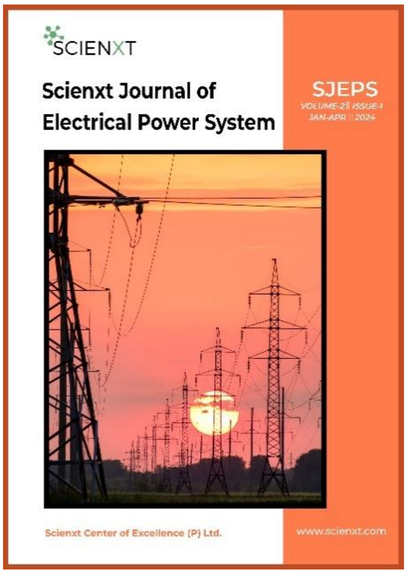

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Study of Flexible AC Transmission System (FACTS) devices

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Abstract:

Since electrical energy provides for a large amount of a modern society's energy needs, human energy consumption and demand have risen consistently since the industrial revolution. Electrical power is an ever-growing resource for industrialized nations, and demand for it has been doubling every ten years on the North American continent. More sophisticated technology is now employed in the power system to ensure the distribution and transmission of power are dependable. It is becoming increasingly evident that more effective use and management of the current transmission system infrastructure is needed to achieve both dependability and financial gain. This paper examines several devices and their types that are employed to optimize the current power system's utilization. By using advanced control technology, improvement is achieved. FACTS devices, or flexible AC transmission system, are the invention of power electronics. In addition to supporting the power system to operate with comfortable margins of stability, FACTS devices are efficient and capable of boosting a line's power transfer capability. Include a discussion of the benefits and uses of various fact devices.

Keywords:

Matlab, Multilevel inverter, Flexible Ac Transmission Systems, Voltage Source, Electrical power

1. Introduction:

Growing Electricity demand and market activities for electricity have governed to heavily stressed power systems. Now-a-days, worldwide the electricity supply industry is going through profound transformation. These changes are continuously being proposed to a once predictable business with the increasing electricity utility industry and the ongoing expansion. Due to these increasing demand of electrical energy consumption forces electrical power utilities to provide a high quality of electrical power and this is the reason why these issues is getting more and more important in power systems. In order to enhance the quality of electrical power a new technology based on power electronics named as Flexible AC Transmission systems (FACTS) is being introduced in the year 1988 by Dr. N. Hingorani. These FACTS concept is based on the consequential incorporation of power electronics devices and methods into the high-voltage side of the network to make it electronically controllable. Due to rapid development of modern power electronics technology up-till now lots of advanced FACTS devices have been put forward. These FACTS technology offers a favorable condition to improve the controllability, power transfer capability, and stability of AC transmission systems, and also overcome the operational complexities with conventional methods of power compensation.

2. Concept of facts technology:

According to IEEE, FACTS and FACTS controller is defined as follows:

2.1. FACTS (flexible AC transmission systems):

Alternating current transmission systems incorporating power electronics based and other static controllers to enhance controllability and increase power transfer capability.

2.2. FACTS controller:

Power electronics-based system and other static equipment that provides control of one or more AC transmission system parameters.

According to Siemens (a German multinational engineering and electronics Conglomerate Company) FACTS is the technology that increases the reliability of AC grids and reduces power delivery costs. They improve transmission quality and efficiency of power transmission by supplying inductive or reactive power to the grid. FACTS technology is not a single high-power controller, but rather a collection of controllers which can be applied individually or in co-ordination with others to control one or more of the inter-related system parameters. In general, the FACTS controllers can be classified as follows:

Thyristor controlled based FACTS controllers and VSI based FACTS controllers. But out of the above two controllers VSI based controllers are much more better then Thyristor controlled based controllers as these controllers possess a drawback of resonance phenomena whereas VSI based FACTS controllers are free from this phenomena.

3. Generation of facts controllers:

The following generation of FACTS controllers for development of FACTS Controllers.

3.1. First generation of FACTS controllers:

FACTS controllers such as SVC, TCSC, and TCPST are developed in the first generation of FACTS controllers.

Second Generation of FACTS Controllers FACTS controllers such as SSSC, STATCOM, and UPFC are developed in the second generation of FACTS technology.

4. Basic types of facts controllers and their functions:

In general, FACTS controllers can be divided into four categories on the basis of their connection diagrams in power systems

4.1. Series connected FACTS devices:

Series FACTS devices could be variable impedance such as reactor, capacitor, etc., or power electronics based variable source of main frequency, sub synchronous and harmonics frequencies (or a combination) to serve the desired need. In principle, all series FACTS devices inject voltage in series with the transmission line.

4.2. Shunt connected FACTS devices:

Shunt FACTS devices may be variable impedance, variable source, or a combination of these. They inject current into the system at the point of connection.

4.3. Combined series-series connected FACTS devices:

Combined series-series FACTS devices are a combination of separate series FACTS devices, which are controlled in a coordinated manner.

4.4. Combined Series-shunt connected FACTS devices:

Combined series-shunt FACTS devices is a combination of separate shunt and series devices, which are controlled in a coordinated manner or one device with shunt and series elements.

Control attributes for various FACTS Controllers

1. SVC: Voltage control, VAR compensation, Power Oscillation Damping, Voltage Stability, Transient Stability and Distributed Generations
2. TCSC: Current control, Power Oscillation Damping, Voltage Stability, Transient Stability and Distributed Generations, Fault Current Limiting.
3. SSSC without storage: Current control, Power Oscillation Damping, Voltage Stability, Transient Stability and Distributed Generations, Fault Current Limiting.
4. SSSC with storage: Current control, Power Oscillation Damping, Voltage Stability, Transient Stability and Distributed Generations.
5. STATCOM without storage: Voltage control, VAR compensation, Power Oscillation Damping, Voltage Stability.
6. STATCOM with storage, BESS, SMES, large dc capacitor: Voltage control, VAR compensation, Power Oscillation Damping, Voltage Stability, Transient Stability and Distributed Generations, AGC.
7. UPFC: Active Power and Reactive Power control, voltage control, VAR compensation, Power Oscillation Damping, Voltage Stability, Transient Stability and Distributed Generations, Fault Current Limiting.

5. Introduction to various facts controllers:

5.1. SVC (static VAR compensator):

According to IEEE-CIGRE co-definition, an SVC (Static VAR Compensator) is a static VAR generator whose output is varied so as to control or maintain specific parameters (e.g. voltage or reactive power of bus) of the electric power system. SVC are used in two main situations: Connected near large industrial loads, to improve power quality i.e. Industrial SVC. Connected to the power system, to regulate Transmission voltage i.e. Transmission SVC. The SVC can be operated in two different modes: In voltage regulation mode (the voltage is regulated within certain specified limits.) and In VAR control mode (the SVC susceptance is kept constant.) The voltage Vref is the terminal voltage of the SVC when it is neither generating nor absorbing any reactive power. The reference voltage value can be varied between the maximum and minimum limits, Vref max and Vref min, using SVC control system. The V-I characteristics is described by the following equations:

V = Vref + Xs * I if SVC is in the regulation range

(- Bcmax < B < Blmax)

5.2. TCSC (thyristor-controlled series capacitor):

TCSC is a capacitive reactance compensator, which consists of s series capacitor bank shunted by a thyristor-controlled reactor in order to provide a smoothly variable series capacitive reactance. TCSC designs operates in the same way as Fixed Series Compensation but it provide variable control of the reactance absorbed by the capacitor bank.. The effective reactance is the parallel combination of a variable reactance and fixed capacitor. At certain values of firing angle parallel resonance may occur.

5.3. SSSC (static synchronous series compensator):

A SSSC is a static synchronous generator operated without an external electric energy source as a series compensator 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. The SSSC may include transiently rated energy source or energy absorbing device to enhance the dynamic behavior of the power system by additional temporary real power compensation, to increase or decrease momentarily, the overall real voltage drop across the line.

The SSSC is a device that belongs to the FACTS family using power electronics to improve power oscillation damping and to control power flow on power grids. The SSSC injects a voltage in series with the transmission line where it is connected. The SSSC contains a solid-state voltage source inverter connected in series with the transmission line through an insertion transformer. This connection enables the SSSC to control power flow in the line for a wide range of system conditions.

5.4. Statcom (static synchronous compensator):

A STATCOM is a static synchronous generator operated as a shunt connected static VAR compensator whose capacitive or inductive output current can be controlled independent of the ac system voltage. When the STATCOM is operated in voltage regulation mode, In STATCOM, the resonance phenomenon has been removed. So, STATCOM is having more superior performance as compared to a SVC.

5.5. UPFC (unified power flow controller):

A combination of Static synchronous compensator (STATCOM) and a static synchronous series compensator (SSSC) which are coupled via a common dc link, to allow bidirectional flow of real power between the series output terminals of the SSSC and the shunt output terminals of the STATCOM, and are controlled to provide concurrent real and reactive series line compensation without an external electric energy source. The UPFC, by means of angularity unconstrained series voltage injection, is able to control, concurrently or selectively, the transmission, line voltage, impedance, and angle or, alternatively, the real and reactive power flow in the line. The UPFC may also provide independently controllable shunt reactive compensation. This FACTS topology provides much more flexibility than the SSSC for controlling the line active and reactive power because active power can now be transferred from the shunt converter to the series converter, through the DC bus. Contrary to the SSSC where the injected voltage Vs is constrained to stay in quadrature with line current I, the injected voltage Vs can now have any angle with respect to line current. If the magnitude of injected voltage Vs is kept constant and if its phase angle with respect to V1 is varied from 0 to 360 degrees, the locus described by the end of vector V2 (V2 =V1 + VS) is a circle. As is varying, the phase shift between voltages V2 and V3 at the two line ends also varies. It follows that both the active power P and the reactive power Q transmitted at one line end can be controlled.

6. Conclusion:

In this paper an attempt has been made to review various literatures for the introduction of various FACTS controllers such as SVC, TCSC, STATCOM, SSSC and UPFC. Also in this review article an attempt is made to find out possible benefits of these controllers and recent applications of the same. According to the proposed schemes existing FACTS controllers are being classified.

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