Newcomers' Notebook

A ringing endorsement for the Decibel (dB)

Simple explanation without complex mathematics

by Jules Perrin VK3JFP

This article, addressing the Decibel (dB), was requested by Jeff Rickerby VK3JHR. I hope this helps.

The first time most people hear the expression dB is in relation to sound. Looking at a noise chart, traffic is quoted at 70 dB (this really is 70 dB SPL (sound pressure level). I checked with a friend and her interpretation of this 70 dB value is that noise is measured in units of dBs. That is a fair assumption to make.

Most new amateur operators next encounter the dB while preparing for their Foundation licence. This is where some confusion can start. How can the measurement of noise be used to also measure electronics such as voltage and amplifier gain? A good question.

Let us look at the dB. Firstly, there are two very important facts about dBs.

1. The dB is a ratio of one level against a second level. More to come about this.
2. The measuring points for the dB levels must be at the same impedance / resistance.

Origin

The original unit was the Bel, in honour of Alexander Graham Bell, and was developed by Bell Telephone Laboratories to measure losses in telephony cables in the 1920s. The unit the Bel was found to be too large so the decibel (dB), meaning one tenth of a Bel, was implemented.

The dB is based on the logarithmic scale so that a large range of ratios can be represented by a convenient number. Example is that 100 dBW may be clearer than "10 billion times greater".

Using the numbers as a logarithm, to the base 10, also makes multiplication and division easier with a series of gains or losses.

Formulae

The formulae for calculating dB are shown in Figure 1.

Power Ratio.

Formula: $dB = 10 \log_{10}$ (Power 1 / Power 2)

Means: dB = 10 times the logarithm to base ten of (P1 divided by P2)

Example – P1 = 10 W P2 = 2 W

$dB = 10 \times \text{Log}_{10} (10 / 2)$

$dB = 10 \times \text{Log}_{10} 5$

$dB = 10 \times 0.6989$

6.989 dB gain

Amplitude Ratio

(Voltage or current)

Formula: $dB = 20 \log_{10}$ (Amplitude 1 / Amplitude 2)

Means: dB = 20 times the logarithm to base ten of (A1 divided by A2)

Example – A1 = 10V A2 = 2V

$dB = 20 \times \text{Log}_{10} (10 / 2)$

$dB = 20 \times \text{Log}_{10} 5$

$dB = 20 \times 0.6989$

13.978 dB gain

Figure 1: Decibel Formulae and examples.

We are not going through the maths in detail, but the examples are interesting. The figures in both examples are the same with a ratio of five yet the dB results differ.

Why are the formulae different? The dB was originally defined with respect to power, not amplitude. Looking at Ohm's law, voltage and current can be calculated easily from a known resistance (E=IR). The power formulae with relation to resistance are more complex ($P=E^2/R$ or $P=I^2R$) so the squaring of the E or I needs to be accounted for in dB formulae.

This means that conversions of voltage and current ratios to dBs must square the amplitude. As shown in Fig, 1 the factor of twenty is used in amplitude dBs and the factor of ten is used in power dBs.

Plotting the numbers visually requires a logarithmic graph. A semi log graph is reproduced at Figure 2, which provides a quick reference without doing complex maths.

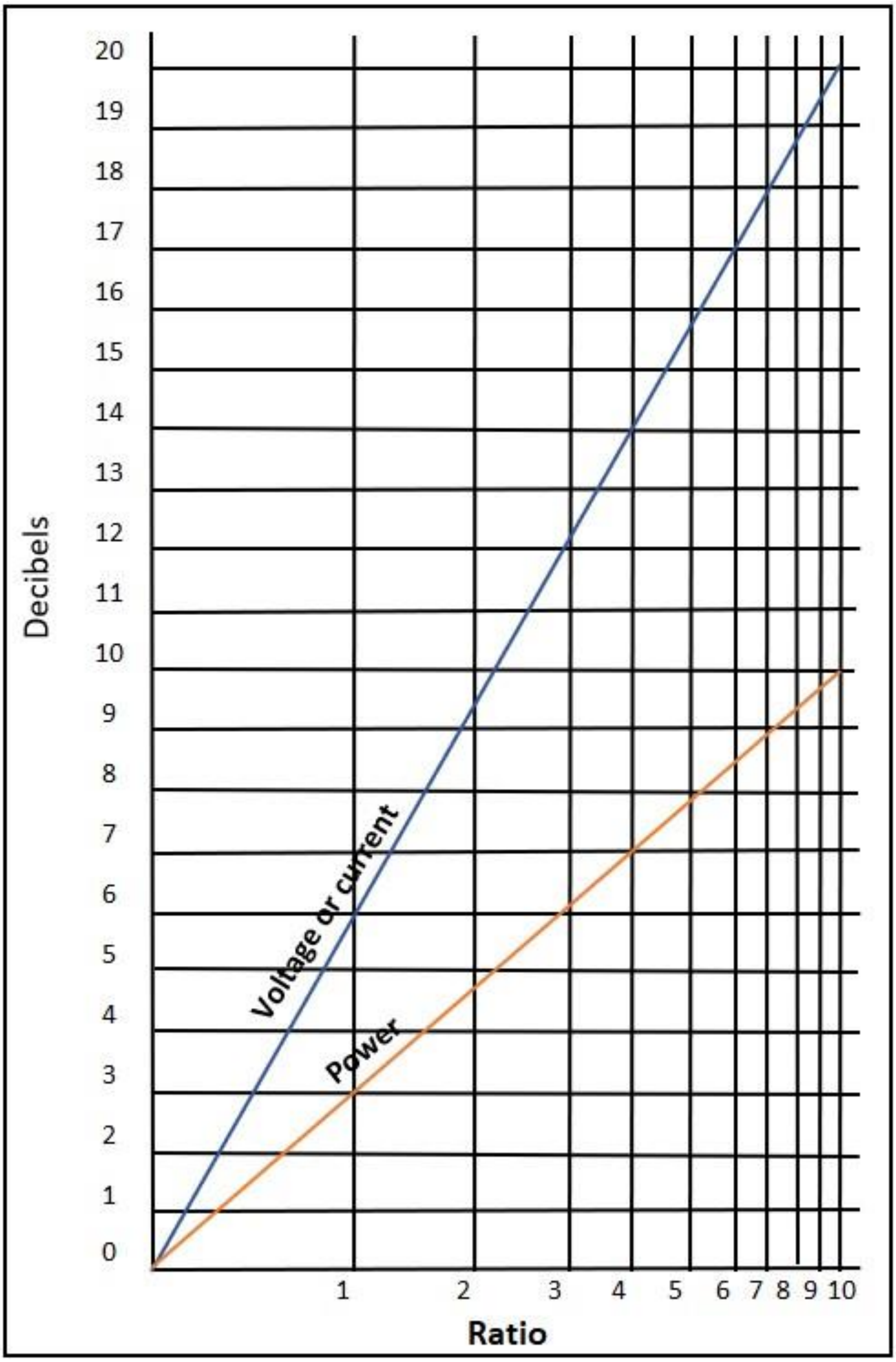

Figure 2: Approximate Decibel Graph showing power and amplitude lines.

Using the numbers from Figure 1, plot the dB levels on the graph at Figure 2. Follow the line up from the ratio of 5 till it meets the voltage / current line. Follow the line across to the left and we see this is a gain around 15 dB. If Point A was 10 V and Point B was 5 V, this would be a loss and equal to approximately – 15 dB. Not highly accurate but is a handy reference.

If an article quotes a 6 dB power gain, you can use the graph and find this is an increase of three times.

Decibels	Ratios	
	Power	E or I
1	1.2589	1.122
2	1.5849	1.2589
3	1.9953	1.4125
4	2.5119	1.5849
5	3.1623	1.7783
6	3.9811	1.9953
7	5.0119	2.2387
8	6.3006	2.5119
9	7.9433	2.8184
10	10	3.1623
11	12.589	3.5481
12	15.849	3.9811
13	19.953	4.4668
14	25.119	5.0119
15	31.623	5.6231
20	100	10
26	398.11	19.953
30	1000	31.623
40	10000	100
50	10000	316.23
60	1000000	1000
70	10000000	3162.3
80	100000000	10000
90	1000000000	31623
100	10000000000	100000

Figure 3: Decibel Table.

Figure 3 provides a more detailed listing of dB equivalents and demonstrates the benefit of using dB over the longer numbers.

Again, using the numbers from Figure 1, plotting the power ratio of five gives level of 7 dB. While the amplitude ratio of five gives a dB level of 14 dBs.

Base Levels

In the first fact, I stated that dB is a ratio. There are many dB measurements with prescribed base level reference points. I selected only a few examples and they are listed in Figure 4.

Term	Reference Base
dBV	dB(V_{RMS}) – voltage relative to 1 volt
dB SPL	dB SPL (sound pressure level) – approximately the quietest sound a human can hear.
dBHL	dB HL (Hearing Level) dB relative to the quietest sounds that a young healthy individual ought to be able to hear. See at your hearing test.
dBm	dB(mW) – power relative to 1 milliwatt.
dBW	dB(W) – power relative to 1 watt.
dBk	dB(kW) – power relative to 1 kilowatt.
dBi	dB(isotropic) – the gain of an antenna compared with the gain of a theoretical isotropic antenna, which uniformly distributes energy in all directions.
dBd	dB(dipole) – the gain of an antenna compared with the gain a half-wave dipole antenna.

Figure 4 Example of Decibel base levels.

If a figure of 15 dBm gain was quoted as an example. Referencing Figure 4, dBm is referenced to 1 milliwatt. Using Figure 2 or Figure 3, a 15 dBm gain is 31 times greater or approximately 31 mW.

Practical Examples

TH3 Jnr Yagi	The Yagi is rated as having a gain of 5.8 dBd (avg). This means the ratio between a dipole and the Yagi will provide a gain of 5.8 dB or nearly four times better than a dipole. (dBd is the antenna gain relative to a dipole)
ICOM IC-7300	The receiver has a built-in three-step RF attenuator (6, 12 and 18 dB). This refers to signal voltage levels and means the attenuator can drop the levels by 2, 4 or 8 times.
Kenwood TS-480	Carrier Suppression is more than 40 dB (SSB). This refers to the suppression of the carrier by 100 times.

Find more references and have a look at the ratios associated with these numbers.

If you have a topic you would like to nominate to be covered in a future instalment of Newcomers' Notebook, email Jules at jp.bqt@bigpond.net.au

Have fun and stay safe.