5 IIR Filter Design

Filter:

In signal processing, filter is a ckt (or) system that allow or pass the desired frequency component and disallow or stop the undesired frequency com

Filters are of two types

1. Analog filters
2. Digital filters.

Analog filters

Analog filter is ckt which uses inductors, capacitors and resistors to attenuate the unwanted frequency components.

Digital filters:

Digital filter is a software or program (or) hard which accepts digital noisy i/p signal and produce noise-free digital o/p signal.

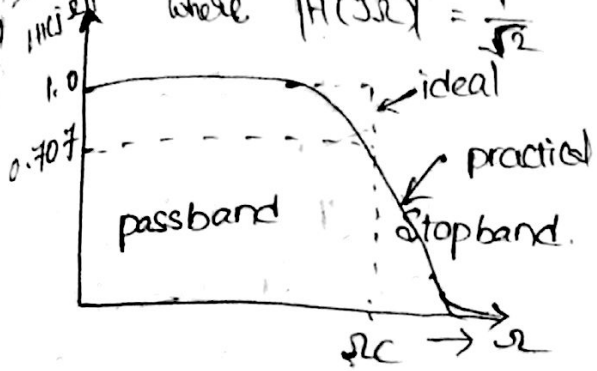
The digital filters do not use ~~resistance~~ resistor capacitors or inductors. It uses adders, multipliers delays.

The filters are of different types.

1. Lowpass filter
2. Highpass filter
3. Bandpass filter
4. Bandreject filter

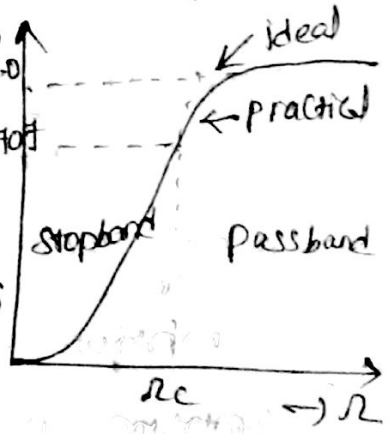
Lowpass filter :

The magnitude response of an ideal lowpass filter allows low frequencies in the passband $0 < \Omega < \Omega_c$ to pass, whereas the higher frequencies in the stopband $\Omega > \Omega_c$ are blocked. The Ω_c b/w two bands is cutoff frequency where $|H(j\Omega)| = \frac{1}{\sqrt{2}}$



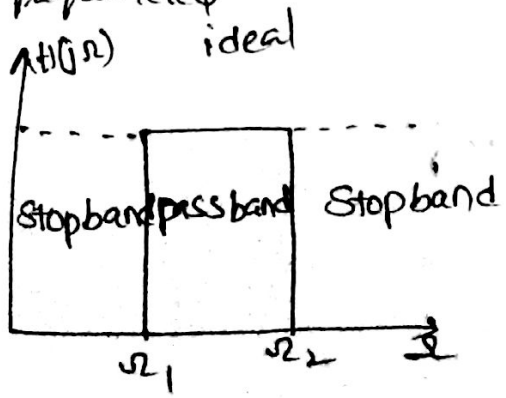
Highpass filter :-

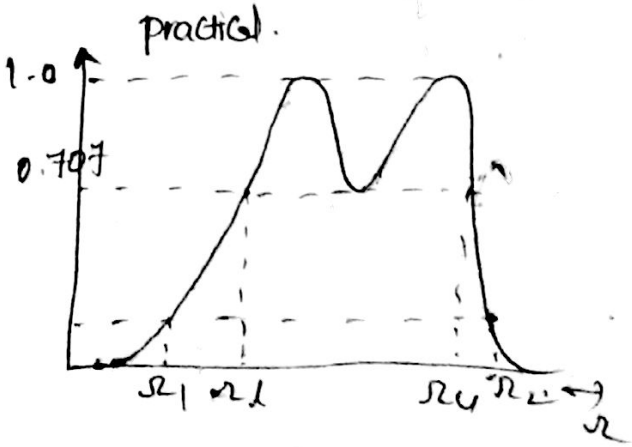
The highpass filter allows high frequencies above $\Omega > \Omega_c$ and rejects the frequencies between $\Omega = 0$ & $\Omega = \Omega_c$.



Bandpass filter :-

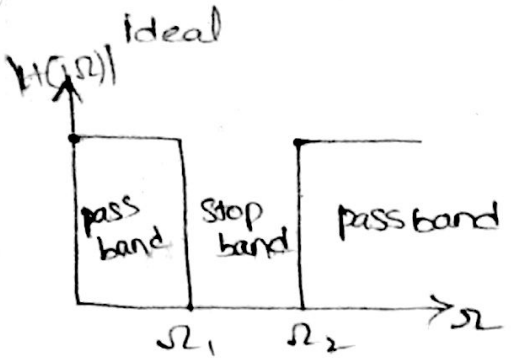
It allows only a band of frequencies Ω_1 to Ω_2 to pass and stops all other frequencies

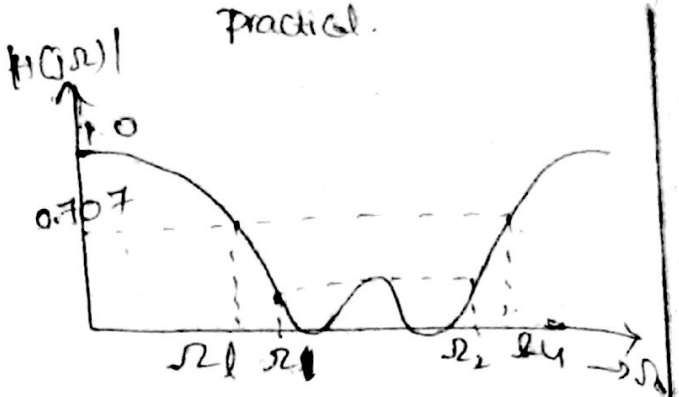




Bandreject filter :-

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

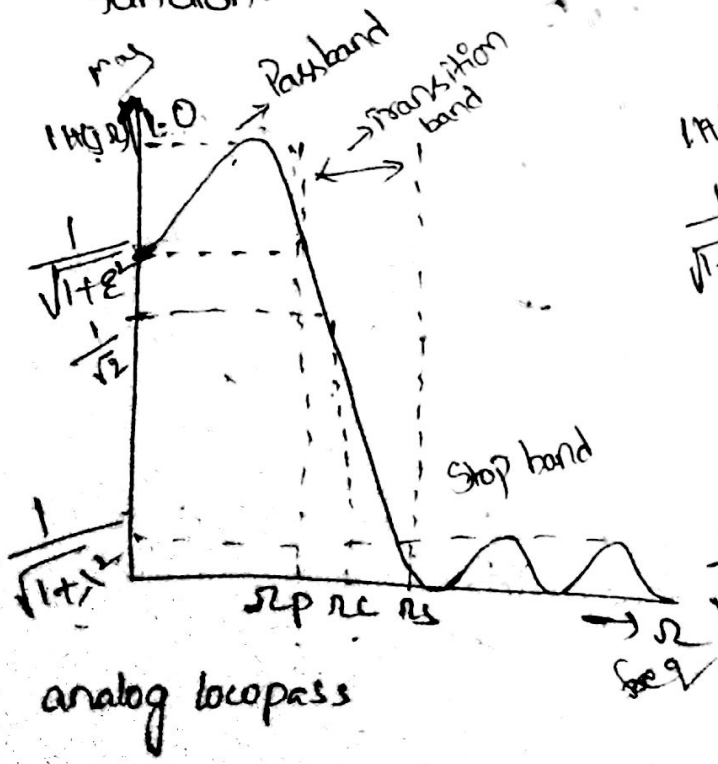


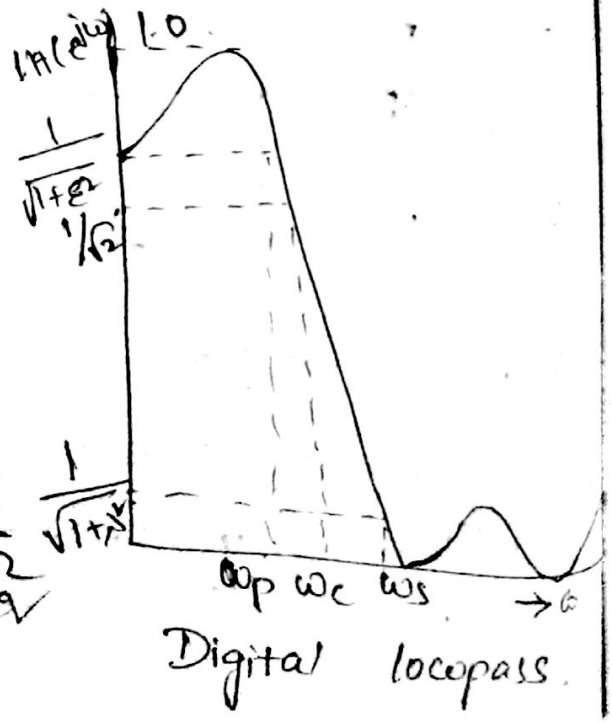


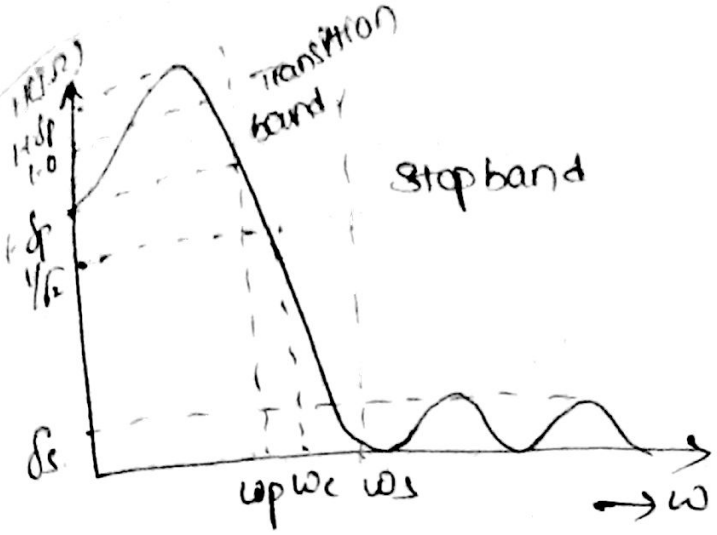
Design of Digital filters from Analog filter :-

The 1st designing an analog prototype & then transform the prototype to a digital filter. For the given specifications of a digital filter, the derivation of the digital filter transfer function requires three steps.

1. Map the desired digital filter specifications into those for an equivalent analog filter.
2. Derive the analog transfer function for the analog prototype.
3. Transform the transfer function of the analog prototype into an equivalent digital filter transfer function.







ω_p = passband frequency in radians

ω_s = Stopband frequency in radians

ω_c = 3-db cut-off frequency in radians

ε = parameter specifying allowable passband

λ = parameter specifying allowable Stopband

$$\varepsilon = \frac{2\sqrt{\delta_p}}{1-\delta_p}$$

$$\lambda = \frac{\sqrt{(1+\delta_p)^2 - \delta_s^2}}{\delta_s}$$

using the analog filter specifications the transfer function of analog lowpass filter is designed and it is transformed to digital filter using suitable transformation method.

Analog filter	Digital filter
1. analog filter processes analog i/p's & generates analog o/p's.	1. A Digital filter processes and generates digital da
2. Analog filters are constructed from active or passive electronic components	2. A Digital filter consis of elements like adder multiplier and delay uni
3. Analog filter is described by a differential equation.	3. Digital filter is described by a difference equation
4. The frequency response of an analog filter can be modified by changing the components	4. The frequency response can be changed by changin the filter coefficients.

Advantages & disadvantages of Digital filters:-

1. Unlike analog filter, the digital filter performance is not influenced by component ageing, temperature and power supply variations.
2. A digital filter is highly immune to noise and possesses considerable parameter stability
3. Digital filters afford a wide variety of shapes for the amplitude and phase responses.
4. There are no problems of i/p or o/p impedance matching with digital filters.
5. Digital filters can be operated over a wide ran of frequencies.
6. The coefficients of digital filter can be program