module 2B practice problem solutions

① Difference Amp (assume ideal & matched resistors)

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

$\boxed{R_1 = 25k\Omega}$

$A_d = 50 = \frac{R_2}{R_1}$ $\quad \boxed{R_2 = 1.25M\Omega}$

for $A_{cm} = 0$ $\quad \boxed{R_4 = R_2 = 1.25M\Omega}$

$\boxed{R_1 = R_3 = 25k\Omega}$

(2) since $R_1 \neq R_3$

$R_2 \neq R_4$

$R_1 = 10\,k\Omega$
$R_2 = 55\,k\Omega$
$R_3 = 6\,k\Omega$
$R_4 = 58\,k\Omega$

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

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

$$A_{cm} = \frac{-55}{10} + \left(1 + \frac{55}{10}\right)\left(\frac{58}{6+58}\right)$$

$$\boxed{A_{cm} = 0.39\ V/V}$$

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

$$\boxed{A_d = 5.70\ V/V}$$

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

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

second gain stage

I didn't specify the size of the pot. I chose 100kΩ

lots of possible designs!

$$\frac{R_4}{R_3} = 2\,\frac{V}{V} \qquad \text{let} \quad \boxed{\begin{aligned} R_4 &= 200k\Omega \\ R_3 &= 100k\Omega \end{aligned}}$$

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

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

$A_d = 5$ for $2R_1$ at max value

$A_d = 500$ for $2R_1$ at min value

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

$$\boxed{2R_2 = 1.5\left(R_f + 100 \times 10^3\right)}$$

$$\left(1 + \frac{2R_2}{R_f}\right)(2) = 500$$

$$2R_2 = 249R_f$$

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

$$247.5R_f = 150 \times 10^3$$

$$R_f = 606.06\,\Omega$$

$$R_2 = 75.45\,k\Omega$$