 Phys 2426 2016-11-15 Lec 24

Decibels - Why?

- Huge range of powers.
- Dynamic Range
- Scientific Notation can be cumbersome.
- Power often scaled and compared by multiplication and division.
  - Attenuation = loss
  - Amplification = gain
  - Noise
- Common in communications & medical equip.

How? "Levels" in decibels are exponents.

$$\underbrace{(x^2)(x^3)}_{\text{multiplied quantities}} = (x \cdot x)(x \cdot x \cdot x) = x^{\overbrace{5}^{\text{Added Powers}}}$$

dB Levels are a "logarithmic scale"

Quick Basics:
- dB always describe an energy ratio
- When energy is mult/div., dB are add/subtracted.
- 3 dB = Factor of 2
  5 dB = factor of 3
  7 dB = Factor of 5
  10 dB = factor of 10

Formulas For dB:

$$\text{Ratio} = 10^{\beta/10}$$

Ex: $3\,dB \Rightarrow \text{Ratio} = 10^{0.3} = 2$

Inverse process: $\log(\text{Ratio}) = \beta/10$

$$10\log(\text{Ratio}) = \beta$$

Ex: How many dB is a factor of 25000?

$1000 \rightarrow 30\ dB$

$25 \rightarrow 14\ dB$

$25000 \rightarrow 44\ dB$

$$10\log(25000) = 10(4.40) = 44$$

How much is 1 dB? $10^{0.1} = 1.26$

+1 dB is a 26 % increase.

−1 dB is a 21 % decrease.

$10^{-0.1} = 0.79$

Absolute levels measured in dB.

Sound: Reference Intensity 10^{-12} W/m²

RF Power: Reference Power 1 mW
Reference Voltage 1 mV

Ex: Conversation 60 dB

$\text{Ratio} = 10^{6.0}$ ~~Power = 10~~

$\text{Intensity} = (10^{-12}\ \text{W/m}^2)(10^6)$

$= (10^{-6}\ \text{W/m}^2)$

Spherical Wave Spreading

$$\text{Intensity} = \frac{\text{Power}}{4\pi r^2}$$ ← Area of sphere

Ex: @ 10 km, P = −100 dBm
$P_{ref} = 1$ mW

@ 50×10^6 km, $P = ? = -234$ dBm

Distance Ratio = 5×10^6

Power Ratio = 25×10^{12}

Decibel Change = (14 dB) + (120 dB) = 134 dB

Signal to Noise Ratio

38 dB $\quad 10^{3.8} = 6300$

Signal is ~6000x more powerful than noise

Received Power

0 dBmV $\quad 10^{0} = 1$

Received signal is 1 mV

Upstream Power

48 dBmV $\quad 10^{4.8} = 63000$

Transmitted signal is 63000x more powerful than 1 mV signal.

Recall: $P = IV = \frac{V^2}{Z}$ $\quad$ Power ratio = 63000

Voltage ratio = 250

$V_{ref} = 1$ mV $\quad V_{sig} = 250$ mV

How many dB is a voltage ratio of 10?

power ratio = 100 $\Rightarrow$ 20 dB