**Frequency and Intuitive Step Response of RC Filters**

**ECE 2100 Circuit Analysis**
updated 11 June 2021

**PROCEDURES**

**THERE IS NO PRELAB**

**LOW PASS FILTER**

1. For the circuit of Figure 1 use phasor analysis to find the circuit voltage gain \( \frac{V_{\text{out}}}{V_1} \) and phase \( \angle V(\text{out}) \) as a function of the voltage source frequency in Hz. Since the angle of \( V_1 \) is zero \( \angle V(\text{out}) \) is the phase shift.

2. Obtain gain and phase plots (Bode plot) of this circuit using LTspice® (that is, plot the voltage gain and phase as a function of the voltage source frequency). In the LTspice® “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 the waveform viewer and select “Add Traces” and plot \( V(\text{out}) \). Right click the left vertical axis, check “Decibel,” and set “Top,” “Tick,” and “Bottom” to 0dB, 20dB, and -60dB, respectively. Right click the right vertical axis and set “Top,” “Tick,” and “Bottom” to 0, 10, and -90 degrees respectively. Under “Plot Settings” select “Grid.” Your graph should be identical to Figure 2. You can set colors using the “Tools”->“Color Preferences” dialog box.

3. Compare the computed and simulated gains and phases for \( f=10^n \)Hz, where \( n=0..6 \). You can find the LTspice® gains and phases by right clicking on Vout and attaching a cursor. Use a table with these headings. Find the percent error for each comparison using your computed value as the reference. Are the errors reasonable?

<table>
<thead>
<tr>
<th>f</th>
<th>Gain</th>
<th>% error</th>
<th>Phase</th>
<th>% error</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Computed</td>
<td>LTspice®</td>
<td>Computed</td>
<td>LTspice®</td>
</tr>
</tbody>
</table>

4. Compute and use LTspice® to verify \( f_{3dB} \), that is, the frequency where the gain is -3dB.

5. Now apply a square wave to the low pass filter as in Figure 3. Right click on V1, select PULSE, and set the parameters as indicated. Under “Simulate” change to a transient simulation with the indicated settings. Run the simulation. Your result should look like Figure 4

6. Explain the shape of the filter response.

**HIGH PASS FILTER**

7. Reverse the position of the resistor and capacitor. Repeat steps 1-6.
Figure 1. Low Pass RC Filter (Bode plot)

Figure 2. Gain (solid) and Phase (dashed) Plots for a Low Pass Filter
Figure 3. Low Pass Filter (Square Wave Response)

Figure 4. Square Wave Response of a Low Pass Filter
8. **YOU MUST submit this worksheet with your report AS THE LAST PAGE**

**ECE 2100 Laboratory RC Low Pass Filter Design Worksheet**

9. Identify the alphabet number position of the first letter of your first name. For example, Alex would be 1, Hussein 8, Maria 13, and Zoe 26. Multiply that number by 1kHz. **THIS IS YOUR 3dB frequency.** Enter here:

<table>
<thead>
<tr>
<th>$f_{3dB}$</th>
<th>(kHz)</th>
</tr>
</thead>
</table>

10. Keep $C_1=0.1\mu F$ in Figure 1 and compute the value of $R_1$ needed to realize your 3dB frequency. **YOU MUST use a standard 1/4W resistor value as listed at**

https://ecee.colorado.edu/~mcclurel/resistorsandcaps.pdf

The specification is to meet $f_{3dB}$ as closely as possible, ideally with 5%. Enter your value here. Be sure to include units.

<table>
<thead>
<tr>
<th>$R_1$</th>
</tr>
</thead>
</table>

11. Describe how you can quickly find $f_{3dB}$ using LTspice® (limited to the space below):


12. Did you meet the specification? Why or why not (limited to the space below)?


13. **ENTER YOUR ENGINEERING MAJOR HERE:**


Credits and Copyright
Thanks to Simin Masihi, Masoud Panahi, and Juan Ramirez for improvements to this lab.
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