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Examination of the FACTS Equipment Function in Communication Networks

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Abstract
The operation of the Flexible AC Transmission System (FACTS) equipment in transmission systems is studied in this report. The need for electrical energy has multiplied in the current environment. As a result, the energy sector is now dealing with a crisis of power transmission limitations.systems of transmission. The restrictions result from having to strike a compromise between supplying the permitted voltage level and preserving system stability. The FACTS devices are vital in the current situation because of the power outage. FACTS are efficient equipment for power control in energy transmission systems. They minimize transmission losses and environmental impact while aiding in the increase of power transmission capability. Additionally, they support enhancing power quality while preserving the stability of the main forms of operation and uses of FACTS equipment in transmission and distribution systems include the Thyristor controlled series capacitor (TCSC), Static Synchronous Series, Static Var Compensator (SVC), and Static Synchronous Compensator (STATCOM).This study discusses the Unified Power Flow Controller (UPFC) and the Siemens Compensator (SSSC). The features of UPFC and FC-TCR were examined, and Matlab's Simulink was used to run the models for each. The power flow in a fixed capacitor thyristor controlled reactor was regulated by altering the thyristor's firing angle. Better compensation than a typical transmission line was received. The control parameters for the Unified Power Flow Controller were the injected voltage and the injected current. It is possible to control the power flow by altering the phase or magnitude

Keywords- Facts, Flexible AC Transmission Systems, Modelling, Network control, Power Electronics,Power System control,Power Systems

I. INTRODUCTION

The need for electricity has grown dramatically over the last few years, and as a result, energy transmission networks are experiencing a problem related to power transmission limitations. The restrictions result from striking a compromise between providing the permitted amount of voltage and preserving stability. Consequently because of this, the system's actual operating capacity is much higher than its practical operating capacity. The energy transmission systems operate less than optimally as a result. Building new transmission lines is one way to address the issue of expanding power transmission capacity. Both practically and economically, this is not possible. Owing to the expanding semiconductor market and its uses in power systems the FACTS idea is put forth to increase transmission lines' actual capacity. The application of FACTS devices will modify engineers' methods for designing and managing power systems. The devices can be used in transmission lines in series, shunt, or shunt-series configurations, and they can be used to adjust the parameters of operation in steady state transmission systems and dynamic behavior of the system in a temporary state can be attained.

The following uses are possible for FACTS devices [1]

Control of power flow Enhanced transmission capacity, Voltage control,Reactive power adjustment and improved stability,Enhancing the quality of power,Power conditioning, flicker mitigation, and the integration of distributed and renewable energy sources and storage systems Phase shift control, series compensation, or switched or controlled shunt compensation are the methods used to employ FACTS-devices. The gadgets function electrically as controllers for fast current, voltage, or impedance. Power electronics allows for an extremely short reaction time, down to much less than a second. An organized synopsis of FACTS-devices is provided beforehand. The various domains of application for the gadgets are mapped to them.

II.Overview FACTS devices have been developed as a result of power electronic components' expanding capabilities. Devices for high power levels have been made accessible in converters for high and even maximum voltage levels. The overall starting points are the network elements affecting the reactive power or the impedance of a section of the power system.

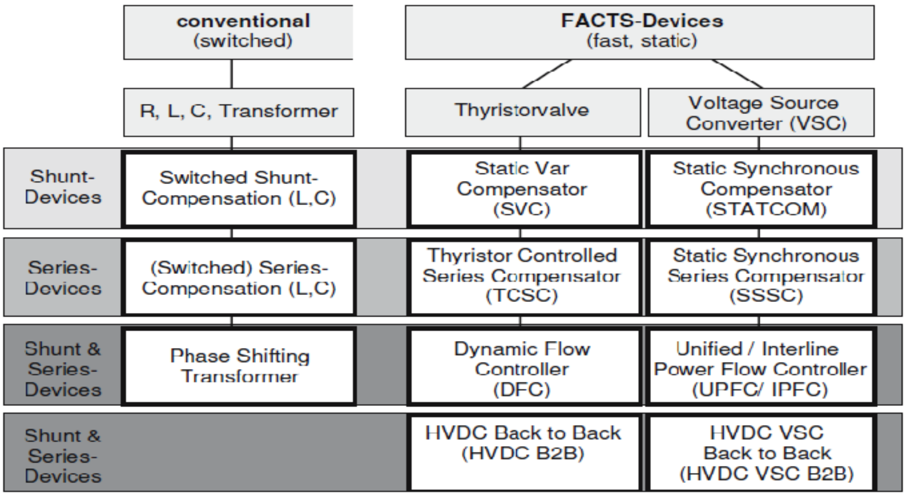

Fig.1: Overview Of major FACTS devices [1]

A breakdown of the number of basic devices into conventional and FACTS devices is shown in Fig. 1[1]. The taxonomy for the FACTS side is divided into dynamic and static categories. The word "dynamic" refers to the power electronics' facilitation of the quick controllability of FACTS devices. This is one of the primary elements that sets it apart from traditional gadgets. The word "static" suggests that the gadgets used to achieve dynamic controllability don't have any moving parts, such as mechanical switches. Because of this, the majority of FACTS devices can be both static and dynamic. The traditional devices, as depicted in Fig. 1, are composed of transformers and fixed or mechanically switchable components such as capacitance, inductance, and resistance. In addition to these components, the FACTS devices make use of extra power electronic valves or converters to Within an alternating current cycle, flip the elements in smaller increments or in patterns. The FACTS devices in the left-hand column use converters or thyristor valves. These valves or converters are well known since several years. They have low switching frequency of once a cycle in the converters and hence the have low losses. The thyristors can be also used to simply bridge impedances in the valves. The more sophisticated voltage source converters in the right-hand column of the FACTS devices are mostly based on insulated gate bipolar transistors (IGBT) or insulated gate commutated thyristors (IGCT). Because the IGBTs or IGCTs modulate their pulse width, a free controllable Voltage source converters supply voltage in both magnitude and phase. There is a high modulation frequency. Low harmonics are therefore permitted in the output signal, and network disruptions are even compensated for. However, the losses also increase as the switching frequency does. The only drawback is this. The converters' unique designs can make up for this.

III.Configuration Shunt Devices for FACTS Devices

The most popular FACTS device is SVC, or the version with the Voltage Source Converter known as STATCOM. Reactive power compensators are what these gadgets do. Shunt devices are mostly used in transmission, distribution, and industrial networks for the reasons listed below [1]: Diminished network losses through the elimination of undesired reactive power flows Keeping balanced reactive power in contractual power transfers • Consumer compensation and power quality enhancement, particularly in applications with large demand variations such as industrial machinery, metal melting facilities, railway or subterranean train systems • Thyristor converter compensation, for example in traditional HVDC lines Enhancement of stability, either temporary or steady. Nearly half of SVCs and more than half of STATCOMs are employed in industrial applications.The prerequisite is power quality.

Compensator for Static Var (SVC)

Thyristor controlled reactors (TCR), thyristor switched capacitors (TSC), and/or fixed capacitors (FC) set to filters are the foundation of the Static Var Compensator. A stationary reactor connected in series with a bidirectional thyristor mechanism. TCR reactors come in a variety of forms, including air core, glass fiber insulated, and epoxy resin impregnated models [2].

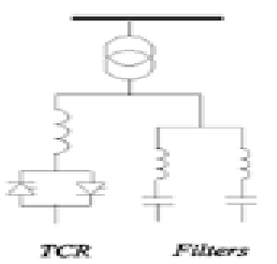

Fig. 2a: Configuration of TCR/FC

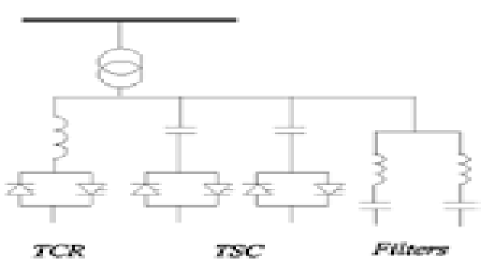

Fig. 2b: Configuration of TCR/TSC

The TSC is made up of a capacitor bank connected in series with a bi-directional thyristor valve and a damping reactor that also serves to detune the circuit to prevent parallel resonance with the network. The thyristor switch functions to connect or disconnect the applied voltage for an integral number of half-cycles. Cut off the capacitor bank. For fulfillment of several standards and conditions in the there are numerous approaches to create a full SVC based on TCR and TSC for grid operation. Figures 2a and 2b depict two extremely popular design types. Each has unique advantages.

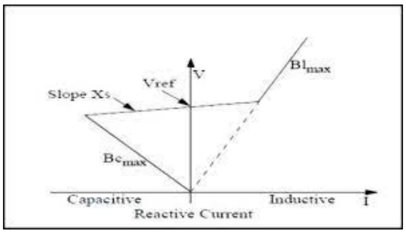

Fig.3: Voltage/Current Characteristics of SVC [1]

Statcom, or Static Synchronous Compensator

Within the converter's capacity, STATCOM can dynamically alter the required reactive power when used in shunt configurations in transmission lines. The regulated current extracted by the The active and reactive components of a converter are separated into two halves. While the reactive component of current is employed to achieve the correct reference level, the active component of current automatically satisfies the DC link capacitor's demand for active power. Figure 4 depicts the STATCOM's structure [1], and Figure 5 depicts its operational characteristics.

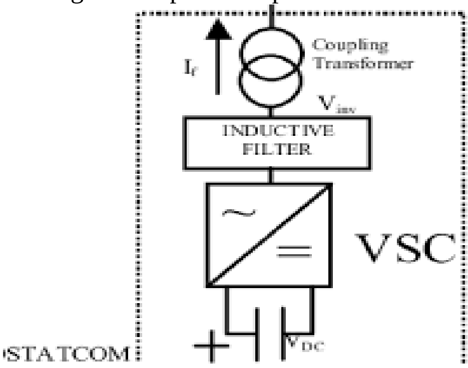

Fig.4: STATCOM Structure [1]

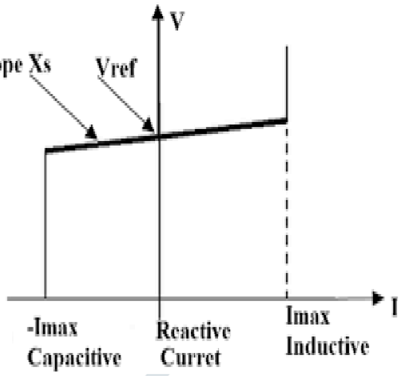

Fig.5: Voltage/Current Characteristics [1]

The steepness of the static line between the current restrictions determines the voltage control characteristic. One benefit of the STATCOM is that its reactive power supply is not influenced by the connecting point's real voltage. This is deduced from the schematic for the maximal currents being voltage-independent relative to the SVC in Figure 5. This indicates that the STATCOM maintains its entire capacity even in the most dire situations.

There are two ways that STATCOM can function [2]. They are listed in the following order:

The control mode for reactive power (Var):

The reference input for reactive power is assumed to be an inductive or capacitive reactive power request. manner of control. The converter control converts the Var reference into a corresponding current request, and then modifies the converter's gating to set the desired current.

Mode of automatic voltage control:-

The voltage control mode is typically employed in real-world scenarios. When in voltage control mode, the converter's reactive current is automatically controlled to keep the transmission line voltage at the connection point at a reference value.

Devices in Series

Thyristor Controlled Series Compensation (TCSC) and Voltage Source Converter based devices are the next evolution of series devices, which started off as fixed or manually switched compensations. The principal uses are [1]: Diminished angle and amount of series voltage decrease across a power line Decrease in voltage swings within specified bounds when power transmissions change Enhancement of oscillation damping and system damping Controlling short circuit currents in substations or networks Preventing loop flows and making modifications to power flows.

Series capacitor with thyristor control (TCSC)

Thyristor Controlled Series Capacitors (TCSC) address certain dynamical difficulties in transmission systems. It promotes damping in large-scale, networked electrical systems. Additionally, it solves the Sub-Synchronous Resonance (SSR) issue [2]. A phenomenon known as sub-synchronous resonance is the result of interaction between big thermal generators and transmission networks with series compensation. TCSCs' high-speed switching capacity offers a way to regulate the flow of line electricity. This enables higher loads on already-existing transmission lines and quick readjustments of line power flow in the event of different emergencies. The TCSC has the authority to regulate steady-state power flow within its rating parameters.

From a basic technological perspective, the TCSC is similar to the traditional series capacitor. Every piece of power equipment, including the thyristor valve that regulates the behavior of the main capacitor bank, is housed on a separate steel platform. In a similar manner, where protection and control reside on-ground potential in addition to additional support systems. Figure 6 depicts a TCSC's basic configuration, and Figure 7 its operational diagram. The firing angle and the Thyristors' maximum operating temperature define the operational diagram's border.

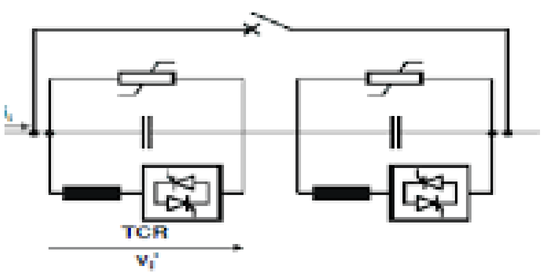

Fig. 6: Principle setup of TCSC [1]

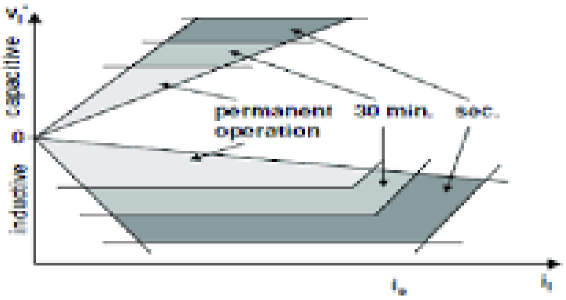

Fig. 7: Operational characteristics of TCSC [1]

Compensator for Static Synchronous Series (SSSC)

The SSSC injects a voltage into the transmission line with a regulated magnitude and angle by connecting it in series. The injected voltage regulates the electricity flowing via the line [2]. The one who injected However, the operating mode used by the SSSC to regulate power flow affects voltage. Fig. 8 below illustrates the basic arrangement of an SSSC.

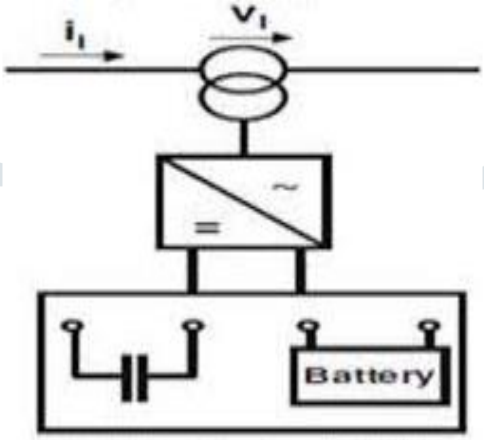

Fig. 8: Principle Setup of SSSC [1]

The following are the two operational modes:

Mode of line impedance compensation:- When the line current and the injected voltage are maintained in quadrature, allowing the series When viewed from the line, insertion simulates impedance in order to simulate solely reactive (inductive or capacitive) compensation. This mode can be chosen to work with the system's current series capacitive line compensation.

Autonomous power flow control mode: The injected voltage's magnitude and angle are adjusted to compel a line current that produces the intended real and reactive power flow in the line. When the power flow control is automated, A closed-loop control system automatically and constantly determines the series injected voltage to guarantee that the intended actual and reactive power flow is maintained despite changes in the power supply.

Devices in Series and Shunt

Controller for Unified Power Flow

Static compensator and static series compensation are used to create the UPFC. It performs dual functions as a phase-shifting and shunt-compensating device. A common DC-capacitor connects two voltage source converters that connect a shunt and a series transformer, which make up the UPFC [2].The DC-circuit enables the active power exchange between the series and shunt transformers to regulate the series voltage's phase shift [8]. A thyristor bridge is required to protect the series converter.A UPFC's high cost stems from the high maintenance required for both protection and voltage source converters. This limits the viable applications in which simultaneous control over power flow and voltage is needed.

Conclusion

In this study, the foundation of FACTS was examined, and a review of the literature was completed. The FACTS equipment's numerous operating modes and features were also examined. The following outcomes were attained by simulating a transmission line's characteristics in SIMULINK both with and without the addition of FACTS equipment.Real power was measured at 0.12 MW before the addition of FACTS devices (FC-TCR), and it increased to 0.17 MW after that. Prior to the deployment of FACTS devices, the reactive power was measured at 0.35 MVAR; following the implementation of FACTS devices (FC-TCR), the value increased to 0.55 MVAR. Following the implementation of the FACTS device, an increase in power flow was noted. Real and reactive power variations in response to capacitance changes were noted and recorded.Reactive power was measured at 0.66MVAR and real power at 0.23 MW upon the adoption of the Unified Power Flow Controller. Following the installation of the FACTS device, an increase in power flow was noted. Real and reactive power fluctuations in response to shifts in the strength and direction of the voltage that was injected was noted and recorded. When the injected voltage's magnitude increased, real and reactive power were observed to increase, but when the injected voltage's phase increased, real and reactive power decreased. Variations in resistive shunt current and resistance were observed, together with changes in real and reactive power, while the resistive shunt current remained constant.

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