Newcomers' Notebook

Simple explanation without complex mathematics

A ringing endorsement for dB, the decibel

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This article, addressing the decibel (dB), was requested by Jeff Rickerby VK3JHR. I hope that it helps.

Back in the day when telephones were still a wondrous technology that turned sound into electrical signals – and back again somewhere far away – the engineers at the telephone company known as Bell Telephone Laboratories, had a problem.

It was this: what were they to call the sound measurement unit they'd developed? Easy, said Jimmy the lab floor sweeper to the pondering engineers; call it a "Bel" after 'im wot star'ed it all – Alexander Gra'am Bell."

Little Jimmy never learned to read or write so well, but he could sweep them floors like he was ringin' a bell. "D'Oh," said the engineers, "D'Oh! D'Oh! D'Oh!, Jimmy be good!" The engineering term Bel and musician Chuck Berry were born in the same era – the late 1920s.

As it turned out, the Bel was a tad too big and the engineers found it easier to deal with a tenth of it – hence, the *decibel*. When written down, it's a lower-case 'd' for the Latin '*deci*' (a tenth) and upper case 'B', respecting Bell himself. When referring to plural decibels, it's dBs (no apostrophe).

Sounds good

The first time many people hear the expression 'dB' is in relation to sound. Looking at a noise chart, for example, traffic noise is quoted at 70 dB; this is really 70 dB SPL (sound pressure level).

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 things in electronics, such as voltage changes or amplifier gain? A good question.

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

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

Origin

The dB is based on the logarithmic scale 'to the base ten' so that a large range of ratios can be represented by a convenient or manageable number. For example, 100 dB 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, because you can simply add or subtract the numbers.

Formulae

The formulae for calculating things in dB are shown in **Figure 1.**
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 dB must square the amplitude.

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 x Log 10 (10 / 2)

dB = 10 x Log 10 5

dB = 10 x 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 x Log 10 (10 / 2)

dB = 20 x Log 10 5

dB = 20 x 0.6989

13.978 dB gain

Figure 1: decibel formulae and examples.

As shown in **Figure 1**, the factor of twenty is used in amplitude dBs, while the factor of ten is used in power dBs.

Figure 2 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**, the power ratio of five gives level of 7 dB, while the amplitude ratio of five yields a value of 14 dB.

Decibels	Ratios	
	Power	E or I
1	1.259	1.122
2	1.585	1.259
3	1.995	1.413
4	2.512	1.585
5	3.162	1.778
6	3.981	1.995
7	5.012	2.239
8	6.301	2.512
9	7.943	2.818
10	10	3.162
11	12.589	3.548
12	15.849	3.981
13	19.953	4.467
14	25.119	5.012
15	31.623	5.623
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 2: a look-up table of dB for a wide range of ratios, both for power and for E or I.

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 the **Figure 3** table.

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

Practical Examples

TH3 Jnr Yagi. This Yagi is rated at having a gain of 5.8 dBd (avg); dBd is the antenna gain relative to a dipole. This means the Yagi will provide a gain of 5.8 dB compared to a dipole, or nearly four times improvement over 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 on SSB is specified as being more than 40 dB. 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.

Term	Reference base
dB SPL	dB sound pressure level – sound level relative to the quietest sound a human can hear
dB HL	dB hearing level or hearing loss – relative to the quietest sounds a healthy young person should be able to hear
dBV	dB – with respect to 1 V (one volt); 0 dBV is 1 V.
dBuV	dB – with respect to 1 uV (one microvolt); 0 dBuV is 1 uV.
dBm	dB power level relative to 1 milliwatt (mW)
dBW	dB power level relative to 1 watt (W)
dBK	dB power level relative to 1 kilowatt (kW)
dBi	dB isotropic – antenna gain/loss relative to an isotropic (theoretical) antenna that sends or receives energy uniformly in/from all directions
dBd	dB dipole – antenna gain/loss relative to the gain of a half-wave dipole

Figure 3: Examples of decibel base levels.

Further Reading

"Dude! What is it with these decibels?" Building Blocks, by Phil Wait VK2ASD. *Amateur Radio*, WIA, Vol. 88, No. 3, 2020, pp 6-7.

The Decibel (dB), *Your Entry Into Amateur Radio, The Foundation Licence Manual* – Fourth Edition, Edited by Phil Wait VK2ASD, WIA, pp 98-99.

Alexander Graham Bell

For whom the Bel's named: Scottish-born inventor, scientist and engineer, credited with patenting the first practical telephone; he co-founded the American Telephone and Telegraph Company (AT&T). US National Portrait Gallery image (CC0).