Impedance

Impedance, Z is, in general, a complex quantity composed of a real part and an imaginary part. We usually use the symbol R to represent its real part and we call it its resistance, and we use the symbol X to represent its imaginary part and we call it its reactance.

$$\mathbf{Z = R + jX}$$

Since the impedance of a capacitor imaginary and negative,

$$Z_C = \frac{1}{j\omega C} = -\frac{j}{\omega C}$$

and that of an inductor is imaginary and positive,

$$Z_L = j\omega L$$

we say that when X is positive (as in $Z_1 = 3 + 4j$) we call Z an inductive impedance and when X is negative (as in $Z_2 = 9 - 17j$) we call it a capacitive impedance.

Occasionally, we may need to express Z in polar form

$$\mathbf{Z} = |\mathbf{Z}|e^{j\theta}$$

where its magnitude |Z| and phase angle θ are related to components R and X of the rectangular form by

$$|\mathbf{Z}| = \sqrt[+]{R^2 + X^2}, \qquad \text{and} \qquad \theta = \tan^{-1}\left(\frac{X}{R}\right)$$

Impedances in Series and in Parallel

N impedances connected in series (sharing the same phasor current) can be combined into a single equivalent impedance Z_{eq} whose value is equal to the algebraic sum of the individual impedances.

$$Z_{eq} = \sum_{i=1}^{N} Z_i$$

N impedances connected in parallel (sharing the same phasor voltage) can be combined into a single equivalent impedance Z_{eq} whose value is equal to:

$$\frac{1}{Z_{eq}} = \sum_{i=1}^{N} \frac{1}{Z_i}$$