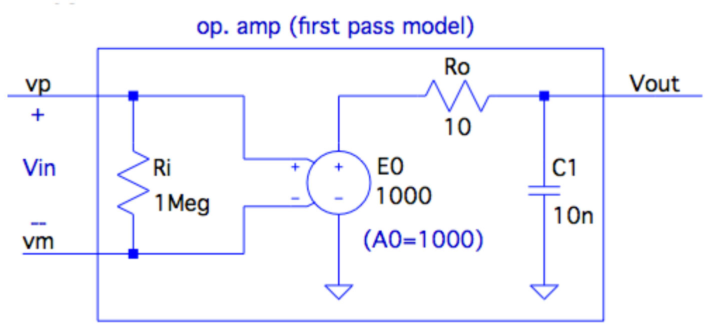
The purpose of this laboratory is

1) Show that the basic functionality needed to build amplification is a controlled (aka dependent) source
2) How the various performance parameters (Ri, Ro, A0 and BW) of the amplifier affect its overall operation w.r.t to the driving signal Vsig and the driven load RL
3) Show that the output signal issued by a practical amplifier is limited by its supply

Pre-Lab:

Given the following simplified single pole amplifier's model:

$$T(s) = \frac{A0}{1 + \frac{s}{\omega_p}}$$



1. What are the values of:

Ri = ______________________________

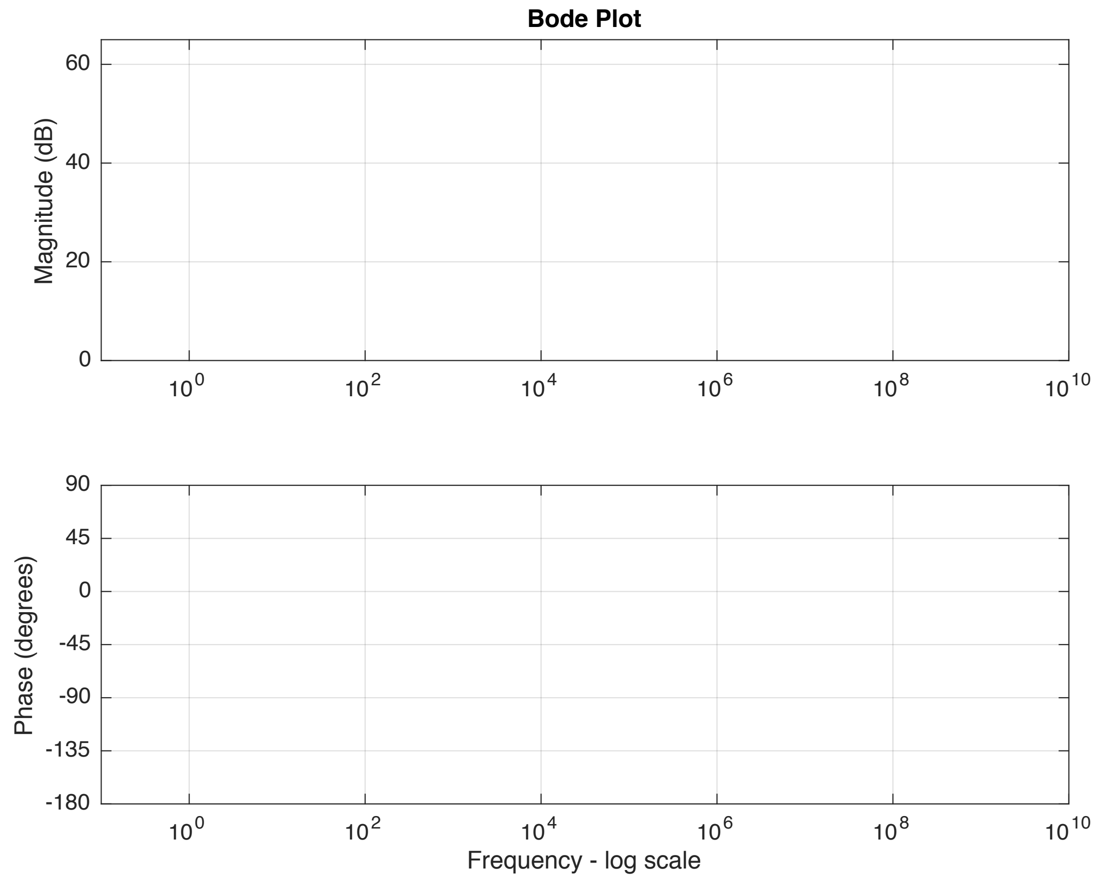
Ro = ______________________________

A0 = ______________________________

BW = ω_p = ______________________________

2. Plot the "asymptotic" transfer function of the amplifier (both magnitude M = |T(s)| and phase Θ = ∠T(s)):

$$T(s) = \frac{A0}{1 + \frac{s}{\omega_p}}$$

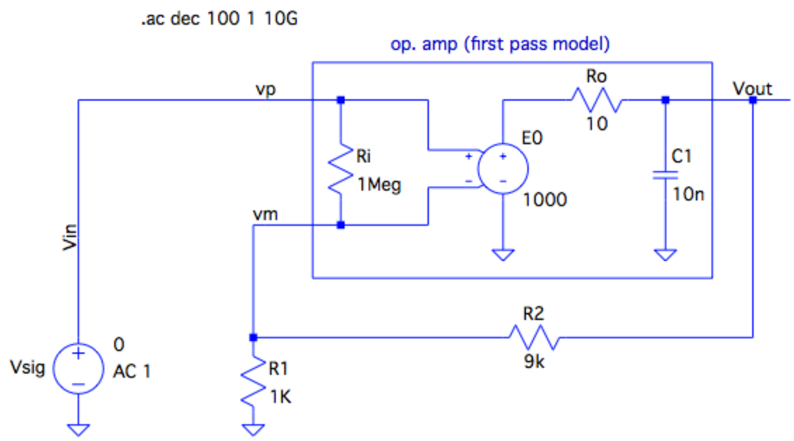


3. Verify the Bode Plot you have just drawn is correct by using LTSPICE. Connect vp to an AC voltage source of 1V and vm to ground. Simulate your circuit by running an LTSPICE's AC analysis. Run the AC analysis command sweeping the frequency in decades by using 100 points per decade. Start the sweep at 1 Hz and stop it at 10GHz.
Have LTSPICE plot magnitude and phase on two separate panes, and bring the printout with you to lab.

4. Go through the Lab. and answer all the theoretical/analytical questions.

Lab. - Part A

Modify your circuit to build a non-inverting op amp based amplifier, and run again the AC analysis.



Analytical expression of gain = ______________________________________

Using you analytical expression, compute the gain in dB = _________________

LTSPICE gain in dB = ______________________________________

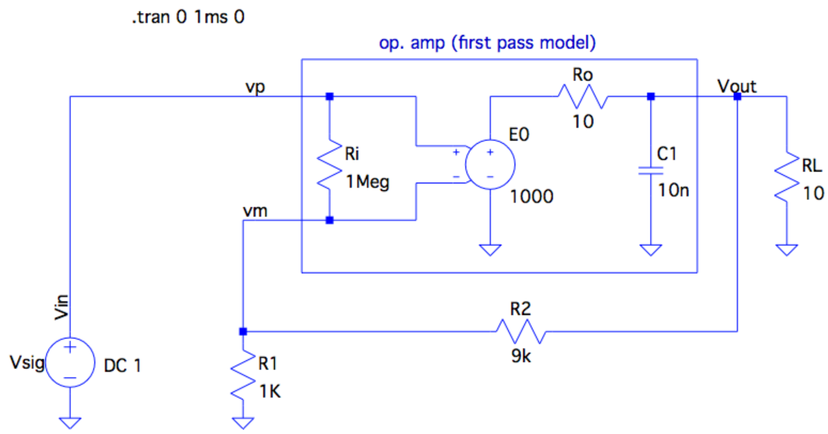
Bandwidth in Hz = ______________________________________
(hint: the gain-BW product must stay the same as the one you had for the open-loop op amp you analyzed in the prelab (open loop means the op amp is without the R1, R2 feedback network wrapped around it).

LTSPICE bandwidth in Hz = ______________________________________

Attach your LTSPICE magnitude plot.

Lab. - Part B

Modify the previous circuit as follows. Change Vsig into a DC voltage of 1V. Add a load RL = 10 Ω between the node Vout and ground. Change your simulation to be a TRAN analysis running for 1ms.



Calculate the following quantities (show the symbolic expressions you used). For simplicity in your derivations assume Ri is infinite.

Vout =

V(vm) =

I(Ri) =

I(Ro) =

I(R1) = I(R2) =

I(RL) =

Do the values simulated with LTSPICE match reasonably well? (is it within 10-20 %?) __________________

Vout =

V(vm) =

I(Ri) =

I(Ro) =

I(R1) =

I(R2) =

I(RL) =

How do you expect Vout to change if Ro increases to 100 Ω ?

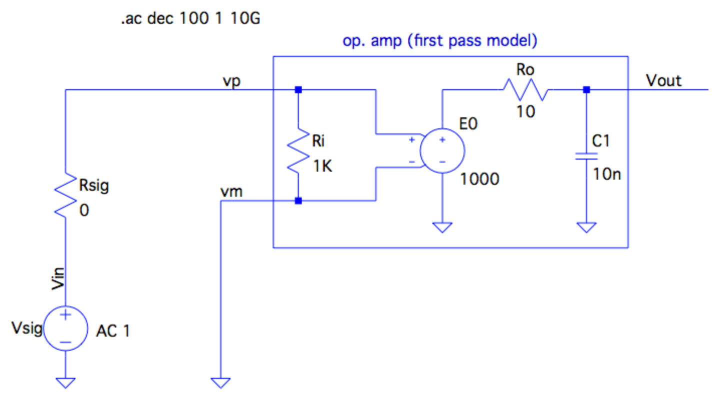
Vout =

Does the value simulated with LTSPICE match reasonably well? (is it within 10-20 %?) __________________

Vout =

Lab. - Part C

Modify the op amp model by reducing its input resistance to 1KΩ.



Do you expect Vout/Vin to change? ________________________

Why? ____

Run the AC analysis command and **attach the plot of the magnitude**?

LTSPICE Vout/Vin in dB = __________________________________

Let's now change Rsig to 1KΩ.
Do you expect Vout/Vin to change? ________________________

Why? ____

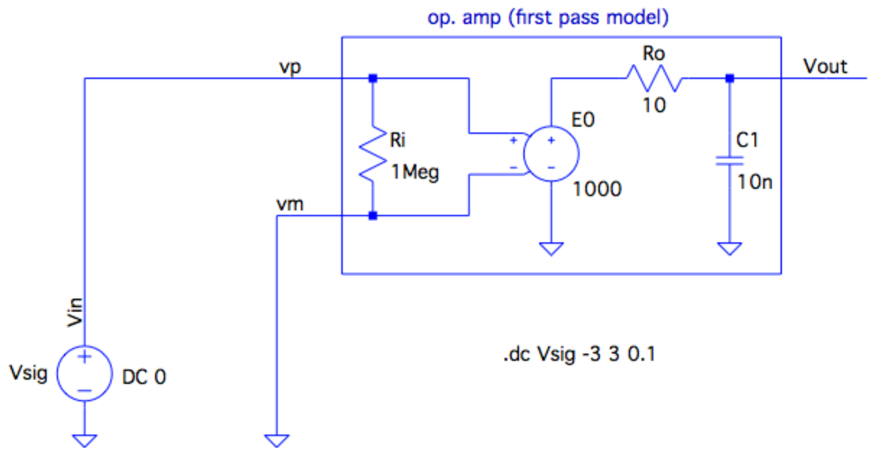
Compute the value of Vout/Vin and show the symbolic expression you used:

Vout/Vin in dB = __________________________________

LTSPICE Vout/Vin in dB = __________________________________

Lab. - Part D

Use LTSPICE to sweep the DC signal applied to the input of the open-loop op. amp from -3V to 3V.



Run the DC sweep analysis command and plot Vout vs. Vin simulation obtained. **Attach the plot**. What are the max and min values Vout according to the LTSPICE simulation?

LTSPICE Vout(max) =

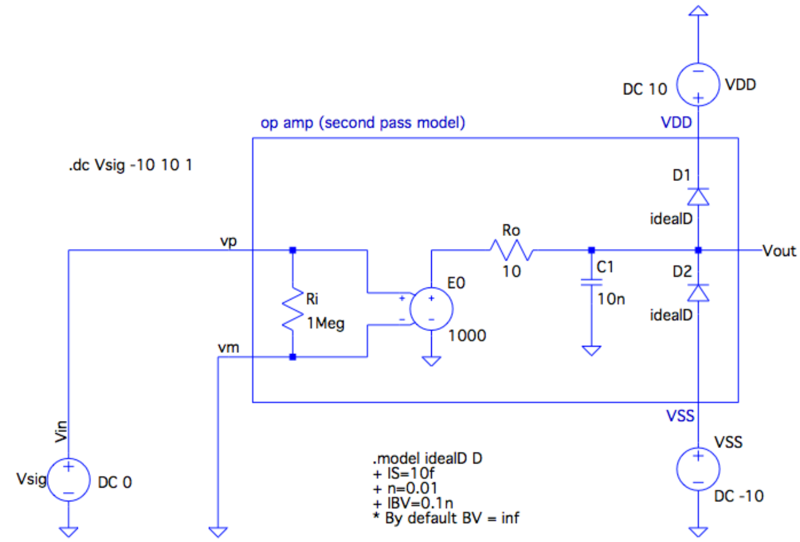
LTSPICE Vout(min) =

Assuming the op-amp has a positive supply rail of +10V and a negative supply rail of -10V what are the max and min values of Vin that can be applied to the op-amp without having the output saturating to the supply rail values

Vin(max) =

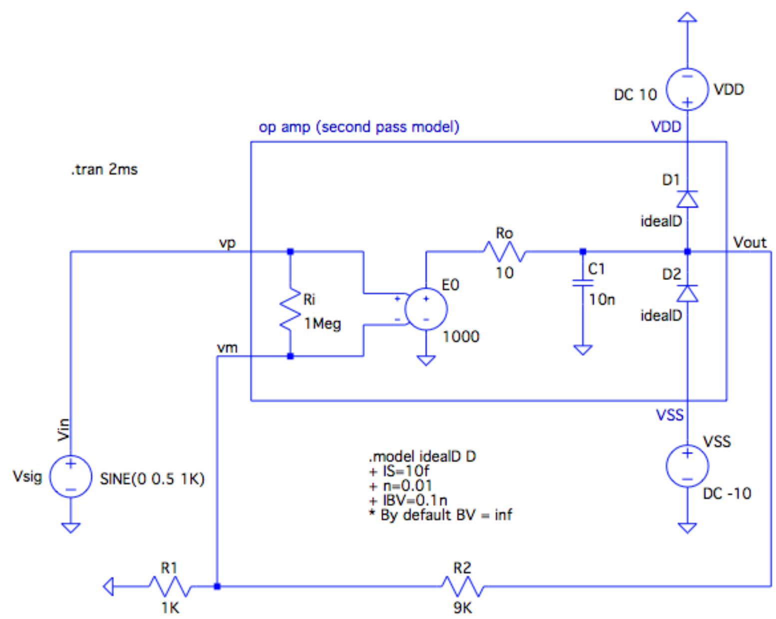
Vin(min) =

Modify the op amp model as follows to make the Vout vs. Vin DC transfer characteristic saturate at the supply rails.



Run the DC sweep analysis command and plot the Vout vs. Vin DC transfer characteristic. **Attach the plot**.

Modify your circuit to build a non-inverting op amp based amplifier. This time apply at the input a sinusoidal signal with 0.5 peak voltage and 1KHz frequency.



What is the max voltage at the output?

Vout(max) = ______________________

What is the frequency of Vout?

f = ________________________________

Run a TRAN analysis simulation and plot the Vout vs. time. Select the run time of the simulation to show exactly two full cycles of the Vout sinusoid.

Stop time = ____

Attach the plot.

What happen to Vout if you increase the peak voltage of Vsig to 2V?

Vout(max) =

Vout(min) =

Run the TRAN analysis simulation and plot the Vout vs. time. **Attach the plot.**

Modify the peak voltage of Vsif back to 0.5V, but this time increase the frequency to 1GHz. Run a TRAN analysis simulation and plot the Vout vs. time. Run the simulation for 12ns, but start saving the data only at 10ns

Attach the plot.

Why is Vout(max) smaller than 0.5V times the amplifier gain?

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