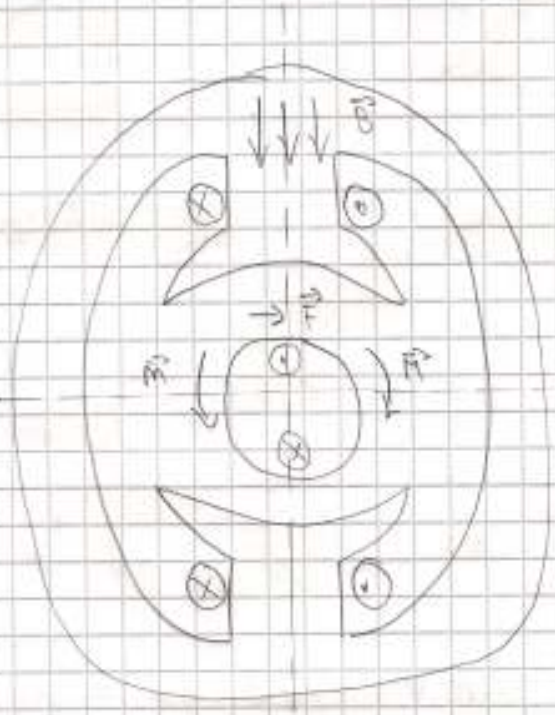
ISTOSMJERNI STROJEVI

ZADACI S AUDITORNIH VJEŽBI:

① - ⑩

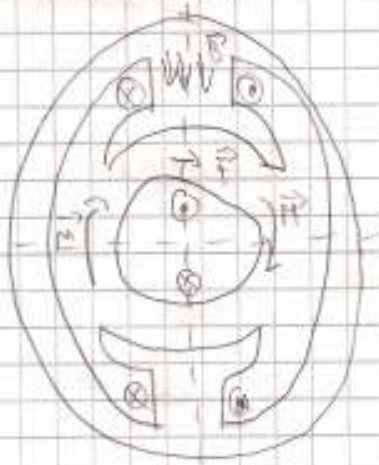
• SKICIRATI PRESJEK 2-POLNOG DC-MOTORA I OBJASNITI SMJEROVE STRUJA U NODIĆIMA:

a) GENERATORSKI REŽIM RADA

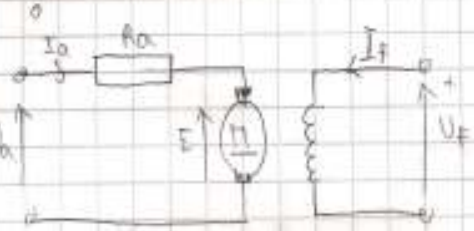


$\vec{F} = I(\vec{l} \times \vec{B})$ [N]

b) MOTORSKI REŽIM RADA:



(2) - (41) DC - NV



$U = 110$ [V]

$R_a = 0.1$ [Ω]

$\Delta U_č = 2$ [V]

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a) $E = 105$ [V]

• REŽIM RADA:

$E = 105$ [V] (2) $U_a = 110$ [V]

MOTORSKI REŽIM RADA $\uparrow P$

• NAPONSKA JEDNAČINA:

$$U_a = I_a R_a + \Delta U_č + E \quad [V]$$

• STRUJA ARMATURE:

$$I_a = \frac{U_a - \Delta U_č - E}{R_a} = \frac{110 - 2 - 105}{0.1} = 30 \text{ [A]}$$

b) $E = 115$ [V]

• REŽIM RADA:

$E = 115$ [V] (>) $U = 110$ [V]

GENERATORSKI REŽIM RADA $\downarrow P$

• STRUJA ARMATURE:

$$I_a = \frac{-U_a - \Delta U_č + E}{R_a} = \frac{-110 - 2 + 115}{0.1} = 30 \text{ [A]}$$

c) $E = 110$ [V]

• REŽIM RADA: $E = 110$ [V] (=) $U = 110$ [V]

PRAZNI HOD

• STRUJA ARMATURE: $I_a = 0$ [A] P_0

(3) (15). DC - NV ↑

$U_0 = 220$ [V].

$n_{P.T.} = 1250$ [°/min]

$I_{a_M} = 25$ [A]

$n_M = 1180$ [°/min]

$I_{a_G} = 25$ [A]

$n_G = ?$

- U PRAZNOM HODU VRIJEDI: $\boxed{E_{PH} = U}$

1) $\boxed{E = \frac{k_e}{2\ell} \Phi \omega = C_E \omega \ [V]}$

2) KUTNA BRZINA U P.H.: $\omega_{PH} = \frac{n_{PH} \cdot \pi}{30} = 130.9 \ [s^{-1}]$

3) KONSTANTA ELEKTROMOTORA C_E:

$$C_E = \frac{E}{\omega} = \frac{E_n}{\omega_{PH}} = \frac{220}{130.9} = 1.681 \left[\frac{V}{s^{-1}}\right]$$

- U MOTORSKOM REŽIMU RADA: $\boxed{E_M < U}$

1) $\boxed{U = I_a R_a + E \ [V]}$

2) INDUCIRANA EMS: $E_M = C_E \cdot \omega_M = C_E \frac{n_M \cdot \pi}{30} = 207.72 \ [V]$

3) OTPOR ARMATURE:

$$R_a = \frac{U - E_M}{I_a} = \frac{220 - 207.72}{25} = 0.491 \ [\Omega]$$

- U GENERATORSKOM REŽIMU RADA: $\boxed{E_G > U}$

1) $\boxed{E_G = U + I_a R_a} = 220 + 25 \cdot 0.491 = 232.275 \ [V]$

1) BRZINA VRTNJE:

$$\omega_G = \frac{E_G}{C_E} = 138.146 \ [s^{-1}] \Rightarrow n_G = \frac{\omega_G \cdot 30}{\pi} = \boxed{1319.4 \ [°/min]}$$

(5) - (83) DC-GENERATOR - SAMOUZBUDNI

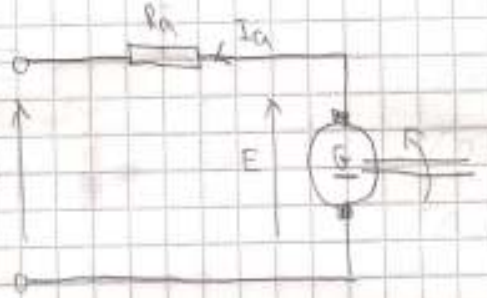
$P_m = 11$ [kW]

$U_a = 220$ [V]

$n_{PH.} = 1318$ [o/min]

$R_a = 0.4$ [Ω]

$\Delta U_č = 1$ [V]



a) ŠTO TREBA UČINITI DA SE GENERATOR NAZIVNO OPTERETI?

• U PRAZNOM HODU: $E_{PH.} = U_a$

1) KONSTANTA EMS:

$E = C_E \cdot \omega_{PH.}$ [V]; $\omega_{PH.} = \frac{n_{PH.} \cdot \pi}{30} = 138.02$ [rad/s]

$C_E = \frac{E}{\omega_{PH.}} = \frac{220}{138.02} = 1.594$ $\left[\frac{V}{rad/s}\right]$

2) NAZIVNA STRUJA:

$I_m = \frac{P_m}{U_a} = \frac{11 \cdot 10^3}{220} = 50$ [A]

b) PRI KOJOJ BRZINI ĆE GENERATOR BITI NAZIVNO OPTEREĆEN?

1) INDUCIRANA EMS PRI NAZIVNOM OPTEREĆENJU:

$E = U_a + I_a R_a + \Delta U_č$ [V]

2) KAD NIJE ZADAN OTPOR R_a ONDA VRIJEDI:

$I_a \approx I_m = 50$ [A]

3) BRZINA PRI NAZIVNOM OPTEREĆENJU:

$E = \omega_m C_E = U_a + I_a R_a + \Delta U_č$ [V]

$\omega_m = \frac{U_a + I_a R_a + \Delta U_č}{C_E} = 139.22$ [rad/s] $\Rightarrow$ $n_m = \frac{\omega_m \cdot 30}{\pi} = 1330$ [o/min]

(6) DC-MOTOR - N.V. 5

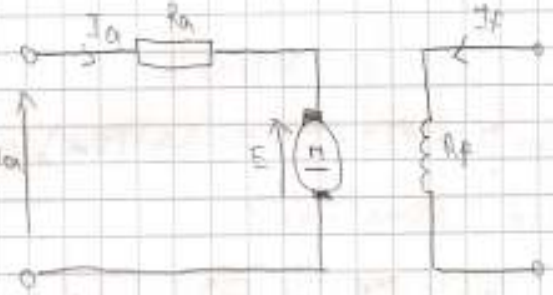
$U_m = 220$ [V]

$I_m = 28$ [A]

$n_m = 1500$ [o/min]

$R_a = 1.5$ [Ω]

$M_t = 25$ [Nm]



a) KOLIKO BRŽINO SE DIGNE MOTOR PRI PODIZANJU TERETA AKO SE PRIKLJUČEN NA U_m ?

- PRI NAZIVNOJ BRŽINI:

1) INDUCIRANA EMS:

$$E = U_m - I_m R_a = 220 - 28 \cdot 1.5 = 178 \text{ [V]}$$

2) KONSTANTA EMS:

$$C_E = \frac{E}{\omega_m} = \frac{E}{\frac{n_m \pi}{30}} = 1.13$$

- PRI PODIZANJU TERETA:

1) STRUJA ARMATURE?

$$I_a = \frac{M_t}{C_E} = \frac{M_{em}}{C_m} = \frac{25}{1.13} = 22.124 \text{ [A]}$$

2) BRZINA VRTNJE PODIZANJA TERETA PRI U_m:

$$\omega_t = \frac{U_m - I_a R_a}{C_E} = \frac{220 - 22.124 \cdot 1.5}{1.13} = 165.82 \text{ [A]}$$

$$n_t = \frac{\omega_t \cdot 30}{\pi} = 1578.4 \text{ [o/min]}$$

b) KOLIKO BI TREBAO IZNOSITI NAPON ARMATURE, DA BI SE PRI PODIZANJU TERETA MOTOR VRTIO SA 50% n_m UZ POVEĆANJE M_t ↑ 20 [%] ?

• PRI 50 % n_m: $n_t = 0,5 \cdot 1500 = 750$ [1/min] $\Rightarrow \omega_t = \frac{750 \cdot \pi}{30} = 78,54$ [rad/s]

1) MOMENT TERETA:

$M_t = 1,2 \cdot 25 = 30$ [Nm]

2) STRUJA ARMATURE:

$I_a = \frac{M_t}{C_e} = \frac{30}{1,93} = 26,548$ [A]

3) INDUCIRANA EMS:

$E = C_e \cdot \omega_t = 88,75$ [V]

4) NAPON ARMATURE:

$U_a = I_a R_a + E$ [V]

$= 26,548 \cdot 1,5 + 88,75 = 128,57$ [V]

c) KOLIKI PROTOK SE POTREBNO DOBITI DA BI MOTOR RAZVIJAO BRZINU S 50 % n_m, PRI NAZIVNOM NAPONU?

$n_m \cdot 50\,\% = 1500 \cdot 0,5 = 750$ [1/min] $\Rightarrow \omega_m = 78,54$ [rad/s]

• STRUJA ARMATURE:

$I_a = \frac{M_t}{C_e} = 22,194$ [A]

• INDUCIRANA EMS:

$U_a = -E_{R.S.} + I_a (R_a + R_{dod})$

$E_{R.S.} = C_e \cdot \omega_m = 1,93 \cdot 78,54 = 88,75$ [V]

$R_{dod} = \frac{U_a + E_{R.S.} - I_a R_a}{I_a} = 12,458$ [Ω]

(7) DC - MOTOR - SERIJSKA VZBUDA

$P_m = 8$ [kW]

$U_m = 110$ [V]

$I_m = 90$ [A]

$n_m = 600$ [^{0}/min] $\Rightarrow$ $\omega_m = \frac{600 \cdot \pi}{30} = 20\pi = 62.83$ [rad/s]

$R_a = 0.11$ [Ω]

$R_f = 0.05$ [Ω]

I_I[A]	36	54	72	90	107	126	144	180
n_I[^{0}/min]	960	740	655	600	560	535	510	465

a) POTREBNO JE ODREDITI PRED OTPOR V DVA STOPNJA:

I) $n_I = 500$ [^{0}/min] ; $I_a = 90$ [A]

II) $n_{II} = 320$ [^{0}/min] ; $I_a = 90$ [A]

1) INDUCIRANA EMS PRI n_m:

$$E = U_m - I_m (R_a + R_f) = 110 - 90(0.11 + 0.05) = 94.7 \text{ [V]}$$

2) KONSTANTE EMS ZA SERIJSKI VZBUJALNI:

$$\boxed{E = k_\Phi \Phi N = k_e k_\Phi I_a \omega_m \text{ [V]}}$$

$$k_e k_\Phi = \frac{E}{I_a \omega_m} = \frac{94.7}{90 \cdot 62.83} = 0.0167$$

3) INDUCIRANA EMS PRI n_I:

$$E = k_e k_\Phi I_a \omega_I = k_e k_\Phi I_a \frac{n_I \pi}{30} = 78.91 \text{ [V]}$$

4) NAPONSKA ENAČBA:

$$U_a = E + I_a (R_a + R_f + R_{dod}) \text{ [V]}$$

$$R_{dod_I} = \frac{U_a - E - I_a (R_a + R_f)}{I_a} = \frac{110 - 78.91 - 90(0.11 + 0.05)}{90}$$

$$= 0.173 \text{ [}\Omega\text{]}$$

b) KOLIKI JE OTPOR POTREBNO DKLJUČITI DA BI PRI KRETANJU NIZBRDICOM MOTOR SUPROTSTAVLJA KRETANJU MOMENTOM OD 50 [Nm] NA OSOVINI PRI $n = 750$ [o/min], MOMENT TRENJA IZNOSI $M_{trn} = 4,7$ [Nm]

$M_{os} = 50$ [Nm]

$M_{trn} = 4,7$ [Nm]

- MOMENT MOTORA: $M_{em} = M_{os} - M_{trn} = 45,3$ [Nm]

- MOMENT TERETA JEDNAK JE MOMENTU MOTORA PRI KONSTANTNOJ BRZINI I_0 $\boxed{M_{em} = M_t}$ $\cdot \omega = konst. \Rightarrow \Phi_0$

- KONSTANTNA EMS:

- PROIZVOLJNA TAČKA U NEZASIĆENOM PODRUČJU: $< I_m$

$I_a = 5$ [A]

$n = 750$ [o/min] $\Rightarrow \omega = \frac{750 \cdot \pi}{30} = 77,5$ [rad/s]

- INDUKOVANA EMS:

$E = V_a - I_a (R_a + R_d) = 100 - 5 \cdot 0,1 = 100,82$ [V]

- KONSTANTA EMS:

$k_e \Phi_0 = \frac{E}{\omega I_a} = \frac{100,82}{77,5 \cdot 5} = 0,024$

- STRUJA ARMATURE PRI $M_t = 45,3$ [Nm]

$\boxed{M_t = I_a^2 \cdot k_e k_\Phi \cdot$ [Nm]$}$

$I_0 = \sqrt{\frac{M_t}{k_e k_\Phi}} = 43,38$ [A]

IZNOS PREDOTPORA : - PROTUSTRUJNO KOČENJE

$V_a = -E_{a2} + I_a (R_a + R_f + R_{dod})$ [V]

$E = k_e k_\phi I_a \omega = 0{,}029 \cdot 43{,}38 \cdot \frac{130 \cdot \pi}{30} = 16{,}346$ [V]

$$R_{dod} = \frac{U_a + E_a - I_a (R_a + R_f)}{I_a} = \frac{110 + 16{,}346 - 43{,}38 \cdot 0{,}14}{43{,}38}$$

$= 2{,}75$ [Ω]