EveryCircuit Assignment: Basic MOSFET Circuits

In this assignment you will analyze a collection of basic MOSFET circuits. For each circuit, you will do the following:

1. Use MOSFET equations to predict the DC operating point.
2. For amplifier circuits, calculate small-signal parameters g_m, r_o, and predict the amplifier gain.
3. Simulate using EveryCircuit and compare the results to your calculations.
4. Take a screenshot showing the EveryCircuit simulation.

Throughout this assignment you will use the default MOSFET parameters from EveryCircuit:

	NMOS	PMOS
K	590u	454.5u
Vth	0.43	0.4
lambda	0.06	0.1

Additionally, you will use these circuit parameters for each problem:

- VDD = 10V
- IB = 100uA

Problem 1: NMOS Current Mirror

For the NMOS current mirrow shown below, the desired bias current is IB, and the current delivered to the load is IL. Determine the required bias resistor R, calculate the gate voltage VG, and predict the drain voltage and current on the load side, VD and IL respectively.

Enter your calculations in the table below. Then simulate the circuit and enter measured values in the table. If the simulations are very different from the calculations, you should check your work for mistakes.

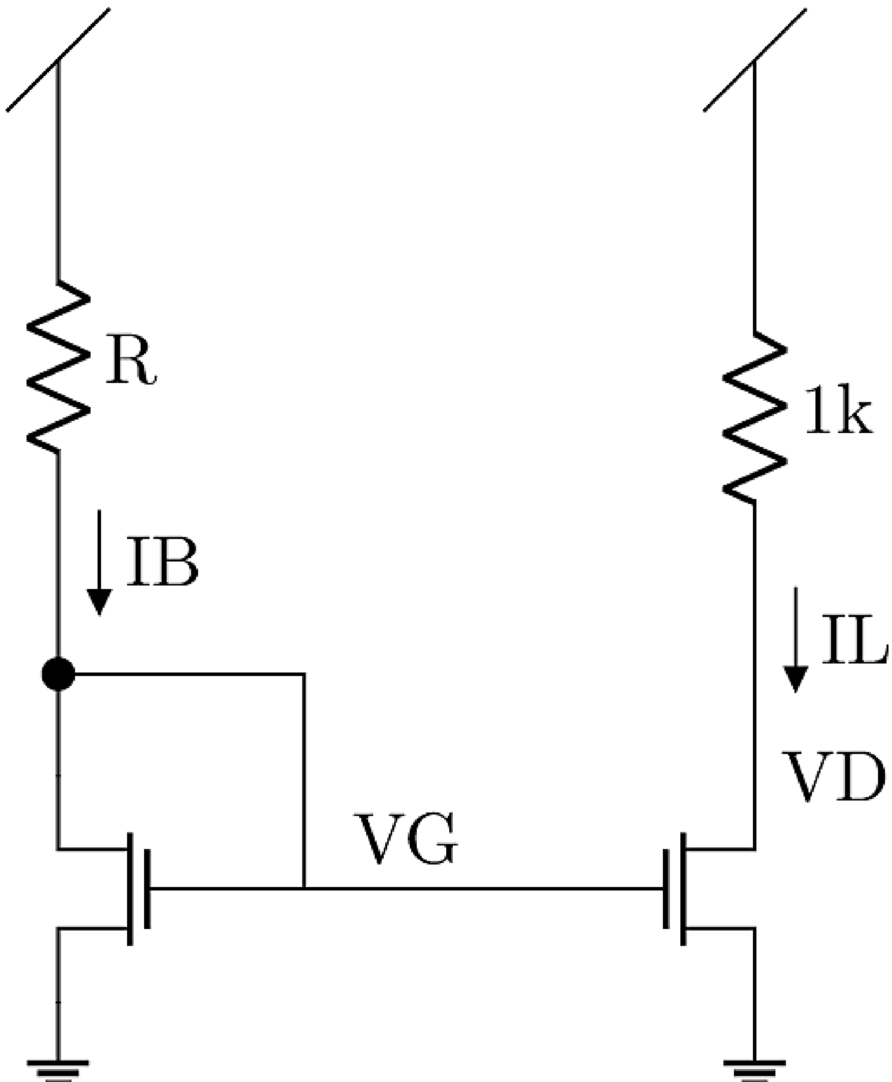

Figure 1: NMOS current mirror circuit.

	Calculation	Simulation
R		
VG		
IL		
VD		

Attach a screenshot of the EveryCircuit simulation showing your measurements.

Problem 2: NMOS Passive-Bias Amplifier

Now modify the NMOS current mirror circuit to create the amplifier shown below. Note that the 1k load resistor is now replaced with a duplicate of your bias resistor R. The signal source should have a zero-to-peak amplitude of 5mV and a frequency of 1kHz. Calculate the small-signal parameters gm, ro, and the amplifier's gain, then compare to simulation results.

Enter your calculations in the table below. Then simulate the circuit and enter measured values in the table. If the simulations are very different from the calculations, you should check your work for mistakes.

	Calculation	Simulation
gmn		X
ron		X
Av		

Attach a screenshot of the EveryCircuit simulation showing your measurements.

Problem 2: NMOS Ideal Active-Bias Amplifier

Now modify the NMOS current mirror circuit to create the amplifier shown below. Note that the load resistor is now replaced with an ideal current source. The signal source should have a zero-to-peak amplitude of 5mV and a frequency of 1kHz. Calculate the small-signal parameters gm, ro, and the amplifier's gain, then compare to simulation results.

Enter your calculations in the table below. Then simulate the circuit and enter measured values in the table. If the simulations are very different from the calculations, you should check your work for mistakes.

	Calculation	Simulation
gmn		X
ron		X

	Calculation	Simulation
Av		

Attach a screenshot of the EveryCircuit simulation showing your measurements.

Problem 4: PMOS Current Mirror

For the PMOS current mirrow shown below, the desired bias current is IB, and the current delivered to the load is IL. Determine the required bias resistor R, calculate the gate voltage VG, and predict the drain voltage and current on the load side, VD and IL respectively.

Enter your calculations in the table below. Then simulate the circuit and enter measured values in the table. If the simulations are very different from the calculations, you should check your work for mistakes.

	Calculation	Simulation
R		
VG		
IL		
VD		

Attach a screenshot of the EveryCircuit simulation showing your measurements.

Problem 5: PMOS Passive-Bias Amplifier

Now modify the PMOS current mirror circuit to create the amplifier shown below. Note that the 1k load resistor is now replaced with a duplicate of your bias resistor R. The signal source should have a zero-to-peak amplitude of 5mV and a frequency of 1kHz. Calculate the small-signal parameters gm, ro, and the amplifier's gain, then compare to simulation results.

Enter your calculations in the table below. Then simulate the circuit and enter measured values in the table. If the simulations are very different from the calculations, you should check your work for mistakes.

	Calculation	Simulation
gmp		X
rop		X
Av		

Attach a screenshot of the EveryCircuit simulation showing your measurements.

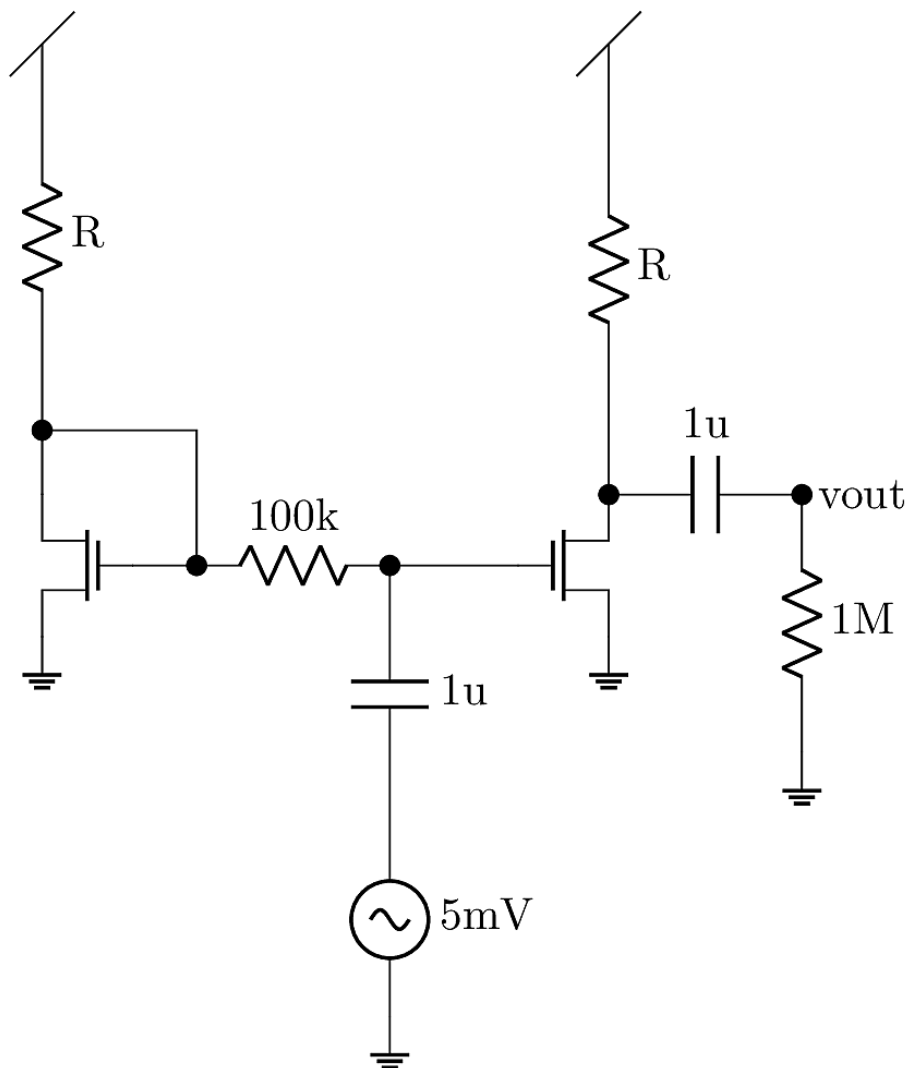

Figure 2: NMOS passive-bias amplifier circuit.

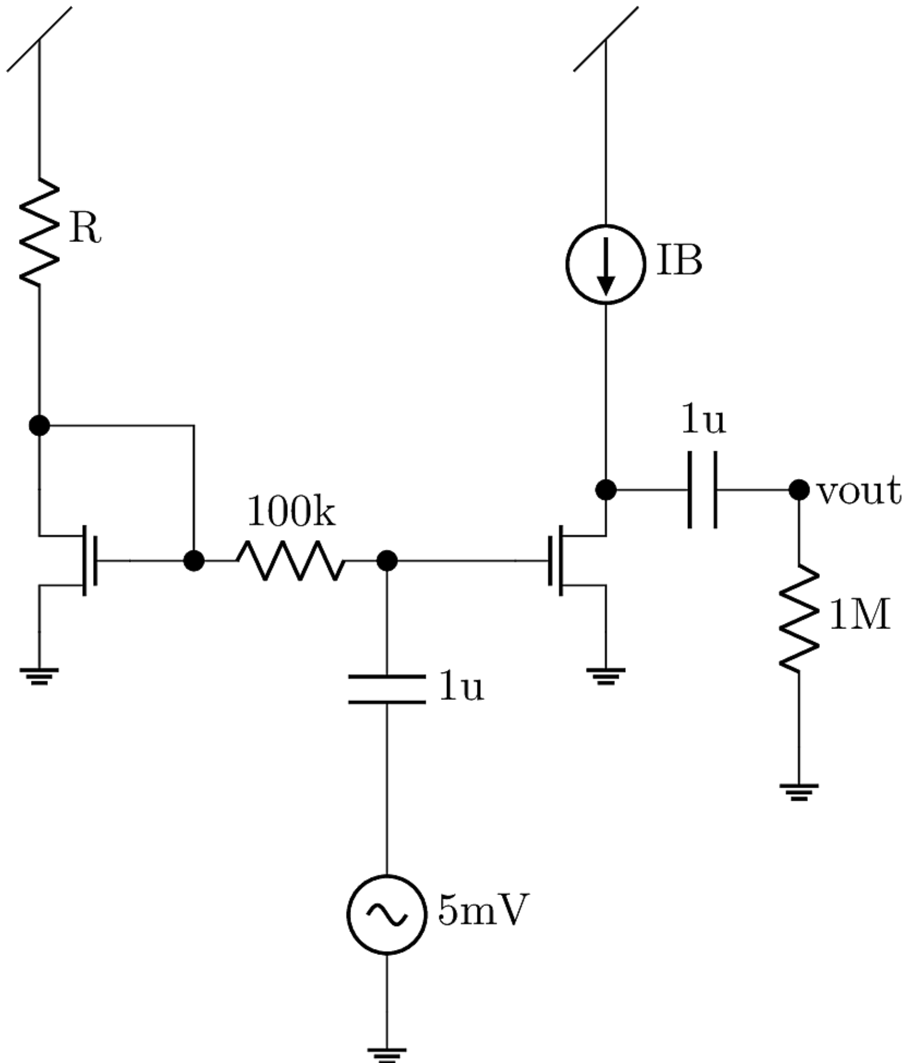

Figure 3: NMOS ideal active-bias amplifier circuit.

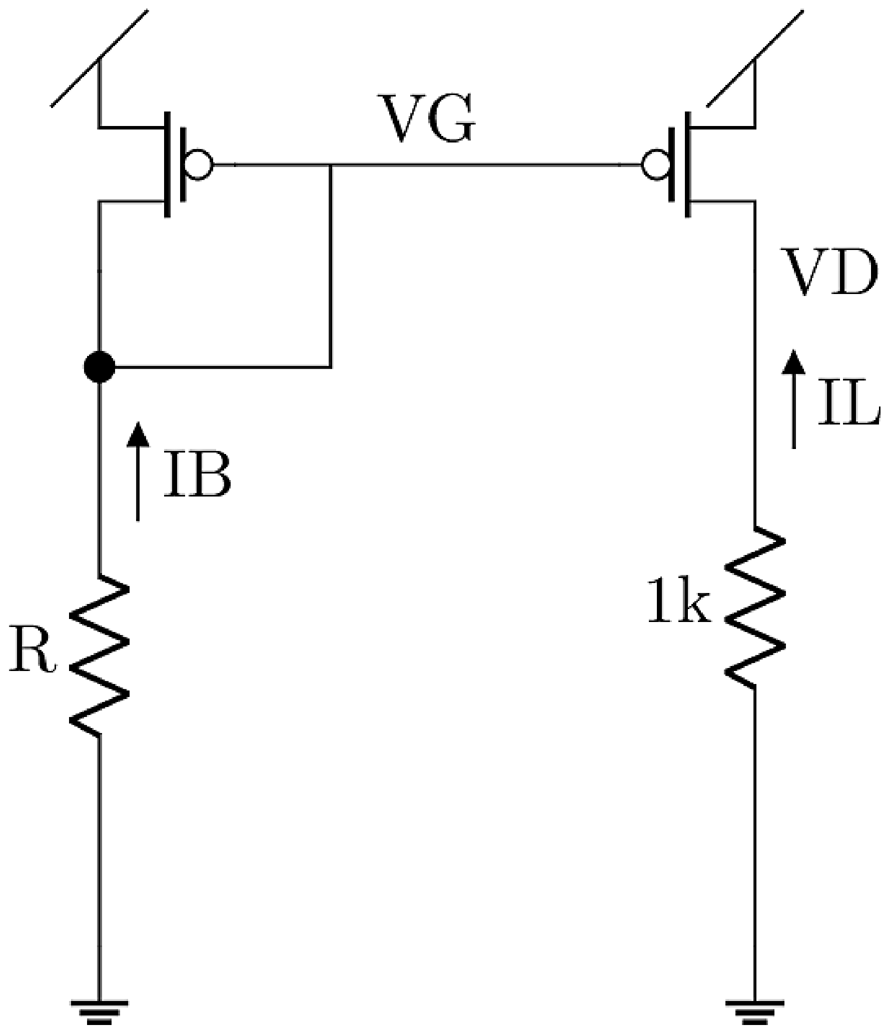

Figure 4: PMOS current mirror circuit.

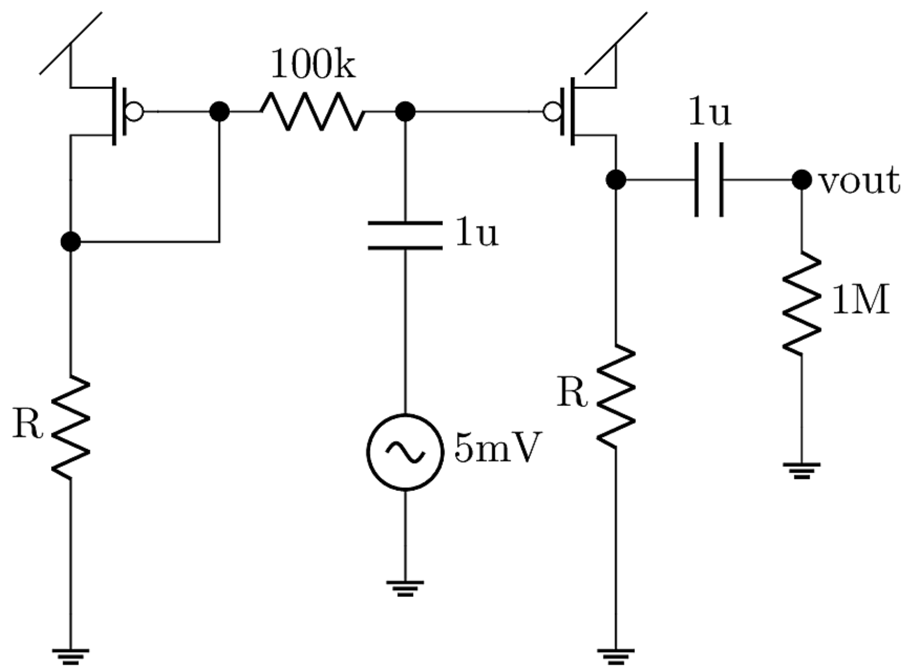

Figure 5: PMOS passive-bias amplifier circuit.

Problem 6: PMOS Ideal Active-Bias Amplifier

Now modify the PMOS current mirror circuit to create the amplifier shown below. Note that the load resistor is now replaced with an ideal current source. The signal source should have a zero-to-peak amplitude of 5mV and a frequency of 1kHz. Calculate the small-signal parameters gm, ro, and the amplifier's gain, then compare to simulation results.

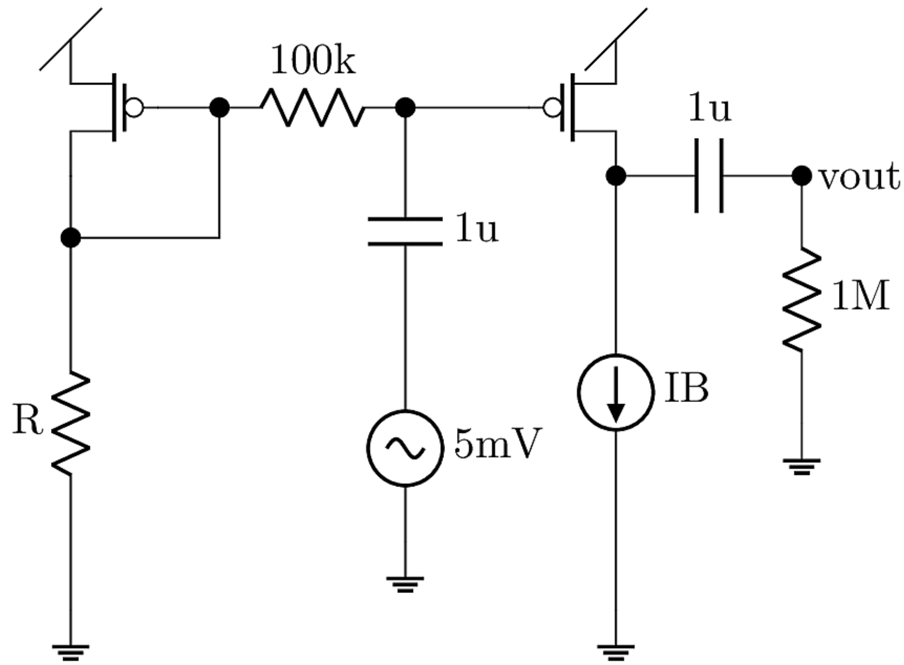

Figure 6: PMOS ideal active-bias amplifier circuit.

Enter your calculations in the table below. Then simulate the circuit and enter measured values in the table. If the simulations are very different from the calculations, you should check your work for mistakes.

	Calculation	Simulation
gmp		X
rop		X
Av		

Attach a screenshot of the EveryCircuit simulation showing your measurements.

Problem 7: CMOS Active-Bias Amplifier

Now you will combine NMOS and PMOS mirrors to create a practical amplifier circuit. This circuit is called a "Complementary" MOS or "CMOS" amplifier because it combines both device polarities. For this circuit, you can re-use calculations for R, gm and ro. Using those calculations, predict the amplifier's gain and confirm the result using EveryCircuit.

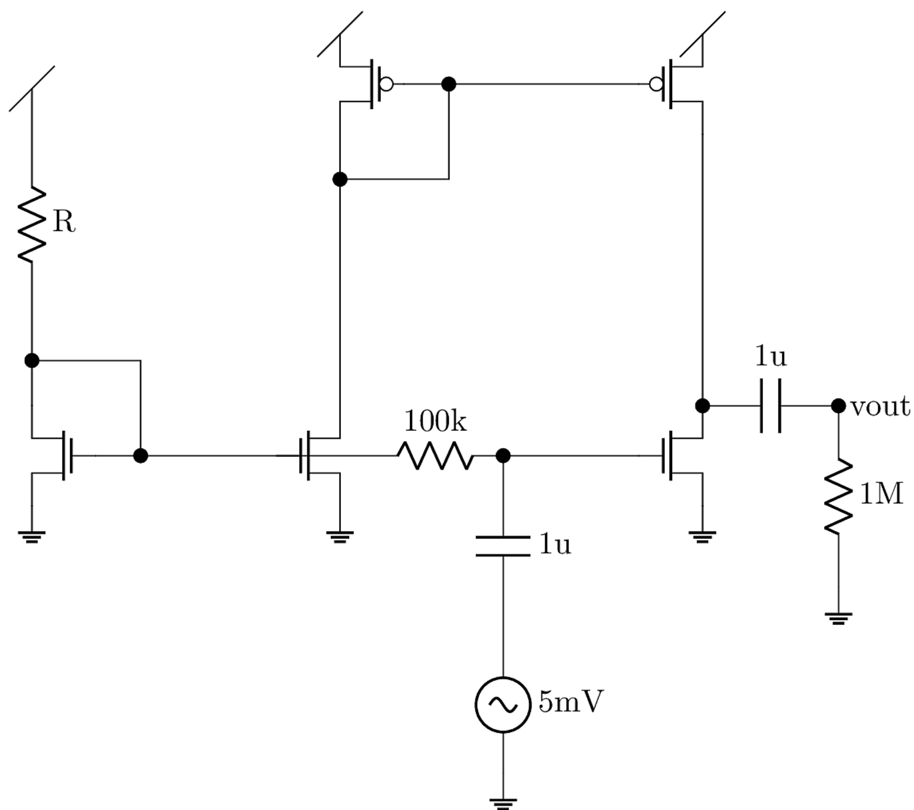

Figure 7: CMOS active-bias amplifier circuit.

	Calculation	Simulation
Av		

Attach a screenshot of the EveryCircuit simulation showing your measurements.