Industrijsko inženjerstvo

Osnovi elektrotehnike

Trofazni sistemi 1

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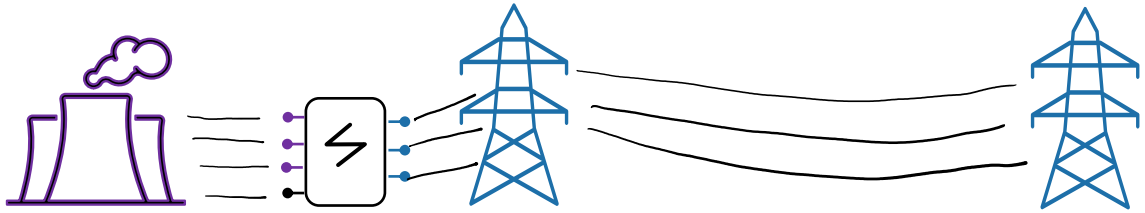
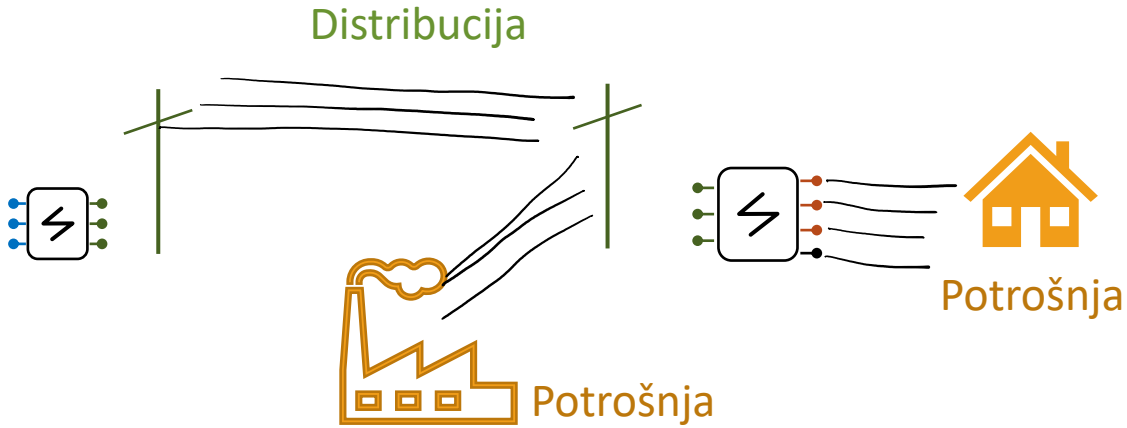
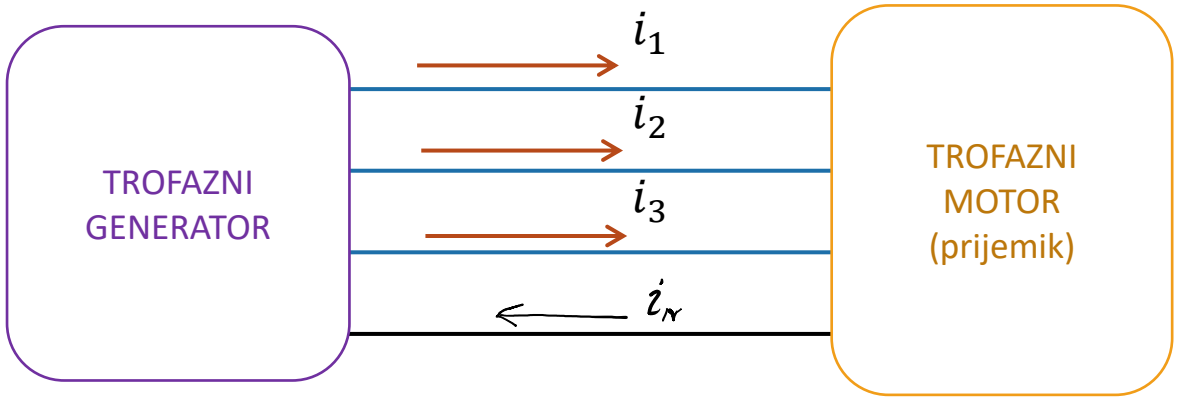
Trofazni sistem



Proizvodnja

Prenos

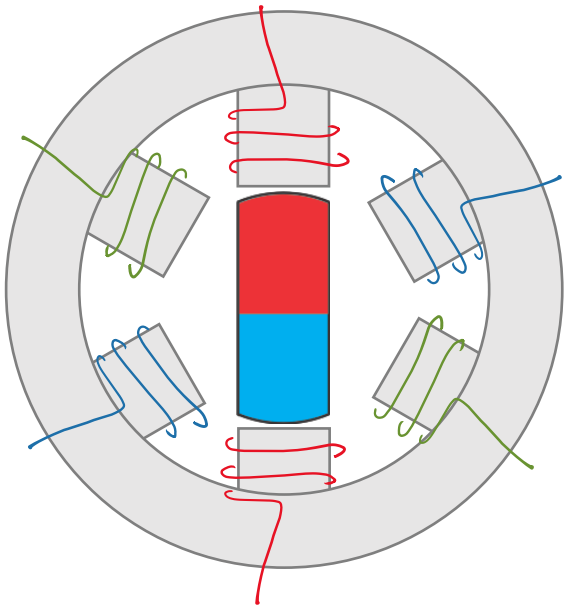


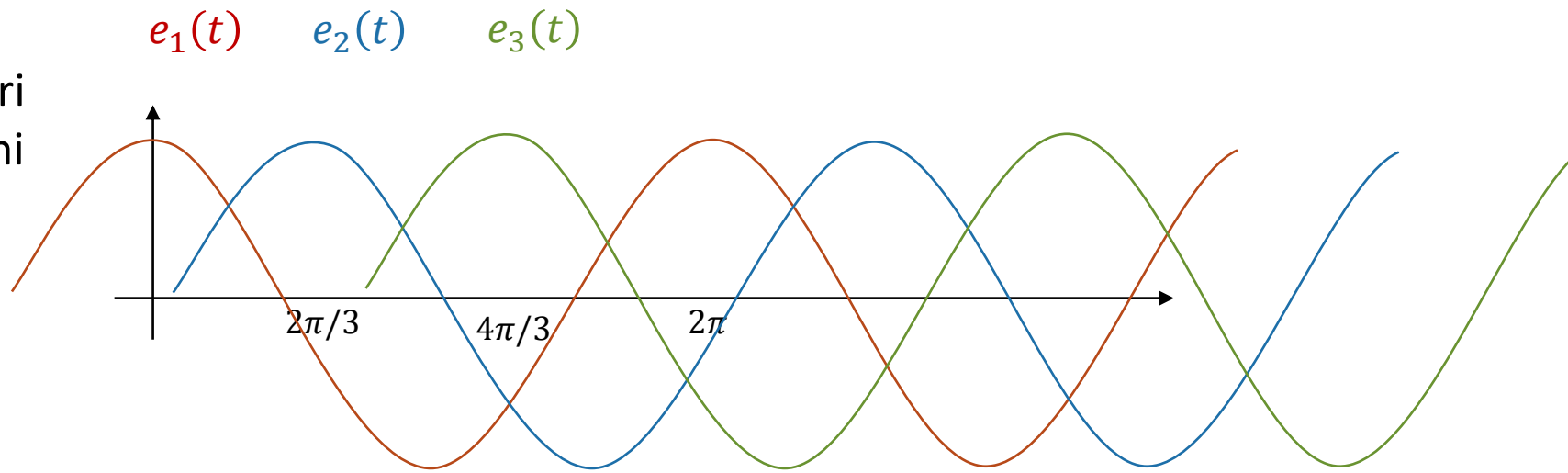


3F SISTEM ZA PRENOS

Trofazni generator

Generator se sastoji od statora sa tri grupe namotaja i rotora koji je stalni magnet ili elektromagnet.





$$e_1(t) = \sqrt{2}E\cos(\omega t)$$

$$e_2(t) = \sqrt{2}E\cos(\omega t - 2\pi/3)$$

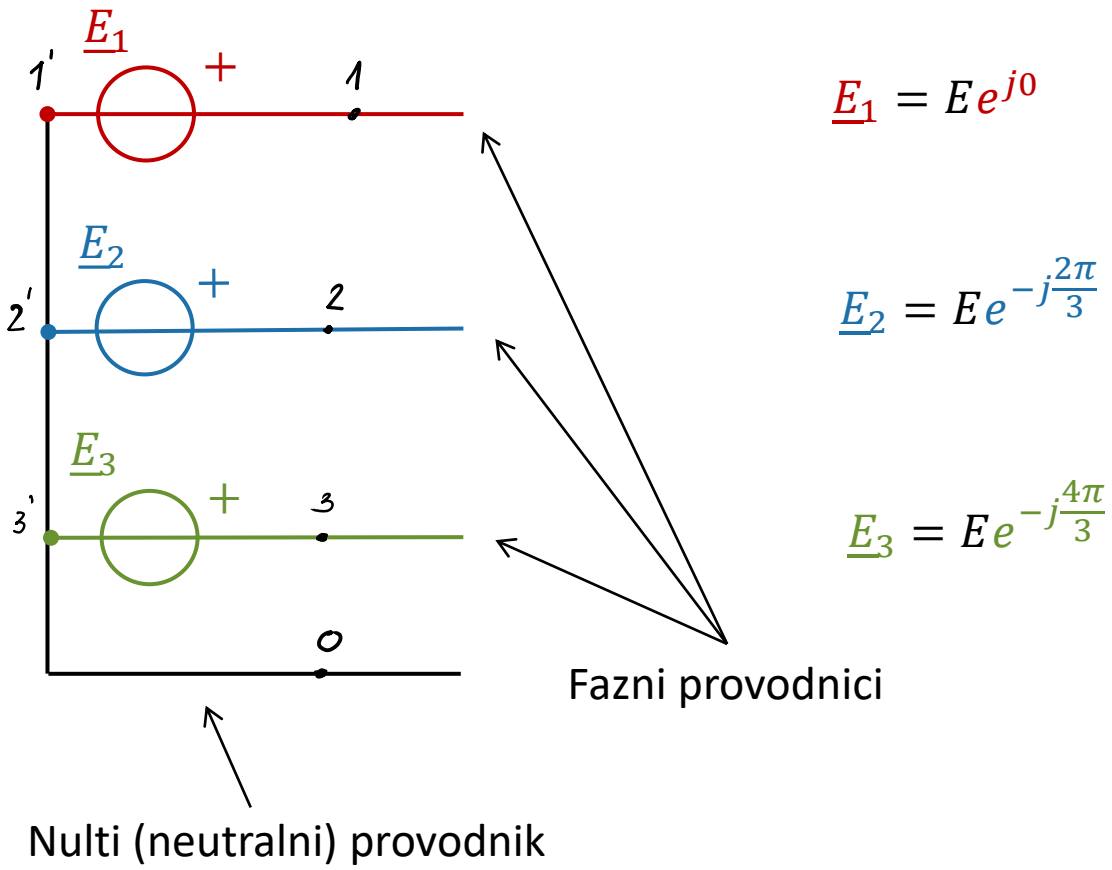
$$e_3(t) = \sqrt{2}E\cos(\omega t - 4\pi/3)$$

$$\underline{E_1} = Ee^{j0}$$

$$\underline{E_2} = Ee^{-j\frac{2\pi}{3}}$$

$$\underline{E_3} = Ee^{-j\frac{4\pi}{3}}$$

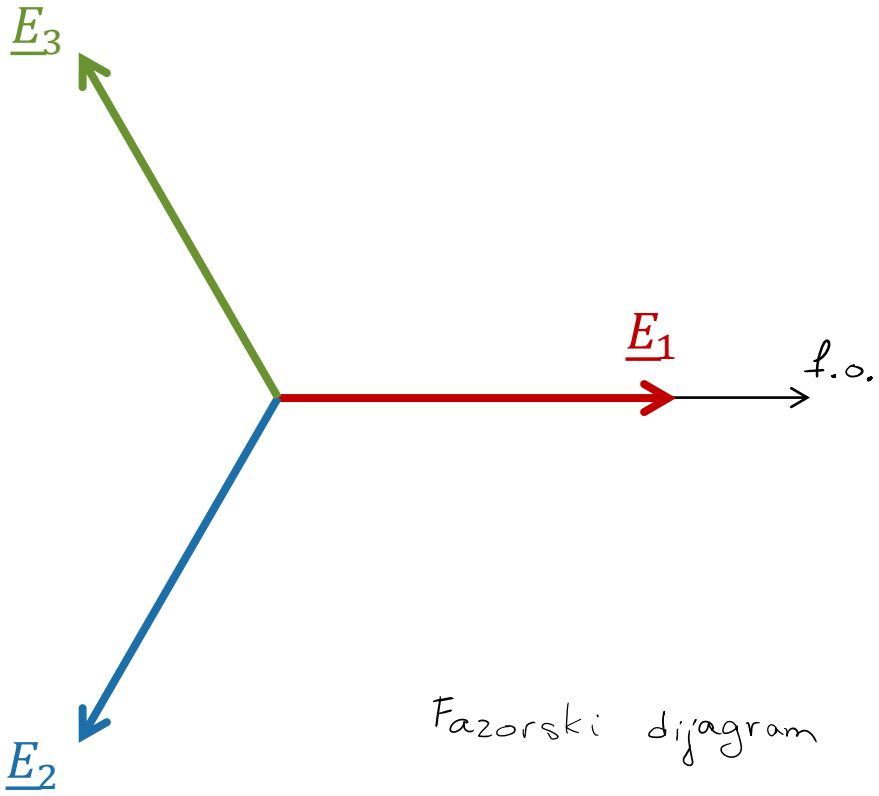
Trofazni generator



$$\underline{E}_1 = Ee^{j0}$$

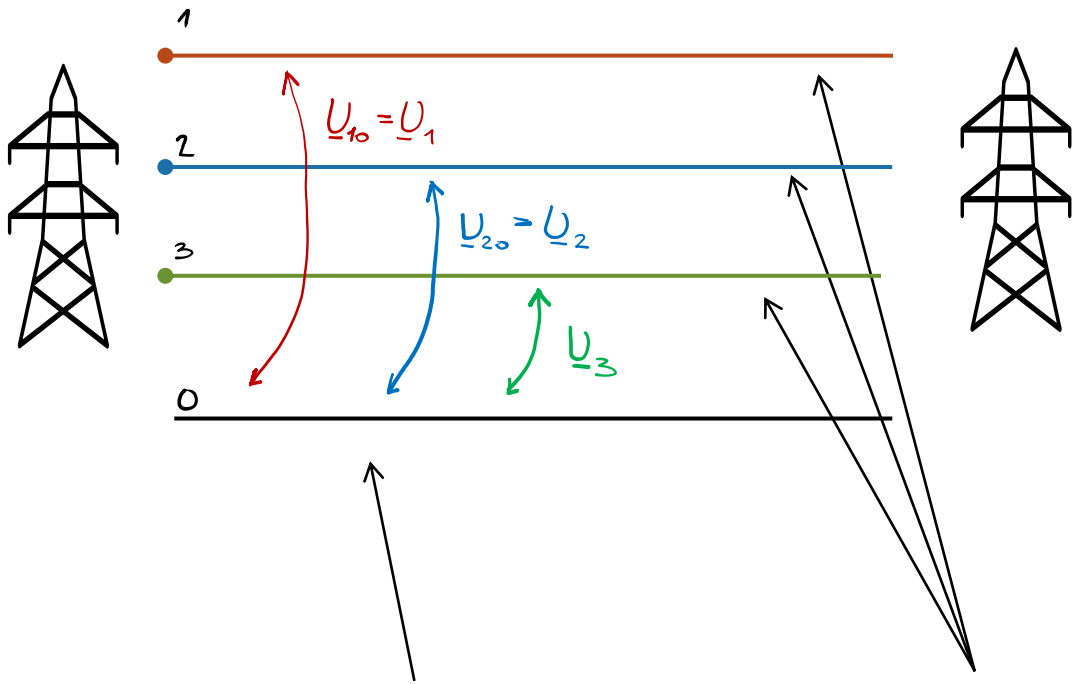
$$\underline{E}_2 = Ee^{-j\frac{2\pi}{3}}$$

$$\underline{E}_3 = Ee^{-j\frac{4\pi}{3}}$$



Fazni i međufazni naponi

Fazni napon je napon između faznog i nultog provodnika.



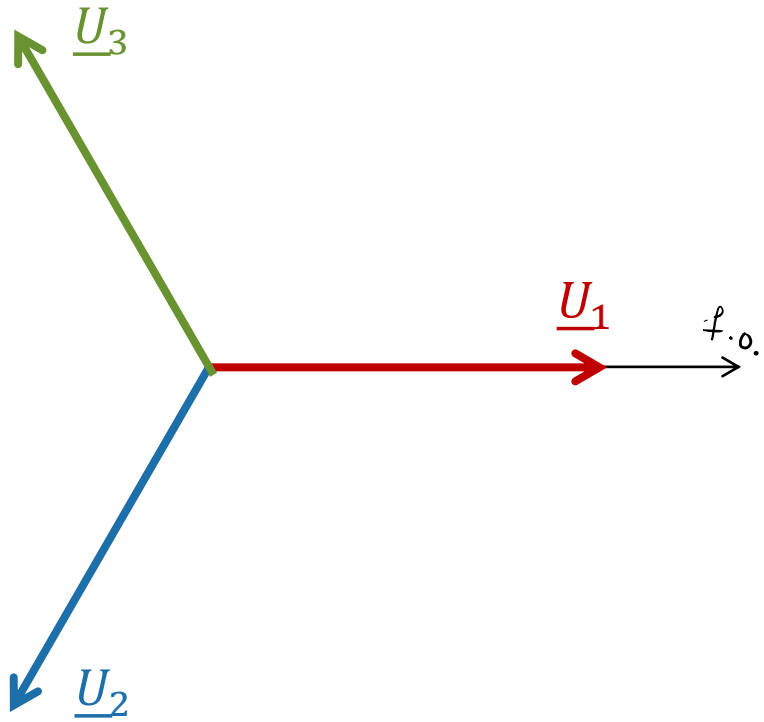
Nulti (neutralni) provodnik

Fazni provodnici

$$\underline{U}_1 = Ue^{j0}$$

$$\underline{U}_2 = Ue^{-j\frac{2\pi}{3}}$$

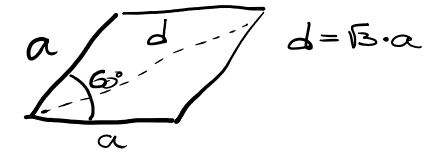
$$\underline{U}_3 = Ue^{-j\frac{4\pi}{3}}$$

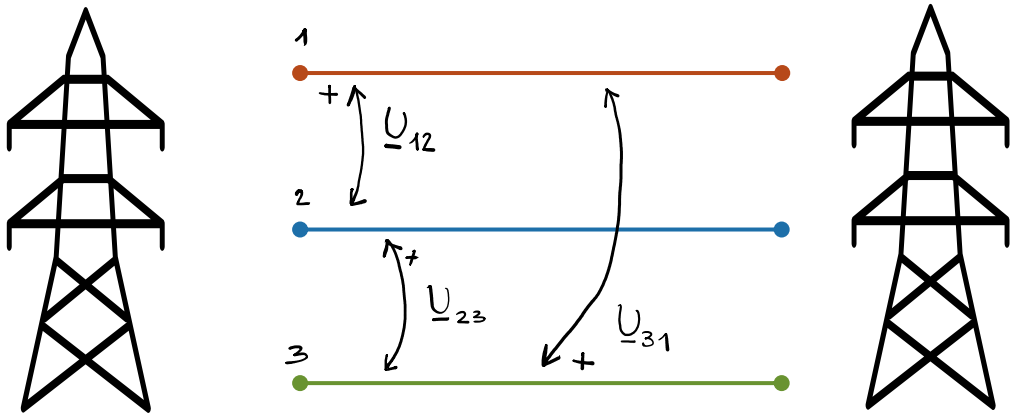


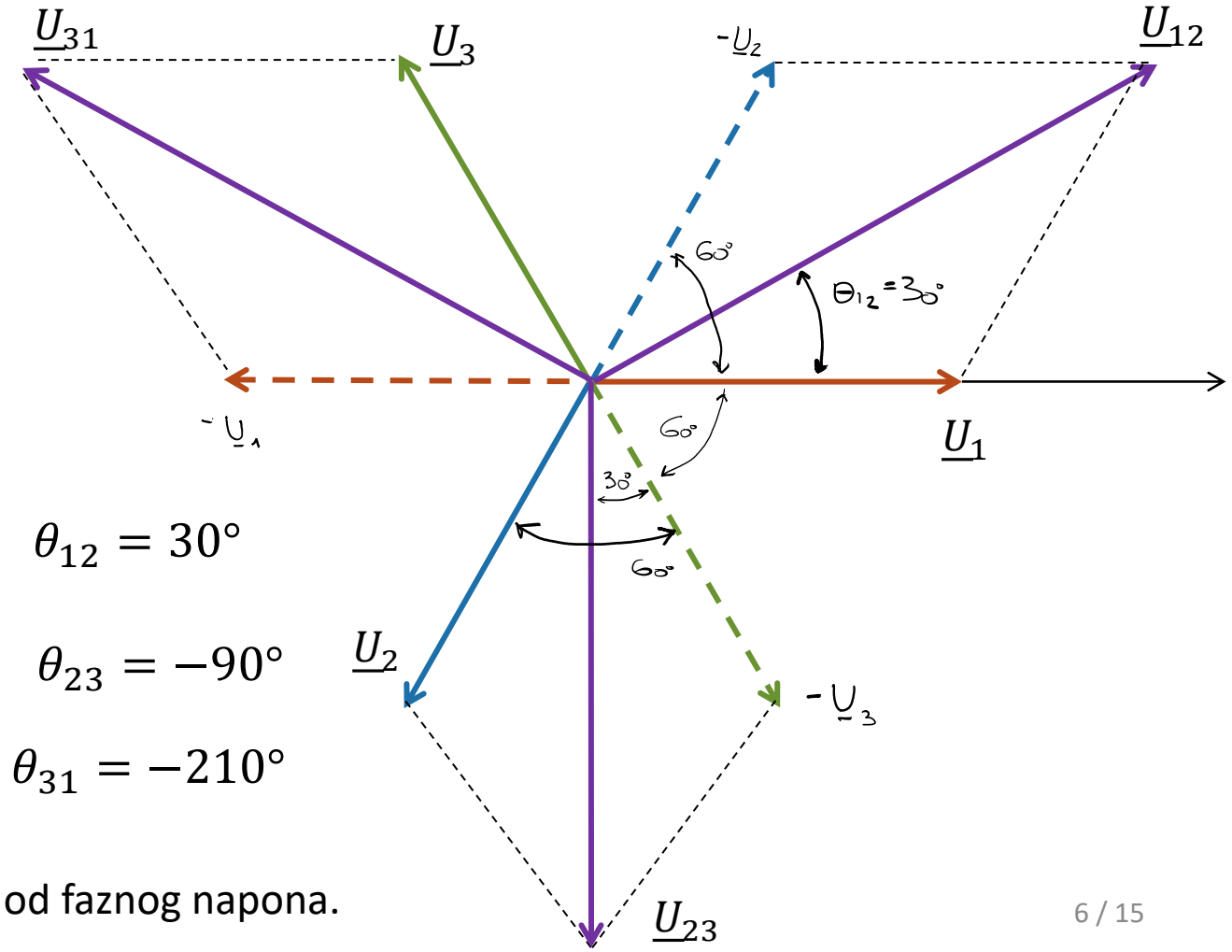
U – efektivna vrednost faznog napona

Fazni i međufazni naponi

Međufazni napon je napon između dva fazna provodnika.







$$\underline{U}_{12} = \underline{U}_1 - \underline{U}_2 = U_{12}e^{j\theta_{12}} \qquad U_{12} = \sqrt{3}U \qquad \theta_{12} = 30°$$

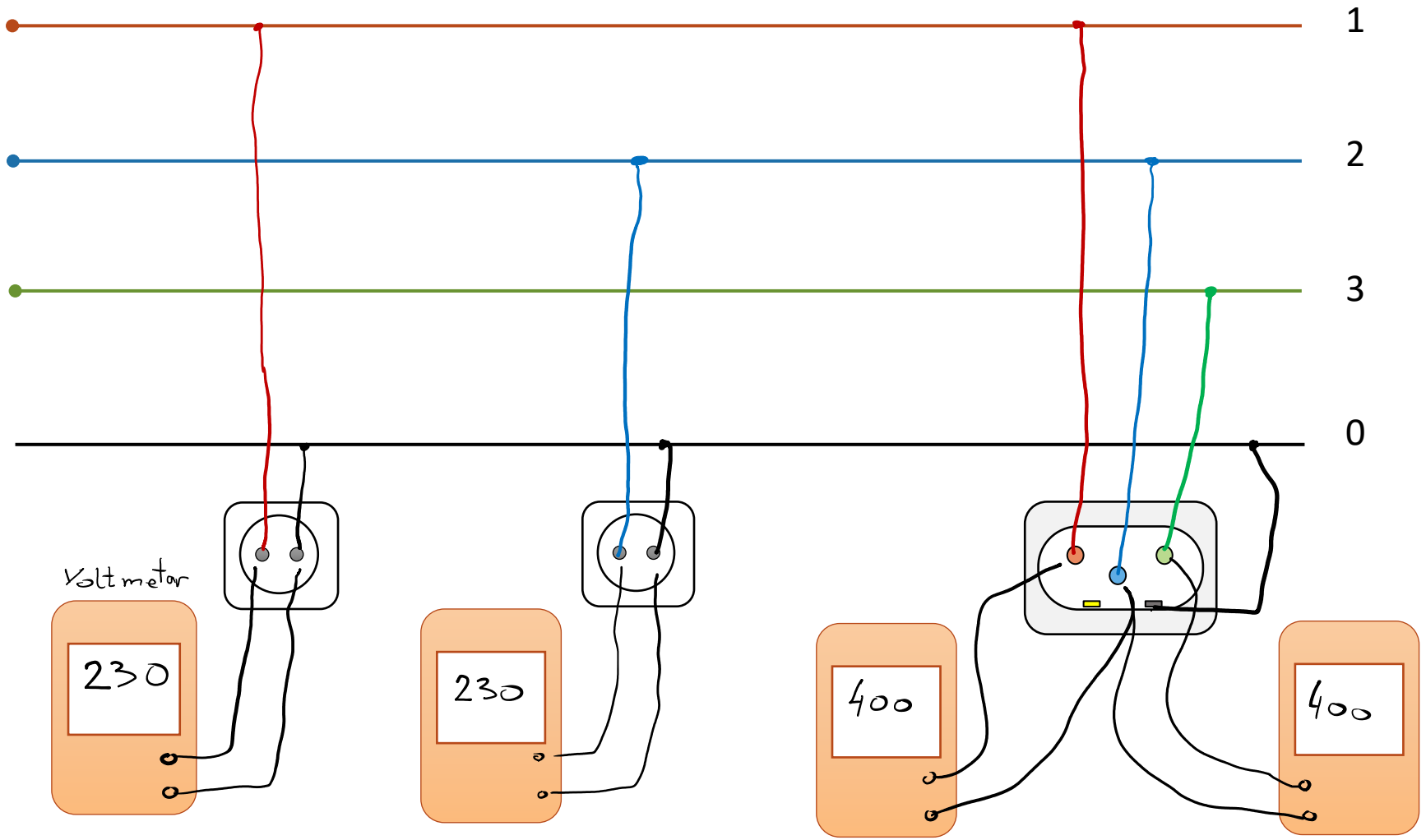
$$\underline{U}_{23} = \underline{U}_2 - \underline{U}_3 = U_{23}e^{j\theta_{23}} \qquad U_{23} = \sqrt{3}U \qquad \theta_{23} = -90°$$

$$\underline{U}_{31} = \underline{U}_3 - \underline{U}_1 = U_{31}e^{j\theta_{31}} \qquad U_{31} = \sqrt{3}U \qquad \theta_{31} = -210°$$

Međufazni napon je $\sqrt{3}$ puta veći od faznog napona.

Fazni i međufazni naponi

Instrumenti mere efektivnu vrednost napona



$\underline{U}_1 = 230e^{j0}\ \mathrm{V}$

$\underline{U}_2 = 230e^{-j120}\ \mathrm{V}$

$\underline{U}_3 = 230e^{-j240}\ \mathrm{V}$

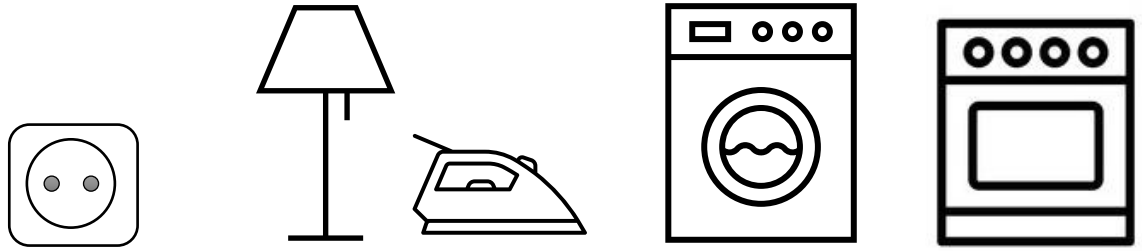
$\underline{U}_{12} = 400e^{j30}\ V$

$\underline{U}_{23} = 400e^{-j90}\ V$

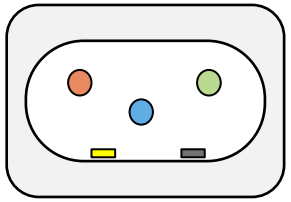
$\underline{U}_{31} = 400e^{-j210}\ V$

Prijemnici u trofaznom sistemu

- Monofazni
  - Svi kućni uređaji (sijalice, pegla, usisivač, bojler, računar, TV, električni šporet, ...)
  - Potrebna je jedna (bilo koja faza) i nulti provodnik

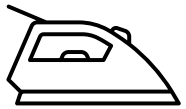


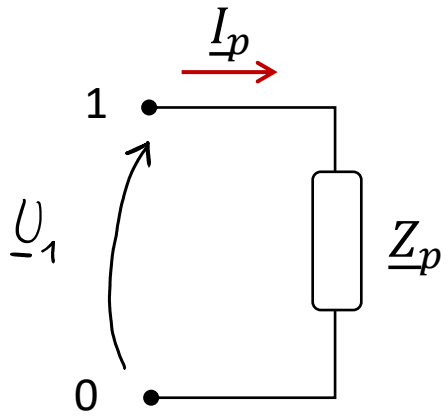
- Trofazni
  - Trofazni elektromotori u industriji (mešalica, mlin, strug, ...)
  - Potrebne su sve tri faze i nulti provodnik



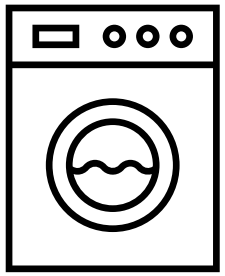
Modelovanje prijemnika

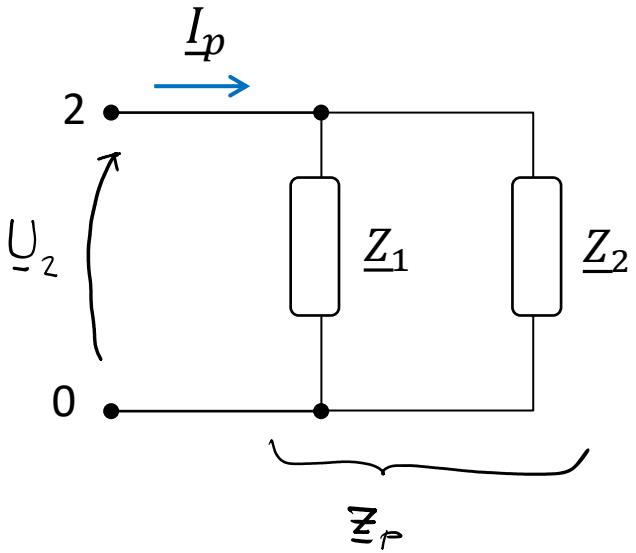
Monofazni

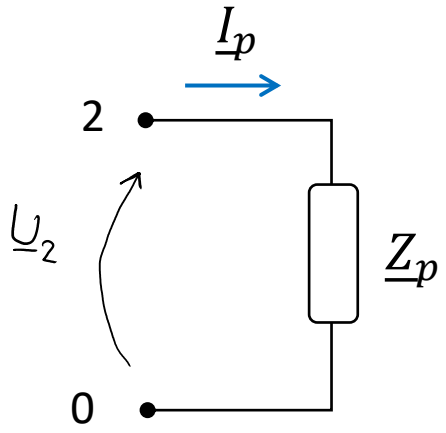




$$I_p = \frac{U_1}{Z_p}$$



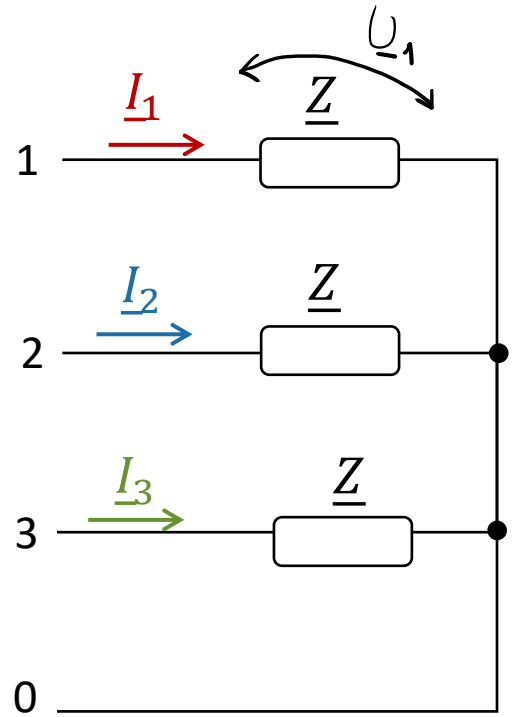




$$I_p = \frac{U_2}{Z_p}$$

Modelovanje prijemnika

Trofazni – veza zvezda



$$\underline{Z} = Ze^{j\varphi}$$

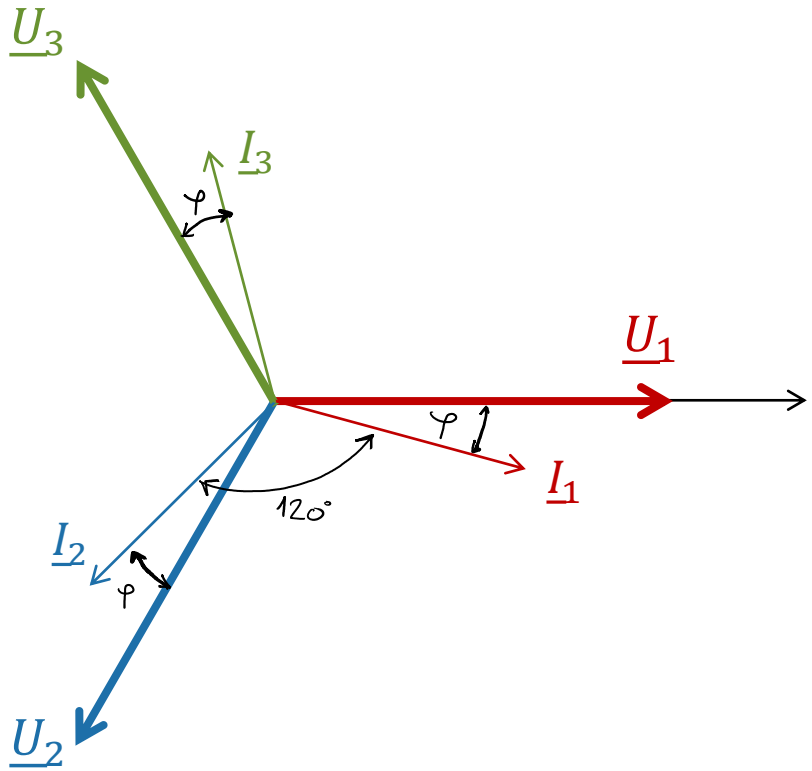
$$\underline{I}_1 = \frac{\underline{U}_1}{\underline{Z}} = \frac{U}{Z}e^{j(\theta_1-\varphi)} = Ie^{j\psi_1}$$

$$\underline{I}_2 = \frac{\underline{U}_2}{\underline{Z}} = \frac{U}{Z}e^{j(\theta_2-\varphi)} = Ie^{j\psi_2}$$

$$= Ie^{j(\psi_1-120)}$$

$$\underline{I}_3 = \frac{\underline{U}_3}{\underline{Z}} = \frac{U}{Z}e^{j(\theta_3-\varphi)} = Ie^{j\psi_3}$$

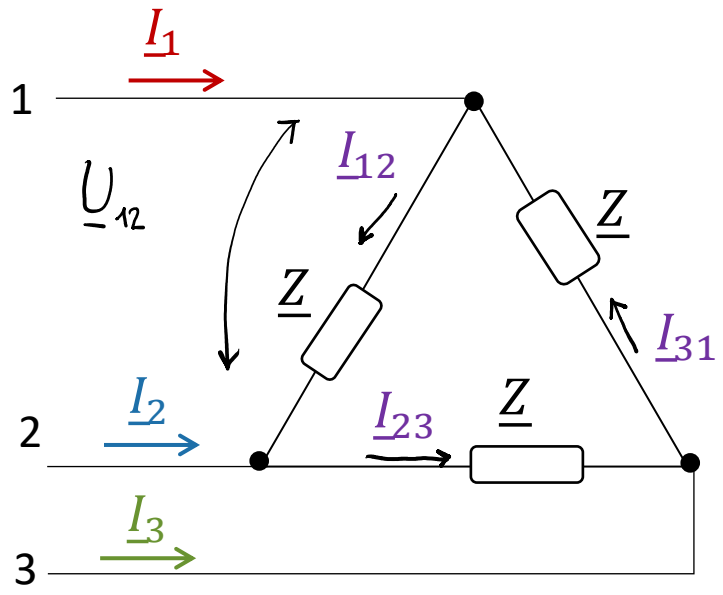
$$= Ie^{j(\psi_1-240)}$$



$\underline{I}_1$ $\underline{I}_2$ $\underline{I}_3$ struje prijemnika

Modelovanje prijemnika

Trofazni – veza trougao



$$\underline{Z} = Ze^{j\varphi}$$

$\underline{I}_{12}$ $\underline{I}_{23}$ $\underline{I}_{31}$ Struje prijemnika

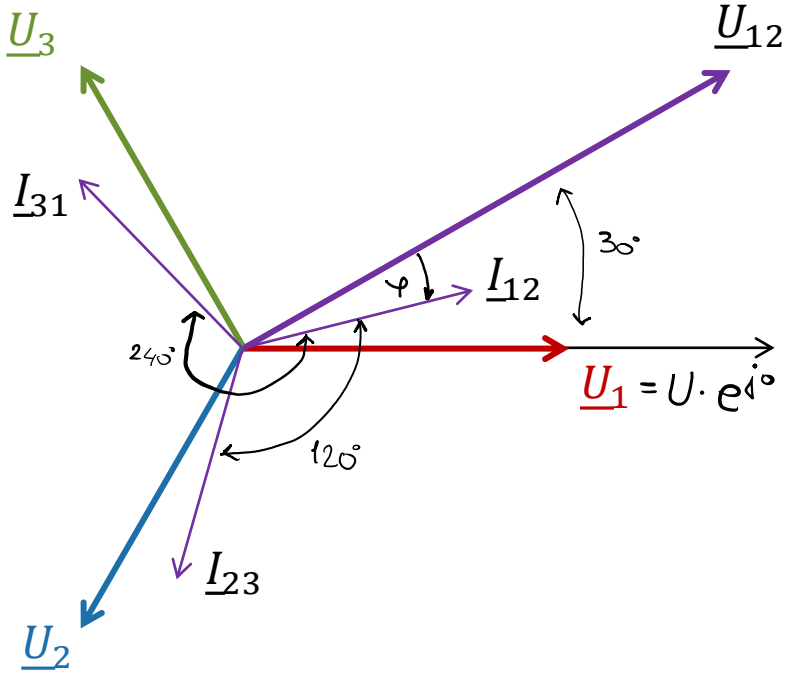
$\underline{I}_1$ $\underline{I}_2$ $\underline{I}_3$ Fazne struje

$$\underline{I}_{12} = \frac{\underline{U}_{12}}{\underline{Z}} = \frac{\sqrt{3}U}{Z} e^{j(\theta_{12}-\varphi)}$$

$$\underline{I}_{12} = I_p e^{j\psi_{12}}$$

$$\underline{I}_{23} = \frac{\underline{U}_{23}}{\underline{Z}} = I_p e^{j\psi_{23}} = I_p e^{j(\psi_{12}-120)}$$

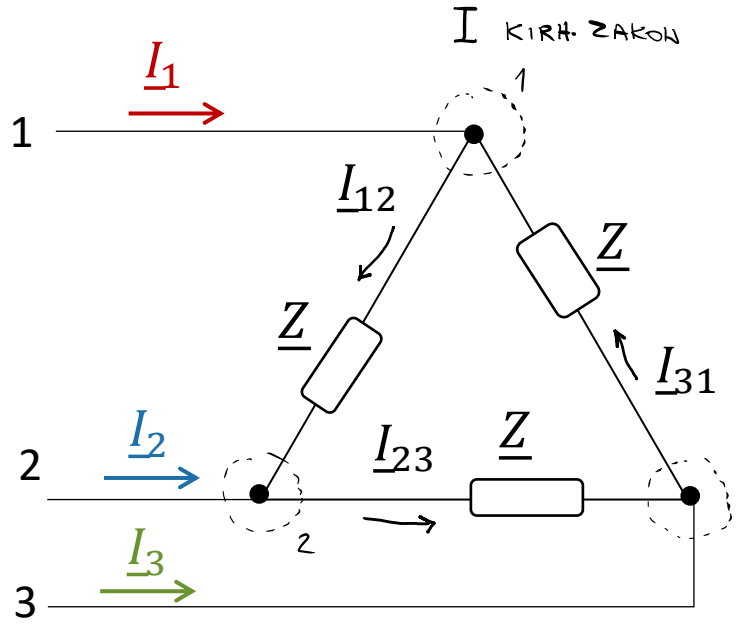
$$\underline{I}_{31} = \frac{\underline{U}_{31}}{\underline{Z}} = I_p e^{j\psi_{31}} = I_p e^{j(\psi_{12}-240)}$$



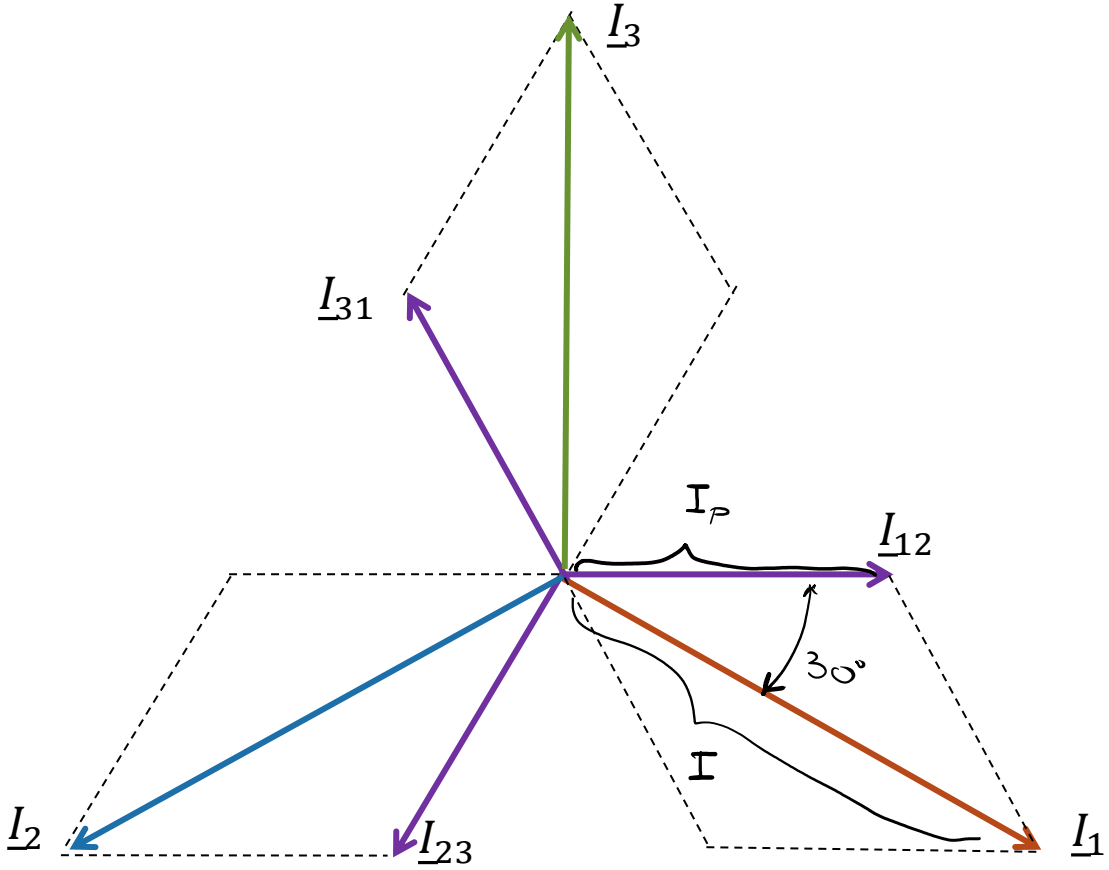
Fazne struje ≠ struje prijemnika

Modelovanje prijemnika

Trofazni – veza trougao



$$\underline{I}_{12} = I_p e^{j\psi_{12}}$$



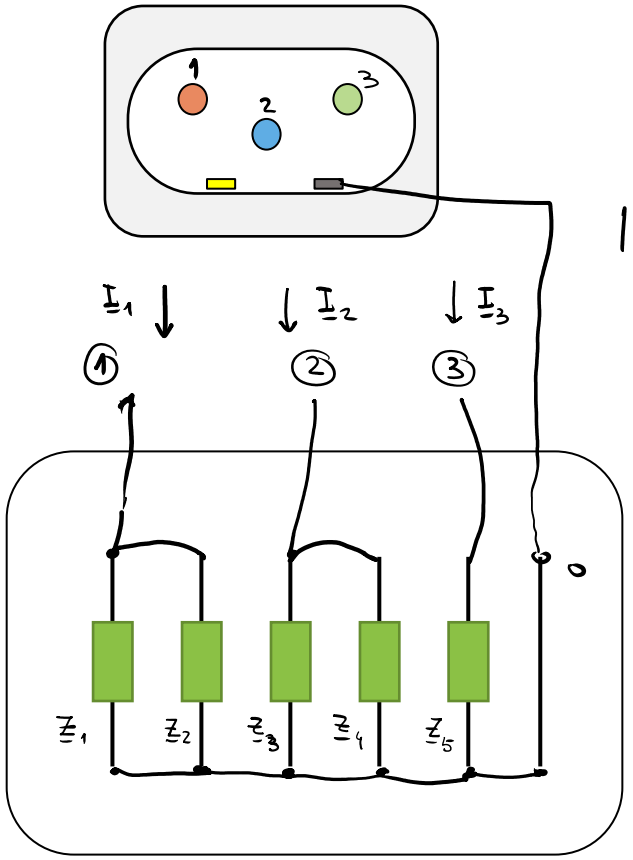
1) $\underline{I}_1 = \underline{I}_{12} - \underline{I}_{31} = Ie^{j\psi_1}$ $\quad \psi_1 = \psi_{12} - 30°$

2) $\underline{I}_2 = \underline{I}_{23} - \underline{I}_{12} = Ie^{j\psi_2} = Ie^{j(\psi_1 - 120°)}$

3) $\underline{I}_3 = \underline{I}_{31} - \underline{I}_{23} = Ie^{j\psi_3} = Ie^{j(\psi_1 - 240°)}$

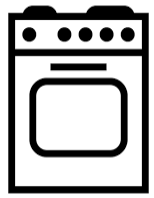
$$I = I_p\sqrt{3}$$

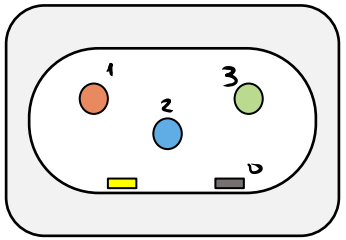
Neuravnoteženi i uravnoteženi 3F prijemnik



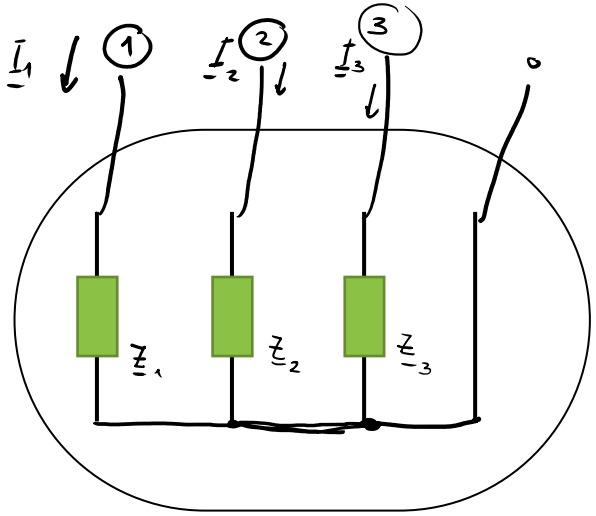
$|\underline{I}_1| \neq |\underline{I}_2| \neq |\underline{I}_3|$

Trofazni – zvezda (neuravnoteženi)

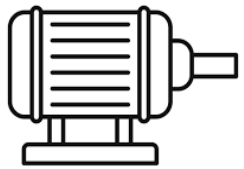




$|\underline{I}_1| = |\underline{I}_2| = |\underline{I}_3|$

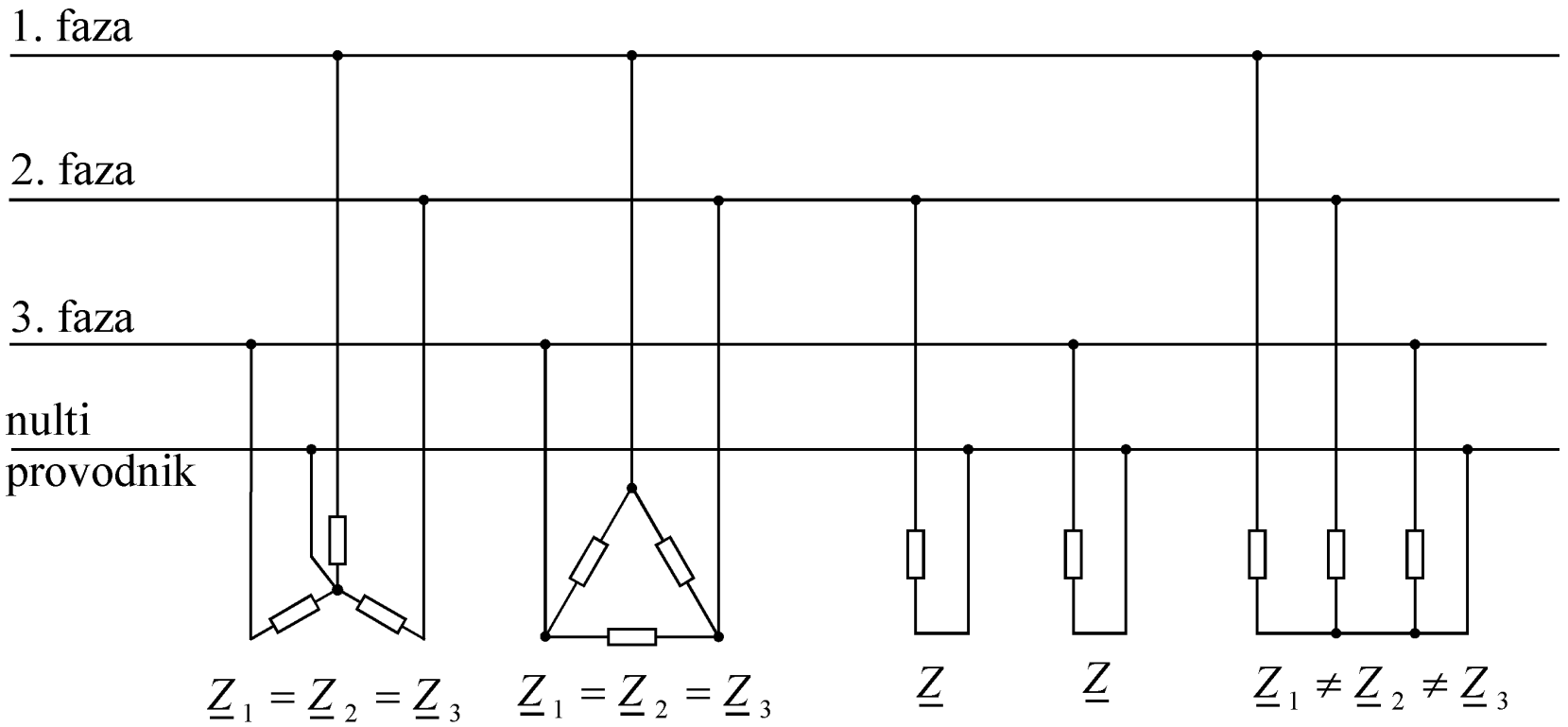


$\underline{Z}_1 = \underline{Z}_2 = \underline{Z}_3$



Trofazni – zvezda (uravnoteženi)

Povezivanje prijemnika



Trofazni - zvezda Trofazni - trougao Monofazni Trofazni – zvezda (neuravnoteženi)