Some Equations Useful in AC Power Calculations

Notation**:** All **bold-face** letters represent **complex** numbers.

RMS Value of a Sinusoid

$V_{rms} = V_p / \sqrt{2}$

$I_{rms} = I_p / \sqrt{2}$

Impedance

$\mathbf{Z} = R + j\,X = |\mathbf{Z}|\angle\theta$

$|\mathbf{Z}| = (R^2 + X^2)^{1/2}$

$\theta = \tan^{-1}(X/R)$

Note**:** θ is the angle of the load impedance (We have suppressed the subscript z.)

Ohm's Law in Frequency Domain

$\mathbf{V} = \mathbf{IZ}$

$V_p = I_p\,|\mathbf{Z}|$

$\mathbf{V}_{rms} = \mathbf{V} / \sqrt{2}$

$\mathbf{I}_{rms} = \mathbf{I} / \sqrt{2}$

$V_{rms} = I_{rms}\,|\mathbf{Z}|$

$\theta_v - \theta_i = \theta$

$\theta > 0$ when $X > 0$ (Inductive impedance)

$\theta < 0$ when $X < 0$ (Capacitive impedance)

Average Power (W)

$P = V_{rms}\,I_{rms}\cos\theta = I_{rms}^2\,R = (V_{rms}^2\cos\theta)/|\mathbf{Z}|$

Power Factor

$pf = \cos\theta = R/(R^2 + X^2)^{1/2}, \quad 1 \geq pf \geq 0.$

If $\theta > 0$ (inductive impedance), $\theta_i < \theta_v$, pf lagging

If $\theta < 0$ (capacitive impedance), $\theta_i > \theta_v$, pf leading

If $\theta = 0$ for purely resistive load and the pf is unity

Reactive Power (VAR)

$Q = V_{rms}\,I_{rms}\sin\theta = I_{rms}^2\,X$

Apparent Power (VA)

$S = V_{rms}\,I_{rms} = I_{rms}^2\,|\mathbf{Z}| = V_{rms}^2 / |\mathbf{Z}|$

Complex Power (VA)

$\mathbf{S} = \mathbf{V}_{rms}\,(\mathbf{I}_{rms})^* = V_{rms}\,I_{rms}\angle\theta = P + j\,Q = I_{rms}^2\,\mathbf{Z} = (V_{rms})^2 / \mathbf{Z}^*$

Note: The only quantities that can be complex are impedance, phasor, RMS phasor, and complex power.