COMPARATIVELY ANALYSIS OF REACTIVE POWER COMPENSATION BETWEEN STATCOM & SVC COMPENSATION TECHNIQUE USING MATLAB/SIMULINK

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Abstract- In Electrical power system, while the performance of a system is investigated then the investigation is mainly governed on the basis of their stability under the different Faulty conditions which include their steady state & transient Stability & recovering of the system after being subjected in such type of condition. However there are various compensation Techniques available to improve the system performance & stability. This paper is carried out the comparison between STACOM & Conventional SVC Compensation techniques to investigate that which type of compensation techniques gives the better stability in terms of reactive power compensation.

Keywords- Power Transmission, Reactive Power Compensation, Power System Transient Stability, FACT Devices, STATCOM & SVC Controllers.

I. INTRODUCTION

The use of compensation devices for the compensation of reactive power is implemented day by day for the improvement of power system voltage profile. An operational power system is considering as a generation & consumption of Reactive power. Reactive power compensation has a great influence on the dynamic performance of the voltage stability and helps to maintain a flat voltage profile.

Though at each operating point in power system, the reactive power compensation can be greater or less than its generation.

Thus the compensation is an essential tool in power system for obtaining the flat voltage profile. basic considerations to increase the transmittable power by idea l shunt-connected Var compensation will be reviewed in order to provide a foundation for power electronics-based compensation and control techniques to meet specific compensation objectives.

II. PRINCIPLE OF POWER TRANSMISSION &REACTIVE POWER COMPENSATION

To illustrate that the power system only has certain variables that may be impacted by control system, we have considered here the power-angle curve, given in the Fig 2. Although this is a steady-state curve and the implementation of FACTS is primarily for dynamic issue, this design demonstrates the point that there are primarily three main variables that can be directly controlled in the power system to impact its performance.

- Voltage
- Angle
- Impedance

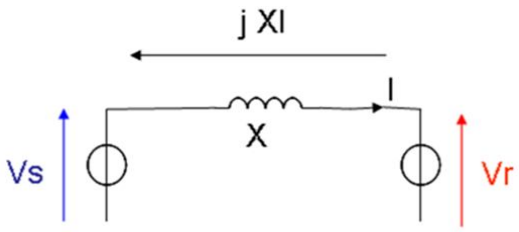


Fig.1 Shows a simple Power System network.

The Active power & Reactive power of the above system is given by

$$P = (V^2 \text{Sin}\delta) /X$$
$$Q = V^2 /\{X (1 - \text{Cos}\ \delta)\}$$

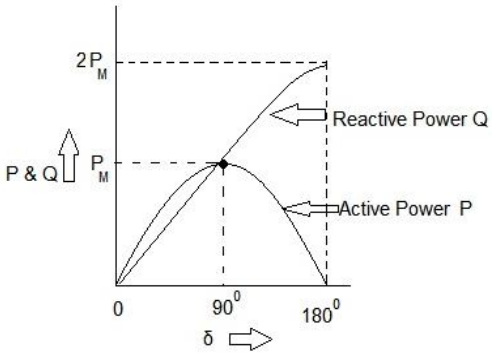


Fig.2 Shows the Controllability of Power System.

Power & Current flow can be controlled by one of the following means:

- Applying a shunt voltage at the midpoint.
- Varying the Line Reactance X.
- Applying a voltage with the variable magnitude in series with line.

Power system operation & its control is one of the most complicated process, though the fastest growing semiconductor Technology has reduced the complexity in terms of controlling process.

III. FACTS TECHNOLOGY

IN 1980 EPRI (Electrical Power Research institute) brought an revolution in the field of Electrical power system. The technology has replaced the use of mechanically operated switches to the semiconductor operated switches for the very high operating frequency range.

Depending on the power electronic devices used in power system, the FACTS controllers can be classified as

- Variable impedance type.
- Voltage Source Converter (VSC).

Variable impedance controllers include:

- Static Var Compensator (SVC), (shunt connected)
- Thyrister Controlled Series Capacitor or compensator (TCSC), (series connected)
- Thyristor Controlled Phase Shifting Transformer (TCPST)
- PST (combined shunt and series)
- The VSC based FACTS controllers are:
- Static synchronous Compensator (STATCOM) (shunt connected)
- Static Synchronous Series Compensator (SSSC) (series connected)
- Interline Power Flow Controller (IPFC) (combined series-series)
- Unified Power Flow Controller (UPFC) (combined shunt-series)

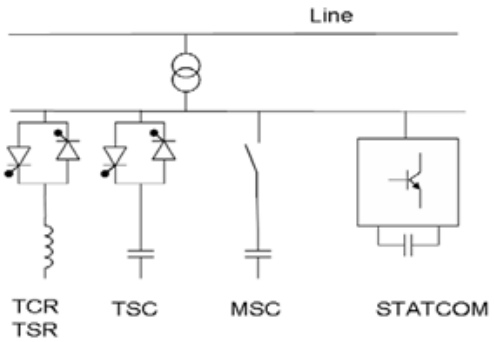


Fig.3 Installation of various FACTS Devices over the transmission line.

IV. PRINCIPLE OF SHUNT COMPENSATION

In shunt compensation, power system is connected in shunt parallel with the FACTS. This works as a controllable current source. The shunt compensation is of two types:

- Shunt capacitive compensation.
- Shunt inductive compensation.

Var compensation is thus used for voltage regulation at the midpoint (or some intermediate) to segment the transmission line and at the end of the (radial) line to prevent voltage instability, also for dynamic voltage control to increase transient stability and the damp power oscillations.

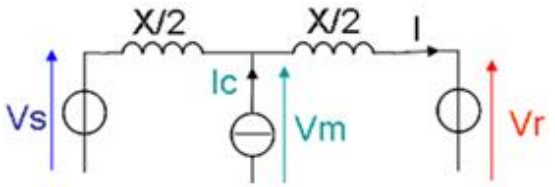


Fig 4 : Principle of Shunt Compensation.

Let us assume that the magnitudes of the terminal voltages remain constant equal to V i.e. $V_S = V_R = V_M = V$

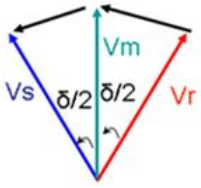


Fig.5 Phasor presentation of Shunt Compensation.

The line current phasor is given by

$$I = (V_S - V_R) / X$$

Where the Magnitude of the current is given by

$$I = 2V/X \, Sin\delta$$

For a lossless line the power is the same at both the ends and at the midpoint thus the active & Reactive power is given by

$$P = \frac{2V^2}{X} Sin\frac{\delta}{2}$$

$$Q = \frac{4V^2}{X}(1 - Cos\delta)$$

V. SVC CONTROLLER

The two main popular configuration of this type of shunt controller are the fixed capacitor (FC) with a thyristor controlled reactor (TCR) and the thyristor switched capacitor (TSC). In its simplest form, the SVC consists of a TCR in parallel with a bank of capacitors. From an operational kind, the SVC behaves like a shunt-connected variable reactance, which can generates or absorbs reactive power in order to regulate the voltage magnitude at the point of connection to the AC network.

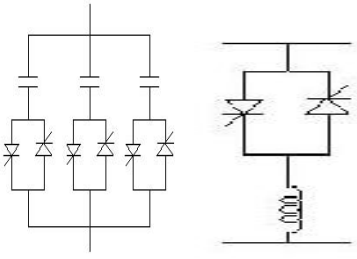


Fig. 6 TSC & TCR Based SVC Power Controller.

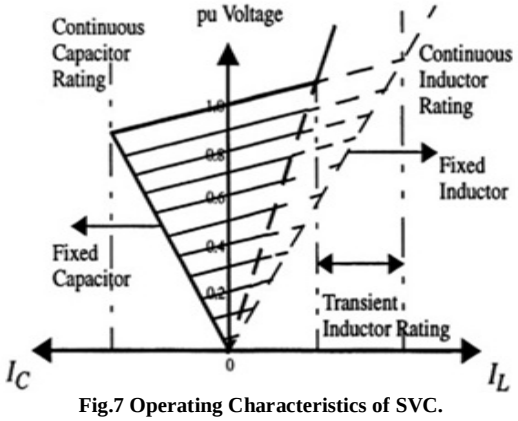


Fig.7 Operating Characteristics of SVC.

VI. STATCOM CONTROLLER

A static synchronous compensator (STATCOM), also known as a "static synchronous condenser" ("STATCON"), is regulating mechanism used on alternating current electricity transmission networks. It is based on the power electronics voltage-source converter and can act as either a source or sink of reactive AC power to an electricity network. If it is connected to a source of power it can also provide active AC power. That is a member of the FACTS family of devices.

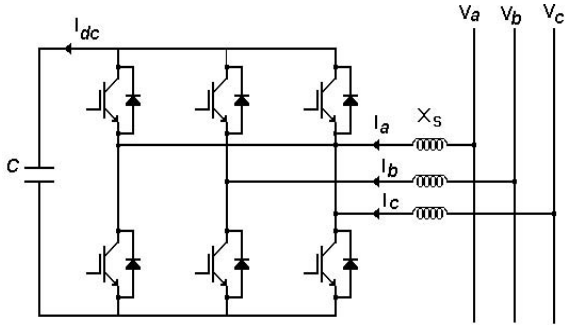


Fig.8 VSC based STATCOM Power Controller.

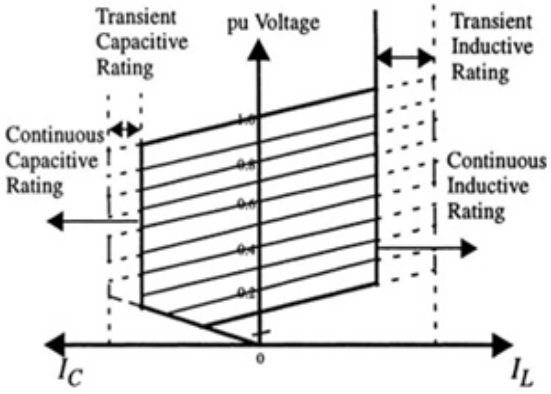


Fig. 9 Operating characteristics of STATCOM.

VII. PRINCIPLE OF OPERATION

If the line voltage V is in the phase with the converter output voltage Vo and has the same magnitude so that $V = V_0$ Thus there will be no current flowing in or out of the compensator thus there will be no exchange of Reactive power within the line. if the converter voltage is increased the voltage difference between the V & V_0 appear across the Leakage reactance of the step down transformer. As a result of this a leading current with respect to V is drawn and the compensators behave as a Capacitor generating VAR's. Conversely if V ▪ V_0 then compensators draw lag VAR's & behaving as a Reactor.

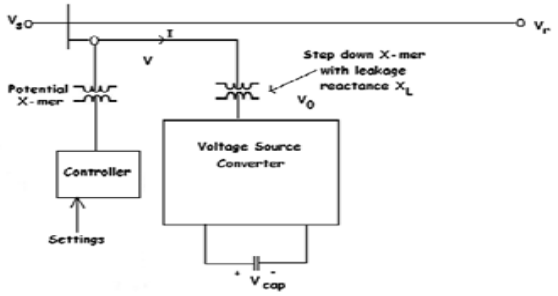


Fig:-10 STATCOM Power Controller.

VII. COMPARISION BETWEEN STATCOM & SVC POWER CONTROLLER

The operating Principle of both the FACT Devices are different, both of the devices are used for the improvement of power system stability. Fig shows the operating characteristics of both the FACT Devices the STATCOM has the capability to maintain the full capacitive current even at low system voltage while the SVC has the absent of same characteristics. This ability make the STATCOM more effective than the SVC in the improvement of power system stability.

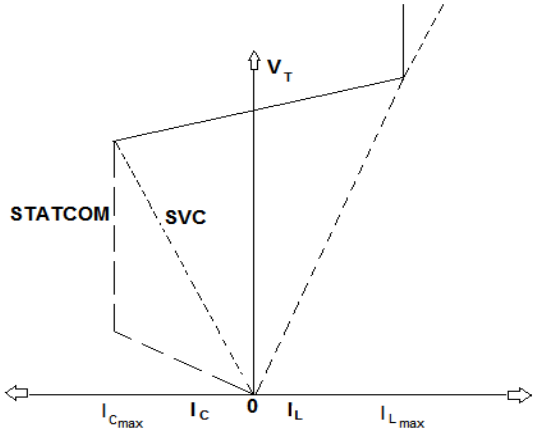


Fig 11 V-I Characteristic of STATCOM & SVC

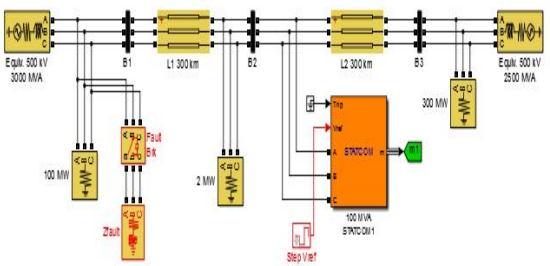


Fig. 12 shows a STATCOM Power system.

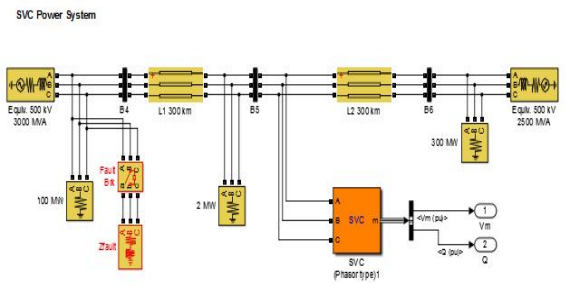
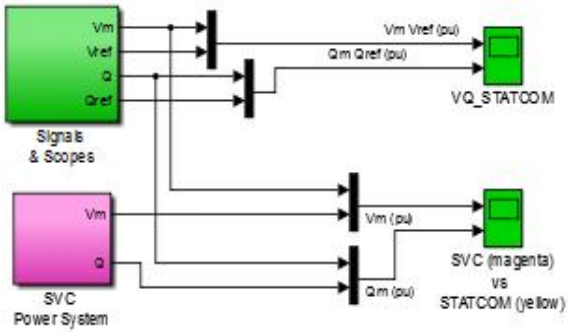


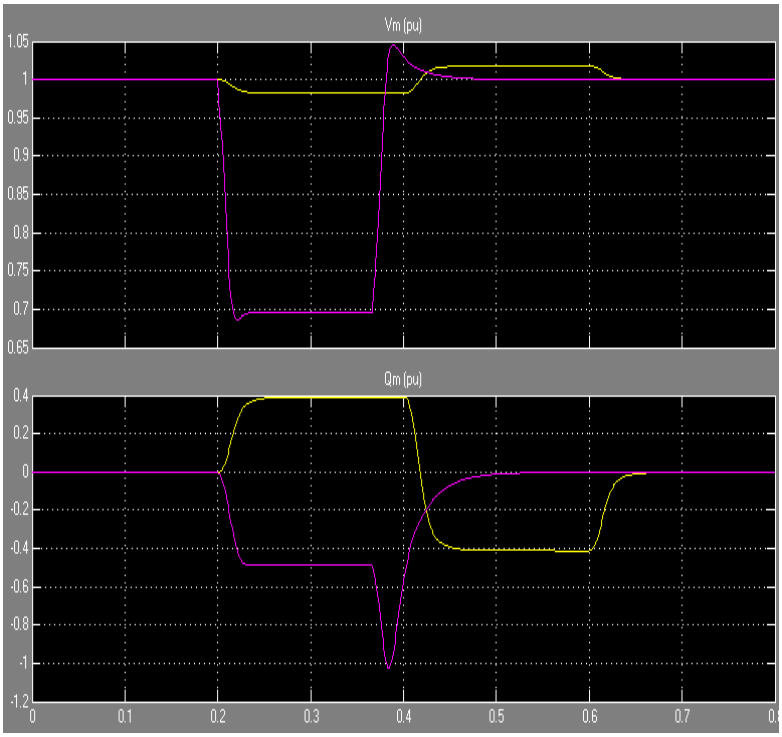
Fig 13 SVC Power System.



VIII. SIMULINK RESULTS

Run the simulation and look at results. Result displays the measured reactive power Q_m generated by the SVC (magenta trace) and the STATCOM. During the 10-cycle fault, a key difference between the SVC and the STATCOM may be observed. The reactive power is generated by the SVC is -0.48 pu and the reactive power generated by the STATCOM is -0.71 pu.

We can then see that the maximum capacitive power generated by a SVC is proportional to the square of the system voltage while the maximum capacitive power generated by a STATCOM decreases linearly with voltage decrease (constant current). This ability is to provide more capacitive power during a fault is one important advantage of the STATCOM over the SVC. Moreover, the STATCOM will normally exhibit a faster response than the SVC because of the presence of Voltage Source Convertor.



CONCLUSION

In this paper the operating characteristics of STATCOM & SVC is discussed. Though the principle of operation of both the FACT devices are different, however both of them is used to improve the behavior of power system under the Transient condition. SVC is Thyristor-based FACTS Device & works on the principle of Variable Impedance by means of controlling the firing angle of high speed semiconductor switch, on the other hand STATCOM is a VSC (Voltage Source Convertor) based FACTS Devices & Regulate the system voltage by observing or generating the Reactive Power Independent of System Voltage.

The response of the STATCOM is faster as compared to SVC .STATCOM has the attributes of Superior dynamic response & fast fault recovery as compared to that of conventional SVC.

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