
Experiment 14 - Frequency Response of Differential Amplifiers

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UC Berkeley EE 105

1.0 Objective

This lab will introduce the student to frequency response of differential pairs. The student will be introduced to dominant poles analysis of differential pairs. The student will analyze how the differential pair responds to the presence of one large Miller capacitor. The student will also analyze the frequency response of a differential pair with differential and common mode inputs. SPICE will also be used to simulate the frequency response of the differential pairs. The key concepts introduced in this experiment are:

- Frequency response for differential and common mode input.

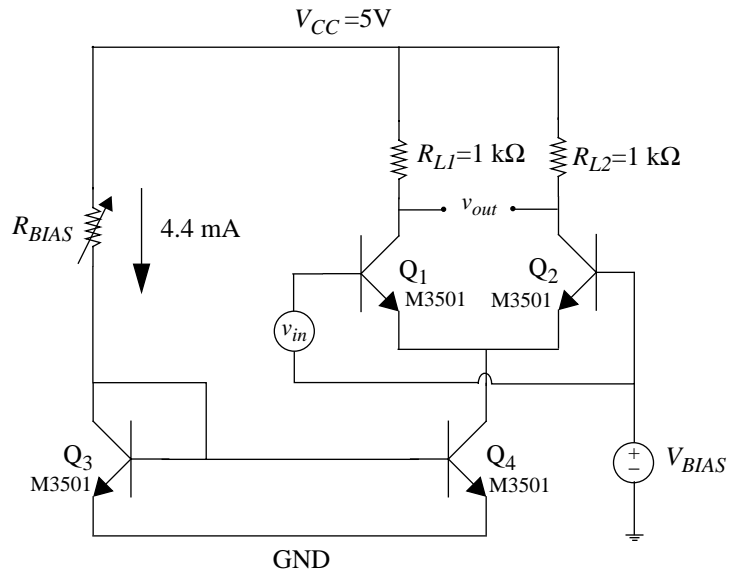
2.0 Prelab

- H & S: Chapters 10.1 - 10.3 and 11.4-11.5.

For the Common Emitter Amplifier below, determine the poles of the system ($\beta_F=100$ $V_{A_n}=50$ V). Use $C_\mu = 50$ fF and $C_\pi = 1.5$ pF.

FIGURE 1.

Bipolar Differential Pair



3.0 Procedure

3.1 Frequency Response of Differential Pair

FIGURE 2.

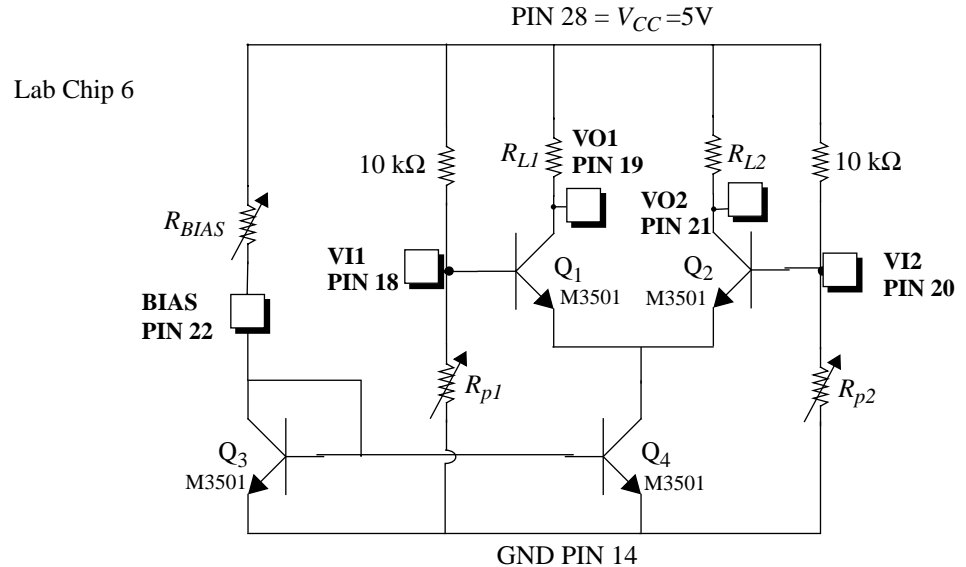
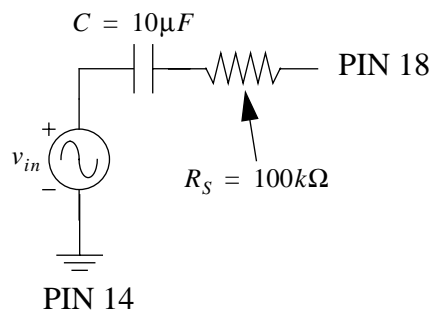


FIGURE 3.

Input Signal into Common Emitter Amplifier



1. Construct the circuit in figure 2. Use $R_{L1,L2} = 1k\Omega$
2. Using the oscilloscope or the gain phase meter, find the gain v_{out}/v_{in} .
3. Now increase the frequency until the output decreases by a factor of 0.707 (-3dB). Note also the phase at this frequency. Is the phase consistent with the magnitude?
4. Make a bode plot of the gain (both magnitude and phase) for differential mode and common mode inputs.
5. Using the data of part 4 plot the Bode Plot of the CMRR of this differential pair.

Lab Tip

At higher frequencies, the input signal will begin to attenuate to the point that the gain-phase meter will not be able to detect it. You can compensate by increasing the amplitude of the signal generator. The oscilloscope is helpful in determining if the amplitude of the input waveform needs to be increased.

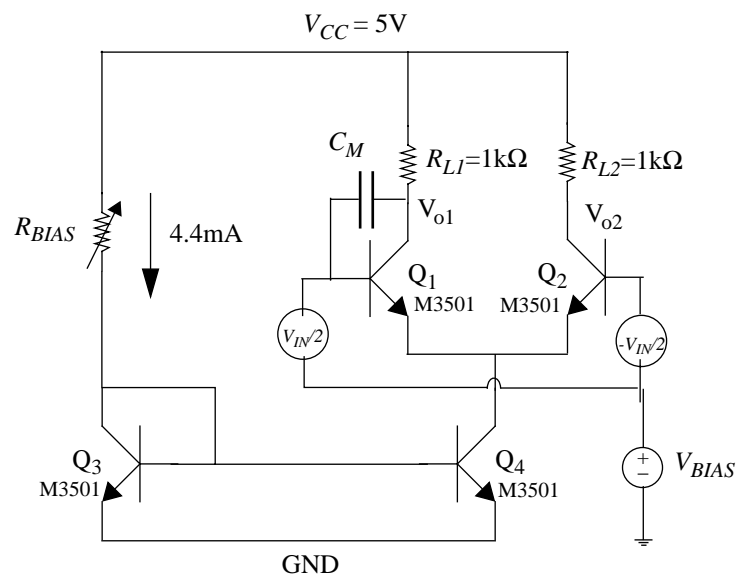
On the gain-phase meter, changing the phase reference dial from A to -A will either give you a starting reference of 0 or -180. Pick one and be consistent.

It is helpful to have the oscilloscope monitoring the waveforms so you can see them at all times

3.1.1 Miller Effect

1. Add $C_M = 1$ nF to the circuit you built as in figure 4. Measure the -3dB frequency from each output node.
2. For each of the output nodes, find the frequency and phase response and determine the poles.
3. Looking at the differential input of figure 4, can you explain why each output has a dominant pole at very different frequencies. Do the poles that you found in part 2 make sense?

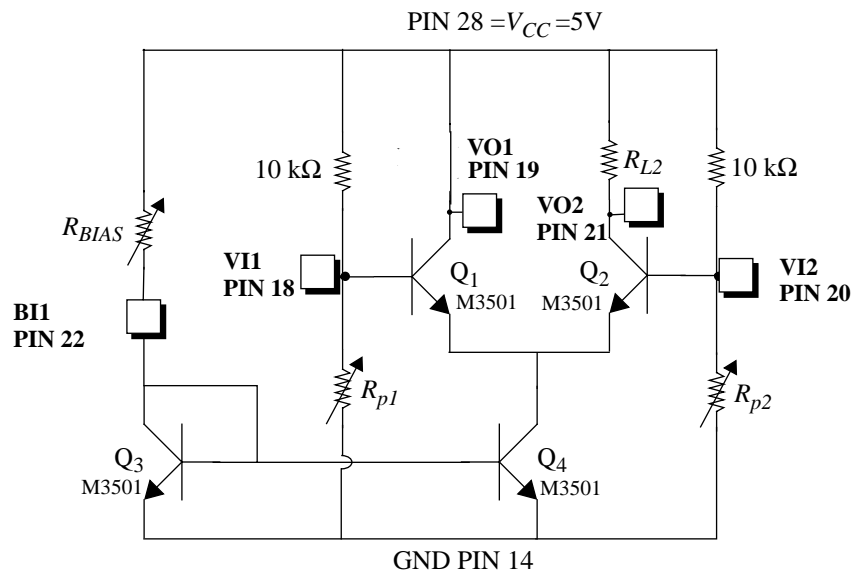
FIGURE 4.



3.1.2 Quasi- Differential Pair (actually, common base - common collector cascade)

1. Remove R_{LI} and connect PIN 19 to V_{CC} as in figure 5.
2. Find the frequency (both magnitude and phase) responses of the circuit in figure 5 for both differential and common mode input.
3. With the data collected in part 2, make bode plots for A_{vd} , A_{vc} and CMRR.
4. What can you tell about this circuit. Is it really a differential pair? Does it have good CMRR?

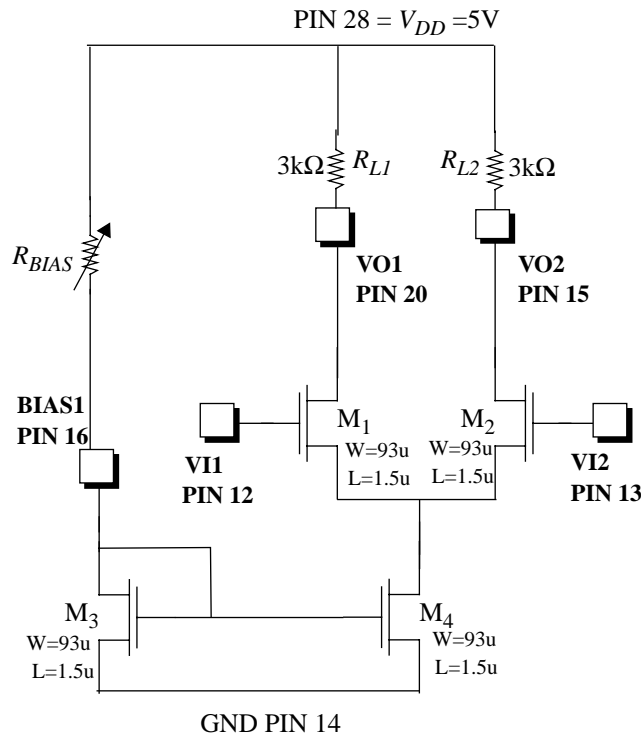
FIGURE 5.



3.2 Frequency Response of MOS Differential Pair

1. Construct the circuit shown in figure 6.

FIGURE 6. MOS Differential Amplifier (MOSDP, Lab Chip 5)



Note: Don't forget to bias the gates to about 3V.

2. Find the frequency response (both magnitude and phase) of this circuit for both differential and common mode inputs.
3. Make body plots for A_{vd} , A_{vc} , and CMRR.
4. Compare the frequency response of the MOS differential amplifier with the frequency response of the BJT differential amplifier

3.3 Two Stage MOS Differential Pair

1. Build the amplifier shown in figure 7. Make sure that the output voltages of each stage are biased around 2.75V. Make sure all transistors are in saturation.
2. Feed a small signal into VI11 in the same manner that we explained in Experiment 13. The amplitude of the signal should be around 1.5V.
3. Find the frequency response (both gain and phase) of the amplifier for both stages. Record the location of the poles. You should be able to see two poles without much difficulty.
4. Explain how the poles affect the gain response and the phase response of the amplifier.

