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What is a Decibel?

We've approached with the term "Decibel" in our daily lives, and we generally know it's a measure of loudness. We scream things like "Turn down that Decibel Level!" to our kids, and we don't think much more about it. We don't think about it UNTIL we are tasked to measure it.

Before we get into any math, we have to understand that a sound (measured in Decibels) is simply changes in air pressure. I know you're saying, "Wait – I measure air pressure in PSI in my tire! I hear about air pressure on the weather when they talk about the barometric pressure!" The difference is that our ears can only hear CHANGES in air pressure. You're can't hear a storm coming, however, just because the barometric pressure is dropping. Only air pressure that's changing at 20 times per second (20Hz) or greater is actually picked up by our ears and registered in our brain as a sound. In fact, you can hear sound pressure changes up to 15,000 times per second (15,000Hz), depending on your age and how many rock concerts you've attended.

A guitar, or a piano, an airplane, or a screaming spouse: They may seem very different from each other, but they are all doing nothing more than causing very tiny and very fast changes in the air pressure around us.
Not only do the air pressure changes have to fall within a certain frequency range (20Hz – 15kHz) to be heard, it has to fall within a certain MAGNITUDE also. Some people can "hear" a small wiggle in the air pressure as small as 0.000000003 PSI (depending on the person, of course). Pretty impressive considering there's probably about 30 PSI in your tire. We won't meet our threshold of pain, on the high side, until the air pressure is jumping up at down (at least 20 times / sec) at 0.002 PSI or higher. These are very small numbers in PSI – it's like trying to measure the length of bacteria in "meters". Consequently, the "Pascal" (Pa) is generally used to measure changes in air pressure when you're trying to measure sound. 1 PSI is the same as 6,895 Pascals. This is what a second of normal office noise looks like as a function of the change in air pressure (Pa) vs. Time:

You'll see that the pressure level values go positive and negative. The "Zero" is actually the constant pressure of the atmosphere and you're seeing the vast deviations in the pressure. Taking this data is the first step to calculating the decibel which is a key point: The decibel is calculated, not measured directly. The decibel is simply the average deviation from the atmospheric pressure. So why isn't it measured as the average "Pascal"? Well, it sure could be, but the Decibel calculation resulted in much more round numbers.

Calculating the decibel level starts by calculating the RMS (Root Mean Square) pressure level in Pascals:

Step 1: Take a sample from that waveform of the pressure vs. time a few thousand times per second
Step 2: Square each term you get from step 1 (this is easily done in Excel)
Step 3: Add the results in step 2.
Step 4: Take the square root of the result in step 3.

The result you get is the RMS level of the sound in Pascals – a nice easy, single number rather than a messy graph.
Now you have what you need to measure Decibels:
The decibel level = 20 x log (Pa / 0.00002)

Where the "Pa" term is the RMS level of the sound in Pascals. Occasionally, the peak sound level (the maximum deviation from the "0" value on the above graph) is also expressed in Decibels. You can simply plug in that maximum level in Pascals as the "Pa" term in the equation and get the peak Decibel level.

There is a lot more involved in measuring sound, including the selection of the microphone, the environment in which you're measuring, the compensation for how the human ear changes the sound, Etc. - If you have any acoustics testing requirements that you would like to discuss, please contact your local T&M Instruments sales representative.

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