Control Engineering II

Academic Year: (2020 / 2021) **Review date: 28-01-2021**

Department assigned to the subject: Systems Engineering and Automation Department

Coordinating teacher: MONJE MICHARET, CONCEPCION ALICIA

Type: Compulsory ECTS Credits : 6.0

Year : 3 Semester : 2

REQUIREMENTS (SUBJECTS THAT ARE ASSUMED TO BE KNOWN)

Control Engineering I

OBJECTIVES

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

1. A systematic understanding of the key aspects and concepts of the design of discrete controllers through their analysis in the time (state space) and frequency (transfer function) domains.
2. Coherent knowledge of their branch of engineering including some at the forefront of the branch in control engineering.
3. The ability to apply their knowledge and understanding of control engineering to identify, formulate and solve engineering problems using established methods for the time and frequency analysis of discrete control systems.
4. The ability to apply their knowledge and understanding to develop and realise designs of discrete controllers to meet defined and specified requirements.
5. An understanding of design methodologies for discrete controllers, and an ability to use them.
6. Workshop and laboratory skills to implement discrete controllers in real platforms.
7. The ability to select and use appropriate equipment, tools and methods for the design and implementation of discrete controllers.
8. The ability to combine theory and practice to solve problems related to the design and implementation of discrete controllers.
9. An understanding of applicable techniques and methods in control engineering, and of their limitations.

DESCRIPTION OF CONTENTS: PROGRAMME

The programme is composed of the following parts:

First Part:
1. Z Transform.
1.1 Modelling of a discrete-time system.
1.2 Differences equations.
1.3 Z Transform, inverse and properties.
1.4 Differences equation solution.

2. Obtaining the Transfer Function.
2.1 Hold and Sampler.
2.2 Obtaining the transfer function in the z domain.
2.3 Sampling theorem.

3. Stability analysis.
3.1 Stability analysis in the z plane.
3.2 s and z planes
3.3 Jury stability test.
3.3 Root locus in the z plane.
3.4 Analysis of the system response.

4. Discretization of continuous systems.
4.1 Discretization of a continuous system.
4.2 Equivalent discrete transfer function.
4.3 Sampling a transfer function.

4.4 Discretization of an analogic controller.

5. Design of PID Controllers.
5.1 PID controllers in discrete time.
5.2 Discretization of an analogic PID controller.
5.3 Obtaining the sampling time.
5.4 Design of PID controllers by the root locus method.
5.5 Structure of a real discrete PID.

6. Design of controllers by direct synthesis.
6.1 Design of controllers by direct synthesis.
6.2 Restrictions: physically possible and stability.
6.3 Simplicity.

Second Part:
7. Modelling and analysis of systems in the state space.
7.1 Introduction to the state space.
7.2 Dinamic systems.
7.3 Linearization and invariance.
7.4 Linearization process.
7.5 Representations in the state space.
7.6 Equivalences between systems.
7.7 Obtaining the state space model.
7.8 Transformations between representation.
7.9 Obtaining the transfer function from the state space model.

8. Solution of the state space equation.
8.1 Transition matrix.
8.2 Calculation of the transition matrix. Properties.
8.3 Solution of the state space equation in discrete time.

9. State Feedback Control.
9.1 Controllability and observability.
9.2 Complete controlability of the states.
9.3 Complete controlability of the output.
9.4 Complete observability of the states.
9.5 Invariance of the controlability and observability through transformations.
9.6 State feedback control: positioning poles.
9.7 Pole position adjustment in closed loop.
9.8 Gain adjustment.
9.9 Modification of the type of a system.

10. Design of states observers.
10.1 Concept of state observer.
10.2 Conditions for the state observation.
10.3 Full-order state observer.
10.4 Error dynamics in the full-order state observer.
10.5 Design of the feedback gains matrix of the observer.
10.6 Dynamics of the combined system with a full-order observer and a state feedback matrix.
10.7 Minimum-order observer.

LEARNING ACTIVITIES AND METHODOLOGY

This course is composed of different activities:

1. Lectures (in synchronous and interactive online modality through Blackboard Collaborate). Main concepts (explanation and discussion). Different units in slides with the theoretical concepts.
2. Seminars (in face-to-face-modality). Various problems will be proposed for each unit. The solutions will be given after the seminars.
3. Lab sessions (three in total). Two practical cases will be proposed to be solved using Matlab (in synchronous and interactive online modality through Blackboard Collaborate), and the students will have to obtain simulation data and discuss them. Besides, a first experimental practical case will be done in the lab using the available servomotors in order for the students to identify the system to control and implement and test the controllers designed.

ASSESSMENT SYSTEM

The score will be formed by a theoretical and a practical part. The grade of the theoretical part is obtained from two partial exams:
* If the student fails one of the partial exams, the corresponding part will be repeated in the recovery exam of the continuous evaluation. The average between the recovery exam, if it is passed, and the passed partial exam is computed. The resulting mark will be the final mark. If the partial exam is failed again, then the theory exam will be failed.
* If the student fails both partial exams, the whole parts will be repeated in the recovery exam of the continuous evaluation. The theoretical mark will be the score of the recovery exam.
* If the student passes both exams (minimum mark of 5 in each exam), it is not necessary to do the recovery exam. If the student still wants to do to the recovery exam to improve his/her score, the previous mark will be erased (only the recovery exam counts).

Regarding the practical part, it is also necessary to pass it (5 or greater). This part will have three practical sessions in which the student will have to design and implement different controllers. Each practice must be passed separately in order to do the average and pass the practical part of the subject.

The final score is computed from the theoretical part (70% of the final score) and the practical part (30% of the final score). But it is important to remark that this subject will be passed only if both parts are passed separately.

The recovery exam of the continuous evaluation will be the same date and place as for the final exam (according to the official exams schedule).

The extraordinary exam will have a theoretical part and a practical part, which will be evaluated in the same way as in the ordinary call (70% theory and 30% practices). The theory exam will be on all the contents of the subject. If the student has passed the practical part in the ordinary call, his/her mark will be saved and taken into account for the extraordinary exam.

% end-of-term-examination:	0
% of continuous assessment (assigments, laboratory, practicals…):	100

BASIC BIBLIOGRAPHY

- DeRusso, P.M.; Roy, R.J. and Close, C.M. State Variables for Engineers, Wiley, 1965
- Martín, F. Problemas de Ingeniería de Control para Sistemas Discretos, CopyRed.
- Moreno, L.; Garrido, S. y Balaguer, C. Ingeniería de Control, Ariel.
- Ogata, K. Discrete-Time Control Systems, Prentice Hall.

ADDITIONAL BIBLIOGRAPHY

- Franklin, G.F; Powell, J.D. y Workman, M. Digital control of dynamic systems, Addison Wesley, 1998