Fault Current Interruption by Custom Power Devices

G.Sripriya, Dr R.Prakash

Abstract:-Nowadays Power quality is the one of the major concerns. It has become important, with the introduction of facts devices, whose performance is very sensitive to the supply power. Power quality problem is an occurrence manifested as a result nonstandard voltage, current or frequency that failures. The voltage sag is the major power quality problem. To solve that type of problem, custom power devices are used. One of those devices is the Dual Dynamic Voltage Restorer (DVR), which is the most efficient and effective modern custom power device used in power distribution line. It includes reduces the cost, compact size, and its fast dynamic response to the disturbance. The modeling, analysis and simulation of a Dual Dynamic Voltage Restorer (DVR) using MATLAB.

Index terms:- Digital filters, Distribution, Dynamic voltage restorer(DVR), Fault current interruption, Multiloop control, Voltage sag, Voltage source converter.

1. INTRODUCTION

Nowadays, power quality problems become a major concern of industries due to concerns of times and money by massive loss problems. Hence, there are always demands of power quality which concerns this positively results in reduction of problems like Voltage sag, harmonic and flicker, 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 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 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.

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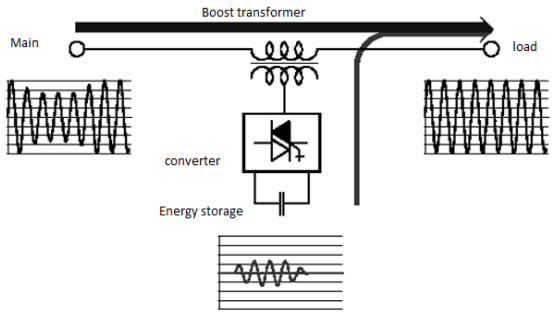


Fig.1.Schematic diagram of a DVR with a line-side harmonic filter.

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 [13].

2. 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.

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.

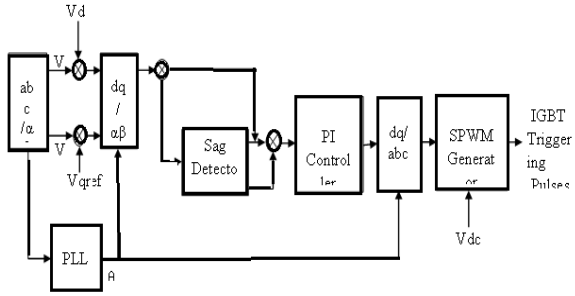


Fig.2. Block Diagram of Control Strategy for DVR

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 $\alpha\beta$ using $\alpha\beta 0$ transform.

3 EQUIVALENTCURCUIT TO DVR

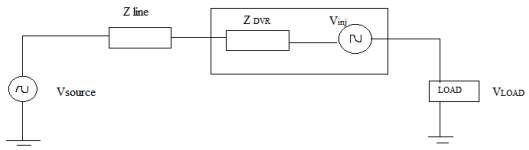


Fig 3. Equivalent Circuit Diagram of DVR

The system impedance Z_{th} depends on the fault level of the load bus. When the system voltage (V_{th}) drops, the DVR injects a series voltage V_{DVR} through the injection transformer so that the desired load voltage magnitude V_L can be maintained. It requires the injection of only reactive power and the DVR itself is capable of generating the reactive power [14]. 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. Generally, there are two control schemes, open loop and closed loop which are used in the DVR applications.

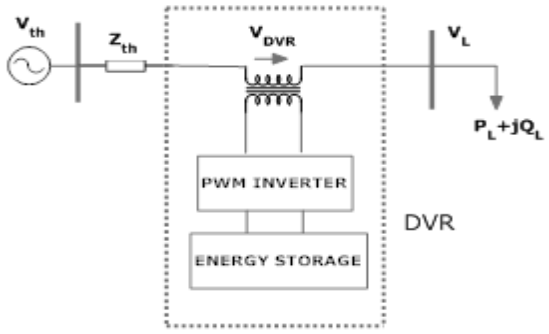


Fig 4. DVR voltage injection

3.1 Principal of Operation

The basic function of Dual DVR is to inject dynamically voltage required, dual DVR to compensate sagging occurrence. Generally the operation of DVR can be categorized into two modes; standby mode and injection mode [16]. In standby mode, DVR either in short circuited operation or inject small voltage to cover voltage drop due to transformer reactance losses. The DVR is turn into injection mode as soon as sagging is detected. VDVR is injected in series with load with required magnitude and phase for compensation.

4 CONTROLLER CIRCUIT

4.1 DVR Control Techniques

The fundamental roles of a controller in a DVR are to detect the voltage sag occurrences in the system; calculate the compensating voltage, to generate trigger pulses of PWM inverter and stop triggering pulses when the occurrence has passed. Using RMS value calculation of the voltage to analyze the

sags does not give fast result. In this study, the dq0 transformation is used in voltage calculation [8].

4.2 Proportional-Integral (PI) Controller

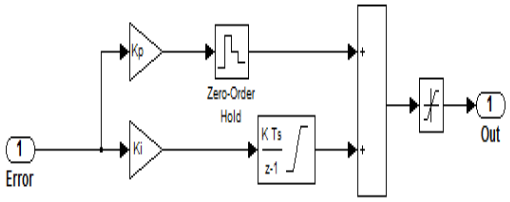


Fig 5. Discrete PI controller

PI Controller shown in Fig. 5 is a feedback controller which drives the plant to be controlled with a weighted sum of the error and the integral of that value [8]. The proportional response can be adjusted by multiplying the error by constant, called proportional gain. The contribution from integral term is proportional to both the magnitude of error and duration of error. The integral gain, Ki error is first multiplied and after then only integrated [11].

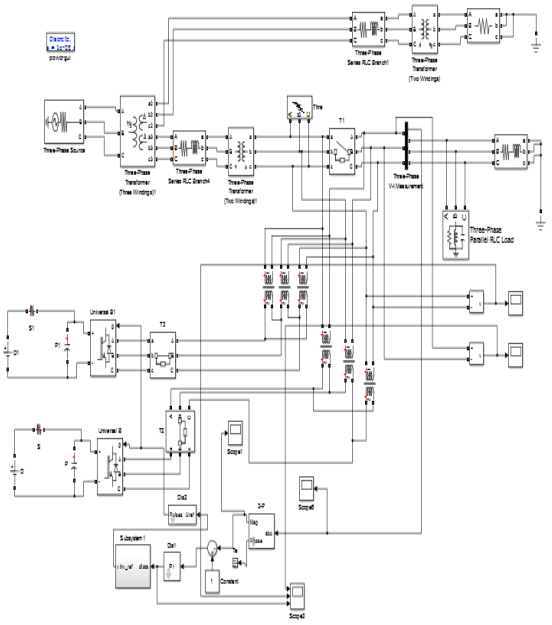
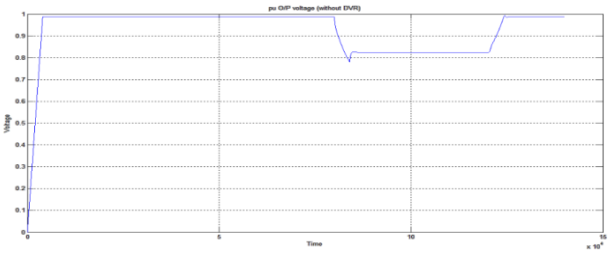


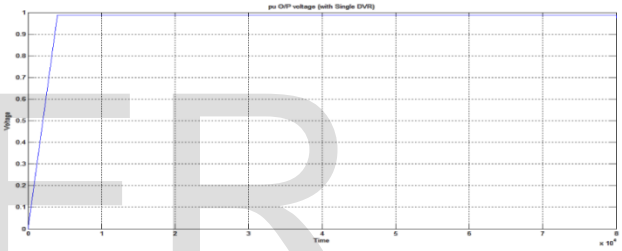
Fig 6. DVR Modeling using Matlab/Simulink

The simulation is carried out at the same scenario as above but a Dual DVR is now introduced at the load side to compensate the voltage sag occurred due to the three phase fault applied[12]. The rms voltage at load point when the system operates with no DVR and a three phase fault is applied to the system the DVR is operated the voltage interruption is compensated almost completely and the rms voltage at the sensitive load point is maintained at normal condition.

5 RESULTS AND DISCUSSION



(a)



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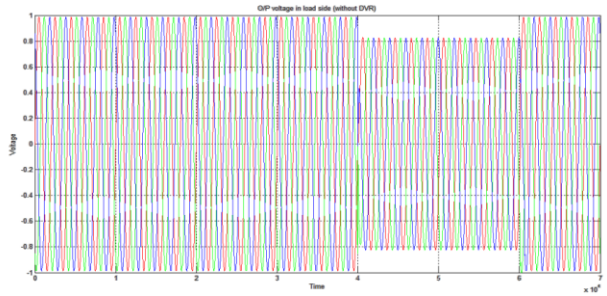

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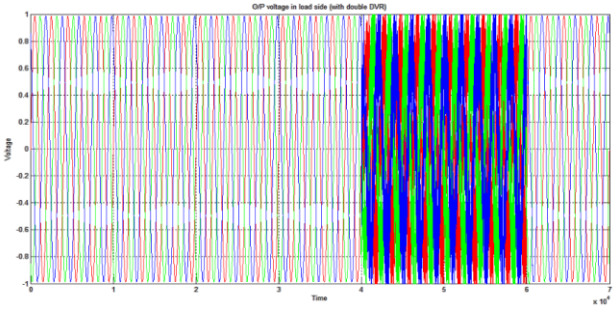

(d)

Fig 7(a)P.U Voltage at load point, with three phase fault, without DVR. 7(b) P.U Voltage at load point, with three phase fault, with DVR. 7(c) Three phase load voltage at load point, with three phase

fault without DVR. 7(d) three phase load voltage at load point, with three phase fault with DVR.

From the above results the performance in distribution line, three phase voltage fault is occurred here Dual Dynamic Voltage Restorer is used to rectify the fault.

VI CONCLUSION

In the simulation study, MATLAB Simulink is used to simulate the model of dual dynamic voltage restorer is an effective custom power device for voltage sags and swells mitigation. The Dual DVR controls under different faults without any difficulties and injects the appropriate voltage component to correct rapidly any abnormally in the supply voltage to keep the load voltage balanced and constant at the nominal value.

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