	Author(s) Name(s) Gaia Petrillo, Israel Yepez Lopez	Function Teaching Assistants
	Professor Name Dražen Dujić	Date of Release 11.03.2025

Title

EXERCISE 2 - PART 1: DC MACHINE CONTROL OFFLINE

Course Name

EE-565 Industrial Electronics II

1 GUIDELINES

Consider the DC machine described in Tab. 1 and answer the following questions:

Table 1 Machine parameters

P_n	2 500 W	$U_{a,n}$	400 V	R_a	3.8 Ω	$U_{f,n}$	340 V	R_f	729 Ω	N_f	5	J	0.001 2 N m s
$\Omega_{m,n}$	1500rpm	$I_{a,n}$	7.8 A	L_a	50 mH	$I_{f,n}$	0.45 A	L_f	34.6 H	k_e, k_m	0.8375	k_F	0.003 64 N m s

2 TASKS DESCRIPTION

1. Determine the minimal switching frequency of the IGBT-based full bridge to ensure the armature peak-to-peak current ripple stays below 9 % of the nominal current value. Consider that the converter DC link is energized by a rectified three-phase AC grid (grid voltage of 400 $V_{\text{line-to-line}}$). Which duty cycle results in the maximum ripple? Justify your answer (you can neglect losses, assume bipolar PWM, and assume that the back EMF is constant during a switching cycle). Justify your answer and display the current ripple in PLECS under the maximum ripple condition. For following simulations, set the switching frequency by rounding up to the closes kHz value (round 4.53 kHz up to 5 kHz).
2. Implement a field current controller for the machine. Your implementation should be done in discrete time. Don't forget output saturation and integrator anti reset windup (ARW). Display your implementation here.
3. Provide the parameters used for the tuning of your field current controller. How did you select these values? Show the step response of your controller.
4. Implement an armature current controller for the machine. Your implementation should be done in discrete time. Don't forget output saturation and integrator anti reset windup (ARW). Display your implementation here.
5. Provide the parameters used for the tuning of your armature current controller. How did you select these values? Show the step response of your controller.
6. Implement a speed current controller for the machine. Your implementation should be done in discrete time. Don't forget output saturation and integrator anti reset windup (ARW). Display your implementation here.
7. Provide the values used for the tuning of your speed controller. How did you select these values? Show the step response of your controller with and without ARW for a speed reference step from $-\Omega_n/50$ to $+\Omega_n/50$.
8. The nominal voltage of the machine should not be exceeded by the back EMF. Add field weakening to your control, to enable operation at higher speed. Show your implementation and provide a scope capture of the full simulation using the provided reference profiles.
9. What limits the speed of the machine when taking advantage of field weakening?
10. In which period of the simulation is the breaking chopper active? What purpose does it serve ?