DECIBEL

❖ *Power Levels*

The term *decibel* has its origin in the fact that power or voltage levels are related on a logarithmic basis. Amplifier gains are often not expressed as simple ratios. rather they are mapped into a logarithmic scale. For standardization, the bel (B) is defined by the following equation relating two power levels, P_1 and P_2.

$$G = \log_{10}\frac{P_2}{P_1} \quad \text{bel}$$

It was found, however, that the bel was too large a unit of measurement for practical purposes, so the decibel (dB) is defined such that 10 decibels = 1 bel. Therefore,

$$G_{\text{dB}} = 10\log_{10}\frac{P_2}{P_1} \quad \text{dB}$$

and

$$G_{\text{dB}} = 20\log_{10}\frac{V_2}{V_1} \quad \text{dB}$$

❖ *Cascaded Stages*

One of the advantages of the logarithmic relationship is the manner in which it can be applied to cascaded stages. For example, the magnitude of the overall voltage gain of a cascaded system is given by:

$$|A_{v_T}| = |A_{v_1}| \cdot |A_{v_2}| \cdot |A_{v_3}| \cdots |A_{v_n}|$$

Applying the proper logarithmic relationship results in

$$G_v = 20\log_{10}|A_{v_T}| = 20\log_{10}|A_{v_1}| + 20\log_{10}|A_{v_2}| + 20\log_{10}|A_{v_3}| + \cdots + 20\log_{10}|A_{v_n}| \quad \text{(db)}$$

In words, the equation states that the decibel gain of a cascaded system is simply the sum of the decibel gains of each stage, that is,

$$G_{dB_T} = G_{dB_1} + G_{dB_2} + G_{dB_3} + \cdots + G_{dB_n} \quad \text{dB}$$

EXAMPLE **:** Find the magnitude gain corresponding to a voltage gain of 100 dB.

Solution:

$$G_{dB} = 20\log_{10}\frac{V_2}{V_1} = 100 \text{ dB} \Rightarrow \log_{10}\frac{V_2}{V_1} = 5$$

So that

$$\frac{V_2}{V_1} = 10^5 = 100{,}000$$

H.W The input power to a device is 10,000 W at a voltage of 1000 V. The output power is 500 W and the output impedance is 20 Ω.

a. Find the power gain in decibels.

b. Find the voltage gain in decibels.

GENERAL FREQUENCY CONSIDERATIONS

❖ *Typical Frequency Response*

The magnitudes of the gain response curves of an RC-coupled and direct-coupled, amplifier system are provided in Fig. 1. Note that the horizontal scale is a logarithmic scale to permit a plot extending from the low to the high frequency regions. For each plot, a low, a high, and a mid-frequency region have been defined. For the RC-coupled amplifier, the drop at low frequencies is due to the increasing reactance of C_C, C_S, or C_E, whereas it's upper frequency limit is determined by either the parasitic capacitive elements of the network or the frequency dependence of the gain of the active device. For the direct-coupled amplifier, there are no coupling or bypass capacitors to cause a drop in gain at low frequencies. As the figure indicates, it is a flat response to the upper cutoff frequency.

❖ *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:

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

Both $|A_V|$ and $\angle A_V$ are functions of frequency and can be plotted.

- *Magnitude Response:*

A plot of $|A_V|$ is called the *magnitude response* of the amplifier.

- *Phase Response:*

A plot of $\angle A_V$ is called the *phase response* of the amplifier.

- *Frequency Response:*

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

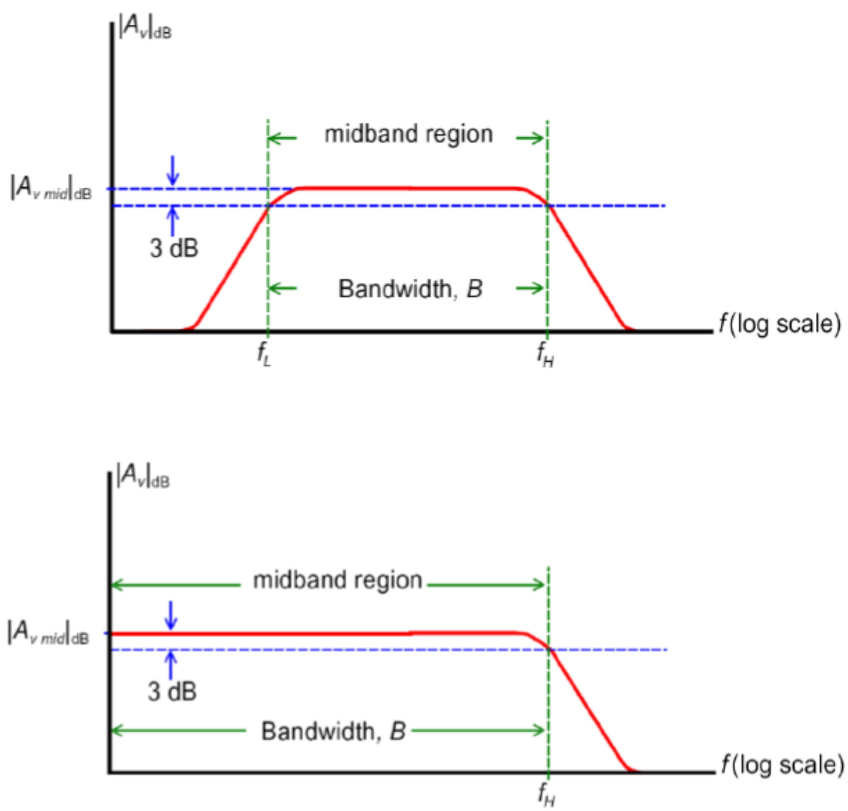

Fig.1

Gain versus frequency: (a) RC-coupled amplifiers; (b) direct-coupled amplifiers

For each system of Fig.1, there is a band of frequencies in which the magnitude of the gain is either equal or relatively close to the midband value. To fix the frequency boundaries of relatively high gain, $0.707A_{V\,mid}$ was chosen to be the gain at the cutoff levels. The corresponding frequencies f_1 and f_2 are generally called the *corner, cutoff, band, break,* or *half-power frequencies.* The multiplier 0.707 was chosen because at this level the output power is half the midband power output, that is, at midfrequencies,

$$P_{o_{\text{mid}}} = \frac{|V_o^2|}{R_o} = \frac{|A_{v_{\text{mid}}} V_i|^2}{R_o}$$

And at the half-power frequencies,

$$P_{o_{HPF}} = \frac{|0.707\,A_{v_{\text{mid}}} V_i|^2}{R_o} = 0.5\,\frac{|A_{v_{\text{mid}}} V_i|^2}{R_o}$$

And

$$P_{o_{HPF}} = 0.5\,P_{o_{\text{mid}}}$$

The bandwidth (or passband) of each system is determined by f_H and f_L, that is,

$$\text{bandwidth (BW)} = f_H - f_L$$

With f_H and f_L defined in each curve of Fig. 1.