DIESEL GENERATOR EMPLOYED D-STATCOM FOR ISOLATED GENERATION SYSTEM TO COMPENSATE LOAD BY USING PI AND NEURO-FUZZY CONTROLLERS

Shaik Chandbi[1], Sk.Shareef[2], Dr.Abdul Ahad[3]

[1]Student, Dept.of EEE, Nimra Collage of Engineering & Technology, Ibrahimpatnam, VJA
[2]Assistant Professor, [3]Prof &Head, Dept.of EEE,
Nimra Collage Of Engineering & Technology, Ibrahimpatnam(India)

ABSTRACT

This paper presents the control of distribution static synchronous compensator (DSTATCOM) for reactive power, harmonics and unbalanced load current compensation of a diesel generator set for an isolated system. The control of DSTATCOM is achieved using least mean square-based adaptive linear element (Adaline). An Adaline is used to extract balanced positive sequence real fundamental frequency component of the load current and a proportional–integral (PI) controller is used to maintain a constant voltage at the dc-bus of a voltage-source converter (VSC) working as a DSTATCOM. Switching of VSC is achieved by controlling source currents to follow reference currents using hysteresis-based PWM control. This scheme is simulated under MATLAB environment using Simulink and PSB block-set toolboxes for feeding linear and nonlinear loads. The modeling is performed for a three-phase, three-wire star connected synchronous generator coupled to a diesel engine, along with the three-leg VSC working as a DSTATCOM. Results are presented to verify the effectiveness of the control of DSTATCOM for the load compensation and an optimal operation of the DG set.

Index Terms: Adaline, Diesel Generator Set, Distribution Static Synchronous Compensator (DSTATCOM), Harmonic Elimination, Load Compensation.

I INTRODUCTION

Installation of the diesel engine-based electricity generation unit (DG set) is a widely used practice to feed the power to some crucial equipment in remote areas [1], [2]. DG sets used for these purposes are loaded with unbalanced, reactive and nonlinear loads such as power supplies in some telecommunication equipment and medical equipment. The source impedance of the DG set is quite high, and the unbalanced and distorted currents lead to the unbalanced and distorted three-phase voltages at point of common coupling (PCC). Harmonics and unbalanced currents flowing through the generator result into torque ripples at the generator shaft. All of these factors lead to the increased fuel consumption and reduced life of the DG sets. These forces the DG sets to be operated with derating, which results into an increased cost of the system. Nowadays, small generator units are available with full conversion (inverter-converter) units to meet stringent power quality norms [3]. Instead of using these, a

DSTATCOM [2] can be used with a three-phase DG set to feed unbalanced loads without derating the DG set and to have the same cost involved. The performance of DSTATCOM is very much dependent on the method of deriving reference compensating signals. Instantaneous reactive power theory, modified p-q theory, synchronous reference frame theory.

This paper presents a DSTATCOM for the load compensation of a diesel generator set to enhance its performance. The control of DSTATCOM with capabilities of reactive power, harmonics and unbalanced load compensation is achieved by Least Mean Square (LMS) algorithm [8], [9] based adaptive linear element (Adaline). The Adaline is used to extract positive-sequence fundamental frequency real component of the load current. The dc-bus voltage of voltage source converter (VSC) is supported by a proportional–integral (PI) controller which computes current component to compensate losses in DSTATCOM. The extraction of reference currents using Adaline involves an estimation of weights. These weights are measure of peak of fundamental frequency real current component of the load current. The life of a DG set is enhanced in the absence of unbalanced and harmonic currents. The modeling of the DG set is performed using a synchronous generator, a speed governor, and the excitation control system. This proposed system is simulated under MATLAB environment using Simulink and PSB Block-set toolboxes.

II SYSTEM CONFIGURATION

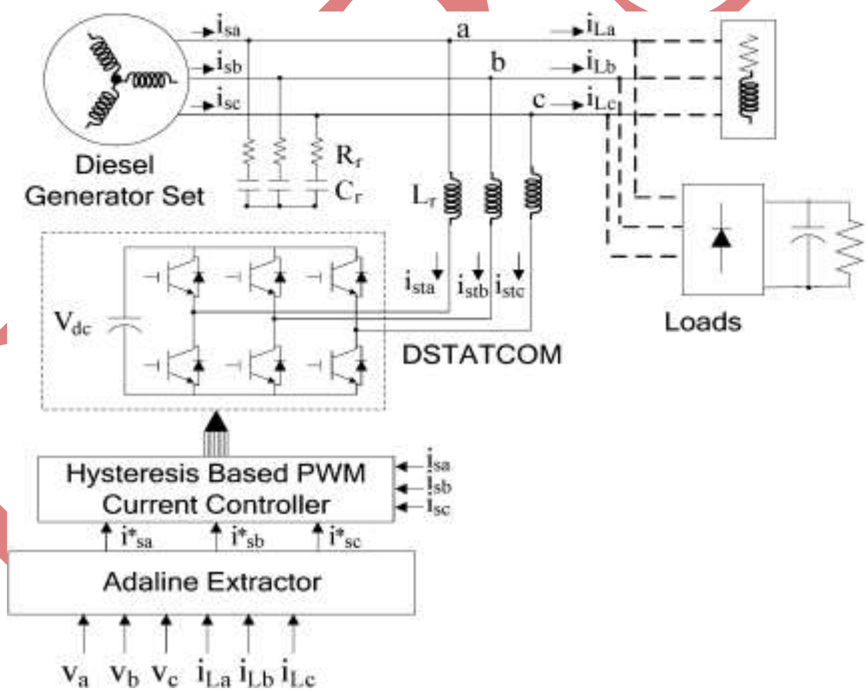

Fig. 1. Basic Configuration of the DG Set With DSTATCOM

Fig. 1 shows the configuration of the system for a three phase three-wire DG set feeding to variety of loads. A 30 kVA system is chosen to demonstrate the work of the system with the DSTATCOM. The DSTATCOM consists of an insulated gate bipolar transistors-based three-phase three-leg VSC system. The load current is tracked using Adaline-based reference current generator, which in conjunction with the hysteresis-based PWM current controller that provides switching signals for VSC-based DSTATCOM. It controls source currents to follow a set of three-phase reference currents.

III CONTROL STRUCTURE

The operation of this system requires a DG set to supply real power needed to the load and some losses (switching losses of devices used in VSC, losses in the reactor, and dielectric losses of the dc capacitor) in DSTATCOM. Therefore, the reference source current used to decide the switching of the DSTATCOM has two parts. One is real fundamental frequency component of the load current, which is being extracted using Adaline and another component, which corresponds to the losses in the DSTATCOM, are estimated using a PI controller over dc voltage of DSTATCOM. Fig. 2(a) shows the control scheme for the implementation of reactive, unbalanced and harmonic currents compensation. The output of the PI controller is added to the weight calculated by the Adaline to maintain the dc-bus voltage of the DSTATCOM.

To compute the second component of reference active power current, a reference dc-bus voltage is compared with sensed dc- bus voltage of DSTATCOM. This comparison of sensed dc-bus voltage (vdc) to the reference dc-bus voltage (vdc)(5) of VSC. The output of the PI controller accounts for the losses in DSTATCOM and it is considered as the loss component of the current, which is added with the weight estimated by the Adaline corresponding to fundamental frequency positive sequence reference active current component. Therefore, the total real reference current has component corresponding to the load and component corresponding to feed the losses of DSTATCOM, is expressed as

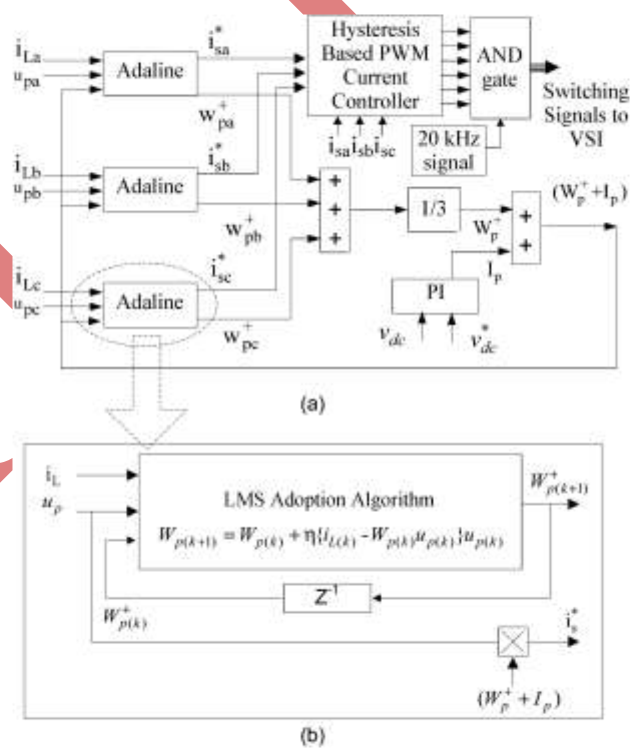

Fig. 2. (a), (b). Control Block Diagram of the Reference Current Extraction Scheme

$$i_{sa}^{*} = \left(W_p^{+} + I_p\right) u_{pa}; i_{sb}^{*} = \left(W_p^{+} + I_p\right) u_{pb};$$
$$i_{sc}^{*} = \left(W_p^{+} + I_p\right) u_{pc}.$$

These three-phase currents are considered reference source currents and along with sensed source currents these are fed to the hysteresis based PWM current controller to control the source currents to follow these reference currents. The switching signals generated by the PWM current controller force actual source currents to acquire shape close to the reference source currents. This indirect current control results in the control of the slow varying source current (as compared to DSTATCOM currents) and therefore requires less computational efforts. Switching signals are generated on the following logic:

if $(i_{act}) < (i_{ref} - hb/2)$ upper switch of the leg is ON and lower switch is OFF

if $(i_{act}) > (i_{ref} + hb/2)$ upper switch of the leg is OFF and lower switch is ON

The weights are computed online by LMS algorithm. The update equation of weights based on LMS algorithm is described in (5) for each phase. The structure of such Adaline is depicted in Fig. 2(b). Weights are averaged not only for averaging at fundamental frequency but to cancel out sinusoidal oscillating components in weights present due to harmonics in the source current. The averaging of weights in different phases is shown in Fig. 2(a). Thus Adaline is trained at fundamental frequency of a particular sequence in-phase with voltage. Fig. 2(a) and (b) show the detailed scheme implemented for control of DSTATCOM.

IV MATLAB SIMULATION

Fig. 3 shows the MATLAB model of the DSTATCOM-DG set isolated system. The modeling of the DG set is carried out using a star connected synchronous generator of 30 kVA, controlled by a speed governor and an excitation system. The linear load applied to the generator is at 0.8 lagging pf which is modeled as a delta connection of the series combination of resistance and inductance (R-L) models. The nonlinear load is modeled using discrete diodes connected in a bridge with a capacitor filter and a resistive load on the dc bus. The unbalanced was realized by disconnecting phase-a from the diode bridge.

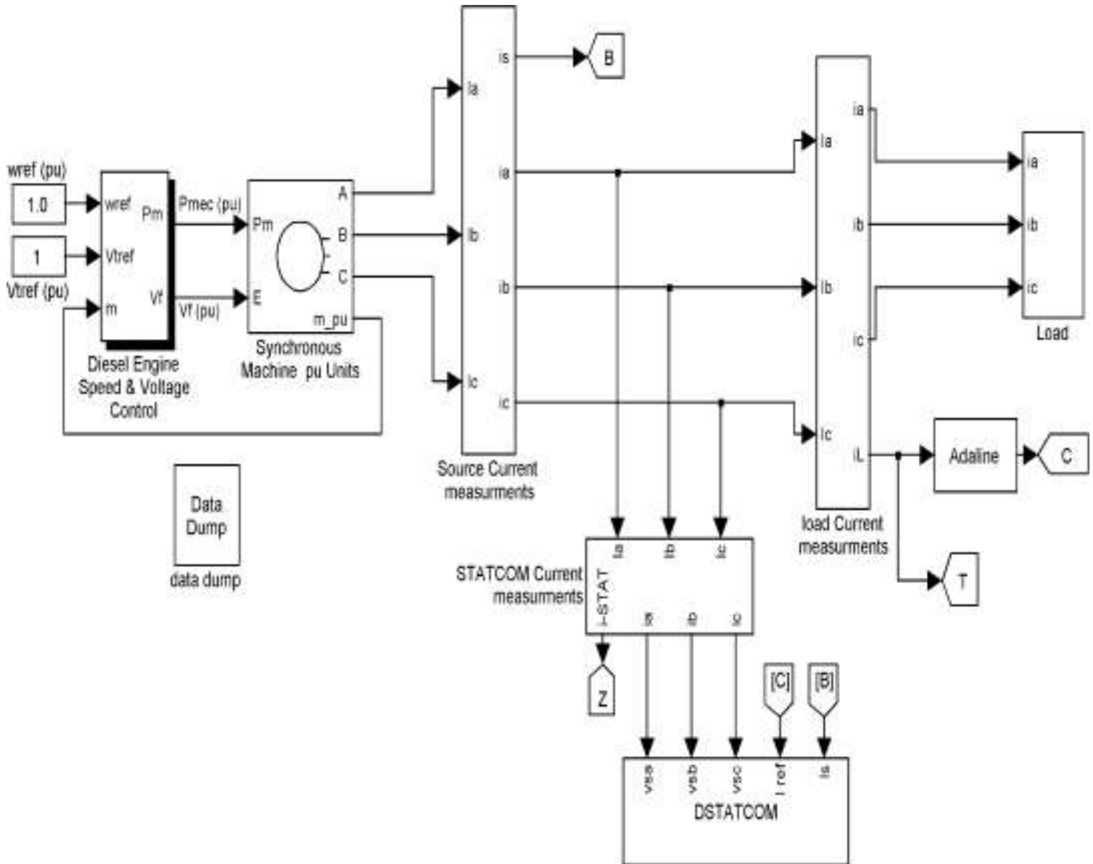

Fig. 3. MATLAB Based Simulation Model

The simulation of the DSTATCOM-DG isolated system is carried out with different types of loads i.e., a linear R-L load, a nonlinear load i.e., a diode bridge converter load. The load compensation is demonstrated for these types of loads using DSTATCOM system for an isolated DG set. The following observations are made on the basis of obtained simulation results under different system conditions.

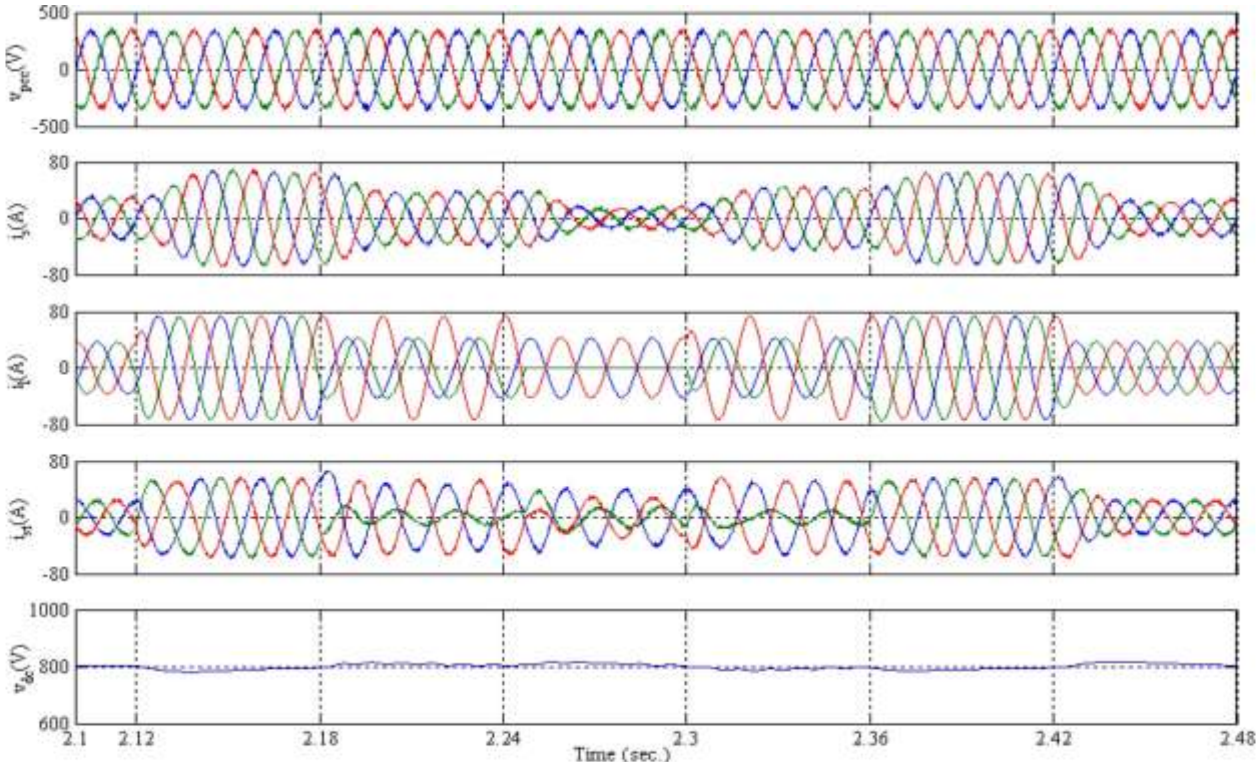

Fig. 4. Dynamic performance of the DSTATCOM-DG isolated system with linear load

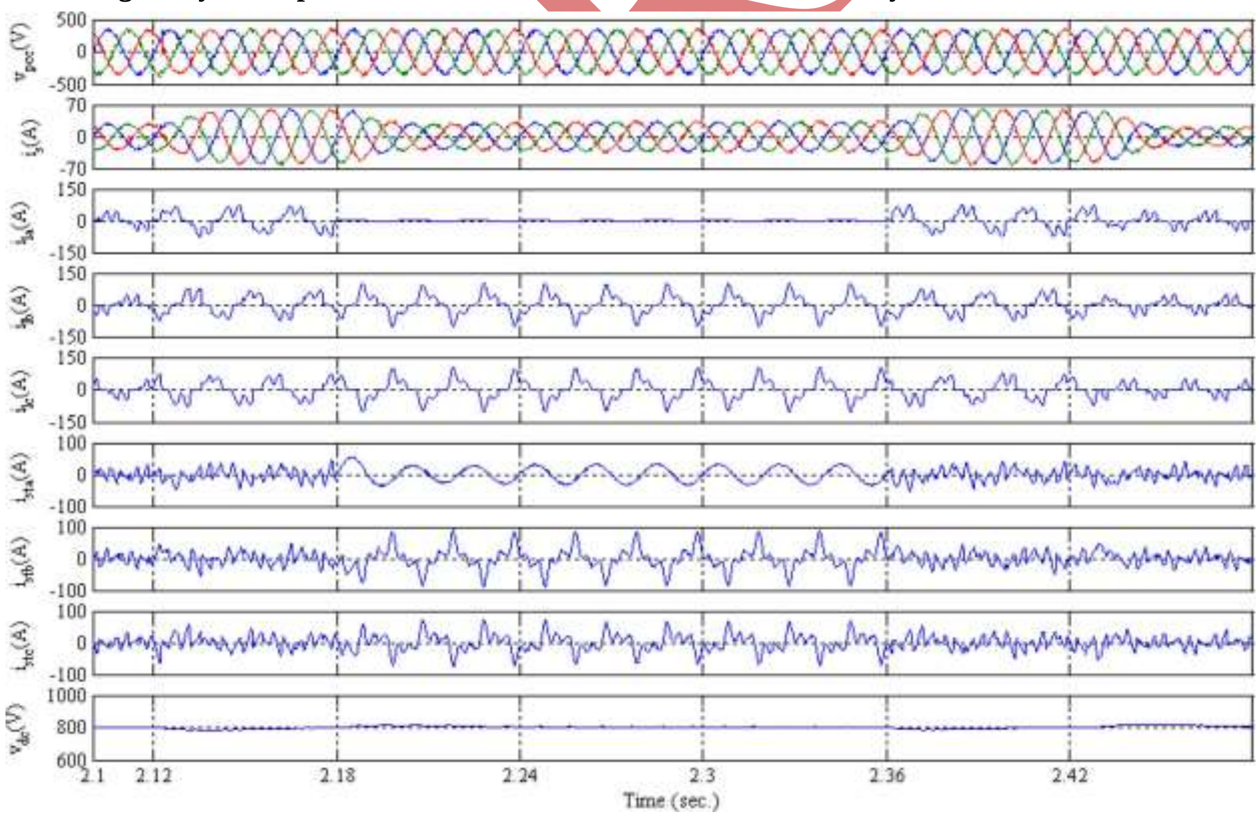

Fig. 5. Dynamic performance of the DSTATCOM-DG isolated system with nonlinear load

V CONCLUSION

The proposed control algorithm of the DSTATCOM has been found to improve the performance of the isolated DG system. The DSTATOM has compensated the variety of loads on the DG set and it has sinusoidal voltages at PCC and currents with compensated and equivalent linear balanced unity power factor loads. The cost of the installation of DSTATCOM system with the DG set can be compensated as it leads to less initial and running cost of DG set as its ideal operation while feeding variety of loads.

REFERENCES

[1] IEEE Standard Criteria for Diesel-Generator Units Applied as Standby Power Supplies for Nuclear Power Generating Stations, IEEE Std 3871995, 1996.
[2] B. Singh, A. Adya, A. P. Mittal, and J. R. P. Gupta, "Performance of DSTATCOM for isolated small alternator feeding non-linear loads," in Proc. Int. Conf. Comput. Appl. Elect. Eng. Recent Adv., 2005, pp. 211–216.
[3] [Online]. Available: http://www.yamahageneratorstore.com/ef2800i htm. [4] E. Acha, V. G. Agelidis, O. Anaya-Lara, and T. J. E. Miller, Power Electronic Control in Electrical Systems. London, U.K.: Newnes, 2002.
[5] H. Akagi, Y. Kanazawa, and A. Nabae, "Generalized theory of the instantaneous reactive power in three-phase circuits," in Proc. IEEE IPEC, Tokyo, Japan, 1983, pp. 821–827.
[6] 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," IEEE Trans. Power Electron., vol. 15, no. 3, pp. 495–507, May 2000.
[7] G. D. Marques, "A comparison of active power filter control methods in unbalanced and non-sinusoidal conditions," in Proc. IEEE Annu. Conf. Ind. Electron. Soc., 1998, vol. 1, pp. 444–449.
[8] B. Widrow and M. A. Lehr, "30 years of adaptive neural networks: Perceptron, Madaline, and backpropagation," Proc. IEEE, vol. 78, no. 9, pp. 1415–1442, Sep. 1990.
[9] B. Widrow, J. M. McCool, and M. Ball, "The complex LMS algorithm," Proc. IEEE, vol. 63, no. 4, pp. 719–720, Apr. 1975.