Buletin Teknik Elektro dan Informatika
(Bulletin of Electrical Engineering and Informatics)
Vol. 3, No. 2, June 2014, pp. 109~112
ISSN: 2089-3191

Voltage Sag Mitigation and Load Reactive Power Compensation by UPQC

P Ajitha*[1], D Jananisri[2]
Dept of EEE, M. Kumarasamy College of Engineering, Karur, India.
*Corresponding author, email: ajitha27me@gmail.com[1], djananisri@gmail.com[2]

Abstract

This paper presents Unified Power Quality Conditioner(UPQC) that consist of series inverter and shunt inverter in back to back configuration which simultaneously compensate the power quality(PQ) problems of both voltage sag and load reactive power compensation . In this paper, Neural network is tool which is considered for solving power quality problems. The simulation results from MATLAB/SIMULINK are discussed to validate the proposed method.

Keywords*: unified power quality conditioner (UPQC), power quality, neural network*

1. Introduction

Nowadays electronic controllers have been used widely which causes serious problem in distribution system and leads to unwanted harmonics that ultimately result in decreased efficiency [1-2]. UPQC has been used widely in the distribution level because it compensates several major power quality problems. Combined operation system of UPQC and distributed generation which is connected to the dc link through a rectifier compensates voltage interruption, as well as voltage sag, swell and harmonics and also reactive power compensation [3]. UPQC-Q controls the voltage sag and reactive power by quadrature voltage injection method [4].

Passive power filters are used due to the lack of poor power factor which leads to the ineffective use of volt-ampere rating in transformer and generator [4]. UPQC is economical when compared to the passive filters. Effective VA optimization of overall UPQC is used to compensate the voltage sag [5]. But the time duration of compensation takes few cycles. Though PI, PID controllers are in use they all need a precise mathematical model. In this paper the proposed concept of neural network has been used. Neural network controller with PI controller is used. Neural network has been used widely because of its fast dynamic response in maintaining the stability of system over a wide range [6]. The effectiveness of the proposed method can be done with the help of simulation results.

2. UPQC

UPQC consist of a series and shunt inverter that are connected back to back to a dc link capacitor as Figure 1. UPQC has the capability of compensating the voltage sag and reactive power compensation.

Phasor diagram shown relates presag voltage V_{s1}, the postsag voltage V_{s2}, the resultant voltage phasor V_{L2}. Variables with subscript 1 and subscript 2 are presag and postsag variables respectively as Figure 2.

3. Design of PI Controller

The design of PI controller for current source inverter is done by the following assumptions:

1) The voltage at PCC is sinusoidal and balanced

Received January 27, 2014; Revised May 7, 2014; Accepted May 21, 2014

2) Since the harmonic component does not affect the average power balance expressions, only the fundamental component of currents is considered
3) Losses of the system are lumped and represented by an equivalent resistance connected in series with the filter inductor
4) Ripples in the dc-link current are neglected.
The block diagram of the current control loop is shown in Figure where '*G 'gain of the PI controller*, k_c is the transfer function of the PWM converter. A linear model of the PWM converter can be derived by applying a small-signal perturbation technique to obtain its transfer function. In this method of deriving a linear model

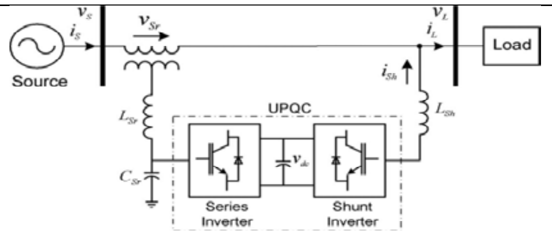

Figure 1. Unified power quality conditioner (UPQC) system configuration.

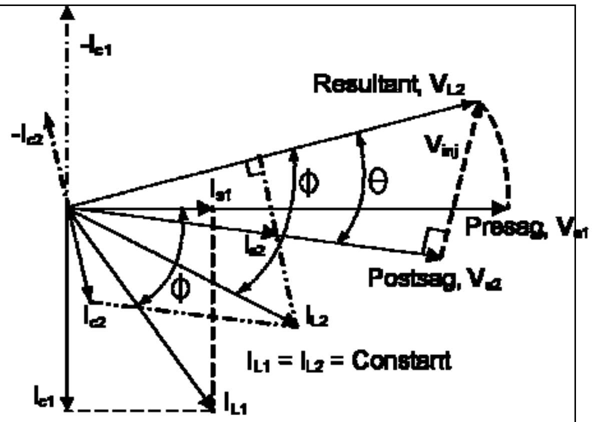

Figure 2. Phasor representation of various current and voltages in UPQC

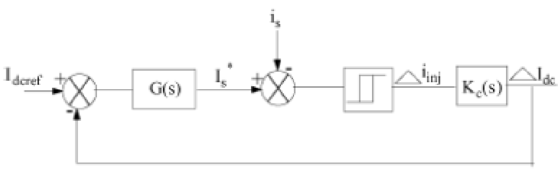

Figure 3. Block diagram of current control loop

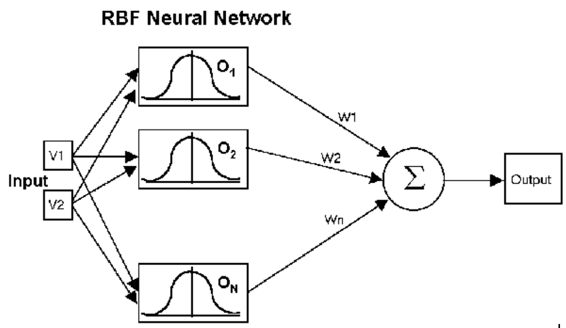

Figure 4. RBF Neural Network

The system is assumed to operate in the steady state, and the defining equations are linearized for small-signal perturbation. Steps to be followed for proper tuning of PI controller are:
1) Turn off the integration part of controller
2) Try to tune proportional gain, $k_{p,}$ until result ok
3) If step 2 do not accomplish control target,then turn ON integer part.

4. Design of ANN

The rapid detection of the disturbance signal with high accuracy, fast processing of the reference signal, and high dynamic response of the controller are the prime requirements for desired compensation in case of UPQC. The conventional controller fails to perform satisfactorily under parameter variations nonlinearity load disturbance, etc. A recent study shows that NN-based controllers provide fast dynamic response while maintaining stability of the converter system over wide operating range.

The ANN is made up of interconnecting artificial neurons. It is essentially a cluster of suitably interconnected nonlinear elements of very simple form that possess the ability to learn and adapt. It resembles the brain in two aspects: 1) the knowledge is acquired by the network through the learning process and 2) interneuron connection strengths are used to store the knowledge [7]. These networks are characterized by their topology, the way in which they communicate with their environment, the
manner in which they are trained, and their ability to process information. ANNs are being used to solve AI problems without necessarily creating a model of a real dynamic system.

The algorithm used is radial basis function method. Different types of radial basis function could be used, but the most common is Gaussian Function. RBF networks as Figure 4 have three layers namely: input layer, hidden layer and summation layer

Training RBF Networks

The following parameters are determined by the training process:
1. The number of neurons in the hidden layer.
2. The coordinates of the center of each hidden-layer RBF function.
3. The radius (spread) of each RBF function in each dimension.
4. The weights applied to the RBF function outputs as they are passed to the summation layer.

Various methods have been used to train RBF networks. One approach first uses K-means clustering to find cluster centers which are then used as the centers for the RBF functions. However, K-means clustering is a computationally intensive procedure, and it often does not generate the optimal number of centers. Another approach is to use a random subset of the training points as the centers.

DTREG uses a algorithm uses an evolutionary approach to determine the_optimal center points and spreads for each neuron. It also determines when to stop adding neurons to the network by monitoring the estimated leave-one-out (LOO) error and terminating when the LOO error beings to increase due to over fitting.

The computation of the optimal weights between the neurons in the hidden layer and the summation layer is done using ridge regression. An iterative procedure developed by Mark Orr (Orr, 1966) is used to compute the optimal regularization Lambda parameter that minimizes generalized cross-validation (GCV) error.

5. Results and Discussions

Using Simulink toolbar and its respective library, a sequence of model is required to meet the requirements.

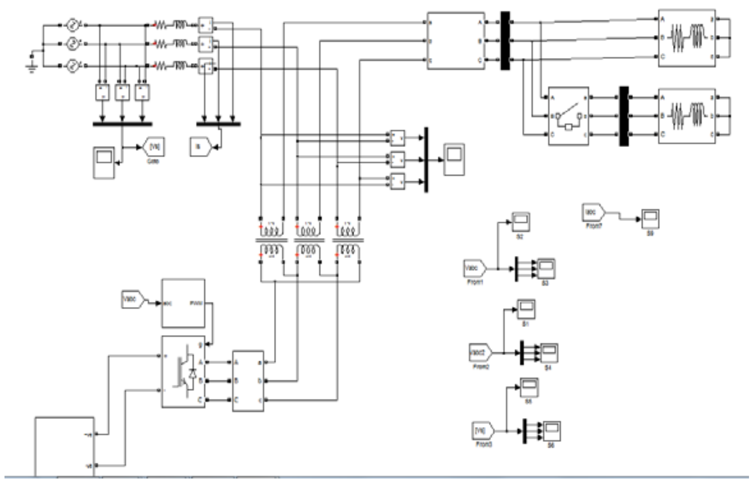

Figure 4. Simulation diagram UPQC with ANN

Sag voltage simulation is performed for period 0.3 sec and the disturbance at the load is applied for a certain period of time.

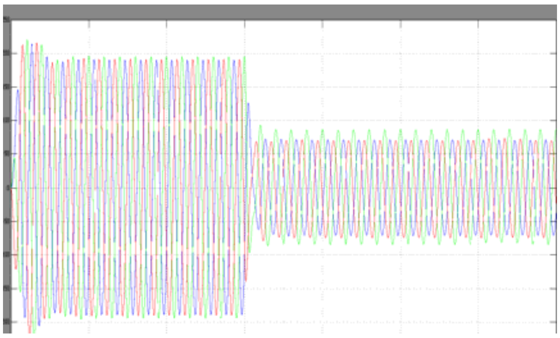

Figure 5. Sag voltage waveform

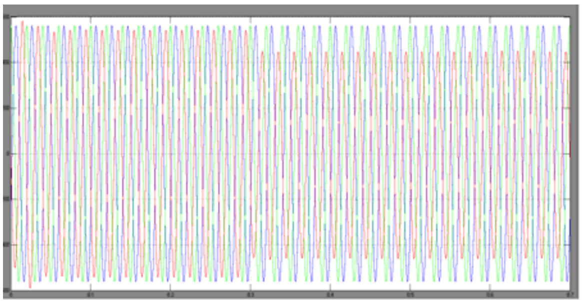

Figure 6. Improved Sag Voltage waveform

The Voltage Sag Compensation which occurs due to addition of new loads such that the Voltage of the system is affected. Hence compensation is required to bring back to the normal operation without Sag. The sag voltage is shown in Figure 5.Here we use a three phase AC source connected to the load. While a Additional Load component comes into the picture the performance of the line is affected due to Voltage sag occurred. With the help of Neural network and PI the voltage sag occurred has been effectively reduced is shown in Figure 6.

6. Conclusion

The performance of the UPQC mainly depends upon how accurately and quickly the reference signals are derived. The conventional UPQC-S cannot compensate the voltage sag effectively due to the increased power angle value. However the performance of PI was not satisfactory in non linear loads so PI and ANN are used in combination.ANN is used to improve the gain of PI in the system. The proposed system can effectively compensate the voltage sag and reactive power compensations. The proposed system can improve the power quality at the point of installation on power distribution systems or industrial power systems. The proposed system was successfully verified by Matlab/Simulink.

References

[1] B Singh, K Al-Haddad, and A Chandra. "A review of active power filters for power quality improvement". *IEEE Trans. Ind. Electron*. 1999; 45(5): 960–971.
[2] H Akagi. "New trends in active filters for power conditioning". *IEEE Trans. Ind. Appl*. 1996; 32(6): 1312–1322.
[3] B Han, B Bae, H Kim, and S Baek. "Combined operation of unified power-quality conditioner with distributed generation". *IEEE Trans.Power Del*. 2006; 21(1): 330–338.
[4] YY Kolhatkar and SP Das. "Experimental investigation of a single phase UPQC with minimum VA loading". *IEEE Trans. Power Del*. 2007; 22(1): 373–380.
[5] M Yun, W Lee, I Suh, and D Hyun. "*A new control scheme of unified power quality compensator-Q with minimum power injection*". in Pro IEEE Ind. Electron. Soc (IECON). 2004: 51–56.
[6] K Sunat. Neural Networks and Theory and Applications. ser. Lecture Notes. India: Burapha Univ., 2006.
[7] Vadirajacharya G Kinhal, Promod Agarwal, and Hari Oam Gupta. "Performance Investigation of Neural-Network-Based Unified Power-Quality Conditioner". *IEEE Transactions on Power Delivery*. 2011; 26(1).