Rochester Institute of Technology

EEEE 381 - Electronics I
Technical Memorandum

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To:	To: Tyler Nicholson — Section L3
Date:	Performed: 04-03-2015; Due: 04-17-2015
Subject:	Lab #4: MOSFET Differential Pair with Active Load

Abstract

The purpose of this exercise was to utilize the previously designed current source to implement an amplifier circuit. The modified Wilson current source was used as a bias current source for an active load differential amplifier with a single output. Once the circuit was designed and implemented correctly, it exhibited a gain that was close to the calculated value.

Theory

The circuit used for this exercise is shown in figure 1.

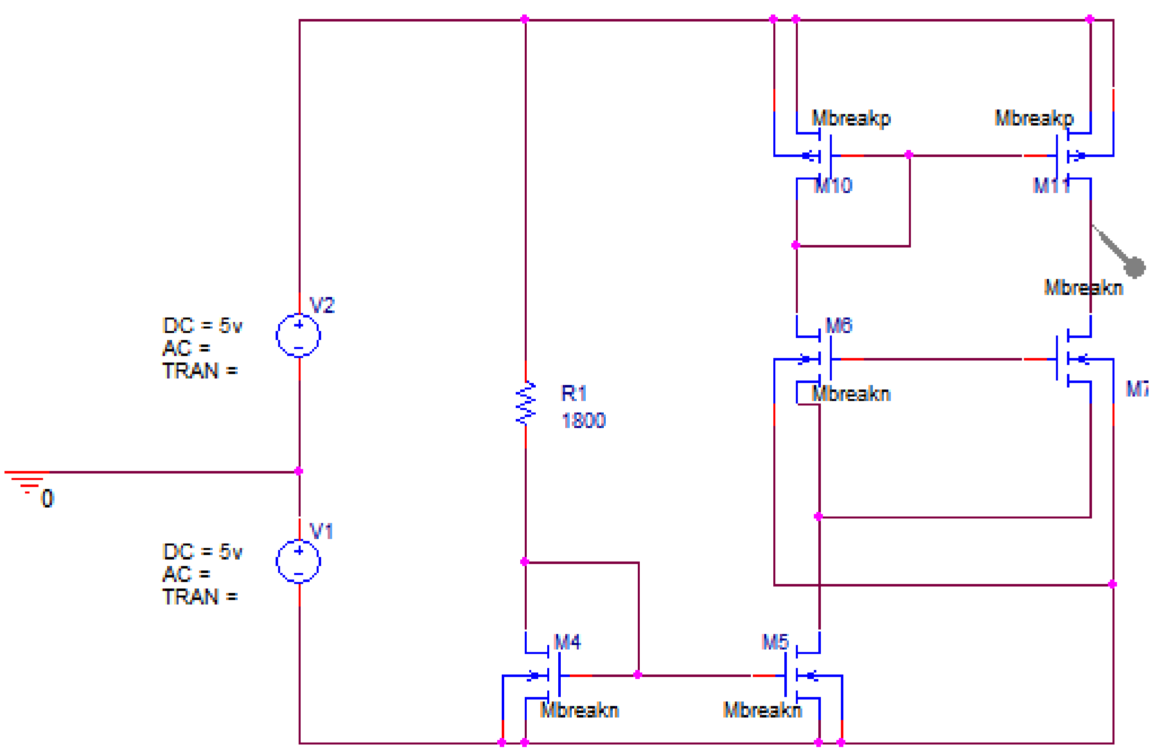

Figure 1: Basic Amplifier Circuit

By grounding the gates of the two NMOS transistors in the amplifier circuit, and assuming an I_{ref} of 4mA, the Q-point values V_{GSQ1} and V_{GSQ2} can be found through the application of equation 1. V_{GSQ1} and V_{GSQ2} were calculated to be 1.96V.

$$I_D = \frac{1}{2}k(V_{GS} - V_t)^2 \tag{1}$$

Equation 1: MOSFET Current Equation

In order to allow bias current to flow through both sides of the amplifier, a common mode voltage, V_{COM} needs to be applied. To ensure that all transistors remain in saturation, a minimum V_{COM} value needs to be found. This value is calculated through equation **??**. This value was found to be ¡TODO¿.

An important parameter of an amplifier is its gain. In the differential amplifier, there are two types of gain, differential and common mode. Differential gain refers to the gain when there is a differential voltage applied. Common mode gain is the gain of a common mode signal, or the same voltage applied to both inputs in addition to the differential signal.

Common mode signals are most likely noise that affects both inputs. Because the differential amplifier takes a difference between its two inputs, it is relatively good at filtering out common mode signals. To calculate the differential gain, A_d, equation 2 is used. Calculation of the common mode gain, A_{cm}, uses equation 3.

$$A_d = (fracv_o v_{diff}) = g_m(r_{o2}||r_{o4}||R_L) \tag{2}$$

Equation 2: Equation for the Calculation of the Differential Gain

$$A_{CM} = (\frac{v_o}{v_{cm}}) \approx -\frac{1}{2g_{m3}R_o} \tag{3}$$

Equation 3: Equation for the Calculation of the Common Mode Gain

The ratio of differential gain to common mode gain is called the common mode rejection ratio. This is usually measured in decibels, and is calculated through equation 4.

$$CMRR(dB) = 20log\left|\frac{A_d}{A_{CM}}\right| \tag{4}$$

Equation 4: Equation for the Calculation of the Common Mode Rejection Ratio

¡TODO¿ RESULTS

The MOSFET parameters previously calculated can also be found through the use of PSpice simulation software. The simulated Q-point values were found to be ¡TODO¿. Adding an AC signal to one of the gates of the amplifier, in addition to the common mode voltage, enables the study of the amplifier over many voltages. The circuit used to accomplish this is given in figure **??**.

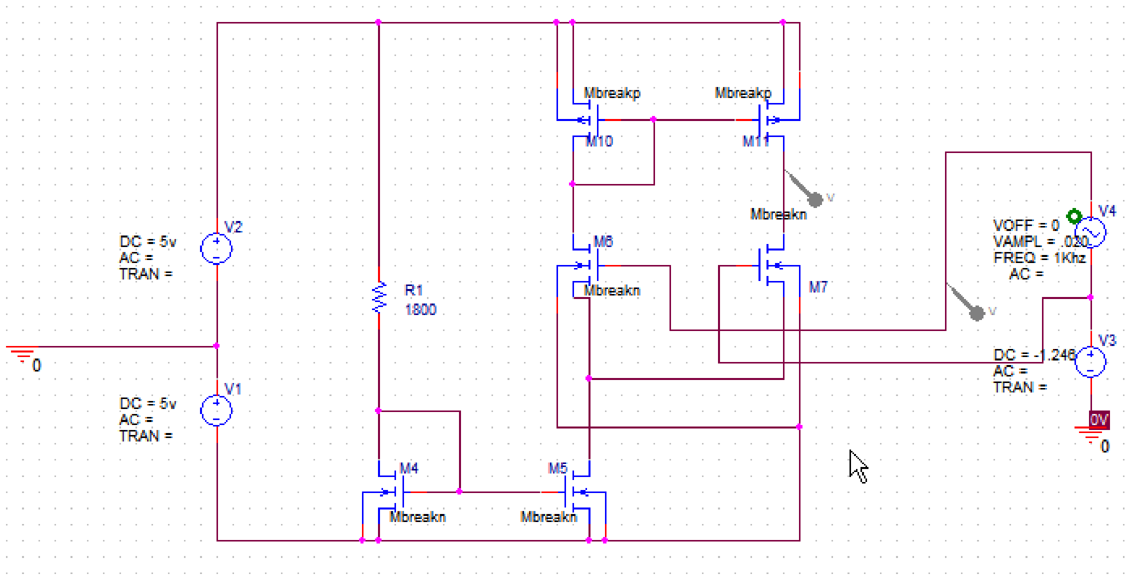

Figure 2: AC Differential Input Circuit

A plot of the data gathered is shown in figure ??. Using the input and output voltages gathered from the simulation, the differential gain was simulated to be ¡TODO¿. Similarly to how the differential gain was calculated, the common mode gain can be calculated using a simulation. This was done using the circuit in figure 3. The plot of the data gathered is given in figure ??.

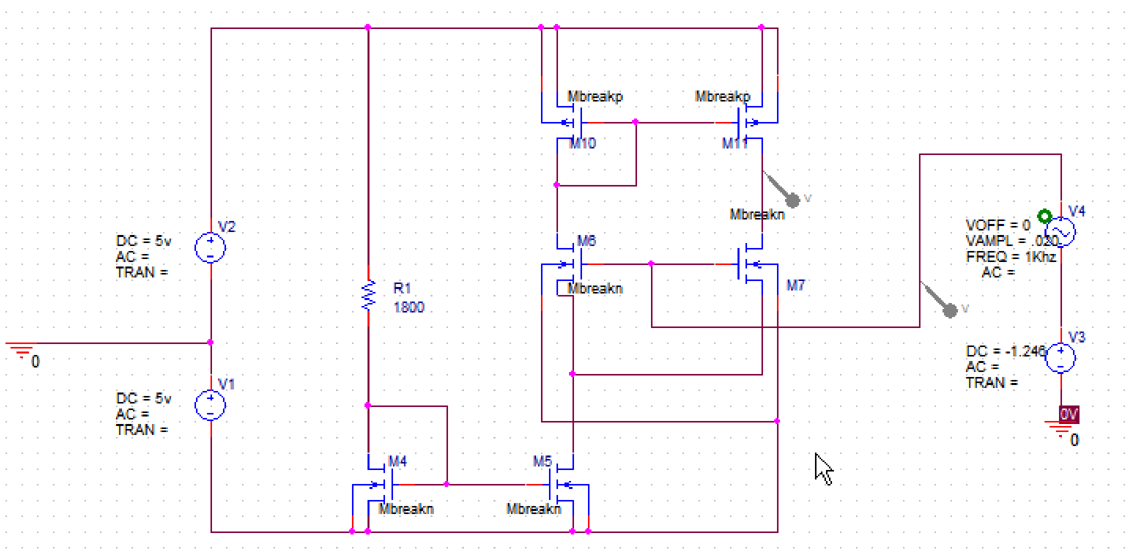

Figure 3: Common Mode Gain Input Circuit

The common mode gain was calculated to be ¡TODO¿, giving a common mode rejection ratio of ¡TODO¿.

Results

Conclusion

Current sources are important for amplifying circuits. The more stable the source, the bettor quality of amplification. This exercise reinforced theory learned in class and was valuable in that it taught the use and troubleshooting of important circuits which will be used later in lab. Even though the results for the output resistance were off for the Wilson source, the results were consistent, suggesting a problem with the measurements, or the chip. The results for the simple source were consistent and close to the expected values.