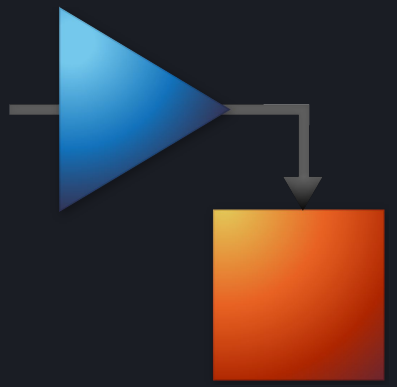
Simulink Basics Module

Model-Based Development Program

Simulink Basics Module

Objectives

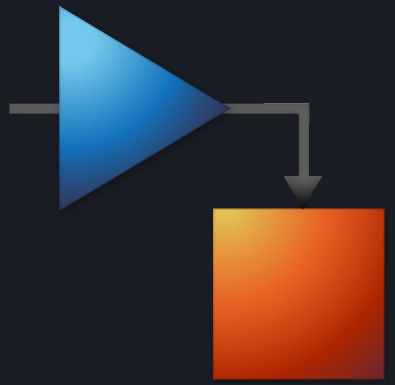
- Navigate Simulink environment, add blocks, and run models.
- Understand and compare Simulink solvers for embedded systems.
- Explore basic libraries, recognize key blocks, and analyze parameters.
- Learn code generation for individual and combined blocks.
- Create and reuse custom libraries across models.
- Integrate MATLAB functions seamlessly into Simulink models.
- Apply Simulink skills to real-world applications.



Simulink Basics Module

Module Content

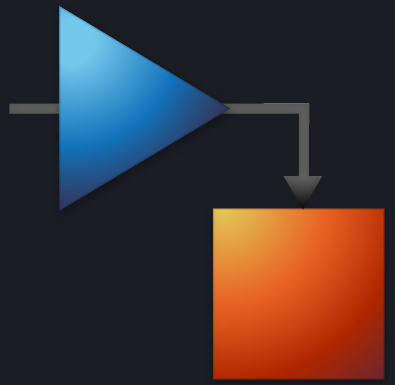
- Introduction to Simulink.
- Subsystems, Solvers and code generation process.
- Real World Applications.



Introduction to Simulink

Session Content

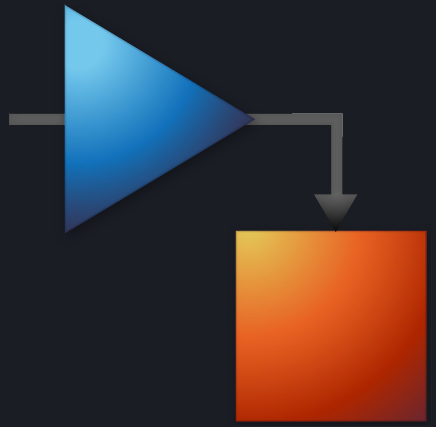
- Simulink Environment
- Commonly Used Blocks
- Examples



Introduction to Simulink

Simulink Environment

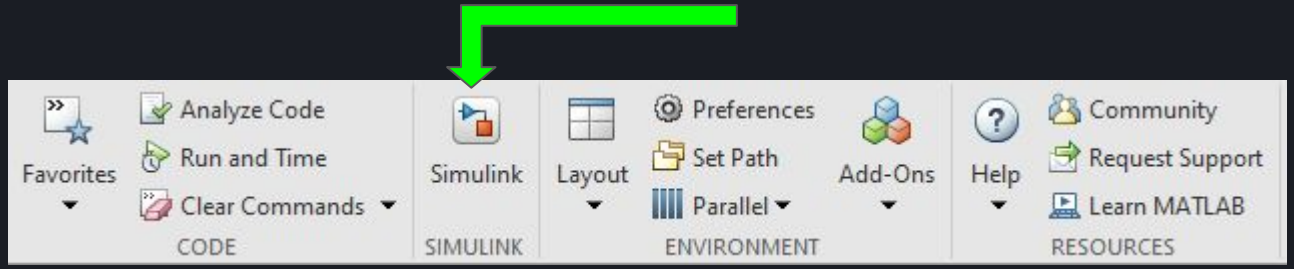
- Simulink: An extensive library collection for creating simulations.
- Block Linking: Allows specific blocks to be linked for simulation development.



Introduction to Simulink

Simulink Environment

- How To open Simulink Model



Introduction to Simulink

Simulink Environment

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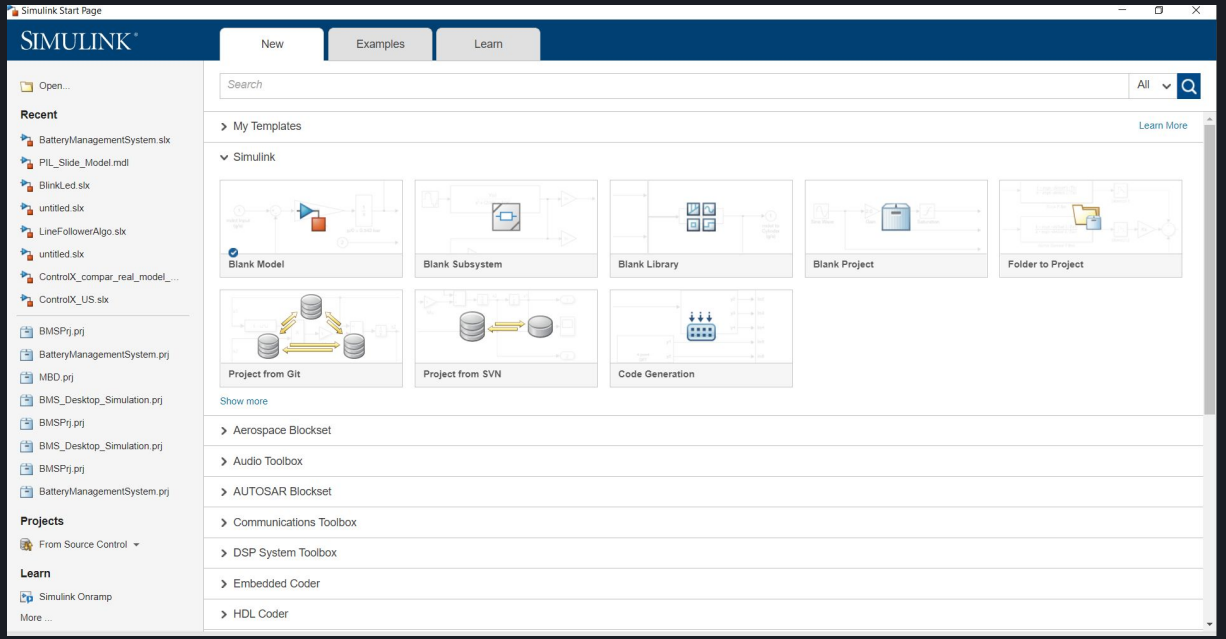
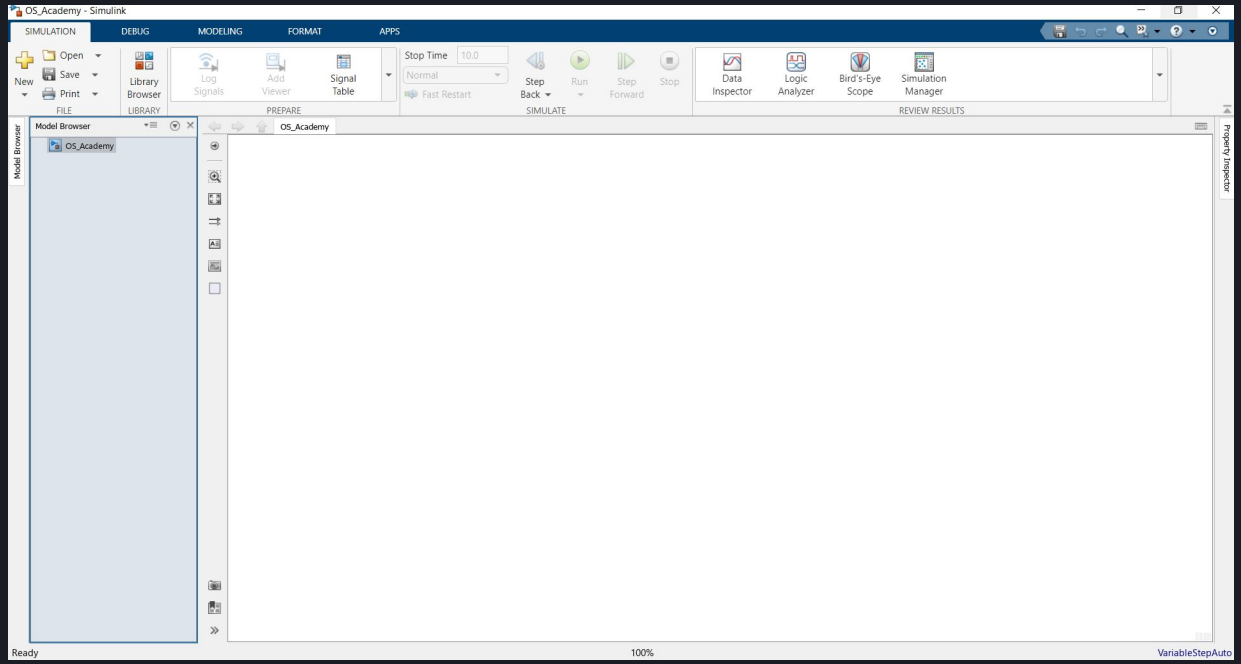


Introduction to Simulink

Simulink Environment

- How To open Simulink Model

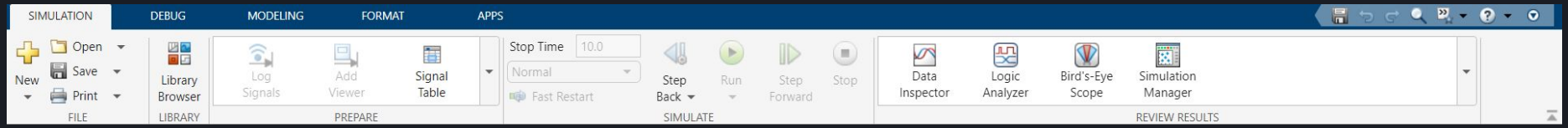


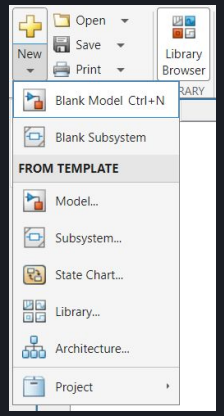
Model-Based Development Program

Introduction to Simulink

Simulink Environment

- Simulation Tap



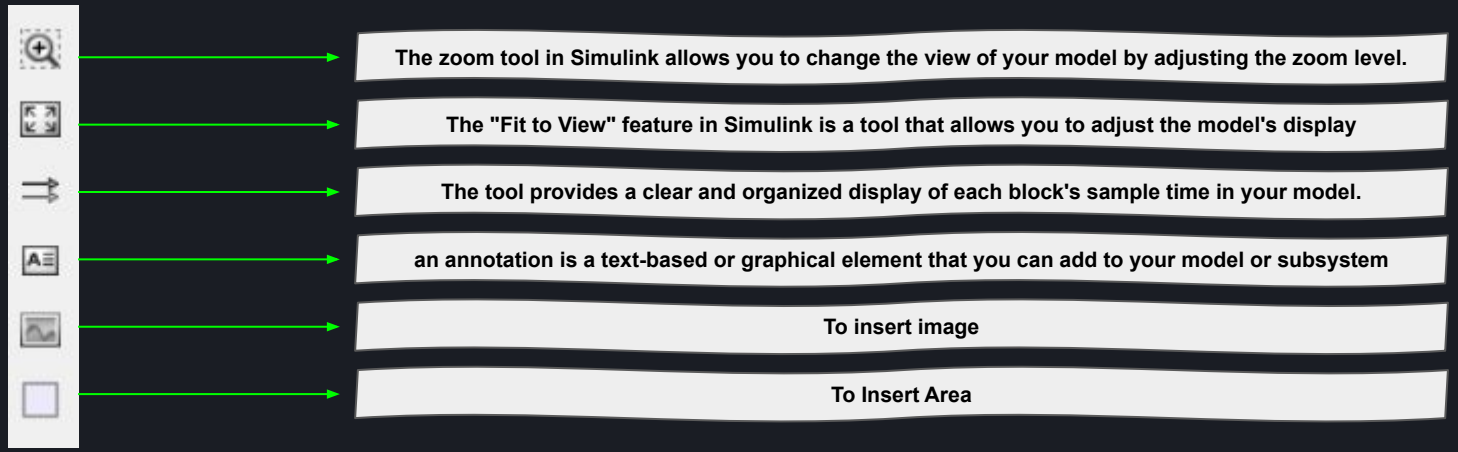


In Simulink, the "Simulation" tab provides various tools and settings to configure and control the simulation of your model. This tab is primarily focused on how you want to run and analyze your simulation

Introduction to Simulink

Simulink Environment

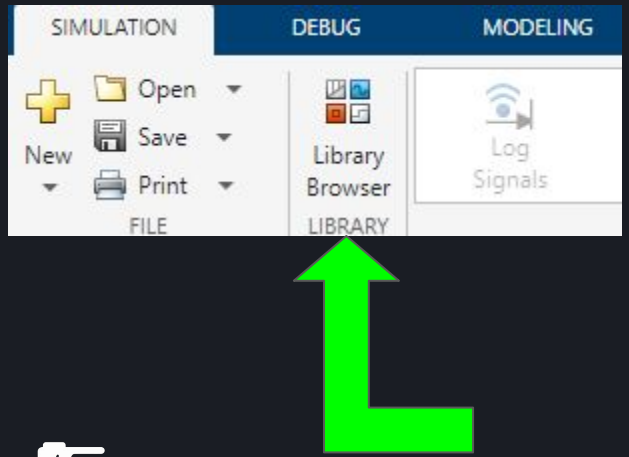
- Toolbar

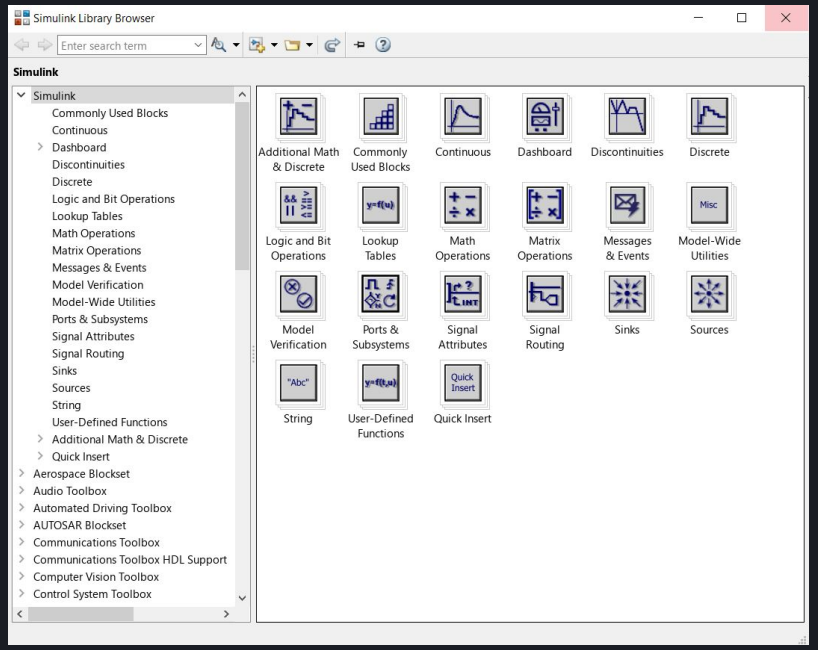


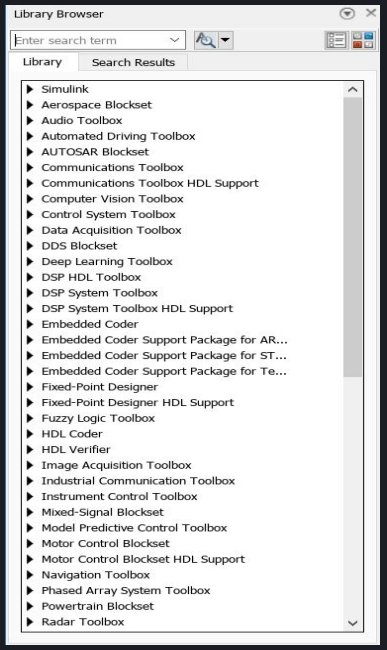
Introduction to Simulink

Simulink Environment

- How to Open Library Browser





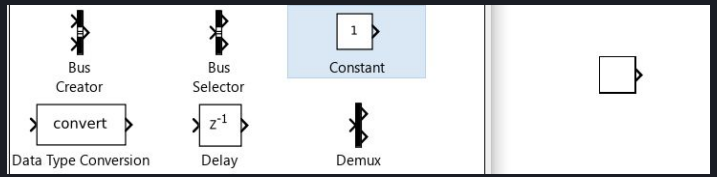


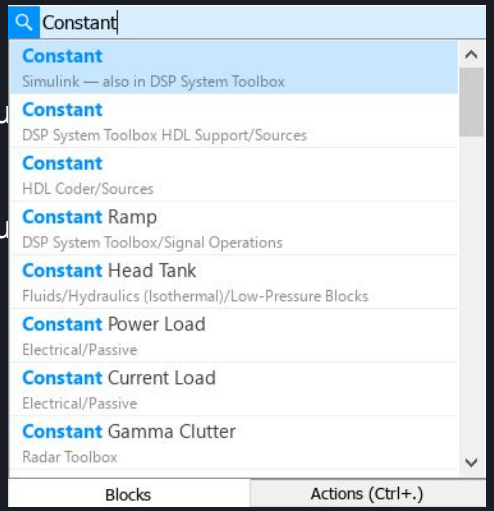
Model-Based Development Program

Introduction to Simulink

Simulink Environment

- How to insert Block in simulink model
  - Open Simulink: Launch MATLAB and open your Simulink model or create a new one.
  - Locate the Library Browser
  - Browse for Blocks
  - To insert a block, simply **drag and drop** the block from the Library Browser into the Simulink model window.
  - If your block needs to be connected to other blocks in your model, you can u the appropriate connections like lines (signal lines) and connect the blocks together.
  - If your block needs to be connected to other blocks in your model, you can u the appropriate connections like lines (signal lines) and connect the blocks together.
  - Save the Model

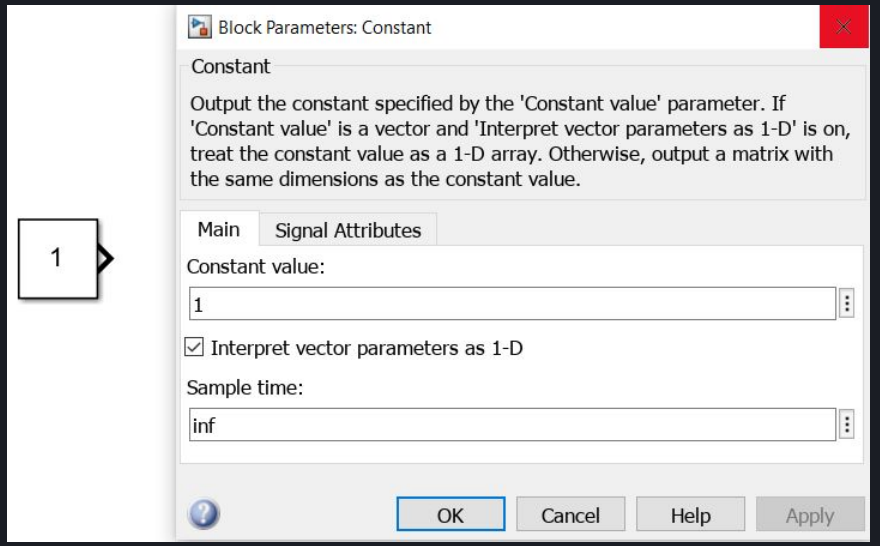




Introduction to Simulink

Simulink Environment

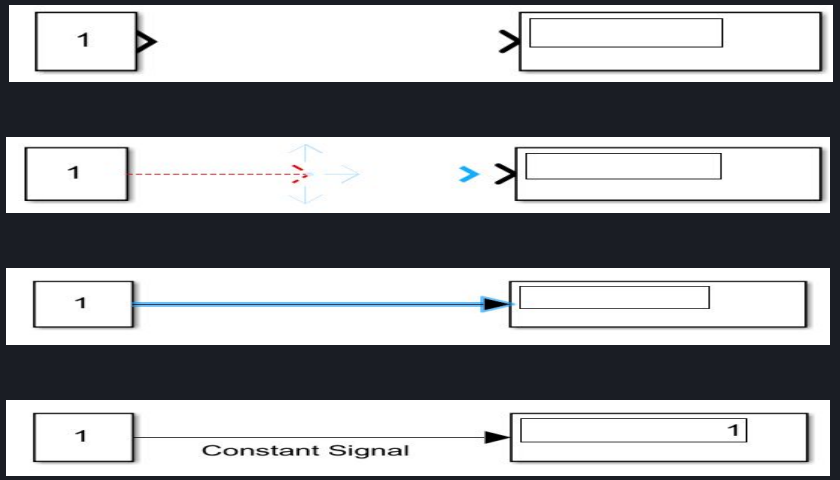
- Configure Block Parameters
  - Double-click on the block to open its block parameters dialog box. Here, you can set the specific parameters and properties of the block, such as block name, input/output ports, and other settings.



Introduction to Simulink

Simulink Environment

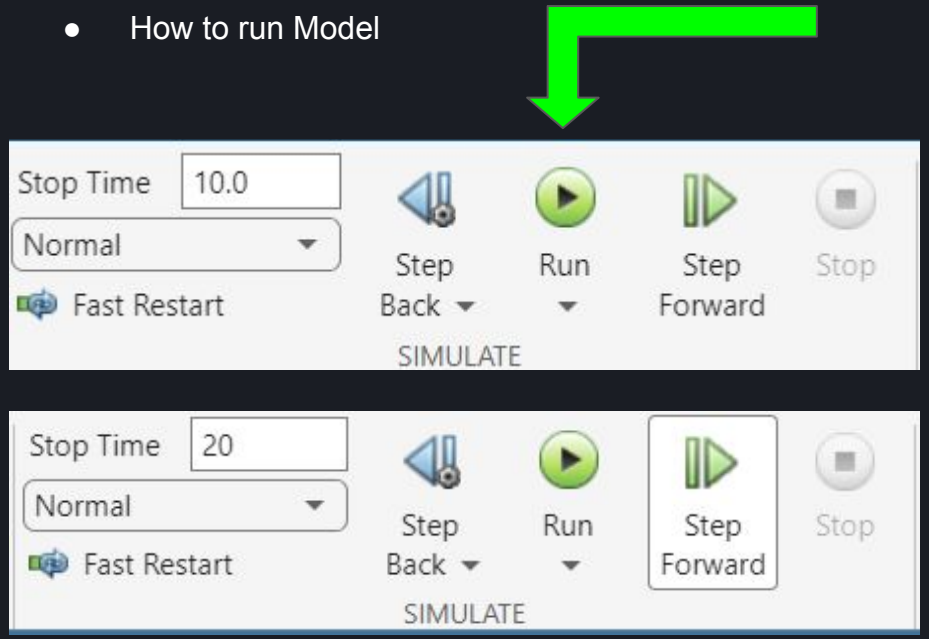
- How to Connect Two Blocks Together
  - Open your Simulink model.
  - Make sure the blocks you want to connect are in the model.
  - Select the source block.
  - **Click and drag from the source block's output port to the target block's input port**.
  - Configure the connection if needed.
  - Repeat for other connections.
  - Save your model.

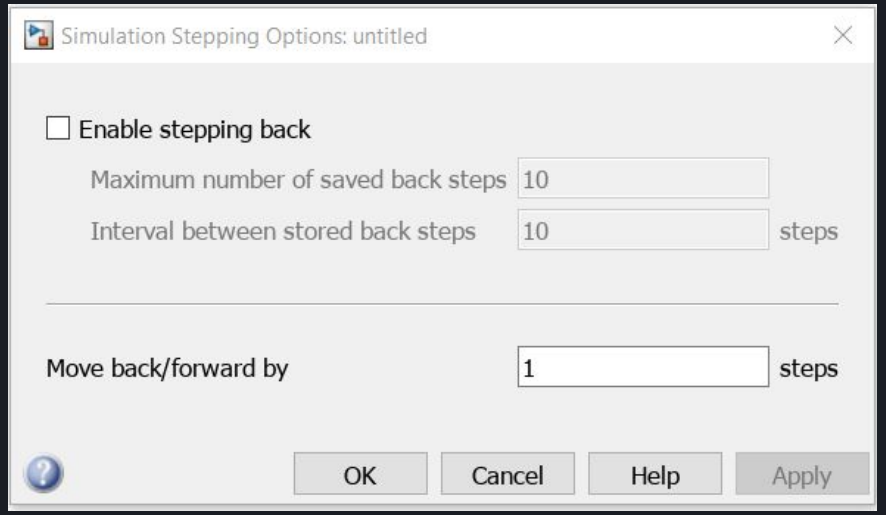


Introduction to Simulink

Simulink Environment

- How to run Model





Introduction to Simulink

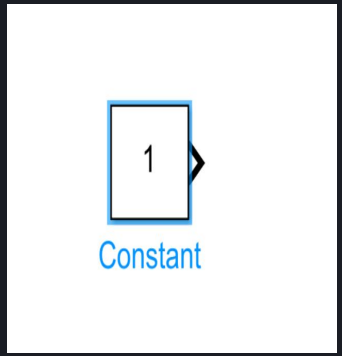
Quiz 1: Click Here To Start

Introduction to Simulink

Commonly Used Blocks

- Constant Block
  The Constant block in Simulink is used to generate a constant signal or value. It's a fundamental building block that allows you to inject a fixed numeric value or signal into your Simulink model.

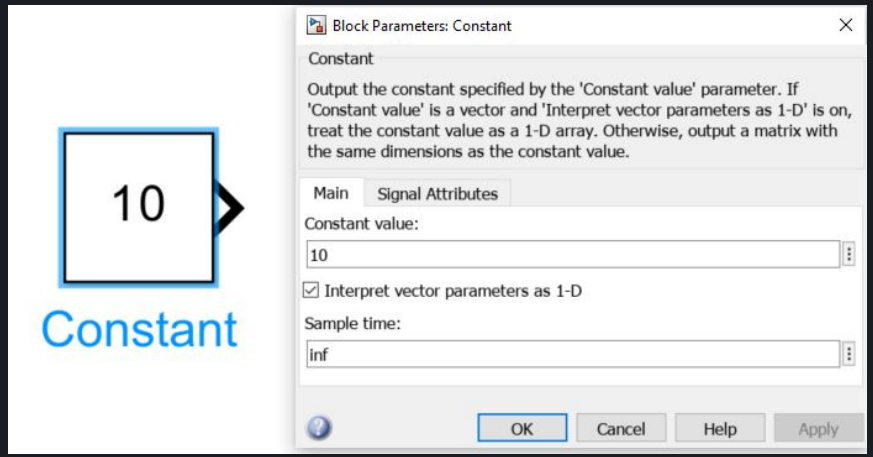
  The Constant block has one output port, and its value remains constant throughout the simulation. It's often used to provide fixed inputs or parameters to other blocks in your Simulink model.



Introduction to Simulink

Commonly Used Blocks

- Constant Block
  Example 1: Constant Value
  Suppose you want to input a constant value, such as 10, into your Simulink model.
  Here's how to use the Constant block:



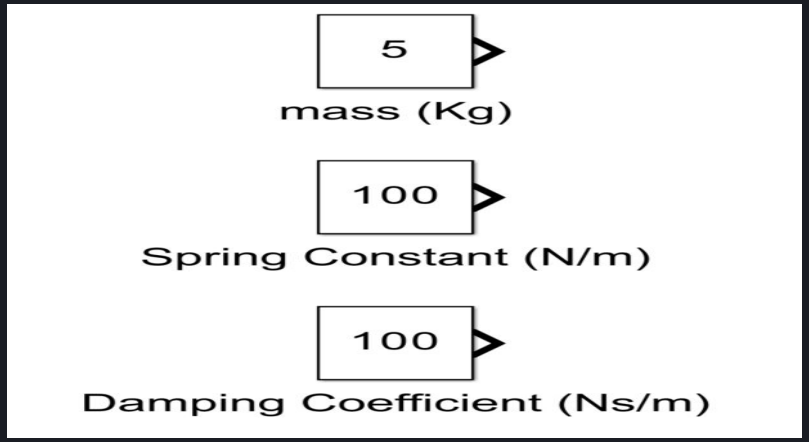
1. Drag and drop a Constant block from the Simulink library to your model.
2. Double-click on the Constant block to open its Block Parameters dialog.
3. In the "Constant value" field, enter the desired constant value, like 10.
4. Close the Block Parameters dialog.
5. Connect the output of the Constant block to the input of the block that needs this constant value.

The Constant block will generate a constant signal with a value of 10, which is then fed into the connected block.

Introduction to Simulink

Commonly Used Blocks

- Constant Block
  Example 2: System Parameters: Constants are often used to represent system parameters or physical constants. For instance, if you're modeling a spring-mass-damper system and want to use known constants like mass, spring constant, and damping coefficient:



1. Create a Constant block for each parameter.
2. Set the values of these Constant blocks to the known physical constants (e.g., mass = 5 kg, spring constant = 100 N/m, damping coefficient = 2 Ns/m).
3. Connect these Constant blocks to the appropriate blocks in your model (e.g., Mass, Spring, and Damper blocks).

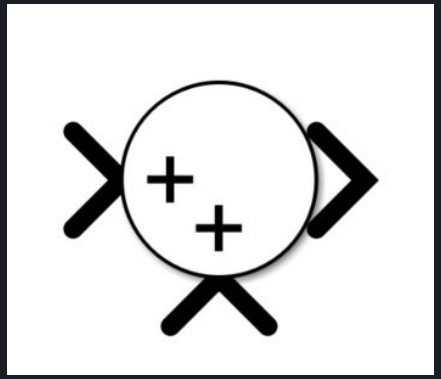
The Constant blocks store and provide the physical constants to your model.

Introduction to Simulink

Commonly Used Blocks

- Sum Block
  The Sum block in Simulink is a fundamental block used to perform mathematical operations, particularly addition and subtraction. It can take multiple input signals and combine them based on the operation specified.

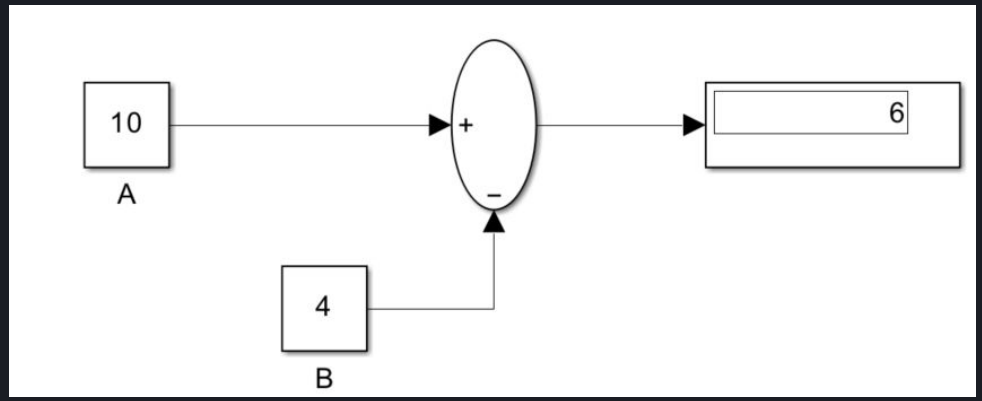
  The Sum block allows you to add or subtract input signals, providing a simple way to perform basic arithmetic operations within a Simulink model. It can be used to create control signals, model system behavior, or implement various mathematical relationships.



Introduction to Simulink

Commonly Used Blocks

- Sum Block
  Example 1: Simple Addition: Suppose you want to add two input signals, A and B, in your Simulink model. Here's how to use the Sum block for addition:



1. Drag and drop a Sum block from the Simulink library to your model.
2. Double-click on the Sum block to open its Block Parameters dialog.
3. In the "Number of inputs" field, set the number of input ports to 2.
4. Connect input signal A to the "+" input port and input signal B to the "-" input port.
5. The output of the Sum block will be the result of adding signals A and B.

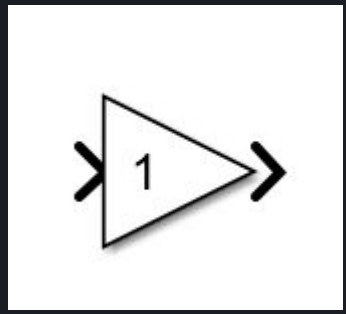
This Sum block will calculate A - B, effectively adding the two input signals.

Introduction to Simulink

Commonly Used Blocks

- Gain Block
  The Gain block in Simulink is used to scale or amplify input signals by a constant factor. It's a fundamental block often used to adjust the magnitude or amplitude of signals in your Simulink model.

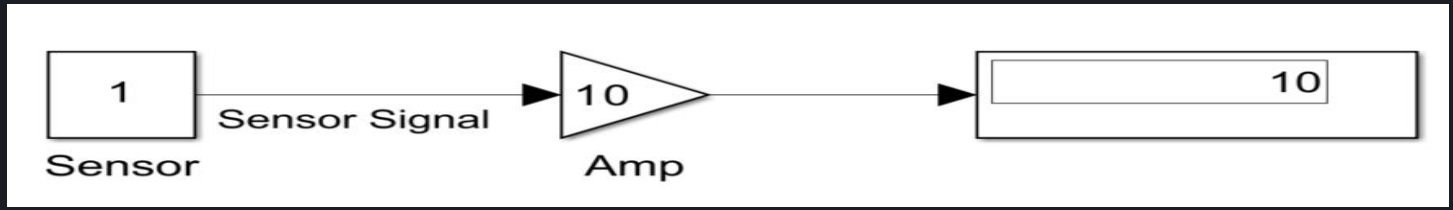
  The Gain block simply multiplies the input signal(s) by a constant scaling factor (the gain). It's commonly used for control systems, signal conditioning, and signal processing applications where signal amplitudes need to be adjusted.



Introduction to Simulink

Commonly Used Blocks

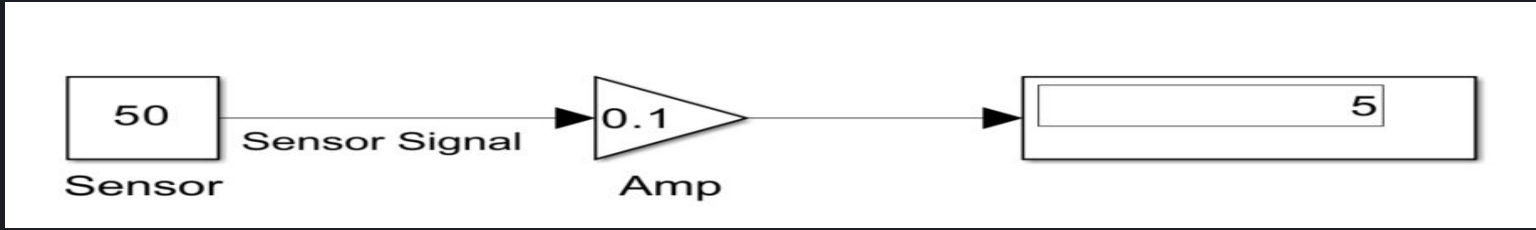
- Gain Block
  Example 1: Signal Amplification:Suppose you have a sensor that produces a signal in the range of 0 to 1V, but you need to amplify it to match a control system that operates in the range of 0 to 10V. Here's how to use the Gain block to amplify the signal:



Introduction to Simulink

Commonly Used Blocks

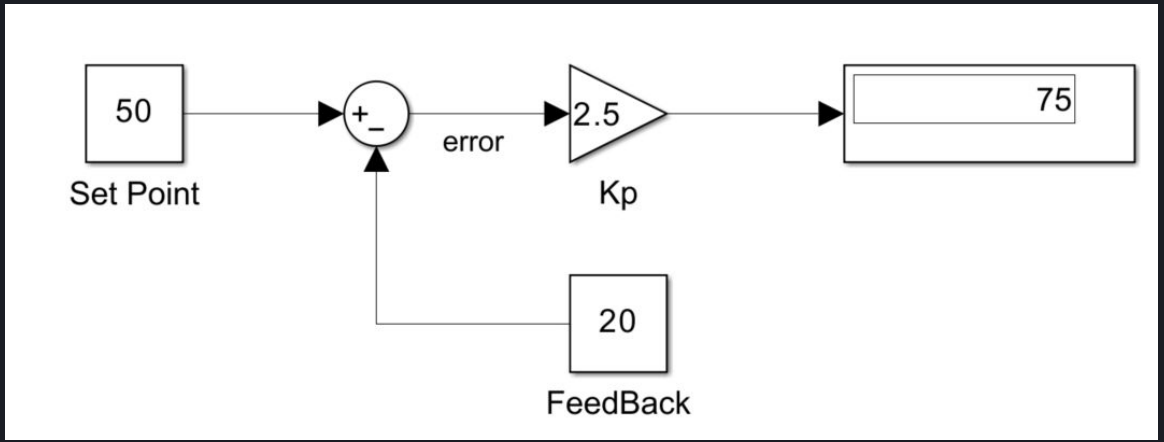
- Gain Block
  Example 2: Signal Attenuation:
  Conversely, you might need to reduce the amplitude of a signal. For instance, if you have a signal in the range of 0 to 100V, but your equipment can only handle a maximum of 10V, you can use the Gain block to attenuate the signal:



Introduction to Simulink

Commonly Used Blocks

- Gain Block
  Example 3: Control System Gain:
  In control system modeling, the Gain block is often used to represent the proportional gain (Kp) of a controller. For example, in a simple proportional-integral-derivative (PID) controller, the proportional term multiplies the error signal by a gain factor. Here's how to model the proportional gain using the Gain block:



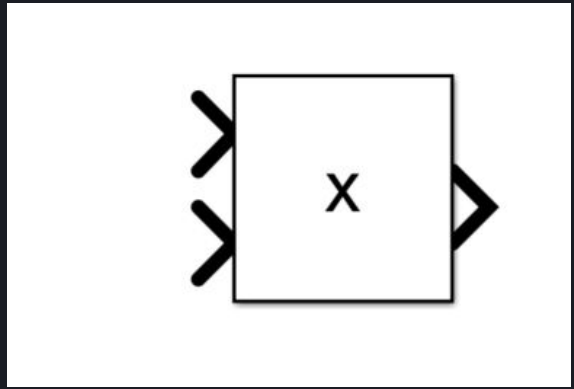
1. Insert a Gain block into your model.
2. Set the "Gain" field to the desired proportional gain value (e.g., Kp = 2.5).
3. Connect the error signal (the difference between the desired setpoint and the actual output) to the input of the Gain block.

Introduction to Simulink

Commonly Used Blocks

- Product Block
  The Product block in Simulink is used for multiplication operations in a model. It multiplies two or more input signals to produce an output signal.

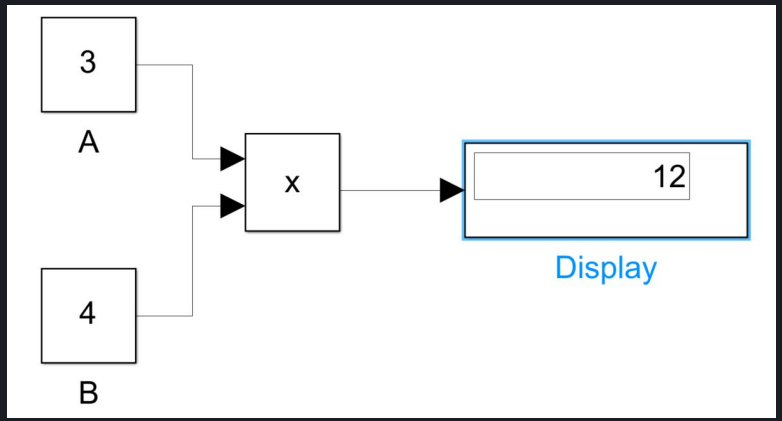
  The Product block is a fundamental component in Simulink for performing multiplication operations within your model. It's useful for various applications, including simple multiplication, power calculations, and scaling signals. Depending on the specific use case, the Product block can be configured to perform various multiplication operations, making it a versatile tool in your Simulink toolbox.



Introduction to Simulink

Commonly Used Blocks

- Product Block
  Example 1: Simple Multiplication
  Suppose you have two input signals, A and B, and you want to multiply them together. Here's how to use the Product block to do that



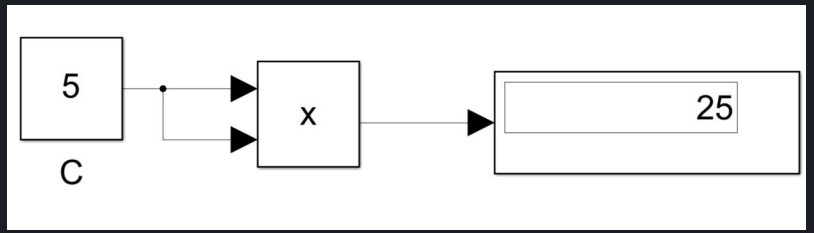
1. Drag and drop a Product block from the Simulink library to your model.
2. Connect input signal A to the "In1" port of the Product block.
3. Connect input signal B to the "In2" port of the Product block.
4. The output of the Product block will be the result of multiplying signals A and B.

In this case, if A is 3 and B is 4, the output will be 12. The Product block computes the product of its input signals.

Introduction to Simulink

Commonly Used Blocks

- Product Block
  Example 2: Power Calculation
  You can also use the Product block to perform power calculations. For instance, if you want to square an input signal, here's how you can do it:



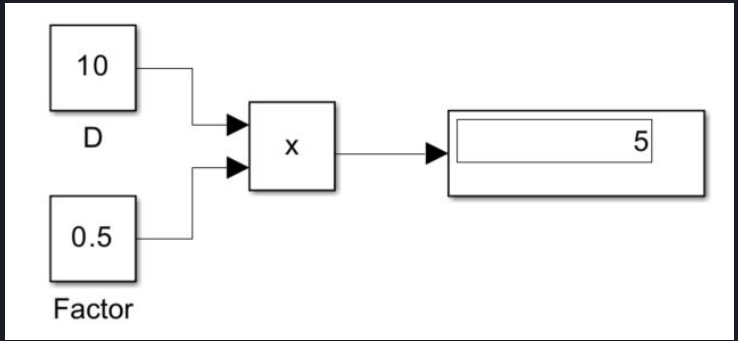
1. Add a Product block to your model.
2. Connect the input signal, C, to both "In1" and "In2" ports of the Product block.
3. The output of the Product block will be the square of signal C.

   So, if C is 5, the output will be 25. The Product block multiplies the signal by itself, effectively squaring it.

Introduction to Simulink

Commonly Used Blocks

- Product Block
  Example 3: Scaling a Signal
  Sometimes, you need to scale a signal by multiplying it by a constant factor. Here's how to do that using the Product block.



1. Insert a Product block into your model.
2. Connect the input signal, D, to the "In1" port of the Product block.
3. In the "In2" port, enter the scaling factor (e.g., 0.5).
4. The output of the Product block will be half of the input signal D.

If D is 10, the output will be 5. The Product block scales the input signal by multiplying it by the specified constant.

Introduction to Simulink

Commonly Used Blocks

- Mux Block
  The "Mux" block in Simulink, which stands for "multiplexer," is used to combine multiple input signals into a single output signal. This is commonly used when you want to merge several signals to feed them into a subsystem or display them in a scope.

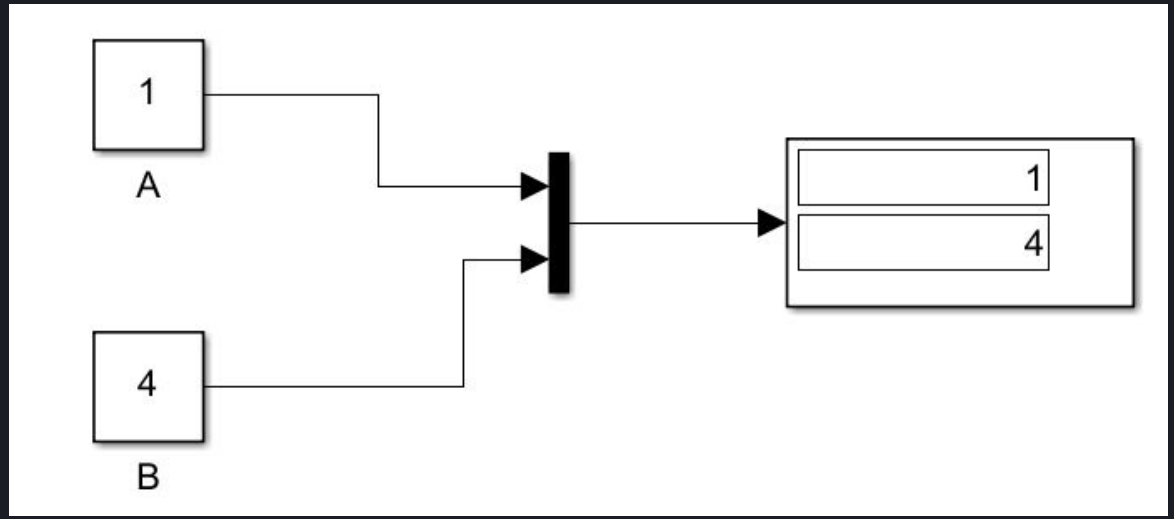
  A Mux (multiplexer) block in Simulink is used to combine multiple input signals into a single output signal. It's a fundamental building block for creating systems that need to merge or route signals from various sources.

  The Mux block in Simulink typically has multiple input ports, and it outputs a combined signal. The number of input ports determines how many signals can be combined. For example, if you have a 4-input Mux block, you can merge up to four signals into one output.

Introduction to Simulink

Commonly Used Blocks

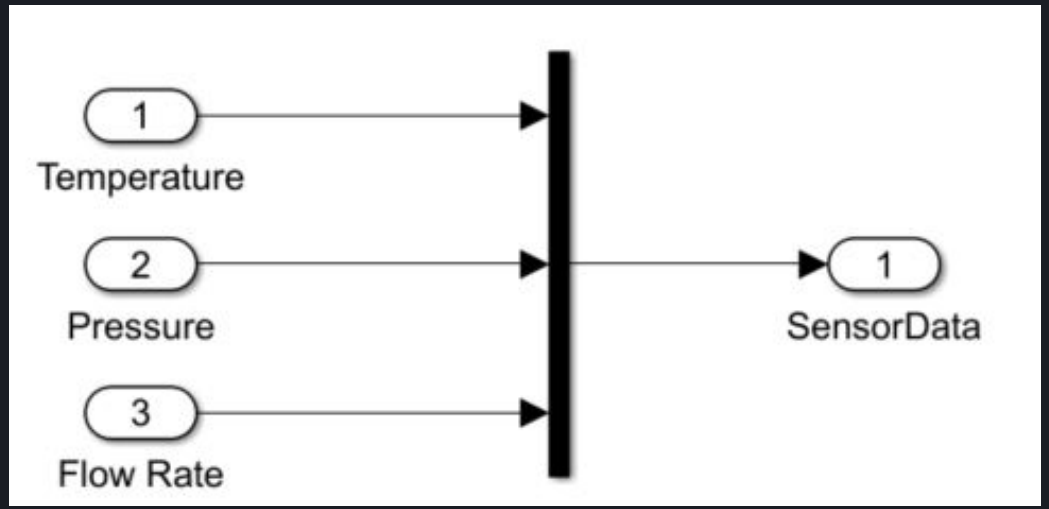
- Mux Block
  Example 1 - Combining Two Signals: Suppose you have two signals, 'Signal A' and 'Signal B,' and you want to merge them into a single signal 'Combined Signal.' You can use a Mux block with two input ports:



Introduction to Simulink

Commonly Used Blocks

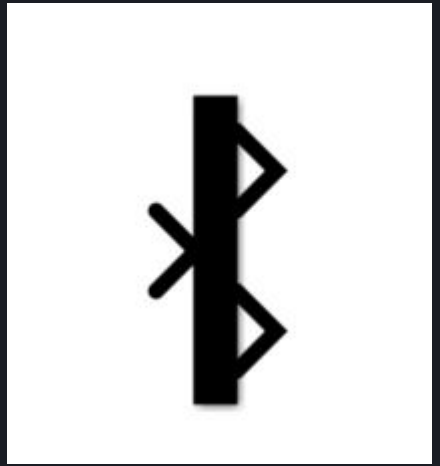
- Mux Block
  Example 2 - Combining Multiple Signals: Now, consider a scenario where you have three signals: 'Temperature,' 'Pressure,' and 'Flow Rate.' You want to merge these into a single signal 'Sensor Data.' You can use a Mux block with three input ports:



Introduction to Simulink

Commonly Used Blocks

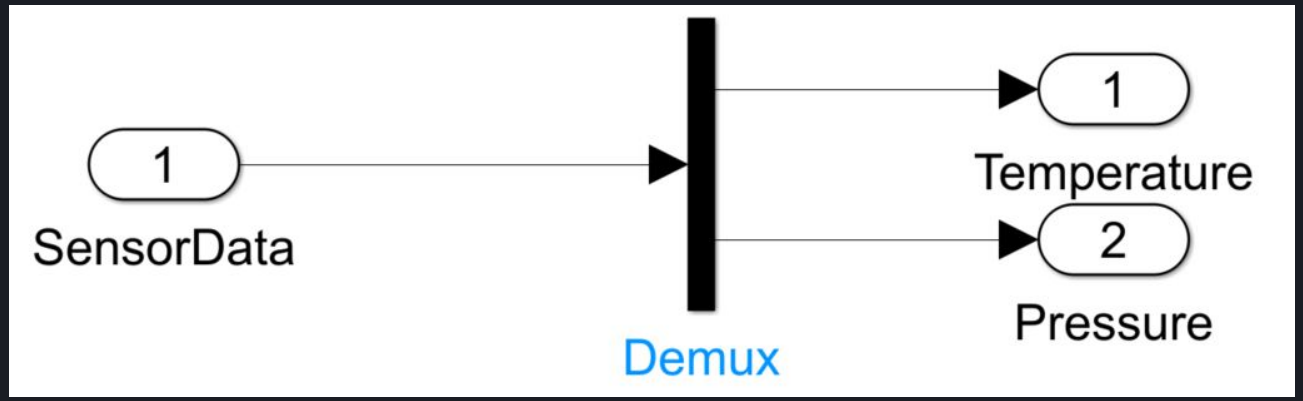
- DeMux Block
  The "Demux" block in Simulink, which stands for "demultiplexer," is used to separate a single input signal into multiple output signals. It is the reverse operation of the Mux block, which combines multiple signals into one. The Demux block is useful when you need to distribute a single signal to different parts of your Simulink model. Let's explain the Demux block with an example:



Introduction to Simulink

Commonly Used Blocks

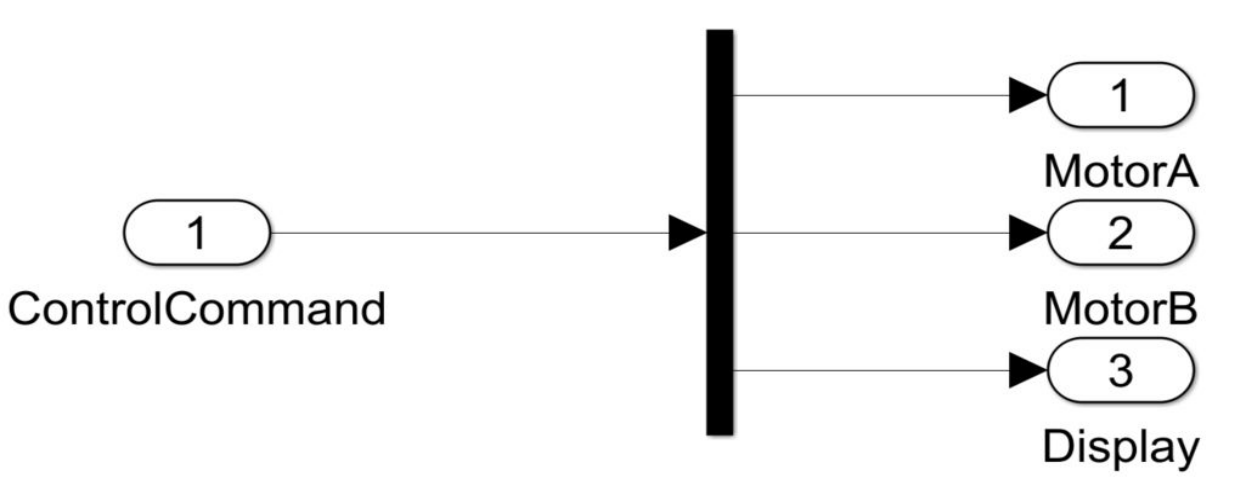
- DeMux Block
  Example 1 - Splitting a Signal into Two Outputs: Suppose you have a single input signal 'Combined Signal' that carries both 'Temperature' and 'Pressure' information. You want to split this signal into two separate signals: 'Temperature' and 'Pressure.' You can use a Demux block with two output ports:



Introduction to Simulink

Commonly Used Blocks

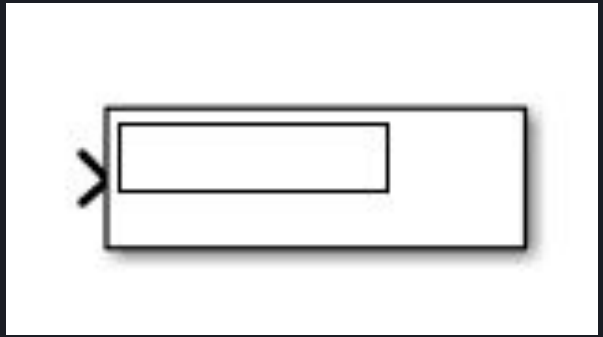
- DeMux Block
  Example 2 - Distributing a Signal to Multiple Components: Now, consider a scenario where you have a control signal 'Control Commands' that needs to be distributed to three different components: 'Motor A,' 'Motor B,' and 'Display.' You can use a Demux block with three output ports:



Introduction to Simulink

Commonly Used Blocks

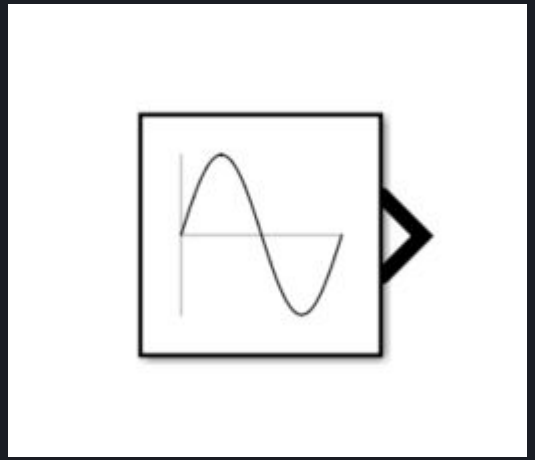
- Display Block
  In Simulink, the "Display Block" is not a standard block or component like other fundamental blocks such as Gain or Sum. Instead, it's a type of block that is typically not used for modeling the dynamics of a system but rather for visualization and monitoring purposes.



Introduction to Simulink

Commonly Used Blocks

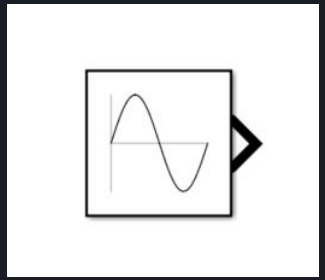
- Sine wave Block
  A Sine Wave block in Simulink is used to generate a sine wave signal with specific parameters, such as frequency, amplitude, phase, and sample time. It's commonly used for creating periodic signals in various applications.

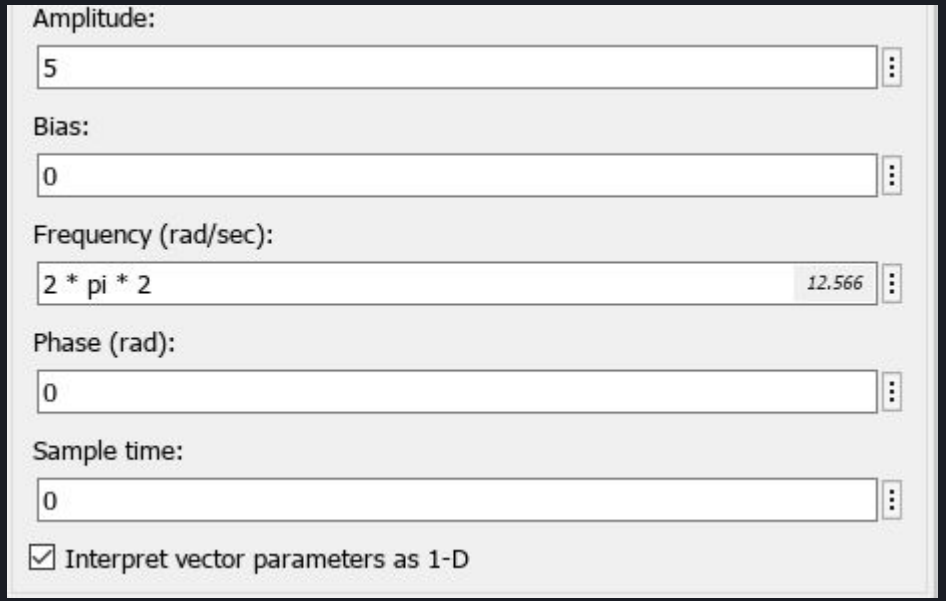


Introduction to Simulink

Commonly Used Blocks

- Sine wave Block
  Example - Generating a Simple Sine Wave: Suppose you want to create a sine wave signal with the following specifications:
  - Amplitude: 5
  - Frequency: 2 Hz
  - Phase: 0 degrees
  - Offset: 0





Introduction to Simulink

Commonly Used Blocks

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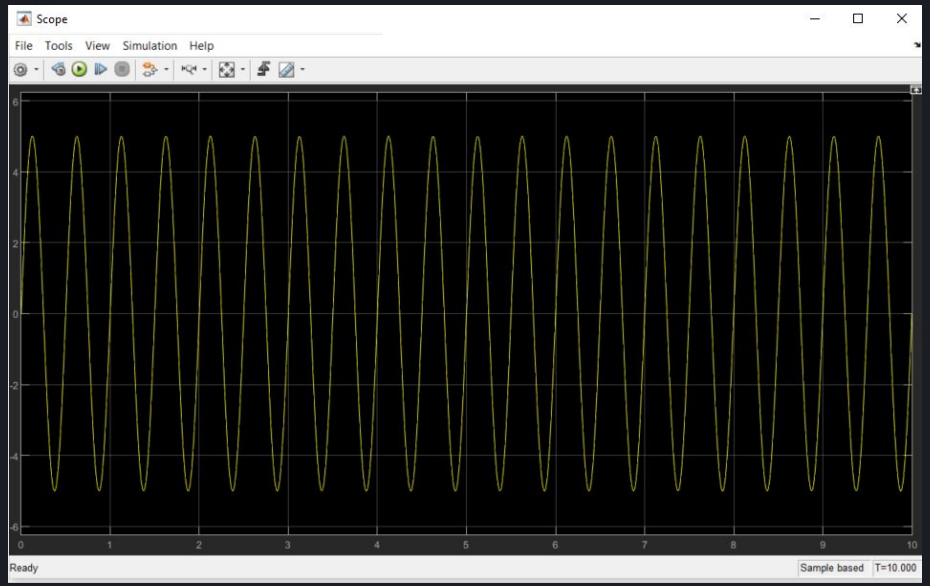
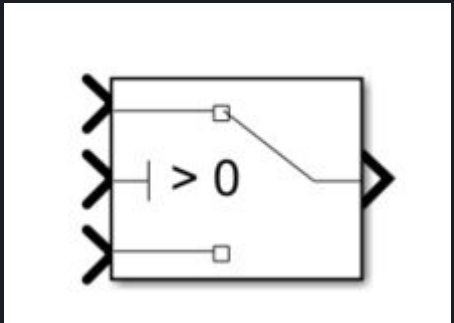


Introduction to Simulink

Commonly Used Blocks

- Switch Block
  In Simulink, the "Switch" block is a fundamental block that allows you to select between two input signals based on a control signal. This block is essential for creating decision-based systems and logic in your Simulink models.

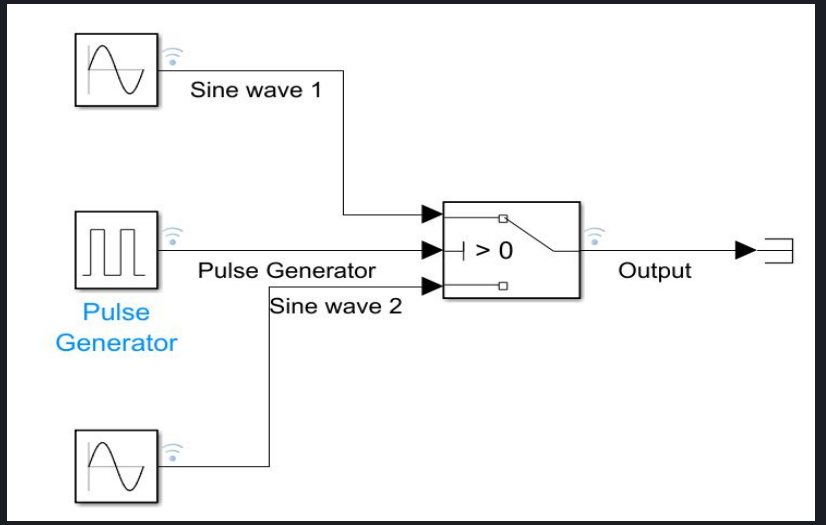


Introduction to Simulink

Commonly Used Blocks

- Switch Block
  Example 1 - Basic Switch: Suppose you have two sine wave signals as inputs, and you want to select one of them based on a control signal. Here's how you can use the "Switch" block in Simulink to achieve this:

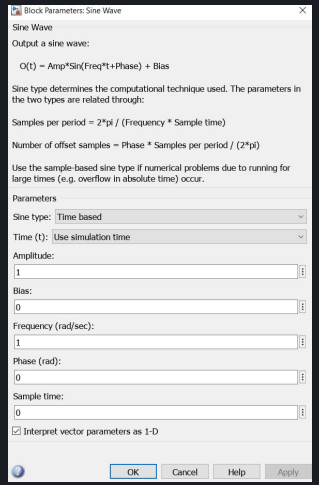
1. Drag and drop a "Switch" block from the Simulink Library Browser into your model.
2. Connect the two sine wave signals to the "Switch" block's two input ports.
3. Connect the control signal (e.g., a Pulse Generator) to the control input port.
4. Configure the block to your needs. You can choose whether to select the first or second input based on your control signal.

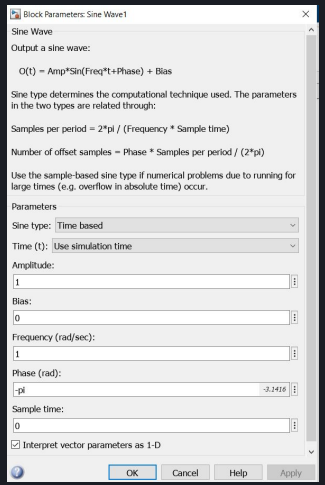


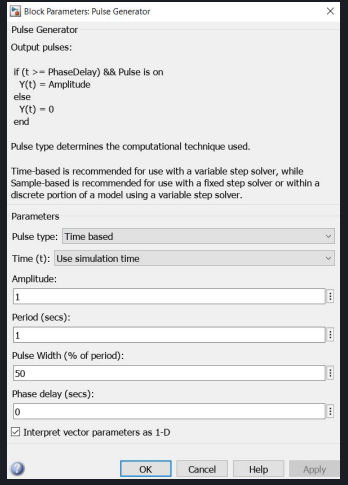
Introduction to Simulink

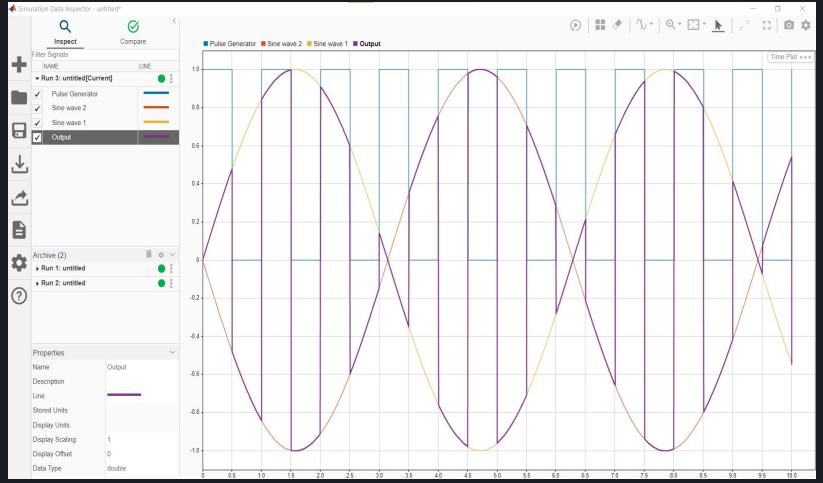
Commonly Used Blocks

- Switch Block







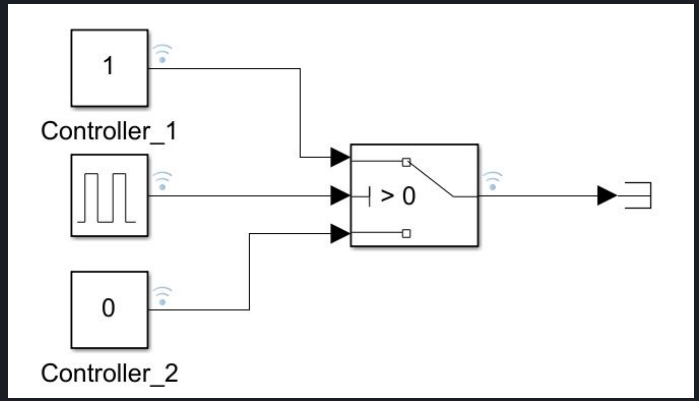


Introduction to Simulink

Commonly Used Blocks

- Switch Block
  Example 2 - Toggle Between Different Controllers: In control systems, you may want to switch between different control strategies. For instance, you have two different controllers (PID and LQR), and you want to toggle between them. You can use the "Switch" block with a binary control signal (0 or 1) to choose between the two controllers.

These examples demonstrate how the "Switch" block can be used to introduce conditional logic into your Simulink models. It allows you to dynamically select between different inputs based on the value of the control signal, making it a versatile tool for building complex systems and simulations.



Introduction to Simulink

Commonly Used Blocks

- Switch Block
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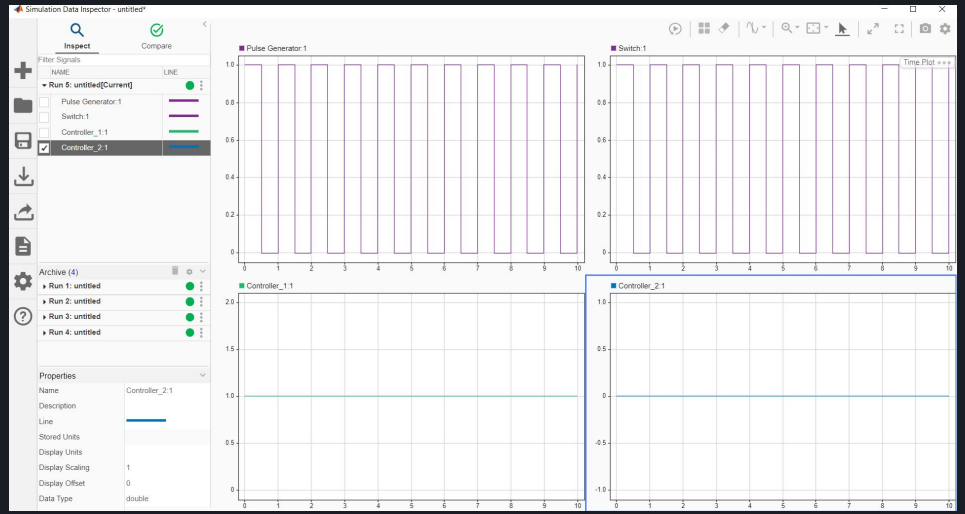
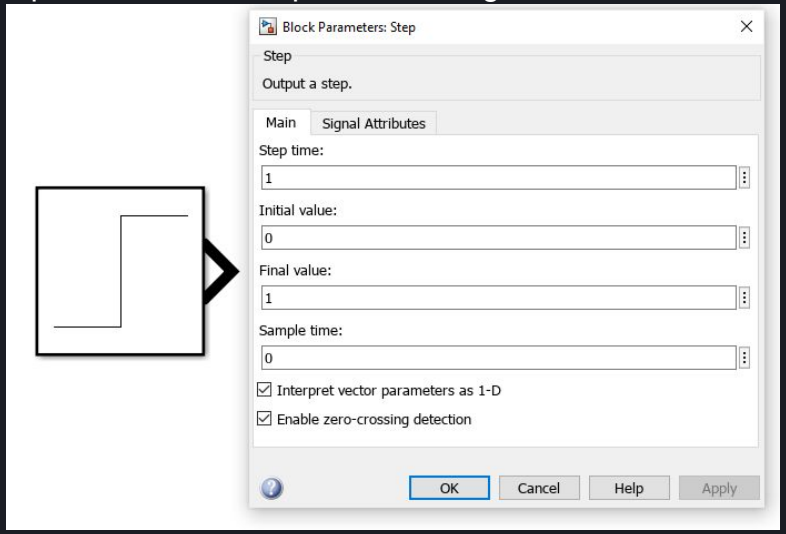


Model-Based Development Program

Introduction to Simulink

Commonly Used Blocks

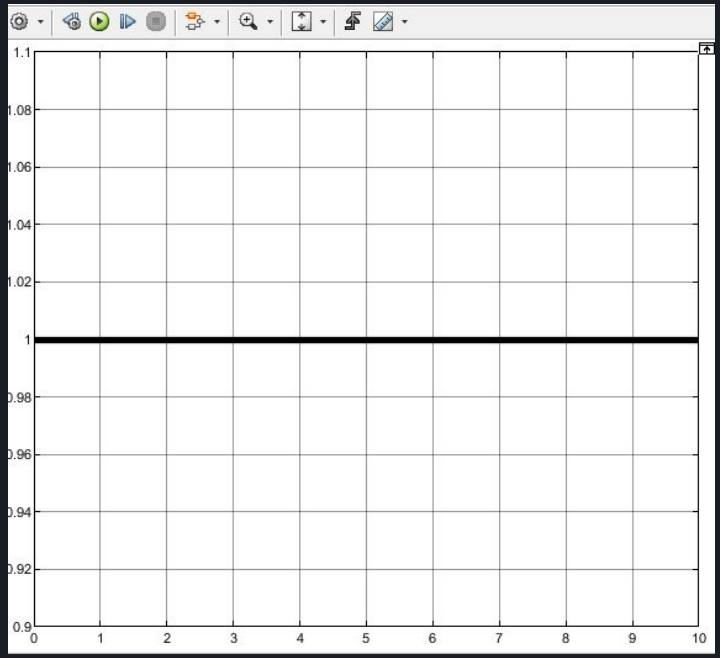
- Step Block
  In Simulink, the Step block is a fundamental building block used to generate a step function as an input signal for a dynamic system. It provides a straightforward way to simulate a sudden change or transition in a system's input. The step function typically represents a unit step, transitioning from one value to another at a specific time.



Introduction to Simulink

Commonly Used Blocks

- Step Block
  Example 1: A Simple Unit Step
  - Time of Step: 0 (default)
  - Initial Value: 0
  - Final Value: 1

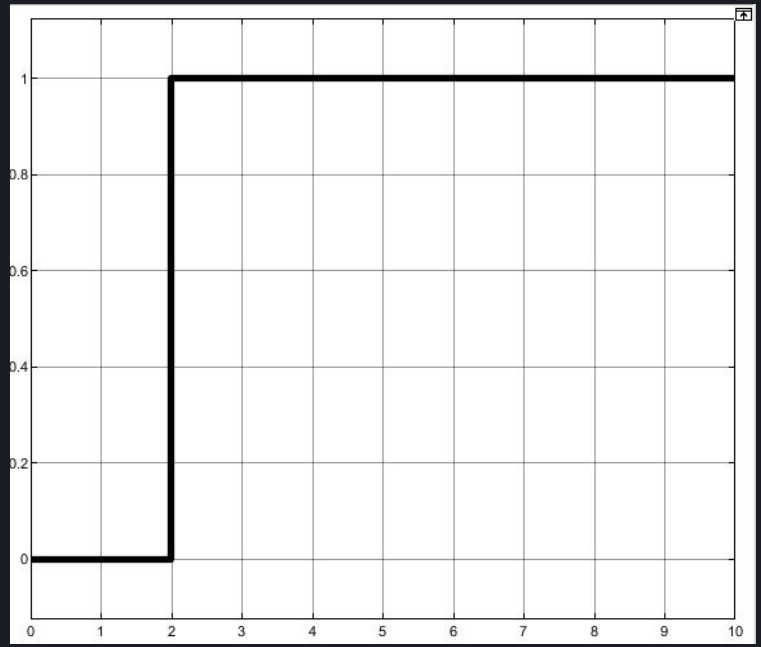


This example generates a unit step function that starts at time 0 with an initial value of 0 and transitions to a final value of 1. It represents an instantaneous change in the input from 0 to 1.

Introduction to Simulink

Commonly Used Blocks

- Step Block
  Example 2: A Delayed Step
  - Time of Step: 2
  - Initial Value: 0
  - Final Value: 1



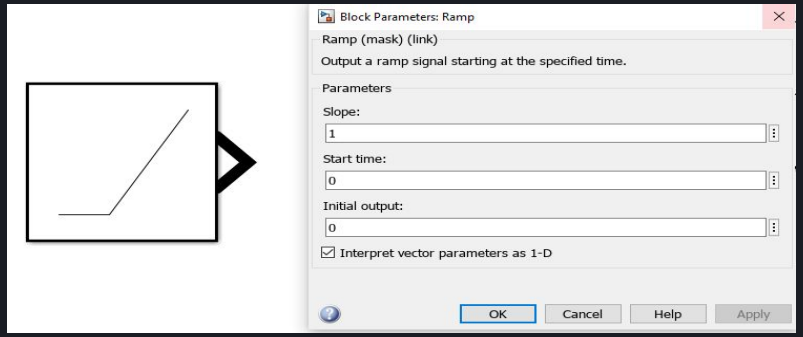
This example introduces a time delay, with the step function starting at time 2. Before time 2, the input remains at the initial value of 0, and after time 2, it transitions to the final value of 1

Introduction to Simulink

Commonly Used Blocks

- Ramp Block
  In Simulink, the Ramp block is a fundamental building block used to generate a continuous ramp signal as an input for dynamic systems. It is particularly useful for modeling linearly changing quantities over time. The Ramp block has parameters that allow you to control the slope and initial value of the ramp signal.

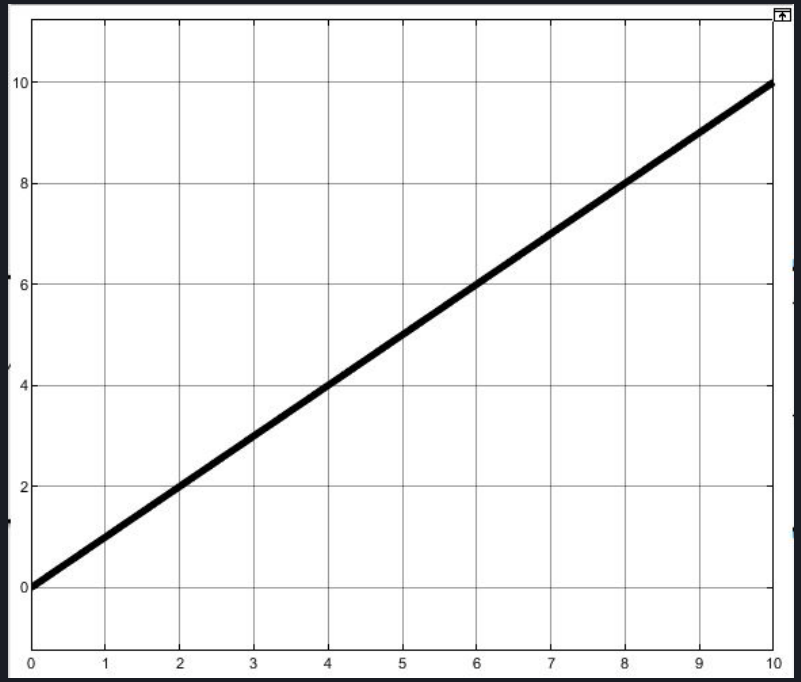
  - Slope (m): The rate of change of the ramp signal. It determines how fast the ramp signal increases or decreases with time.
  - Initial output (b): The value of the ramp signal at the starting time.



Introduction to Simulink

Commonly Used Blocks

- Ramp Block
  Simple Ramp:
    Slope (m): 1
    Initial output (b): 0

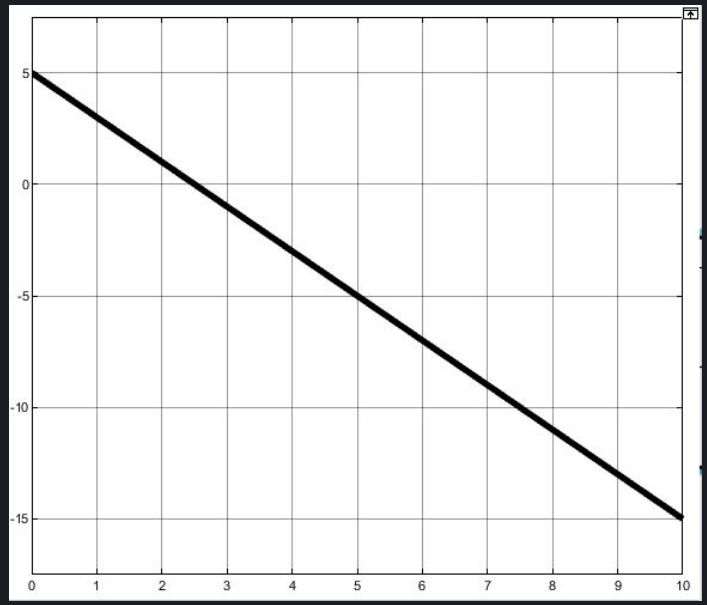


This configuration generates a basic ramp signal that starts from 0 and increases at a rate of 1 unit per unit time.

Introduction to Simulink

Commonly Used Blocks

- Ramp Block
  Negative Slope Ramp:
  - Slope (m): -2
  - Initial output (b): 5

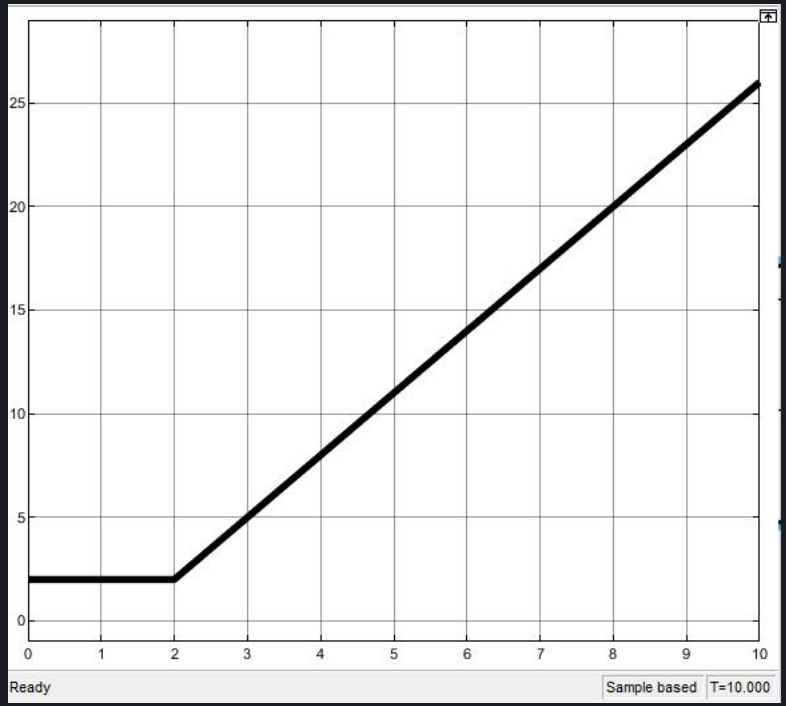


This example produces a ramp signal with a negative slope, causing it to decrease over time. It starts from an initial value of 5 and decreases at a rate of 2 units per unit time.

Introduction to Simulink

Commonly Used Blocks

- Ramp Block
  Delayed Ramp:
  - Slope (m): 3
  - Initial output (b): 2
  - Start time: 2

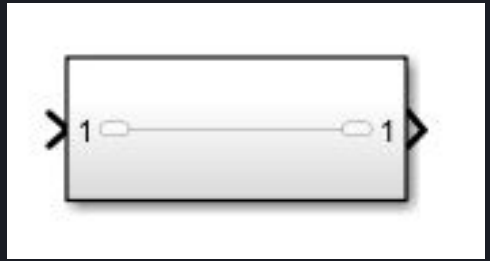


In this case, the ramp signal starts at time 2 with an initial value of 2 and increases at a rate of 3 units per unit time.

Introduction to Simulink

Commonly Used Blocks

- Subsystem Blocks
  In Simulink, a Subsystem is a powerful organizational and modular building block used to structure and simplify complex models. It allows you to group related blocks and signals together into a single functional unit, making your Simulink models more organized, readable, and maintainable.



Introduction to Simulink

Quiz 2: Click Here To Start

Introduction to Simulink

Examples

- Example 1

Design a converter that converts a speed of rad/s to rpm.

Introduction to Simulink

Examples

- Example 2

Design a Simulink model that converts temperatures from Celsius to Fahrenheit.

Introduction to Simulink

Examples

- Example 3

Create a Simulink model for converting units of meters to feet.

Introduction to Simulink

Examples

- Example 4

Create a Simulink model for converting units of kilograms to pounds.

Introduction to Simulink

Examples

- Example 5

Design a Simulink model that converts a voltage signal into a current signal using a specific resistor value

Introduction to Simulink

Examples

- Example 6

Develop a Simulink model that calculates the distance traveled by a moving object based on velocity and time inputs.

Introduction to Simulink

Examples

- Example 1

$$f(x) = 5x + 4$$

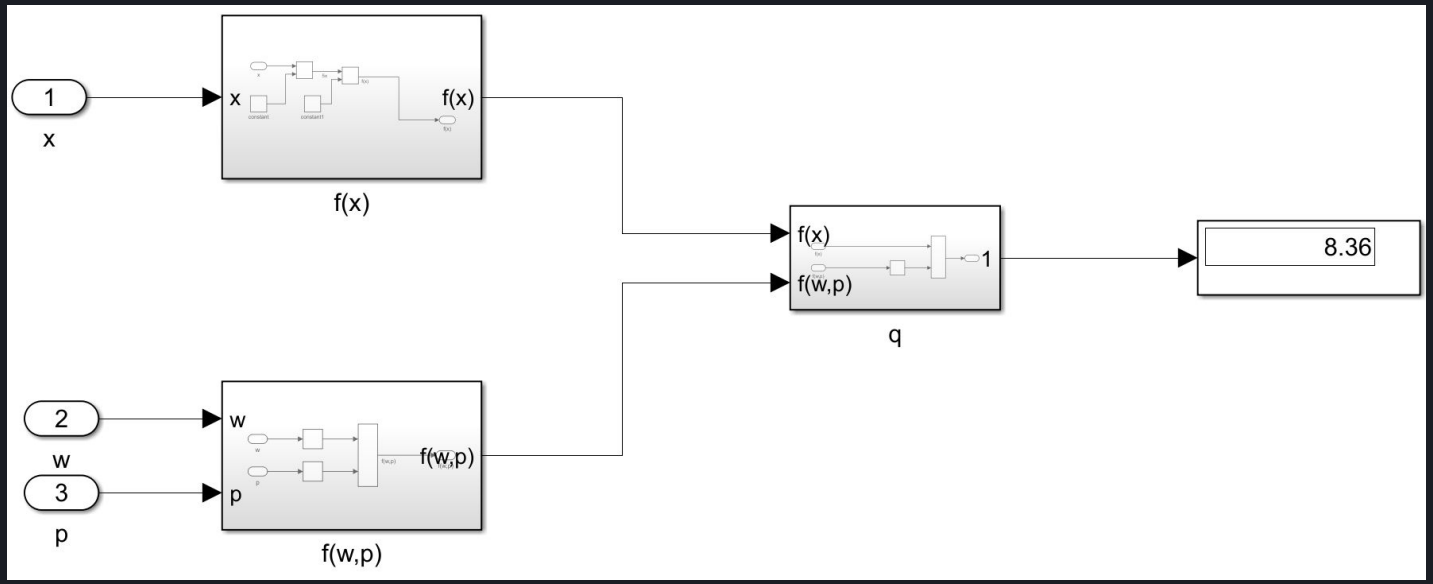
$$f(w,p) = (w^2)(p^{-2})$$

$$q = f(x) + \cos(f(w,p))$$

Introduction to Simulink

Examples

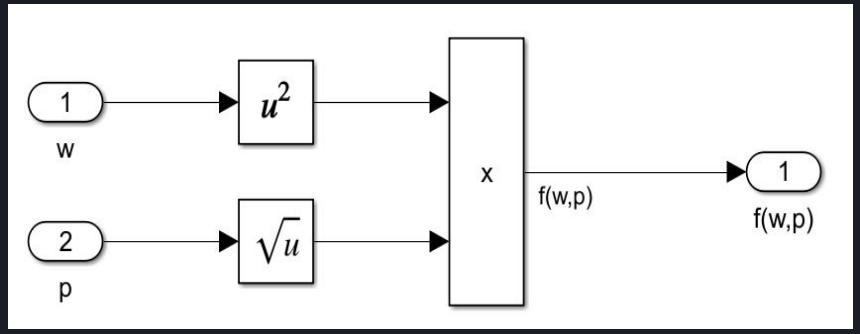
- Example 1

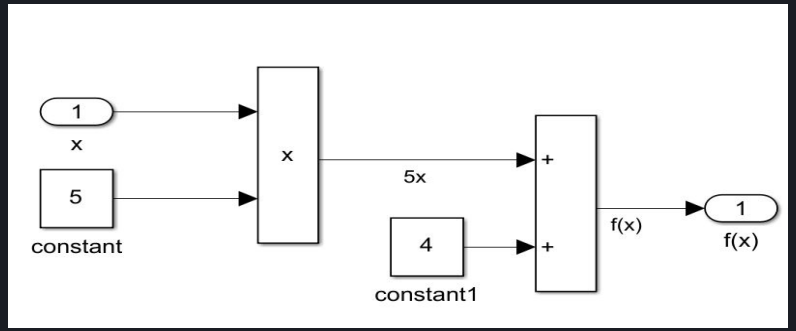


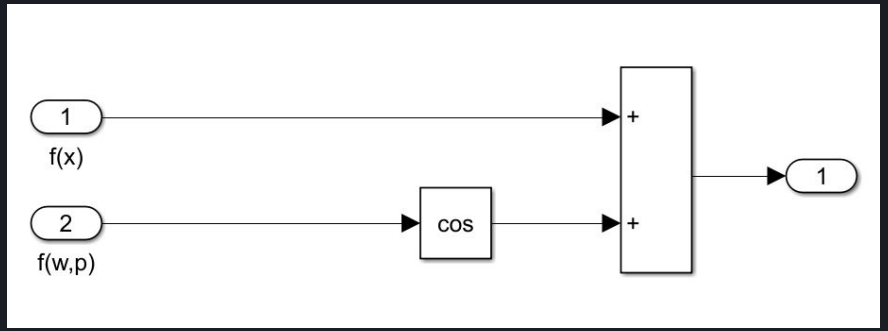
Introduction to Simulink

Examples

- Example 1





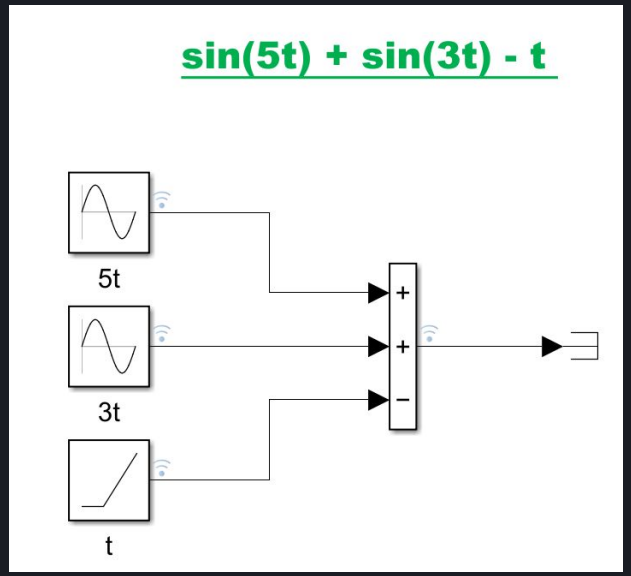


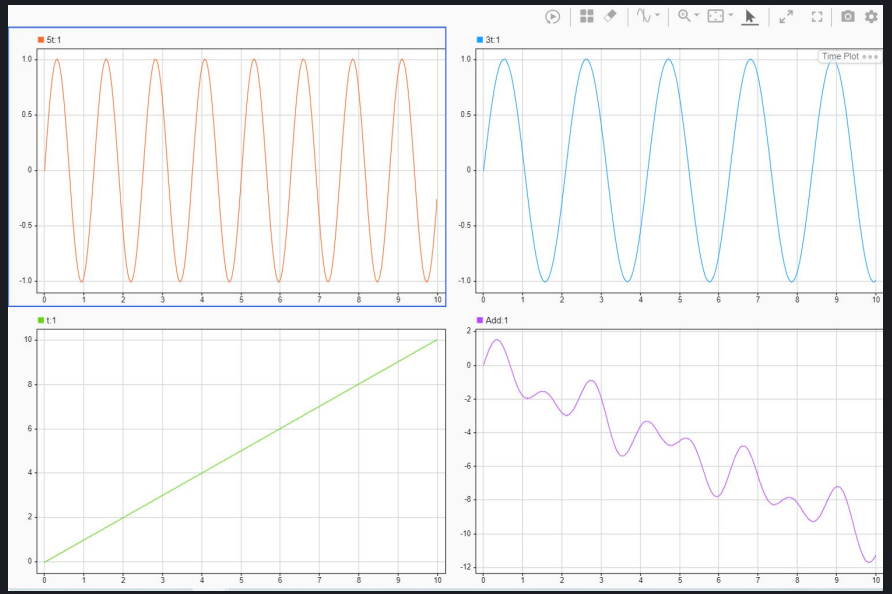
Introduction to Simulink

Examples

- Example 1

sin(5t) + sin(3t) - t





Introduction to Simulink

Lab 1: Click Here To Start


Thank You!