Experiments **X**

Experiments on the motion setup

Make sure to read `4CM00_ExperimentTutorial.pdf` first!

X.1 Introduction

The final assignment of Control Engineering involves the experimental setup depicted in Figure X.1. It consists of two rotating masses, with a flexible joint in between. One of the masses is connected to a DC-motor. Each mass is connected to an incremental encoder to measure the actual rotation; one sensor is thus co-located with the motor, the other is on the load-side. The whole assembly is mounted onto a current amplifier; the voltage sent to this amplifier thus scales linearly with the current sent to the motor, which scales linearly with the torque applied by the motor.

For this assignment we assume that this setup represents an actual industrial application

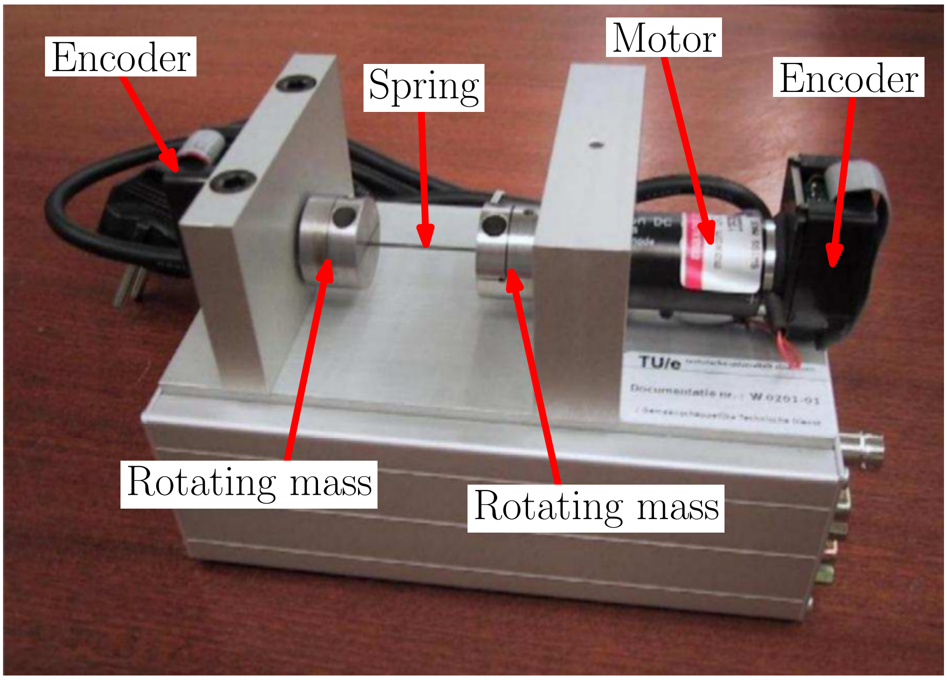

Figure X.1: Motion setup used for the experiments.

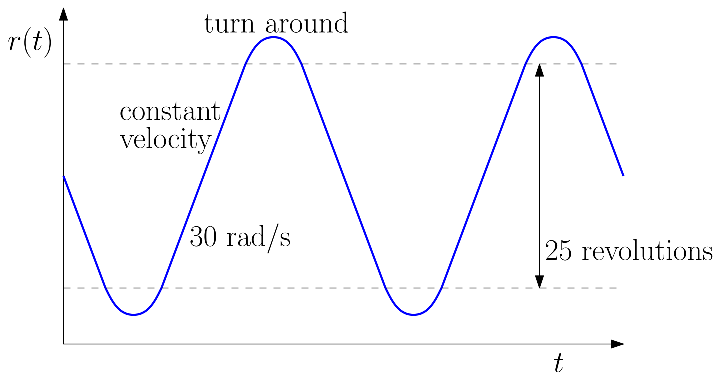

Figure X.2: Visualization of the setpoint for the non co-located mass.

where the ultimate goal is to accurately position the second (non co-located) mass. The application prescribes that the second mass should rotate with a constant velocity (scan) of 30 rad/s over a stroke of exactly 25 revolutions (back and forth), as illustrated in Figure X.2. To maximize performance

- the error during constant velocity should be minimal;
- and there should be as many constant velocity scans within a certain timeframe as possible (hence the turn around phases should be short).

We further assume that the sampling rate is restricted to at most 4 kHz, and that it is desired to have at most 6 dB modulus margin.

X.2 The assignments

You have the honourable task to analyse and control this system in an attempt to optimize its performance. It is however up to you to decide how to do so.

Hence, *you* decide which measurements to take, which sensor to use as feedback sensor, whether to include feedforward, how to assess performance, etc. Remember to always motivate your decisions!

X.2.1 Preparation

Your time is limited; you have only two experiment sessions (of 3.5 hours) to play around with the setup. Hence, you should prepare your sessions as good as possible. Document your preparation in a detailed measurement plan (to be handed in at the end of week 5, before the experiments start); such a plan could contain e.g.

- a rough prediction of the dynamics you expect to encounter;
- a description of the FRF measurements (and settings) you want to carry out;
- a proposed control strategy (feedforward or not, motor or load feedback, etc);
- a proposal of a performance criterion (in time and/or frequency domain); i.e. how will you judge the performance;
- an approach to tune the controller(s);

including a proper motivation of your choices. Needless to say, the outcome of your measurement plan should be that you know which data to take in which order, and that you have prepared the m-scripts to do so.

Of course, not all choices are easy to make beforehand; in that case try to define measurements or tests in your plan which can help you to make these choices properly.

X.2.2 Execution

Document the execution of your measurements in a second report (to be handed in a week before your exam). In this report, show your intermediate results, validate your predictions, describe your lessons learned, and demonstrate the system performance you have achieved. Show the appropriate Bode diagrams, Nyquist plots and time traces, e.g. to prove your achieved bandwidth, margins and error.

Try to stick to your measurement plan when doing the experiments, but make modifications whenever necessary. Make sure you document which insights led to these modifications in your execution report.

X.3 Some last suggestions...

- Use the time between sessions to process your data, design controllers and perhaps modify your plan.
- Remember that you have access to both encoders, both yielding different dynamics with a different control problem. Try to use the co-located encoder as well, especially when validating your predicted dynamics or performing your first closed-loop FRF measurements. Moreover, you are encouraged to assess the consequence of either encoder as the feedback sensor on the achievable bandwidth and resulting performance at the load-side.
- In case you need more time than the two scheduled experiments, you can always borrow a setup at SELSOL and work on it *in your own time* (i.e. without supervision).