Frequency Domain | *Four-Element Flow*

目錄

Transfer function settings

Just 4 csv files. No programming and multiplying out needed.

Transfer Function Files

- System Transfer Function(Real coefficient)：

  G(s)：forward gain

  H(s)：feedback gain

- File list：

  G(s)_nominator：nominator polynomial of G(s)

  G(s)_denominator：denominator polynomial of G(s)

  H(s)_nominator：nominator polynomial of G(s)

  H(s)_denominator：denominator polynomial of G(s)

Polynomial Settings

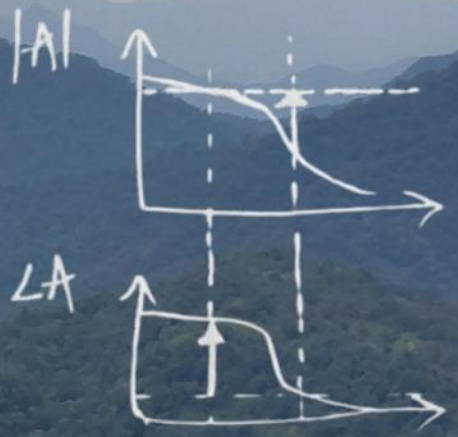
- Represent with 0-deg(coefficient), 1-deg(single real root) or 2-deg(two conjugate imaginary roots or two real roots)
  - eg. $5s(s^2+2s+2)$

s**2	s**1	1	
0	0	5	5
0	1	0	s
1	2	2	s^2+2s+2

Application Description and Tutorial

Convenient applications and plot settings, suits every scene.

Bode Plot

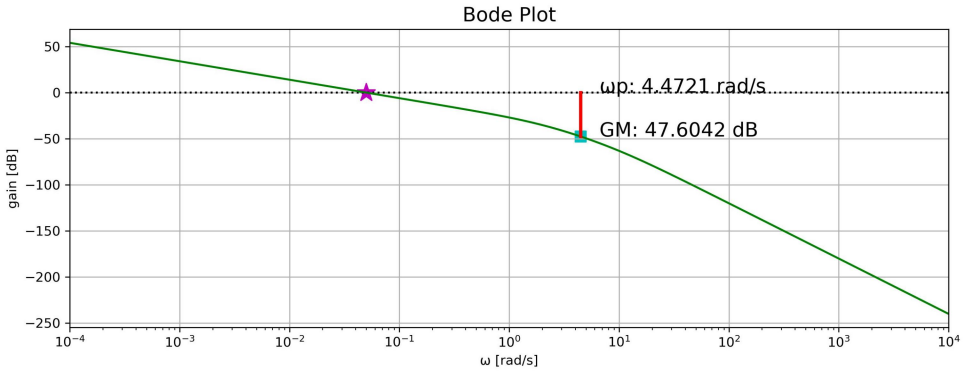


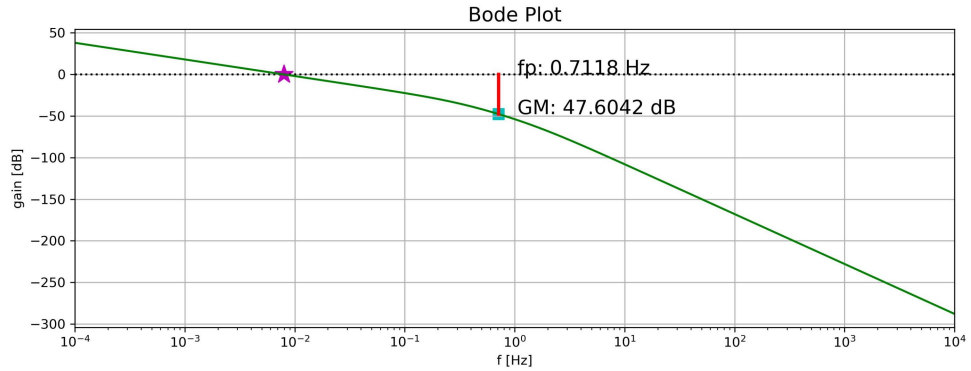
張睿傑、Roger Chang

Designed Features

- Displays gain margin and phase margin (applicable only to minimum-phase systems).
- Highlights phase crossover points, gain crossover points, and their corresponding frequencies.
- Offers selectable frequency units (rad/s or Hz).

Plotting Examples





Kernel Examples

```
-----------------------------------------
Gain Margin:                  47.6042 dB
Phase crossover freq:          4.4721 rad/s
-----------------------------------------
Phase Margin(if min. ph):     88.2820 degrees
Gain crossover freq:           0.0500 rad/s
```

```
-----------------------------------------
Gain Margin:                  47.6042 dB
Phase crossover freq:          0.7118 Hz
-----------------------------------------
Phase Margin(if min. ph):     88.2820 degrees
Gain crossover freq:           0.0080 Hz
```

Preference Settings

- Filepath: " ./settings/Bode plot.csv"
- Parameters:

prec	4
ang_freq	0
samp_range	4
quantity	10000

display precision(decimal digits)
freq unit(0: Hz，1: rad/s)
sample range(10^{-samp_range}~10^{-samp_range})
sampling quantity

Note: Unit of sample range is same as selected freq unit.

Operation

- Finish entering transfer function and preference parameters
- Run Bode plot.py
- Obtain plots from ./Bode_plot

Complete Root Locus

張宥傑、Roger Chang

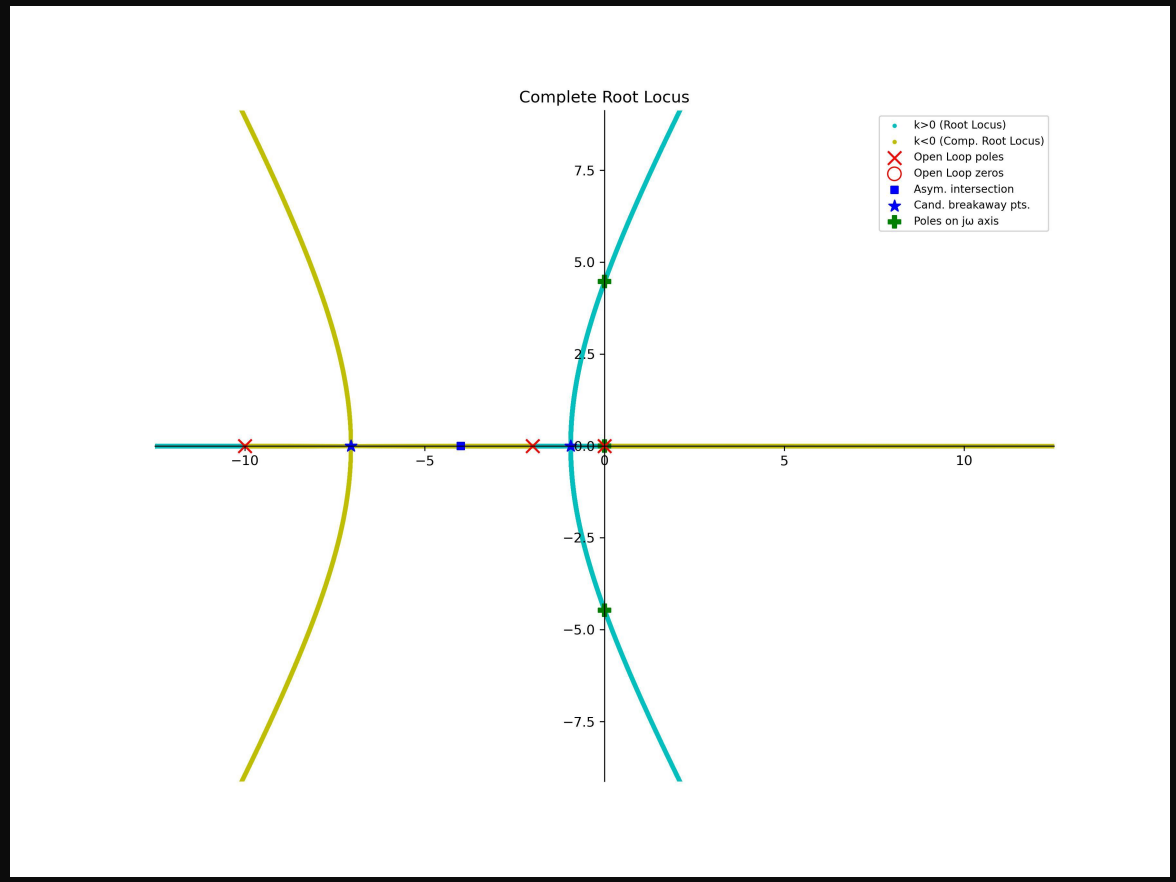
Designed Features - Sampling

- Plot with respect to $1+kG(s)H(s) = 0$
- Automatically tuned k_0
  - Enhanced sampling density when the weights of open-loop poles and zeros are close to each other
  - $k_0 = \frac{\text{highest degree term coefficient in } G(s)H(s)' \text{ s denominator}}{\text{highest degree term coefficient in } G(s)H(s)' \text{ s nominator}}$
- Exponentially-spaced sampling
  - samples distributed more uniformly

Designed Features - Plotting

- Root locus for both k>0 and k<0
  - with different colors
- Open-loop poles and zeros labeling
- Display angles and intersection of asymptotes
- Display candidates of breakaway points
  - all roots of $\frac{d}{ds}(G(s)H(s)) = 0$
- labeled jω axis poles with corresponding gains

Plotting Examples



Kernel Examples

```
Angles of asymptotes (k>0):
  θr_1 = 0.3333 π
  θr_2 = 1.0 π
  θr_3 = 1.6667 π

Angles of asymptotes (k<0):
  θc_1 = 0.0 π
  θc_2 = 0.6667 π
  θc_3 = 1.3333 π
```

```
Intersection of asymptotes:
  Inters:  s = -4.0
---------------------------------
Candidates of breakaway points:
  cand. 1: s = -7.0551
  cand. 2: s = -0.9449
```

```
Candidates of breakaway points:
  cand. 1: s = -7.0551
  cand. 2: s = -0.9449
---------------------------------
Poles on jw axis: 3 found.
  pole 1:  s =  4.4721j, k = 240.0
  pole 2:  s = -4.4721j, k = 240.0
  pole 3:  s =  0.0j, k = -0.0
---------------------------------
Open loop poles:
  OLP. 1:  s = (-10+0j)
  OLP. 2:  s = (-2+0j)
  OLP. 3:  s = 0j
```

Preference Settings

- Filepath: " ./settings/Complete Root Locus.csv"
- Parameters:

prec	4
xRange	-1
lb	-6
ub	6
quantity	20000

display precision(decimal digits)
freq unit(0: Hz，1: rad/s)
unilateral sample lowerbound(10^{lb})
unilateral sample upperbound(10^{ub})
sampling quantity

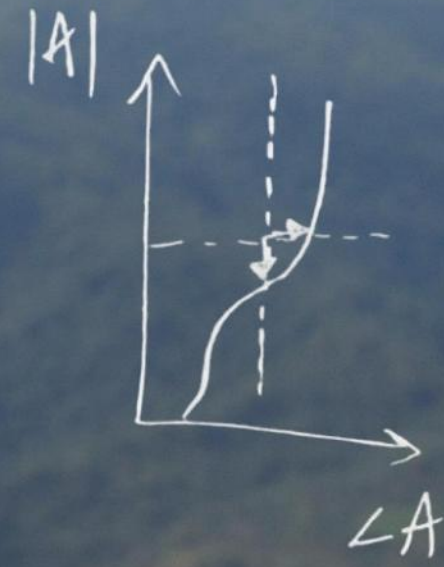
Tuning Hints

- suggested lb within[-4, 0], ub within[0, 4]
- Insufficient samples lead to dashed-line-like locus.
  - The plot is generated with plt.scatter()
- Execessive samples cause low operation speed
  - quantity above 20,000 is not suggested

Operation

- Finish entering transfer function and preference parameters
- Run Complete Root Locus.py
- Obtain plots from ./Complete_Root_Locus

Nichols Plot



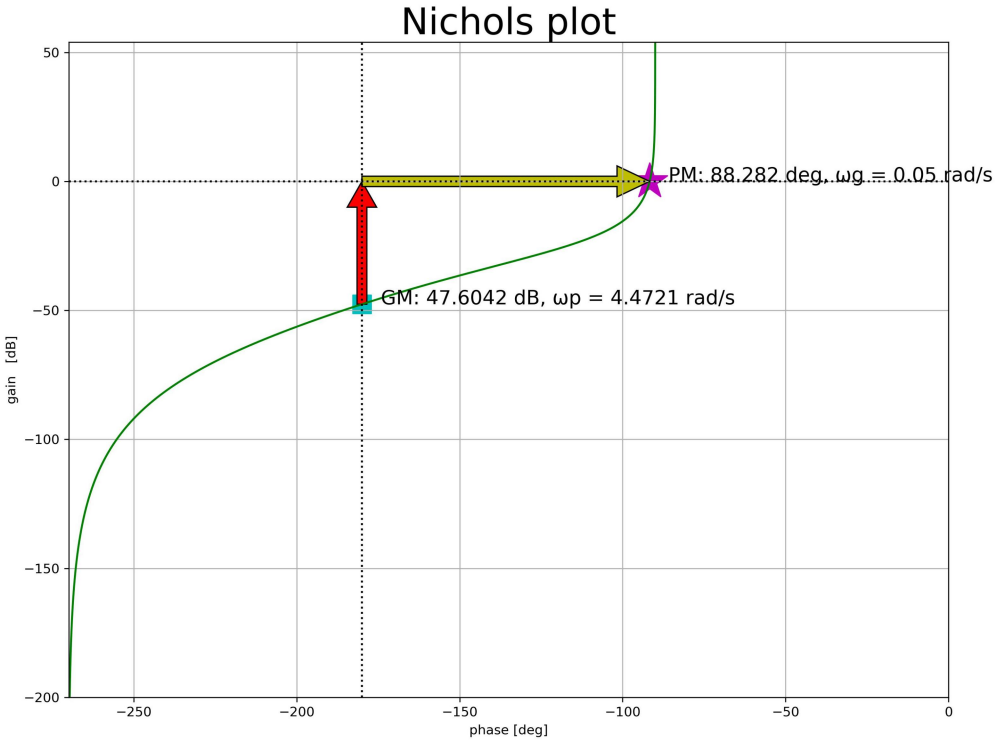
張睿傑、

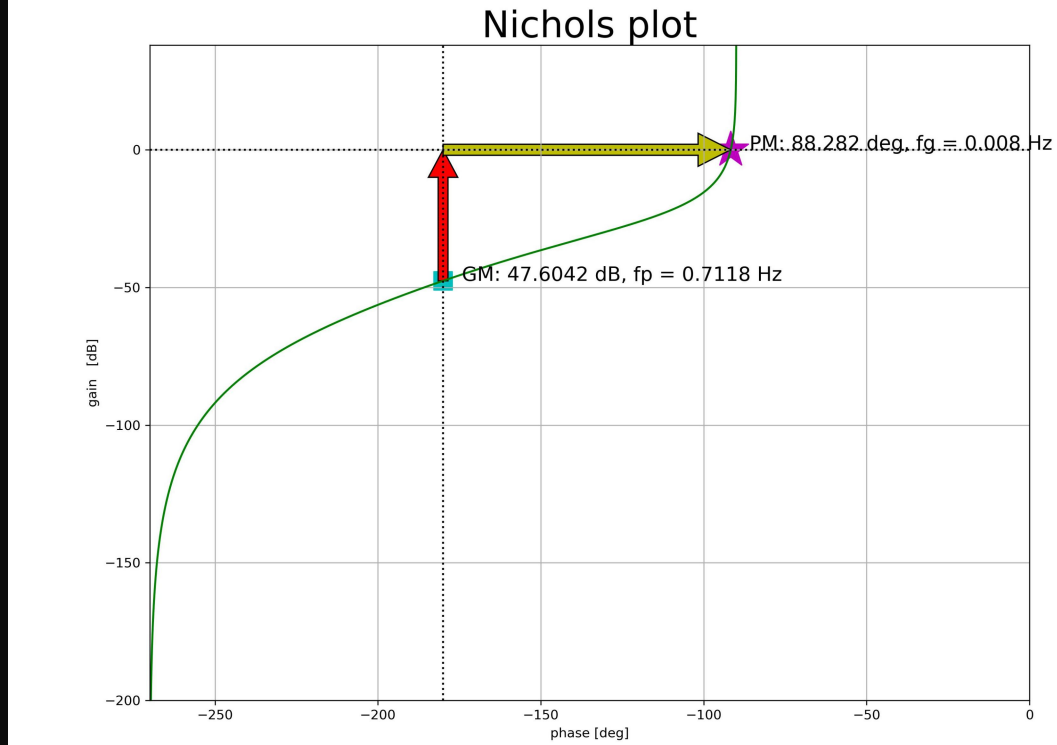
Roger Chang

Designed Features

- Marks the gain margin and phase margin (valid only for minimum-phase systems).
- Marks the phase crossover points, gain crossover points, and their corresponding frequencies.
- Optional frequency units (rad/s or Hz).
- Automatically adjusts the display range.
- Gain lower limit is displayed down to at least -200 dB, and phase lower limit is displayed down to at least -180°.
- Upper limits are determined by the graph.

Plotting Examples





Kernel Examples

```
-----------------------------------------
Gain Margin:                  47.6042 dB
Phase crossover freq:          4.4721 rad/s
-----------------------------------------
Phase Margin(if min. ph):     88.2820 degrees
Gain crossover freq:           0.0500 rad/s
```

```
-----------------------------------------
Gain Margin:                  47.6042 dB
Phase crossover freq:          0.7118 Hz
-----------------------------------------
Phase Margin(if min. ph):     88.2820 degrees
Gain crossover freq:           0.0080 Hz
```

Preference Settings

- Filepath: " ./settings/Bode plot.csv"
- Parameters:

prec	4
ang_freq	0
samp_range	4
quantity	10000

display precision(decimal digits)
freq unit(0: Hz，1: rad/s)
sample range(10^{-samp_range}~10^{-samp_range})
sampling quantity

Note: Unit of sample range is same as selected freq unit.

Operation

- Finish entering transfer function and preference parameters
- Run Nichols plot.py
- Obtain plots from ./Nichols_plot

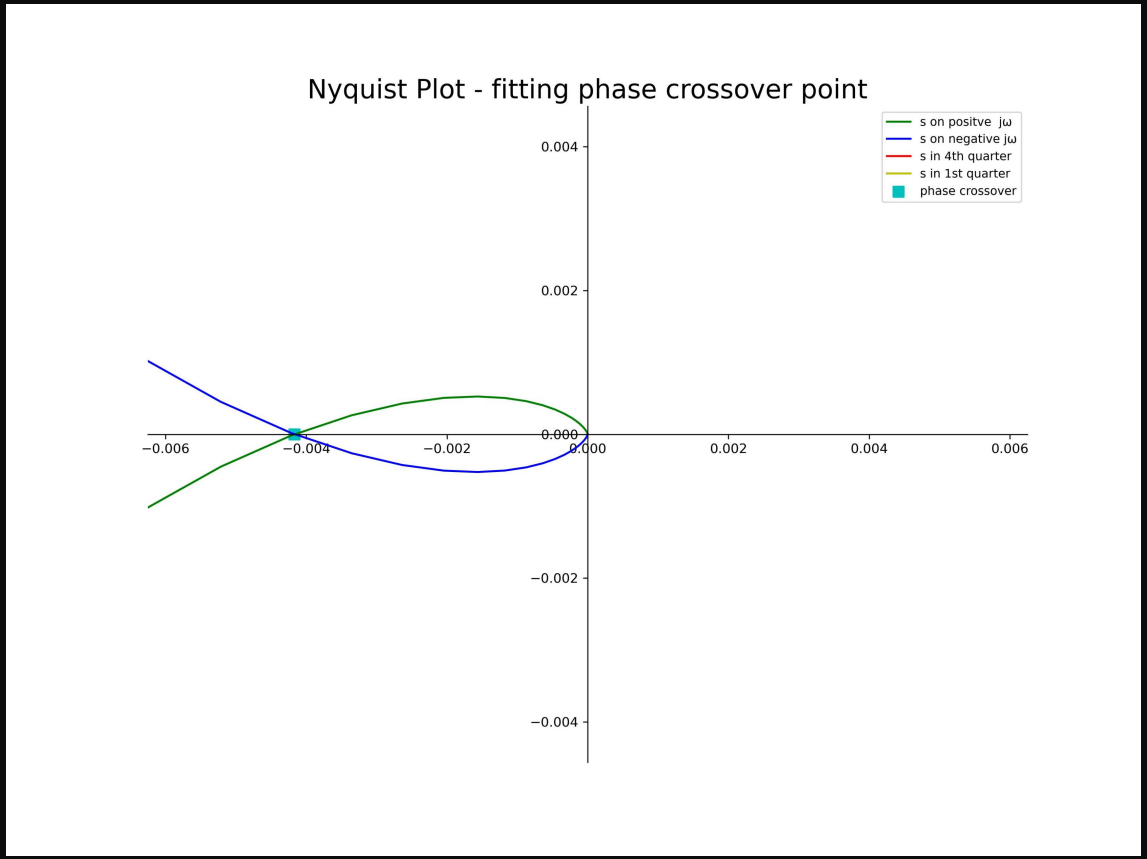
Nyquist Plot

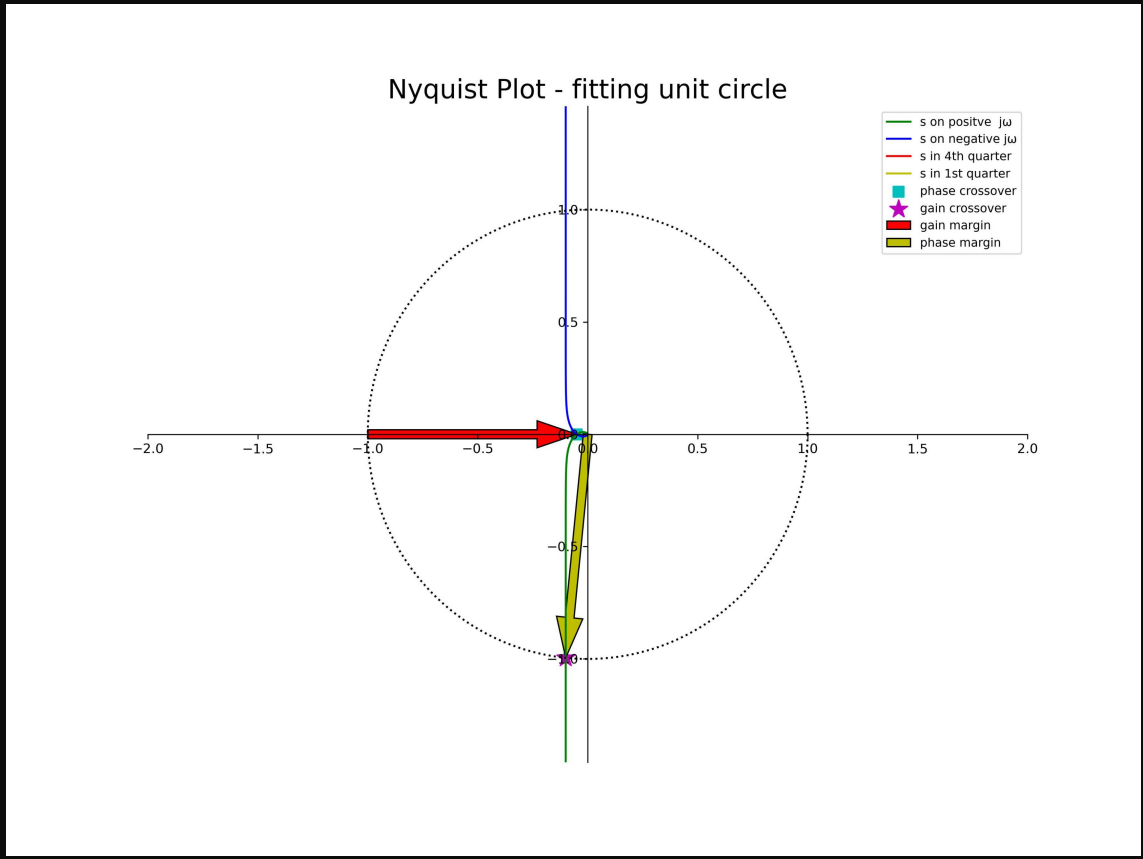
張睿傑、Roger Chang

Designed Features

- Displays gain margin and phase margin (applicable only to minimum-phase systems).
- Shows phase crossover points, gain crossover points, and their corresponding frequencies.
- Offers selectable frequency units (rad/s or Hz).
- Automatically adjusts the display range (two selectable modes):
  - Mode 0: Phase Crossover Mode: Adjusts based on phase crossover points.
  - Mode 1: Unit Circle Mode: Adjusts based on the unit circle.

Plotting Examples





Kernel Examples

```
-----------------------------------------
Gain Margin:                  47.6042 dB
Phase crossover freq:          4.4721 rad/s
-----------------------------------------
Phase Margin(if min. ph):     88.2820 degrees
Gain crossover freq:           0.0500 rad/s
```

```
-----------------------------------------
Gain Margin:                  47.6042 dB
Phase crossover freq:          0.7118 Hz
-----------------------------------------
Phase Margin(if min. ph):     88.2820 degrees
Gain crossover freq:           0.0080 Hz
```

Preference Settings

- Filepath: " ./settings/Nyquist plot.csv"
- Parameters:

prec	4
ang_freq	1
samp_radius	60
quantity	10000
fit uc	0

display precision(decimal digits)
freq unit(0: Hz，1: rad/s)
sample range(10^{-samp_range}~10^{-samp_range})
sampling quantity
display range mode

Note: Unit of sample range is same as selected freq unit.

Operation

- Finish entering transfer function and preference parameters
- Run Nyquist plot.py
- Obtain plots from ./Nyquist_plot

User Reports

Reporting bugs and feedback.

Reporting Issues

- Gmail: rogerchang424@gmail.com
- Email Subject: (Feature to Report) + (Error Description)
- Example: “Nyquist plot phase margin calculation error
- Attachment: (.zip format)
- Please include the complete Transfer Function and settings files to facilitate debugging.