SRM VALLIAMMAI ENGINEERING COLLEGE

(Autonomous Institution)

SRM Nagar, Kattankulathur – 603 203

DEPARTMENT OF

ELECTRICAL AND ELECTRONICS ENGINEERING

QUESTION BANK

II SEMESTER

PS3262- HVDC AND FACTS

Regulation – 2023

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Prepared by

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SUBJECT & SUBJECT CODE: PS3262- HVDC AND FACTS SEM / YEAR: II / I

UNIT-I INTRODUCTION				
Review of basics of power transmission networks-control of power flow in AC transmission line- Analysis of uncompensated AC Transmission line- Passive reactive power compensation : Effect of series and shunt compensation at the mid-point of the line on power transfer- Need for FACTS controllers- types of FACTS controllers-Need for HVDC system MTDC system Review of basics of LCC and VSC HVDC system. Configurations- Mono polar Asymmetric and Symmetric MMC-HVDC Scheme- Bipolar and Homo polar HVDC Scheme Multi-Terminal HVDC Configuration- Layout of HVDC system (LCC, VSC).				
PART-A				
Q. No	**Questions**	**BT Level**	**Competence**	**CO**
1.	Define basics of power transmission network.	BTL1	Remembering	CO1
2.	Articulate about uncompensated AC transmission line.	BTL2	Understanding	CO1
3.	List the need for FACTS controllers.	BTL1	Remembering	CO1
4.	Give the types of FACTS controllers	BTL2	Understanding	CO1
5.	Compare load and system compensation	BTL3	Applying	CO1
6.	List the factors that decide the loading on the transmission line.	BTL3	Applying	CO1
7.	Name the HVDC Transmission in India.	BTL1	Remembering	CO1
8.	What is meant by real power?	BTL5	Evaluating	CO1
9.	What is meant by Flexible AC Transmission system?	BTL2	Understanding	CO1
10.	Define Static converters.	BTL4	Analyzing	CO1
11.	Discuss about significance of power factor.	BTL1	Remembering	CO1
12.	Discuss conventional control mechanisms for voltage control.	BTL4	Analyzing	CO1
13.	Discuss about Thyristor controlled reactor.	BTL2	Understanding	CO1
14.	Summarize any two disadvantages of DC transmission.	BTL4	Analyzing	CO1
15.	Classify the conventional control mechanisms for voltage control.	BTL3	Applying	CO1
16.	Relate the expression for real power flow through the line.	BTL1	Remembering	CO1

17.	Classify the FACTS devices to control the line power flows.		BTL1	Remembering	CO1
18.	Explain reactive power.		BTL6	Creating	CO1
19.	Explain the need of FACTS controller in modern power system.		BTL6	Creating	CO1
20.	Differentiate TSC and TCR.		BTL5	Evaluating	CO1
21.	Choose the suitable FACTS devices to control the line power flows.		BTL1	Remembering	CO1
22.	Justify the components used in Thyristor controlled reactor.		BTL2	Understanding	CO1
23.	Propose the objectives of reactive power compensation.		BTL3	Applying	CO1
24.	Propose the fictional requirements of reactive power compensators.		BTL4	Analyzing	CO1
	PART-B				
1.	Describe how the maximum amount of active power flow will change using power flow curve.	(16)	BTL1	Remembering	CO1
2.	Compare fixed series compensation and fixed shunt compensation.	(16)	BTL2	Understanding	CO1
3.	Compare the basic procedure for controller design.	(16)	BTL3	Applying	CO1
4.	Interpret about reactive power compensation at the sending end of the transmission lines.	(16)	BTL2	Understanding	CO1
5.	Define the concept and need for reactive power. Discuss the possible control actions to maintain the voltage at rated value in transmission line.	(16)	BTL1	Remembering	CO1
6.	Discuss about the analysis of uncompensated transmission line.	(16)	BTL3	Applying	CO1
7.	Compile expression for active as well as reactive power flow in a lossless transmission Line? Draw necessary phasor diagram.	(16)	BTL4	Analyzing	CO1
8.	Justify the way by which the transient stability is enhanced due to static VAR compensator.	(16)	BTL1	Remembering	CO1
9.	(i) Compare AC & DC transmission. (ii) Explain the application of DC transmission.	(8) (8)	BTL2	Understanding	CO1
10.	Classify the types of FACTS devices and explain in detail.	(16)	BTL1	Remembering	CO1
11.	Explain the operation of UPFC with diagram.	(16)	BTL4	Analyzing	CO1
12.	Classify the FACTS devices in reactive power compensation	(16)	BTL3	Applying	CO1

	and explain their role.				
13.	Classify the various types of conventional control Mechanism of voltage in electrical transmission network and explain.	(16)	BTL5	Evaluating	CO1
14.	(i) Explain the need for FACTS Controllers. (ii) What are the advantages of FACTS Controllers?	(8) (8)	BTL6	Creating	CO1
15.	Discuss briefly about the variation of the TCSC reactance with firing angle 'alpha'.	(16)	BTL1	Remembering	CO1
16.	Compare fixed series compensation and fixed shunt compensation.	(16)	BTL2	Understanding	CO1
17.	Formulate FACTS devices in reactive power compensation and to Reduce Losses.	(16)	BTL3	Applying	CO1

UNIT-II THYRISTOR BASED FACTS CONTROLLERS

Configuration of SVC- voltage regulation by SVC- Modeling of SVC for power flow analysis Stability studies- Applications: transient stability enhancement and power oscillation damping of SMIB system with SVC connected at the mid-point of the line-Concepts of Controlled Series Compensation – Operation of TCSC- Analysis of TCSC – Modeling of TCSC for power flow and stability studies.

PART-A

Q. No	Questions	BT Level	Competence	CO
1.	Define the configuration of SVC.	BTL1	Remembering	CO2
2.	How is voltage controlled by SVC?	BTL2	Understanding	CO2
3.	Analyze the characteristics of SVC.	BTL1	Remembering	CO2
4.	Discuss the two types of SVC.	BTL2	Understanding	CO2
5.	Discuss load compensation.	BTL3	Applying	CO2
6.	List the voltage regulators used in SVC control block diagram.	BTL3	Applying	CO2
7.	Identify the factors to be considered for designing SVC to regulate mid-point voltage.	BTL1	Remembering	CO2
8.	How the system compensation is made in power system.	BTL5	Evaluating	CO2
9.	List the merits of having the slope in SVC VI dynamic characteristics.	BTL2	Understanding	CO2
10.	Formulate the objectives of SVC.	BTL4	Analyzing	CO2
11.	What is meant by shunt compensation?	BTL1	Remembering	CO2
12.	Propose the basic circuit of STATCOM.	BTL4	Analyzing	CO2
13.	Classify the components of STATCOM.	BTL2	Understanding	CO2

14.	Give the types of SVC		BTL4	Analyzing	CO2
15.	Analyze VQ characteristics of SVC.		BTL3	Applying	CO2
16.	What are the advantages of TSC-TCR type SVC over-FC TCR type SVC?		BTL1	Remembering	CO2
17.	What is meant by UPFC?		BTL1	Remembering	CO2
18.	How to achieve the series compensation.		BTL6	Creating	CO2
19.	Discuss the objectives of SVC.		BTL6	Creating	CO2
20.	Compose the V-I characteristics of STATCOM?		BTL5	Evaluating	CO2
21.	Evaluate V-Q characteristics of STATCOM?		BTL1	Remembering	CO2
22.	Distinguish between TSC-TCR type SVC and FC-TCR type SVC.		BTL2	Understanding	CO2
23.	Define TSC-TCR.		BTL3	Applying	CO2
24.	List the different types of SVC		BTL4	Analyzing	CO2
	PART-B				
1.	Explain about various configuration of SVC.	(16)	BTL1	Remembering	CO2
2.	Interpret the functions and principles of voltage regulation by SVC.	(16)	BTL2	Understanding	CO2
3.	Elaborate in detail about Stability studies and applications of SVC.	(16)	BTL3	Applying	CO2
4.	Explain the basic construction, working and characteristics of any one type of SVC.	(16)	BTL2	Understanding	CO2
5.	Explain the application of SVC for prevention of voltage instability.	(16)	BTL1	Remembering	CO2
6.	Give the advantages of the slope in the dynamic characteristics of SVC and comment on the reason for slope.	(16)	BTL3	Applying	CO2
7.	Analyze how an SVC can be used to enhance the steady state power transfer capacity of a transmission line and using power angle curves, Explain how SVC enhances transient stability of a power system.	(16)	BTL4	Analyzing	CO2
8.	Label the general schematic diagram and Explain the three basic modes of SVC control in detail.	(16)	BTL1	Remembering	CO2
9.	How to evaluate the performance of SVC in controlling voltage in a power system.	(16)	BTL2	Understanding	CO2
10.	Discuss the SVC with respect to the following aspects. i) Diagram ii) Operation iii) V-I characteristics.	(16)	BTL1	Remembering	CO2
11.	Write the operation in detail about SVC-SVC	(16)	BTL4	Analyzing	CO2

	interaction.				
12.	Articulate about the modeling of TCSC for power flow and stability studies.	(16)	BTL3	Applying	CO2
13.	Outline the operation of TCSC.	(16)	BTL5	Evaluating	CO2
14.	Describe the concepts of Controlled Series Compensation	(16)	BTL6	Creating	CO2
15.	Infer regarding power oscillation damping of SMIB system with SVC connected at the mid-point of the line.	(16)	BTL1	Remembering	CO2
16.	Formulate with SVC, the transient stability margin can be improved by enhancing the synchronizing torque. Derive the necessary equation for it.	(16)	BTL2	Understanding	CO2
17.	Explain how the SVC is able to regulate the HVAC bus voltage. Derive the formula used.	(16)	BTL3	Applying	CO2

UNIT-III ANALYSIS OF LCC HVDC CONVERTERS AND HVDC SYSTEM CONTROL

Choice of converter configuration – Simplified analysis of Graetz circuit Converter bridge characteristics – characteristics of a twelve-pulse converter- detailed analysis of converters General principles of DC link control – Converter control characteristics – System control hierarchy - Firing angle control – Current and extinction angle control – Generation of harmonics and filtering - power control – Higher level controllers. Modelling of LCC HVDC system and controllers, transformer derating and core saturation instability, Concepts of Power Oscillation Damping Controller, Frequency Controller and Sub synchronous Damping controller in LCC HVDC.

PART-A

Q. No	Questions	BT Level	Competence	CO
1.	List the different types of HVDC converters.	BTL1	Remembering	CO3
2.	Classify the types of converter control characteristics	BTL2	Understanding	CO3
3.	Point out the difference between VSC and LCC.	BTL1	Remembering	CO3
4.	Which converter is used in HVDC line?	BTL2	Understanding	CO3
5.	Articulate the characteristics of Graetz circuit Converter.	BTL3	Applying	CO3
6.	Illustrate the characteristics of a 12 pulse converter.	BTL3	Applying	CO3
7.	Give the expansion of LCC and define.	BTL1	Remembering	CO3
8.	Attach the purpose of a 12 pulse rectifier.	BTL5	Evaluating	CO3
9.	Define Graetz bridge converter	BTL2	Understanding	CO3
10.	Analyze Graetz circuit without overlap.	BTL4	Analyzing	CO3

11.	Give the principles of DC Link Control.	BTL1	Remembering	CO3
12.	Analyze the function of DC link.	BTL4	Analyzing	CO3
13.	Infer the different types of DC links.	BTL2	Understanding	CO3
14.	Make a comparison of HVDC and EHVAC on economic basis.	BTL4	Analyzing	CO3
15.	List some faults that can occur in converters.	BTL3	Applying	CO3
16.	Define Value rating.	BTL1	Remembering	CO3
17.	Identify the assumptions made to simplify the analysis of Graetz circuit.	BTL1	Remembering	CO3
18.	Draw the Equivalent Circuit of bipolar DC Link.	BTL6	Creating	CO3
19.	Summarize the 3 variations of the equidistant pulse control.	BTL6	Creating	CO3
20.	Describe Graetz's circuit and its main advantages.	BTL5	Evaluating	CO3
21.	Distinguish overlap angle and extinction angle.	BTL1	Remembering	CO3
22.	Describe the term delay angle and its significance in rectifier control.	BTL2	Understanding	CO3
23.	Illustrate mode ambiguity.	BTL3	Applying	CO3
24.	Make a comparison of HVDC and EHVAC on economic basis.	BTL4	Analyzing	CO3

PART-B

1.	Describe the Converter Control Characteristics in detail.	(16)	BTL1	Remembering	CO3
2.	Explain Energization and De energization of a Bridge.	(16)	BTL2	Understanding	CO3
3.	Interpret the characteristics of a twelve-pulse converter	(16)	BTL3	Applying	CO3
4.	Describe the basic converter control characteristic.	(16)	BTL2	Understanding	CO3
5.	Illustrate in detail the principle of DC link control.	(16)	BTL1	Remembering	CO3
6.	Prepare the output DC voltage waveform and voltage across any one value for 6 pulse bridge converters for the following two cases. (i) Delay angle $\alpha = 30°$ & overlap angle u=5° (ii) Angle of advance $\beta = 30°$ & overlap angle u=5°	(16)	BTL3	Applying	CO3
7.	An HVDC link delivers DC power with AC line voltage to the rectifier being 180 kV and that at the inverter being 165 kV. Taking $\alpha = 15$ degree	(16)	BTL4	Analyzing	CO3

	and γ = 20 degree, R_{c1} and R = 10 Ω and R=5Ω. Estimate the DC voltage at both the ends and the current in the DC link.				
8.	Explain system control hierarchy.	(16)	BTL1	Remembering	CO3
9.	Elaborate about Frequency Controller and Sub synchronous Damping controller in LCC HVDC.	(16)	BTL2	Understanding	CO3
10.	Outline the Converter Control Characteristics in detail.	(16)	BTL1	Remembering	CO3
11.	Analyze in detail concerning Sub synchronous Damping controller in LCC HVDC.	(16)	BTL4	Analyzing	CO3
12.	A 3 phase fully controlled bridge converter is connectedto a 400 V, 50 Hz supply having a source reactance of 0.3Ω/ph. The converter is operating as a rectifier at a firing angle of 60. Estimate the average load voltage and the overlap angle when the converter is supplying a steady current 100A.	(16)	BTL3	Applying	CO3
13.	Evaluate the concept of Power Oscillation.	(16)	BTL5	Evaluating	CO3
14.	Demonstrate in detail the principle of DC link control.	(16)	BTL6	Creating	CO3
15.	Give details about system control hierarchy.	(16)	BTL1	Remembering	CO3
16.	Discuss about Energization and Deenergization of a Bridge.	(16)	BTL2	Understanding	CO3
17.	Sketch the characteristics of a twelve-pulse converter	(16)	BTL3	Applying	CO3

UNIT-IV VOLTAGE SOURCE CONVERTER BASED FACTS CONTROLLERS

Static synchronous compensator (STATCOM) - Static synchronous series compensator (SSSC) Operation of STATCOM and SSSC-Power flow control with STATCOM and SSSC Modelling of STATCOM and SSSC for power flow and transient stability studies –operation of Unified and Interline power flow controllers (UPFC) - Modelling of UPFC and IPFC for power flow and transient stability studies-Concepts of Power Oscillation Damping using FACTS controllers.

PART-A

Q. No	Questions	BT Level	Competence	CO
1.	Define shunt compensation.	BTL1	Remembering	CO4
2.	Propose the basic circuit of STATCOM.	BTL2	Understanding	CO4
3.	Classify the components of STATCOM.	BTL1	Remembering	CO4
4.	Give short note on UPFC?	BTL2	Understanding	CO4
5.	What is meant V-I characteristics of STATCOM?	BTL3	Applying	CO4

6.	How to achieve the series compensation.		BTL3	Applying	CO4
7.	Compare and contrast STATCOM and SVC.		BTL1	Remembering	CO4
8.	Distinguish between STATCOM and SSSC.		BTL5	Evaluating	CO4
9.	Give the operations of SSSC.		BTL2	Understanding	CO4
10.	Analyze the merits of SSSC.		BTL4	Analyzing	CO4
11.	What is a static synchronous compensator?		BTL1	Remembering	CO4
12.	Explore the demerits of SSSC.		BTL4	Analyzing	CO4
13.	Infer in detail regarding static synchronous compensator?		BTL2	Understanding	CO4
14.	Analyze the operations of SSSC.		BTL4	Analyzing	CO4
15.	Where is STATCOM used?		BTL3	Applying	CO4
16.	Is STATCOM active or passive		BTL1	Remembering	CO4
17.	List out the disadvantages of SSSC.		BTL1	Remembering	CO4
18.	Compose the advantages of SSSC.		BTL6	Creating	CO4
19.	Discriminate about STATCOM and SSSC.		BTL6	Creating	CO4
20.	Draw the V-I characteristics of STATCOM.		BTL5	Evaluating	CO4
21.	Expand UPFC and give short note.		BTL1	Remembering	CO4
22.	Outline the components of STATCOM.		BTL2	Understanding	CO4
23.	Interpret the basic circuit of STATCOM.		BTL3	Applying	CO4
24.	Identify and analyze shunt compensation.		BTL4	Analyzing	CO4
PART-B					
1.	Write short notes on operation of STATCOM with an aid of block diagram.	(16)	BTL1	Remembering	CO4
2.	Explain the basic operating principle and the control capability of STATCOM.	(16)	BTL2	Understanding	CO4
3.	Write the principle of operation of SSSC.	(16)	BTL3	Applying	CO4
4.	Explain the power flow control and oscillation damping in the two-area system using UPFC.	(16)	BTL2	Understanding	CO4
5.	Apply the modeling of SSSC for power flow studies.	(16)	BTL1	Remembering	CO4
6.	Collect the need for variable and fixed series compensation schemes.	(16)	BTL3	Applying	CO4
7.	Analyze the modeling of UPFC for power flow studies.	(16)	BTL4	Analyzing	CO4
8.	Discuss the basic principle and control capability of unified power flow controller.	(16)	BTL1	Remembering	CO4
9.	Explain the operation of UPFC with relevant diagrams.	(16)	BTL2	Understanding	CO4
10.	Write the principle of operation of SSSC.	(16)	BTL1	Remembering	CO4

11.	Analyze the transient stability studies of STATCOM.	(16)	BTL4	Analyzing	CO4
12.	Investigate the transient stability studies of SSSC.	(16)	BTL3	Applying	CO4
13.	Evaluate power oscillation damping using UPFC.	(16)	BTL5	Evaluating	CO4
14.	Compose the concepts of Power Oscillation Damping using FACTS controllers.	(16)	BTL6	Creating	CO4
15.	Explain the classification of power system oscillators.	(16)	BTL1	Remembering	CO4
16.	Describe about transient stability studies of STATCOM.	(16)	BTL2	Understanding	CO4
17.	Illustrate about the transient stability studies of SSSC.	(16)	BTL3	Applying	CO4

UNIT-V VOLTAGE SOURCE CONVERTER BASED HVDC SYSTEM AND CONTROL

Applications VSC based HVDC: Operation, Modelling for steady state and dynamic studies. Introduction to modular multilevel converters- main circuit design- converter operating Principle and Averaged Dynamic Model- Per-Phase Output-Current Control - Arm-Balancing (Internal) Control- Vector Output-Current Control-Higher-Level Control-Modulation and Submodule Energy Balancing- Offshore HVDC integration System Studies -Control and Protection of MMC-HVDC under AC and DC Network Fault Contingencies- Modeling and Simulation of MMC based MTDC Simulation exercises, Steady state, Fault recovery characteristics - Solution of DC load flow-Solution of AC-DC power flow: Sequential and Simultaneous methods.

PART-A

Q. No	Questions	BT Level	Competence	CO
1.	Give the applications of HVDC system.	BTL1	Remembering	CO5
2.	What are the advantages of VSC based HVDC system.	BTL2	Understanding	CO5
3.	Point out are advantages and disadvantages of HVDC.	BTL1	Remembering	CO5
4.	Infer the main features of HVDC system control.	BTL2	Understanding	CO5
5.	List any two applications of HVDC.	BTL3	Applying	CO5
6.	Infer about model predictive control of MMC	BTL3	Applying	CO5
7.	What is the principle of operation of converters?	BTL1	Remembering	CO5
8.	Evaluate the solution methods of AC-DC load flow.	BTL5	Evaluating	CO5
9.	Define HVDC offshore.	BTL2	Understanding	CO5
10.	Analyze model predictive control of MMC.	BTL4	Analyzing	CO5
11.	What are simultaneous and sequential methods of power flow analysis?	BTL1	Remembering	CO5
12.	Analyze the principle of operation of converters.	BTL4	Analyzing	CO5
13.	Expand MMC and define it.	BTL2	Understanding	CO5
14.	What is the methodology of AC-DC power flow?	BTL4	Analyzing	CO5

15.	Distinguish between sequential and simultaneous power flow.		BTL3	Applying	CO5
16.	Define MTDC.		BTL1	Remembering	CO5
17.	Define Steady state.		BTL1	Remembering	CO5
18.	Compose the various methodology of AC-DC power flow.		BTL6	Creating	CO5
19.	Compose the flow chart of the ac-dc power flow.		BTL6	Creating	CO5
20.	Infer the two solution methodologies for ac.		BTL5	Evaluating	CO5
21.	Which of the following methods are used for load flow?		BTL1	Remembering	CO5
22.	What are the solution methods of AC-DC load flow?		BTL2	Understanding	CO5
23.	Articulate Steady state characteristics.		BTL3	Applying	CO5
24.	What is the expansion of MTDC.		BTL4	Analyzing	CO5
PART-B					
1.	Describe the concept behind averaged dynamic modeling.	(16)	BTL1	Remembering	CO5
2.	Illustrate the Operation of VSC based HVDC.	(16)	BTL2	Understanding	CO5
3.	Illustrate the power flow analysis with VSC based HVDC system	(16)	BTL3	Applying	CO5
4.	Elaborate the generalized theory on Arm-Balancing (Internal) Control.	(16)	BTL2	Understanding	CO5
5.	Examine the Fault recovery characteristics.	(16)	BTL1	Remembering	CO5
6.	Modeling and Simulation of MMC based MTDC Simulation- interpret.	(16)	BTL3	Applying	CO5
7.	Analyze in detail about modulation and sub module Energy Balancing topology.	(16)	BTL4	Analyzing	CO5
8.	Explain the simultaneous and sequential methods of power flow analysis?	(16)	BTL1	Remembering	CO5
9.	Explain the Modeling and Simulation of MMC based MTDC.	(16)	BTL2	Understanding	CO5
10.	Infer the two solution methodologies for ac in detail.	(16)	BTL1	Remembering	CO5
11.	Analyze the simultaneous and sequential methods of power flow analysis.	(16)	BTL4	Analyzing	CO5
12.	Compose the flow chart of the ac-dc power flow and explain.	(16)	BTL3	Applying	CO5
13.	Evaluate the Fault recovery characteristics.	(16)	BTL5	Evaluating	CO5
14.	Elaborate Steady state characteristics of MMC based MTDC simulation.	(16)	BTL6	Creating	CO5
15.	Explain the Operation of VSC based HVDC and	(16)	BTL1	Remembering	CO5

	identify the applications.				
16.	Demonstrate the power flow analysis with VSC based HVDC system	(16)	BTL2	Understanding	CO5
17.	Interpret the Steady state characteristics of MMC based MTDC simulation.	(16)	BTL3	Applying	CO5
PART-C					
Course Outcome:					
➢ Learners will be able to refresh on basics of power transmission.					
➢ Ability to design series and shunt compensating devices.					
➢ Ability to understand FACTS controllers.					
➢ Learners will attain knowledge on HVDC Link.					
➢ Learners will able to explore MMC converter applications FACTS and MTDC systems					