A Review on Power Quality Improvement by Using D-STATCOM

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Abstract-- A Static Compensator (STATCOM) is a flexible ac transmission system (FACTS) controller, which can either absorb or deliver reactive power to a power system. Distribution Static Compensator (DSTATCOM) is proposed for compensation of reactive power and unbalance caused by various loads in distribution system. Distribution static compensator is based on the VSC principle. A D-STATCOM injects a current into the system to correct the voltage sag, swell and power factor. Distribution Static Synchronous Compensator (D- STATCOM) is an effective measure to maintain voltage stability and improve power quality of distribution system. This paper deals with the modeling and control scheme of D-STATCOM. In this project by analyzing the different control techniques for designing the DSTATCOM & implementing the algorithm which will help in to design the model & working of DSTATCOM in MATLAB/simulink for the required result.

Keywords-- *Distribution System, Power Quality, Custom Power Device, Shunt Compensation Device, Distribution Static Compensator (D-STATCOM), Voltage source converter (VSC)*

I. INTRODUCTION

As commercial and industrial customers become more and more reliant on high-quality and high- reliability electric power. Insufficient power quality can be caused by failures and switching operations in the network, which mainly result in voltage dips, interruptions, transients and network disturbances from loads that mainly result in flicker i.e. fast voltage variations, harmonics, and phase imbalance. Momentary voltage sags and interruptions are by the most common disturbances that adversely impact electric customer process operations in large distribution systems. An increasing demand for high quality, reliable electrical power and increasing number of distorting loads may leads to an increased awareness of power quality both by customers and utilities. The most common power quality problems today are voltage sags, voltage swell, harmonic distortion and low power factor.

Momentary voltage sags and interruptions are by far the most common disturbances that adversely impact electric customer process operations in large distribution systems. In fact, an event lasting less than one- sixtieth of a second (one-cycle) can cause a multimillion-dollar process disruption for a single industrial customer. Several compensation devices are available to mitigate the impacts of momentary voltage sags and interruptions. When PQ problems are arising from nonlinear customer loads, such as arc furnaces, welding operations, voltage flicker and harmonic problems can affect the entire distribution feeder. Several devices have been designed to minimize or reduce the impact of these variations. The primary concept is to provide dynamic capacitance and reactance to stabilize the power system. This is typically accomplished by using static switching devices to control the capacitance and reactance, or by using an injection transformer to supply the reactive power to the system.

Custom power is formally defined as the employment of power electronic or static controllers in distribution systems rated up to 38 kV for the purpose of supplying a level of reliability or power quality that is needed by electric power customers who are sensitive to power variations. Custom power devices or controllers, include static switches, inverters, converters, injection transformers, master-control modules and energy-storage modules that have the ability to perform current-interruption and voltage-regulation functions within a distribution system.

This paper presents the operating principle of DSTATCOM. It is nothing but a STATCOM but used at the Distribution level. The key component of the DSTATCOM is a power VSC that is based on high power electronics technologies as shown below.
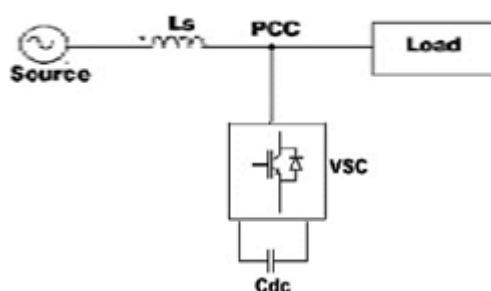
In this paper, the D-STATCOM is used to regulate the voltage at the point of connection. The control is based on

sinusoidal PWM and only requires the measurement of the rms voltage at the load point.

All above problems in distribution system can be mitigated by using the most cost effective custom power device i.e. Distribution STATCOM.

II. VOLTAGE SOURCE CONVERTER (VSC)

A voltage-source converter is a power electronic device, which can generate a sinusoidal voltage with any required magnitude, frequency and phase angle. Voltage source converters are widely used in adjustable- speed drives, but can also be used to mitigate voltage dips. The VSC is used to either completely replace the voltage or to inject the „missing voltage". The „missing voltage" is the difference between the nominal voltage and the actual. The converter is normally based on some kind of energy storage, which will supply the converter with a DC voltage. The solid-state electronics in the converter is then switched to get the desired output voltage. Normally the VSC is not only used for voltage sag/swell mitigation, but also for other power quality issues, e.g. flicker and harmonics.
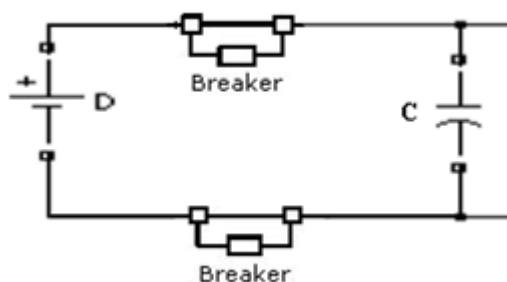
III. ENERGY STORAGE CIRCUIT

Figure 1: Circuit Diagram of DC Storage

From figure 1 DC source is connected in parallel with the DC capacitor. It carries the input ripple current of the converter and it is the main reactive energy storage element. This DC capacitor could be charged by a battery source or could be recharged by the converter itself.

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 r.m.s 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.
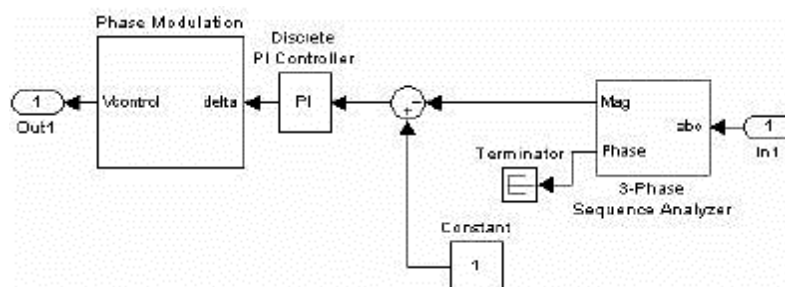

Figure 2: Simulink Model of D-STATCOM Controller.

V. DISTRIBUTION STATIC COMPENSATOR (D-STATCOM)

A D-STATCOM (Distribution Static Compensator), which is schematically depicted in Figure-3, 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. The VSC connected in shunt with the ac system provides a multifunctional topology which can be used for up to three quite distinct purposes:

1. Voltage regulation and compensation of reactive power.

2. Correction of power factor and

3. Elimination of current harmonics.

The value of I_{sh} can be controlled by adjusting the output voltage of the converter. The shunt injected current I_{sh} can be written as:

$$I_{sh=} I_{L\text{-}} I_{S=} I_{L\text{-}} (Vth - VL)/Zth..............(5.1)$$

$$Ish^\wedge\eta_= I_L{}^\wedge -\theta - (Vth/Zth)^\wedge(\delta-\beta) + (Vth/Zth)^\wedge- \beta ...... (5.2)$$

I_{out} = output current , I_L = load current

I_S = source current , Vth = thevenin voltage V_L = load voltage , Zth = impedence

Referring to the equation 5.2, output current, will correct the voltage sags by adjusting the voltage drop across the system impedance, (Z th = R + jX).
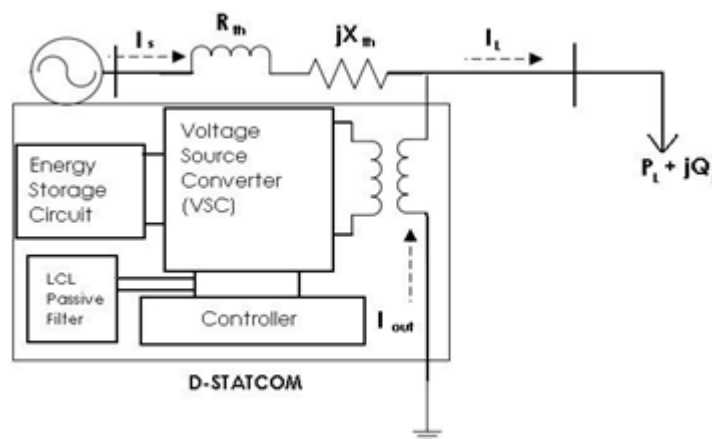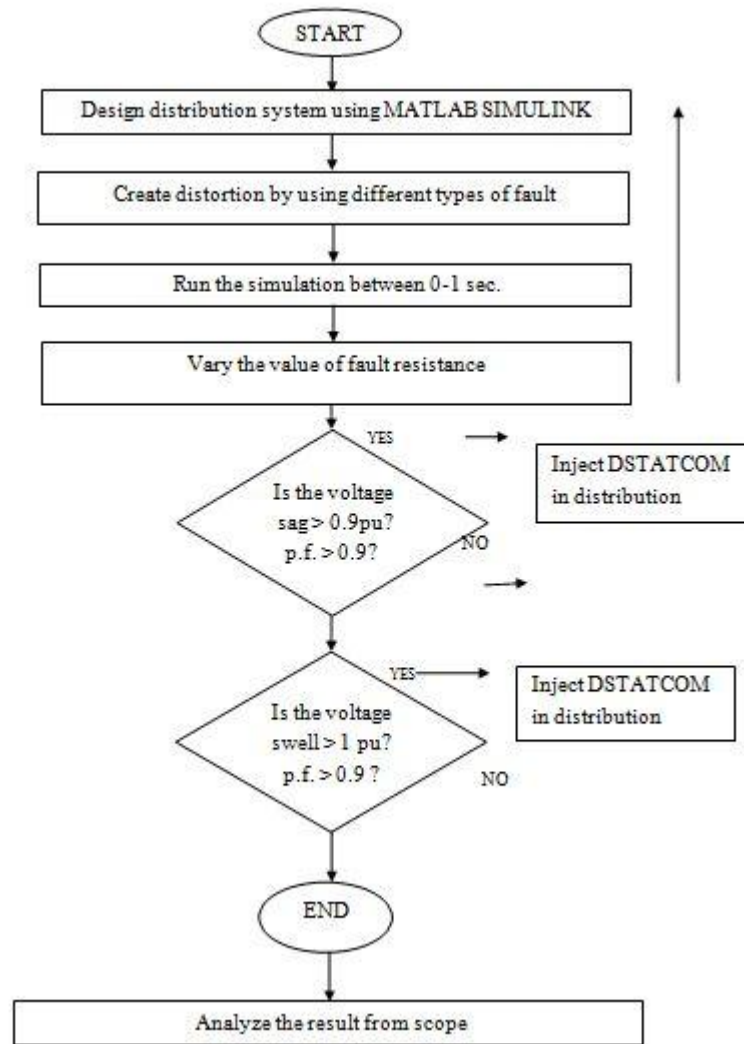

Figure 3: Schematic Diagram of D-STATCOM

A. Proposed Methodology

The proposed method for this work is shown by designing the following algorithm for design of DSTATCOM circuit in MATLAB.

In this section, the model is developed in MATLAB / SIMULINKS. All the network components were represented by three-phase models. The distribution feeders were modeled as series RL impedances. The three-phase transformers were simulated taking into account the core losses (T circuit). The faults applied are,

(1) 3 line to ground fault (2) 3 line fault (3) line to ground fault (4) line to line fault (5) line to line to ground fault.

VI. TEST SYSTEMS FOR VOLTAGE SAG AND SWELL WITHOUT D-STATCOM

The test system composes a 19 kV, 50 Hz generation system, represented by a Thevenin equivalent, feeding into the primary side of a 3-winding transformer. A varying load is connected to the 11 kV, secondary side of the transformer. In the absence of DSTATCOM we can see the voltage sag due to the three phase fault introduced during different conditions. Figure 4
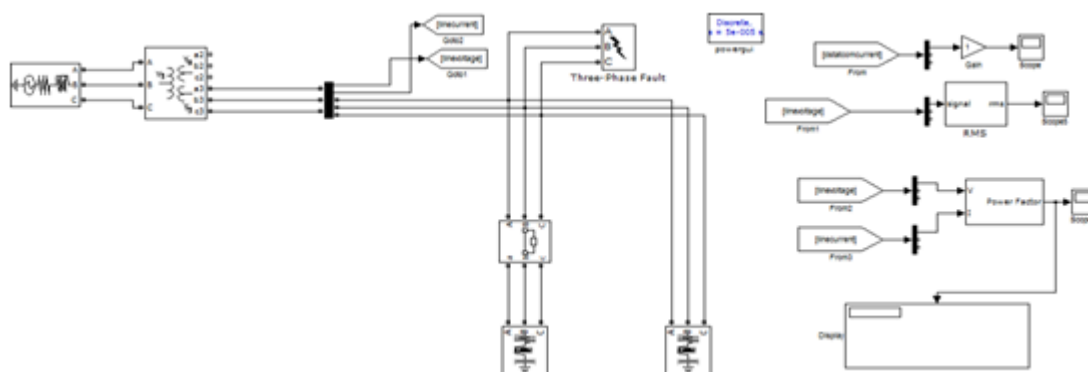

Figure 4: Test system for voltage Sag and swell Without DSTATCOM.

A. FOR VOLTAGE SAG AND SWELL WITH D-STATCOM

The DSTATCOM along with the test system is simulated in MATLAB /SIMULINK Software and the diagram is shown in Fig 6.2 below. In the absence of the DSTATCOM, the terminal voltage varies considerably, but such

variations are minimized in the presence of the DSTATCOM. The voltage sag conditions are compensated with DSTATCOM.
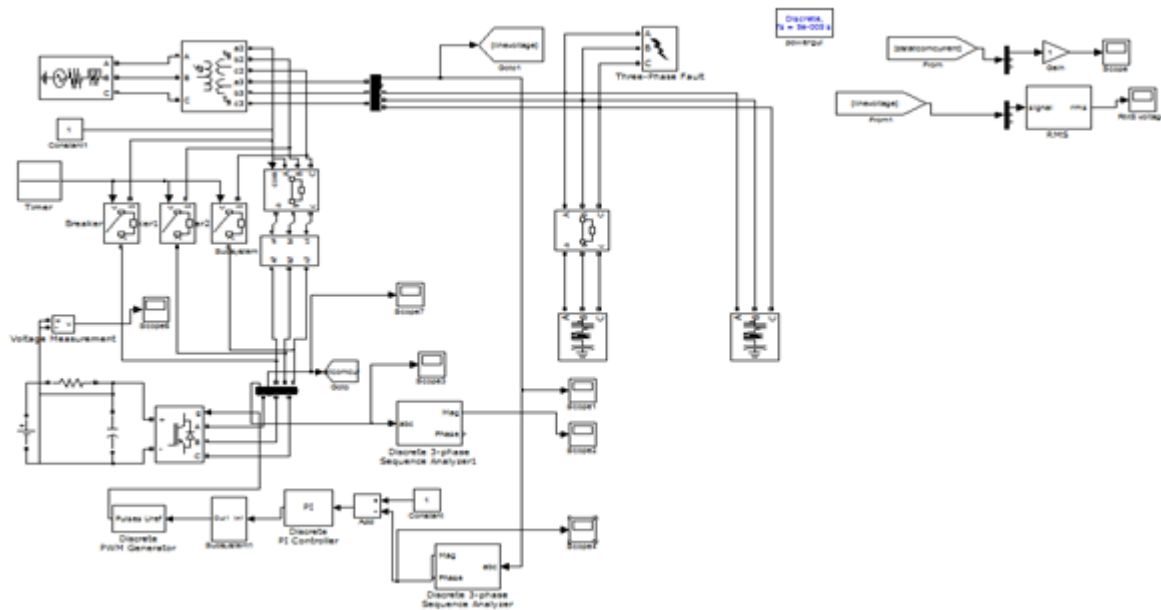

Figure 5: Test system for voltage Sag and swell With DSTATCOM

CONCLUSION

In this paper by analyzing the different control techniques for designing the DSTATCOM & implementing the algorithm which will help in to design the model & working of DSTATCOM in MATLAB/simulink for the required result. By designing the DSTATCOM using MATLAB simulink probable results having low percentage of voltage sag & swell should be obtained.

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