Contents

Lab_12 problem 3.1 from lab 11

```
clear; clc; close all;
```

```
k    = 1;
taum = 0.02; %s
Hc = k*tf(1,[1 0]); %controller structure
Hp = zpk([],[-20 -40], 2400, 'iodelay', taum)
```

```
Hp =

                       2400
  exp(-0.02*s) * -------------
                 (s+20) (s+40)

Continuous-time zero/pole/gain model.
```

discritizing the controller using tustin

```
%(
% tustuin-bilinear transformation:
% we replace s -> 2/T(z-1)/(z+1)
%
% backward Euler transformation:
% we replace s-> (z-1)/T/z
%
% forward Euler transformation:
% we replace s-> (z-1)/T
% )

%time constants of the process, the time delay and the input frequencies
% time constants: 1/20, 1/40 (we have to choose the biggest one) -> 1/20 (50ms)
% and compare it to the time delay whitch is 20 ms
% we see that 10 ms would be sufficient to cover the time constants and the
% time delay to;
```

```
T = 0.01;
Hcd = tf(T,[1,-1],T) %discrete tf for a controller (integrator) using forward euler
```

```
Hcd =

  0.01
  -----
  z - 1

Sample time: 0.01 seconds
Discrete-time transfer function.
```

discritizing the tf using zoh method

```
Hpd = c2d(Hp,T,'zoh')
```

```
Hpd =

            0.098576 (z+0.8187)
  z^(-2) * ---------------------
           (z-0.8187) (z-0.6703)

Sample time: 0.01 seconds
Discrete-time zero/pole/gain model.
```

obtaining the open loop discrete tf

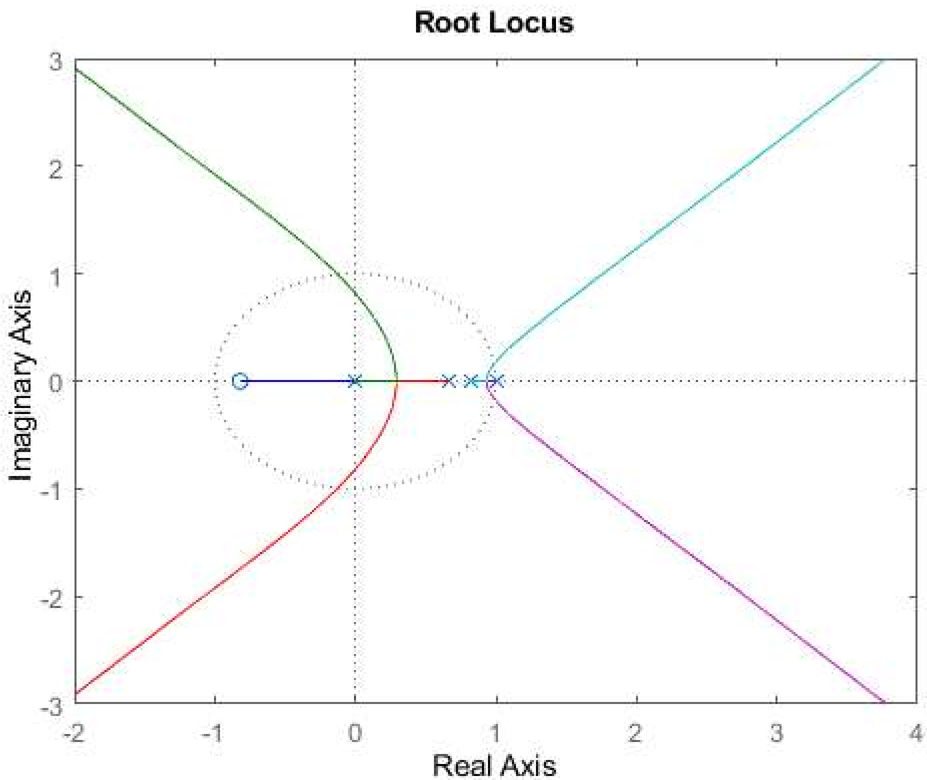
```
Hold = Hcd*Hpd
```

```
Hold =

              0.00098576 (z+0.8187)
  z^(-2) * ---------------------------
           (z-1) (z-0.8187) (z-0.6703)

Sample time: 0.01 seconds
Discrete-time zero/pole/gain model.
```

analyzing the closed loop stability depending on k with rlocus

```
rlocus(Hold)
%stability:
% a system is stable if it is in the unit cricle
% we have 5 branches
% for k from 0 to 7.86  the sys is asimptotically stable

% behaviours:
```

```
% k from 1.01 to 7.86 the closed loop system is underdamped
% k = 1.01 the system is critically damped
% k from 0 to 1.01 the system is overdamped damped
% k = 7.86 the system is undamped
```



generate the control signal c(kT) starting from the discrete controller structure

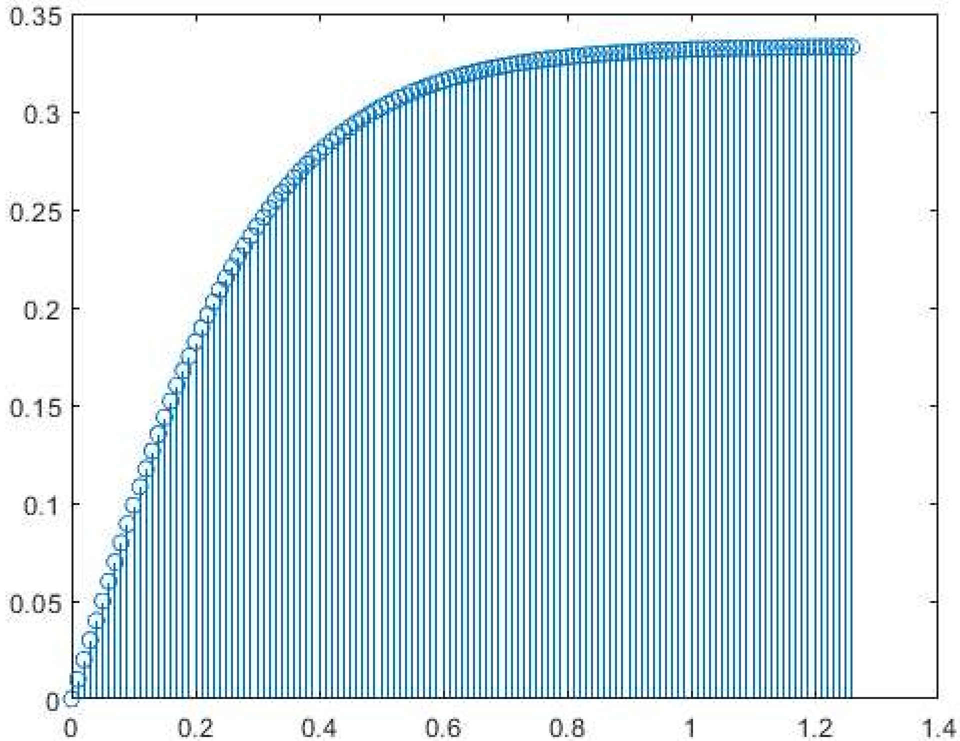
```
%C(z) = Hcd(z)*E(z)
%C(z)*(z-1) = 0.01*E(a) now apply the inverse Z transfrom
% c[(k+1)]-c[kT] = 0.01*e(kT)
% c[(k+1)T]-c[kT] = 0.01*(ref(kT)-y(kT)) we shift it back with one sample
% c(kT)=c((k-1)*T) + 0.01* (ref((k-1)T)-y((k-1)T))
```

generate the control signal for ref(t) = 1;

store the outputs y(t);

```
y = step(feedback(Hold,1));

c(1)=0;
for k=2:length(y)
    c(k)=c(k-1) + 0.01* (1-y(k-1));
end

t = 0:T:(length(y)-1)*T;
figure;
stem(t,c);
```

```
Warning: Use the state-space representation for more efficient modeling of
discrete-time delays.
```

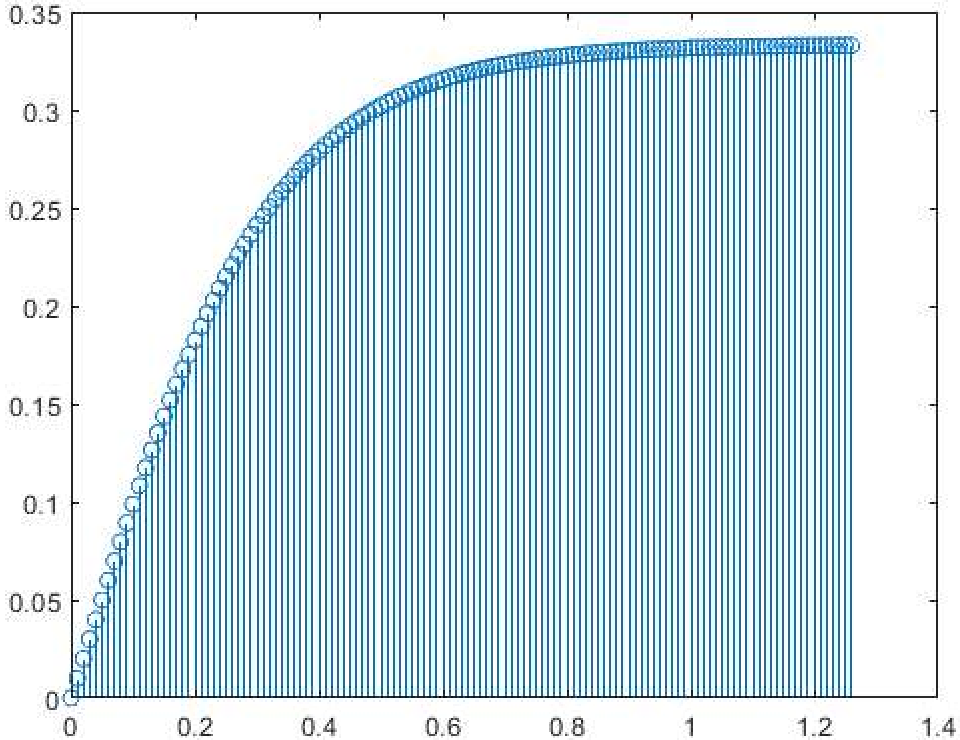


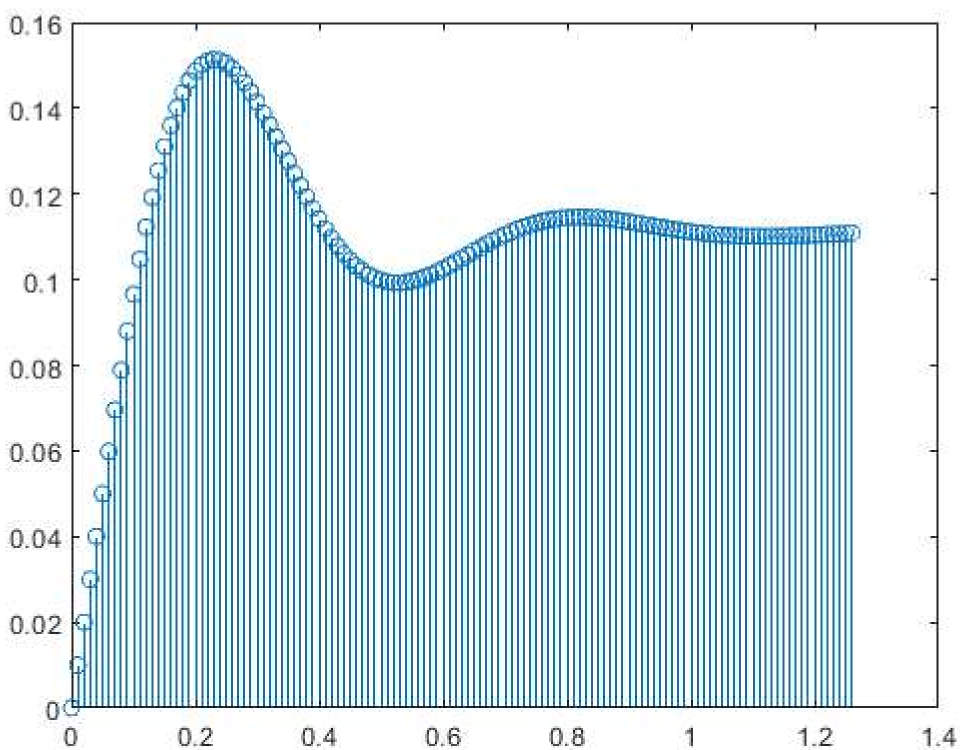
hw for k = 3 represent the command signal

```
k_3 = 3;
Hcd_3 = Hcd*k_3;

Hold_3 = Hcd_3*Hpd,1;
y_3 = step(feedback(Hold_3,1));

c_3(1)=0;
for k=2:length(y_3)
    c_3(k)=c_3(k-1) + 0.01* (1-y_3(k-1));
end

t_3 = 0:T:(length(y_3)-1)*T;
figure;
stem(t,c_3);
```

```
Hold_3 =

              0.0029573 (z+0.8187)
  z^(-2) * ---------------------------
           (z-1) (z-0.8187) (z-0.6703)

Sample time: 0.01 seconds
Discrete-time zero/pole/gain model.
```

```
Warning: Use the state-space representation for more efficient modeling of
discrete-time delays.
```



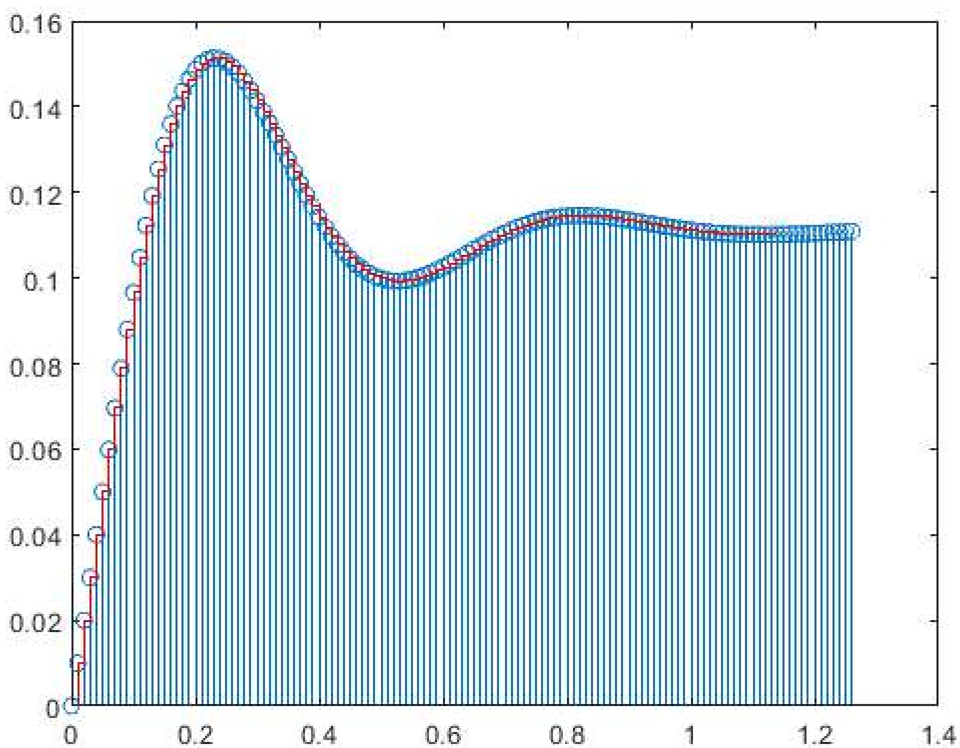


we can simulate the simulink example:

by calculating the tf from ref to command signal

```
H_ref_c = feedback(Hcd_3,Hpd);
cs = step(H_ref_c)/k_3;
ts = 0:T:(length(cs)-1)*T;
hold on
stairs(ts,cs,'r');
hold off
```

```
Warning: Use the state-space representation for more efficient modeling of
discrete-time delays.
```



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