Master's Department of Engineering Sciences

Name of the unit: Automatic control: frequency domain analysis

Lecturer: Mokrane Boudaoud (mokrane.boudaoud@sorbonne-universite.fr)
Course code: UM4RBR10-Freq
Student workload: 12h of lectures, 8h of tutorial sessions, 8h of lab sessions@
Credits: 3 ECTS

Specialization tracks:	- **E3A** :	☒ CIMES	☐ Syscom	☒ IPS
	- **AR** :	☒ ROBOT	☒ SI	☒ MeDH
	- **MECA** :	☐ MS2	☐ MF2A	☐ CompMech
		☐ ACOU	☐ EE	☐ EE APP

Semester offered: ☒ S1 ☐ S2 ☐ S3 ☐ S4
Language of instruction: ☒ French ☐ English
Targeted audience: ☒ Engineering Sciences students ☐ Other (specify):
Localization : ☒ PMC Campus ☐ Other (specify):

Course Overview

Introduction to the basic tools for modeling, analysis, and control of Linear Time Invariant (LTI) systems. Modeling of dynamic systems. Linear analysis of dynamic systems in the time and frequency domains. Output feedback control. Feedforward control. Design of multi-loop controllers.
Keywords: Linear Time Invariant (LTI) systems, Laplace transform, Bode diagram, output feedback control, feedforward control, design of multi-loop controllers.

Prerequisites

Students should have previously acquired the following prerequisites to follow this course:

- Mathematics for signal processing

Intended Learning Outcomes

By the end of this course, students will be able to:

1. Modeling of LTI systems in the time domain (differential equation) and the frequency domain (transfer function)
2. Bode diagram of first order and second order LTI systems
3. Determination of the static and dynamic properties of an LTI system in the time and frequency domains
4. Modeling of a closed loop system
5. Translation of control specifications into a system of equations
6. Definition of a controller structure meeting the specifications and calculation of the controller gains
7. Feedback control
8. Feedforward control
9. Disturbance observer
10. Design of multi loop, multi objective controllers
11. Implementation of a controller in an experimental setup

Indicative Teaching Sequence and Methods

Week	C/TD/TP*	Content	Preparation	Learn. outc.
S1	C1 (2h)	Analysis of linear time-invariant systems in the time domain: - Definitions and properties of systems - Laplace Transform (LT) - Transfer function, poles and zeros - Temporal responses.		AAV1
S2	C2 (2h)	Analysis of linear time-invariant systems in the frequency domain: - Bode diagram: reminders and definitions - Bode diagram of elementary functions of first and second order - Nyquist diagram		AAV2, AAV3
S2	TD1 (2h)	Tutorial 1: Analysis of linear time-invariant systems in time and frequency domains (Modeling of a mechanical system, Bode plot, Time/frequency analysis, Quarter Car Suspension Model)		
S3	C3 (2h)	Output feedback control of linear systems: - Introduction - Regulation and control - Modeling of a closed loop system - Stability of a closed loop system - Stability margins - Precision and disturbance rejection - Correction structures		AAV4, AAV5, AAV6, AAV7
S3	TD2 (2h)	Tutorial 2: Output feedback control strategies for LTI systems (Proportional control, Phase-lead control, Dynamic controller with integral action)		
S4	C4 (2h)	Feedforward Control: - Wy Feedforward? - Disturbance feedforward - Application		AAV8, AAV 9
S5	C5 (2h)	Dynamic output feedback control: - Closed loop performance and specifications - Proportional control - Proportional Integral (PI) control - Ideal PI control - Approximate PI control - Lead and Lag Compensators - Design of a dynamic output feedback control based on stability, accuracy and bandwidth specifications		AAV7
S5	TD3 (2h)	Tutorial 3: Feedforward control for LTI systems (Tracking feedforward, Control of a hydraulic cylinder and disturbance rejection, Disturbance observer (DOB))		
S6	C6 (2h)	Multi-loop control: - Principle and advantages of Multi-loop control - Tachometric feedback		AAV10
S6	TD4 (2h)	Tutorial 4: Multiloop control for LTI systems (Control of a DC motor with tachometric feedback)		
S7	TP (4h)	Simulation work: Control of an active force sensor		
S9	TP (4h)	Experimental work: Control of DC motor and a Twin Rotor MIMO		AAV11

* C/TD/TP respectively corresponds to lectures, tutorials and lab sessions.

Indicative Assessment of Intended Learning Outcomes (1st session)

Week	Individ./group	In-person/remote	Type of exam	Evaluated outcomes	Scale %
S10	Individual	In-person	Written	AAV1-AAV10	70 %
S11	Individual	In-person	Practical	AAV11	30 %

2nde session of exam

Session	Individ./group	In-person/remote	Type of exam	Evaluated outcomes	Scale %
2	Individual	In-person	Written	AAV1-AAV10	70 %
1	Individual	In-person	Practical	AAV11	30 %

Bibliographic references

- Eric Ostertag, "Systèmes et asservissements continus : Modélisation, analyse, synthèse des lois de commande". ELLIPSES, ISBN-10 : 2-7298-2013-2

Date of generation of this unit description: January 14, 2026