(1) Bgrupa

→ stvarni presjek $A = 56.3\ mm^2$

→ promjer $d = 9.6\ mm$

→ dopušteno naprezanje $\sigma_d = 100\ N/mm^2$

→ specifična težina $3.45 \cdot 10^{-2}\ N/m\ mm^2 = \gamma_0$

→ temp. koef. naprezanja $\beta = 1.89 \cdot 10^{-5}\ 1/K$

→ modul elastičnosti $E = 7.7 \cdot 10^4\ N/mm^2$

→ $k_{led} = 1.6$

$\sigma_{max} = \sigma_d$; $g = 10\ m/s^2$

a) f_{max} pri rasponu od 200 m

$a = 200\ m$

$$f_{max} = \frac{a^2 \gamma}{8\sigma}$$

1) $a_{KR} = ?$

$$a_{KR} = \sigma_{max} \sqrt{\frac{360\beta}{\gamma_z^2 - \gamma_0^2}}$$

$$\gamma_z = \gamma_0 + \gamma_e = \gamma_0 + \frac{0.18 \cdot g \cdot \sqrt{d}}{A} \cdot k_{led} = 0.0345 + \frac{0.18 \cdot 10 \cdot \sqrt{9.6}}{56.3} \cdot 1.6 =$$

$$= 0.193\ N/m\ mm^2$$

$$a_{KR} = 100 \cdot \sqrt{\frac{360 \cdot 1.89 \cdot 10^{-5}}{0.193^2 - 0.0345^2}} = \underline{\underline{43.4387\ m}}$$

$a_{KR} < a \rightarrow \sigma_{max}$ na $-5°C$ +led

2) $\vartheta_{KR} = ?$

$\sigma = \sigma_{max}$

$$\vartheta_{KR} = \frac{\sigma_{max}}{\beta E}\left(1 - \frac{\gamma_0}{\gamma_z}\right) - 5 = \frac{100}{\beta E}\left(1 - \frac{0.0345}{0.193}\right) - 5 = 51.43°C$$

$\vartheta_{KR} > 40°C \rightarrow$ max. prepes pri $-5°C$ + led

$$f_{max} = \frac{a^2 \gamma_z}{8 \sigma_{max}} = \frac{200^2 \cdot 0.193}{8 \cdot 100} = \underline{\underline{9.65\ m}}$$

b) relativni otpust pri $17°C$, ukoliko je naprezanje pri tej temperaturi $\sigma_{17} = 18.8717\ N/mm^2$

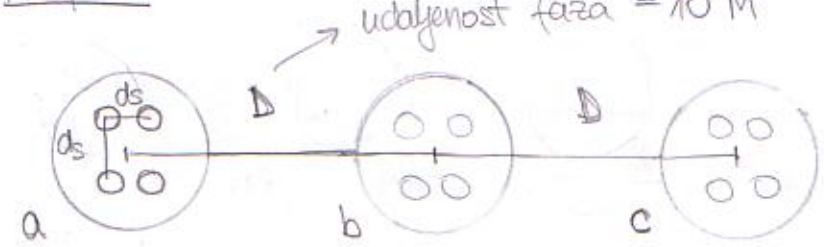
$$\lambda = \frac{l - a}{a} \cdot 1000\ ‰$$

$$l = a + \frac{a^3 \gamma_0^2}{24 \sigma_{17}^2}$$

$$\lambda = \frac{a^2 \gamma_0^2}{24 \sigma_{17}^2} \cdot 1000\ ‰ = \frac{200^2 \cdot (0.0345)^2}{24 \cdot (18.8717)^2} \cdot 1000\ ‰ =$$

$$= \underline{\underline{5.57\ ‰}}$$

(2) **PREPLET**



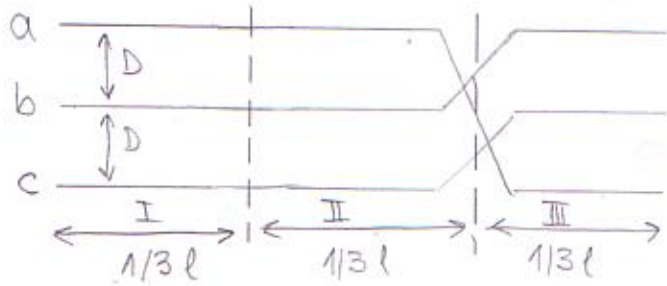
$$D_s = \sqrt[16]{(d_s^2 \cdot (d_s\sqrt{2})^4 (0.7788r)^4}$$

$$= \sqrt[4]{d_s^3 \sqrt{2} \cdot 0.7788r} =$$

$$= 0.1345 \text{ m}$$

$r = 11 \text{ mm} = 11 \cdot 10^{-3} \text{ M}$ – radijus vodiča

$d_s = 0.3 \text{ M}$ → razmak vodiča u snopu



$L_a, L_b, L_c = ?$

1) $L_A = \frac{1}{3}(L_{AI} + L_{AII} + L_{AIII})$

$$L_{AI} = 2 \cdot 10^{-7} \ln \frac{D_M}{D_s} = 2 \cdot 10^{-7} \ln \frac{\sqrt[1\cdot2]{D \cdot 2D}}{D_s} = 0.931 \text{ mH/km}$$

$$L_{AII} = 2 \cdot 10^{-7} \ln \frac{D_M}{D_s} = 2 \cdot 10^{-7} \ln \frac{\sqrt[1\cdot2]{D \cdot 2D}}{D_s} = 0.931 \text{ mH/km}$$

$$L_{AIII} = 2 \cdot 10^{-7} \ln \frac{D_M}{D_s} = 2 \cdot 10^{-7} \ln \frac{\sqrt[1\cdot2]{D \cdot 2D}}{D_s} = 0.931 \text{ mH/km}$$

$$L_A = 0.931 \text{ mH/km}$$

2) $L_B = \frac{1}{3}(L_{BI} + L_{BII} + L_{BIII})$

$$L_{BI} = 2 \cdot 10^{-7} \ln \frac{D_M}{D_s} = 2 \cdot 10^{-7} \ln \frac{\sqrt{D \cdot D}}{D_s} = 0.862 \text{ mH/km}$$

$$L_{BII} = 2 \cdot 10^{-7} \ln \frac{D_M}{D_s} = 2 \cdot 10^{-7} \ln \frac{\sqrt{D \cdot D}}{D_s} = 0.862 \text{ mH/km}$$

$$L_{BIII} = 2 \cdot 10^{-7} \ln \frac{D_M}{D_s} = 2 \cdot 10^{-7} \ln \frac{\sqrt{D \cdot 2D}}{D_s} = 0.931 \text{ mH/km}$$

$$L_B = 0.8848 \text{ mH/km}$$

3) $L_c = \frac{1}{3}(L_{cI} + L_{cII} + L_{cIII})$

$$L_{cI} = 2 \cdot 10^{-7} \ln \frac{D_m}{D_s} = 2 \cdot 10^{-7} \ln \frac{\sqrt{2D \cdot D}}{D_s} = 0.931 \text{ mH/km}$$

$$L_{cII} = 2 \cdot 10^{-7} \ln \frac{D_m}{D_s} = 2 \cdot 10^{-7} \ln \frac{\sqrt{2D \cdot D}}{D_s} = 0.931 \text{ mH/km}$$

$$L_{cIII} = 2 \cdot 10^{-7} \ln \frac{D_m}{D_s} = 2 \cdot 10^{-7} \ln \frac{\sqrt{D \cdot D}}{D_s} = 0.862 \text{ mH/km}$$

$$L_c = 0.9079 \text{ mH/km}$$

- mogli smo odmah pisati $L_I = L_{II}$:)

(3) Vod 220 kV, dužine 250 km

$Z_1 = 0.06 + j0.32 \ \Omega/km = 0.3256 \angle 79.38° \ \Omega/km$

$Y_1 = j3.5 \ \mu S/km = 3.5 \cdot 10^{-6} \angle 90° \ S/km$

$S_1 = 80 - j15 \ MVA$

$U_1 = U_n = 220 \ kV \rightarrow V_1 = \frac{220}{\sqrt{3}} = 127.017 \ kV$

$\Delta S = ?$

$\Delta S = S_1 - S_2$

$Z_c = \sqrt{\frac{Z_1}{Y_1}} = 305 \angle -5.31° \ \Omega$

$I_1 = \left(\frac{S_1}{3V_1}\right)^* = 0.2099 + j0.0394 \ kA$

$\gamma = \sqrt{Z_1 Y_1} = 1.067 \cdot 10^{-3} \angle 84.69 \ 1/km$

$\gamma l = 0.02469 + j0.2656$

$ch(\gamma l) = \ldots = 0.965 \angle 0.385°$

$sh(\gamma l) = \ldots = 0.264 \angle 84.82°$

$S_2 = 3 V_2 I_2^*$?

$V_2 = V_1 ch(\gamma l) - I_1 Z_c sh(\gamma l)$

$I_2 = I_1 ch(\gamma l) - \frac{V_1}{Z_c} sh(\gamma l)$

$V_2 = 122.611 - j16.37 \ kV$

$I_2 = 0.2025 - j0.0706 \ kA$

$S_2 = 3 \cdot (122.611 - j16.37)(0.2025 + j0.0706) =$

$= 77.95 + j16.024 \ MVA$

$\Delta S = S_1 - S_2 = 2.05 - j31.024 \ MVA$

(4) $U_1 = 110\ kV \rightarrow V_1 = 63.51\ kV$

$l = 60\ km$

$Z_1 = 0.12 + j0.42\ \Omega/km = 0.437 \angle 74.05°\ \Omega/km$

$Y_1 = j2.7\ \mu S/km = 2.7 \cdot 10^{-6} \angle 90°\ S/km$

$Z_c = \sqrt{\frac{Z_1}{Y_1}} = 402.31 \angle -7.975°$

$V_1 = V_2 \cosh(\gamma l) + I_2 Z_c \sinh(\gamma l)$

$V_2 = I_2 Z_c$

$V_1 = V_2 (\cosh(\gamma l) + \sinh(\gamma l))$

$\gamma = \sqrt{Z_1 Y_1} = 1.086 \cdot 10^{-3} \angle 82.02°$

$\gamma l = 9.046 \cdot 10^{-3} + j0.065$

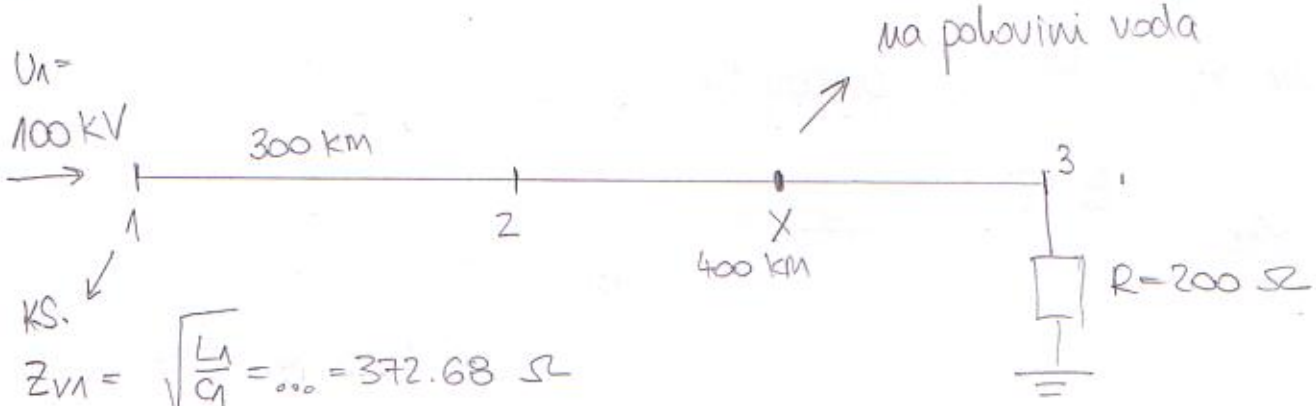
$\cosh(\gamma l) = \ldots = 0.998 \angle 0.0304°$

$\sinh(\gamma l) = \ldots = 0.066 \angle 82.08°$

$$V_2 = \frac{V_1}{\cosh(\gamma l) + \sinh(\gamma l)} = 62.79 - j\,4.113\ kV$$

$U_2 = \sqrt{3} V_2 = 108.76 - j\,7.123\ kV$

5



$$Z_{v1} = \sqrt{\frac{L_1}{C_1}} = \ldots = 372.68\ \Omega$$

$$t_{v1} = \frac{l_1}{c_1} = \frac{l_1}{\frac{1}{\sqrt{L_1 C_1}}} = l_1\sqrt{L_1 C_1} = 1.006\ ms$$

$$Z_{v2} = \sqrt{\frac{L_2}{C_2}} = \ldots = 377.96\ \Omega$$

$$t_{v2} = \frac{l_2}{c_2} = l_2\sqrt{L_2 C_2} = 1.376\ ms$$

a) napon u X u 2ms

$$\alpha_2 = \frac{2 \cdot Z_{v2}}{Z_{v1} + Z_{v2}} = 1.007 \qquad \beta = \alpha - 1 = 0.07$$

$$U_{p2} = U_1 \cdot \alpha_2 \cdot e^{-\frac{R_1}{L_1} \cdot t_{v1}} = 95.953\ kV$$

$$U_{x2ms} = U_{p2} \cdot e^{-\frac{R_2}{L_2} \cdot \frac{t_{v2}}{2}} = 91.975\ kV$$

b) X u 4ms

$$\alpha_3 = \frac{2R}{R + Z_{v2}} = 0.692 \qquad \beta = -0.308$$

$$U_{3r} = \beta U_{2p} \cdot e^{-\frac{R_2}{L_2} t_{v2}} = -27.15\ kV$$

→ prolazni val u 2
→ reflektirani u 3

$$U_{x4ms}\ (\text{od reflektiranog vala u } 3) = U_{3r} \cdot e^{-\frac{R_2}{L_2} \cdot \frac{t_{v2}}{2}} = -26.02\ kV$$

$$U_{2r} = \alpha_2 U_1 \cdot e^{-\frac{R_1}{L_1} \cdot t_{v1}} = 0.667\ kV$$

$\alpha_1 = 0$ (zbog kratkog spoja)

$\beta = -1$

$$U_{1r} = U_{2i} \cdot \beta \cdot e^{-\frac{R_1}{L_1} \cdot t_{v1}} = -0.6356 \text{ kV}$$

$$U_{2p_2} = U_{1r} \cdot \alpha_2 \; e^{-\frac{R_1}{L_1} t_{v1}} = -0.6099 \text{ kV}$$

$$U_{X_{4MS}} = U_{2p2} \cdot e^{-\frac{R_2}{L_2} \cdot \frac{t_{v2}}{2}} = -0.585 \text{ kV}$$

↓

→ reflektirani val u 2
→ reflektirani val u 1
→ prolazni val u 2

$$U_X = 91.775 + (26.02) + (-0.585) = \underline{65.17 \text{ kV}}$$