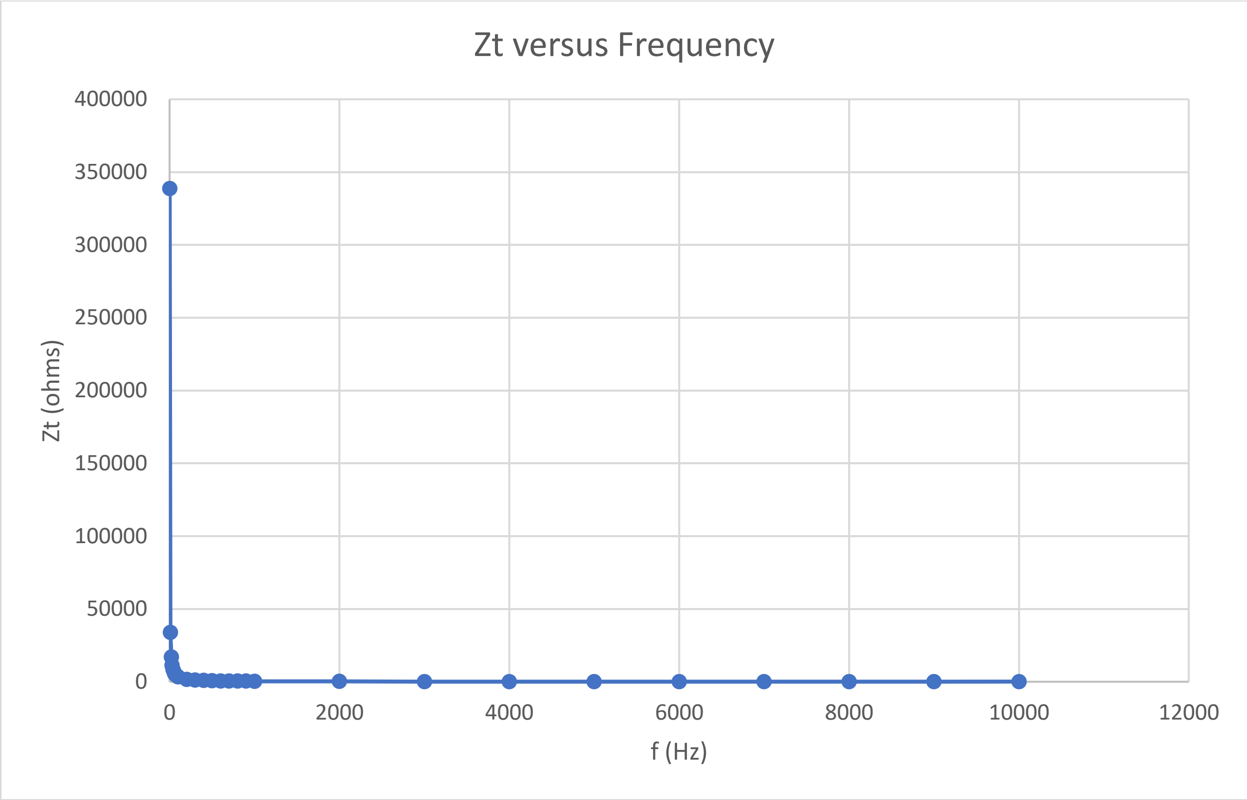
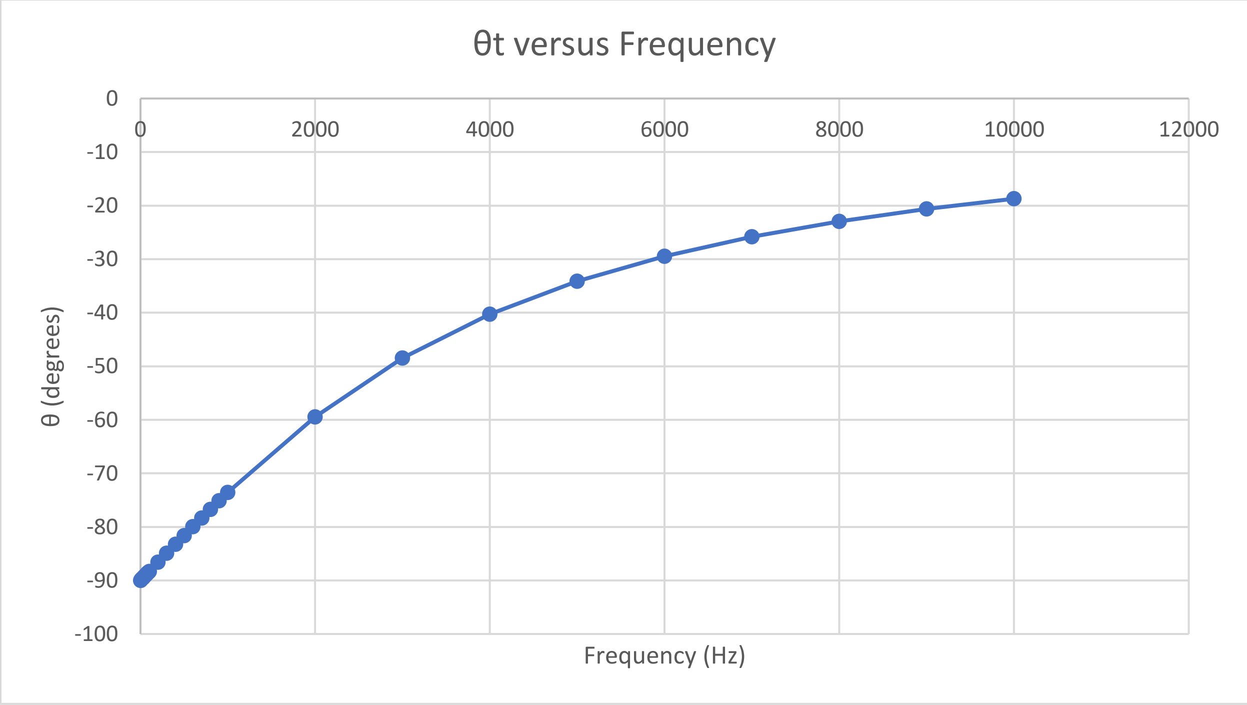
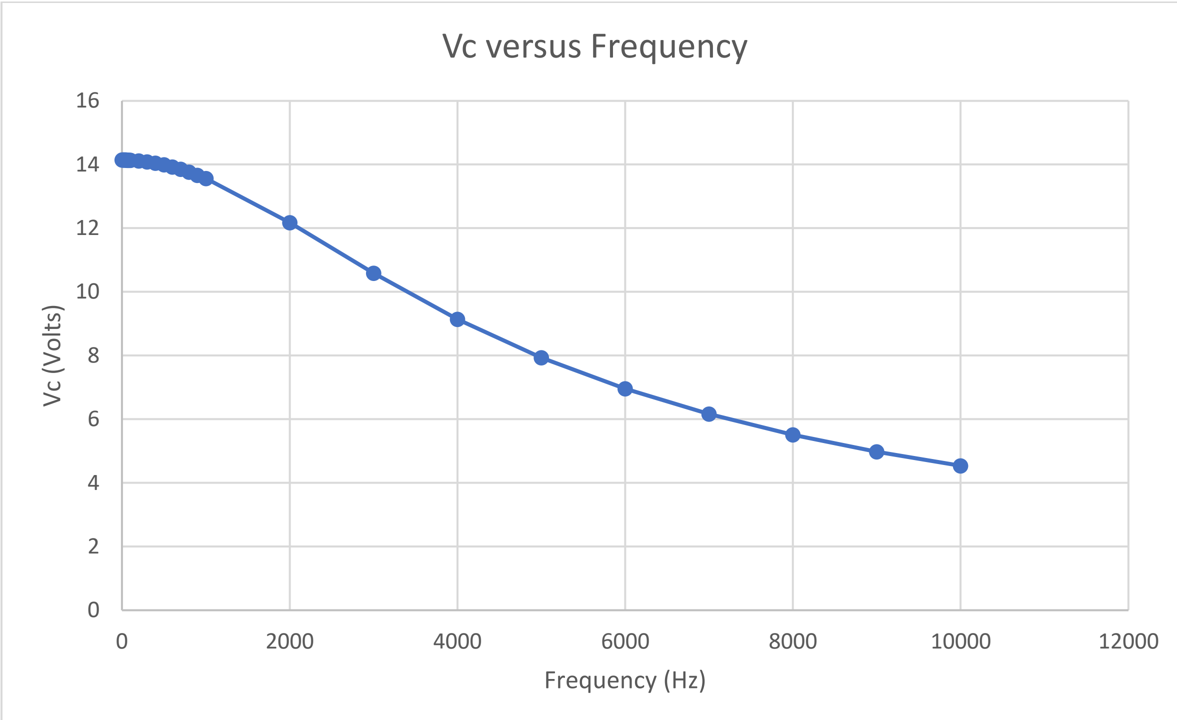
15-31 For the circuit of Figure 15.107:

a. Plot Z_T and θ_T versus frequency for a frequency range of zero to 10kHz.

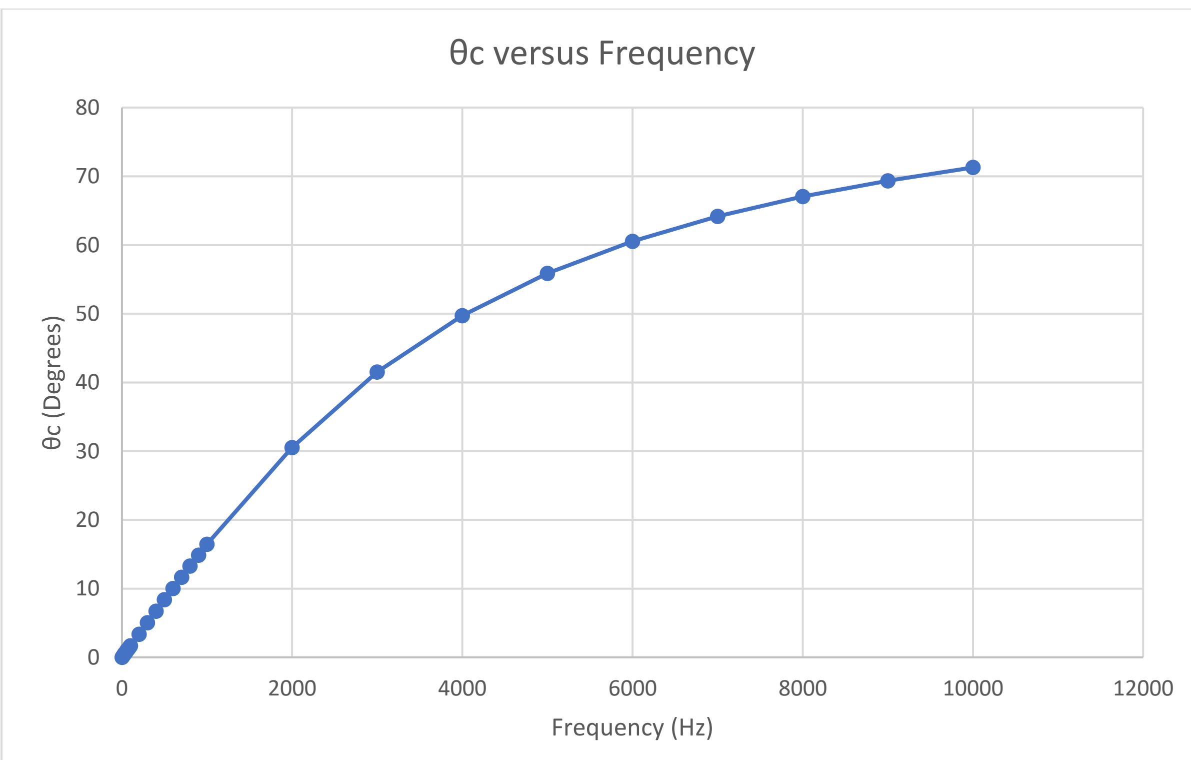




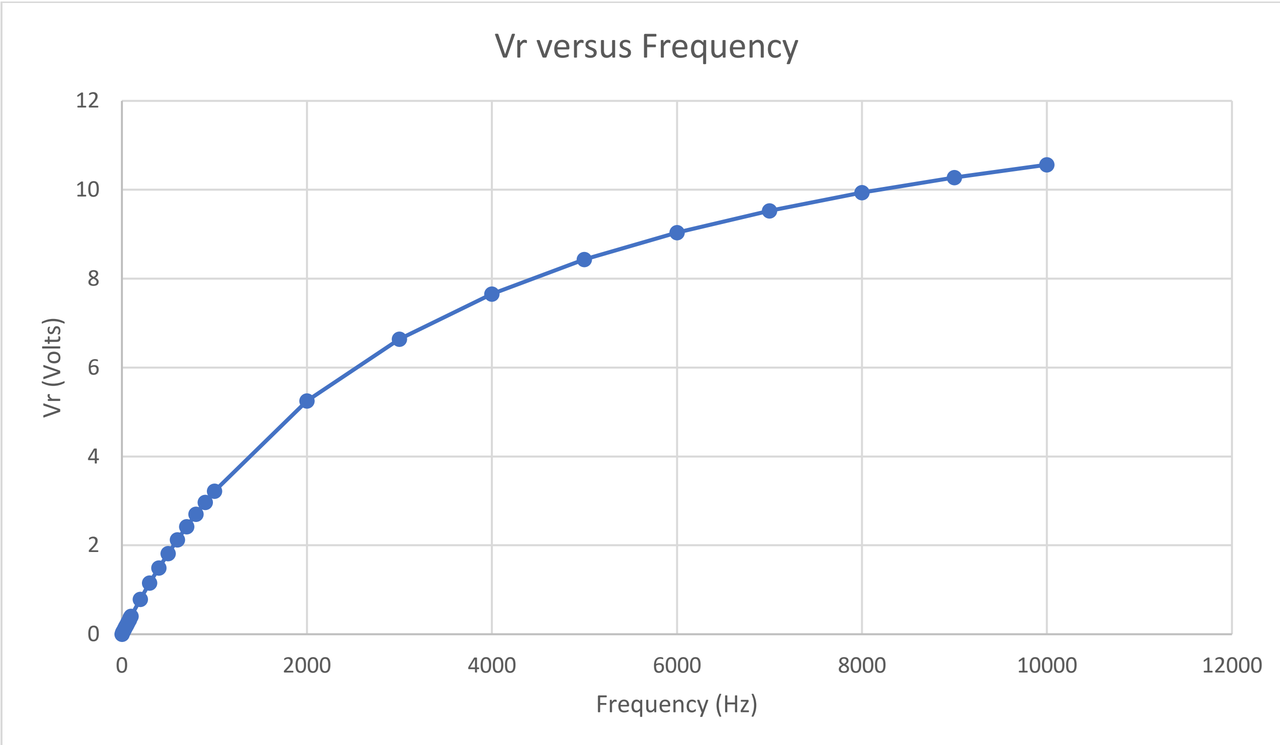
b. Plot V_C versus frequency for the same frequency range



c. Plot θ_C for the same frequency range



d. Plot V_R for the same frequency range



15-35 For the traces in Figure 15.111

a) Determine the phase relationship between the waveform, and indicate which one leads or lags

b) Determine the pk-pk and rms values of each waveform

c) Find the frequency of each waveform

Trace I

a) $\theta_{div} = .8 \text{ divisions} \cdot .2\text{ms/division} = .08\text{ms}$

$T(\text{Period}) = 4 \text{ divisions} \cdot .2\text{ms/division} = .4\text{ms}$

$\theta = \frac{\theta_{div}}{T} \cdot 360° = \frac{.08}{.4} \cdot 360 = 72°$

$\boxed{V_1 \text{ leads } V_2 \text{ by } 72°}$

b) $V_{1PK\text{-}PK} = 5.6 \text{ division} \cdot .5\text{V/div} = \boxed{2.8\text{V}}$

$V_1(\text{rms}) = \frac{2.8\text{V}}{\sqrt{2} \cdot 2 *} = \boxed{989.949\text{mV}}$

* Divide by 2 for peak value

$V_{2PK\text{-}PK} = 2.4 \text{ div.} \cdot .5\text{V/div} = \boxed{1.2\text{V}}$

$V_2(\text{rms}) = \frac{1.2\text{V}}{\sqrt{2} \cdot 2} = \boxed{424.264\text{mV}}$

c) $T = 4 \text{ div} \cdot .2\text{ms/div} = 0.8\text{ms}$

$f = 1/T = 1/.8\text{ms} = \boxed{1.25\text{kHz}}$

Trace II

a) $\theta_{div} = 2.2\text{div} \cdot 10\mu\text{s/div} = 22\mu\text{s}$

$T = 6 \text{ div} \cdot 10\mu\text{s/div} = 60\mu\text{s}$

$\theta = \frac{22\mu\text{s}}{60\mu\text{s}} \times 360° = 132°$ $\boxed{V_1 \text{ leads } V_2 \text{ by } 132°}$

b) $V_{1PK\text{-}PK} = 2.8\text{div} \cdot 2\text{V/div} = \boxed{5.6\text{V}}$ $V_1(\text{rms}) = \frac{5.6\text{V}}{\sqrt{2} \cdot 2} = \boxed{1.98\text{V}}$

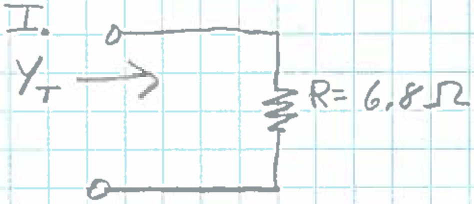
$V_{2PK\text{-}PK} = 4 \text{ div} \cdot 2\text{V/div} = \boxed{8\text{V}}$ $V_2(\text{rms}) = \frac{8\text{V}}{\sqrt{2} \cdot 2} = \boxed{2.828\text{V}}$

c) $T = 6\text{div} \cdot 10\mu\text{s/div} = 60\mu\text{s}$

$f = \frac{1}{60\mu\text{s}} = \boxed{16.667\text{kHz}}$

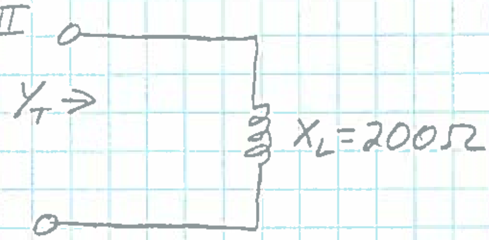
16-3 a) Find the admittance in regular and polar form
b) Sketch the admittance diagram

a) I.



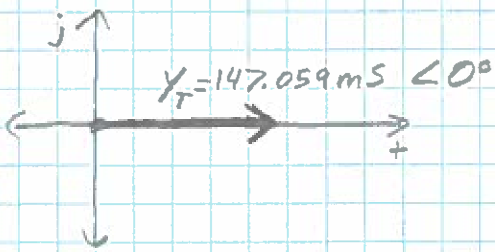
$$Y_T = \frac{1}{Z_T} = \frac{1}{6.8\angle 0} = 147.059\,mS\angle 0^\circ = 147.059\,mS$$

II

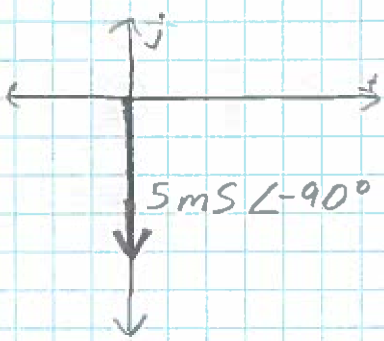


$$Y_T = \frac{1}{Z_T} = \frac{1}{200\angle 90^\circ} = 5\,mS\angle -90 = -j5\,mS$$

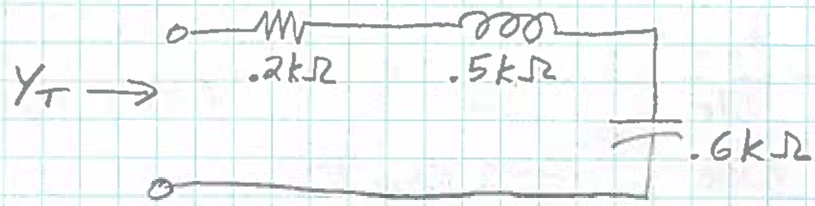
b) I.



II.



16-5 III



a) Find the total impedance in polar form

$$Z_T = 200\Omega + j500 - j600 = 200 - j100 = \boxed{223.607\Omega\angle -26.57}$$

b) Find the total admittance

$$Y_T = \frac{1}{Z_T} = \frac{1}{223.607\angle -26.57} = \boxed{4.472\,mS\angle 26.57}$$

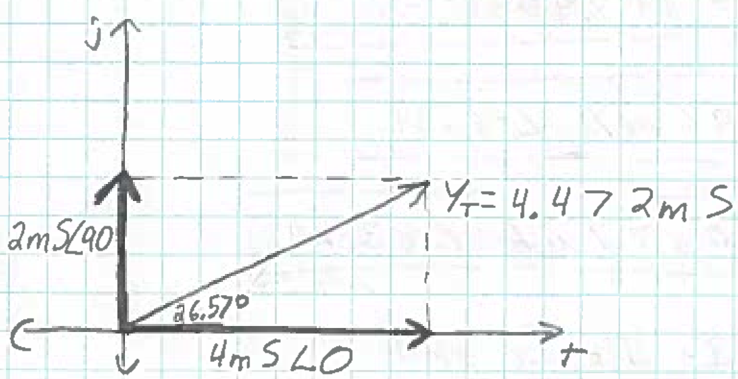
c) Identify the total conductance and susceptance parts of the total admittance

$$4.472\,mS\angle 26.57 = 4\,mS + j\,2\,mS$$

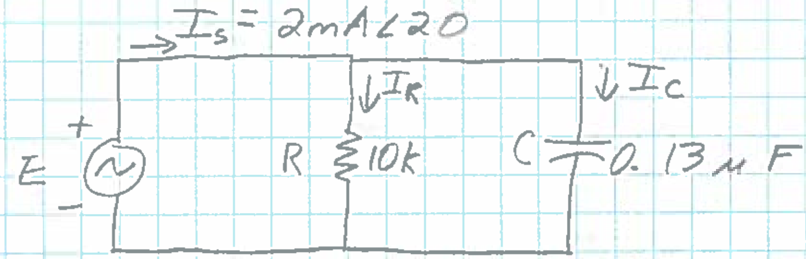
$$G(\text{conductance}) = \boxed{4\,mS}$$

$$B_C(\text{susceptance}) = \boxed{2\,mS}$$

d) Sketch the admittance diagram



16-10



$f = 60\ Hz$

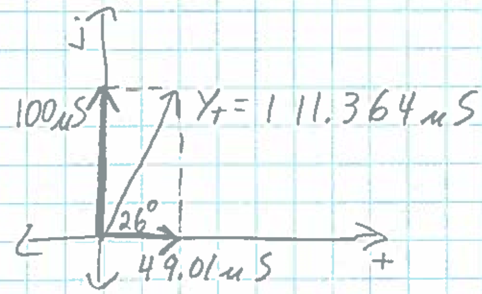
a) Find the total admittance Y_T in polar form

$$X_C = \frac{1}{2\pi f C} = \frac{1}{2\pi \cdot 60 \cdot .13\mu F} = 20.404\,k\Omega$$

$$Y_T = \frac{1}{10k\angle 0} + \frac{1}{20.404k\angle -90} = \boxed{111.364\,\mu S\angle 26.11}$$

b) Draw the admittance diagram

$$Y_T = 100\mu S + j\,49.01\,\mu S$$



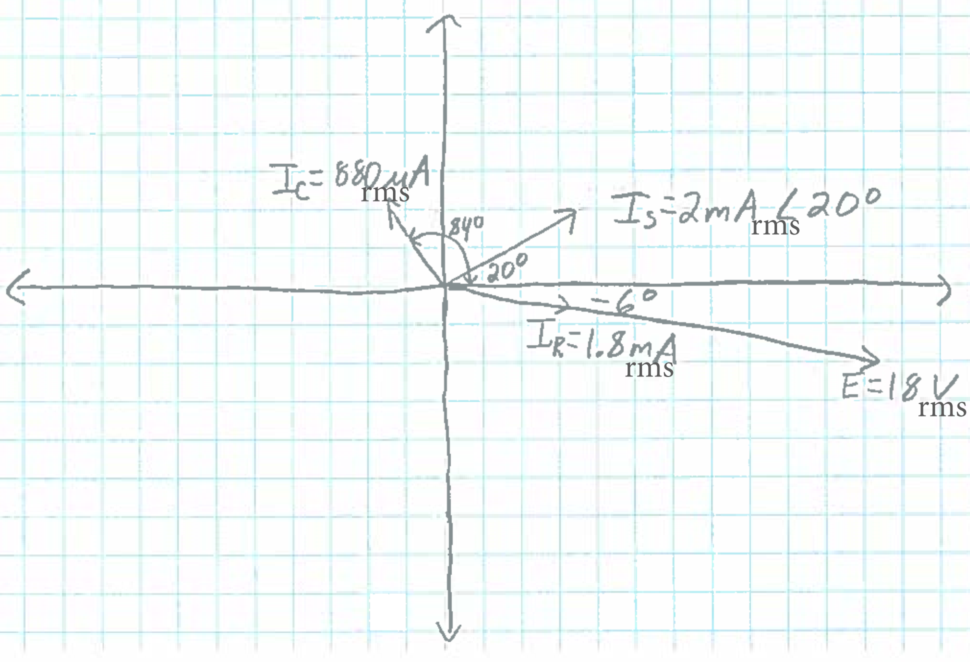
c) Find the voltage E and the currents I_R & I_C in phasor form

$$E = I_S \cdot Z_T = \frac{I_S}{Y_T} = \frac{2\,mA_{rms}\angle 20}{111.364\mu S\angle 26.11} = \boxed{17.959\,V_{rms}\angle -6.11}$$

$$I_R = \frac{E}{Z_R} = \frac{17.959\,V_{rms}\angle -6.11}{10k\angle 0} = \boxed{1.796\,mA_{rms}\angle -6.11}$$

$$I_C = \frac{E}{Z_C} = \frac{17.959\,V_{rms}\angle -6.11}{20.404k\angle -90} = \boxed{880.177\,\mu A_{rms}\angle 83.89}$$

d) Draw the phasor diagram of I_s, I_R, I_C and E



e) Verify Kirchoff's current law at one node

$I_s = I_R + I_C$

$2mA_{rms}\angle 20 = 1.796\,mA_{rms}\angle -6.11 + 880.177\,uA_{rms}\angle 83.89$

$2mA_{rms}\angle 20 \cong 2mA_{rms}\angle 19.998^\circ$

f) Find the average power delivered to the circuit

$P = I^2 R = (1.796\,mA_{rms})^2\, 10k\Omega = \boxed{32.256\,mW}$

g) Find the power factor and indicate whether it is leading or lagging

$F_p = \cos\theta = \cos(20^\circ - (-6.11)) = 0.897 \cong \boxed{0.9 \text{ Leading}}$

h) Find the sinusoidal expressions for the currents and voltage if $f = 60Hz$

$\omega = 2\pi f = 2\pi \cdot 60Hz = 377\, rad/s$

is given in RMS, so convert to Peak values

$e = 25.402 \sin(377t - 6.11^\circ)$

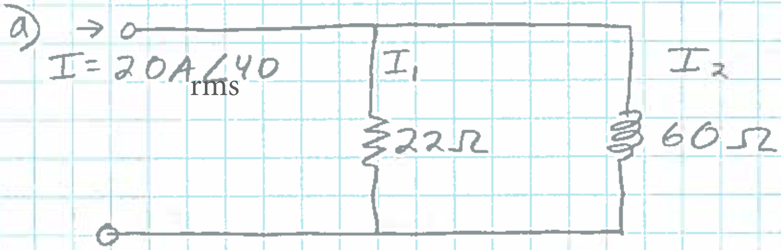
$i_s = 2.829 \times 10^{-3} \sin(377t + 20^\circ)$

$i_R = 2.54 \times 10^{-3} \sin(377t - 6.11^\circ)$

$i_c = 1.245 \times 10^{-3} \sin(377t + 83.89^\circ)$

16-14 Calculate I_1 + I_2 in phasor form using current divider

a)



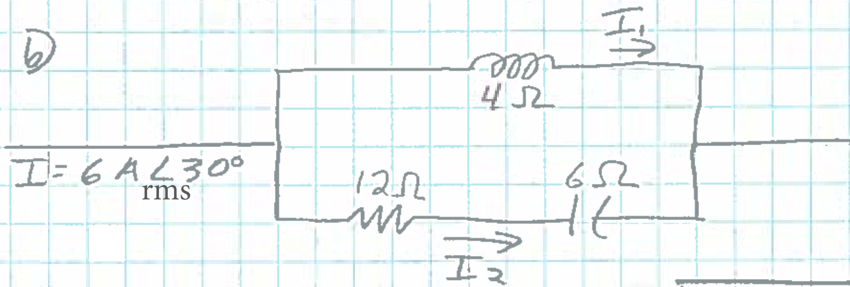
$$I_1 = \frac{I\,Z_2}{Z_T}$$

$$I_2 = \frac{I\,Z_1}{Z_T}$$

$$I_1 = \frac{(20A_{rms}\angle 40)(60\angle 90)}{22\angle 0 + 60\angle 90} = \boxed{18.778\,A_{rms}\angle 60.136^\circ}$$

$$I_2 = \frac{(20_{rms}\angle 40)\,(22\angle 0)}{22\angle 0 + 60\angle 90} = \boxed{6.885\,A_{rms}\angle -29.864^\circ}$$

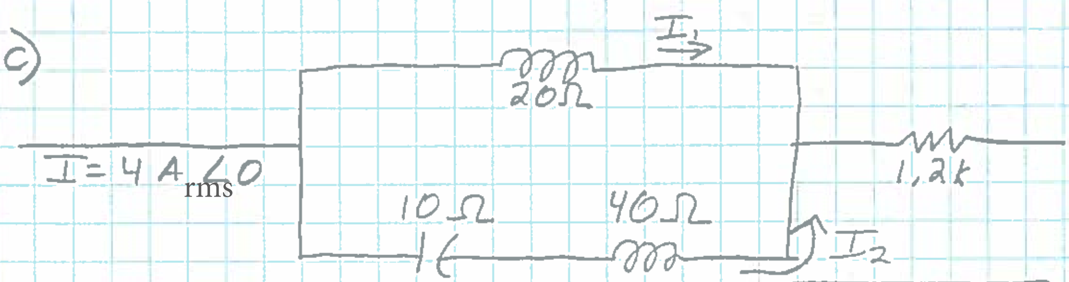
b)



$$I_1 = \frac{(6_{rms}\angle 30)(12\angle 0 + 6\angle -90)}{12\angle 0 + 6\angle -90 + 4\angle 90} = \boxed{6.617\,A_{rms}\angle 12.897^\circ}$$

$$I_2 = \frac{(6_{rms}\angle 30)\,(4\angle 90)}{12\angle 0 + 6\angle -90 + 4\angle 90} = \boxed{1.973\,A_{rms}\angle 129.462^\circ}$$

c)



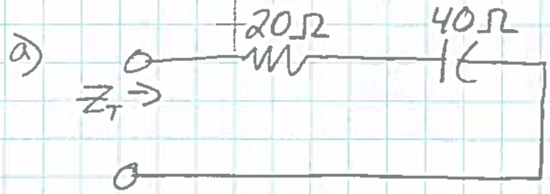
$$I_1 = \frac{(4_{rms}\angle 0)(10\angle -90 + 40\angle 90)}{20\angle 90 + 10\angle -90 + 40\angle 90} = \boxed{2.4\,A_{rms}\angle 0^\circ}$$

$$I_2 = \frac{(4_{rms}\angle 0)\,(20\angle 90)}{20\angle 90 + 10\angle -90 + 40\angle 90} = \boxed{1.6\,A_{rms}\angle 0^\circ}$$

* All Values in RMS *
Voltage and Current

16-20 Find a parallel circuit with the same total impedance (Z_T)

a)

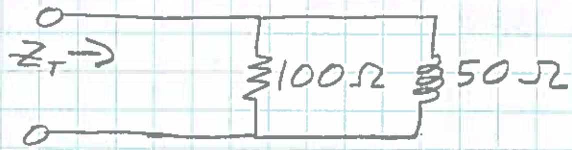


$$R_p = \frac{R_s^2 + X_s^2}{R_s}$$

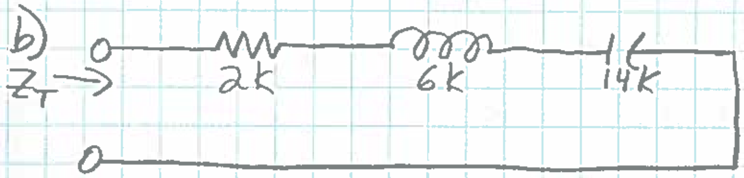
$$X_p = \frac{R_s^2 + X_s^2}{X_s}$$

$$R_p = \frac{(20\Omega)^2 + (40\Omega)^2}{20\Omega} = \boxed{100\ \Omega}\ (R)$$

$$X_p = \frac{(20\Omega)^2 + (40\Omega)^2}{40\Omega} = \boxed{50\ \Omega}\ (C)$$

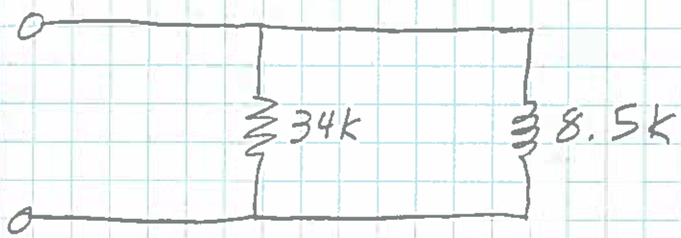


b)



$$R_p = \frac{(2k)^2 + (14k - 6k)^2}{2k} = \boxed{34\ k\Omega}\ (R)$$

$$X_p = \frac{(2k)^2 + (14k - 6k)^2}{(14k - 6k)} = \boxed{8.5k}\ (L)$$



15-33.) For the series R-C circuit in Fig. 15.109:

a.) Determine the frequency at which $X_C = R$

$$X_C = \frac{1}{2\pi f_1 C} = R$$

$$f_1 = \frac{1}{2\pi RC} = \frac{1}{2\pi \cdot 200 \cdot 0.47 \cdot 10^{-6}} = 1.54\,\text{kHz}$$

b.) Develop a mental image of the change in total impedance with frequency without resorting to a single calculation.
The circuits total impedance over the frequency range of interest can be subdivided into to regions, low frequency and high frequency regions.
Low frequency: The circuit capacitance dominates the circuits total impedance
High frequency: The circuit resistance dominate the circuits total impedance

c.) Find the total impedance at 100 Hz and 10 kHz, and compare your answer with the assumptions of part (b).
The circuit total impedance is given by:

$$\begin{aligned}\boldsymbol{Z_T} &= R - jX_C \\ &= Z_T\angle\theta_T \\ &= \sqrt{(R)^2 + (X_C)^2}\angle - \tan^{-1}\frac{X_C}{R}\end{aligned}$$

At $f = 100\,\text{Hz}$

$$\begin{aligned}\boldsymbol{Z_T} &= R - jX_C = 220 - j3386.3 \\ &= Z_T\angle\theta_T = 3.39\,\text{k}\Omega\angle - 86^\circ\end{aligned}$$

At $f = 10\,\text{kHz}$

$$\begin{aligned}\boldsymbol{Z_T} &= R - jX_C = 220 - j33.9 \\ &= Z_T\angle\theta_T = 222.6\,\Omega\angle - 8.8^\circ\end{aligned}$$

The results confirms the assumptions of part (b), where the total impedance at $10\,\text{kHz}$ had phase of -8.8° which is more resistive than low frequency $100\,\text{Hz}$ that had a phase angle of -86° which is more capacitive.

16-4.) For each configuration of Fig. 16.66 II:

a.) Find the total impedance in polar form.

$$\begin{aligned}
\boldsymbol{Z_T} &= \frac{1}{(1/R_1) + (1/R_2) + (1/C)} \\
&= \frac{1}{(1/22) + (1/2.2) + (1/6)} \\
&= \boxed{1.90\ \Omega\angle - 18.4^\circ}
\end{aligned}$$

b.) Calculate the total admittance using the results of part (a).

$$\begin{aligned}
\boldsymbol{Y_T} &= \frac{1}{\boldsymbol{Z_T}} \\
&= \frac{1}{1.90\ \Omega\angle - 18.4^\circ} \\
&= \boxed{0.53\ \Omega\angle 18.4^\circ}
\end{aligned}$$

16-7(a-d). For the circuit of Fig. 16.69:

a.) Find the total admittance in rectangular form.

$$\boldsymbol{Z_R} = 4.7\,\mathrm{k}\Omega\angle 0^\circ$$

$$\begin{aligned} X_L &= \omega L = 2\pi f \cdot L = 2\pi \cdot 2\,\mathrm{kHz} \cdot 470\,\mathrm{mH} \\ &= 5906.2\Omega \end{aligned}$$

$$\boldsymbol{Z_L} = X_L\angle 90^\circ = 5906.2\ \Omega\angle 90^\circ$$

$$\boldsymbol{Z_T} = Z_R + Z_L = 4.7\,\mathrm{k}\Omega\angle 0^\circ + 5906.2\ \Omega\angle 90^\circ$$

$$\begin{aligned} \mathbf{Y_T} &= \frac{1}{Z_T} = 82.5\,\mu\mathrm{S} - j103.7\,\mu\mathrm{S} = \\ &= 132.5\,\mu\mathrm{S}\angle - 51.49^\circ \end{aligned}$$

b.) Construct a parallel network from the components found in part (a).

$$R = \frac{1}{\mathbf{Y_R}} = \frac{1}{82.5\,\mu\mathrm{S}} = 12.1\,\mathrm{k}\Omega$$

$$X_L = \frac{1}{\boldsymbol{B_L}} = \frac{1}{103.7\,\mu\mathrm{S}} = 9.65\,\mathrm{k}\Omega$$

c.) Determine the value of the resistive and inductive components.

$$R = 12.1\,\mathrm{k}\Omega$$

$$\begin{aligned} X_L &= 2\pi f L = 9.65\,\mathrm{k}\Omega \\ L &= \frac{X_L}{2\pi f} = 9.65\,\mathrm{mH} \end{aligned}$$

d.) How do the components of part (c) compare with the original components of Fig. 16.69? The type of component remained the same (resistive and inductive components).

16-19.) For the parallel R-L-C network in Fig. 16.79:

a.) Plot Y_T and θ_T (of $Y_T = Y_T \angle \theta_T$) for frequency range of zero to 20 kHz.

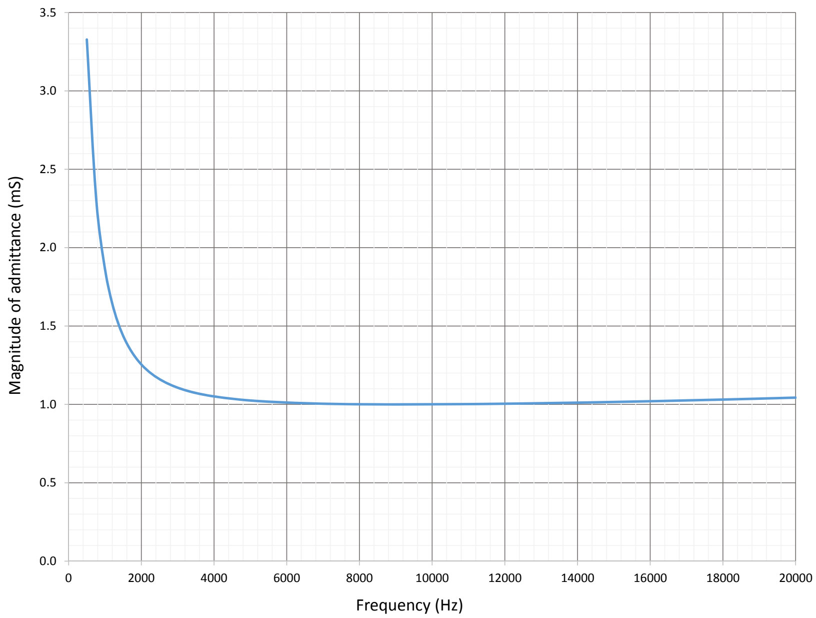


Figure 2: Magnitude of admittance versus frequency

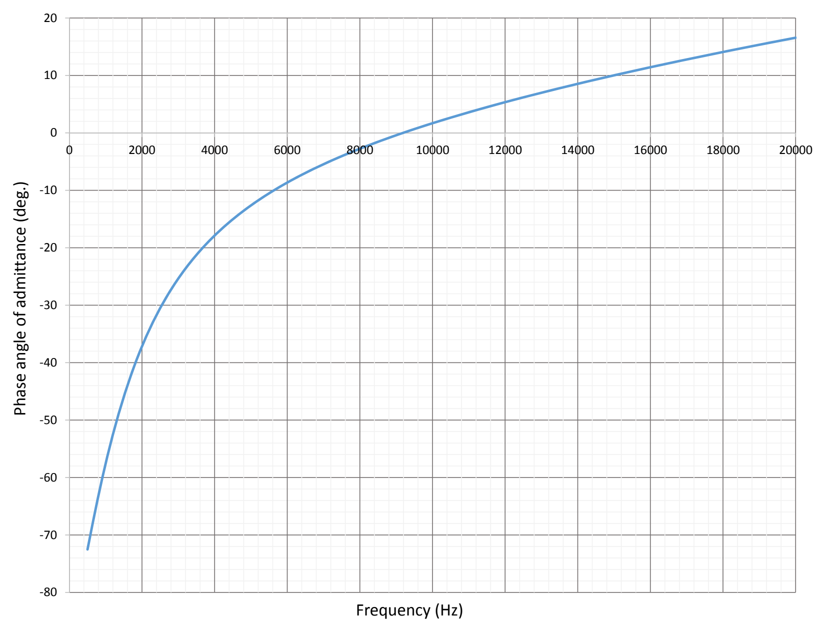


Figure 3: Phase angle of admittance versus frequency

b.) Repeat part (a) for Z_T and θ_T (of $Z_T = Z_T \angle \theta_T$).

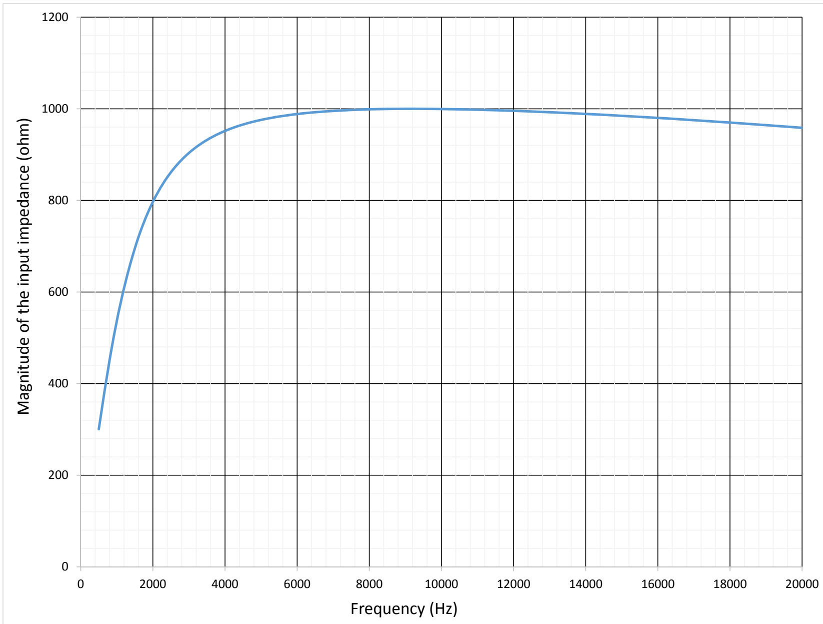


Figure 4: Magnitude of input impedance versus frequency

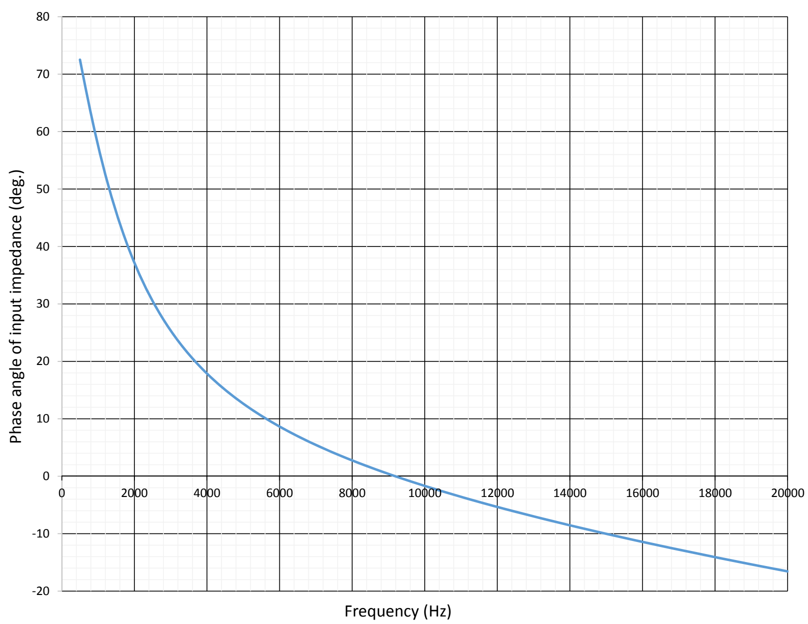


Figure 5: Phase angle of input impedance versus frequency

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

$$
\begin{aligned}
\boldsymbol{E} &= I\angle\theta_I \cdot Z_T\angle\theta_T \\
&= I \cdot Z_T\angle(\theta_I + \theta_T) \\
&= V_C
\end{aligned}
$$

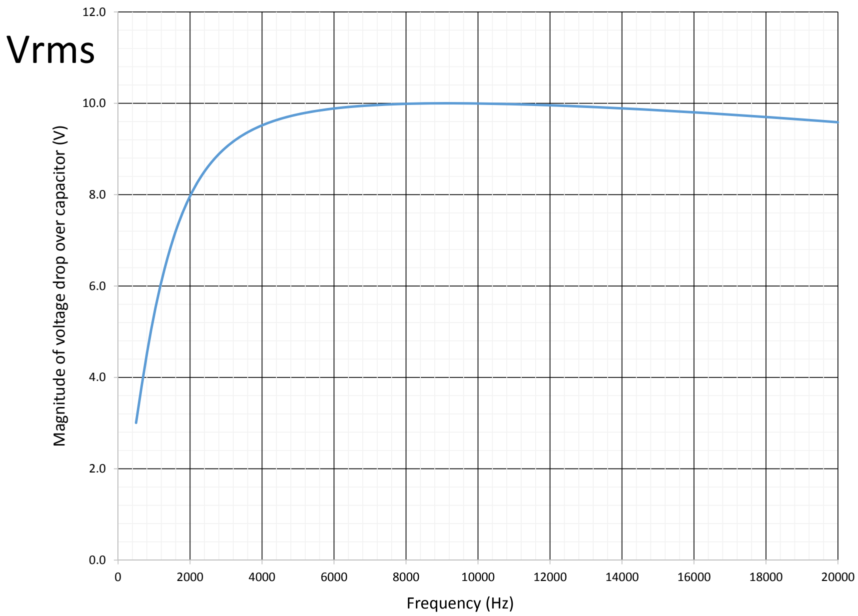


Figure 6: Magnitude of Vc versus frequency

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

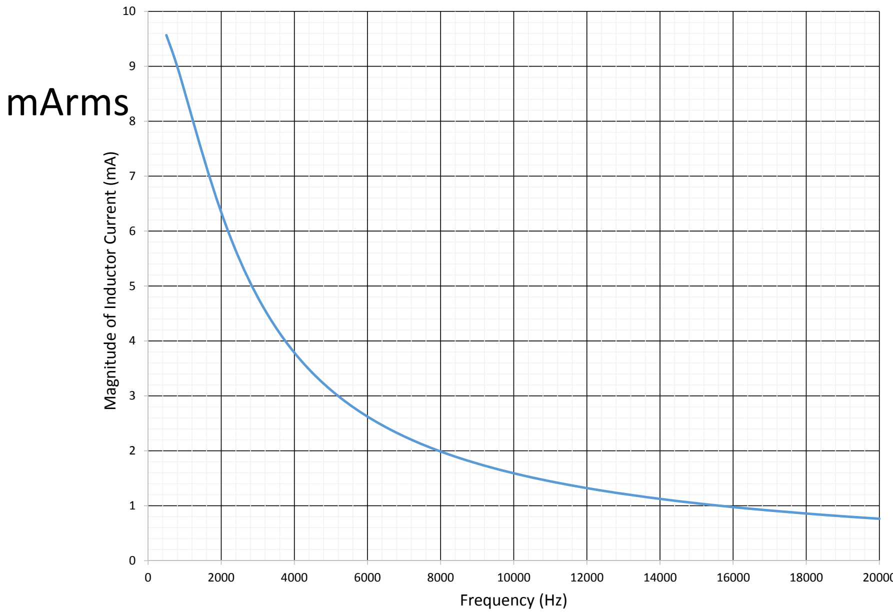


Figure 7: Magnitude of inductive current versus frequency