The Amateur in You, Part 2

What have you been pondering?

Decibels

The term *decibel* often shows up in literature, specifications, and exams. Many believe it's a standard of audio loudness, while others in the technical world find it to be a somewhat cryptic way of measuring things. Turns out it's a method of describing a ratio between two values, making it a unitless descriptor.

History

In the early days of telephone, it was well-known that the longer the wire, the more the phone signal degraded. So, engineers came up with a way to measure the loss by MSC, or *miles of standard cable* for wire close to today's 19 gauge. In 1924, Bell Telephone came up with the TU, or *transmission unit*, which is a logarithm-based value that allowed for easy calculations of both small and large numbers. In 1928, ten TUs was declared to be equal to a *bel*, in honor of Alexander Graham Bell.

The bel began to replace the TU, but it soon became more popular to refer to *tenths of a bel* instead of bels for two reasons. One is that a tenth of a bel is the smallest difference in loudness discernible to the human ear, as had been determined in that day. Another is the convenience of calculation, as will be shown here. This tenths of bels, therefore, came to be called ***decibels*** (abbreviated "dB"), and is defined as

$$1 \text{ dB} = 10\log_{10}(S_o/S_I),$$

or ten times the based-ten logarithm of the measured (output) signal divided by the reference (input) signal.

Keep it simple

We can simplify most dB calculations and conversions by using the following:

3 dB = **two times**	–3 dB = **half**
10 dB = **ten times**	–10 dB = **tenth**

This means, if a signal changes by 3 dB, its strength doubles; if it changes by 10 dB, it's ten times as strong. But remember that decibels are based on logarithms, and one reason that decibels make calculations easier is that when values multiply, logarithms add, and when values divide, logarithms subtract.

This way, if a signal changes by 9 dB, its strength increases by 3 dB + 3 dB + 3 dB = 2 x 2 x 2 = 8 times. And if a signal changes by 23 dB, its strength increases by 10 dB + 10 dB + 3 dB = 10 x 10 x 3 = 300 times! By the same idea, if a signal changes by –12 dB, its strength becomes –3 dB –3 dB –3 dB –3 dB = ½ x ½ x ½ x ½ = 1/16 as much.

Application

As much as we tend to use decibels for radio and electricity, it can be used for nearly any ratio. If I have five marbles on one day, and twenty marbles the next day, my quantity of marbles increased by 20 ÷ 5 = 4 times, which equals 2 x 2, or 3 dB + 3 dB = 6 dB.

For added convenience, we sometimes append a modifier to the dB, such as dBi (referenced to an isotropic radiator), dBd (referenced to a dipole), and dBm (referenced to a milliwatt).

Finally

More typically, the unitless decibel is used to denote a ratio in antenna gain or signal strength in our amateur radio world. On HF, for example, according to Part 97.307(d), the largest spurious emission legally permitted is –43 dB of the primary or fundamental signal, or –10 dB –10 dB –10 dB –10 dB –3 dB = 1/10 x 1/10 x 1/10 x 1/10 x 1/2 = 1/20,000 of the primary signal. This means if I've set my HF power to 100 watts, then the largest allowable spurious signal is 100 watts x 1/20,000 = 1/200 of a watt, or 5 mW!