

A Taxonomy and Survey on Power Quality Improvement using Static Synchronous Compensator

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Abstract: Power generation is always done keeping in mind the power generating cost and making the generation capability optimal. In this paper, a survey is carried out on the De-coupling STATCOM which is a device used for power quality improvement and is being used extensively for wind generating farms. It analyzes the design aspects of the conventional STATCOM and then the de-coupling STATCOM. Literature survey is carried out and presented.

Keywords: STATCOM, D-STATCOM.

I. INTRODUCTION

The generation of electrical power is always an evolving mechanism with a constant need to meet supply demand constraints. If a power system prefers to have a grid based topology, then the system is more flexible compared to radial lines transferring power from individual sources. This often leads to lower generation cost. Generation of ac power through renewable sources has become an invariably important aspect with the generation turning towards non-fossil fuels. One of the sources on the forefront are large scale wind generating farms. However, due to the dependence on wind speed, which in itself is an extremely variable parameters, its often difficult to

render steady power to the load. These fluctuations may lead to undesirable operation of devices. Thus the Static Synchronous Compensator or STATCOM is often used to regulate the amount of power flow to the

load and also enhance the transient stability. The surges during the transient phase may lead to severe damage to load and generator alike. Hence transient stability is critically important.

There are several problems in the power line conditions with conditions in voltage. This in turn increases or decreases the amplitude of the voltage and

hence impacts the power quality. Some of the major effects are:

- 1) Voltage Sag
- 2) Voltage Swell
- 3) Transients
- 4) Overshoots
- 5) Undershoots
- 6) Damping
- 7) Oscillations
- 8) Flickers
- 9) Impulses etc

The STATCOM is relatively capable of removing the disturbing factors and maintaining power quality.

II. Literature Survey

The literature survey is presented in a tabular form below:

Sr. No.	Author's Name	FACTS Device Used	Method/ Techniques	Performance
1	Moayed Moghbel ; Mohammad A. S. Masoum , AlirezaFereidouni, Sara Deilami	D-STATCOM	PV Power Injection by DSTATCOM with Variable DC Link Voltage Control	Power Quality Improvement in PV System and find MPPT.
2	MR Nasiri, S Farhangi	VAR and STATCOM	Model predictive control using diophantine equations for cascaded-H- bridge-based static VAR compensator (CHB STATCOM)	Regulates voltage and hence improves power quality
3	AR Gupta, A Kumar,	D-STATCOM	D-STATCOM allocation in UBRDS with an objective of providing reactive power support	Improves active and reactive power quality for Radial Distribution System
4	KDE Kerrouche, L Wang, A Mezouar,	D-STATCOM	Fractional-order sliding mode control for D- STATCOM	Improves voltage quality
5	S Choudhury, P Bhowmik, PK Rout,	D-STATCOM	Economic load sharing in a D-STATCOM integrated islanded microgrid based on fuzzy logic and seeker optimization approach	Improves power quality in micro grid systems under load varying conditions.
6	A Khoshooei, JS Moghani, I Candela	D-STATCOM	Control of D-STATCOM during unbalanced grid faults	Removes grid faults for oscillations and peak current limitations
7	Moayed Moghbel, Mohammad A. S. Masoum , AlirezaFereidouni, Sara Deilami	D- STATCOM	Optimal Sizing, Siting and Operation of Custom Power Devices With STATCOM and APLC Functions	Reactive Power and Network Voltage Quality Control of Smart Grid
8	T Yuvaraja, K Ramya, M Gopinath	D- STATCOM	Vector Control Strategy	Power Optimization in Renewable Cluster GridS
9	G Farivar, CD Townsend, B Hredzak	Multi-Level STATCOM	Low-capacitance cascaded H-bridge multilevel STATCOM	Improve voltage regulation and renders multi-level voltage output
10	D Lu, J Wang, J Yao, S Wang, J Zhu	STATCOM	Clustered voltage balancing mechanism and its control strategy	Improves active and reactive power quality.

III. STATCOM and D-STATCOM

The STATCOM is a member of the FACTS devices and is connected as a shunt device to the transmission line. The STATCOM has the capability to generate or to absorb reactive power in the power system with the variation in the demand-supply conditions of the power systems.

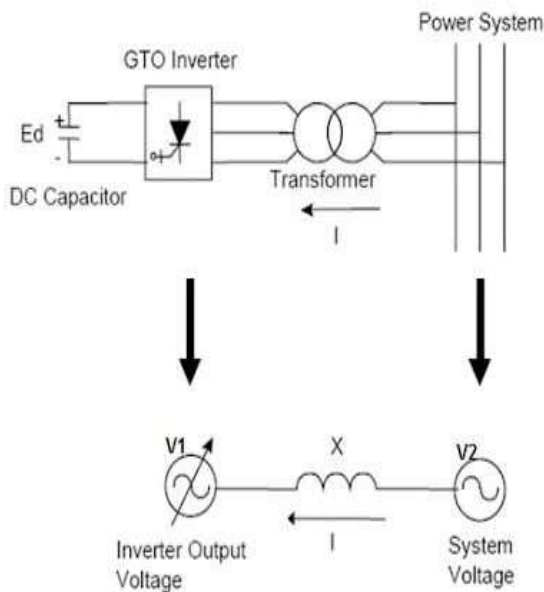


Fig.1 Basic schematic of STATCOM

The the STATCOM is capable of maintaining the reactive power in the system. The building components of a STATCOM are:

- 1) A voltage source converter (VSC)
- 2) Capacitor
- 3) Inductive reactance
- 4) Harmonic filter.

The diagram below shows the basic STATCOM

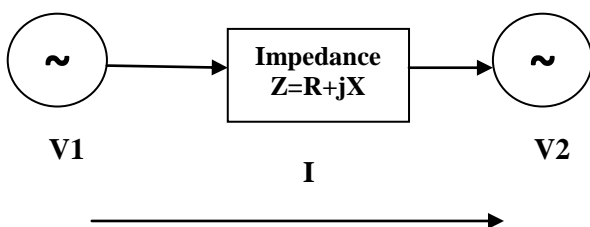


Fig.2 Circuit illustrating the working principle of STATCOM

If we assume that the real part of the impedance if R and is zero, then the flow of the reactive power between the two sources V1 and V2 is given by:

$$Q = \left(\frac{V2}{X}\right) \{V1 \cos \delta - V2\} \quad (1)$$

Here,

V1 is first voltage source

V2 is second voltage source

X is the real part of the impedance

cosδ is the phase difference between the sources.

It can be seen that if the phase difference δ becomes zero, then the active power flow will become

$$P = \frac{V1V2 \sin \delta}{X} = 0 \quad (2)$$

and

the reactive power flow will become:

$$P = \left(\frac{V2}{X}\right) (V1 - V2) \quad (3)$$

Thus the power flow will depend on V1 and V2.

The working principle of the STATCOM can be understood as:

Let us consider that V1 is the output voltage of the STATCOM which is actually the inverter output and V2 is the system voltage.

In case the demand for reactive power in the system shoots up, the STATCOM will increase the voltage V1 while maintaining the phase difference zero thereby rendering reactive power.

However, if there is surplus reactive power, then $V2 > V1$ and hence STATCOM will reduce its voltage to absorb power.

Thus the STATCOM is capable to maintain power stability in the system. This operation of the STATCOM is often called the **Voltage Regulation Mode**.

The STATCOM is in general limited in its capability to absorb or deliver reactive power the reason for which is the finite current carrying capacity of the gate turn off thyristors (GTO). If the power to be generated or absorbed surpasses the capacity of the STATCOM, then it generates/absorbs a finite and constant amount of power and in this mode, the STATCOM is said to operate in the **VAR Mode**.

The STATCOM components and their respective uses is summarized below:

The voltage source converter (VSC) is used typically to convert the DC to AC.

The capacitor supplies constant DC voltage to the VSC.

The inductive reactance (typically transformer) acts as a coupling device between the VSC and the power system

The harmonic elimination filter eliminates the harmonics introduced due to the GTO based VSC. Thus it can be seen that the STATCOM is capable of controlling the reactive power. But in case both active and reactive power needs to be controlled simultaneously, the decoupling STATCOM (D-STATCOM) can be used. It is widely used for voltage regulation and power management.

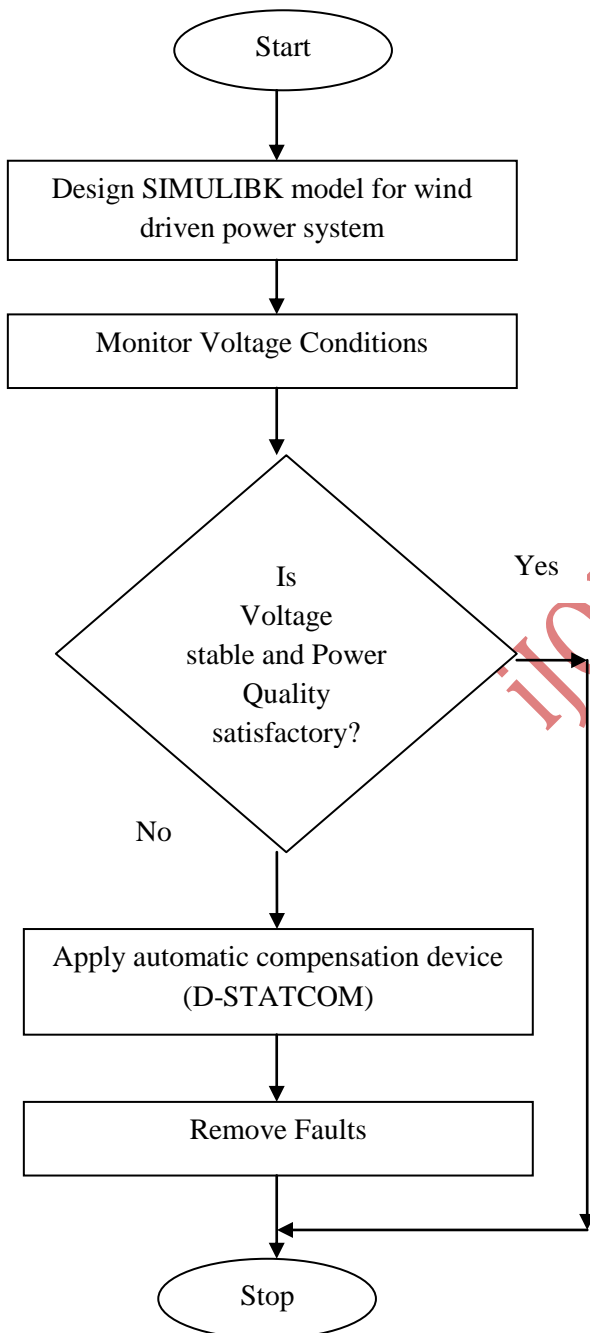


Fig.3 System Design Flowchart

Thus it is important to sense the sag/swell in the voltage and design an automatic compensation

IV. Power Quality Improvement for Voltage Sag/Swell

The power quality depends on the voltage conditions of the system. If there are sag/swell voltage conditions in the line, then it is necessary to remove the voltage sag/swell by either absorbing the voltage or injecting the voltage to maintain power quality. A flowchart for the detection of deviation of power form ideal values and a possible solution to it is shown in the figure below:

technique using the D-STATCOM for power quality improvement. The voltage needs to be continuously sensed so as to maintain power quality after applying the D-STATCOM in case there is any deviation from ideal characteristics.

V. Conclusion: It can be concluded from previous discussions that interconnectivity of generators in a grid based power system can prove to be cost effective. However, due to the non-linearities in the loads, the stability or regulation is difficult to achieve. The STATCOM is presented as a device capable of controlling the reactive power flow thereby regulating the power quality. The D-STATCOM is shown to control both active and reactive power simultaneously rendering more effectiveness. The previous works cited give an idea about the latest trends on the domain

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