Frequency and Intuitive Step Response of RC Filters

ECE 2100 Circuit Analysis
updated 7 September 2016

Equipment and Supplies

<table>
<thead>
<tr>
<th>Equipment</th>
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<tbody>
<tr>
<td>oscilloscope</td>
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<tr>
<td>function generator</td>
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<tr>
<td>1.6kΩ resistor (via variable resistor box)</td>
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<tr>
<td>0.1µF capacitor (via variable capacitor box)</td>
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Pre-Laboratory Assignment

1. Consider the circuit of Figure 1. Using phasor analysis, find the circuit voltage gain $V(\text{out})/V1$ as a function of the voltage source frequency in Hz.

2. Obtain gain and phase plots of this circuit using your SPICE engine (that is, plot the voltage gain and phase difference between $V(\text{out})$ and $V1$ as a function of the voltage source frequency). In the LTspice/ SwitcherCAD™ III “Edit Simulation Cmd” menu use an AC Analysis and be sure that the voltage source value is AC 1. Use a DECADE frequency sweep from 1 Hz to 1 MHz with 100 points per decade. After running your simulation, right click in the plot plane and select “Add Trace” and plot $V(\text{out})$. Also in the plot plane menu select “Manual Limits” and set the “Top,” “Tick,” and “Bottom” values to 0, 20, and -60, respectively, and then select a “Decibel” vertical axis. Also, add a plot grid using the plot plane menu. Your graph should be identical to Figure 2 (you can change the background color using the “Tools”->“Color Preferences” dialog box). Place a copy of the plot in your lab notebook. The plot must be large enough to enable accurate plotting of experimental data.
that will be obtained in the lab session.

3. Verify at least three gain values on the plot using your equation from pre-laboratory step 1.

4. Repeat steps 1 to 3 for the circuit of Figure 3.

"out" is the node name (use icon with A in box on toolbar)

![High Pass RC Filter Diagram]

Figure 3. High Pass RC Filter
Procedures

Part One

1. Build the circuit of Figure 1. Use a waveform generator for the voltage source to produce a sinusoid that varies between -1V and 1V. Connect the waveform generator to CH 1 of the oscilloscope. Connect \( V(\text{out}) \) to CH 2 of the oscilloscope.

Using oscilloscope cursors, accurately measure the voltage gain \( \frac{V(\text{out})}{V1} \) and the phase shift between \( V(\text{out}) \) and \( V1 \) for at least ten frequencies more or less evenly spread between 1 Hz and 1 MHz. Is there a problem with your high frequency measurements? Tabulate and then plot your gain and phase shift results (as single points) on your SPICE plot for points that you measured accurately. They must be in close agreement!

**BEFORE PROCEEDING TO THE NEXT STEP** ask the lab instructor to verify your results.

2. Change the waveform generator to a square wave. Place a plot of \( V1 \) and \( V(\text{out}) \) in your lab notebook.

Part Two

3. Build the circuit of Figure 3. Use a waveform generator for the voltage source to produce a sinusoid that varies between -1V and 1V. Connect the waveform generator to CH 1 of the oscilloscope. Connect \( V(\text{out}) \) to CH 2 of the oscilloscope.

Using oscilloscope cursors, accurately measure the voltage gain \( \frac{V(\text{out})}{V1} \) and the phase shift between \( V(\text{out}) \) and \( V1 \) for at least ten frequencies more or less evenly spread between 1 Hz and 1 MHz. Is there a problem with your low frequency measurements? Tabulate and then plot your gain and phase shift results (as single points) on your SPICE plot for points that you measured accurately. They must be in close agreement!

**BEFORE PROCEEDING TO THE NEXT STEP** ask the lab instructor to verify your results.

4. Change the waveform generator to a square wave. Place a plot of \( V1 \) and \( V(\text{out}) \) in your lab notebook.

Analysis

1. Why are the circuit gain and phase plots obtained in the lab using a sinusoidal source?

2. Explain the shape of the low and high pass filter outputs for laboratory procedures parts 2 and 4.

Credits and Copyright

Thanks to Juan Ramirez for improvements to this lab.

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