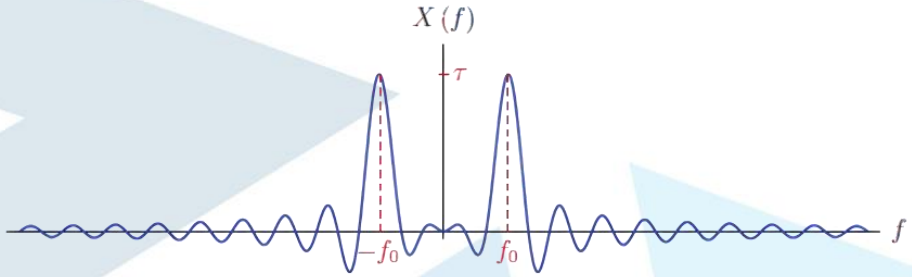
CECC507: Signals and Systems

Lecture 2: Using **Simulink** in MATLAB for Signals and Systems



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What is Simulink?

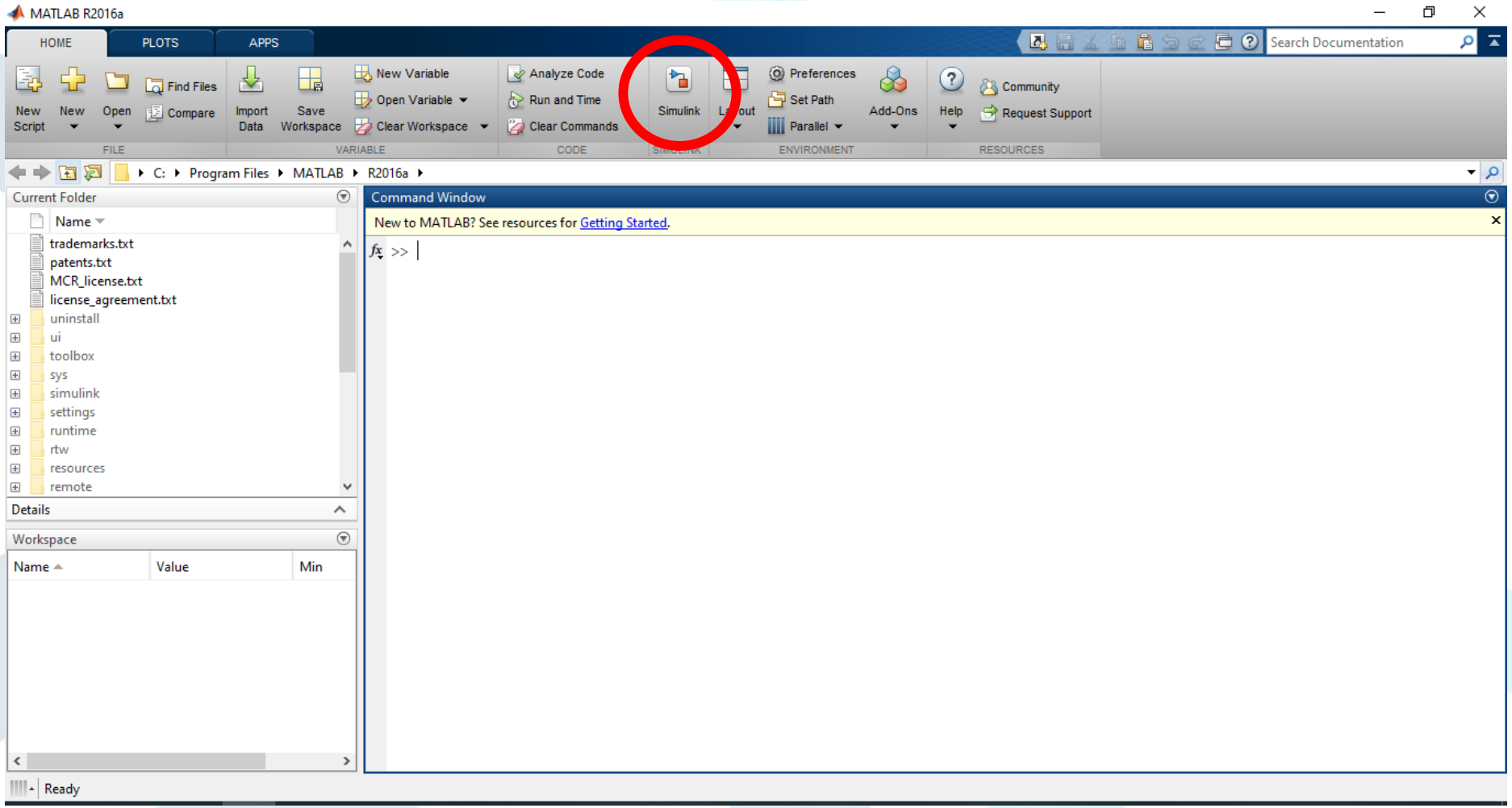
- Simulink is a graphical environment within **MATLAB** used for **modeling, simulating, and analyzing dynamic systems**.

- Instead of writing code, it uses **block diagrams**, which makes it easier to visualize how systems and signals interact.

What is Simulink?

Key Uses :

- **Modeling linear and nonlinear systems** with blocks such as integrators, gains, and summation.
- **Generating and simulating signals** (sine waves, square waves, noise) to study their behavior.
- **Analyzing system responses** in both time and frequency domains.
- **Designing and testing filters** (low-pass, high-pass, band-pass) before applying them in practice.


MATLAB R2016a
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Run and Time
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New to MATLAB? See resources for Getting Started.
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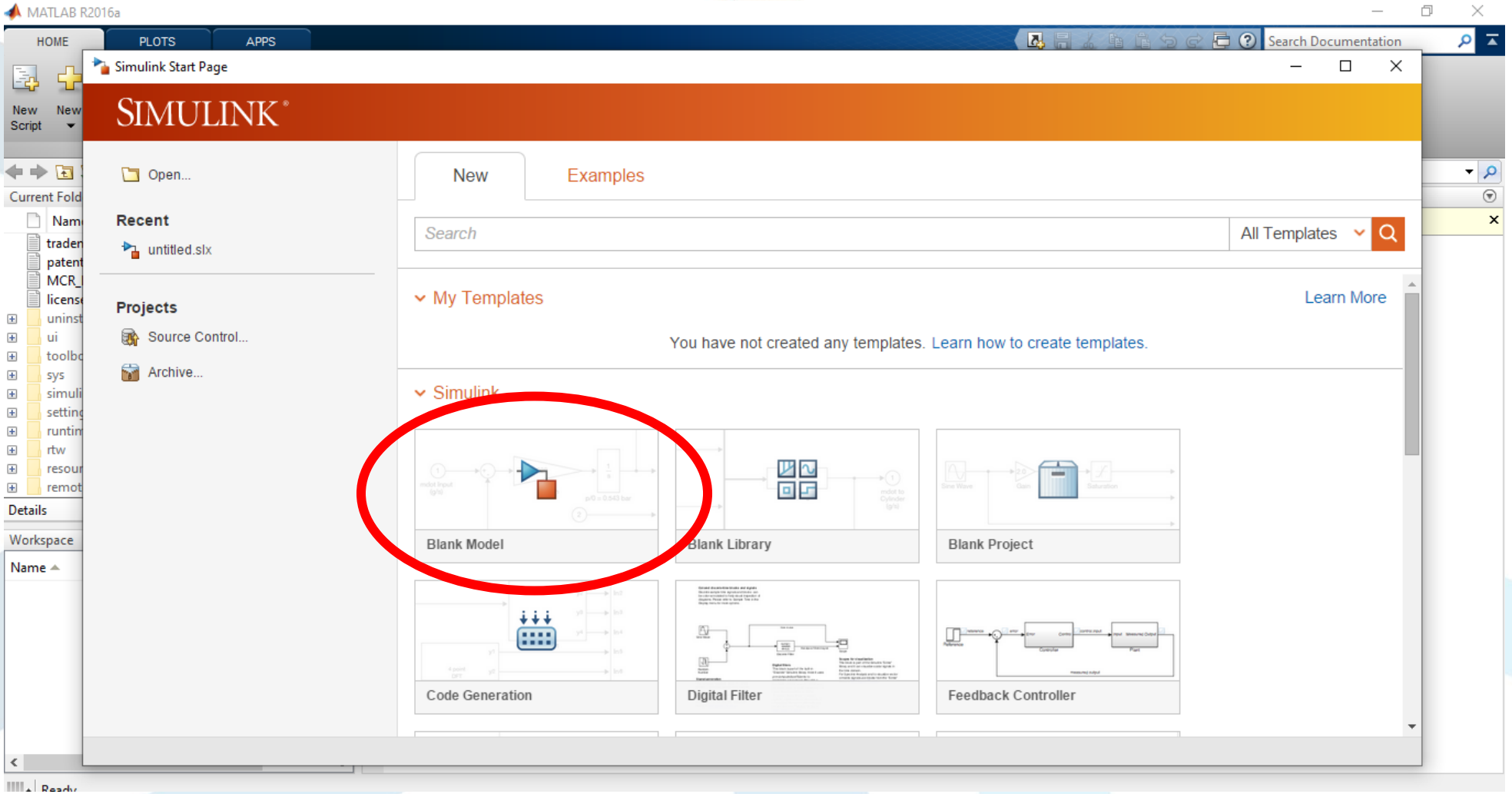
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Learn More
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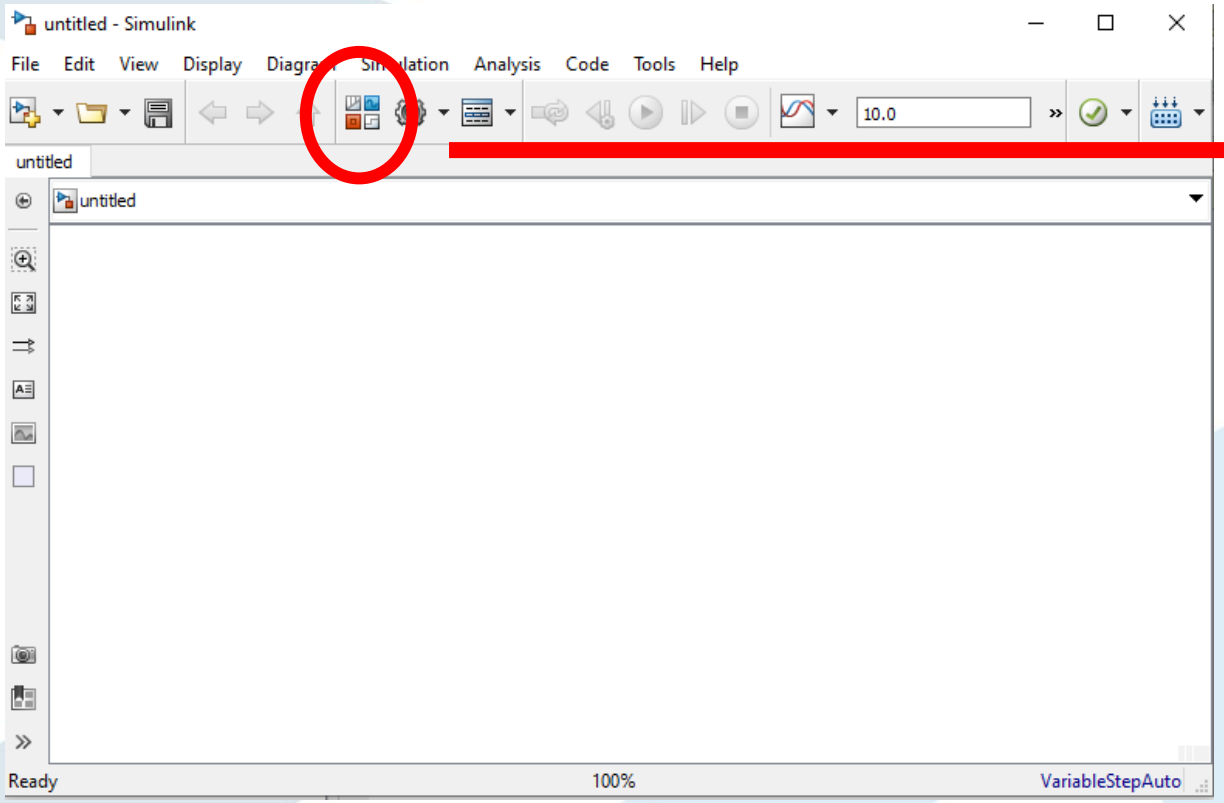
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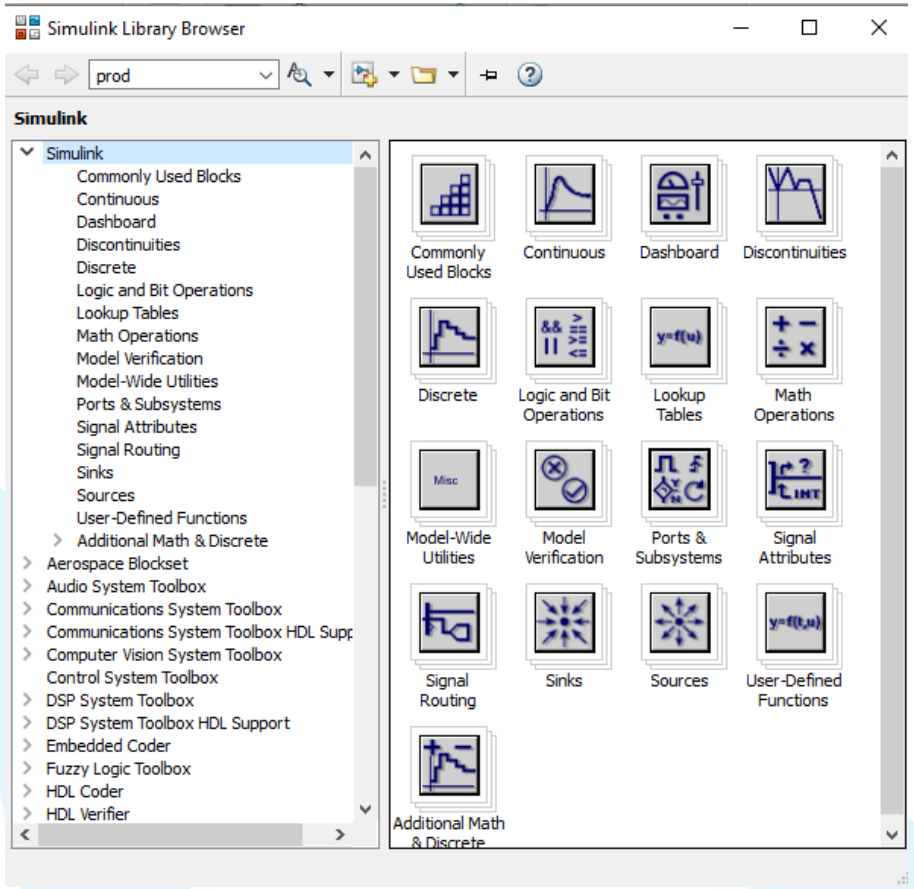
Simulink Library Browser
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Commonly Used Blocks
Continuous
Dashboard
Discontinuities
Discrete
Logic and Bit Operations
Lookup Tables
Math Operations
Model Verification
Model-Wide Utilities
Ports & Subsystems
Signal Attributes
Signal Routing
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User-Defined Functions
Additional Math & Discrete
Aerospace Blockset
Audio System Toolbox
Communications System Toolbox
Communications System Toolbox HDL Supp
Computer Vision System Toolbox
Control System Toolbox
DSP System Toolbox
DSP System Toolbox HDL Support
Embedded Coder
Fuzzy Logic Toolbox
HDL Coder
HDL Verifier
Commonly Used Blocks
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Dashboard
Discontinuities
Discrete
Logic and Bit Operations
Lookup Tables
Math Operations
Model-Wide Utilities
Model Verification
Ports & Subsystems
Signal Attributes
Signal Routing
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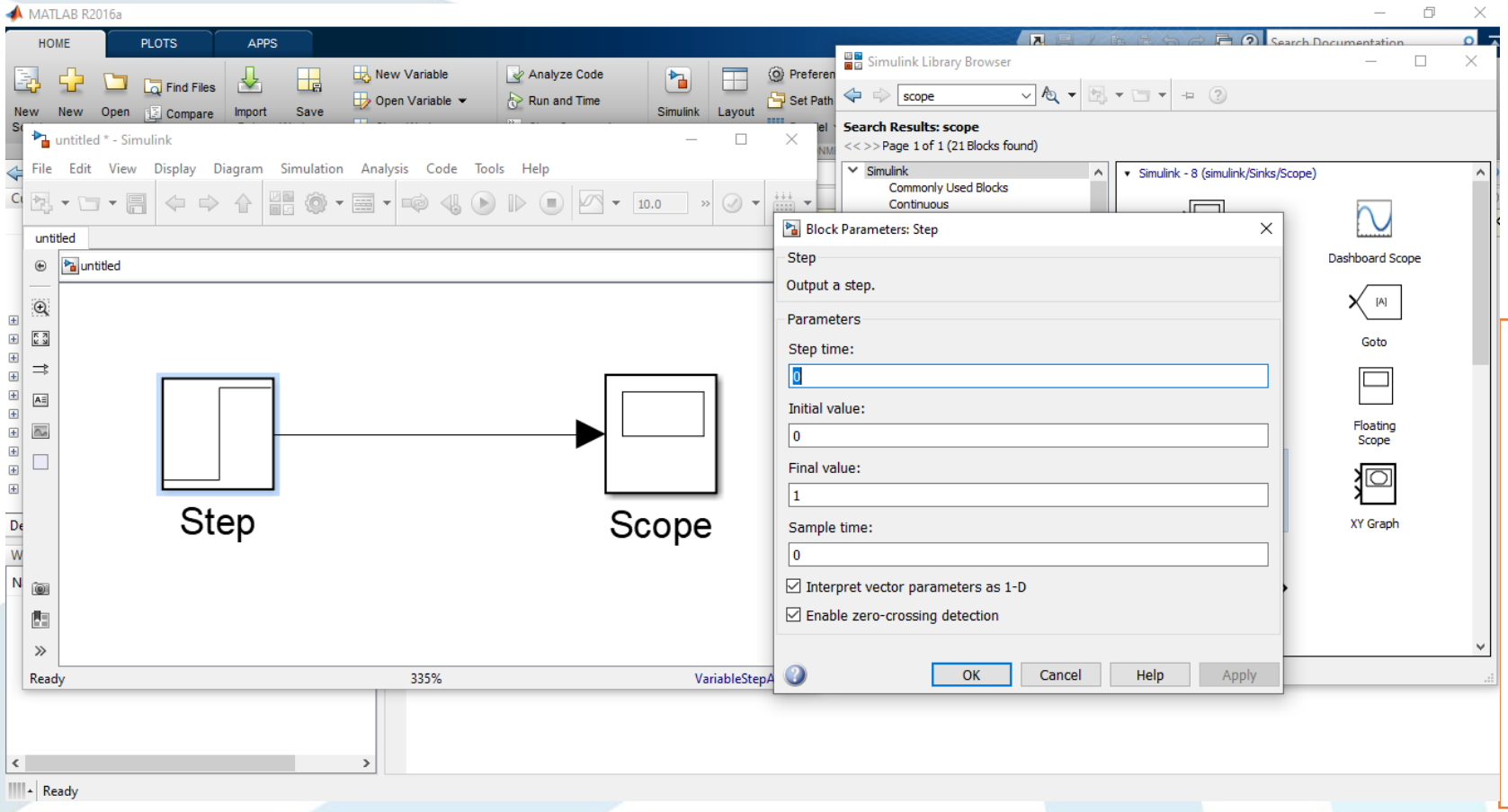
Sources
User-Defined Functions
Additional Math & Discrete

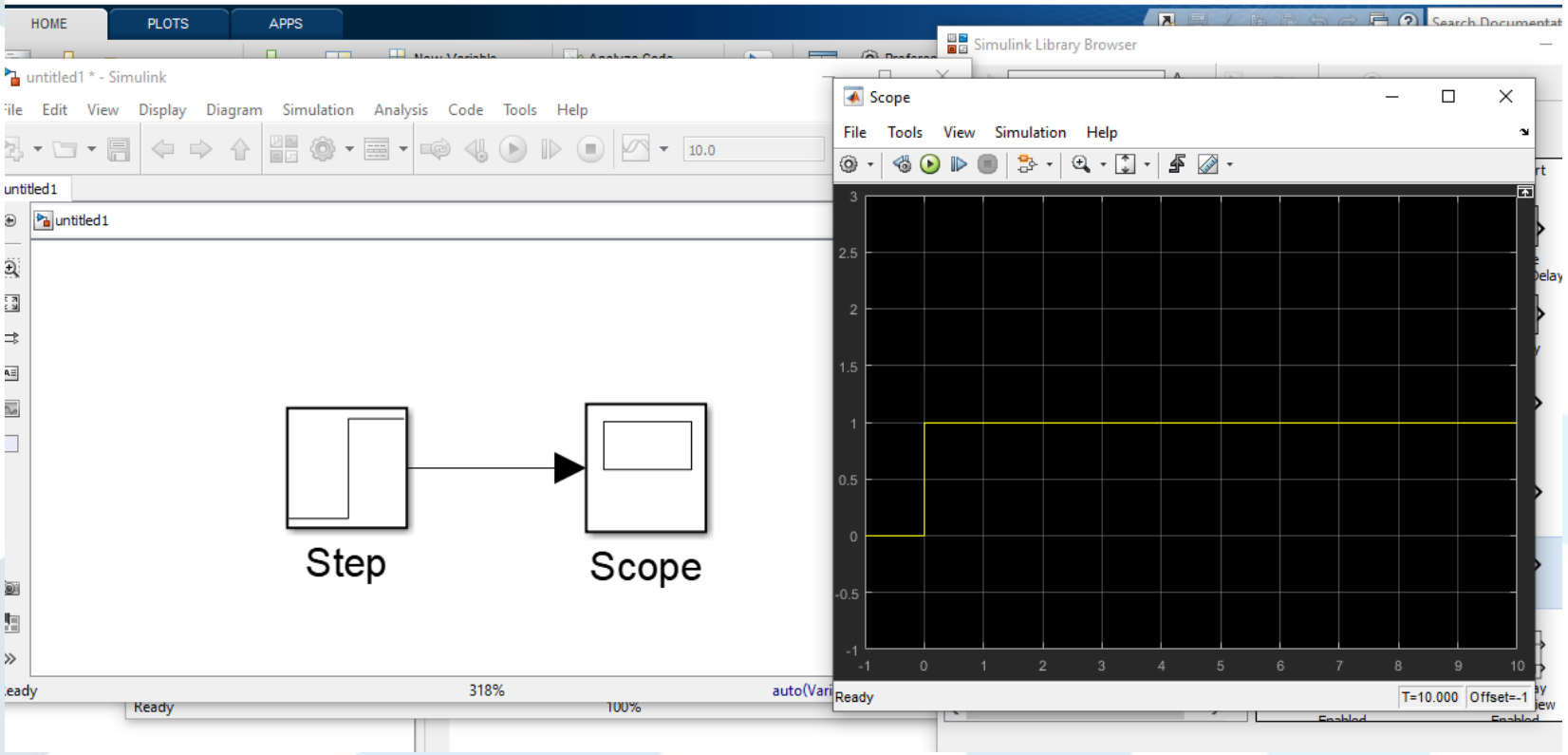
What is a Unit step function and how can we simulate it in Simulink?



The **unit step function**, denoted as x(t)=u(t-a), is a basic signal used in systems and signals analysis. It represents a sudden change from 0 to 1 at time t=a

- We use the **Step block** to simulate u(t - a).
- The block has parameters:
  - Step Time: the time t=a at which the signal jumps from 0 to .1
  - Initial Value 0 meaning x(t) = 0 when t < a
  - Final Value 1 x(t) = 1 when t >= a

Unit step function and how can we simulate it in Simulink?



The **Scope** shows that the amplitude of the step function is zero before time t=0 and after t=0 the amplitude becomes 1

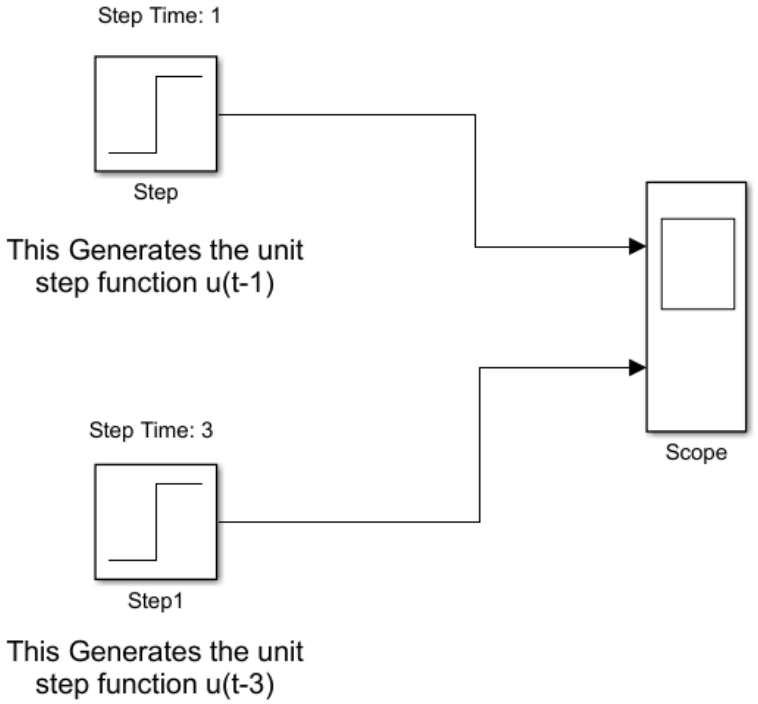
• Shifted Unit step

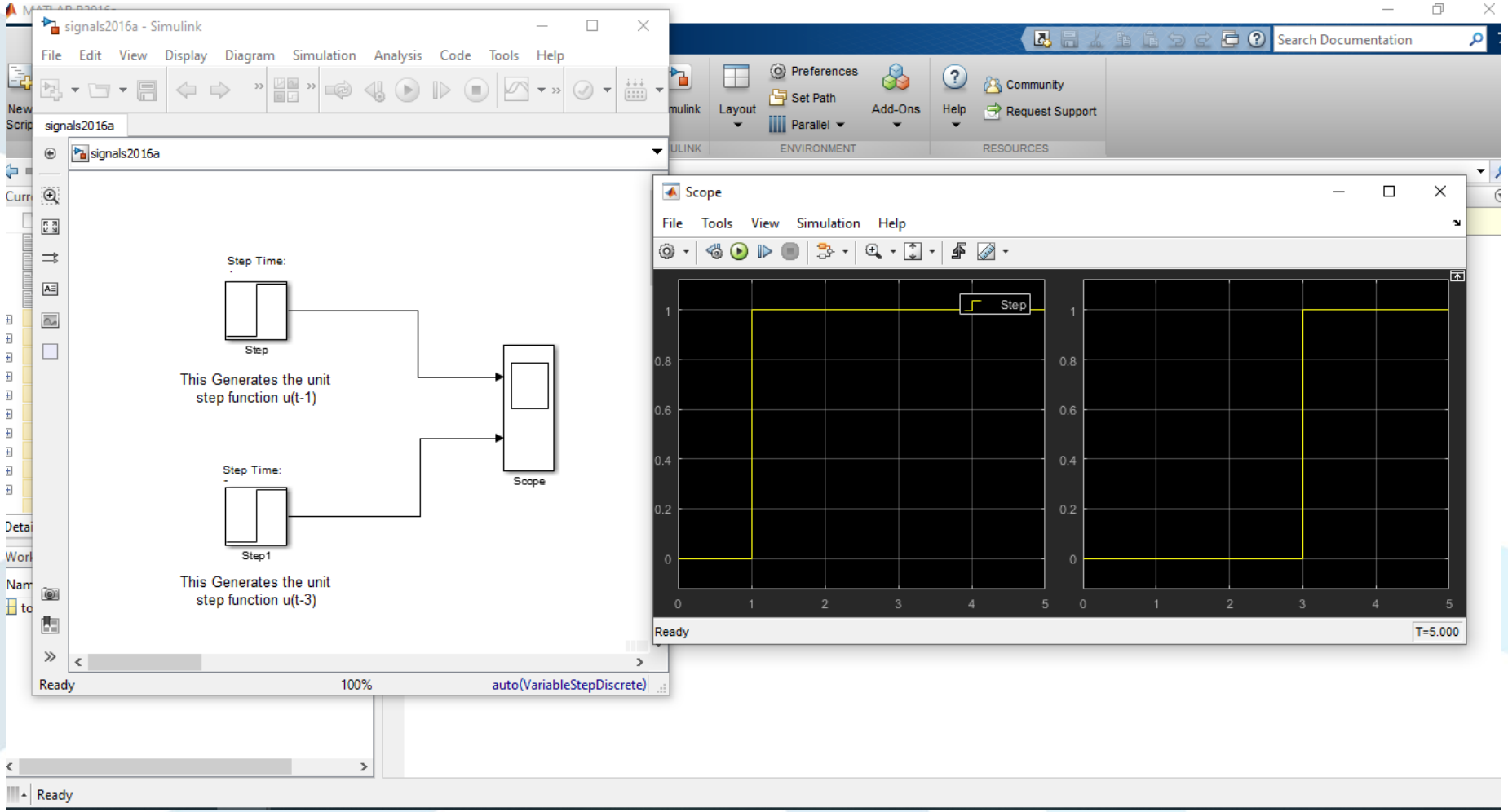
Task: Design a Simulink model that generates two time-shifted unit step functions and displays them on a Scope.

Requirements:

Add two **Step** blocks:

- The first should have a **Step Time** of 1 to represent the function u(t-1).
- The second should have a **Step Time** fo 3 to represent the function u(t-3) .




signals2016a - Simulink
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signals2016a
signals2016a
Step Time:
Step
This Generates the unit
step function u(t-1)
Step Time:
Step1
This Generates the unit
step function u(t-3)
Scope
Ready
100%
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Search Documentation
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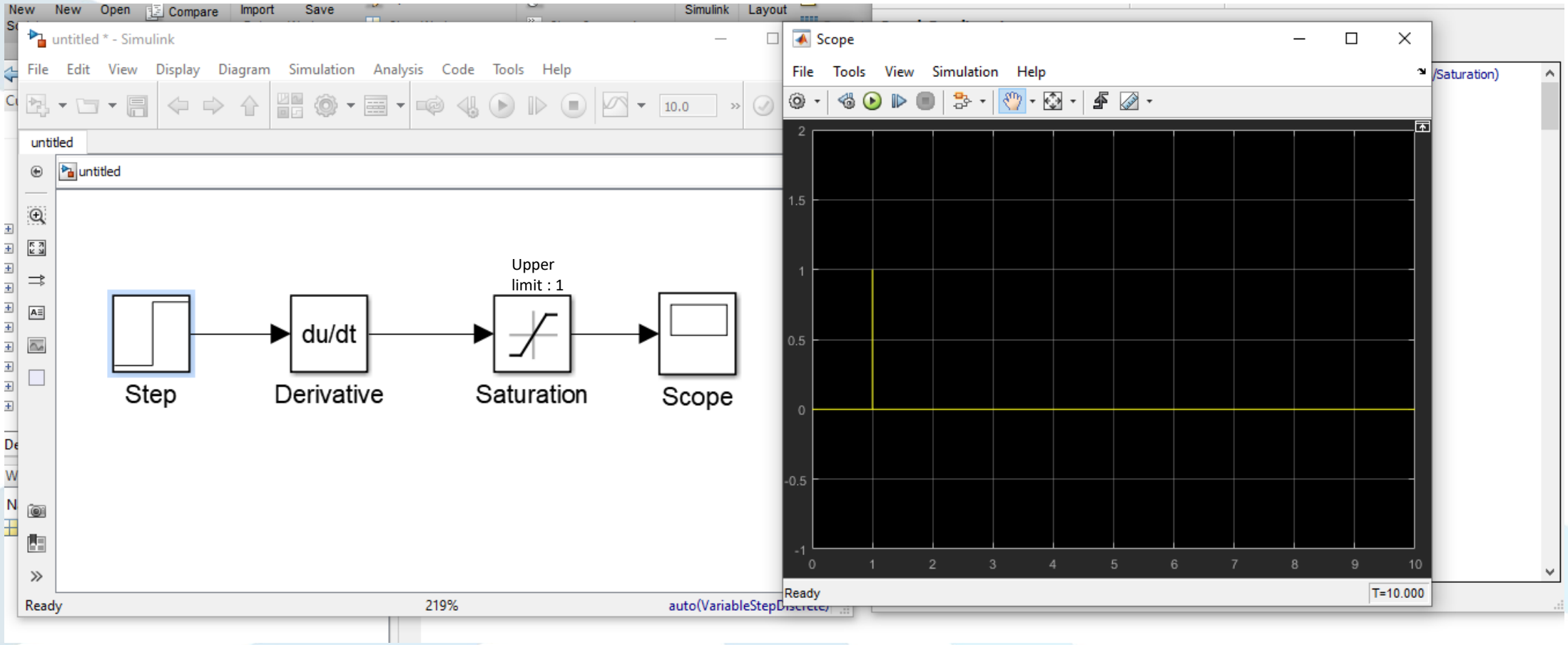
Community
Request Support
ENVIRONMENT
RESOURCES
Scope
File Tools View Simulation Help
Step
Ready
T=5.000
Ready

Simulating Dirac delta pulses using Simulink

In Simulink, we can approximate Dirac delta pulses by using the **derivative of a step function**.
The idea is that the derivative of a unit step function u(t-a) produces a Dirac-like impulse δ(t-a) at time t = a .
Here's how it's done:

- **Step Block :** Generates a unit step function at a specific time
- **Derivative Block :** Computes the derivative of the step function, which approximates a Dirac pulse.
- **Saturation Block :** Limits the amplitude to avoid infinite values and keeps the pulse within a visible range.
- **Scope Block:** Displays the result.


untitled * - Simulink
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Upper limit : 1
Step
du/dt
Derivative
Saturation
Scope
Ready
219%
Scope
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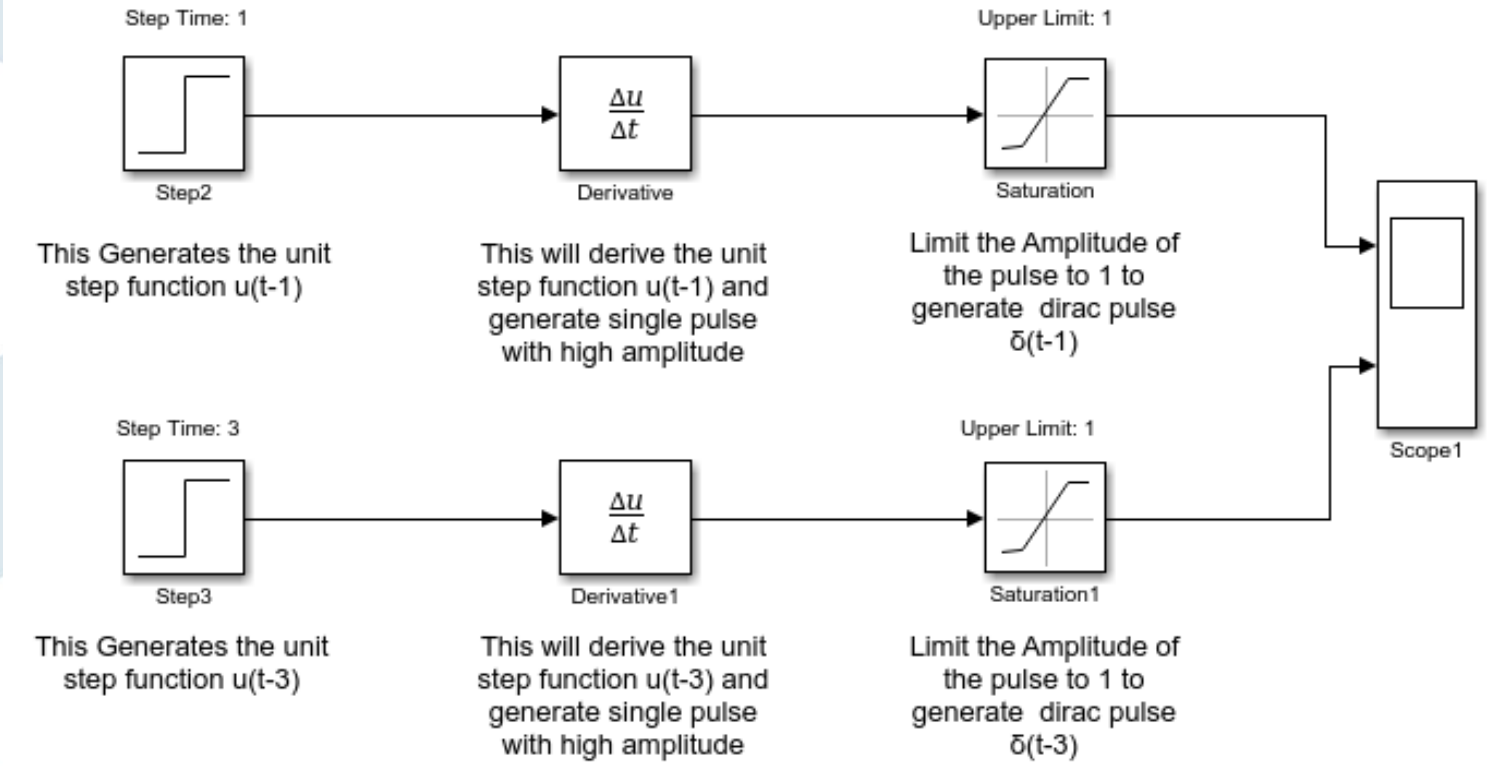
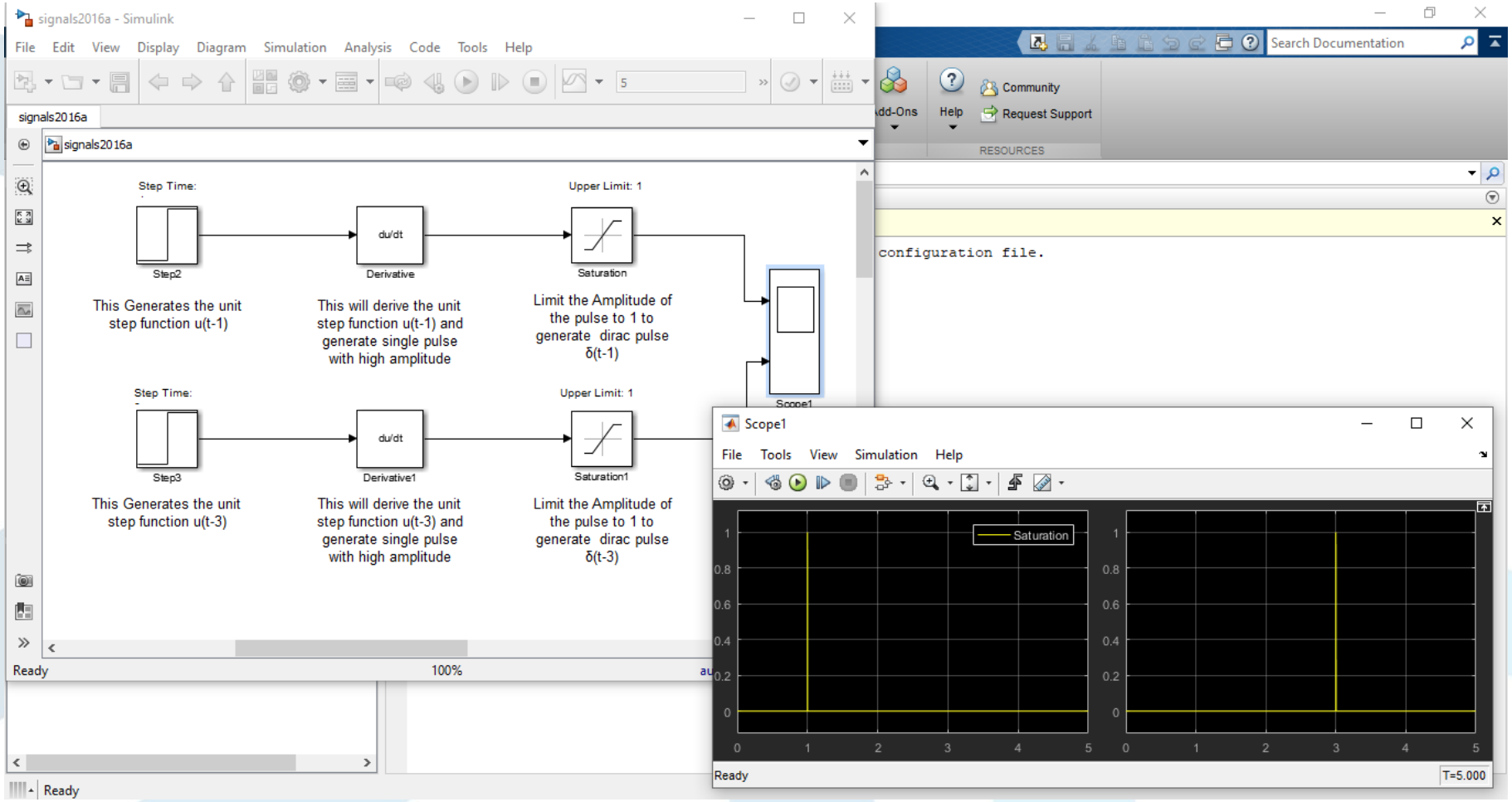
Ready
T=10.000

Simulating Dirac pulses using Simulink




signals2016a - Simulink
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signals2016a
Step Time:
Step2
This Generates the unit step function u(t-1)
du/dt
Derivative
This will derive the unit step function u(t-1) and generate single pulse with high amplitude
Upper Limit: 1
Saturation
Limit the Amplitude of the pulse to 1 to generate dirac pulse δ(t-1)
Scope1
Step Time:
Step3
This Generates the unit step function u(t-3)
du/dt
Derivative1
This will derive the unit step function u(t-3) and generate single pulse with high amplitude
Upper Limit: 1
Saturation1
Limit the Amplitude of the pulse to 1 to generate dirac pulse δ(t-3)
Ready
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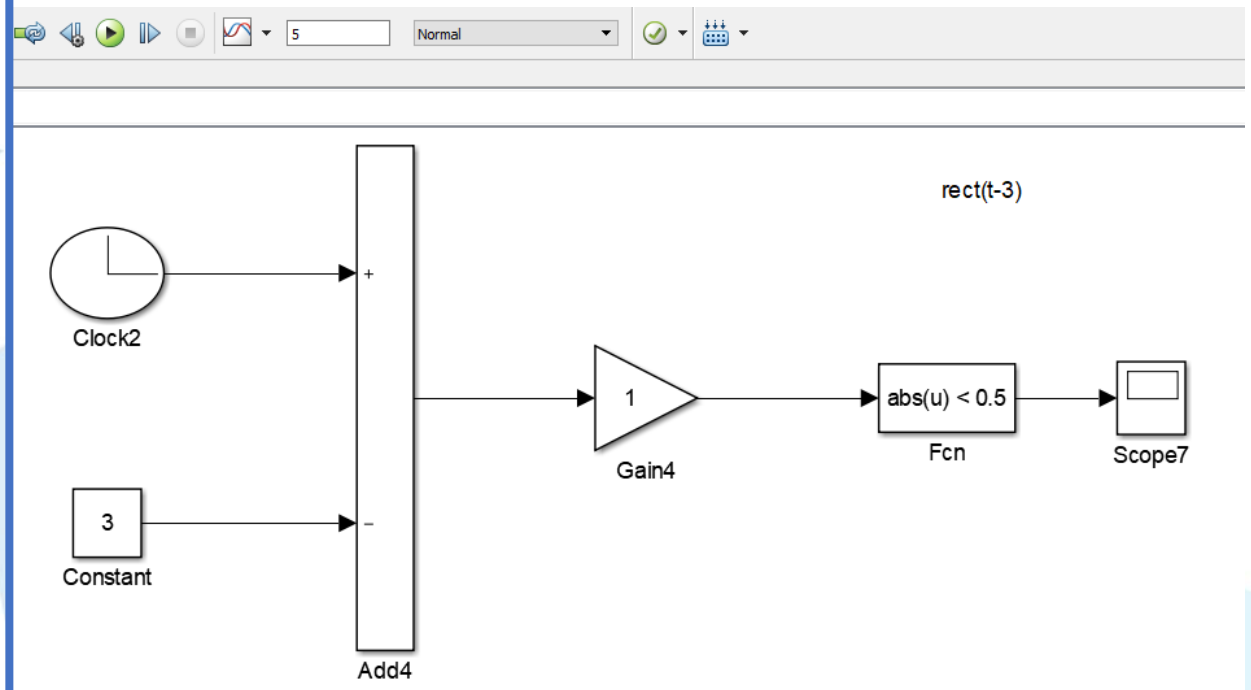
Search Documentation
Add-Ons
Help
Community
Request Support
RESOURCES
configuration file.
Scope1
File Tools View Simulation Help
Saturation
Ready
T=5.000

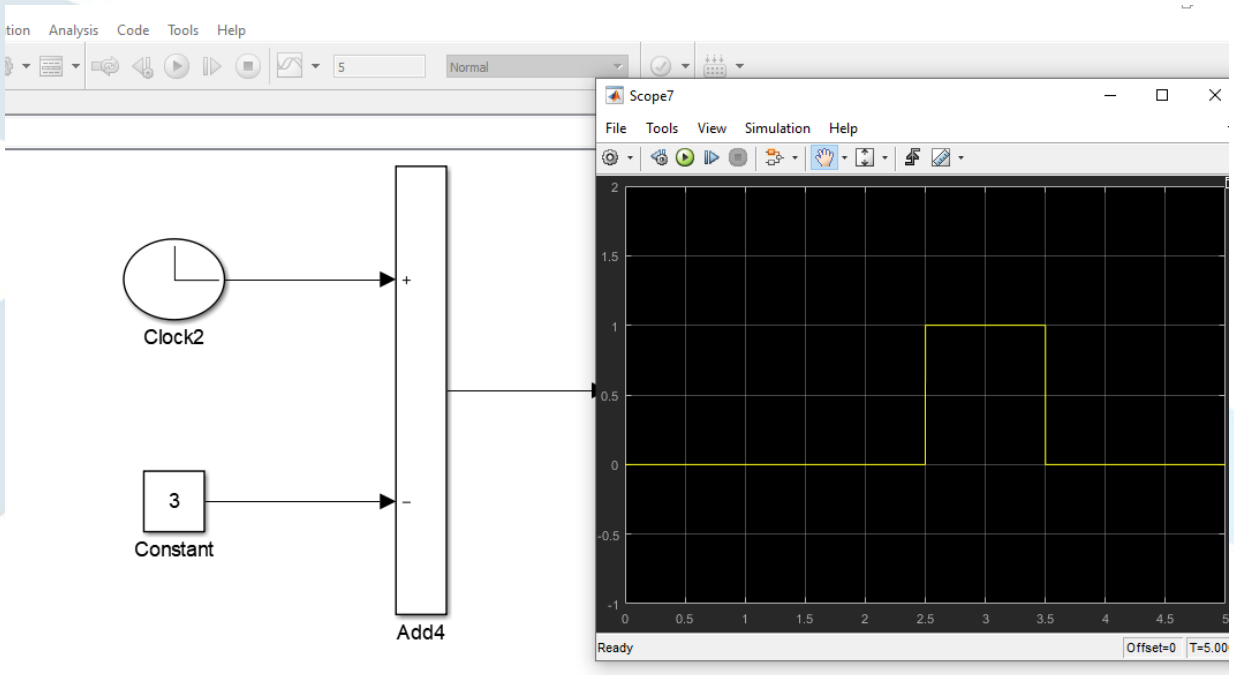
Simulating a Rect Π signal using Simulink

This model simulates a rectangular pulse centered at t=3 using basic Simulink blocks:

- **Clock**: Outputs the current simulation time (t).
- **Constant (value = 3)**: Provides a fixed offset.
- **Add**: Computes t-3 by subtracting the constant from the clock signal.
- **Gain4 (gain = 1)**: multiplies the signal by (1) which Passes the signal unchanged.
- **Fcn: abs(u)<0.5** Applies a logical condition. It outputs:
  - **1 when |t-3| < 0.5**
  - **0 otherwise**

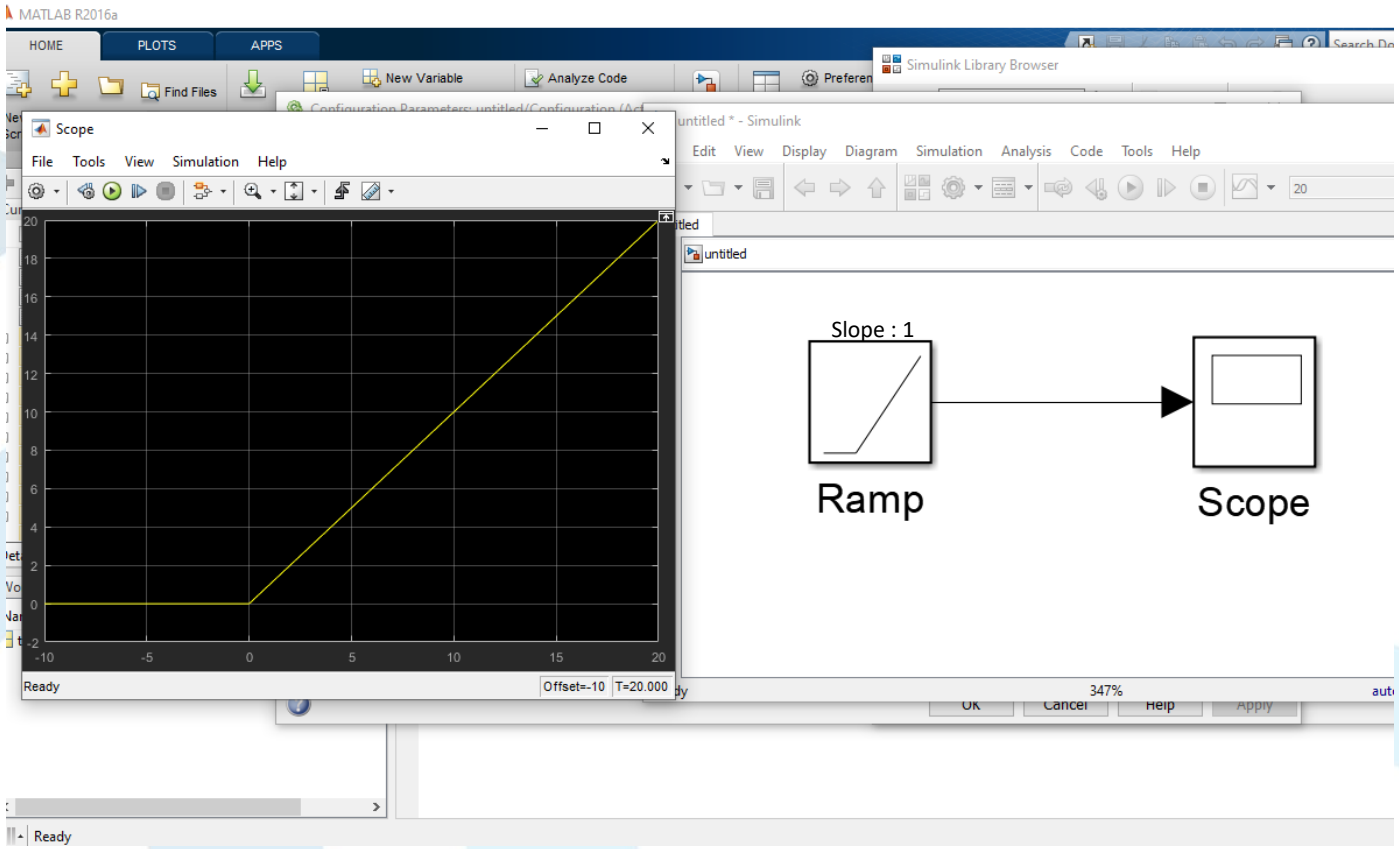


Simulating a Rect Π(t-3) signal using Simulink



Simulating a ramp (r) signal using Simulink

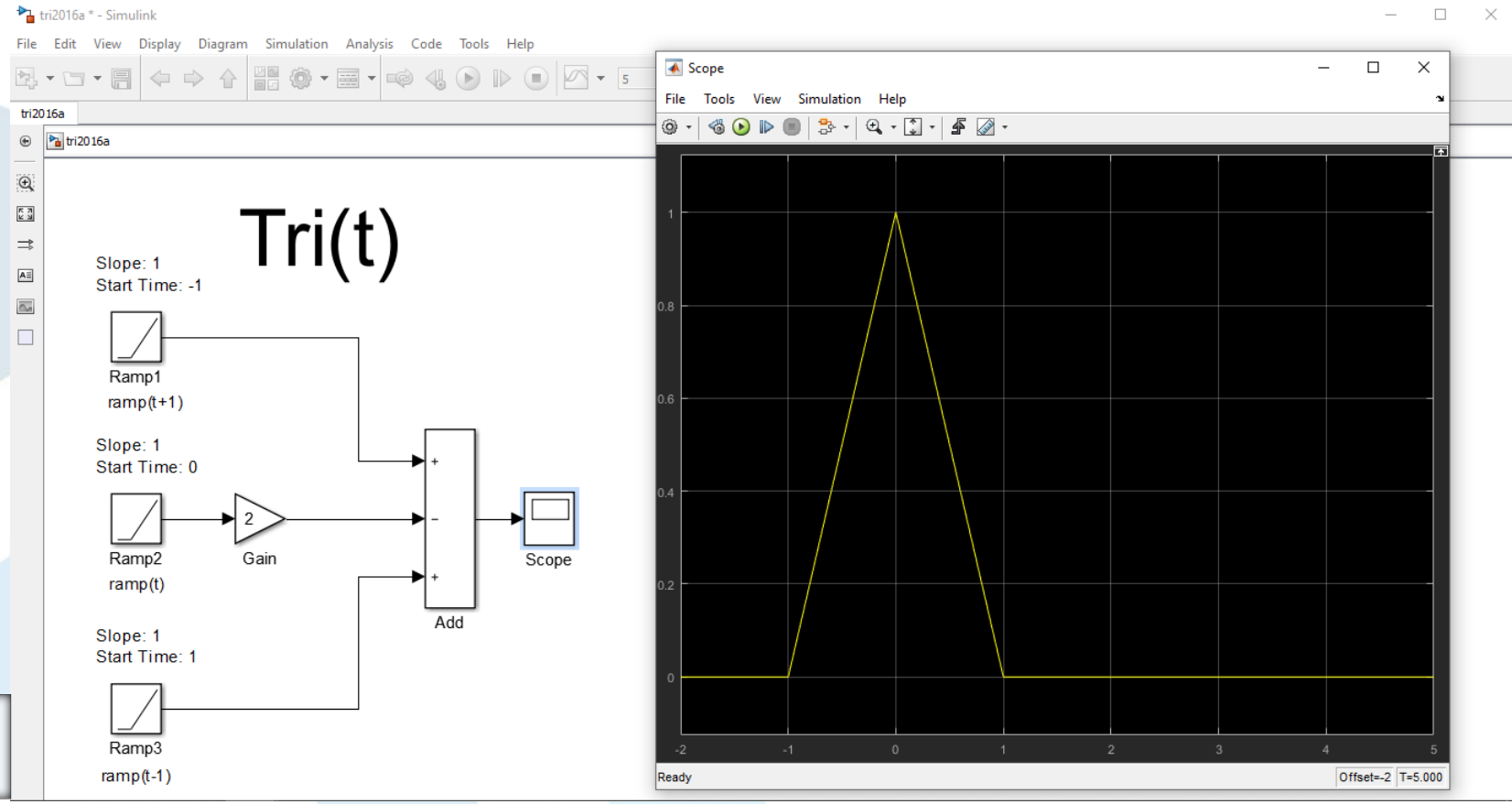
This model demonstrates how to generate and observe a **ramp signal** using Simulink:
Ramp Block: Produces a signal that increases linearly over time.
Scope Block: Displays the ramp signal in real time. The graph shows a straight yellow line sloping upward, confirming the linear increase.
Interpretation: The ramp signal starts at zero and increases continuously, representing the mathematical function



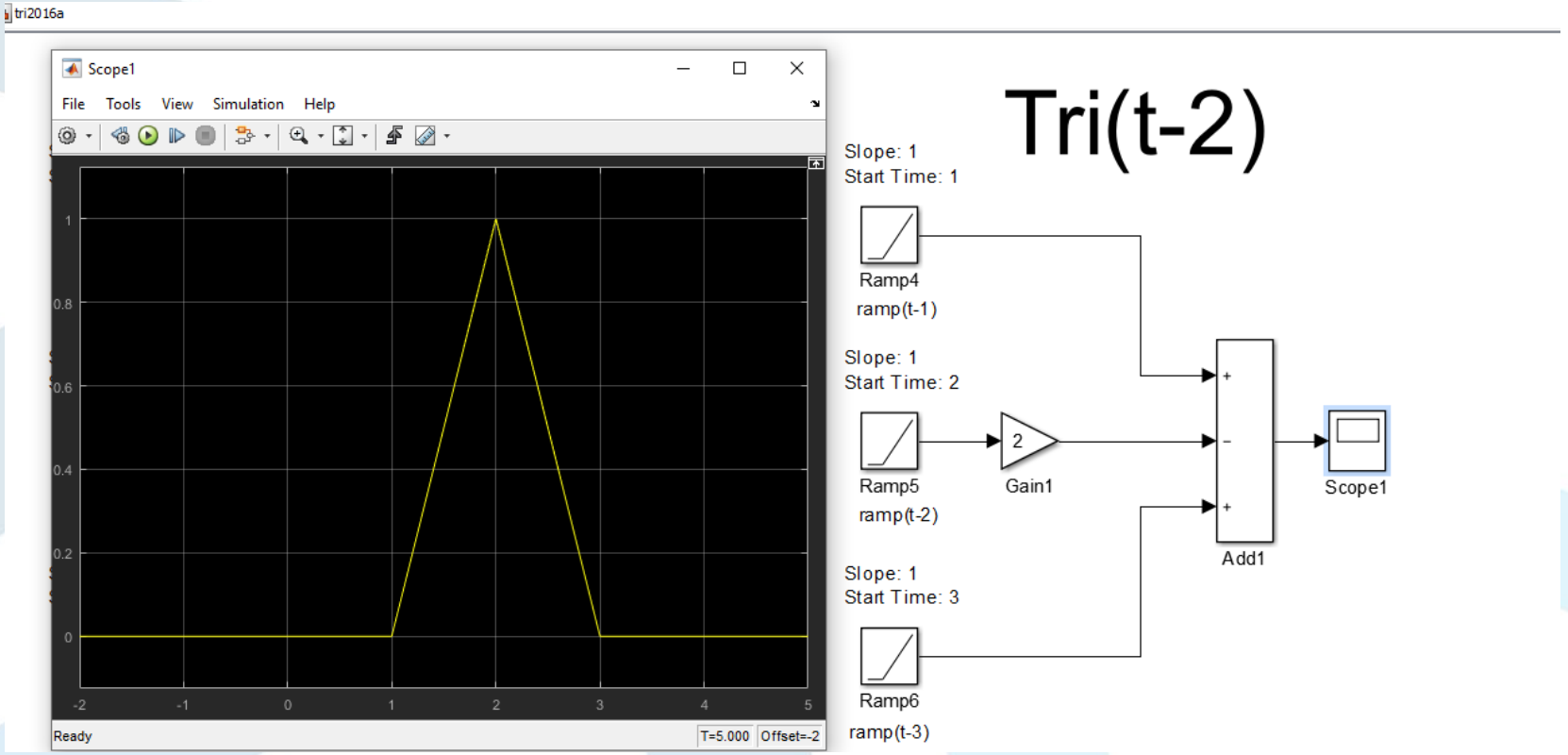
Simulating a Unit triangle signal using Simulink

This Simulink model generates a triangular waveform using two ramp signals and basic arithmetic blocks. Ramp1 rises from t=-1 to 0, while Ramp2 (scaled by 2) falls from t=1 to 0 (because of its negative slope,).
The combined output forms a symmetric triangle centered at t=0.

$$\Lambda(t) = r(t+1) - 2r(t) + r(t-1)$$



Shifted Unit Triangle signal using Simulink



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Thanks for Listening