14 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2075 Bhadra

Exam.	Regular		
Level	BE	Full Marks	80
Programme	BEL	Pass Marks	32
Year / Part	II / II	Time	3 hrs.

Subject: - Power System Analysis I *(EE555)*

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ *Assume suitable data if necessary.*

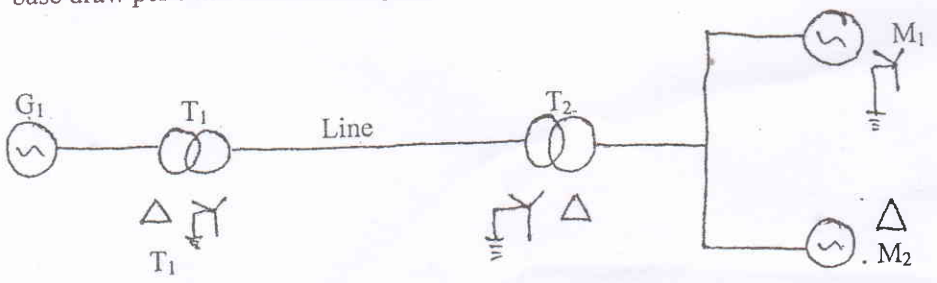
1 a) What is infinite bus in power system? Write the advantages of HVDC transmission over HVAC system with single line diagram. [8]

b) A 4 unit insulator string is fitted with a guard ring. The capacitance of the link pins to metal work and guard ring can be assumed to be 10% and 5% of the capacitance of each unit. Determine the voltage distribution and string efficiency. [8]

2. a) In a transmission line, each conductor is at 20 kV and supported by a string of 3-suspension insulators. The air-capacitance between each cap-pin junction and tower is $1/5^{th}$ of the capacitance C of each insulator unit. A guard ring, effectively only over the line end insulator unit is fitted so that the voltages on the two units nearest the line-end are equal. [8]

i) Calculate the voltage on the line-end unit.
ii) Calculate the value of capacitance between the ring and pin.

b) A 90 MVA 11 kV 3-phase generator has a reactance of 25%. The generator supplies two motors through transformers and transmission line shown in figure below. The transformer T_1 is a 3-phase, 100 MVA, 10/132 kV, 6% reactance. The transformer T_2 is composed of three single phase units each rated at 30 MVA, 66/10 kV with 5% reactance. The connection of T_1 and T_2 are shown in figure. The motors are rated at 50 MVA and 40 MVA both 10 kV and 20% reactance. Taking the generator rating as base draw per unit reactance diagram. The reactance of the line is 100 Ω. [8]



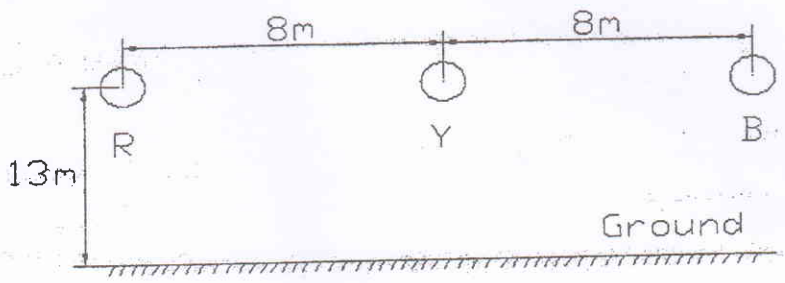
3. a) What will be consequences if the ac complex power S is not taken as S=VI*. Draw necessary phasor if necessary to support your answer. [4]

b) With necessary approximation show that the impedance of transformer referred to primary and secondary is same if calculation is done in p.u system. [6]

c) What are the line parameters? Also show how these parameters are affected by the line configurations. [6]

4. a) Figure below shows arrangement of three transmission line. The line is transposed and the diameter of each conductor is 2.6 cm. Calculate the capacitance of the transmission line per phase for the following two cases. [4+4]

   i) Neglecting the effect of ground
   ii) Considering the effect of earth



   b) A 150 km long three phase overhead line has a resistance of 45 ohms per phase, inductive reactance of 85 ohms per phase and capacitance (line to neutral) 9.00 nF per km. It supplied a load of 60 MW at a voltage of 132 kV and pf 0.9 lagging. Find (i) Sending end active power (ii) Efficiency (iii) Line losses and (iv) Voltage regulation. Use T-model. [8]

5. a) A 3ϕlong line of about 150 km has the following parameters A=D=0.96 < 1.0° and B = 100 < 80°. For a load of 30 MW at 0.8 p.f lag, 110 kV, find [8]

   i) Sending end voltage and regulations of line.
   ii) Reactive power supplied by line
   iii) Maximum power that can be transferred on the line if sending and receiving end voltages are same as in question

   b) What do you mean by reactive power compensation of a transmission line, how can we do that? Also with necessary example justify that compensation of line does not reduce the reactive power demand of load. [8]

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1. a) What do you mean by inter-connected power system? Draw a typical diagram of inter-connected power system. What are its advantage over isolated power system. [6]

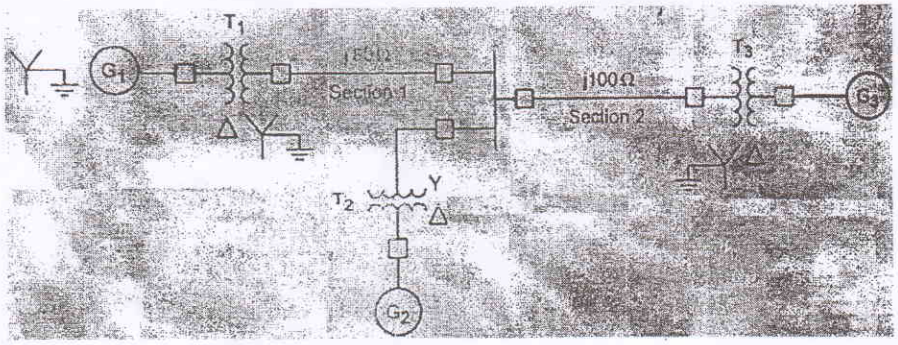
   b) Explain how electrical energy can be generated from hydropower plant with basic block diagram. [4]

   c) Find the mutual capacitances of the remaining disc if the mutual capacitance of the top disc is 7C of a graded string of 4 insulators having a uniform voltage across each disc and the capacitance of each pin to earth is C. [6]

2. a) Prove that dielectric stress is maximum at the conductor surface and its value goes on decreasing as we move away from the conductor. [6]

   b) Draw the reactance diagram using a base of 50 MVA and 13.8kV on generator G_1 of a given single line diagram of a power system. The ratings of the generators and transformers are given below: [6]

   G_1: 20MVA, 13.8KV, X'' = 20%
   G_2: 30MVA, 18KV, X'' = 20%
   G_3: 30MVA, 20KV, X'' = 20%
   T1: 25MVA, 220/13.8 KV, X= 10%
   T2: 3 single phase units each rated 10MVA, 127/18 KV, X= 10%
   T3: 35MVA, 220/22KV, X= 10%



   c) A single phase voltage source with V = 100 ∠ 0° volts delivers a current I = 10<10° A, which leaves the positive terminal of the source. Calculate the source real and reactive power and state whether the source delivers or absorbs each of these. [4]

3. a) What is per unit system? What are the advantages of per unit representation? [4]

   b) Explain skin and proximity effect in a transmission line. [6]

   c) Find the capacitance of phase to neutral per kilometer of a three phase line having conductors of 2cm diameter placed at the corner of a triangle with sides 5m, 6m, 7m respectively. Assume that the line is fully transposed and carries balanced load. [6]

4. a) Derive the expression for the inductance per meter of a single phase two wire transmission line. [5]

   b) Draw phasor diagram for a nominal T circuit of a transmission line. Derive expressions for sending end voltage and current. [5]

   c) A 220 kV, three phase transmission line is 40 km long. The resistance per phase is 0.15 Ω per km and the inductance per phase is 1.3263 mH per km. The shunt capacitance is negligible. Use the short line model to find the voltage and power at the sending end and the voltage regulation and efficiency when the line is supplying a three phase load of 381 MVA at 0.8 power factor lagging at 220 kV. [6]

5. a) Why compensation is needed in transmission line? What are the methods of voltage control implied in transmission line? Explain one of them. [5]

   b) Verify that reactive power transferred over a transmission line is directly proportional to voltage drop along the line and is independent of power angle. [5]

   c) A 220 kV, three phase transmission line is 300 km long. The line has resistance of 0.12 ohm per phase per km, line inductance of 1.5mH per phase per km and shunt capacitance of 2μF per phase per km. Calculate ABCD parameters of the line with longline model in equivalent T-model. If the line is excited by 220kV from the sending end, calculate the receiving voltage. [6]

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1. a) Draw a single line diagram showing generation, transmission and distribution components of a power system with typical voltage levels and discuss why different voltages are used in these three components of power system. Also, explain the reason why transmission and distribution systems are three phase ac system instead of single phase ac system. [3+4+3]

   b) What will happen if long line is modelled by short line model and vice versa? [4]

2. a) Determine the maximum voltage that the string of suspension insulators having 3 no. of disc, can with stand if the maximum voltage per unit is 17.5 KV. It is given that shunt capacitance between each joint and metal work is 12.5% of the capacitance of each disc. [7]

   b) Explain one of the techniques to locate phase to phase fault on underground power cable. [5]

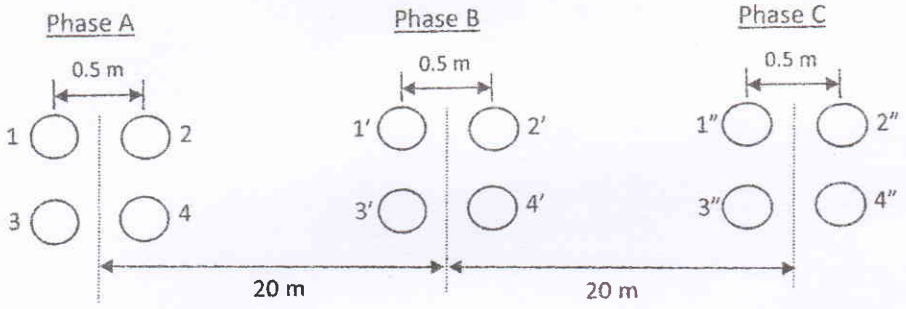
   c) Define the meaning of complex power in power system. Explain the sign conventions of power for sources and loads. [4]

3. a) Develop the reactance diagram of following network and express all the parameters in p.u values based on power 1000 KVA and base voltage of 11 kV at low voltage side: [10]

   G_1 : 1000 KVA, 11 kV, X= 2.5% G_2 : 500 KVA, 11 kV, X= 0.1%
   T_{r-1} : 1000 KVA, 11 kV/66 KV, X= 2% T_{r-2} : 500 KVA, 12.5 kV/75 kV, X= 2%
   T_{r-3} : 1500 KVA, 66 kV/400 kV, X= 2% TL : 10 Ω/Phase
   If the load draws a current of 1200A, calculate the current supplied by G_1 & G_2.

   b) What is the importance of transposition of high voltage transmission lines? Derive the line capacitance and phase capacitance of single phase line considering the effect of ground. [6]

4. a) Figure below shows a quadruple-conductor circuit of a signal-circuit, three-phase, 400 kV, 50 Hz line with a horizontal spacing of 20 m. Each sub-conductor of the bundle has a diameter of 40 mm and spacing between the sub-conductors is 0.5 m. Each phase group shares the total current and charge equally and the line is completely transposed. Determine the inductive reactance, capacitive reactance, charging current and charging VAR per phase per km of the line. [10]



b) How transmission lines are classified according to their lengths? Explain why all lines can be represented by long transmission line model where as all the lines cannot be represented by short transmission line model. [4]

c) Draw a nominal π-model of medium transmission line and derive the expressions to determine ABCD parameters of the model. [5]

5. a) 15000 kVA is received at 33 kV at 0.85 power factor lagging over an 8 km three-phase overhead transmission line. Each line has R = 0.29 ohm/km, and X = 0.65 ohm/km. Calculate: [8]

i) Voltage at the sending end
ii) Power factor at the sending end
iii) Voltage regulation of the line
iv) Efficiency of the transmission line

b) Discuss why the receiving end voltage of an unloaded transmission line may be more than the sending end voltage. Describe the compensating measures to limit the receiving end voltage of long transmission lines at no load. [7]

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