Department of Electrical Engineering
Assignment
Date: 14/04/2020

Course Details

Course Title: Electric Power Transmission **Module:** 4rth
Instructor: Eng Amir Aman **Total Marks:** 30

Student Details

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Q1	(a)	In a 66 kV overhead line, there are three units in the string of insulators. If the capacitance between each insulator pin and earth is 22% of self-capacitance of each insulator, Find i) The distribution of voltage over 3 insulators and ii) String efficiency.	Marks 05 CLO 1
	(b)	A 3-phase line has conductors 4 cm in diameter spaced equilaterally 2 m apart. If the dielectric strength of air is 60 kV (max) per cm. Find the disruptive critical voltage for the line. Take air density factor $\delta = 1.5$and irregularity factor mo = 0·6.	Marks 05 CLO 1
Q2	(a)	An overhead transmission line conductor having a parabolic configuration weighs 3.789 kg per meter of length. The area of X-section of the conductor is 6·2 $cm^2$and the ultimate strength is 950.665 kg/cm^2. The supports are 300 m apart having 25 m difference of levels. Calculate the sag from the taller of the two supports which must be allowed so that the factor of safety shall be 2. Assume that ice load is 2 kg per meter run and there is no wind pressure.	Marks 10 CLO 1
Q3	(a)	A transmission line has a span of 400 meters between level supports. The conductor has a cross-sectional area of 2.34 cm2, weighs 70 kg/km and has a breaking stress of 42 kg/cm^2. Calculate the sag for a safety factor of 6, allowing a wind pressure of 522 kg per square meter of projected area. What is the vertical sag?	Marks 05 CLO 2
	(b)	The towers of height 60 m and 120 m respectively support a transmission line conductor at water crossing. The horizontal distance between the towers is 800 m. If the tension in the conductor is 400 kg, Find the minimum clearance of the conductor and water and clearance mid-way between the supports. Weight of conductor is 3.5 kg/m. Bases of the towers can be considered to be at water level.	Marks 05 CLO 2

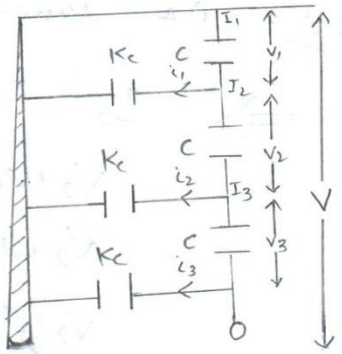
Question NO:- 1 Part (A)

In a 66 kv overhead Line there are the three Unit in the String of Insulation. If the capacitance between each Insulator Pin and earth is 22% of Self capacitance of each Insulator. Find

i) The Distribution of voltage over 3 Insulator

ii) String efficincy.

Diagram of overhead Line there are three Unit in the String of Insulator.



Solution

We know that the above circuit diagram show that 'C' is the Self Capacitance and Kc is the Shunt Capacitance. 'V' is the Total voltage and V_1, V_2, V_3 is a across voltage from top to Bottom.

First we find the value of 'K'

$$K = \frac{\text{Shunt capacitance}}{\text{Self capacitance}}$$

$K = 22\% \quad 0.22$

$K = 0.22$

Voltag across the string

$$V = \frac{66kv}{\sqrt{3}} \Rightarrow V = 38.10\,kV$$

$\Rightarrow$ At junction 'A'

$\Rightarrow$ $I_2 = I_1 + i_1$

$V_2 \omega c = V_1 \omega c + V_1 K \omega c$

$V_2 \omega c = V_1 \omega c + V_1 K \omega c$

$V_2 \omega c = V_1 \omega c (1+K)$

$V_2 = V_1 (1+K)$ $\Rightarrow$ Putting of 'k' The value

$V_2 = V_1 (1+0.22)$

$V_2 = 1.22 V_1$

$\Rightarrow$ At junction 'B'

$I_3 = I_2 + i_2$

$V_3 \omega c = V_2 \omega c + (V_1 + V_2) K \omega c$

$V_3 = V_2 + (V_1 + V_2) K \quad \Rightarrow$ ii

Putting value in above equation (ii)

$$V_3 = 1.22V_1 + (V_1 + 1.22V_1)\,0.22$$

$$V_3 = 1.7084\,V_1$$

Next voltage across the whole string

$$V = V_1 + V_2 + V_3 \longrightarrow \text{(iii)}$$

Putting the value of V_2 and V_3 in above equation (iii)

Now $V = V_1 + 1.22V_1 + 1.7084V_1$

$$38.10 = 3.9284V_1$$

$$V_1 = \frac{38.10}{3.9284} = V_1 = 9.698\,KV$$

So $V_2 = 1.22\,V_1$ $\quad V_2 = 1.22 \times 9.698$

$$V_2 = 11.83KV$$

Next $V_3 = 1.7084\,V_1$ Putting the value of 'V_1'

$$V_3 = 1.7084 \times 9.698$$

$$V_3 = 16.54KV$$

Second Final string Efficiency.

We know that

$$= \frac{\text{voltage across string}}{\text{No of insulator} \times V_3} \times 100$$

Putting value

$$\Rightarrow \frac{38.10}{3 \times 16.54} \times 100$$

$$\Rightarrow \frac{38.10}{49.62} \times 100$$

$$= 76.78\ \%$$

Question NO 1
Part B

A 3 phase Line has conductors 4 cm in diameter spaced equilaterally 2 m apart if the dielectric strength of air is 60 Kv (max) Per cm. Find the disructive critical Voltag for the Line. Take air density factor $\delta = 1.5$ and irregularity factor $m_0 = 0.6$

Given data:

Diameter of conductor = 4 cm

Dielectric strength of air = 60 Kv/cm

Conductor spacing = 2 m

Air density factor = $\delta = 1.5$

Irregularity factor $m_0 = 0.6$

Required data

Disruptive Critical voltag $V_c = ?$

Solution

First convert Conductor spacing From metter to Cm.

$$2m = 0.02cm$$

Now we know that

$$\Rightarrow V_c = m_0 g_0 \delta_r \log_e (d/r) \text{ KV/phase} \quad \text{(r.m.s value)}$$

Radius of Conductor is

$$r = 4cm/2 = 2cm$$

Putting value in above equation.

$$0.6 \times 42.4 \times 1.5 \times 2 \times \log 0.02/2$$

$$= 353.46 \text{ KV/phase}$$

Line voltage (rms)

$$= \sqrt{3} \times 353.46 = 612.21 \text{ KV}$$

Question NO 2

Given data

$w = 3.789$ kg/m

$h = 25$m

$L = 300$m

Ultimate String $= 950.665$ kg/cm^2

$wi = 2$ kg/m

Safety factor $= 2$

X-Section area of conductor $= 6.2$cm^2

Required data

Calculate Sag from that the taller of two Support.

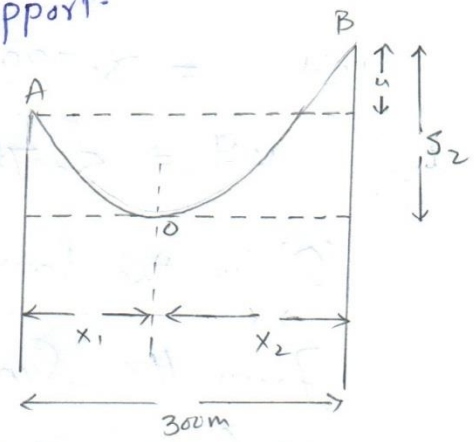


Diagram (A)

The above Diagram (A) Show that the Conductor Suspended between two Supports A and B at different Level and 'O' is the Lowest on the Conductor.

Solution

First we find working tention (T)

Here $T = \frac{\text{Ultimate Streugth} \times \text{Cross Section}}{\text{Safty factor}}$

$T = \frac{950.665 \times 6.2}{2}$

$T = \frac{5894.123}{2} \Rightarrow T = 2947.00\,kg$

Now

$wt = w + wi$ ⇐ Total weight of Length of Conductor

$wt = 3.789 + 2$

$wt = 5.789\,kg$

'O' is the Lowest Point Let X_2 distance From the Support of higher Level and X_1 distance From the Support of Lower Level.

Let $x_1 + x_2 = 300m \rightarrow (1)$

$$h = S_2 - S_1$$

$$h = \frac{\omega_1 x_2^2}{2T} = \frac{\omega + r_1^2}{2T}$$

$$h = \frac{\omega t}{2T}(x_2^2 - x_1^2)$$

$$\frac{2T \times h}{\omega t (x_2 + x_1)} = x_2 \cdot x_1$$

$$\Rightarrow \quad x_2 - x_1 = \frac{2 \times T \times h}{\omega t \times (r_2 + x_1)}$$

Putting value

$$\frac{2 \times 2947.06 \times 25}{5.789 \times 300}$$

$$x_2 - x_1 = \frac{147353}{1736.7}$$

$$x_2 - x_1 = 84.84m \Rightarrow (2)$$

Compare equation 1) and (2) and find the value x_1 and x_2

So $x_1 + x_2 = 300m$

$$-x_1 + x_2 = 84.84m$$

$$\frac{2x_2}{2} = \frac{384.84}{2}$$

$x_2 = 192.42\,m$

Put the value of X_2 or above value in equation (1) and get X_1 value

$$X_1 + X_2 = 300$$

$$X_1 + 192.42 = 300$$

$$X_1 = 300 - 192.42$$

$$X_1 = 107.58\,m$$

Next we know that

$$S = \frac{wt\, x_2^2}{2T} = (1)$$

Sag from the taller of two tower

$$S = \frac{wt\, x_2^2}{2T} \Rightarrow \text{putting the value}$$

$$S = \frac{5.789 \times (192.42)^2}{2 \times 2947.06}$$

$$S = \frac{5.789 \times 37025.45}{5894.12}$$

$$S = \frac{214340.36}{5894.12}$$

$$\boxed{S = 36.36\,m}$$

Question NO 3 Part A

Give data

Weight = 70 kg/km 0.07kg

Length of Span = 400m

X-Section area of Conductor = $2.34 cm^2$

Safty factor = 6

Breaking stress = $42\ kg/cm^2$

Pressure of wind = $522\ kg/m^2$

Find vertical Sag = ?

Solution

First we Find 'T'

Now $T = \frac{\text{Breaking stress} \times \text{Cross-Sectional area of Conductor}}{\text{Safty factor}}$

=) putting value

$T = \frac{42\ kg/cm^2 \times 2.34 cm^2}{6}$

$$T = \frac{98.28}{6} = \boxed{T = 16.38 \text{ kg}}$$

Next we Find - Diameter of Conductor 'd'

Now $d = \sqrt{\frac{4 \times \text{area}}{\pi}}$ putting value

$$d = \sqrt{\frac{4 \times 2.34}{3.14}}$$

$$d = \sqrt{2.98} = \boxed{d = 1.726 \text{ cm}}$$

So wind force /m Length = Pressure x projected area

$$W_w = 522 \text{ kg/m}^2 \times (1.726 \times 10^{-2} \times 1)$$

$$\boxed{W_w = 9 \text{ kg}}$$

Total weight of Conductor per meter Length

$$W_t = \sqrt{W_2 + W_w^2}$$ Putting value

$$W_t = \sqrt{(0.07)^2 + (9)^2}$$

$$W_t = \sqrt{0.0049 + 81}$$

$$\boxed{W_t = 9 \text{ kg}}$$

Now

$$S = \frac{W_t \ell^2}{8t} = \frac{9 \times (400)^2}{8 \times 16.38}$$

$$S = \frac{9 \times 160{,}000}{131.04}$$

$$S = \frac{1440{,}00}{131.04} = \boxed{S = 10989.01 m}$$

Now we know that the value of (S) is given

$$\textcircled{x} = \tan^{-1}\left(\frac{W_w}{W}\right)$$

$$\textcircled{x} = \tan^{-1}(9/0.07)$$

$$\tan^{-1}(128.5) = \boxed{\textcircled{x} = 89.5541}$$

vertical sag $= S \cos \textcircled{x}$

vertical sag $= S \times \cos(89.5541)$ Putting the value of 'S'

$= 10989.01 \cos(89.5541$

$= 10989.01 \times 0.00785$

vertical sag = $\boxed{86.2966 m}$

Question No 3

Part B

Given data:

weight of conductor = 3.5 kg/m

height $h = 120m - 60m = 6m$

Tension $T = 400kg$

Length = 800 m

Find minimum clearence of the conductor and water and clearence mid-way between the Support.

Solution

we know that 'O' is the lowest point on the conductor at a distance X_1 from the Support at lower level and distance X_2 from

The Support at higher level.
and the Conductor Show that Suspended between two Support A and B.

Let us =)

$$X_1 + X_2 = 800m \quad \text{— (A)}$$

$$h = S_2 - S_1$$

$$h = \frac{wx_2}{2T} - \frac{wx_1^2}{2T}$$

$$h = \frac{w}{2T}(x_2^2 - x_1^2)$$

$$h = \frac{w}{2T}(x_2 - x_1)(x_2 + x_1)$$

$$\frac{2Th}{w(x_2 + x_1)} = x_2 - x_1$$

$$x_2 - x_1 = \frac{2 \times T \times h}{w \times (x_2 + x_1)} \longrightarrow (i)$$

Now put value in (i)

So $$x_2 - x_1 = \frac{2 \times 400 \times 60}{3.5 \times 800}$$

$$x_2 - x_1 = \frac{48000}{2800}$$

$$x_2 - x_1 = 17.14m \longrightarrow (B)$$

Now we Compare the value of equation (A) and B and get the value of x_1 and x_2

$$x_1 + x_2 = 800^m$$
$$- x_1 + x_2 = 17.14$$
$$\overline{2x^2 = 817.14}$$

devided both Side by 2

$$\frac{2x^2}{2} = \frac{817.14}{2}$$

$$x^2 = 408.57^m$$

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Next put the value of X^2 in Equation (A) and get the value of X_1,

$$x_1 + x_2 = 800$$

$$X_1 + 408.57 = 800$$

$$X_1 = 800 - 408.57$$

$$X_1 = 391.43\,m$$

So

$$\delta_1 = \frac{w x_1^2}{2T} \Rightarrow \delta_1 = \frac{3.5 \times (391.43)^2}{2 \times 400}$$

$$\delta_1 = \frac{3.5 \times 153217.49}{800}$$

$$\delta_1 = \frac{536261.04}{800}$$

$$\delta_1 = 670.32\,m$$

if that: Now clearance of the lowest point 'O' from water level.

$= 60.670.32$

$= -610.32m$

Next ⇒ let the mid point of 'P' be at a distance x from the lowest point 'O'

$X = 400 - x_1$

$x = 400 - 391.43$

$X = 8.57m$

Hat the Sag at mid point P

$$P = \frac{wx^2}{2T} \longrightarrow (2)$$

$$= \frac{3.5 \times (3.57)^2}{2 \times 400}$$

$$= \frac{3.5 \times 73.44}{800}$$

Smid P = 0.3213m

Clearance of mid point 'P' from water level.

$= -610.32 + 0.3213$

$= -609.9\ m$