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Different Types of FACTS Devices for Improving Steady State Transient Stability

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***Abstract*— Flexible Alternating Current Transmission Systems (FACTS) technology opens new opportunities for controlling active and reactive power capacity of present transmission lines. The STATCOM, SSSC, UPFC and IPFC are a second generation FACTS device which enables control of active and reactive power to improve reliability and quality of the power supply. Transient stability control plays a significant role in ensuring the stable operation of power systems to prevent any fault. The objective of this paper is to improve the transient stability of an interconnected power system, using STATCOM, SSSC and UPFC. This paper proposes a FACTS device model existing MATLAB based simulation for transient stability studies. The simulations results demonstrate in transmission system using UPFC on transient stability improve.**

***Keywords*— Reactive power compensation, STATCOM, SSSC, UPFC, Transient stability. MATLAB**

I. INTRODUCTION

In present time, power system is a complex network comprising of number of generators, transformers, transmission lines and different type of loads. As a result of increasing power demand, some transmission lines are more loaded than was planned when they were built. In transmission line load is increased, the problem of transient stability after a major fault can become a transmission limiting factor. Also some other issues are overcrowding management, power losses, and power quality and voltage stability. To overcome these issues, using FACTS devices.

Flexible Alternating Current Transmission Systems (FACTS) is a new integrated concept based on power electronic switching converters and dynamic controllers to enhance the system utilization and power transfer capacity & stability, security, reliability and power quality of AC system interconnections.

STATCOM based on power electronics device. It is a regulating device which can used to regulate the flow of reactive power in the transmission line. If connected to a source it can also supply active power. It is connected in shunt with transmission line and injects required current. The structure of a STATCOM as shown in Fig. 1. For construction of STATCOM required a voltage source converter, a coupling transformer and a D.C. capacitor.

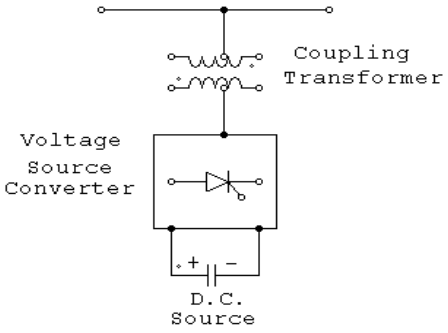

Fig. 1 STATCOM connected to a transmission line

The Static Synchronous Series Compensator (SSSC) works the same way as the STATCOM. SSSC is recent FCATS devices for series compensation. SSSC is able to supplies and/or absorbs active either reactive power in transmission line. It is work like a controllable serial condenser and serial reactor. SSSC work independently and not dependent on line intensity. In SSSC component same as a STATCOM, but coupling transformer connect in series with transmission line. SSSC construction shown in Fig. 2.

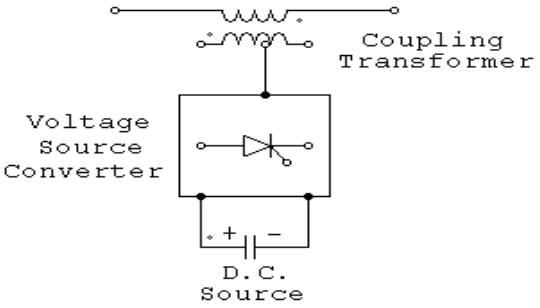

Fig. 2 SSSC connected to a transmission line

Unified Power Flow Controller (UPFC) system can regulate the active and reactive power at same time. It is the ability to control bus voltage, transmission line reactance and phase angle between two buses, either simultaneously or independently. In UPFC converter-2 injects an AC voltage to the line, magnitude and phase angle are controllable through a coupling transformer and converter-1 supplies and absorbs the active power demand for converter-2. UPFC is a combination of STATCOM and SSSC as a shown in

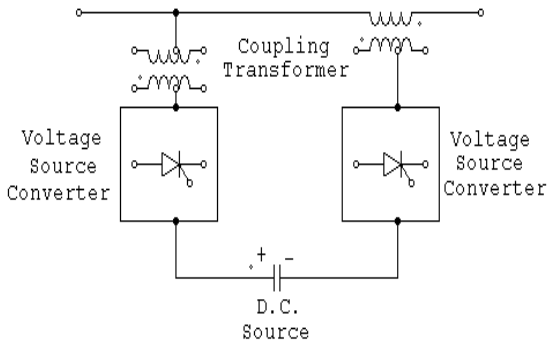

Fig.3 UPFC connected to a transmission line

II. CONCEPT OF REACTIVE POWER

When power supplies in power system some energy store in reactive element is called reactive power. Power is combination of active (real) and reactive power. Apparent power is sum of active (real) and reactive power. In AC system, some energy stored in inductive and capacitive elements for small time. Stored energy is reversal flow between source and load. Reactive power is stored temporary in the form of electric and magnetic fields. Inductive element store/absorb reactive power in the form of magnetic field and capacitor element generate reactive power, because store energy in the form of electric field.

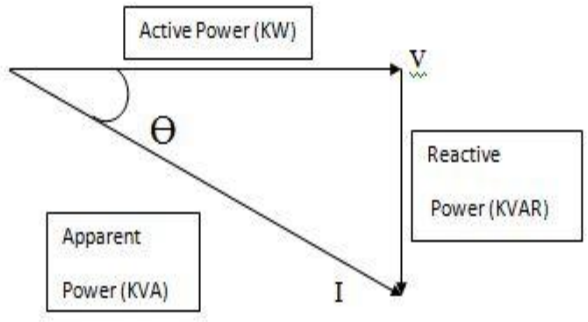

Fig. 4 Power triangle

Reactive power is dependent on power factor; power factor is cosine angle between voltage and current. Power factor angle increase reactive power is increase and power factor angle decrease reactive power also decrease.

$$\text{Power factor } (\cos \Theta) = \frac{Active\ power\ (KW)}{Apparent\ power\ (KVA)} \quad (1)$$

$$\Theta = \cos^{-1}\frac{KW}{KVA} \quad (2)$$

Where, Θ = Power factor angle

By injecting reactive power we can improve the power factor of system.

III. NEED FOR REACTIVE POWER COMPENSATION

Reason for reactive power compensation in system;

(1) Voltage regulation
(2) Increase system stability
(3) Better utilization of machine
(4) Minimize losses
(5) Prevent voltage collapse

IV. CLASSIFICATION OF FACT DEVICES

(1) VAR generators
  (a) Fixed or mechanically switched capacitors
  (b) Synchronous condensers
  (c) Thyristorized VAR compensators
    (i) Thyristor switched capacitors
    (ii) Thyristor controlled reactor
    (iii) Combined TSC and TCR
    (iv) Thyristor controlled series capacitor
(2) Self Commutated VAR compensators
  (a) Static synchronous compensators
  (b) Static synchronous series compensators
  (c) Unified power flow controllers
  (d) Dynamic voltage restorers

V. SIMULATION MODEL

(1) STATCOM model

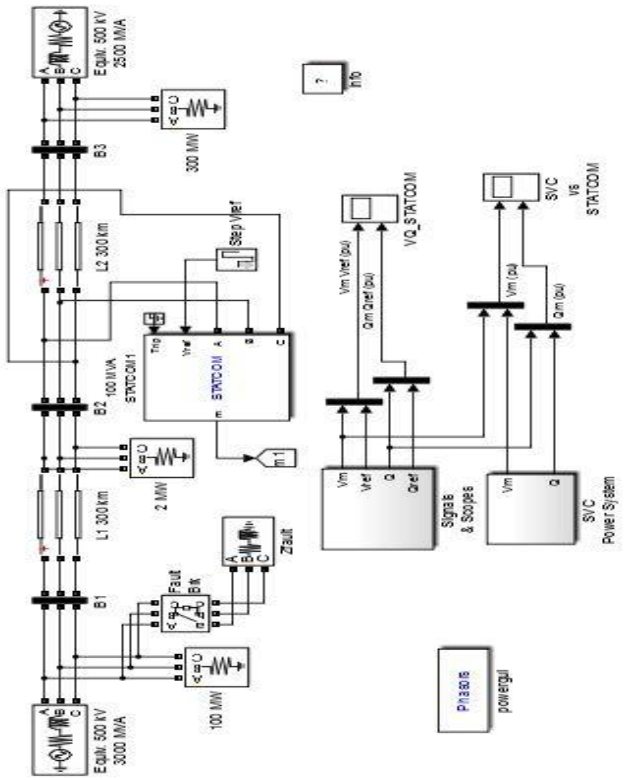

Fig. 5 Two area inter connected power system STATCOM

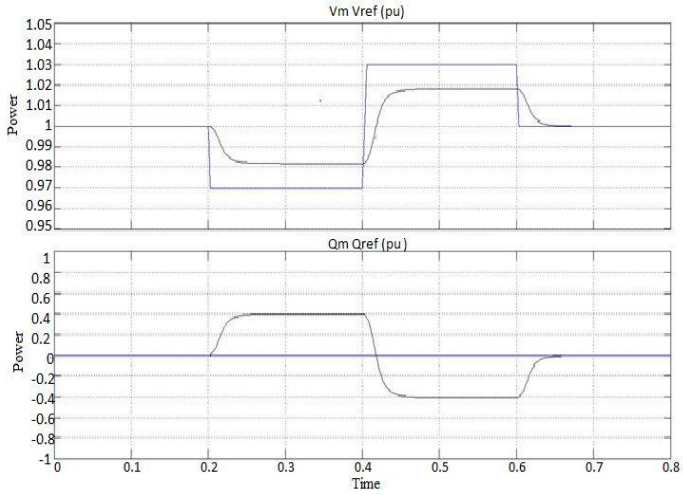

Fig. 6 Transient stability Two area inter connected power system STATCOM

(2) SSSC model

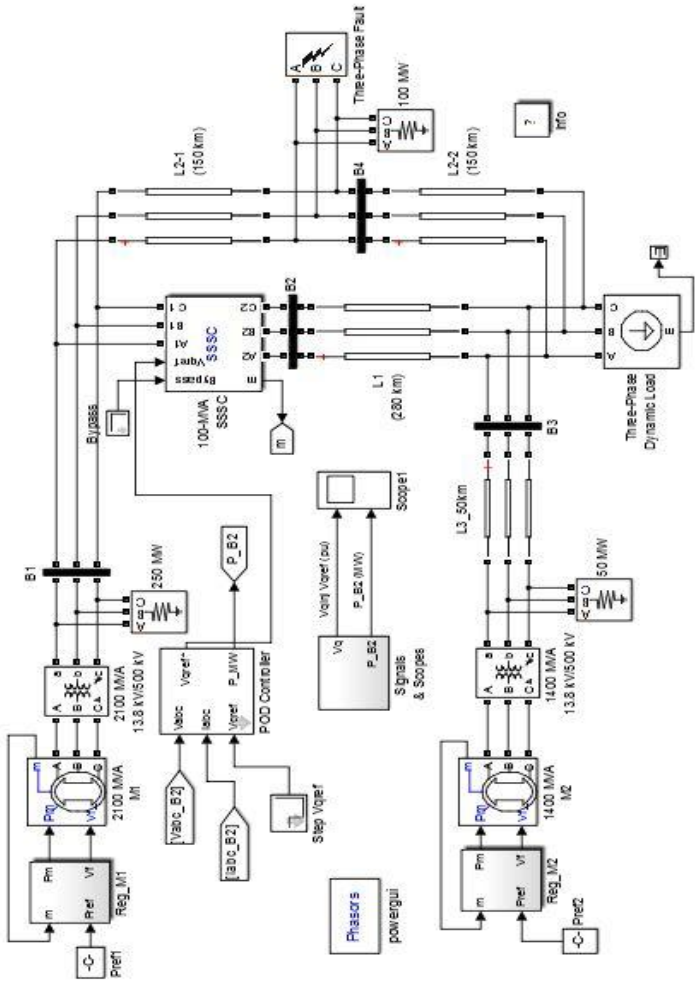

Fig. 7 Two area inter connected power system SSSC

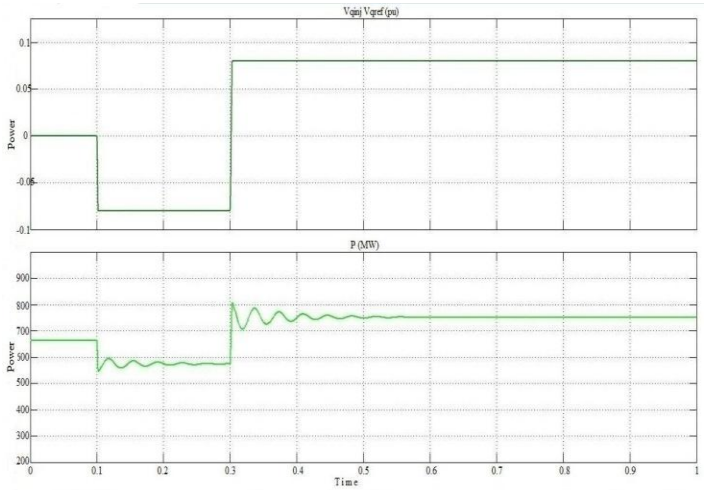

Fig. 8 Transient stability Two area inter connected power system SSSC

(3) UPFC model

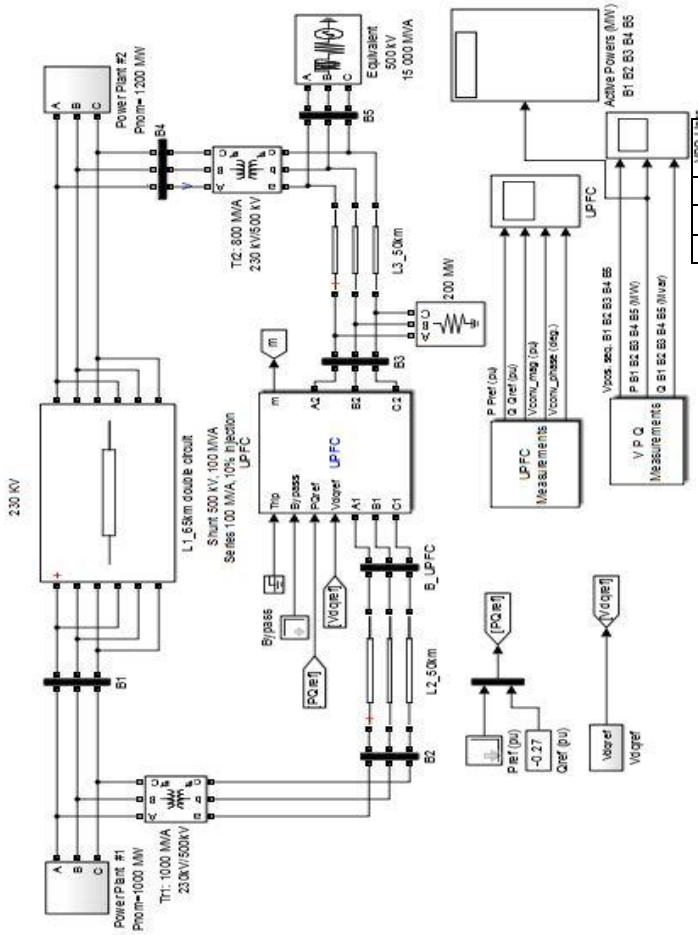

Fig. 9 Two area inter connected power system UPFC

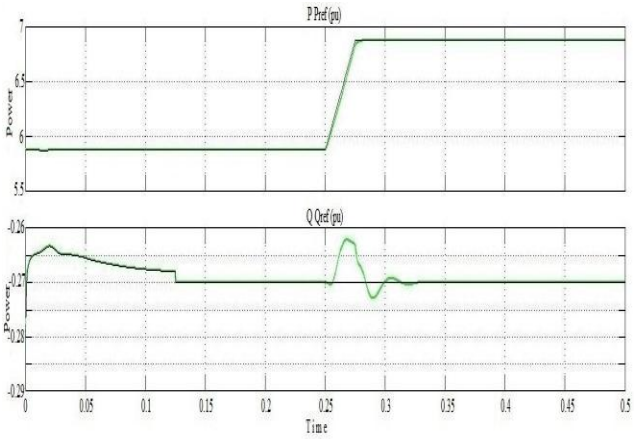

Fig. 10 Transient stability Two area inter connected power system UPFC

VI. COMPARISON BETWEEN STATCOM, SSSC AND UPFC FOR TRANSIENT STABILITY OF POWER SYSTEM

From the simulation results showed in Figs. a comparison between the above FACTS devices for Transient stability of two area power system study in Table I.

TABLE I
Comparison between FACTS Devices for Transient stability of power system

Two area power system with	Transient stability of power system	Steady state time (In seconds)
STATCOM	Medium	0.65
SSSC	Strong	0.5
UPFC	Strong	0.35

From the Table I, it is investigated that the UPFC Transient stability is strong in two area power system.

VII. CONCLUSIONS

Here we discussed the power system transient stability improvement of two area power system by various FACTS. The performance of the UPFC for power system transient stability improvement is compared with the STATCOM and SSSC. So from the simulation results it is clear that there is a considerable improvement in the system performance by installing UPFC. The steady state time is reached to be around 0.35 second.

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