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21 – Mapeamento entre os planos s e z

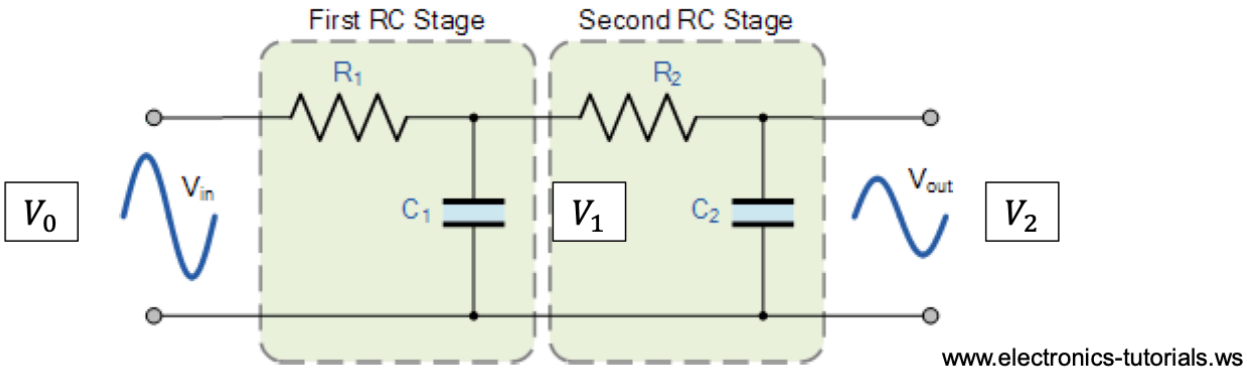
Ex. 21.1)

Considere um filtro RC passivo de dois estágios:

• Estágio1: $R1$ =100 Ω, $C1$ = 0.1 F;

• Estágio2: $R2$ =2000 Ω, $C2$ = 0.1 F;

Plote o diagrama do lugar das raízes e a reposta em malha fechada do filtro RC com 1 ou 2 estágios nas formas contínua e discreta (ZOH, 1 s). Avalie a estabilidade do sistema.



Filtro RC – 1 estágio:

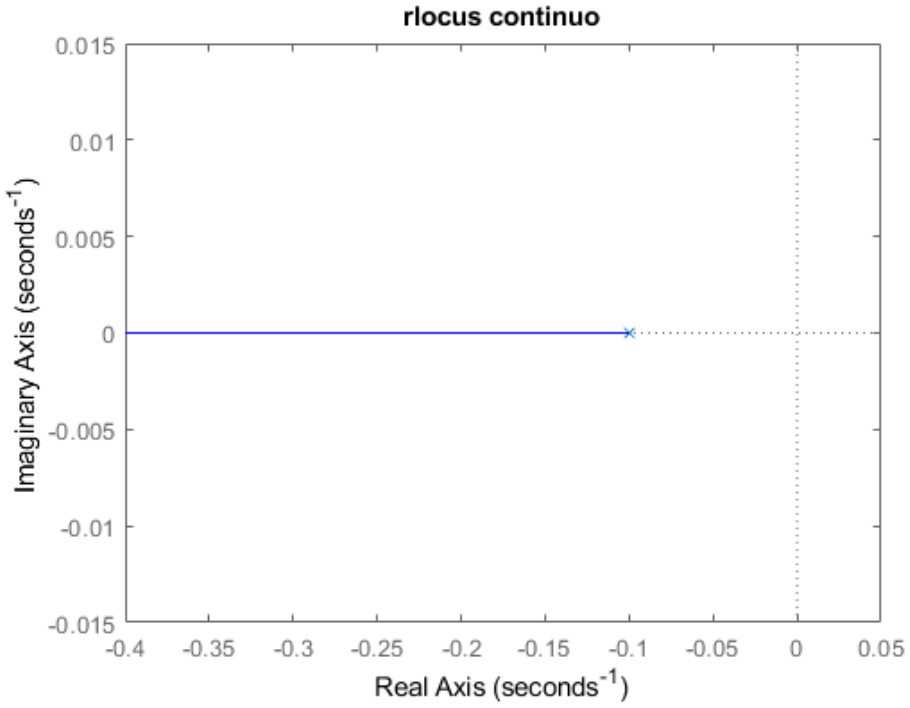
• Função de transferência contínua:

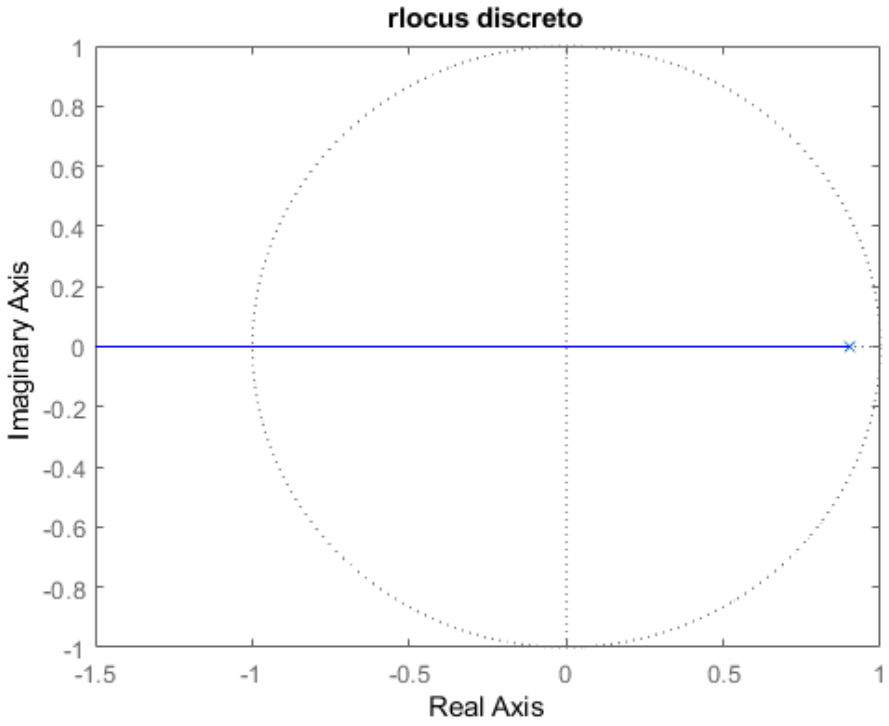
$$G_1(s) = \frac{V_1}{V_0} = \frac{0.1}{s + 0.1}$$

• Função de transferência discreta:

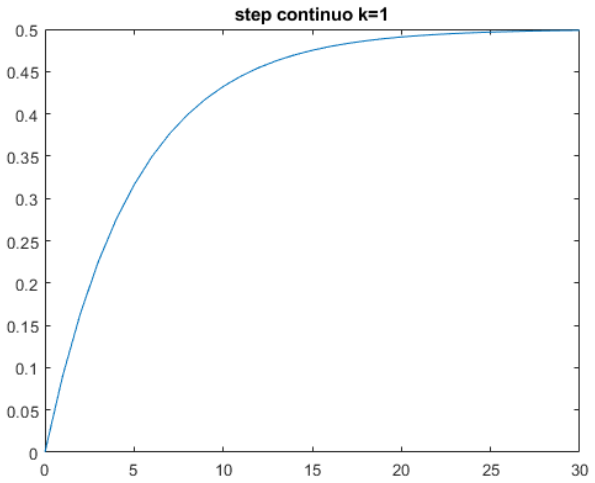
$$G_1(z) = \frac{V_1}{V_0} = \frac{0.1}{z + 0.9}$$

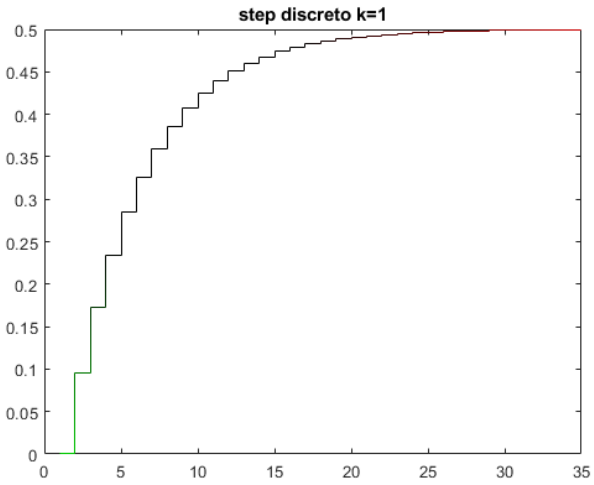
• Filtro RC – 1 estágio: Root locus

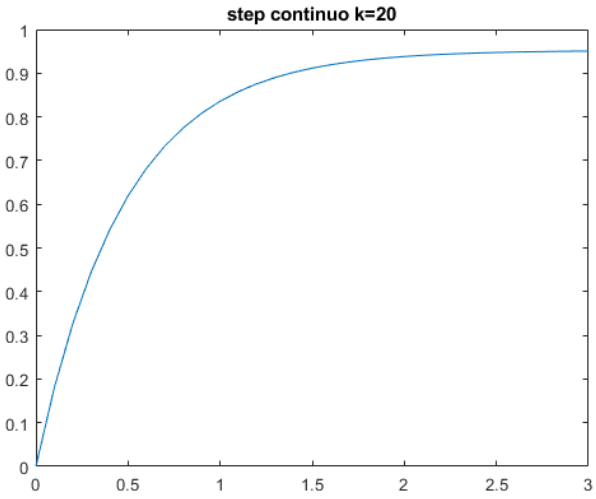


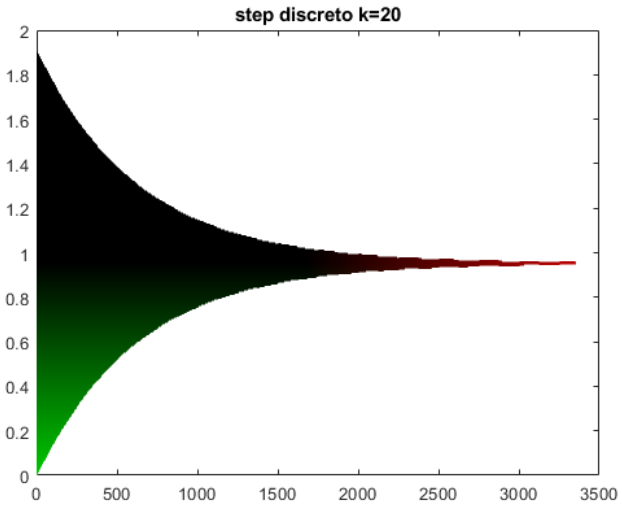


• Filtro RC – 1 estágio: resposta ao degrau em malha fechada









Código Matlab:

```
clc; clear ; close all
%Parametros do sistema
T = 1;
K=1;
%Funcao de transferencia malha aberta
s = tf('s'); G1 = 0.1/(s+0.1);
Hz = c2d(G1,T,'zoh');

rlocus(G1)
title('rlocus continuo')
figure
rlocus(c2d(G1,T,'zoh'))
title('rlocus discreto')

%funcao de trasnferencia de malha fechada k=1
Ts = K*G1/(1+K*G1)
Tz = K*Hz/(1+K*Hz)
```

```
%Resposta ao degrau
[ys,t,u] = step(Ts,[0:T:30]);
yb = dstep(Tz,[0:T:30]);

figure
plot(t, ys)
title('step continuo k=1')
figure
stairs(yb)
title('step discreto k=1')

K=20;
%funcao de trasnferencia de malha fechada k=1
Ts = K*G1/(1+K*G1)
Tz = K*Hz/(1+K*Hz)

T = 0.1;
%Resposta ao degrau
[ys,t,u] = step(Ts,[0:T:3]);
yb = dstep(Tz,[0:T:3500]);


figure
plot(t, ys)
title('step continuo k=20')
figure
stairs(yb)
title('step discreto k=20')
```

Filtro RC – 2 estágios:

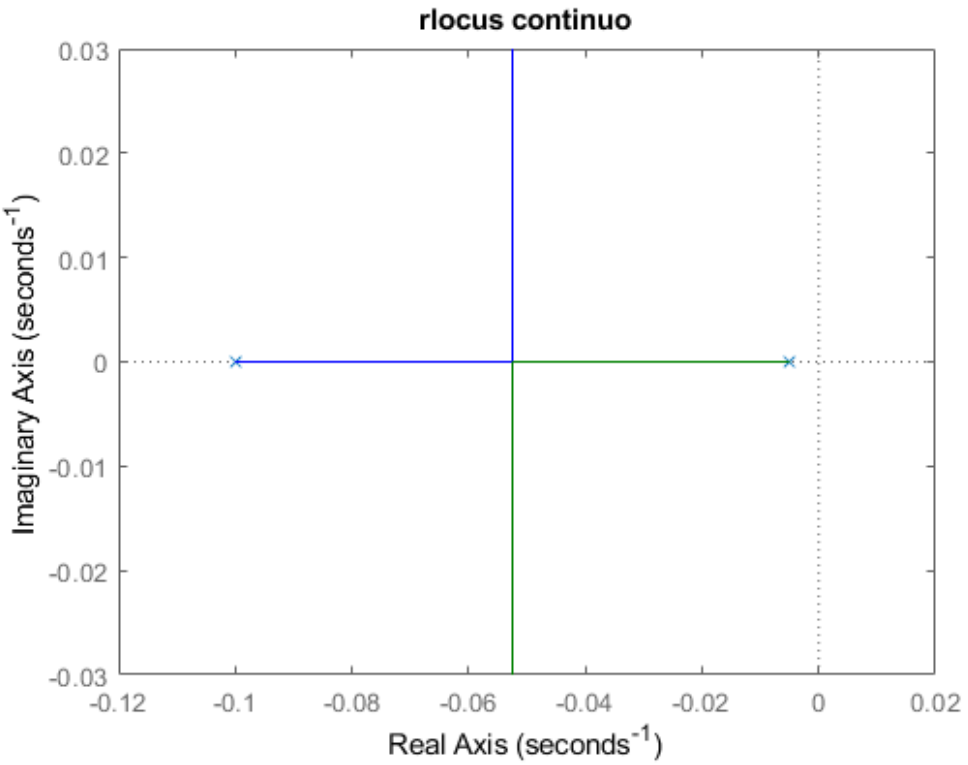
- Função de transferência contínua:

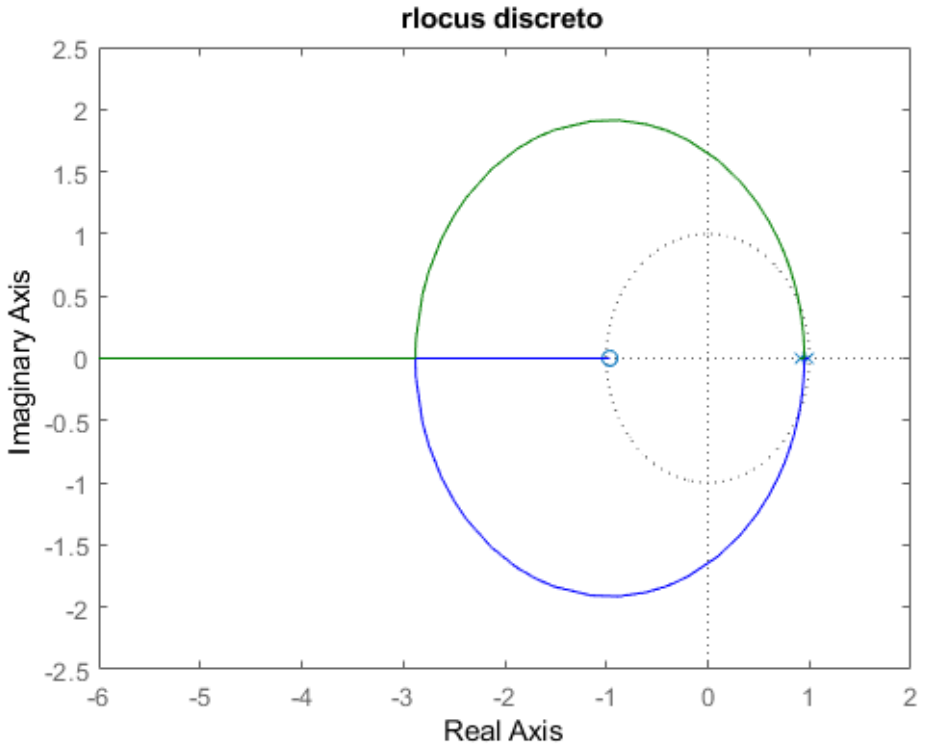
$$G_2(s) = \frac{V_2}{V_0} = \frac{0.0005}{s^2 + 0.105s + 0.0005}$$

- Função de transferência discreta:

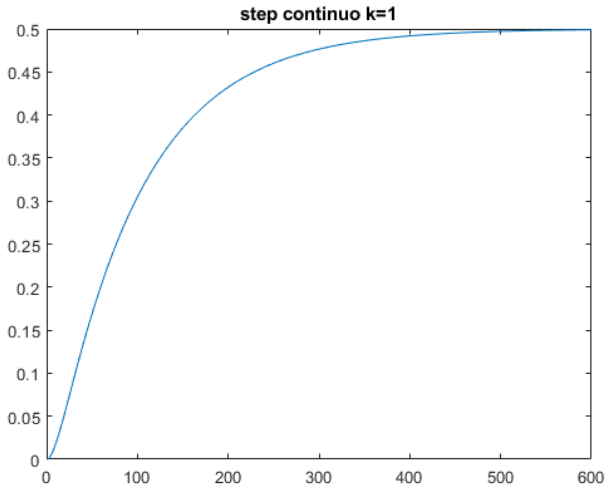
$$G_2(z) = \frac{V_2}{V_0} = \frac{0.0002z + 0.0002}{s^2 - 1.9z + 0.9}$$

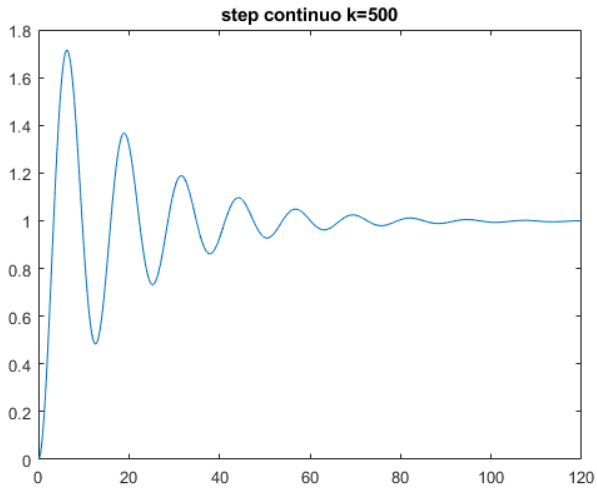
• Filtro RC – 2 estágios: Root locus

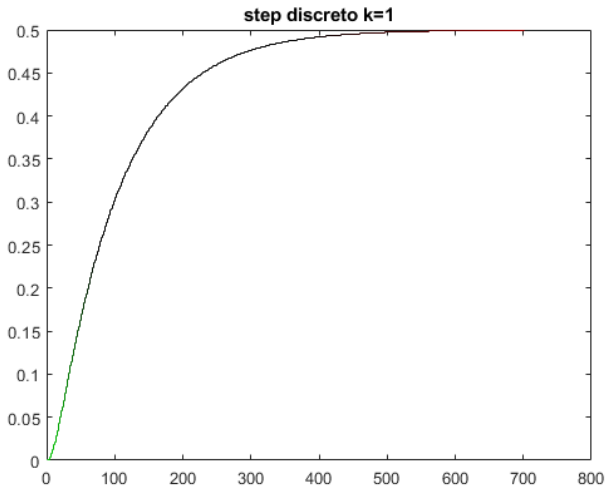




• Filtro RC – 2 estágios: resposta ao degrau em malha fechada







Código:

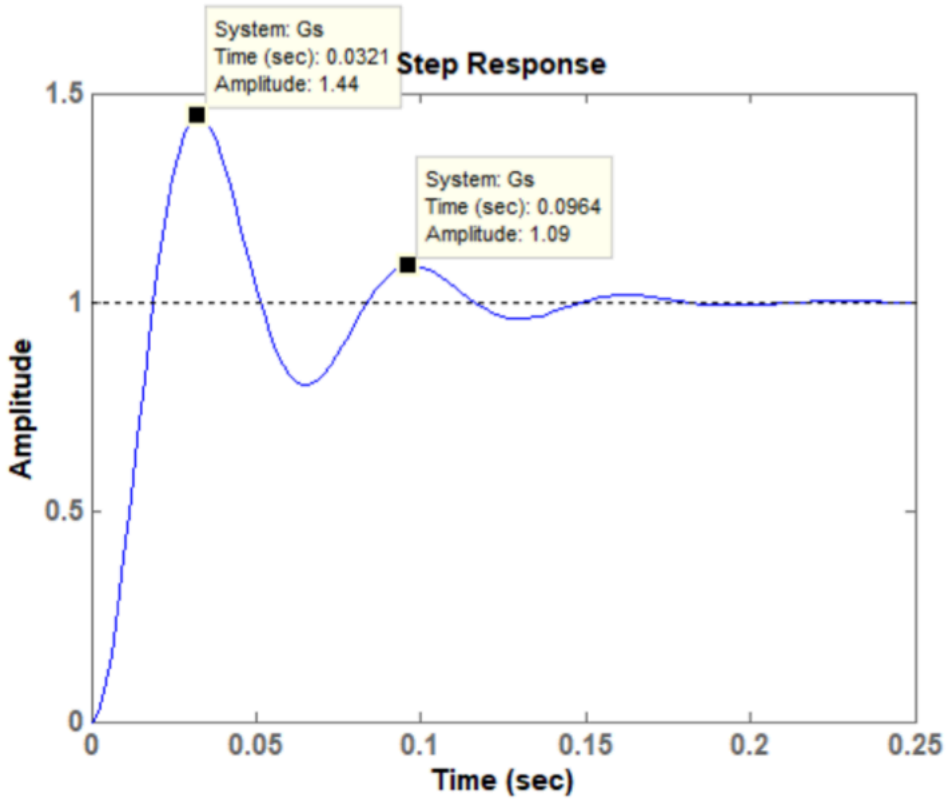
```
clc; clear ; close all
%Parametros do sistema
T = 1;
K = 1;
%Funcao de transferencia malha aberta
s = tf('s'); G1 = 0.0005/(s^2 +0.105*s + 0.0005);
Hz = c2d(G1,T,'zoh');

rlocus(G1)
title('rlocus continuo')
figure
rlocus(c2d(G1,T,'zoh'))
title('rlocus discreto')

%funÁ„o de trasnferencia de malha fechada k=1
Ts = K*G1/(1+K*G1);
Tz = K*Hz/(1+K*Hz);
```

```
%Resposta ao degrau
[ys,t,u] = step(Ts,[0:T:600]);
yb = dstep(Tz,[0:T:600]);

figure
plot(t, ys)
title('step continuo k=1')
figure
stairs(yb)
title('step discreto k=1')

K=500;
%funÁ„o de trasnferencia de malha fechada k=1
Ts = K*G1/(1+K*G1);
Tz = K*Hz/(1+K*Hz);

%Resposta ao degrau
[ys,t,u] = step(Ts,[0:0.1:120]);
yb = dstep(Tz,[0:1:300]);

figure
plot(t, ys)
title('step continuo k=500')
figure
stairs(yb)
title('step discreto k=500')
```

Ex. 21.2)

A figura abaixo apresenta a resposta ao degrau unitário e um posicionador linear.

- Plote o diagrama do lugar das raízes e a resposta em malha fechada do sistemas contínuo e discreto para T = 1, 0.01, 0.001 s. Avalie também estabilidade do sistema.



Identificação da planta (sistema de segunda ordem):

• ωd = 96.8 rad/s;

• ξ=0.25;

• ωn = 100 rad/s

$$G(s) = \frac{10000}{s^2 + 50s + 10000}$$

Segurador de ordem zero:

• T = 1s

$$G(z) = \frac{z + 10^{-11}}{z^2 - 10^{-11}z + 10^{-22}}$$

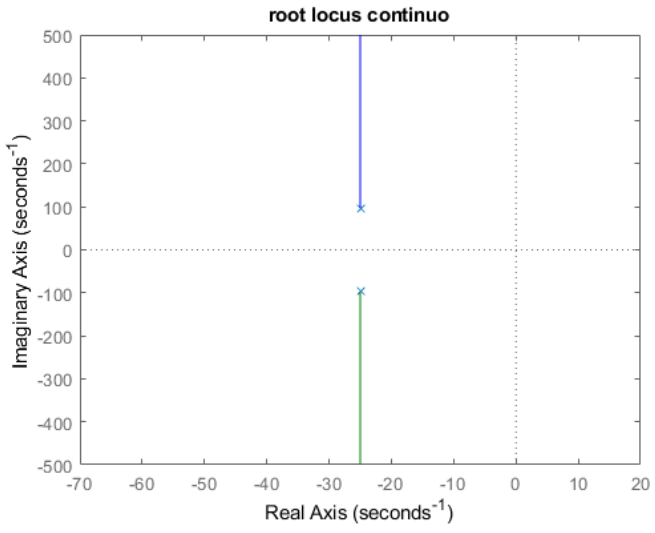
• T = 0.01s

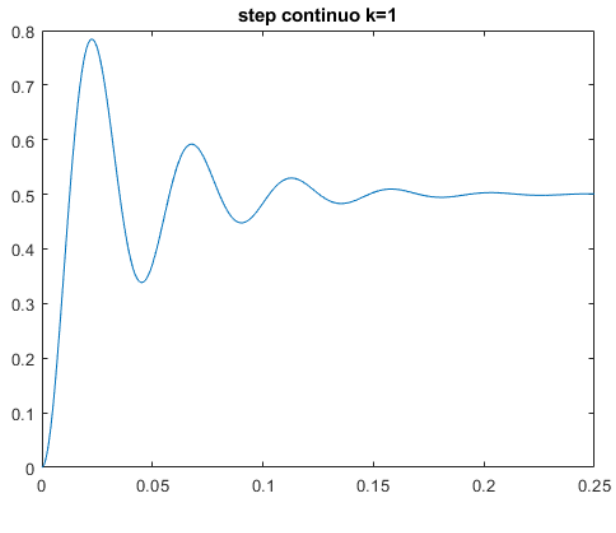
$$G(z) = \frac{0.39z + 0.33}{z^2 - 0.9z + 0.61}$$

• T = 0.001s

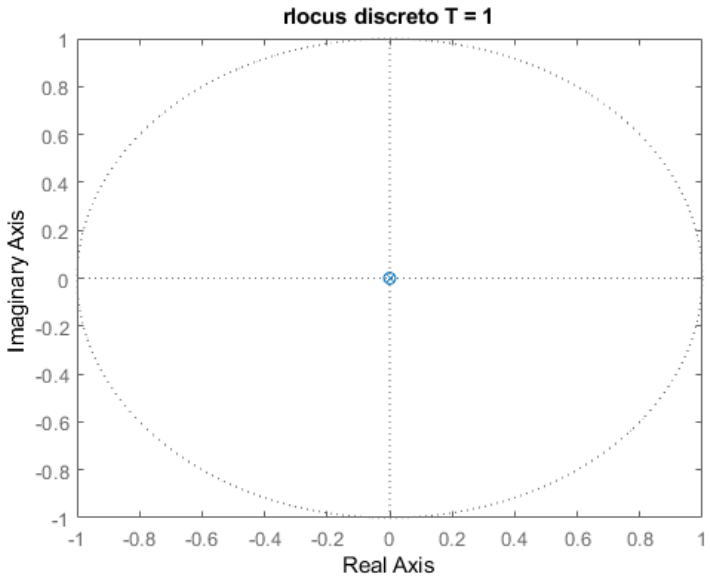
$$G(z) = \frac{0.005z + 0.005}{z^2 - 1.9z + 0.95}$$

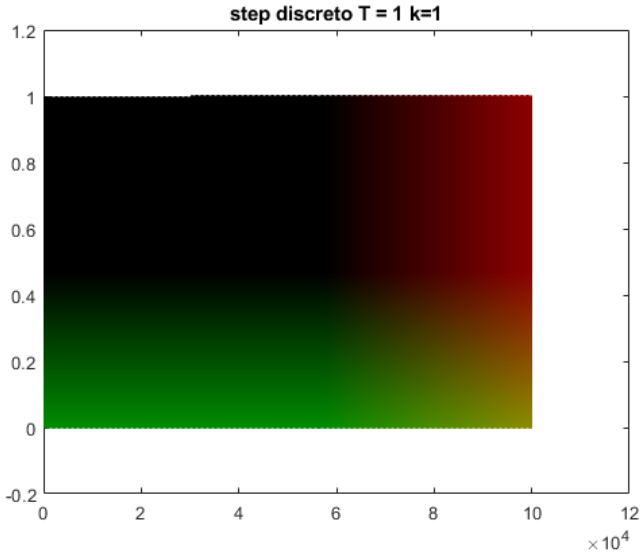
• Root locus e resposta ao degrau (K = 1):



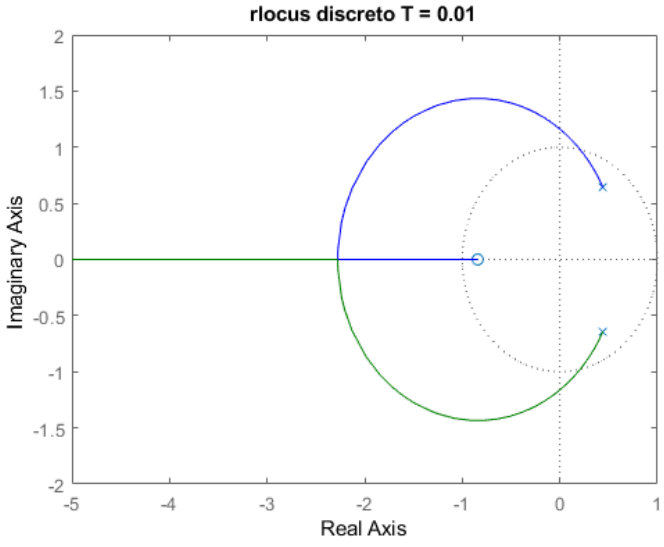


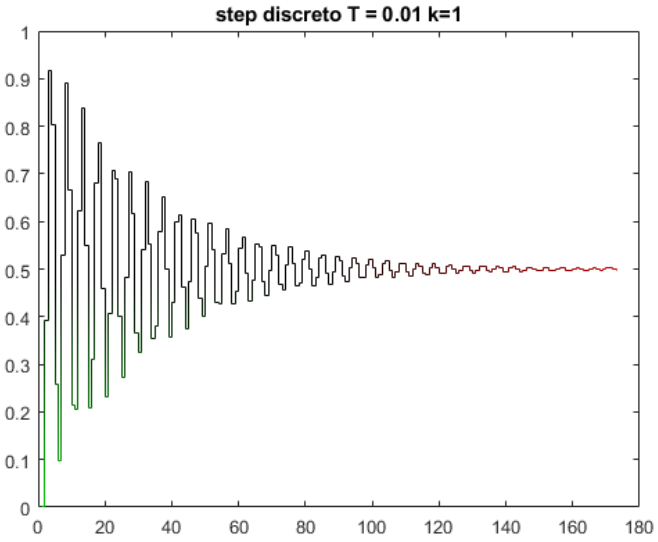
- Root locus e resposta ao degrau ($T = 1$, $K = 1$):



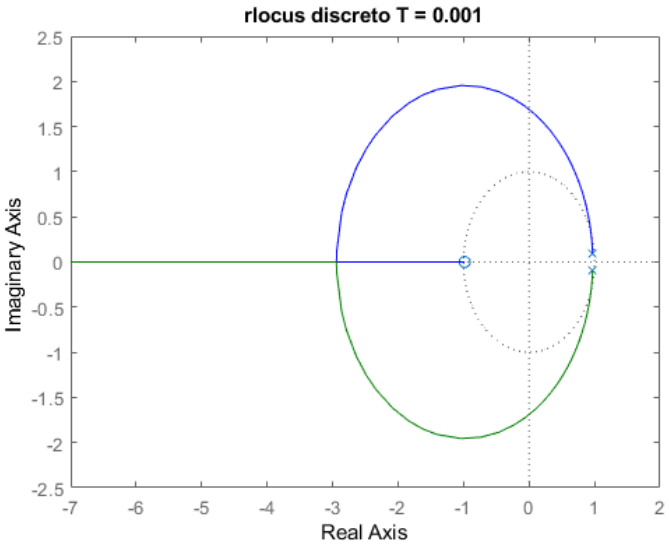


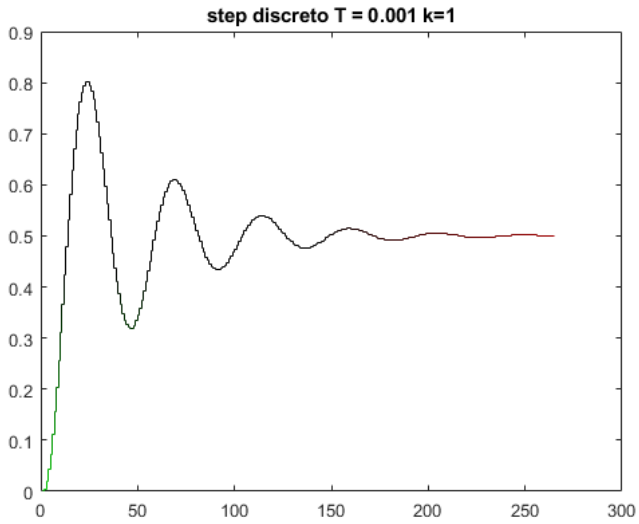
- Root locus e resposta ao degrau ($T = 0.01$, $K = 1$):





- Root locus e resposta ao degrau ($T = 0.001$, $K = 1$):





Código:

```
clc; clear ; close all
%Parametros do sistema

%Funcao de transferencia malha aberta
s = tf('s'); G1 = 10000/(s^2 +50*s + 10000);

rlocus(G1)
title('root locus continuo')


K=1;
Ts = K*G1/(1+K*G1);
[ys,t,u] = step(Ts,[0:0.001:0.25]);

figure
plot(t, ys)
title('step continuo k=1')

T1= 1;
Hz1 = c2d(G1,T1,'zoh')
figure
rlocus(Hz1)
title('rlocus discreto T = 1')

Tz1 = K*Hz1/(1+K*Hz1);
yb = dstep(Tz1,[0:T1:50]);
figure
stairs(yb)
title('step discreto T = 1 k=1')

T2= 0.01;
Hz2 = c2d(G1,T2,'zoh')
figure
rlocus(Hz2)
title('rlocus discreto T = 0.01')
```

```
Tz2 = K*Hz2/(1+K*Hz2);
yb = dstep(Tz2,[0:T2:50]);
figure
stairs(yb)
title('step discreto T = 0.01 k=1')

T3= 0.001;
Hz3 = c2d(G1,T3,'zoh')
figure
rlocus(Hz3)
title('rlocus discreto T = 0.001')

Tz3 = K*Hz3/(1+K*Hz3);
yb = dstep(Tz3,[0:T3:50]);
figure
stairs(yb)
title('step discreto T = 0.001 k=1')
```