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	IV / II	Time	3 hrs.

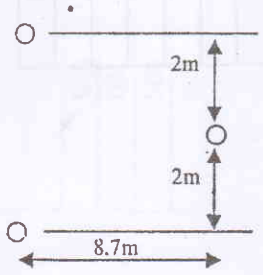
Subject: - Transmission and Distribution System Design *(EE754)*

- ✓ 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**.*
- ✓ ***Conductor Table and Appendix attached herewith.***
- ✓ *Assume suitable data if necessary.*

1. State the following statements are TRUE or FALSE? Justify your answer with a brief explanation. [(1+3)×4]
   a) Impulse withstand voltage of an overhead transmission line insulator depends on system (Neutral) earthing condition.
   b) Height of tower is the function of voltage only.
   c) Thermal limit design for distribution feeder is applicable in dense urban areas but power losses and voltage drop is major concern in rural areas.
   d) The peak demand of a load centre is the sum of the peak demand of different consumer classes.
2. In design of a transmission line for delivering power of 180 MW for a distance of 200 km. Considering that the system is to be operated at power factor of 0.85, find the required numbers of insulator disc per string to be selected. [16]
3. a) For the design of most economical span of a high voltage transmission line, following data are available for a particular conductor. Select the most economical span. [10]

   Given that: conductor diameter = 28 mm
   Cross sectional area = 463 mm^2
   UTS = 15910 kg
   Wind Pressure = 100 kg/m^2
   Factory of safety = 2

Span(m)	Maximum Sag(m)
250	3.24
275	3.88
300	4.57
325	5.32
350	6.12



   Assume: All towers are straight line towers. The air clearance is shown in figure. Minimum ground clearance is 6m. Neglect the effect of ground wire.

   b) What do you mean by corona? Derive the expression for corona inception voltage. [6]

4. a) With the help of a suitable load curve, show that loss of load factor may be expressed as;
$LLF = K_1*LF + K_2*LF^2$ [6]

b) The initial survey of a particular load center, the following consumer data has been obtained.

Consumer Class	Potential Consumer Number	Avg. Monthly consumption (KWH)	No. of effective day/month	5th year load Pattern	
				Responsibility factor	Load factor
Domestic	100	30	30	1.0	0.25
Commercial	20	30	25	0.5	0.3
Non-commercial	50	20	20	0.1	0.25

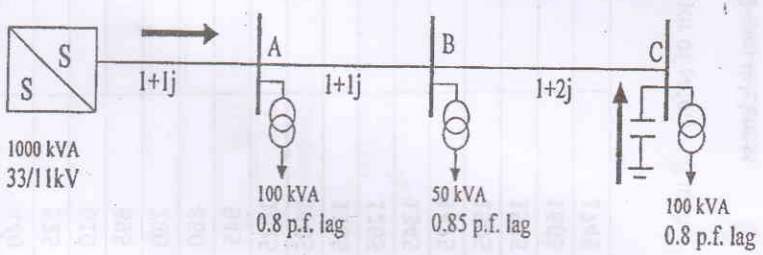
Assuming consumption growth factor of 5% in each year for each class and electrification coverage factor by 5th year is 70% for all consumer classes. Determine 5th year peak load of the load center in KW. (Neglect project implementation period) [10]

5. a) A particular load center has a peak demand of 50 kW at power factor of 0.8 lagging. Compute % peak power loss and voltage drop in 3 phase LT feeder configuration with rated transformer of 11/0.4 kV.

Option	Feeder configuration
I	4 feeders each of length 3km
II	2 feeders each of 4 km
III	3 feeders each of 2 km

Impedance per phase = (1.1+0.25) Ω/km. Assume uniformly distributed load along feeders [10]

b) For the 11 kV Primary distribution Network shown below, determine the size (kVAR) of the capacitor to be placed at the location shown in diagram to achieve the maximum loss reduction. For simplifying the analysis assume voltage at each node is 1 p.u. All impedances are in p.u. at 1000 kVA. [6]



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APPENDIX

i. Most Economical Voltage Empirical Formula: $V = \left[\frac{L}{1.6} + \frac{P \times 1000}{\cos\emptyset \times N_c \times 150}\right]^{0.5}$

ii. Standard Voltage: 66 kV, 132 kV, 220 kV, 400 kV

iii. Table A-1: Transmission line capability curve with the assumption of single circuit transmission surge impedance of 400 Ω.

Length	Power Transmission Capability/SIL
80	2.75
160	2.25
240	1.75
320	1.35
480	1.00
640	0.75

iv. Table A-2: Withstand voltage capability for different system voltage.

Maximum System Voltage	1 Minute Dry withstand (kV)	1 Minute Wet Withstand (kV)	Impulse Withstand (kV)
123	215	185	450
145	265	230	550
255	435	395	900
420	760	680	1550

v. Table A-3: Flashover voltages for 254 x 154 mm disc insulators

Number of Discs	1 Minute Dry FOV (kV)	1 Minute Wet FOV (kV)	Impulse FOV (kV)
1	80	50	150
2	155	90	255
3	215	130	355
4	270	170	440
5	325	210	525
6	380	250	610
7	435	290	695
8	485	330	780
9	535	370	860
10	585	410	945
11	635	450	1025
12	685	485	1105
13	730	520	1185
14	775	555	1265
15	820	590	1345
16	865	620	1425
17	910	650	1505
18	955	680	1585
19	100	710	1665
20	1045	740	1745

vi. Minimum air clearance: 6.5 inch per 10 kV (rms) and factor of safety = 8 inch

vii. Maximum insulator string swing: 45^0

~~viii. Toughest Condition: 0^0C, Wind pressure 100 kg/m^2, Ice 2 mm thickness~~

~~ix. Stringing Condition: 27^0C, No wind, No Ice~~

~~x. Easiest Condition: 60^0C, No Wind, No Ice~~

xi. Minimum ground clearance = $Hg = \frac{V-33}{33} + 17\ feet$, V is L-L ~~system~~ Voltage (kV)

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Subject: - Transmission and Distribution System Design *(EE754)*

- ✓ 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**.*
- ✓ ***Necessary tables are attached herewith.***
- ✓ *Assume suitable data if necessary.*

1. State and justify whether the following statements are true or false. [(1+3)*4]
   a) Interconnected system decreases SCMVA of the connected bus.
   b) The effective way to increase corona inception voltage is to increase the conductor size.
   c) The value of SSR should not be chosen below 1.8.
   d) For design of urban distribution line first select the transformer location and then size of the conductor.

2. a) Discuss the economical and technical criterion to be considered while selecting the best suitable standard voltage level and number of circuits for transmission line design. [8]

   b) For a double circuit, 132 kV transmission line, find the following air clearance with justifications. [8]
      i) Cross arm length
      ii) Insulator string length
      iii) Horizontal and Vertical separation of conductor
      iv) Height of earth wire from top most conductor.

3. a) Determine the horizontal position of maximum sag from either supporting towers of equal height at a different elevation from a common reference. Also, explain the condition of virtual sag. [6]

   b) Explain the different types of insulator failure. [4]

4. a) To transmit the given amount of power to a given distance a single circuit with single earth wire is chosen for which the following design steps are completed, compute the most economical span if the transmission length is 200 km. [12]

span(m)	Dmax(m)	H1(m)	H2(m)	H3(m)	Ht(m)
250	3.14	10.245	13.555	16.865	28.815
275	3.69	10.801	14.111	17.421	29.371
300	4.27	11.383	14.693	18.003	29.953
325	4.88	11.965	15.298	18.608	30.558
350	5.50	12.548	15.923	19.233	31.183

Where H1 height of lower conductor from ground
H2 height of middle conductor from ground
H3 height of top conductor from ground
Ht total height of tower.

The power conductor has maximum working tension of 6890 kg and diameter of 25.97mm. The earth wire has maximum working tension of 2856 kg and diameter of 16.52mm. Assume 80% tower are of A type. 15% are of B type and 5% are of C type and the wind force is 100 kg/m^2.

b) What is Ruling span? Explain the surveying requirement for transmission and distribution line design. [1+3]

5. a)Show that the voltage drop and power loss in feeder of uniformly distributed load is half and one third of that in end loaded condition. [8]

b) The consumer data for particular distribution transformer for a specified year is as shown as follows.

Table-1 [10]

Consumer class	Class A	Class B	Class C
Consumer Number	80	30	40
Monthly energy consumption	30 kwh	22 kwh	25 kwh
No. of effective days per month	30	24	26
Coincidence factor	1	0.9	0.95
Power factor	0.9	0.8	0.85
Load pattern	Table 2	Table 2	Table 2

Table-2

Time (hrs.)	0.00-6.00	6.00-10.00	10.00-14.00	14.00-18.00	18.00-21.00	21.00-24.00
Class A	0.1	0.4	0.2	0.2	1	0.4
Class B	0.1	0.1	0.5	1	0.5	0.1
Class C	0.1	0.1	1	1	0.1	0.1

Determine the following.

For each class of consumer:

i. peak load
ii. Load factor (daily and annual)
iii. Contribution factor
iv. Annual energy sell

For distribution transformer (Neglect LT losses)

i. peak load
ii. Load factor
iii. Annual energy sells.

c) Explain the small area load forecasting with the help of load growth curve of small area. [4]

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Appendix-A

I. Most economical voltage empirical formula: $5.5\sqrt{\{\frac{length\ in\ km}{1.6}+\frac{power\ in\ MW*1000}{cos\emptyset*Nc*150}\}}$

II. Standard voltage: 66kv, 132kv, 220kv, 400kv.

III. Table-A-1: transmission line capability curve with assumption of single circuit transmission line surge impedance of 400Ω

Length(km)	Multiplying factor(m.f.)
80	2.75
160	2.25
240	1.75
320	1.35
480	1.00
640	0.75

IV. Table-A-2: withstand voltage capability for different system voltages.

Maximum system voltage	1 min dry withstand (KV)	1 min wet withstand (KV)	Impulse withstand (KV)
123	215	185	450
145	265	230	550
255	435	395	900
420	760	680	1550

V. Table-A-3: flashover voltages for 254X154 mm disc insulators.

No. of Discs	1 min dry FOV(KV)	1 min wet FOV(KV)	Impulse FOV(KV)
1	80	50	150
2	155	90	255
3	215	130	355
4	270	170	440
5	325	210	525
6	380	250	610
7	435	290	695
8	485	330	780
9	535	370	860
10	585	410	945
11	635	450	1025
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13	730	520	1185
14	775	555	1265
15	820	590	1345
16	865	620	1425
17	910	650	1505
18	955	680	1585
19	1000	710	1665
20	1045	740	1745

Minimum Air clearance (a):

I. 1 cm for 1KV (maximum per phase peak) and factor of safety is 30 cm.

II. 6.5 inch per 10KV (maximum per phase rms) and factor of safety is 8 inch.

22 TRIBHUVAN UNIVERSITY
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Exam.	Regular		
Level	BE	Full Marks	80
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Year / Part	IV / II	Time	3 hrs.

Subject: - Transmission and Distribution System Design *(EE 754)*

- ✓ 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**.*
- ✓ ***Necessary tables are attached herewith.***
- ✓ *Assume suitable data if necessary.*

1. State and justify whether the following statements are true of false. [4×4]
   a) Horizontal conductor configuration is general choice for and above 400 kV transmission line.
   b) The current carrying capacity of conductor increases with increase in ambient temperature.
   c) Corona is more dominating design criterion for LV Transmission lines.
   d) Network distribution system is more reliable than Radial Distribution system.
2. a) Explain the effect of varying following parameter on conductor and insulator cost per unit length of transmission line. [8]
   (i) Power to be transmitted and length of line
   (ii) Voltage level
   (iii)Number of circuit
   b) Compute the various air clearances required for a 220 kV single circuit Transmission line. [8]
3. a) Explain the factors affecting the choice of BIL of a transmission line for insulator discs selections. [6]
   b) To transmit the given amount of power to a given distance a single circuit with single earth wire is chosen for which the following design steps are completed, compute the most economical span if the transmission length is 200 km. Assume 10% of Towers have been used to take care of maximum angle deviation of 15° and rest are straight line Towers.

Span (m)	Dmax(m)	H1(m)	H2(m)	H3(m)	Ht(m)
250	3.14	10.245	13.555	16.865	28.815
275	3.69	10.801	14.111	17.421	29.371
300	4.27	11.383	14.693	18.003	29.953
325	4.88	11.965	15.298	18.608	30.558
350	5.50	12.548	15.923	19.233	31.183

where,

H_1 height of lower conductor from ground
H_2 height of middle conductor from ground
H_3 height of top conductor from ground
H_t total height of tower

The power conductor has UTS of 8000 kg and diameter of 20 mm. The earth wire has maximum working tension of 4000 kg and diameter of 16 mm.
Wind Force: 80 kg/m^2 and Factor of safety for Tension is 2. [10]

4. a) Explain the dependency of energy loss computation in a transmission / distribution line on the load factor with proper mathematical aid. [8]

   b) Show that the percentage voltage Regulation in a Primary distribution feeder is inversely proportional to the square of the line voltage. [8]

5. a) Explain one of the small area forecasting method. [6]

   b) A 11 kr /0.4 kv, 100 KVA distribution transfomer has 4 outgoing secondary distribution lines of 1.5 km each. The conductor used has resistance of 1Ω / km. Determine the monthly energy loss in the lines if the peak demand of the load centre has 80 KVA at the load factor of 0.4. Given LLF = 0.3LF + 0.7 LF^2. [10]

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P.T.O.

Appendix-A

I. Most economical voltage empirical formula: $5.5\sqrt{\{\frac{length\ in\ km}{1.6}+\frac{power\ in\ MW*1000}{cos\emptyset*Nc*150}\}}$

II. Standard voltage: 66kv, 132kv, 220kv, 400kv.

III. Table-A-1: transmission line capability curve with assumption of single circuit transmission line surge impedance of 400Ω

Length(km)	Multiplying factor(m.f.)
80	2.75
160	2.25
240	1.75
320	1.35
480	1.00
640	0.75

IV. Table-A-2: withstand voltage capability for different system voltages.

Maximum system voltage	1 min dry withstand (KV)	1 min wet withstand (KV)	Impulse withstand (KV)
123	215	185	450
145	265	230	550
255	435	395	900
420	760	680	1550

V. Table-A-3: flashover voltages for 254X154 mm disc insulators.

No. of Discs	1 min dry FOV(KV)	1 min wet FOV(KV)	Impulse FOV(KV)
1	80	50	150
2	155	90	255
3	215	130	355
4	270	170	440
5	325	210	525
6	380	250	610
7	435	290	695
8	485	330	780
9	535	370	860
10	585	410	945
11	635	450	1025
12	685	485	1105
13	730	520	1185
14	775	555	1265
15	820	590	1345
16	865	620	1425
17	910	650	1505
18	955	680	1585
19	1000	710	1665
20	1045	740	1745

Appendix B

Table A2 Aluminium Conductor Steel Reinforced (Based on IS : 398 (1961))

Conductor		Electrical Properties			Mechanical Properties											
Code name	Nominal Cu area mm²	Equiv. area of Al mm²	Calculated resist. at 20°C Ω/km	Approx. current carrying capacity 40°C ambient temp.	Stranding and wire diameter mm				Conductor dia mm	Conductor area mm²	Approx. weight			Approx ult. strength kg	Calculated linear coeff. per °C × 10⁻⁶	Calculated modulus of elasticity kg/cm² × 10⁶
					Aluminium		Steel				Total	Al	St			
					No.	Diam.	No.	Diam.								
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
MOLE	6.5	10.47	2.71800	—	6	1.50	1	1.50	4.50	12.37	43	29	14	407	18.99	0.809
SQUIRREL	13	20.71	1.37400	115	6	2.11	1	2.11	6.33	24.48	85	58	27	771	18.99	0.809
GOPHER	16	25.91	1.09800	133	6	2.36	1	2.36	7.08	30.62	106	72	34	952	18.99	0.809
WEASEL	20	31.21	0.91160	150	6	2.59	1	2.59	7.77	36.88	128	87	41	1136	18.99	0.809
FERRET	25	41.87	0.67950	181	6	3.00	1	3.00	9.00	49.48	171	116	55	1503	18.99	0.809
RABBIT	30	52.21	0.54490	208	6	3.35	1	3.35	10.05	61.70	214	145	69	1860	18.99	0.809
MINK	40	62.32	0.45650	234	6	3.66	1	3.66	10.98	73.65	255	173	82	2207	18.99	0.809
HORSE	42	71.58	0.39770	—	12	2.79	7	2.79	13.95	116.20	542	204	338	6108	15.30	1.070
HEAVER	45	74.07	0.38410	261	6	3.99	1	3.99	11.97	87.53	303	205	98	2613	18.99	0.8[illegible]
RACCOON	48	77.83	0.36560	270	6	4.09	1	4.09	12.27	91.97	318	215	103	2746	18.99	0.[illegible]
OTTER	50	82.85	0.34340	281	6	4.22	1	4.22	12.66	97.91	339	230	109	2923	18.99	0.809
CAT	55	94.21	0.30200	305	6	4.50	1	4.50	13.50	111.30	385	261	124	3324	18.99	0.809
DOG	65	105.60	0.27450	324	6	4.72	7	1.57	14.16	118.50	394	288	106	3299	19.53	0.735
LEOPARD	80	129.70	0.21930	375	6	5.28	7	1.76	15.84	148.40	493	360	133	4137	19.53	0.735
COYOTE	80	131.50	0.22140	375	26	2.54	7	1.90	15.86	151.60	521	365	156	4638	18.99	0.773
TIGER	80	123.10	0.22210	382	30	2.36	7	2.36	16.52	161.80	604	363	241	5758	17.73	0.787
WOLF	95	154.30	0.18440	430	30	2.59	7	2.59	18.13	195.00	727	436	291	6880	17.73	0.787
LYNX	110	179.00	0.15890	475	30	2.79	7	2.79	19.53	226.20	844	506	338	7950	17.73	0.787
PANTHER	130	207.00	0.13750	520	30	3.00	7	3.00	21.00	261.60	976	586	390	9127	17.73	0.787
LION	140	232.50	0.12230	555	30	3.18	7	3.18	22.26	293.90	1097	659	438	10210	17.73	0.787
BEAR	160	258.10	0.11020	595	30	3.35	7	3.35	23.45	326.10	1219	734	485	11310	17.73	0.787
GOAT	185	316.50	0.08989	680	30	3.71	7	3.71	25.97	400.00	1492	896	596	13780	17.73	0.787
SHEEP	225	366.10	0.07771	745	30	3.99	7	3.99	27.93	462.60	1726	1036	690	15910	17.73	0.789
KUNDAH	250	394.40	0.07434	—	42	3.50	7	1.94	26.82	424.80	1282	1120	162	9002	21.42	0.646
DEER	260	419.30	0.06786	806	30	4.27	7	4.27	[illegible]	529.30	1977	1188	789	18230	17.73	0.787
ZEBRA	260	418.60	0.06800	795	54	3.18	7	3.18	[illegible]	484.50	1623	1185	438	13316	19.35	0.686
ELK	300	465.70	0.06110	860	30	4.50	7	4.50	31.50	588.40	2196	1320	876	20240	17.73	0.787
CAMEL	300	464.50	0.06125	—	54	3.35	7	3.35	30.15	537.70	1804	1318	486	14750	19.35	0.686
MOOSE	325	515.70	0.05517	900	54	3.53	7	3.53	31.77	597.00	2002	1463	539	16250	19.53	0.686
MORKULLA	330	549.20	0.05182	—	42	4.13	7	2.30	31.68	591.70	1790	1564	226	12236	21.42	0.6[illegible]
SPARROW	20	33.16	0.35780	—	6	2.67	1	2.67	8.01	39.22	135	92	43	1208	18.99	0.809
FOX	22	36.21	0.78570	165	6	2.79	1	2.79	8.37	42.92	149	101	48	1313	18.99	0.809
GUINEA	49	78.56	0.36200	—	12	2.92	7	2.92	14.60	127.20	590	224	366	6664	15.30	1.070
LARK	125	196.10	0.14510	—	30	2.92	7	2.92	20.44	247.80	922	556	366	8659	17.73	0.787

Note: (i) The resistance (R_T) of the conductor at any other temperature (T) will be:

$R_T = R_{20}[1 + 0.004 (T - 20)]$ where R = resistance at temperature 'T'

R_{20} = " " " 20°C given in the tables

(ii) Ampere rating is given for conductor working temperature 75°C