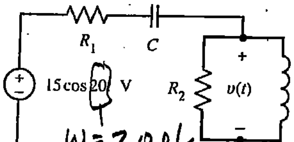
P 10.5-9 Figure P 10.5-9 shows an ac circuit represented in both the time domain and the frequency domain. Suppose

$$Z_1 = 15.3\angle -24.1°\ \Omega \quad \text{and} \quad Z_2 = 14.4\angle 53.1°\ \Omega$$

Determine the voltage $v(t)$ and the values of R_1, R_2, L, and C.



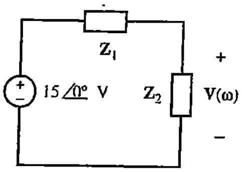


Figure P 10.5-9

HW 18, #1, Due Wed 4/21

ω Radians/sec for this circuit is 20. Freq (Hz) $= \frac{\omega}{2\pi}$

Z_1 is $R_1 + \frac{1}{j\omega C}$

Z_2 is $R_2 \| j\omega L = \frac{(R_2)(j\omega L)}{R_2 + j\omega L}$

$Z_1 = 15\angle -24.1 = \boxed{15\cos(-24.1)} + \boxed{j15\sin(-24.1°)}$

$R_1 + jX, \quad X = \frac{1}{j\omega C}$

so $\boxed{R_1 = 13.69\ \Omega}$

$X = 15(-0.4083) = -6.125$

$jX = -j6.125\ \Omega$

$jX = \frac{1}{j\omega C} = -j6.125$

$\frac{-j}{\omega C} = -j6.125, \quad \omega C = \frac{1}{6.125}, \quad C = \frac{1}{6.125(20)} = 0.0082$ F

Check $\frac{1}{\omega C} = \frac{1}{(20)(8163\times 10^{-6})} = 6.125$ ✓ $\quad \boxed{C = 8163\ \mu F}$

$Z_2 = 14.4\angle 53.1 = 14.4[\cos(53.1) + j\sin(53.1)] = 8.646 + j11.52$

Check $\sqrt{(8.646)^2 + (11.52)^2} = 14.40$ ✓

Im; 14.40; 11.52; ATAN( ) = 53.1° ✓; 8.646

Define $Y_2 = \frac{1}{Z_2}$

$Y_2 = \frac{1}{Z_2} = \frac{1}{R_2} + \frac{1}{j\omega L} = \frac{1}{14.4\angle 53.1} = \frac{1\angle -53.1}{14.4}$ (Real; Imag)

$Y_2 = 0.0694\angle -53.1 = 0.0694[\cos(-53.1) + j\sin(-53.1)]$

$Y_2 = 0.0694[0.600 - j0.800] = 0.04164 - j0.0555$

So Real part of Y_2 is 0.04164, Imag part of Y_2 is $-j0.0555$

So $R_2 = 1/0.04164 = 24.0\ \Omega$, $\frac{1}{j\omega L} = -j0.0555$, $0.0555\omega L = 1$, $L = \frac{1}{0.0555(20)} = 0.901$ H

Check $R \| j\omega L = \frac{j\omega RL}{R + j\omega L} = \frac{j(20)(24)(0.901)}{24 + j18.02} = \frac{j432.5}{30\angle 36.9°} = 14.4\angle 90-36.9 = 14.4\angle 53.1°$ ✓

P 10.5-18 Determine the steady-state current $i(t)$ for the circuit shown in Figure P 10.5-18.

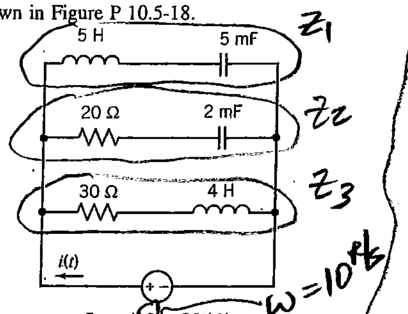


Figure P 10.5-18

$5\angle 30°$ Volts

HW 18, #C

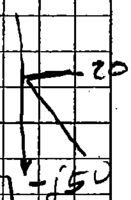
$$Z_1 = j\omega 5 + \frac{1}{j\omega(5\times10^{-3})}$$
$$= j\omega 5 - j\left[\frac{200}{\omega}\right] = j50 - j20 = j30\,\Omega = 30\angle 90°$$

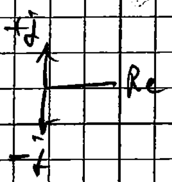
$$Z_2 = 20 + \frac{1}{j\omega(2\times10^{-3})}$$
$$= 20 - j\left[\frac{0.5\times10^3 = 500}{\omega}\right] = 20 - j50$$

$$Z_3 = 30 + j\omega 4 = 30 + j40 = 50\angle 53.1$$

Convert each Z to polar form and find the current passing through each Z

$$Z_1 = 30\angle 90°, \quad Z_2 = \sqrt{20^2 + 50^2}\angle \tan^{-1}\frac{-50}{20} = 53.9\angle -68.2°$$





$$\tilde{I}_{TOT} = \left[5\angle 30\right]\left[\frac{1}{30\angle 90} + \frac{1}{53.9\angle -68.2} + \frac{1}{50\angle 53.1}\right]$$
$$= 0.1667\angle(30-90) + 0.0928\angle 30+68.2$$
$$+ 0.100\angle 30-53.1$$

$$\tilde{I}_{TOT} = 0.1667\angle -60° + 0.0928\angle 98.2° + 0.1\angle -23.1°$$
$$0.0834 - j0.1444 \quad -0.0132 + j0.0919 \quad + 0.09198 - j0.03923$$
$$= 0.1662 - j0.09137 = \sqrt{0.1662^2 + 0.0917^2}\angle \tan^{-1}\left(\frac{0.0917}{0.1662}\right)$$

$$I_{TOT} = 0.1897\angle -28.9°\ A$$

P 10.5-19 Determine the steady-state voltage $v(t)$ for the circuit shown in Figure P 10.5-19.

HW 18, #3

$\omega = 5$ R/s

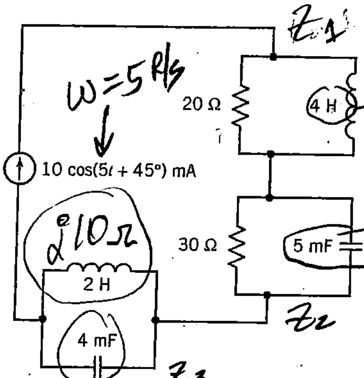


Figure P 10.5-19

$j\omega 4 = j20\,\Omega$

$\dfrac{1}{j\omega(5\times10^{-3})} = \dfrac{0.2\times10^{3}}{j5} = -j\dfrac{200}{5} = -j40\,\Omega$

$\frac{5}{4}$ RATIO

$\dfrac{1}{j\omega(4\times10^{-3})} = \dfrac{0.25\times10^{3}}{j\omega} = -j\dfrac{250}{5} = -j50\,\Omega$

Z_1

$20\,\Omega \,||\, j20 = \dfrac{20(j20)}{20+j20} = \dfrac{j20}{1+j} = \dfrac{20\angle 90^\circ}{\sqrt{2}\angle 45^\circ} = \boxed{\dfrac{20}{\sqrt{2}}\angle 45^\circ\ \Omega}$

Z_2 $\quad 30\,\Omega \,||\, (-j40) = \dfrac{(30)(-j40)}{30-j40} = \dfrac{-j1200}{50\angle -53.1^\circ} = \dfrac{1200\angle -90}{50\angle -53.1^\circ}$

$Z_2 = 24\angle -90+53.1 = \boxed{24\angle -36.9^\circ\ \Omega}$

$Z_3 = j10 \,||\, (-j50) = \dfrac{(j10)(-j50)}{j10-j50} = \dfrac{500}{-j40} = \dfrac{j500}{40} = \boxed{j12.5\,\Omega}$

KUL, $-\tilde{V} + \underset{\text{Amps}}{10\angle 45^\circ}\left[Z_1+Z_2+Z_3\right] = 0$

$\tilde{V} = \underset{\text{mA}}{10\angle 45}\left[Z_1+Z_2+Z_3\right]$

$\dfrac{20}{\sqrt{2}}\angle 45^\circ + 24\angle -36.9 + 12.5\angle 90^\circ$

$= 14.14(0.7071 + j0.7071) + 24[0.800 - j0.600] + j12.5$

Gather terms $(Z_1+Z_2+Z_3) = [10 + 19.2] + j[10 - 14.4 + 12.5]$

$= 29.2 + j120.6\ \Omega$

$= 124.1\angle 76.4^\circ$

$\tilde{V} = \left[\underset{\text{Amps}}{0.01\angle 45}\right]\left[124\angle 76.4\right]$

$= 1.24\angle 121.4^\circ$

P 10.5-24 When the switch in the circuit shown in Figure P 10.5-24 is open and the circuit is at steady state, the capacitor voltage is

$$v(t) = 14.14 \cos(100t - 45°) \text{ V}$$

$\omega = 100$ R/S

When the switch is closed and the circuit is at steady state, the capacitor voltage is

$$v(t) = 17.89 \cos(100t - 26.6°) \text{ V}$$

Determine the values of the resistances R_1 and R_2.

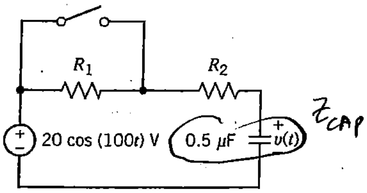


Figure P 10.5-24

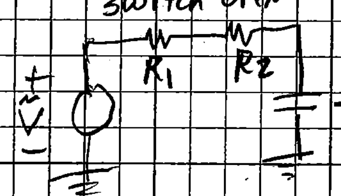
HW 18, ~~#4~~

$$Z_{CAP} = \frac{1}{j\omega C} = \frac{1}{j(100)(0.5\times10^{-6})}$$

$$Z_{CAP} = \frac{10^6}{j50} = = \frac{100\times10^4}{j50} = -j20000$$

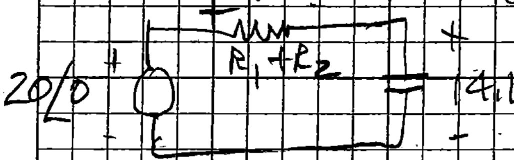
$$= -j20\text{ K}\Omega$$

switch OPEN



$\hat{V}_{CAP} = 14.14\angle -45°$ V.

Switch Open



$\tilde{Z}_{CAP} = -j20\text{K}\Omega$, so $\tilde{I}_{CAP} = \dfrac{14.14\angle -45°}{20\text{K}\Omega\angle -90°}$ minus

$\tilde{I}_{CAP} = \tilde{I}_{LOOP}$

$= 0.707\angle 45°$ mA milliamps

Now $\underbrace{V_{R1R2}}_{\text{both}} = [20\angle 0 - 14.14\angle -45°] = \tilde{I}_{CAP}(R_1+R_2)$

$$(R_1+R_2) = \frac{V_{R1R2}}{I_{CAP}} = \frac{20-[10-j10]}{0.707\angle 45 \text{ mA}} = \frac{10+j10}{0.707\angle 45}$$

$$= \frac{14.14\angle 45}{0.707\angle 45}$$

$$\boxed{R_1+R_2 = 20\text{K}\Omega}$$

Now R_1 is shorted

$\tilde{V}_{CAP} = 17.89\angle -26.6°$

$$\hat{I}_{CAP} = \frac{17.89\angle -26.6}{-j20\text{K}\Omega} = \frac{17.89\angle -26.6}{20\text{K}\Omega\angle -90°}$$

$I_{CAP} = 0.895\text{ mA}\angle 63.4°$

Now, we have that $V_{SOURCE} - V_{CAP} = V_{R2} = 20\angle 0 - 17.88\angle -26.6$

$V_{R2} = [20 - [16.0 - j8.0]] = [4+j8]$ Volts $= 8.94\angle 63.4°$

$$R_2 = \frac{V_{R2}}{I_{CAP}} = \frac{8.94\angle 63.4}{0.895\text{ mA}\angle 63.4} = 10\text{ K}\Omega$$, so R_1 & R_2 are each $10\text{ K}\Omega$

HW 18, #5

P 10.8-6 The inputs to the circuit shown in Figure P 10.8-6 are

$$v_{s1}(t) = 30\cos(20t + 70^\circ)\ \text{V} \qquad \omega_1 = 20\ \text{R/s}$$

and

$$v_{s2}(t) = 18\cos(10t - 15^\circ)\ \text{V} \qquad \omega_2 = 10\ \text{R/s}$$

The response of this circuit is the current $i(t)$. Determine the steady-state response of the circuit.

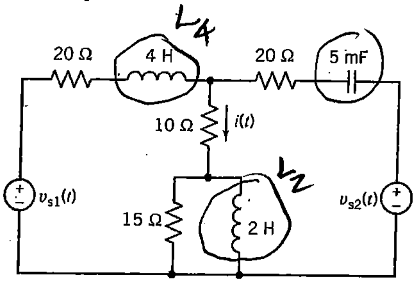


Figure P 10.8-6

Use superposition, one source at a time

Step 1, V_{S1} ON, V_{S2} OFF (shorted)

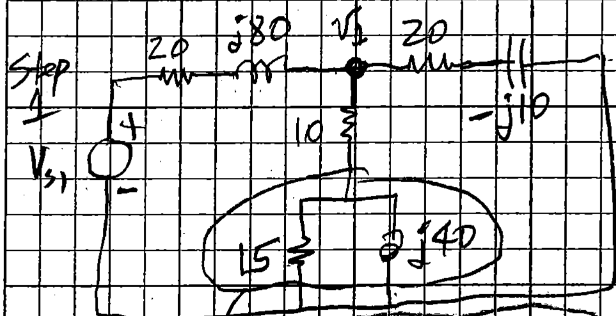
V_{S1} is 20 R/s

$j\omega L_4 = j80\,\Omega$, $j\omega L_2 = j40\,\Omega$

$$\frac{1}{j\omega C} = \frac{1}{j(20)(5\times10^{-3})} = \frac{1000}{j100}$$

$$= -j10\,\Omega$$

Step 1



$$15 \,\|\, j40 = \frac{15(j40)}{15+j40}$$

$$= \frac{j600}{\sqrt{15^2+40^2}\ \angle \tan^{-1}\left(\frac{40}{15}\right)}$$

$$= \frac{j600}{42.72\angle 69.4} = \boxed{14.05\angle 20.6}$$

KCL

$$\frac{V_1 - V_{S1}}{20+j80} + \frac{V_1}{20-j10} + \frac{V_1}{10+14.05\angle 20.6} = 0.$$

Solve for V_1,

Then $I = \dfrac{V_1}{10+14.05\angle 20.6}$

Then do Step 2. The final answer is Step 1 + Step 2

P 10.8-9 Using the principle of superposition, determine $i(t)$ of the circuit shown in Figure P 10.8-9 when $v_1 = 10\cos(10t)$ V.

Answer: $i = -2 + 0.71\cos(10t - 45°)$ A

$\omega = 10$ R/s

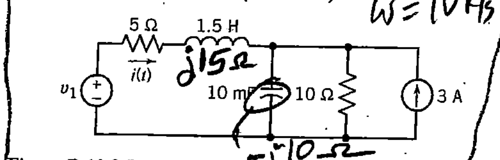


Figure P 10.8-9

HW 18, #6

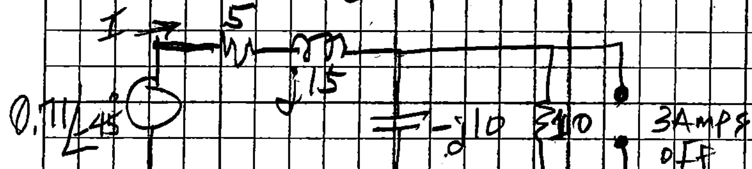
$1.5H \Rightarrow j\omega L = j(10)(1.5) = j15\ \Omega$

$10\ mF \Rightarrow \dfrac{1}{j\omega C} = \dfrac{1}{j(10)(10\times10^{-3})}$

$= \dfrac{10^3}{j(10)(10)} = \dfrac{1000}{j\,100}$

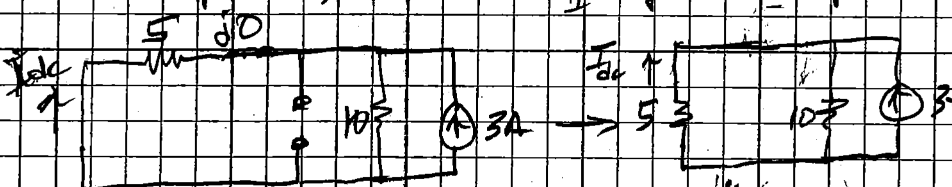
$= -j10\ \Omega$

For the AC ckt, turn off the 3A dc - Open Ckt



The I will be $\dfrac{0.71\angle -45°}{5 + j15 + (-j10)\|(10)}$

For the DC problem, turn off v_1 by shorting it



$10 \| 5 = 3.333\ \Omega$

$3A(3.333\ \Omega) = 10V$

$I_{dc} = -\dfrac{10}{5} = -2A$

Now Add the two circuit Results