

# Questions?

- Show and Tell?
  - Deadline for improvement: last day for class (05/10/07)
- Project?

# Filtering

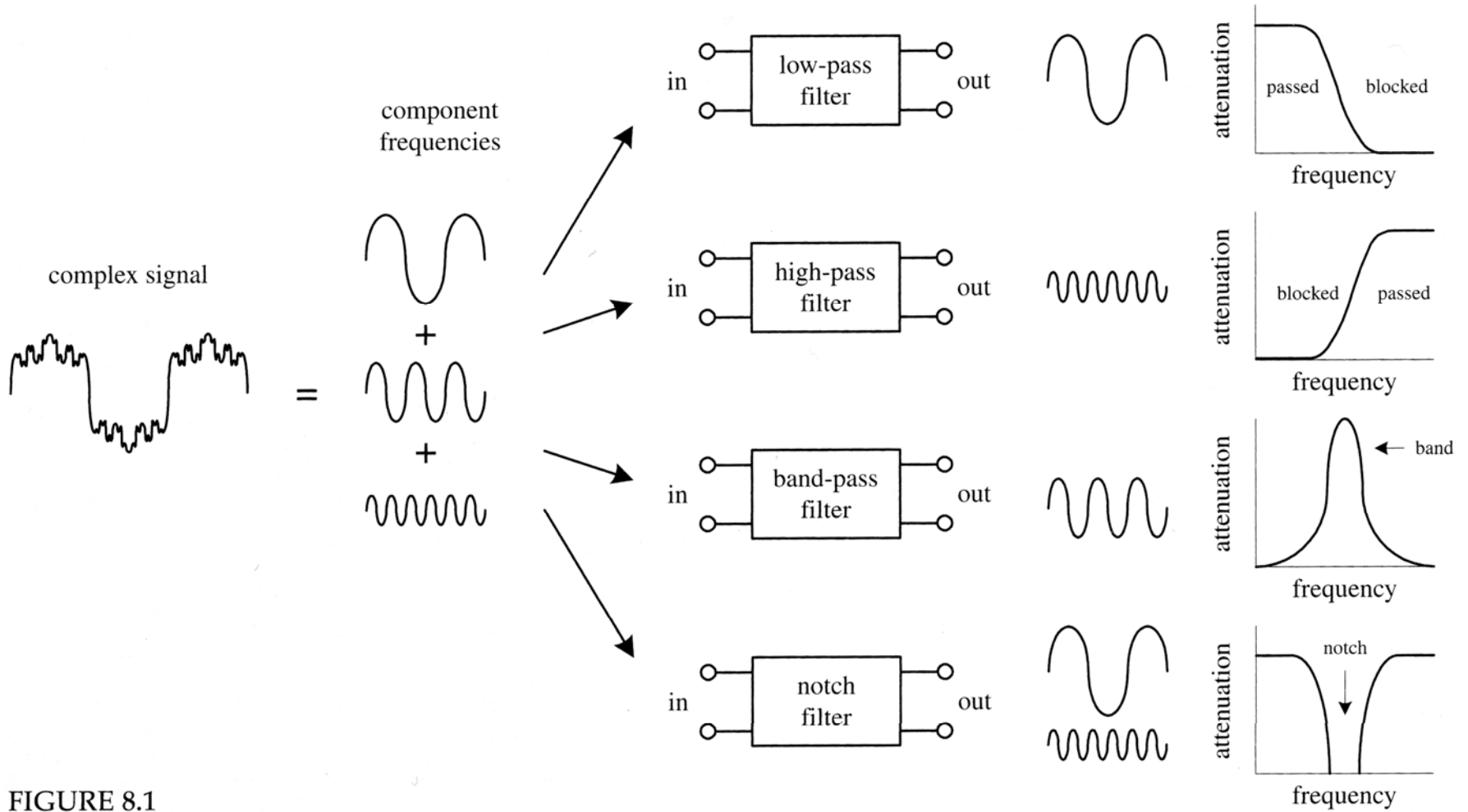
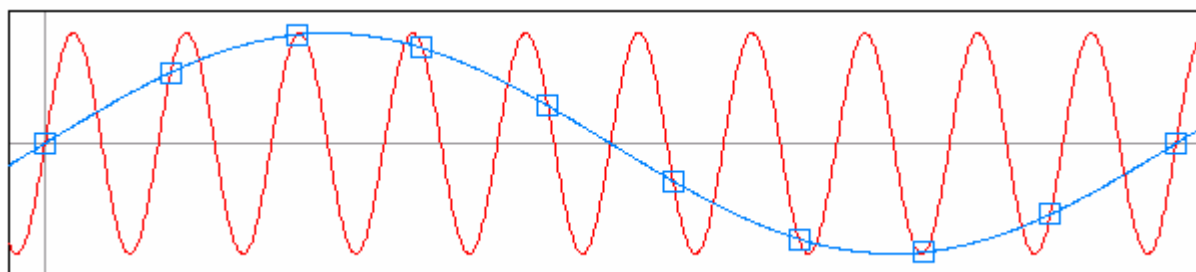


FIGURE 8.1

# Why filtering?

- Prepare the signal for further processing
  - Avoid aliasing before sampling a signal
    - $f_{sample} > 2f_{max}$

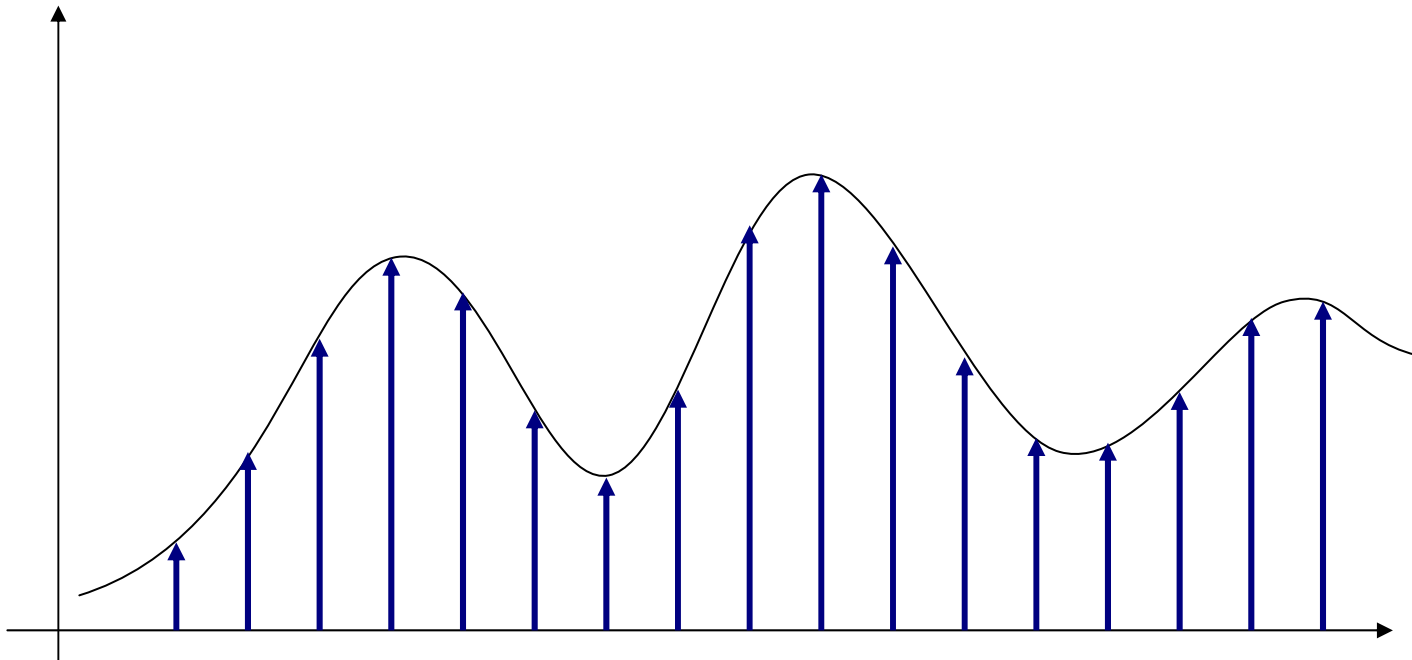


From Wikipedia

- See <http://www.dsptutor.freeuk.com/aliasing/AliasingDemo.html>

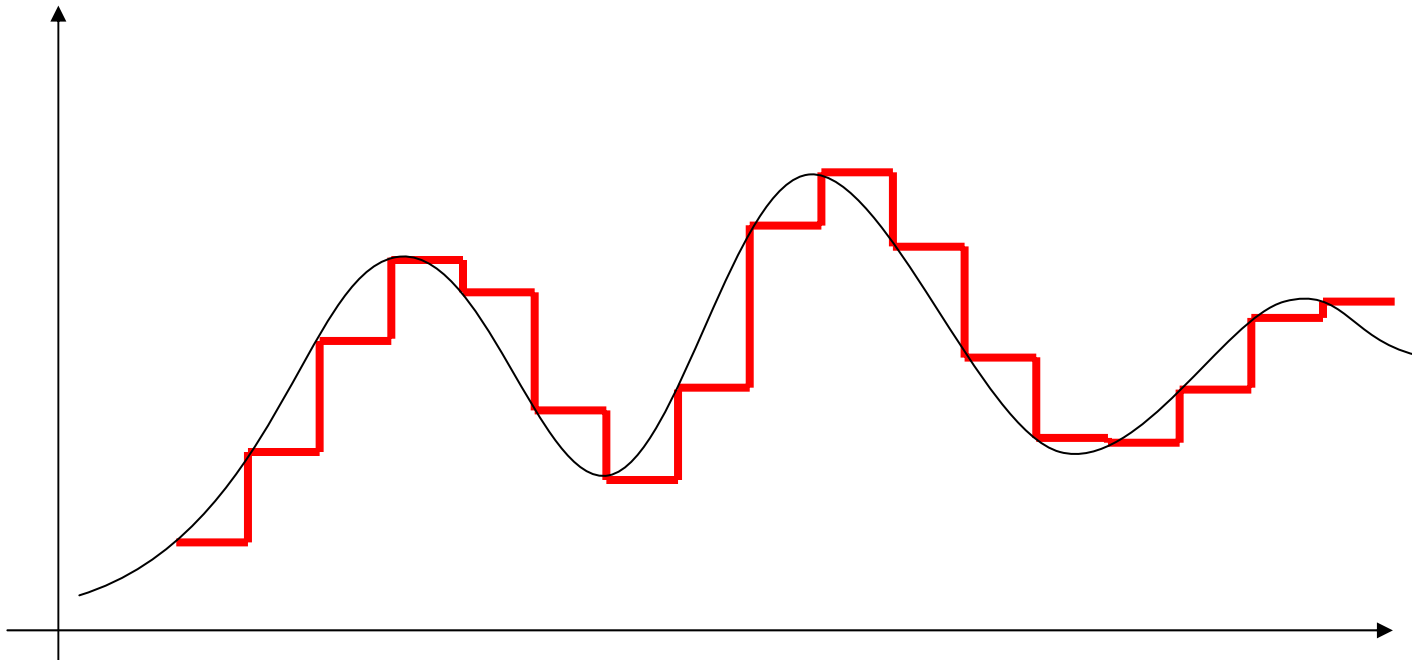
# Why filtering?

- Remove signal artifact
  - Remove high frequency noise after digital to analog conversion



# Why filtering?

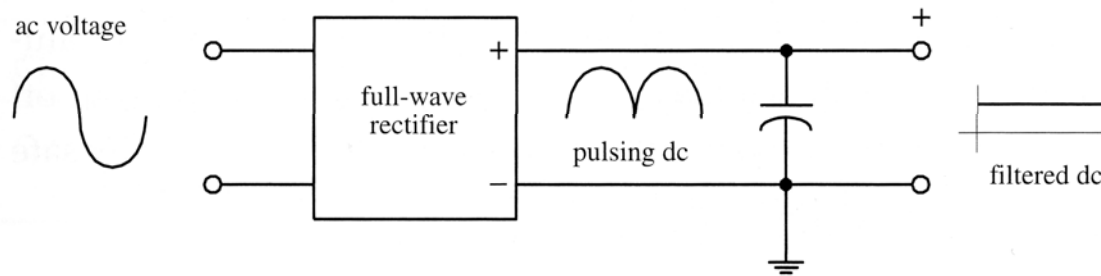
- Remove signal artifact
  - Remove high frequency noise after digital to analog conversion



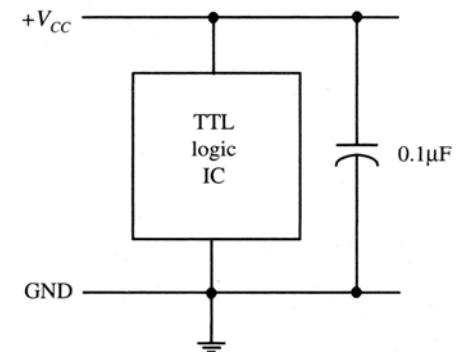
# Why filtering?

- Remove harmful signal
  - High frequency in inductance
  - High frequency on the power line in logic
  - ...

## Power Supply Filtering

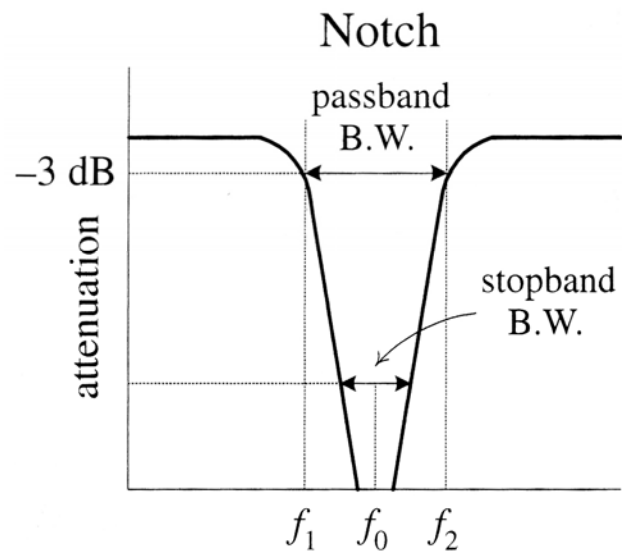
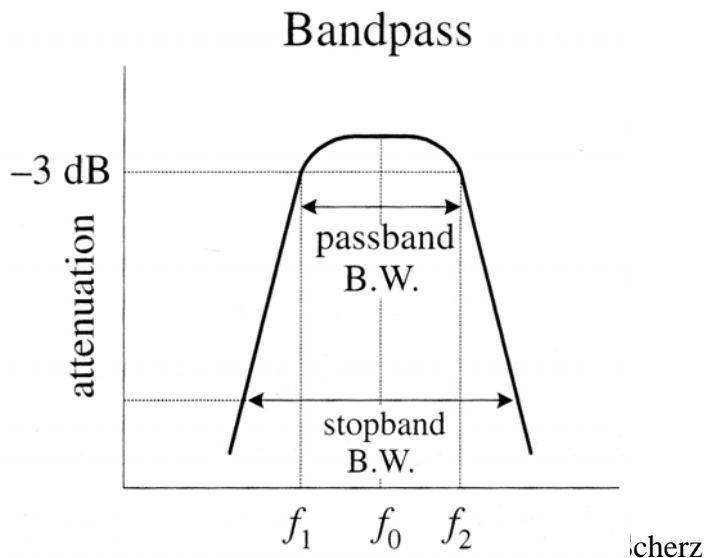
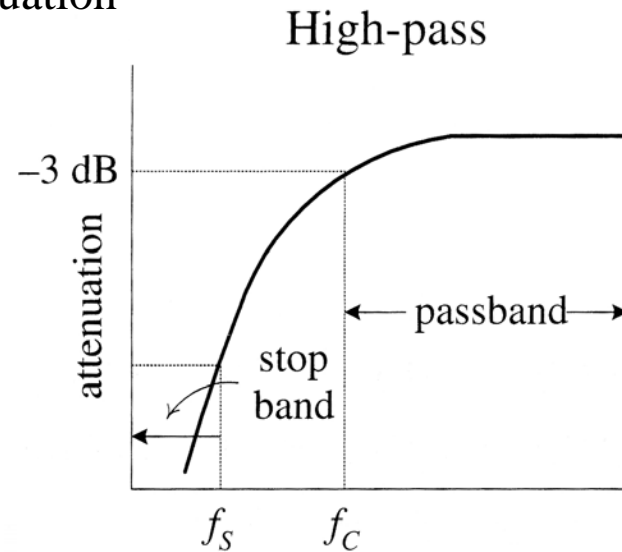
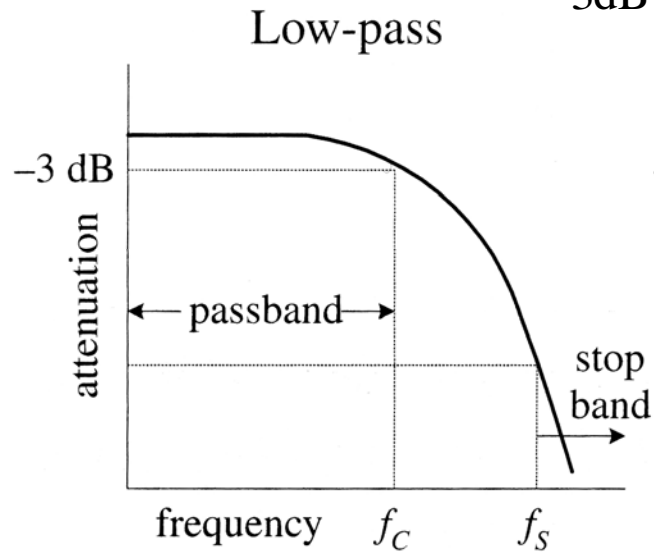


## Spike and Noise Suppression



# Basic Filters

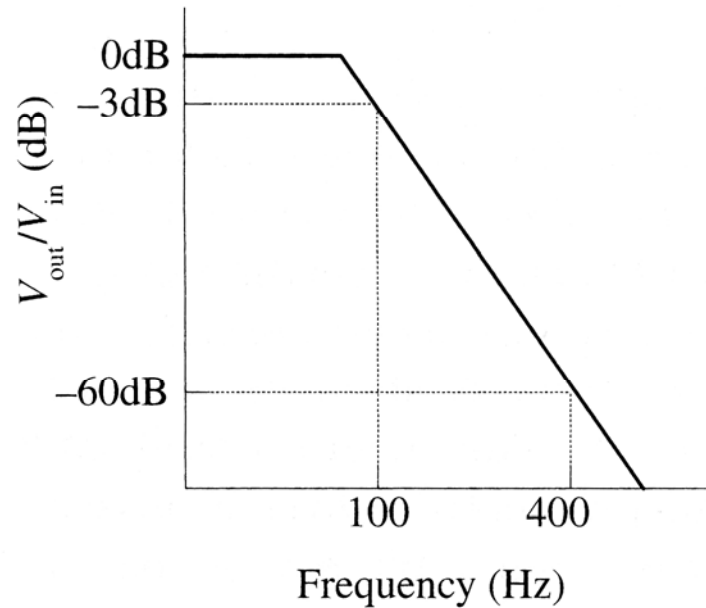
$$3\text{dB} \approx \frac{1}{\sqrt{2}} \text{ attenuation}$$



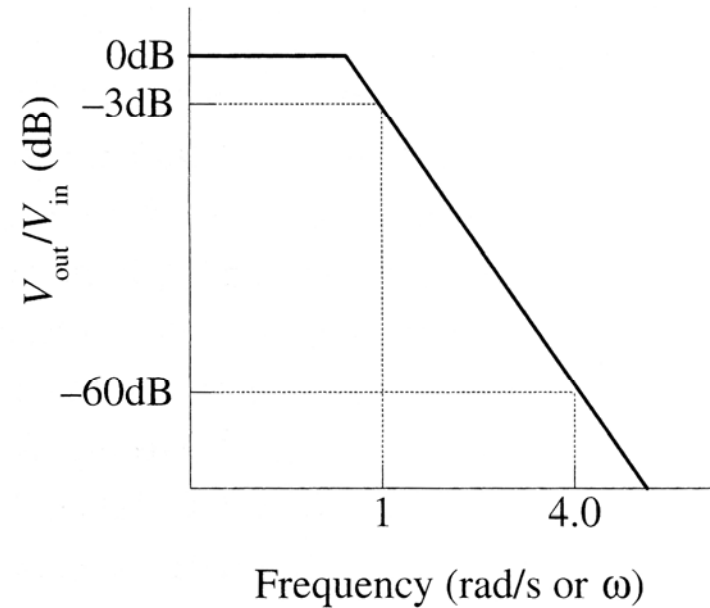
# How to build an active low-pass filter

- Normalization

Frequency response curve

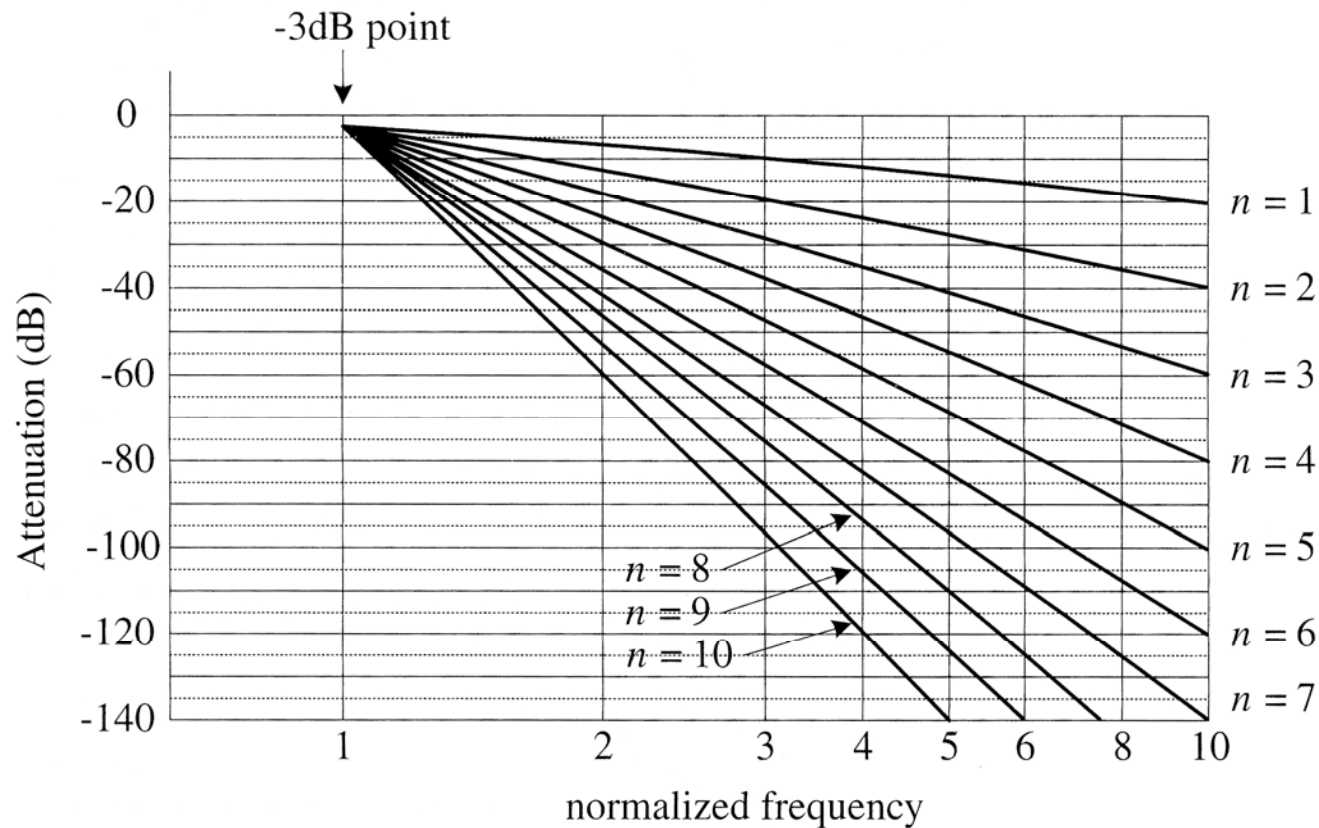


Normalized translation to low-pass filter



# How to build an active low-pass filter

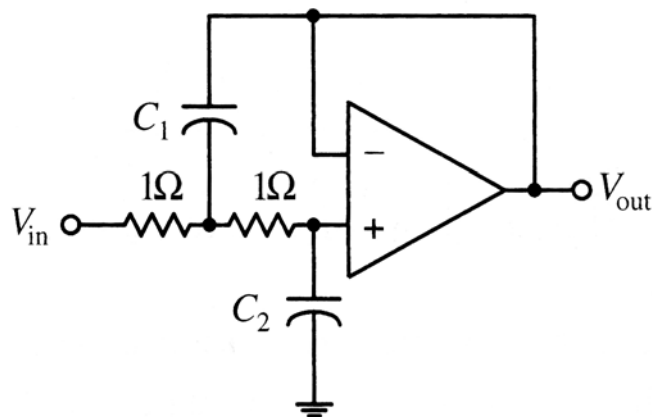
- Determine the order



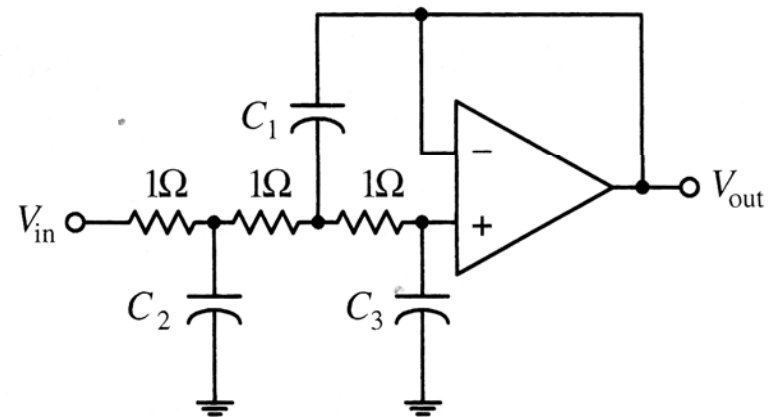
# How to build an active low-pass filter

- Create the basic normalized filter

Basic two-pole section



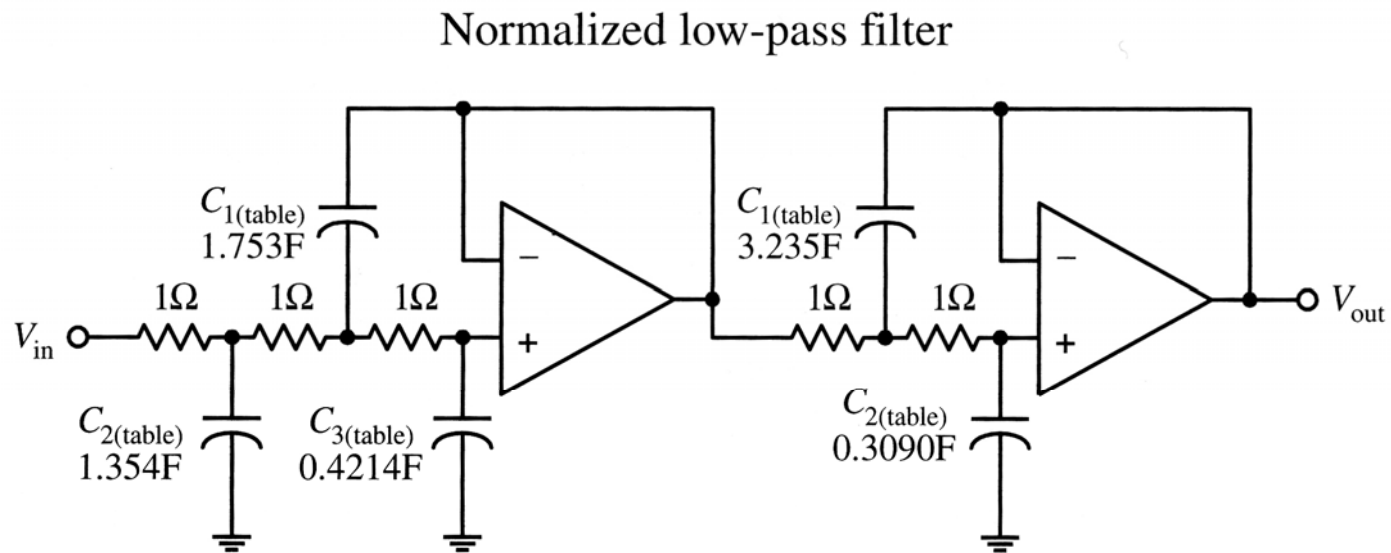
Basic three-pole section



ORDER $n$	NUMBER OF SECTIONS	SECTIONS	$C_1$	$C_2$	$C_3$
2	1	2-pole	1.414	0.7071	
3	1	3-pole	3.546	1.392	0.2024
4	2	2-pole	1.082	0.9241	
		2-pole	2.613	0.3825	
5	2	3-pole	1.753	1.354	0.4214
		2-pole	3.235	0.3090	

# How to build an active low-pass filter

- Create the basic normalized filter



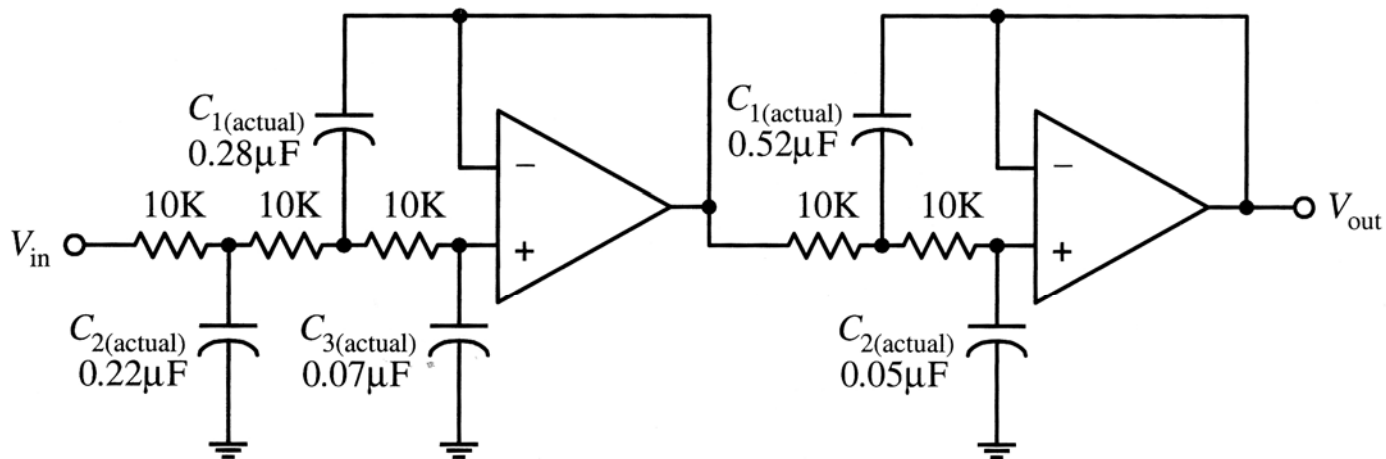
# How to build an active low-pass filter

- Create the final filter

$$C_{\text{actual}} = \frac{C_{\text{table}}}{Z \cdot 2\pi f_{-3\text{dB}}}$$

$$R_{\text{actual}} = Z R_{\text{table}}$$

Final low-pass filter



# Assignment

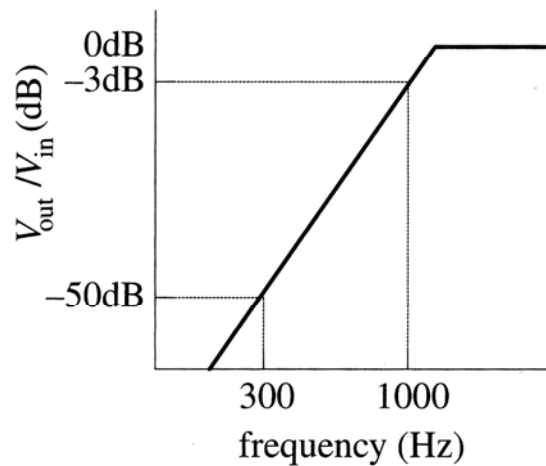
- Build an active filter
  - $f_c=6\text{KHz}$
  - $-70\text{dB} @ f_s=24\text{KHz}$

<b>ORDER <math>n</math></b>	<b>NUMBER OF SECTIONS</b>	<b>SECTIONS</b>	<b><math>C_1</math></b>	<b><math>C_2</math></b>	<b><math>C_3</math></b>
2	1	2-pole	1.414	0.7071	
3	1	3-pole	3.546	1.392	0.2024
4	2	2-pole	1.082	0.9241	
		2-pole	2.613	0.3825	
5	2	3-pole	1.753	1.354	0.4214
		2-pole	3.235	0.3090	
6	3	2-pole	1.035	0.9660	
		2-pole	1.414	0.7071	
		2-pole	3.863	0.2588	
7	3	3-pole	1.531	1.336	0.4885
		2-pole	1.604	0.6235	
		2-pole	4.493	0.2225	

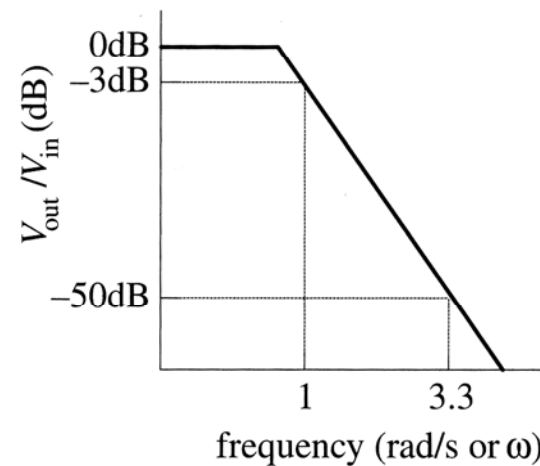
# How to build an active high-pass filter

- Translate to a normalized low-pass

High-pass frequency response

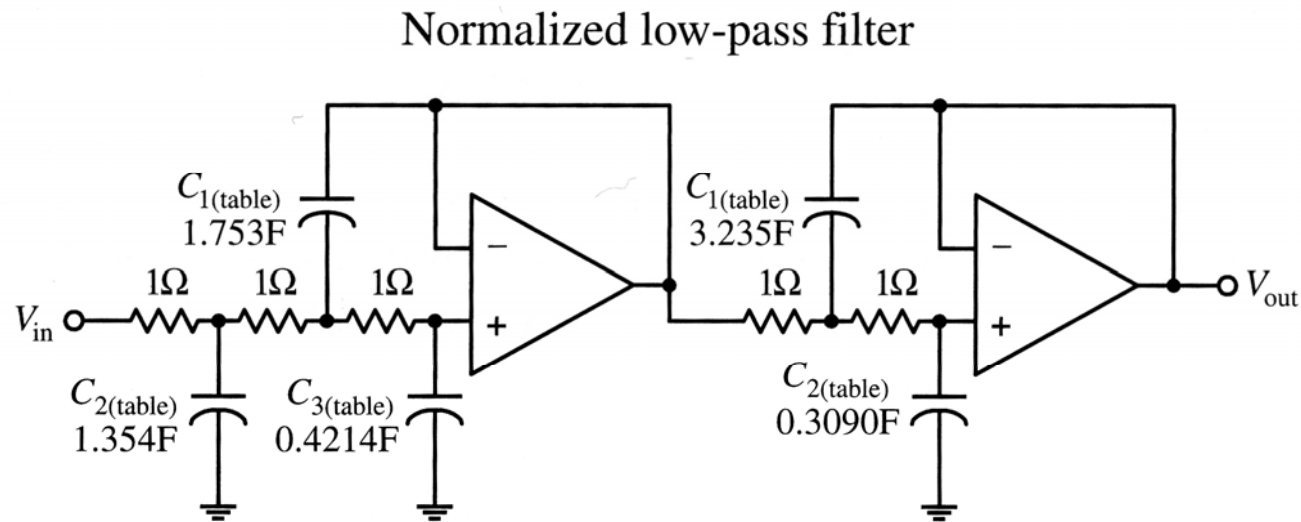


Translation to normalized low-pass response



# How to build an active high-pass filter

- Build the normalized low-pass



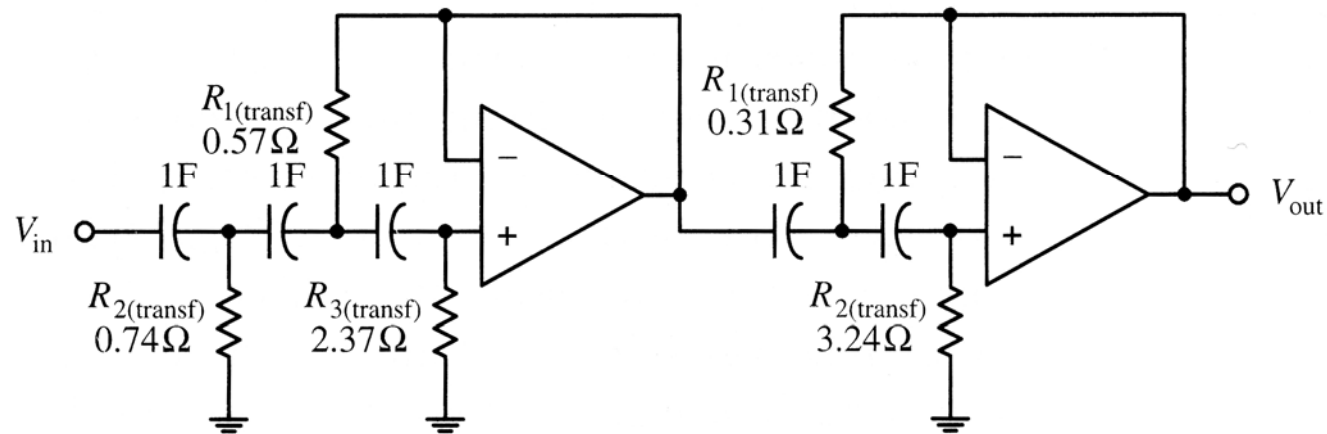
# How to build an active high-pass filter

- Transform to a normalized high-pass filter

$$C_{\text{transformed}} = \frac{1}{R_{\text{table}}} \text{ F}$$

$$R_{\text{transformed}} = \frac{1}{C_{\text{table}}} \Omega$$

Normalized high-pass filter (transformed low-pass filter)



# How to build an active high-pass filter

- Build the final high-pass filter

$$C_{\text{actual}} = \frac{C_{\text{transformed}}}{Z \cdot 2\pi f_{-3\text{dB}}}$$

$$R_{\text{actual}} = Z R_{\text{transformed}}$$

Final high-pass filter

