A Review on Mitigation of Voltage Power Quality Problems by the Dynamic Voltage Restorer

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Abstract*: In the recent developments with power electronic devices, voltage issues can be easily mitigated from the existing system. Many industries utilize a large number of electronic equipment which is sensitive to small changes in voltages. When sensitive devices like programmable logic controllers and adjustable speed drives are involved in industries voltage disturbances cause huge damage to the equipment. Dynamic Voltage Restorer (DVR) which is a custom power device gives an easy and simple solution to reduce the voltage fluctuations in the power system. Whenever power quality problems occur DVR has to automatically detect and inject the required voltage to the system. The performance of DVR depends on the efficiency of the control technique involved in switching the inverters.*

Keywords: *Dynamic Voltage Restorer, Voltage Sags and Swells, Sensitive loads.*

1.Introduction

Whenever power quality problems occur, DVR has to automatically detect and inject the required voltage to the system. The performance of DVR depends on the control technique involved in switching the inverters. Different control strategies of DVR to compensate voltage disturbances are analyzed. To reduce the effect of voltage sags and voltage swells, DVR is one of the effective solutions. Energy storage is possible even during fault occurrence by the DVR. The cost of DVR is less and hence it is most popular for protecting sensitive loads from voltage disturbances. The use of a custom power device is considered to be the most efficient method to improve power quality problems. Voltage sag and swell can cause sensitive equipment to fail, shutdown, and create a large current unbalance. These effects can incur a lot of expenses from the customer and cause equipment damage [10]. The voltage dip magnitude is ranged from 10% to 90% of nominal voltage and with the duration from half a cycle to 1 min and 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 p.u [11].

2.Dynamic Voltage Restorer

A Dynamic Voltage Restorer (DVR) is a custom power device having a series-connected solid-state device that injects voltage into the system to regulate the load side voltage. DVR is normally installed between the supply and critical load of the distribution system. The basic structure of a DVR is shown in Fig.1.

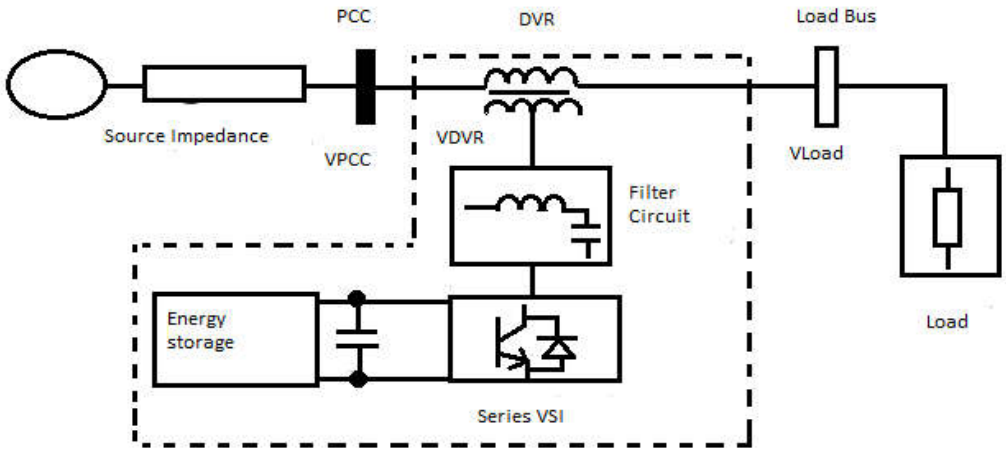

Figure-1: Series Connected DVR

2.1 Injection Transformer: The Injection transformer is a specially designed transformer that transforms energy from the primary side to the secondary side and limits the coupling of noise.

2.2 Harmonic Filters: Unwanted harmonic components generated by VSI action are filtered by converting the inverted PWM waveform into a sinusoidal waveform.

2.3 Inverter: A VSI can generate a sinusoidal voltage at any required magnitude, frequency, and phase angle from dc storage. It consists of a storage device and a switching device. Generally, fast-acting IGBT's are used in VSI.

2.4 Energy Storage Unit: Generating injected voltages by VSI via DC link is done with the energy storage unit.

2.5 Capacitor: To ensure stiff DC voltage input to the inverter, a large capacitor is used in the DVR.

2.6 By-Pass Switch: If the over current on the load side exceeds a permissible limit due to a short circuit on the load or large inrush current, the DVR will be isolated from the system by using the bypass switches and supplying another path for current.

3. Literature Survey

Chunming Tu(2019) has proposed the strategies to decrease active power consumption during the voltage compensation stage and increase active power absorption during energy self-recovery stage. A super capacitor is chosen to get a smooth transition between two stages of the dynamic process to ensure flexible switching. Sensitive devices are protected by phase angle jump during voltage sag. SPWM technique is used to drive the IGBT's in the converter circuit. DVR (Dynamic Voltage Restorer) is the best cost-effective solution to remove the problem for Voltage Sags and Swells for the protection of sensitive loads. Based on the final state of voltage compensation, the initial operating point of the recovery process should be adjusted to avoid any further phase angle jump after fault removal. The perfect linkage between recovery operation and voltage compensation is designed. The DC link voltage after the voltage sag disappearance is

recovery to the set value promptly, which ensures the equipment ready for the next compensation. Meanwhile, the injected voltage will not perturb the magnitude and phase angle of load voltage during the whole recovery operation.

Tejaswita L. Ilamkar(2018) has presented the method based on Synchronously Reference Frame theory to control the device. Switching pulses for the three-phase inverter is generated with the help of a hysteresis voltage controller. The voltage profile is maintained sinusoidal at a linear load terminal against voltage sag. Dynamic Voltage Restorer is used to mitigating voltage sag in supply-side voltage as well as linear load side voltage. The cost and size of this device are useful for generating a compensating voltage required to regulate load side voltage undisturbed. The control technique is based on the hysteresis voltage controller and synchronously reference frame theory applied to DVR for better operation and fast response of DVR. In this paper, they show the solution to remove voltage sags.

Abderrahim Telli(2018) has presented a paper with a new configuration where DVR in the operating side along with fuel cells are fed to the distributed generation system. Here, the solid oxide fuel cell(SOFC) serves the double purpose of feeding a DVR as well as injecting power in the grid. Through simulating this new configuration they proved that power quality problems can be solved easily by providing clean energy. Both in shunt and series grid connections at various operating conditions multilevel inverters are used to verify the outputs. The main generation device is the SOFC-DG system, where the DVR acts as the power quality device. The DVR provides good voltage regulation with low total harmonic distortion and compensates for the voltage sag and swell.

S.Srinivasa Rao (2017) has presented a paper with voltage sag/swell compensation by using the battery energy storage system(BESS) DVR and PV DVR using PI Controller. The rating of DVR is reduced due to voltage injection in-phase with the PCC voltage. Also, power quality has been improved. In this paper, the in-phase voltage injection scheme for DVR is employed with a Photovoltaic system. PV cells are arranged in series and parallel alignments. Modules lumped in a group give an array or array field. To get the required voltage, series and parallel combinations are suitable for it. Dynamic Voltage Restorer (DVR) is a cost-effective custom power device. DVR responds quickly whenever the voltage fluctuates.

Monika Gupta(2016) has presented a paper where DVR with three different controllers—PI, neural network controller with backpropagation, and neural controller with particle swarm optimization was implemented individually and the performance of the controllers was compared using maximum total harmonic distortion values and load voltage plots. The hybrid neural controller with PSO has the least distortions and is most robust of the three controllers.

V. Ansal (2016) has presented a paper on DVR voltage compensation without using an injection transformer. The cost and size of DVR are reduced, as such losses are reduced. Control of DVR is implemented by Synchronously Reference Frame theory. Unit vectors are used to estimate reference load voltage. the load voltages from abc frame to dqO frame are converted by using Park's transformation. The reference load voltages (VLa *, V Lb *, VLc *) and the source voltages are also converted to the rotating reference frame using Park's transformation. A separate DC-link is used for isolation of the proposed DVR.

Abhay Tiwari (2015) has given an easier solution for linear and non-linear devices using DVR because of voltage disturbances. The DVR can handle effectively both linear and non-linear loads situations and inject appropriate voltage components. The abc to dq0

control algorithm is used to check the error between the source side of the DVR and reference signal. Voltage sags and swells can be compensated by using DVR effectively with this control strategy. A PWM based voltage source inverter is used to control any series voltage injection and terminating pulses after the voltage sag has passed away.

A.Praveena(2014) has presented a paper on DVR voltage compensation using a PI controller and a discrete PWM pulse generator is used for the control purpose. The DC Link capacitor is eliminated. The DVR size, volume, and cost are low. Storage of energy is possible even during fault occurrence. It can compensate for the unbalance voltage sags and swells. It will give a guarantee that the regulated voltage can be achieved for sensitive loads. In this paper, the feed foreword technique is proposed.

G.Sivasankar(2014) has presented a paper on DVR which compensates voltage disturbances in wind power generation. Wind power generation has prime importance with wind generators connected to the grid. The DVR is used to mitigate the symmetrical and unsymmetrical voltage dip on fixed speed wind generators. The Induction generator based wind farm with low voltage ride-through capability is improved by the series voltage control scheme. The wind generator can remain connected to the grid without loss of stability.

4.Conclusion

Mitigation of Voltage SAG using Dynamic Voltage Restorer is proposed for eliminating the problem of a voltage dip, swell, and other voltage disturbances problems in the industrial distribution system using DVR. In the Voltage Transmission Voltage Sags and Swells is the main factor which occurs at the time of transmission. Voltage Sags and Swells are the disturbances that increase the losses in the transmission and voltage gets unstable. We can find this type of disturbance and remove that so that transfer voltage can be used in applications. Intelligent controllers along with DVR can protect the linear loads and sensitive loads from the Voltage Sags and Swells. In this paper, we are giving the Literature review to remove the Voltage Sags and Swells Issue at the transmission time. We are showing the solution for the Voltage Sags and Swells. We can use many types of methodology. The custom power device, DVR is the main method by which we can reduce the problem of voltage Sags and Swells. Voltage Sags and Swells are giving the main problem to the sensitive load in the distribution network.

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