

# Exadatal 5

MI 2009-2010

→ mikrotrubata linij

$$W = 4 \mu m$$

$$\epsilon = 5,81 \cdot 10^{-7} S/m$$

$$h = 1,5 \mu m$$

$$\epsilon_r = 2,5$$

$$\epsilon_g = 2 \cdot 10^{-3}$$

$$f = 3 GHz$$

dispersija

$$Z = Y = ?$$

Ef sa disperziju

$$\epsilon_{ef} = \left[ \frac{\sqrt{\epsilon_r} - \sqrt{\epsilon_g(b)}}{1 + 4F^{-1,5}} + \sqrt{\epsilon_g(b)} \right] \quad F = \frac{4 \cdot h \cdot f \sqrt{\epsilon_r - 1}}{c} \left[ \frac{1}{2} + \left( 1 + 2 \log \left( 1 + \frac{W}{h} \right) \right)^2 \right]$$

$$Z_0 = \frac{\eta_0}{\sqrt{\epsilon_{ef}}} \cdot \frac{1}{\frac{W}{h} + 1,38 \left( \frac{W}{h} \right)^{0,172}} \quad Y = 2 + j3$$

$$\epsilon_{ef}(0) = \frac{\epsilon_r + 1}{2} + \frac{\epsilon_r - 1}{2} \left( 1 + 10 \cdot \frac{1}{W} \right)^{-0,555} = \frac{2,5 + 1}{2} + \frac{2,5 - 1}{2} \left( 1 + 10 \cdot \frac{1,5^{-3}}{4 - 3} \right)^{-0,555} = 2,066$$

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

$$= 73,4847 \cdot 10^{-2} [5,0307] = 0,37$$

$$\epsilon_{ef}(f) = \left[ \frac{\sqrt{2,5} - \sqrt{2,066}}{1 + 4 \cdot \frac{0,37}{18,773}} + \sqrt{2,066} \right] = 1,445$$

$$Z_0 = \frac{377}{\sqrt{1,445}} \cdot \frac{1}{\frac{4^{-3}}{1,5^{-3}} + 1,38 \left( \frac{4 \cdot 10^{-3}}{1,5^{-3}} \right)^{0,172}} = 62,6 \Omega$$

Da disperziju

$$Z(f) = \frac{Z_0 \cdot \epsilon_{ef}(f) - 1}{\epsilon_{ef}(f) - 1} \cdot \sqrt{\frac{\epsilon_{ef}(0)}{\epsilon_{ef}(f)}} = \frac{62,6 \cdot 1,445 - 1}{2,066 - 1} \cdot \sqrt{\frac{2,066}{1,445}} = 100$$

$$L = L_c + L_d$$

$$L_c = \frac{R_s}{Z_0 \cdot W}$$

$$R_s = \sqrt{\frac{W \cdot \mu}{2 \epsilon}} = \sqrt{\frac{2 \pi f \cdot 4 \cdot 10^{-7}}{2 \cdot 5,81 \cdot 10^{-7}}} = 14,2775 \cdot 10^{-3} \Omega$$

$$= \frac{14,2775 \cdot 10^{-3}}{100 \cdot 3,33 \cdot 4 \cdot 10^{-3}} = 35,5716 \cdot 10^{-2} Np/m$$

$$L_d = \frac{\pi}{\lambda_g} \cdot \frac{\epsilon_r (\epsilon_{ef} - 1)}{\epsilon_{ef} (\epsilon_r - 1)} \cdot \epsilon_g \quad \lambda_g = \frac{c}{f \sqrt{\epsilon_{ef}}} = \frac{3^8}{3^3 \sqrt{1,445}} = 0,08318 m$$

$$= \frac{\pi}{83,15^3} \cdot \frac{2,5 (1,445 - 1)}{1,445 (2,5 - 1)} \cdot 2 \cdot 10^{-3} = 38,766 \cdot 10^{-3} Np/m$$

$$L_{uk} = L_c + L_d = 35,5716 \cdot 10^{-2} + 38,766 \cdot 10^{-3} = 74,338 \cdot 10^{-3} Np/m$$



$$\beta = \frac{\omega}{c} \sqrt{\epsilon_{pr}} = \frac{2\pi f}{c} \sqrt{2.5 \cdot 1} = 93.346 \text{ rad/m}$$

$$\gamma = \alpha + j\beta = 74.338 \cdot 10^{-3} + j93.346$$

### Zadatak 6.

FET

$$f = 16 \text{ Hz}$$

$$Z_0 = 50 \Omega$$

$$[S] = \begin{bmatrix} 1.02 \angle -13^\circ & 0.02 \angle 77.4^\circ \\ 2.21 \angle 162.3^\circ & 0.73 \angle -125^\circ \end{bmatrix}$$

→ stabilnost tranzistora:  $|a| < 1 \quad K > 1$

$$|a| = S_{11} S_{22} - S_{12} S_{21} = 1.02 \angle -13^\circ \cdot 0.73 \angle -125^\circ - 0.02 \angle 77.4^\circ \cdot 2.21 \angle 162.3^\circ$$

$$= 0.7446 \angle -31.5^\circ - 0.0442 \angle 233.7^\circ$$

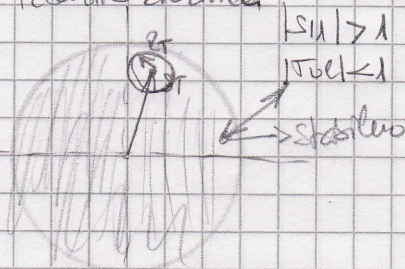
$$= 0.7446 [\cos(-31.5^\circ) + j\sin(-31.5^\circ)] - 0.0442 [\cos(233.7^\circ) + j\sin(233.7^\circ)]$$

$$= 0.6348 - j0.389 - 0.0213 + j0.038162$$

$$= 0.6135 - j0.3509 = 0.7067 \angle -29.76^\circ$$

$$K = \frac{1 - |S_{11}|^2 - |S_{22}|^2 + |a|^2}{2|S_{12}S_{21}|} = \frac{1 - (1.02)^2 - (0.73)^2 + (0.7067)^2}{2 \cdot 2.21 \cdot 0.02} = 0.8357 < 1$$

- uvjetno stabilan  
izlazna zvrtnica



ulazna zvrtnica



$$Z_T = 100 - j100 \Omega$$

$$\Gamma_T = \frac{Z_T - Z_0}{Z_T + Z_0} = \frac{100 - j100 - 50}{100 - j100 + 50} = \frac{50 - j100}{150 - j100} = 0.538 - j0.3074$$

$$= 0.62 \angle -29.76^\circ$$

→ pogonsko pojačanje:  $G_p = \frac{1}{1 - |\Gamma_{in}|^2} |S_{21}|^2 \frac{1 - |\Gamma_T|^2}{1 - |S_{22}\Gamma_T|^2}$

$$|\Gamma_{in}| = S_{11} + \frac{S_{12}S_{21}\Gamma_T}{1 - S_{22}\Gamma_T} = 1.02 \angle -13^\circ + \frac{0.02 \angle 77.4^\circ \cdot 2.21 \angle 162.3^\circ \cdot 0.62 \angle -29.76^\circ}{1 - 0.73 \angle -125^\circ \cdot 0.62 \angle -29.76^\circ}$$

$$= 1.02 \angle -13^\circ + \frac{0.027404 \angle 203.34^\circ}{1 - 0.4526 \angle -42.26^\circ}$$

$$= 1.02 \angle -13^\circ + \frac{0.027404 (\cos 203.34^\circ + j\sin 203.34^\circ)}{1 - 0.4526 (\cos(-42.26^\circ) + j\sin(-42.26^\circ))} = 1.02 \angle -13^\circ - \frac{0.0237 + j0.0136}{0.665 + j0.30434}$$

$$= 1.02 \angle -13^\circ - 0.0372 - j0.0034 = 0.9827 - j0.33548 = 0.986 \angle -19.85^\circ$$



$$\Gamma_{bl} = 1.0288 \angle -22.32^\circ$$

$$\Gamma_T = 0.62 \angle -23.76^\circ$$

$$G_p = \frac{1}{1 - (0.986)^2} \cdot (2.21)^2 \frac{1 - 0.62^2}{1 - 0.73 \angle -12.5^\circ \cdot 0.62 \angle -23.76^\circ} \cdot 0.4526$$

$$= \frac{1}{1 - 0.972} \cdot 4.8841 \frac{1 - 0.3844}{1.4034 + j0.1831} \cdot 0.4526$$

$$= 175.66 \cdot \frac{0.6156}{2.0237} = 53.435$$

izlaza jednačina:

$$S_T = \frac{(S_{22} - \Delta \cdot S_{11}^*)^*}{|S_{22}|^2 - |\Delta|^2} \quad \text{pluser: } R_T = \left| \frac{S_{12} S_{21}}{|S_{11}|^2 - |\Delta|^2} \right|$$

$$S_T = \frac{(0.73 \angle -12.5^\circ - 0.7067 \angle -8.7^\circ \cdot 1.02 \angle 19^\circ)^*}{(0.73)^2 - (0.7067)^2}$$

$$= \frac{(0.73 \angle -12.5^\circ - 0.7208 \angle -10.76^\circ)^*}{0.03347} = \frac{(0.7187 \angle -0.158^\circ - 0.708 \angle 0.1346^\circ)^*}{0.03347}$$

$$= \frac{(4.7^{-3} - j0.01343)^*}{0.03347} = \frac{4.7^{-3} + j0.02343}{0.03347} = 0.14 + j0.7$$

$$= 0.7138 \angle 78.7^\circ$$

$$R_T = \left| \frac{S_{12} S_{21}}{|S_{11}|^2 - |\Delta|^2} \right| = \left| \frac{0.0442 \angle 23.5^\circ}{(1.02)^2 - (0.7067)^2} \right| = \left| \frac{0.0442}{0.54035} \right| = 0.0817$$