

Home Work #5

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1 Question 1

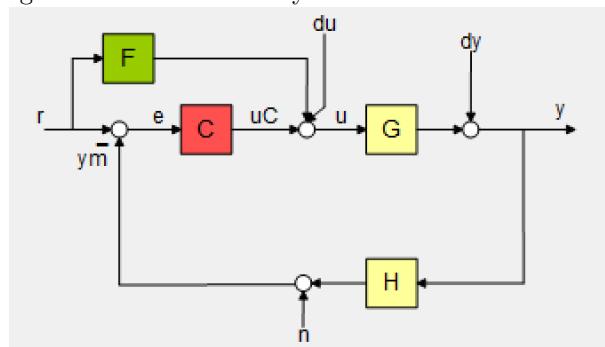
System:

$$G(s) = \frac{s + 1}{s^2 - 2s + 4}$$

System is NMP (Non Minimum Phase) because it have poles in right side and system is unstable.

Architector:

Figure 1: Architector of system in siso matlab toolbox

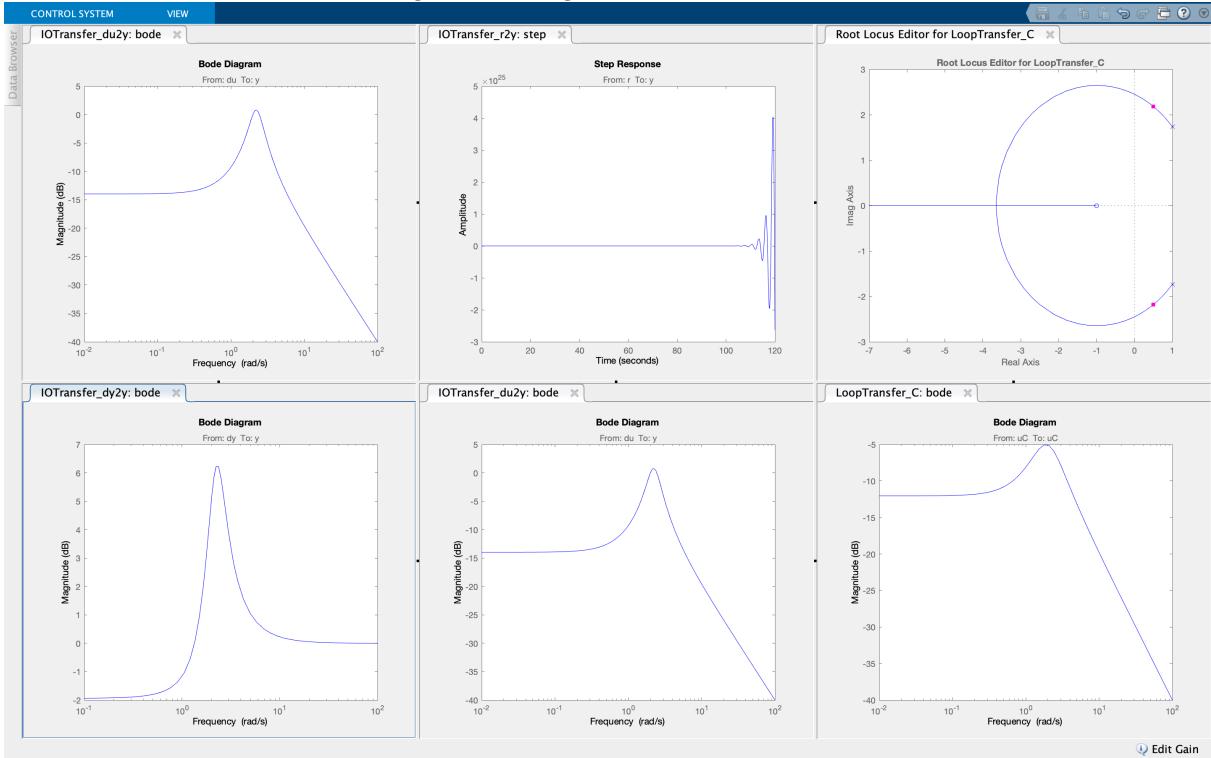


1.1 part a

In condition without controller from architect C(s) = 1 and F(s) = 0.

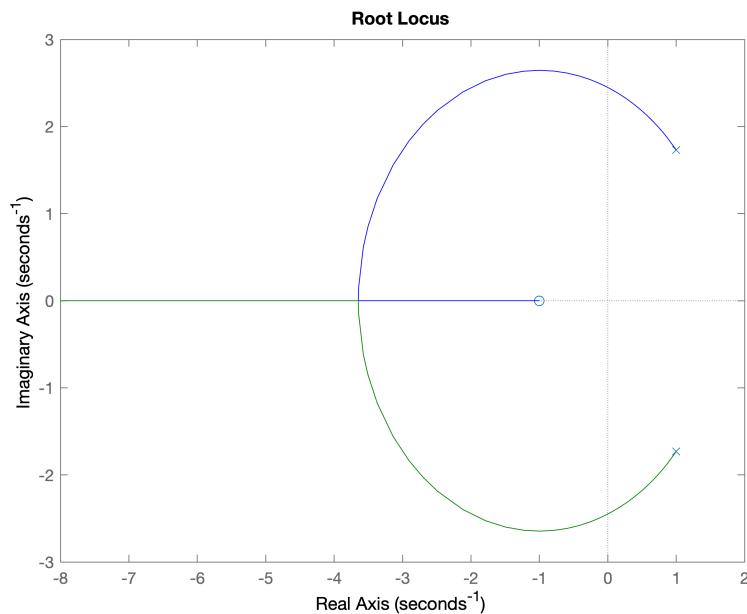
- all figures from siso toolbox

Figure 2: All figures from siso toolbox



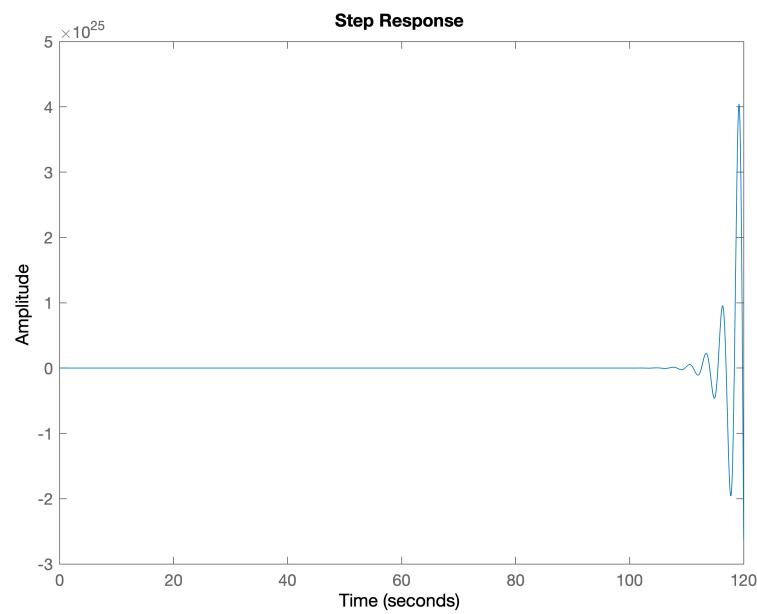
- root locus

Figure 3: root locus



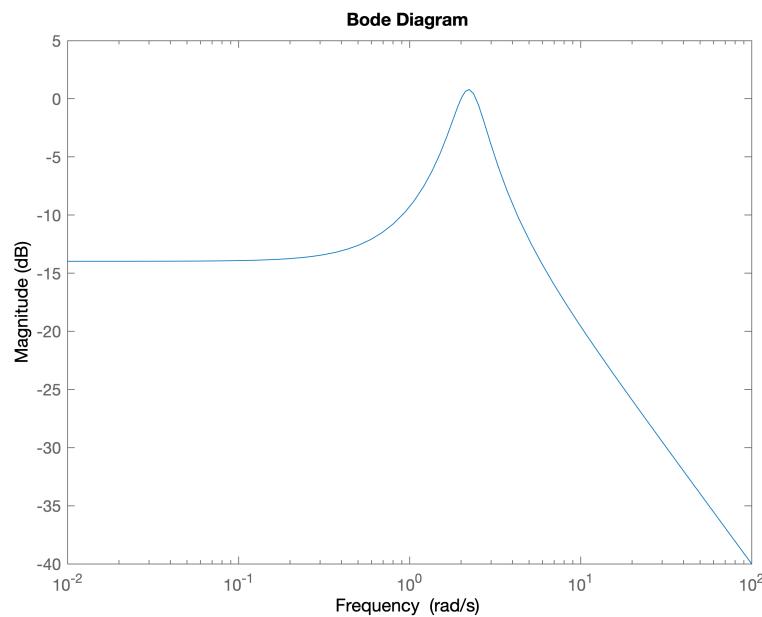
- step response for closeloop system

Figure 4: step response for closeloop system



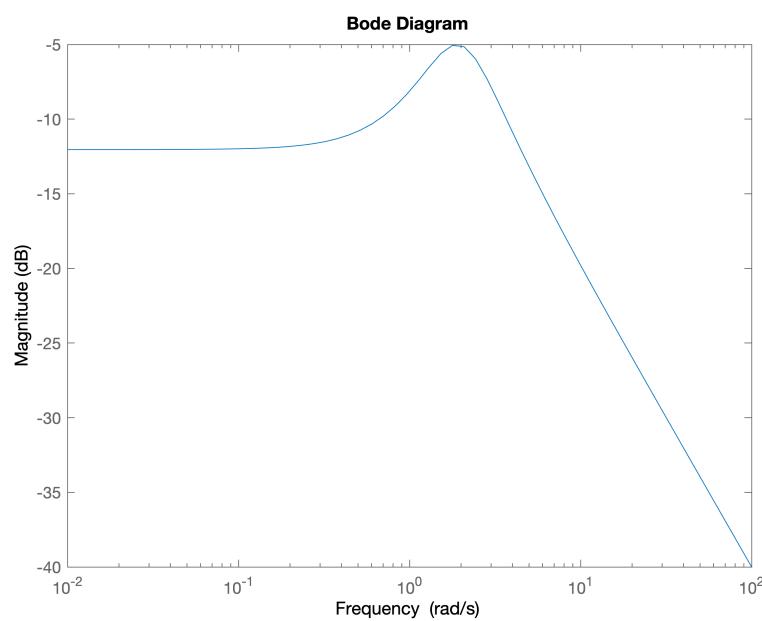
- closeloop bode (magnitude)

Figure 5: closeloop bode (magnitude)



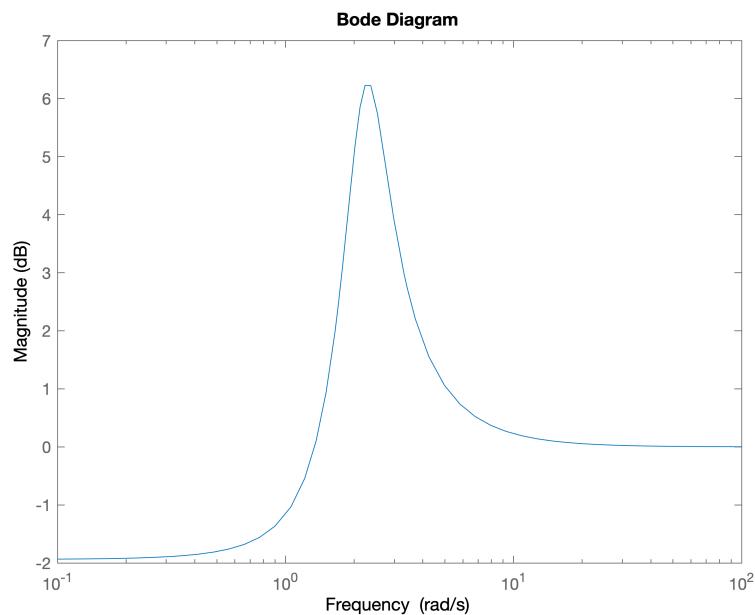
- openloop bode (magnitude)

Figure 6: openloop bode (magnitude)



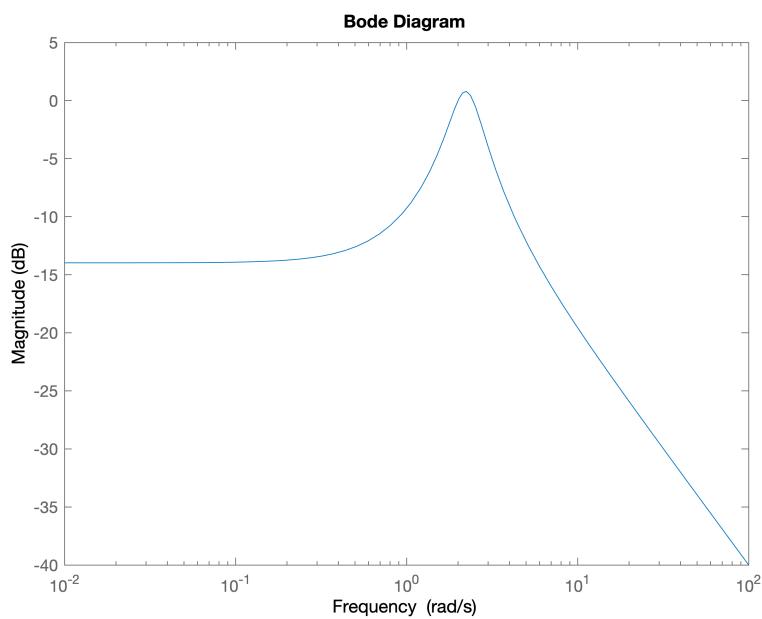
- sensitivity function

Figure 7: sensitivity function



- complementary sensitivity function

Figure 8: complementary sensitivity function



1.2 part b

In this section we design P, I, lead, PD and lag controller and see how them work in system.

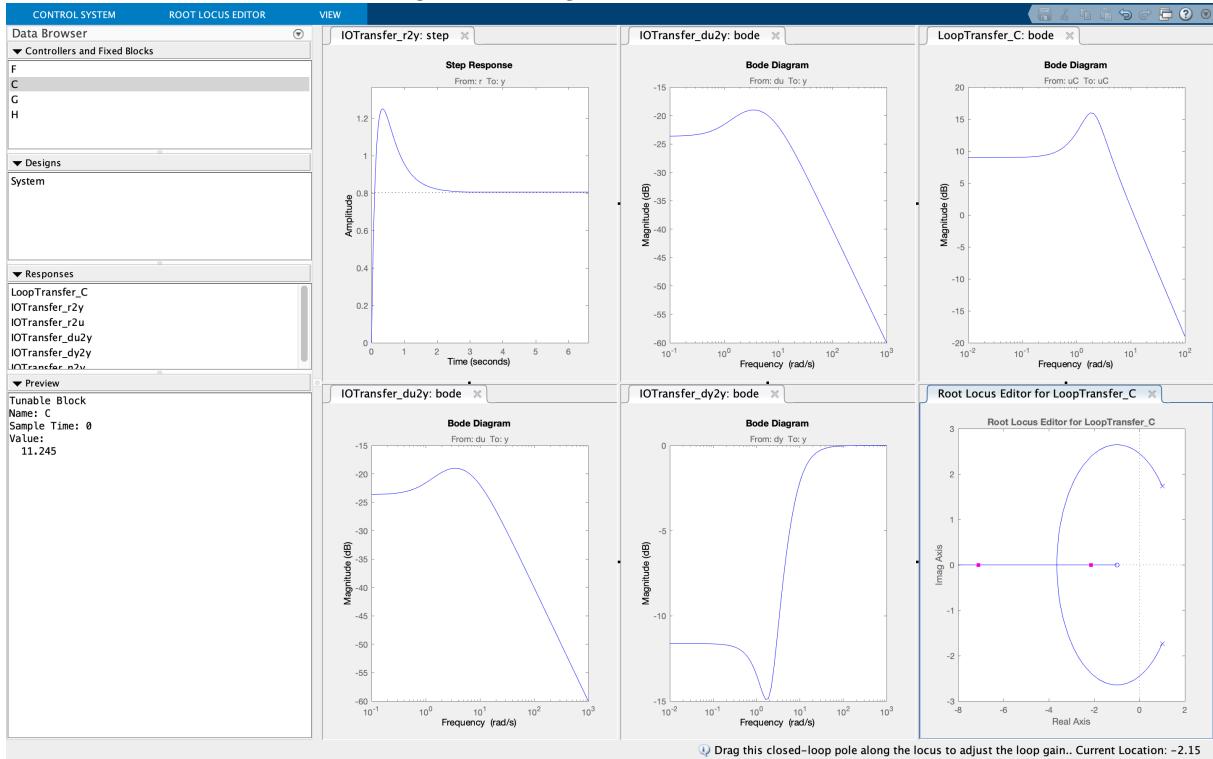
1.2.1 P

We design aPcontroller with siso tool box.

$$C(s) = 11.245$$

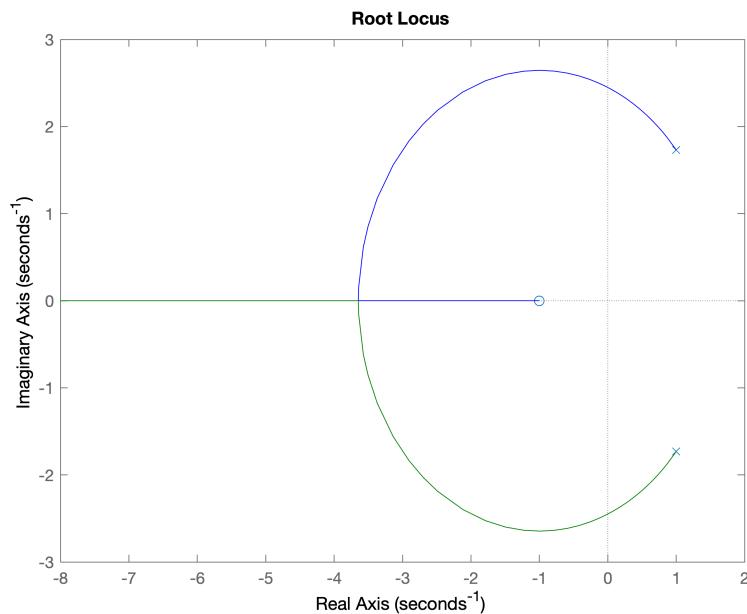
- all figures from siso toolbox

Figure 9: All figures from siso toolbox



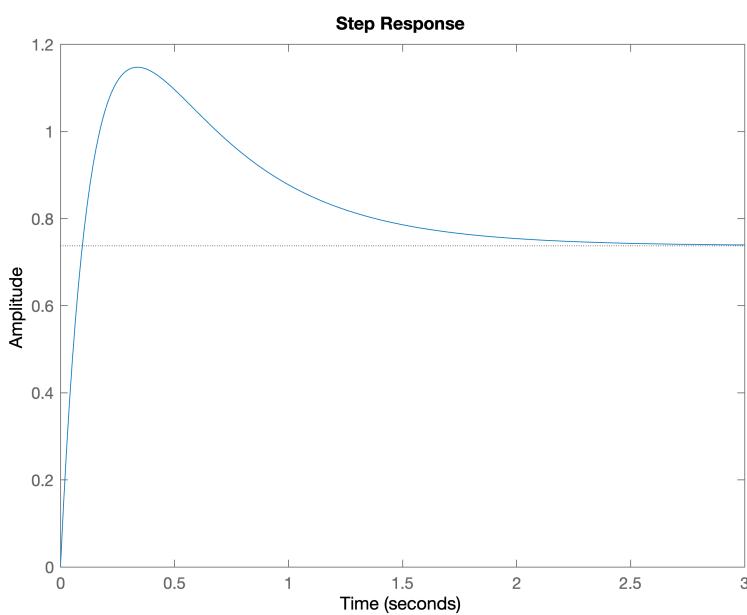
- root locus withPcontroller

Figure 10: root locus



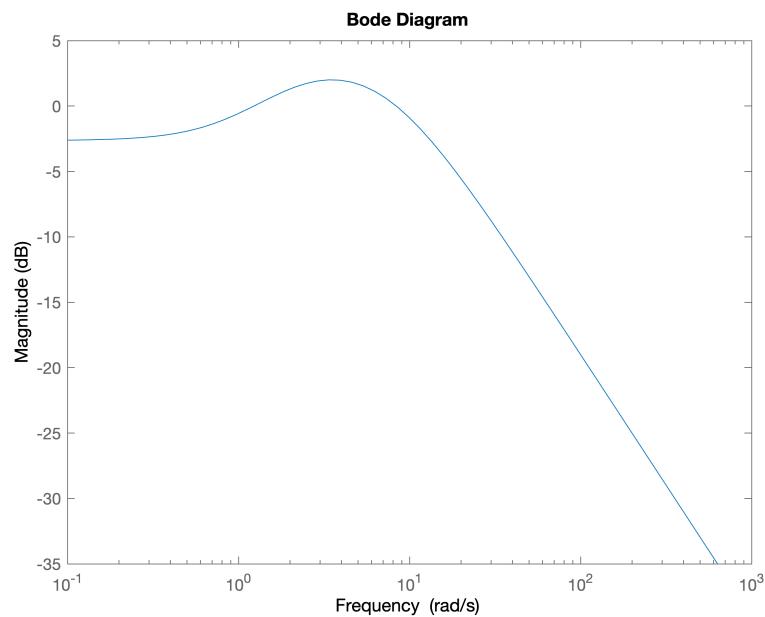
- step response for closeloop system withPcontroller

Figure 11: step response for closeloop system



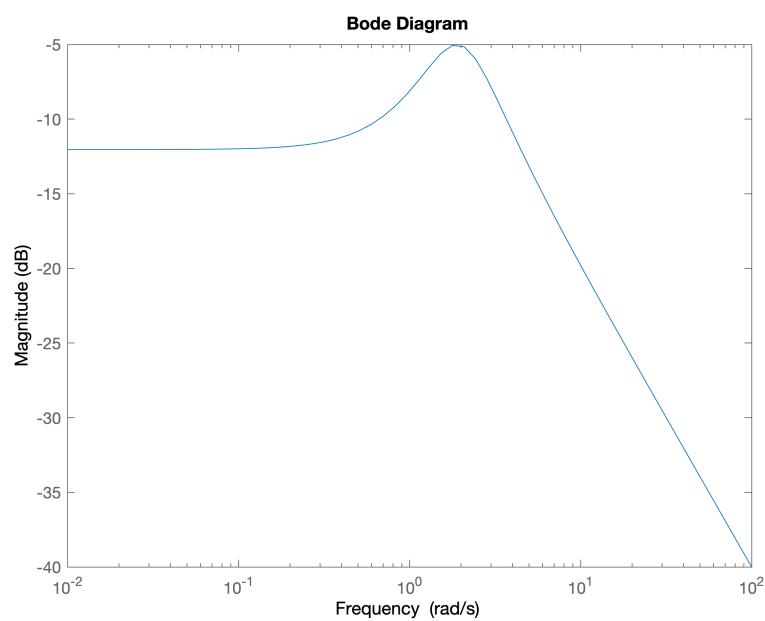
- closeloop bode (magnitude) withPcontroller

Figure 12: closeloop bode (magnitude)



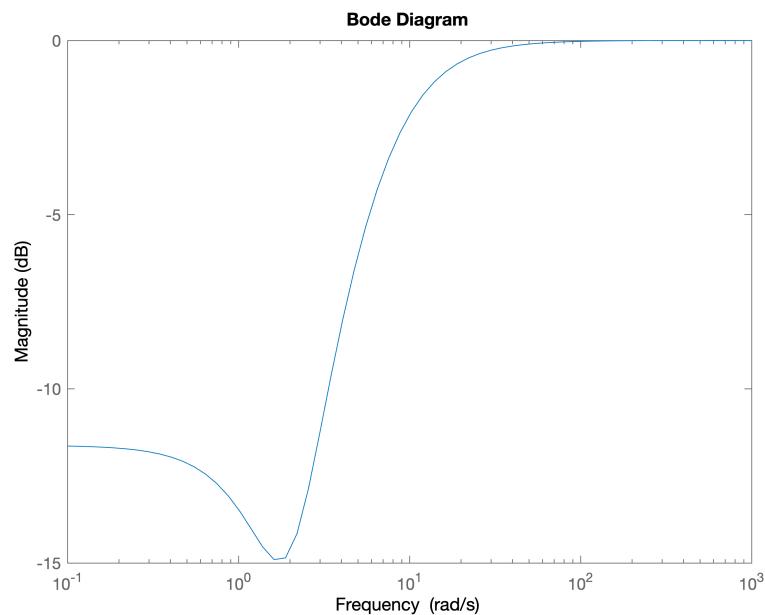
- openloop bode (magnitude) withPcontroller

Figure 13: openloop bode (magnitude)



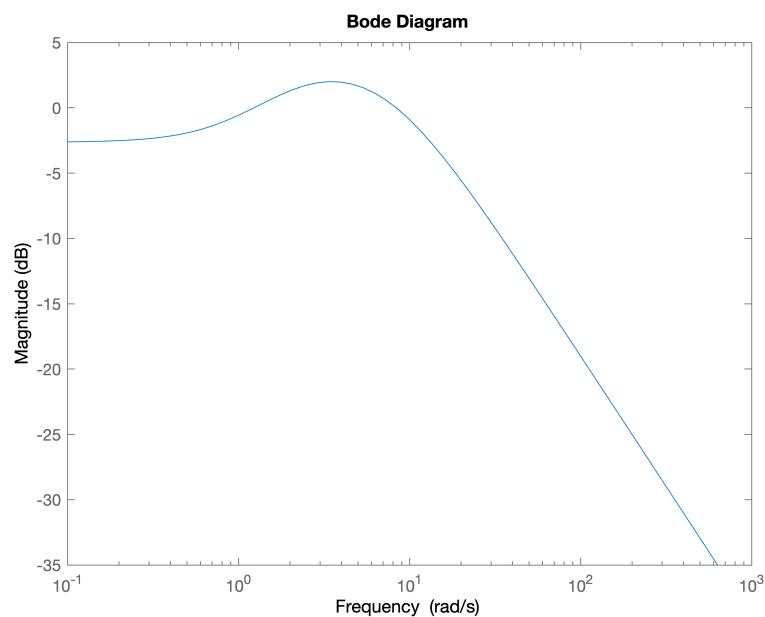
- sensitivity function withPcontroller

Figure 14: sensitivity function



- complementary sensitivity function withPcontroller

Figure 15: complementary sensitivity function



System is stable with controller and have a noise cancelation for frequency after $100_{rad/sec}$ and it have effect on system about -20_{dB} . System have very good disturbance rejection about $1_{rad/sec}$ and have a good disturbance rejection about $10_{rad/sec}$ and disturbance have effect on system about -5_{dB} .

In this question we don't know what is plant and actuator and how noise or disturbance effect on system and about what frequency so we assume that noise is about more than $100_{rad/sec}$ and disturbance is about $10_{rad/sec}$ and -5_{dB} is a low effect and system work well.

No. System have staedy state error. we could increase gain in controller but it needed very high gaib controller and no actuator can do this so we can't make staedy state error zero with this requirements.

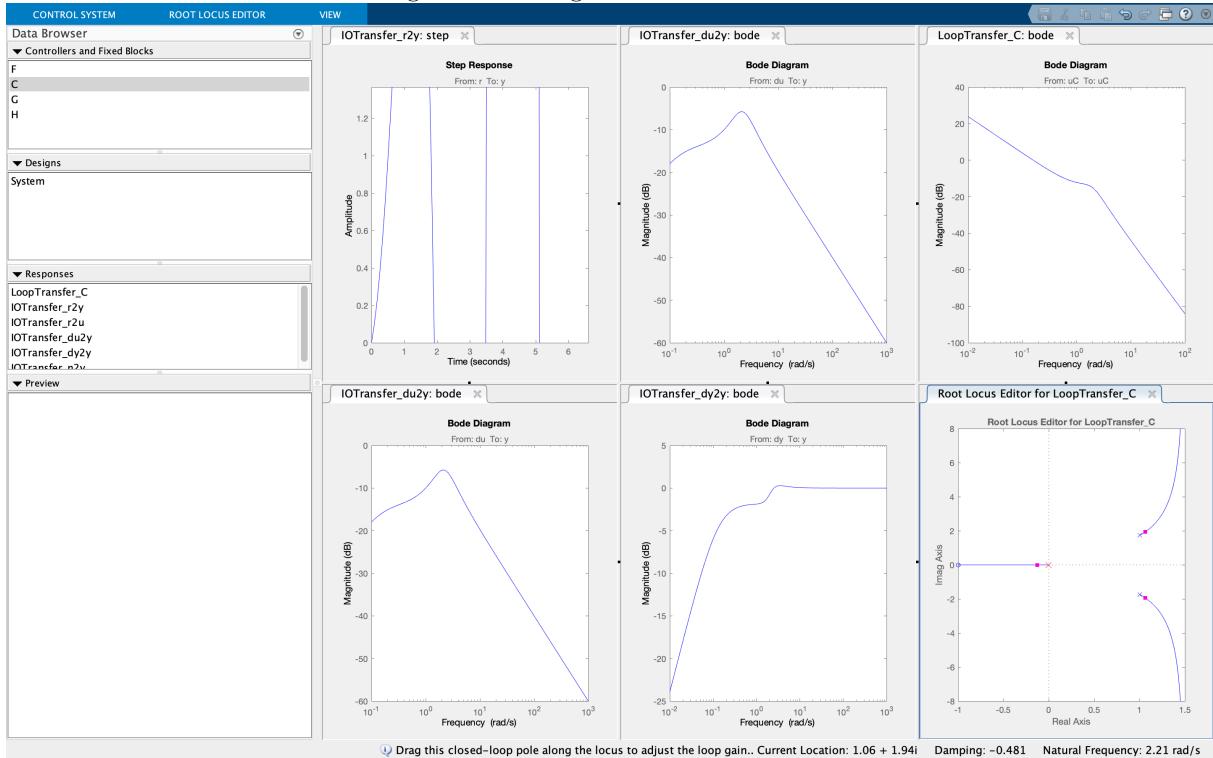
1.2.2 I

We design a I controller with siso tool box.

$$C(s) = \frac{1}{s}$$

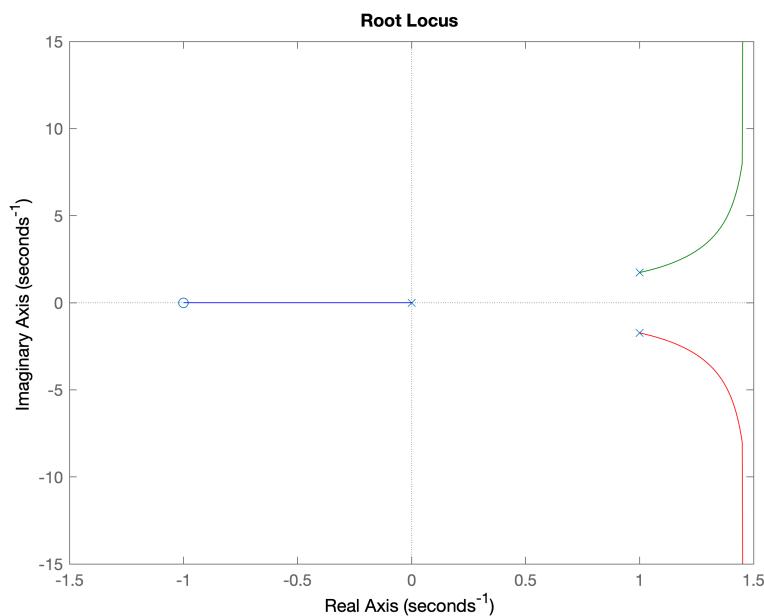
- all figures from siso toolbox

Figure 16: All figures from siso toolbox



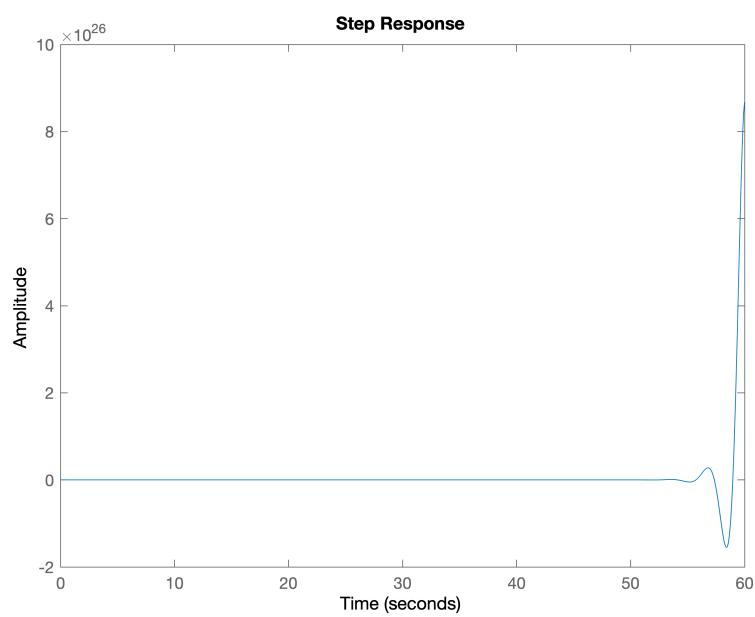
- root locus with I controller

Figure 17: root locus



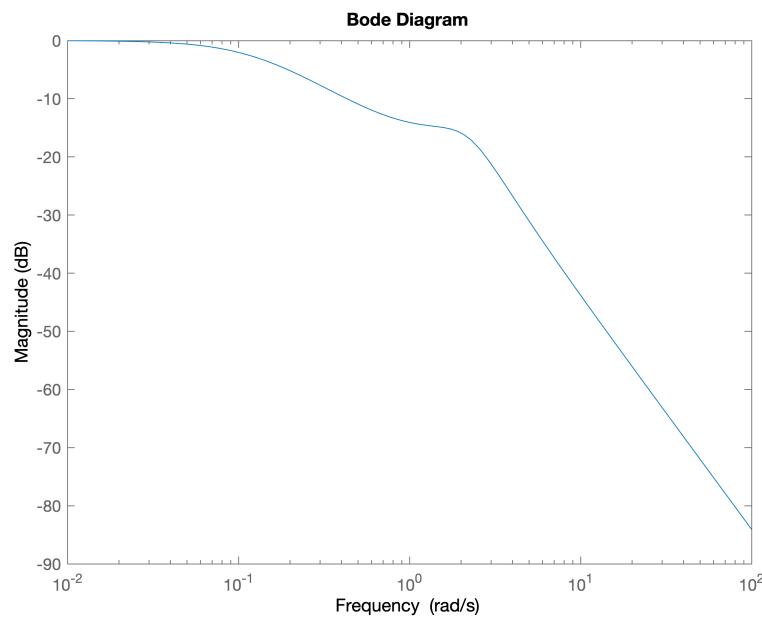
- step response for closeloop system with I controller

Figure 18: step response for closeloop system



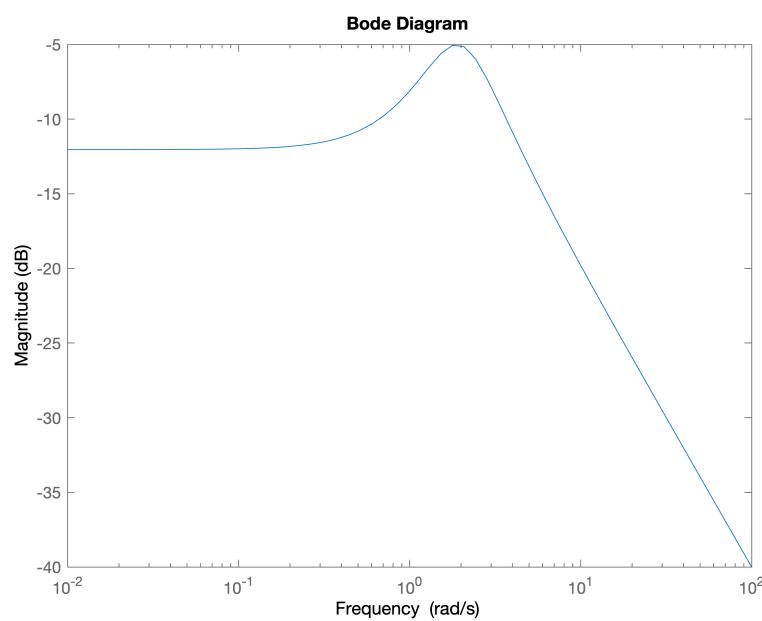
- closeloop bode (magnitude) with I controller

Figure 19: closeloop bode (magnitude)



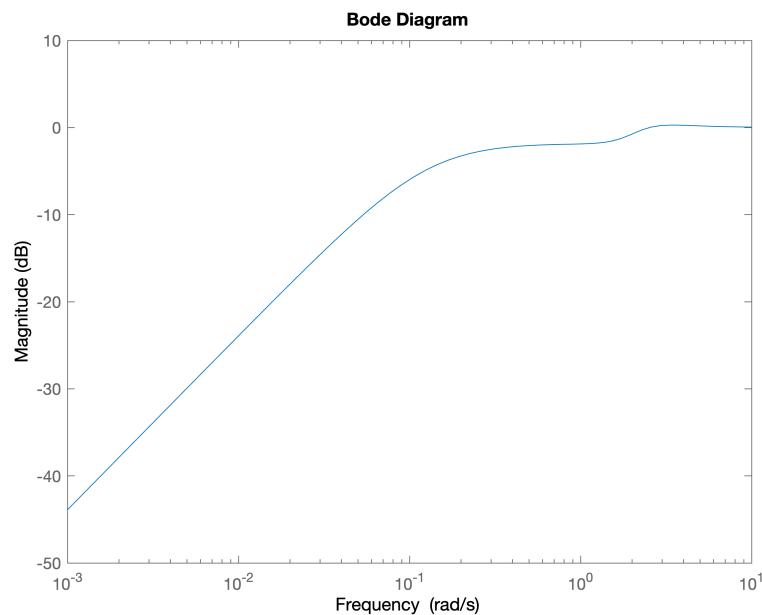
- openloop bode (magnitude) with I controller

Figure 20: openloop bode (magnitude)



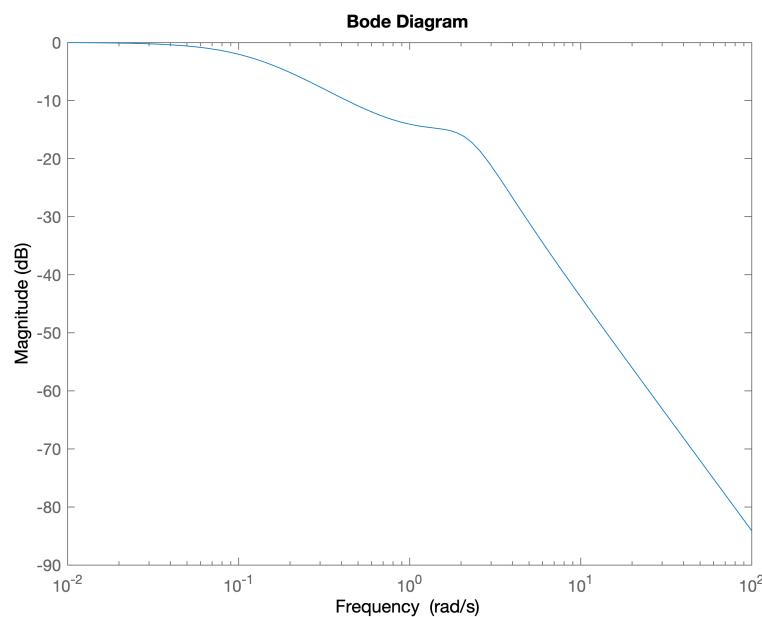
- sensitivity function with I controller

Figure 21: sensitivity function



- complementary sensitivity function with I controller

Figure 22: complementary sensitivity function



system is always unstable.

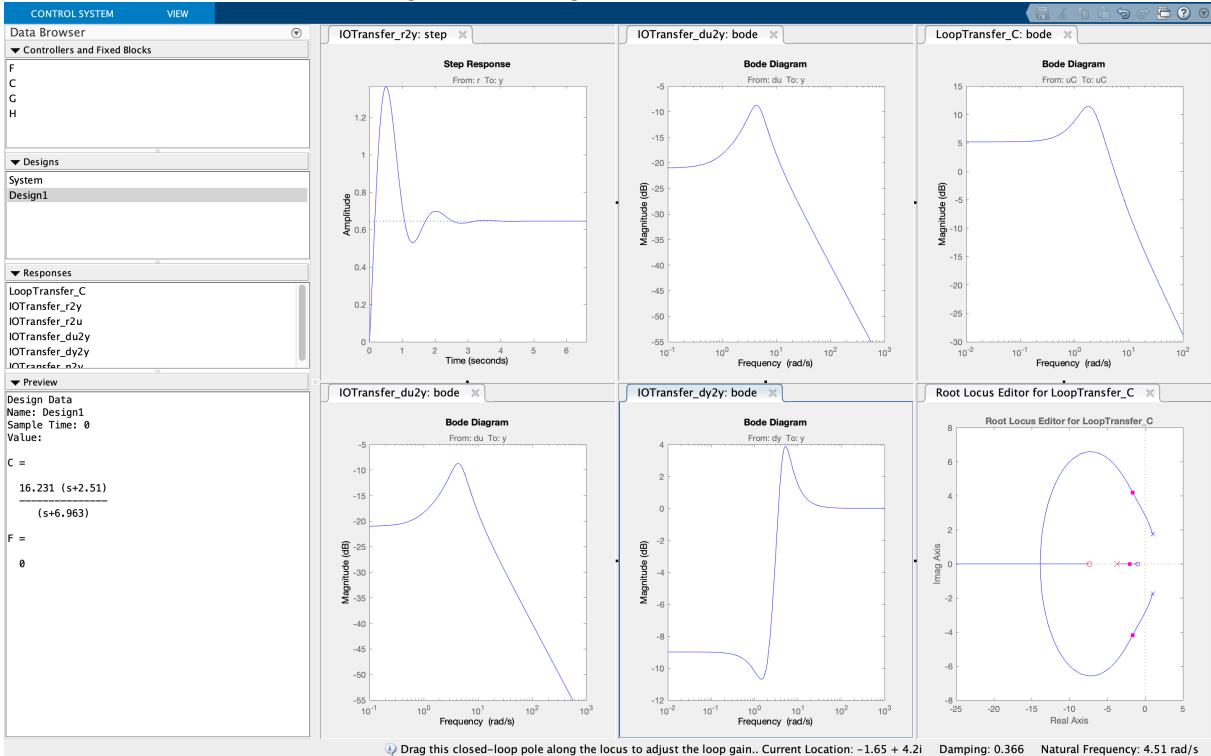
1.2.3 lag

We design a lag controller with siso tool box.

$$C(s) = \frac{3.6493(s + 7.347)}{s + 3.694}$$

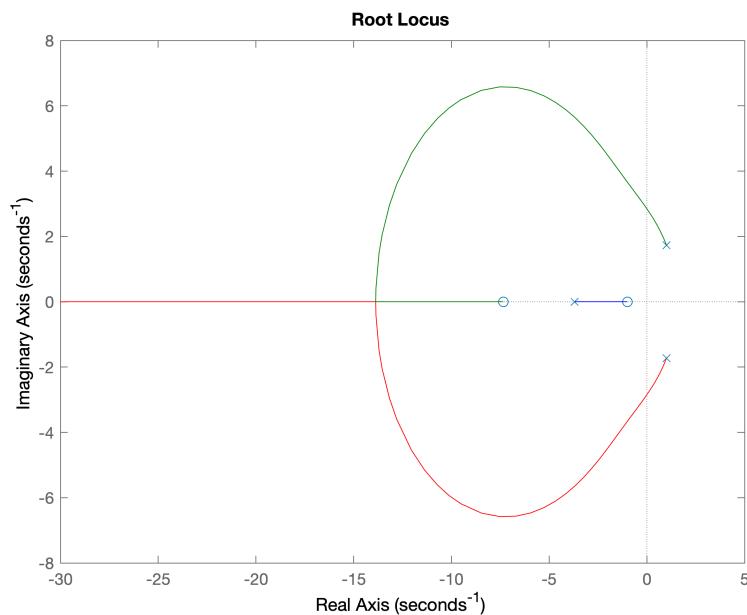
- all figures from siso toolbox

Figure 23: All figures from siso toolbox



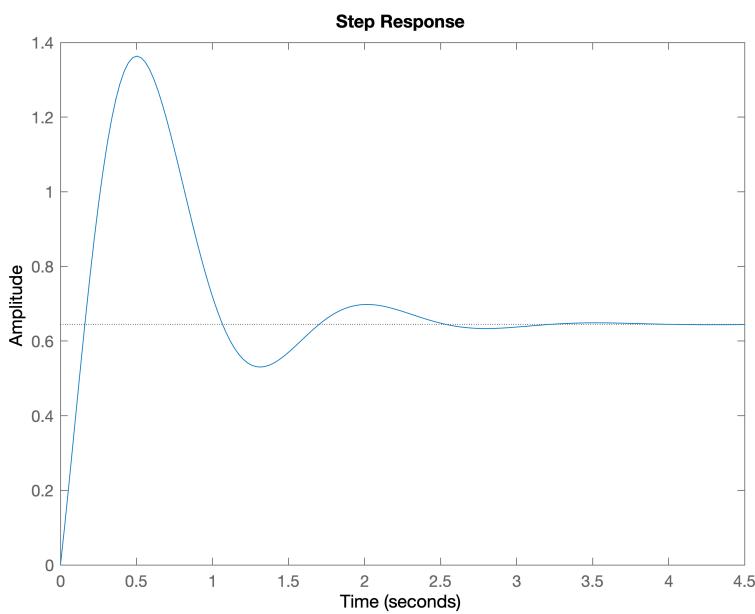
- root locus with lag controller

Figure 24: root locus



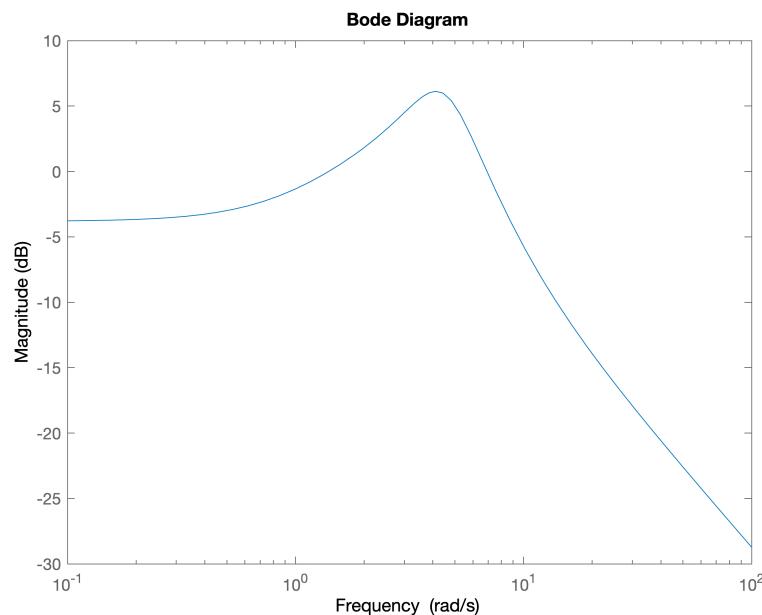
- step response for closeloop system with lag controller

Figure 25: step response for closeloop system



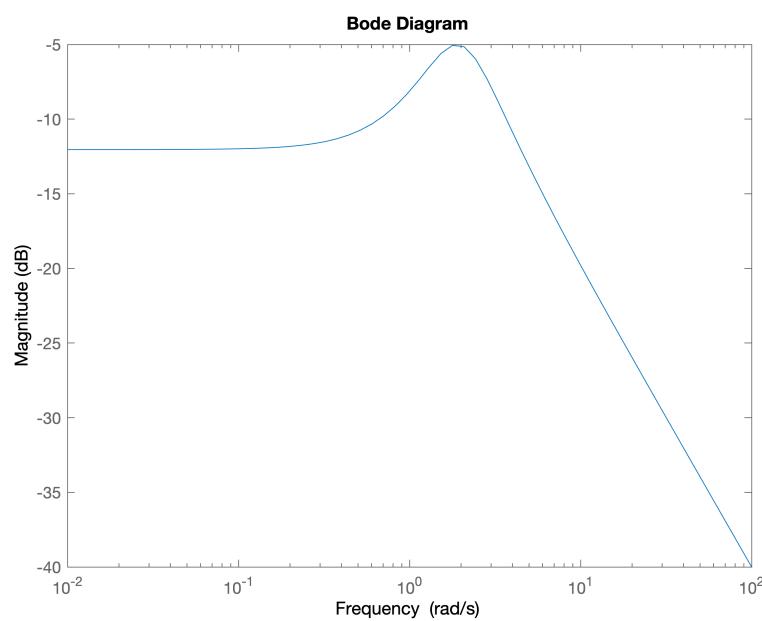
- closeloop bode (magnitude) with lag controller

Figure 26: closeloop bode (magnitude)



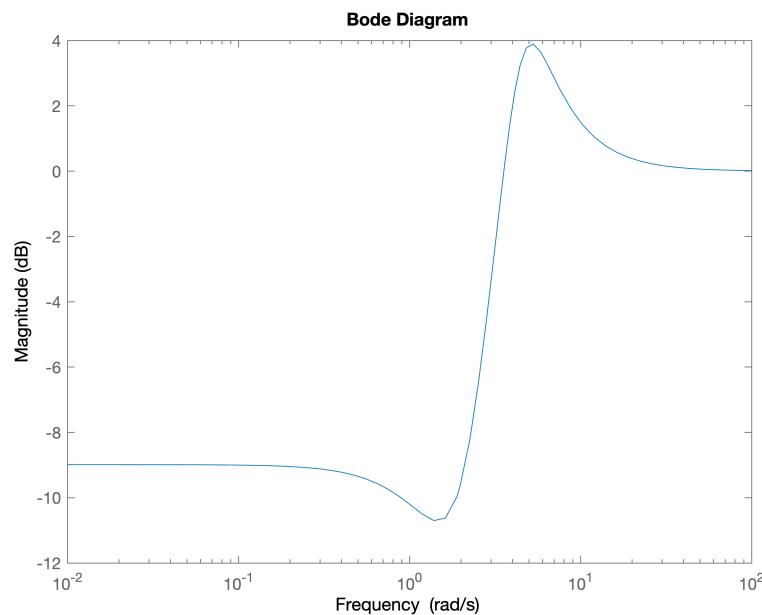
- openloop bode (magnitude) with lag controller

Figure 27: openloop bode (magnitude)



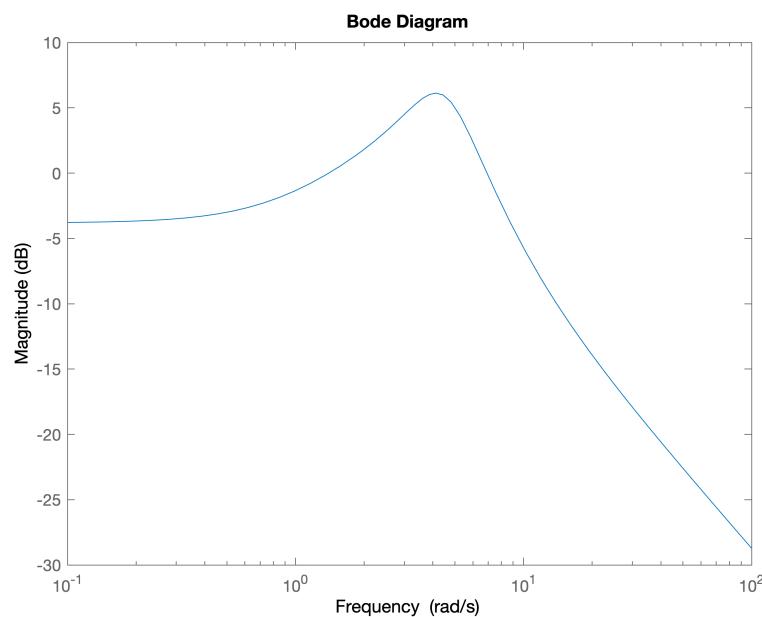
- sensitivity function with lag controller

Figure 28: sensitivity function



- complementary sensitivity function with lag controller

Figure 29: complementary sensitivity function



System is stable with controller and have a noise cancelation for frequency after $100_{rad/sec}$ and it have effect on system about -20_{dB} . System have very good disturbance rejection about $1_{rad/sec}$ and have a good disturbance rejection about $10_{rad/sec}$ and disturbance have effect on system about -5_{dB} .

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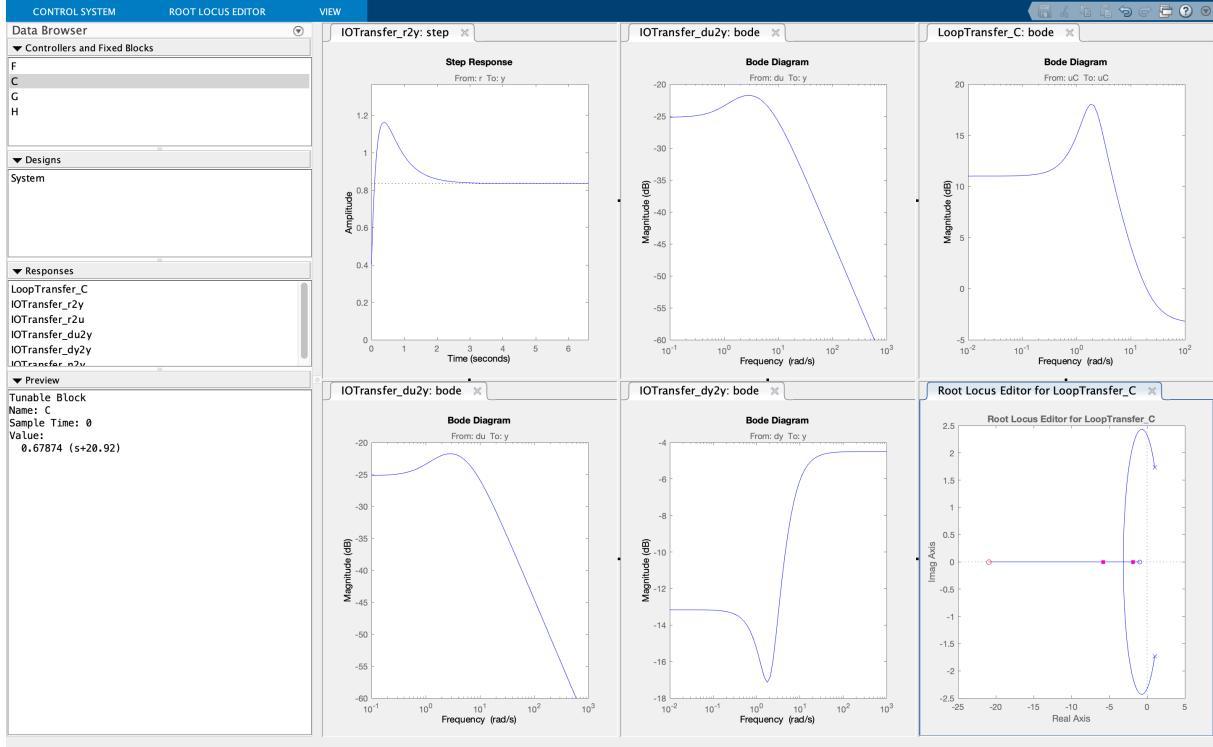
1.2.4 PD

We design a PD controller with siso tool box.

$$C(s) = 0.67874(s + 20.92)$$

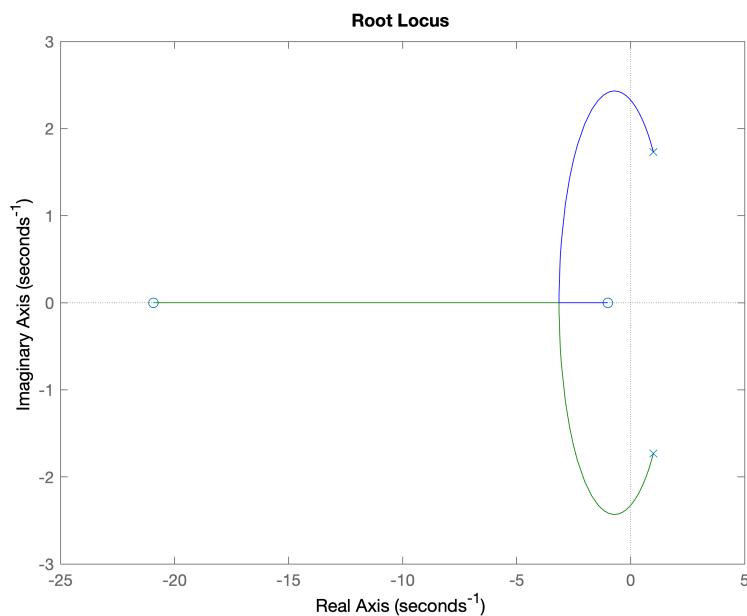
- all figures from siso toolbox

Figure 30: All figures from siso toolbox



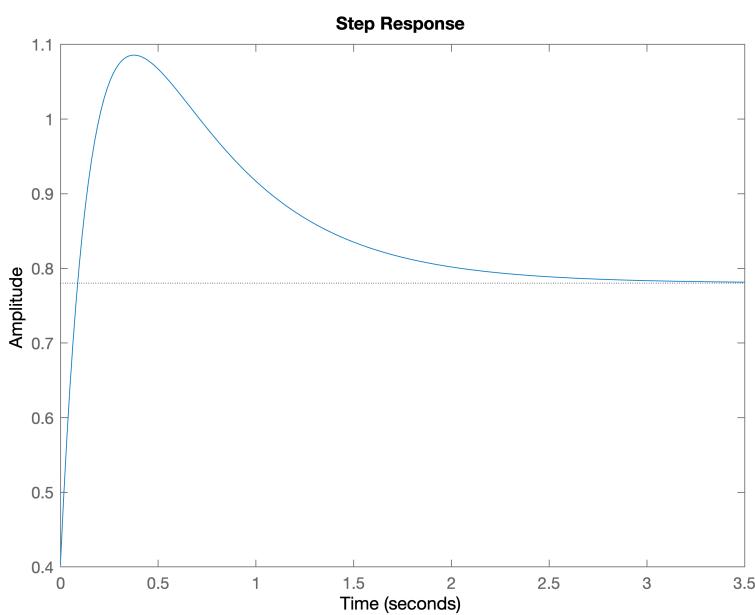
- root locus with PD controller

Figure 31: root locus



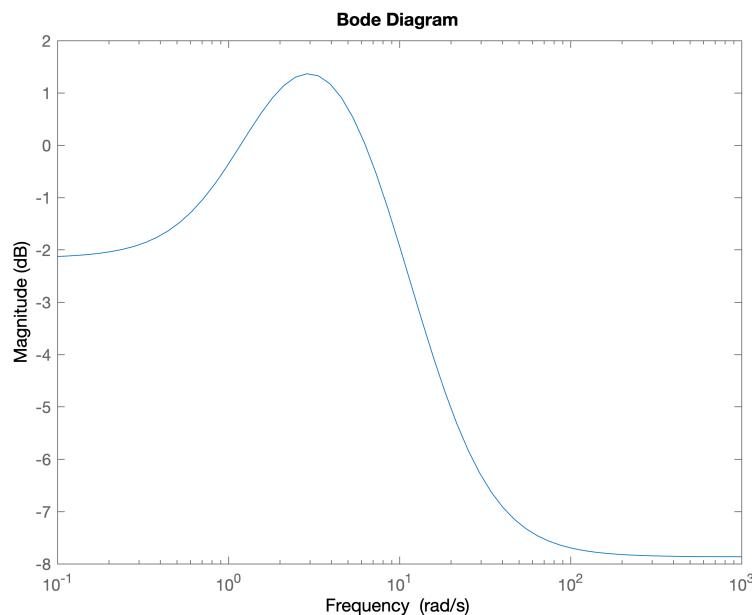
- step response for closeloop system with PD controller

Figure 32: step response for closeloop system



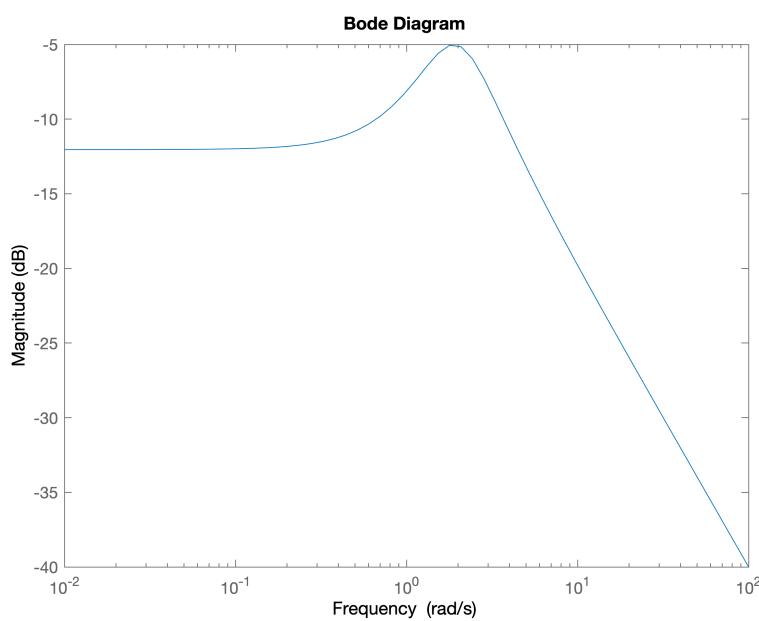
- closeloop bode (magnitude) with PD controller

Figure 33: closeloop bode (magnitude)



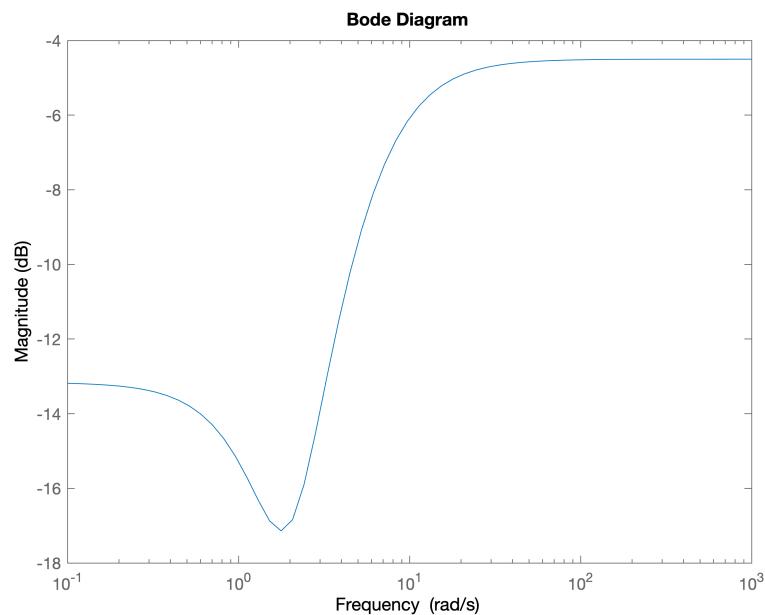
- openloop bode (magnitude) with PD controller

Figure 34: openloop bode (magnitude)



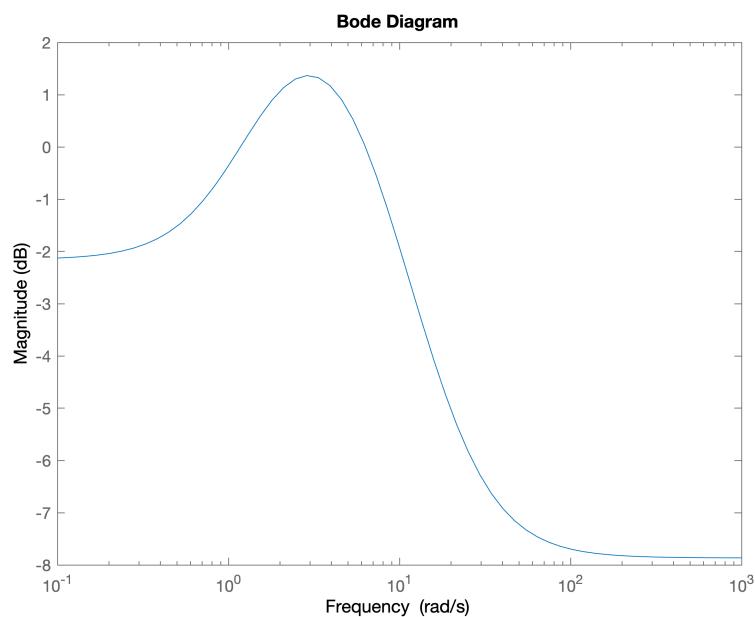
- sensitivity function with PD controller

Figure 35: sensitivity function



- complementary sensitivity function with PD controller

Figure 36: complementary sensitivity function



System is stable with controller and have a noise cancelation for frequency after $100_{rad/sec}$ and it have effect on system about -20_{dB} . System have very good disturbance rejection about $1_{rad/sec}$ and have a good disturbance rejection about $10_{rad/sec}$ and disturbance have effect on system about -5_{dB} .

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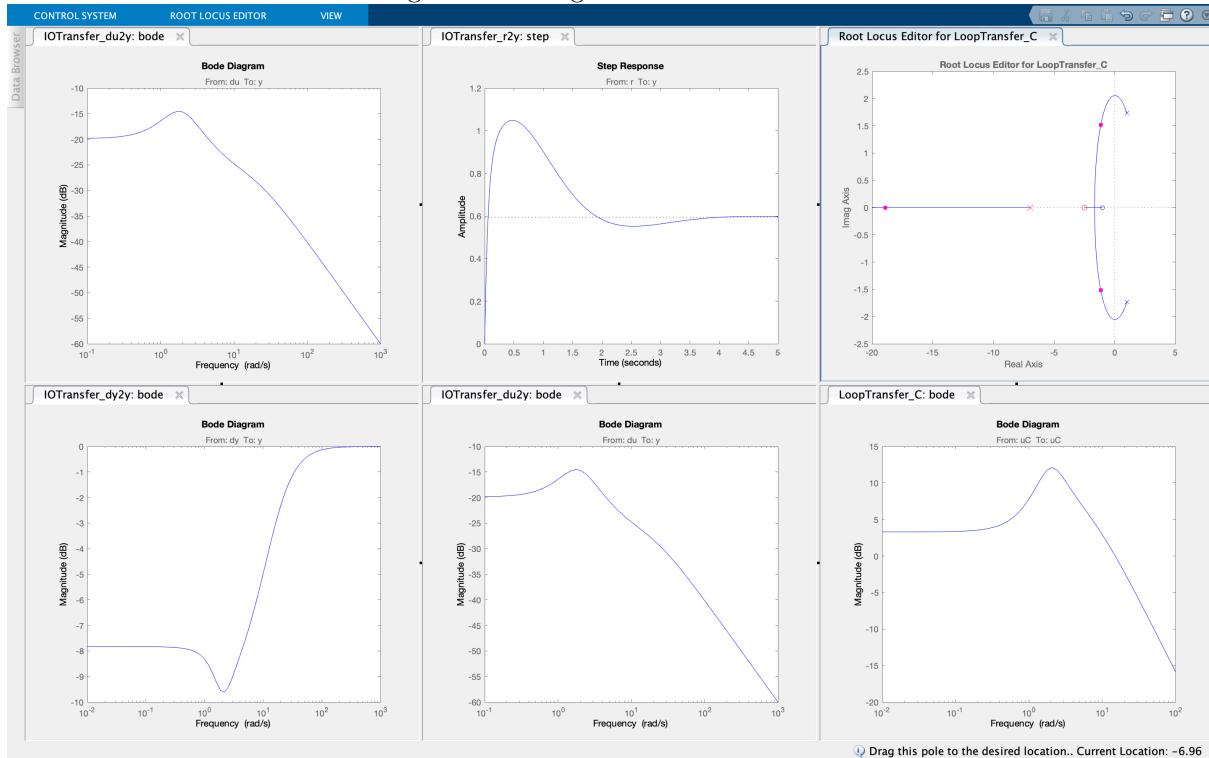
1.2.5 lead

We design a lead controller with siso tool box.

$$C(s) = \frac{16.231(s + 2.51)}{s + 6.963}$$

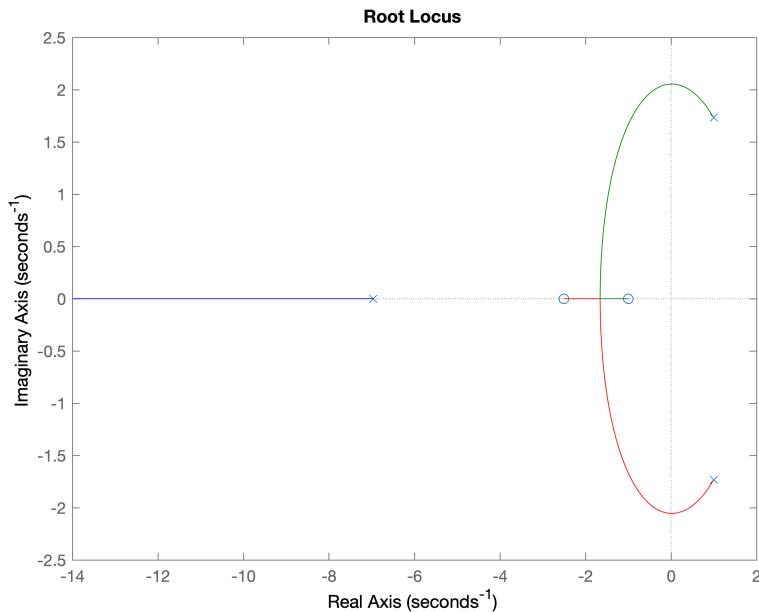
- all figures from siso toolbox

Figure 37: All figures from siso toolbox



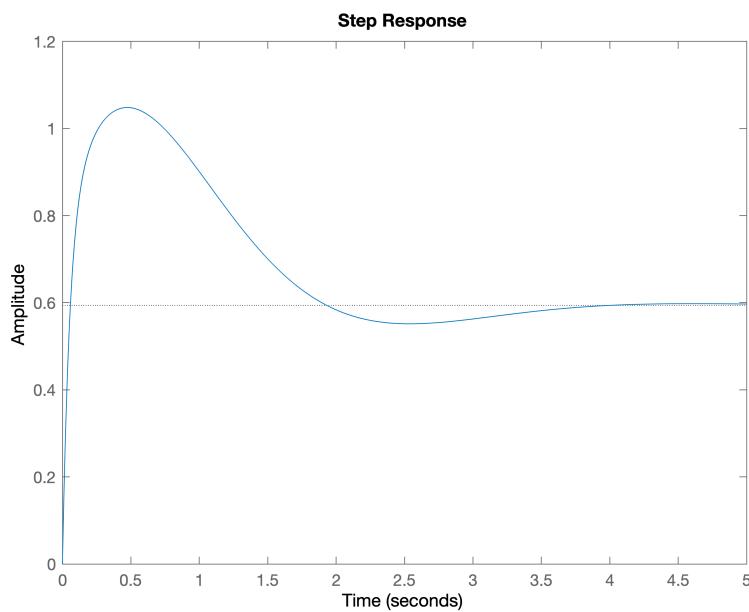
- root locus with lead controller

Figure 38: root locus



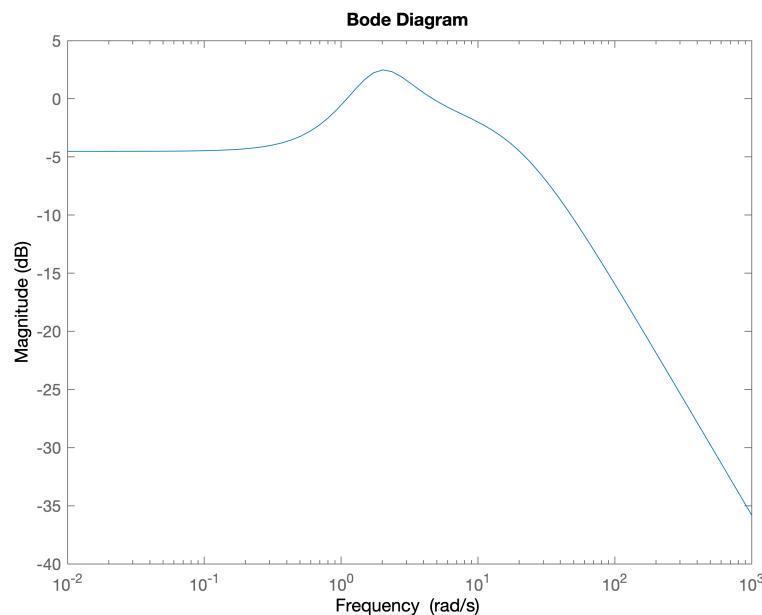
- step response for closeloop system with lead controller

Figure 39: step response for closeloop system



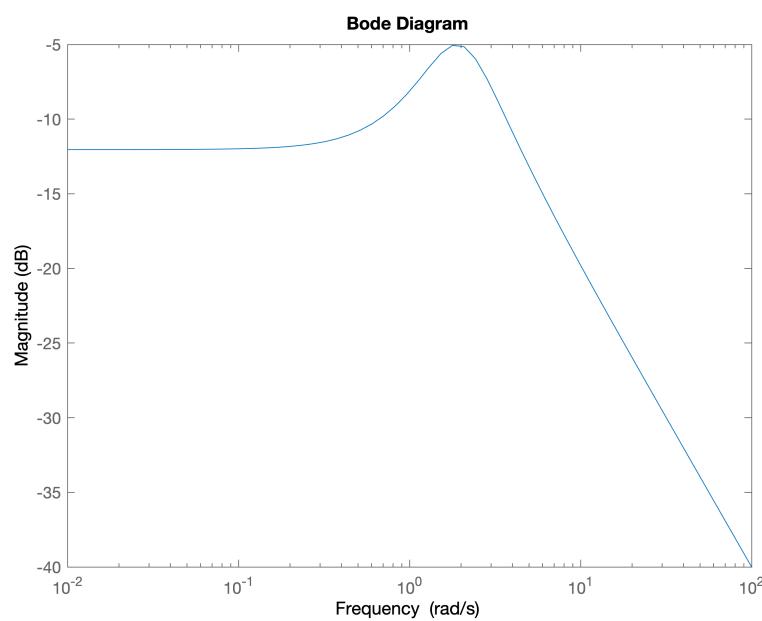
- closeloop bode (magnitude) with lead controller

Figure 40: closeloop bode (magnitude)



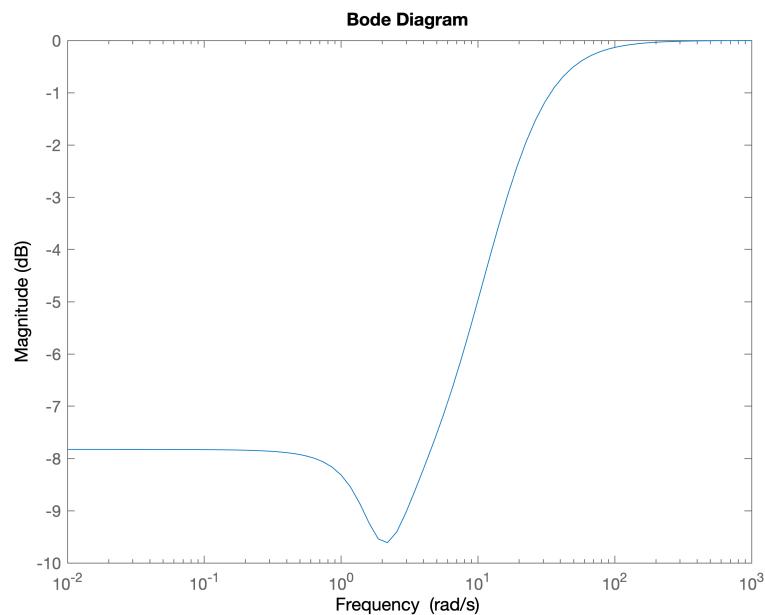
- openloop bode (magnitude) with lead controller

Figure 41: openloop bode (magnitude)



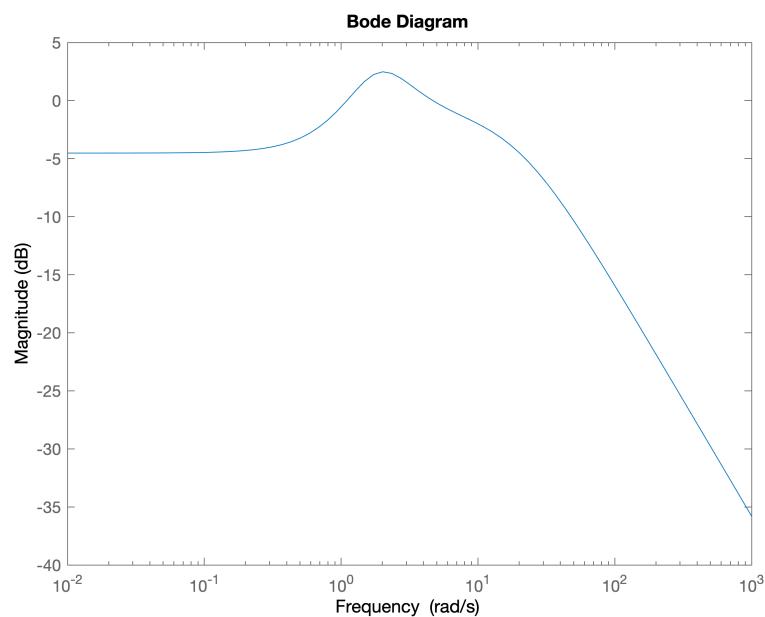
- sensitivity function with lead controller

Figure 42: sensitivity function



- complementary sensitivity function with lead controller

Figure 43: complementary sensitivity function



System is stable with controller and have a noise cancelation for frequency after $100_{rad/sec}$ and it have effect on system about -20_{dB} . System have very good disturbance rejection about $1_{rad/sec}$ and have a good disturbance rejection about $10_{rad/sec}$ and disturbance have effect on system about -5_{dB} .

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1.2.6 conclusion

All controller integrator controller work good and system wrok very well but in all of them we have staedy state error. We use lead controller that worked little better than another controller.

1.3 part c

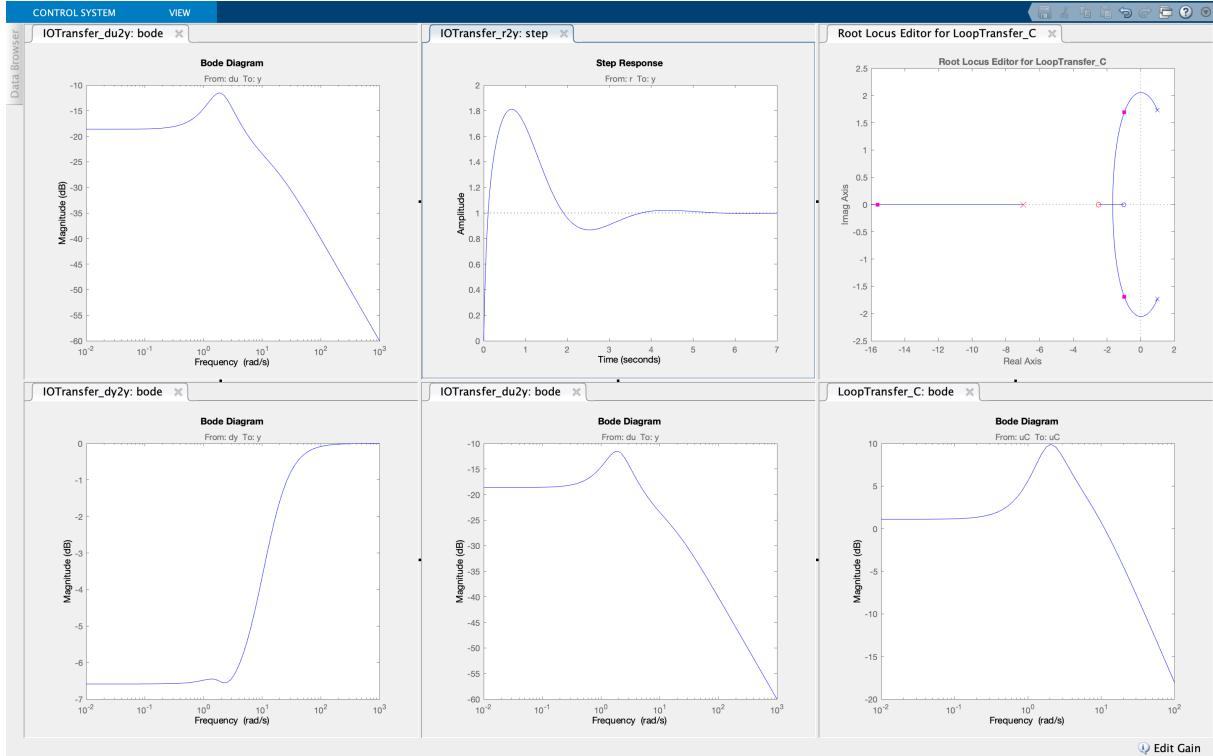
Now we design feedforward controller to make steady state error zero.

$$\lim_{s \rightarrow 0} \frac{s+1}{s^2 - 2s + 4} = 4 \rightarrow F(s) = 4$$

With this controller steady state is zero and with lead controller (that we have designed in part d) we achieve requirements.

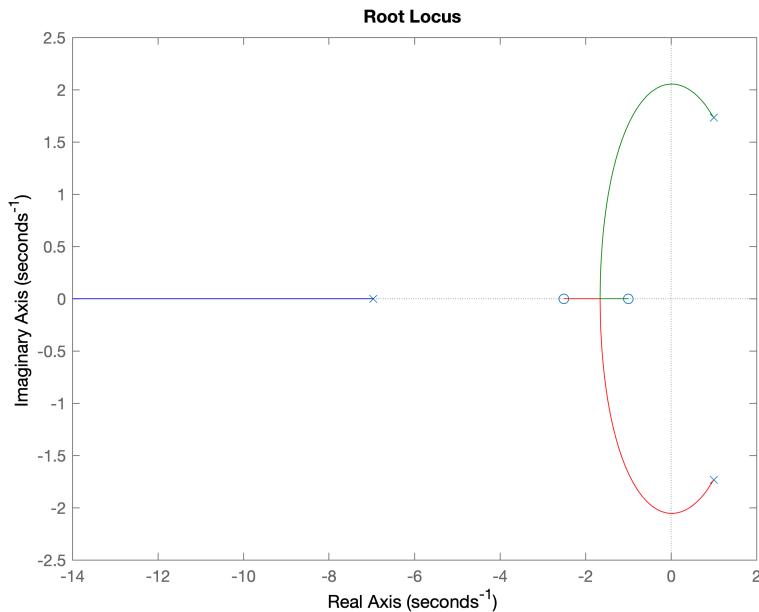
- all figures from siso toolbox

Figure 44: All figures from siso toolbox



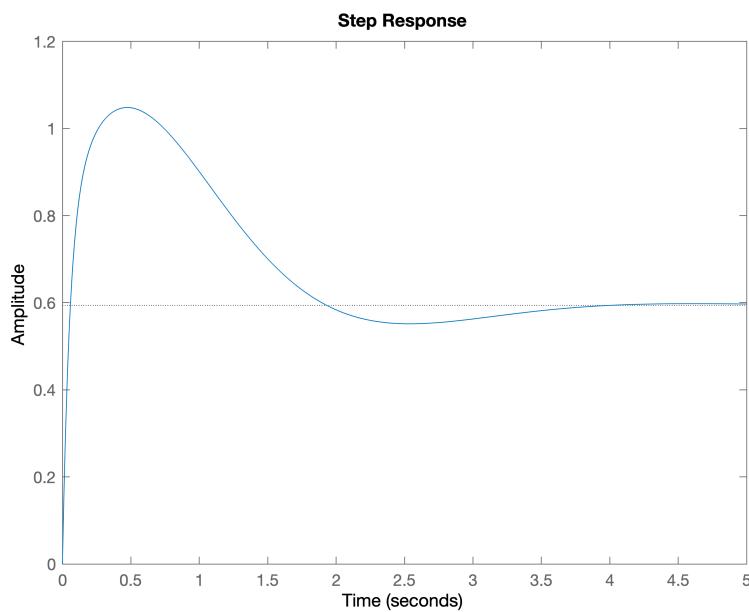
- root locus with lead and feedforward controller

Figure 45: root locus



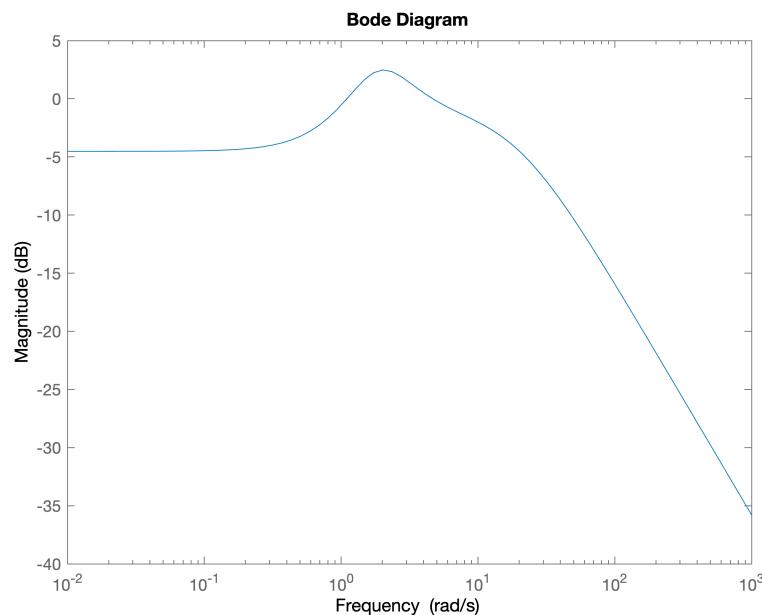
- step response for closeloop system with lead and feedforward controller

Figure 46: step response for closeloop system



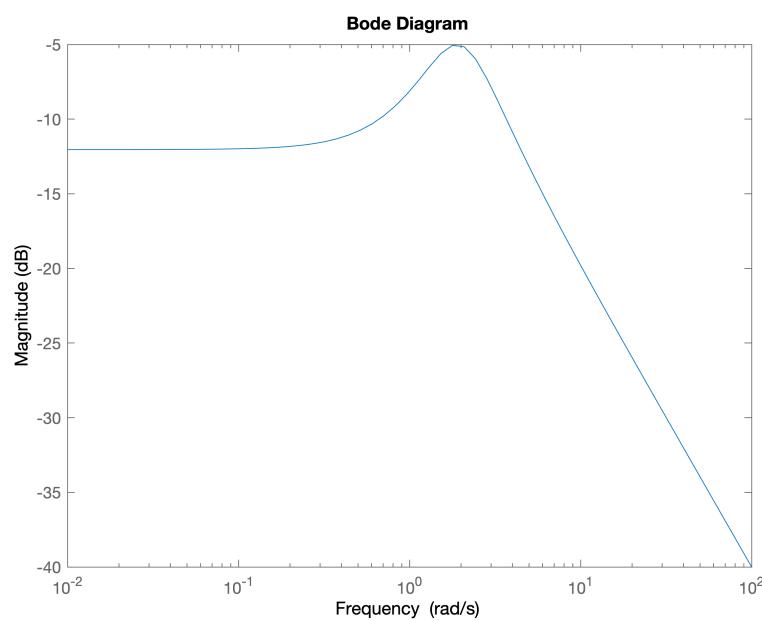
- closeloop bode (magnitude) with lead and feedforward controller

Figure 47: closeloop bode (magnitude)



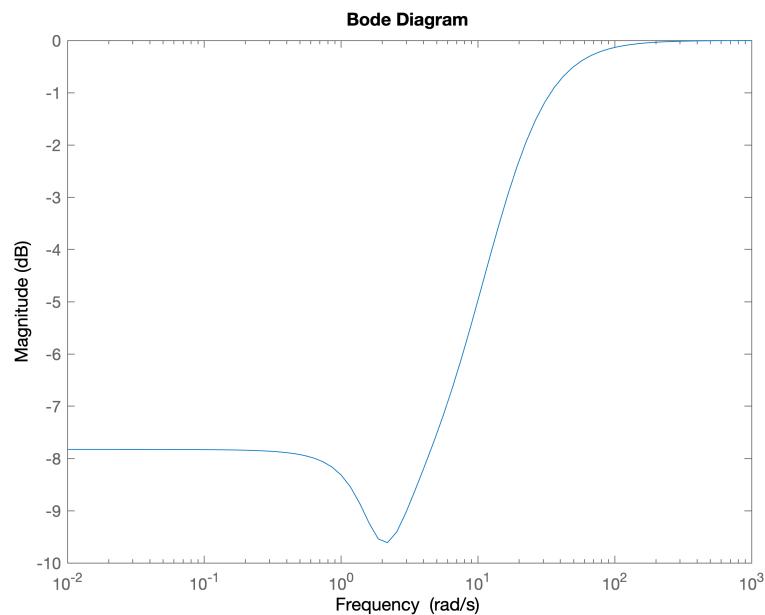
- openloop bode (magnitude) with lead and feedforward controller

Figure 48: openloop bode (magnitude)



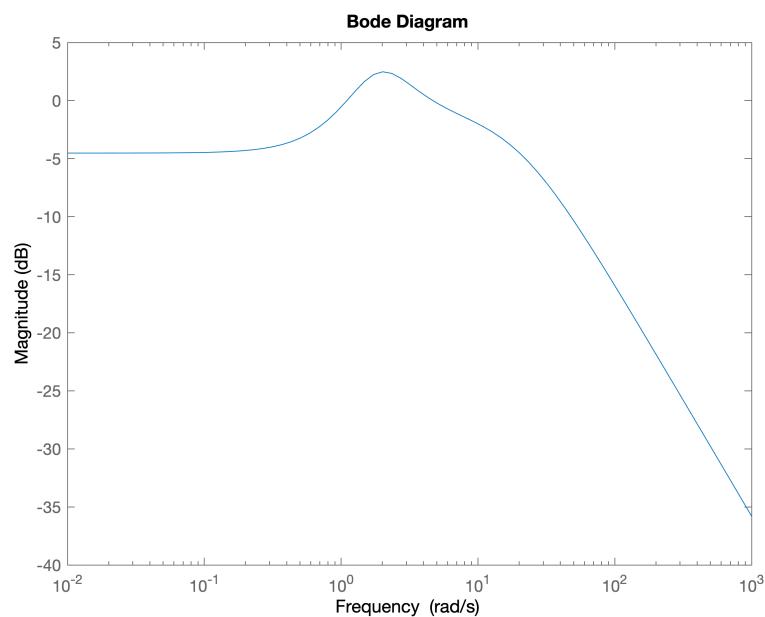
- sensitivity function with lead and feedforward controller

Figure 49: sensitivity function



- complementary sensitivity function with lead and feedforward controller

Figure 50: complementary sensitivity function



Contents

1 Question 1	2
1.1 part a	3
1.2 part b	7
1.2.1 P	8
1.2.2 I	13
1.2.3 lag	18
1.2.4 PD	23
1.2.5 lead	28
1.2.6 conclusion	33
1.3 part c	34

List of Figures

1	Architector of system in siso matlab toolbox	2
2	All figures from siso toolbox	3
3	root locus	4
4	step response for closeloop system	4
5	closeloop bode (magnitude)	5
6	openloop bode (magnitude)	5
7	sensitivity function	6
8	complementary sensitivity function	6
9	All figures from siso toolbox	8
10	root locus	9
11	step response for closeloop system	9
12	closeloop bode (magnitude)	10
13	openloop bode (magnitude)	10
14	sensitivity function	11
15	complementary sensitivity function	11
16	All figures from siso toolbox	13
17	root locus	14
18	step response for closeloop system	14
19	closeloop bode (magnitude)	15
20	openloop bode (magnitude)	15
21	sensitivity function	16
22	complementary sensitivity function	16
23	All figures from siso toolbox	18
24	root locus	19
25	step response for closeloop system	19
26	closeloop bode (magnitude)	20
27	openloop bode (magnitude)	20
28	sensitivity function	21
29	complementary sensitivity function	21
30	All figures from siso toolbox	23
31	root locus	24
32	step response for closeloop system	24
33	closeloop bode (magnitude)	25
34	openloop bode (magnitude)	25
35	sensitivity function	26
36	complementary sensitivity function	26
37	All figures from siso toolbox	28
38	root locus	29
39	step response for closeloop system	29
40	closeloop bode (magnitude)	30
41	openloop bode (magnitude)	30
42	sensitivity function	31
43	complementary sensitivity function	31
44	All figures from siso toolbox	35
45	root locus	36
46	step response for closeloop system	36
47	closeloop bode (magnitude)	37
48	openloop bode (magnitude)	37
49	sensitivity function	38
50	complementary sensitivity function	38

List of Tables