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VOLTAGE SAG AND SWELL COMPENSATION USING IDVR

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ABSTRACT

Now days, there is increase in power electronic devices and nonlinear loads which are more sensitive to power quality. So power quality is more concerned issue from customer side. Most of the power quality problem is related to the voltage. Such power quality problem causes enough damage and economic losses in manufacturing process.Mr. N. G. Hingorani has proposed Custom Power Devices (CPD) to overcome such problems. This paper discusses operational principle of Dynamic Voltage Restorer (DVR) and SVPWM control techniqueused for VSC in DVR. DVR has limitations to compensate long duration voltage sag. Solution over this problem is inter-line DVR. Effectiveness and operational result of IDVR can be seen from matlab Simulinkmodel and its results.

Keywords: Voltage Sag and Swell, DVR,IDVR, SVPWM,

I. INTRODUCTION

Development in any county is mainly because of the growth in modern industries. Such modern industries always include innovation in technologies and they come to success only by optimized production to have maximum profits.Modern industries require stable and uninterrupted power supply to perform efficiently. The main complains from distribution side related to the voltage quality. Most of the economical and manufacturing losses in industries are due to voltage sag and swell. Such power quality problems are compensated by using Custom Power Devices which were introduced in 1990's.

This paper introduces the Dynamic Voltage Restorer which one is the best CPD to overcome these problems. Series connected DVR works on basic principle of injection of require amount of voltage in transmission line by appropriate value of magnitude and phase angle. That injected voltage is taken out from any storing devices like batteries, flywheels. Efficiency and performance of DVR depends on energy stored in storing device. Such DVR cannot perform veryefficiently for long duration voltage sag compensation. This paper also introduces interline connection of DVR and it is called as IDVR.

DVR includes five main parts are as injecting transformer,converter, filter, control circuit and source unit. Space vector pulse width modulation (SVPWM) technique is used to control the inverting operation. Voltage source inverter is usedto convert dc voltage to three phase AC voltage. A fault in system iscalculatedusing parktransformation with respect to reference value [5].

II. OPERATING PRINCIPLE OF DVR

DVR is connected in series with load and source. Sudden change in large load or other factors can cause quality problem in system.If system is under voltage sag then there will be lesser magnitude across load as compared to deserving voltage. DVR needsto inject voltage in system to maintain constant voltage across load.

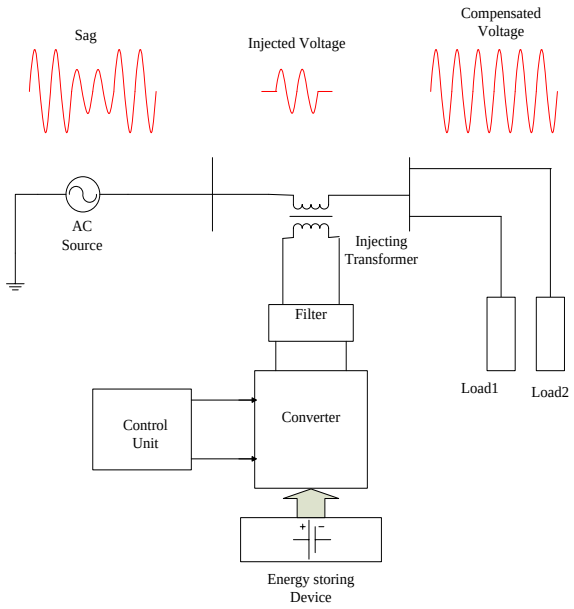

Fig 1. Operating principle of DVR

Operating principle of DVR is as shown in fig 1. As there is voltage sag from source side, the injecting transformer feeds required amount of voltage from storing device and compensated constant voltage is delivered to the load [6].

III. BASIC CONFIGURATION OF DVR

Basically DVR requires five main components for proper operation. These are as fallows.

1. Injecting Transformer
2. Energy Storing Device
3. Voltage Source Converter
4. Filter
5. Control Unit

All above components are shown in fig 1 and discussed ahead briefly [6].

1. Injecting Transformer

Injecting transformer is used to inject require amount of voltage in magnitude and phase shift. It is used in series with distribution feeder. We can use any one of three phase transformer or three single phase transformer.

2. Energy Storing Device

It is used to supply real amount of power in system. Performance of DVR mostly depends on the stored energy in device. It supplies the required amount of voltage to the converter. Energy storing device could be any of batteries, PV cell, Fly wheel etc.

3. Voltage Source Converter

Input of the converter is connected to DC batteries. Inverter is required to convert DC to AC and this converter is of two types, one is voltage source and other one is current source based.Different control techniques have been used for switching operation of inverter.

4. Filter

It filters out the higher harmonics components. We can connect filter either load side or inverter side of injecting transformer. Inverter side filter eliminates higher order harmonics but there might be voltage drop and phase shift in inverteroutput side. Load side filter avoids above problems but this position injects higher order current in secondary side.

5. Control Unit

Efficiency of DVR depends on control technique used for inverter. Pulses are generated and these pulses are used for the switching of the inverter. In this paperSVPWM control technique is introduced to generate pulses. DVR operates only when there are differences inload voltage and referencevoltage, that difference is measured by PID controller.

IV. INTER LINE DYNAMIC VOLTAGE RESTORER

Most of the loads and commercials areas are supplied by two or more feeder. Any abnormalities in feeder can causes problem in quality of supply to the load. This problem would be eliminated by transferring the required amount of power from another feeder. Static transfer switches has been used for this purpose but it is not possible to alleviate all power quality problems.

To maintain reliability over voltage sag and swell problems, DVR is installed for each feeder and these DVRsare connected to a common DC link. This arrangement of DVRs with common DC supply source is called as Inter line Dynamic Voltage Restorer (IDVR). In IDVR structure, required amount of real power can be feed easily from another healthy feeder but it has own limitation due to operational characteristics. Capabilities of DVR for compensating long duration voltage sag depends on the amount of energy stored in dc link [3]. IDVR has been proposed in many studies to replenish dc link. Mostly two feeders do not cause same problem at an instant. DVR 1 is connected to feeder 1 and another one is connected to feeder 2. In general when feeder 1 goes under long duration voltage sag then DVR 1 takes real power dc link and injects required voltage to feeder 1. At the same time another feeder 2 feeds real power to replenish common dc link [8]. Here we have simulated two feeders; each one is connected with a DVR. Feeder 1 and feeder 2 cause voltage sag and swell power quality problem respectively. Block diagram of IDVR is as shown in fig 2.

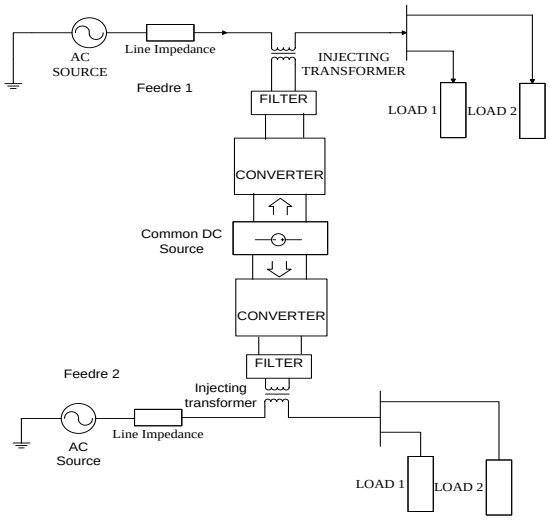

Fig 2. Block Diagram of IDVR

V. CONTROL TECHNIQUE USED FOR CONVERTER

Three phase voltage source inverter has wide application in control and power system. Operational characteristic of any inverter is always a switching technique used for it. PWM technique has been famous trade used to control switching operation. Here we have introduced Space Vector Pulse Width Modulation technique to control inverter. Rotating flux in ac machine is taken as avoltage vector which is combination of three phase supply voltage [1].

Followings are the three phase voltage

$$Va = Vm\ \sin(\omega t)$$

$$Vb = Vm\ \sin(\omega t - 2\pi/3)$$

$$Vc = Vm\ \sin(\omega t - 4\pi/3)$$

Combinations of all above three vectors are represented in single rotating vector. Magnitude and phase angle of that space vector is calculated by Clark's transformation [1]. Space vector is represented in complex plane as shown in fig 3.

$$V = V\alpha + V\beta$$

$$= 2/3\ (Va + \alpha Vb + \alpha^2 Vc)$$

$$\alpha = e^{j2\pi/3}$$

$$|V| = [V\alpha + V\beta]^{1/2}$$

$$\theta = \tan^{-1}(V\beta/V\alpha)$$

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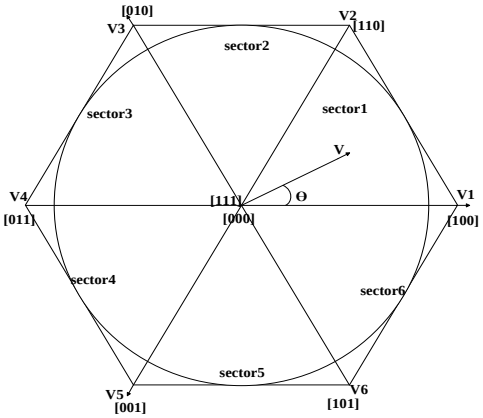

Fig3. Representation of rotating vector in complex plane

Switching time period can be calculated as fallows.

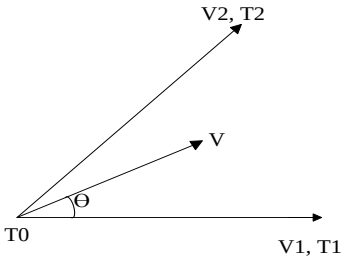

Fig4. Representation of T for sector 1

$$T1 = \frac{\sqrt{3}}{Vdc} Tz\,|V|\,\{\sin(n\pi/3 - \theta)\}$$

$$T2 = \frac{\sqrt{3}}{Vdc} Tz\,|V|\,\{\sin(\theta - (n-1)\pi/3)\}$$

$$T0 = Tz - (T1+T2)$$

Where $n = 1$ to 6 for any sector

$0 \leq \theta \leq 60$

VI. SIMULATION RESULTS

This paper introduced two feeders connected through DVR to a common DC link.This system model is called as IDVR and simulated in MATLAB software. Simulation model is shown in fig 5. DVR 1 compensates voltage sag and another DVR is used to compensate swell quality problem for duration in between 0.3 to 0.8. Simulation results and parameters used for simulation are as shown in fig 6 and table 1.

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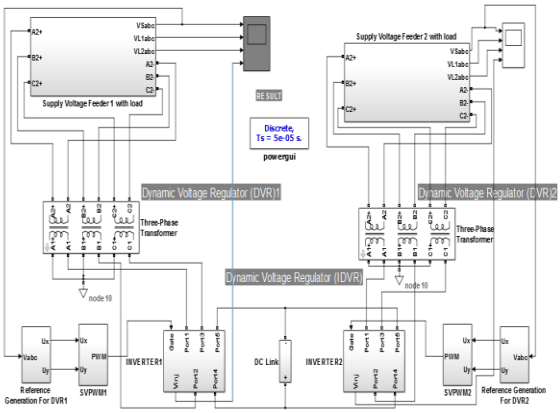

Fig 5. Simulation model for IDVR in Matlab

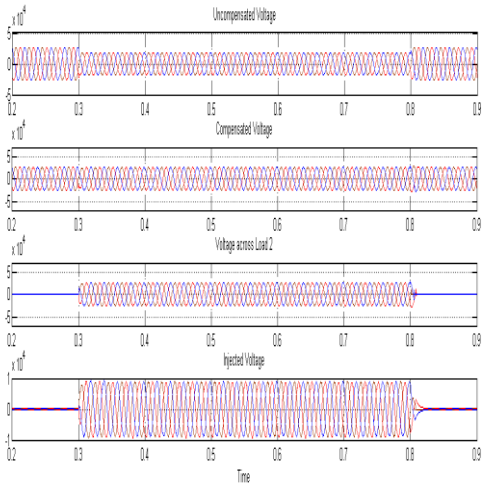

Fig 6.1 simulation results for feeder1 (voltage sag)

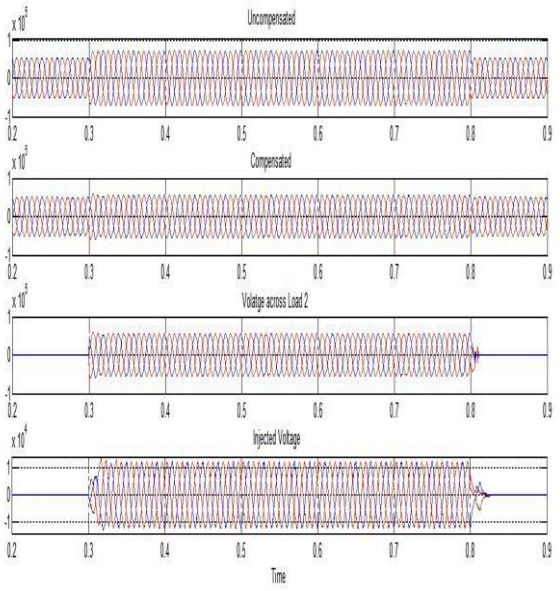

Fig 6.2 simulation results for feeder 2 (voltage swell)

	Feeder 1	Feeder 2
Main supply voltage rmsph-ph	33kv	66kv
Line Impedance	4 Ω ; 110Mh	4 Ω ; 110mH
Common DC Bus Voltage	35000	35000
Filter Inductance and capacitance	2 Ω ; 10 mH ; 0.0177 µF	3 Ω ; 10mH ; 0.0177 µF
Load resistance and inductance	500 Ω ; 0.8 H	500 Ω ; 0.8H
Supply frequency	50 Hz	50 Hz
Series transformer turns ratio	1:1	1:1

Table 1. System Parameter

VII. CONCLUSION

DVR is suitable device to compensate power quality voltage sag, swell problems. DVR has limitation for long duration sag compensation. Introduced system model of IDVR is efficient and performed well to mitigate voltage sag and swell. SVPWM control strategy is used for voltage source converter. SVPWM is easy and famous technique.

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