Lab 2: Current Mirrors

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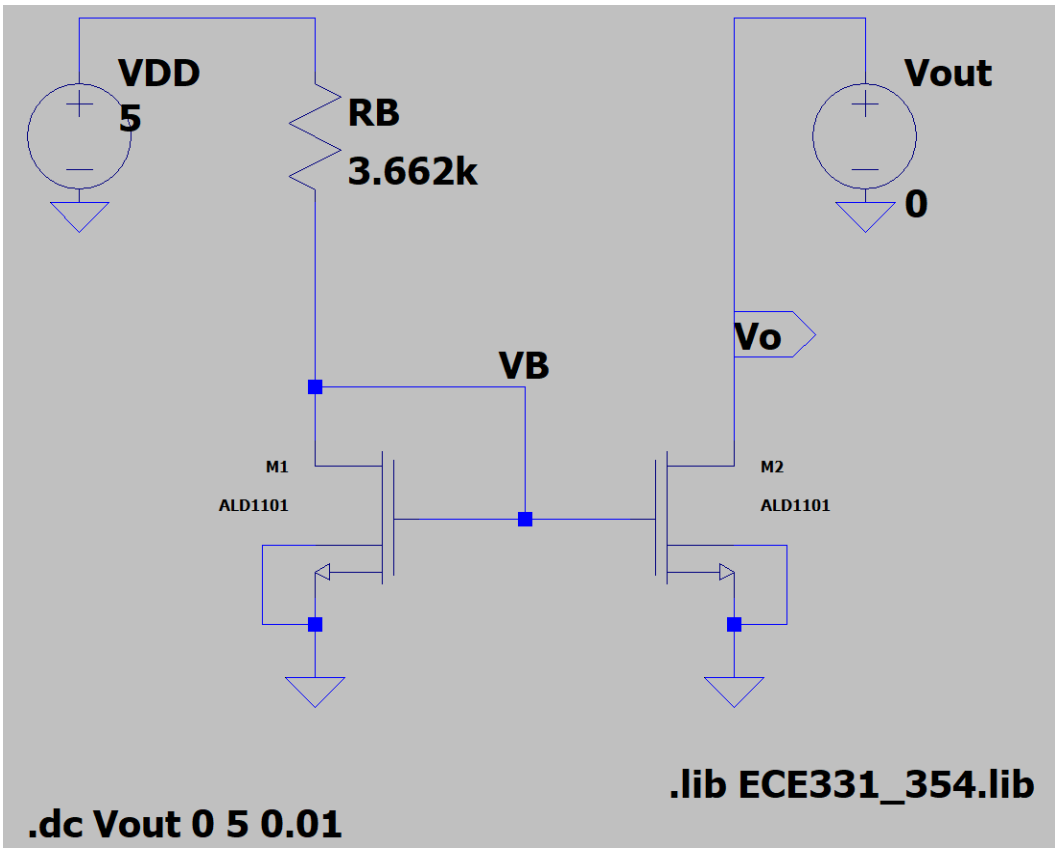
Preparation

1. Current mirrors

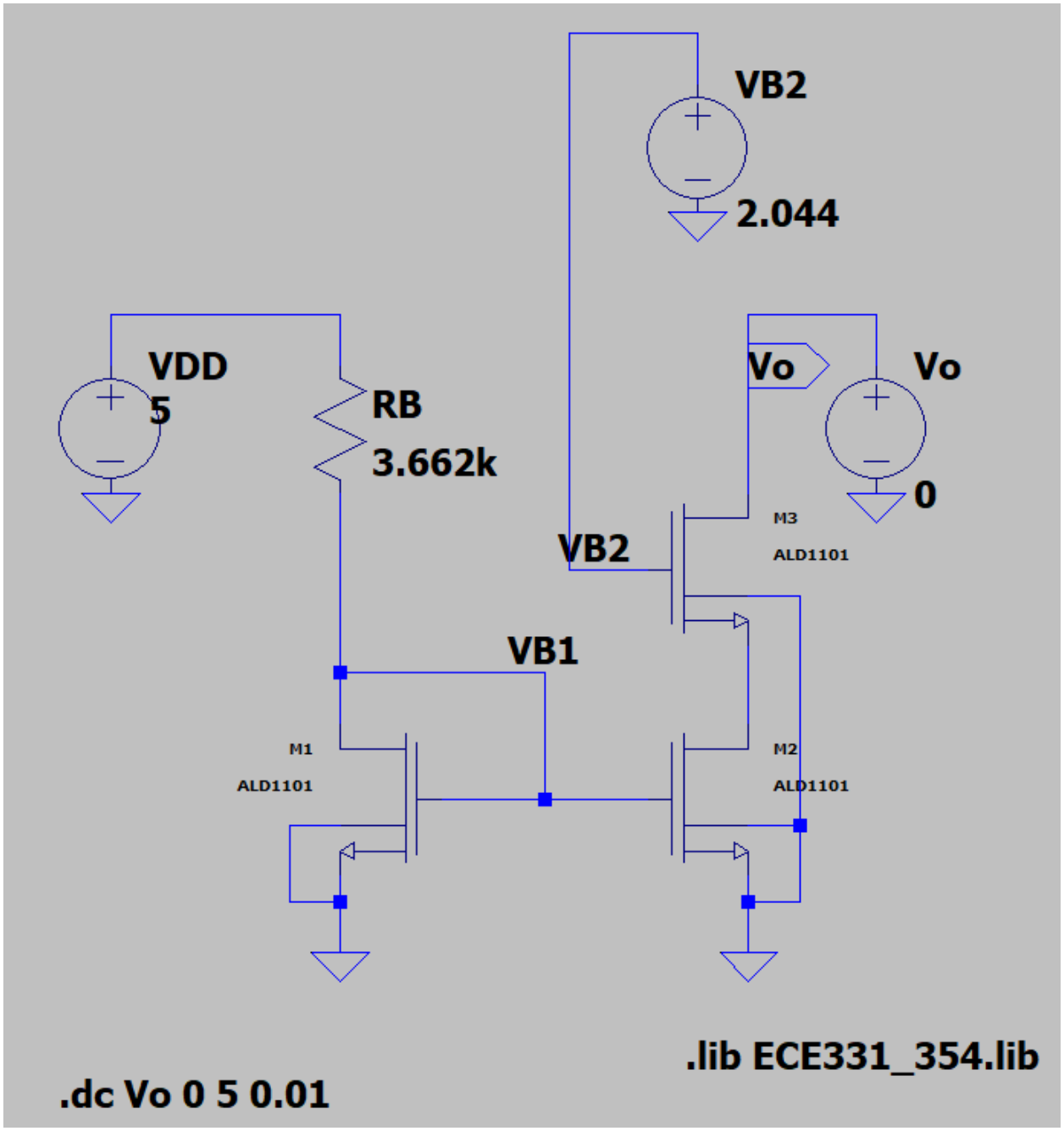
Do the following for both of the current mirrors in Figure 1. Use ID1 = 1 mA and VDD = 5 V. For the cascode current mirror, set VB2 wisely to maximize the output swing while keeping the transistors in saturation.

Use the formula for Ids to find Vb

NMOS Current Mirror

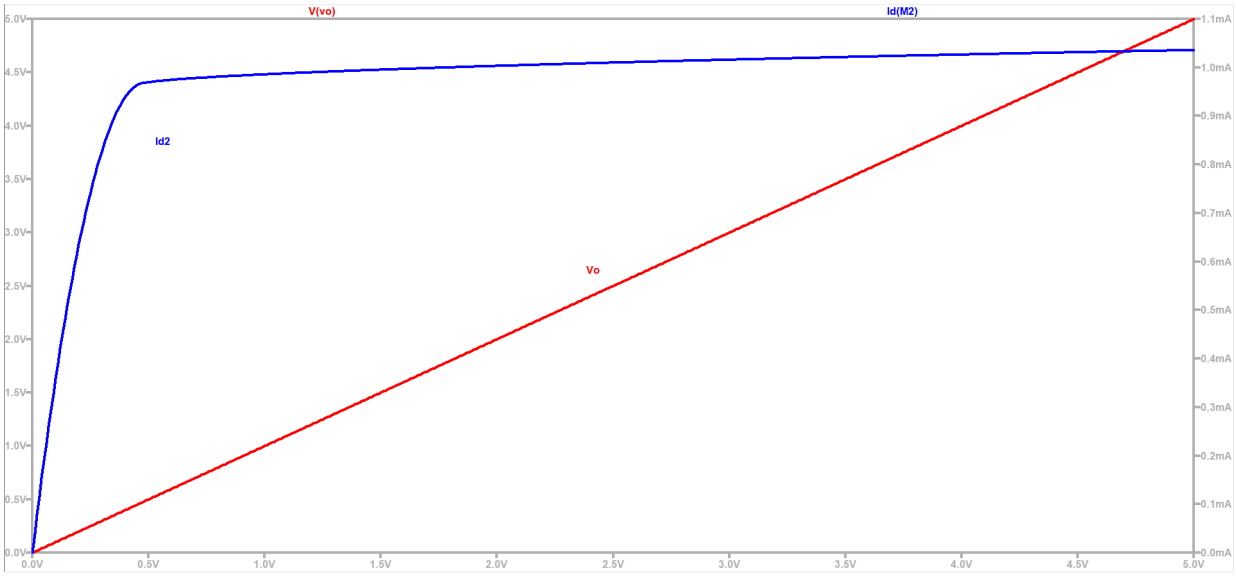


NMOS Current Mirror with a cascode transistor



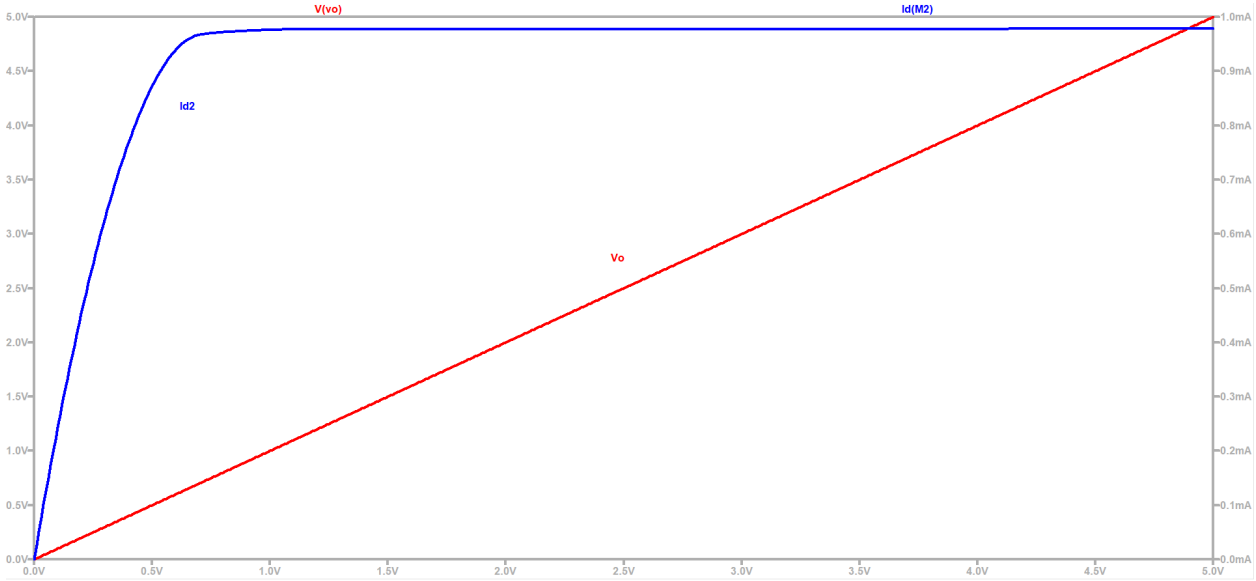
1. Run a DC sweep to plot ID2 versus Vo. You need to connect a DC voltage source to the output of the current mirror to provide Vo and sweep it.

NMOS Current Mirror



Id is little above 1mA because of channel length modulation. We can increase the Rout by cascading method and get a more ideal current mirror.

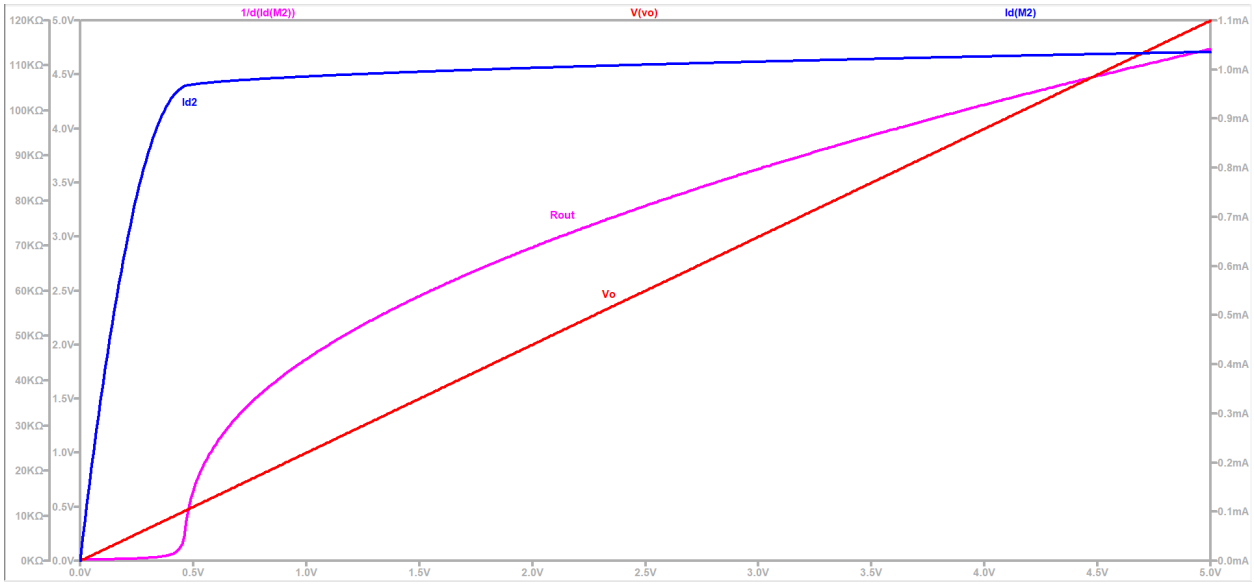
NMOS Current Mirror with a cascode transistor



As we can see in this graph, the slope of Id is way less than the one in a simple current mirror since we have a much higher output resistance.

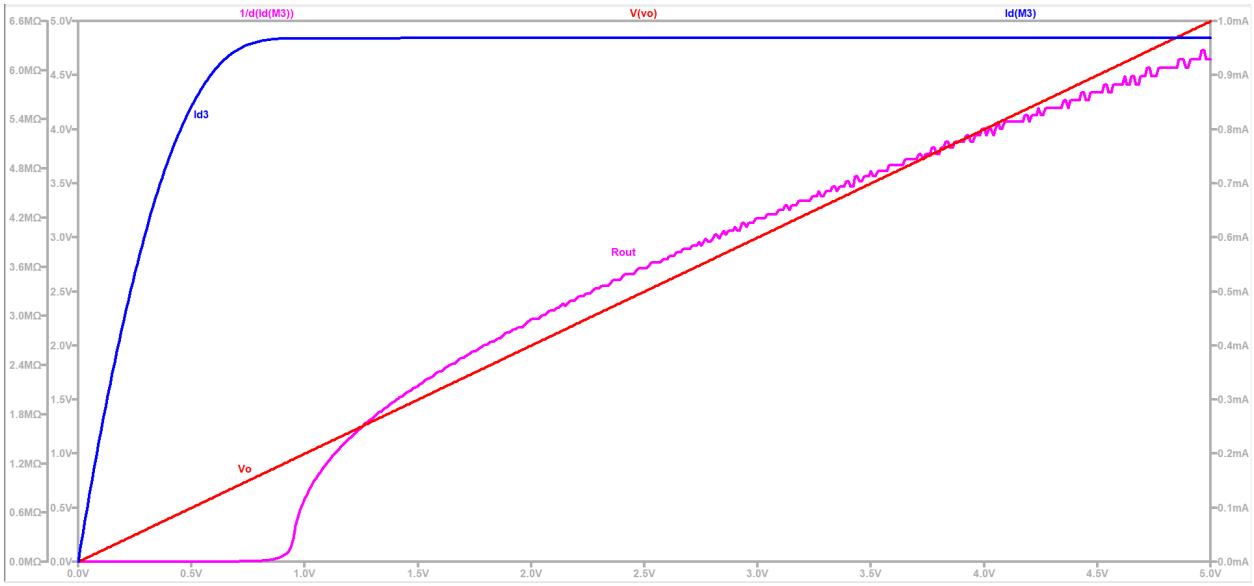
2. Show the output swing and output impedance of the current mirror on the plot in the previous step.

NMOS Current Mirror



Output swing Vov to Vdd = 0.481V to 5V

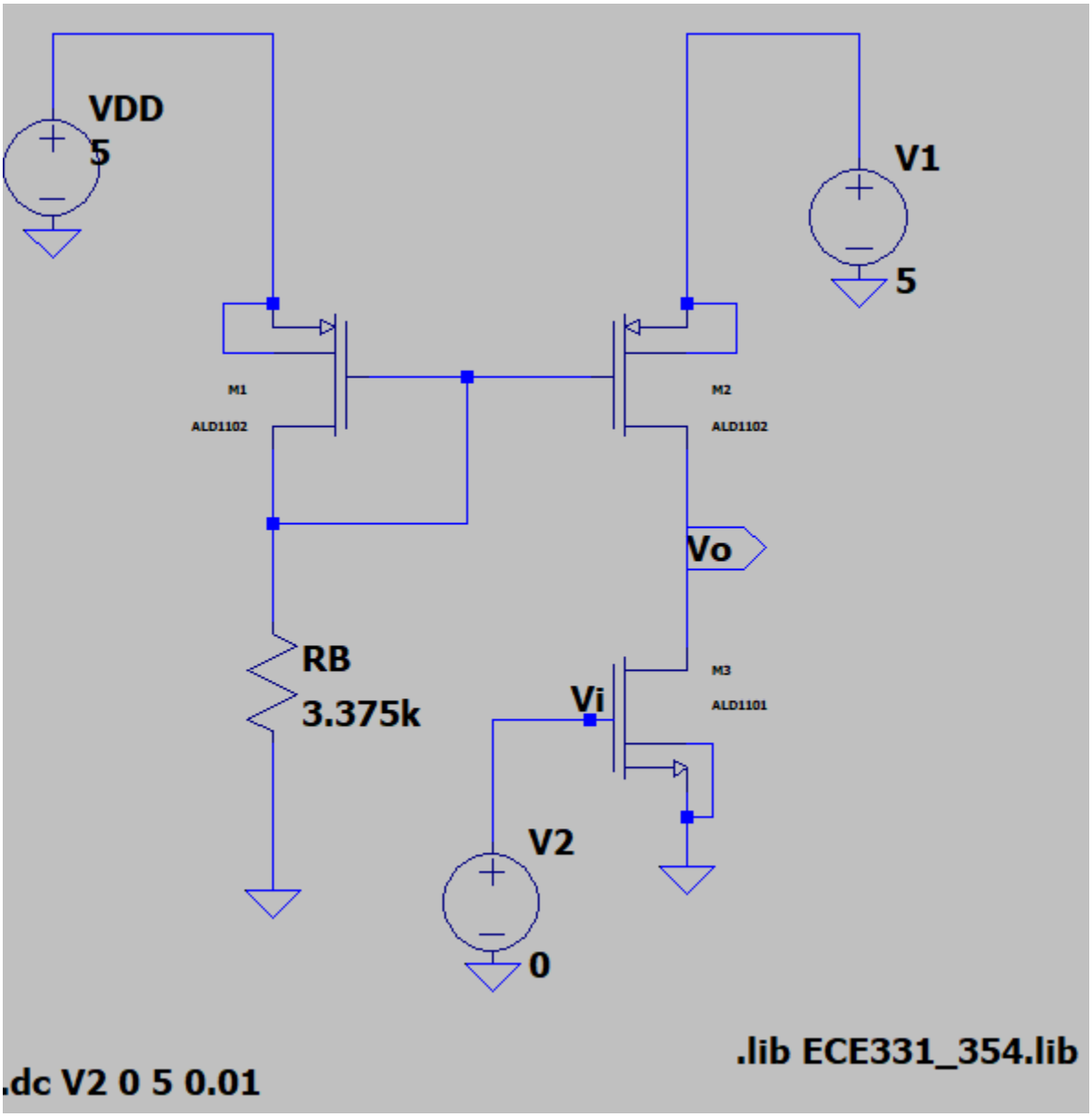
NMOS Current Mirror with a cascode transistor



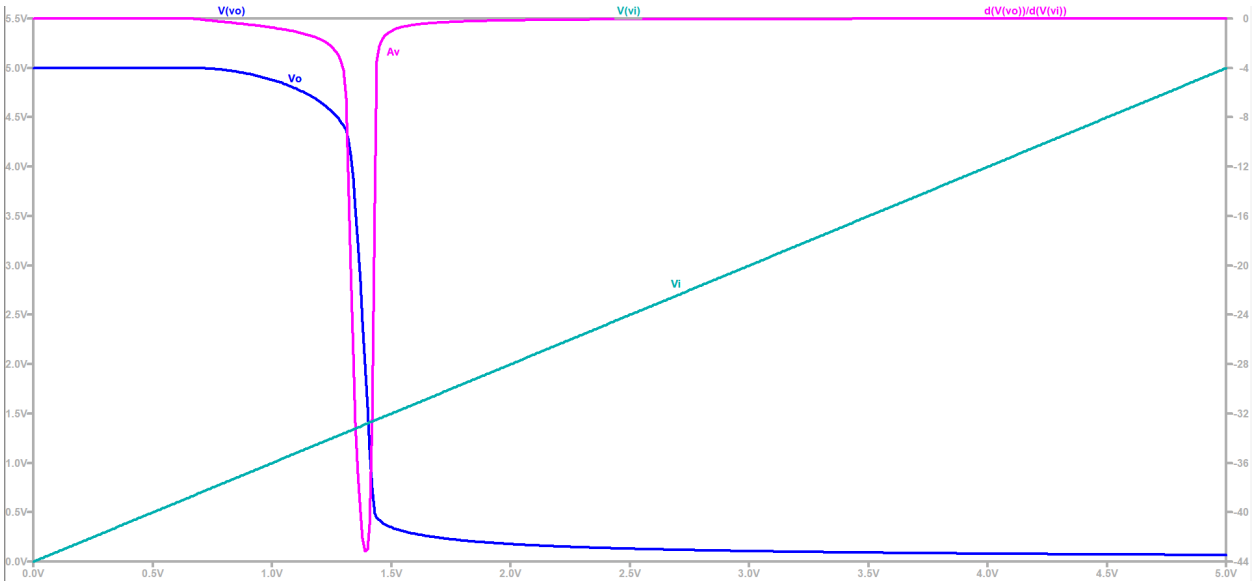
Output swing is Vov to Vdd = 0.677 to 5V

2. Common-source amplifier with an active load

Do the following for the common-source amplifier with an active load shown in Figure 2. Use ID1 = 1 mA and VDD = 5 V.



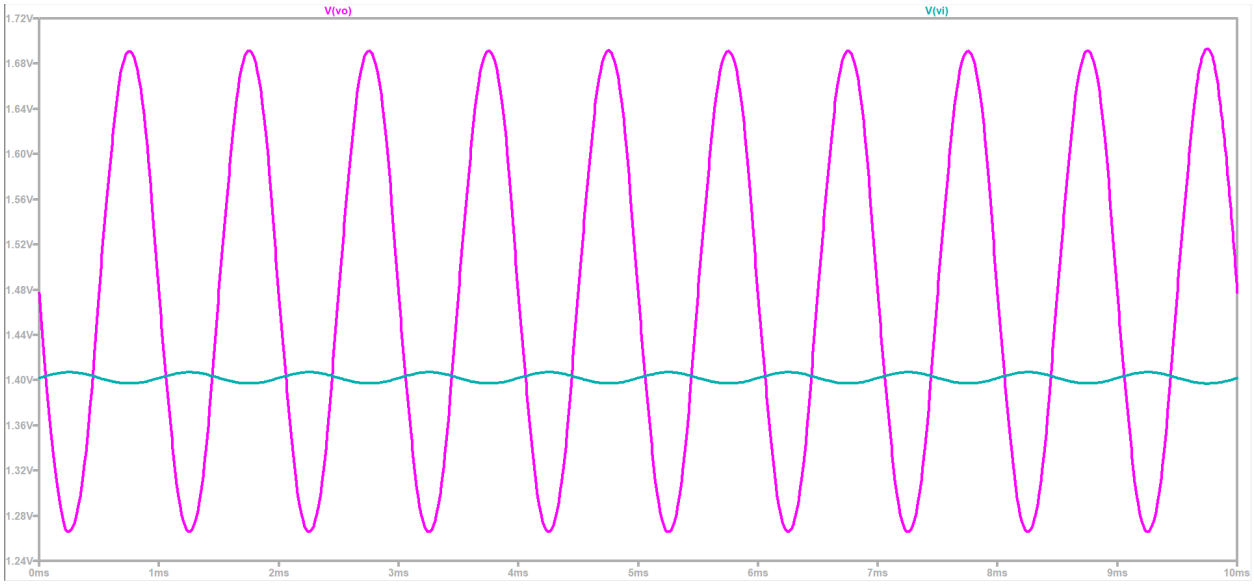
1. Run a DC sweep to plot Vo and Av = dVo/dVi versus Vi . Determine the input bias point for maximum signal swing.



Input bias point is in the middle of Vo max and Vo min so it is around 1.4.

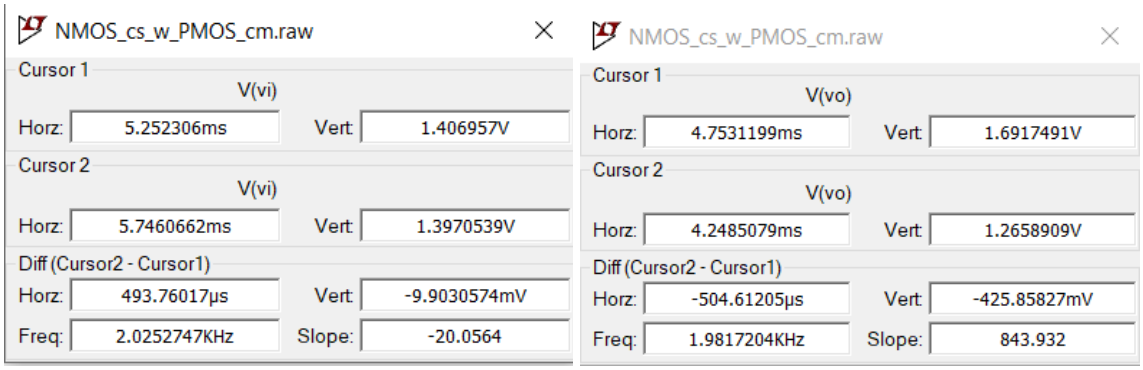
Vin = 1.402V for the maximum output swing

2. Run a transient analysis for 10 ms with a 10-mVpp 1-kHz sinusoidal input biased at the voltage found in the previous step. Plot Vo and verify the small-signal gain found in the previous step.



Peak to peak Vin = 1.4069 - 1.3970 = 0.01 V

Peak to peak Vout = 1.6917 - 1.2658 = 0.426 V

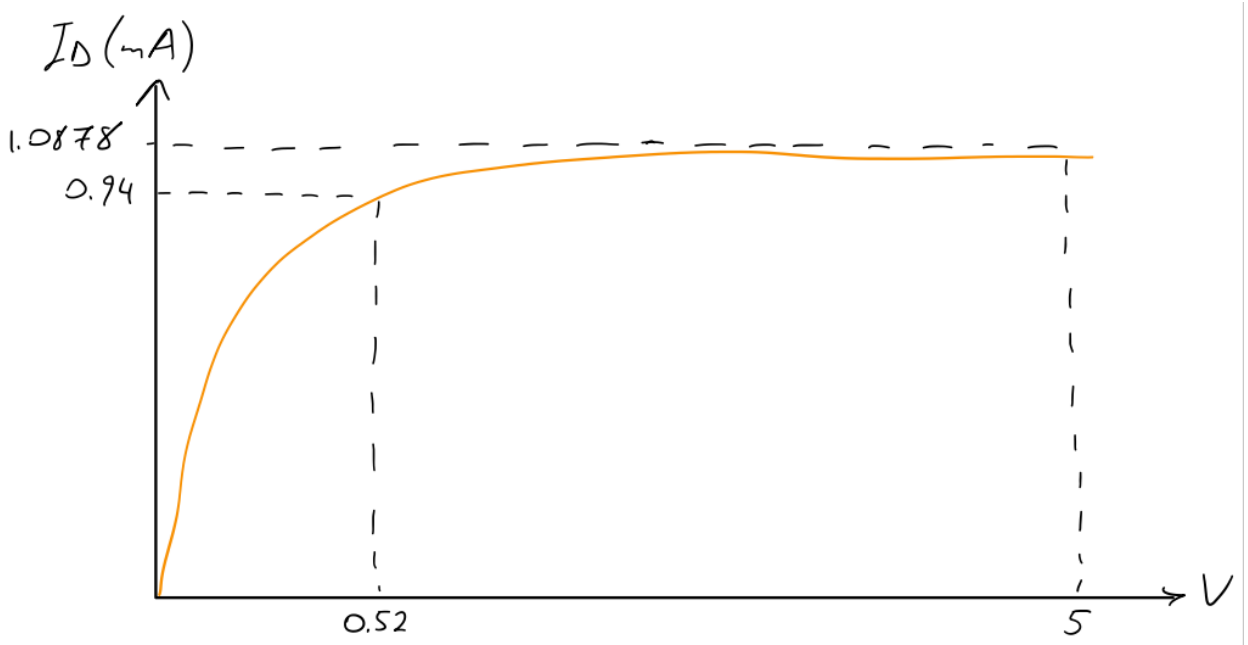


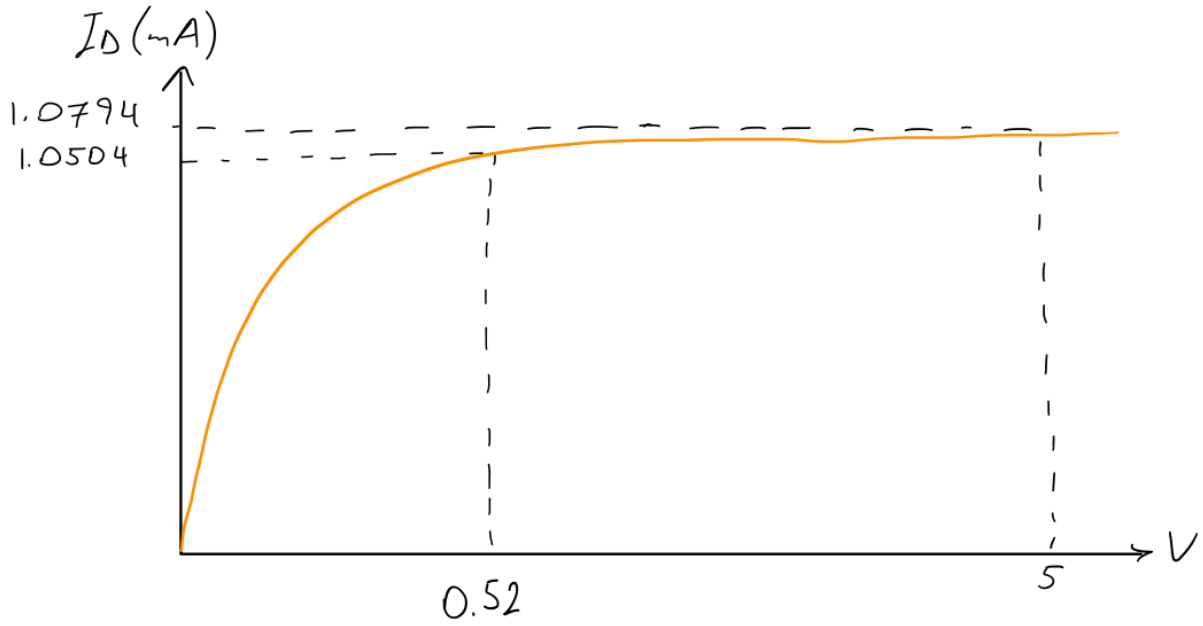
Small signal gain:
Vout / Vin = 0.426 / 0.1 = 42.6 V/V ~ 44 V/V approximately equal to the gain from the previous graph

Lab - Part II: Current Mirror Implementation

1. Current mirrors

4. Vary Vo from 0~V to 5~V and measure I_D to plot an I_D versus V_D curve.





Output Impedance:

For simple current mirror: 1/ ((1 - 0.94)mA / (5-0.52)V) = 6.96k Ohm

For cascode connected: 1/((1-1.0504)mA/(5-0.52))

Output Swing:

For simple current mirror: 0.52V - 5V

For cascode connected: 0.52-5V

2.Common-source amplifier with an active load.

Small signal gain: 42.31

Output Swing: 1.21-1.73