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Simulation Examples

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Introduction

- We want to simulate a 1. order differential equation using LabVIEW
- We will use 3 different alternatives:
  - MathScript Window (similar to MATLAB)
  - MathScript Node inside LabVIEW
  - LabVIEW Control Design and Simulation Module
- We should of course expect the same simulation results using the 3 different alternatives

Model

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Mathematical Model

In this example we will use the following 1. order differential equation:

$$\dot{x} = -ax + bu$$

Note that $\dot{x} = \frac{dx}{dt} = x'(t)$

Different notation is used in different textbooks and examples

We can set, e.g., $a = 0.25$ and $b = 2$ in the simulations

Simulation

- We want to simulate this differential equation by applying a step in the input signal $u = 1$ at $t = 0s$
- Then we will observe the simulation results (Step Response) by plotting the results

Alternative #1

MathScript Module

LabVIEW MathScript Window

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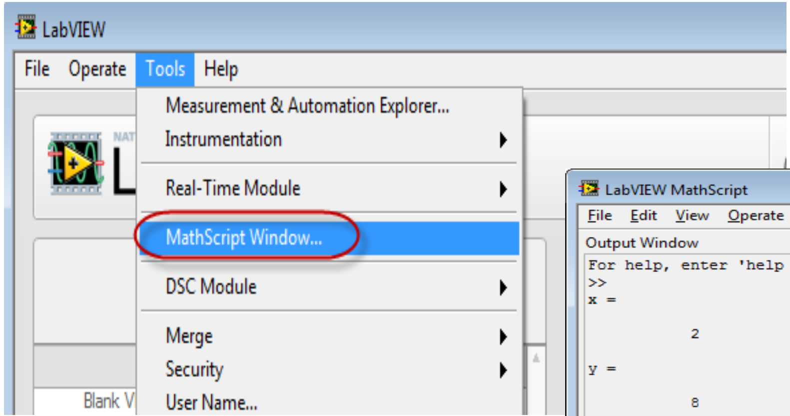
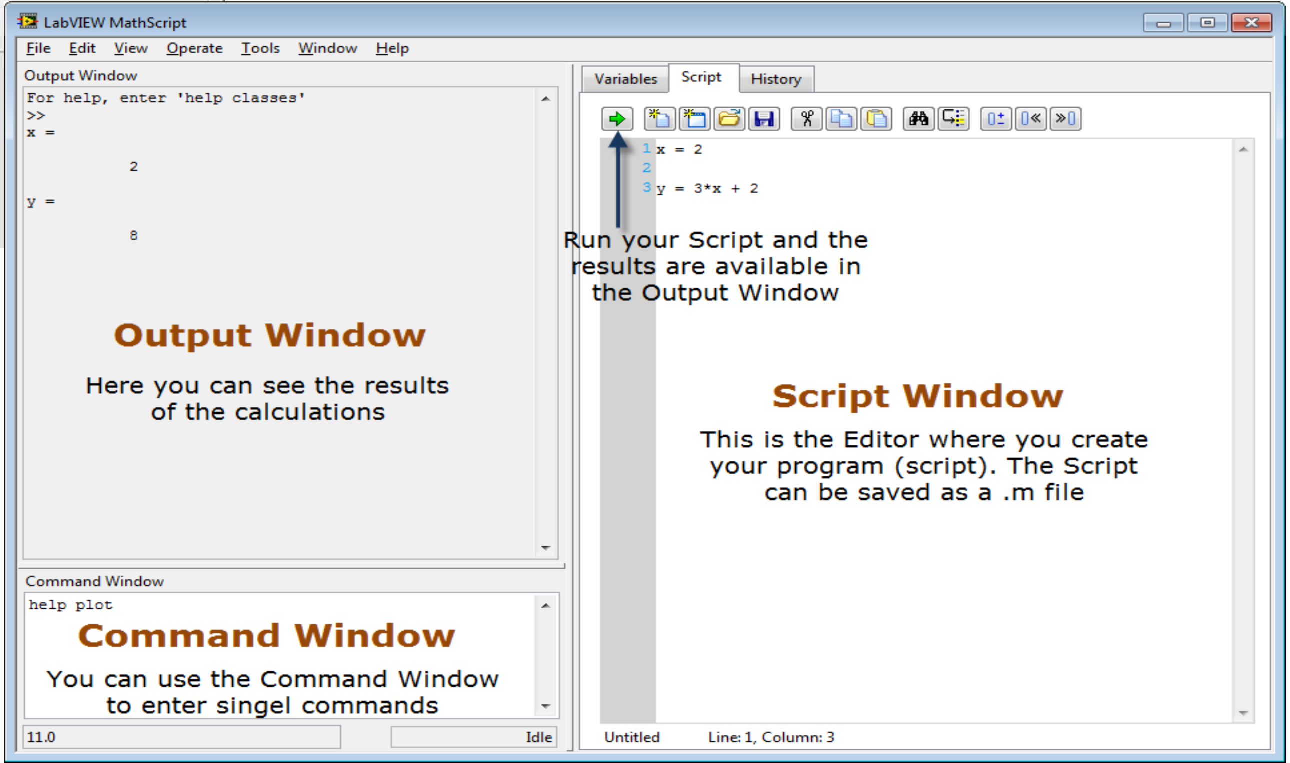
MathScript Window

LabVIEW MathScript RT Module





Add-on Module for LabVIEW where we can do text-based programming and simulations – very powerful!

Discretization

- In order to simulate this system, we typically need to find the discrete differential equation (difference equation)
- We can use e.g., the **Euler** Approximation:

$$\dot{x} \approx \frac{x(k+1) - x(k)}{T_s}$$

Discrete Model

We have the continuous differential equation: $\dot{x} = -ax + bu$

We apply Euler: $\dot{x} \approx \frac{x(k+1)-x(k)}{T_s}$

Then we get:

$$\frac{x(k+1) - x(k)}{T_s} = -ax(k) + bu(k)$$

This gives the following discrete differential equation (difference equation):

$$x(k+1) = (1 - T_s a)x(k) + T_s bu(k)$$

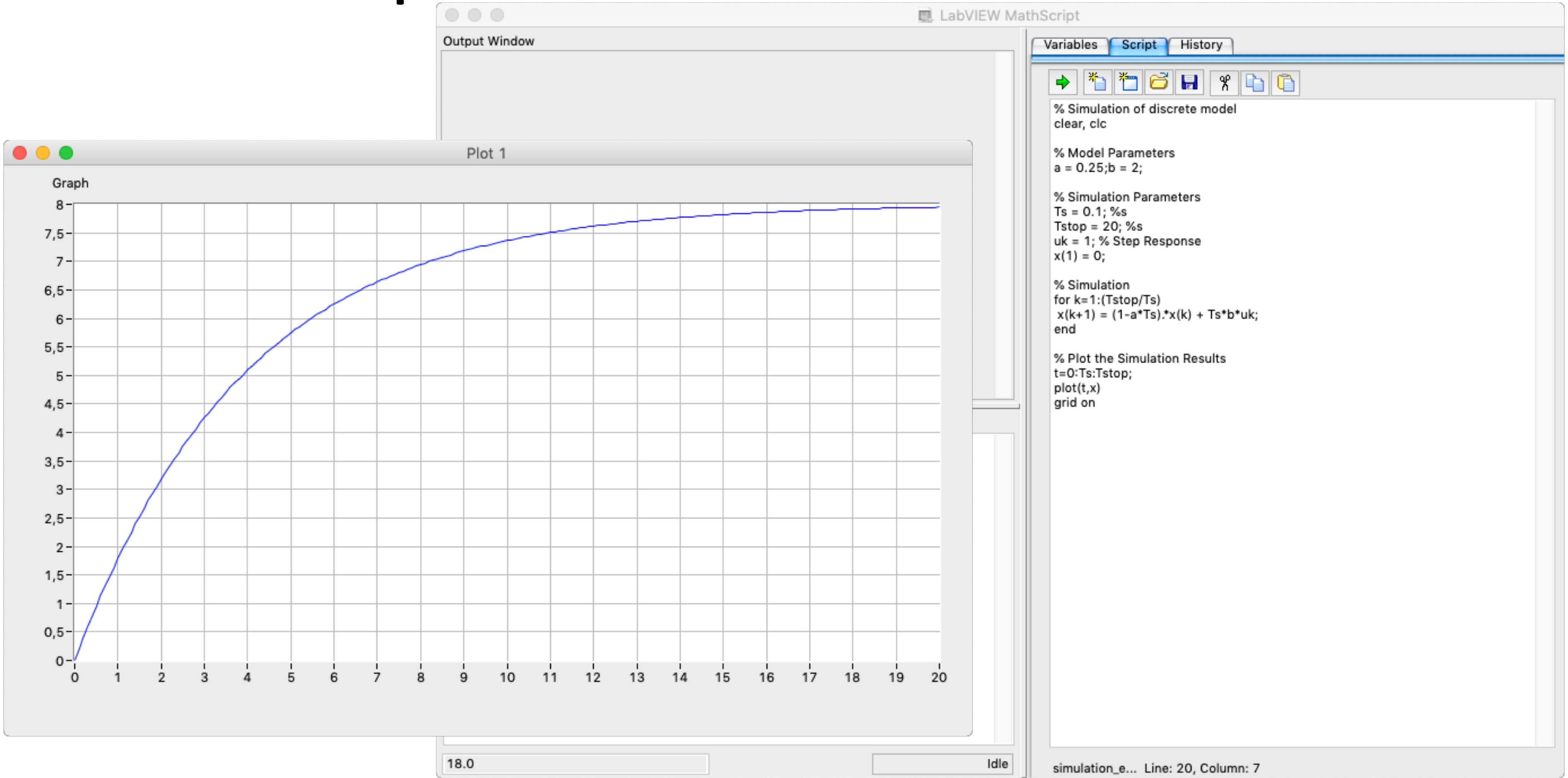
This equation can easily be implemented in any text based programming language

MathScript Code

This is an example.
You can implement it in many different ways

```
% Simulation of discrete model
clear, clc

% Model Parameters
a = 0.25;b = 2;

% Simulation Parameters
Ts = 0.1; %s
Tstop = 20; %s
uk = 1; % Step Response
x(1) = 0;

% Simulation
for k=1:(Tstop/Ts)
        x(k+1) = (1-a*Ts).*x(k) + Ts*b*uk;
end

% Plot the Simulation Results
t=0:Ts:Tstop;
plot(t,x)
grid on
```

MathScript Code and Simulation Results



Alternative #2

MathScript Node

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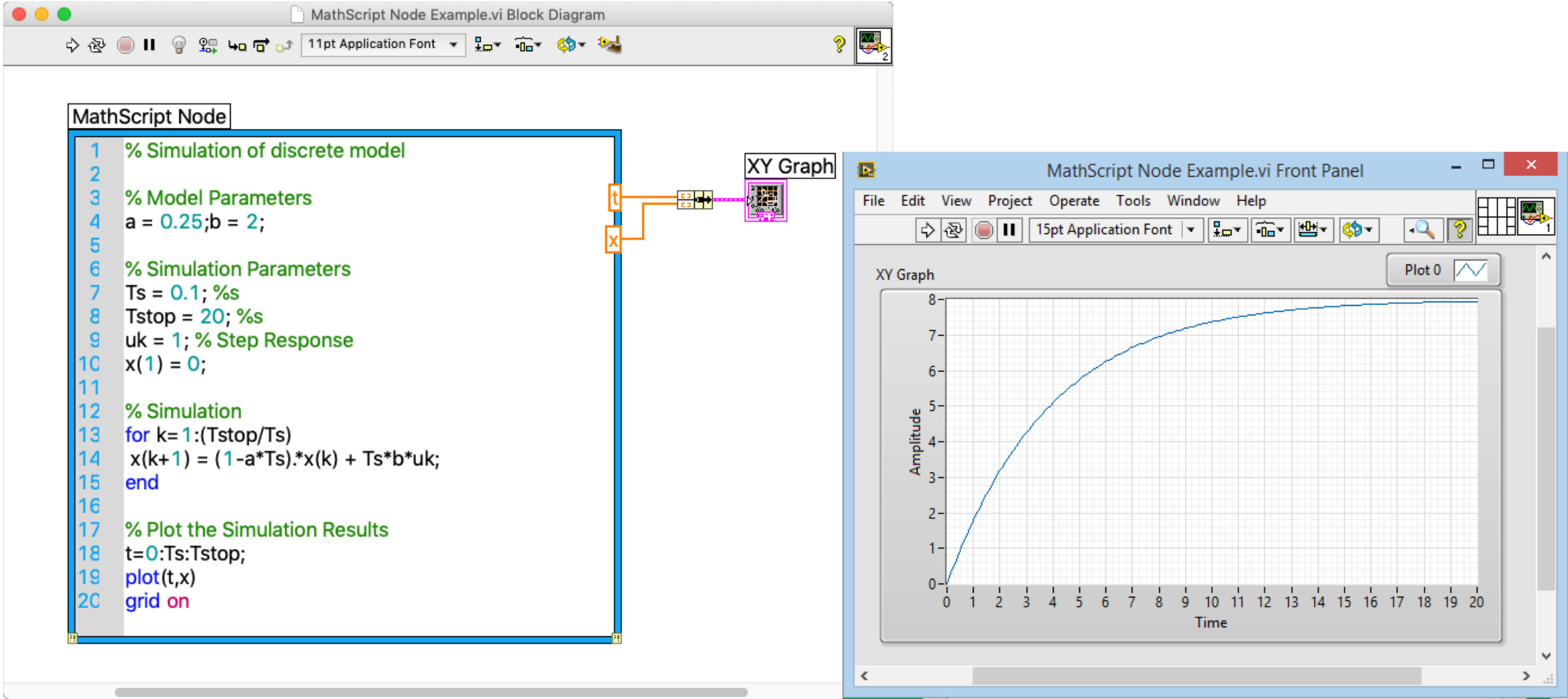
MathScript Node Code Example

We just copy the previous code into a MathScript Node inside LabVIEW:



Alternative #3

LabVIEW

LabVIEW Control and Design and Simulation Module

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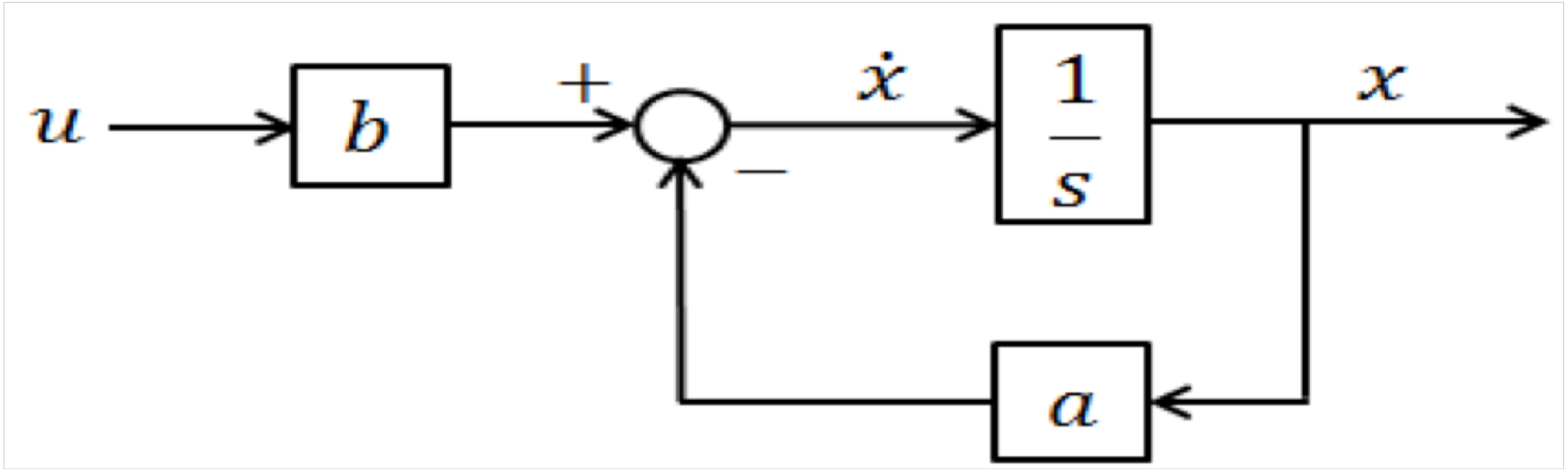
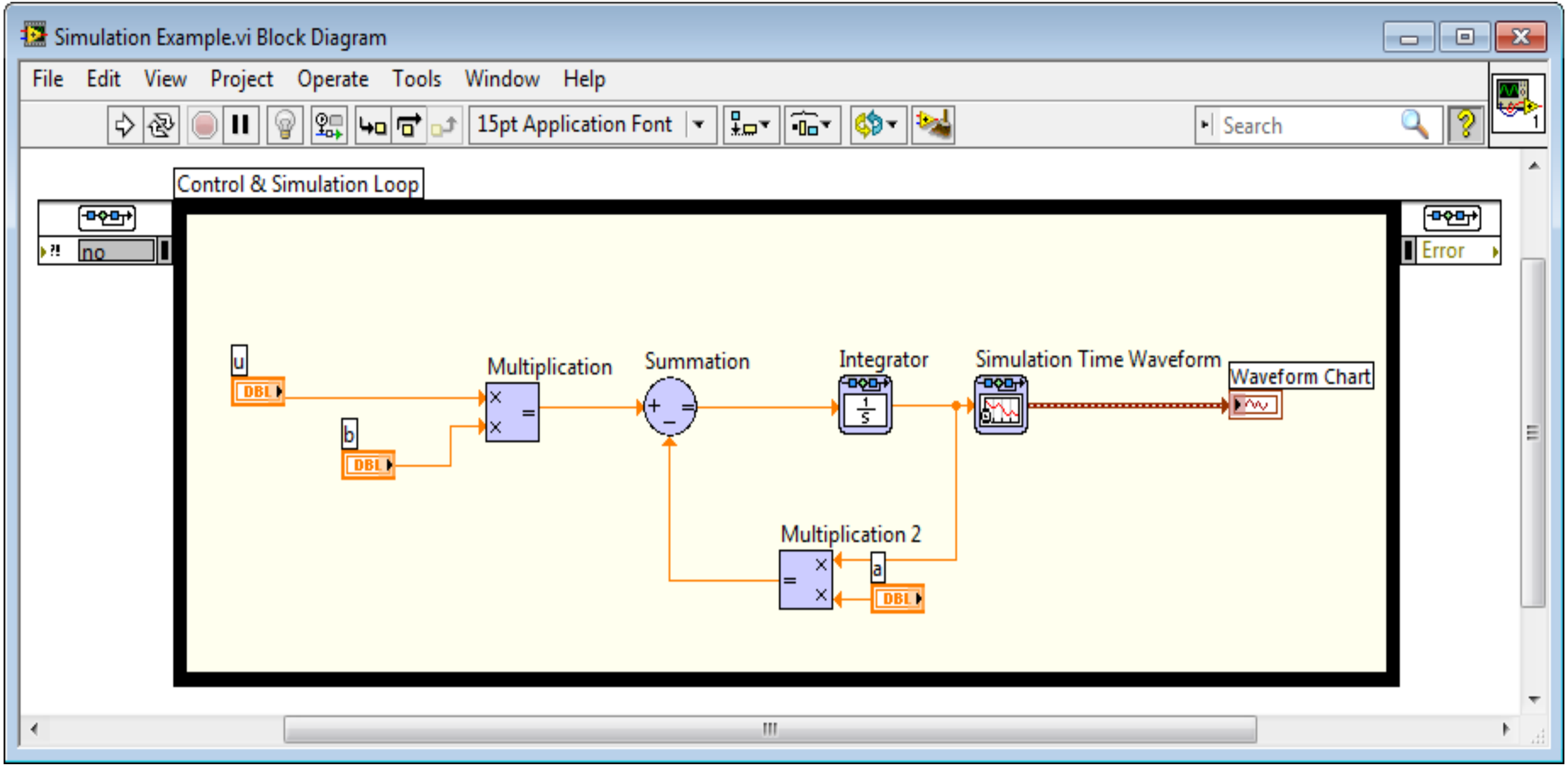
Block Diagram

$$\dot{x} = -ax + bu$$

A Block Diagram for the model/differentia equation above becomes:

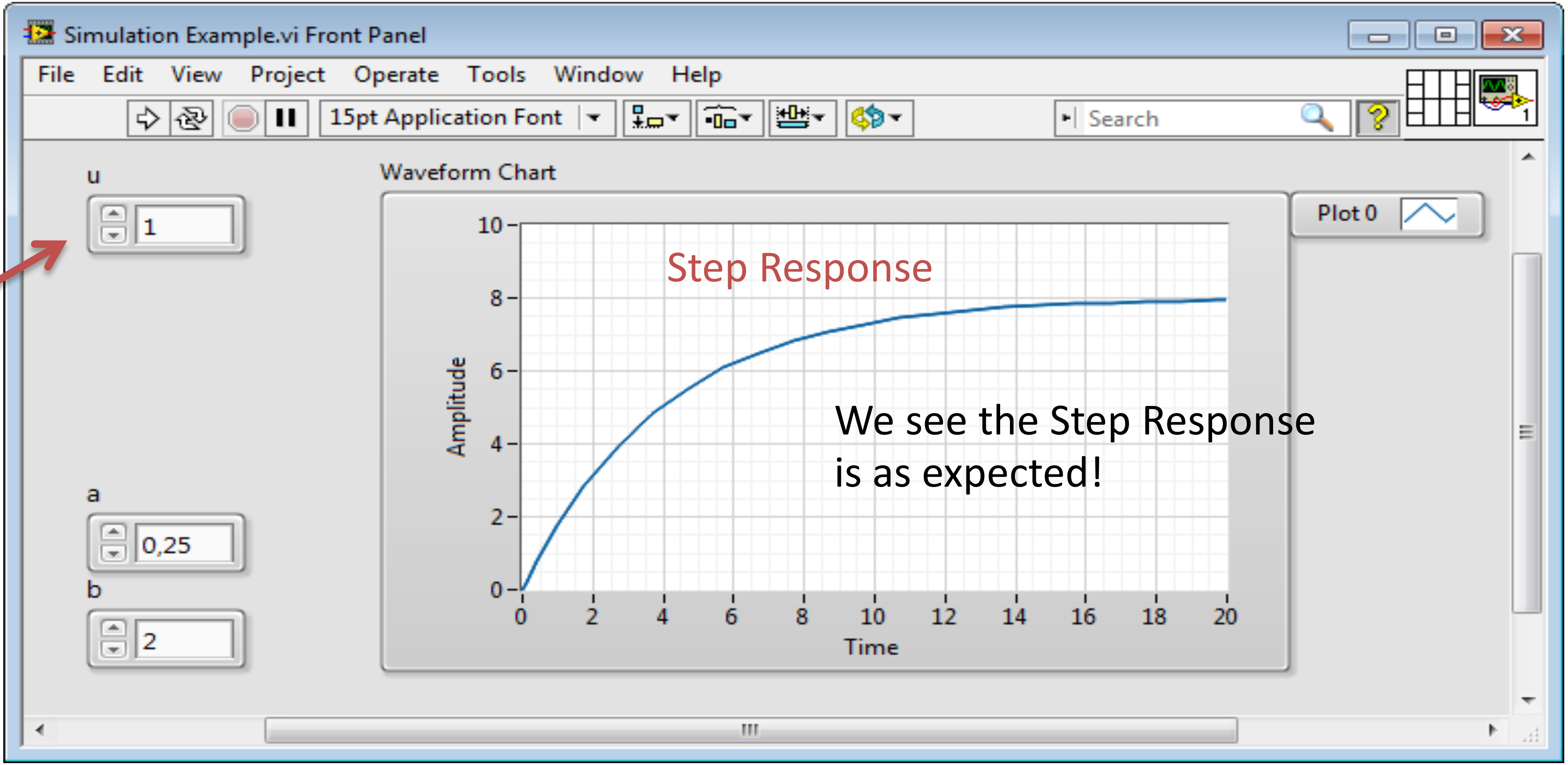


LabVIEW Code (Block Diagram)



LabVIEW GUI (Front Panel)

Step in u



Summary

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Discussion/Summary/Conclusion

- We have simulated a 1. order differential equation using LabVIEW
- We have used 3 different alternatives:
  - MathScript Window (similar to MATLAB)
  - MathScript Node inside LabVIEW
  - LabVIEW Control Design and Simulation Module
- We got (of course) the same simulation results using the 3 different alternatives
- What to do next: Do the same for <u>your</u> differential equation

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