Control Systems

Final Project

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This project was done on a TCP/IP router packet drop probability algorithm. This algorithm helps in understanding the throughput of a TCP system to know whether to account for a large amount of lost information. The base transfer function is given as,

Within the function there is a time delay given as . In order to use this transfer function, using a first order Padé approximation is used to convert the transfer function into,

The model of the system is shown below as well, with unity feedback as well.

Diagram

Description automatically generated

From these equations we can see that there are poles at -0.667, -5, and -50 with a zero occurring at 1.25. This is due to the coefficient of the s in the numerator being 75% of the constant. The root locus of the open-loop transfer function is shown.

Diagram

Description automatically generated

The closed-loop transfer function is given as

Solving the denominator for k using the Routh-Hurwitz criterion the stable range of k is found to be

This can be shown by finding the gain margin of the system during the open-loop test in the matlab code, as shown below by the output of the open-loop transfer function.

P =

-50.0000

-5.0000

-0.6670

Warning: The closed-loop system is unstable.

Gm =

4.9326e-05

>>

Inputing several values into k will give varying outputs of different stabilities. Here are examples of the range of k.

**K = -1e-5**

Diagram

Description automatically generated with medium confidence

**K = 4e-5**

Chart, line chart

Description automatically generated

**K = 5.5e-5**

Chart

Description automatically generated

The poles, , for each of these cases is shown below. The cases where the system is unstable are noted to have at least one positive pole, whereas the stable systems have only negative poles.

**-1e-5**

P =

-48.6626

-6.7120

-0.2954

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**4e-5**

P =

-54.6911 + 0.0000i

-0.4895 + 2.8201i

-0.4895 - 2.8201i

>>

**5.5e-5**

P =

-56.2475 + 0.0000i

0.2888 + 3.1237i

0.2888 - 3.1237i

>>

For the Nyquist plot, when using , the system becomes stable, and the Nyquist plot looks as such:

Diagram

Description automatically generated

As one can see, the crossing point is greater than -1, making the system stable since it is within the range of K for stability.