ELEC 341 – Electro-Mechanical Control Project

Project Part 2
Controller Design

20 Marks

WARNING

Fix all errors in Part 1 before proceeding to Part 2.

*The **CORRECT** system model will be used to grade Part 2.*

*In Part 1, you found various forward path transfer functions G, and the sensor transfer function H. As stated in Part 1, the sensor measures rotor angle **qr**, and has an internal filter for noise reduction so a **weighted sum filter is not necessary**.*

An ISR with a 50% duty cycle (using ½ the available processing time) runs at:

__CF__ = 15 x #C

*The dimension we wish to control is finger angle **qf** (deg).*

Q1 4 mark(s) Feedback Path

Compute the required controller feedback gain **Kh**.
Compute the feedback path delay multiplier **Ndt**.
Find the ultimate gain **Ku**.
Compute the goal overshoot **GOS** and steady-state error **Ess** when proportional gain **K** = **Ku** * 25%.

- Q1.Kh (deg/V) scalar
- Q1.Ndt (pure) scalar
- Q1.GOS (%) scalar
- Q1.Ess (%) scalar

Develop a PID Controller to control the gripper.
Filter your finite difference derivative with a weighted-sum filter.

Q2 2 mark(s) FDD WS Filter

Find the vector of filter coefficients **W** for a filter with **Nd** = **#B**.
Find the associated delay multiple **Ndhat**.

- Q2.W (pure) Vector (1x#B)
- Q2.Ndhat (pure) Scalar

***COW**: ΣW = 1 ??? It should be.*
*Compute the partial dynamics **Dp**.*

Q3 3 mark(s) Controller Metrics

Specify the (forward path) PID controller poles **p** = [p1 p2].
Find the ultimate gain **K0** using the partial dynamics Dp.
Find the associated cross-over frequency **wxo**.

- Q3.p (rad/s) Vector (1x2)
- Q3.K0 (V/deg) Scalar
- Q3.wxo (rad/s) Scalar

***COW**: PM = 0 ??? It should be.*

Q4 4 mark(s) Initial Zeros

Find the zeros **z** that maximize phase margin **PM** when a gain of **K0** is applied.
Use the zeros **z** to compute the full PID dynamics **D**.
Find the gain **K** that achieves a phase margin of **30°**.

- Q4.z (rad/s) Vector (1x2)
- Q4.PM (deg) Scalar
- Q4.D (pure) LTI
- Q4.K (V/deg) Scalar

Now that you have a reasonable starting point, it's time for heuristic tuning to satisfy a particular RCG specification. To do this, you need to know where you are starting from.
*Compute your initial PID controller gains, and **normalize** them so master gain **K=1**.*

Q5 3 mark(s) Initial PID Gains

Specify the normalized PID gains **Kp**, **Ki**, and **Kd**.

- Q5.Kp (pure) Scalar
- Q5.Ki (sec^{-1}) Scalar
- Q5.Kd (sec) Scalar

REQUIREMENTS:

1. *GOS < 5%*
2. *Ts < 100 ms*
3. *Ess = 0%*

GOALS (in decreasing order of importance):

1. *GOS as small as possible*
2. *Ts as small as possible*

Q6 4 mark(s) Meet RCGs

Tune the PID controller gains to satisfy the RCGs. It is not necessary to normalize the gains.

• Q6.K	(V/deg)	Scalar
• Q6.Kp	(pure)	Scalar
• Q6.Ki	(1/sec)	Scalar
• Q6.Kd	(sec)	Scalar

You may find it easier to meet these RCGs if you first repeat the prior 2 steps using a different target Phase Margin that is closer to the desired response.

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