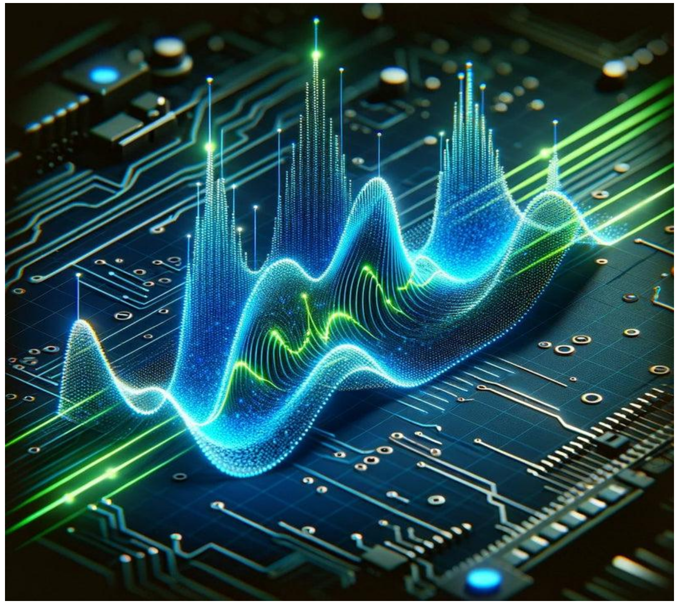
22EE603 – PRINCIPLES OF DIGITAL SIGNAL PROCESSING



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22EE603 – PRINCIPLES OF DIGITAL SIGNAL PROCESSING - CO's

CO1	Illustrate the basics of discrete time signals and systems. [U]
CO2	Interpret the concepts of Discrete and Fast Fourier transform [U]
CO3	Comprehend the architecture of advanced processors. [U]
CO4	Apply the concept of transformation techniques in Discrete Time systems. [AP]
CO5	Design different types of filters using various filter design techniques. [AP]

22EE603 – PRINCIPLES OF DIGITAL SIGNAL PROCESSING - Modules

1	Signals and Systems
2	Discrete Fourier Transform and Fast Fourier Transform
3	FIR Filters, IIR Filters and Digital Signal Processors

MODULE – III : FIR Filters, IIR Filters and Digital Signal Processors

3.1	**Design of FIR filters**
3.2	Design of IIR filters
3.3	Architecture of TMS320C64xx processor

3.1 Design of FIR filters

Introduction

3.1.1 What is Filter?

- A filter is a device or process that removes some unwanted components or features from a signal.

Watch this video
https://youtu.be/s16uvXTFprk

3.1.2 Types of Filter

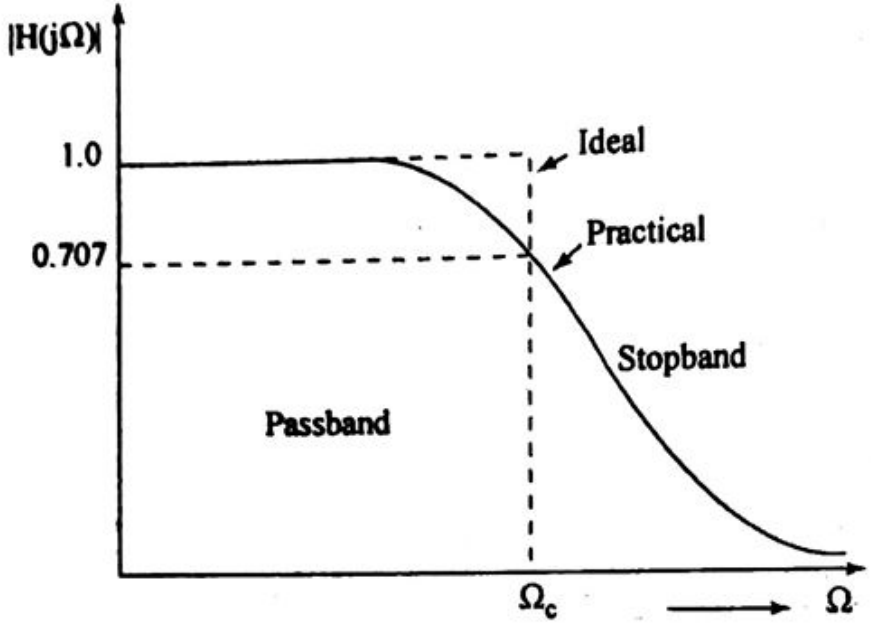
- Filters can be active or passive.
- The four main types of filters are **low-pass, high-pass, band-pass, and notch/band-reject**

Watch this video
https://youtu.be/9x1Sjz-VPSg

3.1 Design of FIR filters

Lowpass Filter

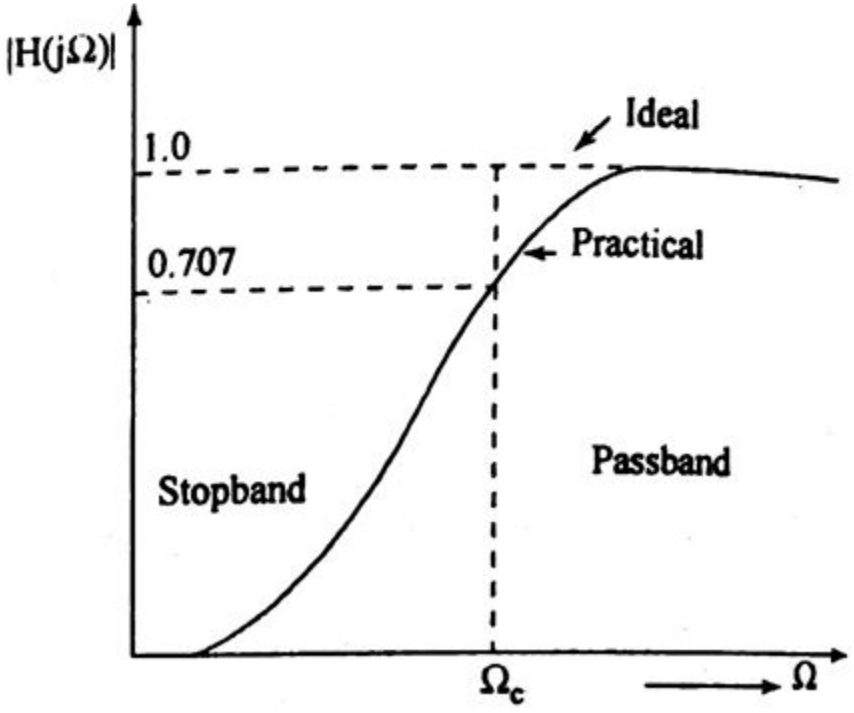
- The magnitude response of an ideal lowpass filter allows low frequencies in the pass-band $0 < \Omega < \Omega_c$ to pass, whereas the higher frequencies in the stop band $\Omega > \Omega_c$ are blocked.
- The frequency Ω_c between the two bands is the cut off frequency, where the magnitude $|H(j\Omega)| = 1/\sqrt{2}$



3.1 Design of FIR filters

Highpass Filter

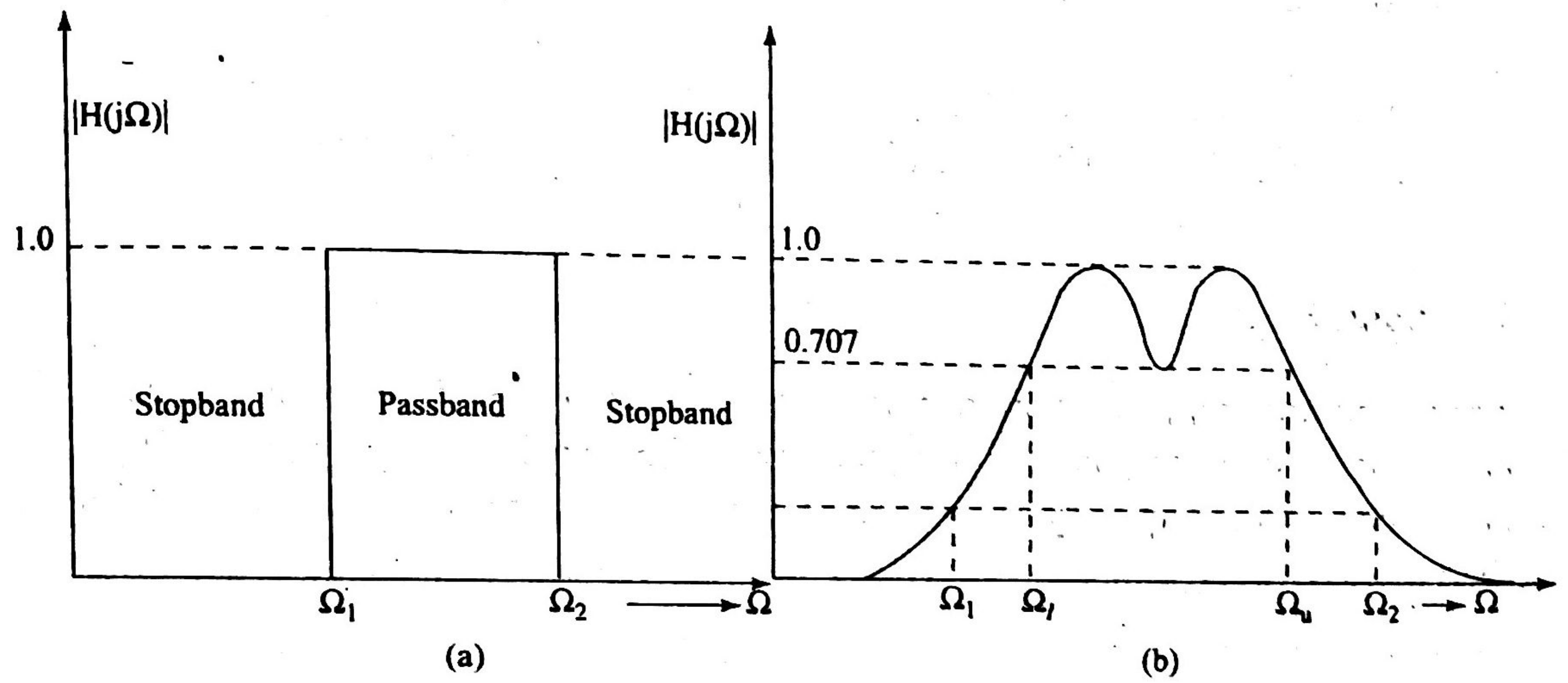
The highpass filter allows high frequencies above $\Omega > \Omega_c$ and rejects the frequencies between $\Omega = 0$ and $\Omega = \Omega_{c.}$



3.1 Design of FIR filters

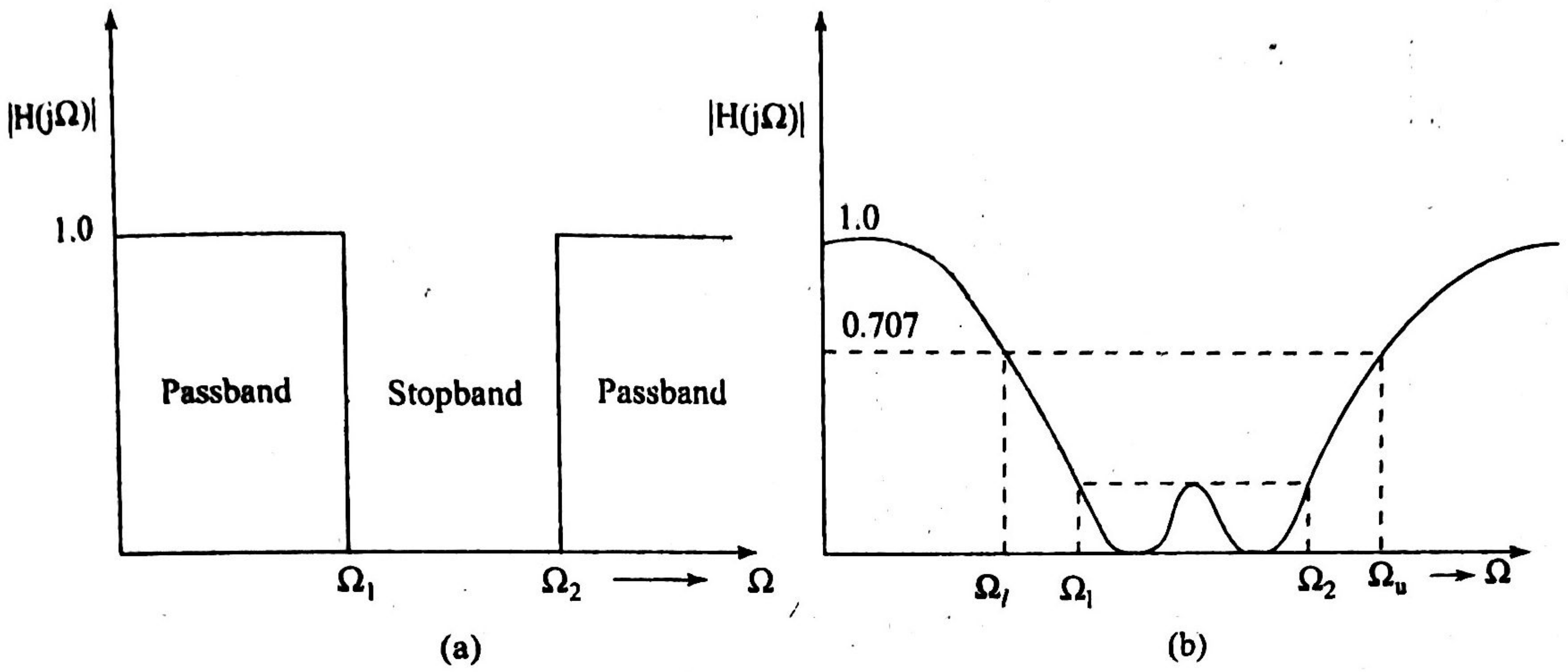
Bandpass Filter

It allows only a band of frequencies Ω_1 to Ω_2 to pass and stops all other frequencies.



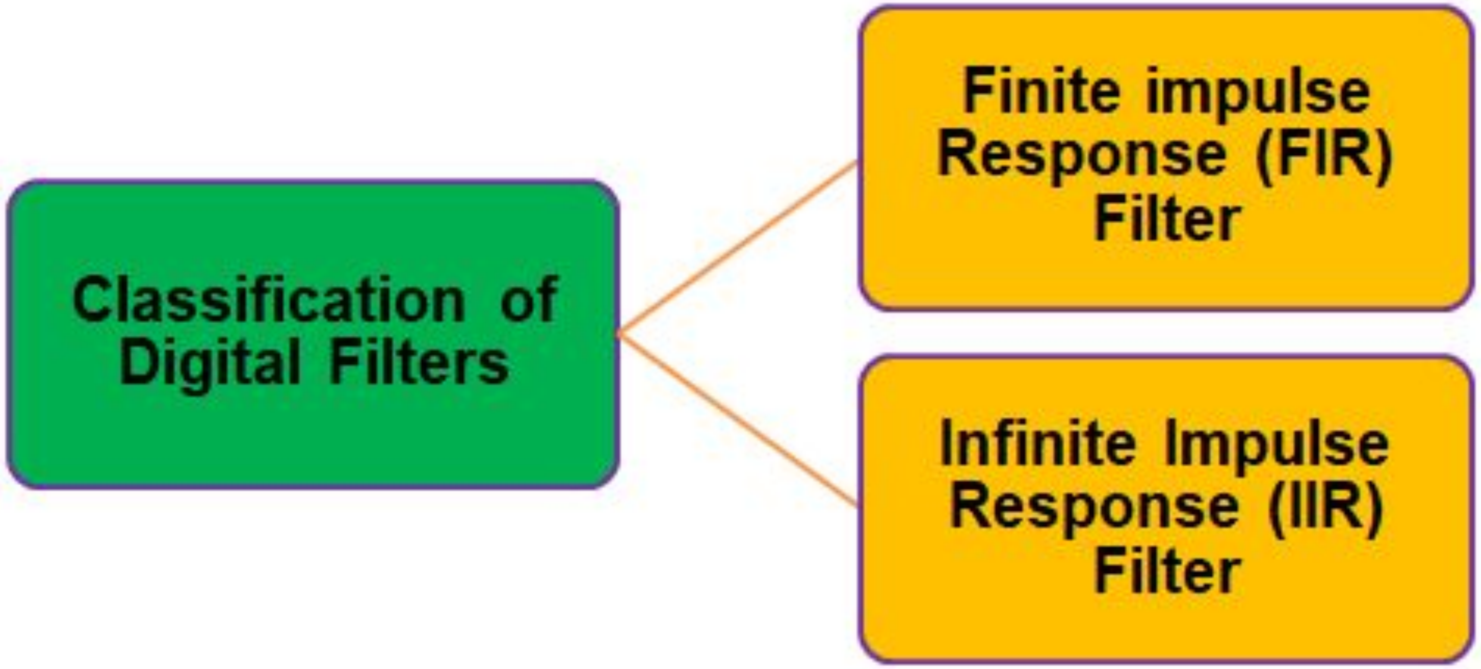
Bandreject Filter

It rejects all the frequencies between Ω_1 to Ω_2 and allows remaining frequencies.



3.1 Design of FIR filters

Types of Digital Filter



Watch this video

https://youtu.be/9yNQBWKRSs4

3.1 Design of FIR filters

Finite Impulse Response:

The FIR filters are of non-recursive type, whereby the present output sample depends on the present input sample and previous input samples.

Infinite Impulse Response:

IIR filters are of recursive type, whereby the present output sample depends on the present input, past input samples and output samples.

3.1 Design of FIR filters

Selection of Digital Filters (FIR)

- **Finite Impulse Response (FIR) filter**
  - always stable,
  - the phase can be made exactly linear,
  - we can approximate any filter we want.
  - Higher order w.r.t IIR filter (we need a lot of coefficients (*N large*) for good performance)

3.1 Design of FIR filters

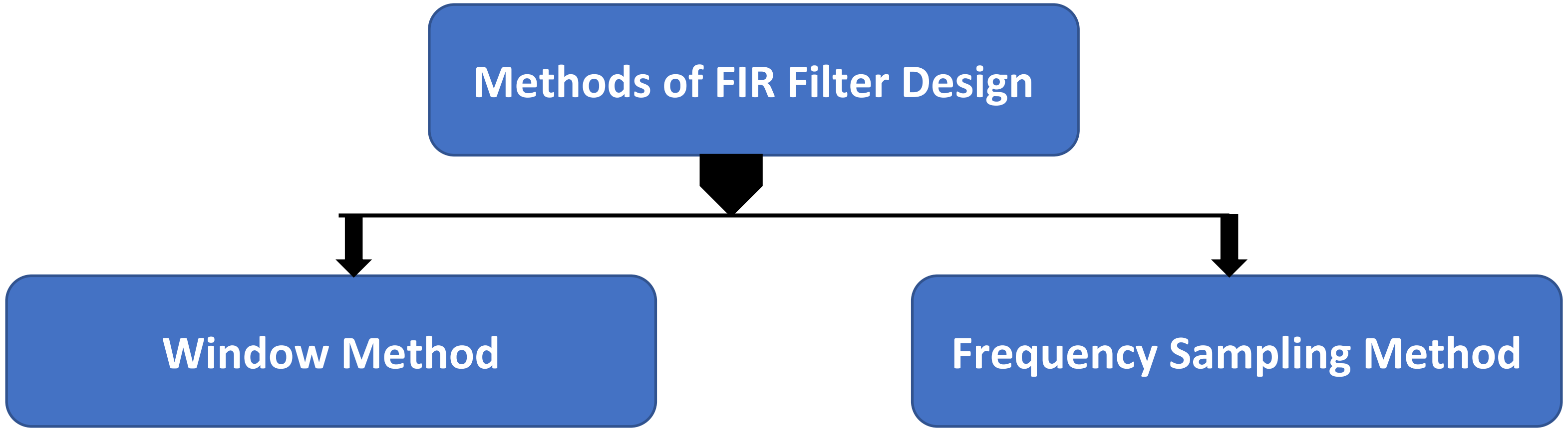
Design of FIR Filters

Design means calculation (determination) of the coefficients of the difference equation or the transfer function.

$$y(n) = \sum_{k=0} h(k)\, x(n-k)$$

$$H(z) = \sum_{k=0} h(k)\, z^{-k}$$

Design of FIR Filters



3.1 Design of FIR filters

Design of FIR Filters

Design of FIR Filters (Window Method)

- Simplest way of designing FIR filters
- Method is all discrete-time no continuous-time involved
- Start with ideal frequency response

$$H_d(e^{j\omega}) = \sum_{n=-\infty}^{\infty} h_d[n] e^{-j\omega n} \quad \Longrightarrow \quad h_d[n] = \frac{1}{2\pi} \int_{-\pi}^{\pi} H_d(e^{j\omega}) e^{j\omega n} \, d\omega$$

- Choose ideal frequency response as desired response
- Most ideal impulse responses are of infinite length

3.1 Design of FIR filters

Design of FIR Filters

The easiest way to obtain a causal FIR filter from ideal is by evaluating the

$$h_D(n) = \frac{1}{\omega_s}\int_{-\omega_c}^{\omega_c} H_D(e^{j\omega})\, e^{j\omega n T_s}\, d\omega = \frac{1}{\omega_s}\int_{-\omega_c}^{\omega_c} 1.e^{j\omega n \times 1/f_s}\, d\omega$$

$$= \frac{2\omega_c}{\omega_s}\frac{\sin(n\omega_c / f_s)}{(n\omega_c / f_s)}$$

3.1 Design of FIR filters

Design of FIR Filters

In general, the obtained impulse response $h_d(n)$ is infinite in duration and must be truncated at some point say at: $n = M$ to give an FIR filter of length M. Truncation of $hd\ (n)$ to a length M is equivalent to multiplying by a rectangular window defined as:

$$w(n) = \begin{cases} 1 & for\ |n| = 0, 1, \ldots, M \\ 0 & otherwise \end{cases}$$

3.1 Design of FIR filters

Thus, the impulse response of the FIR filter becomes :

$$h[n] = h_d[n]w[n] \quad \text{where} \quad w[n] = \begin{cases} 1 & 0 \le n \le M \\ 0 & else \end{cases}$$

$$h[n] = \begin{cases} h_d[n] & 0 \le n \le M \\ 0 & else \end{cases}$$

$$h_d(n)\,w(n) \xrightarrow{F.T} H_D(e^{j\omega}) * W(e^{j\omega})$$

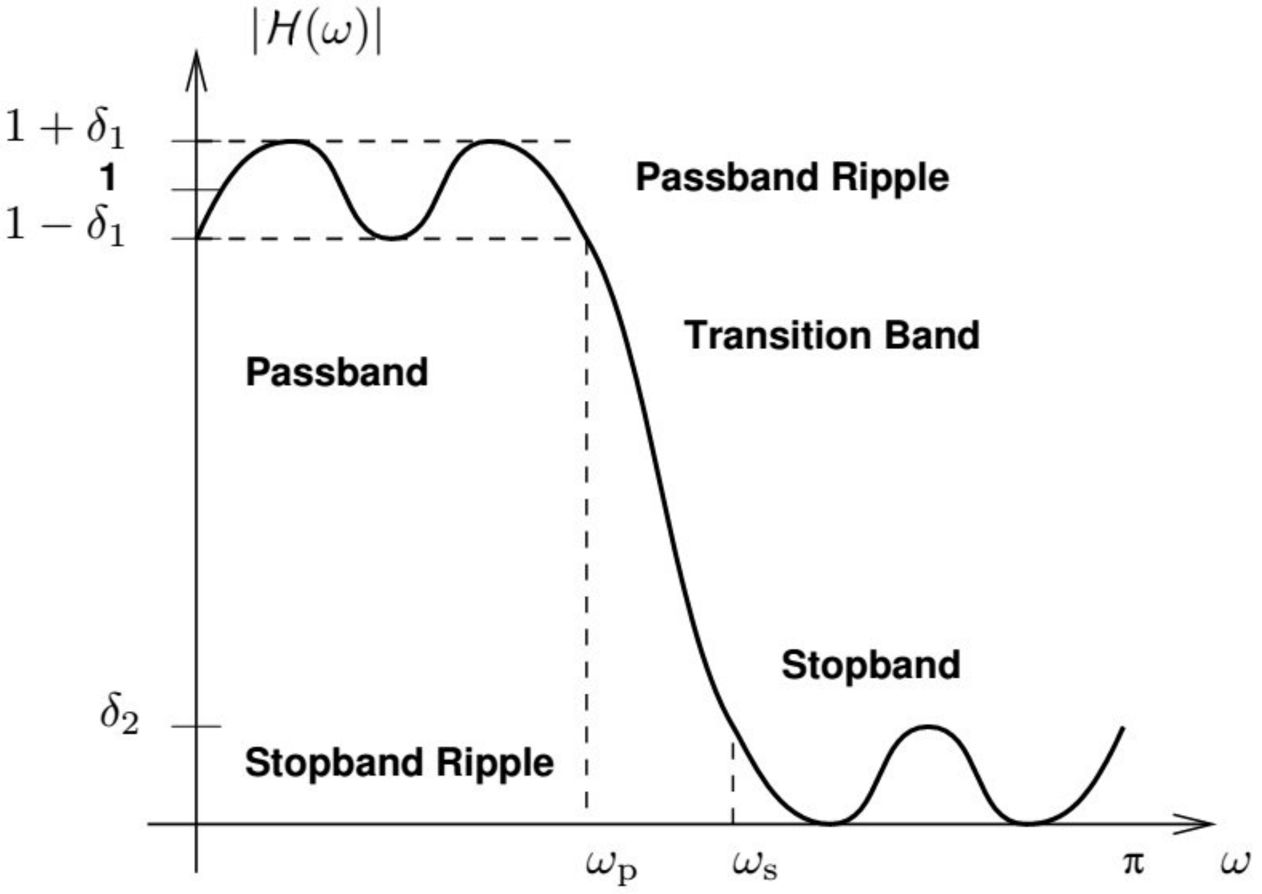
3.1 Design of FIR filters

Types of Window

Name of Window function	*Window function* $w(n),\ 0 \le n \le N$
Rectangular	1
Hanning	$0.5 - 0.5\cos(\frac{2\pi n}{N})$
Hamming	$0.5 - 0.46\cos(\frac{2\pi n}{N})$
Blackman	$0.42 - 0.5\cos(\frac{2\pi n}{N}) + 0.08\cos(\frac{4\pi n}{N})$

3.1 Design of FIR filters

Filter Specifications



3.1 Design of FIR filters

Linear Phase FIR Filters

The phase function of frequency response of a filter is linear function of frequency, then the filter is called linear phase filter.

Frequency Response of Linear Phase FIR Filters

- Depending on the value of N **(odd or even)** and the type of symmetry of the filter impulse response sequence **(symmetric or antisymmetric)** there are four possible types of linear phase FIR filters.

Case (i) : Symmetric impulse response and N is odd with centre of

symmetry at $(N - 1)/2$.

3.1 Design of FIR filters

Case (ii) : Symmetric impulse response and N is even with centre of symmetry at (N – 1)/2.

Case (iii) : Antisymmetric impulse response and N is odd with centre of antisymmetry at (N – 1)/2.

Case (iv) : Antisymmetric impulse response and N is even with centre of antisymmetry at (N – 1)/2.

Watch this video:

https://www.youtube.com/watch?v=KVOkWcknvc4

https://youtu.be/S0Fx-Uxq-mc