# Frequency response of BJT Amplifier

An audio frequency amplifier which operates over audio frequency range extending from 20 Hz to 20 kHz are used in radio receivers, large public meeting and various announcements to be made for the passengers on railway platforms. Over the range of frequencies at which it is to be used an amplifier should ideally provide the same amplification for all frequencies.The degree to which this is done is usually indicated by the curve in figure 1 known as frequency response curve of the amplifier.

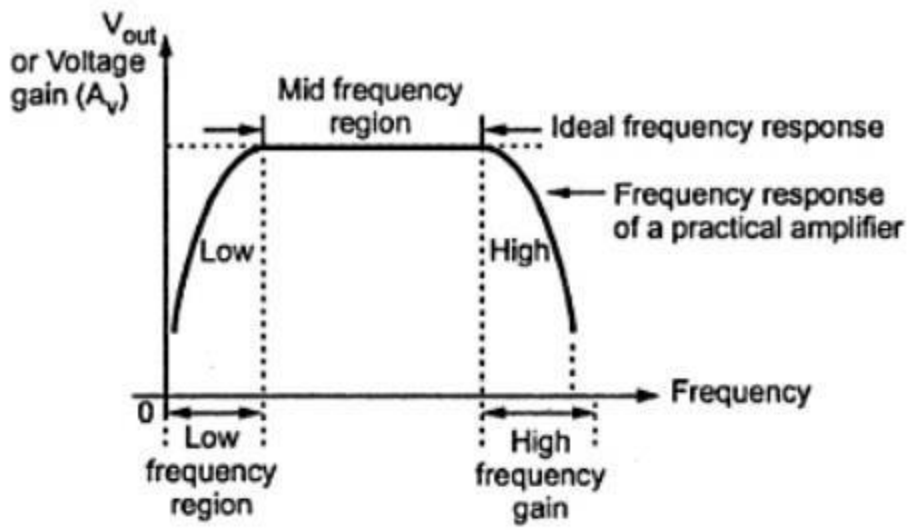


**Figure 1 A Typical frequency response of an Amplifier**

*Diagram Source Brain Kart*

To plot this curve, input voltage to the amplifier is kept constant and frequency of input signal is continuously varied. The output voltage at each frequency of input signal is noted and the gain of the amplifier is calculated. For an audio frequency amplifier, the frequency range is quite large from 20 Hz to 20 kHz. In this frequency response, the gain of the amplifier remains constant in mid-frequency while the gain varies with frequency in low and high frequency regions of the curve. Only at low and high frequency ends, gain deviates from ideal characteristics. The decrease in voltage gain with frequency is called roll-off.

**Definition of cut-off frequencies and bandwidth:**

The range of frequencies can be specified over which the gain does not deviate more than 70.7% of the maximum gain at some reference mid-frequency.

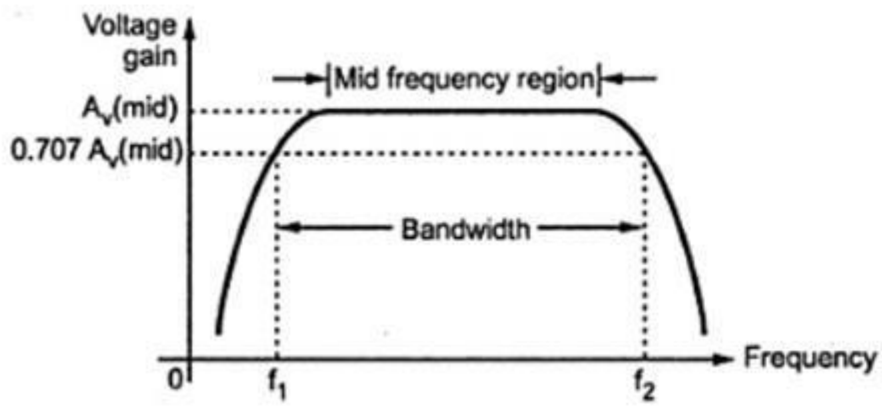


**Figure.2 Frequency Response, Half power frequencies and Bandwidth of an RC coupled amplifier**

*Diagram Source Brain Kart*

From above figure, the frequencies $f_1$& $f_2$ are called lower cut-off and upper cut-off frequencies. Bandwidth of the amplifier is defined as the difference between $f_2$& $f_1$.

$$\text{Bandwidth of the amplifier} = f_2 - f_1$$

The frequency $f_2$ lies in high frequency region while frequency $f_1$ lies in low frequency region. These two frequencies are also called as half-power frequencies since gain or output voltage drops to 70.7% of maximum value and this represents a power level of one half the power at the reference frequency in mid-frequency region.

**Low frequency analysis of amplifier to obtain lower cut-off frequency:**

**1. Decibel Unit:**

The decibel is a logarithmic measurement of the ratio of one power to another or one voltage to another. Voltage gain of the amplifier is represented in decibels (dBs). It is given by,

Voltage gain in dB = 20 log $A_v$

Power gain in decibels is given by,

Power gain in dB = 10 log $A_p$

Where $A_v$ is greater than one, gain is positive and when $A_v$ is less than one, gain is negative. The positive and negative gain indicates that the amplification and attenuation respectively. Usually the maximum gain is called mid frequency range gain is assigned a 0 db value. Any value of gain below mid frequency range can be referred as 0 db and expressed as a negative db value.

Assume that mid frequency gain of a certain amplifier is 100.

Then, Voltage gain = 20 log 100 = 40 db

At $f_1$ and $f_2$ $A_v = 100/\sqrt{2} = 70.7$

Voltage gain at $f_1$ = Voltage gain at $f_2$ = 20 log 70.7 = 37 db

From the figure. 3, it shows that the voltage gain at $f_1$ and $f_2$ is less than 3db of the maximum voltage gain. Due to this the frequencies $f_1$ and $f_2$ are also called as 3db frequencies. At $f_1$& $f_2$ power gain drops by 3 db.

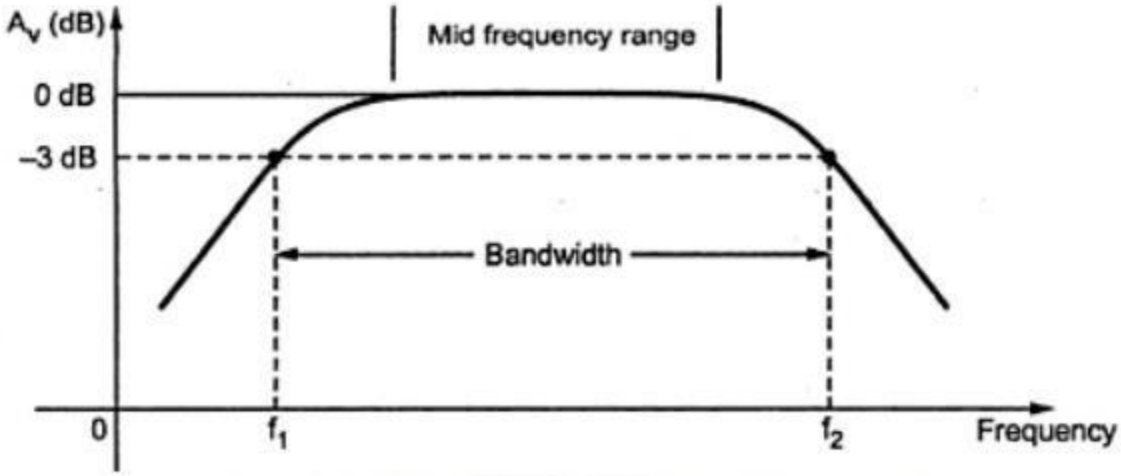


**Figure .3 Normalized voltage Vs frequency**

*Diagram Source Brain Kart*

For all frequencies within the bandwidth, amplifier power gain is at least half of the maximum power gain. This bandwidth is also referred to as 3 dB bandwidth.

**2. Significance of octaves and decades:**

The octaves and decades are the measures of change in frequency. A ten times change in frequency is called a decade. Otherwise, an octave corresponds to a doubling or halving of the frequency.

Example:

An increase in frequency from 100 Hz to 200 Hz is an octave.

A decrease in frequency from 100 kHz to 50 kHz is also an octave

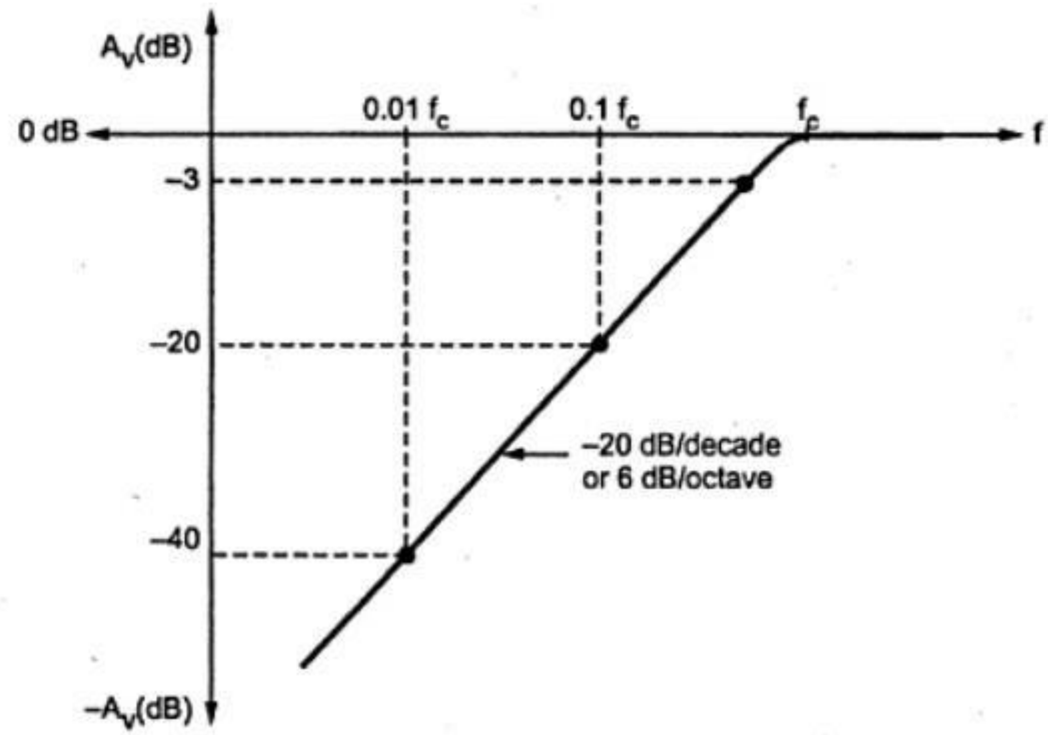


**Figure.4 Frequency Response showing significance of decade and Octave**

*Diagram Source Brain Kart*

At lower and higher frequencies the decrease in the gain of amplifiers is often indicated in terms of db/decades or db/octaves shown in figure.4. If the attenuation in gain is 20 db for each decade, then it is indicated by line having slope of 20 db/decade. A rate of -20 db/decade is approximately equivalent to -6db/octave. A rate of -40 db/decade is approximately equivalent to -12db/octave.

**3. Midband gain:**

It is defined as the band of frequencies between 10 $f_1$ and 0.1 $f_2$. It is denoted as midband gain or $A_{mid}$.The voltage gain of the amplifier outside the midband is approximately given as,

$$A = \frac{A_{mid}}{\sqrt{1+(f_1/f)^2}\sqrt{1+(f/f_2)^2}}$$

In midband,

$$f_1/f \approx 0 \text{ and } f/f_2 \approx 0.$$

**Midband:**

$$A = A_{mid}$$

Below the midband,

$$f/f_2 \approx 0$$

As a result, the equation becomes,

**Below midband:**

$$A = \frac{A_{mid}}{\sqrt{1+(f_1/f)^2}}$$

Above midband,

$$f_1/f \approx 0.$$

As a result, the equation becomes,

**Above midband:**

$$A = \frac{A_{mid}}{\sqrt{1+(f/f_2)^2}}$$