Engineering News

ALTEC LANSING

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GRAPH RELATING THERMAL NOISE TO BANDWIDTH

Any resistance which is at a temperature above absolute zero generates noise due to the thermal agitation of free electrons in the material. The magnitude of the noise can be calculated from a knowledge of resistance, absolute temperature and equivalent noise bandwidth of the measuring system. A completely noise free amplifier whose input is connected to its equivalent source resistance will have noise in its output equal to the product of amplification and source resistor noise. This noise is said to be the "theoretical minimum."

The accompanying graph provides a quick means for determining the rms value of thermal noise voltage in terms of resistance and circuit bandwidth. The approximate formula, at an ambient temperatures of 23° C is:

$$E_{rms} = 1.28 \times 10^{-10} (R_{\Delta}\ Hz)^{\frac{1}{2}}$$

Example of use; a line amplifier has a specified bandwidth of 50 Hz, source impedance of 600 Ω and input impedance of 600 Ω, what is the theoretical (lowest value) of equivalent input noise?

From the chart, 300 Ω of resistance (600 Ω source in parallel with 600 Ω input) with a bandwidth of 50 Hz produces a voltage of 0.48 μV. dB re 1 mW = 20 log .78/.48 x 10^{-6} = 20 log 1.63 x 10^{6} = 124.2 dB. If the amplifier specification for equivalent input noise was -123 dBm it would be within 1.2 dB of theoretical which is considered to be very good. If the bandwidth is narrowed to 20 Hz, thermal noise reduces to 0.3 μV reducing equivalent input noise by 4 dB.

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THERMAL NOISE (23° C)