

Load Compensation of Diesel Generator Based Isolated Generation System Employing DSTATCOM using PI and Neuro Fuzzy Controllers

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Abstract—This paper presents the control scheme of distribution static synchronous compensator (DSTATCOM) for reactive power, harmonics and unbalanced load current compensation of a diesel generator set for an isolated generation system. The control of DSTATCOM is attained by using least mean square-based adaptive linear element (Adaline). An Adaline is mainly used to extract balanced positive sequence real fundamental frequency component from 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 Voltage Source Converter is achieved by controlling source currents to follow reference currents using hysteresis based PWM control. This control scheme is simulated under MATLAB environment using Simulink 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 with implementation of neuro fuzzy controller.

Index Terms—Adaline, diesel generator set, distribution static synchronous compensator (DSTATCOM), harmonic elimination, load compensation, neuro fuzzy controller

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. DG sets used for these purposes are loaded with unbalanced, reactive and nonlinear loads such as power supplies in some fundamental current component from the load current. These techniques are based on complex calculations and generally incorporate a set of low-pass filter which results in a delay in the computation of reference currents and therefore leads to slow dynamic response of the DSTATCOM. In this paper, a fast and simple neural network-based control scheme is used

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. Instead of using these, a DSTATCOM 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. For example, a 24-kW lagging power factor load of 0.8 pf will consume 18 kVAR which is 60% of total kVA rating of a 30 kVA generator. The market price of an inverter is \$50–70 per kVA which can be easily be configured to work as a DSTATCOM. However, the capital cost of the diesel generator is approximately \$500 per kVA rating. Moreover, the DSTATCOM can provide compensation for harmonics which facilitates to load the DG set up to its full kVA rating. 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, instantaneous id – iq theory, and method for estimation of reference currents by maintaining the voltage of dc link are generally reported in the literature for an estimation of reference currents for the DSTATCOM through the extraction of positive-sequence real to estimate reference source currents for the control of the DSTATCOM. This technique 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.

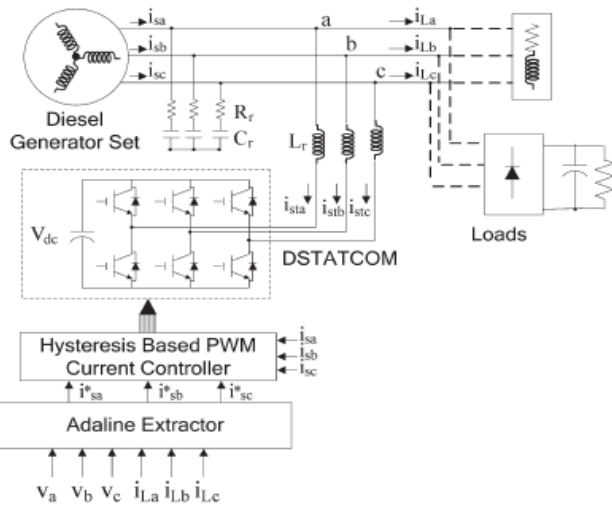


Figure: 1 Basic configuration of the DG set with DSTATCOM

II. SYSTEM CONFIGURATION

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. The parameters of a salient pole synchronous generator are 415 V, 30 kVA, 4 pole, 1500 rpm, 50Hz, $X_d = 1.56$ pu, $X'_d = 0.15$ pu $X''_d = 0.11$ pu, $X_q = 0.78$, $X'_q = 0.17$, $X''_q = 0.6$, $Hs = 0.08$.

III. CONTROL SCHEME

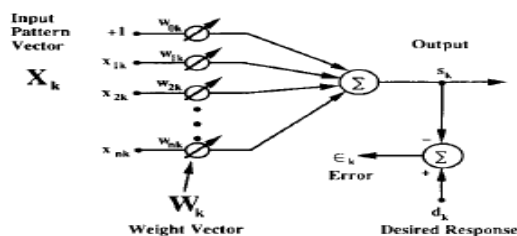


Figure: 2 linear combiner
ADALINE means an Adaptive Linear Element

(or) Neuron. developed by Professor Bernard Widrow. Adaline is a single layer neural network with multiple nodes where each node accepts multiple inputs and generates one output. The output of adaline is expressed as:

$$y = \sum_{j=1}^n x_j w_j + \theta \tag{2.1}$$

Where x is input vector

W is weight vector

n is no of inputs

y is output

The difference between adaline and the standard mccullohpts perceptron is that in the learning phase the weights are adjusted according to the weighted sum of the inputs. In the standard perceptron the net is passed to the activation function and function output is used for adjustment of weights.

An advantage of adaline is that it provides fast convergence to low error solutions even when the data is not linearly seperable.

Here the least mean square algorithm is used as learning algorithm. Let us assume η as convergence factor and d is the desired output, o is actual output then according to algorithm the weights are updated as follows:

$$w \leftarrow w + \eta(d - o)x$$

The adaline converges to the least square error which is $E=(d-o)^2$.

Generalization of LMS algorithm:

$$w(k + 1) = w(k) + \eta e(k) p^t(k) \tag{2.2}$$

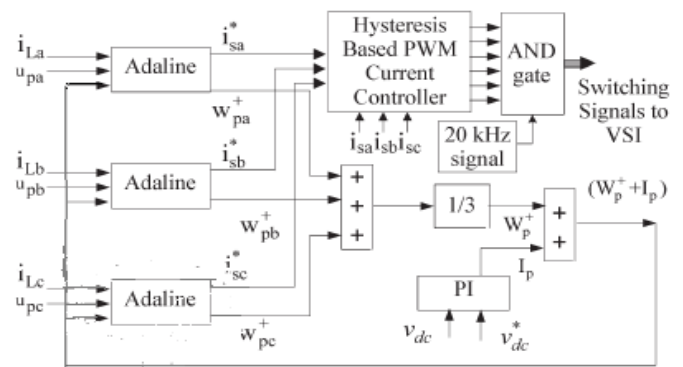


Figure: 3 Block diagram of control circuit for reference current extraction

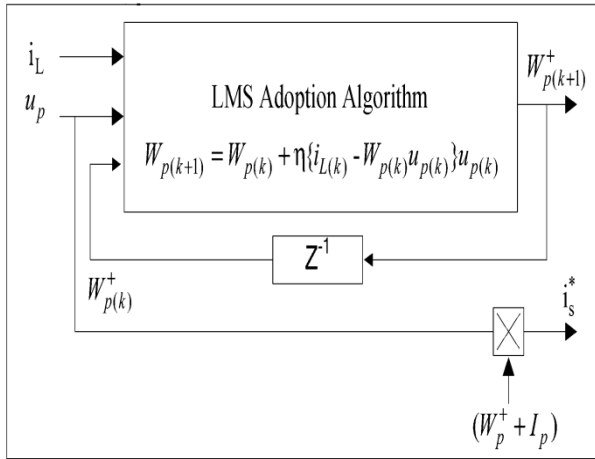


Figure: 4 block diagram of weight updating in adaline

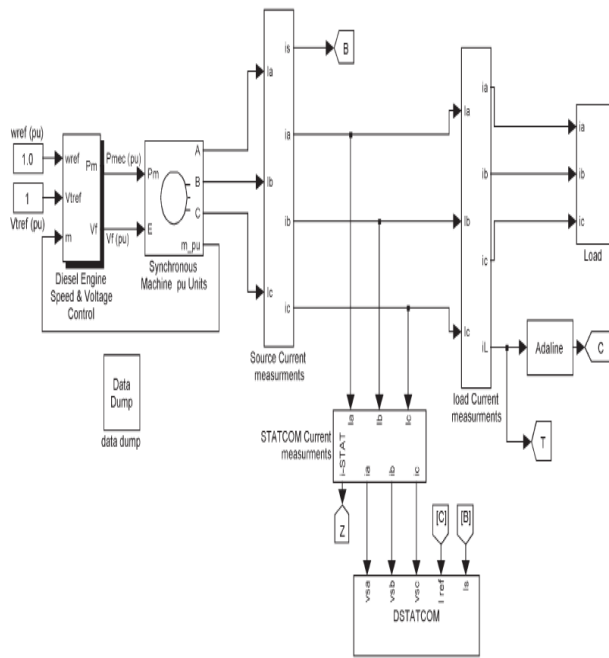


Figure: 5 MATLAB based simulation Model

The control algorithm is based on the extraction of the current component in phase with unit voltage template. To estimate the fundamental frequency positive-sequence real component of load current, the unit voltage template should be in phase with the system voltage and should have unit amplitude. The unit voltage template (u_p) derived from the system phase voltage can be represented as:

$$u_p = v_s/v$$

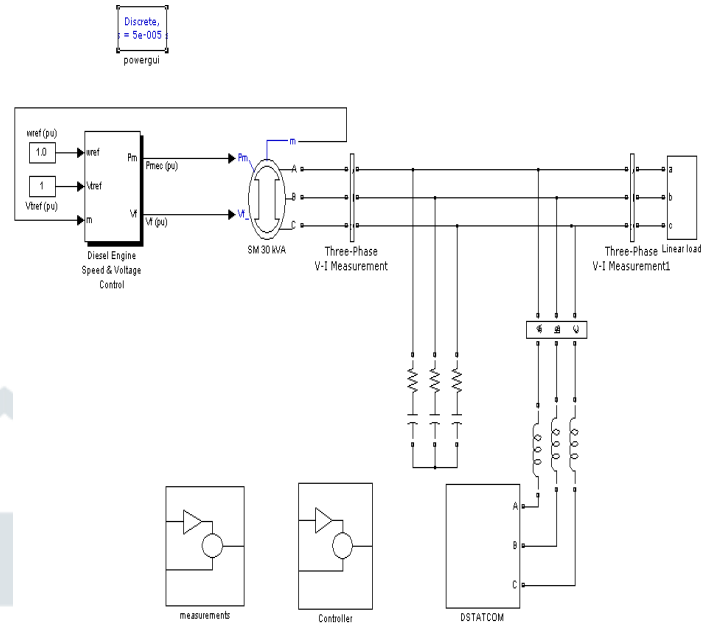


Figure: 6 Simulation Circuit of DG with DSTATCOM feeding to Linear Load using PI controller

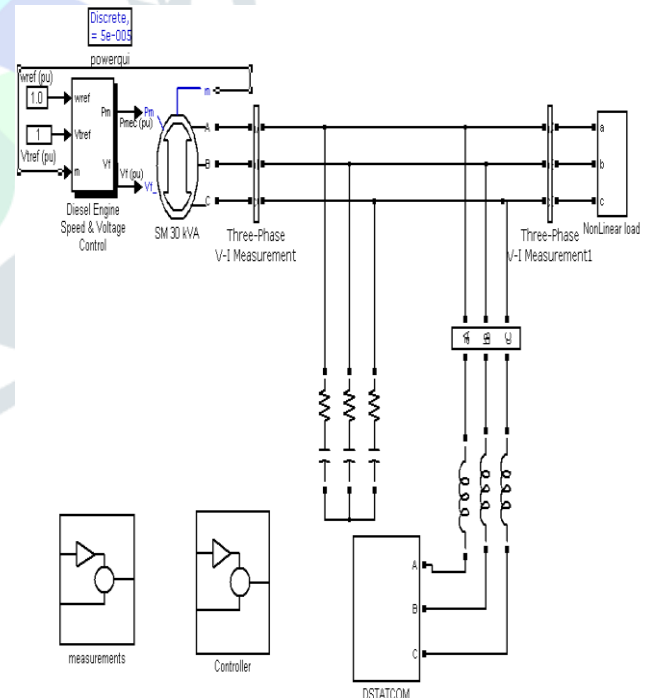


Figure: 7 Simulation Circuit of DG with DSTATCOM feeding to Non linear load using PI and Neuro-Fuzzy controllers

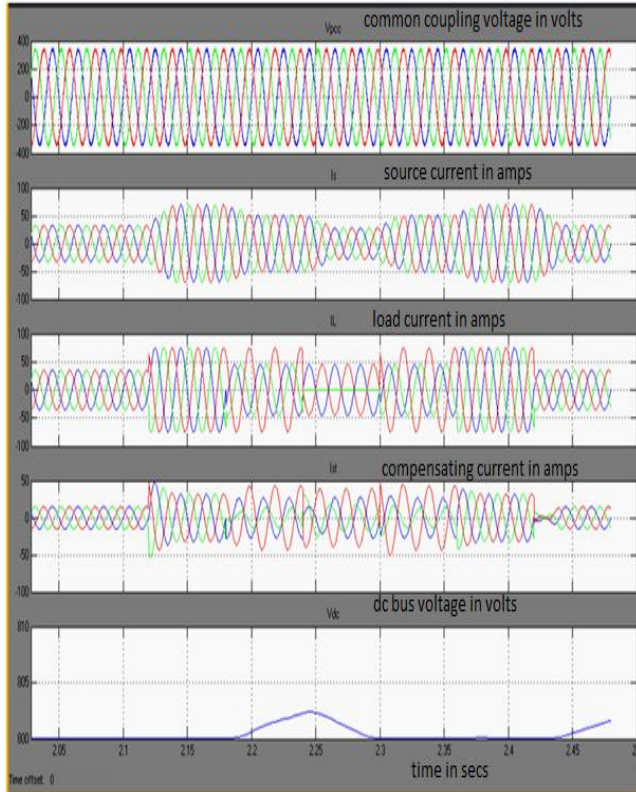


Figure: 8 Result for linear load using PI controller

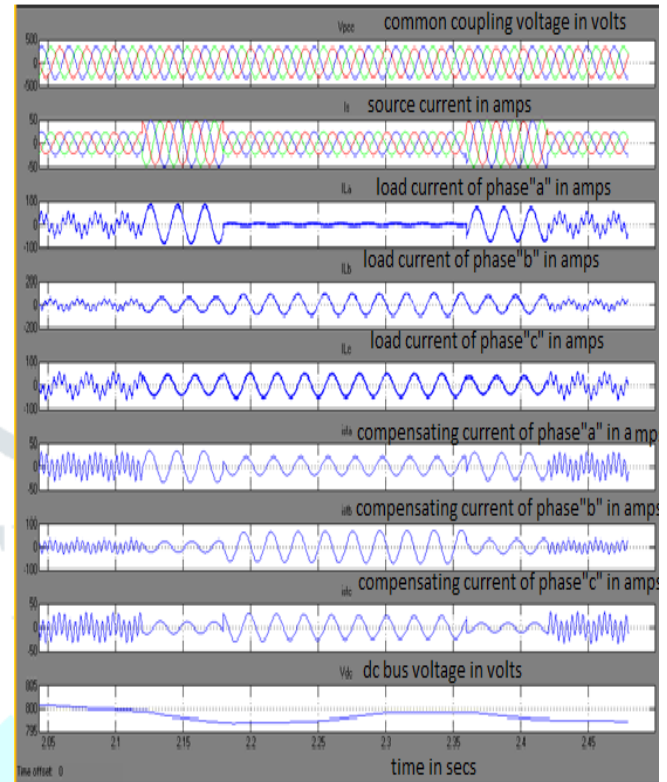


Figure: 10 Result for Non linear load using Neuro-Fuzzy controller

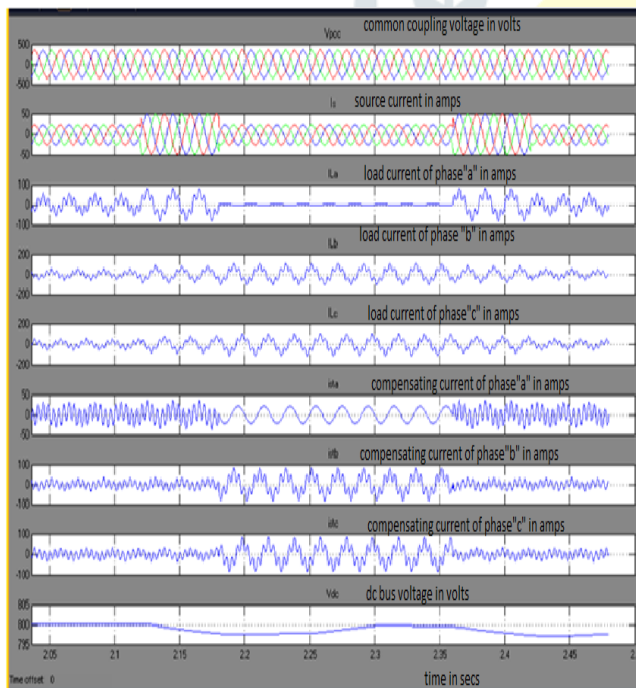


Figure: 9 Result for Non linear load using PI controller

IV.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. The THD analysis of the DG set with DSTATCOM under non linear load with PI and Neuro-Fuzzy controllers are calculated, and by observing this THD values, an improvement in THD is observed in case of Neuro-Fuzzy controller.

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