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Power Quality Improvement by Using Dynamic Voltage Restorer

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ABSTRACT

This paper presents a Comparative Analysis of Three-phase Four-wire Performance of UPQC for Power Quality Improvement The UPQC is realized by integration of series and shunt active power filters (APFs) sharing a common dc bus capacitor. The shunt APF is realized using a three-phase, four leg voltage source inverter (VSI) and the series APF is realized using a three-phase, three legs VSI. A control technique based on unit vector template technique (UTT) is used to get the reference signals for series APF, while (ICosÖ) theory is used for the control of Shunt APF. The performance of the implemented control algorithm is evaluated in terms of power-factor correction; load balancing, neutral source current mitigation and mitigation of voltage and current harmonics, voltage sag and swell and voltage dips in a three-phase four-wire distribution system for different combination of linear and non-linear loads. In this control scheme, the current/voltage control is applied over the fundamental supply currents/voltages instead of fast changing APFs currents/voltages, thereby reducing the computational delay and the required sensors. The performances of the proposed topologies of UPQC are analyzed through simulations using MATLAB software with its Simulink and Power System Block set toolboxes.

Keywords— Dynamic Voltage Restorer (DVR), MATLAB SIMULINK, sensitive load, voltage sags, voltage swells.

1.Introduction

Nowadays, modern industrial devices are mostly based on electronic devices such as programmable logic controllers and electronic drives. The electronic devices are very sensitive to disturbances and become less tolerant to power quality problems such as voltage sags, swells and harmonics. Voltage dips are considered to be one of the most severe disturbances to the industrial equipments. Voltage support at a load can be achieved by reactive power injection at the load point of common coupling. The common method for this is to install mechanically switched shunt capacitors in the primary terminal of the distribution transformer. The mechanical switching may be on a schedule, via signals from a supervisory control and data acquisition (SCADA) system, with some timing schedule, or with no switching at all. The disadvantage is that, high speed transients cannot be compensated. Some sags are not corrected within the limited time frame of mechanical switching devices. Transformer taps may be used, but tap changing under load is costly.

2. Power quality

Power quality may be defined as the “Degree to which both the utilization and delivery of electric power affects the performance of electrical equipment.”

Unbalanced voltages in three-phase system also are a power quality problem. Voltage sag and harmonics are the two power quality problems which affect the end customers and end users

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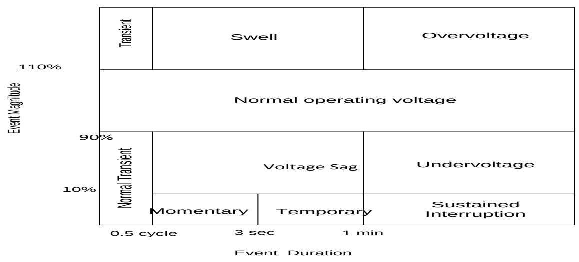

Figure 1 IEEE Standard 1159-1995

Power Quality problems can occur in three ways:

1. Frequency events: change of the supply frequency outside of the normal range.
2. Waveform events: distortion of the voltage waveform outside the normal range.
3. Voltage events: change of the voltage amplitude outside its normal range.

2.1 Voltage Sag and Swell Definition

In Power system voltage reduction in voltage below a user- defined low limit for between one cycle and 2.55 seconds. Surges are now called as swells, except that the voltage exceeds a particular user-defined high limit. While different definitions pertaining to the amplitude and duration are still in use, the IEEE 1159-1995 Recommended Practice on Monitoring Electric Power Quality has defined them as follows:

Sag (dip) can be defined as, “A decrease to between 0.1 and 0.9 pu in rms voltage or current at the power frequency for durations of 0.5 cycles to 1 minute.”

Swell can be defined as, “An increase to between 1.1 pu and 1.8 pu in rms voltage or current at the power frequency durations from 0.5 to 1 minute.”

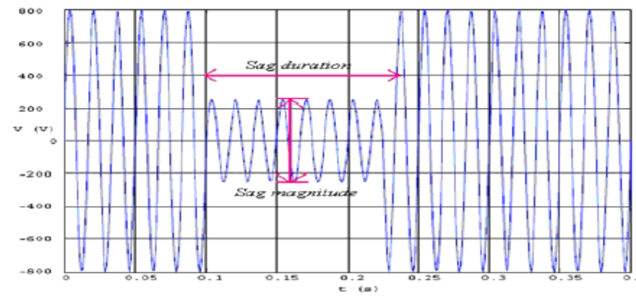

Figure 2 Voltage Sag Depictions

With respect to an outage or interruption, sag is differentiated by the amplitude being greater than or equal to 0.1 per unit (of nominal voltage). The IEEE 1159 document further categorizes the duration values into: Instantaneous, momentary, and temporary, as illustrated in the following table2.1

According to the IEEE Std. 1995-2009 voltage sag is “A decrease in rms voltage or current at the power frequency for duration of 0.5 cycles to 1 minute”.

IEC has the following definition for a dip (IEC 61000-2-1, 1990) “A voltage dip is a sudden reduction of the voltage at a point in the electrical system, followed by a voltage recovery after a short period of time, from half a cycle to a few seconds”.

• Disturbances	• Voltage	• Duration
• Voltage Sag	• 0.1-0.9 pu	• 0.5-30 cycle

Volltage Swell	• 1.1-1.8 pu	• 0.5-30 cycle

Table 2..1 IEEE definitions of Voltage Sags and Voltage Swells

2.2 Effects of Voltage Sag

Voltage sags can effect on sensitive electrical devices, such as personal computers, adjustable speed drives power electronic equipment and programmable logic controllers. The least sensitive loads failed when the voltage dropped to 30 % of the specified voltage. On the other hand, the most sensitive components failed when the voltage dropped to 80-86 % of rated value.

• Type of Sag	• Duration	• Magnitude
• Instantaneous	• 0.5-30 cycles	• 0.10-0.90 pu
• Momentary	• 30 cycles – 3 s	• 0.10-.90 pu
• Temporary	• 3 s- 1 min	• 0.10-.90 pu

Table 2.2 Classification of Voltage Sags according to IEEE 1159

The power system voltage can be given by a sine wave. A reduction in the amplitude of the waveform indicates a Voltage Sag.

2.3 A Typical Voltage Sag Waveform:

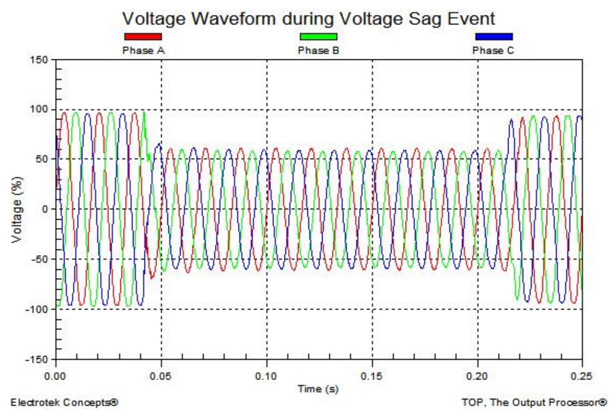

Figure 2.1 A Typical Voltage Sag Waveform

3.Dynamic Voltage Restorer

In the industries power quality problems such as voltage sags, voltage swells, and harmonicsare the most severe disturbances. In order to overcome these problems the concept of custom power devices is introduced recently. There are many custom power devices are used to overcome these problems. Dynamic Voltage Restorer (DVR), is the one of those devices which is the most efficient and effective modern custom power device used in power distribution networks.

3.1 Operation modes of DVR

A DVR is a solid state power electronics switching device which is connected between the distribution system and the load, DVR comprises of a capacitor bank as energy storage device, IGBT or GTO and injection transformers. The basic idea of DVR is that by means of an injecting transformer a control voltage is generated by a forced commuted convertor which is in series to the bus voltage.

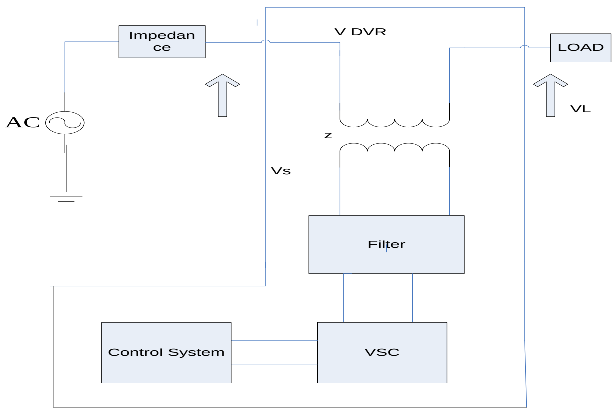

Figure.3.1 DVR Structure

Note that the DVR capable of generating or absorbing reactive power but the reactive power injection of the device must be provided by an external energy source or energy storage system.

Equations Related 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. The series injected voltage of the DVR can be written as

$$\mathbf{V_{DVR} = V_L + Z_{TH} I_L - V_{TH}}$$

Where

$\mathbf{V_L}$: The desired load voltage magnitude

$\mathbf{Z_{TH}}$: The load impedance.

$\mathbf{I_L}$: The load current

$\mathbf{V_{TH}}$: The system voltage during fault condition

CONCLUSIONS

This paper has presented the power quality problems such as voltage dips, swells, Distortions and harmonics. Compensation techniques of custom power electronic devices DVR was presented. The design and applications of DVR for voltage sags and comprehensive results were presented. A PWM-based control scheme was implemented. As opposed to fundamental frequency switching schemes already available in the MATLAB/SIMULINK, this PWM control scheme only requires voltage measurements. This characteristic makes it ideally suitable for low-voltage custom power applications. In this paper Solar cell is used as a renewable energy source instead for batteries. This dc voltage is filtered using the filter and fed to the inverter input. The results are verified by the MATLAB/SIMULINK software.

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