UNIVERSITY OF CALIFORNIA AT BERKELEY
College of Engineering
Department of Electrical Engineering and Computer Sciences

EE105 Lab Experiments

Prelab 1: Introduction to SPICE

Solutions

1. Before you begin, you will need some instructions on how to run and use HSPICE. We have a tutorial specifically for EE105 containing instructions for both the Windows and UNIX versions of HSPICE. The tutorial includes a number of examples to help you get started.

   - HSPICE Tutorial

2. Figure 1 shows a simple network of resistors and a capacitor. Find the transfer functions v_x/v_s and v_y/v_s (as functions of $j\omega$) by hand.

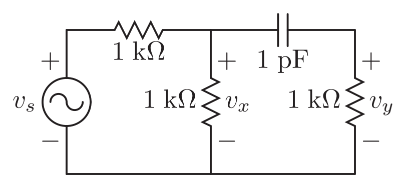


Figure 1: Circuit to simulate for the prelab

$$\frac{v_x}{v_s}(j\omega) = \frac{10^3 \parallel \left(10^3 + \frac{1}{j\omega 10^{-12}}\right)}{10^3 + 10^3 \parallel \left(10^3 + \frac{1}{j\omega 10^{-12}}\right)}$$

$$\begin{aligned}
10^3 \parallel \left(10^3 + \frac{1}{j\omega 10^{-12}}\right) &= \left[\frac{1}{10^3} + \frac{1}{10^3 + \frac{1}{j\omega 10^{-12}}}\right]^{-1} \\
&= \frac{10^3\left(10^3 + \frac{1}{j\omega 10^{-12}}\right)}{2\times 10^3 + \frac{1}{j\omega 10^{-12}}} \\
&= \frac{10^6 + \frac{10^{15}}{j\omega}}{2\times 10^3 + \frac{10^{12}}{j\omega}} \\
&= \frac{1 + j\omega 10^{-9}}{10^{-3} + j\omega\left(2\times 10^{-12}\right)} \\
&= 10^3 \frac{1 + j\omega 10^{-9}}{1 + j\omega\left(2\times 10^{-9}\right)} \\
\frac{v_x}{v_s}(j\omega) &= \frac{10^3 \frac{1+j\omega 10^{-9}}{1+j\omega(2\times 10^{-9})}}{10^3 + 10^3 \frac{1+j\omega 10^{-9}}{1+j\omega(2\times 10^{-9})}} \\
&= \frac{1 + j\omega 10^{-9}}{2 + j\omega\left(3\times 10^{-9}\right)} \\
\frac{v_x}{v_s}(j\omega) &= \boxed{\frac{1}{2}\frac{1 + j\frac{\omega}{10^9}}{1 + j\frac{\omega}{2/3\times 10^9}}}
\end{aligned}$$

$$\omega_z = 10^9 \text{ rad/s} \qquad \omega_p = 2/3\times 10^9 \text{ rad/s}$$

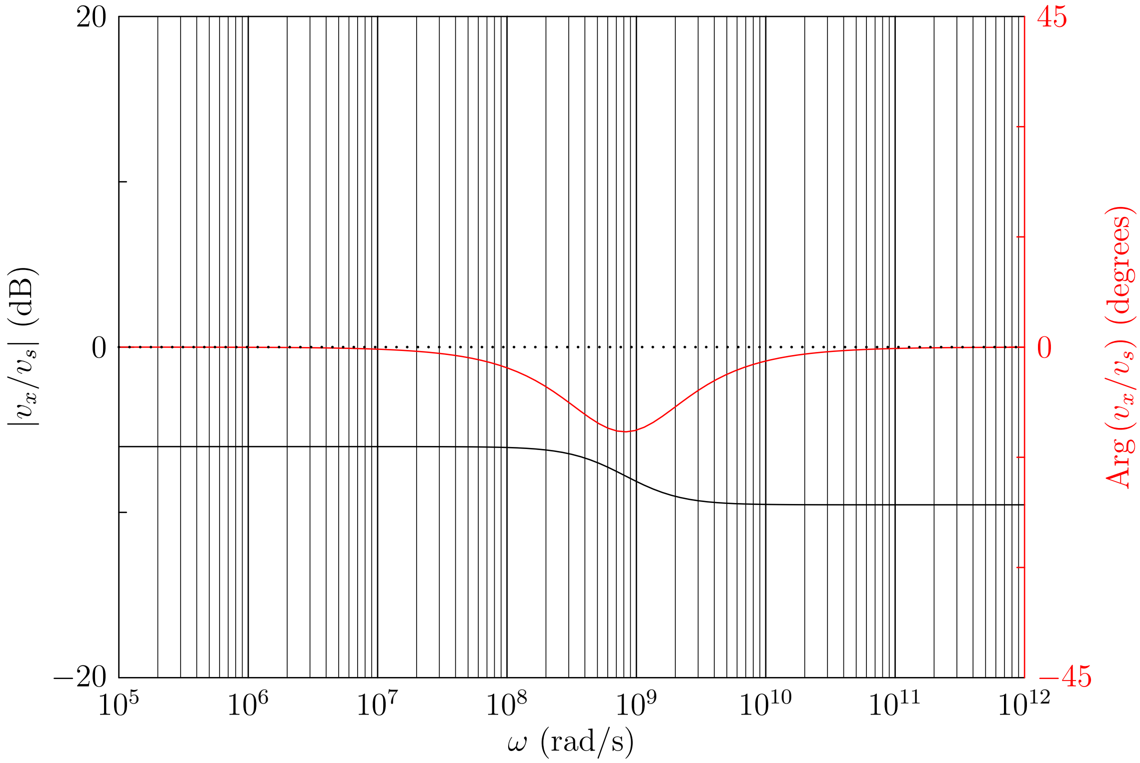
$$\left|\frac{v_x}{v_s}\right|_{\omega=0} = \frac{1}{2} = -6 \text{ dB} \qquad \angle\left(\frac{v_x}{v_s}\right)_{\omega=0} = 0^\circ$$

$$\begin{aligned}
\frac{v_y}{v_s}(j\omega) &= \frac{v_x}{v_s}(j\omega)\frac{v_y}{v_x}(j\omega) \\
\frac{v_y}{v_x}(j\omega) &= \frac{10^3}{10^3 + \frac{10^{12}}{j\omega}} \\
&= \frac{j\omega 10^3}{j\omega 10^3 + 10^{12}} \\
&= \frac{j\frac{\omega}{10^9}}{1 + j\frac{\omega}{10^9}} \\
\frac{v_y}{v_s}(j\omega) &= \frac{1}{2}\frac{1 + j\frac{\omega}{10^9}}{1 + j\frac{\omega}{2/3\times 10^9}}\frac{j\frac{\omega}{10^9}}{1 + j\frac{\omega}{10^9}} \\
\frac{v_y}{v_s}(j\omega) &= \boxed{\frac{1}{2}\frac{j\frac{\omega}{10^9}}{1 + j\frac{\omega}{2/3\times 10^9}}}
\end{aligned}$$

$$\omega_z = 0 \text{ rad/s} \qquad \omega_p = 2/3\times 10^9 \text{ rad/s}$$

$$\left|\frac{v_y}{v_s}\right|_{\omega=0} = 0 = -\infty \text{ dB} \qquad \angle\left(\frac{v_y}{v_s}\right)_{\omega=0} = 90^\circ$$

3. Use the transfer functions you derived to make Bode plots (magnitude and phase) for v_x/v_s and v_y/v_s. On each graph, indicate which curve is the magnitude and which is the phase. *Note: If you need a review of Bode plots, read the Bode Plot Tutorial.*



4. Now write an HSPICE netlist for this circuit.

5. Perform an AC analysis of this circuit from 100 kHz to 1 THz in HSPICE. Attach your netlist to this worksheet.

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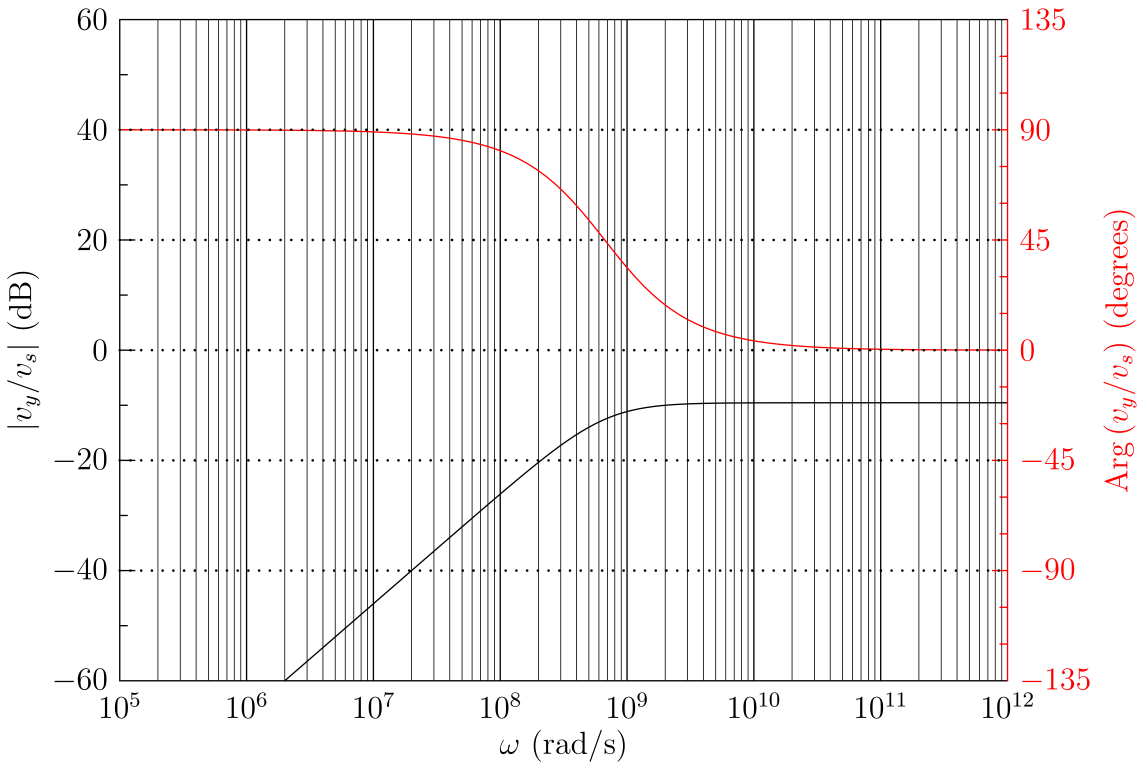
EE105 Experiment 1: Prelab

vs vs gnd ac 1
r1 vs vx  1k
r2 vx gnd 1k
c1 vx vy  1p
r3 vy gnd 1k

.ac dec 100 100 10G
.option post=2
.end
```

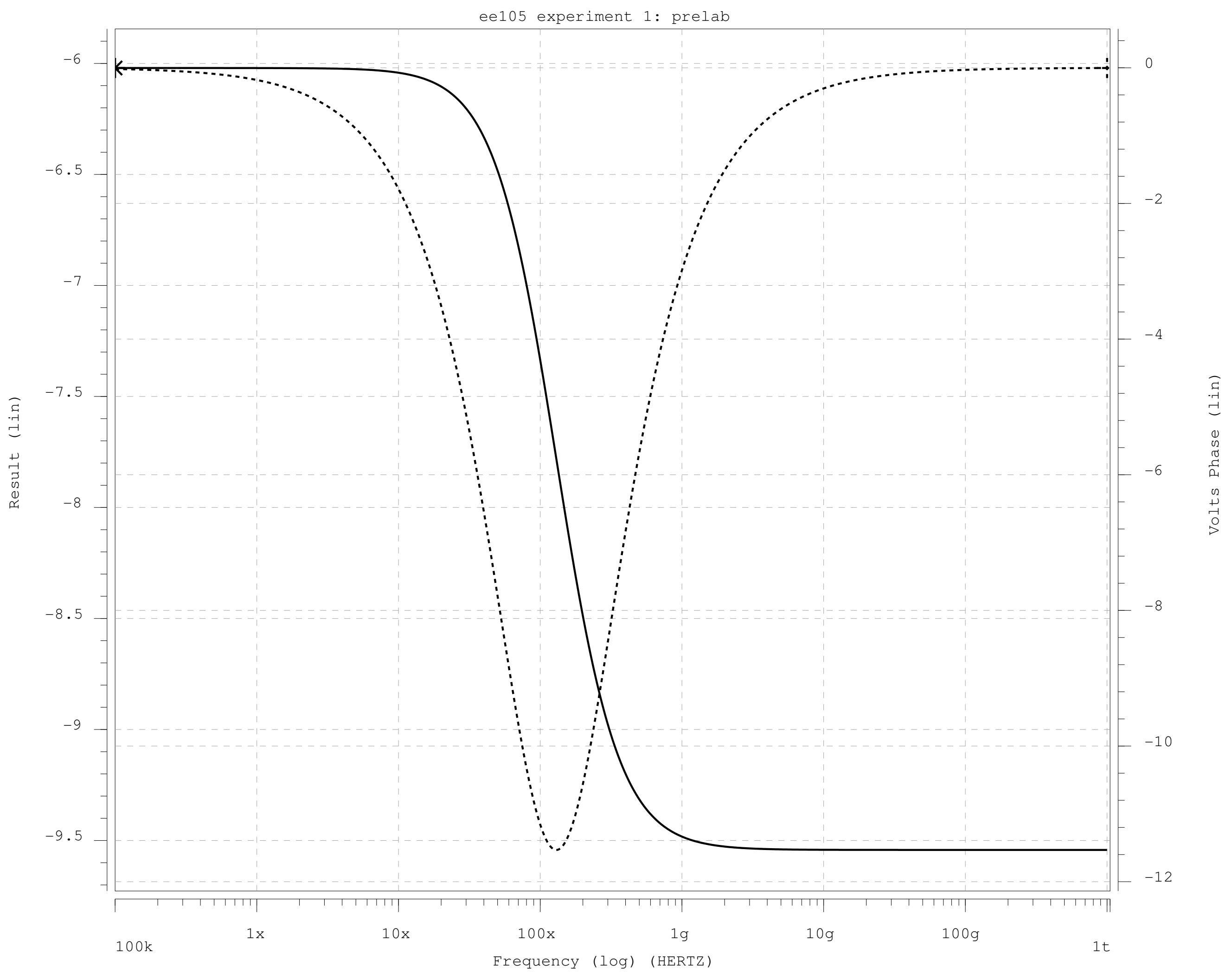
6. Use Awaves to generate Bode plots (magnitude and phase) for the circuit in Figure 1 for v_x/v_s and v_y/v_s. Do the results agree with your hand calculations? *Hint: The default x-axis in Awaves has units* Hz, *not* rad/s. *Note: If you do not have a 3-button mouse, you will not be able to generate a*



magnitude Bode plot. Instead, simply plot $|v_x/v_s|$ *and* $|v_y/v_s|$ *on a log-log plot by right-clicking the axes and selecting "Set Logarithmic Scale".*

The results are almost identical to the hand calculations. To compare them directly you must remember to convert the zero and pole frequencies from Awaves to rad/s (or the frequencies in your hand plot to Hz).

7. Turn in your hand calculations, netlist, and Bode plots (hand-made and simulated) at the beginning of your lab for checkoff. **Please print your plots with a white background. You can set a white background in Awaves by clicking *Window* → *Flip Color*.**



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D0: PRELAB	Expression	None
D0: PRELAB	AC	C:\documents and settings\eudean\my documents\ee105\fall 2007\labs\lab 1\solution\prelab\prelab.ac0

Figure 2: Bode plot for v_x/v_s

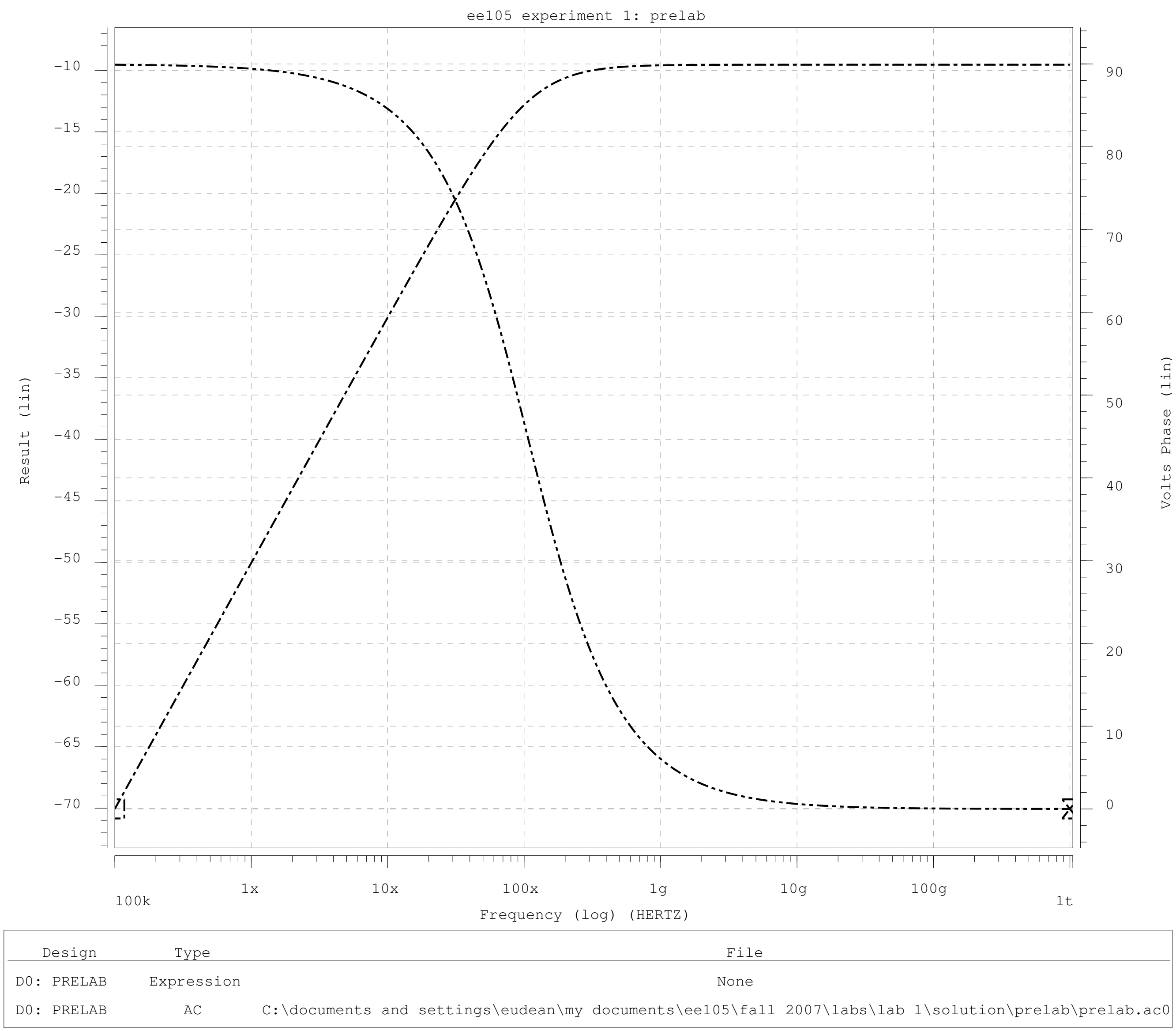

Figure 3: Bode plot for v_y/v_s