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.

$$Z = R + jX$$

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

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

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

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

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.

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

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:

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