Simulink and block diagram

2016 BRAZIL STUDY ABROAD PROGRAM

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Simulink and block diagram

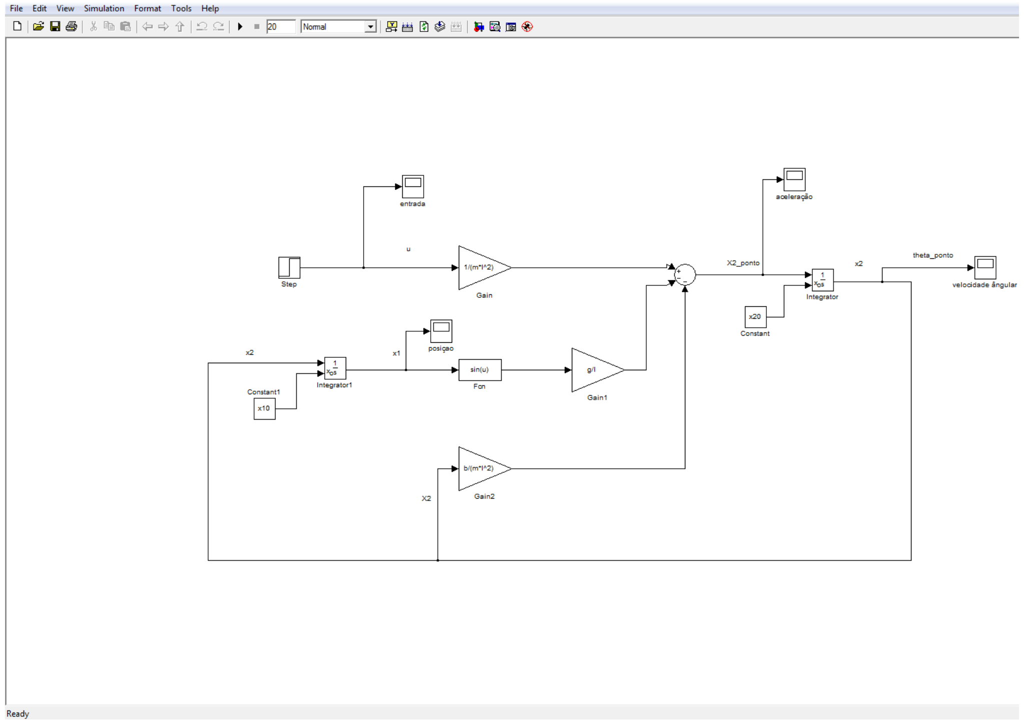
Matlab has a tool called Simulink. Simulink allows you to create block diagrams, system modelling, analysis and so on.

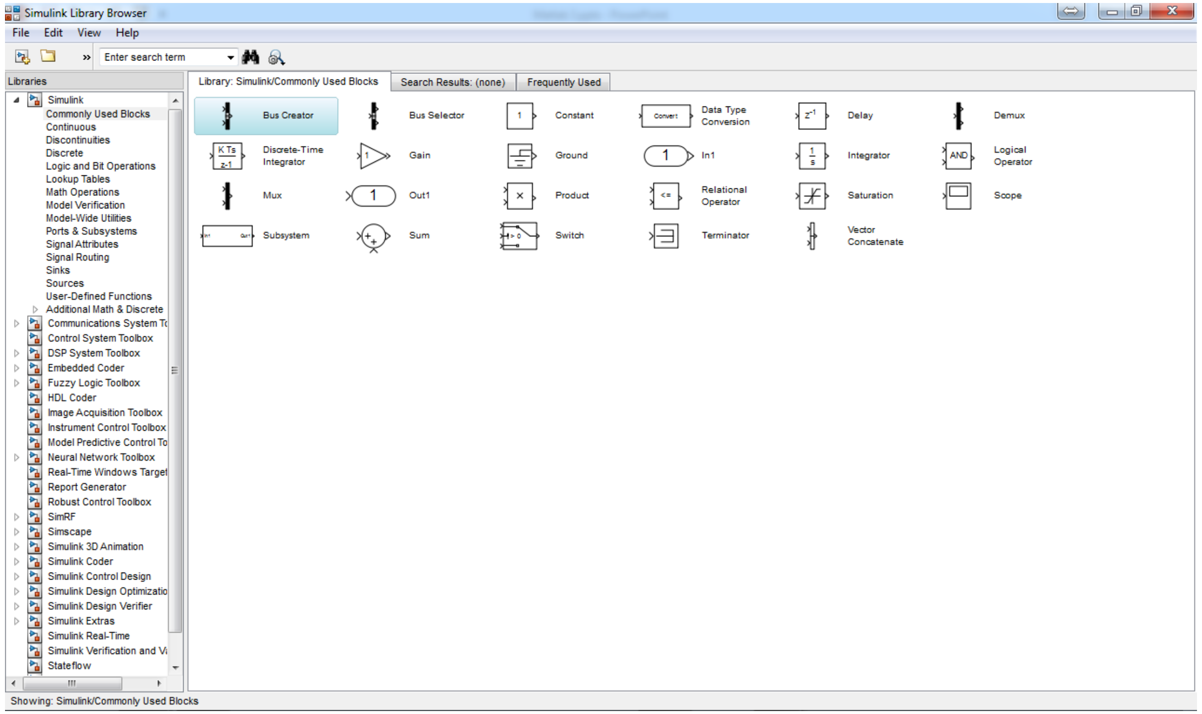
To access Simulink, type:

```
>> simulink
```

Simulink and block diagram

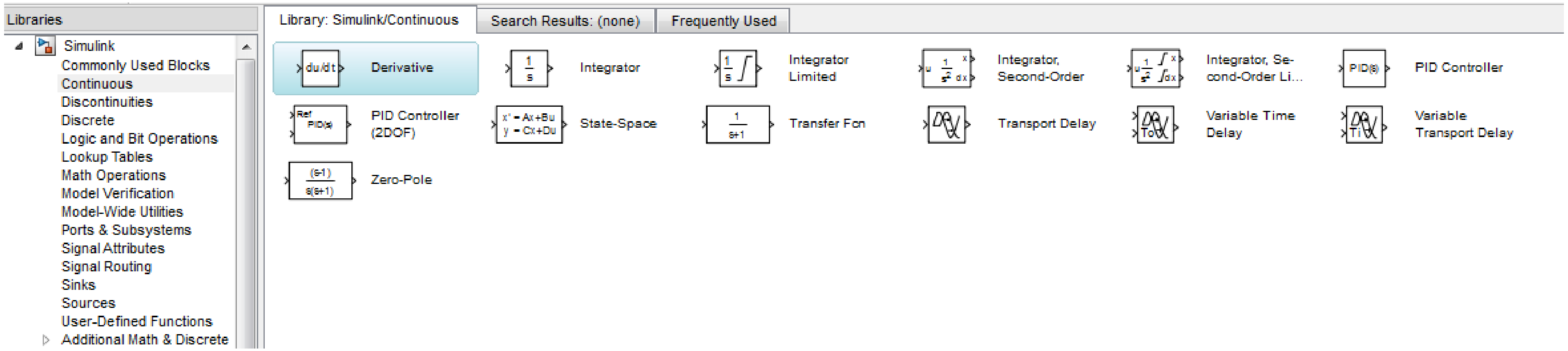
Simulink interface

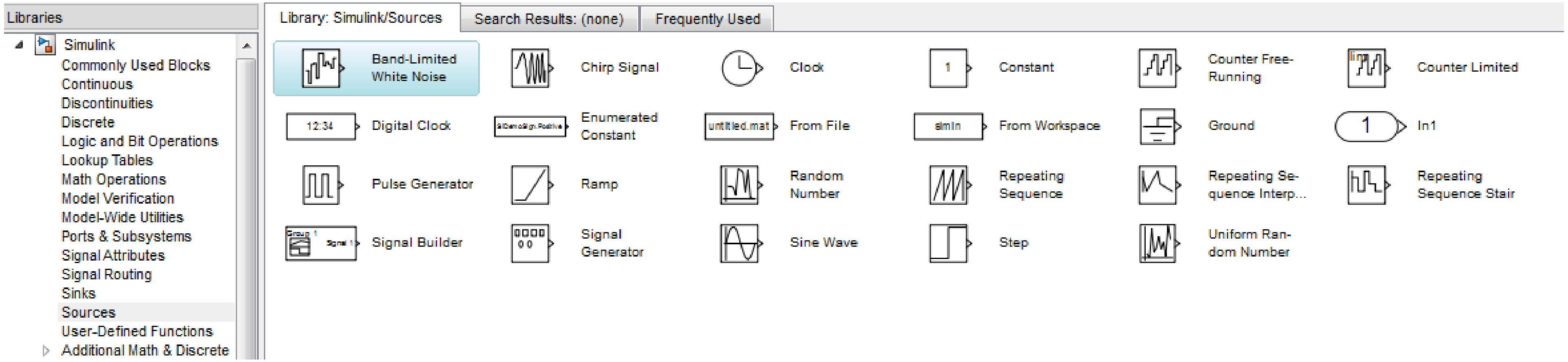




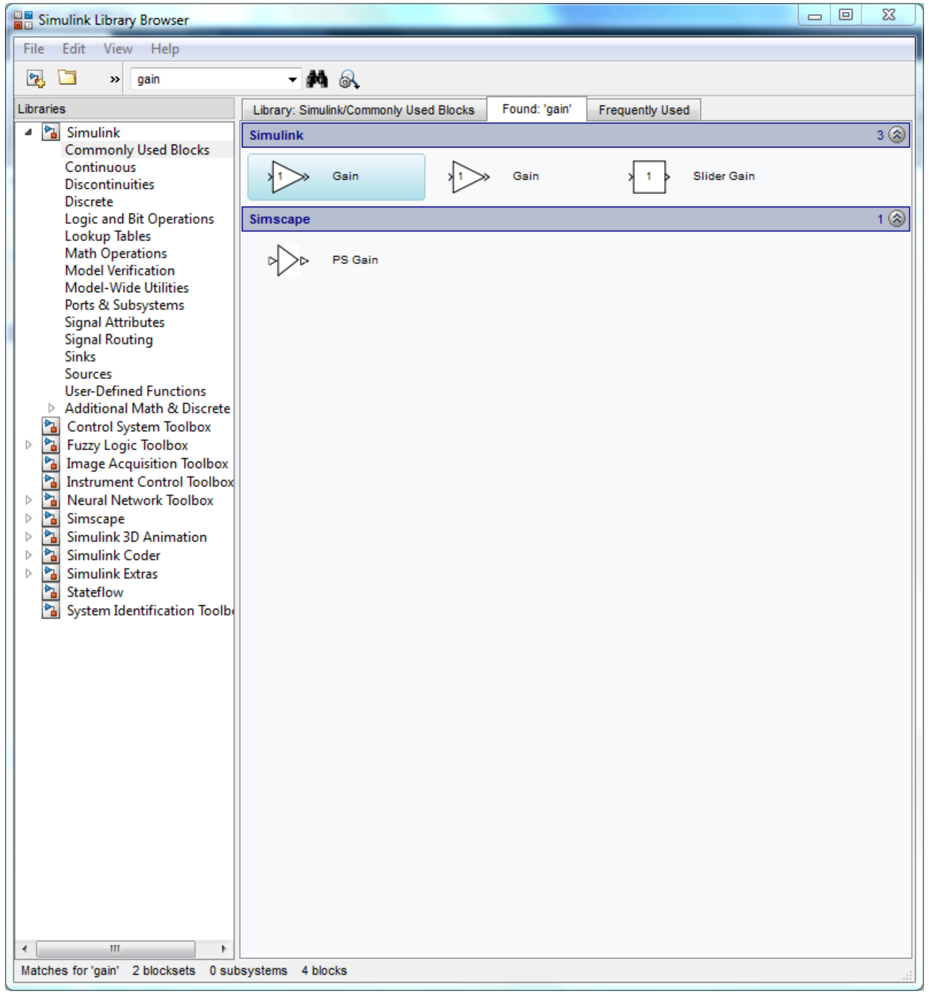
Simulink and block diagram

Simulink interface





Simulation using gain, sum and integrator



This is the Simulink library. You can search for the block you want using the search box or the options on the left side. For example:

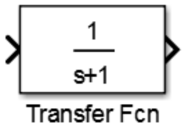
Gain

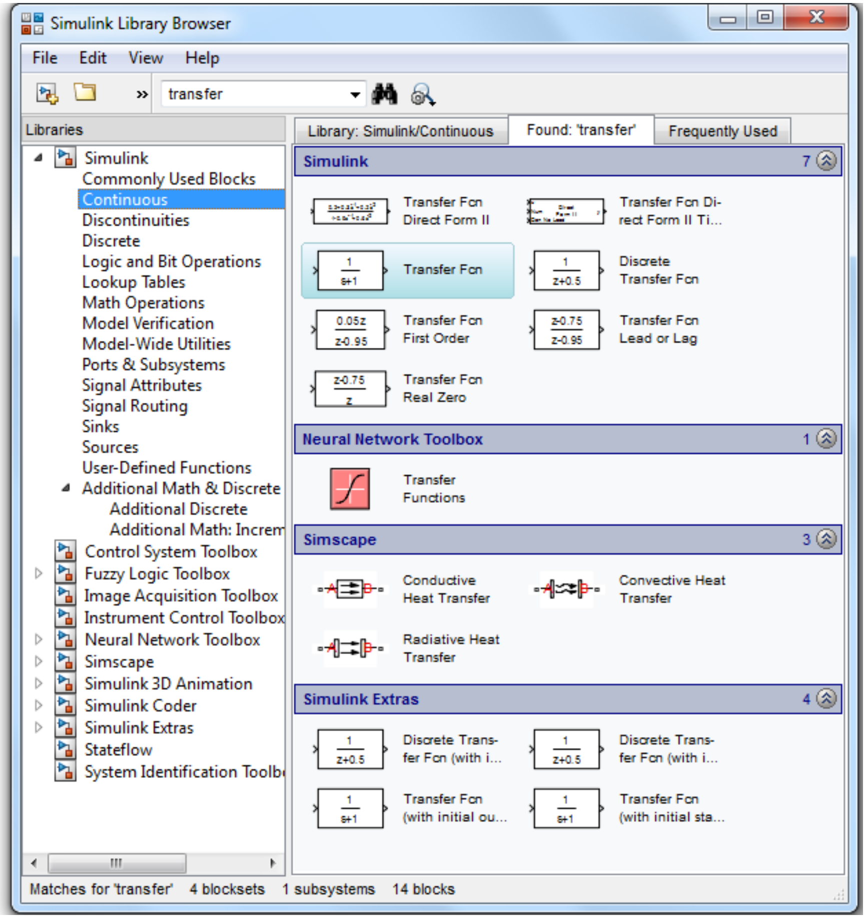
Sum

Integrator

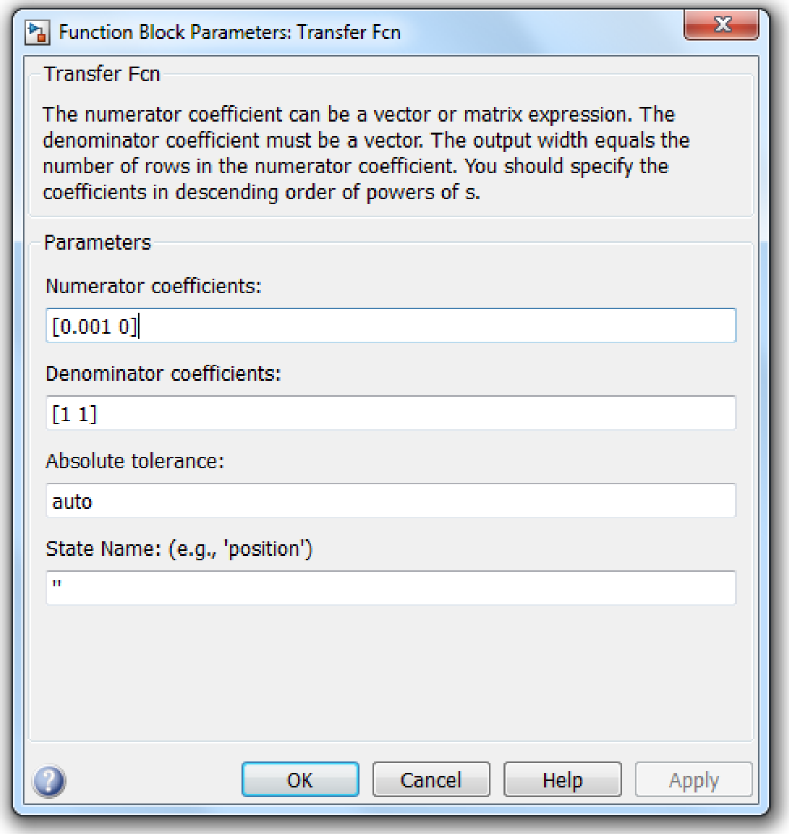
Transfer function

To create a transfer function on Simulink, you can use the ‘Transfer Fcn’ block.



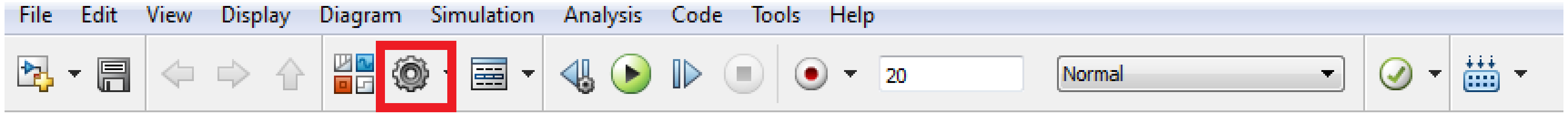


First order simple example

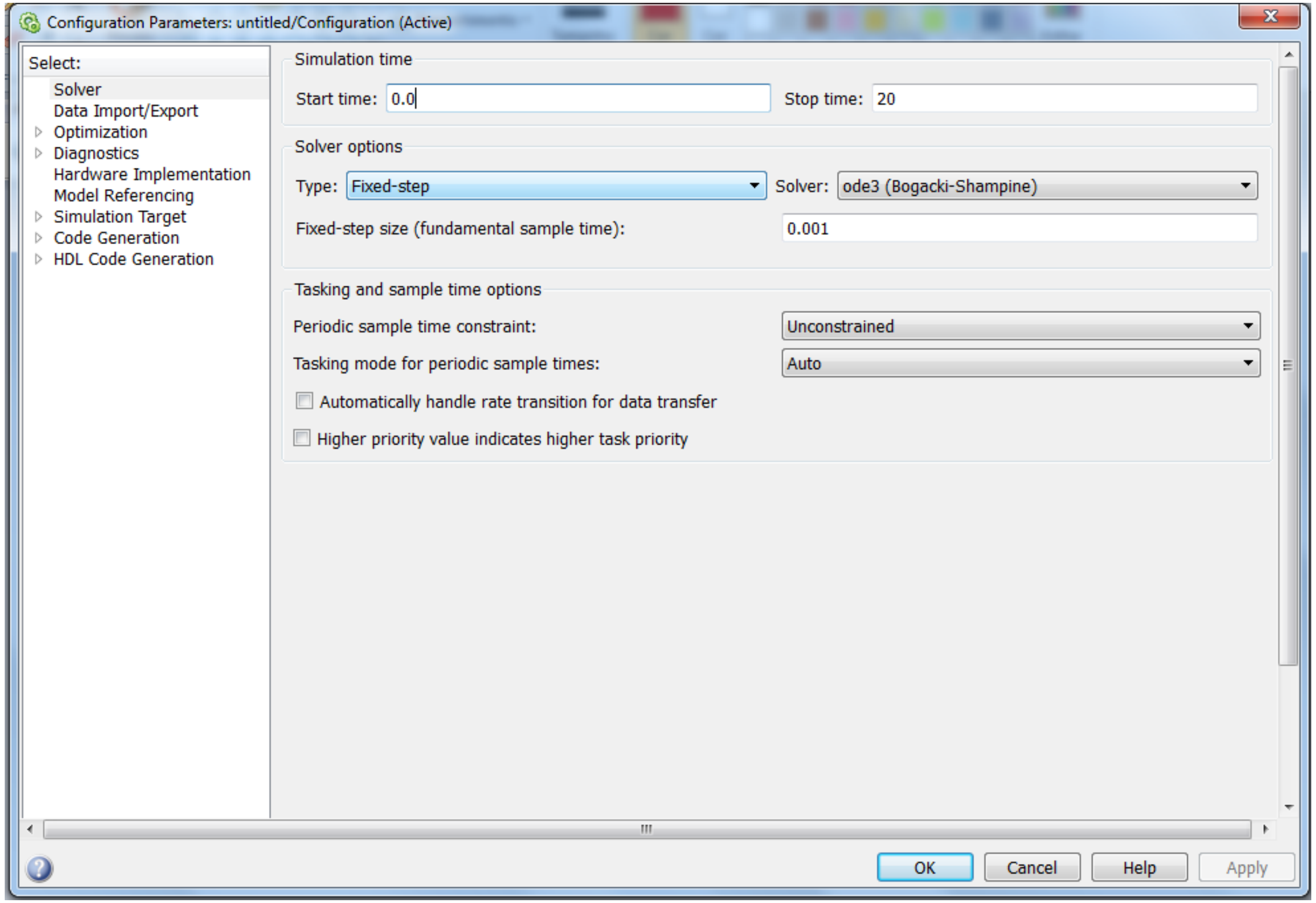


Simulation parameters

Before you run your simulation, it's necessary to set the configurations:

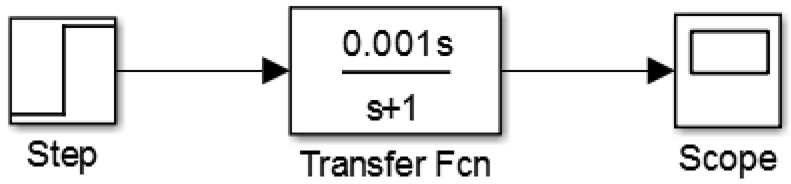


Simulation parameters



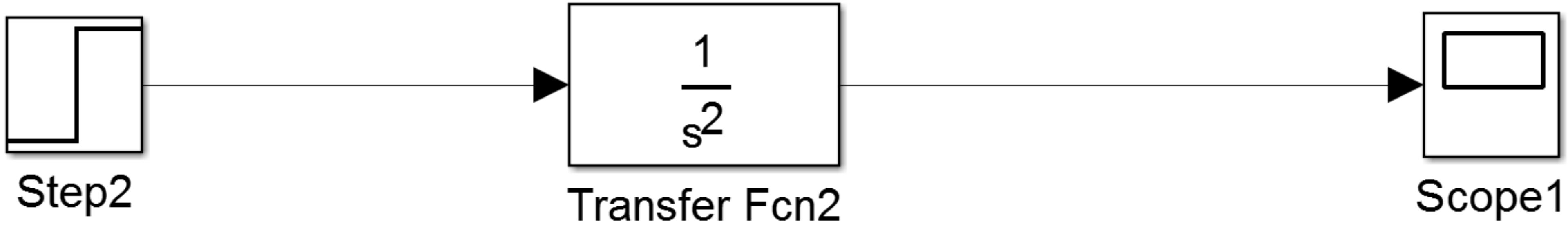
First order system example

To check the response of a transfer function, use the ‘Step’ and ‘Scope’ on Simulink. Run and double click on ‘Scope’ to see the response.



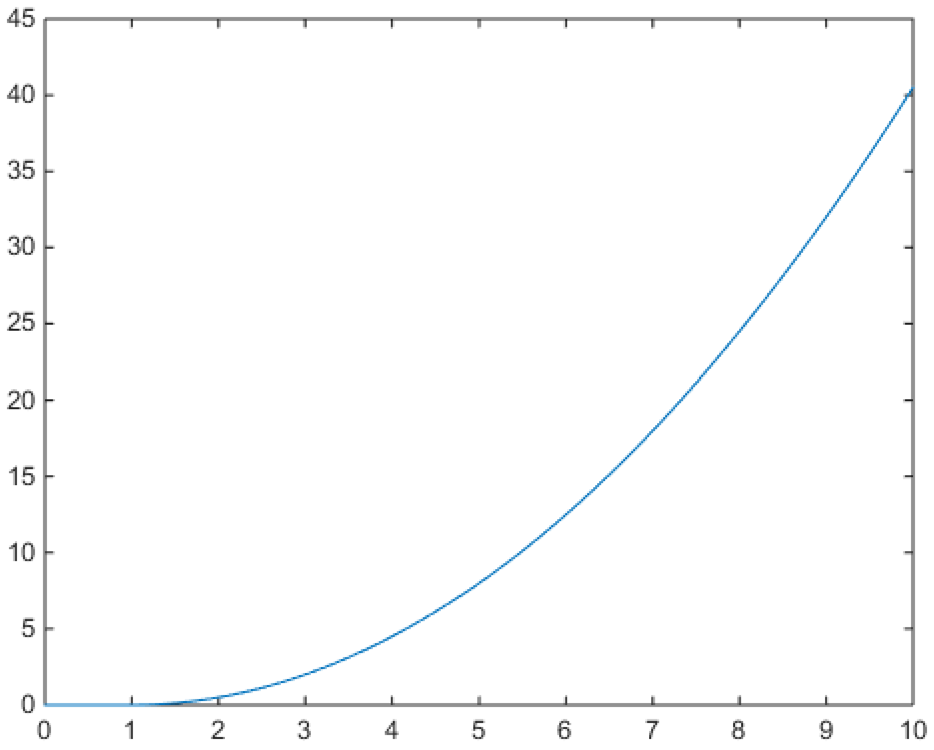
Closed loop example

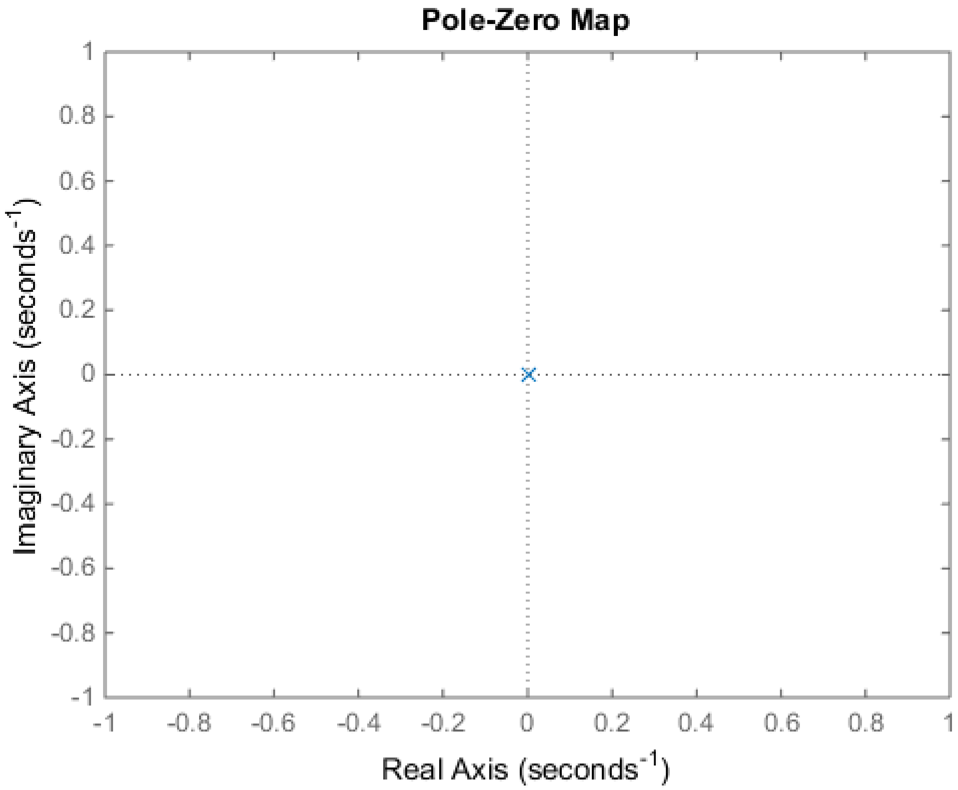
Lets try this transfer function and see what is the step response using Simulink



Closed loop example

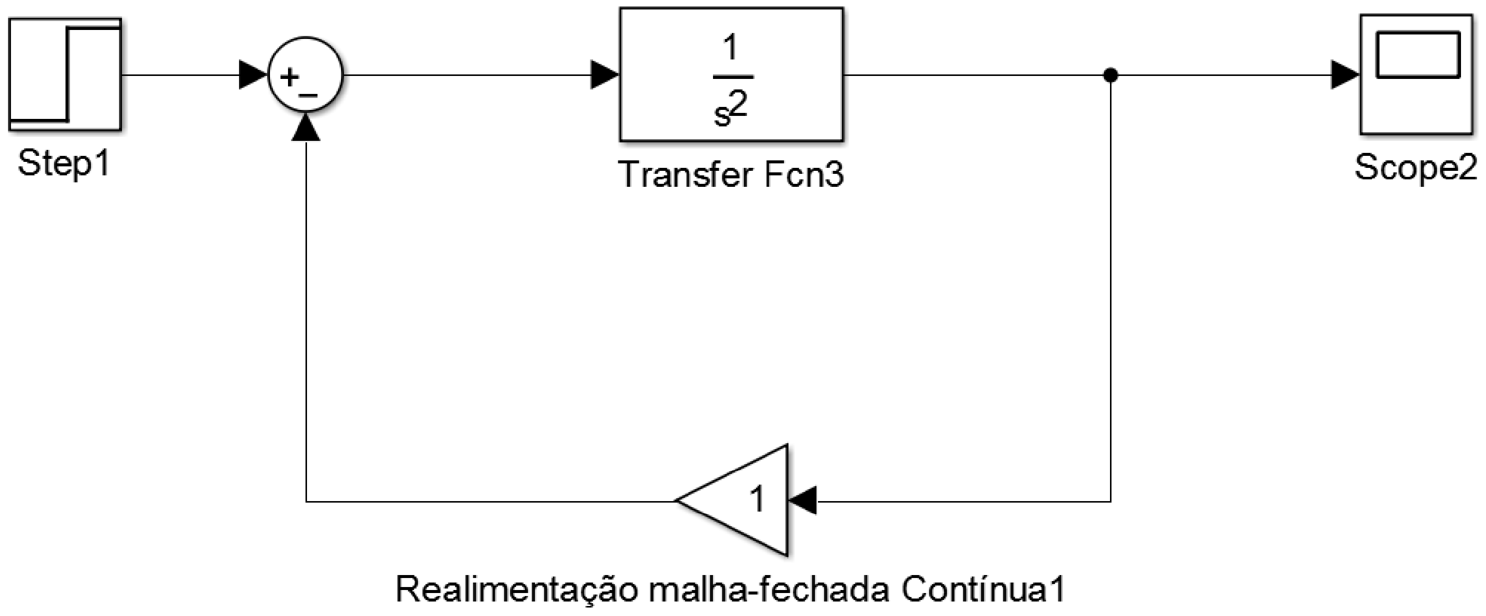
Forced step response





Closed loop example

Lets try the same transfer function used in open loop, but now in a closed loop and see what happen using a step response.



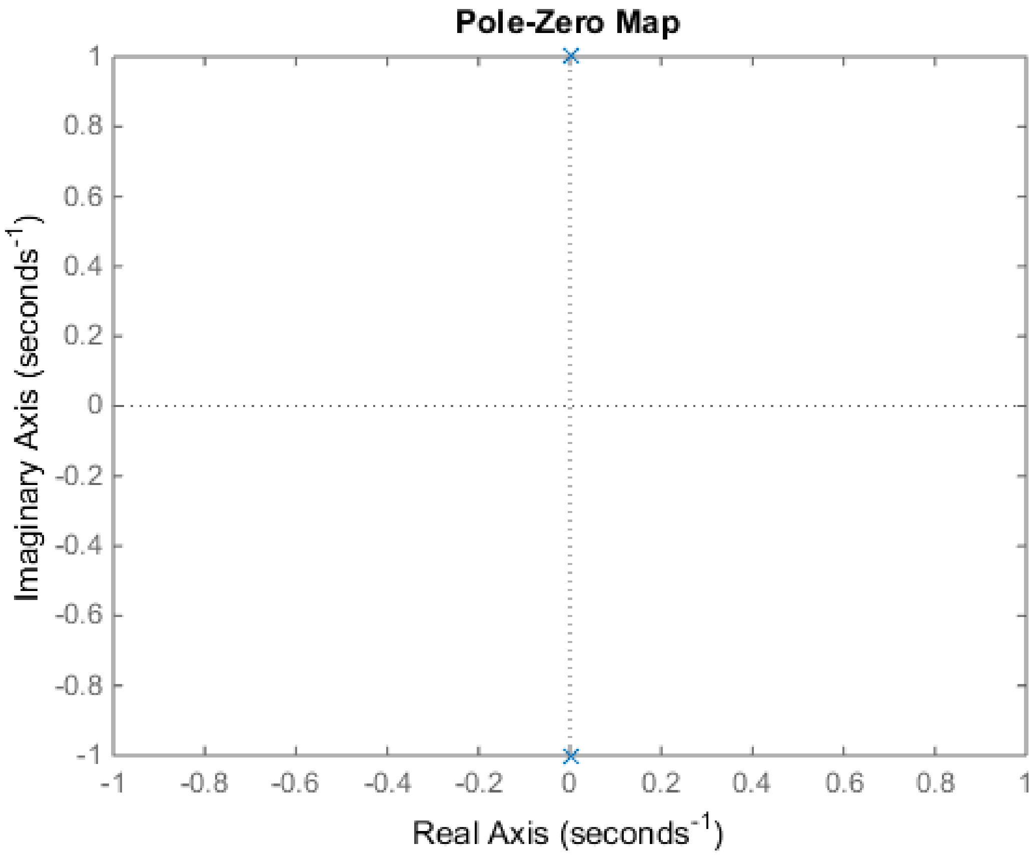
Closed loop example

Before run the Simulink lets get the transfer function in a closed loop via Matlab console typing

```
s = tf('s');
G = 1/s^2;
T = feedback(G,1)
pzmap(T)
```

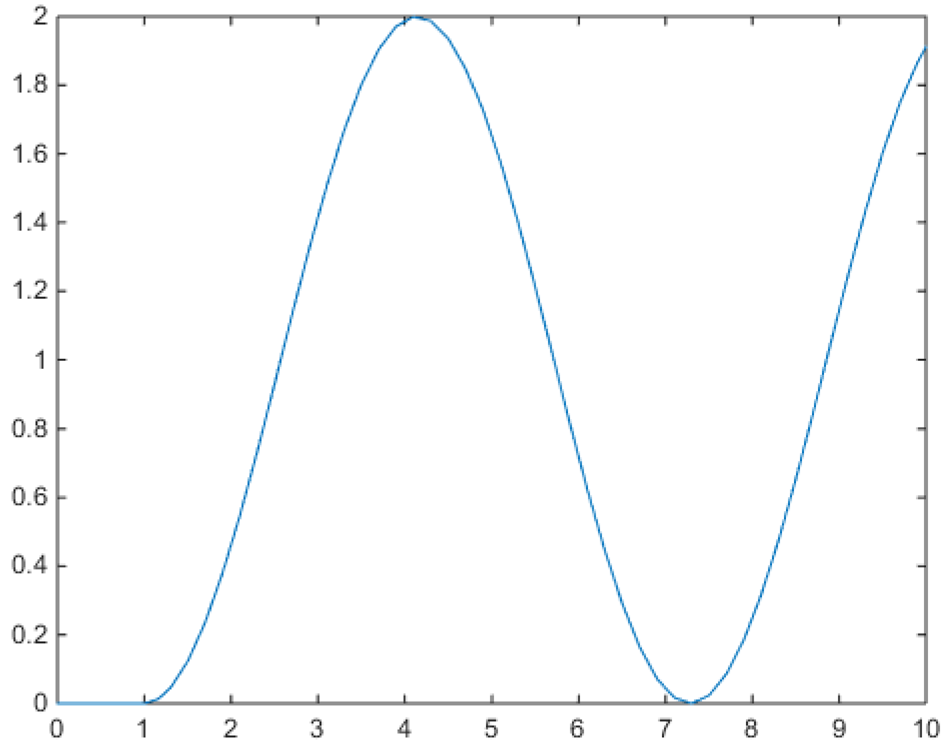
Now the transfer function is given by:

$$G_{cl} = \frac{1}{s^2 + 1}$$



Closed loop example

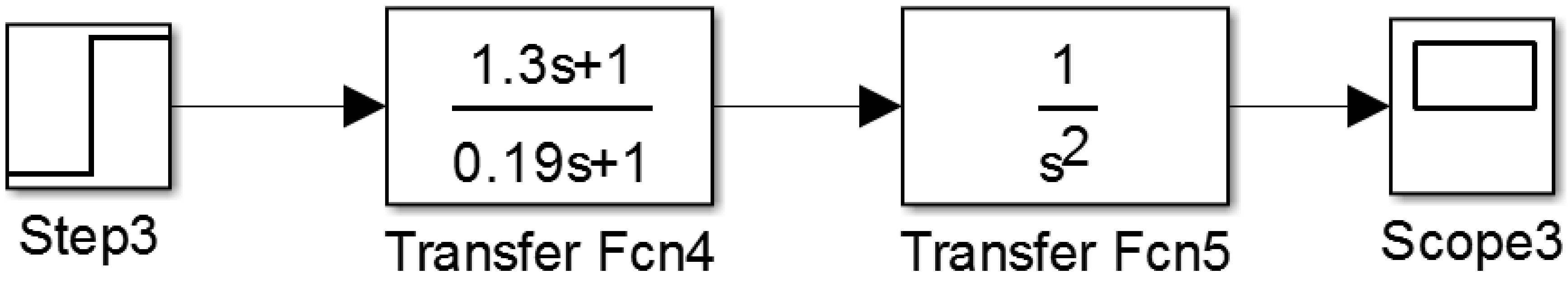
The new closed loop response is:



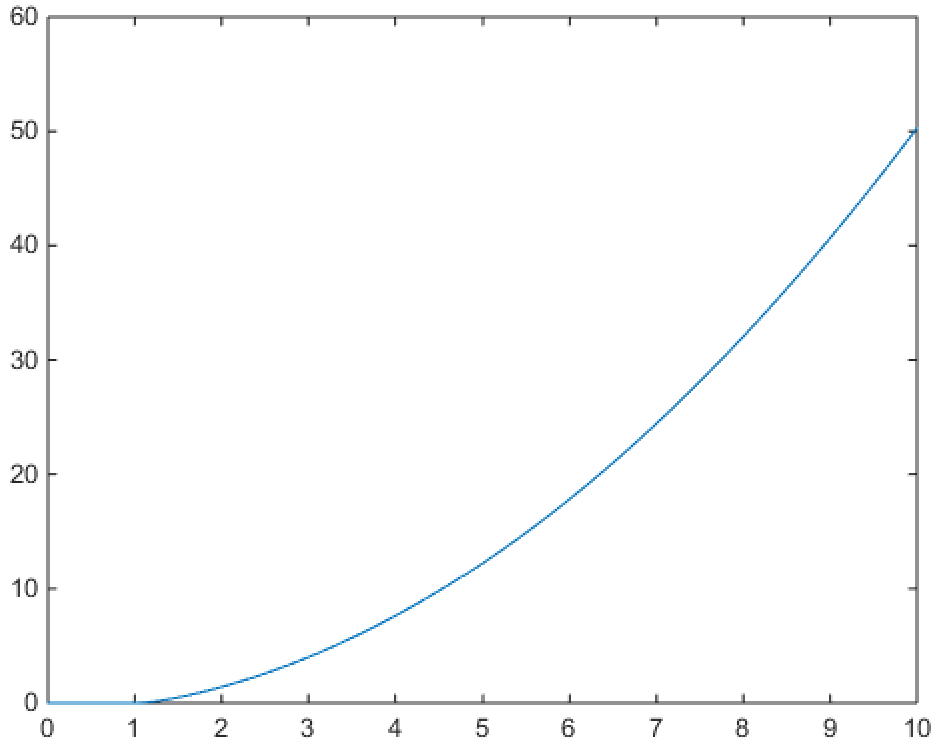
Closed loop example

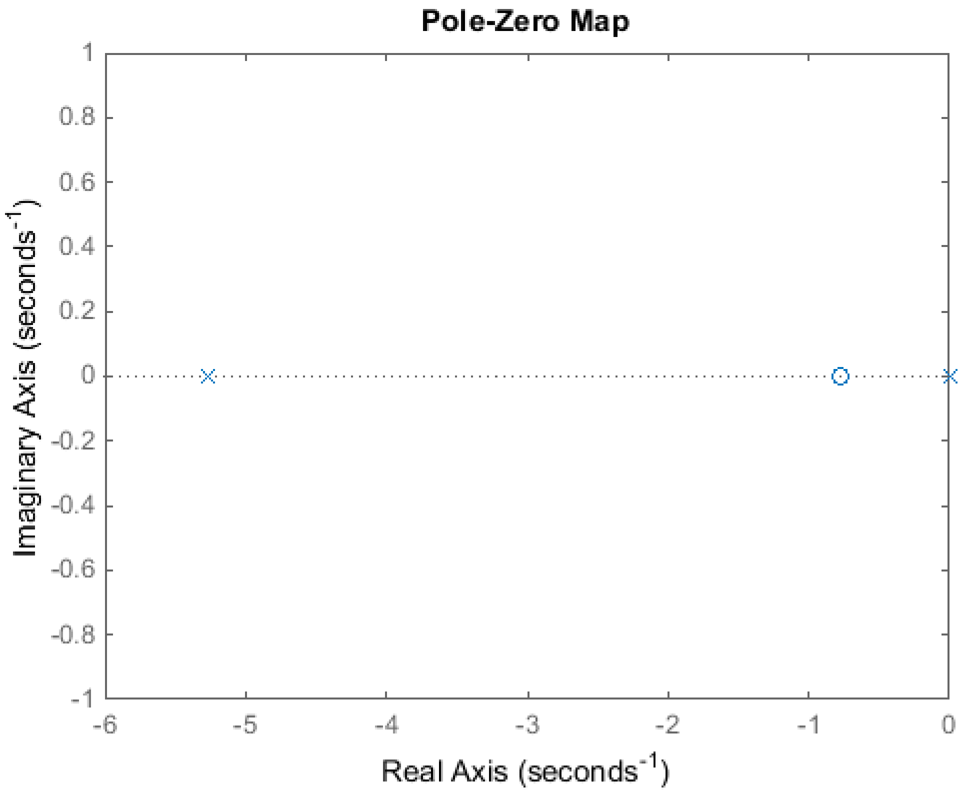
Now lets try to do the same to this system:

- Plot the root locus using of this system “pzmap()”
- Plot the step forced response to the system



Closed loop example

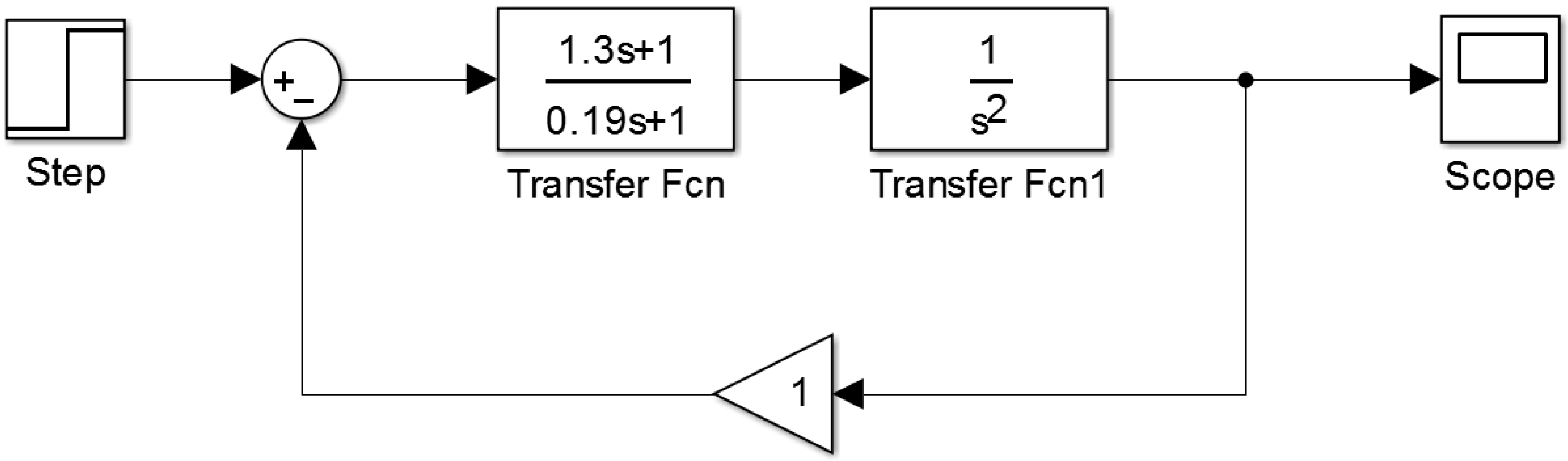




Closed loop example

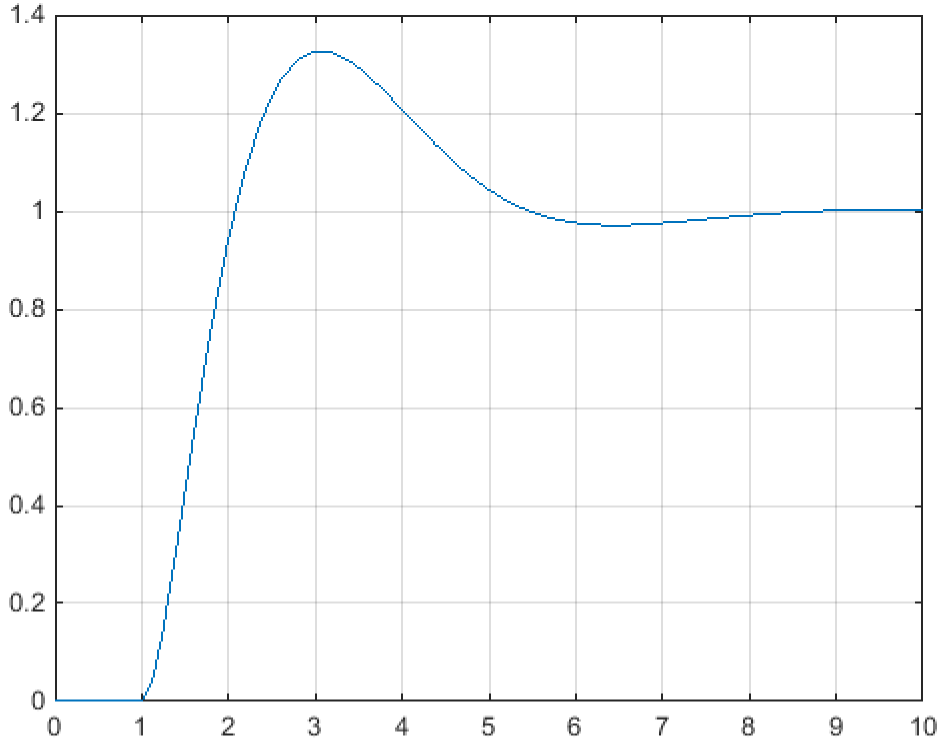
Analyze the same system before but with a unit feedback loop:

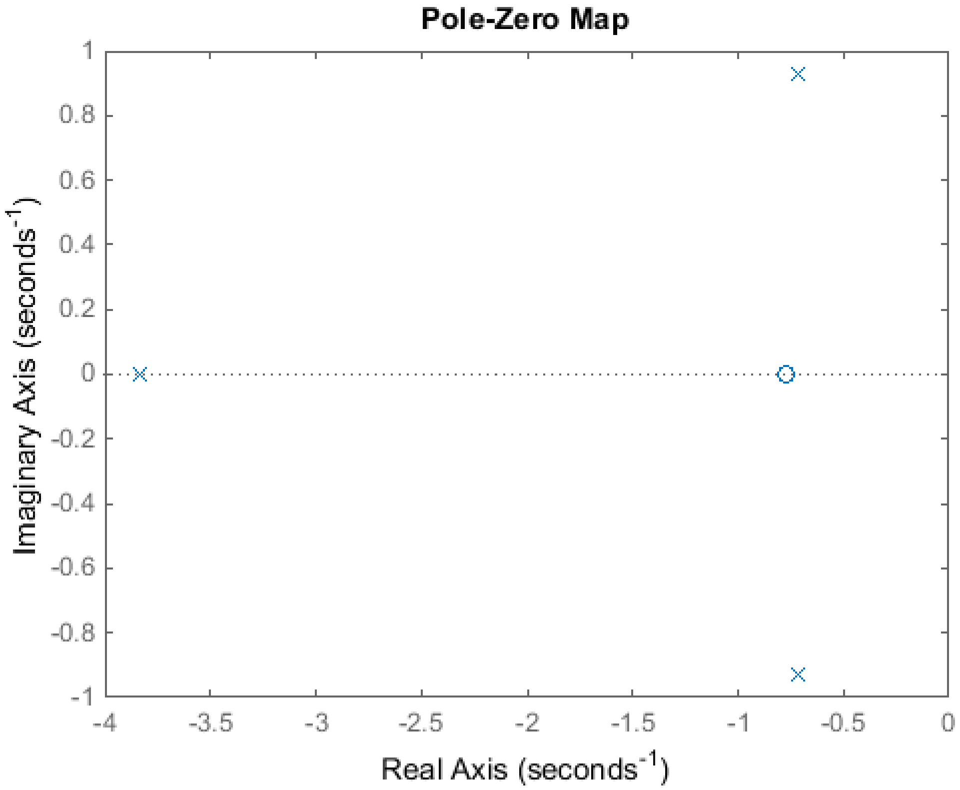
- Plot the root locus using of this system “pzmap()”
- Plot the step forced response to the system



Unit Feedback Loop

Closed loop example





Hands on!

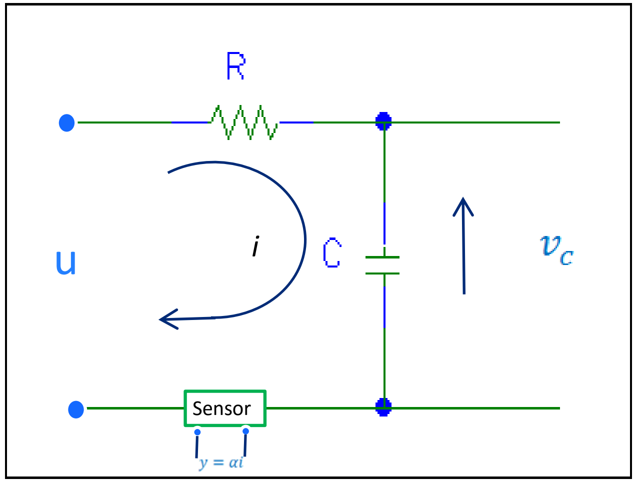
Built the transfer function bellow in Simulink and compare the responses to a Step input, with a Proportional, Integral and Derivative controllers:

$$G(s) = \frac{6(s+2)}{(s+1)(s+3)}$$

You'll have to use the 'Transfer Fcn', 'PID Controller', 'Scope', 'Step', 'Sum' and 'Bus Creator' blocks for this simulation.

Simple RC circuit example

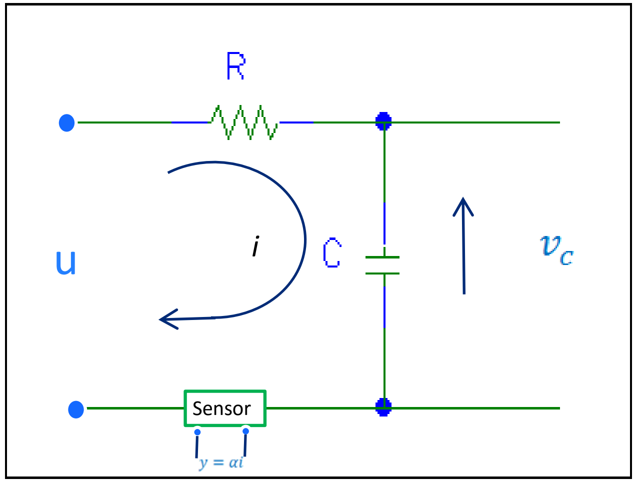
If $v_c = \frac{1}{C}\int i\,dt$ then $\frac{dv_c}{dt} = \frac{i}{C}$

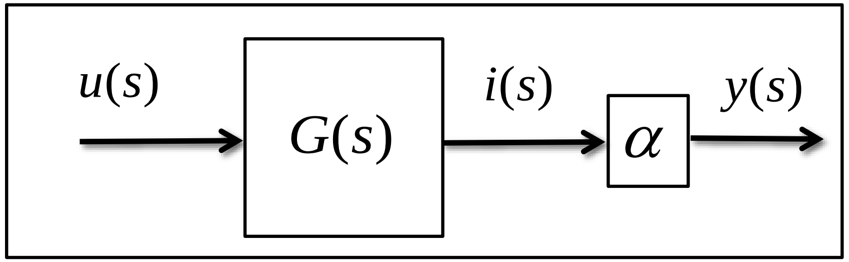


$$i = \frac{u - v_c}{R}$$

$$\frac{dv_c}{dt} = \frac{u - v_c}{RC}$$ First order differential equation.

RC circuit transfer function





Kirchhoff

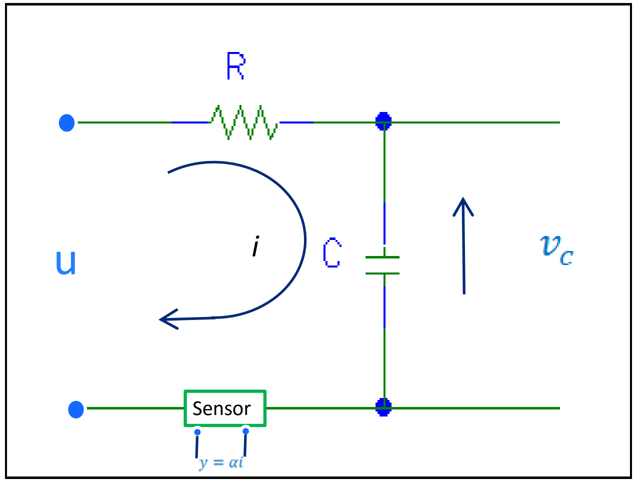
$$u(s) = Ri(s) + \frac{1}{sC} i(s)$$

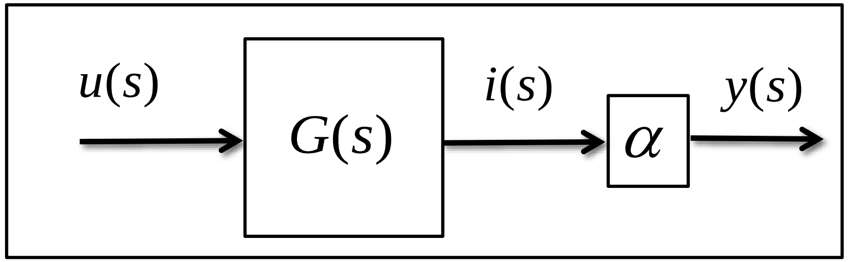
$$i(s) = \frac{\alpha}{y(s)}$$

$$i(s) = \left(\frac{Cs}{RCs+1} \right) u(s)$$

$$G(s) = \frac{Cs}{RCs+1}$$

RC circuit transfer function





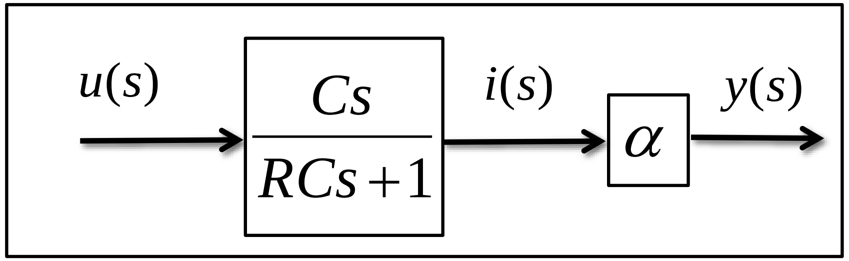
$$K(s) = \frac{y(s)}{u(s)} = \alpha G(s) = \frac{\alpha Cs}{RCs+1}$$

$$y(s) = \left(\frac{\alpha Cs}{RCs+1}\right)u(s)$$

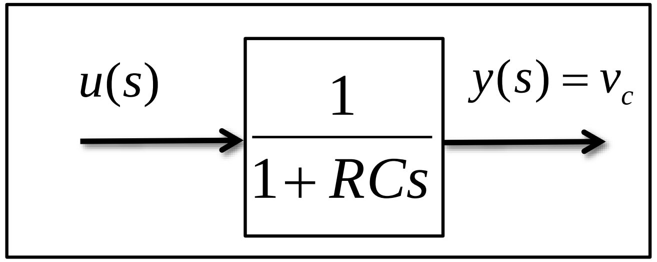
Hands on!

1. Built the closed loop system of the RC circuit using Simulink:

a)



b)



% constants can be defined at the Command Window or in a file .m

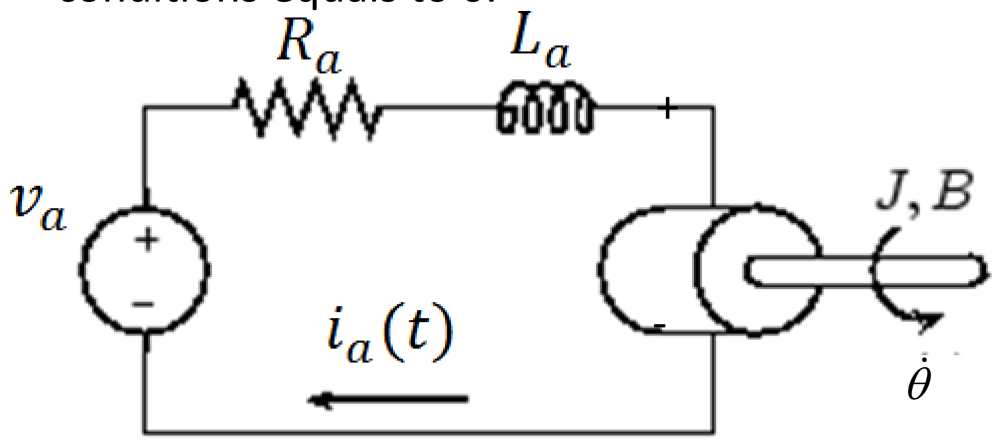
```
>>R = 1000;
>>C = 1000e-6;
>>alpha = 1000;
```

2. Simulate the step responses .

R=1000 (ohm); C=0.001 (F); alpha=10;

Test #3

1. Find the transfer function representation of a DC motor with input V_a and output θ. Consider the initial conditions equals to 0.



Newton

$$K_t i_a(t) = B\dot{\theta} + J\ddot{\theta}$$

Kirchhoff

$$L_a \frac{di_a}{dt} + R_a i_a = v_a - K_e\dot{\theta}$$

2. Build the closed loop system using Simulink.

3. Simulate the step response.

Constants:
J=3.2284E-6; B=3.5077E-6; Kt=Ke=0.0274; Ra=4; La=2.75E-6;

References

[1] Matlab Product Help.

[2] Matlab Demystified. A Self-Teaching Guide, David McMahon, McGraw Hill.

[3] Matlab: An Introduction with Applications, Amos Gilat, Fourth Edition, JOHN WILEY & SONS.