Linear control system design SSY285

Assignment M2: Analysis of linear state-space model of a DC motor with flywheel

Problem

Consider the DC motor with flywheel that was introduced in the previous assignment. The starting point of this assignment is the linear state-space model obtained in assignment **M1**. When required, use the same numerical values as in subproblem d) of assignment **M1**. When answering the following questions, consider both cases from subproblem c) of the previous assignment.

Questions

a) Investigate if the system is controllable and observable for nonzero, positive and real parameter values of the motor resistance R and flexibility coefficient D_1. Make sure to enforce these assumptions when setting R and D_1 as symbolic variables. Do not use `Matlab`'s `ctrb` and `obsv` routines to build the controllability and observability matrices. Confirm `rank` computations by looking at the reduced row echelon form, `rref`, and checking if there is any set of values for which the matrices loose rank, i.e. the determinant is equal to zero.

b) If the system is not controllable or observable, is it still stabilizable or detectable for nonzero, positive and real parameter values of the motor resistance R and flexibility coefficient D_1?

c) Given the numerical parameter values from assignment **M1**, repeat the above tasks by using the standard `Matlab` routines. Check the condition number of the controllability and observability matrices, before you conclude the analytic properties.

d) Choose the value $T_s = 1\,ms$ as the sampling interval and calculate the discrete time system matrix $A_d = e^{A_c T_s}$. (Here A_c denotes the corresponding continuous time matrix.)

e) Using the same sampling interval as above, calculate the discrete time input matrix with ZOH principle, given by the expression $B_d = \int_0^{T_s} e^{A_c t} B_c \, \mathrm{d}t$.

f) Check (numerically) if the resulting discrete time state-space model is minimal realization and if its eigenvalues are in the region of stability.

Pre-approval of solution is mandatory before submission (by TA in tutorial session)