**Frequency Compensation of an Operational Amplifier (Computer Experiment)**

ECE 3200 Electronics II
updated 6 April 2020

## References

1. A. S. Sedra and K. C. Smith, *Microelectronic Circuits*, 6th ed., Oxford University Press, 2009.

## Objectives

1. To develop an in-depth understanding of frequency compensation and negative feedback

2. To apply mathematical and/or circuit analysis skills and software to a non-trivial engineering design problem

## Procedures
## (MUST BE COMPLETED INDIVIDUALLY)

1. Document all work for this lab in your laboratory notebook. When performing this lab you may use any suitable mathematical and/or circuit analysis tools, e.g. LTspice (linear.com), MATLAB®, etc.

2. *Op-Amp Characterization*. Figure 1 shows the model of an operational amplifier to be used in this experiment. Find the transfer function $T(s) = Vo(s)/V_{id}(s)$. Provide a Bode magnitude and phase plot for this transfer function.

3. *Uncompensated Closed Loop Operation*. Now consider use of the operational amplifier of Figure 1 in the non-inverting amplifier configuration of Figure 2. Assume $C_c = 0$. Find the minimum closed loop gain that will guarantee stable amplifier operation. While your Bode plot can be used to obtain an approximate gain, your final answer must be within 0.5% of the true value. Thus you will need to use computational and not graphical techniques to obtain the gain value.

4. Consider use of the non-inverting amplifier configuration of Figure 2 to obtain a closed loop gain of 60dB. Based on your previous results, will this circuit "work?" Plot the time domain response $v_o(t)$ of this circuit to a 1mV step input.

5. *Compensation*. Determine all component values (including the value of $C_c$) so that the operational amplifier of Figure 1 can be used to provide a closed loop gain of 60dB with a phase margin of 45° ± 1% using the non-inverting configuration of Figure 2. Again, you will need to use computational and not graphical techniques to obtain the final component values.

6. Plot the time domain response $v_o(t)$ of your compensated circuit design to a 1mV step input.

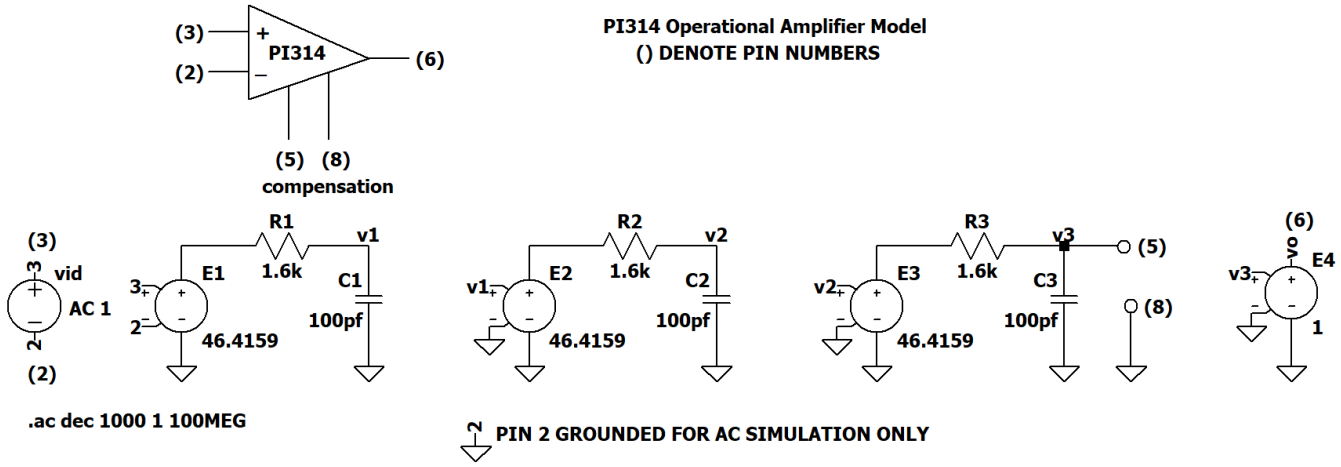


Figure 1. PI314 Operational Amplifier Model

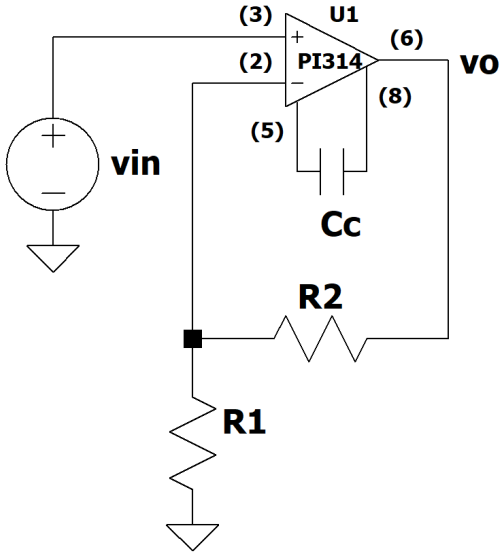


Figure 2. Non-inverting amplifier using a PI314 Op-Amp

**Exercises**

1. Report your work using the ECE 3200 laboratory report format.
   Include answers to the remaining exercises as an appendix.

2. Some operational amplifiers (as in the PI314) are not unity-gain stable without compensation. Why would manufacturers sell op-amps that are not unity-gain stable?

3. Why is the final voltage dependent voltage source (gain of 1) used in the op-amp model of Figure 1?

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