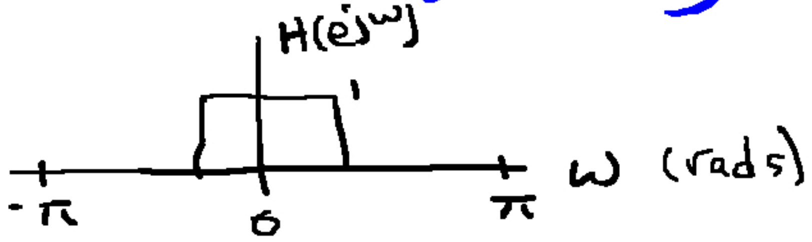
Introduction to Frequency Selective Filtering

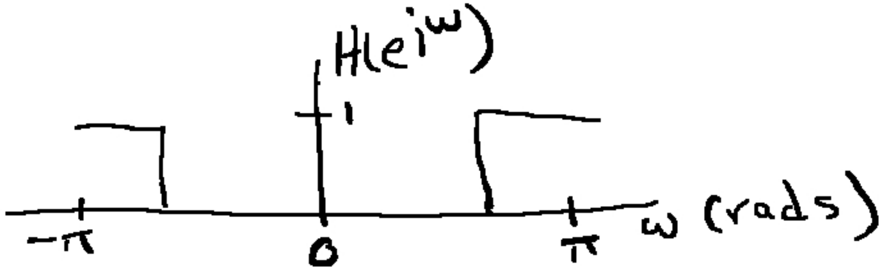
Filter: to separate

Frequency selective filtering - separate based on frequency

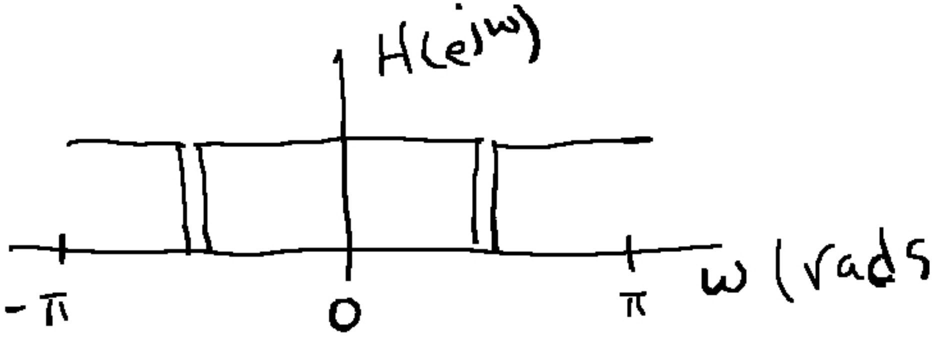
Lowpass



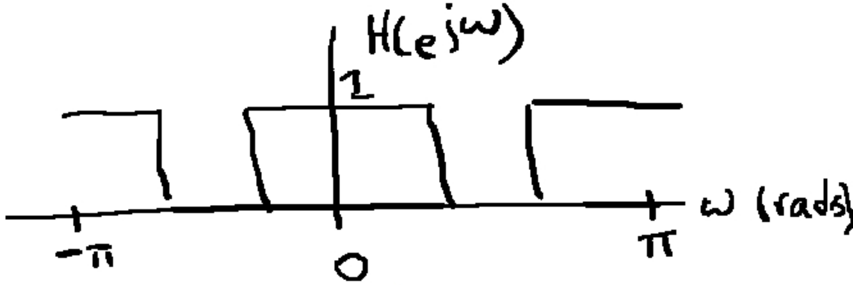
Highpass



Notch



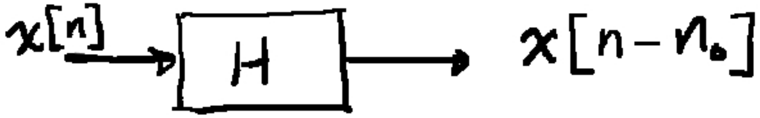
Bandpass



Bandstop

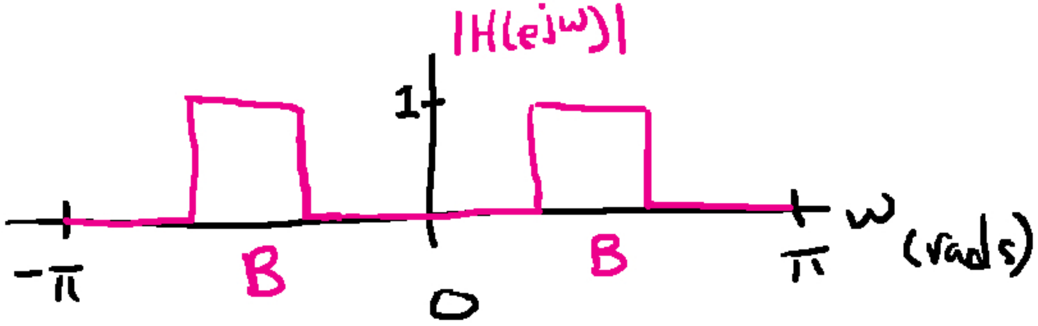
Ideal Filters

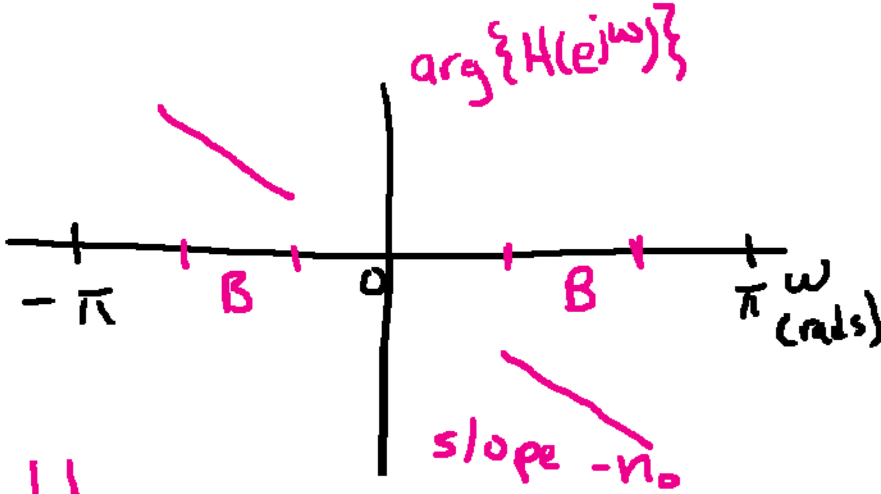
$x[n] \in B$



$y[n] \notin B$

$$x[n-n_0] \xleftrightarrow{\text{DTFT}} e^{-j\omega n_0} X(e^{j\omega})$$

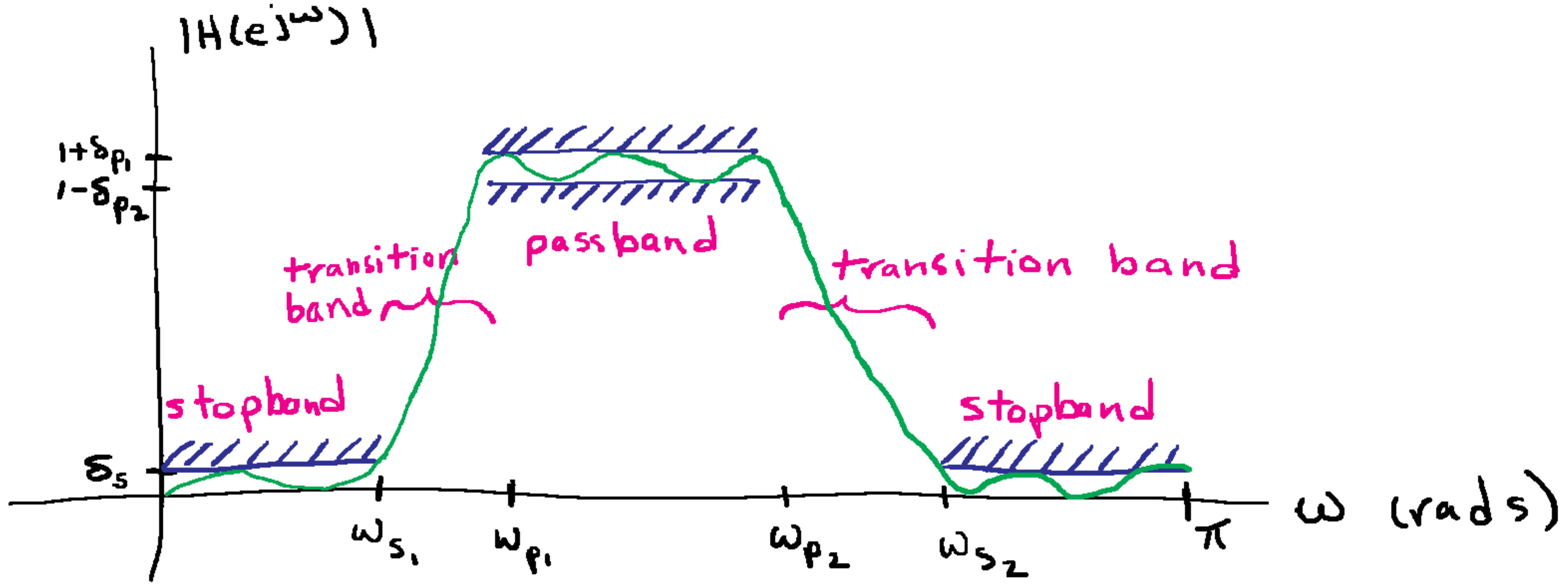




Ideal filters cannot be implemented!

Practical filters: variable gain in passband
nonzero gain in stopband
transition band
nonlinear phase

Filter gain specifications: tolerance diagram



$|H(e^{j\omega})| < \delta_s$, $|\omega| < \omega_{s_1}$, $\omega_{s_2} < |\omega| < \pi$ — stop

$1-\delta_{p_2} < |H(e^{j\omega})| < 1+\delta_{p_1}$, $\omega_{p_1} < |\omega| < \omega_{p_2}$ — pass

"don't care" , $\omega_{s_1} < |\omega| < \omega_{p_1}$, $\omega_{p_2} < |\omega| < \omega_{s_2}$

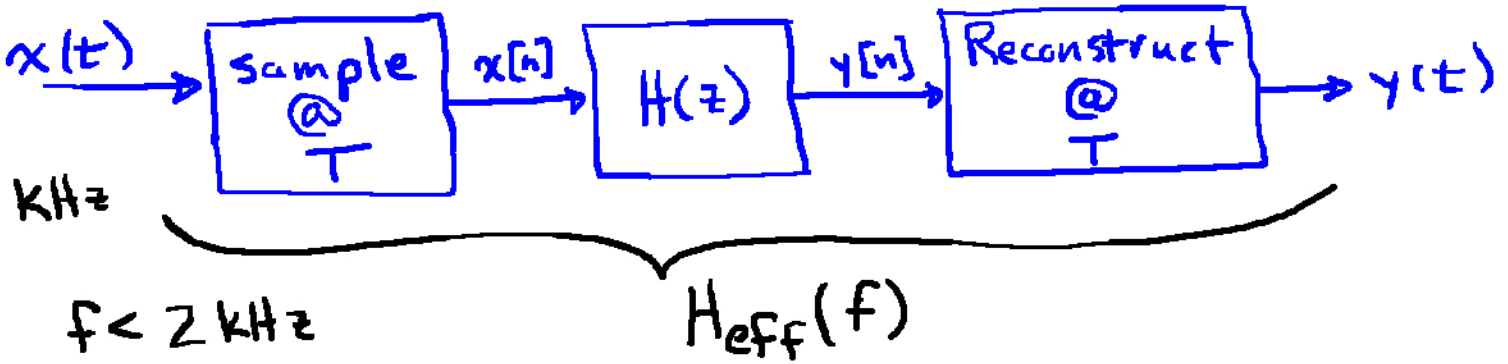
Filter phase specifications:

1) Linear – distortionless

2) Don't care

3) Zero-phase – noncausal filtering of stored signals

Example:



$T = 10^{-4}\,s \Rightarrow f_s = 10\text{ kHz}$

$0.99 < |H_{eff}(f)| < 1, \quad f < 2\text{ kHz}$

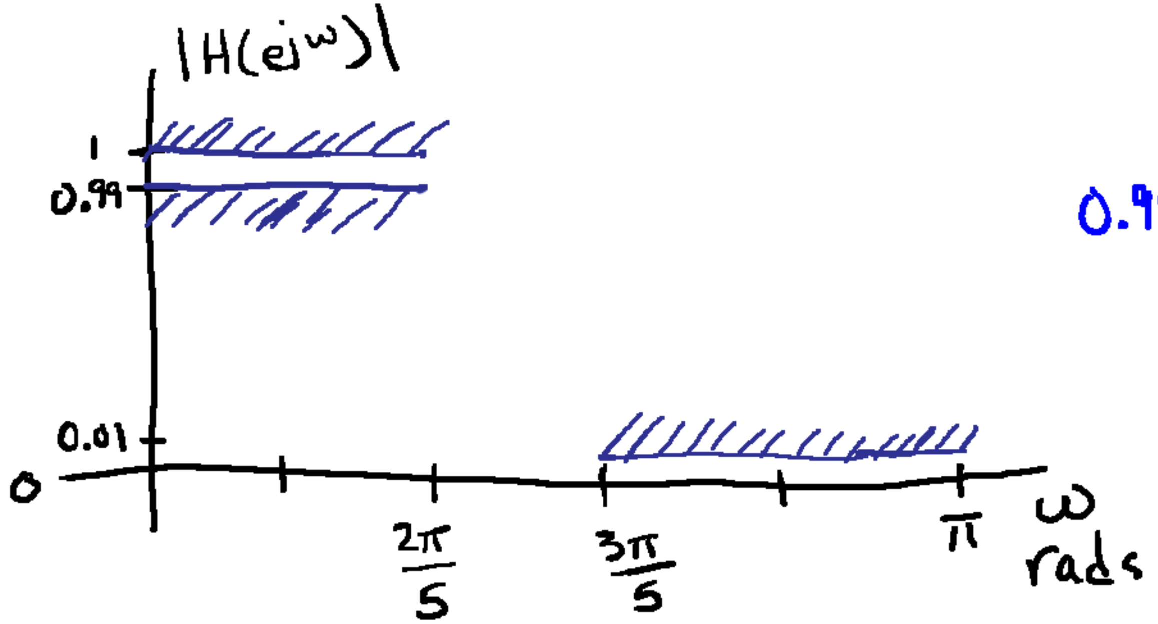
$|H_{eff}(f)| < 0.01, \quad f > 3\text{ kHz}$

Find specs on $H(e^{j\omega})$

$\omega = 2\pi f T$

$f = 2\text{kHz} \Rightarrow \omega = \frac{2\pi}{5}$

$f = 3\text{kHz} \Rightarrow \omega = \frac{3\pi}{5}$



$0.99 < |H(e^{j\omega})| < 1, \quad |\omega| < \frac{2\pi}{5}$

$|H(e^{j\omega})| < 0.01, \quad |\omega| > \frac{3\pi}{5}$