***FLEXIBLE AC TRANSMISSION SYSTEMS***

***Q: What is meant by FACTS?***

Ans: FACTS devices are made by advanced power electronic control equipment’s. The Flexible ac transmission systems (FACTS) give solutions to the problems and limitations which were introduced in the power system with the introduction of power electronics-based control for reactive power.

***Q: What are the main objectives of FACTS?***

Ans: i) The power transfer capability of transmission system is to be increased.

ii) The power flow is to be kept over designated routes.

***Q: Who implemented the FACTS concept? For what?***

Ans: The concept of FACTS was first defined in 1988 by N.G.Hingorani. It controls the interrelated parameters which are involved in power system operation such as series and shunt impedance, current, voltage and phase angle. Also, it damps the oscillations at various frequencies below the rated frequency.

***Q: What are the types of FACTS devices?***

Ans: SVC - Static Var Compensator

TCSC - Thyristor Controlled Series Capacitor

UPFC - Unified Power Flow Controller

IPFC - Interline Power Flow Controller

SSSC - Static Synchronous Series Compensator

SSC - Static Synchronous Compensator (STATCOM)

***Q: Write down the advantages of FACTS.***

Ans: i) It controls line impedance angle and voltage which helps in controlling the power flow in transmission lines.

ii) The power flow in the transmission lines can be made optimum.

iii) It helps in damping out the oscillations and avoids damage of various equipment’s.

iv) It limits the impacts of faults and equipment failures.

***Q: What are the types of FACTS controllers?***

Ans: i) Series controller

ii) Shunt controller

iii) Combined series-series controllers

iv) Combined series-shunt controllers

**COMPENSATION**

***Q: What is the necessity of compensation?***

Q: Distinguish between the load compensation and system compensation?

***Q: What is reactive power compensation? Compensators?***

Ans: Reactive power control for a transmission line is often called reactive power compensation. External devices or sub systems that control reactive power on transmission line are known as compensators.

***Q: What is shunt compensation?***

Ans: The Shunt compensators are connected parallel to the transmission lines with the help of Circuit breakers. Shunt reactors compensate for the line capacitance, and they control over voltages at no loads and light load conditions. The shunt compensators need careful system design because of high charging in-rush currents.

***Q: What is series compensation?***

Ans: The Series compensators are connected series with the transmission lines. Series compensators are used to partially offset the effects of the series inductances of transmission lines. It provides automatic adjustment of reactive power compensation.

***Q: What are the design factors considered for the series compensators?***

Ans: i)The voltage magnitudes across the capacitor bank ii) The fault currents at the terminals of a capacitor bank iii) The fault currents at the terminals of a capacitor bank iv) The placement of shunt reactors in relation to the series capacitors.

***Q: What are the methods used for compensating the uncompensated transmission lines?***

i) Load compensation- One capacitor is connected parallel across the load ii) System compensation - In addition with the parallel capacitor the power utility devices are also connected.

**CONTROLLERS**

***Q: List the various possible combinations for the study of controller interactions?***

***Q: What are the frequency range for the study of different controller interactions?***

***Q: Explain the objectives of FACTS controllers in the power system network.***

***Q: Compare the conventional series controller with the advanced series controller (IPFC)?***

Ans:

|  |  |
| --- | --- |
| **Conventional series controller** | **Advanced series controller (IPFC)** |
| 1. Load balancing of transmission lines is very Poor. | 1. It has better load balancing. |
| 2. It has very low X/R ratio. | 2. It has high X/R ratio. |
| 3. Transmission line losses are very high. | 3. Transmission line losses are low. |
| 4. It controls both real and reactive power with low operating efficiency. | 4. It controls both real and reactive power with high operating efficiency. |

***SVC***

***Q: Define the term static VAR compensator (SVC)***

***Q: What is the best location of SVC***

***Q: Explain the voltage-control action by the SVC with necessary diagrams?***

***Q: Explain the role of SVC in increasing the steady state power-transfer capacity with necessary diagrams and expressions?***

***Q: Explain the coordination features of parallel SVCs and electrically close SVCs.***

***Q: Short notes on voltage control by SVC?***

Ans: The transmission line voltage is maintained by connecting static var compensator (SVC) in the receiving end side. The comparator will measure the actual and reference values of transmission line voltage; depends on the comparator output the reactive power is injected into the transmission line, and the transmission line voltage will be controlled.

***Q: Write down the equation for SVC bus voltage?***

Ans:

***Q: Give the advantages of the slope in the SVC dynamic characteristics?***

Ans: i) The reactive power rating is reduced ii) SVC is prevented from reaching its reactive power limit too frequently iii) It provides effective parallel operation of two parallel connected SVC’s.

***Q: What is SVC slope in the dynamic characteristics?***

Ans: To improve the power system operating performance 2.5% voltage deregulation will be provided in SVC operation. So, this voltage de-regulation results in 5% slope in the SVC dynamic characteristics.

Q: How the SVC prevents the reactive power rating, reaching its limit too frequently?

Ans: Due to slope in the SVC dynamic characteristics the no load to change in load variation limit will be increased, so the SVC is prevented from reaching its reactive power limit too frequently. Thus, the total reactive power needed is reduced to certain limit.

***Q: Explain the load sharing of two parallel connected SVC’s?***

Ans: Without slope in the SVC dynamic characteristics there is a discontinuous gap between capacitive and inductive region. This gap will be reduced by operating two parallel connected SVC’s with slope (2.5% voltage de-regulation) in the SVC dynamic characteristics.

***Q: What are the conditions involved for influence of the SVC on system voltage?***

Ans: i) Coupling transformer ignored ii) With coupling transformer iii) System gain

***TCSC***

Q: List the different modes of TCSC operation?

Q: Draw the VI capability characteristics for single-module TCSC?

Q: Discuss the advantages of TCSC in detail?

Q: Describe the variable reactance model of TCSC with block diagram?

Q: Briefly describe the steps to be followed for SSR mitigation by TCSC?

Q: What is meant by TCSC?

Ans: TCSC is a thyristor controlled series capacitor. It has one parallel connected thyristor controlled inductor and a series capacitor connected with the transmission line. It provides continuous variable capacitive reactance and variable inductive reactance to control the transmission line parameters.

Q: Write down the expression for equivalent impedance of a TCSC?

Ans:

Q: What is the condition for variable capacitive reactance in a TCSC?

Ans:

Q: What is the condition for variable inductive reactance in a TCSC?

Ans:

Q: What are the different modes of operation of TCSC?

Ans: i) Bypassed- thyristor mode ii) Blocked - thyristor mode iii) Partially conducting thyristor or Vernier mode

**STATCOM**

Q: State the salient features of STATCOM

Q: List the modes of operation of STATCOM

Q: Draw the VI characteristics of STATCOM

Q: Explain the principle operation and application of STATCOM

Q: Explain the power exchange process between STATCOM and power system

Q: Where the first STATCOM was implemented?

Ans: Tennesee Valley Authority (TVA) installed the first static synchronous compensator (STATCOM) in 1955 to strengthen transmission line ties between its Sullivan substation and the rest of its network. It reduces the need of additional transformer bank and avoiding more labors.

Q: What is meant by emerging facts controllers?

Ans: The emerging facts controllers exchange the reactive power to the transmission lines with the help of phase shifting techniques. If needed the real power is also supplied in addition to the reactive power in to the transmission line with the help of emerging FACTS devices such as STATCOM and UPFC. Here the need of large size capacitor bank and inductor bank are reduced, so the operating performance will be improved.

Q: What is meant by STATCOM?

Ans: The static synchronous compensator (STATCOM or SSC) is a shunt connected reactive power compensation device that is capable of generating and/or absorbing reactive power and in which the output can be varied to control the specific parameters of an electric power system. It is capable of generating or absorbing independently controllable real and reactive power at its output terminals when it is fed from a dc energy source or energy storage device at its input terminals.

Q: What are the functions of STATCOM in the improvement of power system performance area?

Ans: i) It provides dynamic voltage control in transmission and distribution system ii) It provides damping against the oscillation in power system. iii) It provides better transient stability iv) It has voltage flicker control (it withstands sudden changes) v) It controls both real and reactive power.

Q: What are the common advantages of STATCOM?

Ans: i) It required small space because it replaces the passive inductor and capacitor bank by compact electronic converters. ii) It has modular factory build electronic equipment’s, so site work and commissioning time will be reduced. iii) It uses encapsulated electronic converters, thereby minimizing its environmental impact.

Q: Give details about first installed STATCOM device at Sullivan Sub-station?

Ans: Tennessee Valley Authority (TVA) installed the first ± 100 MVA STATCOM in 1995 at its Sullivan substation.

Q: What are the applications of first installed STATCOM device at Sullivan Sub-station?

Ans: The application of this STATCOM is expected to reduce the TVA’s need for load tap changing transformers, there by achieving savings by minimizing the potential for transformer failure. This STATCOM solves the problems against off-peak dilemma of over voltages in the Sullivan substation area while avoiding the more labor and apace intensive installation of an additional transformer bank.

Q: What are the advantages of first installed STATCOM device at Sullivan Substation?

Ans: i) It increases the capacity of transmission line voltage by providing instantaneous control. ii) It provides greater flexibility in bulk power transactions. iii) It also increases the system reliability by damping grids of major oscillations in this grid.

Q: Write short notes on principle of operation of STATCOM?

Ans: A STATCOM is a controlled reactive power source. It provides the desired reactive power generation and absorption entirely by means of electronic processing of the voltage and current waveforms in a voltage source converter.

Q: What is the importance of V-I characteristics of STATCOM?

Ans: The V-I characteristics of STATCOM shows that it can supply both the capacitive and inductive compensation and is able to independently control its output current over the rated maximum capacitive or inductive range irrespective of the amount of ac system voltage. That is, the STATCOM can provide full capacitive reactive power at any ac system voltage even as low as 0.15 p.u.

Q: How will you determine the maximum attainable transient over current region?

Ans: The maximum attainable transient over current in the capacitive region is determined by the maximum current turn-off capacity of the converter switches.

Q: Why the converters (STATCOM) absorb the small amount of real power from the ac system?

Ans: The converter absorbs the small amount of real power from the ac system to meet its internal losses and keep the capacitor (energy storage device) voltage at the desired level.

**SSSC**

Q: Define SSSC and list the components in it.

Q: Explain the principle of operation of SSSC and series-compensation using SSSC with necessary diagram and expressions.

Q: Where the first UPFC was implemented?

Ans: In 1998 installation of the first unified power flow controller (UPFC) was completed at the Inez Substations owned by American Electrical Power (AEP). It represents the first controller capable of providing complete control of all the three basic transmission system parameters that is voltage, line impedance, phase angle.

**UPFC**

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**Q:** Write short on UPFC?

Ans: The unified power flow controller (UPFC) is the most versatile FACTS controller developed so far, with all encompassing of voltage regulation, series compensation and phase shifting. It can independently and very rapidly control both real and reactive power flows in a transmission line

**Q:** What are the functions of series converter in the UPFC?

Ans: In a UPFC series converter exchanges both real and reactive power with the transmission line. Although the reactive power is internally generated or absorbed by the series converter, the real power generation or absorption is made feasible by the dc energy storage device.

**Q:** What are the functions of shunt converter in the UPFC?

Ans: In a UPFC shunt converter mainly used to supply the real power demand of series converter, which it derives from the transmission line itself. The shunt converter maintains constant voltage of the dc bus. In addition, the shunt converter functions like a STATCOM and independently regulate the terminal voltage of the interconnected bus by generating or absorbing a requisite amount of reactive power.

**Q:** What are the operating variable constraints of UPFC?

Ans:

i) The series injected voltage magnitude ii) The line current through series converter iii) The shunt converter current iv) The maximum line side voltage of the UPFC V) The minimum line side voltage of the UPFC vi) The real power transfer between the series converter and the shunt converter

**SINGLE LINE DIAGRAMS**

Q: Draw the single line diagrams of TCSC, STATCOM, SSSC and UPFC?