Tasks protocol: The Furuta pendulum

1 INTRODUCTION

This document lists the different tasks that constitute the practice to be done with the rotational inverted pendulum or Furuta pendulum:

1. THEORETICAL AND SIMULATION TASKS

Task 1: Analysis of the model. In this section, starting from the non-linear model of pendulum that is specified in the practice guide, the following theoretical study mut be performed:

1A) Determination of equilibrium points.
1B) Linearization around the upper equilibrium point.
1C) Characterization of equilibrium points (stable or unstable).

Task 2: Linear control design:

In this task, a linear control must be designed by state feedback able to keep the pendulum in horizontal position and upwards while the base of the same follows changes of slogan in position.

Task 3: Linear control analysis:

In this phase, we will analyze the stability of the linear control obtained in the previous task by using the Lyapunov function in three stages:

3A) A Lyapunov function will be calculated for the linear model.
3B) This function will be applied to the non-linear model.
3C) It will be verified that the non-linear model is stable at the point of equilibrium and the region of attraction will be estimated.
3D) It will be shown that the system has no minimum phase.

Task 4: Checking the linear control in Simulation.

This task consists in checking the theoretical results of the previous points through the simulation of the system, for this the designed control will be implemented and it will be verified that:

4A) If the pendulum is left near the equilibrium point, the control is capable of stabilizing it by taking it to it.
4B) In the case of a small setpoint change, the control is able to maintain the pendulum in the correct position.
4C) If a disturbance is applied that brings the pendulum out of the region of attraction the control does not work and the pendulum falls.

Task 5: Checking the linear control in the real laboratory:

In this section, it will be verified that the control works not only in the simulated system but also in the real pendulum. The effect of the sampling period in the control will be analyzed and the maximum applicable control period before the system becomes unstable will be determined.

Tarea 6: Design a control law for the swing-up:

In this task, a control law will be designed to "lift" the pendulum from the stable equilibrium position to its position of unstable equilibrium with the object to subsequently apply the linear control designed in task 2.

The student is totally free to implement any control technique that it is convenient, although the teaching team will propose a way of doing it.

Tarea 7: Checking the non-linear control in Simulation:

In this task, the control designed in the real pendulum will be implemented in simulation to check if it is capable to lift and stabilize the pendulum in its upper position from any initial condition.

Tarea 8: Checking the non-linear control in the real laboratory:

In this section, the correct functioning of the non-linear control proposed for the lifting of the pendulum will be checked to verify that the proposed objectives are reached in the real laboratory.