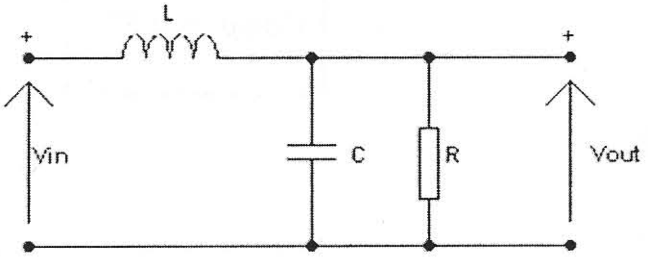
SOLUTION HTTTC BAMBILI, ELECTROTECHNICS 2010

EXERCISE 1 :



1.a- Let's find the equivalent impedance viewed from the input

From the figure above, $Z_{eq} = L + C//R$

$$Z_{eq} = jLw + \frac{\frac{R}{jwC}}{R+\frac{1}{jCw}};$$

$$\boxed{Z_{eq} = jLw + \frac{R}{1+jwRC}}$$

Deducing Z_{eq} in the following cases

i) **When w = 2**

$$Z_{eq} = j0.4 + \frac{10}{1+j0.8};$$

$$\boxed{Z_{eq} = 7.57\angle - 36.5° \ (\Omega)}$$

Let's deduce the parallel equivalence.

$$Y_p = \frac{1}{R_p} + \frac{1}{X_p};$$

but the series equivalence is given as:

$$Y_s = \frac{1}{7.57\angle-36.3°} = 0.1064 + j0.078$$

$$Y_p = \frac{1}{0.1064} + \frac{1}{j0.078} = 9.4 - j12.82 \ (\Omega);$$

$$\boxed{Y_p = 9.4 - j12.82 \ (si)}$$

ii) **When w=10**

$$Z_{eq} = j10x0.2 + \frac{10}{1+j10x10x0.04};$$

$$\boxed{Z_{eq} = 0.686\angle - 30.98° \ (\Omega)}$$

Deducing the parallel equivalence

$$Y_p = \frac{1}{R_p} + \frac{1}{X_p}; \text{ but } Y_s = \frac{1}{0.686\angle -30.98°} = 1.458\angle 30.98° = 1.25 + j0.75$$

$$Y_p = \frac{1}{1.95} + \frac{1}{j0.75} = 0.8 - j1.333; \ Y_p = 0.8 - j1.333\ (si)$$

iii) <u>When w=100;</u>

let's deduce the Z_{eq}

$$Z_{eq} = j100x0.2 + \frac{10}{1+j100x10x0.04}; \quad \boxed{Z_{eq} = 19.75\angle 89.98°\ (\Omega)}$$

Deducing the parallel equivalence, the series equivalenceis given as

$$Y_s = \frac{1}{19.75\angle 89.98°} = 0.0506\angle -89.98° = 1.7.10^{-5} - j0.0506$$

$$Y_p = \frac{1}{R_p} + \frac{1}{X_p} = \frac{1}{1.7.10^{-5}} + \frac{1}{-j0.0506}; Y_p = 56497.18 - j19.76\ (si)$$

<u>1.b- Let's find the frequency at which Z_{eq} is real.</u>

$$Z_{eq} = jLw + \frac{R}{1 + jwRC}$$

$$Z_{eq} = \frac{(jLw(1 + jwRC) + R)(1 - jwRC)}{1 + (wRC)^2} = \frac{(R - LRCw^2 + jLw)(1 - jwRC)}{1 + (wRC)^2}$$

$$= \frac{(R - LRCw^2 + LRCw^2 + j(\ L(RC)^2w^3 - wCR^2 + Lw)}{1 + (wRC)^2}$$

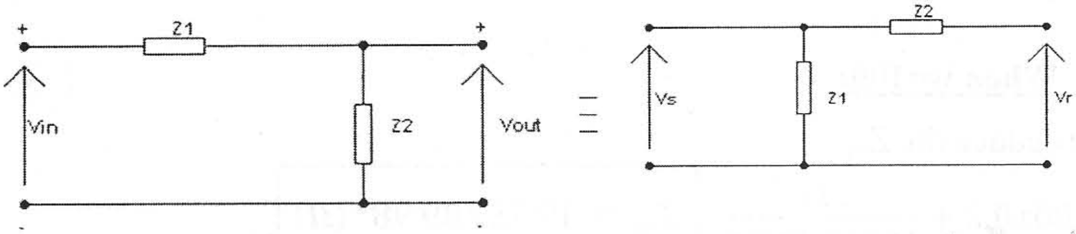
Zeq is real if $L(RC)^2w^3 - wCR^2 + Lw = 0 \rightarrow w = \sqrt{\frac{CR^2 - L}{L(RC)^2}}$

$$\boxed{f = \frac{\sqrt{\frac{CR^2-L}{L(RC)^2}}}{2\pi}} \quad ; f = \frac{\sqrt{\frac{0.04x100-0.2}{0.2(0.4)^2}}}{2\pi}; \quad \boxed{\text{f=1.73Hz}}$$

1.c Given V_{in}=100∠10° . Let's determine Vout

The circuit becomes

Thevenizing the circuit, it becomes



Where $Z_2 = X_C // R \quad \rightarrow Z = \frac{R}{1+jwRC}$

Then $$V_{out} = \frac{Z_2}{Z_2+Z_1} V_{in}$$

Note that these values are already calculated above, so let's just deduce Z_2 and Z_1 for the various cases.

i) **For w = 2 ; Z_2 = 6.1-j4.878 ; Z_1 = j0.4**

Z_2+Z_1=7.57∠-36.3° (Ω)

Then $V_{out} = \frac{7.8\angle -38.65}{7.57\angle -36.3} 100$; $$V_{out} = 103\angle -2.4° \ (V)$$

ii) **For w = 10**

$V_{out} = \frac{2.43\angle -75.97°}{0.686\angle -30.98} 100$; $$V_{out} = 354\angle -44.99° \ (V)$$

iii) **W=100**

$V_{out} = \frac{0.25\angle -88.57°}{19.75\angle 89.98} 100$; $$V_{out} = 1.266\angle -178.55° \ (V)$$

EXERCISE 2

Given the following load source configuration

a) $\Delta - \Delta$; b) Y-Y ; c) $Y - \Delta$

a) <u>For configuration $\Delta - \Delta$</u>

- ***The phase current:***

$I_L = \sqrt{3}I_p \rightarrow I_p = \frac{I_L}{\sqrt{3}} = \frac{V_1}{Z_1}$; $Z_1 = R + j(X_L + X_C) = 10\angle 36.87°$

$I_p = \frac{V_1}{Z_1} = \frac{220}{10\angle 36.87°}$; $\boxed{I_p = 38.1\angle - 36.87°\ (A)}$

- ***Let's calculate the active power***

$P_a = \sqrt{3}U_L I_L cos\varphi$; $P_a = \sqrt{3}x220x38.1x0.8$; $\boxed{P_a = 11.6KW}$

b) <u>For Y-Y connection</u>

$I_L = I_P$ and $U = \sqrt{3}V_p$

- ***The line current:***

$I_L = I_p = \frac{U}{Z}$;

$I_L = \frac{\sqrt{3}220}{10\angle 36.87}$; $\boxed{I_L = 38.1\angle - 36.87\ \ (A)}$

- ***The absorbed power***

$P_a = U_L I_L cos\varphi$ but $U_L = \sqrt{3}V_p$

$P_a = \sqrt{3}x220x38.1x0.8$; $\boxed{P_a = 11.16KW}$

c) <u>For $Y - \Delta$ connection</u>

$I_p = \frac{\sqrt{3}V_1}{Z}$;

$I_p = \frac{\sqrt{3}x220\angle -30}{10\angle -36.87}$; $\boxed{I_p = 38.1\angle - 6.87°\ (A)}$

- ***Line current***

$I_L = \sqrt{3}I_p$;

$I_L = 66\ A$

- ***Let's calculate the absorbed power***

$P_a = \sqrt{3}V_1 I_L cos\varphi$;

$P_a = \sqrt{3}x220x66x0.8$;

$P_a = 34.843KW$

2.4 Comparing the Pa consumed in configuration a) and b)

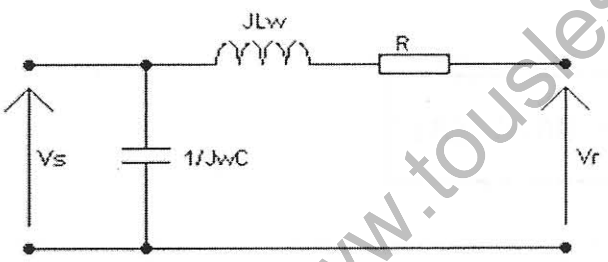
The power consumed in Y is equal to the power consumed in Δ.

2.5 Comparing the power consumed in configuration b) and c)

$$3P_{YY} = P_{Y\Delta}$$

EXERCISE 3

1. **Let's draw the electric circuit of this transmission.**



a) **Sending end voltage**

$V_S = V_r + I_2Z_2$ but $P = V_rI_2cos\phi$

$\rightarrow I_2 = \frac{P}{V_r cos\varphi}$; $I_2 = \frac{15000000}{66000x0.8}$; $I_2 = 284\angle -36.87°\ (A)$

$V_S = V_r + I_2Z_2$

$V_S = 66000 + 19319.66 + j13897.97$; $V_S = 81097.67\angle 9.86°\ (V)$

b) **Sending end current**

$I_s = I_1 + I_2$

But $I_1 = \frac{V_1}{X_C} = \frac{81097.67\angle 9.86}{1714.25\angle -90} = 47.3\angle 99.86°\ (A)$

$I_s = 47.3\angle 99.86° + 284\angle -36.57°$; $I_s = 251.66\angle -29.46°\ (A)$

c) **The sending end power factor**

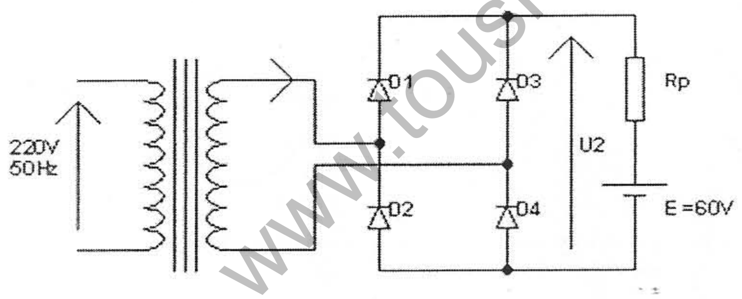
$Cos\phi_S = cos(9.86+29.46) = 39.32°$; Pf = 0.77

d) **The voltage regulation of the line**

$V_{reg} = \frac{V_s - V_r}{V_s} x100$;

$V_{reg} = \frac{81097.67-66000}{81097.67} x100$; $V_{reg} = 18.6\%$

EXERCISE 4



1- **Let's calculate the transformation ratio,**

knowing the conducting time is T/3

Then $= \frac{2\pi}{3}$; also $z = 2\theta_0 \rightarrow \theta_0 = \frac{\pi}{3}$

$Vcos\theta_0 = E$; $V = \frac{E}{cos\theta_0} = \frac{60}{0.5}$; V=120V

Then $m = \frac{V}{Vin} = \frac{120}{220}$; $m = 0.5455$

2) Calculation of the protective resistance R_p

V=E+R_pI → $R_p = \frac{V-E}{I}$;

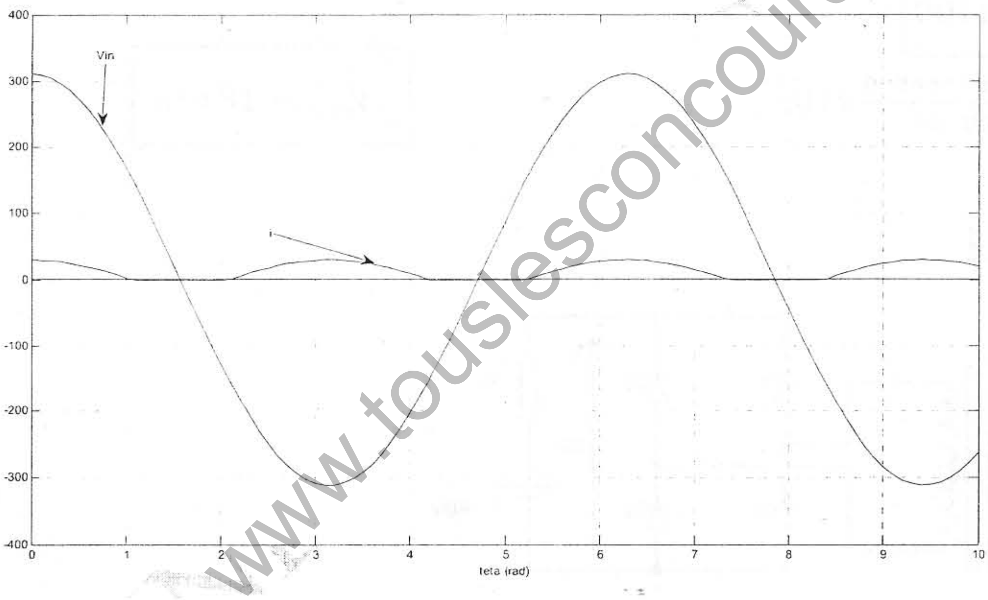
$R_p = \frac{120-60}{30}$; $R_p = 2\Omega$

3) Expression of I in function of ϕ where $\varphi \epsilon \left[-\frac{\pi}{3};\frac{\pi}{3}\right]$

The charging current flowing

$i = \frac{V cos\varphi - E}{R}$;

$i = 60(cos\varphi - 0.5)\ (A)$; for $cos\varphi > 0$; $else\ i = 0$



4) Calculating the average value of i

$$I = \frac{1}{\pi}\int_{\theta_0}^{\theta_1} i d\theta = \frac{1}{\pi}\int_{0}^{\pi/3} 60(cos\varphi - 0.5)d\theta$$

$$I = 13.1A$$

5) Calculating the charging time

T = Q/I = 500/13.1 ; T=38h10min

6) Calculating the effective value of i

$$I^2 = \frac{1}{\pi}\int_{\theta_0}^{\theta_1} i^2 d\theta$$;

$$I^2 = \frac{2}{\pi}\int_0^{\pi/3} 60^2((\cos\theta)^2 - cos\theta + \frac{1}{4})d\theta;$$

I=17.65 A

7) The efficiency of the charger

$$\eta = \frac{P_u}{P_u+P_c}x100$$;

where P_U =EI = 60x13.1 = 786W

$P_C = R.I^2 = 2x17.65^2 = 623W$

$$\eta = \frac{786}{786+623_c}x100;$$

η = 56%