Power Quality Improvement in Distribution Network using D-STATCOM

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Abstract— This paper discusses a different scheme to diminish the power quality problem associated with the distribution system. nowadays there is a large number of power electronics and semiconductor-based machinery and apparatus will create power quality problems like flicker, sag, swell, voltage drop, voltage rise, harmonics, THD etc. the D-STACOM manly use in 33 kV distribution network at the load end where load current changes continuously. A level of exertion of rely upon the power factor of the load connected to the system.[5] Hence D-STACOM manly connected near the fluctuating load or source. For the reference voltage and current calculation, different strategies are used now a day.

Key words: Voltage Sag, Swell, Power Quality, D-STATCOM, FACTS, Reactive Power

I. INTRODUCTION

Power for the growing world is the main concern for the power utility companies. For the minimum cost of transportation and fewer losses distributed generation can be used instead of an increase of power plant size by introducing the power source nearer to the load. the renewable resources like solar, wind, biogas is mainly used but the problem with these resources is it create power quality problem in the grid due to its abnormal and uneven behavior at a different time of a day.[10] The challenges to generate enough power to reduce consumption from the main grid is more, as a distributed generator which commonly used solar or wind is unpredictable and their behavior is unacceptable to the consumer who carry sensitive load i.e. hospital, hotel[1] D-STATCOM can be utilized to alleviated different power quality issue with the different configuration of it. By small changes in its construction, it can be used for the different problem of the power system e.g. D-STATCOM with power storing device can be used for the real power compensation.[2] D-statcom can be used for nearly all the problem related to the distributed generation it can compensate the real as well as reactive power efficiently. This paper considers the operation of D-statcom in voltage control mode (VSC) for the proper operation of DG system connected to the grid.

D-statcom can be done these jobs by absorbing or generating reactive power with a faster response with respect to time. This ability of faster time response is one of the important advantages over SVC and capacitor bank.[5]

VSC based D-statcom are designed to compensate reactive power by injecting reactive power into the system by modifying phase angle and amplitude of the injected voltage.[8] Distributed generation offers the possibility to supply customers with electricity in a continuous manner.

At the transmission level statcom handle only fundamental reactive power and provide voltage support but at distribution level D-statcom at load end provide dynamic compensation. Ideally, reactive power should be generated at a place close to load to compensate it in order to free more capacity of conductor and transformer in network.[11]

II. POWER SYSTEM PROBLEM

Power quality is the set of electrical circumference that allow a unit of appliances to function in its proposed way without serious loss of performance. Voltage sag:-voltage sag can be defined as the lowering in the RMS voltage of the power system line between 0.1 to 0.9pu in the fundamental wave with duration from 0.5 cycle to a few cycles. Longer in the time of the voltage sag then is called the sustained sag.[7]

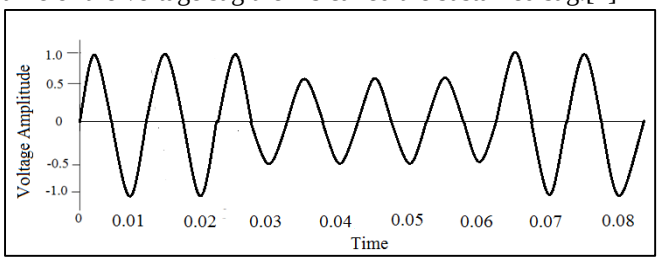

Fig. 1: Waveform of voltage sag

A. Voltage swell:

Voltage Swell is defined as the increase in the RMS voltage level to 110% - 180% of nominal, at the power frequency for durations of ½ cycles to one minute.

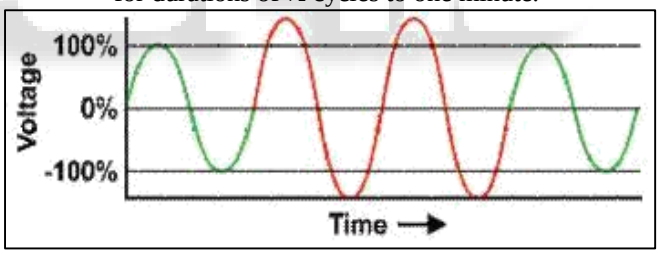

Fig. 2 Waveform of Voltage swell

B. Harmonics:

is an integral multiple of the fundamental frequency of electrical quantities (voltage or current); this is due to the nonlinear load which results in overheating of electrical equipment

C. D-statcom

D-statcom is one of the well-known member of fact family. It is famous for it ability of absorbing and providing reactive power also absorbing reactive power and providing real power as a output from system. D-statcom is a shunt connected device which gives control on various parameter like phase angle, frequency, voltage magnitude etc. the main part of the d statcom is the VSI(voltage source inverter) which also can be referred as heart of D-STATCOM. In this device constant dc voltage source is maintain by static capacitor with reference to the VSI.[3]

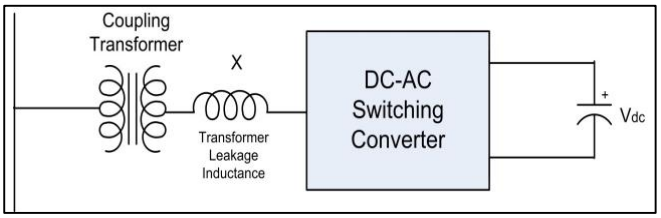

Fig. 3: Single line diagram of D-statcom

The fundamental block diagram of the D-statcom is delineated in fig. where it connected to the distribution system with the help of leakage reactance of the distribution transformer. This link reactor which links the inverter outputs to the distribution system refines the high frequency components due to PWM inverter. The VSC circuit is linked to the constant DC source which is capacitor in most of the cases. The AC system and converter produce reactive (capacitive) control for the AC system. In the event that the of yield voltage diminished underneath that of the AC system voltage then reactive current stream from AC system into converter and it ingest reactive power. The BESS (battery energy storage system) is incorporated to support real power source under fluctuating source like wind and sunlight based power.

III. Operational Principle

The operational principle is very basic it needs to give the given measure of reactive power when required and ingest the active power or reactive power when required as needs be. The exchanging of the power between the D-statcom and the AC system is just constrained by the electronic control system. Its power electronic equipment interconnects between one another with some control system and produces required reactive power for trade with the reactive system. The essential exchange of real power between the system and the D-statcom should be possible by changing the phase angle and voltage magnitude of the yield of the D-statcom of the system.[7]

By making the changes in the phase angle of the D-statcom can effects the reactive power exchange with the system and if the value of the phase angle increased above that of AC bus voltage then D-statcom provide the real power into the power system and when the AC bus voltage is greater than the D-statcom phase angle then real power flow into the D-statcom. Inside the D-statcom the different power electronics switches reconnect themselves efficient. Inductor connected at PCC is work as filter which filter out higher harmonics from the system which come from the inverter of statcom. When phase angle of D-statcom voltage is greater than distribution line voltage then D-statcom supplies real power to the system to make the reactive power generation into the systen so it tends to be taken a conclusion that the capacitor do not take participation in the generation of reactive power. Reactive power supplied by the D-statcom.

$$Q = \frac{V_{statcom} - V_s}{X} * V_s$$

Where, The current got from the compensator is 90 degrees moved from system voltage it tends to lead in nature(generating reactive power) or slacking in nature(absorb reactive power). On the off chance that the output(v0) is expanded over that of AC system voltage(v) at that point current move through the tie reactive from

Q= reactive power,

$V_{statcom}$= magnitude of output voltage,

V_s=magnitude of system voltage,

X=equivalent impedance between D-statcom and system

At the point when Q is certain D-statcom supplies reactive power and if Q is negative D-statcom takes in reactive power.

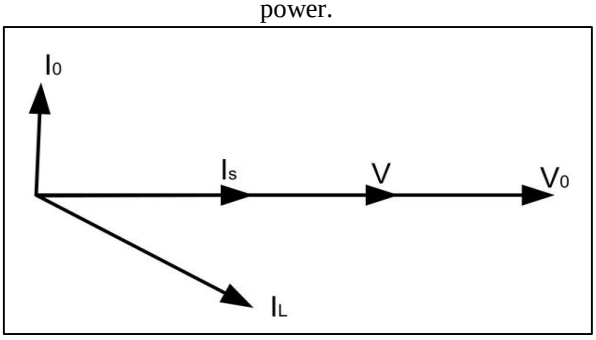

Fig. 4: vector diagram of D-statcom in capacitive mode

when I_L (load current) lagging the supply voltage generally in (inductive load) to get the unity power factor I_0 (D-statcom injected current) is injected into the system though coupling transformer such that resultant of those current which is compensated source current is in phase with PCC voltage.[6] If load current lead the system voltage usually when capacitive load is connected then

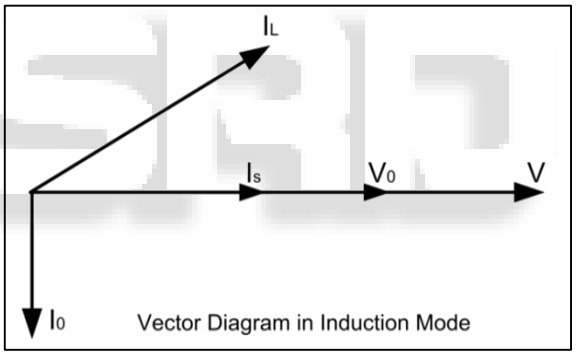

Fig. 5: vector diagram of D-statcom in induction mode

Inductor connected at PCC is work as filter which filter out higher harmonics from the system which come from the inverter of statcom. When phase angle of D-statcom voltage is greater than distribution line voltage then D-statcom supplies real power to the system to form unity pf D-statcom inject lagging current so that resultant of load current and injected D-statcom cureent will in phase with system voltage[6]

IV. Different Configeration of D-statcom

There are mainly three configuration are available they are

1) Single phase two wire system
2) Three phase three wire system
3) Three phase four wire system

single phase two wire D-statcom have been examined in varying setup and control methodologies to meet the prerequisite of a single phase system. The issue of neutral current and unbalance load current can be settled by utilizing four-wire D-statcom in four wire distribution system which causes a load adjusting, reactive power compensation, decrease of neutral current, and harmonic compensation.

V. DESIGN PARAMETER OF D-STATCOM

A. Choice of DC Bus Voltage (Vdc)

Least DC bus voltage of VSC should be more prominent than double the peak of the phase voltage of the distribution system. [3]

The DC bus voltage is determined as

$$V_{dc} = \frac{2\sqrt{2}}{\sqrt{3}m} V_{LL}$$

m= modulation idex

V_{LL}=AC line output voltage of D-statcom

Choice of DC bus voltage (Vdc)

The estimation of the DC capacitor of the VSC of the d-statcom relies upon the instantaneous energy accessible to the D-statcom during transient.[3]

Principal of the energy conversion

$$\frac{1}{2} C_{dc}(V_{dc}^2 - V_{dc1}^2) = k_1 3alt$$

Where,

V_{dc}= the nominal DC voltage

V_{dc1}= the minimum dc voltage of the dc bus

$a =$ The overloading factor

V= the phase voltage

l = the phase current

t = the time at which the DC voltage is to be regained

Choice of AC inductor

Determination of AC inductor L_r of a VSC relies upon the switching frequencyf_s, DC bus voltage V_{dc} and current ripple $I_{cr,pp}$and it given as [2]0

$$L_r = \sqrt{3}\, mV_{dc}/(12af_sI_{cr,pp})$$

VI. CONCLUSION

In this paper, principal of d-statcom shows that all current related power quality problems can be mitigated in real time. Capacitive reactance and inductive reactance power can be compensated from the power system easily by injecting the require compensation current. With the energy storing device we can compensate real power hence power quality improves.

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