University of Utah

Department of Electrical & Computer Engineering

ECE 5570 **Control of Electric Motors** **Fall 2010**

Homework#1 – Due September 3, 2010

1. Courses notes. Problem 1.1.

2. The side view of an electric machine's rotor is shown in Fig. 1. The stator is built so that a flux enters the rotor in the lower half of the rotor, and exits in the upper half. The magnetic flux density vector is perpendicular to the surface of the rotor and has a constant magnitude of 1.2T. 16 conductors are placed along the surface of the rotor and each carries a current of magnitude 2A. As shown on the figure, the direction of the current is away from the viewer in the upper half of the rotor, and towards the viewer in the lower half. The distance between the conductors and the center of rotation is 0.6 in and the length of the rotor is 2.25 in.

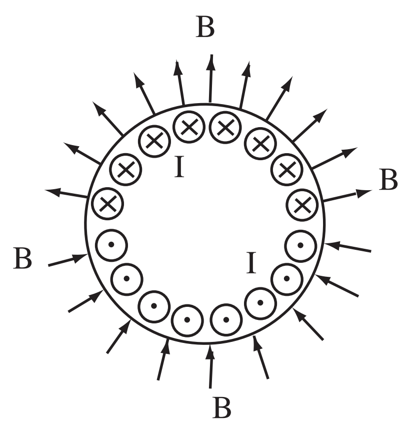

Figure 1: Motor for problem 2

a) what torque does the motor produce (in N.m and in oz.in). Is the torque direction clockwise or counterclockwise?

b) a weight is attached to a pulley as shown in Fig. 1.6 of the course notes. The diameter of the pulley is 0.6 in. What mass (in kg) can the torque of part a) hold in place?

c) a weight equal to 1/2 of the weight computed in part b) is attached to the pulley. The inertia of the motor and pulley (not including the weight) is equal to $J = 5\ 10^{-5}$ kg.m^2. Assume that the current is such that the torque is equal to the torque computed in part a) and pulls the weight upwards. At what acceleration will the motor rotate at the initial time (in rad/s^2) and at what acceleration will the mass move upwards (in m/s^2)?

3. Courses notes. Problem 1.2.

4. Consider the equations of a transformer with primary winding labelled "1" and secondary winding labelled "2"

$$
\begin{aligned}
L_1 \frac{di_1}{dt} + M \frac{di_2}{dt} &= v_1 - R_1 i_1 \\
M \frac{di_1}{dt} + L_2 \frac{di_2}{dt} &= v_2 - R_2 i_2
\end{aligned}
\tag{1}
$$

Assume that the windings are perfectly coupled, so that $L_1 L_2 = M^2$.

a) Show that there is a constant ρ such that the change of variables

$$
M' = \frac{M}{\rho}, \quad v_2' = \frac{v_2}{\rho}, \quad R_2' = \frac{R_2}{\rho^2}, \quad i_2' = \rho i_2 \tag{2}
$$

makes the transformer equations equivalent to the circuit shown in Fig. 2.

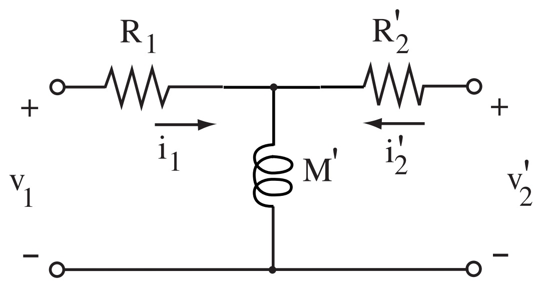

Figure 2: Equivalent circuit for problem 4

b) Assume that a load with impedance $Z(s)$ is placed at the secondary. Use the equivalent circuit to compute the transfer function $H_1(s)$ from v_1 to v_2' and the transfer function $H_2(s)$ from i_1 to i_2'. Show that the transfer functions reduce to fixed gains when $R_1, R_2' \to 0$ for $H_1(s)$ and when $M' \to \infty$ for $H_2(s)$. Compute the gains for the original variables v_2/v_1 and i_2/i_1 in terms of the constants R_1, R_2, L_1 and M.

5. Courses notes. Problem 1.3. (a) to (e).

6. Courses notes. Problem 1.4.