

dB/dBW/dBm cheat sheet

- dB is a logarithmic **ratio of powers**. So saying $P_1 = 2 \cdot P_2$ is equivalent to saying $P_1/P_2 \triangleq 3 \text{ dB}$, because

$$10 \cdot \log_{10} \left(\frac{P_1}{P_2} \right) \text{ dB} = 10 \cdot \log_{10}(2) \text{ dB} = 3 \text{ dB}.$$

The unit dBi can be treated just like dB, because it measures the gain of an antenna relative to an isotropic antenna which has the gain of 1 (0 dB).

- dBm and dBW is a (logarithmic) **unit to measure powers**. Since dB is a ratio of powers, dBm and dBW are defined by forming the ratio of the power you want to express relative to a reference power, which is 1 W for dBW and 1 mW for dBm. Formally speaking,

$$P_T|_{\text{dBm}} = 10 \cdot \log_{10} \left(\frac{P_T}{1 \text{ mW}} \right)$$

$$P_T|_{\text{dBW}} = 10 \cdot \log_{10} \left(\frac{P_T}{1 \text{ W}} \right) = P_T|_{\text{dBm}} - 30 \text{ dB}$$

Consequently, **two things are okay**:

- Starting with a **power** (dBW or dBm) you can *add* and *subtract ratios* (dB or dBi) as often as you like and you still have a **power** (dBW or dBm):

$$P_1 \cdot G_1/L_1 = P_2 \quad \Leftrightarrow \quad 10 \cdot \log_{10} \left(\frac{P_1 \cdot G_1/L_1}{1 \text{ W}} \right) = 10 \cdot \log_{10} \frac{P_2}{1 \text{ W}}$$

$$\Leftrightarrow \quad P_1|_{\text{dBW}} + G_1|_{\text{dB}} - L_1|_{\text{dB}} = P_2|_{\text{dBW}}$$

- *Subtracting two powers* (dBW or dBm) which is equivalent to computing their **ratio** (dB):

$$\frac{P_1}{P_2} \triangleq 10 \cdot \log_{10} \left(\frac{P_1}{P_2} \right) \text{ dB} = 10 \cdot \log_{10} \left(\frac{P_1}{1 \text{ W}} \right) - 10 \cdot \log_{10} \left(\frac{P_2}{1 \text{ W}} \right) = P_1|_{\text{dBW}} - P_2|_{\text{dBW}}$$

$$= 10 \cdot \log_{10} \left(\frac{P_1}{1 \text{ mW}} \right) - 10 \cdot \log_{10} \left(\frac{P_2}{1 \text{ mW}} \right) = P_1|_{\text{dBm}} - P_2|_{\text{dBm}}$$

Both powers must have the same unit, do not mix dBW and dBm.

Short hand notation for **things that are okay**:

dBW ± dB	=	dBW
dBm ± dB	=	dBm
dBW - dBW	=	dB
dBm - dBm	=	dB

On the other hand, the following things **are not okay**:

- **Never ever multiply dBW with dB!** I have seen students claiming that a power of $P_T = 10$ W with an antenna gain of $G_T = 10$ gives an effective radiated power of 100 dBW. **No!** 100 dBW is 10 Gigawatts! Multiply in linear scale, that becomes addition in logarithmic scale:

$$P_T \cdot G_T = 10 \text{ W} \cdot 10 = 100 \text{ W} \triangleq 20 \text{ dBW}$$
$$\Leftrightarrow P_T|_{\text{dBW}} + G_T|_{\text{dBi}} = 10 \text{ dBW} + 10 \text{ dBi} = 20 \text{ dBW}$$

- **Never add a bunch of quantities in dBW or dBm!** Adding powers in log scale means multiplying them in linear scale. If you add 10 dBW with 3 dBW and 6 dBW then you have

$$10 \text{ dBW} + 3 \text{ dBW} + 6 \text{ dBW} \triangleq 10 \text{ W} \cdot 2 \text{ W} \cdot 4 \text{ W} = 80 \text{ W}^3$$

What unit is Watt cubed? I don't know, you tell me...

- A power **cannot** be measured in dB. A gain/loss **cannot** be measured in dBm or dBW.