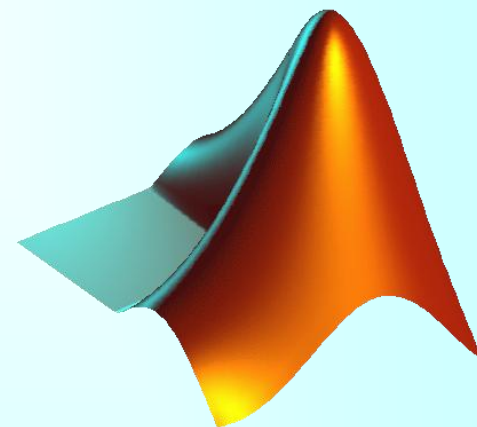
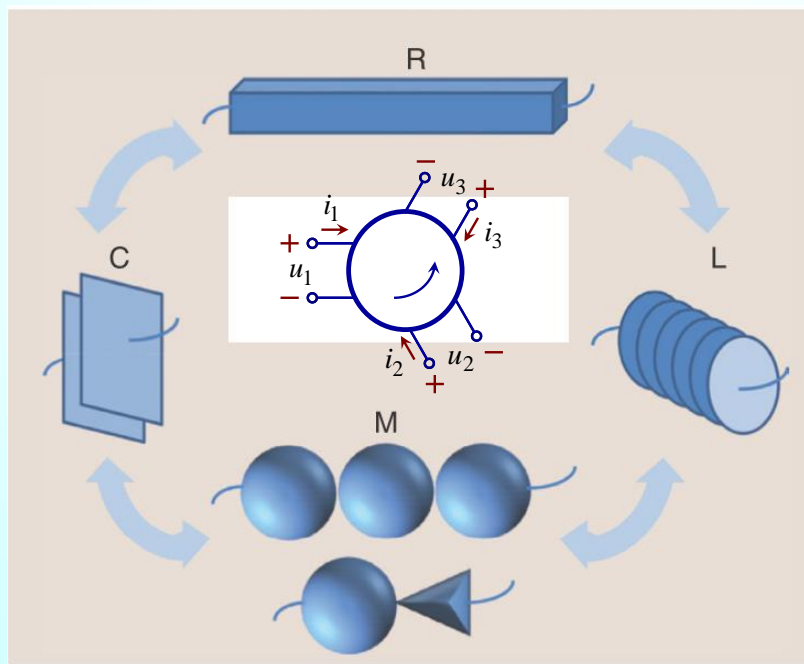


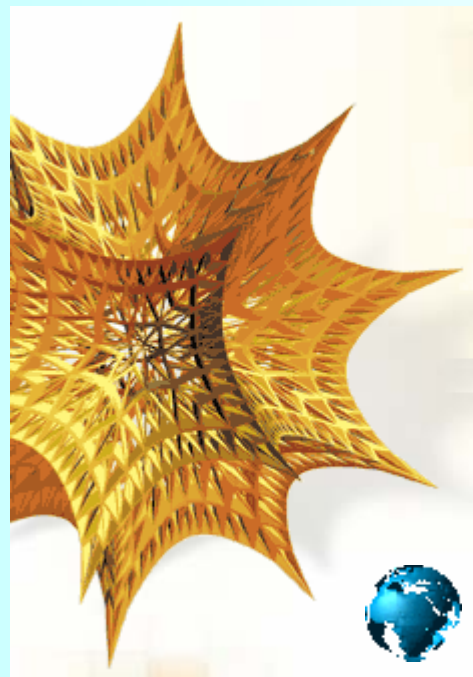
# Практикум из рачунарске анализе кола

## 1. Увод



Милка Потребих Иваниш

Никола Баста



# Практикум из рачунарске анализе кола

## 13E072PRK3, 19E072PRK

- **Настава се изводи према текућем студијском програму који је Електротехнички факултет акредитовао** <http://www.etf.bg.ac.rs>
- Студијски програм: **Електротехника и рачунарство**
- Изборно подручје (модул): **Физичка електроника, Сигнали и системи, Телекомуникације и информационе технологије**
- **Циљ.** Излагање основних концепата анализе помоћу рачунара који се користе у софтверским пакетима за симулацију електричних кола са гледишта инжењера и истраживача електротехнике. Увођење основа за анализу модела електротехничких система и направа за нумеричку и симболичку анализу у временском и фреквенцијском домену. Изградња основних знања аналогне обраде сигнала помоћу електричних кола.
- **Исход.** Разумевање основних концепата анализе електричних кола помоћу рачунара и одговарајућих математичких алгоритама. Решавање линеарних електричних кола у временском и фреквенцијском домену помоћу система компјутерске алгебре.
- **Садржај.** Основни концепти рачунарске симулације електричних кола помоћу савремених софтверских алата. Фазорска анализа. Одзив на почетне услове, побуду и потпун одзив. Резонанција. Фреквенцијски одзив. Бодоови дијаграми. Трофазна кола. Симболичко решавање електричних кола. Водови.
- **Наставници.** Др **Милка Потребих Иваниш**, редовни професор, соба 64 ([milka\\_potrebic@etf.rs](mailto:milka_potrebic@etf.rs)); Др **Никола Баста**, доцент, соба 63 ([nbasta@etf.rs](mailto:nbasta@etf.rs)).
- **Сарадници у настави.** **Ања Ковачевић**, мс. инж., **Филип Нешковић**, мс. инж.
- Белешке са предавања и лаб. вежби, примери испитних задатака и питања, <http://tek.etf.rs>
- **Додатни материјали и консултације биће организовани преко канала на MS Teams платформи** (линкови за канале су на адреси <http://tek.etf.rs>)
- **Начин одржавања наставе.** Рачунски центар.
- **Начин полагања испита.** 1) Решавање задатака на рачунару у пару (или смостално) у РЦ, или алтернативно  
2) издрада два домаћа задатка у пару (или самостално) са пратећим извештајем у виду презентације која се усмено брани.  
Испит се може полагати у сваком испитном року.  
Усмена одбрана домаћих задатака се заказује са предметним наставницима.  
**За издраду домаћих задатака јавити се е-поштом Милки Потребих Иваниш.**
- **Пратити** званично представљање предмета и објављивање општих службених порука на адреси <http://tek.etf.rs/>

# Рачунарски (софтверски) алати

- *Mathematica*, WolframAlpha, MuPAD, Maxima, SymPy, SymPy Live, SymPy Gamma
- MATLAB, Scilab, Octave, FreeMat, Julia
- LTspice, QucsStudio, ngspice, Xyce, XCircuit
- Python, MathCAD, MAPLE, GeoGebra, Sage
- Symbolab, SpeQ Mathematics, meta-calculator, Desmos, ...
- Android apk: NCalc+, CalcES, SymJa CAS, Scientific Calculator Pro, CYZSoft Scientific Calculator Plus

Free/Libre Open Source Software (FLOSS)

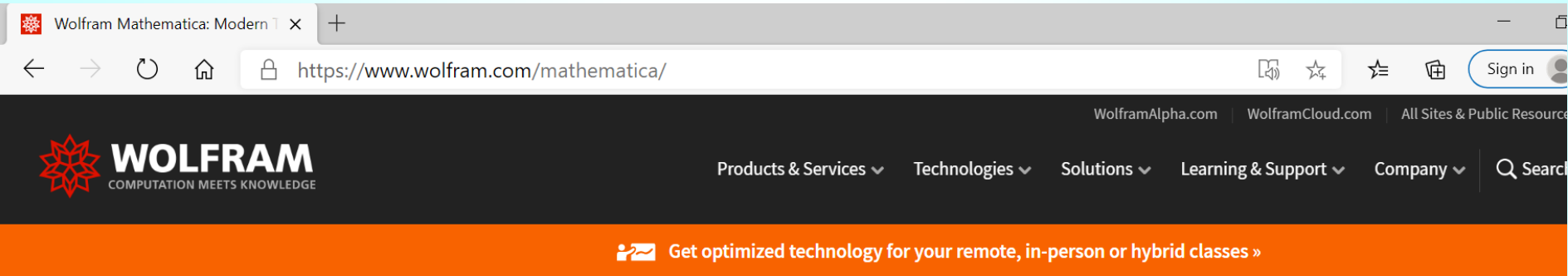
# Моделовање електричних кола

- PSpice, ngSpice, Xcos, SciLab, TINA-TI, Micro-Cap, Plexim, 5Spice...
- **Online Circuit Simulator:** DoCircuits, Circuit Lab, PartSim, EasyEda, Multisim, PartQuest (SystemVision Cloud)...
- **Android circuit simulator:** Electric Circuit Studio, Circuit Safari SPICE Simulator...



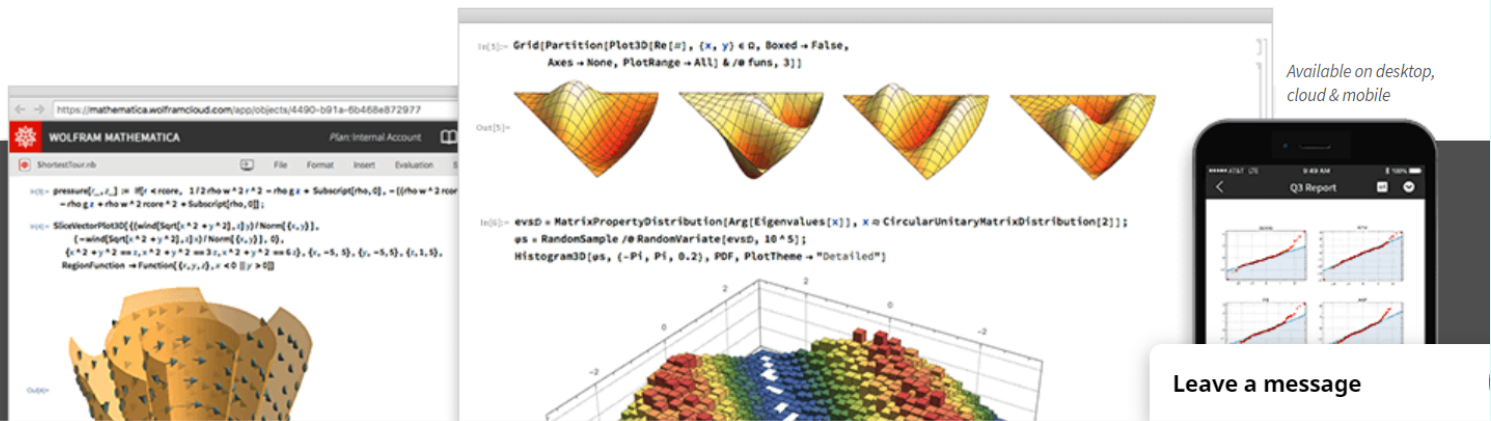
# Mathematica

<https://www.wolfram.com/mathematica/>



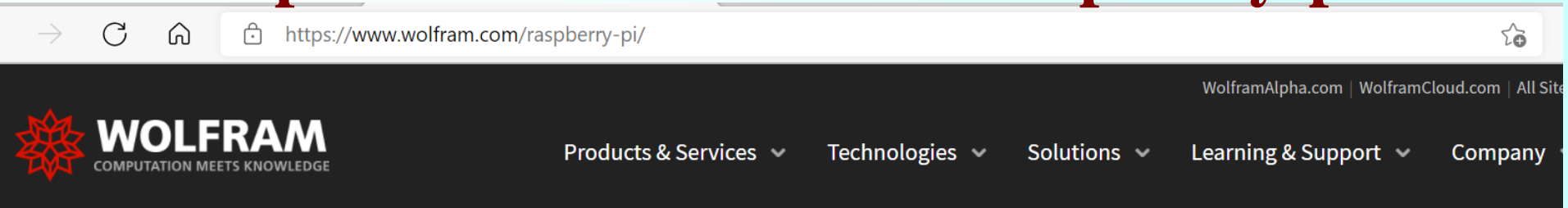
## WOLFRAM MATHEMATICA

The world's definitive system for modern technical computing

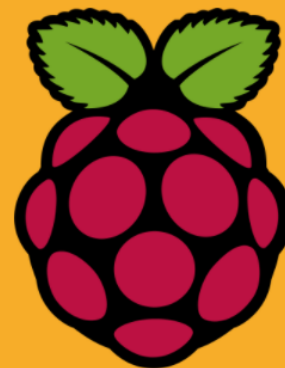


# Mathematica free on every Raspberry Pi!

<https://www.wolfram.com/raspberry-pi/>



Wolfram Language &  
Mathematica free on  
every Raspberry Pi!



+



Give your brain a quick workout with Wolfram Problem Generator.



$$y' + 1000 * y = 10000, y(0) = -10$$



Examples Random

Input:

$$\{y'(x) + 1000 y(x) = 10\,000, y(0) = -10\}$$

ODE classification:

first-order linear ordinary differential equation

Alternate forms:

$$\{y'(x) = 10\,000 - 1000 y(x), y(0) = -10\}$$

$$\{y'(x) + 1000 (y(x) - 10) = 0, y(0) = -10\}$$

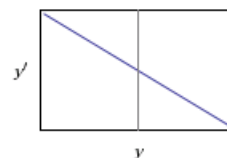
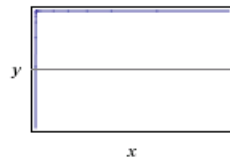
Differential equation solution:

Approximate form

Step-by-step solution

$$y(x) = 10 - 20 e^{-1000 x}$$

Plots of the solution:



New to  
Wolfram|Alpha?



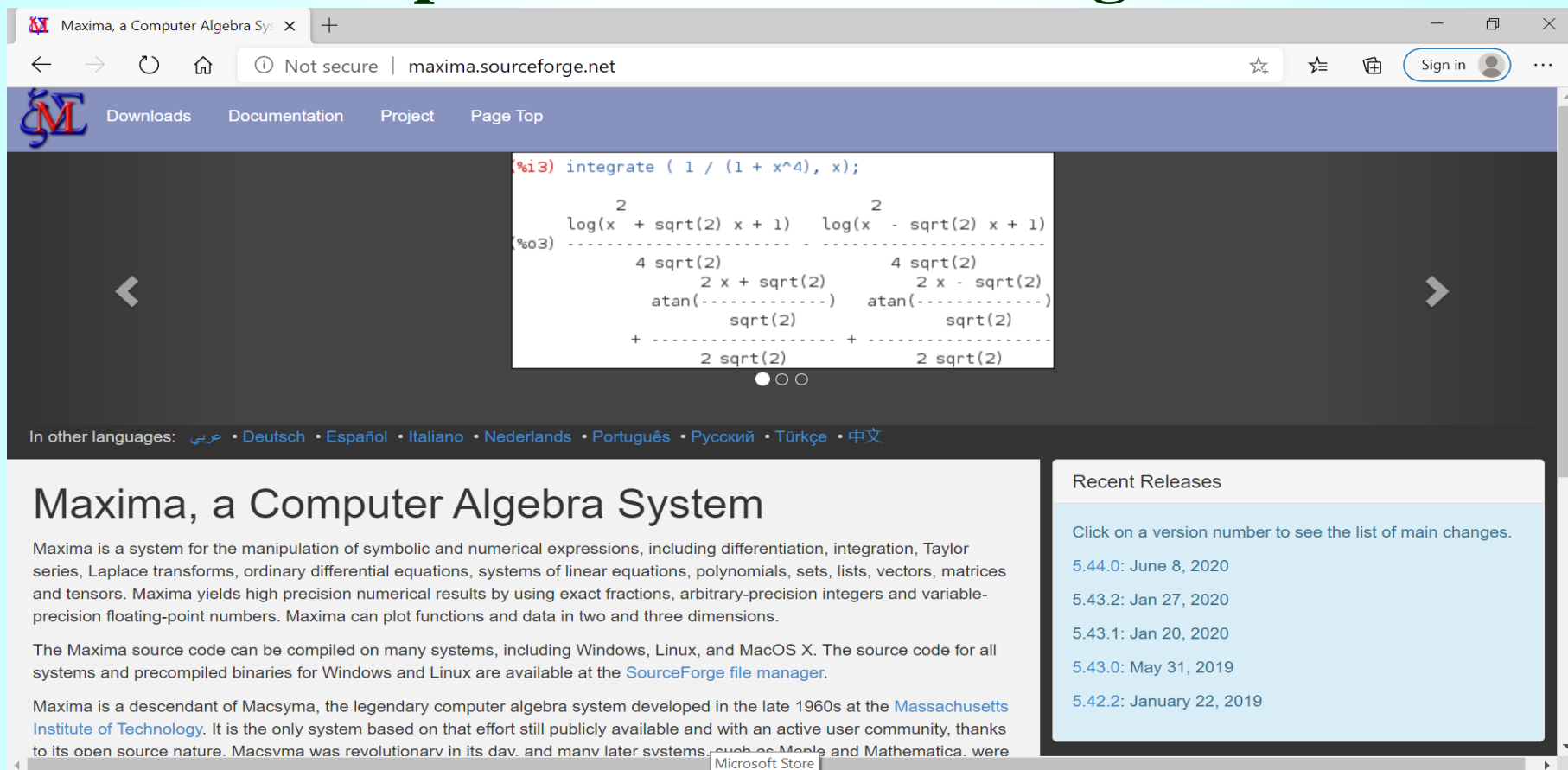
Take the Tour >>

New!  
Wolfram Problem  
Generator

Need a hint?

# Maxima

<http://maxima.sourceforge.net/>



The screenshot shows the Maxima website interface. At the top, there is a navigation bar with links for Downloads, Documentation, Project, and Page Top. Below this is a code editor window displaying a Maxima command and its output:

```
(%i3) integrate ( 1 / (1 + x^4), x);
```


$$\frac{\log(x^2 + \sqrt{2}x + 1) - \log(x^2 - \sqrt{2}x + 1)}{4\sqrt{2}} + \frac{\operatorname{atan}\left(\frac{2x + \sqrt{2}}{\sqrt{2}}\right) - \operatorname{atan}\left(\frac{2x - \sqrt{2}}{\sqrt{2}}\right)}{2\sqrt{2}}$$

Below the code editor, there is a section titled "Maxima, a Computer Algebra System" with a brief description of the system's capabilities. To the right, there is a "Recent Releases" section listing the latest versions and their release dates:

- 5.44.0: June 8, 2020
- 5.43.2: Jan 27, 2020
- 5.43.1: Jan 20, 2020
- 5.43.0: May 31, 2019
- 5.42.2: January 22, 2019

# Maxima on line

## <http://maxima.cesga.es/>

Servicio proporcionado por  CESGA

*Maxima on line*

Help: [Español](#), [English](#), [Galego](#)

```
expand((x-2)^3*(x+1/3)^2);  
solve(x^2-x+2=0);  
invert(matrix([2,3,1], [a,0,0], [1,4,8]));  
integrate(x * sin(x), x);  
draw3d(implicit(x^2+y^2,x,-1,1,y,-1,1));
```

Click

Clear

[AVISO LEGAL](#)

(%i1) `expand((x-2)^3*(x+1/3)^2);`

(%o1)  $x^5 - \frac{16x^4}{3} + \frac{73x^3}{9} - \frac{2x^2}{3} - 4x - \frac{8}{9}$

(%i2) `solve(x^2-x+2=0);`

(%o2)  $\left[ x = -\frac{\sqrt{7}i-1}{2}, x = \frac{\sqrt{7}i+1}{2} \right]$

(%i3) `invert(matrix([2,3,1], [a,0,0], [1,4,8]));`

(%o3)  $\begin{pmatrix} 0 & \frac{1}{a} & 0 \\ \frac{2}{5} & -\frac{3}{4a} & -\frac{1}{20} \\ -\frac{1}{5} & \frac{1}{4a} & \frac{3}{20} \end{pmatrix}$

# Maxima on Android

[https://play.google.com/store/apps/details?id=jp.yhonda&hl=en\\_US&gl=US](https://play.google.com/store/apps/details?id=jp.yhonda&hl=en_US&gl=US)

The screenshot shows the Google Play Store interface for the app "Maxima on Android" by Yasuaki Honda. The app is categorized under "Education" and is rated "Everyone". The page features a green "Install" button and a "2,100" user rating. Below the main app information, there are three preview images: the first shows the app's version history (Maxima on Android 1.1, Aug 11, 2012), the second shows a 3D surface plot of the function  $2^{*(v^2-u^2)}$ , and the third shows the "Maxima 5.28.0 Manual" page.


← → ↻ 🏠 🔒 [https://play.google.com/store/apps/details?id=jp.yhonda&hl=en\\_US&gl=US](https://play.google.com/store/apps/details?id=jp.yhonda&hl=en_US&gl=US)

**Google Play** Search 🔍

**Apps** Categories ▾ Home Top charts New releases

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Shop  
Games  
Kids  
Editors' Choice

Account  
Payment methods  
Play Points **New**  
My subscriptions  
Redeem  
Buy gift card  
My wishlist  
My Play activity  
Parent Guide

 **Maxima on Android**  
Yasuaki Honda Education ★★★★★ 2,100  
Everyone  
⚠️ You don't have any devices  
Add to Wishlist **Install**

MaximaOnAndroid 9:58  
Maxima on Android 1.1, Aug 11, 2012  
powered by MathJax 2.0 for math rendering  
written by Yasuaki Honda  
Maxima 5.27post <http://maxima.sourceforge.net>  
using Lisp ECL 11.1.1  
Distributed under the GNU Public License.  
See the file COPYING.  
Dedicated to the memory of William Schelter.  
The function `bug_report()` provides bug reporting information.  
(%i1) 'integrate(exp(-x)\*sin(x),x,0,inf)=

MaximaOnAndroid 10:38 PM  
MaximaOnAndroid  
 $2^{*(v^2-u^2)}$

MaximaOnAndroid 9:44  
[\[Top\]](#) [\[Contents\]](#) [\[Index\]](#) [\[2\]](#)  
**Maxima 5.28.0 Manual**  
Maxima is a computer algebra system, implemented in Lisp.  
Maxima is derived from the Macsyma system, developed at MIT in the years 1968 through 1982 as part of Project MAC. MIT turned over a copy of the Macsyma source code to the Department of Energy in 1982; that version is now known as DOE Macsyma. A copy of DOE Macsyma was maintained by Professor William F. Schelter of the University of Texas from 1982 until his death in 2001. In 1996, Schelter obtained permission from the Department of Energy to release the DOE Macsyma source code under the GNU Public License, and in 2000 he

# SymPy

## www.sympy.org/

The screenshot shows the SymPy website homepage. At the top, there is a navigation bar with links: Main Page, Features, Download, Documentation, Support, Development, Roadmap, Donate, and Online Shell. The main content area is divided into several sections:

- About:** A dark green box containing the text: "SymPy is a Python library for symbolic mathematics. It aims to become a full-featured computer algebra system (CAS) while keeping the code as simple as possible in order to be comprehensible and easily extensible. SymPy is written entirely in Python." Below this text are two buttons: "Get started with the tutorial" and "Download Now".
- Compute with Gamma:** A white box with a text input field containing the code `integrate(1 / (1 + x^2))` and a dark red "Compute" button.
- Download Now:** A white box with two links: "Latest Version" and "Development Version".
- Why SymPy:** A white box with the heading "Why SymPy" and the sub-heading "SymPy is...". It contains a bulleted list of features:
  - **Free:** Licensed under BSD, SymPy is free both as in speech and as in beer.
  - **Python-based:** SymPy is written entirely in Python and uses Python for its language.
  - **Lightweight:** SymPy only depends on `mpmath`, a pure Python library for arbitrary floating point arithmetic, making it easy to use.
  - **A library:** Beyond use as an interactive tool, SymPy can be embedded in other applications and extended with custom functions.Below the list are two links: "See SymPy's features" and "Projects using SymPy".
- Quick Links:** A white box with a heading "Quick Links" and a bulleted list of links:
  - Documentation
  - Downloads (source tarballs)
  - Mailing list
  - Source code
  - Issues tracker
  - Wiki
  - Introduction to contributing



# SymPy live

## live.sympy.org

live.sympy.org



Main Page Download Documentation Support Development Donate **Online Shell**

These commands were executed:

```
>>> from __future__ import division
>>> from sympy import *
>>> x, y, z, t = symbols('x y z t')
>>> k, m, n = symbols('k m n', integer=True)
>>> f, g, h = symbols('f g h', cls=Function)
```

Documentation can be found at <http://docs.sympy.org/>.

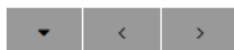
```
>>> diffeq = Eq(f(x).diff(x) + 1000*f(x), 10000)
>>> diffeq
```

$$1000f(x) + \frac{d}{dx} f(x) = 10000$$

```
>>> dsolve(diffeq, f(x))
```

$$f(x) = C_1 e^{-1000x} + 10$$

```
>>>
```



**Evaluate** Clear Fullscreen

Log In

### About this page

SymPy Live is SymPy running on the SymPy Engine.

This is just a regular Python shell with the following commands executed

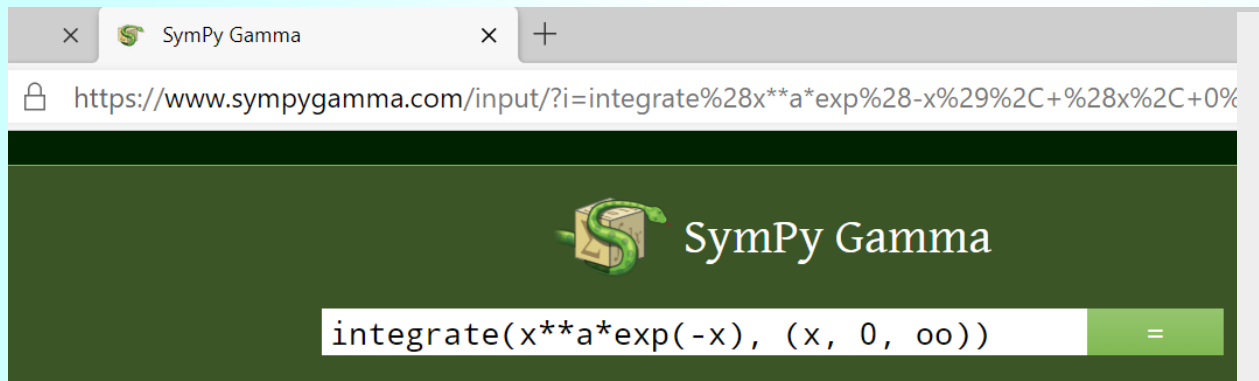
```
>>> from __future__ import division
>>> from sympy import *
>>> x, y, z, t = symbols('x y z t')
>>> k, m, n = symbols('k m n', integer=True)
>>> f, g, h = symbols('f g h', cls=Function)
```

Please note that the Google App Engine has a timeout of 60 seconds for computation due to a quirk in Safari on iOS, which is 58 seconds.

The thumbtack icon is from the Bar Icon Pack and is used under a Creative Commons license. You may use the materials in this presentation without restriction to develop your application.

# SymPy Gamma

<https://www.sympygamma.com/>



SymPy:

```
integrate (x**a*exp (-x),(x,0,oo ))
```

$$\int_0^{\infty} x^a e^{-x} dx$$

Antiderivative forms:

```
integrate(x**a*exp(-x), (x, 0, oo))
```

$$\begin{cases} \Gamma(a+1) & \text{for } \operatorname{re}(a) > -1 \\ \int_0^{\infty} x^a e^{-x} dx & \text{otherwise} \end{cases}$$

```
sympy.integrals.manualintegrate(x**a*exp(-x), (x, 0, oo))
```

$$-\Gamma(a+1, x)$$

## Examples

### Random Example

Arithmetic

Algebra

Trigonometry

Calculus

Number Theory

Discrete Mathematics

Plotting

Miscellaneous



The image shows a screenshot of the Jupyter website homepage. The browser address bar displays "https://jupyter.org". The website header includes the Jupyter logo and navigation links: "Install", "About Us", "Community", "Events", "Documentation", "NBViewer", and "Jupyter". A large, semi-transparent text overlay in a dark red serif font reads "SymPy and the Jupyter Notebook for engineering calculations". The Jupyter logo is also visible in the background. At the bottom of the page, a small text snippet reads: "Project Jupyter exists to develop open-source software, open interactive computing across dozens of programr".

```
[1]: from sympy import *  
x = symbols('x')  
import sympy; sympy.__version__
```

[1]: '1.4'

```
[2]: Integral(exp(-x**2), (x, -oo, oo))
```

[2]: 
$$\int_{-\infty}^{\infty} e^{-x^2} dx$$

```
[3]: _.doit()
```

[3]:  $\sqrt{\pi}$

# Google калкулатор

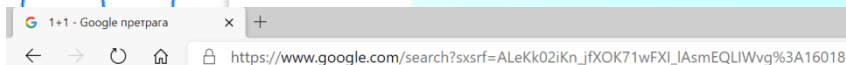
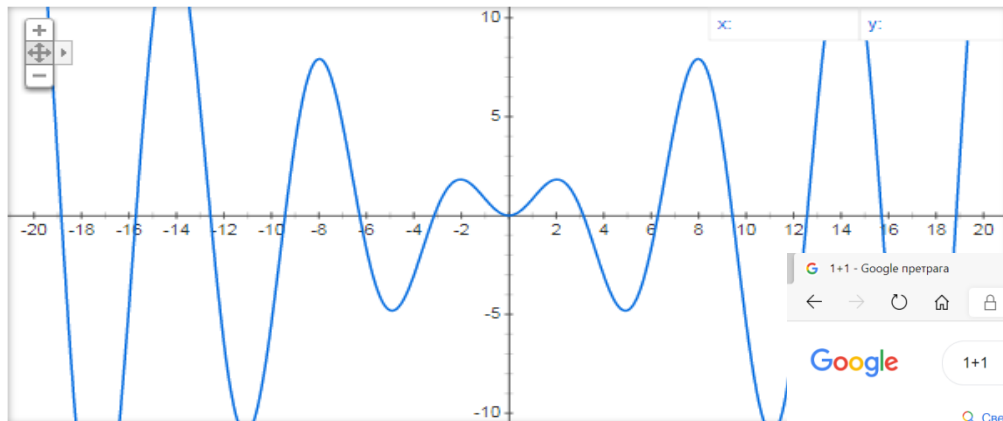


$x \cdot \sin(x)$

Све Сlike Видео Мапе Вести Још Подешавања Алатке

Око 3.640.000.000 резултата (0,57 секунде/и)

Графикон за  $x \cdot \sin(x)$



1+1

Све Сlike Мапе Видео Вести Још Подешавања Алатке

Око 25.270.000.000 резултата (0,72 секунде/и)

[www.mytutor.co.uk](http://www.mytutor.co.uk) > Maths > Преведи ову страницу

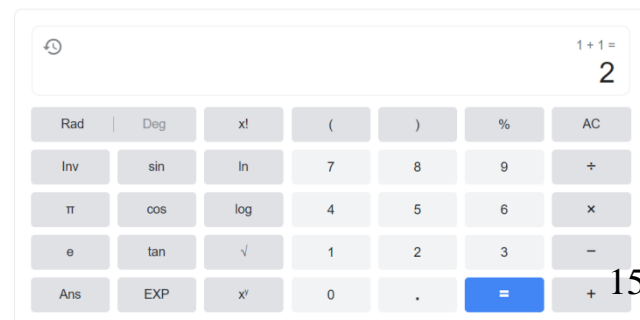
### What is the integral of $x \sin(x) dx$ ? | MyTutor

Find the following integral:  $\int x \sin(x) dx$  This question is a good candidate for parts method, as it is the product of two different 'parts'. R...

[www.teachoo.com](http://www.teachoo.com) > category > Преведи ову страницу

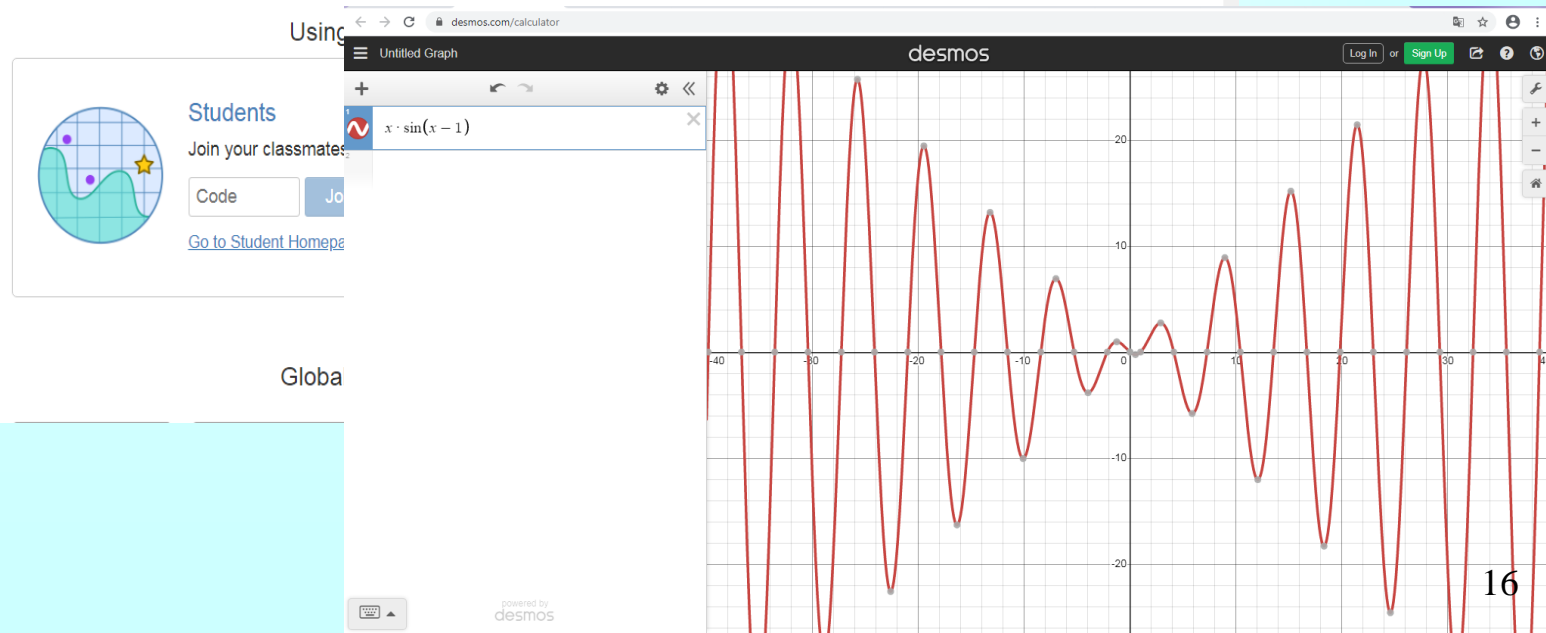
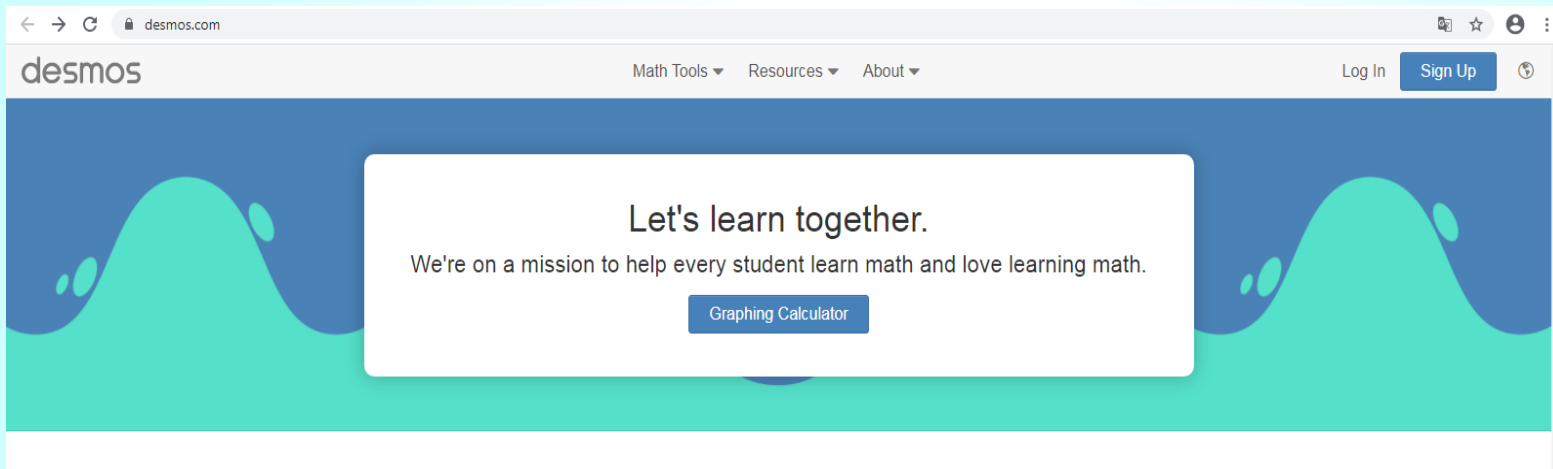
### Ex 7.6, 1 - Find integration of $x \sin x$ - Chapter 7 Clas

25.09.2018. - Ex 7.6,  $1x \sin x \int 1 \cdot [x \sin x] dx$  || Algebraic Trigonometric V  $g(x) \int dx = f(x) \int 1 \cdot g(x) \dots$



# Graphing Calculator – Desmos

<https://www.desmos.com/calculator>



# Symbolab Math Solver - Step by Step calculator

<https://www.symbolab.com/>

Try our new Geometry solver! [Got it](#)

Formatting tips »

Home What's New Blog About Privacy Terms Popular Problems Help

Most Used Actions: simplify, solve for, inverse, tangent, line

Step-by-Step Calculator Solve problems from Pre Algebra to Calculus step-by-step

Solution [Keep Practicing >](#)

$\int_0^T x \sin(x) dx = \sin(T) - T \cos(T)$

Steps

$\int_0^T x \sin(x) dx$

Apply Integration By Parts:  $u = x, v' = \sin(x)$  [Show Steps](#)

$= [-x \cos(x) - \int -\cos(x) dx]_0^T$

$\int -\cos(x) dx = -\sin(x)$  [Show Steps](#)

$= [-x \cos(x) - (-\sin(x))]_0^T$

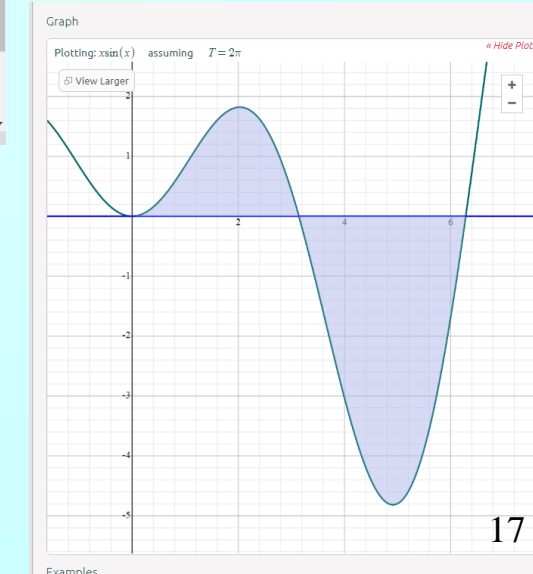
Simplify

$= [-x \cos(x) + \sin(x)]_0^T$

Compute the boundaries:  $[-x \cos(x) + \sin(x)]_0^T = \sin(T) - T \cos(T)$  [Show Steps](#)

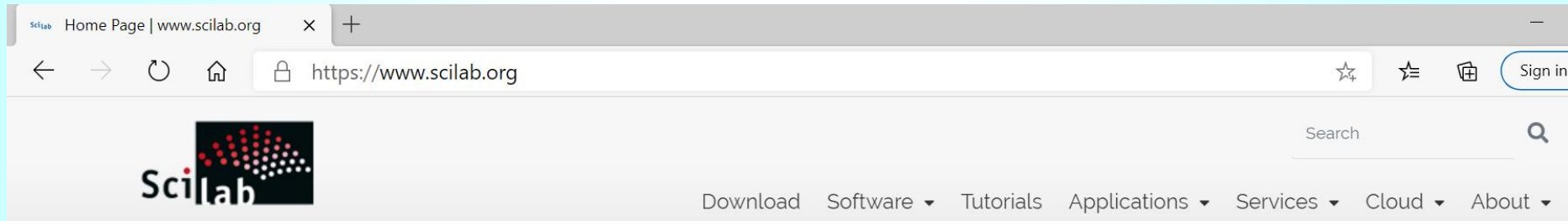
$= \sin(T) - T \cos(T)$

[Got a different answer? Check if it's correct](#) [Verify](#)



# SciLab

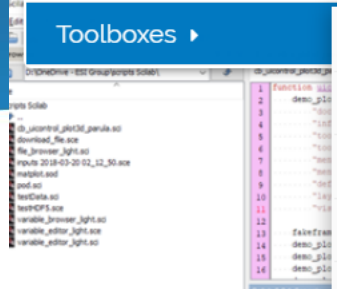
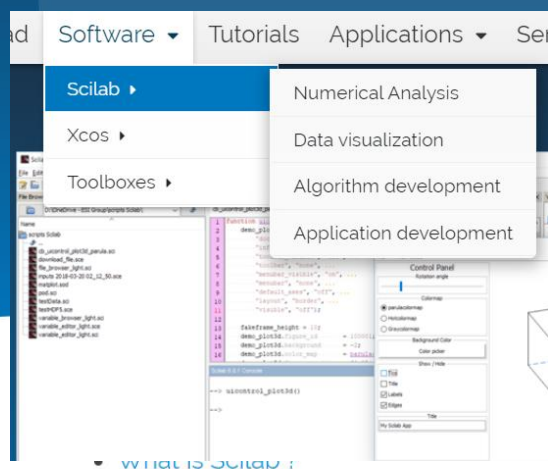
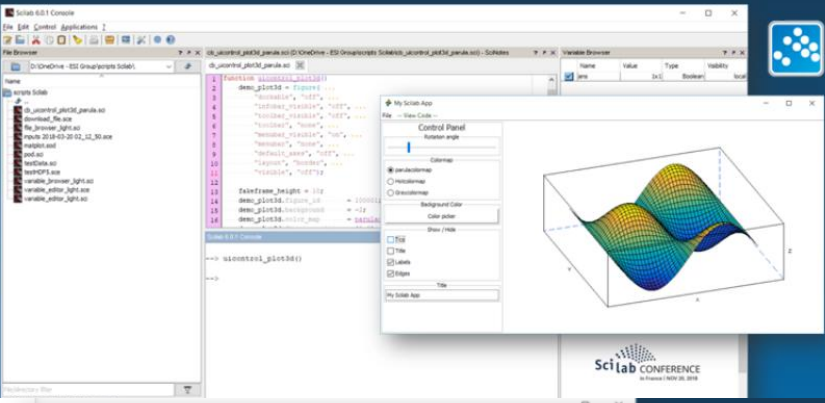
<https://www.scilab.org/>



Download SciLab 6.1.0

Windows, Linux and Mac OS X

Open source software for numerical computation

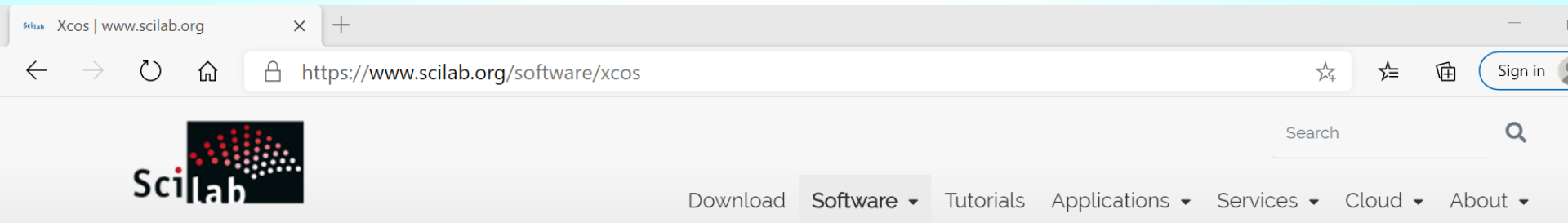


- Image Processing & Computer Vision
- Model Order Reduction
- Scilab Code Generator
- Signal acquisition & instrument control
- Functional Mock-Up Interface (FMI) for Model-Exchange & Co-Simulation



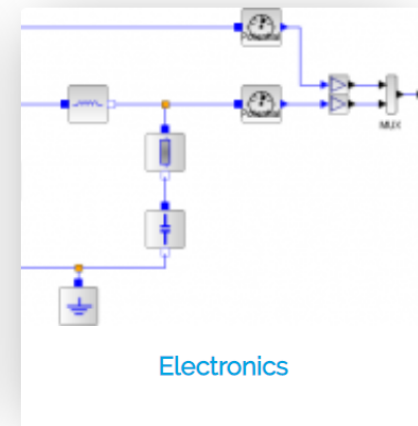
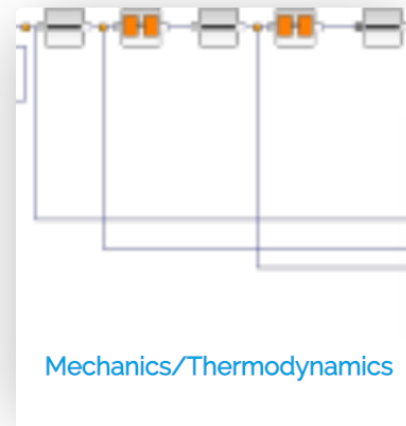
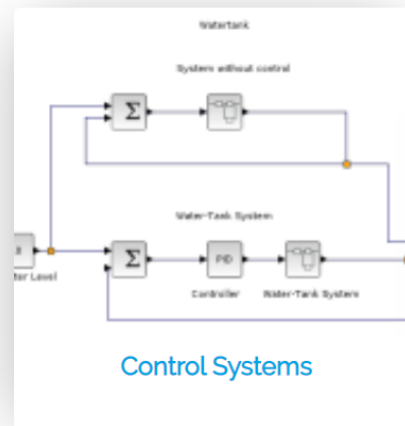
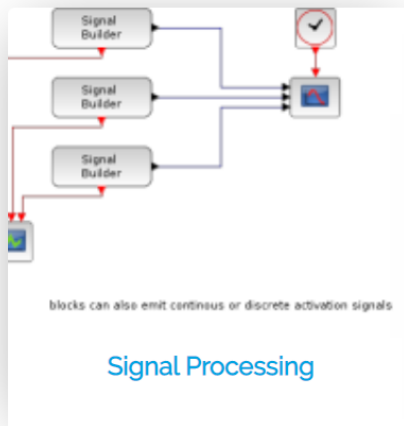
# Xcos

<https://www.scilab.org/software/xcos>



Home > Software

## Xcos



# GNU Octave

<https://www.gnu.org/software/octave/>

GNU Octave

About Bugs Donate Download Get Involved News Support/Help Docs

Need help? Try out our new user and developer forum [Octave Discourse](#).

**GNU Octave**

**Scientific Programming Language**

- Powerful mathematics-oriented syntax with built-in 2D/3D plotting and visualization tools
- Free software, runs on GNU/Linux, macOS, BSD, and Microsoft Windows
- Drop-in compatible with many Matlab scripts

Download

Documentation

# Micro-Cap

<http://www.spectrum-soft.com/index.shtml>



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## Industrial Strength Simulation

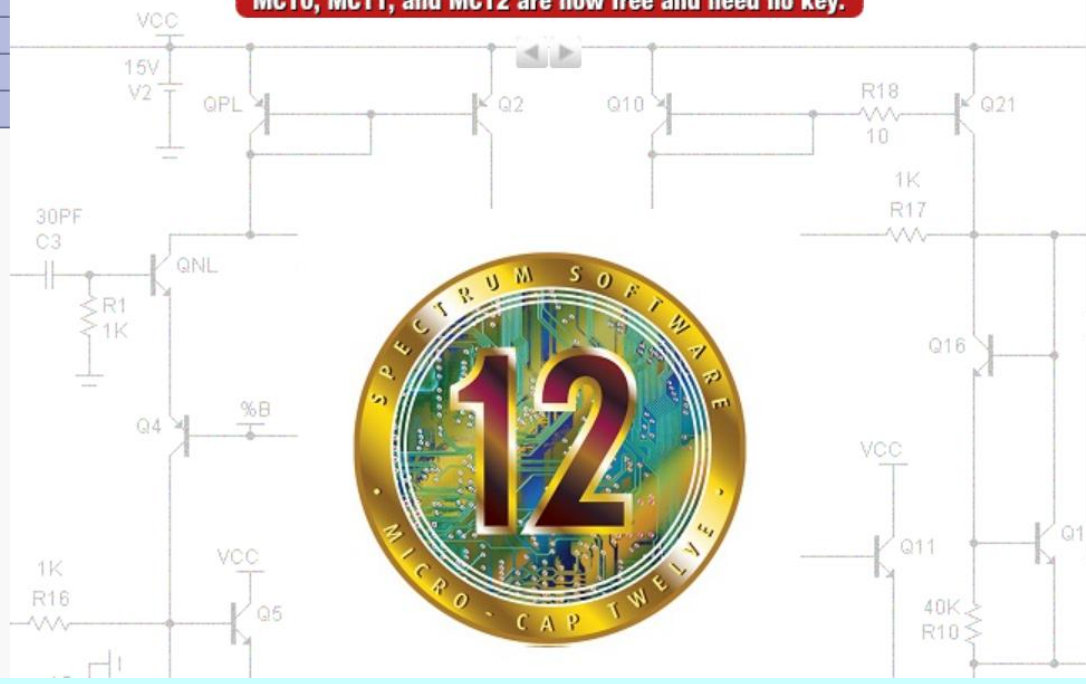
- Select :
- MC12 Revision History
  - Product Information
  - Features Tour
  - New MC12 Features

News:  
Effective 7/4/2019, Spectrum Software is closed. Micro-Cap is now free.

Technical support will be available for at least 90 days via email at [Support](#).

You can download the latest versions of Micro-Cap here: [Download](#)  
You can choose either the executable program or the entire installation CD for MC10, MC11, and MC12. If you have an earlier version, download and use MC12. These new versions do not require

**MC10, MC11, and MC12 are now free and need no key.**



### About Spectrum

Spectrum Software was founded in February of 1980 to provide software for personal computers. Initially, the company concentrated on providing software for Apple II systems.

One of the earliest products was Logic Designer and Simulator. Released in June 1980, this product was the first integrated circuit editor and logic simulation system available for personal computers. More...

### Help

Search our newsletter issues which contain application notes for Micro-Cap or view our Frequently Asked Questions section for common questions that arise with Micro-Cap use.

# QucsStudio

<http://qucsstudio.de>

*Octave engine  
inside!*

The screenshot displays the QucsStudio 2.4.1 interface. The main window shows a schematic diagram of a conventional power supply circuit. The circuit includes an AC voltage source V1 (230 V, 50 Hz) connected to a primary winding of a transformer Tr1 (T=20). The primary winding has a resistance R\_prim = 0.05 Ohm. The secondary winding is connected to a secondary resistance R\_sec = 0.3 Ohm, followed by a 2-way rectifier (four diodes) and a filter capacitor C1 (1000 μF). The output is connected to a load resistor R = 100 Ohm. A 'dc voltage' measurement point is indicated at the load. A 'transient simulation' box is overlaid on the schematic, with parameters: TR1 Type=lin, Stop=60 ms, Points=3001.

The left sidebar shows the 'Content of Simulation\_Transient' window, listing various schematics such as RTD\_oscillator.sch, astable.sch, buck\_converter.sch, etc. The bottom right window shows the 'Content of Simulation\_Octave' window, displaying a list of files and a console output with the following text:

```
1 clear all
2 % *****
3 % This script c
4 % simulated aft
5 %
6 % The schematic
7 % transission l
8 %
9 % Copyright 201
10 % Published und
11 % No warranty at
12 % *****
13
14 FILENAME = "taper
15
16 TAPER_LENGTH =
17 NUM_SECTIONS =
18 LENGTH_PER_SECT
19
```



# CircuitLab

<https://www.circuitlab.com/>

CIRCUIT LAB

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## Circuit simulation and schematics.

Build and simulate circuits right in your browser.

- Design with our easy-to-use schematic editor.
- Analog & digital circuit simulations in seconds.
- Professional schematic PDFs, wiring diagrams, and plots.
- No installation required! Launch it *instantly* with [one click](#).

▶ Launch CircuitLab

[or watch a quick demo video →](#)

Getting Started with CircuitLab

Гледајте К... Дели

CIRCUIT LAB

File Edit Run Help

Press 'F' to search

Essentials

DC Sources

Passive Elements

Voltage Signal Sources

Current Signal Sources

Operational Amplifiers

Diodes

V1 square 1 kHz

R1 100  $\Omega$

C1 10  $\mu\text{F}$

in

out

### 1-minute Tutorial

1. Click and drag a wire from the right of R1 to the top of C1.
2. Click "Simulate."
3. Click "Run Time-domain Simulation" and look at the filter output V(out)
4. Double-click R1, change it to "1k", and simulate again.
5. Run the Frequency-Domain simulation and see the Bode plot.

Powered by CircuitLab - to learn about the full version, please visit [www.circuitlab.com](https://www.circuitlab.com)

148%

Textbook **NEW!**

Electronic systems with CircuitLab's free, quick.

[Full Circuit Design and Analysis](#)

# DoCircuits Circuit Simulator

Do Circuits

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## circuits

Experience virtual labs for electronics on browser. Work with real looking components and devices. Build circuits - run, analyse and save them in easy steps.  
Reach us at [info@docircuits.com](mailto:info@docircuits.com)

Launch Online Labs Download Free Trial

Share More info

Select required signal such as sine, square

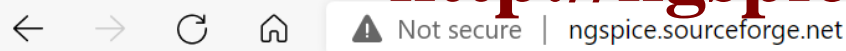
### Get started with some sample circuits !

- Colpitts Oscillator**  
This circuit generates a continuous sinusoidal signal. The tank circuit is made up of two capacitors and an inductor in parallel
- Active Low Pass Filter**  
This circuit made up using op-amp and will allow signals lower than a particular cut off frequency to pass though and attenuates those above it.
- Active High Pass Filter**  
This circuit uses an op-amp as the active element and allows only the input signals with frequency higher than the cut-off frequency and rejects those below it.
- Clipper**  
This is a wave-shaping circuit. It will modify the shape of the signal by "clipping" off a portion of it. When the diode is forward-biased, the voltage across it will be a constant 0.7 V. And when the diode is reverse-biased, it will be open. Thus the output will follow the input when it is forward biased.
- Clamper**  
This circuit is another level shape. The wave is positive or r

Fig. 1: DoCircuits - Home

# ngSpice

<http://ngspice.sourceforge.net/>



MIXED MODE - MIXED LEVEL  
CIRCUIT SIMULATOR

NGSPICE SUMMARY

BASED ON BERKELEY'S SPICE3F5

- Home
- News
- Screenshots
- Download
- Documentation
- Tutorials
- Extras/Options
- Applications
- Development
- Simulation Environments
- Recipes

## Ngspice Home

- Home
- What is ngspice ?
- Features, Extras & Options
- F.A.Q.
- Tutorials
- Sourceforge Developer Pages

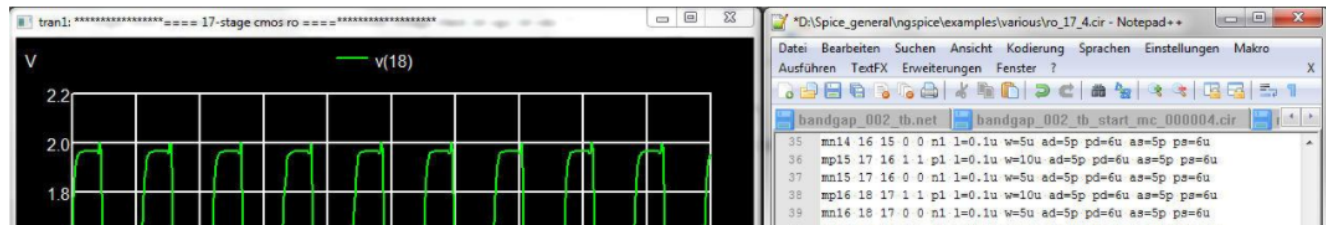
## ngspice - open source spice simulator

ngspice is the open source spice simulator for electric and electronic circuits.

Such a circuit may comprise of JFETs, bipolar and MOS transistors, passive elements like R, L, or C, diodes, transmission lines and other devices, all interconnected in a netlist. Digital circuits are simulated as well, event driven and fast, from single gates to complex circuits. And you may enter the combination of both analog and digital as a mixed-signal circuit.

ngspice offers a wealth of device models for active, passive, analog, and digital elements. Model parameters are provided by our [collections](#), by the [semiconductor device manufacturers](#), or from [semiconductor foundries](#). The user adds her circuits as a netlist, and the output is one or more graphs of currents, voltages and other electrical quantities or is saved in a data file.

ngspice does not provide schematic entry. Its input is command line or file based. There are however [third party](#) interfaces available.





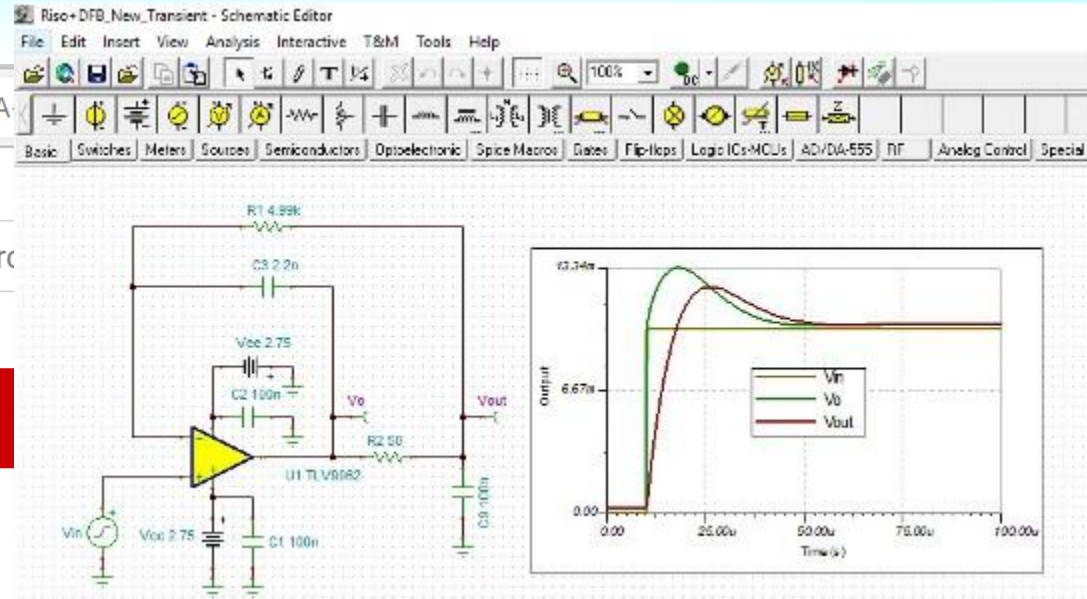
← → ↻ 🏠 🔒 <https://www.ti.com/tool/TINA>



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# TINA-TI

SPICE-based analog simulation program

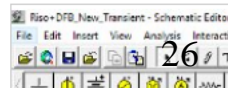
Overview Downloads Technical documentation Support & training

# TINA-TI

# <https://www.ti.com/tool/TINA-TI>

## Overview

TINA-TI provides all the conventional DC, transient and frequency domain analysis of SPICE and much more. TINA has extensive post-processing capability that allows you to format results the way you want them. Virtual instruments allow you to



# Electric Circuit Studio

← → ↻ 🏠 [https://play.google.com/store/apps/details?id=com.ecstudiosystems.electriccircuitstudio&hl=en\\_US&gl=US](https://play.google.com/store/apps/details?id=com.ecstudiosystems.electriccircuitstudio&hl=en_US&gl=US)



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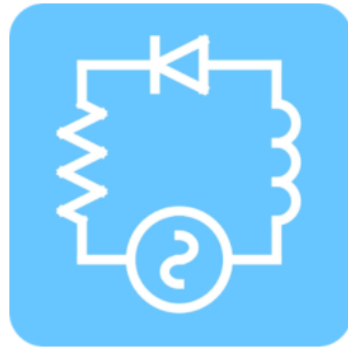
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Buy gift card

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My Play activity

Parent Guide



## Electric Circuit Studio

ECStudio Systems Education

★★★★☆ 2,709

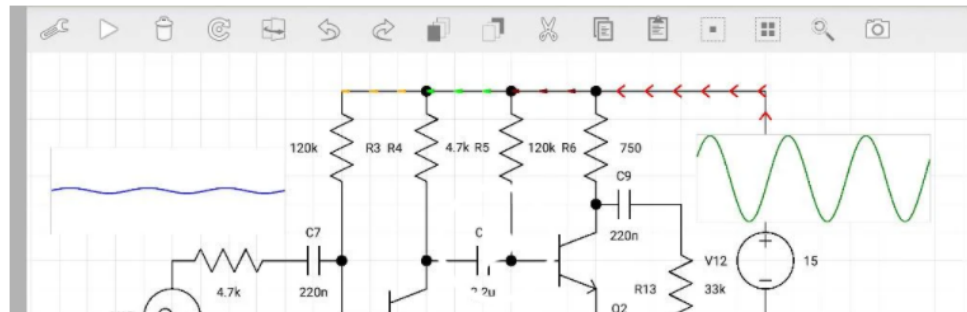
Everyone

Contains Ads

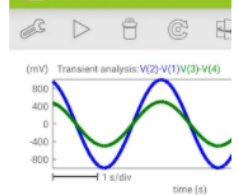
⚠ You don't have any devices

➕ Add to Wishlist

Install



divider



# CircuitSafari SPICE Simulator

← → ↻ 🏠 🔒 [https://play.google.com/store/apps/details?id=com.logipipe.circuitsafari&hl=en\\_US&gl=US](https://play.google.com/store/apps/details?id=com.logipipe.circuitsafari&hl=en_US&gl=US)



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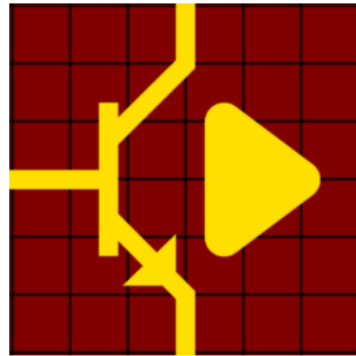
Redeem

Buy gift card

My wishlist

My Play activity

Parent Guide



## CircuitSafari SPICE Simulator (Early Access)

Logipipe, LLC Productivity

**E** Everyone

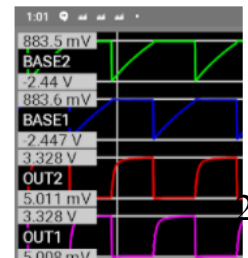
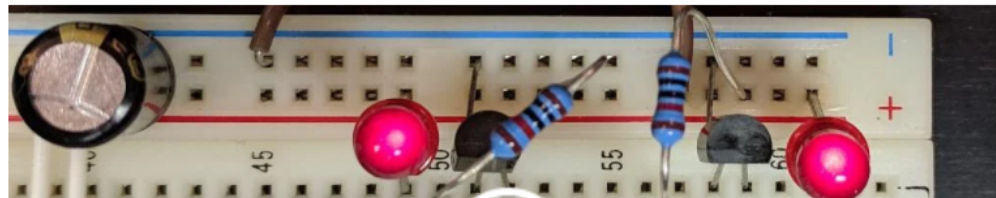
Offers in-app purchases

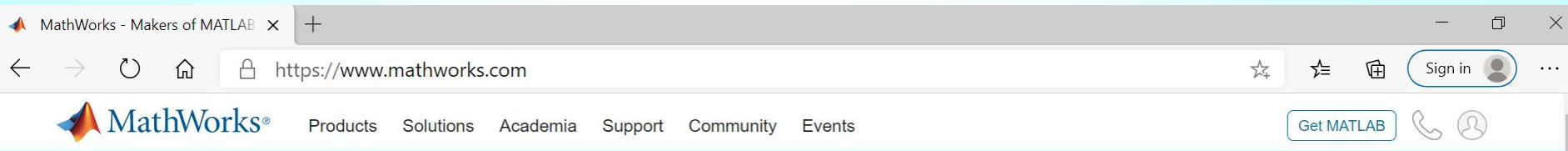
📌 This app is in development. It may be unstable.

⚠️ You don't have any devices

🔖 Add to Wishlist

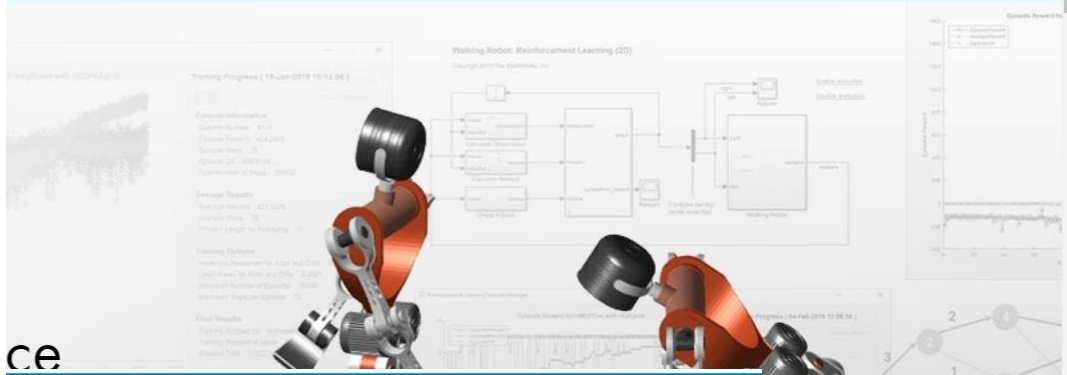
Install



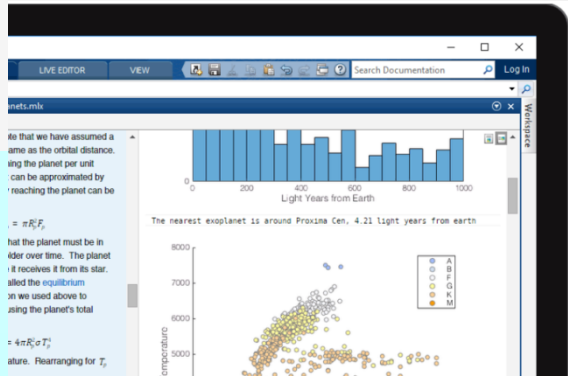


# Millions of Engineers and Scientists Trust MATLAB

MATLAB® combines a desktop environment tuned for iterative analysis and design processes with a programming language that expresses matrix and array mathematics directly. It includes the [Live Editor](#) for creating scripts that combine code, output, and formatted text in an executable notebook.



## Design AI models and AI-driven systems



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**MATLAB®**  
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- MATLAB Parallel Server

**Math and Optimization**

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- Optimization Toolbox
- Global Optimization Toolbox
- Symbolic Math Toolbox
- Mapping Toolbox

**SIMULINK®**  
PRODUCT FAMILY

**Simulink**

System Composer

**Event-Based Modeling**

- Stateflow
- SimEvents

**Physical Modeling**

- Simscape
- Simscape Driveline
- Simscape Electrical
- Simscape Fluids

**SERVICES**

- Software Maintenance
- Training
- Consulting

**LICENSE TYPES**

- Industry Use
- Student Use
- University Use
- Startup Use
- Primary and Secondary School Use
- Home Use



# MATLAB



The image displays the MATLAB R2019a software interface. The Simulink icon in the ribbon is highlighted with a red box. A 'System target file browser' dialog box is open, showing a list of target files with 'dsdsh.tlc' selected. The 'Simulink 2D SHplus' logo is overlaid on the dialog box. The Command Window shows a message: 'New to MATLAB? See resources for [Getting Started.](#)' The Workspace window is empty. The bottom right corner features a blue MATLAB R2019a license banner with the following text:

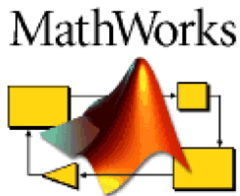
R2019a (9.6.0.1072779)  
64-bit (win64)  
March 8, 2019  
License Number: 968398

MATLAB®  
Professional License

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MathWorks R2019a

## Toolboxes...

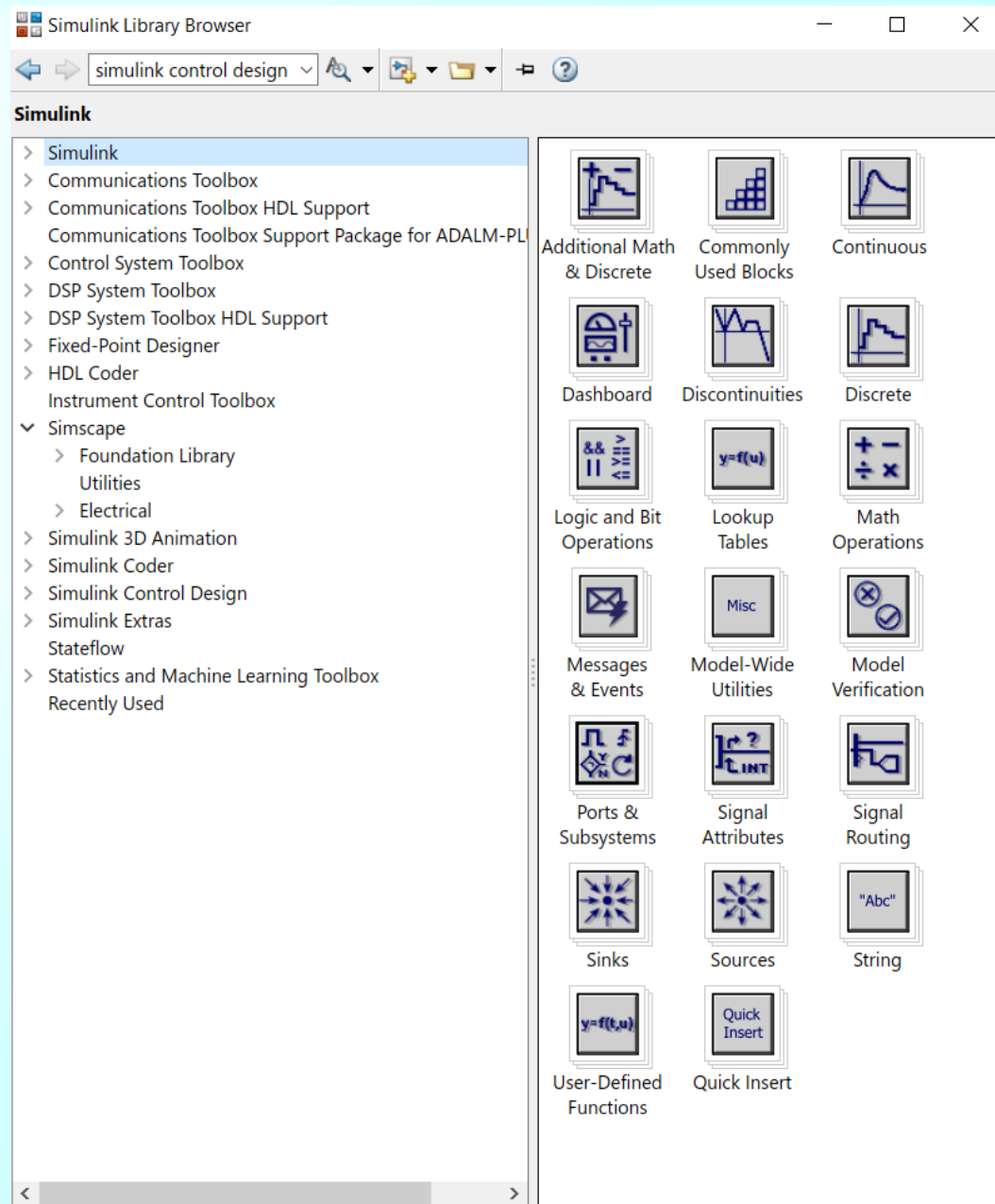




# MATLAB

## Simulink

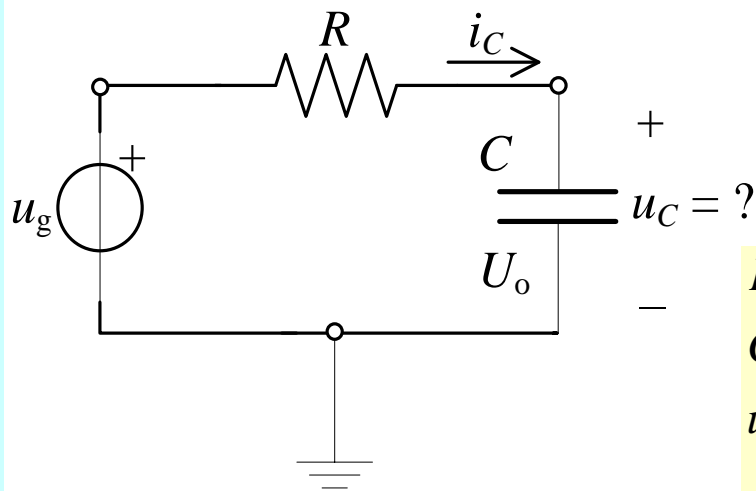
- Алатка за нумеричку анализу математичких модела
- Систем се дефинише графички, уметањем блокова и њиховим повезивањем у мрежу



# Simulink > Simscape

- Библиотека за симулацију и нумеричку анализу мултидоменских проблема (механика, електродинамика, оптика)
- Пример једноставног електричног кола:

коло је образовано у тренутку  $t_0 = 0$

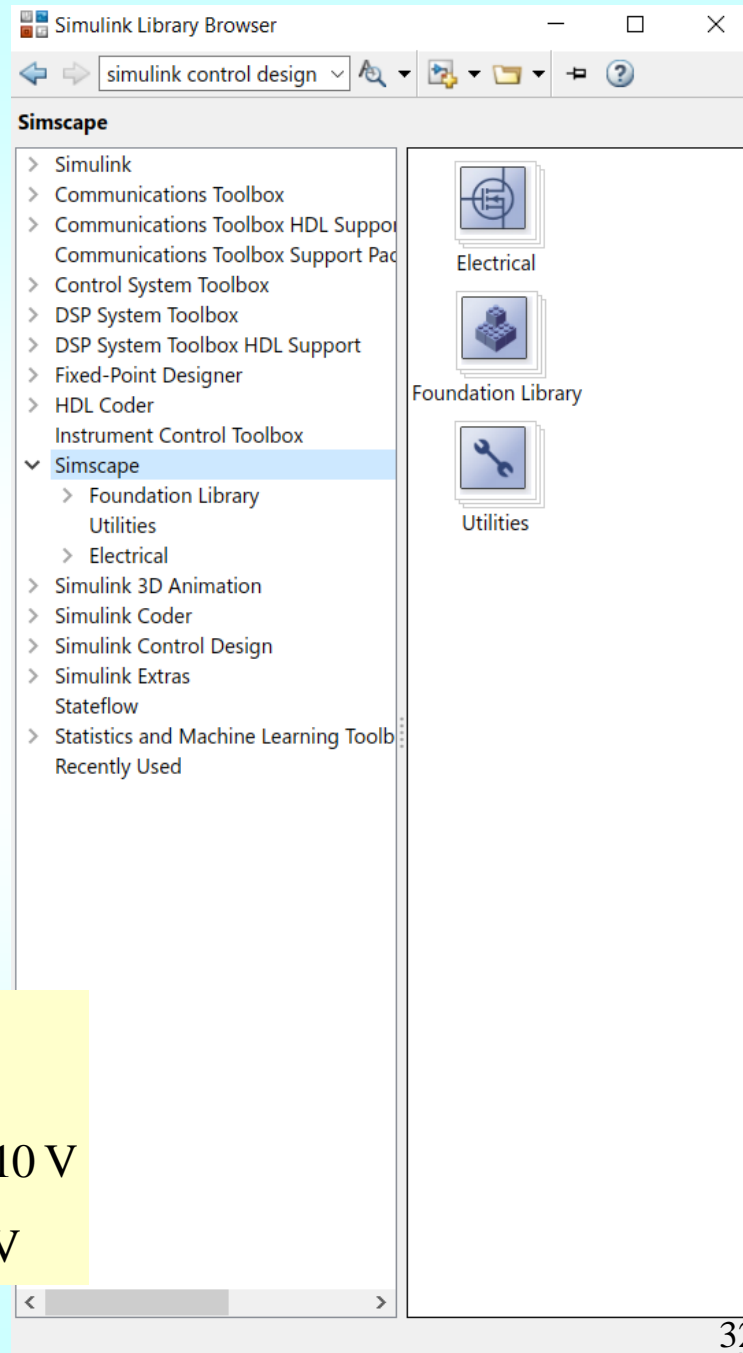


$$R = 1 \text{ k}\Omega$$

$$C = 1 \mu\text{F}$$

$$u_g(t) = U h(t), U = 10 \text{ V}$$

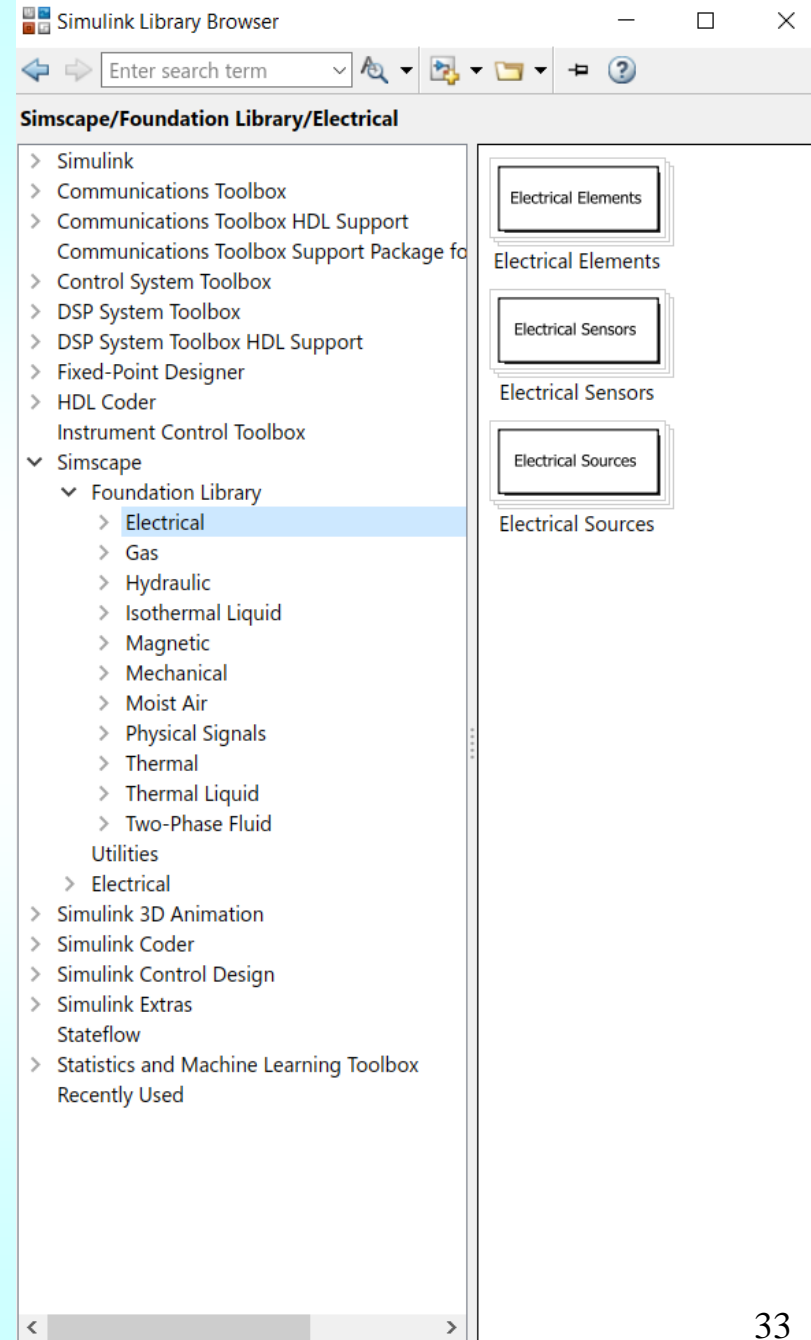
$$u_C(t_0^-) = U_0 = -10 \text{ V}$$





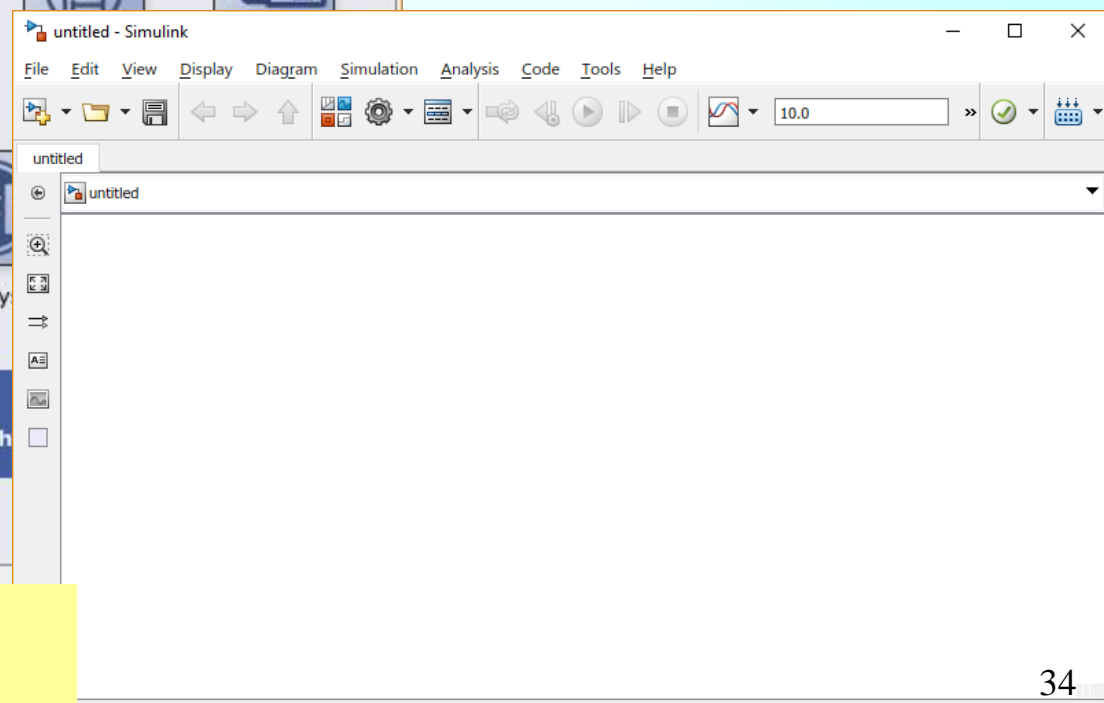
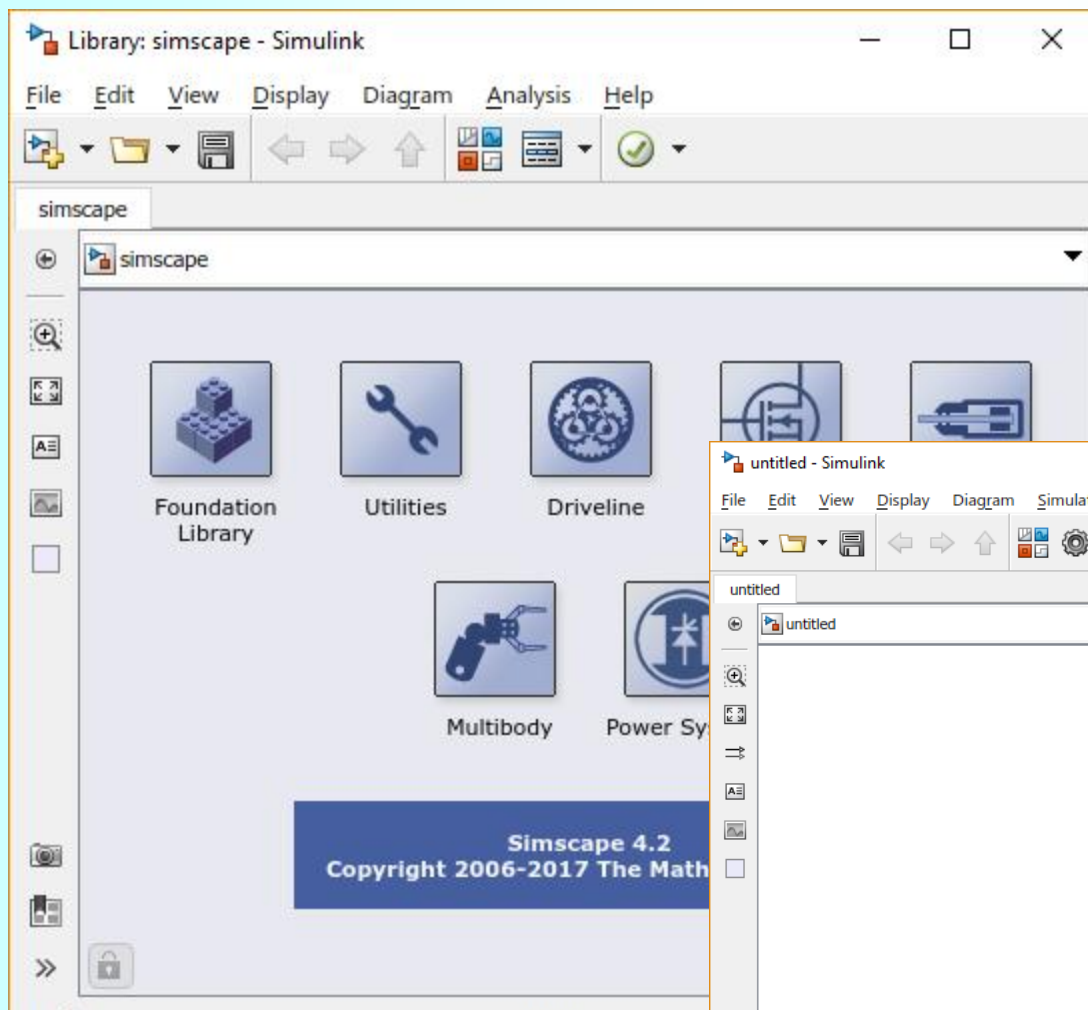
# Simulink > Simscape > Foundation Library > Electrical

- Симулација линеарних и нелинеарних електричних кола

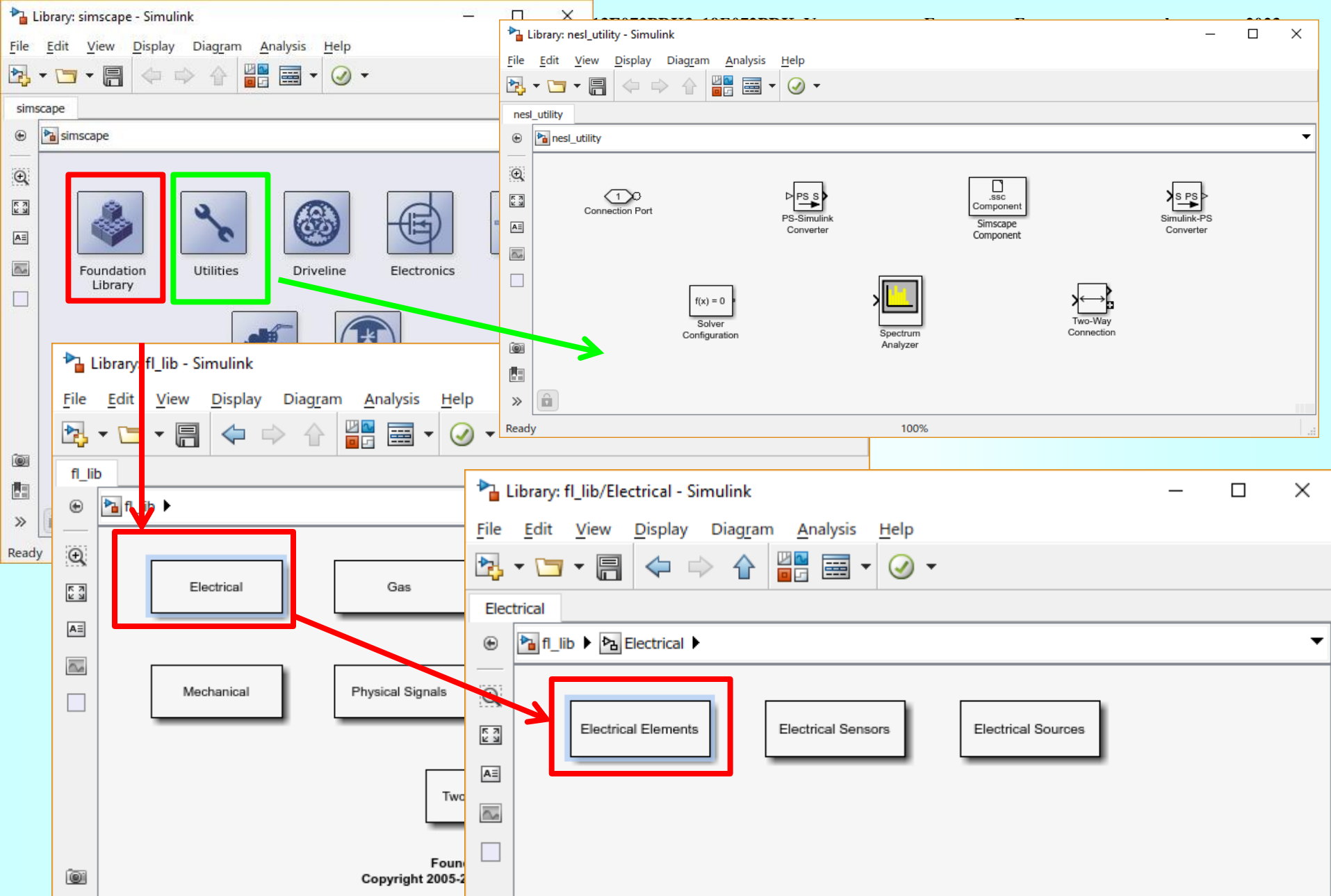


**MATLAB > Simscape >  
Foundation Library, Utilities**

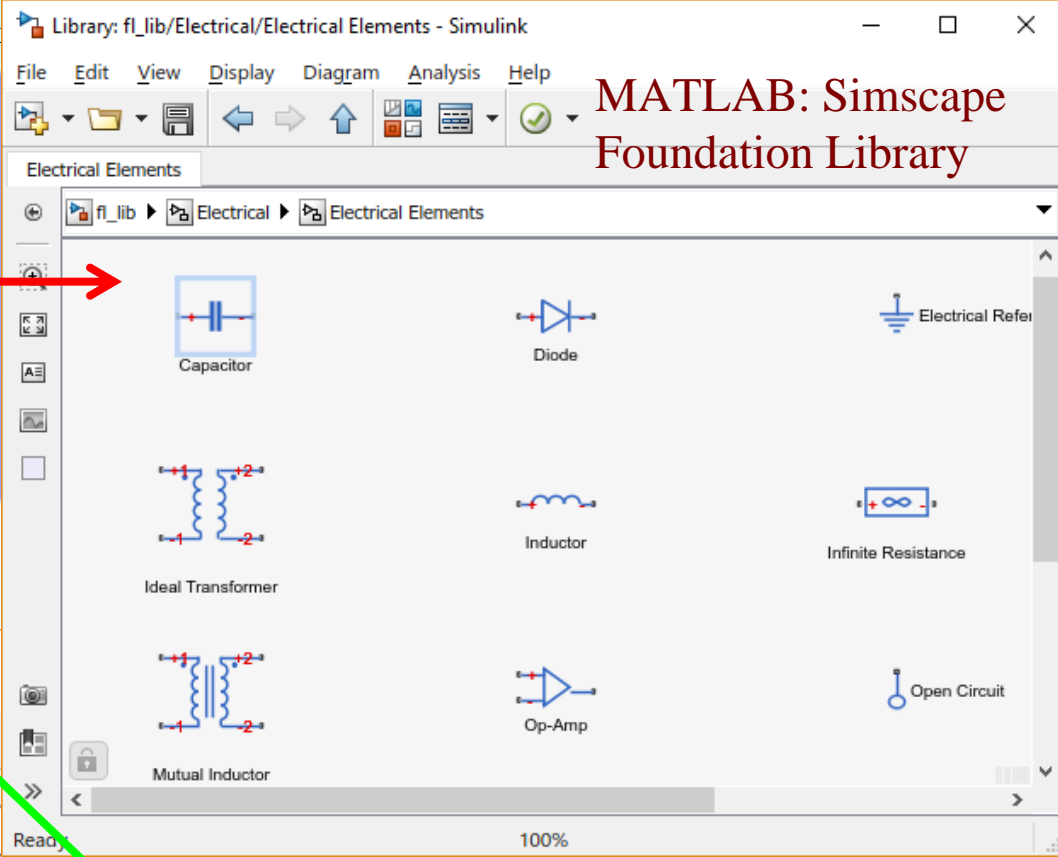
# Симулација електричног кола коришћењем Simscape > Foundation Library библиотеке



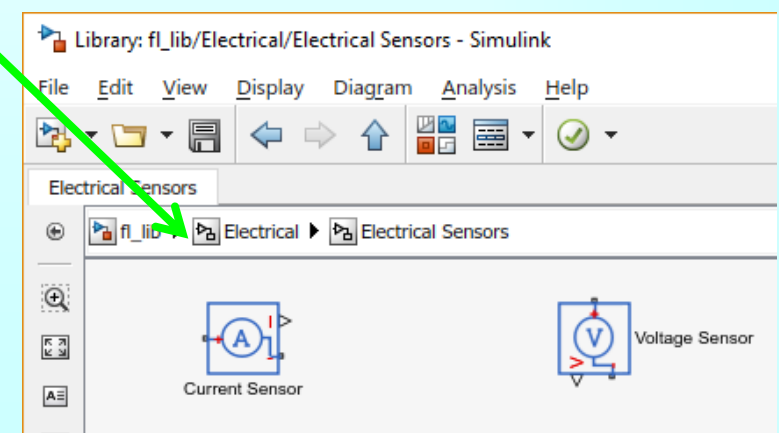
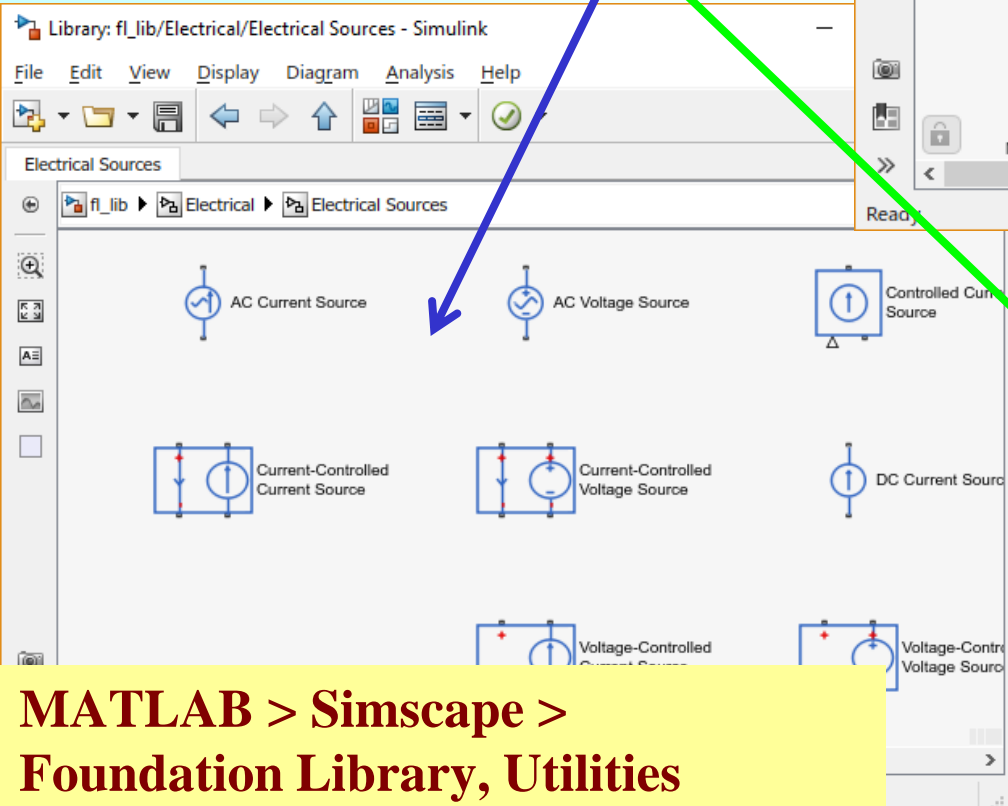
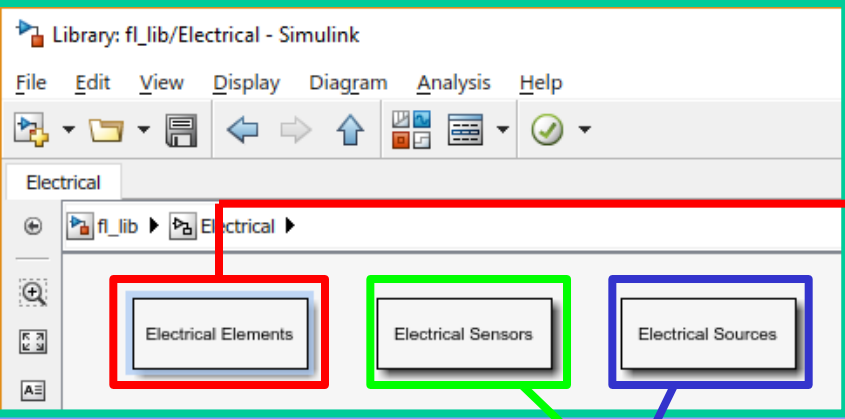
**MATLAB > Simscape >  
Foundation Library, Utilities**



**MATLAB > Simscape > Foundation Library, Utilities**

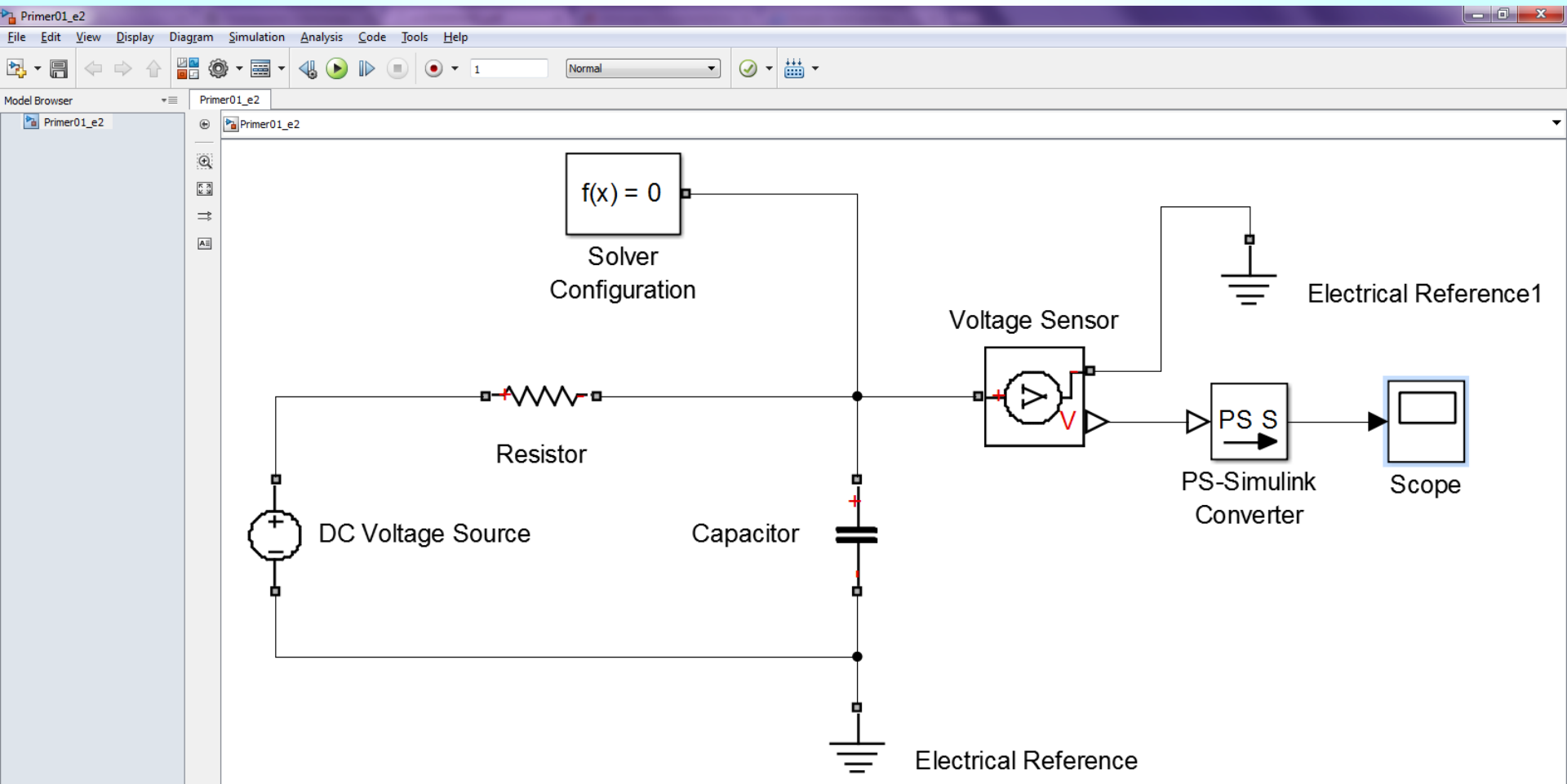


# MATLAB: Simscape Foundation Library



**MATLAB > Simscape > Foundation Library, Utilities**

# Симулација електричног кола коришћењем Simscape > Foundation Library библиотеке



**MATLAB > Simscape >  
Foundation Library, Utilities**

**Block Parameters: Solver Configuration**

Solver Configuration  
Defines solver settings to use for simulation.

Parameters

- Start simulation from steady state
- Consistency tolerance: 1e-09
- Use local solver
- Solver type: Backward Euler
- Sample time: 0.001
- Use fixed-cost runtime consistency iterations
- Nonlinear iterations: 3
- Mode iterations: 2
- Linear Algebra: Sparse
- Delay memory budget [kB]: 1024
- Apply filtering at 1-D/3-D connections when needed
- Filtering time constant: 0.001

OK Cancel Help Apply

**Block Parameters: DC Voltage Source**

DC Voltage Source

The ideal voltage source maintains a constant voltage across its output terminals, independent of the current flowing through the source. The output voltage is defined by the Constant voltage parameter, and can be any real value.

[Source code](#)

Settings

Parameters

Constant voltage: 10 V

OK Cancel Help Apply

**Block Parameters: Resistor**

Resistor

The voltage-current (V-I) relationship for a linear resistor is  $V=I \cdot R$ , where R is the constant resistance in ohms.

The positive and negative terminals of the resistor are denoted by the + and - signs respectively. By convention, the voltage across the resistor is given by  $V(+)-V(-)$ , and the sign of the current is positive when flowing through the device from the positive to the negative terminal. This convention ensures that the power absorbed by a resistor is always positive.

[Source code](#)

Settings

Parameters Variables

Resistance: 1000 Ohm

OK Cancel Help Apply

Block Parameters: Capacitor

# Почетни услов...

Capacitor

Models a linear capacitor. The relationship between voltage  $V$  and current  $I$  is  $I=C*dV/dt$  where  $C$  is the capacitance in farads.

The Series resistance and Parallel conductance represent small parasitic effects. The parallel conductance can be used to model dielectric losses and the series resistance used to represent the effective series resistance (ESR) of the capacitor. Simulation of some circuits may require the presence of the small series resistance. Consult the documentation for further details.

[Source code](#)

Settings

Parameters Variables

Capacitance:

Series resistance:

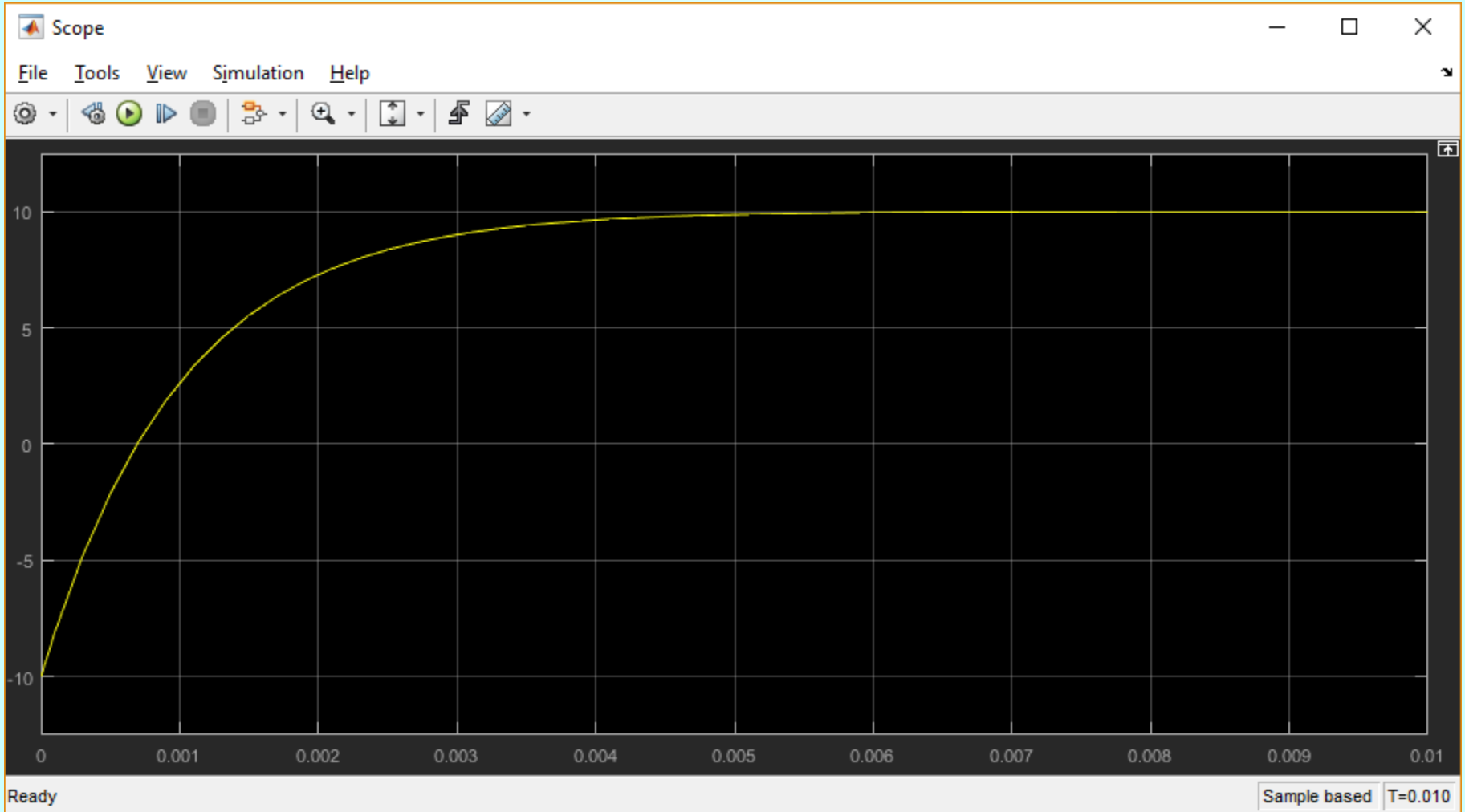
Parallel conductance:

Settings

Parameters Variables

Override	Variable	Priority	Beginning Value	Unit
<input type="checkbox"/>	Current	None	0	A
<input type="checkbox"/>	Voltage	None	0	V
<input checked="" type="checkbox"/>	Capacitor voltage	High	-10	V

# Налажење одзива...

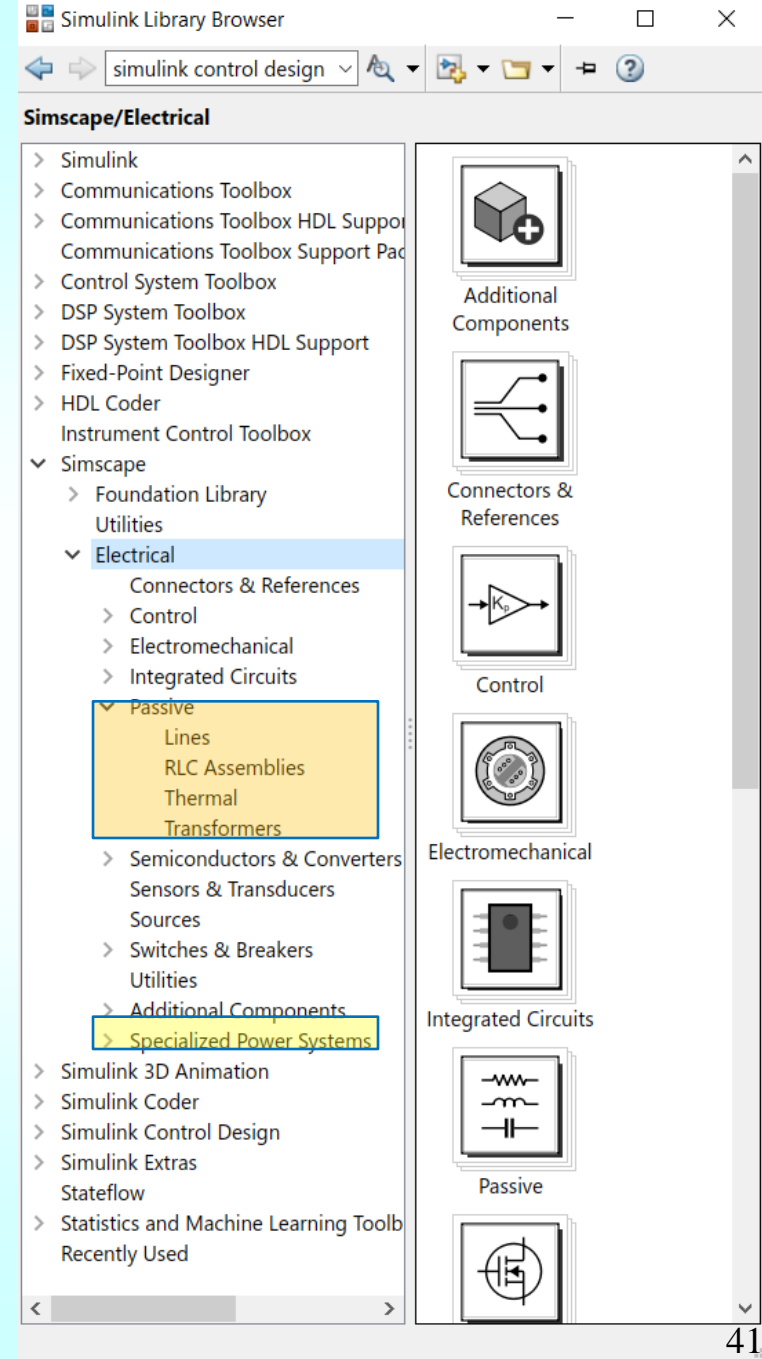


**MATLAB > Simscape > Foundation Library, Utilities**

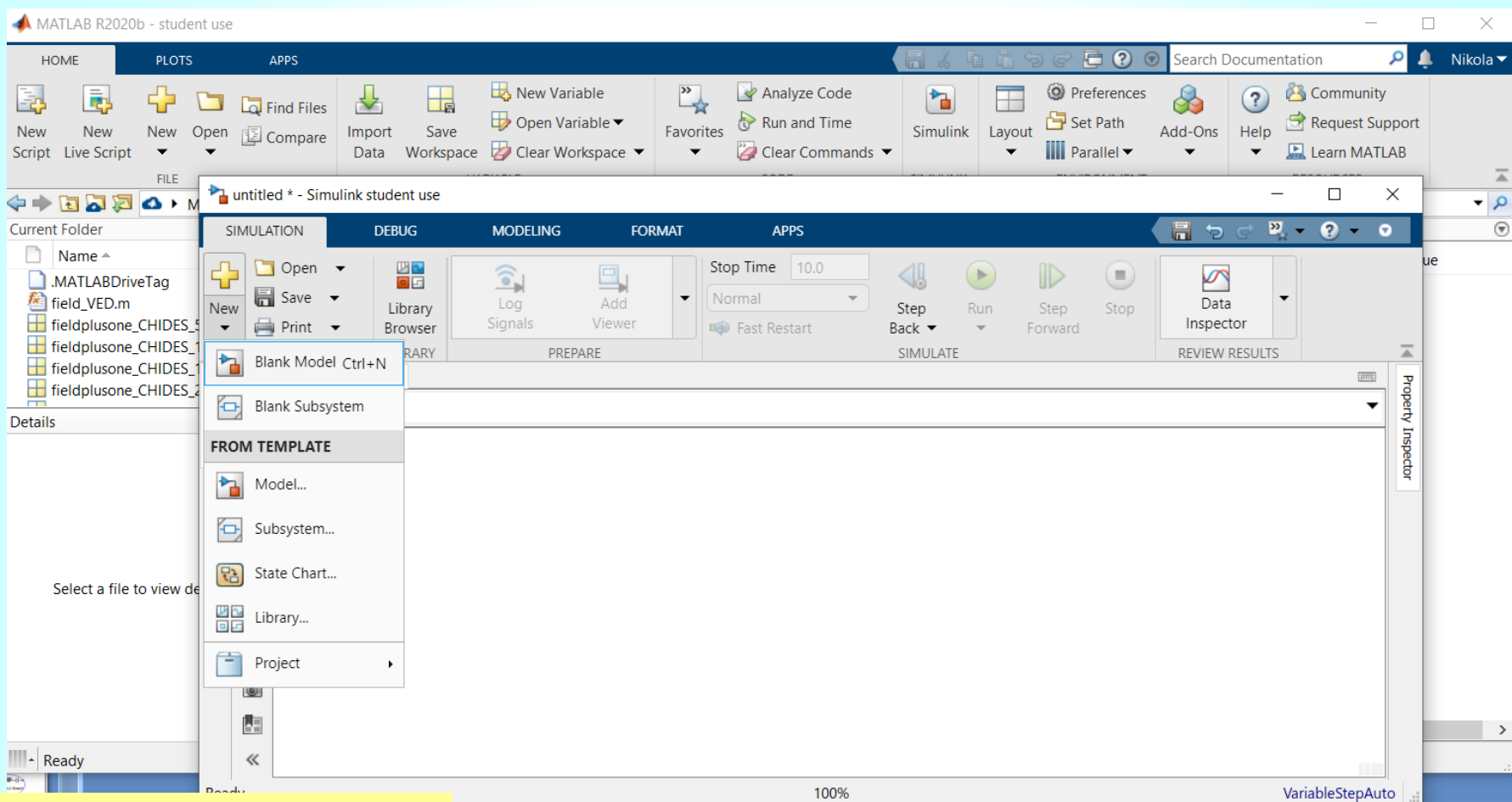


# Simulink > Simscape > Electrical

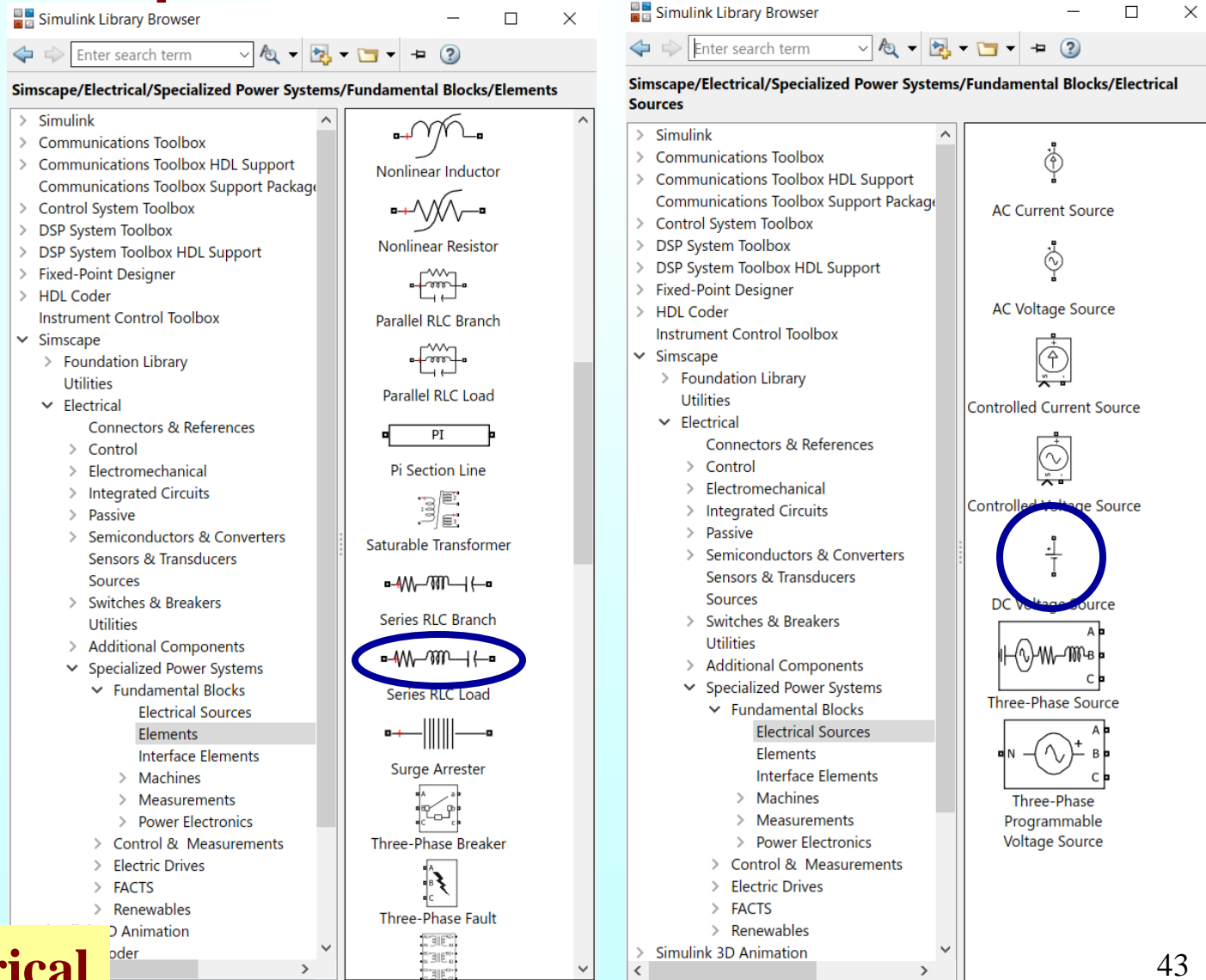
- Библиотека за симулацију и нумеричку анализу електроенергетских система
- Трофазни извори, водови, трансформатори, потрошачи
- Термална анализа



# Симулација електричног кола коришћењем **Simscape>Electrical** библиотеке

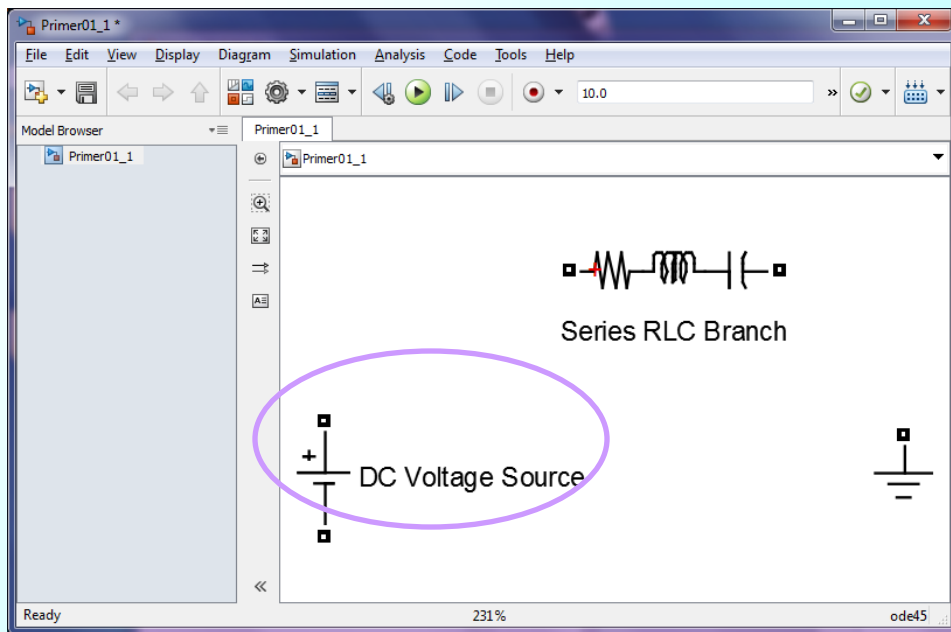
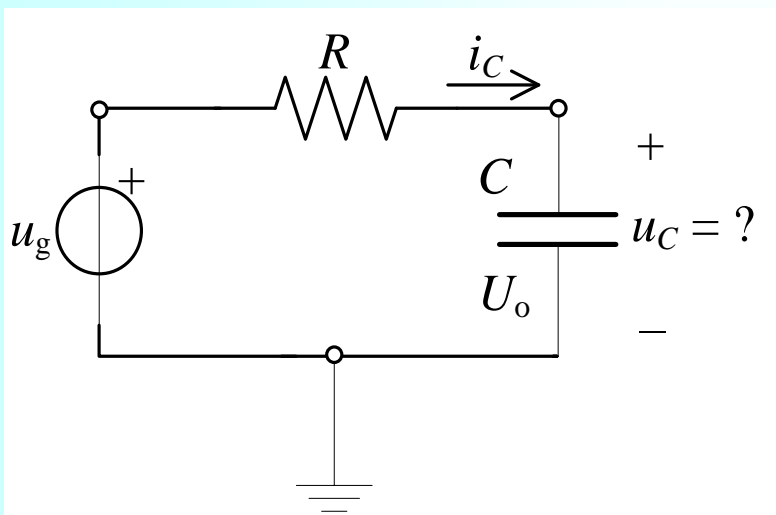


# Симулација електричног кола коришћењем Simscape>Electrical библиотеке



# Симулација електричног кола коришћењем **Simscape>Electrical** библиотеке

коло је образовано у тренутку  $t_0 = 0$

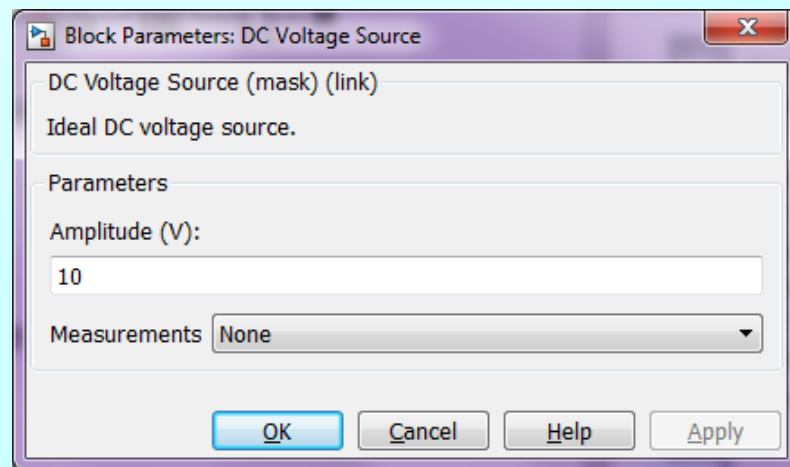


$$R = 1 \text{ k}\Omega$$

$$C = 1 \mu\text{F}$$

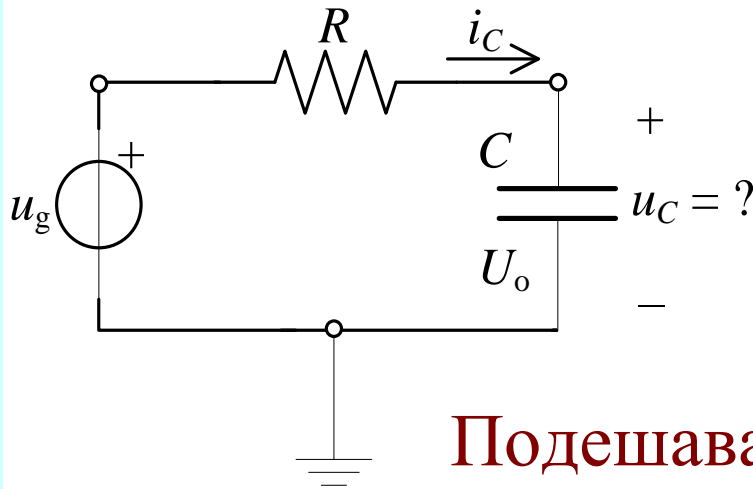
$$u_g(t) = U h(t), U = 10 \text{ V}$$

$$u(t_0^-) = U_0 = -10 \text{ V}$$



# Симулација електричног кола коришћењем **Simscape>Electrical** библиотеке

коло је образовано у тренутку  $t_0 = 0$



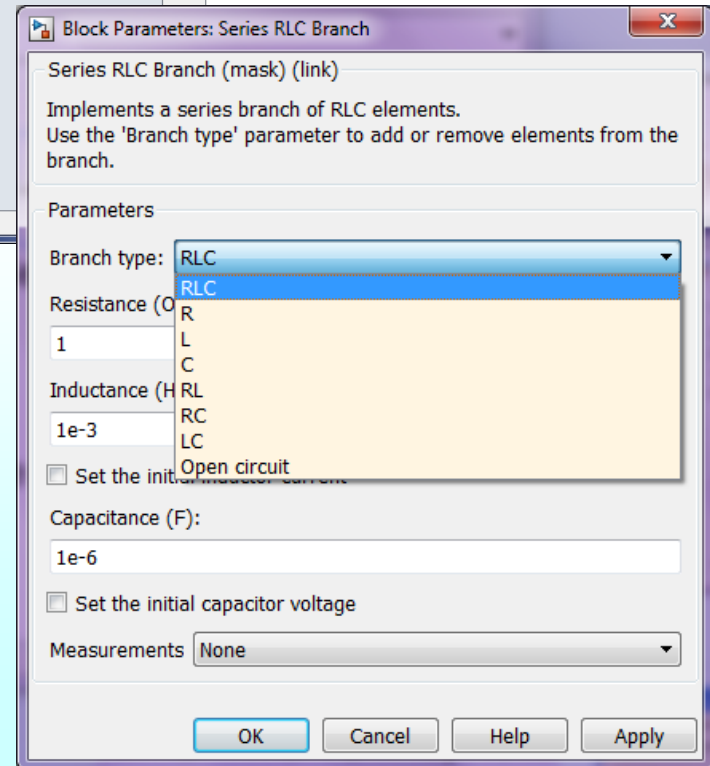
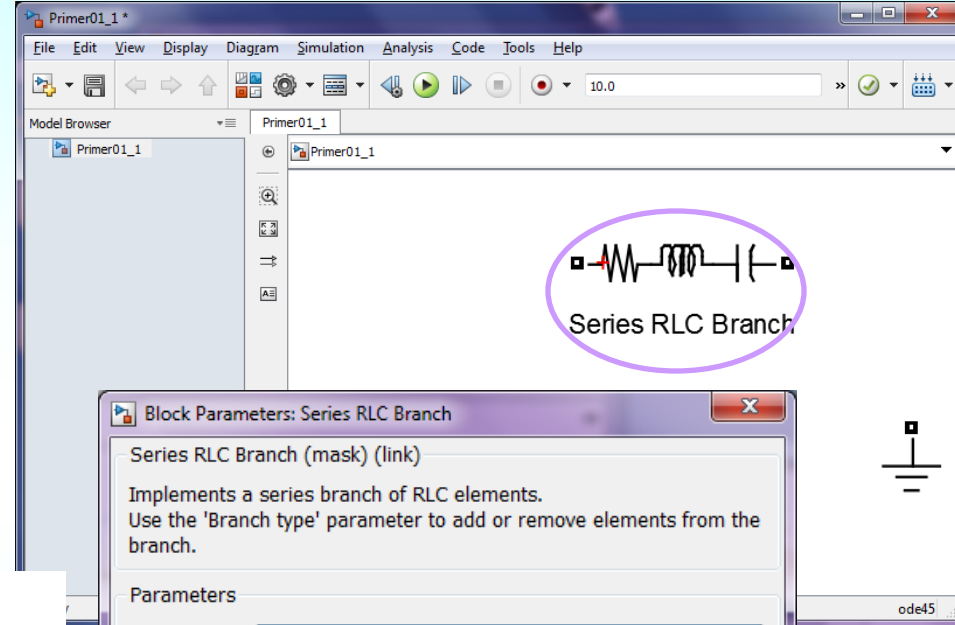
Подешавање  
параметара  
симулације

$$R = 1 \text{ k}\Omega$$

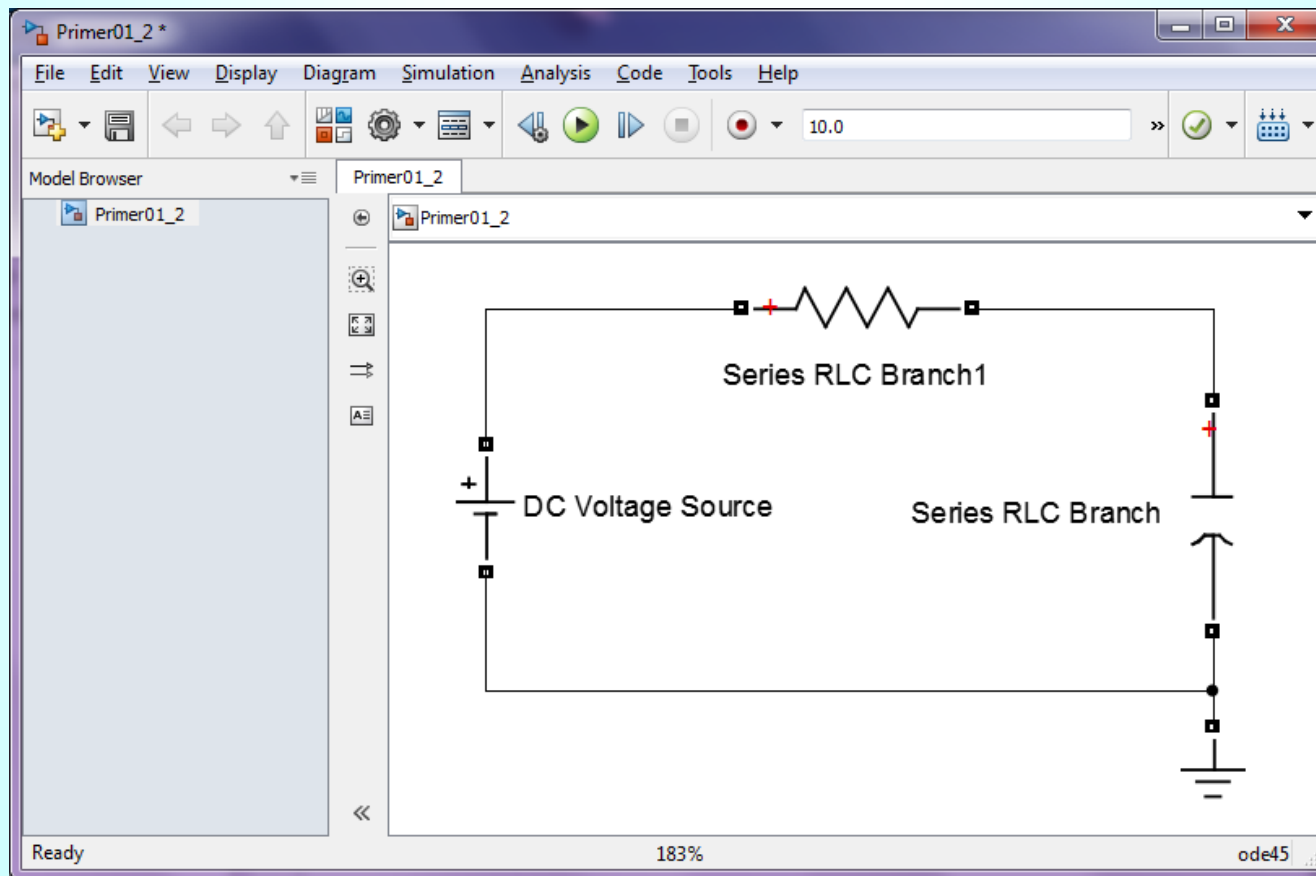
$$C = 1 \mu\text{F}$$

$$u_g(t) = U h(t), U = 10 \text{ V}$$

$$u(t_0^-) = U_0 = -10 \text{ V}$$

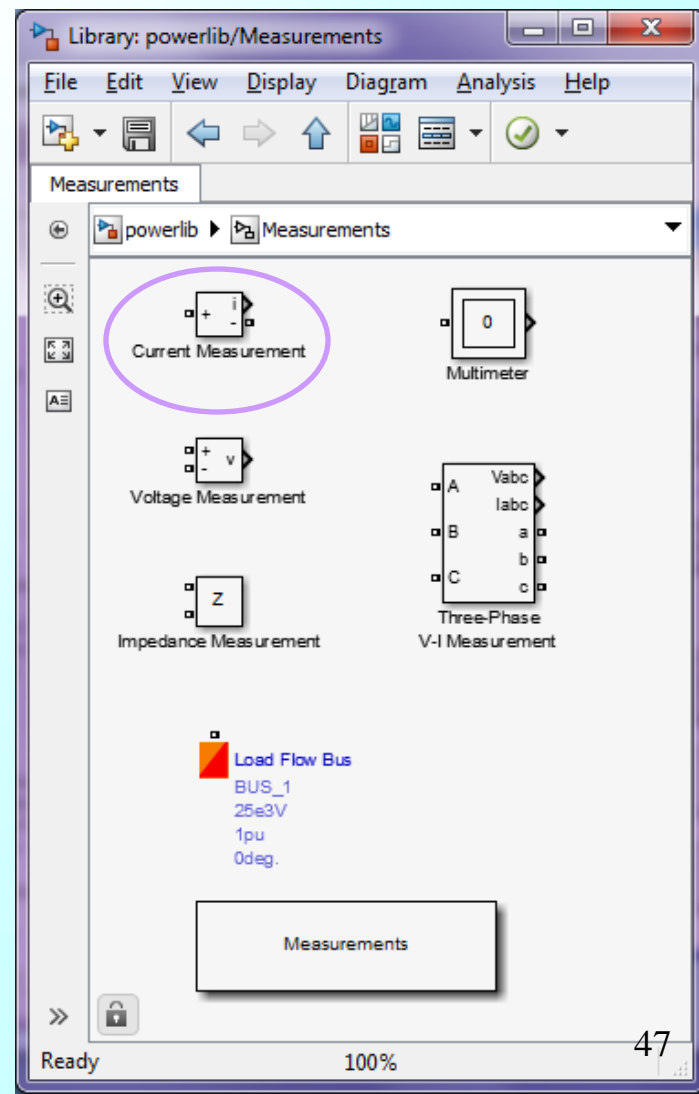
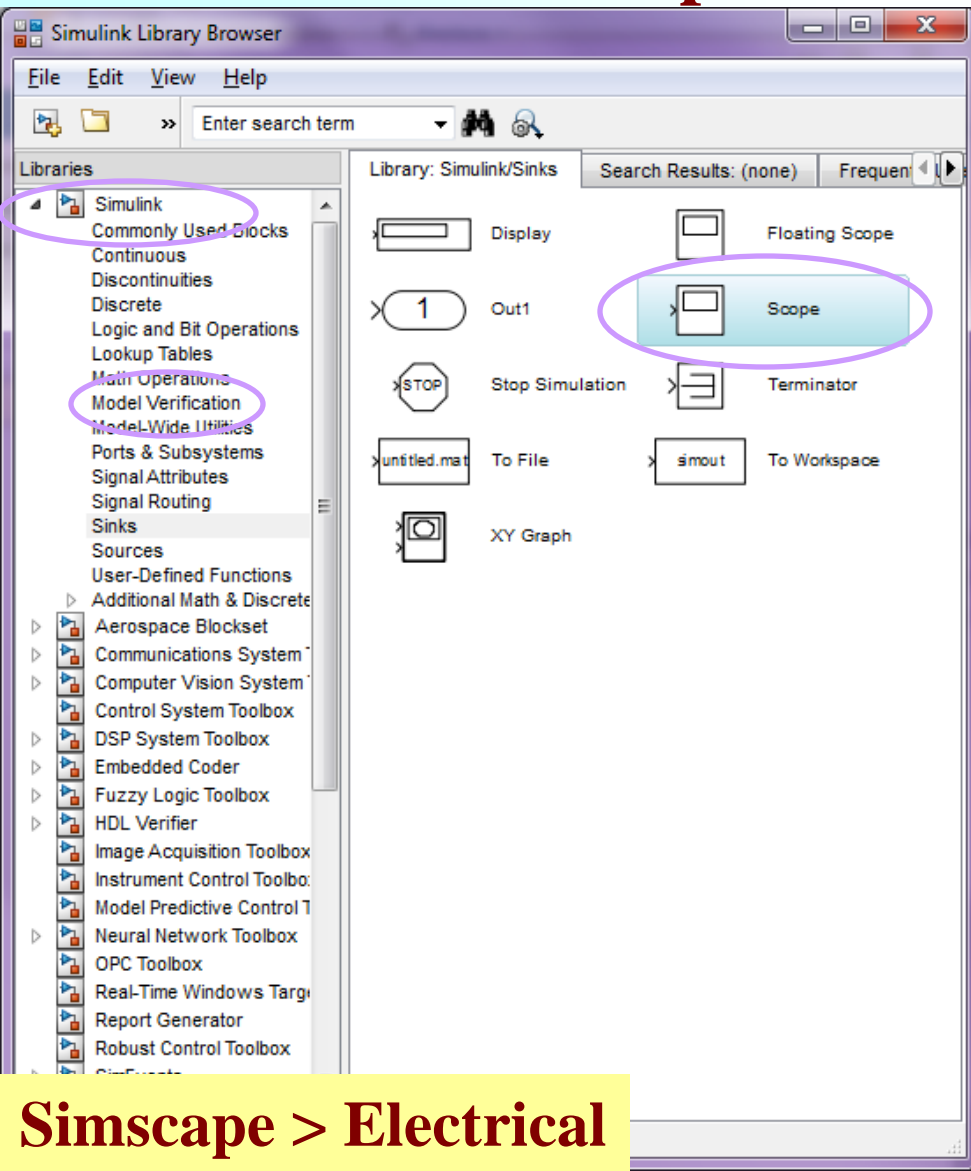


# Симулација електричног кола коришћењем **Simscape>Electrical** библиотеке



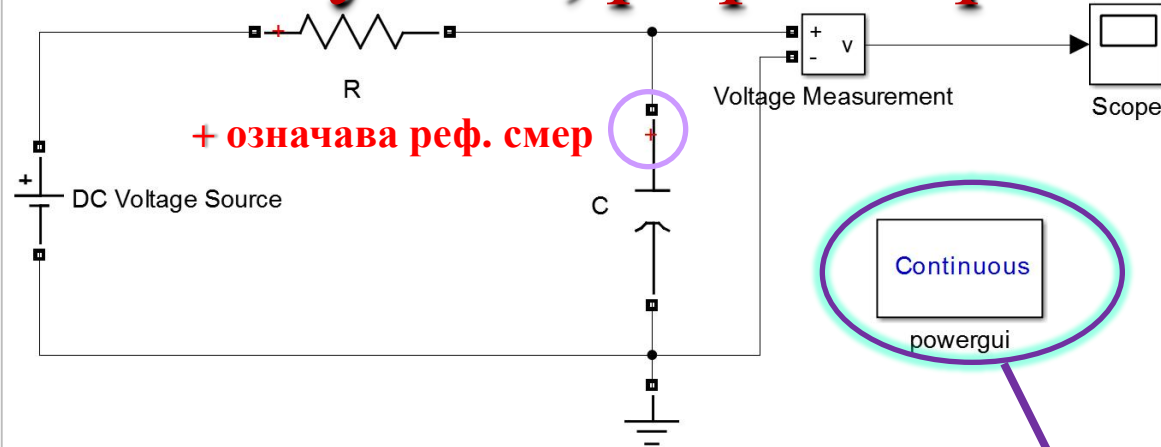
## Како се мери напон?

# Симулација електричног кола коришћењем **Simscape>Electrical** библиотеке



# Почетни услов, реф. смер...

+ означава реф. смер



Block Parameters: C

Series RLC Branch (mask) (link)

Implements a series branch of RLC elements. Use the 'Branch type' parameter to add or remove elements from the branch.

Parameters

Branch type: C

Capacitance (F): 1e-6

Set the initial capacitor voltage

Capacitor initial voltage (V): -10

Measurements: None

OK Cancel Help

Плоче кондензатора се разликују!!!

Block Parameters: powergui

PSB option menu block (mask)

Set simulation type, simulation parameters, and preferences.

Solver Tools Preferences

Steady-State	Initial State
Machine Initialization	Impedance Measurement
FFT Analysis	Use Linear System Analyzer
Hysteresis Design	RLC Line Parameters
Generate Report	Customize SPS blocks
Load Flow	
Load flow settings	

OK Cancel Help

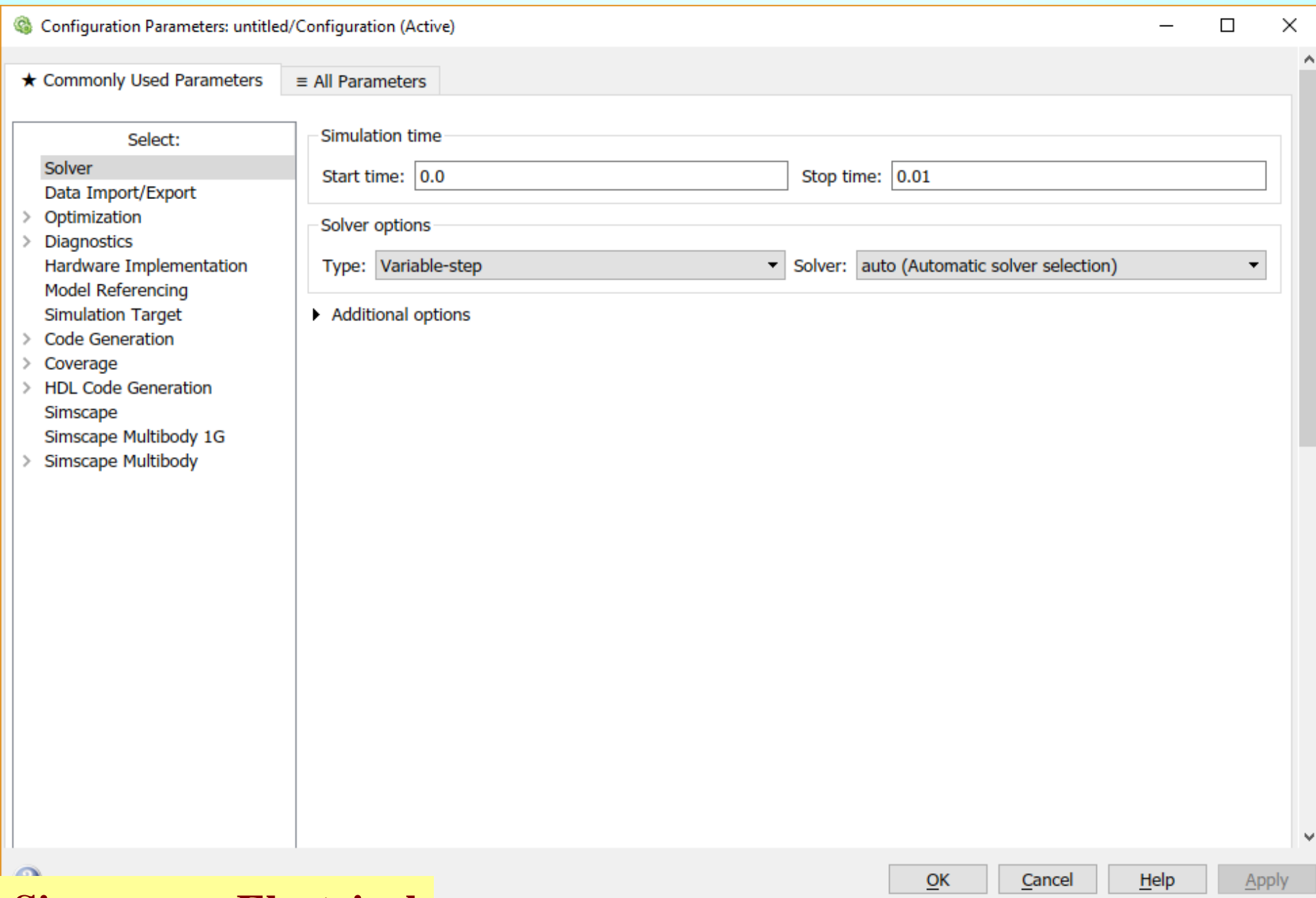
Powergui Initial States Setting Tool. model: untitled

Initial electrical state values for simulation:

1	'Uc'	C	=	-10 V
---	------	---	---	-------

Simscape > Electrical





Configuration Parameters: untitled/Configuration (Active)

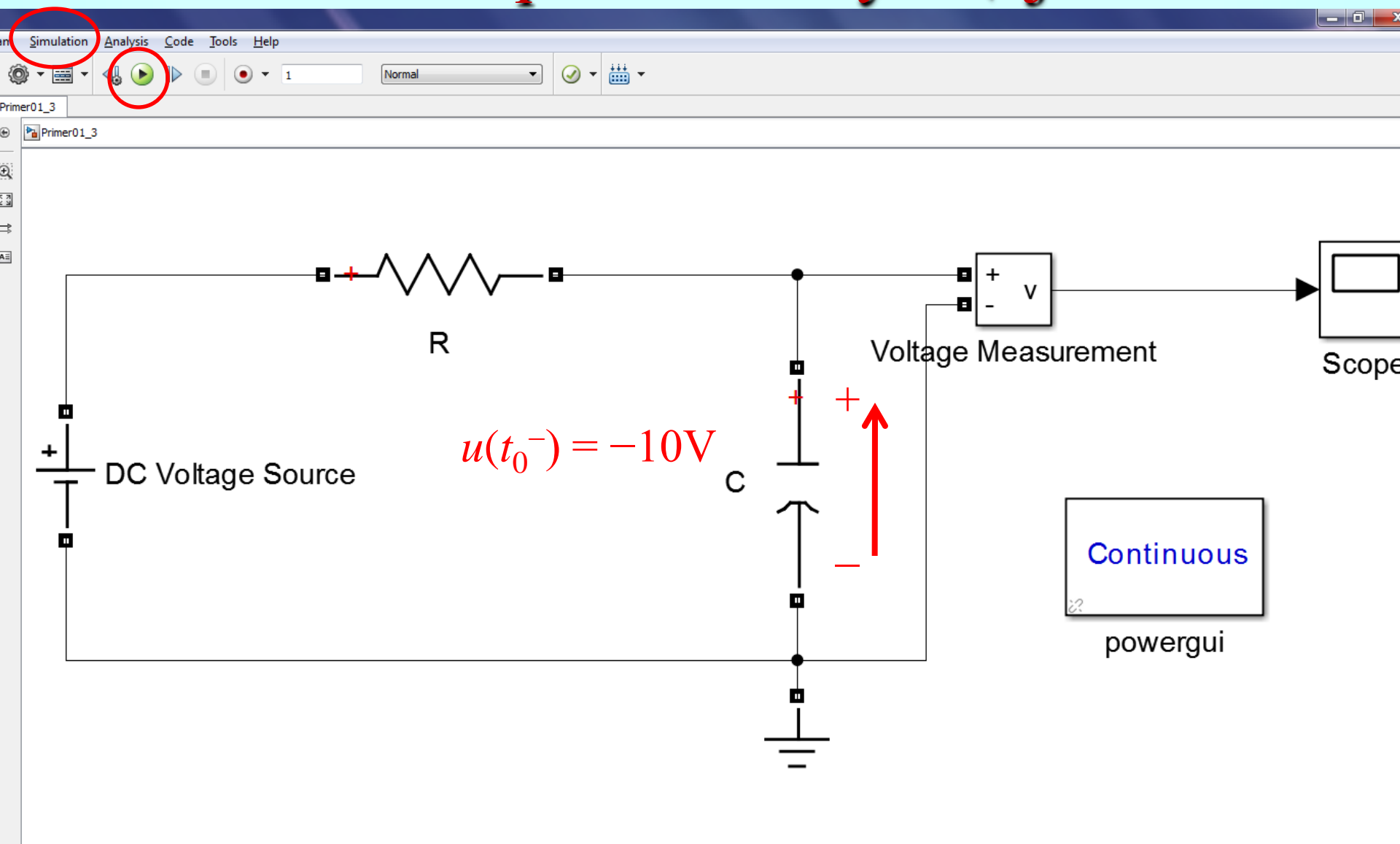
★ Commonly Used Parameters    ≡ All Parameters

Category: All    Search selected category

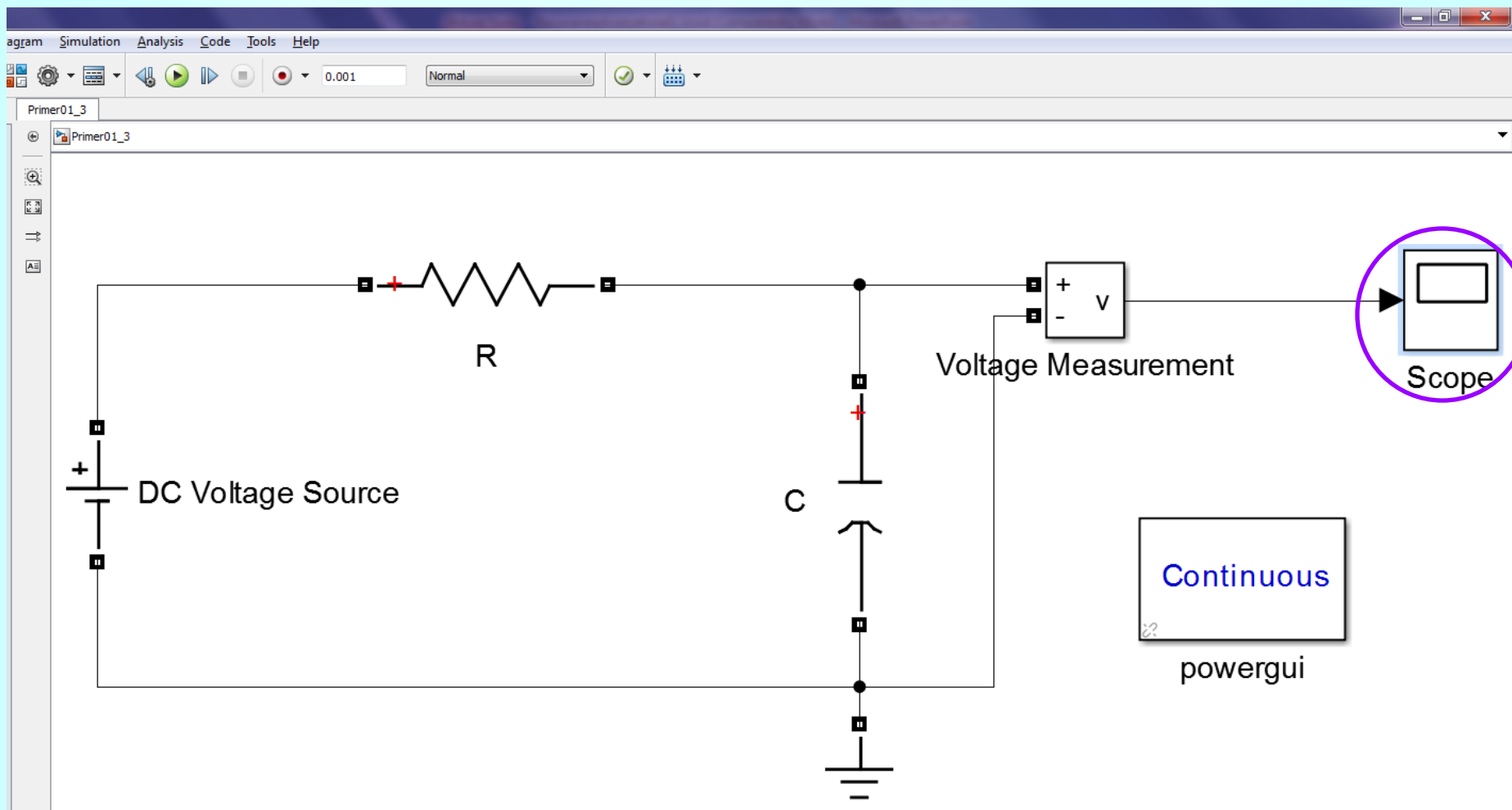
Parameter	Value	Command-Line Name
<b>Solver ▶ Simulation time</b>		
> Start time Simulation start time. Note that the values that you specify as block i...	0.0	StartTime
> Stop time Simulation stop time.	0.01	StopTime
<b>Solver ▶ Solver options</b>		
> Type Choose a variable or fixed-step solver.	Variable-step	SolverType
> Solver Choose a solver. If disabled, enable in "Additional options" by changi...	auto (Automatic solver selection)	Solver
<b>Solver ▶ Additional options</b>		
> Max step size Maximum step size for a variable-step solver.	1e-4	MaxStep
> Relative tolerance Specify the largest acceptable solver error, relative to the size of eac...	1e-3	RelTol
> Min step size Minimum step size for a variable-step solver.	auto	MinStep
> Absolute tolerance Specify the largest acceptable solver error, as the value of the meas...	auto	AbsTol
> Initial step size Specify the size of the first time step that the solver takes.	auto	InitialStep
> Shape preservation Improve the integration accuracy by preserving the shape of states b...	Disable All	ShapePreserveControl

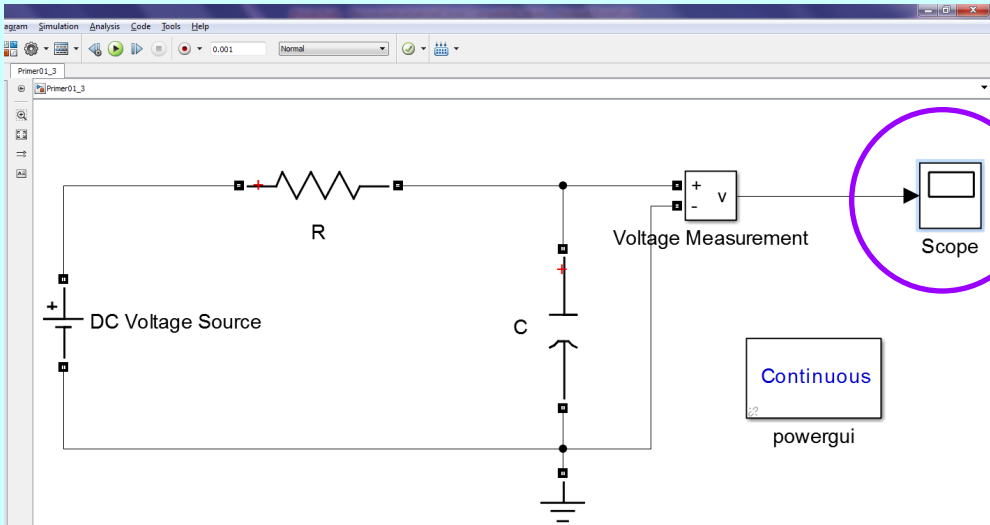
OK    Cancel    Help    Apply

# Покретање симулације...



# Налажење одзива... Осцилоскоп

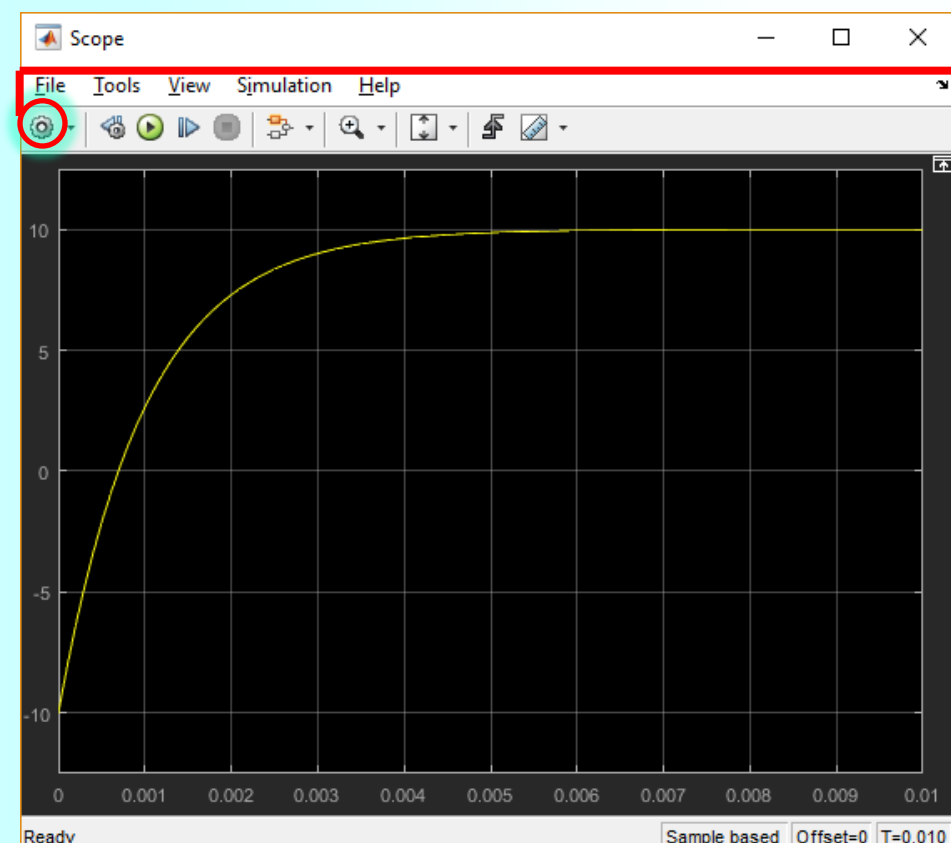




Configuration Properties: Scope

Main Time Display Logging

- Open at simulation start
- Display the full path
- Number of input ports: 1 Layout
- Sample time: -1
- Input processing: Elements as channels (sample based) ▼
- Maximize axes: Off ▼
- Axes scaling: Manual



Configuration Properties: Scope

Main Time Display Logging

- Time span: Auto
- Time span overrun action: Wrap
- Time units: None
- Time display offset: 0
- Time-axis labels: Bottom displays only
- Show time-axis label

Configuration Properties: Scope

Main Time Display Logging

- Active display: 1 ▼
- Title: %<SignalLabel>
- Show legend  Show grid
- Plot signals as magnitude and phase
- Y-limits (Minimum): -12.49989
- Y-limits (Maximum): 12.49898
- Y-label:

Configuration Properties: Scope

Main Time Display Logging

- Limit data points to last: 5000
- Decimation: 2
- Log data to workspace
- Variable name: ScopeData
- Save format: Dataset

**Simscape > Electrical**

Configuration Parameters: untitled/Configuration (Active)

★ Commonly Used Parameters    ≡ All Parameters

Category: All    Search selected category

Parameter	Value	Command-Line Name
<b>Solver ▶ Simulation time</b>		
> Start time Simulation start time. Note that the values that you specify as block i...	0.0	StartTime
> Stop time Simulation stop time.	0.01	StopTime
<b>Solver ▶ Solver options</b>		
> Type Choose a variable or fixed-step solver.	Variable-step	SolverType
> Solver Choose a solver. If disabled, enable in "Additional options" by changi...	auto (Automatic solver selection)	Solver
<b>Solver ▶ Additional options</b>		
> Max step size Maximum step size for a variable-step solver.	1e-4	MaxStep
> Relative tolerance Specify the largest acceptable solver error, relative to the size of eac...	1e-3	RelTol
> Min step size Minimum step size for a variable-step solver.	auto	MinStep
> Absolute tolerance Specify the largest acceptable solver error, as the value of the meas...	auto	AbsTol
> Initial step size Specify the size of the first time step that the solver takes.	auto	InitialStep
> Shape preservation Improve the integration accuracy by preserving the shape of states b...	Disable All	ShapePreserveControl

$\tau = RC = 1 \text{ ms}$

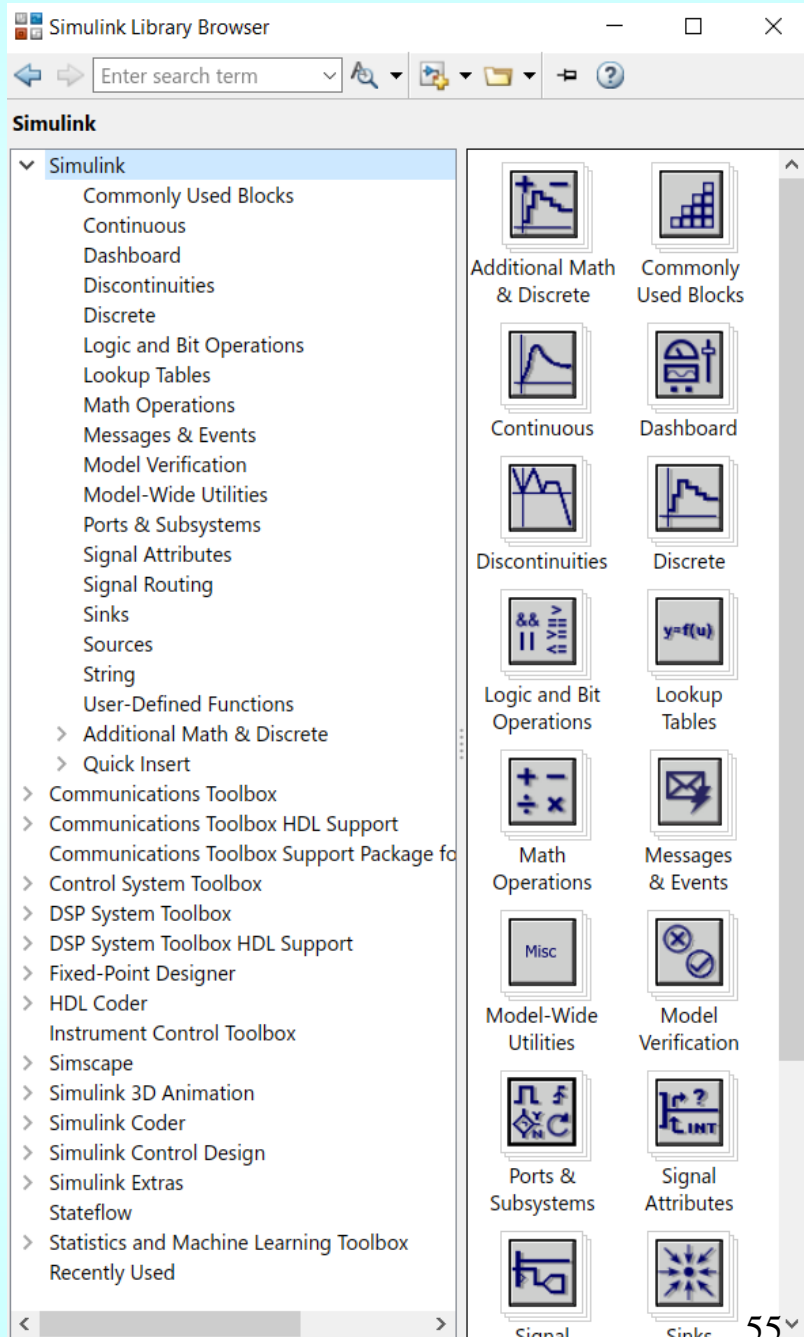
$\tau/10 = 0.1 \text{ ms}$

OK    Cancel    Help    Apply

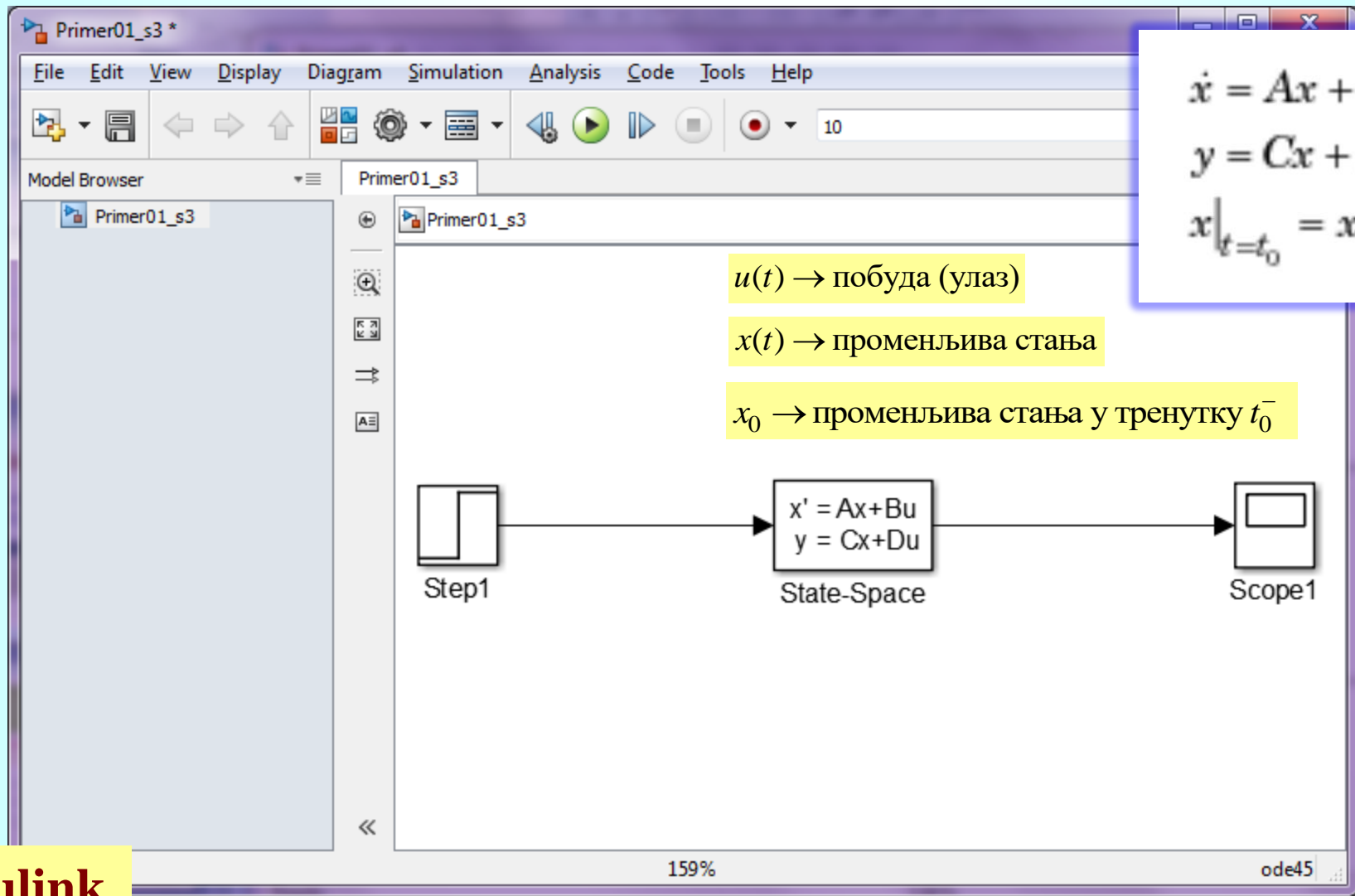


# Simulink

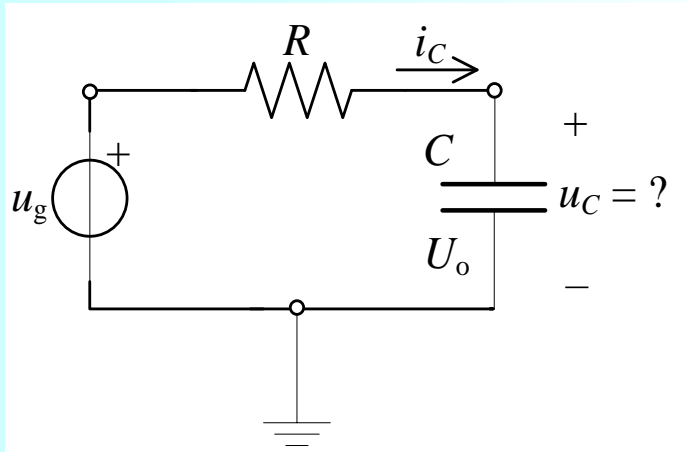
- Решавање кола може се извршити његовим свођењем на систем линеарних диференцијалних једначина
- Дати систем може се представити једноставним блоком са више улаза и излаза



# Симулација електричног кола као уопштеног система коришћењем Simulink-а



# Симулација електричног кола као уопштеног система коришћењем Simulink-а



$u = u_g(t) \rightarrow$  побуда (улаз)

$x = u_C(t) \rightarrow$  напон кондензатора (променљива стања и одзив - излаз)

$x(t_0^-) = U_0 \rightarrow$  напон кондензатора у тренутку  $t_0^-$

коло је образовано у тренутку  $t_0 = 0$

$$R = 1 \text{ k}\Omega$$

$$C = 1 \mu\text{F}$$

$$u_g(t) = U h(t), U = 10 \text{ V}$$

$$u_C(t_0^-) = U_0 = -10 \text{ V}$$

$$u_g(t) = Ri_C + u_C(t)$$

$$i_C = C \frac{du_C}{dt}$$

$$u_C(t_0^-) = U_0 = -10 \text{ V}$$

$$\begin{aligned} \dot{x} &= Ax + Bu \\ y &= Cx + Du \\ x|_{t=t_0} &= x_0, \end{aligned}$$

$$\frac{du_C(t)}{dt} = \frac{i_C}{C} = \frac{u_g(t) - u_C(t)}{RC} = -\frac{u_C(t)}{RC} + \frac{u_g(t)}{RC}$$

$$u_C(t_0^-) = U_0 = -10 \text{ V}$$

$$\frac{du_C(t)}{dt} = Au_C(t) + Bu_g(t) \Rightarrow A = -\frac{1}{RC} = -1000, B = 1000$$

$$u_C(t) = Cu_C(t) \Rightarrow C = 1, D = 0$$

$$u_C(t_0^-) = U_0 = -10 \text{ V}$$

# Симулација електричног кола као уопштеног система коришћењем Simulink-а

Source Block Parameters: Step1

Step

Output a step.

Parameters

Step time:  
0

Initial value:  
0

Final value:  
10

Sample time:  
0

Interpret vector parameters as 1-D

Enable zero-crossing detection

OK Cancel Help Apply

Function Block Parameters: State-Space

State Space

State-space model:  
 $dx/dt = Ax + Bu$   
 $y = Cx + Du$

Parameters

A:  
-1000

B:  
1000

C:  
1

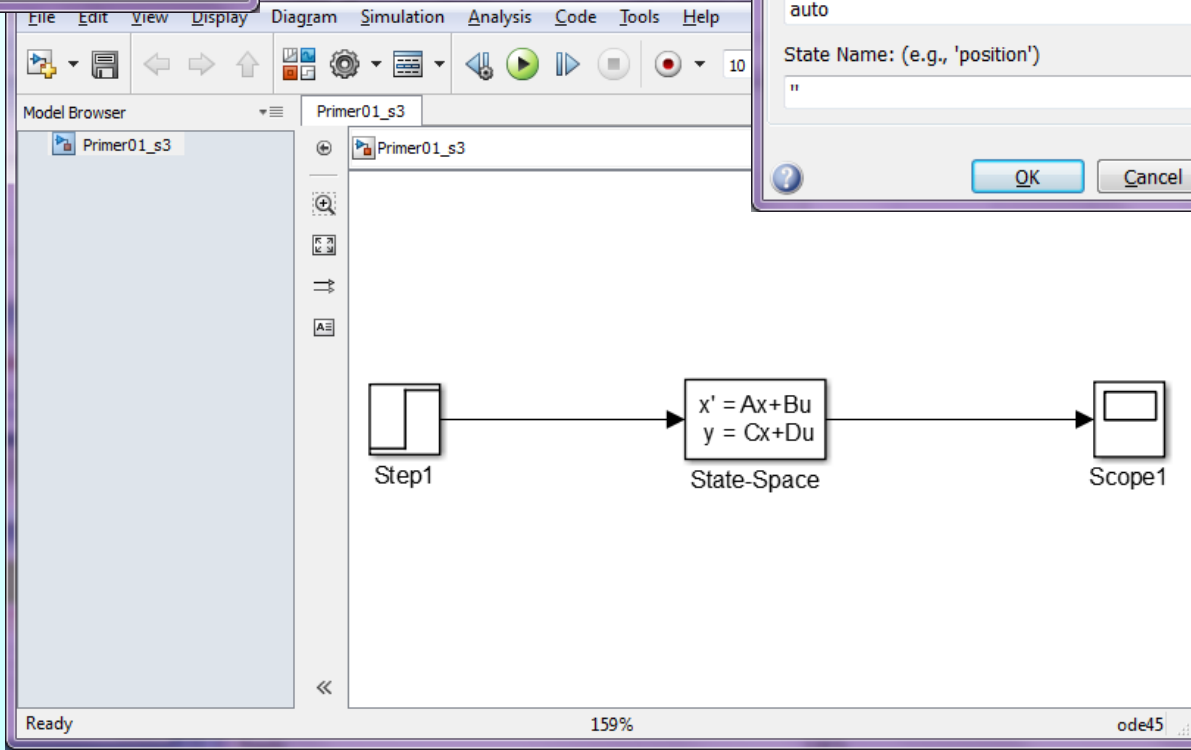
D:  
0

Initial conditions:  
-10

Absolute tolerance:  
auto

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

OK Cancel Help Apply



# Симулација електричног кола као уопштеног система коришћењем Simulink-а

Function Block Parameters: State-Space

State Space

State-space model:  
 $dx/dt = Ax + Bu$   
 $y = Cx + Du$

Parameters

A:  
-1000

B:  
1000

C:  
1

D:  
0

Initial conditions:  
-10

Absolute tolerance:  
auto

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

OK Cancel

Source Block Parameters: Step1

Step

Output a step.

Parameters

Step time:  
0

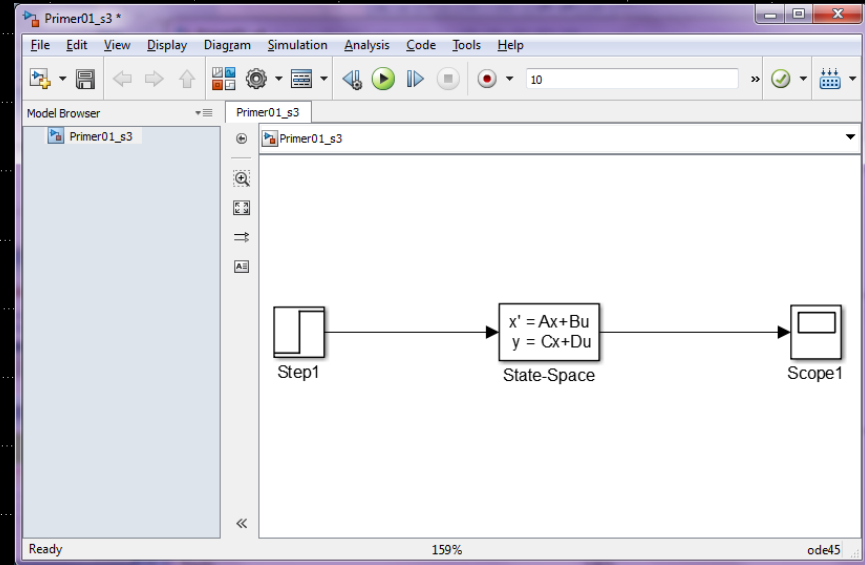
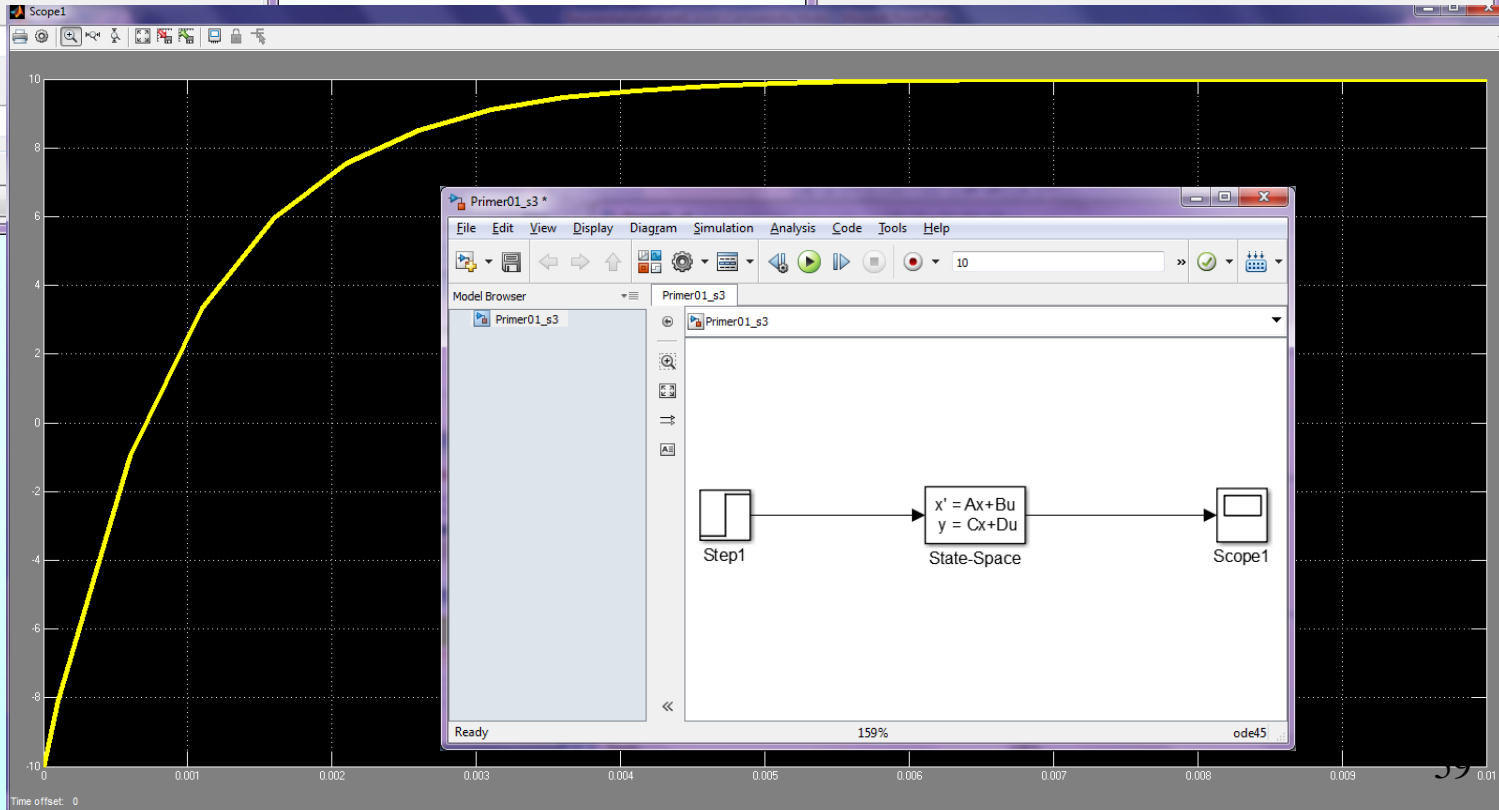
Initial value:  
0

Final value:  
10

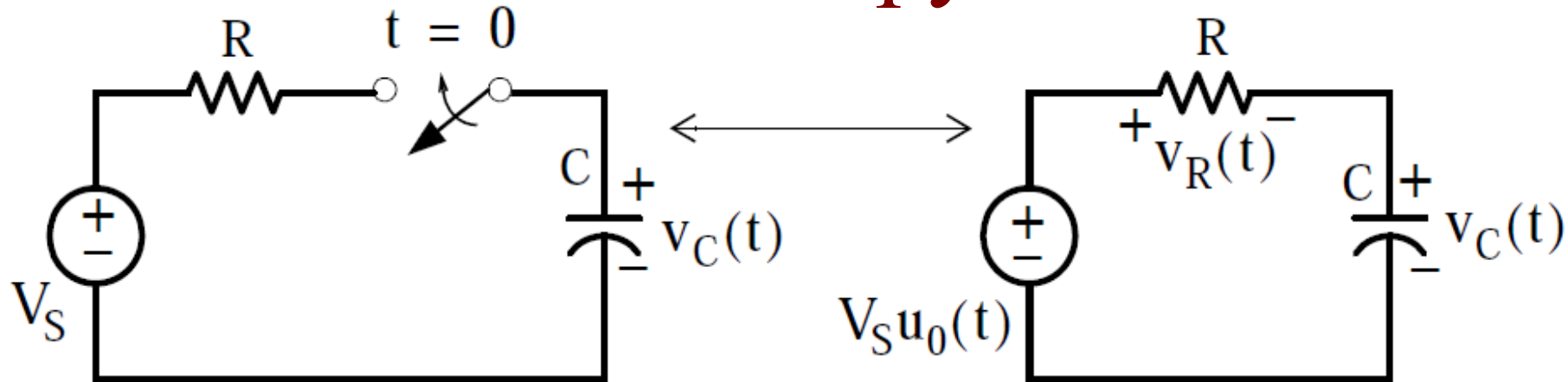
Sample time:  
0

Interpret vector parameters as 1-D

Enable zero-crossing detection



# Решимо “ручно”



$$v_R + v_C = V_S u_0(t)$$

$$i = i_C = C \frac{dv_C}{dt}$$

$$v_R = Ri = RC \frac{dv_C}{dt}$$

$$RC \frac{dv_C}{dt} + v_C = V_S u_0(t)$$

$$t > 0$$

$$RC \frac{dv_C}{dt} + v_C = V_S$$

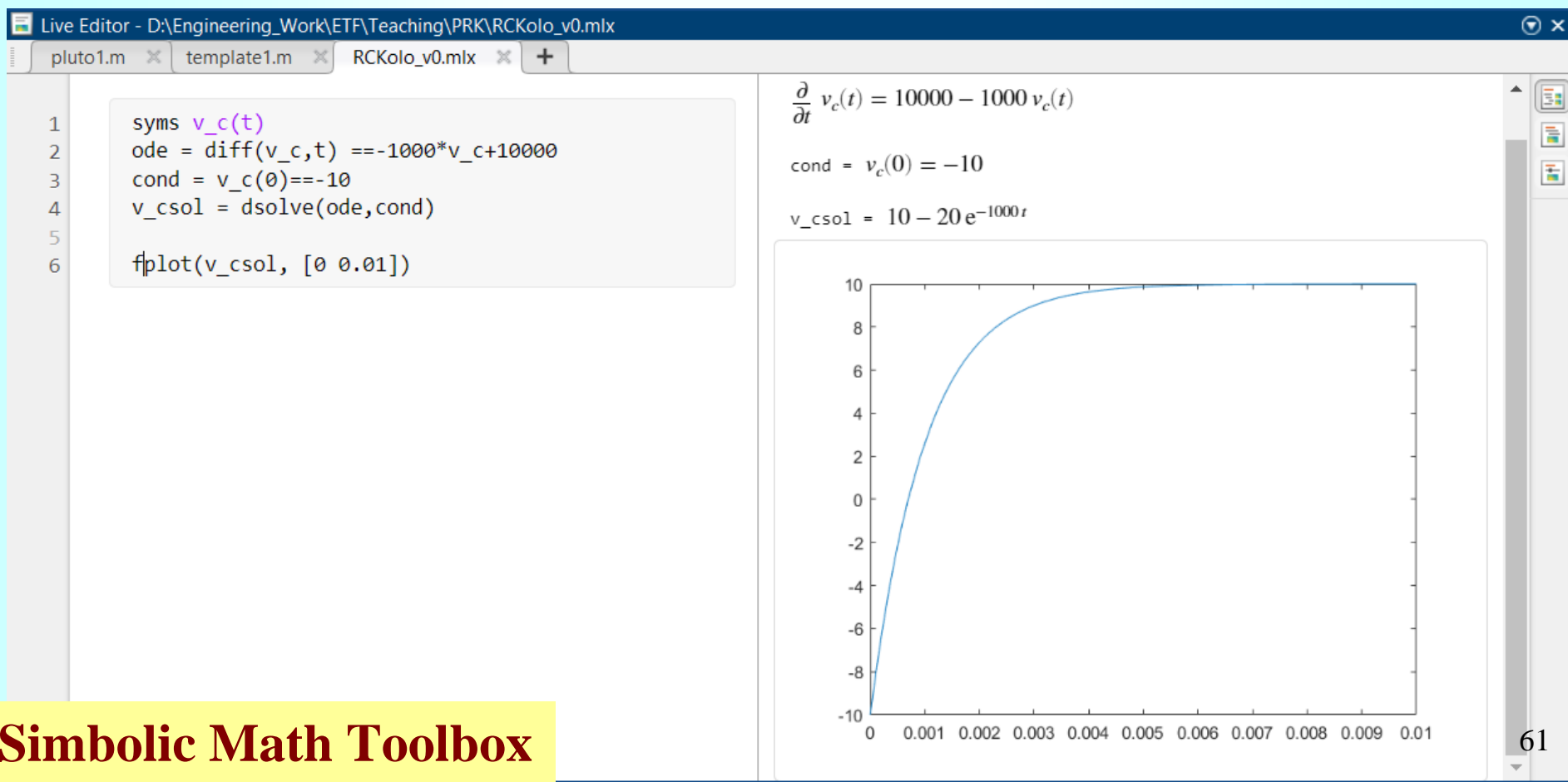
$$v_C(t) = (V_S - V_S e^{-(1/RC)t}) u_0(t)$$



# MATLAB

## Symbolic Math Toolbox (Live Script)

- Библиотека за симболички рачун (алгебарске и диференцијалне једначине)
- Омогућава нумеричку анализу резултата прорачуна



# wxMaxima

wxMaxima 20.06.6 [unsaved\*]

File Edit View Cell Maxima Equations Algebra Calculus Simplify List Plot Numeric Help

Maths

Mathematical Symbols

Plot using Draw

2D	3D
Expression	Implicit Plot
Parametric Plot	Points
Diagram title	Axis
Contour	Plot name
Line color	Fill color
Grid	Accuracy

```
(%i1) jednacine: [ug=R·iC+uC, iC=C·'diff(uC,t)];
(%o1) [ug = uC + R iC, iC = C (d/dt uC)]

(%i2) jednacineDuC: jednacine, 'diff(uC,t)=DuC;
(%o2) [ug = uC + R iC, iC = C DuC]

(%i3) JednacineIzvoda: eliminate(jednacineDuC,
[iC]);
(%o3) [-ug + uC + C DuC R]

(%i4) jednacineStanja: linsolve(JednacineIzvoda, DuC);
(%o4) [DuC = (ug - uC) / (C R)]

(%i5) jednacineDiff: jednacineStanja, DuC='diff(uC, t);
(%o5) [d/dt uC = (ug - uC) / (C R)]
```

```
(%i6) zamene: [ug=U];
(%o6) [ug=U]

(%i7) vrednosti: [R=1000, C=10^(-6), U=10, U0=-10];
(%o7) [R=1000, C= $\frac{1}{1000000}$ , U=10, U0=-10]

(%i8) JednacineDiffZamena: jednacineDiff, zamene;
(%o8) [ $\frac{d}{dt} uC = \frac{U - uC}{CR}$ ]

(%i9) ode2(JednacineDiffZamena, uC, t);
(%o9)  $uC = \%e^{-\frac{t}{CR}} \left( U \%e^{\frac{t}{CR}} + \%c \right)$ 

(%i10) ic1(% , t=0, uC=U0);
(%o10)  $uC = \%e^{-\frac{t}{CR}} \left( U \%e^{\frac{t}{CR}} + U0 - U \right)$ 

(%i11) uCt: ev(% , vrednosti);
(%o11)  $uC = \%e^{-1000 t} \left\{ 10 \%e^{1000 t} - 20 \right\}$ 

(%i17) wxplot2d(rhs(uCt), [t,0,0.01],
[xlabel," t [s] "],
[ylabel," uC [V] "],
[xtics, 0, 0.002, 0.01],
[legend, "Napon kondenzatora"], grid2d)$
```

