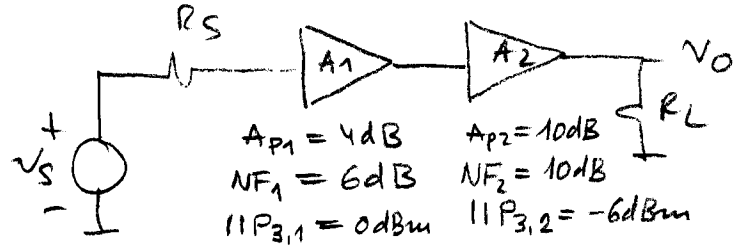
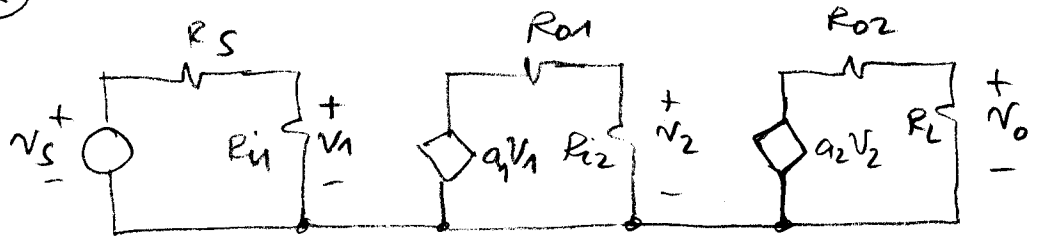
(2)



Smatrajući da su pojačavači prilagođeni odrediti NF, A_P, IIP_3.

(R)



$R_{i1} = R_S$, $R_{i2} = R_{o1}$, $R_L = R_{o2}$

$$P_O = \frac{V_O^2}{R_L} = \frac{1}{R_L} a_1^2 \cdot \frac{1}{4} \cdot a_2^2 \cdot \frac{1}{4} \cdot \frac{V_S^2}{4}$$

$$A_{P1} = \frac{P_{O1}}{P_{in}} = \frac{\frac{1}{4}(a_1 V_1)^2 / R_{i2}}{\frac{1}{4} V_S^2 / R_{i1}} = \frac{\frac{1}{4} a_1^2 \frac{1}{4} V_S^2 / R_{i2}}{\frac{1}{4^2} V_S^2 / R_{i1}} = \frac{1}{4} a_1^2 \cdot \frac{R_{i1}}{R_{i2}} = \frac{1}{4} a_1^2$$

$$A_P = A_{P1} \cdot A_{P2} = \frac{a_1^2}{4} \cdot \frac{a_2^2}{4}$$

$$a_P = A_{P1}[dB] + A_{P2}[dB] = 14dB$$

$NF_1 = 6dB \Rightarrow F_1 = 10^{0.6} = 3.98$

$NF_2 = 10dB \Rightarrow F_2 = 10^1 = 10$

Friisova j-na $F = 1 + (F_1 - 1) + \frac{F_2 - 1}{A_{P1}}$, $A_{P1} = 10^{0.4} = 2.51$

$F = 7.57 \Rightarrow NF = 10 \log F = 8.79dB.$

$$\frac{1}{IIP_3^2} = \frac{1}{IIP_{3,1}^2} + \frac{a_1^2}{IIP_{3,2}^2}$$

$\frac{a_1^2}{4} = 4dB \Rightarrow a_1 = 3.17$

$IIP_{3,1} = 0dBm \Rightarrow 10 \log \frac{V_{rms1}^2/50}{1mW} 0 \Rightarrow V_{rms}^2 = 50 \cdot 10^{-3} V^2$

$IIP_{3,2} = -6dBm \Rightarrow V_{rms2}^2 = 12.5 \cdot 10^{-3} V^2$

$$\frac{1}{IIP_3^2} = \frac{1}{50 \cdot 10^{-3}} + \frac{10}{12.5 \cdot 10^{-3}} \Rightarrow IIP_3 = 34.9 \cdot 10^{-3} V$$

$$\Rightarrow IIP_3 = 10 \log \frac{IIP_3^2/50}{1mW} = -16dBm.$$

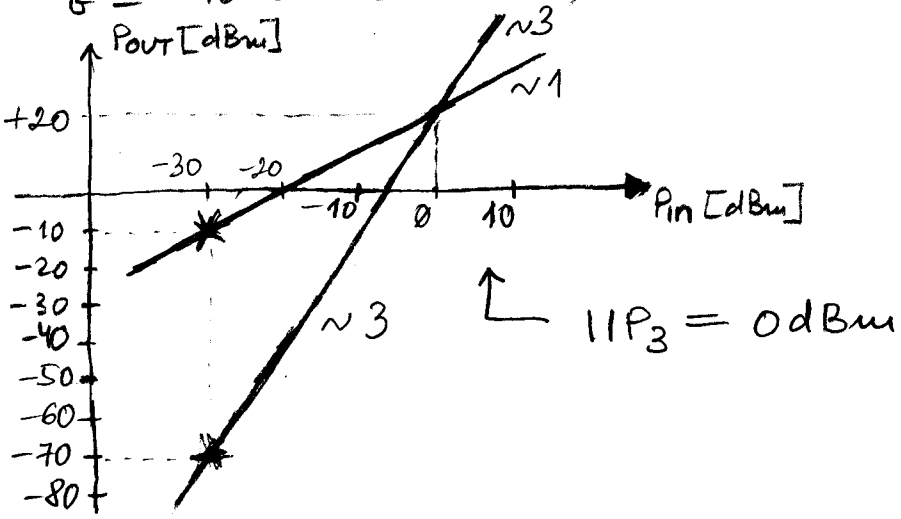
(Z) a) Na ulaz jednog RF pojačavača se dovodi signal osnovne učestanosti snage −30dBm. Tada se na njegovom izlazu dobije signal na osnovnoj učestanosti, čija je snaga −10dBm. Kada se na ulaz istog pojačavača dovedu dva tona čije su snage −30 dBm, na izlazu se dobije IM_3 komponenta čija je snaga −70 dBm.

a1) odrediti pojačanje snage RF pojačavača

a2) odrediti IIP_3.

(R) a1) $G = -10dBm - (-30dBm) = 20dB$

a2)



$IIP_3 = 0dBm$

(Z) b) Ako je propusni opseg pojačavača 10 MHz i faktor šuma 14dB, odrediti minimalni signal koji se može detektovati na ulazu pojačavača MDS

c) Odrediti SFDR (Spurious Free Dynamic Range)

(R) b) $P_S = P_N \Rightarrow P_{MDS} = 10 \log(kTB) + NF$

$$P_{MDS} = -174 \frac{dBm}{Hz} + 10 \log(B) + NF$$

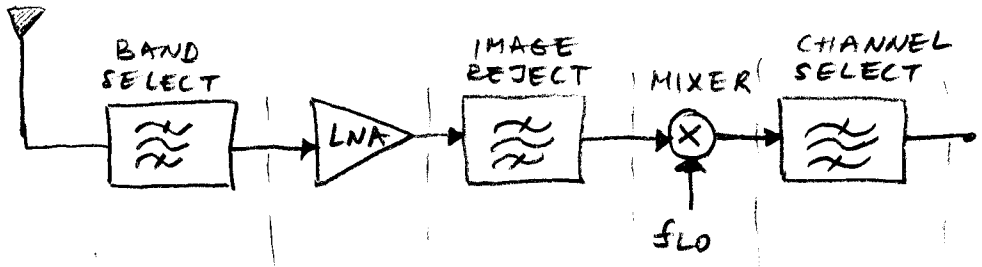
$$P_{MDS} = -174 + 70 + 14 = -90dBm$$

Šum na izlazu $P_{nOUT} = G \cdot P_{nin} = -90dBm + 20dB = -70dBm$

c) Pošto je nivo šuma na izlazu −70dBm to je

$$SFDR = -10dBm - (-70dBm) = \underline{60dB}.$$

(Z)



NF [dB]	0	3	0	10	0
POJAČANJE SNAGE [dB]	-3	20	-3	10	-3

Na slici je prikazan blok šema FRONT-END dela jednog RF prijemnika, a pored svakog dela prijemnika dat je njegov faktor šuma i pojačanje snage. Poznato je $f_{RF} = 900MHz$, $f_{LO} = 850MHz$.

a) odrediti međufrekventnu učestanost f_{IF}

b) odrediti Q-faktor filtra za selektovanje kanala koji zauzimaju propusni opseg 2MHz

c) odrediti faktor šuma prijemnika NF.

(R) a) $f_{IF} = f_{RF} - f_{LO} = 50MHz$

b) $Q = \frac{f_0}{\Delta f} = \frac{f_{IF}}{\Delta f} = \frac{50MHz}{2MHz} = 25$

c) Friisova j-na

$$F_{TOT} = 1 + F_1 - 1 + \frac{F_2 - 1}{G_1} + \frac{F_3 - 1}{G_1 G_2} + \frac{F_4 - 1}{G_1 G_2 G_3} + \frac{F_5 - 1}{G_1 G_2 G_3 G_4}$$

	BS	LNA	IR	MIX	CS
N	1	2	3	4	5
F	1	2	1	10	1
G	1/2	100	1/2	10	1/2

$NF = 10 \log F$

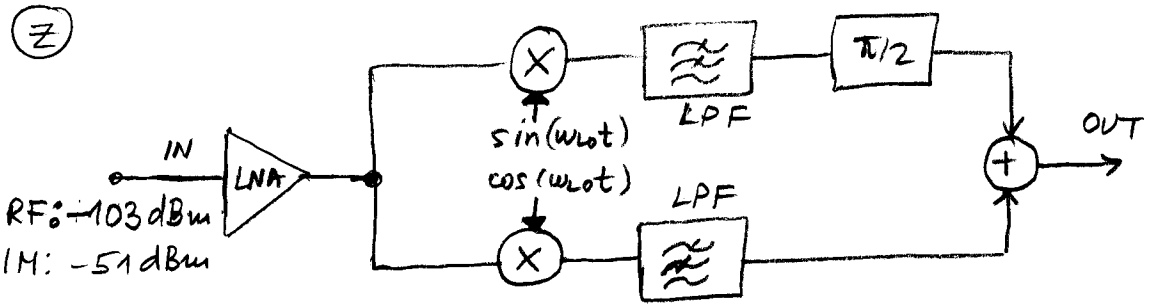
$G[dB] = 10 \log G$

$$F_{TOT} = 1 + (1-1) + \frac{2-1}{1/2} + \frac{1-1}{\frac{1}{2}\cdot 100} + \frac{10-1}{\frac{1}{2}\cdot\frac{1}{2}\cdot 100} + \frac{1-1}{\frac{1}{2}\cdot\frac{1}{2}\cdot 100\cdot 10}$$

$$F_{TOT} = 1 + 0 + 2 + 0 + \frac{36}{100} + 0 = 3.36$$

$$NF = 10 \log F_{TOT} = 5.26\ dB.$$

(Z)



Hartleyeva arhitektura za potiskivanje simetrične f. Prihvatljiv nivo interferirajuće komponente na simetričnoj učestanosti na izlazu je $P_{OUT\,IM} = P_{OUT\,RF} + 12\,dB$. Ako je pojačanje od ulaza do izlaza $A_{IN\text{-}OUT} = 50\,dB$, odrediti potrebni faktor potiskivanja simetrične učestanosti IRR.

(R) Bez potiskivanja simetrične učestanosti je

$$P_{RF\,OUT} = -103\,dBm + 50\,dB = -53\,dBm$$

$$P_{IM\,OUT} = -51\,dBm + 50\,dB = -1\,dBm$$

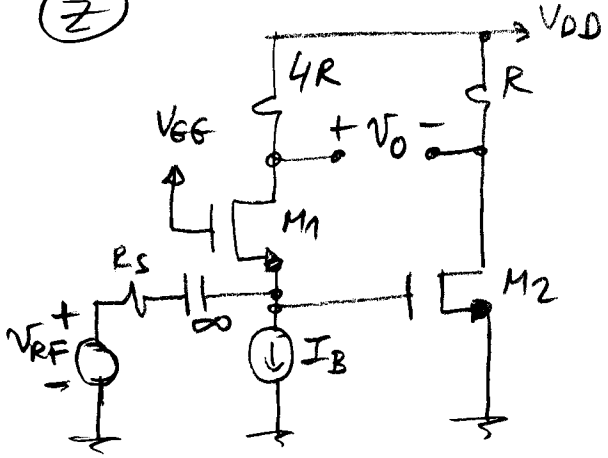
Prihvatljiv nivo IM smetnji je

$$P_{IM,\,ACC} = P_{RF\,OUT} + 12\,dB = -41\,dBm$$

Faktor potiskivanja mora biti veći od

$$IRR = -1\,dBm - (-41\,dBm) = \underline{\underline{40\,dB}}$$

(7)



U širokopojasnom pojačavaču sa slike je $g_{m2} = 4g_{m1}$

a) odrediti g_{m1} tako da se ostvari prilagođenje po snazi

b) Odrediti naponsko pojačanje u propusnom opsegu

c) odrediti faktor šuma F(NF)

Razmatrati samo uticaj termičkog šuma.

(R)

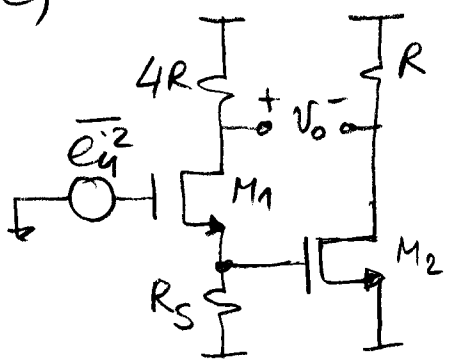
a) $R_S = \frac{1}{g_{m1}} \Rightarrow g_{m1} = \frac{1}{R_S}$

b) $v_{s1} = \frac{\frac{1}{g_{m1}}}{\frac{1}{g_{m1}} + R_S} v_{RF} = \frac{v_{RF}}{2}$

$$v_0 = v_{d1} - v_{d2} = 4R \cdot g_{m1} \cdot \frac{v_{RF}}{2} - R\left(-g_{m2}\frac{v_{RF}}{2}\right)$$

$$v_0 = 8R g_{m1} \frac{v_{RF}}{2} \Rightarrow a_v = \frac{v_0}{v_{RF}} = 4R g_{m1}$$

c)



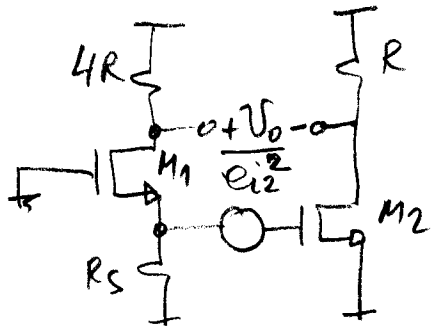
$$\frac{\overline{e_i^2}}{\Delta f} = \frac{8}{3}\frac{kT}{g_m}$$

M_1: $v_{on1} = -\frac{g_{m1} 4R}{1 + g_{m1} R_S} e_{i1}$

$$v_{on1} = -\frac{\frac{g_{m1}}{2}}{} 4R \cdot e_{i1}$$

M_2: $v_{on2} = \frac{g_{m1} R_S}{1 + g_{m1} R_S} \cdot g_{m2} R\, e_{i1}$

$$v_{on2} = \frac{g_{m1}}{2} 4R\, e_{i1} \Rightarrow v_{on} = v_{on1} + v_{on2} = 0$$



$$v_{on} = g_{m2} R\, e_{i2}$$

$$\Rightarrow \overline{v_{on}^2} = (4 g_{m1} R)^2 \cdot \frac{8}{3}\frac{kT}{4g_{m1}}$$

Šum na izlazu koji potiče od R_S

$$\frac{\overline{v_{on}^2}}{\Delta f} = 4kTR_S \cdot (4R g_{m1})^2$$

FAKTOR ŠUMA: $F = 1 + \frac{\frac{8}{3}\frac{kT}{4g_{m1}} \cdot (4g_{m1}R)^2}{4kTR_S(4R g_{m1})^2}$

$$F = 1 + \frac{1}{6} = \frac{7}{6}.$$