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AC VOLTAGE SAGS/SWELLS COMPENSATION BASED ON DYNAMIC VOLTAGE RESTORER (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 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. The control of the compensation voltages in DVR based on. The proposed control scheme is simple to design. Simulation results carried out by MATLAB/SIMULINK verify the performance of the proposed method.**

Index terms- **Dynamic Voltage Restorer (DVR), voltage sags, voltage swells, sensitive load.**

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 is defined as an decrease in rms voltage. It 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, 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 equipments 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,energizing a large capacitor bank is a typical system event that causes swells. This paper 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. 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
- **e.** a control system

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 VDVR 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 *VL*. This means that any differential voltages caused by ransient 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.

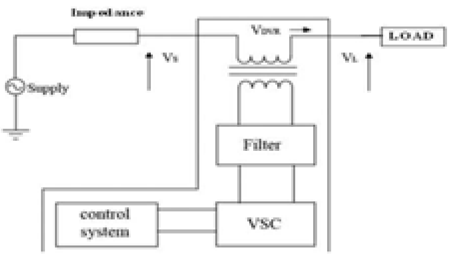

Figure 1: Schematic diagram of DVR

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 ($V_{DVR}=0$), 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.Figure 2 shows the equivalent circuit of the DVR.

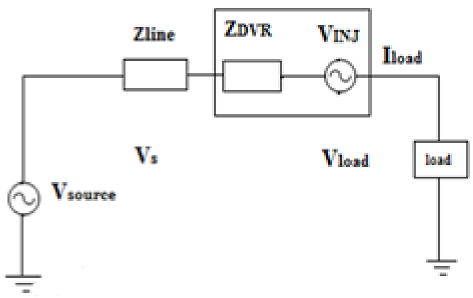

Figure 2: Equivalent Circuit of DVR

III. 3. PROPOSED METHOD

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. 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 whereas voltage swells is detected when supply voltage increases up to 25% 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.

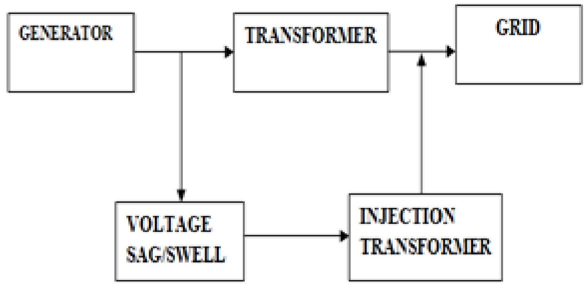

Figure 3: Block diagram for sag/swell compensation.

The figure shows the block diagram for compensation of voltage sag and swells through injection transformer. The basic function of injection transformer is to increase the voltage supplied by the filtered VSI output to the desired level while isolating the DVR circuit from the distribution network. The transformer winding ratio is predetermined according to the supply voltage required in the secondary side of the transformer (generally this is kept equal to the supply voltage to allow the DVR to compensate for full voltage sag). A higher transformer winding ratio will increase the primary side

adversely affect the performance of the power electronic devices connected in the VSI. The rating of the injection transformer is an important factor when deciding the DVR performance, since it limits the maximum compensation ability of the DVR.

IV. 4. SIMULATION RESULTS AND DISCUSSION

The figure shows the simulation diagram for voltage sag/swell compensation through DVR using MATLAB/SIMULINK software

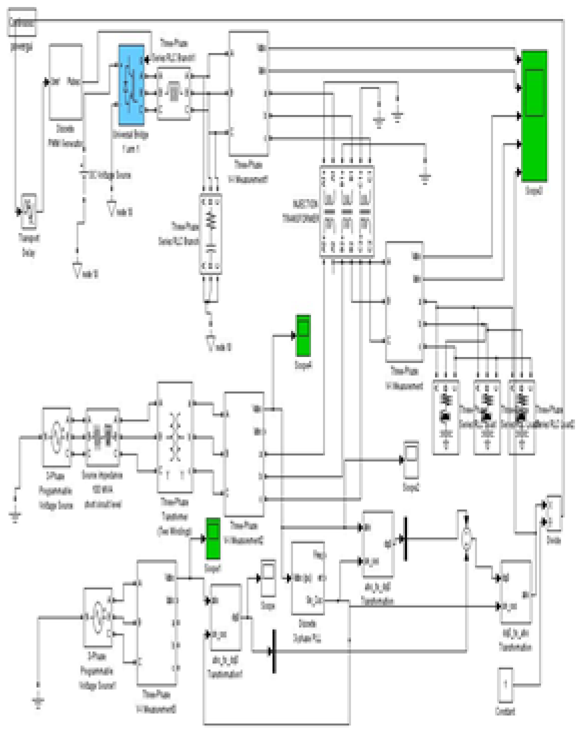

Figure 4: simulation circuit diagram

In this circuit the various types of scopes can be seen, of which the scopes for current and voltage is present, the voltage response and current response for the input that given and it will be gained by running this scopes. The proposed circuit diagram is shown.

VOLTAGE SAG

A voltage sag or voltage dip is a short duration reduction in rms voltage which can be caused by a short circuit, overload or starting of electric motors. A voltage sag happens when the rms voltage decreases between 10 and 90 percent of nominal voltage for one-half cycle tone minute. Some references define the duration of a sag for a period of 0.5 cycle to a few seconds, and longer duration of low voltage would be called a "sustained sag".

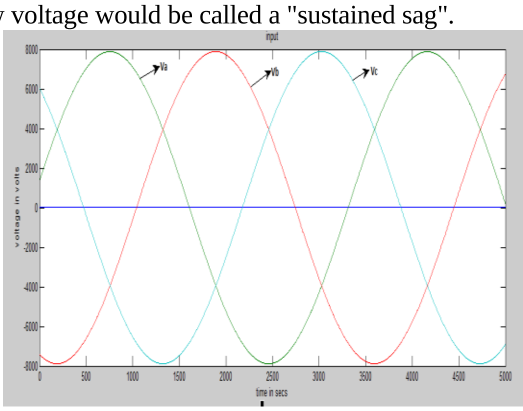

Figure 5: Input waveform of voltage response

VOLTAGE SWELL

Voltage swell is the opposite of voltage sag. Voltage swell, which is a momentary increase in voltage, happens when a heavy load turns off in a power system. The graph shows the power quality disturbance of voltage sag/swell.

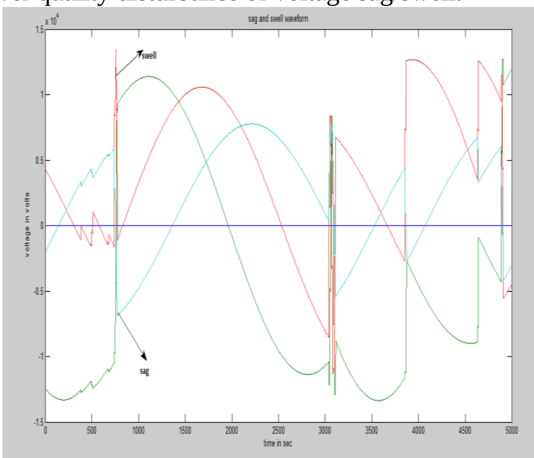

Figure 6: waveform of voltage sag/swell

The output waveform of voltage response is shown below. From the output waveform it is clear that the voltage passes during the given input value. The output waveform of current response is shown below. The waveform shows the three phases current like phase a, phase b and phase c. The line current is shown here so the waveform is from negative value to positive value.

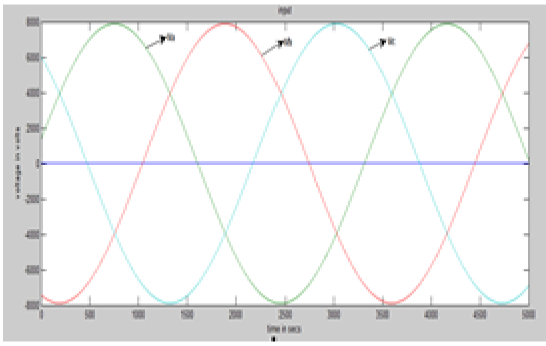

Figure 7: output waveform

V. CONCLUSION

The modelling 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. 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.

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BIOGRAPHIES

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