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Estimation of voltage sag mitigation by using DVR

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ABSTRACT : *We know that the problem of voltage sag and its severe contact on sensitive loads. For solve this problem one of the custom power device is the dynamic Voltage restorer (DVR), which is the most accomplished and emphatic modern custom power device used in power distribution networks. It gives fast dynamic response to the disturbance. One of the major problems deals with the voltage sag which is very severe for the industrial customers as it can cause malfunctioning of several sensitive electronic equipments. DVR improve the voltage disturbance in the electrical system which is connected in series with the network. For control purpose of simulation DVR imply PI controller and PWM generator. Simulation results are also presented to illustrate and know the performance of DVR under various fault conditions such as single phase to ground, three phases to ground fault or line to line fault.*

Keywords: - *Custom Power, Dynamic Voltage Restorer (DVR), PI Controller, Power Quality, Voltage Sags.*

I. INTRODUCTION

Now a day's electrical power system generated, transmitted and distributed in the form of alternating current [1]. When the power is generated it possesses certain electrical properties that permit electrical system to role in their intended method i.e. it can energizes all electrical equipment regularly and acceptably. But power travels long distances through supports. Due to various pieces of equipments or due to any unusual conditions in the network, the importance of the power changes and thus it becomes less suitable for any further purpose. Voltage magnitude is one of the most important factors that determine the superiority of electrical power [1]. Hence it is necessary to improve the quality of power before it is used to energize any load. Though the man's circulatory system is similar for transmission system and the distribution system, in present set-up power quality directly related to distribution system. Its reason is nothing but the distribution system locates at the end of the power system and is directly connected to the consumer. The distribution system is the part of power system for utilization which distributes electrical power to the consumer [2]. Earlier the main focus for power system reliability was on generation and transmission system but now a day's distribution system receives more attention. Because most of the electrical distribution network failures account for about 90% of the average customer interruptions and if any disturbance occur in the distribution system a large amount of financial losses may happen with the resultant loss of efficiency and competitiveness. DVR is one of the most proficient and useful custom power devices due to its fast response, lower price and smaller size [2]. Control Unit is the vital part of DVR and its main function is to sense the presence of voltage sags in the electrical system and to calculate the required amount of compensating voltage. The controlling of DVR is done by a Proportional Integral (PI) Controller and a PWM Generator. Feedback controller having the type PI controller which is operates the system to be controlled with a weighted sum of error. It generates the desired signal for the PWM generator to trigger the PWM inverter. The Park's transformation is the basic components of DVR [2]. This paper, investigate the presentation of DVR in improving the quality of power under line to ground fault.

II. CONFIGURATION AND OPERATION OF DVR

There are various problems of power quality like sag, swell, harmonic, transients, overvoltage, under voltage etc, voltage sag i.e. is a short duration reduction in rms voltage which can be caused by a short circuit, overload or starting of electric motors. When the rms voltage decreases between 10 and 90 percent of nominal voltage for one-half cycle to one minute then voltage sag happens. Unexpected voltage Sag is the most severe trouble in the power system, normally caused by faults. The main objective of the DVR is to produce a set of neat balanced sinusoidal voltages across the load terminals irrespective of voltage sag in the supply voltage, distortion and unbalance. It last for duration range from 3 cycles to 30 cycles [3]. During starting large induction motors can also result in voltage sag as it draws a large amount of current. In order to moderate this problem DVR is one of the efficient and effective custom power devices. DVR injects voltage into the system in order to compensate the voltage dip in the load side and maintain the load voltage at actual magnitude. DVR is

a solid state power electronic switching device which is connected in series to the power system. It comprises of the following components:

[1] Energy storage device
[2] Injection transformer
[3] Voltage source Inverter
[4] Control unit.

a. **Energy storage device:**

This energy storage device is to supply the required energy to the VSI which converted into alternating quantity and feed to the injection transformer. Batteries are most commonly used in energy source and the capacity of the battery determine the period of the sag which can be compensated by the DVR.

b. **Injection transformer:**

Injection transformer contains two voltage side one is high voltage side and low voltage side. The distribution network connected in series with the first high voltage side while the low voltage side is connected to the power circuit of the DVR [3]. The DVR transfer the voltage through the injection transformer which is required for the compensation from DC side of the inverter to the distribution network. The transformer also helps in separating the line from the DVR system.

The Injection or we can say Booster transformer is a especially designed transformer that attempt to maximum value of coupling noise and transient energy from the primary side to the secondary side [3]. Its main tasks are connects the DVR to the distribution network through the HV-windings and transforms and couples the injected compensating voltages generated by the voltage source converters to the incoming supply voltage. In addition, the Injection / Booster transformer serves the purpose of separating the load from the system (VSC and control mechanism).

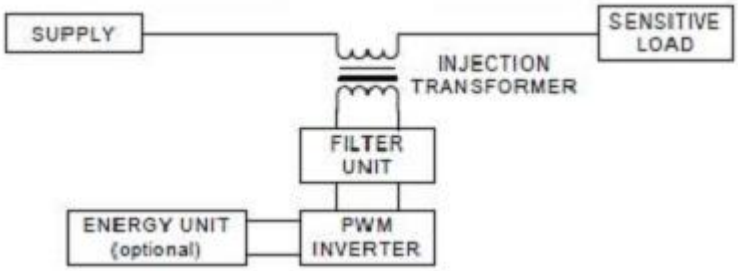


Fig. 1 Injection Transformer

c. **Voltage Source Inverter (VSI):**

It is a power electronic device consisting of a switching device and a storage device. VSI can create a sinusoidal voltage at any requisite magnitude, amplitude, time period, phase and frequency. VSI is used to for the moment generates the part of the supply voltage that is missing. The electronic device IGBT is the new compact switching device that is used for the operation of DVR.

d. **Control unit:**

the control unit is used for the proper operation of DVR system. DVR detects the presence of voltage sags and operates to mitigate the voltage sag. Pulse Width Modulation (PWM) control technique is applied for inverter switching so as to generate 50 Hz sinusoidal voltages at the load terminals. The magnitude of load voltage is reference voltage and if any difference occurs in between load and reference voltage then the error signal will be generated as shown in the Fig.2.4.

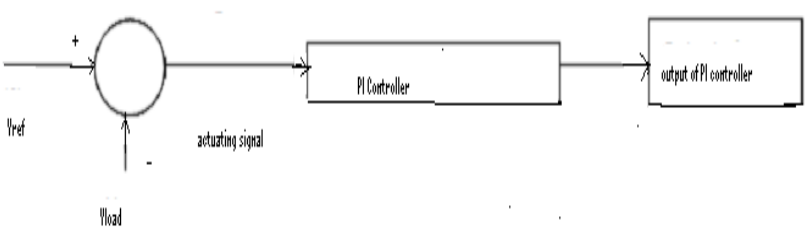


Fig 2.4 control unit

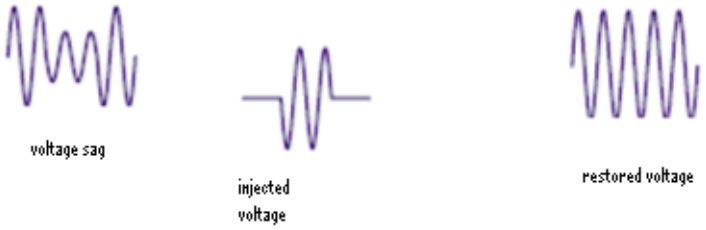
This error having input signal is the actuating signal which drives the PI controller and the output signal is the controls of pulses for the Inverter. PI controller is a response controller which controls the system depending on the error signal. In PI controller technique the proportional response can be obtained by multiplying the error with proportional gain. The integral response is proportional to the magnitude of error as well as duration of error.

III. DYNAMIC VOLTAGE RESTORER (DVR)

A Dynamic Voltage Restorer (DVR) is connected in series with the solid state device that inject voltage to the system in order to regulate the low side i.e. load side voltage. The DVR was first installed in 1996 [2]. It is normally installed in a distribution system between the supply and the critical load feeder [3]. Its primary function is to rapidly boost up the load-side voltage in the event of a disturbance in order to avoid any power disruption to that load [1]. There are various circuit topologies and control schemes that can be used to implement a DVR. In addition to voltage sags compensation, DVR can also added other features such as: line voltage harmonics compensation, reduction of transients in voltage and fault current limitations. The general arrangement of the DVR consists of an Injection / Booster transformer, a Harmonic filter, a Voltage Source Converter (VSC), DC charging circuit and a Control and Protection system.

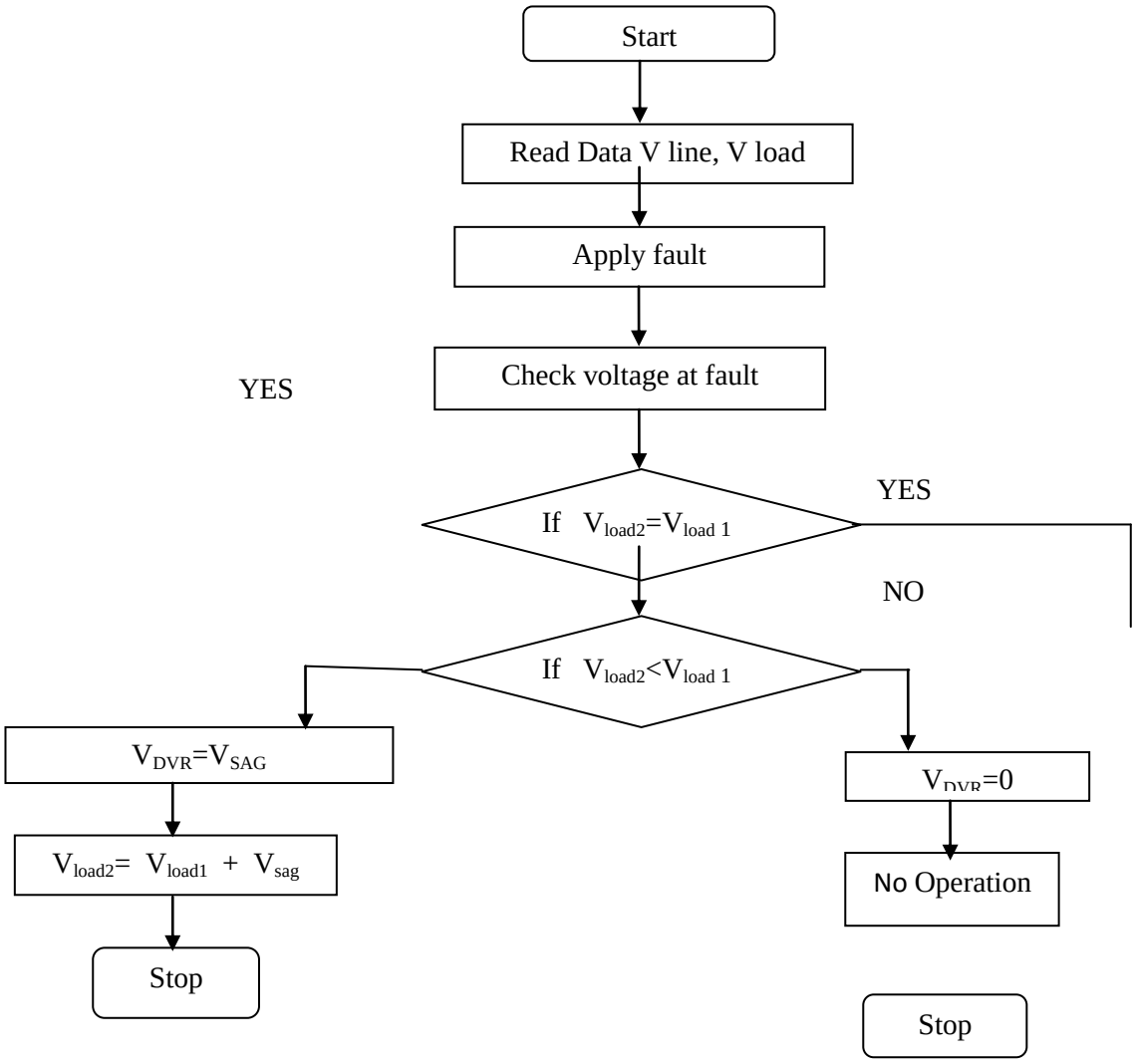
IV. OPERATING PRINCIPLE OF DVR

DVR is connected to the supply and the load as shown in the Fig 3. The main purpose of the DVR is to increase the load side voltage so that load is free from any power disruption. Besides voltage sag damages DVR also carry out other functions such as line voltage harmonic compensation, reduction of transients in voltage and limitation of fault current.



The main function of the DVR is to inject a dynamically controlled voltage VDVR generated by a forced commutated converter in series to the bus voltage by means of a booster transformer. The momentary amplitudes of the three injected phase voltages are controlled such as to eliminate any damaging effects of a bus fault to the load voltage VL. This means that any differential voltages caused by transient disturbances in the ac feeder will be compensated by an corresponding voltage generated by the converter and injected on the intermediate voltage level through the injection transformer. The DVR works separately 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 compensate the constructive, helpful and negative sequence components of the voltage problem seen at the input side of the DVR. This option is Reasonable because for a characteristic 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 contain two modes of operation which are standby mode and boost mode. In standby mode (VDVR=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 the standby mode. In boost mode (VDVR>0), the DVR is injecting a compensation voltage through the booster transformer due to a finding of a supply voltage disturbance.



IV. CONCLUSION

In this paper an overview of DVR is presented. DVR is an effective recent custom power device for voltage sags mitigation. The impact of voltage sags on sensitive equipment is severe. Therefore, DVR is considered to be an efficient solution due to its low cost, small size, and fast dynamic response.DVR handled both balanced and unbalanced situation and inject appropriate voltage deviation .The Dynamic Voltage Restorer (DVR) is fast, flexible and efficient solution to voltage sag problems.

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