4.13) $G_A(dB) = 14 + 14 + 14 - 7.5 + 16 + 16 = 66.5\ dB$

THE NOISE FIGURE OF THE LNB IS DETERMINED BY THE NOISE FIGURE OF THE LNA (i.e., THE FIRST 3 AMPLIFIERS).

$$F = F_1 + \frac{F_2 - 1}{G_{A1}} + \frac{F_3 - 1}{G_{A1}G_{A2}} = 10^{0.05} + \frac{10^{0.09} - 1}{10^{1.4}} + \frac{10^{0.11} - 1}{10^{1.4}10^{1.4}} = 1.131 \text{ OR } 0.54\ dB$$

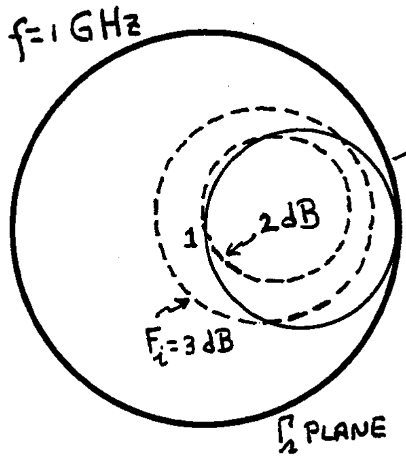
THE CONTRIBUTION TO F FROM THE MIXER, AMP. 5, AND AMP. 6 IS NEGLIGIBLE.

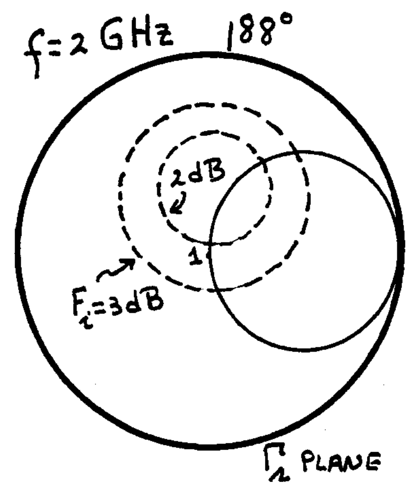
4.15) $G_{TU} = G_s G_o G_L$, $G_{TU}(dB) = G_s(dB) + G_o(dB) + G_L(dB)$

f(GHz)	$G_{s,max}$(dB)	$G_o = \lvert S_{21}\rvert^2$(dB)	$G_{L,max}$(dB)	$G_{TU,max}$(dB)
1	2.3	14.05	4.25	20.6
2	1.86	9.97	3.6	15.43

NOISE CIRCLES CALCULATIONS:

f(GHz)	F_i(dB)	C_{F_i}	r_{F_i}
1	2	$0.395\angle 23^\circ$	0.378
	3	$0.286\angle 23^\circ$	0.591
	4	$0.212\angle 23^\circ$	0.708
2	2	$0.377\angle 88^\circ$	0.261
	3	$0.304\angle 88^\circ$	0.477
	4	$0.244\angle 88^\circ$	0.604



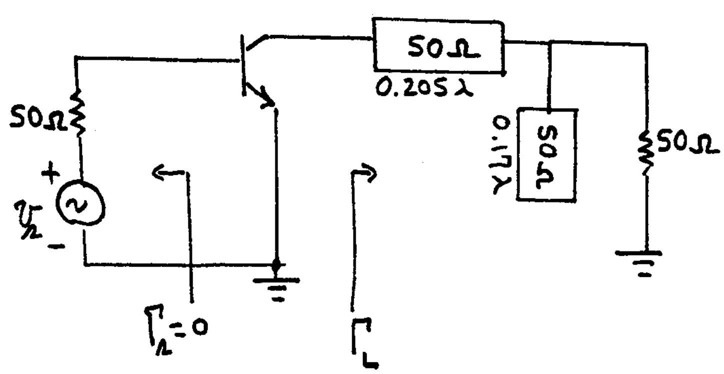


IT IS SEEN THAT THE NOISE FIGURE IS LESS THAN 3 dB AT 1 GHz AND 2 GHz WITH $\Gamma_s = 0$. THE INPUT MATCHING NETWORK IS DESIGNED WITH $\Gamma_s = 0$, AND IT FOLLOWS THAT $G_s = 0$ dB.

A DESIGN FOR $G_{TU} = 10$ dB REQUIRES THAT $G_L = -4$ dB AT 1 GHz, AND $G_L = 0$ dB AT 2GHz. THAT IS,

AT 1GHz: $G_{TU} = 0 + 14.05 - 4 \approx 10$dB ; AT 2GHz: $G_{TU} = 0 + 9.97 + 0 \approx 10$dB

A MATCHING CIRCUIT FOR THIS DESIGN IS:



4.16) (a) $S_{11a} = S_{11b} = S_{11}$ $\quad S_{21a} = S_{21b} = S_{21}$

$S_{12a} = S_{12b} = S_{12}$ $\quad S_{22a} = S_{22b} = S_{22}$

$S_{11} = \frac{e^{-j\pi}}{2}(S_{11a} - S_{11b}) = 0$, $(VSWR)_{in} = 1$

$S_{22} = \frac{e^{-j\pi}}{2}(S_{22a} - S_{22b}) = 0$, $(VSWR)_{OUT} = 1$

$G_T = (0.5)^2 |S_{21a} + S_{21b}|^2 = (0.5)^2 [2(3.4)]^2 = 11.56$ OR 10.6 dB

(b) $S_{11b} = 0.525 \angle 168^\circ$, $S_{12b} = 0.084 \angle 63^\circ$, $S_{21b} = 3.57 \angle 73.5^\circ$, $S_{22b} = 0.42 \angle -42.75^\circ$

$S_{11} = \frac{e^{-j\pi}}{2}(0.5 \angle 160^\circ - 0.525 \angle 168^\circ) = 0.038 \angle -125.2^\circ$, $(VSWR)_{in} = \frac{1+0.038}{1-0.038} = 1.08$

$S_{22} = \frac{e^{-j\pi}}{2}(0.4 \angle -45^\circ - 0.42 \angle -42.75^\circ) = 0.013 \angle -5^\circ$, $(VSWR)_{OUT} = \frac{1+0.013}{1-0.013} = 1.03$

$G_T = (0.5)^2 |3.4 \angle 70^\circ + 3.57 \angle 73.5^\circ|^2 = 12.13$ OR 10.8 dB

4.19) IF S_{11} IS APPROXIMATED BY $0.97 \angle 0^\circ$, THE ASSOCIATED $r_{b'e}$ IS 3.28 kΩ.

$G_T = 10 = |S_{21}|^2 \Rightarrow S_{21} = -3.16$

FROM (4.4.10):

$$R_2 = Z_0(1 - S_{21}) = 50(1 + 3.16) = 208\ \Omega$$

THE VALUE OF g_m FOR $(VSWR)_{in} \approx 1$ AND $(VSWR)_{OUT} \approx 1$ FOLLOWS FROM (4.4.9). THAT IS,

$$g_m = \frac{R_2}{Z_0^2} = \frac{208}{50^2} = 83\ mS$$

4.24) (a) $\Gamma_s = S_{11}^* = 0.75 \angle 100^\circ$ AND $\Gamma_L = S_{22}^* = 0.7 \angle 50^\circ$

(b) $Y_s = \frac{1}{Z_s} = 7 - j23$ mS , $Y_L = \frac{1}{Z_L} = 4 - j9$ mS

$$(BW)_{IN}^i = \frac{2f_0 G_{s,m}}{|B_{s,m}|} = \frac{2(8\,10^9)\,0.007}{0.023} = 4.87 \text{ GHz}$$

$$(BW)_{OUT}^i = \frac{2f_0 G_{L,m}}{|B_{L,m}|} = \frac{2(8\,10^9)(0.004)}{0.009} = 7.11 \text{ GHz}$$

(c) $(BW)_{IN} = 20\%\ (BW)_{IN}^i = 974$ MHz

$Y_{IN} = 7 + j23$ mS

THE REQUIRED VALUE OF C'_{IN} (FROM (4.6.5)) IS:

$$C'_{IN} = \frac{B_{IN,M}}{\omega_0}\left[\frac{(BW)_{IN}^i}{(BW)_{IN}} - 1\right] = \frac{23\,10^{-3}}{2\pi(8\,10^9)}\left[\frac{4.87}{0.974} - 1\right] = 1.83 \text{ pF}$$

(d) $Y'_{IN} = Y_{IN} + j\omega C'_{IN} = (7 + j23)\,10^{-3} + j2\pi(8\,10^9)(1.83\,10^{-12}) = 7 + j115$ mS

$\Gamma'_{IN} = 0.98 \angle -160.4^\circ$, $\therefore \Gamma_s = \Gamma'^*_{IN} = 0.98 \angle 160.4^\circ$, $\Gamma_L = S_{22}^* = 0.7 \angle 50^\circ$

$$G_{TU,max} = \frac{1}{1 - (0.98)^2}(2.5)^2 \frac{1}{1 - (0.7)^2} = 309.4 \text{ OR } 24.9 \text{ dB}$$