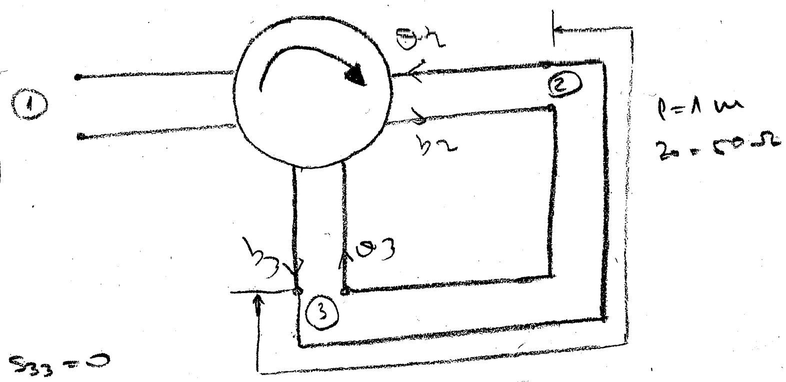
2012./2013.

ZI - MIKELE
(ISPITI)

LJETNI ROK

(3.) Prilagođeni cirkulator bez gubitaka ima u nepropusnom smjeru gušenje od 20 dB. Fazno kašnjenje između susjednih prolaza je -30°. Odrediti raspršnu matricu cirkulatora! Ako su prolazi cirkulatora 2 i 3 povezani prijenosnom linijom duljine 1 m, koeficijente širenja $\gamma = 0.1 \frac{Np}{m} + j\frac{\pi}{3} \frac{rad}{m}$ i karakteristične impedancije 50 Ω, odrediti koeficijent refleksije na prolazu 1 cirkulatora. Karakteristična impedancija sustava je 50 Ω.



$$[S] = \begin{bmatrix} \cancel{S_{11}} & \cancel{S_{12}} & S_{13} \\ S_{21} & \cancel{S_{22}} & \cancel{S_{23}} \\ \cancel{S_{31}} & S_{32} & \cancel{S_{33}} \end{bmatrix}$$

prilagođen $\Rightarrow S_{11} = S_{22} = S_{33} = 0$

$\varphi = -30°$

$\alpha = 20$ dB

$$S_{12} = S_{23} = S_{31} = 10^{-\frac{20}{20}} e^{-j30°} = 0.1\angle -30°$$

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

$$|S_{21}|^2 = 1 - |S_{11}|^2 - |S_{31}|^2 = 0.994$$

$$S_{21} = S_{13} = S_{32} = 0.994\angle -30°$$

$$[S] = \begin{bmatrix} 0_{11} & 0.1\angle -30°_{12} & 0.994\angle -30°_{13} \\ 0.994\angle -30°_{21} & 0_{22} & 0.1\angle -30°_{23} \\ 0.1\angle -30°_{31} & 0.994\angle -30°_{32} & 0_{33} \end{bmatrix}$$

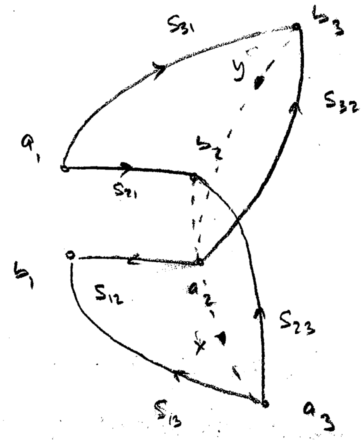
$\Rightarrow \Gamma$

$l = 1\ m$

$\gamma = 0.1 + j\frac{\pi}{3}$

$Z_0 = 50\,\Omega$

$\Gamma_1 = ? = \frac{b_1}{a_1}$



$$\Gamma_1 = \frac{b_1}{a_1} = ?$$

$$e^{-\gamma l} = e^{-(0.1 + j\frac{\pi}{3})\cdot 1}$$

$$= e^{-0.1} \cdot e^{-j\frac{\pi}{3}} = 0.905 \angle -60$$

$b_1 = S_{12} a_2 + S_{13} a_3$ $\qquad a_2 = e^{-\gamma l} b_3$

$b_2 = S_{21} a_1 + S_{23} a_3$ $\qquad a_3 = e^{-\gamma l} b_2$

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

$$b_3 = S_{31} a_1 + S_{32} e^{-\gamma l} b_3 \qquad b_2 = S_{21} a_1 + S_{23} e^{-\gamma l} b_2$$

$$b_3 = \frac{S_{31} a_1}{1 - S_{32} e^{-\gamma l}} \qquad b_2 = \frac{S_{21} a_1}{1 - S_{23} e^{-\gamma l}}$$

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

$$\frac{b_1}{a_1} = \frac{S_{12} \cdot S_{31}\, e^{-\gamma l}}{1 - S_{32} e^{-\gamma l}} + \frac{S_{13} \cdot S_{21} \cdot e^{-\gamma l}}{1 - S_{23} e^{-\gamma l}} = 0.896 \angle \underline{-125.4}$$

4) Za tranzistor u spoju zajedničke baze na frekvenciji 2.1 GHz u sustavu karakteristične impedancije 50 Ω zadana je raspršna matrica [S]. Ispitati stabilnost tranzistora, Nacrtati kružnice stabilnosti i označiti nestabilno područje. Izračunati koeficijent refleksije i impedanciju na ulazu tranzistora (prolaz 1) ako je na izlaz (prolaz 2) priključen teret impedancije 80 + j 180 Ω. Da li ovaj teret osigurava stabilan rad pojačala? obrazložiti odgovor. (2)

$$[S] = \begin{bmatrix} 1.194\angle 162.7^\circ_{11} & 0.126\angle 156.6^\circ_{12} \\ 2.270\angle -38.8_{21} & 1.218\angle -26^\circ_{22} \end{bmatrix}$$

$$\Delta = S_{11}S_{22} - S_{12}S_{21} = 1.187\angle 141.17^\circ$$

$$K = \frac{1-|S_{11}|^2-|S_{22}|^2+|\Delta|^2}{2|S_{12}\cdot S_{21}|} = -0.874 > 1 \quad \times$$

$$|\Delta| = 1.187 < 1 \quad \times$$

potencijalno nestabilan tranzistor

$$Z_T = 80 + j\,180\,\Omega = 196.97\angle 66.03^\circ\,\Omega$$

ulazne kružnice

$$S_g = \frac{(S_{11}-\Delta S_{22}^*)^*}{|S_{11}|^2-|\Delta|^2} = \frac{0.269-0.034j}{|S_{11}|^2-|\Delta|^2} = 16.309\angle -7.189$$

$$R_g = \left|\frac{S_{12}\cdot S_{21}}{|S_{11}|^2-|\Delta|^2}\right| = 17.16$$

izlazne kružnice

$$S_T = \frac{(S_{22}-\Delta S_{11}^*)^*}{|S_{22}|^2-|\Delta|^2} = 2.743\angle 176.46^\circ$$

$$R_T = \left|\frac{S_{12}\cdot S_{21}}{|S_{22}|^2-|\Delta|^2}\right| = 3.83$$

$$\Gamma_T = \frac{Z_T-Z_0}{Z_T+Z_0} = 0.8218\angle 26.37^\circ$$

$$\Gamma_{ul} = S_{11} + \frac{S_{12}\cdot S_{21}\cdot \Gamma_T}{1-S_{22}\Gamma_T} = 45.25\angle -127.7$$

$$\Gamma_{ul} = \frac{Z_{ul}-Z_0}{Z_{ul}+Z_0} \Rightarrow Z_{ul}\Gamma_{ul} + Z_0\Gamma_{ul} = Z_{ul} - Z_0$$

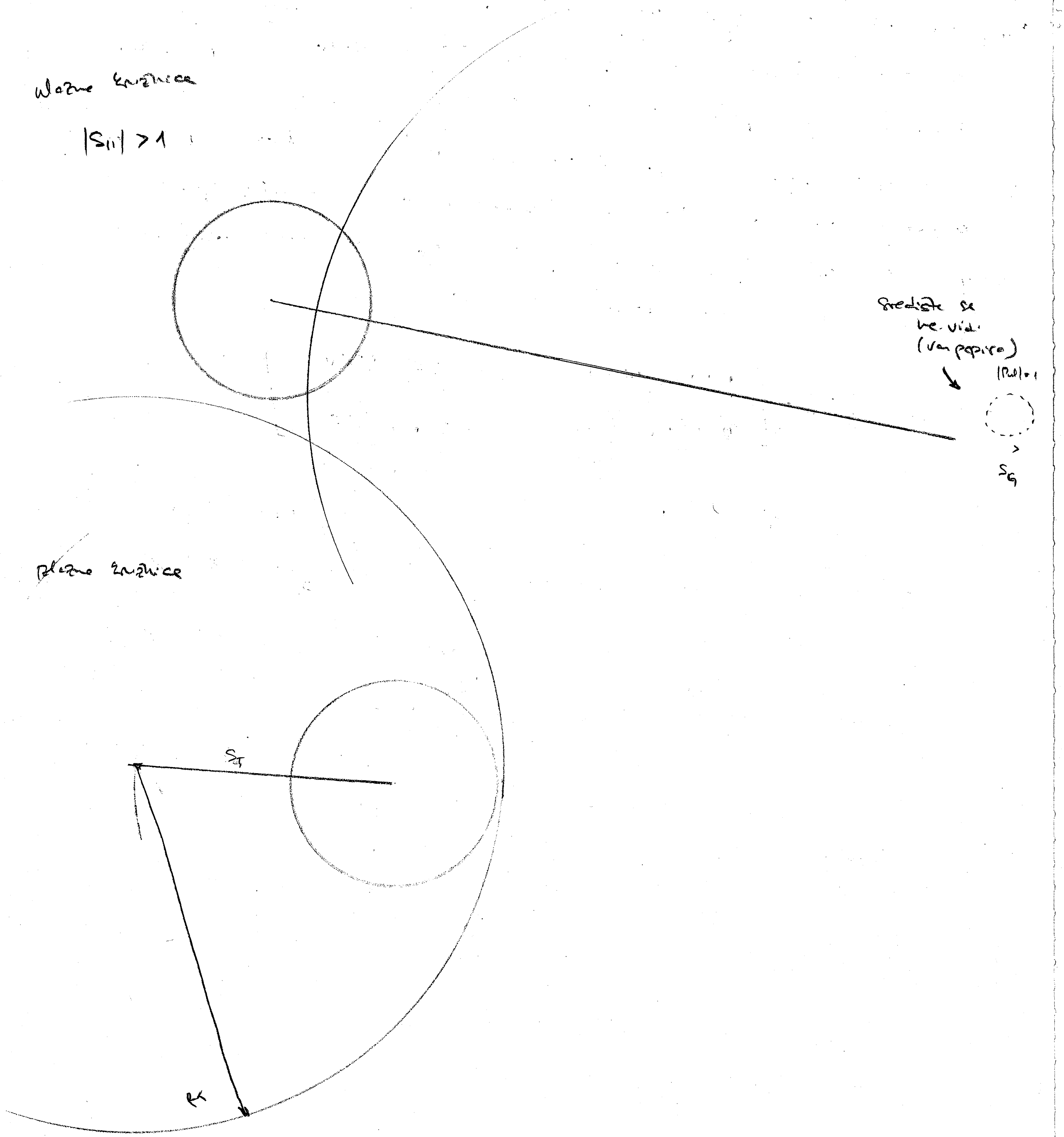
$$Z_{ul}[\Gamma_{ul}-1] = Z_0[-1-\Gamma_{ul}]$$

$$Z_{ul} = Z_0\frac{1+\Gamma_{ul}}{1-\Gamma_{ul}} = 48.66\angle -177.24^\circ\,\Omega$$

Ulazne kružnice

$|S_{11}| > 1$

Izlazne kružnice

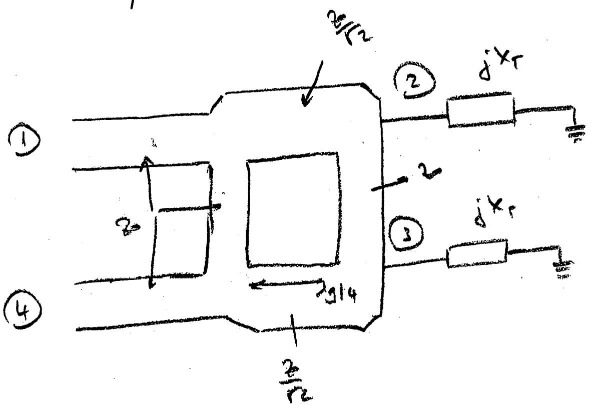


DEKANSKI ROK

(3)

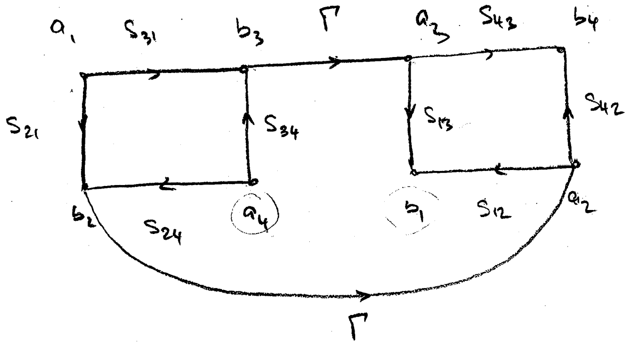
(3.) Prolazi 2 : 3 kvadraturnog hibrida zaključeni su teretima reaktancije X_T. Koliko mora iznositi reaktancija X_T ako je faza signala na izlazu skopa zakrenuta za 90° u odnosu na ulazni signal? Izračunati raspršnu matricu za novi dvoprolazni sklop! Linije su bez gubitaka. Karakteristična impedancija sustava je 50 Ω. Odrediti iznos induktiviteta ili kapaciteta koji čini reaktanciju X_T ako je radna frekvencija 4 GHz.

$T_{14} = 1\angle 90°$



$$[S] = \frac{-j}{\sqrt{2}} \begin{bmatrix} 0 & 1 & -j & 0 \\ 1 & 0 & 0 & -j \\ -j & 0 & 0 & 1 \\ 0 & -j & 1 & 0 \end{bmatrix}$$

$$\Gamma_T = \frac{jX_T - Z_0}{jX_T + Z_0}$$



$$T_{14} = \frac{b_1}{a_4} = \frac{S_{34}\cdot\Gamma\cdot S_{13}(1-0) + S_{24}\cdot\Gamma\cdot S_{12}}{1} = j\Gamma$$

$$T_{41} = \frac{b_4}{a_1} = S_{31}\cdot\Gamma\cdot S_{43} + S_{21}\cdot\Gamma\cdot S_{42} = j\Gamma$$

$$T_{11} = \frac{b_1}{a_1} = S_{31}\,\Gamma\cdot S_{13} + S_{21}\cdot\Gamma\cdot S_{12} = 0$$

$$T_{44} = \frac{b_4}{a_4} = S_{24}\cdot\Gamma\cdot S_{42} + S_{34}\cdot\Gamma\cdot S_{43} = 0$$

$$[S'] = \begin{bmatrix} 0 & j\Gamma \\ j\Gamma & 0 \end{bmatrix} \Longrightarrow$$

$T_{14} = 1 \angle -70^\circ$

$T_{14} = j\Gamma = j \dfrac{Z - Z_0}{Z + Z_0}$

$T_{14} \cdot Z + T_{14} \cdot Z_0 = Z j - Z_0 j$

$Z(T_{14} - j) = Z_0(-j - T_{14})$

$Z = \dfrac{Z_0(-j - T_{14})}{T_{14} - j} = -8.816 j = 8.816 \angle -90^\circ \ \Omega$

$Z = jX_T \Rightarrow X_T = -8.816 \ \Omega$

$X_C = \dfrac{1}{j\omega C} \Rightarrow C = \dfrac{1}{j\omega X_C} = \underline{\underline{4.51 \ pF}}$

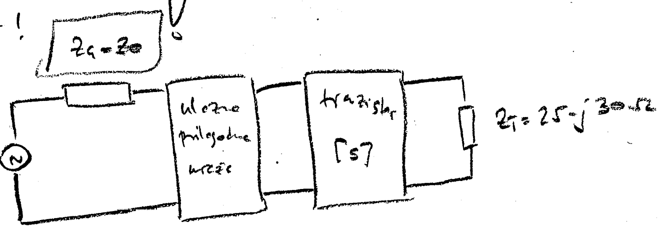
(4.) Za tranzistor na frekvenciji 2 GHz izmjereni su raspršni parametri u sustavu karakteristične impedancije 50 Ω. Ispitati stabilnost tranzistora. (4)

1.

nek. prijenos

$$[S] = \begin{bmatrix} 0.82\angle -96^\circ & 0.03\angle 56^\circ \\ 4.28\angle 110^\circ & 0.73\angle -60^\circ \end{bmatrix}$$

Nacrtati ulaznu i izlaznu kružnicu stabilnosti i označiti nestabilno područje. Ako je ulazna prilagodna mreža pojačala projektirana za maksimalni prijenos snage u ulaznom krugu, izračunati prijenosno pojačanje. Ucrtati Γ_G i Γ_T na odgovarajuće crteže kružnice stabilnosti i na osnovi crteža zaključiti da li će prilagodba na maksimalni prijenos snage u ulaznom krugu osigurati stabilan rad pojačala. Obrazložiti odgovor!



$$\Delta = S_{11}S_{22} - S_{12}S_{21} = 0.503\angle -146.9^\circ$$

$$K = \frac{1 - |S_{11}|^2 - |S_{22}|^2 + |\Delta|^2}{2|S_{12}S_{21}|} = 0.185$$

$|K| = 0.185 > 1$ ✗
$|\Delta| = 0.503 < 1$ ✓
→ potencijalno nestabilan tranzistor

ulazna kružnica

$$S_G = \frac{(S_{11} - \Delta S_{22}^*)^*}{|S_{11}|^2 - |\Delta|^2} = 1.099\angle 103.3^\circ$$

$$R_G = \left| \frac{S_{12}S_{21}}{|S_{11}|^2 - |\Delta|^2} \right| = 0.306$$

izlazna kružnica

$$S_T = \frac{(S_{22} - \Delta S_{11}^*)^*}{|S_{22}|^2 - |\Delta|^2} = 1.17\angle 71.42^\circ$$

$$R_T = \left| \frac{S_{12} \cdot S_{21}}{|S_{22}|^2 - |\Delta|^2} \right| = 0.458$$

$$\Gamma_T = \frac{Z_T - Z_0}{Z_T + Z_0} = 0.483\angle -108.01^\circ$$

$$\Gamma_G = \Gamma_{ul}^* = 0.78\angle 94.35^\circ$$

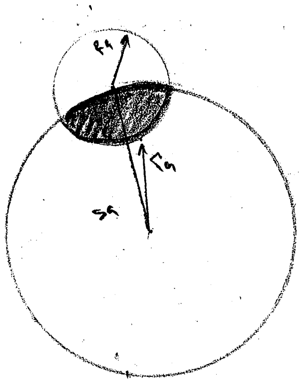
$$\Gamma_{ul} = S_{11} + \frac{S_{12} \cdot S_{21} \cdot \Gamma_T}{1 - S_{22}\Gamma_T} = 0.78\angle -94.35^\circ$$

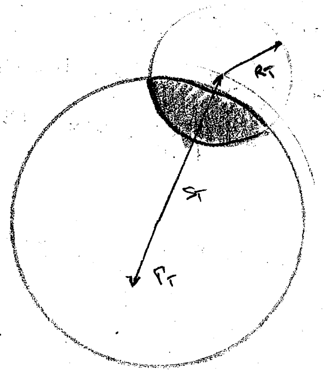
$$\Gamma_{iz} = S_{22} + \frac{S_{12}S_{21}\Gamma_G}{1 - S_{11}\Gamma_G} = 0.95\angle -71.35^\circ$$

⇒ D

— nestabilno područje
= stabilno područje

$|\Gamma_{ul}| < 1$ $|\Gamma_{iz}| < 1$





max. prijenos

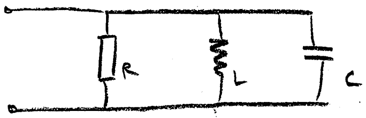
$\Gamma_{ul} = \Gamma_g^*$ $\Gamma_{iz} = \Gamma_T^*$ $\Gamma_{ul} = 0.78\angle -94.35^\circ$ $\Gamma_{iz} = 0.95\angle -71.35^\circ$

$$G_T = \frac{1-|\Gamma_g|^2}{|1-\Gamma_{ul}\Gamma_g|^2} \cdot |S_{21}|^2 \cdot \frac{1-|\Gamma_T|^2}{|1-S_{22}\Gamma_T|^2} = 4.84 = 6.85\ \mathrm{dB}$$

Treba uočiti kako se kod prilagodbe na maksimalni prijenos snage koeficijent Γ_g nalazi vrlo blizu nestabilnom području. U njega može upasti npr. zbog promjene temperature ili zamjene tranzistora drugim iz iste serije. Stoga je u realnosti potreban kompromis između stabilnijeg rada pojačala i rozgođenja na ulazu.

(5) Rezonator je izrađen od dijela snosne linije duljine $\lambda/2$ zaključene otvorenim krajem koja je ispunjena dielektrikom relativne dielektrične konstante 2.52 i tangensa gubitaka $2\cdot10^{-4}$. Polumjer unutarnjeg vodiča je 1 mm, a vanjskog 3 mm. Vodiči su izrađeni od bakra vodljivosti $5.81\cdot10^{7}$ S/m. Rezonantna frekvencija ovog rezonatora je 4 GHz. Nacrtati nadomjesni sklop s koncentriranim elementima za ovaj rezonator u okolini rezonantne frekvencije i odrediti vrijednosti elemenata nadomjesnog sklopa. Odrediti unutarnji faktor dobrote i ulaznu impedanciju rezonatora na rezonantnoj frekvenciji. (5)

OTVORENI KRAJ → PARALELNI



$l=\frac{\lambda}{2}$

$\varepsilon_r=2.52$

$tg\delta=2\cdot10^{-4}$

$a=1\,mm$

$b=3\,mm$

$\sigma=5.81\cdot10^{7}$ S/m

$f=4$ GHz

$R,L,C=?$

$Q_0=?$

$Z_{ul}=?$

$$R_s=\sqrt{\frac{\omega\mu}{2\sigma}}=0.0164\,\Omega$$

$$R=\frac{R_s}{2\pi}\left(\frac{1}{a}+\frac{1}{b}\right)=3.49\,\Omega$$

$$C=\frac{2\pi\varepsilon'}{\ln\left(\frac{b}{a}\right)}=\frac{2\pi\varepsilon_0\cdot\varepsilon_r}{\ln\left(\frac{b}{a}\right)}=1.27\cdot10^{-10}\ F$$

$$L=\frac{\mu}{2\pi}\ln\left(\frac{b}{a}\right)=2.19\cdot10^{-7}\ H$$

$$Z_0=\sqrt{\frac{L}{C}}=41.52\,\Omega$$

$$l=\frac{1}{2}\cdot\frac{c}{f}=0.0375\ m$$

$$G=\frac{2\pi\omega\varepsilon_0\varepsilon_r\cdot tg\delta}{\ln\frac{b}{a}}=6.4\cdot10^{-4}\ \Omega^{-1}$$

$$\left.\begin{array}{l}\alpha_d=\frac{1}{2}\sqrt{LC}\cdot\frac{G}{C}=0.0132\ \frac{Np}{m}\\ \alpha_c=\frac{1}{2}\sqrt{LC}\cdot\frac{R}{L}=0.042\ \frac{Np}{m}\end{array}\right\}\alpha=0.0552\ \frac{Np}{m}$$

=>

$$R' = \frac{Z_0}{\alpha \cdot l} = 20\ 579{,}9\ \Omega$$

$$L' = \frac{1}{\omega_0^2 \cdot C} = 1{,}05 \cdot 10^{-9}\ H$$

$$C' = \frac{\pi}{2 \cdot \omega_0 \cdot Z_0} = 1{,}515 \cdot 10^{-12}\ F$$

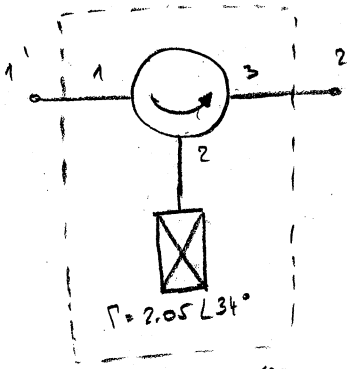
$$Q_0 = \frac{\beta}{2\alpha} = 1235{,}87$$

$$Z_{ul} = R' = 20\ 057{,}97\ \Omega$$

2011./2012.

ZAVRŠNI ISPIT

1. Izračunati raspršnu matricu [s'] refleksijskog pojačala prema slici. Fazno kašnjenje između susjednih prolaza cirkulatora je 20°, izolacija mu je 20 dB, a gušenje u propusnom smjeru je 0.3 dB. Svi prolazi cirkulatora su prilagođeni. Pretpostaviti da su električne udaljenost prolaza 2 cirkulatora i terete, udaljenost prolaza 1 i 1' te 3 i 2' zanemarive.



$$[S] = \begin{bmatrix} S_{11} & S_{12} & S_{13} \\ S_{21} & S_{22} & S_{23} \\ S_{31} & S_{32} & S_{33} \end{bmatrix}$$

$$10^{-\frac{0.3}{20}}$$

$$10^{-\frac{20}{20}}$$

$\alpha = 0.3\ dB = 0.966$

$I = 20\ db = 0.1$

$\varphi = 20°$

$$S' = \begin{array}{c} \begin{array}{cc} a_1 & a_2 \end{array} \\ \begin{bmatrix} S_{11} & S_{12} \\ S_{21} & S_{22} \end{bmatrix} \end{array} \begin{array}{c} b_1 \\ b_2 \end{array}$$

$S_{11} = S_{22} = S_{33} = 0$

$S_{21} = S_{32} = S_{13} = 0.966 \angle -20°$

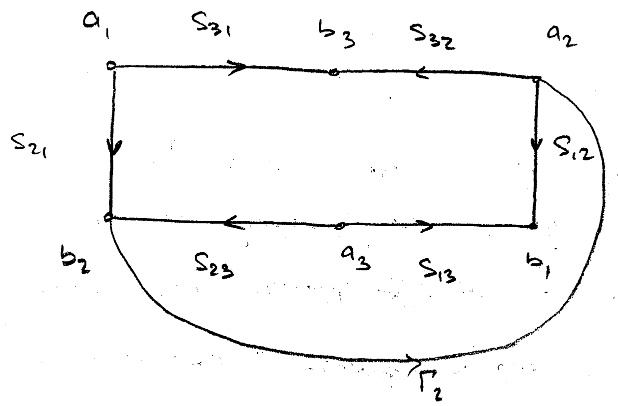
$S_{12} = S_{23} = S_{31} = 0.1 \angle -20°$

$$S'_{11} = \frac{b_1}{a_1} =$$

$$S'_{12} = \frac{b_1}{a_2} = \frac{b_1}{a_3}$$

$$[S] = \begin{bmatrix} 0 & 0.1\angle -20° & 0.966\angle -20° \\ 0.966\angle -20° & 0 & 0.1\angle -20° \\ 0.1\angle -20° & 0.966\angle -20° & 0 \end{bmatrix}$$

$\Gamma_2 = 2.05 \angle 34°$



$$S_{11}' = \frac{b_1}{a_1} = \frac{S_{21}\cdot\Gamma_2\cdot S_{12}}{1} = 0.198\angle -6^\circ$$

$$S_{12}' = \frac{b_1}{a_3} = \frac{S_{13} + S_{23}\cdot\Gamma_2\cdot S_{12}}{1} = 0.985\angle -19.7^\circ$$

$$S_{21}' = \frac{b_3}{a_1} = S_{31} + S_{21}\cdot\Gamma_2\cdot S_{32} = 2.010\angle -6.68^\circ$$

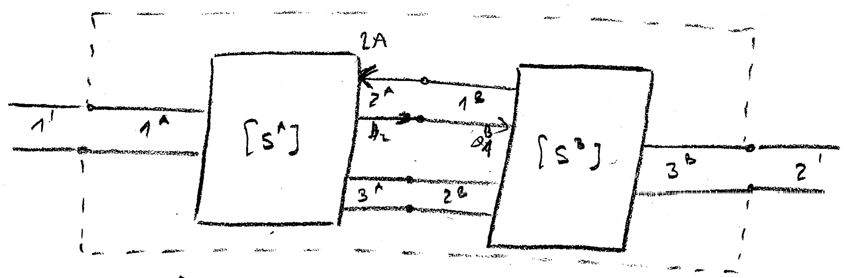
$$S_{22}' = \frac{b_3}{a_3} = S_{23}\Gamma_2 S_{32} = 0.198\angle -6^\circ$$

$$[S'] = \begin{bmatrix} 0.198\angle -6^\circ & 0.985\angle -19.7^\circ \\ 2.01\angle -6.68^\circ & 0.198\angle -6^\circ \end{bmatrix}$$

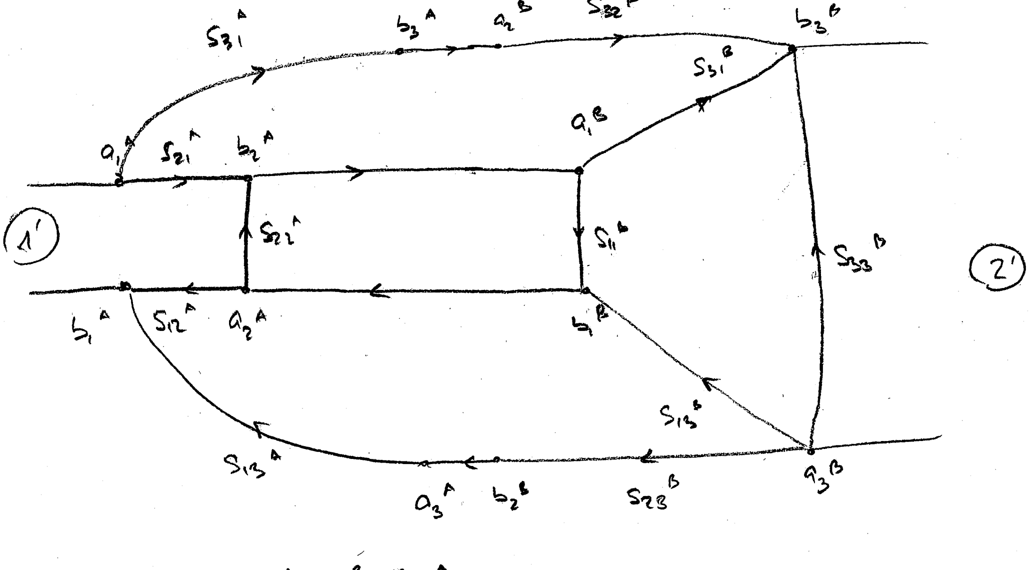
• 2010/2011

1. 2. MI

(3.) Dva troprolazna sklopa zadana raspršnim matricama $[S^A]$ i $[S^B]$ međusobno su spojeni prema slici. Odrediti raspršne parametre novog dvoprolaznog sklopa između prolaza 1' i 2'. Pretpostaviti da su električke udaljenosti prolaza 1' i 1^A, 3^B i 2', 2^A i 1^B te 3^A i 2^B zanemarive.



$$[S^A] = \begin{bmatrix} 0 & S_{12}^A & S_{13}^A \\ S_{21}^A & S_{22}^A & 0 \\ S_{31}^A & 0 & 0 \end{bmatrix} \qquad [S^B] = \begin{bmatrix} S_{11}^B & 0 & S_{13}^B \\ 0 & 0 & S_{23}^B \\ S_{31}^B & S_{32}^B & S_{33}^B \end{bmatrix}$$



$$S_{11} = \frac{b_1^A}{a_1^A} = \frac{S_{12}^A \cdot S_{11}^B \cdot S_{12}^A}{1 - (S_{22}^A \cdot S_{11}^B)}$$

$$S_{12} = \frac{b_1^A}{a_3^B} = \frac{S_{23}^B \cdot S_{13}^A\,(1 - S_{22}^A \cdot S_{11}^B) + S_{13}^B S_{12}^A\,(1-0)}{1 - S_{22}^A S_{11}^B} = \frac{S_{23}^B S_{13}^A (1 - S_{22}^A S_{11}^B) + S_{13}^B S_{12}^A}{1 - S_{22}^A S_{11}^B}$$

$$S_{21} = \frac{b_3^B}{a_1^A} = \frac{S_{31}^A \cdot S_{32}^B (1 - S_{22}^A S_{11}^B) + S_{21}^A S_{31}^B}{1 - S_{22}^A S_{11}^B}$$

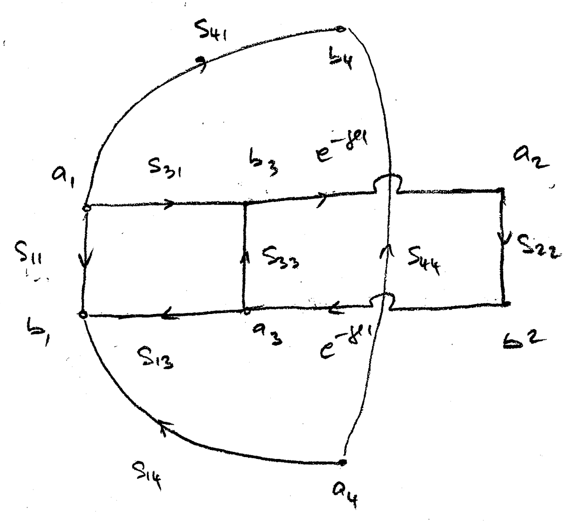
$$S_{22} = \frac{b_3^B}{a_3^B} = \frac{S_{33}^B (1 - S_{22}^A S_{11}^B) + S_{13}^B S_{22}^A S_{31}^B}{1 - S_{22}^A S_{11}^B}$$

2009/2010.

2. MI

(3) Četveroprolazni sklop zadan je raspršnom matricom [S]. Odredite koeficijent refleksije na prolazu 1. Ako su prolazi 2 i 3 spojeni prijenosnom linijom duljine 1 m i karakteristične impedancije 50 Ω i koeficijenta širenja $\gamma = 0.5\,\frac{Np}{m} + j\frac{\pi}{3}\,\frac{rad}{m}$, a prolaz 4 zaključen teretom impedancije $75+j30\,\Omega$. Pretpostavite da je karakteristična impedancija sustava je 50 Ω. Pretpostavite da je prolaz 1 prilagođen.

$$[S] = \begin{bmatrix} 0.1\angle 30^\circ & 0 & 0.4\angle 60^\circ & 0.8\angle 45^\circ \\ 0 & 0.5\angle 0 & 0 & 0 \\ 0.4\angle 60^\circ & 0 & 0.5\angle 120^\circ & 0 \\ 0.8\angle -45^\circ & 0 & 0 & 0.6\angle 90^\circ \end{bmatrix}$$



$$e^{-\gamma l} = e^{-(0.5+j\frac{\pi}{3})} = e^{-0.5}\cdot e^{-j\frac{\pi}{3}} = 0.606\angle -60^\circ = \Gamma$$

$$\Gamma_1 = \frac{b_1}{a_1} = \frac{S_{11}(1 - S_{33}e^{-\gamma l}S_{22}e^{-\gamma l}) + S_{31}e^{-\gamma l}S_{22}\cdot e^{-\gamma l}\cdot S_{13}}{1 - S_{33}e^{-\gamma l}S_{22}e^{-\gamma l}} = 0.12\angle -8.96^\circ$$

ZAVRŠNI ISPIT

(6.) Za FET na frekvenciji 1 GHz je u sustavu karakteristične impedancije 50 Ω izmjerena raspršna matrica [S]. Ispitati stabilnost tranzistora. Nacrtati ulaznu i izlaznu kružnicu stabilnosti i označiti nestabilno područje. Izračunati pogonsko pojačanje tranzistora ako je na izlaz tranzistora priključen teret impedancije 100 − j100 Ω

ako je?

$$[S] = \begin{bmatrix} 1.02 \angle -19^\circ & 0.02 \angle 77.4^\circ \\ 2.21 \angle 162.3^\circ & 0.73 \angle -12.5^\circ \end{bmatrix}$$

$\Delta = S_{11} S_{22} - S_{12} S_{21} = 0.744 \angle -28.09^\circ$

$|\Delta| = 0.744 < 1$ ✓

$$K = \frac{1 - |S_{11}|^2 - |S_{22}|^2 + |\Delta|^2}{2\,|S_{12} \cdot S_{21}|} = -0.223$$

$|K| = 0.223 > 1$ ✗

potencijalno nestabilan FET

ulazna kružnica

$$S_G = \frac{(S_{11} - \Delta \cdot S_{22}^*)^*}{|S_{11}|^2 - |\Delta|^2} = 0.983 \angle 22.8^\circ$$

$$R_G = \left| \frac{S_{12} \cdot S_{21}}{|S_{11}|^2 - |\Delta|^2} \right| = 0.0907$$

$|S_{22}| < 1$ ✓

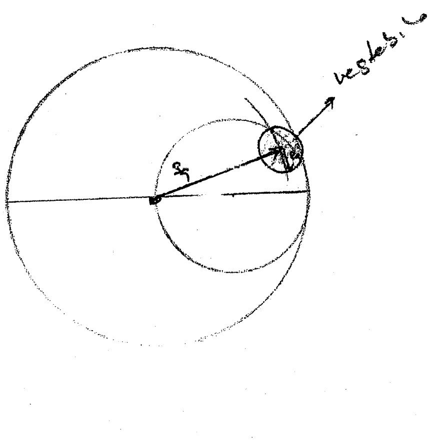
izlazna kružnica

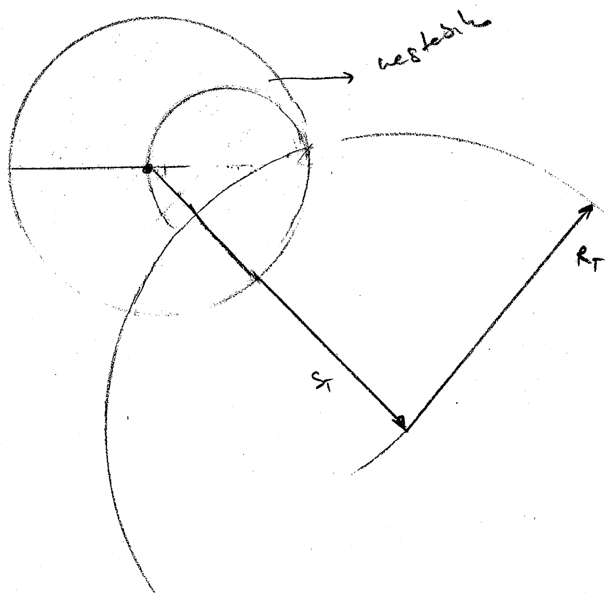
$$S_T = \frac{(S_{22} - \Delta \cdot S_{11}^*)^*}{|S_{22}|^2 - |\Delta|^2} = 2.56 \angle -46.115^\circ$$

$$R_T = \left| \frac{S_{12} \cdot S_{21}}{|S_{22}|^2 - |\Delta|^2} \right| = 2.14$$

$|S_{11}| < 1$ ✗

⇒





$Z_T = 100 - j100\ \Omega$

$$\Gamma_T = \frac{Z_T - Z_0}{Z_T + Z_0} = 0.62 \angle -29.74$$

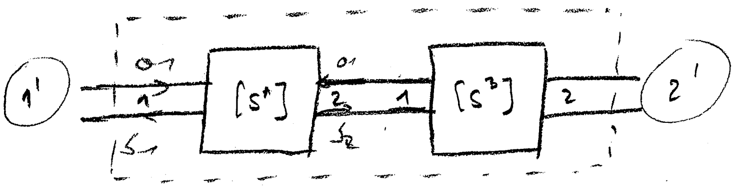
$$\Gamma_{in} = S_{11} + \frac{S_{12} \cdot S_{21}\, \Gamma_T}{1 - S_{22}\Gamma_T} = 0.98 \angle -19.89°$$

$$G_P = \frac{1}{1 - |\Gamma_{in}|^2} \cdot |S_{21}|^2 \cdot \frac{1 - |\Gamma_T|^2}{|1 - S_{22}\Gamma_T|^2} = 142.11 = \underline{\underline{21.52\ dB}}$$

- ISPITI S FER-a

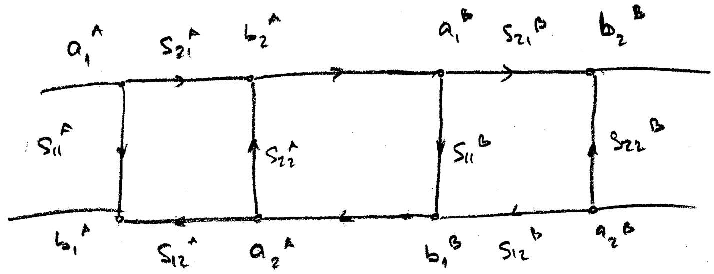
17. travnja 2003.

(3.) Dvoprolazni sklopovi zadani raspršnim matricama $[S^A]$ i $[S^B]$ spojeni su u kaskadu. Naći raspršnu matricu dvoprolaznog sklopa između prolaza 1' i 2' i ispitati njihova svojstva simetrije, recipročnosti, disipativnosti i prilagodbe.



$$[S^A] = \begin{bmatrix} 1/5 & 4/5 \\ 4/5 & 1/5 \end{bmatrix}$$

$$[S^B] = \begin{bmatrix} -1/3 & 3/5 \\ 3/5 & -1/3 \end{bmatrix}$$



$$S_{11} = \frac{b_1^A}{a_1^A} = \frac{S_{11}^A(1 - S_{11}^B S_{22}^A) + S_{21}^A S_{11}^B S_{12}^A}{1 - S_{11}^B S_{22}^A} = 0$$

$$S_{12} = \frac{b_1^A}{a_2^B} = \frac{S_{12}^B \cdot S_{12}^A}{1 - S_{11}^B S_{22}^A} = 0.45$$

$$S_{21} = \frac{b_2^B}{a_1^A} = \frac{S_{21}^A \cdot S_{21}^B}{1 - S_{11}^B S_{22}^A} = 0.45$$

$$S_{22} = \frac{b_2^B}{a_2^B} = \frac{S_{22}^B(1 - S_{11}^B S_{22}^A) + S_{12}^B S_{22}^A S_{21}^B}{1 - S_{11}^B S_{22}^A} = -0.265$$

$\Rightarrow$

$$[s'] = \begin{bmatrix} 0 & 0.45 \\ 0.45 & -0.265 \end{bmatrix}$$

$$\left.\begin{aligned} S_{11} &\neq S_{22} \\ S_{12} &= S_{21} \end{aligned}\right\} \text{nije simetrična}$$

$S_{12} = S_{21}$ → recipročna

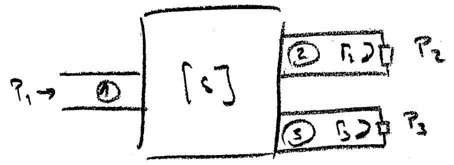
$$\left.\begin{aligned} S_{11} &= 0 \\ S_{22} &\neq 0 \end{aligned}\right\} \text{nije prilagođena}$$

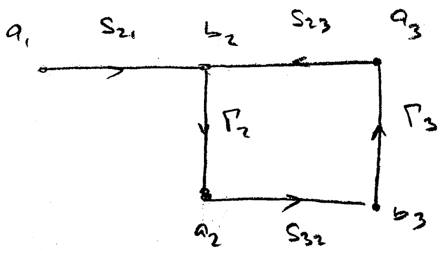
$|S_{11}|^2 + |S_{21}|^2 = 1$

$0.2025 < 1$ mreža s gubicima

4. Troprolazni sklop zadan je raspršnom matricom $[S]$. Prolazi 2 i 3 zaključeni su teretima s koeficijentima refleksije Γ_2 i Γ_3. Primjenom grafova toka signala odrediti omjere snaga $\frac{P_2}{P_1}$ i $\frac{P_3}{P_1}$.

$$[S] = \begin{bmatrix} 0 & S_{12} & 0 \\ S_{12} & 0 & S_{23} \\ 0 & S_{23} & 0 \end{bmatrix}$$





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

$b_1 = S_{12}a_2$ $\qquad a_2 = \Gamma_2 \cdot b_2$

$b_2 = S_{12}a_1 + S_{23}a_3$ $\qquad a_3 = \Gamma_3 \cdot b_3$

$b_3 = S_{23}a_2$

$b_1 = S_{12}\cdot\Gamma_2\cdot b_2$

$b_2 = S_{12}a_1 + S_{23}\cdot\Gamma_3 b_3$ $\quad \Big\} \quad b_2 = S_{12}\cdot a_1 + S_{23}\cdot\Gamma_3\cdot S_{23}\cdot\Gamma_2\cdot b_2$

$b_3 = S_{23}\Gamma_2 b_2$

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

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

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

$$b_2 = \frac{a_2}{\Gamma_2} = S_{12}a_1 + S_{23}\cdot\Gamma_3\cdot S_{23}\cdot\cancel{\Gamma_2}\cdot\frac{a_2}{\cancel{\Gamma_2}} = S_{12}a_1 + S_{23}^2\Gamma_3 a_2$$

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

$\rightarrow$

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

$$\frac{b_3}{S_{23}\Gamma_2} = S_{12}\, a_1 + S_{23} \cdot \Gamma_3 \cdot \frac{a_3}{\Gamma_3} \Rightarrow \frac{a_3}{S_{23}\Gamma_2\Gamma_3} = S_{12}\, a_1 + S_{22}\frac{a_3}{\Gamma_3}$$

$$\frac{a_3}{a_1} = \frac{S_{12}}{\frac{1}{S_{23}\Gamma_2\Gamma_3} - S_{23}} = \frac{S_{12}S_{23}\Gamma_2\Gamma_3}{1 - S_{23}^2\Gamma_2\Gamma_3}$$

wrsh?

5) Izračunati raspršnu matricu na frekvenciji 10 GHz u sustavu karakteristične impedancije Z_0 za dvoprolazni sklop koji se sastoji od 10 m koaksijalne linije sa sljedećim parametrima: $a = 0.936$ mm, $b = 3.5$ mm, $\varepsilon_r = 2.5$, $tg\,\delta = 10^{-4}$, $\sigma = 5.88 \cdot 10^7$ S/m ; $\mu_r = 1$; $\mu_0 = 4\pi \cdot 10^{-7}$ H/m; $\varepsilon_0 = 8.854 \cdot 10^{-12}$ F/m. Koliki iznosi karakteristična impedancija sustava Z_0 ako je ona jednaka karakterističnoj impedanciji linije? Koliki su gubici (prijenosni) tog dvoprolaznog sklopa ako su svi prolazi prilagođeni?

$f = 10$ GHz

$l = 10$ m

$a = 0.936$ mm

$b = 3.5$ mm

$\varepsilon_r = 2.5$

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

$\sigma = 5.88 \cdot 10^7$ S/m

$Z_0 = ?$

$\alpha = ?$

$$R = \frac{R_S}{2\pi}\left(\frac{1}{a} + \frac{1}{b}\right) = 5.58\ \Omega \qquad R_S = \sqrt{\frac{\omega\mu}{2\sigma}} = 0.025\ \Omega$$

$$L = \frac{\mu}{2\pi} \ln\left(\frac{b}{a}\right) = 2.6 \cdot 10^{-7}\ H$$

$$C = \frac{2\pi\varepsilon_0\varepsilon_r}{\ln\frac{b}{a}} = 1.05 \cdot 10^{-10}\ F$$

$$G = \frac{2\pi\omega\varepsilon_0\varepsilon_r\, tg\,\delta}{\ln\left(\frac{b}{a}\right)} = 6.6 \cdot 10^{-4}\ \Omega^{-1}$$

$$Z_0 = \sqrt{\frac{L}{C}} = 49.76\ \Omega$$

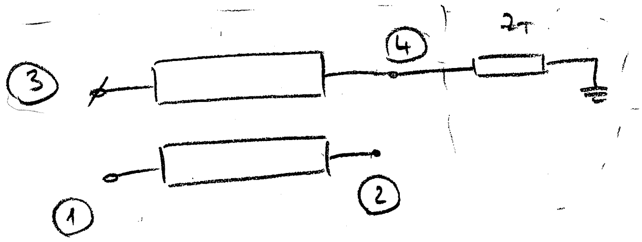
$$\left.\begin{aligned}\alpha_d &= \frac{1}{2}\sqrt{LC} \cdot \frac{G}{C} = 0.0164 \\ \alpha_c &= \frac{1}{2}\sqrt{LC} \cdot \frac{R}{L} = 0.056\end{aligned}\right\} \alpha = 0.0724\ \frac{Np}{m}$$

$$\beta = \frac{2\pi f}{c} = 20.94\ \text{rad/m}$$

$$\gamma = 0.0724\ \frac{Np}{m} + j\,20.94\ \frac{rad}{m}$$

5 studenog 2001

(2) Prolaz 3 mikrotrakastog linijskog sprežnika prema slici zaključan je otvorenim krajem. Koliki mora biti koeficijent refleksije kraja prilagođenog na prolaz 4 te da na središnjoj frekvenciji, na kojoj je duljina linije $\lambda_g/4$ ne bude prijenosa signala između prolaza 1 i 2?
Za taj slučaj odrediti raspršnu matricu dvoprolaznog sklopa između prolaza 1 i 2.

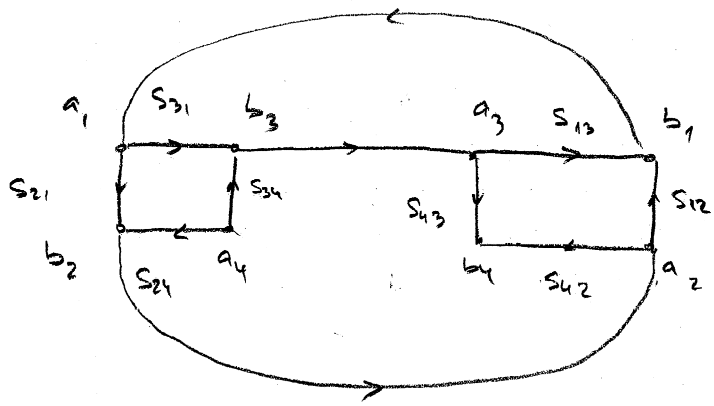


$\Gamma_4 = ?$

$l = \frac{\lambda_g}{4} = \frac{1}{4} \cdot \frac{c}{f}$

(3) O.K. $a_3 = b_3$

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



? ?

$$\Gamma_4 = \frac{b_4}{a_4} = \quad S_{24} \cdot S_{42} + S_{34} \cdot S_{43} = \beta^2 + (-j\alpha)(-j\alpha) = \beta^2 - \alpha^2 = c^2 - 1 + c^2$$
$$= c^2 - 1$$