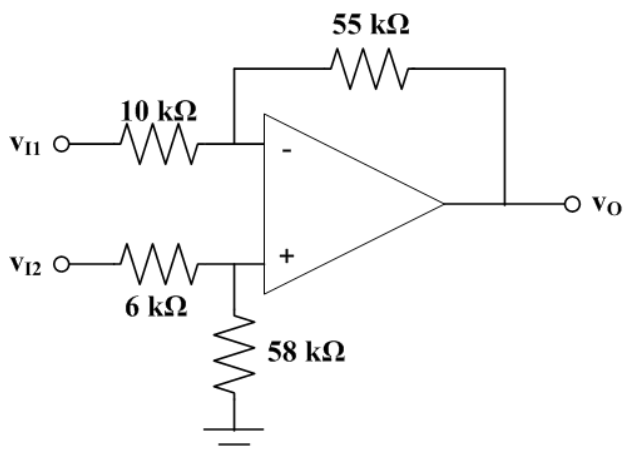
EE 315

Module 2B – Practice Problems

1. Design a difference amplifier such that the differential gain is 50 V/V, the minimum differential input resistance is 50kΩ, and the common mode gain is zero.

2. For the following circuit, derive and solve for the differential and common mode gain and the CMRR.



3. Design an instrumentation amplifier for a differential gain that is adjustable between 5 and 500 V/V. Assume that the gain of the second stage is 2 V/V.

1. Design a difference amplifier such that the differential gain is 50 V/V, the minimum differential input resistance is 50kΩ, and the common mode gain is zero.

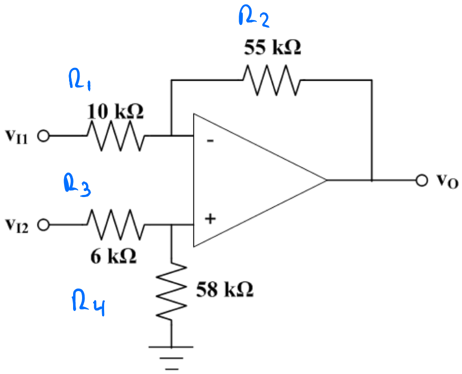
$A_d = 50 = \frac{R_2}{R_1}$ $R_{id} = 50 = 2R_1$ $R_1 = 50k\Omega$

$R_2 = 1.25m\Omega$

For $A_{CM} = 0$ $R_4 = R_2 = 1.25m\Omega$

Common mode gain $R_1 = R_3 = 25k\Omega$

2. For the following circuit, derive and solve for the differential and common mode gain and the CMRR.



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

$$= -\frac{55}{10} + \left(1 + \frac{55}{10}\right)\left(\frac{58}{58+6}\right) = -5.5 + (6.5)(0.90625)$$

$$= -0.39 \text{ V/V} \qquad 14.59$$

$$A_d = \frac{1}{2}\left(\frac{R_2}{R_1} + \left(1 + \frac{R_2}{R_1}\right)\left(\frac{R_4}{R_3 + R_4}\right)\right)$$

$R_1 = 10$
$R_2 = 55$
$R_3 = 6$
$R_4 = 58$

$$A_d = \frac{1}{2}\left(\frac{55}{10} + \left(1 + \frac{55}{10}\right)\left(\frac{58}{58+6}\right)\right) = 5.69 \text{ V/V}$$

$$CMRR = 20 \log \left|\frac{A_d}{A_{CM}}\right| = 23.29$$

3. Design an instrumentation amplifier for a differential gain that is adjustable between 5 and 500 V/V. Assume that the gain of the second stage is 2 V/V.

$$5 \le A_d \le 500 \qquad A_{d2} = 2 \text{ V/V}$$

$$A_d = \left(1 + \frac{2R_2}{2R_1}\right)\underbrace{\left(\frac{R_4}{R_3}\right)}_{\text{second stage gain}}$$

Did not specify the size of the pot

$$\left.\frac{R_4}{R_3} = 2 \text{ V/V}\right\} \text{ let } \left.\begin{aligned} R_4 &= 200\,k\Omega \\ R_3 &= 100\,k\Omega \end{aligned}\right\}$$

Lots of possible designs.

$$2R_1 = R_F + 100\,k\Omega \begin{cases} \text{max}: R_F + 100 \\ \text{min}: R_F \end{cases}$$

$Ad = \left(1 + \frac{2R_2}{2R_1}\right)(2)$

$Ad = 5$ for $2R_1$ at max

$Ad = 500$ for $2R_1$ at min

$\left(1 + \frac{2R_2}{RF + 100}\right)(2) = 5$

$2R_2 = 1.5(RF + 100 \times 10^3)$

$\left(1 + \frac{2R_2}{RF}\right)(2) = 5$

$2R_2 = 249 rF$

$R_2 = 124.5 rF$

$249 rF = 1.5(RF + 100 \times 10^3)$

$249 rF = 1.5 rF + 150 \times 10^3$

$247.5 rF = 150E3$

$rF = 606\,\Omega$

$R_2 = 75454.54$

$75.45 \times 10^3\,\Omega$