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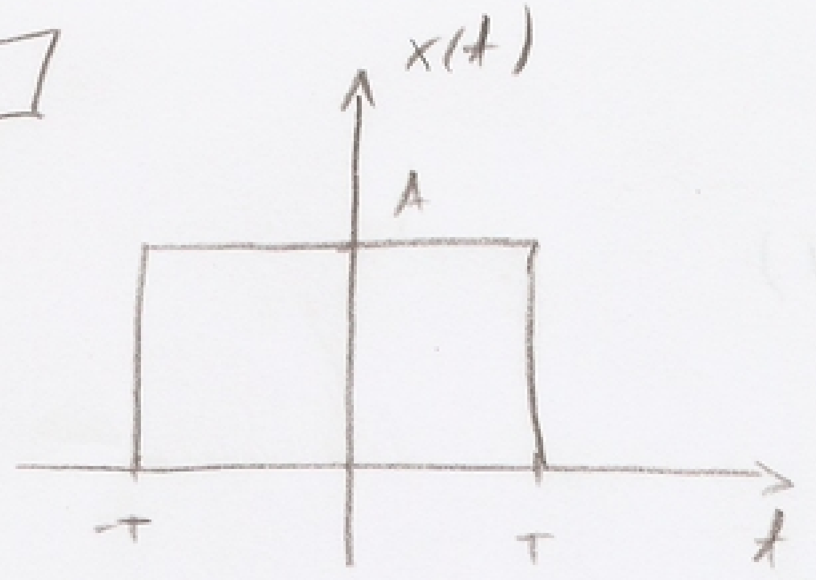
$\boxed{1.}$



$$z(t) = x(t) + j\hat{x}(t)$$

$$\hat{x}(t) = \frac{1}{\pi}\,(v.p.)\int_{-\infty}^{\infty}\frac{x(\tau)}{t-\tau}\,d\tau = \frac{1}{\pi}\,(v.p.)\int_{-T}^{T} A\,\frac{1}{t-\tau}\,d\tau =$$

$$= \frac{A}{\pi}\cdot\left(\int_{-T}^{0}\frac{1}{t-\tau}\,d\tau + \int_{0}^{T}\frac{1}{t-\tau}\,d\tau\right) =$$

$$= \frac{A}{\pi}\cdot\left(-\ln(t-\tau)\Big|_{-T}^{0} - \ln(t-\tau)\Big|_{0}^{T}\right) =$$

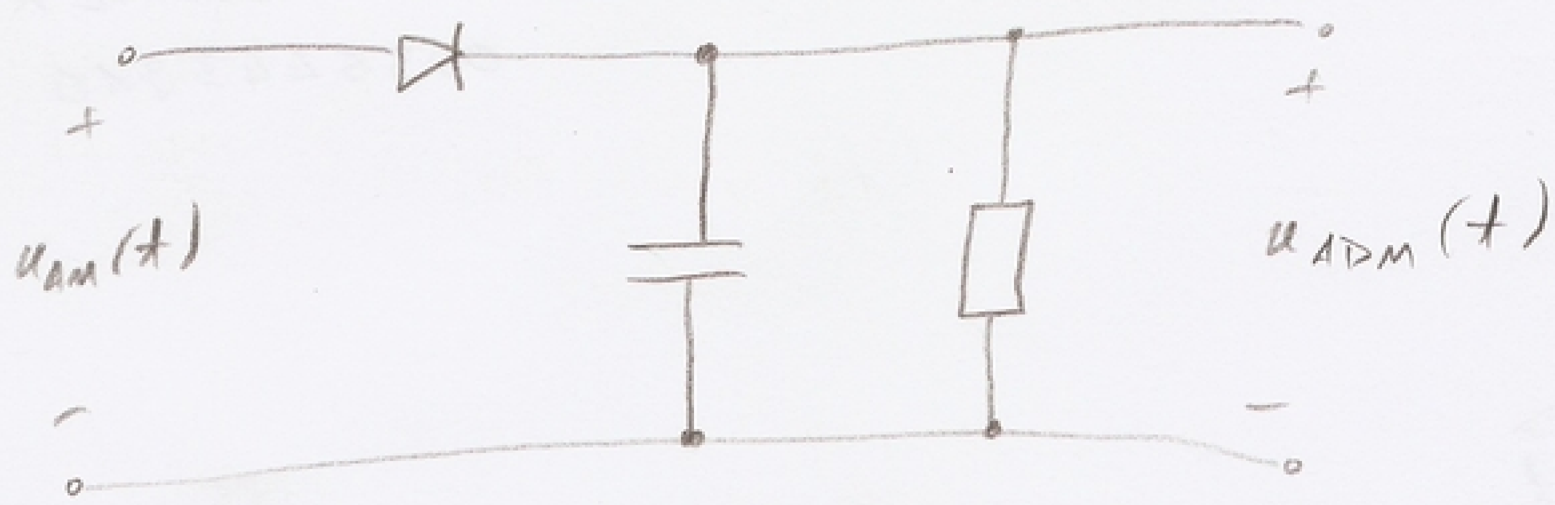
$$= \frac{A}{\pi}\left(-\ln(t+T) - \ln(t-\tau) - \cancel{\ln(t)} + \cancel{\ln(t)}\right) =$$

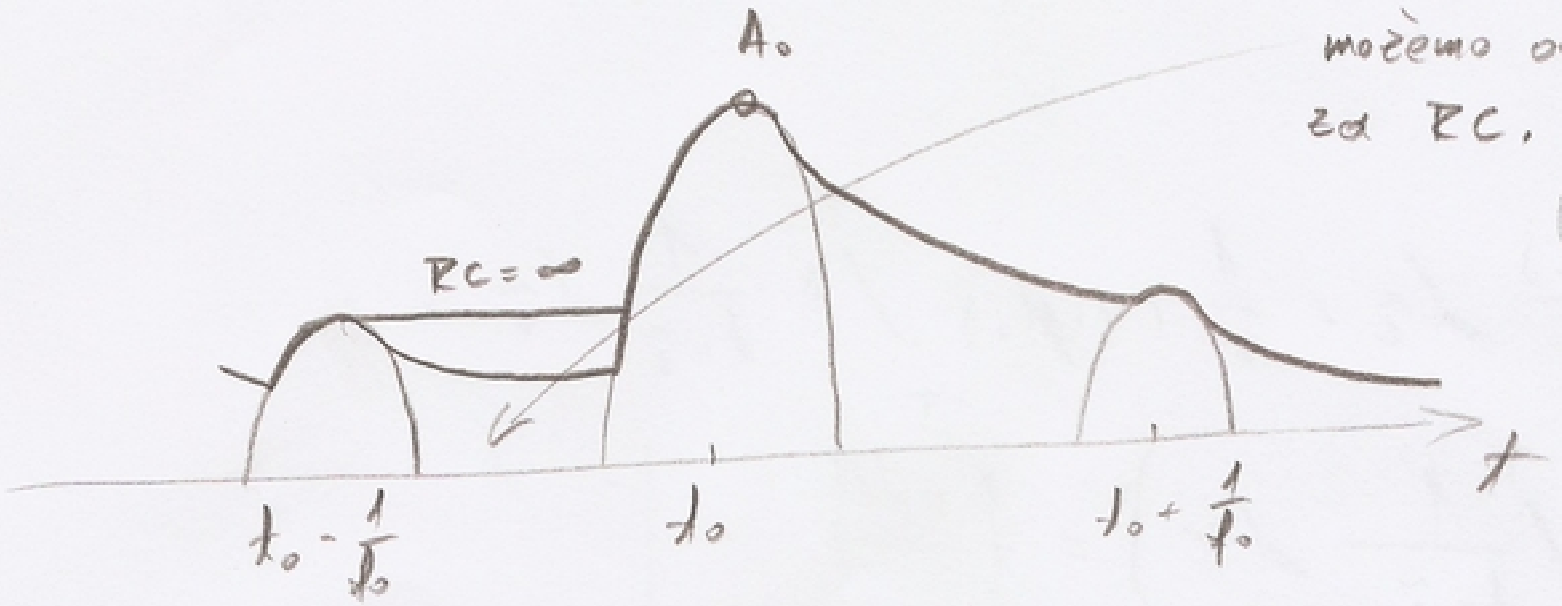
$$= \frac{A}{\pi}\ln\left|\frac{t+T}{t-T}\right|$$

$$z(t) = A\,\mathrm{rect}\left(\frac{t}{2T}\right) + j\,\frac{A}{\pi}\ln\left|\frac{t+T}{t-T}\right|$$

$$E(\hat{x}(t)) = \int_{-T}^{T}\left(A\,\mathrm{rect}\left(\frac{t}{2T}\right)\right)^2 dt = \int_{-T}^{T} A^2\,dt = 2A^2T$$

2.

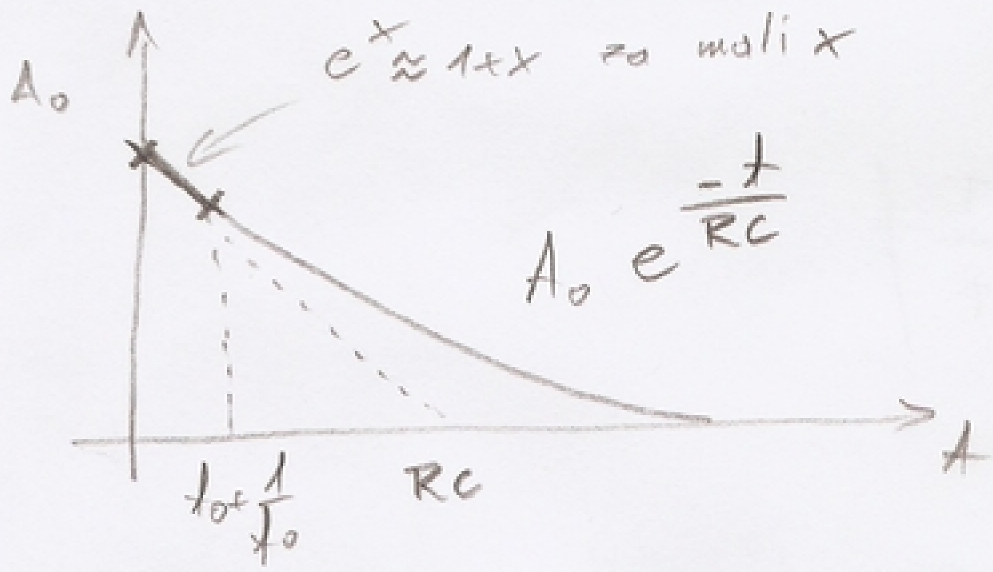




Iz trenutaka kada anvelopa raste možemo odrediti <u>donju</u> ogradu za RC. $\boxed{RC >> \frac{1}{\omega_0}}$

$$u_{AM}(t) = (U_0 + K_a \underbrace{u_m(t)}_{= U_m \cos(\omega_m t)})\cos(\omega_0 t) = U_0(1 + m\cdot\cos(\omega_m t))\cos(\omega_0 t)$$

$A_0 = U_0(1 + m\cdot\cos(\omega_m t_0))$ ← pretp. da se kondenzator izbija do max.



$$u_{ADM}(t) = A_0 e^{-\frac{t-t_0}{RC}}$$

Za $RC >> \frac{1}{\omega_0}$ vrijedi aproksimacija

$$u_{ADM}(t) \approx A_0\left(1 - \frac{t-t_0}{RC}\right)$$

Napon na kondenzatoru ne smije preći maksimum u sljedećoj poluperiodi

NASTAVAK →

$\boxed{2.}$ $u_{ADM}\left(t_0+\frac{1}{f_0}\right) \leq U_0\left(1+m\cdot\cos\left(\omega_m\left(t_0+\frac{1}{f_0}\right)\right)\right)$

$$U_0\left(1+m\cos(\omega_m t_0)\right)\cdot\left(1-\frac{1}{RCf_0}\right) \leq U_0\left[1+\underbrace{m\cdot\cos\left(\omega_m t_0+\frac{\omega_m}{f_0}\right)}\right]$$

$$= m\cos(\omega_m t_0)\underbrace{\cos\left(\frac{\omega_m}{f_0}\right)}_{\approx 1} - m\sin(\omega_m t_0)\underbrace{\sin\left(\frac{\omega_m}{f_0}\right)}_{\approx \frac{\omega_m}{f_0}}$$

$$\cancel{1}+\cancel{m\cdot\cos(\omega_m t_0)}-\frac{1}{RC\cancel{f_0}}\left(1+m\cdot\cos(\omega_m t_0)\right) \leq \cancel{1}+\cancel{m\cdot\cos(\omega_m t_0)}-\frac{m\omega_m}{\cancel{f_0}}\sin(\omega_m t_0)$$

$$\frac{1}{RC}+\frac{m}{RC}\cos(\omega_m t_0) \geq m\,\omega_m\sin(\omega_m t_0)$$

$$\frac{1}{RC} \geq m\,\underbrace{\left(\omega_m\sin(\omega_m t_0)-\frac{1}{RC}\cos(\omega_m t_0)\right)}_{\leq \sqrt{\omega_m^2+\left(\frac{1}{RC}\right)^2}}$$

$$\frac{1}{RC} \geq m\sqrt{\omega_m^2+\left(\frac{1}{RC}\right)^2} \quad /^2$$

$$\boxed{RC \leq \frac{1}{\omega_m}\,\frac{\sqrt{1-m^2}}{m}}$$

gornja ograda

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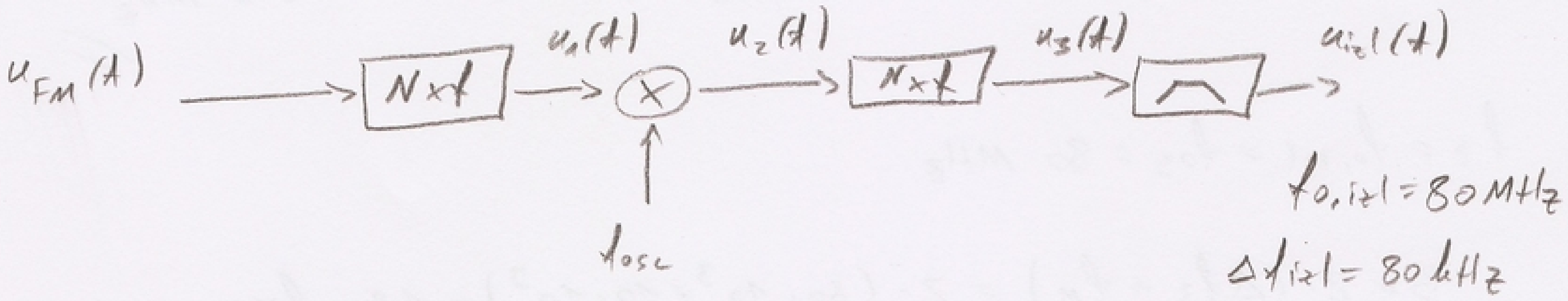
3.

$k_f = 10$ kHz/V

$f_m = 10$ kHz

$U_m = 20$ mV

$f_0 = 0.5$ MHz



$N, f_{osc}, B = ?$

$$u_{FM}(t) = U_0 \cos\left[2\pi f_0 t + 2\pi k_f \int_{-\infty}^{\infty} u_m(t)\, dt\right]$$

$$\Delta f_{FM} = k_f \cdot U_m = 10 \cdot \cancel{10^3} \cdot 20 \cdot \cancel{10^{-3}} = 200 \text{ Hz}$$

$$\Delta f_{1,izl} = 8 \text{ kHz}$$

$$\Delta f_{1,izl} = \Delta f_{FM} \cdot N^2 \Rightarrow N^2 = \frac{80 \cdot 10^3}{200} = 400$$

$$N = 20$$

$u_1(t)$

$$f_{01} = f_0 \cdot N = 5 \cdot 10^5 \cdot 20 = 10^7 \text{ Hz} = 10 \text{ MHz}$$

$$\Delta f_1 = \Delta f_{FM} \cdot N = 200 \cdot 20 = 4 \text{ kHz}$$

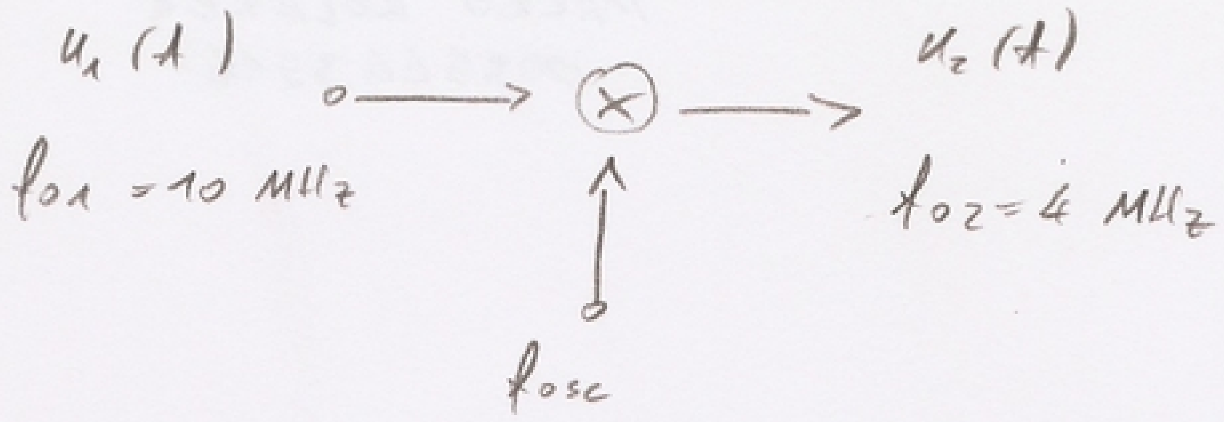
$$f_{03} = 80 \text{ MHz}$$

$$\Delta f_3 = 80 \text{ kHz}$$

$u_2(t)$

$$f_{02} = \frac{f_{03}}{N} = \frac{80 \cdot 10^6}{20} = 4 \text{ MHz}$$

$$\Delta f_2 = \frac{\Delta f_3}{N} = \frac{80 \cdot 10^3}{20} = 4 \text{ kHz}$$



$$f_{01} - f_{osc} = f_{02} \Rightarrow f_{osc} = f_{01} - f_{02} = 10 - 4 = 6 \text{ MHz}$$

$$f_2 = f_{0,izl} = f_{03} = 80 \text{ MHz}$$

$$B = 2\cdot(\Delta f_3 + f_m) = 2\cdot(80\cdot 10^3 + 10\cdot 10^3) = 180 \text{ kHz}$$

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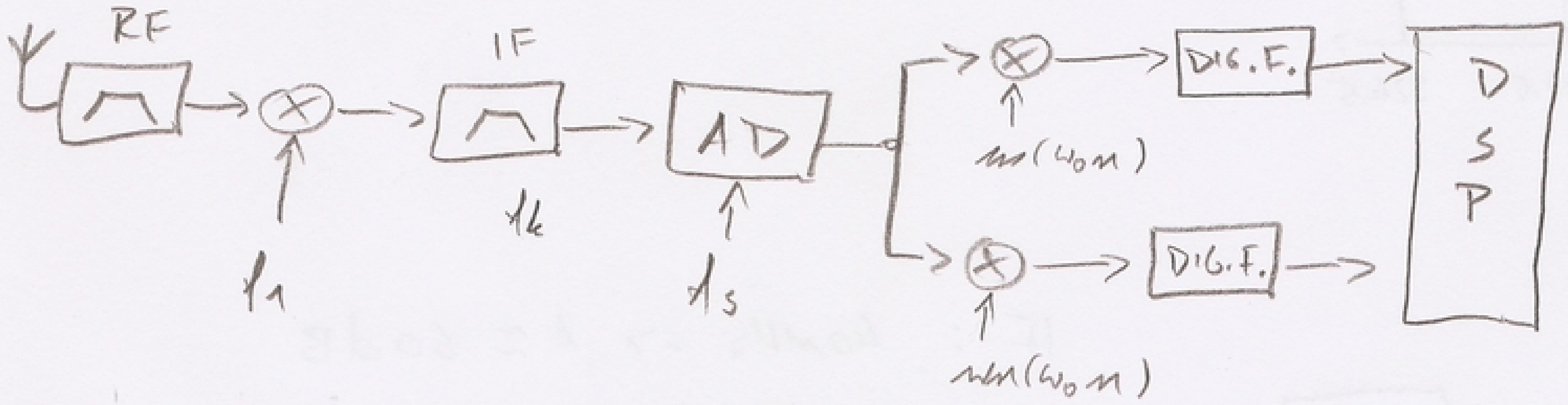
4. JEDNOSTRUKO TRANSPONIRANA FREKVENCIJA U ANALOGNOJ DOMENI, DIREKTNA PRETVORBA FREKVENCIJE I KOMPLEKSNA OBRADA U DIGITALNOJ DOMENI

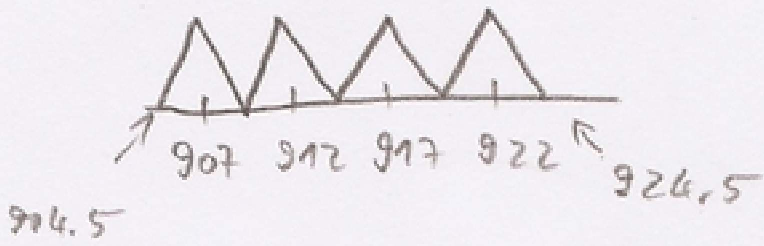
a)



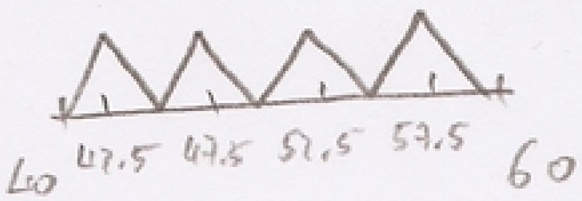
$B = 5$ MHz, $f_s = 70$ MHz

$f_c = \{907, 912, 917, 922\}$ MHz $\xrightarrow{\text{transponirano}}$ $[40, 60]$ MHz

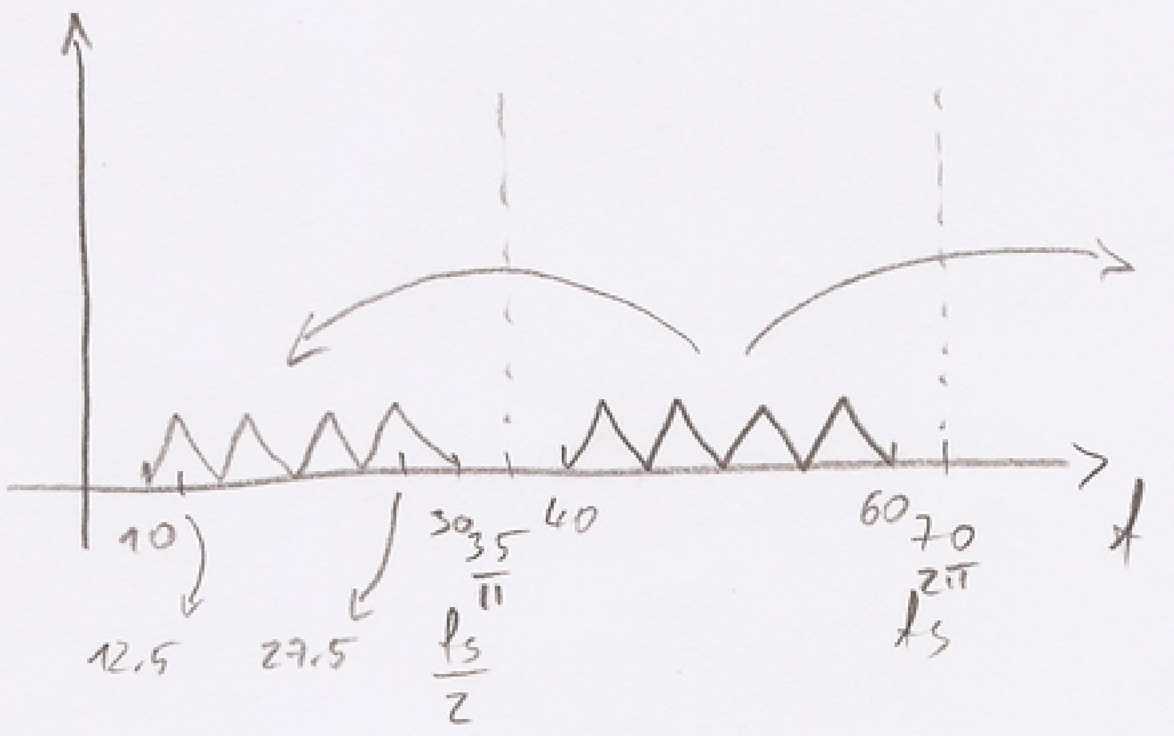
b)



$f_1 = 904.5 - 40 = 864.5$ MHz



AD



35 MHz $\Leftrightarrow$ π

$12.5 \text{ MHz} = \omega_0$

$35\,\omega_0 = 12.5\,\pi$

$\omega_0 = \frac{12.5}{35}\pi = \frac{5}{14}\pi$ rad

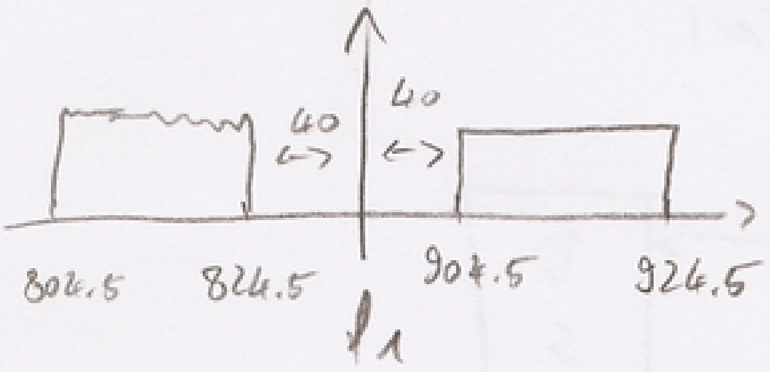
$\Delta\omega = \frac{5}{35}\pi = \frac{2}{14}\pi$ rad

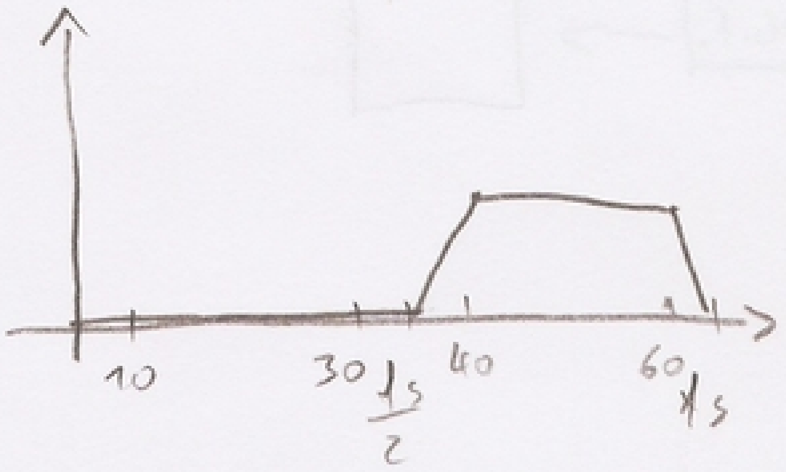
$\omega = \left\{\frac{5}{14}, \frac{7}{14}, \frac{9}{14}, \frac{11}{14}\right\} \cdot \pi$ rad

$f_k = \{12.5, 17.5, 22.5, 27.5\}$ MHz

c) GUŠENJE ZRCALNIH I ALIAS KOMPONENTI

RF: $A > 50\,dB$





IF: $40\,MHz \Rightarrow A \approx 60\,dB$

$60\,MHz \Rightarrow A \approx 60\,dB$

d)

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$\boxed{5.}$ Razina signala je logaritamsko izražavanje gušenja uz pomoć omjera s nekim referentnim naponom, snagom ili strujom.

1) Ako je poznata <u>snaga</u> u nekoj točki prijenosnog sustava razinu određujemo iz izmjerene snage:

$$P_S = 10 \log_{10} \frac{|S|}{1W} \; [dBW]$$

↳ ako je referentna snaga 1W

ili npr.

$$P_S = 10 \log_{10} \frac{|S|}{1mW} \; [dBm].$$

↳ ako je referentna snaga 1mW

2) Ako je poznata <u>impedancija i napon</u> u nekoj točki prijenosnog sustava razinu određujemo iz izmjerenog napona:

$$P_U = 10 \log_{10} \left(\frac{U_{rms}}{0.2236 V_{rms}} \right)^2 = 20 \log_{10} \frac{U_{rms}}{0.2236 \; V_{rms}} \; [dBm]$$

↳ ako je $P = 1mW$ i $R = 50\Omega$

$$U = \sqrt{(1 \cdot 10^{-3}) \cdot 50} = 0.2236 \, V$$

3) Ako je poznata <u>impedancija i struja</u> u nekoj točki prijenosnog sustava razinu određujemo iz izmjerene struje:

$$P_I = 20 \log_{10} \frac{I_{rms}}{4.472 \cdot 10^{-3} A_{rms}} \; [dBm]$$

↳ ako je $P = 1mW$ i $R = 50\Omega$

$$I = \sqrt{\frac{1 \cdot 10^{-3}}{50}} = 4.472 \cdot 10^{-3} A$$

$P_{U_1} = 2\ dBm \quad (R = 50\ \Omega)$

$P_{U_2} = ?\ [dBmV]$

$$P_{U_1} = 20 \log_{10} \frac{U_{rms}}{0.2236\ V} = 2\ dBm$$

$$10 \log_{10} \frac{U_{rms}}{0.2236} = 1$$

$$\log_{10} \frac{U_{rms}}{0.2236} = \frac{1}{10}$$

$$\frac{U_{rms}}{0.2236} = 10^{\frac{1}{10}}$$

$$U_{rms} = 0.2236 \cdot 10^{\frac{1}{10}} = 0.2815\ V_{rms}$$

$$P_{U_2} = 20 \log_{10} \frac{U_{rms}}{1\ mV_{rms}} = 20 \log_{10} \frac{0.2815}{1 \cdot 10^{-3}} = 49\ dBmV$$

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$\boxed{6.}$ SSB - AM

$$u_{USB}(t) = \mathrm{Re}\left[\left(u_m(t) + j\hat{u}_m(t)\right) e^{j\omega_0 t}\right]$$

ili

$$u_{LSB}(t) = \mathrm{Re}\left[\left(u_m(t) - j\hat{u}_m(t)\right) e^{j\omega_0 t}\right]$$

$U_{USB}(\omega) = ?$

$u_m(t) \circ\!\!-\!\!\bullet\; U_m(\omega)$

$$u_{USB}(t) = \mathrm{Re}\left[\left(u_m(t) + j\hat{u}_m(t)\right) e^{j\omega_0 t}\right] =$$

$$= \mathrm{Re}\left[\left(u_m(t) + j\hat{u}_m(t)\right)\left(\cos(\omega_0 t) + j\sin(\omega_0 t)\right)\right] =$$

$$= \mathrm{Re}\left[\underline{u_m(t)\cos(\omega_0 t)} + ju_m(t)\sin(\omega_0 t) + j\hat{u}_m(t)\cos(\omega_0 t) \underline{- \hat{u}_m(t)\sin(\omega_0 t)}\right]$$

$$= u_m(t)\cos(\omega_0 t) - \hat{u}_m(t)\sin(\omega_0 t)$$

$$U_{USB}(\omega) = \int_{-\infty}^{\infty} u_{USB}(t) e^{-j\omega t}\, dt = \int_{-\infty}^{\infty}\left(u_m(t)\cos(\omega_0 t) - \hat{u}_m(t)\sin(\omega_0 t)\right) e^{-j\omega t}\, dt$$

$$= \int_{-\infty}^{\infty} u_m(t)\cos(\omega_0 t) e^{-j\omega t}\, dt - \int_{-\infty}^{\infty} \hat{u}_m(t)\sin(\omega_0 t) e^{-j\omega t}\, dt =$$

$$= \frac{\pi}{2}\left(U_m(\omega-\omega_0) + U_m(\omega+\omega_0)\right) + \frac{j\pi}{2}\left(\hat{U}_m(\omega-\omega_0) - \hat{U}_m(\omega+\omega_0)\right) =$$

$$= \frac{\pi}{2}U_m(\omega-\omega_0) + \frac{\pi}{2}U_m(\omega+\omega_0) + \frac{\pi}{2}U_m(\omega-\omega_0) + \frac{\pi}{2}U_m(\omega+\omega_0) =$$

$$= \pi U_m(\omega-\omega_0) + \pi U_m(\omega+\omega_0)$$