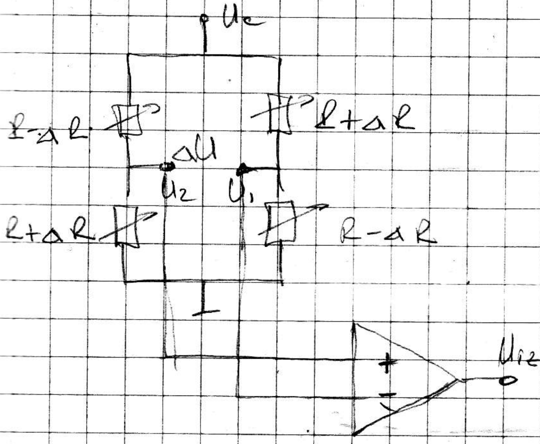
# Zadaća 2.

## Zadatak 1.

$\frac{\Delta R}{R} = k \cdot \frac{\Delta l}{l}$ → važna stvar kod tenzometra




- veća osjetljivost sa 4 otpora za razliku od 1 otpora $R' = R+\Delta R$

$$\Delta U = U_2 - U_1 = U\left(\frac{R+\Delta R}{R-\Delta R+R+\Delta R} - \frac{R-\Delta R}{R+\Delta R+R-\Delta R}\right)$$

$$= U\frac{\Delta R}{R} = 5 \cdot 2 \cdot \frac{0.1}{100} = 10\,mV$$

$$U_{iz} = A_D \cdot U_d \boxed{\pm A_z U_z} \qquad A_z = \frac{A_D}{F}$$

→ pogreška < 0.5%

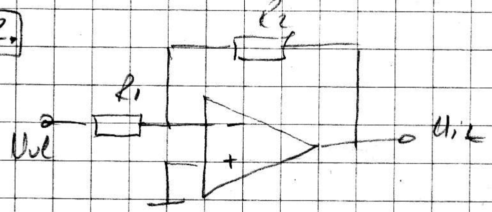
$$U_D = \Delta U$$

$$U_z = \frac{U_2+U_1}{2} = \frac{U}{2}\left[\frac{R+\Delta R}{2R} + \frac{R-\Delta R}{2R}\right] = \frac{U_0}{2}$$

$$A_z U_z \Rightarrow \frac{A_D}{F}\frac{U_0}{2} = p \cdot A_D U_D \qquad F > \frac{U_0}{2p \cdot U_D} = \frac{5}{2 \cdot \frac{0.5}{100} \cdot 10^{-3}} = 50000 = 94\,dB$$

$$U_{iz} = 300 \cdot 10^{-3} \pm \frac{300}{50000} \cdot \frac{5}{2} = (3 \pm 0.15)\,V$$

## Zadatak 2.




$$R_{ul} = R_1 = 2\,M\Omega$$

$$A = -\frac{R_2}{R_1} \qquad \text{za } A_v = 100 \Rightarrow R_2 = 200\,M\Omega$$

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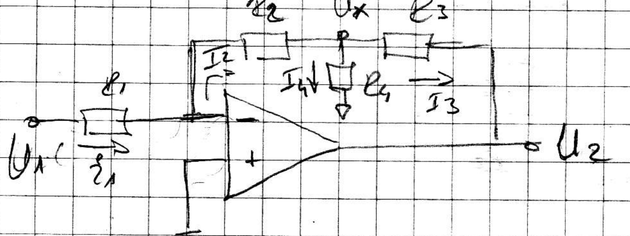



$$I_1 = -I_2$$

$$\frac{U_1}{R_1} = -\frac{U_x}{R_2}$$

$$-\frac{U_x}{R_2} = \frac{U_x}{R_4} + \frac{U_x - U_2}{R_3}$$

$$U_x\left(\frac{1}{R_2} + \frac{1}{R_3} + \frac{1}{R_4}\right) = \frac{U_2}{R_3}$$

$$\frac{R_2(-U_1)}{R_1}\left(\frac{1}{R_2} + \frac{1}{R_3} + \frac{1}{R_4}\right) = \frac{U_2}{R_3}$$

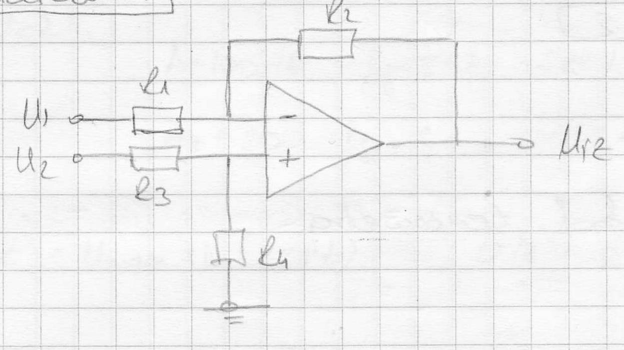
...

$$\hookrightarrow A = \frac{1}{R_1}\underbrace{\left(R_3 + R_2 + \frac{R_3 R_2}{R_4}\right)}_{R_2'} = \frac{U_2}{U_1}$$

$$R_2' = 2M\Omega + 2M\Omega + \frac{2M\Omega + 2M\Omega}{27{,}4\,k\Omega} = 150\,M\Omega$$

$$A = -\frac{150\,M\Omega}{2\,M\Omega} = -75 \qquad R_{ul} = 2\,M\Omega$$

## Zadatak 3.




$$U_{12} = \overbrace{(U_2-U_1)}^{U_D}\cdot\frac{R_2}{R_1} + U_2\left(\frac{R_4}{R_3+R_4}\left(1+\frac{R_2}{R_1}\right)-\frac{R_2}{R_1}\right)$$

$$A_D=\frac{R_2}{R_1} \qquad F=\left|\frac{A_D}{A_Z}\right| = \frac{\frac{R_2}{R_1}}{\frac{R_4}{R_3+R_4}\left(1+\frac{R_2}{R_1}\right)-\frac{R_2}{R_1}} = \frac{A_D}{(1+A_D)\frac{R_4}{R_3+R_4}-A_D}$$

idealno OP: $\left.\begin{matrix} R_2=R_4 \\ R_1=R_3 \end{matrix}\right\} \Rightarrow F=\infty$ $\qquad R_2'=1.01R_2 \Rightarrow A_D'=1.01A_D$

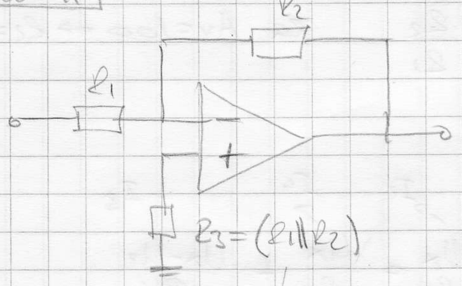
$$F=\frac{A_D'}{(1+A_D')\cdot\frac{A_D}{1+A_D}-A_D'} = \frac{1.01\cdot 100}{(1+1.01\cdot 100)\cdot\frac{100}{101}-1.01\cdot 100} = 80.2\,dB$$

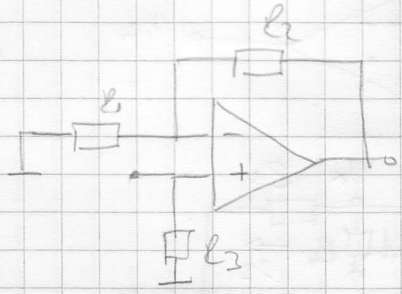
↳ $\frac{R_4}{R_3+R_4}=\frac{R_2}{R_1+R_2}=\frac{A_D}{1+A_D}$

!!! → more se dobit $F_{op}$ pa se računa $F_{uk}=\frac{F_{op}\cdot F_R}{F_{op}+F_R}$

- $F_{op}\to\infty$ $\quad F_{uk}=F_R$
  $F_R\to\infty$ $\quad F_{uk}=F_{op}$
- $R_{ul}=R_1+R_3$ $\quad$ ($R_{ul}=200\,k\Omega$ $\quad A_D=100$, $R_2=R_4$)

## Zadatak 4.




$A=-\frac{R_2}{R_1}$ $\qquad\qquad A=1+\frac{R_2}{R_1}$

$R_{ul}=R_1$ $\qquad\qquad R_{ul}=R_3$

→ što bliže toj vrijednosti jer se time izgubi struje pomaka

!!! proučiti dobro i naučiti napone pomaka; $U_p=I(R_3-R_1\|R_2)$

Zadatak 4.

$A_0 = 100\,dB$  $A = 20$  $S = 1.5\,V/\mu s$

$f_0 = 5\,Hz$

$A_0 f_0 = A \cdot f_g$  $f_g = \frac{A_0 f_0}{A} = \frac{10^5 \cdot 5}{20} = 25\,kHz$

$\frac{dU_{iz}}{dt} \le S$

$U_{ul} = U_{ul} \cdot \sin(2\pi f t)$  $U_{iz} = A \cdot U_{ul} \sin(2\pi f t)$

$\frac{dU_{iz}}{dt} = A U_{ul} \cdot 2\pi f \cos(2\pi f t)$

$A \cdot U_{ul} \cdot 2\pi f \le S$

$\frac{20 \cdot 0.7 \cdot 2\pi \cdot 25^3}{\sqrt{2}} \le S$

$1.56\,V/\mu s \le 1.5\,V/\mu s$ → ne može radit

↳ $\sqrt{2}$ jer pojačanje na graničnim frekvencijama pada za 3dB ($\sqrt{2}$)

Sinusni:

$f \le \frac{S}{A U_{ul} \cdot 2\pi} = \frac{1.5 \cdot 10^6}{20 \cdot 0.7 \cdot 2 \cdot \pi} = 17052\,Hz$

Trokutasti:

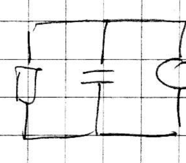
$\frac{dU_{iz}}{dt} = \frac{A \cdot U_{ul}}{\frac{T}{4}} = 4f \cdot A \cdot U_{ul}$  $f \le \frac{S}{4 \cdot A \cdot U_{ul}} = 26786\,Hz$

→ brzina porasta definirana za izlazni napon

Zadatak 5.

$U_R^2 = 4kTR$  $U_R = \sqrt{4kTR \cdot f_g \cdot \frac{\pi}{2}}$

↳ član prvog reda



$f_g = \frac{1}{2\pi} \cdot \frac{1}{RC}$

$U_R = \sqrt{4kTR \cdot \frac{1}{2\pi} \cdot \frac{1}{RC} \cdot \frac{\pi}{2}} = \sqrt{\frac{kT}{C}} = 2\mu V_{ef}$