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| Name:  Click or tap here to enter text. | Date:  Click or tap to enter a date. |

# Find Unknown and

A picture containing text, hanger, clock

Description automatically generatedUse the provided unknown resistor and capacitor to construct the circuit shown.  Create a square wave that is offset so that it goes between the limits of 0 and 4 volts. Measure the input voltage on channel 1 of the oscilloscope and the voltage across the capacitor on channel 2. Adjust the frequency of the square wave input signal so that the voltage across the capacitor has time to fully charge and discharge.

## Estimate the time constant .

Use this oscilloscope trace to estimate the value of the time constant of this circuit. Upload an image of your oscilloscope below.

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State your time constant result and explain how you found it below.

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## Find the resistance .

Diagram, schematic

Description automatically generatedModify the circuit by adding a resistor (unlabeled in the adjacent schematic) as shown between the function generator and the original network.  Change the input signal from the function generator to a sine wave. Carefully change the oscilloscope channels so that it monitors the locations shown in the schematic. Note that we are not looking at the output voltage across the capacitor as we were before.

Modify the frequency until the phase difference between Channel 1 and Channel 2 is zero.  If you are confused about what is happening, you could briefly check the voltage across the capacitor after the frequency is properly set but be sure to set the scope channels back to the locations shown before capturing a screenshot and uploading it below.

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State the value of the resistance you found and explain how you found it below.

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## Use your time constant and resistance to find the capacitance .

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# A picture containing clock Description automatically generatedLow-Pass Filter

Build the low-pass filter circuit shown to the right. Use the function generator to apply a sine wave signal to the input. Use the oscilloscope to monitor the input voltage on channel 1 and the output on channel 2.

## Compute the cutoff frequency .

For the first-order, low-pass filter the cutoff frequency is given by . At this frequency, the ratio of the power in the output signal to the power in the input signal has been reduced to . The ratio of output voltage to input voltage is . Compute the cutoff frequency for this circuit using the nominal values of and used to build the circuit.

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## Describe the filter behavior at low frequencies.

Apply a signal that has a frequency of approximately 1/10 of the cutoff frequency. Capture an oscilloscope trace that shows both the input signal and the output signal.

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| Scope trace at |

Compute the gain factor both as the ratio and in decibels, where

and estimate the phase difference between the input and the output signals. Enter these results and describe your observations below.

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## Describe the filter behavior near the cutoff frequency.

Apply a signal that has a frequency of approximately the cutoff frequency. Capture an oscilloscope trace that shows both the input signal and the output signal.

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| Shape  Description automatically generated with low confidence |
| Scope trace at |

Compute the gain factor both as the ratio of voltages and in decibels and estimate the phase difference between the input and the output signals. Enter these results and describe your observations below.

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## Describe the filter behavior at high frequencies.

Apply a signal that has a frequency of approximately ten times the cutoff frequency. Capture an oscilloscope trace that shows both the input signal and the output signal.

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| Scope trace at |

Compute the gain factor both as the ratio and in decibels and estimate the phase difference between the input and the output signals. Enter these results and describe your observations below.

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## Use Bode Analyzer to characterize the frequency dependence of the filter.

The Bode Analyzer is an instrument that can be used to quickly assess the frequency dependence of a filter circuit. It uses the function generator to apply a signal to the input of your circuit and measures the amplitude and phase of the output signal as a function of frequency. The Function Generator and Oscilloscope virtual instruments are not used and must be off for the Bode Analyzer to work properly.

Familiarize yourself with the controls of the Bode Analyzer and take a sweep that spans four decades of frequency from 10 Hz to 10 kHz with at least 10 measurements per decade. Notice that the Mapping control under Graph Settings can be set on Linear where the gain is plotted as the ratio of or on Logarithmic where it is plotted in dB. The normal setting for this scale is Logarithmic but it might be instructive to switch to Linear to make sure you understand the difference.

Show a screenshot of your Bode plot (using Logarithmic mapping) below.

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| Shape  Description automatically generated with low confidence |
| Bode Plot for Low Pass Filter |

Compare the results of the Bode plot to your manual measurements at , , and .

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## Characterize the rate of attenuation versus frequency.

Observe your Bode plot for the low-pass filter and describe the rate of attenuation (decrease in gain) as a function of frequency. Note that this roll off is linear when viewed on the dB scale? In particular describe how the attenuation changes when the frequency goes up one octave (when the frequency doubles), and also describe the rate of attenuation in terms of dB per decade. These observations are characteristics of a first order filter. Note that a plot of vs will have a slope of -1.

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# High Pass Filter

Now modify your circuit to investigate the following high pass filter.

Diagram, schematic

Description automatically generated

Again, monitor the input on channel 1 and the output on channel 2 of your oscilloscope. After viewing the response of this circuit for various frequencies on your scope, capture a Bode plot spanning 10 Hz to 10 kHz in frequency.

## Bode plot for high pass filter.

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| Shape  Description automatically generated with low confidence |
| Bode Plot for High Pass Filter |

## Find cutoff frequency using the Bode plot.

Using your Bode plot, find the cutoff frequency of this filter and compare it to the value you expect for this and from theory.

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## Discuss Bode plot for high-pass filter.

Use your Bode plot to discuss how the gain and phase depend on frequency.

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