1Lecture No.

Decibel Notation

Amplifier gains are often not expressed as simple ratios . . . rather they are mapped into a logarithmic scale.

The fundamental definition begins with a *power ratio*.

Power Gain

Recall that $G = P_o / P_i$, and define:

$$G_{dB} = 10 \log G$$

G_{dB} is expressed in units of *decibels*, abbreviated *dB.*

Cascaded Amplifiers

We know that $G_{total} = G_1 G_2$. Thus:

$$G_{total,\,dB} = 10 \log G_1 G_2 = 10 \log G_1 + 10 \log G_2 = G_{1,\,dB} + G_{2,\,dB}$$

Thus, the *product* of gains becomes the *sum* of gains in decibels.

Voltage Gain

To derive the expression for voltage gain in decibels, we begin by $G = A_v^2 (R_i / R_L)$. Thus:

$$10 \log G = 10 \log A_v{}^2 \frac{R_i}{R_L}$$

$$= 10 \log A_v{}^2 + 10 \log R_i - 10 \log R_L$$

$$= 20 \log A_v + 10 \log R_i - 10 \log R_L$$

Even though R_i may not equal R_L in most cases, we _define_:

$$A_{v\,dB} = 20\log A_v$$

Only when R_i does equal R_L , will the _numerical values_ of G_{dB} and $A_{v\,dB}$ be the same. In all other cases they will differ.

We can see that in an amplifier cascade the _product_
of voltage gains becomes the _sum_ of voltage gains in decibels.

Current Gain

In a manner similar to the preceding voltage-gain derivation, we can arrive at a similar definition for current gain:

$$A_{i\,dB} = 20\log A_i$$

Using Decibels to Indicate Specific Magnitudes

Decibels are _defined_ in terms of _ratios_, but are often used to indicate a specific magnitude of voltage or power.

This is done by defining a reference and referring to it in the units notation:

Voltage levels:

dBV, decibels with respect to 1 V . . . for example,

$$3.16\text{ V} = 20\log\frac{3.16\text{ V}}{1\text{ V}} = 10\text{ dBV}$$

Frequency Response of Amplifiers

Terms and Definitions

In real amplifiers, gain changes with frequency . . .

“Frequency response” is changing the Voltage gain (*amplitude* & *phase)* withe frequency:

$$\mathbf{A_v} = \frac{\mathbf{V_o}}{\mathbf{V_i}} = \frac{|\mathbf{V_o}|\angle \mathbf{V_o}}{|\mathbf{V_i}|\angle \mathbf{V_i}} = |\mathbf{A_v}|\angle \mathbf{A_v}$$

Both $|\mathbf{A_v}|$ and $\angle \mathbf{A_v}$ are functions of frequency and can be plotted.

Magnitude Response:

A plot of $|\mathbf{A_v}|$ vs. *f* is called the *magnitude response* of the amplifier.

Phase Response:

A plot of $\angle \mathbf{A_v}$ vs. *f* is called the *phase response* of the amplifier.

Frequency Response:

Taken together the two responses are called the *frequency response* .

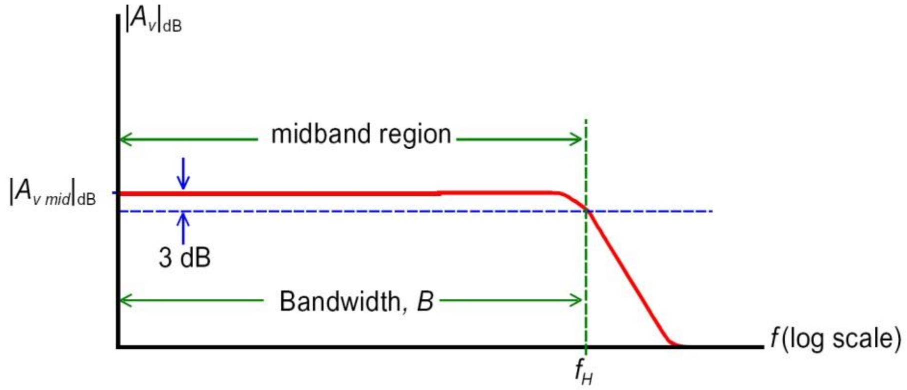
Amplifier Gain:

The *gain* of an amplifier usually refers only to the magnitudes:

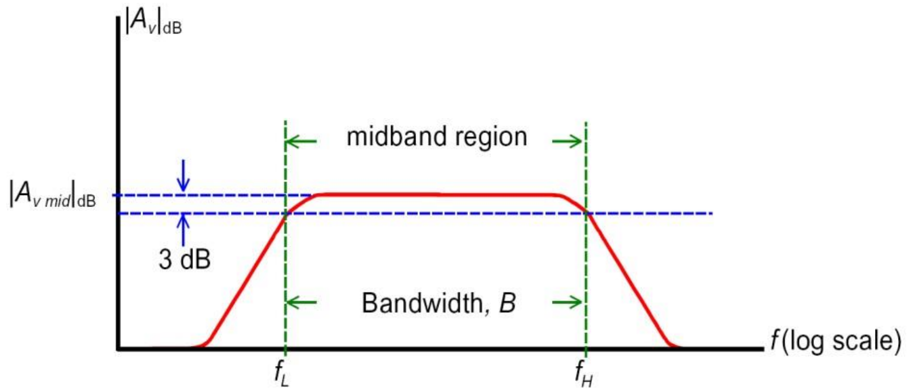
$$|\mathbf{A_v}|_{dB} = 20\log|\mathbf{A_v}|$$

The Magnitude Response

Much terminology and measures of amplifier performance are derived from the magnitude response . . .



Magnitude response of a *dc-coupled*, or *direct-coupled* amplifier.



Magnitude response of an *ac-coupled*, or *RC-coupled* amplifier.

$|A_{v\ mid}|_{dB}$ is called the *midband gain* . . .

f_L and f_H are the *3-dB frequencies*, the *corner frequencies*, or the *half-power frequencies* (why this last one?) . . .

B is the *3-dB bandwidth*, the *half-power bandwidth*, or simply the *bandwidth* (of the *midband region*) . . .

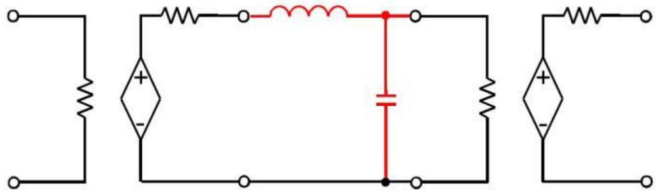
Causes of Reduced Gain at Higher Frequencies

Stray wiring inductances . . .

Stray capacitances . . .

Capacitances in the amplifying devices (not yet included in our amplifier models) . . .

The figure immediately below provides an example:



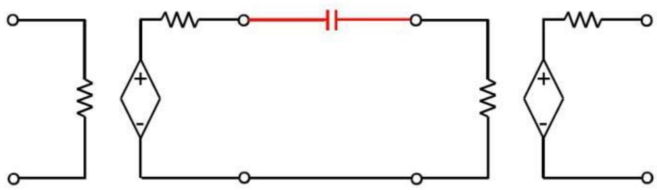
Two-stage amplifier model including stray wiring inductance and stray capacitance between stages. These effects are also found within each amplifier stage.

Causes of Reduced Gain at Lower Frequencies

This decrease is due to capacitors placed between amplifier stages (in *RC-coupled* or *capacitively-coupled* amplifiers) . . .

This prevents dc voltages in one stage from affecting the next.

Signal source and load are often coupled in this manner also.



Two-stage amplifier model showing capacitive coupling between stages.