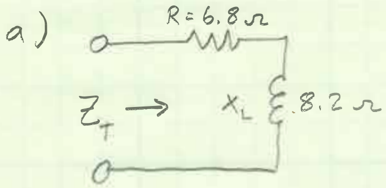
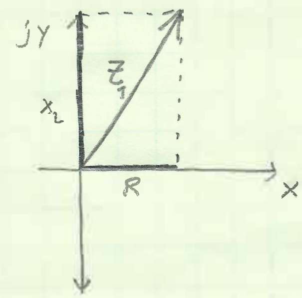
(12) Calculate the total impedance of the circuit shown. Express your answer in both polar and rectangular form, and draw the impedance diagram.

a)

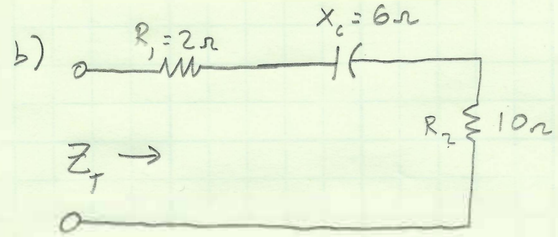


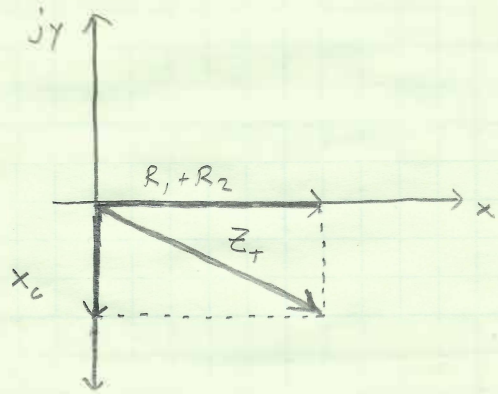


$$Z_T = \boxed{(6.8 + j\,8.2)\,\Omega}$$

$$= \boxed{10.65\,\Omega \angle 50.3^\circ}$$

b)

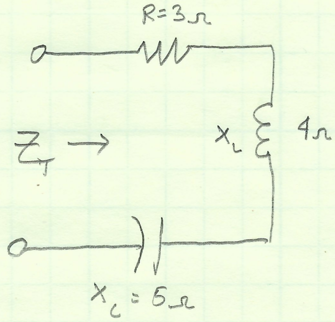


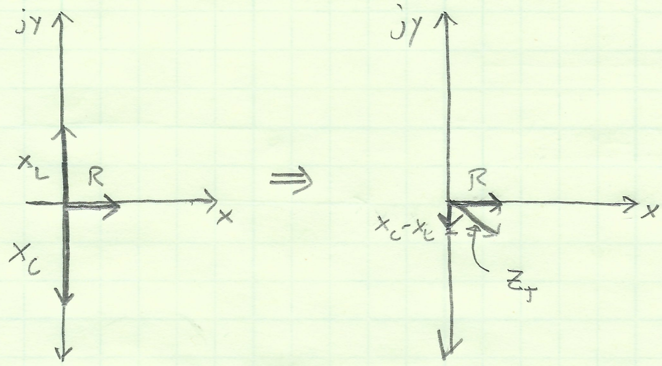


$$Z_T = \boxed{(12 - j6)\,\Omega} = \boxed{13.42\,\Omega \angle -26.6^\circ}$$

(13) Calculate the total impedance of the circuit shown. Express your answer in both rectangular and polar form, and draw the impedance diagram.

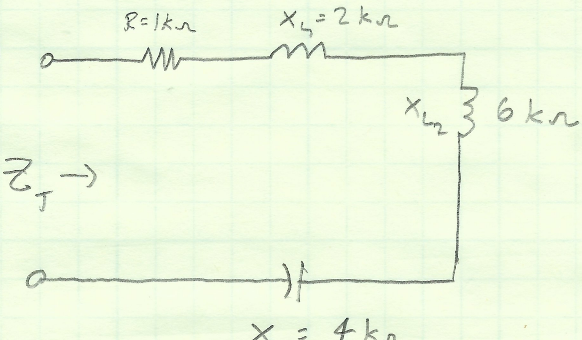
a)

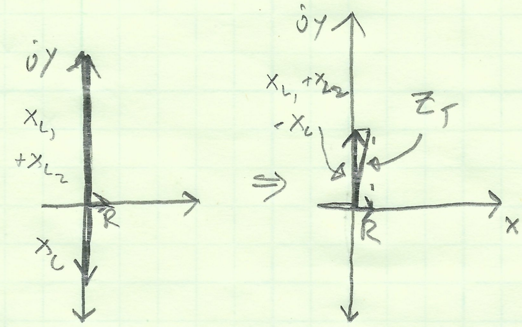




$$Z_T = 3\Omega + (j4\Omega) + (-j5\Omega) = \boxed{(3 - j1)\Omega = 3.162\Omega \angle -18.4°}$$

b)





$$Z_T = 1k\Omega + (j2k\Omega) + (j6k\Omega) + (-j4k\Omega) = \boxed{(1k + j4k)\Omega = 4123\Omega \angle 76.0°}$$

(14) Find the type and impedance in ohms of the circuit in the closed container (Voltage and current phasors are in RMS)

a) $E = 120V\angle 0^\circ$

$I = 6A\angle 45^\circ$

$$Z = \frac{E}{I} = \frac{120V\angle 0^\circ}{6A\angle 45^\circ} = \boxed{20\Omega\angle -45^\circ = (14.14 - j14.14)\Omega}$$

$R = 14.14\Omega$

$X_c = j14.14\Omega$

$\boxed{\text{Capacitive Load}}$

* Check: We calculated that the load is capacitive. If this is correct, input current must lead input voltage, which it does.

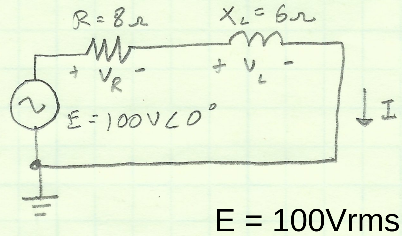
b) $E = 80V\angle 130^\circ$

$I = 20mA\angle 40^\circ$

$$Z_T = \frac{E}{I} = \frac{80V\angle 130^\circ}{20mA\angle 40^\circ} = \boxed{4000\Omega\angle 90^\circ = (0 + j4000)\Omega}$$

$\boxed{\text{Purely inductive load}}$

15 For the circuit:

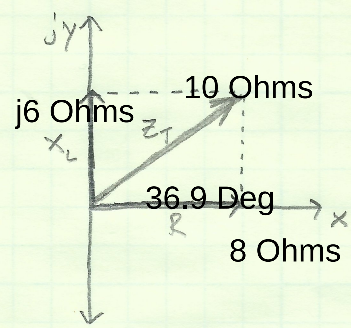


E = 100Vrms < 0 Deg

a) Find Z_T in polar form

$$Z_T = (8 + j6)\,\Omega = \boxed{10\,\Omega \angle 36.9^\circ}$$

b) Draw the impedance diagram



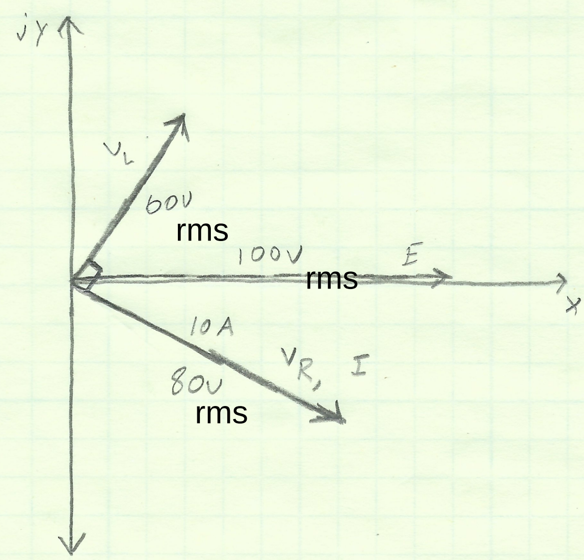
c) Find the current I and voltages V_R and V_L in phasor form

$$I = \frac{E}{Z_T} = \frac{100\,\text{V}_{\text{rms}} \angle 0^\circ}{10\,\Omega \angle 36.9^\circ} = \boxed{10\,\text{A}_{\text{rms}} \angle -36.9^\circ}$$

$$V_R = I \cdot R = (10\,\text{A} \angle -36.9^\circ)(8 + j0)\,\Omega = \boxed{80\,\text{V}_{\text{rms}} \angle -36.9^\circ}$$

$$V_L = I \cdot X_L = (10\,\text{A} \angle -36.9^\circ)(0 + j6)\,\Omega = \boxed{60\,\text{V}_{\text{rms}} \angle 53.1^\circ}$$

d) Draw the phasor diagram of the voltages E, V_R, V_L, and the current I.



e) Verify KVL around the closed loop

$$E = V_R + V_L = 100V_{rms}\angle 0^\circ = 80V_{rms}\angle -36.9^\circ + 60V_{rms}\angle 53.1^\circ$$

$$= (63.97 - j48.03)V_{rms} + (36.03 + j47.98)V_{rms} \approx 100V_{rms}\angle 0^\circ$$

f) Find the average power delivered to the circuit

*Remember that reactive components do not dissipate power

$$P = I^2R = (10A_{rms})^2(8\Omega) = \boxed{800W}$$

g) Find the power factor of the circuit

$$F_p = \cos(\theta_T) = \frac{R}{Z_T} = \frac{8\Omega}{10\Omega} = \boxed{0.8}$$

* I_T has a negative angle, which by definition means F_p is $\boxed{\text{lagging}}$

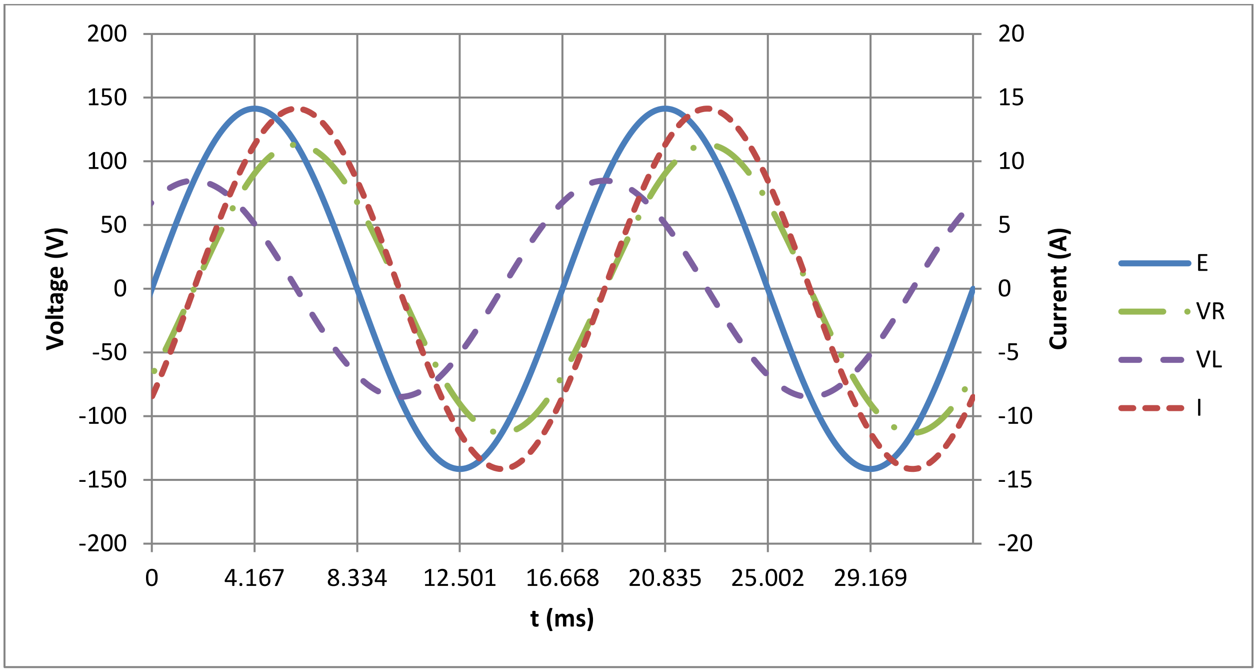
h) Find sinusoidal expressions for voltage and current if $f = 60\,Hz$

$E = 141.4V_p \sin(60t)$ $\quad$ $I = 14.14A_p \sin(60t - 36.9^\circ)$

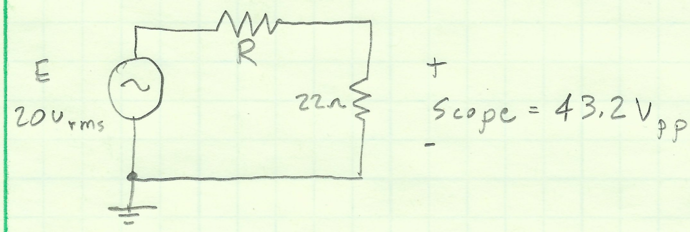
$V_R = 113.1V_p \sin(60t - 36.9^\circ)$ $\quad$ $V_L = 84.85V_p \sin(60t + 53.1^\circ)$

* No need for the "p" designation here, by definition the number in front of a sinusoid is the peak value *

i) Plot the waveforms for the voltage and current on the same set of axes.



(22) Using the oscilloscope reading in Fig. 15.99, determine the resistance R (closest standard value).

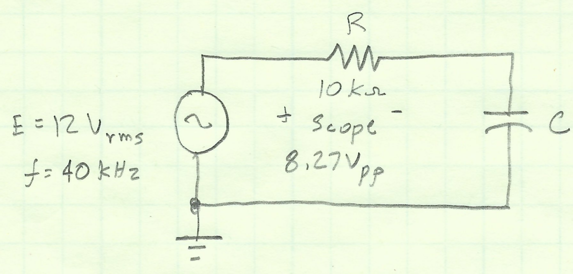


$20 V_{rms} = 28.28 V_p$ $\qquad$ $43.2 V_{pp} = 21.6 V_p$

$V_R = E - \text{Scope} = 28.28 V_p - 21.6 V_p = 6.684 V_p$

$$\frac{R}{22\Omega} = \frac{6.684 V_p}{21.6 V_p} \qquad R = 6.808\Omega \approx \boxed{6.8\Omega}$$

(24) Using the oscilloscope reading in Fig. 15.101



a) Find the rms value of the current

$$I = \frac{\text{Scope}}{R} = \frac{8.27\,V_{pp}}{10\,k\Omega} = 827\,\mu A_{pp} = \boxed{292.4\,\mu A_{rms}}$$

b) Determine the capacitance C

$$E^2 = V_R^2 + V_c^2 \longrightarrow V_c = \sqrt{E^2 - V_R^2}$$

$$= \sqrt{(12V_{rms})^2 + (2.924V_{rms})^2}$$

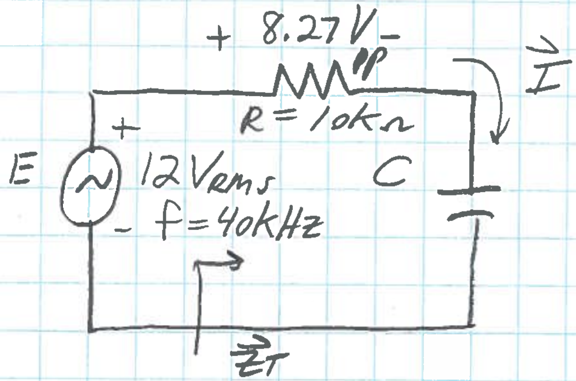
$$= 11.64\,V_{rms}$$

$$X_c = \frac{V_{c(rms)}}{I_{rms}} = \frac{11.64\,V_{rms}}{292.4\,\mu A_{rms}} = 39.81\,k\Omega = \frac{1}{2\pi f C}$$

$$C = \frac{1}{2\pi f X_c} = \frac{1}{2\pi(40k)(39.81k)} = \boxed{100\,pF}$$

P15.24

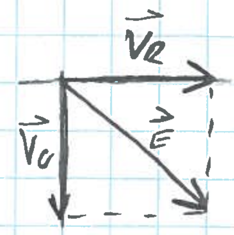
GIVEN:



FIND: (a) I_{RMS}

(b) C

ALTERNATE TO VOLTAGE PHASOR SOLN THAT STARTS:



$$|E| = \sqrt{|V_R|^2 + |V_C|^2}$$

OR

$$E^2 = V_R^2 + V_C^2 \ldots$$

(a) $$|\vec{I}| = \frac{|\vec{V}_R|}{R} = \frac{8.27V_{pp}}{10k\Omega} = 827\mu A_{pp}$$

$$= \underbrace{413.5\mu A_{pk}}_{I_{pk\text{-}pk}/2} = \boxed{292.4\mu A_{RMS}}$$

$I_{pk}/\sqrt{2}$

(b) $$\vec{Z}_T = R - jX_C$$

$$= (10{,}000 - jX_C)\Omega, \quad \text{NEED } X_C \text{ TO FIND } C$$

$$|\vec{Z}_T| = \sqrt{(10{,}000\Omega)^2 + (X_C\Omega)^2} \quad (1)$$

BUT $$\vec{Z}_T = \frac{\vec{E}}{\vec{I}} = \frac{16.97V_{pk}\angle 0^\circ}{413.5\mu A_{pk}\angle X^\circ} \leftarrow \text{UNKNOWN PHASE}$$

$$\therefore \vec{Z}_T = 41{,}041\Omega\angle(0^\circ - X^\circ)$$

OR $$|\vec{Z}_T| = 41{,}041$$

INTO (1): $$41{,}041\Omega = \sqrt{(10{,}000\Omega)^2 + (X_C\Omega)^2} \quad (2)$$

SOLVING YIELDS $\underline{X_C = 39{,}804\Omega} = \dfrac{1}{2\pi f C}$ ← 40kHz

HENCE $\boxed{C = 99.96pF}$

28. Calculate the voltages V_1 and V_2 for the circuits in Fig. 15.104 in phasor form using the voltage divider rule.

a.)

E = 20Vrms < 70 Deg

The voltage divider rule is give by:

$$V_x = \frac{Z_x E}{Z_T}$$

The total impedance of the circuit Z_T is:

$$Z_T = Z_R + Z_L + Z_C = (20 + j0) + (0 + j20) + (0 - j40) = (20 - j20)\Omega$$

Therefore, the voltage drop over the inductor is given by:

$$V_1 = \frac{Z_L E}{Z_T} = \frac{(20\angle 90^\circ) \cdot (20\angle 70^\circ)}{(20 - j20)}$$

$$V_1 = \frac{(400\angle 160^\circ)}{(20 - j20)} = \frac{(400\angle 160^\circ)}{28.28\angle \tan^{-1}(\frac{-20}{20})}$$

$$V_1 = \frac{(400\angle 160^\circ)}{28.28\angle -45^\circ} = \boxed{(14.14\angle 205^\circ)\mathrm{V_{rms}}}$$

$$V_1 = \boxed{(14.14\angle -155^\circ)\mathrm{V_{rms}}}$$

$$V_2 = \frac{Z_C E}{Z_T} = \frac{(40\angle -90^\circ) \cdot (20\angle 70^\circ)}{(20 - j20)}$$

$$V_2 = \frac{(800\angle -20^\circ)}{(20 - j20)} = \frac{(800\angle -20^\circ)}{28.28\angle \tan^{-1}(\frac{-20}{20})}$$

$$V_2 = \frac{(800\angle -20^\circ)}{28.28\angle -45^\circ} = \boxed{(28.28\angle 25^\circ)\mathrm{V_{rms}}}$$

b.)

E = 120Vrms < 0 Deg

$$V_1 = \frac{(Z_L + Z_R + Z_C) \cdot E}{Z_T} = \frac{[(0 + j30 \cdot 10^3)\Omega + (3.3 \cdot 10^3 + j0)\Omega + (0 - j10 \cdot 10^3)\Omega] \cdot (120\angle 0^\circ)}{(Z_R + Z_L + Z_R + Z_C)}$$

$$V_1 = \frac{(3.3 \cdot 10^3 + j20 \cdot 10^3)\Omega \cdot (120\angle 0^\circ)}{(4.7 \cdot 10^3 + j0)\Omega + (0 + j30 \cdot 10^3)\Omega + (3.3 \cdot 10^3 + j0)\Omega + (0 - j10 \cdot 10^3)\Omega}$$

$$V_1 = \frac{(2.43 \cdot 10^6 \angle 80.63)}{(8 \cdot 10^3 + j20 \cdot 10^3)\Omega} = \boxed{(112.92\angle 12.43^\circ)\mathrm{V_{rms}}}$$

$$V_2 = \frac{(Z_R + Z_C) \cdot E}{Z_T} = \frac{[(3.3 \cdot 10^3 + j0)\Omega + (0 - j10 \cdot 10^3)\Omega] \cdot (120\angle 0°)}{(Z_R + Z_L + Z_R + Z_C)}$$
$$V_2 = \frac{(3.3 \cdot 10^3 - j10 \cdot 10^3)\Omega \cdot (120\angle 0°)}{(4.7 \cdot 10^3 + j0)\Omega + (0 + j30 \cdot 10^3)\Omega + (3.3 \cdot 10^3 + j0)\Omega + (0 - j10 \cdot 10^3)\Omega}$$
$$V_2 = \frac{(1.26 \cdot 10^6\angle - 71°)}{(8 \cdot 10^3 + j20 \cdot 10^3)\Omega} = \boxed{(58.66\angle - 139.94°)\mathrm{V_{rms}}}$$

29. For the circuit in Fig.105:

a. Determine I, V_R and V_C in phasor form.
The source frequency is:

$$w = 2\pi \cdot f = 1000$$
$$Z_L = jwL = j \cdot 1000 \cdot 20 \cdot 10^-3 = 20\Omega$$
$$Z_C = \frac{1}{jwC} = \frac{1}{j1000 \cdot 39 \cdot 10^{-6}} = 25.64\Omega\angle - 90°$$
$$Z_T = Z_R + Z_L + Z_C = (30 + j0) + (0 + j20) + (0 - j25.64) = (30 - j5.64)\Omega$$

$$I = \frac{E}{Z_T} = \frac{20\angle 40°\mathrm{V_{rms}}}{(30 - j5.64)\Omega} = \boxed{655\mathrm{mA}\angle 50.65°}\ \text{rms}$$
$$V_R = IZ_R = (655\mathrm{mA}\angle 50.65°) \cdot (30\Omega) = \boxed{19.66\mathrm{V_{rms}}\angle 50.65°}$$
$$V_C = IZ_C = (655\mathrm{mA}\angle 50.65°) \cdot (25.64\Omega\angle - 90°) = \boxed{16.80\mathrm{V_{rms}}\angle - 39.35°}$$

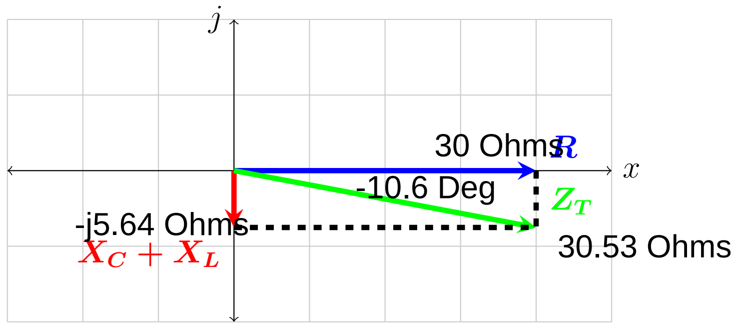
b. Calculate the total power factor, and indicate whether it is leading or lagging.

$$F_P = \cos(\phi_I - \phi_E) = \cos(50.65 - 40) = 0.983 \ \ \textit{leading}$$

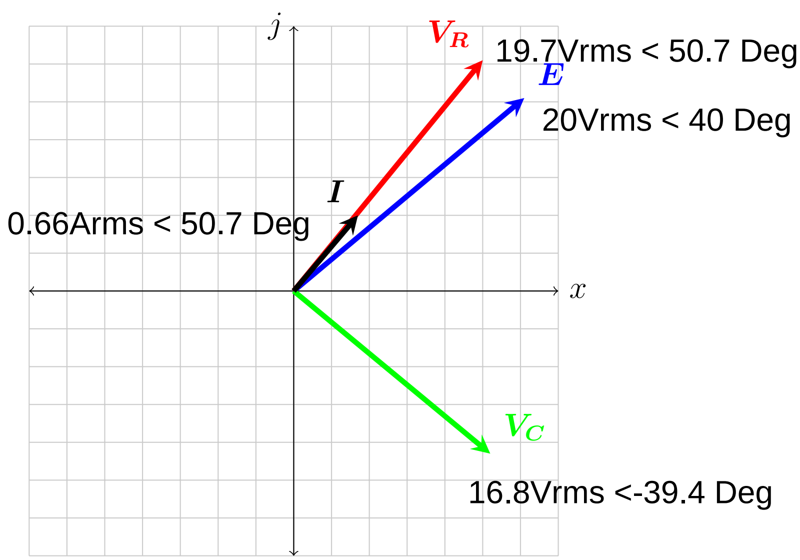
c. Calculate the average power delivered to the circuit.

$$P_{ave} = V_{rms} \cdot I_{rms} \cos(\phi_I - \phi_E) = 20 \cdot 655 \cdot 10^-3 \cdot \cos(50.65 - 40) = \boxed{12.87\mathrm{W}}$$

d. Draw the impedance diagram. **Note:** Not drawn to scale.



e. Draw the phasor diagram of the voltages E, V_R and V_C and the current I. **Note:** The phasor are not drawn to scale (especially current)



f. Find the voltages V_R and V_C using the voltage divider rule, and compare them with the results of part (a).

$$V_R = \frac{R \cdot E}{Z_T} = \frac{30 \cdot 20\angle 40° \mathrm{V_{rms}}}{(30 - j5.64)} = \boxed{19.66\mathrm{V_{rms}}\angle 50.65°}$$

$$V_C = \frac{Z_C \cdot E}{Z_T} = \frac{(25.64\mathrm{V_{rms}}\angle -90°) \cdot (20\angle 40° \mathrm{V_{rms}})}{(30 - j5.64)} = \boxed{16.80\mathrm{V_{rms}}\angle -39.35°}$$

g. Draw the equivalent series circuit of the above as far as the total impedance and the current i are concerned.

The series circuit will contain the following parameters:

Source voltage, E: $20\angle 40° \mathrm{V_{rms}}$

Impedance, Z_T: $(30 - j5.64)\Omega$

Current, I: $655\mathrm{mA}\angle 50.65°$

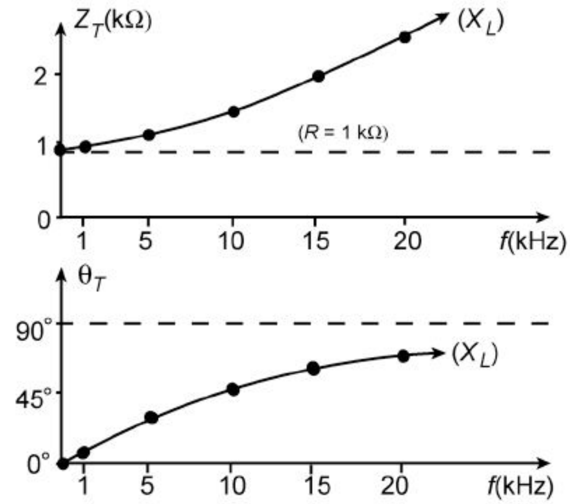
rms

30. For the circuit in Fig.106:

a. Plot Z_T and ϕ_T versus frequency for a frequency range of zero to 20kHz

$$\mathbf{Z}_T = \sqrt{R^2 + X_L^2}\ \angle \tan^{-1} X_L/R$$

f	Z_T	θ_T
0 Hz	1.0 kΩ	0.0°
1 kHz	1.008 kΩ	7.16°
5 kHz	1.181 kΩ	32.14°
10 kHz	1.606 kΩ	51.49°
15 kHz	2.134 kΩ	62.05°
20 kHz	2.705 kΩ	68.3°

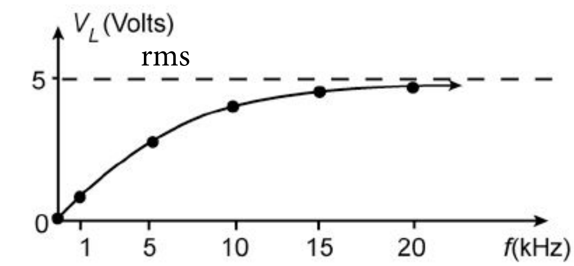


b. Plot V_L versus frequency for the frequency range of part (a)

b. $V_L = \dfrac{X_L E}{Z_T}$

f	V_L
0 Hz	0.0 V
1 kHz	0.623 V
5 kHz	2.66 V
10 kHz	3.888 V
15 kHz	4.416 V
20 kHz	4.646 V

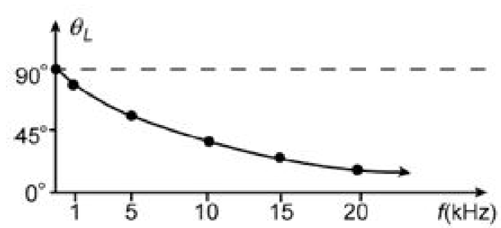
(Vrms)



c. Plot ϕ_L versus frequency for the frequency range of part (a)

c.

f	$\theta_L = 90° - \tan^{-1} X_L/R$
0 Hz	90.0°
1 kHz	82.84°
5 kHz	57.85°
10 kHz	38.5°
15 kHz	27.96°
20 kHz	21.7°



d. Plot V_R versus frequency for the frequency range of part (a)

d.

f	$V_R = RE/Z_T$
0 Hz	5.0 V
1 kHz	4.96 V
5 kHz	4.23 V
10 kHz	3.11 V
15 kHz	2.34 V
20 kHz	1.848 V

(Vrms)