

시스템공학

MATLAB 시스템응답 해석 실습

기계시스템공학과

1 시스템 응답 해석을 위한 기본적인 지식

1. 시뮬레이션 과정

전달함수 생성

$$\frac{25}{s^2 + s + 25}$$



num=[25];
den=[1 1 25];

시스템응답
시뮬레이션

step, impulse....

응답 그래프 생성

plot, title, grid, xlabel, ylabel...

2. 사용할 MATLAB 명령어

a. Step

사용법 : step(num,den)

b. impulse

사용법 : impulse(num,den)

c. grid on 또는 grid off

d. title

사용법 : title('문자열')

e. xlabel, ylabel

사용법 : xlabel('문자열')

f. plot

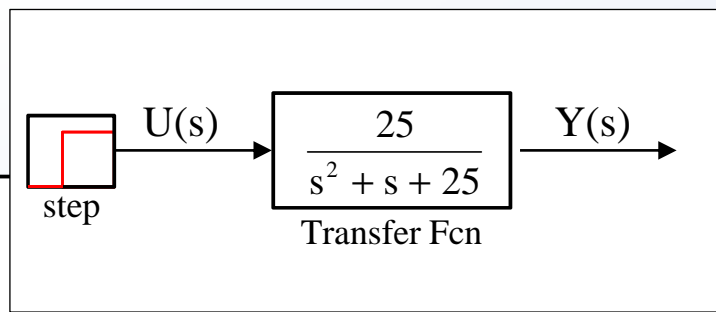
사용법 : plot(x,y,'linestyle')

2 Step응답 시뮬레이션

```
%%% Program 1
% Transfer function
num=[25];
den=[1 1 25];

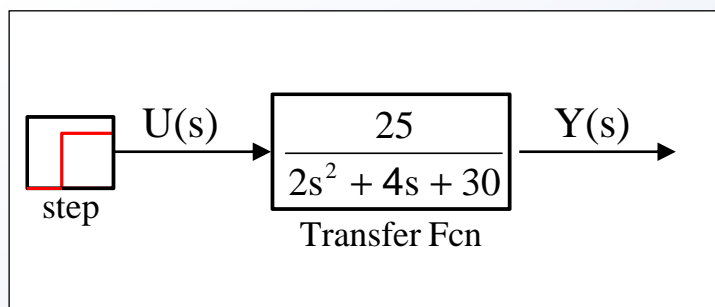
% Step-response
step(num,den)

% Title
grid
title('Unit-step Response of G(s)=25/(s^2+1*s+25)')
```



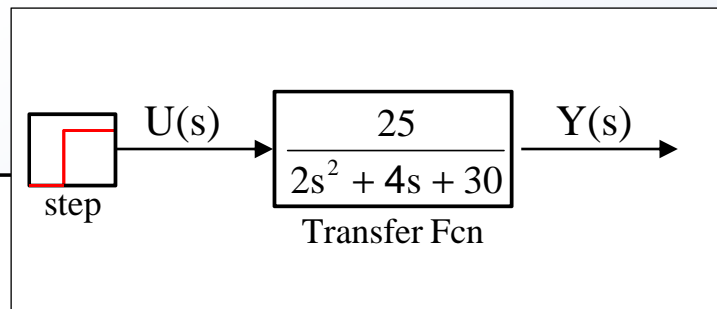
2 Step응답 시뮬레이션

예제1 (ex01.m)



2 Step응답 시뮬레이션

예제1 (ex01.m)

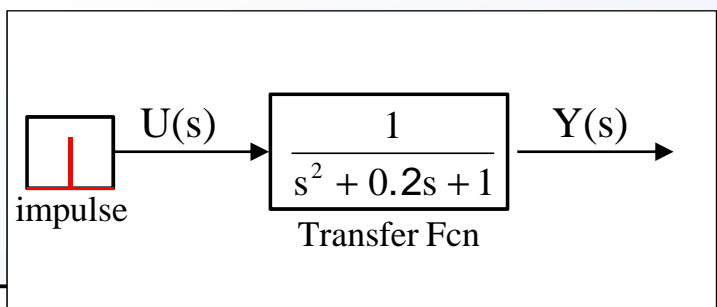


```
%%% ex01
% Transfer function
num=[25];
den=[2 4 30];

% Step-response
step(num,den)

% Title
grid
title('Unit-step Response of G(s)=25/(s^2+4*s+30)')
```

3 Impulse응답 시뮬레이션



```
%%% Program 2
% Transfer function
num=[1];
den=[1 0.2 1];

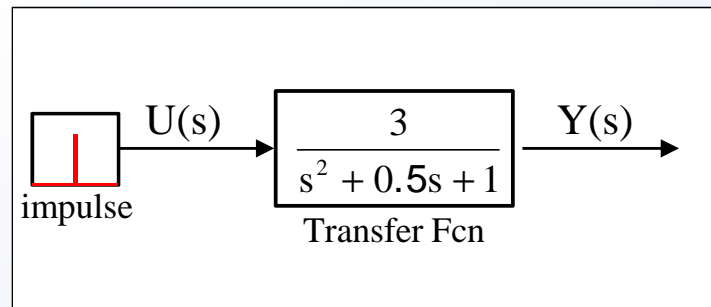
% Impulse-response
impulse(num,den)

% Title
grid
title('Unit-Impulse Response of G(s)=1/(s^2+0.2*s+1)')
```

3

Impulse응답 시뮬레이션

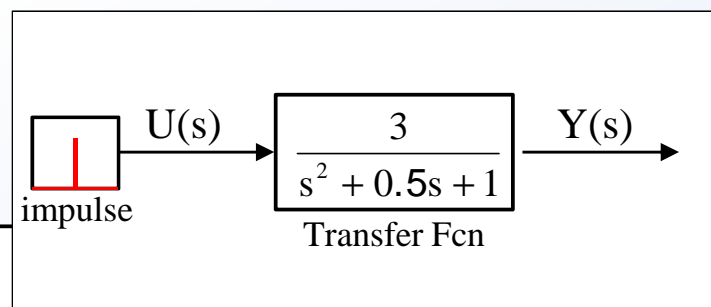
예제2 (ex02.m)



3

Impulse응답 시뮬레이션

예제2 (ex02.m)

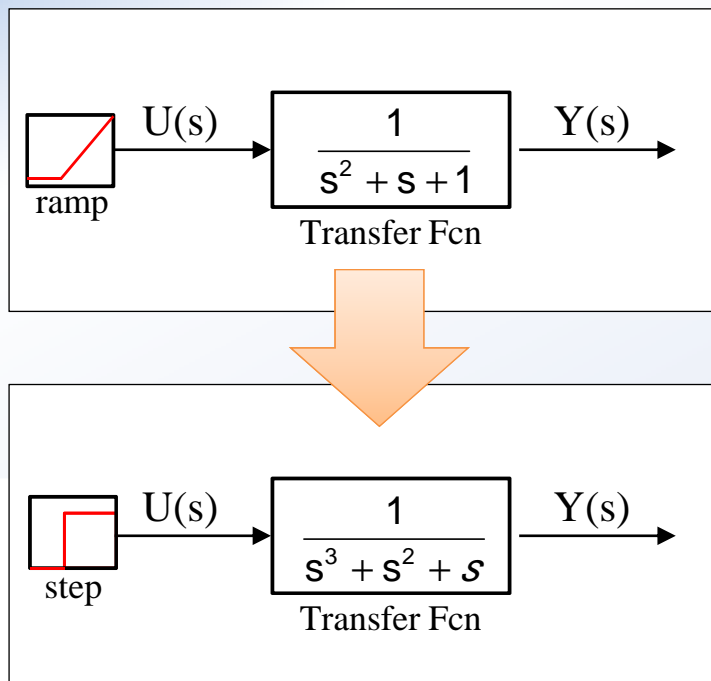


```
%%% ex02
% Transfer function
num=[3];
den=[1 0.5 1];

% Impulse-response
impz(num,den)

% Title
grid
title('Unit-Impulse Response of G(s)=3/(s^2+0.5*s+1)')
```

4 Ramp응답 시뮬레이션



$$\therefore \text{ramp} = \frac{1}{s^2} = \text{step} \times \frac{1}{s}$$

4 Ramp응답 시뮬레이션

```

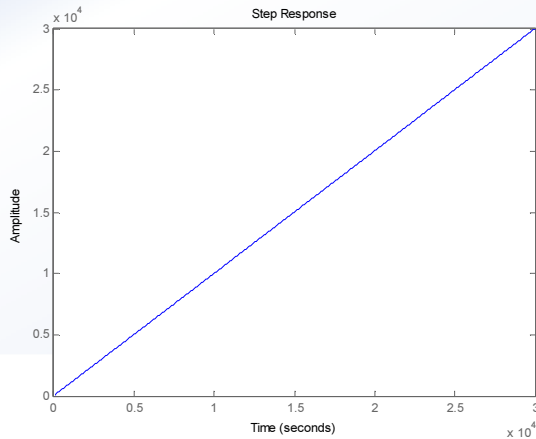
%%% Program 3
% Transfer function G(s)/s
num=[1];
den=[1 1 1 0];
den=[1 1 1];

%
t=0:0.1:7;
y=step(num,den,t);
step(num,den)

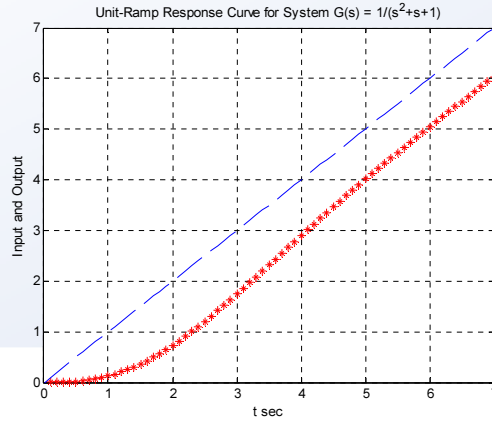
% Plot
plot(t,y,'r*',t,t,'b--')
grid
title('Unit-Ramp Response Curve for System G(s) = 1/(s^2+s+1)')
xlabel('t sec')
ylabel('Input and Output')
    
```

4 Ramp 응답 시뮬레이션

`step(num,den)`



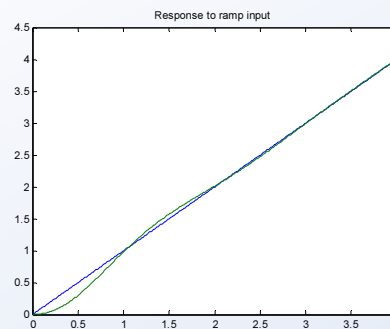
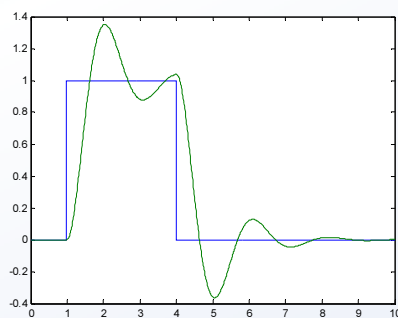
`t=0:0.1:7;`
`y=step(num,den,t);`



5 임의의 입력에 대한 응답

1. Ramp 응답 시뮬레이션 (lsim 함수 이용)

`lsim(sys,u,t)` : 임의의 입력에 대한 시스템응답 시뮬레이션



step, impulse

전달함수 생성

시스템응답
시뮬레이션

응답 그래프 생성

lsim

전달함수 생성

입력 프로파일생성

시스템응답
시뮬레이션

응답 그래프 생성

5

임의입력에 대한 응답

1. Ramp 응답 시뮬레이션 (lsim 함수 이용)

```
%%% Program 4
% Transfer function
num=[1];
den=[1 1 1];
```

```
% input profile
```

```
t=0:0.1:7;
```

```
u=t;
```

```
sys=tf(num,den)
```

```
y=lsim(sys,u,t);
```

```
% Plot
```

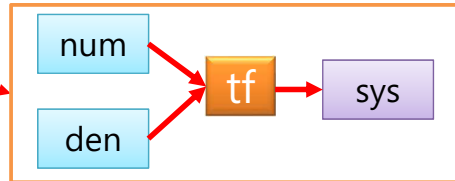
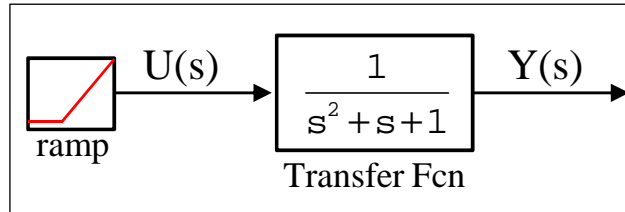
```
plot(t,y,'r*',t,u,'b--')
```

```
grid
```

```
title('Unit-Ramp Response Curve for System  $G(s) = 1/(s^2+s+1)$ ')
```

```
xlabel('t sec')
```

```
ylabel('Input and Output')
```

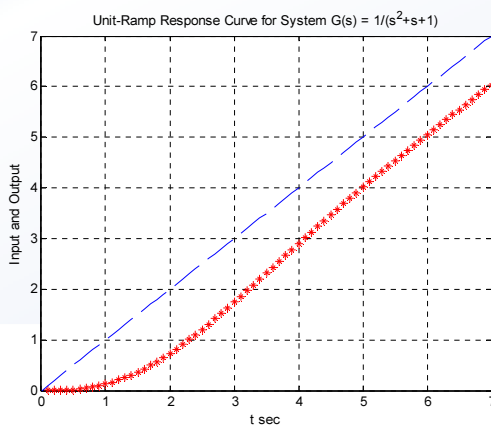


5

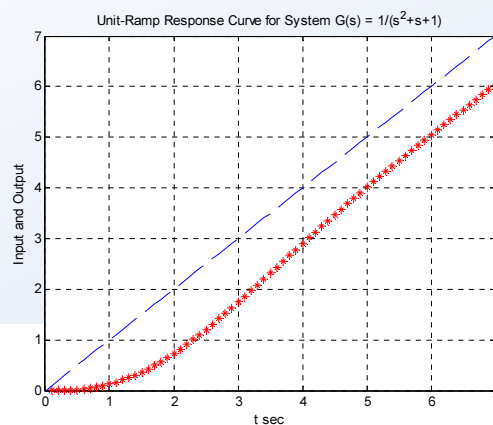
임의입력에 대한 응답

2. Ramp 응답 비교

Step함수 이용



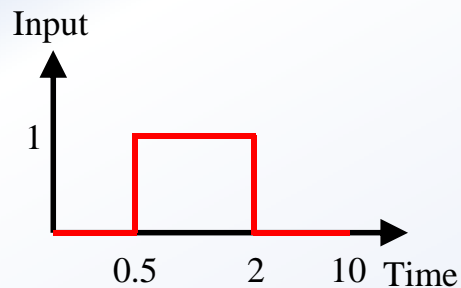
lsim함수 이용



5

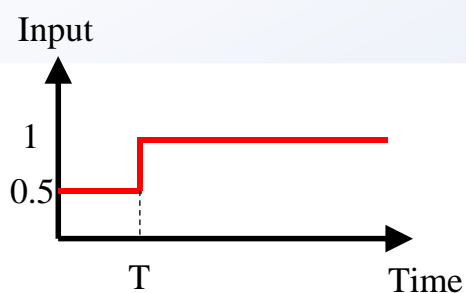
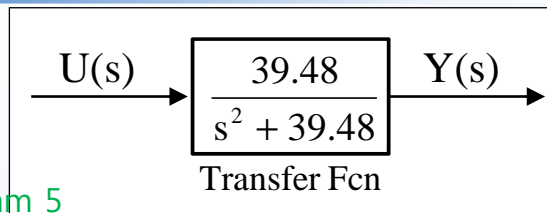
임의입력에 대한 응답

3. 변형된 계단입력 응답



%%% Program 5

```
dt=0.01;
t=0:dt:10;
u1=zeros(1, 0.5/dt+1);
u2=ones(1, 1.5/dt);
u3=zeros(1, 8/dt);
u=[u1 u2 u3];
```



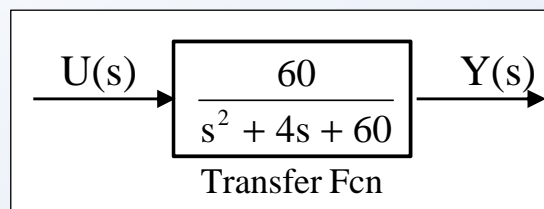
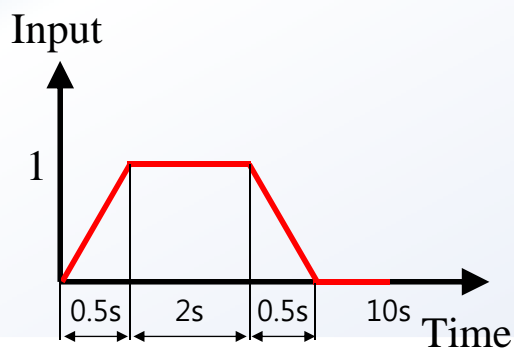
%%% Program 6

```
T=input('시간을 입력하시오:');
dt=0.01;
t=0:dt:10;
u1=0.5*ones(1, T/dt+1);
u2=ones(1, (t(end)-T)/dt);
u=[u1 u2];
```

5

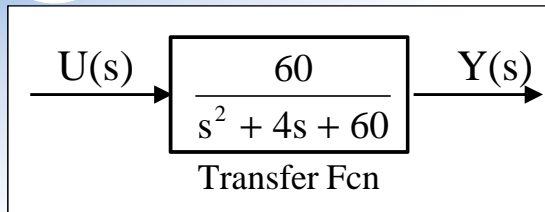
임의입력에 대한 응답

예제3 (ex03.m)



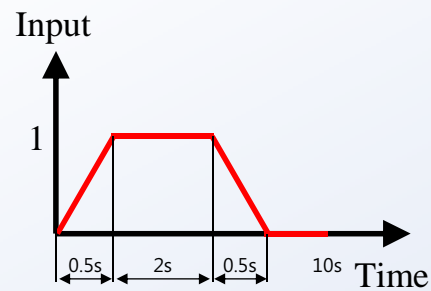
5

임의입력에 대한 응답



```
%%% ex03
% Transfer function
num=[60];
den=[1 4 60];
```

```
%Input profile
dt=0.01;
t=0:dt:10;
u1=0:2*dt:1
u2=ones(1, 2/dt);
u3=1-2*dt:-2*dt:0;
u4=zeros(1, 7/dt);
u=[u1 u2 u3 u4];
```



```
sys=tf(num,den)

y=lsim(sys,u,t);

% Plot
plot(t,y,'r',t,u,'b')
grid
xlabel('t sec')
ylabel('Input and Output')
```

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진동계 시뮬레이션

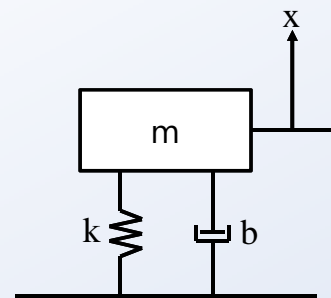
5. 초기조건을 가진 진동계 응답 시뮬레이션

$$\ddot{x} + 3\dot{x} + 2x = 0, \quad x(0) = 0.1, \quad \dot{x}(0) = 0.05$$

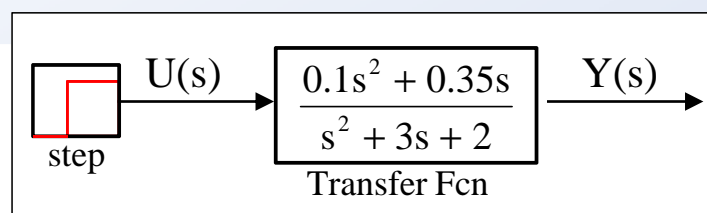
$$m\ddot{x} + b\dot{x} + kx = 0, \quad x(0), \quad \dot{x}(0)$$

$$(ms^2 + bs + k)X(s) = mx(0)s + m\dot{x}(0) + bx(0)$$

$$X(s) = \frac{mx(0)s + m\dot{x}(0) + bx(0)}{ms^2 + bs + k}$$



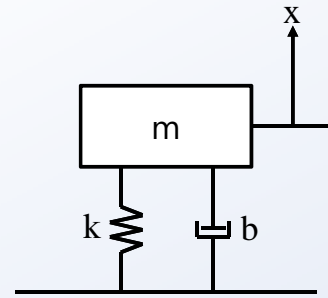
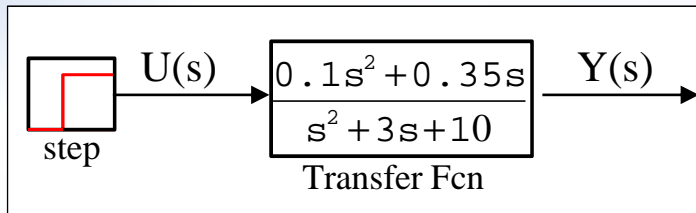
$$X(s) = \frac{0.1s^2 + 0.35s}{s^2 + 3s + 2} \frac{1}{s}$$



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진동계 시뮬레이션

5. 초기조건을 가진 진동계 응답 시뮬레이션



```

%%% Program 7
% Transfer function
num=[0.1 0.35 0];
den=[1 3 10];

% Step-Response
step(num,den)

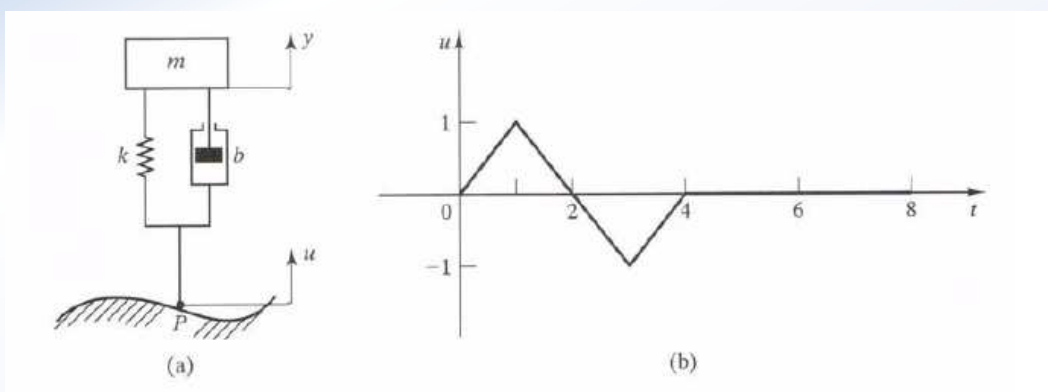
% Title : x(0)=0.1, x'(0)=0.05
grid
title('Response of Spring-Mass-Damper System by Initial Conditions')

```

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연습문제

연습문제



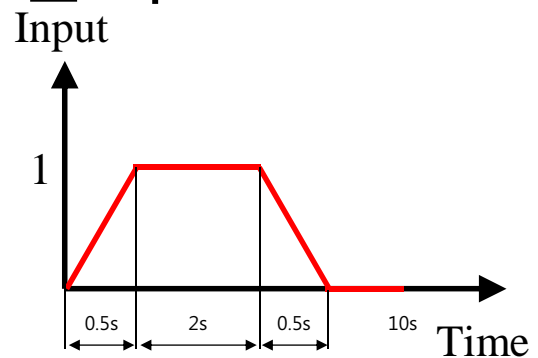
- 1) $m = 100\text{kg}$, $b = 400\text{Ns/m}$, $k = 400\text{N/m}$
- 2) $m = 100\text{kg}$, $b = 200\text{Ns/m}$, $k = 500\text{N/m}$, $x(0) = 0$, $\dot{x}(0) = 0.5\text{m/s}$
- 3) Make your own problem and solve it.

추가문제

사다리꼴 입력

```
% 사다리꼴 입력 생성
dt=0.01;
t1=0:dt:3;
u1=0:1/(0.5/dt):1;
u2(1,1:(2/dt)-1)=1;
u3=1:(-1/(0.5/dt)):0;
t2=3+dt:dt:10;
u4=zeros(1,length(t2));
u=[u1 u2 u3 u4];
t=[t1 t2];

% 입력 그리기
plot(t,u,'k:')
hold on
```

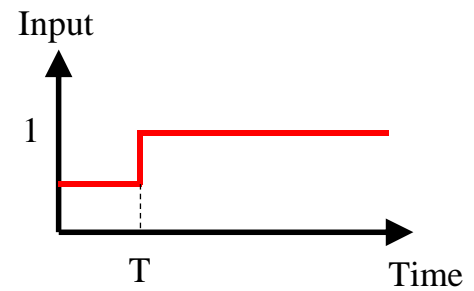


```
% 전달함수
num=[25];
den=[1 1 25];
sys=tf(num,den);

% 응답계산 및 그리기
y=lsim(sys,u,t);
plot(t,y,'b')
```

입력성형

```
% 기준입력 및 시간열 생성
u=ones(1,400);
dt=0.01; % 시간간격
t=0:dt:(length(u)-1)*dt;
% 대상 시스템 정의 (비감쇠)
fn=1; wn=fn*2*pi; % rad/s
zeta=0.0;
sys=tf(wn^2,[1 2*zeta*wn wn^2]);
% 두 번째 임펄스 시간 위치
fd=fn*sqrt(1-zeta^2);
T=1/fd/2;
% ZV 성형된 계단입력 구성
us=u;
us(1,1:T/dt)=0.5;
```



```
% 응답계산 및 결과 그리기
[ys,ts]=lsim(sys,us,t);
plot(t,us,'k:',ts,ys,'b')
```