# EE595S
# Fall 2003
# Exam 1

Problem 1 (20 pts)

The 'instantaneous magnitude' of a three phase $\mathbf{f}_{abc}$ is defined as

$$\left|\mathbf{f}_{abc}\right| = \frac{1}{\sqrt{6}}\sqrt{f_{as}^2 + f_{bs}^2 + f_{cs}^2}$$

Express $\left|\mathbf{f}_{abc}\right|$ in terms of qd0 variables.

Problem 2 (10 pts)

At an instant of time the a- to b-phase line-to-line voltage across a PMSM is 100 V, and the b- to c-phase voltage is 50 V. If the electrical rotor position is 30 degrees, what is the instantaneous value of q- and d-axis voltage.

Problem 3 (10 pts)

The inverter has a transistor with a 2.5 V forward drop, and a diode with a 1 V forward drop. Given that the dc voltage is 100 V, that either the upper transistor is on or the lower transistor is on, and that the current is non-zero, itemize all possible line-to-bottom rail voltages that could be observed.

Problem 4 (20 pts)

Consider a PMSM being fed by a sine-triangle modulated inverter (with 3rd harmonic injection of 1/6 the fundamental). The dc voltage is 100 V, and the desired q- and d-axis voltages are 20 V and -20 V, respectively. At a rotor position of 30 degrees, what is the a-phase duty cycle ?

Problem 5 (20 pts).

A brushless dc machine has the following parameters: $r_s = 2\Omega$, $L_q = 12$ mH, $L_d = 8$ mH, $\lambda_m = 0.2$ Vs, $P = 4$. We wish to operate at a speed of 1000 rpm (mechanical) and achieve a torque of 10 Nm. If we set the d-axis current to zero, what is the minimum required inverter voltage if we are to achieve the desired operating point and maintain current tracking.

Problem 6 (20 pts)

A PMSM is operated with a dc source of 10 V applied between the b (+) and a (-) terminals. The c-phase is open circuited. The b-phase current is 20 A. The rotor is free to spin (assume no friction). What is the d-axis voltage ? What is the d-axis current ? What is the q-axis current ?