• Filters are circuits that are capable of passing signals with certain selected frequencies while rejecting signals with other frequencies. This property is called selectivity.

• Passive filters use RC, RL or RCL circuits. The passive circuits provide frequency selectivity. The four basic categories of passive filters are: low pass filter, high pass filter, band pass filter, band stop filter (Notch filter)

1. LOW PASS FILTER

![Diagram of Ideal and Practical Response for Low Pass Filter]

- Ideal Response
  - \( Av(dB) = \frac{V_o}{V_i} \)
  - 0 dB
  - Slope = -20 dB/decade
  - \( BW = \text{Band Width} \)

- Practical Response
  - -3 dB
  - \( BW = \text{Band Width} \)
  - \( fc, 10fc \)
• One pole Low Pass Filter (LPF) (one resistor, one capacitor)

• LPF only allows low frequency signals from 0 hertz to its cut-off frequency $f_c$ point to pass while blocking those any higher

• cut-off frequency or corner frequency or critical frequency is calculated by the following formula: $f_c = \frac{1}{2\pi RC}$

Where $f = \text{Hz}$, $R = \text{Ohm}$, $C = \text{farad}$.

• at cut-off frequency the Gain (AV) is down -3dB or the output going down to 70.7% (same as 0.707) of its maximum values.

• after $f_c$ output decreases at a constant rate a the frequency increases. That is, when the frequency is increased tenfold (one decade) the voltage gain is divided by 10, in other words, the gain decreased 20dB($=20\log_{10}$) each time the frequency is increases by 10.

• One pole LPF (one R, one C) roll-off rate -20dB/Decade or 0.1

• Two pole LPF (two R, two C) roll-off rate -40dB/decade or 0.01

• Three pole LPF (three R, three C) roll-off rate -60dB/decade or 0.001
The following shows the response for RC LPF with different poles:

- Cut off frequency $f_C$

\[ f_C = \frac{1}{2\pi RC} \]

Vout is at any frequencies:

\[ V_{out} = \frac{X_C}{\sqrt{R^2 + X_C^2}} \times V_{in} \]
• **RL Low Pass Filter**
• Cut off frequency: $F_c = \frac{R}{2\pi L}$

![RL Low Pass Filter circuit diagram]

• Output is at any frequencies:
• $V_{out} = R / \sqrt{R^2 + XL^2} \times V_{IN}$
By Pass Capacitors
Capacitors are connected in parallel with a resistance for the purpose of by
Passing or shunting ac signals around the resistance above a specified
frequency. The above circuit shows a bypass capacitor C1 connect across
R2. To bypass R2 effectively, XC value must be one-tenth of the value of R2
The result is practically zero ac voltage across R2 for the frequencies that
Produce an XC value 1 kOhm or less. The circuit is definitely a low pass filter.
2. RC HIGH PASS FILTER (HPF)

- Pass any frequencies higher than cut-off frequency (fc)
- Cut-off frequency formula is the same as LPF: \( fc = \frac{1}{2\pi RC} \)

**HPF Response**

- \( Av(dB) = \frac{Vo}{Vi} \)
- 20 dB
- 40 dB

High Pass RL circuit
5. BAND PASS FILTER RESPONSE

- Pass frequencies higher \( f_l \) and less than \( f_H \)
- \( BW \) (bandwidth) = \( f_H - f_L \)
- Quality \( Q = \frac{f_{center}}{BW} \)
- Quality \( Q \) controls the roll-off rate and the bandwidth of the filter
6. BAND STOP (Notch) FILTER RESPONSE

- Pass frequencies less than $f_L$ and higher than $f_H$
Fig. 2-43  How cascading filter sections narrow the bandwidth and improve selectivity.
Fig. 2-46  Butterworth, elliptical, Bessel, and Chebyshev response curves.