System Identification – Practical Assignment 4
Transient Analysis of Impulse Responses

Logistics

Please reread the logistics part of lab 2, the same rules will apply to this lab. The only things that change are the Teams assignment, which for this lab is "Lab 4 (impulse response)", and of course the lab number in the file name.

Assignment description

We will analyse the impulse response of a DC motor in the time domain, using data obtained from the real system. See the course material, *Transient Analysis of Step and Impulse Responses*.[1]

Each student will obtain a dataset using the DC motor and will identify the system, as detailed in the following instructions:

- Apply a small signal with a value $u = 0.1$ and let the system reach steady state (we therefore have non-zero initial conditions for the impulse response).
- Apply a sequence of 3-4 impulses with value $u = 1$ and each of length 1-2 time samples; after each impulse let the system reach steady state again.
- How much larger should the impulses be for these to be conidered a correct practical implementation of an ideal impulse (do not try to implement this on the actual system, as it may xceed saturation limits)? Let's name this factor α.
- Identify the transfer function from the first impulse. It is best to use y_{ss} for obtaining the gain rather than y_{max} (using y_{max} is possible, but requires a correct rescaling by α).
- Validate the identified model using the `lsim` function applied on validation data consisting of all impulse responses except the first. Important observations: (a) You should use a state-space model and take into account the nonzero initial condition. (b) The time vector used in `lsim` needs to be equidistant, unlike the real time vector obtained from the system, in which the sampling instants are not perfectly spaced. When simulating, use either the imposed sampling time, or the average sampling time computed *a posteriori* from the data. If the model deviates too much due to the timing, use `interp1` to resample the real-system output with a constant sampling rate and compare with that resampled signal instead of the aperiodically sampled, original signal.
- The system may have a small time delay. Optionally, if you still have time, tune this delay by hand to get a better response (do this for the transfer function only, not for the state-space model, and ignore the transient in which the model may make mistakes due to its zero initial condition).

Some relevant Matlab functions: `tf, ss, lsim, find, sum, interp1`.

[1] Presumably you already did this for the previous labs, but if you did not, prior to starting the lab familiarize yourself with the DC motor system and the ways in which input signals can be applied and output signals can be read, using the guide linked from the website.