faktor snage na početku voda:

$$\cos\varphi_1 = \cos(\varphi_{u_1} - \varphi_{i_1}) = \cos(21{,}62° - 22{,}79°) =$$
$$= \cos(-1{,}17°) = 0{,}99979 \approx 1$$

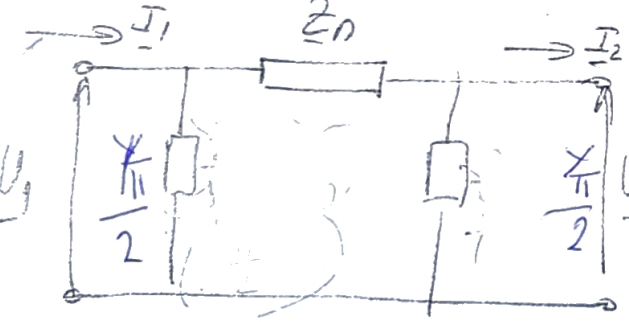
snaga na početku voda:

$$\underline{S}_1 = 3\underline{U}_1 \underline{I}_1^* = 3 \cdot 136{,}75 \angle 21{,}62° \cdot 0{,}3297 \angle -22{,}79° =$$
$$= 135{,}16 \angle -1{,}17° = (135{,}23 - j2{,}76)\ MVA$$

$P_1 = 135{,}26\ MW$

$Q_1 = -2{,}76\ MVAr$

b) EKVIVALENTNA „Π" ŠEMA VODA



$$\begin{bmatrix} \underline{U}_1 \\ \underline{I}_1 \end{bmatrix} = \begin{bmatrix} 1 + \frac{\underline{Z}_n \underline{Y}_n}{2} & \underline{Z}_n \\ \frac{\underline{Y}_n}{2}\left(2 + \frac{\underline{Z}_n \underline{Y}_n}{2}\right) & 1 + \frac{\underline{Z}_n \underline{Y}_n}{2} \end{bmatrix} \begin{bmatrix} \underline{U}_2 \\ \underline{I}_2 \end{bmatrix} =$$

$$= \begin{bmatrix} \underline{A}_n & \underline{B}_n \\ \underline{C}_n & \underline{D}_n \end{bmatrix} \begin{bmatrix} \underline{U}_2 \\ \underline{I}_2 \end{bmatrix}$$

$$\underline{Z}_n = \underline{Z}_c \operatorname{sh} \underline{\gamma} l$$

$$\frac{\underline{Y}_n}{2} = \frac{\operatorname{ch} \underline{\gamma} l - 1}{\underline{Z}_c \operatorname{sh} \underline{\gamma} l} = \underline{Y}_c \operatorname{th} \frac{\underline{\gamma} l}{2}$$

$$\underline{Z}_n = \underline{Z}_c \operatorname{sh} \underline{\gamma} l = 100{,}84 \angle 79°\ \Omega$$

$$\frac{\underline{Y}_n}{2} = \frac{\operatorname{ch} \underline{\gamma} l - 1}{\underline{Z}_c \operatorname{sh} \underline{\gamma} l} = \frac{0{,}92683 + j0{,}0144 - 1}{398 \angle -5{,}64 \cdot 0{,}379 \angle 84{,}64} = 4{,}9438 \cdot 10^{-4} \angle 89{,}66°\ (1)$$

$$\underline{A}_n = 1 + \frac{\underline{z}_n \underline{y}_n}{2} = 0{,}9269\angle 0{,}89°$$

$$\underline{B}_n = \underline{z}_n = 100{,}842\angle 79° \ [\Omega]$$

$$\underline{C}_n = \frac{\underline{y}_n}{2}\left(2 + \frac{\underline{z}_n \underline{y}_n}{2}\right) = 9{,}526 \cdot 10^{-4}\angle 90{,}79° \ [S]$$

$$\underline{D}_n = 1 + \frac{\underline{z}_n \underline{y}_n}{2} = 0{,}9265\angle 0{,}89°$$

$$\underline{U}_1 = \underline{A}_n \underline{U}_2 + \underline{B}_n \underline{I}_2 = 136{,}766\angle 21{,}62 \ [kV]$$

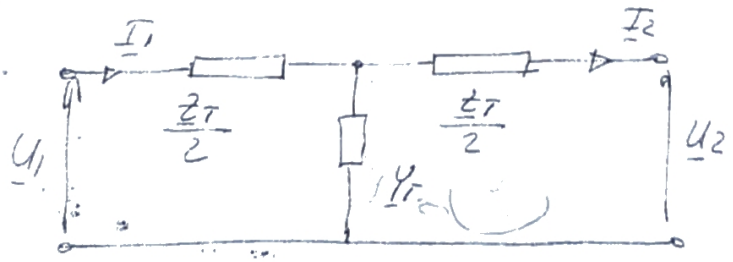
$$U_{1f} = \sqrt{3}\,\underline{U}_1 = 236{,}6\angle 21{,}62 \ [kV]$$

$$\underline{I}_1 = \underline{C}_n \underline{U}_2 + \underline{D}_n \underline{I}_2 = 0{,}3297\angle 22{,}79 \ [kA]$$

$$\underline{S}_1 = 3\underline{U}_1 \underline{I}_1^* = (135{,}23 - j2{,}76)\ MVA$$

Kao pod a)

c) EKVIVALENTNA „T" ŠEMA



$$\begin{bmatrix} \underline{U}_1 \\ \underline{I}_1 \end{bmatrix} = \begin{bmatrix} 1 + \frac{\underline{z}_T \underline{Y}_T}{2} & \frac{\underline{z}_T}{2}\left(2 + \frac{\underline{z}_T \underline{Y}_T}{2}\right) \\ \underline{Y}_T & 1 + \frac{\underline{z}_T \underline{Y}_T}{2} \end{bmatrix} \begin{bmatrix} \underline{U}_2 \\ \underline{I}_2 \end{bmatrix} =$$

$$= \begin{bmatrix} \underline{A}_T & \underline{B}_T \\ \underline{C}_T & \underline{D}_T \end{bmatrix} \begin{bmatrix} \underline{U}_2 \\ \underline{I}_2 \end{bmatrix}$$

$$\underline{Y}_T = \underline{Y}_c \operatorname{th}\frac{\underline{\gamma}\ell}{2} =$$

$$\frac{\underline{z}_T}{2} = \frac{\operatorname{ch}\underline{\gamma}\ell - 1}{\underline{Y}_c \operatorname{sh}\underline{\gamma}\ell} = \underline{z}_c \operatorname{th}\frac{\underline{\gamma}\ell}{2} =$$

$$\underline{Y}_T = \frac{\operatorname{sh}\underline{\gamma}\ell}{\underline{z}_c} = \frac{0{,}379\angle 84{,}64°}{398\angle -5{,}64°} = 5{,}5226\cdot 10^{-4}\angle 90{,}28° \ [S]$$

$$\frac{\underline{z}_T}{2} = \frac{\operatorname{ch}\underline{\gamma}\ell - 1}{\underline{Y}_c \operatorname{sh}\underline{\gamma}\ell} = \frac{\underline{z}_c(\operatorname{ch}\underline{\gamma}\ell - 1)}{\operatorname{sh}\underline{\gamma}\ell} = \frac{398\angle -5{,}64° \cdot 0{,}07473\angle 168{,}86°}{0{,}379\angle 84{,}64°} =$$

$$= 78{,}3R0139\angle 78{,}586 \ [\Omega]$$

Parametri ekvivalentnog četveropola

$$\underline{A}_T = 1 + \frac{\underline{z}_T \underline{Y}_T}{2} = \underline{A}_n$$

$$\underline{B}_T = \underline{z}_T + \frac{\underline{Y}_T \underline{z}_T^2}{4} = \underline{B}_n$$

$$\underline{C}_T = \underline{Y}_T = \underline{C}_n$$

$$\underline{D}_T = 1 + \frac{\underline{z}_T \underline{Y}_T}{2} = \underline{D}_n$$

} kao u dijelu pod b)

$$\underline{U}_1 = \underline{A}_T \underline{U}_2 + \underline{B}_T \underline{I}_2 = 136{,}786\angle 21{,}62° \ [kV]$$

$$\underline{I}_1 = \underline{C}_T \underline{U}_2 + \underline{D}_T \underline{I}_2 = 0{,}3297\angle 22{,}29° \ [kA]$$

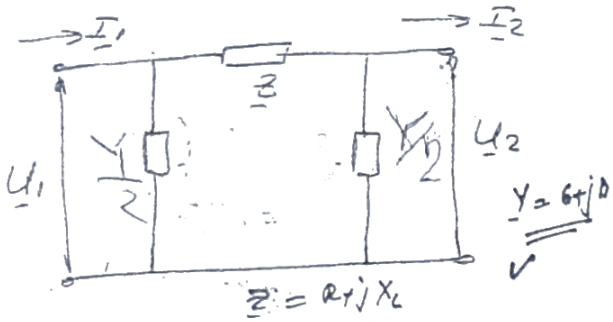
$$\underline{S}_1 = 3\underline{U}_1 \underline{I}_1^* = (135{,}23 - j2{,}76) \ MVA$$

} kao u dijelu pod a) i pod b)

c) Za duljine vodova $\ell \leq 150$ km dovoljno je hiperbolne funkcije $\operatorname{sh}\underline{\gamma}\ell$ i $\operatorname{ch}\underline{\gamma}\ell$ zamijeniti prvim članovima reda, pošto je $\underline{\gamma} = \sqrt{\underline{z}_l \underline{Y}_l}$ mala, kao i duljina ℓ

Sprotuil pribline ekvivalentne šeme:

PRIBLIŽNA EKVIVALENTNA „Π" ŠEMA



$$\begin{bmatrix} \underline{U}_1 \\ \underline{I}_1 \end{bmatrix} = \begin{bmatrix} 1+\frac{\underline{Z}\underline{Y}}{2} & \underline{Z} \\ \frac{\underline{Y}}{2}\left(2+\frac{\underline{Z}\underline{Y}}{2}\right) & 1+\frac{\underline{Z}\underline{Y}}{2} \end{bmatrix} \begin{bmatrix} \underline{U}_2 \\ \underline{I}_2 \end{bmatrix} = \begin{bmatrix} \underline{A} & \underline{B} \\ \underline{C} & \underline{D} \end{bmatrix} \begin{bmatrix} \underline{U}_2 \\ \underline{I}_2 \end{bmatrix}$$

$\underline{Z} = \underline{Z}_1 L$ ... uzdužna impedansa

$\underline{Y} = \underline{Y}_1 L$ ... poprečna admitansa

$\underline{Z} = \underline{Z}_1 L = 360 \cdot 0{,}43 \angle 78{,}72° = 154{,}8 \angle 78{,}72° \ [\Omega]$

$\underline{Y} = \underline{Y}_1 L = 360 \cdot 2{,}7 \cdot 10^{-6} \angle 90° = 975{,}6 \angle 90° \cdot 10^{-6} \ [S]$

$\underline{A} = 1 + \frac{\underline{Z}\underline{Y}}{2} = 0{,}926 \angle 0{,}9° = \underline{D}$

$\underline{B} = \underline{Z} = 154{,}8 \angle 78{,}72 \ [\Omega]$

$\underline{C} = \frac{\underline{Y}}{2}\left(2 + \frac{\underline{Z}\underline{Y}}{2}\right) = 9{,}355 \cdot 10^{-4} \angle 90{,}493° \ [S]$

$\underline{U}_1 = \underline{A}\underline{U}_2 + \underline{B}\underline{I}_2 = 137{,}43 \angle 21{,}95° \ [kV]$

$\underline{U}_{1c} = \sqrt{3}\underline{U}_1 = 238{,}035 \angle 21{,}95° \ [kV]$

$\underline{I}_1 = \underline{C}\underline{U}_2 + \underline{D}\underline{I}_2 = 0{,}327 \angle 22{,}2° \ [kA]$

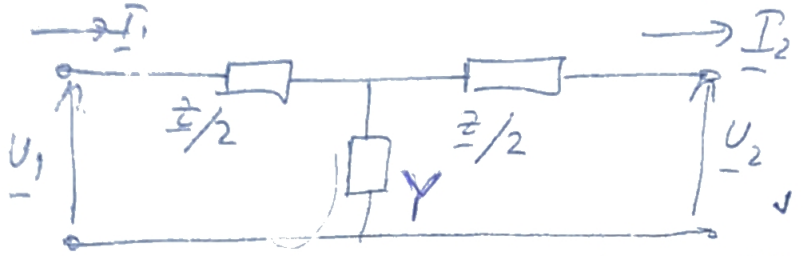
$\underline{S}_1 = 3\underline{U}_1 \underline{I}_1^* = 3 \cdot 137{,}43 \angle 21{,}95 \cdot 0{,}327 \angle 22{,}2 = 134{,}82 - j0{,}59 \ [MVA]$

Fazna prostorna napaka po pribl. „Π" šemi

$$M_{n/.} = \left| \frac{\underline{U}_{1nr} - \underline{U}_{1np}}{\underline{U}_{1nr}} \right| 100 = \left| \frac{136{,}766 \angle 21{,}62 - 137{,}43 \angle 21{,}95}{136{,}766 \angle 21{,}62} \right| 100 =$$

$= 0{,}7562\ \%$ ... zadovoljivo

c) PRIBLIŽNA EKVIVALENTNA „T" ČLENA



$$\begin{bmatrix} \underline{U}_1 \\ \underline{I}_1 \end{bmatrix} = \begin{bmatrix} 1+\frac{\underline{z}\underline{Y}}{2} & \frac{\underline{z}}{2}\left(2+\frac{\underline{z}\underline{Y}}{2}\right) \\ \underline{Y} & 1+\frac{\underline{z}\underline{Y}}{2} \end{bmatrix} \begin{bmatrix} \underline{U}_2 \\ \underline{I}_2 \end{bmatrix} =$$

$$= \begin{bmatrix} \underline{A} & \underline{B} \\ \underline{C} & \underline{D} \end{bmatrix} \begin{bmatrix} \underline{U}_2 \\ \underline{I}_2 \end{bmatrix}$$

$$\underline{A} = 1+\frac{\underline{z}\underline{Y}}{2} = 0{,}926\angle 0{,}9°$$

$$\underline{D} = \underline{A}$$

$$\underline{B} = \underline{z} + \frac{\underline{z}}{2}\cdot\frac{\underline{Y}\underline{z}}{2} = \frac{\underline{z}}{2}\left(2+\frac{\underline{z}\underline{Y}}{2}\right) = 149{,}073\angle 79{,}16°\ \Omega$$

$$\underline{C} = \underline{Y} = 975{,}6\cdot 10^{-6}\angle 90°\ \mathrm{S}$$

$$\underline{U}_1 = \underline{A}\,\underline{U}_2 + \underline{B}\,\underline{I}_2 = 136{,}24\angle 21{,}47°\ [\mathrm{kV}]$$

$$\underline{I}_1 = \underline{C}\,\underline{U}_2 + \underline{D}\,\underline{I}_2 = 0{,}3282\angle 22{,}27°\ [\mathrm{kA}]$$

$$\underline{S}_1 = 3\,\underline{U}_1\,\underline{I}_1^{*} = (134{,}054 - j1{,}872)\ \mathrm{MVA}$$

Dobiveno rješenje za približnu „T" člena

$$U_T\% = \left|\frac{\underline{U}_{TT} - \underline{U}_{PT}}{U_{TT}}\right| 100 = \left|\frac{136{,}766\angle 21{,}62° - 136{,}24\angle 21{,}47°}{136{,}766\angle 21{,}62°}\right| 100 =$$

$$= 0{,}4162\%$$