Frequency Response Techniques in Feedback Control Systems

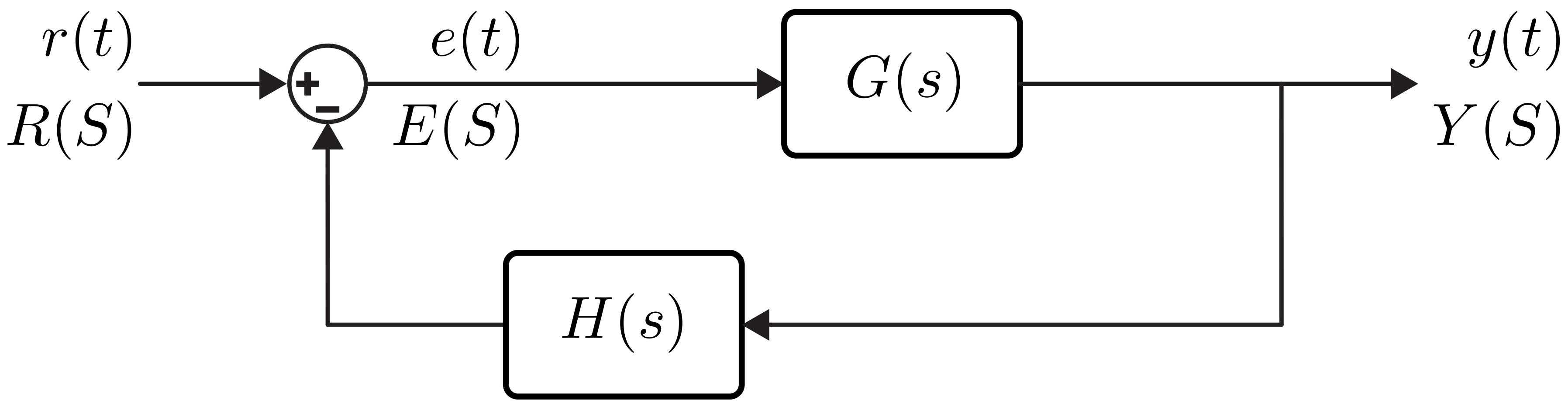
https://github.com/mertankarali/Lecture-Notes/tree/master/METU-EE302/Frequency_Response

Part I - Polar Plot

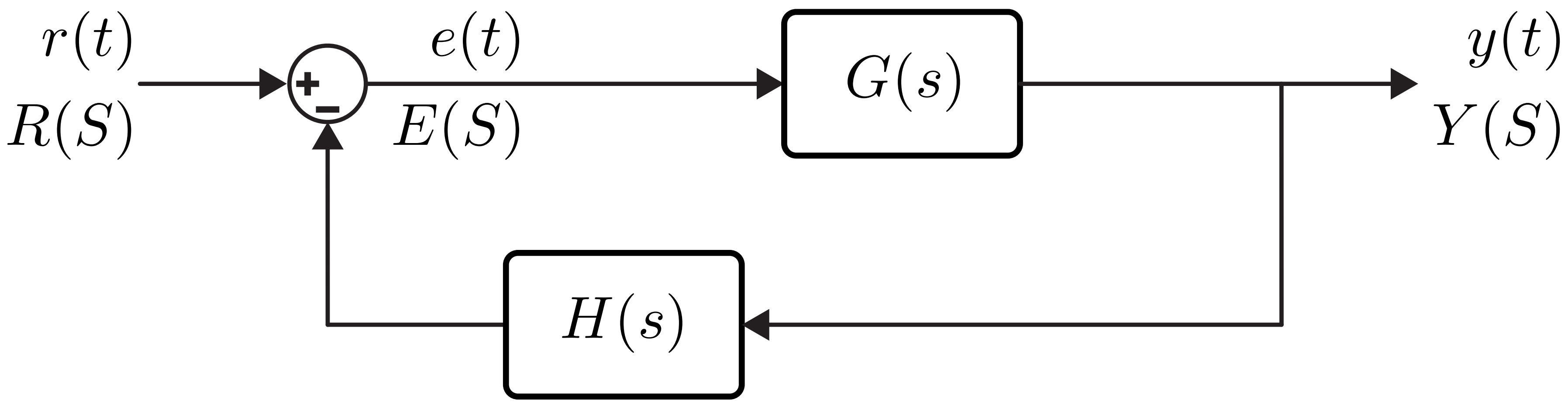
Part II - Nyquist Plot

Part III - Nyquist Stability

Nyquist Stability for Feedback Systems



Nyquist Stability for Feedback Systems



Assumptions

- $G_{OL}(s)$ is a *minimum-phase* system, i.e.
  - No poles/zeros in the Open Right Half Plane
  - $\lim_{\omega \to \infty} [\frac{G_{OL}(s)}{s}]_{s=\jmath\omega} = 0$
- The feed-back system is Type $0 - 2$
- Polar plot of $G_{OL}(j\omega)$ crosses the negative real-axis at most once.

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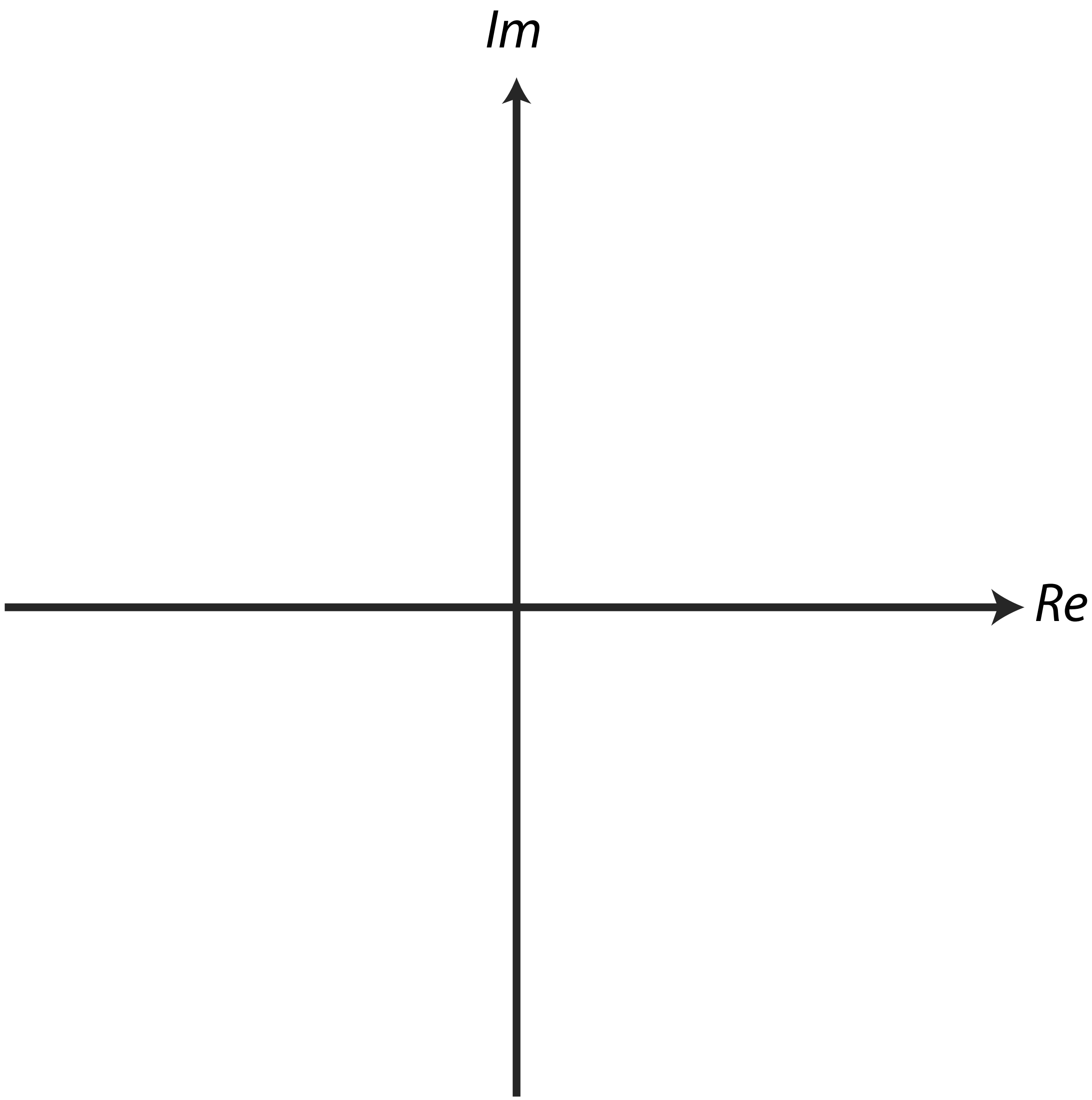
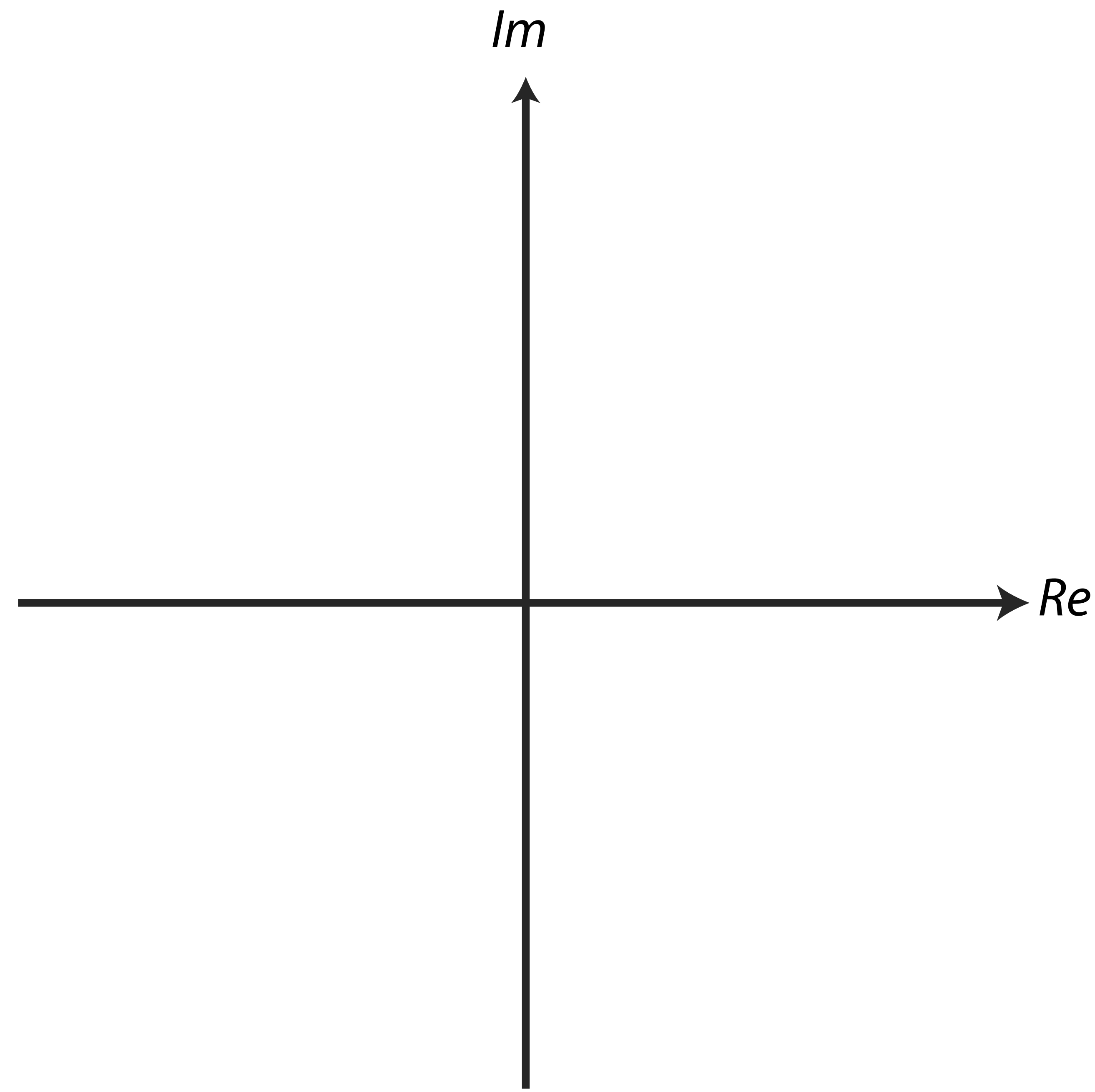
Assumptions $\Rightarrow$ Nyquist Stability

Def: T(s) is BIBO stable, if the Nyquist plot of $G_{OL}(s)$ does not encircle $(\mathbf{-1+0j})$


Im
Re

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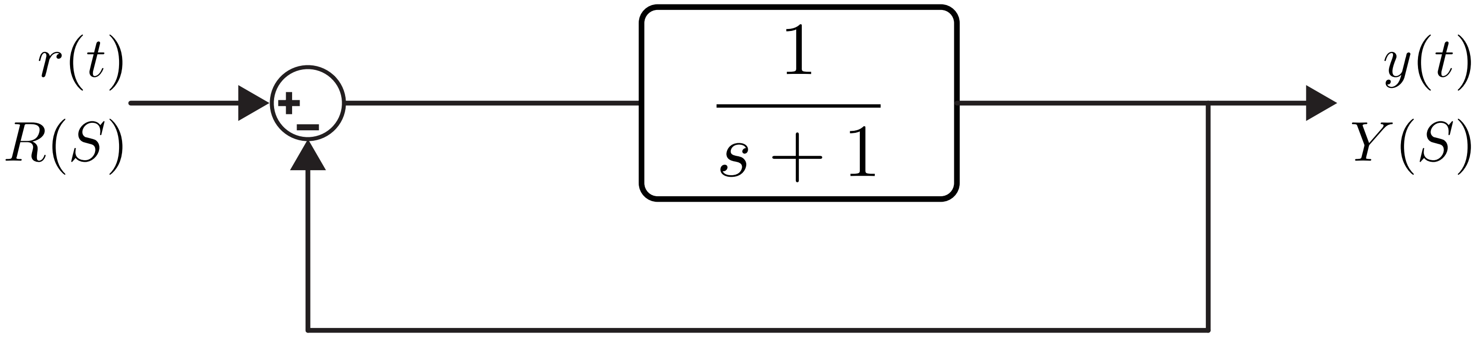
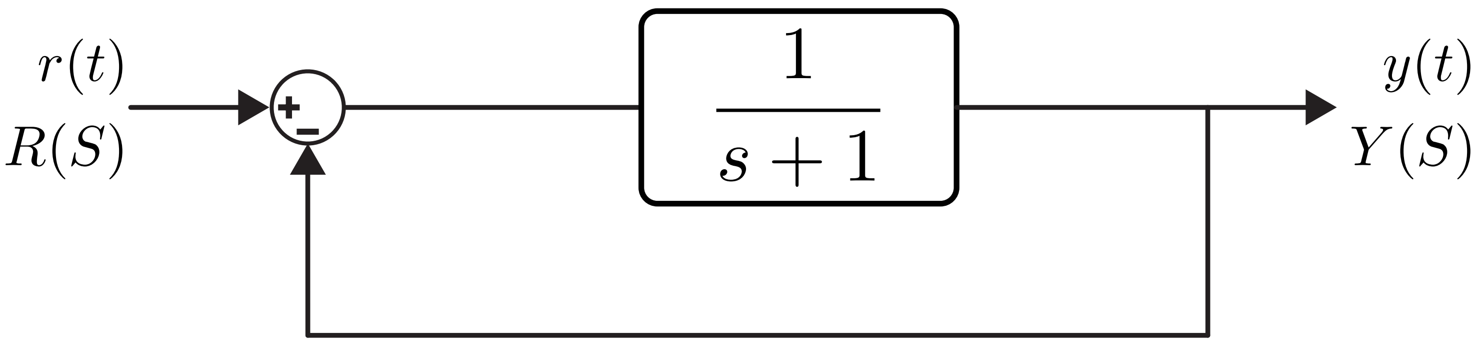
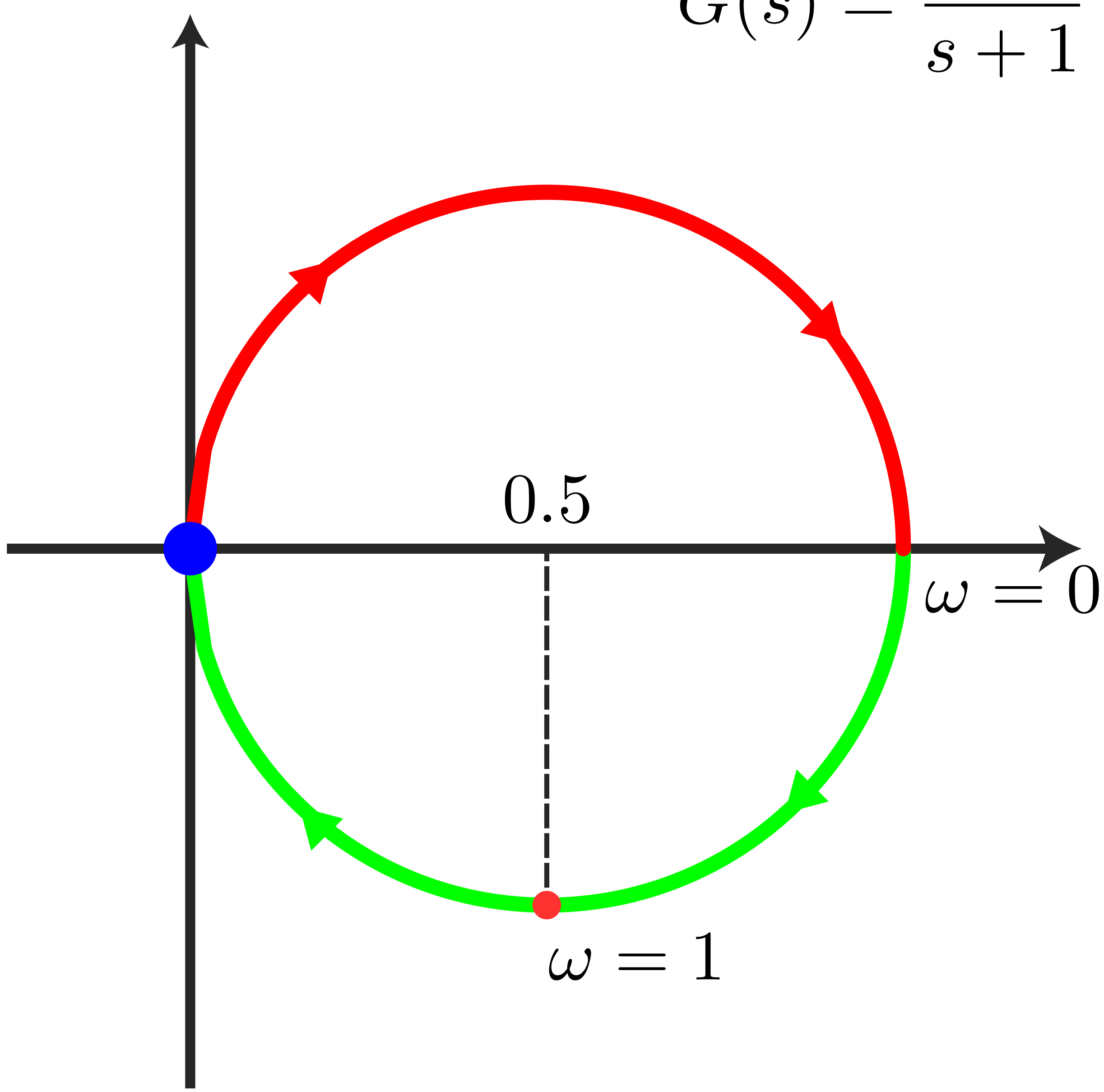
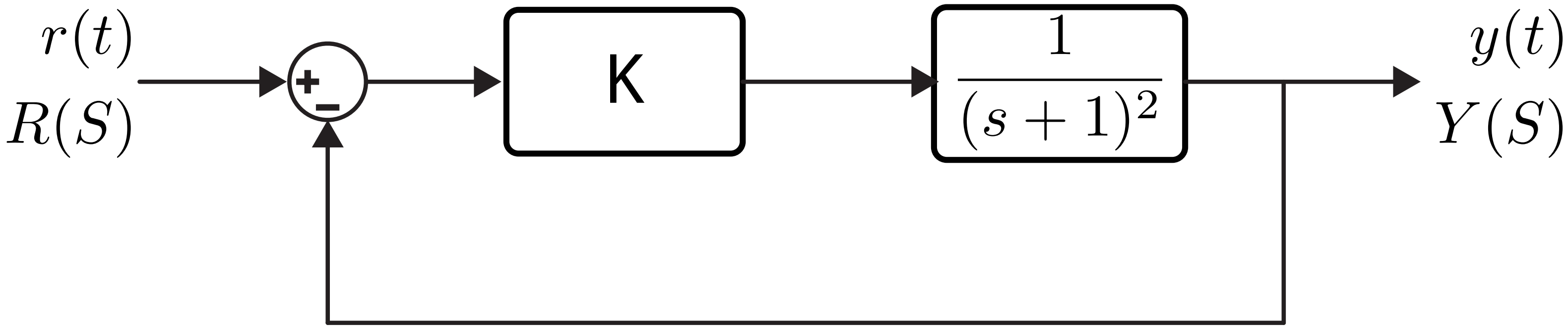
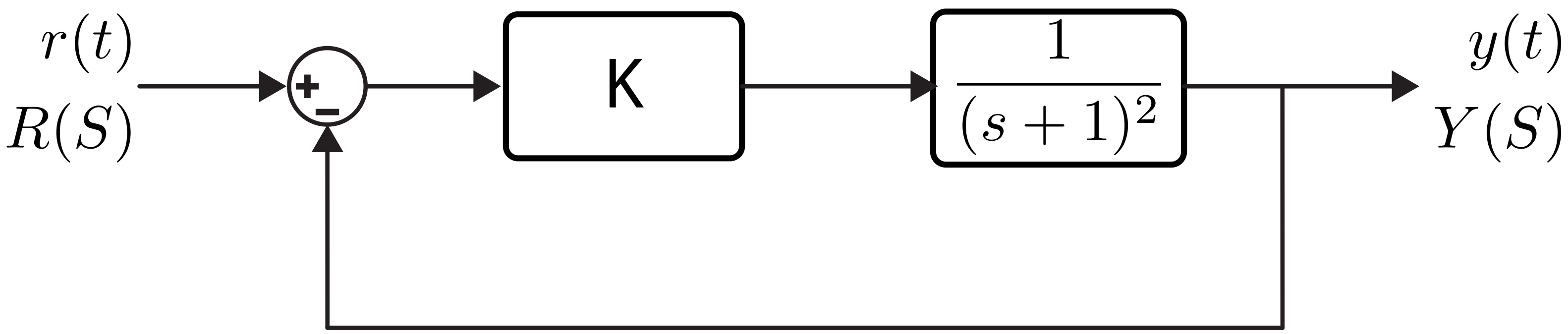

$r(t)$
$R(S)$
$\frac{1}{s+1}$
$y(t)$
$Y(S)$



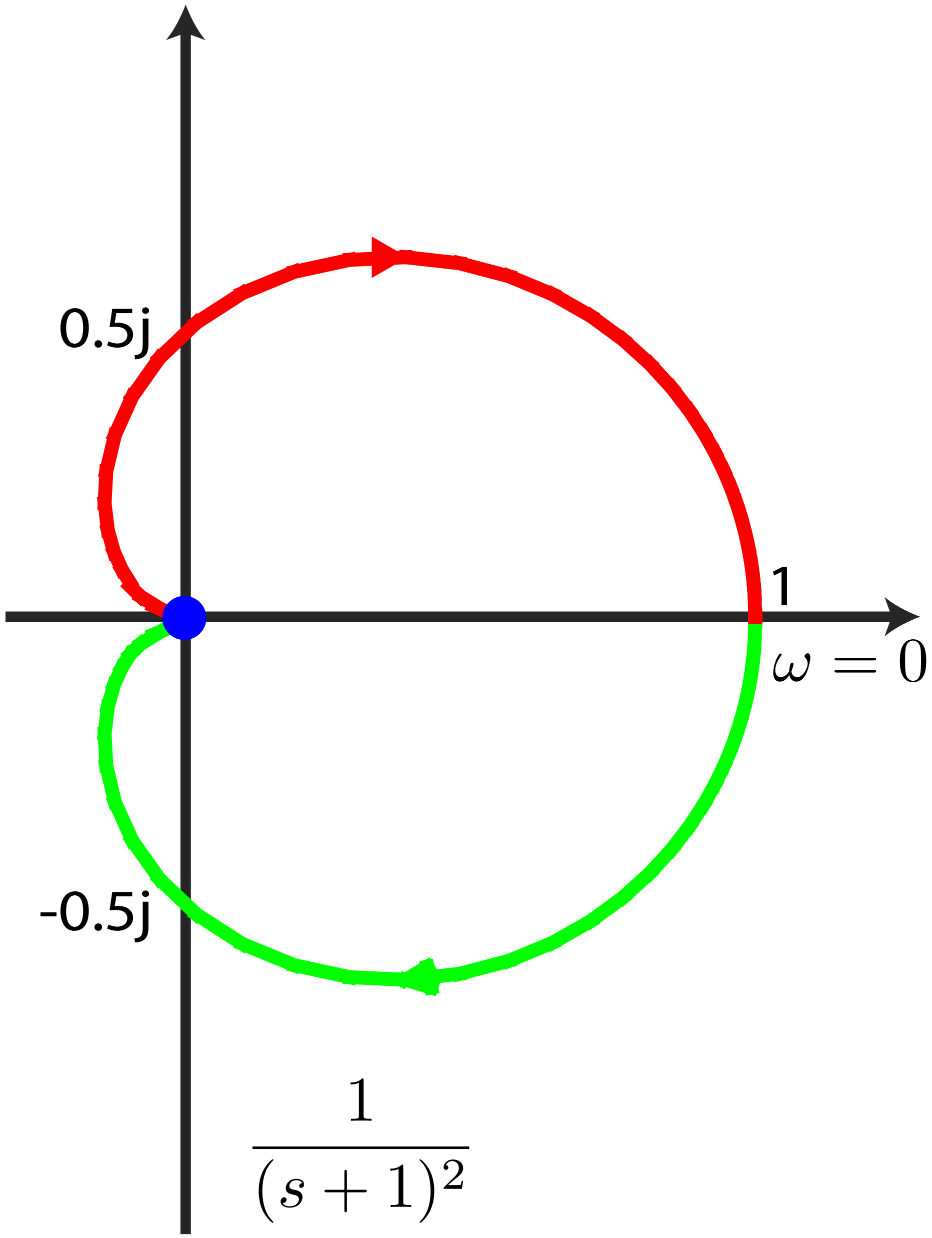
$$G(s) = \frac{1}{s+1}$$



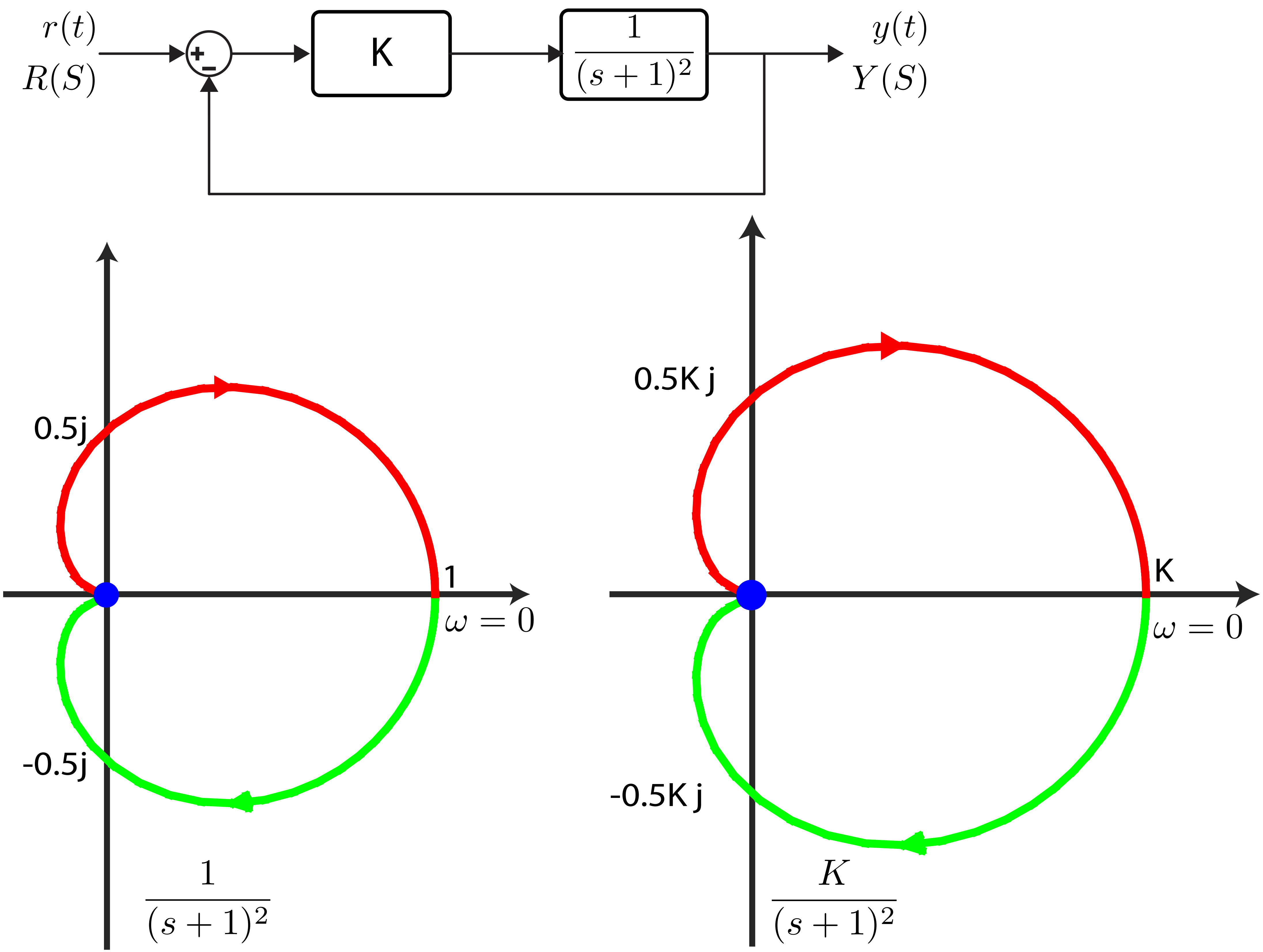

$r(t)$
$R(S)$
+
−
K
$\frac{1}{(s+1)^2}$
$y(t)$
$Y(S)$



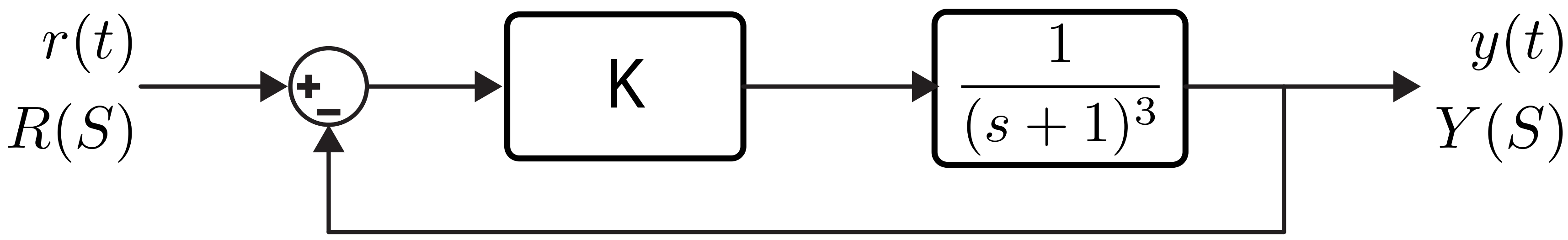
$r(t)$
$R(S)$
K
$\frac{1}{(s+1)^2}$
$y(t)$
$Y(S)$

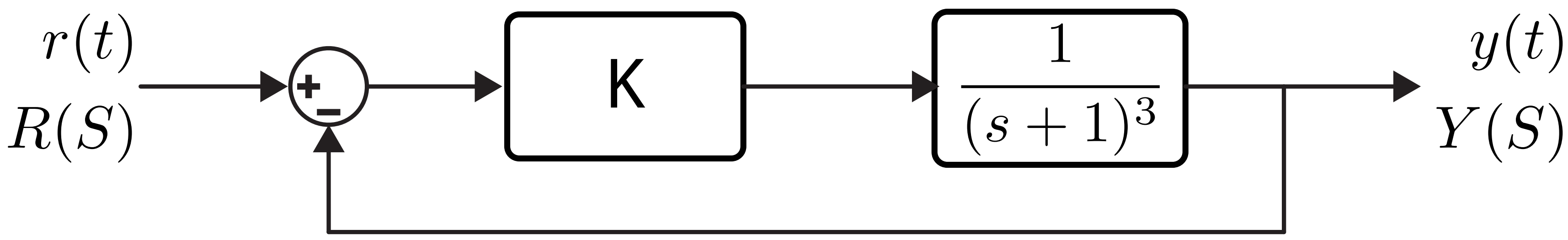


0.5j
-0.5j
1
$\omega = 0$
$\frac{1}{(s+1)^2}$

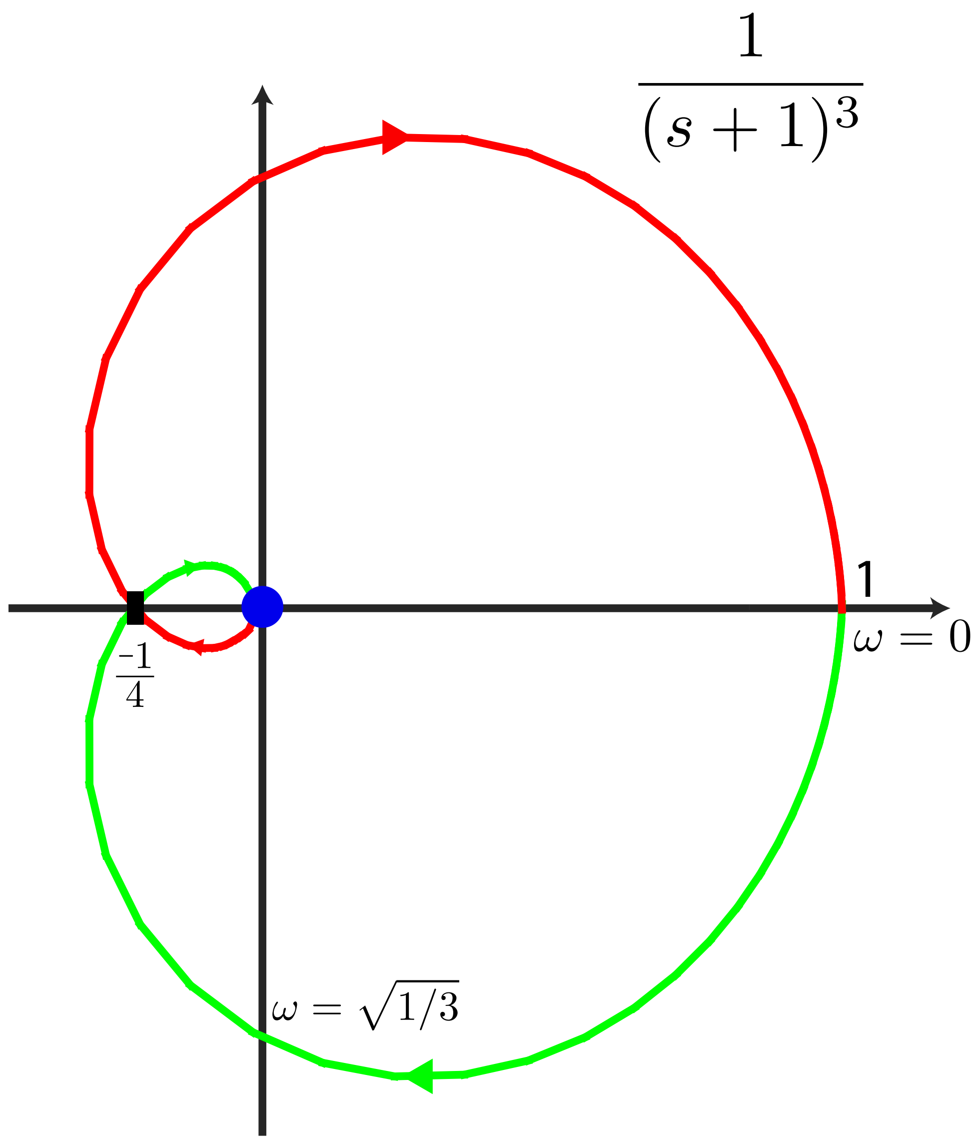


$r(t)$
$R(S)$
K
$\frac{1}{(s+1)^2}$
$y(t)$
$Y(S)$
0.5j
1
$\omega = 0$
-0.5j
$\frac{1}{(s+1)^2}$
0.5K j
K
$\omega = 0$
-0.5K j
$\frac{K}{(s+1)^2}$

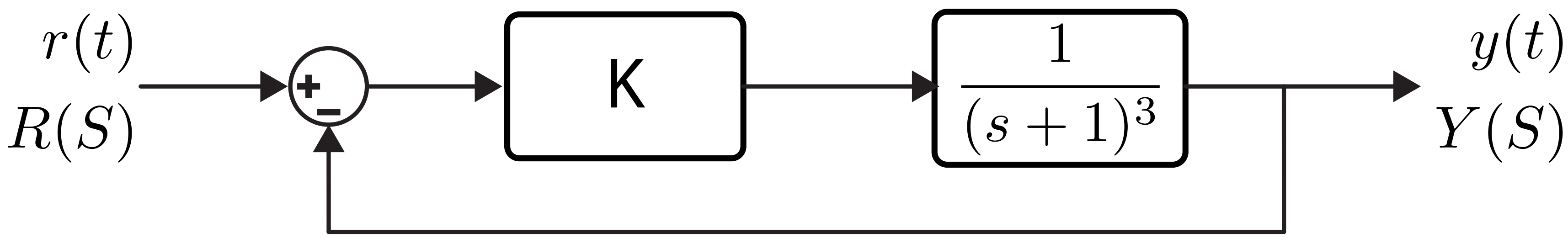

$r(t)$
$R(S)$
K
$\frac{1}{(s+1)^3}$
$y(t)$
$Y(S)$



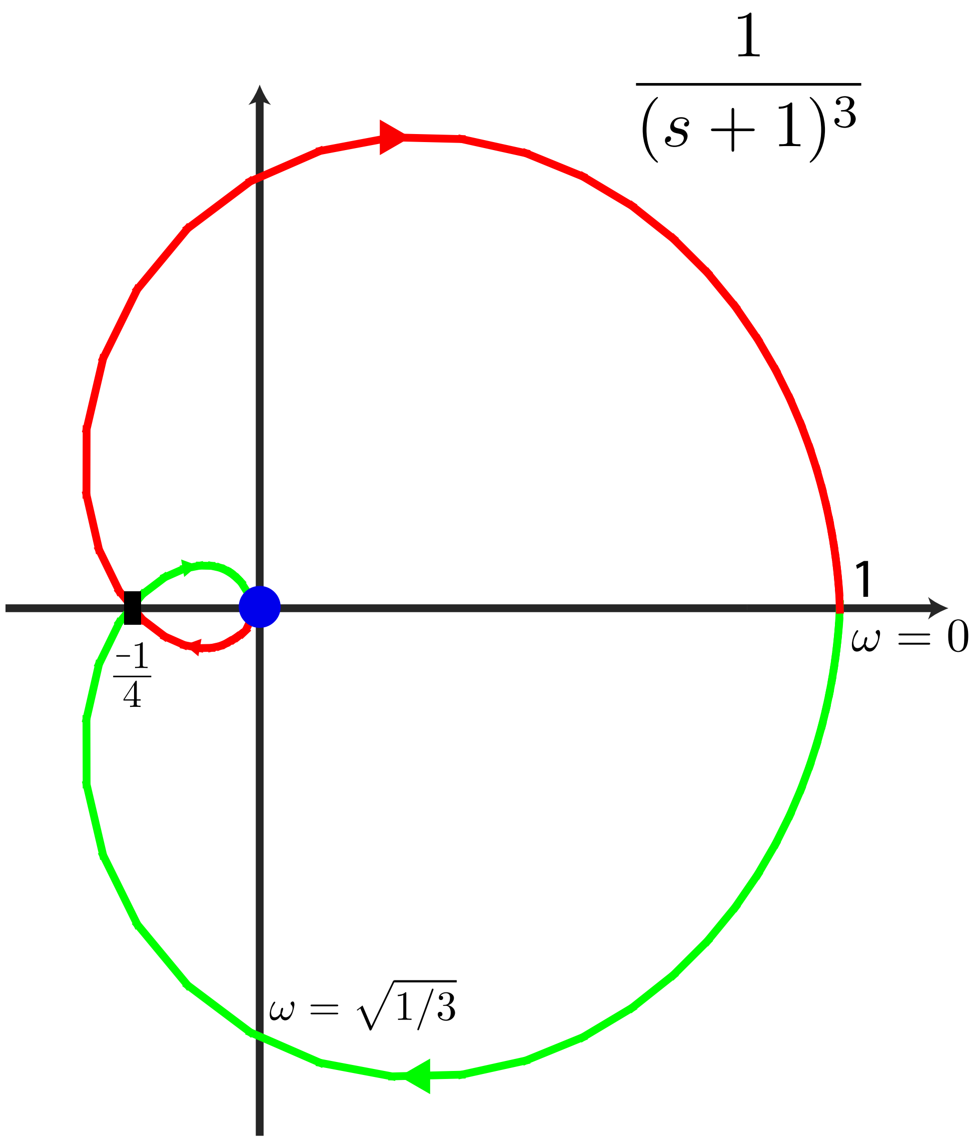
$r(t)$
$R(S)$
K
$\frac{1}{(s+1)^3}$
$y(t)$
$Y(S)$



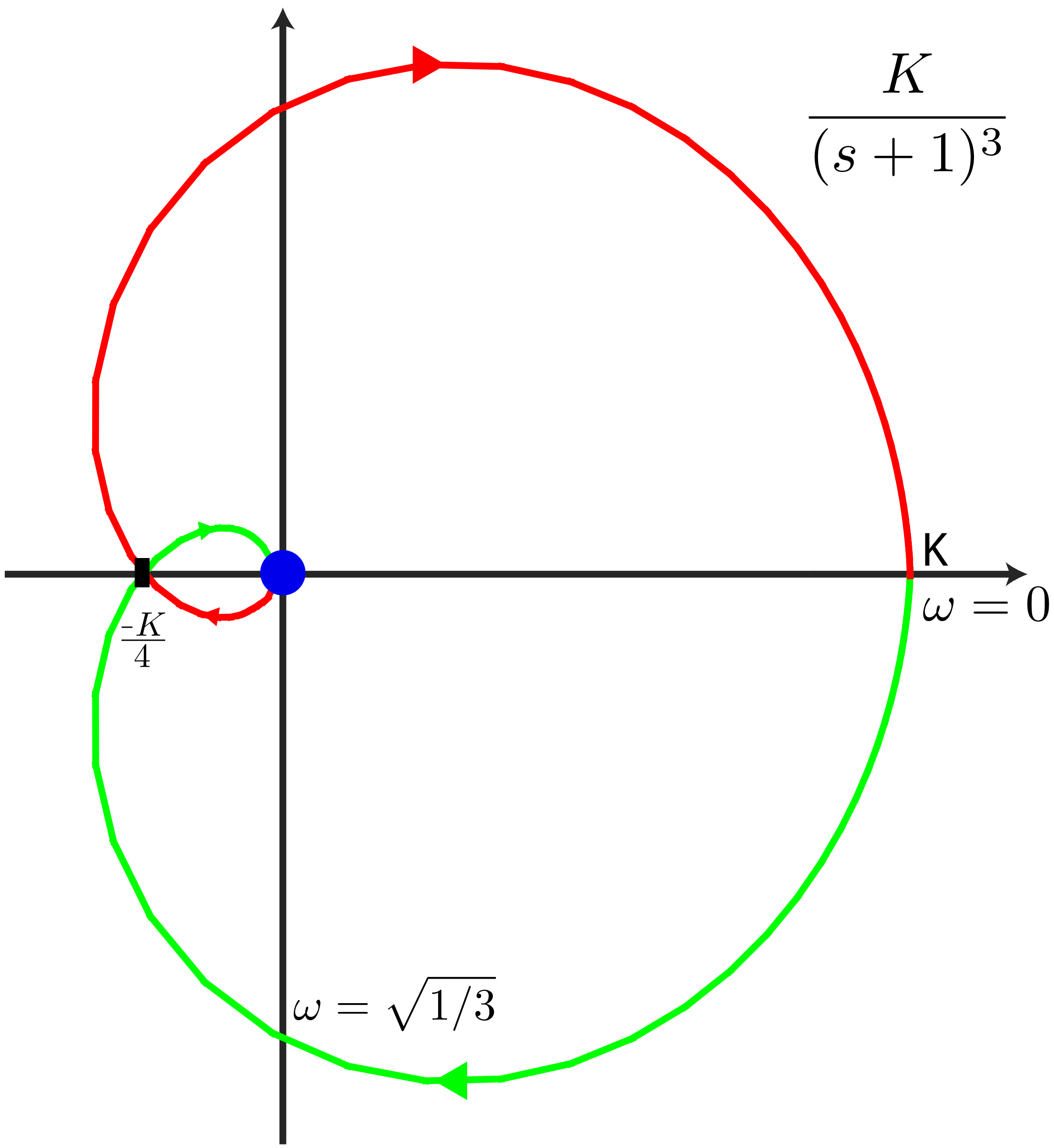
$\frac{1}{(s+1)^3}$
1
$\omega = 0$
$\frac{-1}{4}$
$\omega = \sqrt{1/3}$



$r(t)$
$R(S)$
K
$\frac{1}{(s+1)^3}$
$y(t)$
$Y(S)$



$\frac{1}{(s+1)^3}$
1
$\omega = 0$
$\frac{-1}{4}$
$\omega = \sqrt{1/3}$



$\frac{K}{(s+1)^3}$
K
$\omega = 0$
$\frac{-K}{4}$
$\omega = \sqrt{1/3}$