Enhancement Of Power Quality Under Different Fault Conditions And Harmonic Elimination By Using D-Statcom

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Abstract— this paper mainly focuses on power quality with D-STATCOM Due to the non-standard voltage, frequency, and current at distribution side. In this paper the role of D-STATCOM (Distribution Static Compensator) are located at load side in electrical distribution system under normal operating and fault conditions is examine. Here D-STATCOM is used as a FACTS device which can compensate the reactive power. D-STATCOM is a voltage source converter; it can be used to compensate the voltage and make the system stable by compelling and generating reactive power. Here by using D-STATCOM to compensate the problems in distribution system such as voltage sag, voltage instability, in power systems with different fault conditions for LG, LLG, 3-phase, LCL filter The D-STATCOM injects a current into the system to mitigate the voltage sags. LCL Passive Filter was then added to D-STATCOM to improve harmonic distortion and low power factor in power faults. Here Simulink model and control system is designed in MATLAB/SIMULINK.

Index Terms — D-STATCOM, distribution system, voltage sag, voltage source converter, harmonics.

1. INTRODUCTION:

The In recent years, Power engineers are increasingly concerned over the quality of the electrical power. Presently in modern industries, load equipment’s uses electronic controllers which are sensitive to poor voltage quality and will shut down if the supply voltage is and may mal-function in other ways if harmonic Distortion of the supply voltage is unrestricted. D-STATCOM [3] gives a fast response and it makes the efficient results for upgrading the power quality at distribution system. Here the D-STATCOM is used with PI controller [7] to improve the power quality under different untypical conditions. Due to the non-linear loads in the distribution system which results voltage distortions and power quality problems. In order to avoid the power quality problems, they are so many mitigation techniques here D-STATCOM basically a voltage source converter based FACTS[4] devices and STATCOM is located in transmission line[1]. A STATCOM at transmission line which can be handle only reactive power and give the voltage support. The D-STATCOM is actively used in load side it also behaves like a shunt active filter. The shunt active power filters which injects the negative harmonic currents in to the line to cancel the harmonics generated by the non-linear loads. [5]This illustrates the concept of harmonic current cancellation. Current being supplied by the source is sinusoidal. The main application of STATCOM is D- STATCOM exhibit high speed control of reactive power to provide voltage stabilization in power system.

II. VOLTAGE SOURCE CONVERTERS (VSC):

A voltage-source converter is a power electronic device, which can produce a sinusoidal [2]voltage with any demand magnitude, frequency and phase angle. Voltage source converters are mainly used in adjustable speed drives. But it can also be used to mitigate the voltage sags. Voltage source
converters are used either completely substitute the voltage. D-STATCOM[8] can be functioned to correcting the voltage sag depending up on the depending up on the value of Zth or fault level of the load bus. When the shunt injected current Ish is kept in quadrature with VL the desired value can be achieved without correcting the active power in to the system. On the other hand Ish value is minimised. With minimum apparent power[8] injection into the system the same voltage correction can be achieved the converter is normally based on some kind of energy storage, which will supply the converter with a DC voltage. The solid-state electronics in the converter is then switched to get the desired output voltage. Normally the voltage source converter is not only used for voltage sag mitigation, but also for other power quality issues.

FIGURE1: VOLTAGE SOURCE CONVERTER

III. D-STATCOM

The Distribution Static Compensator (DSTATCOM) is a voltage source inverter. Here D-STATCOM is used as a shunt voltage controller[9]. Which is shown in fig.1? it consists of a two-level Voltage Source Converter (VSC), a dc energy storage device, a coupling transformer connected in shunt to the distribution network through a coupling transformer. The voltage source converter which converts dc voltage across the storage device into a set of three-phase ac output voltages. These voltages are in phase

\[ I_{sh} = I_L - I_s = I_L - (\frac{(V_{m} - V_L)}{Z_{th}}) \]  \hspace{1cm} (1)

\[ I_{sh} \eta=I_L - O-V_{m}/Z_{th} (\delta-\beta)+V_{s} /Z_{th} - \beta \] \hspace{1cm} (2)

The complex power injection of the D-STATCOM can be expressed as,

\[ S_{sh} = V_{L} \cdot I_{sh} \] \hspace{1cm} (3)

IV. FUNCTION OF D-STATCOM:

The aim of the control schema is to maintain constant voltage magnitude under system disturbances at the point where a sensitive load is connected [13]. The control system measures RMS voltage at the point where no reactive power measurements are required. A sinusoidal PWM technique based VSC switching strategy offers simplicity and good response PWM methods offer a more flexible option than the Fundamental Frequency Switching (FFS) methods favoured in FACTS applications as custom power is a relatively low-power application. High switching frequencies can be used to improve the efficiency of the converter without significant switching losses [15]. The controlled input can be obtained from the reference voltage and the value RMS of the terminal voltage to inject the absent voltage. The absent voltage is the difference between the nominal voltage and actual Measured and it is an error signal.
FIGURE3: PI CONTROLLER
The output is the angle δ, which is provided to the PWM signal generator and is processed by a PI controller[14]. It is important to note that there is active and reactive power exchange with the network simultaneously. An error signal is obtained by comparing the reference voltage with the RMS voltage measured at the load point. The PI controller processes the error signal and generates required angle to drive the error to zero. This means the load RMS[12] voltage is brought back to the reference voltage.

FIGURE4: Active filter harmonic to cancel harmonic current
Active filters use active conditioning to compensate for harmonic current in a power system. Figure shows an active filter [16] applied in a harmonic environment. The filter samples the distorted current and, using power electronic switching devices, draws a current from the source of such magnitude, frequency composition, and phase shift to cancel the harmonics in the load. The result is that the current drawn from the source is free of harmonics. An advantage of active filters can respond to changing load and harmonic conditions, whereas passive filters are fixed in their harmonic response.

V. HARMONIC
Webster’s new world dictionary defines harmonics as pure tones marking up a composite tone in music. A pure tone is a musical sound of a single frequency, and a combination of many pure tones makes up a composite sound. Sound waves[7] electromagnetic waves traveling through space as a periodic function of time. Can the principle behind pure music tones apply to other functions or quantities that are time dependent? In the early 1800s [9], French mathematician, jean Baptiste Fourier formulated that a periodic non sinusoidal function of a fundamental frequency f, may be expressed as the sum of sinusoidal function of frequencies which are multiples of the fundamental frequency. In our discussions here, we are mainly consumed with periodic functions of voltage and current due to their importance in the field of power quality. In other applications, the periodic function might refer to radio frequency transmission, heat flow through a medium, vibrations of a mechanical structure, or the motions of a pendulum in a clock. A sinusoidal voltage or current that is dependent on time t, may be represented by the following expressions: Voltage function,
\[ v(t) = V \sin(\omega t) \]  [4]
Current function,
\[ c(t) = C \sin(\omega t + \delta) \]  [5]
Applying harmonic filters requires careful consideration. Series-tuned filters appear to be of low impedance to harmonic currents but they also form a parallel resonance circuit with the source impedance. In some instances, a situation can be created that is worse than the condition being corrected. It is imperative that computer simulations of the entire power system be performed prior to applying harmonic filters.

\[ IDH_n = \frac{I_n}{I_1} \]  [6]
\[ L_g = \frac{E_o}{\nu_{ripn}f_{sw}} \]  [7]
\[ I_c = \frac{L_g}{2} f_c \leq \frac{L + L_g}{L_g(2m_{sw})/2} \]  [8]
\[ 10f_n = \leq f_{res} \leq 0.5f_{sw} \]  [9]
V. MATLAB APPROACH OF TEST SYSTEM WITH AND WITHOUT D-STATCOM AND ITS FUNCTION:

In this system generating unit of 25kV, 50hz .the system consisting of D-STATCOM for simulation. The output of generating unit is connected to the primary windings of three phase transformer. Further it divided in to two parallel feeders of 11kV each can draw. In any one of the feeders D-STATCOM is connected other one is kept as it is. At the end of the feeder non-liner loads are connected consisting of D-STATCOM. Here PI controller is used to solve the section. The simulation is carried out between time 0.4 to 0.9 sec. During which circuit breaker is not connected to the power system, such as CB2 is closed when D-STATCOM is not in operating mode.

FIGURE: 5 Simulation Diagram for with and without D-STATCOM

FIGURE: 6 Simulation Diagram for with and without LCL filter

7.2.2 DOUBLE LINE TO GROUND FAULT:
7.2.2.1 FFT Analysis during Fault without D-STATCOM:

Total harmonic distor rations (THD):109.38%

7.2.1a Three phase to ground fault:

a) Voltage at load point is 0.7666 p.u

7.2.1b Three Phase Voltage Waveform Without D-STATCOM :

b) Voltage at load point is 0.788 p.u

Total harmonic distor rations (THD):109.38%
7.2.3 LINE TO LINE FAULT:

c) Voltage at load point is 0.833 p.u

7.2.4 SINGLE LINE TO GROUND FAULT:

d) Voltage at load point is 0.877 p.u

7.3 WITH D-STATCOM:

7.3.1a FFT Analysis during Fault with D-STATCOM

Total harmonic distortions (THD): 1.11%

a) Voltage at load point is 0.944%

7.3.1b Three Phase Voltage Waveform with D-STATCOM

7.3.2 DOUBLE LINE TO GROUND FAULT:

7.3.3 LINE TO LINE FAULT:

7.3.4 SINGLE LINE TO GROUND FAULT:

d) Voltage at load point is 0.988%

Without LCL filter:

7.3.1 FFT Analysis during Fault with D-STATCOM
Total harmonic distortions (THD): 48.26%

Three Phase Voltage Waveform With D-STATCOM:

- Voltage at load point is 0.983%

THD Comparison:

<table>
<thead>
<tr>
<th>Fault Resistance(Ω)</th>
<th>Without D-STATCOM</th>
<th>With D-STATCOM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voltage sags for TPG fault(p.u)</td>
<td>0.7666</td>
<td>0.944</td>
</tr>
<tr>
<td>Voltage sags for DLG fault(p.u)</td>
<td>0.788</td>
<td>0.986</td>
</tr>
<tr>
<td>Voltage sag for LL fault (p.u)</td>
<td>0.833</td>
<td>1.12</td>
</tr>
<tr>
<td>Voltage sags for SLG (p.u)</td>
<td>0.877</td>
<td>0.988</td>
</tr>
</tbody>
</table>

7.3 With LCL filters:

7.4.1 FFT Analysis during Fault with LCL Filter:

CONCLUSION:
The simulation results show that the voltage sags and harmonic elimination can be mitigate by inserting D-STATCOM to the distribution system. By adding LCL Passive filter to D-STATCOM, the THD reduced within. The power factors also increase close to unity. Thus, it can be concluded that by adding D-STATCOM with LCL filter the power quality is improved. The simulation results show that the voltage sags can be mitigate by inserting D-STATCOM to the distribution system. By adding LCL Passive filter to D-STATCOM, the THD reduced. The power factors also increase close to unity. Thus, it can be concluded that by adding D-STATCOM with LCL filter the power quality is improved.

REFERENCES:


