Control System Engineering Laboratory

Overview:

Control system engineering is the process of designing, analyzing, and optimizing a control system. A control system is a set of devices that regulates the behavior of other devices or systems. It can comprise mechanical devices like machinery, electronics such as computers, or a combination of the two. There are many different types of control systems, but each one serves the same purpose: to control outputs.

Scope of the Lab:

The topics and concepts that will be covered in the lab. This could include:

- Modeling of dynamic systems
- Analysis of system behavior and response
- Controller design and implementation
- System simulation and validation the outputs

MATLAB Software

MATLAB/Simulink is an integrated software package developed by MathWorks, designed to address the diverse needs of control system engineers, researchers, and students. It provides a powerful environment for modeling, simulating, and analyzing complex dynamic systems.

Review of the Signal Source Blocks

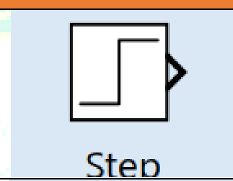
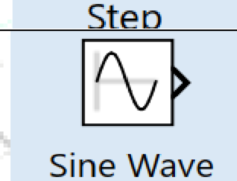
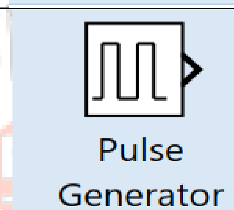
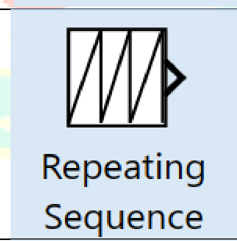
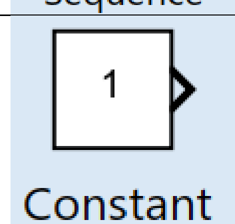
Overview:

In MATLAB/Simulink, the Signal Source block serves as a fundamental component for generating various types of signals essential for control system simulations and analyses. This versatile block provides a convenient means to input signals into your system models, allowing you to replicate real-world scenarios and test the behavior of your control systems under different conditions.

1. **Signal Types:**
   - Constant Signal: The Signal Source block allows you to generate constant signals, providing a steady input to your system for analysis.
   - Step Signal: Simulate sudden changes or step inputs in your system to observe transient responses.
   - Ramp Signal: Model gradual changes in input values with ramp signals, useful for studying system behavior over time.
   - Sine Wave Signal: Generate periodic signals, such as sine waves, to analyze the response of your system to oscillatory inputs.

2. **Parameters and Customization:**
   - Amplitude, Frequency, and Phase: You have control over the amplitude, frequency, and phase of generated signals, enabling you to tailor inputs according to your system requirements.
   - Pulse Width and Duty Cycle: Customize pulse signals with parameters like pulse width and duty cycle for detailed analysis.

- Time and Duration: Start and Stop Time: Define the time span over which the signal is generated. This flexibility allows you to focus on specific time intervals during your simulations.
- Sample Time: Adjust the sample time to control the time resolution of the generated signal.

No	Blocks name	Shape	Parameter
1	Step		Step Time Initial Value Final Value
2	Sine wave		Amplitude Bias Frequency
3	Pulse Generator		Amplitude Period Pulse Width
4	Repeating Sequence		Time Values Output Values
5	Constant		Constant Value

Simple Math Operations Blocks

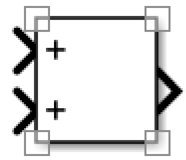
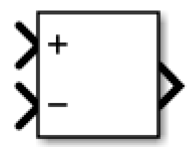
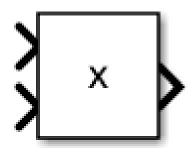
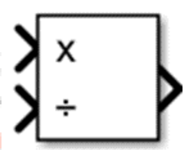
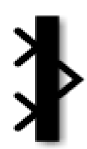
Overview:

In MATLAB/Simulink, simple math operations are performed using various blocks that allow users to manipulate signals, variables, and data in their models. Here's an overview of some common simple math operations blocks available in Simulink:

1. **Addition Block:**
   - Description: The Addition block is used to add two or more input signals.
   - Usage: It is commonly employed for tasks such as summing signals or adding constants to a signal.
2. **Subtraction Block:**
   - Description: The Subtraction block subtracts the second input signal from the first.
   - Usage: Useful for tasks like finding the difference between two signals or subtracting a constant value.
3. **Multiplication Block:**
   - Description: The Multiplication block performs the multiplication operation on its input signals.
   - Usage: Applied for tasks such as scaling signals or multiplying variables.
4. **Division Block:**
   - Description: The Division block divides the first input signal by the second.
   - Usage: Useful for tasks like computing ratios or scaling signals.
5. **Summation Block:**
   - Description: The Summation block is a versatile block that performs summation of multiple input signals with specified coefficients.
   - Usage: Useful for combining multiple signals with adjustable weights.

6. **Product Block:**
   - Description: The Product block computes the product of multiple input signals with specified coefficients.
   - Usage: Similar to the Summation block but for multiplication.
7. **Multiplexer Block:**
   - Description**:** The MUX block in MATLAB/Simulink consolidates multiple input signals into a single output based on a control signal. It features input ports, a control input, and a single output port.
   - Usage: Used for dynamic signal routing, the MUX block is crucial in scenarios requiring the selection of one input from several based on a control condition. It finds applications in signal switching, data bus handling, and control logic implementation within Simulink models.

Simple Math Operations Blocks

No	Blocks name	Shape	Parameter
1	Sum		List of signs
2	Subtract		List of signs
3	product		Number of inputs
4	divide		Non
5	MUX		Number of inputs

Transfer Functions

Transfer Functions in MATLAB

Overview

In MATLAB, a transfer function is a mathematical representation of the relationship between the input and output of a dynamic system in the frequency domain. It is commonly used in control system analysis and design. The transfer function is expressed as the ratio of the Laplace transform of the output to the Laplace transform of the input, assuming all initial conditions are zero.

Example 1: -

find the transfer function for ($\frac{1}{S^2+S+1}$)

numerator = [1]

denominator = [1 1 1]

Sys= tf(1, [1 1 1])

Example 2: -

find the transfer function for ($\frac{1}{S^3+S^2+S+1}$)

numerator = [1]

denominator = [1 1 1 1]

Sys= tf(1, [1 1 1 1])

Example 3: -

find the transfer function for ($\frac{S+1}{S^2+S+1}$)

numerator = [1 1]

denominator = [1 1 1]

Sys= tf([1 1] , [1 1 1])

Example 4: -

find the transfer function for ($\frac{S^2+S+1}{S^2+S+1}$)

numerator = [1 1 1]

denominator = [1 1 1]

Sys= tf([1 1 1], [1 1 1])

Example 5: -

find the transfer function for ($\frac{3}{S^2+S+1}$)
numerator = [3]

denominator = [1 1 1]

Sys= tf(3, [1 1 1])

Example 6: -

find the transfer function for ($\frac{3}{S^3+S^2+S+1}$)
numerator = [3]

denominator = [1 1 1 1]

Sys= tf(3, [1 1 1 1])

Example 7: -

find the transfer function for ($\frac{S+1}{S^2+2S+3}$)

numerator = [1 1]

denominator = [1 2 3]

Sys= tf([1 1] , [1 2 3])

Example 8: -

find the transfer function for ($\frac{3S^2+S+0.6}{5S^2+S+0.3}$)

numerator = [3 1 0.6]

denominator = [5 1 0.3]

Sys= tf([3 1 0.6], [5 1 0.3])

Example 9: -

find the transfer function for ($\frac{3S}{S^2+S+1}$)
numerator = [3 0]

denominator = [1 1 1]

Sys= tf([3 0], [1 1 1])

Example 10: -

find the transfer function for ($\frac{3S^2}{5S^3+S+1}$)
numerator = [3 0 0]

denominator = [5 0 1 1]

Sys= tf([3 0 0], [5 0 1 1])

Example 11: -

find the transfer function for ($\frac{81}{100} \times \frac{S+1}{S^2+2S+3}$)
numerator = [81 81]

denominator = [100 200 300]

Sys= tf([81 81] , [100 200 300])

Example 12: -

find the transfer function for ($0.81 \times \frac{S^2+S+1}{5S^2+S+1}$)
numerator = [0.81 0.81 0.81]

denominator = [5 1 1]

Sys= tf([0.81 0.81 0.81], [5 1 1])

Documents ▸ MATLAB

Command Window

New to MATLAB? See resources for Getting Started.

```
>> sys= tf(1,[1 1 1])

sys =

        1
  -----------
  s^2 + s + 1

Continuous-time transfer function.
```

Command Window

New to MATLAB? See resources for Getting Started.

```
>> Sys= tf([3 0], [1 1 1])

Sys =

      3 s
  -----------
  s^2 + s + 1

Continuous-time transfer function.
```

Command Window

New to MATLAB? See resources for Getting Started.

```
>> Sys= tf([3 0 0], [5  0  1 1])

Sys =

      3 s^2
  -------------
  5 s^3 + s + 1

Continuous-time transfer function.
```

Command Window

New to MATLAB? See resources for Getting Started.

```
>> Sys= tf([0.81  0.81  0.81], [5 1 1])

Sys =

  0.81 s^2 + 0.81 s + 0.81
  ------------------------
       5 s^2 + s + 1

Continuous-time transfer function.
```

Transfer Functions Blocks

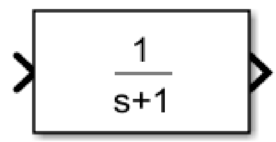
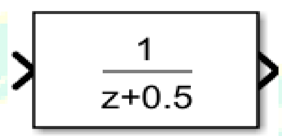
No	Blocks name	Shape	Parameters
1	Transfer Function		Numerator Denominator
2	Discrete Transfer Function		Numerator Denominator

Table of Laplace Transform

No.	Time Domain	Laplace Domain
1	$\delta(t)$	1
2	$\delta(t-a)$	e^{-as}
3	$u(t)$	$\frac{1}{s}$
4	$u(t-a)$	$\frac{e^{-as}}{s}$
5	$tu(t)$	$\frac{1}{s^2}$
6	$t^n u(t)$	$\frac{n!}{s^{n+1}}$
7	$\frac{1}{\sqrt{\pi t}}u(t)$	$\frac{1}{\sqrt{s}}$
8	$e^{at}u(t)$	$\frac{1}{s-a}$
9	$t^n e^{at} u(t)$	$\frac{n!}{(s-a)^{n+1}}$
10	$\cos(\omega t)u(t)$	$\frac{s}{s^2+\omega^2}$
11	$\sin(\omega t)u(t)$	$\frac{\omega}{s^2+\omega^2}$
12	$\cosh(\omega t)u(t)$	$\frac{s}{s^2-\omega^2}$
13	$\sinh(\omega t)u(t)$	$\frac{\omega}{s^2-\omega^2}$