

Comparative Study of Different Facts Devices

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Abstract: Today with the drastic growth of the people, the problems in our power system are increasing rapidly and are causing severe problems. To overcome these problems new technology is used. This new technology is called the FACTS, i.e., Flexible AC Transmission System. FACTS are the power electronics based new techniques which are being used more frequently nowadays. FACTS open the new opportunity for the power flow control and for enhancing the capability, for voltage stability both for dynamic static conditions of a system.

This paper presents a complete review on enhancement of power system stability such as rotor angle stability, frequency stability, and voltage stability by using different FACTS controllers such as TCSC, TSSC, SVC, SSSC, STATCOM, and UPFC in an incorporated power system networks.

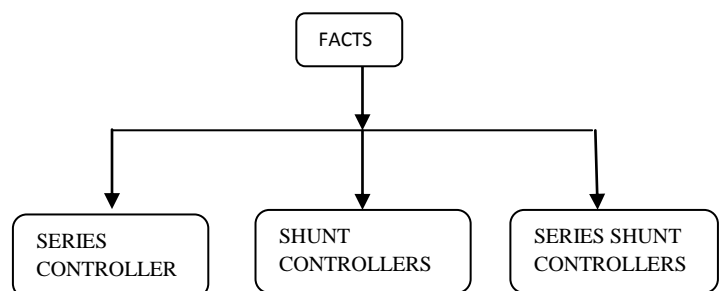
Keywords: FACTS, Power electronics, Power flow control, Voltage Stability.

I INTRODUCTION

The drastic growth of people is causing serious problems in our system, by increasing the demand of power. This increase in power is making the system more stressed or overloaded. The overloading of the system causes the problems like voltage instability, controllability problem, and load ability problem, etc. To overcome such serious problems the phase shifting transformers, tap changing transformers and etc were some techniques which were used. As these had certain disadvantages as:

1. Slower response.
2. More time consuming.
3. Less reliable.
4. Does not provide better flexibility.

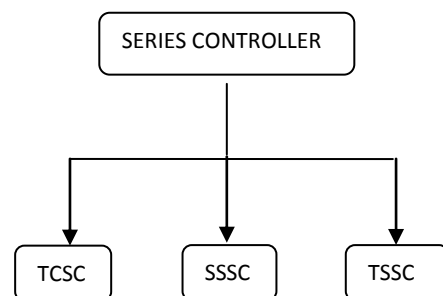
Therefore, the new technique is launched called FACTS (Flexible AC Transmission System). FACTS are based on the thyristor devices with only the gate turn on capability and no gate turn off capability. FACTS are the power electronics based new technique used for controllability, load ability, power flow control, voltage profile etc. FACTS overcome all the above drawbacks, and are also used to overcome any of the stability limits and are used more frequently in our system. FACTS devices are classified as:



II SERIES CONTROLLERS

These are the FACTS devices which are preferably used for power flow controls, reducing system losses through optimal location in power system network. Series controllers are used for injecting the voltage in series with the line. It supplies reactive power when the injected voltage gets in phase quadrature, else will deal with real power. It is used for long distance lines. Series Controllers implies the fractional neutralization of the transmission line reactance by a capacitor bank installed in series with line.

Types of series controllers:



1. TCSC: "IEEE Definition: A capacitive reactance controller which consists of a series capacitor bank shunted by a thyristor controlled reactor in order to provide a smoothly variable series capacitive reactance."

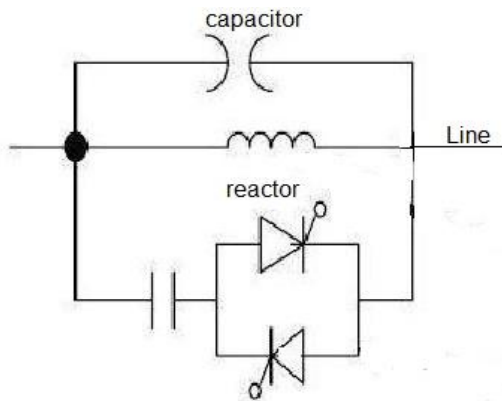


Fig. 1: TCSC layout

2. SSSC: “IEEE Definition: A static synchronous generator operated without an external electric energy source as a series controller whose output voltage is in quadrature with, and controllable independently of, the line current for the purpose of increasing or decreasing the overall reactive voltage drop across the line and thereby controlling the transmitted electric power”.

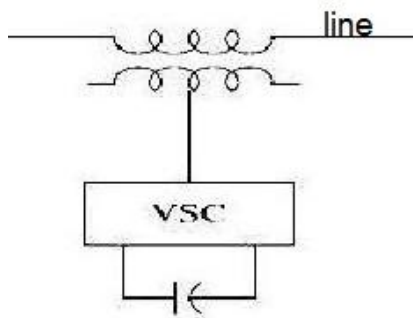


Fig. 2: SSSC layout

3. TSSC: “IEEE Definition: A capacitive reactance controller which consist of a series capacitor bank shunted by a thyristor switched reactor to provide a stepwise control of series capacitive reactance.”

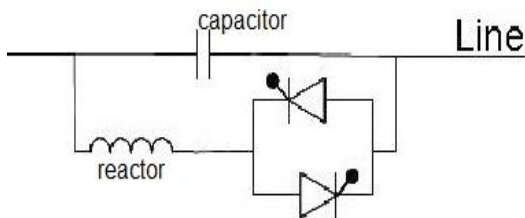


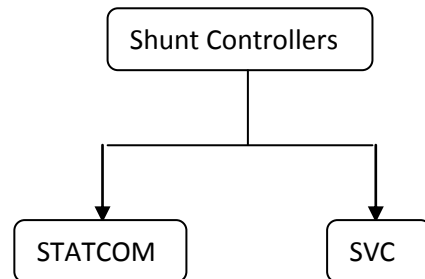
Fig. 3: TSSC layout

III SHUNT CONTROLLERS

These are the FACTS devices which are used for maintaining the voltage profile, reducing the losses through optimal placement of FACTS in the power system network.

Shunt controllers are used for injecting the current in the line. It supplies reactive power when the injected current gets in phase quadrature with the line voltage else will deal with real power.

Type of shunt controllers:



1. STATCOM: “IEEE Definition: A static synchronous generator operated as a shunt connected static VAR controller whose capacitive or inductive output current can be controlled independent of the ac system voltage.”

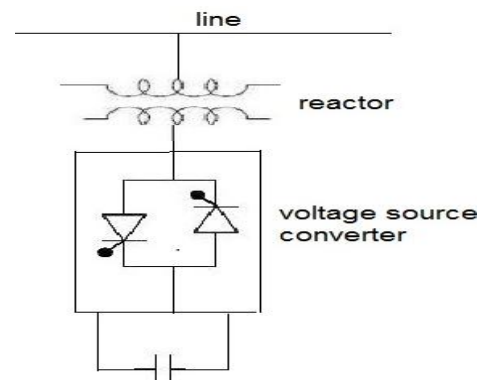


Fig. 4: STATCOM layout

2. SVC: “IEEE Definition: A shunt connected static VAR generator or absorber whose output is adjusted to exchange capacitive or inductive current so as to maintain or control specific parameters of the electrical power system.”

Some SVC schemes areas follows:

- a. Thyristor Controlled Reactor (TCR).
- b. Thyristor Switched Capacitor (TSC).

A. THYRISTOR CONTROLLED REACTOR (TCR)

“It is the shunt connected, thyristor controlled inductor whose reactance is changed in a partial conduction control of the thyristor valve”. By adjusting the firing angle the reactive power of the system is adjusted. It is characterised as “continuous control” and here no harmonics are generated.

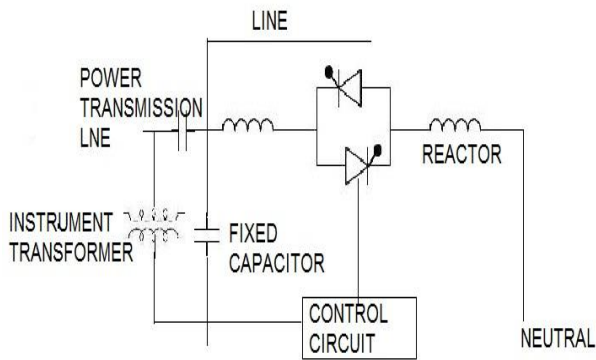


Fig. 5: TCR layout

B. THYRISTOR SWITCHED CAPACITOR (TSC)

It is characterised in “stepwise action by full or zero conduction control”, and it produces low losses, harmonics, redundancy and flexibility. It consist of many shunt connected inductors which changes in and out by thyristors without firing angle, and therefore, they are used to switch in and out of shunt capacitor units.

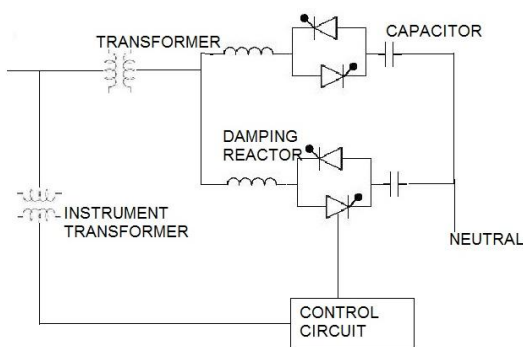


Fig. 6: TSC layout

IV SERIES SHUNT CONTROLLERS

These controllers are the combination of both shunt type and series type controllers. Therefore they exhibits the characteristics of both the types of controllers and are used for both power flow control and voltage profiles, reduces the losses, makes system more reliable, flexible, and secure. The type of series-shunt controller is UPFC i.e. Unified Power Flow Control.

UPFC: As it is the type of series-shunt controller, it is the combination of SSSC and STATCOM without any external energy source and exhibits the characteristics of both the types of controllers. It is the multi-tasking controllers. The two controllers are connected via a dc link which allows the bi-directional flow of real power. It can control the transmission line parameters such as impedance, voltage, angle and the line reactive power simultaneously.

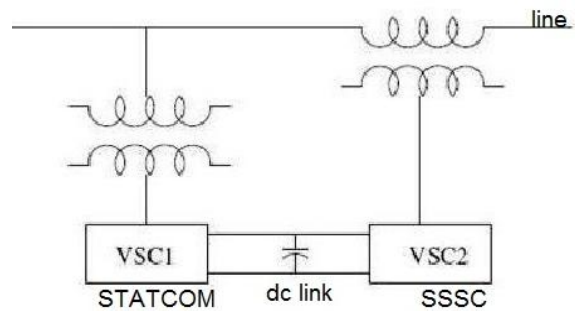


Fig. 7: UPFC layout

V BENEFITS OF USING FACTS CONTROLLERS

- ✓ Reduces the losses in the system and makes the system secure.
- ✓ With the help of STATCOM the voltage fluctuation is controlled.
- ✓ Power carrying capacity of the line is improved.
- ✓ Transient stability is ameliorated.
- ✓ Improves quality of supply.
- ✓ Superior use of the existent transmission system.
- ✓ Diminishes the reactive power flow.

VI COMPARISON OF SERIES AND SHUNT CONTROLLERS

1. Series controllers are used for controlling the current or power flow and damp oscillations.
2. In series controllers given MVA size is several times more powerful than the shunt controllers.
3. As shunt controllers can be used as current source which draws from or injects current into the line. Therefore, it is better to use shunt controllers for controlling voltage at and around the point of connection through injection of leading or lagging reactive current or both the active and reactive current for more effective control of voltage and damping of voltage oscillation.
4. Shunt controllers serves the bus node independently of the individual lines connected to the bus.

Table 1: COMPARISON FOR DIFFERENT FACTS CONTROLLERS

S.NO	CONTROL ATTRIBUTES	FACTS CONTROLLERS					
		TCSC	SSSC	TSSC	STATCOM	SVC	UPFC
1.	Power flow control	✓	✓	✓			✓
2.	Voltage profile improvement				✓	✓	✓
3.	Line commutated	✓		✓		✓	
4.	Forced commutated		✓		✓		✓
5.	Voltage source converter		✓		✓		✓
6.	Current source converter	✓	✓	✓	✓	✓	
7.	Transient and dynamic converter	✓	✓	✓		✓	✓
8.	Damping oscillation	✓	✓	✓	✓	✓	✓
9.	Fault current limiting	✓		✓			✓
10.	Voltage stability	✓	✓	✓	✓	✓	✓

Table 2: PROBLEMS AND THEIR CORRECTIVE MEASURES IN THE POWER SYSTEM NETWORK

S.NO.	PROBLEMS	FACTS DEVICES	CORRECTIVE MEASURE
1.	Parallel line load sharing	SSSC, UPFC, TCSC	Series reactance is adjusted
2.	Post-fault power flow sharing	SSSC, UPFC, TCSC	Network is reorganized
3.	Power flow direction reversal	SSSC, UPFC	Phase angle is adjusted
4.	Low voltage at heavy loads	STATCOM, SVC	Supply reactive power
5.	High voltage at low loads	STATCOM, SVC	Absorb reactive power
6.	High voltage following at outage	STATCOM, SVC	Absorb reactive power and prevent overloading
7.	Low voltage following at outage	STATCOM, SVC	Supply reactive power and prevent overloading
8.	Transmission circuit overload	TCSC, SSSC, UPFC	Reduce overload
9.	Tripping of Parallel circuits	TCSC, SSSC, UPFC	Limit circuit loading

VII CONCLUSION

This paper discussed about the different types of FACTS devices and also their comparative studies and benefits. The FACTS is the new technology which is based on power electronics and provides many benefits.

The application of FACTS devices can be seen in different ways in a system such as: for voltage stability enhancement

using Shunt type controllers[1] [4], for Power flow control, reducing losses Series type controllers are used[9] or the Multi type FACTS devices can be used[3].

There is every reason to consider that in a decade or so, FACTS controllers will modernize electrical power transmission systems making them more reliable, optimally utilized and better controlled.

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