Sprawozdanie - WEAIiIB			
Podstawy automatyki			
Ćwiczenie 8: Zapasy stabilności			
Czwartek godz.	14.30	Data wykonania:	11.05.2023
Imię i nazwisko:	Janusz Pawlicki	Data zaliczenia:	
		Ocena:	

1. Cel ćwiczenia

Celem ćwiczenia jest ugruntowanie i rozszerzenie zagadnień z zakresu zapasów stabilności, omawianych podczas ćwiczeń rachunkowych. Zostanie pokazany wpływ poszczególnych części regulatora PID na zapasy stabilności w układzie. Ćwiczenie jest kontynuacą¡ tematów: "kryterium Nyquista" oraz "zapasy stabilności i jakość regulacji" z ćwiczeń rachunkowych.

2. Wstęp

W ćwiczeniu rozważamy zamknięty układ regulacji złożony z obiektu o transmitancji G(s) oraz regulatora liniowego ciągłego o transmitancji Gr(s), pokazany na rysunku 1. Będziemy rozważać regulatory: P, PI, PD oraz PID w wersji IND (independent). Przypomnijmy, że transmitancja układu otwartego jest równa:

$$\mathbf{Go}(s) = \mathbf{Gr}(s)\boldsymbol{G}(s),$$

a marginesy stabilności wyznaczamy wyłącznie w oparciu o transmitancję układu otwartego.

3. Przebieg laboratorium

3.1 Zadanie 3

Dla poniższych obiektów należy wyznaczyć wartości zapasów stabilności przy pomocy funkcji margin bez argumentów wejściowych (generuje wykres Bodego z zaznaczonymi zapasami stabilności).

$$G(s) = \frac{1}{s^3 + 3s^2 + 3s + 1},$$

$$G(s) = \frac{1}{s^3 + 2s^2 + 2s + 1},$$

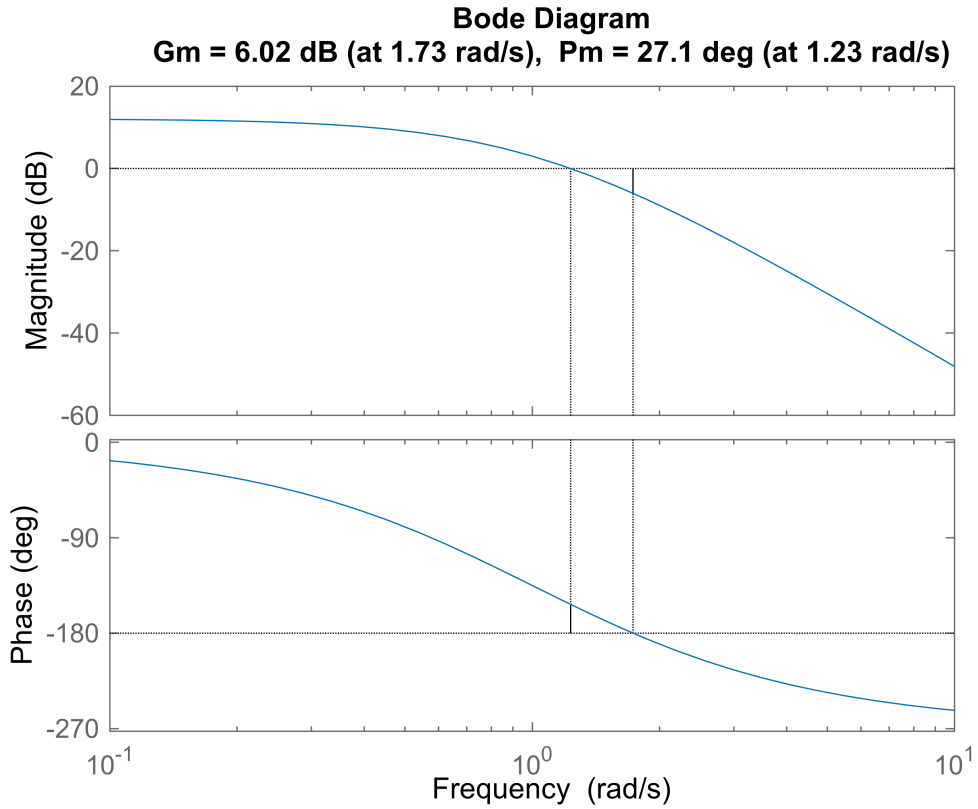
$$G(s) = \frac{1}{s^3 + 3s^2 + 2s + 1},$$

$$G(s) = \frac{1}{2s^3 + s^2 + s}.$$

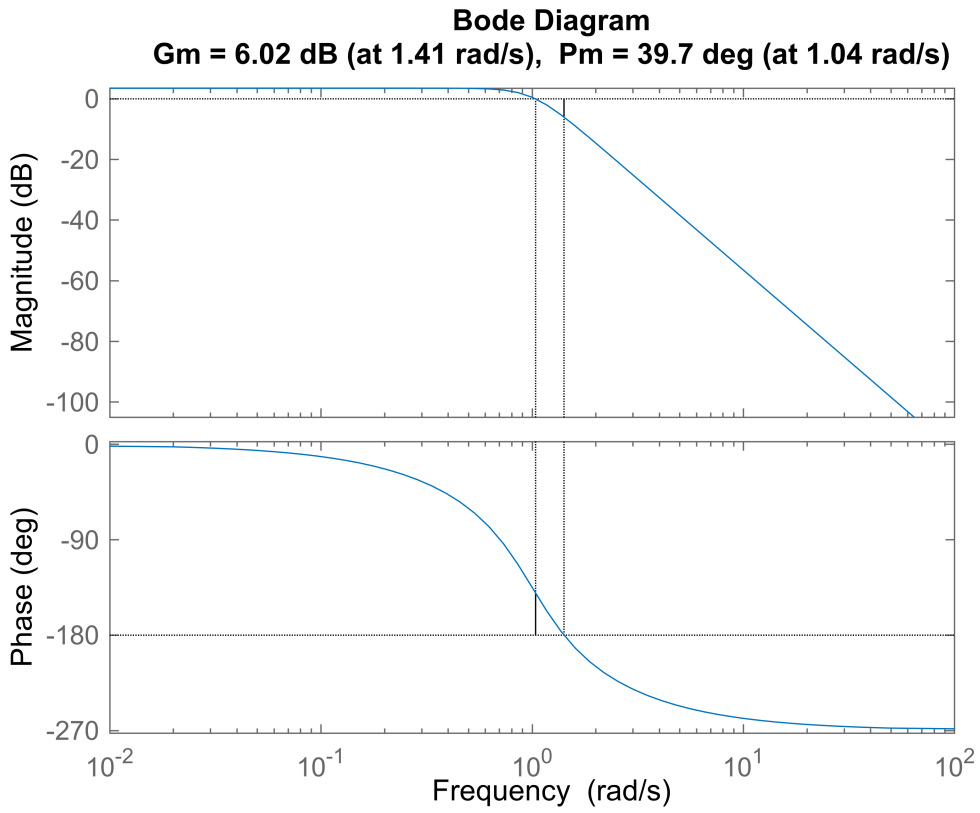
```
G1 = tf([0 0 0 1], [1 3 3 1]);
G2 = tf([0 0 0 1], [1 2 2 1]);
G3 = tf([0 0 0 1], [1 3 2 1]);
G4 = tf([0 0 0 1], [2 1 1 0]);

Gi = [G1, G2, G3, G4];
```

```
k = [4.0005 1.5 5/4 1/4];

for i = 1:4
    fprintf("Transmitancja")
    G = Gi(i)
    fprintf("Transmitancja regulatora: ")
    GR = tf(k(i), 1)

    figure
    margin(series(GR, Gi(i)));

    [gm, pm, c, d] = margin(series(GR, Gi(i)));

    fprintf(strcat("Zapas modulu " + num2str(gm)))
    fprintf(strcat("Zapas fazy " + num2str(pm)))
end
```

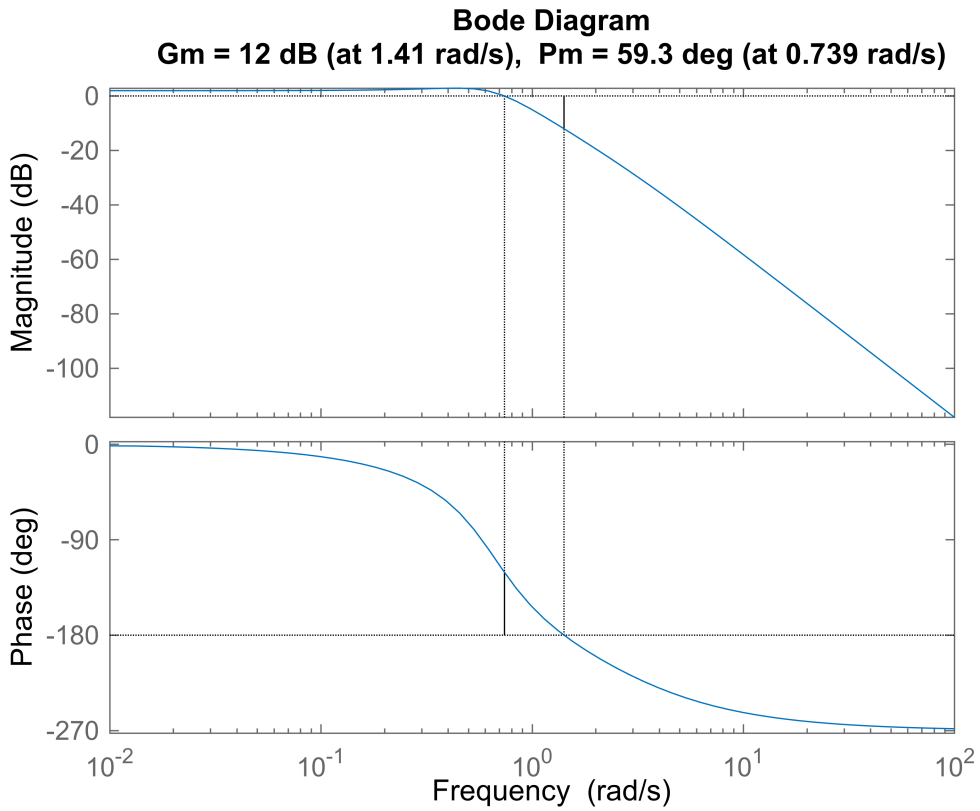
```
Transmitancja
G =

           1
  --------------------
  s^3 + 3 s^2 + 3 s + 1

Continuous-time transfer function.
Model Properties
Transmitancja regulatora:
GR =

  4

Static gain.
Model Properties
```



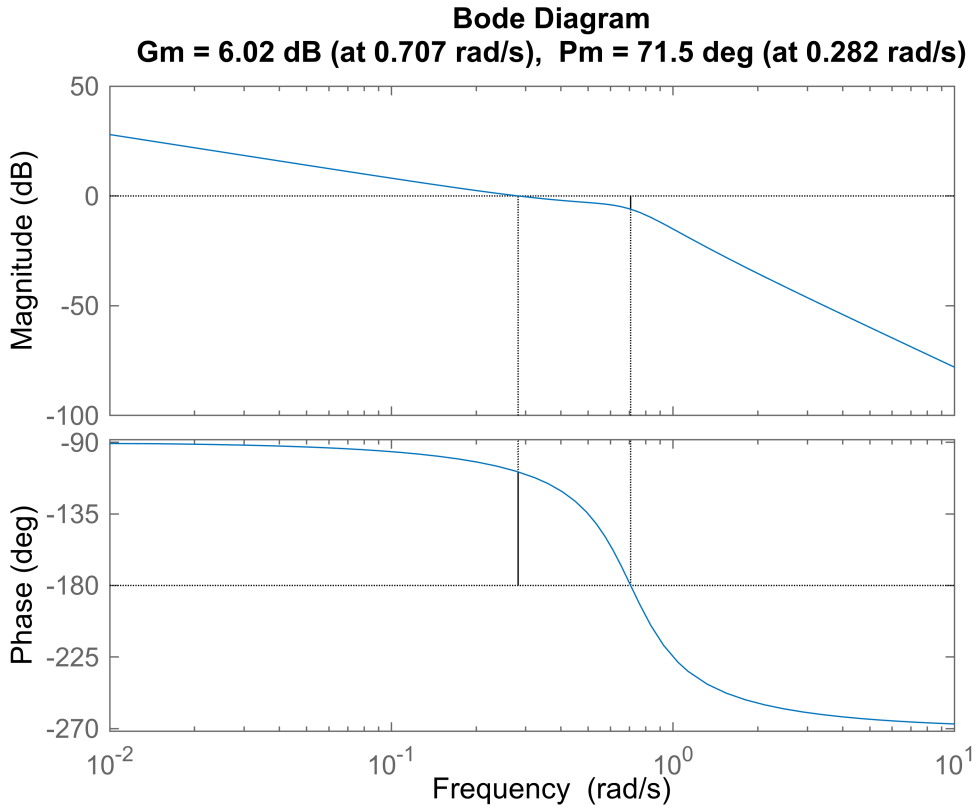

```
Zapas modulu 2
Zapas fazy 27.1366
Transmitancja
G =

            1
  ---------------------
  s^3 + 2 s^2 + 2 s + 1

Continuous-time transfer function.
Model Properties
Transmitancja regulatora:
GR =

  1.5

Static gain.
Model Properties
```




```
Zapas modulu 2
Zapas fazy 39.6836
Transmitancja
G =

            1
  ---------------------
  s^3 + 3 s^2 + 2 s + 1

Continuous-time transfer function.
Model Properties
Transmitancja regulatora:
GR =

  1.25

Static gain.
Model Properties
```




```
Zapas modulu 4.0023
Zapas fazy 59.2716
Transmitancja
G =

         1
  ---------------
  2 s^3 + s^2 + s

Continuous-time transfer function.
Model Properties
Transmitancja regulatora:
GR =

  0.25

Static gain.
Model Properties
```




```
Zapas modulu 2
Zapas fazy 71.4778
```

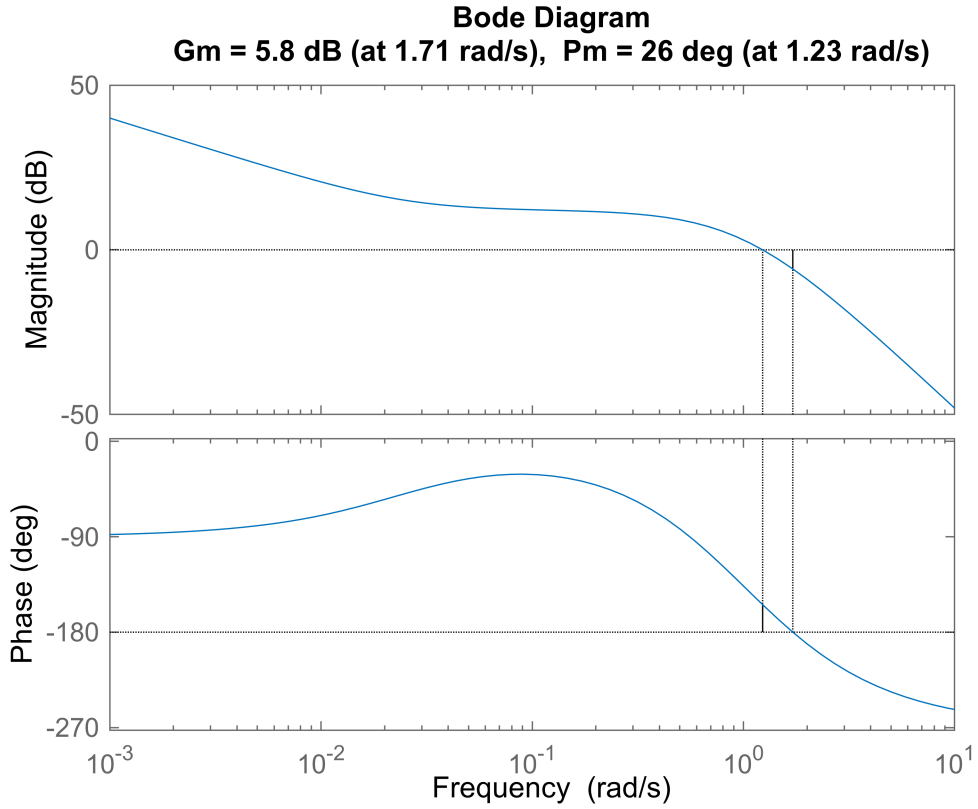
3.2 Zadanie 4

Dla regulatora PI

```
for alfa = [0.1 1]
    for i = 1:4
        fprintf("Transmitancja")
        G = Gi(i)

        fprintf("Transmitancja regulatora: ")
        GR = tf([k(i) alfa], [1 0])

        figure
        margin(series(GR, Gi(i)));

        [gm, pm, c, d] = margin(series(GR, Gi(i)));

        fprintf(strcat("Zapas modulu " + num2str(gm)))
        fprintf(strcat("Zapas fazy " + num2str(pm)))
    end
end
```

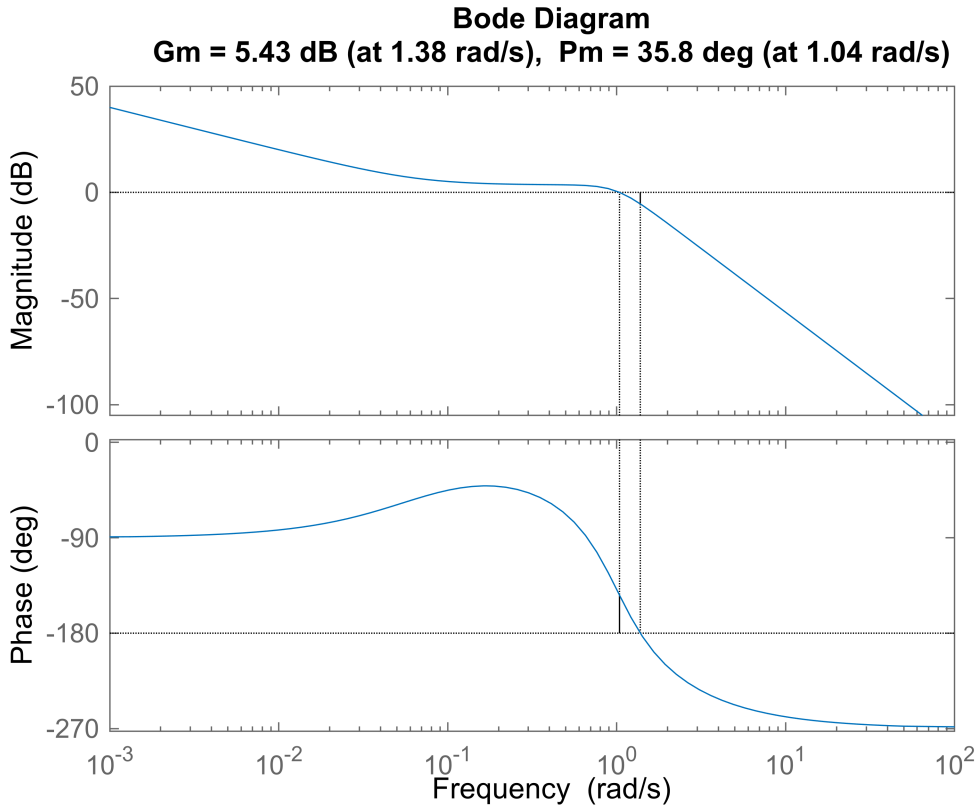
```
Transmitancja
G =
```

```
           1
  ---------------------
  s^3 + 3 s^2 + 3 s + 1

Continuous-time transfer function.
Model Properties
Transmitancja regulatora:
GR =

  4 s + 0.1
  ---------
      s

Continuous-time transfer function.
Model Properties
```

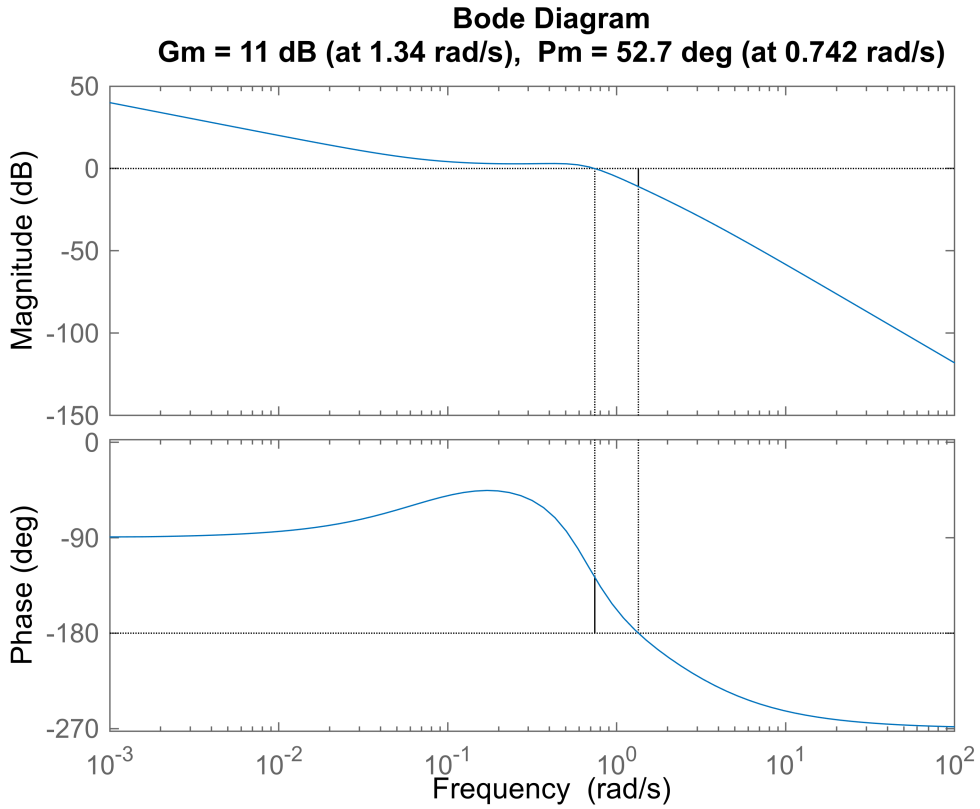



```
Zapas modulu 1.9502
Zapas fazy 25.9657
Transmitancja
G =

           1
  ---------------------
  s^3 + 2 s^2 + 2 s + 1

Continuous-time transfer function.
Model Properties
Transmitancja regulatora:
GR =

  1.5 s + 0.1
  -----------
       s
```

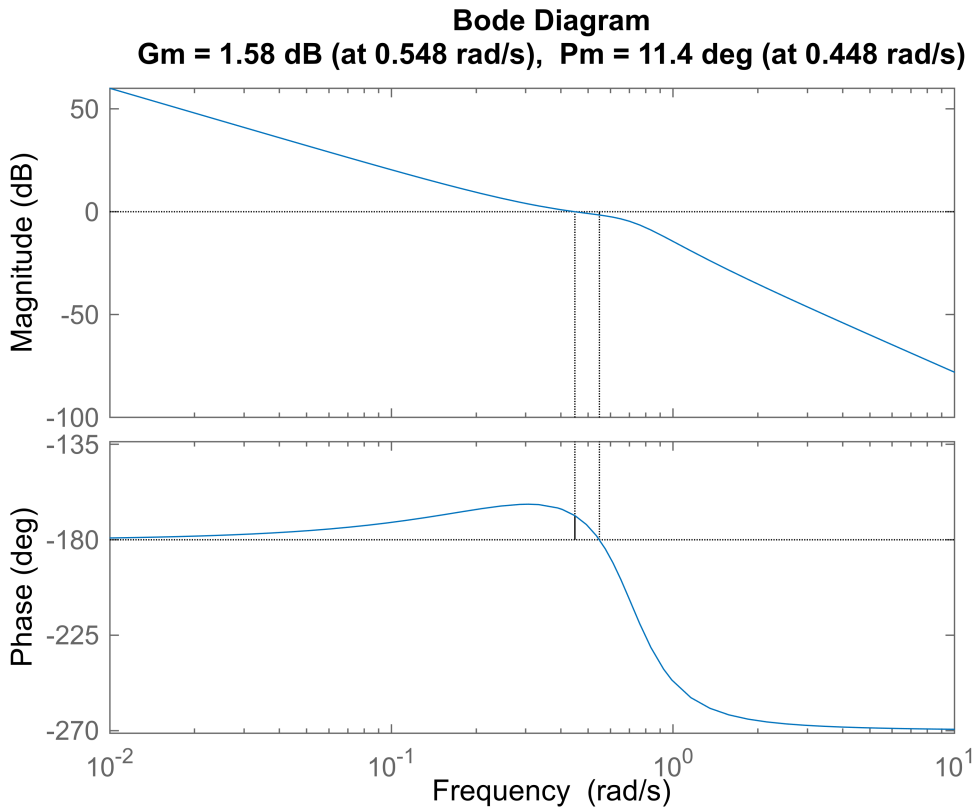
```
Continuous-time transfer function.
Model Properties
```



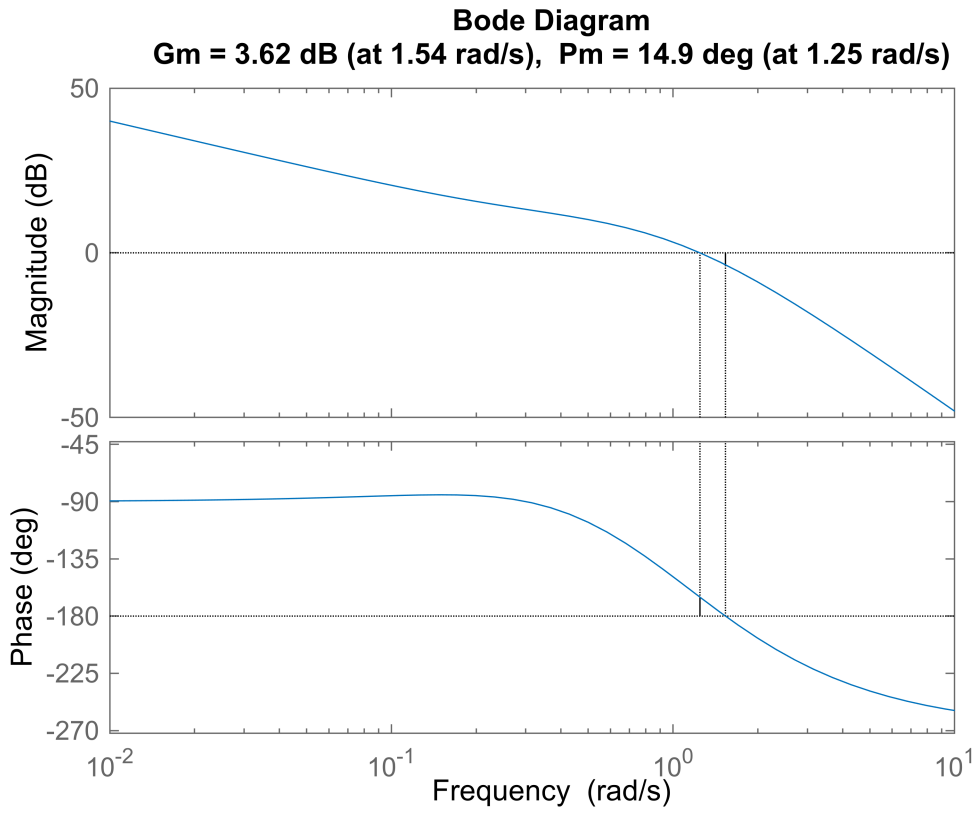

```
Zapas modulu 1.869
Zapas fazy 35.8373
Transmitancja
G =

            1
  ----------------------
  s^3 + 3 s^2 + 2 s + 1

Continuous-time transfer function.
Model Properties
Transmitancja regulatora:
GR =

  1.25 s + 0.1
  ------------
       s

Continuous-time transfer function.
Model Properties
```



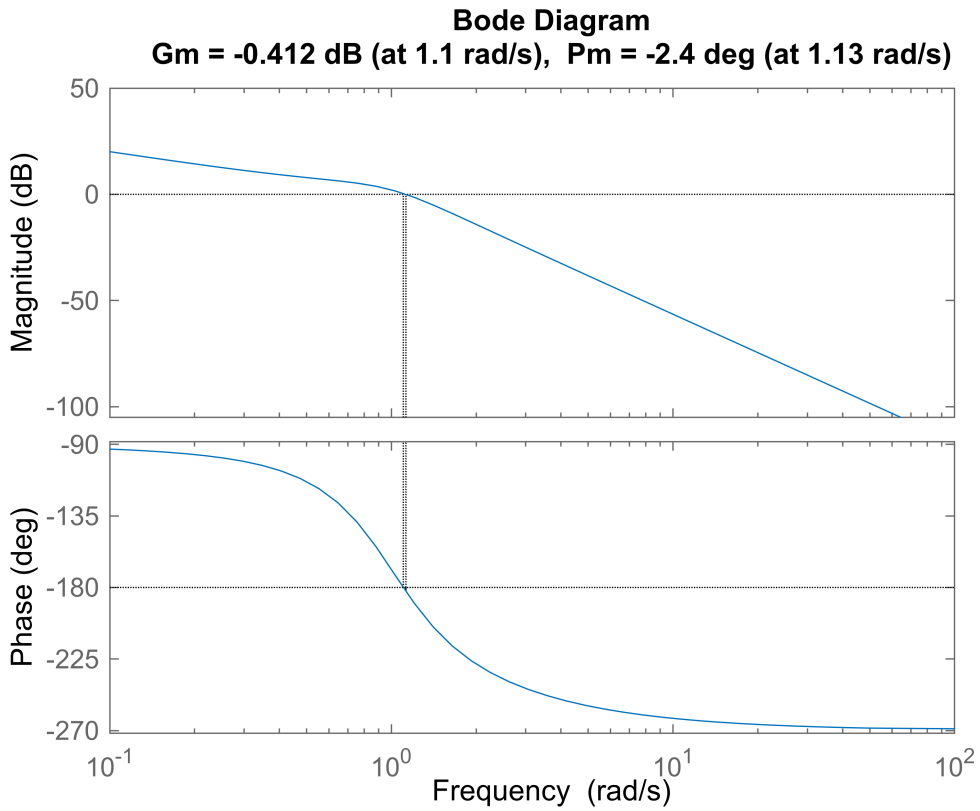

```
Zapas modulu 3.5304
Zapas fazy 52.6537
Transmitancja
G =

         1
  ---------------
  2 s^3 + s^2 + s

Continuous-time transfer function.
Model Properties
Transmitancja regulatora:
GR =

  0.25 s + 0.1
  ------------
       s

Continuous-time transfer function.
Model Properties
```



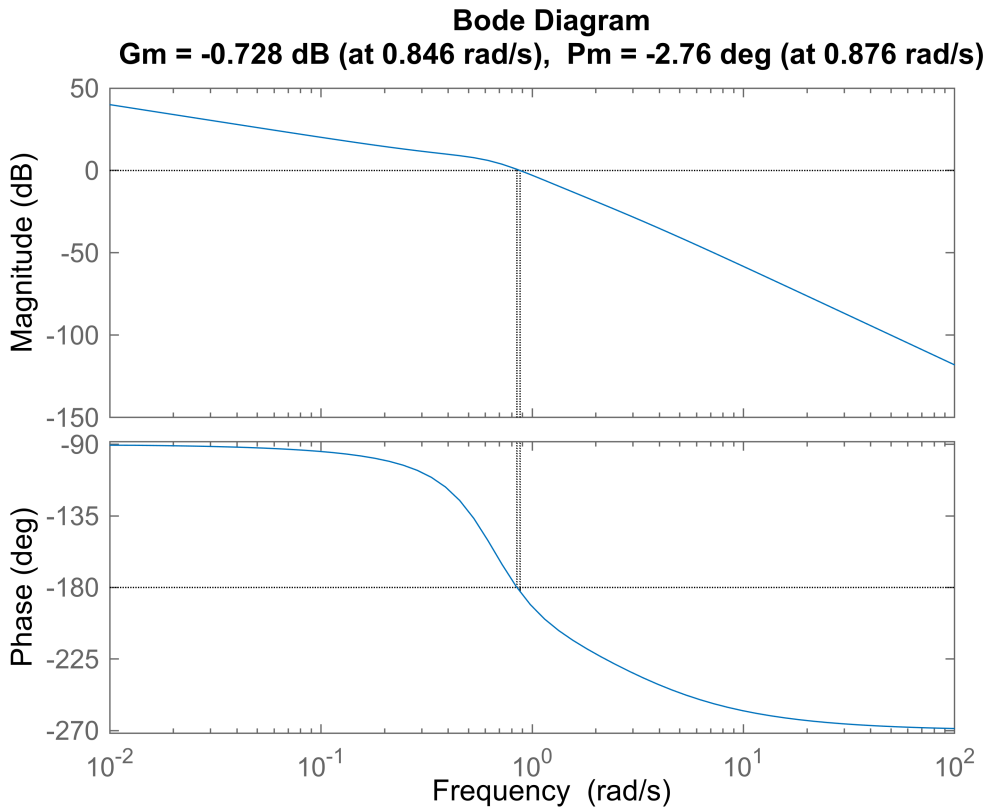

```
Zapas modulu 1.2
Zapas fazy 11.4055
Transmitancja
G =

            1
  ---------------------
  s^3 + 3 s^2 + 3 s + 1

Continuous-time transfer function.
Model Properties
Transmitancja regulatora:
GR =

  4 s + 1
  -------
     s

Continuous-time transfer function.
Model Properties
```



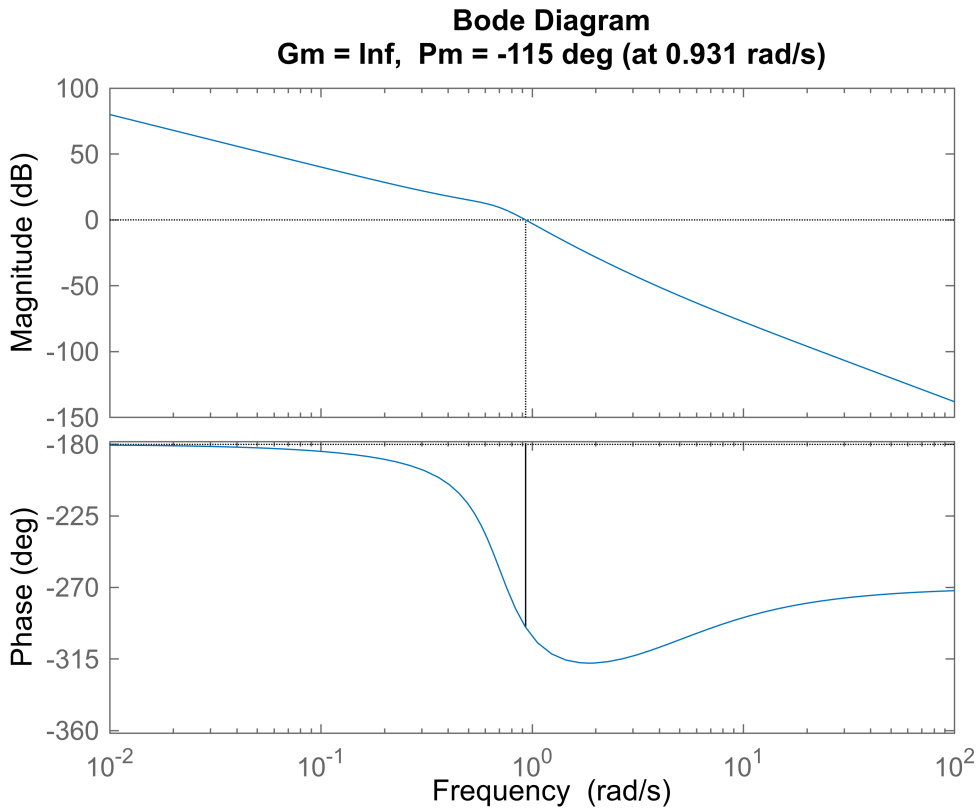

```
Zapas modulu 1.5175
Zapas fazy 14.885
Transmitancja
G =

            1
  ----------------------
  s^3 + 2 s^2 + 2 s + 1

Continuous-time transfer function.
Model Properties
Transmitancja regulatora:
GR =

  1.5 s + 1
  ---------
      s

Continuous-time transfer function.
Model Properties
```




```
Warning: The closed-loop system is unstable.
Zapas modulu 0.95367
Zapas fazy -2.4014
Transmitancja
G =

            1
  ---------------------
  s^3 + 3 s^2 + 2 s + 1

Continuous-time transfer function.
Model Properties
Transmitancja regulatora:
GR =

  1.25 s + 1
  ----------
      s

Continuous-time transfer function.
Model Properties
```




```
Warning: The closed-loop system is unstable.
Zapas modulu 0.91964
Zapas fazy -2.7599
Transmitancja
G =

         1
  ---------------
  2 s^3 + s^2 + s

Continuous-time transfer function.
Model Properties
Transmitancja regulatora:
GR =

  0.25 s + 1
  ----------
      s

Continuous-time transfer function.
Model Properties
```




```
Warning: The closed-loop system is unstable.
Zapas modulu 0
Zapas fazy -115.1196
```

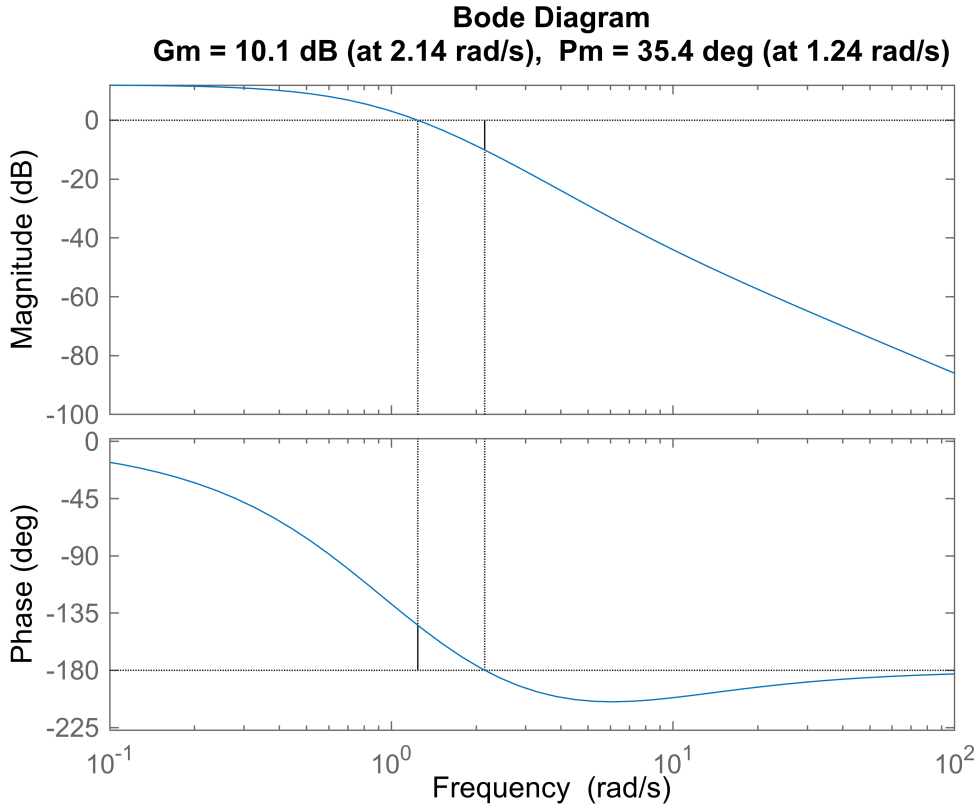
3.3 Zadanie 5

Dla regulatora PD

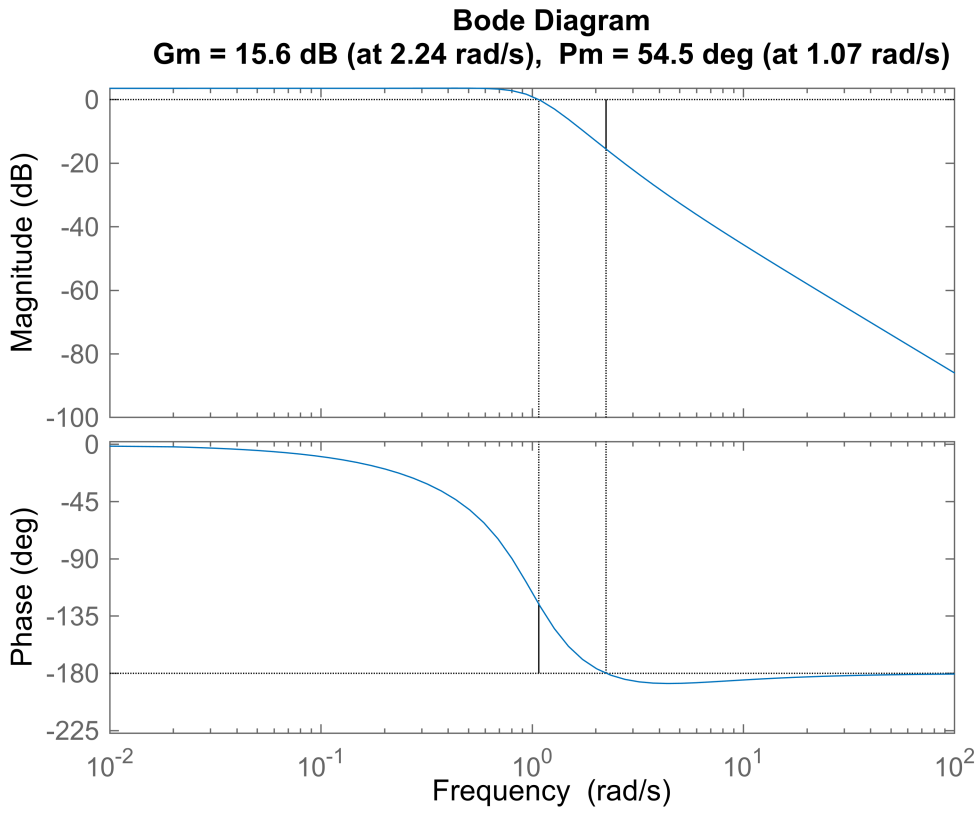
```
for beta = [0.5 1]
    for i = 1:4
        fprintf("Transmitancja")
        G = Gi(i)

        fprintf("Transmitancja regulatora: ")
        GR = tf([beta k(i)], 1)

        figure
        margin(series(GR, Gi(i)));

        [gm, pm, c, d] = margin(series(GR, Gi(i)));

        fprintf(strcat("Zapas modulu " + num2str(gm)))
        fprintf(strcat("Zapas fazy " + num2str(pm)))
    end
end
```

```
Transmitancja
```

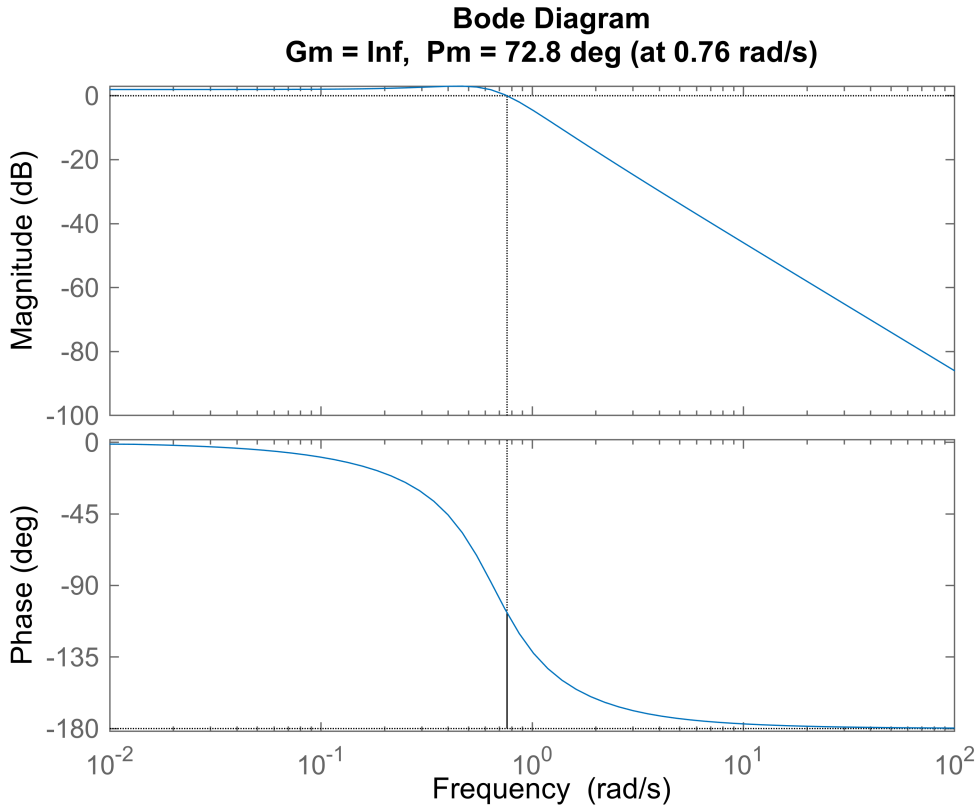
```
G =

           1
  ---------------------
  s^3 + 3 s^2 + 3 s + 1

Continuous-time transfer function.
Model Properties
Transmitancja regulatora:
GR =

  0.5 s + 4

Continuous-time transfer function.
Model Properties
```



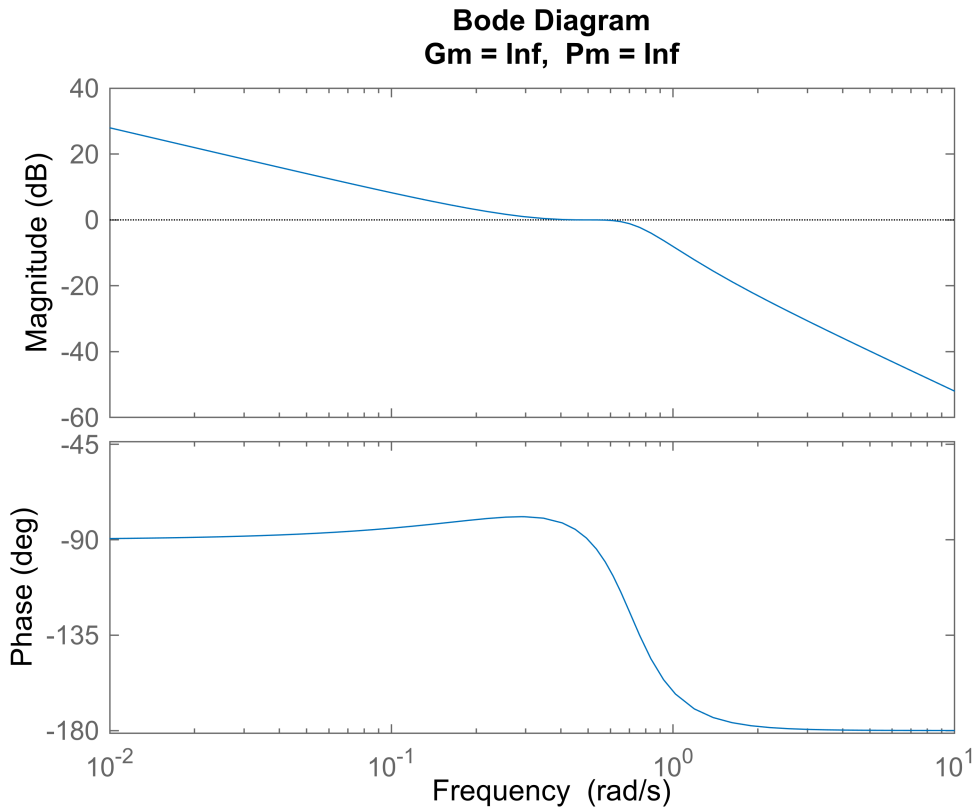

```
Zapas modulu 3.1994
Zapas fazy 35.403
Transmitancja
G =

           1
  ---------------------
  s^3 + 2 s^2 + 2 s + 1

Continuous-time transfer function.
Model Properties
Transmitancja regulatora:
GR =

  0.5 s + 1.5

Continuous-time transfer function.
Model Properties
```



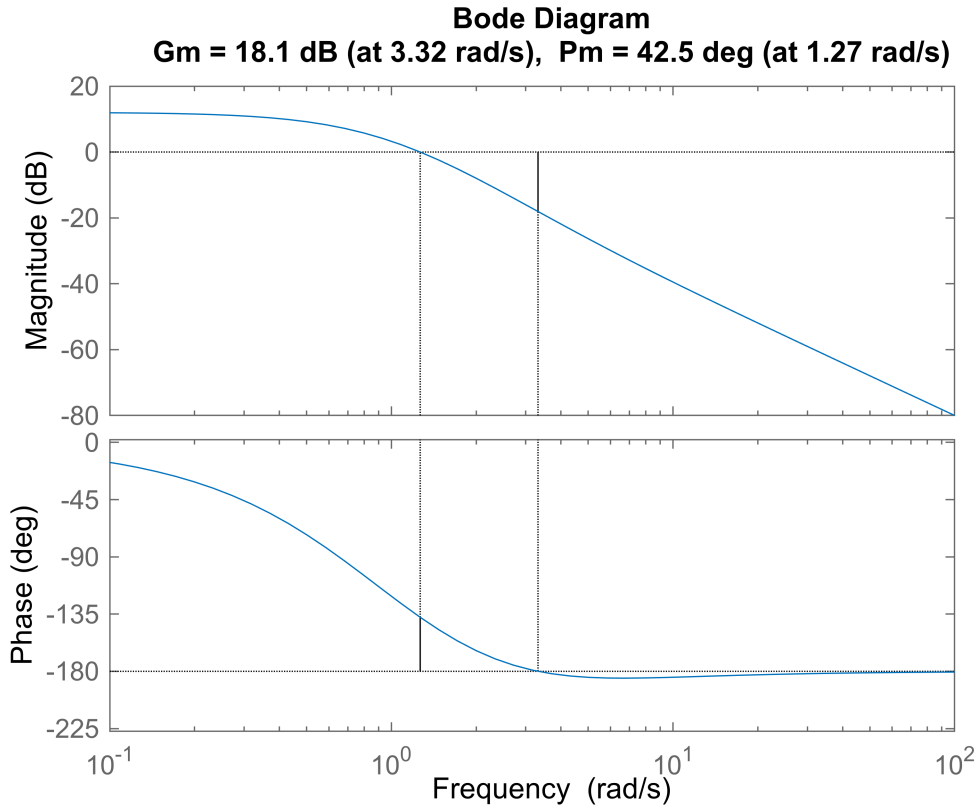

```
Zapas modulu 6.0002
Zapas fazy 54.4706
Transmitancja
G =

            1
  ---------------------
  s^3 + 3 s^2 + 2 s + 1

Continuous-time transfer function.
Model Properties
Transmitancja regulatora:
GR =

  0.5 s + 1.25

Continuous-time transfer function.
Model Properties
```



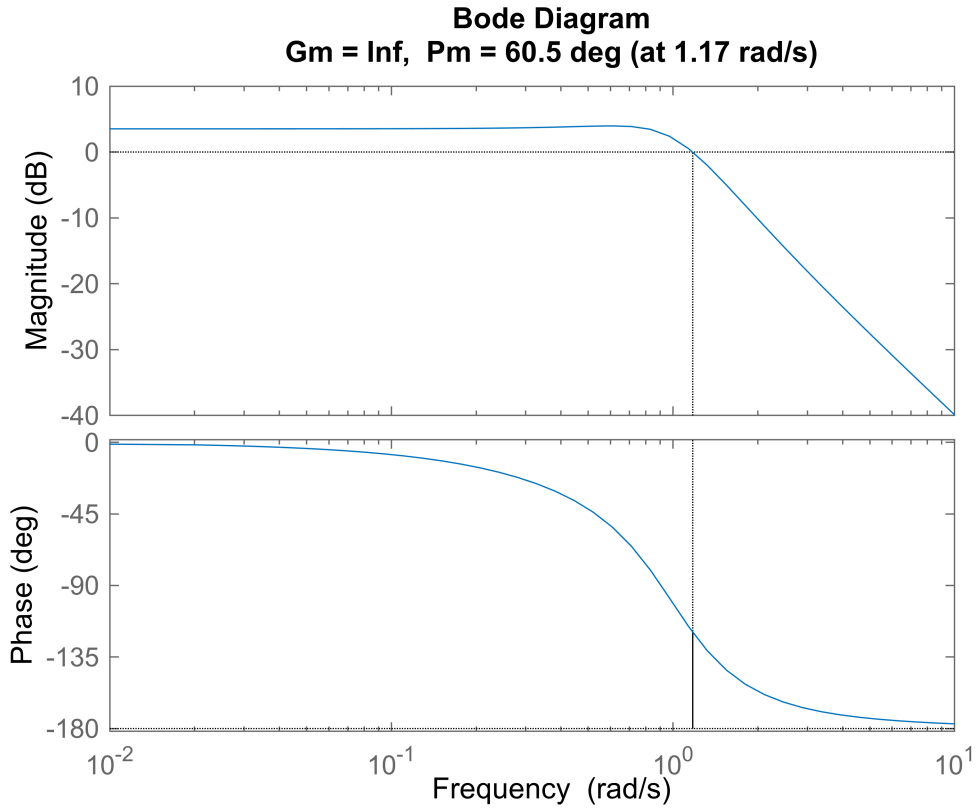

```
Zapas modulu Inf
Zapas fazy 72.7612
Transmitancja
G =

         1
  ---------------
  2 s^3 + s^2 + s

Continuous-time transfer function.
Model Properties
Transmitancja regulatora:
GR =

  0.5 s + 0.25

Continuous-time transfer function.
Model Properties
```



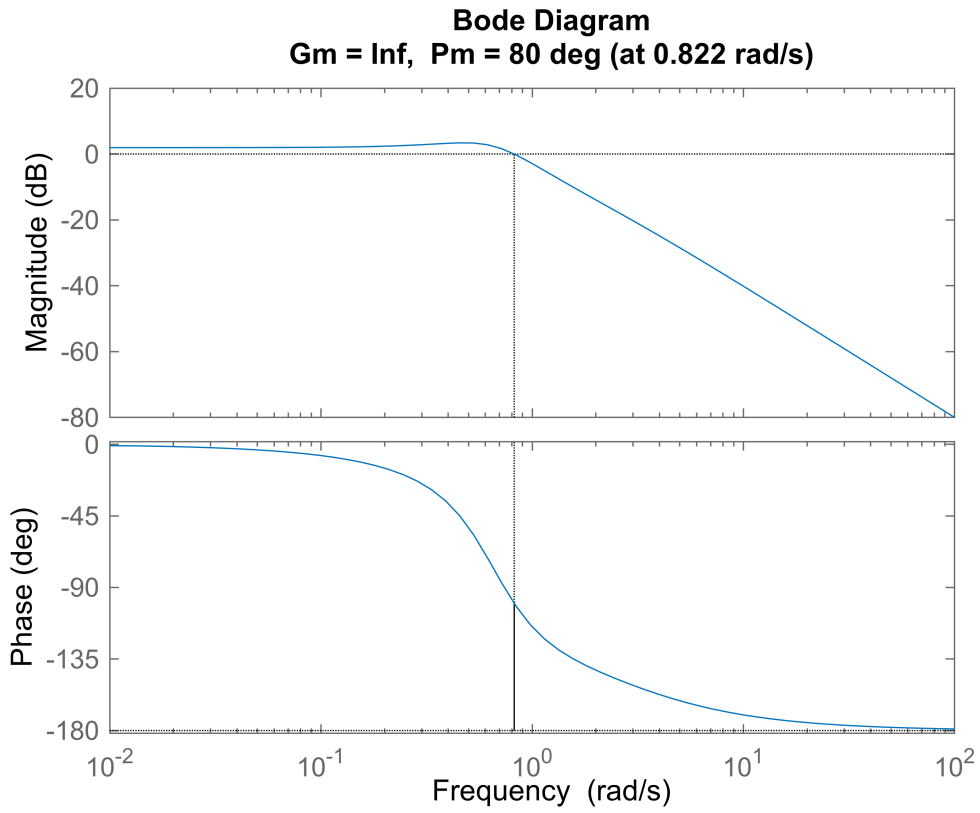

```
Zapas modulu Inf
Zapas fazy Inf
Transmitancja
G =

           1
  ---------------------
  s^3 + 3 s^2 + 3 s + 1

Continuous-time transfer function.
Model Properties
Transmitancja regulatora:
GR =

  s + 4

Continuous-time transfer function.
Model Properties
```



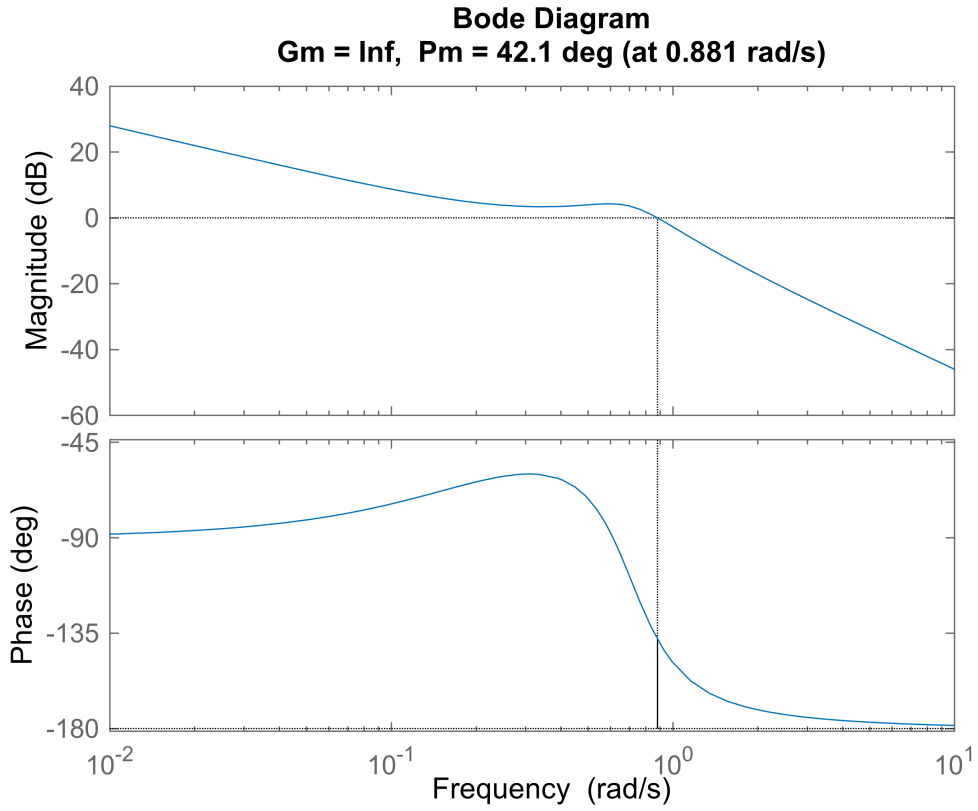

```
Zapas modulu 7.996
Zapas fazy 42.5038
Transmitancja
G =

           1
  ---------------------
  s^3 + 2 s^2 + 2 s + 1

Continuous-time transfer function.
Model Properties
Transmitancja regulatora:
GR =

  s + 1.5

Continuous-time transfer function.
Model Properties
```




```
Zapas modulu Inf
Zapas fazy 60.5323
Transmitancja
G =

            1
  ---------------------
  s^3 + 3 s^2 + 2 s + 1

Continuous-time transfer function.
Model Properties
Transmitancja regulatora:
GR =

  s + 1.25

Continuous-time transfer function.
Model Properties
```




```
Zapas modulu Inf
Zapas fazy 80.0192
Transmitancja
G =

         1
  ---------------
  2 s^3 + s^2 + s

Continuous-time transfer function.
Model Properties
Transmitancja regulatora:
GR =

  s + 0.25

Continuous-time transfer function.
Model Properties
```



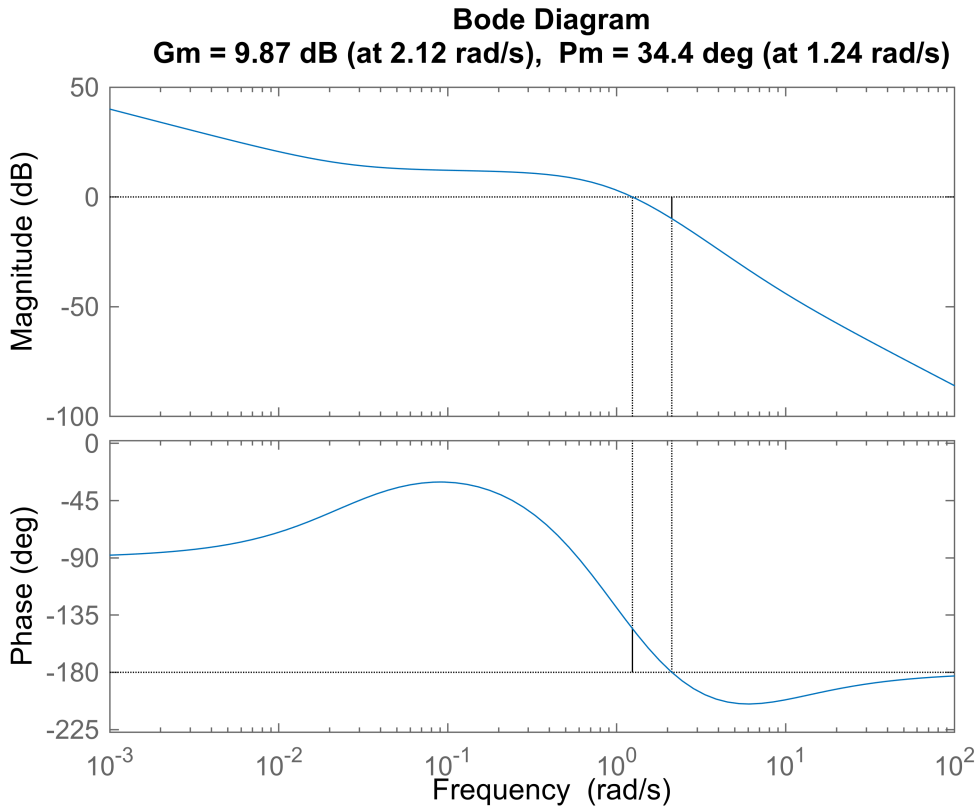

```
Zapas modulu Inf
Zapas fazy 42.0872
```

3.4 Zadanie 6

Dla regulatora PID

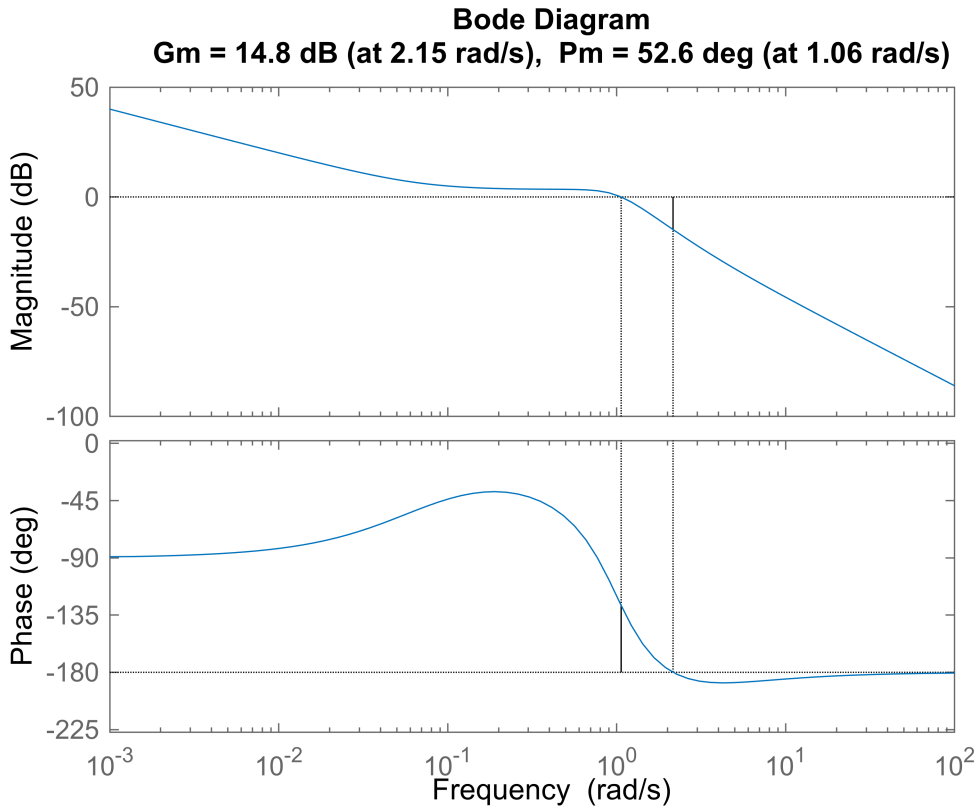
```
for alfa = [0.1 1]
    for beta = [0.5 1]
        for i = 1:4
            fprintf("Transmitancja")
        G = Gi(i)

        fprintf("Transmitancja regulatora: ")
        GR = tf([beta k(i) alfa], [1 0])

        figure
        margin(series(GR, Gi(i)));

        [gm, pm, c, d] = margin(series(GR, Gi(i)));

        fprintf(strcat("Zapas modulu " + num2str(gm)))
        fprintf(strcat("Zapas fazy " + num2str(pm)))
        end
    end
end
```

```
Transmitancja
G =

           1
  ---------------------
  s^3 + 3 s^2 + 3 s + 1

Continuous-time transfer function.
Model Properties
Transmitancja regulatora:
GR =

  0.5 s^2 + 4 s + 0.1
  -------------------
           s

Continuous-time transfer function.
Model Properties
```

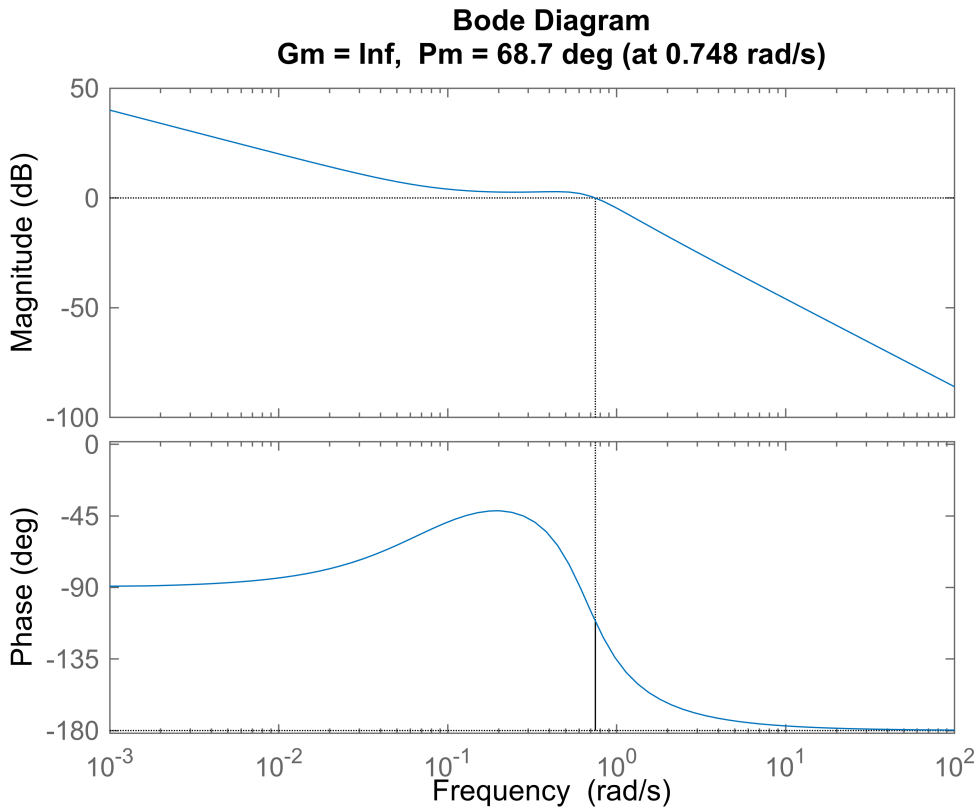



```
Zapas modulu 3.1161
Zapas fazy 34.3909
Transmitancja
G =

           1
  ---------------------
  s^3 + 2 s^2 + 2 s + 1

Continuous-time transfer function.
Model Properties
Transmitancja regulatora:
GR =

  0.5 s^2 + 1.5 s + 0.1
  ---------------------
```

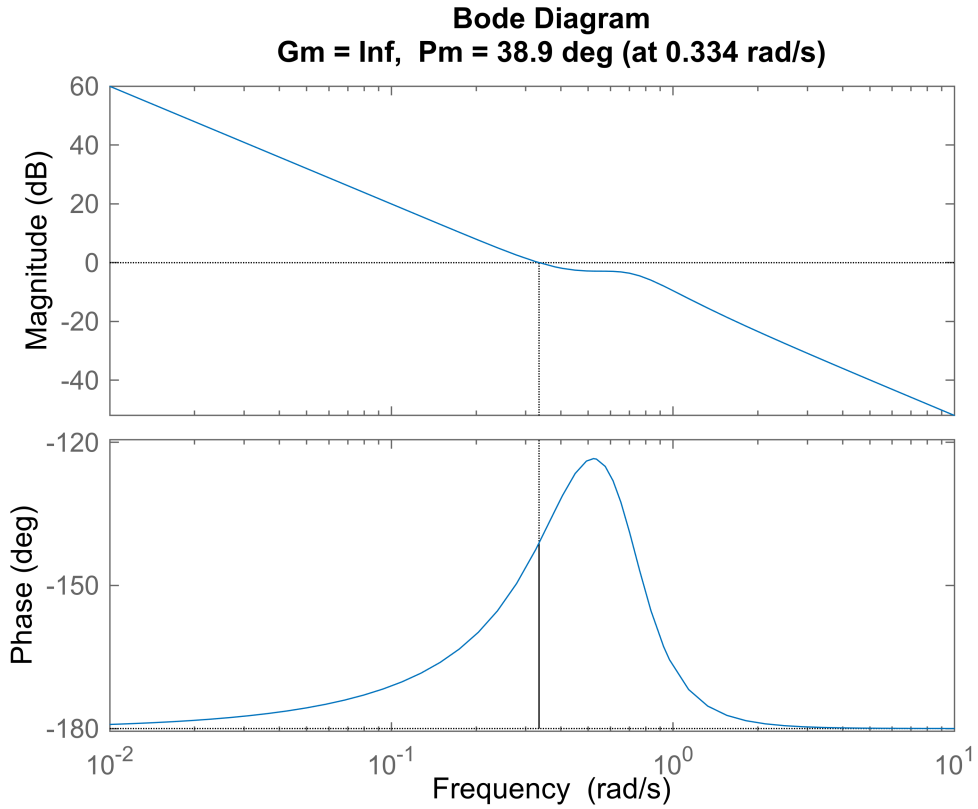
```
           s

Continuous-time transfer function.
Model Properties
```



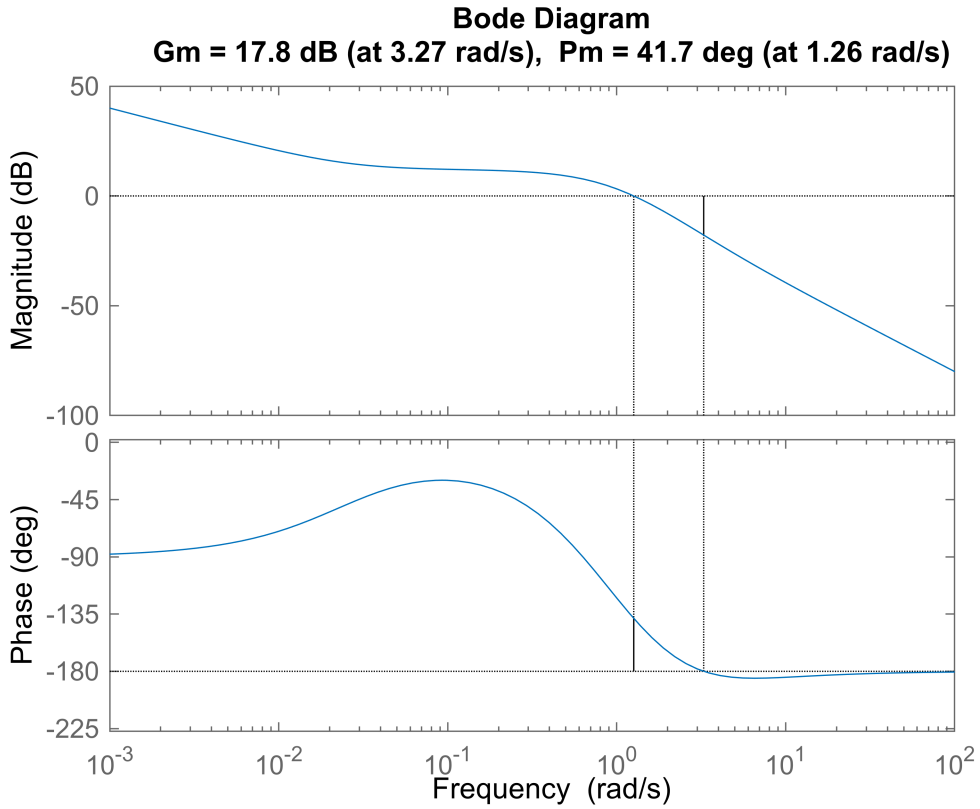

```
Zapas modulu 5.5245
Zapas fazy 52.5602
Transmitancja
G =

           1
  ---------------------
  s^3 + 3 s^2 + 2 s + 1

Continuous-time transfer function.
Model Properties
Transmitancja regulatora:
GR =

  0.5 s^2 + 1.25 s + 0.1
  ----------------------
           s

Continuous-time transfer function.
Model Properties
```



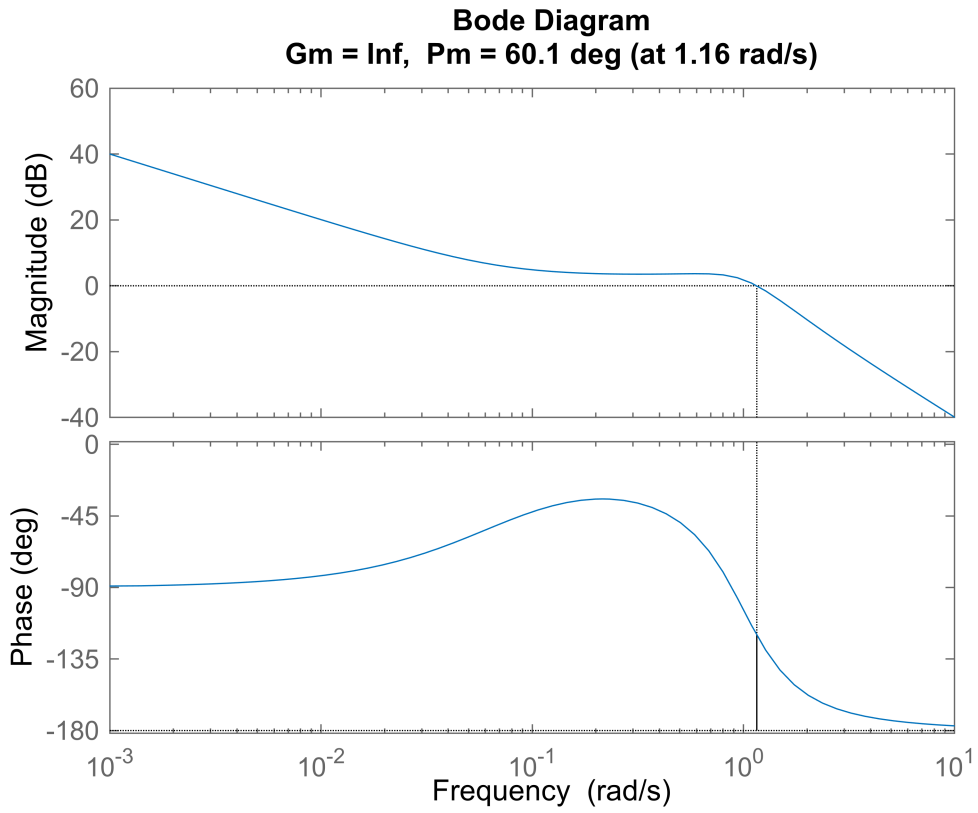

```
Zapas modulu Inf
Zapas fazy 68.7139
Transmitancja
G =

         1
  ---------------
  2 s^3 + s^2 + s

Continuous-time transfer function.
Model Properties
Transmitancja regulatora:
GR =

  0.5 s^2 + 0.25 s + 0.1
  ----------------------
            s

Continuous-time transfer function.
Model Properties
```



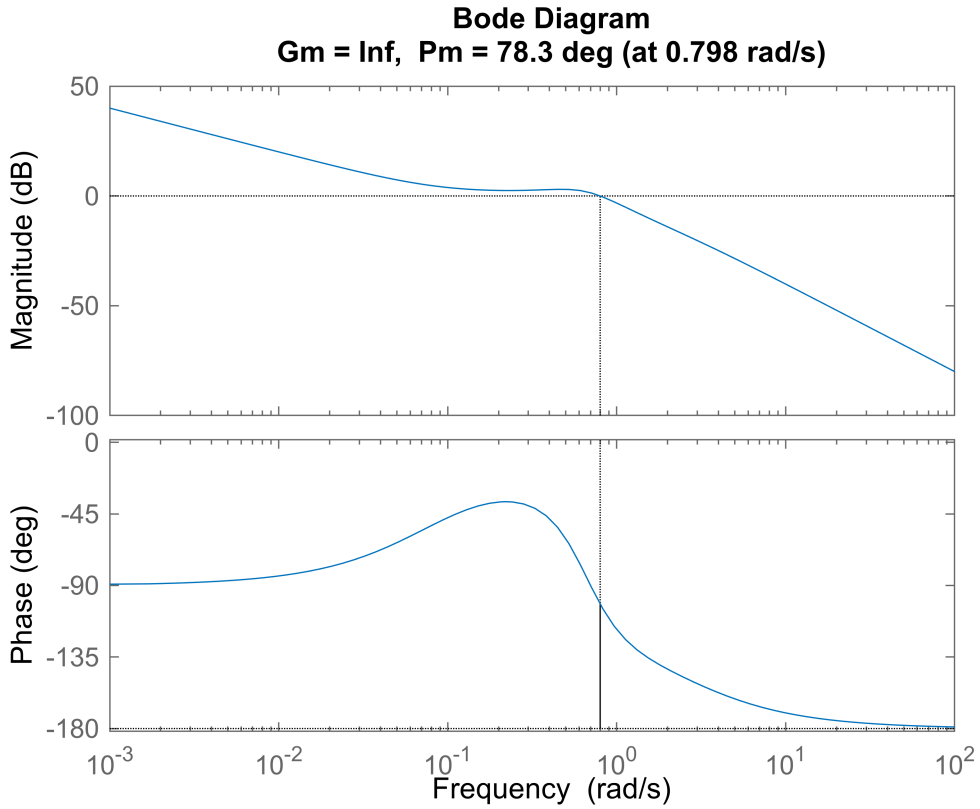

```
Zapas modulu 0
Zapas fazy 38.8882
Transmitancja
G =

            1
  ---------------------
  s^3 + 3 s^2 + 3 s + 1

Continuous-time transfer function.
Model Properties
Transmitancja regulatora:
GR =

  s^2 + 4 s + 0.1
  ---------------
         s

Continuous-time transfer function.
Model Properties
```



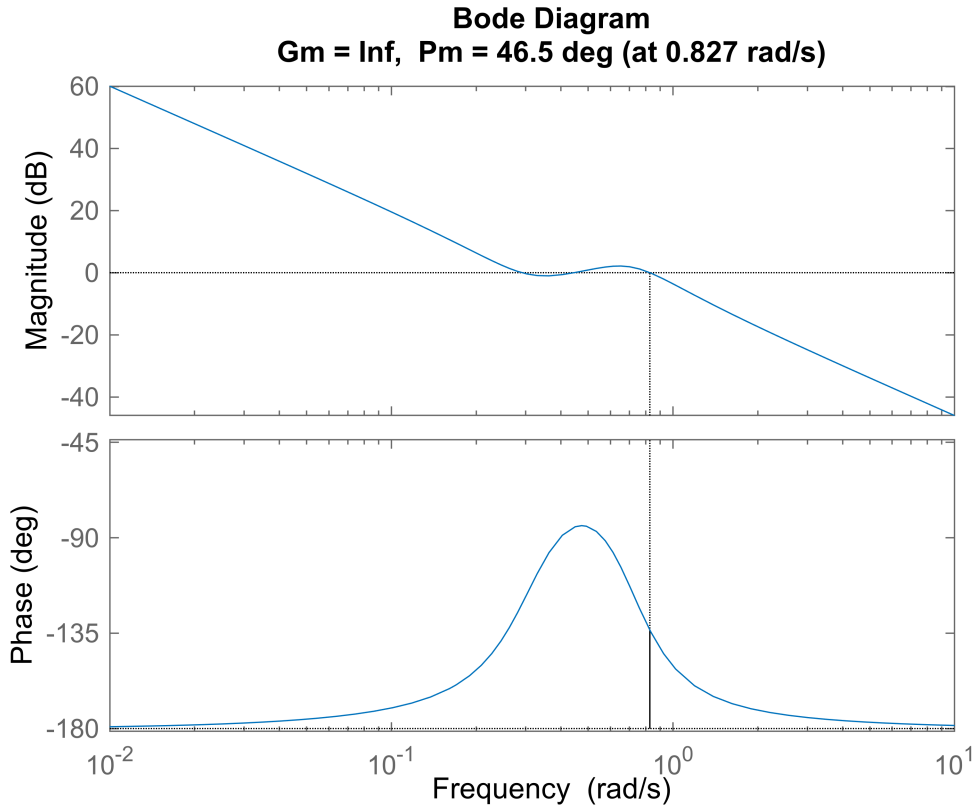

```
Zapas modulu 7.7782
Zapas fazy 41.6774
Transmitancja
G =

           1
  ---------------------
  s^3 + 2 s^2 + 2 s + 1

Continuous-time transfer function.
Model Properties
Transmitancja regulatora:
GR =

  s^2 + 1.5 s + 0.1
  -----------------
          s

Continuous-time transfer function.
Model Properties
```



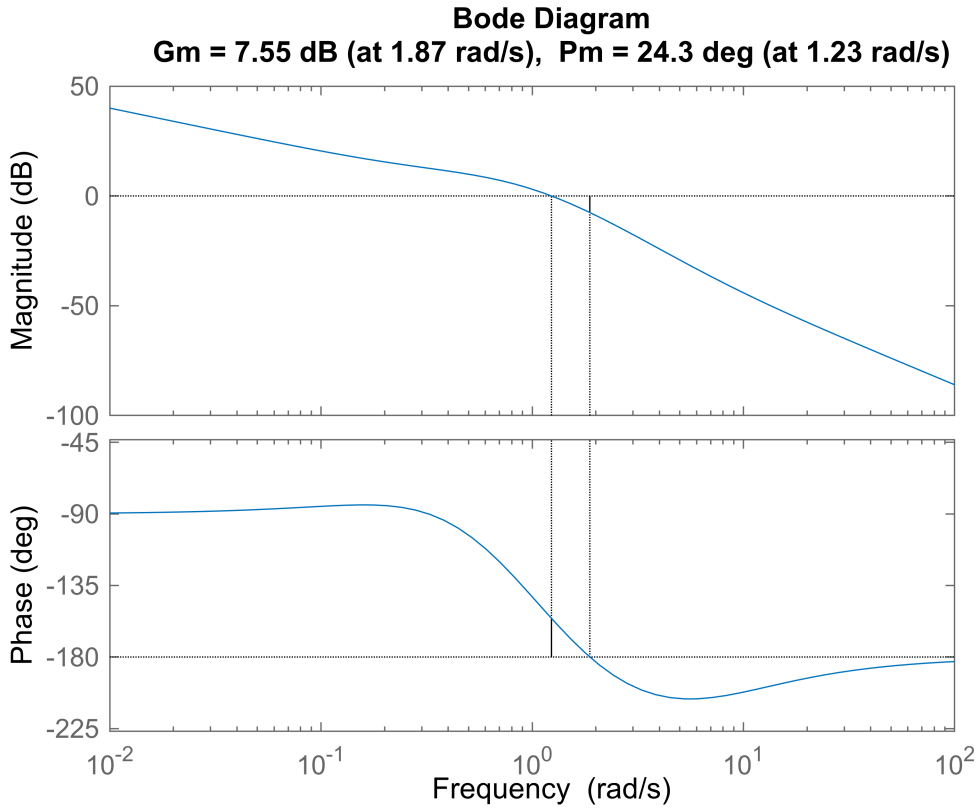

```
Zapas modulu Inf
Zapas fazy 60.0626
Transmitancja
G =

            1
  ---------------------
  s^3 + 3 s^2 + 2 s + 1

Continuous-time transfer function.
Model Properties
Transmitancja regulatora:
GR =

  s^2 + 1.25 s + 0.1
  ------------------
          s

Continuous-time transfer function.
Model Properties
```



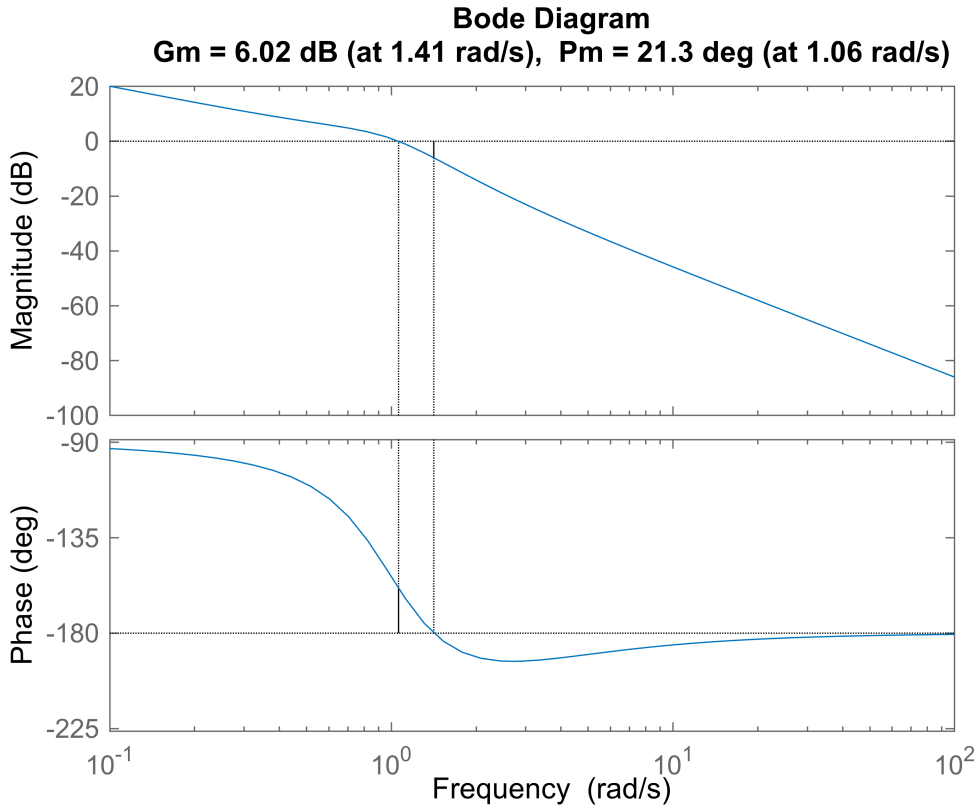

```
Zapas modulu Inf
Zapas fazy 78.3241
Transmitancja
G =

         1
  ---------------
  2 s^3 + s^2 + s

Continuous-time transfer function.
Model Properties
Transmitancja regulatora:
GR =

  s^2 + 0.25 s + 0.1
  ------------------
          s

Continuous-time transfer function.
Model Properties
```



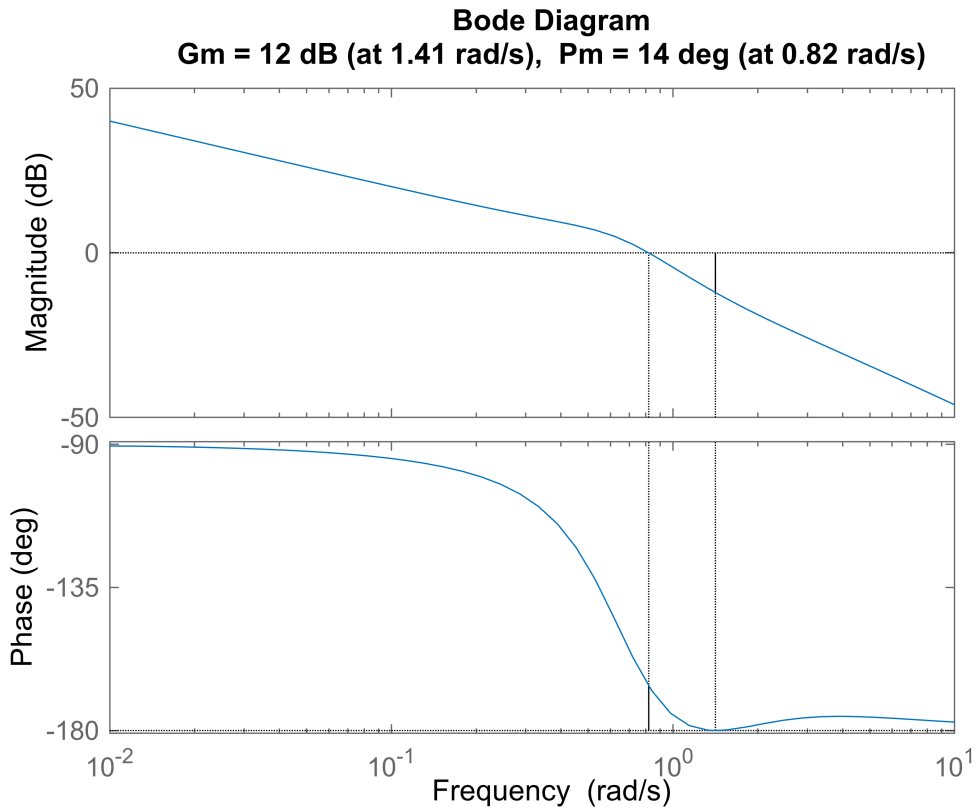

```
Zapas modulu 0
Zapas fazy 46.4855
Transmitancja
G =

           1
  ---------------------
  s^3 + 3 s^2 + 3 s + 1

Continuous-time transfer function.
Model Properties
Transmitancja regulatora:
GR =

  0.5 s^2 + 4 s + 1
  -----------------
          s

Continuous-time transfer function.
Model Properties
```



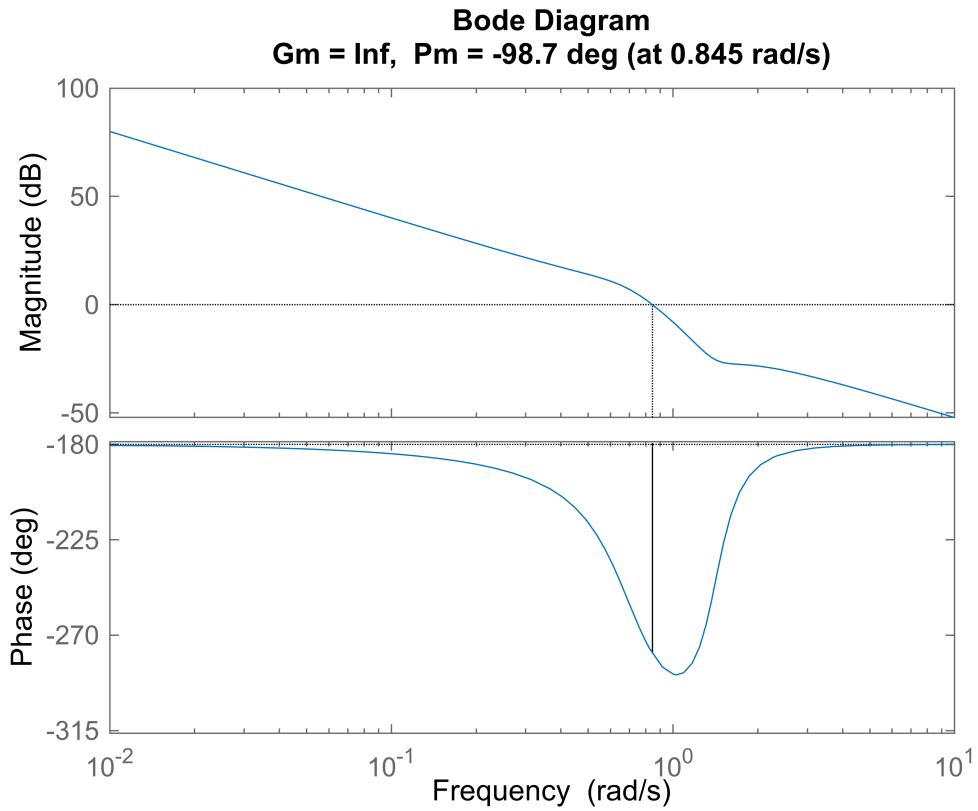

```
Zapas modulu 2.3852
Zapas fazy 24.3108
Transmitancja
G =

            1
  ---------------------
  s^3 + 2 s^2 + 2 s + 1

Continuous-time transfer function.
Model Properties
Transmitancja regulatora:
GR =

  0.5 s^2 + 1.5 s + 1
  -------------------
           s

Continuous-time transfer function.
Model Properties
```



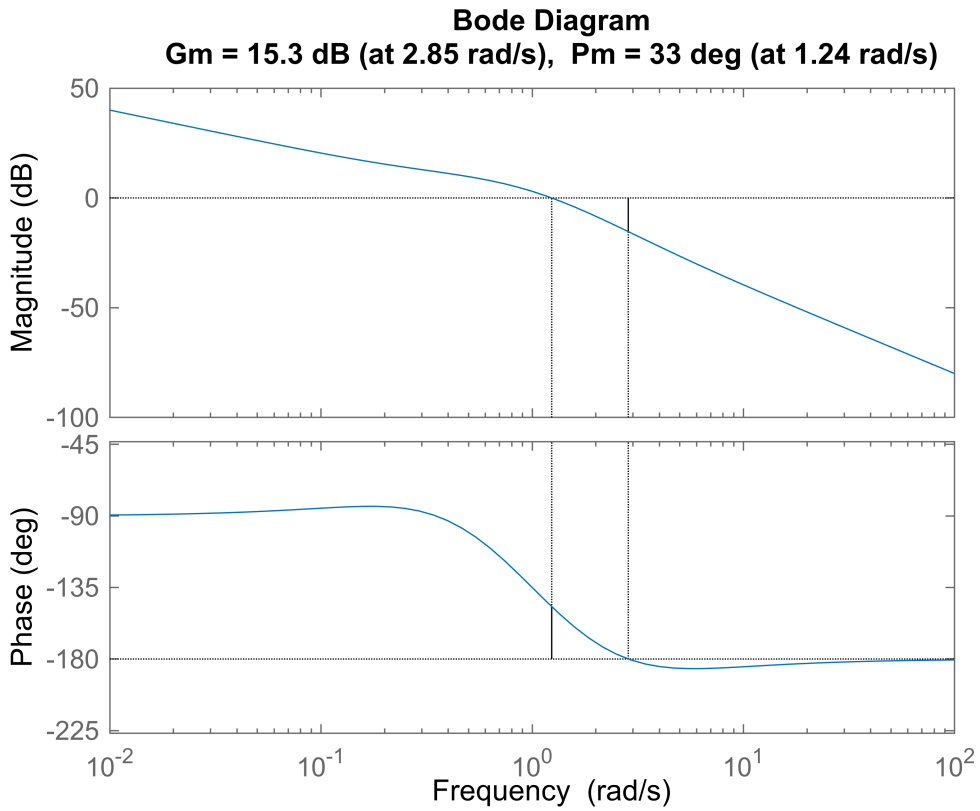

```
Zapas modulu 2
Zapas fazy 21.251
Transmitancja
G =

            1
  ---------------------
  s^3 + 3 s^2 + 2 s + 1

Continuous-time transfer function.
Model Properties
Transmitancja regulatora:
GR =

  0.5 s^2 + 1.25 s + 1
  --------------------
           s

Continuous-time transfer function.
Model Properties
```



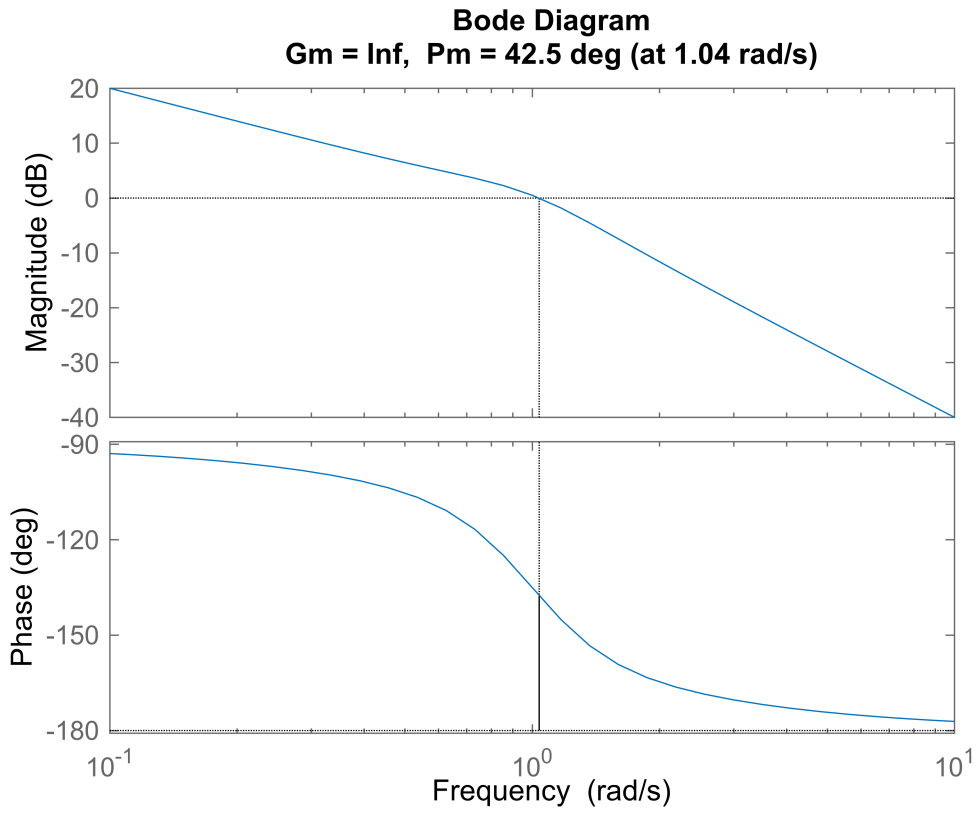

```
Zapas modulu 4
Zapas fazy 14.0271
Transmitancja
G =

         1
  ---------------
  2 s^3 + s^2 + s

Continuous-time transfer function.
Model Properties
Transmitancja regulatora:
GR =

  0.5 s^2 + 0.25 s + 1
  --------------------
           s

Continuous-time transfer function.
Model Properties
```



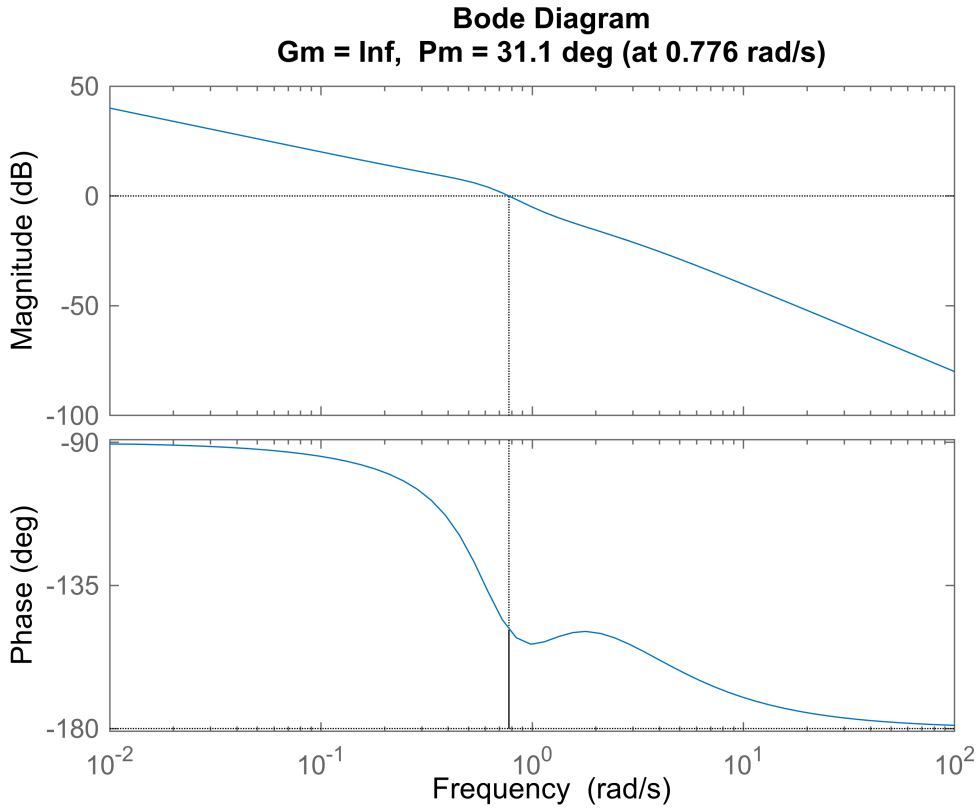

```
Warning: The closed-loop system is unstable.
Zapas modulu 0
Zapas fazy -98.6901
Transmitancja
G =

            1
  ---------------------
  s^3 + 3 s^2 + 3 s + 1

Continuous-time transfer function.
Model Properties
Transmitancja regulatora:
GR =

  s^2 + 4 s + 1
  -------------
        s

Continuous-time transfer function.
Model Properties
```



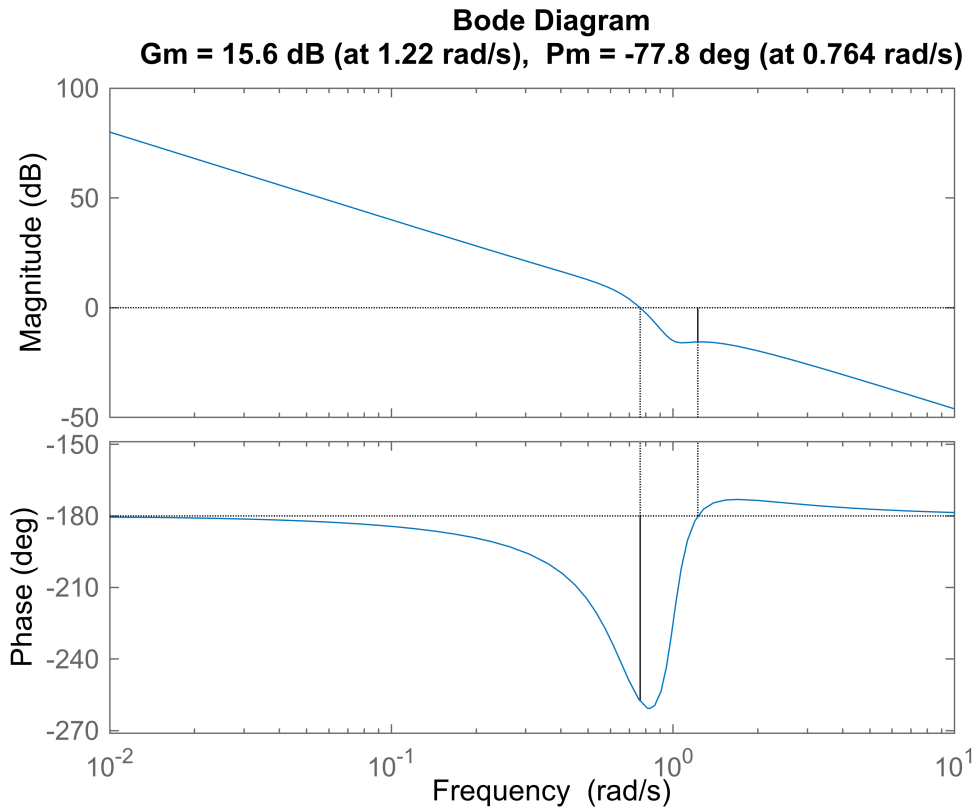

```
Zapas modulu 5.8402
Zapas fazy 32.9828
Transmitancja
G =

            1
  ---------------------
  s^3 + 2 s^2 + 2 s + 1

Continuous-time transfer function.
Model Properties
Transmitancja regulatora:
GR =

  s^2 + 1.5 s + 1
  ---------------
         s

Continuous-time transfer function.
Model Properties
```




```
Zapas modulu Inf
Zapas fazy 42.4687
Transmitancja
G =

            1
  ----------------------
  s^3 + 3 s^2 + 2 s + 1

Continuous-time transfer function.
Model Properties
Transmitancja regulatora:
GR =

  s^2 + 1.25 s + 1
  ----------------
         s

Continuous-time transfer function.
Model Properties
```




```
Zapas modulu Inf
Zapas fazy 31.076
Transmitancja
G =

         1
  ---------------
  2 s^3 + s^2 + s

Continuous-time transfer function.
Model Properties
Transmitancja regulatora:
GR =

  s^2 + 0.25 s + 1
  ----------------
         s

Continuous-time transfer function.
Model Properties
```




```
Warning: The closed-loop system is unstable.
Zapas modulu 6
Zapas fazy -77.754
```

4. Wnioski

Patrząc na wyniki operacji możemy stwierdzić że:

- Regulator P - zmniejsza zapas stabilności,
- Regulator PI - zmniejsza zapas stabilności,
- Regulator PD - zwiększa zapas stabilności,
- Regulator PID - zwiększa zapas stabilności.