Alexander Graham Bell has brought many things to the communications of the world, but modesty wasn't one of them. When dealing with the amplifiers necessary to cope with long distance links he invented a unit which he called The Bell to express the gains in a more manageable way. The Bell was simply the logarithm (to the base 10) of the ratio of the powers involved in the lines. i.e. Bells=$\log_{10}$(output power/input power). Where the input and output powers relate to the amplifier or cable in question. For more information, see what's a logarithm?

In practice the Bell was rather a large unit for the job - in much the same way as a meter is a large unit for measuring everyday objects. So, in the same way as the centimeter (100th of a meter) became the everyday unit, so the decibel (10th of a Bell) became common. Thus the formula became dB=10$\log_{10}$(output/input) being 10 times the value of the Bell formula.

It is important to note that any figure expressing a ratio of two identical units is a unit divided by another identical unit (power/power, meters/meter, ferrets/ferrets) and so has no units of its own, it is simply a ratio; decibels only specify ratios. For example, you could say I had 20 ferrets this morning, then 5 escaped, so now I only have 15:

$10\log_{10}(15/20)=-1.2$

So my ferret loss is 1.2dB. This is a valid statement. What I am trying to say here is that any number expressed in dB is relatively meaningless unless you know the context.

So, decibels are used to express ratios of power, but what about expressing ratios of voltages or even currents? Well this is possible, useful and frequent but you need to remember one thing:

- for power ratios use dB=**10**log(power out/power in)
- for voltage or current ratios use dB=**20**log(voltage out/voltage in).

Why?
From V=IR (volts = amps times impedance) and P=VI (power = volts times amps) we can get either $P=V^2/R$ or $P=I^2R$ (power = either volts squared divided by impedance or current squared times impedance). Thus voltage and current have a **squared** relationship to power - so the logarithm multiplier (10 for power) is doubled (to 20 for voltage and current).See what's a logarithm

If this makes no sense at all, just remember:

- dB=10log(ratio) - for power
- dB=20log(ratio) - for voltage and current

As I mentioned above, a dB value is meaningless without a context (or reference) unless it simply expresses a ratio. The context is often quoted by using a suffix of one or more letters. For example:

convention	**meaning**
dBm	expresses a power relative to a reference value of 1mW
dBv	expresses a voltage relative to to a reference value 1V
dBu	expresses a voltage relative to a reference 0.775V
dBA	expresses a sound pressure variance relative to 20 micro Pascals pressure variance (sound pressure level) within the range of human hearing, where different frequencies are measured at different but specific levels (known as a weighting curve) to reflect the non-linear sensitivity of the human ear
dBC	as dBA but with a different weighting curve
dBr	Although not a standard, I have seen this used to reinforce a pure ratio value and thus only expresses a ratio e.g. signal to noise or dynamic range.

So what does this mean?

In electronic terms the most common suffix encountered today is dBu, so lets look at these examples:

to express 3.25V as dBu	20log(3.25/0.775) =12.45dBu
to express 0.15V as dBu	20log(0.15/0.775)=-14.26dBu

Note that it is equally correct to write these expressions in the form 20(log0.15 - log0.775)=-14.26dBu. See what's a logarithm

So here the reference value of 0.775V is always taken as the lower part (denominator) of the log fraction (or ratio) to which the voltage in question is compared.

Going the other way, expressing dBu as volts:

to express 12.45dBu in volts	$0.775 \times 10^{(12.45/20)}$ =3.25
to express -14.2dBu in volts	$0.775 \times 10^{(-14.2/20)}$ =0.15

note that the $10^{(12.45/20)}$ can be easily worked out on most calculators with the key sequence: 12.45 ÷ 20 = [inv][log]

Why 0.775V? Well this is the voltage needed to drive a power of 1mW into a load of 600Ω, which was a base reference from early days of telecommunications systems and the convention has remained.

Here are some dBu values with the voltage equivalents.

dBu	V_{rms}	dBu	V_{rms}
45	137.8	-1	691mV
40	77.5	-2	616mV
20	7.75	-5	436mV
10	2.45	-10	245mV
5	1.378	-20	77.5mV
2	976mV	-40	7.75mV
1	870mV	-50	245μV
0	775mV	-60	78μV

Note that 0dBu is 775mV (0.775V) not 0V.