Department of Electrical Engineering
Assignment
Date: 24/06/2020

Course Details

Course Title:	Electric Power Transmission	**Module:**	4rth
Instructor:	**ENGR. AMIR AAMAN**	**Total Marks:**	50

Student Details

Name:	**AZHAD NIAZ**	**Student ID:**	**15493**

Q1	A single phase line has two parallel conductors 2 meters apart. The diameter of each conductor is 1·2 cm. Calculate the loop inductance per km of the line.	Marks 10 CLO 1
Q2	A single phase transmission line has two parallel conductors 3 m apart, the radius of each conductor being 1 cm. Calculate the loop inductance per km length of the line if the material of the conductor is (i) Copper (ii) Steel with relative permeability of 100.	Marks 10 CLO 1
Q3	A long transmission lines more than 240kms are consisting of high amount of capacitance and inductance distributed across the entire length of the line. Ferranti effect occurs when current drawn by the distributed capacitance of the line itself is greater than the current associated with the load at the receiving end of the line (during light or no load). Why Ferranti effect occurs in long transmission line? Back your answer with valid data, facts and figures.	Marks 10 CLO 1
Q4	A 3-phase load of 2000 kVA, 0·8 p.f. is supplied at 6·6 kV, 50 Hz by means of a 33 kV transmission line 20 km long and 33/6·6 kV step-down transformer. The resistance and reactance of each conductor are 0·4 Ω and 0·5 Ω per km respectively. The resistance and reactance of transformer primary are 7.5 Ω and 13.2 Ω, while those of secondary are 0.35 Ω and 0.65 Ω respectively. Find the voltage necessary at the sending end of transmission line when 6.6 kV is maintained at the receiving end. Determine also the sending end power factor and transmission efficiency.	Marks 10 CLO 2
Q5	A 132 kV line with 1.956 cm dia. conductors is built so that corona	Marks 10

	takes place if the line voltage exceeds 210 kV (r.m.s.). If the value of potential gradient at which ionization occurs can be taken as 30 kV per cm, find the spacing between the conductors.	CLO 2

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Q1: A single phase line has two parallel conductors 2 meters apart. The diameter of each conductor is 1·2 cm.
Calculate the loop inductance per km of the line.

Solution
Given data:

Spacing of conductors, d = 2 m = 200 cm

Radius of conductor, r = $\frac{1.2}{2}$ **= 0·6 cm**

Loop inductance per meter length of the line= 10^{-7} $\left(\frac{1+4\ \text{logged}}{r}\right)$ **H**

= 10^{-7} $\left(\frac{1+4\ \text{loge}\ 200}{0.6}\right)$ **H = 24·23 ×** 10^{-7}**H**

Loop inductance per km of the line = 24·23 ×10^{-7}**×1000 H**

= 24·23 ×10^{-4}**H = 2·423 mH**

Ans.

Q2: A single phase transmission line has two parallel conductors 3 m apart, the radius of each conductor being 1 cm. Calculate the loop inductance per km length of the line if the material of the conductor is

(i) Copper

Steel with relative permeability of 100

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ANS2:

Solution:

given data

Spacing of conductors, d = 300 cm

Radius of conductor, r = 1 cm

Loop inductance = 10^{-7} $\left(\frac{\mu r + 4 \log e\ d}{r}\right)$ H/m

∴ Loop inductance/m = 10^{-7}

$\left(\frac{1 + 4 \log e\ d}{r}\right)$ H = 10^{-7}

$\left(\frac{1 + 4 \log e\ 300}{1}\right)$ H = 23.8×10^{-7}

Loop inductance/km = $23{\cdot}8 \times 10^{-7}$

$\times 1000 = 2{\cdot}38 \times 10^{-3}$ H = 2·38 mH

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With steel conductors, μ r = 100

∴ Loop inductance/m = 10^{-7}

$\left(\frac{100 + 4 \text{ loge } 300}{1}\right)$ H = 122·8 × 10^{-7}H

Loop inductance/km = 122·8 × 10^{-7} × 1000

= 12·28 ×10^{-3} H

= 12·28 mH

Q3:

A long transmission lines more than 240kms are consisting of high amount of capacitance and inductance distributed across the entire length of the line. Ferranti effect occurs when current drawn by the distributed capacitance of the line itself is greater than the current associated with the load at the receiving end of the line (during light

or no load). Why Ferranti effect occurs in long transmission line? Back your answer with valid data, facts and figures

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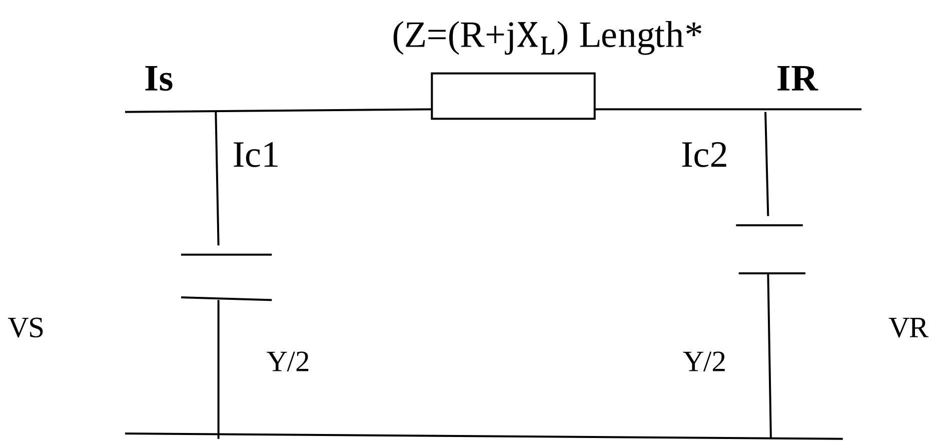
ANS:

A long transmission lines more than 240kms are consisting of high amount of capacitance and inductance distributed across the entire length of the line. Ferranti effect occurs when current drawn by the distributed capacitance of the line itself is greater than the current associated with the load at the receiving end of the line (during light or no load) This capacitor charging current leads to a voltage drops across the line inductor of transmission system which is in phase with sending end voltages this voltage drop keeps on increasing additionally as e move toward the load end of the line and subsequently the receiving end voltage tend to get larger than applied voltage leading to the phenomena called Ferranti effect.

During no load or light load condition, the reactive power generated at a point on the Transmission Line will be more than the reactive power absorbed and therefore the voltage at that point will rise. Mind that during no load or light load condition the line capacitance will dominate to inductance.

The Ferranti Effect occurs when current drawn by the distributed capacitance of the transmission line itself is greater than the current associated with the load at the receiving end of the line. Therefore, the Ferranti effect tends to be a bigger problem on lightly loaded lines and especially on underground cable circuits where the shunt capacitance is greater than with a corresponding overhead line. This effect is due to the voltage drop across the line inductance (due to charging current) being in phase with the sending end voltages. As this voltage drop affects the sending end voltage, the receiving end voltage becomes greater. The Ferranti Effect will be more pronounced the longer the line and the higher the voltage applied.

The Ferranti Effect is not a problem with lines that are loaded because line capacitive effect is constant independent of load, while inductance will vary with load. As inductive load is added, the VAR generated by the line capacitance is consumed by the load.



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VR = receiving end voltage

VS = sending end voltage

IL = Line current

Is = current at sending end

Ir = receiving end current

Ic1 = line capacitive current at sending end

Ic2 = line capacitive current at receiving end

Z = line impedance

R = line resistance

L = inductance of transmission line

C = capacitance of line

Y = conductance of line

L = length of conductor

XL = inductive reactants of conductor

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Q:A 3-phase load of 2000 kVA, 0·8 p.f. is supplied at 6·6 kV, 50 Hz by means of a 33 kV transmission line 20 km long and 33/6·6 kV step-down transformer. The resistance and reactance of each conductor are 0·4 Ω and 0·5 Ω per km respectively. The resistance and reactance of transformer primary are 7.5 Ω and 13.2 Ω, while those of secondary are 0.35 Ω and 0.65 Ω respectively. Find the voltage necessary at the sending end of transmission line when 6.6 kV is maintained at the receiving end. Determine also the sending end power factor and transmission efficiency

Solution:

The single diagram of the transmission system. Here, the voltage drop will be due to the impedance of transmission line and also due to the impedance of transformer.

Resistance of each conductor = 20 x 04 = 8Ω

Reactance of each conductor = 20 x 0.5 = 10Ω

Let us transfer the impedance of transformer secondary to high tension side i.e., 33 kV side.

Equivalent resistance of transformer referred to 33 kV side

= Primary resistance + 0.35 (33/6.6)2

= 7.5 + 815 = 16.25Ω

Equivalent reactance of transformer referred to 33 kV side

= Primary reactance + 0.65 (33/6.6)2

=13-2 + 16-25 = 29-45Ω

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Total resistance of line and transformer is

R = 8+16.25=24.25Q

Total reactance of line and transformer is

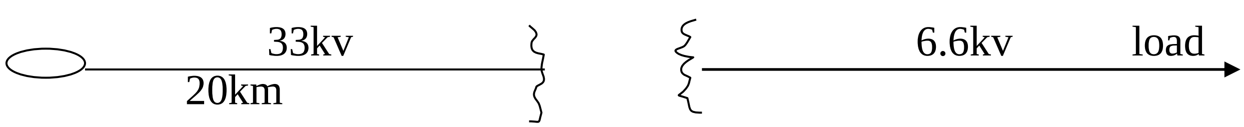
x_L= 10 + 29.45 = 39.45Ω

Receiving end voltage per phase is

v_R=33,000/$\sqrt{3}$=19052 V

Line current

$$I=\frac{2000\times10^3}{\sqrt{3}\times33000} = 35\ A$$



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Using the approximate expression for sending end voltage v_s per phase.

$v_s = v_R + IR\cos\phi_R + I x_L \sin\phi_R$

= 19052 + 35 x 24-25 x 0-8 + 35 x 39-45 x 0-6

= 19052 + 679 + 828 = 20559 V = 20-559 kV = 45

Sending end line voltage $= \sqrt{3} \times 20.559$ kV = 35.6 Kv

Sending end p.f.. $\cos\phi_S = \frac{v_R\, cos\phi_R + IR}{V_S} = \frac{19052\times0.8+35\times24.25}{1000}$ =89.12Kw

$= \frac{3I^2R}{1000}$ kW $= \frac{3\times(35^2)\times24.25}{1000}$ =89.12 Kw

=2000Kva ×0.8 =1600Kw

- Transmission efficiency

$$= \frac{1600}{1600+89.12} \times 100 = 94.75\ \%$$

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Q5:

A 132 kV line with 1.956 cm dia. conductors is built so that corona takes place if the line voltage exceeds 210 kV (r.m.s.). If the value of potential gradient at which ionization occurs can be taken as 30 kV per cm, find the spacing between the conductors.

SOLUTION:

$$r\frac{1.956}{2} = 0.978\text{cm}$$

$$E_o = \frac{30}{\sqrt{3}} = 21.2(\text{r.m.s})$$

$$m_o = 1 \text{ (smooth conductor)}$$

$$\delta = 1 \text{ (stander pressure and temperature}$$

$$V_o = 21.1 m_o \delta \, r \, 1n \frac{d}{r}$$

$$\text{Disruptive voltage/phase} = \frac{210}{\sqrt{3}} = 121.25\text{Kv}$$

$$\therefore 121.25 = 21.1 \times 1 \times 1 \times D.978 \times 1n\frac{d}{r}$$

$$1n\frac{d}{r} = 5.84$$

Ans.