MECH 3140 Lecture: Common Controllers

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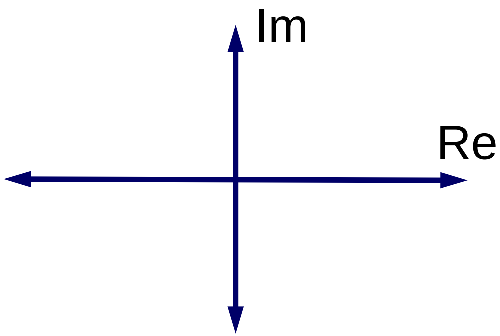
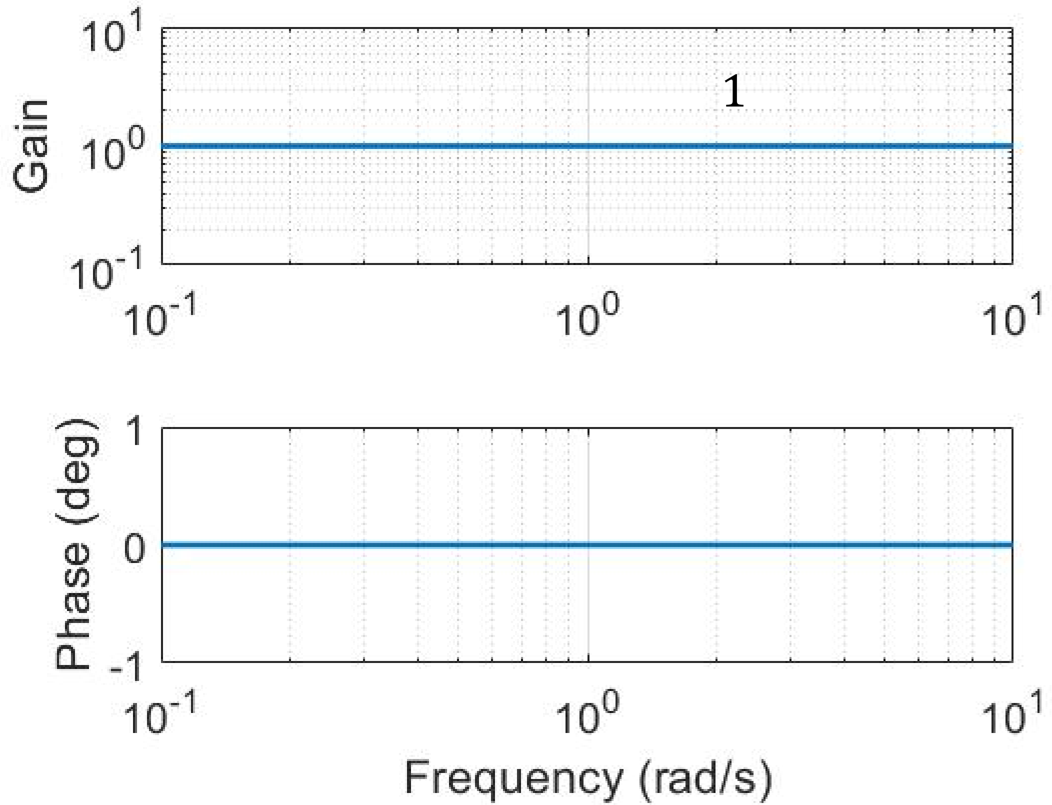
Proportional Control

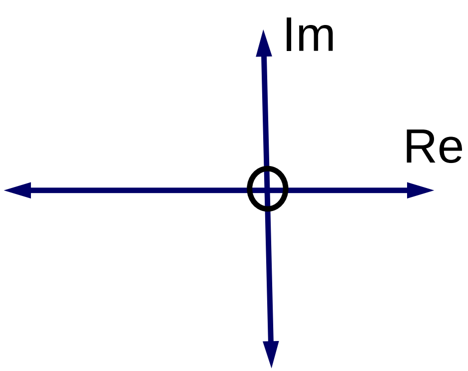
- Simplest controller
  - – Doesn't add any poles or zeros
- $K(s) = k$
- $u(t) = ke(t)$

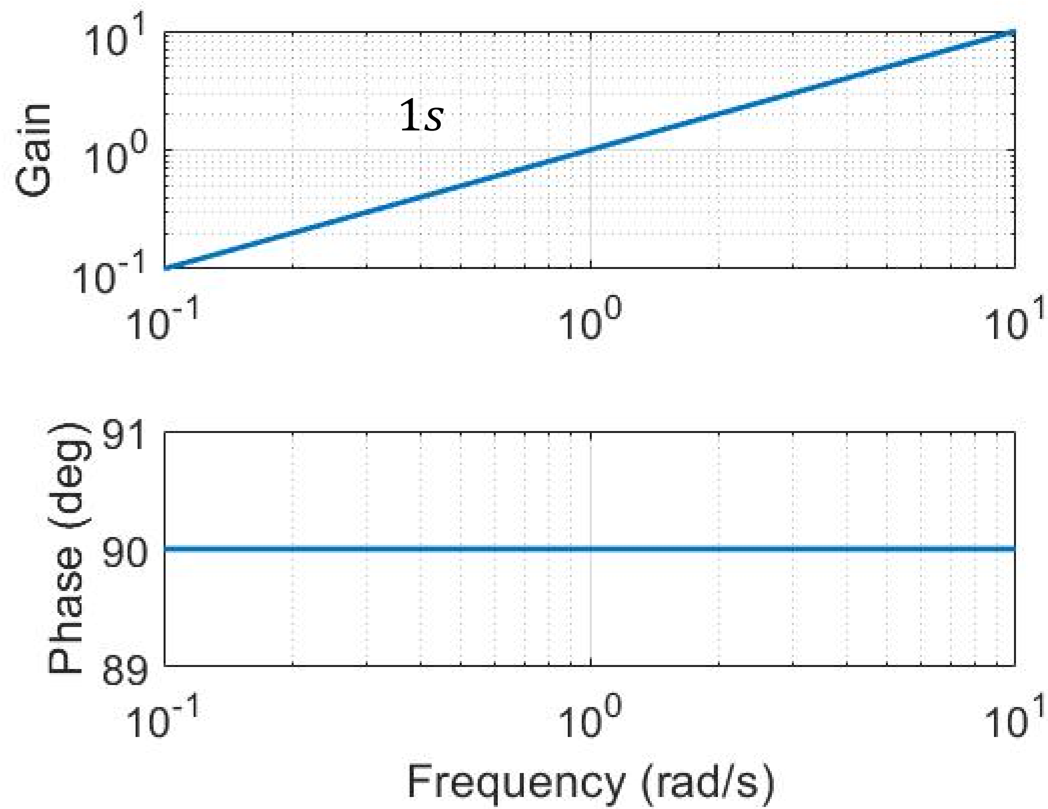




Derivative

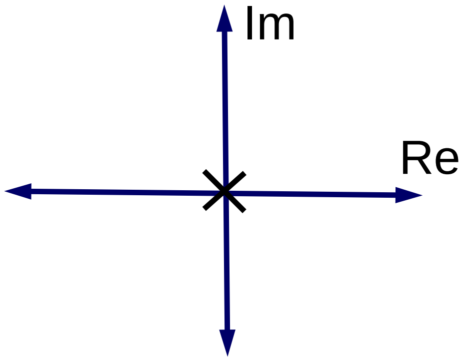
- Adds phase lead ("anticipation")
  - Adds zero to the system
  - Amplifies high frequencies (i.e. sensor noise)
- $K(s) = ks$
- $u(t) = k\dot{e}(t)$

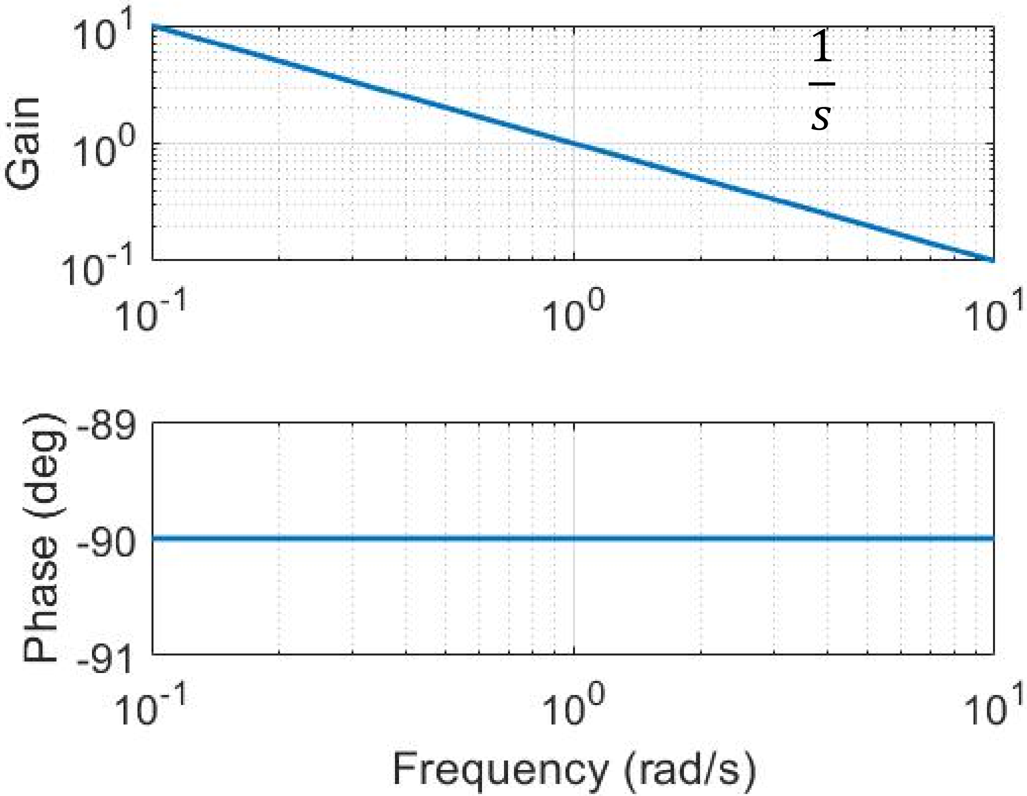




Integral Control

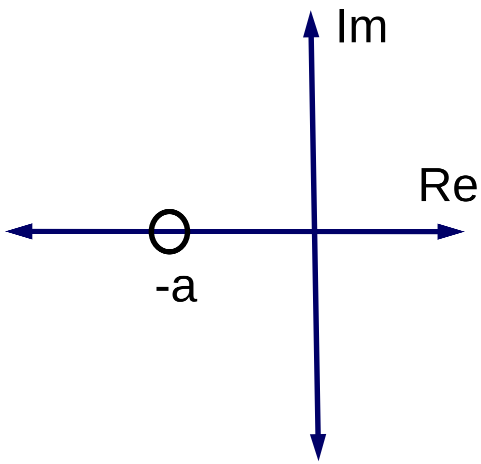
- Adds phase lag
  - Infinite DC gain
  - Adds pole at the origin
- $K(s) = \frac{k}{s}$
- $u(t) = k \int e(t)dt$

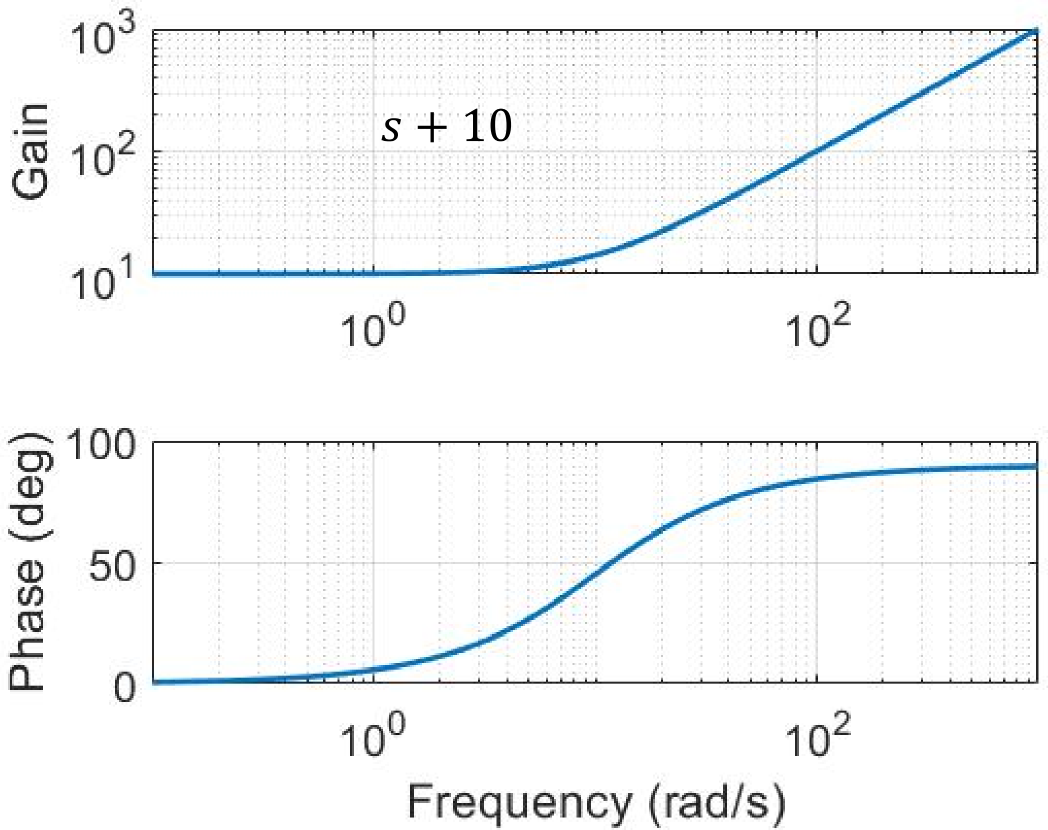




PD

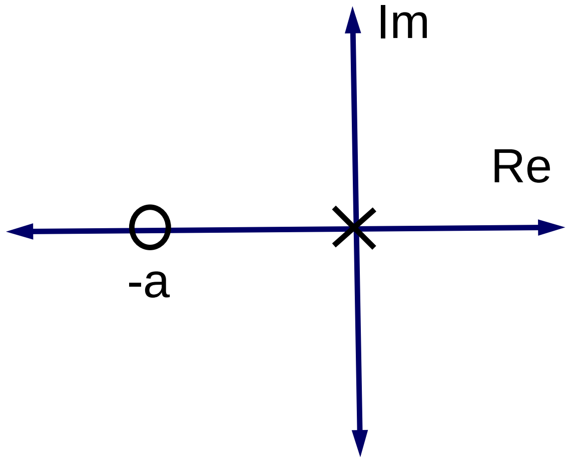
- Adds phase lead (“anticipation”)
  - Adds zero to the system
  - Amplifies high frequencies (i.e. noise)
- $K(s) = k(s + a)$
- $u(t) = ke + ka\dot{e}$

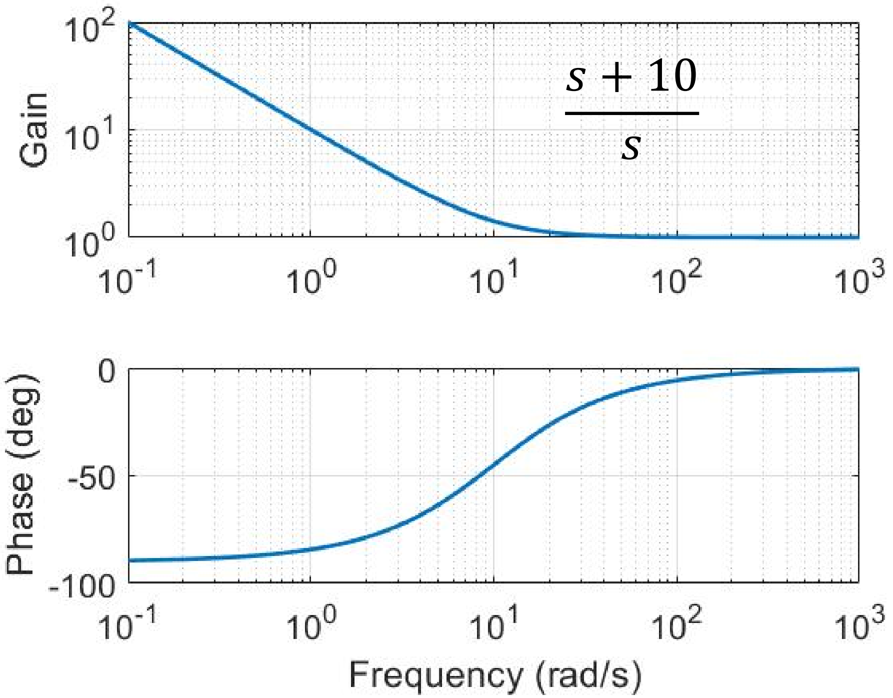




PI

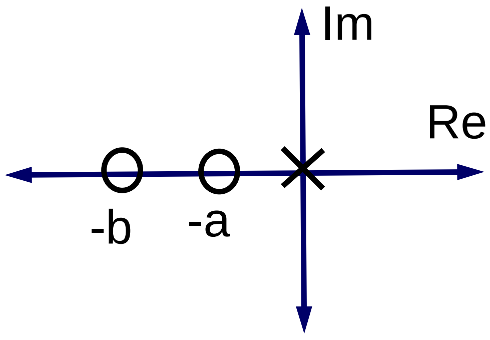
- Adds phase lag (especially at low frequencies)
  - High gain (stiffness) at low frequency ($G_{DC}=\infty$)
  - Adds pole at the origin and zero
- $K(s) = k\frac{s+a}{s}$
- $u(t) = ke + ka\int edt$

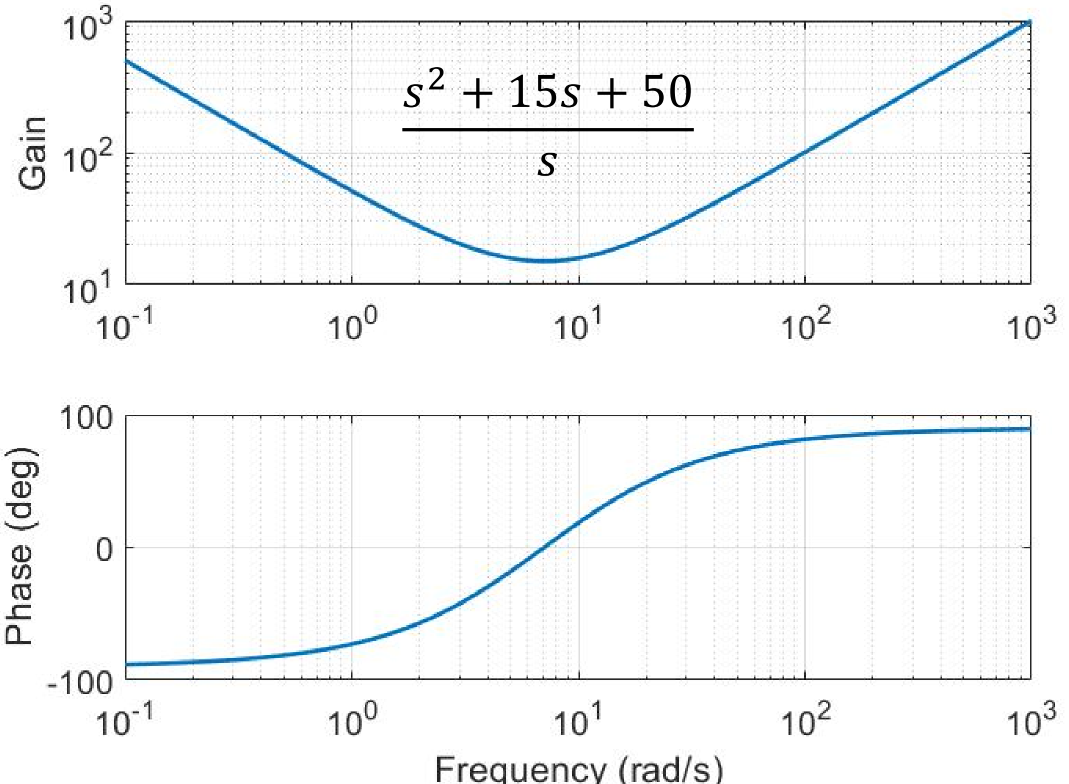




PID

- Adds two zeros (real or complex pair) and one pole at the origin
- $K(s) = k\frac{s^2+as+b}{s}$ $\qquad u(t) = k\dot{e} + kae + kb\int e$





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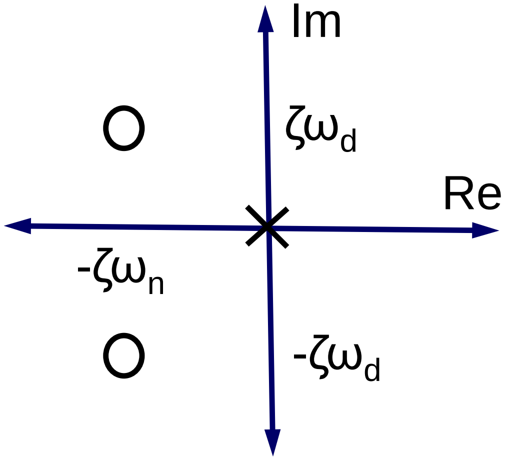
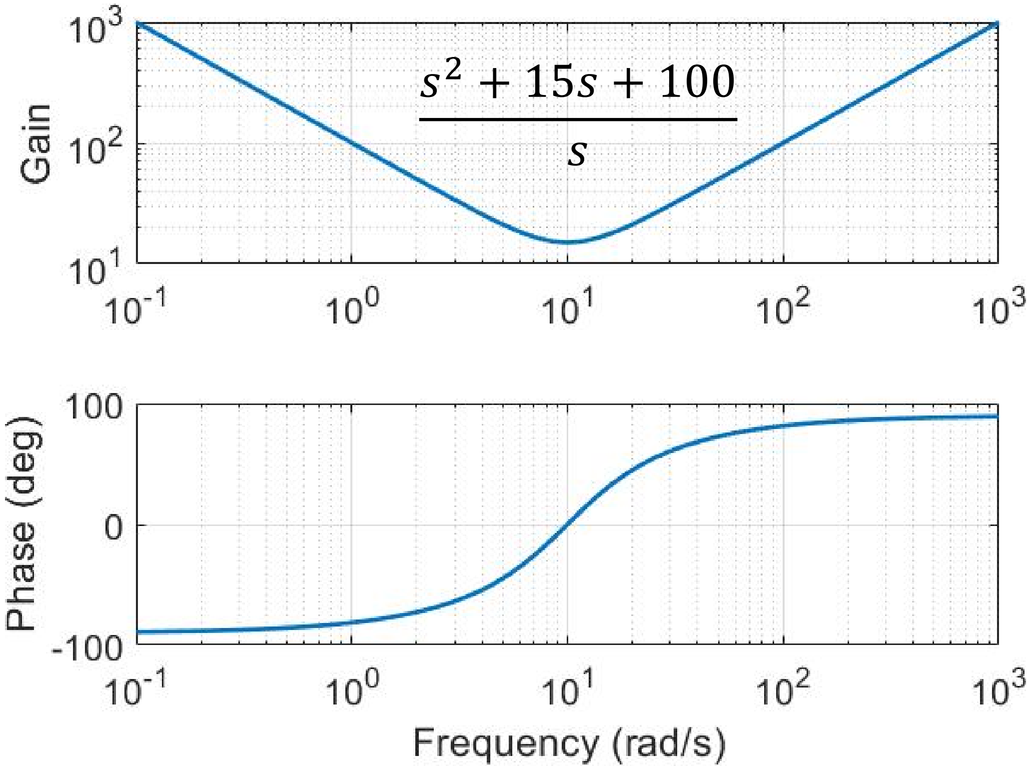
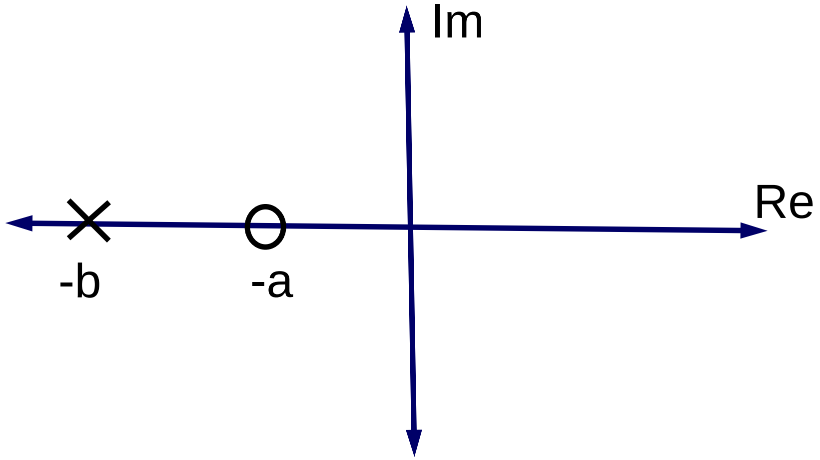
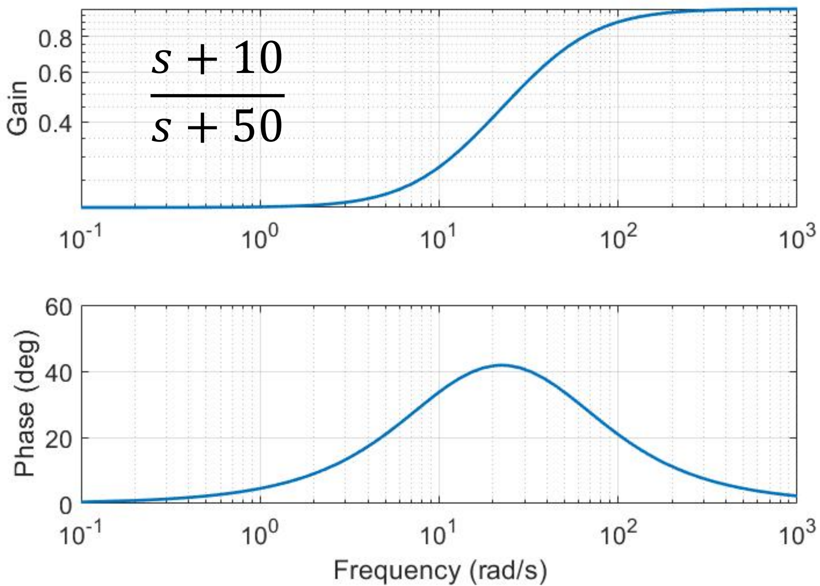




Lead

- $K(s) = k\frac{s+a}{s+b}\ \ |a| < |b|$
- Basically a PD controller with a 1st order low pass filter
  - Adds phase lead and gain at higher frequencies
    - Doesn't increasingly amplify high frequency like PD





Lag

- $K(s) = k\frac{s+a}{s+b}\ |a| > |b|$
- Similar to PI Controller
  - Exactly a PI controller if b=0
  - High gain at low frequencies