Project Report for ECE 351

Lab 07 - Block Diagrams and System Stability

Skyler Corrigan

October 9, 2022

ECE351 Code Repository:
$https://github.com/ElfinPeach/ECE351_Code.git$

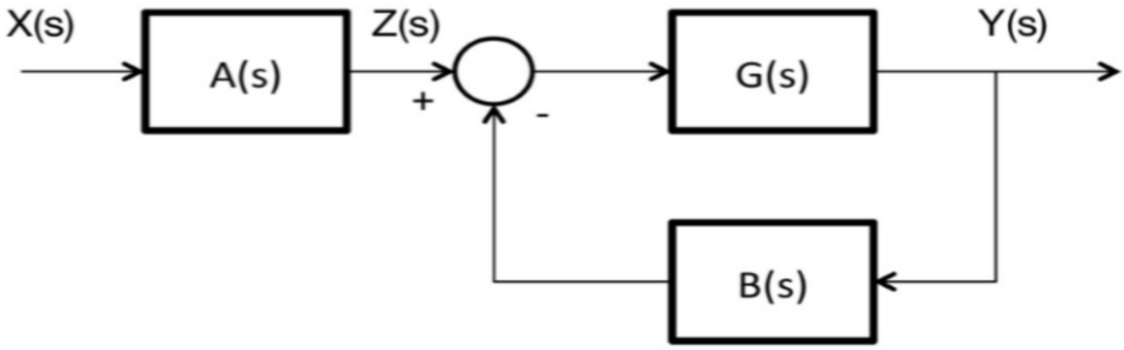
ECE351 Report Repository:
$https://github.com/ElfinPeach/ECE351_Report.git$

Contents

1 Objective

This lab is designed to work on block diagrams and Laplace domains. The block diagram used in this lab is shown below.

Figure 1



2 Equations

The following equations are used in throughout the lab report, and will be referenced by their Roman Numeral numbers.

$$G(s) = \frac{s+9}{(s^2-6s-16)(s+4)} = \frac{5}{24(s+4)} - \frac{7}{20(s+2)} + \frac{17}{120(s-8)} \text{ (I)}$$
$$A(s) = \frac{s+4}{s^2+4s+3} = \frac{3}{2(s+1)} - \frac{1}{2(s+3)} \text{ (II)}$$
$$B(s) = s^2 + 26s + 168 \text{ (III)}$$
$$H_{open}(s) = \frac{s+9}{s^4-2s^3-37s^2-82s-48} \text{ (IV)}$$
$$H_{closed}(s) = \frac{1+13s+36}{2s^5+41s^4+500s^3+2995s^2+6878s+4344} \text{ (V)}$$

3 Code

The following is the entirety of the code I used for this lab.

Lab Code

```
import numpy as np
import matplotlib.pyplot as plt
import scipy.signal as sig

        #Universal Stuff for Lab

    #Step size
```

```
steps = 1e-2

    #t for part 1
start = 0
stop = 10
    #Define a range of t. Start at 0 and go to 20 (+a step)
t = np.arange(start, stop + steps, steps)

#-----------PART 1, Open Loop Test-----------------------------#
    #Find the roots and the poles

    #A(s)=(s+4)/((s^2+4s+3))
A_num = [1, 4]
A_den = [1, 4, 3]

    #B(s)=s^2+26s+168
B_num = [1, 26, 168]
B_den = [1]

    #G(s)=(s+9)/((s^2+-6s-16)(s+4))=(s+4)/(s^3-2s^2-40s-64)
G_num = [1, 4]
G_den = [1, -2, -40, -64]

Azeros, Apoles, Again = sig.tf2zpk(A_num, A_den)
Bzeros, Bpoles, Bgain = sig.tf2zpk(B_num, B_den)
Gzeros, Gpoles, Ggain = sig.tf2zpk(G_num, G_den)

print("Zeros for A: ", Azeros)
print("")
print("Poles for A: ", Apoles)
print("")
print("Zeros for B: ", Bzeros)
print("")
print("Poles for B: ", Bpoles)
print("")
print("Zeros for G: ", Gzeros)
print("")
print("Poles for G: ", Gpoles)
print("")

H_open_num = [1, 9]
H_open_den = [1, -2, -37, -82, -48]

H_open_zeros, H_open_poles, H_open_gain
sig.tf2zpk(H_open_num, H_open_den)
```

```
print("Zeros of the Open Loop H(s)")
print(H_open_zeros)
print("")
print("Poles of the Open loop H(s)")
print(H_open_poles)
print("")

stepTOpen, stepHOpen = sig.step((H_open_num, H_open_den),
T = t)

plt.figure(figsize=(10,7))
plt.plot(stepTOpen, stepHOpen)
plt.grid()
plt.xlabel("Time")
plt.ylabel("Output")
plt.title("Open Loop H(s) Step Response")

#----------------PART 2, Closed Loop Test----------------

    #Finding the Numerator and Denomenator of transfer function
H_closed_num = sig.convolve([1,4],[1,9])

part_den = sig.convolve([1,1],[1,3])
H_closed_den = sig.convolve(part_den,[2,33,362,1448])

print("Closed loop numerator = ", H_closed_num)
print("Closed loop denemonator = ", H_closed_den)
print()

    #Numbers I got by hand:
#H_clo_num = [1, 13, 36]
#H_clo_den = [2, 41, 500, 2995, 6878, 4344]

H_closed_zeros, H_closed_poles, H_closed_gain =
sig.tf2zpk(H_closed_num, H_closed_den)

print("Poles of the Closed loop H(s):")
print(H_closed_poles)
print("")

    #Define transfer function!
stepTClosed, stepHClosed = sig.step((H_closed_num,
H_closed_den), T = t)

    #Make plots for pt1
```

```
plt.figure(figsize=(10,7))
plt.plot(stepTClosed, stepHClosed)
plt.grid()
plt.xlabel("Time")
plt.ylabel("Output")
plt.title("Closed Loop H(s) Step Response")

#------------SHOW PLOTS------------------------------#
plt.show()
```

4 Part 1

Running the code gives the following values for poles and zeros for A, B, and G.

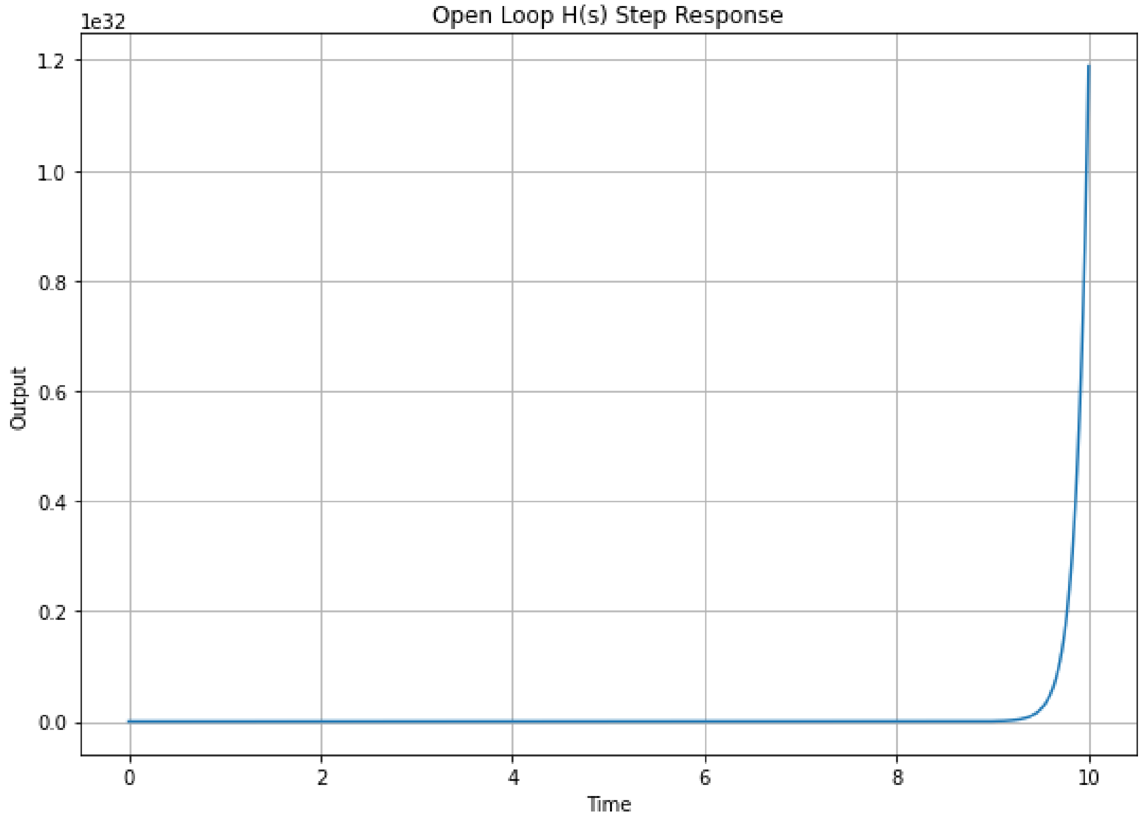
Equation	Holes	Poles
A(s)	-4	-3, -1
B(s)	-14, -12	N/A
G(s)	-4	8, -4, -2

These values are consist ant with Equations (I), (II), and (III).

The Open Loop equation for the system found in *Figure 1* can be found in (IV). Since the limit as "s" goes to 0 is negative, the system is unstable.

The following figure shows the output for the Open Loop Step Response of (IV).

Figure 2: Open Loop Step Response



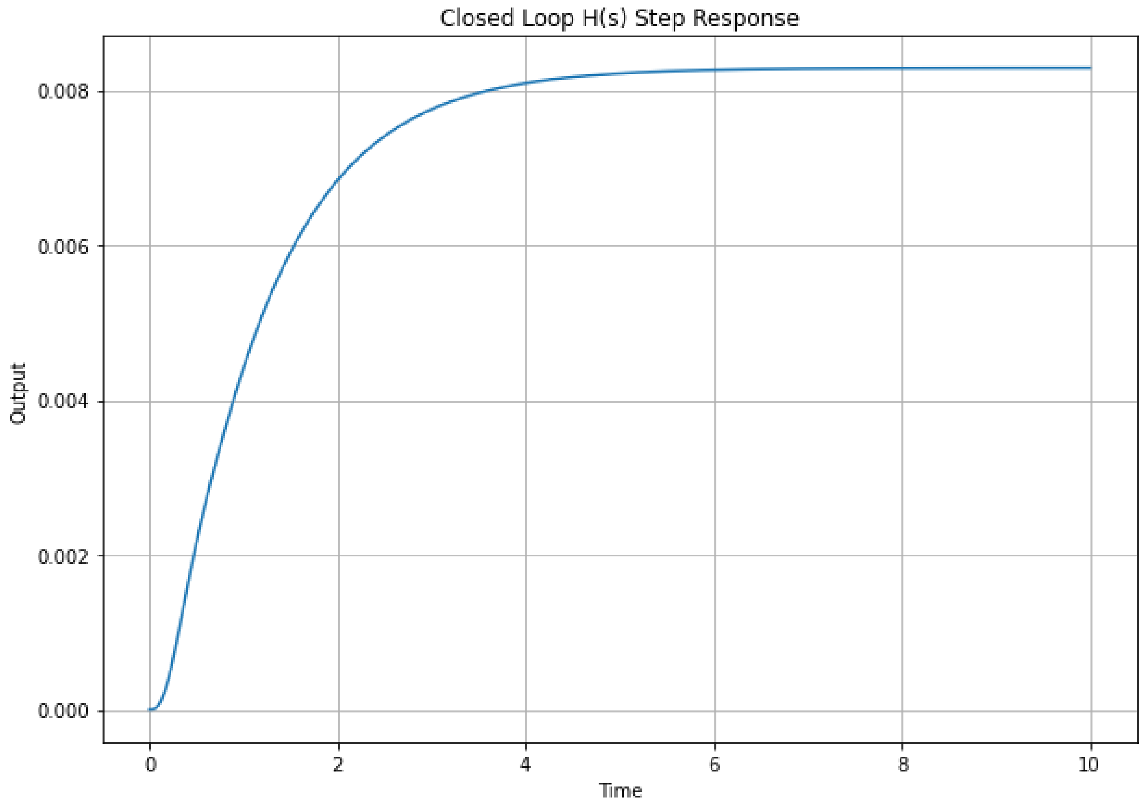
This shows an unstable system, as the values shoot off to infinity as time increases.

5 Part 2

The Closed Loop equation for the found in *Figure 1* can be found in (V). Since the limit as "s" goes to 0 is positive, the system is stable.

The following figure shows the output for the Open Loop Step Response of (V).

Figure 3: Closed Loop Step Response



This shows a stable system because the system plateaus (reaches a limit) as time progresses.