

High Pass Filters & Blocking Capacitors

Physics 251

Fall 2022

In this lab, you will study a high pass filter, and learn about blocking capacitors.

Part 1: Simple high pass filter.

In this first portion, you will build and measure the frequency response of a high pass filter as shown in Figure 1. As the name suggests, a high pass filter will allow frequencies above the -3 dB frequency defined by

$$f_{-3\text{dB}} = \frac{1}{2\pi RC}$$

to pass through to the output relatively unscathed, whereas frequencies below this value are severely attenuated. The -3dB frequency is the frequency at which the signal power is half the value of the input power; in terms of the peak voltages,

$$-3\text{dB} = 10 \log \frac{P_{\text{out}}}{P_{\text{in}}} \equiv 20 \log \frac{V_{\text{out}}}{V_{\text{in}}}$$

Build the circuit shown in Figure 1, being careful to measure and record each component (this prevents mistakes that could—in more complicated circuits — be very challenging to find). Then, use your function generator (for V_{in} , 10 V peak to peak is a convenient value) and oscilloscope (V_{out}) to record the filter response. Take more points below the -3dB frequency so you have a good picture of the behavior as you approach and exceed the -3dB point.

Make a plot of $20 \log \frac{V_{\text{out}}}{V_{\text{in}}}$ vs $\log f$, and indicate on the plot the -3dB point. Check to see if the output amplitude at low frequencies is proportional to frequency. If you halve this frequency how many dB's do you lose?

Testing your high pass filter with a dual frequency input

Your function generator has the ability to produce two independent outputs. Set one channel with a 100 Hz output and the other at 3000 Hz. Feed both of these into the input and look at the input on channel one of the scope, and the output on channel two. Does the behavior make sense? vary the frequencies one at a time, and convince yourself you understand what you are seeing.

Mapping out the phase response

Now using just one output from your function generator, monitor the input on the scope on channel 1 and the output on channel two. Record the phase shift between the two traces as your change the frequency from far below the -3dB point to well above the -3dB point. Make a plot of the phase shift vs $\log f$. You should see

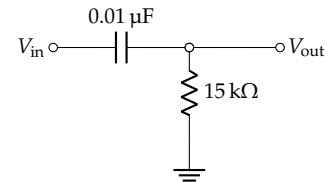


Figure 1: A basic high pass filter.

that the output *leads* the input. What are the limiting values for the phase shift?

Part 2: Blocking capacitors

A frequent application of capacitors is for “blocking” dc while coupling an ac signal. You can think of a capacitor (in a high pass configuration) as passing all signals whose frequencies are well above the -3dB point, and blocking dc. As a first step, wire up the circuit in Figure 2. Note that the flat side of the $4.7\ \mu\text{F}$ capacitor symbol **must** be more positive than the left, as this is an electrolytic capacitor. Because of this, make sure that your input peak-to-peak voltage from the function generator is no greater than 8 volts so that the electrolytic cap is not reversed biased. Now drive this circuit with the function generator, and look at the output on the scope (dc coupled). The circuit lets the signal “ride” on the (roughly) +5 Volts (convince yourself and me that the dc level is around 5 Volts).

Next add the following circuit (see Figure 3) to the output of the first (another “blocking” capacitor), and observe the new output signal. Explain what you see. Why is the resistor in this additional circuit set to $100\ \text{k}\Omega$? Explain!

The overall circuit

Here is the resulting circuit when you combine Figure 2 and Figure 3:

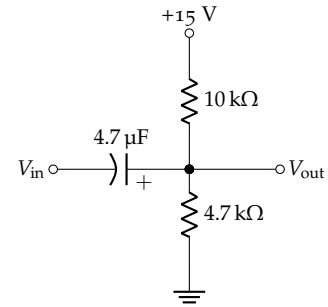
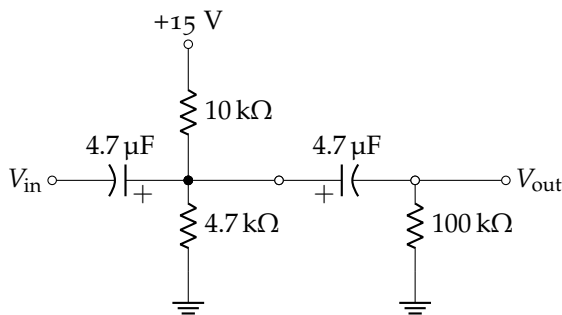


Figure 2: Adding a blocking capacitor to a voltage divider. Note the polarity of the electrolytic capacitor!

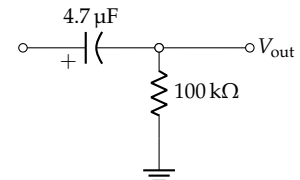


Figure 3: Another blocking capacitor to add to output of previous figure. Note the polarity!