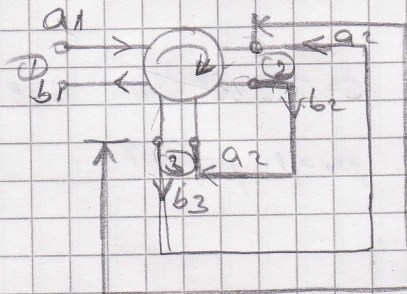


# Zadatak 4.

2009/2010



$$l = 1 \text{ m}$$

$$Z_0 = 50 \Omega$$

→ nepropusni sujer 20 dB gušćije

→ ferno dasujćije izuadu sujedmli proleza  $-30^\circ$

a) Raspršna matrica = ?

bez gubitaka  $\Rightarrow$  zadržu očuvanja energije  $|S_{11}|^2 + |S_{21}|^2 + |S_{31}|^2 = 1$

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

$S_{11} = S_{22} = S_{33} = 0 \rightarrow$  priklagotem' cirkulator naha refleksije

$$20 \text{ dB} \Rightarrow 10^{-\frac{20}{10}} = 0.1 / -30^\circ$$

→ susjedni prolezi  $S_{12}, S_{23}, S_{31} = 0.1 / -30^\circ$

$$[S] = \begin{bmatrix} 0 & 0.1 / -30^\circ & S_{13} \\ S_{21} & 0 & 0.1 / -30^\circ \\ 0.1 / -30^\circ & S_{32} & 0 \end{bmatrix}$$

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

$$0 + |S_{21}|^2 + (0.1)^2 = 1$$

$$|S_{21}| = \sqrt{1 - (0.1)^2} = \sqrt{1 - 0.01} = 0.995 / -30^\circ$$

$$|S_{21}| = |S_{13}| = |S_{31}| = 0.995$$

$$[S] = \begin{bmatrix} 0 & 0.1 / -30^\circ & 0.995 / -30^\circ \\ 0.995 / -30^\circ & 0 & 0.1 / -30^\circ \\ 0.1 / -30^\circ & 0.995 / -30^\circ & 0 \end{bmatrix}$$

b)  $Z_0 = 50 \Omega$   $l = 1 \text{ m}$   $\gamma = 0.1 + j\frac{\pi}{3} \text{ rad/m}$

$$Z_{in} = Z_0 \frac{Z_L + Z_0 \tanh(\gamma l)}{Z_0 + Z_L \tanh(\gamma l)} = 50 \frac{50 + 50 \tanh(0.1 + j\frac{\pi}{3})}{50 + 50 \tanh(0.1 + j\frac{\pi}{3})} \quad \frac{\pi}{3} \frac{180^\circ}{\pi}$$

$$\tanh(0.1 + j\frac{\pi}{3}) = \frac{\tanh(x) + j \tanh(y)}{1 + j \tanh(x) \tanh(y)} = \frac{\tanh(0.1) + j \tanh(\frac{\pi}{3})}{1 + j \tanh(0.1) \tanh(\frac{\pi}{3})} = \frac{0.099 + j1.732}{1 + j0.099 \cdot 1.732} = \frac{0.099 + j1.732}{0.172625} = 0.38647 + j1.665$$

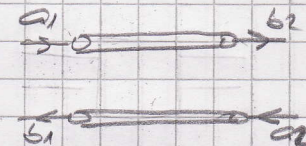
$$Z_{in} = 50 \frac{50 + 50(0.38647 + j1.665)}{50 + 50(0.38647 + j1.665)} = 50 \frac{50 + 19.3235 + j83.25}{50 + 19.3235 + j83.25} = 50 \frac{69.3235 + j83.25}{69.3235 + j83.25} = 50 \frac{1}{1} = 50 \Omega$$



zadatak 5. 2003.

$$f = 10 \text{ GHz} \quad a = 0.936 \text{ mm} \quad \epsilon_r = 2.5 \quad G = 588 \cdot 10^{-7} \text{ S/m} \quad \epsilon_0 = 8.854 \cdot 10^{-12} \text{ F/m}$$

$$l = 10 \text{ cm} \quad b = 3.5 \text{ mm} \quad \text{tg} \delta = 1 \cdot 10^{-4} \quad \mu_r = 1 \quad \mu_0 = 4\pi \cdot 10^{-7} \text{ H/m}$$



$$[S] = ? \quad [S] = \begin{bmatrix} S_{11} & S_{12} \\ S_{21} & S_{22} \end{bmatrix}$$

$$\gamma = \alpha + j\beta$$

$$Z_0 = \frac{2Z}{\eta_0 \cdot 2 \ln\left(\frac{b}{a}\right)} \sqrt{\frac{\epsilon_r}{\mu_r} \left(1 + \frac{1}{\epsilon_r}\right)} \quad Z_s = \frac{\sqrt{\omega \mu}}{2G} = \frac{\sqrt{2\pi f \cdot 4\pi \cdot 10^{-7}}}{2 \cdot 588 \cdot 10^{-7}} = 25.91 \Omega$$

$$= \frac{25.91^{-3}}{377 \cdot 2 \cdot \ln\left(\frac{3.5}{0.936}\right)} \sqrt{\frac{2.5}{1} \left(\frac{1}{0.936^{-3}} + \frac{1}{3.5^{-3}}\right)} = 4.11358 \cdot 10^{-5} (1354.09) = 55.783$$

$$\alpha = \frac{\omega \text{tg} \delta}{2 \cdot c} \sqrt{\epsilon_r \mu_r} = \frac{2\pi f \cdot 1 \cdot 10^{-4}}{2 \cdot 3 \cdot 10^8} \sqrt{2.5} = 16.5576 \cdot 10^{-3} \text{ Np/m}$$

$$\beta = \frac{\omega}{c} \sqrt{\epsilon_r \mu_r} = \frac{2\pi f}{c} \cdot \sqrt{2.5} = \frac{2\pi \cdot 10^9}{3 \cdot 10^8} \sqrt{2.5} = 331.153 \text{ rad/m}$$

$$\gamma = \alpha + j\beta = 72.34 \cdot 10^{-3} \text{ Np/m} + j331.153 \text{ rad/m}$$

Karakteristična impedancija suviše linije sa gubicima

$$Z = \frac{2Z_s}{2\pi} \left(\frac{1}{a} + \frac{1}{b}\right) = \frac{25.91^{-3}}{2\pi} (1354.09) = 5.5832 \Omega/\text{m}$$

$$L = \frac{\mu}{2\pi} \ln\left(\frac{b}{a}\right) = \frac{4\pi \cdot 10^{-7}}{2\pi} \ln\left(\frac{3.5}{0.936}\right) = 2.638 \cdot 10^{-7} \text{ H/m}$$

$$G = \frac{2\pi \cdot 2\pi f \cdot \epsilon_r \cdot \epsilon_0 \text{tg} \delta}{\ln\left(\frac{b}{a}\right)} = \frac{4\pi^2 \cdot 10^9 \cdot 2.5 \cdot 8.854 \cdot 10^{-12} \cdot 1 \cdot 10^{-4}}{\ln\left(\frac{3.5}{0.936}\right)} = 6.6256 \cdot 10^{-4} \text{ S/m}$$

$$C = \frac{2\pi \cdot \epsilon_0 \cdot \epsilon_r}{\ln\left(\frac{b}{a}\right)} = \frac{2\pi \cdot 2.5 \cdot 8.854 \cdot 10^{-12}}{\ln\left(\frac{b}{a}\right)} = 1.0545 \cdot 10^{-10} \text{ F/m}$$

$$Z_0 = \sqrt{\frac{2 + j2\pi f L}{G + j2\pi f C}} = \sqrt{\frac{5.5832 + j16545.0484}{6.6256^{-4} + j6.6256}} = \sqrt{25011.66 - j0.5926} = 50.0166 - j0.772$$

$$= 50.02 \angle -0.88^\circ$$

$$Z_0 = 50 \Omega$$

Karakteristična impedancija sustava jednaka impedanciji linije  $Z_0 = Z_{0s} = 50 \Omega$