$m_m := 0.015N \cdot m$ Podatak o opterećenju $o := 2 \cdot \pi$

Podaci o prvom motoru

$U_{an1} := 12V$ $I_{an1} := 0.56A$ $n_{n1} := 10500 \frac{o}{min}$

Mathcad može da konvertuje jedince $\omega_{n1} := n_{n1} = 1.1 \times 10^3 \cdot \frac{rad}{s}$

$R_{a1} := 3.6\Omega$ $\psi_{f1} := 0.0089 \frac{N \cdot m}{A}$ $T_{a1} := 0.11ms$ $J_1 := 0.22 \cdot 10^{-6} \cdot kg \cdot m^2$

Podaci o drugom motoru

$U_{an2} := 24V$ $I_{an2} := 0.56A$ $n_{n2} := 9200 \frac{o}{min}$ $\omega_{n2} := n_{n2} = 963.422 \cdot \frac{rad}{s}$

$R_{a2} := 6.3\Omega$ $\psi_{f2} := 0.023 \frac{N \cdot m}{A}$ $T_{a2} := 0.2ms$ $J_2 := 0.58 \cdot 10^{-6} \cdot kg \cdot m^2$

A) Kako motori dele opterećenje ako su priključeni na nominalne napone:

$\omega_{1A} = \omega_{2A} = \omega_A$ Zbog krute mehaničke veze brzine motora su iste.

$\omega_A := 0 \frac{rad}{s}$ $i_{1A} := 0A$ $i_{2A} := 0A$ Početne vrednosti za numeričko rešavanje sistema jednačina

Given

$U_{an1} = \psi_{f1} \cdot \omega_A + R_{a1} \cdot i_{1A}$

$U_{an2} = \psi_{f2} \cdot \omega_A + R_{a2} \cdot i_{2A}$

$m_m = \psi_{f1} \cdot i_{1A} + \psi_{f2} \cdot i_{2A}$

$\begin{pmatrix} i_{1A} \\ i_{2A} \\ \omega_A \end{pmatrix} := Find(i_{1A}, i_{2A}, \omega_A)$ Bez normalizacije je lakše

$i_{1A} = 0.947\ A$ $i_{2A} = 0.286\ A$ $\omega_A = 965.223 \cdot \frac{rad}{s}$

$\frac{i_{1A}}{I_{an1}} = 169.123 \cdot \%$ $\frac{i_{2A}}{I_{an2}} = 51.017 \cdot \%$

C1) Promenom napona napajanja

$n_C := 5000 \cdot \frac{o}{min}$ $\omega_C := n_C = 523.599 \cdot \frac{rad}{s}$

$u_{1C} := 0V$ $u_{2C} := 0V$ $i_{1C} := 0A$ $i_{2C} := 1A$ Početne vrednosti za numeričko rešavanje sistema jednačina

Given

$u_{1C} = \psi_{f1} \cdot \omega_C + R_{a1} \cdot i_{1C}$

$u_{2C} = \psi_{f2} \cdot \omega_C + R_{a2} \cdot i_{2C}$

$m_m = \psi_{f1} \cdot i_{1C} + \psi_{f2} \cdot i_{2C}$

$i_{1C} = \frac{I_{an1}}{I_{an2}} i_{2C}$

$\begin{pmatrix} u_{1C} \\ u_{2C} \\ i_{1C} \\ i_{2C} \end{pmatrix} := \text{Find}(u_{1C}, u_{2C}, i_{1C}, i_{2C})$

$u_{1C} = 6.353\,V$ $u_{2C} = 15.005\,V$ $i_{1C} = 0.47\,A$ $i_{2C} = 0.47\,A$

$\frac{i_{1C}}{I_{an1}} = 83.968 \cdot \%$ $\frac{i_{2C}}{I_{an2}} = 83.968 \cdot \%$

C2) Ukoliko se odlučimo za dodavanje otpora na red, naponi ostaju nominalni

$R_{d1} := 0\Omega$ $R_{d2} := 0V$ $i_{1C} := 0A$ $i_{2C} := 1A$ Početne vrednosti za numeričko rešavanje sistema jednačina

Given

$U_{an1} = \psi_{f1} \cdot \omega_C + \left(R_{a1} + R_{d1}\right) \cdot i_{1C}$

$U_{an2} = \psi_{f2} \cdot \omega_C + \left(R_{a2} + R_{d2}\right) \cdot i_{2C}$

$m_m = \psi_{f1} \cdot i_{1C} + \psi_{f2} \cdot i_{2C}$

$i_{1C} = \frac{I_{an1}}{I_{an2}} i_{2C}$

$\begin{pmatrix} R_{1C} \\ R_{2C} \\ i_{1C} \\ i_{2C} \end{pmatrix} := \text{Find}\left(R_{d1}, R_{d2}, i_{1C}, i_{2C}\right)$

$R_{1C} = 12.01\,\Omega$ $R_{2C} = 19.129\,\Omega$ $i_{1C} = 0.47\,A$ $i_{2C} = 0.47\,A$

$\frac{i_{1C}}{I_{an1}} = 83.968 \cdot \%$ $\frac{i_{2C}}{I_{an2}} = 83.968 \cdot \%$

D) Matematički model pogona

U formi diferencijalnih jednačina

$$\left(R_{a1}\cdot T_{a1}\right)\cdot\left(\frac{d}{dt}i_{a1}\right) = u_{a1} - \psi_{f1}\cdot\omega - R_{a1}\cdot i_{a1}$$

$$\left(R_{a2}\cdot T_{a2}\right)\cdot\left(\frac{d}{dt}i_{a2}\right) = u_{a2} - \psi_{f2}\cdot\omega - R_{a2}\cdot i_{a2}$$

$$\left(J_1 + J_2\right)\cdot\left(\frac{d}{dt}\omega\right) = \psi_{f1}\cdot i_{a1} + \psi_{f2}\cdot i_{a2} - m_m$$

U formi prostora stanja

$$\frac{d}{dt}\begin{pmatrix} i_{a1} \\ i_{a2} \\ \omega \end{pmatrix} = \begin{pmatrix} -\frac{1}{T_{a1}} & 0 & -\frac{\psi_{f1}}{T_{a1}\cdot R_{a1}} \\ 0 & -\frac{1}{T_{a2}} & -\frac{\psi_{f2}}{T_{a2}\cdot R_{a2}} \\ \frac{\psi_{f1}}{J_1 + J_2} & \frac{\psi_{f2}}{J_1 + J_2} & 0 \end{pmatrix}\cdot\begin{pmatrix} i_{a1} \\ i_{a2} \\ \omega \end{pmatrix} + \begin{pmatrix} \frac{1}{R_{a1}\cdot T_{a1}} & 0 & 0 \\ 0 & \frac{1}{R_{a2}\cdot T_{a2}} & 0 \\ 0 & 0 & -\frac{1}{J_1 + J_2} \end{pmatrix}\cdot\begin{pmatrix} u_{a1} \\ u_{a2} \\ m_m \end{pmatrix}$$

Matrica sistema

$$A = \begin{pmatrix} -\frac{1}{T_{a1}} & 0 & -\frac{\psi_{f1}}{T_{a1}\cdot R_{a1}} \\ 0 & -\frac{1}{T_{a2}} & -\frac{\psi_{f2}}{T_{a2}\cdot R_{a2}} \\ \frac{\psi_{f1}}{J_1 + J_2} & \frac{\psi_{f2}}{J_1 + J_2} & 0 \end{pmatrix}$$

Matrica ulaza

$$B = \begin{pmatrix} \frac{1}{R_{a1}\cdot T_{a1}} & 0 & 0 \\ 0 & \frac{1}{R_{a2}\cdot T_{a2}} & 0 \\ 0 & 0 & -\frac{1}{J_1 + J_2} \end{pmatrix}$$