A dB is a dB is a dB

By

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Many amateur radio operators do not understand the difference in absolute values when comparing dB (decibel) factors between power and voltage. For example, "everyone" knows that a 3 dB increase in power means that twice the power is involved. However, twice the voltage (i.e. when measuring the sensitivity of a receiver) means a 6 dB increase. Conversely, if the power is reduced by one-half, the reduction is 3 dB. But, if the voltage is reduced by one-half, the reduction is 6 dB.

On the surface, this does not "seem right"! However, since decibels are a logarithmic expression and not a linear expression, this is due to the fact that power involves the "squaring" of a factor and voltage does not. The following mathematical representation shows just why the difference. The values have been chosen for ease in calculation and thus explanation, but any values could be used. 50 ohms was chosen as the resistance / impedance since has become the "standard" in amateur radio circles. The wattage figures were again chosen for ease in explanation. Thus, the following:

A reduction of 6 dB will result in only half of the voltage but the power will be reduced to 1/4 the amount.

In the following formulae the algebraic notations are thus:

E = voltage

I = current

P = power

R = resistance

Remember that P = I x I x R (I "squared" R).

E = IR

P = EI

For example, if we have a resistance of 50 ohms and a current of 2 amps, power would be 2 x 2 x 50 = 200 watts. The voltage at this point would be 2 x 50 or 100 volts.

If we cut the power to 50 watts, the current would be 1 amp (this is a 6 dB reduction). P = 1 x 1 x 50.

But, the voltage is equal to the current times the resistance. This would make for 1 x 50 = 50 volts.

50 volts is one half of the voltage to get to the 6 dB point while the power is only one quarter.

That is why the formula for dB in power is 10 times the logarithm of p1/p2 but the formula for dB in voltage is 20 times the logarithm of v1/v2.

Thus, if an S-meter reading of S-9 is equal to 50 microvolts with an input impedance of 50 ohms (the "standard" used in many of the older receivers), and if the "standard" of 6 dB per S-unit is used (again the "standard" of many of the older receivers), then a signal level of 25 microvolts will produce an S-8 reading and a signal level of 12.5 microvolts will produce an S-7 reading, and "so on".

Don't feel bad about not understanding why the difference in power and voltage ratios are not the same. I suspect that well over half (and probably "way" over half) of amateurs do not understand the relationship of voltage and power. It is the fact that power requires a "squaring" of the current and voltage only requires a straight multiplication.

But, the statement that a dB is a dB is a dB definitely holds true. If you have a reduction in power of 3 dB (one-half power), the voltage reduction will be .707 times the original voltage. This is the "square root of 2" divided by 2. Or, 1.414 / 2 = .707.

For example, if we start at 100 watts and 50 ohms, the current will be 1.414 amps (1.414 x 1.414 x 50 = 100 watts). The voltage would be 1.414 x 50 = 70.7 volts. If we drop the power to 50 watts (3 dB reduction), the current drops to 1 amp (1 x 1 x 50 = 50 watts) and the voltage drops to 50 volts (1 x 50 = 50). The ratio of the original voltage to the new voltage is .707 (50 divided by 70.7 is equal to .707).

I am using the "even" figures for power because the math is simpler. However, you can use any power and any impedance/ resistance and get the same ratios. It just involves use of log tables (or calculator, etc.). The end answers will still be the same.

Hopefully, the above calculations will allow the better understanding of the relationship of power to voltage when dealing with decibels. Remember that a dB is a dB is a dB! It is just the calculations that get confusing!