dBm cheat sheet

- dB is a logarithmic ra… …ying $P_1 = 2 \cdot P_2$ is equivalent to saying $P_1/P_2 \triangleq 3$ dB, because

$$\dots\text{dB} = 10 \cdot \log_{10}(2)\ \text{dB} = 3\ \text{dB}.$$

  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,

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

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**:

$\text{dBW} \pm \text{dB}$	$= \text{dBW}$
$\text{dBm} \pm \text{dB}$	$= \text{dBm}$
$\text{dBW} - \text{dBW}$	$= \text{dB}$
$\text{dBm} - \text{dBm}$	$= \text{dB}$

On the other hand, the fo  **okay**:

- **Never ever multiply** seen students claiming that a power of P_{T} =10 W with an antenna gain of G_{T} = diated power of 100 dBW. **No!** 100 dBW is 10 Gigawatts! Multiply in linear scal n in logarithmic scale:

$$P_{\mathrm{T}} \cdot G_{\mathrm{T}} = 10 \text{ W} \cdot 10 = 100 \text{ W} \triangleq 20 \text{ dBW}$$
$$\Leftrightarrow P_{\mathrm{T}}|_{\mathrm{dBW}} + G_{\mathrm{T}}|_{\mathrm{dBi}} = 10 \text{ dBW} + 10 \text{ dBi} = 20 \text{ dBW}$$

- **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.