

5.8 FACTS

- A Flexible Alternating Current Transmission System (FACTS) is a system composed of static equipment used for the AC transmission of electrical energy and it is meant to enhance controllability and increase power transfer capability of the network and it is generally a power electronics-based system.
- A FACT is defined by the IEEE as “a power electronics based system other static equipment that provide control of one or more AC transmission system parameters to enhance controllability and increase power transfer capability”.

Description

The main objective of FACTS devices is to replace the existing slow acting mechanical controls required to react to the changing system conditions by rather fast acting electronic controls. The mechanical controls require power system operators and designers to provide generous margins to assure a stable and reliable operation of the system. As a result the existing systems cannot be made use of to their full capacity. However, with the use of fast acting controls, the power system margins could be reduced and power system capability could be more fully utilised while maintaining the present levels of quality and reliability.

The concept of FACTS is explaining as follows:

We know that, the power transfer between two systems interconnected through a tie line is given as

$$P = \frac{V_1 V_2}{X} \sin \delta$$

It can be seen that the power flow can be controlled by three parameters, the voltages at the two systems, the reactance of the tie-line and the difference in the voltage angles at the two ends. The FACTS devices can be used to control one or more of these parameters. The various devices used are (i) Static var compensators (SVC) (ii) Controlled series

compensation (iii) Static condensers (STATCOM) (iv) Advanced controlled series compensation (v) Thyristor controlled phase shifting transformer.

5.8.1 Stati Compensators (STATCOM)

Figure.5.8.1 shows a basic circuit of a STATCOM which is GTO (gate turn-off) based compensation system. These devices are known as STATCOM or static synchronous condensers as these exhibit characteristics similar to conventional synchronous condensers without the moving parts.

The basic elements of a Voltage Source Inverter (VSI) based STATCOM are an inverter, a d.c. capacitor and a transformer to match the line voltage as shown in Fig.5.8.1. Voltage source inverter inverts a d.c. voltage (PWM inverter) with a balanced set of three quasi-square voltage waveforms by connecting the d.c. source sequentially to three output terminals. The three phase a.c. generated by inverter is synchronised to the a.c. line through a small tie reactance, which is the leakage reactance of a transformer.

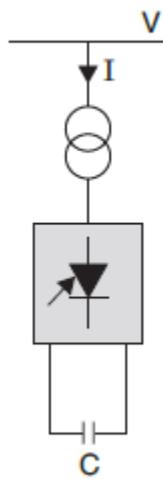


Figure 5.8.1 Statcom

[Source: "Electrical Power Systems" by C.L.Wadhwa Page: 714]

When the inverter fundamental output voltage is higher than the system line voltage, the STATCOM works as a capacitor and reactive vars are generated. However when the inverter voltage is lower than the system line voltage, the STATCOM acts as an inductor thereby absorbing the reactive Vars from the system. To control the reactive current, thus the magnitude of d.c. voltage is raised or lower by adjusting the phase angle of the inverter output voltage. The capacitor here does not play an active role in the var generation. It is

only required to maintain a smooth d.c. voltage while carrying the ripple current drawn by the inverter.

5.8.2 Thyristor Controlled Series Compensator

Just as static var compensator can be improved to STATCOM device using GTO converter, a controlled series compensator (CSC) can be improved to an ATCSC using a voltage-driven GTO converter in series with the line as shown in Fig.5.8.2.

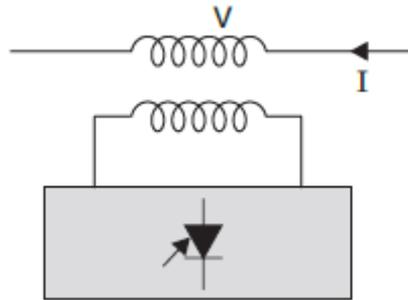


Figure 5.8.2 Thyristor Controlled Series Compensator

[Source: "Electrical Power Systems" by C.L.Wadhwa Page: 715]

Here the line current I is made perpendicular to the injected voltage V with the help of an ATCSC coordinator which forms a part of the whole control scheme.

5.8.3 Thyristor controlled phase shifting transformer

Thyristor controlled phase shifting transformer or phase angle regulator consists of a shunt transformer and a boosting transformer inserted in the line as shown in Fig.5.8.3.

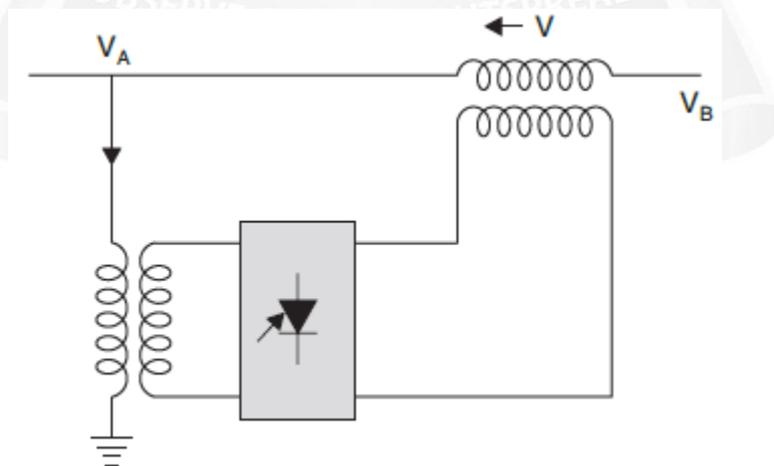


Figure 5.8.2 Thyristor controlled phase shifting transformer

[Source: "Electrical Power Systems" by C.L.Wadhwa Page: 715]

The voltage V is perpendicular to the terminal voltage V_A as shown in phasor diagram. Its' magnitude can be controlled by the thyristor converter. The reactive power required to induce voltage V is transmitted via the shunt transformer and the thyristor converter to the boosting transformer.

