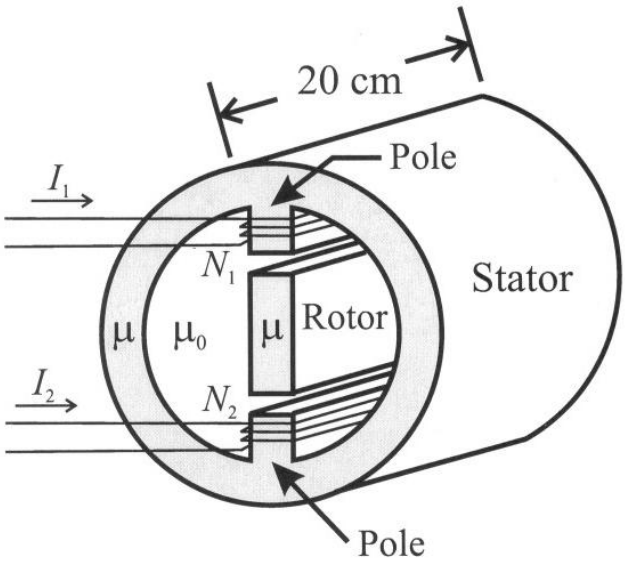
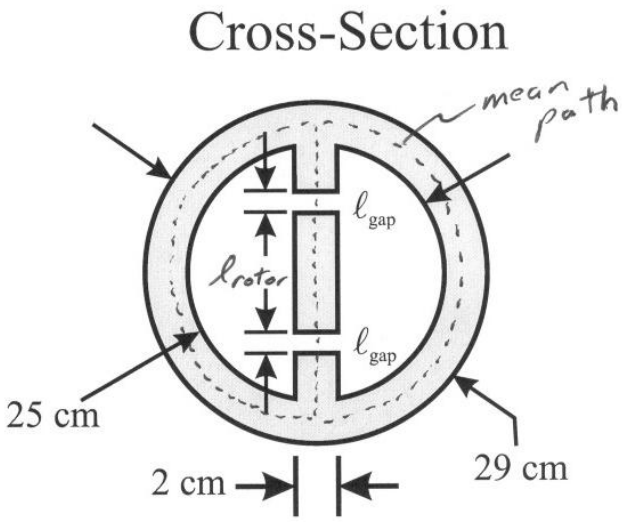
ex. Motor Magnetic Circuit





Given: $\mu = 5000\mu_0$ for rotor & stator

$\ell_{gap} = 2\,mm$

$\ell_{rotor} = 21cm$

Assume: $I_1 = I_2 = I$ and $N_1 = N_2 = N$

→ Typical for motors to be "balanced"

Calculate the mmf(s) required to achieve $\Psi_{rotor} = 5 \times 10^{-3}\,Wb = 5\,mWb$. Then, select I and N given the requirement that the current $I \leq 80\%$ of $15A = 12A$

ex. cont.

Calculate reluctances for equivalent magnetic circuit

$$\mathcal{R}_{rotor} = \frac{l_{rotor}}{\mu S_{rotor}} = \frac{21\times10^{-2}}{5000\,\mu_0\,(2\times10^{-2})(20\times10^{-2})}$$

$$\mathcal{R}_{rotor} = 8355.6345 \ \text{A·t/wb}$$

$$\mathcal{R}_{gap} \ (2\ \text{gaps}) = \frac{l_{gap}}{\mu_0 S_{gap}} = \frac{2\times10^{-3}}{(4\pi\times10^{-7})\left[(2\times10^{-2}+2\times10^{-3})(20\times10^{-2}+2\times10^{-3})\right]}$$

$$\mathcal{R}_{gap} = 358{,}134.4354 \ \text{A·t/wb}$$

$$\mathcal{R}_{pole} \ (2\ \text{poles}) = \frac{l_{pole}}{\mu S_{pole}} = \frac{\left[\frac{\left(\frac{29\times10^{-2}+25\times10^{-2}}{2}\right)}{2} - \frac{21\times10^{-2}}{2} - 2(2\times10^{-3})\right]}{5000(4\pi\times10^{-7})(2\times10^{-2})(20\times10^{-2})}$$

(27×10^{-2} ← mean diameter; rotor diameter; gaps)

$$\mathcal{R}_{pole} = \frac{0.028}{2.5133\times10^{-5}} = 1114.0846 \ \text{A·t/wb}$$

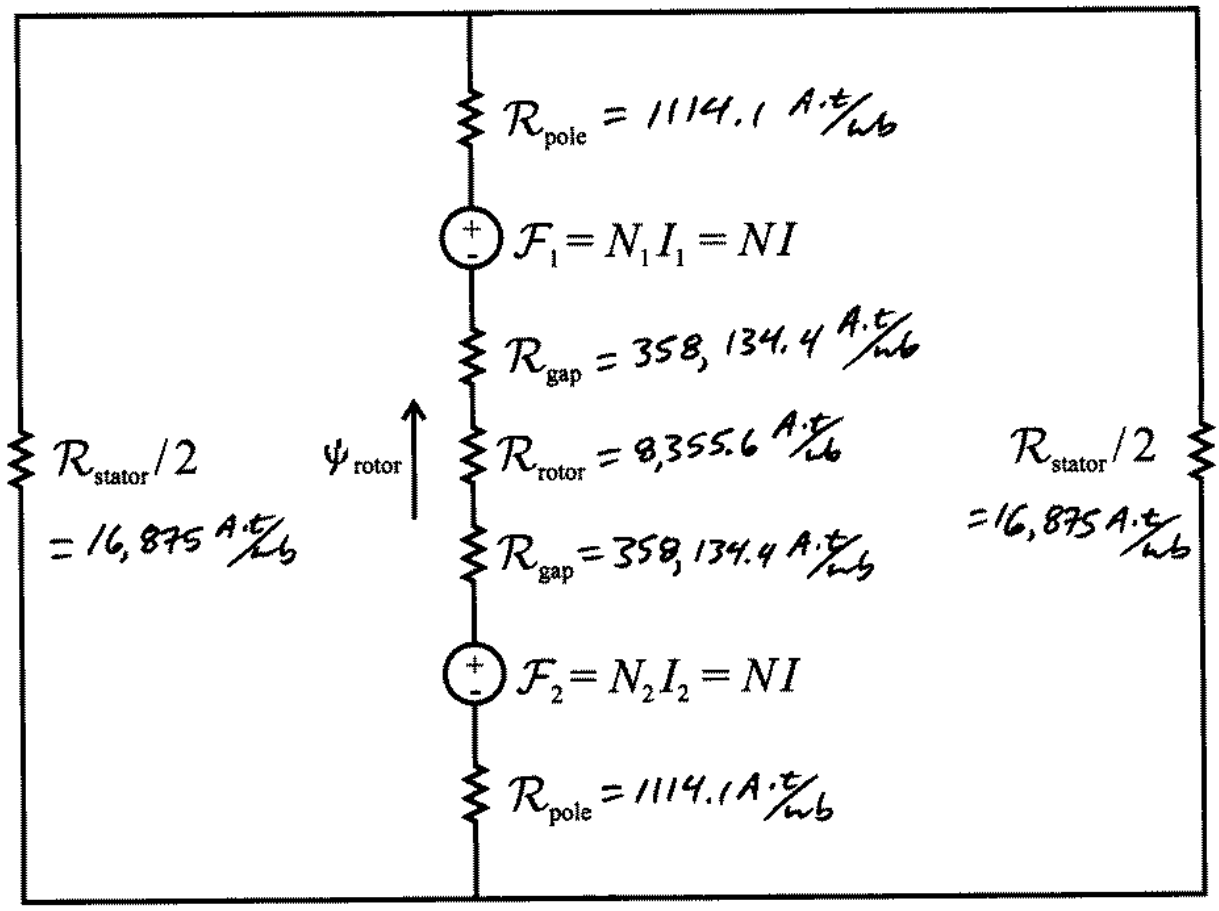
$$\frac{\mathcal{R}_{stator}}{2} = \frac{\left(\frac{\text{mean circumference}}{2}\right)}{\mu S_{stator}} = \frac{\frac{\pi(27\times10^{-2})}{2}}{5000(4\pi\times10^{-7})\left(\frac{29\times10^{-2}-25\times10^{-2}}{2}\right)(20\times10^{-2})}$$

↑ each half of stator

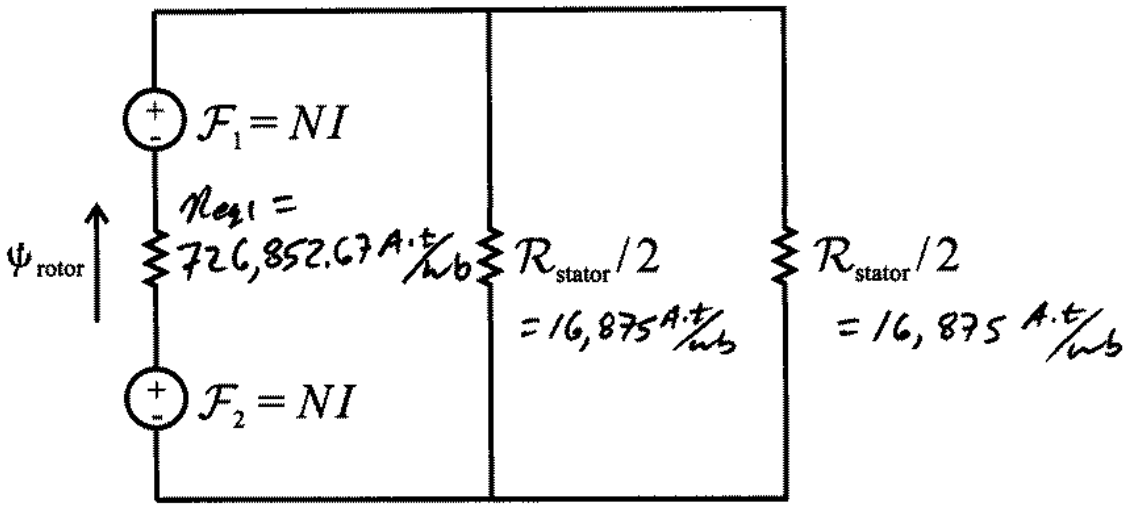
$$= \frac{0.424115}{2.5133\times10^{-5}}$$

$$\frac{\mathcal{R}_{stator}}{2} = 16{,}875 \ \text{A·t/wb}$$

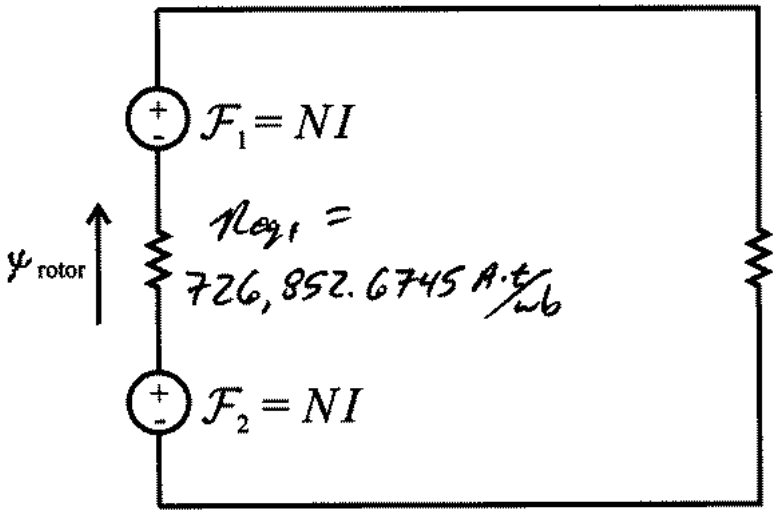
ex. cont. Equivalent Magnetic Circuit



Simplify



ex. cont.



$$\mathcal{R}_{eq2} = \frac{\mathcal{R}_{stator}}{2} \,//\, \frac{\mathcal{R}_{stator}}{2} = 8437.5 \ \frac{A\cdot t}{wb}$$

Apply KVL (go in CW direction)

$$-NI + \psi_{rotor}(726,852.6745) - NI + \psi_{rotor}(8437.5) = 0$$

→ substitute $\psi_{rotor} = 5 \times 10^{-3}$ wb into eq'n to get

$$\mathcal{F} = NI = \frac{(5\times10^{-3})[726,852.6745 + 8437.5]}{2}$$

$$= 1838.225 \ A\cdot t$$

Choose $I = 12A$, then the number of turns is

$$N = \frac{1838.225}{12} = 153.185$$

Since N must be an integer, choose

$$\underline{N = 154} \quad \text{and} \quad \underline{I = 11.9365\,A} = \frac{1838.225}{154}$$