The Deci Bell (dB) Concept

- The Deci Bell (dB) concept is used to represent very large or very small numbers employed in scientific Works.
- dB version of any number is defined as

$$N\ (dB) = 10 \times \log_{10} n$$

- By definition, ratios or ordinary numbers are represented in small case where the dB values are represented in capital case.
- If the ratio of two numbers is given by *r*, the dB representation will be given by

$$R\ (dB) = 10 \log_{10} r\ dB$$

Gain and Loss

In a communication system, the power loss in a transmission line is defined as the received power divided by the transmitted power

$$L\ (dB) = 10 \times \log_{10} l = 10 \times \log_{10}(p_1/p_2)\ dB$$

Note that loss has no unit since it is the ratio of two power units in Watts

Similarly, the gain in an amplifier circuit is given by

$$G\ (dB) = 10 \times \log_{10} g\ dB$$

Where g is the gain of the amplifier defined as the ratio of the output power divided by the input power given by

$$g = p_2/p_1$$

Here, gain also has no unit since it is division of two powers in Watts.

Power Levels w.r.t. a Reference Signal

- When measuring very small powers with respect to a reference power level such as 1 W, we use the definition

$$P\ (dBm) = 10\log_{10}\frac{p}{1mW} = 10\log_{10}\frac{p}{10^{-3}}$$

- The sensitivity of mobile phones are as high as $1pW = 10^{-12}\text{W}$
- The sensitivity can also ve written with respect to 1 mW, which is

$$S\ (dBm) = 10\log_{10}\frac{s}{1mW} = 10\log_{10}\frac{10^{-12}}{10^{-3}} = 10\log_{10}10^{-9}$$
$$= -90\log_{10}10 = -90\ dBm$$

Representing Received Powers

- The received power is radio and TV broadcasting are of the order of μWs. Hence, in radio broadcasting, the received power levels are handled with respect to 1 μW.
- If the received power level in a radio broadcast system at a distance d away from the transmitter is, say, 2 μW*, this value can be represented as*

$$P_r = 10\log_{10}\frac{p_r}{1\mu W} = 10\log_{10}\frac{2\times 10^{-6}}{1\times 10^{-6}} = 10\log_{10}2 = 3dB_{\mu}$$

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DECIBELL CONCEPT AND EXAMPLES

If the signal from a 1 kW Tx with a 15 dB antenna gain is received by a Rx of 15 dB antenna gain and the required signal level at Rx is 60 dBu, calculate max distance between the Tx and Rx.

$G_{dB} = 10\log_{10}\frac{P_{rp}}{P_{tx}} \Rightarrow 10\log_{10}\frac{10^3}{1W} = 30\log_{10}10 = 30\,dB$ General

$P_{dBm} = 10\log_{10}\frac{P_w}{1mW} \Rightarrow 10\log_{10}\frac{10^3}{10^{-3}} = 60\,dBm$ ---- Mobile/Cellular comm.

$P_{dB\mu} = 10\log_{10}\frac{P_w}{1\mu W} \Rightarrow 10\log_{10}\frac{10^3}{10^{-6}} = 90\,dB\mu$ ... Radio Broadcast.

$P_{dBW} = 10\log_{10}\frac{P_w}{1W} \Rightarrow 10\log_{10}\frac{10^3}{1} = 30\,dBW$ --- Homo Stereo-Hi-Fi Music

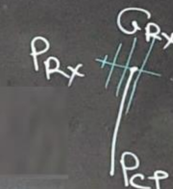
$P_{dBA} = 10\log_{10} P_w \cdot G_{Ear}$

$10\log\frac{P_w}{1\mu W} = P_{\mu w} = 60\,dB\mu$

$\log_{10} P_w 10^6 = 6 \Rightarrow P \cdot 10^6 = 10^6$

$P_{cp} = 1W$

$\log_a b = c$
$a^c = b$



$P_{rx}\, g_{rx} = P_{cp}$

$P_{rx}\, 30 = 1W$

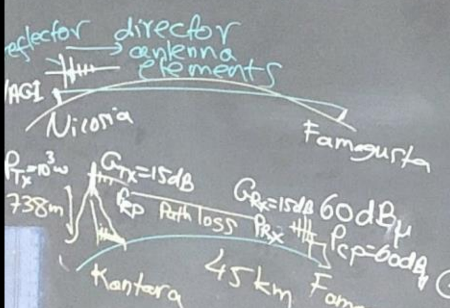
$P_{rx} = \frac{1}{30}W = 0.03W = 30mW$

What is the max distance we can receive?

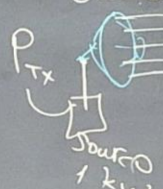
$P_{rx} = \frac{P_{rp}}{(4\pi)d^2}$

$d^2 = \frac{P_{rp}}{P_{rx}4\pi} = \frac{10^6}{4\pi} \approx 78000$

$d = 278\,m$.



$G = 30\,dB = 1000$ times



$P_{tx}\, g = P_{rp}$

$g = \frac{P_{rp}}{P_{tx}} \Rightarrow G_{dB} = 10\log_{10}\frac{P_{rp}}{P_{tx}} =$

$G_{Tx} = 10\log_{10} g_{tx} = 1.5 \Rightarrow \log_{10} g_{tx} = 1.5 \Rightarrow g_{tx} = 10^{1.5} = 31.6$ times ≈ 30

$P_{rp} = P_{tx}\, g_{tx} = 1000 \times 30 = 30000\,W$

$P_{rp} = 30\,kW$ $\quad P_{rx} = 30\,mW$

$loss = l = \frac{P_{rp}}{P_{rx}} = \frac{30\,kW}{30\,mW} = 10^{+6}$ times

$L_{dB} = 10\log_{10}10^6 = 60\,dB$