Politecnico di Milano

AUTOMATION AND CONTROL ENGINEERING

Study and Control of the Mechanichal System: Rotary Flexible Joint

Course

Automation and Control Laboratory

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Problem Description

This report will describe the model of the system, our solution and some attempts to describe and control the system.

The system is composed by a motor's module that provide torque to a turret, above the turret there's a beam which is attached at one of the two edges through a screw to the turret. The beam will follow the movement of the base due to two springs attached between the turret and the beam.

The system has several interfaces that could be connected to an acquisition system (DAC/ADC + Amplifier) to acquire measurements and provide input signal, the interfaces are:

- Actuators:

  Power Supply input of the motor's module (changing the voltage);

- Sensors:

  Incremental Encoder for the position of the turret with respect to to the motor's module;

  Incremental Encoder for the relative position of the arm with respect to the turret.

The acquisition system composed by ADC/DAC + Amplifier is already configured, it doesn't require our attention, for this reason it will not treat in this report.

The main task is to control a low damped system with variable parameters, this goal is divided in sub-tasks to be achieved:

1. position control of the top base, with a frequency based approach;
2. position control of the arm tip, with a frequency based or a state space approach;
3. position control of the arm tip with uncertainty in the spring stiffness and arm moment of inertia, with a state space approach or other advanced control techniques.

Model Identification

The system could be schematized:

It is possible to recognize models of a DC electric motor powered by a voltage V_{dc} coupled with a gearbox (both modeled in the same box) that provide torque u to a flexible (due the springs) joint, at last an encoder to model all the conversion's dynamics between the angular positions y and the red ones $\hat{y}$.

2.1 Mathematical Model Creation

2.1.1 DC Motor

The first task is to decide the shape of the model in terms of which dynamics consider or neglect.

Starting from the DC motor we assumed a static model due to the fact that from the data sheet of the motor, it should have a dynamic given by the inductance at a frequency:

$$\frac{R}{L} = \frac{2.6\Omega}{0.18mH} \approx 15KHz$$

this is clearly above the frequency range of the mechanical system, that for its nature should have a frequency in the order at last of $100Hz$ (deeper treatment in its section).

The physical equations of the Static DC Motor:

$$\begin{cases} V_a = R_a I_a + E \\ E = k_m \Omega \\ \tau = k_t I_a \end{cases} \tag{2.1}$$

After several mathematician steps and considering the gearbox effect:

$$\tau = \frac{\eta_m \eta_g K_t K_g (V - K_g K_m \dot{\theta})}{R_m}$$

this is the output of the DC Motor's Model.

2.1.2 Flexible Joint and The Gearbox

Considering in the same section the joint and the mechanical components of the motor, it is possible to write down the two equation of the 2 mechanical system considering:

To model the inertia and the friction of the gearbox instead we consider their equivalent effect using the coefficient J_{eq} and B_{eq}. The turret

Position Control of the Base

Position Control of The Tip

Position Control of the Tip with Uncertanties

Conclusioni