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Power Quality Mitigation using DSTATCOM and DVR

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Abstract - *With the increasing demand of electronics device, high efficiency variable speed drive, power electronic controllers and also more & more non-linear loads in electrical power system for monitoring, controlling and protection, Power Quality has become an increasing concern to utilities and customers. This paper presents the problems associated with the power quality or power quality issues and their mitigation techniques. A practical system is considered for analyzing of power quality issues such as voltage sags, harmonics and transients and with DSTATCOM and combine application of DVR & DSTATCOM compensation devices and are presented by MATLAB/ Simulink model..*

Key Words: Power Quality, DVR, DSTATCOM.

1. INTRODUCTION

Power quality has become major concern to both electric utilities and customers. In many countries, the effects of lack of power quality have been resulting in wastage of several billions of dollars every year. This is due to carelessness of most industries in not upgrading their plants which result in very high cost due to loss of products, loss of production time, clean up and recalibration of the process. The use of complexity and sensitivity of new technologies in electric equipment's is one of the major causes of power quality problems such as voltage disturbances on the supply network. Power electronic equipment's are more sensitive to voltage disturbances and leads to large growth of voltage disturbances. It is difficult to detect the sources leading to power quality problems. Factors for the causes of most power quality problems are beyond the control of utilities and can never be totally eliminated. Some of the sources of power quality problems in order of frequency of occurrence are[1,3]:

- ✓ User loads
- ✓ User electrical system and grounding
- ✓ Weather related such as lightening, wind and rain
- ✓ Utility distribution system
- ✓ Utility transmission system
- ✓ Utility generation system

Power quality review is a complex subject and involves aspects such as power system, equipment modelling, power quality event mitigation and optimization and data analysis. The basic knowledge of the different power system disturbances is important in order to determine the events and causes of equipment failure as well as to apply mitigation measures more effectively. Power system disturbances are dominated by voltage quality and harmonics.

2. DEFINITION OF POWER QUALITY

As indicated by the IEEE principles, "***Power quality can be characterized as the technique for grounding and supplying sensitive equipment with power so as to get a reasonable and agreeable performance of the equipment***". Overall power quality represents a blend of quality of the current and voltage. Voltage quality at the point of connection is governed by the network operator whereas the quality of current at the connection point is governed by the client's load.

A. Need of Better Power Quality:

Power quality is becoming an important concern because of many reasons. Some major reasons are[2]-

- ✓ To increase the efficiency of power system many new devices such as shunt capacitors and adjustable-speed motor drives are gaining popularity. These devices increase the harmonic level of the power system which increases the concern.
- ✓ Power electronic devices and loads that make use of control based on microprocessor and microcontroller based are more affected by power quality issues.
- ✓ The interconnected networks that are used nowadays are badly affected by the power system disturbances because if any component is failed the entire system is affected.
- ✓ The awareness of problems in the quality of power and difficulties faced like under voltage, overvoltage, flickers etc. is among the utility customers or end users is tremendously increasing which arises the demand of a high and better quality of power.

3. DSTATCOM

A Distribution Static Compensator is in short known as D-STATCOM. It is a power electronic converter-based device used to protect the distribution bus from voltage unbalances.

It is connected in shunt to the distribution bus generally at the PCC[4].

A. Basis Structure:

D-STATCOM is a shunt connected device designed to regulate the voltage either by generating or absorbing the reactive power. The schematic diagram of a D-STATCOM is as shown in Fig.1. It contains[8]-

- ✓ DC Capacitor
- ✓ Voltage Source Inverter (VSI)
- ✓ Coupling Transformer
- ✓ Reactor

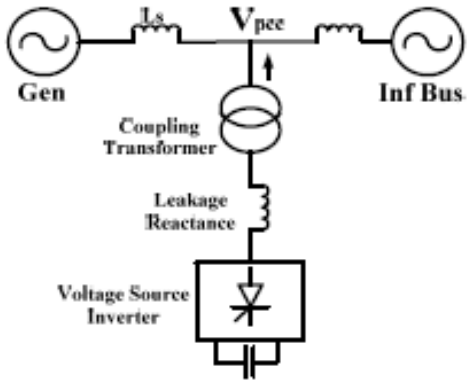

Figure.1: Schematic Diagram of D-STATCOM

B. Operating Principle:

D-STATCOM is capable of compensating either bus voltage or line current. It can operate in two modes based on the parameter which it regulates, They are

- ✓ Voltage Mode Operation: In this mode, it can make the bus voltage to which it is connected a sinusoid. This can be achieved irrespective of the unbalance or distortion in the supply voltage.
- ✓ Current Mode Operation: In this mode of operation, the D-STATCOM forces the source current to be a balanced sinusoid irrespective of the load current harmonics.

The basic operating principle of a D-STATCOM in voltage sag mitigation is to regulate the bus voltage by generating or absorbing the reactive power. Therefore, the DSTATCOM operates either as an inductor or as a capacitor based on the magnitude of the bus voltage.

4. DVR

The DVR is used to protect critical or sensitive loads by mitigating the effects of voltage sags or swells on the distribution feeder due to faults in the system by maintaining constant voltage magnitude. It is basically a BESS connected to an inverter which itself is connected to an injected transformer that is mounted in series with the 3 phase sensitive load. The DVR can compensate voltage sags by injecting reactive power or real and reactive power. This depends on the depth and width of the sag or swell[5-6].

A. Basis Structure:

The DVR is a series connected power electronic device used to inject voltage of required magnitude and frequency. The basic structure of a DVR is shown in Fig.5. It contains the following components[7]-

- ✓ Voltage Source Inverter (VSI)
- ✓ DC storage unit
- ✓ Filter circuit
- ✓ Series Transformer

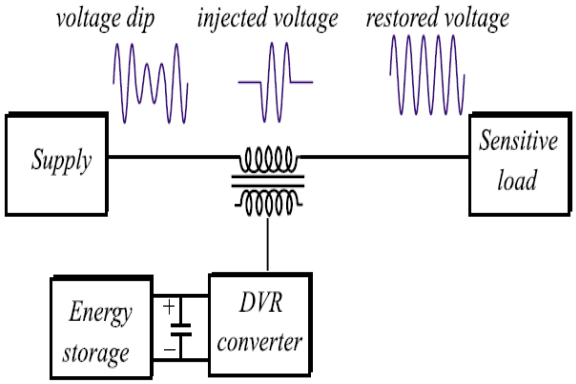

Figure.2: Basic configuration of DVR installation.

B. Operating Principle:

The The main operation of the DVR is to inject voltage of required magnitude and frequency when desired by the power system network. During the normal operation, the DVR will be in stand-by mode. During the disturbances in the system, the nominal or rated voltage is compared with the voltage variation and the DVR injects the difference voltage that is required by the load. The equivalent circuit of a DVR connected to the power network is shown in Fig. 3. Here Vs is the supply voltage, Vinj is the voltage injected by the DVR and VL is the load voltage.

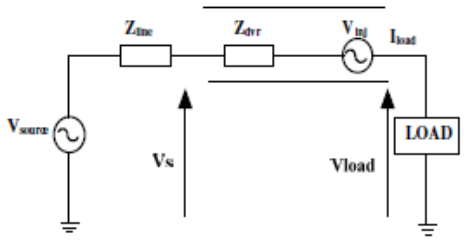

Figure.3: Circuit for working principal of DVR

5. MATLAB MODEL AND RESULT:

A. Simulink Model for Mitigation Of Power Quality Using DSTATCOM:

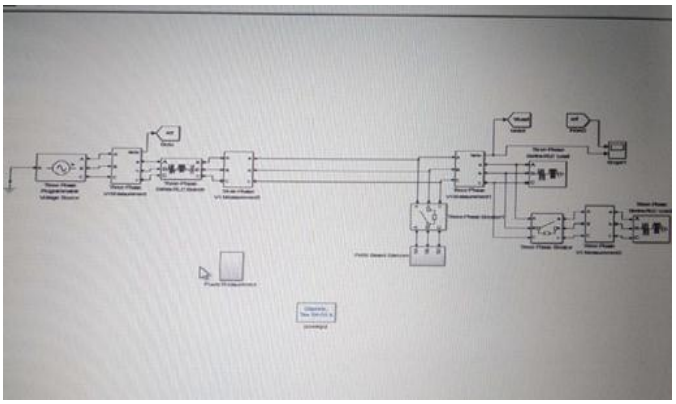

Figure.4: Simulink Model using DSTATCOM

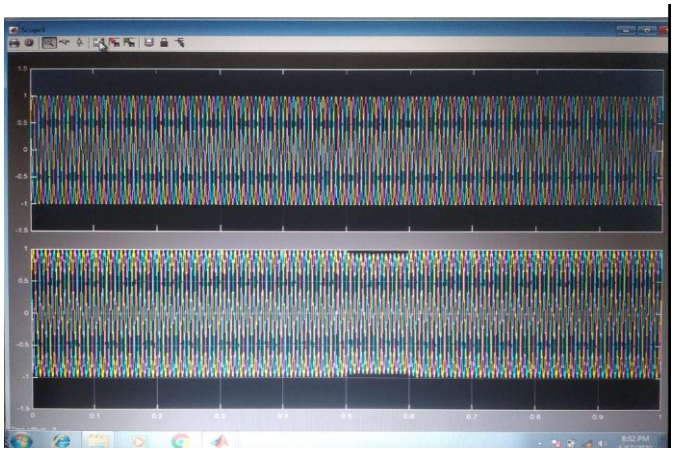

Figure.5: Simulink result using DSTATCOM

B. Simulink MODEL for MITIGATION OF POWER QUALITY USING DVR & DSTATCOM:

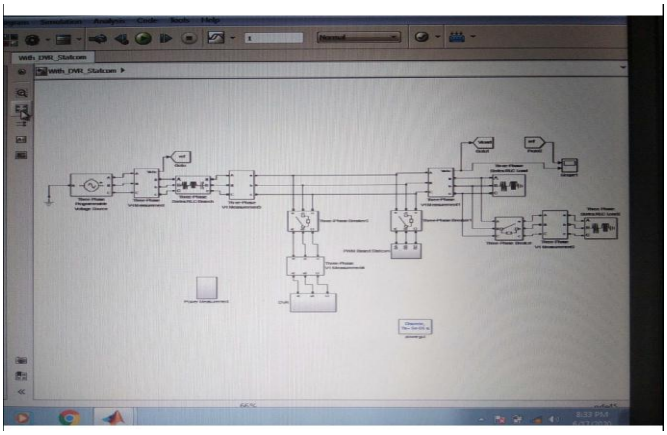

Figure.6: Simulink model using DSTATCOM &DVR

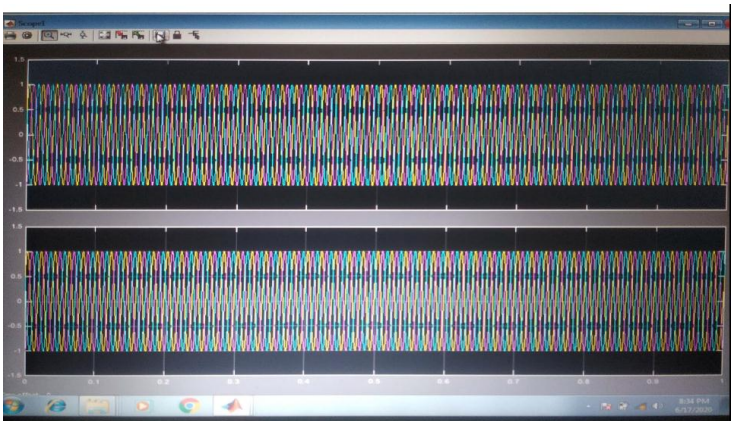

Figure.7: Simulink result using DSTATCOM &DVR

6. CONCLUSIONS:

In this analysis using Simulink model the methods to mitigate the voltage sag are presented. From this analysis, the following conclusions are made Among the different methods to mitigate the voltage sag, the use of FACTs devices is the best method

- ✓ The FACT devices like DVR, D-STATCOM are helpful in overcoming the voltage unbalance problems in power system
- ✓ DVR is a series connected device and injects voltage to compensate the voltage imbalance.
- ✓ D-STATCOM is a shunt connected device and injects current into the system.
- ✓ These devices are connected to the power network at the point of interest to protect the critical loads.

- ✓ These devices also have other advantages like harmonic reduction, power factor Correction.

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