

Dynamic Voltage Restorer for Compensation of Voltage Sag

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Abstract - Superiority of the output power delivered from the utilities has become a major concern of the modern industries for the last decade. The rise of voltage-sensitive load equipment has made industrial processes much more vulnerable to deprivation in the quality of power supply. Voltage variations, often in the form of voltage sags and swells, can cause rigorous process disturbances and result in significant financial loss. The custom power devices which uses the power electronic devices, is one of the method by which power quality problems might be compensate. Among the numerous norm power devices, the dynamic voltage restorer (DVR) for use in distribution systems is a recent innovation. The mitigation capability of a DVR depends initially on the maximum voltage injection ability and within the restorer the amount of stored energy existing. In this paper a presage compensation control scheme is used to increase the voltage renovation property of the device. Using this novel method it can be shown that the disturbances occurred in the system can be corrected with less amount of storage energy. Modelling of proposed method is implemented in MATLAB SOFTWARE.

Keywords: Dynamic voltage restorer (DVR), maximum voltage injection, Phase advanced compensation (PAC).

INTRODUCTION

Reliable customer power device is dynamic voltage restorer (DVR) used to tackle the voltage sag, swell problem. It is a series connected norm power device, which is considered to be a cost effective unusual when compared with other available custom power devices to mitigate voltage sag and swells. The main purpose of the DVR is to supervise the load voltage waveform constantly and if any sag occurs, or excess voltage is absorbed from the load voltage. To reach the above functionality a reference voltage waveform and source voltage waveforms are similar in magnitude and phase angle. Thereby during any malformation of the voltage waveform it can be analyzed by comparing the reference and the actual voltage waveforms. The main principle of DVR operation is finding of voltage dips and inserting vanished voltage to the network. The series interconnection allows the DVR inserted voltage to be inserted to the utility source voltage. The amplitude and phase angles of the inserted three-phase voltages can be varied, thereby permitting control of real and reactive power exchanged between the DVR and the distribution system [1] [2] [10].

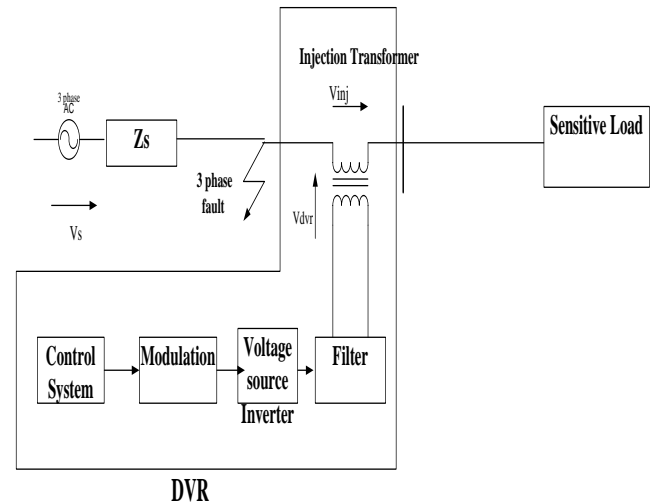


Fig. 1 Schematic Diagram of DVR

Fig. 1 shows the schematic diagram of DVR for distribution system. In the figure V_s is source voltage, V_{DVR} is the series injected voltage of DVR. The restorer consists of an injection transformer, the secondary winding of transformer connected in series with the distribution line, to the primary winding of the injection transformer a VSC is connected through the filter and an energy storage device connected at with it. The inverter bridge output is filtered in order to compensate the switching frequency harmonics generated in the inverter [3] [1].

To correct larger faults DVR may need to increase active power. In this paper phase advanced compensation is used to correct the voltage dips and swells. This method includes the new closed loop load voltage and inner loop current mode control. In this method the error voltage is given out by comparing the source and reference voltage which gives to the gain in the system. In phase advanced multi-loop technique all three phase voltage are advanced by particular angle to minimize the quantity of supplied power by the DVR. This paper is therefore planned as follows: the propose method PAC is described in section 2; the simulation of a control scheme for DVR operation is accessible in section 3; the system parameters with their values shown in section 4; the results based on simulation are shown in section 5 and the effectiveness of the pro-posed DVR control systems are evaluated [1] [4].

PROPOSED METHOD

There are Many injection methods for DVR as In-phase compensation technique, pre-sag compensation technique, energy optimizing technique, phase advanced compensation technique uses for mitigate the voltage sags and swell. The pre-sag method tracks the supply voltage continuously and if it detects any distraction in supply voltage it will inject the difference voltage between the sag or voltage at PCC and pre-fault condition, hence the load voltage can be restored back to the pre-fault condition. In this method control of the injected active power cannot be possible and it is determined by external conditions such as the type of faults and load conditions [8][9].

$$V_{dvr} = V_{pre-fault} - V_{sag} \tag{12}$$

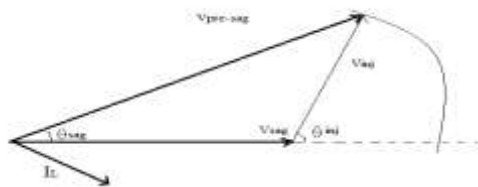


Fig.3. Pre-sag compensation method

Fig. 2 Phasor Diagram of PAC

From this method it must be noticed that inserted reactive and active powers might be obtained. Moreover, injected voltage phase and magnitude could be obtained using the subsequent equations:

$$S_i = ILV_i = \sqrt{VL^2 + V_s^2 - 2VLV_s \cos \theta L} \tag{1}$$

$$P_i = IL(VL \cos \theta L - V_s) \tag{2}$$

$$\theta_s = \cos \left(\frac{VL \cos \theta L s}{V_s} \right) \tag{3}$$

$$V_i = \sqrt{VL^2 + V_s^2 - 2VL V_s \cos (\theta L - \theta_s)} \tag{4}$$

$$\theta_i = \tan \left(\frac{VL \sin \theta L - V_s \sin \theta_s}{VL \cos \theta L - V_s \cos \theta_s} \right) \tag{5}$$

The above equations express that if $VL \cos \theta > V_s$ DVR have to make V_s and I_L in phase via injecting voltage; though, if $VL \cos \theta < V_s$ P_i is negative and active power may be set to zero without adjusting to θ_s zero. In other words, voltage sag is mitigated by reactive power. In this situation inserted voltage is perpendicular to load current. Its value for zero power flow is calculating using P_i equation. As compared to other injection techniques with PAC magnitude of inserted voltage is greater than that based on injection methods [6].

CONTROL SYSTEM DESIGN

Another name for dq0 transformation is Park's transformation. dq0 stand for direct- quadrature -zero transformation. In electrical engineering, to simplify the study related to three-phase circuit this mathematical transformation has been used. This method can be applied to decrease the three AC quantities to two DC quantities. It makes the calculation and simulation simpler. Basically this technique operates in such way that, it compares the reference voltage with the measured supply voltage. From the definition of voltage sag, the voltage sag is noticed when the source voltage falls less than 90% of the reference value. Hence it creates the error signal which is used as a modulation signal that permits to generate a commutation for the power electronic devices including the voltage source converter. Then, commutation pattern is used by Pulse Width Modulation (PWM). Thus, voltage can be controlled via modulation. The control system services abc to dq0 transformation to dq0 voltages. In normal conditions, the voltage will be constant and d-axis voltage is 1 pu and q-axis voltage is 0 in pu, but when fault occurs these voltages varies. By comparing d-axis voltage and q-axis voltage to preferred voltage, errors are generated for d and q respectively. These d-error and q-error components using dq0 to abc transformation [12].

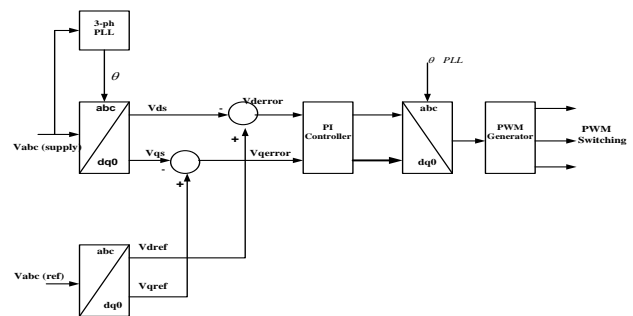


Fig. 3 Block Diagram of Control strategy

SYSTEM PARAMETERS

| Parameters | Constant Values |
|----------------------------|---------------------|
| 3 phase Source | 400V, 50Hz |
| Line Impedance | R=0.01Ω, L= 0.75mH |
| Sq. Cage Induction Motor | 400V, 50Hz, 1440rpm |
| Injected Transformer Ratio | 1:1 |

RESULTS

The simulation results for the Three phase voltage sag as shown in fig 4 consisting plots of voltage after sag, plot of injection voltage to compensate the voltage sag and plot of voltage after injecting the voltage the fault has been removed

in system will run in normal condition. As shown in fig 4.1, plot of voltage sag which is occurred due to the 3 phase to ground fault which occurred after 0.2 sec upto 0.4 sec after that system continues to run. Hence here created the 20% sag. To compensate this sag we have to inject the proper voltage during the duration 0.2 sec to 0.4 sec as shown in fig 4.2. By injecting the voltage the system will continues to run in proper manner and in this way by using this control strategy voltage sag mitigated.

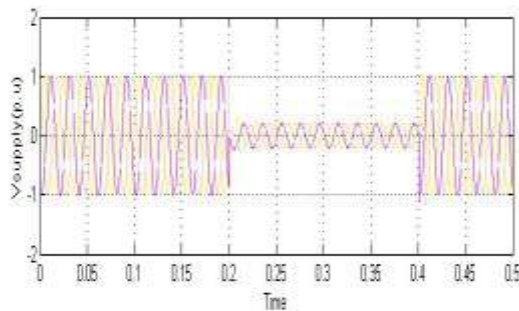


Fig 4.1 Waveforms after sag in the system

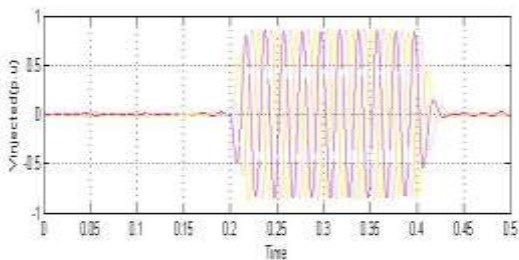


Fig 4.2 Waveforms of injected voltage

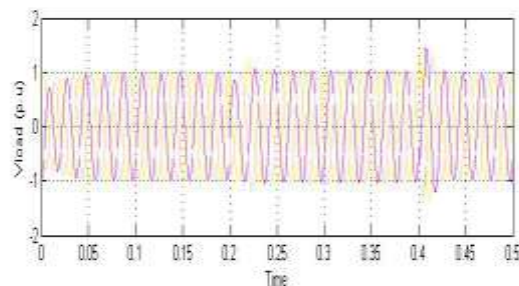


Fig 4.3 Waveforms of Compensated sag in the system

CONCLUSION

A novel phase advanced compensation technique has been proposed for the dynamic voltage restorer. From the simulation results the proposed scheme is superior injection technique in the form of dynamic performance and energy saving. The both outer voltage loop and inner current loop raised the quality of load voltage. Control system is robust, due to this property the load variations can be improved by taking inductor and capacitor current feedback in the system. The efficiency, Robustness and the effectiveness in voltage sags mitigation showed by the DVR makes it an fascinating power quality device.

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