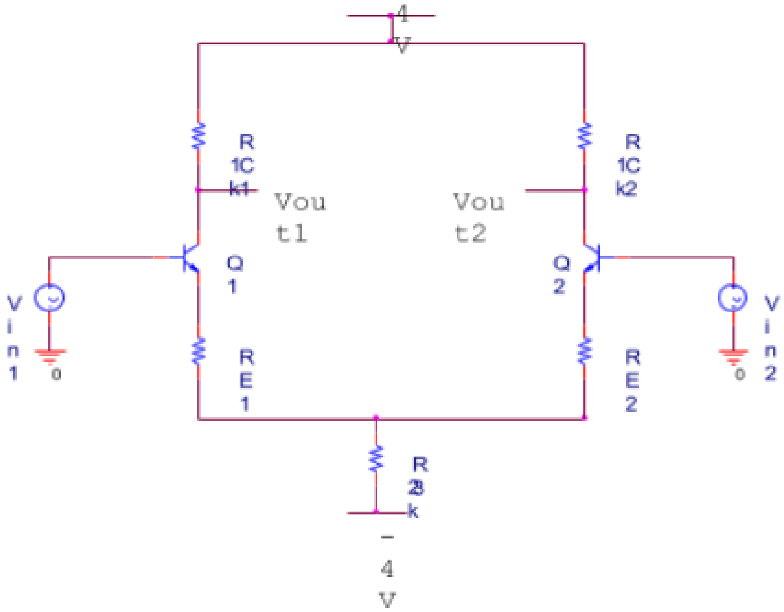
Hayden Fuller
IE lab 5

Pre Lab Exercise 1:



(RC1 = RC2 = 1 kΩ; Shared emitter resistor R3 = 2 kΩ)
Hint: Figure 8.18 of the Sedra & Smith textbook shows the curves to expect:

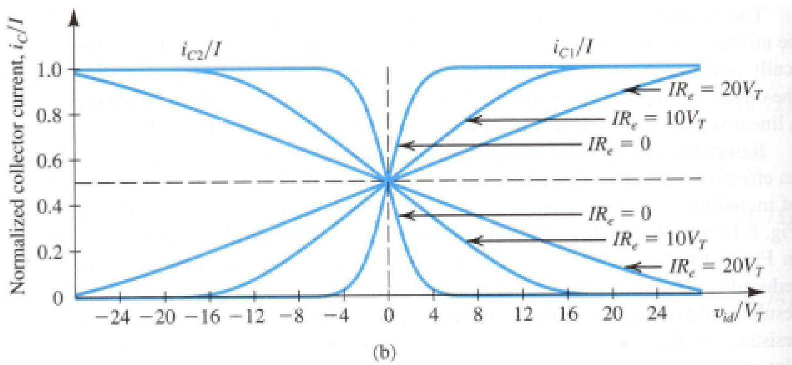
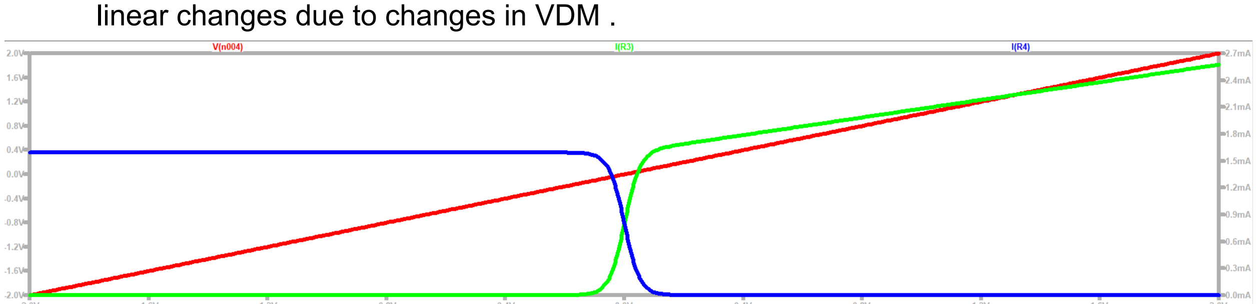


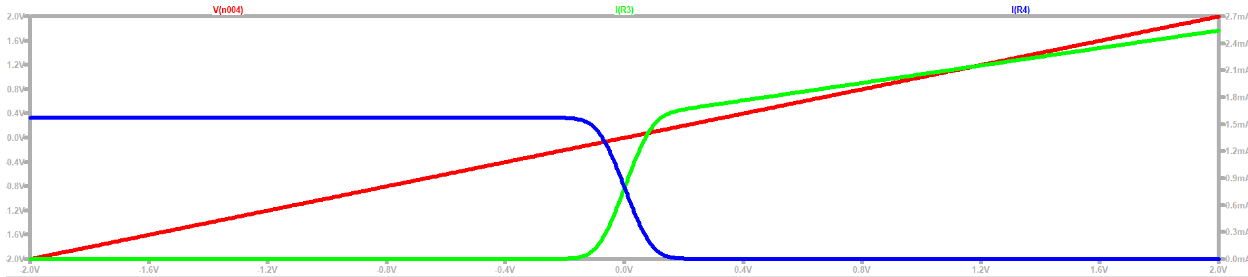
Figure 8.18 The transfer characteristics of the BJT differential pair **(a)** can be linearized **(b)** (i.e., the linear range of operation can be extended) by including resistances in the emitters.

1. Build the circuit in PSpice with RE1 = RE2 = 0 Ω (grounded) Ground Vin2 and run a DC sweep for Vin1 (–2 to 2 V), plotting IC1 and IC2 versus Vin1 . In your plot, estimate the range of VDM (VDM = Vin1 – Vin2 = Vin) such that both currents have approximately linear changes due to changes in VDM .



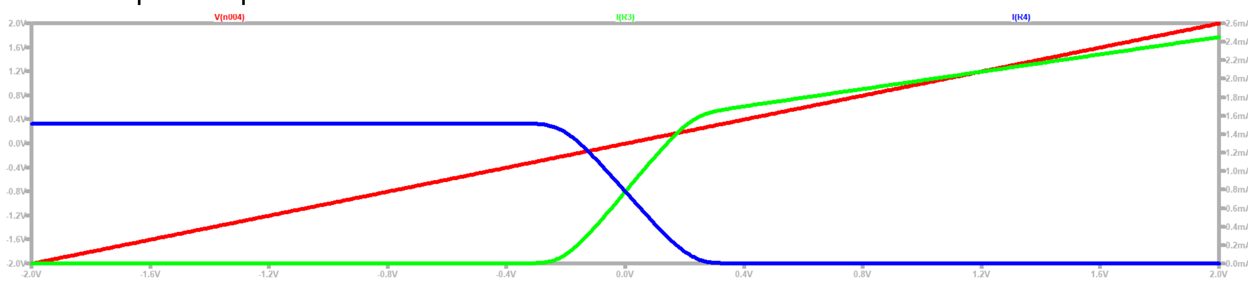
About -60mV to 60mV

2. Repeat step 1 with RE1 = RE2 = 25 Ω



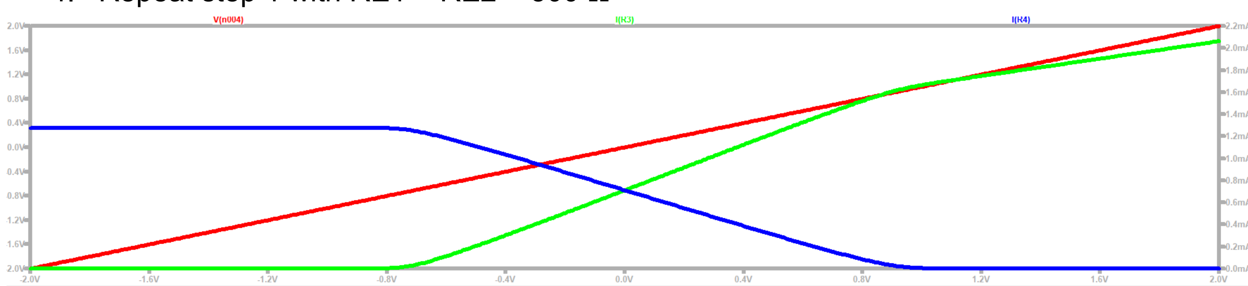
About -100mV to 100mV

3. Repeat step 1 with RE1 = RE2 = 100 Ω



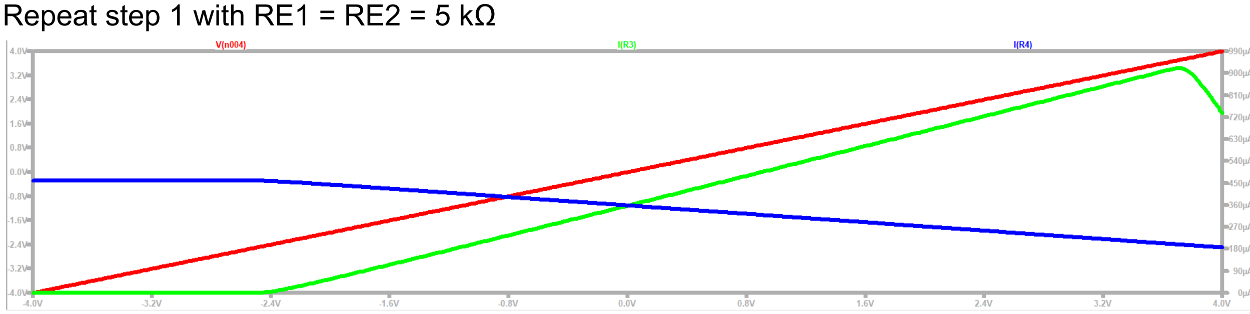
About -200mV to 200mV

4. Repeat step 1 with RE1 = RE2 = 500 Ω



About -650mV to 750mV

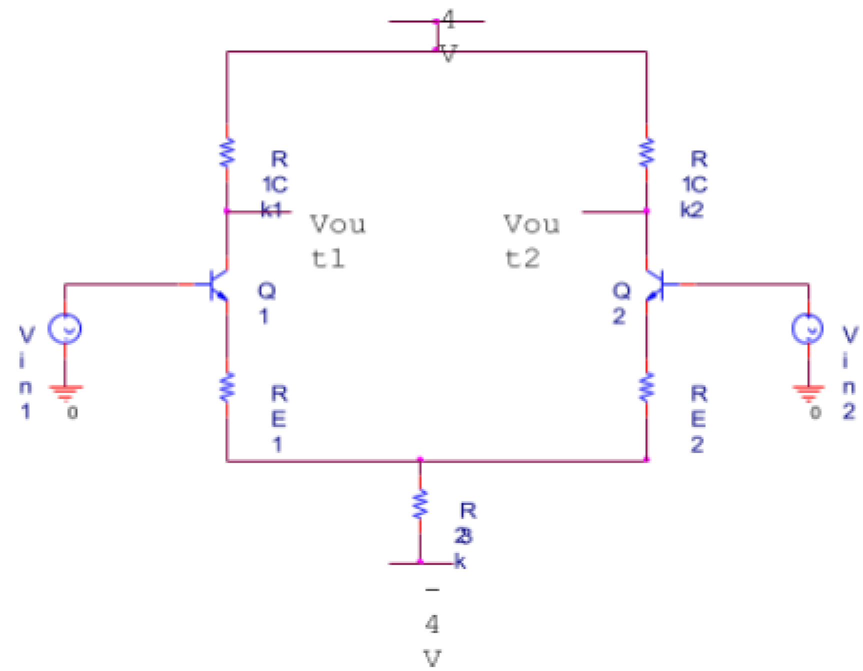
5. Repeat step 1 with RE1 = RE2 = 5 kΩ



6.

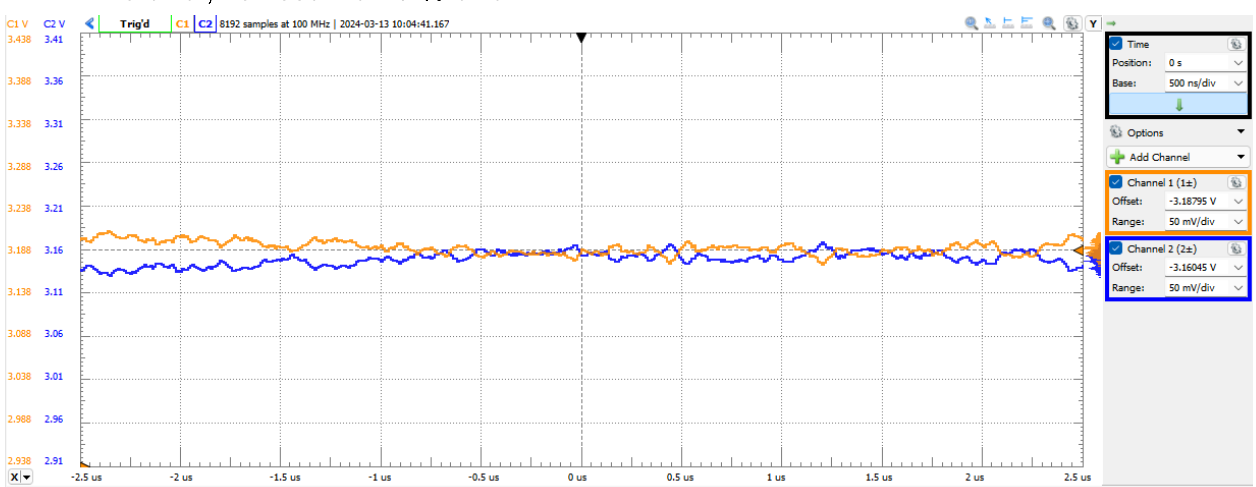
About -2.3V to 3.6V

Exercise 1:



(RC1 = RC2 = 1 kΩ; Shared emitter resistor R3 = 2 kΩ)

1. Build the differential amplifier shown in Figure 4, using RE1 = RE2 = 0 Ω.
2. With both Vin1 and Vin2 grounded (equal to each other), compare Vout1 and Vout2 . Are they equal as expected? If they are not equal, is resistor tolerance sufficient to explain the error, i.e. less than 5 % error?



(3.18795-3.16045)/3.16045=0.009, within 1% of each other, well within tolerance

3. Measure IC and VCE to determine the DC bias conditions of each transistor.

T1:

IC: (4.0013V-3.24325V)/1000ohm=0.75805mA

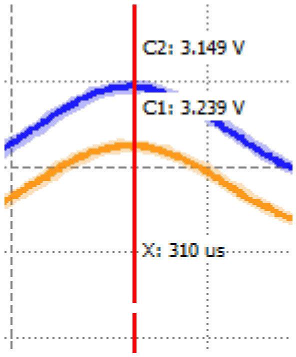
VCE: 3.22535V+0.63775V=3.8631V

T2:

IC: (3.9994V-3.0903V)/1000ohm=0.9091mA
VCE: 3.1163V+0.6258V=3.7421V

4. Connect both inputs together to the same voltage source with a 200 mV peak-to-peak 1 kHz sine wave with zero offset. For the common mode (CM) input, measure the differential output voltage, i.e. the voltage Vout2 – Vout1 . Determine the common mode gain, ACM = (Vout2 – Vout1) / VCM Is the differential output close to zero? If not (which is likely), in context of your part 2 answer, is the difference explained by resistor tolerances? transistor characteristics?

ACM=(3.239-3.149)/.1=0.9
Explained by both resistor and transistor tolerances. With non identical transistors, there will be some ACM, but less than one is better than I expected



5. For the same common mode input, measure the output at just Vout1 . Determine the half circuit gain, ACM-HC = Vout1 / VCM. Is the gain consistent with the common mode half-circuit amplifier model?

HC=ACM- Vout1/VCM
=3.239/.1=32.39

6. Set RE1 = RE2 = 470 Ω and repeat steps 2-5.

2:
(3.253-3.251)/3.251=0.06%, even better

3:
T1:
IC: (3.995V-3.256V)/1000ohm=0.739mA
VCE: 3.254V+0.62462V=3.87862V

T2:
IC: (3.995V-3.252V)/1000ohm=0.743mA
VCE: 3.252V+0.62428V=3.87628V

4:
ACM=(3.277-3.274)/.1=0.03

5:

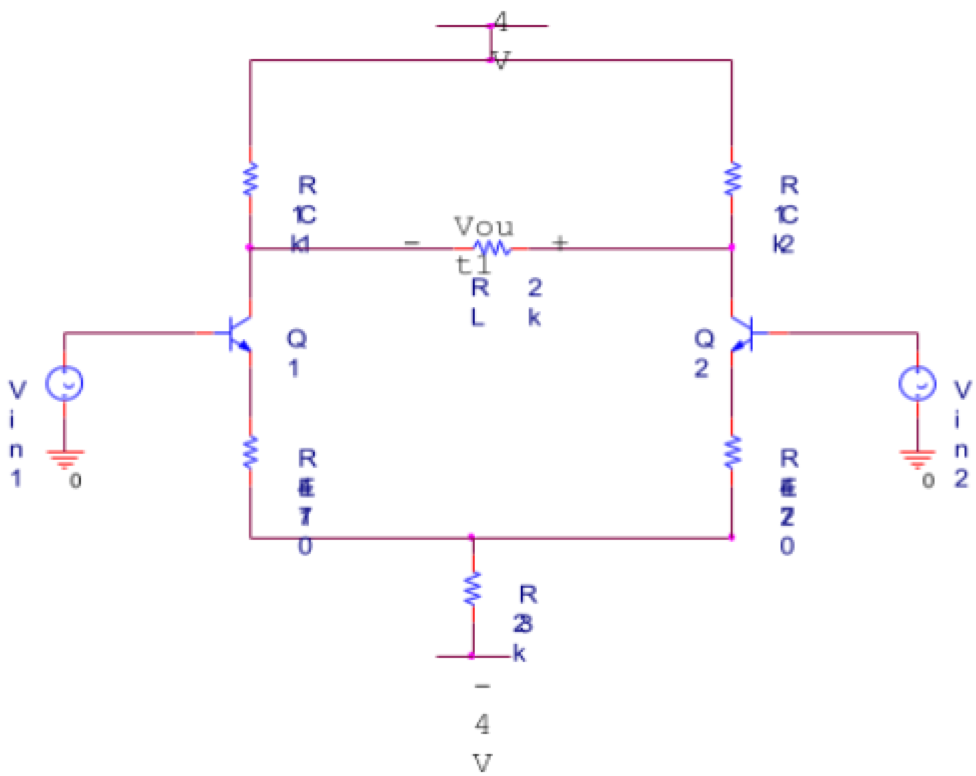
HC=ACM- Vout1/VCM
=3.274/.1=32.74

7. Keeping the emitter resistors, set Vin1 to 50 mV and Vin2 to –50 mV (180o phase shift). Measure the differential mode (DM) gain, ADM = (Vout2 – Vout1) / (Vin2 – Vin1). Is the gain consistent with the estimate using the half circuit model?

ADM=(3.156-3.35)/.1=-1.94, Yes, it's consistent with the model

8. The Common Mode Rejection Ratio (CMRR) is defined as CMRR = ADM /ACM = 10 log10 (ADM /ACM) 2 dB. Based on your above results, what is the CMRR?

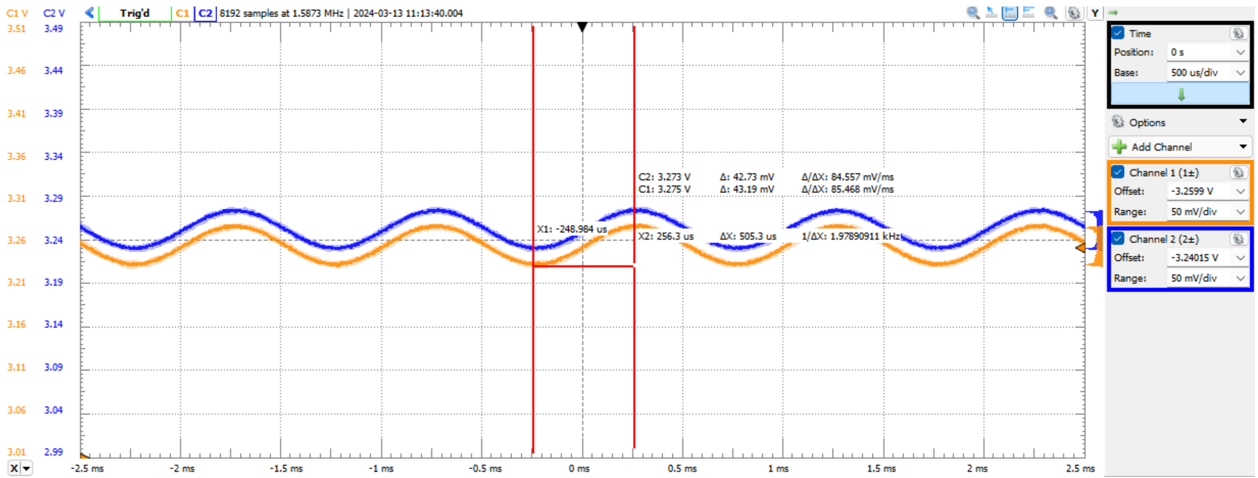
CMRR = 1.94 /0.03 = 64.67

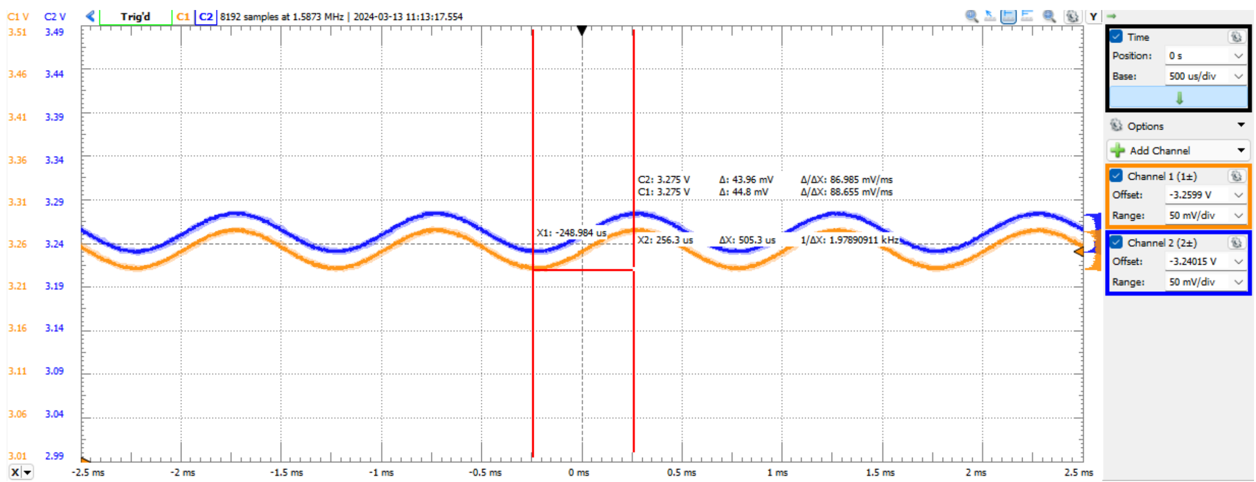


(RC1 = RC2 = 1 kΩ; Shared emitter resistor R3 = 2 kΩ)

9. Add a 2 kΩ load resistor. Apply the same common mode and differential mode inputs as above.
Is the common mode output approximately the same with and without the load resistor?
Is the differential output approximately one-half the open circuit gain?

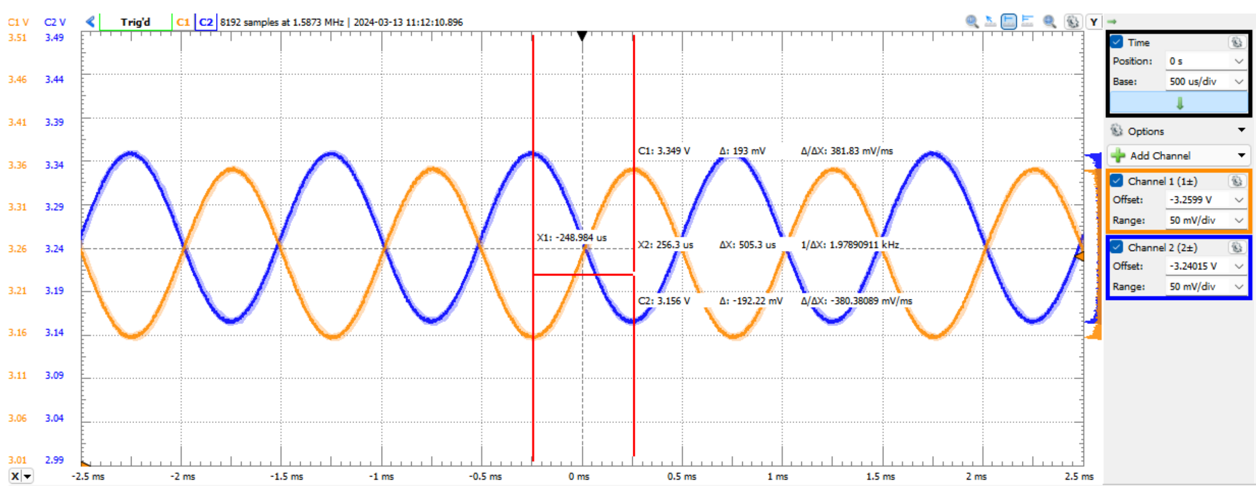
Common:

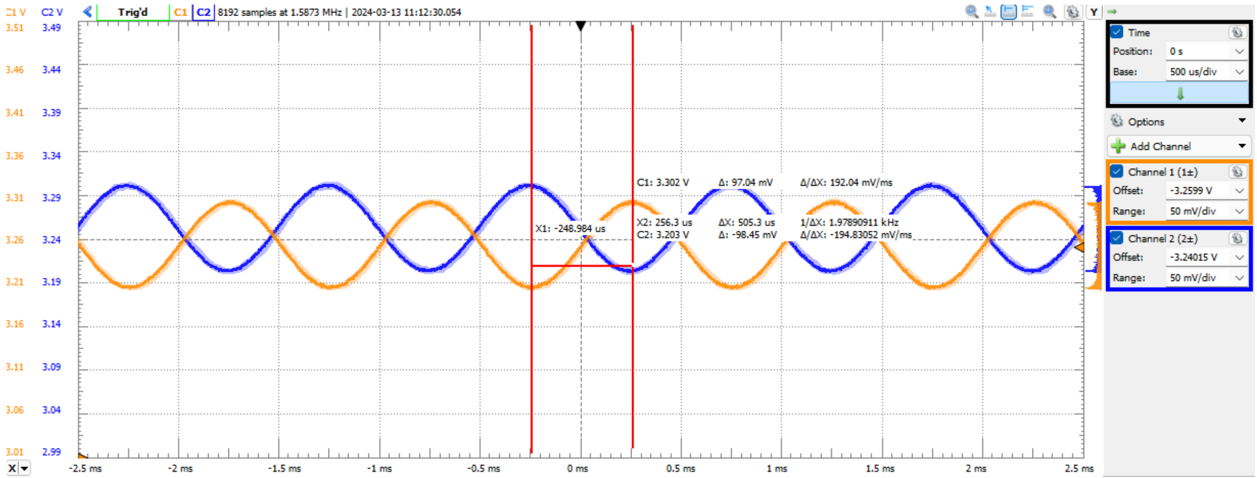




Yes, about the same

Differential:





Yes, about half

10. Based on your above results, what is the CMRR?

Half of what it used to be, so 32.33