Indian Institute of Information Technology, Allahabad
ELECTRONICS AND COMMUNICATION ENGINEERING DEPARTMENT

Course Name: Analog Electronics Laboratory

EXPERIMENT NO: 7

Objective:

To calculate the Common Mode Rejection Ratio (CMRR) of a given Op-Amp IC.

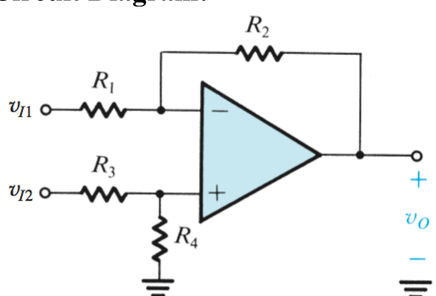
Materials/ Component Required:

Resistance	4	
Op-Amp IC	1	741
Supply	DC	±15V
Function Generator		
Multimeter		

Theory:
The CMRR in an operational amplifier is a common mode rejection ratio. Generally, the op amp as two input terminals which are positive and negative terminals and the two inputs are applied at the same point. This will give the opposite polarity signals at the output. Hence the positive and the negative voltage of the terminals will cancel out and it will give the resultant output voltage. The op amp common-mode rejection ratio (CMRR) is the ratio of the differential-mode gain to common-mode gain. The ideal op amp will have the infinite CMRR and with the finite differential gain and zero common mode gain.

Procedure:
1. Connect the Op-Amp in common mode providing or shorting both input at single supply.
   a. At this the inverting and non-inverting amplified signals must cancel each other, hence zero output.
   b. Common mode gain (A_{CM}) can be calculated as output/input which must be minimum
   c. Ideal op-amp has zero common-mode gain (A_{CM}).
2. Connect the Op-Amp in differential mode, i.e. each input has different input amplitude in phase.
   a. At this configuration, the circuit must provide some amplified output of the difference voltage at input.
   b. The differential gain (A_d) can be calculated by output/(input signal difference).
   c. Ideal op-amp have infinite differential gain (A_d)

Circuit Diagram:



Design and Calculations:
Solving the differential output

$$V_{od} = V_{i2}\left(1+\frac{R_2}{R_1}\right)\left(\frac{R_4}{R_3+R_4}\right) - V_{i1}\left(\frac{R_2}{R_1}\right) = V_{i2}\left(1+\frac{R_2}{R_1}\right)\left(\frac{R_4/R_3}{1+R_4/R_3}\right) - V_{i1}\left(\frac{R_2}{R_1}\right)$$

If $\frac{R_2}{R_1} = \frac{R_4}{R_3}$, then
$V_{od} = \frac{R_2}{R_1}(V_{i2} - V_{i1})$ (Applying one input zero/ground would be easy for experimental purpose)

Differential Gain (A_d): $A_d = \frac{V_{od}}{V_{id}} = \frac{R_2}{R_1}$

Next solving for common-mode gain (A_{CM}), i.e. $V_{i1}=V_{i2}=V_i$

$$A_{CM} = \frac{V_{od}}{V_i} = \left(1+\frac{R_2}{R_1}\right)\left(\frac{R_4/R_3}{1+R_4/R_3}\right) - \left(\frac{R_2}{R_1}\right)$$

Using the same constraint ratio for resistances

$A_{CM} = \frac{R_4}{R_3} - \frac{R_2}{R_1} \sim 0$ (Ideally)

Due to manufacturing faults/mismatch and also due to error in resistive values, A_{CM} would have some value which provides some offset, hence CMRR and can be calculated as

$$CMRR = 20\log_{10}\left(\frac{A_d}{A_{CM}}\right)$$

Observation Table:

Parameters	Values
V_{in} (V)	
V_{od} (V)	
V_{oCM} (V)	
A_d	
A_{CM}	
CMRR (dB)	

Report:

Result:

Common-mode rejection ratio has been calculated for the given op-amp IC.

Precautions:

a) Connections should be verified before switching on the supply.
b) The resistance to be chosen should be in proper range and of calculated values.

References:

1. https://www.electronics-tutorials.ws/filter/filter_6.html
2. R.A. Gayakward, "Op-Amps and Linear Integrated Circuits" 4^{th} Ed. Pearson-Prentice Hall