Circuit Design Equations

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I. Sinusoidal signals

$$V(t) = V_{pk}\sin(\omega t + \phi) \qquad I(t) = I_{pk}\sin(\omega t + \phi) \tag{1}$$

II. Signal Voltage, Current, & Power

$$P = \int_T \frac{V^2(t)}{RT}\mathrm{d}t \qquad P = \int_T \frac{RI^2(t)}{T}\mathrm{d}t \tag{2}$$

Sub (1) in (2) & solving:

$$P = \frac{V_{pk}^2}{2R} \qquad P = \frac{RI_{pk}^2}{2}$$

RMS Voltage & Current,

$$V_{RMS} \triangleq \sqrt{RP} = \frac{V_{pk}}{\sqrt{2}} \qquad I_{RMS} \triangleq \sqrt{\frac{P}{R}} = \frac{I_{pk}}{\sqrt{2}}$$

III. Decibels & Nepers

Power (Decibels),

$$P_{\mathrm{dB}} \triangleq 10\log_{10}\frac{P_1}{P_2}\,[\mathrm{dB}] \quad \Leftrightarrow \quad \frac{P_1}{P_2} = 10^{\frac{P_{\mathrm{dB}}}{10}}$$

$$= 10\log_{10}\frac{V_1^2 R_2}{V_2^2 R_1}\,[\mathrm{dB}] \quad \Leftrightarrow \quad \frac{V_1}{V_2}\sqrt{\frac{R_2}{R_1}} = 10^{\frac{P_{\mathrm{dB}}}{20}}$$

$$= 10\log_{10}\frac{I_1^2 R_1}{I_2^2 R_2}\,[\mathrm{dB}] \quad \Leftrightarrow \quad \frac{I_1}{I_2}\sqrt{\frac{R_1}{R_2}} = 10^{\frac{P_{\mathrm{dB}}}{20}}$$

Power (Nepers),

$$P_{\mathrm{Np}} \triangleq \frac{1}{2}\ln\frac{P_1}{P_2}\,[\mathrm{Np}] \quad \Leftrightarrow \quad \frac{P_1}{P_2} = e^{2P_{\mathrm{Np}}}$$

$$= \ln\frac{V_1\sqrt{R_2}}{V_2\sqrt{R_1}}\,[\mathrm{Np}] \quad \Leftrightarrow \quad \frac{V_1}{V_2}\sqrt{\frac{R_2}{R_1}} = e^{P_{\mathrm{Np}}}$$

$$= \ln\frac{I_1\sqrt{R_1}}{I_2\sqrt{R_2}}\,[\mathrm{Np}] \quad \Leftrightarrow \quad \frac{I_1}{I_2}\sqrt{\frac{R_1}{R_2}} = e^{P_{\mathrm{Np}}}$$

Decibels $\Leftrightarrow$ Nepers,

$$e^{2P_{\mathrm{Np}}} = \frac{P_1}{P_2} = 10^{\frac{P_{\mathrm{dB}}}{10}}$$

$$P_{\mathrm{dB}} = \frac{20}{\ln 10}P_{\mathrm{Np}} = (20\log_{10} e)P_{\mathrm{Np}}$$

$$1\,[\mathrm{Np}] \approx 8.686\,[\mathrm{dB}]$$