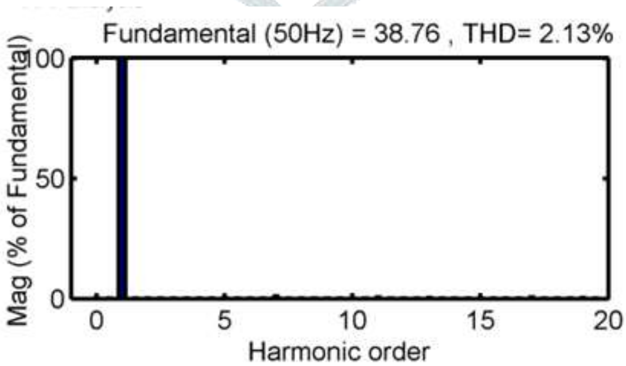

Fig. 9. Source current with compensation

IV. CONCLUSIONS

A control scheme for high performance three-phase STATCOM with improved power factor and displacement factor has been proposed. The compensating performance of controller has been investigated with different control scheme . The current control based on hysteresis scheme have been implemented. The simulated response shows that the proposed control schemes (LMS based low pass filter IRPT scheme) with FLC controller have a good performance in the harmonic compensation and improving the power factor, displacement factor and dynamic performance of the system.

REFERENCES

[1] B. Singh, K. Al-Haddad and A. Chandra, "A review of active filters for power quality improvement," in *IEEE Tran., on Ind. Electron.*, vol. 46, no. 5, pp. 960-971, Oct 1999.

[2] S. Buso, L. Malesani and P. Mattavelli, "Comparison of current control techniques for active filter applications," in *IEEE Transactions on Industrial Electronics*, vol. 45, no. 5, pp. 722-729, Oct 1998.

[3] D. M. Divan, S. Bhattacharya, and B. Banerjee, "Synchronous frameharmonic isolator using active series filter," in Proc. Eur. Power Electron.Conf., , pp. 3030–3035, 1991.

[4] D. Floricau, E. Floricau, G. Gateau, "Three-level active NPC converter: PWM strategies and loss distribution", Proc. IEEE IECON, pp. 3333-3338, 2008.

[5] S. Saad, L. Zellouma, "Fuzzy logic controller for three-level shunt active filter compensating harmonics and reactive power," Electric Power Sys. Res., vol. 79, Is. 10, pp. 1337-1341, Oct. 2009.

[6] J. Li et al., "Three-level active neutral-point-clamped zero-current-transition converter for sustainable energy systems", *IEEE Trans. Power Electron.*, vol. 26, no. 12, pp. 3680-3693, Dec. 2011.

[7] Xiao Peng, Venayagamoorthy GK, Corzine KA, "Seven-level shunt active filter for high power drive systems," IEEE Trans., Power Electron., vol. 24, no.1, pp. 6-13, 2009.

[8] Wenjin Dai, Yongtao Dai and Min Wu, "A new study for harmonic suppression and reactive power compensation," Industrial Technology, *in proc., IEEE ICIT 2008,* vol., no., pp.1,6, 21-24 April 2008

[9] B. Singh, V. Verma, and J. Solanki, "Neural network-based selective compensation current quality problems in distribution system," IEEE Trans. Ind. Electron., vol. 54, no. 1, pp. 53–60, Feb. 2007.

[10] Dhanavath Suresh, S.P. Singh, "design of single input fuzzy logic controller for shunt DSTATCOM," IETE journal of research, vol.61, no.5, 2016.

[11] Karnik, N. N., Mendel, J. M., and Qilian, L., "Type-2 fuzzy logic systems," *IEEE Trans. Fuzzy Syst.*, Vol. 7, pp. 643–658,1999.

[12] Y. Jiao, S. Lu, F. C. Lee, "Switching performance optimization of a high power high frequency 3-level active neutral point clamped phase leg building block", IEEE Trans. Power Electron., vol. 29, no. 7, pp. 3255-3266, Jul. 2014.

[13] B. Singh, A. Adya, A. P. Mittal, J. R. P. Gupta, "Performance of DSTATCOM for isolated small alternator feeding non-linear loads", *Proc. Int. Conf. Comput. Appl. Elect. Eng. Recent Adv.*, pp. 211-216, 2005.

[14] B. Singh, K. Al-Haddad and A. Chandra, "A review of active filters for power quality improvement," in *IEEE Tran., on Ind. Electron.*, vol. 46, no. 5, pp. 960-971, Oct 1999.

[15] H. Akagi, E. H. Watanabe, and M. Aredes, *Instantaneous Power Theory and Applications to Power Conditioning*. Hoboken, NJ: Wiley, 2007.

[16] R. S. Herrera, P. Salmeron, and H. Kim, "Instantaneous reactive power theory applied to active power filter compensation: Different approaches, assessment, and experimental results," *IEEE Trans. Ind. Electron.*, vol. 55,no. 1, pp. 184–196, Jan. 2008.

[17] S. Buso, L. Malesani and P. Mattavelli, "Comparison of current control techniques for active filter applications, in *IEEE Transactions on Industrial Electronics*, vol. 45, no. 5, pp. 722-729, Oct 1998.

[18] Po-Tai Cheng, S. Bhattacharya and D. D. Divan, "Line harmonics reduction in high-power systems using square-wave inverters-based dominant harmonic active filter," in *IEEE Transactions on Power Electronics*, vol. 14, no. 2, pp. 265-272, Mar 1999.

[19] P. Verdelho and G. D. Marques, "Four-wire current-regulated PWM voltage converter," in IEEE Transactions on Industrial Electronics, vol. 45, no. 5, pp. 761-770, Oct 1998.

[20] A. Chandra, B. Singh, B. N. Singh and K. Al-Haddad, "An improved control algorithm of shunt active filter for voltage regulation, harmonic elimination, power-factor correction, and balancing of nonlinear loads," in *IEEE Transactions on Power Electronics*, vol. 15, no. 3, pp. 495-507, May 2000.

[21] B. Singh and J. Solanki, "An Implementation of an Adaptive Control Algorithm for a Three-Phase Shunt Active Filter," in IEEE Transactions on Industrial Electronics, vol. 56, no. 8, pp. 2811-2820, Aug. 2009.

[22] H. Li, Z. Wu and F. Liu, "A Novel Variable Step size Adaptive Harmonic Detecting Algorithm Applied to Active Power Filter," 2006 IEEE International Conference on Industrial Technology, Mumbai, 2006, pp. 574-578.

[23] Bhim Singh, J. Solanki, "Load Compensation for Diesel Generator-Based Isolated Generation System Employing DSTATCOM," *in IEEE Trans., on Indu. Appl.* Vol. 47, No. 1, Jan.-Feb. 2011.

[24] M. G. Villalva, J. R. Gazoli, and E. R. Filho, ``Comprehensive approach to modeling and simulation of photovoltaic arrays," *IEEE Trans. Power Electron*., vol. 24, no. 5, pp. 11981208, May 2009.