 NAME: Shafiq khan ID 14859

Electrical Transmission System Sessional Assignment

Total Marks=20

Question No 1: A 3-phase, 50-Hz overhead transmission line 100 km long has the following constants:

Resistance/km/phase = 0.1 Ω

Inductive reactance/km/phase = 0·2 Ω

Capacitive Susceptance/km/phase = 0·04 × 10− 4

siemen

Determine (i) the sending end current (ii) sending end voltage (iii) sending end power factor and (iv) transmission efficiency when supplying a balanced load of 10,000 kW at 66 kV, p.f. 0·8 lagging. Use nominal T method.

Question No 2: A (medium) single phase transmission line 100 km long has the following constants:

Resistance/km = 0·25 Ω ; Reactance/km = 0·8 Ω

Susceptance/km = 14 × 10−6 siemen; Receiving end line voltage = 66,000 V

Assuming that the total capacitance of the line is localised at the receiving end alone, determine

(i) The sending end current (ii) The sending end voltage (iii) Regulation and (iv) supply power factor. The line is delivering 15,000 kW at 0.8 power factor lagging.

Draw the phasor diagram to illustrate your calculations.

Question No 3: Describe Ferranti Effect, Why Ferranti effect occurs? Detail

explanation of the Ferranti effect by considering a nominal pi (π) model. How toreduce Ferranti effect.

SOLUTION:1

Total resistance/phase= 0·1 ×100 = 10

ΩTotal reactance/phase.XL= 0·2 ×100 = 20

Capacitive susceptance, Y= 0·04 ×10−4×100 = 4 ×10−4S

Receiving end voltage/phase, VR= 66,000/√ 3 = 38105 V

Load current, IR =

10 000×103

,

√3 ×66×103×0.8

= 109A

cos�R = 0·8; sin�R = 0·6

Impedance per phase, Z=R+ j XL= 10 + j20

(i) Taking receiving end voltage as the reference phase

We have,

Receiving end voltage, VR=VR+ j0 = 38,105 V

Load current, IR = IR (cos �R-j sin �R) = 109 (0·8 -j0·6) = 87·2 -j65·4

Voltage across C, V1 = Vr +Ir Z/2 = 38, 105 + (87·2 -j65·4) (5 +j10)=38,105 + 436 + j872 −j327 + 654 = 39,195 + j545

Charging current, IC = j Y ￼1 14×10−4

(39,195+ j 545) -0.218 + j15.6

Sending end current, IS = ￼￼ ÷ ￼￼ = (87·2 ￼j 65·4) + (￼0·218 + j15·6)

= 87·0 ￼j 49·8 = 100 ⊾ 29º47￼A

Sending end current= 100A

(ii) Sending end voltage, VS = $V1$+Is Z/2= (39,195 + j 545) + (87·0￼j 49·8)

(5+j 10)

= 39,195 + j 545 + 434·9 + j 870￼j249 + 498

= 40128 + j 1170 = 40145 < 1°40￼ V

￼￼ Line value of sending end voltage

= 40145 ￼ √3 = 69 533 V = 69.53 KV

(iii) Referring to phases =

,1 = angle between $Vr$and Vs= 1°40￼

θ2 = angle between $Vr$and Is= 29°47￼￼

θS = angle between $VsandIs$

= θ1 + θ2= 1°40￼+ 29°47￼= 31°27￼

Sending end power = cosθs = cos31°27 = 0.853 lag

(iv) Sending end power = 3 Vs

Is cosθs = 3.40,145 ×100×0.853

= 10273105W = 10273.105 KW

Power delivered = 10,000KW

:. Transmission efficiency =

10,000

10273.105

× 100 = 97.34%

SOLUTION 2

Total resistance, R = 0.2 × 100 = 25ohms

Total reactance, Xl

= 0.8 × 100 = 80 ohms

Total susceptance, Y = 14 × 10−6 × 100 - 14 × 10−4 S

Receiving end voltage, VR = 66,000V

:. Load current IR =

15000×103

66,000×0.8

= 284A

CosθR = 0.8: sinθR = 0.6

Taking receiving end voltage as the reference phasor we have,

VR = VR + J0 = 66,000V

Load current IR = IR (CosθR - j sinθR) -284 (0.8 – j 0.6) -27 – j170

Capacitive current Ic = jY× VR = -j14×10−4 × 66000-j92

(i) Sending end current, IS = IR+IC= (227-j170+j92

= 227-j78

Magnitude of IS = √(227)

2 + (78)

2 = 240A

(II) Voltage drop = ISZ = IS

(R+jXL

) = (227-j78) (25+j80)

= 5.675+j1816-j1950+6240

11,915+j16210

Sending end voltage, VS = VR+IS Z = 66000+11915+j16210

= 77915 =+j16210

Magnitude of VS = √(77915)

2 + (16210)

2 = 79583V

(III) % voltage regulation = $VS-VR$

VR

× 100 =

79583−66000

66000

× 100 = 20.58%

(IV) referreing to exp (i), phase angle between $VRandIR$ is :

$\theta 1$ = tan−1

- 78/227 - tan−1

(-0.3436) = -18.96°

Referring to exp (ii), phase angle between VR and VS

is;

$\theta 1$ = tan−1

16210

77915

= tan−1

(0.236) = 11.50°

Supply power factor angle, $\phi S = 18.96° + 11.50° = 30.46°$

Supply p.f = $\cos\phi S$

- cos 30.46°= 0.86lag

ANSWER NO 3

Ferranti Effec:

Definition: **The effect in which the voltage at the receiving end of the transmission**

line is more than the sending voltage is known as the Ferranti effect. Such type of effect mainly

occurs because of light load or open circuit at the receiving end.

Ferranti effect occurs:

Capacitance and inductance are the main parameters of the lines having a length 240km or above.

On such transmission lines, the capacitance is not concentrated at some definite points. It is

distributed uniformly along the whole length of the line.

When the voltage is applied at the sending end, the current drawn by the capacitance of the line is

more than current associated with the load. Thus, at no load or light load, the voltage at the

receiving end is quite large as compared to the constant voltage at the sending end

Ferranti effect by considering a nominal pi (π) model:

Let us consider the long transmission line in which OE represents the

receiving end voltage; OH represents the current through the capacitor at the receiving end. The

phasor FE represents the voltage drop across the resistance R. The voltage drop across the X

(inductance). The phasor OG represents the sending end voltage under a no-load condition.

It is seen from phasor diagram that OE > OG. In other words, the voltage at the receiving end is

greater than the voltage at the sending end when the line is at no load.

For a small Pi (π) replica

Vs = (1+ZY/2)Vr + ZIr

Where, Ir =0 at no load condition

Vs = (1+ZY/2)Vr + Z (0)

= (1+ZY/2) Vr

Vs-Vr = (1+ZY/2)Vr- Vr

Vs-Vr = Vr [1+ZY/2-1]

Vs-Vr = (ZY/2) Vr

Z= (r + jwl)S, and Y = (jwc)S

If the transmission line's resistance is unnoticed

Vs-Vr = (ZY/2) Vr

Substitute Z= (r + jwl)S, and Y = (jwc)S in the above Vs

Vs-Vr= ½ (jwls) (jwcs) Vr

Vs-Vr= – ½ (W2S2) lcVr

For the lines of overhead, 1/√LC = 3×108m/s (velocity of electromagnetic wave transmission on

the broadcast lines).1/√LC = 3×108m/s

√LC = 1/3×108

$LC = 1/(3\times108\ )2$

$VS\text{-}VR = -\ ½\ W2S2\ .\ (1/(3\times108\ )2)\ Vr$

$W = 2\pi f$

$VS\text{-}VR = -\ ((4\pi2/18)*\ 10\text{-}16)\ f2S2Vr$

The above eq illustrates that (VS-Vr) is negative, that means Vr is greater than VS. This is also

illustrated that this effect will also determine by the electrical period of the transmission lines and

frequency.

Generally, for each line

$Vs = AVr + BLr$

On no load state,

$Ir =0, Vr = Vrnl$

$Vs = AVrnl$

$|Vrnl| = |Vs|/|A$

How to Reduce Ferranti Effect In Transmission Line:

Electrical machines work on specific electrical energy. If the voltage is far above the ground at the

consumer end their device get damaged, and the windings of the device also burn due to high

electrical energy.

Ferranti effect on extensive transmission lines at no-load status, then the voltage will increase at the

collecting end. This can be restricted by keeping the shunt-reactors next to the collecting end of the

transmission lines.

This reactor allied between the lines along with neutral to give back the capacitive current as of

transmission lines. As this outcome happens in lengthy transmission lines, these reactors pay off

the transmission lines & thus the voltage is regulated within the set limits.