Introduction
Frequency-Response Analysis

MATLAB and Simulink

Create Transfer Function

Transfer function is

$$G(s) = \frac{num}{den}$$

Example

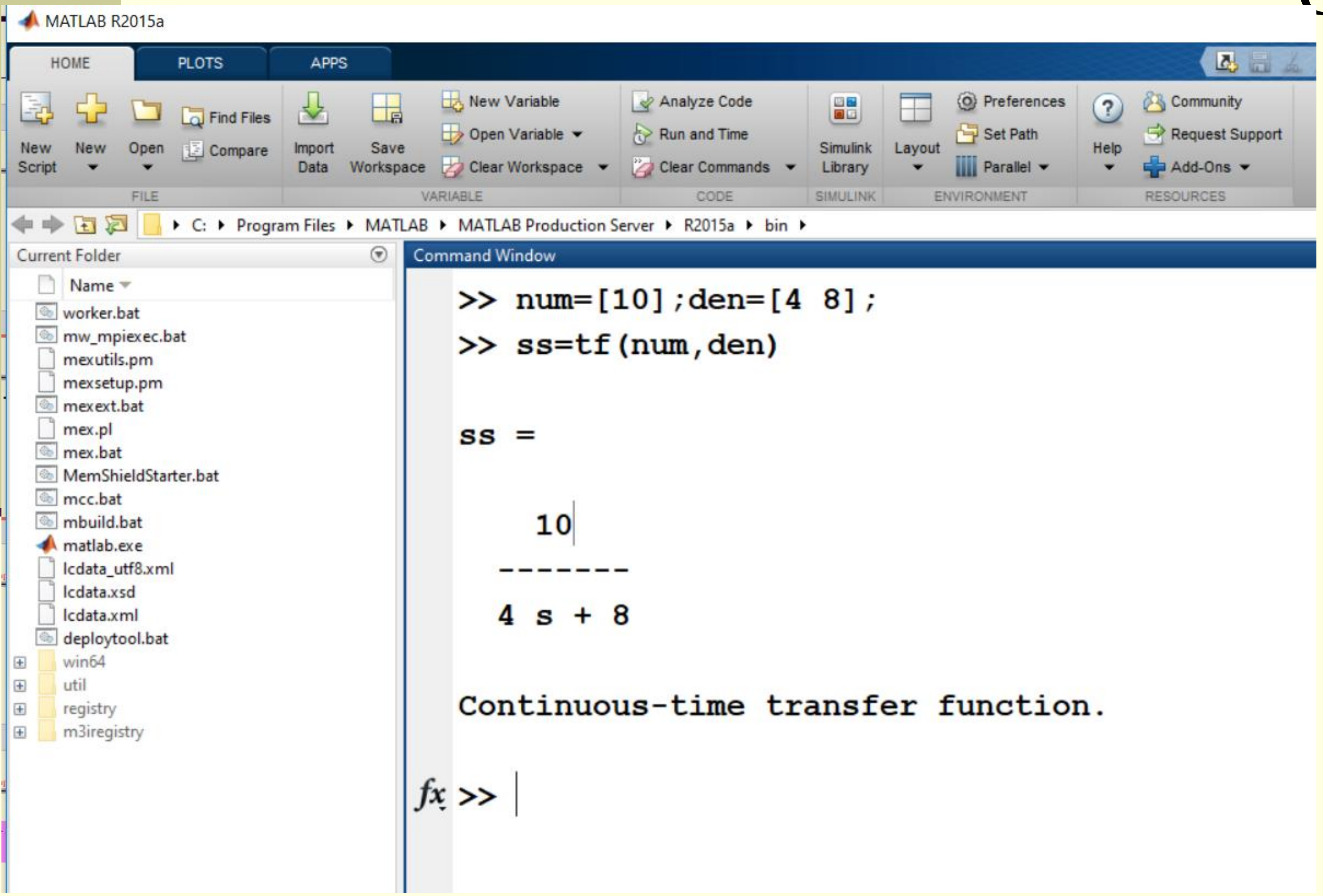
$$G(s) = \frac{10}{4s + 8}$$

```
>> num=[10];den=[4 8];
>> ss=tf(num,den)
```

Create Transfer Function

Example Transfer function is

$$G(s) = \frac{10}{4s+8}$$



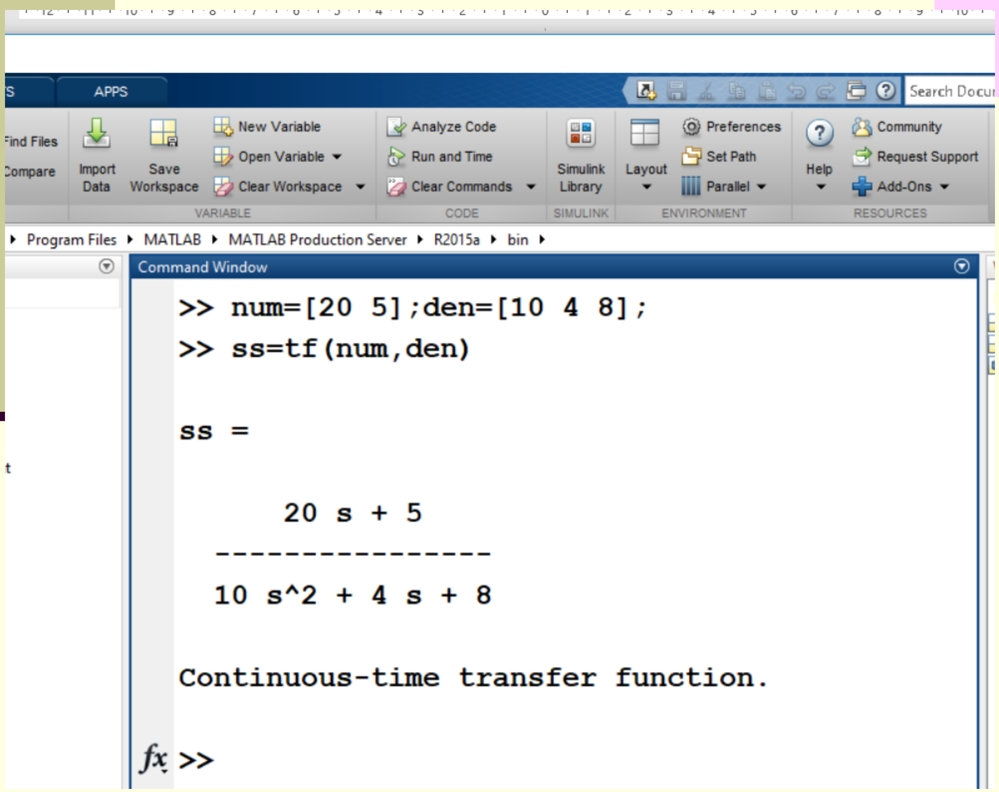
Create Transfer Function

Example

Transfer function is

$$G(s) = \frac{20s + 5}{10s^2 + 4s + 8}$$

```
>> num=[20 5];den=[10 4 8];
> ss=tf(num,den)
```



Plot Bode Diagram

Example No.I

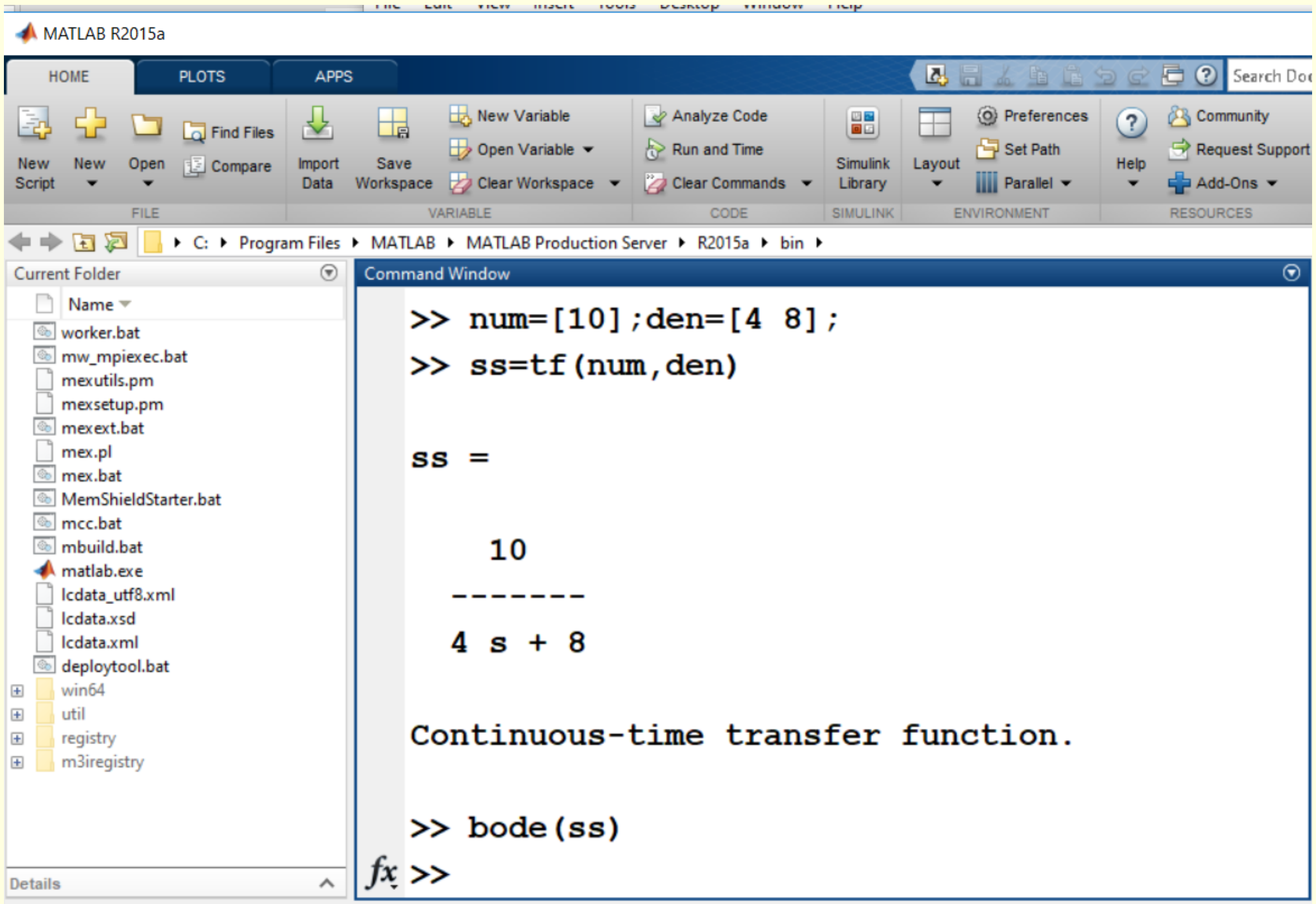
$$G(s) = \frac{10}{4s + 8}$$

```
>> num=[10];den=[4 8];
>> ss=tf(num,den)
>> bode(ss)
```

Plot Bode Diagram

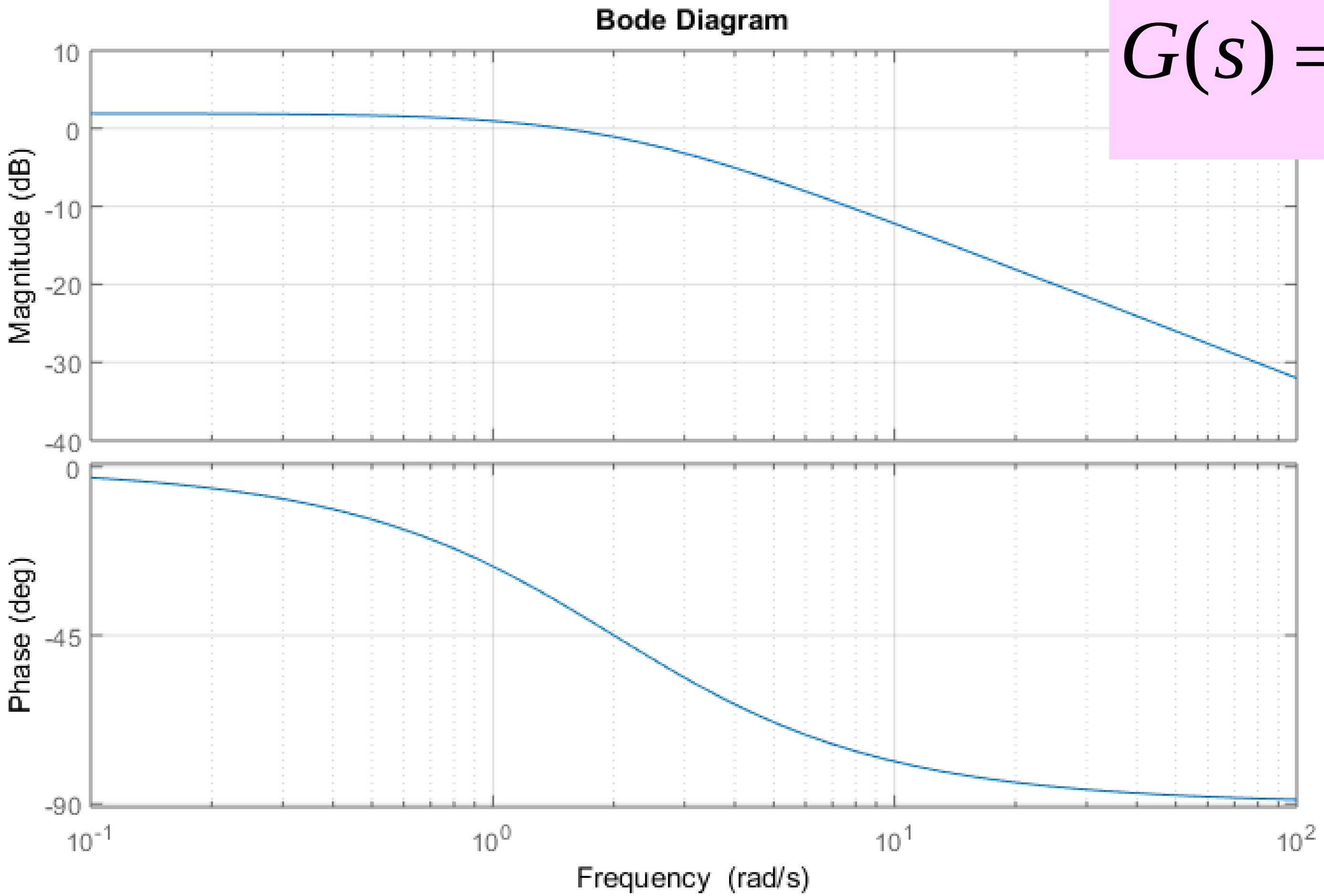
Example

$$G(s) = \frac{10}{4s+8}$$



Plot Bode Diagram

$$G(s) = \frac{10}{4s+8}$$



Plot Bode Diagram

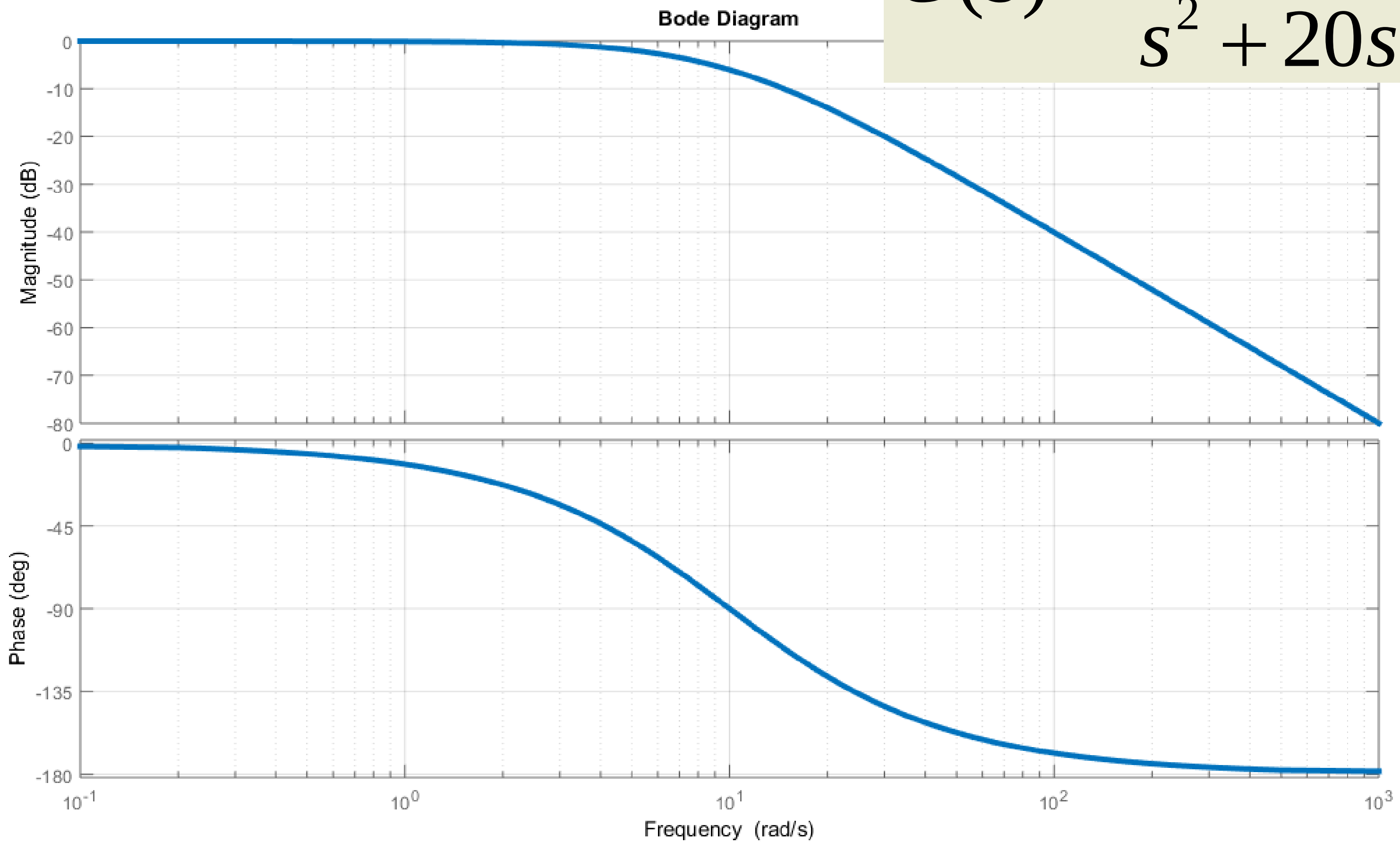
Example No.II

$$G(s) = \frac{100}{s^2 + 20s + 100}$$

```
>> num=[100];den=[1 20 100];
>> ss=tf(num,den);
>> bode(ss)
```

Plot Bode Diagram

$$G(s) = \frac{100}{s^2 + 20s + 100}$$



Introduction
Frequency-Response Analysis

MATLAB and Simulink

Frequency-Response Analysis

First-order transfer function(Closed-loop TF)

$$G(s) = \frac{K}{Ts+1}$$

<u>Example</u>

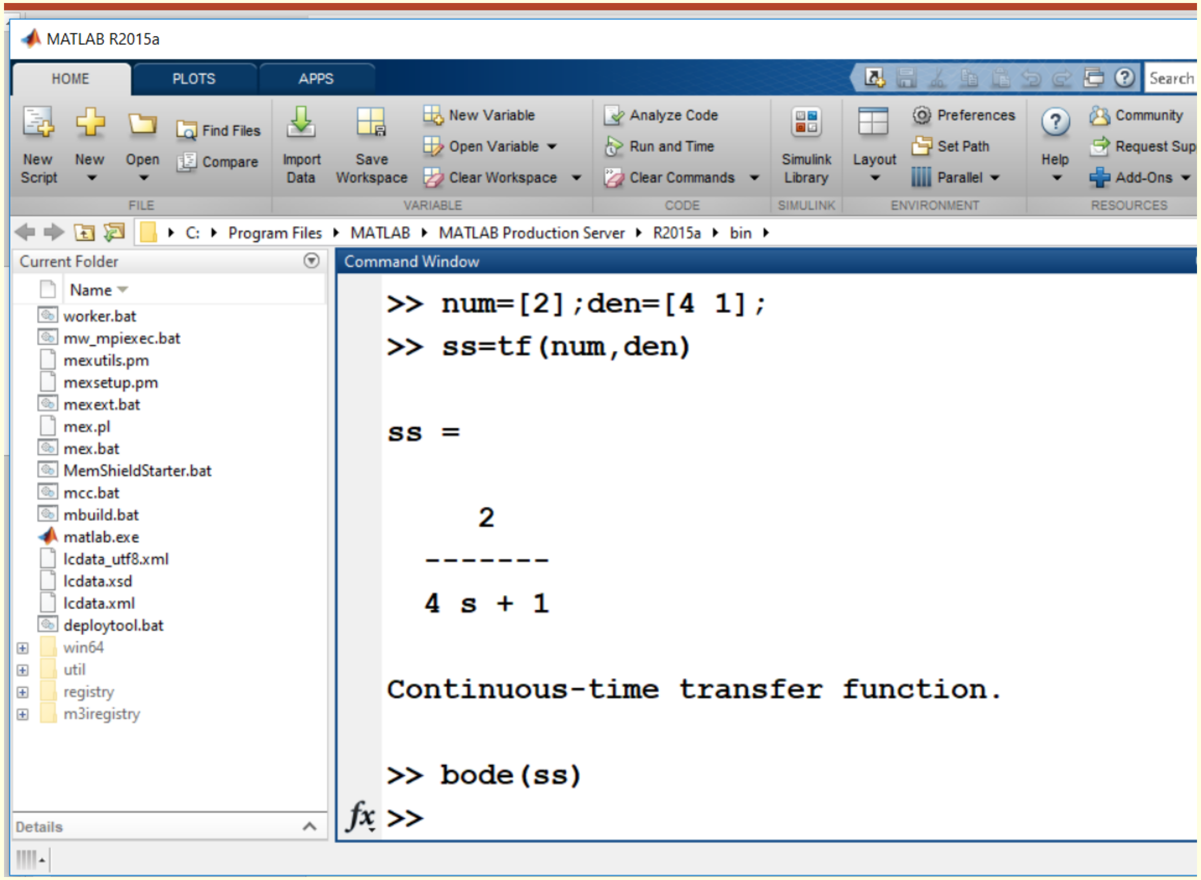
$$G(s) = \frac{2}{4s+1}; \qquad K = 2 \text{ and } T = 4$$

```
>> num=[2];den=[4 1];
>> ss=tf(num,den);
>> bode(ss)
```

Frequency-Response Analysis

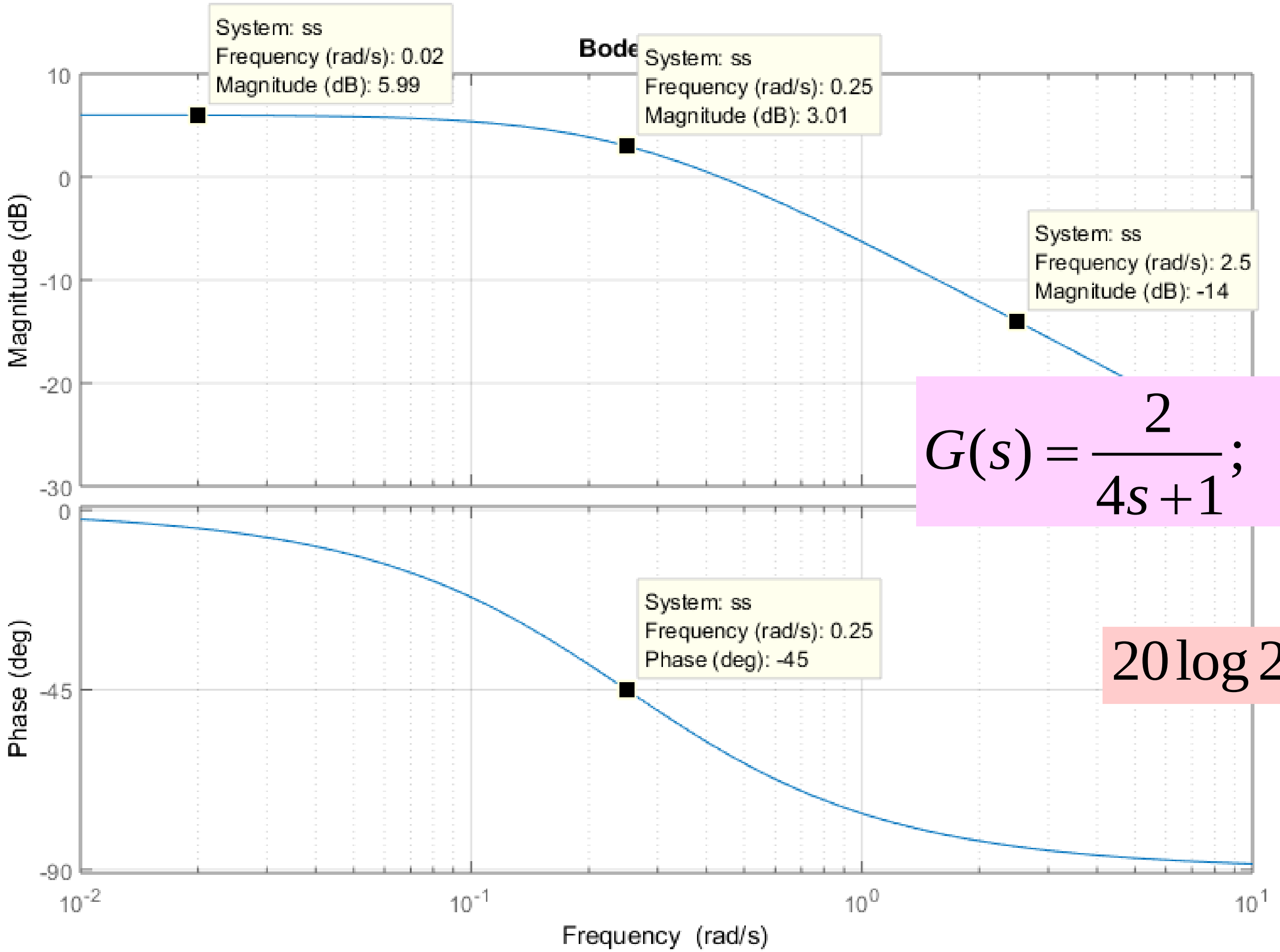
First-order transfer function

$$G(s) = \frac{2}{4s+1}; \qquad K = 2 \text{ and } T = 4$$



Frequency-Response Analysis

First-order transfer function



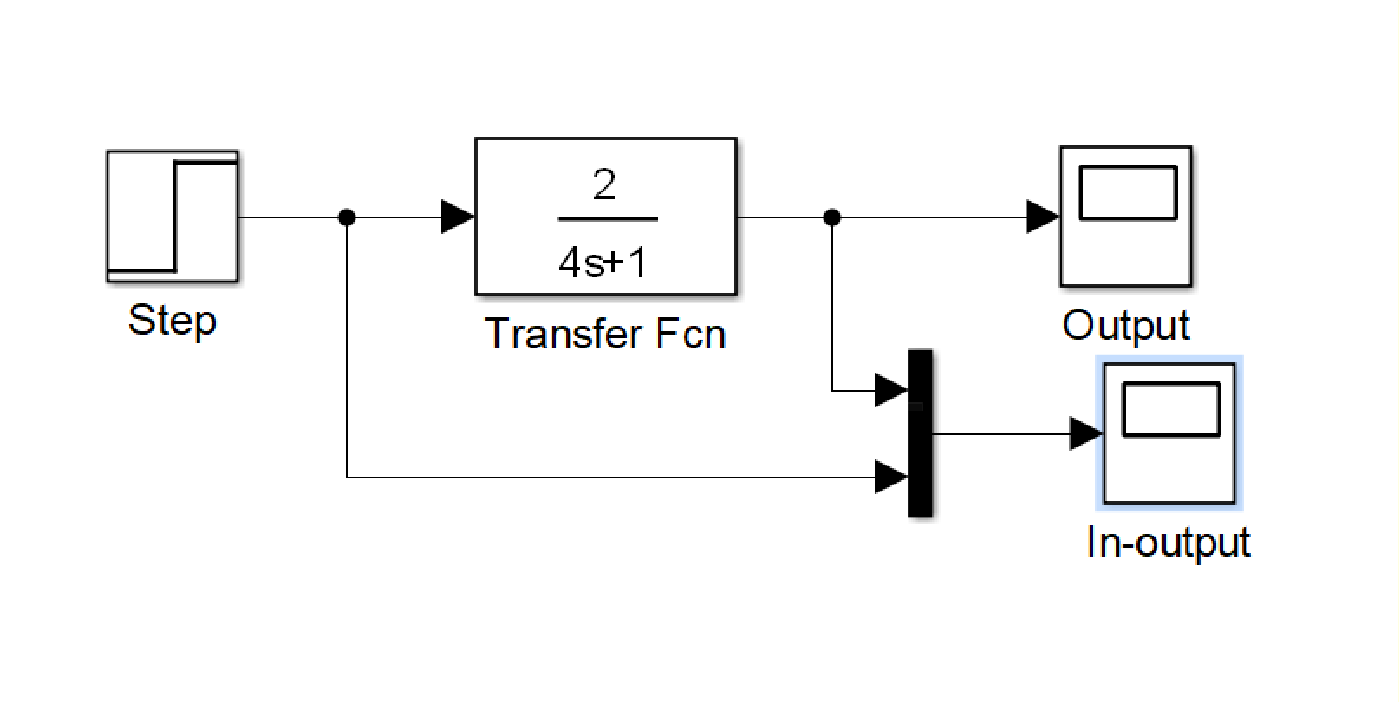
$$G(s) = \frac{2}{4s+1}; \quad K = 2 \text{ and } T = 4$$

$$20 \log 2 = 6 \ \text{ dB}$$

Frequency-Response Analysis

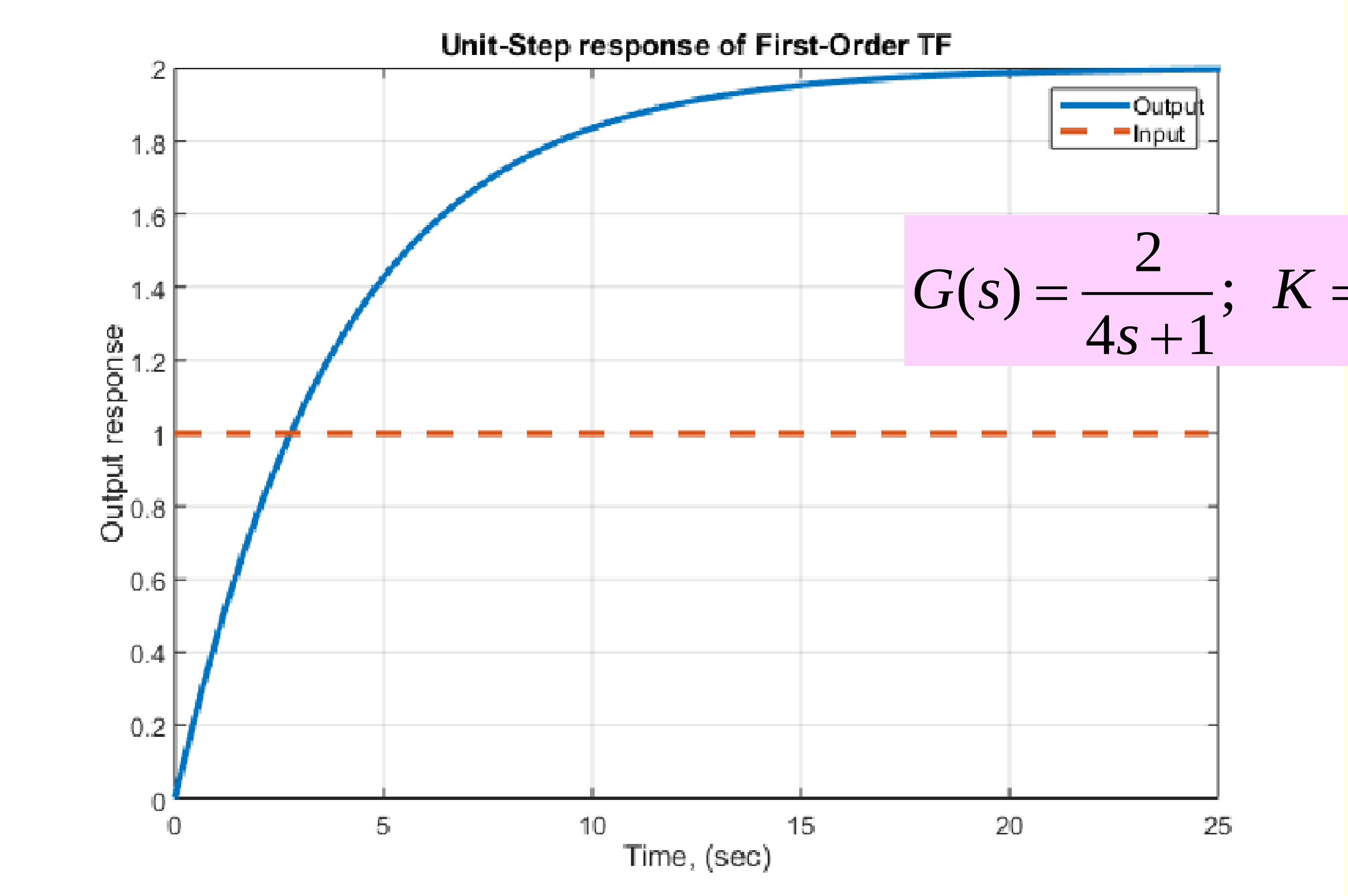
First-order transfer function - Time domain

$$G(s) = \frac{2}{4s+1}; \quad K = 2 \text{ and } T = 4$$



Frequency-Response Analysis

First-order transfer function - Time domain



$$G(s) = \frac{2}{4s+1}; \quad K = 2 \text{ and } T = 4$$

Frequency-Response Analysis

Second-order transfer function(Closed-loop TF)

$$G(s) = \frac{K\omega_n^2}{s^2 + 2\zeta\omega_n s + \omega_n^2}$$

Example

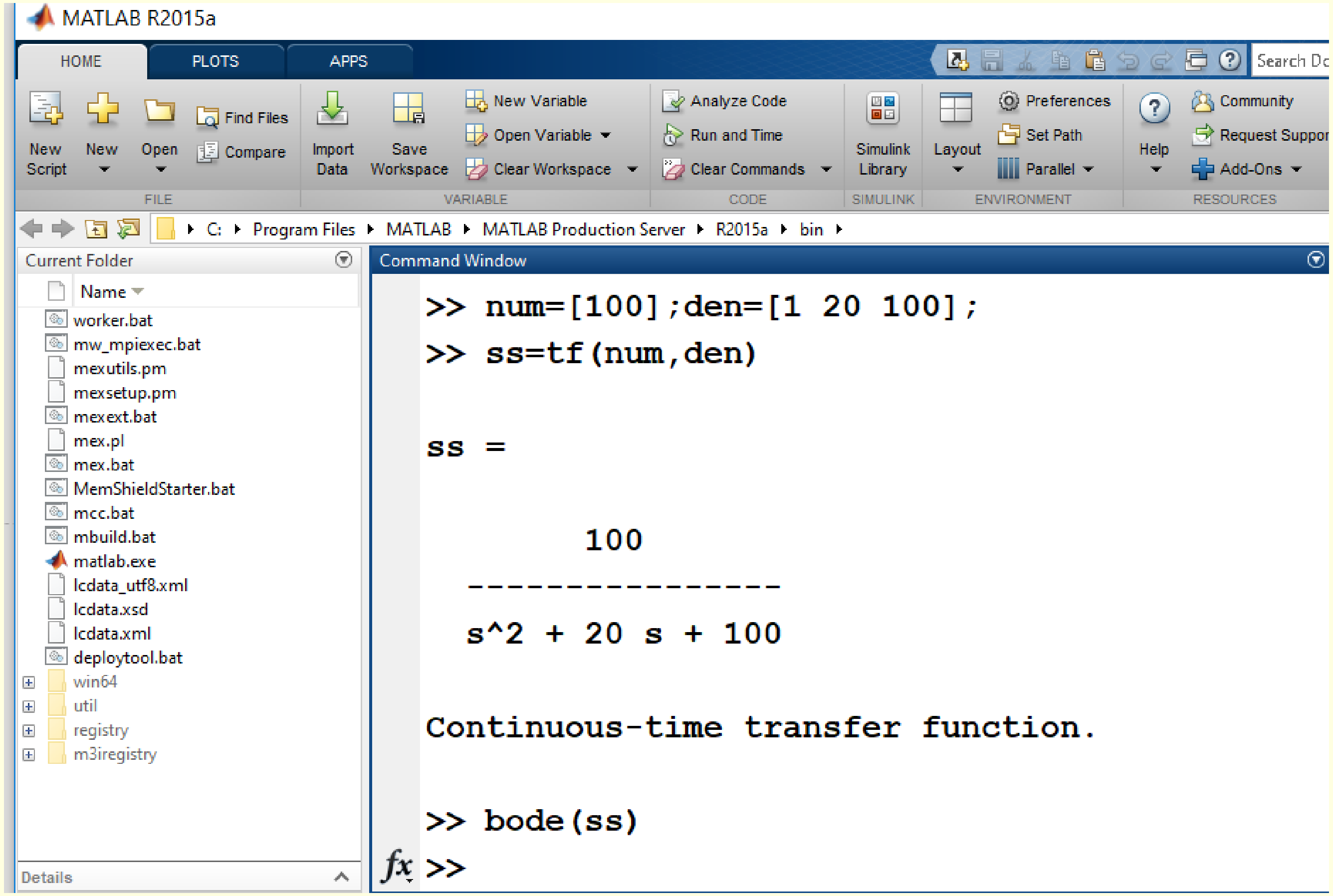
$$G(s) = \frac{100}{s^2 + 20s + 100}; \qquad K = 100, \zeta = 1 \text{ and } \omega_n = 10 \text{ rad/sec}$$

```
>> num=[100];den=[1 20 100];
>> ss=tf(num,den);
>> bode(ss)
```

Frequency-Response Analysis

Second-order transfer function

$$G(s)=\frac{100}{s^2+20s+100}; \qquad K=100, \zeta=1 \text{ and } \omega_n=10 \ \text{ rad/sec}$$

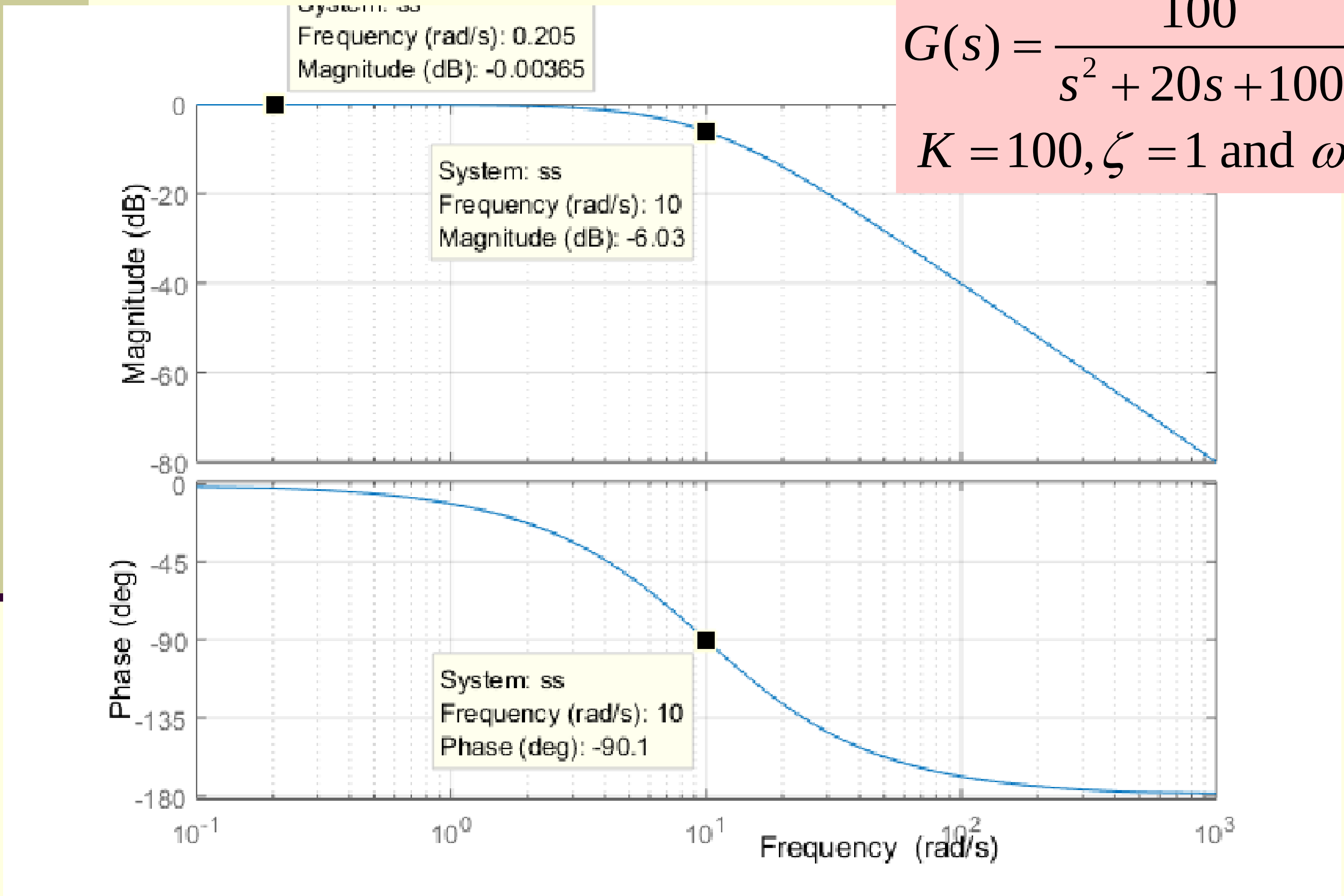


Frequency-Response Analysis

Second-order transfer function

$$G(s) = \frac{100}{s^2 + 20s + 100};$$

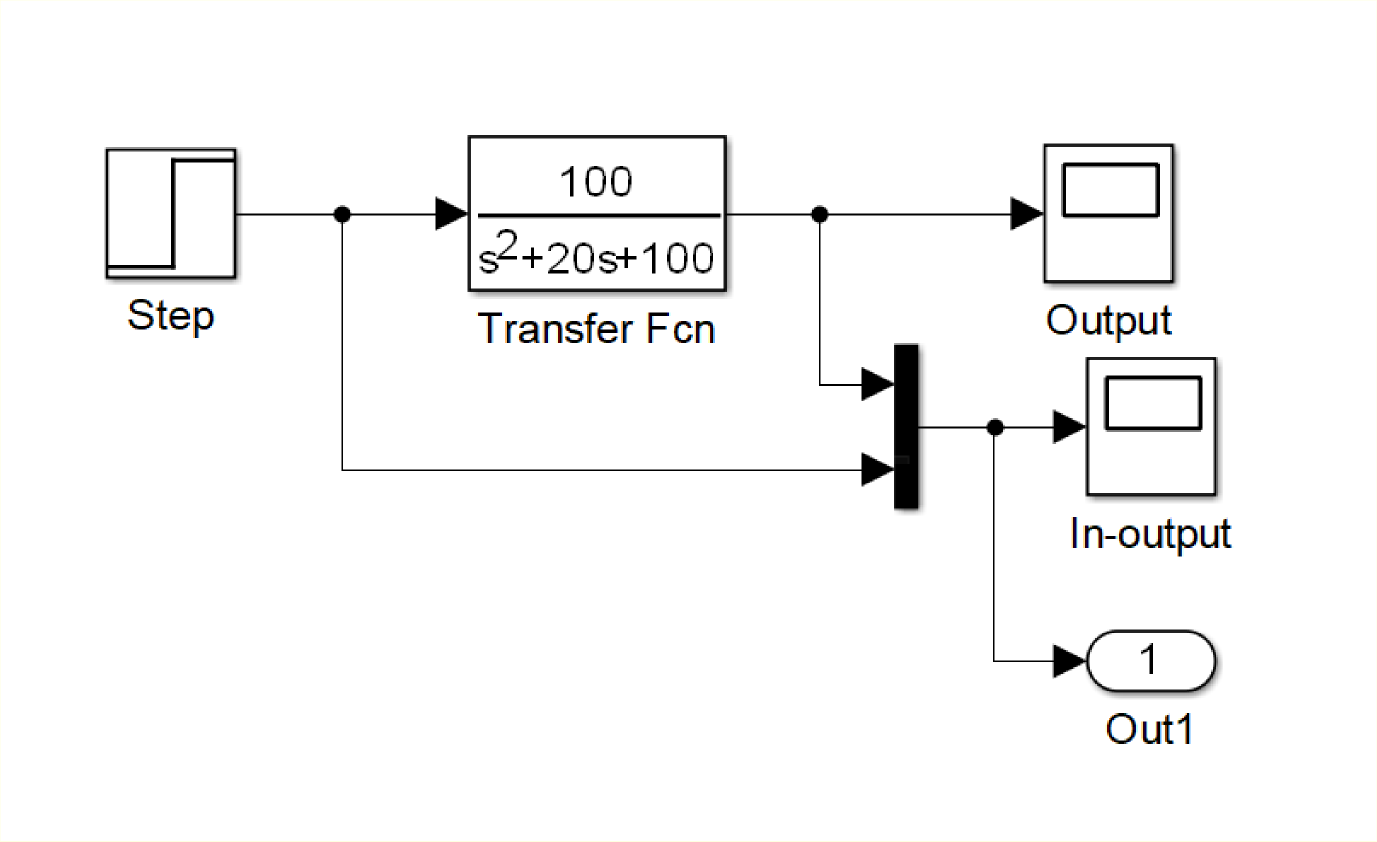
$$K = 100, \zeta = 1 \text{ and } \omega_n = 10 \ \text{rad/sec}$$



Frequency-Response Analysis

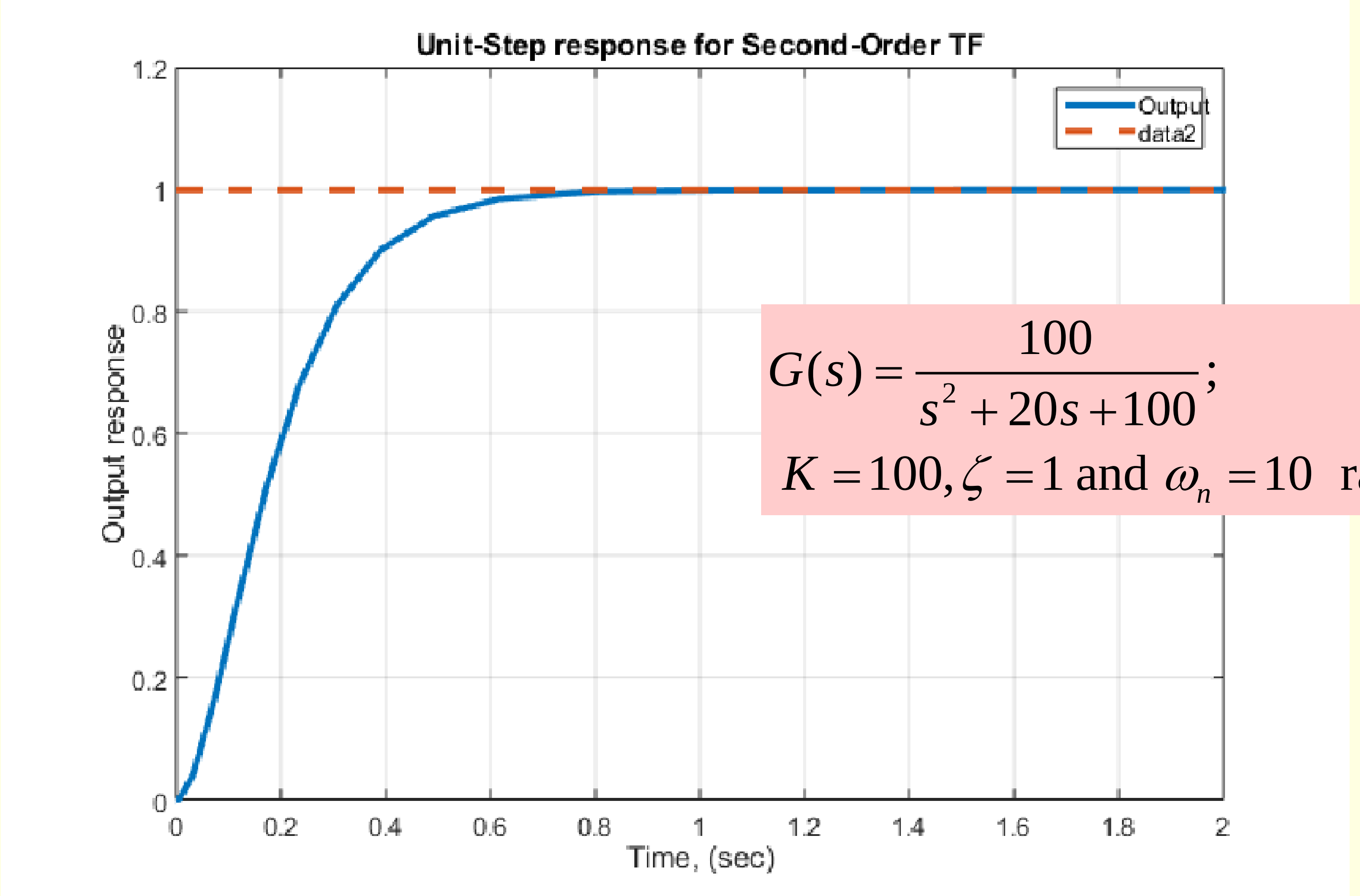
Second-order transfer function - Time domain

$$G(s) = \frac{100}{s^2 + 20s + 100}; \qquad K = 100, \zeta = 0.5 \text{ and } \omega_n = 10 \ \text{ rad/sec}$$



Frequency-Response Analysis

Second-order transfer function - Time domain



$$G(s)=\frac{100}{s^2+20s+100};$$

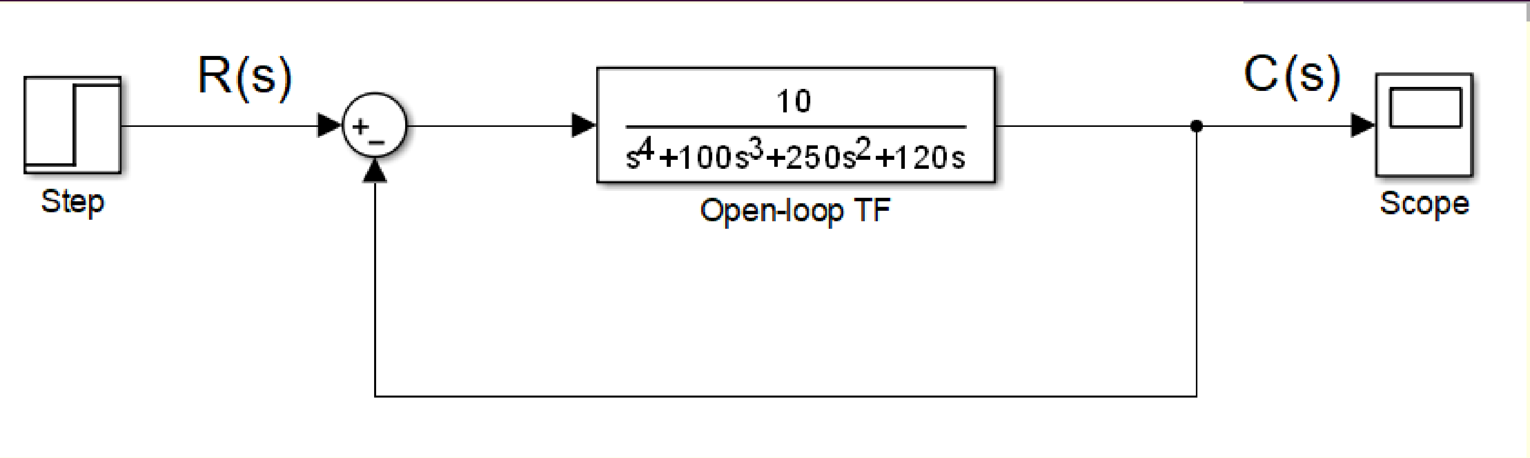
$$K=100, \zeta=1 \text{ and } \omega_n=10 \text{ rad/sec}$$

Stability Analysis by FRA

- Unity feedback system
- Open-loop transfer function via Bode Diagram
  - Gain Margin(GM)
  - Phase Margin(PM)
  - Percent overshoot and damping ratio

Gain Margin(GM) and Phase Margin(PM)

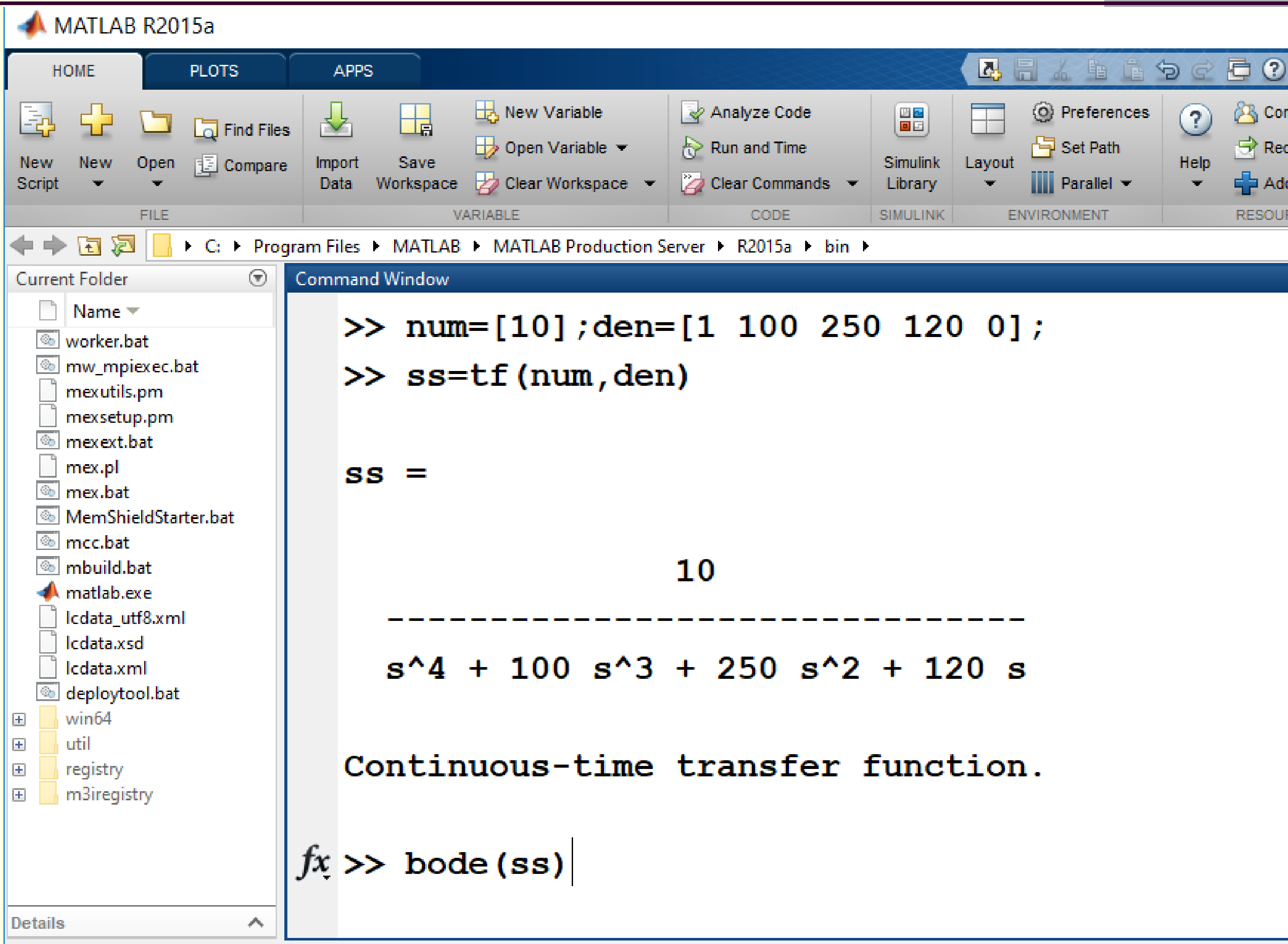
Stable system




```
>> num=[10];den=[1 100 250 120 0];
>> ss=tf(num,den);
>> bode(ss)
```

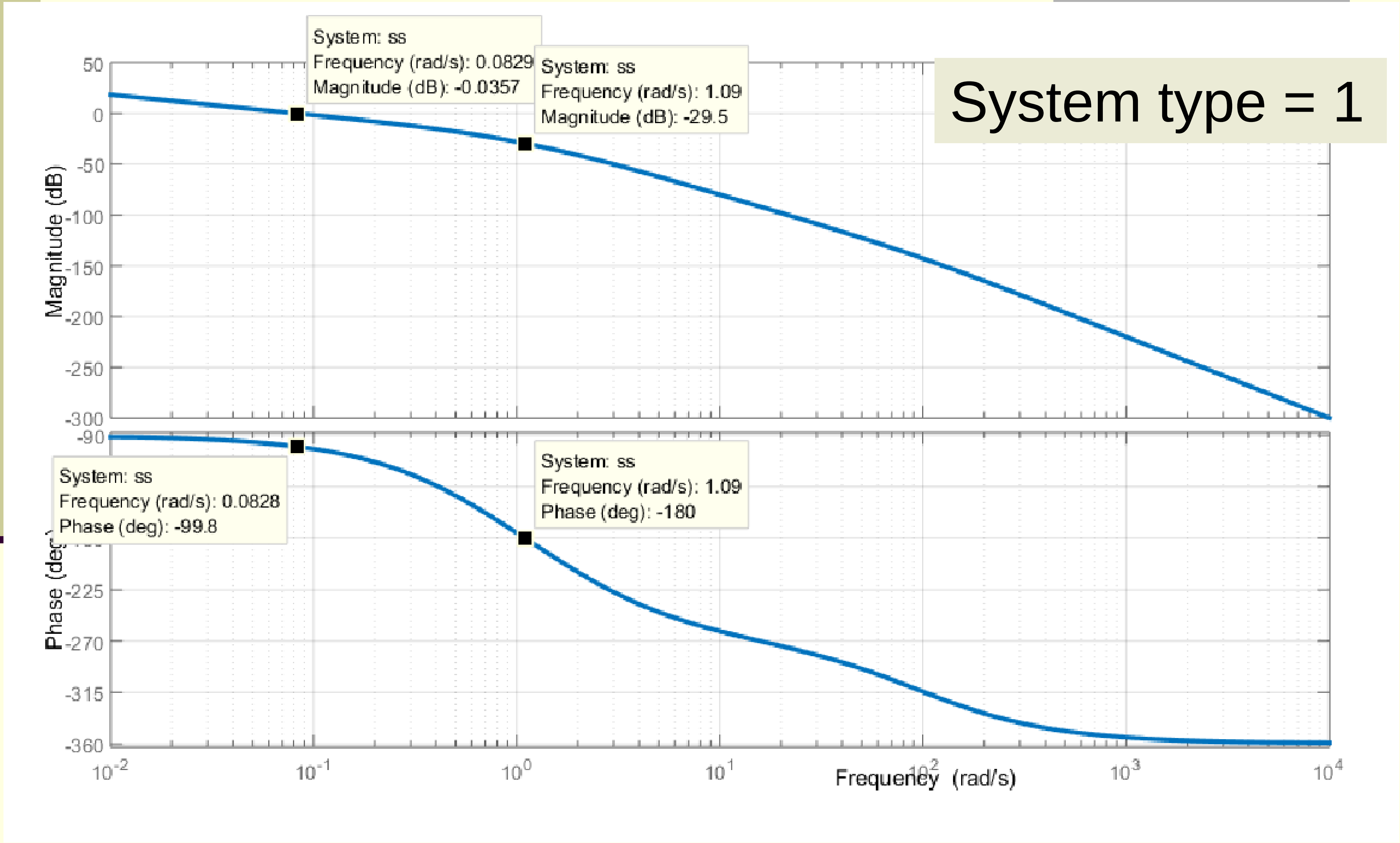
Gain Margin(GM) and Phase Margin(PM)

Stable system



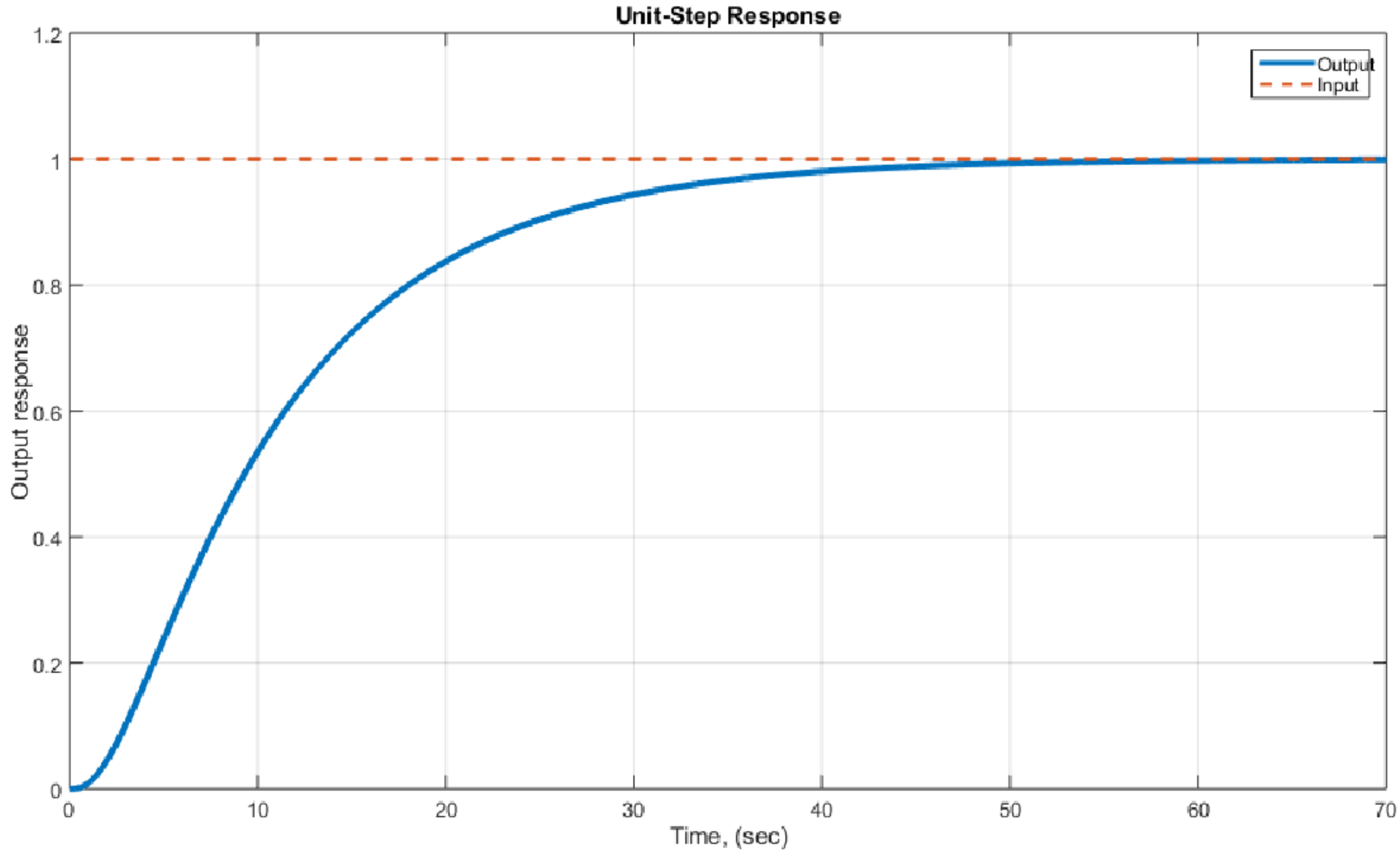
Gain Margin(GM) and Phase Margin(PM)

Stable system

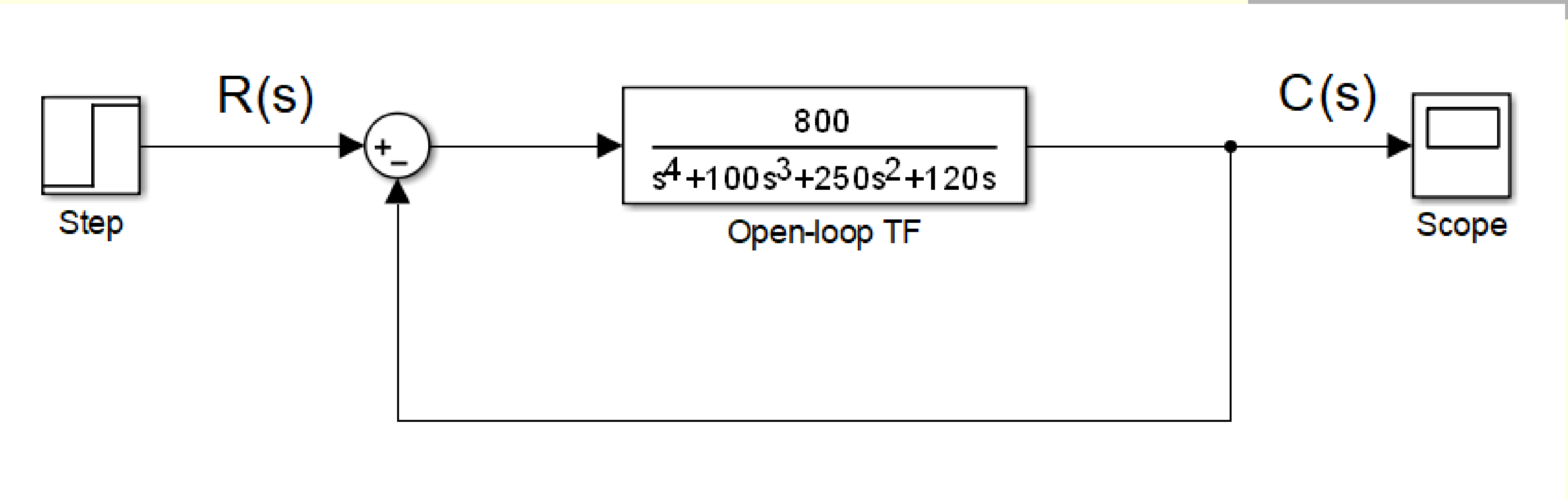


Gain Margin(GM) and Phase Margin(PM)

Stable system

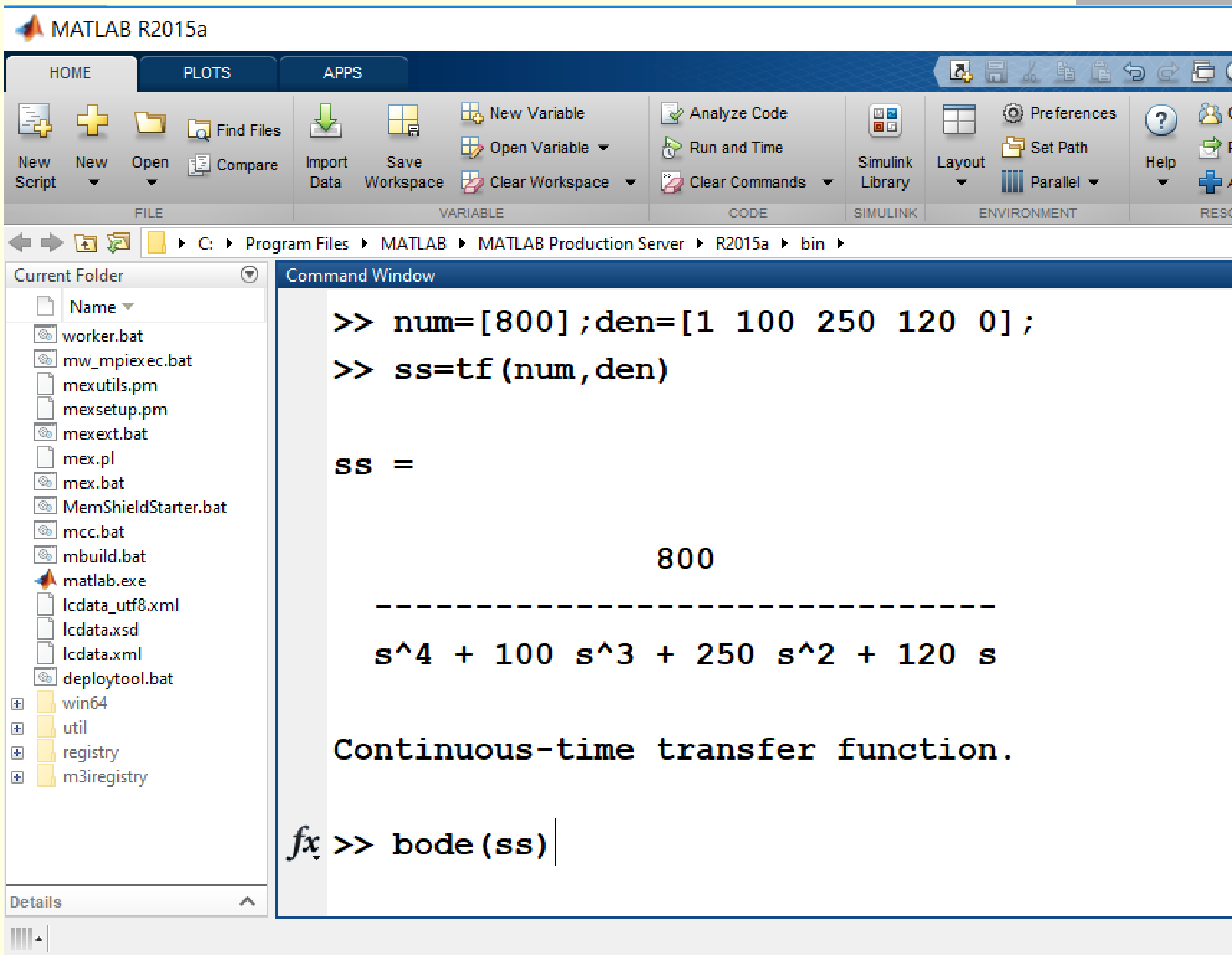


Gain Margin(GM) and Phase Margin(PM)

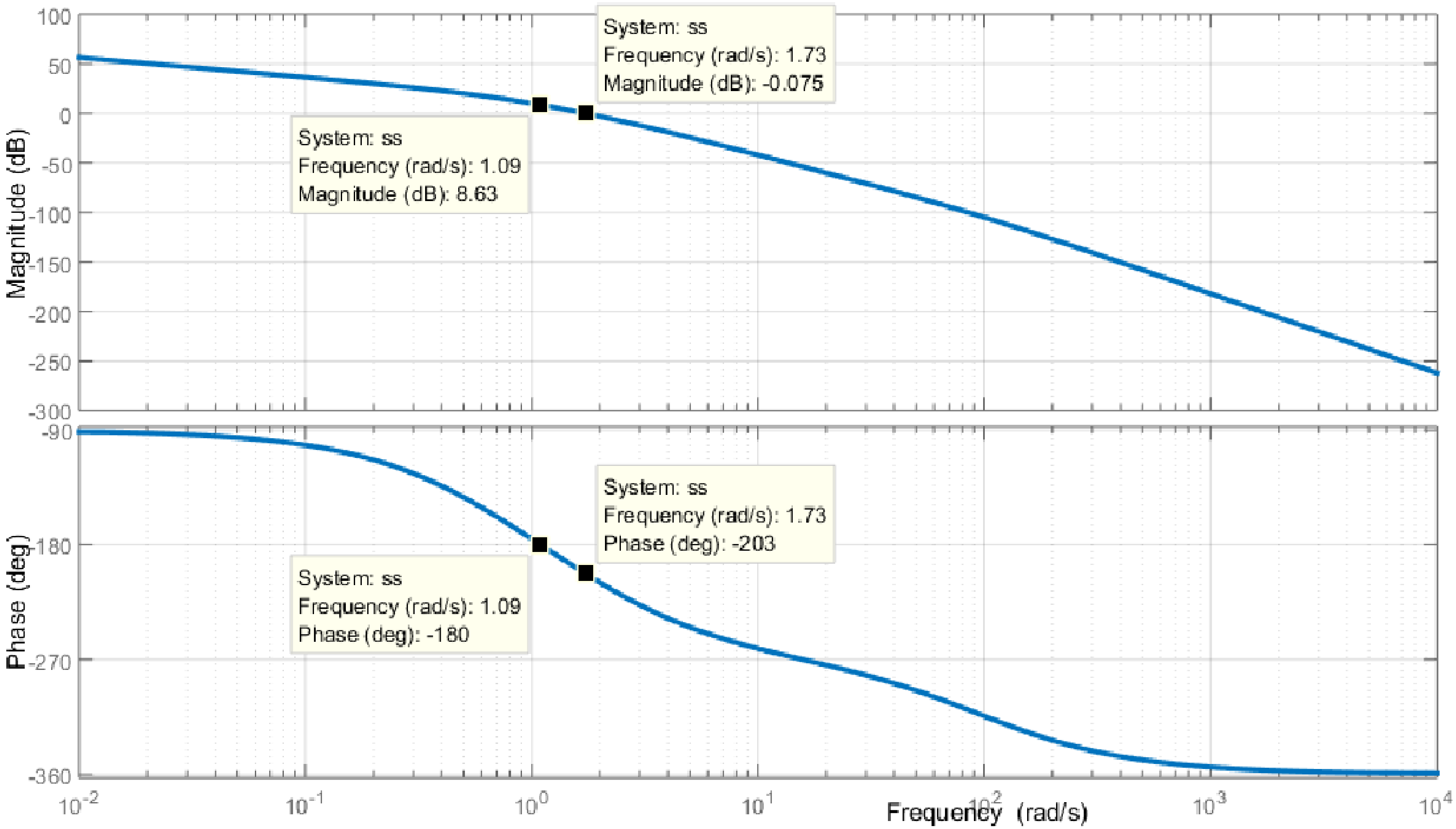



```
>> num=[800];den=[1 100 250 120 0];
>> ss=tf(num,den);
>> bode(ss)
```

Gain Margin(GM) and Phase Margin(PM)



Gain Margin(GM) and Phase Margin(PM)



Gain Margin(GM) and Phase Margin(PM)

Unstable system