Power Quality Measurement by Artificial Neural Network And Mitigation Using Dstatcom

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Abstract

An uninterrupted supply of high quality power to customers in a secure and economic environment is the goal of power system engineers. An important task in power system operation is to decide whether the system, at a given point of time, operates safely, critically and optimally while the system operates safely. In this thesis work the problem of power quality of voltage sag is detected by artificial neural network then trained data and neural network output simulated in neural network block set, then it will be mitigated using DSTATCOM with neural network control block. Different aspects or power line status were considered and simulated using Artificial Neural Network to get the response under changed operating conditions.

Key words: Voltage Sag, DSTATCOM, Artificial Neural Network

1. Introduction

In electrical power distribution networks, it is essential to balance the supply and demand of active and reactive power in an electric power system. If the balance is lost, the system frequency and voltage excursion may occur resulting, in the worst case, in the collapse of the power system. Appropriate voltage and reactive power control is one of the most important factors for stable power system. The distribution system losses and various power quality problems are increasing due to reactive power. Nowadays electrical power transmission and distribution system face increasing demand for more power, better quality with higher reliability at a lower cost as well as low environmental impact. Present developing countries applying versatile voltage regulation and system stabilization measure, in order to utilize more effectively the latent capacity in existing transmission networks in preference to committing larger resources to new overhead lines and substations.The analysis of power quality in electrical power systems includes the study of transient disturbances as frequency variations, sags, swells, flicker or interruptions. In this project, a measurement system of some transient disturbances based on Artificial Neural Networks will be presented. A feedforward Artificial Neural Network (ANN) has been off-line trained to detect the initial time, the final time and the magnitude of voltage sags and swells. Besides, the designed system will be applied to detect transient voltage in electrical power systems. The performance of the designed measure method will be tested trough a simulation platform designed in Matlab/Simulink through the analysis of some practical cases.The main features this study will consider are those concerning voltage and current deviations, such as: sags, under and over voltages etc. The goal of the artificial intelligence monitoring techniques used will be to recognise a particular power quality deficiency, such as voltage sag to produce an output that can then be communicated to appropriate power electronic device capable of rectifying the problem. The purpose of the study is to design a neural network monitoring system capable of diagnosing power signal data for flaws in the power quality. The path to achieving this goal contains 4 main steps:

1. Modelling the Neural Network Architectures.
2. Simulating/Training the Neural Network System.
3. Saving the state of neural network in software.
4. Output of neural network applies to DSTATCOM which mitigate voltage sag.

2. Neural network architecture:

The Artificial Neural Networks includes a large number of strongly connected elements: the artificial neurons, a biological neuron abstraction. The model of an artificial neuron in a schematic configuration is shown in figure 1.

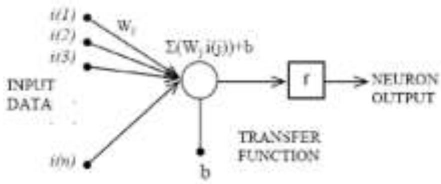

Fig. 1. Artificial Neuron Model

The input data *i(1)*, *i(2)*, *i(3)*, …, *i(n)* flow through the synapses weights Wj. These weights amplify or attenuate the inputs signals before the addition at the node represented by a circle. The summed data flows to the output through a transfer function, f. The neurons are interconnected creating different layers. The feedforward architecture is the most commonly adopted. The scheme is shown in figure 2.

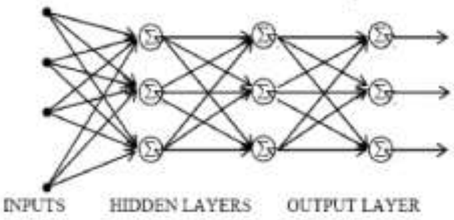

Fig.1.1.Feedforward Neural NetworkArchitecture

This network can be trained to give a desired pattern at the output, when the corresponding input data set is applied. This training process is carried out with a large number of input and output target data. These data can be obtained using a simulation platform or an experimental system. The training method most commonly used is the back propagation algorithm. The initial output pattern is compared with the desired output pattern and the weights are adjusted by the algorithm to minimize the error. The iterative process finishes when the error becomes near null.

3. Principle of Operation of Dstatcom:

The D-STATCOM is a three phase and shunt connected power electronics based reactive power compensation equipment, which generates and /or absorbs the reactive power whose output can be varied so as to maintain control of specific parameters of the electric power system.The D-STATCOM basically consists of a coupling transformer with a leakage reactance, a three phase GTO/IGBT voltage source inverter (VSI), and a dc capacitor. The ac voltage difference across the leakage reactance power exchange between the D-STATCOM and the Power system, such that the AC voltages at the bus bar can be regulated to improve the voltage profile of the power system, which is primary duty of the D-STATCOM.However a secondary damping function can be added in to the D-STATCOM for enhancing power system oscillation stability. The D-STATCOM provides operating characteristics similar to a rotating Synchronous compensator without the mechanical inertia. The D-STATCOM employs solid state power switching devices and provides rapid controllability of the three phase voltages, both in magnitude and phase angle.The D-STATCOM employs an inverter to convert the DC link voltage V_{dc} on the capacitor to a voltage source of adjustable magnitude and phase. Therefore the D-STATCOM can be treated as a voltage controlled source. The D-STATCOM can also be seen as a current controlled source.

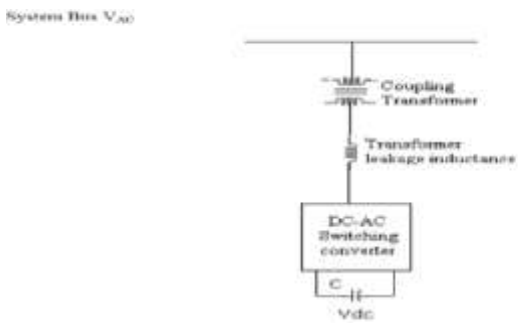

Fig 2.0 Single line diagram of a D-STATCOM

DSTATCOM Voltage Controller

The aim of the control scheme is to maintain constant voltage magnitude at the point where a sensitive load is connected, under system disturbances. The control system only measures the r.m.s voltage at the load point, i.e., no reactive power measurements are required. The VSC switching strategy is based on a sinusoidal PWM technique which offers simplicity and good response. Since custom power is a relatively low-power application, PWM methods offer a more flexible option than the Fundamental Frequency Switching (FFS) methods favored in FACTS applications.

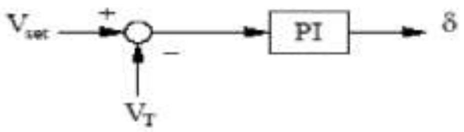

Fig.2.1. Controller for DSTATCOM

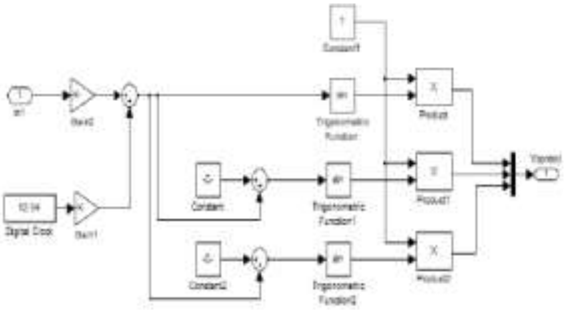

Fig 2.2. Generation of reference control signals for PWM controller

4. Simulation platform:

To simulate the proposed measurement system, including the ANN training process and its on-line performance, a Matlab/Simulink platform has been designed. To carry out the network training process, a set of input voltage waveforms with different length and depth sags was generated in Matlab/Simulink platform. The per unit voltage amplitude was considered as desired network output. The training process of the neural network was carried out helped by the Neural Network Matlab toolbox. The error evolution during the training process is presented in figure 3.In this paper two layerNeural network model is used. In layer 1 transfer function is tansig and in layer 2 is purelin are used. The numbers of neurons in layer 1 and in layer 2 are 10. The number of epochs used to train the network is 20 and error evolution during training process performance is 0.00223422 and goal is 0.001. The Back propagation feed forward neural networks are used to train the neurons in this model and with this developed model we are easily identified Voltage Sag.

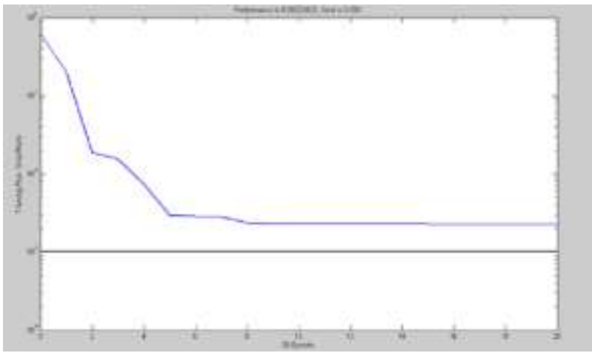

Fig. 3. Error evolution during the training process

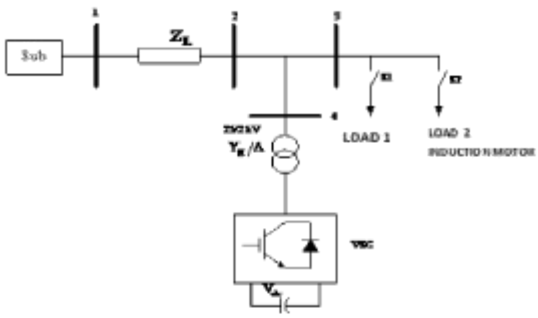

Fig 4.0: Single-line diagram of the test system with DSTATCOM

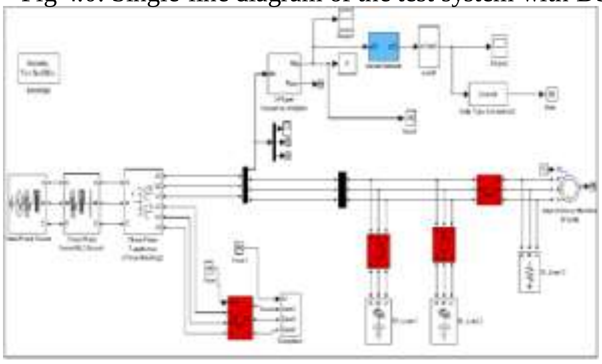

Fig 4.1: Simulink model of test system to measure Voltage Sag, detection by Neural Network and mitigation by DSTATCOM.

5. Results and Discussion:

The output of ANN is applied to the DSTATCOM by Breaker through external control switches. The first simulation contains of a healthy system shows target for ANN as shown in fig.5.0, and a load is increased by three phase induction motor, during the period 500-900ms. The voltage sag at the load point is 30% with respect to the reference voltage. The second simulation is carried out using the same scenario as above now without DSTATCOM then now DSTATCOM in operation in third simulation. Figure 5.1 shows the duration of voltage sag from 0.35s to 0.7s and during this period the DSTATCOM responds well to give the system better ride through capability. The sag was mitigated within 20 ms and limited to less than 20% of sag before the system recovered to 1.0
p.u. The total simulation period is 1400ms. A set of simulations was carried out for the test system shown in Fig.4. The simulations relate to three main operating conditions.

1) In the simulation period 500–900 ms, the load is increased by closing switch S1. In this case, the voltage drops by almost 75% with respect to the reference value.
2) At 800 ms, the switch S1 is opened and remains so throughout the rest of the simulation. The load voltage is very close to the reference value, i.e.1 pu.
3) In order to gain insight into the influence that capacitor size has on D-STATCOM performance, simulations were carried. The total simulation period is 1.4 sec.

The DSTATCOM which mitigate the Voltage Sag is shown in fig. 5.3. Figure below shows a voltage waveform with depth sag and the corresponding network output in fig 5.4.

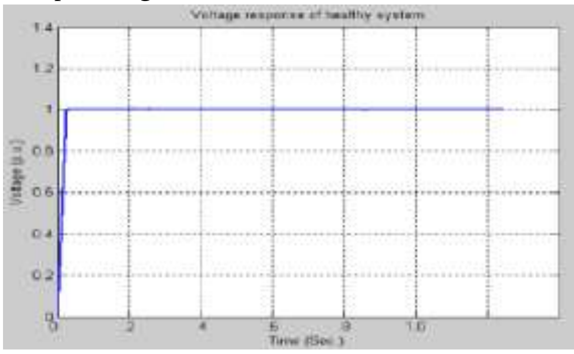

Fig. 5.0 Voltage response in p.u. of a healthy system

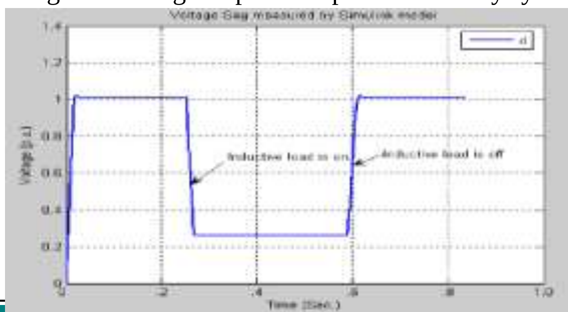

Fig 5.1. Voltage response of the test system without DSTATCOM

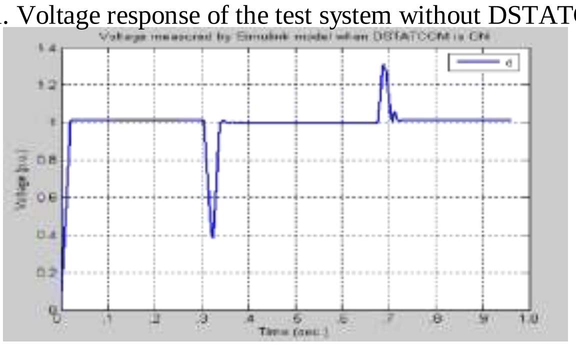

Fig 5.3 Voltage response of the test system with DSTATCOM.

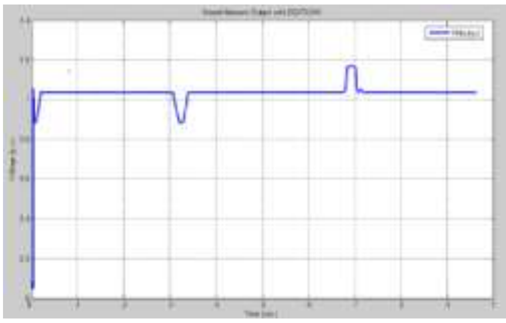

Fig5.4.NeuralNetwork output with DSTATCOM for layer 2 network.

6. Conclusions:

A procedure to measure on-line voltage disturbances using artificial neural networks has been presented. A feed forward neural network has been designed and trained using input/output data supplied with computer simulations. The neural network was satisfactorily tested for the detection and measurement of different voltage sags and swells and for the detection of transient voltages in electrical power systems.The Voltage Sag is detected between the time 0.3 to 0.7 seconds and during this period DSTATCOM is ON to mitigate the Voltage Sag. The results obtained showed that the computational time is nearly instantaneous. The results are sufficiently accurate.

7. References:

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