2.1 Characteristics of practical frequency selective filters and Characteristics of commonly used analog filters

1. Characteristics of Practical Frequency Selective Filters
An ideal filter is not realizable. Practical filters show the following characteristics:

1. Passband

- Frequency range where signals are allowed to pass
- Gain is approximately constant
- Small variations called passband ripple
- Gain ≠ exactly 1 in practice

2. Stopband

- Frequency range where signals are attenuated
- Attenuation is finite, not infinite
- Specified by minimum stopband attenuation (As) in dB

3. Transition Band

- Region between passband and stopband
- Gain changes gradually
- Narrower transition band → higher filter order

4. Cutoff Frequency (fc)

- Frequency at which gain drops to −3 dB (≈0.707 of max)
- Practical filters may have multiple cutoff frequencies

5. Roll-off Rate

- Rate at which attenuation increases beyond cutoff
- Measured in dB/decade or dB/octave
- Increases with filter order

6. Phase Response

- Practical filters have non-linear phase
- Causes phase distortion
- Important in audio and data communication systems

7. Group Delay

- Measure of signal delay variation with frequency
- Non-constant group delay causes signal distortion

2. Characteristics of Commonly Used Analog Filters
1. Butterworth Filter
(Maximally Flat Magnitude Response)
Characteristics:

- ◆ No ripples in passband or stopband
- ◆ Smooth, monotonic response
- ◆ Moderate roll-off

Advantages:

- ◆ Simple design

◆ Good overall performance

Disadvantages:

◆ Poorer selectivity than Chebyshev

◆ Applications:

◆ Audio systems

◆ General-purpose filtering

2. Chebyshev Filter (Type-I)

(Equal Ripple in Passband)
Characteristics:

◆ Ripple present in passband

◆ Monotonic stopband

◆ Sharper cutoff than Butterworth

Advantages:

◆ Better selectivity

◆ Lower order required

Disadvantages:

◆ Passband ripple

◆ Phase distortion

◆ Applications:

◆ Communication systems

◆ RF filters

3. Chebyshev Filter (Type-II)
(Inverse Chebyshev)
Characteristics:

◆ Flat passband

◆ Ripple in stopband

◆ Sharp transition

Applications:

◆ When stopband attenuation is critical

4. Elliptic (Cauer) Filter
(Ripple in Both Passband and Stopband)
Characteristics:

◆ Fastest roll-off

◆ Ripples in both bands

◆ Narrowest transition band

Advantages:

◆ Minimum order for given specs

Disadvantages:

◆ High phase distortion

◆ Complex design

Applications:

◆ Highly selective systems

5. Bessel Filter
(Linear Phase Filter)
Characteristics:

◆ Linear phase response

◆ Constant group delay

◆ Poor magnitude selectivity

Advantages:

◆ Minimal signal distortion

Disadvantages:

◆ Slow roll-off

◆ Applications:

◆ Pulse shaping

◆ Audio and video systems

Comparison

Filter Type	Passband Ripple	Stopband Ripple	Roll-off	Phase Linearity
Butterworth	No	No	Moderate	Poor
Chebyshev-I	Yes	No	High	Poor
Chebyshev-II	No	Yes	High	Poor
Elliptic	Yes	Yes	Very High	Very Poor
Bessel	No	No	Very Low	Excellent