ECE 215 Spring 2025

Objective 2.4:
Analog Filters

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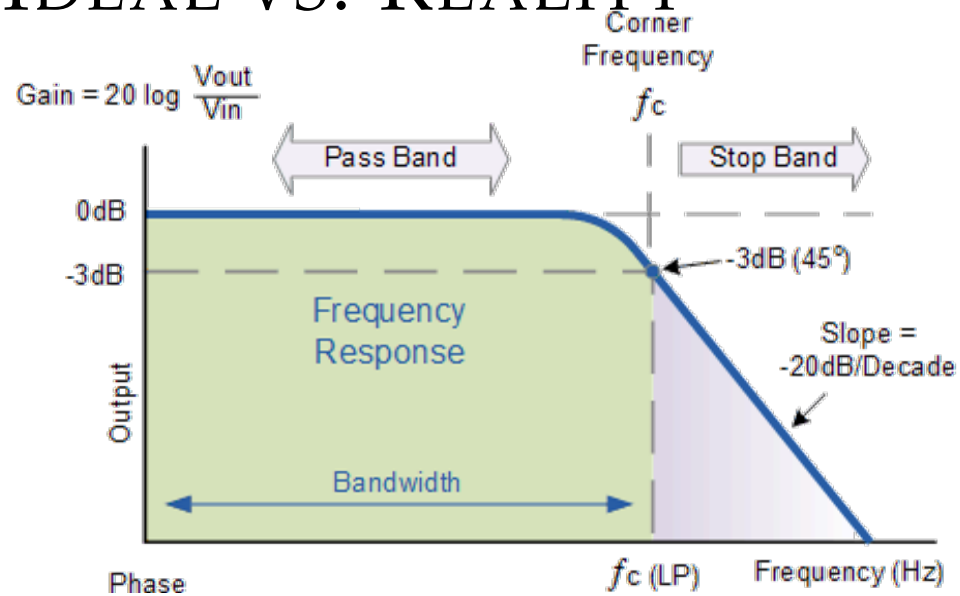
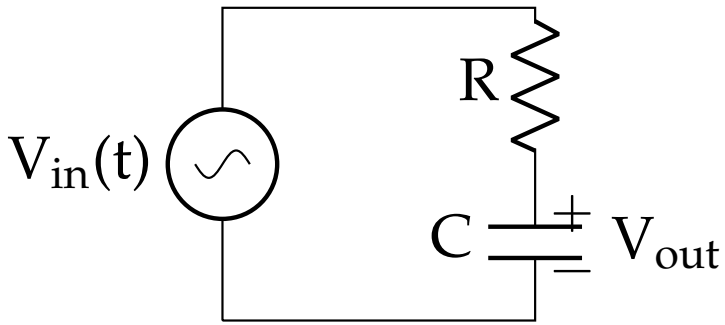
I can determine the filter type and gain of simple series circuits containing a resistor, capacitor, and/or inductor.

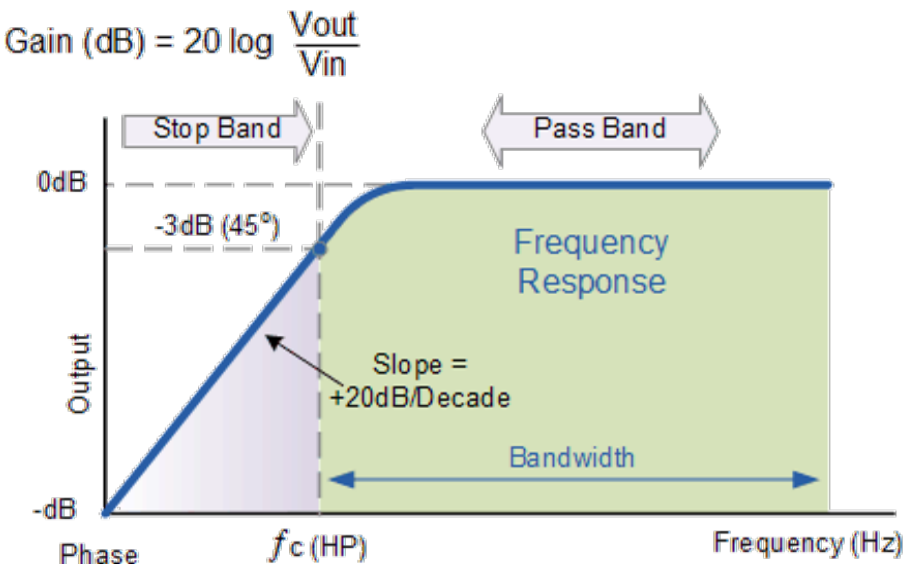
Analog Filters

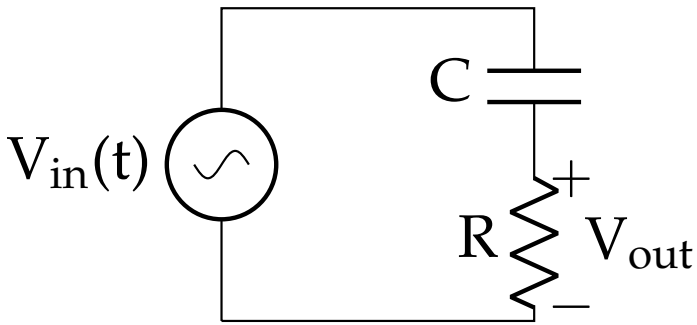
- *Every* signal will experience some level of noise
  - Intentional - jamming
  - Unintentional - environmental (thermal, lightening) or other signals (poor planning)
- Signal conditioning uses LPFs near the system input to remove unwanted high frequency noise (more on this in Obj 2.5!)
- **Gain** is the amplitude scaling, or ratio of V_{out}/V_{in}, provided by the circuit at every frequency
  - Ideal filters do not exist - gain does not abruptly change but gradually transitions between passband and stopband
  - "Real" filters are built using resistors with inductors and/or capacitors, both of whose "resistance" (i.e., impedance) changes with frequency

Ideal vs. Reality



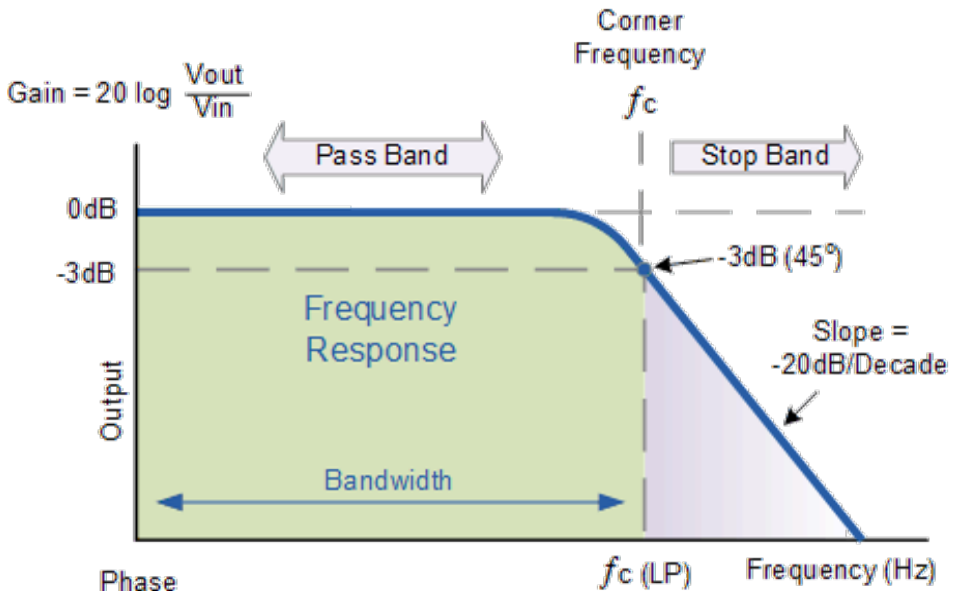




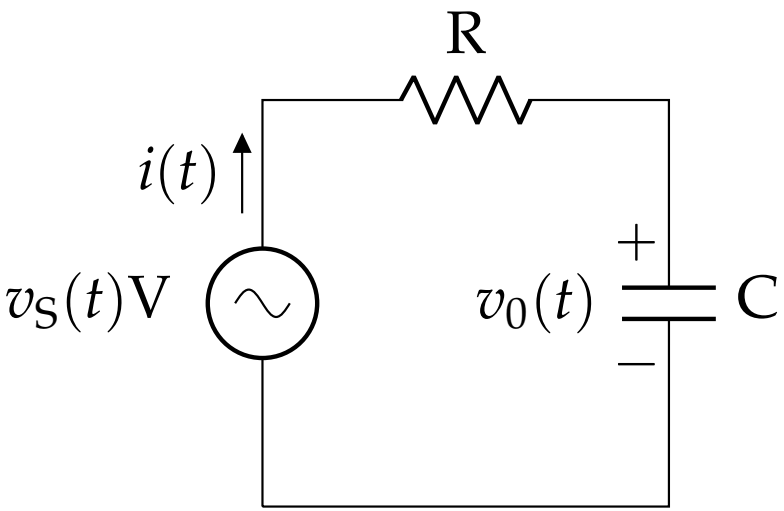


Rolloff and Cutoff Frequency

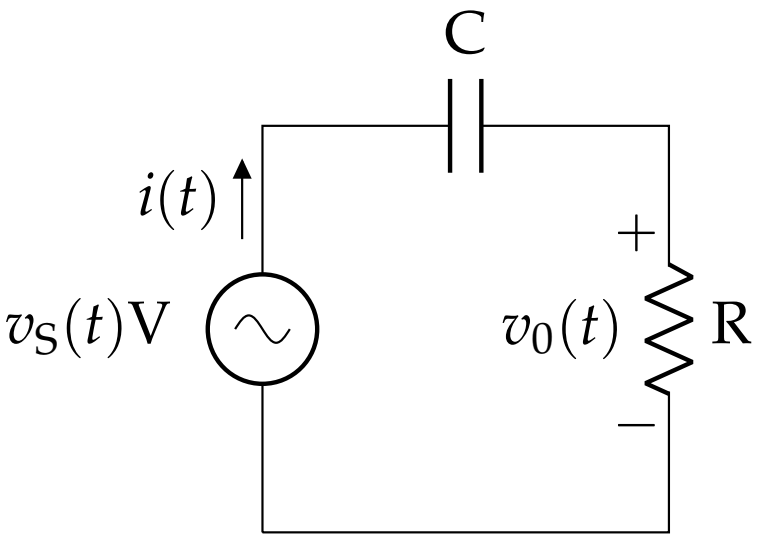
- Where is the cutoff frequency?
- Why is it there?
- 3dB point = $\frac{P_{out}}{P_{in}} = \frac{1}{2}$
- This means $\left|\frac{V_{out}}{V_{in}}\right| = \frac{1}{\sqrt{2}}$



What does this circuit do (R-C)?

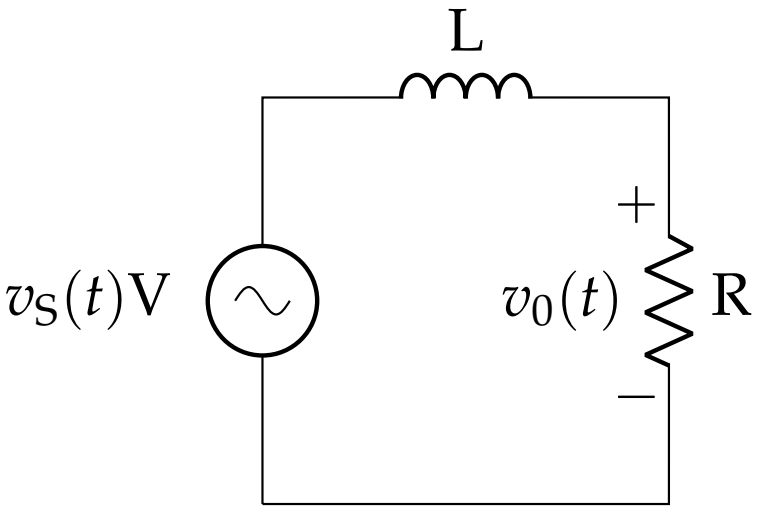


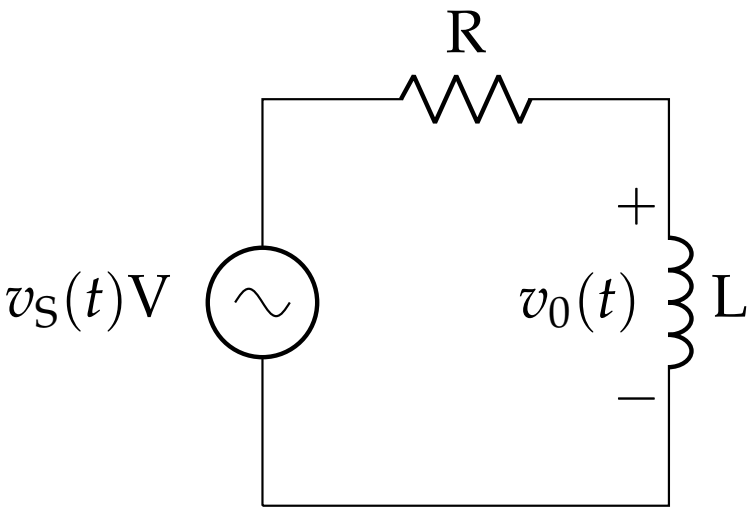
How about this one (C-R)?



R-L Circuits

Your turn! Determine HPF or LPF.





Cutoff Frequency for R-C Circuit

$$\text{Gain} = \frac{V_{out}}{V_{in}} = \frac{1}{j2\pi fRC + 1}$$

R-C Cutoff

$$f_{cutoff} = \frac{1}{2\pi fRC}$$

Cutoff Frequency for C-R Circuit

$$\text{Gain} = \frac{v_o(t)}{v_s(t)} = \frac{1}{1 - j\frac{1}{2\pi fRC}}$$

R-C Cutoff

$$f_{\text{cutoff}} = \frac{1}{2\pi fRC} \rightarrow \text{Same as the R-C!!!!}$$

CALCULATE THE CUTOFF FREQUENCY FOR...

A transmission line modeled as an R-L circuit with $R = 4\Omega$ and $L = 5\mu\text{H}$

An R-C low pass filter with $R = 60\Omega$ and $C = 5nF$

A C-R high pass filter with $R = 100\Omega$ and $C = 8\mu\text{F}$.

Practice

Your communications radio has a lower frequency bound of 800kHz. You know it has a capacitor value of 100nF, but what is the resistor value?

A signal passes through a circuit consisting of a 60Ω resistor and a 1μF capacitor in series. The output voltage is across the capacitor. What kind of filter is this and what is the cutoff frequency?