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# A Review Article Of Enhancement Of Statcom Performance Using Srf Based Shunt Filter Power Transmission

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***Abstract* – Power transformers are important and expensive components in the electric power system. The de-regulation of electric power requires a reduction of the service and maintenance cost of the power utilities. Monitoring systems can help to decrease the transformer life cycle cost and to increase the high level of availability and reliability. On line monitoring is the record of relevant data of a transformer. Diagnosis is the interpretation of these monitored data including the history of the transformer and the statistical judgement of the failure rate. The importance of the monitored transformer and the economic consequences are the basis for the asset management of power transformer together with the risk evaluation. This paper attempts to present the different methodologies adopted for on line monitoring of power transformers.**

***Keywords* - Condition monitoring, Transformer diagnostics, Maintenance.**

## I. INTRODUCTION

Power engineers consider rising power quality and giving certain power at the lowest cost a major situation. Achievable solutions to power distribution difficulties have been recommended in the form of a number of power electronic based devices for enhanced power quality. Distribution Static Compensator (D-STATCOM), Distribution Voltage Regulator (DVR), Unified Power Quality Compensator (UPQC), BESS, HVDC Light are few of the prominent custom power devices employ at distribution level. The Distribution Static synchronous Compensator (DSTATCOM) is a chief member of the FACTS family of power electronic based controllers. It has been studied for many years, and is probably the most widely used FACTS device in present's power systems.

The D-STATCOM voltage and reactive power compensation are normally related through with the magnetic of the D-STATCOM. This traditional power flow framework of the D-STATCOM neglects the impression of the high frequency effects and the switching diagnostics of the power electronics on the active power losses and the reactive power insertion. The D-STATCOM has appeared as a hopeful device to offering not only for voltage sag reduction but also for a host of other power quality solutions such as voltage stabilization, flicker suppression, power factor correction, and harmonic control. D-STATCOM is a shunt device that produces a balanced 3-Φ voltage or current with capability to control the magnitude and the phase angle. Generally, the D-STATCOM configuration consists of a typical 12-pulse inverter arrangement, a dc energy storage device. A coupling transformer linked in shunt with ac system and connected control circuits.

## II. DESCRIPTION OF POWER QUALITY

Power quality is a term that means different things to different group. Institute of Electrical and Electronic Engineers (IEEE) Standard IEEE1100 defines power quality as "the concept of powering and grounding sensitive electronic equipment in a manner suitable for the equipment." As appropriate as this description might seem, the limitation of power quality to "sensitive electronic equipment" might be subject to disagreement. Electrical equipment susceptible to power quality or more appropriately to lack of power quality would fall within a seemingly boundless domain.

All electrical devices are prone to failure or malfunction when exposed to one or more power quality problems. The electrical device might be an electric motor, a transformer, a generator, a computer, a printer, communication equipment, or a household appliance. All of these devices and others react adversely to power quality issues, depending on the severity of problems. The role of monitors for troubleshooting power quality problems is undeniable. Industrial plant electricians will use disturbance analyzers to settle arguments about the quality of power, especially during the installation of new plant equipment when there are inevitably a number of problems associated with the normal commissioning process. Disturbance analyzers, set to trigger on abnormal voltage conditions, allow the troubleshooter to determine if the electric power is to blame for the problem. The consumer expects an electricity supply which is available at all times and provides a tight control of voltage and frequency for all appliances. The fact that all consumers are free to alter their demand at any time, coupled with the inability to store AC power, creates the underlying power system control task.

## III. POWER QUALITY PROBLEMS

**1.Voltage Sag:-**Defined sag voltage in IEEE1159-1995 is, IEEE is the reduction in the RMS voltage at power frequency for 0.5 cycles duration of 1 minute, the remaining of which has been suggested compliance with the quality of the motion of electric energy It was reported that tension. Cause: Failure in the transmission or distribution (most of the time in the feeder in parallel). Consumer installation of failure.

**2. Voltage Swell:-** Transient increment of the voltage, at the power frequency, outside the ordinary resilience, with length of time of more than one cycle and regularly not as much as a few moments. Reasons: Start/stop of overwhelming burdens, seriously dimensioned power sources, gravely controlled transformers (for the most part amid off-crest hours).

**3. Interruption:-**Interruption is characterized as the complete loss of supply voltage or load current. Contingent upon its duration, an intrusion is arranged as instantaneous, momentary, temporary, or sustained.

**4. Under Voltage:-**Under voltages are the aftereffects of long haul issues that make sags. The expression "brownout" has been normally used to depict this issue, and has been superseded by he term under voltage. Brownout is vague in that it likewise alludes to business power conveyance system amid times of developed appeal.

**5. Electrical Noise: -** Noise is undesirable voltage or current superimposed on the power system voltage or current waveform. Noise can be created by power electronic gadgets, control circuits, circular segment welders, exchanging power supplies, radio transmitters et cetera. Inadequately grounded destinations make the system more defenseless to noise.

## IV.COMPENSATION PRINCIPLE OF STATCOM

STATCOM is a converter type FACTS device, which generally provides superior performance characteristics when compared with conventional compensation methods employing TSCs and TCRs. STATCOM based on VSC topology utilize either GTO or IGBT devices. A functional model of a STATCOM is shown in Figure 4.1. In its simplest form, the STATCOM is made up of a coupling transformer, a VSC, and a DC energy storage device. The energy storage device is a relatively small DC capacitor, and hence the STATCOM is capable of only reactive power exchange with the transmission system

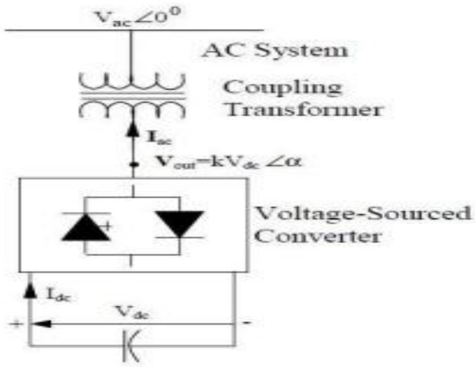


Fig.1 Functional model of a STATCOM.

If a DC storage battery or other DC voltage source were used to replace the DC capacitor, the controller can exchange real and reactive power with the transmission system, extending its region of operation from two to four quadrants.

## V.LITERATURE SURVEY

Conventionally the low cost Mechanical Switched Capacitor (MSC) banks and Mechanical Switched Reactor (MSR) are used to address the issues related to stability and power quality. Mechanically switched fixed shunt capacitors can enhance the system's voltage stability limit, but is not very sensitive to voltage changes. Also, voltage regulated with only fixed capacitors can become higher than the voltage limit of 1.05 pu. Capacitors however are restricted to injecting reactive power.

If the voltage rises, and there is no load to consume the reactive power, the capacitor output will only contribute to the increase of voltage. Moreover, capacitors can be dangerous in short circuit scenarios because they produce high overvoltages. Hence, a fixed capacitor cannot serve as the only source of reactive power compensation (SaadSaoud et al. 1998). In general these conventional techniques will not be able to solve voltage and power fluctuations in the power system network but leads to stress on the existing power system components (Alan Mullane et al. 2005).

Various researchers (Vaahedi et al. 1999) have carried out this subject and analyzed that the Thyristor Controlled Switched Capacitor (TCSC) and Static Var Compensator (SVC) are used to keep bus voltages and to ensure the voltage stability margin **(Guygyi 1997, Mathur 2002).** But the power quality issues such as power fluctuations, voltage fluctuations and harmonics cannot be solved satisfactorily due to slow response. Hence a fast dynamic var compensator is needed to suppress these issues more effectively as has been pointed out in many literature papers (Mohan 1995). FACTS based devices can provide probably the most effective solutions to such problems (Lasseter and Jalali 1991).

Reactive power compensation using Voltage Source Converter (VSC) based STATCOM with conventional Pulse Width Modulation (PWM) technique have been studied and presented in various literatures **(Lehn et al. 1998 and Dong Shen et al. 2001).** In the proposed research work, this concept has been adopted to verify the reactive power management of the system with nonlinear load by using a VSC based STATCOM with interpolation firing scheme of PWM technique (Gole et al. 2001).

In recent power semiconductor technologies, a traditional 2-level VSC is not competent for FACTS controller applications because of` the needing for bulky zigzag transformers and series/parallel switches to match harmonics, voltage and power specifications. Traditional magnetic coupled multipulse converters typically synthesize the staircase voltage wave by varying the transformer turns ratio with complicated zig - zag connections (Lai and Peng 1996). This method is bulky, heavy and lossy (Liang and Nwankpo 1999, Chen et al. 1997). In the proposed work, the capacitor voltage synthesis method is used.

Multilevel inverters have been receiving increasing attention in recent years and the Symmetrical Cascaded Multi Level Inverter (SCMLI) was first proposed in 1975 and patented in **1997 (Lai and Peng 1996)**. Although the Cascaded Multilevel Converter (CMC) was invented earlier, its application did not prevail until the mid 1990s. Multilevel VSC structure has been developed to overcome inadequacy in power semiconductor voltage ratings so that they can be applied to high-voltage electrical systems like FACTS (Liu and Luo 2005).

**It has been proved in many literatures that the SCMLIs have many attractive features like reduced Total Harmonic Distortion (THD) and reduced switching losses (Hochgraf et al. 1994, Rodriguez et al. 2007).** CMC with different switch topology (Hybrid CMLI) results in loss of modularity produced, problems with switching frequency and modulation index restrictions etc. In reactive power compensation, SCMLI based STATCOM with Separated DC Sources (SDCS) are preferred due to its attractive features (Zhong et al. 2006).

To obtain Low Voltage Ride Through (LVRT) capability and to withstand the effects of voltage disturbances are the new challenges with the integration of wind farms into the power system (Thomas Ackermann 2005). Under any voltage disturbances, the fixed speed wind turbines must remain connected to the network to maintain voltage profile. It is documented in (Chong Han et al. 2008) that the core of voltage instability is lack of reactive power support in a power system. Conventional VSC based STATCOM's are implemented for reactive power compensation and voltage flicker elimination in wind farms and rapidly changing arc furnace loads. In this research, both CMC and ACMC based STATCOM topologies is proposed to achieve the same objective of compensating the reactive power and improving the voltage profile with even more reduced THD. Previous works have shown that enhanced performance in power oscillation damping can be achieved with the additional active power support from STATCOMs (Arsoy et al. 2003).

**It has been shown in (Luongo et al. 2003)** that by injecting a certain amount of active power into the grid in addition to the reactive power, the voltage sag mitigation effect of the STATCOM can be improved. In the previous literatures, as far as voltage quality is concerned, the focus has been on the magnitude whereas less attention has been paid to enhance the real power flow that might accompany the voltage magnitude fluctuations caused by sudden active load changes. The voltage sag mitigation techniques investigated by the aforementioned works aim only to reduce the impact of voltage sags on some particularly protected loads. The proposed research work is focused on the disturbances in the power flow caused by sudden changes in the cyclic loads connected at the PCC[1-6].

Voltage sags can also occur during the start-up of large induction generators or during the operation of electrical equipments such as welders, arc furnaces, smelters, etc. It has been shown in (Ribeiro et al. 2001) that by injecting a certain amount of active power into the grid in addition to the reactive power, the voltage sag mitigation effect of the STATCOM can be improved. In the literature, it has also been investigated how energy storage can be used for the improvement of power quality and reliability (Karami et al. 2007). Studies in (Buckles and Hassenzahl 2000) show that an energy source power system stabilizer can provide damping of power swings by modulating the power output/input of the ESS to respond to the system frequency deviations caused by oscillations. Some other different control schemes that have been studied showed the enhanced performance of STATCOM in damping of power system oscillation by the integration of ESS.

**(Kobayashi et al. 2003, Yang et al. 2001,** Sutanto and Tsang 2004, Zhang et al. 2001).Work also has been done to investigate the utilization of energy storage for the improvement of power quality and reliability (Arsoy et al. 2001). The impacts of phase jump on AC motors and their drives are described in Albasri et al. 2007, Albasri et al. 2006 and Sidhu et al. 2005. A Multi pulse STATCOM with Superconducting Magnetic Energy Storage (SMES) as the Energy Storage System (ESS) is proposed which has been done comprehensively in this research and has been successfully implemented and the power flow results are presented to improve the power quality at the PCC where the cyclic load is connected.

## VI.APPLICATION OF BATTERY ENERGY OPERATED SYSTEMT O ISOLATED POWER DISTRIBUTION SYSTEMS

Bhim Singh, A. Adya,A.P. Mittal and J.R.P Gupta This paper [1] manages model of battery energy worked system for a 42.5kVA DG set utilizing Simulink and Power System Square set in MATLAB environment. Battery energy storage System (BESS) is utilized for pay alongside a little synchronous generator of 42.5kVA limit coupled to a diesel motor as a prime mover. The DG set sustains a wide mixed bag of loads. The system execution is reproduced for straight, non-direct adjusted and lopsided loads. Simulation results justify upgraded power quality of the system with BESS application.

## VII.OPERATION OF D-STATCOM FOR VOLTAGE CONTROL IN DISTRIBUTION NETWORKS WITH A NEW CONTROL STRATEGY

Dipesh. M .Patel, Dattesh Y. Joshi, Sameer H. Patel, Hiren S. Parmar This paper [4] presents DSTATCOM (Dispersion Static Compensator) is utilized for pay of receptive power and unbalance brought on by different burdens in distribution systems. This paper addresses the demonstrating and investigation of custom power controllers, power electronic-based gear went for upgrading the unwavering quality and nature of power streams in low voltage dispersion systems utilizing DSTATCOM. Another PWM-based control plan has been suggested that just obliges voltage estimations and no responsive force estimations are needed. The operation of the proposed control system is exhibited for D-STATCOM. Reproductions and examination are completed in PSCAD with this control strategy for two proposed systems.

## VIII.POWER FLOW CONTROL THROUGH SHUNT REACTIVE POWER COMPENSATOR

STATCOM Among FACTS controllers, the shunt controllers have shown feasibility in term of cost effectiveness in a wide range of problem-solving applications from transmission to distribution levels. Moreover, the shunt controller can improve transient stability and can damp power oscillation during a post-fault event. Using a higher-speed power converter, the shunt controller can even eliminate the flicker problem. The shunt controller basically consists of three groups; Static Var Compensator (SVC) STATic synchronous COMpensator (STATCOM) Static Synchronous Generator (SSG) or STATCOM with Energy Storage System (ESS) The STATCOM is the first power-converter-based shuntconnected controller.

The concept of STATCOM was disclosed by Gyugyi in 1976 (Hingorani and Gyugyi 2001). Instead of directly deriving reactive power from the energy storage components, the STATCOM basically circulates power with the connected network. The reactive components used in the STATCOM, therefore, can be much smaller than those in the SVC (Taylor 1993). In 1995, the first ±100 MVA STATCOM was installed at the Sullivan substation of Tennessee Valley Authority (TVA) in northeastern Tennessee. This unit is mainly used to regulate 161 kV bus during the daily load cycle to reduce the operation of the tap changer of a 1.2 GVA-161 kV/500 kV transformer. The control scheme used in this STATCOM is a 60 Hz staircase. Due to the slow switching speed of the GTOs, the firing angles of the output waveform are fixed; therefore, the amplitude of each output waveform is controlled by exchanging real power of the DC-link capacitor with the power grid.

**1.Synchronous Reference Frame theory**

The inductance of synchronous and induction machines are functions of rotor speed and the coefficient equations of voltage and current are represented in differential equations describing the time varying behavior of these machine. A change of variable can be used to reduce the complexity of differential equation by representing the equations in another frame called arbitrary reference frame that rotates at any angular velocity or remain stationary. All power system components are represented in synchronously rotating reference frame and the variables associated is transformed on to a synchronously rotating reference frame [1]. This represents the theory of SRF with the equations obtained by Park‟s transformation matrix, [2] that is transformation from α-β to d-q frame.

The transformation Matrix is given below:

$$\begin{bmatrix} d \\ q \end{bmatrix} \Rightarrow \begin{bmatrix} \sin\theta & -\cos\theta \\ \cos\theta & \sin\theta \end{bmatrix} \begin{bmatrix} \alpha \\ \beta \end{bmatrix} \quad (1)$$

The inverse transformation can be calculated using the equation (2) as below:

$$\begin{bmatrix} \alpha \\ \beta \end{bmatrix} \Rightarrow \begin{bmatrix} \sin\theta & \cos\theta \\ \cos\theta & -\sin\theta \end{bmatrix} \begin{bmatrix} d \\ q \end{bmatrix} \quad (2)$$

The equation above is used to obtain the values corresponding to the reference frame by moving at an average of 100Hz [2].

**2. Advantages Of Srf Theory**

- The number of voltage equations are reduced.
- The time – varying voltage equations become time – invariant ones.
- Performance of power systems and electric machines can be analysed without complexities in the voltage equations.
- Transformations make it possible for control algorithms to be implemented on the DSP
- With aid of this technique, many of the basic concepts and interpretations of these general transformations are concisely established.

## VII. STATCOM MODELING

The control blocks should be modeled in great detail, representing all necessary firing pulses for each of the valves. The models should be simplified to reduce computational time and should accurately capture the controller behavior at the desired fundamental frequency (Jovcic et al. 1999).

The controls should be represented with all functions that are relevant to the proposed study. Several authors have demonstrated the importance of realistic modeling of FACTS controllers for steady state and transient stability studies (Nelson et al. 1995). The STATCOM have been typically modeled as ideal VSC or Current Source Converter (CSC) without operating and control limits, i.e. capable of generating or absorbing unlimited amounts of reactive power. More accurate dynamic and steady state models, similar to the ones presented in this thesis have been proposed based on power balance principles between the AC and DC sides of the VSC.

However, these models have been discussed at a theoretical level and only tested with conventional PWM. The STATCOM proposed in this chapter are tested in a more realistic power system environment, which clearly identify the need for representing properly the operating and control limits.

## VIII. CONCLUSION

The electrical power system is a complex, variable system with non-linear loads and power correction devices that make the system all but predictable. If the reactive power of the load is changing rapidly, then a suitable fast response compensator is needed. SVC and STATCOM are two such compensators belonging to FACTS family. In this Chapter, a basic understanding of power flow control has been presented. Among FACTS controllers, the shunt controllers have shown feasibility in terms of cost effectiveness in a wide range of problem-solving abilities from transmission to distribution levels. A comparision between the STATCOM and the SVC is made and based on several aspects it is concluded that a STATCOM is more preferred when compared to SVC.

Instead of directly deriving reactive power from the energy storage components, the STATCOM, the first power-converter based shunt-connected controller basically circulates power with the connected network. Therefore, the reactive components used in the STATCOM, can be much smaller than those in the SVC. With energy storage system, it also offers the unique potential to exchange real power directly with the AC system, providing powerful new options for power flow control and the counteraction of dynamic disturbances.

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