ECE 2300

Electronics Circuits
and
Electronics Devices Laboratory

Gregg Chapman

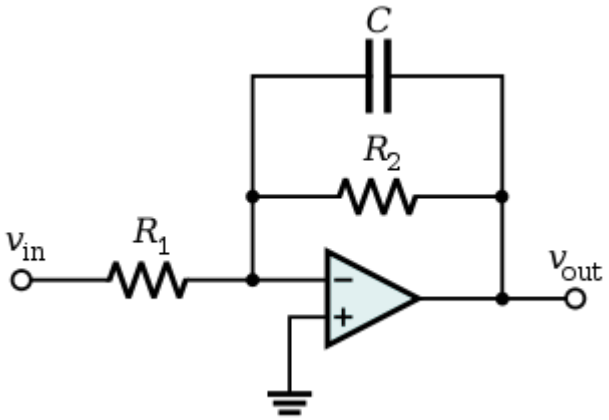
Laboratory 6

Operational Amplifiers 2
Active Filters

Background

- Filter Configurations
- Cutoff Frequencies
- Gain
- Frequency Response

First Order Low Pass Active Filter

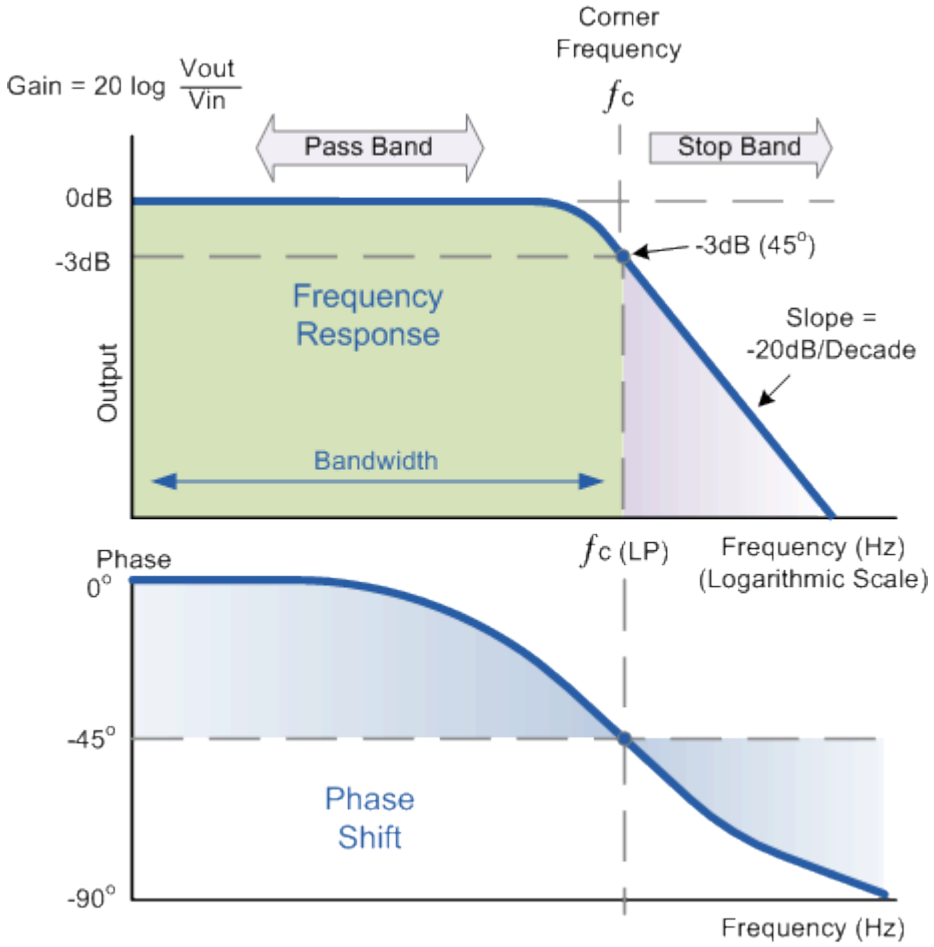


$$f_{cutoff} = \frac{1}{2\pi R_2 C} \ (Hz)$$

$$Gain = -\frac{R_2}{R_1}$$

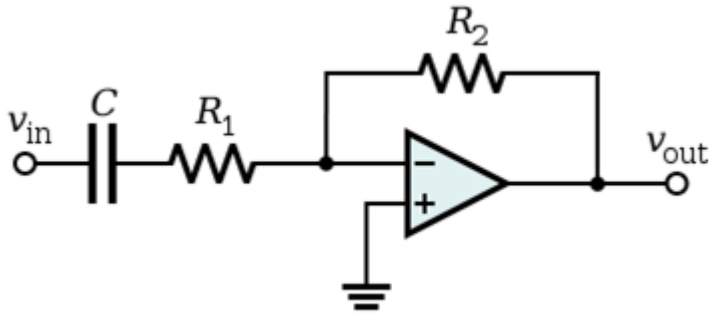
From - http://en.wikipedia.org/wiki/filters/ , Accessed July 14, 2012

First Order Low Pass Active Filter



From - http://www.electronics-tutorials.ws, Accessed July 14, 2012

First Order High Pass Active Filter



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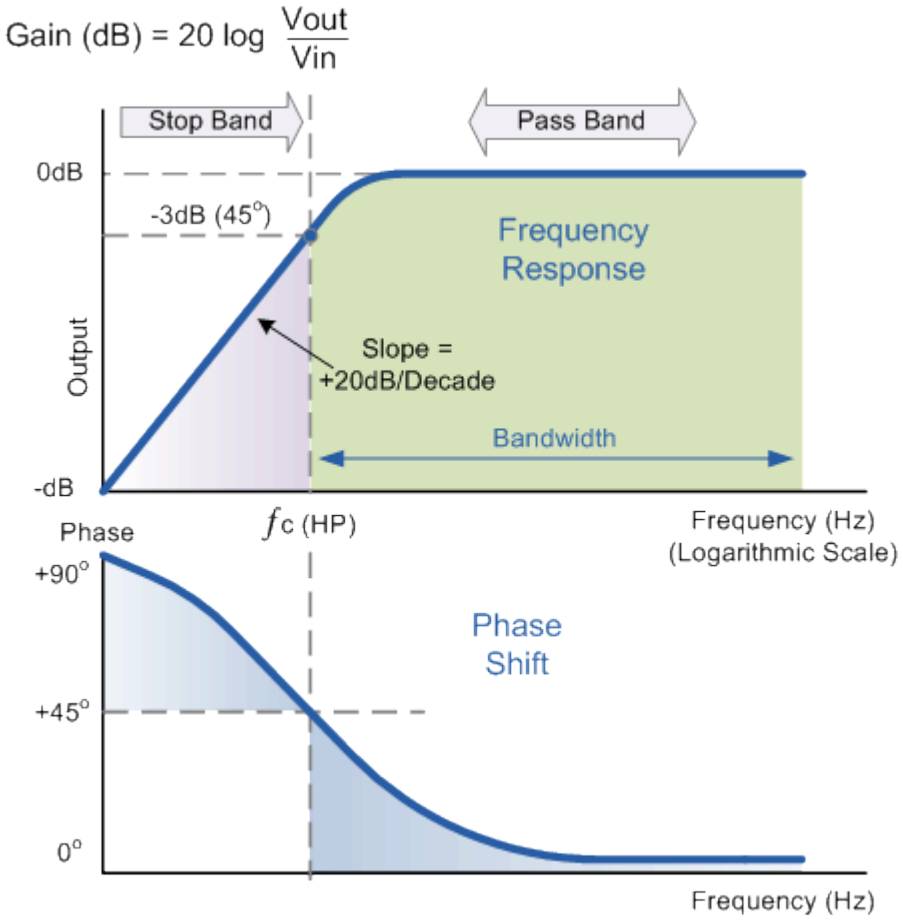
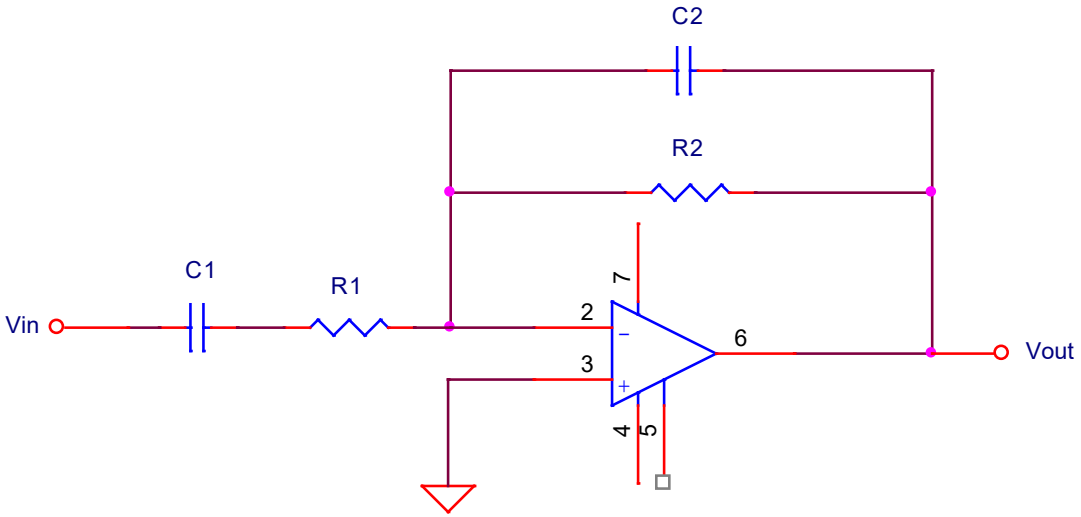


From - http://www.electronics-tutorials.ws, Accessed July 14, 2012

First Order Band Pass Active Filter

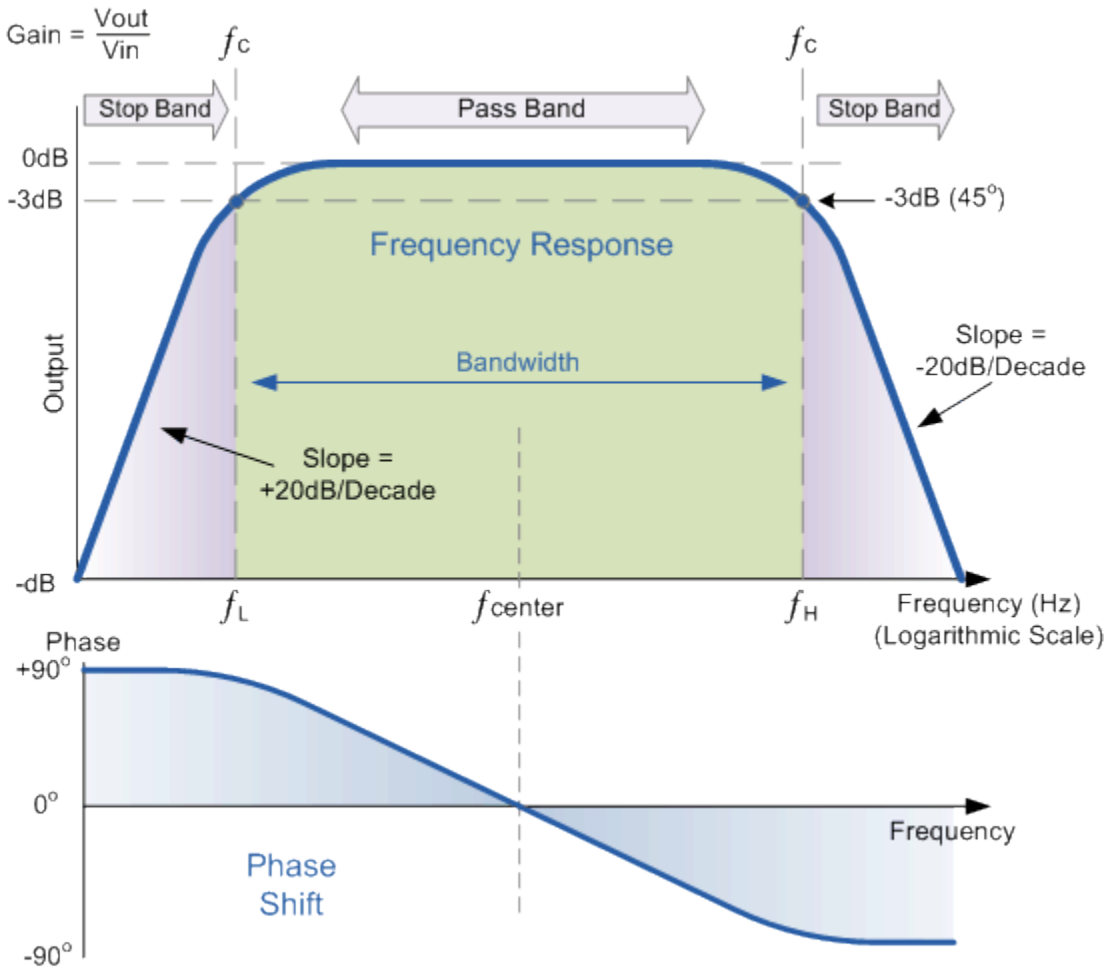


$$f_{cutoff\ low\ pass} = \frac{1}{2\pi R_2 C_2}\ (Hz)$$

$$f_{cutoff\ high\ pass} = \frac{1}{2\pi R_1 C_1}\ (Hz)$$

$$Gain = -\frac{R_2}{R_1}$$

First Order Band Pass Active Filter

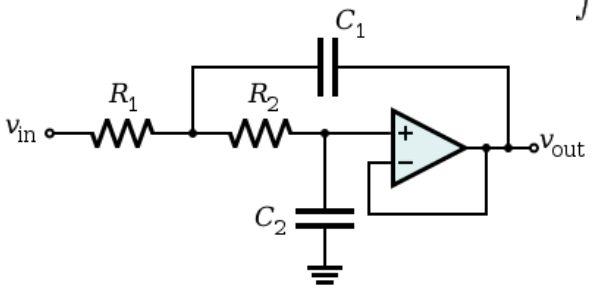


From - http://www.electronics-tutorials.ws, Accessed July 14, 2012

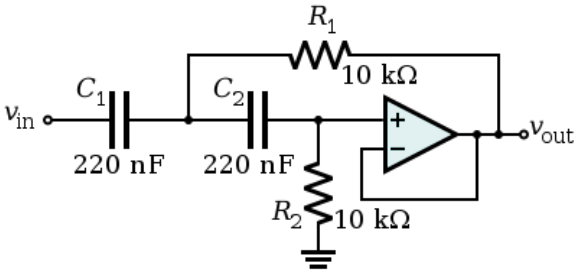
Sallen-Key Filters

(The Real Deal)

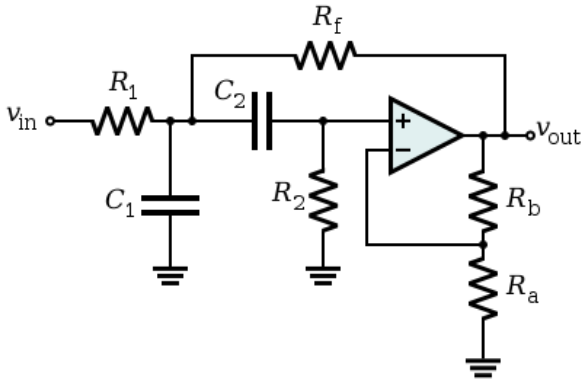
$$f_0 = \frac{1}{2\pi\sqrt{R_1 R_2 C_1 C_2}}$$



2 pole low pass filter with unity gain



2 pole high pass filter with unity gain



$$G = 1 + \frac{R_b}{R_a}$$

Band pass filter with non-inverting gain

See: pp. 777-778 of Rizzoni: Principles and Applications of Electrical Engineering, 3rd Edition

Lab Supplies

- Resistors
  - 2 16.2 KOhm
- Capacitors
  - 2 0.01 uF Ceramic
  - 2 1.0 uF Tantalum
  - 1 1000 pF Ceramic
  - 1 0.1 uF Ceramic
- IC
  - 1 AD817AN Op-Amp

Lab Supplies

- Breadboard
- Oscilloscope
- Function Generator
- Power Supply
- BNC-to-Mini-grabber (2)
- BNC Cable
- BNC T-Adapter
- Red Banana-to-Mini-grabber (2)
- Black Banana-to-Mini-grabber (1)

Cabling

Test Set-up

- BNC T-Adapter on output of Function Generator
- BNC cable from T-Adapter to Channel 1 of the Oscilloscope
- BNC to Mini-clip from T-Adapter to the input
- BNC to Mini-clip from Channel 2 of the Oscilloscope to the output
- Use the three Banana-to-Mini-clip cables for +12V, -12V and GND

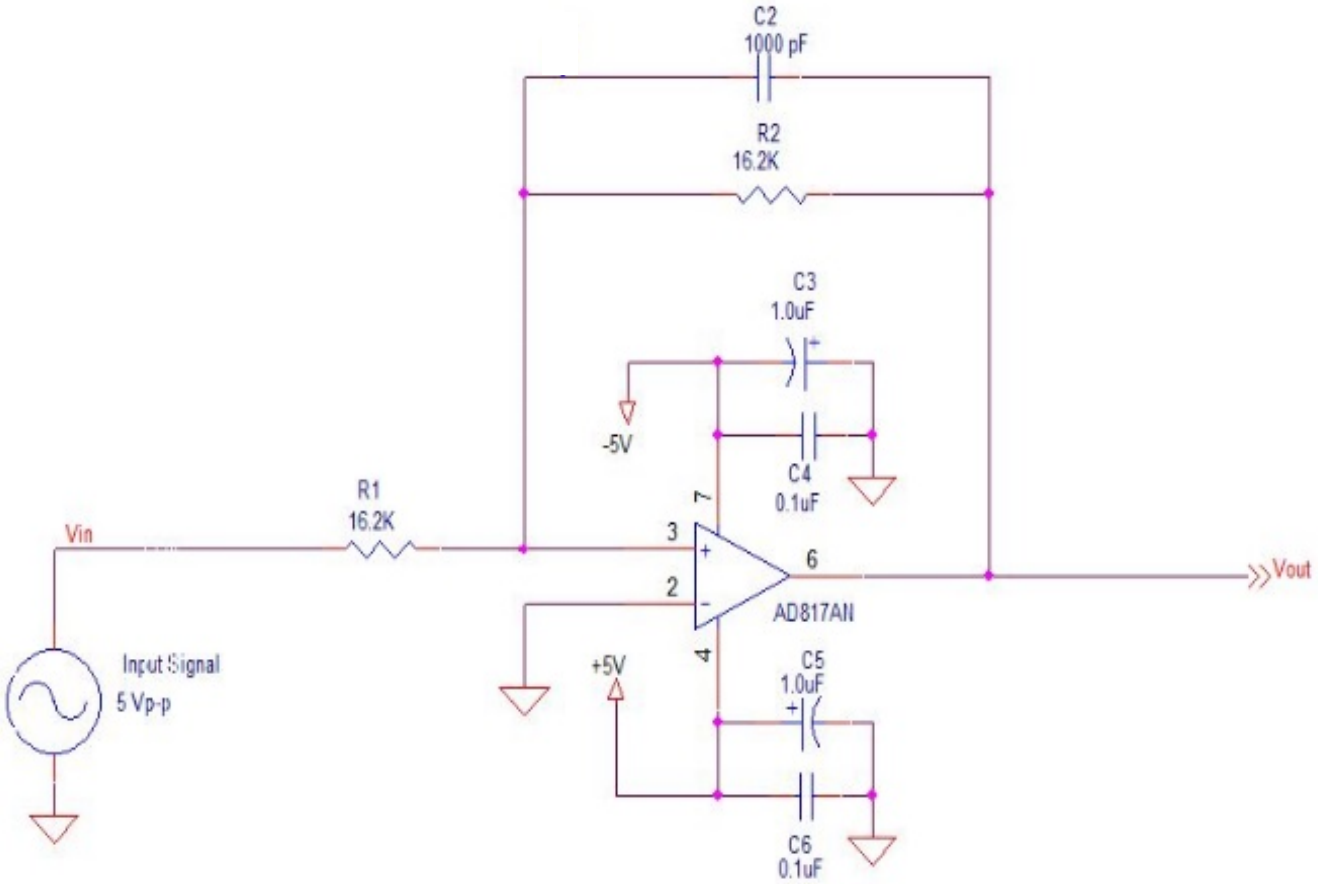
Function Generator Setup

- Sine Wave
- 5V peak-to-peak amplitude
- Begin with 10 Hz

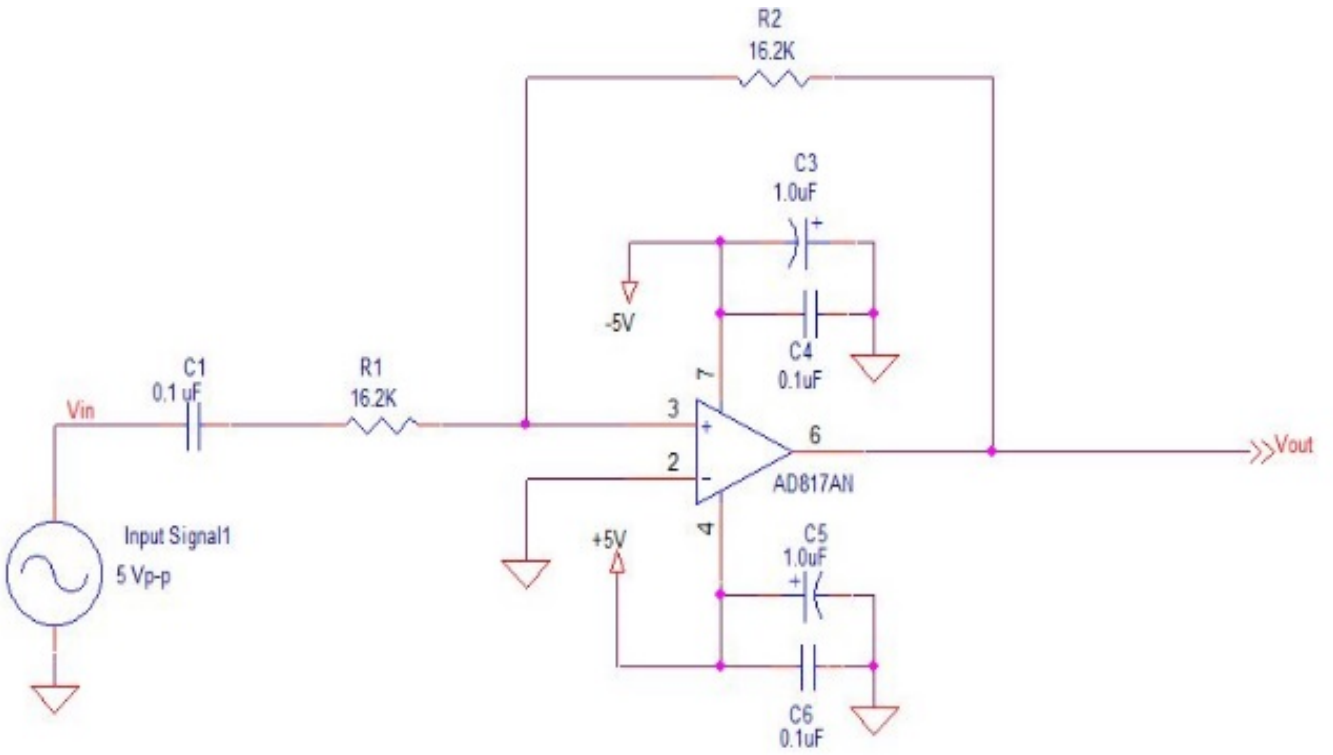
Circuits

1. Low Pass Filter
2. High Pass Filter
3. Band Pass Filter

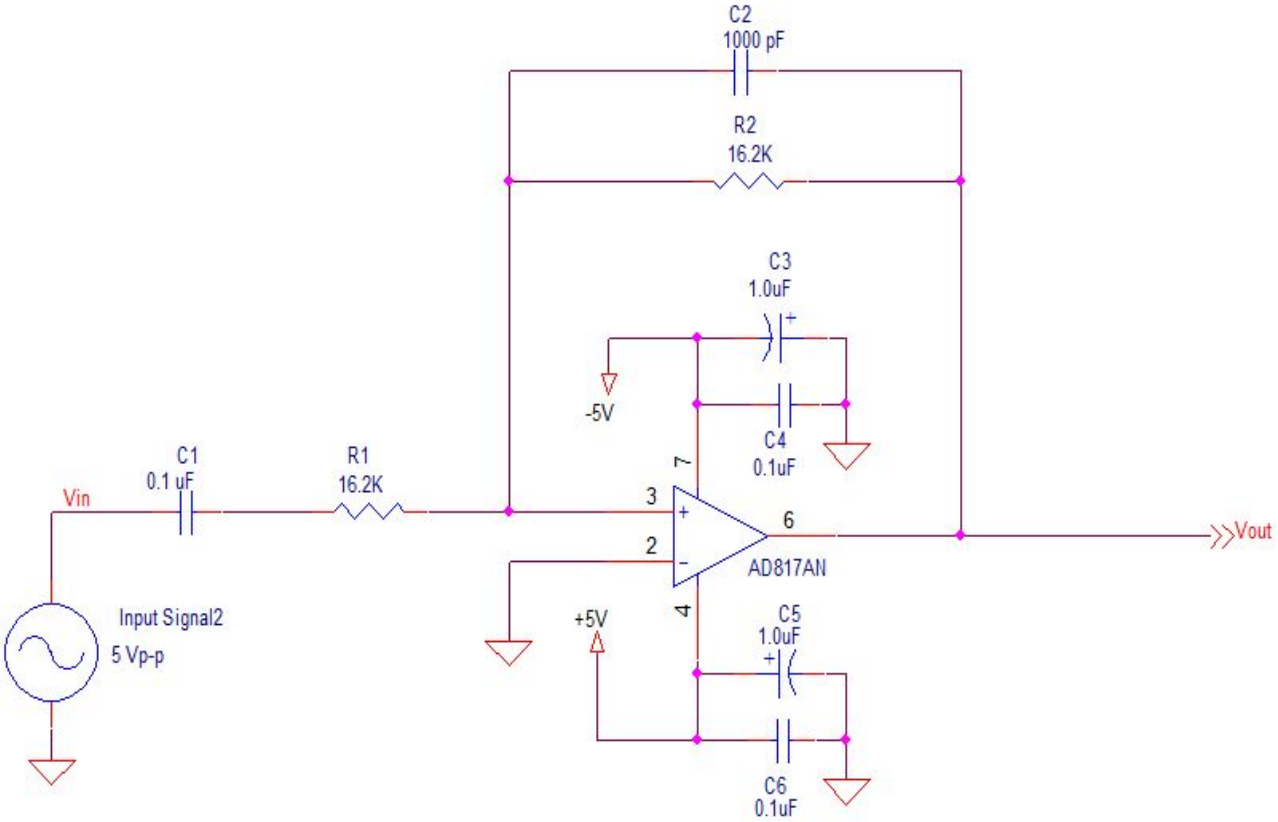
Low Pass Filter



High Pass Filter



Band Pass Filter



Measurements

Frequency (Hz)	V in	V out
10		
20		
50		
100		
200		
500		
1000		
2000		
5000		
10,000		
20,000		
50,000		
100,000		
200,000		

Note: These values are a suggested starting point. Please find the cutoff frequencies as closely as possible to the -3 dB values

Calculations

Cutoff Frequency:

$$f_{cutoff} = \frac{1}{2\pi RC} \ (Hz)$$

NOTE: Use Ohms and Farads for calculations

Measurements

- Measured Cutoff Frequency is at – 3dB

$$dB = 20 * log_{10}(\frac{V_{out}}{V_{in}})$$

- Phase Shift is in degrees:

$$Phase\ Shift = 360° * \frac{\Delta t}{Period_{in}} = 360° * \Delta t * f_{in}$$

- Define un-attenuated frequency is > 95% of Vin

Results

Laboratory 6

Circuit		Calculated Cutoff (Hz)	Measured Cutoff (f_c) (Hz)	Phase Shift (at f_c) (degs)	Un-attenuated Frequency (Hz)
Low Pass Filter					
High Pass Filter					
Band Pass Filter	Low Frequency				
	High Frequency				