Improvement of Sag under Different Fault Conditions

N Saida Naik, A Sai Pallavi, L Srujana

Abstract: The improvement of power flow in a distributed system can be achieved by the FACTS compensator that is D-STATCOM (DISTRIBUTION_STATIC_COMPENSATOR) also known as which is shunt connected, is explained in this paper. To reduced the Sag-in-voltage issues(power quality issue), a Distribution-STATCOM is used which is connected at PCC (Point of Common Coupling). The advantage of quick operation of Distribution-STATCOM makes the it more efficient and hence power flow is improved. Varied controllers are utilized to operate the Distribution-STATCOM. To enhance the power flow, we are simulating and designing it with PI Controller. In distribution networks with linear balanced loads, their power flow can be increases at varied fault conditions such as L-L Faults (Line to Line), L-G Faults (Line to Ground), L-L-G Faults, L-L-L-G Faults. These faults are studied and simulated output waveforms are presented also calculating THD (Total Harmonic Distortion) with and without Distribution-STATCOM Compensator. The harmonics and Sag-in-volages due to L-G, LLG & LLLG faults in this proposed system are reduced and we can achieve enhanced power flow. The reduction of faults and true value of THD (Total-Harmonic-Distortion) can be simulated and studied in MATLAB.

Index Terms: DSTATCOM, PI, FAULTS, PWM

I. INTRODUCTION

In power system, loads are dynamically keeps changing with time and customer which make it even more difficult for forecasting. This leads to a great need of improving power utilization methods now-a-days. By maintaining accurate balance in both generated capacity and its demand, we can have optimized power flow.

Due to increased usage of inductive and capacitive load containing power electronics in recent years, this is causing power flow concerns (power pollution) in powersystems. Power flow issue is caused because of using IGBT based loads and non-linear loads in most of the power utilities. Swells and sags in voltage are the major power flow issue problems in utility distribution networks, which affects the sensitive loads connected with it. The usual compensating devices like capacitor bank parallel feeder, UPS are used to clear the Sag-in-voltages, however the usual compensating devices cannot resolve the power flow issues completely. Hence, custom power device is initiated to solve the problem related to the power flow. CPD’s solve the most of the power flow issues.

D-STATCOM and DVR are the efficient compensators which belonging to FACTS family. These FACTS devices which use the IGBT switches, are reliable and quick. We can have the control in the power flow in transmission line and parameters such as phase angle, line impedance and line voltage. Also FACTS devices improves the power transfer capability, we can mitigate Sag-in-voltages and Swells. The compensation of reactive power in the distributed system. By implementing the Pulse-Width modulation based control scheme, the electronic values of D-STATCOM are controlled to enhance the power flow during varied cases, which causes the power transmission issues.

II. LITERATURE SURVEY

Varied methods are used to mitigate the Sag-in-voltages problems, but a Custom Power Device (CPD) is the most efficient method. There are several types of CPD. CPD concept was introduced by Hingorani. N.G. CPD means the utilization of IGBT’s and controllers for the distribution systems. D-STATCOM is used for regulation of voltage, elimination of neutral current, correction of power factor and balancing of load in three-phase distribution system feeding domestic and commercial consumers. D-STATCOM will inject the reactive in distribution system and mitigate the Sag-in-voltages.

III. D-STATCOM

AD-STATCOM is a VSC based power electronic device. DSTATCOM are always shunted with electrical distribution system. Generally DSTATCOM can be connected to capacitor for back up and the energy is stored in capacitor in the form of DC. In Distribution system when D-STATCOM is connected before load, it injects the compensating currents into the line, so that to meet the total load demand requirements for utility supply. DSTATCOM generates reactive power internally in the capacitor and inductor. Its control operation is quick and capable to provide enough power to compensate reactive power in the test system.
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IV. CONTROLLER

The error in the desired set point and output can be controlled using the PI (Proportional Integral) controller which drives the test system to get the controlled output and the integral of that value. Figure 2 shows PI-SPWM controller. The PI-SPWM controller is a part of electrical distribution system.

PWM generator gives the Sine PWM waveform. To operate it, the PWM sine wave angle and the phase angle of the balanced supply voltage are added exactly separated by 120 degrees. Therefore, the required synced signal is obtained. The obtained error is given to the PI controller and the modulated signal is compared with a carrier signal, which gives pulses for the IGBT’s in the VSC.

V. SIMULATION RESULTS

The simulation diagram of test system of D-STATCOM is shown in fig.8. The stated test system has two feeders connected with an ideal three winding transformer and loaded with balanced linear loads. This stated test system is analyzed under varied fault conditions. The D-STATCOM invariant fault cases are tested with both un-balanced and balanced faults are simulated. In LG fault analysis, ‘A’ phase is subjected to fault, while in LLG fault analysis, the A phase and B phase are subjected to fault. In addition, in three phase fault, the A phase, B phase, and C phase are subjected to fault. In LL fault analysis, phase A and phase B are subjected to fault without ground terminal.

CASE I: WITHOUT DSTATCOM
Figure 4 to 7 show the simulation results of the test system of proposed system for varied types of fault conditions. The fault create during (0.6sec to 0.7sec) when the resistance of the fault, \( R_f = 0.6 \, \Omega \).

**Table 1: Sag-in-voltage of varied types of faults with varied fault resistances**

<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>0.6</td>
<td>0.626</td>
<td>0.677</td>
<td>0.809</td>
<td>0.735</td>
</tr>
<tr>
<td>0.7</td>
<td>0.681</td>
<td>0.723</td>
<td>0.834</td>
<td>0.771</td>
</tr>
<tr>
<td>0.8</td>
<td>0.727</td>
<td>0.762</td>
<td>0.855</td>
<td>0.802</td>
</tr>
</tbody>
</table>

From the table 1, it gives the Sag-in-voltage is reduced for increase of fault resistance value for varied types of fault.

**CASE II: WITH DSTATCOM**

Figure 9 to 12 display the simulated output of the test system of proposed system at varied fault conditions. The fault create during (0.6sec to 0.7sec) when the resistance of the fault, \( R_f = 0.6 \, \Omega \).

**Table 2: Sag-in-voltages at varied faults with varied fault resistances**

<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>0.6</td>
<td>0.920</td>
<td>0.967</td>
<td>0.972</td>
<td>1.000</td>
</tr>
<tr>
<td>0.7</td>
<td>0.940</td>
<td>0.975</td>
<td>0.980</td>
<td>1.010</td>
</tr>
<tr>
<td>0.8</td>
<td>0.948</td>
<td>0.980</td>
<td>0.983</td>
<td>1.014</td>
</tr>
</tbody>
</table>

From the table 2, Sag-in-voltages improved with combination of D-STATCOM in varied types fault conditions. The range of Sag-in-voltages in between (0.9pu to 1.014pu.)
Table 3: overall improvement of Sag-in-voltage with and without DSTATCOM

<table>
<thead>
<tr>
<th>TYPES OF FAULT</th>
<th>WITHOUT DSTATCOM (p.u)</th>
<th>WITHOUT DSTATCOM (p.u)</th>
<th>PERCENTAGE OF IMPROVEMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>LLLG</td>
<td>0.626</td>
<td>0.920</td>
<td>29.4%</td>
</tr>
<tr>
<td>LG</td>
<td>0.677</td>
<td>0.967</td>
<td>29%</td>
</tr>
<tr>
<td>LL</td>
<td>0.809</td>
<td>1.00</td>
<td>16.3%</td>
</tr>
</tbody>
</table>

From table 3 it observed that D-STATCOM improves the Sag-in-voltage at varied fault cases with varied resistance values.

VI. CONCLUSION

The DSTATCOM is in shunt with distribution system for improvement of the power flow problems. The VSC based shunt connected DSTATCOM successfully mitigates the one of the power transmission problems is Sag-in-voltage with the help of the sinusoidal Pulse Width Modulation control technique. The entire controlling action of DSTATCOM is performed by employing the PI controller in the controller circuit. The Simulation/MATLAB results shows the overall performance of shunt connected distributed static compensator (DSTATCOM) for mitigation of Sag-in-voltage under varied faults conditions.

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