Second-Order Circuits (Series RLC Circuit)

I. The ‘Q’ Factor (Quality Factor)

The $Q$ factor is a measure of how much energy is lost in a circuit or device when it is driven by a sinusoidal signal. We may also define $Q$ in terms of an energy ratio:

$$Q = 2\pi \frac{\text{maximum energy stored}}{\text{total energy lost per period}}$$

A high $Q$ factor means high-energy storage at low loss. For a series RLC circuit resonant at a frequency of $\omega_0 = \frac{1}{\sqrt{LC}}$, the $Q$ factor can be expressed in several ways:

$$Q = \frac{\omega_0 L}{R} = \frac{1}{\omega_0 R C} = \frac{1}{R \sqrt{C}}$$

II. Frequency Response of an RLC Series Circuit

1) $H_R(j\omega) = \frac{V_R(j\omega)}{V_S(j\omega)} = \frac{j\omega \omega_0}{\omega_0^2 + (j\omega)^2 + j\omega \omega_0 / Q}$

\[\text{Graph showing the frequency response for different Q values.}\]

$\omega_0 = 1 \text{ Mrad/s}$
2) \[ H_C(j\omega) = \frac{V_C(j\omega)}{V_S(j\omega)} = \frac{\omega_0^2}{\omega_0^2 + (j\omega)^2 + j\omega \frac{\omega_0}{Q}} \]

\[ \omega_0 = 1 \text{ Mrad/s} \]