Fall 2005 EE595S
Homework Assignment Number 5 Solution

Problem 1
N/A.

Problem 2
N/A. See text for start/end points.

Problem 3
Our control law is

$$v_{qs}^{r*} = \underbrace{\omega_r L_d i_{ds}^r + \omega_r \lambda_m}_{v_{qs,ff}^{r*}} + \underbrace{K\left(1+\frac{1}{\tau s}\right)\left(i_{qs}^{r*} - i_{qs}^r\right)}_{v_{qs,fb}^{r*}}$$

which yields a transfer function of

$$i_{qs}^r = \frac{K(\tau s+1)}{(r_s+K)\tau s+K} i_{qs}^{r*} + \frac{\tau s}{(r_s+K)\tau s+K} \Delta v_{qs}^r$$

In order to be able to neglect the low pass filter on the transfer function, we should set the closed loop pole so as the transfer function has a cut-off frequency an order of magnitude lower than the closed loop pole. Thus we have

$$\frac{(r_s+K)\tau 2\pi 200}{K} = 1$$

However, we have two degrees of freedom, K and τ. From our control law and transfer function observe two considerations. First, as we keep K small, it will keep current ripple from entering our current command. Second, if we keep K large relative to r_s, then in will reduce the sensitivity of the control performance on the machine parameters. As a compromise, let's choose $K = 10 r_s$ which yields a value of 2 Ohms. Then we can set

$$\tau = \frac{K}{(r_s+K)2\pi 200} = 0.72 \text{ ms}$$

Consider an indirect current control as shown in Fig. 3.5-1 and 3.5-2 of [2]. Suppose the switching frequency is 20 kHz, and that the low pass filter has a cut-off frequency of 2 kHz. Further suppose that $r_s = 0.2$ Ohms. Select an appropriate value of K and τ. Plot the magnitude and phase of the transfer function between i_{qs}^{r*} (input) and i_{qs}^r (output) as well as Δv_{qs}^r (input) and i_{qs}^r (output).

Problem 4

I would be a wound rotor induction motor because I like well defined current paths.

Problem 5

N/A. See text for start/end points.

Problem 6

N/A. See text for start/end points.

Problem 7

N/A. See text for start/end points.

Problem 8

Barring an algebraic error, the result is: $T_e = -\frac{3}{2}\frac{P}{2}\frac{\omega_r r_r^{'} L_M^2}{r_r^{'2} + \omega_r^2 L_{rr}^2} i_{dc}^2$

Reference

[1] *Analysis of Electric Machinery and Drive Systems*

[2] *Analysis and Design of Permanent Magnet Synchronous Machines*