

Le logiciel de simulation

Simulink

Partie 1

Présentation

Professeur Ali Tahri
Université des sciences et de la technologie d'Oran
Mohamed Boudiaf

1. Introduction

Simulink est le logiciel de simulation couplé au logiciel de calcul MATLAB.

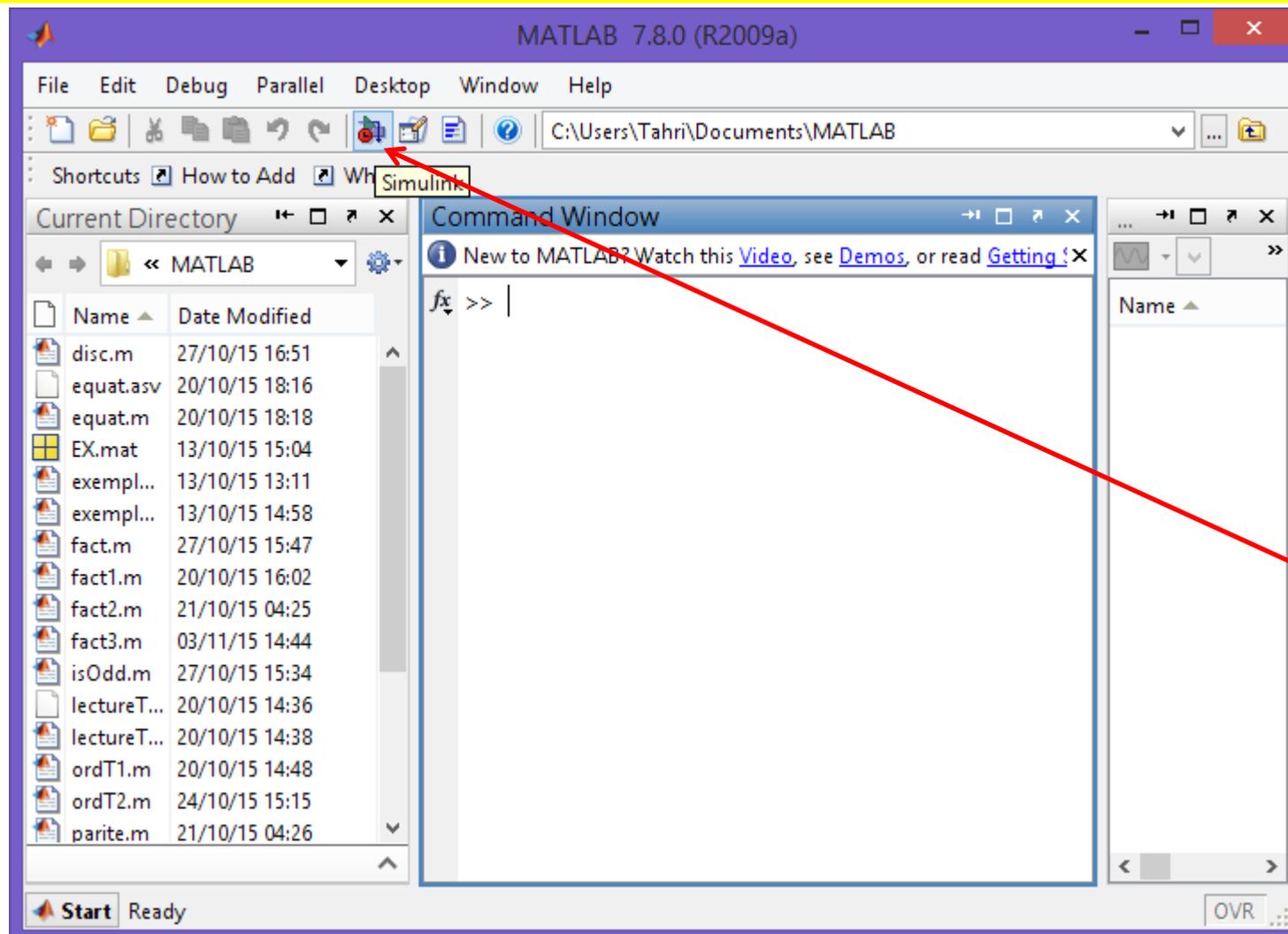
Simulink manipule des *blocs fonctionnels* disponibles dans des bibliothèques spécialisées et qu'on copie dans une fenêtre d'édition en les reliant selon le schéma-bloc pour représenter le système à étudier. La bibliothèque *sources* fournit des signaux d'excitation et la bibliothèque *sink* les outils d'observation comme, par exemple, le bloc oscilloscope

Particulièrement bien adapté à l'étude des schémas de l'Automatique, Simulink met en œuvre des éléments familiers, ce qui le rend facile à utiliser.

Simulink communique parfaitement avec MATLAB dont il profite de toutes les fonctionnalités. Il est possible, par exemple, de recueillir la réponse d'un modèle et de la visualiser dans MATLAB pour l'annoter et l'analyser.

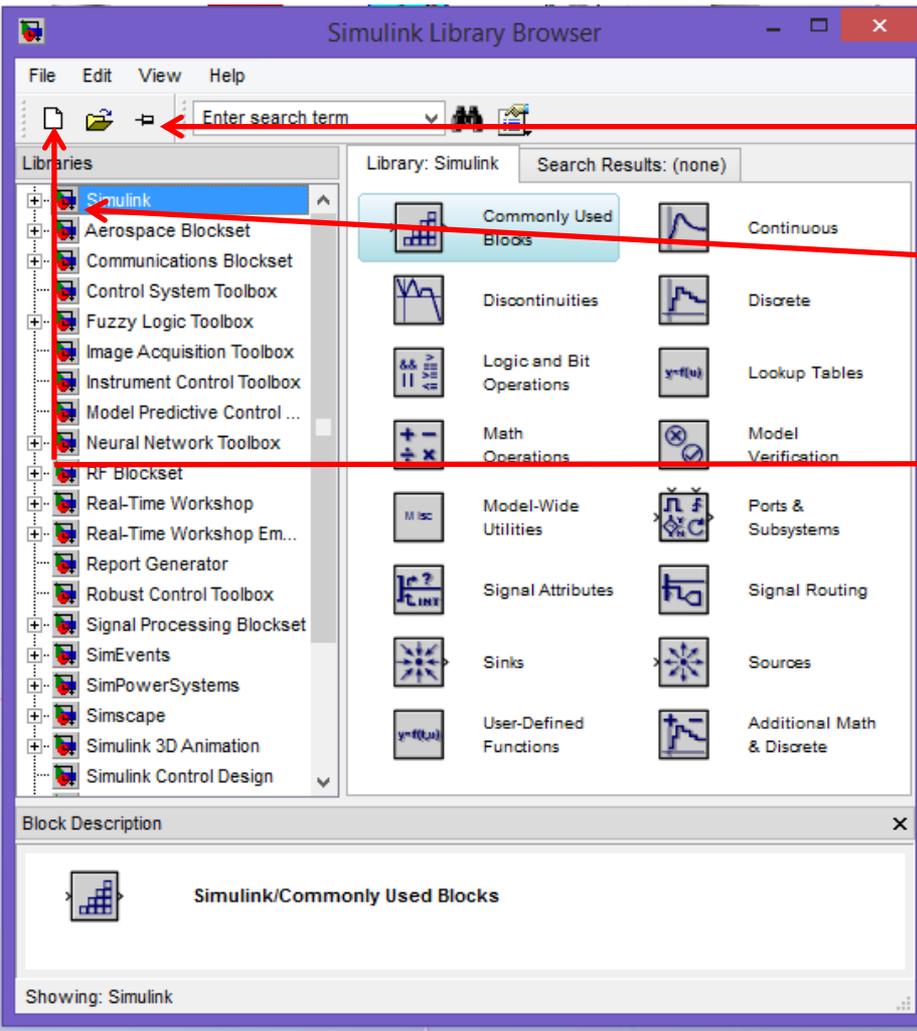
Dans Simulink un schéma se substitue aux équations pour constituer le *modèle*. Les équations différentielles représentatives du fonctionnement du système physique modélisé sont sous-jacentes (en dessous). Le logiciel *simule* le comportement du modèle représentatif du système en calculant, pas après pas, les points du signal de sortie dès lors qu'il connaît ceux du signal d'entrée et le point de départ (conditions initiales)

2. Lancer Simulink



*Simulink peut être
lancer en cliquant
sur l'icone Simulink.*

3. Le Simulink

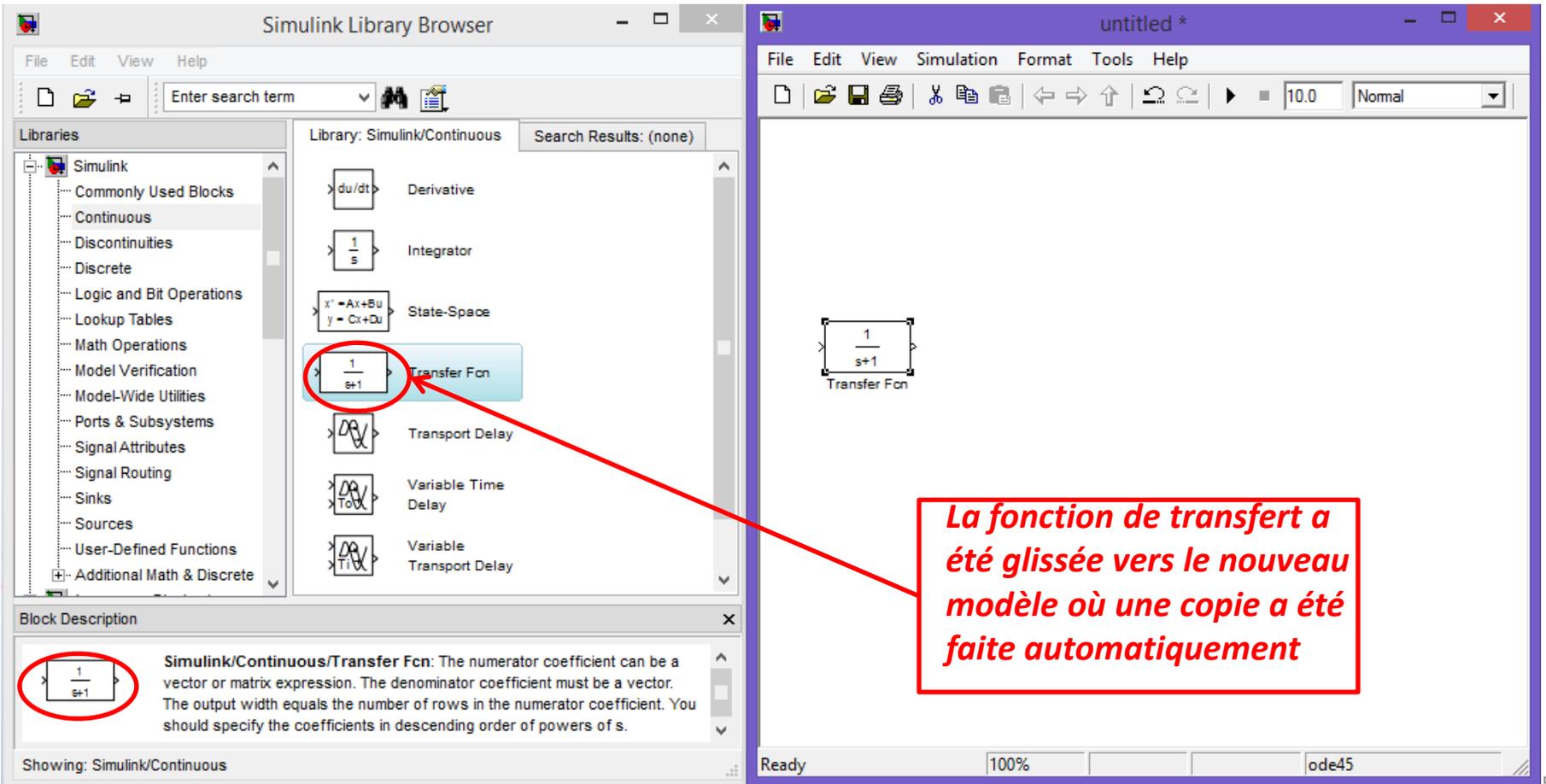


Epingler pour la visibilité permanente

Bibliothèques de blocs

Créer un nouveau modèle

4. Créer un nouveau modèle



The image shows two windows from the Simulink environment. The left window is the 'Simulink Library Browser' with the 'Transfer Fcn' block highlighted in the 'Simulink/Continuous' library. The right window is a new model titled 'untitled *' containing a 'Transfer Fcn' block with the transfer function $\frac{1}{s+1}$. A red arrow points from the highlighted block in the library to the block in the model. A red text box with a white background contains the text: *La fonction de transfert a été glissée vers le nouveau modèle où une copie a été faite automatiquement*.

Simulink Library Browser

File Edit View Help

Enter search term

Libraries

- Simulink
 - Commonly Used Blocks
 - Continuous
 - Discontinuities
 - Discrete
 - Logic and Bit Operations
 - Lookup Tables
 - Math Operations
 - Model Verification
 - Model-Wide Utilities
 - Ports & Subsystems
 - Signal Attributes
 - Signal Routing
 - Sinks
 - Sources
 - User-Defined Functions
 - Additional Math & Discrete

Library: Simulink/Continuous Search Results: (none)

- $\frac{du}{dt}$ Derivative
- $\frac{1}{s}$ Integrator
- $\begin{matrix} \dot{x}' = Ax + Bu \\ y = Cx + Du \end{matrix}$ State-Space
- $\frac{1}{s+1}$ Transfer Fcn
- $\frac{\Delta y}{T}$ Transport Delay
- $\frac{\Delta y}{T(s)}$ Variable Time Delay
- $\frac{\Delta y}{T(s)}$ Variable Transport Delay

Block Description

$\frac{1}{s+1}$ Simulink/Continuous/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.

Showing: Simulink/Continuous

untitled *

File Edit View Simulation Format Tools Help

10.0 Normal

Transfer Fcn

La fonction de transfert a été glissée vers le nouveau modèle où une copie a été faite automatiquement

Ready 100% ode45

Avec la souris on peut connecter les deux blocs, le bloc signal sinus de la bibliothèque source avec la fonction de transfert.

The image shows two windows from the Simulink environment. The left window is the 'Simulink Library Browser' with the 'Sources' category selected. The 'Sine Wave' block is highlighted in the search results. The right window is an 'untitled' Simulink model showing a 'Sine Wave' block connected to a 'Transfer Fcn' block with the transfer function $\frac{1}{s+1}$.

Simulink Library Browser

File Edit View Help

Enter search term

Libraries

- Simulink
 - Commonly Used Blocks
 - Continuous
 - Discontinuities
 - Discrete
 - Logic and Bit Operations
 - Lookup Tables
 - Math Operations
 - Model Verification
 - Model-Wide Utilities
 - Ports & Subsystems
 - Signal Attributes
 - Signal Routing
 - Sinks
 - Sources
 - User-Defined Functions
 - Additional Math & Discrete

Library: Simulink/Sources Search Results: (none)

- Repeating Sequence
- Repeating Sequence Interpol...
- Repeating Sequence Stair
- Signal Builder
- Signal Generator
- Sine Wave**
- Step

Block Description

Simulink/Sources/Sine Wave: Output a sine wave:
 $O(t) = \text{Amp} \cdot \sin(\text{Freq} \cdot t + \text{Phase}) + \text{Bias}$

Showing: Simulink/Sources

untitled *

File Edit View Simulation Format Tools Help

10.0 Normal

Sine Wave → Transfer Fcn

Ready 100% ode45

On a ajouté un oscilloscope (Scope) pour la visualisation de la sortie.

The image shows two windows from the Simulink environment. The left window is the 'Simulink Library Browser' with the 'Scope' block selected in the 'Sinks' category. The right window is an 'untitled *' model window showing a block diagram with a 'Sine Wave' block, a 'Transfer Fon' block with the transfer function $\frac{1}{s+1}$, and a 'Scope' block. A red arrow points from a text box to the 'Run' button (a right-pointing triangle) in the top toolbar of the model window.

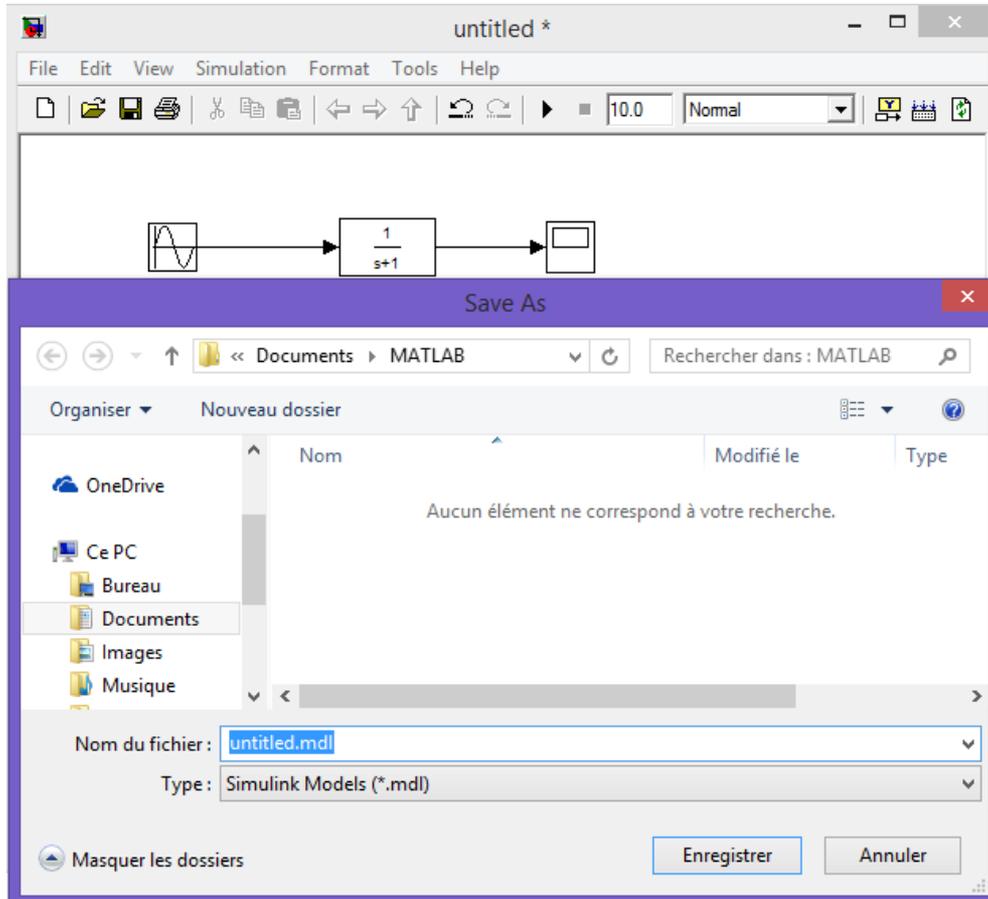
On peut exécuter notre modèle en cliquant sur ce bouton

En exécutant le modèle, on clique deux fois sur l'oscilloscope (Scope) pour afficher le signal de sortie.

The image displays the MATLAB/Simulink environment. On the left, the **Simulink Library Browser** window is open, showing the **Simulink/Sinks** library. The **Scope** block is highlighted. The **Block Description** pane at the bottom left shows the details for the **Simulink/Sinks/Scope** block.

On the right, the **untitled *** window shows a Simulink model. The model consists of three blocks connected in series: a **Sine Wave** block, a **Transfer Fcn** block with the transfer function $\frac{1}{s+1}$, and a **Scope** block. The **Scope** block is open, displaying a plot of the output signal. The plot shows a damped sine wave starting at 0, peaking at approximately 0.7, crossing zero at approximately 3.5, reaching a trough at approximately -0.7, and crossing zero again at approximately 6.5. The x-axis is labeled from 0 to 10, and the y-axis is labeled from -1 to 1. The plot title is **Scope** and the time offset is 0.

5. Sauvegarder un modèle



*En Simulink, un modèle est sauvegardé dans un fichier avec l'extension **mdl***

*Ainsi le modèle est sauvegardé dans le fichier **modele1.mdl***

The image shows two windows from the Simulink environment. The left window is the 'Simulink Library Browser' with the 'Sinks' category selected, showing a list of blocks including 'Scope'. The right window is a Simulink model named 'modele1' containing a 'Sine Wave' block, a 'Transfer Fcn' block with the transfer function $\frac{1}{s+1}$, and a 'Scope' block connected in series.

Simulink Library Browser

File Edit View Help

Enter search term

Libraries

- Simulink
 - Commonly Used Blocks
 - Continuous
 - Discontinuities
 - Discrete
 - Logic and Bit Operations
 - Lookup Tables
 - Math Operations
 - Model Verification
 - Model-Wide Utilities
 - Ports & Subsystems
 - Signal Attributes
 - Signal Routing
 - Sinks
 - Sources
 - User-Defined Functions
 - Additional Math & Discrete

Library: Simulink/Sinks Search Results: (none)

- Display
- Floating Scope
- Out1
- Scope
- Stop Simulation
- Terminator
- To File

Block Description

Simulink/Sinks/Scope

modele1

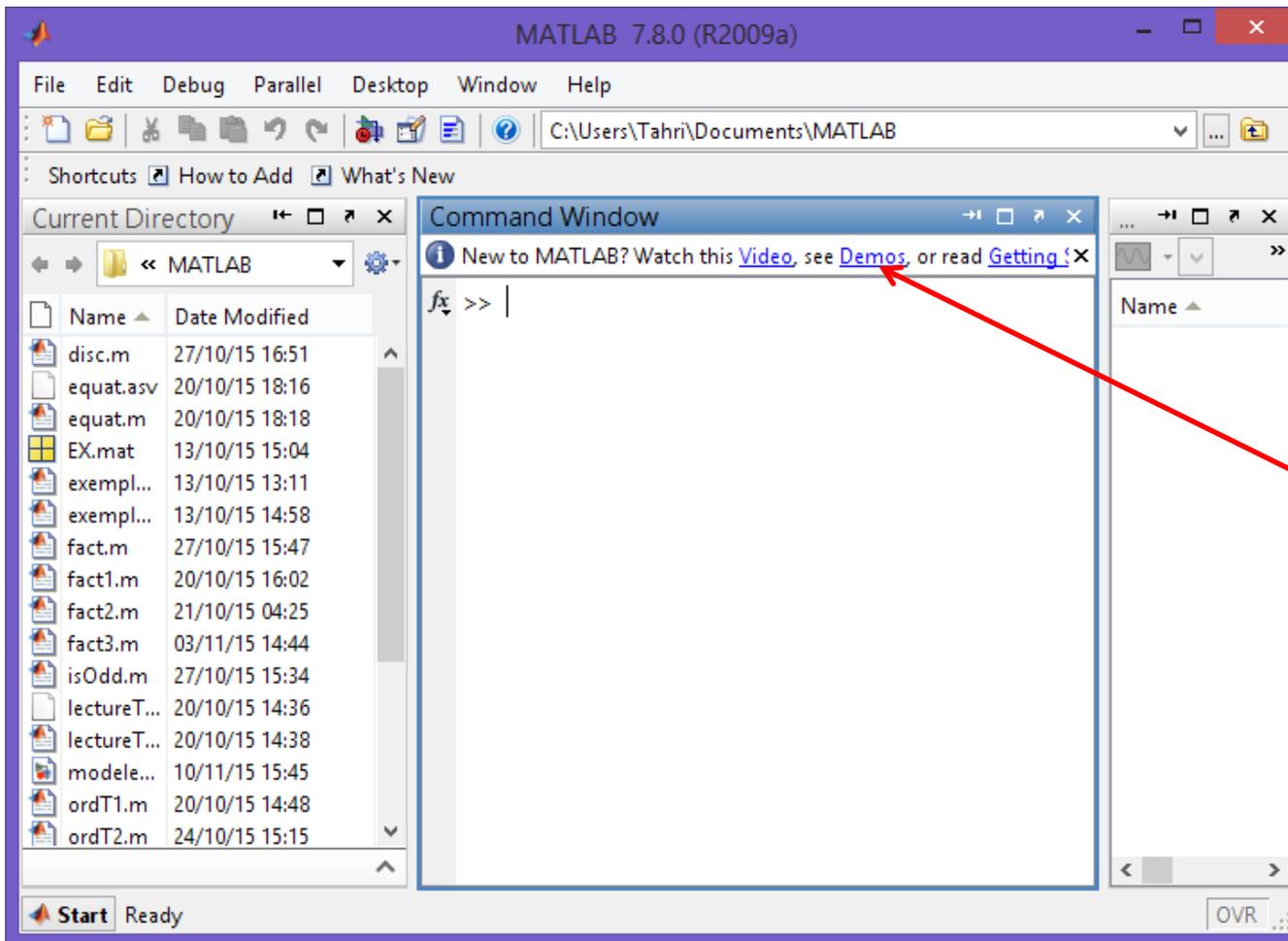
File Edit View Simulation Format Tools Help

10.0 Normal

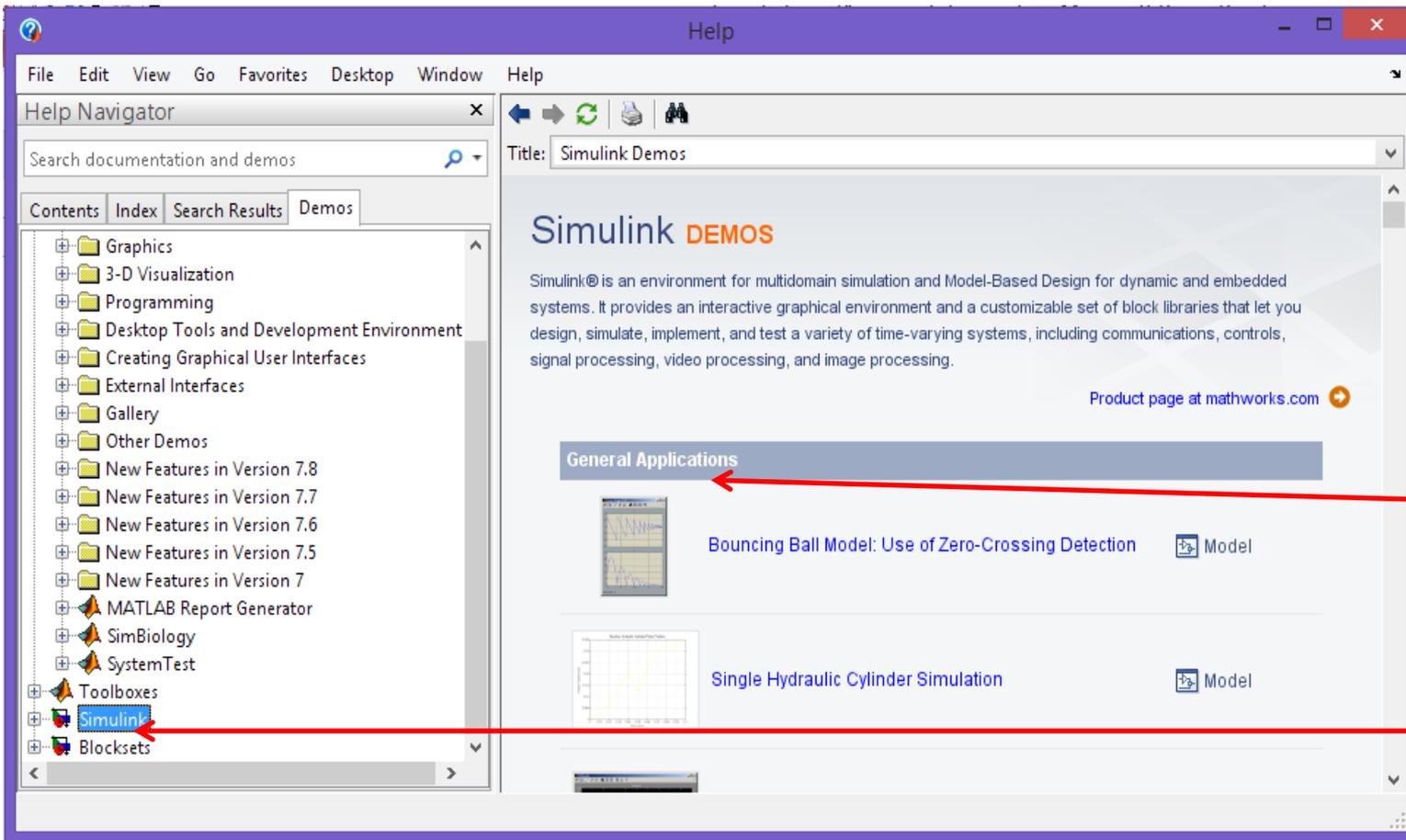
Sine Wave → Transfer Fcn ($\frac{1}{s+1}$) → Scope

Ready 100% ode45

6. Explorer Simulink

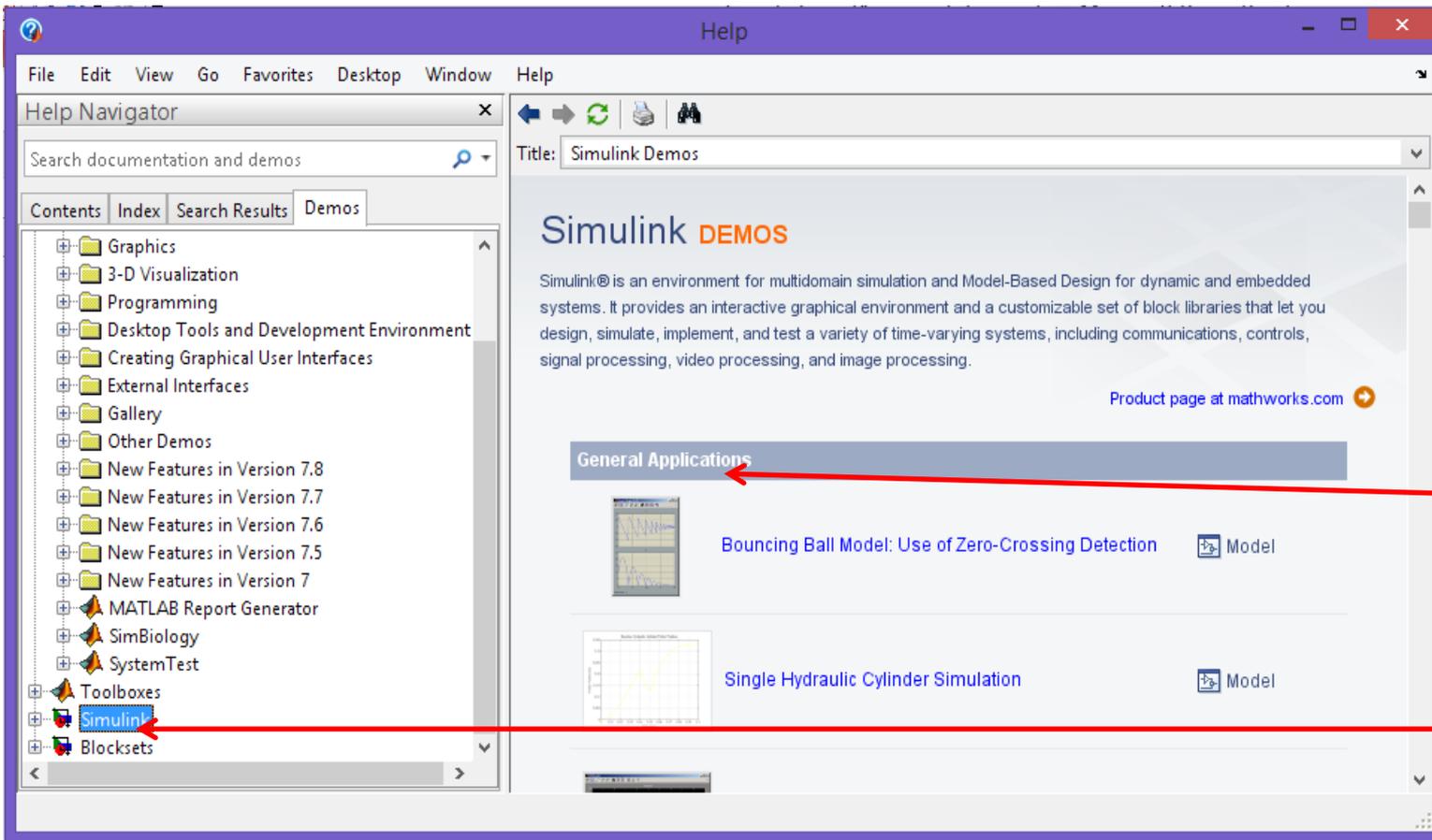


Cliquez sur Demos



Exemples de de Simulink

Demos de Simulink



Exemples de de Simulink

Demos de Simulink

Help

File Edit View Go Favorites Desktop Window Help

Help Navigator

Search documentation and demos

Contents Index Search Results Demos

- Graphics
- 3-D Visualization
- Programming
- Desktop Tools and Development Environment
- Creating Graphical User Interfaces
- External Interfaces
- Gallery
- Other Demos
- New Features in Version 7.8
- New Features in Version 7.7
- New Features in Version 7.6
- New Features in Version 7.5
- New Features in Version 7
- MATLAB Report Generator
- SimBiology
- SystemTest
- Toolboxes
- Simulink
- Blocksets

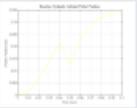
Title: Simulink Demos

Simulink DEMOS

Simulink® is an environment for multidomain simulation and Model-Based Design for dynamic and embedded systems. It provides an interactive graphical environment and a customizable set of block libraries that let you design, simulate, implement, and test a variety of time-varying systems, including communications, controls, signal processing, video processing, and image processing.

[Product page at mathworks.com](#)

General Applications

-  [Bouncing Ball Model: Use of Zero-Crossing Detection](#)  Model
-  [Single Hydraulic Cylinder Simulation](#)  Model

Cliquez sur cet exemple

La fenêtre explique en détail le modèle, le modèle peut être ouvert en cliquant sur *open this model* en haut à droite de la fenêtre.

The screenshot shows the MATLAB Help Navigator window. The title bar reads "Help". The menu bar includes "File", "Edit", "View", "Go", "Favorites", "Desktop", "Window", and "Help". The "Help Navigator" pane on the left contains a search bar and a tree view of documentation categories. The main content area displays the "Bouncing Ball Model: Use of Zero-Crossing Detection" page. The page title is "sldemo_bounce.mdl" and it features a prominent "Open this model" link. The text describes a rubber ball model and its implementation using a reset integrator. Below the text is a block diagram titled "Bouncing Ball Model" showing the flow from Gravity and Initial Velocity through integrators to Velocity and Position, which are then plotted and terminated.

File Edit View Go Favorites Desktop Window Help

Help Navigator

Search documentation and demos

Contents Index Search Results Demos

Graphics

3-D Visualization

Programming

Desktop Tools and Development Environment

Creating Graphical User Interfaces

External Interfaces

Gallery

Other Demos

New Features in Version 7.8

New Features in Version 7.7

New Features in Version 7.6

New Features in Version 7.5

New Features in Version 7

MATLAB Report Generator

SimBiology

SystemTest

Toolboxes

Simulink

Blocksets

Title: Bouncing Ball Model: Use of Zero-Crossing Detection

sldemo_bounce.mdl [Open this model](#)

Bouncing Ball Model: Use of Zero-Crossing Detection

A rubber ball is thrown into the air with a velocity of 15 meters per second from a height of 10 m. The position of the ball is shown in the lower plot of the scope, and the velocity of the ball is shown in the upper plot.

This system uses a reset integrator to change the direction of the ball as it comes into contact with the ground, the zero crossing detection prevents the ball from going below the ground.

Bouncing Ball Model

Gravity: -9.81

Initial Velocity: [15]

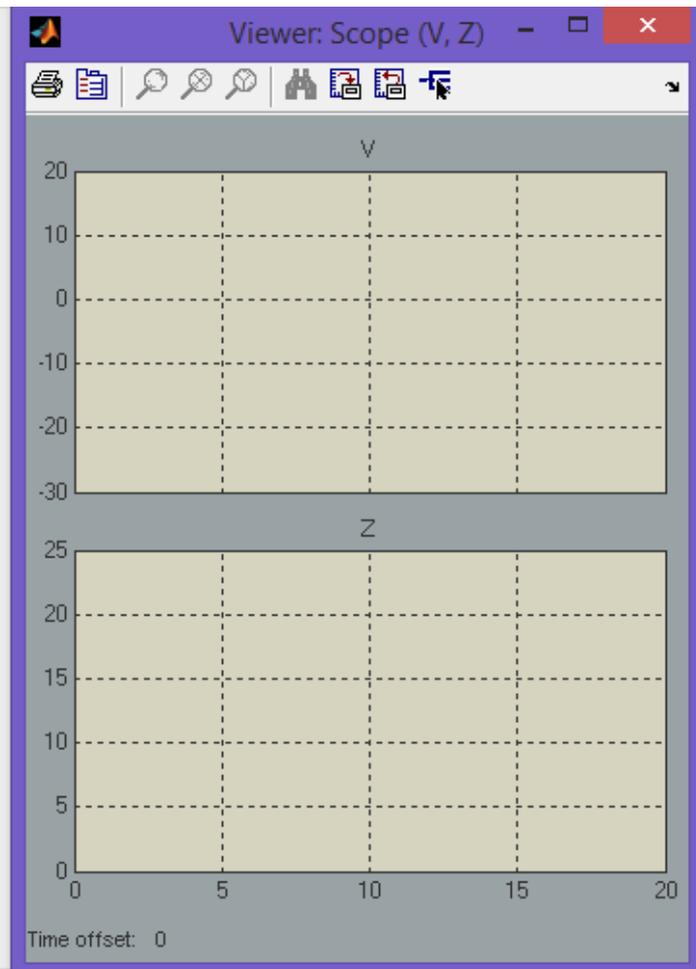
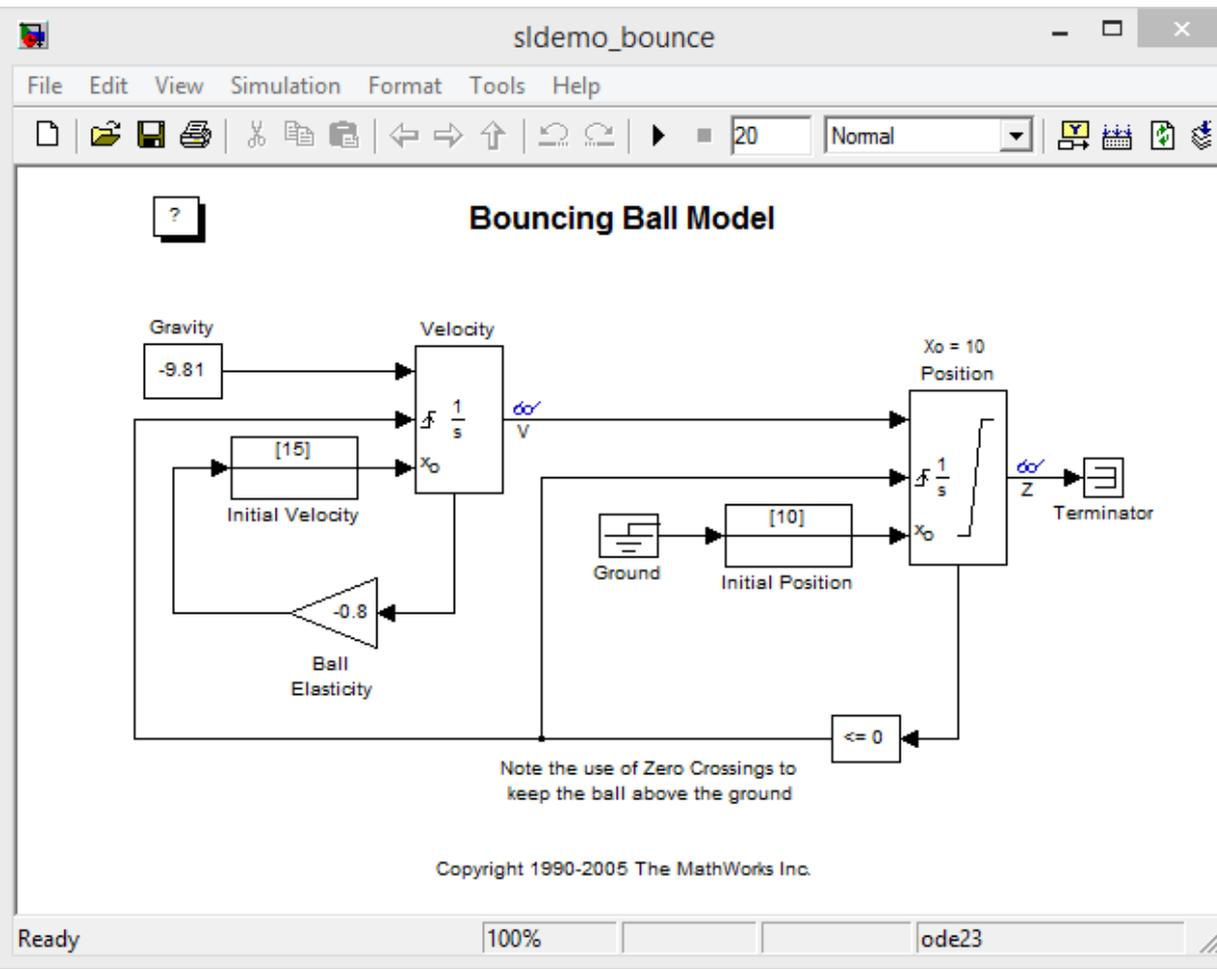
Velocity: $\int \frac{1}{s}$

Position: $\int \frac{1}{s}$

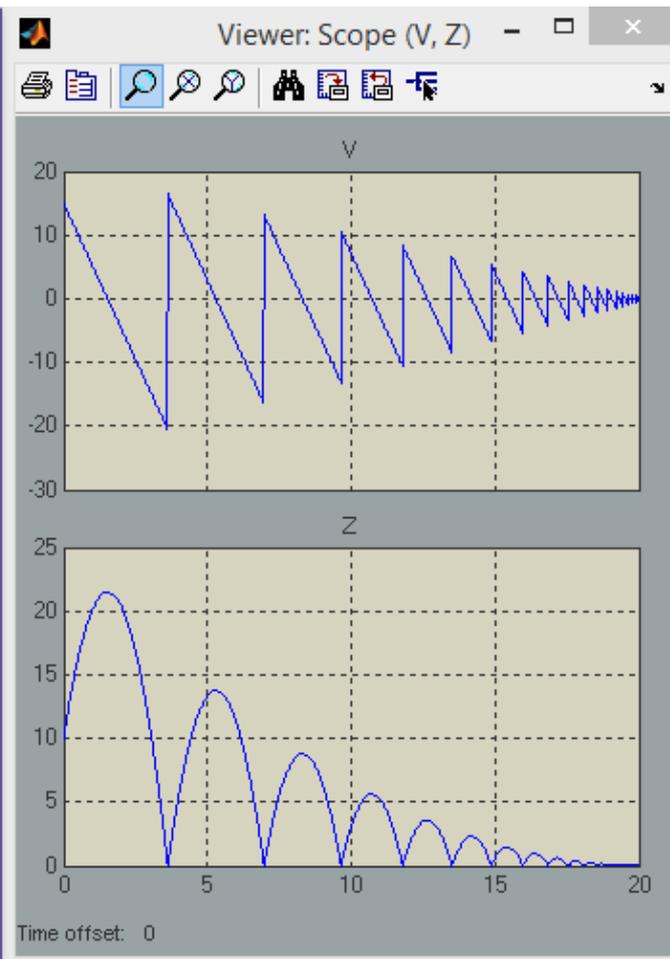
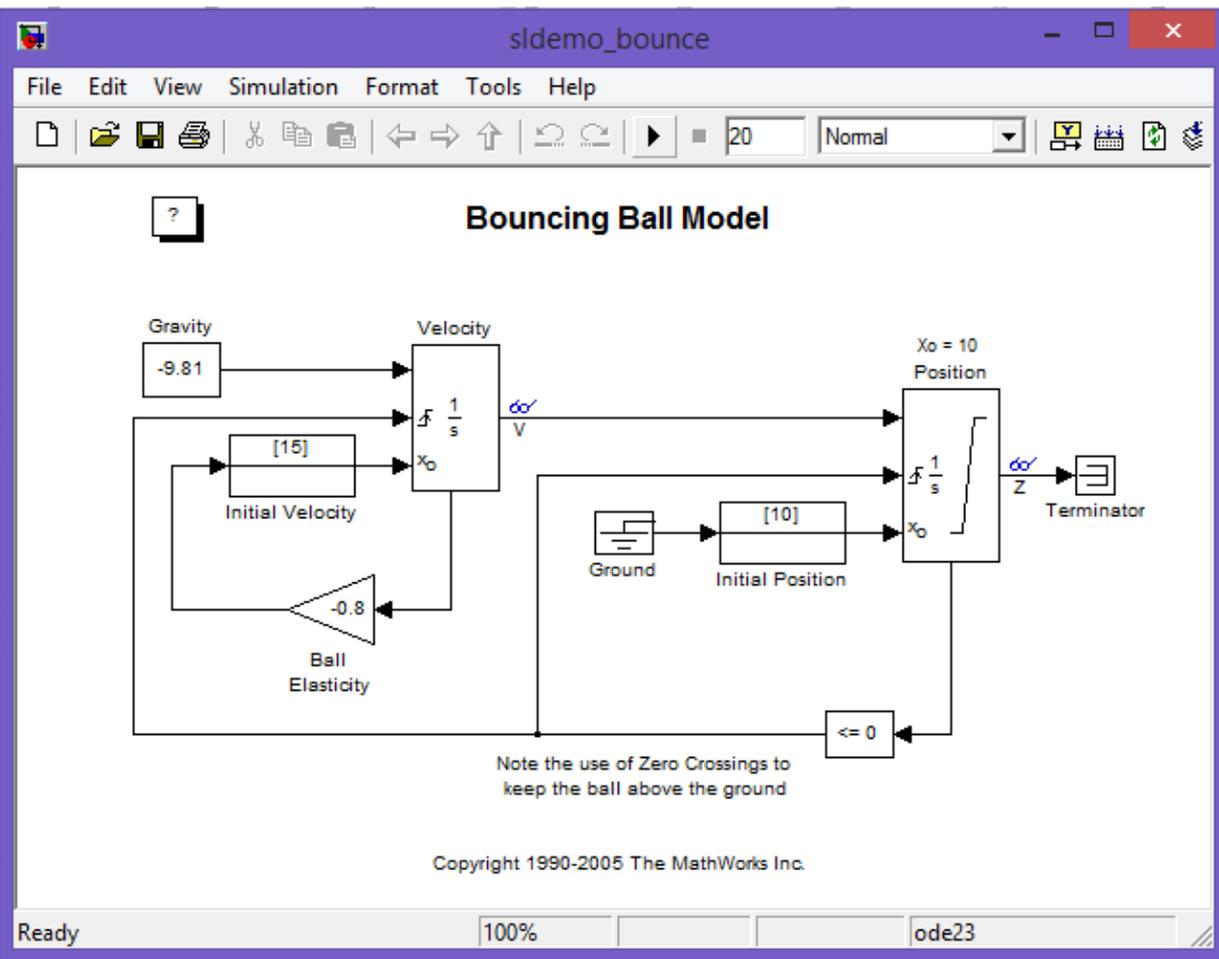
Terminator

Cliquez pour ouvrir le modèle

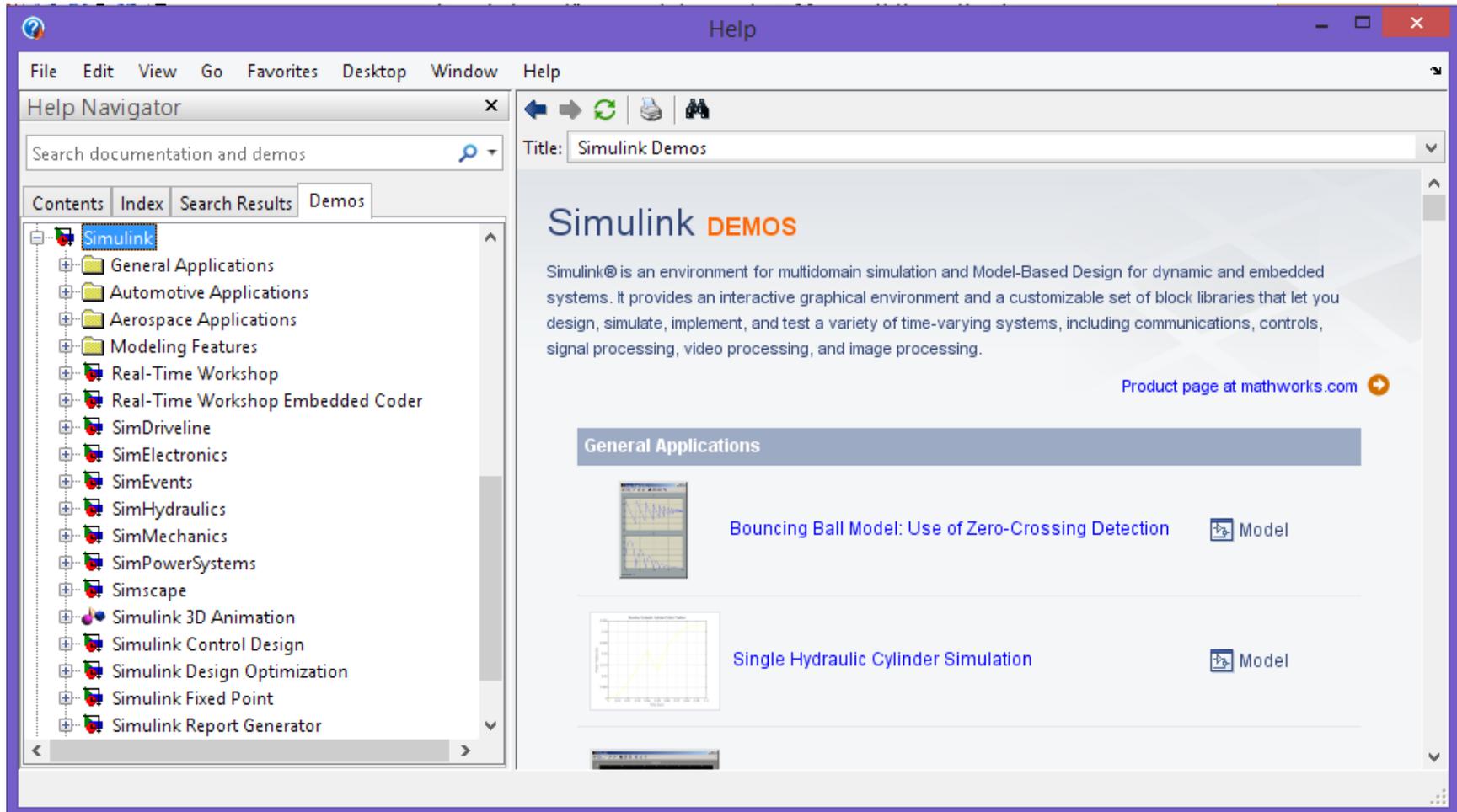
Ainsi le modèle est ouvert avec l'oscilloscope (Scope) pour la visualisation des sortie et on peut exécuter le modèle facilement.



Après exécution du modèle dans l'oscilloscope (Scope), on a la visualisation de la position de la balle et sa vitesse.



Dans la démos de Simulink, il y'a aussi beaucoup d'exemples des Toolboxes utilisées par ce dernier. Une Toolboxe nous intéresse et celle du *SimPowerSystems*



The screenshot shows the Simulink Help Navigator window. The window title is "Help". The menu bar includes "File", "Edit", "View", "Go", "Favorites", "Desktop", "Window", and "Help". The "Help Navigator" pane on the left contains a search bar and a tree view of Simulink toolboxes. The "Demos" tab is selected, and the "Simulink" folder is expanded, showing various application categories. The main content area displays the "Simulink DEMOS" page, which includes a description of Simulink and a list of demo models.

File Edit View Go Favorites Desktop Window Help

Help Navigator

Search documentation and demos

Contents Index Search Results Demos

Simulink

- General Applications
- Automotive Applications
- Aerospace Applications
- Modeling Features
- Real-Time Workshop
- Real-Time Workshop Embedded Coder
- SimDriveline
- SimElectronics
- SimEvents
- SimHydraulics
- SimMechanics
- SimPowerSystems
- Simscape
- Simulink 3D Animation
- Simulink Control Design
- Simulink Design Optimization
- Simulink Fixed Point
- Simulink Report Generator

Help

Title: Simulink Demos

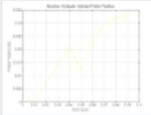
Simulink DEMOS

Simulink® is an environment for multidomain simulation and Model-Based Design for dynamic and embedded systems. It provides an interactive graphical environment and a customizable set of block libraries that let you design, simulate, implement, and test a variety of time-varying systems, including communications, controls, signal processing, video processing, and image processing.

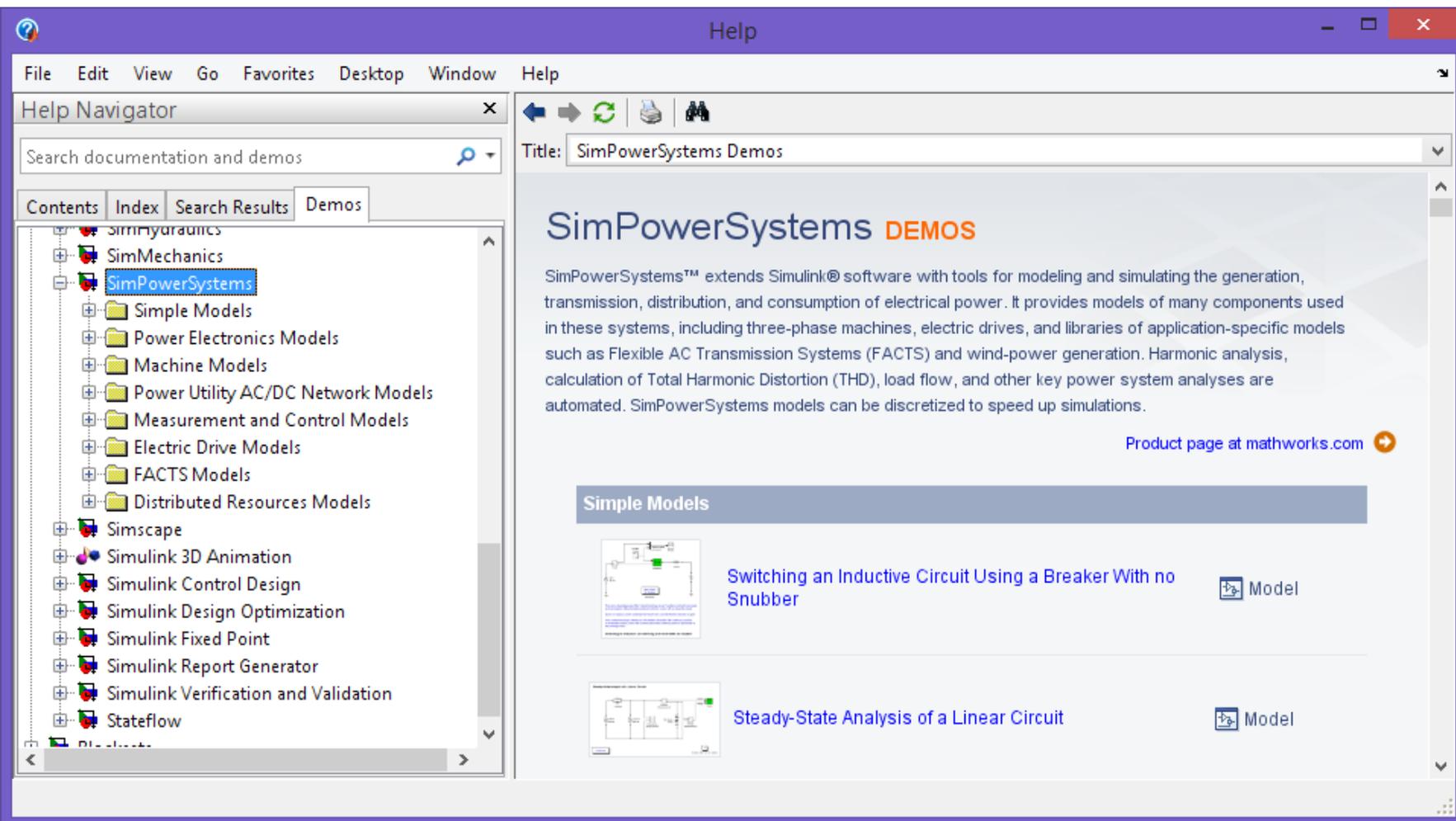
[Product page at mathworks.com](#)

General Applications

 [Bouncing Ball Model: Use of Zero-Crossing Detection](#)  Model

 [Single Hydraulic Cylinder Simulation](#)  Model

Dans la démos de *SimPowerSystems*, il y'a aussi beaucoup d'exemples qu'on peut explorer.

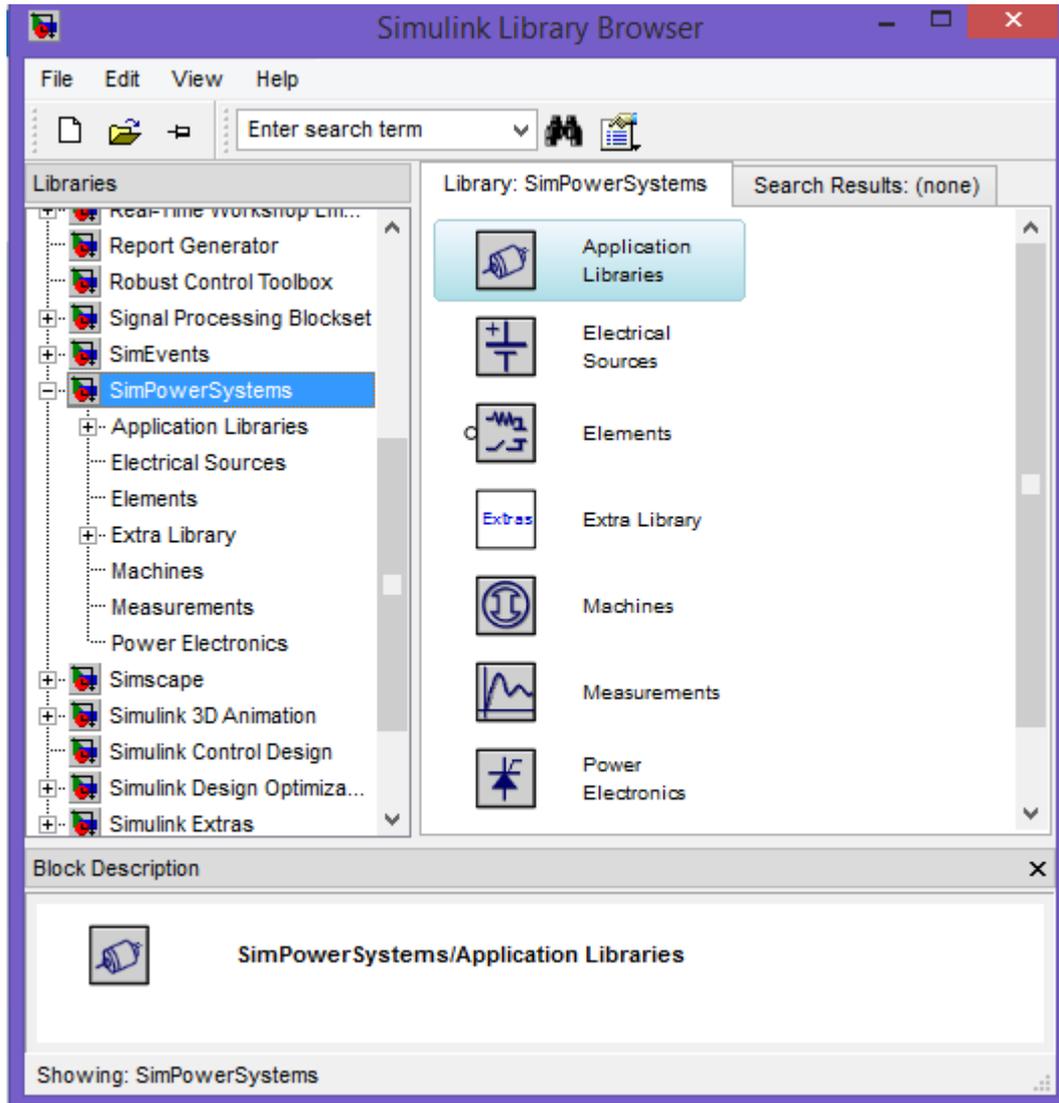


The screenshot shows a web browser window titled "Help" displaying the "SimPowerSystems Demos" page. The browser's address bar shows "Title: SimPowerSystems Demos". The page content includes:

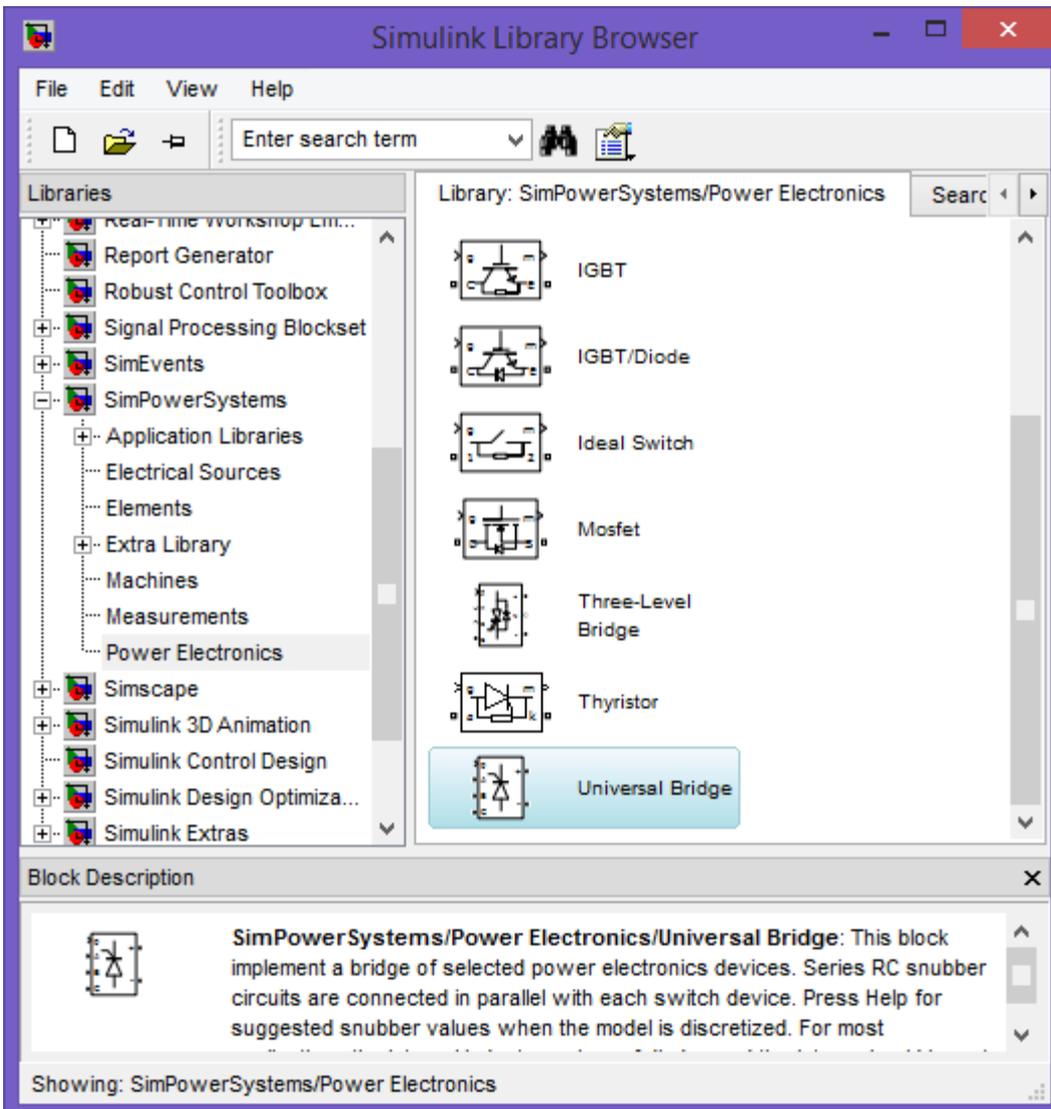
- SimPowerSystems DEMOS** (Section Header)
- Text: "SimPowerSystems™ extends Simulink® software with tools for modeling and simulating the generation, transmission, distribution, and consumption of electrical power. It provides models of many components used in these systems, including three-phase machines, electric drives, and libraries of application-specific models such as Flexible AC Transmission Systems (FACTS) and wind-power generation. Harmonic analysis, calculation of Total Harmonic Distortion (THD), load flow, and other key power system analyses are automated. SimPowerSystems models can be discretized to speed up simulations."
- Link: [Product page at mathworks.com](#)
- Simple Models** (Section Header)
- Two model entries:
 - Switching an Inductive Circuit Using a Breaker With no Snubber** (with a thumbnail image and a "Model" icon)
 - Steady-State Analysis of a Linear Circuit** (with a thumbnail image and a "Model" icon)

The left sidebar of the browser shows the "Help Navigator" with a search bar and a tree view of documentation categories. The "SimPowerSystems" category is selected and expanded, showing sub-categories like "Simple Models", "Power Electronics Models", "Machine Models", etc.

Revenant au Simulink et essayant d'explorer la toolbox *SimPowerSystems*.



Vous remarquez que cette toolbox est vraiment destinée aux électrotechniciens vu la richesse des blocs fonctionnels spécialisés pour tout ce qui touche le génie électrique.



Essayant de voir par exemple le bloc *Universal Bridge* (pont universel).

Double click sur le bloc *Universal Bridge*, on peut remarquer quand peut changer les paramètres suivant notre application.

The image shows a Simulink workspace with three windows:

- Simulink Library Browser:** Displays the 'SimPowerSystems/Power Electronics' library. The 'Universal Bridge' block is highlighted in blue. The 'Block Description' pane at the bottom shows the text: "SimPowerSystems/Power Electronics/Universal Bridge: This block implement a bridge of selected power electronics devices. Series RC snubber circuits are connected in parallel with each switch device. Press Help for suggested snubber values when the model is discretized. For most applications the internal inductance Lon of diodes and thyristors should be set to zero".
- untitled *:** Shows a schematic diagram of the 'Universal Bridge' block with terminals labeled G, A, B, and C.
- Block Parameters: Universal Bridge:** A dialog box with the following settings:
 - Universal Bridge (mask) (link): This block implement a bridge of selected power electronics devices. Series RC snubber circuits are connected in parallel with each switch device. Press Help for suggested snubber values when the model is discretized. For most applications the internal inductance Lon of diodes and thyristors should be set to zero.
 - Parameters:
 - Number of bridge arms: 3
 - Snubber resistance Rs (Ohms): 1e5
 - Snubber capacitance Cs (F): inf
 - Power Electronic device: Thyristors
 - Ron (Ohms): 1e-3
 - Lon (H): 0
 - Forward voltage Vf (V): 0
 - Measurements: None

On peut choisir entre un pont à 3, 2 et 1 bras (*Number of bridge*)

The image shows a Simulink environment with three windows:

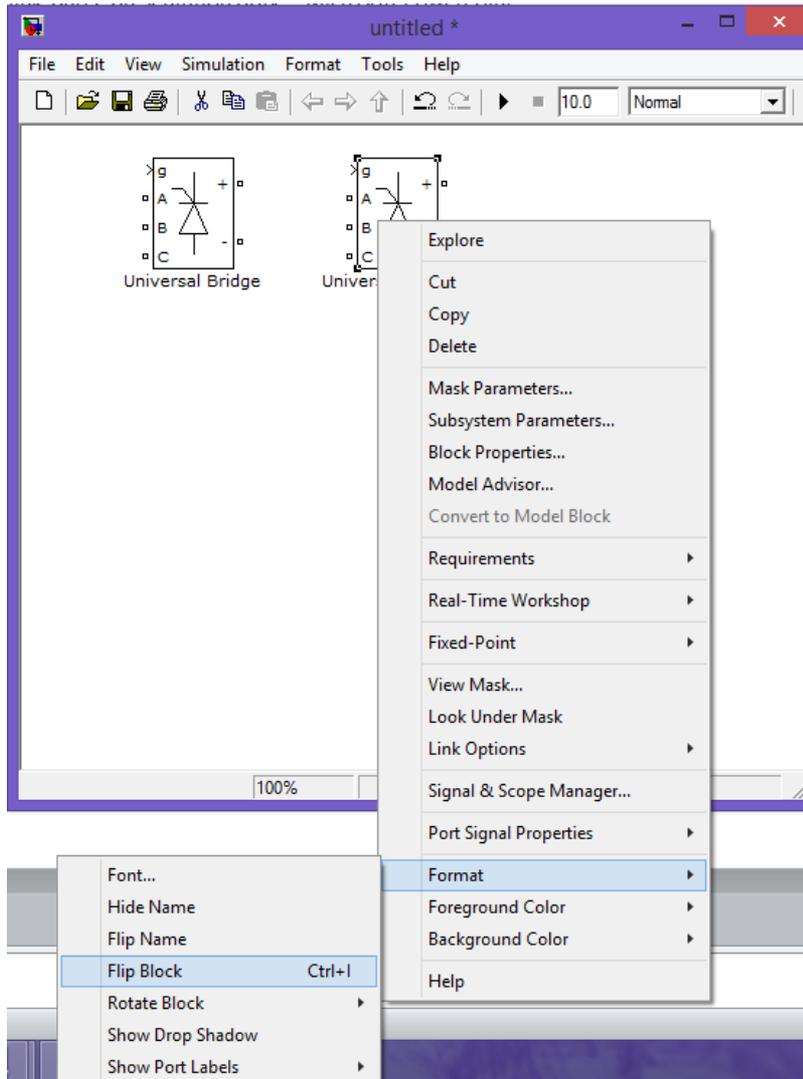
- Simulink Library Browser:** Displays the 'SimPowerSystems/Power Electronics' library. The 'Universal Bridge' block is highlighted in blue. The 'Block Description' pane at the bottom shows the block's documentation: "SimPowerSystems/Power Electronics/Universal Bridge: This block implement a bridge of selected power electronics devices. Series RC snubber circuits are connected in parallel with each switch device. Press Help for suggested snubber values when the model is discretized. For most".
- untitled *:** Shows a schematic diagram of a three-phase bridge circuit with terminals labeled A, B, and C. The block is labeled "Universal Bridge".
- Block Parameters: Universal Bridge:** A dialog box for configuring the block. The "Number of bridge arms" dropdown is set to 3. The "Snubber resistance Rs (C)" dropdown is also set to 3, with a value of 1e5 entered in the adjacent text field. Other parameters include "Snubber capacitance Cs (F)" set to inf, "Power Electronic device" set to Thyristors, "Ron (Ohms)" set to 1e-3, and "Lon (H)" set to 0. The "Forward voltage Vf (V)" is also set to 0. The "Measurements" dropdown is set to None.

On peut aussi choisir quels sont les semi-conducteurs qu'on veut utiliser, on a le choix entre Diodes Thyristors, GTO etc...

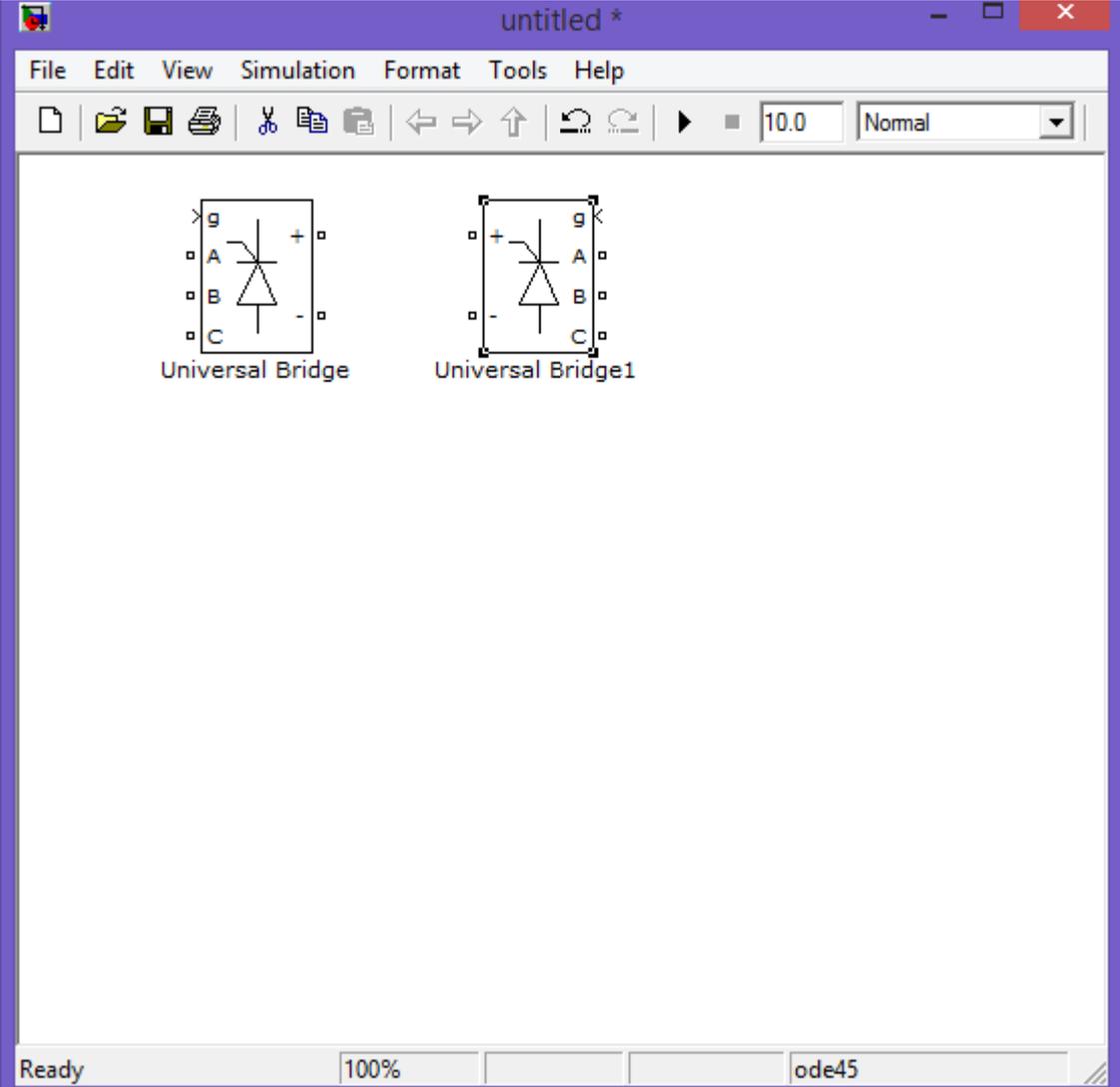
The image shows a Simulink environment with three windows:

- Simulink Library Browser:** Displays the 'Power Electronics' library. The 'Universal Bridge' block is highlighted in blue. The 'Block Description' pane at the bottom shows the text: "SimPowerSystems/Power Electronics/Universal Bridge: This block implement a bridge of selected power electronics devices. Series RC snubber circuits are connected in parallel with each switch device. Press Help for suggested snubber values when the model is discretized. For most...".
- untitled*:** Shows a schematic diagram of the 'Universal Bridge' block with terminals labeled G, A, B, and C.
- Block Parameters: Universal Bridge:** A configuration dialog for the block. It includes:
 - Universal Bridge (mask) (link):** A text box with a link icon.
 - Description:** "This block implement a bridge of selected power electronics devices. Series RC snubber circuits are connected in parallel with each switch device. Press Help for suggested snubber values when the model is discretized. For most applications the internal inductance Lon of diodes and thyristors should be set to zero".
 - Parameters:**
 - Number of bridge arms: 3
 - Snubber resistance Rs (Ohms): 1e5
 - Snubber capacitance Cs (F): inf
 - Power Electronic device: A dropdown menu with 'Thyristors' selected. The list includes: Diodes, Thyristors, GTO / Diodes, MOSFET / Diodes, IGBT / Diodes, Ideal Switches, Switching-function based VSC, and Average-model based VSC.
 - Ron (Ohms): 1e-3
 - Lon (H): 0
 - Forward voltage Vf (V): 0
 - Measurements: None
 - Buttons:** OK, Cancel, Help, and Apply.

On peut aussi inverser ou basculer le bloc en utilisant *Flip Block*



Remarquer le deuxième bloc a été inverser



Ready

100%

ode45

Merci

pour

votre Attention