

REVIEW ON POWER QUALITY IMPROVEMENT USING D-STATCOM

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Abstract: This paper illustrates the power quality improvement aspects in distribution system by DSTATCOM. The utilities like domestic, commercial and industrial facing the power quality problems in the form of voltage dip, voltage swell and voltage variation or fluctuations. In this work the mitigation of the voltage sag, swell, fluctuation for different conditions in utility by using Custom power devices. The DSTATCOM has taken as a compensating device. DSTATCOM is connected in shunt with the three-phase source feeding a constant and heavy inductive load, which is developed by using Matlab/Simulink. The test circuit developed in the matlab is also present in this paper.

Key Words: Custom power devices, D-STATCOM, Voltage Sag/dip, and Voltage source converter (VSC).

I. INTRODUCTION

In electrical power, industry mainly consists of electrical generation, transmission and distribution to the customer. There are various complications to flow an electrical energy from its generating place to its consumption place like, weather variation, generation deficit with respect to demand, faults and fluctuations of connected load with the line. The modern day equipment used by commercial and industrial consumers is very much sensitive in power quality problems [1]. Recently, more importance has given to the Power quality issue as their effect became significant on electricity providers, equipment manufacturers and consumers [1]. Due to the advent of sensitive equipment based on semiconductor devices, the quality of voltage has become an important factor for smooth operation of the apparatus. The deviance in voltage, current and frequency in power system from its nominal value has defined as Power quality problem according [2]. The most common disturbances among the power or voltage quality issues are momentary voltage dip, voltage swell and fluctuations are greatly affect electric customer process operations in large distribution systems. Several compensation devices are available to mitigate the impacts of above mentioned disturbances, like SVC, STATCOM, UPFC, SSSC etc. have been designed to minimize or reduce the impact of these variations.

From decades to decades, power electronics have been introduced and developed further due to its economical and power saving advantages. Flexible AC Transmission System (FACTS) are widely used to solve power quality disturbances and Distribution Static Compensator (DSTATCOM) is one of the members of FACTS devices family which is effective and flexible. Its function is similar to the usage of synchronous transformer. In other words, DSTATCOM is a fast-respond reactive power source compensator, which can properly solve various power disturbances with appropriate controller designed, such as voltage sag, voltage swell, flicker, harmonic, and transient. It contains an injection transformer, a voltage source converter (VSC) and a PI controller with specific control scheme in order to perform its main function efficient and effectively. In this paper, the function of DSTATCOM in voltage mitigation was mainly be discussed and it is one of the most important function of D-STATCOM devices.

This paper is represent with the 33kv transmission line model in MATLAB/SIMULINK and this paper is also contains the basic review on the various components used in D-STATCOM.

II. COMPONENTS OF D-STATCOM

2.1 VOLTAGE SOURCE CONVERTER (VSC)

Voltage Source Converter (VSC) is one of the power electronic devices. VSC is the most important component in D-STATCOM and it can generate a sinusoidal voltage waveform with any required magnitude, with any required phase angle and also with any required frequency. Usually VSC is mostly used in Adjustable Speed Drive but it also can be used to mitigate the voltage sags. VSC is used to replace the voltage or to inject the 'missing voltage'. The missing voltage can be defined as the difference between the actual voltage and the nominal voltage [3].

Normally, the converter is based on some kind of energy storage which will get the supply from the DC voltage. This converter is used the switching based on a sinusoidal PWM method. The PWM offers simplicity and good response. The device that used for the switching is an IGBT power electronic device.

2.2 ENERGY STORAGE CIRCUIT

The purpose of energy storage is to maintain the DC side voltage of VSC. It can be capacitor or DC source, e.g. battery. Traditional STATCOM only has DC capacitor, thus; only reactive power can be injected to the power system by STATCOM, whereas both active and reactive power can be injected to the power system by STATCOM if DC source is used. In energy storage

circuit, the DC source was connected in parallel with the DC capacitor. DC source is act as a battery that will supply a power meanwhile the DC capacitor is the main reactive energy storage element. It carries the input ripple current of the converter. To charge the DC capacitor, it could be used either a battery source or it could be recharged by the converter itself [5].

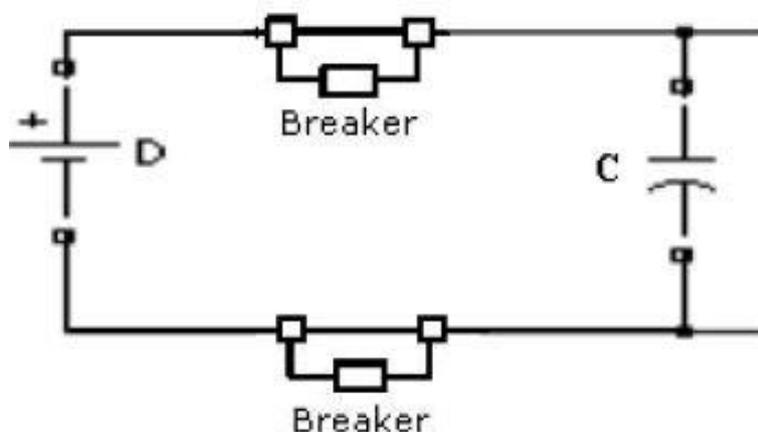


Fig. 2.1 Energy storage circuit

2.3 FILTER

As the Pulse-Width Modulation (PWM) technique is used in VSC, the output voltage of VSC has switching ripple, which bring harmonics into the current injected to the power system. These harmonics will affect the voltage quality of the power system. Therefore, a relatively small reactor is installed between VSC and the point of the system which the D-STATCOM is connected, to filter those harmonics in the current. The filter can be L-filter, LC-filter and LCL-filter [4].

2.4 CONTROLLER

The aim of the controller system is to maintain the constant voltage magnitude at the point where a sensitive load is connected under system disturbances. The control system element can only measure the RMS voltage magnitude that measured at the load point. For the controller system there is no requirements of the reactive power measurements. The input for the controller system is an error signal. This error signal is obtained from the reference signal measured at the terminal voltage and RMS voltage magnitude that measured at the load point. First of all, this error signal will enter to the sequence analyser block which is functioning to measure the harmonic level in that signal. Then, the PI controller will process this error signal and come out with the output in term of the angle, δ . This angle can drive the error to zero. Next, this angle will be summed with the phase angle of the supply voltage which is assumed to be 120° to produce the suitable synchronizing signal, required to operate the PWM generator. Then, this angle will be submitted to the PWM signal generator. PWM generator will generate the sinusoidal PWM waveform or signal [6].

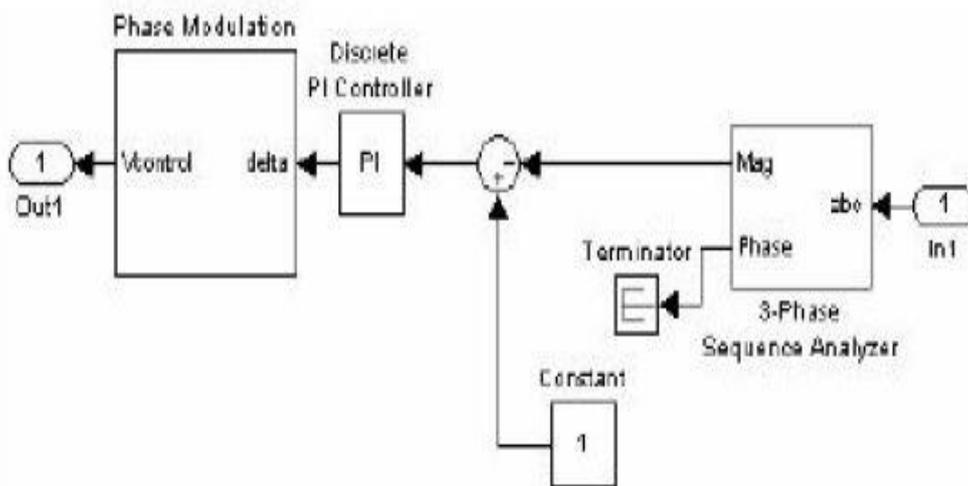


Fig. 2.2 Controller of statcom

III. DISTRIBUTION STATIC COMPENSATOR (D-STATCOM)

The STATCOM configuration consist of a two level voltage source converter (VSC), a dc energy storage device, a coupling transformer connected in shunt with ac system, and associated control circuit .Figure (A) depicts the schematic diagram of the STATCOM. The VSC will convert the DC voltage across the storage device into AC output voltages that are in phase and

coupled with the AC system through the reactance of coupling transformer. Since the AC output voltage connected directly with the coupling transformer, the exchange of active and reactive powers can be easily made between the converters and the AC system. The active and reactive power can be exchanged directly by adjusting the phase angle between the converter output voltage and the bus voltage at the point of common coupling [7].

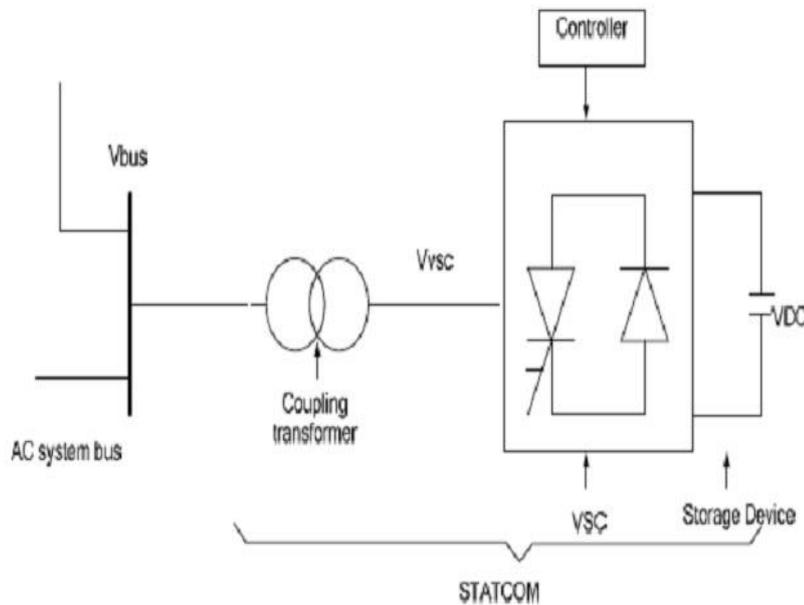


Fig.3.1 Schematic Diagram of STATCOM

3.1 D-STATCOM OPERATION

The shunt connected Static Synchronous Compensator is a custom power device and when it is placed in the utilization segment of power system then it is known as D-STATCOM. The D-STATCOM is a parallel-connected device based on Voltage Source Converter (VSC), incorporating advanced power electronics to deliver power quality solutions for utility and for commercial or industrial applications [7]. A schematic diagram and corresponding Phasor diagram showed in Fig. B and C respectively.

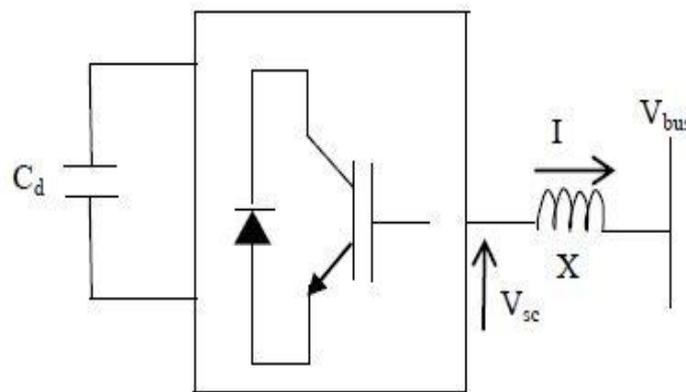


Fig.3.2 Schematic of D-STATCOM

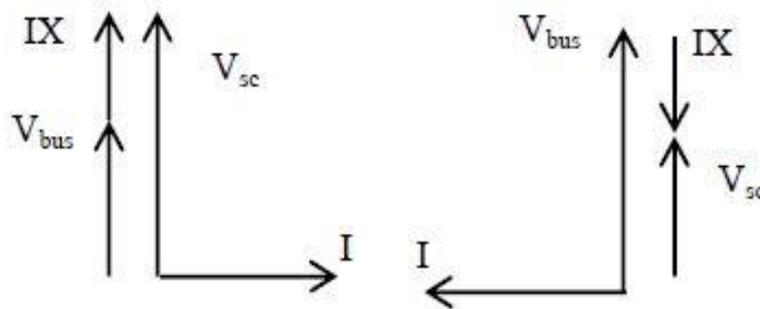


Fig.3.3 Phasor Diagram

The converter may arrange to act as a Distribution STATCOM [7, 8]. In its simplest implementation, a sine PWM technique has incorporated to generate desired gate signal for IGBT. The power flow across the inductor has governed by equations:

$$I = \frac{V_c - V_{bus}}{jX} \tag{1}$$

Or in terms of real and imaginary power

$$P = \frac{V_c \times V_{bus}}{X} \sin \delta \tag{2}$$

$$Q = \frac{V_c \times V_{bus}}{X} \cos \delta - \frac{V_{bus}^2}{X} \tag{3}$$

Where:

V_c- converter output voltage

V_{bus}- system voltage

X - Coupling reactance

I - converter current

δ -angle between V_c and V_{bus}.

3.2 V-I CHARACTERISTIC OF DSTATCOM

The STATCOM can be operated in two different modes which is in voltage regulation mode and can operate in reactive power control mode. When then STATCOM operated in reactive power mode, the STATCOM reactive power output itself will remain constant. When the STATCOM is operated in voltage regulation mode, it will produces the following Voltage versus Current (V-I) characteristic [8].

Figure (D) shows the V-I characteristic of STATCOM. The STATCOM can supply both the capacitive and the inductive compensation and is able to independently control its output current over the rated maximum capacitive or inductive range irrespective of the amount of ac-system voltage. The STATCOM can provide full capacitive-reactive power at any system voltage. This capability is useful for situations in which the STATCOM is needed to support the system voltage during and after faults where voltage collapse would otherwise be a limiting factor.

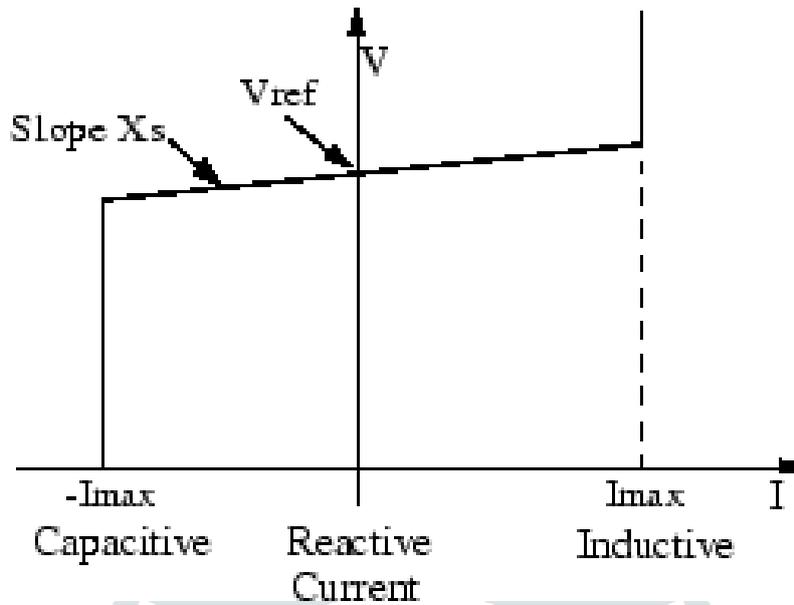
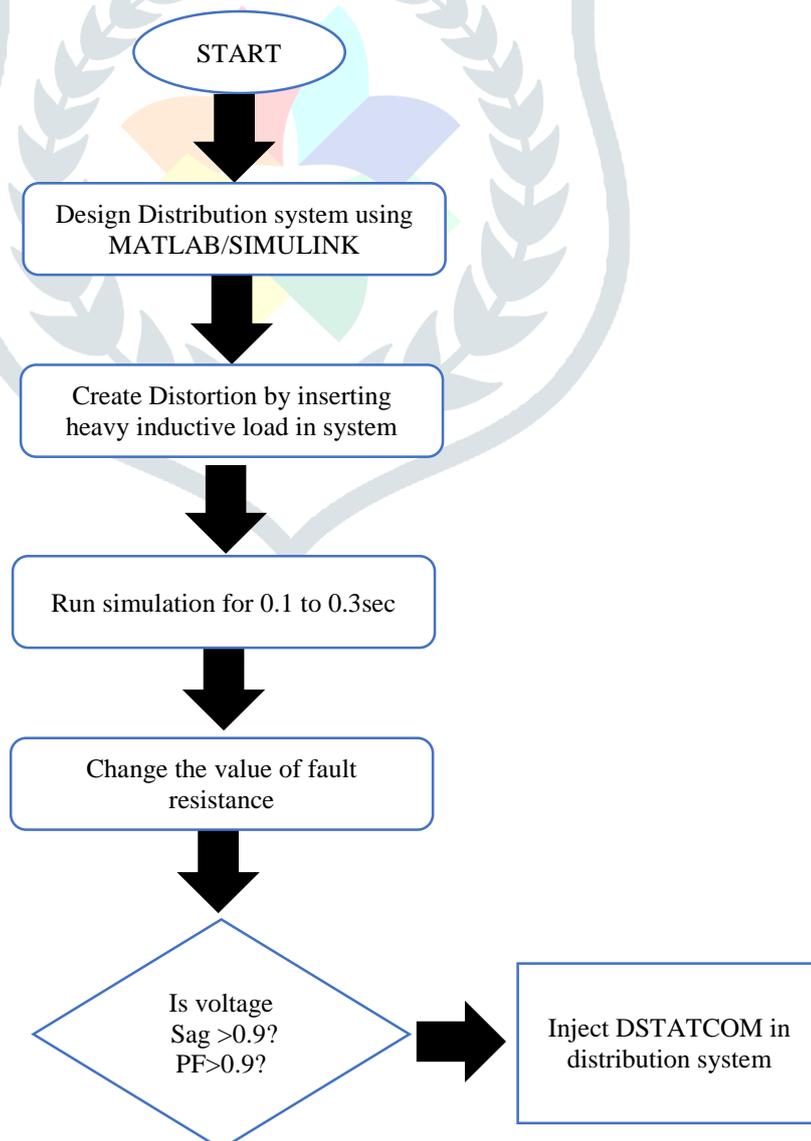


Fig.3.4 V-I characteristic of STATCOM

IV. PROPOSED METHODOLOGY

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



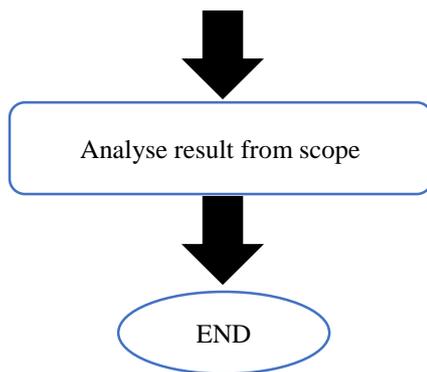


Fig.4 Flow chart of process

V. TEST SYSTEM

5.1 TRANSMISSION LINE WITHOUT D-STATCOM

The test system consists 33-kv, 50 Hz, 25km long transmission line with the impedance value of 0.8929Ω and 16.58mH connected with 6MVA, 33kv/415V, Δ / Y step down distribution transformer.

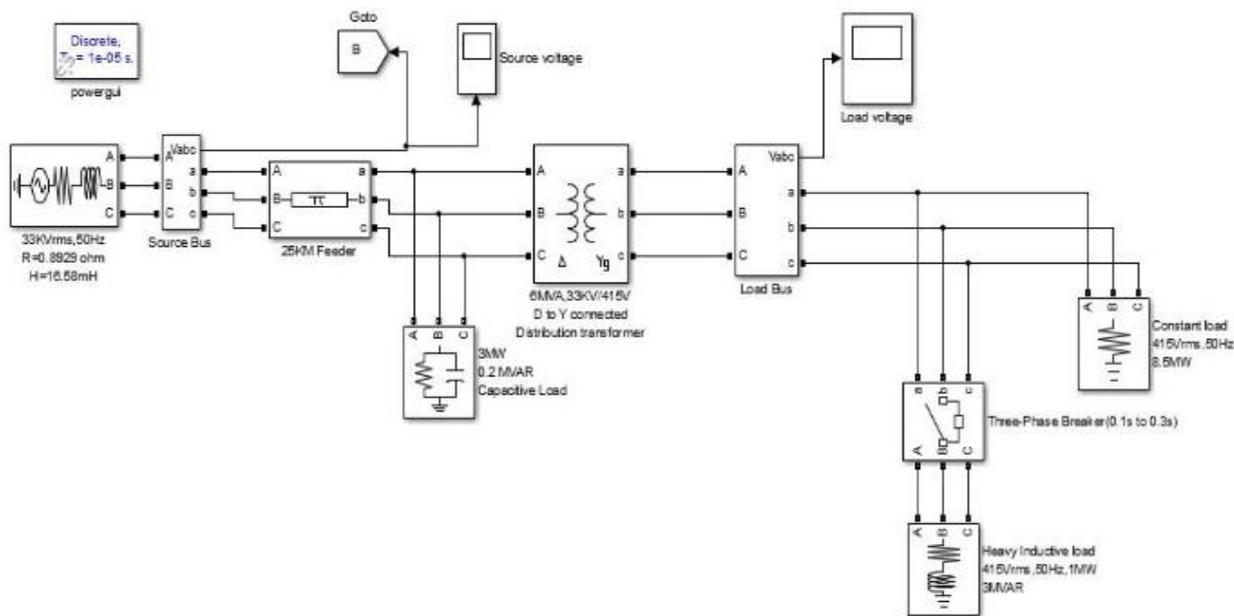


Fig.5.1 Transmission line without statcom

When the heavy inductive load is connects with the system for 0.1 sec to 0.3 sec, voltage sag is occurred in transmission line.

5.2 TRANSMISSION LINE WITH D-STATCOM

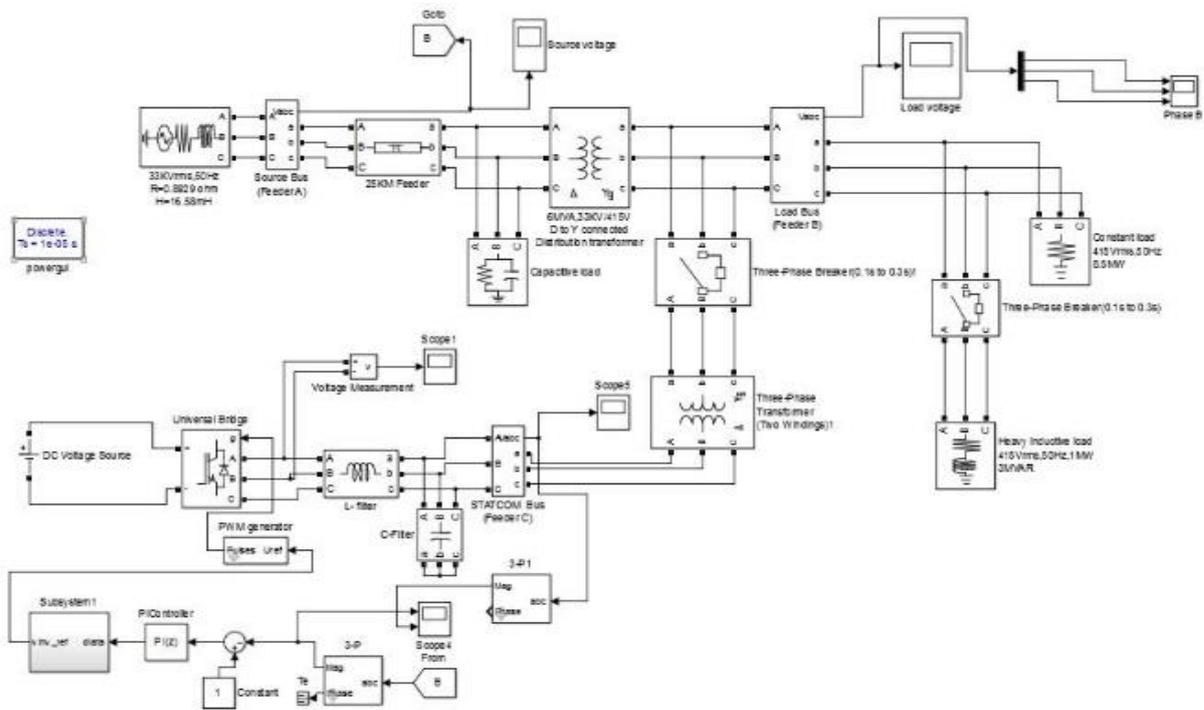


Fig.5.2 Transmission line with statcom

The D-STATCOM along with the transmission line is simulated in MATLAB/SIMULINK software and diagram is shown in figure. In the absence of D-STATCOM, the terminal voltage varies considerably but such variations are minimised in the presence of the D-STATCOM. The voltage sag is compensated with D-STATCOM.

CONCLUSION

In this paper by analysing 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 result having low percentage of voltage sag should be obtained.

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