Massachusetts Institute of Technology

Department of Electrical Engineering and Computer Science

6.685 Electric Machinery

Quiz 1 **One Crib Sheet Allowed** **November 6, 2013**

There is space for you to write your answers on this quiz.
There are four problems on this quiz. They have equal weight

Problem 1: Induction Motors

The single phase equivalent circuit of a three-phase, four pole induction motor is shown in Figure 1. For the purposes of this problem we will assume armature resistance is negligible. The machine is connected to a three-phase voltage source with line-neutral voltage of 200 volts, RMS (346 volts, line-line) and a frequency of 400 radians/second. The motor reaches peak torque at a speed of 160 Radians/second (about 1528 RPM).

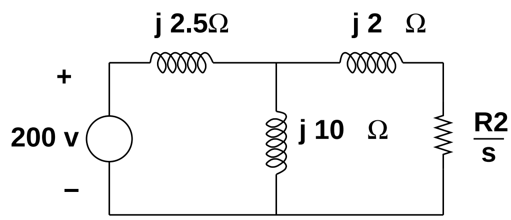

Figure 1: Induction Motor Equivalent Circuit

1. What is the value of that peak torque (in N-m)?

2. What is the value of R_2? (in Ω)

Problem 2 DC Machines

A permanent magnet DC motor is connected to a 250 Volt (DC) source. Running 'light' (no mechanical load), it draws negligible current and turns at a speed of 200 Radians/second. (about 1910 RPM). The armature circuit of the machine has a resistance of one Ω. Now the machine is loaded so that it is driving a load torque of 100 N-m, still connected to the 250 VDC source.

1. How much current is it drawing?

2. How fast is it turning?

Problem 3 Time constants

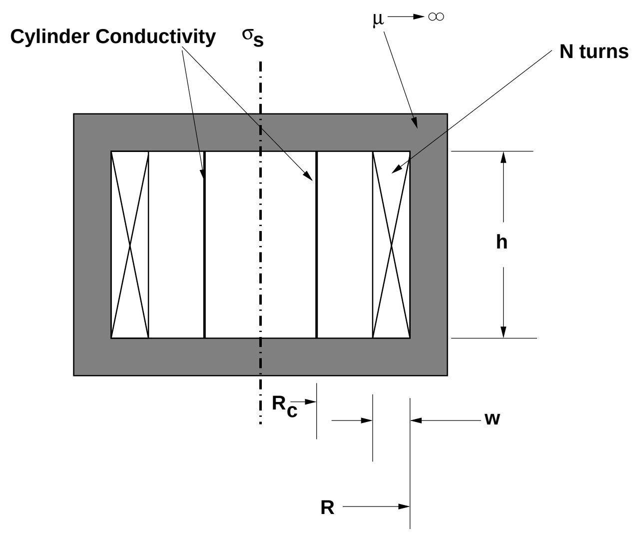

Figure 2: Pot Core with Coil and Shell Inside

Shown in Figure 2 is a pot core with two elements inside: a coil with N turns is located at the outer radius of the cavity within the core. The other thing is a conductive shell of radius R and height h, which just fits inside the axial dimension of the cavity. The shell is thin and has surface conductivity σ_s.

For the purpose of this problem, we are in a universe in which $\frac{1}{\mu_0} = 800,000$. The coil has 1,000 turns, the cylinder radius is $R_c = 10$cm and the coil radius is $R = 20$cm. Height of both elements and of the inside of the pot core is $h = 10$cm.

1. Assuming the coil is radially 'thin', and ignoring the conductive cylinder, what is the coil inductance?

2. Now: assuming the conductive cylinder is 'perfectly diamagnetic', meaning zero flux can penetrate it, as you would have with infinite cylinder conductivity, what is the coil inductance?

3. Assuming that the cylinder has surface conductivity of 80,000 S (reciprocal ohms), and the coil is driven by a step of 10 A, what is the magnetic field *inside* of the cylinder, as a function of time?

Problem 4 Synchronous Machine

A three-phase, two pole synchronous machine has the following characteristics:

Rated Power	P_B	3	MVA
Rated Voltage	V_B	1	kV (Peak)
Synchronous Inductance	$L_a - L_{ab}$	2.5	mH
Field to Phase Mutual Inductance	M	25	mH
Synchronous Frequency	ω_0	400	Radians/Second

Assume that armature resistance is negligible.

1. On no-load, open-circuit test at rated speed, what field current is required to produce rated voltage?

2. On short-circuit test, what field current is required to produce rated current?

3. Running at rated speed, with field current $I_f = 300A$ and with rated armature terminal voltage (1,000 V, *Peak*, what is the *peak* torque the machine can produce?

4. Running at rated speed with field current $I_f = 300A$ and with the armature driven by a balanced three-phase current of $I_a = 3,000A$, *Peak*, what is the maximum *peak* torque that the machine can produce?

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