dB and Filters - Intro

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dB and Filters – Objectives and Introduction

- Be able to calculate the cutoff frequencies and sketch the frequency response of a low-pass, high-pass, band-pass (pass-band) or band-reject (stop-band) filter.
- Develop skills in interpreting and establishing the Bode response (frequency response) of any filter.
- The unit decibel (dB), defined by a logarithmic expression, is used throughout the industry to define levels of audio, voltage gain, energy, field strength, and so on.

A few definitions

Power and Voltage Gain

$$\boxed{\text{dB} = 10\log_{10}\frac{P_2}{P_1}} \quad \text{(decibels, dB)}$$

$$\boxed{\text{dB}_v = 20\log_{10}\frac{V_2}{V_1}} \quad \text{(dB)}$$

Power and Sound Pressure Levels

$$\boxed{dB_m = 10\log_{10}\frac{P}{1\ \text{mW}}}$$

$$\boxed{\text{dB}_s = 20\log_{10}\frac{P}{0.0002\ \mu\text{bar}}}$$

dB – Introduction and Applications

- Some Areas of Application – log function

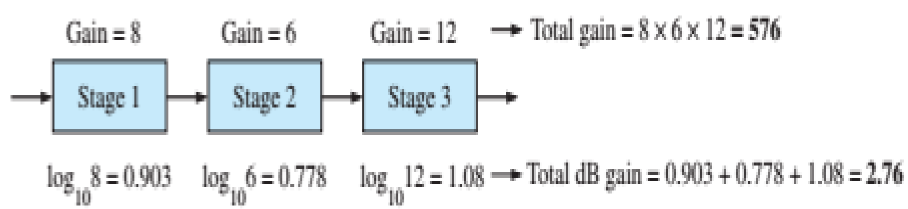
  1. The response of a system can be plotted for a range of values that may otherwise be impossible or unwieldy with a linear scale.

  2. Levels of power, voltage, and the like can be compared without dealing with very large or very small numbers that often cloud the true impact of the difference in magnitudes.

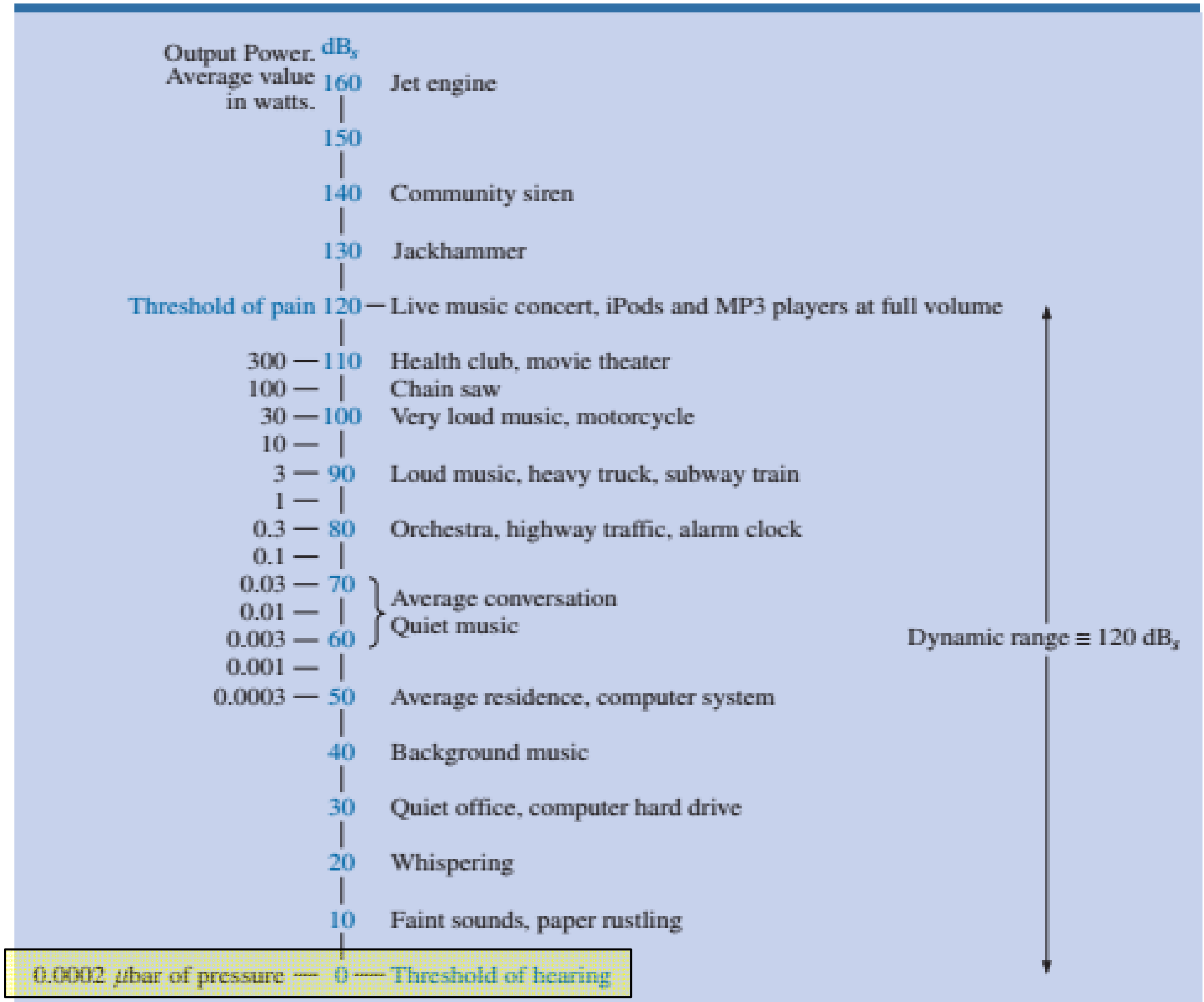
  3. A number of systems respond to outside stimuli in a nonlinear logarithmic manner.

  4. The response of a cascaded or compound system can be rapidly determined using logarithms if the gain of each stage is known on a logarithmic basis.

V_o/V_i	$\text{dB} = 20 \log_{10}(V_o/V_i)$
1	0 dB
2	6 dB
10	20 dB
20	26 dB
100	40 dB
1,000	60 dB
100,000	100 dB



dB – Human Hearing



At normal hearing levels, it would take a change of about 3 dB (twice the power level) for the change to be noticeable to the human ear.

At low levels of sound, a change of 2 dB may be noticeable, but it may take a 6 dB (four times the power level) change for much higher levels of sound.

Sound pressure level:

$$\mathrm{dB}_s = 20 \log_{10} \frac{P}{\boxed{0.0002\ \mu\mathrm{bar}}}$$

dB – Voltage Example (Amplifier Stages)

$$dB_v = 20 \log_{10} \frac{V_2}{V_1} \quad \text{(dB)}$$

A_v	$A_v(dB)$	
0.1	−20	
0.2	−13.98	~ −14
0.4	−7.96	~ −8
0.5	−6.02	~ −6
0.707	−3.01	~ −3
1.0	0	
1.414	3.01	~ 3
2	6.02	~ 6
5	13.98	~ 14
10	20	
100	40	
1000	60	

$A_v < 1$, "−" dB VALUES

$A_v > 1$, "+" dB VALUES

DOUBLING ⇒ +6dB

1) Find Vout
2) Find the voltage at the output of the 10dB gain stage

Vin = 10mV → 5dB → 10dB → 5dB → Vout

20dB => Gain of 10
(10mV)(10) = 100mV

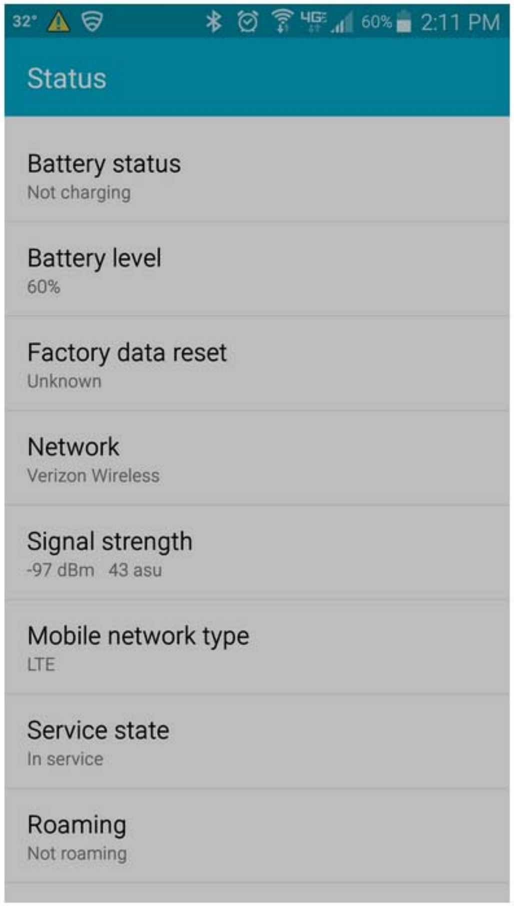
15dB => Gain of 5.62
(10mV)(5.62) = 56.2mV

dB – In Class Problem (Power)

1) Assuming a cellular phone base station transmits at 10W and a smartphone transmits at 100mW, what's the difference in these two power levels in dB?

2) If the received signal is -97dBm (a realistic number), how many watts is this?

3) How many volts is this in a 50 Ohm system?



$$dB_m = 10 \log_{10} \frac{P}{1 \text{ mW}}$$

Filters – Introduction

- Any combination of passive (R, L, and C) and/or active (transistors or operational amplifiers) elements designed to select or reject a band of frequencies is called a filter.
- In communication systems, filters are used to pass those frequencies containing the desired information and to reject the remaining frequencies.
- In general, there are two classifications of filters:
  - Passive filters
  - Active filters

Filters – Classification and Examples