

**OBJECTIVE:**

This subject deals with the importance of HVDC transmission, analysis of HVDC converters, faults and protections, harmonic and filters. It also deals with reactive power control and Power factor improvements of the system

S. No	Question	Blooms Taxonomy Level	Course Outcome
<b>UNIT - I</b> <b>BASIC CONCEPTS</b> <b>SHORT ANSWER TYPE QUESTIONS</b>			
1	List out the applications of HVDC?	Understand	1
2	What are the types of transmission system?	Analyze	1
3	State the comparison of AC & DC transmission system?	Remember	1
4	State the disadvantage in dc transmission?	Understand	1
5	State the advantages in DC transmission?	Remember	1
6	What are the types of DC link?	Understand	1
7	Name the HVDC transmission in india?	Understand	1
8	What are the limitations of EHVAC transmission?	Remember	1
9	What are the types of dc links?	Understand	1
10	Draw the cost vs distance curve of ac and dc transmission?	Understand	1
11	Define pulse number?	Remember	1
12	Draw the diagram graetz bridge circuit	Analyze	1
13	Write the equation of ac current and dc voltage harmonics	Analyze	1
14	What is choice of converter configuration?	Analyze	1

15	Define peak inverse voltage?	Remember	1
16	Draw the schematic diagram of three & two valve conduction mode	Understand	1
17	Define twelve pulse converter with schematic diagram	Remember	1
18	What is meant by neglecting overlap in graetz in bridge circuit	Remember	1
19	What is commutation voltage of valves?	Understand	1
20	What are the assumptions made to simplify the analysis of Graetz circuit?	Remember	1
<b>LONG ANSWER QUESTIONS</b>			
1	What are the different applications of dc transmission system? Explain them in detail?	Analyze	1
2	With neat sketches explain the different kinds of dc link available?	Analyze	1
3	Explain the comparison of AC and DC transmission in detail	Understand	1
4	Explain in detail about the planning of HVDC transmission?	Analyze	1
5	Explain the technological development of modern trends in dc transmission	Analyze	1
6	Explain the major components of HVDC transmission in converter station unit?	Apply	1
7	State the advantages and disadvantages of dc transmission system with following economics, reliability, and performance	Understand	1
8	Draw a typical HVDC layout and explain their basic components?	Analyze	1
9	Explain the modern trends in dc transmission?	Apply	1
10	Explain the application of HVDC c transmission system?	Analyze	1
11	Draw the schematic circuit diagram of a 6 pulse graetz circuit and explain its principle of operation.	Understand	1
12	Explain the individual characteristics of a rectifier and an inverter with sketch	Understand	1
13	Derive the expression for input power, output power and power factor of 12-pulse bridge converter with delay angle $\alpha$ . Assume there is no overlap.	Analyze	1
14	Explain the effect of overlap angle on the performance of converter circuit	Analyze	1
15	Explain the choice of converter configuration for any pulse number	Analyze	1
16	Explain the analysis of 12 pulse converter with bridge rectifier	Analyze	1
17	Give the typical converter transformer rating for a HVDC transmission system?	Analyze	1
18	Explain the term angle of advance and its significance in inverter control	Analyze	1
19	What are the different types of modes of operation of rectifier?	Understand	1
20	Write down the average dc voltage of Graetz circuit without overlap?	Understand	1
<b>ANALYTICAL QUESTIONS</b>			
1	Compare EHVAC and HVDC transmission?	Understand	1

2	Explain the limitation of EHVAC system?	Understand	1
3	Explain the different types of HVDC link?	Understand	1
4	Explain the application of HVDC transmission system?	Understand	1
5	Explain the planning for HVDC transmission system?	Remember	1
6	Explain the modern trends in dc transmission?	Evaluate	1
7	Draw the variation of voltage along the transmission line during different loading condition?	Apply	1
8	What are the different applications of dc transmission system? Explain them in detail?		1
9	Explain in detail about the planning of HVDC Transmission?	Apply	1
10	State the advantages and disadvantages of dc transmission system with following economics, reliability, and performance	Apply	1
11	Explain with the help of neat diagram and wave forms, the operation of 6-pulse bridge converter with delay angle $\alpha$ and overlap angle $u$ . derive the expression for its dc output voltage	Remember	1
12	Show the rating of the valve used in gratez circuit is $2.094P_d$ where $P_d$ is dc power transmitted.	Understand	1
13	What are the different types of modes of operation of rectifier?	Remember	1
14	Write down the converter bridge characteristics?	Understand	1
15	Derive the expression for input power, output power and power factor of 6-pulse bridge converter with delay angle $\alpha$ . Assume there is no overlap.	Apply	1
16	Sketch the output dc voltage waveform and voltage across any one valve for 6-pulse bridge converter for the following two cases, (i) Delay angle $\alpha=30$ degree and overlap angle $u=5$ degree. (ii) angle of advance $\beta=30$ degree and overlap angle $u=5$ degree	Remember	1
17	Explain in detail the principle of DC Link control.	Apply	1
18	Explain firing angle control & current and extinction angle control	Remember	1
19	Sketch the output dc voltage waveform and voltage across any one valve for 12-pulse bridge	Apply	1
20	Give the typical converter transformer rating for aHVDC transmission system?	Apply	1

**UNIT - II**  
**CONVERTER AND HVDC SYSTEM CONTROL**  
**SHORT ANSWER TYPE QUESTIONS**

1	What will be the current regulation in inverter side?	Understand	2
2	Define firing angle control.	Understand	2
3	What is un compounded inverter?	Understand	2
4	Draw the characteristics curve for inverter compounding?	Analyze	2
5	Write down the converter bridge characteristics?	Analyze	2

6	Explain overlap angle and extinction angle.	Analyze	2
7	Discuss in detail the effect of source inductance on hvdc system	Analyze	2
8	Explain the individual characteristics of a rectifier and an inverter with sketches.	Analyze	2
9	Explain current and extinction angle control.	Analyze	2
10	Draw and explain the inverter and rectifier compounding characteristics with constant voltage and current curve.	Apply	2
<b>LONG ANSWER QUESTIONS</b>			
1	Explain firing angle control & current and extinction angle control	Analyze	2
2	Explain overlap angle and extinction angle.	Remember	2
3	Define the term angle of advance and its significance in inverter control	Remember	2
4	Explain the individual characteristics of a rectifier and an inverter with sketches	Analyze	2
5	Discuss in detail about the transformer tap changer with its types	Analyze	2
6	Discuss in detail about the converter control characteristics of hvdc system	Analyze	2
7	Discuss in detail the principle of DC Link control.	Analyze	2
8	Explain the system control hierarchy	Analyze	2
9	Explain the un compounded inverter with neat sketches	Understand	2
10	Why the delay angle and extinction angles are to be maintained to minimum value	Understand	2
<b>ANALYTICAL QUESTIONS</b>			
1	Explain in detail the principle of DC Link control	Understand	2
2	Explain the term angle of advance and its significance in inverter control	Understand	2
3	What are the different types of modes of operation of rectifier?	Understand	2
4	Explain firing angle control & current and extinction angle control	Understand	2
5	Explain the system control hierarchy	Analyze	2
6	Explain overlap angle and extinction angle.	Apply	2
7	What will be the current regulation in inverter side	Apply	2
8	Why the delay angle and extinction angles are to be maintained to minimum value	Understand	2
9	Explain the individual characteristics of a rectifier and an inverter with sketches	Apply	2
10	Explain in detail about the transformer tap changer with its types	Apply	2
<b>UNIT - III</b> <b>HARMONICS, FILTERS AND REACTIVE POWER CONTROL</b> <b>SHORT ANSWER TYPE QUESTIONS</b>			
1	Write the different types of AC/DC power flow	Analyze	3

2	What is unified method of DC power flow?	Understand	3
3	What is sequential method of DC power flow?	Remember	3
4	What are the advantages of variable elimination method over extended variable method?	Apply	3
5	Draw the DC system model	Remember	3
6	Draw the norton's equivalent circuit for a converter	Remember	3
7	What are the additional constraints needed to include for ac-dc power flow	Remember	3
8	List some essentials of power flow analysis	Evaluate	3
9	Compare sequential and simultaneous methods of ac-dc power flow.	Remember	3
10	What are the major steps in the power flow analysis of MTDC-AC Systems	Remember	3
11	Define Harmonic	Analyze	3
12	How harmonics are generated?	Understand	3
13	Mention the various sources of harmonic generation in HVDC system	Remember	3
14	What are other methods of eliminating harmonics with HVDC system	Remember	3
15	Write the different types of AC/DC power flow	Analyze	3
16	What is unified method of DC power flow?	Understand	3
17	What is sequential method of DC power flow?	Remember	3
18	What are the advantages of variable elimination method over extended variable method?	Apply	3
19	Draw the DC system model	Remember	3
20	Draw the norton's equivalent circuit for a converter	Understand	3
21	What are the additional constraints needed to include for ac-dc power flow?	Remember	3
22	List some essentials of power flow analysis	Evaluate	3
23	Compare sequential and simultaneous methods of ac-dc power flow.	Remember	3
24	What are the major steps in the power flow analysis of MTDC-AC Systems	Remember	3
25	Define AC filter?	Remember	3
26	Define DC Filter?	Understand	3
27	What are the components present in AC & DC filter?	Remember	3
28	What are the types of AC filters & Dc?	Apply	3
29	Define single tuned filter?	Remember	3
30	How will protect the filter?	Remember	3

**LONG ANSWER QUESTIONS**

1	Discuss the various sources of reactive power for HVDC converters.	Understand	3
2	What is the reactive power requirement in steady state	Remember	3
3	Discuss conventional control strategies	Evaluate	3
4	Discuss alternate control strategies	Evaluate	3
5	Write the operation of synchronous condensers.	Analyze	3
6	Explain extended variable method of DC power flow	Analyze	3
7	Explain the variable elimination method of DC power flow	Evaluate	3
8	Explain the sequential method of DC power flow. Draw the necessary flow chart.	Evaluate	3
9	Explain about per unit system for DC quantities	Evaluate	3
10	Compare sequential and unified methods of DC power flow.	Apply	3
11	Explain unified method of DC power flow	Analyze	3
12	What are the additional constraints needed to include for ac-dc power flow?	Analyze	3
13	Compare sequential and simultaneous methods of ac-dc power flow	Apply	3
13	Write a short note on the following: (a) Harmonic distortion (b) telephone Influence factor	Apply	3
14	Mention the various sources of harmonic generation in HVDC systems and suggest methods to eliminate them	Analyze	3
15	Define telephone interference Factor and Explain how it varies with harmonic order.	Analyze	3
16	What are the order of harmonics present on the AC side of the VSC converter DC systems	Analyze	3
17	What are the filter configurations that are employed for HVDC Converter station? Give design aspect of one such filter	Understand	3
18	Derive an equation for harmonic voltage and current for single tuned filter and discuss the influence of network admittance	Evaluate	3
19	Give a detailed account of design aspects of following filters (a) Single tuned filter (b) Double tuned filter	Understand	3
20	What are the different types of filters used on the AC side of an HVDC system? How are they located and arranged?	Apply	3
<b>ANALYTICAL QUESTIONS</b>			
1	Discuss the various sources of active power for HVDC converters	Understand	4
2	What is the reactive power requirement in steady state	Apply	3
3	Explain extended variable method of DC power flow	Remember	3
4	Explain the variable elimination method of DC power flow	Remember	3
5	Explain the sequential method of DC power flow. Draw the necessary flow chart	Remember	3

6	Explain about per unit system for DC quantities	Remember	3
7	Compare sequential and unified methods of DC power flow	Apply	3
8	Explain unified method of DC power flow	Remember	3
9	What are the additional constraints needed to include for ac-dc power flow?	Understand	3
10	Compare sequential and simultaneous methods of ac-dc power flow	Apply	3
11	State the various sources of harmonics generation in HVDC-VSC systems and mention the adverse effects caused by these harmonics	Apply	3
12	With neat sketches, explain how a converter transformer is responsible for generation of harmonics and suggest various methods for minimising them	Evaluate	3
13	Define telephone interference Factor and Explain how it varies with harmonic order.	Remember	3
14	What are the non-characteristics of harmonics in HVDC system? How are they generated?	Evaluate	3
15	What are other methods of eliminating harmonics with HVDC system	Apply	3
16	Explain the need to employ filter circuit in HVDC systems. Derive an Expression for minimum cost of tuned AC filters used in HVDC systems.	Apply	3
17	Derive an equation for harmonic voltage and current for single tuned filter and discuss the influence of network admittance	Analyse	3
18	Give a detailed account of design aspects of following filters (a) Single tuned filter (b) Double tuned filter	Analyse	3
19	What are the other methods of eliminating or suppressing harmonics with HVDC system? Give a comparison using passive filter network	Analyze	3
<b>UNIT - IV</b> <b>FACTS AND STATIC SHUNT COMPENSATORS</b> <b>SHORT ANSWER TYPE QUESTIONS</b>			
1	Why there is a need of interconnection in electrical power systems?	Analyze	4
2	What are the problems with interconnected power systems?	Understand	4
3	Why there is need of compensation in power systems?	Remember	4
4	What are the conventional methods used for compensation in power systems?	Understand	4
5	Explain how power flows & types of powers in ac systems?	Analyze	4
6	How power flow takes place in parallel electrical systems?	Remember	4
7	What are the different methods to control how of power in a parallel path in electrical power systems?	Understand	4
8	How amount of power flow can be controlled in a mesh connected ac power system?	Remember	4
9	What are the objectives of shunt compensation?	Understand	4
10	How shunt compensation is classified? Explain in detail.	Understand	4
<b>LONG ANSWER QUESTIONS</b>			

1	The operation of STATCOM is based on the operation of syn. m/c as rotating syn.	Understand	4
2	Condenser explains?	Apply	4
3	Explain the working principle & V – I char. Of STATCOM?	Remember	4
4	Draw control schemer of STATCOM & explain?	Remember	4
5	What are the different types of losses in STATCOM?	Remember	4
6	Why there is need of hybrid VAR generators?	Remember	4
7	Explain the comparison between different types of SVC's	Apply	4
8	Explain the operation of the SVC (FC+TCR) and derive the equations used. Also explain how the SVC is able to regulate the HVAC bus voltage.	Remember	4
9	Explain the principle of operation of STATCOM. Show that the steady state stability margin can be enhanced	Understand	4
10	Compare STATCOM with SVC.	Apply	4

### ANALYTICAL QUESTIONS

1	Explain about the effect of electrical coupling and short circuit level on the controller interaction between multiple SVCs that are located in a power system.	Understand	4
2	Discuss in detail about the role of SVC in improving the stability limit and enhancing the power system damping	Understand	4
3	Describe the construction and operating characteristics of synchronous condensers.	Understand	4
4	Explain the performance of VSC based STATCOM.	Understand	4
5	Explain the design of SVC voltage regulator. Also discuss the influence of SVC on system voltage	Analyze	4
6	Discuss in detail the effect of SVC for the enhancement of transient stability.	Apply	4
7	Using a general schematic diagram, explain the three basic modes of SVC control in detail.	Apply	4
8	Explain the application of SVC for prevention of voltage instability.	Understand	4
9	How do you enhance the damping in power system using SVC?	Remember	4
10	Explain the design of SVC voltage regulator and discuss the voltage control capability of SVC. What are the advantages of slope in dynamic characteristics of SVC	Remember	4

### UNIT - V STATIC SERIES AND COMBINED COMPENSATORS SHORT ANSWER TYPE QUESTIONS

1	Explain the basic operating principle of an UPFC.	Understand	5
2	Explain how a UPFC is different than a simple VSC.	Analyze	5

3	How an UPFC scheme can be implemented using two back to back voltage source converters.	Remember	5
4	Give the block diagram for a basic UPFC control scheme.	Understand	5
5	Differentiate clearly between an UPFC & IPFC	Remember	5
6	Give a basic two-converter scheme for IPFC.	Understand	5
7	Explain how the control of a basic IPFC is achieved	Understand	5
8	What do you mean by a generalized FACTS controller?	Remember	5
9	Give the block diagram for a generalize IPFC.	Understand	5
10	Draw the VI Characteristics of SSSC	Understand	5
<b>LONG ANSWER QUESTIONS</b>			
1	Give the functional control scheme for a SSSC	Understand	5
2	Explain what you mean by Variable Impedance type and Switching Converter type FACTS devices.	Remember	5
3	Draw V-I Characteristics and loss characteristics for: i) GCSC ii) TCSC iii) SSSC	Remember	5
4	Explain what you mean by Variable Impedance type and Switching Converter type FACTS devices.	Remember	5
5	How voltage stability at load bus can be achieved using series compensation.	Remember	5
6	How series FACTS devices respond to the problem of Sub synchronous reactance.	Remember	5
7	With the help of power angle curve explain how transient stability is improved with the help of series controllers. with the help of series controllers.	Apply	5
8	Draw the compensating voltage v/s line current characteristics of TCSC & SSSC.	Remember	5
9	Explain with a neat sketch and waveforms the TCSC type of series controller.	Understand	5
10	Explain with a neat sketch and waveforms the SSSC type of series controller.	Understand	5
11	Explain how real and reactive power flow control is achieved using phase angle regulators.	Remember	5
<b>ANALYTICAL QUESTIONS</b>			
1	By means of a block diagram simulate a generalize IPFC which can be operated as a STATCOM, SSSC, UPFC OR IPFC.	Understand	5
2	Explain in detail the phenomenon of sub synchronous resonance (SSR) with an Example.	Apply	5
3	Explain why present transmission system with capacitive series compensation is prone to SSR.	Remember	5

4	Give the objective of NGH-SSR damping scheme	Remember	5
5	Give detailed explanation NGH-SSR damping scheme with circuit diagram, wave diagram & control scheme.	Remember	5
6	Explain the basic control of TCBR.	Remember	5
7	How TCBR. is used to improve the transient stability.	Apply	5
8	Give use of TCBR for power oscillation damping.	Remember	5
9	Explain the different modes of operations of TCSC?	Understand	5
10	Draw V-I and X-I characteristics curves for single module TCSC and Two module TCSC.	Apply	5