

# Lecture 6b: Review of Decibel (dB)

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## SNR is usually expressed in dB

$$SNR = \frac{\text{Signal Power}}{\text{Noise Power}} = \frac{P_x}{P_n} \quad (\text{unitless})$$

$$SNR = 10 \times \log_{10} \left( \frac{P_x}{P_n} \right) \quad (dB)$$


$$\frac{P_2}{P_1} [dB] = 10 \times \log_{10} \left( \frac{P_2}{P_1} [\text{unitless}] \right) = 10 \times \log_{10} \left( \left( \frac{V_2}{V_1} \right)^2 [\text{unitless}] \right)$$

$$\frac{V_2}{V_1} [dB] = 20 \times \log_{10} \left( \frac{V_2}{V_1} [\text{unitless}] \right)$$

## Unitless vs. dB

$$\frac{P_2}{P_1} [dB] = 10 \times \log_{10} \left( \frac{P_2}{P_1} [unitless] \right)$$

$$\frac{P_2}{P_1} [unitless] = 10^{\left[ \frac{P_2 [dB]}{10} \right]}$$



$$1000 \text{ unitless} \Rightarrow 10 \times \log_{10}(1000) = 30 \text{ dB}$$

$$30 \text{ dB} \Rightarrow 10^{\left[ \frac{30}{10} \right]} = 10^3 = 1000 \text{ unitless}$$

Gain, Power	Gain in dB
1 (no gain)	0 dB
2 (twice the power)	≈ +3 dB
10 (ten times the power)	+10 dB
100	+20 dB
1000	+30 dB
10000	+40 dB

Attenuation, Power	Attenuation in dB
0.5 (half the power)	≈ -3 dB
0.25 (quarter the power)	≈ -6 dB
0.1 (tenth the power)	-10 dB
0.01 (one hundredth)	-20 dB
0.001 (one in a thousand)	-30 dB
0.0001 (one in 10 thousand)	-40 dB

## dB, dBm and dBW

$$\frac{P_2}{P_1} [\text{unitless}] \rightarrow \frac{P_2}{P_1} [\text{dB}] = 10 \times \log_{10} \left( \frac{P_2}{P_1} [\text{unitless}] \right)$$

$$P_2 [\text{mW}] \rightarrow P_2 [\text{dBm}] = 10 \times \log_{10} \left( \frac{P_2 [\text{mW}]}{1 \text{ mW}} \right)$$

$$P_2 [\text{W}] \rightarrow P_2 [\text{dBW}] = 10 \times \log_{10} \left( \frac{P_2 [\text{W}]}{1 \text{ W}} \right)$$



## Easier Math!

$$\log_{10}(ab) = \log_{10}(a) + \log_{10}(b)$$

Multiplication → Addition

$$\log_{10} \left( \frac{a}{b} \right) = \log_{10}(a) - \log_{10}(b)$$

Division → Subtraction



## Summary

- $\text{dB} + \text{dB} = \text{dB}$
- $\text{dBW} + \text{dB} = \text{dBW}$
- $\text{dBm} + \text{dB} = \text{dBm}$
- $\text{dB} - \text{dB} = \text{dB}$
- $\text{dBW} - \text{dB} = \text{dBW}$
- $\text{dBm} - \text{dB} = \text{dBm}$
- $\text{dBW} + \text{dBW} = ?$
- $\text{dBm} + \text{dBm} = ?$
- $\text{unitless} \times \text{unitless} = \text{unitless}$
- $W \times \text{unitless} = W$
- $\text{mW} \times \text{unitless} = \text{mW}$
- $\frac{\text{unitless}}{\text{unitless}} = \text{unitless}$
- $\frac{W}{\text{unitless}} = W$
- $\frac{\text{mW}}{\text{unitless}} = \text{mW}$
- $W \times W = W^2$
- $\text{mW} \times \text{mW} = \mu\text{W}^2$