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ESE 547 Wise
Take-Home Midterm

RSLQR Design Commanding a Constant AOA using State Feedback Controller

Plant Without Actuator

```
Ap1 =

  -1.2100e+00   1.0000e+00
   4.4251e+01            0


Bp1 =

  -1.9870e-01
  -9.7321e+01


Cp1 =

     1     0
     0     1


Dp1 =

     0
     0
```

RSLQR Design

qq = logspace(-3,2, 500); *Exit on abs(rdmin-srmin) < .0005*

```
Aw =

            0   1.0000e+00            0
            0  -1.2100e+00   1.0000e+00
            0   4.4251e+01            0


Bw =

            0
  -1.9870e-01
  -9.7321e+01


Q =

   5.2172e+00            0            0
            0            0            0
            0            0            0


R =

     1


Kc =

  -2.2841e+00  -1.2434e+00  -1.5833e-01
```

Plant With Actuator

```
Ap2 =

  -1.2100e+00   1.0000e+00  -1.9870e-01            0
   4.4251e+01            0  -9.7321e+01            0
            0            0           0   1.0000e+00
            0            0  -1.9344e+03  -5.2779e+01


Bp2 =

            0
            0
            0
   1.9344e+03


Cp2 =

     1     0     0     0
     0     1     0     0
     0     0     1     0
     0     0     0     1


Bp2 =

            0
            0
            0
   1.9344e+03
```

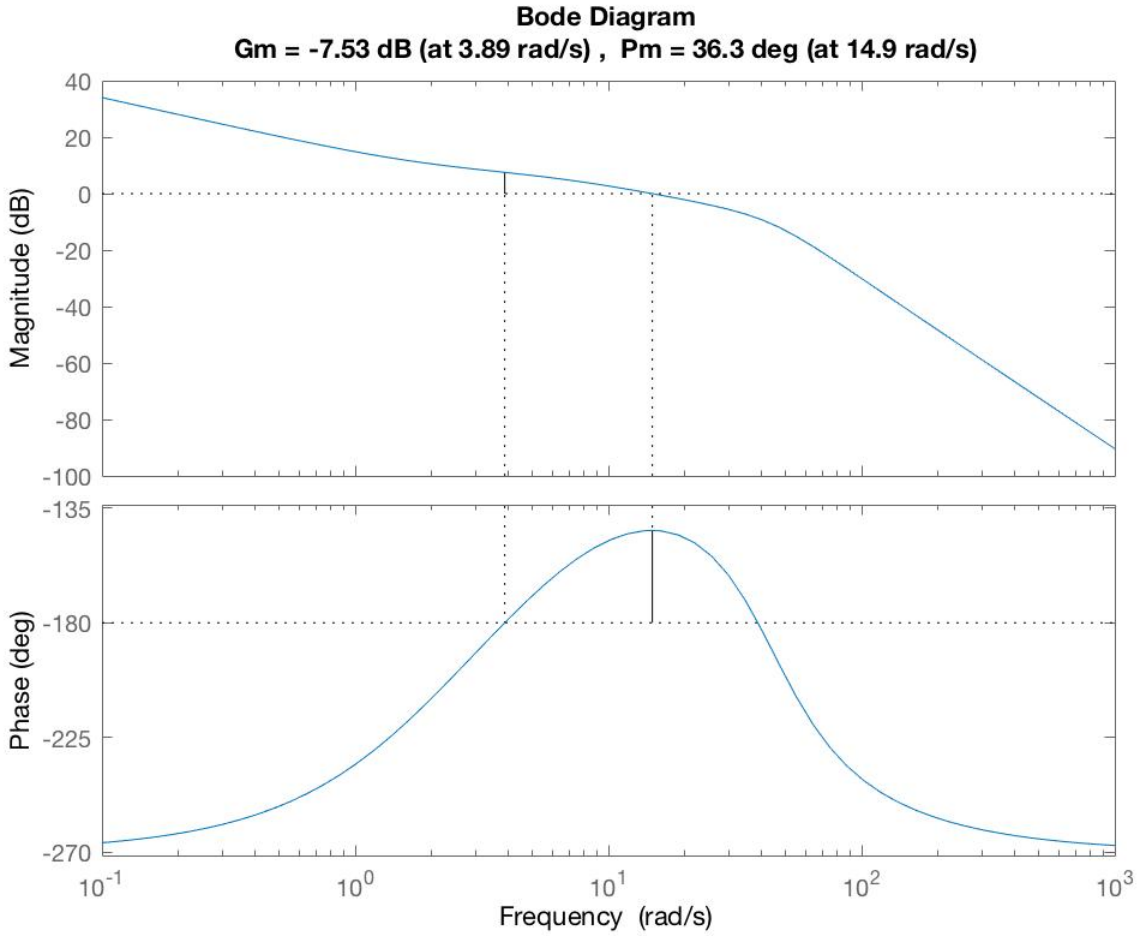
State Space Model for Controller:

```
Ac =

     0


Bc1 =

     1     0     0     0


Bc2 =

    -1


Cc =

   2.2841e+00


Dc1 =

   1.2434e+00   1.5833e-01            0            0


Dc2 =

     0
```

Closed Loop Eigenvalues/Eigenvectors

```
xx =

  -1.5468e+01 + 2.8958e+01i
  -1.5468e+01 - 2.8958e+01i
  -1.2660e+01 + 0.0000e+00i
  -5.1962e+00 + 2.1245e+00i
  -5.1962e+00 - 2.1245e+00i


eigVecs =

  -1.7433e-01 - 9.6060e-02i  -1.7433e-01 + 9.6060e-02i   5.5990e-02 + 0.0000e+00i  -2.5696e-03 - 5.9121e-04i  -2.5696e-03 + 5.9121e-04i
   8.9271e-01 + 0.0000e+00i   8.9271e-01 + 0.0000e+00i  -6.5292e-01 + 0.0000e+00i   5.0919e-02 - 7.1296e-02i   5.0919e-02 + 7.1296e-02i
  -3.1602e-02 - 6.3164e-02i  -3.1602e-02 + 6.3164e-02i  -5.9478e-02 + 0.0000e+00i  -1.4290e-02 - 2.6751e-02i  -1.4290e-02 + 2.6751e-02i
   2.9840e-01 + 2.6107e-01i   2.9840e-01 - 2.6107e-01i   7.5300e-01 + 0.0000e+00i   9.9569e-01 + 0.0000e+00i   9.9569e-01 + 0.0000e+00i
   2.2269e-02 + 2.7591e-02i   2.2269e-02 - 2.7591e-02i  -4.4226e-03 + 0.0000e+00i   2.0994e-05 + 7.7523e-05i   2.0994e-05 - 7.7523e-05i
```

Loop Gain Crossover Frequency, Phase Crossover Frequency

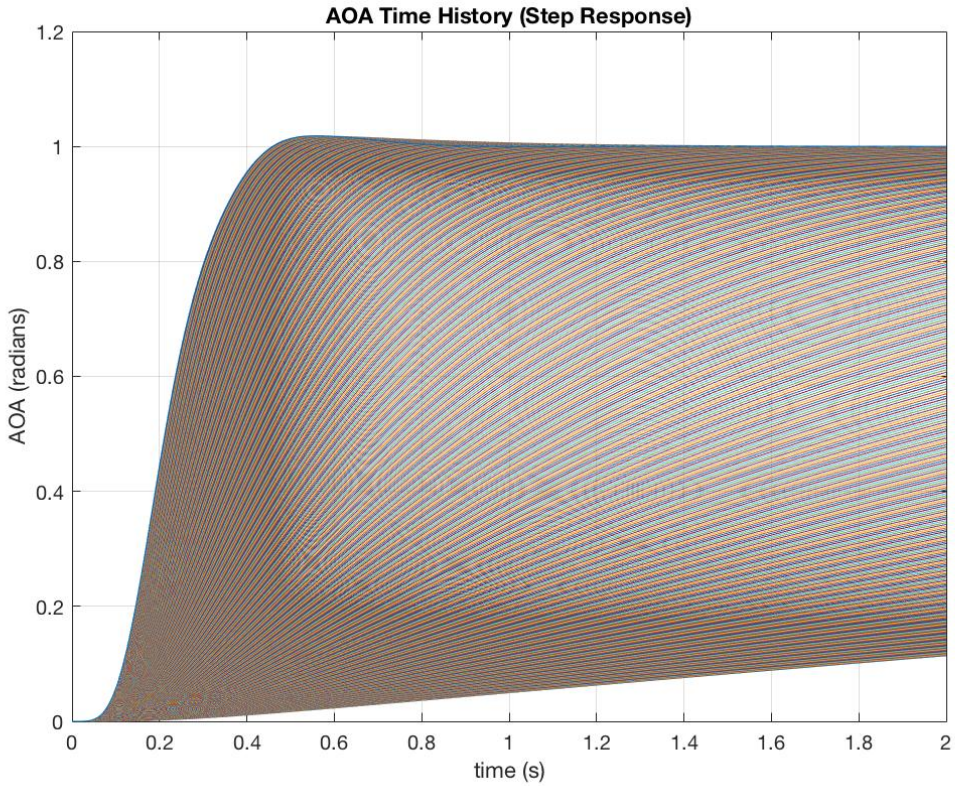


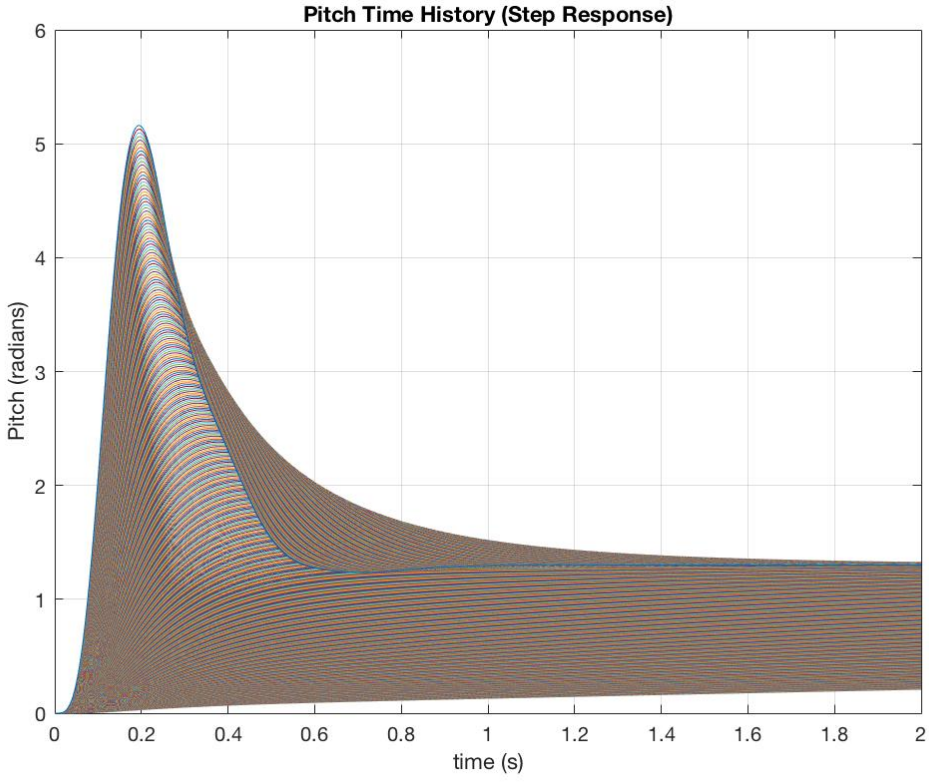

```
 GainMargin: [4.2020e-01 2.7299e+00]
GMFrequency: [3.8949e+00 3.8948e+01]
PhaseMargin: 3.6264e+01
PMFrequency: 1.4912e+01
DelayMargin: 4.2444e-02
DMFrequency: 1.4912e+01
     Stable: 1
```

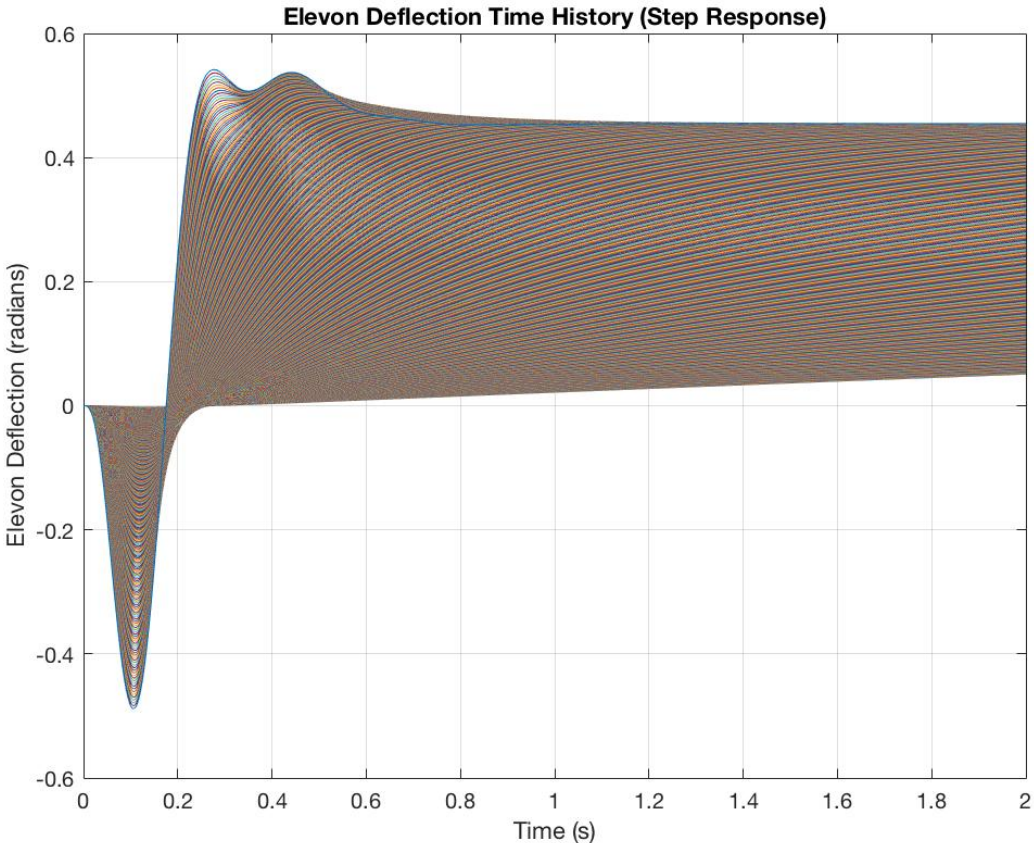
Singular Value Margins

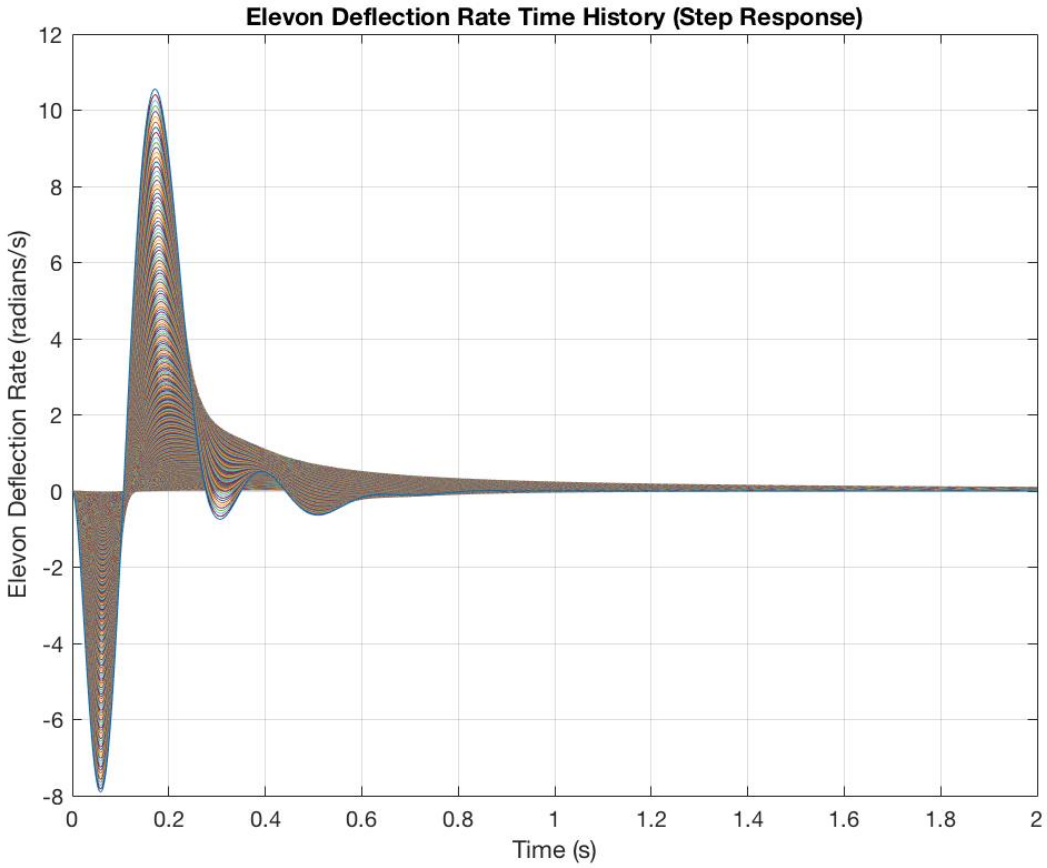
```
\\\ Singular Value Margins \\\
Return Difference at Input
  Negative Gain Margin: -3.6383 dB,  Positive Gain Margin: 6.3796 dB
  Phase Margin: +/-30.1548 deg

Stability Robustness at Input
  Negative Gain Margin: -6.3806 dB,  Positive Gain Margin: 3.6386 dB
  Phase Margin: +/-30.1579 deg
```

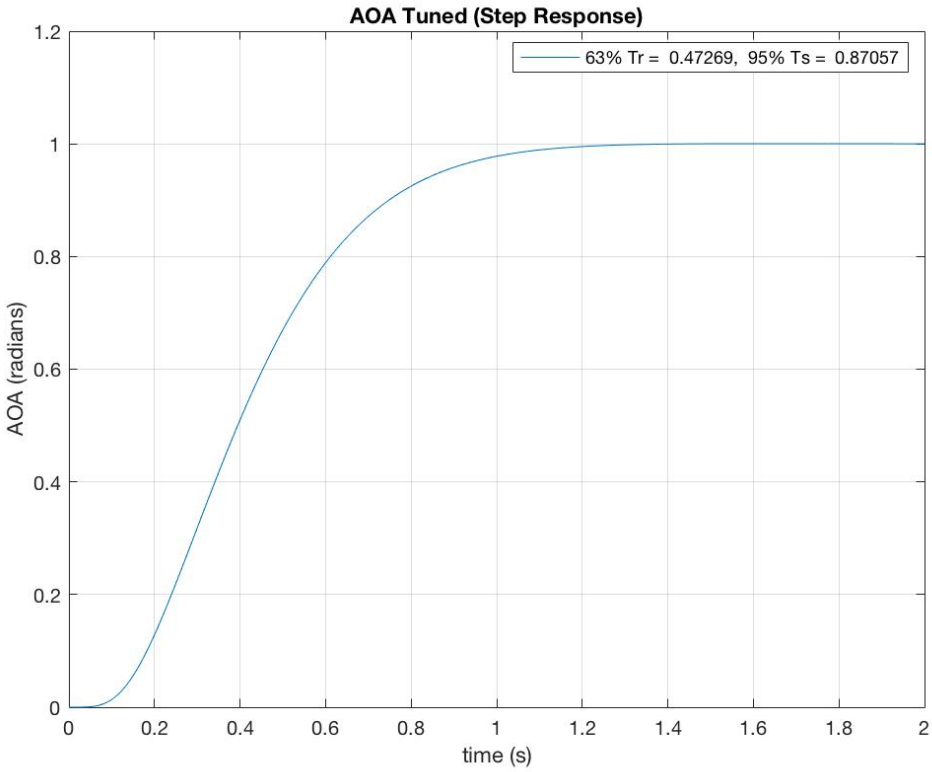
Time Domain Performance Metrics (Time Histories along with Tuned Step Responses)

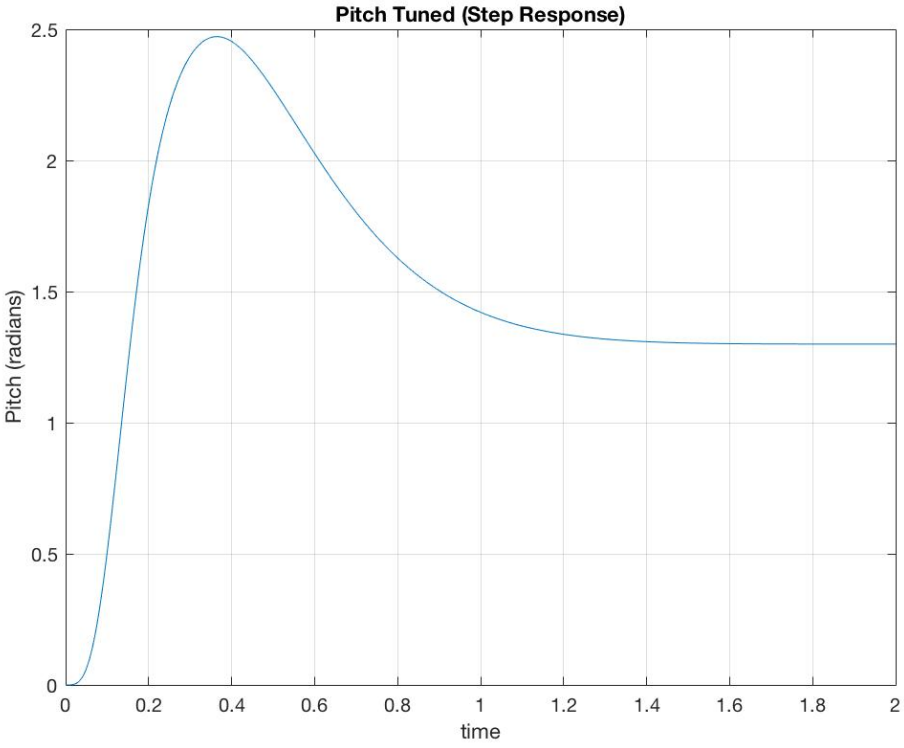


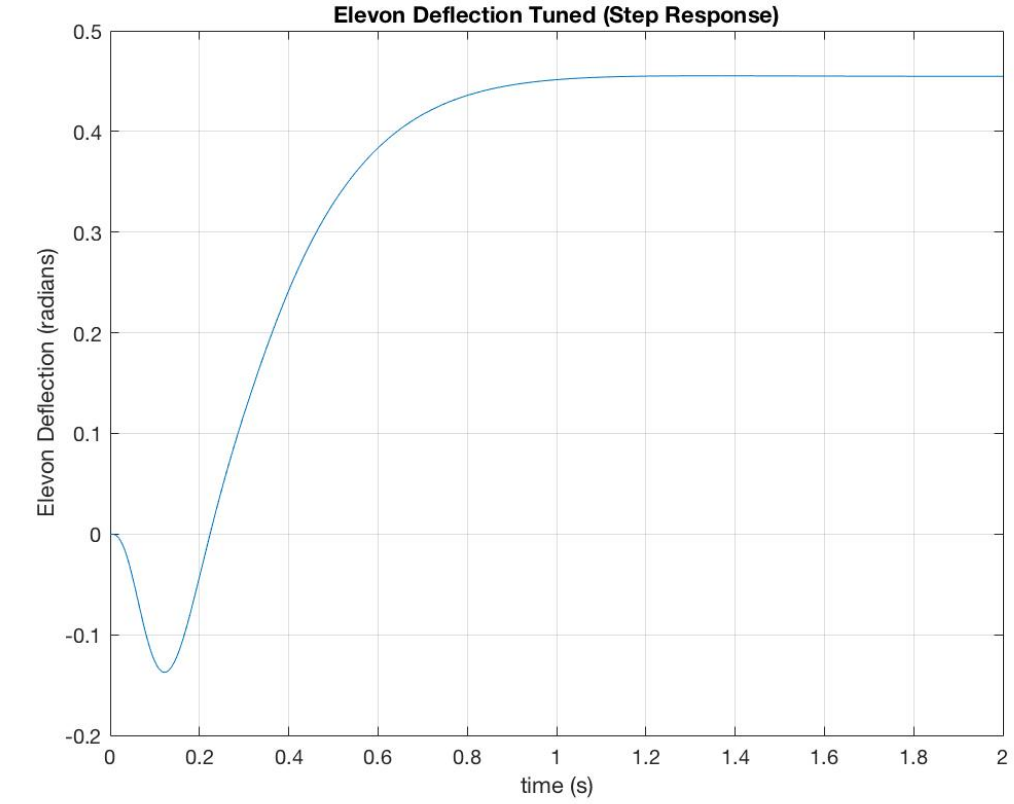


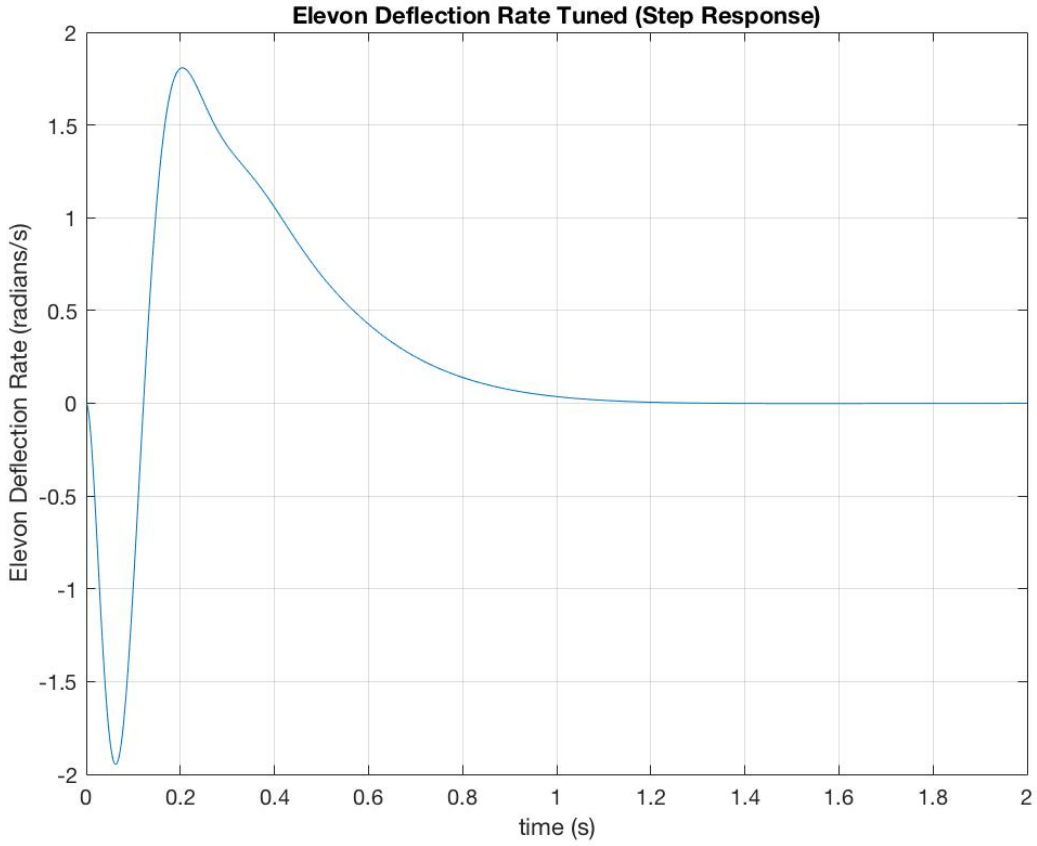

Elevon Deflection Time History (Step Response)
Elevon Deflection (radians)
Time (s)
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2


Elevon Deflection Rate Time History (Step Response)
Elevon Deflection Rate (radians/s)
Time (s)
12
10
8
6
4
2
0
-2
-4
-6
-8
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2

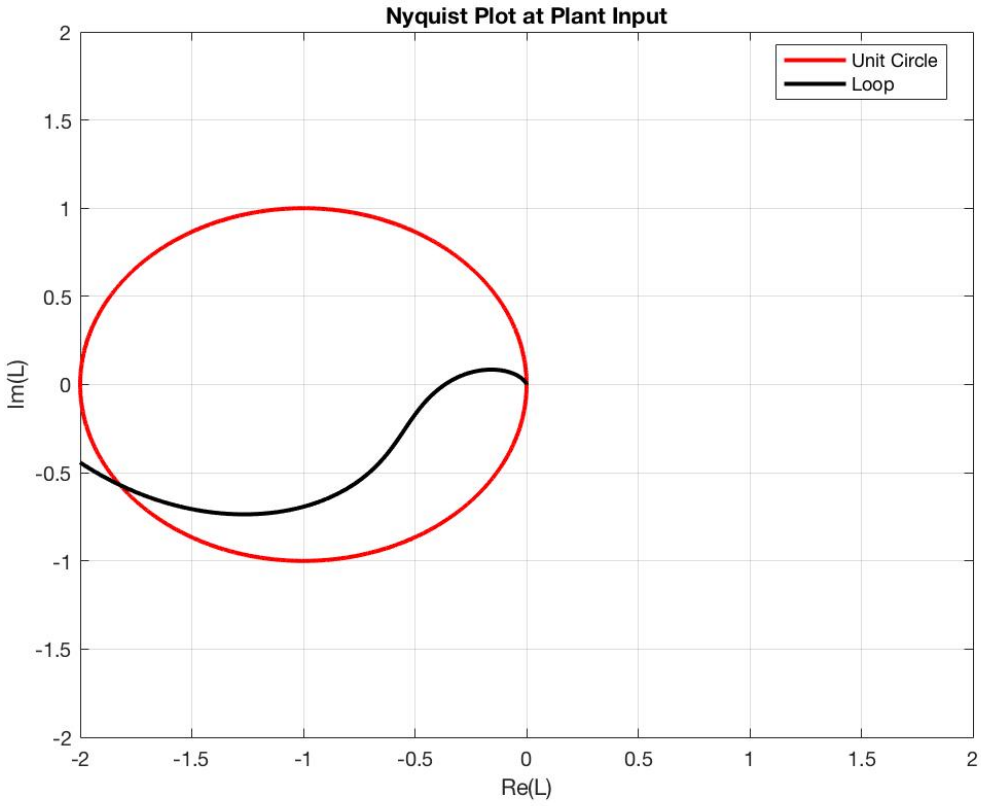

AOA Tuned (Step Response)
63% Tr = 0.47269, 95% Ts = 0.87057
AOA (radians)
time (s)
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2

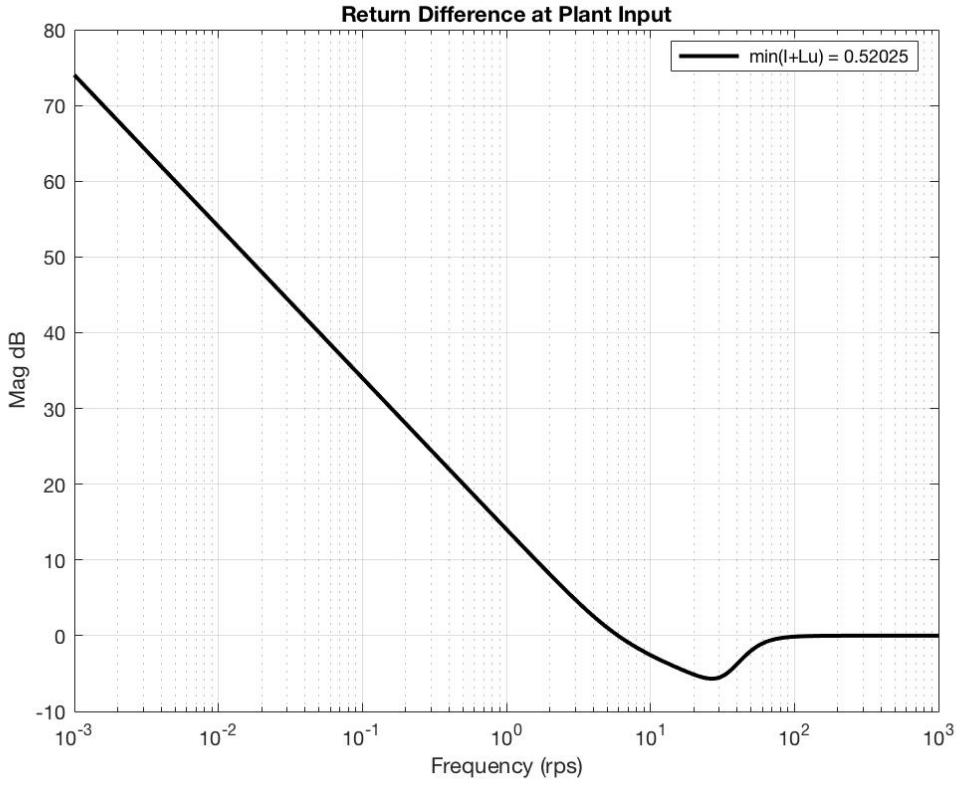

Pitch Tuned (Step Response)
Pitch (radians)
time
0
0.5
1
1.5
2
2.5
0.2
0.4
0.6
0.8
1.2
1.4
1.6
1.8

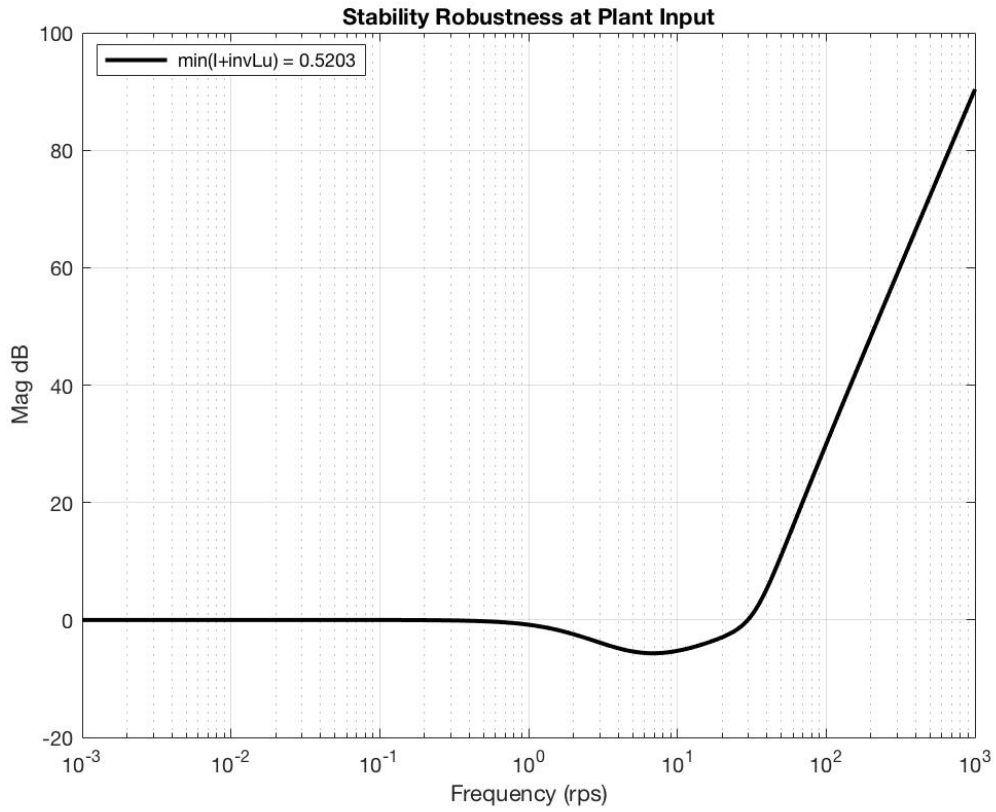

Elevon Deflection Tuned (Step Response)
Elevon Deflection (radians)
time (s)
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2


Elevon Deflection Rate Tuned (Step Response)
Elevon Deflection Rate (radians/s)
time (s)
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2

Frequency Domain at the Plant Input






Stability Robustness at Plant Input
min(I+invLu) = 0.5203
Mag dB
Frequency (rps)
100
80
60
40
20
0
-20
10^-3
10^-2
10^-1
10^0
10^1
10^2
10^3

Frequency Domain Analysis at Plant Output