Code No: **RT41022** **R13** **Set No. 1**

**IV B.Tech I Semester Regular/Supplementary Examinations, October/November - 2017**

## HVAC AND DC TRANSMISSION

**(Electrical and Electronics Engineering)**

**Time: 3 hours** **Max. Marks: 70**

***Question paper consists of Part-A and Part-B***
***Answer ALL sub questions from Part-A***
***Answer any THREE questions from Part-B***

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## PART–A *(22 Marks)*

1. a) What are the properties of bundled conductors? [4]
   b) What are the causes for RI and RIV generation in transmission lines? [4]
   c) Give the comparison between HVAC and HVDC transmission. [4]
   d) What the effect of source induction on the performance of HVDC transmission. [3]
   e) What is the role of synchronous condenser in HVDC transmission? [3]
   f) What are the adverse effects of harmonics? [4]

## PART–B *(3x16 = 48 Marks)*

2. a) Explain about the power handling capacity and power loss in EHV transmission line. [8]
   b) A 735 kV line has $N = 4$, $r = 0.0176$ m, $B = 0.4572$ m for the bundled conductor of each phase. The line height and phase spacing in horizontal configuration are $H = 15$, $S = 15$ m. Calculate the maximum surface voltage gradients on the centre phase and outer phases. [8]

3. a) Using charge-voltage diagram, show that energy loss in EHV conductor in the presence of corona is $P_C = \frac{1}{2}KC(V_m^2 - V_0^2)$. [10]
   b) Explain briefly about measurement of excitation function. [6]

4. a) Draw the schematic diagram of typical HVDC converter station and explain the functions of equipment in it. [8]
   b) Briefly explain the different types of HVDC links and their relative merits. [8]

5. a) Draw the complete converter control characteristics and explain the process of power reversal. [8]
   b) A Graetz bridge operates with a delay angle of $15^0$. The leakage reactance of the transformer is 10 Ω. The line to line voltage is 90 kV. Compute the direct voltage and overlap angle if $I_d = 2500$ A. [8]

6. a) Why Reactive power sources need to be employed in a converter station? [8]
   b) Discuss about the alternate control strategies which need to be adopted for reactive power control in HVDC links. [8]

7. a) Explain with a neat diagram about the functionalities of single tuned filter. [8]
   b) How do you estimate the harmonic order based upon pulse number of HVDC converter station? Give a detailed harmonic analysis of a 12 pulse converter for characteristic harmonics. [8]

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***Answer ALL sub questions from Part-A***
***Answer any THREE questions from Part-B***
*****

## PART–A *(22 Marks)*

1. a) What are the problems with EHV AC transmission? [4]
   b) Explain briefly about RI excitation function. [3]
   c) Draw the diagrams of various types of DC links [4]
   d) Explain briefly about starting and stopping of HVDC link. [4]
   e) What are the various sources of reactive power in HVDC converters? [3]
   f) Write the differences between characteristics harmonics and non–characteristics harmonics. [4]

## PART–B *(3x16 = 48 Marks)*

2. a) Show that equivalent radius of a bundled conductor is $r_{eq} = R\left[\frac{N.r}{R}\right]^{\frac{1}{N}}$. [8]
   b) A power of 2000 MW is to be transmitted from a super thermal power station in central India over 800 km to Delhi. Use 400 kV and 750 kV alternatives. Suggest the number of circuits required with 50 % series capacitor compensation, and calculate the total power loss and loss per km. (Assume resistance of conductor for 400 kV and 750 kV as 0.031 and 0.0136 ohm/km & reactance of conductor for 400 kV and 750 kV as 0.327 and 0.272 ohm/km). [8]

3. a) Explain the generation, characteristics, limits and measurement of audio noise due to corona in EHV lines. [9]
   b) For $r$ = 1 cm, $H$ = 5m, $f$ = 50 Hz, calculate corona loss $P_C$ according to Peek's formula when $E = 1.1\ E_O$, and $\delta$= 1. Also calculate corona current. [7]

4. a) Explain planning and modern trends used in HVDC transmission system to improve its reliability and performance. [8]
   b) Compare HVDC and HVAC systems with respect to (i) Cost (ii) Voltage control (iii) stability limits (iv) reliability. [8]

5. a) Draw the configuration of 12-pulse converter and explain with the help of its characteristics. [8]
   b) Briefly explain the current and extinction angle control schemes in HVDC systems. [8]

6. a) Discuss how reactive power requirement is met using synchronous condensers and AC filters. [8]
   b) Discuss about conventional control strategies for reactive power control in HVDC link. [8]

7. a) Discuss about various types of AC filters which will be employed for a HVDC link. [8]
   b) A double tuned AC filter at certain HVDC converter station has the following parameters: $C_1$=0.77 μF, $C_2$=31.69 μF, $L_1$=94.43 mH, $L_2$=2.29 mH, f=50Hz, $V_1$=400 kV. Compute $\omega_1$, $\omega_2$ and $Q_r$. [8]

Code No: **RT41022** **R13** **Set No. 3**

**IV B.Tech I Semester Regular/Supplementary Examinations, October/November - 2017**

**HVAC AND DC TRANSMISSION**

**(Electrical and Electronics Engineering)**

**Time: 3 hours** **Max. Marks: 70**

***Question paper consists of Part-A and Part-B***
***Answer ALL sub questions from Part-A***
***Answer any THREE questions from Part-B***

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**PART–A** ***(22 Marks)***

1. a) What are the various types of conductor vibrations in a transmission line? [4]
   b) Derive the relation between single-phase and 3-phase audible noise levels. [4]
   c) Give the applications of HVDC transmission systems. [4]
   d) What is the principal of HVDC Link control? [3]
   e) What is the need of reactive power control in HVDC power stations? [3]
   f) Discuss the effect of pulse number on harmonics. [4]

**PART–B** ***(3x16 = 48 Marks)***

2. a) Derive the Magnoldt formula for the calculation of maximum surface voltage gradient on the high voltage lines. [9]
   b) A Moose conductor has the following details—Outer dia = 31.8 mm. Area = 515.7 $mm^2$. Calculate the resistance of 1 km of a double-Moose bundled conductor at 50°C given that $\rho_a = 2.7 \times 10^{-8}$ ohm-m at 20°C and temperature resistance coefficient of A1= $4.46 \times 10^{-3}$/°C. (Increase length by 5% for stranding.) [7]

3. a) List out different corona loss formulae available for calculation of corona loss and explain them briefly. [8]
   b) An overhead conductor of 1.6 cm radius is 10 m above ground. The normal voltage is 133 kV r.m.s. to ground (230 kV, line-to-line). The switching surge experienced is 3.5 p.u. Taking experimental factor, $K = 0.7$, calculate the energy loss per km of line. Assume smooth conductor. [8]

4. a) Discuss the economic and technical advantages of HVDC transmission over EHVAC for transmitting bulk power from point to point based on Insulation requirements and stability. [9]
   b) Discuss about back to back HVDC link. How does it compare with other types? [7]

5. a) Explain the following firing angle control schemes: (i) Individual Phase Control (IPC) (ii) Equidistant Pulse control (EPC). [8]
   b) Explain clearly the procedure for start up of a DC link with both long-pulse and short- pulse firing. [8]

6. a) What are the various types of AC filters employed in HVDC and discuss any two filters in detail? [8]
   b) Describe the method of Compensation of reactive power in HVDC substation. Draw simple single line schematics for each. [8]

7. a) What do you understand by characteristic and non characteristic harmonics in HVDC System? [8]

   b) Show that lowest current harmonic generated in a 6-pulse Graetz converter is of the order $5^{th}$ and its magnitude is $1/5^{th}$ of the fundamental. Mention the assumptions made. [8]

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***Answer ALL sub questions from Part-A***
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*****

## PART–A *(22 Marks)*

1. a) How to calculate the surface voltage gradient on bundled conductors. [4]
   b) The audible noise level of one phase of a 3-phase transmission line at a point is 50 dB. Calculate (i) the Sound Pressure Level (SPL) in Pascals; (*b*) if a second source of noise contributes 48 dB at the same location, calculate the combined AN level due to the two sources. [4]
   c) Write the demerits of monopolar, bipolar and homopolar DC links. [4]
   d) Why reverse power flow is needed in HVDC system. [3]
   e) What is the role of shunt capacitors in HVDC transmission? [3]
   f) Explain the significance of AC filters in HVDC system. [4]

## PART–B *(3x16 = 48 Marks)*

2. a) Discuss the charge-potential relations in multi-conductor lines. [8]
   b) The configuration of some EHV lines for 400 kV to 1200 kV is given. Calculate $r_{eq}$ of each.
   (i) 400 kV:N=2, d=2r=3.18 cm, B=45 cm (ii) 750 kV: N=4, d=3.46 cm, B=45 cm
   (iii) 1000 kV: N=6, d=4.6 cm, B=12 d (iv) 1200 kV: N=8, d=4.6 cm, R=0.6 m [8]

3. a) Discuss the frequency spectrum of the radio interference field produced in an EHV line. [8]
   b) A single conductor 6.35 cm in diameter of a 525-kV line (line-to-line voltage) is strung 13 m above ground. Calculate (i) the corona-inception voltage and (ii) the effective radius of conductor at an overvoltage of 2.5 p.u. Consider a stranding factor $m$ = 1.25 for roughness. (*iii*) Calculate the capacitance of conductor to ground with and without corona. Take $\delta$ =1. [8]

4. a) Compare the power transfer capacities of HVAC and HVDC transmission systems when an existing HVAC line is converted into HVDC line, with following conditions: (i) Same current and insulating level (ii) Same percentage losses and insulation level. [10]
   b) Explain about apparatus required for HVDC Systems. [6]

5. a) With block diagram, explain the hierarchical control structure for a DC link. [8]
   b) Explain the working of a Graetz circuit with the help of neat schematic and relevant waveforms. Show that its aggregate valve rating is 2.094 $P_d$, where $P_d$ is dc power. [8]





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6. a) Plot the characteristics which show the variation of reactive power as a function of active power and also develop the equations for them? [8]

   b) A back to back HVDC link with one bridge at each end is transmitting 100 MW with $V_d$ = 100 kV. If $\alpha = 15^0$, $\gamma = 18^0$, find ideal no-load direct voltage of rectifier ($V_{dor}$ ), ideal no- load direct voltage of inverter ($V_{doi}$), reactive power $Q_r$ and $Q_i$. Assume $R_{cr}$ and $R_{ci}$ = 12Ω. Also if the DC link is controlled such that $Q_i$ is kept at a value calculated earlier find $V_d$, $I_d$, $Q_r$, α and γ for $P_d$=50 MW. [8]

7. Give a detailed account of design aspects of the following filters:
   (a) Single tuned filter
   (b) Double tuned filter. [16]