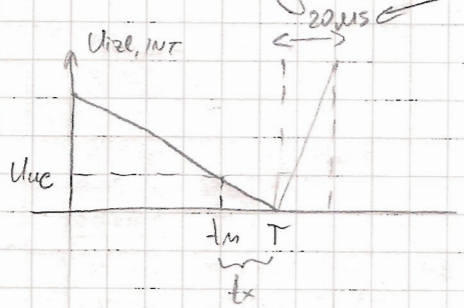
3. AUDITORNE

1: AD $U \to t$

Millerov integrator – vrijeme povrata

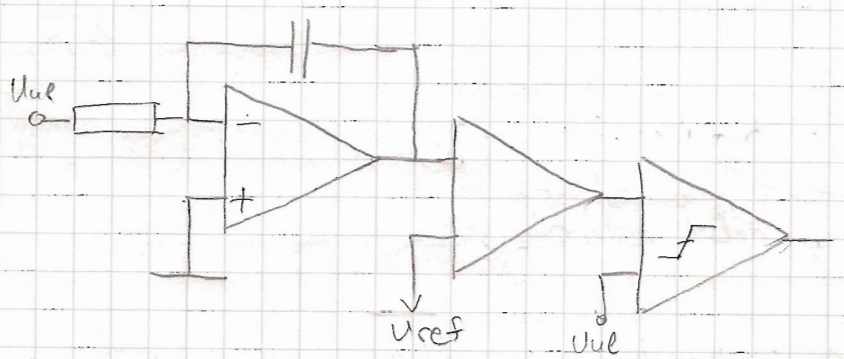


$U_{izl,INT} = U_0\left(1 - \frac{t}{T}\right)$

$U_m = U_0\left(1 - \frac{t_m}{T}\right)$

$\frac{U_m}{U_0} = \frac{T - t_m}{T} = \frac{t_x}{T}$, $t_x = N \cdot \frac{1}{f_{osc}}$

t_x → vrijeme u kojem brojimo impulse

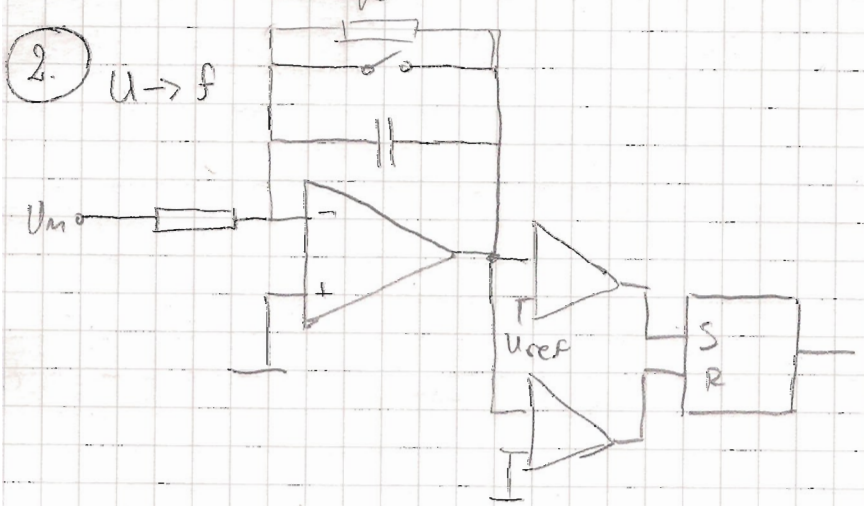


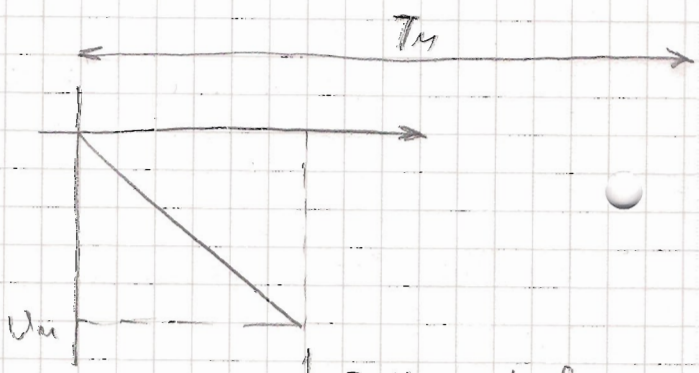
$\frac{4,7V}{10V} = \frac{t_x}{10ms} \Rightarrow t_x = 4,7ms$

$N = 4,7ms \cdot 10kHz = 47$

$f_{s\,max} = \frac{1}{10ms + 20\mu s} = 99,8\ S/s\ (Hz)$

2. $U \to f$





$\frac{1}{RC} \cdot T \cdot U_M = U_{ref}$

$T = RC\,U_{ref}\frac{1}{U_m} = 300\mu s \cdot 3V \cdot \frac{1}{2,8V} =$

$= 321,429\mu s$

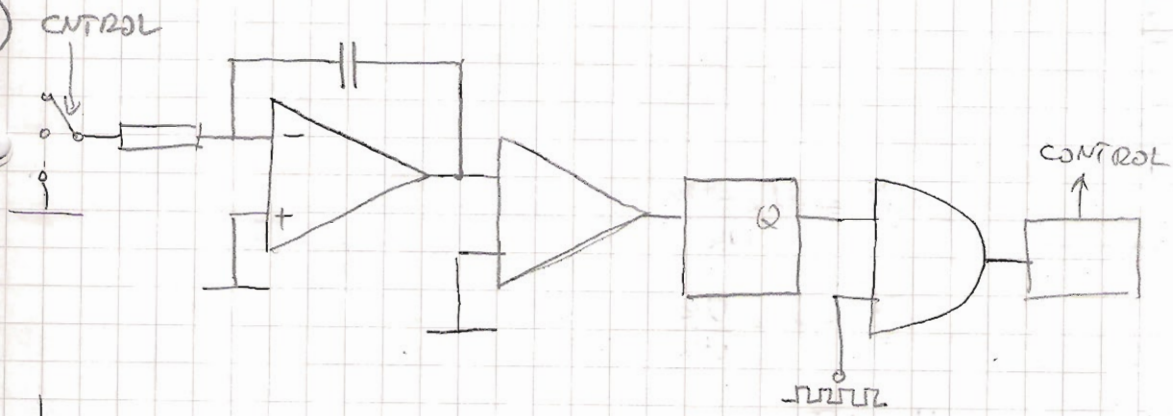
$T_M = 250ms$

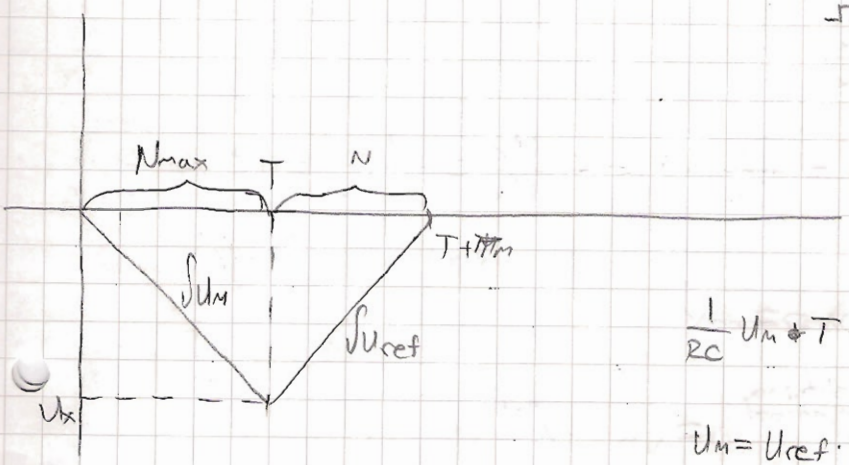
$N = \frac{T_M}{T} = \frac{250ms}{321,429\mu s} = 777$ ← zaokružuje se na manje

$0 = U_{ref}\left(1 - \frac{T_{izB}}{R_{ON} \cdot C}\right) \Rightarrow T_{izB} = R_{ON} \cdot C = 0,477\mu s$

$\Rightarrow N' = \frac{T_M}{T + T_{izB}} = 776 \Rightarrow \varepsilon = \frac{777 - 776}{777} \approx 0,13\%$

3.





trebalo bi biti obrnuta slika zbog Uref

$$\frac{1}{RC} U_M \cdot T = \frac{1}{RC} U_{ref} \cdot T_M$$

$$U_M = U_{ref} \cdot \frac{T_M}{T} = U_{ref} \frac{N}{N_{max}}$$

$N_{max} = 2^{14}$, $T = \frac{1}{50Hz}$ ← ne smije biti kraći zbog smetnji mreže

$T = 20ms \Rightarrow f_{osc} = \frac{N_{max}}{T} = 819,2\,kHz$

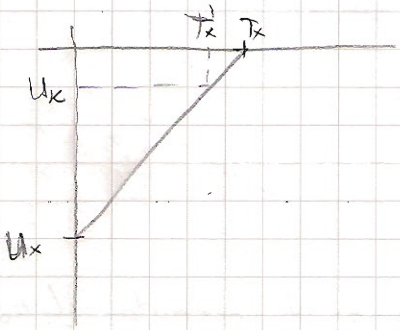
b) $U_{max,IN} = \frac{1}{RC} U_{ref} T \Rightarrow RC = \frac{2,5V}{5V} \cdot 20ms = 10ms$

$\tau = R_2 \cdot C_2 = R \cdot 1,05 \cdot C \cdot 0,98 = 10,29\,ms$

$U_x' = \frac{1}{\tau} U_{ref} \cdot T = 4,859\,V$

4. $U_m = U_{ref} \cdot \frac{T_x}{T}$

$U_m' = U_{ref} \cdot \frac{T_x'}{T}$



$$\frac{U_x}{T_x} = \frac{U_x - U_k}{U_x}$$

$$\frac{T_x'}{T_x} = 1 - \frac{U_k}{U_x}$$

$$\frac{U_m'}{U_m} = \frac{T_x'}{T_x}$$

$$P = \frac{U_m' - U_m}{U_m} = \frac{T_x'}{T_x} - 1 = -\frac{U_k}{U_x} = -\frac{15mV}{3V} = 0{,}5\%$$

5.

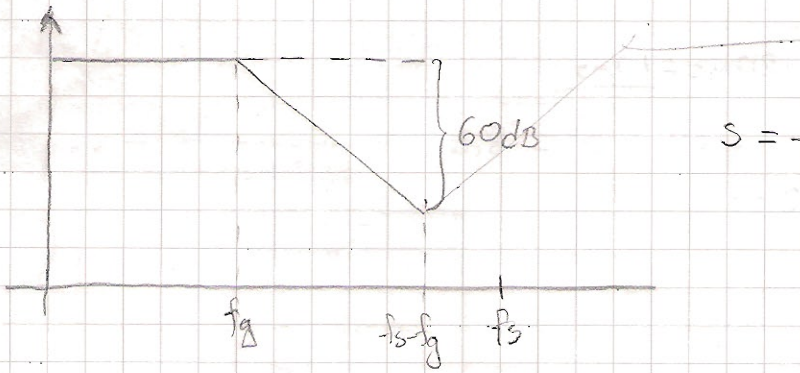
$$\varepsilon_{RMS} = \frac{Q}{\sqrt{12}} = \frac{10V}{2^{12}\cdot\sqrt{12}} = 0{,}704277\,mV$$

$$SNR = \frac{U_{sig}}{\varepsilon_{RMS}} = \frac{\frac{1}{2}F_s \cdot \frac{1}{\sqrt{2}}}{\varepsilon_{RMS}} = \sqrt{6}\cdot 2^{n-1}$$

(efektivna vrijednost)

$$SNR_{dB} = 20\log\left(\sqrt{6}\cdot 2^{n-1}\right) = 10\log 6 + 20(n-1)\log 2 = 6{,}02\cdot n + 1{,}76\,dB =$$

$$= 74\,dB$$



$$s = \frac{60dB}{\log\frac{f_s - f_g}{f_g}} = \begin{cases} 125{,}7\,dB/dek \\ 71\,dB/dek \end{cases}$$

6.

$$e_{RMS}^2 = \frac{\mathcal{E}_{RMS}^2}{f_s/2} \Rightarrow e_{RMS} = \sqrt{2}\,\frac{\mathcal{E}_{RMS}}{\sqrt{f_s}}$$

$$SNR = \frac{\frac{1}{\sqrt{2}} \cdot \frac{1}{2} \cdot U_{FS}}{\sqrt{2}\,\frac{\mathcal{E}_{RMS}}{\sqrt{f_s}} \cdot \sqrt{f_g}} = \sqrt{6} \cdot 2^{n-1} \cdot \sqrt{\frac{f_s}{2f_g}} = \sqrt{6} \cdot 2^{n+\Delta n-1}$$

Usrednjavanjem dobijemo veći SNR ako otipkavamo većom f_s od Nyquistove

$n' = n + \Delta n$

$$\sqrt{\frac{f_s}{2f_g}} = 2^{\Delta n}$$

$$f_s = 2f_g \cdot 2^{2\cdot\Delta n} = 2 \cdot 100\,kHz \cdot 2^{2\cdot 4} = \underline{51{,}2\,MHz}$$

$$10\log\frac{f_s}{2f_g} = 6{,}02 \cdot \Delta n$$

$$e_{RMS} = \mathcal{E}_{RMS} \cdot \frac{\pi}{\sqrt{3}} \left(\frac{2f_g}{f_s}\right)^{3/2}$$

$$SNR = \sqrt{6} \cdot 2^{n-1} \frac{\sqrt{3}}{\pi} \left(\frac{f_s}{2f_g}\right)^{3/2} = 6{,}02 \cdot n - 3{,}41 + 30\log\frac{f_s}{2f_g}$$

$$\boxed{30\log\frac{f_s}{2f_g} = 6{,}02 \cdot \Delta n}$$

$$\frac{f_s}{2f_g} = 6{,}35 \Rightarrow f_s = \underline{1{,}27\,MHz} \quad \text{za } \Sigma\Delta$$

7.

$$SNR = 6{,}02 \cdot n - 3{,}41 + 30\log\frac{f_s}{2f_g}$$

$$120 = 6{,}02 \cdot 16 - 3{,}41 + 30\log\frac{f_s}{2f_g}$$

$$30\log\frac{f_s}{2f_g} = 27{,}09$$

$$\frac{f_s}{2f_g} = 8 \Rightarrow f_s = 16 f_g = \underline{352\,kHz}$$