A Review of Enhancement of Voltage Profile and Fault Current Interruption using DVR

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Abstract— Power quality is big issue that becoming increasingly issue in industrial electricity in consumer side view. This paper presents about an improvement voltage profile and fault current interruption using DVR.There are different control strategy are available and introduces an auxiliary control strategy for downstream fault current interruption in a radial distribution line by means of a dynamic voltage restorer (DVR). The proposed controller presents the voltage-sag compensation control of the DVR. It does not require phase-locked loop and independently controls the magnitude and phase angle of the injected voltage for each phase. Fast least error squares digital filters are used to estimate the magnitude and phase of the measured voltages and effectively reduce the impacts of noise, harmonics, and disturbances on the estimated phasor parameters, and this enables effective fault current interrupting even under arcing fault condition. In review there different control strategy are available which are described.

Index Terms—**Digital filter**, **Dynamic voltage restorer, fault current interrupting, Distribution**

I. INTRODUCTION

Nowadays, with a widespread use of electronic equipment, loads are become nonlinear and sensitive and less tolerant to short term voltage sag. Power quality problems become a major concern of industries and also for consumer of residential because of increasing use of nonlinear load and also due to concerns of times and money loss in industries if production is interrupting. Hence, there are always demands of power quality improvement device which concerns this positively results in reduction of problems like Voltage sag, harmonic and flicker, voltage interruptions, harmonic distortion [1].High power supply is needed, because due to failures such disturbances usually have a high impact on production costs. One approach is to use Dynamic Voltage Restorers with energy storage. The DVR is a power electronics device that is able to compensate voltage sags on critical loads dynamically [2].Dynamic voltage restorer injects an appropriate voltage waveform, and ensures constant load voltage. The Dynamic Voltage Restorer (DVR) with the lead acid battery is an attractive way to provide excellent dynamic voltage compensation capability as well as being economical when compared to DSTATCOM shunt-connected devices. The DVR is a custom power device that is connected in series with the distribution system. The DVR employs IGBTs to maintain the voltage applied to the load by injecting single-phase output voltages whose magnitude, phase and frequency can be controlled. The basic function of DVR is to inject dynamically voltage required, V_{DVR} to compensate sagging occurrence [3]. Generally, the operation of DVR can be categorized into two modes; standby mode and injection mode. The DVR is turn into injection mode as soon as sagging is detected. V_{DVR} is injected in series with load with required magnitude and phase of their desired waveform [4]-[6].An energy storage device and injection transformers which they are consisting of power electronics devices either GTO or IGBT. Distribution system and a load are linked to series transformer.

The first DVR was installed in North Carolina, for the rug manufacturing industry .Another installed to provide service for large dairy food processing plant in Australia. DVR usually built round a DC-AC Power converter that is connected in series with a distribution line through a three single phase transformer. Energy state of the device is regulated by taking power from the feeder. The field of series compensation in distribution system is relatively new Peng introducing the use of series active filter in conjunction with shunt passive filter [3]. By integrating shunt and series active filter, Akagi have proposed a UPQC that is capable of eliminating voltage flicker, negative sequence current, harmonic etc.

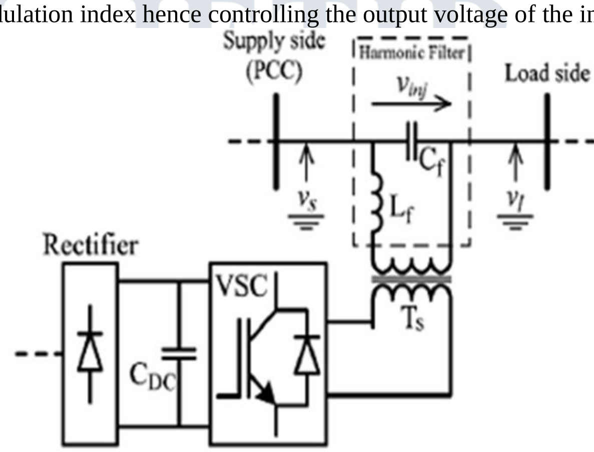
Potential mode of transient performance of operation of the DVR are compared and control strategy of developed. The basic idea of the DVR is to inject a controlled voltage generated by a forced commuted converter in a series by injecting transformer. A sinusoidal PWM technique regulates the voltage by means of DC to AC inverter. The dual dynamic voltage restorer it is series to series connected devices and it is the new method of device control. In this connection of devices are also similar to upfc device. The Dual dynamic voltage restorer injects only a low voltage to compensate for the voltage drop of the transformer injection and power quality losses. When voltage sag occurs in the distribution system, the DVR controller calculates and compensate the voltage required output voltage to the load by injecting a controlled voltage with a certain magnitude and phase angle into the distribution system to the critical load [7].

Note that the DVR capable of generating or absorbing reactive power but the active power injection of the device must be provided by an external energy source. The DVR response time is very short and is limited by the power electronics devices, and which is much less than some of the traditional methods of voltage correction such as tap-changing transformers. There are various types of voltage sag mitigation equipment that available nowadays such as Uninterrupted Power Supply (UPS), flywheel, and the flexible ac technology (FACTS) devices which have been widely used in the power system due to reliability [8]-[11]. The most FACTS devices that have been improving the performance of power quality are Dynamic Voltage Restorer (DVR) also known as custom power devices. DVR which consists of the injection transformer, filter unit, PWM inverter, and energy storage issued to mitigate the voltage sag problem in the power distribution system. Control unit is the heart of the DVR where it main function is to detect the presence of voltage sags in the system, calculating the required compensating voltage for the DVR and generate the reference voltage for PWM generator to trigger on the PWM inverter [12]. The components of control system unit are the dq0-transformation, Phase-lock-loop (PLL) and the PI or FL Controller. PI Controller is a feedback controller which drives the plant to be controlled with a weighted sum of the error (difference between output and desired set-point) and the integral of that value [10].

There is also a technique of interline power flow controller IDVR proposed and provide a way to replenish the energy in the common dc link energy storage dynamicall.IDVR system consists of several DVRSfoe protecting sensitive loads in different distribution line feeders emanating from different grid substation and this DVRs share a common link.IPFC provide a good control strategy for controlling power in different power system transmission line. [4]

II. DYNAMIC VOLTAGE RESTORER

SPWM or Sinusoidal Pulse Width Modulation is widely used in power electronics to digitize the power so that a sequence of voltage pulses can be generated by power switches on and off. The PWM inverter has been the main choice in power electronic for decades, because of its circuit simplicity and difficulty. SPWM techniques are characterized by constant amplitude pulses with different duty cycle. The width of the pulses are modulating in order to obtain inverter output voltage control and to reduce its harmonic values. The most common method in motor control and inverter application are used in SPWM to generate the signal, triangle wave as a carrier signal and to compare with the sinusoidal wave, whose frequency is the desired frequency. The use of the Atmel microcontroller brings flexibility to change the real-time control algorithms. It will reduce the overall cost and has a compact size of control circuit for the single phase full bridge inverter. The inverter circuit in DVR is responsible for generation of the compensating voltage. Hence the control of the inverter will directly affect the performance of the DVR. The inverter used in the proposed DVR is a three phase six pulse inverter. The thyristor used in the inverter circuit are chosen to be Insulated Gate Bipolar Transistors (IGBT) for their fast response and speed operation. Sinusoidal Pulse Width Modulation (SPWM) technique used the inverter for controlling the modulation index hence controlling the output voltage of the inverter.



Figure; 1.schmetic diagram of DVR with line side harmonic filter

Different component:

1. Energy storage unit:

During voltage sag condition, energy storage is used to provide the shortage of missing energy. Commercially available the DVR use large capacitor bank. The capacity of energy storage device become big impact on the compensation capability of the system.DVR configured alternatively to use line energy supply, that's absorb the energy that is injected which itself from utility feeder.

2. Voltage source inverter:

The DC voltage is converted from the energy storage unit to a controllable AC voltage which is to be injected to the line voltage.

3. Filter Circuit:

Normally, a second-order LC filter is introduced between the inverter and the transformer to cancel high frequency harmonic components in the inverter output voltage.

4. Bypass Switches and Control Circuits the DVR may be configured to operate as a standby compensator where the inverter is passive in the circuit until triggered by a voltage sag event. Alternatively, the DVR may be working continuously during normal and abnormal conditions.

5. Injection Transformer

Its primary connected in parallel to the output of the VSI and its secondary connected in series between the Point of Common Coupling (PCC) and the load bus, and which injects the controllable three phase voltage V_{DVR} to the PCC voltage. This ensures that the load bus voltage, V_L remains almost unaffected by the sag condition.

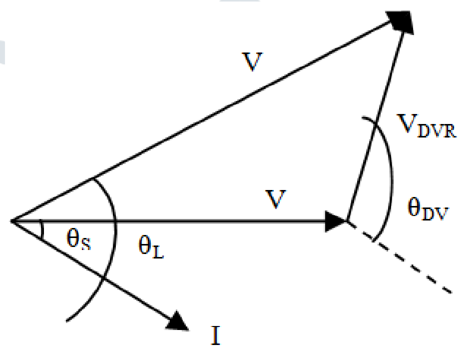
In SPWM, a sinusoidal reference signal of supply frequency (i.e. 50 Hz) is compared with a high frequency triangular carrier waveform (i.e. 1080 Hz for this study). When the sinusoidal reference signal is greater than the triangular carrier wave, a batch of three IGBT switches out of the six are turned on and the counter switches are turned off and when the reference sinusoidal signal is smaller than the triangular carrier waveform in magnitude then the second batch of three IGBT switches are turned on and the first batch of switches are turned off. The magnitude of the sinusoidal reference signal determines the modulation index of the PWM signal generator which is dependent upon the error signal. The magnitude of the sinusoidal reference signal is controlled by the PI based feedback controller which adjusts the magnitude according to the error magnitude and hence control the modulation index. The proposed DVR utilizes large capacitor banks for storing dc energy. The capacitor banks are used to charge the rectified supply line voltage. DC voltage from alternative supply sources can also be utilized with the proposed configuration of DVR. Dynamic Voltage Restorer controls an important role, with the fast response of voltage sags and with variations in the connected load. Generally, there are two control schemes, open loop and closed loop which are used in the DVR applications. This project presents an extensive analysis to develop suitable control strategies for the DVRs. The DVR control system consists of an open loop load voltage using phase locked loop (PLL). The PLL circuit is used to generate a unit sinusoidal wave in phase with mains voltage. The three phase voltages can be converted into αβ using αβ0 transform.

III. Control Strategy

Different type of voltage sag and load conditions can limit the possibility of compensating voltage sag. Therefore, the control strategy depends on the type of load characteristics. There are three different methods to inject DVR compensating voltage.

A. Pre-fault Compensation

Pre-fault control strategy restores voltage to the Perrault value, i.e. both sag magnitude and phase shift are compensated. The reference voltage is set as pre-fault voltage magnitude and phase angle. Fig. 2 shows the single-phase vector diagram of pre-fault compensation method [10].



Figure; 2. Pre-fault compensation method.

B. In-phase Compensation

In-phase voltage compensation method restores voltage to be in phase with the voltage sag. In other words, the phase angle will be same as the angle of sagged voltage while the voltage magnitude is restored to pre-fault value. Fig 3 shows the single-phase vector diagram for in-phase compensation method [10]. For restore the voltage sag or disturbance by applying pre-sag and in-phase compensation method, must inject active power to loads. The disadvantage of the active

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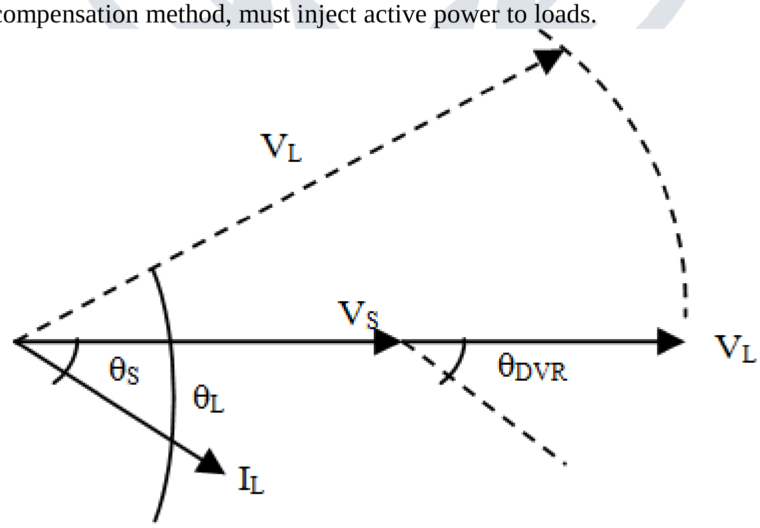

Figure: 3. In-phase compensation method

For restore the voltage sag or disturbance by applying pre-sag and in-phase compensation method, must inject active power to loads. The disadvantage of the active power is the amount of injection which depends on the stored energy in the storage unit. DVR restoration time and performance are important in pre-sag and in-phase compensation methods, due to the limited energy storage of the capacity unit.

C. In-phase Advance Compensation

The advantage of in-phase advance compensation is that less active power needs to be injected from DVR energy storage unit into the distribution system. Fig. 4 shows the single-phase vector diagram of in-phase advance compensation method [10].

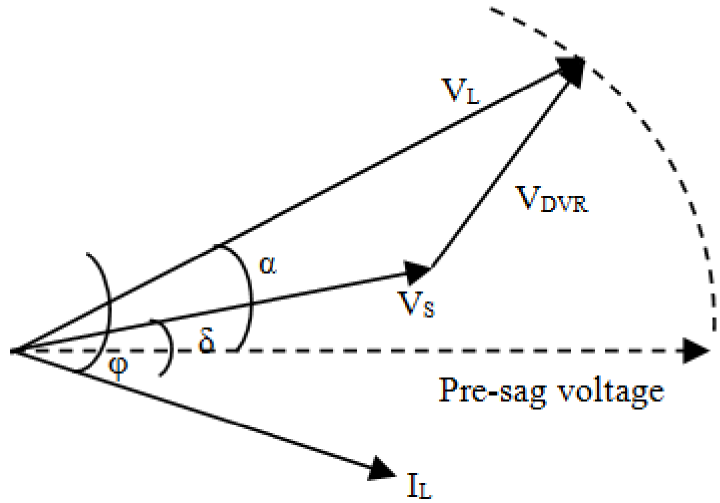

Figure 4. In-phase advance compensation method

IV. EQUIVALENTCURCUIT TO DVR

The system impedance Zth depends on the fault level of the load bus. When the system voltage (Vth) drops, the DVR injects a series voltage VDVR through the injection transformer so that the desired load voltage magnitude VL can be maintained. It requires the injection of only reactive power and the DVR itself is capable of generating the reactive power [10]. The magnitude of the sinusoidal reference signal determines the modulation index of the PWM signal generator which is dependent upon the error signal.

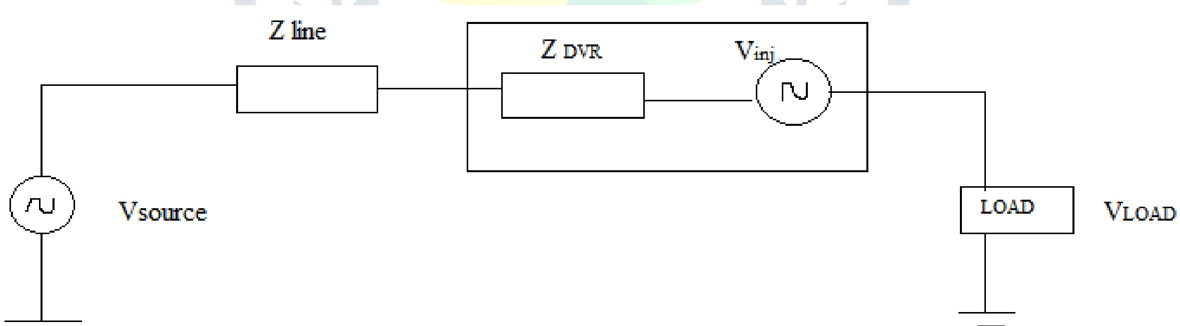

Fig 5. Equivalent Circuit Diagram of DVR

The magnitude of the sinusoidal reference signal is controlled by the PI based feedback controller which adjusts the magnitude according to the error magnitude and hence control the modulation index. Generally, there are two control schemes, open loop and closed loop which are used in the DVR applications.

Equation related to DVR.

Per sag compensation voltage as given,

$V_l = V_{sag} + V_{DVR}$.............(1),

A. Injection of Reactive Power.

When injected reactive power only from DVR, the power equation given by:

$jQ = V_{DVR} + I_l$............ (2)

$S_l = V_l + I_l$ ....(3)

Where: Q is the injected reactive power by DVR, S_l is the load at bus and I_l is the load current.

B. Injection of Active Power. When injected active power only from DVR, the power equation given by:
$P = V_{DVR} + I_l$ ....(4)
If the injected reactive power is unable to compensate the voltage sag (voltage magnitude), then restoration continues with injection of active power.

V.CONCLUSION

There are different configuration and different control statagy are presented in different paper but in this gives best technique which controlling the votage sag harmonic disturbances and voltage flickering and interruption in the distribution system for enhancement of voltage profile. SVPWM technique is good for the DVR operation which interrupting fault current less than 10 ms.

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