What is Flexible AC Transmission (FACTS)?

In conventional AC transmission, the power transfer capability has been limited by various dynamic and static limits such as transient stability, voltage stability, thermal limits, etc. These inherent power system limits led to the under utilization of existing transmission sources.

Traditional methods of solving these problems use fixed and mechanically switched series and shunt capacitors, reactors and synchronous generators. However, desired response has not been effective due to slow response, wear and tear of mechanical components.

With the invention of thyristor devices, power electronic converters are developed that led to implement FACTS controllers. These power electronic based controllers can provide smooth, continuous, rapid and repeatable operations for power system control.

FACTS is an acronym for Flexible AC Transmission System and it is an application of power electronic devices to electrical transmission system.
It is an AC transmission system that incorporates a power electronic controller and other static controllers to improve the controllability as well as power transfer capability. It improves the performance of electrical networks by managing active and reactive power.

The IEEE definition for FACTS controller is stated as , it is a power electronic based system and other static equipment that provides the control of one or more AC transmission parameters (such as voltage, impedance, phase angle and power).

The possibilities offered by the FACTS technology include

- Power can be controlled for desired amount such that it flows through prescribed transmission routes
- Loading of the transmission lines near their thermal, steady-state and dynamic limits
- Enhancing the power transfer capability between interconnected transmission lines
- Increasing the quality of supply for sensitive industries
- Enhancing transmission system reliability and availability by limiting the impact of multiple faults

Why Compensation Techniques are used in Power system?

Power System network consist of three kinds of powers, namely, active, reactive and apparent power. Active power is the useful or true power that performs a useful work in the system or load.
Reactive power is caused entirely by energy storage components and the losses due to reactive power may be considerable, although reactive power is not consumed by the loads.

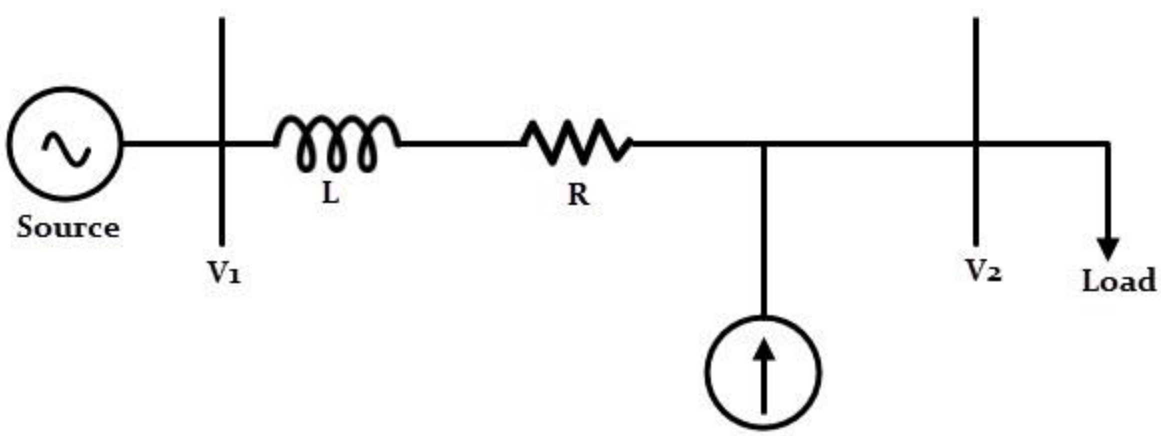
The presence of reactive power reduces the capability of delivering the active power by the transmission lines. And the apparent power is the combination of active and reactive power.
In order to achieve maximum active power transmission, the reactive power must be compensated. This compensation is necessary for

- Improving the voltage regulation
- Increasing system stability
- Reducing the losses associated with the system
- Improving the power factor
- Better utilization of machines connected to the system

  The compensation techniques of the power system supplies the inductive or capacitive reactive power (to its particular limits) in order to improve the quality and efficiency of the power transmission system. The following are the two popular compensation techniques used in power system.

Shunt Compensation

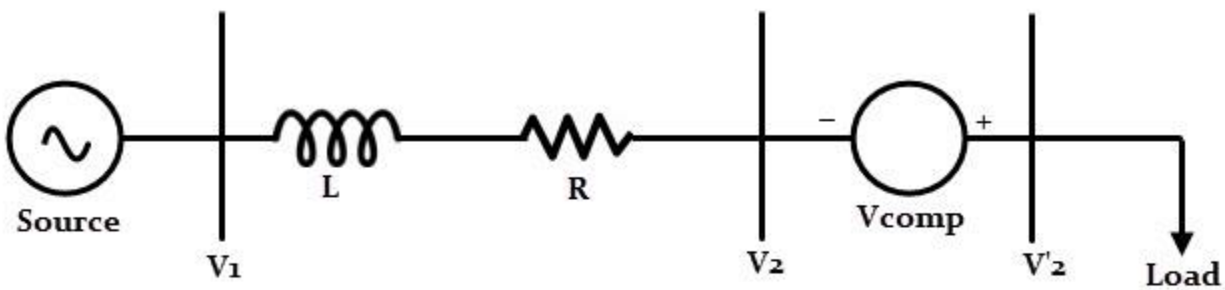
In this type of reactive power compensation, various compensation or FACTS devices (which can be either switched or controlled) are connected in parallel to the transmission lines at particular nodes.
These devices inject the current into the lines so that the reactive component of the load current is compensated thereby the losses are reduced and voltage regulation is improved.
The types of shunt compensation devices include static synchronous compensator (STATCOM) and static VAR compensator (SVC).



Series Compensation

In this, various compensation or FACTS devices (which can be either switched or controlled) are connected in series with the transmission lines at particular nodes. This compensation will give more control of power flow through the line and also improves the dynamic stability limit of the power system.

Mostly, capacitors are installed in series with the lines. The amount of compensation is varied by installing several capacitor banks in series with the lines. This is achieved by thyristors controlled series capacitors. Thyristor controlled switched capacitors (TCSC) and fixed series capacitor (FSC) techniques are widely used for series compensation.



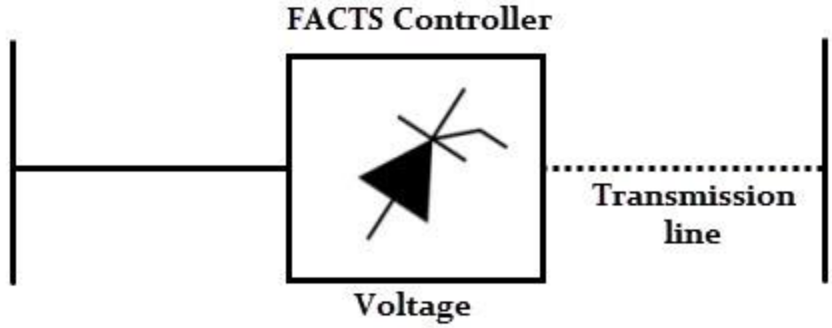
Types of FACTS Controllers

FACTS controllers are classified as

- Shunt connected controllers
- Series connected controllers
- Combined series-series controllers
- Combined shunt-series controllers

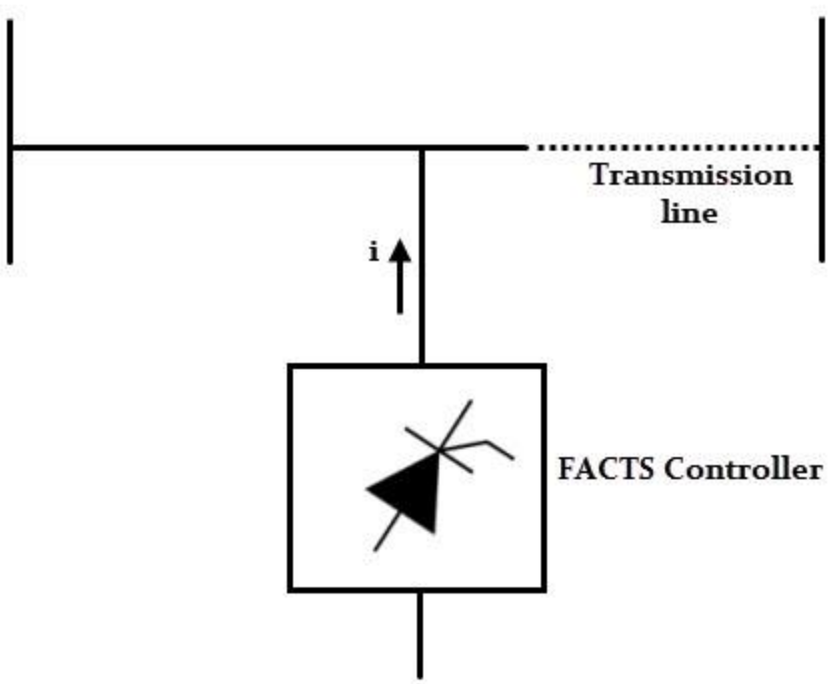
Series connected controllers

These controllers inject a voltage in series with the line. If this voltage is in phase quadrature with the current, the controller consumes or supplies variable reactive power to the network.
These controllers could be variable impedance such as a reactor or capacitor or a power electronic based variable source. Examples of the series controllers include SSSC, TCSR, IPFC, TSSC, TCSC, and TCSR.



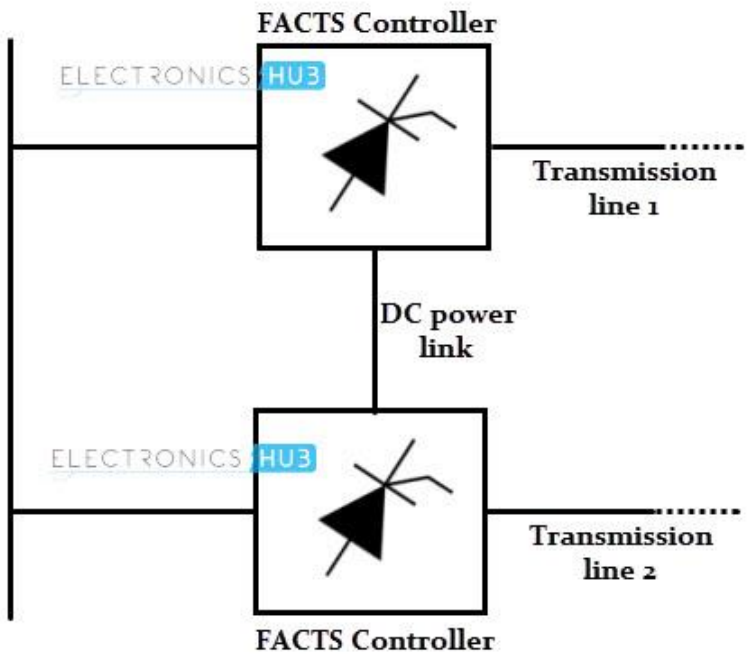
Shunt connected controllers

These controllers inject a current into the system at the point of connection. If this current is in phase quadrature with the line voltage, a shunt controller consumes or supplies variable reactive power to the network.
Similar to the series connected controllers, these controllers could be a variable reactor or capacitor or a power electronic based variable source. Examples of the shunt controllers include TCR, STATCOM, TSR, TCBR and TSC.



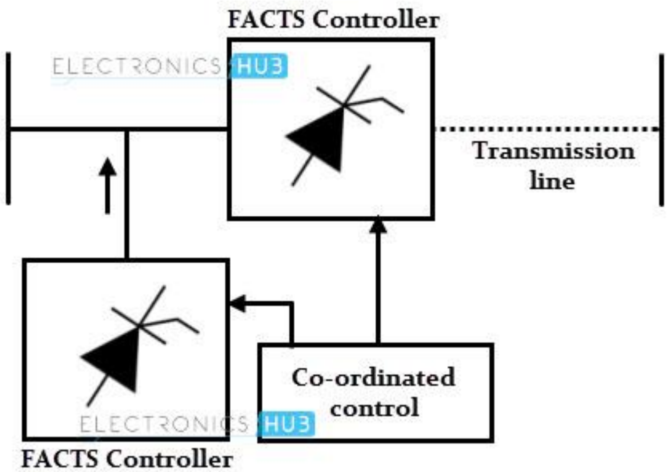
Combined series-series controllers

These controllers are the combination of individual series controllers that are controlled in a coordinated manner in multiple power transmission systems. Or these could be a unified controllers in which separate series controllers are employed in each line for series reactive power compensation and also to transfer the real power among the lines via proper link.
Example of this controller is IPFC that balances the real and reactive power flow in the lines in order to maximize the power transmission.

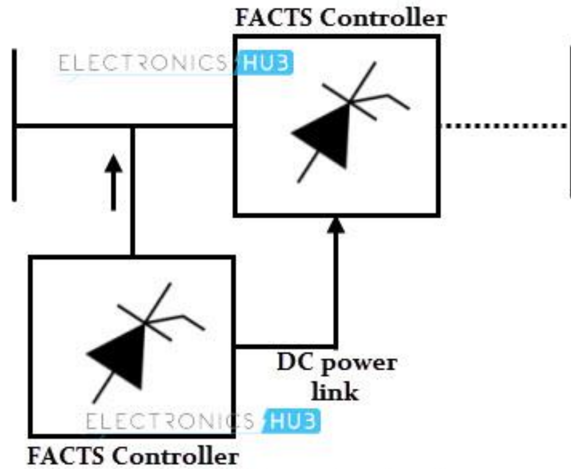


Combined series-shunt controllers

These are the combination of separate series and shunt controllers that are controlled in a coordinate manner or a unified power flow controller (UPFC) with series and shunt elements.
These combined controllers inject current into the system with series part of the controller and voltage in series in the line with shunt part of the controller.
Examples of these controllers include TCPST, UPFC and TCPAR.



Co-ordinated series-shunt controller



Unified series-shunt controller