PHILIPS CTT Hogeschool van Utrecht

Systeem en Regeltechniek

FMT / Mechatronica

Deel 5: Toepassing: PID regelaarontwerp

Blok 11: Toepassing: Tunen PID regelaar mechatronisch systeem

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Cursus Systeem en Regeltechniek

Overzicht

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Application: Tuning PID controller mechatronic system

Tuning the PID controller: what does that mean in practice?

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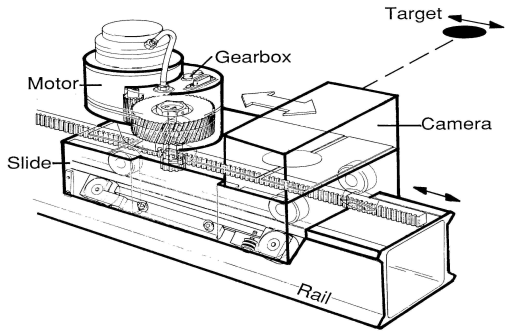
Mechatronic system



Moving target: 3 Hz, 3mm

Allowed tracking error: 40μm

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Data Mechanics

Motor inertia:	**2.5×10^{-5} [Kgm^2]**
Motor gear wheel inertia:	**2.5×10^{-5} [Kgm^2]**
Gear+pinion wheel inertia:	**5.0×10^{-5} [Kgm^2]**
Mass slide:	**5.0 Kg**
Mass camera:	**3.0 Kg**
Transmission gearbox:	**0.2 [-]**
Diameter pinion wheel:	**30 [mm]**

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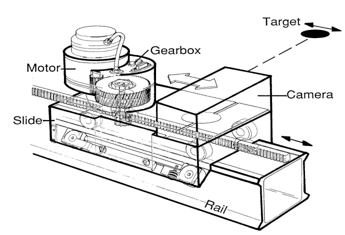
Objective Exercise

- Dimension a stable control loop in which the error is reduced to 40 µm
- The phase margin at the crossover is about 50 degrees



Moving target: **3 Hz, 3mm**

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Exercise - Part 1

Solve the sketched control problem for a system without flexibilities

- Assignment 1:
  Sketch a simple model without flexibilities
  - All elements included
  - Reduced model with single mass
- Assignment 2:
  Implement the model(s) in 20-sim
- Assignment 3:
  Design a PID controller and check performance

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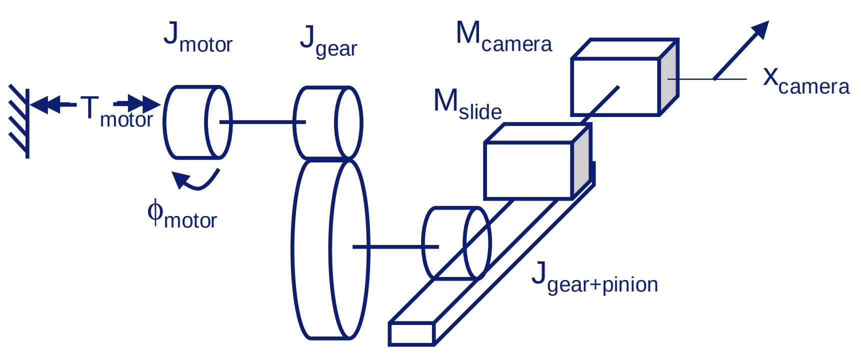
Assignment 1: Model without flexibilities



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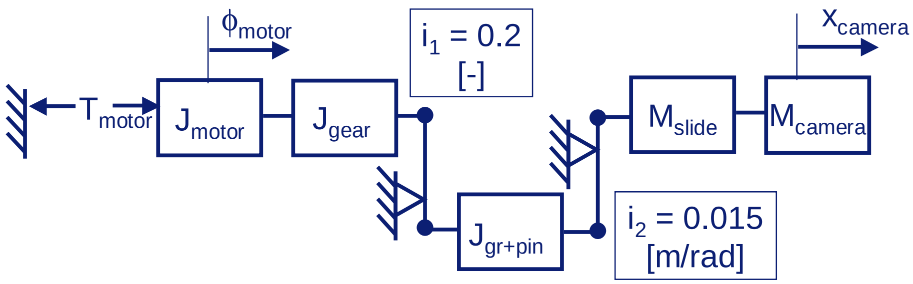
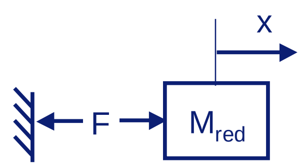
Assignment 1: Model without flexibilities



Reduced model (to camera):

$$M_{red} = M_{camera} + M_{slide} + J_{gr+pin}/i_2^2 + (J_{gear}+J_{motor})/(i_1^2 i_2^2)$$



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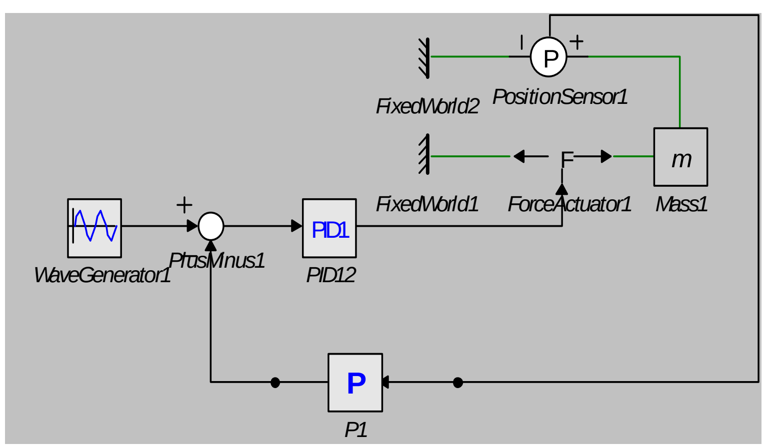
Assignment 2: Reduced model in 20-sim



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Assignment 3: Design a PID controller and check performance

- Determine the needed reduction at 3 Hz
- Simulate the open loop gain (frequency analysis)
- Adjust KP for the needed reduction
- Adjust the width of the Lead-lag for the required phase margin
- Position the Lead-lag around 0 dB
- Repeat the above adjustments if necessary
- Check the reduction via a time plot with 3 Hz sine

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Exercise - Part 2

Analyse the dynamics of a flexible system

- Assignment 1:

  Sketch and implement 2 models with flexibilities:
  - Motor shaft k_t = 20 [Nm/rad]; d_t = 0.001 [Nms/rad]
  - Camera suspension k = 2.4 10^6 [N/m]; d = 120 [Ns/m]
- Assignment 2:

  Compare the dynamic behavior of both systems using:
  - a rotational measurement on the motor (ϕ_{motor})
  - a linear measurement on the slide (x_{slide})

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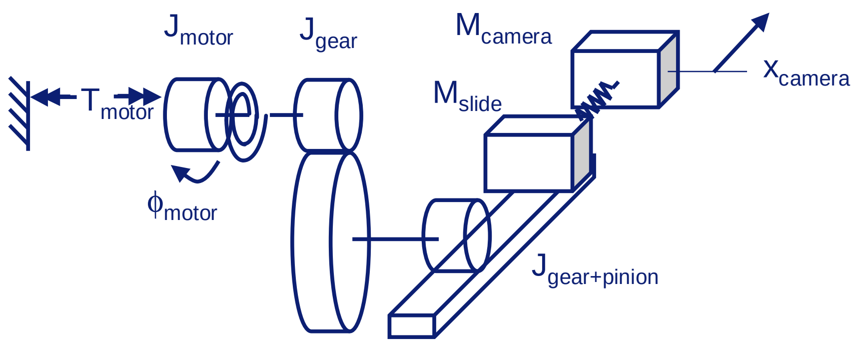
Assignment 1:
Model(s) with flexibilities



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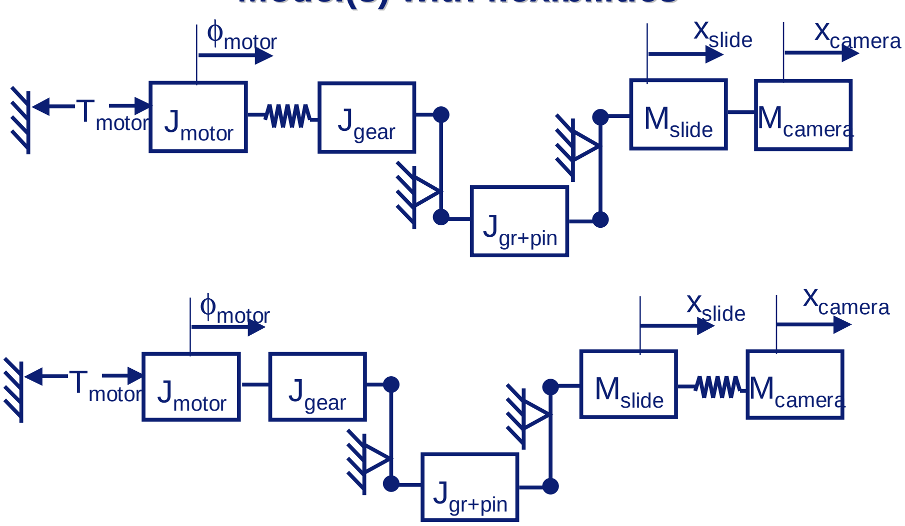
Assignment 1:
Model(s) with flexibilities



Assignment 2:

- Check Bode plots:
  - Minus 2 slope with resonance
  - Minus 2 slope with anti-resonance/resonance
- Compare and investigate differences:
  - Physical interpretation of anti-resonance
  - Effect on stability of control loop…

Exercise - Part 3

Solve the control problem again
– now for the flexible system

- Step 1: Choose the system to be controlled:
  - Choose type of flexibility:
    - Motor shaft k_t = 20 [Nm/rad]; d_t = 0.001 [Nms/rad]
    - Camera suspension k = 2.4 10^6 [N/m]; d = 120 [Ns/m]
  - Choose location of feedback sensor:
    - an encoder measurement on the motor (ϕ_{motor})
    - a linear measurement on the slide (x_{slide})
- Step 2: Design a PID controller
  - Follow same procedure as before
  - Add filters if necessary

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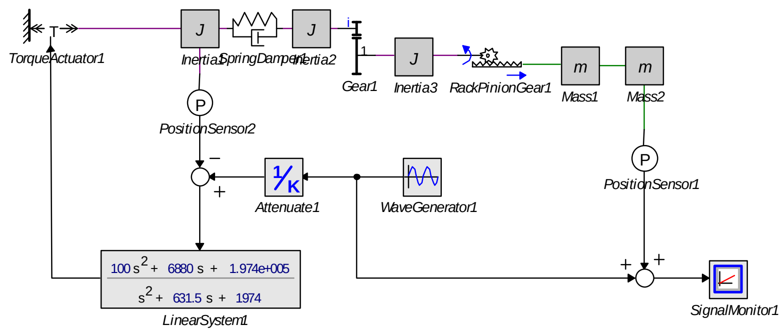
Example of implementation

Motor feedback / motor flexibility



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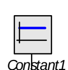
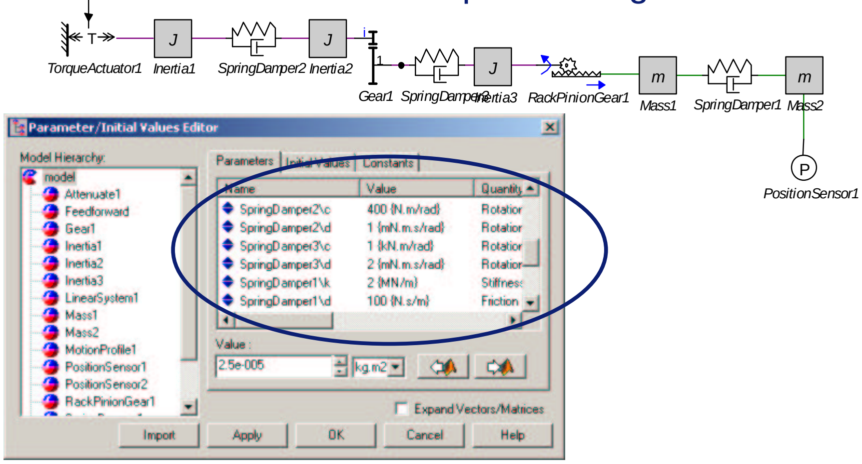
Exercise - Part 4



Add flexibility's like shown here and solve the control problem again!



Summary

- Modelling a mechatronic system in 20-sim
  - – Sketch (simplified) model
  - – Implement in 20-sim
- Loop shaping / design for performance:
  - – S small where disturbances occur
  - – High bandwidth - small S for low frequency
- Effect of mechatronic system design:
  - – Location of flexibilities
  - – Location of feedback sensors

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