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Sub: Electric Network Analysis

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Date: 22 June 2020

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Module: Final Exam

Q1

Assume that a 2000k.w turbine generator of 0.85 power factor operates.... but keep it from being overloaded?

Ans

Original Load:

$P_1 = 2000 kW$, $\cos\theta_1 = 0.85 \rightarrow \theta_1 = 31.79^\circ$

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

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

-Additional load

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

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

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

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

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

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

The capacitor must supply the difference between the total load kVAR (i.e Q) and the Permissible generator kVAR (i.e Q_n)

Thus

$$Q_c = Q - Q_n = 968.2 \text{ kVAR}$$

Q2

A balanced abc sequence, one line voltage of a balanced ...... Find Phase and line current?

Ans

Sol

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

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

Using formula

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

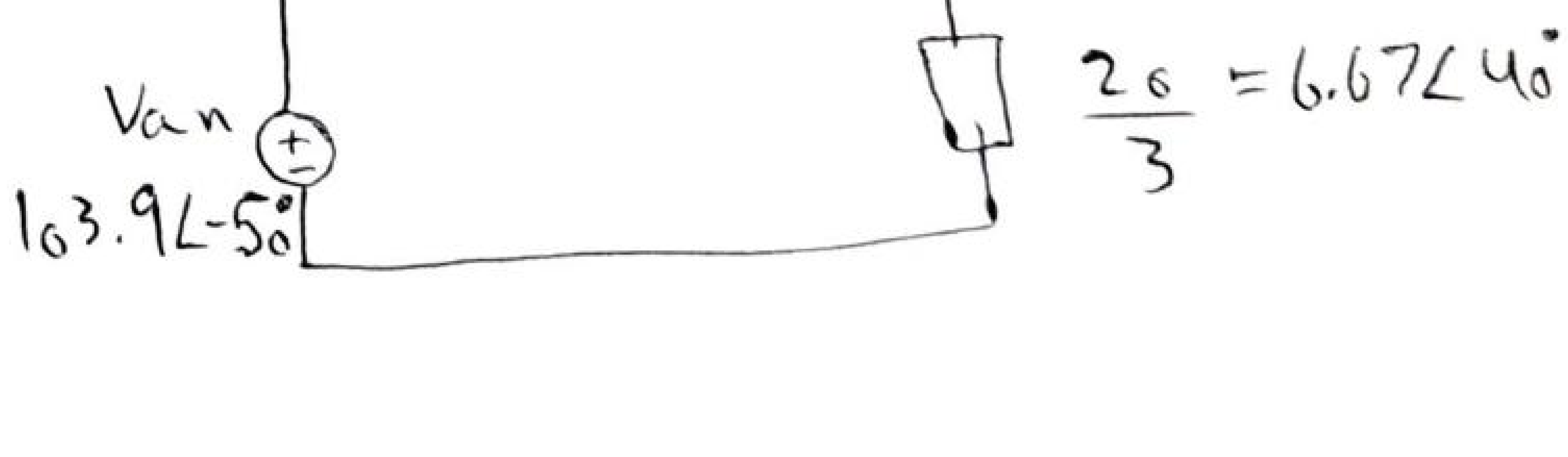
Phase voltage

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

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

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

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

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

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

Q3

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

a) The complex and apparent Power

b) The real and reactive Power

c) The Power factor and the load impedance

Ans

Sol:

Given: $V_{rms} = 110\angle 85^\circ V$

$I_{rms} = 0.4\angle 15^\circ A$

a) The complex power is

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

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

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

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

The apparent power is

$S = |S|$

$\therefore S = 44VA$

b) Express the complex in rectangular form

$S = 44\angle 70^\circ$

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

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

$S = 15.05 + j\,41.35$

Since $S = P + jQ$

The real power is

$\therefore P = 75.05\,W$

The reactive power is

$\therefore Q = 41.35\,VAR$

c)

The power factor is

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

$\therefore pf = 0.342$ (lagging)

The power factor is lagging as the reactive power is positive The load impedance is

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

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

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

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

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

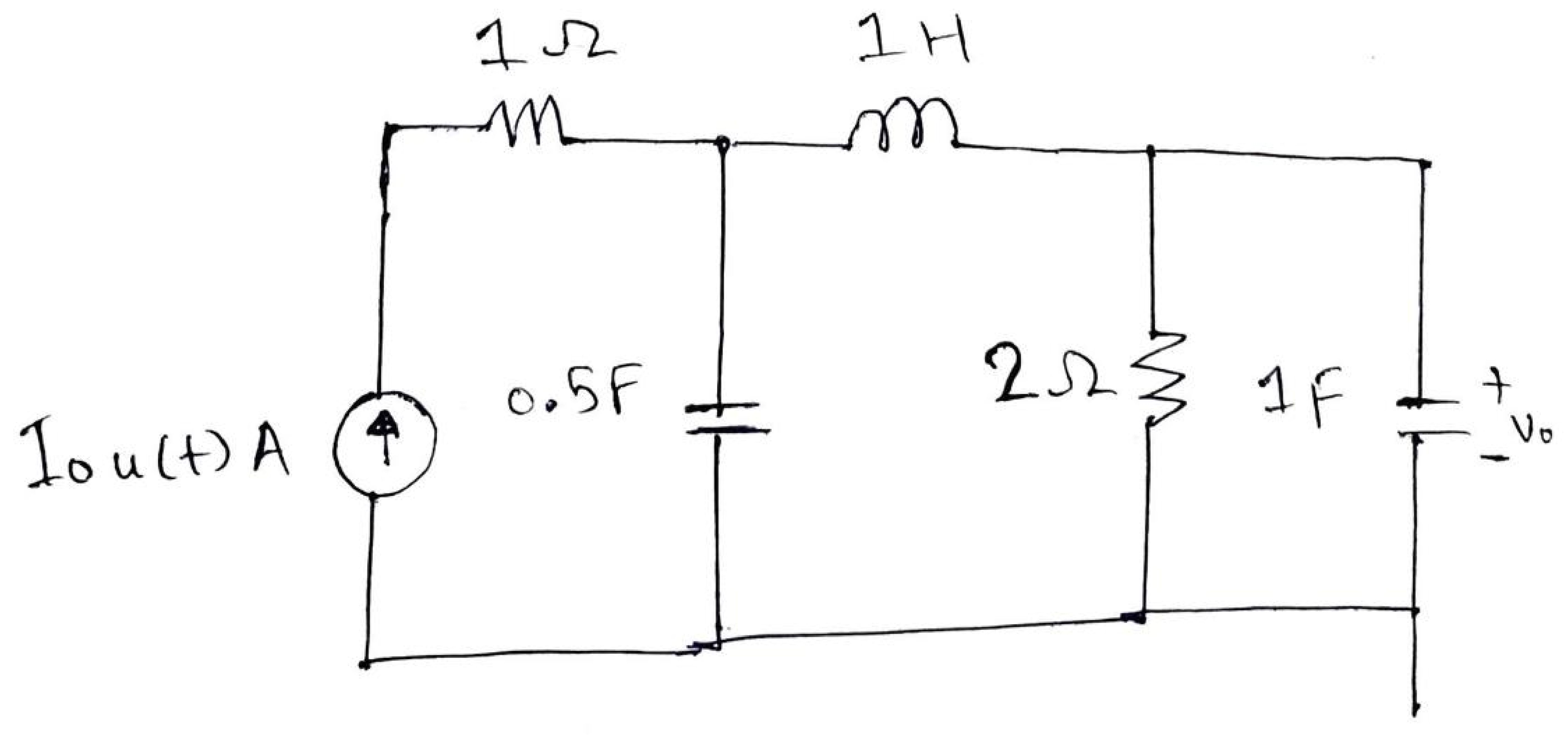
$$Z = 275[\cos(70^\circ) + j\sin(70^\circ)]$$

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

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

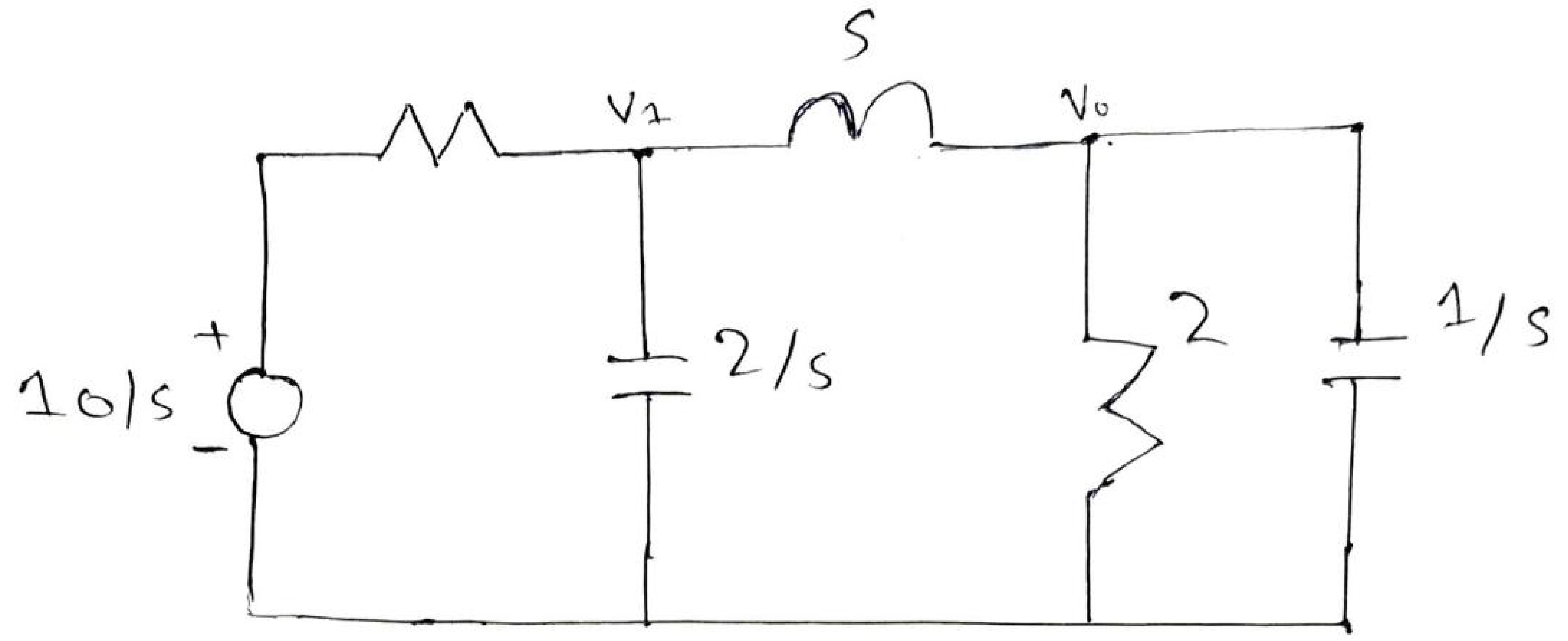
Q4

Apply Laplace transform and calculate the output voltage $V_o(t)$ in the circuit.



Ans

The s-domain version of the circuit is shown below.



At node 1.

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

At node 2.

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

Substituting (2) into (1) gives

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

$$s(s^2 + 2s + 1.5)V_o$$

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

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

s^2: $\quad 0 = A + B$

s: $\quad 0 = 2A + C$

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

$$C = -40/3$$

$$V_o = \frac{20}{3}\left[\frac{1}{s} - \frac{s+2}{s^2+2s+1.5}\right] = \frac{20}{3}\left[\frac{1}{s} - \frac{s+1}{(s+1)^2+0.7071^2} - 1.414\,\frac{0.7071}{(s+1)^2+0.7071^2}\right]$$

Taking the inverse laplace transform finally yields

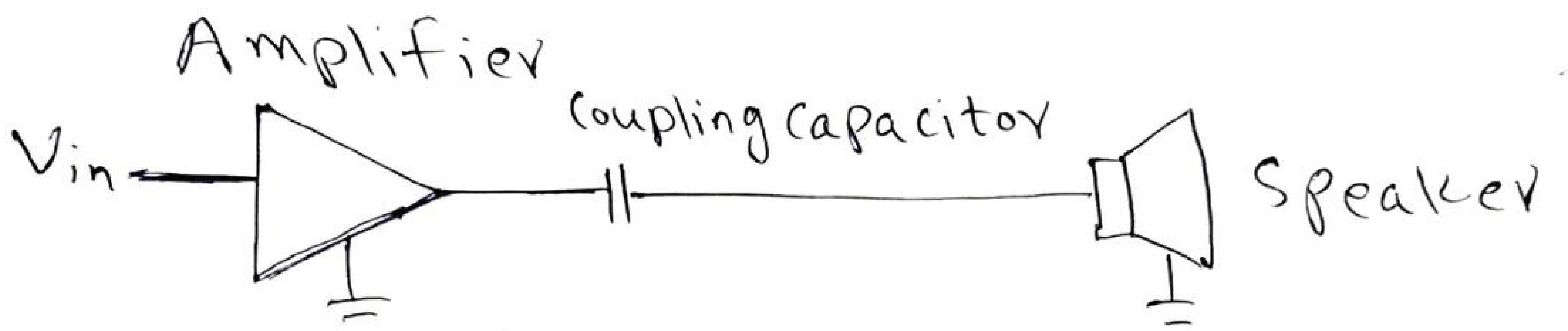
$$V_o(t) = \frac{20}{3}\left[1 - e^{-t}\cos 0.7071t - 1414e^{-t}\sin 0.7071t\right]u(t)\,V$$

Q5

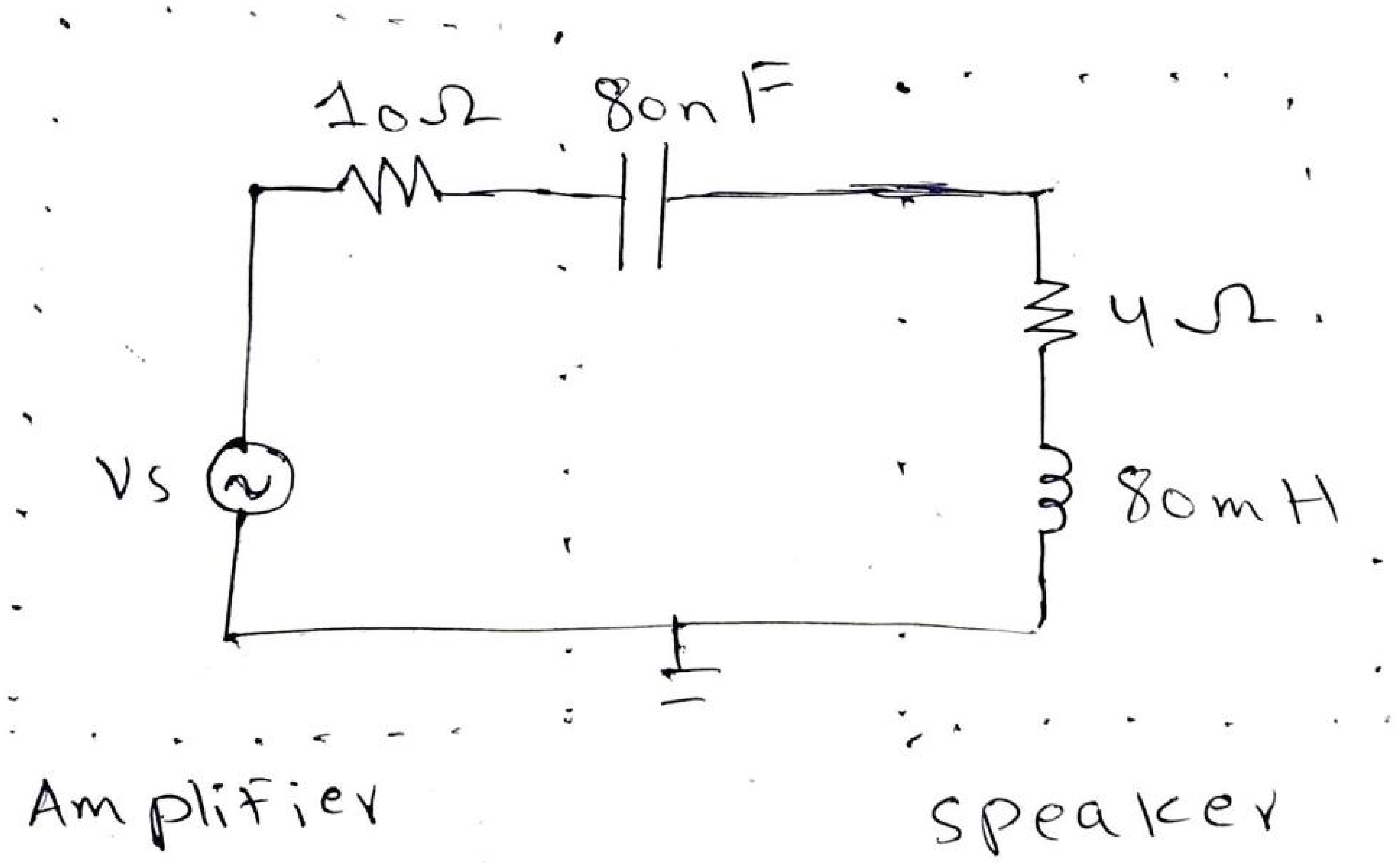
For the circuit given below .....
calculate the following

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

b) If Vs = 5 Vrms how much power is delivered to the speaker at that



(a)



Ans (a)

The amplifier and the capacitor act as a source and the speaker acts as load

so

Source impedance, $Z_S = R_S - jX_C$

load impedance, $Z_L = R_L + jX_L$

Maximum Power when

$$Z_S = Z_L$$

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

so

$$R_S = R_L$$

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

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

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

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

$$= 1990.44586$$

$$= 2.044 \text{ KHZ}$$

Thus the frequency f at which maximum Power transfer to the Speaker is 2.044 kHz

b) A frequency of f = 2.044 kHz the reactive power are cancelled because they are in series. So to find Power

$$P = (I_s)^2 R_L$$

$$= \left[\frac{V_s}{(R_s+R_L)}\right]^2 R_L$$

$$= \left[\frac{5}{70+4}\right]^2 4$$

$$= 0.51020 \text{ W}$$

$$= 510.20 \text{ mW}$$

The Power P delivered to the Speaker is

$$P = 510.20 \text{ mW}$$