Power Quality Improvement using DSTATCOM in Power System

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Abstract— This paper presents the enhancement of power quality using DSTATCOM which is a FACTS based device. Power Quality problems like voltage sag and harmonic distortion is compensated in the proposed paper. Voltage sag and harmonics in distribution line are caused by the intermittent switching of heavy non-linear loads and hence the critical loads connected to this distribution line are adversely affected by voltage sag and harmonics. The system is simulated using MATLAB-SIMULINK software version R2015b.

Key words: D-STATCOM, Power System, Voltage Sag, Harmonics

I. Introduction

Nowadays there is increased in concern of the power quality (PQ), at the end user mainly due to more sensitive loads, more emphasis on efficiency and awareness in them.Power Quality in distribution system depends on various parameters. Voltage sag and harmonics are more observed PQ problem faced by the customers.

Reactive power compensation is an important issue in the control of electric power systems. Reactive power increases the transmission system losses and reduces the power transmission capability of the transmission lines. Moreover, reactive power flow through the transmission lines can cause large amplitude variations in the receiving-end voltage. This chapter illustrates the effect of STATCOM in power system on reactive power control by proper modelling of simple power system and voltage source converter based STATCOM using simulink and simpower system toolboxes in MATLAB.

A wide application of non-linear load has increased harmonic content at PCC. This harmonic current resulted in a non-sinusoidal wave having frequencies other than fundamental frequency. It has many impacts on power system equipment as well as on its operations. Distribution Static Compensator (DSTATCOM) is a very effective tool for improvement of power quality issue in the distribution system. Many PQ issues can be addressed by the D-STATCOM like voltage fluctuation suppression, power factor improvement, and harmonics. There are various control strategy and many converter topologies used for D-STATCOM operation . For the fast control over inductive and capacitive compensation using D-STATCOM, in this paper six pulse [nsulated Gate Bipolar Transistor (IGBT) based Voltage Source Converter (VSC) is used. There are many methods for reference current generation.

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II. D-STATCOM

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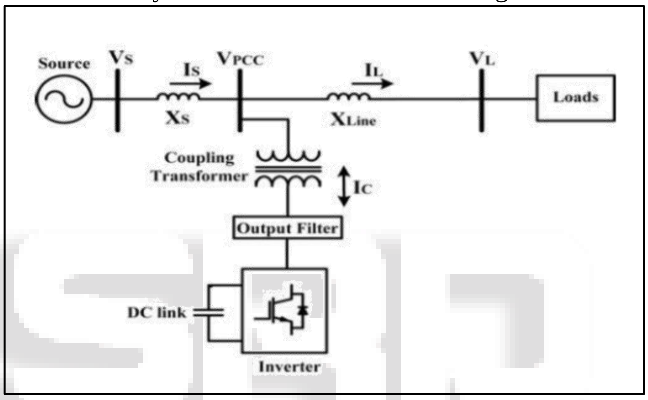

Fig. 1: A generalized connection of D-STATCOM

A STATCOM is a controlled reactive-power source. It provides the desired reactive-power generation and absorption entirely by means of electronic processing of the voltage and current waveforms in a VSC. The VSC is connected to a utility bus through shunt transformer. Vac is the bus voltage. Iac is STATCOM injected current. Vout is the VSC output voltage. Vdc and Idc are the DC capacitor side voltage and current. An IGBT with back to back diode denotes the 3 arm IGBT bridge. Top three IGBTs are called as positive group and bottom three IGBTs are called as negative group IGBTs. The inverter operation takes place, when IGBTs conduct and converter operation takes place, when diode conduct.

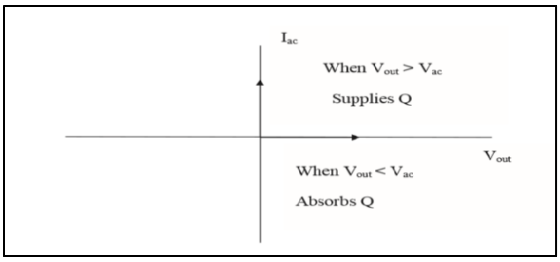

Fig. 2: D- STATCOM power exchange

A. *Voltage Source Converter (VSC)*

A voltage-source converter is a power electronic device that connected in shunt or parallel to the system. It can generate a sinusoidal voltage with any required magnitude, frequency and phase angle. The VSC 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 also converts the DC voltage across storage devices into a set of three phase AC output voltages. In addition, D-STATCOM is also capable to generate or absorbs reactive power. If the output voltage of the VSC is greater than AC bus terminal voltages, D-STATCOM is said to be in capacitive mode. So, it will compensate the reactive power through AC system and regulates missing voltages. These voltages are in phase and coupled with the AC system through the reactance of coupling transformers. Suitable adjustment of the phase and magnitude of the DSTATCOM output voltages allows effectives control of active and reactive power exchanges between D-STATCOM and AC system. In addition, the converter is normally based on some kind of energy storage, which will supply the converter with a DC voltage.

B. *Controller*

Ccontroller system is partially part of distribution system. Proportional-integral controller (PI Controller) is a feedback controller which drives the system to be controlled with a weighted sum of the error signal (difference between the output and desired set point) and the integral of that value. In this case, PI controller will process the error signal to zero. The load r.m.s voltage is brought back to the reference voltage by comparing the reference voltage with the r.m.s voltages that had been measured at the load point. It also is used to control the flow of reactive power from the DC capacitor storage circuit. PWM generator is the device that generates the Sinusoidal PWM waveform or signal. To operate PWM generator, the angle is summed with the phase angle of the balance supply voltages equally at 120 degrees. Therefore, it can produce the desired synchronizing signal that required. PWM generator also received the error signal angle from PI controller. The modulated signal is compared against a triangle signal in order to generate the switching signals for VSC valves.

III. CONTROL TECHNIQUE

Dynamic response, flexibility and implementation pprocedure are the characteristics of good control strategy.The common steps involved in implementing any control algorithm of D-ST ATCOM are as below:

– Measurement of voltage and current at PCC
– Signal Conditioning
– Calculation for compensating signal
– Gating pulse generation for VSC

IV. UNIT TEMPLATE ALGORITHM

Formations of unit vectors for inphase component and quadrature component is carried out from instantaneous value of voltage measured at PCC. The transient and dynamic performance of D-STATCOM depends upon firing pulse generation of VSC. From many methods the unit template is a simple method for reference signal generation. The PI controller is used in voltage control loop and Hysteresis current controller is used for switching pulse generation . The Ua, Ub and Uc are the in-phase unit vectors and the Wa, Wb and We are the quadrature unit vevctor.

V. SIMULATION SYSTEM PARAMETER

The various parameters used for simulation in this paper, are shown in Table 1.

Parameter	Value
Source Voltage, V	415v
Frequency, f	50Hz
Capacitor for D-STATCOM	3000μF
Reference DC Voltage	700 V
Non-Linear Load	Three-Phase rectifier with 50 ohm
Active Power for Main Load	20kW
Reactive Power for Main Load	20kVAR
Active Power for Switching Load	15kW
Reactive Power for Switching Load	25kVAR

Table 1: Parameter of Test System

DSTATCOM was designed using MATLAB simulink version R2015a. Figure below shows the flowchart for the system.

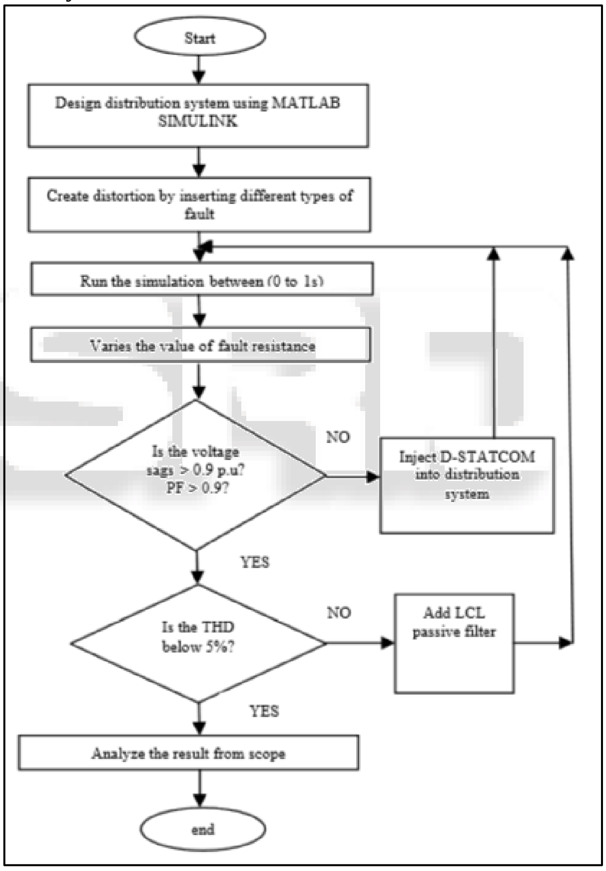

Fig. 3: Flowchart for the methodology

The test system was design using MATLAB simulink is shown in figure 4 below.

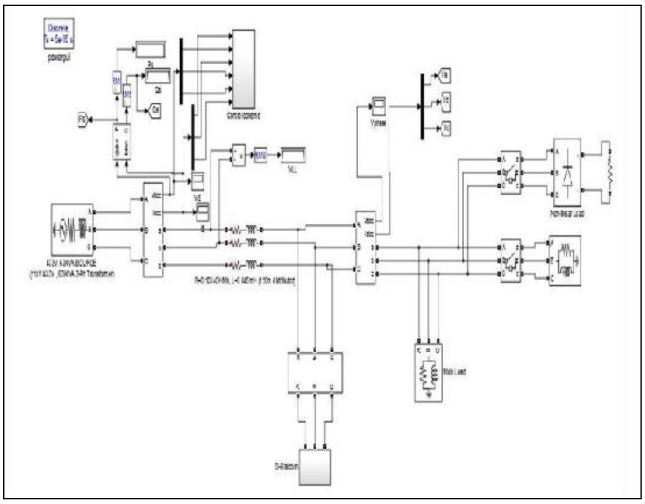

Fig. 4: Main Simulation Circuit

VI. SIMULATION RESULTS

Using MATLAB-SIMULINK software, the circuit is simulated to show the effect of intermittent heavy load by adding load of 15kW and 25 kVAR between 1.5 to 2 second. The main simulation circuit is shown in Fig.4. The simulation is carried out without D-STATCOM. The waveform of load voltage when D-STATCOM is not connected is shown in Fig. 4. These results show that when additional load is connected; the sag iscreated in load voltage. Now, the D-ST A TCOM is connected, during the period of 1.5 to 2 seconds, when an additional load of 15kW and 25 kVAR is connected.

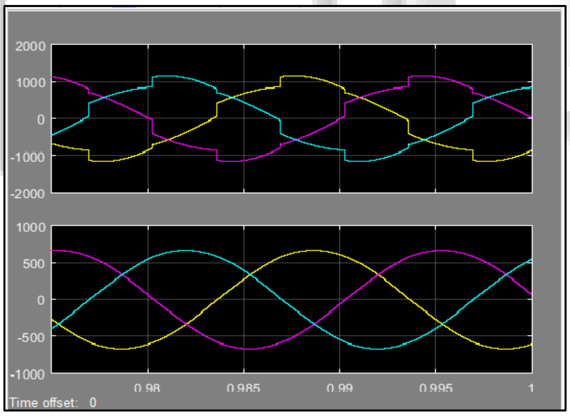

Fig. 5: Waveform of Load Voltage when D-STATCOM is not connected

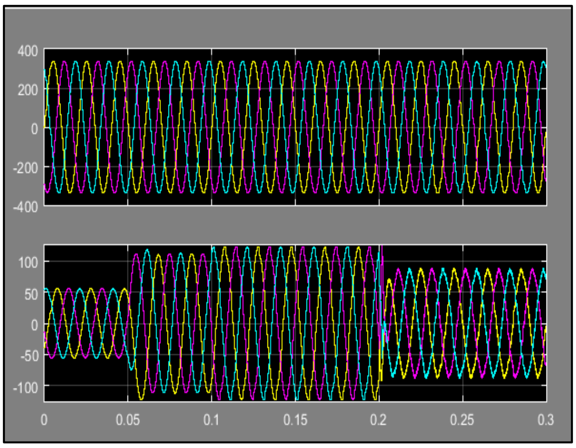

Fig. 6: Waveform of Load Voltage when D-STATCOM is not connected

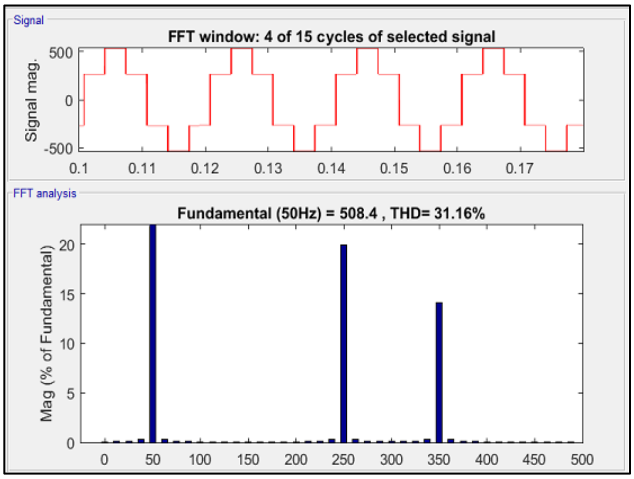

Fig. 7: Total Harmonics Distortion without compensation

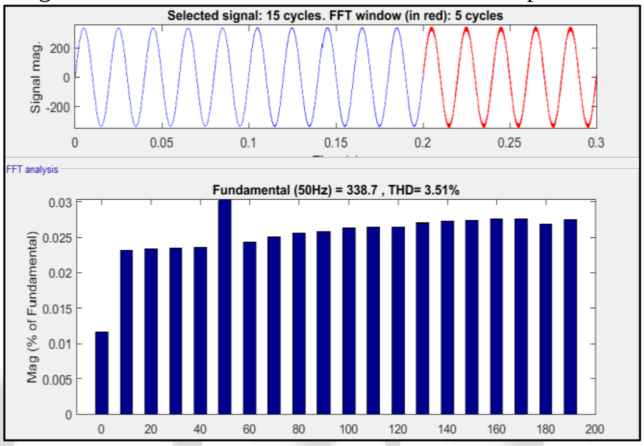

Fig. 8: Total Harmonics Distortion with compensation

VII. CONCLUSION

MATLAB Simulink software is used for the simulation of 415 V distribution line. The 15% decrement in voltage magnitude is observed during 0.05 to 0.2 sec due to switching of heavy loads. The switching of nonlinear load resulted in 31.16 % THD in source current. The DSTATCOM with unit template algorithm is implemented for voltage sag mitigation and harmonics compensation. The compensation with unit template algorithm has improved voltage profile at PCC by reducing 15% sag and THD has reduced to 0%.The power quality has enhanced using DSTATCOM by mitigation of voltage sag and harmonics.

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