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New Control Techniques Using DVR as a Series Compensator to Protect Sensitive Loads from Voltage Disturbances

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ABSTRACT

In power systems, custom power devices are used in series to avoid the voltage drop. Dynamic voltage restorer (DVR) is one of these tools. The various control techniques are available for the operating DVR. This paper is to use the dq0 technique to control DVR Series as a compensator for protection at fault furthermore, dents and bump's voltage sensitive loads to the system. The proposed control system is simulation using MATLAB / Simulink software environment. The result shows that the dynamic voltage restorer system is useful for improving the voltage disturbances.

Keywords: voltage disturbance, time sensitive, series compensation, error, DVR

1. INTRODUCTION

Today, power quality problem is important caused by the excessive use of sensitive and non-linear loads in power systems and the rapid growth of renewable-energy sources. Power quality conditions sag, voltage bump and harmonic, and so on because of power quality disturbances, many industrial consumers severely effect. Today, power quality is important current issues with the liberalization and competition among utilities. Voltage drop (sag) occurs in a short time, to check the size and time should be considered also it five cycles and 1-minute.

Custom power devices are used in series to keep the voltage drop in the supply of decretive loads. Thinking this means was identified using an electronic controller for power system network. Some of these units are given below.

DSTATCOM, Dynamic voltage restorer (DVR), Unified power quality controller (UPQC), power filters, battery systems (BESS), a Distributed series capacitor (DSC), the Spark gap (SA), uninterruptible power supply (UPS). Listed unit has its own benefits and limitations. It caused the advantages of the successful DVR unit known as [1].

- Active power flow management.
- Less expensive than others.
- Need less maintenance.
- Higher energy capacity.
- Size and costs less than the DSTATCOM.

Drop down the voltage profile is one of the problems in the power grid voltage will decrease in effective supply voltage. IEEE-1159-1995 standard embayment, Root meant square (RMS) voltage as the voltage to 0.1 to 0.9% of the rated voltage 0.5 cycles to one minute in time to be defined, shown in “Fig. 1”. Although, the load current drops to less than 0.1 pu voltage amplitude and duration less than one-minute intervals as defined in [2].

To reach best performance, different control, such as predictive control [3], sliding method control [4], and the robust control [5] is used to control the injection voltage. In [6] the H∞ controller in the [7], of the controller is based on repetition are used to get better performance in steady and transient states. In [8], the fuzzy controller is used in the DVR. In [9] the multilevel is used in inverter structure optimization and predictive control.

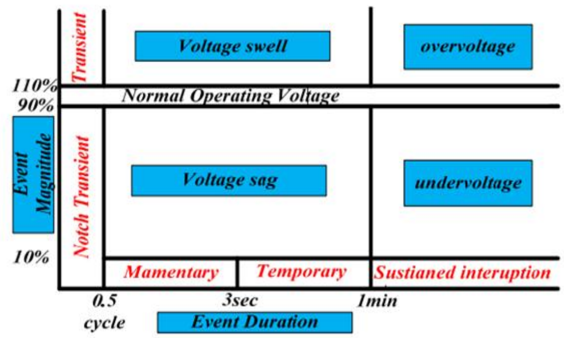

Fig. 1. IEEE-1159-1995 standard for voltage sag.

In [8-9], improving voltage Total harmonic distortion (THD) as a target and considered an important control measure.

One of the causes of embayment voltage of the power system, fault on the power network. Errors in the power network consist of, errors in three-phase and three-phase to ground faults, symmetric or asymmetric errors such as single-phase to ground faults, phase and phase to earth. Voltages drop down by cutting the voltage amplitude, duration, continuity and the number specified. Cutting the voltage amplitude is determined by the network impedance. Embayment, when the voltage is generated by a fault of the system. Determining proper safeguards to cut the duration and the errors in the network, determines the number embayment of voltage [10].

2. Dynamic voltage restorer (DVR)

Dynamic voltage restorer is safe for sensitive load from dents and bump’s voltage. When a short circuit occurs within a power system network, a sudden will close the drop in voltage on the feeder. DVR can be restored with introducing in feeding the load, when the line voltage to normal levels within a few milliseconds. Active power supply storage of DC power to the DVR and thus its production of reactive power is injected into the system. DVR can be applied to systems with low and medium voltage levels [11].

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3. Introducing the DVR

"Fig. 2" describes the overview of the DVR and "Fig. 3" shows the DVR equivalent electrical circuit diagram [12].

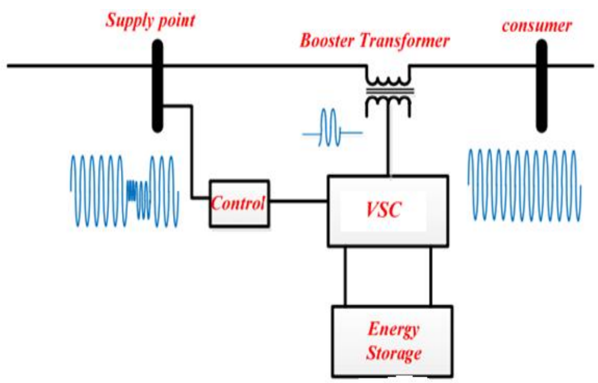

Fig. 2. Overview of the DVR.

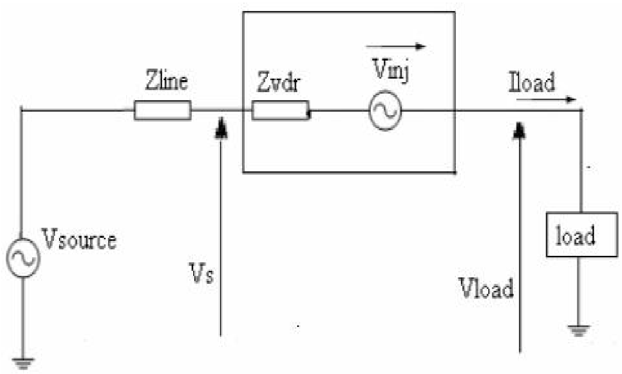

Fig. 3. Equivalent electrical circuit diagram of the DVR.

Dynamic voltage restorer following major parts.

• Power amplifier / injection DVR voltage on the system in the event of failure to protect voltage sensitive loads inject.

• Controller.

Switching process.

• Harmonic Filter.

Cut out harmonic in pulse width modulation (PWM) is generated.

• Inverter for converting DC voltage waveform of the AC voltage waveform.

• Energy storage devices.

Power supply for producing injection voltage to the voltage source inverter. The DVR unit active power required to provide the compensation.

• Capacitors DVR.

It consists of a large capacitor to the input inverter.

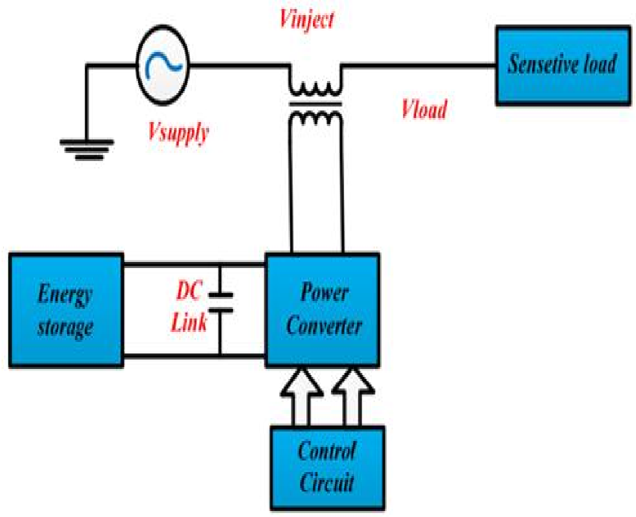

Fig. 4. Structure of DVR control, using dq0 technique.

If an error occurs in other lines before the error is rectified, DVR has produced a series of voltage and load voltage compensation to the voltage before the error. "Fig. 5" shows a flowchart of the DVR.

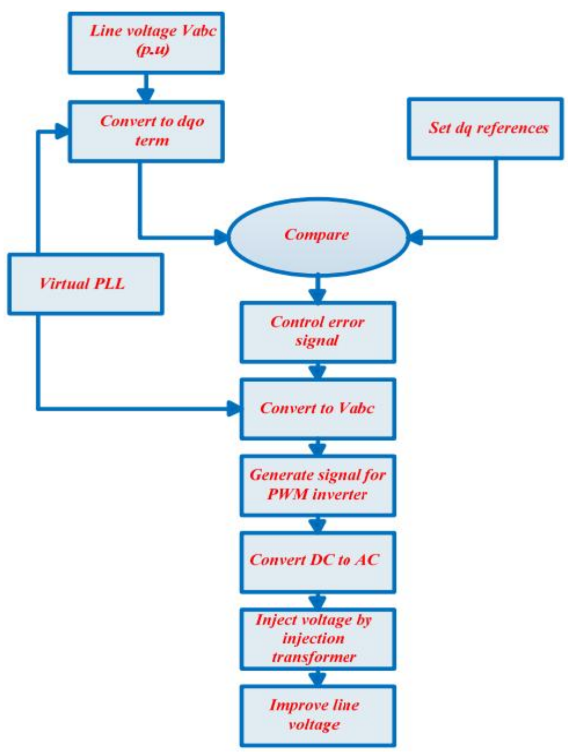

Fig. 5. Flowchart of the DVR.

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4. DVR control techniques

Dents or bumps occur when the voltage, DVR must act quickly and inject the AC voltage across the network. There are several ways to control the DVR. Different parts of the DVR controls include.

- identify the occurrence of dents / bumps in the system.
- Calculate the offset voltage.
- Pulse output of the PWM inverter fire and stop it when the problem is resolved.

In normal and synchronous conditions, the voltage is a constant, d-voltage is one pu and q-voltage unit is zero pu, but in normal circumstances can be a change. The d-voltage and q-voltage with the interest that needed for best performance is compared then the d and q error is generated. Thus the d-q contents of error become abc content.

Choose to provide dq0 method, give information about the size (d), phase shift (q) with start and end voltage fallen leaves. Load voltages base on the Park transformations, and according to the following equation becomes.

$$\vec{V_d} = \frac{2}{3}[V_a \cos\omega t + V_b \cos(\omega t - \frac{2\pi}{3}) + V_c \cos(\omega t - \frac{2\pi}{3})] \quad (1)$$

$$\vec{V_q} = \frac{2}{3}[V_a \sin\omega t + V_b \sin(\omega t - \frac{2\pi}{3}) + V_c \sin(\omega t - \frac{2\pi}{3})] \quad (2)$$

$$\vec{V_0} = [V_a + V_b + V_c]/3 \quad (3)$$

$$\begin{bmatrix} V_d \\ V_q \\ V_0 \end{bmatrix} = \begin{bmatrix} \cos(\theta) & \cos(\theta - 2\pi/3) & 1 \\ -\sin(\theta) & -\cos(\theta - 2\pi/3) & 1 \\ 1/2 & 1/2 & 1/2 \end{bmatrix} \begin{bmatrix} V_a \\ V_b \\ V_c \end{bmatrix} \quad (4)$$

Main voltages used as a Phase lock loop (PLL) to generate sine-wave single phase. The contents are used for production abc three phases PWM pulses. Control technique employed throughout this paper is shown in "Fig. 6".

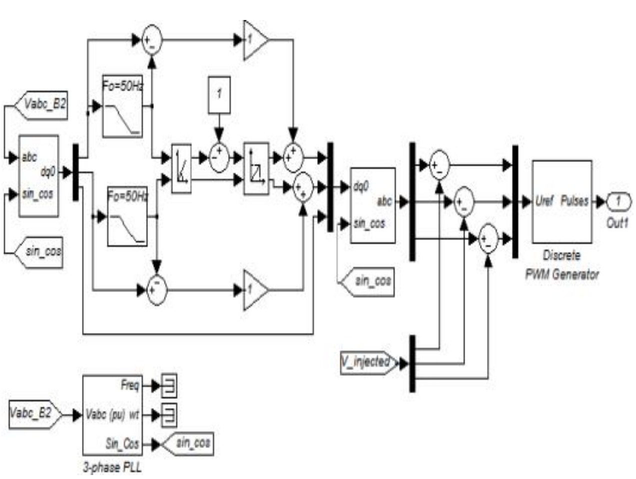

Fig. 6. Schematic diagrams of the DVR control block.

5. Simulation results

Dynamic voltage restorer is a static var device that has applications in a variety of transmission and distribution systems. The basic principle of the dynamic voltage restorer to inject a voltage of required magnitude and frequency, so that it can restore the load side voltage to the desired amplitude and waveform even when the source voltage is unbalanced or distorted. The DVR can generate controllable real and reactive power on the load side. The DVR is made of a solid-state DC to AC switching power converter that injects a three-phase AC output voltage in series and synchronism with the distribution line voltages.

Networks studied, with two buses that one of which is a load sensitive. The simple network shown in "Fig. 7" and the parameters in Table, I. The error occurred within the distribution system is closer to the desired point, the greater voltage drop on the spot. Errors, including two-phase error the ground in the line L_1, the phase error on the line L_1, and L_1 three-phase fault lines are ground together.

TABLE, I.
Parameters and quantities of the simulation results.

Parameters	Quantities
Grid frequency voltage power supply.	Fn=50 (Hz) Vs=22500 (V)
Active and reactive Power loads sensitive.	P=2000 (W) Ql=40 (var) QC=10 (var)
Active and reactive power to the load resistance.	P=2500 (W) Ql=40 (var)
Nominal power to the transformer turns ratio networks.	Pn=3200 (W) 20000/380
Two trans-impedance network.	Rl=0.0003 (p.u) Xl=0.001 (p.u) Rm=Xm=500 (p.u)
Nominal power to the transformer turns ratio injection.	Pn=1500 (W) 100/1000
Injection transformer impedances.	Rl=0.00001 (p.u) Xl=0.0003 (p.u) Rm=Xm=500 (p.u)
Switching frequency, DVR.	FS=10000 (Hz)
Voltage energy storage element.	VDC=200 (V)
Filter impedance in series and parallel.	RS=0.2 (ohm) LS=6 (mH) RP=0.2 (ohm) CP=20 (µF)

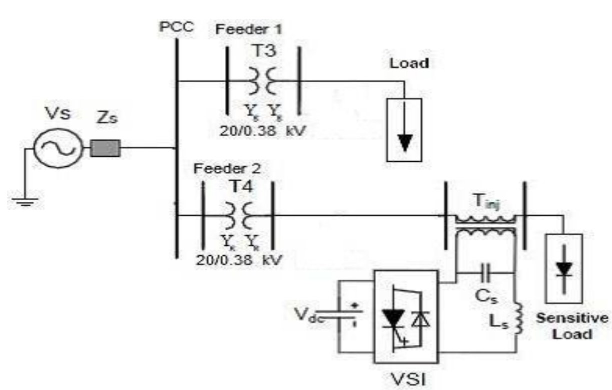

Fig. 7. The network review.

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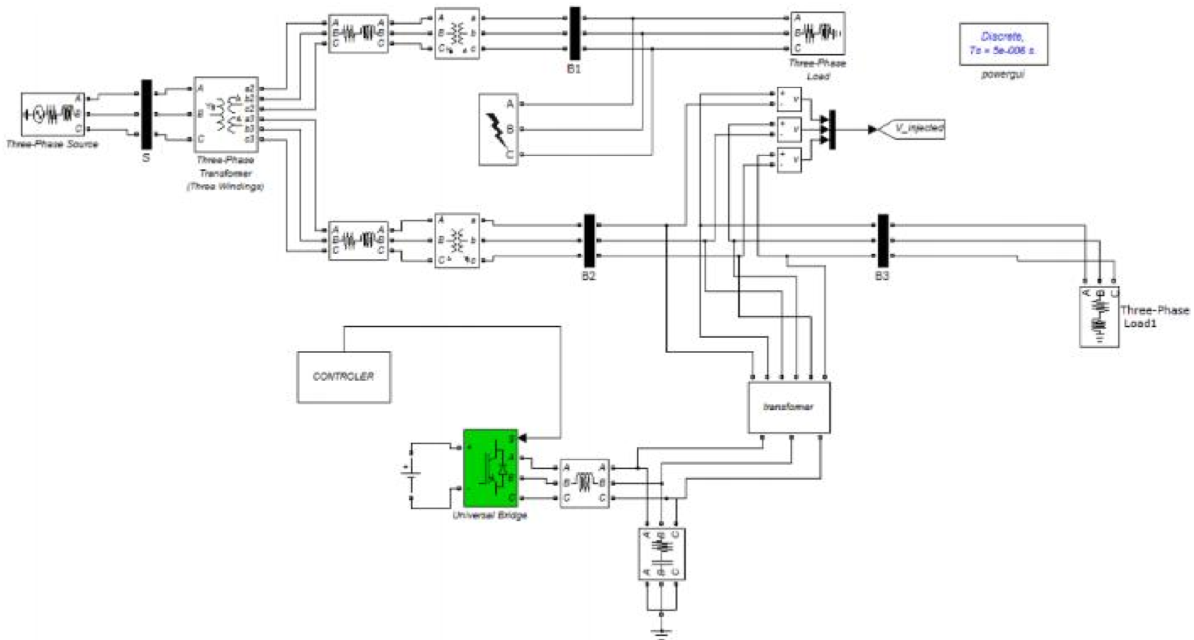

Fig. 8. Simulink model of DVR connected with the power system.

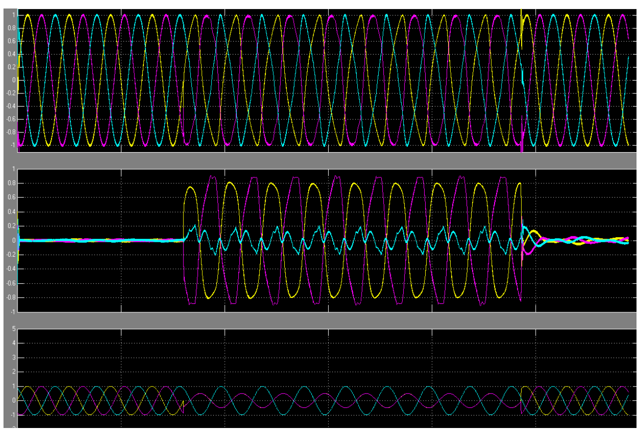

Fig. 9. Two-phase to ground fault on the line L_1.

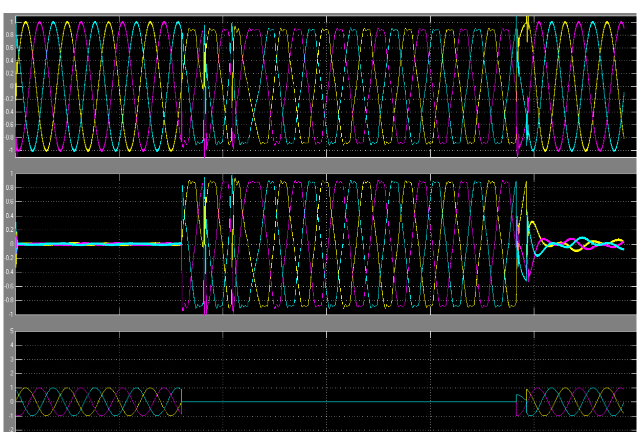

Fig. 10. Two-phase fault on the line L_1.

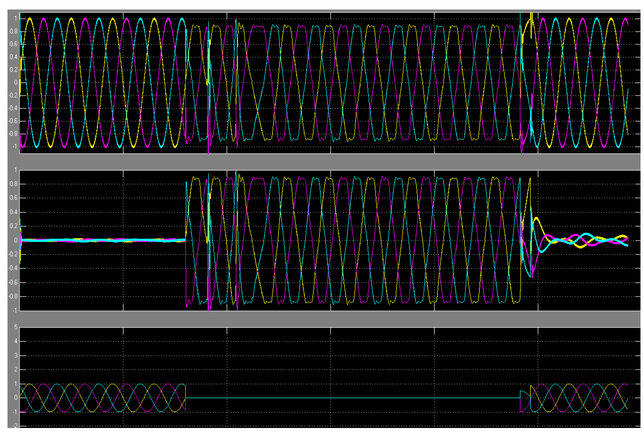

Fig. 11. Three-phase to ground fault on the line L_1.

Contact sag caused the great loads on the network with and without the DVR shown in “Fig. 12”.

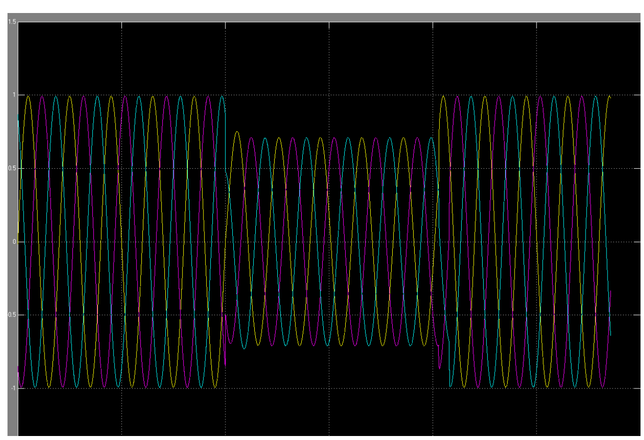

Fig. 12. Contact sag due to a large load on the network without the DVR.

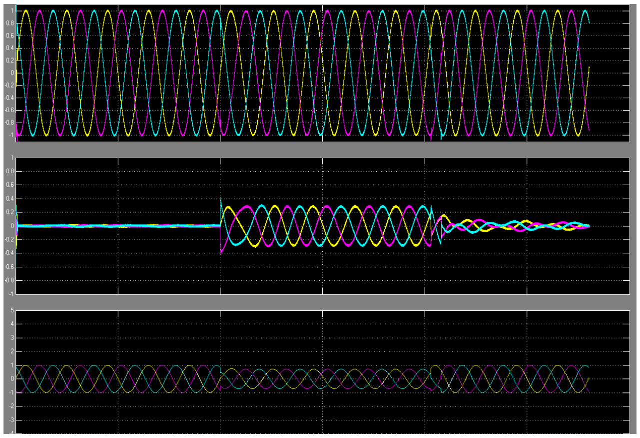

Fig. 13. Contact sag due to a large load on the network without the DVR.

6. Conclusion

In this paper, using the DVR and dq0 control technique's impressive performance during the sinking of the fault voltage, large loads connected to the network, also shows the overhang to protect sensitive loads and unbalanced voltage. The proposed system analysis and presented using MATLAB / SIMULINK software environment.

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