ISSN (Online) : 2319 - 8753
ISSN (Print) : 2347 - 6710

International Journal of Innovative Research in Science, Engineering and Technology

Volume 3, Special Issue 3, March 2014

2014 International Conference on Innovations in Engineering and Technology (ICIET'14)
On 21st & 22nd March Organized by

K.L.N. College of Engineering, Madurai, Tamil Nadu, India

Voltage Sag, Swell And Interruptions Compensation Based On Feed Forward Backpropagation Network Using Dynamic Voltage Restorer

M.GaneshKumari M.E. (Ph.D) [1], Dr.K.Gnanambal [2], R.Andalpriyatharshini [3]

[1]Assistant Professor , (Sr.Gr)/EEE, K.L.N.C.E, Dept. of Electrical and Electronics Eng., K.L.N. College of Engineering, Pottapalayam, Madurai, India.

[2]Professor/ EEE, K.L.N.C.E, Dept. of Electrical and Electronics Eng., K.L.N. College of Engineering,, Pottapalayam, Madurai, India.

[3]PG Scholar /EEE, K.L.N.C.E, Dept. of Electrical and Electronics Eng., K.L.N. College of Engineering, Pottapalayam, Madurai, India.

ABSTRACT— The widespread use of power electronics devices has led to a complete change in electrical load nature, all these variations in load causes disturbances in voltage waveforms. The disturbance includes Voltage sag/ swell, interruption etc. the use of custom power devices is considered to be the most efficient method for restoration of system voltage. Dynamic Voltage Restorer (DVR) can provide the cost effective solution for mitigation of short duration voltage disturbances in distribution system. Here in this paper, Three phase Dynamic voltage Restorer based on Neural Network controller with Levenberg-Marquardt Back propagation training algorithm are proposed for mitigating voltage sag, swell and interruptions. Short duration voltage disturbances are simulated on a three phase system and the comparative results has been presented using MATLAB/SIMULINK.

KEYWORDS— Three Phase DVR, Voltage Sag, Voltage Swell, Interruptions, Back propagation feed forward network

I. INTRODUCTION

In the recent era, due to the advent of sophisticated devices, the quality of power supplied to the end users holds greater importance. The distortion in the quality of supply power may lead to mis-operation or failure of end use equipment. So the demand of high quality of power is increased. The use of custom power devices is considered to be the most efficient method for restoration of the system voltage. Dynamic Voltage Restorer (DVR) is a series custom power device used to protect sensitive loads against short duration voltage disturbances such as Voltage Sag/Swell and interruptions. Different control Strategies and configuration has been proposed for the DVR in mitigation of Voltage Sag/Swell and interruptions. [1] Here in this paper three multilayer perceptron is proposed for mitigation of voltage sag, swell and unbalance. The proposed controller provides optimal mitigation of disturbances. [2] In this paper, adaptive neural network is proposed for mitigation of voltage sag with minimum energy injection from DVR for compensation; here a simple feed forward structure is used. [3] Here in this paper, the advantages of both PI controller and neural network controller are discussed and the performance is analyzed. [4] Here, high power DVR with neural network controller is proposed. It is used to detect the voltage disturbance and for regulation of output voltage, also it compensates the voltage disturbances as fast as possible. [5] Here the performance of both PI and Fuzzy logic controller based DVR is analyzed. [6] Proposes a generalized PI controller for mitigation of voltage sag with DVR. [7] Proposes a novel control scheme to mitigate the voltage disturbance effectively and to compensate the disturbance in very faster rates. [8] Here voltage sag, swell and harmonics are compensated by using DVR. Now, here in this paper, feed forward Neural Network controller with Levenberg-Marquardt Back propagation algorithm is used for the mitigation of three phase Voltage Sag, Voltage Swell and interruptions in the system using DVR. The simulation result shows that the performance of Neural Network controller is considered to be good when compared to the conventional controllers. The results are presented using MATLAB/SIMULINK.

II. SHORT DURATION VOLTAGE DISTURBANCES

Voltage sag is the decrease in the normal voltage level between 10 and 90% of the nominal RMS voltage at the power frequency for duration of 0, 5 cycles to 1 minute. The main causes of voltage sag are, fuse (or) breaker operation, capacitor switching, faults on the transmission or distribution network, faults in consumer's installation, Connection of heavy loads and start-up of large motors.

Voltage Swell is defined as the increase of voltage above the normal tolerance lasting for duration of few seconds. The main causes of voltage swell are start and stop of heavy loads, badly dimensioned power source.

Voltage interruptions are the total interruptions of electrical supply for duration of few milliseconds to one or two seconds.

The above short duration disturbances results in malfunction of information technology equipment, namely microprocessor-based control systems (PC's, PLC's, ASD's) that may lead to a process stoppage, tripping of contactors and electromechanical relays, disconnection and loss of efficiency in electric rotating machines.

III. DYNAMIC VOLTAGE RESTORER

Dynamic Voltage Restorer (DVR) is a series connected voltage source converter based compensator which has been designed to protect sensitive equipment like PLC, ASD from short duration voltage disturbances.

Its main function is to monitor the load voltage waveforms constantly by injecting required voltage in the case of disturbances. If a fault occurs on any feeder, then DVR inserts series voltage and compensates load voltage to pre-fault voltage.

The basic configuration of DVR includes, an injection/booster transformer, a harmonic filter, a voltage source converter, an energy unit and control system

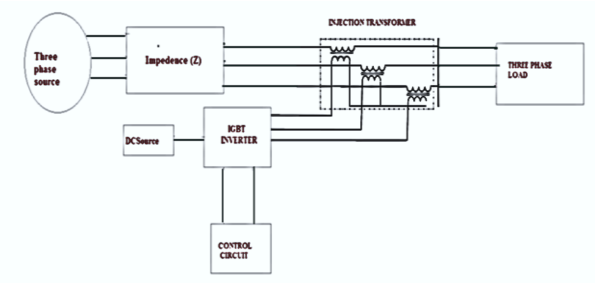

Fig.1. Three Phase Test System With DVR

An injection/booster transformer:

An injection/booster transformer connects the DVR to the distribution network via the high voltage windings and it's also used to couple the injected compensating voltage from DVR energy storage to the incoming supply voltage.

A harmonic filter: A harmonic filter is used to decrease the output harmonics which is generated by the VSC.

A voltage source converter (VSC): A VSC consists of energy storage and switching device. It generates a sinusoidal voltage at any required frequency, magnitude and phase angle. The major types of switching devices used are MOSFET, GTO, and IGBT.

Energy storage: The DC energy storage device satisfies the real power requirement of the DVR during Compensation. Various storage technologies have been proposed which includes flywheel energy storage, super-conducting magnetic energy storage (SMES) and super capacitors.

Flywheel: A flywheel is an electromechanical device that couples a rotating electric machine with rotating mass to store energy for short durations. The motor/ generator draw power provided by the grid to keep the rotor of the flywheel spinning. During a power disturbance, the kinetic energy stored in the rotor is transformed to DC electric energy by the generator, and the energy is delivered at a constant frequency and voltage through an inverter and a control system. The flywheel provides power during a period between the loss of utility supplied power and either the return of utility power or the start of a back-up power system.

Super capacitors: super capacitors also known as ultra-capacitors are DC energy sources and must be interfaced to the electric grid with a static power conditioner, providing energy output at the grid frequency. A super capacitor provides power during short duration interruptions or voltage sags. Medium size super capacitors are commercially available to implement ride-through capability in small electronic equipment, but large super capacitors are still in development, but may soon become a viable component of the energy storage field.

SMES: A magnetic field is created by circulating a DC current in a closed coil of superconducting wire. The path of the coil circulating current can be opened with a solid state switch which is modulated on and off. Due to the high inductance of the coil, when the switch is off the magnetic coil behaves as a current source and will force current into the power converter which will charge to some voltage level. Proper modulation of the solid state switch can hold the voltage within the proper operating range of the inverter, which converts the DC voltage into AC power.

Control System:

The aim of the control system is to maintain constant voltage magnitude at the point where a sensitive load is connected, under system disturbances; the control system of the general configurations typically consists of a voltage correction method which determines the reference voltage that should be injected by DVR.

Operating Modes of DVR:

The basic function of the DVR is to inject a dynamically controlled voltage generated by a forced commutated converter in series to the bus voltage by means of a booster transformer. The momentary amplitudes of the three injected phase voltages are controlled such as to eliminate any detrimental effects of a bus fault to the load voltage. This means that any differential voltage caused by transient disturbances in the ac feeder will be compensated by an equivalent voltage generated by the converter and injected on the medium voltage level through the booster transformer. The three modes of operation of DVR are Protection mode, Standby mode, Injection or boost mode

Protection mode:

If the over current on the load side exceeds a permissible limit due to short circuit on the load or large inrush current. The DVR will be isolated from the systems by using the bypass switches and supplying another path for current.

Standby mode:

In standby mode the booster transformer's low voltage winding is shorted through the converter. No switching of semiconductors occurs in this mode of operation, because the individual converter legs are triggered such as to establish a short-circuit path for the transformer connection. Therefore, the only comparatively low conduction losses of the semiconductors in this current loop contribute to the losses. The DVR will be most of the time in this mode.

Boost mode:

In boost mode, the DVR is injecting a compensating voltage through the booster transformer due to a detection of a supply voltage disturbance.

The existing DVR control strategies are the following,

- In phase voltage injection technique
- Phase advance compensation technique.

In phase voltage injection technique:

Here the voltage injected by the DVR is in phase with the sag voltage. This method does not consider the phase shift of the voltage disturbances therefore maximum power should be injected by the DVR energy storage unit into the distribution system. Hence this method does not minimize the energy required for the compensation of voltage disturbances.

Phase advance compensation technique:

In phase advance compensation technique, the load voltage advance angle 'α' is adjusted in such a way that less real power needs to be injected by the DVR energy storage into the distribution system. The advancement of load voltage advance angle 'α' at the beginning of the disturbance as well as the restoration of the phase angle at the end of the disturbance must be carried out without interrupting the operation of sensitive loads. When compared to conventional In-Phase compensation technique, the phase advance compensation technique reduces the energy requirement of the DVR energy storage unit.

IV NEURAL NETWORK CONTROLLER

An artificial Neural Network (ANN) is an information processing paradigm that is inspired by the way biological nervous system, such as the brain, process information. An ANN controller used in the control system consists of three neuron layer, i.e., the input layer, the hidden layer, the output layer.

In this paper, Neural Network controller is proposed for the control of DVR. The artificial neural network includes a large number of strongly connected elements. The input data flow through the synapse weight. These weights amplify or attenuate the input signals before the addition at the node. The summed data flows through a transfer function, f. the neurons are interconnected creating different layers.

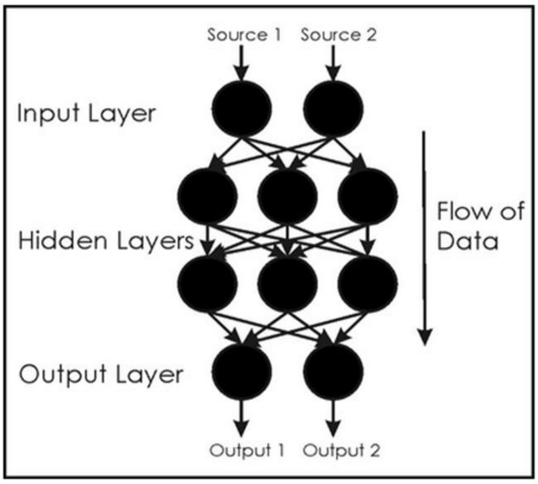

Fig.2.Architecture of simple Neural Network

The feed forward architecture is the most commonly adopted. In feed forward method, the information moves in only one direction forward from the input nodes through the hidden nodes and to the output nodes. Back propagation is a form of supervised training. The network must be provided with both sample inputs and anticipated outputs the anticipated outputs are compared against the actual outputs for a given inputs. It takes a calculated error and adjusts the weight of the various layers backwards from the output layer to the input layer.

The network has been trained to give desired pattern at the output, when the corresponding input data set is applied. This training process is carried out with large number of input and output target data. These data can be obtained using a simulation platform or an experimental system. 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.

V THREE PHASE DVR TEST SYSTEM

The Three Phase DVR test system comprises of 230V, 50HZ rating. When the short duration voltage disturbances are detected, the DVR injects the required real power such that it effectively compensates the voltage disturbance at load terminals. Here Neural Network controller is used for the control of DVR. The Input layer transmits the input signal to the hidden layer. The Hidden layer uses TANSIG transfer function while the output layer uses linear transfer function.

The Input to the ANN is the three phase voltage errors of Dynamic Voltage Restorer (DVR). The Output of ANN is compared with the carrier signal and the respective output is triggered.

The neural network controller is also used to control the DVR. Detailed simulations are performed on the DVR test system using MATLAB/SIMULINK. System performance is analyzed for compensating voltage sag, swell and interruptions so as to achieve rated voltage at a given load. The voltage magnitude of the load bus is maintained at 1pu during the short duration voltage disturbances.

VI SIMULATION RESULTS

In a Three Phase DVR Test system, the short duration voltage disturbances namely Voltage Sag, Voltage Swell and Interruptions are simulated using MATLAB/SIMULINK. The results are discussed below.

(i) Voltage Sag

Three phase voltage sag is simulated for the duration of 0.1 seconds. Fig.(3) Shows the voltage sag waveform under fault conditions without DVR. Fig.(4) shows the Voltage Sag waveform compensated with DVR.

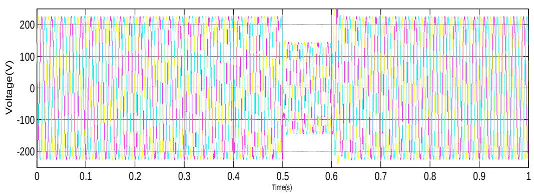

Fig. 3. Voltage Sag Waveform Without DVR

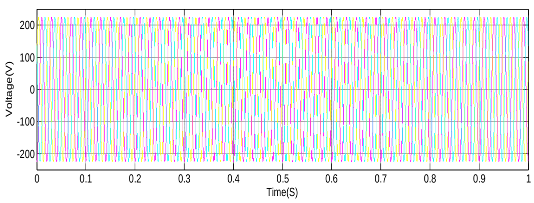

Fig. 4. Voltage Sag Waveform Compensated with DVR

(ii) Voltage Swell

Voltage Swell is simulated by varying the load and it lasts for a duration of 0.1 seconds. Here the voltage exceeds the normal voltage level. Fig.(5) shows the Uncompensated Voltage Swell waveform at the load point. Fig. (6) shows the compensated load voltage with DVR.

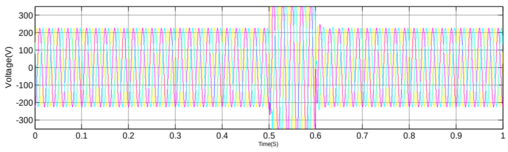

Fig. 5. Voltage Swell Waveform without DVR

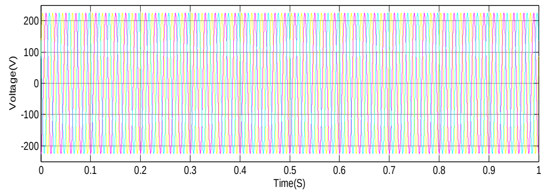

Fig.6.Voltage Swell Waveform Compensated With DVR

(iii) Interruptions

The voltage at the load terminal is dropped to zero for a duration of 0.1 seconds. It results in total interruptions of electrical supply. Fig.(7) shows the interruptions at load terminals without DVR. Fig.(8) shows the compensated interruptions at load terminal using DVR.

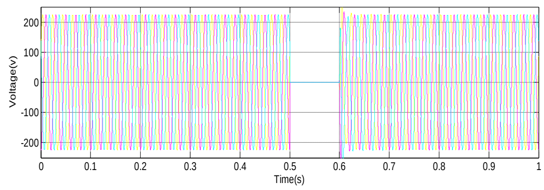

Fig. 7. Interruptions at load point Without DVR

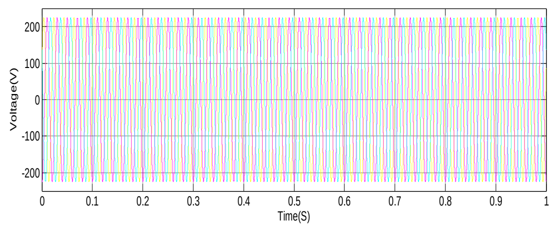

Fig. 8. Interruption compensated with DVR

TABLE I: COMPARISON OF PI CONTROLLER AND NEURAL NETWORK CONTROLLER

FACTORS	CONVENTIONAL CONTROLLER	NEURAL NETWORK CONTROLLER
Sag/swell and interuptions duration	0.1s	0.1s
Mitigation time	1ms	0.8ms
Short duration voltage disturbances	Eliminated	Eliminated

Table.1. shows the comparative results of conventional controller and Neural Network Controller. From the above results it can be concluded that, the mitigation time is significantly reduced with the proposed controller

VII CONCLUSION

The Simulation results shows that the, the ANN based controller provides better performance when compared with the conventional controllers. The ANN controller for DVR is very effective and robust in compensation of Voltage Sag, swell and interruptions. The ANN controller has fast dynamic response when compared with the conventional controllers. Thus the detection and elimination of voltage sag,swell and interruptions helps in improvement of power quality.

REFERENCES

[1]Seyedreza Aali, Daryoush Nazarpour, "Voltage Quality improvement with Neural Network-based interline Dynamic Voltage Restorer", Journal of Electrical Engineering and Technology Vol.6, No.6, pp.769-775, 2011.

[2]Banaei, M.R.; Hosseini, S.H.; Khajee, M.D.," Mitigation of Voltage Sag using Adaptive Neural Network with Dynamic Voltage Restorer", IPEMC 2006. CES/IEEE.

[3]Jurado,F.; Hidalgo, F.P.," Neural Network Control for Dynamic Voltage Restorer", IECON 02, IEEE Conference publications, 2002.

[4]Chung, Y.H,; Kim, H.j.; Kwon, G.H. et.al., "Neural Network Controlled Voltage disturbance detector and output voltage regulator for Dynamic Voltage Restorer, EPE.2007, IEEE Conference publications.

[5]Babu, P.S.; Kamraj, N.," Performance investigation of dynamic voltage restorer using PI and Fuzzy controller", ICPEC, 2013, IEEE Conference Publications.

[6]Torres, A.P.; Roncero-Sanchez, P," Generalized Proportional-Integral Control for Voltage-sag compensation in Dynamic Voltage Restorers, CPE, 2011, IEEE Conference Publications.

[7]Firouz Badrkhani Ajaei, Saeed Afsharnia, Alireza Kahrobaeian, and Shahrokh Farhangi," A Fast and Effective Control Scheme for the Dynamic Voltage Restorer", IEEE transactions on power delivery, vol. 26, no. 4, october 2011.

[8]Ebrahim Babaei, Mohammad Farhadi Kangarlu, "Sensitive load voltage compensation against voltage sags/swells and harmonics in the grid voltage and limit downstream fault currents using DVR". Electric Power Systems Research 83(2012) 80-90, 2012.

[9] Shamsi-Nejad, M.A.; Khalghani, M.R.," DVR Control using adaptive PI controller based on human brain learning", EPDC 2012, IEEE Conference Publications.