What’s a dB and Why Do You Care?

V 1.1

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Topics

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- Types of dBs
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- Using dBs with antennas (gain)
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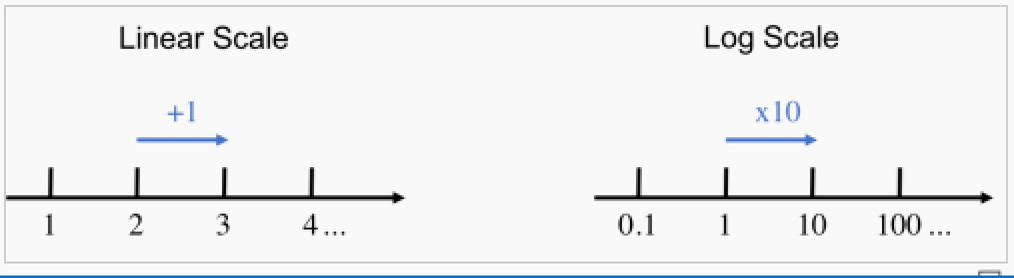
A dB is …

- Decibels are used in ham radio to compare equipment such as antennas and coax and RF switches
- There are other uses such as performing system link budgets and analysis
- It is a way to express the ratio of one power to another on a logarithmic scale
- A decibel one tenth of a Bel, named after Alexander Graham Bell
- A decibel is easy to use, it involves addition and subtraction

Why we use dBs

- Being logarithmic allows us to represent very large and very small values with few digits
  - 100 = 20dB, 1,000 = 30dB, 1/1,000,000 = -60dB

- We can show larger values in the same place than with linear values



- Instead of multiplying or dividing values, when they are converted to dBs we can add and subtract them
  - 10 X 1,000,000 = 10,000,000 vs 10dB + 60dB = 70dB

Types of dBs

- There are several different types of dBs
- To simplify things we are going to use power dBs which are more common in ham radio
- There are also absolute dBs and relative dBs
  - An absolute dB indicates the ratio of two absolute values such as the power output of a transmitter.
    - The absolute dB has another letter (or 2) that indicates the referenced value
    - 10 * Log(100W/1W) = 20dBW
- Relative dBs are just a comparison between two values of the same type but without a reference value
  - An antenna has a gain of 20dB

A few dB values

- A dB with a + sign indicates an increase (gain)
  - +10dB indicates an increase of 10 times
- A dB with a – sign indicates a decrease (loss)
  - -3dB indicates a loss of 1/2
- An antenna with 10dB of gain fed with coax with a loss of 3dB
  - Logarithmic: +10dB – 3 dB = 7dB
  - Linear: 100/2 = 50
- Common values (there's a chart at the end of this document)
  - 1 linear = 0dB
  - 2 linear = 3dB ½ linear = -3dB
  - 10 linear = 10dB 1/10 linear = -10dB

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Using dBs with antennas

- Antennas are almost always specified by gain in dBs
- The antenna gain is usually compared to a theoretical point source called an Isotropic radiator
  - Referenced as dBi
- As long as the antennas being compared are referenced to the same thing (i.e. the dBi) we can compare them to each other
- Let's compare two 2m mobile antennas
  - A Comet SBB-25 5/8wave has 4.1dBi gain
  - A 1/4wave ground plane has 1.2dBi gain
  - Is the 2.9dB difference significant?
    - Yes, 2.9dB is a bit less than twice the gain

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Using dBs with coax

- Coax is always specified by attenuation in dBs for a specified length
- Coax loss is specified by the manufacturer in dBs per 100ft at different frequencies
- The loss in coax is logarithmic with change in frequency
  - Doubling the frequency does not double the loss
- The loss in coax is linear with change in length
  - So a loss of 10dB at 100ft is a loss of 5dB at 50ft

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Using dBs with coax

- Let's compare some coax
- You can see that loss at HF is very low and there is not much difference between the coax types
- At 2m though the difference between RG-58 and RG-213 is 5.5 - 2.4 = 3.1dB
- Half of the signal in both receive and transmit will be lost in the coax

Coax Loss Chart dB per 100 Feet

	RG-58	RG-8X	LMR-240	RG-213
3.5 MHz	.8	.65	.45	.3
7 MHz	1.2	.85	.64	.5
14 MHz	1.7	1.21	.91	.7
28 MHz	2.4	1.74	1.29	1.00
50 MHz	3.2	2.36	1.73	1.40
144 MHz	5.5	4.20	2.95	2.40
440 MHz	9.9	7.92	5.23	4.40

Think of that: for RG-58 coax, if you transmit 100W, 50W will be lost in the coax compared to RG-213 coax.

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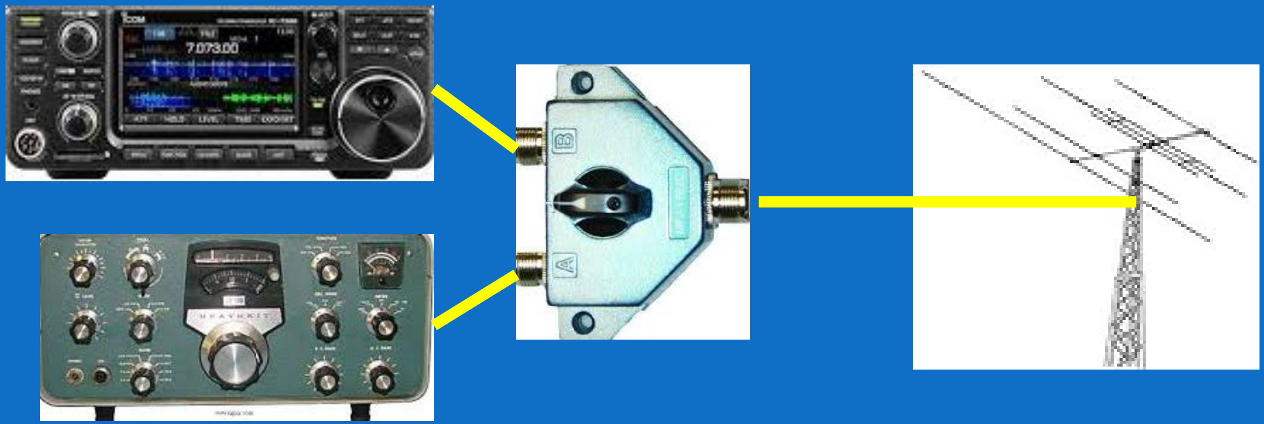
Using dBs with RF switches

- RF switches have many uses, among them are switching one radio to multiple antennas or multiple radios to one antenna

- Example: switching two radios to one antenna:



- The switch will be specified for loss from input to output, (very small)
And from one input port to the other, called isolation.
If the port to port isolation is, say 20dB (as one switch is), how many watts will the unselected receiver get from the selected transmitter?

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Using dBs with RF switches

20dB loss is a ratio of 100 to 1

If the transmitter puts out 100W, the other receiver will have 1W injected into its input

If the transmitter puts out 1000W, the other receiver will have 10W injected into its input

Both of these scenarios will result in a broken receiver

A loss of 50dB is a much better choice

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Using dBs in signal to noise ratios (SNR)

- Signal to noise ratio is the comparison of signal level to noise level
- Hams rarely talk about SNR but it is essential to exchanging information
- All systems generate noise as does the earth's atmosphere
- Noise is related to the bandwidth of the communications channel
  - The smaller the BW the smaller the noise (so CW has a better SNR than SSB)
- We need to have enough signal to receive the information
- There are many modulation techniques, each has its own SNR, some are much better than others
- dBs are used in comparing modulation types

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The KE4PT Color and Mode Correspondence Chart

Table 1
How *HamCAP* Map Colors Correspond to Mode SNRs

SNR span (dB in 1 Hz)	Color	Mode	Threshold SNR in 1 Hz	Threshhold SNR in 2500 Hz BW
48+	Pink	AM	+56 dB	+22 dB
42 – 47	Red	SSB	+42 dB	+8 dB
38 – 41	Orange	FM	+40 dB	+6 dB
33 – 37	Yellow	RTTY	+33 dB	-1 dB
28 – 32	Light Green	CW	+28 dB	-6 dB
22 – 27	Green	PSK31	+22 dB	-12 dB
13 – 21	Light Blue	FT8/FT4	+14/+16 dB	-20/-18 dB
7 – 12	Medium Blue	JT9/JT65	+7/+9 dB	-27/-25 dB
1 – 6	Blue	WSPR	+6 dB	-28 dB

Source: *QST*, April 2020, ARRL.org/QST

Mode

Sensitivity in 2500 Hz

Note:
The "colors" correspond to the colors in propagation maps that HamCAP software computes

This table will appear in a future issue of QST article by Kai KE4PT

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The Math

- Everyone is afraid of math. Get over it. Math is a bunch of rules made up to fit the world we live in. You didn't know how to drive a car before learning the rules. Math is the same way, learn the rules.
- Since everyone carries a calculator around in their phone, you have no excuse for not being able to convert between dBs and linear values
- Using the Scientific calculator in Windows:

Calculate dB from linear: dB = 10 * Log(Output/Input)

Let output be 6 and input be 3 (dB = 10 * Log(6/3)

Divide the output (6) by the input (3) to get 2

Take the Log of 2: Log_{10} (2) = 0.3 (press the log button on the calculator)

Multiply the result 0.3 by 10 = 3

Answer is +3dB

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The Math

- Calculate linear from dB: Linear = Inverse Log_{10} (dB/10) aka “10^{x}” button on the calculator

  10^{x} where X = (3dB/10)

    Divide the dBs (3) by 10 to get 0.3

    Press the 10^{X} button on the calculator: 10^{X} (0.3) = 1.99

    Round up answer to 2

A table to make it easy

dB	Fraction	Loss	Percent Left
0.1	0.98	0.02	98%
0.2	0.95	0.05	95%
0.3	0.93	0.07	93%
0.4	0.91	0.09	91%
0.5	0.89	0.11	89%
0.6	0.87	0.13	87%
0.7	0.85	0.15	85%
0.8	0.83	0.17	83%
0.9	0.81	0.19	81%
1.0	0.79	0.21	79%

dB	Fraction	Loss	Percent Left
1.0	0.79	0.21	79%
1.1	0.78	0.22	78%
1.2	0.76	0.24	76%
1.3	0.74	0.26	74%
1.4	0.72	0.28	72%
1.5	0.71	0.29	71%
1.6	0.69	0.31	69%
1.7	0.68	0.32	68%
1.8	0.66	0.34	66%
1.9	0.65	0.35	65%
2.0	0.63	0.37	63%

dB	Fraction	Loss	Percent Left
1	0.79	0.21	79%
2	0.63	0.37	63%
3	0.50	0.50	50%
4	0.40	0.60	40%
5	0.32	0.68	32%
6	0.25	0.75	25%
7	0.20	0.80	20%
8	0.16	0.84	16%
9	0.13	0.87	13%
10	0.10	0.90	10%

Think of it this way: If you transmit 100W and your coax has this much loss,

Your antenna would get this much power (replacing % with Watts)

References

Those Pesky Decibels

Communications Signal to Noise Radio, definition and application to Radio

The KE4PT Color and Mode Correspondence Chart : personal correspondence from KE4PT