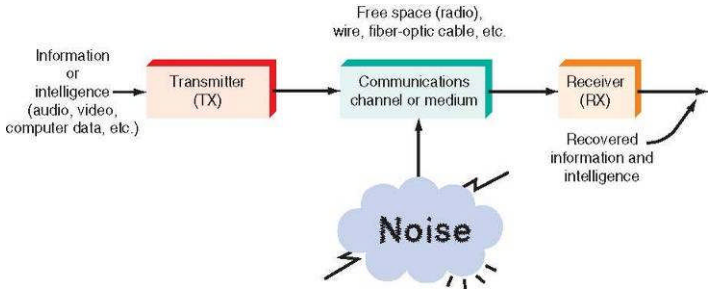
EE303 Lesson 2: Gain and decibels

Communications systems

All communications systems contain

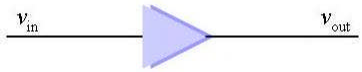
- Transmitter
- Channel (or transmission medium)
- Receiver



Gain

The term _____ means amplification.

For an amplifier, gain (A) is the ratio of the _____ to the _____.



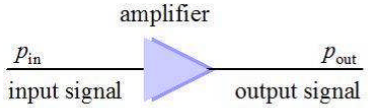
$$A_V = \text{gain} =$$

Because gain is a _____, it is a dimensionless or relative figure.

Power gain

The previous example showed voltage gain (A_V).

Often the quantity of interest in amplifiers is power.

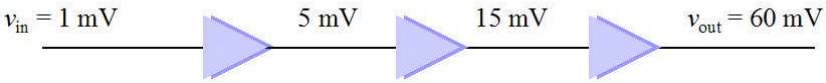


Power gain (A_P) is given

Multistage systems

Communication systems are often comprised of multiple stages cascaded together.

The overall gain (A) of the combination is the _____ of the individual circuit gains.

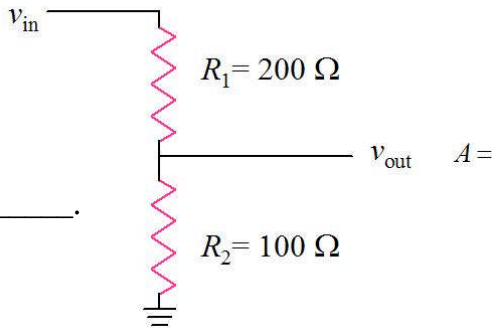


$$A = A_1 \times A_2 \times A_3 = 5 \times 3 \times 4 = 60$$

Attenuation

Elements of communication systems can also reduce the amplitude of a signal.

Reduction or signal loss is termed _____.



Decibels

Signal levels in communications systems often span a tremendous dynamic range.

WYPR-FM 88.1 MHz
Transmitted power 15,500 W

Pioneer DEH-P9800BT
Car receiver

Received power
~0.00000000000001 W

Decibel are a logarithmic measure that provides more convenient gain and attenuation figures. Formulas for computing decibels (dB) are given

$$A_{V(\text{dB})} =$$

$$A_{I(\text{dB})} =$$

$$A_{P(\text{dB})} =$$

Gains _____ than 1 (amplification) will result in a _____ (+) dB value.
Gains _____ than 1 (attenuation) will result in a _____ (-) dB value.

case 1 : $A_P = 1000$ $\quad A_{P(\text{dB})} = 10\log\dfrac{P_{\text{out}}}{P_{\text{in}}} = 10\log 10^3 =$

case 2 : $A_P = 0.0001$ $\quad A_{P(\text{dB})} = 10\log\dfrac{P_{\text{out}}}{P_{\text{in}}} = 10\log 10^{-4} =$

3-dB

A power amplification by a factor of _____ will result in a power gain of _____ dB.

$$A_{P(\text{dB})} = 10\log_{10}(2) =$$

An attenuation by a factor of _____ will result in a power gain of _____ dB.

$$A_{P(\text{dB})} = 10\log_{10}(\frac{1}{2}) =$$

Common decibel values

Ratio	Power (dB)	Voltage (dB)
0.001		
0.01		
0.1		
0.5		
1		
2		
10		
100		
1000		

Converting dB to ratio

How do we convert from decibels back to a ratio? $A_{P(\text{dB})} = 10\log_{10}\frac{P_{out}}{P_{in}}$ $A_{v(\text{dB})} = 20\log_{10}\frac{V_{out}}{V_{in}}$

dBm measure

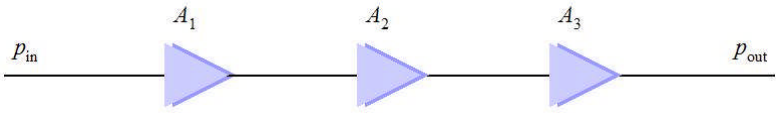
Decibels can also be use to indicate the ratio of a power level with respect to a fixed reference level.

With dBm, the reference power level is _____ and dBm is expressed mathematically as

$$P_{(\text{dBm})} =$$

Multistage systems with dB

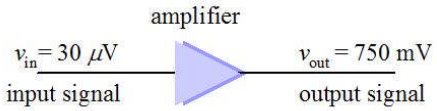
The overall gain of a multistage system ($A_{P\,(\text{dB})}$) is the sum of the individual circuit gains in dB.



$$A_P = A_1 \times A_2 \times A_3$$

Example Problem 1

What is the voltage gain (A_V) of an amplifier that produces an output of 750 mV for a 30-μV input?



Example Problem 2

The transmitter power of radio station WYPR is 15,500 W and the power that arrives car's radio is 10^{-15} W. What is signal attenuation of the channel (free space) expressed in dB?

Example Problem 3

An audio signal with 90-mV_{rms} value is applied to the AUX input of an amplifier. The input impedance is 10-k Ω. The amplified output signal is 7.8-V_{rms} is connected across an 8-Ω speaker. What is the power gain (dB)? The amplifier is rated at 150-W per channel. What is the power gain (dB) at its rated output?.

Example Problem 4

Convert the following from decibels to ratios.

a. A_P= 25 dB

b. A_P= -6 dB

c. A_V= 10 dB

d. A_V= -6 dB

Example Problem 5

Express P_{out} = 12.3 dBm in watts.

Example Problem 6

The circuit below represents the first three stages of a typical AM or FM receiver Find the following quantities.

a. $A_{P1(dB)}$, $A_{P2(dB)}$, and $A_{P3(dB)}$

b. $A_{PT(dB)}$

c. P_1, P_2, and P_{out}.

d. $P_{in\ (dBm)}$, $P_{1\ (dBm)}$, $P_{2\ (dBm)}$, and $P_{out\ (dBm)}$.