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Voltage Sag Enhancement By DVR Based On PQ Theory Using LabView

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Abstract. The voltage sag condition in the power system has a direct effect on the quality of the power system. Voltage sag has a major effect on sensitive-voltage loadscausing a high inrush current, failure in the system, and price loss.The Dynamic Voltage Restorer (DVR) is regarded as one of the effective methods to control voltage in a power system. This paper describes the DVR control unit based on PQ theory to enhance the quality of the power system. The suggested control technique utilizes 3-phase compensation modules, based on the desired Sag condition. Also, this paper used LabView software to simulate the DVR for voltage variation in a power system.

Keywords: Dynamic voltage restorer (DVR), Instantaneous power (PQ) theory, Sag, Power Quality..

1.Introduction

Because of the development in the power grid and the high demand for the electric power, there are several unwanted conditions that occur in the electrical grid, such as (harmonics, noise, flickers, sag & swell, swell...etc.), This effects the quality of system's power [1]. Where, (80 percentage) of power quality issues are caused by sag. As a result, it became one of the main issues in the area of power quality. Voltage sag was described as the decrease in voltage transmission about 10% and 90% from the root mean square (RMS) voltage reference amount. The major causes of voltage sag are load switching, motor starting, faults, non-linear loads, lightning, etc. [2,3]. When a sag happens, the power supply in electronic devices compensates for the decrease of input voltage by using part of its stored energy. The power supply may lose its capacity to provide an accurate DC voltage to all active components, such as the integrated circuits inside the device when energy is lost owing to the sag – even for a few milliseconds. This time is long enough to cause data corruption in microprocessor-based electronics and digital equipment failures [4]. As a result, it is necessary to resolve the voltage sag in the system in order to improve system stability and power system quality. There are several techniques that have been used to mitigate voltage sag, such as (ferro-resonant transformer, tap changing transformers, and uninterruptible power supply (UPS). FACTS devices such as (static synchronous series compensator (sssc), statcom, D-statcom, Dynamic Voltage Restorer (DVR), and etc.) [5]. The (DVR) is a low-cost custom power device and the most successful for preventing voltage sags and swells insensitive loads. A DVR is a series-connected device that detects voltage sags/swells and injects regulated voltage into the system. (DVR) positioned between the sensitive load and the grid in the system [6]. Figure.1 shows the basic structure of the DVR device. DVR can be divide into five classifications: energy storage, voltage source inverter (VSI), filters ,control unit and injection transformer[7]. This paper addresses how to reduce voltage sag in the power system by integrating the DVR system with the transmission line at a common coupling point (PCC) [8]. The main idea behind a Dynamic Voltage Restorer is to transmit the voltage sag compensation value from the Voltage Source Inverter's DC side to the injected transformer after the filter.. The DVR compensation capacity depends on the active power supplied by the DVR and the maximum voltage injection capability [9].

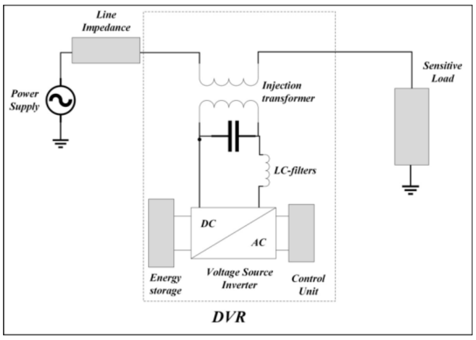
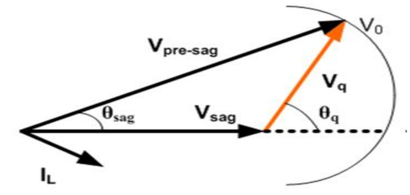


Fig.1: Dynamic Voltage Restorer structure.

2. Stratiges for DVR Voltage Injected

Several limiting variables influence how the (DVR) is utilized during the voltage injection mode, including: The power rating of the DVR, the load conditions, and the voltage sag and swell type are all factors to consider. Some loads, for example, are sensitive to phase-angle jumps, while others are sensitive to voltage magnitude changes, and yet others are tolerant to all of these problems. DVR voltage injection techniques are divide into three categories (as shown in fig.2) : Pre-Sag Compensation,In-phase Compensation and Minimum Energy Compensation [10].



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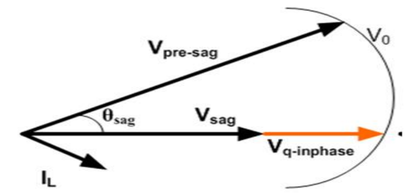

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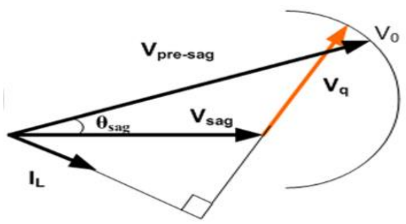


(c)

Fig.2: Methods of DVR : (a)Pr-sag (b) IN-Phase. (c) Minimum Energy.

3. DVR Based on PQ Theory

In this paper, the (DVR) based on (PQ) theory, The load voltages are calculated in this methodology based on active and reactive power components, as shown in (Figure. 3). The Phase-Locked Loop (PLL) is often used to obtain the phase angle (θ) and source voltage frequency. Using the Clark transformations , the three-phase device voltages and three-phase load voltage in the a-b-c coordinates are translated to the (α-β) coordinates as follows [11,12]:

$$\begin{bmatrix} v\alpha \\ v\beta \end{bmatrix} = \sqrt{\frac{2}{3}} \times \begin{bmatrix} 1 & -1/2 & -1/2 \\ 0 & \sqrt{3}/2 & -\sqrt{3}/2 \end{bmatrix} \times \begin{bmatrix} vla \\ vlb \\ vlc \end{bmatrix} \quad \text{.............. (1)}$$

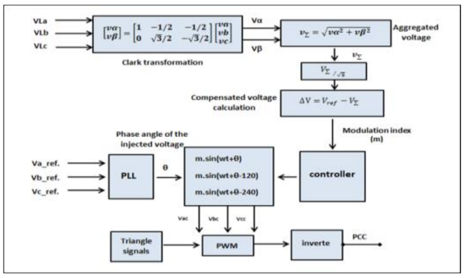
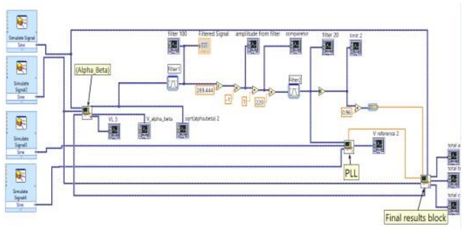


Fig.3: Block diagram of DVR for voltage compensation based on Instantaneous Power Theory

4. Simulation and Results

Utilizing LabView software [13] to simulate the compensation of voltage sag based on PQ theory . In this paper, three case studies of sag in varying percentages (10%, 20% and 30%) in a system at normal voltage (220v). Figure.4 is showing the block diagram of the Dynamic Voltage Restorer's control unit based on PQ theory and the designed diagram of the Phase-locked-loop (PLL).



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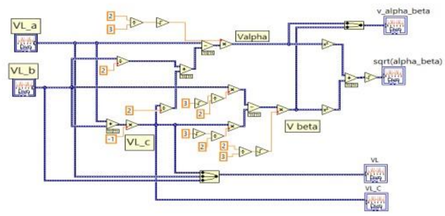

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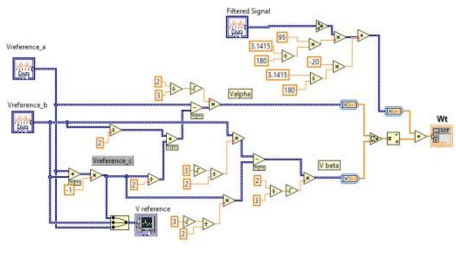

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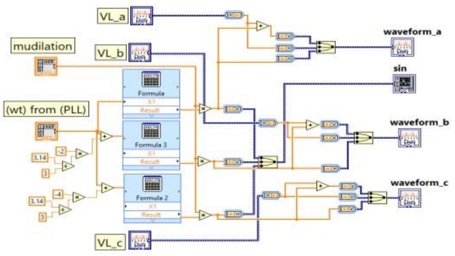


(d)

Fig.4: Block diagram of : (a) Unit control based on (PQ) theory.(b) Clark-transformation. (c) PLL design. (d) Final results.

In the first case (10%), the nominal voltage decreases from (220v) to (198v), the compensated injection is (21.125v) as shown in fig.5.

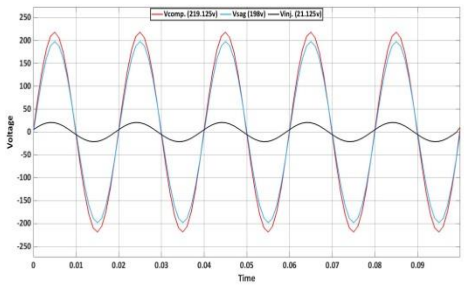


Fig.5: Compensation voltage sage at 10%.

In the second case (20%), the nominal voltage decreases from (220v) to (176v), the compensated injection is (42.182v) as shown in fig.6.

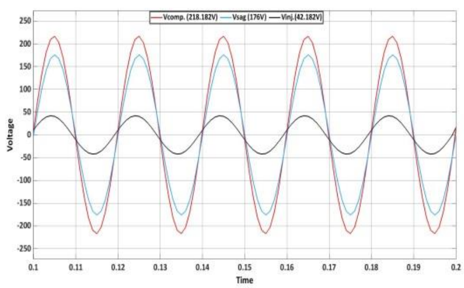


Fig.6: Compensation voltage sage at 20%.

In the third case (30%), the nominal voltage decreases from (220v) to (154v), the compensated injection is (63.27v) as shown in fig.7.

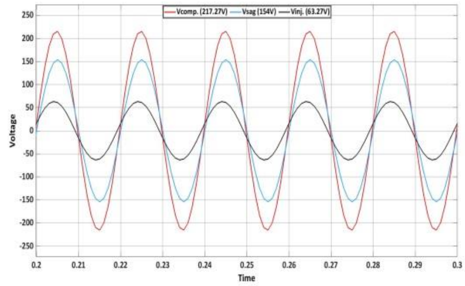
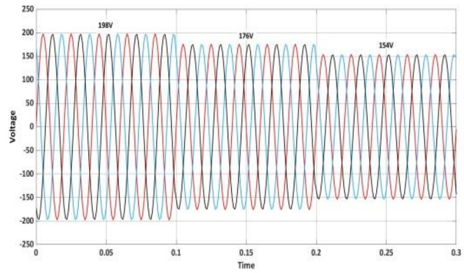


Fig.7: Compensation voltage sage at 30%.

Figure .8 shows the three-phase waveforms in all voltages sag cases.



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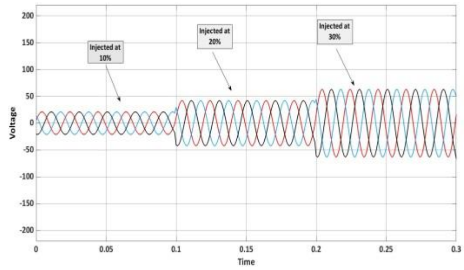

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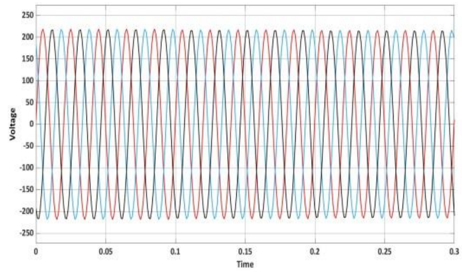

(c)

Fig.7: Waveforms of : (a) Before injected.(b) Injected voltage. (c) After injected.

Table (1) shows the persantage of the injected voltage at all cases.

Table 1. Value of the voltage sag and injected voltage at three-cases.

Cases	10%	20%	30%
Voltage Sag(V)	198	176	154
Voltage inj.(V)	21.125	42.18	63.27
Persantage inj.	9.6%	19.1%	28.8%

5. Conclusion

In this paper, the dynamic voltage restorer (DVR) performance has been presented to instantaneously reduce sag in voltage, which is one of power quality problems on sensitive loads. To control the amount of injected and compensated voltages, PQ theory is used.When voltage sagging occurs at a value of 10% of the total value of the nominal voltage, DVR injects (9.6%) to compensate for the sag. As well as when the voltage sags by (20%), the injected voltage is (19.1%). And also, when the voltage sags by 30%, the injected voltage is (28.8%).

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