Course Title : Electrical Network Analysis

Module : 4th

Instructor : Dr. Sharyar

Name : Farhan Ali

ID : 14873

Signature : Farhan Ali

Q2:-

A balanced abc sequence, one line voltage of a balanced Y-connected source is $V_{AB} = 180\angle -20°$ V. if the source is connected to a Δ-connected load of $20\angle 40°\,\Omega$. Find the phase and line currents.

Solution:-

Line voltage $V_{AB} = 180\angle -20°$ V

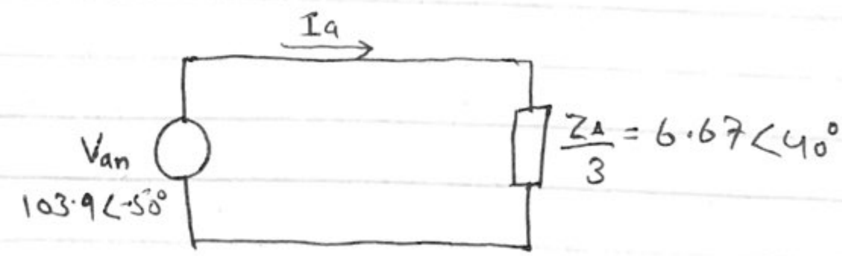
$$Z_\Delta = 20\angle 40°\,\Omega$$

$$V_L = \sqrt{3}\, V_p \angle 30° \Rightarrow V_p = \frac{V_L}{\sqrt{3}\angle 30°}$$

Phase voltage

$$V_{an} = \frac{180\angle -20°}{\sqrt{3}} \cdot \angle -30° = 103.9\angle -50° \text{ V}$$

$$Z_Y = \frac{Z_\Delta}{3} = \frac{20\angle 40°}{3} = 6.67\angle 40°\,\Omega$$



Line Current:

$$I_a = \frac{V_{an}}{Z_a/3} = \frac{103.9\angle -50^\circ}{6.67\angle 40^\circ}$$

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

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

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

Phase Current:

$$I_{AB} = \frac{15.57\angle -90^\circ}{\sqrt{3}} . \angle 30^\circ = 9\angle -60^\circ A$$

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

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

Q 1:-

Assume that a 2000-KW Turbine-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 Capacitors is required to operate the Turbine generated but keep it from being overloaded.

Solution:-

Original Load:

$$P_1 = 2000\,KW \quad \cos\phi_1 = 0.85 \rightarrow \phi_1 = 31.79^\circ$$

$$S_1 = \frac{P_1}{\cos\phi_1} = 2352.94\,KVA$$

$$Q_1 = S_1 \sin\phi_1 = 1239.5\,KVAR$$

Additional load:-

$$P_2 = 300\,KW \quad \cos\theta_2 = 0.8 \rightarrow \theta_2 = 36.87^\circ$$

$$S_2 = \frac{P_2}{\cos\theta_2} = 375\,KVA$$

$Q_2 = S_2 \sin\theta_2 = 225$ KVAR

Total load :-

$S = S_1 + S_2 = (P_1 + P_2) + j(Q_1 + Q_2) = P + jQ$

$P = 2000 + 300 = 2300$ KW

$Q = 1239.5 + 225 = 1464.5$ KVAR

the minimum operating pf for a 2300kW load and not exceeding the KVA rating of the generator is:

$$\cos\theta = \frac{P}{S_1} = \frac{2300}{2352.94} = 0.9775$$

or $\theta = 12.177^\circ$

the maximum load KVAR for this condition is

$$Q_n = S_1 \sin\theta - 2352.94 \sin(12.177^\circ)$$

$$Q_n = 496.313 \text{ KVAR}$$

Q 1:-

Assume that a 2000-KW Turbine-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 Capacitors is required to operate the Turbine generated but keep it from being overloaded.

Solution:-

Original Load:

$P_1 = 2000 KW \quad \cos\Phi_1 = 0.85 \rightarrow \Phi_1 = 31.79°$

$S_1 = \frac{P_1}{\cos\Phi_1} = 2352.94 KVA$

$Q_1 = S_1 \sin\Phi_1 = 1239.5 KVAR$

Additional Load:-

$P_2 = 300 KW \quad \cos\Theta_2 = 0.8 \rightarrow \Theta_2 = 36.87°$

$S_2 = \frac{P_2}{\cos\Theta_2} = 375 KVA$

$Q_2 = S_2 \sin\theta_2 = 225$ KVAR

Total load:-

$S = S_1 + S_2 = (P_1 + P_2) + j(Q_1 + Q_2) = P + jQ$

$P = 2000 + 300 = 2300$ KW

$Q = 1239.5 + 225 = 1464.5$ KVAR

the minimum operating pf for a 2300 kW load and not enceeding the KVA rating of the generator is:

$$\cos\theta = \frac{P}{S_1} = \frac{2300}{2352.94} = 0.9775$$

or $\theta = 12.177°$

the maximum load KVAR for this condition is

$Q_n = S_1 \sin\theta - 2352.94 \sin(12.177°)$

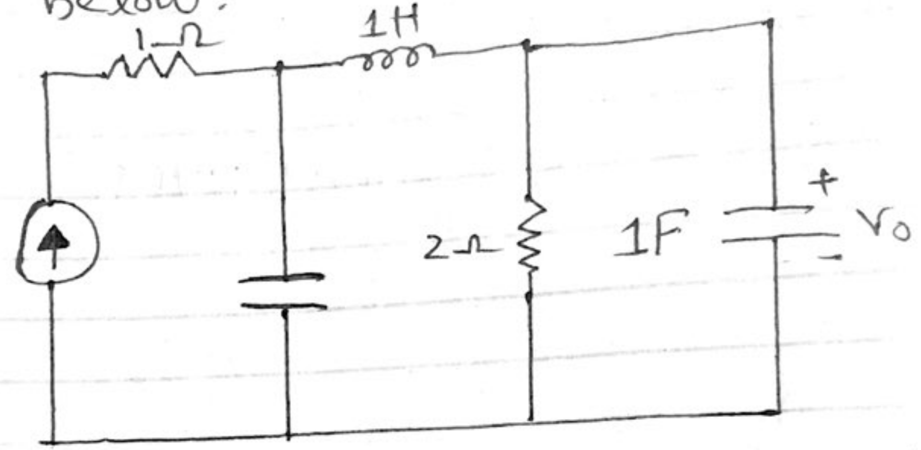
$Q_n = 496.313$ KVAR

the capacitor must supply the difference between the total load KVAR and the permissible generator KVAR.

Thus.-

$$Q_c = Q - Q_n = 968.2 \text{ KVAR}.$$

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



At node 1

$$\frac{\frac{10}{S}-V_1}{1}-\frac{V_1-V_o}{S}+\frac{S}{2}V=10=(S+1)V_1$$

$$\Rightarrow +\left(\frac{S^2}{2}-1\right)V_o$$

At node 2,

$$\frac{V_1-V_o}{S}=\frac{V_o}{2}+SV_o \rightarrow V_1=V_o\left(\frac{S}{2}+S^2+2\right)$$

Substituting (2) into (1)

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

$$s\left(\frac{s^2-1}{2}\right)V_o = s(s^2+2s+1.5)V_o$$

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

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

$$s^2 = 0 = A+B$$
$$s = 0 = 2A+C$$

Constant $= 10 = 1.5A \rightarrow A = 20/3$, $B = \frac{-20}{3}$

$$C = -40/3$$

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

$$\frac{s+1}{(s+1)^2+0.7071^2} - \frac{1.414\,0.7071}{(s+1)^2+0.7071}$$

Taking the inverse Laplace Transform

$$v_o(t) = \frac{20}{3}\left[1 - e^{-t}\cos 0.7071t - 1.414e^{-t}\sin 0.7071t\right]u(t)\,V$$

Q3:-

Consider a load with value of $V_{rms} = 110 \angle 85^\circ V$, $I_{rms} = 0.4 \angle 15^\circ A$. Calculate the following.

a) the complex and apparent powers.

b) the real reactive powers and

c) the power factor and the load impedence.

Solutions:-

Part (a):-

The complex power is

$$S = V_{RS} \, I_{RS}$$

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

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

$$S = 44 \angle 70^\circ \, VA$$

The app arent power is

$$S = |S|$$

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

Part (b):-

Express the Complex power in rectangular form.

$S = 44 \angle 70^\circ$

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

$S = 44[0.3420 + j\,0.9397]$

$S = 15.05 + j\,41.35$

Since $S = P + jQ$

the real power is

$P = 15.05\,W$

the reactive power is

$Q = 41.35\,VAR.$

Part (c):-

the power factor is

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

$pf = 0.342$ (lagging)

the power factor is lagging as the reactive power is positive the load impedence is

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

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

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

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

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

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

$$Z = 275 [0.342 + j0.9397]$$

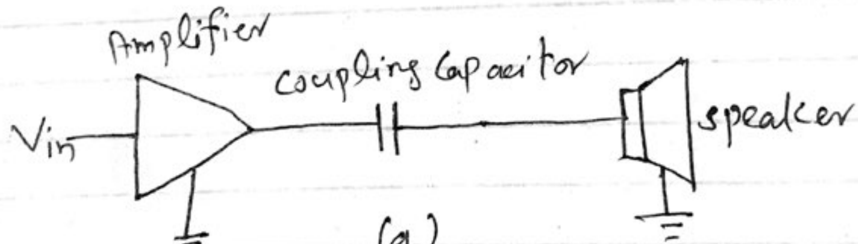
$$Z = (94.05 + j25.4)\Omega .$$

Q5:-

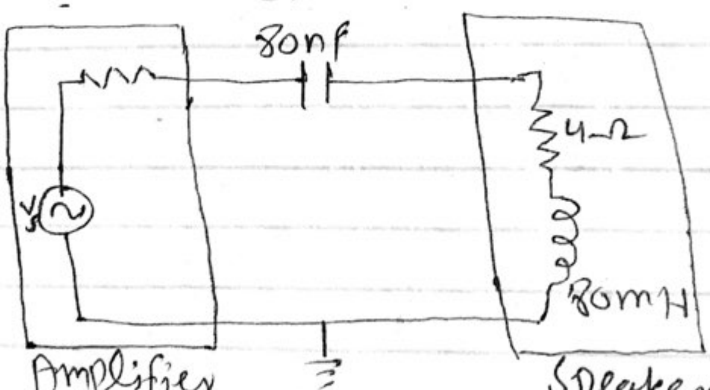
For the given circuit in Figure below. the speaker works as load while the amplifier and the Capacitor act as the Source. to block dc current from an amplifier a Coupling Capacitor of 80 nF is used Calculate the following.

a) At what frequency is maximum power Transfor for the Speaker?

b) if $V_S = 5 V_{rms}$ how much power is deliverd to the speaker.



(a)



Solution:-

Coupling Capacitor = 80nF

V_S = 5 Vrms

Source impedance, $Z_S = R_S - jX_1$

Load impedance, $Z_L = R_L + jX_2$

For maximum load tranfer

$Z_L = Z_S \longrightarrow R_S = R_L,\ X_C = X_L$

$$X_C = X_L \rightarrow \frac{1}{\omega C} = \omega L$$

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

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

$$\boxed{f = 2.055\ \text{kHz}}$$

(b) $P = \left[\frac{V_S}{(10+4)}\right]^2 4 = \left(\frac{5}{14}\right)^2 4 = \frac{25}{196}\cdot 4$

$$\boxed{P = 8.52}\ \text{mW}$$