International Journal of Trend in Scientific Research and Development (IJTSRD)
Volume 4 Issue 1, December 2019 Available Online: www.ijtsrd.com e-ISSN: 2456 – 6470

Power Quality Enhancement using DSTATCOM by Immune Feedback Control Algorithm

P. Thirumala, K. Mahesh

EEE Department, Dr KV Subba Reddy Institute of Technology, Dupadu, Andhra Pradesh, India

ABSTRACT

This paper proposes an immune feedback control algorithm for a three-phase distribution static compensator (DSTATCOM) to mitigate several power quality problems such as harmonics, reactive power, and load unbalancing at distribution level. This control algorithm proposed for DSTATCOM, is validated for maintaining power factor to unity, load balancing, and harmonics reduction of supply currents. In this application, the proposed control algorithm on a DSTATCOM is implemented for the compensation of nonlinear loads. The simulations were performed in the environment of MATLAB/SIMULINK.

KEYWORDS: *Distribution Static Compensator, power quality, power factor, Voltage regulation*

How to cite this paper*:* P. Thirumala | K. Mahesh "Power Quality Enhancement using DSTATCOM by Immune Feedback Control Algorithm" Published in International Journal of Trend in Scientific Research and Development (ijtsrd), ISSN: 2456-6470, Volume-4 | Issue-1, December 2019, pp.1090-1094, URL: www.ijtsrd.com/papers/ijtsrd29812.pdf

IJTSRD29812

I. INRODUCTION

Both electric utilities and end users of electric power are becoming increasingly concerned about the quality of electric power. The term power quality has become one of the most prolific buzzwords in the power industry since the late 1980s. It is an umbrella concept for a multitude of individual types of power system disturbances. The issues that fall under this umbrella are not necessarily new. What is new is that engineers are now attempting to deal with these issues using a system approach rather than handling them as individual problems. Power engineers are concerned about the rapid increase in power quality (PQ) problems and solutions in the distribution level. Consumers even in developing nations are realizing the importance of good PQ and willing to spend extra cost. Several reasons account for PQ problems in distribution systems viz., an unprecedented increase in power electronics loads, which include converters, switch-mode power supplies (SMPS), variable frequency drives, electric arc furnaces, computers, etc. Common PQ problems include load unbalancing, voltage regulation, harmonics injection into the grid supply and poor power factor [1]. Guidelines for limiting harmonics and other PQ-related problems are specified in IEEE-519 standard[2]. An improvement in quality of power is achieved using different custom power devices and one such recent shunt compensating device is a DSTATCOM (distribution static compensator) [3]. It is used for mitigating PQ problems related to currents, such as reduction of harmonics in grid currents, reactive power compensation, and balancing of unbalanced load at distribution level, and it can be controlled in different operating modes.In present day distribution systems, major power consumption has been in reactive loads, such as fans, pumps, etc. These loads draw lagging power-factor currents and therefore give rise to reactive power burden in the distribution side. The action of DSTATCOM based on the control algorithm used for extraction of reference current components. For this purpose, many control schemes are reported in literature, and some of these are instantaneous reactive power (IRP) theory, instantaneous symmetrical components, synchronous reference frame (SRF) theory, current compensation using dc bus regulation, computation based on per phase basis, and scheme based on neural network techniques [3]–[11]. Among these control schemes, IRP and SRF theories are most widely used.

II. FACTS CONTROLLERS

The primary objective of applying a static compensator (this term or the shorter term compensator will be used in a general sense to refer to an SVC as well as to a STATCOM) in a power system is to increase the power transmission capability, with a given transmission network, from the generators to the loads. Since static compensators cannot generate or absorb real power (neglecting the relatively low internal losses of the SVC and assuming no energy storage for the STATCOM), the power transmission of the system is affected indirectly by voltage control. That is, the reactive output power (capacitive or inductive) of the compensator is varied to control the voltage at given terminals of the transmission network so as to maintain the desired power flow under possible system disturbances and contingencies.

The basic compensation needs usually fall into one of the following two main categories: (1) direct voltage support (to maintain sufficient line voltage for facilitating increased power flow under heavy loads and for preventing voltage instability) and (2) transient and dynamic-stability improvements (to increase the first swing stability margin and provide power oscillation damping). In that section it was shown that terminal voltage control can enhance significantly the power transmission capability of the power system. Specifically, the regulation of the voltage at particular intermediate points and selected load terminals of the transmission system, limits voltage variation, prevents voltage instability (voltage collapse), and increases transient (first swing) stability limits, whereas appropriate variation of the terminal voltage can further enhance transient stability and provide effective power oscillation damping (dynamic stability).

III. VOLTAGE SOURCE CONVERTERS

Power converters may be classified into two categories: Current source converters (CSC) and voltage source converters (VSC). Basically, a VSC generates AC voltage from a DC voltage which is supported by a capacitor. In a VSC, the magnitude, the phase angle and the frequency of the output voltage can be controlled by resorting to switching control. One of the many advantages of VSCs using PWM control is that they can produce quasi-sinusoidal voltage waveforms, having almost any desired phase relationship with an existing AC system waveform, thus dictating the direction and magnitude of the active and reactive power exchanged with the AC system. Pulse width modulation (PWM) is a method which facilitates effective control of the harmonic amount and harmonic content generated by means of VSCs, by means of controlling the turn-on and turn-off of the power electronic switching devices.Fig.1 shows a single-phase full wave VSC.

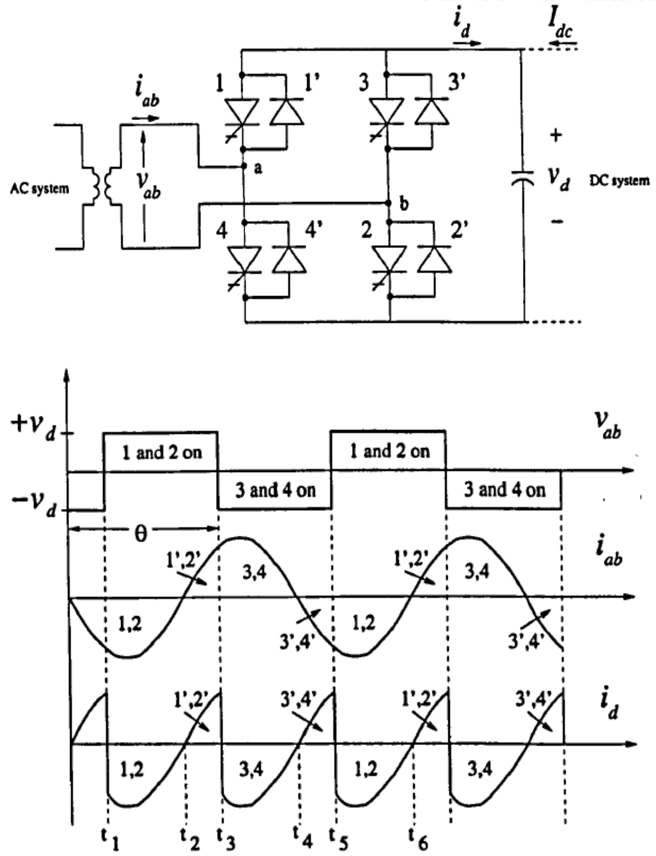

Fig.1:single-phase, full-wave VSC

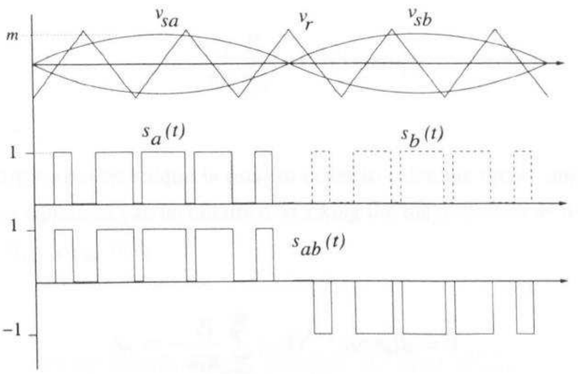

Fig. 2: PWM converter with unipolar voltage switching

The unipolar voltage switching of PWM is represented in Fig.2.

IV. CONTROL ALGORITHM

The Matlab model for weights of active and reactive components for Phase 'a' is shown in Fig.3.The sensed grid currents (i_{sa}, i_{sb}, and i_{sc}) are sensed by the current sensors and compared with estimated reference currents (i^*_{sa}, i^*_{sb}, and i^*_{sc}). Thus, the current errors (i_{sae}, i_{sbe}, and i_{sce}) are generated. After the generation of these error signals, they are processed through PWM current controller to produce six switching pulses for six IGBT switches of VSC. The purpose of using the immune feedback principle is to extract the weighted values of the load currents, which correspond to fundamental positive sequence values.

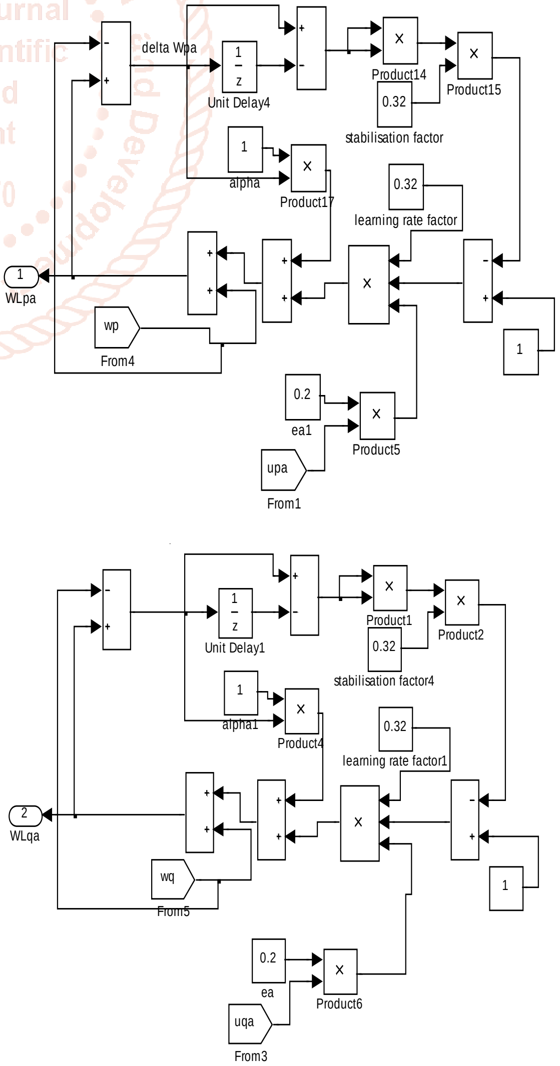

Fig.3: Matlab model for weights of Phase 'a'

V. SIMULATION RESULTS

Simulations are performed using MATLAB/SIMULINK software. The three phase ac mains voltage source converter (VSC)-based DSTATCOM is connected to three phase linear/nonlinear loads with impedance of internal grid which is shown in Fig. 4.

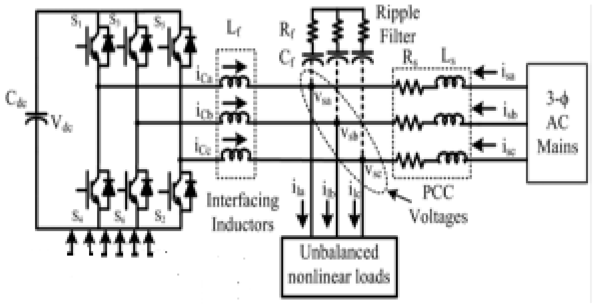

Fig.4: Schematic diagram of VSC-based DSTATCOM

The grid currents still remain balanced due to the DSTATCOM action. It is observed from simulated results that under unbalanced load condition, the maximum overshoot, which occurs in dc bus voltage, is around 25 V. However, it is controlled to 700 V (reference value) with a PI controller action within a couple of cycles.

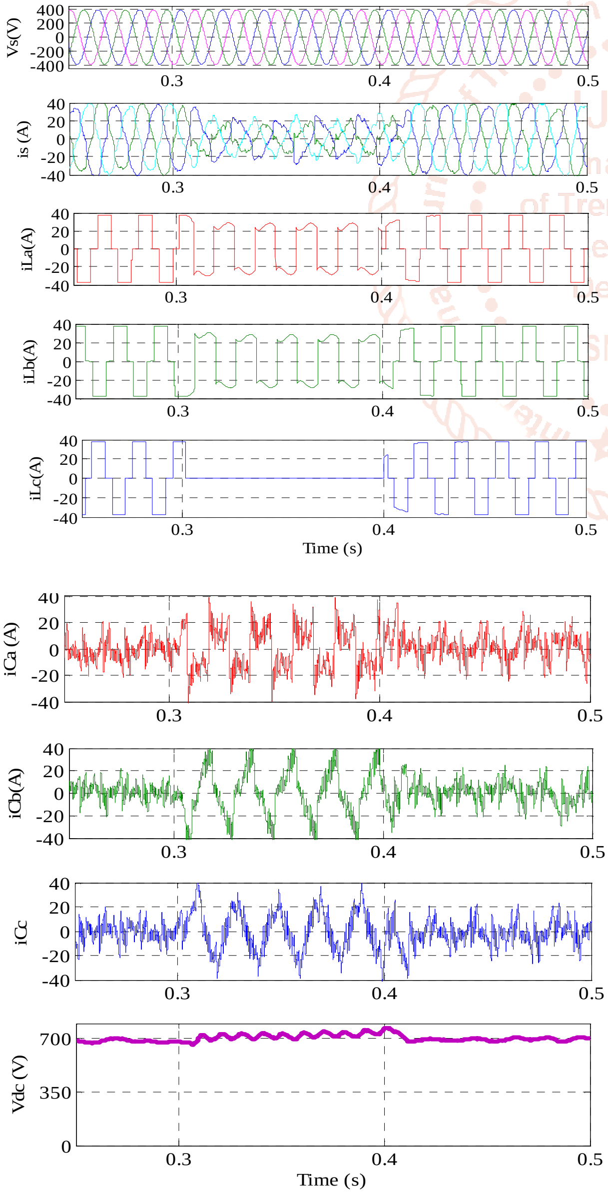

Fig. 5: System response under PFC mode

The harmonic spectra of grid current (i_{sa}) after compensation and load current (i_{la}) in PFC mode are illustrated in Fig.6. The values of total harmonic distortions (THDs) of grid current and load current are observed as 4.69% and 30.54%, respectively. It may be inferred from these results that the harmonic distortion of i_{sa} is less than a limit (<5%) imposed by international standards such as IEEE-519.

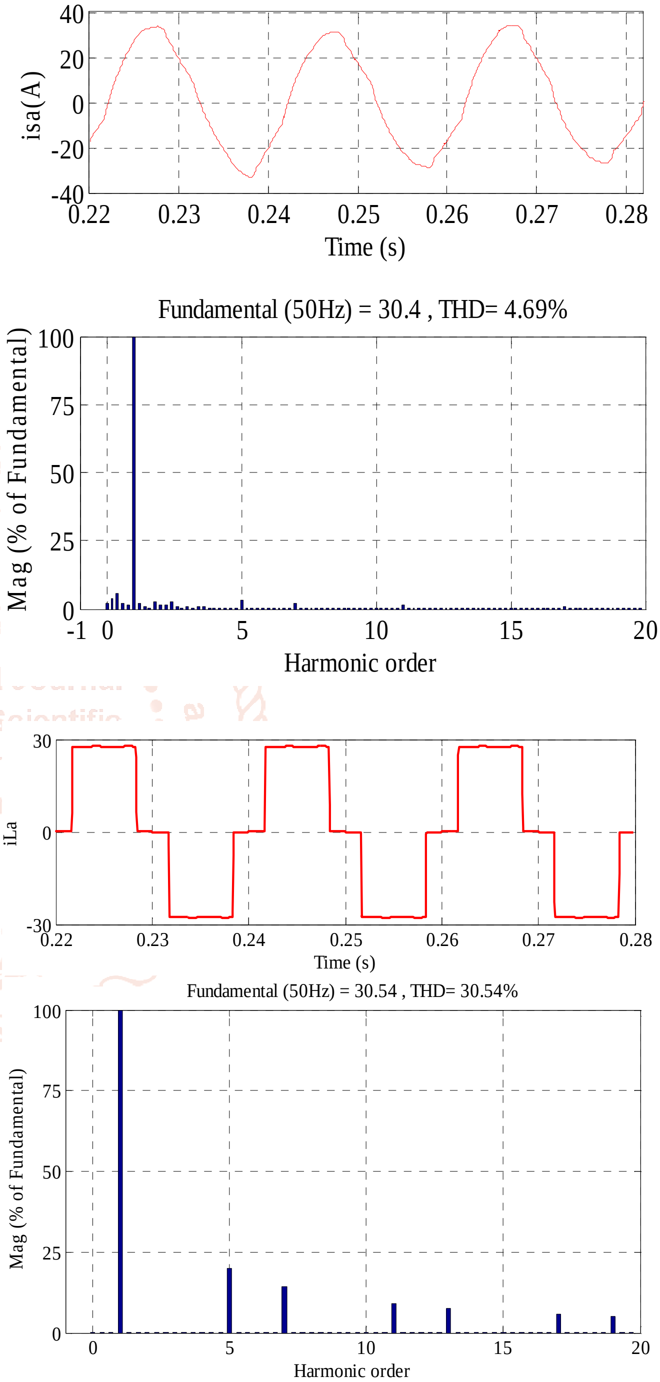

Fig. 6: THD comparison of source current and load current under PFC mode

Fig. 7 shows the harmonic spectra of grid current (i_{sa}) after compensation and load current (i_{la}) in voltage regulation mode. Harmonic distortion in phase "a" of grid current is observed to be 4.86 % when the distortion in load current is 30.59%. Fig. 7 clearly highlights that phase "a" of the grid current, after compensation is maintained sinusoidal and the distortion limits of i_{sa} from harmonics point of view follow a limit of less than 5% specified by an IEEE-519 standard.

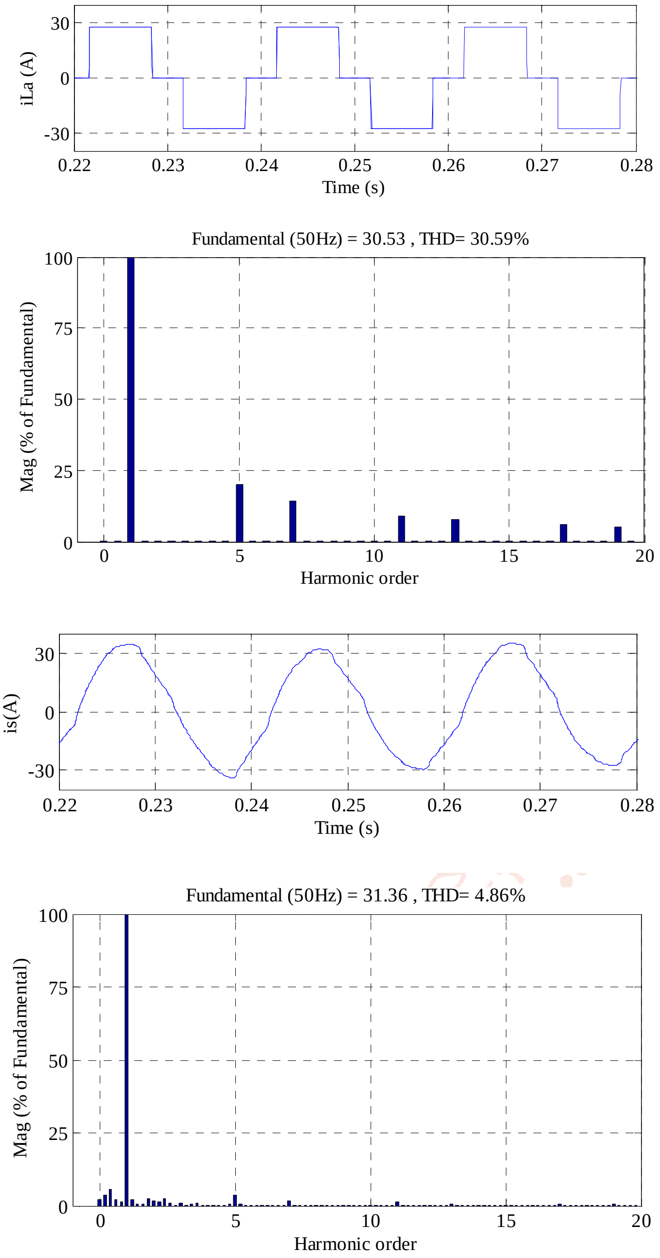

Fig. 7: THD comparison of source current and load current under VR Mode

VI. CONCLUSIONS

The control algorithm has been developed and implemented for generating switching pulses for VSC. Superior performance of an immune feedback control algorithm has been observed in terms of convergence speed, harmonics compensation, error minimization, and computational complexity.

REFERENCES

[1] B. Singh, A. Chandra, and K. Al-Haddad, Power Quality: Problems and Mitigation Techniques, Chichester, U.K.: John Wiley and Sons, 2015.

[2] IEEE Recommended Practices and Requirement for Harmonic Control on Electric Power System, IEEE Std. 519-1992, 1992.

[3] S. R. Arya, B. Singh, R. Niwas, A. Chandra, and K. Al-Haddad, “Power quality enhancement using DSTATCOM in distributed power generation system,” IEEE Trans. Ind. Appl., vol. 52, no. 6, pp. 5203–5212, Nov./Dec. 2016.

[4] H. Akagi, Y. Kanazawa, and A. Nabae, “Generalized theory of the instantaneous reactive power in three-phase circuits,” in Proc. IEEE JIEE IPEC, 1983, pp. 821–827.

[5] M. B. Latran, A. Teke, and Y. Yoldas, “Mitigation of power quality problems using distribution static synchronous compensator: A comprehensive review,” IET Power Electron., vol. 8, no. 7, pp. 1312–1328, Jul. 2015.

[6] R. Kumar, B. Singh, and D. T. Shahani, “Symmetrical components based modified technique for power-quality disturbances detection and classification,” IEEE Trans. Ind. Appl., vol. 52, no. 4, pp. 3443–3450, Jul./Aug. 2016.

[7] H. Yi et al., “A source-current-detected shunt active power filter control scheme based on vector resonant controller,” IEEE Trans. Ind. Appl.,vol. 50, no. 3, pp. 1953–1965, May/Jun. 2014.

[8] J. Taotao and K. M. Smedley, “Operation of one-cycle controlled three phase active power filter with unbalanced source and load,” IEEE Trans. Power Electron., vol. 21, no. 5, pp. 1403–1412, Sep. 2006.

[9] L. Tarisciotti et al., “Model predictive control for shunt active filters with fixed switching frequency,” IEEE Trans. Ind. Appl., vol. 53, no. 1, pp. 296–304, Jan./Feb. 2017.

[10] M. Qasim, P. Kanjiya, and V. Khadkikar, “Optimal current harmonic extractor based on unified ADALINEs for shunt active power filters,” IEEE Trans. Power Electron., vol. 29, no. 12, pp. 6383–6393, Dec. 2014.

[11] B. Singh, S. R. Arya, A. Chandra, and K. Al-Haddad, “Implementation of adaptive filter in distribution static compensator,” IEEE Trans. Ind. Appl.,vol. 50, no. 5, pp. 3026–3036, Sep./Oct. 2014.

[12] A. Singh, M. Badoni, and B. Singh, “Application of least means square algorithm to shunt compensator: An experimental investigation,” in Proc. IEEE Int. Conf. Power Electron. Drives Energy Syst., 2014, pp. 1–6.

[13] S. Haykin, Adaptive Filter Theory. Upper Saddle River, NJ, USA: Prentice-Hall Inc., 2002.

[14] R. K. Agarwal, I. Hussain, and B. Singh, “Grid integration of single stage SPV system using NLMS filtering control technique,” in Proc. IEEE 6th Int. Conf. Power Syst., 2016, pp. 1–6.

[15] M. Badoni, A. Singh, and B. Singh, “Variable forgetting factor recursive least square control algorithm for DSTATCOM,” IEEE Trans. Power Del.,vol. 30, no. 5, pp. 2353–2361, Oct. 2015.

[16] R. Kumar, B. Singh, D. T. Shahani, and C. Jain, “Dual-tree complex wavelet transform-based control algorithm for power quality improvement in a distribution system,” IEEE Trans. Ind. Electron., vol. 64, no. 1,pp. 764–772, Jan. 2017.

[17] K. Venkatraman, M. P. Selvan, and S. Moorthi, “Predictive current control of distribution static compensator for load compensation in distribution system,” IET Gener., Transmiss., Distrib., vol. 10, no. 10, pp. 2410–2423, Jul. 2016.

[18] B. Singh, P. Jayaprakash, S. Kumar, and D. P. Kothari, "Implementation of neural-network-controlled three-leg VSC and a transformer as three phase four-wire DSTATCOM," IEEE Trans. Ind. Appl., vol. 47, no. 4, pp. 1892–1901, Jul./Aug. 2011.

[19] M. Badoni, A. Singh, and B. Singh, "Design and implementation of ANFIS based control algorithm for DSTATCOM," Electr. Power Compon. Syst., vol. 43, no. 15, pp. 1741–1751, 2015.

[20] M. Kawafuku, M. Sasaki, and K. Takahashi, "Adaptive learning method of neural network controller using an immune feedback law," in Proc. IEEE/ASME Int. Conf. Adv. Intell. Mechatronics, 1999, pp. 641–646.

He has received B. Tech in the year of 2012 from Sri Sai Institute of Technology and Science, Rayachoty. He is pursuing M. Tech in Dr KV Subba Reddy Institute of Technology, Kurnool. His areas of interest include Power System, Power Electronics and Electrical Machines.

He is an Asst. Professor at Dr KV Subba Reddy Institute of Technology, Kurnool. His areas of interest include Power System, Power Electronics and Electrical Machines & Drives.