TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2078 Chaitra

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

Subject: - Power System Analysis I (*EE 555*)

- ✓ 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) "Transmission Line efficiency increase with the increase in voltage". Justify the statement mathematically. [5]

   b) For a 3-ph, 200 km long transmission line, derive an expression relating sending end voltages and current to receiving end voltages and current using nominal-JT model. Also write down the expressions for determining active and reactive power losses in the line. Construct a phasor diagram of currents and voltages for a unity power factor load at the receiving end. [4+1+2]

   c) What will happen if a 500 km long transmission line in modeled using medium length transmission line model and a 50 km long line represented by long length model? [2+2]

2. a) Explain Murray Loop test for locating short circuit fault in underground cable. [6]

   b) Briefly explain the reasons behind use of stranded and bundled conductors. [2+2]

   c) Calculate the string efficiency for 4-unit suspension insulator if the capacitance of each unit to earth and line be 20% and 5% of the self-capacitance of the unit respectively. [6]

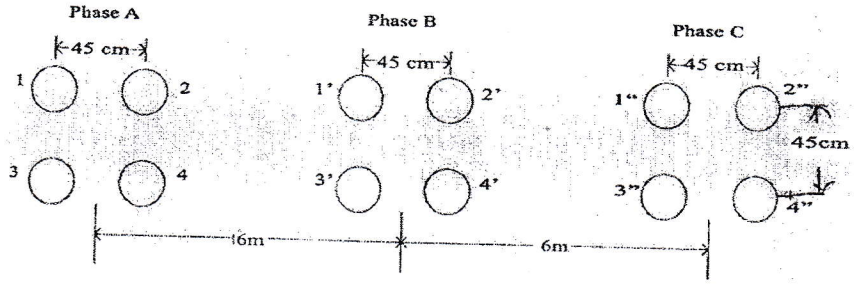
3. a) Two three-phase machines have generated EMF of $11\angle 0$kV and $11\angle 40°$kV. They are connected through a 3-phase line having an impedance of $0 + j15\ \Omega$ per phase. Find, [6]

      i) Whether each machine is acting as generator or motor and the real power generated or consumed by them.
      ii) Whether each machine is delivering or consuming reactive power and the amount of reactive power.

   b) A 20 MVA, 11 kV three-phase synchronous Generator has a sub-transient reactance of 10%. It is connected through three identical single-phase Δ- Y connected Transformer of 5000 kVA, 11/127.02 kV with a reactance of 15% to a high voltage Transmission line having a total series reactance of $j180\ \Omega$. At the end of the HT transmission line, three identical single-phase star/star connected transformers of 5000 kVA, 127.02/12.702 kV with a reactance of 20%. The load is drawing 15 MVA, at 20 kV at 0.9 pf lagging. Draw a signal line diagram of the network and determine the reactance diagram. Choose a common base of 15 kV and 25 MVA. [10]

4. a) Prove that the inductance of a transmission line due to internal flux linkages is independent of the conductor geometry. [6]

b) A 220 kV, 50Hz, 200 km long 3-phase line has conductors spaced as shown in the figure below. Compute the inductance and Capacitance per phase. Each sub-conductor is of a 12 mm radius. Assume transposed configuration of the line. [10]



5. a) A 3-Φ line is 400 km long. The line constants are $z = 0.105 + j0.3768\ \Omega$ per phase per kilometer and $y = 0 + j2.822 \times 10^{-6}\ \mho$ per kilometer. The line delivers 60 MVA at 0.9 power factor lagging at 220 kV. Find the sending end voltage, current, power factor, active and reactive power loss of the line. [10]

6. b) Starting from a suitable point, find the expression of power at the receiving end of a line in terms of sending and receiving end voltages and line ABCD constants. Also, find the expression for maximum active power at the receiving end. [4+2]

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Subject: - Power System Analysis I *(EE 555)*

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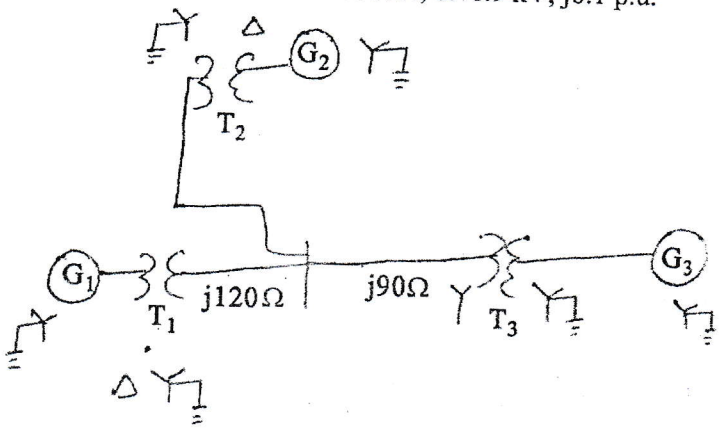
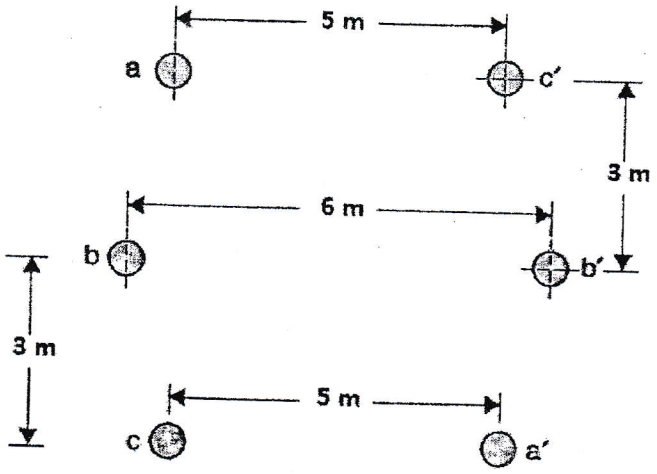
1. a) Draw a typical single line diagram of interconnected power system. How is isolated power system different from interconnected power system? [4+2]
   b) What are the benefits of three phase power delivery over single phase? [4]
   c) Determine the ABCD parameters of a nominal-Π and nominal-T models. What can be said when comparing ABCD parameters of these two models? [6]
2. a) "Voltage across insulator in a string used in overhead lines is uniformly distributed." Is it true or false. Justify your answer with necessary evidence/ mathematical deviations. [6]
   b) Prove that dielectric stress is maximum at the conductor surface and its value goes on decreasing as we move away from the conductor. [5]
   c) How do we detect underground fault in a power cable? Explain with necessary diagram. [5]
3. a) What do you mean by single line diagram? Write its significance in power system analysis. [4]
   b) Draw reactance diagram with all values in p.u. on a base of 30MVA, 6.6kV in the circuit of generator G1. Required data are as follows, [8]
      G1: 25MVA, 6.6kV, j0.2 p.u.
      G2: 15MVA, 6.6kV, j0.15 p.u.
      G3: 30MVA, 13.2kV, j0.15 p.u.
      T1: 30MVA, 6.6 (delta) kV/ 115(star) kV, j0.1 p.u.
      T2: 15MVA, 6.6 (delta) kV/115(star) kV, j0.1 p.u.
      T3: Single phase units each rated 10MVA, 69/6.9 kV, j0.1 p.u.



   c) What is per unit system? What are the advantages of per unit representation? [4]

4. a) Find the capacitance per phase per km of double circuit three phase line shown in figure below. The line is completely transposed and operates at a frequency of 50Hz. Radius of each conductor is 6mm. Also compute the capacitive reactance per phase and total VAR generated by the line of 100km and operating at 132kV. [10]



b) What is the method of images? How can it be used to take into account the presence of ground calculating the capacitance of a line? [6]

5. a) A 15km long 3 phase overhead line delivers 5MW at 11kV at a power factor of 0.8 lagging. Line loss is 12% of the power delivered. Line inductance is 1.1mH per km phase. Calculate:

(i) sending end voltage and regulation,
(ii) power factor of the load to make regulation zero,
(iii)the value of capacitor to be connected at the receiving end to reduce regulation to zero.

[2+2+4]

b) What do you mean by surge impedance loading? Explain its significance in power system. [4]

c) A 3-phase overhead line has following parameters: [4]
$V_S = 132 < 0°$kV, $V_R = 130.5 < 10°$ kV
$A = 0.97 < 0.5°$, $B = 100 < 75°$ ohms/ph
Determine the sending end active power.

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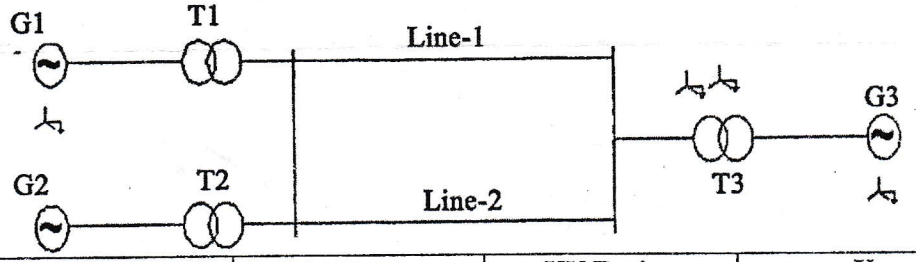
1. a) What do you mean by renewable energy sources, write with examples. Which one is least suitable for our country? Support your answer. [6]

   b) What do you mean by infinite bus in power system? [4]

   c) Draw single line diagram of inter connected power system showing generation, transmission and distribution system and describe function of each system. [6]

2. a) Derive a relation between the conductor radius and inside sheath radius of a single core cable so that the electric stress of the conductor surface may be minimum. [6]

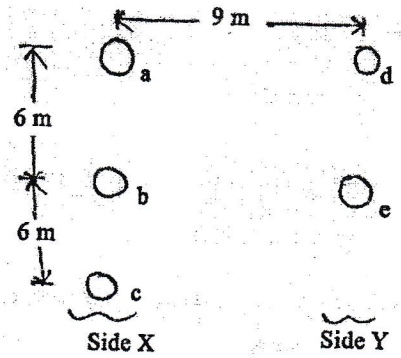
   b) Draw the reactance diagram of following figure with its equivalent per unit system. [10]



Equipment	MVA Rating	KV Rating	X
Generator (G1)	100	11 KV	25%
Generator (G2)	100	11 KV	20%
Generator (G3)	100	11 KV	20%
Transformer (T1)	100	11 / 220 KV	6%
Transformer (T2)	100	11 / 220 KV	7%
Transformer (T3)	100	220 / 11 KV	7%
Line-1	100	220 KV	10%
Line-2	100	220 KV	10%
Take base MVA=100 MVA and base voltage = 11 KV for generator. Compute the reactance diagram.			

3. a) How does the GMR for inductance calculation differ from the GMR for capacitance calculation? Explain. [6]

   b) One circuit of a single-phase transmission line is composed of three solid 0.25-cm-radius wires. The return circuit is composed of two 0.5-cm-radius wires. The arrangement of the conductors is shown below. Find the inductance due to the current in each side of the line and the inductance of the complete line in henrys per meter. [10]



4. a) A 50Hz transmission line 300km long has a total series impedance of 40+j125 ohms and a total shunt admittance of 10^{-3} mho. The receiving-end load is 50MW at 220kV with 0.8 lagging power factor. Find the sending-end voltage, current, power and power factor using:
   i) Short line approximation
   ii) Nominal-π method. [10]

   b) What is bundled conductors? How use of bundle conductors affects capacitance and inductance with compare to line with single conductor? [6]

5. a) The sending end voltage of a three phase overhead line with a series impedance of (20.62<75.96) ohm is 46.85 kv while the receiving is 33 kv. Determine the power output at 0.8 pf lagging and the sending end power factor. [8]

   b) A 275 KV transmission line has the following line constants: [8]
   A=0.85<5°; B= 200<75°
   Determine the power at unity power factor that can be received if the voltage profile at each end is to be maintained at 275KV.

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$V_S = AV_R + BI_R$

$I_R = \frac{V_S - AV_R}{B}$

$=$

$\begin{bmatrix} V \\ S \end{bmatrix} \begin{bmatrix} 1 & Z \end{bmatrix} \begin{bmatrix} V_1 \end{bmatrix}$

$1 + \frac{YZ}{2}$ $\quad B = Z$

$I_R =$

$P_R = 3V_R I_R \cos\phi_{R1}$

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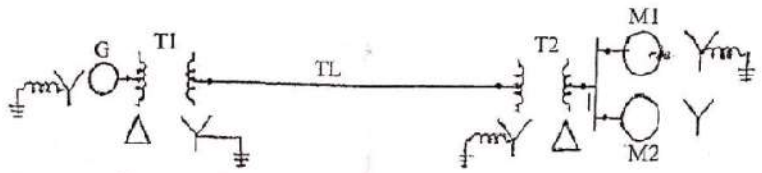
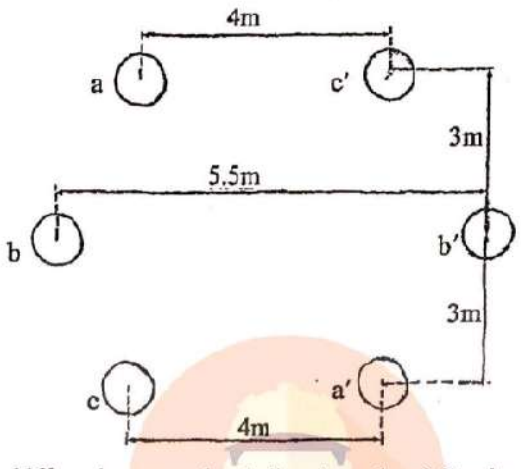
1. Give reasons for the following in brief: [6]
   a) Bundling of conductors in HV transmission line
   b) The frequency and voltage of infinite bus remains constant even after variation in load.
2. Write down the significance of voltage level while transmitting the power from power plant. Suppose if a certain power is transmitted over a long line with a transmission voltage of 132 kV, then will it be feasible to transmit the same power over same distance with a voltage level 400 kV, Justify. [4]
3. a) What are electrical and mechanical characteristics required for good insulator used of HV transmission lines? [4]
   b) How does the Murray's loop for localizing short circuit fault in cable work? [4]
   c) Each conductor at 66kv is suspended by a string of 5 similar insulators, the capacitance of each disc being 5 times the capacitor to earth. Determine the % string efficiency. If the distance between the insulators and tower structure is increased so as to make capacitance of disc 6 times the earth capacitance, what will happen to the string efficiency? [8]
4. a) What is per unit system? Mention the advantages of per unit? [4]
   b) A 300-MVA 20kV three-phase generator has a sub-transient reactance of 20%. The generator supplies two synchronous motors over a 65 kilometer line having transformer at both ends, as shown on the single line diagram. The neutral of one of the motor M_1 is grounded while M_2 is undergrounded. Rated inputs to motor are 200 MVA at 13.2 kV and 100 MVA at 13.2 kV for M_1 and M_2 respectively. For both motor $X''_d = 20\%$. The three phase transformer T_1 is rated 350 MVA, 230/20kV with leakage reactance of 10%. Transformer T_2 is composed of three single phase transformer, each rated 127/13.2 kV,100 MVA with leakage reactance of 10%. Series reactance of the transmission line is 0.8 ohm/km. Draw the reactance diagram with all the reactances marked in P.U. Select the generator rating as base in generator circuit. [10]



5. a) A 3-Φ double circuit line is arranged as shown in figure below. The conductors are transposed. The radius of each conductor is 0.75 cm. Phase sequence is abc, find the inductance and capacitance per phase per km. [8]



b) A 3-Phase 50Hz, 110km long overhead line has the following line constants: resistance per phase per km = 0.153 ohm, inductance per phase per km = 1.21mH, capacitance per phase per km = 0.00958 micro F. The line supplies a load of 20MW at 0.9 power factor lagging at a line voltage of 110 kV at the receiving end. Calculate sending end voltage, current, power factor, regulation efficiency. [8]

6. a) A 3-phases 50Hz line operating at 33kV is supplying a load of 20MW at 0.995 p.f. leading. The series impedance of the line is 4 + j8 Ω/ph. Determine the power transmission efficiency of the line. How can the line voltage regulation be made zero? [4+4]

b) Starting from suitable point, derive the expression for receiving end complex power in terms of voltage and line parameters. Construct the power circle based on the expression. [6+2]

c) What is the reason for long transmission wires being represented by uniformly distributed line parameters? With necessary mathematical derivation, show that the current in a long line is different at different points. [2+6]

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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]

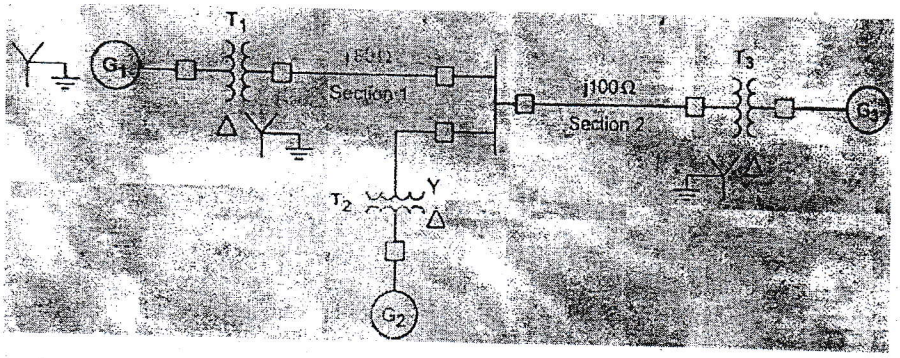
   b) Explain how electrical energy can be generated from hydropower plant with basic block diagram. [4]

   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 $V = 100 \angle 0°$ 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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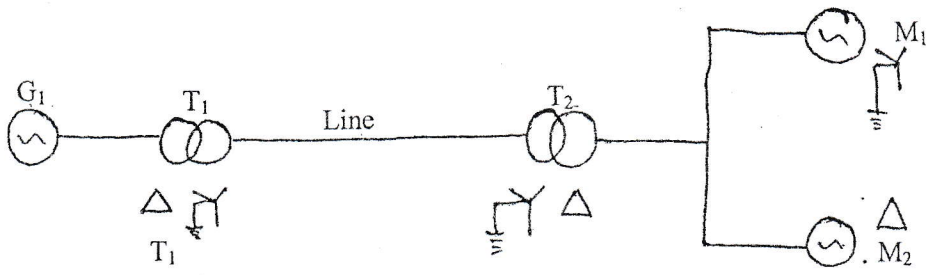
1. a) What is infinite bus in power system? Write the advantages of HVDC transmission over HVAC system with single line diagram. [8]

   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]



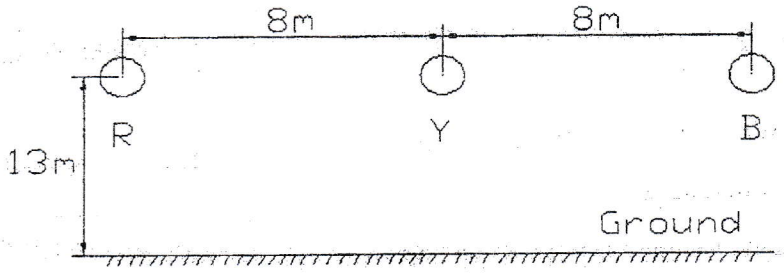
3. a) What will be consequences if the ac complex power S is not taken as S=VI*. Draw necessary phasor if necessary to support your answer. [4]

   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) Describe the advantages and limitations of DC transmission lines over AC transmission lines. [6]

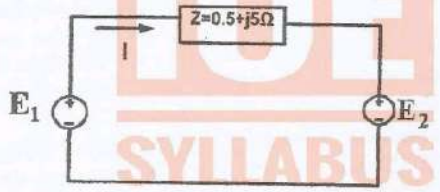
   b) The volume of a conductor material required in the power line decreases with increase in voltage and also with the increase in power factor. Explain. [4]

2. a) A single core 2 km long cable has a conductor radius of 13 mm and an insulation thickness of 4.6 mm. If the resistivity of dielectric is $7*10^{12}$ ohm-m, find the insulation resistance and the capacitance per meter length of cable if the dielectric has relative permittivity of 3.2. [8]

   b) "Per unit impedance of transformer is same whether referred on the primary or secondary side of the transformer" - State whether this statement is true or false and explain to justify your answer. [2+4]

3. a) Two ideal voltage sources designated as machine 1 and 2 are connected as shown in figure below. If $E_1 = 100 \angle 0°V$ and $E_2 = \angle 30°V$ and $Z = 0.5 + j5\ \Omega$. Determine

   (i) Whether each machine is generating or consuming real power and the amount,
   (ii) Whether each machine is receiving or supplying reactive power and the amount, and
   (iii) The P and Q absorbed by the impedance. [6]



   b) A one-line diagram of a three-phase power system is shown in figure below. Compute the per unit values taking generator rating as the base in the generator circuit and draw the impedance diagram of a power system shown in figure below. The system has the following data: [8]

   System Data:

   G_1: 25 MVA, 13.8 kV, X= 0.15 p.u.

   T_1: 30 MVA, 13.2/115 kV, X= 0.11 p.u.

   T_2: Three Single units each rated 10 MVA, 69Y/13.2Δ kV, X= 0.11 p.u.

   M_1: 15 MVA, 13 kV, X= 0.15 p.u.

   M_2: 10 MVA, 13 kV, X= 0.15 p.u.

   Series impedance of transmission line: Z=20+j65 Ω

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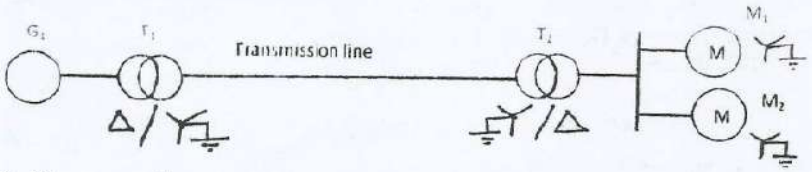
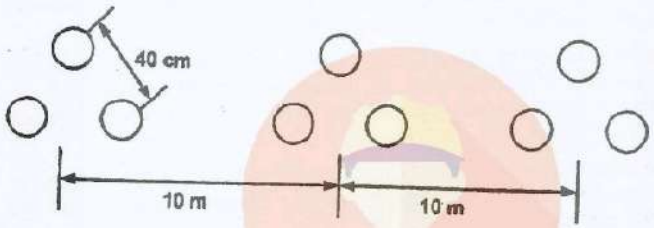


4. a) Why transposition is required in three phase line with unsymmetrical spacing? Derive the expression for the inductance of such transposed line. [6]

   b) Determine the inductive and capacitive reactance, charging current and charging VAR per phase per km of the 400 kV Single circuit, 3 - ϕ 50Hz fully transposed transmission line having three bundle conductor per phase with spacing of sub conductors as d = 40 cm and radius of each sub conductor is 20 mm as shown in figure below. [10]



5. a) A 3-phase short overhead line has a series impedance of 20 + j 50 ohms per phase. Find the maximum active power which can be delivered at the receiving end voltage of 31.2 kV if the sending end voltage is 33 kV. Also, determine the receiving end power factor and line efficiency under this condition. [2+3+3]

   b) What is an equivalent π-model of a long transmission line? Derive expressions for parameters of this circuit in terms of line parameters. [6]

6. a) A 100 km long 3 phase 50 Hz, overhead line delivers 50 MVA at 0.8 pf lagging and at 132 kV. The resistance and inductive reactance are 0.1 Ω per phase per km and j0.2 per phase per km respectively. The shunt admittance is j 4×10^{-6} s/phase per km. Calculate sending end current, sending end voltage, and transmission efficiency using normal T -model. [6]

   b) A 3-phase 132 kV overhead line delivers 50 MVA at 132 kV and 0.8 pf lagging. The constant of line are A = 0.983 ∠3°, B = 110 ∠75°Ω per phase. Determine the capacity of the static compensation equipment at the receiving end to reduce the sending end voltage to 140 kV for the same load condition. [6]

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33 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2073 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) 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]

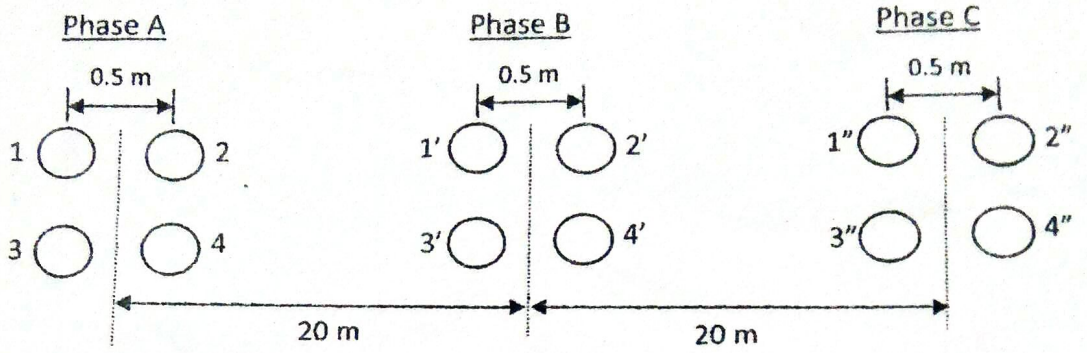
   c) Define the meaning of complex power in power system. Explain the sign conventions of power for sources and loads. [4]

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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INSTITUTE OF ENGINEERING
Examination Control Division
2073 Magh

Exam.	New Back (2066 & Later Batch)		
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.*

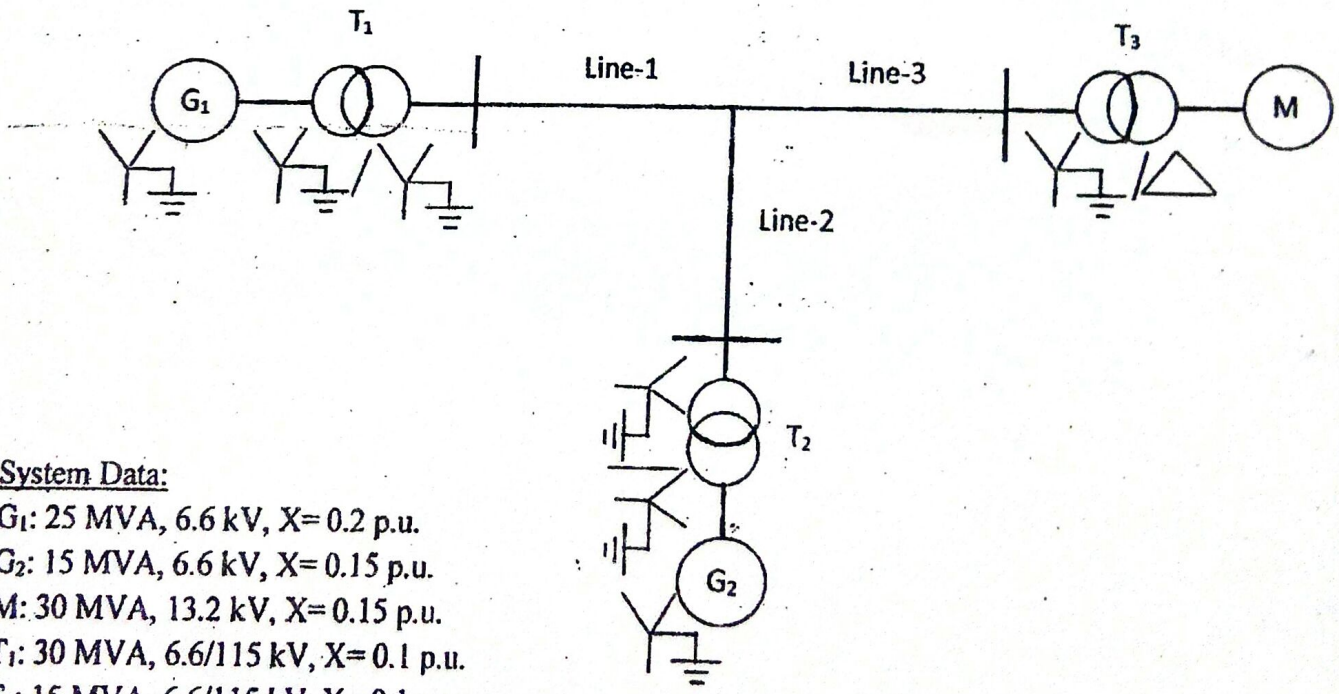
1. a) Describe the concept of infinite bus in electric power system. Discuss how the national electric grid of any country can be considered as infinite bus. [5]

   b) What are conventional sources of energy? List out some features of one of the power generating stations using conventional energy sources. [5]

2. a) A string of disc instructors consist of three units. The capacitance between each link pin and earth is one eighth of the self capacitance of the unit. If the maximum voltage per units is not to exceed 20 kV, find the greatest working voltage and the string efficiency. [6]

   b) What is meant by stranded conductor and bundled conductor in power transmission system? Explain the reason of using bundled conductors in Extra High Voltage (EHV) transmission lines. [5]

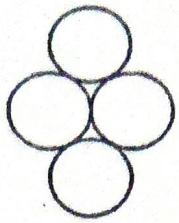
3. a) Compute the per units values taking power base of 30 MVA and 6.6 kV in the circuit of generator G_1 and draw the reactance diagram of a power system shown in figure below. The system has the following data: [10]



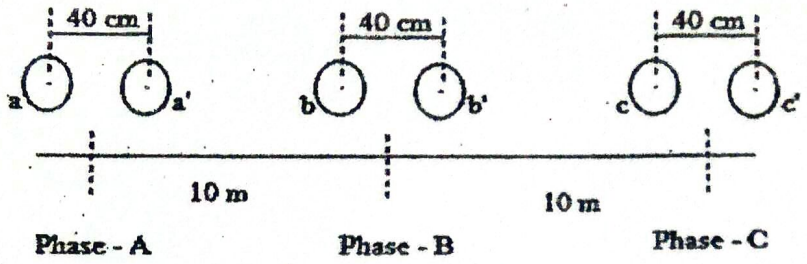
System Data:
G_1: 25 MVA, 6.6 kV, X= 0.2 p.u.
G_2: 15 MVA, 6.6 kV, X= 0.15 p.u.
M: 30 MVA, 13.2 kV, X= 0.15 p.u.
T_1: 30 MVA, 6.6/115 kV, X= 0.1 p.u.
T_2: 15 MVA, 6.6/115 kV, X= 0.1 p.u.

b) Derive the expression for sending end voltage (Vs) in terms of receiving end voltage (Vr), line resistance (R) and reactance (X) and complex power (p+jQ) demand at the receiving end and hence justify that reactive power always flows from higher voltage magnitude to lower voltage magnitude. [4]

4. a) Find the Self GMD for inductance and capacitance calculations for the following conductor configuration. Given that radius of each sub-conductor is r. [4]



b) Determine the inductive and capacitive reactance and charging VAR per phase per km of 400kV single circuit, 3-ϕ, 50Hz transposed transmission line having two bundle conductor per phase with spacing of sub conductors as d = 40cm and radius of each sub-conductor is 20 mm. [8]



c) Describe briefly about skin effect and proximity effects in overhead transmissions lines. [4]

5. a) Starting from suitable point, derive expressions relating sending end voltage and current for a medium length transmission line using nominal-T model. Also construct phasor diagram and expressions to compute power loss in the line, voltage regulation and efficiency. [8]

b) With necessary derivation, show that the voltages along the long transmission line varies continuously. [6]

6. a) A three phase 220KV, 50Hz transmission line supplies a power of 200MW at a power factor of 0.8 lagging and line has ABCD parameters as follows: [10]

$$\begin{bmatrix} A & B \\ C & D \end{bmatrix} = \begin{bmatrix} 0.9 < 0.001° & B\Omega \\ 1.14 \times 10^{-3} < 90° & 0.9 < 0.001° \end{bmatrix}$$

Determine the following:

i) Sending end voltage and current
ii) Real and reactive power at sending and at full load.
iii) Real and reactive power loss in line at full load.
iv) Voltage regulation and line efficiency at full load.

b) What is meant by reactive power compensation in electric power system? List out its benefits to the system. [5]

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33 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
20^2 Ashwin

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) Enlist the major components of electric power station. Describe in brief, the functions of any four major components. [2+4]

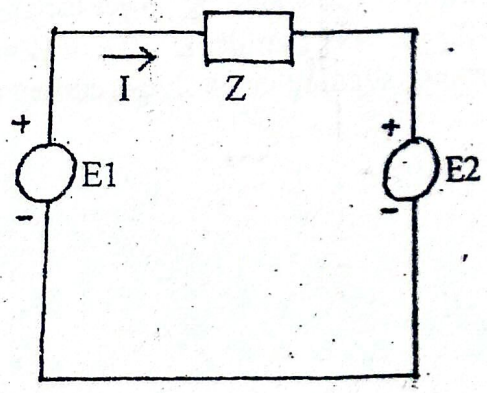
   b) Why AC power generation, transmission and distribution prevailed over DC system in the early both century. [4]

2. a) A string of 4 insulators is connected across a 66 KV line. It has a self-capacitance equal to 10 times the pin to earth capacitance. Calculate (i) the distribution of voltage on the insulator discs and (ii) the string efficiency. [6]

   b) Classify power cables and give reasons for their usage. Briefly discuss about cable installation techniques. [2+2+2]

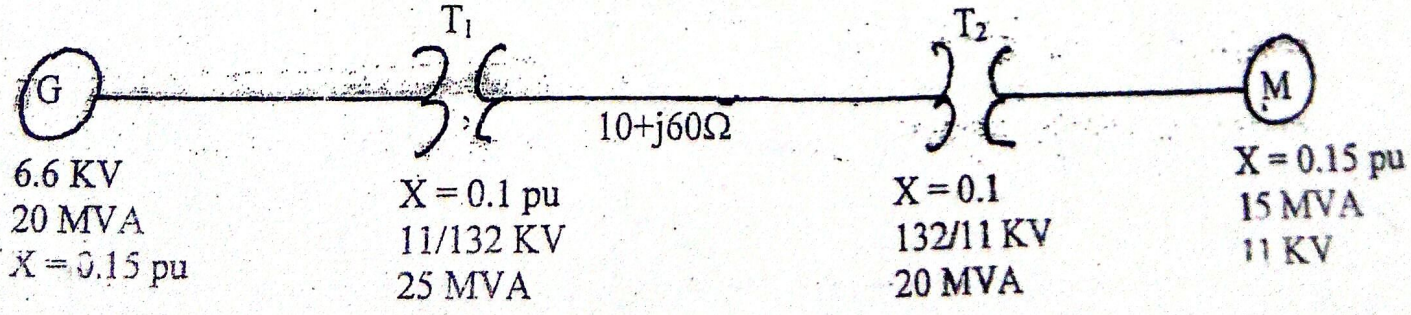
3. a) Two ideal voltage sources designated as machine 1 and 2 are connected as shown in figure. If E1 = 120 < 10° V, E2 = 120 < 30° V and z = 1 + j5Ω. Determine: - [6]

   i) Whether each machine is consuming P and Q or generating P and Q.
   ii) P and Q absorbed by impedance
   iii) Direction of power flow

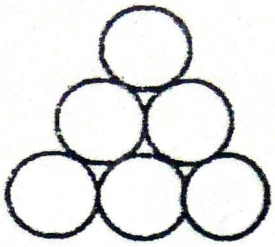


   b) List out the advantages of per unit system. How are the base voltages and base power are chosen? [3+3]

   c) Draw the pu impedance diagram for the system shown below. [4]



4. a) Determine GMR of stranded conductor for calculation of inductance shown in figure below if radius of each sub-conductor is 1 cm. [4]



b) What is the effect of earth on capacitance of an over head line? Explain. [4]

c) A 132 kV, 50 Hz, 3-phase line has its conductors each of diameter 18 mm, are on the triangular configuration. The conductors are transposed at the regular intervals. The distance between phases conductors are 4.0 m, 5.0 m and 4.5 m. Find the inductance, capacitance, charging current and charging MVAR per km. [8]

5. a) Determine the ABCD constants of a medium length transmission line using nominal-Π and nominal –T models. Compare these ABCD constants. [5]

b) What are the typical values of ABCD constants in long transmission lines? Express these constants in terms of line series impedance and shunt admittance where applicable. [5]

6. a) A 3-phase, 50 Hz, 33 KV transmission line is delivering a load of 15 Mw at 0.9 pf lagging. The line series impedance per phase is 5+j18Ω. Determine the power transmission efficiency and voltage regulation of the line. Construct the phasor diagram of currents and voltages in the line. [6]

b) A single circuit, 60 Hz, three phase transmission line is 150 miles long. The line is connected to a load of 50 MVA at a lagging power factor of 0.85 of 138 KV. The line constants are given as R = 0.1858 Ω/mile, L = 2.6 m H/mile, and C = 0.012 μF/mile. Determine ABCD constants, sending end voltage, current and power. [10]

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TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2072 Magh

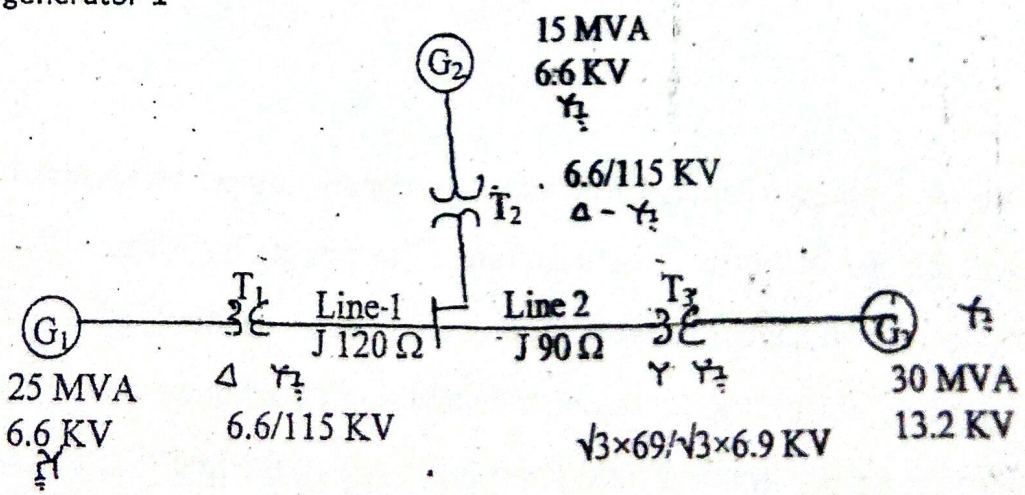
Exam.	New Back (2068 & Later Batch)		
Level	BE	Full Marks	80
Programme	BEL	Pass Marks	32
Year / Part	II / II	Time	3 hrs.

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

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

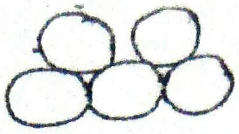
1. a) Describe the basic structure of power system with clear diagram. [5]
   b) List out the typical voltage levels used for power generation, transmission and distribution worldwide. Briefly explain why three phase is preferred over single system in power distribution. [2+3]
2. a) Why do the stranded and bundled conductors used in overhead transmission line? [3]
   b) Starting from a suitable point in a 3 disc insulator string, show that the disc nearest to the line is subjected to highest electric stress. [5]
   c) Describe the Murray loop test method for location of underground cable fault. [4]
3. a) Figure below shows a single line diagram of a power system. The ratings of the generators and transformers are given below: [6]

   G1: 25MVA, 6.6KV, X_{G1}= 0.20pu
   G2: 15MVA, 6.6KV, X_{G2}= 0.15pu
   G3: 30MVA, 13.2KV, X_{G3}= 0.15pu
   T1: 30MVA, 6.6 Δ-115Y KV, X_{T1}= 0.10pu
   T2: 15MVA, 6.6 Δ-115Y KV, X_{T2}= 0.10pu
   T3: Single phase unit each rated 10MVA, 6.9/69 KV, X_{T3}= 0.10pu
   Draw per unit circuit diagram using base values of 30MVA and 6.6KV in the circuit of generator-1



   b) What is complex power? Why complex power is taken VI* rather V*I in power system, explain? [4]
   c) Two 3-phase synchoronous generators connected in star with neutral grounded are connected to each other through a line with series impedance per phase of 2+j8Ω. The terminal voltages of generator 1 and 2 are 200<30°V and 210<50°V respectively. Determine the active and reactive power generated/consumed by each generators. [6]

4. a) Determine the self GMD of the following conductor. Radius of each strand is 6 mm. [4]



b) Per phase, charging current per phase per km and total charging VAR of the line. The line is operated at 330 KV and 50 Hz. [10]

c) Briefly describe about skin effect in power transmission line. [3]

5. a) How can the voltage regulation of a short transmission line be made zero? Explain with necessary mathematical derivation. [6]

b) Define characteristics impedance, SIL, phase shif constant and altenuation constant for an over head transmission line. [4]

6. a) A three phase 132 KV overhead line delivers 50 MVA at 132 KV and power factor 0.8 lagging at its receiving end. The constants of the line are $A = 0.98\angle 0.3^{\circ}$ and $B = 110\angle 75^{\circ}$ ohms per phase. Find (a) Sending end voltage and power angle (b) Sending end active and reactive power (c) Line losses and VARS absorbed by the line. [6]

b) A 50 Hz, 400 kv, 450 km long transmission line has the following parameters: r = 0.033 Ω/km, L = 1.067 mH/km, C = 0.0109μF/km. It is delivering 420 MW at 0.95 power factor lagging. Determine voltage and current at sending end, sending end power and power factor. [9]

Q.No. 4b. A 3 phase overhead line as 4 sub-conductors per phase separated from each other by 45cm and placed at vertices of a square. The phases have flat horizontal configuration with center to center distance between adjacent phases equalling 6m and between far end phases equalling 12m. Assuming complete transposition determine the inductance per phase, charging current per phase per km and total charging VAR of the line. The line is operated at 330KV and 50Hz.

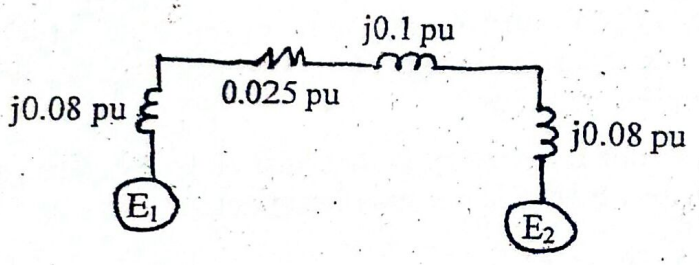
33 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2071 Bhadra

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

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

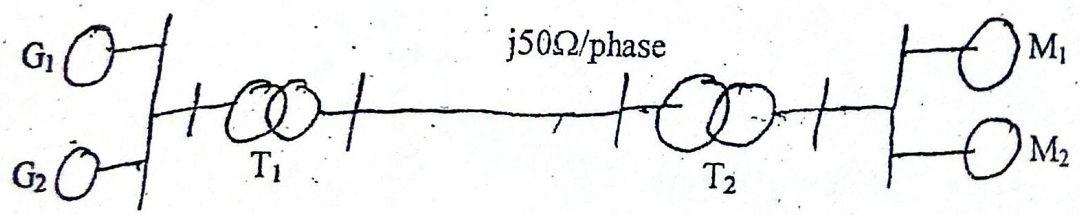
- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ *Assume suitable data if necessary.*

1. a) Explain the evolution of power system and mention its major milestones. [6]
   b) Why AC system prevailed over DC system in early 20th century? Explain briefly. [5]
   c) What is proximity effect in overhead power transmission? Explain briefly. [5]
2. a) How are the faults in underground cables located? Describe one of the methods with necessary figures. [5]
   b) Determine the amount of power generated by each of the generators in the power system network below. Also specify the direction of power flow in the network. [6]



$E_1 = 1.05 < 5°$ pu
$E_2 = 1.05 < 20°$ pu

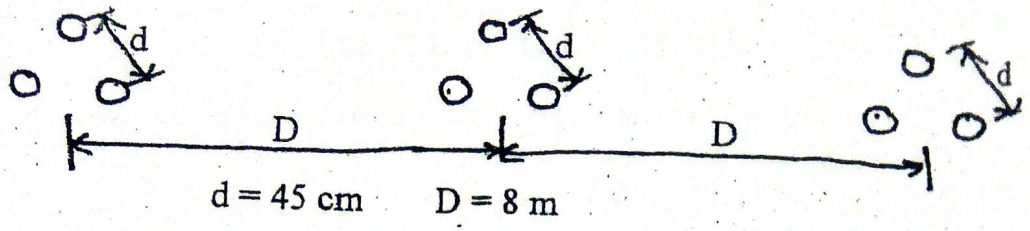
   c) What are the advantages of per unit system in electric power system computation? Mention the common approaches to select Base Power and Base Voltage. [5]
3. a) Draw the per-unit reactance diagram for the power system shown below; choosing suitable base values. [6]



G_1: 25 KV, 20 MVA, 20%
G_2: 25 KV, 30 MVA, 30%
T_1: 50 MVA, 33/220 KV, 15%
T_2: 50 MVA, 220/11 KV
M_1: 20 MVA, 11 KV, 30%
M_1: 30 MVA, 11 KV, 20%

   b) What is the impact of presence of earth on the capacitance of an overhead transmission line? Explain with necessary mathematical expression (derivation not required). [4]
   c) A 120 km long, 50 Hz, 3 phase, 132 kV overhead line has flat horizontal configuration with distance between adjacent phases equal to 4.5 m and distance between extreme end phases equaling 9 m. Compute the shunt capacitive susceptance per phase, charging current per phase per km and the reactive power generated by the line. [6]

4. a) Compute the inductance and capacitance per phase for a 200 km line using phase conductors of 18 mm radius and configured as given below: [5]



Assume complete transposition of the line.

b) What are the parameter of transmission line? Explain how the line configuration affect them. [6]

c) Derive the expression of ABCD constants for a medium length transmission line using nominal-T model. [5]

5. a) A 100 km long 3-phase 50 hz transmission line is nominal-T modeled. The resistance and reactance are 0.2 Ω per phase per km and j0.4 per phase per km respectively. The shunt admittance is $j2.5 \times 10^{-6}$ s/phase per km. Calculate current and voltage at the sending end if the line delivers 20 MW at 110 kV and at 0.9 p.f. lagging. [6]

b) A 50 Hz, 3-phase, 132 kV overhead line is supplying a load of 40 MW at 0.9 p.f. leading. The line has series impedance of 12 + j36 Ω/phase. How can the voltage regulation of the line be made zero? [6]

c) Why shunt compensation is necessary in transmission line? Explain any two methods of shunt compensations applied in transmission system. [4]

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INSTITUTE OF ENGINEERING
Examination Control Division
2071 Magh

Exam.	New Back (2066 & Later Batch)		
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) Produce a neat single line diagram of an interconnected power system showing multiple generating stations, transmission and sub-transmission lines, and primary distribution lines. Mention all bus voltages in the system. [5]

   b) A string of 5 insulators is connected across a 100 KV line. If the ratio of shunt to self-capacitance is 0.1, determine the voltage distribution along the string and string efficiency. [6]

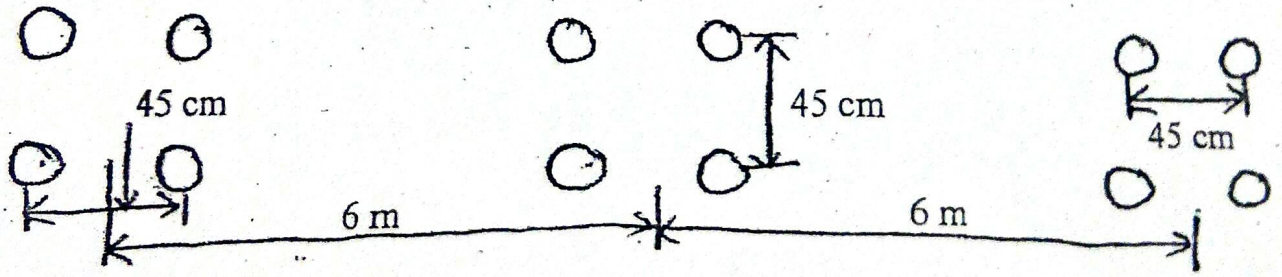
   c) Compare the economic aspects of 1-ϕ and 3-ϕ power delivery system. Give suitable mathematical relationship to justify the argument. [5]

2. a) What are the reason of making stranded and bundled conduction for transmission line. [5]

   b) Two ideal 3-phase synchronous machines A and B are connected by a series impedance of 0 + j5 Ω per phase. The voltages at the two machines are $100\angle 0°$ and $120\angle 30°$ V respectively. Calculate and analyze the direction of power flow in system. [5]

   c) How can underground cable faults be located by Murray loop test method? Explain with necessary figures and mathematical expressions. [6]

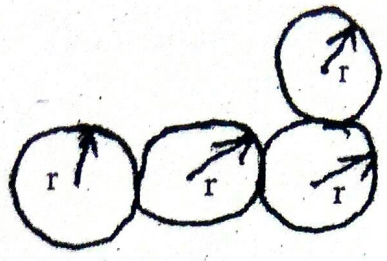
3. a) Compute the inductance per phase for a 200 km line. Each sub-conductors are of 12 mm radius and configured as given below. [5]



   b) Starting from voltage and current phasors, derive the expression for complex power. Construct the phasor diagram of complex power and explain the significance of the components. [6]

   c) Show that the inductance due to internal flux linkages of a conductors is independent of its geometry and the current through it. [5]

4. a) Compute the self-GMD of the conductor shown in figure in terms of strand radius r. All the strands are similar. [5]



b) Why transposition is carried out in overhead transmission line? Draw the schematic layout for complete transposition cycle for 3-ϕ single circuit and 3-ϕ double circuit transmission line. [6]

c) The ABCD constants of a 3-phase overhead line is as follows: [5]

$A = D = 0.9955 < 0.086°$ $B = 31.552 < 71.608°\ \Omega$ $C = 3 \times 10^{-4} < 90°\ S$

If a shunt capacitor with admittance $2.5 \times 10^{-4} < 90°$ S is connected at the end of the line, determine the equivalent ABCD constants of the system.

5. a) A 200 mile long, 3-phase, 220 kV, 60 Hz overhead transmission line has series impedance of $0.8431 < 79.04°\ \Omega$/mi and shunt admittance of $5.105 \times 10^{-6} < 90°$ S/mi. Determine the characteristic impedance, propagation constant, phase shift constant, attenuation constant and SIL of the line. [6]

b) For a 3-phase overhead line, the following data is available: [6]

$V_{S,L} = 138.5 < 8°$ kV $V_{R,L} = 132 < 0°$ kV

$A = 0.983 < 0.68°$ $B = 36.5 < 71.5°\ \Omega$

Determine the transmission line active and reactive power loss.

c) Explain how transmission line behaves as source and sink of reactive power. [4]

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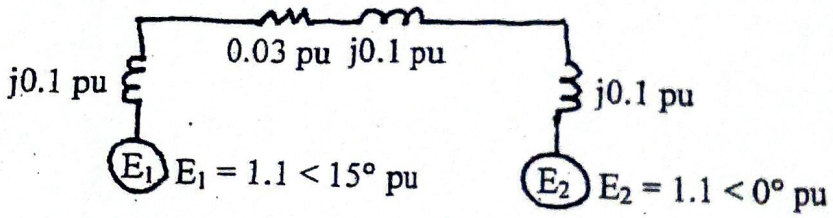
INSTITUTE OF ENGINEERING
Examination Control Division
2070 Bhadra

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) Draw a diagram of a typical power system with typical voltage levels and explain generation, transmission and distribution components. [3+4]
   b) Explain why transmission lines are normally 3-phase instead of single phase? [3]
   c) Prove that inductance of a conductor due to its internal flux linkage is independent of current flowing through it. [6]
2. a) How can underground cable faults be located by Varley loop test method? Explain with necessary figures and mathematical expressions. [6]
   b) Mention the main requirements of conductor for overhead transmission lines. [4]
   c) Determine the amount of power generated by each of the generators in the power system network below. Also specify the direction of power flow in the network. [6]



3. a) At the receiving end of a 70 km long transmission line a 40 MW load at 0.8 lagging power factor is connected at 66 kV. The series resistance and inductive reactance of the conductor per phase are 0.03 ohm/km and 0.15 ohm/km respectively. Calculate [6+2]
   i) Voltage regulation of line and sending end power factor.
   ii) Receiving end power factor to make the voltage regulation zero.
   b) 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. Derive expressions of ABCD parameters of a nominal π-model of medium transmission line. Also draw phasor diagram for lagging power factor load. [2+4+2]
4. a) Determine the charging capacitance and charging current per phase in a 50 Hz, 132 kV, 3-phase overhead line spaced at 6 m from each other and using 18 mm radius conductors per phase. [6]
   b) The ABCD constants of a 3-phase overhead line is as follows: [4]

$A = D = 0.9955 < 0.086°$ $B = 31.552 < 71.608°\ \Omega$ $C = 3 \times 10^{-4} < 90°\ S$

Determine the series resistance, series inductive reactance and shunt admittance of the line.

c) For a long transmission line, derive the expression relating voltage and current at intermediate point of the line and at the receiving end of the line. [6]

5. a) A 50 Hz, 3-phase, 33 kV overhead line is supplying a load of 12 MW at 0.9 p.f. leading. The line has a series impedance of 6 + j16 Ω/phase. Compute the efficiency of transmission line. How can the voltage regulation of the line be made zero? [6]

b) A 150 km long, 50 Hz, 132 kV, 3-phase overhead line with series impedance of 0.1 + j0.3 Ω/m and shunt admittance of $3 \times 10^{-6} < 90°$ S/km is feeding a load of 35 MW at 0.9 p.f. lagging. Determine the transmission line efficiency when a shunt capacitor of susceptance $4 \times 10^{-6} < 90°$ S is connected at the middle of the line. [6]

c) For a 3-phase overhead line, the following data is available: [4]

$V_{S,L} = 138.5 < 8°$ kV $\quad\quad$ $V_{R,L} = 132 < 0°$ kV

$A = 0.983 < 0.68°$ $\quad\quad$ $B = 36.5 < 71.5°$ Ω

Determine the maximum amount of active power that can be delivered by the line. What will be the reactive power delivered at that condition?

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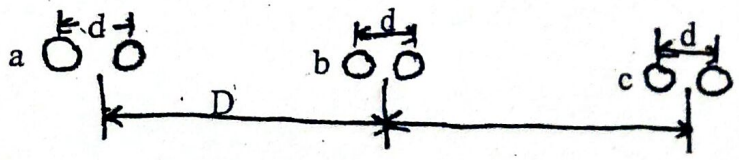
23 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2070 Magh

Exam.	New Back (2066 & Later Batch)		
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) Discuss different types of renewable energy sources. [6]
   b) What are major electrical components in a power station? [5]
   c) Why are bundled and stranded conductors used in overhead lines? [5]
2. a) A 3-ϕ overhead line is supported on 4-disc suspension insulators. The voltage across second and third disc are 13.2 kv and 18.2 kv respectively. Calculate the line voltage. [6]
   b) Two ideal voltage sources designated as machines 1 and 2 are connected to each other via a line with impedance of 0-j5 Ω. If $E_1 = 100 \angle 0°$V and $E_2 = 100 \angle 30°$ V, determine the magnitude and the direction of power flow. [6]
   c) Discuss complex power and its significance in circuit analysis. [4]
3. a) What will happen if the complex power is calculated either without taking the conjugate of current or taking the conjugate of voltage? [6]
   b) Show that the inductance due to internal flux linkages of two conductors of different diameters are same. [5]
   c) Compute the inductance per phase for a 150 km line using phase conductors of 16 mm radius and configured as given below: [5]



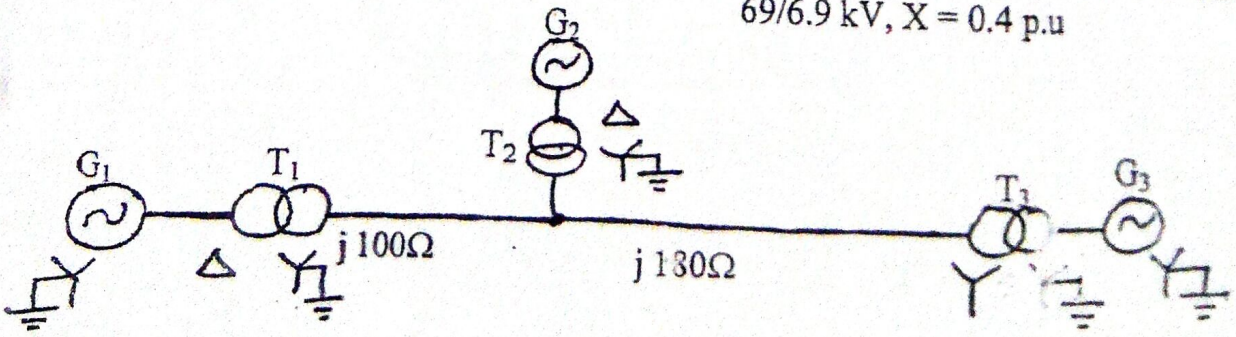
d = 45 cm
D = 7.5 m

Assume complete transposition of the phases.

4. a) Why transposition is required in three-phase line with un-symmetrical spacing? Derive the expression for inductance of such transposed line. [8]
   b) Compute the per unit values taking a common base and draw the impedance diagram of a power shown in figure below. The system has the following data: [8]

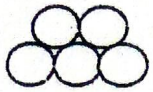
Generators:
G1: 25 MVA, 6.6 kV, X = 0.2 p.u
G2 : 15 MVA, 6.6 kV, X = 0.15 p.u
G3 : 30 MVA, 13.2 kV, X = 0.15 p.u

Transformers:
T1: 30 MVA, 6.6/115 kV, X = 0.1 p.u
T2 : 15 MVA, 6.6/115 kV, X = 0.1 p.u
T3 : Three 1-ph units of 10 MVA, 69/6.9 kV, X = 0.4 p.u



5. a) A 132 kV, 3-phase transmission line has constants $A = 0.98 < 3°$ and $B = 110 < 75°$ ohms per phase. The line is to be operated with both sending end and receiving end voltages at 132 kV. Determine the maximum power which the line can deliver. What will be the power factor at receiving end and efficiency of the line under this condition? [6]

b) Determine GMR of stranded conductor for calculation of inductance shown in figure below if radius of each sub conductor is 0.5 cm. [4]



c) A 220 kV, 50 Hz, 200 km long 3-phase line has its conductors on the corners of a triangle with side 6 m, 6 m, and 12 m. The conductor radius is 1.81 cm. Find the inductance and capacitance per phase per km, capacitive reactance per phase, charging current and total charging MVAR. [6]

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23 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2069 Bhadra

Exam.	Regular (2066 & Later Batch)		
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) Why are different voltage levels required in an interconnected power system? Explain with a neat sketch of interconnected power system showing different voltage levels. [6]

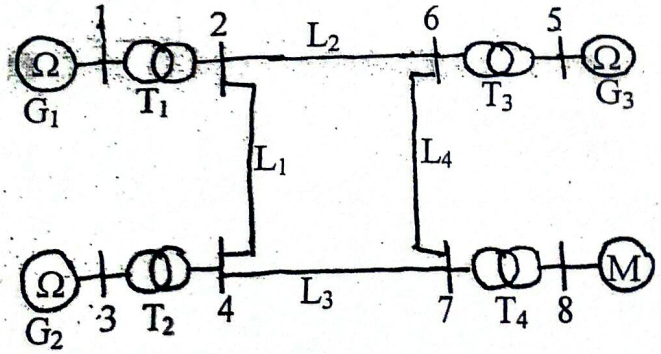
   b) Describe in brief hydro and thermal power sources with basic principles of electricity generation and major features. [6]

   c) What do you mean by complex power? Explain its significance in power system analysis. [4]

2. a) Compare underground cables with overhead lines. [4]

   b) Determine the voltage distribution along a string of 4 disc insulators used in a 33kV overhead line. [6]

   c) Construct a reactance diagram for the system given below and express all the reactances in per unit system. [6]

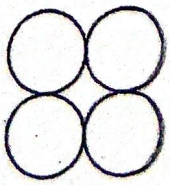


G_1,G_2:10MVA, 11.5KV,10%
G_3 :15MVA, 11.5KV,12%
T_1,T_2:10MVA, 11/66KV,10%
T_3:15MVA, 11/66,15%
T_4 :35 MVA, 66/11KV,18%
L1=L2=L3=L4= j20Ω/ph

3. a) List out the advantages of using per unit system in the analysis of electric power system. Also mention the ways of choosing base voltages and base power. [6]

   b) "Direction of active power flow is from leading phase angle to lagging phase angle whereas direction of reactive power flow is from higher voltage magnitude to lower voltage magnitude." Verify the above statement with mathematical explanation and diagrams. [6]

   c) Compute the self GMD for inductance calculation for the stranded conductor as shown below: [4]



Radius of each strand is 5mm.

4. a) A 120km long 50Hz, 132kV, 3-phase overhead line has flat vertical configuration and uses conductors with radii 12mm. The spacing between adjacent phases is 5m. Assuming complete transposition, compute the inductive reactance per phase for the line. [4]

b) For a signal phase overhead line of having both the conductors of 6mm, calculate the capacitance between the conductors and capacitance of each conductor to ground. The conductors are separated from each other by 1.3m. Assume flat horizontal configuration and effect of earth is negligible. [6]

c) Compute the sending end and receiving end power of a 3-phase line if $A = 0.99\angle 0.1°$ and $B = 18\angle 68°$Ohm if $V_{S,L} = 140\angle 10°$kV and $V_{R,L} = 132\angle 0°$kV. [6]

5. a A 70km long, 50Hz, 3-phase overhead transmission line is operating at 220kV. The series impedance of the line is is 8+j22Ohm/phase. The line is supplying a load of 100MW at 0.9 p.f. lagging. Compute the capacitance per phase to be connected across the load so as to make the voltage regulation of the line zero. [6]

b Two lines are represented by their respective ABCD constants and are connected in parallel. The line constants are as follows: [6]

$A_1 = 0.980\angle 0.1° = D_1$, $B_1 = 45\angle 73.2°$Ohm
$A_2 = 0.975\angle 0.2° = D_2$, $B_2 = 55\angle 75.1°$Ohm

c) What do you mean by surge impedance loading? Explain its significance in power system. [4]

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23 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2069 Poush

Exam.	New Back (2066 & Later Batch)		
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) Justify the need of interconnection of different generating stations by high voltage lines to from a power grid. [6]

   b) Explain why the generation and distribution voltage is generally lower than transmission voltage. [4]

   c) Explain one of the method for locating fault in an underground power cable. [6]

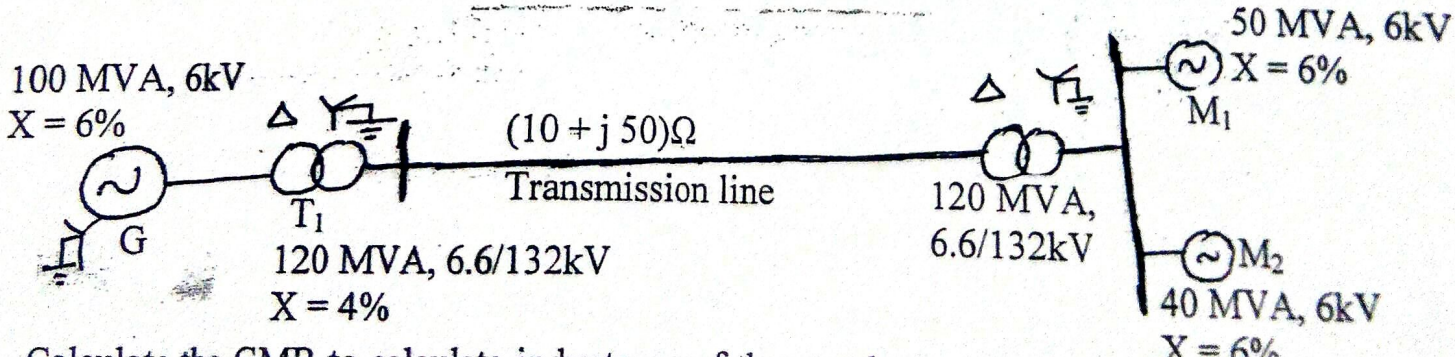
2. a) An insulator string for 33 kV overhead line has 3 dics. The shunt capacitance between each joint and metal work is 10% of the capacitance of each disc. Find the voltage across the different discs and string efficiency. [6]

   b) Two 50Hz, 3-phase synchronous machines are connected to each other via a line with series impedance of 3 + j 10 Ohm/phase. Determine the direction of active and reactive power flow in the line and power generated/ consumed by each of these machines. The terminal phase voltage of machine 1 and 2 are $3.81 < 0°$kV and $3.81 < -18°$kV respectively. [6]

   c) List out the materials used in overhead lines and underground cables. What are the basis for selection of conductors for overhead lines and underground power cables? [4]

3. a) What is complex power? Show and explain the symmetry between impedance triangle and power triangle. [4]

   b) Compute the per unit values of a power system shown in figure below taking the common base generator. [8]



   c) Calculate the GMR to calculate inductance of the standard conductor shown in figure below in terms of radius 'r' of an individual strand. [4]

4. a) Inductance of a conductor due to internal flux linkage does not depend on the current through the conductor. Justify with necessary mathematical expressions and derivations. [4]

b) A 60 Hz, 132 kV, 3-phase overhead line has horizontal configuration and uses conductors with radii 12 mm. the spacing between adjacent phases is 5 m. Assuming complete transposition, compute the charging current per phase and charging VAR for the line. [6]

c) Starting from suitable point, derive the expression of sending end voltage in terms of the receiving end voltage and current for a long length transmission line. [6]

5. a) A 450 km long, 50 Hz, 400 kV overhead transmission line has series resistance of 0.033 Ohm/km, series inductance of 1.067mH/km and shunt capacitance of $0.0109*10^{-6}$F/km. Compute the ABCD parameters, sending end active power, voltage and currents, voltage regulation an if the line is supplying a load of 420 MW at 0.9 power factor lagging. Also compute the power transmission efficiency of the line. [10]

b) A 3-phase overhead line has a series impedance of 20 + j30 Ohm per phase. Find the maximum power that can be delivered at the receiving end keeping the receiving end voltage 31.2 kV while the sending end voltage is 33 kV. What will be the efficiency of the line under this condition? [6]

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23 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2068 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

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

1. a) With a neat sketch of an electric power system, explain the need for different voltage levels in the system. [5]

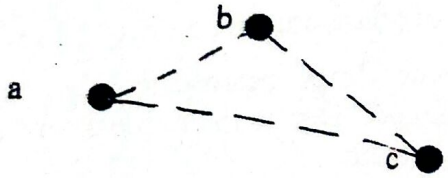
   b) What are the major sources of electricity worldwide? Give reasons why existing electricity supply scenario is not sustainable. [2+4]

   c) There are five discs in a string of insulators used in a 3 –phase, 66kV overhead transmission line. Compute the voltage distribution at the nearest and farthest disc from the phase conductor. [5]

2. a) Give reasons for extensive use of aluminum conductors in overhead transmission lines. [4]

   b) Proximity effect is almost negligible in overhead transmission lines but quite significant in underground power cables. Why? [4]

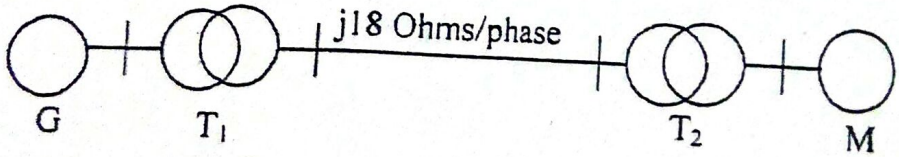
   c) A 3-phase, 50Hz, overhead line has three phase conductors with the following configuration. Compute the inductance per phase per km if each of the phase conductors are round solid of 10mm diameter. Assume completely transposed line. [5]



D_{ab}=4.5m
D_{bc}=5.5m
D_{ca}=7.5m

   d) Mention conditions and advantages of representing a 3-phase system by a single phase system. [3]

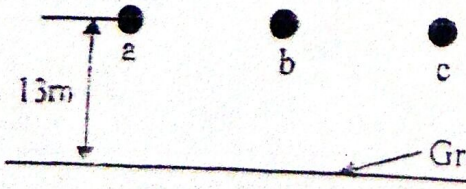
3. a) Draw a reactance diagram of the electric power system given below and express all reactance in per unit system by choosing appropriate base values. [5]



G_1: 14.kV, 30MVA, 10%,
M: 11kV, 25MVA, 13%

T_1: 66/11kV, 25MVA, 12%
T_1: 13.8/66kV, 25MVA, 12%

   b) For a 3-phase overhead line as shown in the figure below, show the effect of neglecting the presence of earth surface in computing the capacitance of line. Assume solid, round conductors for each phase. [6]



$D_{ab}=D_{bc}=6m$; $D_{ca}=12m$
$r_a=r_b=r_c=15mm$

c) How generator and load complex powers are expressed? What will happen if the convention of taking conjugate of current is not followed? Explain with necessary derivation. [2+3]

4. a) A 3-phase line is represented by nominal-π model. The series impedance of the line is $12 + j65$ Ohms/ phase and shunt admittance is $j2.5\times 10^{-4}$ S/phase. Compute the power delivered to a load at the receiving end and construct the phasor diagram for the line if the sending end voltage and current are: [6+2]

$V_{S,L} = 1385\angle 15.2°$ kV $I_{S,L} = 225\angle 18.3°$ A

b) A 12km long, 50Hz, 3-phase line is supplying a load at 32.5kV $\angle -20°$ w.r.t. V_S. The line has a resistance of 2.5×10^{-3} Ohms/m and inductance of 1.3×10^{-6} H/m. The sending end voltage is maintained at 34.1 kV $\angle$ 0°. Calculate the active power flow through the line and voltage regulation. Compute the capacitance per phase to be connected at receiving end to reduce the voltage regulation by 50%. [8]

5. a) A 50Hz, 400km long, 400kV, 3-phase overhead transmission line delivering a power of 400MW at 0.95 power factor lagging has a series resistance of 3.2×10^{-5} Ohm/m, inductance of 1.066×10^{-6} H/m and shunt capacitance of 1.09×10^{-11} F/m per phase. Determine the voltage at 150km from the sending end toward receiving end. [8]

b) Derive the expressions relating sending end current and voltage to the receiving end voltage and current in a medium length transmission line by nominal – T model. Express the active and reactive losses in the line and condition for voltage at the receiving end being higher than at the sending end. [8]

6. a) Two 3-phase synchronous machines are connected by an inductive link of j10 Ohms/phase. If the emfs of machine A and machine B are $V_A = 200\angle 10°$V, $V_B = 200\angle 30°$V, determine the direction of the reactive power flow and reactive power loss in the link. Neglect the voltage drops at both the machines. [6]

b) Give reasons for transposition of phase conductors in overhead transmission lines. [4]

c) Two non-identical transmission lines represented by their respective ABCD parameters are connected in parallel. Derive the expression for the equivalent ABCD parameters of the transmission system. [6]

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23 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2068 Magh

Exam.	New Back (2066 & Later Batch)		
Level	BE	Full Marks	80
Programme	BEL	Pass Marks	32
Year / Part	II / II	Time	3 hrs.

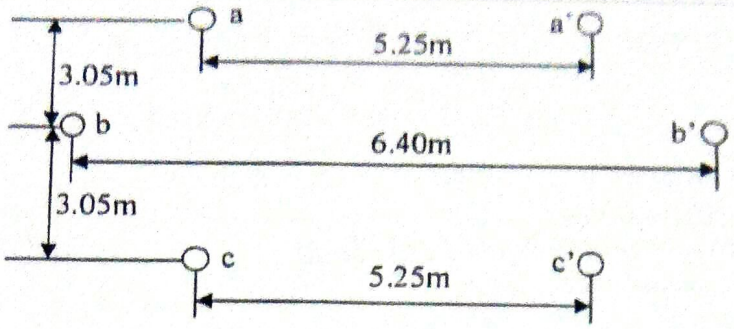
Subject: - Power System Analysis I

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

1. a) Enlist the major components of a typical electric power generating plant. [3]
   b) Compare the advantages and disadvantages associated with fossil fuel based energy supply system and renewable energy systems. [5]
   c) Justify the need to have several voltage levels in an interconnected power system. [4]
   d) With brief explanation enlist the major requirements of conductors used in electric power system. [4]
2. a) For an insulator string consisting of multiple disc insulators, show that the voltage distribution across each disc is not same. [6]
   b) Two 3-phase synchronous machines A and B are connected by a link having series impedance of 0+j10 Ohms/phase. The terminal voltage at machine A and B are $200\angle 0°$V and $200\angle 15°$V respectively. Compute the magnitude direction of active power flow through the link. [6]
   c) What is a power cable? Explain briefly. [4]
3. a) What are the major advantages of adopting per unit system in electric power systems? Explain. [6]
   b) "Inductance due to internal flux linkages of a conductor is independent of the current through the conductor". Justify. [5]
   c) Compute the self-GMD for the following conductor. Radius of each strand is 4mm. [5]

4. a) A long line cannot be represented by short line model whereas short line can be represented by a long line model. Justify your answer. [6]
   b) A 12km long 3-phase line is supplying a load at 33 kV. The line has a resistance of 2.5×10^{-3} Ohms/m and inductance of 1.3×10^{-6} H/m. If the sending end voltage is maintained at $34\text{KV}\angle 20°$. Compute the active and reactive power losses in the line. Compute the capacitance per phase that needs to be connected at the end of the line to make the voltage regulation zero. [6+4]
5. a) A 50Hz, 400 km long, 400kV, 3-phase overhead transmission line delivering a power of 400MW at unity power factor has series resistance of 3.2×10^{-5} Ohm/m, inductance of 1.066×10^{-6} H/m and shunt capacitance of 1.09×10^{-11} F/m per phase. Compute the characteristics impedance, propagation constant and phase shift constant, and voltage regulation of the line. [6]

b) Compute the capacitance per phase per unit length for the 3-phase parallel lines shown in the figure below. Effective radius of each conductor is 9mm. [6]



c) What is reactive power compensation in an electric power system? Why is it required? [4]

6. a) For a 3-phase line following data is available at particular instant: [5]

V_S (Line) = $140.2\angle 18.2°$ KV
V_R (Line) = $132KV\angle 0°$
A = $0.94\angle 0.4°$
B = $64.2\angle 78.8°$ Ohms

Compute the receiving end active power.

b) What will be the equivalent ABCD parameters of the two systems connected in series and represented by their respective ABCD parameters? [6]

c) A 50Hz, 132kV, 3-phase overhead transmission line has symmetrical phase spacing of 6m. The effective radius of the phase conductor is 1.1cm. Compute the charging VAR per unit length generated by the line. [5]

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TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2076 Baisakh

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

Subject: - Power System Analysis I *(EE 555)*

- ✓ 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.*

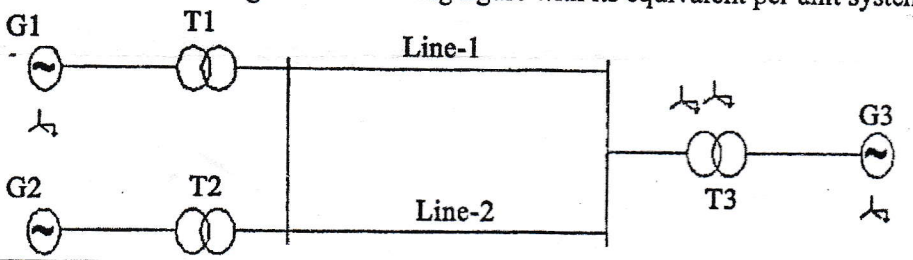
1. a) What do you mean by renewable energy sources, write with examples. Which one is least suitable for our country? Support your answer. [6]

   b) What do you mean by infinite bus in power system? [4]

   c) Draw single line diagram of inter connected power system showing generation, transmission and distribution system and describe function of each system. [6]

2. a) Derive a relation between the conductor radius and inside sheath radius of a single core cable so that the electric stress of the conductor surface may be minimum. [6]

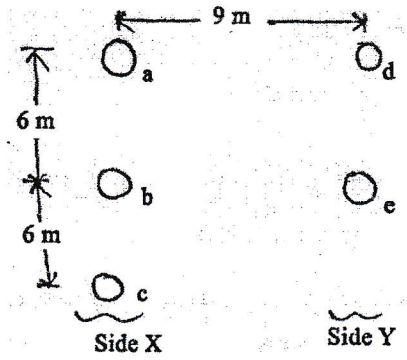
   b) Draw the reactance diagram of following figure with its equivalent per unit system. [10]



Equipment	MVA Rating	KV Rating	X
Generator (G1)	100	11 KV	25%
Generator (G2)	100	11 KV	20%
Generator (G3)	100	11 KV	20%
Transformer (T1)	100	11 / 220 KV	6%
Transformer (T2)	100	11 / 220 KV	7%
Transformer (T3)	100	220 / 11 KV	7%
Line-1	100	220 KV	10%
Line-2	100	220 KV	10%
Take base MVA=100 MVA and base voltage = 11 KV for generator. Compute the reactance diagram.			

3. a) How does the GMR for inductance calculation differ from the GMR for capacitance calculation? Explain. [6]

   b) One circuit of a single-phase transmission line is composed of three solid 0.25-cm-radius wires. The return circuit is composed of two 0.5-cm-radius wires. The arrangement of the conductors is shown below. Find the inductance due to the current in each side of the line and the inductance of the complete line in henrys per meter. [10]



4. a) A 50Hz transmission line 300km long has a total series impedance of 40+j125 ohms and a total shunt admittance of 10^{-3} mho. The receiving-end load is 50MW at 220kV with 0.8 lagging power factor. Find the sending-end voltage, current, power and power factor using: [10]
   i) Short line approximation
   ii) Nominal-π method.

   b) What is bundled conductors? How use of bundle conductors affects capacitance and inductance with compare to line with single conductor? [6]

5. a) The sending end voltage of a three phase overhead line with a series impedance of (20.62<75.96) ohm is 46.85 kv while the receiving is 33 kv. Determine the power output at 0.8 pf lagging and the sending end power factor. [8]

   b) A 275 KV transmission line has the following line constants: [8]
   A=0.85<5°; B= 200<75°
   Determine the power at unity power factor that can be received if the voltage profile at each end is to be maintained at 275KV.

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$V_S = AV_R + BI_R$

$I_R = \frac{V_S - AV_R}{B}$

$=$

$\begin{bmatrix} V \\ S \end{bmatrix} \begin{bmatrix} A & B \end{bmatrix} \begin{bmatrix} V_R \\ \cdot \end{bmatrix}$

$\frac{1+Y_2}{2}$ $B=2$

$I_R =$

$P_R = 3V_R I_R \cos\phi_{R2}$