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Power Quality Improvement by Using D-STATCOM

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Abstract

In recent years the power quality problems is a big issue in distribution system. A Power quality means maintaining the sinusoidal bus voltage at rated frequency. 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. There are different types of problems in power quality. These problems are power factor, reactive power compensation and harmonic distortion. Different types of FACT devices like as SVC, STATCOM, IPC, UPFC, TCSC, and D-STATCOM can be used to solve these types of problems. Among them D-STATCOM is very well known and can provide cost effective solution for the compensation of reactive power and unbalance loading in distribution system. D-STATCOM is capable to inject a current into the system to correct the power factor and reactive power compensation and harmonics reduction. In this paper the test model of D-STATCOM is showed in simulation to observe how D-STATCOM works. The D-STATCOM applications are mainly for sensitive loads that may be drastically affected by fluctuations in the system voltage.

Keywords: *Svc, Statcom, Ipc, Upfc, Tcsc, Fact, D-Statcom, Gto, Igbt, Simulink, Matlab*

INTRODUCTION

In the early days of power transmission due to reactive power unbalances, the problems like voltage deviation during load changes and power transfer limitation were observed. Most of the AC loads are consuming reactive power due to presence of reactance. Power quality is getting poor due to heavy consumption of reactive power. Power disturbance such as voltage sags well, transient and harmonics can destroy or shorten the life of sensitive equipment. The voltage sag or swell is a serious power quality that exists today. The voltage sag/swell magnitude is ranged from 10% to 90% of nominal voltage and with duration from half a cycle to 1 min.

In a three phase system voltage sag is by nature a three-phase phenomenon, which affects both the phase-to-ground and phase-to-phase voltages. Voltage sag is caused by a fault in the utility system, a fault within the customer's facility or a large increase of the load current, like starting a motor or transformer energizing. Voltage Swells are almost always caused by an abrupt reduction in load on a circuit with a poor or damaged voltage regulation, although they can also be caused by a damaged or loose neutral connection.

The development in fast and reliable semiconductors devices (GTO and IGBT) allowed new power electronic configurations to be introduced to the tasks of power Transmission and load flow control. Over the transmission parameters, the FACTS devices offer a fast and reliable control. Most widely known custom power devices are SVC, STATCOM, IPC, UPFC, TCSC, and DSTATCOM. Among them DSTATCOM is very well known and can provide cost effective solution for the compensation of reactive power and unbalance loading in distribution system.

The D-STATCOM has additional capability to sustain reactive current at low voltage, and can be developed as a voltage and frequency support by replacing capacitors with batteries as energy storage. To enhance the power quality such as voltage sags/swell, harmonic distortion and low power factor in distribution system. In this paper the test model of DSTATCOM is showed in simulation to observe how DSTATCOM works.

2. DISTRIBUTED STATIC COMPENSATOR (DSTATCOM)

The Distribution Static Synchronous Compensator (D-STATCOM) is a shunt connected reactive compensation equipment which is capable of generating /or absorbing reactive power whose output can be varied so as to maintain control of specific parameters of the electric power system. The D-STATCOM provides operating characteristics similar to a rotating synchronous compensator without the mechanical inertia, due to the D-STATCOM employ solid state power switching devices it provides rapid controllability of the three phase voltages, both in magnitude and phase angle.

D- STATCOM provides voltage support to buses by modulating bus voltages during dynamic disturbances in order to provide better transient characteristics, improve the transient stability margin sand to damp out the system oscillations due to these disturbances. So we use DSTATCOM for reactive power compensation and also mitigate the voltage fluctuations. For the faster control Voltage Source Converter (VSC) is used with Pulse Width Modulation (PWM) to mitigate the voltage fluctuations. And D-STATCOM is used to mitigate harmonics, power quality improvement and reactive power compensation in distribution system.

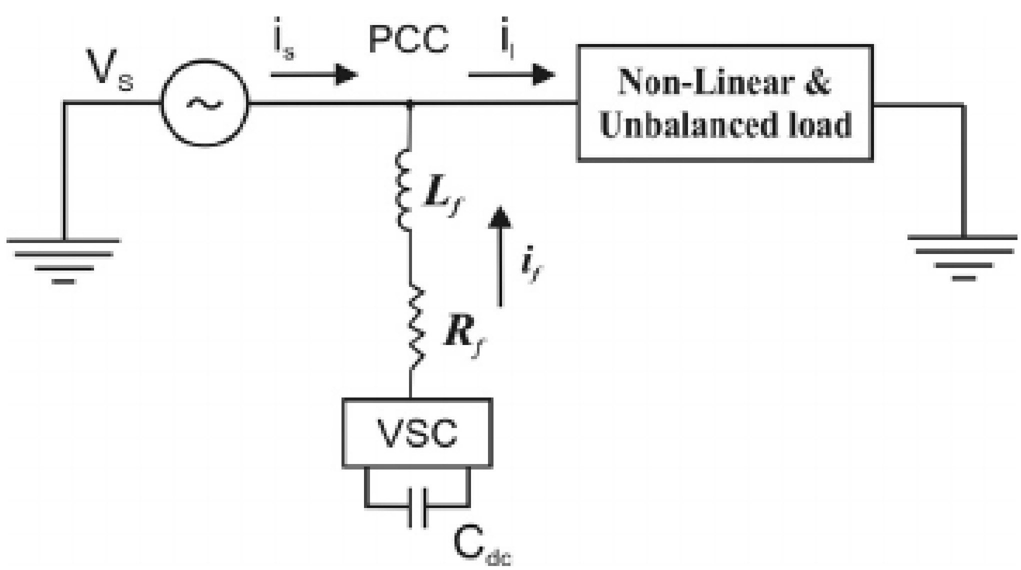

Fig 1: Block Diagram of D-STATCOM

3. WORKING PRINCIPLE:

A D-STATCOM is comparable to a Synchronous Condenser (or Compensator) which can supply variable reactive power and regulate the voltage of the bus where it is connected. (Synchronous condenser is a salient pole synchronous generator without prime mover). The static synchronous compensator regulates voltage at its connection. point by controlling the amount of reactive power that is absorbed from or injected into the power system through a voltage-source converter.

In steady-state operation, the voltage V2 generated by the VSC through the DC capacitor is in phase with the system voltage V1 (δ=0), so that only reactive power (Q) is flowing (P=0).

1. When system voltage is high, the D-STATCOM will absorb reactive power (inductive behavior)

2. When system voltage is low, the D-STATCOM will generate and inject reactive power into the system (capacitive).

4. VOLTAGE SOURCE CONVERTER:

A Voltage Source Converter (VSC) is a power electronic device; this voltage source converter can generate a sinusoidal voltage with any required phase angle, frequency and also for magnitude In variable speed drives, Voltage source converters are most widely used and also be used to decrease the voltage drops. Voltage source converters are forced commutated converter that converts ac voltage into dc voltage and vice versa. The power can flow through the VSC in any direction and from the ac terminals.

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. It can be considered as a controllable voltage source. Normally the VSC is not only used for voltage sag/swell mitigation, but also for other power quality issues, e.g. flicker and harmonics.

5. ENERGY STORAGE:

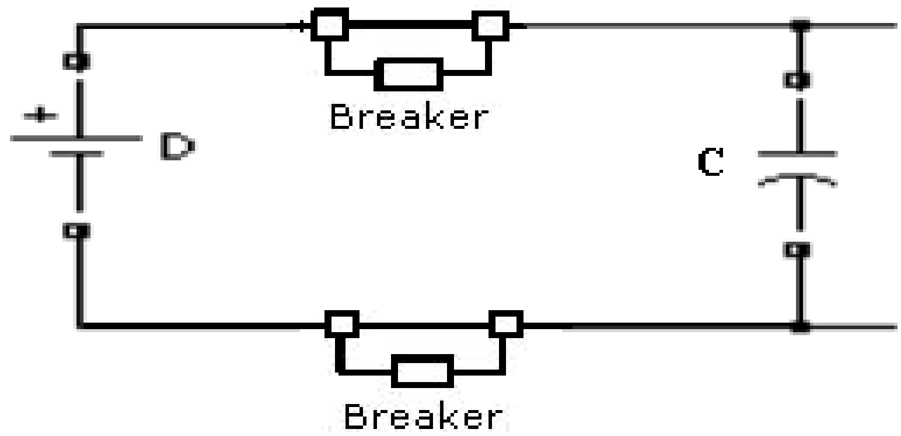

Fig 2: Circuit diagram of DC storage

From fig. 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.

6. 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. High switching frequencies can be used to improve on the efficiency of the converter. The controller input is an error signal obtained from the reference voltage and the rms value of the terminal voltage measured. Such error is processed by a PI controller. 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.

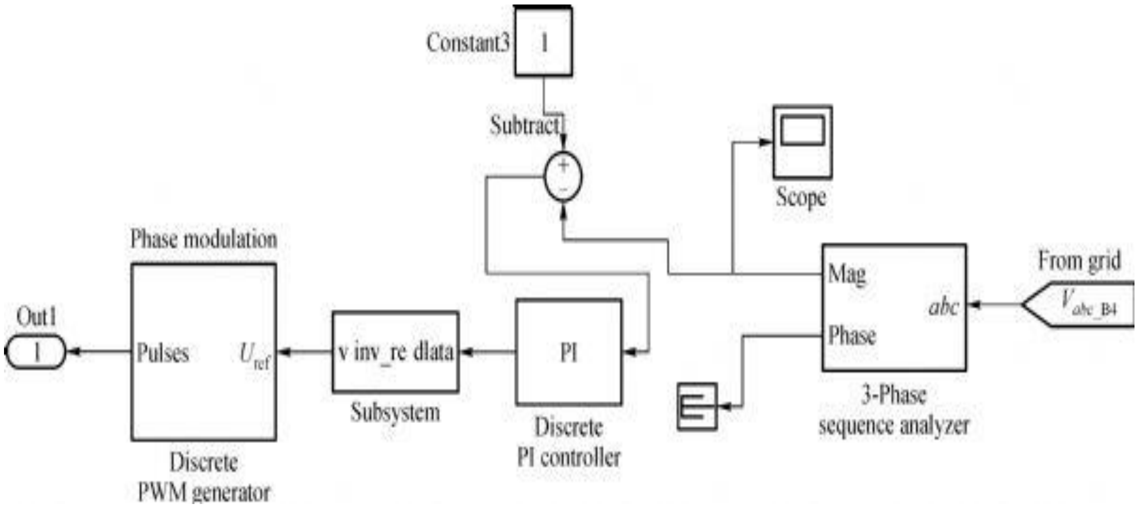

Fig 3: Block Diagram of controller

7. ADVANTAGES OF D-STATCOM :

1. DSTATCOM is used in voltage regulation in distribution line.

2. It is also used to improve power factor as unity.

3. It is also used to mitigate harmonics in distribution system.

4. DSTATCOM can be also used for load balancing.

8.DISADVANTES OF D-STATCOM:

1. The consumption of reactive energy will be important.

2. In transmission lines the voltage drop can be big but their distance would matter.

9. TEST MODEL AND RESULTS:

In this paper the test models are shown in simulation. These models are used for D-STATCOM to determine that how D-STATCOM can work in case of non linear load. The complete configuration of test models for voltage sag problem and voltage swell problem is shown in fig 4 and 5 respectively. In this paper it is shown that how D-STATCOM works in distribution network and controls the voltage and current parameters. Simulation results given below (fig 6 and 7 resp.) have shown the voltage sag and swell problem occurred due to a non-linearity of load and the respective compensation done by D-STATCOM.

Table:1 System Parameters

S.N.	Parameters	Rattings
1.	Grid Voltage	3-Phase, 415V,50 Hz
2.	Three Phase Transformer	6.6 kVA , 50 Hz, R1(pu)=R2(pu)=0.02 ohm, L1(pu)=L2(pu)=0.02 H, Rm=500
3.	Line series inductance	0.05mh
4.	Non-Linear load	415V, 50Hz, 3kw,
5.	IGBT Ratting	Collector voltage = 415 Snubber resistance Rs =0.015Mohm

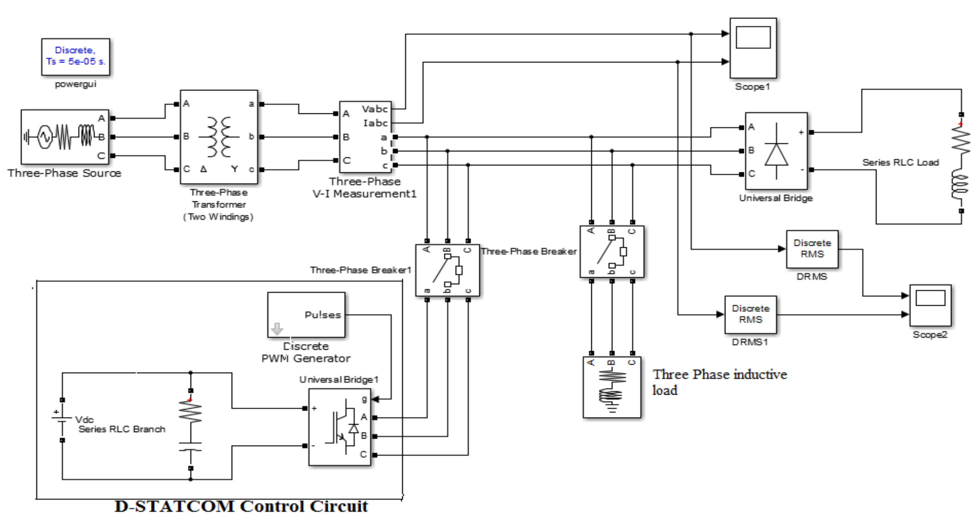

Fig 4: Simulink model of D-STATCOM for voltage sag

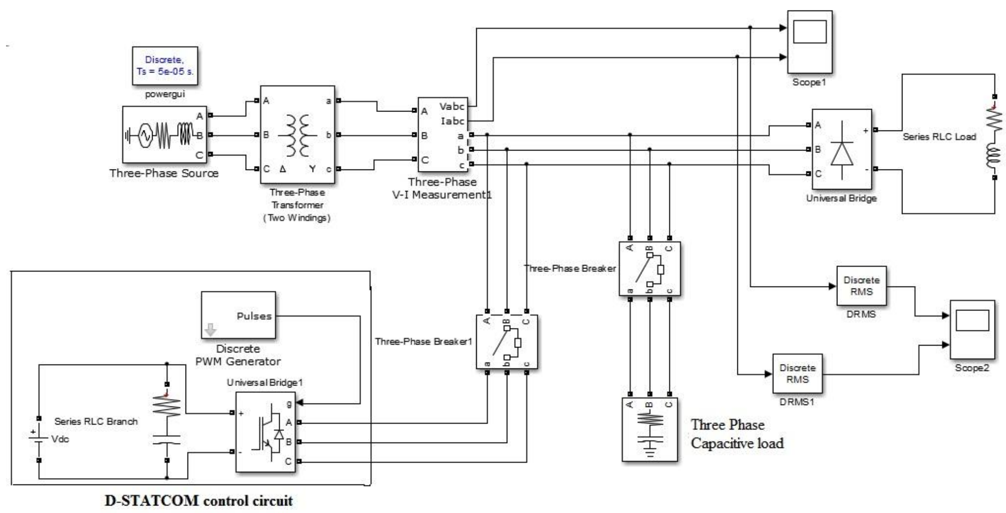

Fig 5: Simulink model of D-STATCOM for voltage swell

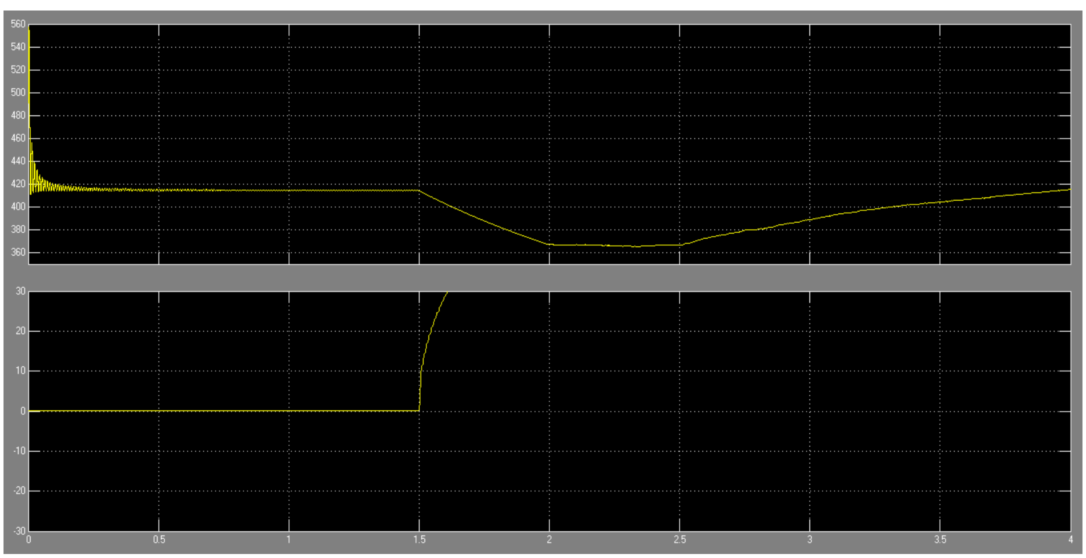

Fig 6: Simulation result for voltage sag.

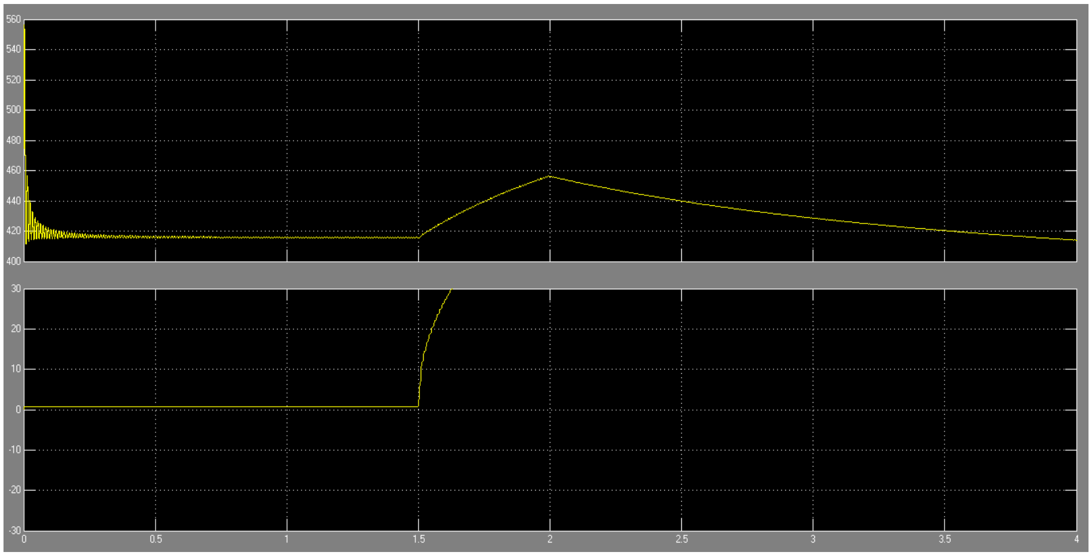

Fig 7: Simulation result for voltage swells

Table: 2

Voltage profile	Without	with
sag	365.2 volt	415.1 volt
swell	456.51 volt	414 volt

CONCLUSION:

This paper has presented the power quality problems such as voltage sags and voltage swell. The objective of work is to study the performance of D-STATCOM for mitigating voltage sag, voltage swell, and to improve the power quality in distribution network with non-linear load. The investigation is made on different condition for nonlinear load. This work presented a study, simulation and behavior of D-STSTCOM to improve the power quality problems of distribution network. From the simulation results, it can be summarized that it is a promising device and helps in mitigating power quality problem.

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