[Resultado do Simulação verificados]

EEL7319 - Circuitos RF — Gustavo Sinus

Seção 6.12

1) $R_0 = 3\,\Omega$, $R_L = 50\,\Omega$

a) $R_{in} = n^2 \cdot R_L \Rightarrow n = \sqrt{\frac{R_{in}}{R_L}} = \sqrt{\frac{3}{50}} \approx 0{,}245$

b) Reflection Coef. $\Gamma_{in} = S_{11} = \frac{n^2-1}{n^2+1} = -0{,}8868$

c) $RL_{dB} = -20\log|\Gamma_{in}| = -20\log(0{,}8868) = 1{,}0435\,dB$

d) $m_2 = 100 \Rightarrow m_1 = \sqrt{\frac{3}{50}} \cdot 100 \approx 25$ ou 24

e) $R_{in} = 0{,}25^2 \cdot R_L = 3{,}125\,\Omega$ para $n = 0{,}24 \Rightarrow R_{in} = 0{,}24^2 \cdot 50 = 2{,}88\,\Omega$

f) $\Gamma_{in} = \frac{0{,}24^2 - 1}{0{,}24^2 + 1} = -0{,}8911$

g) $RL_{dB} = -20\log|\Gamma_{in}| = -20\log(0{,}8911) \approx 1\,dB$

h) $P_S = 20\,dBm \Rightarrow 10\log\left(\frac{P_i}{1m}\right) \Rightarrow P_i = 0{,}001 \cdot 10^{20/10} = 0{,}1\,W$

$\Rightarrow RL = 10\log\left(\frac{P_i}{P_r}\right) \Rightarrow P_r \approx \frac{0{,}1}{10^{1/10}} \approx 79{,}43\,mW$

i) $P_T = P_i - P_r = 20{,}57\,mW \Rightarrow P_{T_{dBm}} = 10\log\left(\frac{20{,}57m}{1m}\right) = 13{,}13\,dBm$

2) $R_0 = 50\,\Omega$, $R_L = 100\,\Omega$

a) $R_{IN} = n^2 \cdot R_L \Rightarrow n = \sqrt{\frac{50}{100}} = 0,7071$

b) $\Gamma_{IN} = \frac{n^2-1}{n^2+1} = -1/3$

c) $R_{L_{dB}} = -20\log(1/3) = 9,54\,dB$

d) $m_2 = 20 \Rightarrow m_1 = m_2 \cdot n = \sqrt{\frac{20}{3}} \approx 14$

e) $n \Rightarrow 14/20 = 0,70 \Rightarrow R_{IN} = 0,70^2 \cdot R_L = 49\,\Omega$

f) $\Gamma_{IN} = \frac{0,7^2-1}{0,7^2+1} = -0,3423$

g) $RL_{dB} = -20\log(0,3423) = 9,31\,dB$

h) $P_S = -10\,dBm \Rightarrow P_i = 0,1\,mW$

$\Rightarrow P_r = \frac{P_i}{10^{\frac{RL_{dB}}{10}}} = \frac{0,1m}{10^{9,3/10}} = 11,71\,\mu W$

$\Rightarrow P_{r_{dBm}} = 10\log\left(\frac{11,71\mu}{1m}\right) = -19,31\,dBm$

i) $P_T = P_i - P_r = 88,28\,\mu W \Rightarrow P_{T_{dBm}} = 10\log\left(\frac{88,28\mu}{1m}\right) = -10,54\,dBm$

3) L-matching network

$f = 1\,GHz$

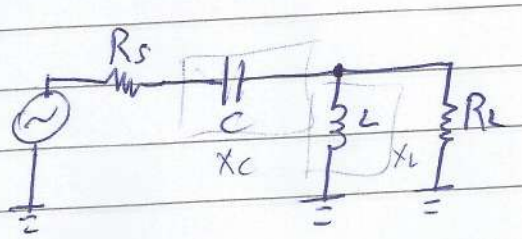
$R_S = 2\,\Omega$

$R_L = 50\,\Omega$

a) $|Q_s| = |Q_p| = \sqrt{\frac{R_L}{R_S} - 1}$

$= \sqrt{\frac{50}{2} - 1} \approx 4,899$

b)



c) $\frac{X_S}{R_S} = |Q_s| = 4,899 \Rightarrow X_S = 2 \cdot 4,899$

$\approx 9,80\,j\,\Omega$

$\Rightarrow \frac{1}{\omega C} = X_S$

$\Rightarrow C = \frac{1}{2\pi \cdot 10^9 \cdot 9,80} = 16,24\,pF$

d) $|Q_p| = \frac{R_L}{X_p} \Rightarrow |X_p| = \frac{R_L}{4,899} = 10,20$

$\Rightarrow \omega L = 10,20$

$\Rightarrow L = \frac{10,20}{2\pi \cdot 10^9} = 1,62\,nH$

e) Series element: $C = 16,24\,pF$

f) Shunt element: $L = 1,62\,nH$

g) Igual item b)

h) $\Delta f = f_r / Q = \frac{10^9}{4,899} \approx 204\,MHz$

4) L-matching network

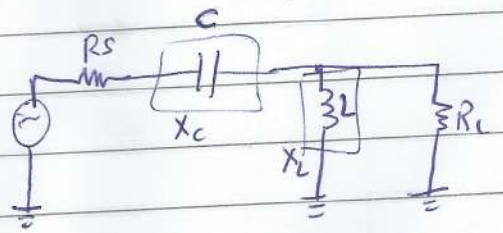
$f = 100\,GHz$

$R_S = 50\,\Omega$

$R_L = 100\,\Omega$

a) $|Q_s| = |Q_p| = \sqrt{\frac{100}{50} - 1} = 1$

b)



c) $X_S = Q_S \cdot R_S = 50\,\Omega$

d) $X_p = \frac{R_L}{Q_p} = 100\,\Omega$

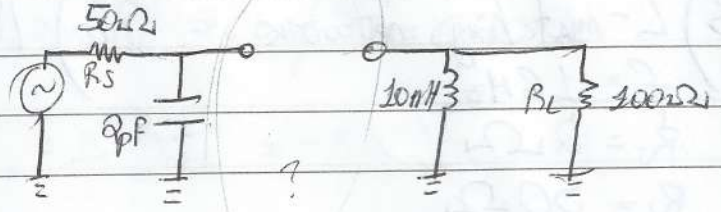
e) Series element: $C = \frac{1}{\omega X_S} = \frac{1}{2\pi \cdot 100 \cdot 10^9 \cdot 50} = 31,83\,fF$

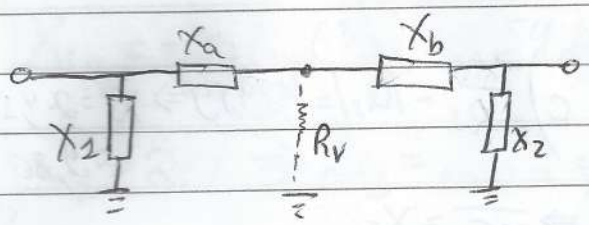
f) Shunt element: $L = \frac{X_p}{\omega} = \frac{100}{2\pi \cdot 10^{11}} = 0,159\,nH$

g) Igual item b)

h) $\Delta f = \frac{10^{11}}{Q} = 100\,GHz$

5) π-network
$f = 900\,MHz$
$Q = 10$





$\Rightarrow R_V = \frac{\max(R_S, R_L)}{Q^2+1} = \frac{100}{101} = 0{,}99\,\Omega$

$\Rightarrow Q_{Left} = \sqrt{\frac{R_S}{R_V} - 1} = 7{,}03 = \frac{|X_a|}{R_V} = \frac{R_S}{|X_1|}$

$\Rightarrow |X_1| = \frac{R_S}{Q_{LEFT}} = \frac{50}{7{,}03} = 7{,}10$ $\quad \Rightarrow |X_a| = R_V \cdot Q_{LEFT} = 0{,}99 \cdot 7{,}03 = 6{,}96$

$|X_1| = \frac{1}{\omega C_1'} \Rightarrow C_1' = \frac{1}{2\pi \cdot 900M \cdot 7{,}1} = 24{,}91\,pF$

$|X_a| = \omega L_a \Rightarrow L_a = \frac{6{,}96}{2\pi \cdot 900M} = 1{,}23\,nH$

$\Rightarrow Q_{RIGHT} = \sqrt{\frac{R_L}{R_V} - 1} \approx 10 = \frac{|X_b|}{R_V} = \frac{R_L}{|X_2|}$

$\Rightarrow |X_2| = \frac{R_L}{Q_{RIGHT}} = \frac{100}{10} = 10$ $\quad \Rightarrow |X_b| = R_V \cdot Q_{RIGHT} = 0{,}99 \cdot 10 = 9{,}9$

$|X_2| = \omega L_2' \Rightarrow L_2' = \frac{10}{2\pi \cdot 900M} = 1{,}77\,nH$

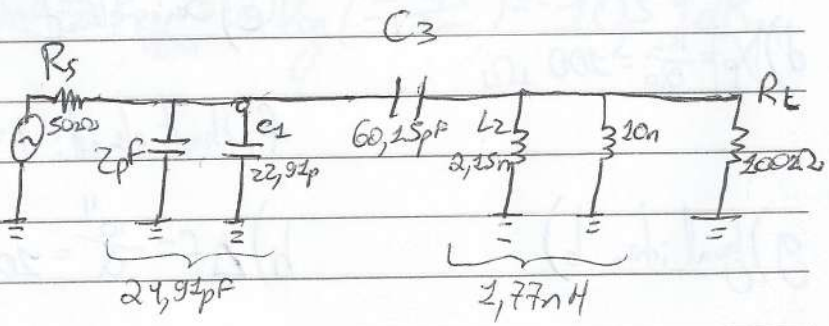
$|X_b| = \frac{1}{\omega C_b} \Rightarrow C_b = \frac{1}{2\pi \cdot 900M \cdot 9{,}9} = 17{,}86\,pF$

$\Rightarrow X_3 = X_a + X_b = 6{,}96 - 9{,}9 = -2{,}94$

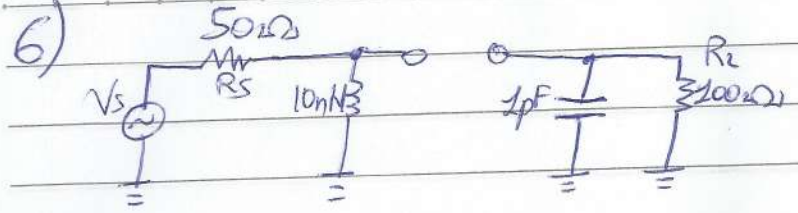
$\Rightarrow C_3 = \frac{1}{2\pi \cdot 900M \cdot 2{,}94} = 60{,}15\,pF$

$\Rightarrow L_2 = \frac{L_2' \cdot 10n}{10n - L_2'} = 2{,}15\,nH$

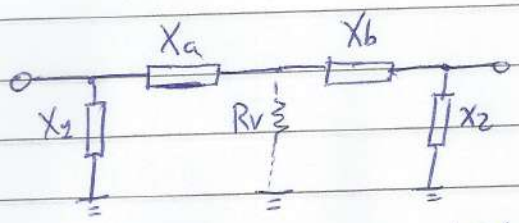
$\Rightarrow C_1 = C_1' - 2p = 22{,}91\,pF$



6)



Π - network
Q = 10
f = 900MHz



$\Rightarrow R_V = \frac{\max(R_S, R_L)}{Q^2+1} = \frac{100}{101} = 0{,}99\,\Omega$

$\Rightarrow Q_{LEFT} = \sqrt{\frac{R_S}{R_V} - 1} = 7{,}03 = \frac{|X_a|}{R_V} = \frac{R_S}{|X_1|}$

$\Rightarrow |X_1| = \frac{R_S}{Q_{LEFT}} = \frac{50}{7{,}03} = 7{,}11$

$\Rightarrow L_1' = \frac{X_1}{\omega} = \frac{7{,}11}{2\pi \cdot 900M} = 1{,}26\,nH$

$\Rightarrow |X_a| = R_V \cdot Q_{LEFT} = 0{,}99 \cdot 7{,}03 = 6{,}96$

$\Rightarrow C_a = \frac{1}{\omega X_a} = \frac{1}{2\pi \cdot 900M \cdot 6{,}96} = 25{,}41\,pF$

$\Rightarrow Q_{RIGHT} = \sqrt{\frac{R_L}{R_V} - 1} \approx 10 = \frac{|X_b|}{R_V} = \frac{R_L}{|X_2|}$

$\Rightarrow |X_2| = \frac{R_L}{Q_{RIGHT}} = \frac{100}{10} = 10$

$\Rightarrow C_2' = \frac{1}{\omega X_2} = \frac{1}{2\pi \cdot 900M \cdot 10} = 17{,}68\,pF$

$\Rightarrow |X_b| = R_V \cdot Q_{RIGHT} = 0{,}99 \cdot 10 = 9{,}9$

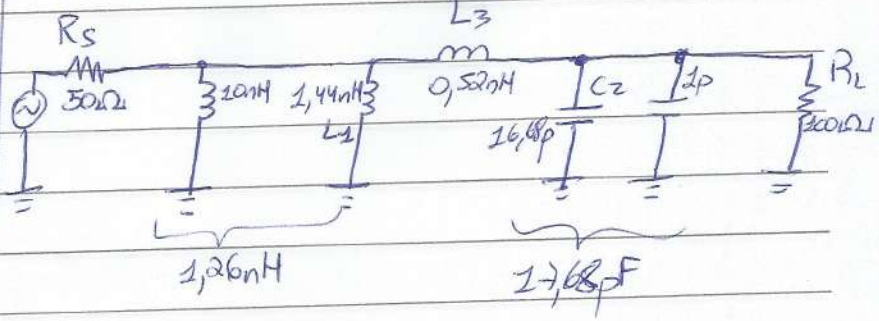
$\Rightarrow L_b = \frac{X_b}{\omega} = \frac{9{,}9}{2\pi \cdot 900M} = 1{,}75\,nH$

$\Rightarrow X_3 = X_a + X_b = -6{,}96 + 9{,}9 = 2{,}94$

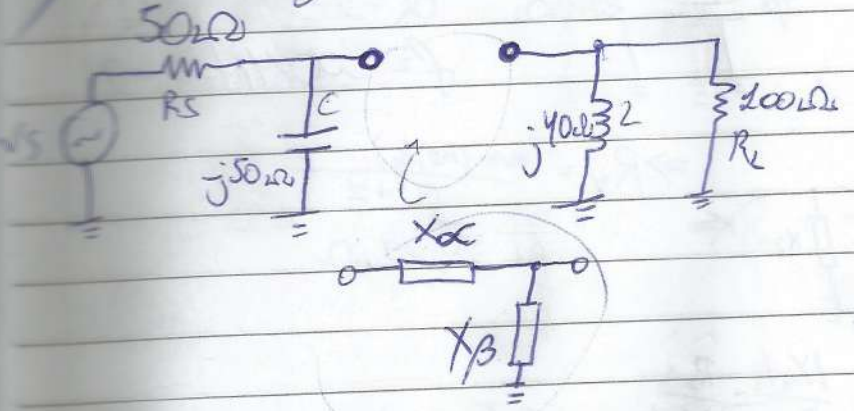
$\Rightarrow L_3 = \frac{2{,}94}{2\pi \cdot 900M} = 0{,}52\,nH$

$\Rightarrow C_2 = C_2' - 1_p = 16{,}68\,pF$

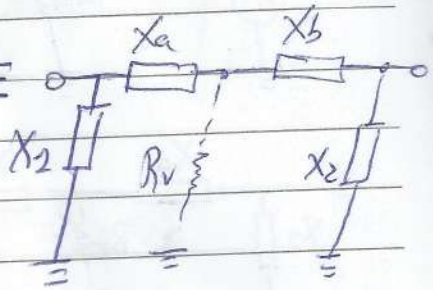
$\Rightarrow L_1 = \frac{L_1' \cdot 10n}{10n - L_1'} = 1{,}44\,nH$



7) L-matching network



Equivale a:



Π-network com $X_1 = 50$ pois $X_c = -j50\Omega$

Então:

$\Rightarrow X_1 = 50 \Rightarrow Q_{LEFT} = \frac{R_S}{X_1} = \frac{50}{50} = 1$

$\Rightarrow R_V = \frac{R_S}{Q_{LEFT}^2 + 1} = \frac{50}{2} = 25$

$\Rightarrow Q_{RIGHT} = \sqrt{\frac{R_L}{R_V} - 1} = \sqrt{\frac{100}{25} - 1} = \sqrt{3} \approx 1,73$

$\Rightarrow X_a = Q_{LEFT} \cdot R_V = 25$

$\Rightarrow X_b = Q_{RIGHT} \cdot R_V = 1,73 \cdot 25 = 43,25$

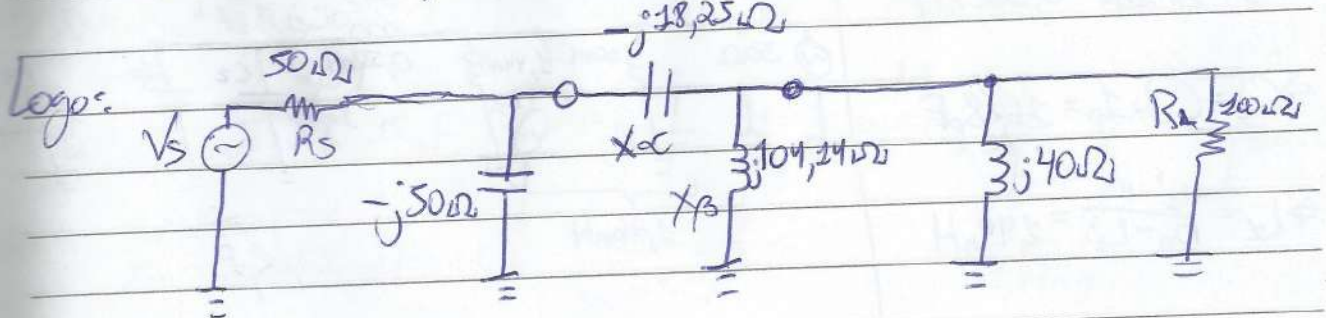
$\Rightarrow X_1 = \frac{R_S}{Q_{LEFT}} = 50$

$\Rightarrow X_2 = \frac{R_S}{Q_{RIGHT}} = \frac{50}{1,73} = 28,9$

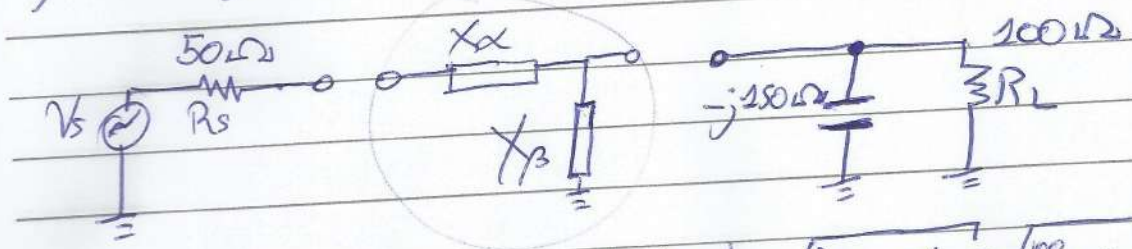
$\Rightarrow X_2 = 28,9 = \frac{X_\beta \cdot 40}{X_\beta + 40} \Rightarrow X_\beta = \frac{40 \cdot X_2}{40 - X_2} = 104,14$

$\Rightarrow X_a + X_b = 25 - 43,25 = -18,25$

Logo:



8) L-matching network



$\Rightarrow X_p = X_\beta // -j150\Omega$ $\Rightarrow |Q_s| = |Q_p| = \sqrt{R_L/R_S - 1} = \sqrt{\frac{100}{50} - 1} = 1$

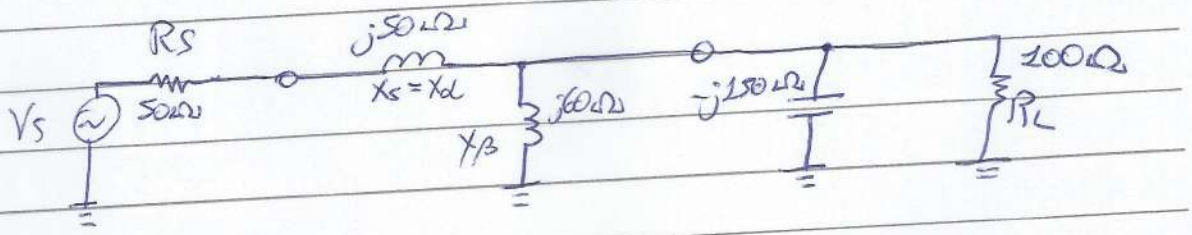
$\Rightarrow X_s = X_\alpha$

$\Rightarrow X_p = \frac{R_L}{Q_p} = R_L = 100$

$\Rightarrow X_\beta = \frac{-j150 X_p}{-j150 - X_p} = 60\ j60\Omega \rightarrow$ indutor

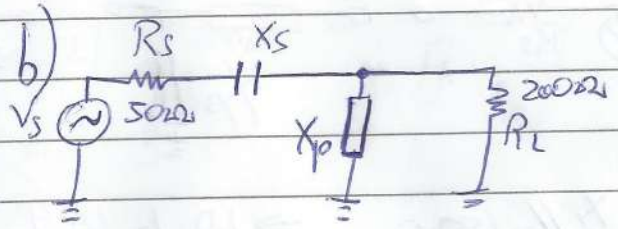
$\Rightarrow X_S = Q_s \cdot R_S = 50$

Logo:



10) L-matching network
$f = 100\,GHz$
$R_S = 50\,\Omega$
$R_L = 200\,\Omega$
DC-blocking

a) $Q_S = \sqrt{\frac{R_L}{R_S} - 1} = \sqrt{\frac{200}{50} - 1}$
$= \sqrt{3} \approx 1,73$

b)


c) $X_S = R_S \cdot Q_S = 50 \cdot 1,73$
$= 86,5$

e) $C = \frac{1}{\omega X_S} = \frac{1}{2\pi \cdot 100G \cdot 86,5}$
$\approx 18,4\,fF$

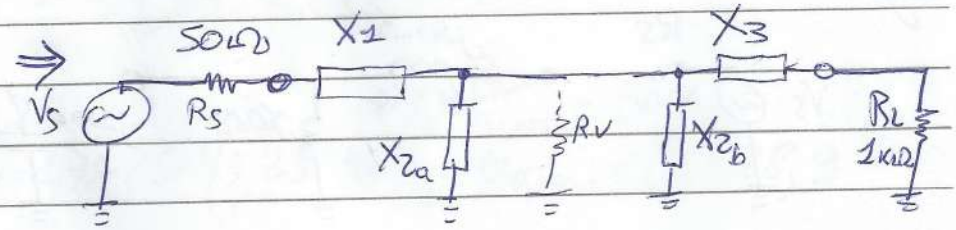
d) $X_p = \frac{R_L}{Q_p} = \frac{200}{1,73} = 115,61$

f) $L = \frac{X_p}{\omega} = \frac{115,61}{2\pi \cdot 100G}$
$\approx 0,184\,nH$

g) Mesmo que item b)
com X_p sendo indutor de $L = 0,184\,nH$

h) $\Delta f = \frac{f_n}{Q} = \frac{10^{11}}{1,73} \approx 57,8\,GHz$

21) T-network
$R_S = 50\,\Omega$
$R_L = 1K\,\Omega$
$Q = 15$



$\Rightarrow Q = \sqrt{\frac{R_V}{\min(R_S, R_L)} - 1} \Rightarrow R_V = (Q^2+1) \cdot [\min(R_S, R_L)]$
$= 11.300$

$\Rightarrow Q_1 = \sqrt{\frac{R_V}{R_S} - 1} = 15$ $\Rightarrow Q_2 = \sqrt{\frac{R_V}{R_L} - 1} = 3,21$

$\Rightarrow |X_1| = R_S \cdot Q_1 = 50 \cdot 15 = 750$ $\Rightarrow |X_3| = R_L \cdot Q_2 = 1K \cdot 3,21 = 3210$

$\Rightarrow |X_{2a}| = \frac{R_V}{Q_1} = \frac{11300}{15} = 75333$ $\Rightarrow |X_{2b}| = \frac{R_V}{Q_2} = \frac{11300}{3,21} = 3520$

$\Rightarrow X_2 = X_{2a} // X_{2b}$
$= +j\,758 // -j\,3520$
$\approx +j\,958$