MITIGATION OF A VOLTAGE SAG SWELL BY DVR USING ANN TECHNIQUES FOR RENEWABLE ENERGY RESOURCES

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ABSTRACT
The power quality (PQ) requirement is one of the most important issues for power companies and their customers. The power quality disturbances are voltage sag, swell, notch, spike and transients etc. The voltage sag and swell is very severe problem for an industrial customer which needs urgent attention for its compensation. There are various methods for the compensation of voltage sag and swell. One of the most popular methods of sag and swell compensation is Dynamic Voltage Restorer (DVR), which is used in both low voltage and medium voltage applications. In this paper, the comprehensive reviews of various articles, the advantages and disadvantages of each possible configuration and control techniques pertaining to DVR are presented. The compensation strategies and controllers have been presented in literature, aiming at fast response, accurate compensation and low costs. This review will help the researchers to select the optimum control strategy and power circuit configuration for DVR applications. This will also very helpful in finalizing the method of analysis and recommendations relating to the power quality problems.

KEYWORDS: Power quality, dynamic voltage restorer, artificial neural network, control algorithm.

I. INTRODUCTION

Power Quality problems encompass a wide range of disturbances such as voltage sags/swells, flicker, harmonics distortion, impulse transient, and interruptions. 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 described by its remaining voltage, in this case, always greater than 1.0up

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. These effects can be very expensive for the customer, ranging from minor quality variations to production downtime and equipment damage. There are many different methods to mitigate voltage sags and swells, but the use of a custom Power device is considered to be the most efficient method. Switching off a large inductive load or Energizing a large capacitor bank is a typical system event that causes swells. This project introduces Dynamic Voltage Restorer and its operating principle. Then, a simple control based on dqo method is used to compensate voltage sags/swell. At the end, MATLAB/SIMULINK model based simulated results were presented to validate the effectiveness of the proposed control method of DVR.

II. DYNAMIC VOLTAGE RESTORER (DVR)

Dynamic Voltage Restorer (DVR) is one of the custom power devices that are used as an effective solution for the protection of sensitive loads against voltage disturbances in power distribution system. The efficiency of the DVR depends on the performance of the efficiency control technique involved in switching the inverters.

Among the power quality problems (sags, swells, harmonics…) voltage sags are the most severe disturbances. In order to overcome these problems the concept of custom power devices is introduced recently. One of those devices is the Dynamic Voltage Restorer (DVR), which is the most efficient and effective modern custom power device used in power distribution networks.

DVR is a recently proposed series connected solid-state device that injects voltage into the system in order to regulate the load side voltage. It is normally installed in a distribution system between the supply and the critical load feeder at the point of common coupling (PCC). Other than voltage sags and swells compensation, DVR can also added other features like: line voltage harmonics compensation, reduction of transients in voltage and fault current limitations.

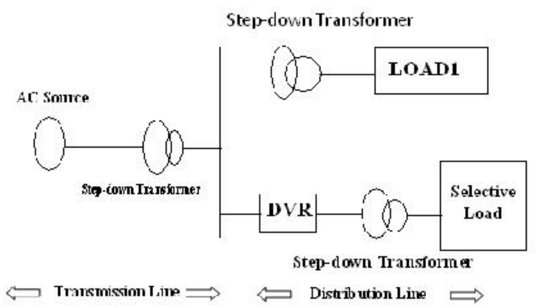

Figure 2.1 Location of DVR

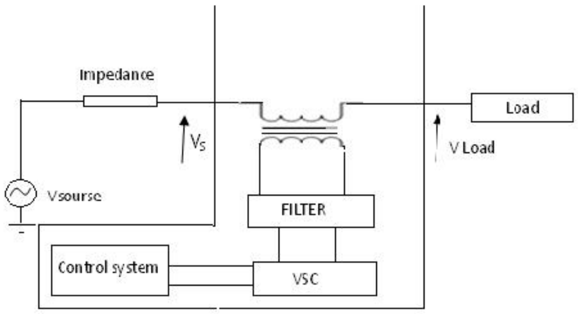

Figure 2.2 Schematic diagram of DVR

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

A. Voltage Source Inverter (VSI)

Voltage Source Inverter converts the DC voltage from the energy storage unit to a controllable three-phase AC voltage. The inverter switches are normally fired using a sinusoidal pulse Width Modulation scheme.

B. Passive Switch

Filters are used to convert the inverted PWM pulse waveform. This is achieved by removing the unnecessary higher harmonic compounds generated during the DC to AC conversion in the Voltage Source Inverter. Higher harmonic components distort the compensated output voltage.

C. Energy Storage Unit

It is important for energy to be stored in the DC form such as flywheels, batteries, superconducting magnetic energy storage (SMES) and super capacitors. They can be used as energy storage devices and supply the real power requirement of the system when DVR used for compensation.

D. Voltage Injection Transform

In a three-phase system, three single-phase transformer units and one-three phase transformer unit can be used inject the voltage in the proposed system.

E. 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.

Equations related to DVR:

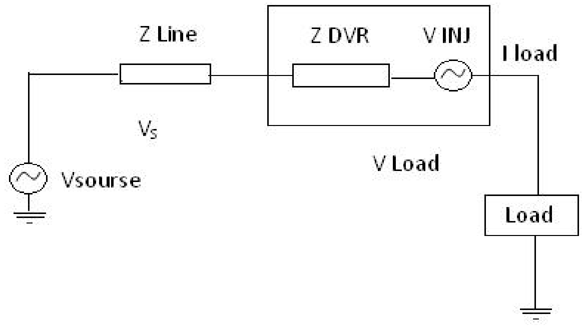

Figure 2.3Equevalet circuit of DVR

The system impedance depends on the fault level of the load bus. When the system voltage drops, the DVR injects a series voltage VDVR through the injection transformer so that the desired load voltage magnitude VL can be maintained. The series injected voltage of the DVR can be written as

VDVR = VL + ZTHIL – VTH……………2.1

Where

VL: The desired load voltage magnitude

ZTH: The load impedance.

IL: The load current

VTH: The system voltage during fault condition

The load current IL is given by

IL = [PL + jQL]/ V…………………2.2

The complex power injection of the DVR can be written as,

SDVR = VDVRIL* ………………2.3

It requires the injection of only reactive power and the DVR itself is capable of generating the Reactive power.

III. ARTIFICIAL NEURAL NETWORKS

Artificial Neural Networks are relatively crude electronic models based on the neural structure of the brain. The brain learns from experiences. It is natural proof that are beyond the scope of current computers are indeed solvable by small energy efficient packages. This brain modeling also promises a less technical way to develop machine solutions. These biologically inspired methods of computing are thought to be the next major advancement in the computing industry. Even simple animal brains are capable of functions that are currently impossible for computers. Computers do rote things well, like keeping ledgers or performing complex math.

However, computers have trouble recognizing even simple patterns much less generalizing those patterns of the past into action of the future. Now, advance in biological research promise an initial understanding of the natural thinking mechanism. This research shows that brain stores information, as patterns. Some of these patterns are very complicated and allow us the ability to recognize individual faces from any different angles. This process of storing information as patterns, utilizing those patterns, and then solving problems encompasses a new field in computing. This field does not utilize traditional programming but involves the creation of massively parallel networks and the training of those networks to solve specific problems. This field also utilizes words very different from traditional computing, words like behave, react, self-organize, learn, generalize, and forgot. An artificial neural network (ANN), often just called a "neural network" (NN), is a mathematical model or computational model based on biological neural networks. It consists of an interconnected group of artificial neurons and processes information using a connectionist approach to computation. In more practical terms neural networks are non-linear statistical data modeling tools. They can be used to model complex relationships between inputs and outputs or to patterns in data.

IV. SIMULATION RESULTS

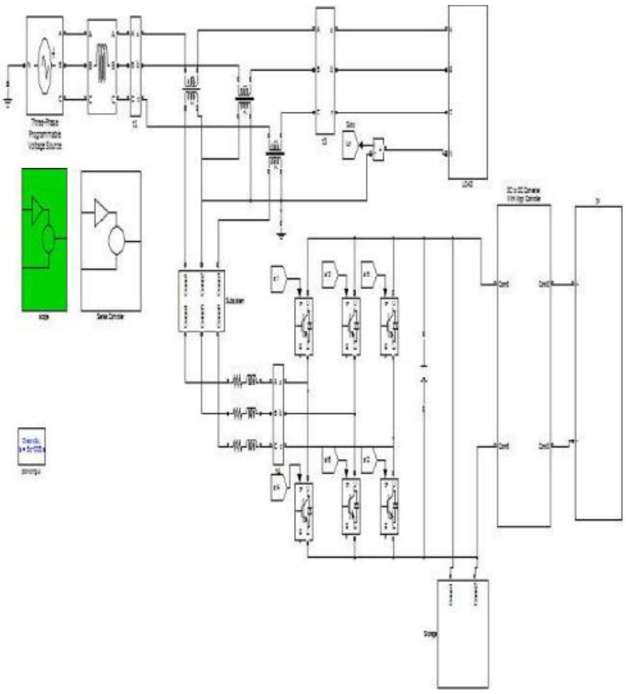

Figure7.3 Simulation Circuit of sag/swell

A detailed system as shown in Figure 7.3 has been modeled by MATLAB/SIMULINK to study the efficiency of suggested control strategy. It is assumed that the voltage magnitude of the load bus is maintained at 1 pu during the voltage sags/swells condition. The results of the most important simulations are represented in Figures. The load has been assumed linear with power factor pf =0.85 lagging and its capacity of 5 KVA.

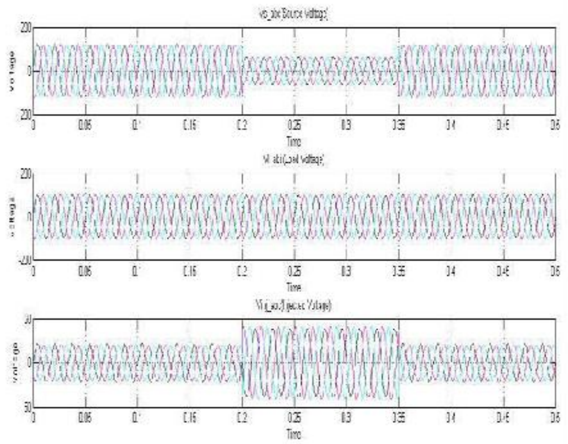

Figure7.5Three-phase voltages sag: (a)-Source voltage, (b)-Injected voltage, (c)-Load voltage

The first simulation show of three phase voltage sag is simulated. The simulation started with the supply voltage 50% sagging as shown in Figure (a).In Figure (a) also shows a 50% voltage sag initiated at 0.15s and it is kept until 0.35s, with total voltage sag duration of 0.2s. Figures (b) and (c) show the voltage injected by the DVR and the corresponding load voltage with compensation. As a result of DVR, the load voltage is kept at 1 pu. The effectiveness of the DVR under unbalanced conditions is shown in figure, in figure also shows the occurrence of 50% single phase voltage sag on a utility grid. Through simulation the supply voltage with one phase voltage dropped down to 50% as shown in Figure (a). The DVR injected voltage and the load voltage are shown in Figures (b) and (c) respectively. Its corresponding load voltages are shown in Figure (c) where it is possible to see that the compensation method is keeping the load voltages constant at 1 p.u.

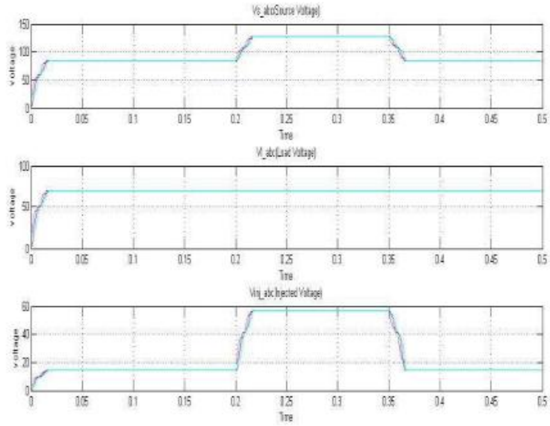

Figure7.8 Three -phase rms voltages swell: (a)-Source voltage, (b)-Injected voltage, (c)-Load voltage

The second simulation shows the DVR performance during a voltage swell condition. The simulation started with the supply voltage swell is generated as shown in Figure (a). As observed from this figure the amplitude of supply voltage is increased about 25% from its nominal voltage. Figures (b) and (c) show the injected and the load voltage respectively. As can be seen from the results, the load voltage is kept at the nominal value with the help of the DVR. Similar to the case of voltage sag, the DVR reacts quickly to inject the appropriate voltage component (negative voltage magnitude) to correct the supply voltage. Figure shows that the performances of the DVR with an unbalanced voltage swell. In this case, two of the three phases are higher by 25% than the third phase as shown in Figure (a). The injected voltage that is produced by DVR in order to correct the load voltages and the load voltages maintain at the constant are shown in Figures (b) and (c), respectively.

CONCLUSION

The modeling and simulation of a DVR using MATLAB/SIMULINK has been presented. A control system based on dqo technique which is a scaled error of the between source side of the DVR and its reference for sags/swell correction has been presented. The simulation shows that the DVR performance is satisfactory in mitigating voltage sags/swells. The operating principle of dynamic voltage restorer and the voltage compensation methods are presented. The main function of the shunt converter is to maintain and control the dc voltage of the inverter during voltage sag. This will allow the DVR to compensate deep and long duration voltage sags and swells.

From simulation results also show that the DVR compensates the sags/swells quickly and provides excellent voltage regulation. The DVR handles both balanced and unbalanced situations without any difficulties and injects the appropriate voltage component to correct rapidly any anomaly in the supply voltage to keep the load voltage balanced and constant at the nominal value

The main advantage of this DVR is low cost and its control is simple. It can mitigate long duration voltage sags/swells efficiently. Future work will include a comparison with a laboratory experiments in order to compare simulation and experimental results. Source side shunt converter is replaced by Solar Power and controlling by ANN technique.

The simulation results clearly show the performance of a DVR in mitigating voltage sags and swells. In case of voltage sag, the DVR injects an equal positive voltage component in all three phases. For voltage swell, the DVR injects a negative voltage in all the phases. The DVR injects the appropriate voltage for both sag and swell in order to keep the load voltage balanced and constant at the nominal value.

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