Study & Comparison of Various Topologies of Dynamic Voltage Restorer & Its type: a Review

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Abstract

Power quality is one of the most important area of power system which we cant ignore as the lot of protective accessories, huge capital and customer safety are the important concern besides providing just a power supply. Power quality is ability of system to provide constant, pure sinusoidal and distortion less supply to power system. Now a days due to advanced technologies interruptions occur in the system which we need to compensate at proper time. For this purpose a research is made to reduce the effect of using non linear load on power system. One of the device used to compensate the unwanted disturbances in power system is studied in this paper . This study represents analysis of various types of dynamic voltage restorer (DVR) used in transmission line. Dynamic voltage restorer is power electronics controller used in series with transmission line to inject three phase voltage. This paper compares various topologies of three phase DVRs. In this research various technologies related to DVR are compared with each other.

Keywords :- *DVR, voltage sag, voltage swell, linear load, non linear load, IGBT*

1. Introduction

Poor power quality includes voltage sag, swell, harmonic flicker, interruptions, harmonic distortions. Preventing such imbalances is necessary because these creates huge of loss in terms time, money and technical loss. Voltage sag is the most common and less avoidable phenomena in power system Voltage sag and voltage swell are most probably common reasones for failure in production plants and failure in end user equipment. Tripping of equipment in production line can cause production interruption and lot of loss in cost of production. To avoid these problems as far as possible one of the solution is to make equipment to bear or tolerate voltage sag. . For improvement of power quality FACTS devices like static synchronous compensator (STATCOM), static synchronous series compensator (SSSC), interline power flow controller(IPFC),unified power flow controller(UPFC)are introduced. But these devices are designed for transmission purpose but during these days distribution system has got all attention to improve power quality. One of solution is to install proper device at sensitive load location to reduce voltage sag and voltage swell is to use dynamic voltage restorer (DVR). Dynamic voltage restorer is power electronic controller used to compensate voltage sag and voltage swell. DVR is connected in series with supply line to inject voltage in series with supply voltage to restore it to restore supply voltage to nominal value. Figure shows typical DVR and the way it is connected to grid. Basically DVR consist of voltage source inverter (VSI) connected in series with grid through Injection transformer, low pass filter and energy storage device.

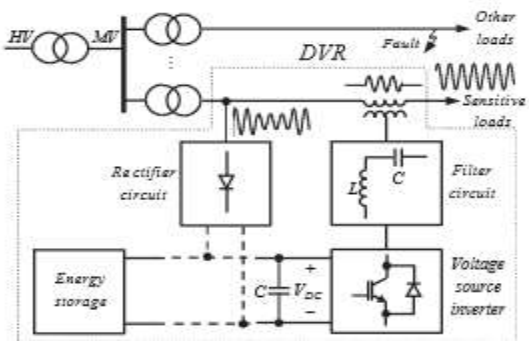

Fig.1. Principle operation of DVR System

VSI produces required compensating voltage and injects it to grid though series injection transformer hence load voltage is restored.DVR has two different constructional types whether it uses or does not uses energy storage element. In the above diagram we are using energy storage unit as DVR needs to exchange active power with grid it has to be placed along with energy storage element. There is another topology if DVR does not uses any energy storing element then rectifier is connected to grid to take power for injecting voltage. As compared to non energy storage element DVR with energy storage element is most useful as it is useful in deep voltage sags too.

2. System topologies for DVR

2.1 Topologies with no energy storage:

Energy is taken from incoming supply through passive shunt converter connected to grid side.

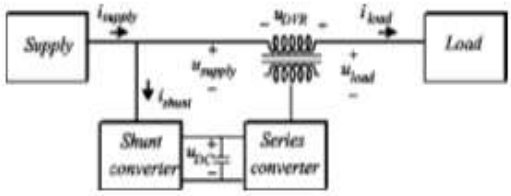

Fig. 2 DVR with no energy storage and supply side connected converter

Energy is taken from incoming supply through passive shunt converter connected to output side.

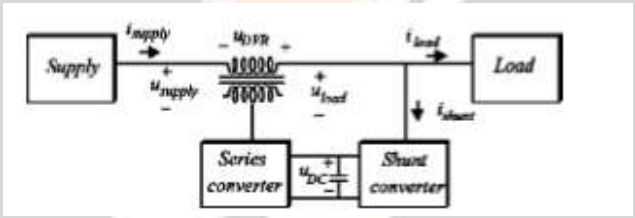

Fig.3 DVR with no energy storage and load-side-connected shunt converter

2.2 Topologies with energy storage

1. Stored energy in dc link and variable dc link voltage. Fig. 5

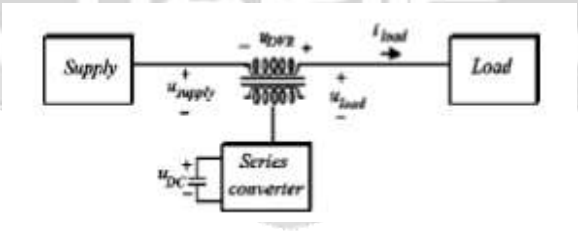

Fig.4 DVR with energy storage and with variable dc-link voltage

2. Arbitrary type of energy storage providing controlled dc link

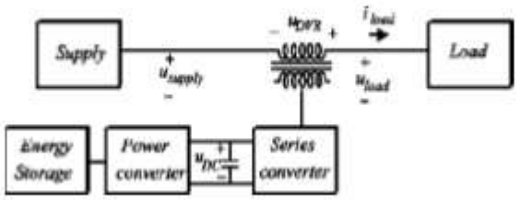

Fig.5 DVR with energy storage and with constant dc-link voltage

Different topologies of DVR are presented in this section. Most of the topologies vary in type of VSI used in DVR.

Mostly VSI topology used in three phase DVR consist of either H bridge inverter or three phase six switch inverter. Sag occurred in transmission line are mostly unbalanced in nature. Hence it is necessary that DVR should generate unbalanced three phase voltage to compensate voltage sag. By using three phase six switch inverter it is difficult to generate unbalanced output. DVR based on h bridge inverter does not face this problem. Even though VSI based DVR are superior, there are some other topologies that uses direct ac to ac converter. These systems have advantage of removing dc link, energy storage element, less price. But these devices does not use any energy storage system they they can not support grid during deep voltage sag. During deep voltage sag their operation becomes complicated

3. Comparison of various DVR

In this section four different topologies of DVR are compared on the basis of their working.

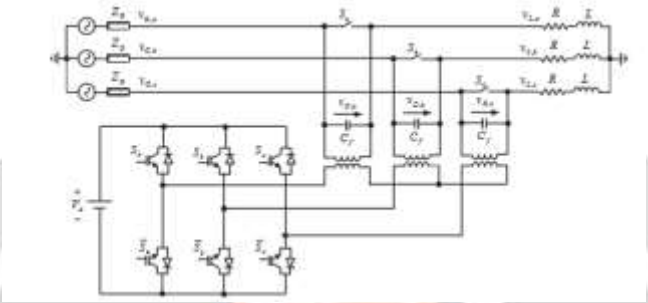

fig.6. Three phase six switch inverter

Fig. shows three phase six switch inverter. inverter shown in figure uses least number of switches as compared to other topologies but is not capable to compensate unbalanced voltage sag and swell if normal sinusoidal PWM technique implemented. We can use space vector PWM to improve condition but problem is not cleared totally. To avoid this condition we use split capacitor scheme shown in fig. 8

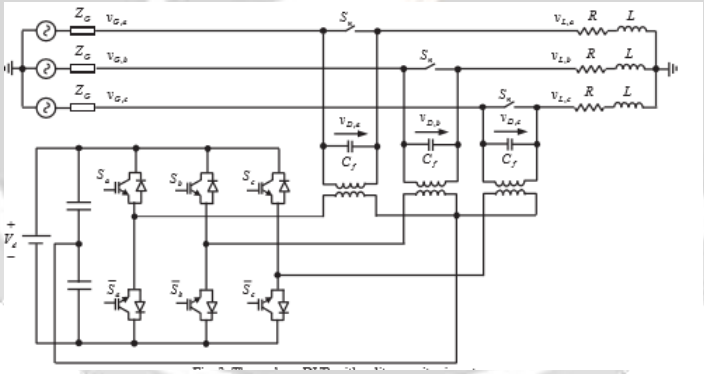

Fig.7 Three phase DVR with split capacitor inverter

In this technique three phases operate individually so that imbalanced voltage sag and swell can be overcome. For this purpose two more capacitors are required. This arrangement is shown in fig. 7. But the above two technologies i.e. three phase DVR with three leg inverter and three phase DVR with split capacitor inverter have a common problem that there output voltage is half of the total output voltage of DC source.

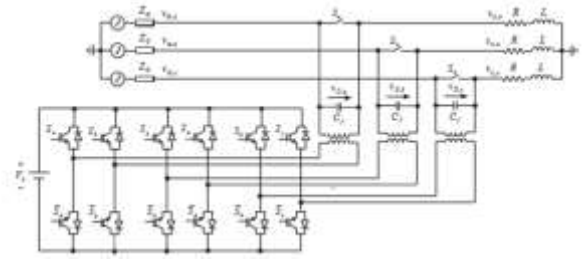

Fig.8 Three phase DVR employing three phase H bridge inverter

As compared to previous two techniques switches and output voltage is made twice. The phases operate individually to reduce voltage sag and swell. It is necessary to understand that if maximum output voltage magnitude is considered same for topologies then H bridge based topology use dc source with value that of used in previous system because of which voltage rating of switch becomes less than half. This topology is shown in fig 8.

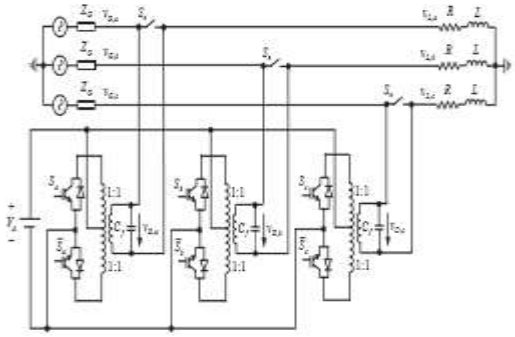

Fig. 9 Three phase push pull inverter based DVR

Topology	Number of switches	Total voltage rating of switches	Unbalanced operation	Maximum compensation capacity
Fig.6	6	6	No	$\frac{Vd}{2\sqrt{2}}$
Fig.7	6	6 Vd	Yes	$\frac{Vd}{2\sqrt{2}}$
Fig.8	12	12 Vd	Yes	$\frac{Vd}{2\sqrt{2}}$
Fig.9	6	6 Vd	Yes	$\frac{Vd}{2\sqrt{2}}$

Chart 1: Summery DVR Specification

Fig. 9 shows push pull inverter based DVR. This type of system uses less number of switches as compared to all three method mentioned previously. This technique is best suitable when voltages are unbalanced and even when they are balanced. Dc link voltage of DVR is determined in such a way that worst expected sag could be compensated. As figure 9 shows turns ratio of transformer is supposed to be 1 then maximum peak value of output voltage of every phase of DVR is limited to Vd. The way in which DVR inject voltage in series with supply voltage to compensate voltage drop is called as compensation technique. There are three types of compensation technique available which are post fault, pre fault, zero energy compensation. Pre fault compensation technique is used for loads which are sensitive for phase jump. In this method injection voltage is calculated and magnitude of load voltage and phase of voltage is restored to nominal value prior to voltage sag. In Post fault compensation technique injected voltage is in phase with source voltage where amplitude of load voltage is kept constant. This is the most simplest method of compensation. It requires smallest amount of injection voltage while it requires largest amount of active power. In Zero energy compensation technique voltage is injected in a way that to be orthogonal to load current after compensation. Hence active power exchange is not possible between DVR and load. This method is used for protection of high power loads.

4.Conclusion

In this paper research is made on basic type of DVR, DVR construction, Working of DVR, different power quality issues related with DVR, how to mitigate voltage sag, different types of DVR, methods of voltage injection. DVR is used to inject voltage in series with transmission line. The way in which it inject voltage makes the various topologies of DVR. DVR is cost effective solution to mitigate voltage sag, voltage swell. There are lot of FACTS devices available in market like STATCOM, SSSC, UPFC, IPFC. But compared to this DVR is best suited for distribution system. DVR is known as custom power device as it adds some voltage magnitude to electrical utilities.

References

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