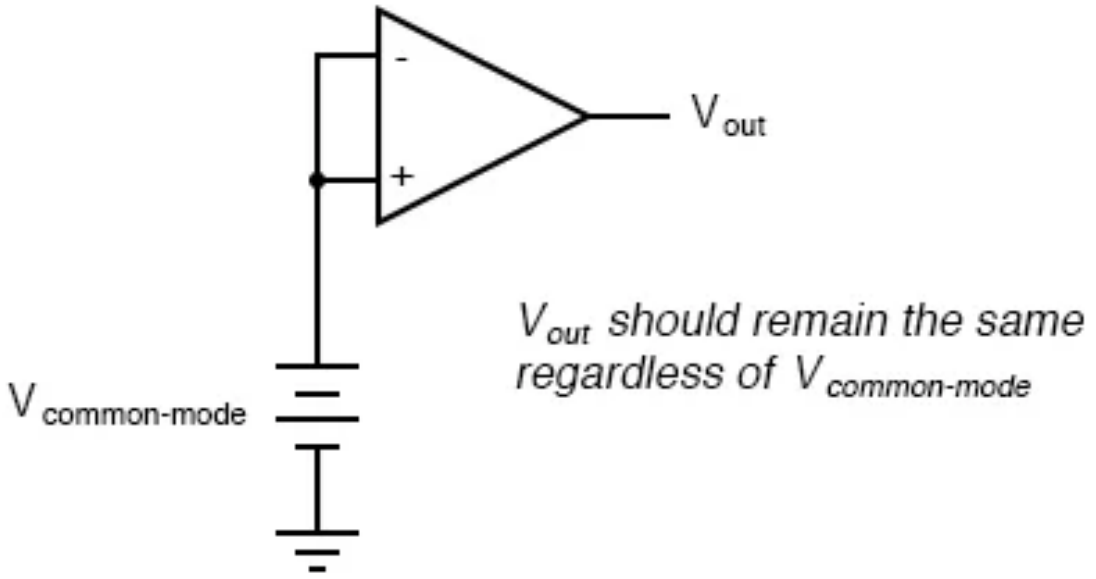
Common mode Rejection Ratio (CMRR)

What is it and why does it matter?

25th October 2021

Common Mode Voltage

- An ideal differential amplifier only amplifies the voltage difference between its two inputs.
- If the two inputs of a differential amplifier were to be shorted together there should be no change in output voltage.
- Voltage that is common between either of the inputs and ground, as "$V_{common\text{-}mode}$" is in this case, is called *common-mode voltage*.



Common Mode Gain

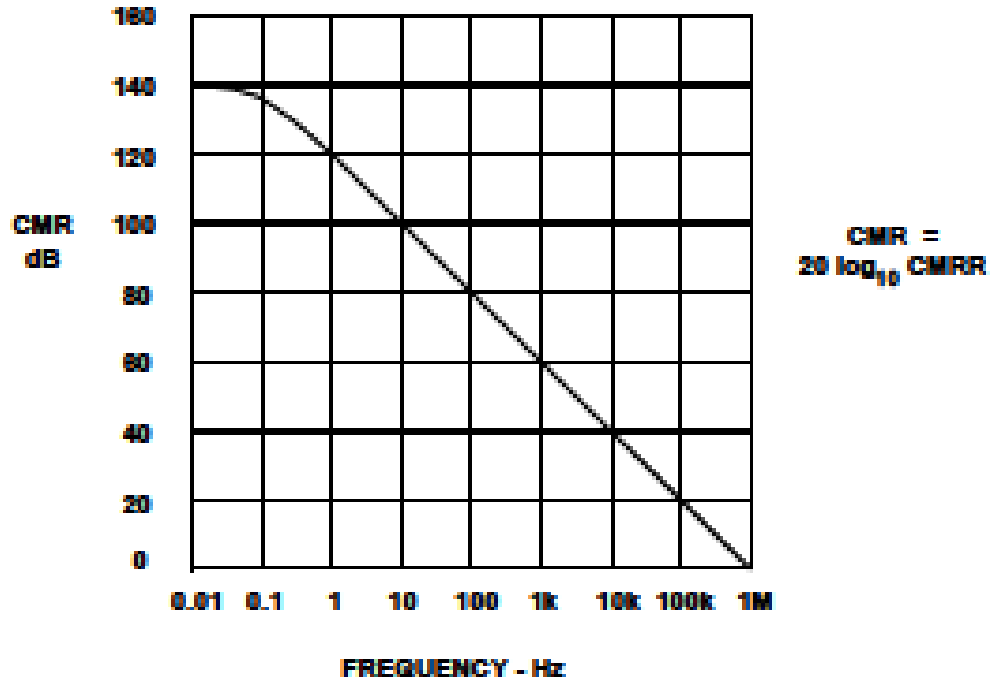
- The operational amplifier, being a differential amplifier with high differential gain, would ideally have zero common-mode gain.
- In reality this is not easily attained.
  - Thus, common-mode voltages will invariably have some effect on the op-amp’s output voltage.

Common Mode Rejection Ratio

- The op amp common-mode rejection ratio (CMRR) is the ratio of thecommon-mode gain to differential-mode gain.
  - For example, if a differential input change of Y volts produces a change of 1 V at the output, and a common-mode change of X volts produces a similar change of 1 V, then the CMRR is X/Y.
- When the common-mode rejection ratio is expressed in dB, it should strictly be referred to as common-mode rejection (CMR) but:
  - there is very little consistency in this throughout the semiconductor industry with regards to the use of dB or ratio values for CMR or CMRR.

Typical Values of CMR (or CMRR)

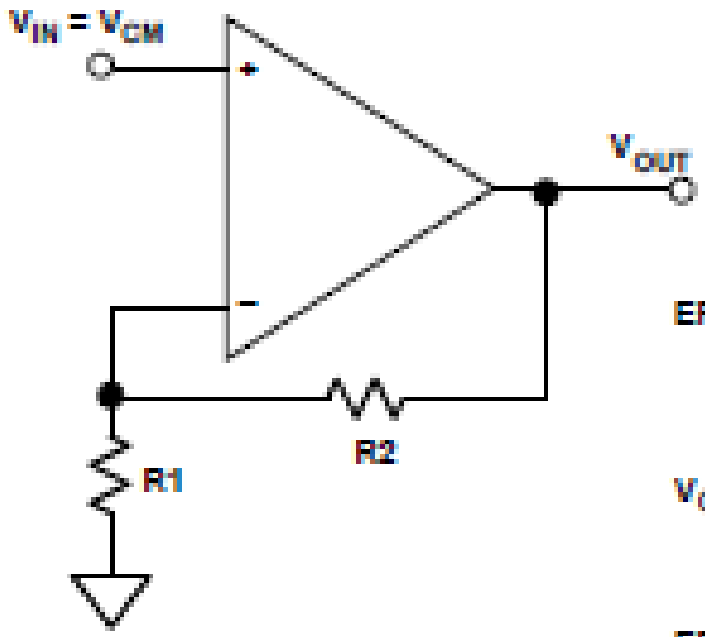
- Typical low frequency CMR values can be between 70 dB and 120 dB, but at higher frequencies CMR deteriorates.



CMRR for the OP177

Non-inverting Mode

- CMRR produces a corresponding output offset voltage error in op amps configured in the noninverting mode.



$$\text{ERROR (RTI)} = \frac{V_{CM}}{CMRR} = \frac{V_{IN}}{CMRR}$$

$$V_{OUT} = \left[1 + \frac{R2}{R1}\right]\left[V_{IN} + \frac{V_{IN}}{CMRR}\right]$$

$$\text{ERROR (RTO)} = \left[1 + \frac{R2}{R1}\right]\left[\frac{V_{IN}}{CMRR}\right]$$

Calculating Offset Error Due to Common-Mode Rejection Ratio (CMRR)

Inverting Mode

- Because the common mode rejection ratio in a typical op-amp is very high, common-mode gain is usually not a great concern in circuits where the op-amp is being used with negative feedback.
- If the common-mode input voltage of an amplifier circuit were to suddenly change, thus producing a corresponding change in the output due to common-mode gain, that change in output would be quickly corrected as negative feedback and differential gain (being *much* greater than common-mode gain) worked to bring the system back to equilibrium.