Lab 4: **Operational Amplifier** **TA**

Preparation

1. $A_d = -g_{m4}(r_{o4}||r_{o2})$
   $A_c = -g_{m4}r_{o4}\frac{1/g_{m2}}{2g_{me4}r_{o4}r_{o5}+1/g_{m2}} \approx -1/2g_{m2}r_{o5}$
   $\text{CMRR} = A_d/A_c = 2g_{m2}g_{m4}r_{o5}(r_{o4}||r_{o2})$
   $f_{\text{3dB}} = 1/2\pi(r_{o4}||r_{o2})C_L$

2. $A_d = -65.1 = 36.3$ dB
   $A_c = -1/231.8 = -47.3$ dB
   $\text{CMRR} = 83.6$ dB
   $f_{3dB} = 5.18$ kHz

3. $V_{CM} = V_{ov5} + V_{gs4} = 667 \text{ mV} + 1.18 \text{ V} = 1.85 \text{ V}$

4. $v_d = v_{ip} - v_{in} = v_s - 0 = v_s$
   $v_c = (v_{ip} + v_{in})/2 = (v_s + 0)/2 = v_s/2$

5. $v_o = A_d v_d + A_c v_c = A_d v_s + A_c v_s/2 = v_s(A_d + A_c/2) \approx A_d v_s$
   Then, $A_d \approx v_o/v_s$.

6. See Figures 1 and 2.
   $A_d = 33.6$ dB
   $A_c = -44.4$ dB
   $\text{CMRR} = 78.0$ dB

Lab

- The measured common-mode gain should be much more than calculated/simulated due to the transistor mismatch.

- The averaging feature of the oscilloscope may be needed to show the small input voltage required to prevent clipping of the output. Proper triggering is essential for correct measurements. Use a reliable clean signal (either the opamp output or sync out of the signal source) as a trigger source.