ENSC380
Lecture 20

Objectives:

- Signals and Systems Fourier Analysis:
  - Analysis of Ideal Filters
  - Learn the definition and frequency response of distortion-less filter
  - Learn the definitions and frequency responses of ideal low-pass, band-pass, high-pass and band-stop filters.

LTI Systems

- An LTI system in time domain is defined by its “impulse response”:

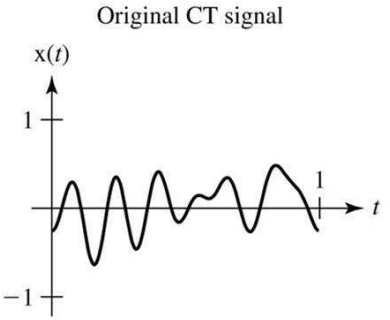
- An LTI system in frequency domain is defined by its “frequency response”:

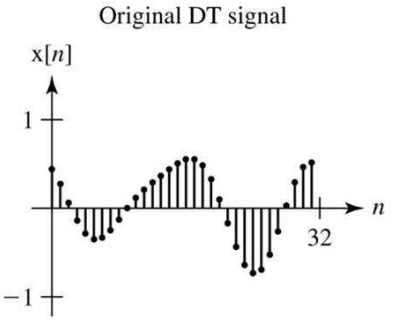
Filters

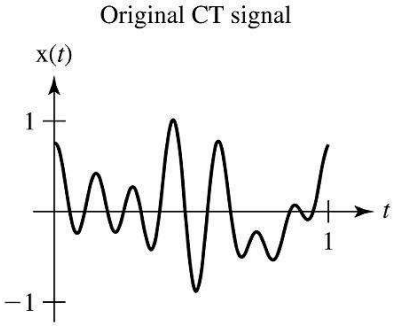
- **Filter** is a very general term, usually referred to a system which separates the desired frequency components of a signal and rejects the undesired ones.
- In other words a filter is a system which passes a certain frequency range of a signal and rejects the rest of the signal. The frequency range that the filter passes is called the “pass band” of the filter (Don’t mix up with the term “band-pass”!).
- An **ideal filter**, is a filter which **passes, without distortion,**all of the signal’s frequency components within its pass band , and **completely rejects** the rest of the signal’s frequency components.

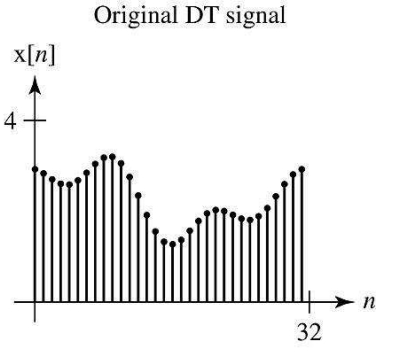
Distortion

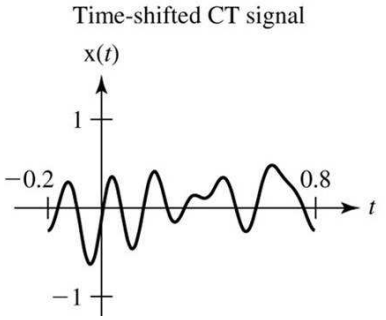
- Distortion means “changing the shape of the signal”.
- Multiplication of a signal by a constant is not considered distortion.
- Time shifting the signal is also not considered distortion.

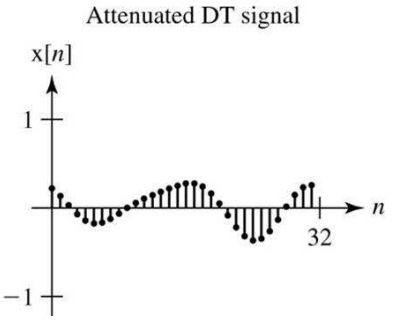


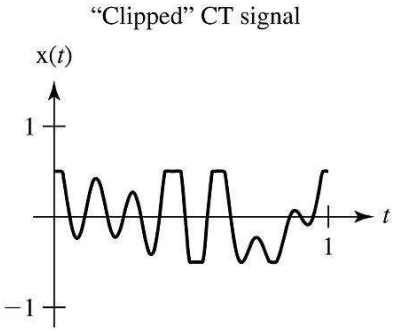


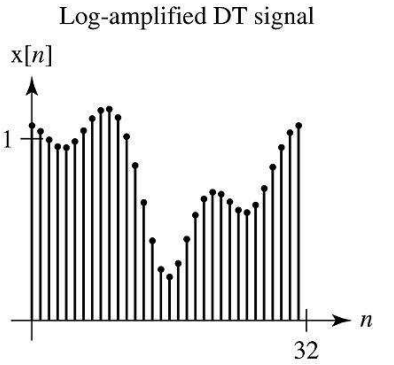












Distortion-Less Filter

- A distortion less fileter, is a filter that only multiplies the signal by a constant and/or shifts it in time.
- What is the general impulse response of a system that does only the above?

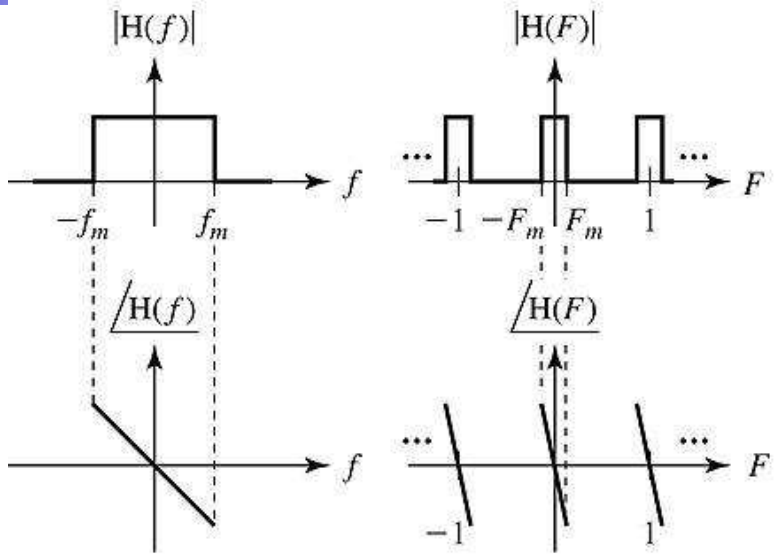
- What is the frequency response of this filter?

Ideal Filters

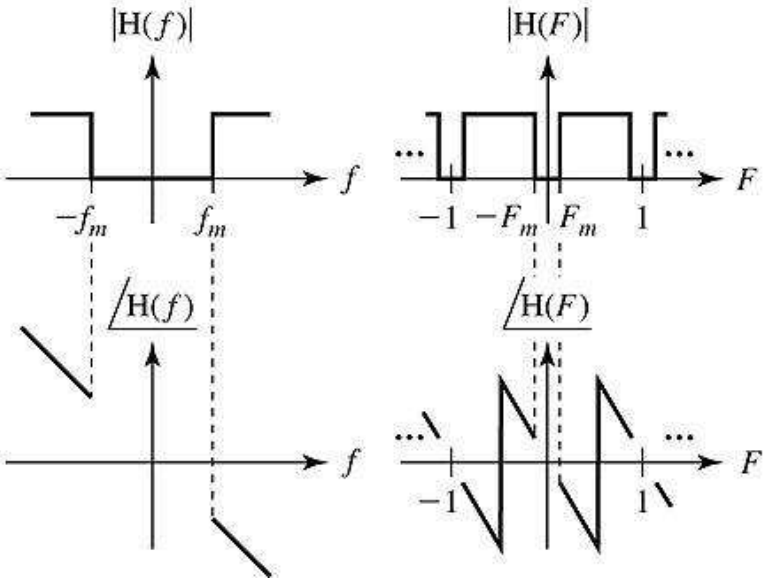
- Ideal filters are filters which pass all of frequency contents of their input signal within their pass band, without distortion, and reject the rest of the frequency components of it.
- Ideal filters are divided into “low pass”, “band pass”, “high pass”, and “band stop” filters. The ideal distortion less filter we just saw is also referred to as “ideal all pass” filter.
- For a filter to be ideal, it should be like an ideal distortion-less filter during its pass band, and zero else where.
- The **band width** of a filter, is length of its pass band frequency range (in positive frequencies):

Ideal Filters (Freq. Response)

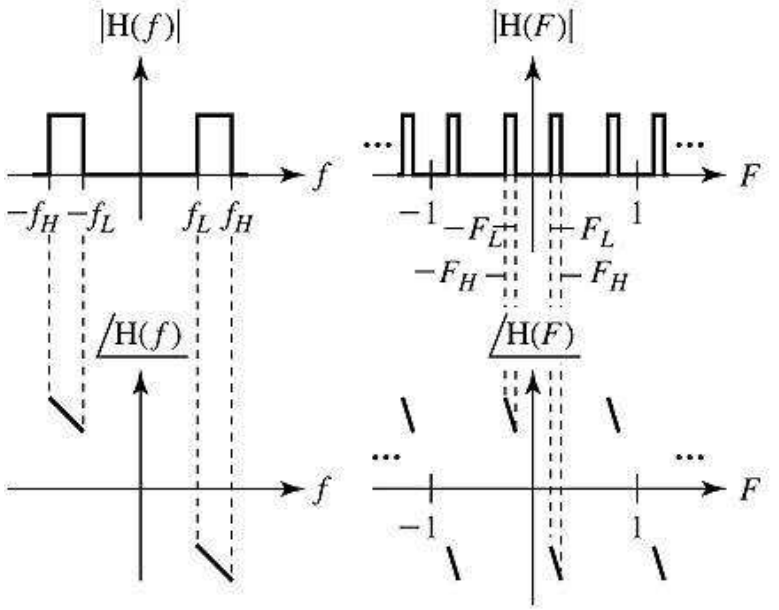
Ideal lowpass filter



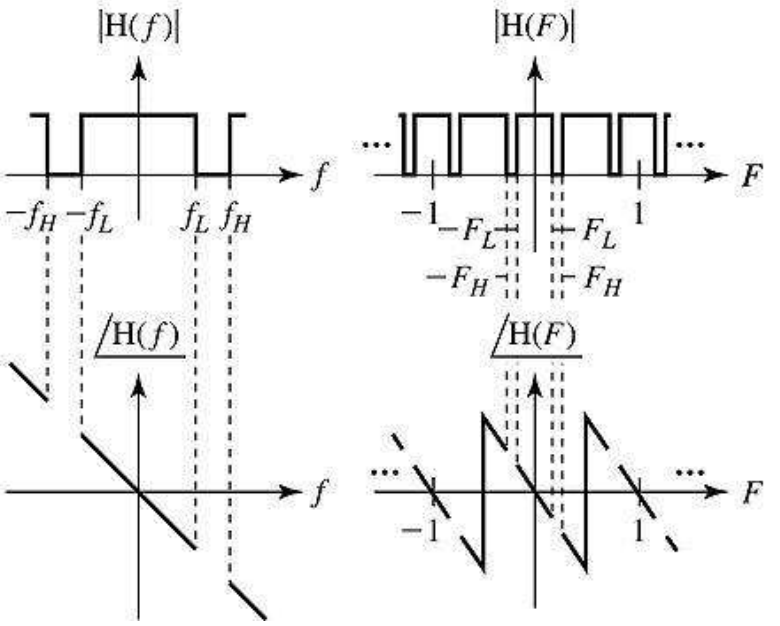
Ideal highpass filter



Ideal bandpass filter

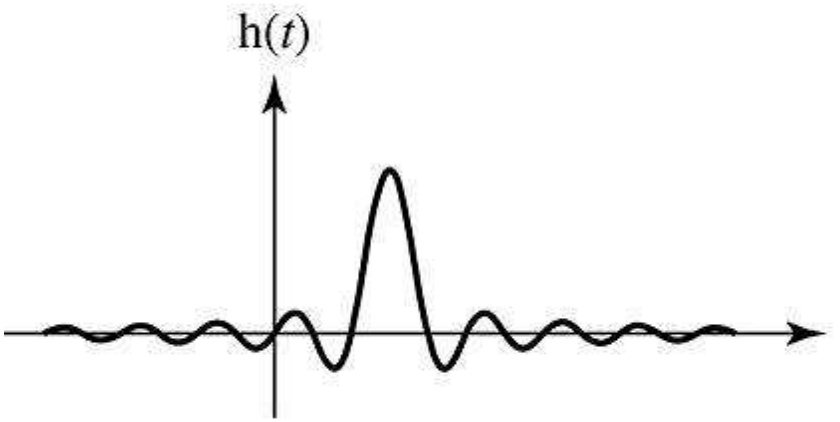


Ideal bandstop filter

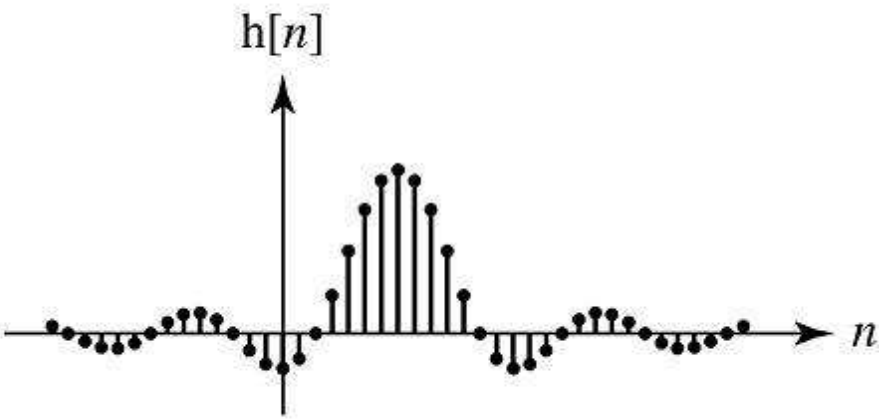


Ideal Filters (Impulse Response)

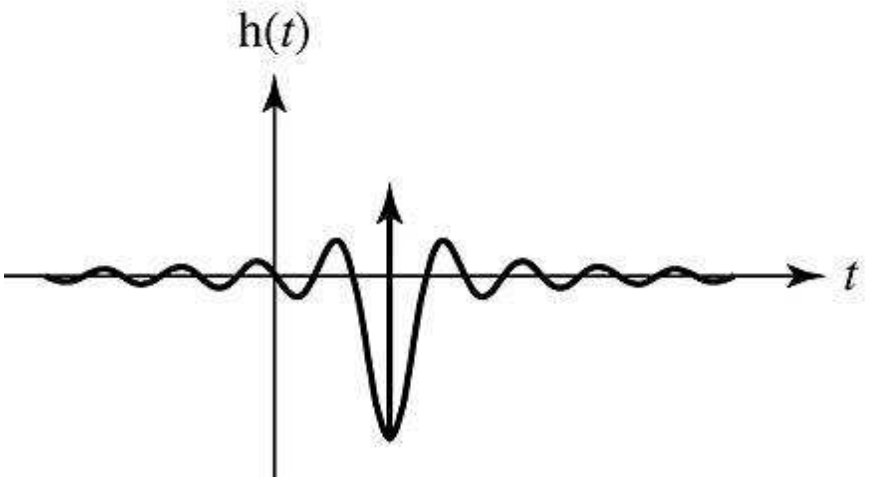
Ideal CT lowpass



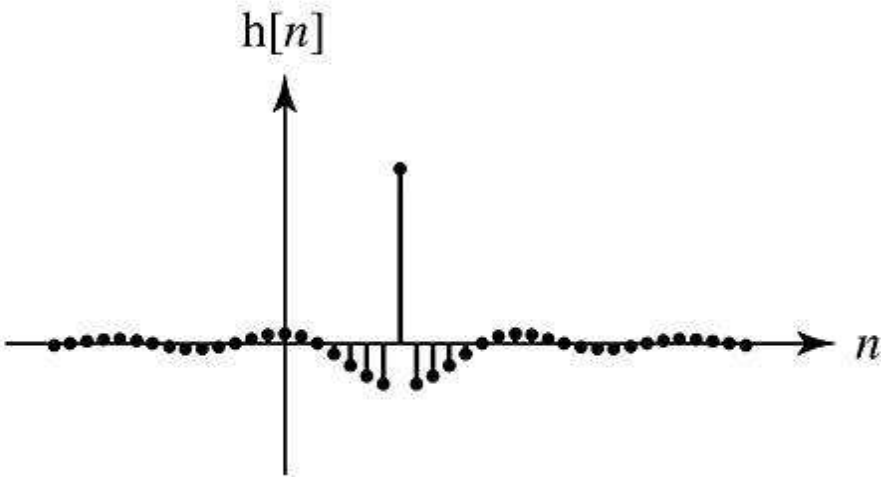
Ideal DT lowpass



Ideal CT highpass

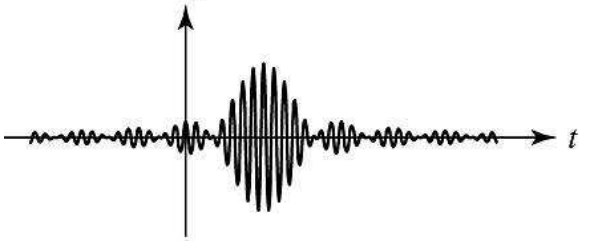


Ideal DT highpass

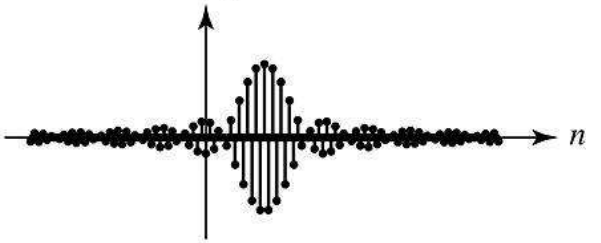


Ideal Filters (Impulse Response)

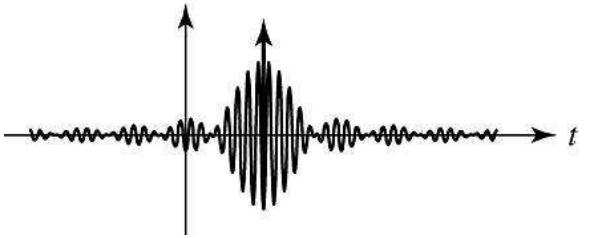
Ideal CT bandpass



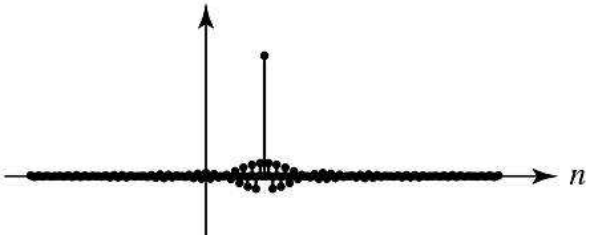
Ideal DT bandpass



Ideal CT bandstop



Ideal DT bandstop



Examples

- Example 1: Find the frequency and impulse response of an ideal low pass filter, with a bandwidth of 10(kHz), which does not time shift its input.

- Example 2: Find the frequency and impulse response of an ideal low pass filter, with a bandwidth of 10(kHz), which causes a delay of 5(ms) to its input.