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Title

EXERCISE 5: INDUCTION MACHINE IFOC AND DFOC CONTROL

Course Name

EE-565 Industrial Electronics II

1 GUIDELINES

Consider the induction machine described in Tab. 1 and answer the following questions:
Note: Five sessions are allocated to complete part 1 and 2 of this exercise.

Table 1 Parameters already reported to the stator

P_n	2.2 kW	U_n Y	230 V	$\Omega_{m,n}$	1 465 rpm	R_s	2.6 Ω	L_{ls}	20 mH	L_m	0.305 H	J	0.014 N m
I_n	7.7 A	U_n Δ	400 V	f_{sw}	5 kHz	R_r	1.1 Ω	L_{lr}	10.5 mH	p	2	k_F	0.003 64 N m s

2 TASKS DESCRIPTION

Part 1: Offline

Indirect Field Oriented Control

1. Name the advantages of vector control over the U/f and DTC control strategies and name an application in which this control strategy is suitable and one where it is not.
2. Explain the principles and theoretical background of the IFOC control of the Induction Machine.
3. Implement indirect field oriented control of the induction machine using the provided PLECS template. At this stage, you are dealing with offline simulations, but remember that the goal is to deploy your controller to a real system. Therefore, your implementation should be done in discrete time, and all PI controllers should have suitable saturation limits and anti-windup.
   Hints:
   - Start with flux estimation. Apply voltages to the machine in open loop and compare your flux estimation with the real machine flux.
   - Then implement current control, you can use an ideal mechanical speed source connected to the machine to test this control layer without your speed controller (you need to set the machine inertia to zero when you use a speed source).

   Provide and comment the block diagrams of your controller and waveforms of the results for the reference profiles provided in the template. Comment on the tuning of your controllers.
4. Implement a speed controller for the induction machine. Show the induction machine response (Scope2) with the provided reference speed and load torque. Comment on the tuning of your controllers.
5. Does your current control implementation allow operation in the field weakening region. Please develop your answer. If your control implementation does not allow field weakening, explain what changes would be required.

Direct Field Oriented Control

1. Explain the principles and theoretical background of the DFOC control of the Induction Machine. How would you estimate the rotor angular frequency? You are forbidden to use a derivation of the angular position.
2. Using the same PLECS template, replace your indirect flux estimation with a direct one and test it with the rest of your control. Provide waveforms to support the discussion.
3. Elaborate on the differences between DFOC and IFOC. Comment on the estimation and control robustness with respect to parameters estimation uncertainty (example: 10% error on the estimation of a resistance, inductance or electrical time constant values).