Decibels 101

When you hear or read the word decibel (or its abbreviation, dB), think “comparison” or “change”.

In radio, decibels are generally used to compare two power levels. The math changes a bit when using decibels to compare two voltage levels, but there are no voltage decibel questions on the General test.

When you hear or use “dB” in a sentence, you are always comparing two power levels, determining gain or loss. When “dB” is followed by a third letter, such as dBi, dBd, or dBm, that third letter specifies a reference that you are comparing a single power level or gain measurement to.

DBi and dBd are used to describe antenna gain, and identify the reference antenna by using an “i” for isotropic antenna (a theoretical antenna) and a “d” for a dipole antenna. A dipole has 2.15 dB gain over an isotropic antenna. Thus 2.15 dBi = 0 dBd, and conversely, -2.15 dBd = 0 dBi. When dBm is used, it specifies a reference power level of 0 dBm, which is defined as 1 mW (one milliwatt or one thousandth of a watt) in a 50 ohm system.

Examples of the correct use of decibel terminology:

* This antenna has 4.2 dBd gain. (You are comparing the gain of an antenna to that of a dipole)
* This antenna has 3 dB gain over that antenna. (You are comparing the gain of one antenna to that of another)
* This amplifier has a 10 dB gain. (You are comparing the power level change of the input signal to the output signal)
* The attenuator is set for -20 dB. (You are comparing the power level change of the input signal to the output signal however an attenuator absorbs power. Since it’s a decrease in signal, mathematically it’s written with a minus sign i.e. -20 dB.)
* The squelch opens on my radio at -100 dBm (You are comparing the squelch setting on your radio to 0 dBm, which is 1 milliwatt (for 50 ohm systems). A one hundred dB reduction in power (because it’s minus) from 1 milliwatt (.001 watt) is .1 pico watt (.000,000,000,000,1 watt).

Memorizing the following three decibel relationships will answer 95% or your ham radio power comparisons.

+ 1 dB = a 26% increase, -1 dB = a 20.5 % decrease in power.

(a 1 dB increase in a 10 watt signal yields about 12.6 watts. A 1 dB decrease yields about 7.9 watts)

+ 3 dB change = twice the power, -3 dB = half the power.

(10 watts into a run of coax with a 3 dB loss in means you get about 5 watts out. 10 watts into a 3 dB amplifier (gain) yields about 20 watts out.)

10 dB change = a 10 fold change in power.

(50 watts into a run of coax with a 10 dB loss in means you get about 5 watts out. 50 watts into an amplifier with 10 dB gain yields about 500 watts out.)

A 30 dB change is a thousand fold, a 60 dB change is a million fold, and a 100 dB change is a ten thousand million fold change in power.

Using decibels allows you to do simple addition and subtraction of relatively small numbers to calculate relatively complicated changes of gain over many orders of magnitude.

Example: If you have a transmitter with an output of 8 watts and you feed into a 9 dB amplifier, then through a length of coax that has a 3 dB loss, and then into a directional antenna with a 6 dBd gain, what is the equivalent radiated power of the antenna?

A: You simply add the dB changes along the signal path (paying attention to the signs): +9 dB + (-3 dB) + 6 dB = 12 dB. Thus the net change to the input power (8 watts) is 12 dB. It is a positive number, so it is a net increase (gain). So what's the equivalent radiated power at the antenna?

One way is to think of the 12 dB change as four 3 dB changes. The first 3 dB doubles the transmitter power (8 watts) to 16 watts, the second 3 dB doubles it again (to 32 watts), the next 3 dB doubles that (to 64 watts), and the last 3 dB doubles that to 128 watts. Your antenna is acting like dipole that was being driven by a 128 watt transmitter connected right at the feed point.

A second way to think about it is a 10 dB change and two 1 dB changes. The 10 dB change increases the 8 watts to 80 watts (a ten fold change). A one dB increase to 80 watts gives you about 100 watts (26 percent more), and another 1 dB increase to 100 watts gives you about 127 watts.

Two approaches above give you a good approximate answer that you can do in your head. If you need an exact number, grab a calculator and use the actual power dB formula: $N_{dB} = 10 \log_{10}\left(\frac{P2}{P1}\right)$ and you would find that a 12 dB gain applied to 8 watts yields 126.7912 watts.

(Memorizing the 1, 3, and 10 dB changes is good enough for me!)