EE321 Exam 2
Spring 2009

Notes**: Write your name and ID on blue book. This part of exam will be recycled.**

You must show work for credit, except for problem 1.

A score of 60% on this exam satisfies ABEST objectives 1,2,4, and 5.

Good luck !

The following questions should be answered true or false. They are worth 2 pts. each. You do not need to show work.

1a) $N_{cr,3}$ describes the number of turns around slot 3 of the c-phase of the rotor.
1b) The number of poles can be found from the winding function
1c) A pm dc machine cannot be connected directly to an ac source and expected to operate
1d) A series connected dc machine cannot be connected directly to an ac source and expected to operate
1e) DC machines would be a poor choice for use in a petroleum plant
1f) Conduction losses limit switching frequency
1g) A two-quadrant converter eliminates discontinuous mode
1h) A pm dc machine has a smaller operating range in terms of capability curve than a separately excited machine with the same maximum torque capability.
1i) Multistack variable reluctance stepper motors have significant mutual inductance between phases.
1j) Changing stator position by $4\pi / P$ in a P-pole machine brings you to a point where the fields would be the same.

On the remaining problems, show your work !

2.) 20 pts. The conductor density of the b-phase of a machine is given by

$$n_{bs} = 100 \sin(8\phi_{sm} - 2\pi / 3)$$

How many b-phase turns go around the stator position $\phi_{sm} = 0.2$ radians ?

3.) 20 pts. Consider a PM dc machine fed from a dc/dc converter. The machine parameters are $k_v = 1$ Vs, $L_{aa} = 1$ mH, $r_a = 5$ mΩ. The machines is fed from a single-quadrant dc/dc converter (buck converter) as we discussed in class. The dc source is 250 V, the forward switch drop is 2 V, and the forward diode drop is 1.5 V. The load torque may be expressed

$$T_L = K_\omega \omega_r^3$$

where ω_r is in rad/s, and $K_w = 10^{-5}$ Nms^3. The switching frequency is 25 KHz. It is desired to operate at 2000 rpm. Find

(a) The required duty cycle (10 pts)
(b) The current ripple at that operating point (5 pts)
(c) The transistor conduction losses at that operating point (5 pts)

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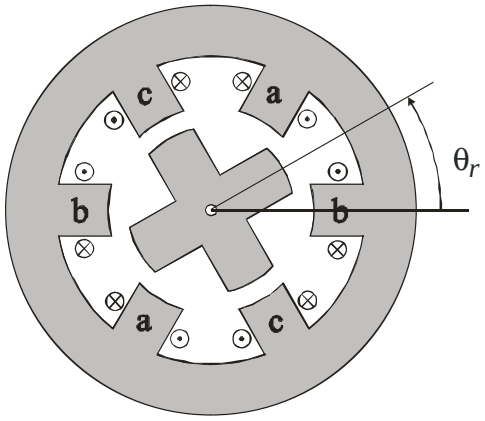
4.) 20 pts. Consider the single-stack variable reluctance stepper motor below. Note the way the phases are labeled. The maximum inductance seen by a phase is 5 mH. The minimum inductance is 2 mH. If the a-phase is energized with -5 A, and the rotor position is 0.1 rad, what is the electromagnetic torque? Note the labeling of the phases.



5.) 20 pts. Consider the elementary dc machine below. There is no current in the winding aa'. Suppose that the maximum mutual inductance between the aa' winding and the fd winding is 10 mH. Suppose that the field current and rotor position are given by

$$i_{fd} = 1000\,t - 999$$

$$\theta_r = 0.1 + 1000t - 1000$$

where t is time in seconds, i_{fd} is in Amps, and θ_r is in radians. Compute the voltage across the aa' winding at $t = 1\text{s}$.