11/3/22 Tutorials

1) A series RLC circuit with $R = 100\Omega$; $L = 2mH$; and $C = 10\mu F$ is connected to an ac source of 220V, 50Hz. Find the current in the circuit. Also find various components of power, power factor and the frequency at which reactances are equal.

Solution:

Given data: $R = 100\Omega$; $L = 2\times10^{-3}H$; $C = 10\times10^{-6}F$; $V = 220V$; $f = 50Hz$.

Formulae:

$$I = \frac{V}{Z} \; ; \; Z = R + j(X_L - X_C) \; ; \; X_L = 2\pi fL \; ; \; X_C = \frac{1}{2\pi fC} \; ; \; |Z| = \sqrt{R^2 + (X_L - X_C)^2}$$

$$\phi_Z = \tan^{-1}\left[\frac{X_L - X_C}{R}\right]$$

$P = VI\cos\phi$ W ; Power factor $= \cos\phi$

$Q = VI\sin\phi$ VAR

$S = VI$ VA

$$X_L = 2\pi f L = 2\pi \times 50 \times 2 \times 10^{-3} = 0.628\ \Omega$$

$$X_C = \frac{1}{2\pi f C} = \frac{1}{2\pi \times 50 \times 10 \times 10^{-6}} = 318.30\ \Omega$$

$$Z = R + j(X_L - X_C) = 100 + j(0.628 - 318.30)\ \Omega = 100 - j317.67\ \Omega$$

$$|Z| = \sqrt{100^2 + 317.67^2} = 333.2\ \Omega$$

$$\phi = \tan^{-1}\left(\frac{-317.67}{100}\right) = -72.54^\circ$$

$$I = \frac{V}{Z} = \frac{220\angle 0}{333.2\angle -72.54^\circ} = \frac{220}{333.2}\angle 0 - (-72.54^\circ) = 0.66\angle 72.54^\circ\ A$$

Real power $P = VI\cos\phi = 220 \times 0.66 \cos(72.54) = 43.56\ W$

Reactive Power $Q = VI\sin\phi = 220 \times 0.66 \sin(-72.54) = -138.52\ VAR$

Apparent Power $S = VI = 220 \times 0.66 = 145.2\ VA$

Power factor $= \cos(-72.54) = 0.3$ [leading]

To find the frequency at which reactances are equal:

f @ $X_L = X_C$

$$2\pi f L = \frac{1}{2\pi f C}$$

$$f^2 = \frac{1}{(2\pi)^2 L C}$$

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

$$= \frac{1}{2\pi\sqrt{2\times10^{-3}\times10\times10^{-6}}}$$

$$\boxed{f = 1125.40\ \text{Hz}}$$

$R = 20\Omega \quad L = 10mH \quad C = 1000\mu F \quad V = 220V, \quad f = 50Hz.$

$X_L = 2\pi fL = 3.141\ \Omega$

$X_C = \frac{1}{2\pi fC} = 3.183$

$Z = R + j(X_L - X_C) = 20 - j0.042$

$|Z| = \sqrt{R^2 + (X_L - X_C)^2} = 20\ \Omega$

$\phi = -0.120$

$I = \frac{V}{Z} = \frac{220}{20\angle -0.120} = 11\angle 0.120$

$P = VI\cos\phi = 2417.58\ W$

$Q = VI\sin\phi = -5.082\ VAR$

$S = VI = 2420\ VA$

$\cos\phi = 0.99$ leading

$f_r = 1/(2\pi\sqrt{LC}) = 5\ Hz.$

Find the circuit parameters of a series three element circuit excited from an ac source of 115V, 60Hz. The circuit consumes 1000W at 0.77 lagging power factor, and resonates at 550 Hz.

Solution:

To find: R, L, C

Data given: $V = 115V$; $f = 60Hz$; $P = 1000W$ $\cos\phi = 0.77$ lag $\rightarrow [X_L > X_C]$

$$Z = R + jX$$

$$P = VI\cos\phi \Rightarrow I = \frac{P}{V\cos\phi} \; ; \; P = I^2R \Rightarrow R = \frac{P}{I^2}$$

$$I = 11.3A$$

$$R = 7.84$$

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

$$\phi = \tan^{-1}\left(\frac{X_L - X_C}{R}\right)$$