D-Statcom with PI Controller for Voltage Stability

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Abstract— In this paper the voltage stability is achieved by the distribution static compensator. The distribution static compensator is a shunt connected device consisting of a voltage source converter, which absorb or inject the current to the system. The STATCOM is connected at the load end or distribution side is termed as D-STATCOM in order to achieve the voltage stability. The D-STATCOM is controlled by PI controller.

***Index Terms*—** D-STATCOM, voltage stability, PI Controller

I. INTRODUCTION

The generation of electricity and consumption has been increased due to the load growth. Now a days the loads are mostly drawn the reactive power [1]. Due to the enormous consumption of reactive power the power system subjected to the power quality problems. Among the power quality issues the under voltage issues are occurred due to the consumption of reactive power and it is stated as the voltage magnitude decreased between 0.9 p.u to 0.1 more than 0.5sec. The requirements of reactive power compensation are,

1. To maintain voltage stability in order to improve the active power along the transmission lines
2. To provide load compensation in order to improve the power factor and better regulation of voltage due to the large fluctuating loads
3. To provide voltage support to electronics controllers .These devices are sensitive to voltage disturbances [2].

This reactive power compensation is achieved using the shunt compensation. In conventional methods the shunt compensation is achieved by capacitors and reactors. Due to the switching of devices, the transient problems are occurred. In order to avoid these problems the FACTS devices are introduced [3]. A Flexible AC transmission system incorporates power electronics devices and controllers to enhance controllability and increase the power transfer capability [4]. FACTS devices can improve power system operations are by providing a means to control power flow, to improve stability, and to better utilize the existing transmission infrastructure [5]. Recently the Distributed Flexible AC Transmission System (D-FACTS) devices are introduced [6-8]. D-FACTS devices are power flow control devices which are small, lightweight, and made of easily purchased mass-produced parts. The static compensator is applied in a distribution system is called as D-STATCOM and it is used for reactive power compensation of industrial loads and also stability improvements for wind turbine system [9]

II. BASIC PRINCIPLE OF DSTATCOM

A Distribution Static Compensator is a three phase shunt connected device. It consists of a Voltage Source Converter (VSC) and DC link capacitor. It is connected in a shunt manner and it is have the capacity of generating and/or absorbing reactive power. The operating principles of a distribution static compensator are same as the synchronous compensator. The AC terminals of a VSC are connected to the Point of Common Coupling (PCC) through the inductance; the inductance can be a filter inductance or the leakage inductance of the coupling transformer, as shown in Fig. 1[10].

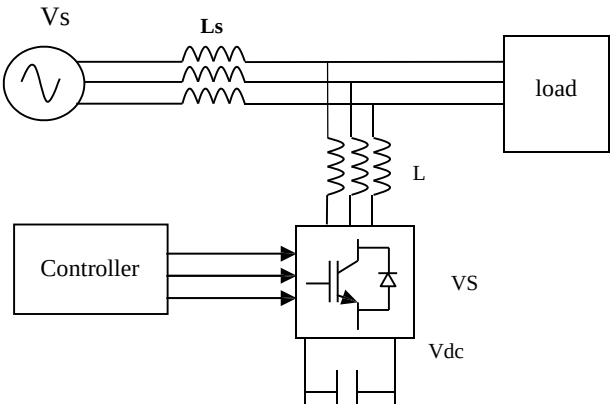

Figure 1.Basic structure of D-STATCOM

III. MODES OF OPERATION OF D-STATCOM

There are three modes of operation in the D-STATCOM with its output current is known as I, it changes according to v_i . If $v_i=v_s$, then reactive power will be 0 and also the D-STATCOM will not produce or absorb the reactive power.

Whenever vi will be greater than vs, the D-STATCOM will act as an inductive reactance over its terminal and the equipment will generate capacitive reactive-power. When Vs is larger than VI, the distribution static compensator is seen by the system as capacitive reactance. When the flow of the current is from the alternating current system to the D-STATCOM it will result in the absorption of the inductive Power [11].

c) Inductive mode (Vi < Vs)
a) No load mode (Vs = Vi)
b) Capacitive mode (Vi > Vs)

provides a faster response, flexible to control and easy to implement the controllers. The control algorithm of DSTATCOM are mainly implemented in the following steps: a

1. Measurements of system voltages, current and Signal conditioning.
2. Calculation of compensating signals.
3. Generation of firing angles of switching devices.

Different control schemes employed in a control strategies.

1. Phase Shift Control
2. Decoupled Current Control (p-q theory)
3. Hysteresis control [12].

S.NO	ALGORITHMS ↓ PARAMETE	PHASE SHIFT CONTROL	DECOUPLED CURRENT CONTRO	REGULATION OF AC/DC LINK VOLTA
1	REACTIVE POWER COMPENSA	Partial	Complete	Complete
2	PERFORMAN CE UNDER BALANCED AND NONLINEAR LOADS	Contains undesired harmonics in case of nonlinear load	Satisfactory in case of linear loads	Capable to maintain upf and below 5% harmonic level in both the
3	APPLICABLE FOR SINGLE PHASE	Yes	No	Yes
4	TOTAL HARMONIC	----	Much higher than 5%	Below 5%

Table 1. Comparison of control algorithm

V. PHASE SHIFT CONTROL

In this method the voltage regulation is achieved by D-STATCOM by the measurement of rms ac voltage at the load side and the sinusoidal Pulse width Modulation technique is used. This control is simple and gives good response. The error signal is obtained by comparing the measured voltage and the reference voltage.

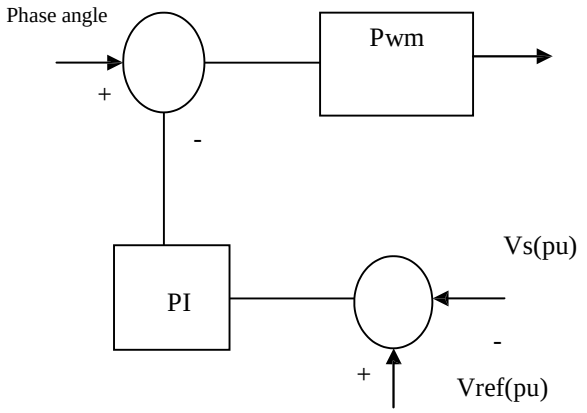

Figure 2. Block diagram of phase shift control

The error signal is fed to the PI controller which generates the necessary phase angle that decides the phase shift between the VSC output voltage and the terminal voltage.
The source current and the source voltage are in phase, inorder to correcting the power factor of the system during balanced fluctuating load.[12][13].

VI. TEST CASE

The simulation are carried out in Simulink with the data presented in the table 2 and the results are compared with and without DSTATCOM.

Three phase source	230kV, 50 HZ
DSTATCOM capacitor	750 microfarad
Load 1	250 KW 100 VAR
Load 2	10 KW, 100 VAR

Table 2. Test System Data

The source voltage maintained at 11KV and the loads are connected to the distribution system.

VII. SIMULATION RESULTS

A. Without D-Statcom

The simulation results are carried out without DSTATCOM. And the voltage magnitude valued are in maintained in 0.65pu value. Due to load the voltage value are dipped.

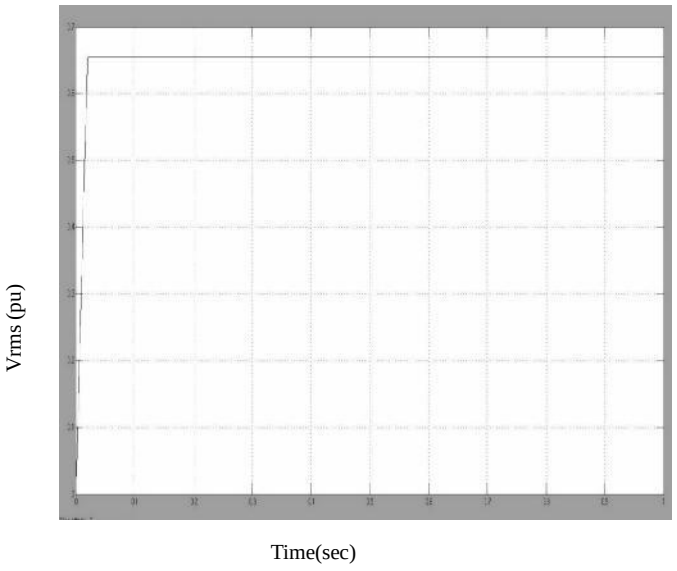

Figure 3. The Voltage Magnitude Value without D-Statcom

The graphs are plotted between the voltage magnitude in per unit value to the time

B. WITH D-STATCOM

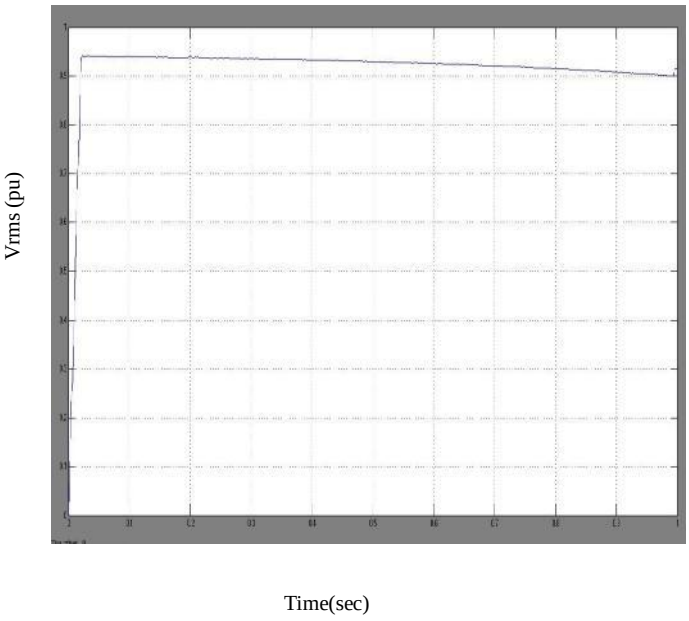

Figure 4. The voltage magnitude value with d-statcom

While adding d-statcom the voltage profile value is improved. The voltage value is improved from 0.65 to 0.95pu

VIII. CONCLUSION

The voltage stability improvement by using distribution static compensator is simulated in this paper. The simulation shows that the voltage profile improved using D-STATCOM.

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