Mitigation of Voltage swell by DSTATCOM

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Abstract— Static Synchronous Compensator (STATCOM) is a device based on a voltage source converter which shunt connected to the grid. The STATCOM goes one step further than SVC and is capable of improving the power quality against even voltage dips and flickers. The advantages of a STATCOM are that the reactive power provision is independent from the actual voltage on the connection point. In this work MATLAB based simulation of STATCOM and its related analysis is done. In this paper the voltage swell is done by heavy load and Circuit breaker and simulation of 11KV transmission line with and without DSTATCOM is done and different faults are applied to the system and analysis of voltage swell is done. The respected simulations are being shown.

Index Terms—Voltage Swell, Power quality, PI controller, PID controller

I. INTRODUCTION

Different power quality problems like voltage sag, voltage swell, blackout, brownout and flash over are necessary to mitigate for power quality purpose. Different FACTS devices are used to mitigate swell in this STATCOM is used.

II. INTRODUCTION OF SWELL

Originally referred to as surges were similar to sags, except that the voltage exceeded a user-defined high limit [2].Swell - an increase to between 1.1 pu and 1.8 pu in rms voltage or current at the power frequency durations from 0.5 to 1 minute. Swells are treated under a single category.

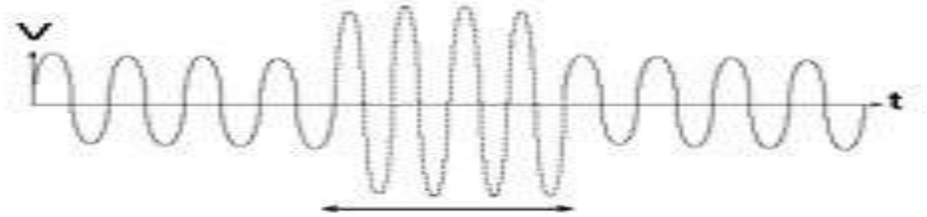

Figure 1 Introduction of swell

A common underlying cause of sags and swells in all three areas is a sudden change of current flow through the source impedance. A swell can occur due to a single line-to- ground fault on the system, which can also result in a temporary voltage rise on the undaunted phases.

III. BASIC CONFIGURATION AND FUNCTION OF DISTRIBUTION STATIC COMPENSATOR (D-STATCOM)

In its most basic form, the D-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 [5].

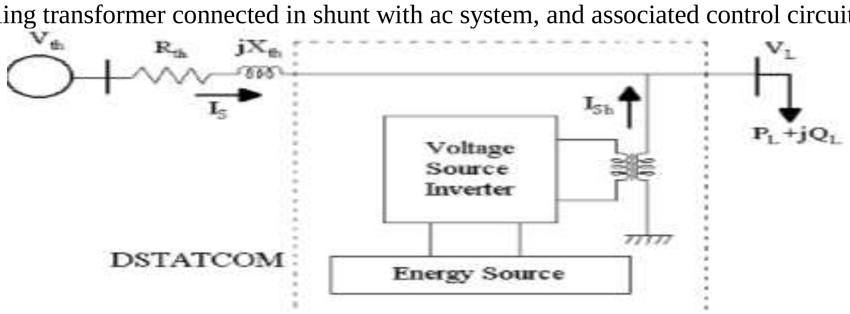

Figure 2 Basic configuration of DSTATCOM

It operates in a similar way as the STATCOM device, with active power flow controlled by the angle between the AC system and VSC voltages and the reactive power flow controlled by the difference between the magnitudes of these voltages.

IV. PROPORTIONAL INTEGRAL DERIVATIVE (PID) CONTROLLER:

Term P is proportional to the current value where error is positive the control output will be large and positive taken in to account gain factor K. Term I account the past value of set point and integrate over the time. When the error is eliminated the integral term will cease to grow.

Term D is a best to eliminate the future trend of the set point based on its rate of change of current. More rapid the change grater the controlling or dampening effect. The mathematical model and practical loop above both use a "direct" control action for all the terms, which means an increasing positive error results in an increasing positive control output for the summed terms to apply correction. However, the output is called "reverse" acting if it is necessary to apply negative corrective action. For instance, if the valve in the flow loop was 100–0% valve opening for 0–100% control output meaning that the controller action has to be reversed. Some process control schemes and final control elements require this reverse action. An example would be a valve for cooling water, where the fail-safe mode, in the case of loss of signal, would be 100% opening of the valve; therefore 0% controller output needs to cause 100% valve opening.

The mathematical form:

$$U(t) = k_p\, e(t) + k_i \int_0^t e(t')dt' + k_d\ \frac{de(t)}{dt}$$

Where k_p, K_i and K_d are non-negative denotes the co efficient for the proportional, integral and derivative control.

V. MATLAB SIMULINK MODEL OF DSTATCOM FOR MITIGATION OF SWELL

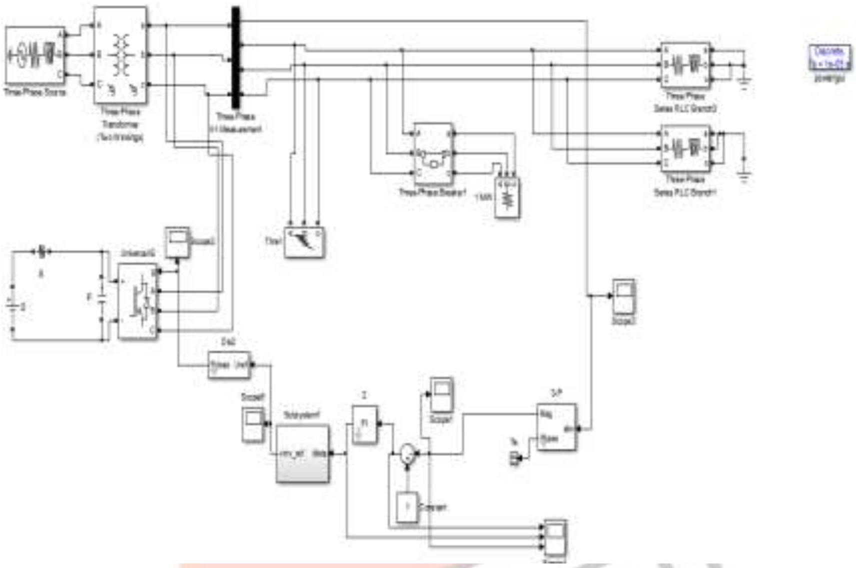

Figure 3 MATLAB Simulink model of DSTATCOM for mitigation of swell

As shown in figure 5.15 for swell Initially CB is close and very high load is connected to the system and suddenly that heavy load will disconnect by opening the CB between 0.4 to 0.6 sec So voltage will increase in that particular time period which is called voltage swell for the transmission system. After connecting the DSTATCOM with the system DSTATCOM will mitigate that swell which is shown in waveforms.

[A] RESULT WHEN SWITCHING OF PHASE A FOR 0.4 TO 0.6 SEC WITHOUT DSTATCOM:

As shown in figure switching of phase A and B is done for 0.4 to 0.6 second and waveforms are taken without DSTATCOM and with DSTATCOM. As shown in results after connecting DSTATCOM it will mitigate the voltage swell.

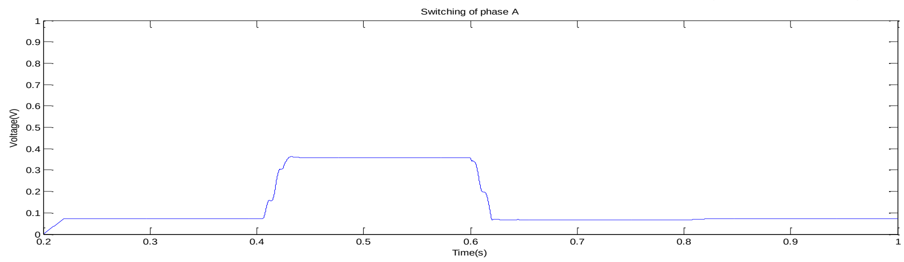

Figure 4 switching of phase A for 0.4 to 0.6 sec without DSTATCOM

[B] RESULT WHEN SWITCHING OF PHASE A FOR 0.4 TO 0.6 SEC WITH DSTATCOM:

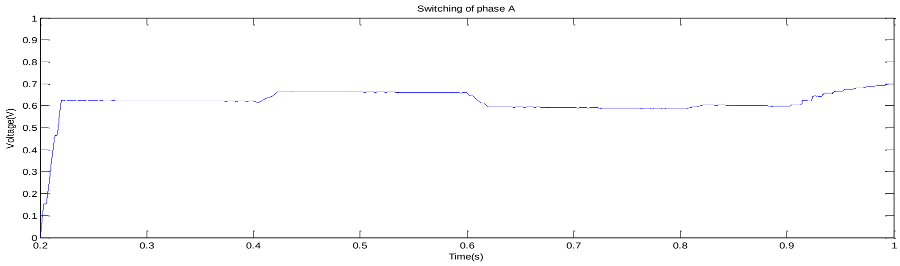

Figure 5 switching of phase A for 0.4 to 0.6 sec with DSTATCOM

[C] RESULT WHEN SWITCHING OF PHASE A AND B FOR 0.4 TO 0.6 SEC WITHOUT DSTATCOM:

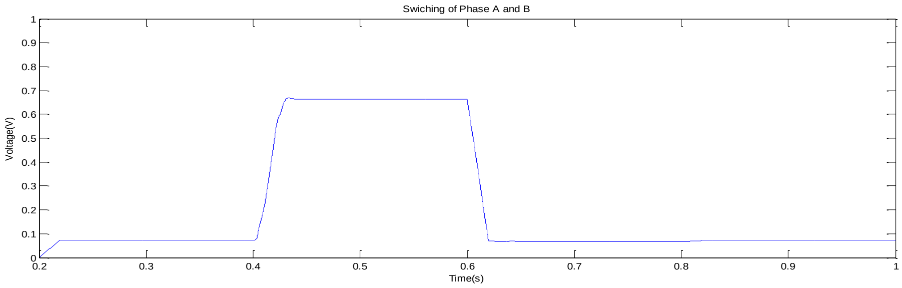

Figure 6 switching of phase A and B for 0.4 to 0.6 sec without DSTATCOM

[D] RESULT WHEN SWITCHING OF PHASE A AND B FOR 0.4 TO 0.6 SEC WITH DSTATCOM:

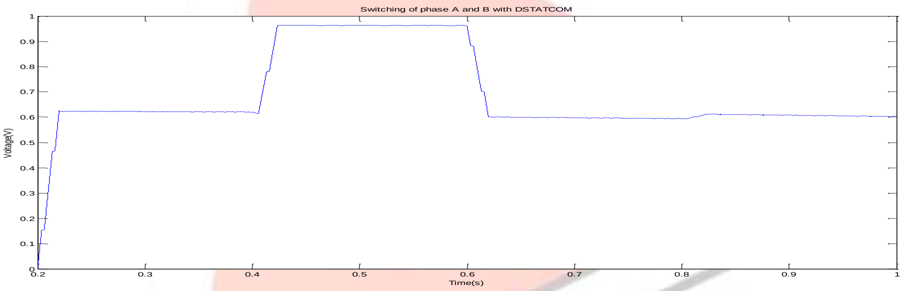

Figure 7 switching of phase A and B for 0.4 to 0.6 sec with DSTATCOM

VI COMPARATIVE ANALYSIS:

As shown in table comparative analysis is done for switching of phase A and B with and without DSTATCOM.

System voltage Without DSTATCOM	System voltage With DSTATCOM	Swell Voltage Without DSTATCOM	Swell Voltage With DSTATCOM	Voltage swell without DSTATCOM	Voltage swell with DSTATCOM
0.0728 (Switching of phase A and B)	0.624	0.365	0.663	0.292	0.039
0.0728(Switching of phase A)	0.62	0.6635	0.965	0.5907	0.345

VII MATLAB Simulink model of DSTATCOM for sag compensation by using PID controller:

As shown in figure 8 PID controller is used in place of PI controller for sag compensation and results are shown below which shows the rise time and settling time of controller.

As we can show the results the rise time and settling time of PI controller is higher compared to PID Controller. The output of system will remain same but the response time and rise time will change in PI and PID controller.

As shown in figure 9 PID controller is used for swell compensation as the output will remain same but the speed of response will change.

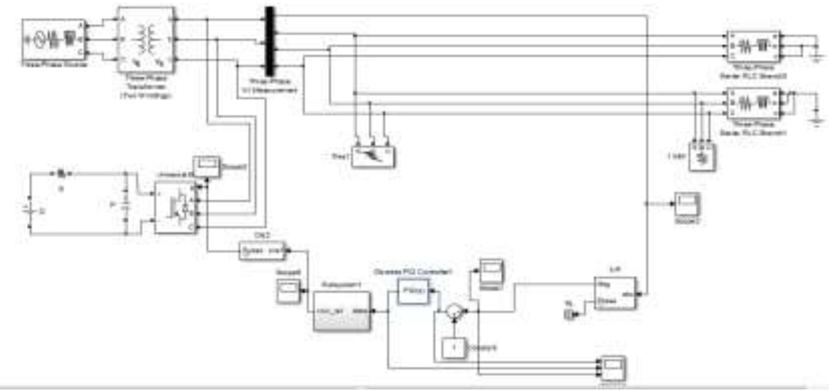

Figure 8 MATLAB Simulink model of DSTATCOM for sag compensation by using PID controller

VIII MATLAB Simulink model of DSTATCOM for swell compensation by using PID controller

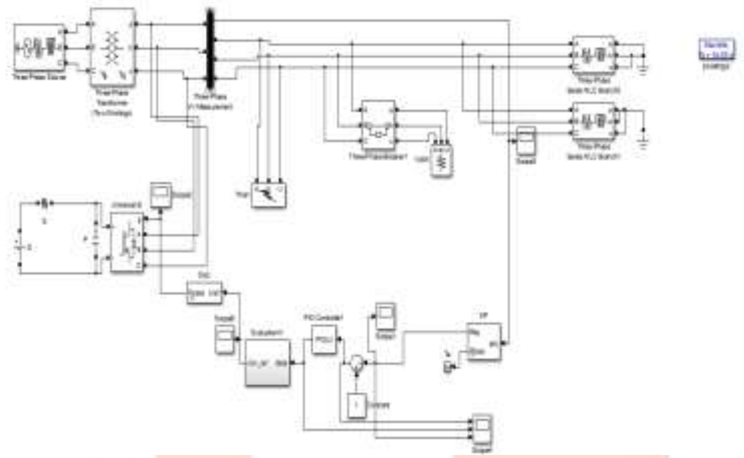

Figure 9 MATLAB Simulink model of DSTATCOM for swell compensation by using PID controller

[A] PI Controller:

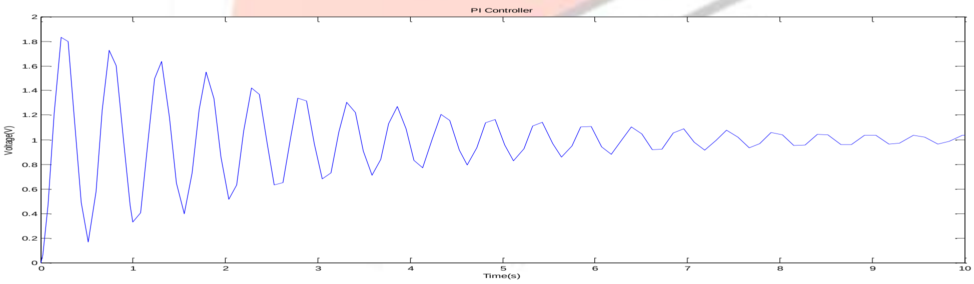

Figure 10 PI Controller

[B] PID controller:

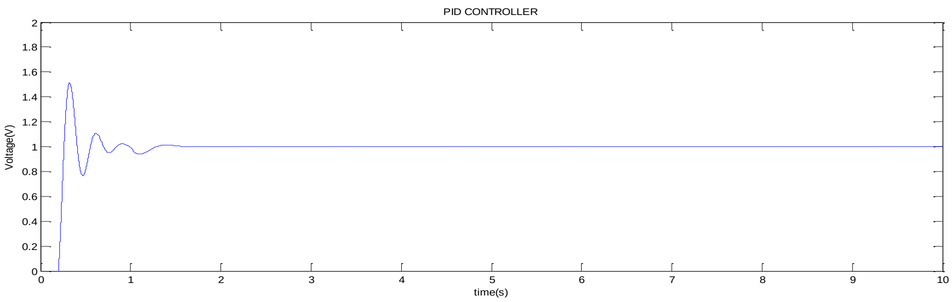

Figure 11 PID controller

IX COMPARATIVE ANALYSIS OF PI AND PID CONTROLLER:

Controller	Rise Time	Settling time
PI	1.83	10
PID	1.3251	2.1

X CONCLUSION:

According to the Simulink model voltage swell is created by heavy load and circuit breaker and mitigated with the help of DSTATCOM and results are shown and comparative analysis of switching of different phases like phase A only and Phase A and B. Analysis of different controller like PI (Proportional Integral) and PID (Proportional Integral Derivative) is done for sag and swell compensation. The comparative results of PI and PID are shown.

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