SRM VALLIAMMAI ENGINEERING COLLEGE

SRM Nagar, Kattankulathur – 603 203

DEPARTMENT OF

ELECTRICAL AND ELECTRONICS ENGINEERING

QUESTION BANK

II SEMESTER

1916202 HVDC AND FACTS

Regulation – 2019

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Prepared by

Mr. P. Tamilarasan, Assistant Professor (O.G) / EEE

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. Comparison of AC & DC Transmission, Applications of DC Transmission Topologies.			
PART – A			
Q.No	**Questions**	**BT Level**	**Competence**
1	Compare load and system compensation	BTL1	Remembering
2	List the factors that decide the loading on the transmission line.	BTL1	Remembering
3	Name the HVDC Transmission in India.	BTL1	Remembering
4	What is meant by real power?	BTL1	Remembering
5	What is meant by Flexible AC Transmission system?	BTL1	Remembering
6	Define Static converters.	BTL1	Remembering
7	Discuss about significance of power factor.	BTL2	Understanding
8	Discuss conventional control mechanisms for voltage control.	BTL2	Understanding
9	Discuss about Thyristor controlled reactor.	BTL2	Understanding
10	Summarize any two disadvantages of DC transmission.	BTL2	Understanding
11	Classify the conventional control mechanisms for voltage control.	BTL3	Applying
12	Relate the expression for real power flow through the line.	BTL3	Applying
13	Classify the FACTS devices to control the line power flows.	BTL3	Applying
14	Explain reactive power.	BTL4	Analysing
15	Explain the need of FACTS controller in modern power system.	BTL4	Analysing
16	Differentiate TSC and TCR.	BTL4	Analysing
17	Choose the suitable FACTS devices to control the line power flows.	BTL5	Evaluating
18	Justify the components used in Thyristor controlled reactor.	BTL5	Evaluating
19	Propose the objectives of reactive power compensation.	BTL6	Creating
20	Propose the fictional requirements of reactive power compensators.	BTL6	Creating
PART – B			
1	Describe how the maximum amount of active power flow will change using power flow curve.	BTL1	Remembering
2	(i) Compare fixed series compensation and fixed shunt compensation. (6) (ii) Compare the basic procedure for controller design.(7)	BTL1	Remembering

3	Write short notes on reactive power compensation at the sending end of the transmission lines.	BTL1	Remembering
4	Define the concept and need for reactive power. Discuss the possible control actions to maintain the voltage at rated value in transmission line.	BTL1	Rememberin g
5	Discuss about the analysis of uncompensated transmission line.	BTL2	Understanding
6	(i) Explain the need for FACTS Controllers. (6) (ii) What are the advantages of FACTS Controllers. (7)	BTL2	Understanding
7	Discuss briefly about the variation of the TCSC reactance with firing angle 'alpha'.	BTL2	Understanding
8	Classify the various types of conventional control Mechanism of voltage in electrical transmission network and explain.	BTL3	Applying
9	Classify the FACTS devices in reactive power compensation and explain their role.	BTL3	Applying
10	Explain the operation of UPFC with diagram.	BTL4	Analysing
11	Classify the types of FACTS devices and explain in detail.	BTL4	Analysing
12	(i) Compare AC & DC transmission. (ii) Explain the application of DC transmission.	BTL4	Analysing
13	Justify the way by which the transient stability is enhanced due to static VAR compensator.	BTL5	Evaluating
14	Compile expression for active as well as reactive power flow in a lossless transmission Line? Draw necessary phasor diagram.	BTL6	Creating
PART – C			
1	Explain by using power angle curve how by changing the value of line impedance the maximum amount of active power flow will change?	BTL5	Evaluating
2	Justify the reactive power compensation at midpoint and receiving ends of the transmission lines.	BTL5	Evaluating
3	Propose efficient type of conventional control Mechanism of voltage in electrical transmission network and explain.	BTL6	Creating
4	Formulate FACTS devices in reactive power compensation and to Reduce Losses.	BTL6	Creating

UNIT II - SVC & STATCOM

Configuration of SVC- voltage regulation by SVC- Modelling of SVC for load flow analysis Design of SVC to regulate the mid-point voltage of a SMIB system- Applications Static synchronous compensator (STATCOM) - Operation of STATCOM – Voltage regulation -Power flow control with STATCOM.

PART - A

Q.No	Questions	BT Level	Competence
1	Analyse the characteristics of SVC.	BTL4	Analysing
2	Discuss the two types of SVC.	BTL2	Understanding
3	Discuss load compensation.	BTL2	Understanding
4	List the voltage regulators used in SVC control block diagram.	BTL3	Applying
5	Identify the factors to be considered for designing SVC to regulate mid-point voltage.	BTL4	Analysing
6	How the system compensation is made in power system.	BTL5	Evaluating
7	List the merits of having the slope in SVC VI dynamic characteristics.	BTL3	Applying
8	Formulate the objectives of SVC.	BTL6	Creating
9	What is meant by shunt compensation?	BTL1	Remembering
10	Propose the basic circuit of STATCOM.	BTL6	Creating
11	Classify the components of STATCOM.	BTL3	Applying
12	Analyse VQ characteristics of SVC.	BTL4	Analysing
13	What are the advantages of TSC-TCR type SVC over FC-TCR type SVC?	BTL1	Remembering
14	What is meant by UPFC?	BTL1	Remembering
15	How to achieve the series compensation.	BTL5	Evaluating
16	Discuss the objectives of SVC.	BTL2	Understanding
17	What is meant V-I characteristics of STATCOM?	BTL1	Remembering
18	What is meant V-Q characteristics of STATCOM?	BTL1	Remembering
19	Distinguish between TSC-TCR type SVC and FC-TCR type SVC.	BTL2	Understanding
20	Define TSC-TCR	BTL1	Remembering

PART - B

Q.No	Questions	BT Level	Competence
1	Discuss the modelling of SVC for stability analysis.	BTL2	Understanding
2	Evaluate the transient stability enhancement of SMIB system using SVC.	BTL5	Evaluating
3	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.	BTL1	Remembering

4	(i) Compare and contrast STATCOM and SVC. (3) (ii) Show that with SVC transient stability margin can be improved by enhancing synchronizing torque. Derive the required equations. (10)	BTL3	Applying
5	Write short notes on operation of STATCOM with an aid of block diagram.	BTL1	Remembering
6	Explain the basic operating principle and the control capability of STATCOM.	BTL4	Analysing
7	Write the operation in detail about SVC-SVC interaction.	BTL1	Remembering
8	Discuss the SVC with respect to the following aspects. i. Diagram. ii .Operation. iii. V-I characteristics.	BTL2	Understanding
9	Classify the two different configuration of SVC and explain.	BTL3	Applying
10	How to evaluate the performance of SVC in controlling voltage in a power system.	BTL6	Creating
11	Label the general schematic diagram; explain the three basic modes of SVC control in detail.	BTL1	Remembering
12	Analyse 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.	BTL4	Analysing
13	Give the advantages of the slope in the dynamic characteristics of SVC and comment on the reason for slope. Explain the application of SVC for prevention of voltage instability.	BTL2	Understanding
14	Explain the basic construction, working and characteristics of any one type of SVC.	BTL4	Analysing
PART - C			
1	Explain is shunt compensation classified. Explain in detail.	BTL5	Evaluating
2	Explain briefly about STATCOM and SVC.	BTL5	Evaluating
3	Formulate with SVC, the transient stability margin can be improved by enhancing the synchronising torque. Derive the necessary equation for it.	BTL6	Creating
4	Propose the steady state and dynamic characteristic of SVC (FC+TCR).Explain how the SVC is able to regulate the HVAC bus voltage. Derive the formula used.	BTL6	Creating

UNIT III - TCSC and SSSC			
Concepts of Controlled Series Compensation- Operation of TCSC - Analysis of TCSC operation - Modelling of TCSC for load flow studies - Static synchronous series Compensator (SSSC) - Operation of SSSC - Modelling of SSSC for power flow – operation of Unified power flow controllers (UPFC).			
PART - A			
Q.No	**Questions**	**BT Level**	**Competence**
1	What is meant by SSSC?	BTL1	Remembering
2	What is meant by close loop control of TCSC?	BTL1	Remembering
3	What do you meant XI capability characteristics of multi module TCSC.	BTL1	Remembering
4	Define VI capability characteristics of multi module TCSC.	BTL1	Remembering
5	Define constant angle control of TCSC.	BTL1	Remembering
6	Write the need for a reactor in series with a capacitor in TSC circuits.	BTL1	Remembering
7	Discuss the need for variable speed compensation.	BTL2	Understanding
8	Discuss the factors to be considered in the placement of TCSC.	BTL2	Understanding
9	Draw the basic block diagram of UPFC.	BTL2	Understanding
10	Discus the applications of TCSC.	BTL2	Understanding
11	Choose the limits which define the capability characteristics of TCSC.	BTL3	Applying
12	Classify the method of control of TCSC.	BTL3	Applying
13	Examine the various functions of SSSC.	BTL3	Applying
14	How to perform open loop control of TCSC.	BTL4	Analysing
15	Identify the factors to be considered in the location of TCSC.	BTL4	Analysing
16	Study the functions of UPFC.	BTL4	Analysing
17	Select the suitable Thyristor controlled series compensator.	BTL5	Evaluating
18	Design the salient features of UPFC.	BTL5	Evaluating
19	Originate the causes of TCSC losses.	BTL6	Creating
20	Compare TCSC and TSSC.	BTL6	Creating
PART - B			
1	Write the principle of operation of SSSC.	BTL1	Remembering
2	Derive the Expression for steady state thyristor current when the TCSC is operating in the Vernier mode with necessary waveforms. Explain the modelling of TCSC for load flow studies.	BTL2	Understanding
3	Explain the power flow control and oscillation damping in the two area system using UPFC	BTL4	Analysing

4	Apply the modelling of SSSC for power flow studies.	BTL3	Applying
5	Explain the different modes of operation of TCSC. Draw VI and XI characteristics curves for single module TCSC and two modules TCSC.	BTL3	Applying
6	Explain with a neat block diagram the closed loop control of TCSC	BTL4	Analysing
7	Collect the need for variable and fixed series compensation schemes.	BTL1	Remembering
8	Discuss in detail the applications of thyristor controlled series capacitor.	BTL2	Understanding
9	Explain the working, characteristics and operating modes of variable reactance model of thyristor controlled series capacitor	BTL4	Analysing
10	Analyse how TCSC is used for the improvement of the stability of a system.	BTL4	Analysing
11	Analyse the modelling of UPFC for power flow studies.	BTL4	Analysing
12	Discuss the basic principle and control capability of unified power flow controller.	BTL2	Understanding
13	Explain the operation of UPFC with relevant diagrams.	BTL1	Remembering
14	Demonstrate the analysis of TCSC with neat sketch.	BTL6	Creating
	PART – C		
1	Explain the operation of SSSC. Compare the performance of SSSC with that of fixed series capacitor compensation.	BTL6	Creating
2	Propose the mathematical modelling of TCSC for power flow analysis.	BTL6	Creating
3	Design: Consider a SMIB system in which the synchronous machine is generating 0.8p.u.MW and 0.25p.u.MVAR. The infinite bus voltage is $1\angle 0°$. The machine transient reactance is 0.32p.u. And transmission line reactance is 0.65p.u. Calculate the value of net reactance offered by the TCSC and the voltage that has to be injected by TCSC to enhance the power transfer to1.0p.u.	BTL6	Creating
4	Why present transmission system with capacitive series compensation is prone to SSR.	BTL5	Evaluating

UNIT IV - ANALYSIS OF HVDC LINK

Simplified analysis of six pulse Graetz bridge – Characteristic's - Analysis of converter Operations – Commutation overlap – Equivalence circuit of bipolar DC transmission link –Modes of operation – Mode ambiguity – Different firing angle controllers – Power flow control.

PART – A

Q.No	Questions	BT Level	Competence
1	Define pulse number.	**BTL-1**	Remembering
2	Make a comparison of HVDC and EHVAC on economic basis.	**BTL-1**	Remembering
3	List some faults that can occur in converters.	**BTL-1**	Remembering
4	Define Value rating.	**BTL-1**	Remembering
5	Identify the assumptions made to simplify the analysis of Graetz circuit.	**BTL-1**	Remembering
6	Draw the Equivalent Circuit of bipolar DC Link.	**BTL-1**	Remembering
7	Summarize the 3 variations of the equidistant pulse control.	**BTL-2**	Understanding
8	Describe Graetz's circuit and its main advantages.	**BTL-2**	Understanding
9	Distinguish overlap angle and extinction angle.	**BTL-2**	Understanding
10	Describe the term delay angle and its significance in rectifier control.	**BTL-2**	Understanding
11	Illustrate mode ambiguity.	**BTL-3**	Applying
12	Examine the expression for the average DC voltage of Graetz circuit without overlap.	**BTL-3**	Applying
13	Examine the converter bridge characteristics.	**BTL-3**	Applying
14	Differentiate Characteristic and non-characteristic harmonics.	**BTL-4**	Analyzing
15	Explain the role of smoothing reactor in a DC link	**BTL-4**	Analyzing
16	Explain the term angle of advance and its significance in inverter control.	**BTL-4**	Analyzing
17	Explain how a HVDC value must be designed to withstand over voltage protection.	**BTL-5**	Evaluating
18	Judge the effect of harmonics on HVDC converter system.	**BTL-5**	Evaluating
19	Generalize the causes of DC side harmonics.	**BTL-6**	Creating
20	Generalize the reason to maintain minimum value of delay angle and extinction angle.	**BTL-6**	Creating

PART - B

1	Describe with the help of neat diagram & wave forms, the operation of 6 pulse bridge converters with delay angle α and without overlap. Derive the expressions for its dc voltage stating the assumptions mode.	**BTL-1**	Remembering
2	Describe the firing angle control and current and extinction angle control.	**BTL-1**	Remembering
3	Deduce the complete equivalent circuit of rectifier and inverter & draw its characteristics.	**BTL-1**	Remembering
4	Show that the expression for the Pf of an HVDC converter is $1/2(\cos \alpha + \cos (\alpha + \mu))$	**BTL-1**	Remembering
5	Describe the basic converter control characteristic.	**BTL-2**	Understanding
6	Express the relation between the DC output voltage & AC line voltage (rms) and rating of the converter transformer with Graetz's converter circuit.	**BTL-2**	Understanding
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 and $\gamma = 20$ degree, R_{c1} and $R = 10\ \Omega$ and $R=5\Omega$. Estimate the DC voltage at both the ends and the current in the DC link.	**BTL-2**	Understanding
8	Illustrate in detail the principle of DC link control.	**BTL-3**	Applying
9	Show that in a 3 phase bridge rectifier operating with no delay and with 60 degree overlap, the direct current is one-half of the crest value of line to line short circuit on the secondary side of the transformer bank.	**BTL-3**	Applying
10	Explain elaborately the equidistant pulse control(EPC)	**BTL-4**	Analyzing
11	Explain with the help of neat diagram & wave forms, the operation of 6 pulse bridge converter with delay angle α and overlap angle u. Derive the expressions for its output dc voltage.	**BTL-4**	Analyzing
12	Explain system control hierarchy.	**BTL-4**	Analyzing
13	With the help of 5 modes, explain the characteristics of a twelve pulse converter.	**BTL-5**	Evaluating
14	Prepare the output DC voltage waveform and voltage across any one value for 6 pulse bridge converter for the following two cases. (i) Delay angle $\alpha = 30°$ & overlap angle $u=5°$ (ii) Angle of advance $\beta = 30°$ & overlap angle $u=5°$	**BTL-6**	Creating
PART - C			

1	A bipolar dc link of $\pm$ 250 kV is rated 1000 MW. The line resistance is 10Ω/line. Each converter has a 12 pulse bridge with Rc = 12Ω (6Ω for each of the 6 pulse bridge). The rectifier ignition delay angle minimum limit is 5°. The Effect of converter losses and forward voltage drop is to be neglected. The dc link is initially operating with the rectifier on the CC control and inverter on CEA control with α_o =18° and γ_o = 18°. The current margin is set as 15% and the transformer turns ratio is 0.5. At the inverter, the dc voltage is 250 kV (for bipolar link). For the above operating condition Evaluate (i) Power factor and the reactive power at the inverter HT bus. (ii) Overlap angle μ. (iii) RMS value of the line to line alternating voltage, fundamental component of the line current and the reactive power at rectifier HT bus. (iv) If the reactive power at rectifier HT side drops by 20% compute the DC voltage at the rectifier and inverter terminals, α, γ and μ.	**BTL-5**	Evaluating
2	Deduce the Expression for equivalent commutation resistance, relationship between the rms fundamental frequency component of the line current in ac side and the dc link current and deduce the equivalent circuit of the dc link. Discuss the factors governing commutation overlap angle μ.	**BTL-5**	Evaluating
3	A 3 phase fully controlled bridge converter is connected to a 400 V, 50 Hz supply having a source reactance of 0.3 Ω/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 100 A.	**BTL-2**	Understanding
4	An HVDC converter rated 100 MW at 100 kV on the dc side has a commutation reactance of 0.2 p.u. The delay angle is varied between 5° and 20°. Calculate the converter transformer rating and percentage of tap-changing required. Also calculate the rating of the condenser to make the p.f. on the primary side of the converter 1.0.	**BTL-3**	Applying

UNIT V - POWER FLOW ANALYSIS IN AC/DC SYSTEMS			
Per unit system for DC Quantities - Modelling of DC links - Solution of DC load flow – Solution of AC-DC power flow – Unified and Sequential methods.			
PART - A			
Q.No	**Questions**	**BT Level**	**Competence**
1	List the assumptions made in DC load flow.	**BTL-1**	Remembering
2	Define per unit system.	**BTL-1**	Remembering
3	List some essentials of power flow analysis.	**BTL-1**	Remembering
4	Classify the solution methodology for AC-DC power flow.	**BTL-1**	Remembering
5	Describe the unified method of DC power flow.	**BTL-1**	Remembering
6	List the types of static generators for AC-DC power flow.	**BTL-1**	Remembering
7	Summarize the sequential method of DC power flow.	**BTL-2**	Understanding
8	Give the dc system model.	**BTL-2**	Understanding
9	Discuss the additional constraints needed to include for AC-DC power flow.	**BTL-2**	Understanding
10	Express the Equations Describing the DC network.	**BTL-2**	Understanding
11	Illustrate the advantages of variable elimination method over extended variable method.	**BTL-3**	Applying
12	Show the Norton's equivalent circuit for a converter.	**BTL-3**	Applying
13	Show the schematic of the dc converter and give the voltage equation.	**BTL-3**	Applying
14	Explain the two solution methodologies for ac-dc power flow.	**BTL-4**	Analyzing
15	Point out the flow chart of the ac-dc power flow.	**BTL-4**	Analyzing
16	Explain about the identical per unit system of the dc converter system.	**BTL-4**	Analyzing
17	Summarize the different approaches evolved in load flow analysis of HVDC transmission system.	**BTL-5**	Evaluating
18	Deduce the schematic diagram of the five terminal HVDC systems.	**BTL-5**	Evaluating
19	Develop the gauss seidal equation for solution of the ac/dc power flow.	**BTL-6**	Creating
20	Evaluate the parameters to control the angle and the transformer tap of the converter.	**BTL-6**	Creating
PART - B			
1	Describe the basic assumptions made in the derivation of the equations representing the ac/dc converter.	**BTL-1**	Remembering

2	Derive the converter basic equations in "per unit system" for power flow calculation of AC?DC interconnected systems.	**BTL-1**	Remembering
3	Describe briefly the different solution of dc load flow.	**BTL-1**	Remembering
4	Describe extended variable method of dc power flow.	**BTL-1**	Remembering
5	(i) Give the solution of AC-DC power flow. (ii) Compare unified and alternating AC-DC power flow.	**BTL-2**	Understanding
6	Explain the DC network and DC convertor using DC link modeling.	**BTL-2**	Understanding
7	Discuss about per unit system for DC quantities.	**BTL-2**	Understanding
8	Illustrate the power flow analysis with VSC Based HVDC system.	**BTL-3**	Applying
9	Demonstrate an overview of power flow analysis.	**BTL-3**	Applying
10	With a neat flow chart explain the solution of ac-dc power flow.	**BTL-4**	Analyzing
11	Explain on-line power flow analysis for security control.	**BTL-4**	Analyzing
12	Explain the ac-dc power flow analysis under dynamic conditions.	**BTL-4**	Analyzing
13	Explain substitution of power injection method for solving AC-DC load flow problem.	**BTL-5**	Evaluating
14	Formulate the different modelling of dc links and explain the solution method of dc load flow.	**BTL-6**	Creating
	PART – C		
1	With any one case study briefly explain about the ac dc power flow.	**BTL-4**	Analyzing
2	Explain the variable elimination method of dc power flow.	**BTL-5**	Evaluating
3	Explain the sequential method of dc power flow. Draw the necessary flow chart.	**BTL-5**	Evaluating
4	Develop the basic mismatch equation for a bipolar dc link. And also explain the formulation of jacobian matric for unified solution of ac dc equations. Illustrate the modification carried out for PDC-QDC interactions.	**BTL-6**	Creating