How to "think" in dB

Every time you talk to a microwave engineer it's dB-this and dB-that. What are they talking about? (if you are a mechanical engineer sitting at a meeting and the topic shifts to "dB", it's probably a good time to get another donut...) A decibel is a convenient logarithmic ratio of two RF power or RF voltage levels (usually input and output levels). If you are asking "why are logarithmic ratios convenient?", you are too young to have owned a slide rule. The beautiful thing about log ratios is that multiplication of "linear" numbers becomes addition, and division becomes subtraction.

The conversion of linear ratios to dB is:

10xlog(power level2/power level1), or

20xlog(voltage level2/voltage level1)

Bear in mind that in microwaves we are most often referring to power levels, not voltage levels. That's because microwave signals are usually measured in milliwatts, not millivolts. You can easily convert from power to voltage and vice-versa if you know the system characteristic impedance (usually 50 ohms).

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Decibels are very useful for talking about increases (gains) or decreases (losses) without talking about the actual power or voltage levels. Remember, though, that dB by itself isn't a unit like millimeters or inch, it's all relative. A negative number of dB indicates loss or reduction in signal strength, while a positive number indicates gain or increase in signal strength. When you refer to a loss in dB, it is customary to eliminate the negative sign. For example, a ten-dB attenuator has 10 dB loss, while it has -10 dB gain. By the way, the decibel is actually a tenth of a Bel, a unit named after (you guessed it) Alexander Graham himself!

You'll also see the term dBm in the field of microwaves (decibels referenced to milliwatts), or sometimes dBW (decibels referenced to watts). This is simply the same logarithmic calculation but instead of comparing two power levels to each

other, you are comparing one power level to 1 milliwatt. 10 dBm is the same at 10 mW, 20 dBm is the same as 100 mw, 30 dBm is the same as 1000 mw (or one watt).

How do you "think" in decibels compared to linear units? Just remember a few key conversions and you will be all set to impress your friends with quick approximations of some heavy multiplication and division (that is, if they are easily impressed). By the way, we rounded these off so they will be easier to remember, if you need an exact answer, get a calculator!

30 dB is an increase of 1000X in power

20 dB is an increase of 100X in power

10 dB is an increase of 10X in power

6 dB is an increase of 4X in power

3 dB is an increase of 2X in power

2 dB is an increase of 1.6X in power

1 dB is an increase of 1.25X in power

0 dB is no increase or decrease in power

-1 dB is a decrease of 20% in power

-2 dB is a decrease of 37% in power (roughly a decrease of 1/3)

-3 dB is a decrease of 50% in power

-6 dB is a decrease of 75% in power

-10 dB is a decrease of 90% in power

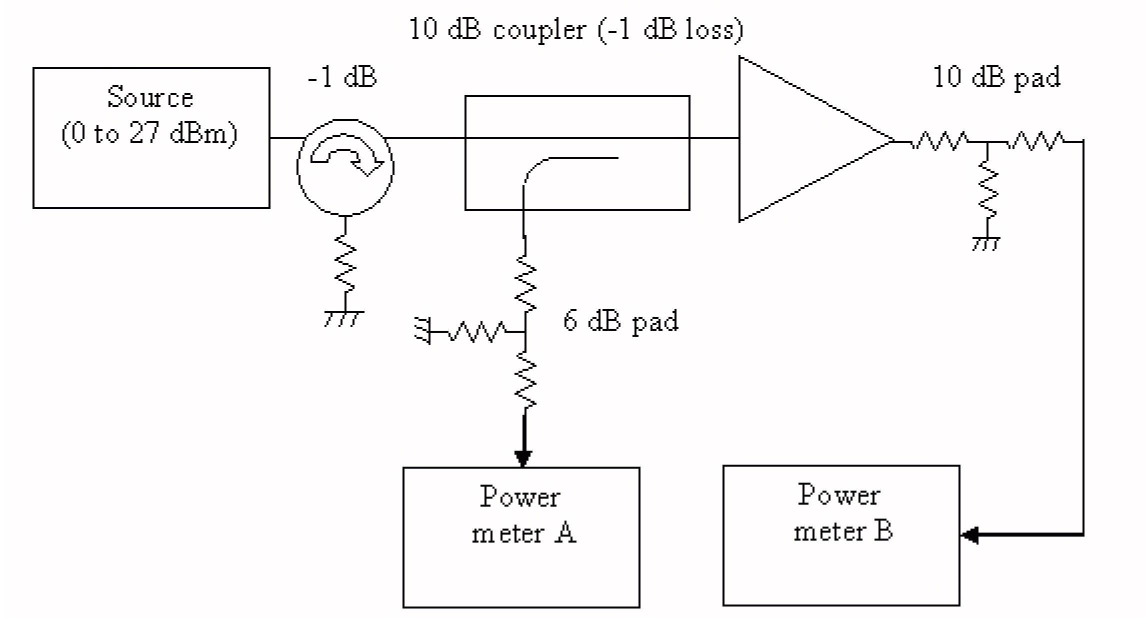
-20 dB is a decrease of 99% in power

-30 dB is a decrease of 99.9% in power

When you input a 5 milliwatt signal into a power amplifier that has 12 dB of gain, the output is 80 mW You can easily do the math in your head. Break down the 12 dB into 6 dB + 6 dB, and remember that each 6 dB increases power by 4X, so you have an increase of 16X (equal to 4x4). Sixteen times five is eighty.

An example

Let's try a harder laboratory calculation. Your signal source has an adjustable power output from 0 to 27 dBm (one milliwatt to half a watt). You have an isolator on the source output (always a good idea) with one dB loss. Then you are coupling off a sample of the signal through a ten dB coupler, attenuating it with a six dB pad before reading the signal strength in decibels with a power meter. The "through" port of the coupler is known to have one dB of loss with respect to its input port, and your device under test (DUT) resides right on the output port of the coupler. When Power meter A reads 6 dBm, how much power does the DUT see?



Working backwards from the "known" power (Power meter A), you have 17 dB loss between it and the source (the 6 dB pad, the 10 dB coupler, and the isolator at one dB). Therefore the source is generating a power of 23 dBm, which is 200 milliwatts (remember that 20 dBm is 100 milliwatts, and you are 3 dB above that). Then working toward the DUT, you have two dB loss total (one dB in the isolator, one dB in the coupler), so the DUT sees 21 dBm, or 15 dB higher than the power meter reading. 21 dBm is 25% more than 100 milliwatts, or 125 milliwatts. Note that once you know the +15 dB difference between the power meter and DUT, you can apply it to *any* power meter reading A; this is your*calibration factor* for input power.

The calibration factor for the output power is +10 dB, this is due to the 10 dB pad we added after the DUT. So if you read 20 dBm on meter B, the amplifier is putting out 30 dBm (1 watt). If meter A is reading 6 dBm, the amplifier has 7 dB gain. Be sure to keep track of the "polarity" of the cal factors, so you don't subtract when you should add or vice-versa!

Note that in real life, you would measure calibration factors more exactly, because nominal values are not exact (and will vary when you measure across frequency). Go to our page on [power meter measurements] to learn more.

With a little practice you will be able to do decibel calculations in your sleep, it's easier than balancing your checkbook. For homework, try the previous calculation using "normal" math... let's see, the pad loses 75% of the signal power, the coupler loses another 90% on top of that and the circulator loses another 10%... forget about it!