# P-PI, PID制御器設計演習

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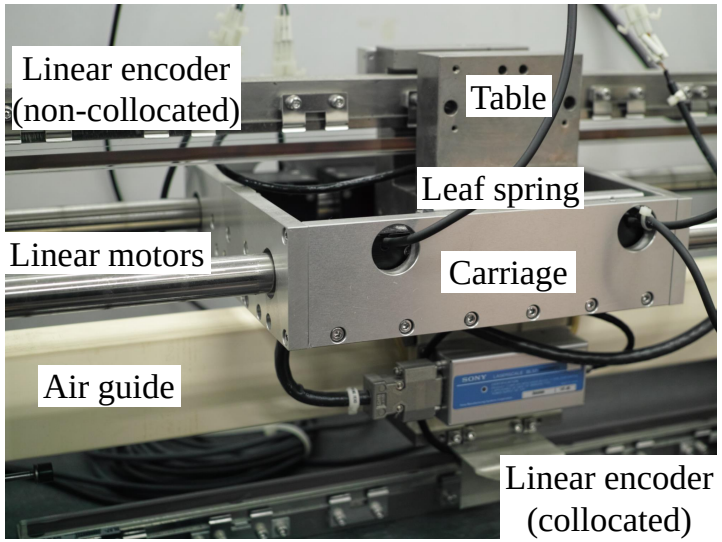
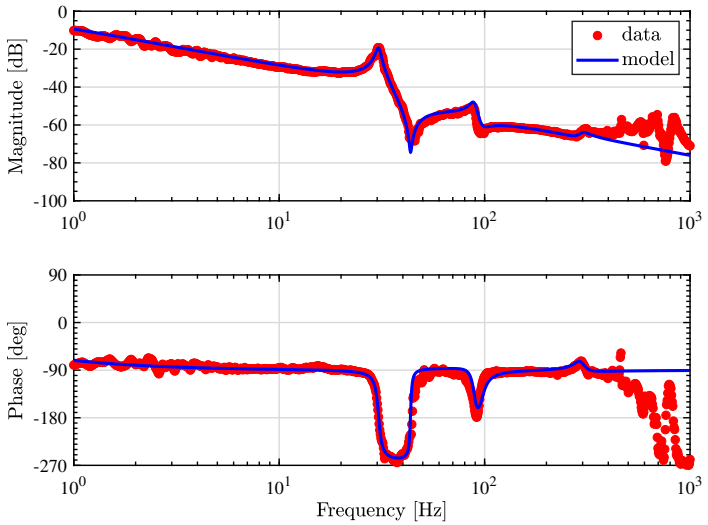
# P-PI，PID制御器設計演習

- 制御対象
  多数の共振を持つ精密位置決めステージ



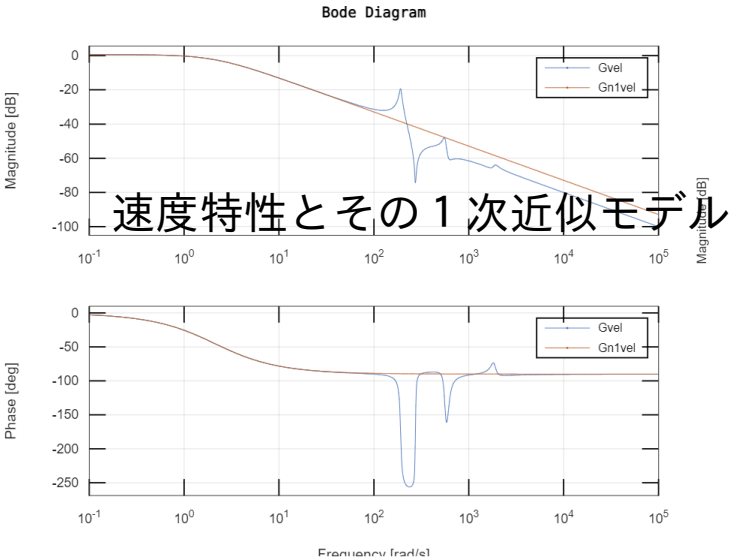

精密位置決めステージ



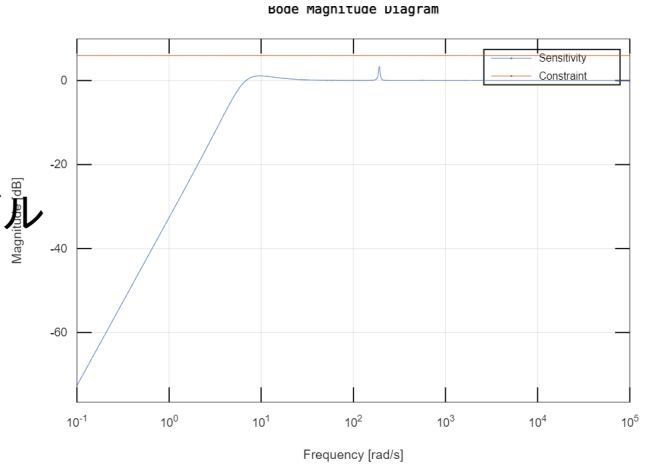

電流→負荷側速度

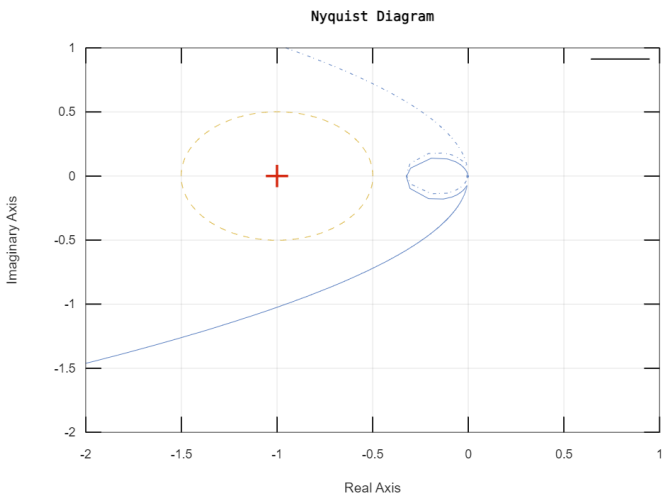
- 制御目標
  ステップ外乱の抑圧。誤差は２乗積分値で評価される。
- 設計制約
  - 閉ループ系の安定性
    （ナイキスト線図で周波数特性から判定可能）
  - 感度関数ピーク6dB以下
    （特定周波数の外乱の過度な増幅を防ぐため，位相余裕29度，ゲイン余裕6dBとほぼ同じ）

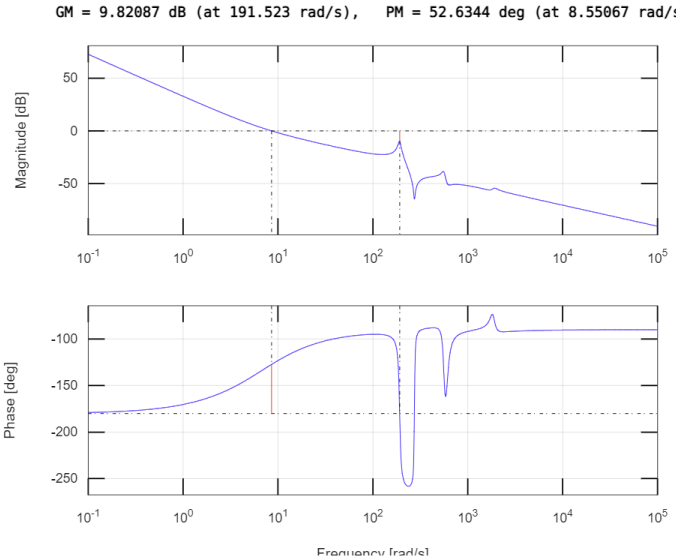
# P-PI制御器設計例（初期ゲイン）

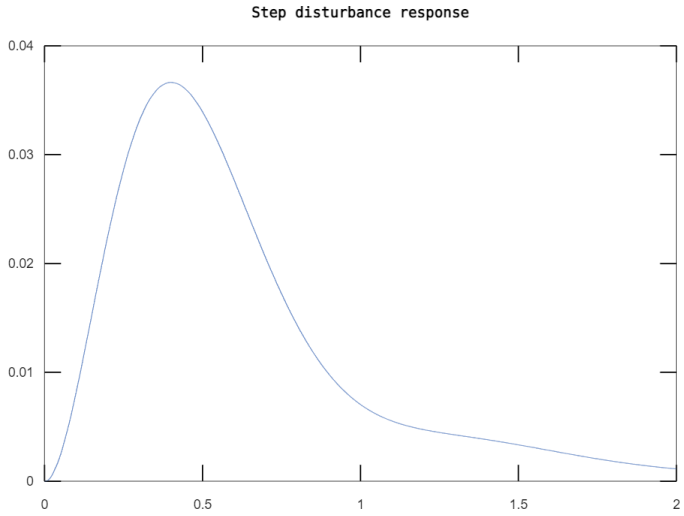



速度特性とその１次近似モデル




初期ゲイン
kvp = 3;
kvi = 20;

kpp = 2;

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ROBUSTNESS SCORE
||S||_inf: 3.40 [dB]
GM: 9.82 [dB] at 30.48 [Hz]
PM: 52.63 [deg] at 1.36 [Hz]

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PERFORMANCE SCORE
Disturbance response: 0.7629
(smaller better)

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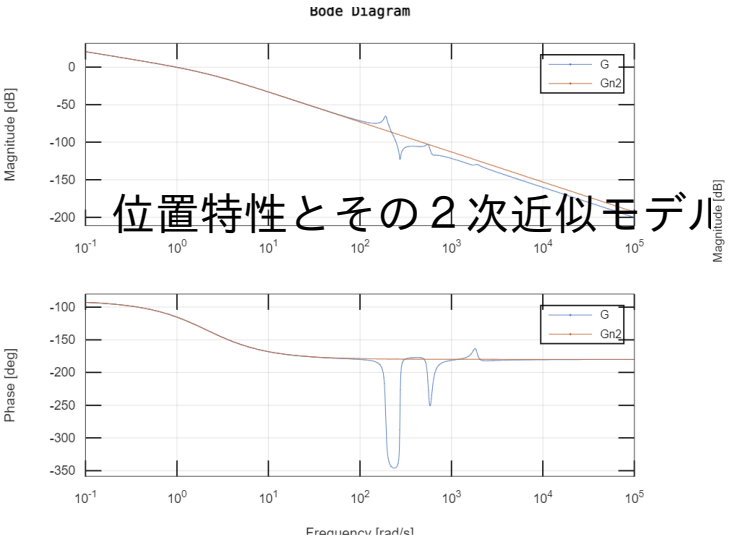
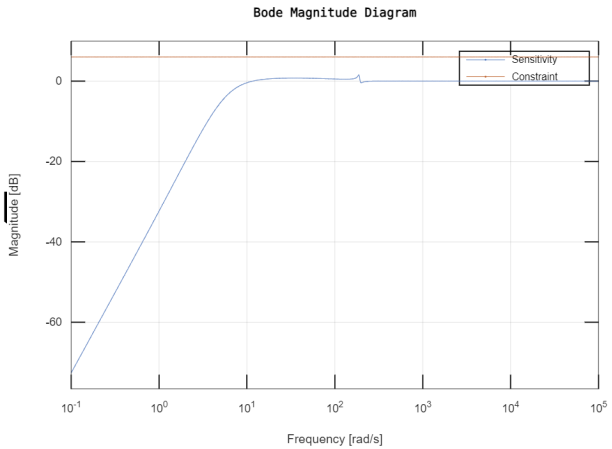
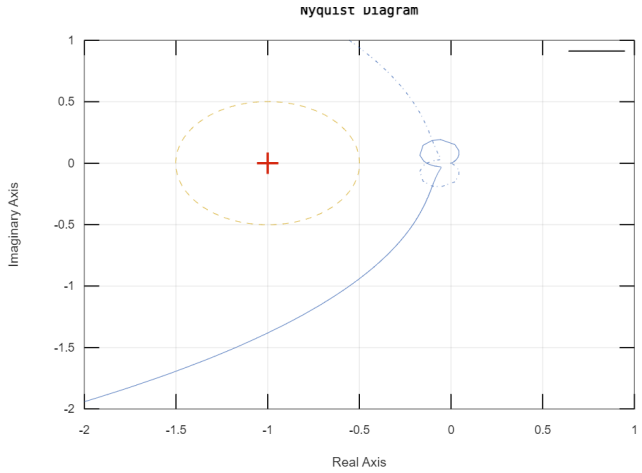
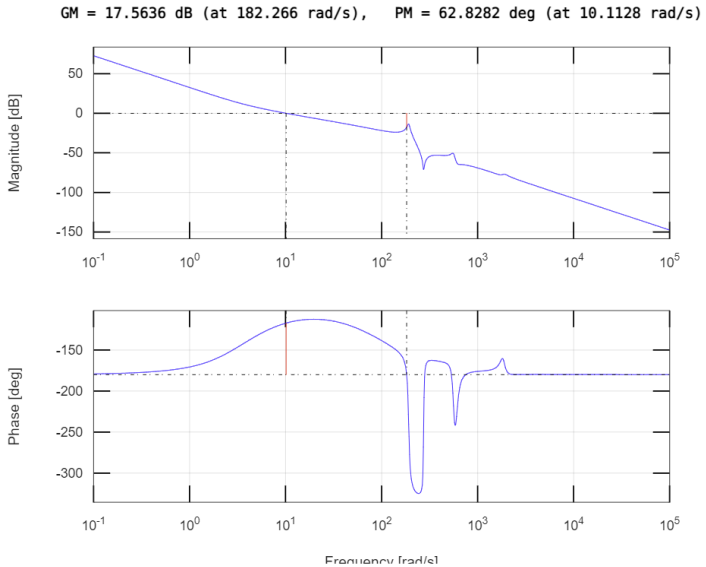
# PID制御器設計例（初期ゲイン）

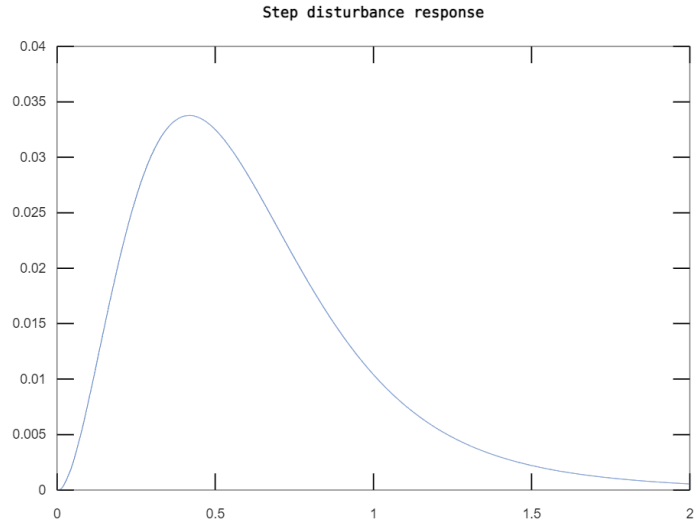



位置特性とその２次近似モデル




初期ゲイン
kp = 25;
ki = 40;
kd = 4;
tau = 0.01;

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ROBUSTNESS SCORE
||S||_inf: 1.57 [dB]
GM: 17.56 [dB] at 29.01 [Hz]
PM: 62.83 [deg] at 1.61 [Hz]

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PERFORMANCE SCORE
Disturbance response: 0.7589
(smaller better)

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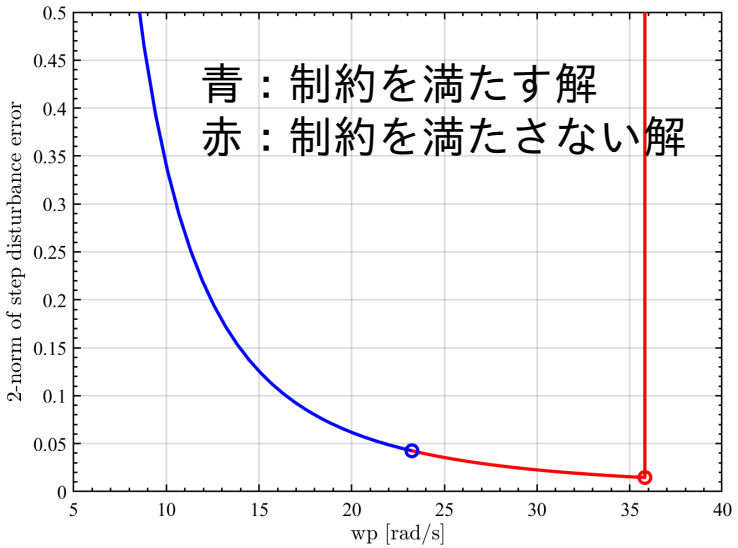
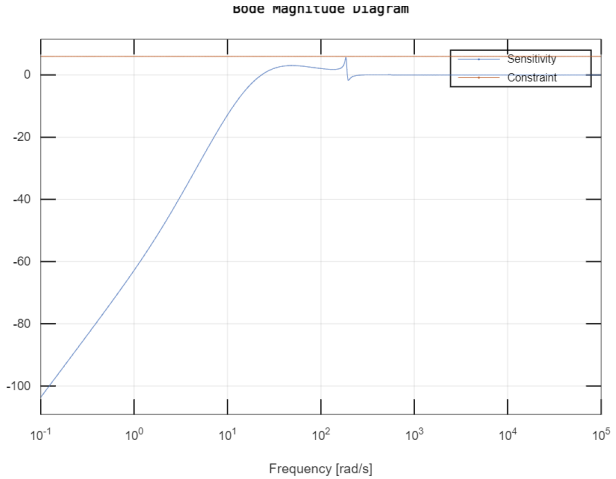
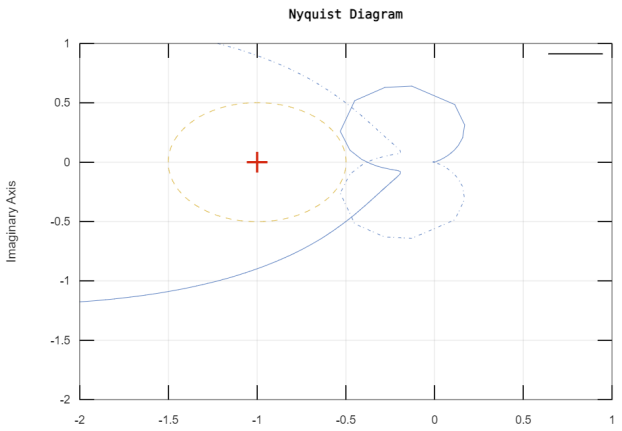
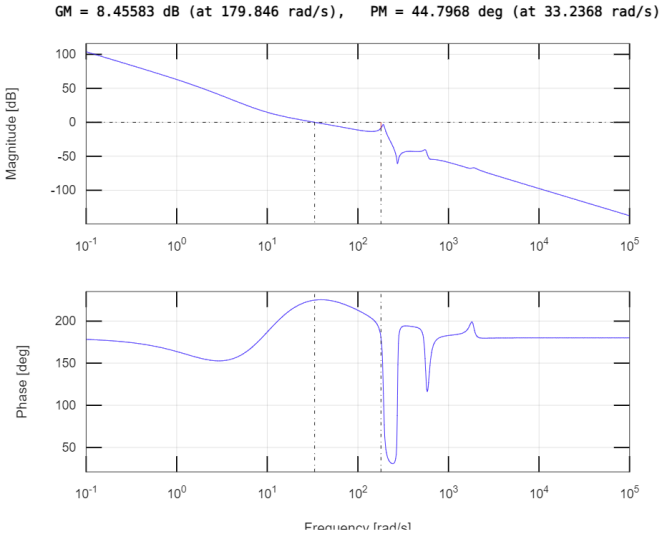
# Appendix

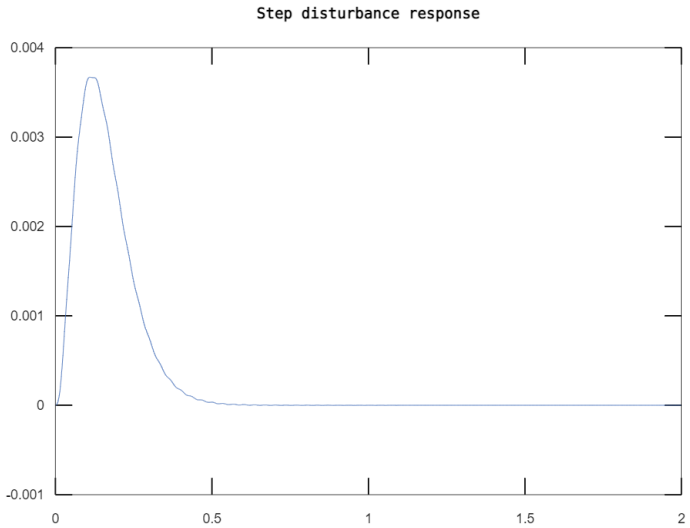
# PID制御器設計例（極配置設計による最適化）




極配置設計による最適化
kp = 2.298964870722361e+02;
ki = 1.427421959776643e+03;
kd = 12.384286893782210;
tau = 0.011002265883388;

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ROBUSTNESS SCORE
||S||_inf: 5.70 [dB]
GM: 8.46 [dB] at 28.62 [Hz]
PM: 44.80 [deg] at 5.29 [Hz]

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PERFORMANCE SCORE
Disturbance response: 0.0425
(smaller better)

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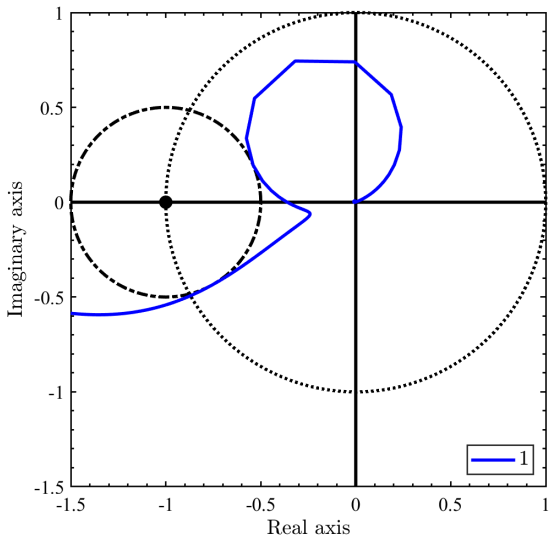
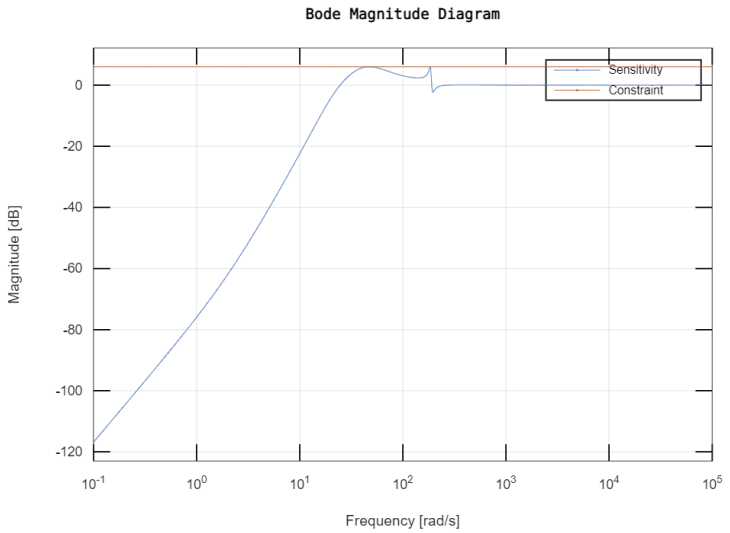
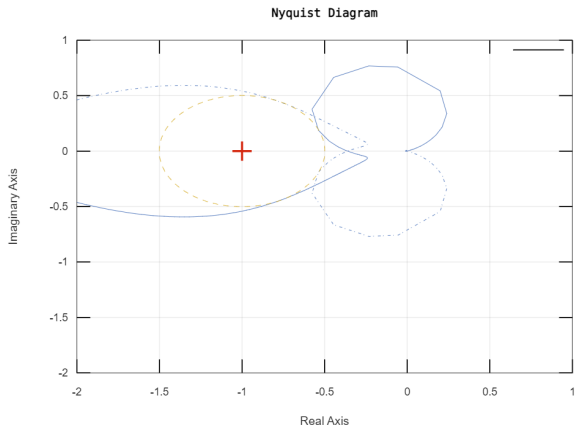
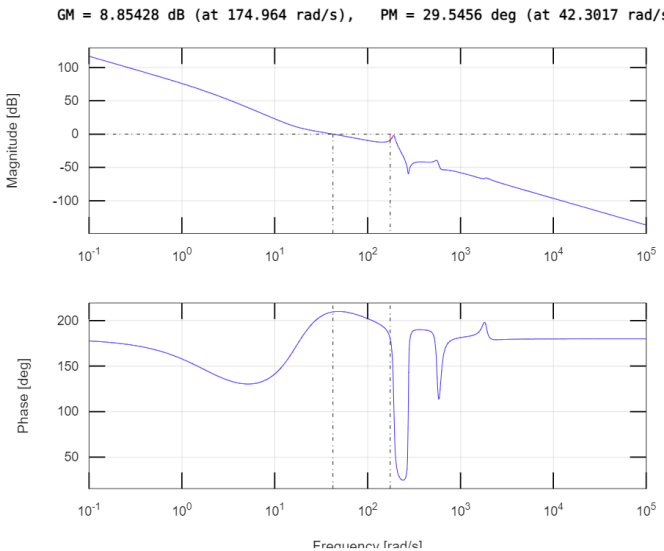
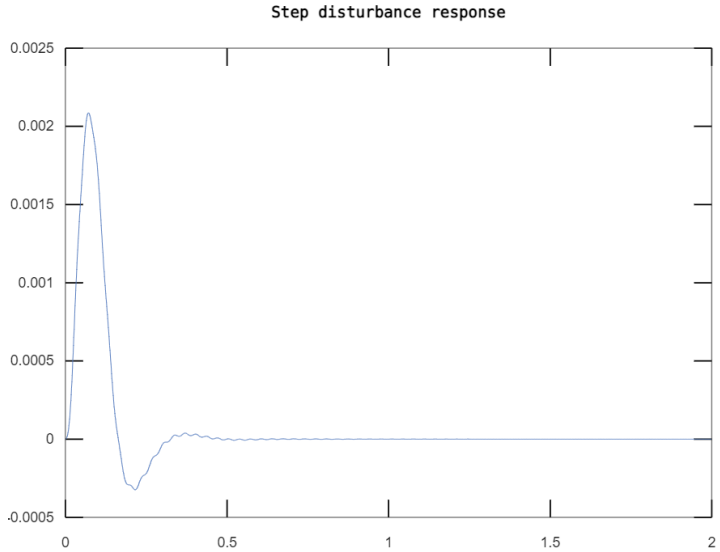
# PID制御器設計例（非線形最適化）




fminconによる最適化
kp = 3.816643132317525e+02;
ki = 6.498790939136171e+03;
kd = 16.406551065421159;
tau = 0.014416760297701;

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ROBUSTNESS SCORE
||S||_inf: 6.02 [dB]
GM: 8.85 [dB] at 27.85 [Hz]
PM: 29.55 [deg] at 6.73 [Hz]

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PERFORMANCE SCORE
Disturbance response: 0.0169
(smaller better)

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