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

In this experiment you will investigate some special cases of high-pass and low-pass RC filters. You will see that, in certain regimes, these circuits can act respectively as integrators or differentiators. That is, we can have a circuit where the output is proportional to the integral or derivative of the input as in

Last week we looked at the gain and phase of both low-pass and high-pass filters as a function of frequency. Specifically, we used the Bode Analyzer to measure these how the gain and phase of these circuits depended upon frequency. These circuits and the Bode gain plots are summarized below.

|  |  |
| --- | --- |
| Low-Pass Filter  Image result for low pass rc filter | High-Pass Filter  Image result for high pass rc filter |
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Last week we used fixed and values and studied the circuit response to different input signal frequencies with the Bode Analyzer. This week, we will keep the input signal fixed at a frequency of 25-kHz and change or to probe different regimes of the Bode plot.

# Characterize the Input Signal

Consider a 25-kHz square wave input signal. Compute the period of this signal and the semi-period which is the time this signal is high. Enter these results in units of microseconds, s.

|  |  |
| --- | --- |
| Period, (s) | Click or tap here to enter text. |
| Semi-period, (s) | Click or tap here to enter text. |

# Integral of 25-kHz Square Wave

Using your knowledge of calculus, describe in words the output waveform that you would expect from a circuit that produces the *integral* of the input when the input is a 25-kHz square wave.

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| Click or tap here to enter text. |

# Derivative of 25-kHz Square Wave

Using your knowledge of calculus, describe in words the output waveform that you would expect from a circuit that produces the *derivative* of the input when the input is a 25-kHz square wave.

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| Click or tap here to enter text. |

# Diagram, schematic Description automatically generatedLow-Pass Filter

The adjacent low-pass filter is available as an interactive simulation on MultiSim Live at <https://www.multisim.com/content/JyLg5BUxVXMVX2UbYrY85P/low-pass-filter/>. The circuit is driven with a 25-kHz square wave and consists of a 1k resistor and a 10nF capacitor. Open this circuit and run it to view both the input and output signals as a function of time. Click on the 10nF value and observe the circuit behavior as you change the capacitor value. Do not change the resistor value.

## Create a unity gain circuit.

Change the capacitor value until the input and output signals are similar, nearly the same. In this regime the gain of the circuit is unity, 1 V/V or 0 dB. Identify the capacitor value you chose to create this output along with the time constant and cutoff frequency of the resulting RC circuit.

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| --- | --- |
| Capacitor Value, (F) | Click or tap here to enter text. |
| Time Constant, (sec) | Click or tap here to enter text. |
| Cutoff Frequency, (Hz) | Click or tap here to enter text. |

## Screenshot of unity gain output.

Click on the Export icon, Icon

Description automatically generated, in the upper right of the page and select the Export Grapher Image option to save an image file showing the simulated input and output traces. Upload that image in the container below.

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| Shape  Description automatically generated with low confidence |

## Compare input signal to circuit characteristics.

Compare the cutoff frequency and time constant of this circuit to the frequency and period of the input signal in the space below.

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| Click or tap here to enter text. |

## Create an integrator circuit.

Now change the capacitor value until the output resembles the integral of the input. Identify the capacitor value you chose to create this output along with the time constant and cutoff frequency of the resulting RC circuit.

|  |  |
| --- | --- |
| Capacitor Value, (F) | Click or tap here to enter text. |
| Time Constant, (sec) | Click or tap here to enter text. |
| Cutoff Frequency, (Hz) | Click or tap here to enter text. |

## Screenshot of integrator output.

Click on the Export icon, Icon

Description automatically generated, in the upper right of the page and select the Export Grapher Image option to save an image file showing the simulated input and output traces. Upload that image in the container below.

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| Shape  Description automatically generated with low confidence |

## Compare input signal to circuit characteristics.

Compare the cutoff frequency and time constant of this circuit to the frequency and period of the input signal in the space below.

|  |
| --- |
| Click or tap here to enter text. |

# Diagram, schematic Description automatically generatedHigh-Pass Filter

The adjacent high-pass filter is available as an interactive simulation on MultiSim Live at <https://www.multisim.com/content/K4LjdoTv4hABssV8yYUUt3/high-pass-filter/>. The circuit is driven with a 25-kHz square wave and consists of a 10-nF capacitor and a 1-k resistor. Open this circuit and run it to view both the input and output signals as a function of time. To see the full output, it may be necessary to click on the graph, then the Gear icon, then scroll to the bottom of the graph settings and change the minimum and maximum voltage values to -5V and +5V respectively. Click on the 1k value and observe the circuit behavior as you change the resistor value. Do not change the capacitor value.

## Create a unity gain circuit.

Change the resistor value until the input and output signals are similar in shape, nearly the same amplitude. The input is a clock signal that goes from 0V to 4V, not a square wave centered around 0 volts. The DC offset of this signal will be stripped out by the circuit. Still, in this regime the gain of the circuit is unity, 1 V/V or 0 dB. Identify the resistor value you chose to create this output along with the time constant and cutoff frequency of the resulting circuit.

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| --- | --- |
| Resistor Value, () | Click or tap here to enter text. |
| Time Constant, (sec) | Click or tap here to enter text. |
| Cutoff Frequency, (Hz) | Click or tap here to enter text. |

## Screenshot of unity gain output.

Click on the Export icon, Icon

Description automatically generated, in the upper right of the page and select the Export Grapher Image option to save an image file showing the simulated input and output traces. Upload that image in the container below.

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| Shape  Description automatically generated with low confidence |

## Compare input signal to circuit characteristics.

Compare the cutoff frequency and time constant of this circuit to the frequency and period of the input signal in the space below.

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| Click or tap here to enter text. |

## Create a differentiator circuit.

Now change the resistor value until the output resembles the derivative of the input. Identify the resistor value you chose to create this output along with the time constant and cutoff frequency of the resulting circuit.

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| --- | --- |
| Resistor Value, () | Click or tap here to enter text. |
| Time Constant, (sec) | Click or tap here to enter text. |
| Cutoff Frequency, (Hz) | Click or tap here to enter text. |

## Screenshot of differentiator output.

Click on the Export icon, Icon

Description automatically generated, in the upper right of the page and select the Export Grapher Image option to save an image file showing the simulated input and output traces. Upload that image in the container below.

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| Shape  Description automatically generated with low confidence |

## Compare input signal to circuit characteristics.

Compare the cutoff frequency and time constant of this circuit to the frequency and period of the input signal in the space below.

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| Click or tap here to enter text. |