Midpoint Voltage Regulation of Transmission Lines and compensation in Pakistan Scenario

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Abstract— When we need to transmit electrical power to a far places like from Mangla Dam to Gujranwala there is need of long transmission lines, we have to maintain the steady voltage level at sending to receiving end but due to different parameters of transmission line such as inductance, capacitance and resistance etc., losses occur and voltage regulation is necessary then we have to need the var compensators like SVC and STATCOM, Voltage regulating systems such as Static var Compensator (SVC) and STATCOM, when these are placed at the midpoint of a long transmission line, play an important role in controlling the reactive power flow to the power network and hence both the system voltage fluctuations and transient stability. In this project we’ll first calculate the voltage regulation, value of capacitance required to stabilize the var and explain the principle structures of STATCOM and the effect of this device on midpoint voltage regulation. Moreover, the performance of the STATCOM is compared with that of conventional static var compensator (SVC) under fault condition. At the last we’ll simulate our project in Mat lab using the tool named as POWER_STATCOM and conclude that STATCOM is effective in midpoint voltage regulation on transmission line than SVC.

Keywords AC Power transmission, Voltage Regulation, SVC, STATCOM.

I. INTRODUCTION

As we know that at Electric power generating station are mostly far away from distribution station so that we require long transmissions to facilitate the consumers. And due to those long transmission lines losses occurs due to inductive, capacitive and resistive parameters. and voltage drop occurs from sending end to receiving end. Moreover the most of the appliances used in commercial and houses are inductive like fans, heavy duty motors, water pumps, transformer etc. These appliances feedback var power to the source which can melt out the source winding that is very dangerous for source. Var power feedback effects on source and power factor.

One way to control and damp voltage oscillations is by injection of leading or lagging reactive current at and around the point of connection. There are various shunt connected FACTS devices; the major ones in terms of applications are the static VAR compensator (SVC) and static synchronous compensator (STATCOM). SVCs are well known to improve power system properties such as steady state stability limits, voltage regulation and var compensation, dynamic over voltage and under voltage control, counteracting subsynchronous resonance, and damp power oscillations [1-2]. STATCOM is basically a voltage source converter, VSC that converts a dc voltage at its input terminals into three-phase ac voltages at fundamental frequency of controlled magnitude and phase angle. The basic principle of operation of a STATCOM is the generation of a controllable AC voltage source behind a transformer leakage reactance by a voltage source converter connected to a DC capacitor. The voltage difference across the reactance produces active and reactive power exchanges between the STATCOM and the power system [3]. We discuss in this paper response of STATCOM and SVC.

Figure 1 Power Diagram

II. PERCENTAGE VOLTAGE REGULATION

Let us consider how to calculate the voltage Drop and regulation of short transmission line:

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Line Load Voltage</td>
<td>11KV</td>
</tr>
<tr>
<td>frequency</td>
<td>50Hz</td>
</tr>
<tr>
<td>Resistance</td>
<td>0.279 Ω</td>
</tr>
<tr>
<td>Reactance</td>
<td>0 Ω</td>
</tr>
</tbody>
</table>
Power factor | 0.8
---|---
Length From source to first load | 1.732x1000x0.8 = 98 Amp.

**Voltage drop at Load A**

\[
A (I) = KW / 1.732xVoltxP.F [4]
A (I) =1500 / 1.732x11000x0.8 = 98 Amp.
\]

Required No of conductor / Phase = 98 / 205 = 0.47 Amp

\[
Vd = ((\sqrt{3}x (R\cos\phi+X\sin\phi) x I) / (Z/Phase x1000)) x L
Vd = ((1.732x (0.272x0.8+0x0.6) x98) / 1x1000) x1500)
= 57 Volt
\]

\[
V_r = V_s-V_d= (1100-57) = 10943 Volt.
% V.R = ((Vs-Vr) / Vr) x100
% V.R = ((11000-10943) / 10943) x100
= 0.52%
\]

**III. MATLAB STATCOM SIMULATION MODEL**

**Table I.** The parameter values of the system

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Source Voltage</td>
<td>500KV</td>
</tr>
<tr>
<td>Frequency</td>
<td>60Hz</td>
</tr>
<tr>
<td>Source Power</td>
<td>3000MVA</td>
</tr>
<tr>
<td>Total Line Length</td>
<td>600Km</td>
</tr>
<tr>
<td>Equivalent Impedance of STATCOM</td>
<td>0.22pu</td>
</tr>
<tr>
<td>Equivalent Capacitance of STATCOM</td>
<td>375uF</td>
</tr>
<tr>
<td>Modulation Frequency</td>
<td>1.68kHz</td>
</tr>
<tr>
<td>DC Link Voltage</td>
<td>40KV</td>
</tr>
</tbody>
</table>

Set these table values in above model in Fig.3.

**IV. SIMULATION RESULTS**

Open the STATCOM by writing command “power_statcom” in matlab main window dialog box will open in a while and Double click on STATCOM box and verify the following parameters:

"Display" is set to “Control parameters”
"Mode of operation" is set to “Voltage regulation” and that "External control of reference voltage V_{ref}" is selected. Also, "Droop" =0.03 and the "V_{ref} Regulator Gains" = [5 1000]

Close the STATCOM dialog block and open the "Step V_{ref}" block by double clicking on the box and set the parameters as follows:

"Time(s)"=[0 0.2 0.4 0.6]
"Amplitude"=[1 0.97 1.03 1]

Close the box and simulate the observe the both scope results shown in figure 4 & 5.

**Figure 4** V_{ref} signal along with the measured positive-sequence voltage V_m at the STATCOM bus
Now To see the effect of the regulator gains, set "V_{ac} Regulator Gains"=[10 2000]
And rerun the simulation. You should observe a much faster response with a small overshoot. Looking at the $V_m$ and $V_{ref}$ signals, you can see that the STATCOM does not operate as a perfect voltage regulator ($V_m$ does not follow exactly the reference voltage $V_{ref}$).

Now Set the "Droop" =0.03 and the "V_{ac} Regulator Gains"=[5 1000]
If you then run a simulation, you will see that the measured voltage $V_m$ now follows perfectly the reference voltage $V_{ref}$.

We programmed the fault breaker by selecting the parameters "Switching of phase A, B and C" and verify that the breaker is programmed as shown in figure 8 below.

And at the last, set the STATCOM
"Droop" = 0.03 and the "Vac Regulator Gains" = [5 1000]
Run the simulation and look at results. Fig. 9 and Fig. 10 show active and reactive power changes.

and how it is compensated by using different compensators like capacitor bank also known as SVC and STATCOM. In this project we explained how to calculate regulation of a transmission line and how we can regulate, stabilize and normalize the voltage. After regulation our power factor is improved and transmission becomes more reliable. Using Matlab tool we compare the compensators which one is more efficiently compensates var power and from simulation results it is prove that STATCOMs is more efficient than SVCs and can be preferred in industrial network grids and under distorted mains.

V. CONCLUSION
This work illustrates in detail how var power is generated and how it is compensated by using different compensators like capacitor bank also known as SVC and STATCOM. In this project we explained how to calculate regulation of a transmission line and how we can regulate, stabilize and normalize the voltage. After regulation our power factor is improved and transmission becomes more reliable. Using Matlab tool we compare the compensators which one is more efficiently compensates var power and from simulation results it is prove that STATCOMs is more efficient than SVCs and can be preferred in industrial network grids and under distorted mains.

REFERENCES