MITIGATION OF HORMONICS AND REACTIVE POWER BY USING DVR

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ABSTRACT

This paper describes the problem of voltage sags and swells and its severe impact on non-linear loads or sensitive loads. The dynamic voltage restorer (DVR) has become popular as a cost effective solution for the protection of sensitive loads from voltage sags and swells. The control of the compensation voltages in DVR based on dqo algorithm is discussed. It first analyzes the power circuit of a DVR system in order to come up with appropriate control limitations and control targets for the compensation voltage control. An ANN controller is also proposed in this paper for better controlling action. Simulation results carried out by Matlab/Simulink verify the performance of the proposed method.

Key Words: DVR, ANN controller, Sag/Swell and Power Quality.

I.INTRODUCTION

Our technological world has become deeply dependent upon the continuous availability of electrical power. In most countries commercial power is made available via nationwide grids, interconnecting numerous generating stations to the loads. The grid must supply basic national needs of residential, lighting, heating, refrigeration, air conditioning and transportation as well as critical supply to governmental, industrial, financial, commercial, and medical and communications communities. Commercial power literally enables today's modern world to function at its busy pace. Many power problems originate in the commercial power grid, which with its thousands of miles of transmission lines is subject to weather conditions such as hurricanes, lightning storms, snow, ice and flooding along with equipment failure, traffic accidents and major switching operations. Modern industrial equipment's are more sensitive to power quality problems such as voltage sag, voltage swells, interruption, harmonic, flickers and impulse transient. Failures due to such disturbances create high impact on production cost. So nowadays high quality power is became basic needs of highly automated industries. Voltage sags can occur at any instant of time, with amplitudes ranging from 10 – 90% and a duration lasting for half a cycle to one minute. Voltage swell, on the other hand, is defined as a swell is defined as an increase in rms voltage or current at the power frequency for durations from 0.5 cycles to 1 min. typical magnitudes are between 1.1 and 1.8 up. Swell magnitude is also is also described by its remaining voltage, in this case, always greater than 1.0.

Voltage swells are not as important as voltage sags because they are less common in distribution systems. Voltage sag and swell can cause sensitive equipment (such as found in semiconductor or chemical plants) to fail, or shutdown, as well as create a large current unbalance that could blow fuses or trip breakers. Switching off a large inductive load or Energizing a large capacitor bank is a typical system event that causes swells.

II.CONFIGURATION OF DVR

Dynamic Voltage Restorer is a series connected device designed to maintain a constant RMS voltage value across a sensitive load. The DVR considered consists of:

A. an injection / series transformer

B. a harmonic filter,

C. a Voltage Source Converter (VSC),

D. an energy storage and

E. a control system, as shown in Figure.

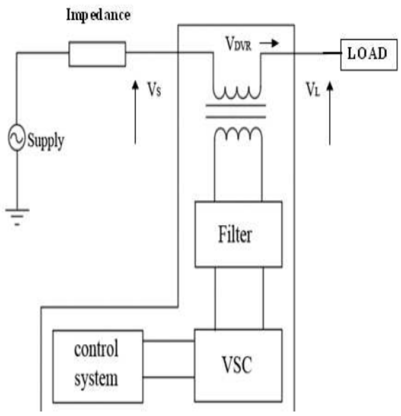

Figure 1: Schematic diagram of DVR

The basic function of the DVR is to inject a dynamically controlled voltage VDVR 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 VL. This means that any differential voltages 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 DVR has three modes of operation which are: protection mode, standby mode, injection/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 (S2 and S3 will open) and supplying another path for current (S1 will be closed).

Standby Mode: (VDVR= 0): In the standby mode the booster transformer's low voltage winding is shorted through the converter. No switching of semiconductors occurs in this mode of operation and the full load current will pass through the primary.

Injection/Boost Mode: (VDVR>0): In the Injection/Boost mode the DVR is injecting a compensating voltage through the booster transformer due to the detection of a disturbance in the supply voltage.In the Figure 2, Vg is the source voltage, V1 is the incoming supply voltage before compensation, V2 is the load voltage after compensation, is the series injected voltage of the DVR and I is the line current. The restorer typically consists of an injection transformer, the secondary winding of which is connected in series with the distribution line, a pulse-width modulated (PWM) voltage source inverter (VSI) bridge connected to the primary of the injection transformer and an energy storage device connected at the dc-link of the inverter bridge. The series injected voltage of the DVR, Vdvr, is synthesized by modulating pulse widths of the inverter-bridge switches.

The injection of an appropriate Vdvr in the face of an up-stream voltage disturbance requires a certain amount of real and reactive power supply from the DVR. The reactive power requirement is generated by the inverter.

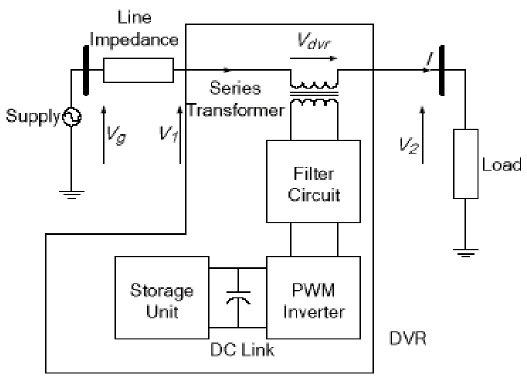

Figure2 Block Diagram of General DVR Circuit

III.CONTROL STRATEGY FOR DVR

Figure 3: shows the control block diagram technique for controlling the dynamic voltage restorer. In this case the source voltage at place of point of common coupling and load voltage are considered for obtaining gate triggering pulses to converter.

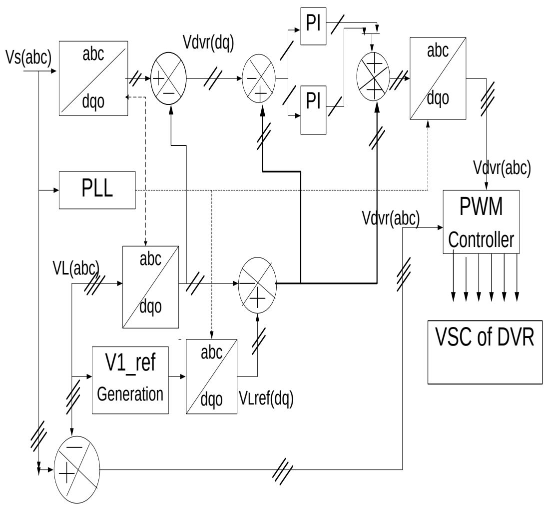

Figure 3: Control Block Diagram for DVR

Basically, the three phase load voltages are transformed to the two phase rotating reference frame using Parks Transformation technique. The source voltage at the point of common coupling is also converted into direct and quadrature axis components using Parks Transformation [14].These source and load voltages are compared and applied to PI controller. The error obtained is used for generating gate firing signals to the voltage source converter.

IV.ARTIFICIAL NEURAL NETWORKS

Figure 4 shows the basic architecture of artificial neural network, in which a hidden layer is indicated by circle, an adaptive node is represented by square. In this structure hidden layers are presented in between input and output layer, these nodes are functioning as membership functions and the rules obtained based on the if-then statements is eliminated. For simplicity, we considering the examined ANN have two inputs and one output. In this network, each neuron and each element of the input vector p are connected with weight matrix W.

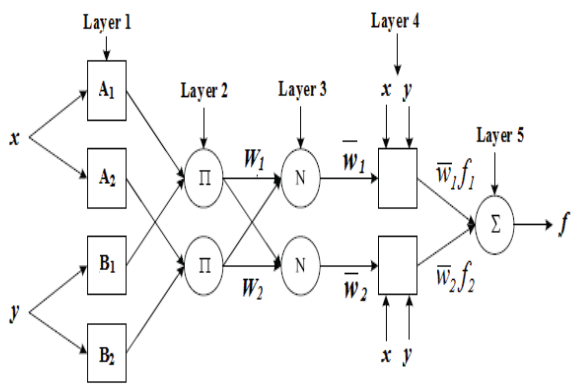

Figure 4: ANN architecture for a two-input multi-layer network

Where the two crisp inputs are x and y, the linguistic variables associated with the node function are Ai and Bi. The system has a total of five layers are shown in Figure 4.

Step by step procedure for implementing ANN:

1. Identify the number of input and outputs in the normalized manner in the range of 0-1.
2. Assume number of input stages.
3. Identify number of hidden layers.
4. By using transig and poslin commands create a feed forward network.
5. Assume the learning rate should be 0.02.
6. Choose the number of iterations.
7. Choose goal and train the system.
9. Generate the simulation block by using 'genism' command.

V.SIMULATION DIAGRAM AND RESULT

Figure 5 shows the simulation diagram for DG system with DVR under different fault conditions.

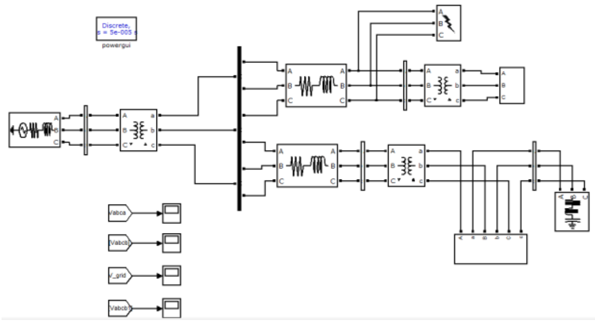

Figure 5: Simulation Diagram for DG system dynamic voltage restorer

This diagram shows the connection of DVR to a Transmission system and the controlling diagram for series converter. In this case study, voltage sag condition is considered during different fault conditions. The simulation results for the input voltage during voltage sag conditions, source current, compensated load voltage, injected capacitor voltage and injected DVR voltage as shown in below Figures. This paper, compares the results for both cases of PI and ANN controller applications.

Case 1: Simulation results of proposed system with Dynamic Voltage restorer and Conventional PI controller

Case A: **Under Single Line – Ground Fault**

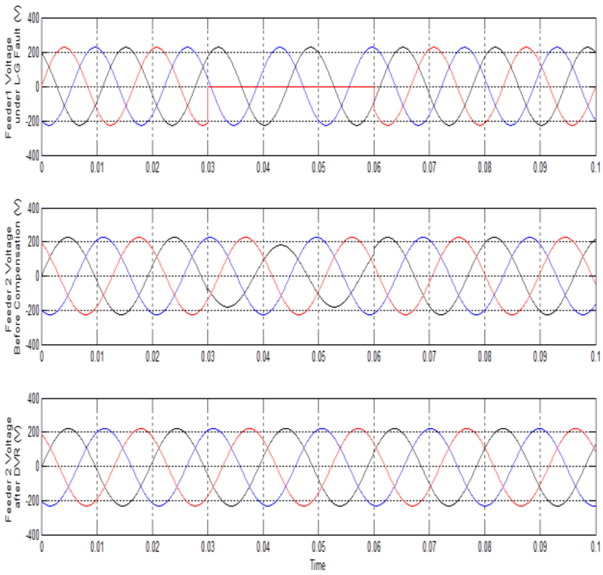

Figure 6: Simulation results for proposed system with PI controller under L-G Fault

Case B: Under Single Line – Ground Fault

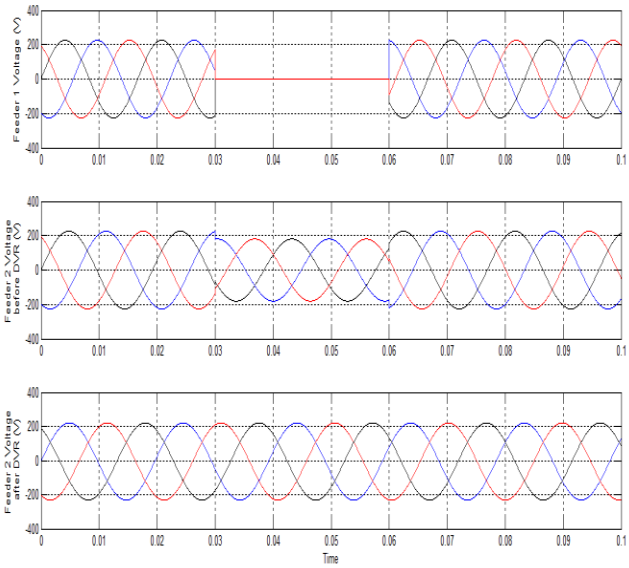

Figure 7: Simulation results for proposed system with PI controller under L-L-L-G Fault

Figure 6(a) shows the simulation results of single area system under single line – ground fault. From this results it is observed that the sag appears in the system between the times 0.02 to 0.06 sec, so that the dynamic voltage restorer compensate these voltage problems as shown in Figure 7(b) & (c). And similarly figure 7 shows the simulation results for dynamic voltage restorer system under L-L-L-G fault.

Comparison of the Total Harmonic Distortion of PI and FLC are shown in Figure 8 and Figure 9.

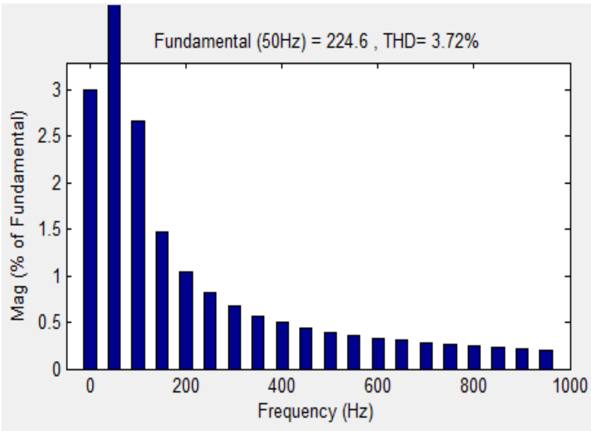

Figure 8: THD for Voltage with PI controller

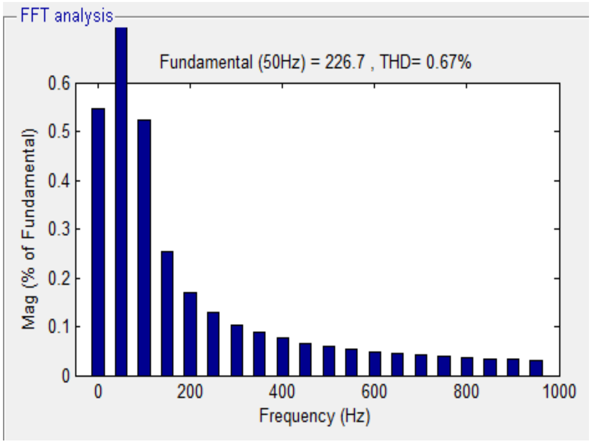

Figure 9: THD for Voltage with ANN controller

Figure 8 and 9 shows the outputs of the total harmonic distortions of the output voltage of the single area system with dynamic voltage restorer by considering conventional PI and ANN controllers. Out of these controllers the ANN controller get good THD as compared with the conventional controllers.

VI.CONCLUSION

In this paper voltage sag/swell compensation and elimination of fault using Dynamic Voltage Restorer is considered. The control technique is designed using in-phase compensation and used a closed loop control system to detect the magnitude error between voltages during pre-sag and sag periods. The modeling and simulation of closed loop control of voltage sag/swell mitigation were carried out using MATLAB software. The conventional PI based control technique is compared with proposed ANN controller. Total harmonic distortion is compared with both PI controller and ANN controller. The simulation results show that the developed control technique with proposed DVR is simple and efficient. From the simulation results it was observed that ANN based dynamic voltage restorer compensates voltage sag and swell problems and also got better THD than other conventional controllers.

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