-: COURSE DETAILS :-

Course Tittle :- ENA

Instructor Name :- Sir Shahrayar

-: STUDENT DETAILS :-

Name :- Naveed Alam

Student ID No. :- 14965

Student Signature :- Naveed

QNO.(1) :-

4 Assume that a 200-KW turbime-generator of 0.85 power factor Operates at the rated load. An additional load of 300 KW at 0.8 power factor is add. What KVAR of capacitors is required to Operate the turbime generator but keep it form being Overloaded?

Ans:- Solution:-

Original load :-

$$P_1 = 2000\,KW, \quad \cos\theta_1 = 0.85$$

$$\rightarrow \theta_1 = 31.79^\circ$$

$$S_1 = \frac{P_1}{\cos\theta_1} = 2352.94\ KVA.$$

$$Q_1 = S_1 \sin\theta_1 = 1239.5\ KVAR$$

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 2300 KW load and not exceeding the KVA rating of the generator is

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

or $\theta = 12.177°$

The maximum load KVAR for this condition is

$Q_m = S_1 \sin\theta = 2352.94 \sin(12.177°)$

$Q_m = 496.313$ KVAR.

The Capacitor must supply the differente between the total load KVAR (ie Q) and the permissble generator KVAR (i.e Q_m).
Thus,

$$Q_c = Q - Q_m = 968.2 \text{ KVAR}$$

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

Q NO. (2) :-

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 $V_{AB} = 180\angle -20° V$

$$Z_\Delta = 20\angle 40° \Omega$$

Using formula:-

$$V_L = \sqrt{3}\, V_p \angle 30°$$

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

Phase voltage:-

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

$$V_{an} = 103.9\angle -50° V.$$

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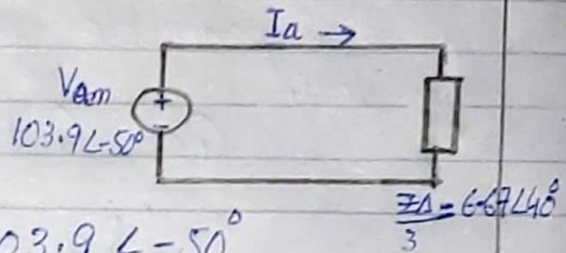
$$Z_Y = \frac{Z_\Delta}{3} = \frac{20\angle -40^\circ}{3} = 6.67\angle 40^\circ\ \Omega.$$

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 :-

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

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

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

Q NO. 3:-

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

ⓐ:- The complex and apparent power.
ⓑ:- The real and reactive powers, and
ⓒ:- The power factor and the load impedance.

Solution:-

Step no. One:-

$$V_{rms} = 110\angle 85^\circ V,$$
$$I_{rms} = 0.4\angle 15^\circ A.$$

Step no. two:-

The complex power is

$$S = V_{rms} \times I_{rms}$$

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

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

The apparent power is

$$S = |S|$$
$$S = 44 VA$$

Step No. Three :-

Express the complex power in rectangular form.

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

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

$$S = 44[0.3420 + j0.9397]$$

$$S = 15.05 + j41.35$$

Since $S = P + jQ$

The real power is

$$P = 15.05\ W$$

The reactive power is

$$Q = 41.35\ VAR$$

Step No. Four :-

The power factor is

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

$$Pf = 0.342\ (\text{lagging})$$

The power factor is lagging as the reactive power is positive

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

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

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

Step No. Five :-

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

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

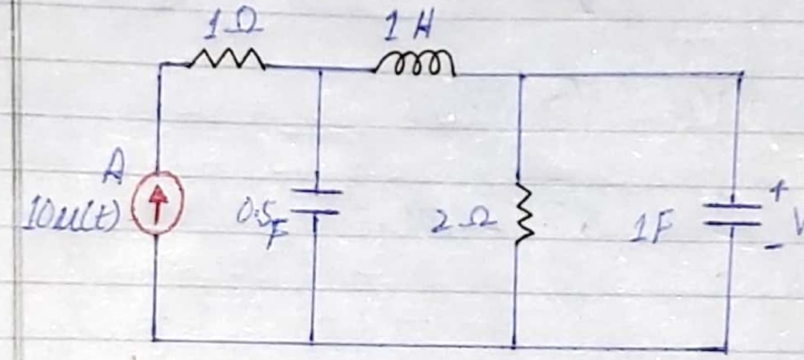
$Z = 275[\cos(70^\circ) + j\sin(70^\circ)]$

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

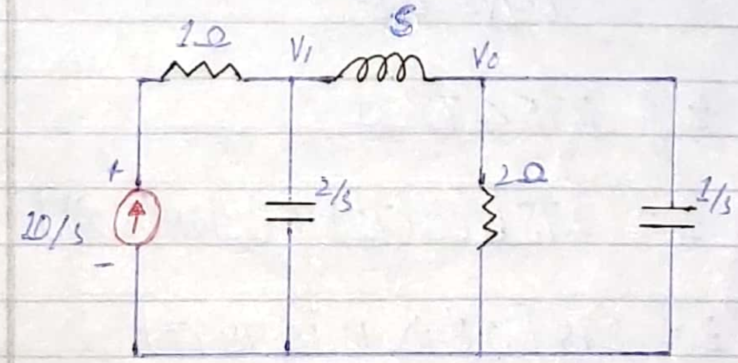
$Z = (94.05 + j258.4)\ \Omega$

Q No. 4 :-

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



→ The s-domain version of the circuit is shown below:-



At node 1

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

$$\longrightarrow \quad 10 = (s+1)V_1 + \left(\frac{s^2}{2} - 1\right) V_o \quad \longrightarrow (1)$$

At node 2,

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

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

Substituting (2) into (1) gives:-

$$10 = (s+1)(s^2 + s/2 + 1)\,V_0 + \left(\frac{s^2}{2} - 1\right)V_0 = s(s^2 + 2s + 1.5)V_0$$

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

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

s^2 : $0 = A + B$

s : $0 = 2A + C$

Constant : $10 = 1.5A \longrightarrow A = 20/3,\; B = -20/3$

$C = -40/3$.

$$V_0 = \frac{20}{3}\left[\frac{1}{s} - \frac{s+2}{s^2 + 2s + 1.5}\right]$$

$$V_0 = \frac{20}{3}\left[\frac{1}{s} - \frac{s+1}{(s+1)^2 + 0.7071^2} - 1.414\frac{0.7071}{(s+1)^2 + 0.7071^2}\right]$$

Taking the inverse laplace transform finally yields

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

Q NO. 5:-

For the circuit given below, the speaker works as load while the amplifier and the capacitor act as the source. To back dc current from an amplifier, a coupling capacitor of 80 mF is used (see figure below). Calculate the following:-

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

(b):- If $V_s = 5\,V_{rms}$, how much power is delivered to the speaker at that -

Solution:-

Given data:-

$V_s = 5\,V_{rms}$

$C = 80\,mF$

$L = 80\,mF$

Source impedence $= Z_1 = R_s + jx_1$

Load impedence $= Z_L = R_L + jx_2$

Form maximum transfor

$Z_L = Z_S$ means

$R_L = R_S$ and $X_L = X_C$

$X_C = X_L$

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

Re-arranging

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

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

$$f = \frac{1}{2(3.14)\sqrt{(80\times10^{-3})(80\times10^{-9})}}$$

$$f = \frac{1}{0.0005024}$$

$f = 1990.44$ Hz

Part (B):-

As we know that

Power deliver $= P = \left(\frac{V}{R_{eq}}\right)^2 (R_L)$

$$P = \left(\frac{V_s}{R_1 + R_2}\right)^2 (R_2)$$

$$P = \left(\frac{5}{10+4}\right)^2 (4)$$

$$P = 0.5104 \text{ w}$$

$$\boxed{P = 510 \text{ mW}}$$