LETNÍ ROK 2014 ZIMS. EI

① $N=16$, $t_{AD}=9{,}779\,\mu s$, $\pm 2{,}5\,V$, $R_{ON}=2\,\Omega$

a) $t_{AKV} = 221\,ns$

$$u\exp\left(-\frac{t_{akv}}{\tau}\right) \leq 1\,LSB$$

$$u\exp\left(-\frac{t_{akv}}{\tau}\right) \leq \frac{u}{2^N}$$

$$-\frac{t_{akv}}{\tau} \leq \ln\frac{1}{2^N}$$

$$\tau \geq -\frac{t_{akv}}{\ln\frac{1}{2^N}}$$

$$\tau \geq -\frac{221\cdot 10^{-9}}{\ln\frac{1}{2^{16}}} \geq 1{,}9927\cdot 10^{-8}\,s$$

$$\tau = R_{ON}\cdot C$$

$$C = \frac{\tau}{R_{ON}} = \frac{1{,}9927\cdot 10^{-8}}{2} = 9{,}9636\cdot 10^{-9}\,F$$

b) $$\frac{du}{dt} = \frac{I}{C}$$

$$\frac{I}{C}\cdot t_{AD} \leq 1\,LSB$$

$$\frac{I}{C}\,t_{AD} \leq \frac{u_{FS}}{2^N}$$

$$I \leq \frac{C\cdot U_{FS}}{t_{AD}\cdot 2^N} \leq \frac{9{,}9636\cdot 10^{-9}\cdot 5}{9{,}779\cdot 10^{-6}\cdot 2^{16}} \leq 7{,}77\cdot 10^{-8}\,A$$

c) $\frac{1}{f_{uz}} = t_{AD} + t_{AKV} = 9{,}779 \cdot 10^{-6} + 221 \cdot 10^{-5}$

$f_{uz} = 100\ kHz$

d) $f = 30\ kHz$

$u(t) = U_{max} \cdot \sin(2\pi f t)$

$\left(\frac{du(t)}{dt}\right)_{max} = U_{max} \cdot 2\pi \cdot f$

$\frac{du(t)}{dt} \cdot t \leq \frac{LSB}{2}$

$U_{max} \cdot 2\pi \cdot f \cdot t \leq \frac{U_{FS}}{2 \cdot 2^N}$

$\frac{U_{FS}}{2} \cdot 2\pi \cdot f \cdot t \leq \frac{U_{FS}}{2 \cdot 2^N}$

$t \leq \frac{1}{2 \cdot 2^N \cdot \pi \cdot f} = \frac{1}{2 \cdot 2^{16} \cdot \pi \cdot 30 \cdot 10^3}$

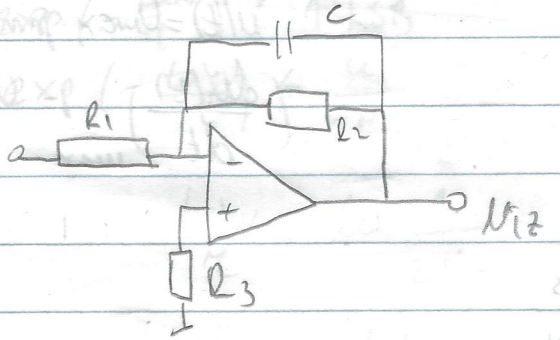
$t \leq 8{,}095 \cdot 10^{-11}\ s$

② $R_{ul} = 30\ k\Omega$, $A = -30$, $R_3 = R_1 \| R_2$, $f_g = 30\ kHz$

$u_{nop} = 40\ nV/\sqrt{Hz}$

$i_{nop} = 1\ pA/\sqrt{Hz}$

$\pm 2V$, $N = 16$ $\quad T = 300$, $k = 1{,}37 \cdot 10^{-23}\ J/K$



$\tau = R_2 \cdot C$

$\omega = \frac{1}{\tau} = \frac{1}{R_2 C}$

$2 \cdot \pi \cdot f \cdot R_2 \cdot C = 1$

$C = \frac{1}{2\pi \cdot f \cdot R_2} = 5{,}89 \cdot 10^{-12}$

$R_1 = R_{ul} = 30\ k\Omega$

$A = -\frac{R_2}{R_1} \rightarrow R_2 = -A \cdot R_1 = 30 \cdot 30 = 900\ k\Omega$

$R_3 = R_1 \| R_2 = 29\,032{,}3\ \Omega$

$U_{R1}^2 = 4kTR_1 = 4 \cdot 1{,}37 \cdot 10^{-23} \cdot 300 \cdot 30 \cdot 10^3 = 4{,}932 \cdot 10^{-16}\ V^2/Hz$

$U_{R2}^2 = 4kTR_2 = 4 \cdot 1{,}37 \cdot 10^{-23} \cdot 300 \cdot 900 \cdot 10^3 = 1{,}4796 \cdot 10^{-14}\ V^2/Hz$

$U_{R3}^2 = 4 \cdot k \cdot T \cdot R_3 = 4 \cdot 1{,}37 \cdot 10^{-23} \cdot 300 \cdot 29\,032{,}3 = 4{,}773 \cdot 10^{-16}\ V^2/Hz$

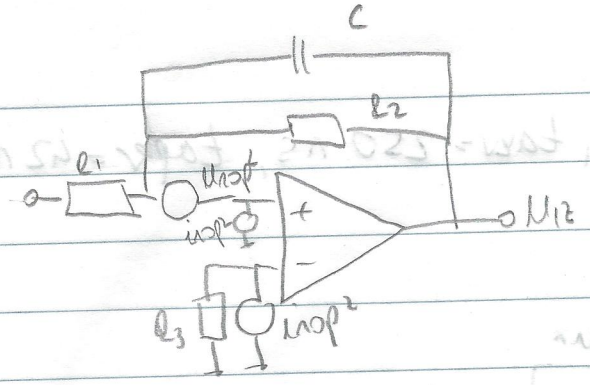
dopirnos otpornika na izlazu

R_1: $U_{R1i}^2 = U_{R1}^2 \cdot \left(\frac{R_2}{R_1}\right)^2 \cdot f_g \cdot \frac{\pi}{2} = 4{,}932 \cdot 10^{-16} \cdot \left(\frac{900}{30}\right)^2 \cdot 30 \cdot 10^3 \cdot \frac{\pi}{2}$

$= 2{,}0917 \cdot 10^{-8}\ V^2/Hz$

R_2: $U_{R2i}^2 = U_{R2}^2 \cdot f_g \cdot \frac{\pi}{2} = 1{,}4796 \cdot 10^{-14} \cdot 30 \cdot 10^3 \cdot \frac{\pi}{2} = 6{,}9725 \cdot 10^{-10}\ V^2/Hz$

R_3: $U_{R3i}^2 = U_{R3}^2 \cdot f_g \cdot \frac{\pi}{2} \cdot \left(\frac{R_2}{R_1}\right)^2 = 4{,}773 \cdot 10^{-16} \cdot 30 \cdot 10^3 \cdot 30^2 \cdot \frac{\pi}{2} = 2{,}0243 \cdot 10^{-8}\ V^2/Hz$



Op. pojačalo:

$$U_{n,op}^2 = \left[U_{nop}^2 + i_{nop}^2 \cdot R_3^2 + i_{nop}^2 \cdot (R_1 \| R_2)^2\right] \cdot \left(1 + \frac{R_2}{R_1}\right)^2 \cdot fg \cdot \frac{\pi}{2}$$

$$= \left[U_{nop}^2 + 2 \cdot i_{nop}^2 \cdot R_3^2\right] \left(1 + \frac{R_2}{R_1}\right)^2 \cdot fg \cdot \frac{\pi}{2}$$

$$= \left[(40 \cdot 10^{-9})^2 + 2 \cdot (1 \cdot 10^{-12} \cdot 29\,032{,}3)^2\right] (1+30)^2 \cdot 30 \cdot 10^3 \cdot \frac{\pi}{2}$$

$$U_{n,op}^2 = 1{,}4879 \cdot 10^{-7}\ V^2/Hz$$

Uk: $U_{n,uk}^2 = U_{R11}^2 + U_{R22}^2 + U_{e33}^2 + U_{nop}^2$

$$= 2{,}0917 \cdot 10^{-8} + 6{,}9725 \cdot 10^{-10} + 2{,}0243 \cdot 10^{-8} + 1{,}4879 \cdot 10^{-7}$$

$$= 1{,}9065 \cdot 10^{-7}\ V^2/Hz$$

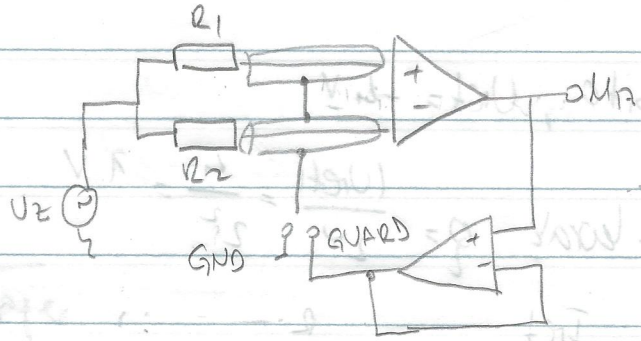
$$U_{n,uk\,ef} = 4{,}3663 \cdot 10^{-4}\ Vef$$

$$U_{nukpp} = 6 \cdot 4{,}3663 \cdot 10^{-4} = 2{,}6198 \cdot 10^{-3}\ Vpp$$

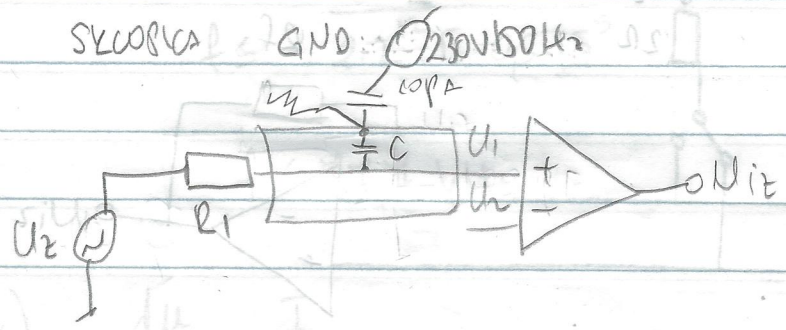
$$\frac{U_{nukpp}}{2SB} = \frac{2{,}6198 \cdot 10^{-3}}{\frac{4}{2^{16}}} = 42{,}92 = 2^n$$

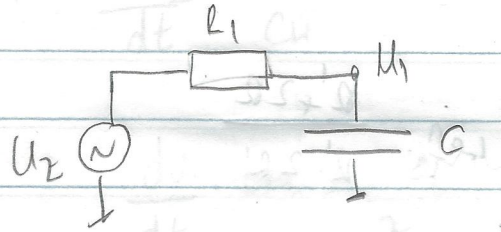
$n = 5{,}42 \rightarrow N = 6$

③ $R_1 = 9\,k\Omega$, $R_2 = 10\,k\Omega$



a) SKICA





$f_{sw} = f_i = 1\,kHz$

$$\frac{U_1}{U_z} = \frac{\frac{1}{j\omega C}}{R_1 + \frac{1}{j\omega C}} = \frac{1}{1 + j\omega C R_1}$$

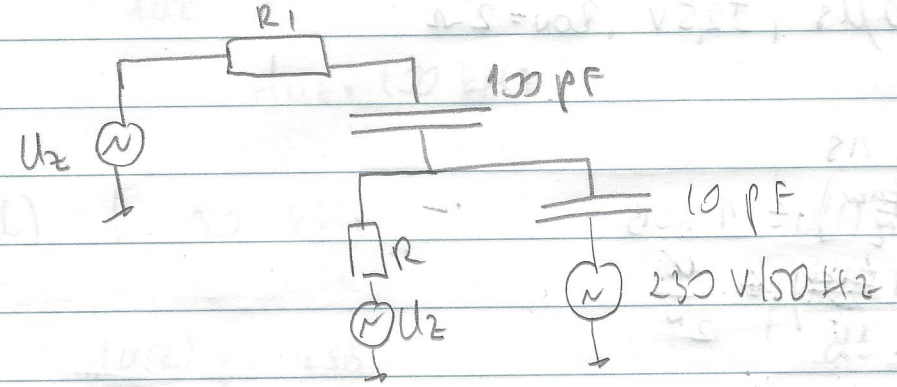
Vrijedi i za U_2:

$$U_{iz} = A_0 U_0 = A_0 (U_1 - U_2) = A_0 U_z \left[\frac{1}{1 + j\omega C R_1} - \frac{1}{1 + j\omega C R_2} \right]$$

$$= 100 \cdot 1 \left[\frac{1}{1 + j \cdot 2\pi \cdot 1 \cdot 10^3 \cdot 9 \cdot 10^3 \cdot 10^{-12}} - \frac{1}{1 + j \cdot 2\pi \cdot 1 \cdot 10^3 \cdot 10 \cdot 10^3 \cdot 10^{-12}} \right]$$

$U_{iz} = 0{,}0628\,V$

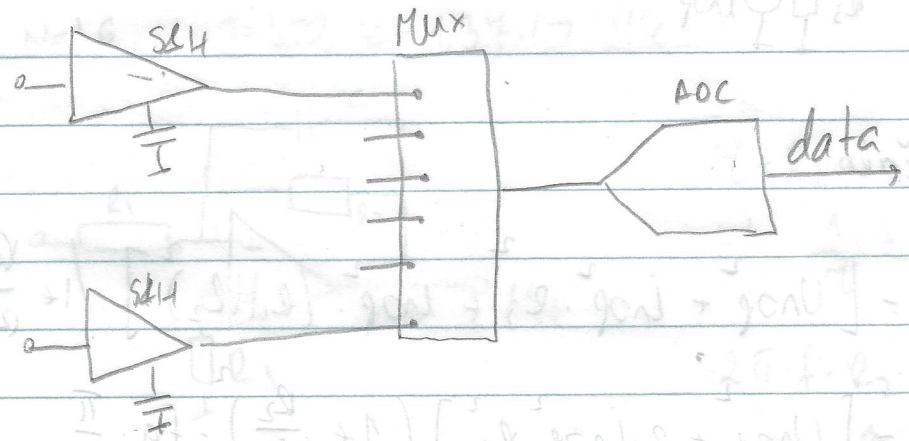
b) SKUPKA GUARD



$f_{SMU} = 50\,Hz$

(4.) 8 kanala, $f_{uz} = 83\ kHz$, $t_{akv} = 250\ ns$, $t_{aper} = 42\ ns$
$N = 14$, $5\ V$, $t_{pret} = 833\ ns$

a)



b)

t_{akv} 250 ns
t_{aper} 42 ns
t_{smir} x
t_{pret} 833 ns

$$\frac{1}{f_{uz}} = 250 \cdot 10^{-9} + 42 \cdot 10^{-9} + 8(x + 833 \cdot 10^{-9})$$

$$x = 7{,}26 \cdot 10^{-7}\ s$$

c) $$\frac{u}{2^N} \cdot 100\,\% = \frac{5}{2^{14}} \cdot 100 = 0{,}0305\,\%$$