Can we determine stability (under feedback/gain) using only the Bode plot?

The pole will be on the $j\omega$-axis if $|H(j\omega)| = 1$ when $\angle = -180°$.

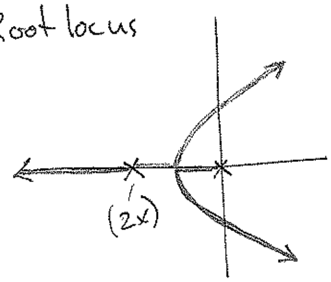
For a single crossing, pole is left of axis if $|H(j\omega)| < 1$ when $\angle = -180°$

or phase $> -180°$ when $|H(j\omega)| = 1$.

We can quantify "how close" we are to instability by looking at gain/phase marg

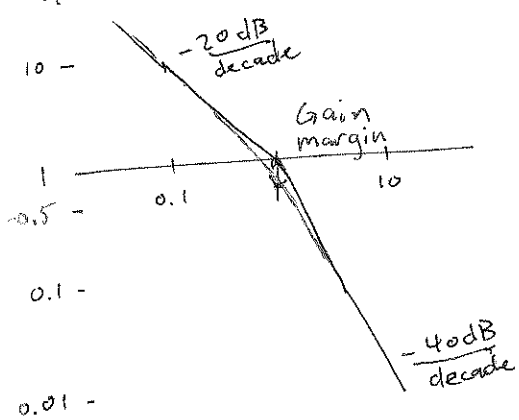
$H(s) = \frac{1}{s(s+1)^2}$ (following FPE)

Root locus



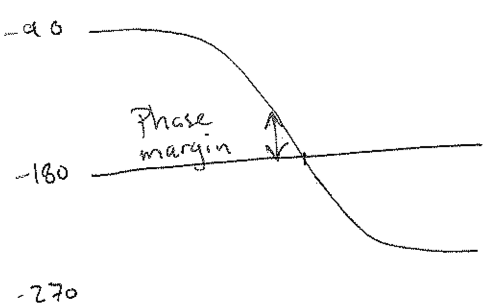
This is stable if the gain is small.

Gain



Note what would happen if we increased the gain by 2x.

Phase



Why phase margin?

EE 105 Frequency domain worksheet

4 November 2019

Steven Bell

Damping ratio and phase margin

Given the system

$$G = \frac{\omega_n}{s\,(s + 2\zeta\omega_n)}$$

which under unity feedback produces an overall TF of

$$H = \frac{\omega_n^2}{s^2 + 2\zeta\omega_n s + \omega_n^2}$$

Use Matlab to draw a Bode plot, and examine how the phase margin changes as a function of ζ. To start, use a fixed ω_n of 1.

If you have time, examine both the gain and phase margin, and consider dependance on ω_n.

Controllers and compensation

For each of the following controllers, make a Bode plot with Matlab and draw some conclusions about what it does in frequency-land. Does it filter/amplify certain frequencies? How does it affect the phase margin, and therefore the stability?

- Proportional control
- PD control
- PI control
- Lead compensation: $\left(\frac{s+z}{s+p}\right)$ with $z < p$ or $\left(\frac{T_D s+1}{\alpha T_D s+1}\right)$, with $\alpha < 1$
- Lag compensation: $\left(\frac{s+z}{s+p}\right)$ with $z > p$ or $\left(\alpha\frac{T_D s+1}{\alpha T_D s+1}\right)$, with $\alpha > 1$