Modeling and Simulation of D-STATCOM for Mitigating Power Quality Problems in Distribution System

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Abstract-*This paper introduces the reenactment of Distributed STATCOM to relieve significant power quality issues, voltage droop and swell. Control quality is immaculate power supply that is without clamor and is dependably inside the voltage and recurrence resilience limits. Synchronization includes voltage, recurrence and stage point controlling for better execution of electrical frameworks. Voltages hang and swell use to be the significant issues related with Distribution framework. To take care of these issues, custom power gadgets are utilized. A standout amongst the best and proficient custom power gadget is Distribution STATCOM (D-STATCOM). D-STATCOM is setup to reinforcement the power framework amid voltage hang and swells conditions. The control of the Voltage Source Converter (VSC) is finished with the assistance of Sinusoidal PWM method. This paper examination the change in the power amid voltage list and swell while utilizing D-STATCOM in various blame conditions. The proposed D-STATCOM is demonstrated and mimicked utilizing MATLAB/SIMULINK programming.*

Keywords-Distribution STATCOM (D-STATCOM), MATLAB/SIMULINK, Power quality problems, Sinusoidal Pulse Width Modulation (SPWM), Voltage sag and swell, Voltage Source Converter (VSC)

I. INTRODUCTION

In today's world there is great importance of electrical energy as it is the most famous from of energy and all are massively relying on it. Without supply of electricity life cannot be imagined. At the same time the quality and continuousness of the electric power supplied is also very important for the efficient functioning of the end user equipment. Many of the commercial and industrial loads require high quality undisturbed and constant power. Thus maintaining the qualitative power is topmost important in today's world.

Due to power electronics devices there is serious effect on quality and continuousness of electric supply. Because of power electronics devices there is uninterrupted power supply, flicker, harmonics, and voltage fluctuations e.tc. There are also power quality problems such as voltage rise/dip due to network faults, lightning, switching of capacitor banks. With the excessive uses of non-linear load (computer, lasers, printers, rectifiers) there is reactive power disturbances and harmonics in power distribution system. It is very essential to overcome this type of problems as its effect may increase in future and cause adverse affect. Traditionally passive filters were used for reactive power disturbances and harmonics generation but there are many problems with them like they are large in size, resonance problem, and effect of source impedance on performance.

The modeling of these complex systems that contains both power circuits and control systems can be done different bases. One of those power electronic solutions to the voltage regulation is the use of a Distribution STATCOM [1] (D-STATCOM). DSTATCOM is a class of custom power devices for providing reliable distribution power quality. They employ a shunt of voltage boost technology using solid state switches for compensating voltage sags and swells. The DSTATCOM applications are mainly for sensitive loads that may be drastically affected by fluctuations in the system voltage.

II. POWER QUALITY

Electricity consumers face power quality problem at all stages of usage. Actually, Power quality defines the assets of power supply distributed to the users in normal operating conditions. New electronic equipments and devices are more prone to power quality problems. Reduced PQ has become a major problem for both power suppliers and customers. Poor PQ means there is enough variation in the power supply to affect equipments and may lead to their mis-operation or failure. It is unfeasible to completely control disturbances on the supply system but efforts and investments are made by utilities to avoid interruptions. Normal operations such as switching loads and capacitors or faults and opening of circuit breakers to clear faults mainly cause disturbances. Faults are commonly caused by incidents such as lightning, birds flying close to power lines and getting electrocuted, and accidental acts such as trees or equipment contacting power lines.

The power disturbances occur on all electrical systems, the sensitivity of today's sophisticated electronic devices make them more susceptible to the quality of power supply. For some sensitive devices, a momentary disturbance can cause scrambled data, interrupted communications, a frozen mouse, system crashes and equipment failure etc [5]. A power voltage spike can damage valuable components. Power quality problems encompass a wide range of disturbances such as voltage sags, swells, flickers, harmonic distortion, impulse transients, and interruptions.

Power quality problems encompass a wide range of disturbances such as Voltage Sags, Voltage Swells, Harmonic Distortion, Impulse Transients, and Interruptions.

The voltage sags in power system under IEEE 1159-1995 standard is the reduction of the magnitude of voltage supply in a short time, since 0.5 cycles until a minute and return to normal conditions as shown in Fig. 1.1. The r.m.s value of voltage between0.1 p.u. and 0.9 p.u. compared with the voltage of the system is 1.0 p.u. There are two important variables, the magnitude and duration of voltage sag.

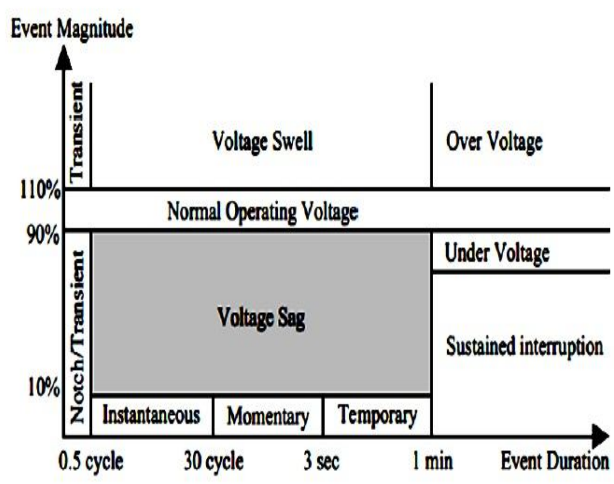

Figure 1: Voltage Reduction Standard of IEEE Std. 1159-1995

III. METHDHOLOGY

3.1 Distributed Static Compensator (DSTATCOM)

The distribution STATCOM is similar to a transmission STATCOM in that it uses a VSC of the required rating. The main task a shunt connected solid state device which is installed at the Distribution level so as to control the load side disturbances. The first DSTATCOM, a SVC with Voltage Source Converter was employed in 1999. It has overcome the synchronous condenser because of its lower investment cost, better dynamics, no inertia, lower operating and maintenance cost. A power VSC based on high power electronic technologies is the heart of DSTATCOM [4]. DSTATCOM provides reactive power compensation in ac networks. The voltage source converter controls the exchange of reactive power between the DC voltages storage device and the AC system through the leakage reactance of a transformer. DSTATCOM constantly verifies the line waveform with respect to the reference ac signal so as to provide the sufficient quantity of leading or lagging reactive current compensation to decrease the voltage fluctuations. A DSTATCOM is similar to STATCOM with the difference that STATCOM is used at the transmission level to control fundamental reactive power and to offer voltage support whereas a DSTATCOM is used at the distribution level for voltage regulation and correcting the power factor. DSTATCOM can also be employed to eliminate the total harmonic distortions; voltage sags and swells [3]. Moreover, a DSTATCOM can act as a shunt active filter, to reduce unbalance or distortions in the source current or the supply voltage.

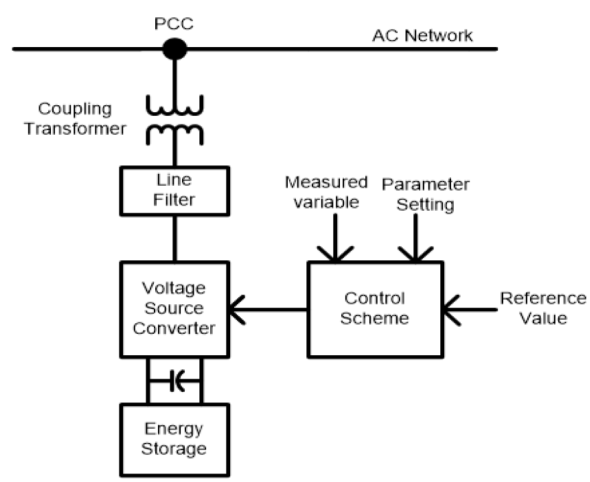

Figure 2: Schematic Representation of the DSTATCOM

3.2 Solution for Power Quality Problems

There are two approaches to mitigate the power quality problems. The solution to the power quality can be done from customer side or from utility side; first approach is called load conditioning, which ensures that the equipment is less sensitive to power disturbances, allowing the operation even under significant voltage distortion. The other solution is to install line conditioning systems that suppress or counteract the power system disturbances. Currently they are based on PWM converters and connect to low and medium voltage distribution system in shunt or in series. Series active power filters must operate in conjunction with shunt passive filters in order to compensate load current harmonics. Shunt active power filters operate as a controllable current source and series active power filters operate as a controllable voltage source. Both schemes are implemented in preferable with voltage source PWM inverters, with a dc bus having a reactive element such as a capacitor.

IV. SINUSOIDAL PWM BASED CONTROL

Sinusoidal Pulse Width Modulation (SPWM) technique is used to control the fundamental component of the line-to-line converter voltage. Three-phase converter voltages are obtained by comparing the same triangular voltage with three sinusoidal control voltages as shown in Fig. 4.6 The aim of the control scheme is to maintain constant voltage magnitude at the point where a sensitive load is connected, under system disturbance. The control system only measures the r.m.s voltage at the load point i.e., no reactive power measurements are required [2]. The VSC switching strategy is based on sinusoidal PWM technique which offers simplicity and good response. The PI controller process identifies the error signal and generates the required angle δ to drive the error to zero, i.e., the load rms voltage is brought back to the reference voltage. In the PWM generator, the sinusoidal signal Vcontrol is compared against a triangular signal (carrier) in order to generate the switching signals for the VSC values. The main parameters of the sinusoidal PWM scheme are the amplitude modulation index Ma of signal Vcontrol and the frequency modulation index Mf of the triangular signal. The amplitude index Ma is kept fixed at 1 pu.

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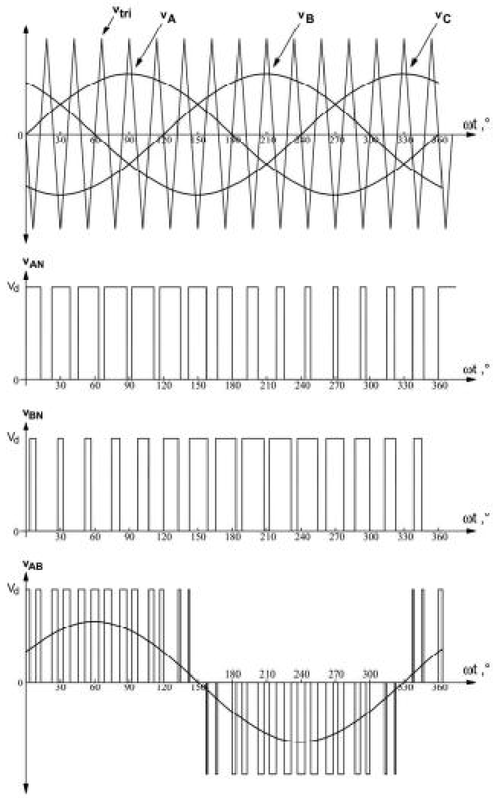

Figure 3: Sinusoidal Pulse Width Modulation Techniques

V. DSTATCOM MODELING FOR VOLTAGE SAG AND SWELL CONDITIONS

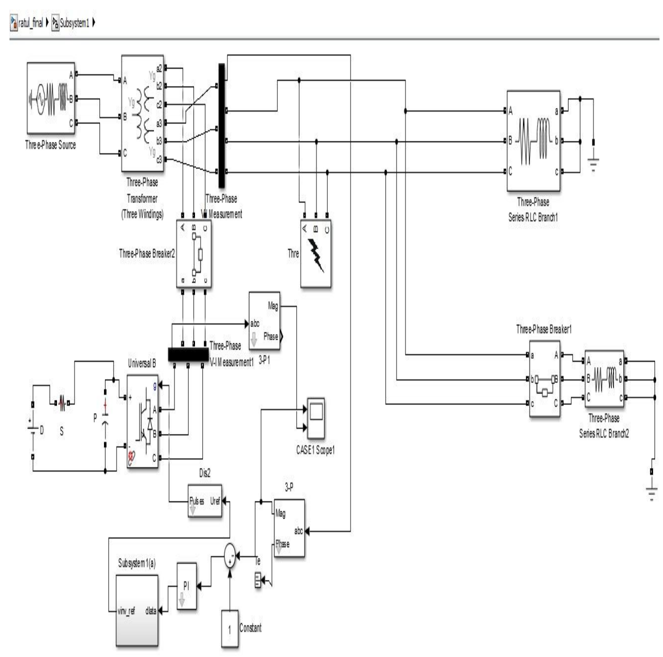

Figure 4:Control scheme and test system implemented in MATLAB/SIMULINK to carry out the D-ST ATCOM simulations.

VI. RESULTS

6.1 Results for Voltage Sag Cases

The main reenactment is managed without D-STATCOM when a three-stage impede is connected with a blame resistance of 0.2 Ω amid the time of 0.3-0.6 seconds. The second reproduction is done utilizing an indistinguishable situation from above, yet now D-STATCOM is associated with the framework, then the voltage list is moderated totally, appeared in figure 5.1

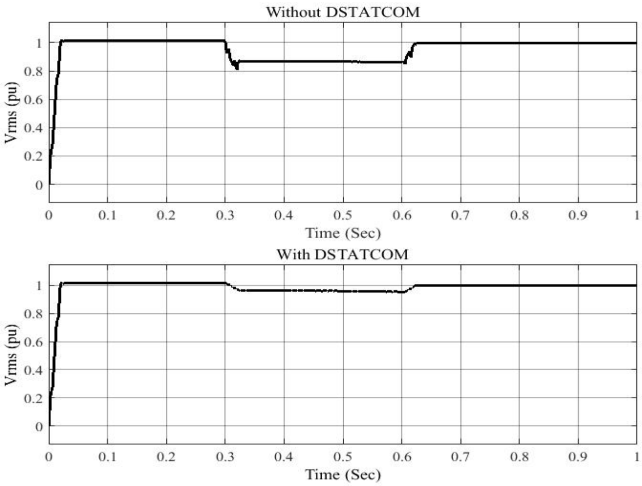

Figure 5.1: Voltage at load point during three phase short circuit fault without DSTATCOM and with DSTATCOM

The main reenactment is managed without D-STATCOM when a three-stage impede is connected with a blame resistance of 0.2 Ω amid the time of 0.3-0.6 seconds. The second reproduction is done utilizing an indistinguishable situation from above, yet now D-STATCOM is associated with the framework, then the voltage list is moderated totally, appeared in figure 5.2

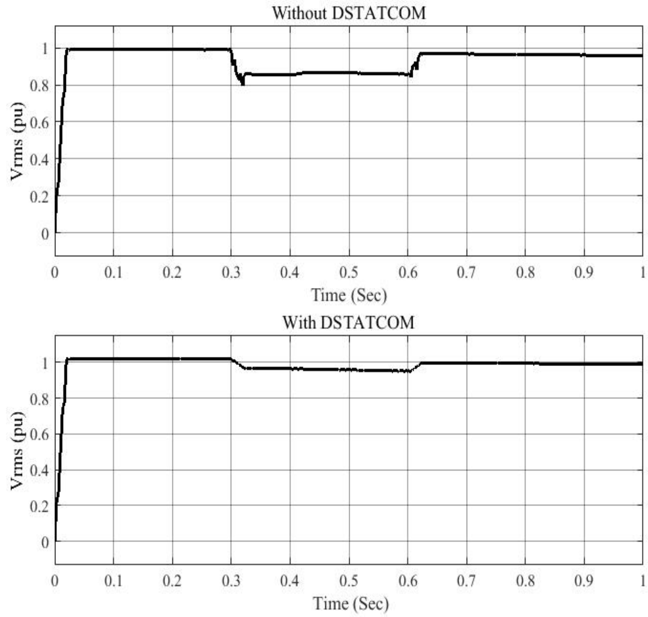

Figure 5.2:Voltage at load point during three phase ground fault without DSTATCOM and with DSTATCOM

The main reenactment is managed without D-STATCOM when a three-stage impede is connected with a blame resistance of 0.2 Ω amid the time of 0.3-0.6 seconds. The second reproduction is done utilizing an indistinguishable situation from above, yet now D-STATCOM is associated with the framework, then the voltage list is moderated totally, appeared in figure 5.3

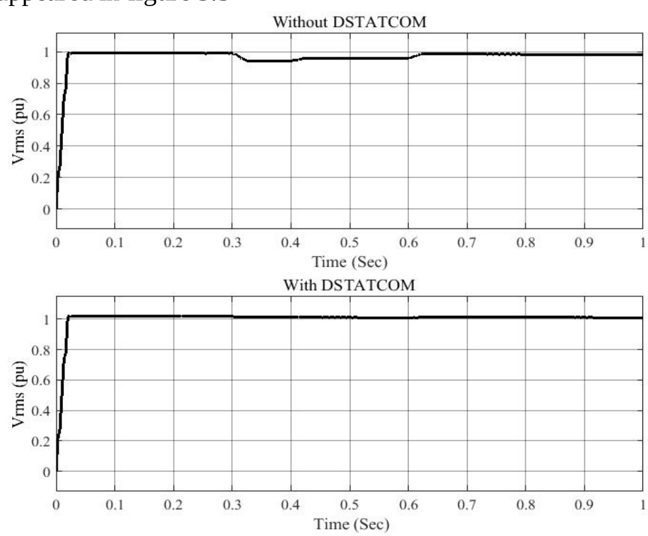

Figure 5.3: Voltage at load point during line-ground fault without DSTATCOM and with DSTATCOM

The main reenactment is managed without D-STATCOM when a three-stage impede is connected with a blame resistance of 0.2 Ω amid the time of 0.3-0.6 seconds. The second reproduction is done utilizing an indistinguishable situation from above, yet now D-STATCOM is associated with the framework, then the voltage list is moderated totally, appeared in figure 5.4

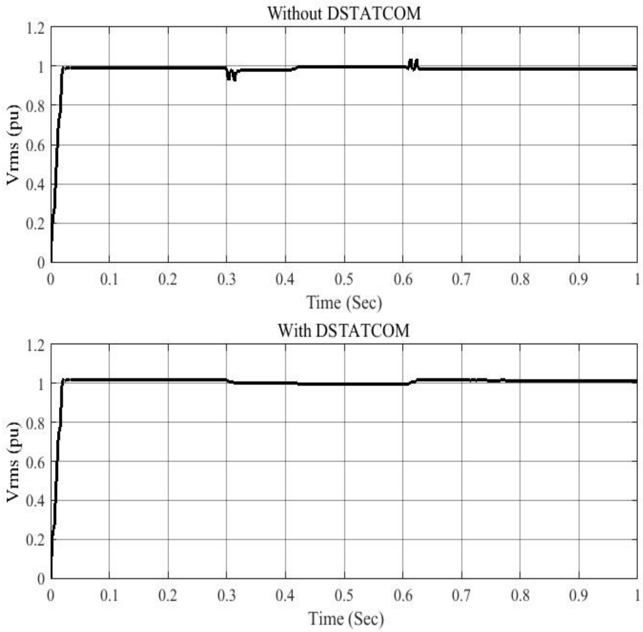

Figure 5.4:Voltage at load point during line-line fault without DSTATCOM and with DSTATCOM

The main reenactment is managed without D-STATCOM when a three-stage impede is connected with a blame resistance of 0.2 Ω amid the time of 0.3-0.6 seconds. The second reproduction is done utilizing an indistinguishable situation from above, yet now D-STATCOM is associated with the framework, then the voltage list is moderated totally, appeared in figure 5.5

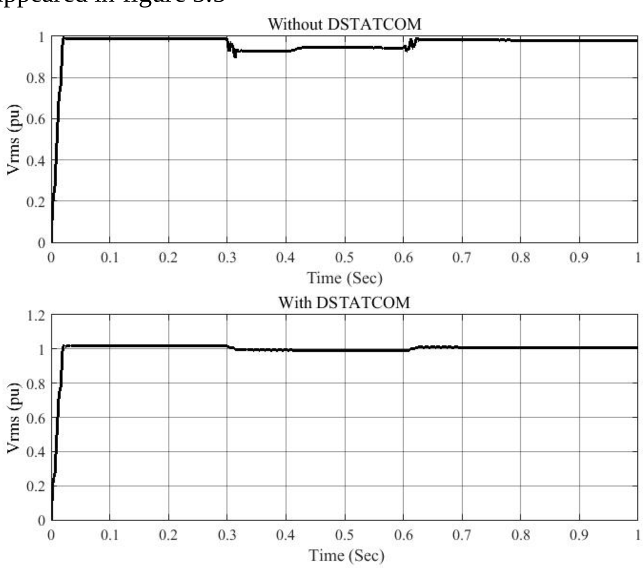

Figure 5.5:Voltage at load point during line-line-ground fault without DSTATCOM and with DSTATCOM

6.2 Result for Voltage Swell Case

The main recreation has no D-STATCOM when three stage blame shows up with a blame resistance of 0.2 Ω amid the time of 0.3-0.6 seconds. The second reproduction is done utilizing an indistinguishable situation from above, yet now D-STATCOM is associated with the framework, then the voltage swell is moderated totally, appeared in figure 5.6.

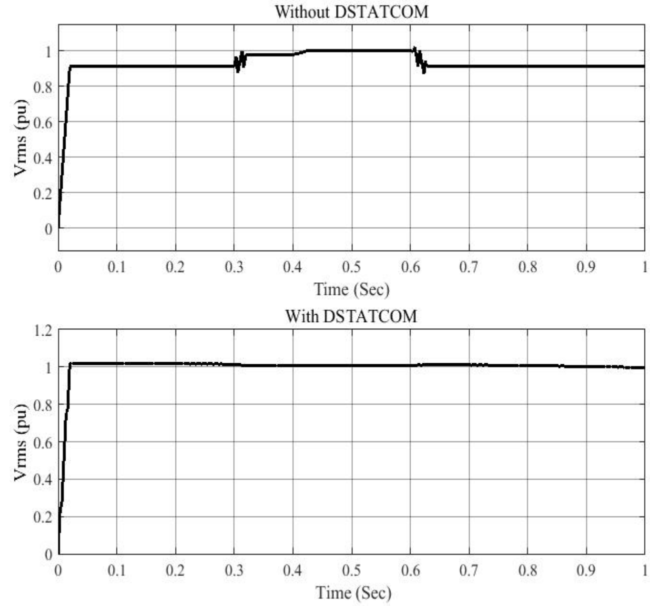

Figure 5.6:Voltage at load point during voltage swell condition without DSTATCOM and with DSTATCOM

VII. CONCLUSION

In this paper, the examination with respect to Distributed Static Synchronous Compensator (D-STATCOM) can reimburse the voltage list and swells under defective condition. The power quality issues, for instance, voltage list and swell remunerating systems of custom power electronic contraption D-STATCOM was presented. The arrangement and uses of D-STATCOM for voltage hang, swells and thorough results were shown. The Voltage Source Change over (VSC) was realized with the help of Sinusoidal Pulse Width Modulation (SPWM). The control plan was attempted under a broad assortment of working conditions, and it apparently was to a great degree effective for every circumstance. For showing and reenactment of a D-STATCOM by using the tremendously made reasonable workplaces open in MATLAB/SIMULINK were used. The reenactments did here show that the D-STATCOM gives for the most part better voltage control capacities.

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