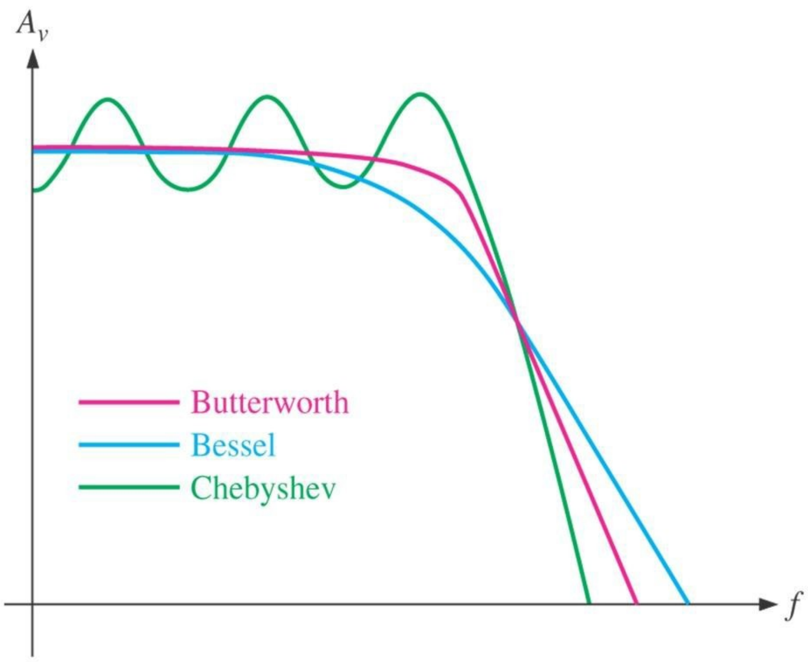
Unit-2
Lecture-5

ButterworthFilter, Chebyshev Filter, Bessel characteristics, Gain, Damping Factor, Critical Frequency

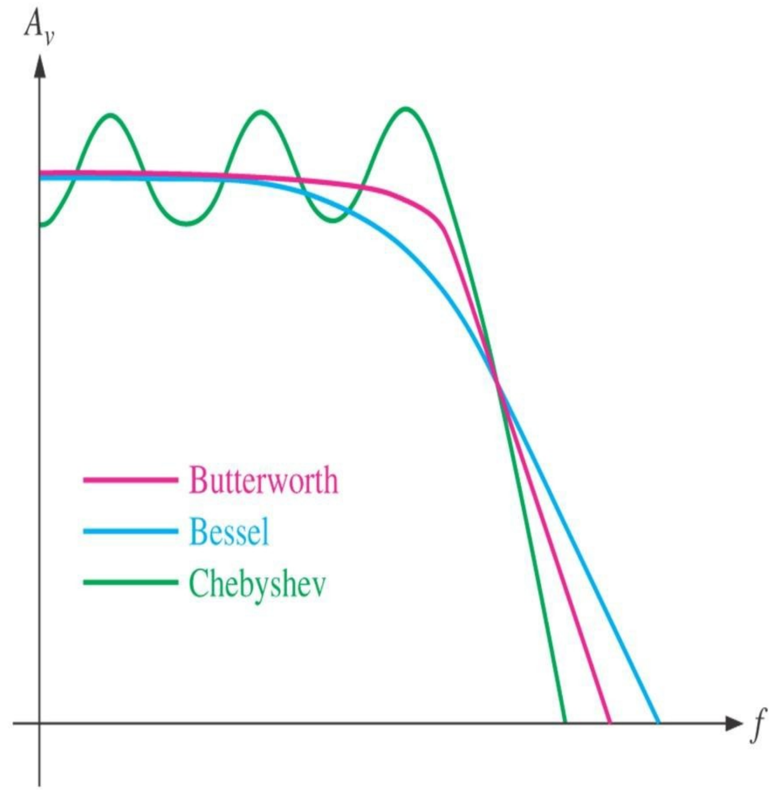
Butterwoth Characteristic

- Filter response is characterized by **flat amplitude response** in the passband.
- Provides a roll-off rate of -20 dB/decade/pole.
- Filters with the Butterworth response are normally used when all frequencies in the passband must have the **same gain**.



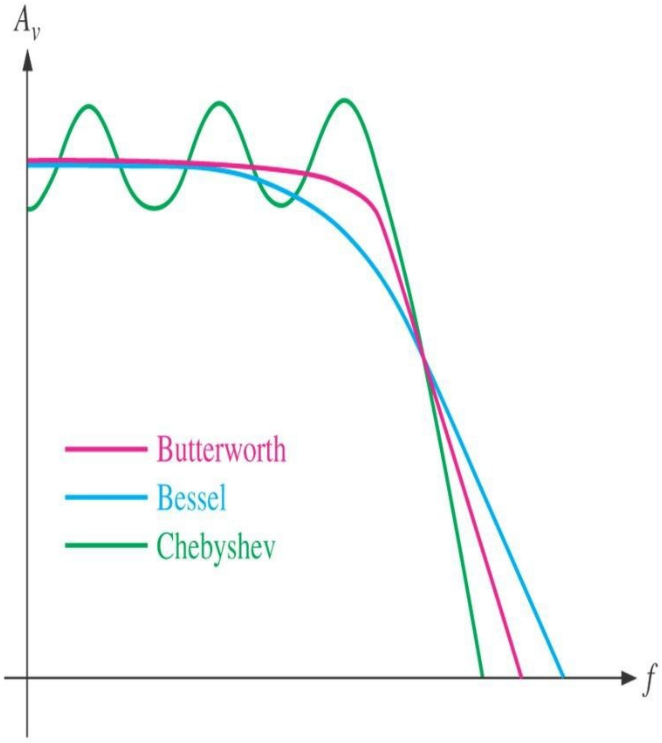
Chebyshev Characteristic

- Filter response is characterized by overshoot or ripples in the passband.
- Provides a roll-off rate greater than -20 dB/decade/pole.
- Filters with the Chebyshev response can be implemented with **fewer poles** and **less complex circuitry** for a given roll-off rate



Bessel Characteristic

- Filter response is characterized by a **linear characteristic**, meaning that the phase shift increases linearly with frequency.
- Filters with the Bessel response are used for filtering pulse waveforms without distorting the shape of waveform.

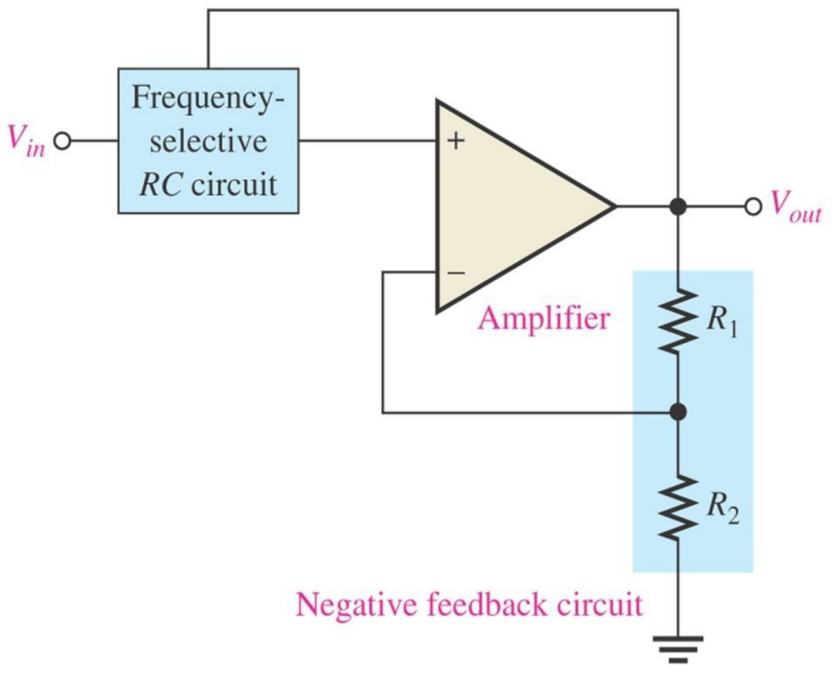


DAMPING FACTOR

- The **damping factor (DF)** of an active filter determines which response characteristic the filter exhibits.

  - This active filter consists of **an amplifier, a negative feedback circuit** and **RC circuit**.
  - The amplifier and feedback are connected in a **non-inverting configuration**.
  - DF is determined by the negative feedback and defined as :

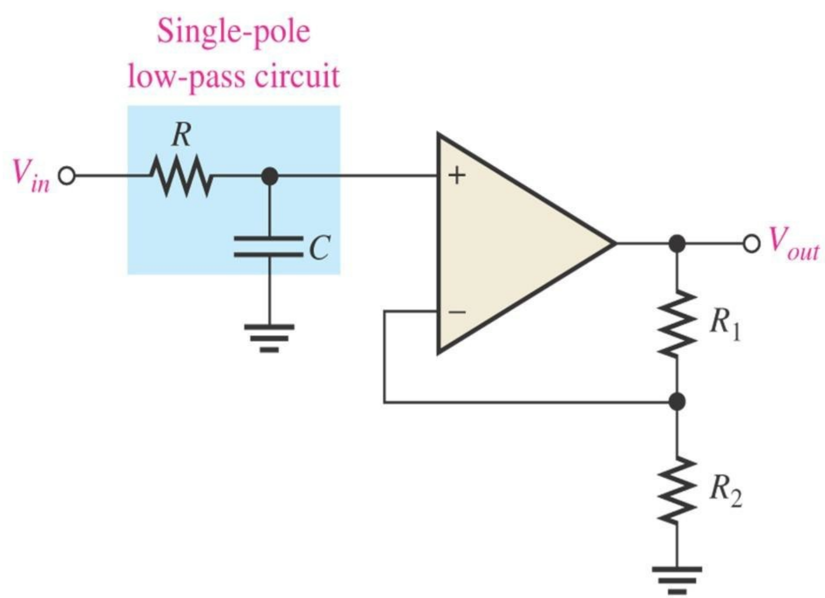
$$DF = 2 - \frac{R_1}{R_2}$$



General diagram of active filter

- The value of DF required to produce a desired response characteristics depends on **order** (number of poles) of the filter.
- A pole (single pole) is simply **one resistor** and **one capacitor**
- The **more poles** filter has, the faster its roll-off rate

CRITICAL FREQUENCY AND ROLL-OFF RATE



One-pole (first-order) low-pass filter.

- The **critical frequency**, f_c is determined by the values of **R** and **C** in the frequency-selective RC circuit.
- Each **RC** set of filter components represents a **pole**.
- **Greater roll-off rates** can be achieved with **more poles**.
- Each pole represents a **-20dB/decade** increase in roll-off.

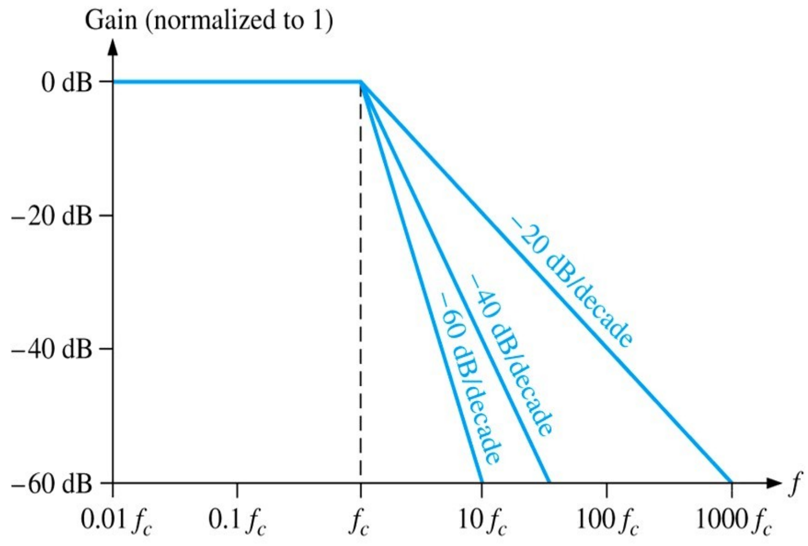
➢ For a single-pole (first-order) filter, the critical frequency is :

$$f_c = \frac{1}{2\pi RC}$$

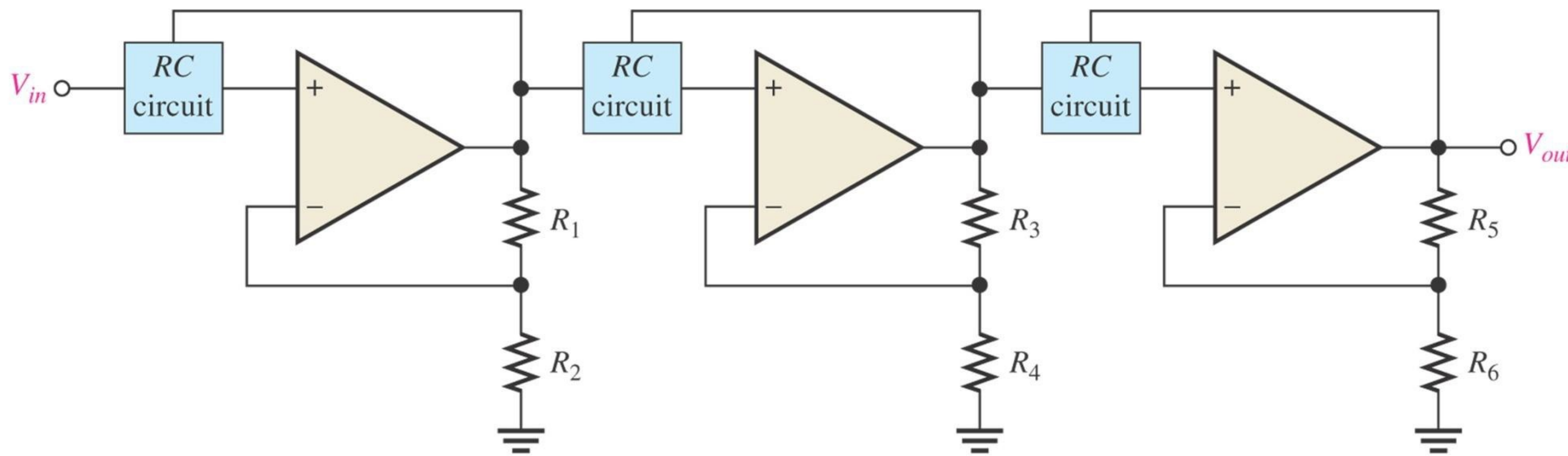
➢ The above formula can be used for both low-pass and high-pass filters.

➢ The number of poles determines the roll-off rate of the filter. For example, a Butterworth response produces -20dB/decade/pole. This means that:

- **One-pole (first-order)** filter has a roll-off of -20 dB/decade
- **Two-pole (second-order)** filter has a roll-off of -40 dB/decade
- **Three-pole (third-order)** filter has a roll-off of -60 dB/decade



➢ The number of filter poles can be increased by **cascading**. To obtain a filter with three poles, cascade a two-pole with one-pole filters.



Three-pole (third-order) low-pass filter.