Com. Elec. Formula Sheet

Decibel Formulas

Relative Power Gain

$$A_P = \frac{P_O}{P_I}$$

where P_O and P_I are defined as the following:

$$P_I = \frac{V_I^2}{R_I}$$

$$P_O = \frac{V_O^2}{R_O}$$

Relative Voltage Gain

$$A_V = \frac{V_O}{V_I}$$

Relative Power Gain in dB

$$A_P(db) = 10\log_{10} A_P$$

Given that $R_O = R_I$

If $R_O \neq R_I$ then the general form is given by the following:

$$A_P(db) = 10\log_{10}\left(\frac{\frac{V_O^2}{R_O}}{\frac{V_I^2}{R_I}}\right)$$

Relative Voltage Gain in dB

$$A_V(db) = 20\log_{10}\left(\frac{V_O}{V_I}\right) = 20\log_{10} A_V$$

If $R_O \neq R_I$ then the general form is given by the following:

$$A_V(db) = 20\log_{10}\left(\frac{V_O}{V_I}\right) - 10\log_{10}\left(\frac{R_O}{R_I}\right)$$

Special Case

If $R_O \neq R_I$ then the general form is given by the following:

$$A_V(db) = 10\log_{10}\left(\frac{V_O^2}{V_I^2}\right) - 10\log_{10}\left(\frac{R_O}{R_I}\right)$$

$$= 20\log_{10}\left(\frac{V_O}{V_I}\right) - 10\log_{10}\left(\frac{R_O}{R_I}\right)$$

Absolute Power Gain dBm

$$A_{P(dBm)} = 10\log_{10}\left(\frac{P}{1\text{ mW}}\right),\ \text{dBm}$$

Absolute Power Gain dBw

$$A_{P(dBw)} = 10\log_{10}\left(\frac{P}{1\text{ W}}\right),\ \text{dBw}$$

Signal-to-Noise Ratio

$$\text{SNR} = 10\log_{10}\left(\frac{\text{Signal Power}}{\text{Noise Power}}\right)$$

And given that $R_O = R_I$,

$$\text{SNR} = 10\log_{10}\left(\frac{V_S^2}{V_N^2}\right)$$

$$\text{SNR} = 20\log_{10}\left(\frac{V_S}{V_N}\right)\text{dB}$$

Impulse Noise

$$dB_S = 20\log_{10}\left(\frac{P}{0.0002\bar{\mu}}\right),\ \text{where P is sound pressure in } \bar{\mu}$$

$$\bar{\mu} = 1\frac{\text{dyne}}{\text{cm}^2} = 10^{-6} \text{ of atmospheric pressure at sea level}$$

Gaussian (White) Noise

$$P_n = kT\Delta f$$

$k =$ Boltzmann's Constant $(1.38 * 10^{-23})$ J/K

$T =$ resistor temperature in Kelvin (K)

$\Delta f =$ system bandwidth.

Gaussian (White) Noise Formulas

Using the above proportionality we can relate bandwidth to noise, shown below:
Given the noise can be represented as e_n then we can say the following:

$$P_n = \frac{V_n^2}{R} = kT\Delta f,\ \text{where } V_n = \frac{e_n}{2}$$

This is true by Ohm's law. By solving in terms of e_n we get the following:

$$\frac{V_n^2}{R} = kT\Delta f \text{ where } V_n = \frac{e_n}{2}$$

$$\frac{\left(\frac{e_n}{2}\right)^2}{R} = \frac{\left(\frac{e_n^2}{4}\right)}{R} = kT\Delta f$$

$$\left(\frac{e_n^2}{4}\right) = kT\Delta f R$$

$$e_n = \sqrt{4kT\Delta f R}$$

Noise Ratio

$$NF = 10\log_{10}\frac{\frac{S_i}{N_i}}{\frac{S_o}{N_o}} = 10\log_{10} NR$$

$$NR = \frac{\frac{S_i}{N_i}}{\frac{S_o}{N_o}} \text{ is the Noise Ratio}$$

$$\frac{S_i}{N_i} = \text{ input SNR}$$

$$\frac{S_o}{N_o} = \text{ output SNR}$$

Reactance Noise Effects

$$\Delta f_{eq} = \frac{\pi}{2} BW$$

$BW = 3$ dB; bandwidth for $RC, LC,$ or RLC circuits.

Noise Created by Amplifiers in Cascade

$$NR = NR_1 + \frac{NR_2 - 1}{P_{G_1}} + ... + \frac{NR_n - 1}{P_{G_1} * P_{G_2} * P_{G_{(n-1)}}}$$

$NR =$ overall noise ratio of n stages.

$P_G =$ power gain ratio

Equivalent Noise Temperature

$$T_{eq} = T_0(NR - 1)$$

where $T_0 = 290$ K, a reference temperature in Kelvin.

Equivalent Noise Resistance

Sometimes used by Manufacturers to represent the noise generated by a device with a fictitious resistance.
The following represents this:

$$R_{eq} = \sqrt{4kT\Delta f R}$$