Lecture (08.01)
BJT Amplifiers 5

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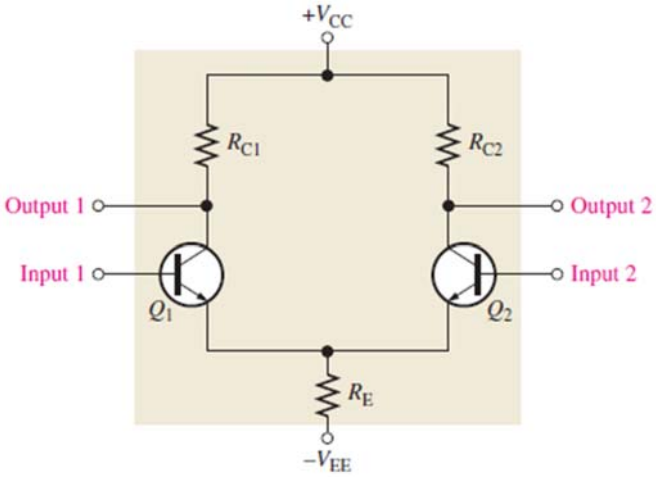
differential amplifier (diff-amp)

1.

- when both inputs are grounded (0 V), the emitters are at -0.7V.
- It is assumed that the transistors are identically matched by careful process control during manufacturing so that their dc emitter currents are the same when there is no input signal.



$$I_{E1} = I_{E2}$$

Since both emitter currents combine through R_E,

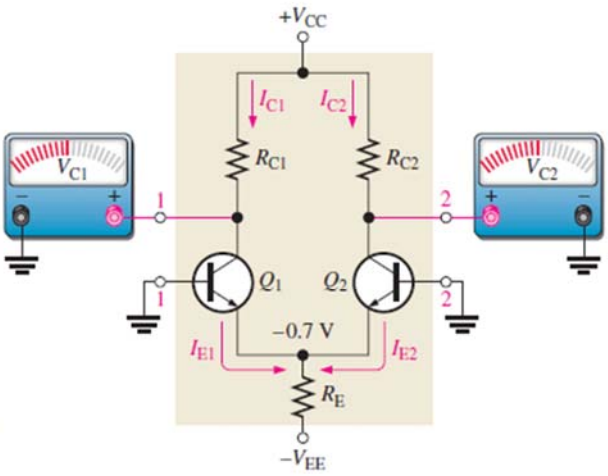
$$I_{E1} = I_{E2} = \frac{I_{R_E}}{2}$$

where

$$I_{R_E} = \frac{V_E - V_{EE}}{R_E}$$

Based on the approximation that $I_C \cong I_E$,

$$I_{C1} = I_{C2} \cong \frac{I_{R_E}}{2}$$



- Since both collector currents and both collector resistors are equal $V_{C1} = V_{C2} = V_{CC} - I_{C1}R_{C1}$

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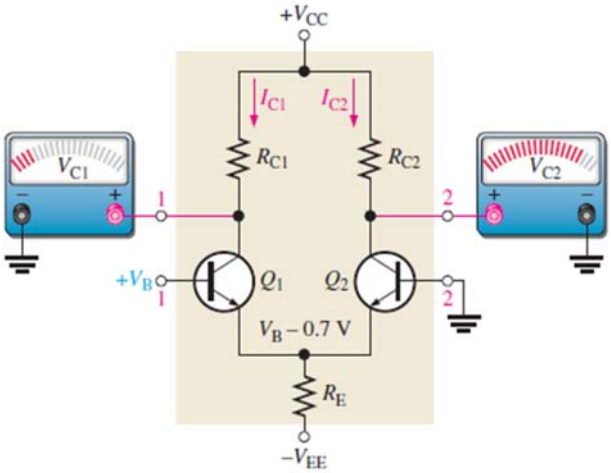
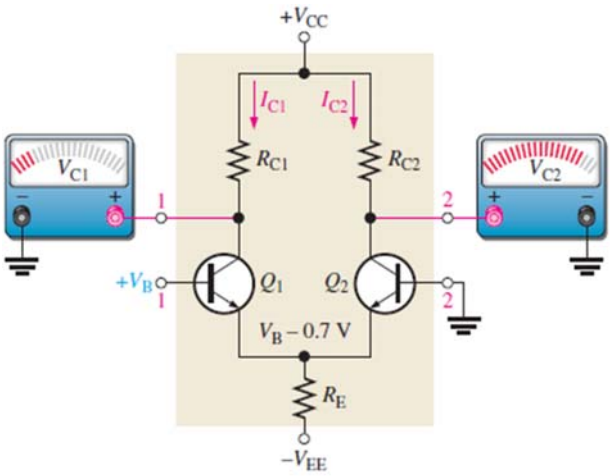
- Next, input 2 is left grounded, and a positive bias voltage is applied to input 1,
- The positive voltage on the base of *Q*1 increases *I*C1 and raises the emitter voltage to

$$V_E = V_B - 0.7\ V$$

- This action reduces the forward bias (*V*BE) of *Q*2 because its base is held at 0 V (ground), *I*C2 decrease



- increase in *I*C1 causes a decrease in *V*C1,
- and the decrease in *I*C2 causes an increase in *V*C2,



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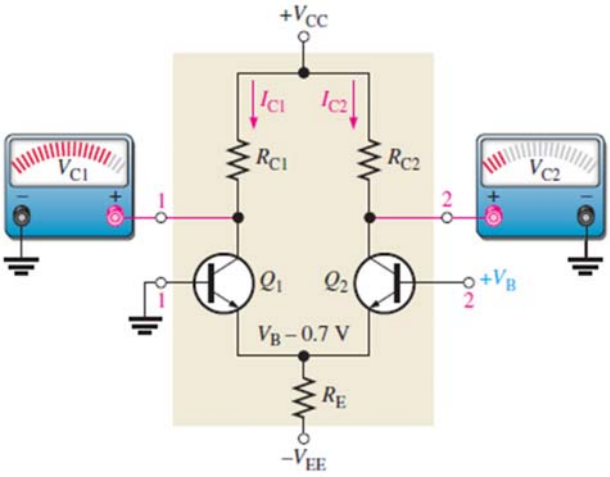
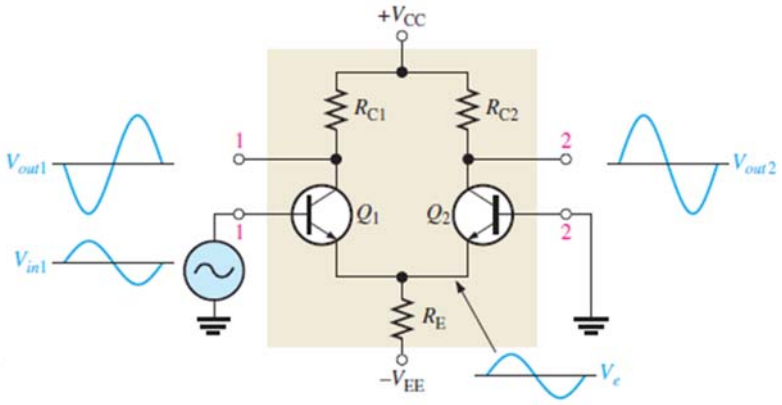
- Finally, input 1 is grounded and a positive bias voltage is applied to input 2.
- Applied V_{B2}, increases *I*C2, decrease in *V*C2, V_{E2} voltage is raised.
- reduces the forward bias of *Q*1,
- decrease in *I*C1 causes *V*C1 to increase

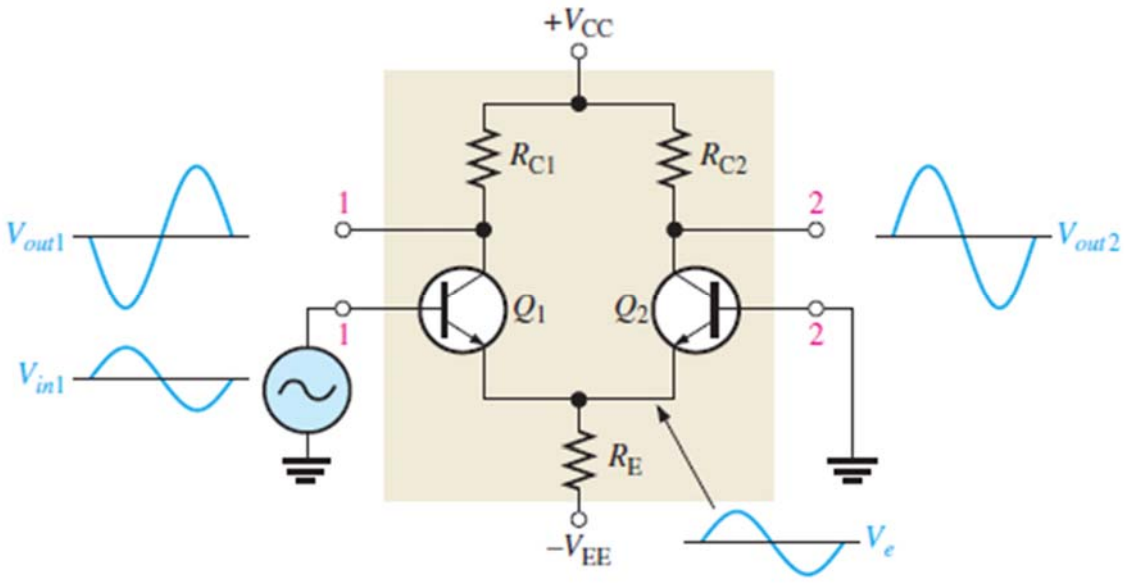


Modes of Signal Operation

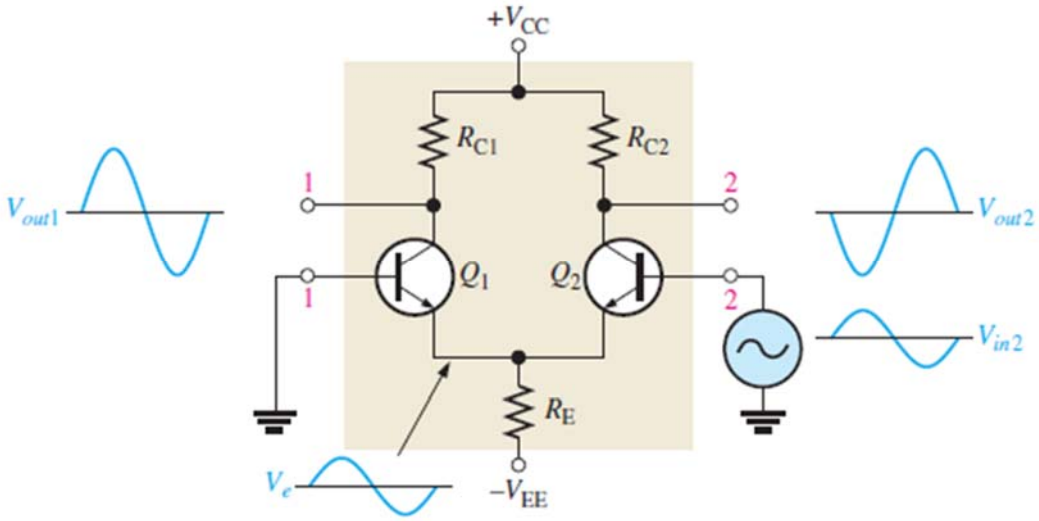
- ***Single-Ended Differential Input:***
- one input is grounded and the signal voltage is applied only to the other input,
- inverted, amplified signal voltage appears at output 1 as shown
- a signal voltage appears in phase at the emitter of *Q1*



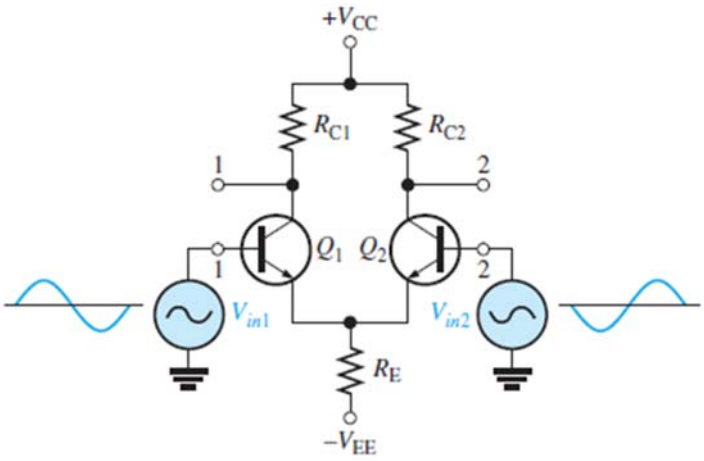
- *Q*1 is common, emitter signal becomes an input to *Q*2, which functions as a common-base amplifier at *Q*2 output 2; amplified noninverted signal.

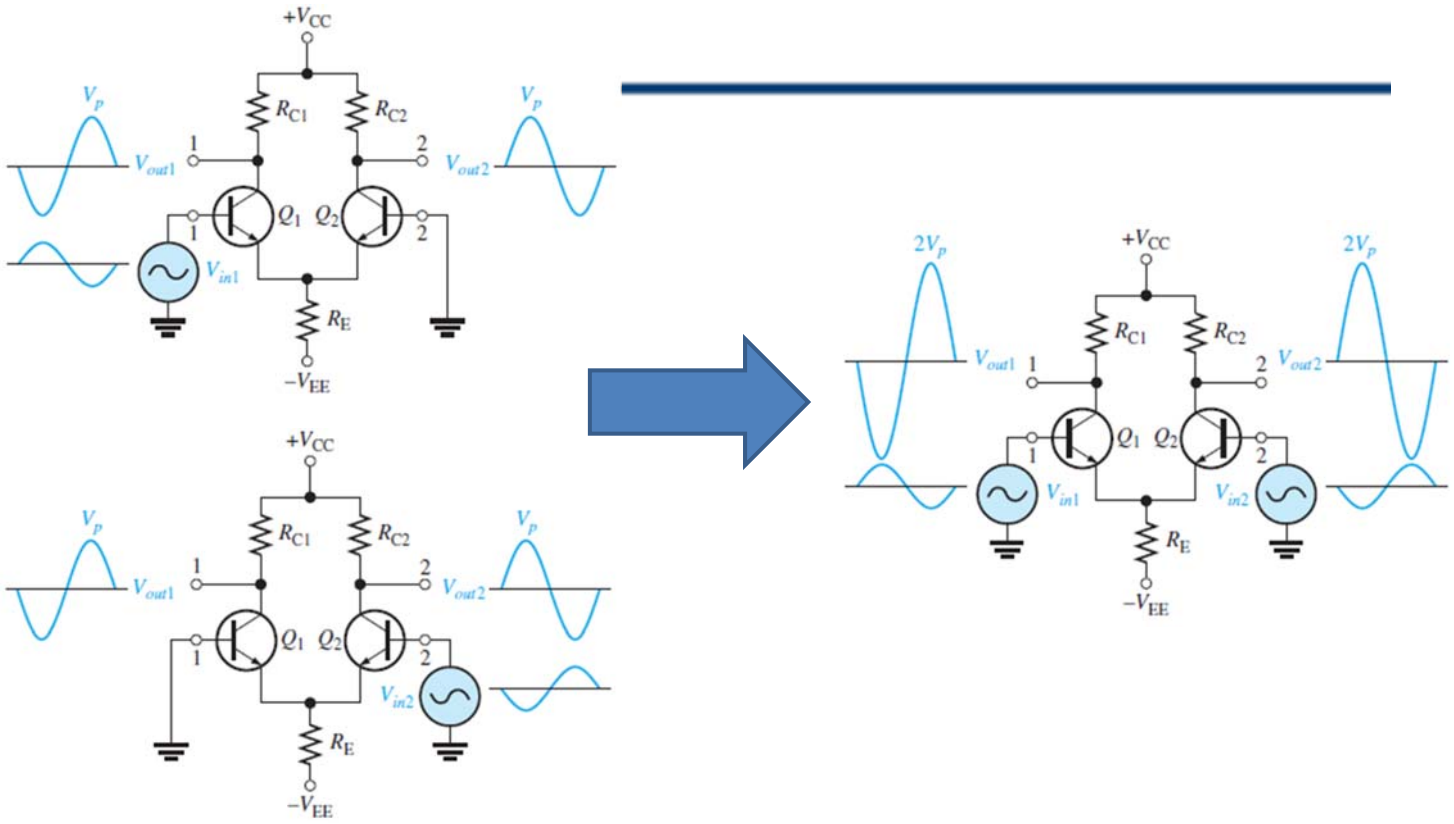


- In the case where the signal is applied to input 2 with input 1 grounded, an inverted, amplified signal voltage appears at output 2, noninverted, amplified signal appears at output 1.

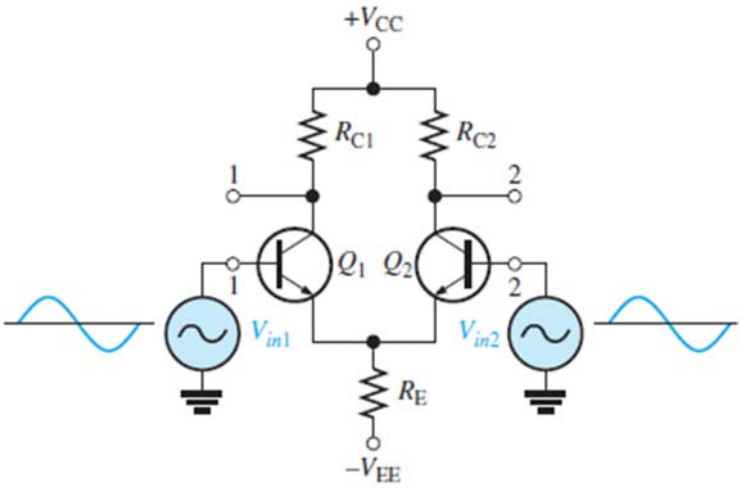


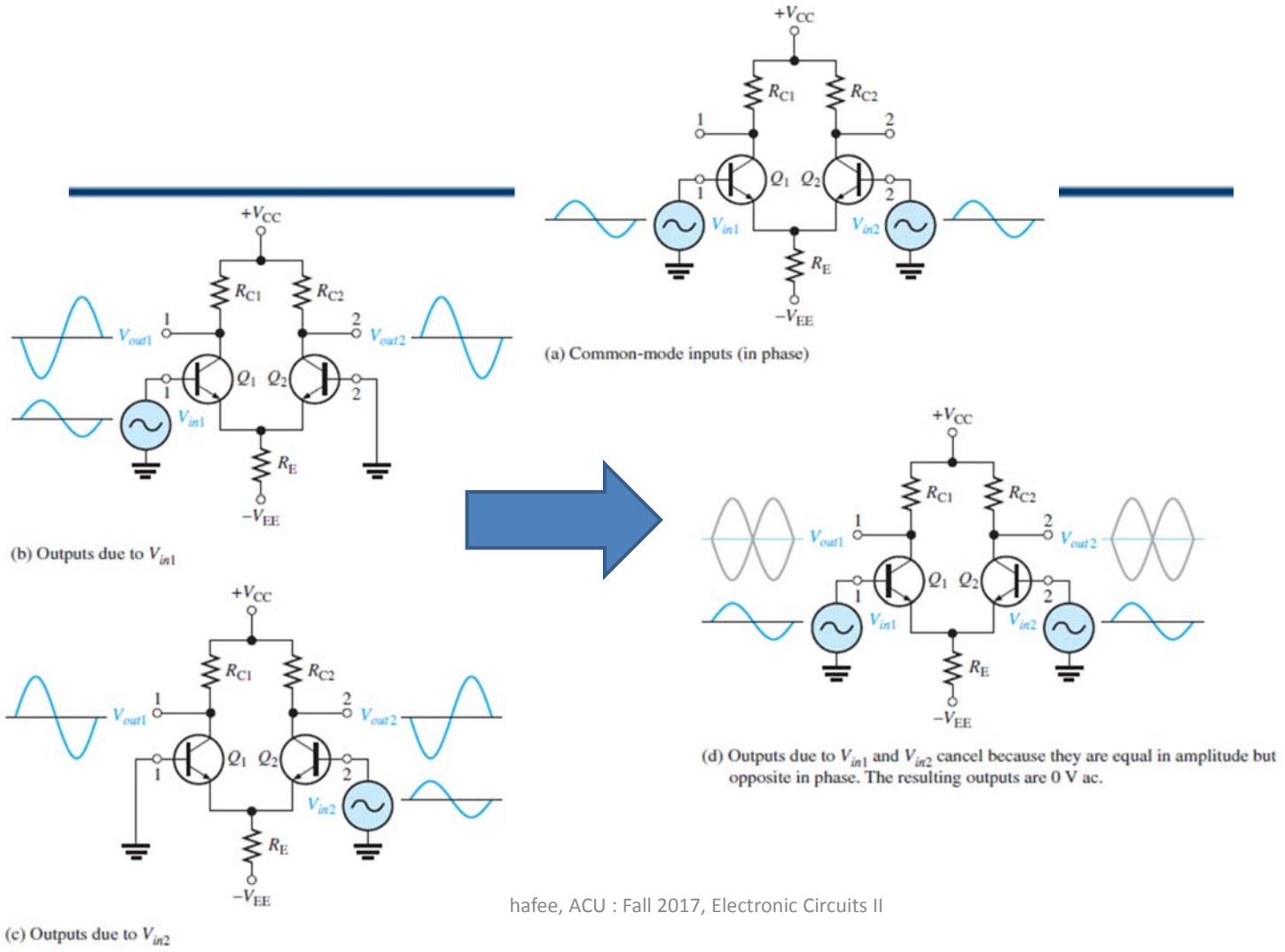
- ***Double-Ended Differential Inputs:***
- two opposite-polarity (out-of-phase) signals are applied to the inputs





- ***Common-Mode Inputs:*** two signal voltages of the same phase, frequency, and amplitude are applied to the two inputs





(a) Common-mode inputs (in phase)

(b) Outputs due to V_{in1}

(c) Outputs due to V_{in2}

(d) Outputs due to V_{in1} and V_{in2} cancel because they are equal in amplitude but opposite in phase. The resulting outputs are 0 V ac.

- This action is called ***common-mode rejection***.
- Common-mode rejection means that this unwanted signal will not appear on the outputs and distort the desired signal.
- Common-mode signals (noise) generally are the result of the pick-up of radiated energy on the input lines from adjacent lines, the 50 Hz power line, or other sources.

Common-Mode Rejection Ratio

- Desired signals appear on only one input or with opposite polarities on both input lines.
- These desired signals are amplified and appear on the outputs as previously discussed.
- Unwanted signals (noise) appearing with the same polarity on both input lines are essentially cancelled by the diff-amp and do not appear on the outputs. The measure of an amplifier's
- ability to reject common-mode signals is a parameter called the **CMRR (commonmode rejection ratio)**.

- Ideally, a diff-amp provides a very high gain for desired signals (single-ended or differential) and zero gain for common-mode signals, practically is a very small value

$$\text{CMRR} = \frac{A_{v(d)}}{A_{cm}}$$

$$\text{CMRR} = 20 \log\left(\frac{A_{v(d)}}{A_{cm}}\right)$$

Example 02

A certain diff-amp has a differential voltage gain of 2000 and a common-mode gain of 0.2. Determine the CMRR and express it in decibels.

$A_{v(d)} = 2000$, and $A_{cm} = 0.2$. Therefore,

$$\text{CMRR} = \frac{A_{v(d)}}{A_{cm}} = \frac{2000}{0.2} = \mathbf{10{,}000}$$

Expressed in decibels,

$$\text{CMRR} = 20 \log (10{,}000) = \mathbf{80\ dB}$$


Thanks,..
See you next week (ISA),…