The Background Noise Analysis

When making measurements, we want to limit the error and decrease the effects of unwanted signals so that we can get the most accurate representation possible. There are sources of noise that are part of the instrument itself and there are external noise sources. For the nature of this discussion, we are going to stick to internal noise sources.

One of the main sources of noise is created by thermal effects in the circuit elements within the instrument. As you may recall, temperature is a measure of the average kinetic energy of a system. On a molecular level, higher temperatures lead to higher average kinetic energy. Due to an increase in molecular vibrations. These vibrations create electrical potentials (voltage) that can effect measurements.

Thermal, or Johnson, Noise, is defined by the following equation:

P_n = kTB

Where: P_n = Noise power in watts
k = Boltzmann's Constant (1.38x10-23 joule/°K)
T = Absolute temperature, °K
B = Bandwidth in Hz

Let's look at two examples.
What is the noise power of a system with T = 293°K (Equivalent to room temperature of 20°C or 68°F) and a measurement bandwidth of 1MHz (1x10+6 HZ)?

P_{n1} = 1.38x10-23 joule/°K * 293°K * 1x10+6HZ = 4x10-15 watts

What if we cut the bandwidth by 10 B = 100kHz (1x10+5)?

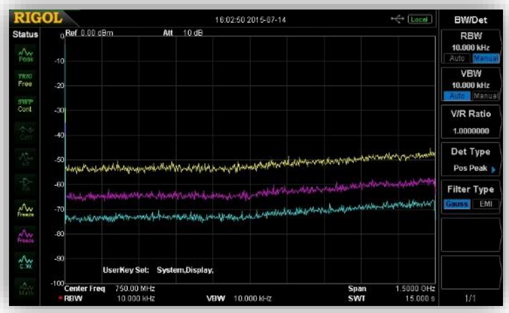
P_{n2} = 1.38x10-23 joule/°K * 293°K * 1x10+6HZ = 4x10-16 watts

Now, what if we compared these two powers in dB?

Recall the equation for Power in dB is $L_p = 10 \log_{10} (P/P_o)$dB.

Using the results from our experiment above, we get:

$L_p = 10 \log_{10} (P_{n1}/P_{n2})\text{dB} = 10 \log_{10} (4\text{x}10\text{-}15$ watts/4x10-16 watts) = 10dB



As you can see, the bandwidth of the measurement directly effects the thermal noise that can influence the measurement. If we want to increase sensitivity (synonymous with decreasing noise), we can lower the bandwidth of the measurement.

The Displayed Average Noise Level, or DANL, of a spectrum analyzer is a term that describes the expected noise level of the analyzer and it determines the lowest signal level that can be measured by the instrument. The DANL represents the noise floor of the instrument. The DANL value is heavily influenced by the frequency span of the measurement, RBW, VBW, preamplifiers, and detector settings but can also be effected by factors such as the number of trace averages being used.

You can lower the DANL quickly by decreasing the RBW setting. Decreasing the RBW by 10 times will decrease the DANL by 10dB as shown below.

In this experiment, there was no input signal to the analyzer. We are simply looking at the noise floor of the instrument. The yellow trace represents a scan from 9kHz to 1.5GHz with an RBW of 1MHz. The purple trace was acquired using an RBW of 100kHz and the light blue trace used an RBW of 10kHz. You can see that each decade (10) decrease in RBW resulted in a 10dB drop in the DANL.

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