Benha University
Faculty of Engineering (Shoubra)
Electrical Engineering Dept.
3rd Year Electrical Power

2014-2015 Mid-Term Exam
Course Title: Transmission and Distribution of Electrical Power
Time Allowed: 90 Minutes
Date: 25-11-2014

Model Answer

This is a closed book Exam. Attempt all Questions

Question # 1: Complete the following sentences (10 points)

1) **Overhead transmission line insulators must have the following characteristics:**
   (a) Mechanically very strong in order to withstand the load due to weight of the conductors.
   (b) High relative permittivity in order to give high dielectric strength.
   (c) High ratio of rupture to flash-over voltage.
   (d) High insulation resistance in order to avoid leakage of current to earth.
   (e) The material employed should not be porous and there should be no effect of change in temperature.
   (f) It must be free from internal impurities and crack and should be impervious to fluids and gases in the atmosphere.
2) **The commonly used materials for overhead transmission line insulators are**
   (a) Porcelain. *(b) Glass.* *(c) Steatite.*
3) **Main types of overhead transmission line insulators are**
   (a) Pin type. *(b) Suspension type.* *(c) Strain insulators.*
4) **The main causes of overhead transmission line insulators failure are**
   (a) Cracking of insulator.
   (b) Porosity of the material.
   (c) Flash-over.
   (d) Mechanical stresses.
   (e) Sort circuits.
   (f) Deposition of dust.
   (g) Improper verification.
5) **The main methods for improving voltage distribution across different units of a string insulators are**
   (a) Long cross-arm method.
   (b) Capacitance grading method.
   (c) Static shielding.

Model Answer

6) The main factors affecting Corona are

(a) Atmosphere.
(b) Conductor.
(c) Spacing between conductors.
(d) Line voltage.

7) The main advantages of Corona are

(a) On the formation of corona the sheath of air surrounding the conductor becomes conductive and there is a virtual increase in conductor diameter and due to this virtual increase in conductor diameter the maximum potential gradient or maximum electro-static stress is reduced.
(b) Probability of flash-over is reduced.
(c) System performance is improved.
(d) Effects of transients produced by lighting and other causes are reduced, since charges induced on the line by lightning or other causes will be partially dissipated as a corona loss.

8) The undesirable effects of corona are

(a) Audible noise and radio interference.
(b) Power loss in the line.
(c) Corrosion due to ozone formation, etc.
(d) Harmonic current flow resulting from corona formation.

9) The Corona is minimizing by

(a) Voltage of the line.
(b) Spacing between the conductors.
(c) Conductor diameter.

10) The dielectric compounds as insulates for power cables should possess the following main properties:

(a) High insulation resistance.
(b) High dielectric strength.
(c) Good mechanical properties.
(d) Capable of being operated at high temperature.
(e) Low thermal resistance.

(f) Low power factor.

(g) Preferably non-hygroscopic, but if hygroscopic it should be provided with an economical water-tight covering or sheath.

11) The methods of equalizing the stress in the dielectric of the cable are:

(a) Capacitance grading. *(b) Intersheath grading.*

12) The most important advantages of plastic cables are:

(a) Reduced cost. *(b) Insulation is resistant to water.*
(c) Simplified jointing. *(d) Reduced weight.*
(e) Increased flexibility. *(f) No compound drainage trouble.*
(g) No plumbing required.

13) The capacitance of a cable transmission line is very much larger than that of an overhead line of the same length due to the following reasons:

(a) The distance between the conductors is very small.

(b) The distance between the cores and the earthed sheath is also small

(c) The permittivity of the cable insulation is usually 3 to 5 times greater than that of air insulation around the conductors of the overhead line.

14) The three main causes for power loss in the dielectric of a cable are

(a) Conductivity of insulation.
(b) Ionization or corona.
(c) Dielectric hysteresis or dielectric absorption.

15) The main factors affecting the selection of power cables are

(a) Operating voltage.
(b) Load Current.
(c) Voltage drop.
(d) Short circuit.

16) The most important methods of installing power cables are:

(a) Direct laying.
(b) Draw-in (duct) system.
(c) Cables installed in tunnels.
(d) Cables installed above ground level in free air.

17) **The metal tape armouring is applied to protect the cable sheath from** *mechanical damage*.
18) **The insulation resistance of a cable of length 5 km is 1 mega ohm its insulation resistance for 25 km length will be** *5 mega ohms.*
19) **The frequency of a transmission system is changed from 50 Hz to 60 Hz the string efficiency will** *remain unchanged.*
20) **A certain cable has an insulation of ε_r =2. If the insulation is replaced by one of ε_r =6, then capacitance of cable is** *three times the original capacitance.*

Question # 2: (10 points)

a) The ratio of shunt capacitance to mutual capacitance $= K$

Where $K = \frac{C_1}{C} = \frac{1}{5} = 0.2$

Voltage across the string, $E = 60\ kV$

Number of units, $n = 4$

Since

$$e_1 = \frac{e_2}{1+K} = \frac{e_3}{1+3K+K^2} = \frac{e_4}{1+6K+5K^2+K^3} = \frac{E}{4+10K+6K^2+K^3}$$

Voltage across the top unit,

$$e_1 = \frac{E}{4+10K+6K^2+K^3}$$

$$e_1 = \frac{60}{4+10\times0.2K+6\times0.2^2+0.2^3} = \frac{60}{6.248} = \mathbf{9.6\ kV}$$

Voltage across the second unit,

$$e_2 = (1+K)e_1 = (\mathbf{1+0.2}) \times \mathbf{9.6} = \mathbf{11.52\ kV}$$

Voltage across the third unit,

$$e_3 = (1+3K+K^2)e_1 = (\mathbf{1+3\times0.2+0.2^2}) = \mathbf{15.75\ kV}$$

Voltage across the bottom unit,

$$e_4 = (1+6K+5K^2+K^3)e_1 = (\mathbf{1+1.2+0.2+0.008}) = \mathbf{23.13\ kV}$$

String efficiency $= \frac{E}{ne_4} \times 100 = \frac{60}{4\times23.13} \times 100 = 64.85\%$

b) Dielectric strength of air, $g_0 = \frac{30}{\sqrt{2}} = 21.21\ kV/cm\ (r.m.s)$

Radius of conductors, $r = 1.5\ cm$

Spacing of conductors, d = 2 m=200 cm

Irregularity factor, $m_0 = 0.8$

Air density factor, $\delta = \frac{3.92b}{273+t} = \frac{3.92\times75}{273+20} = 1.0034$

Disruptive critical voltage to neutral, $V_{d0} = g_0 \delta m_0 r \log_e \frac{d}{r}$

$$= 21.21 \times 1.0034 \times 0.8 \times 1.5 \times \log_e \frac{200}{1.5} = 124.3\ kV$$

Supply frequency, $f = 50\ Hz$

Phase voltage, $V_{ph} = \frac{220}{\sqrt{3}} = 127\ kV$

In fair weather conditions the corona loss,

$$P = \frac{244}{\delta}(f+25)\sqrt{\frac{r}{d}}\left(V_{ph} - V_{d0}\right)^2 \times 10^{-3} kw/km/phase$$

$$P = \frac{244}{1.0034}(50+25)\sqrt{\frac{1.5}{200}}(127-124.3)^2 \times 10^{-3} = 0.115\ kw/km/phase$$

Total corona loss $= 3 \times 0.115 = 0.345\ kw/km$

In stormy weather conditions the corona loss,

$$P = \frac{244}{\delta}(f+25)\sqrt{\frac{r}{d}}\left(V_{ph} - 0.8V_{d0}\right)^2 \times 10^{-3} kw/km/phase$$

$$P = \frac{244}{1.0034}(50+25)\sqrt{\frac{1.5}{200}}(127-0.8\times124.3)^2 \times 10^{-3} = 12\ kw/km/phase$$

Total corona loss $= 3 \times 12 = 36\ kw/km$