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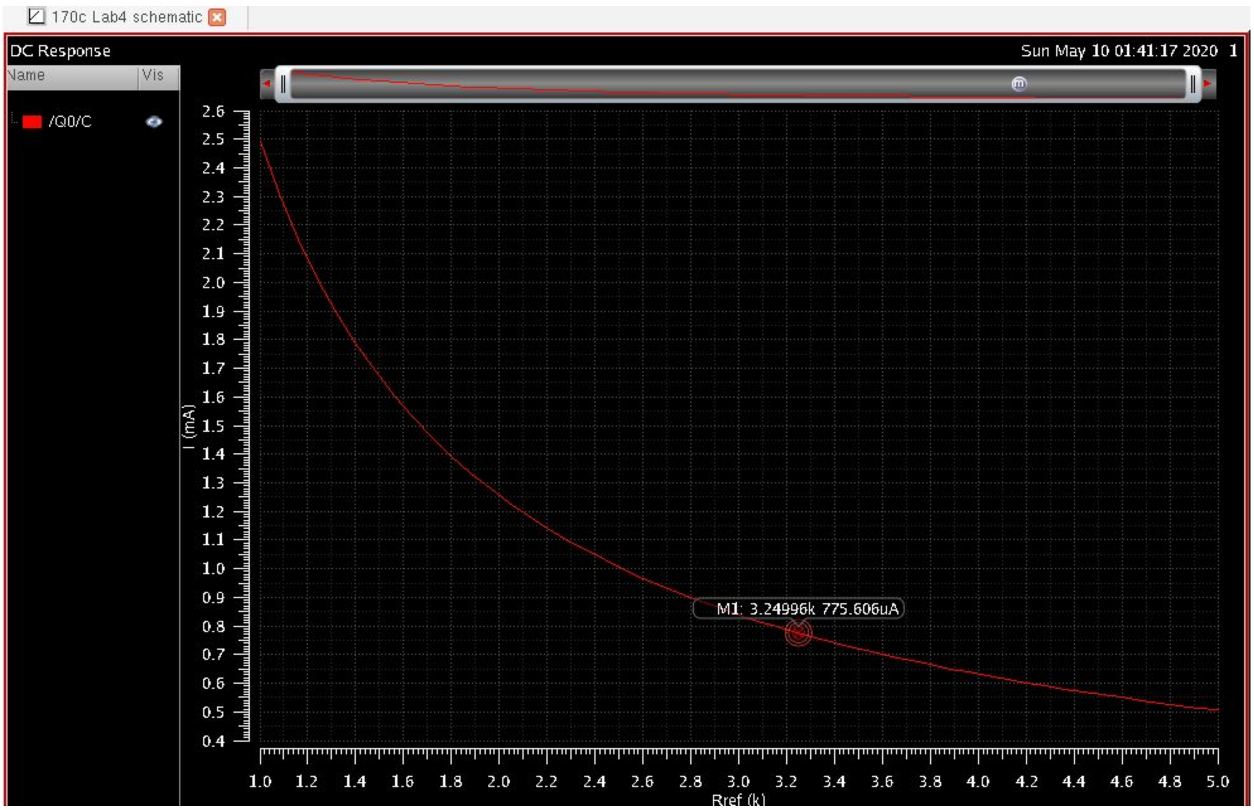
170LC

Lab 4

5/12/2020

SIM 1

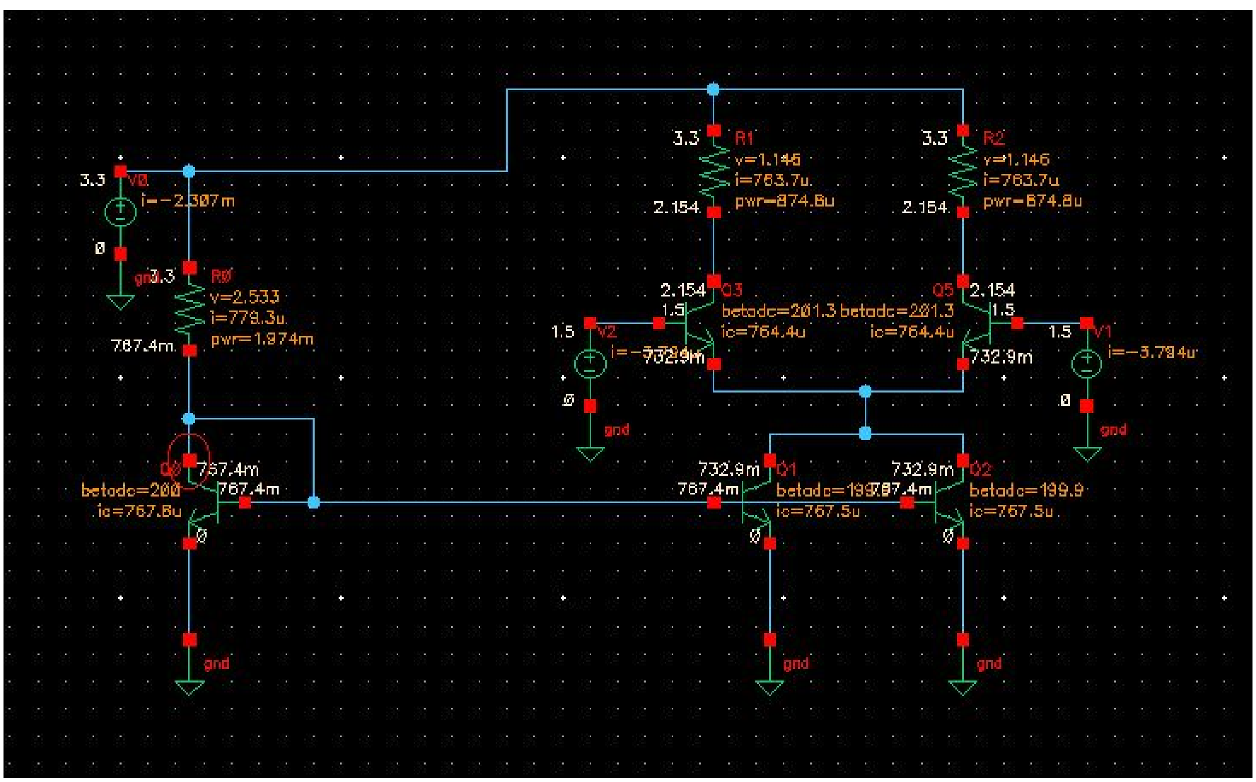
Rref Sweep



Calculations before simulation:

- Ic = ½*Iee
    - ½*1.5mA
        - **Ic = 0.75 mA**
- Rref = Vcc-Vbe(on)/Ic
    - Vcc = 3.3V
    - 3.3V-0.7V/0.75mA
        - **Rref = 3.5kΩ**

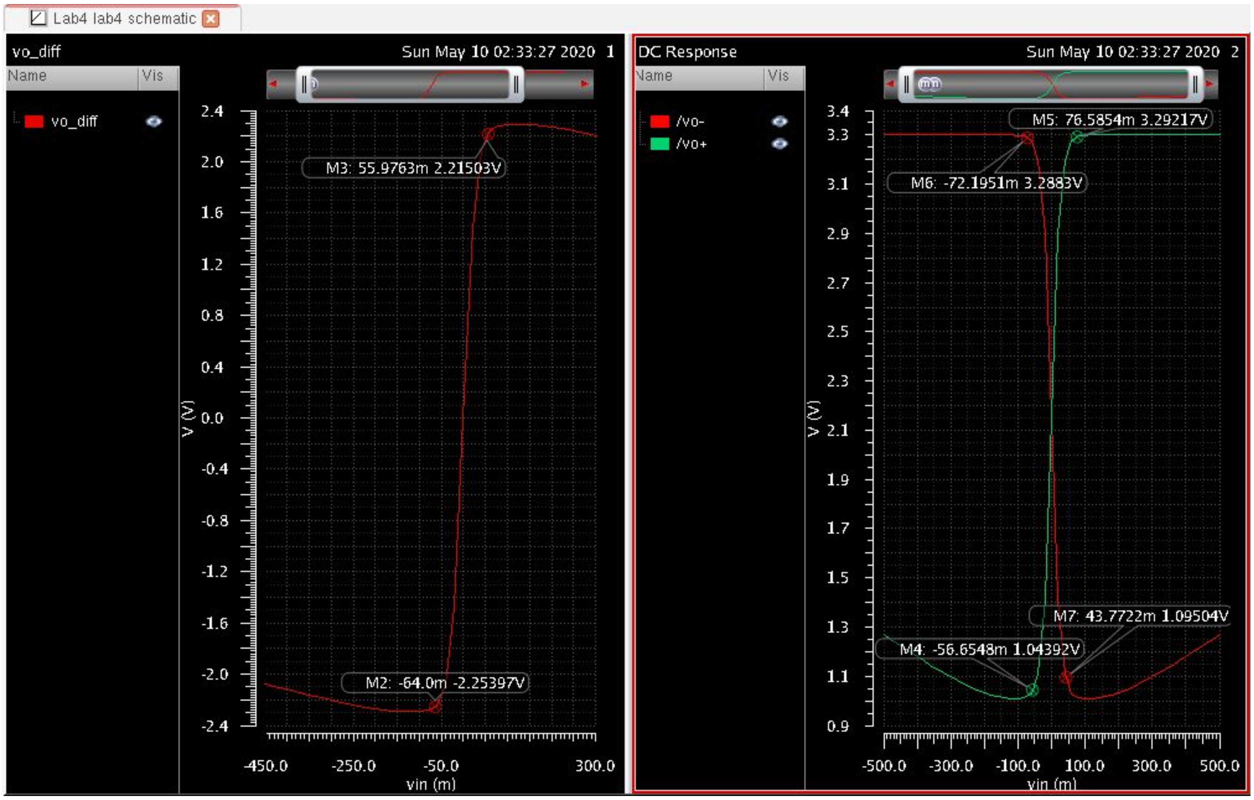
- Emitter Voltage
  - Ve = Vb - Vbe
  - 1.5V - 0.7V
    - **Ve = 0.8V**
- Transistor is in forward active
  - Vce ≥ Vce,sat
  - Vce,sat = 0.2V
  - Vc - Ve ≥ 0.2V; Vc=Vo
  - Vo - 0.8V ≥ 0.2V
    - **Vo > 1V**
- DC operating point
  - Vout(dc) = [Vdd + Vo]/2 → (3.3V + 1V)/2
    - **Vout(dc) = 2.15V**
- Rc value
  - (3.3V-2.15V)/0.75mA
    - **Rc = 1.5kΩ**



Calculations after simulation:

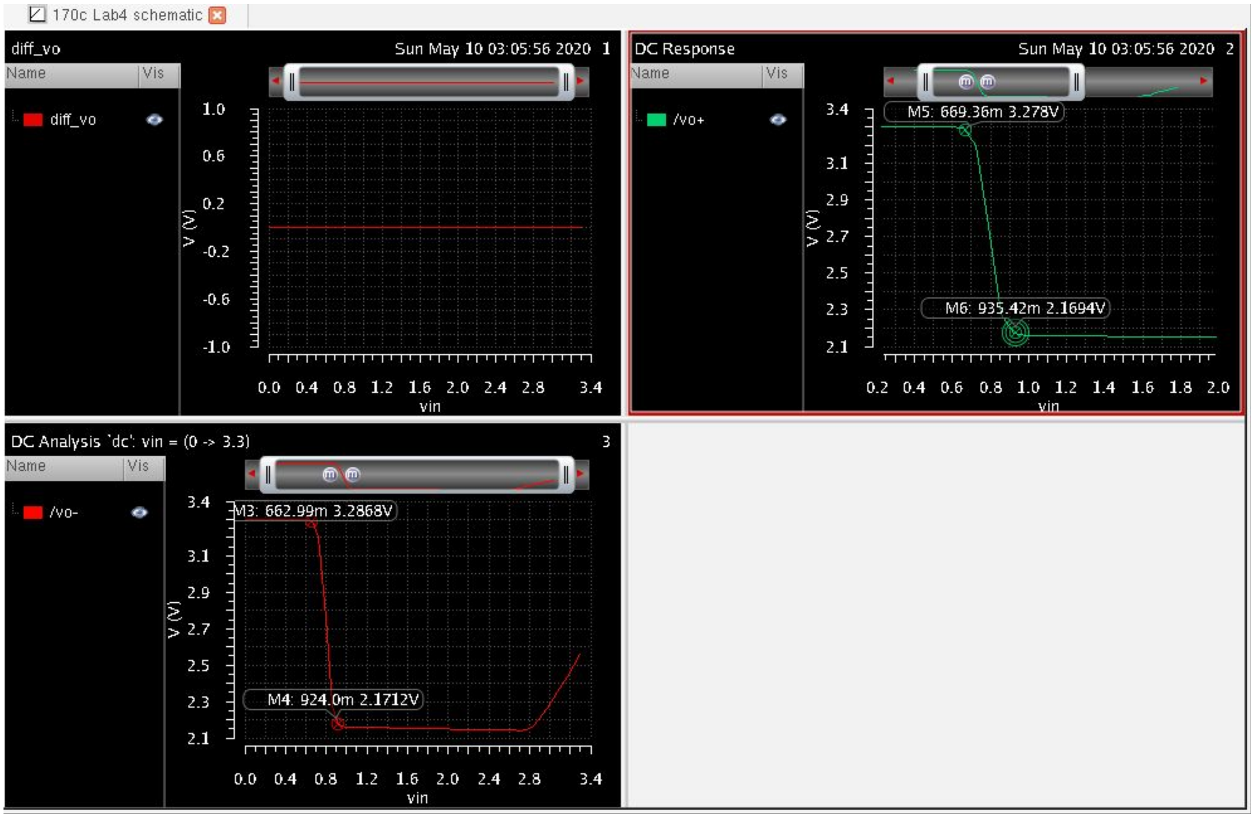
- Differential Mode Gain = -gmRc
    - (-29.55mS)(1.5kΩ)
        - **Adm = -44.3**
- Common Mode Gain = - gmRc/1+gmRee = - gmRc/1+gmro
    - (-29.55mS)(1.5kΩ)/1 + (29.55mS)(130.2kΩ)
        - **Acm = -0.011**

SIM 2



- Input voltage range: -56.65mV to 76.58mV
- Output voltage range: 3.28V to 1.09V
- Slope (vo_diff): y2-y1/x2-x1 = (2.21V+2.25V)/(55.97mV+64mV) = **37.17**
- The value for the slope is slightly different from the calculated value for differential-mode gain.
    - Calculated Value: **-44.3**

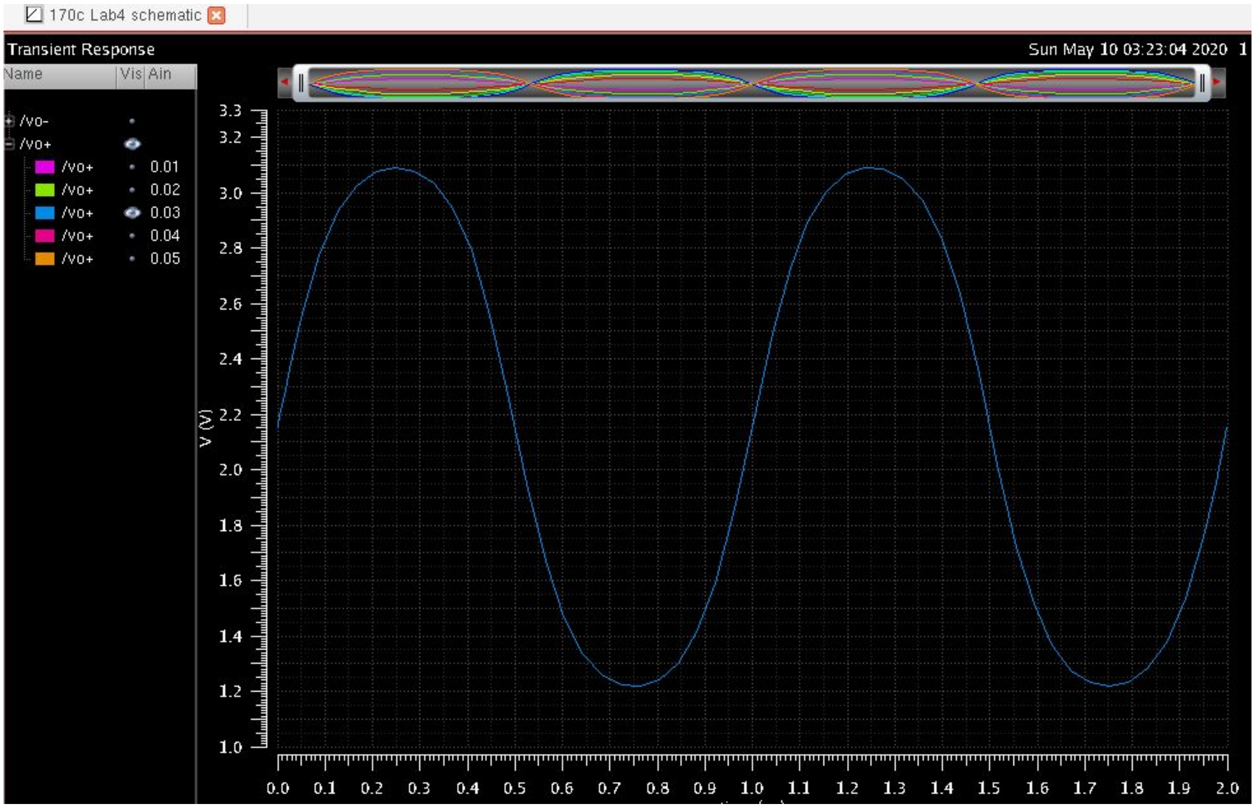
SIM 3



- Input voltage range: 669.3mV to 935.4mV
- Output voltage range: 3.28V to 2.17V
- Slope (diff_vo): y2-y1/x2-x1 = **0**
- The value for the slope is close to the calculated value for the common-mode gain.
    - Calculated Value: **-0.011**

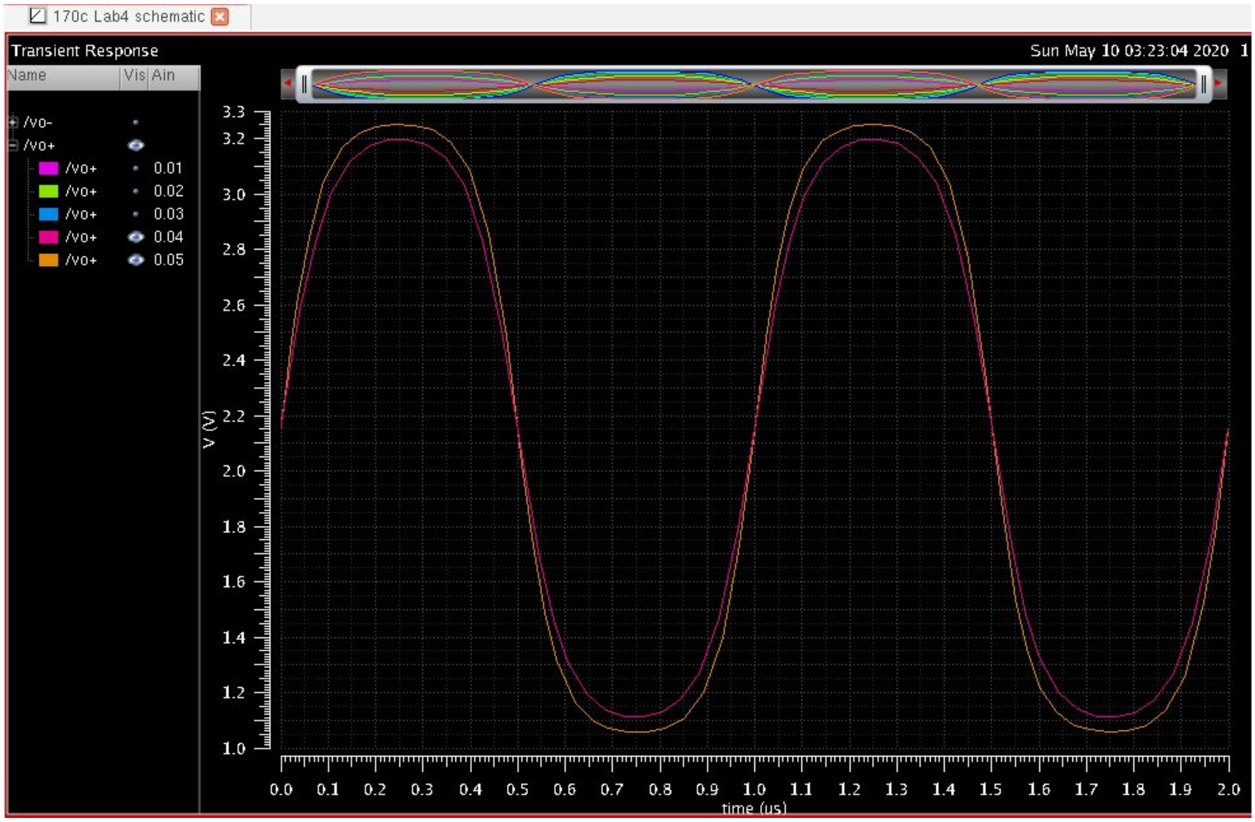
SIM 4

Maximum Amplitude



- The maximum amplitude for which the differential mode output looks sinusoidal is at 30V.

Increasing Amplitude



- When the amplitude is increased higher than its maximum value, the output waveform starts to clip and looks more like a square wave.

Conclusion

In this lab, we were asked to design a BJT differential amplifier. The reference resistor value was determined from Ic, Vcc, and Vbe(on). The DC operating point was determined from the maximum and minimum values that keep the transistor in forward active. The value of Rc was calculated from the DC operating point. Differential and common mode gains were calculated and confirmed with simulation results. The slope for the differential-mode was somewhat close to the calculated value however, the calculated value for the common mode gain was more precise. Adding a differential sine wave to the inputs allowed us to determine the maximum amplitude for which the output looks sinusoidal. The output waveform begins to clip when the amplitude is above 30V and begins to look more like a square wave.