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Amplifier compensation

Goals

- Realize high gain accuracy in a feedback amplifier
- Preserve stability while doing so

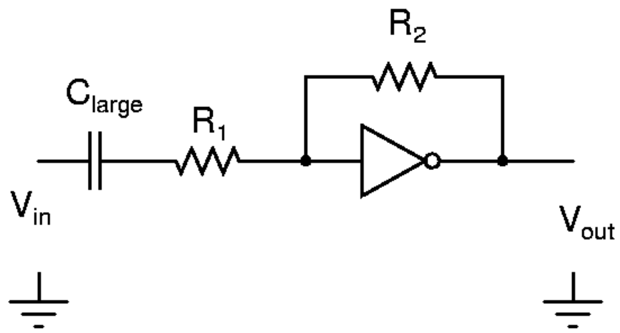
References

- Revisit problems 1 to 7 of this problem set [http://www.ee.iitm.ac.in/vlsi/_media/courses/ee3002_2014/ee3002prob7.pdf] from EE3002: Analog Circuits [http://www.ee.iitm.ac.in/vlsi/courses/ee3002_2014/start]

Notes

- Use a 6V supply for this experiment. You'll need the g_m value measured in the previous experiment.
- Connect inputs of unused inverters to ground

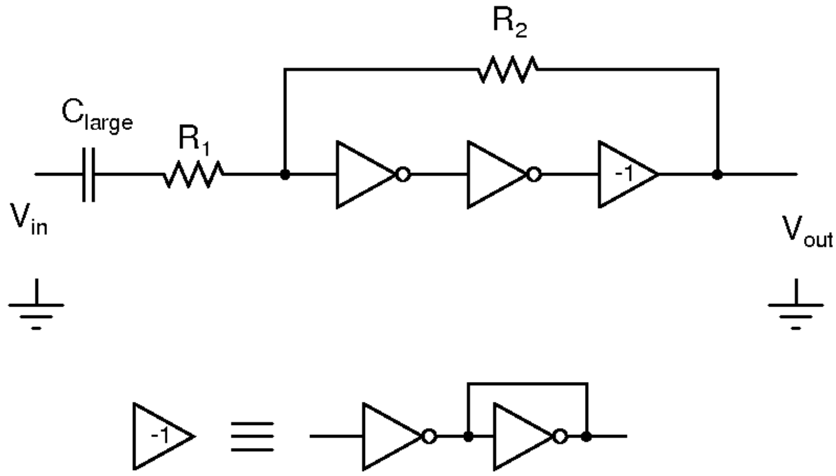
Experiments



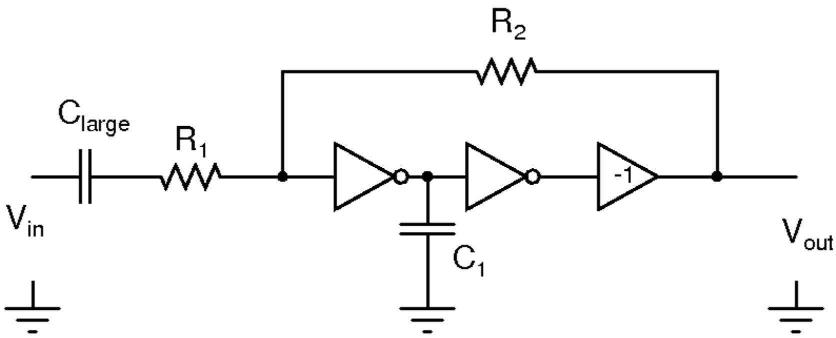
- Determine the gain of the amplifier in (a) when the transconductance of the inverter tends to infinity. Build the amplifier in (a) with an ideal gain of 2 and R_1 in 5kΩ to 10kΩ range. Use a 6V supply for this experiment.

Measure the gain error. Determine the expression for the gain in the above figure and check if theory and experiment are in agreement.

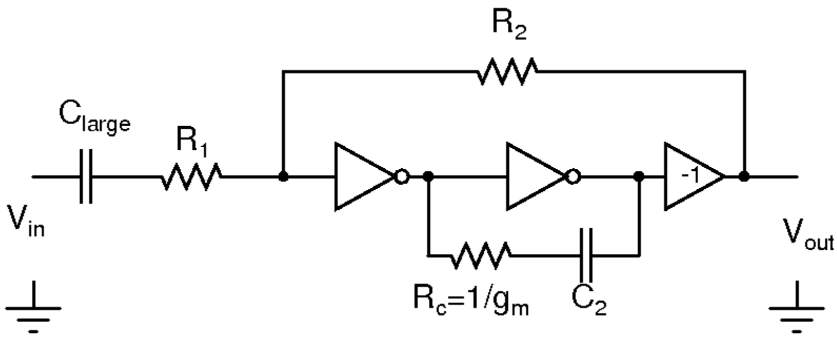
- Apply a small(~100mV_{pp}) squarewave and measure the step response. Is there an overshoot/ringing? Apply a small sinusoidal input, sweep its frequency, and determine the bandwidth-i.e. the frequency at which the gain is 1/sqrt(2) times the low frequency gain("low frequency" should be above the cutoff frequency of the ac coupling network).



- The gain error can be reduced by increasing the loop gain. Use another inverter in cascade (and a unity gain inverter for negative feedback) as shown above and measure the circuit. Does it result in a better amplifier? What do you see at the output? Turn off the input source and observer the output on the scope. What do you see in this case? Explain.



- Compensate the amplifier by connecting a capacitor C_1 to ground as shown above. Adjust its value for 10% overshoot. While choosing the compensation capacitor, start from small values, of the order of 100pF. Determine the bandwidth.



- Compensate the amplifier by connecting a capacitor C_2(with a zero cancelling resistor in series-What should be its value?) across the second stage as shown above. Adjust its value for 10% overshoot. Comment on the compensation capacitor values C_1 and C_2 in the two cases. While choosing the compensation capacitor, start from small values, of the order of 100pF. Determine the bandwidth.

  - Comment on the compensation capacitor value in the two cases.
  - Comment on the bandwidth in the three cases(single stage in feedback, and two compensated amplifiers).

- Short out the zero cancelling resistor and test the step response. Look closely at the step response and determine the qualitative differences between the two cases.

Applications

- A cascade of two transconductor stages(with perhaps an output buffer in some cases) is the most common opamp topology. Miller compensation is the most widely used method of frequency compensation for opamps. Although the transconductor topologies are different in an opamp, the principles of obtaining high gain and frequency compensation are exactly the same as what is done here. For instance see the schematics in the datasheets of LM324 of LF347 opamps which you'll be using later in this lab. You'll be using these steps in simulations/measurements of opamps and other feedback loops(such as the voltage regulator in the next experiment).