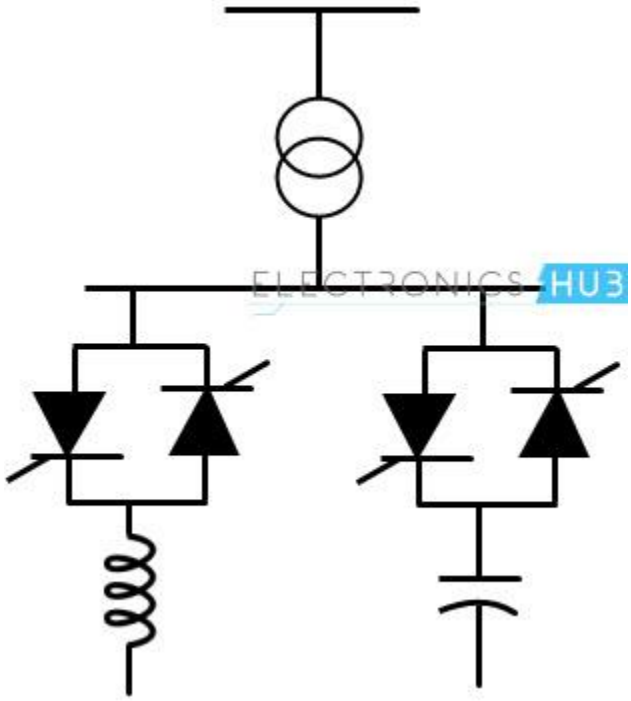
Overview of 10 FACTS Devices or Controllers

In this section we will discuss above mentioned controllers in brief.

Static Var Compensator

It is a shunt type controller which controls the power flow in transmission system and improves the transient stability of power grids. This controller regulates the voltage at its terminals by controlling the amount of reactive power injected into or absorbed from the power system.



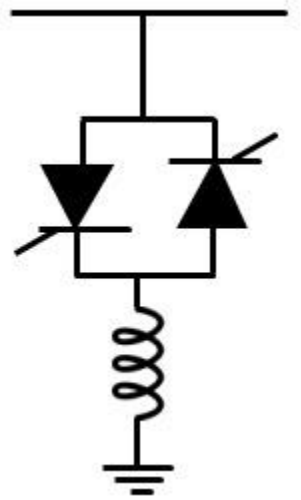
When the system voltage is low, SVC generates the reactive power and when the voltage is high it absorbs the reactive power. The reactive power is varied by switching the three phase inductor and capacitor banks. SVCs are basically thyristor controlled reactive power devices and common types of SVC are given below.

Thyristor controlled Reactor (TCR)

It is a shunt connected static var absorber or generator. It consists of a fixed reactor in series with bidirectional thyristor switches. The impedance of this

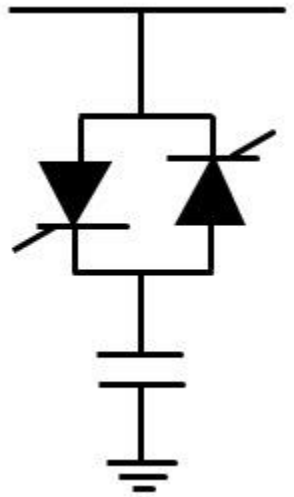
device varied in a continuous manner by varying the conduction angles of thyristors.

The output of this device is adjusted to exchange either inductive or capacitive current. It maintains and controls the parameters (typically a bus voltage) of the power system. It is an alternative to STATCOM in terms of cost.



Thyristor Switched Capacitor (TSC)

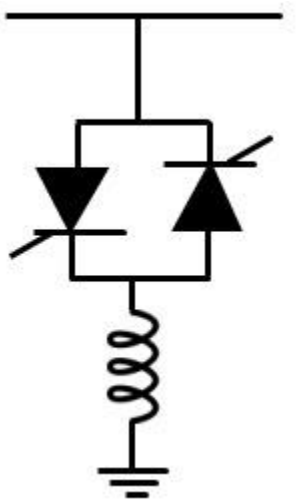
It consists of a shunt connected capacitor which is connected in series with bidirectional thyristor switches. The impedance or reactance of this device is varied in a stepwise manner by controlling the thyristors either in a zero or full conduction operation. This controller offers no harmonics, no transients, and low losses.



Thyristor Switched Reactor (TSR)

It is a special case of a TCR where phase control of the current is not exercised, instead the reactor is switched such that thyristors are either fully ON or OFF as in case of TSC. The advantage of TSR over TCR is that no harmonics current generation. Also, this controller use thyristors without firing control and hence lower cost and losses.

The reactive compensation control in electric power system use the above stated SVC types in different configuration, such as combination of TCR and TSC, combination of TCR and TSC with filter circuit and TCR with filter circuit as shown in figure.

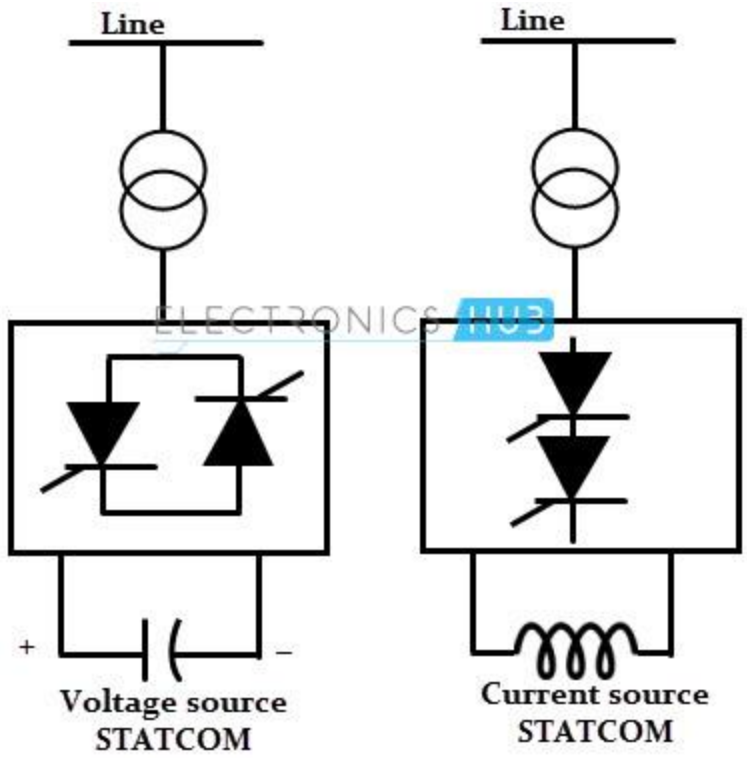


STATCOM

STATCOM means static synchronous compensator and it has the similar characteristics to that of synchronous condenser but it has no inertia as it is an electronic device.

It consists of a solid state voltage source inverter coupled with a transformer and this arrangement is tied to a transmission line. This arrangement supplies or draws reactive power at a faster rate compared with synchronous motor condenser.

This controller injects the current almost in quadrature with the line voltage, so that it matches a capacitive or an inductive reactance at the point where it is connected. STATCOM can be either voltage source or current source based controller but mostly voltage source is preferred.



Static Series Synchronous Compensator (SSSC)

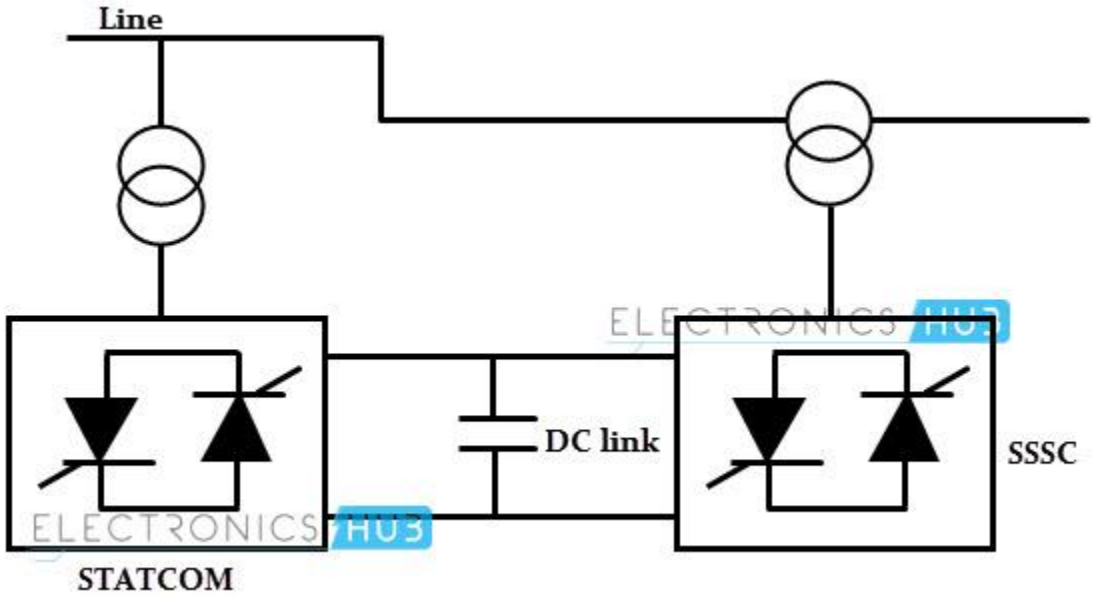
It is a series version of STATCOM and it is an advanced kind of control series compensation. It produces the output voltage in quadrature with the line current such that the overall reactive voltage drop across the line is increased or decreased.

Although it is like a STATCOM, the output voltage is in series with the line and hence it controls the voltage across the line, so its impendence. It has a capability to induce both inductive and capacitive voltage in series with the line and hence the power control.

Unified Power Flow Controller (UPFC)

UPFC is the combination of STATCOM and SSSC which are coupled by via a common DC link. It can exhibit the characteristics of both SSSC with series voltage injection and STATCOM with shunt current injection, with added features.

It has a unique ability to perform independent control of real and reactive power flow. Also, these can be controlled to provide concurrent reactive and real power series line compensation without use of an external energy source.



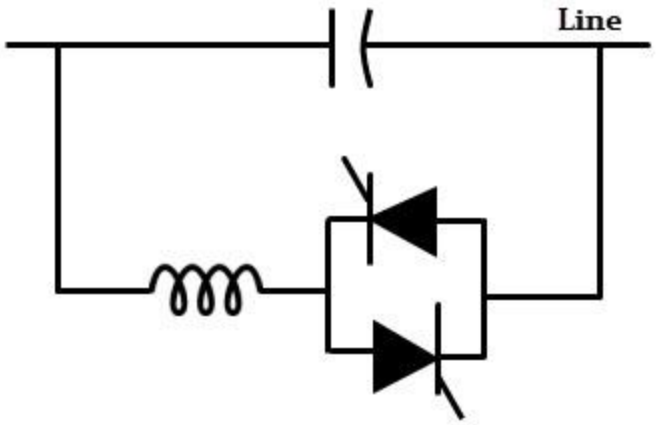
In the above UPFC, SSSC (or converter-2) injects a voltage with controllable magnitude and phase angle in series with the line though a series transformer. The function of STATCOM (or converter-1) is to absorb or supply the reactive power demanded by SSSC at the common DC link.

It can also supply or absorb the controllable reactive power to the transmission line to provide independent shunt reactive compensation.

Thyristor Controlled Series Capacitor (TCSC)

It is a capacitive reactance compensator. It consists of a series capacitor bank which connected in parallel with a thyristor controlled reactor that provides a smooth variable series capacitive reactance.

The total impedance of the system can be varied by changing the conduction angle of the thyristors and hence the circuit becomes either inductive or capacitive. If the total circuit impedance is inductive, the fault current is limited by this controller. A simple model of TCSC is shown in figure below.



Simple model of
TCSC and TSSC

Thyristor Switched Series Capacitor (TSSC)

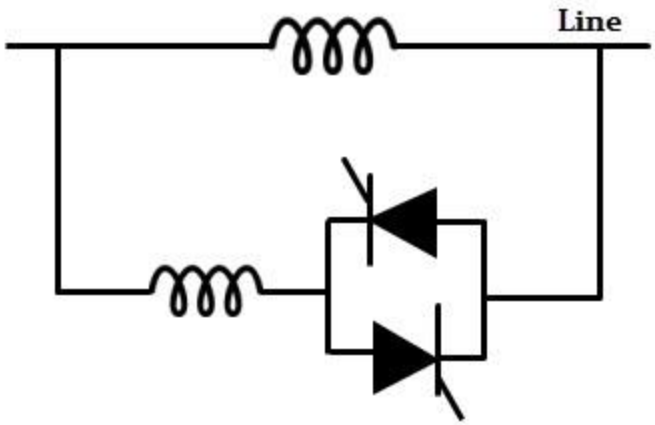
Similar to TCSC, it is also a capacitive reactance compensator consisting of thyristor switched reactor in parallel with a series capacitor. It provides the stepwise control of series capacitive reactance.

Instead of controlling in continuous manner, it switches the reactor such that the thyristors are fired at 900 and 1800. This controller can be implemented without firing angle control to reduce the cost and losses.

Thyristor Controlled Series Reactor (TCSR)

It is an inductive reactance compensator which consists of a series reactor in parallel with thyristor switched reactor. This controller provides a smooth variable inductive reactance.

When the thyristors firing angle is 180^0, the reactor stops conducting and hence the uncontrolled reactor only is in series with the line that acts as a fault current limiter. If the firing angle is below 180^0, the net (or overall) inductance decreases, thereby voltage is controlled in the network.



Simple model of
TCSR and TSSR

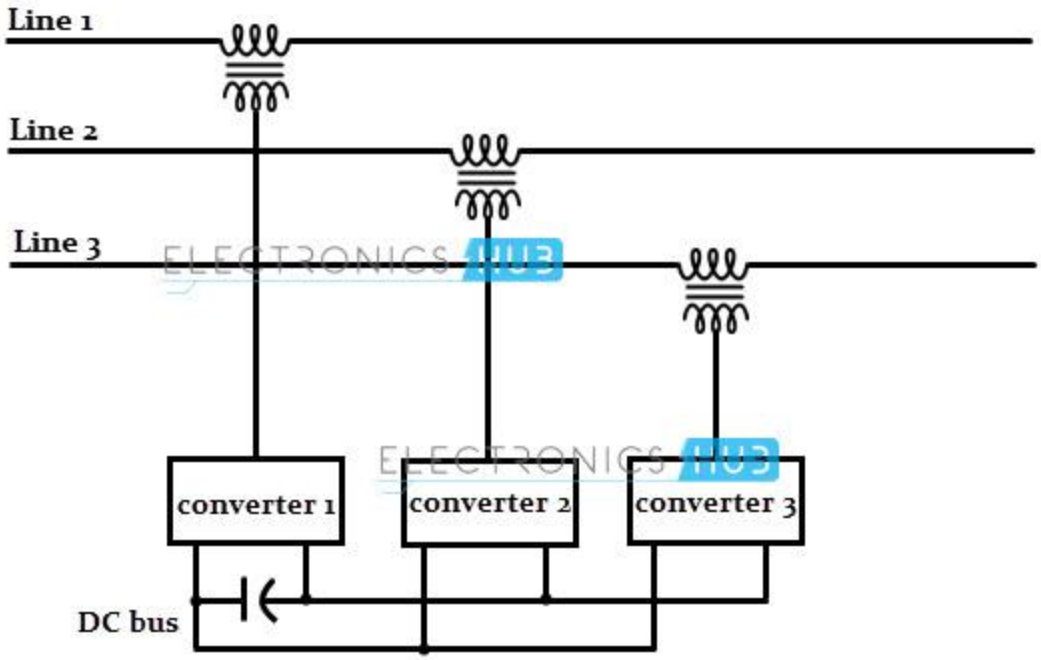
Thyristor Switched Series Reactor (TSSR)

Similar to TCSR, TSSR is also an inductive reactance compensator but it provides the stepwise control. This controller switches thyristors such that they are either fully ON or fully OFF in order to achieve stepped series inductance.

Interline Power Flow Controller (IPFC)

It is the new technique for effective power flow and compensation management of multiline transmission systems. It consists of a number of converters which are connected with a common DC link and each converter is provided for series compensation for a selected transmission line.

In addition to the reactive power compensation, this controller can able to transfer real power among the transmission lines due to a common DC link. So it is possible to equalize both real and reactive power between the lines.



Thyristor Controlled Phase Shifting Transformer (TCPST)

It is a variable phase angle controller, which consists of thyristors and phase shifting transformer. The variable phase angle control is achieved by switching the thyristor for different conduction angles.