Control for Dynamic Voltage Restorer based on DQO algorithm

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ABSTRACT−This paper describes the problem of voltage sags and the effective technique to mitigate it. 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 for DVR based on dqo algorithm is discussed. The proposed control scheme is simple to design. Simulation results carried out by Matlab-Simulink verify the performance of the proposed method.

1, INTRODUCTION

The most expected criteria to be satisfied in a Power system is Power Quality. Power Quality problems include 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 swells are not as important as voltage sags because they are less common in distribution systems. Voltage sag 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 , but the use of a custom Power device is considered to be the most efficient method.

This paper introduces Dynamic Voltage Restorer and its operating principle. Then, a simple control based on dqo method is used to compensate voltage sags. At the end, MATLAB/SIMULINK model based simulated results were presented to validate the effectiveness of the proposed control method of DVR.

2, CONVENTIONAL SYSTEM 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),

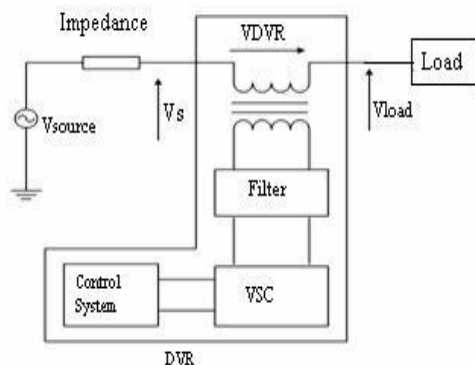   d. an energy storage and

    e. a control system

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Figure 1: Schematic diagram of DVR

The main function of a DVR is the protection of sensitive loads from voltage sags/swells coming from the network. Therefore as shown in Figure 1, the DVR is located on approach of sensitive loads. If a fault occurs on other lines, DVR inserts series voltage V_{DVR} and compensates load voltage to pre fault value. 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 V_L. 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 works independently of the type of fault or any event that happens in the system, provided that the whole system remains connected to the supply grid, i.e. the line breaker does not trip. For most practical cases, a more economical design can be achieved by only compensating the positive and negative sequence components of the voltage disturbance seen at the input of the DVR. This option is Reasonable because for a typical distribution bus configuration, the zero sequence part of a disturbance will not pass through the step down transformer because of infinite impedance for this component.

The DVR has two modes of operation which are: standby mode and boost mode. In standby mode (V_{DVR}=0), 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, only the 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. In boost mode (V_{DVR}>0), the DVR is injecting a compensation voltage through the booster transformer due to a detection of a supply voltage disturbance [4]
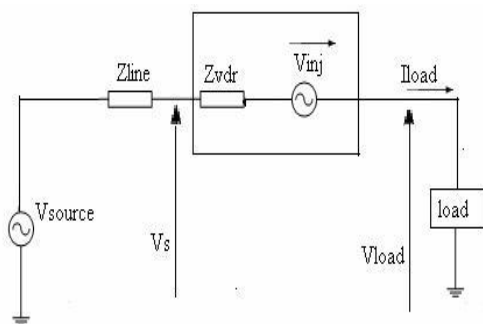
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Figure 2: Equivalent Circuit of DVR

Figure 2 shows the equivalent circuit of the DVR, when the source voltage is drop or increase, the DVR injects a series voltage V_{inj} through the injection transformer so that the desired load voltage magnitude V_L can be maintained.

III.   PROPOSED METHOD

A. Main Circuit

Figure 3 shows the configuration of the proposed DVR design using MATLAB/SIMULINK, where the outputs of a three-phase half-bridge inverter are connected to the utility supply via wye-open connected series transformer.

Once a voltage disturbance occurs, with the aid of dqo transformation based control scheme, the inverter output can be steered in phase with the incoming ac source while the load is maintained constant. As for the filtering scheme of the proposed method, output of inverter is installed with capacitors and inductors.

B. Control Algorithm

The basic functions of a controller in a DVR are the detection of voltage sag/swell events in the system; computation of the correcting voltage, generation of trigger pulses to the sinusoidal PWM based DC-AC inverter, correction of any anomalies in the series voltage injection and termination of the trigger pulses when the event has passed. The controller may also be used to shift the DC-AC inverter into rectifier mode to charge the capacitors in the DC energy link in the absence of voltage sags/swells.
The dqo transformation or Park's transformation [6-7] is used to control of DVR.

The dqo method gives the sag depth and phase shift information with start and end times. The quantities are expressed as the instantaneous space vectors. Firstly convert the

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voltage from a-b-c reference frame to d-q-o reference. For simplicity zero phase sequence components is ignored.

Figure 4 illustrates a flow chart of the feed forward dqo transformation for voltage sags/swells detection. The detection is carried out in each of the three phases.

The control scheme for the proposed system is based on the comparison of a voltage reference and the measured terminal voltage (Va,Vb,Vc).The voltage sags is detected when the supply drops below 90% of the reference value . The error signal is used as a modulation signal that allows to generate a commutation pattern for the power switches (IGBT's) constituting the voltage source converter. The commutation pattern is generated by means of the sinusoidal pulse width modulation technique (SPWM); voltages are controlled through the modulation.

Main Supply Voltage per phase	200V
Line Impedance	Ls =0.5mH Rs = 0.1 Ω
Series transformer turns ratio	1:1
DC Bus Voltage	100V
Filter Inductance	1mH
Filter capacitance	1uF
Load resistance	40 Ω
Load inductance	60mH
Line Frequency	50Hz

A detailed system as shown in Figure 3 has been modeled by **MATLAB/SIMULINK** to study the efficiency of suggested control strategy. The system parameters and constant value are listed in Table I. 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 5-8.The load has been assumed linear with power factor pf =0.85 lagging and its capacity of 5 KVA.

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V. 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.

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.