11 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: - High Voltage Engineering *(EE751)*

- ✓ 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 are FACTS devices and HVDC transmission technology? How can these be utilized to upgrade Nepal's power industry? [4+4]

   b) What are the physiological effects of electric shock? What are good safety practices to avoid shocks?

   c) Write about oil pressure and gas pressure HV cables with necessary diagrams. [4]

2. a) A 3-phase, 220 kV transmission line has a length of 200 km, and inductance of 1.3 mH/km and a capacitance of 8.855×10^{-9} F/km. Calculate (i) the surge impedance of line (ii) the velocity of propagation (iii) the travel time of transient overvoltage (iv) propagation constant. [8]

   b) It's necessary to obtain a tower footing resistance of 20Ω in a soil of resistivity ρ_s = 100 Ω-m, using the three types of electrodes. Take a = 1.25 cm for rods and counter-poises and a depth y = 0.5 m for counter-poises. Calculate the required dimensions. [8]

3. a) A 132 kV transmission line is terminated by transformer at a substation. The transformer is protected by an arrester of rating 120 kV located at the incoming line. The BIL of the transformer is chosen to be 500 kV. The protective ratio required for transformer protection is 1.2. Check whether the transformer is properly coordinated with the arrester if a lightning stroke results in the arrested discharge current of 40 kA. [8]

   Relationship between discharge current and residual voltage:

Discharge Current	Residual Voltage
10 kA	300 kV
20 kA	360 kV

   b) A 400 kV line has conductors in horizontal configuration at average height H = 14 m and phase spacing S = 11m. The conductors of each phase are 2×0.0318 m diameter at B = 0.4572 spacing. Calculate the RI level of each phase at a distance of 30m from one of the outer phase at ground level at 0.5 MHz using the CIGRE formula. Take gm = 17.3 kV/cm on the center phase and 16.2 kV/cm in the two outer phases. What are the values for rainy weather? What is the total value of the RI in fair and rainy weathers? [8]

4. a) A 400 kV, three phase transmission line has flat horizontal configuration with two sub-conductors per bundle. The average ground clearance is 15 m and the inter phase spacing is 11m. The radius of each sub-conductor in the bundle is 3.18 cm and the separation between the sub-conductors is 45.72 cm. Calculate the capacitance matrixes for both the untransposed and the transposed conditions. [8]

   b) Explain 'electromechanical breakdown', 'thermal breakdown' and 'breakdown due to treeing and tracking' occurring in solid dielectrics. [2+3+3]

5. a) An air bubble of 0.5 mm thickness is embedded in a solid insulation of 1.0 cm having a relative dielectric constant of 3.0. The voltage applied across the solid is 30 kV (RMS) of 50 Hz. Calculate the voltage at which internal discharge will occur if the breakdown strength of air if 30 kV (peak)/cm. [8]

b) What are the general tests that are carried out on high voltage equipment? Explain with clean circuit diagram the method of measurement of high voltage using resistance divider and micro-ammeter. [8]

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2074 Bhadra

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

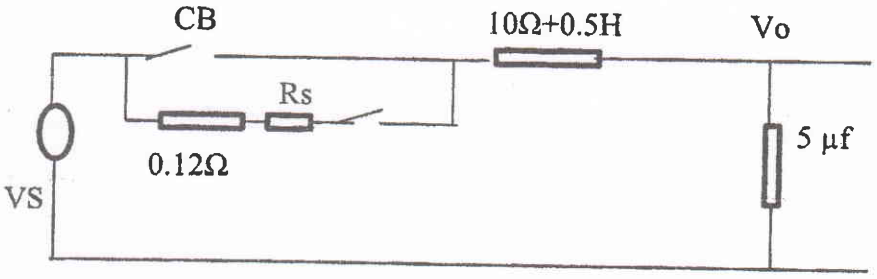
Subject: - High Voltage Engineering *(EE751)*

- ✓ 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) Compare HVAC and HVDC transmission system with suitable justifications. [8]

   b) Improper Earthing leads to high electric potential, justify. Also explain how the system grounding have been incorporated in common practice? [8]

2. a) Using the single phase equivalent lumped parameter model circuit of 3-phase, 400kV, 50Hz, 400 km long EHV line shown below, compute the switching resistance Rs to be inserted during the closing of circuit breaker so that maximum switching overvoltage will be limited to 1.8 pu. [8]



   b) Show that when a loss less infinite line with receiving end open circuit switched on to a source the impedance offered to a travelling wave along the line is surge impedance of the line. Also with mathematical interpretation verify that these waves consist of both backward and forward waves. [8]

3. a) A transformer is protected by a lightening arrestor at the incoming line. The BIL withstand voltage of the transformer is chosen to be 500 kV. The protective ratio required for transformer protection is 1.25. A lighting strike at the arrestor causes an arrestors discharge current of 24 kA. Check whether the transformer is properly coordinated? Assume arrestor residual voltage can be approximated by: $200\, I_d^{0.25}$. [8]

   b) What are the general tests that are carried out on high voltage equipment? Explain with clean circuit diagram the method of measurement of high voltage using resistance divider and micro-ammeter. [8]

4. a) Derive the Townsend's current growth equation based on two different ionization coefficients. [6]

   b) In a experiment in a certain gas it was found that the steady state current is 5.5×10^{-8} A at 8Kv at a distance of 0.4cm between the plane electrodes. Keeping the field constant and reducing the distance to 0.1 cm results in current of 5.5×10^{-9}A. Calculate town sends primary ionization coefficient. [4]

   c) Explain the breakdown phenomenon in commercial liquid in brief. [6]

5. a) In a 3-phase overhead lines the conductors, diameter of 3 cm each are arranged in the form of an equilateral triangle. Assuming fair weather condition and air density factor of 0.95; irregularity factor of 0.96, find the minimum spacing between the conductors if the disruptive critical voltage does not exceed 230 kV between the lines. Breakdown strength of air may be assumed to be 30 kV (peak)/cm. [8]

   b) How the Ferranti effect can be reduced in over voltage issues? Explain

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

Subject: - High Voltage Engineering *(EE 751)*

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

1. a) What is your vision of the electric power system 25 years from now? [4]
   b) Explain the constructional features of belted cable used in HVAC transmission. [4]
   c) Explain different methods of earth resistivity measurement with diagrams. [8]

2. a) It is necessary to obtain a tower-footing resistance of 20 Ω in a soil of resistivity ρ_s=100 Ω-m using the most common three types of electrodes. Take a=1.25 cm for rods and counterpoises and a depth y=0.5 m for counterpoise. Calculate the required dimensions. [8]
   b) A surge of 100 kV travelling in a line of natural impedance 600 Ω arrives at a junction with two lines of impedances 800 Ω and 200 Ω respectively. Find the surge voltages and currents transmitted into each line. [8]

3. a) A lightning arrester with BIL rating of 1000 kV located at the end of the line having surge impedance of 300 Ω receives a travelling wave of 4200 kV. Determine (i) reflected voltage and current at the arrester location (ii) arrester discharge current and resistance offered by the arrester. [8]
   b) A 765 kV line has the following details: N=4, d=3.05 cm, B=bundle spacing=45.72 cm, height H=20 m, phase separation S=14 m in horizontal configuration. The maximum conductor surface voltage gradients are 20 kV/cm and 18.4 kV/cm for the center and outer phases, respectively. Calculate the SPL or AN in dB (A) at a distance of 30 m along ground from the center phase. Assume the microphone is kept at ground level.
   Use empirical formula: $AN=120 \log_{10}E_m(i) + 55 \log_{10}d - 11.4 \log_{10} D(i) + 26.4 \log_{10}N - 128.4$ db
   Where Em is in kV/cm, d is in cm and D is in m. [8]

4. a) A 400 kV, 3-phase bundled conductor line with two sub-conductors per phase has horizontal configuration with phase spacing of 11 m. The radius of each sub-conductor is 3.18 cm and bundle spacing is 45.72 cm. Calculate the capacitance matrix if the average ground clearance of the line is 15 m. [8]
   b) Elaborate the two theories proposed to explain the conduction and breakdown in commercial liquids. [8]

5. a) Determine the power loss in a solid dielectric of area 5 m^2 and thickness 5 cm having volume resistivity 6×10^{12} Ω-cm, loss tangent 0.02 and relative permittivity = 3.5 when subjected to (i) 60 kV rms, 50 Hz AC and (ii) 60 kV DC respectively. [8]