"ENHANCEMENT OF POWER QUALITY IN THE DISTRIBUTION SYSTEM USING D-STATCOM"

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Abstract- Power Quality is a significant tool in the Electrical power system. It defines the wellness of the power received to the user end. Nowadays, the power quality of the system is of major concern. This paper presents the use of Distribution STATCOM (D-STATCOM) for the Power Quality enhancement using the Sinusoidal Pulse Width Modulation (SPWM)Technique in the Distribution system. The D-STATCOM is used to mitigate the power quality problems- voltage sag and voltage swell n distribution lines under different fault conditions like- Single line fault, LL fault, LG fault, LLG fault, 3-phase fault, 3- phase to Ground fault. There are various reasons for the power quality problems, like the excessive use of non linear loads, network faults, lightining, switching of capacitor banks, starting of motors etc. the effect of this leads to severe system failure. The equipment's at the user end may get damaged. In industries, this may lead to heavy financial loss.

Index terms- D-STATCOM, Power Quality, Voltage Sag/ Swell, Line Faults.

Introduction

1. Power Quality

Smooth and steady voltage across the user end also within the specified limit can be termed as Good Power Quality. Power quality rather than its name, it is more of voltage quality than the power or current quality of the system. Voltage quality of the system can be termed as the voltage variations i.e., undervoltage or overvoltage commonly called voltage sag and swell respectively.

Voltage sag is a condition of overload in the system. This happens when a heavy load is turned on, short circuit condition or due to starting of motors. This leads to the reduction in the rms value of the supply voltage for a duration of time. In contrast to this, voltage swell is opposite to voltage sag. This is a condition of overvoltage. When a heavy load is turned off or the shut down of a motor leads to increase in the voltage value for a moment. This variation of the voltage is the reason of poor quality at the end user. We see that nowadays, more of the electronic instruments are used in the industries, such voltage variations are a major shock to them. These voltage sag and swell affects in such a way that it leads to equipment failure and severe financial losses to the industries. Thereof, the power quality problem is a major lookout for the industries and end users nowadays.

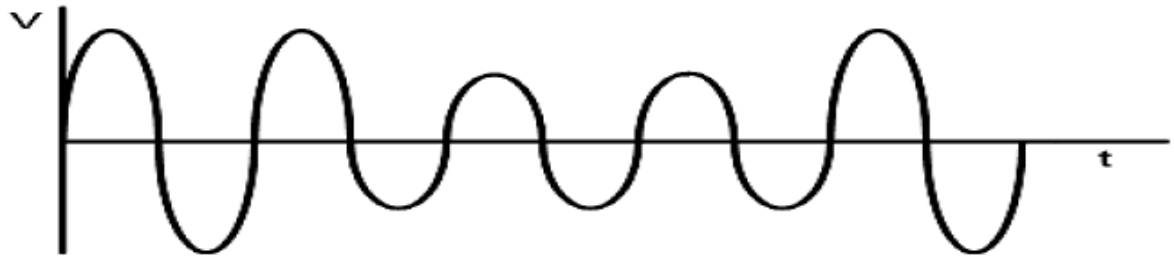

Figure 1: Voltage Sag

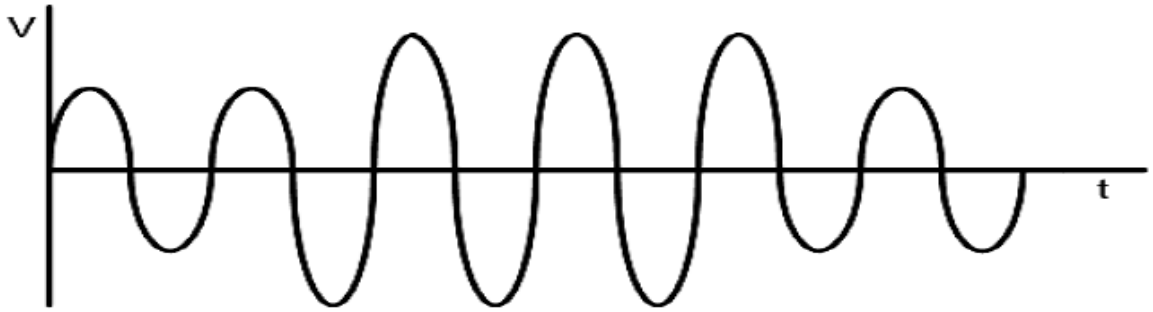

Figure 2: Voltage Swell

2. D-STATCOM

STATCOM is a custom power device that is used at the distribution named as D-STATCOM. The D-STATCOM and the power system is in shunt connection, it is a voltage / current source inverter. The power voltage source convertor (VSC), a set of coupling reactors and a controller are the D-STATCOM components. The D-STATCOM works on the principle of the generation of controllable ac voltage source by using the VSC. The D-STATCOM is connected at the end user side where the power quality is a concern. For the work to be done, all the voltages and currents are fed to the controller and compared. The controller then performs the feedback loop control and gives the output. The output of the controller is then forwarded to the main switching device (here IGBT), that are used at the distribution side. The firing angle controls the ac voltage.

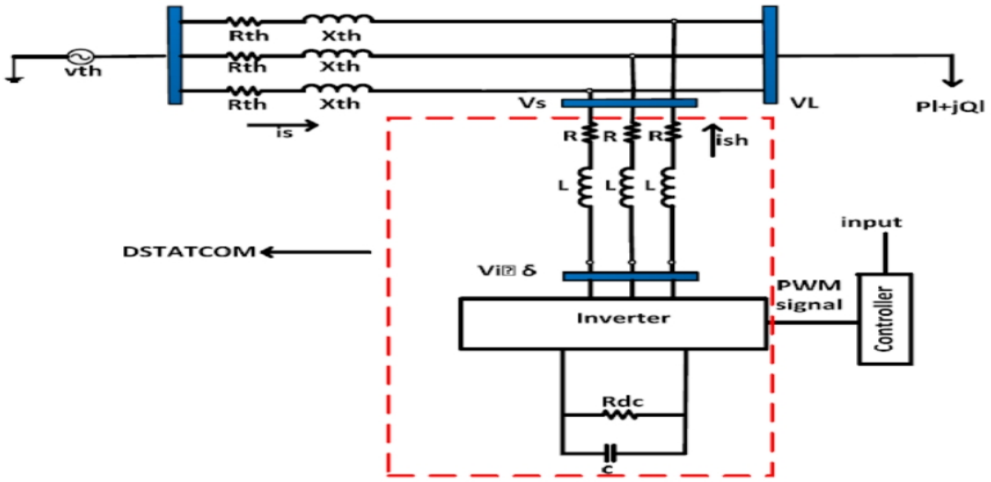

Figure 3: Basic structure of D-STATCOM

2.1 Operation of D-STATCOM

For the reactive power exchange and current filter the inductance L is used in between the D-STATCOM and the line. The DC voltage is provided by the dc link capacitor for the inverter. There is a control unit for the generation of pulses to the inverter switches. The resistances Rdc and R are for the inverter switching losses and winding resistance of coupling inductance. The regulation of reactive voltage is done by the inverter output voltage.

2.2 Equations related to D-STATCOM

By adjusting the voltage drops across the system impedance Zth, the shunt current (Ish) corrects the voltage sag. The output voltage of the converter controls the value of Ish.

The Ish is-

$$I_{sh} = I_L - I_S \quad \text{..... eq. 1}$$

Source current (Is)

$$I_s = \frac{V_{th} - V_L}{Z_{th}} \quad \text{.....eq. 2}$$

By eq 1&2

Injected shunt current can be written as-s

$$I_{sh} = I_L - \frac{V_{th} - V_L}{Z_{th}}$$

$$I_{sh} = I_L - \frac{V_{th}}{Z_{th}} - \frac{V_L}{Z_{th}}$$

Changing to polar form,

$$I_{sh}\angle\eta = I_L\angle(-\theta) - \frac{V_{th}}{Z_{th}}\angle(\alpha - \beta) - \frac{V_L}{Z_{th}}\angle(-\beta)$$

Complex power injection of D-STATCOM can be given as-

$$S_{sh} = V_L I_{sh}^*$$

D-STATCOM Modelling and Simulation Results

For the solution to the power quality problems, the D-STATCOM is implemented as conventional equipment's cannot be used to do so. Therefore, the D-STATCOM power conditioner connected parallelly with a PWM converter in been introduced. The circuitry of D-STATCOM contains a voltage source inverter circuit and a DC capacitor connected at one end. As the IGBT have lower switching losses with small size, it is used for distribution voltage level.

Simulation Tool and Software

MATLAB: This is a high-performance language for practical calculation. MATLAB is for computation, visualization, programming software used as mathematical representation for different network problems and solution.

Modelling the D-STATCOM

The model for the simulation is given below:

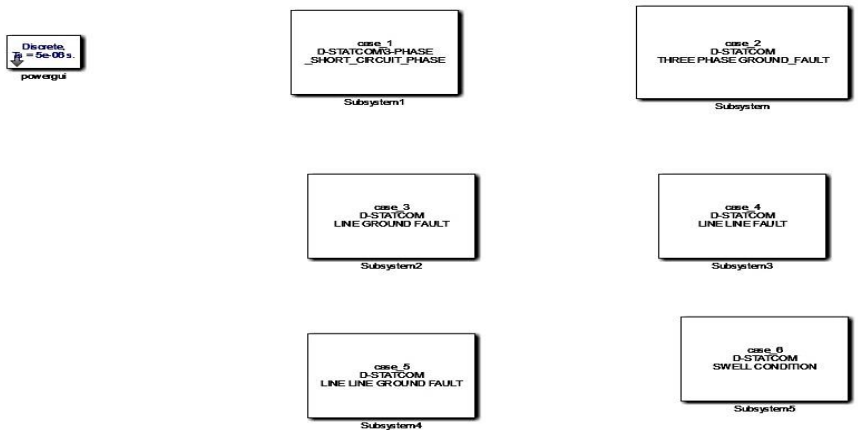

Figure 4: Simulink model of test system

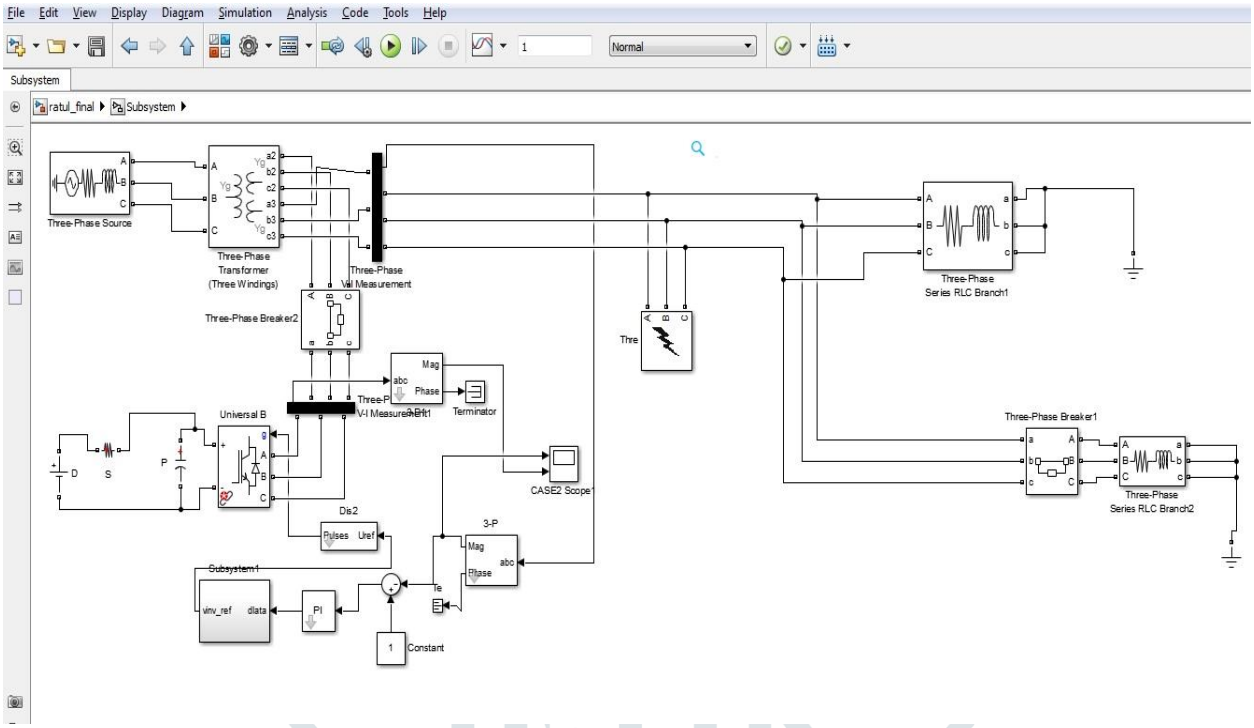

Figure 5: Simulink Circuitry of the System

Simulation Results under different cases

Case 1: 3-Phase Short Circuit Fault Condition

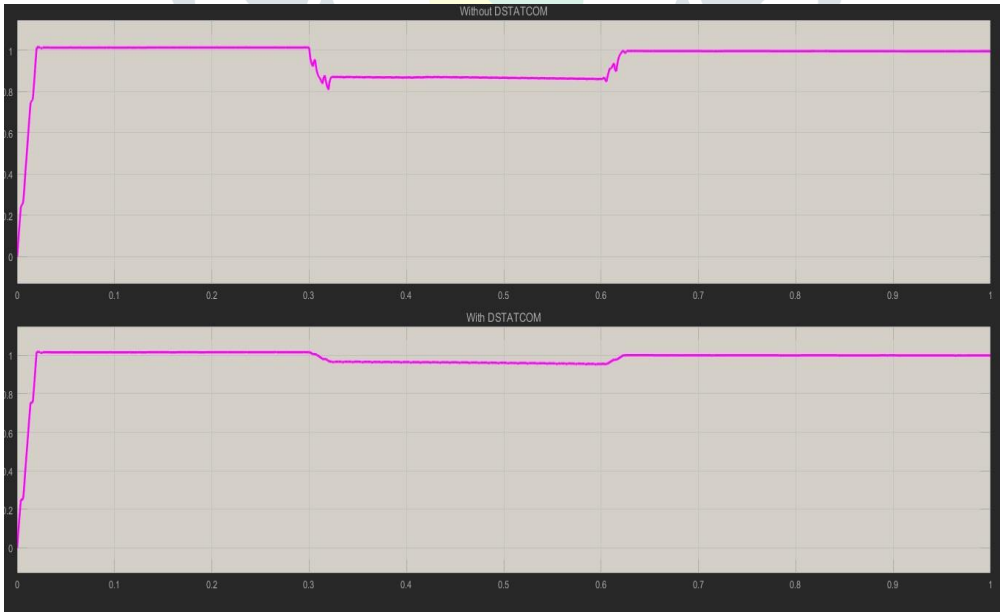

Figure 6: 3-phase short ckt fault condition with and without D-STATCOM

Case 2: 3-Phase to Ground Fault Condition

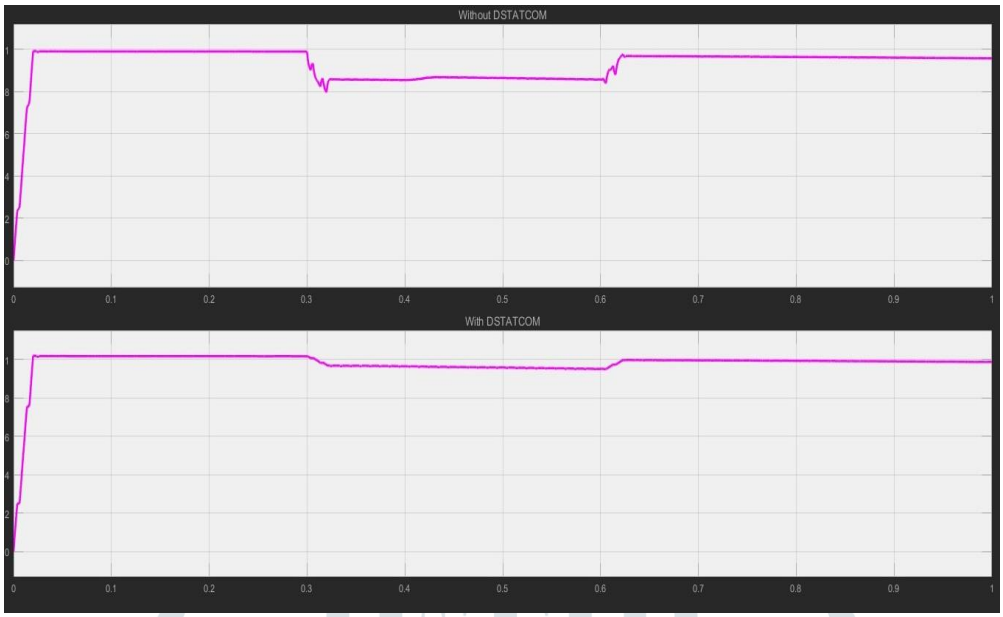

Figure 7: 3- Phase to Ground fault condition with and without D-STATCOM

Case 3: Line to Ground Fault Condition

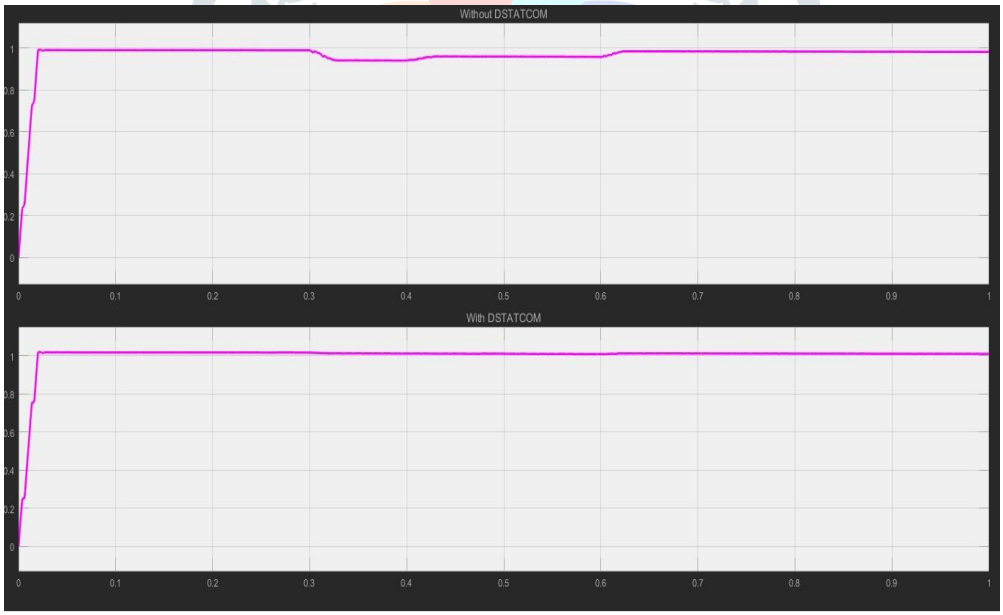

Figure 8: Line to Ground fault condition with and without D-STATCOM

Case 4: Line to Line Fault Condition

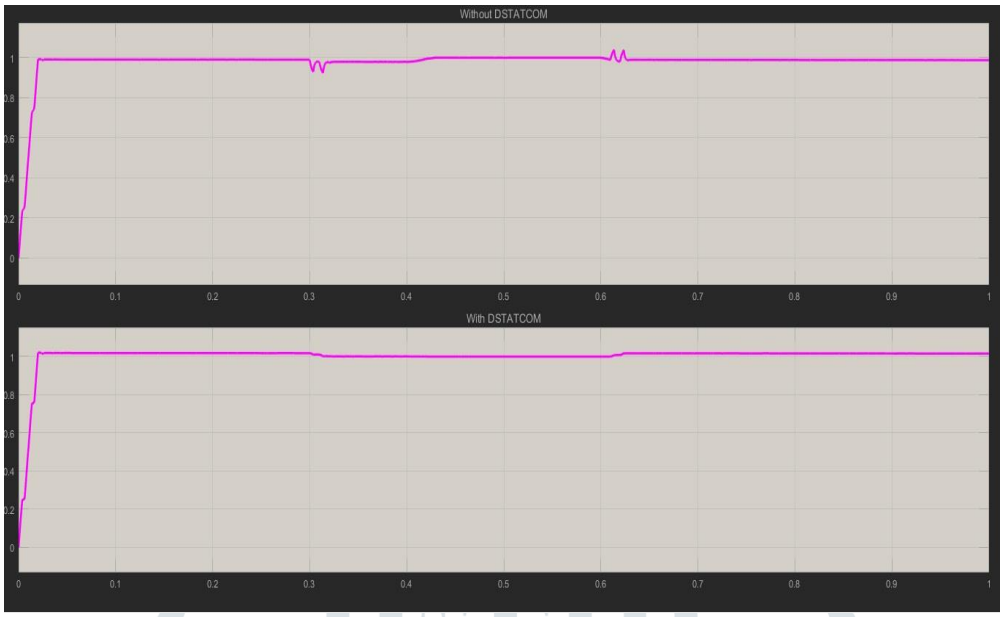

Figure 9: Line to line fault condition with and without D-STATCOM

Case 5: Double line to Ground fault condition

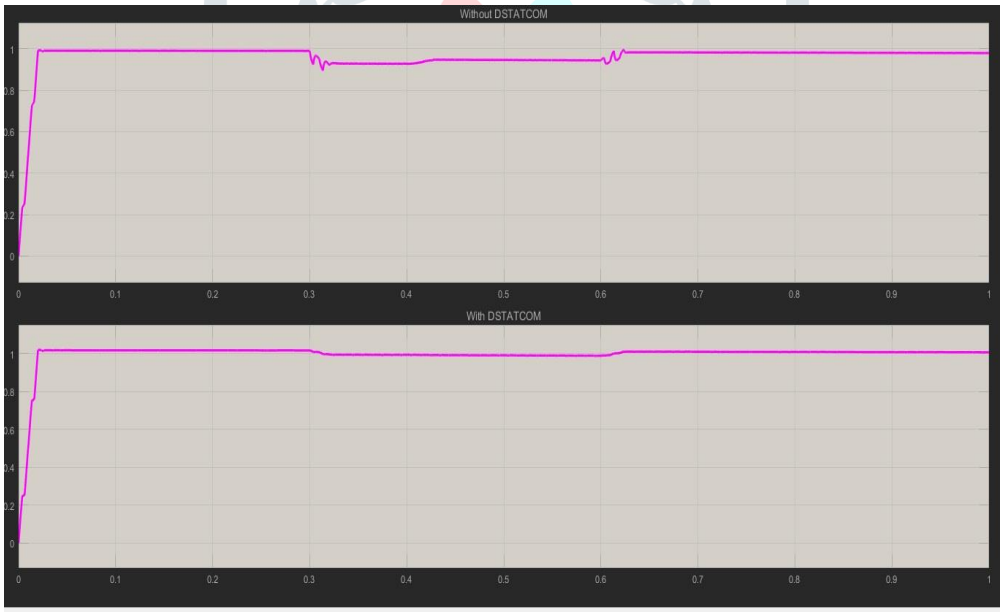

Figure 10: Double line to Ground Fault with and without D-STATCOM

Case 6: Voltage Swell Condition

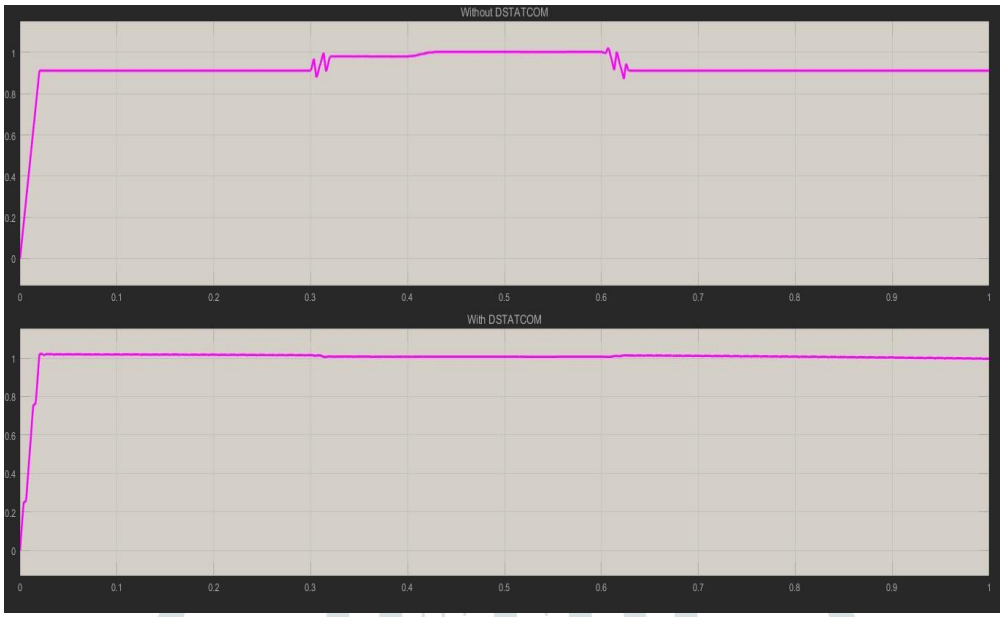

Figure 11: Voltage Swell condition

Conclusion

In this paper, the D-STATCOM is implemented in enhancing the power quality by mitigation of the voltage sag and swell in the distributed network system under different fault conditions. For this process the PI controller is involved. The work process is done by the help of MATLAB/Simulink. The tests are carried out at different fault conditions. The simulation result includes both the graph of with and without D-STATCOM with a clear view of comparison between them.

The Sinusoidal Pulse Width Modulation (SPWM) method is used for the processing of VSC. The universal bridge (IGBT) is used for the switching of the D-STATCOM.

The simulation gives the output that proves that the D-STATCOM is a useful tool in the minimization of voltage sag and swell. In the end, it can be stated that the D-STATCOM can be effectively used for power quality correction of the condition of voltage sag and swell.

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