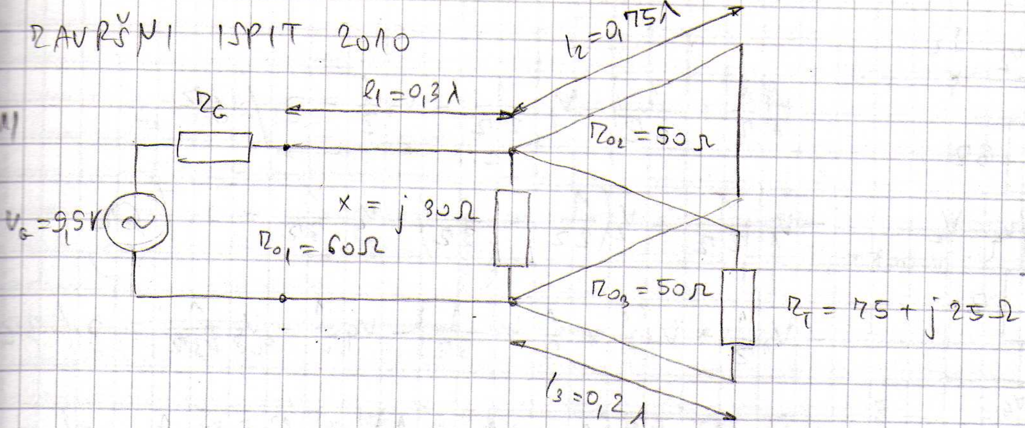
ZAVRŠNI ISPIT 2010

1)



SWR = ?

RL = ?

$Z_{ul} = ?$

$P_{max} = ?$

$$Z_{ul3} = Z_{03}\frac{Z_T + j Z_{03}\tan(\beta l)}{Z_{03} + j Z_T \tan(\beta l)} = 50\,\frac{75 + j25 + j\,50\tan(0,4\pi)}{50 + j(75 + j25)\tan(0,4\pi)} = 50\,\frac{75 + j\,25 + j\,153,88}{50 + j\,230,83 - 76,94}$$

$$= \frac{3750 + j\,8944}{-26,94 + j\,230,83} = \frac{9698,33\,\angle 67,25^\circ}{232,46\,\angle 96,66} = 41,72\,\angle -29,41 = 36,34 - j\,20,49$$

$$Z_{ul2} = Z_{02}\frac{Z_T + j Z_{02}\tan(\beta l)}{Z_{02} + j Z_T \tan(\beta l)} = \cancel{50}\,\frac{0 + j\,50\tan(1,5\pi)}{\cancel{50} + j\,0\tan(1,5\pi)} = \infty$$

$$Z = X \,\|\, Z_{ul2} \,\|\, Z_{ul3} = X \,\|\, \frac{Z_{ul2} Z_{ul3}}{Z_{ul2} + Z_{ul3}} = X \,\|\, \frac{Z_{ul3}}{1 + Z_{ul3}/Z_{ul2}} = X \,\|\, Z_{ul3} = \frac{X \cdot Z_{ul3}}{X + Z_{ul3}} =$$

$$= \frac{j\,30(59,73 - j\,4,96)}{59,73 - j\,4,96 + j\,30} = \frac{148,8 + j\,1791,9}{59,73 + j\,25,04} = \frac{1798,07\,\angle 85,25^\circ}{64,77\,\angle 22,74^\circ} = 27,76\,\angle 62,51^\circ$$

$$= 12,81 + j\,24,63$$

$$\Gamma_T = \frac{Z_T - Z_0}{Z_T + Z_0} = \frac{12,81 + j\,24,63 - 60}{12,81 + j\,24,63 + 60} = \frac{-47,19 + j\,24,63}{82,81 + j\,24,63} = \frac{53,23\,\angle 152,44}{86,4\,\angle 16,56} = 0,616\,\angle$$

$$= 0,616\,\angle 135,88^\circ$$

$$RL = -20\log 0,616 = 4,21\text{ dB}$$

$$SWR = \frac{1 + |\Gamma_T|}{1 - |\Gamma_T|} = \frac{1,616}{0,384} = 4,21$$

$$Z_{ul} = Z_{01}\frac{Z + j Z_{01}\tan(\beta l)}{Z_{01} + j Z \tan(\beta l)} = 60\,\frac{12,81 + j\,24,63 + j\,60\tan(0,6\pi)}{60 + j(12,81 + j\,24,63)\tan(0,6\pi)} =$$

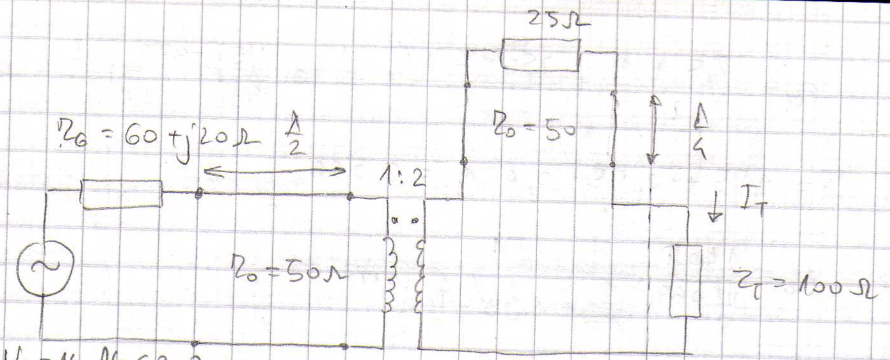
$$= \frac{12,81 - j\,160,03}{135,8 - j\,39,43}\,60 = \frac{768,6 - j\,9601,8}{135,8 - j\,39,43} = \frac{9632,51\,\angle 85,42}{141,41\,\angle 16,19} = 68,12\,\angle 69,23$$

$$= 24,16 + j\,63,69$$

$$Z_G = Z_{ul}^* = 24,16 - j\,63,69$$

$$P_A = \frac{|V_G|^2}{8 R_G} = \frac{9,9^2}{8 \cdot 24,16} = 0,507\text{ W} = 507\text{ mW}$$

3)



$V_G = 14{,}14 \angle 30°$

$$Z_1 = Z_0 \frac{Z_0 + j Z_T \tan(\beta l)}{Z_T + j Z_0 \tan(\beta l)} = 50 \, \frac{50 + j\, 25 \tan\frac{\pi}{2}}{25 + j\, 50 \tan\frac{\pi}{2}} = 50 \, \frac{\frac{50}{25\cdot\infty} + j}{\frac{25}{25\cdot\infty} + 2j} = 50 \cdot \frac{1}{2} = 25$$

$Z_1 = 100\ \Omega$

$$\begin{bmatrix} A & B \\ C & D \end{bmatrix} = \begin{bmatrix} \cos\pi & Z_0 \sin\pi \\ \frac{1}{Z_0}\sin\pi & \cos\pi \end{bmatrix} \begin{bmatrix} 2 & 0 \\ 0 & 1/2 \end{bmatrix} \begin{bmatrix} 1 & 25 \\ 0 & 1 \end{bmatrix} = \begin{bmatrix} -1 & 0 \\ 0 & -1 \end{bmatrix} \begin{bmatrix} 2 & 0 \\ 0 & 1/2 \end{bmatrix} \begin{bmatrix} 1 & 25 \\ 0 & 1 \end{bmatrix} = \begin{bmatrix} -2 & 0 \\ 0 & -1/2 \end{bmatrix} \begin{bmatrix} 1 & 25 \\ 0 & 1 \end{bmatrix} =$$

$$= \begin{bmatrix} -2 & -50 \\ 0 & -1/2 \end{bmatrix} \qquad V_2 = V_T \qquad I_2 = I_T = \frac{V_T}{Z_T} = \frac{V_2}{Z_T}$$

$$Z_{ul} = \frac{V_1}{I_1} = \frac{A V_2 + B I_2}{C V_2 + D I_2} = \frac{A V_2 + B \frac{V_2}{Z_T}}{C V_2 + D \frac{V_2}{Z_T}} = \frac{A Z_T + B}{C Z_T + D} = \frac{-200 - 50}{0 - 1/2} = \frac{-250}{-1/2} = 500\ \Omega$$

$$V_1 = A V_2 + B I_2 = A V_2 + B \frac{V_2}{Z_T} = V_2\left(A + \frac{B}{Z_T}\right)$$

$$V_1 = \frac{Z_{ul}}{Z_G + Z_{ul}} V_G \Rightarrow I_T = \frac{V_2}{Z_T} = V_G \frac{Z_{ul}}{Z_G + Z_{ul}} \frac{1}{\left(A + \frac{B}{Z_T}\right)} \cdot \frac{1}{Z_T} = V_G \frac{Z_{ul}}{Z_G + Z_{ul}} \frac{1}{A Z_T + B} =$$

$$= 14{,}14\angle 30° \, \frac{500}{60 + j20 + 500} \, \frac{1}{-2 \cdot 100 - 50} = \frac{7070 \angle 30°}{(560 + j20)\cdot -250} =$$

$$= \frac{-28{,}28 \angle 30°}{560{,}36 \angle 2{,}05} = -0{,}0505 \angle 27{,}95° = 0{,}0505 \angle 207{,}95° =$$

$$= -0{,}0446 - j\,0{,}0237$$

$$V_1 = \frac{500}{60 + j20 + 500}\, 14{,}14 \angle 30° = \frac{7070 \angle 30°}{560{,}36 \angle 2{,}05} = 12{,}62 \angle 27{,}95°$$

$$P_{ul} = \frac{12{,}62^2}{2} \, \frac{500}{560^2 + 20^2} = \frac{79632{,}2}{628000} = 0{,}1268\ W$$

$$P_T = \frac{|I_T|^2}{2} Z_T = \frac{0{,}0446^2 + 0{,}0237^2}{2} \cdot 100 = 0{,}1275\ W$$

5) $w = 4\ mm$

$\sigma = 5,81 \cdot 10^7\ Sm^{-1}$

$h = 1,5\ mm$

$\varepsilon_r = 2,5$

$\tan\delta = 2 \cdot 10^{-3}$

$Z_0 = ?$

$\beta = ?$

$f = 3\ GHz$

disperzija $\checkmark$

$$\varepsilon_{ef} = \frac{2,5+1}{2} + \frac{2,5-1}{2}\left(1 + 10\,\frac{1,5}{4}\right)^{-0,555} =$$

$$= 1,75 + 0,75 \cdot 0,421 = 2,066$$

$$Z_0 = \frac{120\pi}{\sqrt{2,066}} \; \frac{1}{\frac{4}{1,5} + 1,98\left(\frac{4}{1,5}\right)^{0,172}} = \ldots$$

$$= 262,28 \cdot 0,1996 = 52,35$$

$$\varepsilon_{ef}(f) = \frac{\sqrt{2,5} - \sqrt{2,066}}{1 + 4 \cdot 0,3698^{-1,5}} + \sqrt{2,066} = 1,445$$

$$F = \frac{4 \cdot 1,5 \cdot 10^{-3} \cdot \cancel{3} \cdot 10^{9} \sqrt{1,5}}{\cancel{3} \cdot \cancel{10^8}} \left\{0,5 + \left[1 + 2\log\left(1 + \frac{4}{1,5}\right)\right]^2\right\}$$

$$= 0,0735 \cdot 5,031 = 0,3698$$

$$Z_0(f) = Z_0(0)\,\frac{\varepsilon_{ef}(f) - 1}{\varepsilon_{ef}(0) - 1}\sqrt{\frac{\varepsilon_{ef}(0)}{\varepsilon_{ef}(f)}} = 52,35\,\frac{0,445}{1,066}\sqrt{\frac{2,066}{1,445}} = 26,131\ \Omega$$

1)

2)

$$y_{11} = \frac{I_1}{V_1}\Big|_{V_2=0} = \frac{1}{2R} + \frac{1}{R}$$

$$y_{12} = \frac{I_1}{V_2}\Big|_{V_1=0} = -\frac{1}{R}$$

$$y_{21} = \frac{I_2}{V_1}\Big|_{V_2=0} = -\frac{1}{R}$$

$$y_{22} = \frac{I_2}{V_2}\Big|_{V_1=0} = \frac{1}{R}$$

2003

$$z_{11} = \frac{\frac{1}{R}}{\left(\frac{1}{2R}+\frac{1}{R}\right)\cdot\frac{1}{R} - \frac{1}{R^2}} = \frac{\frac{1}{R}}{\frac{R+2R}{2R^2} - \frac{1}{R^2}} = \frac{\frac{1}{R}}{\frac{3\cancel{R}}{2R^{\cancel{2}3}} - \frac{1}{R^2}}$$

$$= \frac{\frac{1}{R}}{\frac{3-2}{2R}} = \frac{\frac{1}{\cancel{R}}}{\frac{1}{2\cancel{R}}} = 2R \qquad z_{12} = 2R$$

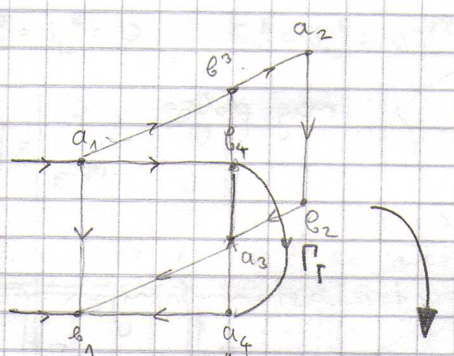
$$z_{21} = 2R \qquad z_{22} = \frac{\frac{1+2}{2R}}{\frac{1}{R}} = \frac{\frac{3}{2R}}{\frac{1}{R}} = \frac{2}{3}R$$

$$[Z^A] + [Z^B] = \begin{bmatrix} R & -R \\ 2R & R \end{bmatrix} + \begin{bmatrix} 2R & 2R \\ 2R & 3R \end{bmatrix} = \begin{bmatrix} 3R & +R \\ 4R & 4R \end{bmatrix}$$

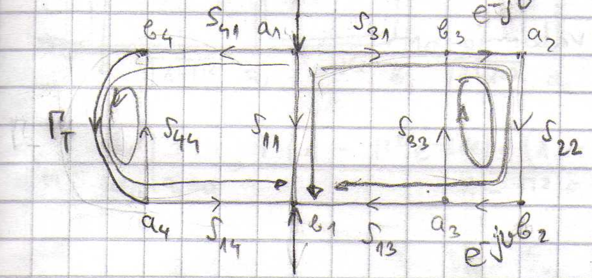
$$\left(\frac{1}{2}y + y\right)\cdot y - y^2 \qquad \frac{1}{2}y + y = \frac{\frac{3}{2}y}{\frac{1}{2}y^2} = \frac{3}{2}R$$

$$\frac{3}{2}y^2 - y^2 = \frac{1}{2}y^2 = \frac{\frac{1}{2}}{\frac{1}{2R^2}} = 2R$$

1)



1997

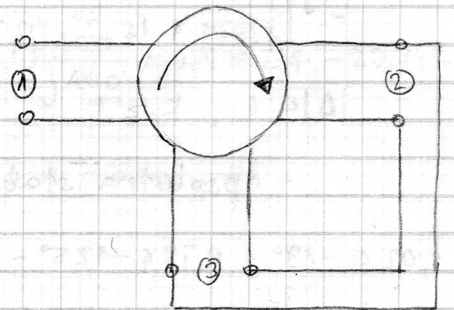


$$\Gamma_T = \frac{b_1}{a_1} = \frac{S_{11}\left[1 - S_{22}S_{33}e^{-j2\vartheta} - S_{44}\Gamma_T\right] + S_{31}S_{22}S_{13}e^{-j2\vartheta}\left[1 - S_{44}\Gamma_T\right] + S_{41}\Gamma_T S_{14}\left[1 - S_{22}S_{33}e^{-j2\vartheta}\right]}{1 - S_{22}S_{33}e^{-j2\vartheta} - S_{44}\Gamma_T}$$

$$\Gamma_T = S_{11} + \frac{S_{31}S_{22}S_{13}e^{-j2\vartheta}\left[1 - S_{44}\Gamma_T\right] + S_{41}\Gamma_T S_{14}\left[1 - S_{22}S_{33}e^{-j2\vartheta}\right]}{1 - S_{22}S_{33}e^{-j2\vartheta} - S_{44}\Gamma_T}$$

21 2010

+) $L = 20\ dB$



$\varphi = -30°$

$l = 1\ m$

$\gamma = 0{,}1\ Np\,m^{-1} + j\,\pi/3\ rad\,m^{-1}$

$Z_0 = 50\ \Omega$ – da se vidi da je linija prilagođena na sustav

$S_{12} = 10^{-\frac{20}{20}} e^{-j30°} = 0{,}1 \angle -30° = S_{23} = S_{31}$ $\qquad S_{11} = S_{22} = S_{33} = 0$

$\gamma l = (0{,}1\ Np\,m^{-1} + j\,\pi/3\ rad\,m^{-1}) \cdot 1\ m = 0{,}1\ Np + j\,\pi/3\ rad$

$\alpha = 0{,}1\ Np, \quad \beta = \pi/3$

$$[S] = \begin{bmatrix} 0 & 0{,}1\angle-30° & 0{,}995\angle-30° \\ 0{,}995\angle-30° & 0 & 0{,}1\angle-30° \\ 0{,}1\angle-30° & 0{,}995\angle-30° & 0 \end{bmatrix}$$

$|S_{11}|^2 + |S_{21}|^2 + |S_{31}|^2 = 1$ – nema gubitaka

$S_{21} = \sqrt{1 - |S_{11}|^2 - |S_{31}|^2} = \sqrt{1 - 0 - 0{,}1^2} = 0{,}995$

$b_1 = S_{12} a_2 + S_{13} a_3$

$b_2 = S_{21} a_1 + S_{23} a_3$

$b_3 = S_{31} a_1 + S_{32} a_2$

$a_3 = e^{-\gamma l} b_2$

$a_2 = e^{-\gamma l} b_3$

$b_1 = S_{12} e^{-\gamma l} b_3 + S_{13} e^{-\gamma l} b_2$

$b_2 = S_{21} a_1 + S_{23} e^{-\gamma l} b_2$

$b_3 = S_{31} a_1 + S_{32} e^{-\gamma l} b_3$

$\rightarrow \quad b_1 = \dfrac{S_{12} S_{31} e^{-\gamma l}}{1 - S_{32} e^{-\gamma l}} a_1 + \dfrac{S_{21} S_{13} e^{-\gamma l}}{1 - S_{23} e^{-\gamma l}} a_1$

$b_2 = \dfrac{S_{21} a_1}{1 - S_{23} e^{-\gamma l}}$

$b_3 = \dfrac{S_{31} a_1}{1 - S_{32} e^{-\gamma l}}$

$\Gamma_T = \dfrac{b_1}{a_1} = \dfrac{S_{12} S_{31} e^{-\gamma l}}{1 - S_{32} e^{-\gamma l}} + \dfrac{S_{21} S_{13} e^{-\gamma l}}{1 - S_{23} e^{-\gamma l}}$

$e^{-0{,}1 - j\frac{\pi}{3}} = e^{-0{,}1}(\cos \pi/3 - j \sin \pi/3) =$

$= e^{-0{,}1}(1/2 - j\sqrt{3}/2)$

$= 0{,}4524 - j0{,}7836 = 0{,}9048 \angle -60°$

$$\Gamma_T = \frac{0{,}1^2 \angle -60° \cdot 0{,}9048 \angle -60°}{1 - 0{,}995 \angle -30° \cdot 0{,}9048 \angle -60°} + \frac{0{,}995^2 \angle -60° \cdot 0{,}9048 \angle -60°}{1 - 0{,}1 \angle -30° \cdot 0{,}9048 \angle -60°} =$$

$$= \frac{9{,}048 \cdot 10^{-3} \angle -120°}{1{,}3455 \angle 42°} + \frac{0{,}8958 \angle -120°}{1{,}0041 \angle 5{,}17°} = 6{,}7246 \cdot 10^{-3} \angle -162° + 0{,}8921 \angle -125{,}17°$$

$$= 0{,}8975 \angle -125{,}43°$$

6) FET

$$[S]=\begin{bmatrix} 1{,}02 \angle -19^\circ & 0{,}02 \angle 77{,}4^\circ \\ 2{,}21 \angle 162{,}3^\circ & 0{,}73 \angle -12{,}5^\circ \end{bmatrix}$$

$f = 1\ GHz$

$Z_0 = 50\ \Omega$ $\qquad |\Delta| < 1\ ,\ K > 1$

$Z_T = 100 - j100\ \Omega$ $\qquad$ – apsolutna stabilnost

$$\Delta = S_{11}S_{22} - S_{12}S_{21} = 1{,}02 \angle -19^\circ \cdot 0{,}73 \angle -12{,}5^\circ - 0{,}02 \angle 77{,}4^\circ \cdot 2{,}21 \angle 162{,}3^\circ =$$

$$= 0{,}7446 \angle -31{,}5^\circ - 0{,}0442 \angle 239{,}7^\circ = 0{,}745 \angle -28{,}1^\circ$$

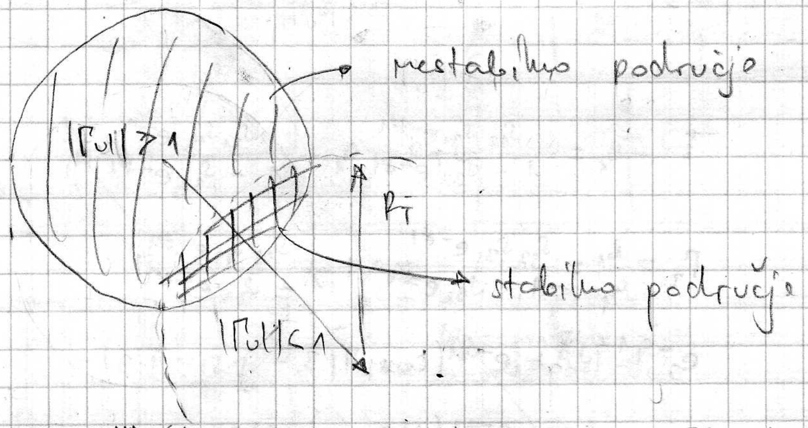
$|\Delta| = 0{,}745 < 1$ ✓

$$K = \frac{1 - |S_{11}|^2 - |S_{22}|^2 + |\Delta|^2}{2|S_{12}S_{21}|} = \frac{1 - 1{,}0404 - 0{,}5329 + 0{,}555}{0{,}0884} = -0{,}207 > 1 \quad \times$$

$$S_T = \frac{(S_{22} - \Delta S_{11}^*)^*}{|S_{22}|^2 - |\Delta|^2} = \frac{(0{,}73 \angle -12{,}5^\circ - 0{,}745 \angle -28{,}1^\circ \cdot 1{,}02 \angle 19^\circ)^*}{0{,}73^2 - 0{,}745^2} =$$

$$= \frac{(0{,}73 \angle -12{,}5^\circ - 0{,}7599 \angle -9{,}1^\circ)^*}{-0{,}0221} = \frac{0{,}0534 \angle +134{,}87^\circ}{-0{,}0221} = 2{,}4143 \angle -45{,}13^\circ$$

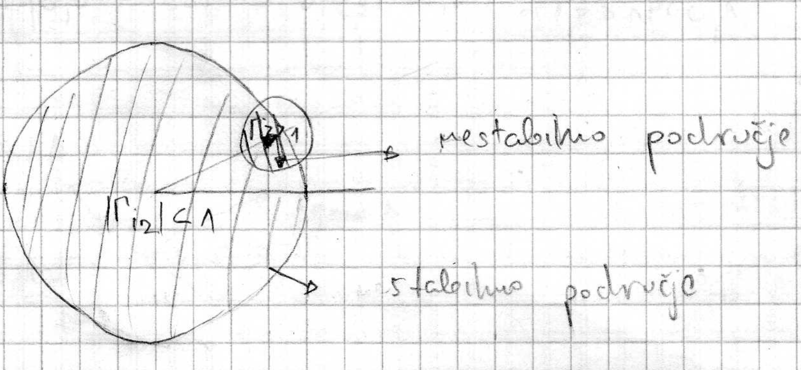
$$R_T = \left|\frac{S_{12}S_{21}}{|S_{22}|^2 - |\Delta|^2}\right| = \left|\frac{0{,}02 \cdot 2{,}21}{0{,}73^2 - 0{,}745^2}\right| = 1{,}9977$$



$$S_G = \frac{(S_{11} - \Delta S_{22}^*)^*}{|S_{11}|^2 - |\Delta|^2} = \frac{(1{,}02 \angle -19^\circ - 0{,}745 \angle -28{,}1^\circ \cdot 0{,}73 \angle 12{,}5^\circ)^*}{1{,}02^2 - 0{,}745^2} =$$

$$= \frac{(1{,}02 \angle -19^\circ - 0{,}5439 \angle -15{,}6^\circ)^*}{0{,}4854} = \frac{0{,}4781 \angle 22{,}87^\circ}{0{,}4854} = 0{,}9851 \angle 22{,}87^\circ$$

$$R_G = \left|\frac{S_{12}S_{21}}{|S_{11}|^2 - |\Delta|^2}\right| = \left|\frac{0{,}02 \cdot 2{,}21}{1{,}02^2 - 0{,}745^2}\right| = 0{,}0911$$



$$G_p = \frac{1}{1-|\Gamma_u|^2}\,|S_{21}|^2\,\frac{1-|\Gamma_T|^2}{|1-S_{22}\Gamma_T|^2}$$

$$\Gamma_T = \frac{Z_T - Z_0}{Z_T + Z_0} = \frac{100 - j100 - 50}{100 - j100 + 50} = \frac{50 - j100}{150 - j100} = 0{,}6202 \angle -29{,}74^\circ$$

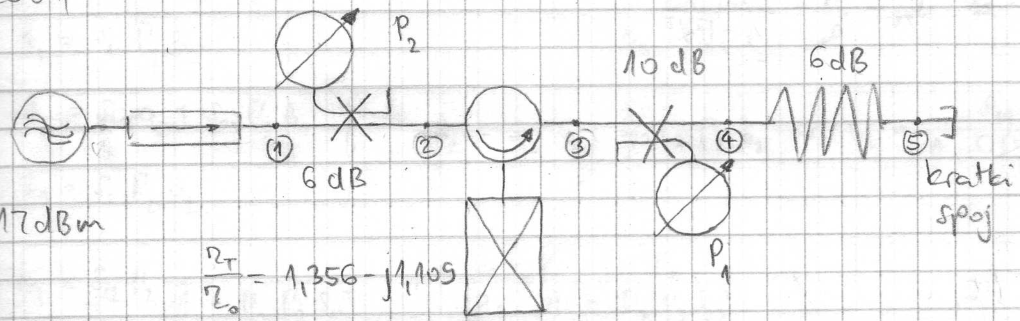
$$\Gamma_u = S_{11} + \frac{S_{12}S_{21}\Gamma_T}{1 - S_{22}\Gamma_T} = 1{,}02 \angle -19^\circ + \frac{0{,}02 \angle 77{,}4^\circ \cdot 2{,}21 \angle 162{,}3^\circ \cdot 0{,}6202 \angle -29{,}74^\circ}{1 - 0{,}73 \angle -12{,}5^\circ \cdot 0{,}6202 \angle -29{,}74^\circ}$$

$$= 1{,}02 \angle -19^\circ + \frac{0{,}0274 \angle 209{,}56^\circ}{0{,}7312 \angle 24{,}6^\circ} = 1{,}02 \angle -19^\circ + 0{,}0375 \angle 184{,}96^\circ = 0{,}9858 \angle -19{,}89$$

$$G_p = \frac{2{,}21^2}{1 - 0{,}9858^2} \cdot \frac{1 - 0{,}6202^2}{|1 - 0{,}73 \angle -12{,}5^\circ \cdot 0{,}6202 \angle -29{,}74^\circ|^2} = \frac{3{,}0054}{0{,}0282} \cdot \frac{1}{0{,}7312^2} =$$

$$= 199{,}33$$

2001



(1) 17 dBm

(2) 11 dBm

(3) $$\Gamma_T = \frac{Z_T - Z_0}{Z_T + Z_0} = \frac{(1{,}356 - j1{,}109)Z_0 - Z_0}{(1{,}356 + j1{,}109)Z_0 + Z_0} = \frac{0{,}356 - j1{,}109}{2{,}356 - j1{,}109} = \frac{1{,}1647 \angle -72{,}2^\circ}{2{,}604 \angle -25{,}21^\circ} =$$

$$= 0{,}4473 \angle 46{,}99^\circ$$

$$P_{i2} = P_u |\Gamma_T|^2 \Rightarrow P_{i2} = P_u + 20\log \Gamma_T = 11 - 6{,}988 = 4{,}012 \text{ dBm}$$

$$P_1 = -5{,}988 \text{ dBm}$$

(4) $10^{0{,}4012} = 2{,}5188 \qquad 0{,}9 \cdot 2{,}5188 = 2{,}267 = 3{,}5544 \text{ dBm}$

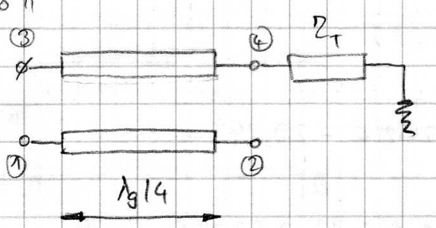
(5) $-2{,}4456$ dBm

(4) $-8{,}4456$

(3), (2) $-18{,}4456$ dBm

$P_2 = -24{,}4456$ dBm

2) 200 Ω



$\lambda_g/4 \Rightarrow \alpha = \sqrt{1-c^2},\ \beta = c$

$a_3 = b_3$

$a_4 = \Gamma b_4$

$b_1 = -j\alpha a_2 + \beta a_3 = -j\alpha a_2 + \beta b_3$

$b_2 = -j\alpha a_1 + \beta a_4 = -j\alpha a_1 + \beta\Gamma b_4$

$b_3 = \beta a_1 - j\alpha a_4 = \beta a_1 - j\alpha\Gamma b_4$

$b_4 = \beta a_2 - j\alpha a_3 = \beta a_2 - j\alpha b_3$

$$[S] = \begin{bmatrix} 0 & -j\alpha & \beta & 0 \\ -j\alpha & 0 & 0 & \beta \\ \beta & 0 & 0 & -j\alpha \\ 0 & \beta & -j\alpha & 0 \end{bmatrix}$$

(1) $a_1 = 0 \qquad b_1 | a_2 = 0$

$b_1 = -j\alpha a_2 + \beta b_3$

$b_2 = \beta\Gamma b_4$

$$\left.\begin{aligned} b_3 &= -j\alpha\Gamma b_4 \\ b_4 &= \beta a_2 - j\alpha b_3 \end{aligned}\right\} \quad b_4 = \beta a_2 - j\alpha(-j\alpha\Gamma b_4) = \beta a_2 + \alpha^2\Gamma b_4 \Rightarrow b_4 = \frac{\beta}{1-\Gamma\alpha^2}a_2$$

$b_2 = \beta\Gamma\frac{\beta}{1-\Gamma\alpha^2}a_2 \Rightarrow S_{22} = \frac{b_2}{a_2} = \frac{\Gamma\beta^2}{1-\Gamma\alpha^2}$

(2) $a_2 = 0 \qquad b_2 | a_1 = 0$

$b_1 = \beta b_3$

$b_2 = -j\alpha a_1 + \beta\Gamma b_4$

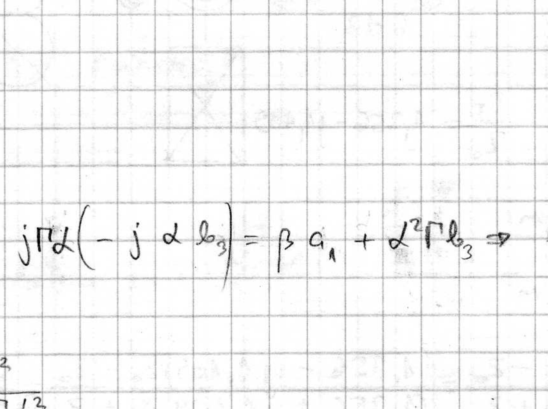
$$\left.\begin{aligned} b_3 &= \beta a_1 - j\alpha\Gamma b_4 \\ b_4 &= -j\alpha b_3 \end{aligned}\right\} \quad b_3 = \beta a_1 - j\Gamma\alpha(-j\alpha b_3) = \beta a_1 + \alpha^2\Gamma b_3 \Rightarrow b_3 = \frac{\beta}{1-\Gamma\alpha^2}a_1$$

$b_1 = \beta\frac{\beta}{1-\Gamma\alpha^2}a_1 \Rightarrow S_{11} = \frac{b_1}{a_1} = \frac{\beta^2}{1-\Gamma\alpha^2}$

$[S'] = \begin{bmatrix} S_{11} & 0 \\ 0 & S_{22} \end{bmatrix} \quad |S_{11}| = 1,\ |S_{22}| = 1$ nema gubitaka, početni sklop je tako definiran

$|S_{11}| = |S_{22}|$

$\left|\frac{\cancel{\beta^2}}{\cancel{1-\Gamma\alpha^2}}\right| = \left|\frac{\Gamma\cancel{\beta^2}}{\cancel{1-\Gamma\alpha^2}}\right| \Rightarrow |\Gamma| = 1$

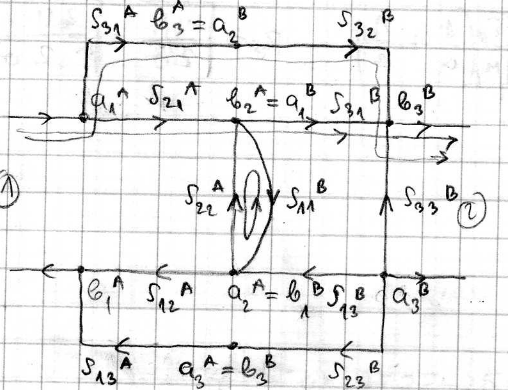


$S_{21} = \dfrac{-j\alpha\beta^2\Gamma(1-0) - j\alpha(1-\alpha^2\Gamma)}{1-\alpha^2\Gamma}$

$S_{21} = -j\alpha\left[1 + \dfrac{\beta^2\Gamma}{1-\alpha^2\Gamma}\right]$

$S_{12} =$

3) 2001



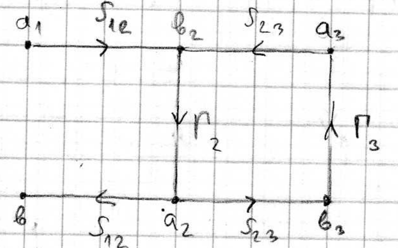
$$S_{21} = \frac{S_{21}^A S_{31}^B (1-0) + S_{31}^A S_{32}^B (1 - S_{22}^A S_{11}^B)}{1 - S_{22}^A S_{11}^B}$$

$$S_{11} = \frac{S_{21}^A S_{11}^B S_{12}^A}{1 - S_{22}^A S_{11}^B}$$

$$S_{22} = \frac{S_{33}^B (1 - S_{22}^A S_{11}^B) + S_{13}^B S_{22}^A S_{31}^B}{1 - S_{22}^A S_{11}^B}$$

$$S_{12} = \frac{S_{13}^B S_{12}^A (1-0) + S_{23}^B S_{13}^A (1 - S_{22}^A S_{11}^B)}{1 - S_{22}^A S_{11}^B}$$

4) 2003



$$\frac{P_2}{P_1} = \frac{a_2^2 - b_2^2}{a_1^2 - b_1^2} = \frac{a_2^2\left(1 - \frac{b_2^2}{a_2^2}\right)}{a_1^2\left(1 - \frac{b_1^2}{a_1^2}\right)}$$

$b_1 = S_{12} a_2$

$b_2 = S_{12} a_1 + S_{23} a_3$

$b_3 = S_{23} a_2$

$a_2 = \Gamma_2 b_2$

$a_3 = \Gamma_3 b_3$

$b_1 = S_{12} \Gamma_2 b_2$

$b_2 = S_{12} a_1 + S_{23} \Gamma_3 b_3$

$b_3 = S_{23} \Gamma_2 b_2$

$$b_2 = S_{12} a_1 + S_{23}^2 \Gamma_3 \Gamma_2 b_2 \Rightarrow b_2 = \frac{S_{12}}{1 - \Gamma_2 \Gamma_3 S_{23}^2} b_2$$

$$b_1 = S_{12} \Gamma_2 \frac{S_{12}}{1 - \Gamma_2 \Gamma_3 S_{23}^2} \Rightarrow \frac{b_1}{a_1} = \frac{S_{12}^2 \Gamma_2}{1 - \Gamma_2 \Gamma_3 S_{23}^2}$$

$$\rightarrow \frac{a_2}{\Gamma_2} = S_{12} a_1 + S_{23}^2 \Gamma_3 \Gamma_2 \frac{a_2}{\Gamma_2} \qquad \frac{a_2}{\Gamma_2} = S_{12} a_1 + S_{23}^2 \Gamma_3 a_2 \Rightarrow \frac{a_2}{a_1} = \frac{S_{12}}{\frac{1}{\Gamma_2} - S_{23}^2 \Gamma_3} = \frac{S_{12} \Gamma_2}{1 - S_{23}^2 \Gamma_2 \Gamma_3}$$

$$\frac{P_3}{P_1} = \frac{a_3^2 - b_3^2}{a_1^2 - b_1^2} = \frac{a_3^2\left(1 - \frac{b_3^2}{a_3^2}\right)}{a_1^2\left(1 - \frac{b_1^2}{a_1^2}\right)}$$

$$\rightarrow \frac{b_3}{S_{23} \Gamma_2} = S_{12} a_1 + S_{23} \Gamma_3 \frac{a_3}{\Gamma_3} \Rightarrow \frac{a_3}{S_{23} \Gamma_2 \Gamma_3} = S_{12} a_1 + S_{22} \frac{a_3}{\Gamma_3} \Rightarrow \frac{a_3}{a_1} = \frac{S_{12}}{\frac{1}{S_{23} \Gamma_2 \Gamma_3} - S_{23}} = \frac{S_{12} S_{23} \Gamma_2 \Gamma_3}{1 - S_{23}^2 \Gamma_2 \Gamma_3}$$

to se sve gore uvrsti

di treba

5) $f = 10\ GHz$

$l = 10\ m$

$a = 0,936\ mm$

$b = 3,5\ mm$

$\varepsilon_r = 2,5$

$tg\delta = 10^{-4}$

$\sigma = 5,88 \cdot 10^7\ Sm^{-1}$

$\mu_r = 1$

$\mu_0 = 4\pi \cdot 10^{-7}\ Hm^{-1}$

$\varepsilon_0 = 8,854 \cdot 10^{-12}\ Fm^{-1}$

$$\alpha_c = \frac{R_s}{\mu_0\, 2 \ln b/a}\sqrt{\frac{\varepsilon_r}{\mu_r}}\left(\frac{1}{a}+\frac{1}{b}\right) \qquad R_s = \sqrt{\frac{\omega\mu}{2\sigma}} = \sqrt{\frac{2\pi f}{2\sigma}\mu_0} = 25,91m$$

$=$

$= 55,783$

$$\alpha_d = \frac{\omega\, tg\delta}{2c}\sqrt{\varepsilon_r\mu_r} = 16,5576 \cdot 10^{-3}$$

$$\beta = \frac{\omega}{c}\sqrt{\mu_r\varepsilon_r} = 331,153\ rad\,m^{-1}$$

$$\gamma = \alpha + j\beta = 72,34 \cdot 10^{-3}\ Np/m + j\ 331,153\ rad\ m$$

$$R = \frac{R_s}{2\pi}\left(\frac{1}{a}+\frac{1}{b}\right) = 5,5838\ \Omega/m$$

$$L = \frac{\mu}{2\pi}\ln\frac{b}{a} = 2,638 \cdot 10^{-7}\ H/m$$

$$G = \frac{2\pi\,\omega\,\varepsilon''}{\ln b/a} = 6,6256 \cdot 10^{-4}\ S/m$$

$$C = \frac{2\pi\,\varepsilon_0\,\varepsilon_r}{\ln b/a} = 1,0545 \cdot 10^{-10}\ \frac{F}{m}$$

$$Z_0 = \sqrt{\frac{R + j\omega L}{G + j\omega C}} = 50,02\angle{-0,88^\circ}$$

$$S = \begin{bmatrix} 0 & 0 \\ e^{-\gamma l} & e^{-\gamma l} \end{bmatrix} \qquad IL\ \ 20\log|e^{-\gamma l}| = 20\log|S_{21}|$$