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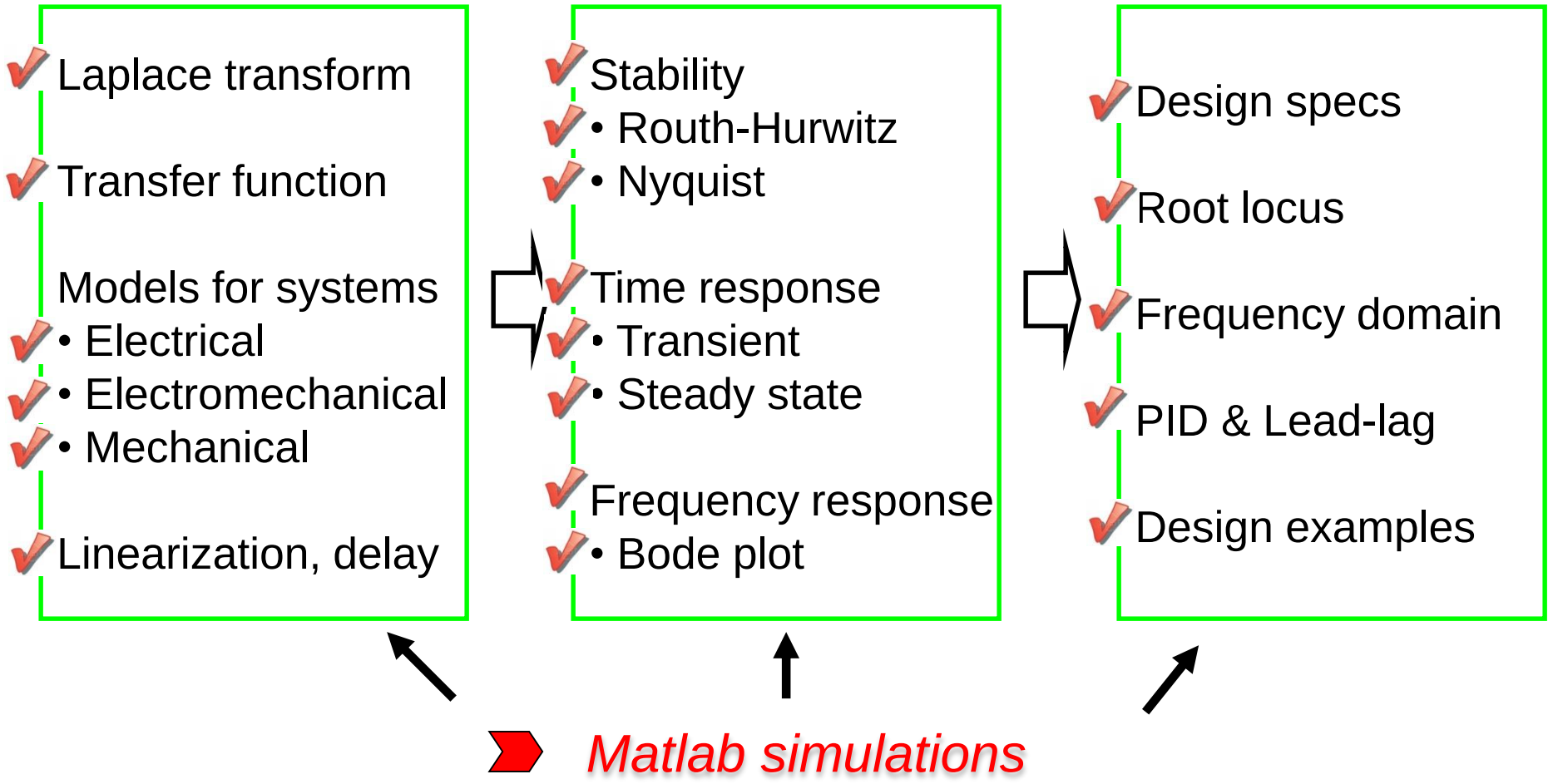
ELEC 341: Systems and Control

Lecture 21

Frequency response shaping with Matlab (Simulink simulation)

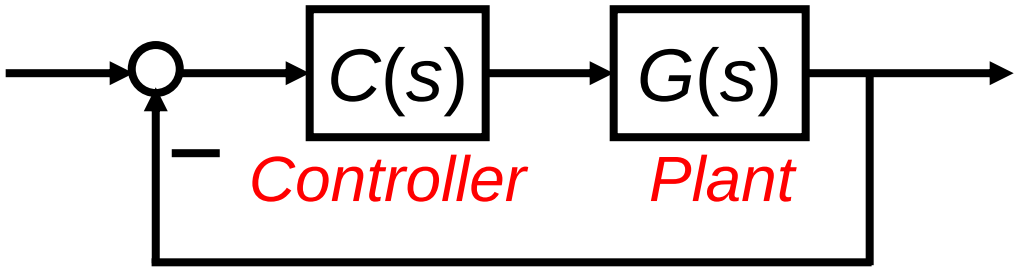
Course roadmap



Example 1 (SISO Design Tool in Matlab)

- Consider a system

$$G(s) = \frac{4}{s(s+1)(s+2)}$$



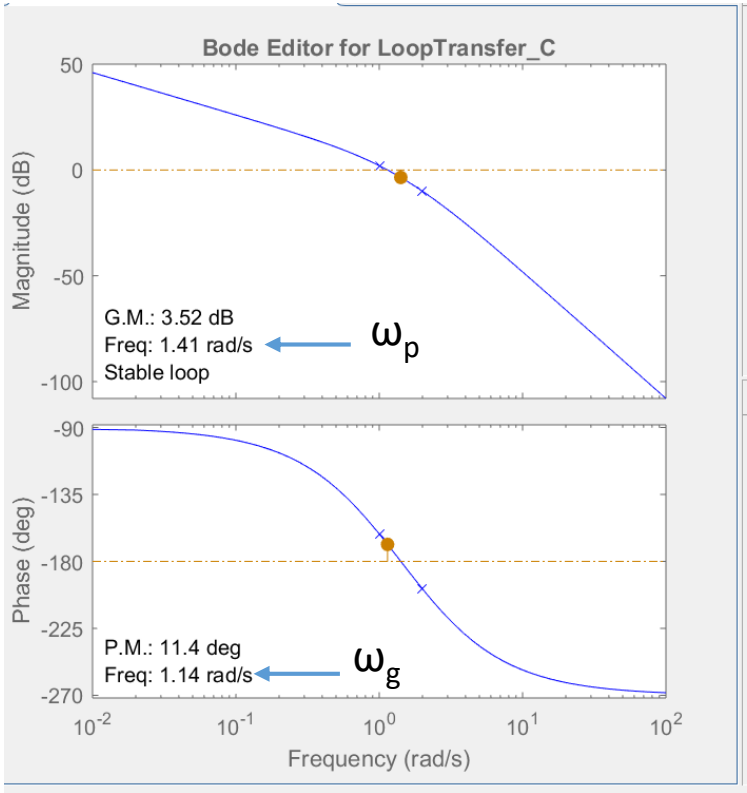
- Specs
  - Closed-loop system is stable
  - PM at least 50 deg
  - 2% Settling time < 4 s
  - Steady-state error
    - For unit step input: $e_{ss} = 0$

Example 1 (cont'd)

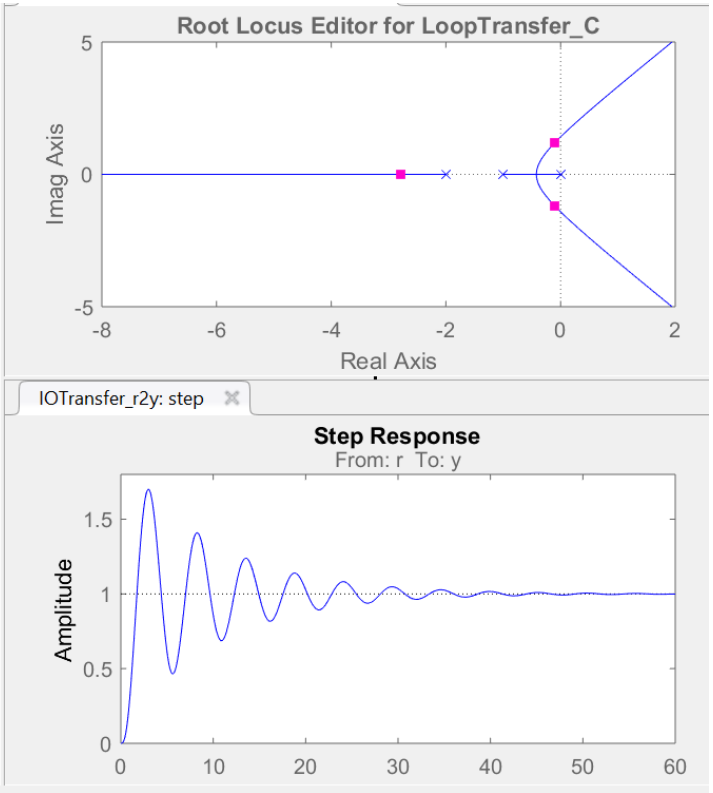
```
>> s = tf('s')
Transfer function:
s
>> sysG = 4/s/(s+1)/(s+2)
Transfer function:
        4
-----------------
s^3 + 3 s^2 + 2 s
>> sisotool(sysG)
```

Default setting: $C(s)=1$

OL Bode plot



Root locus



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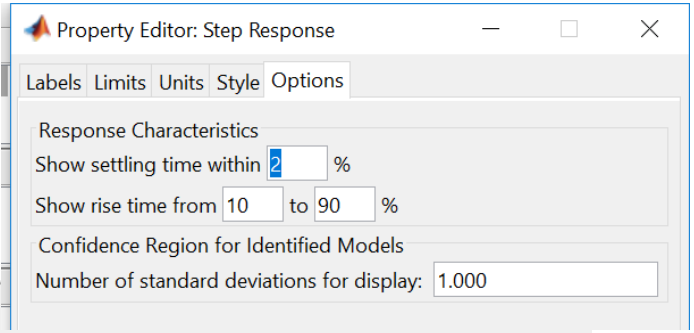
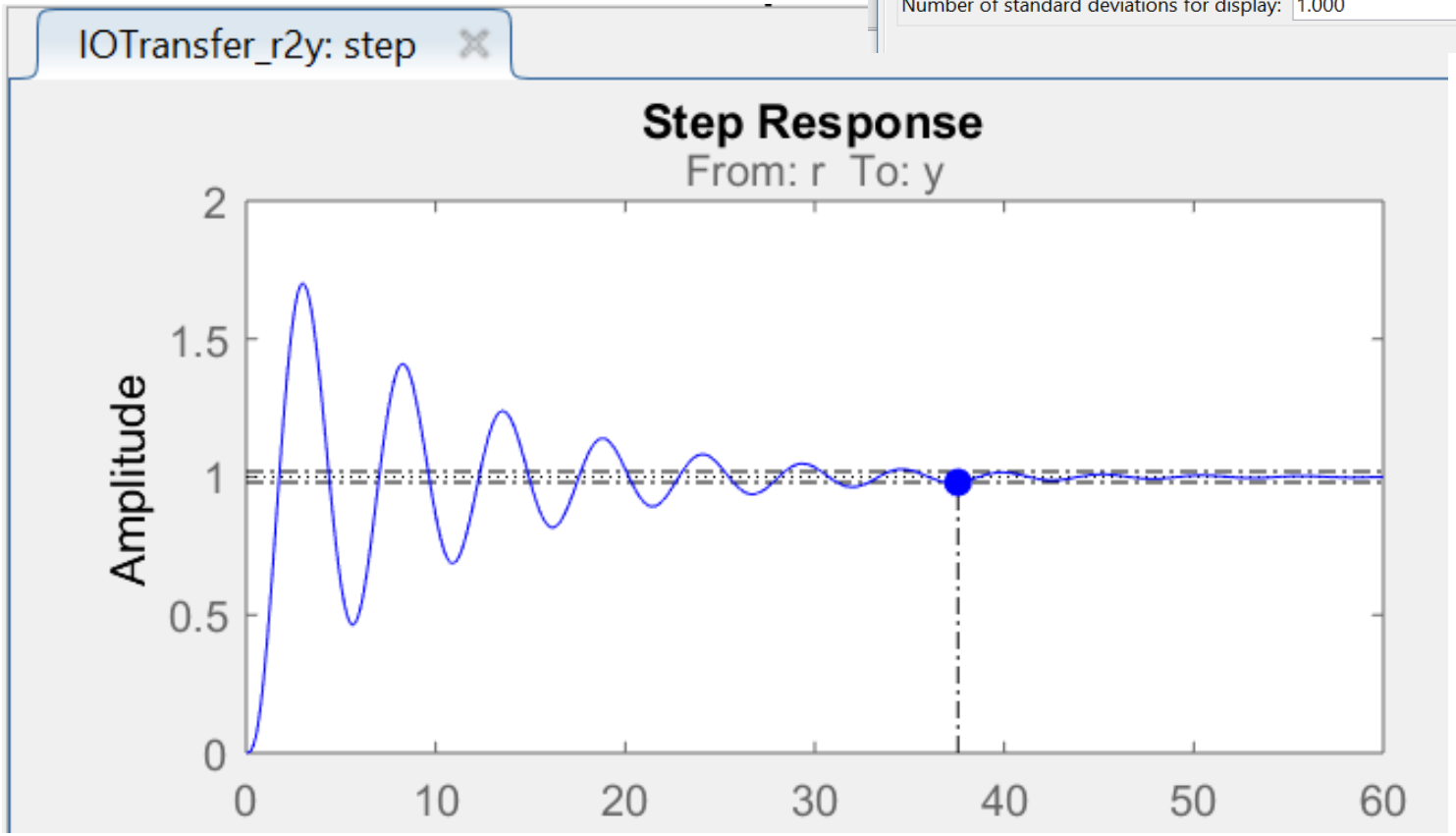
Example 1 (cont'd)

- Show settling time
  - Right click

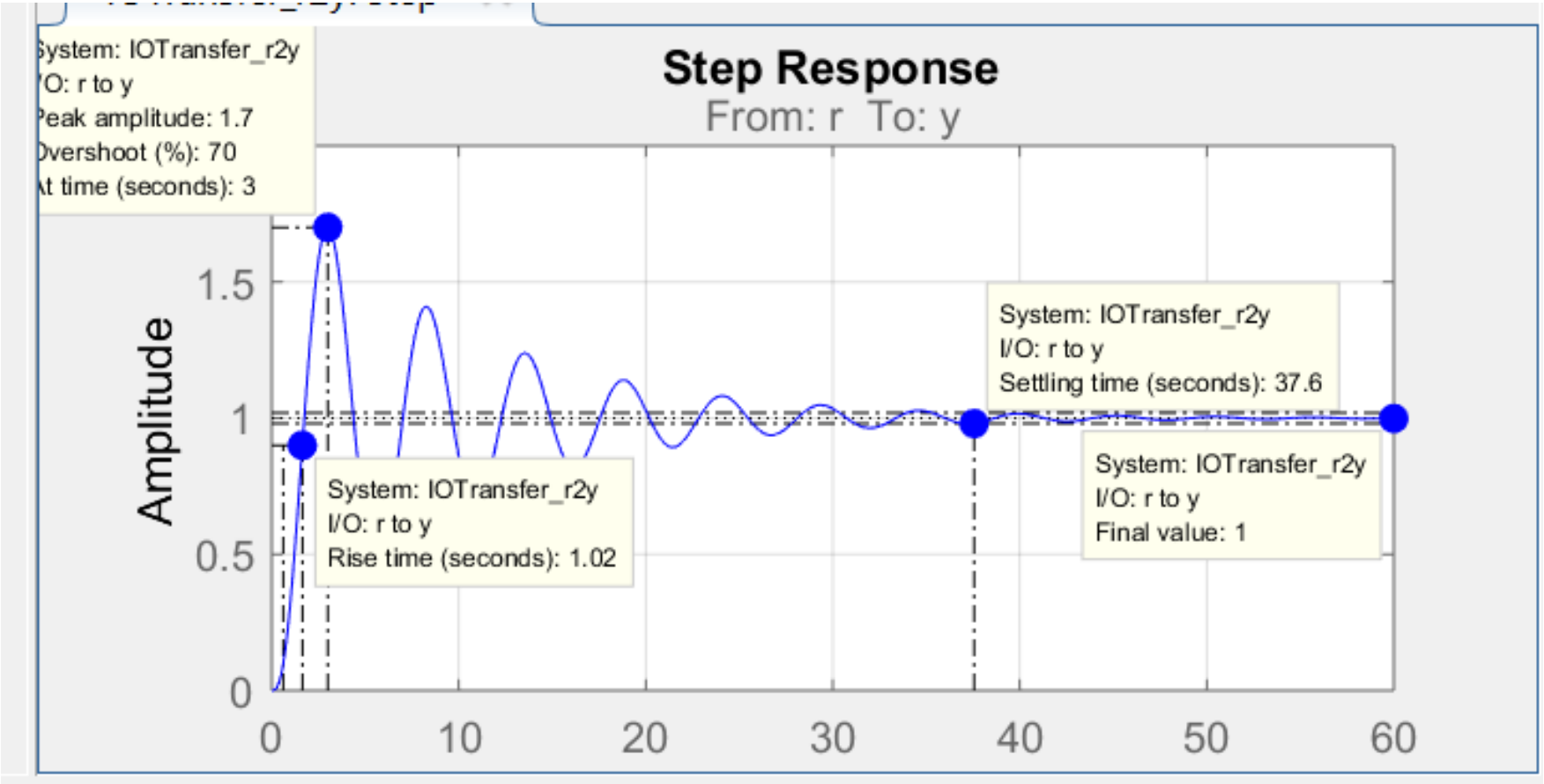
→ Characteristic

→ Settling time





Example 1 (cont'd)



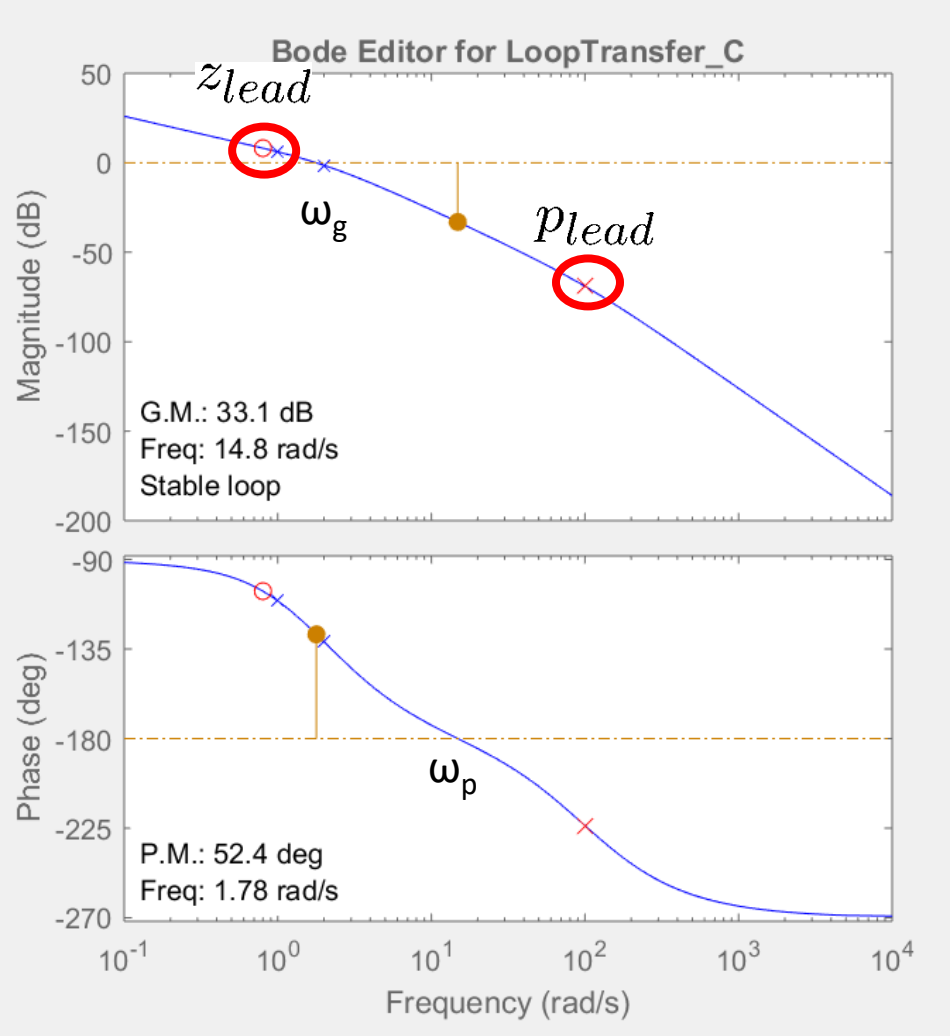
Example 1 (cont'd)

- Add a pole & a zero of a compensator:

$$C_{Lead}(s) = K\frac{s + z_{Lead}}{s + p_{Lead}}$$

- If necessary, move the pole/zero/gain
  - by click-and-drag, or
  - *Design → Edit Compensator…*

```
Tunable Block
Name: C
Sample Time: 0
Value:
  125 (s+0.8)
  -----------
    (s+100)
```



PM (= 52.4) > 50 degree OK!

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Example 1 (cont'd)

Settling time < 4s OK!

Simulink

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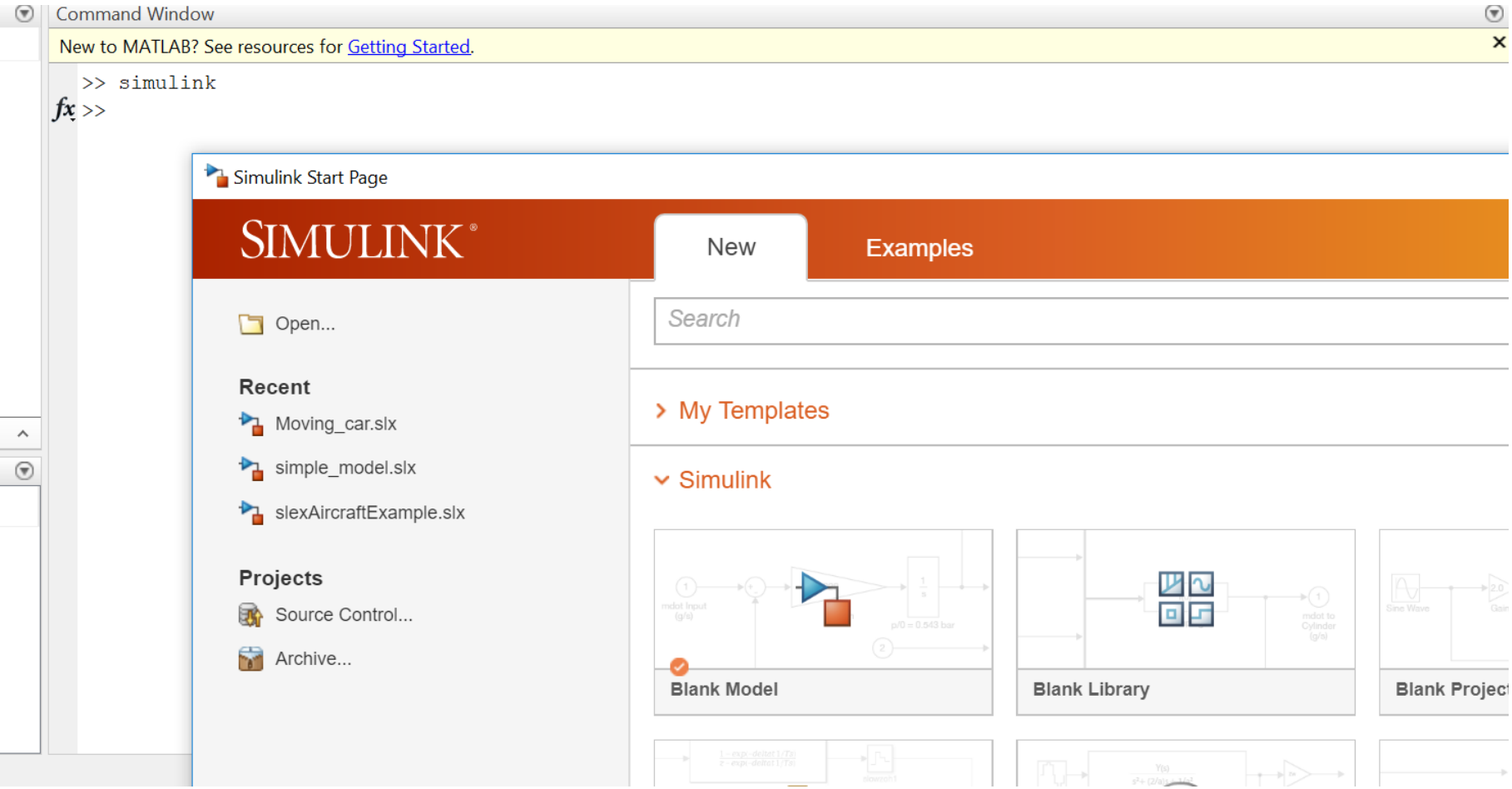
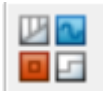
- Simulink, developed by MathWorks, is a graphical programming environment for modeling, simulating, and analyzing dynamic systems. Its primary interface is a graphical block diagramming tool and a customizable set of block libraries. It offers tight integration with the rest of the MATLAB environment.
- It is basically a piece of software for modeling and simulating a system, as well as programing controllers.
- Engineers use Simulink to solve engineering problems in many industries, such as:
  - Automotive
  - Biomedical
  - Aerospace
  - Process industries
  - Communications
  - Industrial automation
  - Electronics
  - etc.

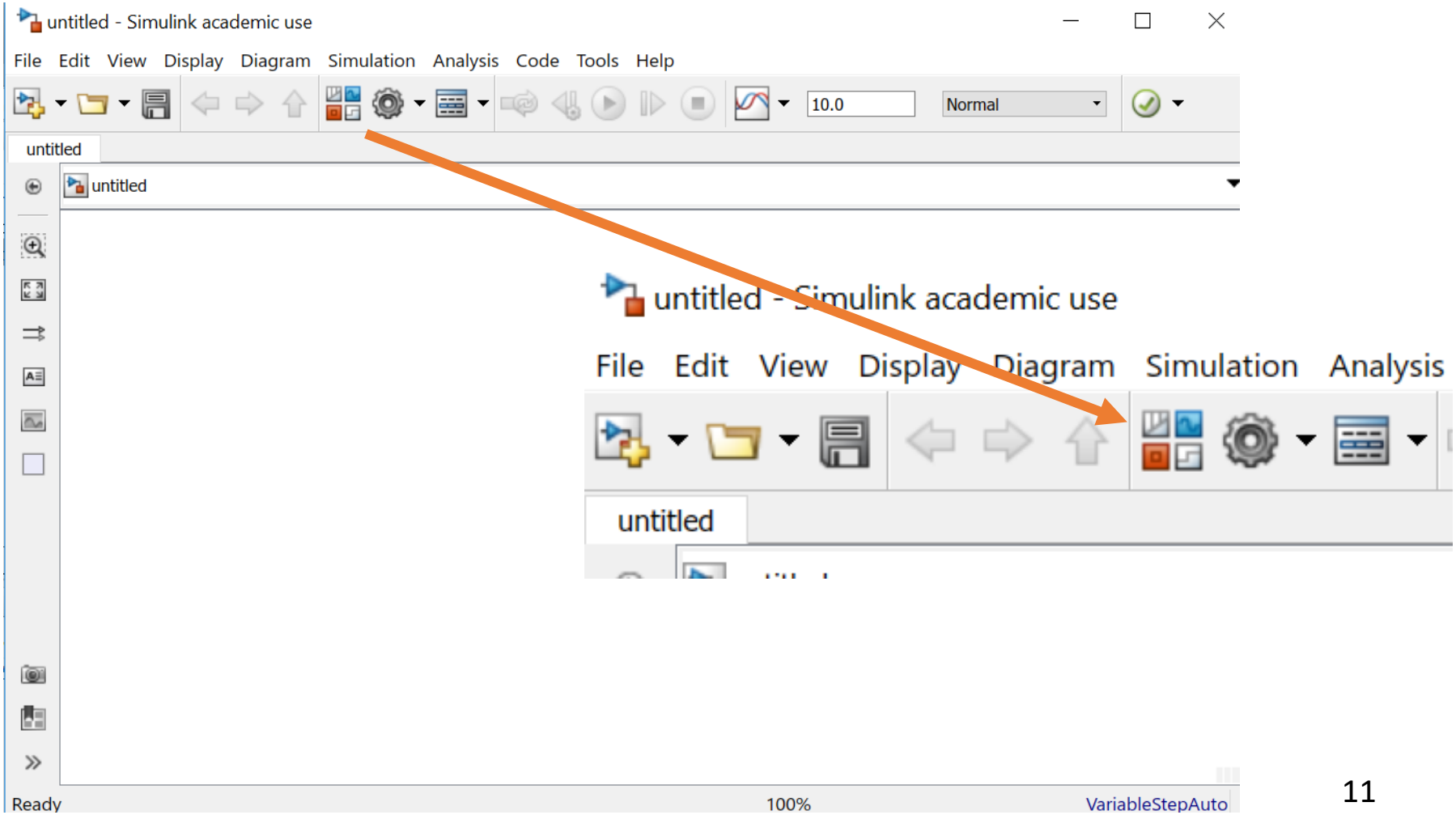
Example 2 (cont'd)

- In MATLAB prompt, type "simulink".
- Click on Blank Model.



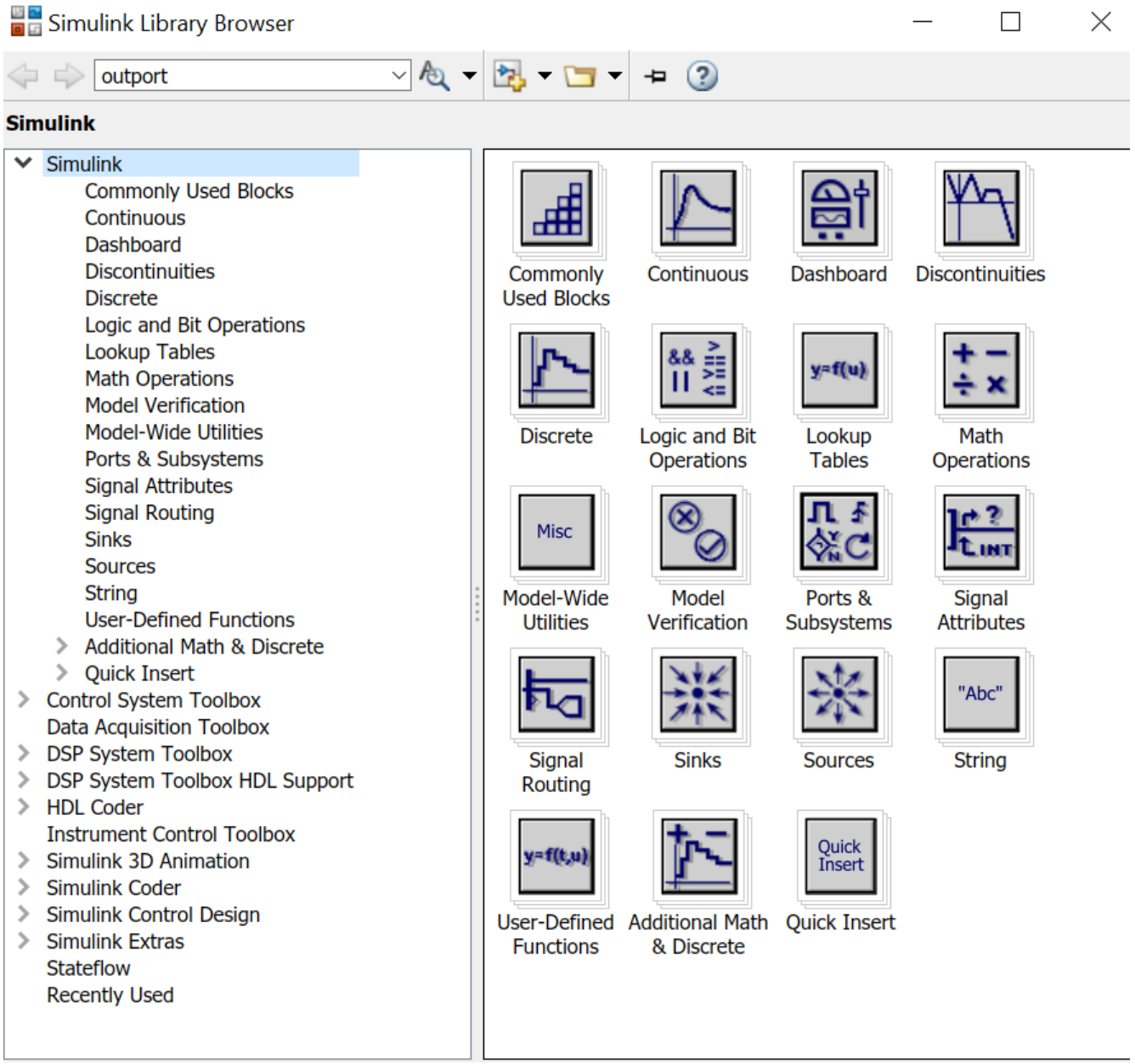
Example 2 (cont'd)

- Click on 

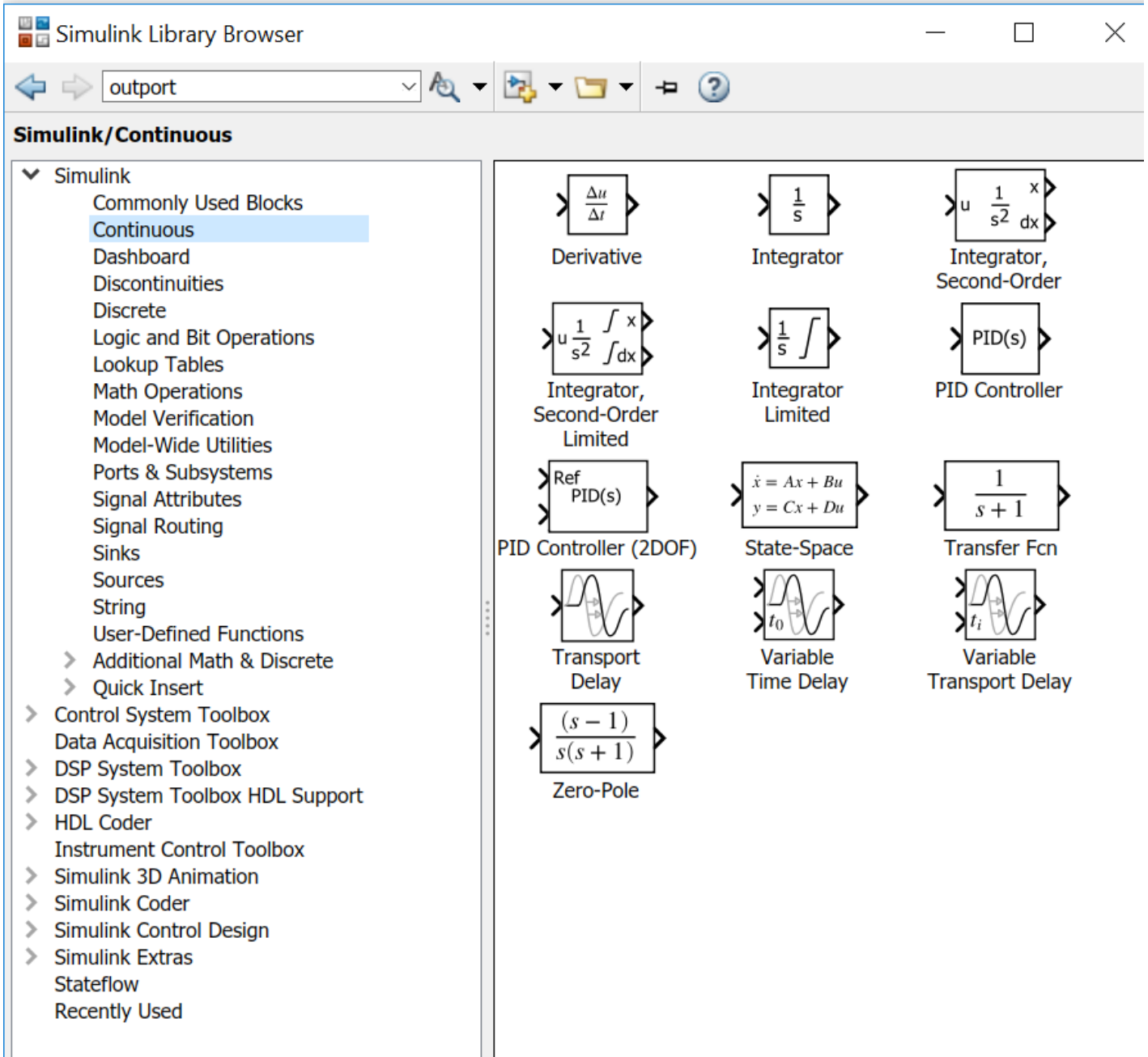


Example 2 (cont'd)

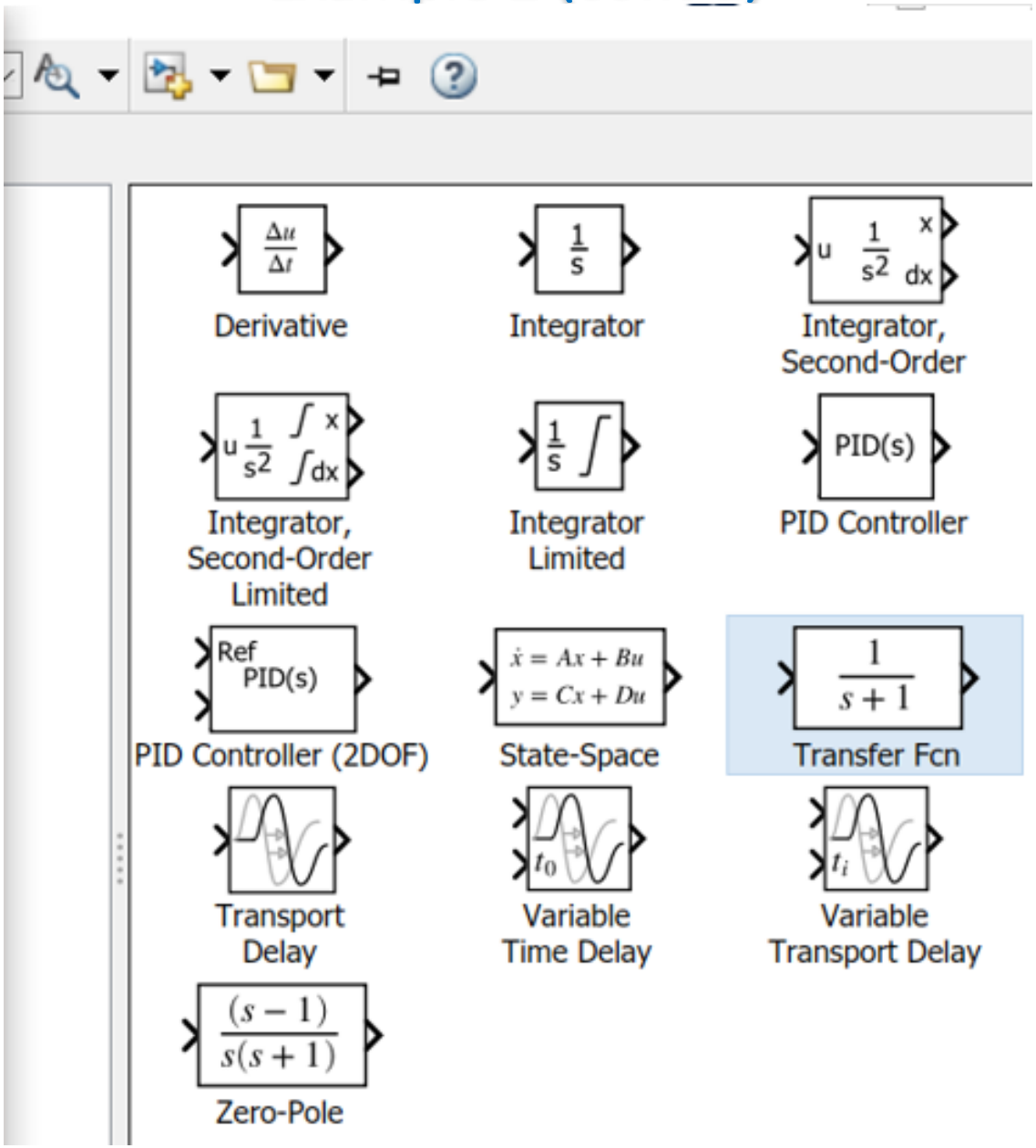
Then, Simulink Library Browser pops up:



Example 2 (cont'd)



Example 2 (cont'd)



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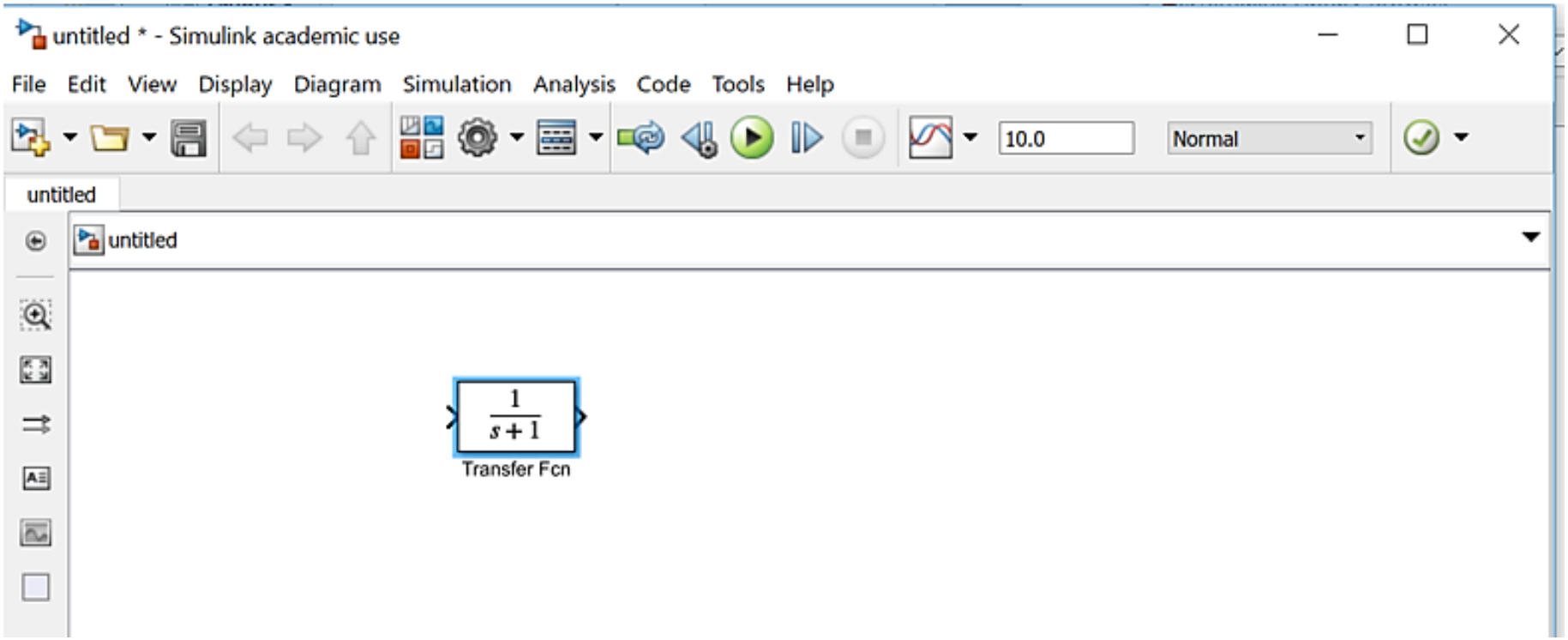
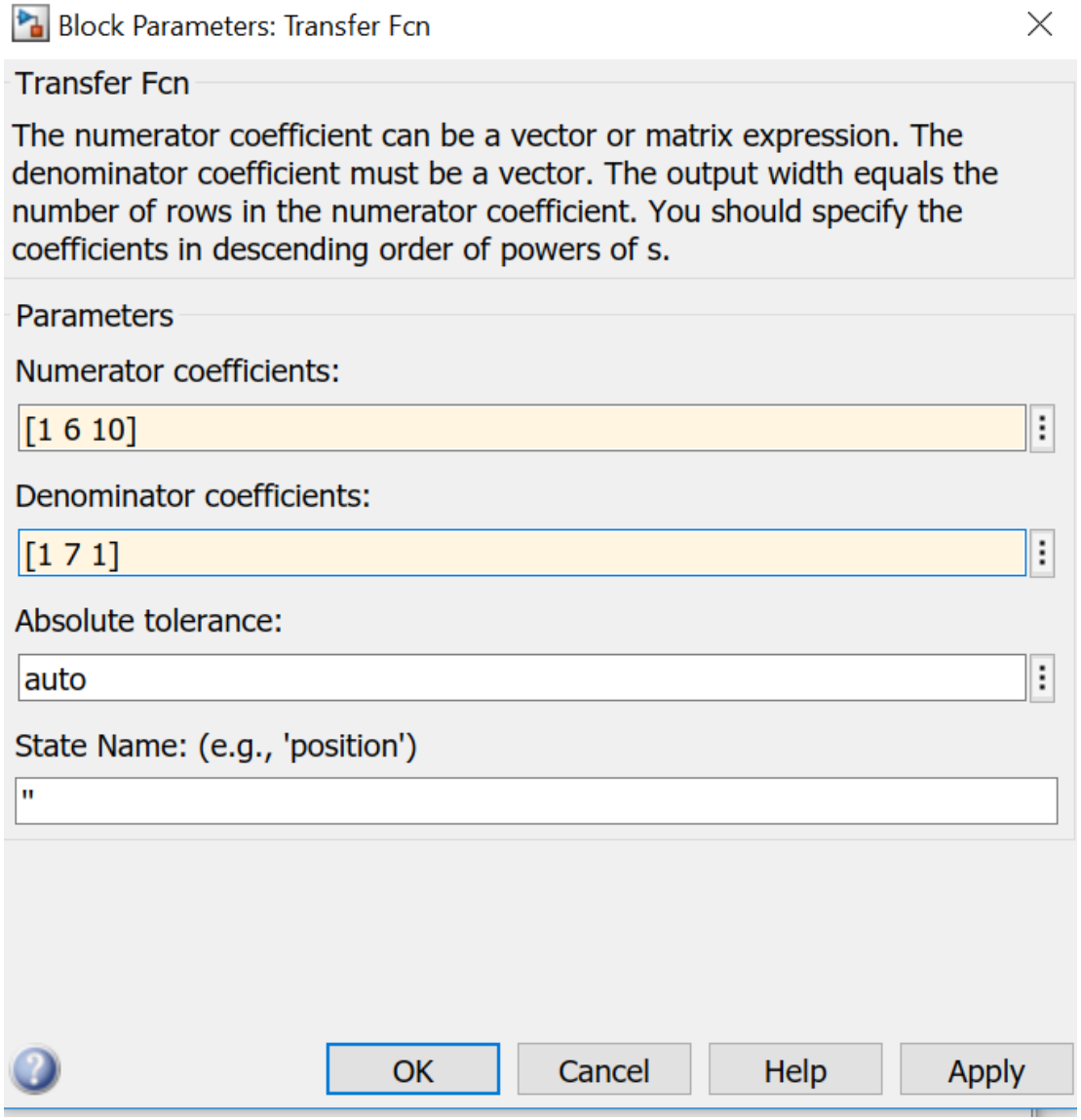
Example 2 (cont'd)

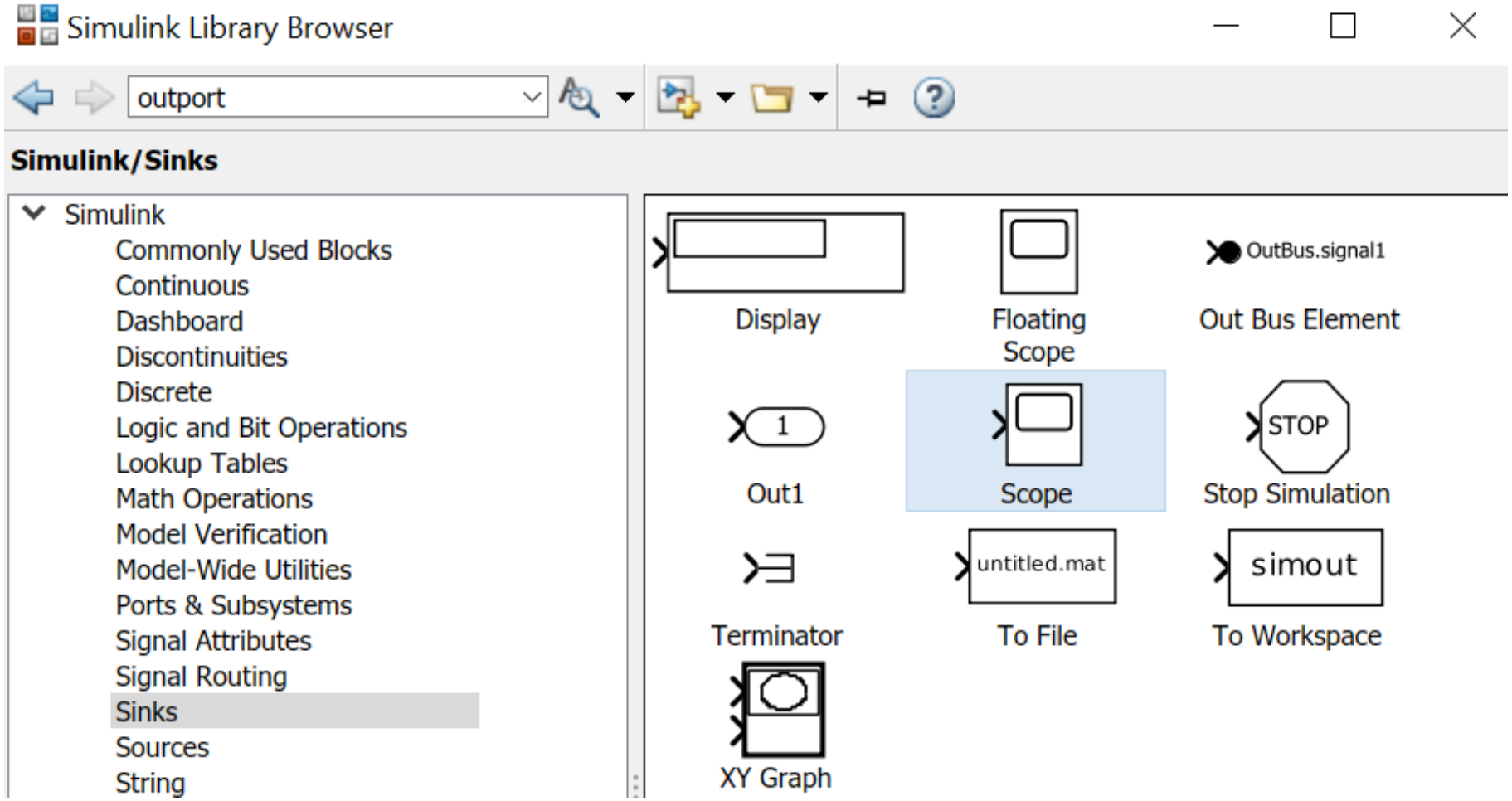


Example 2 (cont'd)

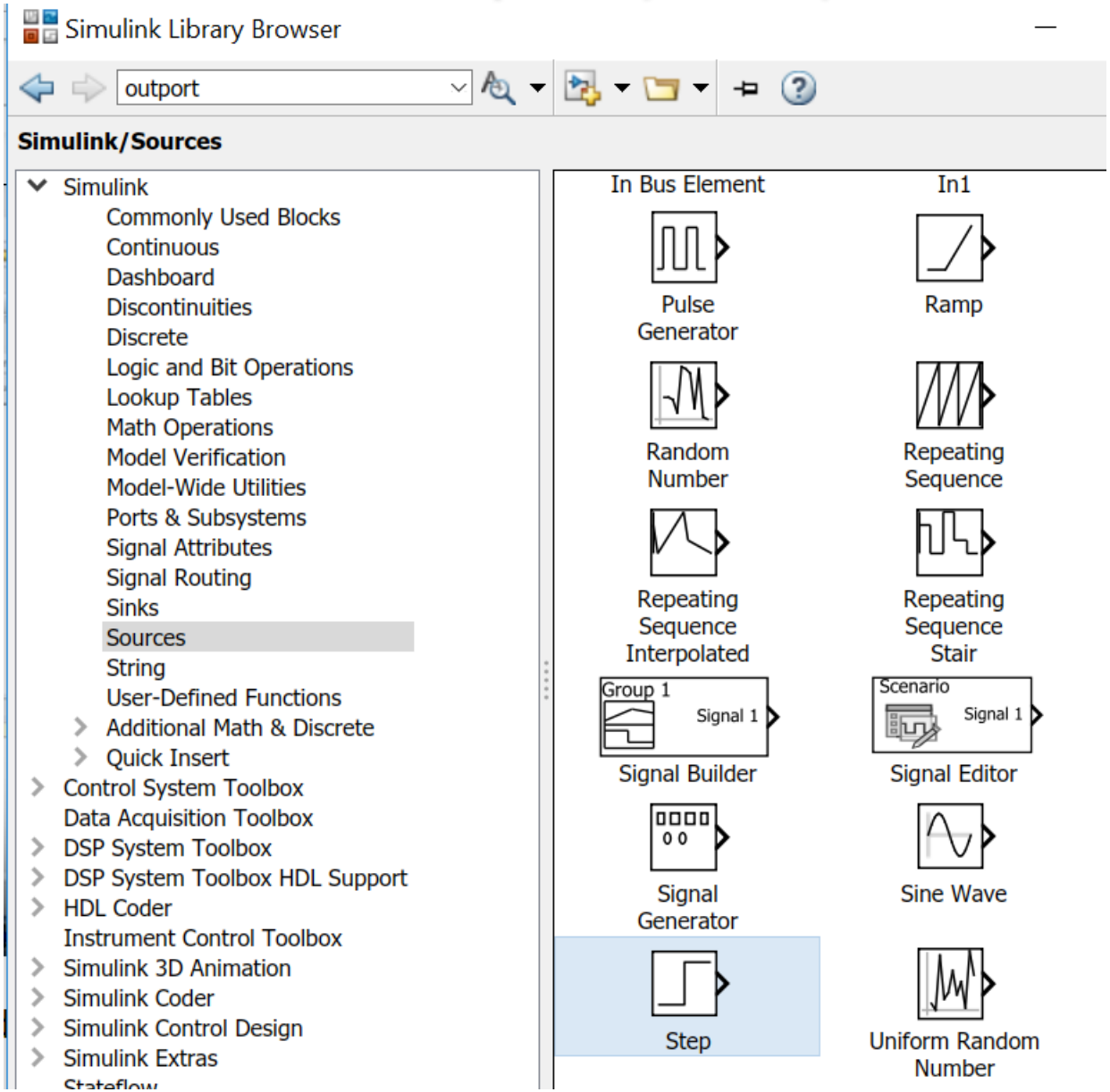
Double-click on the block to enter new numerator and denominator.



Example 2 (cont'd)



Example 2 (cont'd)



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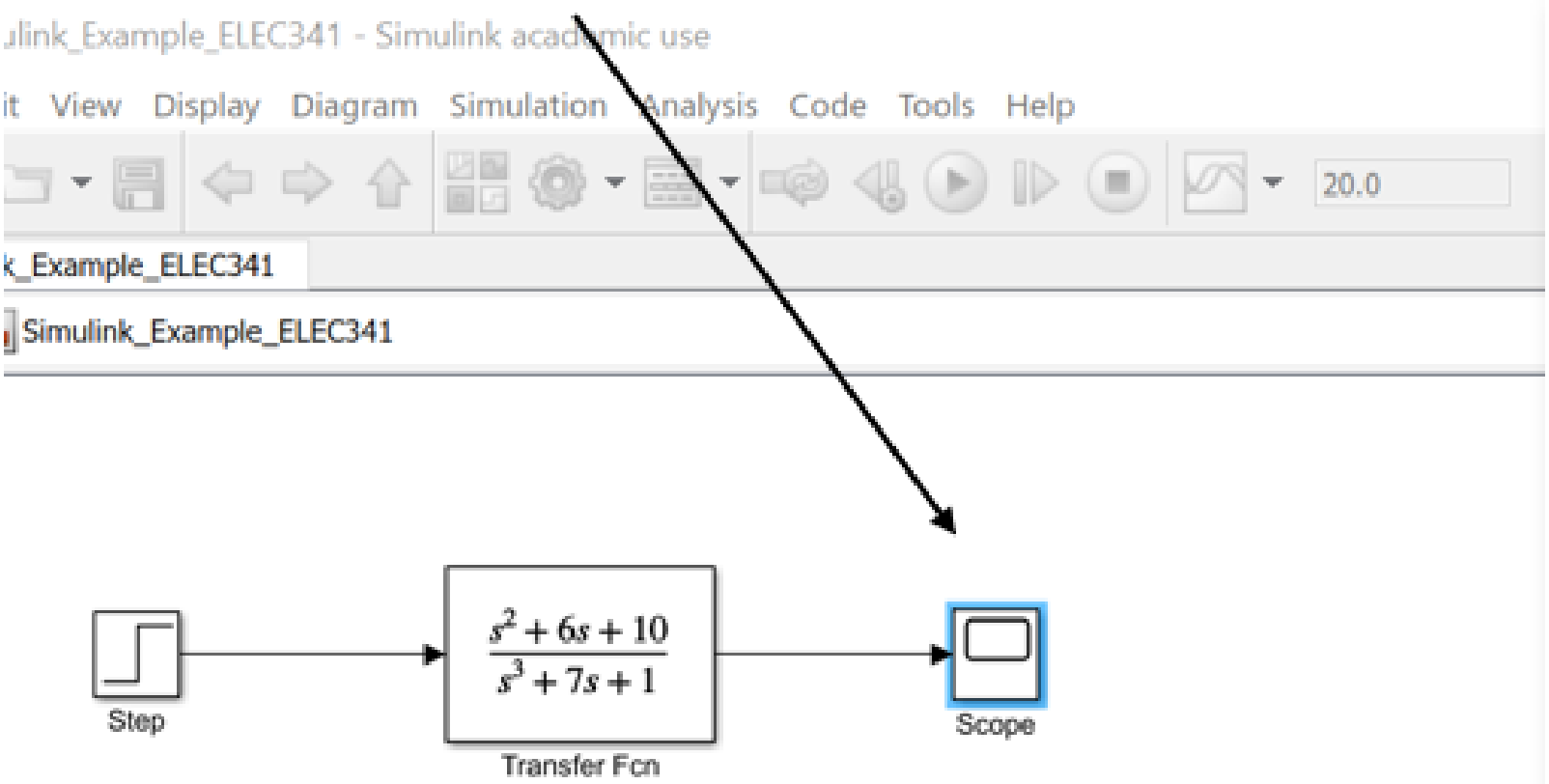
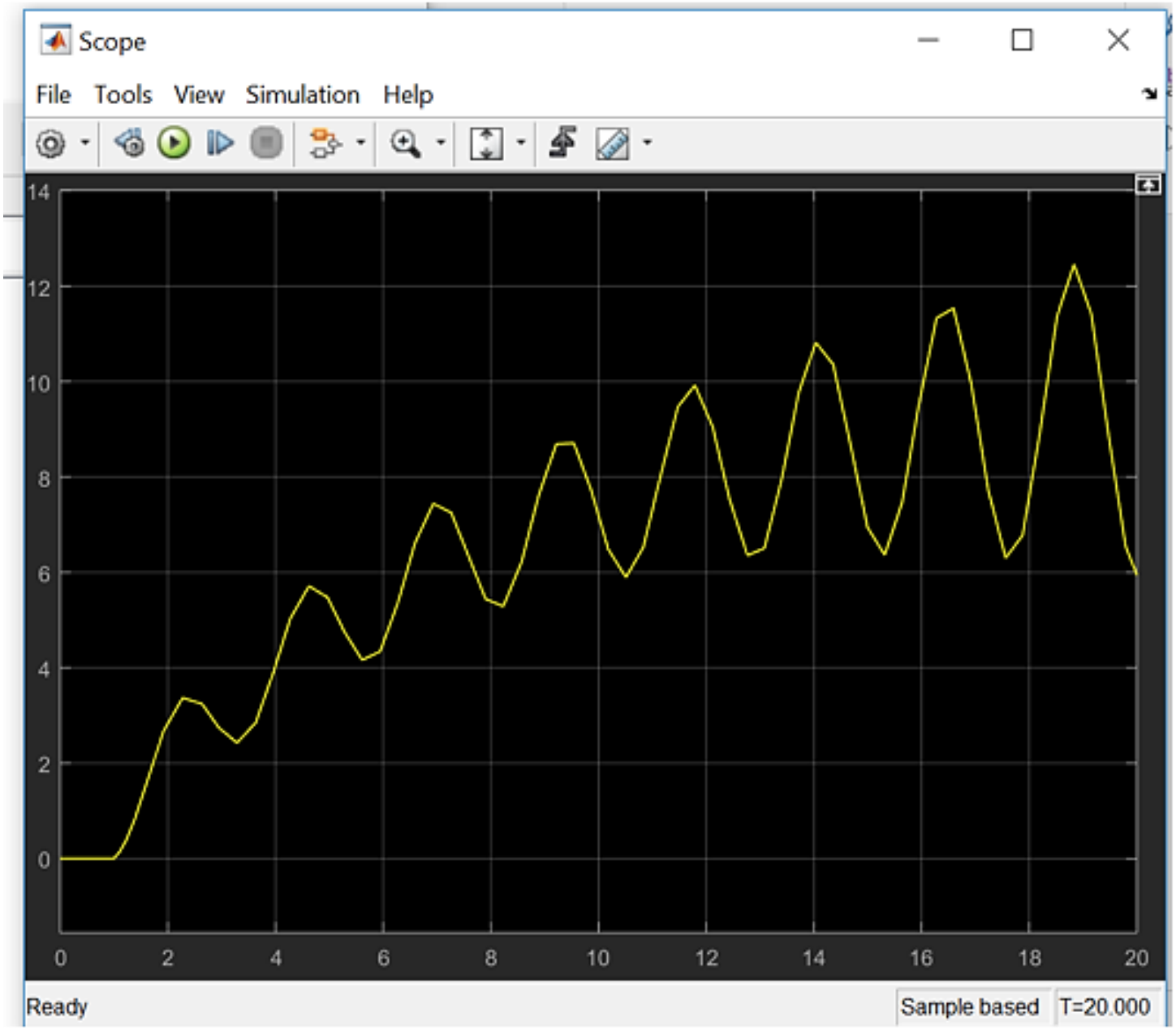
Example 2 (cont'd)

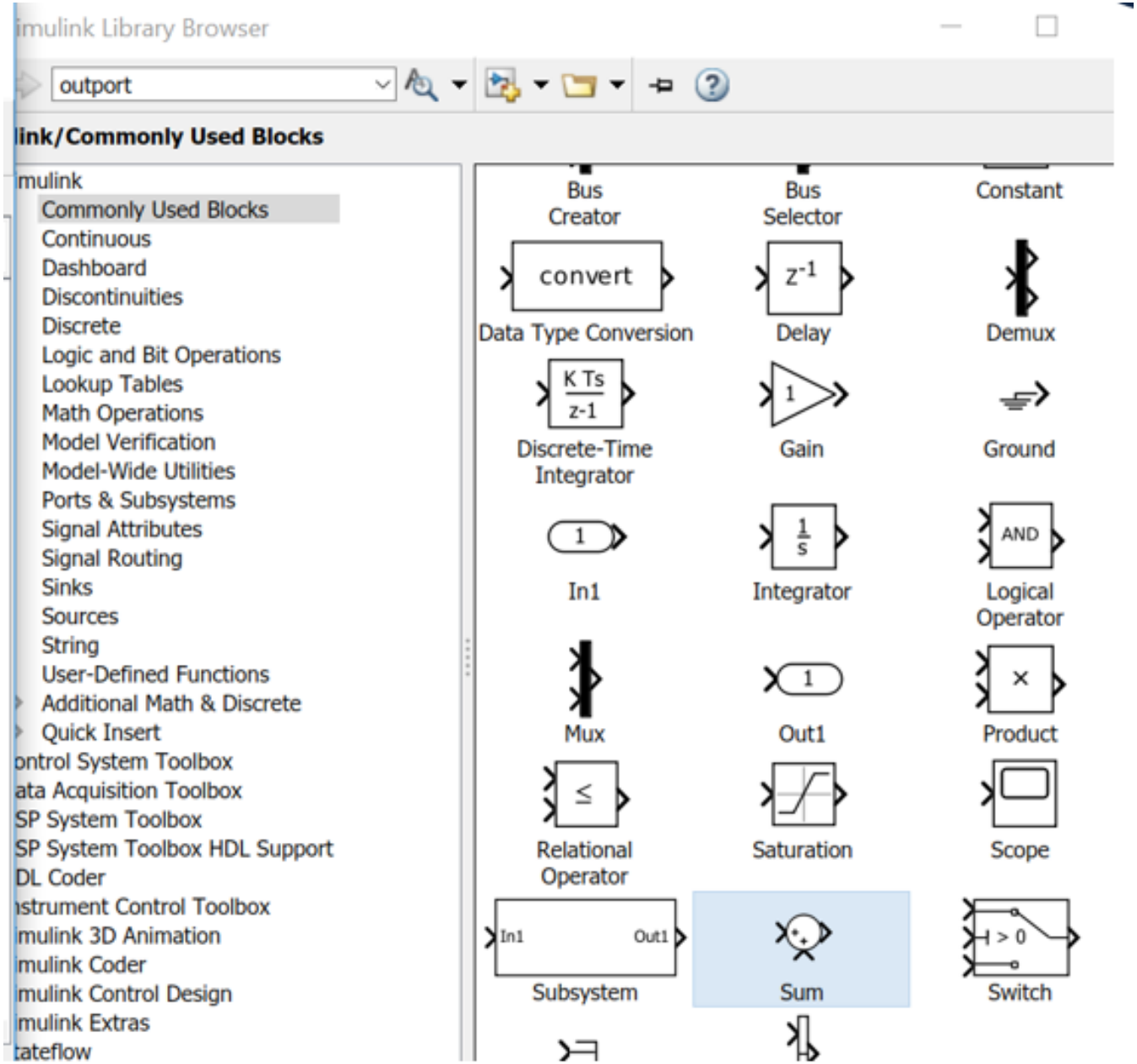
Double-click on scope.



Example 2 (cont'd)



Example 2 (cont'd)



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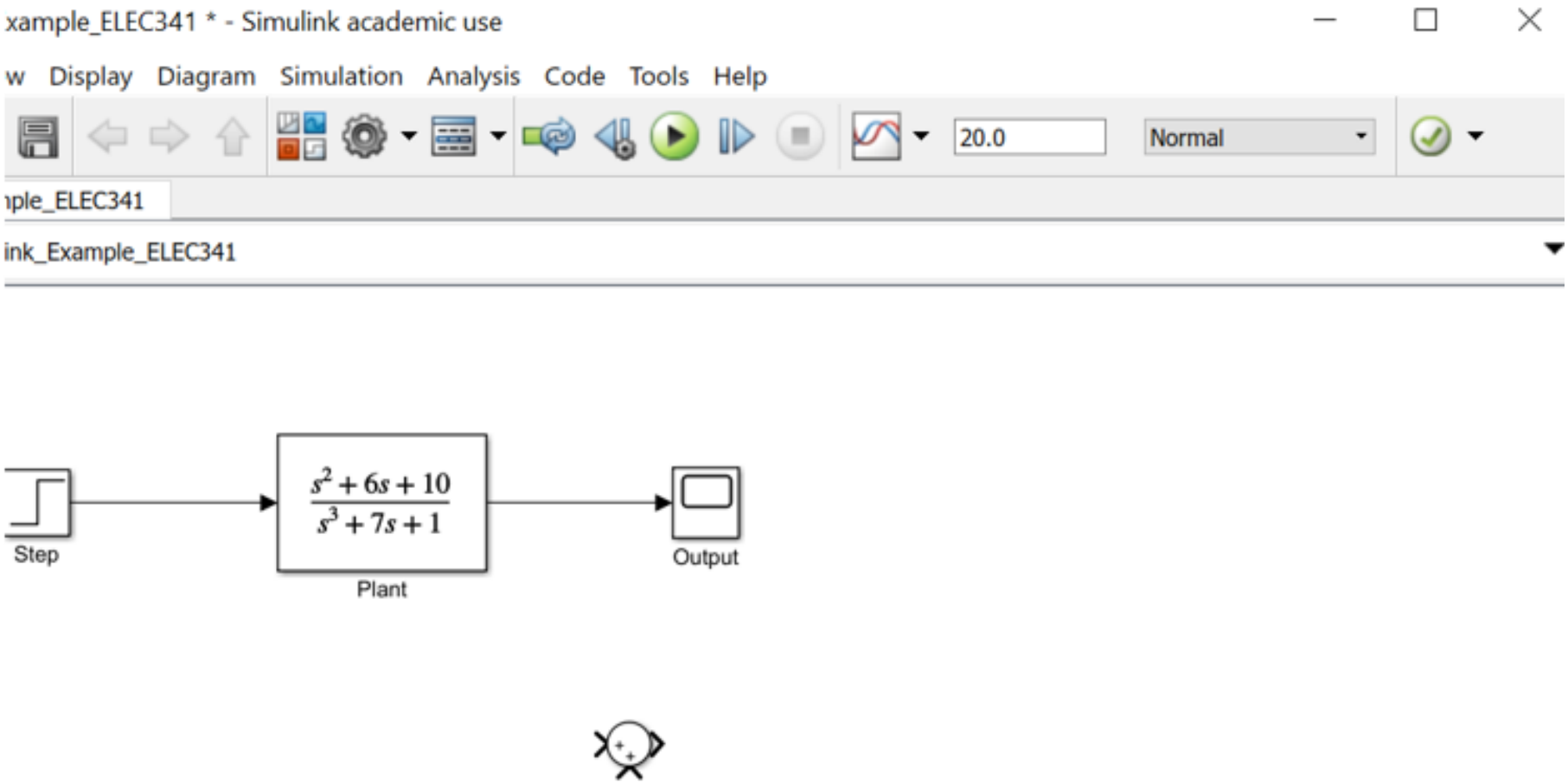
Example 2 (cont'd)



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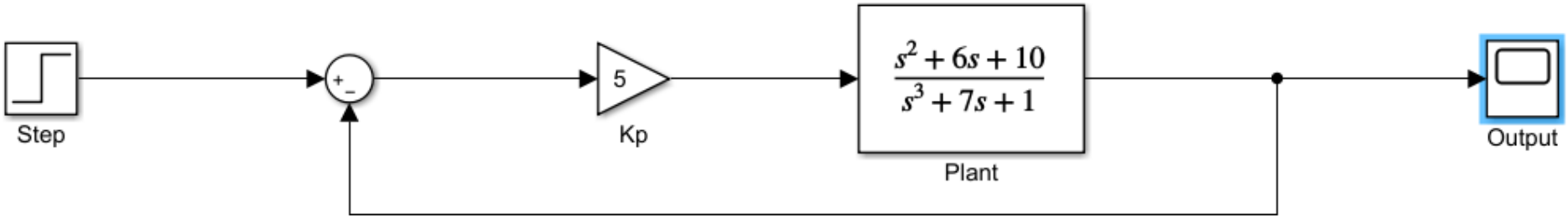

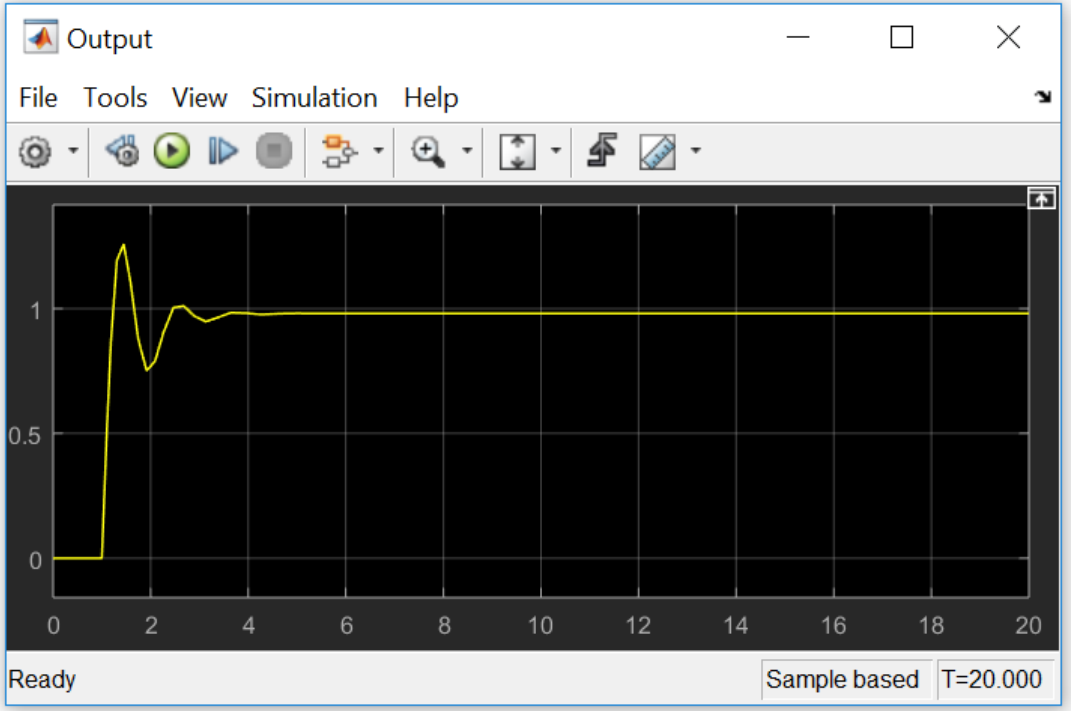

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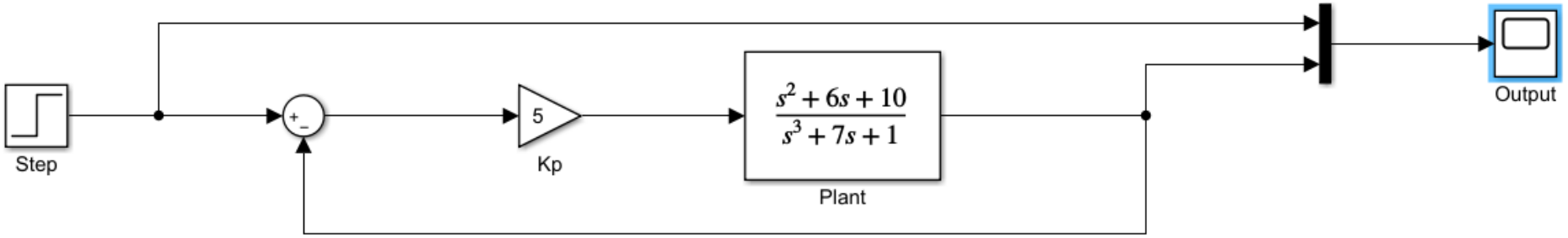
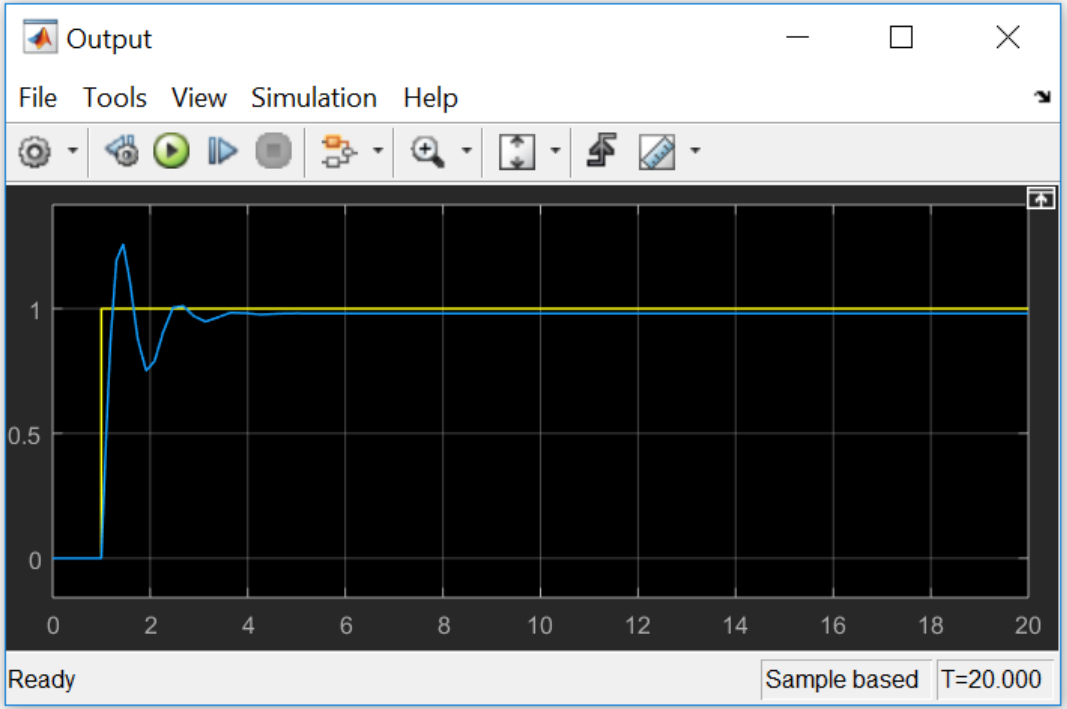
Example 2 (cont'd)





Course roadmap

Modeling

- Laplace transform
- Transfer function
- Models for systems
  - Electrical
  - Electromechanical
  - Mechanical
- Linearization, delay

Analysis

- Stability
  - Routh-Hurwitz
  - Nyquist
- Time response
  - Transient
  - Steady state
- Frequency response
  - Bode plot

Design

- Design specs
- Root locus
- Frequency domain
- PID & Lead-lag
- Design examples

Matlab simulations

Thank You!

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The End