ELEC344 Assignment 2

Kelvin Hsu

April 6, 2019

1)

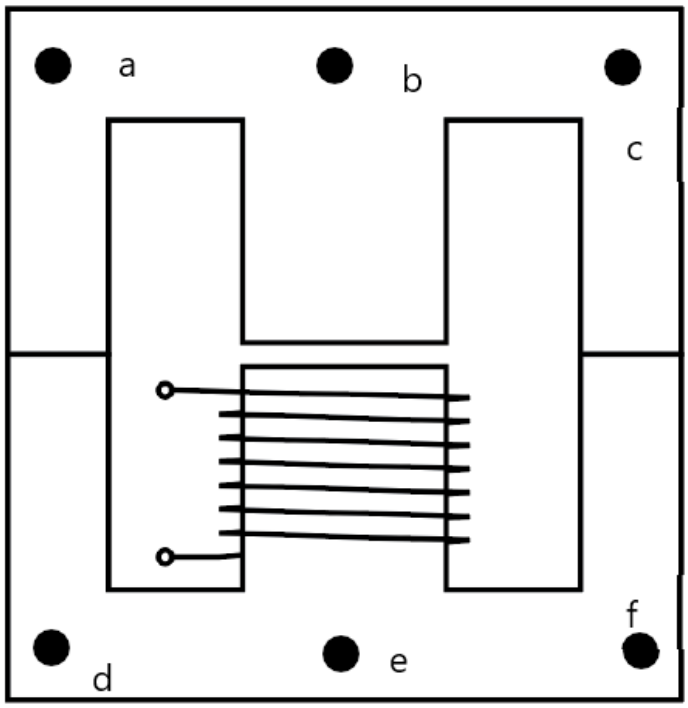


Fig. 1 – EE figure

a.

$$R_{air} = \frac{l}{\mu A} = \frac{10^{-3}}{7.5 * 10^{-3} * 7.5 * 10^{-3} * 4\pi * 10^{-7}} = 1414710.605$$

$$R_{becore} = \frac{l}{\mu A} = \frac{2 * 10.25 * 10^{-3}}{7.5 * 10^{-3} * 7.5 * 10^{-3} * 4\pi * 10^{-7} * 1620} = 179.022$$

$$R_{ac} = \frac{l}{\mu A} = \frac{21.25 * 10^{-3}}{7.5 * 10^{-3} * 4.1 * 10^{-3} * 4\pi * 10^{-7} * 1620} = 186881.5244$$

$$R_{af} = \frac{l}{\mu A} = \frac{21.5 * 10^{-3}}{3.75 * 10^{-3} * 7.5 * 10^{-3} * 4\pi * 10^{-7} * 1620} = 186881.5244$$

$$
\begin{aligned}
R_{total} &= R_{air} + R_{be_core} + [(R_{ac} + R_{af})||(R_{ac} + R_{af})] \\
&= R_{air} + R_{be_core} + \frac{(R_{ac} + R_{af})}{2} \\
&= \boxed{14683613(AT/W)} \\
A_L &= \frac{1}{R_{total}} = 6.8 * 10^{-8}
\end{aligned}
$$

b.

$$
\begin{aligned}
Li &= N\Phi \\
L &= 0.00004256H
\end{aligned}
$$

c.

$$
\begin{aligned}
L &= \frac{N\Phi}{i} \\
B &= 390mT \\
i &= \frac{NBA}{L} = 12.89A
\end{aligned}
$$

d.

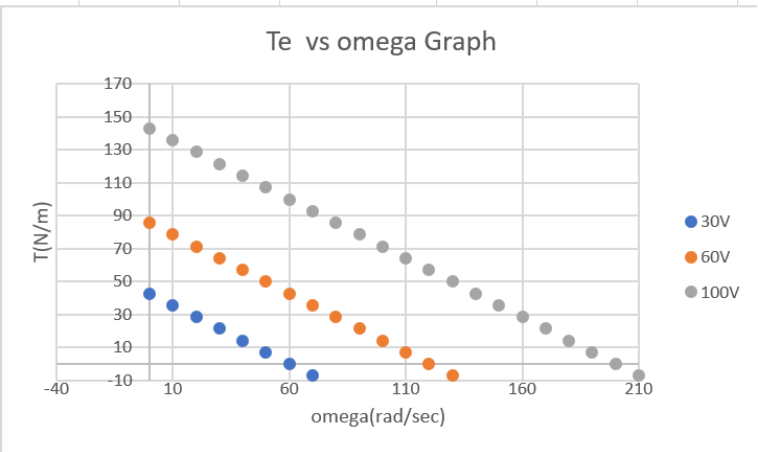
When current exceeds the maximum current, the core is saturated and the reluctance increases.(the slope of B-H graph decrease to μ_{air}). Consequently, the inductance decreases since $L = \frac{N^2}{R}$.

3

a.

$$V_a = e_a + i_a R_a + L_a \frac{di_a}{dt}$$
$$T_e = J_L \frac{d\omega_m}{dt} + B_L \omega + T_L$$
$$\frac{d\omega_m}{dt} = 0$$
$$\frac{di_a}{dt} = 0$$
$$V_a = e_a + i_a R_a$$
$$i_a = \frac{T_e}{k_T}$$
$$e_a = k_e \omega_m$$

$$\boxed{T_e = \frac{k_T}{R_a}[V_a - k_e \omega]}$$



b.

$$V_a = 0.5\frac{V}{rad * s} * 157 rad/s + \frac{3Nm}{0.5Nm/A} * 0.35\Omega$$
$$= 80.6V$$

4

a)

$$Z_1 = (jX_m)||(\frac{R_2}{s} + jX_{e2})$$
$$Z_1 = 2.47\angle 18.98$$
$$Z_{total} = R_1 + jX_e + Z_1 = 2.84\angle 25.76$$
$$i_{stator} = \frac{V_{source}}{Z_{total}} = \boxed{42.24\angle -25.76}$$

$$P_{copper} = 3 * I_{stator}^2 * R_1 = \boxed{1178W}$$

b)

$$P_{ag} = E_{ag} \cdot I_{rotor} \cdot 3 = 3 * I_{stator}^2 * Z_1 = \boxed{12500W}$$
$$\frac{P_{em}}{P_{ag}} = (1-s)s = 0.95$$
$$\boxed{P_{em} = 11880W}$$

c)

$$P_{rotor_loss} = P_{ag} - P_{em} = \boxed{620W}$$

$$\omega_{synchronous} = \frac{2}{p} * 2\pi f = 288.49 rad/s$$
$$T_{em} = \frac{P_{em}}{\omega_{synchronous}} = \boxed{66.3Nm}$$

$$P_{out} = 3 \cdot 120 \cdot 42.25 cos(-25.76) - 1178 - 0.2k - 0.62k - 0.3k = 11.4k$$
$$T_L = \frac{P_{out}}{\omega_m} = \frac{P_{out}}{(1-s)\omega_{synchronous}} = 63.73Nm$$

d)

$$\frac{P_{out}}{P_{in}} = 83.2\%$$

e)

$$\omega_m = (1-s)\omega_{synchronous} = 179 rad/s = 1709 RPM$$