

Simulink e Diagramas de Blocos

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Aula 1c

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Introdução

Esta aula é para ser ministrada de forma interativa utilizando um microcomputador com o aplicativo Matlab instalado. Tem por objetivo apresentar aos alunos o ambiente e funções básicas do Simulink. Na apresentação encontram-se diversos exercícios a serem resolvidos em sala sob a supervisão da professora ou professor.

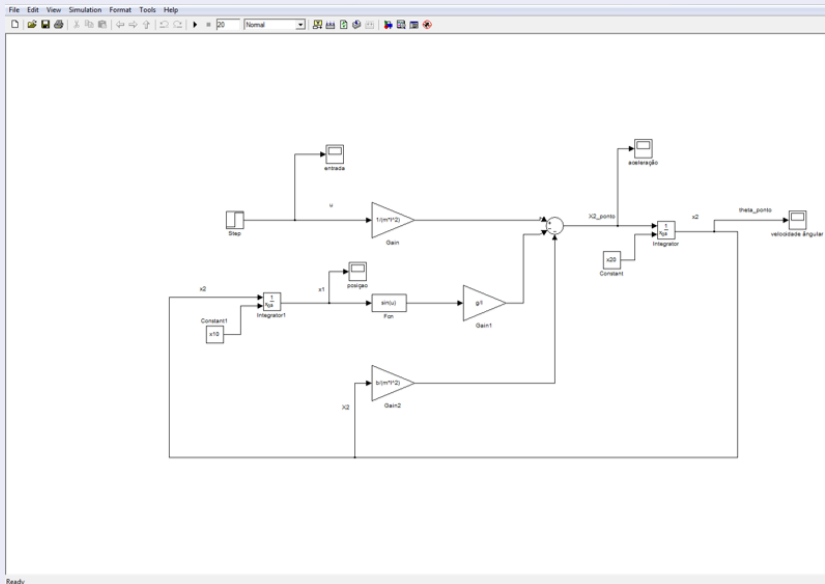
Simulink e diagramas de bloco

Simulink é um aplicativo do Matlab. Simulink permite criar diagrama de blocos, análise de modelos e construção de funções.

Para acessar o Simulink digite:

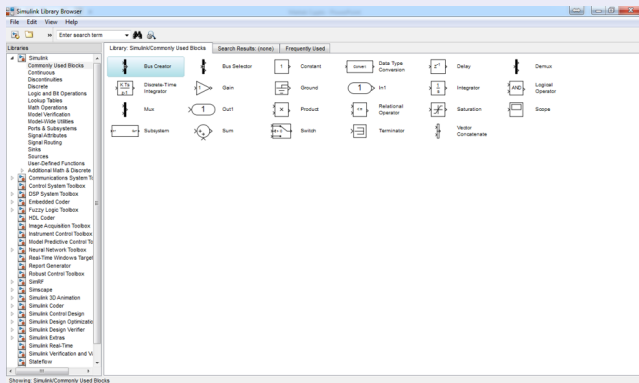
» simulink

Editor do Simulink

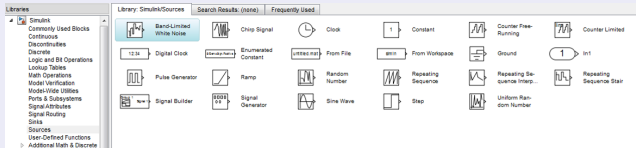


Ready

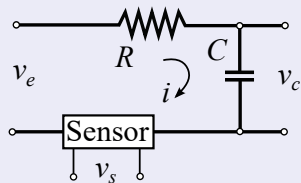
Bibliotecas do Simulink: blocos largamente usados



Bibliotecas do Simulink: sources



Equações de um circuito RC simples



$$v_c = \frac{1}{C} \int i dt, \text{ então } \frac{dv_c}{dt} = \frac{i}{C},$$

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

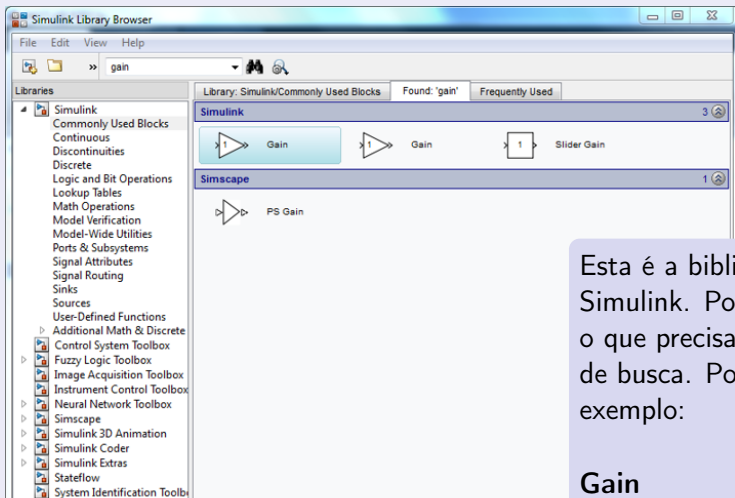
$$\frac{dv_c}{dt} = \frac{v_e - v_c}{RC}$$

Escolhendo $x_1 = v_c$, $\dot{x}_1 = \frac{dv_c}{dt}$,
 $y = v_s = \alpha i$ e $u = v_e$:

$$\dot{x}_1 = -\frac{x_1}{RC} + \frac{u}{RC}$$

$$y = -\frac{\alpha x_1}{R} + \frac{\alpha u}{R}$$

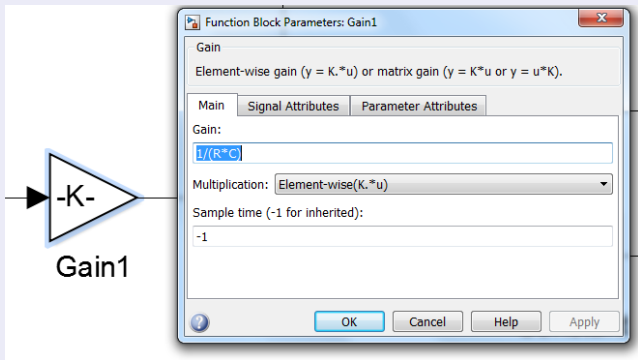
Circuito RC simples



Esta é a biblioteca Simulink. Pode digitar o que precisa na caixa de busca. Por exemplo:

Gain
Sum
Integrator

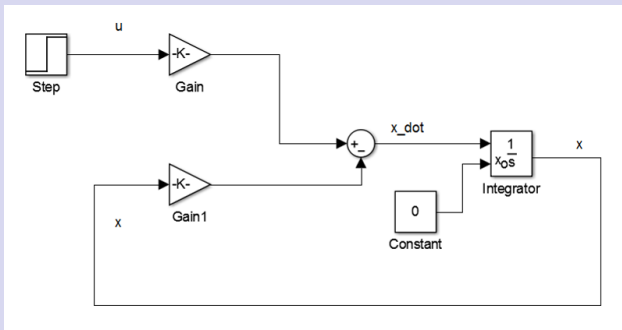
Circuito RC simples: bloco ganho



Circuito RC simples

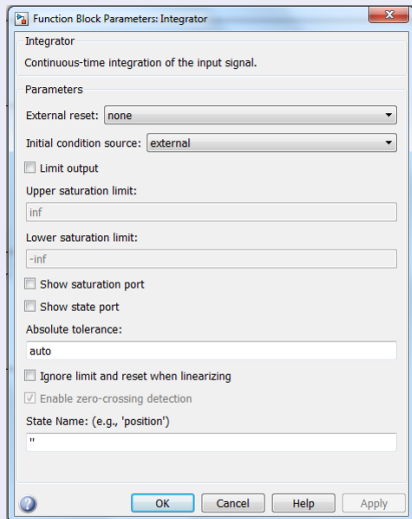
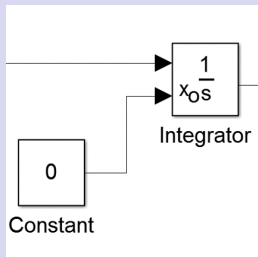
$$\dot{x}_1 = -\frac{x_1}{RC} + \frac{u}{RC}$$

Para criar a primeira equação, pode usar:



Circuito RC simples

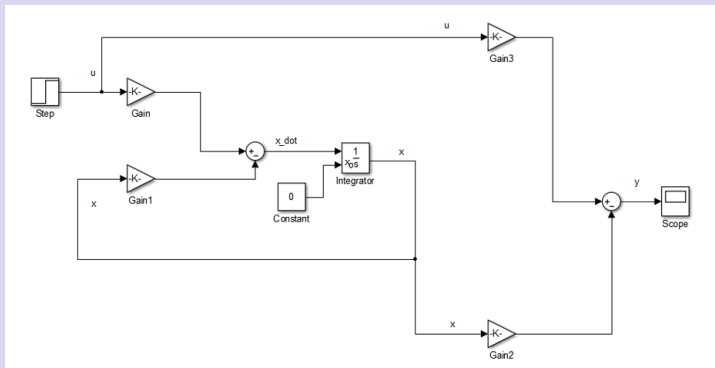
Para usar o integrador com condição inicial externa, clicar duas vezes no bloco integrador.



Circuito RC simples

$$y = -\frac{\alpha x_1}{R} + \frac{\alpha u}{R}$$

Para criar a segunda equação, pode usar:

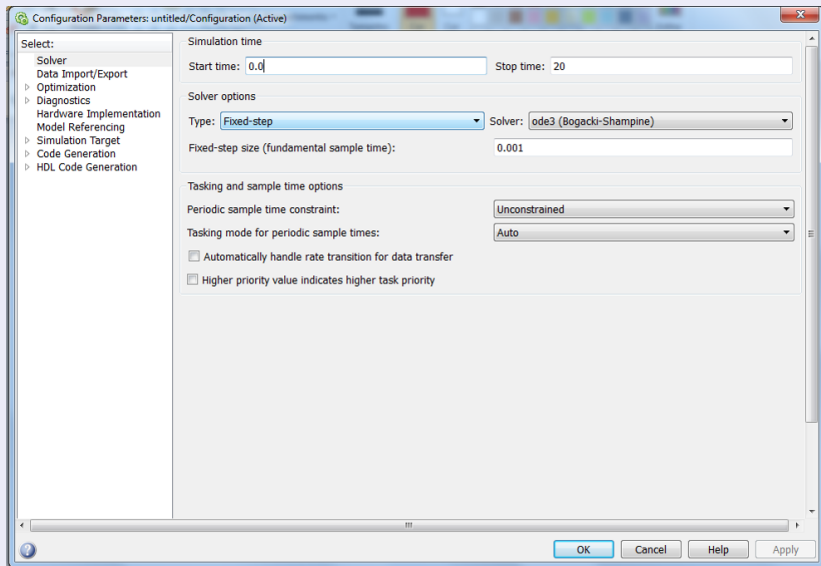


Circuito RC simples: configuração

Antes de rodar o modelo de simulação, precisa configurar o Simulink.



Circuito RC simples: configurações



Circuito RC simples: programa

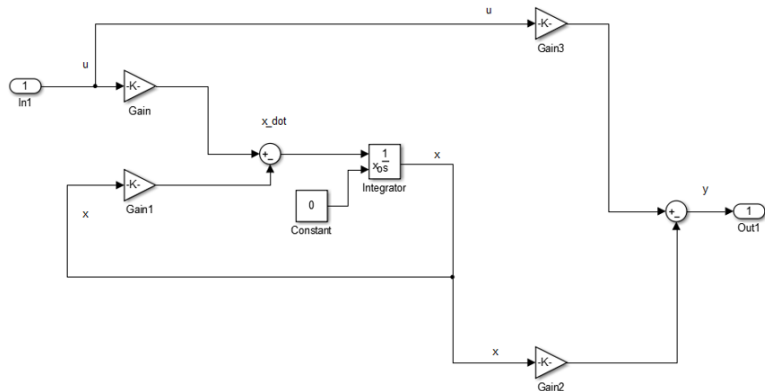
Criar and rodar instruções usando o programa abaixo.

```
% parametros do circuito RC
clear all;
close all ;
clc;
% constants
R = 1000;
C = 1000e-6;
alpha = 1;
```


Circuito RC simples: modelo linear

Para obter o modelo linear, use os blocos **in** e **out** no diagrama. Criar um programa e neste programa usar:

```
[A,B,C,D] = linmod('rc_circuit');
```



Circuito RC simples: função de transferência

Agora, é possível obter a função de transferência do circuito RC. Use o comando `tf` com as matrizes A, B, C, D obtidas via função `linmod`.

```
G = ss(A,B,C,D);
```

```
Gss = tf(G);
```

o que fornece:

```
» G
```

```
G =
```

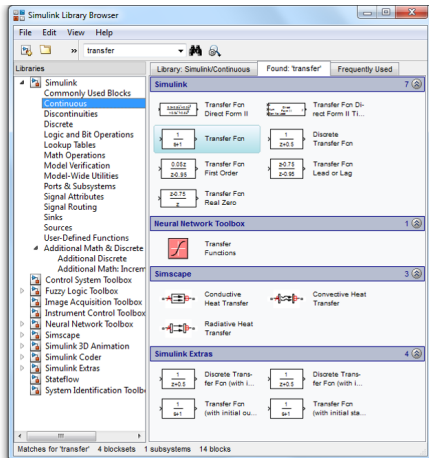
```
0.001 s
```

```
-----
```

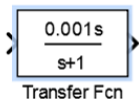
```
s + 1
```

Circuito RC simples: transfer Fcn block

Criar uma transfer function usando a transfer fcn block no Simulink



Circuito RC simples: transfer Fcn block



Function Block Parameters: Transfer Fcn

Transfer Fcn

The numerator coefficient can be a vector or matrix expression. The denominator coefficient must be a vector. The output width equals the number of rows in the numerator coefficient. You should specify the coefficients in descending order of powers of s.

Parameters

Numerator coefficients:

Denominator coefficients:

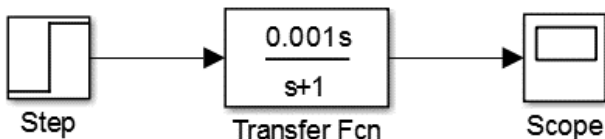
Absolute tolerance:

State Name: (e.g., 'position')

OK Cancel Help Apply

Circuito RC simples: simulação

Para simular a resposta da função de transferência use a função **step** e o osciloscópio no Simulink. Rodar e clicar duas vezes no osciloscópio para ver a resposta.



Pêndulo simples: Representação espaço de estado:

$$\left. \begin{array}{l} x_1 = \theta \\ x_2 = \dot{\theta} \\ u = T_c \\ y = \theta \end{array} \right\} \rightarrow \begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} \rightarrow \ddot{x}_2 = \ddot{\theta} = \frac{u}{ml^2} - \frac{g}{l} \sin(x_1) - \frac{b}{ml^2} x_2^2$$

$$\begin{array}{l} \dot{x}_1 = \dot{\theta} \\ y = x_1 \end{array}$$

Pêndulo simples: notação vetorial

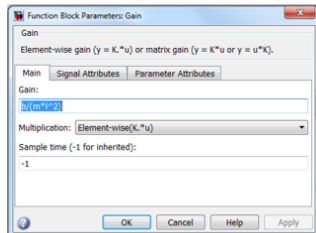
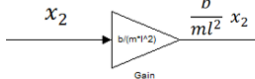
$$\dot{x} = f(x) + bu$$

$$\dot{x} = \begin{bmatrix} x_2 \\ -\frac{g}{\ell} \sin(x_1) \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \\ \frac{1}{ml^2} \end{bmatrix} u$$

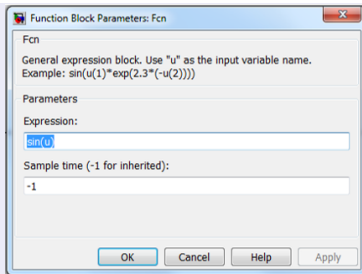
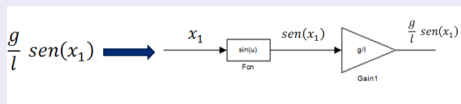
$$y = x_1$$

Pêndulo simples: Simulink

$$\frac{b}{ml^2} x_2$$

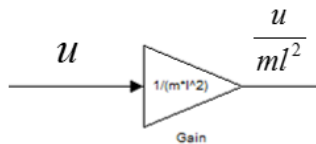


Pêndulo simples: Simulink

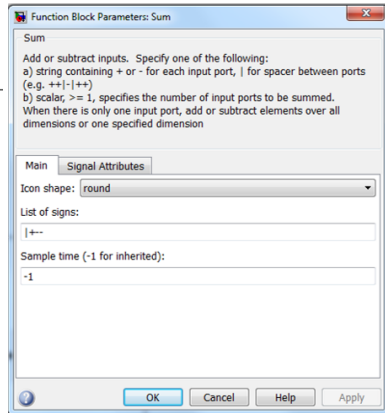
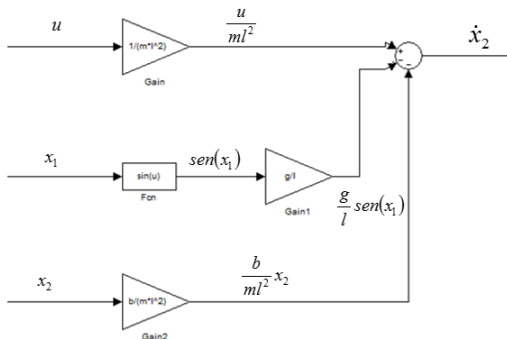


Pêndulo simples: Simulink

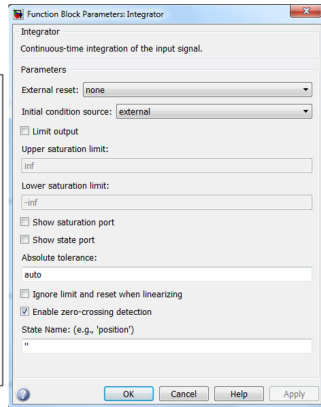
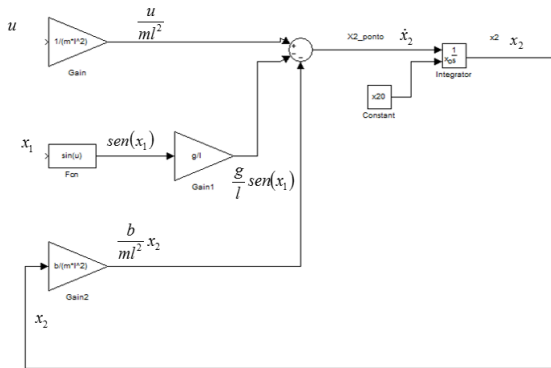
$$\frac{u}{ml^2}$$



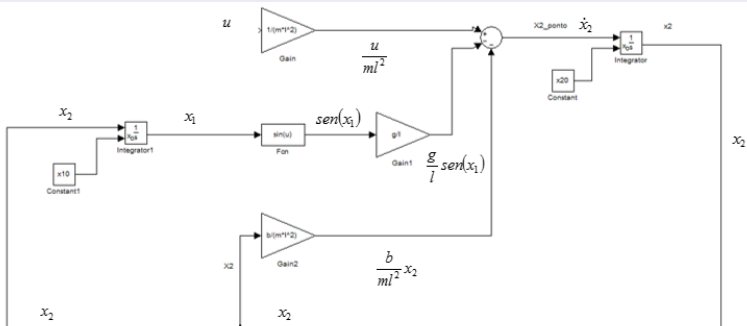
Pêndulo simples: Simulink



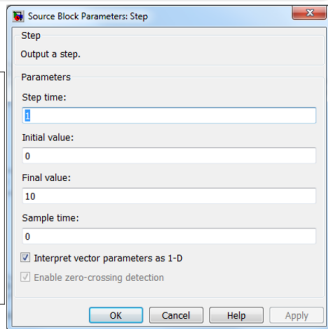
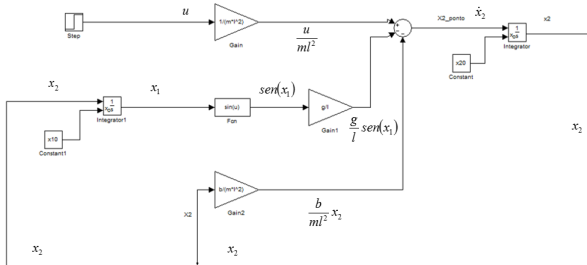
Pêndulo simples: Simulink



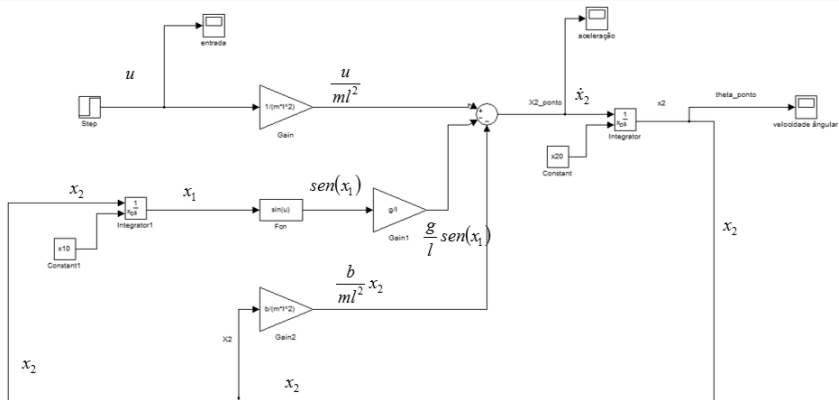
Pêndulo simples: Simulink



Pêndulo simples: Simulink



Pêndulo simples: Simulink



Pêndulo simples: Simulink

Antes de rodar o modelo de simulação, configurar o Simulink.



Pêndulo simples: Simulink

The screenshot shows the 'Configuration Parameters' dialog box in Simulink. The window title is 'Configuration Parameters: untitled/Configuration (Active)'. On the left, a 'Select:' pane lists various configuration categories, with 'Solver' selected. The main area is divided into several sections:

- Simulation time:** 'Start time' is set to 0.0 and 'Stop time' is set to 20.
- Solver options:** 'Type' is set to 'Fixed-step' and 'Solver' is set to 'ode3 (Bogacki-Shampine)'. 'Fixed-step size (fundamental sample time)' is set to 0.001.
- Tasking and sample time options:** 'Periodic sample time constraint' is set to 'Unconstrained' and 'Tasking mode for periodic sample times' is set to 'Auto'. There are two unchecked checkboxes: 'Automatically handle rate transition for data transfer' and 'Higher priority value indicates higher task priority'.

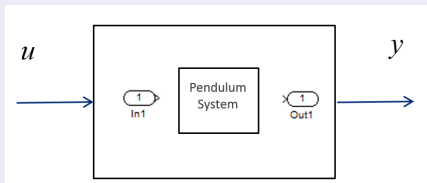
Pêndulo simples: Simulink

Criar um programa usando:

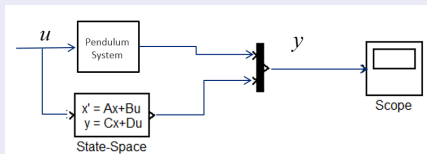
```
%parametros do pêndulo simples  
clear all;  
close all ;  
clc;  
  
% constantes  
l=0.5;m=10;g=9.81;b=4.5;  
%condição inicial  
x20= 0; %velocidade inicial  
x10=30*pi/180; %posição inicial em rad
```

Tarefa: pêndulo simples

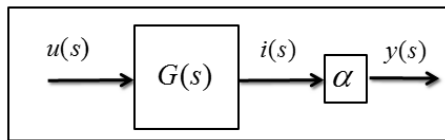
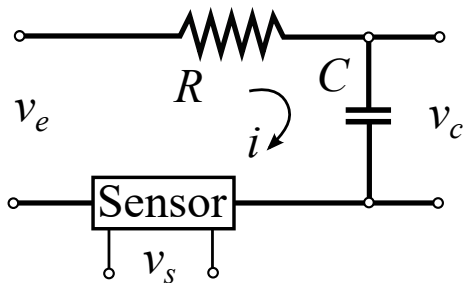
- Usando a função $[A,B,C,D]=\text{linmod}('SYS')$ extrair o modelo espaço de estado do modelo não linear do pêndulo.



- Compare a resposta do sistema linear encontrado com a do não linear construído no Simulink.



Circuito RC



Função de transferência do circuito RC

Kirchhoff:

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

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

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

$$\begin{aligned} G(s) &= \frac{y(s)}{u(s)} \\ &= \alpha \frac{Cs}{RCs + 1} \end{aligned}$$

Circuito RC: Resposta no tempo

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

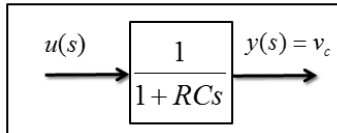
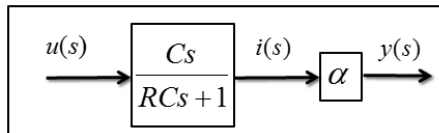
$$y(s) = \frac{\alpha}{R} - \left(\frac{\alpha C}{RCs + 1} \right) u(s)$$

$$y(s) = \left(\frac{\alpha}{R} - \frac{\alpha}{R^2 C} \right) \left(\frac{1}{s + \frac{1}{RC}} \right)$$

$$y(t) = \frac{\alpha}{R} \delta(t) - \frac{\alpha}{R^2 C} e^{\frac{-t}{RC}}, t \geq 0$$

Tarefa: simular a resposta do circuito RC

Simular a resposta ao degrau para $y = v_c$ e $y = \alpha i$.



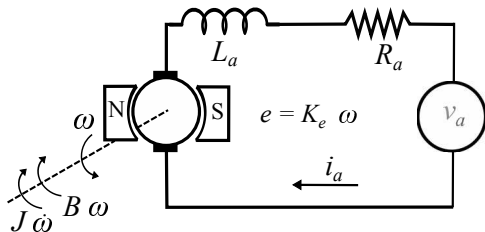
$R = 1000 \Omega$; $C = 0.001 \text{ F}$; $\alpha = 10$.

Tarefa para nota

A solução da tarefa deve conter o que foi estudado, o que foi feito e analisado. A solução deve ser enviada via área do aluno, pode ser via a plataforma Moodle de disciplinas, por exemplo.

Tarefa

1. Obter a representação espaço de estado de um motor CC com saída θ
2. Simular as respostas ao degrau.



Newton:

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

Kirchhoff:

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

$$J=3,2284E-6; B=3,5077E-6;$$

$$K_t=K_e=0,0274; R_a=4;$$

$$L_a=2,75E-6.$$

Referências

- [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 and Sons.