ELEC 341 – Graded Assignments

Assignment A2
2^{nd} Order Approximations

10 Marks

Learning Objectives

Modeling Black Box Systems
2^{nd} Order Performance Metrics
Natural Frequency
Damping Co-efficient
2^{nd} Order Approximations

Matlab
- zpk()
- a2DSPlot()

When you use off-the-shelf (OTS) sub-components, you only have the information available in the data-sheet about what's inside. This is called a "Black Box" system.

*Data sheets often contain experimental curves, but rarely provide a linear model. To use the device in a control system, you must develop one of your own. The best you can do is a linear approximation which will never be perfect, but It's better than nothing. And if you do a good job, it's **a lot** better than nothing.*

Q1 0 mark(s) Experimental Data from a Data-Sheet

Use **a2DSPlot.p** to plot an experimental data curve from a data-sheet.
Estimate Rise Time (Tr), Peak Time (Tp), Settle Time (Ts), and Percent Overshoot (Pos).

- Q1.Tr (ms) Scalar
- Q1.Tp (ms) Scalar
- Q1.Ts (ms) Scalar
- Q1.Pos (%) Scalar

The data has noise, which doesn't make your task particularly easy, but it's experimental data. That's what experimental data looks like.

Zero marks doesn't mean "optional". The whole assignment depends on these values.

Q2 1 mark(s) Approximate #1

Compute the damping co-efficient ζ.
Use **Rise Time** to compute natural frequency ωn.
Use ζ and ωn to compute a 2nd Order Approximation transfer function tf.

- Q2.Z (pure) Scalar
- Q2.Wn (rad/s) Scalar
- Q2.G (V/V) LTI

Q3 1 mark(s) Approximate #2

Use **Peak Time** to re-compute natural frequency ωn.
Use ζ and ωn to compute a 2nd Order Approximation transfer function tf.

- Q3.Wn (rad/s) Scalar
- Q3.G (V/V) LTI

***COW**: Plot the step response of each transfer function.*

*Is the DC Gain of each approximate **identical** to the source function ???*

*Is the Overshoot of each approximate **identical** to the source function ???*

*Is the Rise/Peak Time of each approximate **identical** to the source function ???*

Why not use Settle Time Ts to generate a 3rd approximate ??? Is this ever a good idea ???

Q4 2 mark(s) Approximate #3

Compute the damping co-efficient ζ and natural frequency ωn of a 2^{nd} Order Approximation that has the same **Peak Time** and **DC Gain** as Q3, but only **2/3 the Overshoot**.

- Q4.Z (pure) Scalar
- Q4.Wn (rad/s) Scalar
- Q4.G (V/V) LTI

Q5 2 mark(s) Approximate #4

Compute the damping co-efficient ζ and natural frequency ωn of a 2^{nd} Order Approximation that has the same **Peak Time** and **DC Gain** as Q3, but only **1/3 the Overshoot**.

- Q5.Z (pure) Scalar
- Q5.Wn (rad/s) Scalar
- Q5.G (V/V) LTI

***COW**: Plot the step responses of Approximates #2-#4 all on the same figure.*

Is the Peak-Time all the same but with a varying overshoot ???

Q6 2 mark(s) Approximate #5

Compute a 2^{nd} Order Approximation transfer function that is **Critically Damped**.

- Q6.Z (pure) Scalar
- Q6.Wn (rad/s) Scalar
- Q6.G (V/V)

Which time value did you use to compute ωn *??? Did you have a choice ???*

***COW**: Plot the step responses of Approximates #1 & #5 all on the same figure.*

Does it reach 98% of FV at 4τ ??? Should it ???

Use tf() to create a unity gain Single-pole filter (Filt). Put the pole anywhere.

On the same figure, plot the step responses of:

- *Single-pole filter: step(filt)*
- *Double-pole filter: step(filt*filt)*
- *Triple-pole filter: step(filt*filt*filt)*

Does that clear up how a filter works ???

Does that answer your question ???

Design a 2^{nd} Order Approximation to satisfy the following RCGs.

Requirements:

Tr = Average Tr of Approx #1 and Approx #2
OS = Raw Data OS.

Q7 2 mark(s) Approximate #6

Find the Rise Time Tr that satisfies the RCGs.
Calculate the Rise Time Error Te (difference between Tr of Approximation and Raw Data)
Compute the associated 2^{nd} order approximation G.

- Q7.Tr (ms) Scalar
- Q7.Te (ms) Scalar
- Q7.G (V/V) LTI

***COW**: Plot the step responses of Approximates #1, #2 & #6 all on the same figure.*
Does this seem like a reasonable compromise ???
*See how many options you have ??? Not a bad **DESIGN TOOL**, eh???*