CT_DT_Example_Week7

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Housekeeping

```
clear all
close all
clc
```

Discretization pages 1, 2, 3 Lecture Week 7

consider a PVCF 2nd order system

```
A = [0 1; -125 -20]
B = [0;1]
C = [1,  1]
D = 0
eig(A)

% the two eigenvalues of CT system are
T = 0.001  % 1 millisecond
Ad = expm(A*T)   % remember to use expm() not exp()
Bd = inv(A)*(Ad-eye(2))*B
Cd = C
Dd = D

% using Matlab's built in funtion to find the discrete state
 representation
sys_ct = ss(A, B, C, D)   % create CT LTI object from matrices
sys_dt = c2d(sys_ct, T, 'zoh') % result is DT LTI object at sampling
 time T
```

```
A =

     0     1
  -125   -20


B =
```

```
     0
     1


C =

     1     1


D =

     0


ans =

 -10.0000 + 5.0000i
 -10.0000 - 5.0000i


T =

   1.0000e-03


Ad =

    0.9999    0.0010
   -0.1238    0.9801


Bd =

   1.0e-03 *

    0.0005
    0.9900


Cd =

     1     1


Dd =

     0


sys_ct =

  A =
           x1     x2
```

```
    x1      0      1
    x2   -125    -20

  B =
         u1
    x1    0
    x2    1

  C =
         x1  x2
    y1    1   1

  D =
         u1
    y1    0

Continuous-time state-space model.


sys_dt =

  A =
               x1        x2
    x1    0.9999   0.00099
    x2   -0.1238    0.9801

  B =
                 u1
    x1   4.967e-07
    x2     0.00099

  C =
         x1  x2
    y1    1   1

  D =
         u1
    y1    0

Sample time: 0.001 seconds
Discrete-time state-space model.
```

for completness let us compute Bd by the integral definition

```
syms tal
Bds = eval(int(expm(A*tal), tal, 0, T)*sym(B))   % integrates to value
 of T, eval implifies numbers
```

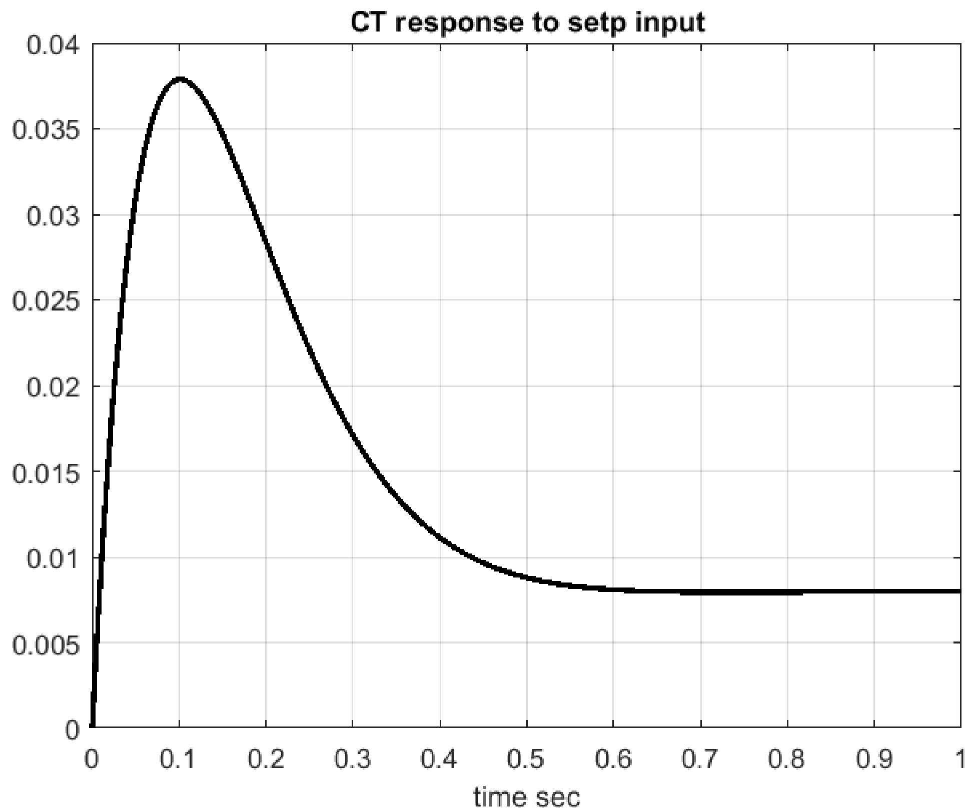
```
Bds =

   1.0e-03 *
```

```
0.0005
0.9900
```

CT response using LTI object and step()

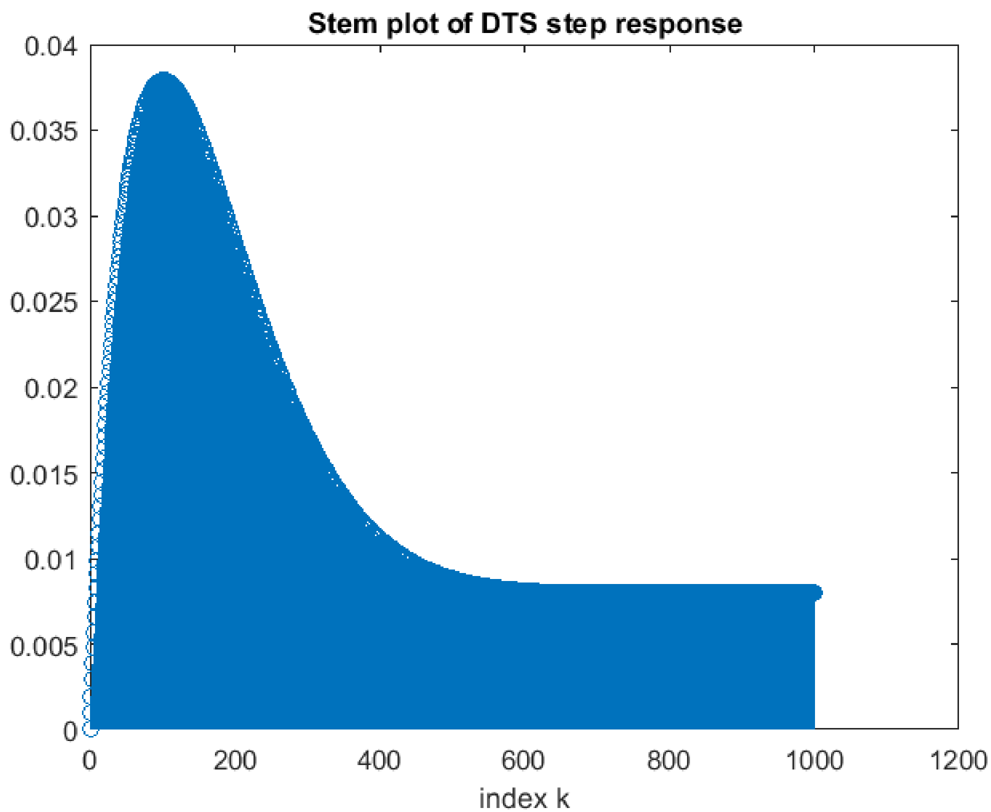
```
[Yc, Tc]=step(sys_ct, [0:T:1]);  % plot CT step response form 0 to 1
 sec
figure
plot(Tc, Yc, 'k', 'linewidth', 2)
grid on
title('CT response to setp input')
xlabel('time sec')
```



recursively solve for the solution in the discrete domain

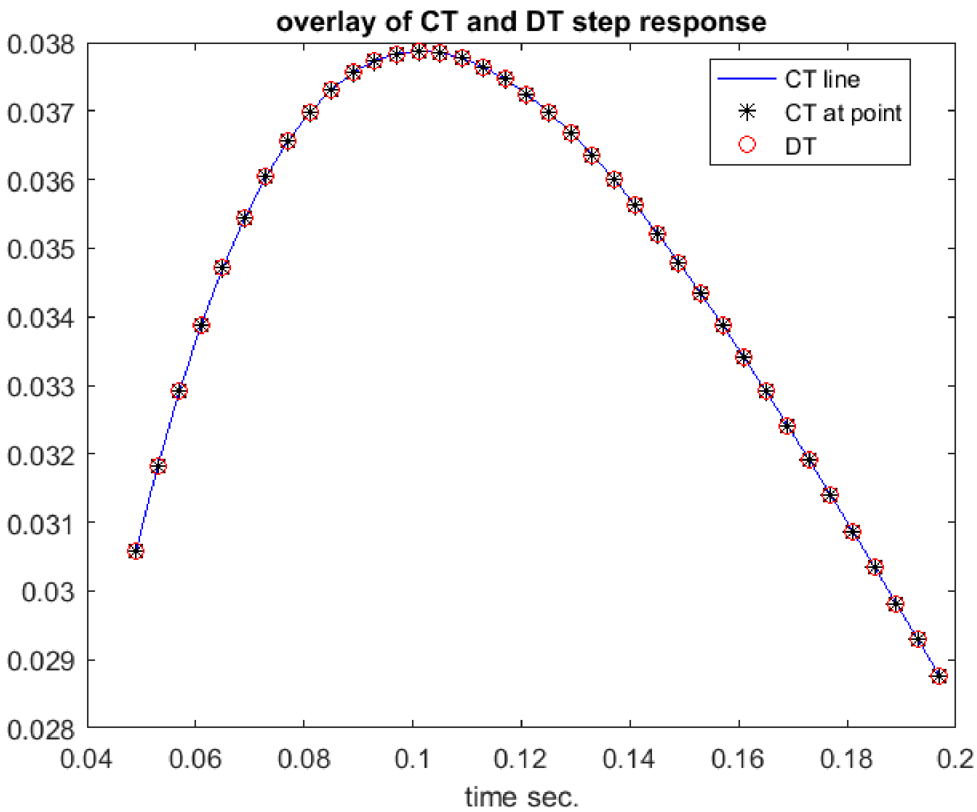
```
Td = zeros(size(Tc));   % set up array to hold time and outputs
Yd = zeros(size(Yc));
% IC = 0 since system is relaxed for step response by definition
Xnew = [0;0];   % at k = 0 IC = [0;0]
Yd(1) = Cd*Xnew;
Td(1) = 0; % remember arrays in Matlab start at 1 these are k values
 not time
```

```
for k = 1: length(Tc);
    Xold = Xnew;
    Xnew = Ad*Xold+ Bd*1;
    Yd(k+1) = Cd*Xnew;   % save output value
    Td(k+1) = k;  % save corresponding discrete time integer index
end
figure
stem(Td, Yd)
title('Stem plot of DTS step response')
xlabel('index k')
```



compare CT and DT from 0.05 to 0.1 sec by overlaying

```
figure
rg = 50:4:200;    % spread out a bit for easier viewing
plot(Tc(rg), Yc(rg), 'b', 'linewidth', .5)
hold on
plot(Tc(rg), Yc(rg), '*k')
plot(T*Td(rg), Yd(rg), 'ro')
legend('CT line', 'CT at point', 'DT', 'location', 'best')
title('overlay of CT and DT step response')
xlabel('time sec.')
```



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