EEE 108L MICRO-ELECTRONICS 1
LAB 2

Lab Session: Tuesday 3PM - 5:40PM

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PRE-LAB CALCULATIONS

STEP 1.

For the circuit of Figure 1, the default component values are (given by instructor). Calculate the magnitude of the transfer function at frequencies for which the capacitor can be considered an open circuit. Also calculate the upper frequency of -3 Db point.

For C treated as an open circuit, (V2/Vs) ~= .318841

Upper frequency of -3 Db point ~= 4.73981 KHz

(Please see figure 1 in appendix A for complete calculations)

STEP 2.

Calculate the 10% to 90% risetime of in response to a step input at Vs.

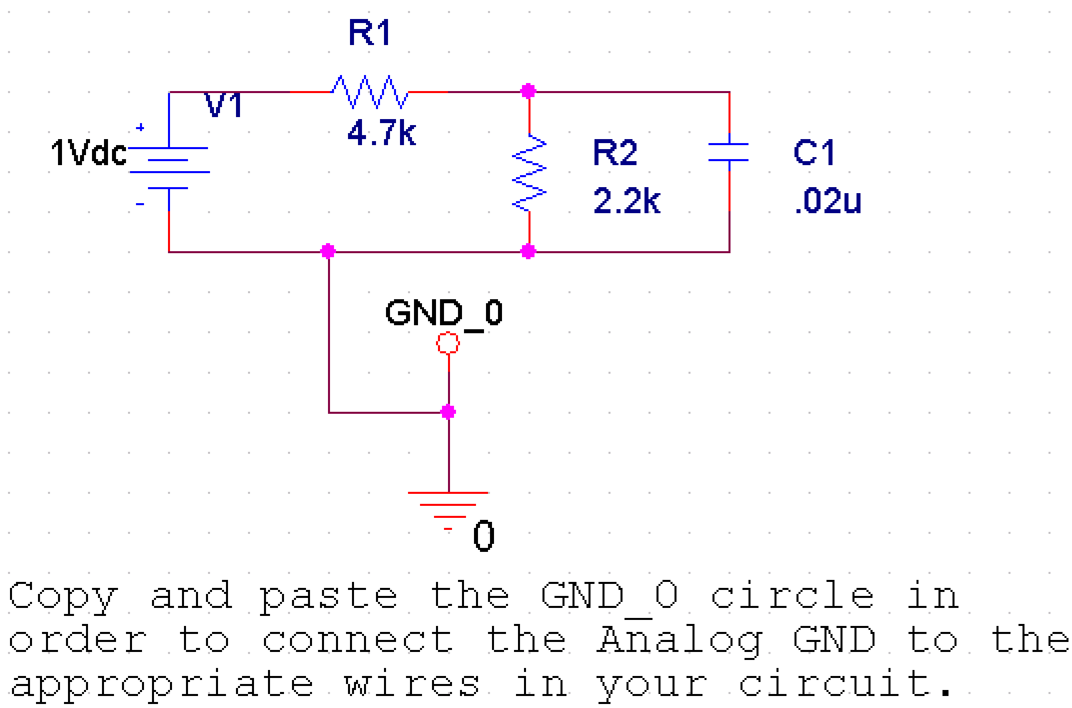
$RT_{10\text{-}90}$ ~= 73.8426 us

(Please see figure 1 in appendix A for complete calculation)

PART 1

STEP 3.

My circuit after entered into PSPICE.

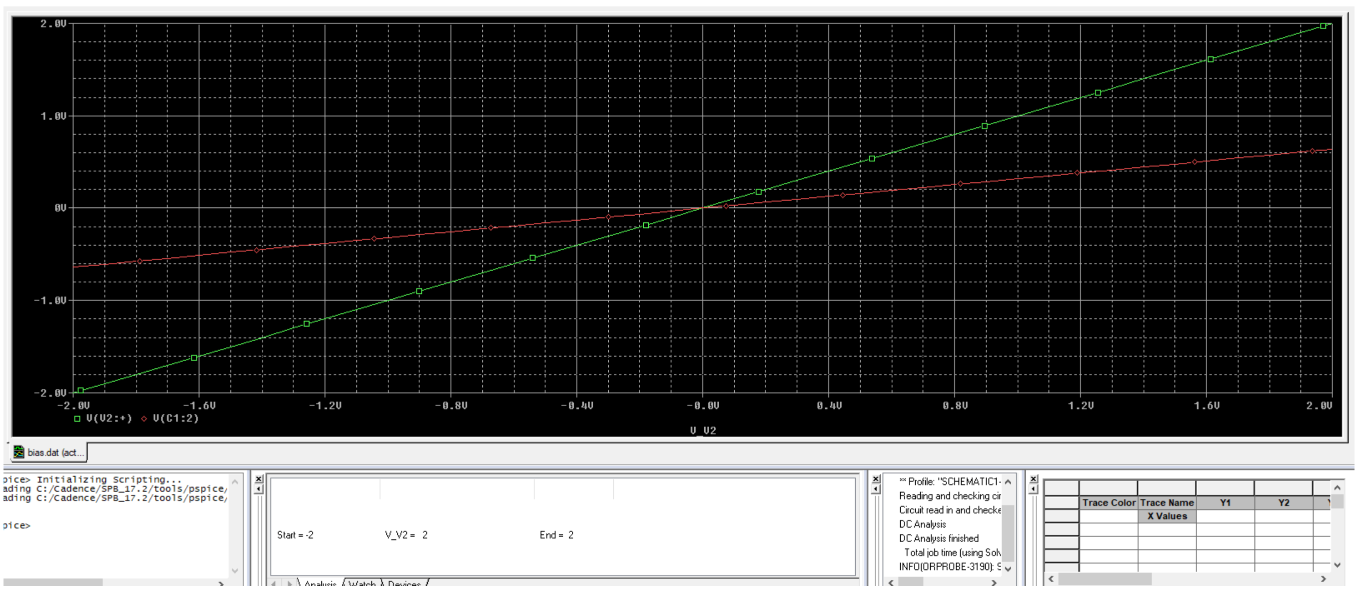


PART 2

This type of analysis is used to find the DC transfer characteristic of a circuit (Appendix A3.1). The simulation will sweep the DC value of a particular source specified by its part reference (i.e., its name). Any of the PSPICE voltage (or current) sources may be swept in a DC sweep.

STEP 4.

This is what the linear sweep looked like from -2V to 2V. The red line is V2 and the green is Vs. Since this is a function of Vs and were sweeping from -2V to 2V, those are its corresponding minimums and maximums.



STEP 5.

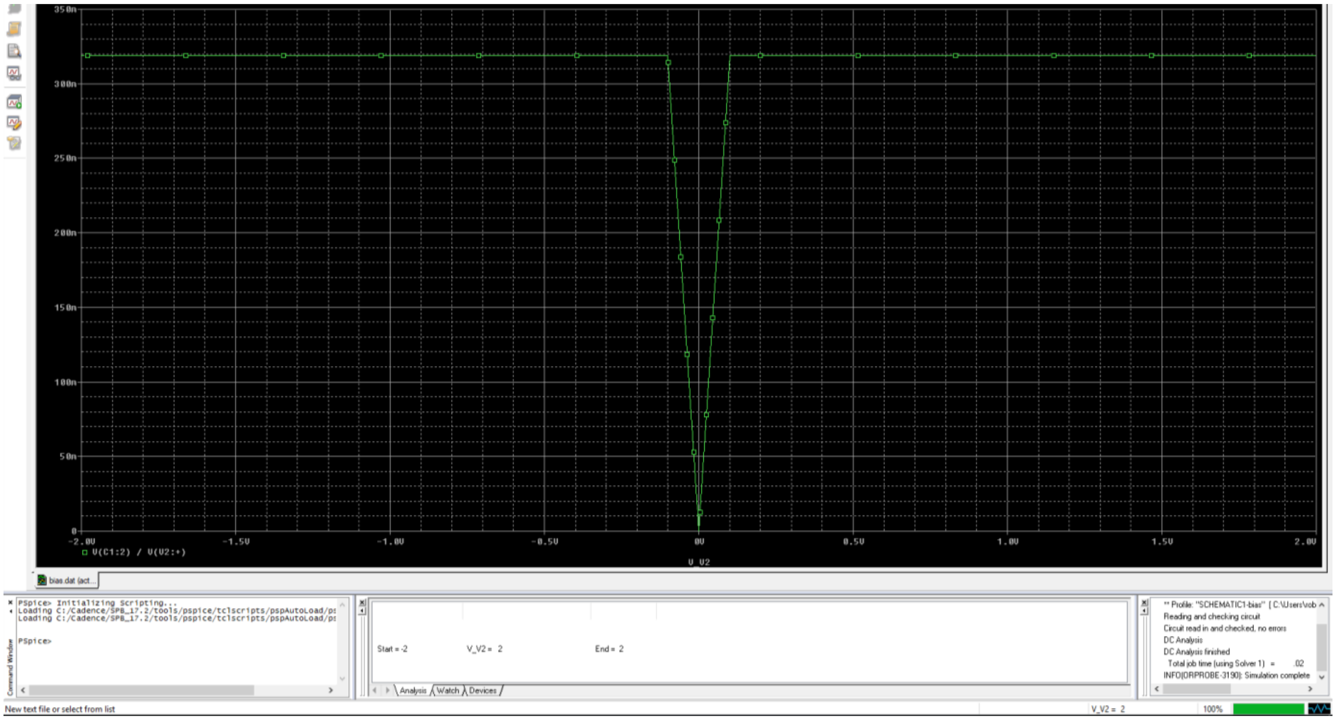
V2 and VS on display in step 4 image. Here, there we no cursors set unfortunately so I needed to use the grid as best as possible to rough out a value and make sure it is near the expected value.

Change in V2 = .2V-0V ~= .333V/V (Indeed near the .318 calculated)

Change in Vs .6V-0V

STEP 6.

This step will explore alternate ways of finding the gain (small-signal) from the simulation data.

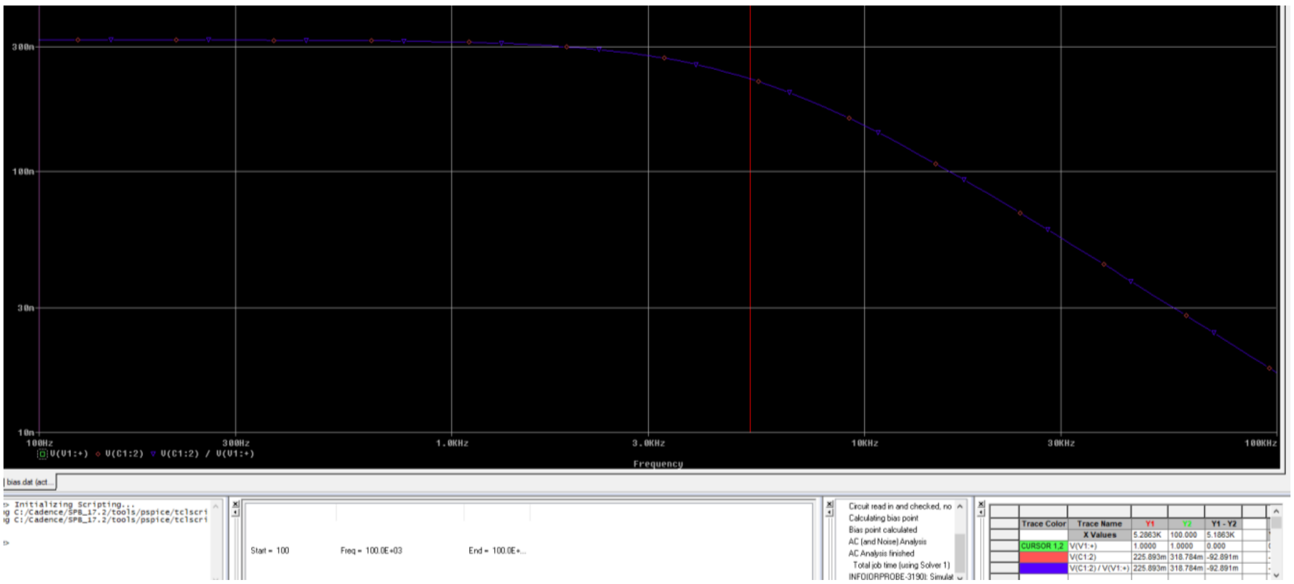


The gain here stays roughly 319mV/V until reaching -.1V where it drops off and returns to the same value on +.1V. This is over the range of -2V to 2V.

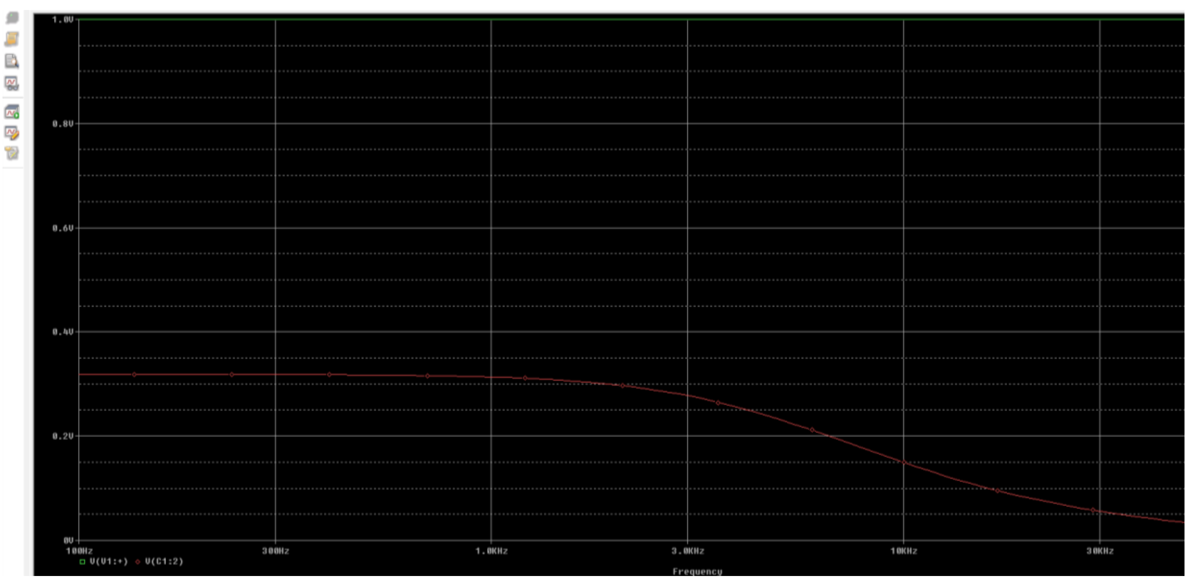
PART 3

STEP 7.

Go to Analysis/Setup/AC Sweep. Then set up a logarithmic sweep by selecting Decade. The sweep should start at 100Hz, end at 100kHz, and have about 30 points per decade7



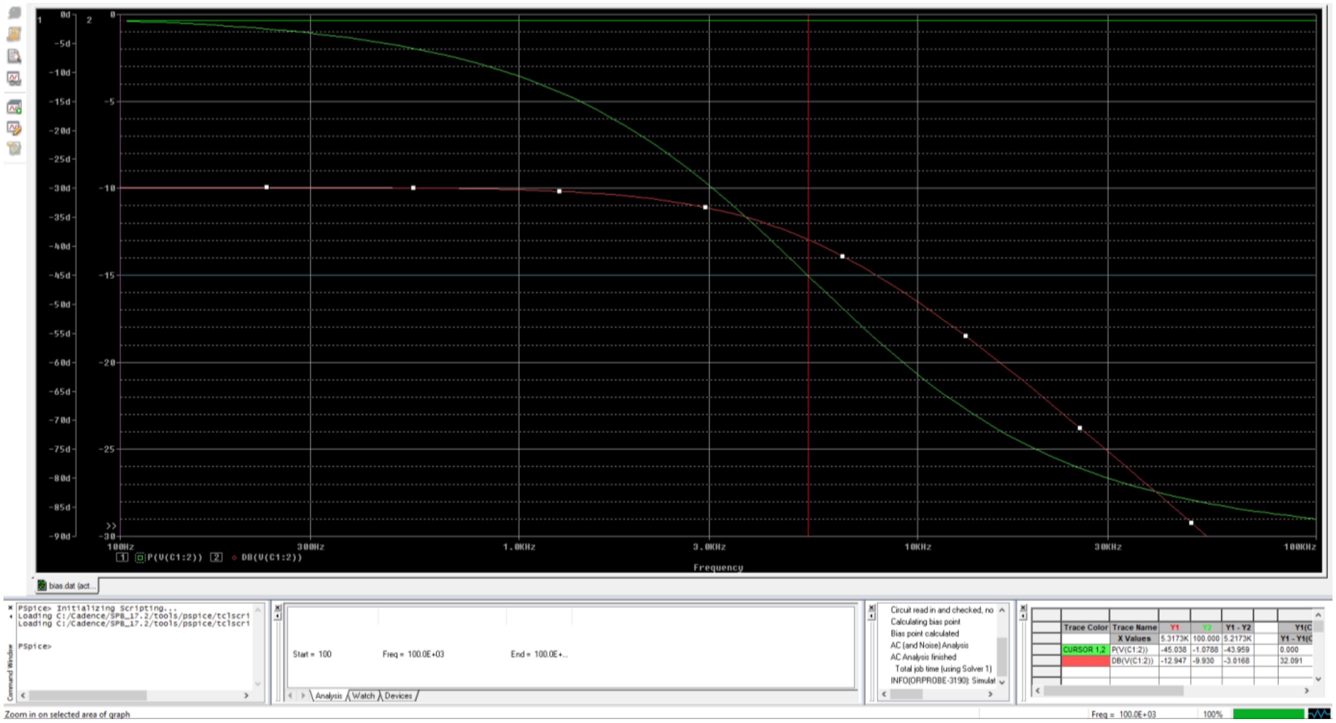
-3Db point occurring at 5.3173kHz, nearly lining up with my calculations



Vs stays at a solid 1V over the entire sweep. Vout begins tapering off after 1Khz. Before the roll off Vout measures about 320mV. Yielding the same ratio as before. 320mV / 1V ~= .320V/V

STEP 8.

Delete all traces on the graph and obtain a new trace by typing the expression "DB(V(v2))".



(Low frequency Db gain converted to V/V in Figure 2 of Appendix A)

STEP 9.

From the AC sweep plot of Step 8, determine the upper –3db frequency of . Compare this to the –3dB frequency calculated in Step 1. (Hint: This is the frequency at which drops by 3dB from its low-frequency value.)

From this graph we retrieved a frequency of 5.3173kHz. Note: our cursor placement was slightly right of where it needed to be, we initially thought this graph began at a -10Db but it was closer to -9.93. Given x is a logarithmic scale it would make a decent difference and bring this value even closer to the calculations.

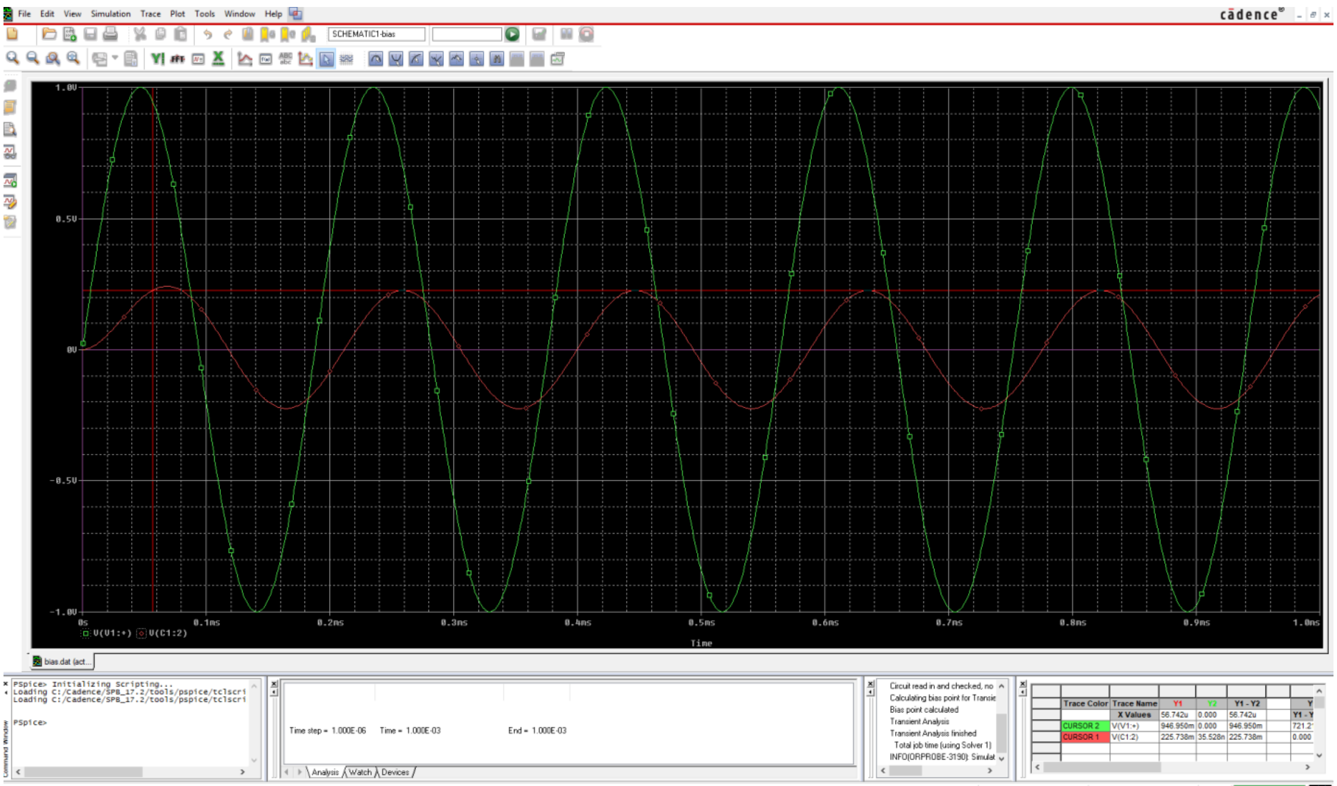
STEP 10.

Using again the graph displayed in step 8, the phase at this frequency is -45 degrees. Using Figure 1 of appendix A we can see the numerator of the transfer function does not contain any angle information, so the phase angle will start at a maximum of zero and drop from there.

PART 4

Transient simulations are used to obtain the circuit voltages and currents as functions of time. This type of simulation is different from those previously discussed in that the sweep must start at zero , and that the results at each time step must depend on the results at the previous time step.

STEP 11.



Peak to peak V2 = 451.476mV

Peak to peak Vs = 1.8939V

Peak to peak V2/Vs = .238384

STEP 12.

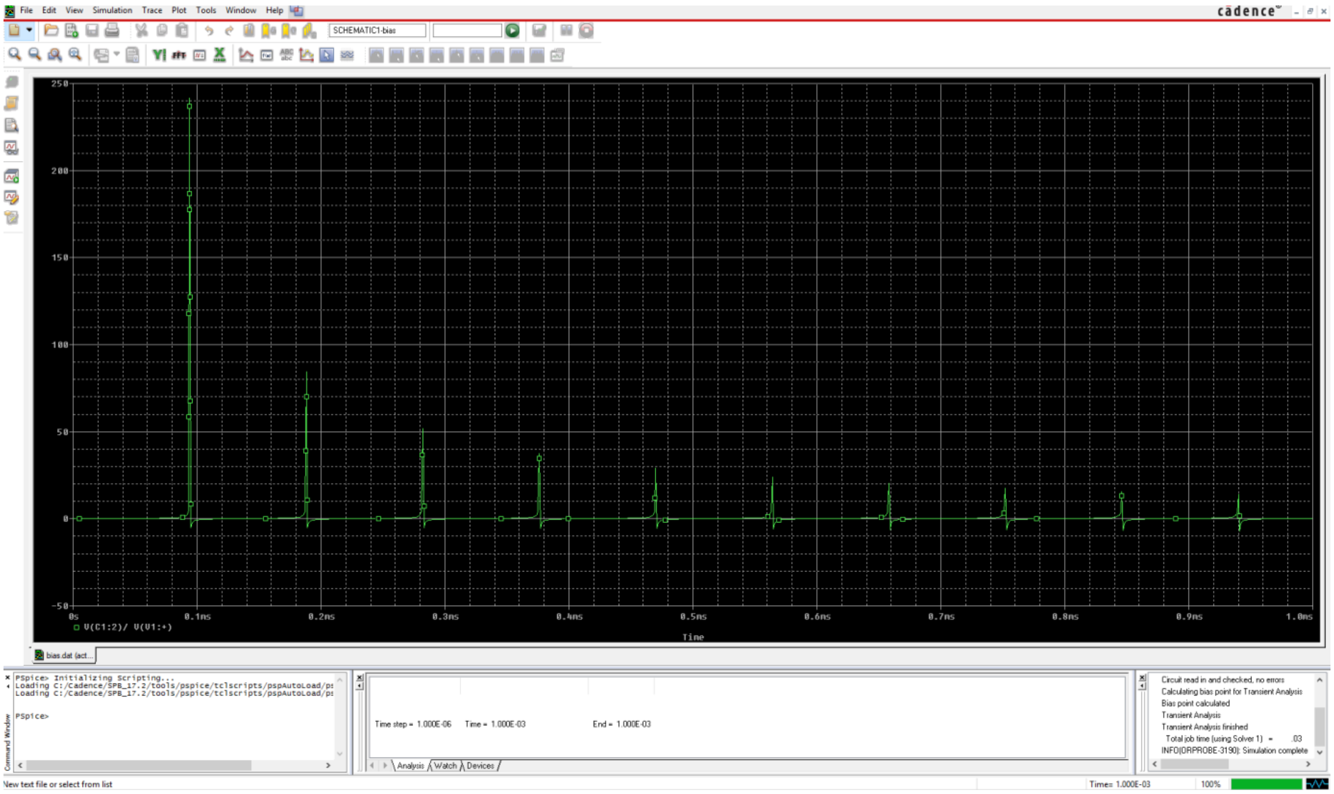
In the plots obtained in Step 11, how is the very first cycle of the output sine wave different from subsequent cycles?

Looking at this graph, the first cycle has a higher output max peak than the rest, all other peaks share the same peak value.

STEP 13.

Display the trace "v(v2)/v(vs)". Why doesn't this trace show the value of |V2/Vs|?

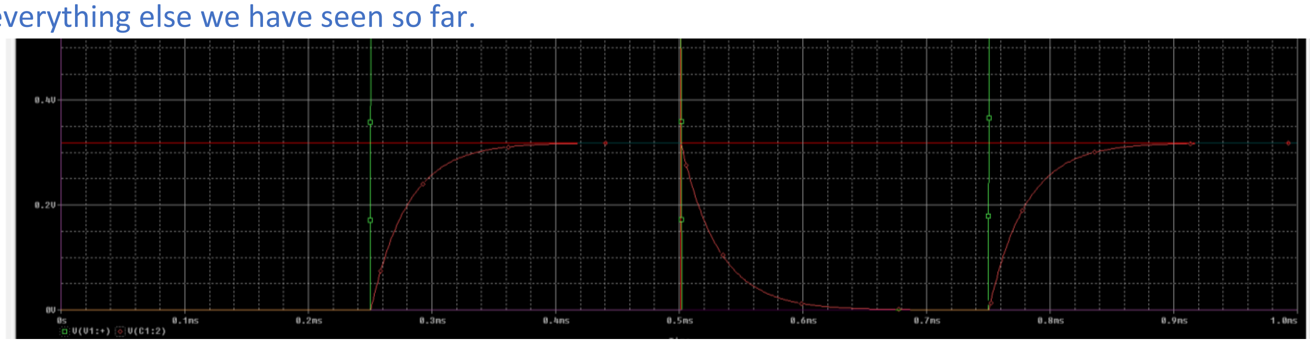
V2 and Vs are out of phase.



STEP 14.

Now edit the circuit of Figure 2 by replacing the vsin voltage source with the part vpulse. Assign the source parameters as given in Table 1. Again, run a transient simulation.

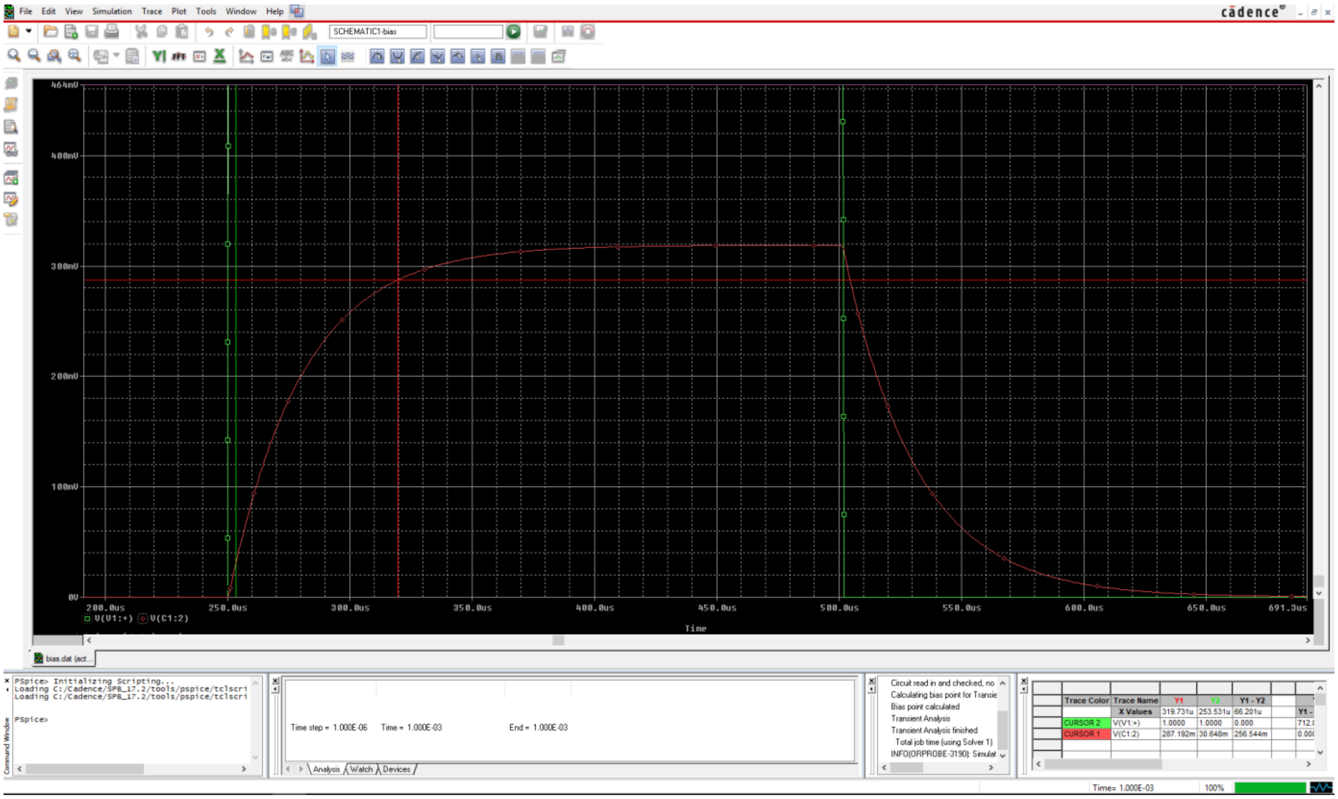
V2 becomes about 319mV at its greatest height before dropping off, this is consistent with everything else we have seen so far.



STEP 15.

From the simulation results of the previous step, determine the 10% to 90% risetime of and compare this value with that calculated in Step 2. A Non-Linear Circuit (DC Sweep)

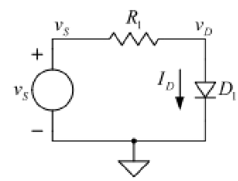
From this graph we see a 10 – 90 risetime of 66.2 microseconds, compared to the 73.8426 microseconds calculated before.

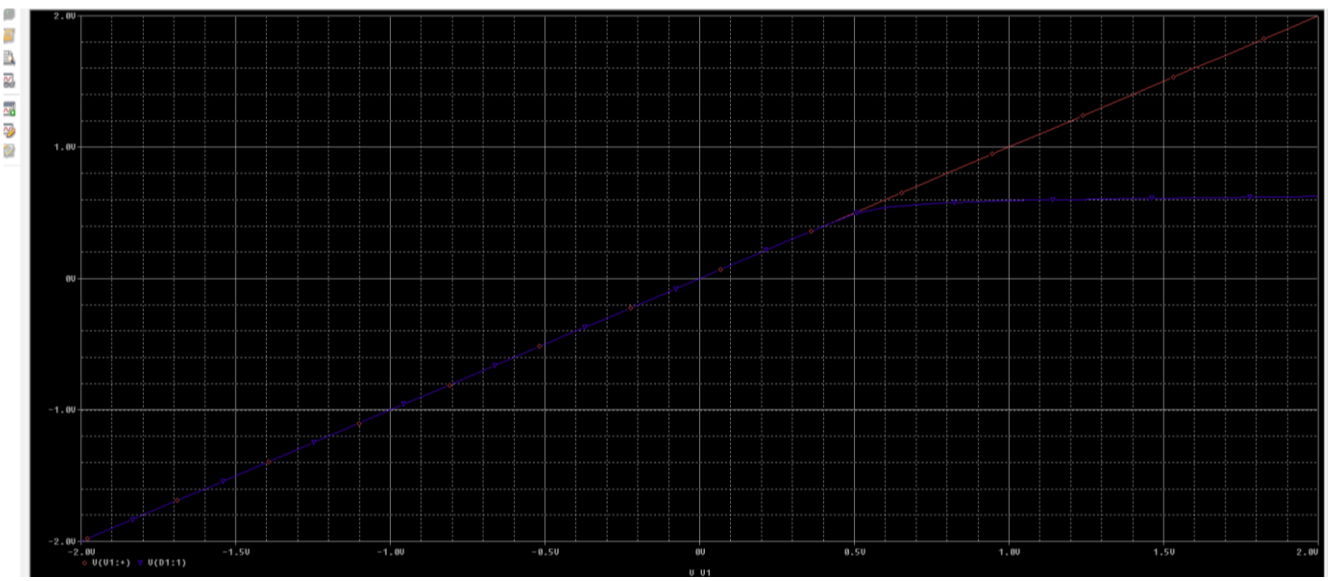


(Risetime)

STEP 16.

Now change the circuit to





Both graphs show are DC sweeps. The top graph represents the current flowing through the diode as the source voltage increases, and the second graph represents the voltage seen over the diode as the source voltage increases. As expected in the top graph there is no current flowing when voltage is negative because that would indicate current in the opposite direction, which the diode does not allow. The bottom graph displays the idea of the diode reaching its top voltage prior to breakdown.

CONCLUSIONS

Item 1.

The graph of Step 5 was used to find the value of . The same value can be found by dividing a single value of by its corresponding value of . Why is this so? What conditions must exist for this to be true?

If we look at these values before op amp saturation or roll off, then we can get this this same value because we are working with a linear op amp. The slope will not change in its stable range so a relationship at a single point will be the same as over the range of stable response.

Item 2.

In general, will obtaining a trace of "V(vy)/V(vx)" show the small-signal gain ? For which types of analyses will this trace show the small-signal gain, and what are the limiting factors?

Not in general, no. The small signal gain is the gain seen from operating within the amplifier's linear range so if we try to do this during saturation we will not be seeing the small signal gain.

Item 3.

Is the midband (low-frequency) gain found in Steps 8 and 9 the same as the gain obtained from the DC transfer characteristic (convert dB to)? Should the gains be the same? Under what condition

can a DC transfer characteristic be used to find the midband AC gain? Explain.

Calculation done in Figure 2 of Appendix A. It did turn out to be the same as found in the previous steps. These gains should be the same yes, were approaching the same equation from the two opposing sides. One way is starting with a known gain and unknown Db, the other is with a known Db and unknown gain.

Item 4.

Consider the graph of the AC sweep data produced in Step 7. Explain the general shape of the graph (where is it flat? where is it increasing or decreasing?) Is this a high-pass filter or low-pass filter?

The simulation is based on principles of sinusoidal steady-state analysis, yet the resulting graph does not

look like a sine wave. Why?

This graph starts as a flat plateau that begins to roll off slightly between 1KHz and 3Khz. After about 10KHz the fall off (decrease) appears linear. With these characteristics, this is a low pass filter. As the frequency increases the response drops. This does not appear to be a sine wave because we are viewing gain, the ratio between the output and input.

Item 5.

What should be the phase response of the circuit of Figure 1 at its upper –3dB frequency? Do the simulation results from the AC and transient analyses agree?

The phase angle should be -45 degrees. Using Figure 1 of appendix A we can see the numerator of the transfer function does not contain any angle information, so the phase angle will start at a maximum of zero and drop from there. The simulation results do agree.

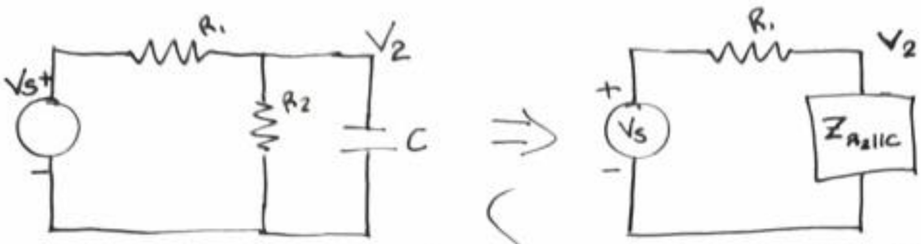
Item 6.

Does the diode-resistor circuit of Step 16 circuit have the same value of for all ? What are the maximum and minimum values of ?

No it does not, at about .5V over the sweep Vd/Vs rapidly plateaus to about .6V Vd . Following the graph delta Vd / delta Vs has a maximum value of 1 and a minimum value that we cant see here. From what we can see, the trend looks like Vs would continue growing while Vd does not so the minimum would be 0.

APPENDIX A

Figure 1.



Step 1

$$V_2 = V_S\left(\frac{Z_{R_2\parallel C}}{Z_{R_2\parallel C} + Z_{R_1}}\right)$$

$$V_2 = V_S\left(\frac{\frac{R_2}{R_2\cdot s\cdot c+1}}{\frac{R_2}{R_2\cdot s\cdot c+1} + R_1}\right)$$

$$\frac{V_2}{V_S} = \left(\frac{\frac{R_2}{R_2\cdot s\cdot c+1}}{\frac{R_2 + R_1(R_2\cdot s\cdot c+1)}{R_2\cdot s\cdot c+1}}\right)$$

$$\frac{V_2}{V_S}(s) = \frac{R_2}{R_2 + R_1 R_2\cdot s\cdot c + R_1}$$

$$\frac{V_2}{V_S}(j\omega) = \frac{R_2}{R_2 + R_1 R_2\cdot j\omega\cdot c + R_1}$$

$$\frac{V_2}{V_S}(j\omega) = \frac{2.2k}{6.9k + j\omega(.2068)}$$

$$Z_{R_2\parallel C} = \frac{(R_2)\left(\frac{1}{s(C)}\right)}{R_2 + \frac{1}{s(C)}}$$

$$= \frac{\frac{R_2}{s\cdot C}}{\frac{R_2\cdot s\cdot C+1}{s\cdot C}}$$

$$= \frac{R_2}{R_2\cdot s\cdot c+1}$$

$$\frac{1}{j2\pi fC}$$

$f\to\infty \quad Z\to 0$

$f\to 0 \quad Z\to\infty$

When low frequencies make C act like an open, we have:

$$V_2 = V_S\left(\frac{R_2}{R_2+R_1}\right)$$

$$\frac{V_2}{V_S} = \frac{2.2k}{6.9k}$$

$$\boxed{\frac{V_2}{V_S} \approx .318841}$$

$$\frac{V_2}{V_S}(j\omega) = \frac{2.2k}{\sqrt{(6.9k)^2+(j.2068\omega)^2}} \angle\, 0 - \arctan\left(\frac{.2068\omega}{6.9k}\right)$$

$$\frac{1}{\sqrt{2}} = \frac{2.2k}{\sqrt{(6.9k)^2-(.2068\omega)^2}}$$

$$\sqrt{(6.9k)^2-(.2068\omega)^2} = (\sqrt{2})(2.2k) \Rightarrow (6.9k)^2-(.2068\omega)^2 = \left((\sqrt{2})(2.2k)\right)^2$$

$$\frac{\sqrt{-\left((\sqrt{2})(2.2k)\right)^2+(6.9k)^2}}{.2068} = \omega$$

$\omega = 29781.1$, $\omega = 2\pi f$, $\boxed{f = 4739.81\ \text{Hz}}$

$$RT(nsec) = \frac{.35}{BW(GHz)} \Rightarrow RT(nsec) = \frac{.35}{.00000473981} = \boxed{73.8426\ ms}$$

Step 2

Figure 2.

-9.93 Vdb

$$9.93 = 20\log(A_v)$$

$$.4965 = \log_{10} A_v$$

$$10^{.4965} = A_v$$

$$3.1369 = A_v$$

inverse is .318787