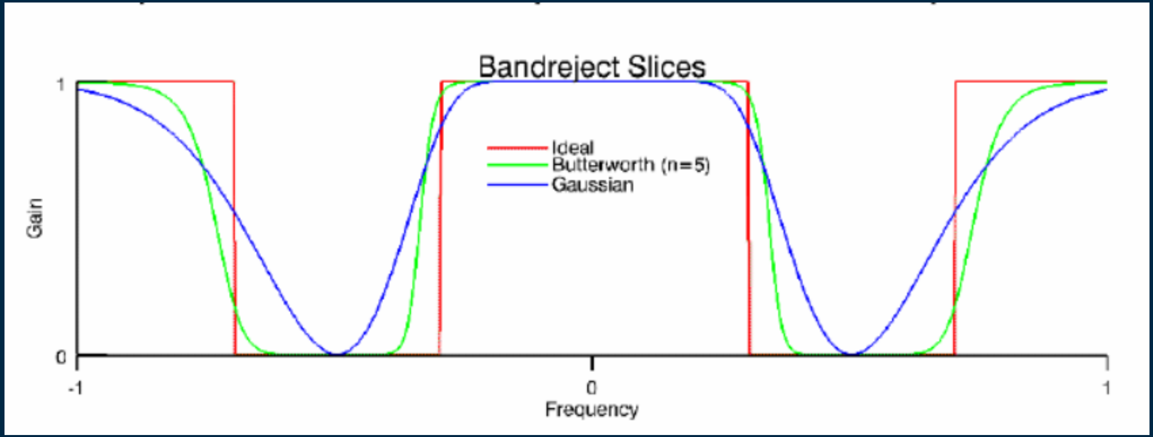
Periodic Noise Reduction by selective filters

- ❑ Bandreject filter
- ❑ Bandpass filter
- ❑ Notch Filter

01 Bandreject filter

They remove frequency components within a certain range (the *stopband* of the filter), while leaving all other frequency components untouched (or amplifying them by a certain gain).



Types of Bandreject filter

01
Ideal

$$H(u,v) = \begin{cases} 0 & \text{if } D_L \leq D(u,v) \leq D_H \\ 1 & \text{otherwise} \end{cases}$$

02
Butterworth

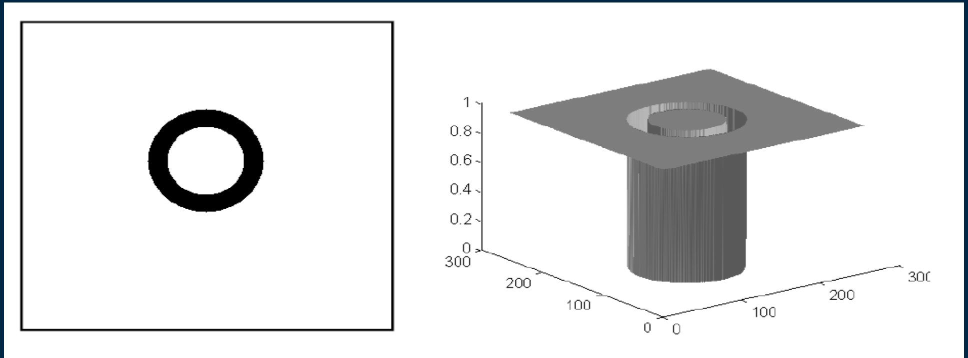
$$H(u,v) = \frac{1}{1 + \left[(DW)/(D^2 - D_0^2)\right]^{2n}}$$

03
Gaussian

$$H(u,v) = e^{-\left[(D^2 - D_0^2)/(DW)\right]^2}$$

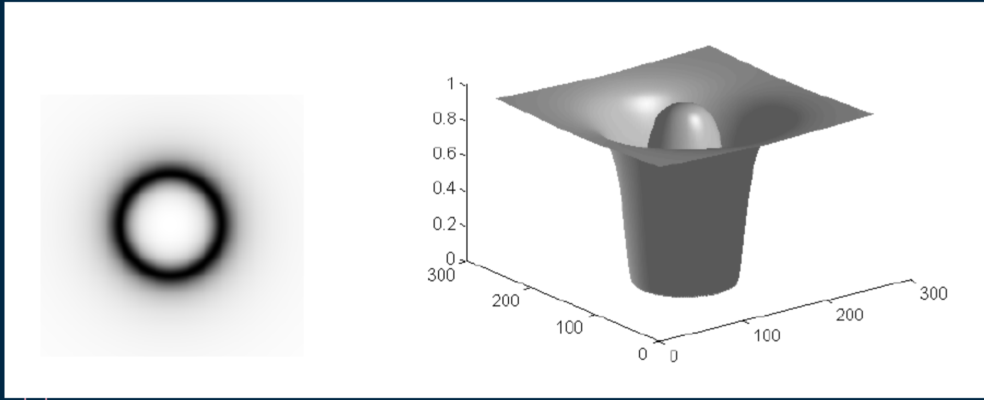
Ideal Bandreject filter

In this type of filter, frequencies outside of the given range are passed without attenuation and frequencies inside of the given range are blocked. This behavior makes ideal band reject filters very sharp.



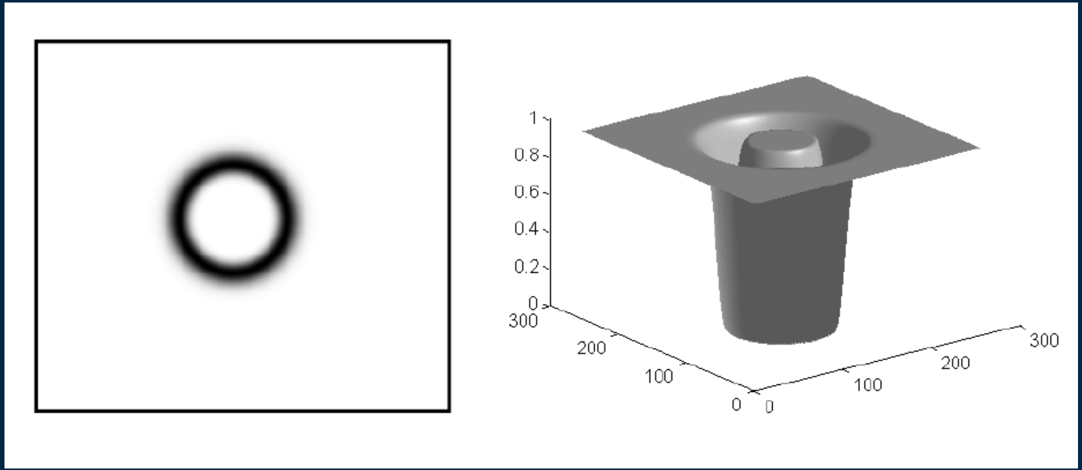
Butterworth Bandreject filter

With a Butterworth band reject filter, frequencies at the center of the frequency band are completely blocked and frequencies at the edge of the band are attenuated by a fraction of the maximum value. The Butterworth filter does not have any sharp discontinuities between passed and filtered frequencies.



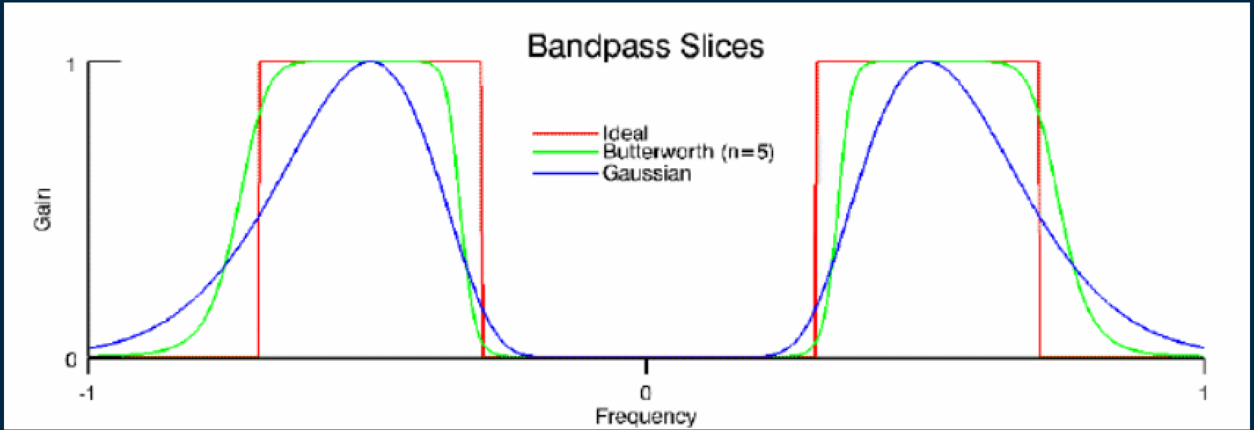
Gaussian Bandreject filter

In this type of filter, the transition between unfiltered and filtered frequencies is very smooth.



02 Banpass filter

They allow certain frequencies (within its passband) to be preserved while removing all others. It is, in effect, the opposite of a bandreject filter.



Types of Bandpass filter

01

Ideal

$$H(u,v) = \begin{cases} 1 & \text{if } D_L \leq D(u,v) \leq D_H \\ 0 & \text{otherwise} \end{cases}$$

02

Butterworth

$$H(u,v) = 1 - \frac{1}{1 + \left[(DW)/(D^2 - D_0^2)\right]^{2n}}$$

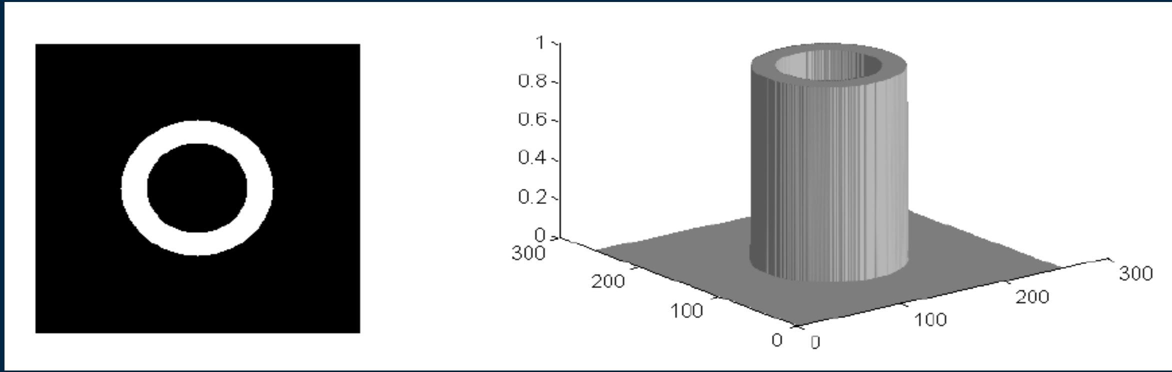
03

Gaussian

$$H(u,v) = e^{-\left[(D^2 - D_0^2)/(DW)\right]^2}$$

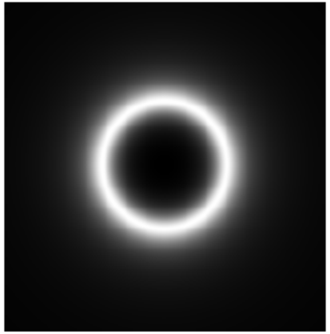
Ideal Bandpass filter

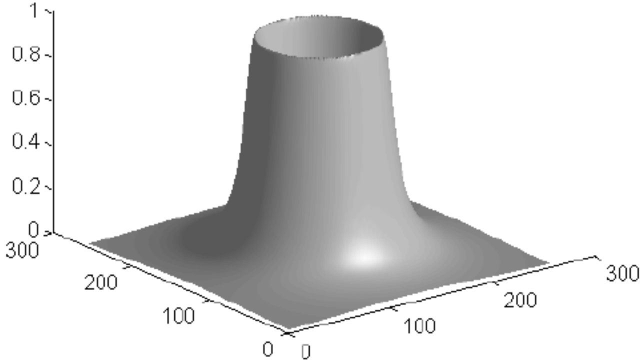
In these filters, frequencies within the given range are passed through without attenuation and frequencies outside of the given range are completely removed. This behavior makes ideal bandpass filters very sharp.



Butterworth Bandpass filter

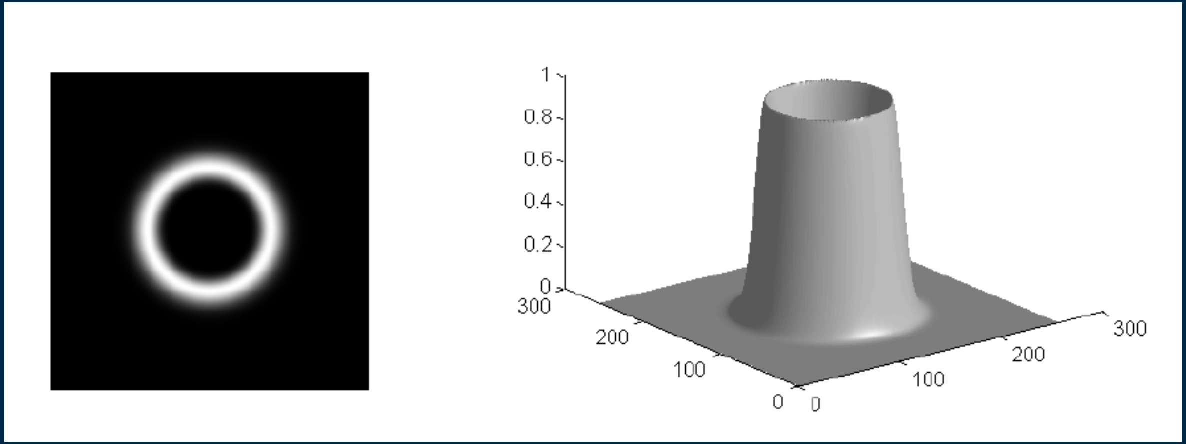
With a Butterworth bandpass filter, frequencies at the center of the frequency band are unattenuated and frequencies at the edge of the band are attenuated by a fraction of the maximum value. The Butterworth filter does not have sharp discontinuities between frequencies that are passed and filtered.





Gaussian Bandpass filter

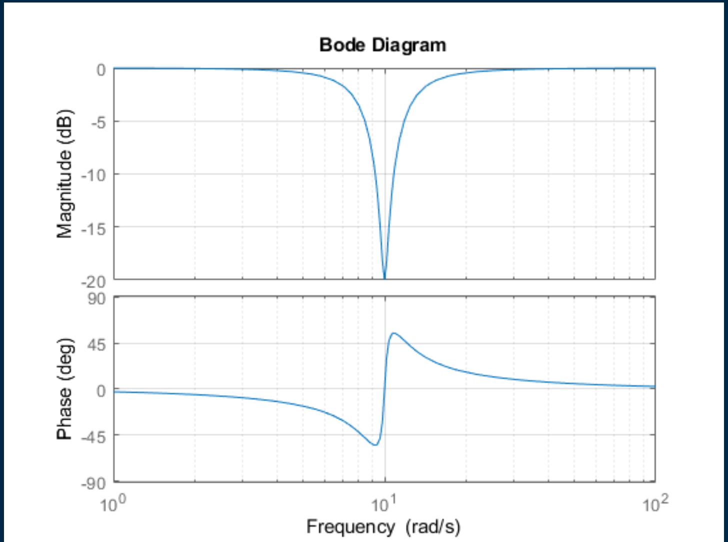
In this type of filter, the transition between unfiltered and filtered frequencies is very smooth.



03 Notch filter

Notch filter is a special kind (most useful) of selective filters, it rejects (or passes) a narrow frequency band in predefined neighborhoods about a center frequency

- Notch reject filter
- Notch pass filter



Types of Notch filter

01

Ideal

$$H(u,v)=\begin{cases}0 & \text{if } D_1(u,v)\le D_0 \text{ or } D_2(u,v)\le D_0\\ 1 & \text{otherwise}\end{cases}$$

$$D_1(u,v)=\sqrt{(u-M/2-u_0)^2+(v-N/2-v_0)^2}$$

$$D_2(u,v)=\sqrt{(u-M/2+u_0)^2+(v-N/2+v_0)^2}$$

02

Butterworth

$$H(u,v)=\frac{1}{1+\left[\dfrac{D_0^{\,2}}{D_1(u,v)D_2(u,v)}\right]^2}$$

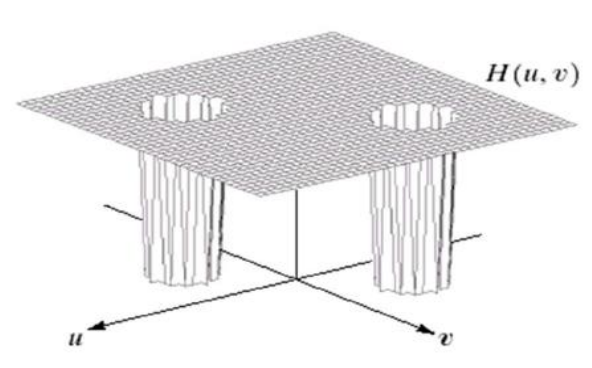
03

Gaussian

$$H(u,v)=1-e^{-\frac{1}{2}\left[\frac{D_1(u,v)D_2(u,v)}{D_0^{\,2}}\right]}$$

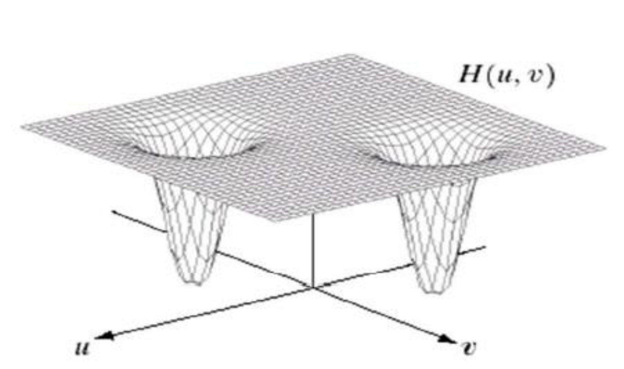
Ideal Notch filter

An ideal Notch filter rejects (passes) some range of frequencies without distortion and passes(rejects) all other frequencies. But in some applications, a simple notch filter is not accurate and reliable because of the low signal to noise ratio. In those cases, Butterworth's notch filter is used to increase accuracy and reliability.



Butterworth Notch filter

Butterworth's notch filter is used to increase accuracy and reliability more than ideal filters in some applications.



Gaussian Notch filter

Gaussian notch based filters not only reject the central noisy peak but also suppress the neighboring noisy frequency areas corresponding to noisy spikes.