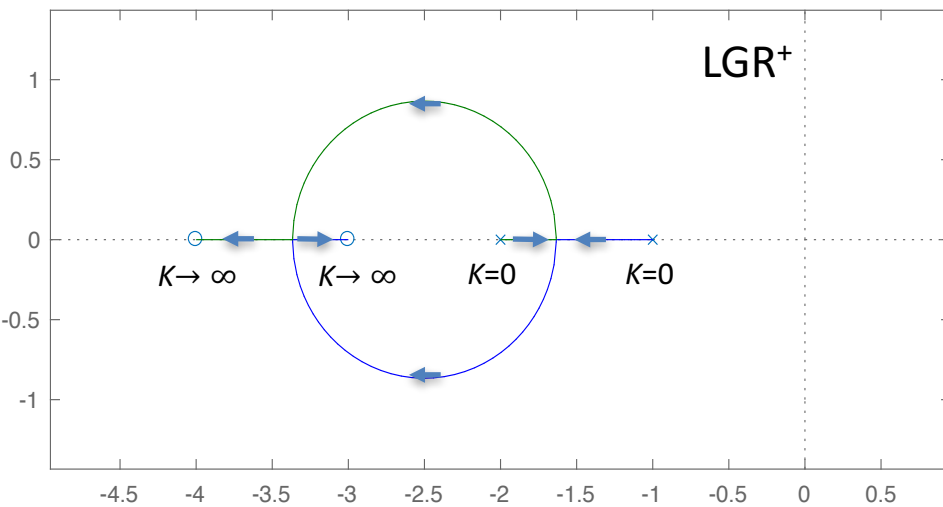


LGR p/ K<0: LGR⁻

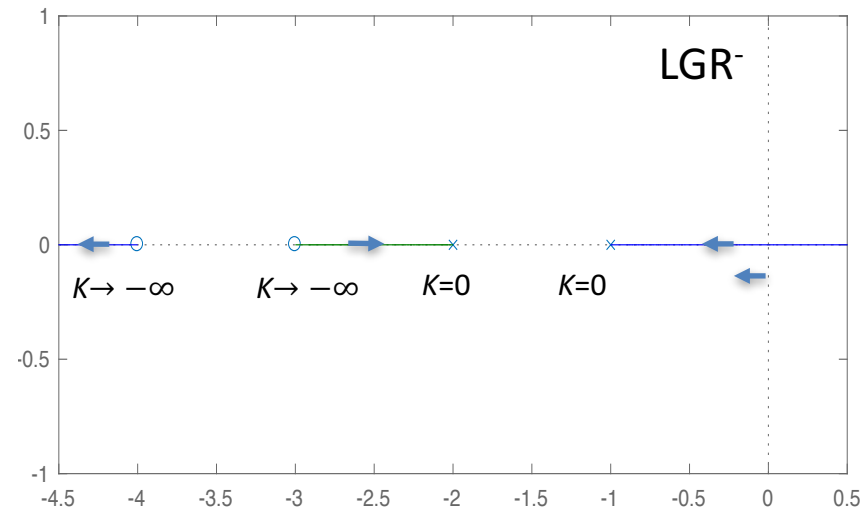
$$1 + KG(s) = 0 \text{ ou } 1 + K \frac{b(s)}{a(s)} = 0 \Rightarrow LGR \begin{cases} |KG(s)| = 1 \\ \angle KG(s) = 180^\circ + 360^\circ l \end{cases}$$

Se $K < 0$ $|K| \angle 180^\circ \Rightarrow$ *Condição de Fase* $|K| \angle G(s) = \underline{\underline{0^\circ + 360^\circ l}}$

Root Locus

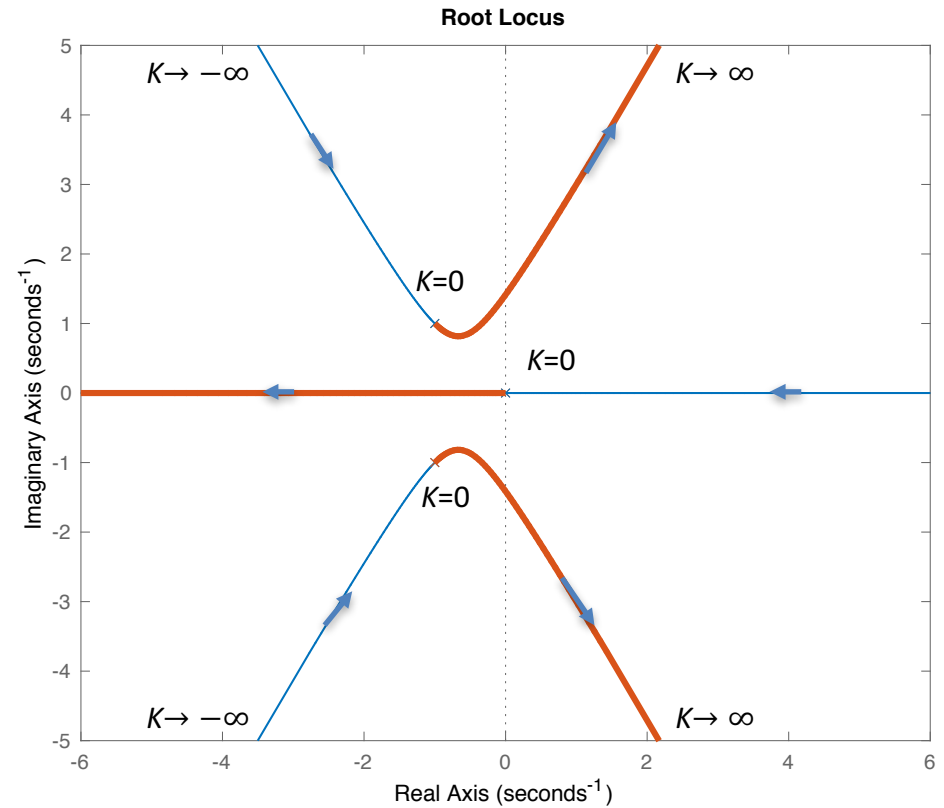
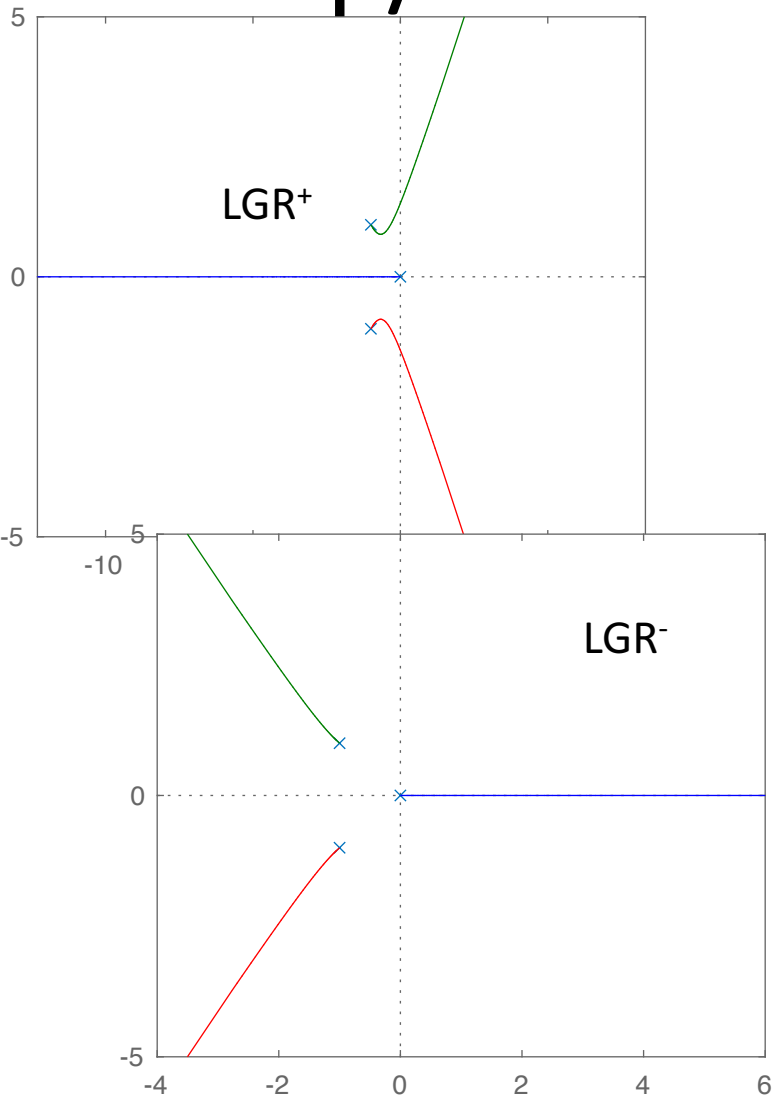


Root Locus



LGR p/ $K < 0$: LGR⁻

Condição de Fase $|K| \angle G(s) = 0^\circ + 360^\circ!$

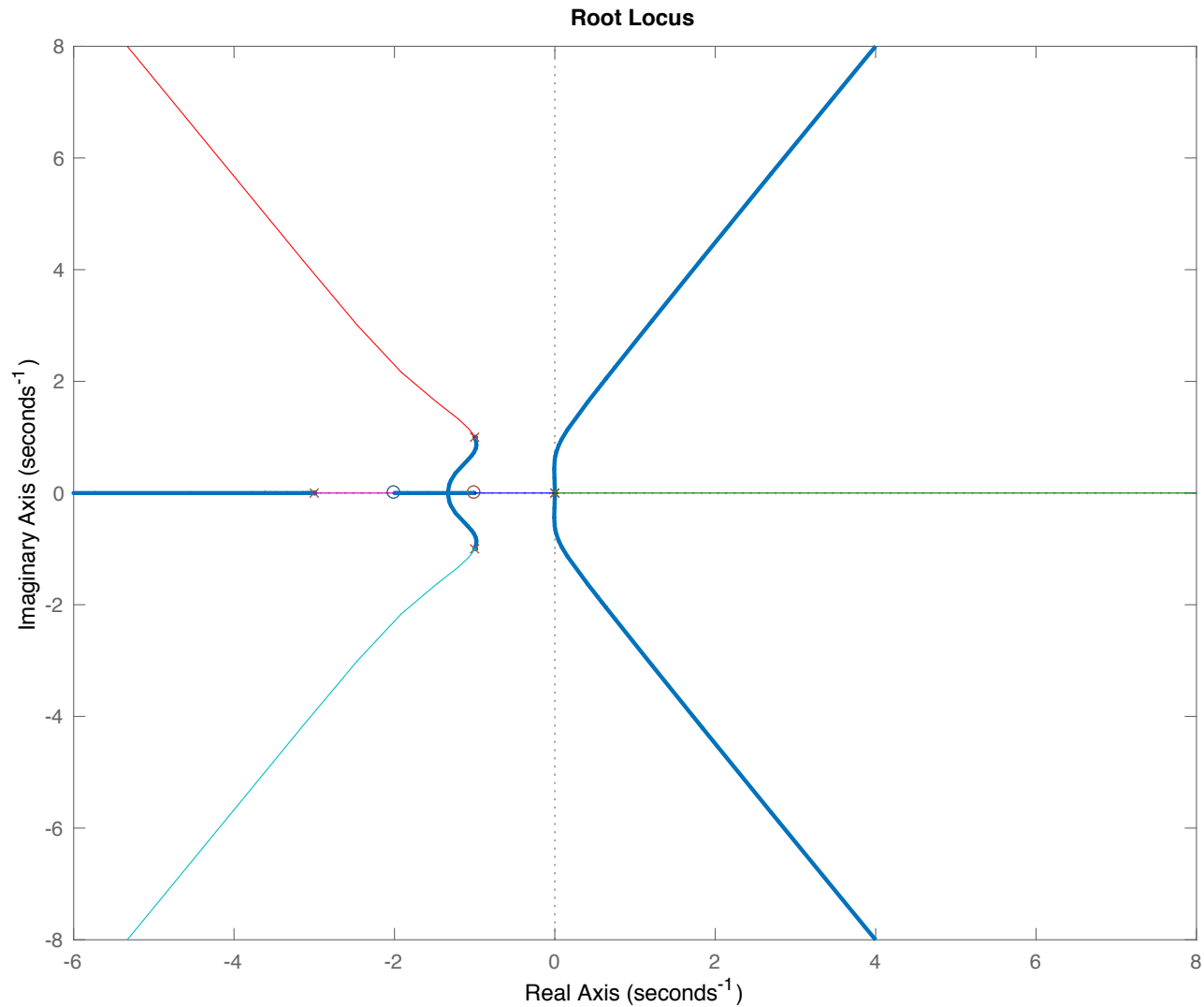


Sentido da seta: K crescente, de $-\infty$ a $+\infty$

LGR p/ K<0: LGR⁻

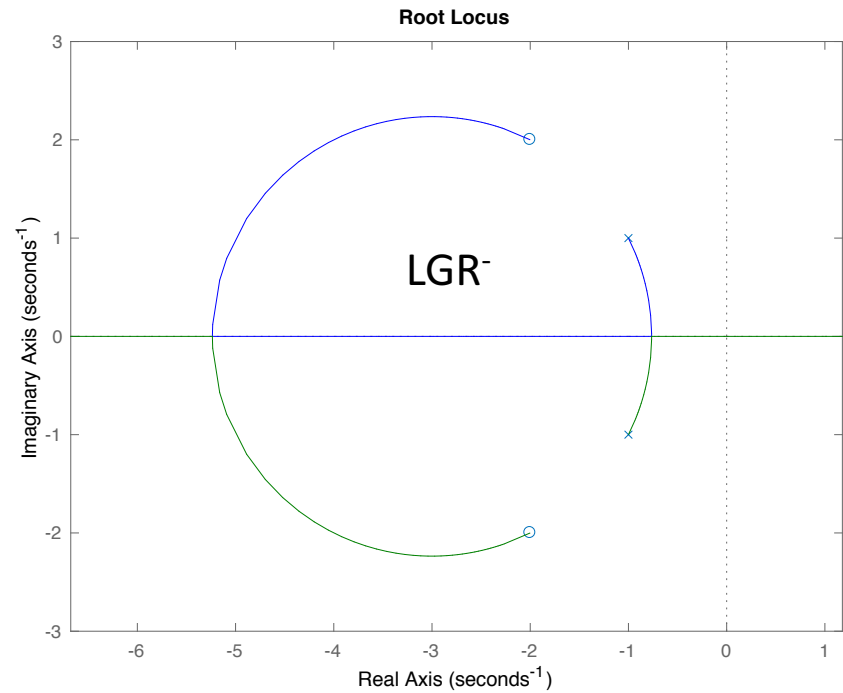
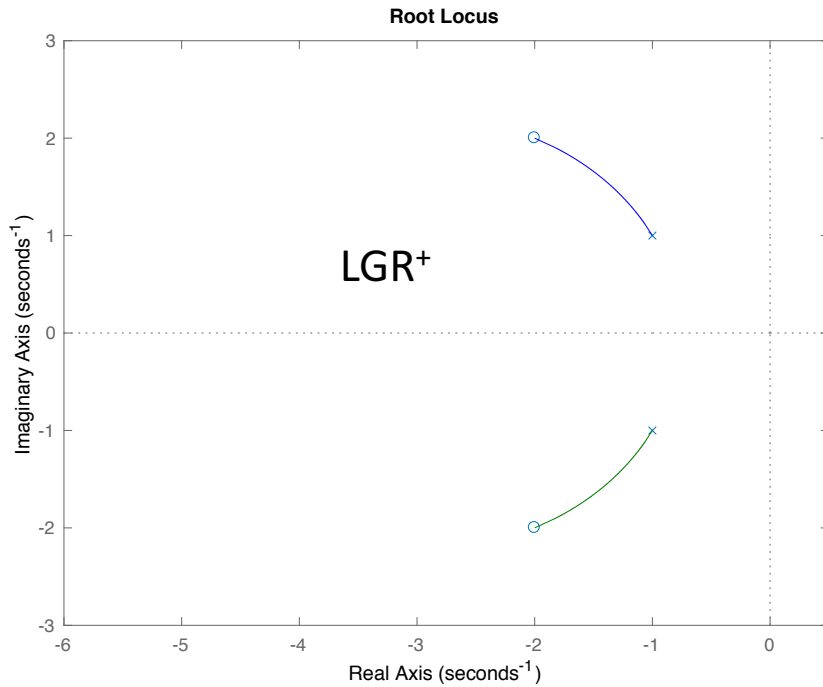
Condição de Fase

$$|K| \angle G(s) = 0^\circ + 360^\circ l$$



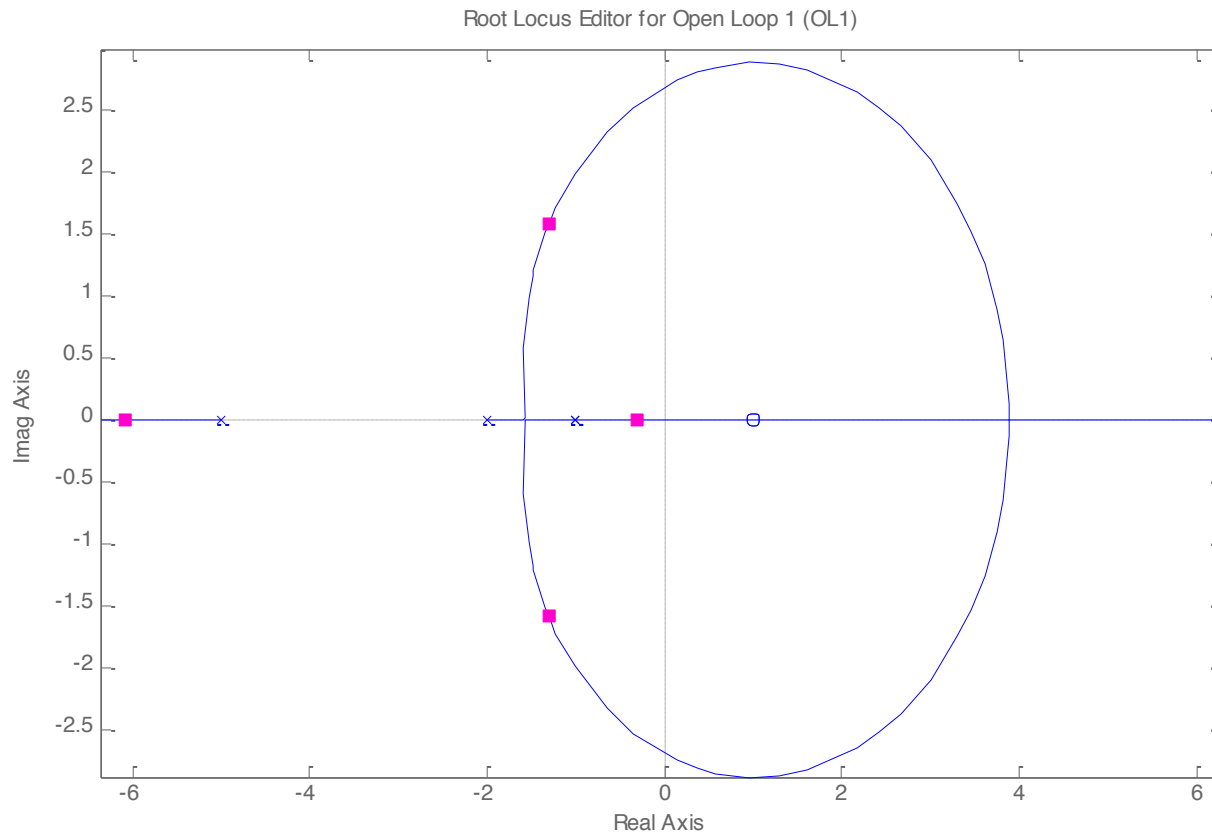
LGR p/ $K < 0$: LGR⁻

Condição de Fase $|K| \angle G(s) = 0^\circ + 360^\circ l$



LGR p/ ganho negativo

```
>> g=zpk([1 1],[-1 -1 -2 -5],1);  
>> rlocus(-g)
```



LGR p/ Sistemas de Fase não-mínima

- Pólo ou zero no SPD

$$\text{Ex. } G(s) = \frac{K(1 - T_a s)}{s(Ts + 1)}$$

$$\angle G(s) = \angle \frac{-K(T_a s - 1)}{s(Ts + 1)} = \angle \frac{K(T_a s - 1)}{s(Ts + 1)} + 180^\circ$$

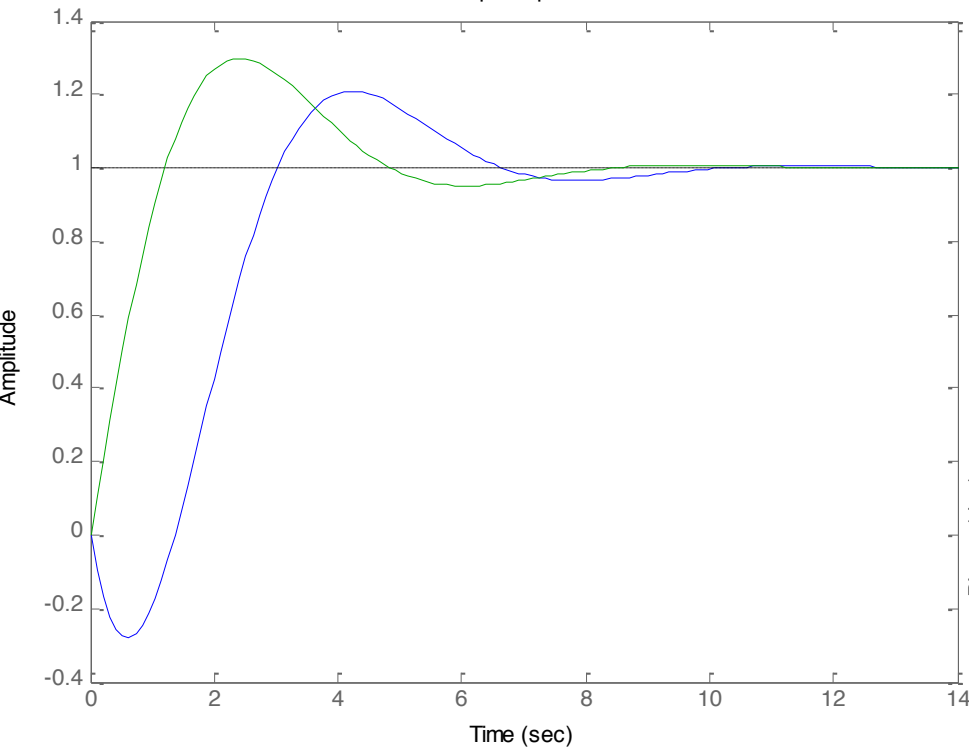
$$\text{Condição LGR Fase: } \angle G(s) = 0^\circ + 360^\circ l$$

Ex. Sistema de Fase não-mínima x Fase mínima

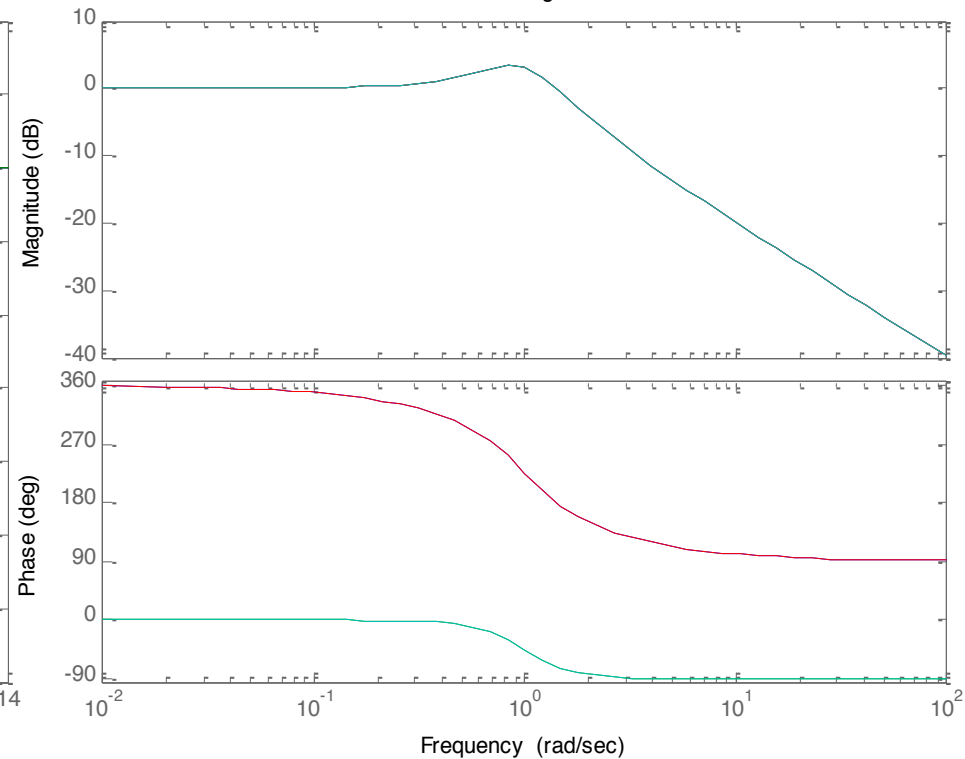
$$G(s) = \frac{1-s}{s^2 + s + 1}$$

$$F(s) = \frac{s+1}{s^2 + s + 1}$$

Step Response



Bode Diagram



```
g=tf([-1 1],[1 1 1]);f=tf([1 1],[1 1 1]);step(g,f)
```

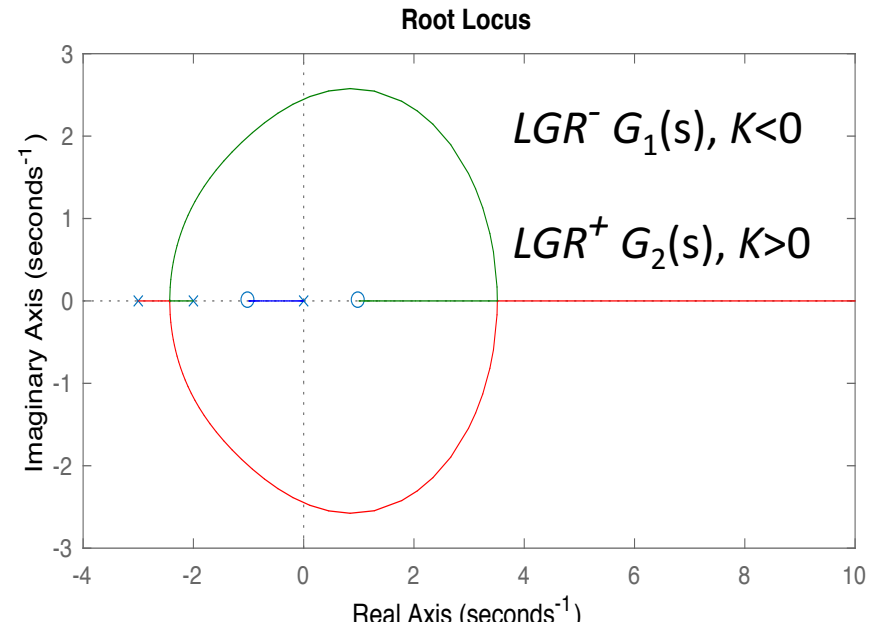
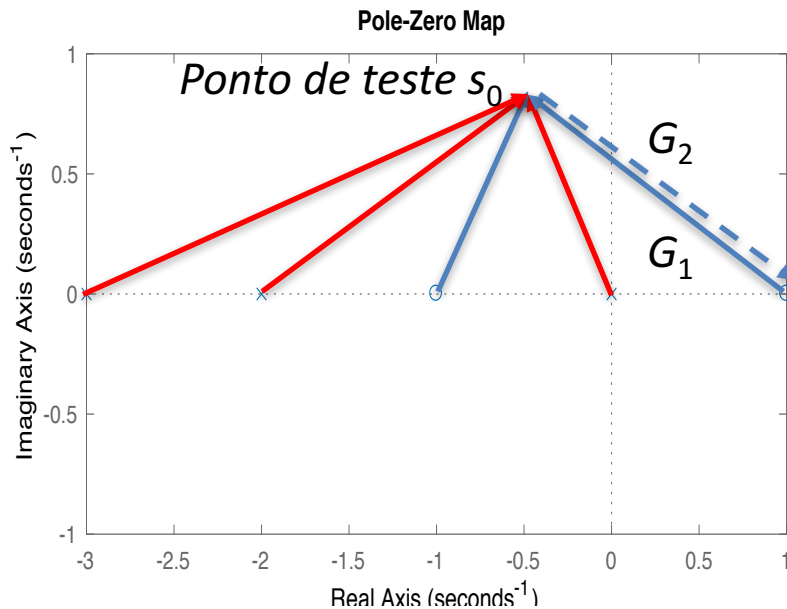
Condições de Fase: 180° x 0°

$$G_1(s) = \frac{K(s+1)(s-1)}{s(s+2)(s+3)} \quad K > 0 \rightarrow LGR \ 180^\circ \quad (\text{Fase não-mínima})$$

$$G_2(s) = \frac{K(s+1)(1-s)}{s(s+2)(s+3)} \quad K > 0 \rightarrow LGR \ 0^\circ \quad (\text{Fase não-mínima})$$

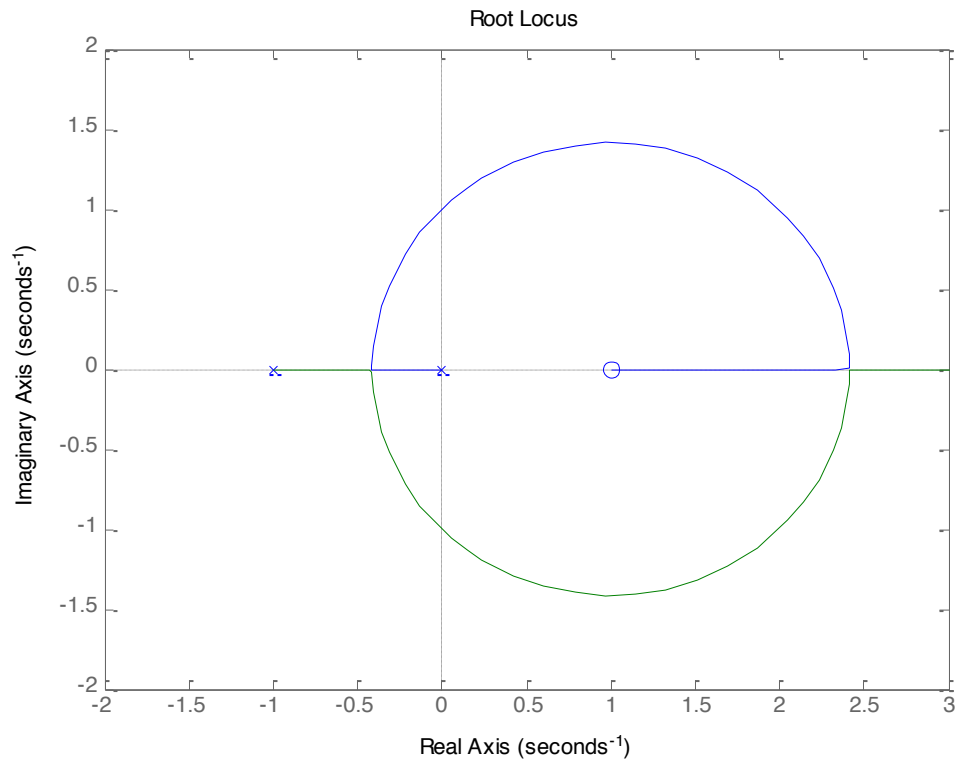
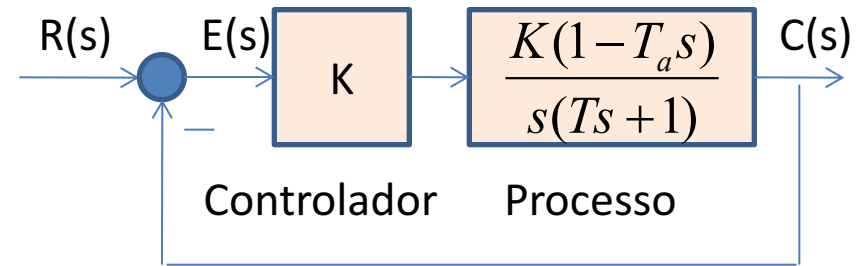
$$G_3(s) = \frac{K(1-s)(1-s)}{s(s+2)(s+3)} \quad K > 0 \rightarrow LGR \ 180^\circ \quad (\text{Fase não-mínima})$$

$$G_4(s) = \frac{K(1-s)(1-s)}{s(s+2)(3-s)} \quad K > 0 \rightarrow LGR \ 0^\circ \quad (\text{Fase não-mínima})$$

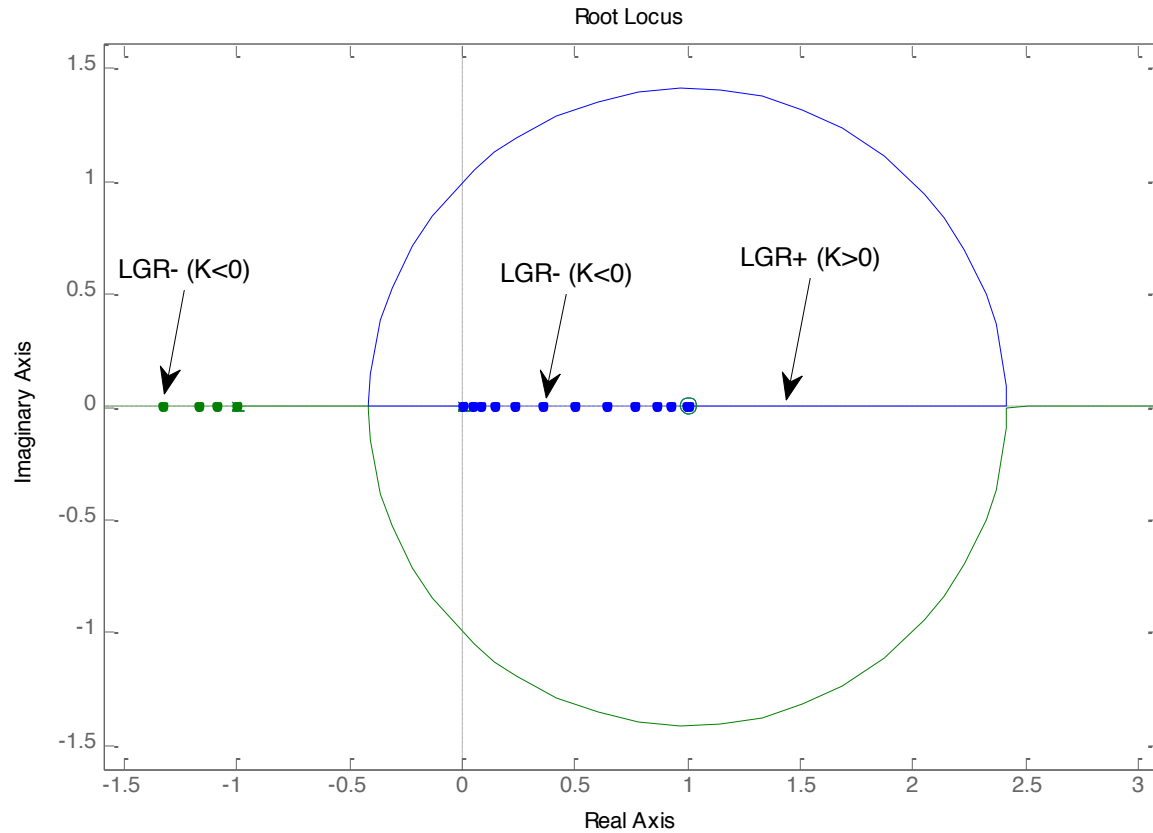
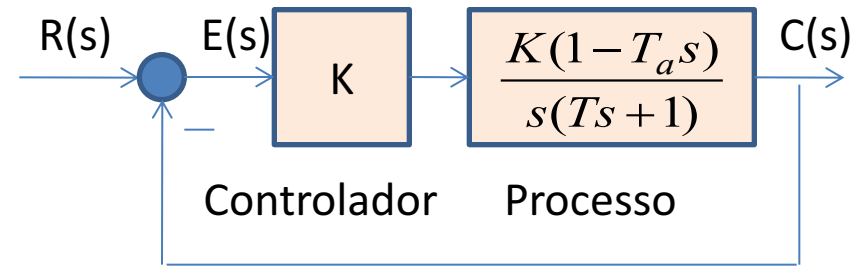


LGR⁺ (K>0)

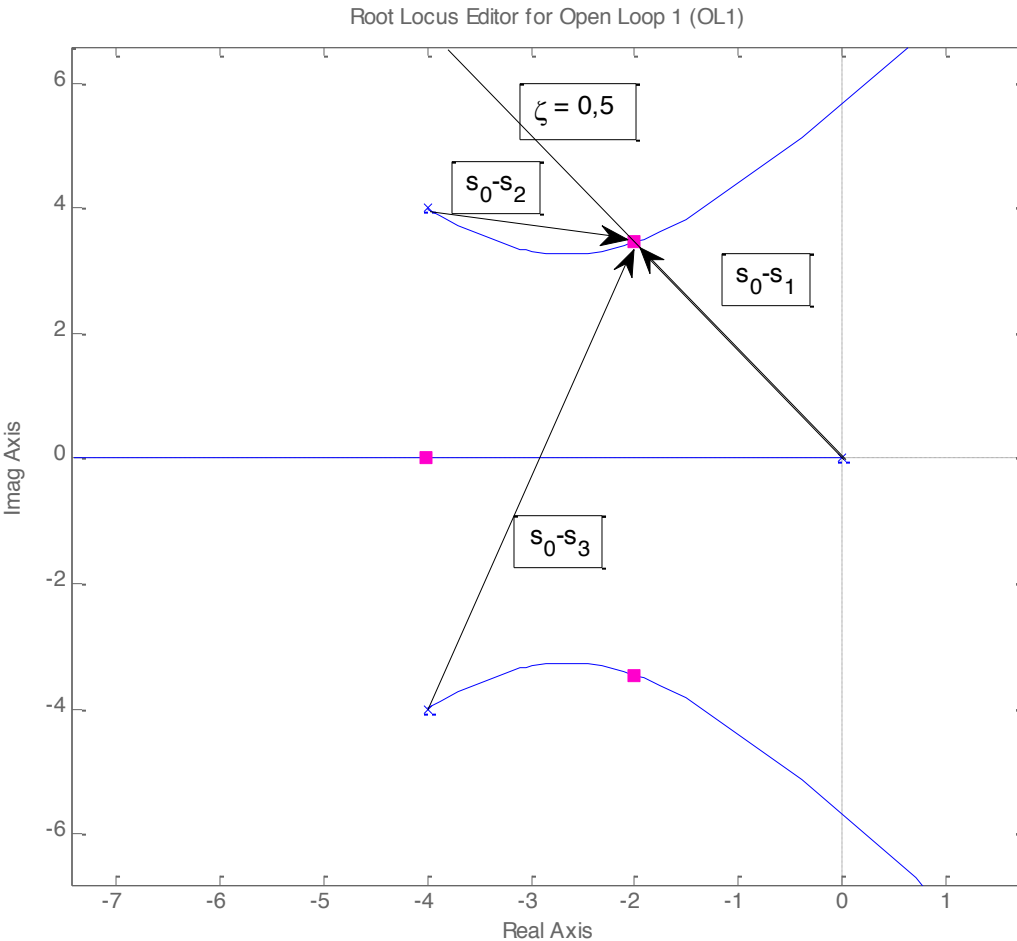
Condição de Fase: Zero-Grau



LGR⁻ (K < 0)



Seleção do ganho a partir do LGR

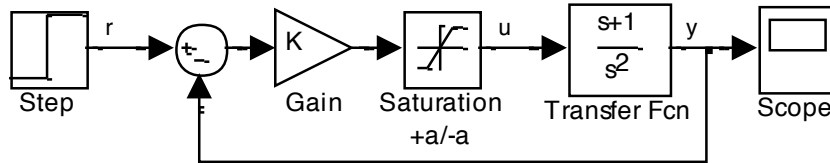


$$G(s) = \frac{1}{s[(s+4)^2 + 16]}$$

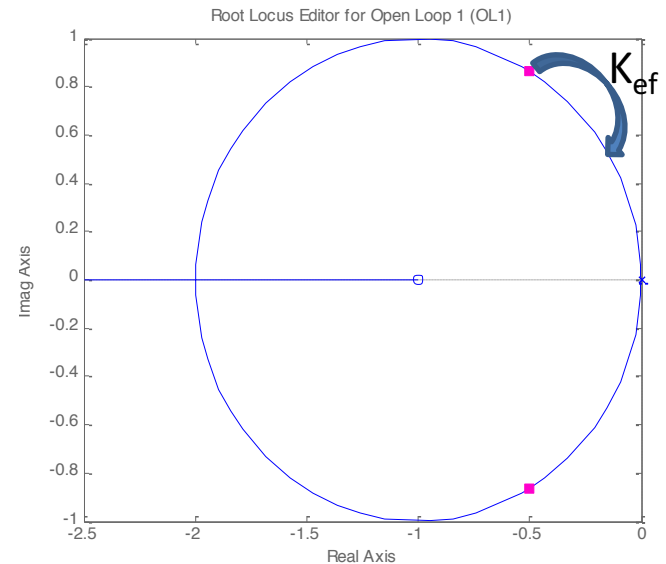
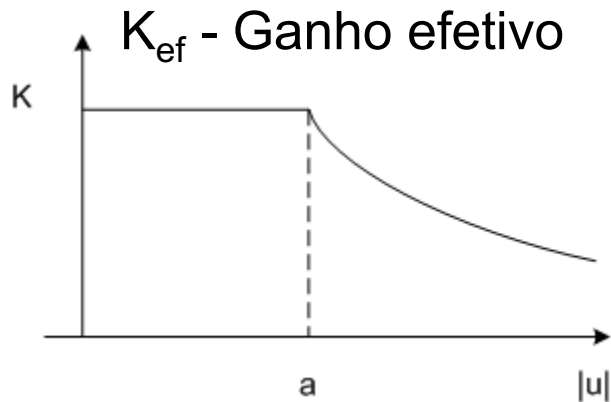
$$K = \frac{1}{|G(s)|} = |s_0 - s_1| |s_0 - s_2| |s_0 - s_3|$$

$$K = 4.0 * 2.1 * 7.7 = 65$$

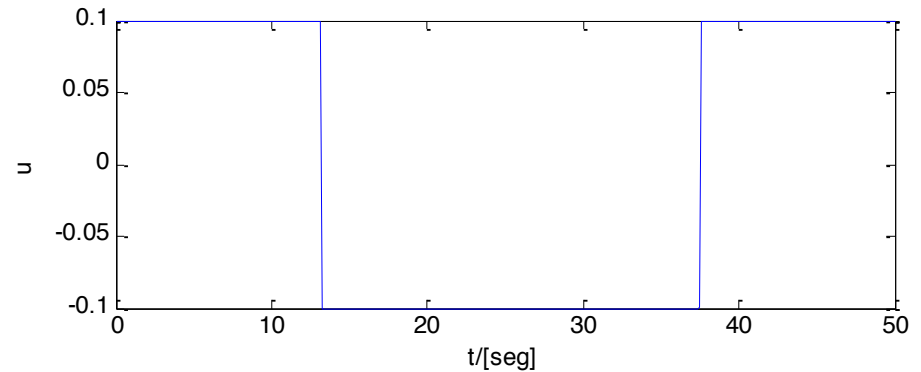
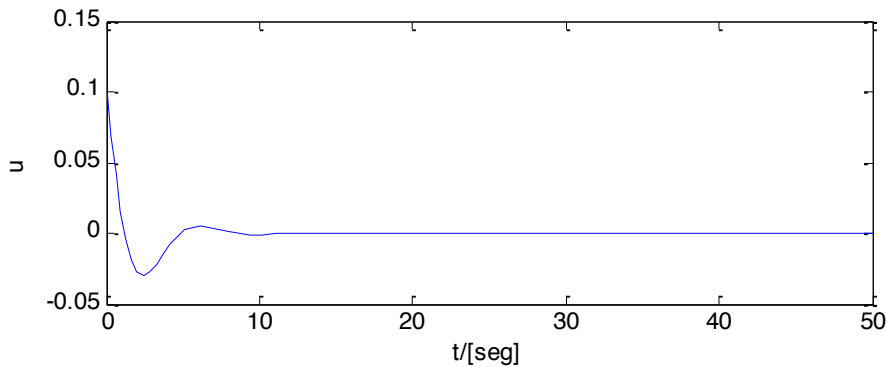
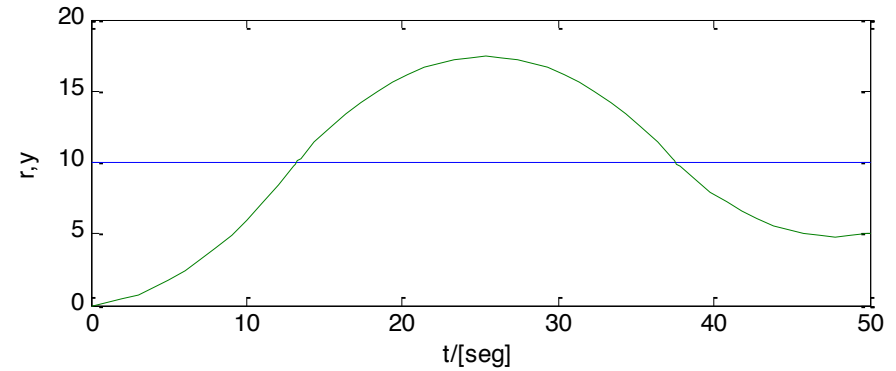
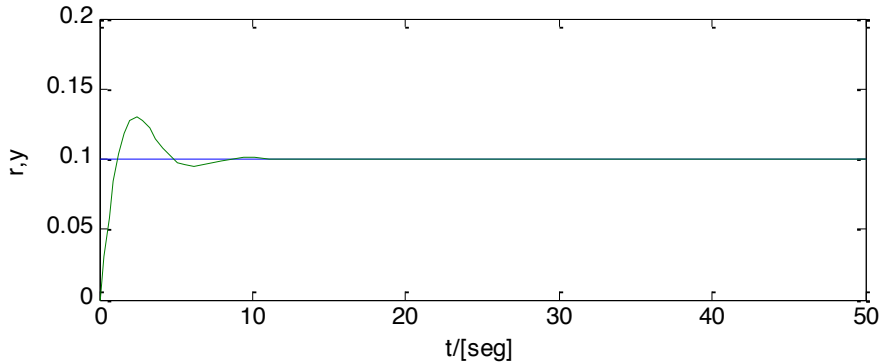
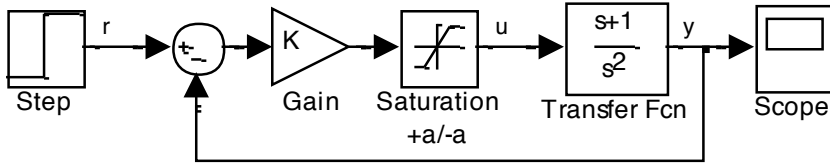
LGR de Sistemas com Saturação



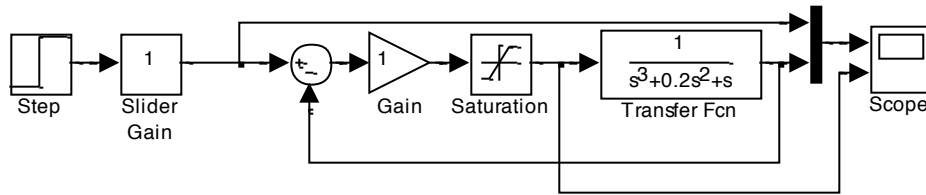
$r \uparrow \rightarrow K_{ef} \downarrow \rightarrow K_{ef} \downarrow \rightarrow M_p \uparrow$



LGR de Sistemas com Saturação



LGR de Sistemas com Saturação



“Ciclo Limite”

