

# Digital Signal Processing

## Introduction to Filter Design Techniques

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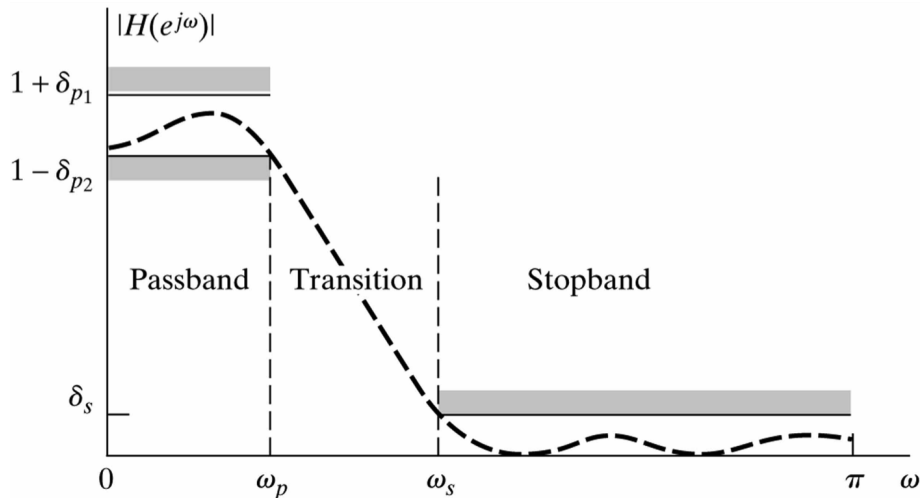
# Filter Design Basics

A common DSP task is to design a frequency-selective filter to approximate either a desired impulse response or desired frequency response within certain tolerances.

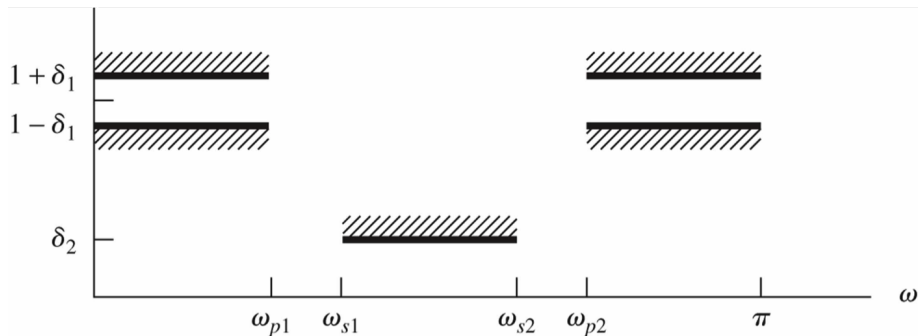
The typical procedure is:

1. Specify the desired properties of the filter
2. Determine the coefficients of linear constant-coefficient causal difference equation that meets the specifications
3. Implement the discrete-time system in a particular realization structure

# Step 1: Specify the Filter Properties (LPF)



# Step 1: Specify the Filter Properties (BSF)



Remarks:

1. In some cases, the maximum passband gain may be 1.
2. In some cases, the magnitude axis may be in decibels.

## Step 2: Determine Coefficients of the Difference Equation

This step can be broken down as

2a Determine whether the filter will be IIR or FIR

2b Determine the design method, e.g.,

- ▶ IIR Butterworth filter with impulse invariant design
- ▶ IIR Chebychev filter with bilinear transform design
- ▶ FIR Kaiser window approximation design
- ▶ FIR Parks-McClellan optimal approximation design
- ▶ ...

2c Compute the difference equation coefficients (iterating if necessary)

Most of the design techniques are specific to the design of lowpass filters. If a different filter design is required, e.g., bandpass, additional steps are necessary to transform to/from the lowpass filter prototype.

# Choosing Between IIR and FIR

Choosing between IIR and FIR is critical since it determines the characteristics of the filter and the available design methods.

IIR	FIR
Rational transfer function	Polynomial transfer function
Can accurately emulate continuous-time systems	Less accurate for emulation of continuous-time systems
Can be unstable	Guaranteed to be stable, even with coefficient quantization
No specification of phase response	Can have (generalized) linear phase
Closed-form expressions for filter coefficients	Iterative procedures usually needed to find coefficients
Generally less coefficients to achieve desired response	Most DSPs have a pipeline structure for efficient FIR filtering

# Overview of IIR and FIR Lowpass Filter Design Methods

