Review of Power Quality Improvement using DSTATCOM6

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Abstract— A Power quality problem is an occurrence manifested as a nonstandard voltage, current or frequency that results in a failure or a mis-operation of end user equipments. In developing countries like India, where the variation of power frequency and many such other determinants of power quality are themselves a serious question, it is very vital to take positive steps in this direction. The present work is to identify the prominent concerns in this area and hence the measures that can enhance the quality of the power are recommended. Distributed static compensator is a device used for power quality improvement. Here we considered voltage source converter based distributed static compensator. It describes to control distribution Static Compensator employed at the distribution end. The phase shift control and AC bus /DC link voltage schemes have been incorporated to control DSTATCOM employed at the distribution end. It describes the salient features of each strategy.

Key words: DSTATCOM, VSI, Facts

I. Introduction

Electrical energy is the simple and well regulated form of energy, can be easily transformed to other forms. Along with its quality and continuity has to maintain for good economy. Power quality has become major concern for today's power industries and consumers. Power quality issues are caused by increasingly demand of electronic equipments and non-linear loads. Many disturbances associated with electrical power are voltage sag, voltage swell, voltage flicker and harmonic contents. This degrades the efficiency and shortens the life time of end user equipment. It also causes data and memory loss of electronic equipment like computer.

Due to complexity of power system network some problems became the major power quality issue affecting the end consumers and industries. It occurs frequently and result in high losses. Voltage sag is due to sudden disconnection of load, fault in the system and voltage swell is due to single line to ground fault results in voltage rise of unfaulted phases. The continuity of power supply can be maintained by clearing the faults at faster rate. Other power quality issues i.e. voltage flickering, harmonics, transients etc. has to be compensated to enhance the power quality.

Power electronic devices i.e. Distribution Static Compensator (D-STATCOM) and Dynamic Voltage Restorer (DVR) been recently used for voltage sag/swell compensation. In this project DSTATCOM is proposed which can protect the end consumer load from any unbalance of voltage supply. It is a series compensating device, can maintain the load voltage profile even when the source side voltage is distorted.

II. Power Quality and Its Problems

Power Quality concerns about the utility ability to provide uninterrupted power supply. The quality of electric power is characterized by parameters such as "continuity of supply, voltage magnitude variation, transients and harmonic contents in electrical signals". Synchronization of electrical quantities allows electrical systems to function properly and without failure or malfunction of an electric device.

PQ expresses the degree of similarity of practical power supply with ideal power supply.

If PQ is good then any load connected to the electric network runs efficiently without decreasing its performance.

If PQ is poor then any load connected to the network leads either to the failure of the equipment or reduction in its lifetime and performance. In order to prevent the consequences of poor PQ and to improve the utility performance the electric power are analysed to resolve the PQ issues in order to determine the efficient compensation technique.

A. Voltage Sag/Dip

The voltage sag or dip can be stated as decrease in nominal voltage level by 10-90% for short duration for half cycle to one minute as shown in fig. Sometime, voltage sag last for long duration such prolonged low voltage profile referred as 'under-voltage'. Voltage sag is further divided in three categories: instantaneous, momentary and temporary sags respectively.

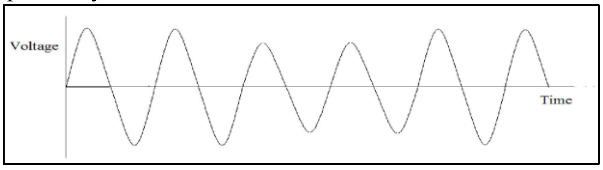

Fig. 1: Voltage sag/dip

B. Voltage Swell

Voltage swell can be stated as voltage rise by 10-80% of normal value for duration of half cycle to one minute as shown in fig. Likewise voltage sag, prolonged high voltage profile is referred as 'over-voltage'.

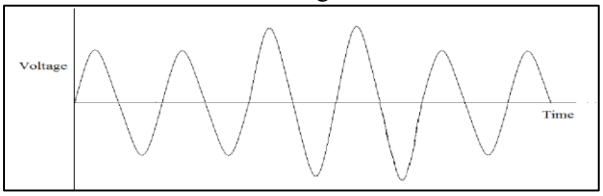

Fig. 2: Voltage Swell

C. Harmonics

A harmonic is an integral multiple of fundamental frequency of electrical quantities. This is due to presence of non-linear loads which results in overheating of electrical equipment. Hence its reduction is desirable.

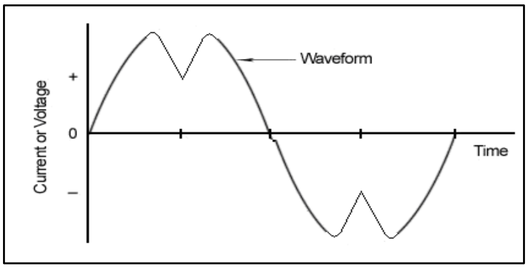

Fig. 3: Distorted Waveform Due to Harmonics

As can be observed from the waveform in Figure, waveform distortions can drastically alter the shape of the sinusoid. However, no matter the level of complexity of the fundamental wave, it is actually just a composite of multiple waveforms called harmonics.

III. Basic Principle of DSTATCOM

A DSTATCOM is a controlled reactive source, which includes a voltage source converter (VSC) and a DC link capacitor connected in shunt, capable of generating and/ or absorbing reactive power. The operating principles of DSTATCOM are based on the exact equivalence of the conventional rotating synchronous compensator. The AC terminals of the VSC are not connected to the point of common coupling (PCC) through an inductance, which could be a filter inductance or leakage inductance of the coupling transformer, as shown in figure1.

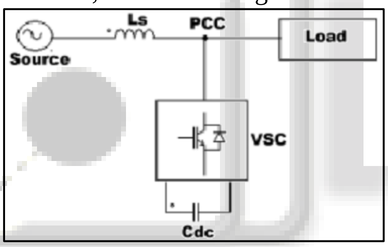

Fig. 4: Basic Structure of DSTATCOM

The DC side of the converter is connected to a DC capacitor, which carries the input ripple current of the converter and is the main reactive storage element. This capacitor could be charged by a battery source, or could be precharged by the converter itself. If the output voltage of the VSC is equal to the AC terminal voltage, no reactive power is delivered to the system. If the output voltage is greater than the AC terminal voltage, the DSTATCOM is in the capacitive mode of operation and vice versa. The quantity of the reactive power flow is proportional to the difference in the two voltages. The voltage regulation at PCC and power factor correction cannot be achieved simultaneously. For a DSTATCOM used for voltage regulation at the PCC, the compensation should be such that the supply current should lead the supply voltages; whereas, for power factor correction, the supply current should be in phase with the supply voltages. The phase shift control are used to study the performance of a DSTATCOM for power factor correction and harmonic mitigation.

IV. Controller

The aim of the control scheme is to maintain constant voltage magnitude at the point where a sensitive load is connected, under system disturbances. The control system only measures the rms voltage at the load point, i.e., no reactive power measurements are required. The VSC switching strategy is based on a sinusoidal PWM technique which offers simplicity and good response. Since custom power is a relatively low-power application, PWM methods offer a more flexible option than the Fundamental Frequency Switching (FFS) methods favored in FACTS applications. Besides, high switching frequencies can be used to improve on the efficiency of the converter, without incurring significant switching losses.

The controller input is an error signal obtained from the reference voltage and the value rms of the terminal voltage measured. Such error is processed by a PI controller the output is the angle δ, which is provided to the PWM signal generator. It is important to note that in this case, indirectly controlled converter, there is active and reactive power exchange with the network simultaneously: an error signal is obtained by comparing the reference voltage with the rms voltage measured at the load point. The PI controller process the error signal generates the required angle to drive the error to zero, i.e., the load rms voltage is brought back to the reference voltage.

V. Distribution Static Compensator (DSTATCOM)

A D-STATCOM (Distribution Static Compensator), which is schematically depicted in Figure-5.1, consists of a two level Voltage Source Converter (VSC), a dc energy storage device, a coupling transformer connected in shunt to the distribution network through a coupling transformer. The VSC converts the dc voltage across the storage device into a set of three-phase ac output voltages. These voltages are in phase and coupled with the ac system through the reactance of the coupling transformer. Suitable adjustment of the phase and magnitude of the D-STATCOM output voltages allows effective control of active and reactive power exchanges between the D-STATCOM and the ac system. Such configuration allows the device to absorb or generate controllable active and reactive power.

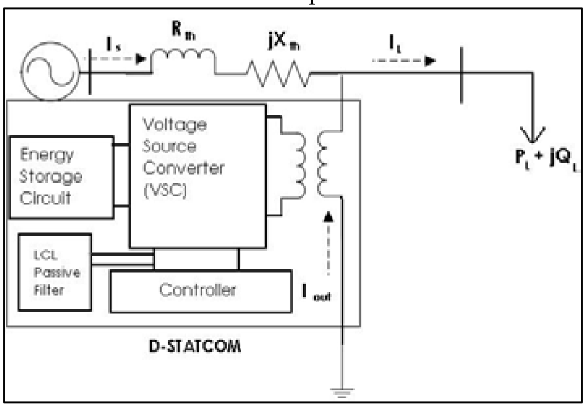

Fig. 5: Schematic Diagram of a D-STATCOM

VI. Conclusion and Future Scope

The demand for quality power has become a challenging issue for industrial area and consumers. Among them voltage unbalance is considered as the major affecting problem leads to degradation in performance of electrical equipments. FACTS devices used for compensation are the best method to overcome such problem. Among them DSTATCOM considered the most efficient and cost effective. Voltage unbalances such as voltage sag/swell & harmonics are considered here. Voltage unbalance under both balanced and unbalanced condition is considered and simulation results are shown.

Modelling and compensating technique used by DSTATCOM for compensating such unbalance are also presented.

Future scopes are

1) Other power quality problem that occurs in power system network has to be compensated.
2) Fuzzy controller and PI controller can be used as a mitigation technique for DSTATCOM.

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