Name : Danish Hayat
Student ID : 14566
Subject : ENA
Instructor : Dr Shahryaar Shafique
Examinations : Final
Date : 22nd june, 2020

Q1:- Assume that a 2000-K-W torbine-generator of 0.85 power factor operates at the rated load. An additional load of 300 KW at 0.8 power factor is added. what KVAR of Capacitor is requir-ed to operate the turbine generator but keep it from being overloaded ?

Sol:- Original Load:

$P_1 = 2000$ KW

$\cos\theta_1 = 0.85$

$\theta_1 = 31.79°$

$S_1 = \frac{P_1}{\cos\theta_1}$, $Q_1 = S_1 \sin\theta_1$

$Q_1 = 1239.5$ KVAR

$S_1 = 2352.94$ KVA

Additional Load:

$P_2 = 300$ KW

$\cos\theta_2 = 0.8$

$\theta_2 = 36.87^\circ$

$S_2 = \dfrac{P_2}{\cos\theta_2}$, $Q_2 = S_2 \sin\theta_2$

$Q_2 = 225$ KVAR

$S_2 = 375$ KVA

Total Load:

$S = S_1 + S_2$

$S = (P_1 + P_2) + j\,(Q_1 + Q_2)$

$S = P + jQ$

$P = 2000 + 300$

$P = 2300$ KW

$Q = 1239.5 + 225$

$Q = 1464.5$ KVAR.

Now,

The minimum operating P for a 2300 KW load and not exceeding the KVA rating of the generator is,

$\cos\theta = \dfrac{P}{S_1}$

$\cos\theta = \dfrac{2300 \times 10^3}{2352.94 \times 10^3}$

$\cos\theta = 0.9775$

$\theta = 12.177$

Now,

The maximum load KVAR for these conditions,

$Q_m = S_1 \sin\theta$

$Q_m = 2352.94 \sin(12.177^\circ)$

$Q_m = 496.313$ K VAR.

The Capacitor must supply the difference between the total loads KVAR (i.e Q) and the permissible generator KVAR (i.e, Qm)

thus,

$Q_c = Q - Q_m$

$Q_c = 1464.5 - 496.313$

$$\boxed{Q_c = 968.2 \text{ KVAR}}$$

Q2:- A balanced abc sequence, one line voltage of a balanced Y- connected Source is $V_{AB} = 180\angle -20^\circ$ V. If the Source is Connected to a Δ - Connected load of $20\angle 40^\circ\ \Omega$, find the phase and line currents.

Sol:- Assume ABC

Line voltage $V_{AB} = 180\angle -20^\circ V$.

$$Z_\Delta = 20 \angle 40^\circ\ \Omega$$

using formula.

$$V_L = \sqrt{3}\ V_P \angle 30^\circ \Rightarrow V_P = \frac{V_L}{\sqrt{3}\angle 30^\circ}$$

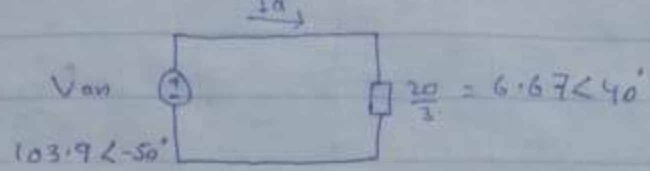
Phase voltage:-

$$V_{an} = \frac{180\angle -20^\circ}{\sqrt{3}} \cdot \angle -30^\circ = 103\cdot 9 \angle -50^\circ V$$

$$Z_Y = \frac{Z_\Delta}{3} = \frac{20\angle 40^\circ}{3} = 6\cdot 67 \angle 40^\circ \Omega.$$

Line current:-

$$I_a = \frac{V_{an}}{Z_\Delta/3} = \frac{103\cdot 9\angle -50^\circ}{6\cdot 67\angle 40^\circ}$$



$I_a = 15.57 \angle -90^\circ$ A

$I_b = I_a \angle -120^\circ = 15.59 \angle +150^\circ$ A

$I_c = I_a \angle +120^\circ = 15.59 \angle 30^\circ$ A

Phase Current:-

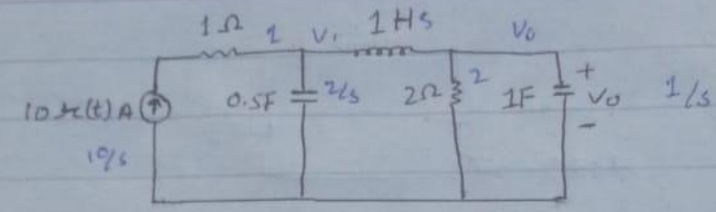
$$I_{AB} = \frac{15.57 \angle -90^\circ}{\sqrt{3}} \cdot \angle 30^\circ$$

$$= 9 \angle -60^\circ \text{ A}$$

$I_{BC} = I_{AB} \angle -120^\circ = 9 \angle -180^\circ$ A

$I_{CA} = I_{AB} \angle +120^\circ = 9 \angle 60^\circ$ A.

Q4:- Apply Laplace transform and Calculate the output voltage $V_o(t)$ in the circuit of figure below:



Sol: At Node 1,

$$\frac{\frac{10}{s} - V_1}{1} = \frac{V_1 - V_0}{s} + \frac{s}{2} V_0$$

$$\Rightarrow 10 = (s+1)V_1 + \left(\frac{s^2}{2} - 1\right)V_0 \rightarrow (1)$$

At Node 2,

$$\frac{V_1 - V_0}{s} = \frac{V_0}{2} + sV_0$$

$$\Rightarrow V_1 = V_0\left(\frac{s}{2} + s^2 + 1\right) \rightarrow (2)$$

substituting (2) into (1) gives

$$10 = (s+1)\left(s^2 + s/2 + 1\right)V_0 + \left(\frac{s^2}{2} - 1\right)V_0$$

$$= s\left(s^2 + 2s + 1.5\right)V_0$$

$$V_0 = \frac{10}{s(s^2 + 2s + 1.5)} = \frac{A}{s} + \frac{Bs + C}{s^2 + 2s + 1.5}$$

$10 = A\ (s^2 + 2s + 1.5) + Bs^2 + Cs$

$s^2 = 0 = A + B$

$s = 0 = 2A + C$

Constant $= 10 = 1.5A$.

$A = \frac{20}{3}$, $B = \frac{-20}{3}$, $C = -\frac{40}{3}$

$V_o = \frac{20}{3}\left[\frac{1}{s} - \frac{s+2}{s^2+2s+1.5}\right]$

$= \frac{20}{3}\left[\frac{1}{s} - \frac{s+1}{(s+1)^2 + 0.7071^2} - \right.$

$\left. 1.414 \frac{0.7071}{(s+1)^2 + 0.7071^2}\right]$

Taking the inverse Laplace transform finally yields.

$V_o(t) = \frac{20}{3}\left[1 - e^{-t}\cos 0.7071t - \right.$

$\left. 1.414e^{-t}\sin 0.7071t\right]$

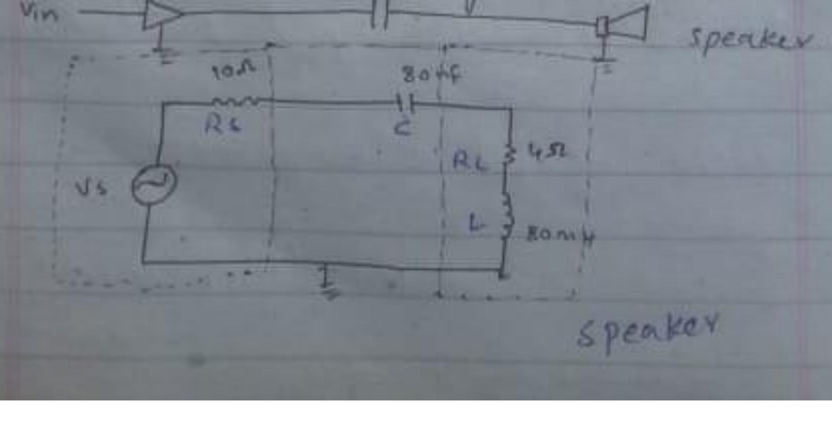
$u(t)$ V.

Q5:- For the Circuit given in figure below. the speaker works as load while the amplifier and the Capacitor act as the Source. To block dc current from amplifier, a Coupling Capacitor of 80 nF is used (see figure below)

Calculate the following:

(a) At what frequency is maximum power transfer to the speaker?

(b) If Vs = 5 vms, how much power is delivered to the Speaker at that amplifier Coupling Capacitor.



Sol:- (a) Consider the following data:-

The amplifyede and the Capacitor act as a Source. Hence the Source impedence,

$Z_s = R_s - jx_c$.

The speaker acts, as a load.

Hence the load impedence,

$Z_L = R_L + jx_L$.

The maximum power is transferred to the Speaker or load when the load impedence is equal to the complex Conjugate of the thevenin's impedance. In this circuit, the thevenin's impedance is equal to the Source impedance. Hence, maximum power is transferred to the Speaker when,

$Z_L = Z_S^*$

$R_L + jX_L = (R_S - jX_C)^*$

$R_L + jX_L = R_S + jX_C$

Equate the real & imaginary terms

$R_S = R_L$

$X_C = X_L$

substitute $\frac{1}{\omega C}$ for X_C & ωL

for X_L.

$X_C = X_L$

$\frac{1}{\omega C} = \omega L$

$1 = \omega^2 LC$

$\omega = \frac{1}{\sqrt{LC}}$

substitute the formula for angular frequency $2\pi f$ in place of ω

$\omega = \frac{1}{\sqrt{LC}}$

$$2\pi f = \frac{1}{\sqrt{LC}}$$

$$f = \frac{1}{2\pi\sqrt{LC}}$$

Now

substitute 80 nF for C

& 80 mH for L.

$$f = \frac{1}{2\pi\sqrt{(80\times10^{-3})(80\times10^{-9})}}$$

$$= \frac{1}{2(3.14)(80\times10^{-6})}$$

$= 1990.44586$

$= 2.044$ kHZ.

Thus, the frequency, f, at which maximum power transfer to the speaker is

$$\boxed{2.044 \text{ kHz}}$$

Q3:- Consider a load with value of $V_{ms} = 110 < 85^\circ V$. $I_{ms} = 0.4 < 15^\circ A$.

Calculate the following:

(a) The complex and apparent powers.

(b) The real & reactive powers, and

(c) The power factor and the load impedance.

Sol:- Given:

$V_{ms} = 110 < 85^\circ V$.

$I_{ms} = 0.4 < 15^\circ V$.

(a) The complex power is

$S = V_{ms} \bar{I}_{ms}$

$S = (110 < 85^\circ)(0.4 < -15^\circ)$

$S = 110 \times 0.4 < (85^\circ - 15^\circ)$

$$\boxed{S = 44 < 70^\circ VA}$$

The apparent power is

$S = |S|$

$$\boxed{S = 44 VA}$$

(b) Express the Complex power in rectangular form.

$S = 44 \angle 70^\circ$

$S = 44 \left[\cos(70^\circ) + j \sin(70^\circ)\right]$

$S = 44 \left[0.3420 + j 0.9397\right]$

$S = 15.05 + j 41.35$

Since $S = P + jQ$.

The real power is

$\boxed{P = 15.05 \text{ W}}$

The reactive power is

$\boxed{Q = 41.35 \text{ VAR}}$

(C) The power factor is.

$Pf = \cos(70^\circ)$

$\boxed{Pf = 0.342}$ (Lagging)

The power factor is lagging as the reactive

power is positive.
The load impedance is

$$Z = \frac{V}{I}$$

$$V = \sqrt{2}\, V_{rms}$$

$$I = \sqrt{2}\, I_{rms}$$

$$Z = \frac{110\sqrt{2}\angle 85^\circ}{0.4\sqrt{2}\angle 15^\circ}$$

$$Z = 275\angle 70^\circ\ \Omega$$

$$Z = 275\left[\cos(70^\circ) + j\sin(70^\circ)\right]$$

$$Z = 275\left[0.342 + j\,0.9397\right]$$

$$\boxed{Z = 94.05 + j\,258.4\ \Omega}$$