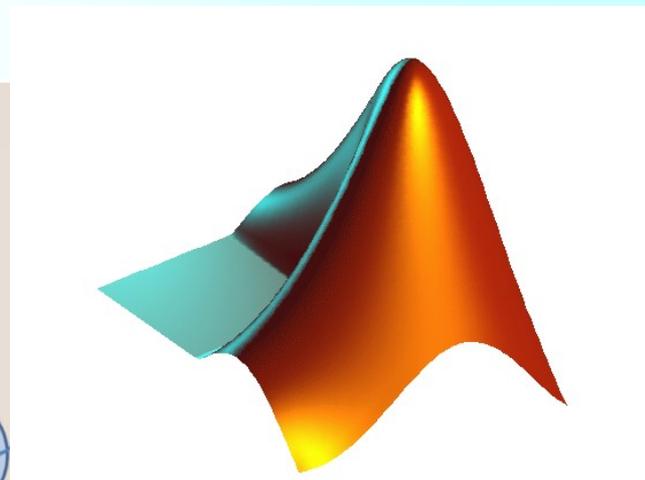
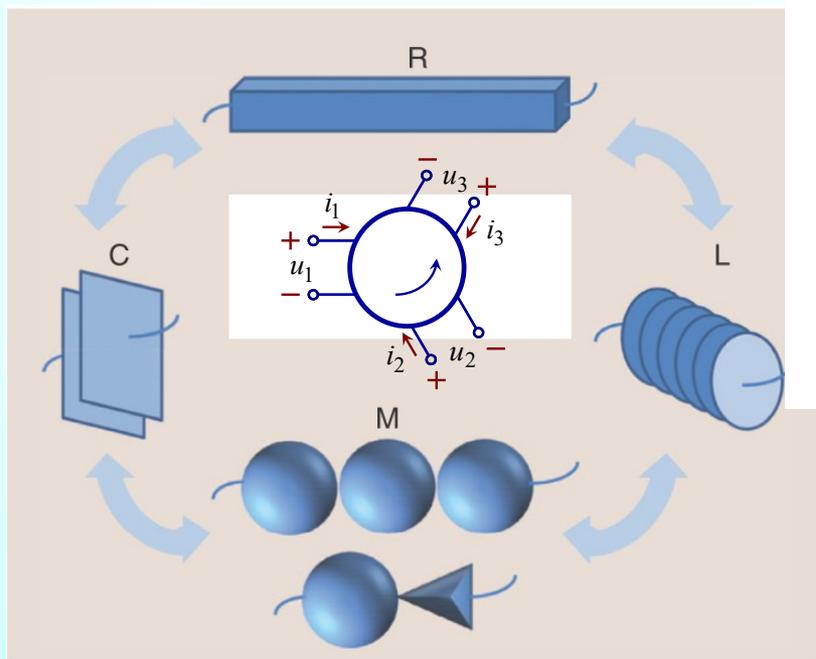


Практикум из рачунарске анализе кола

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**
- **Сарджај:** Рачунарске симулације електричних кола помоћу програма MATLAB/Simulink или Scilab/Xcos, LTspice и QucsStudio. Симболичко решавање кола програмима MATLAB/Symbolic Math или Symbolic Python и Maxima.

- **Наставници.** Др **Милка Потребих Иваниш**, редовни професор, соба 64 (milka_potrebic@etf.rs);
Др **Никола Баста**, доцент, соба 80 (nbasta@etf.rs).
- **Сарадници:** мс. инж. **Ања Ковачевић**, асистент, дипл. инж. **Анђела Нинковић**, сарадник у настави*.

- 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.
- **Пратити** званично представљање предмета и објављивање општих службених порука на адреси <http://tek.etf.rs/>

Начин полагања

- **ПРЕДИСПИТНЕ ОБАВЕЗЕ (70%) + ИСПИТ (30%) = УКУПНО (100%)**
- **Предиспитне обавезе (MATLAB)** реализују се полагањем колоквијума у РЦ, израдом домаћег задатка са усменом одбраном, или поенима освојеним кроз активности на часу – израда једноставнијих задатака у вредности од 5 до 10 испитних поена.
- Добровољна израда **MATLAB Onramp** теста (самостални пролазак кроз основни MATLAB курс у слободно време) носи додатних 5 бонус поена.
- Поени са свих активности се сабирају и максимално се може освојити 70%.
- **Испит** подразумева израду пројекта и његову одбрану, укупно 30%.
- Одбрана пројекта може се реализовати у свим испитним роковима. Израда пројектата се може реализовати у наведеним алтернативним софтверским алатима.
- За заинтересоване студенте може се обезбедити предрок.
- Поред класичних тема за пројекте од ове године нове теме су: Симулатори кола на Интернету. Могућност примене вештачке интелигенције у решавању електричних кола.
- *Напомена: Домаћи задаци и пројекти се могу радити у тиму од два студента, али се бране индивидуално.*

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

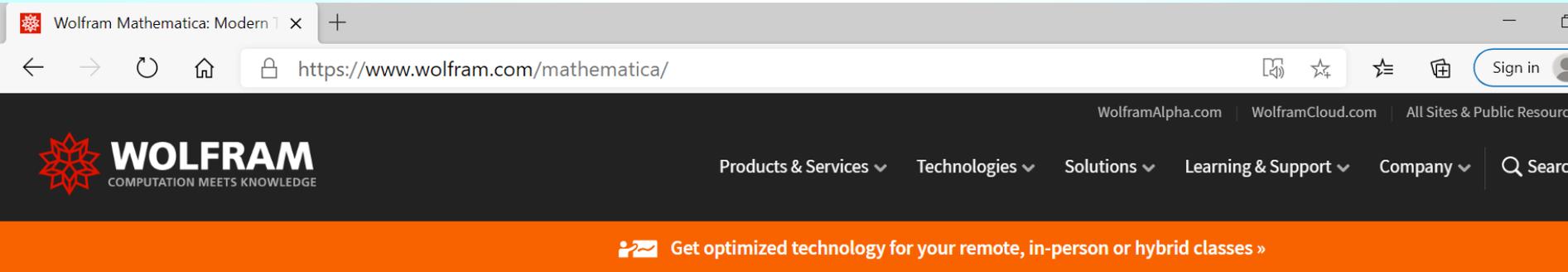
Free/Libre Open Source Software (FLOSS)

Моделовање електричних кола

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

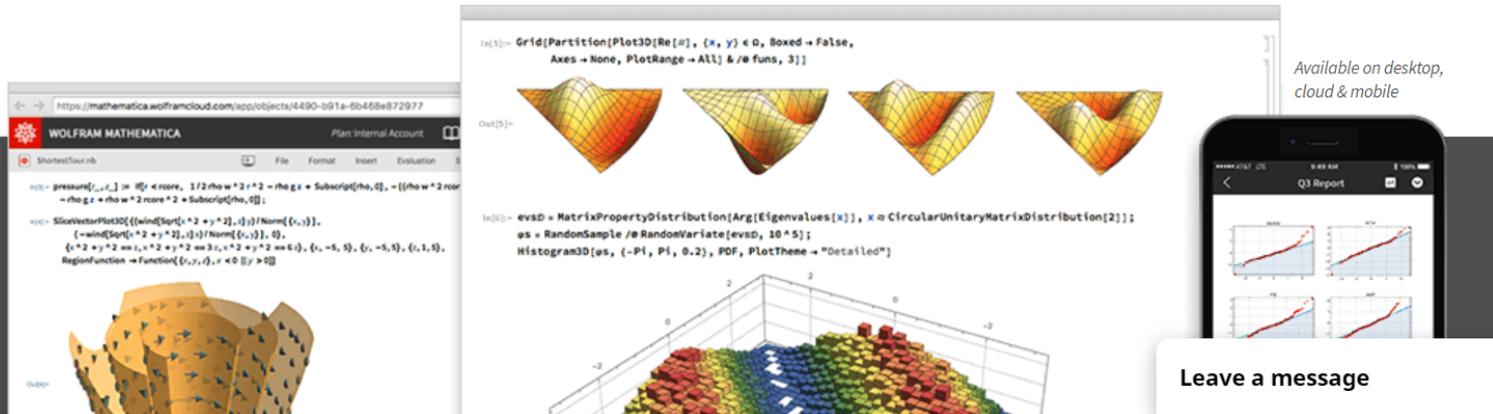
Mathematica

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



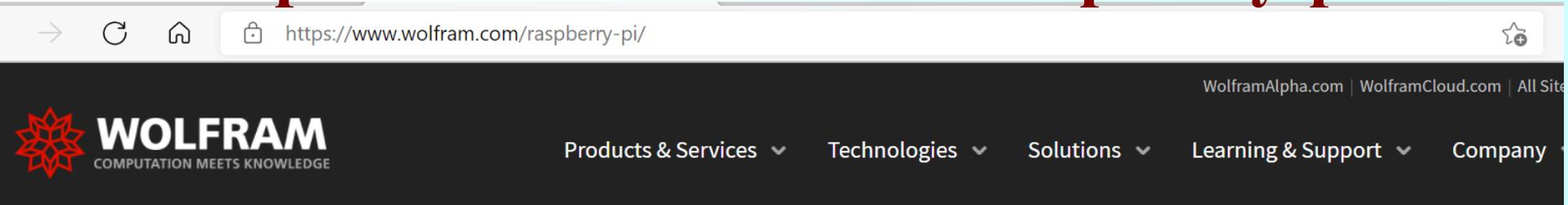
WOLFRAM MATHEMATICA

The world's definitive system for modern technical computing

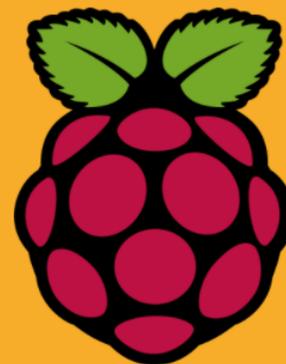


Mathematica free on every Raspberry Pi!

<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:

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

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

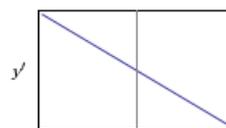
Differential equation solution:

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? 8

Maxima

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

The screenshot shows the Maxima website interface. At the top, there's a navigation bar with links for Downloads, Documentation, Project, and Page Top. Below that, a code editor displays the following Maxima code 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 are language options: In other languages: عربي • Deutsch • Español • Italiano • Nederlands • Português • Русский • Türkçe • 中文.

Maxima, a Computer Algebra System

Maxima is a system for the manipulation of symbolic and numerical expressions, including differentiation, integration, Taylor series, Laplace transforms, ordinary differential equations, systems of linear equations, polynomials, sets, lists, vectors, matrices and tensors. Maxima yields high precision numerical results by using exact fractions, arbitrary-precision integers and variable-precision floating-point numbers. Maxima can plot functions and data in two and three dimensions.

The Maxima source code can be compiled on many systems, including Windows, Linux, and MacOS X. The source code for all systems and precompiled binaries for Windows and Linux are available at the [SourceForge file manager](#).

Maxima is a descendant of Macsyma, the legendary computer algebra system developed in the late 1960s at the [Massachusetts Institute of Technology](#). It is the only system based on that effort still publicly available and with an active user community, thanks to its open source nature. Macsyma was revolutionary in its day, and many later systems, such as Maple and Mathematica, were

Recent Releases

Click on a version number to see the list of main changes.

- 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

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 large 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.

SymPy

www.sympy.org/

The screenshot shows the SymPy website homepage. The browser address bar displays `https://www.sympy.org/en/index.html`. The page features a dark green 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:
 - **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 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/>.

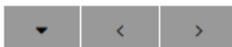
```
>>> diffeq = Eq(f(x).diff(x) + 1000*f(x), 10000)  
>>> diffeq
```

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

```
>>> 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. The following commands were executed:

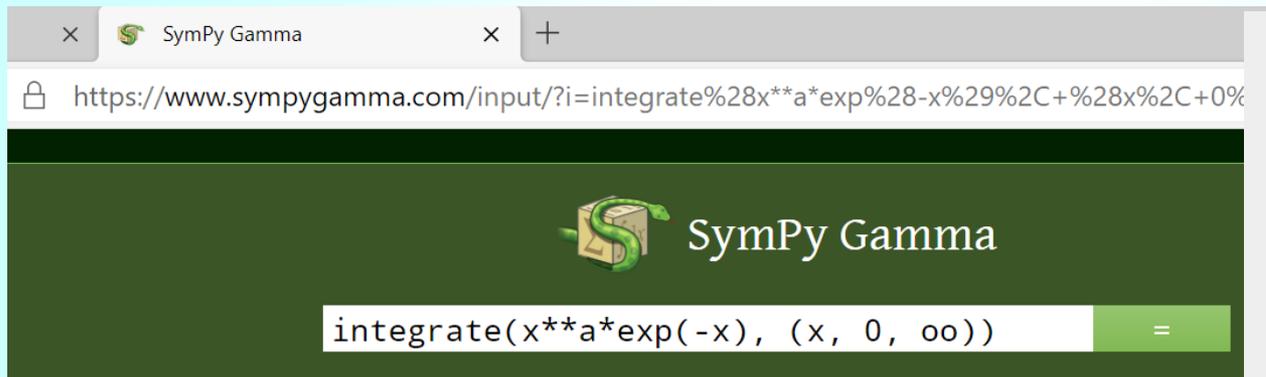
```
>>> from __future__ import division  
>>> from sympy import *  
>>> x, y, z, t = symbols('x y z t')  
>>> k, m, n = symbols('k m n', integer=True)  
>>> f, g, h = symbols('f g h', cls=Function)
```

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

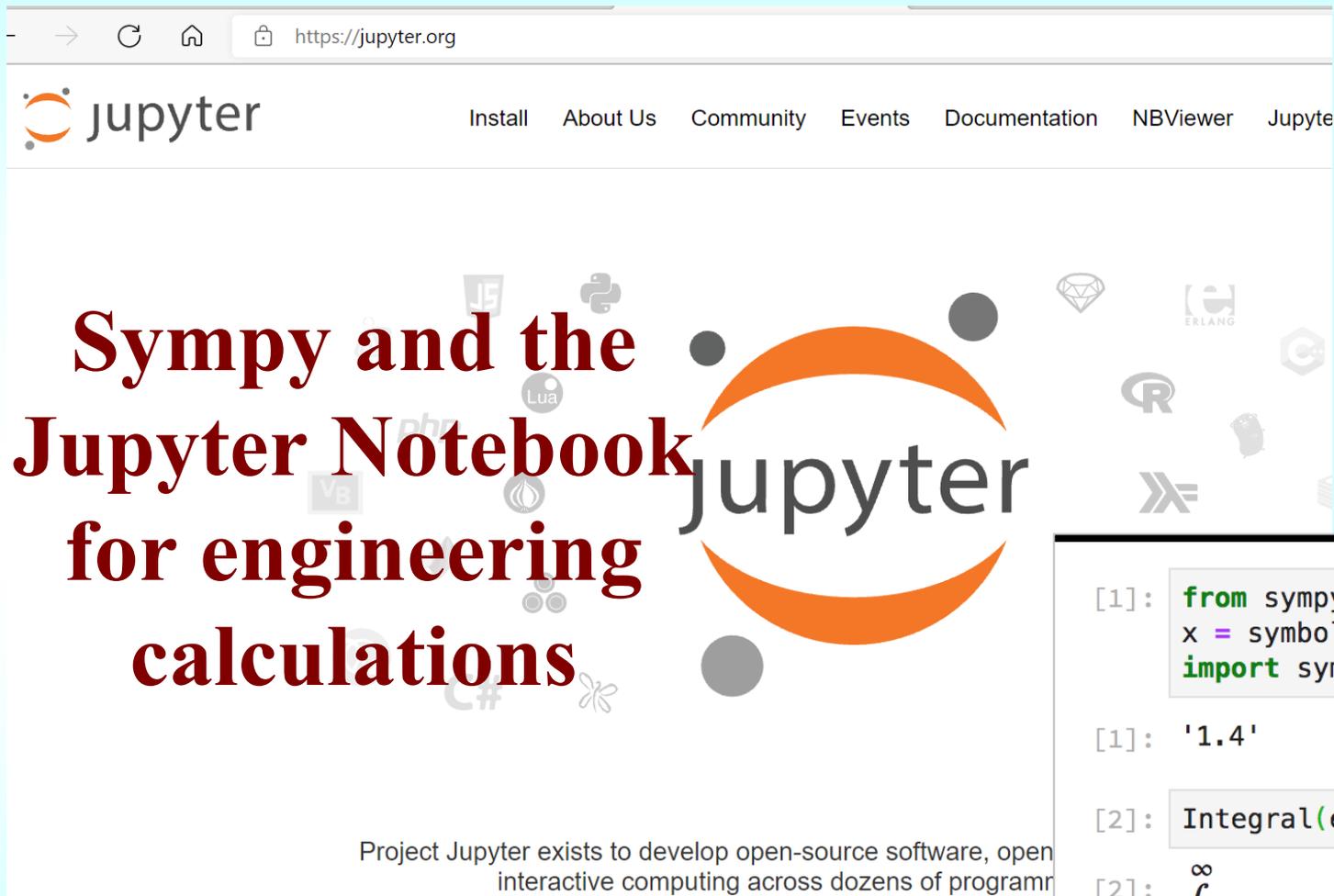
Calculus

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 navigation menu includes "Install", "About Us", "Community", "Events", "Documentation", "NBViewer", and "Jupyter". A large, semi-transparent Jupyter logo is centered on the page. Overlaid on the left side of the logo is the text "SymPy and the Jupyter Notebook for engineering calculations" in a large, dark red serif font. At the bottom of the page, a line of text reads: "Project Jupyter exists to develop open-source software, open interactive computing across dozens of programr".

Sympy and the Jupyter Notebook for engineering calculations

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



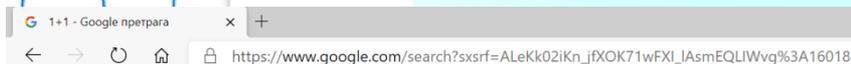
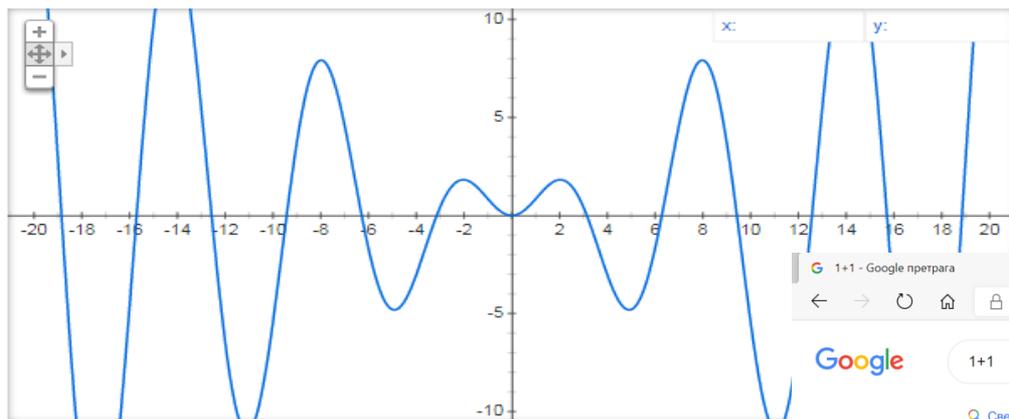
$x \cdot \sin(x)$



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 > Maths > Преведи ову страницу

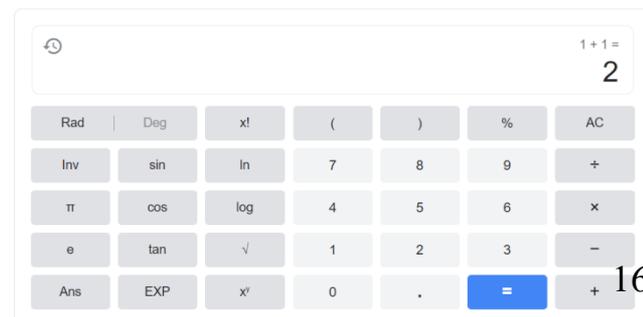
What is the integral of $x \sin(x) dx$? | MyTutor

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 > category > Преведи ову страницу

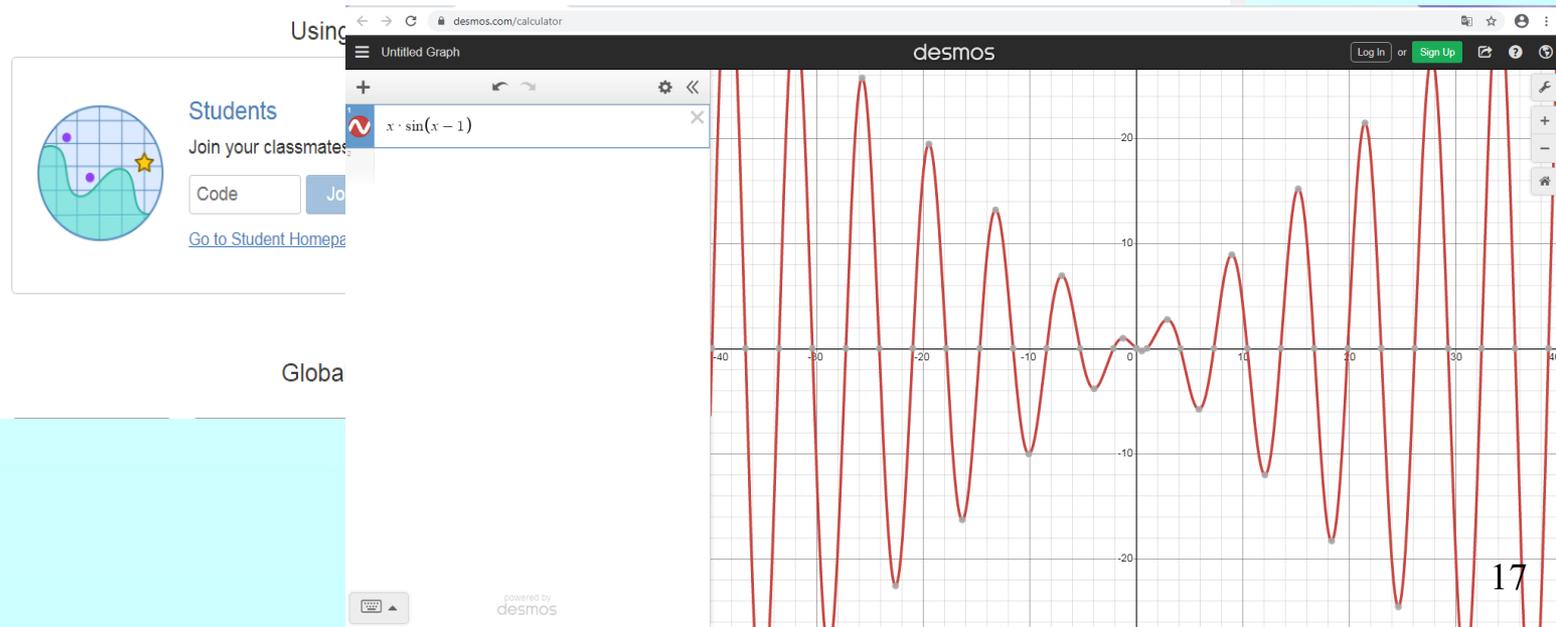
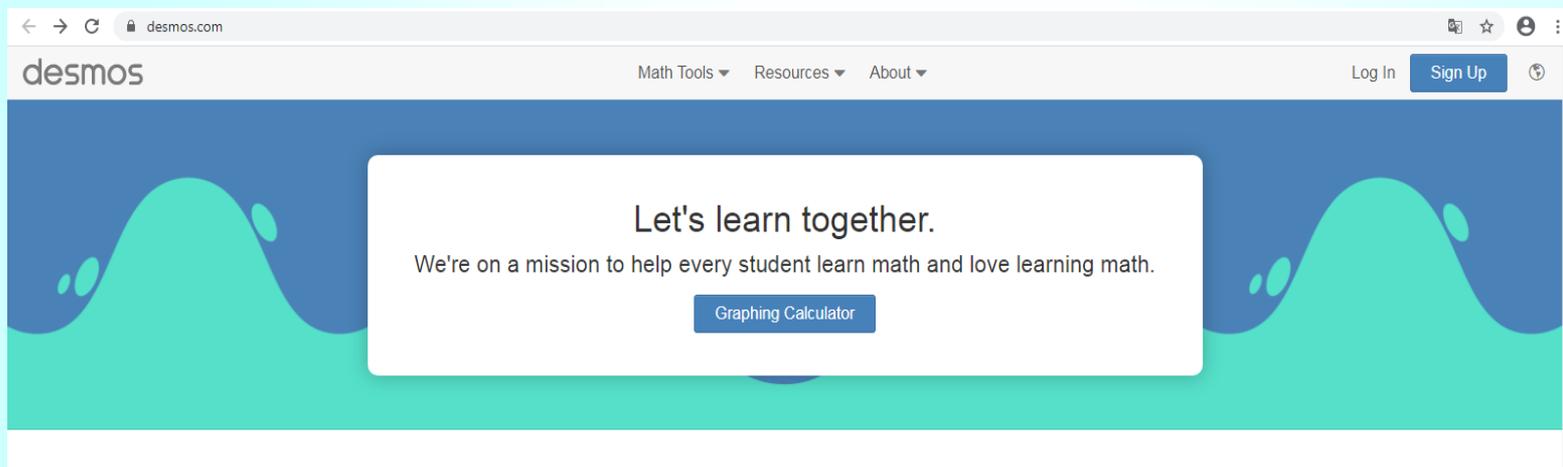
Ex 7.6, 1 - Find integration of $x \sin x$ - Chapter 7 Clas

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 >](#)

[Show Steps](#)

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

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](#)

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

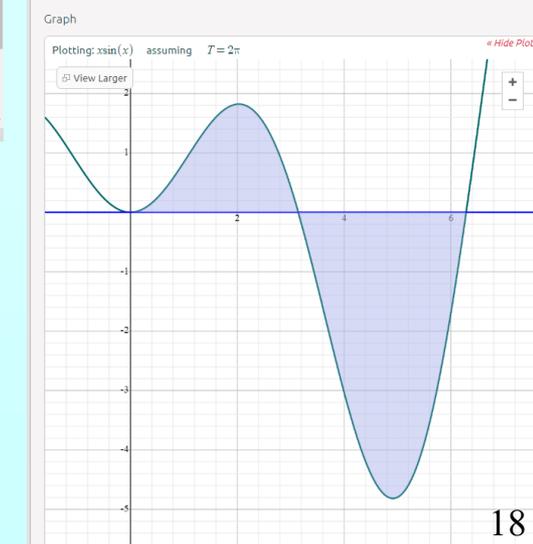
Simplify

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

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

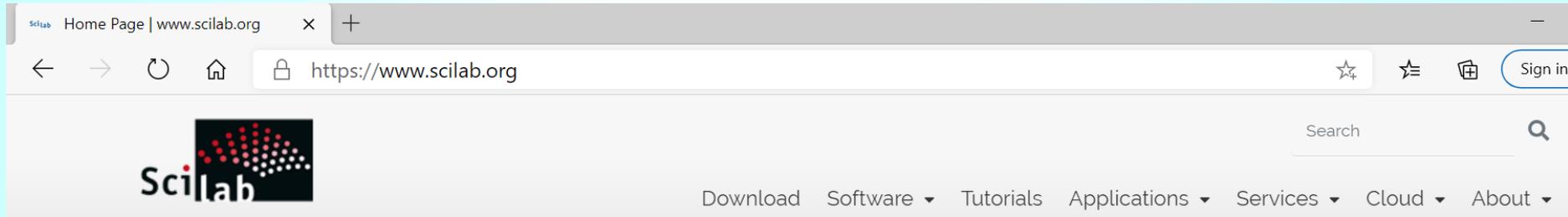
$= \sin(T) - T \cos(T)$

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



SciLab

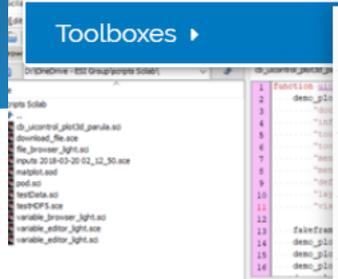
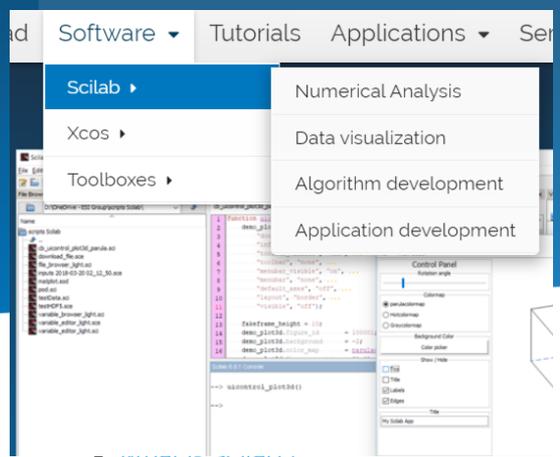
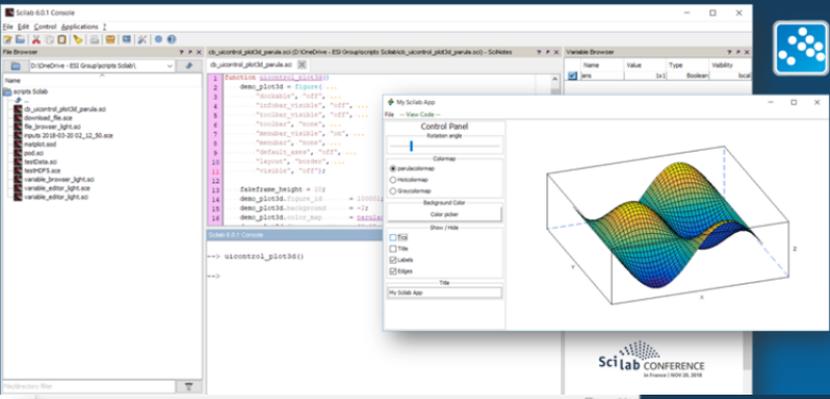
<https://www.scilab.org/>



Download Scilab 6.1.0

Windows, Linux and Mac OS X

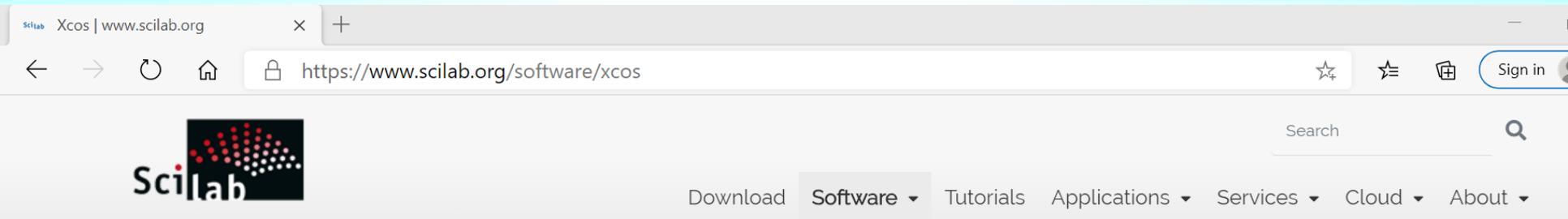
Open source software for numerical computation



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

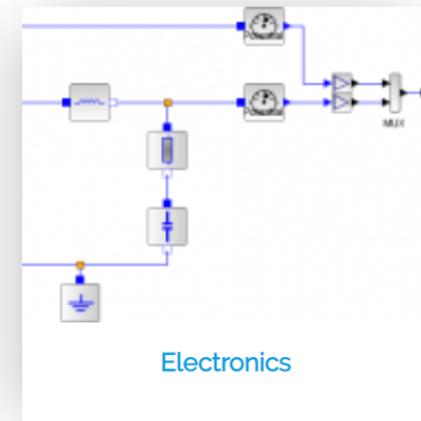
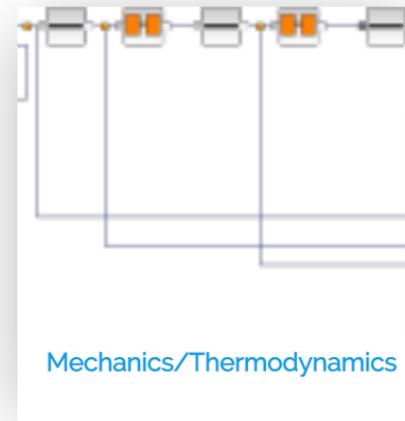
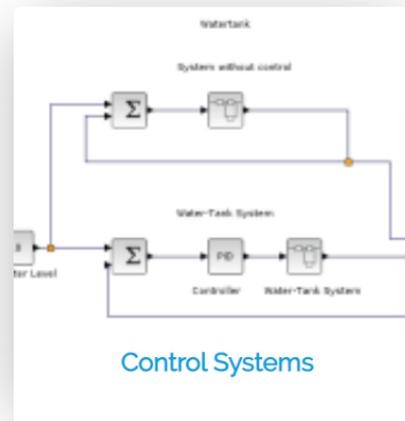
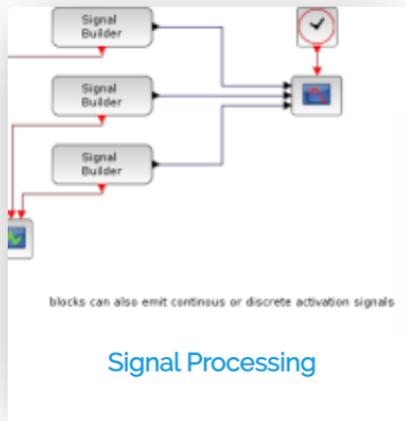
Xcos

<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 :

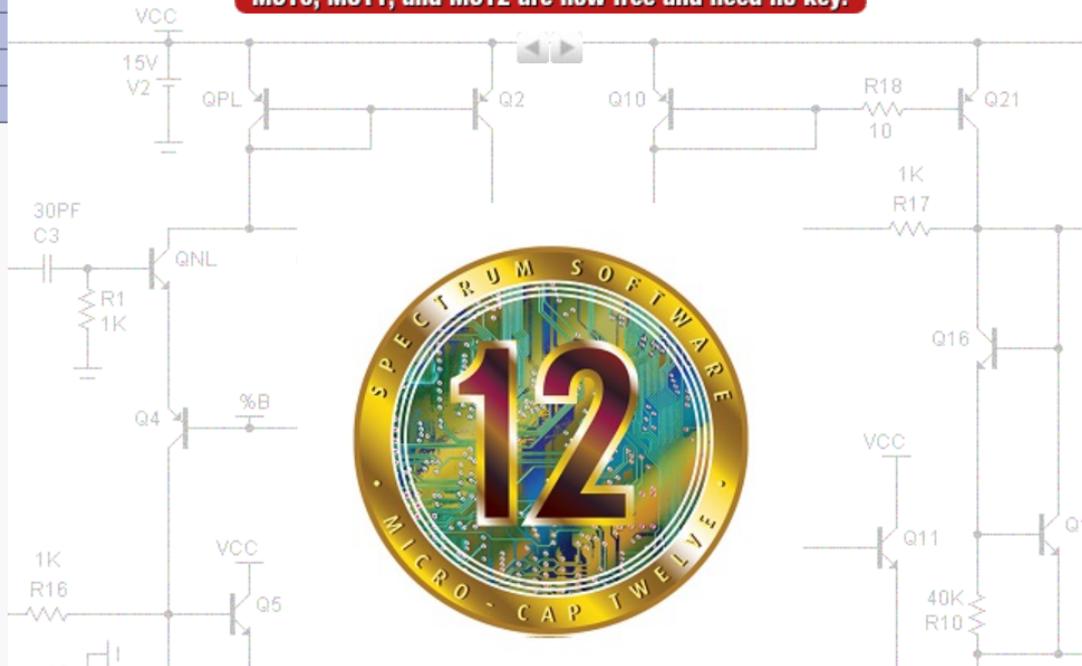
- MC12 Revision History
- Product Information
- Features Tour
- New MC12 Features

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, labeled "conventional power supply: transformer, 2-way-rectifier, filter". The circuit includes an AC voltage source V1 (230 V, 50 Hz), a primary resistor R_prim (0.05 Ohm), a transformer Tr1 (T=20), a secondary resistor R_sec (0.3 Ohm), a bridge rectifier, a filter capacitor C1 (1000 μF), and a load resistor R=100 Ohm. A "transient simulation" box is overlaid on the schematic, with parameters: TR1 Type=lin, Stop=60 ms, Points=3001. The left sidebar shows a project tree for "Simulation_Transient" with a list of schematics. The bottom right shows a simulation console window for "Simulation_Octave" with a list of files and a script listing parameters like TAPER_LENGTH and NUM_SECTION.

CircuitLab

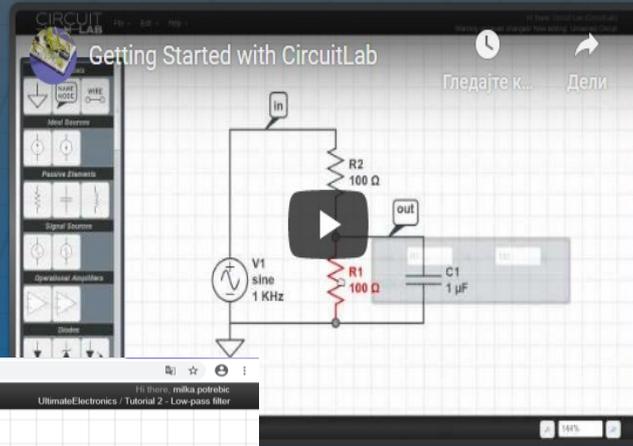
<https://www.circuitlab.com/>

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 →



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.

Textbook **NEW!**

Electronic systems with CircuitLab's free, quick.

[Full Circuit Design and Analysis](#)

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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

Launch Online Labs Download Free Trial

Select required signal such as sine, square

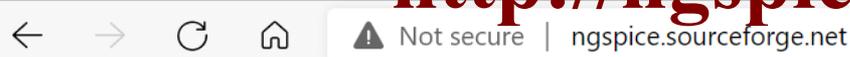
Get started with some sample circuits !

- 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 a positive or r

Fig. 1: DoCircuits - Home

ngSpice

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



MIXED MODE - MIXED LEVEL
CIRCUIT SIMULATOR
BASED ON BERKELEY'S SPICE3F5

NGSPICE SUMMARY

- 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

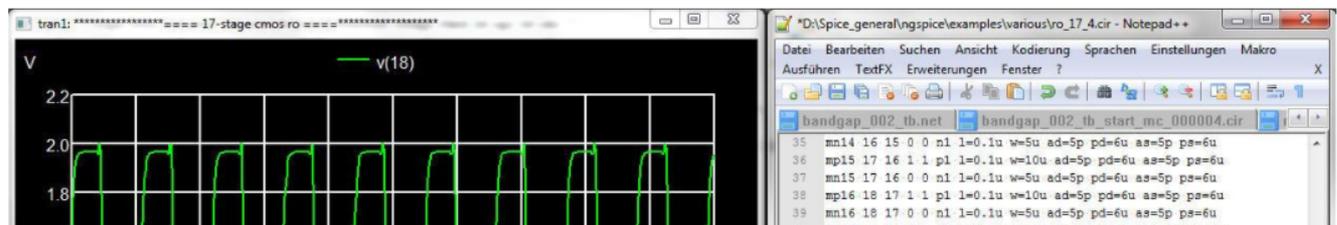
ngspice - open source spice simulator

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.



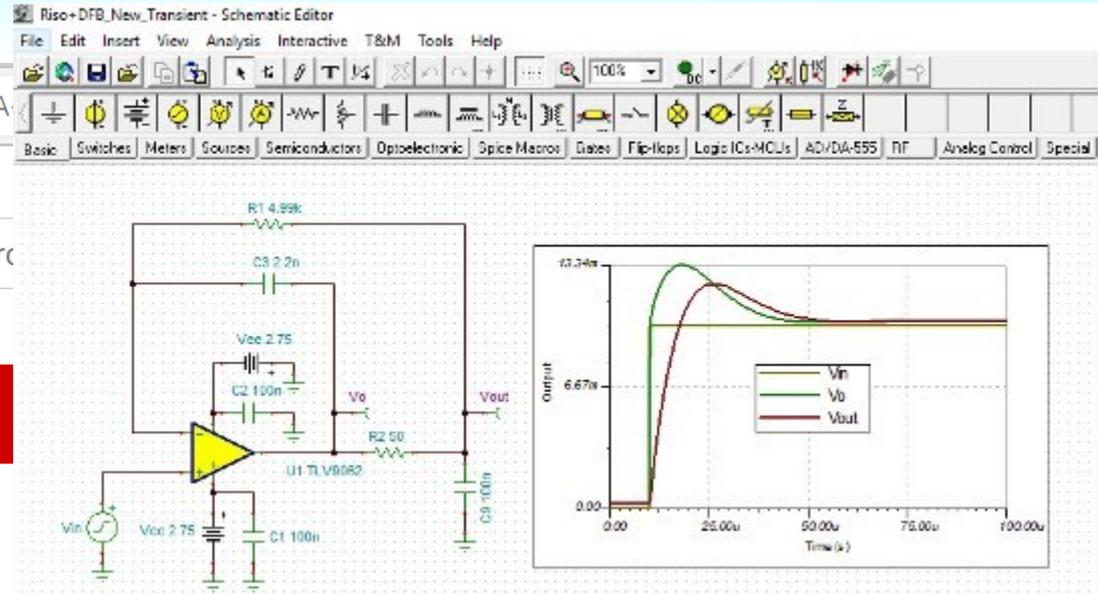
← → ↻ 🏠 🔒 <https://www.ti.com/tool/TINA>



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TINA-TI

SPICE-based analog simulation program

Overview Downloads Technical documentation Support & training

TINA-TI

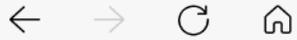
<https://www.ti.com/tool/TINA-TI>

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



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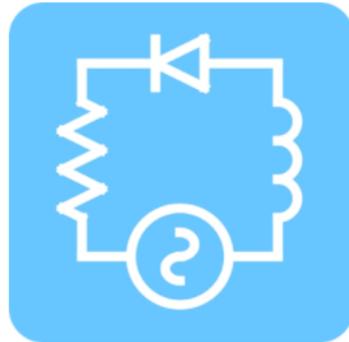
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Electric Circuit Studio

ECStudio Systems Education

★★★★☆ 2,709

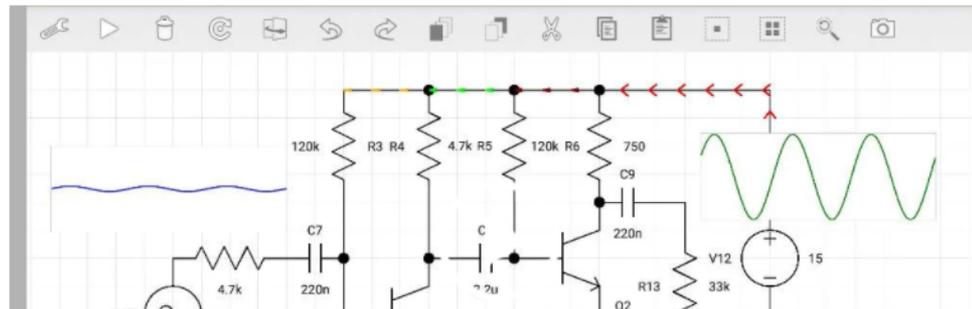
Everyone

Contains Ads

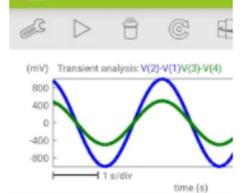
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CircuitSafari SPICE Simulator

← → ↻ 🏠 🔒 https://play.google.com/store/apps/details?id=com.logipipe.circuitsafari&hl=en_US&gl=US



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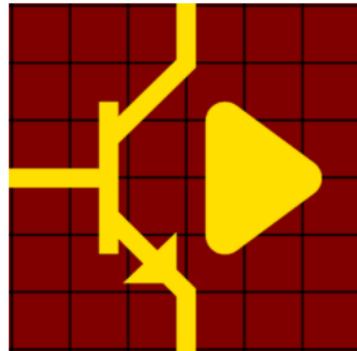
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CircuitSafari SPICE Simulator (Early Access)

Logipipe, LLC Productivity

E Everyone

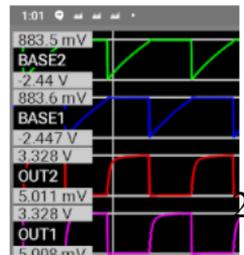
Offers in-app purchases

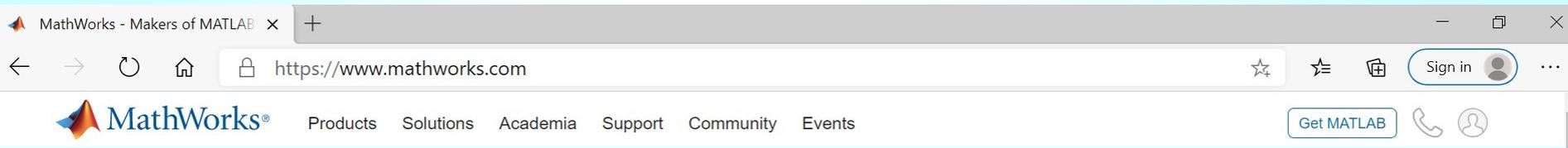
📌 This app is in development. It may be unstable.

⚠️ You don't have any devices

🔖 Add to Wishlist

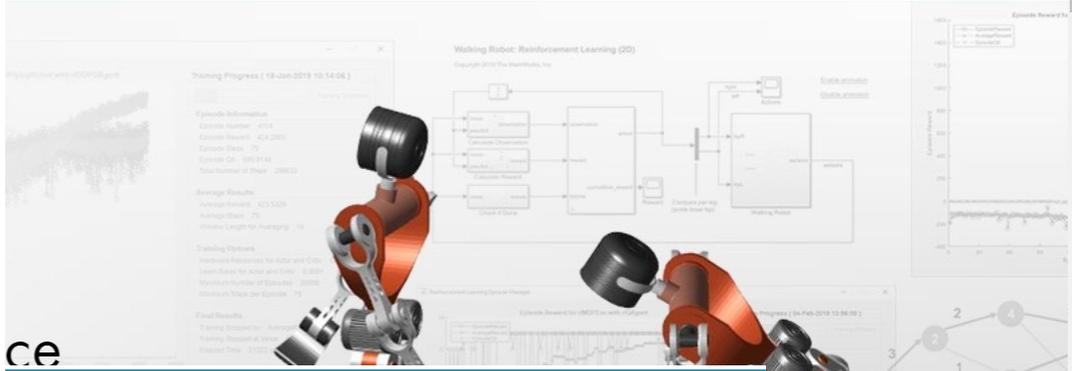
Install



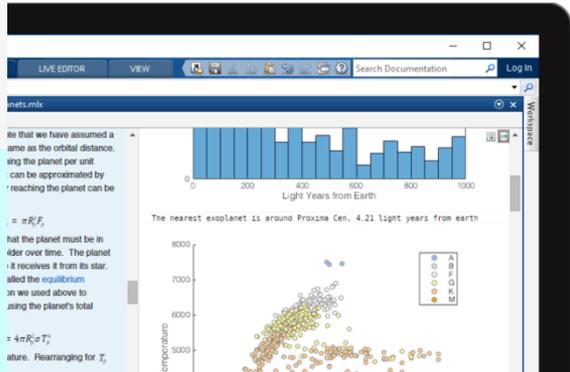


Millions of Engineers and Scientists Trust MATLAB

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



Products by Category | Alphabetical Trial software

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MATLAB

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 - Parallel Computing Toolbox
 - MATLAB Parallel Server
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 - Optimization Toolbox
 - Global Optimization Toolbox
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 - Mapping Toolbox

SIMULINK® PRODUCT FAMILY

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LICENSE TYPES

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



MATLAB

<http://www.mathworks.com/>

The screenshot displays the MATLAB R2019a software interface. The top ribbon includes tabs for HOME, PLOTS, and APPS. The APPS tab is active, showing various toolboxes. The Simulink toolbox icon is highlighted with a red rectangle. Below the ribbon, the current folder path is shown as 'C:\Program Files\Polyspace\R2019a\bin'. The Command Window displays a message: 'New to MATLAB? See resources for [Getting Started.](#)'. The Workspace window is empty. A 'System target file browser: Simulink2DSHplus' dialog is open, showing a list of system target files with columns for 'System target file:' and 'Description:'. The Simulink logo is visible in the bottom left corner of the interface.

Toolboxes...

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

MATLAB®

Professional License

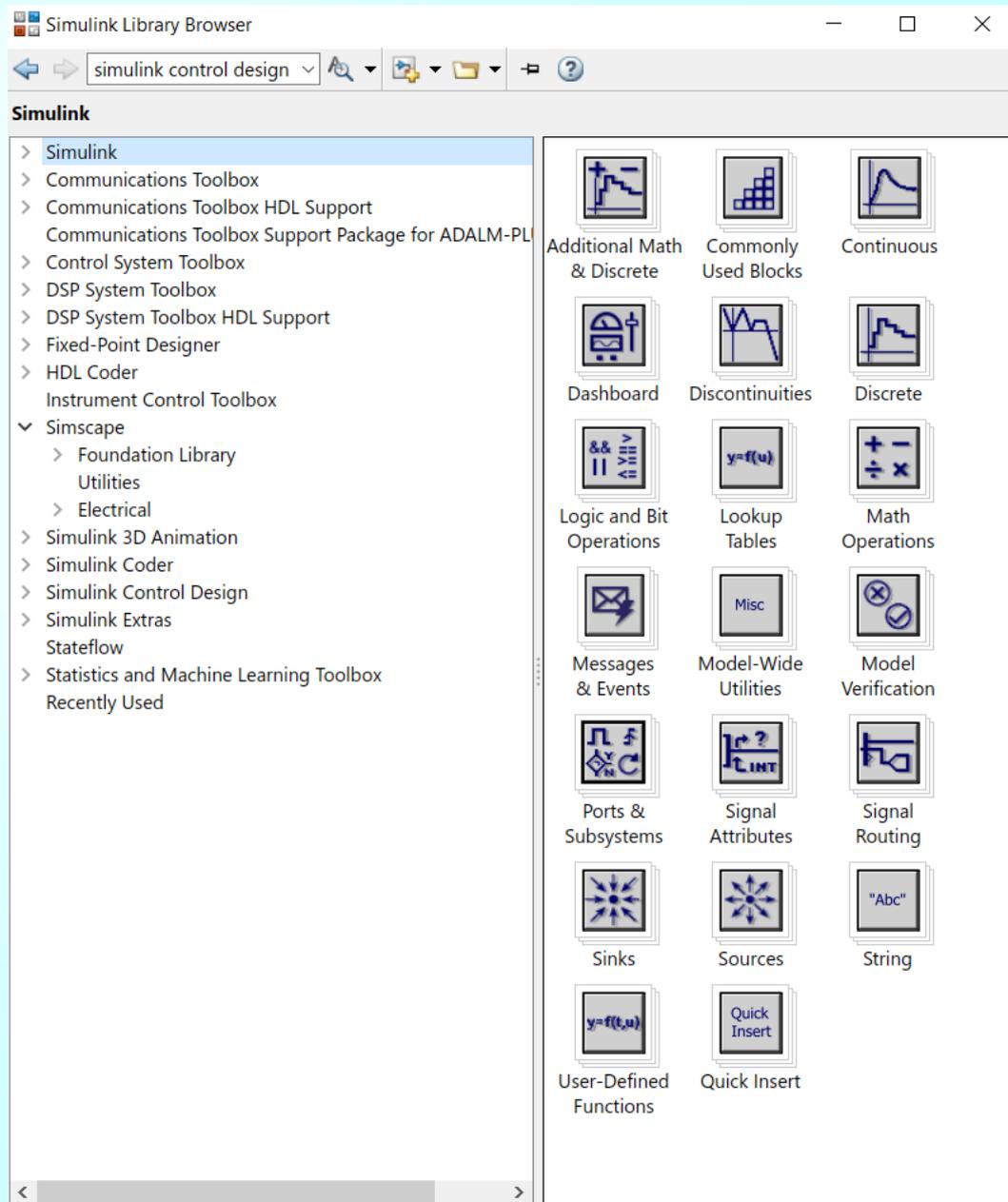
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MathWorks® R2019a

MATLAB

Simulink

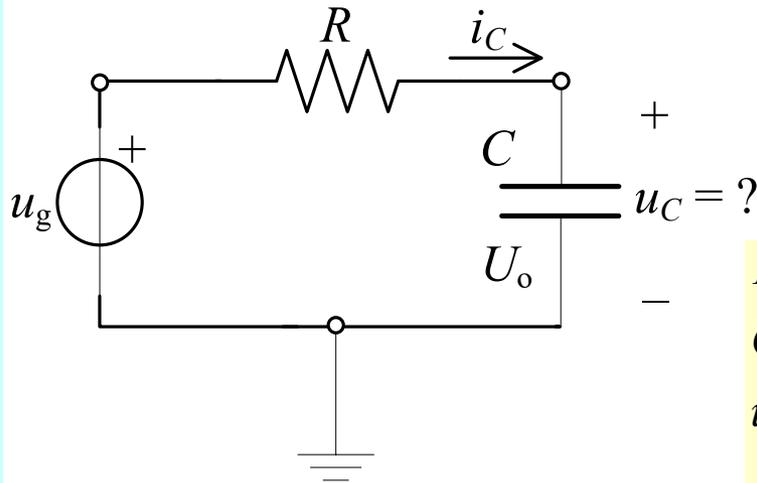
- Алатка за нумеричку анализу математичких модела
- Систем се дефинише графички, уметањем блокова и њиховим повезивањем у мрежу



Simulink > Simscape

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

коло је образовано у тренутку $t_0 = 0$

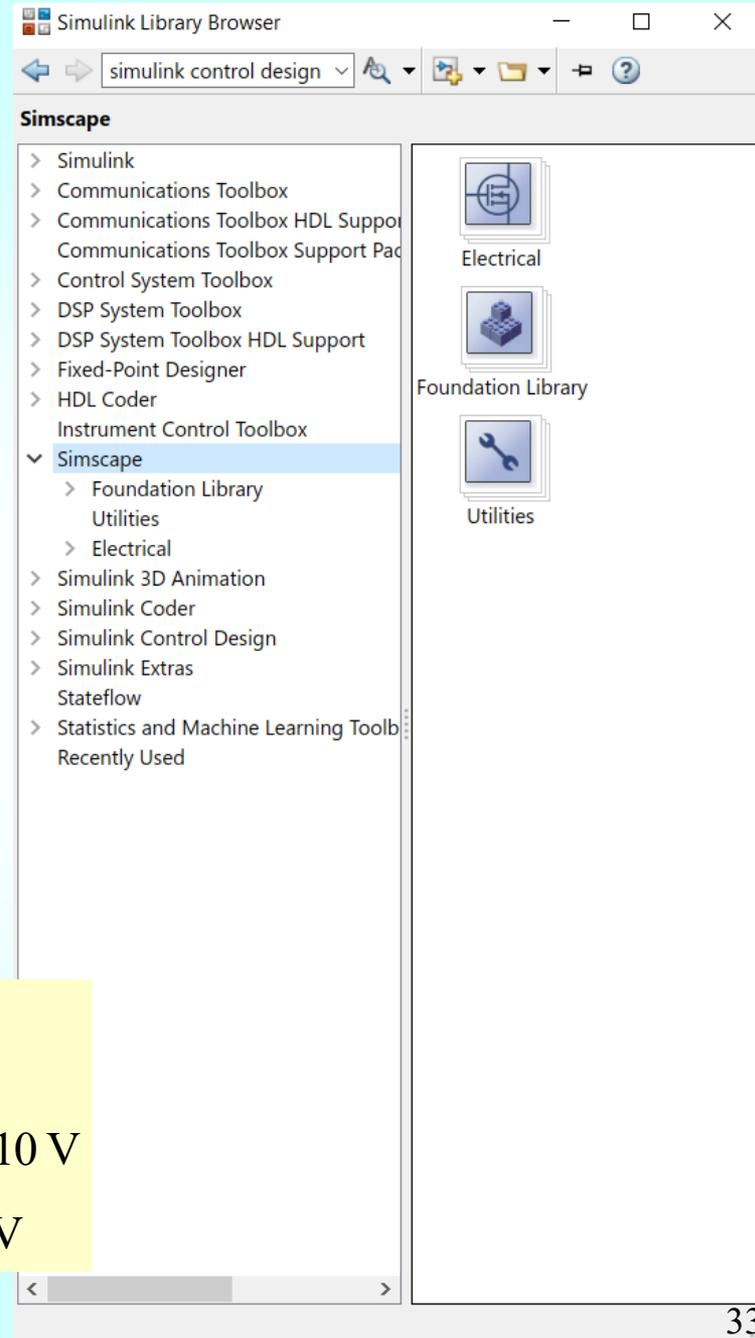


$$R = 1 \text{ k}\Omega$$

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

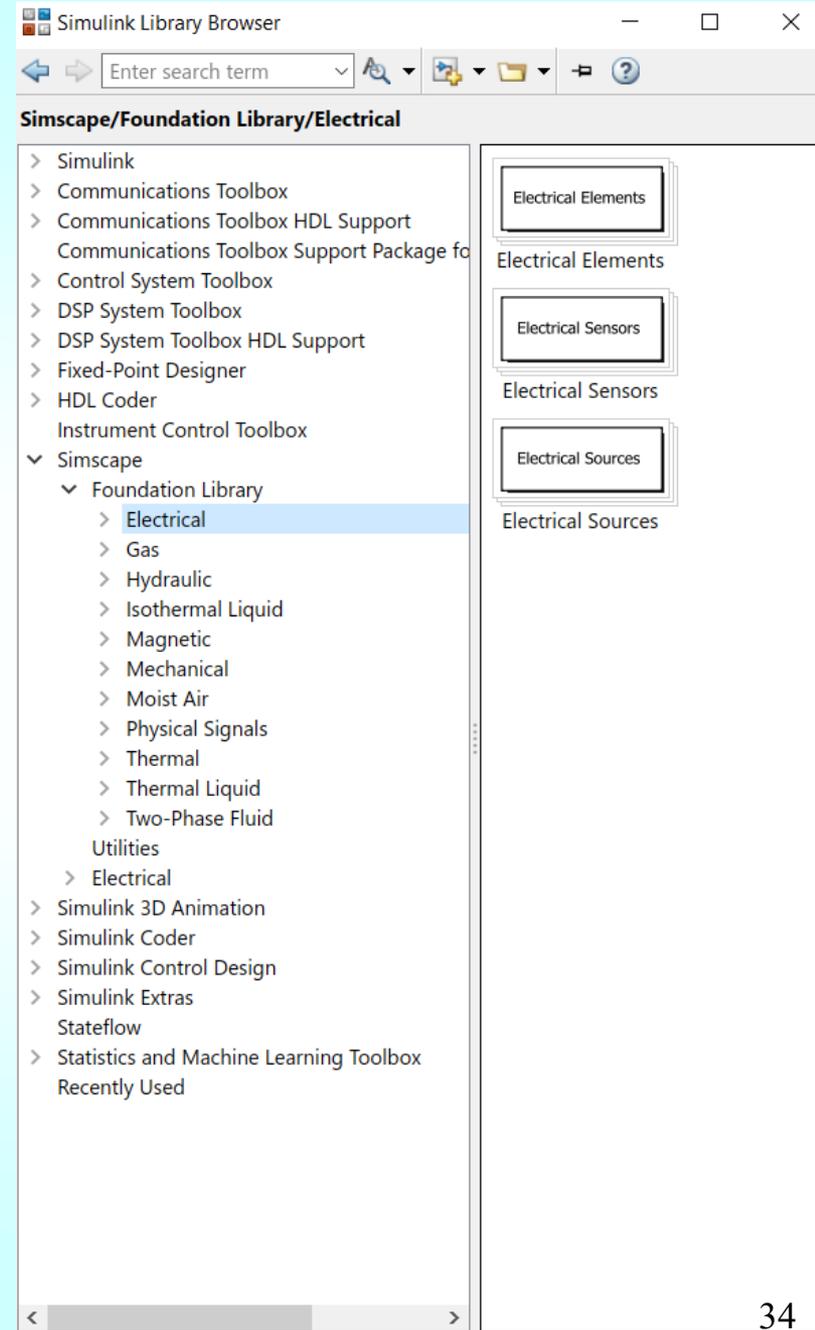
$$u_g(t) = U h(t), U = 10 \text{ V}$$

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



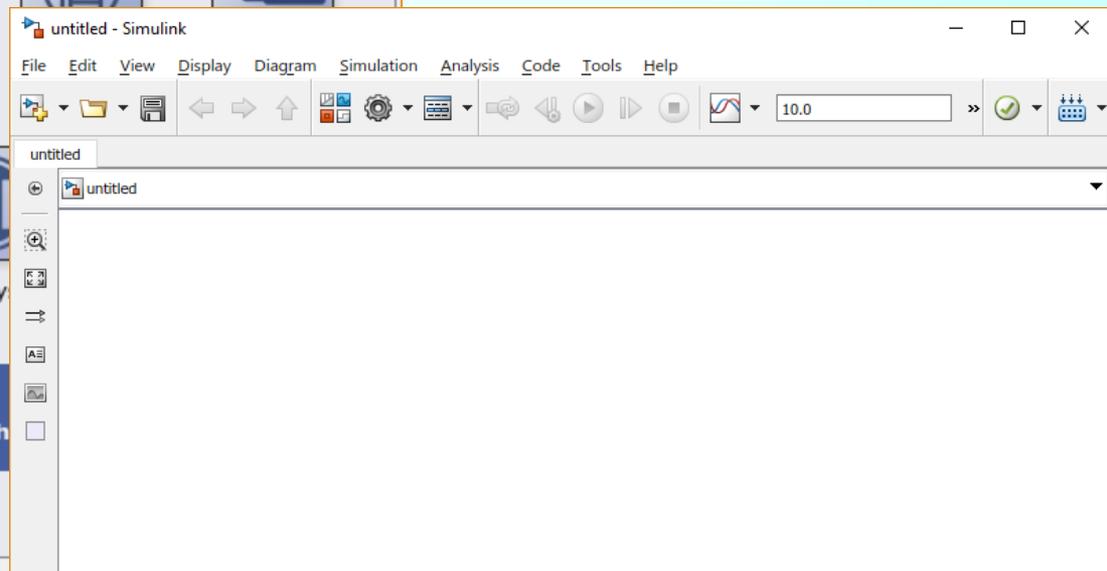
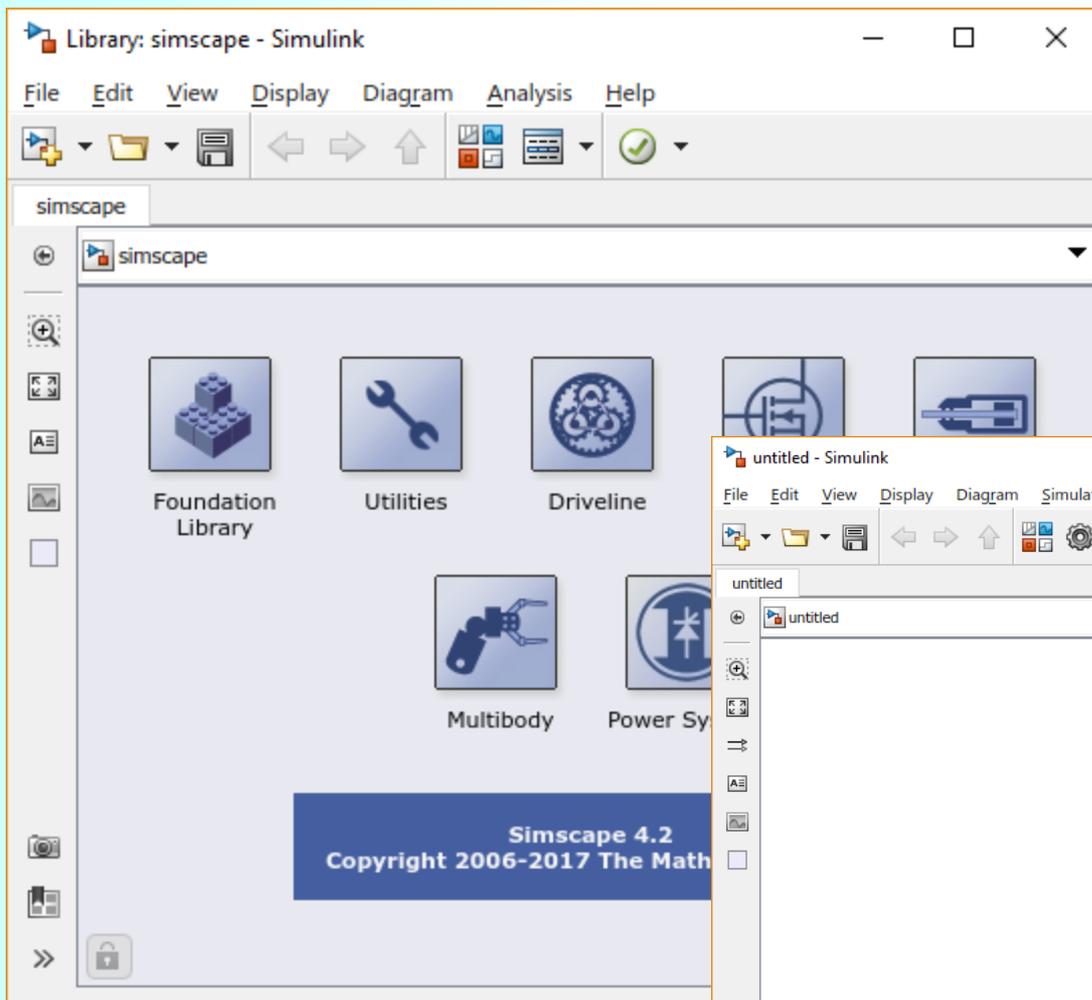
Simulink > Simscape > Foundation Library > Electrical

- Симулација линеарних и нелинеарних електричних кола

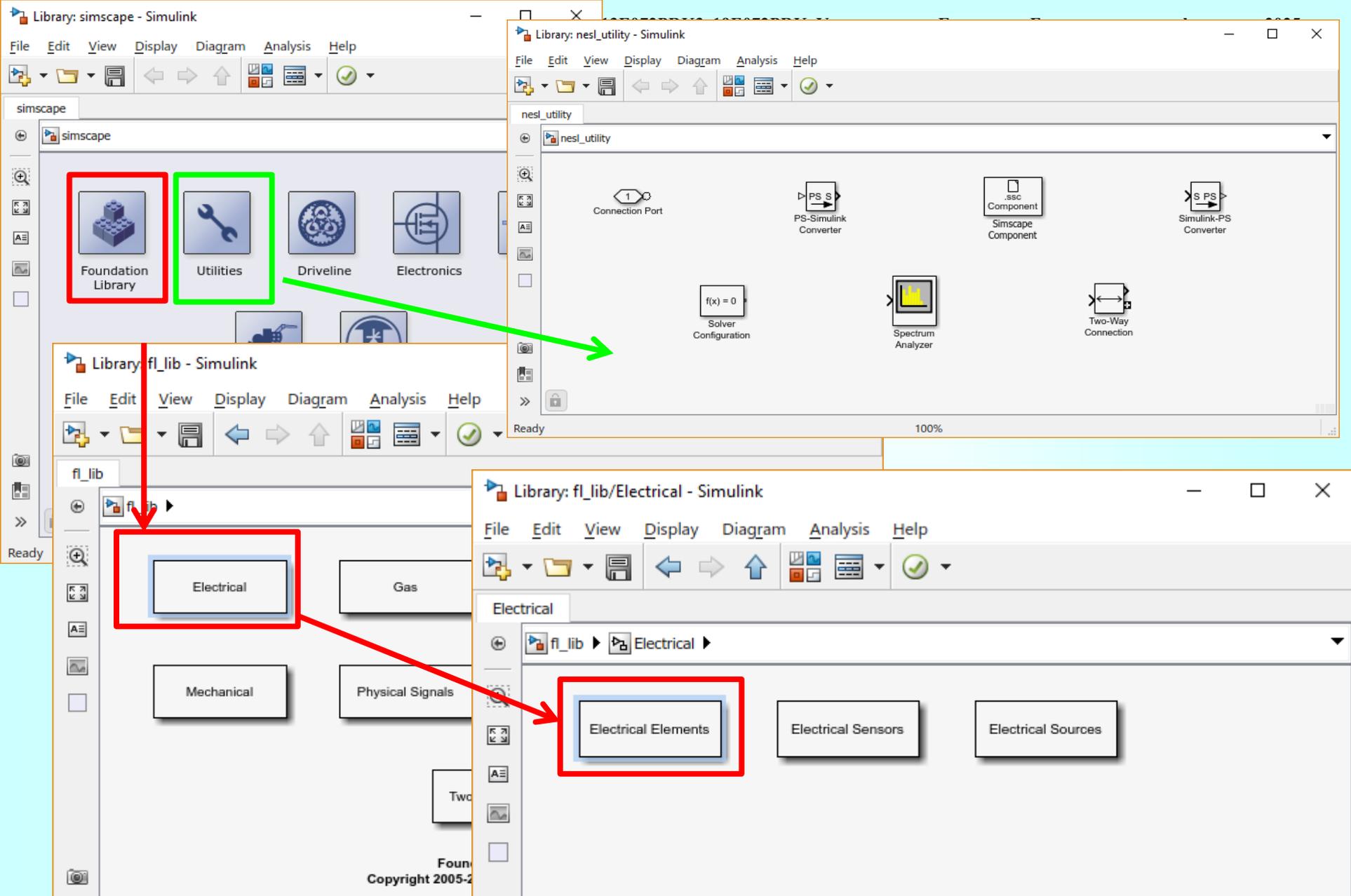


**MATLAB > Simscape >
Foundation Library, Utilities**

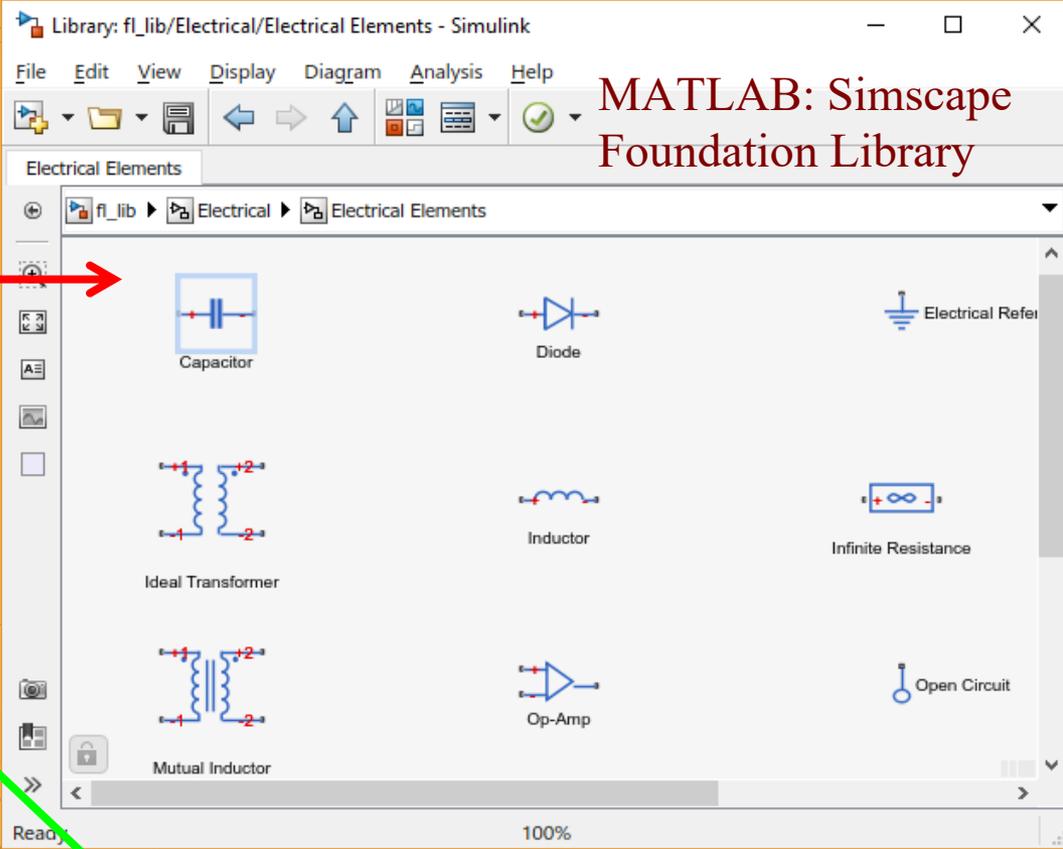
Симулација електричног кола коришћењем Simscape > Foundation Library библиотеке



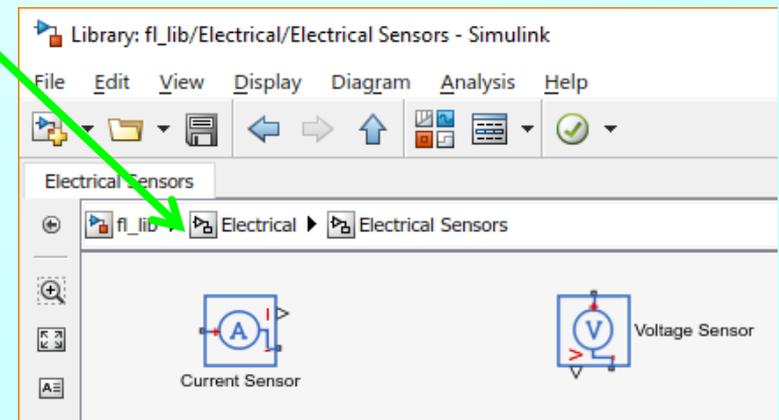
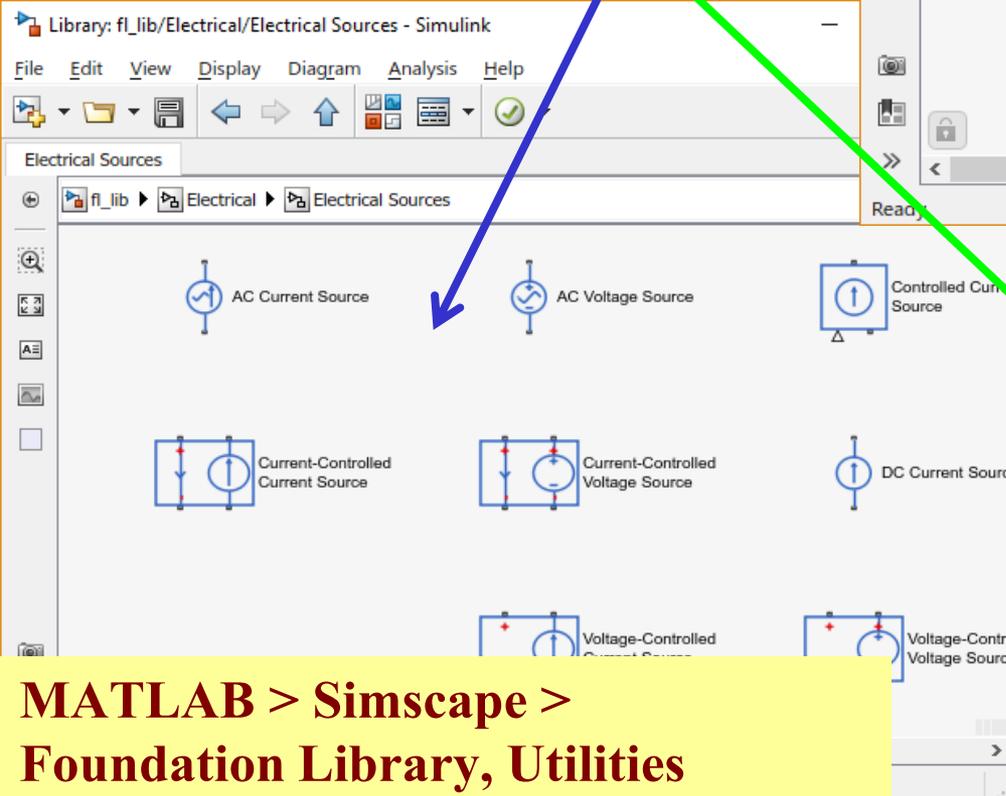
**MATLAB > Simscape >
Foundation Library, Utilities**



MATLAB > Simscape > Foundation Library, Utilities

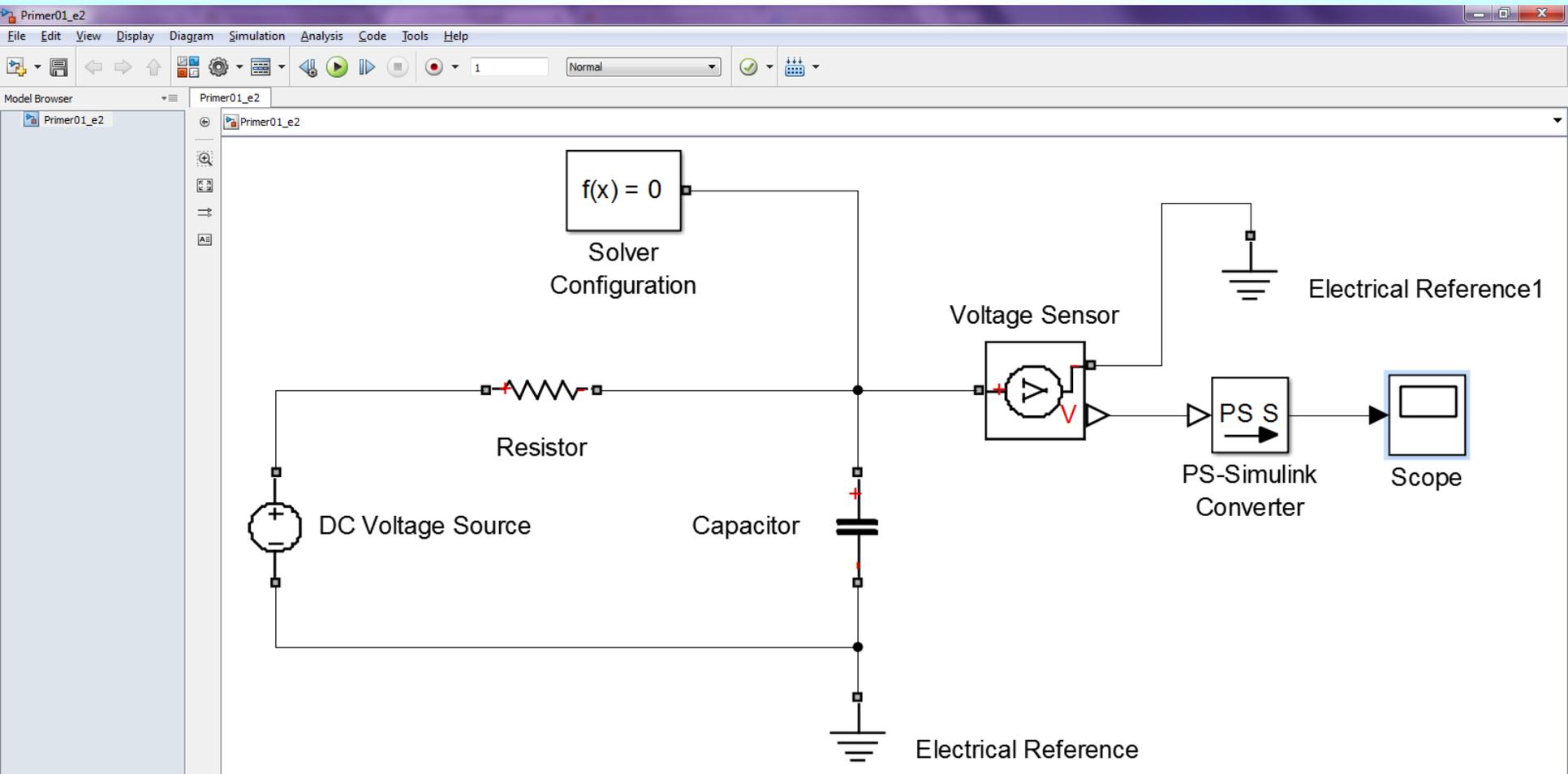


MATLAB: Simscape Foundation Library

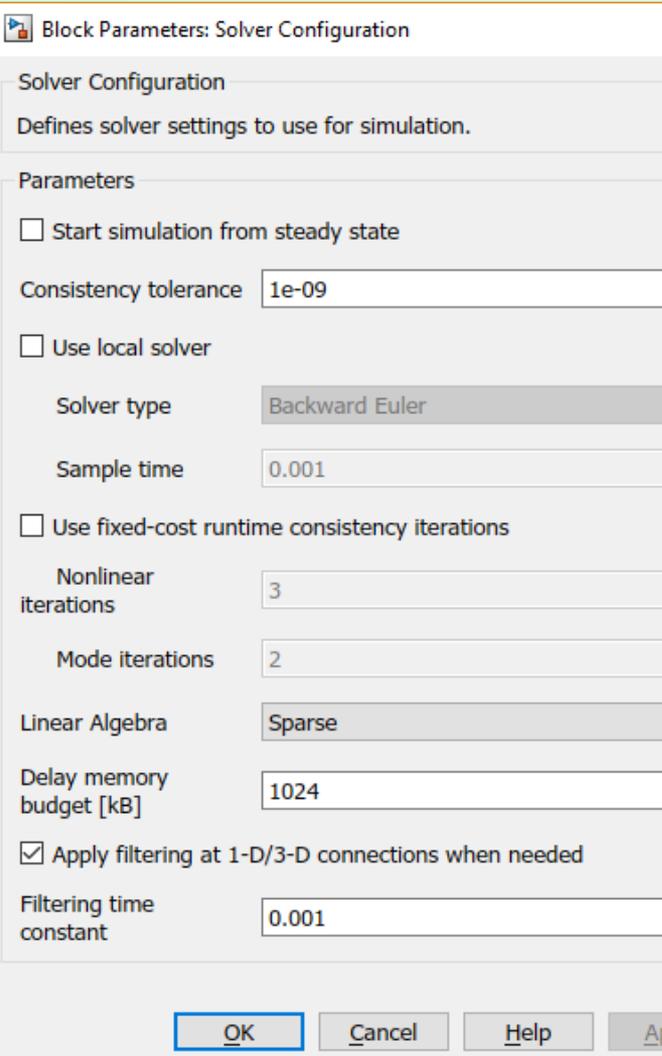
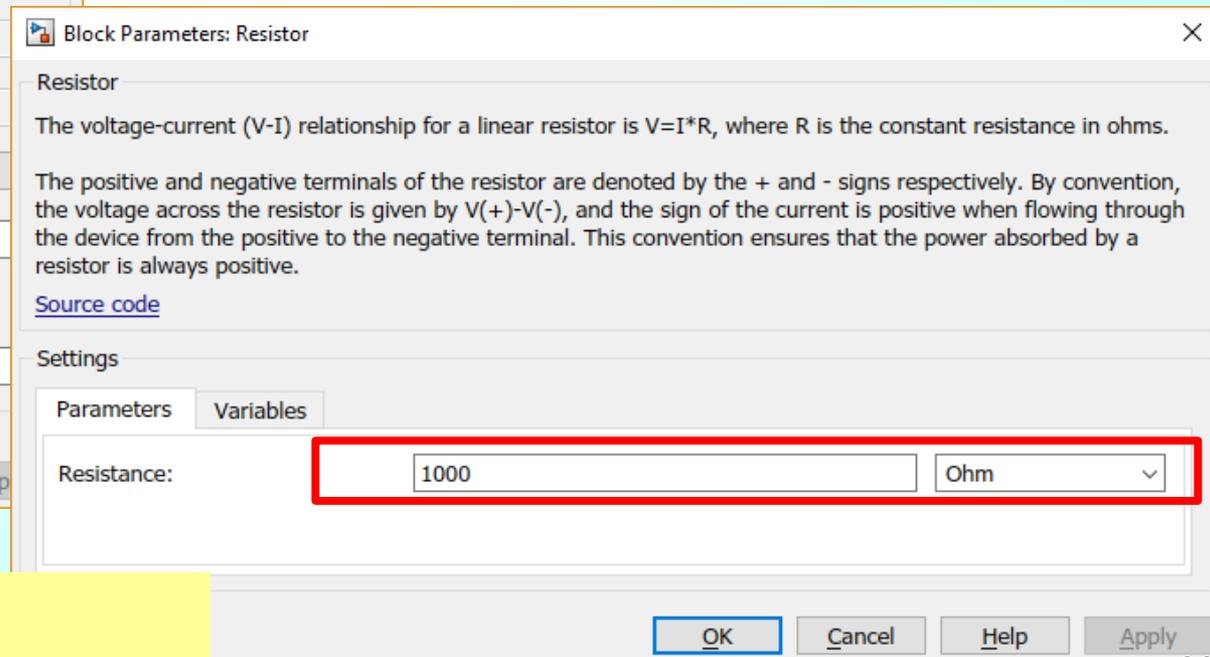
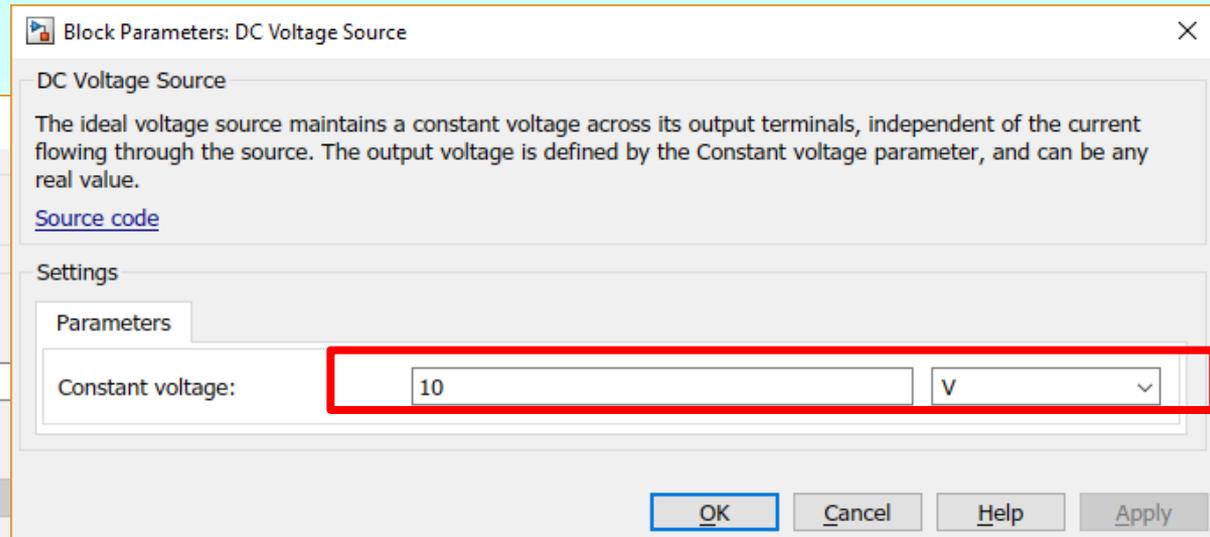


MATLAB > Simscape > Foundation Library, Utilities

Симулација електричног кола коришћењем Simscape > Foundation Library библиотеке



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



Block Parameters: Capacitor

Почетни услов...

Capacitor
Models a linear capacitor. The relationship between voltage V and 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:

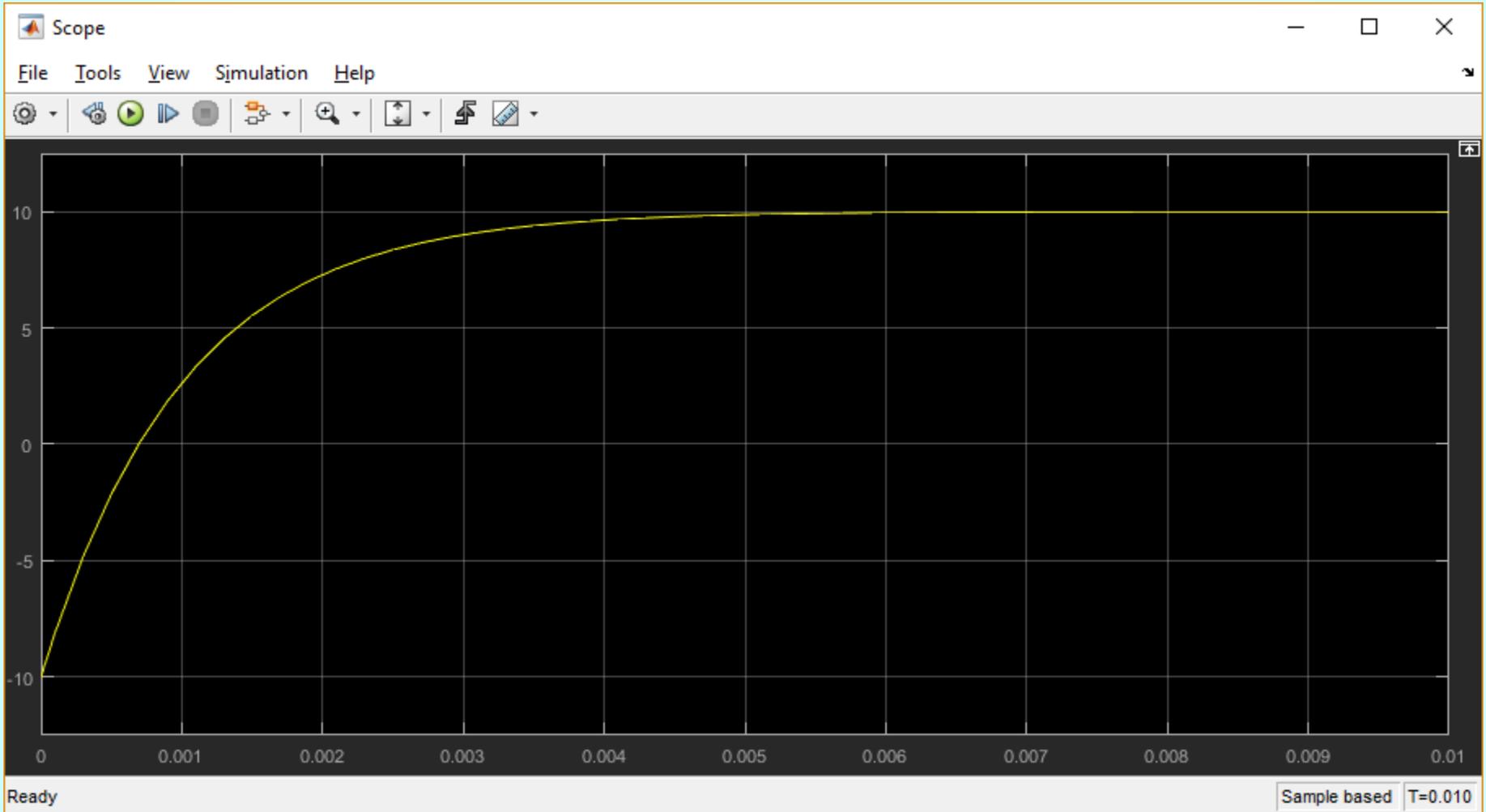
Parallel conductance:

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

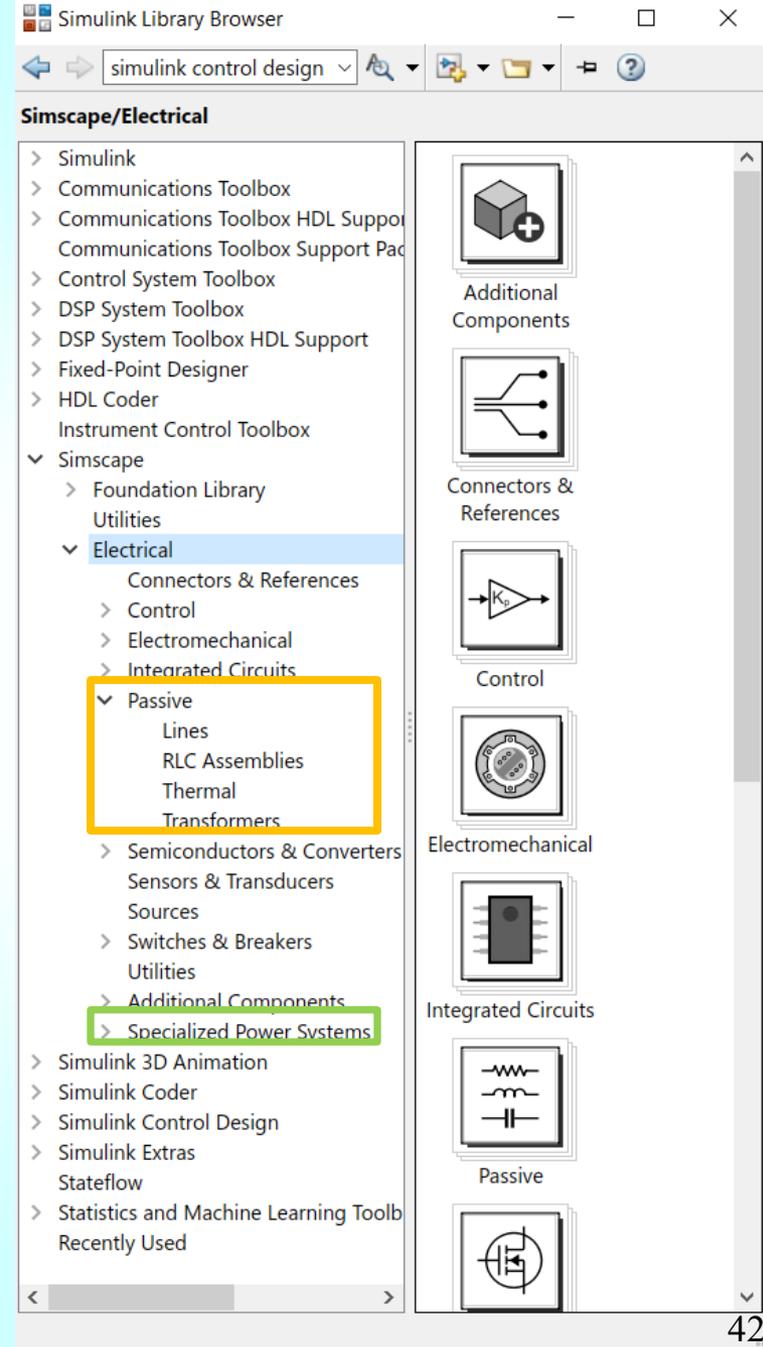
Налажење одзива...



**MATLAB > Simscape >
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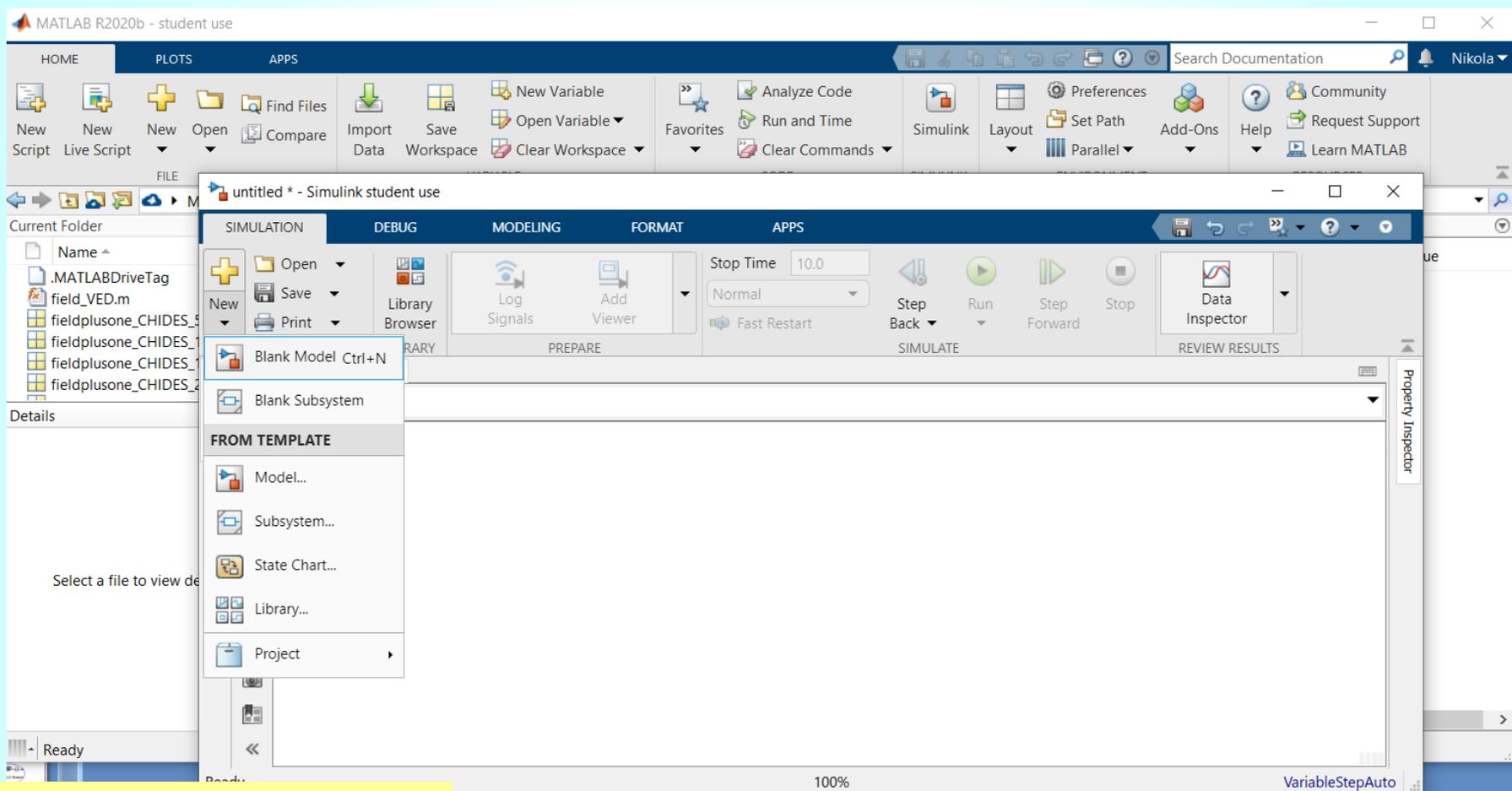
Simulink > Simscape > Electrical

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

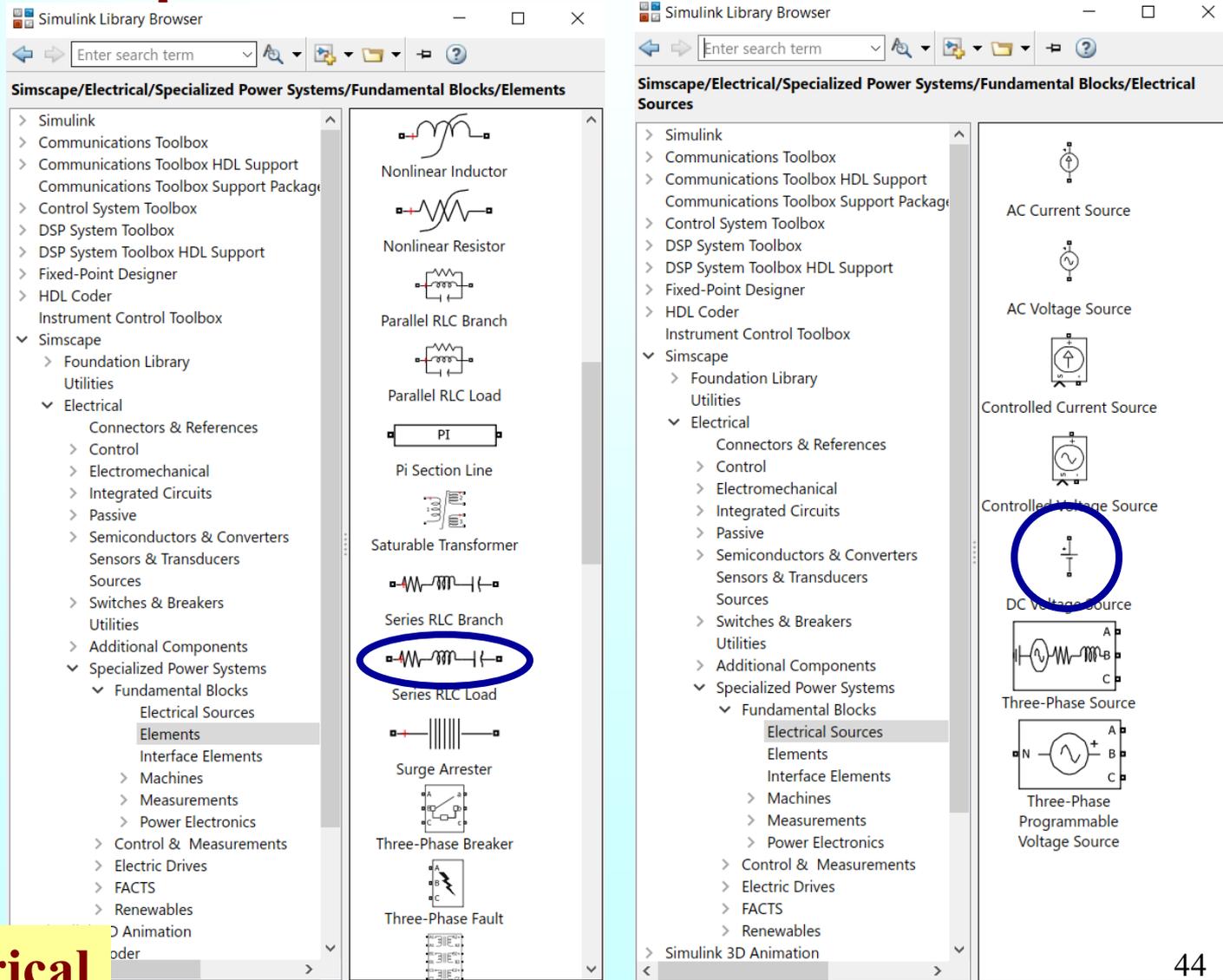


Simulink > Simscape > Electrical

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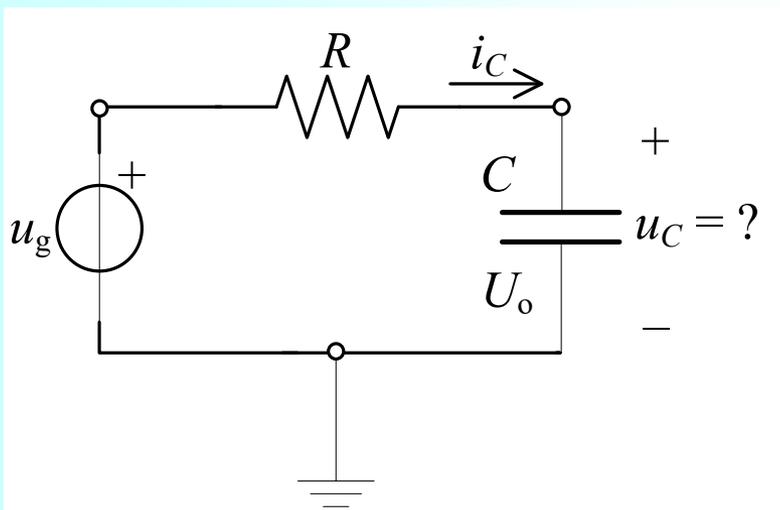


Симулација електричног кола коришћењем Simscape>Electrical библиотеке



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

коло је образовано у тренутку $t_0 = 0$

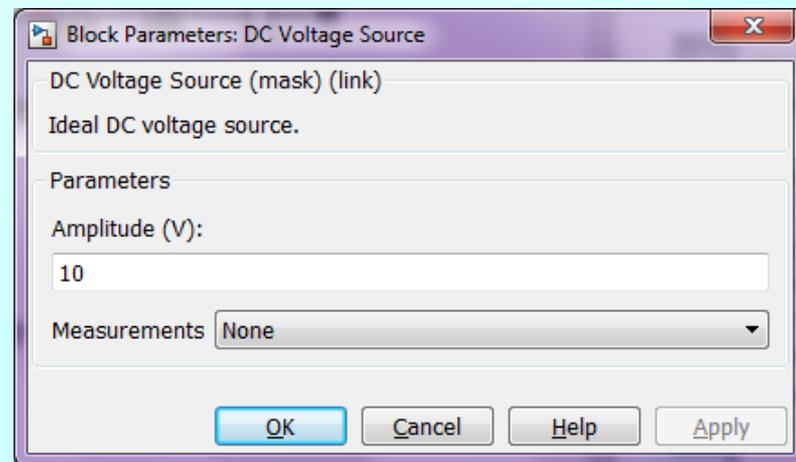
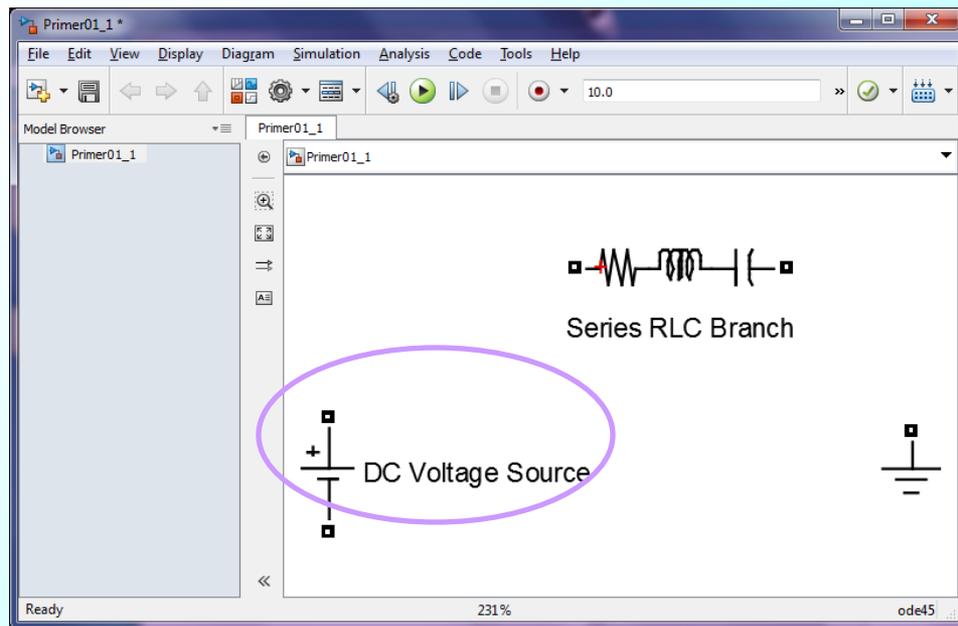


$$R = 1 \text{ k}\Omega$$

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

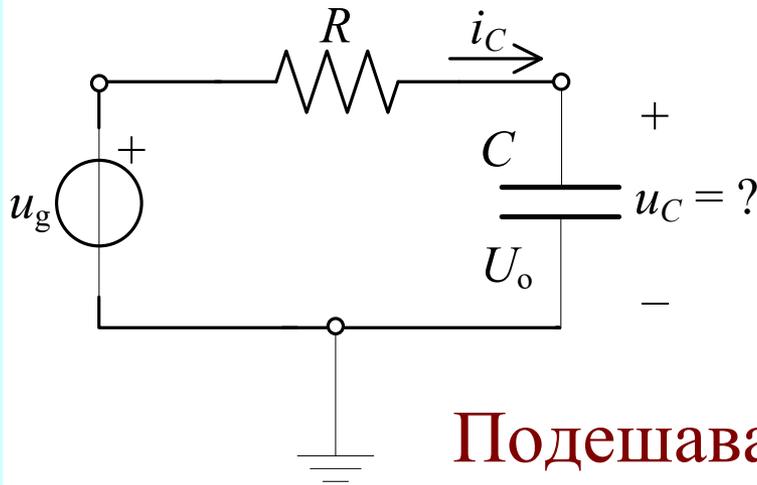
$$u_g(t) = U h(t), U = 10 \text{ V}$$

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



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

коло је образовано у тренутку $t_0 = 0$



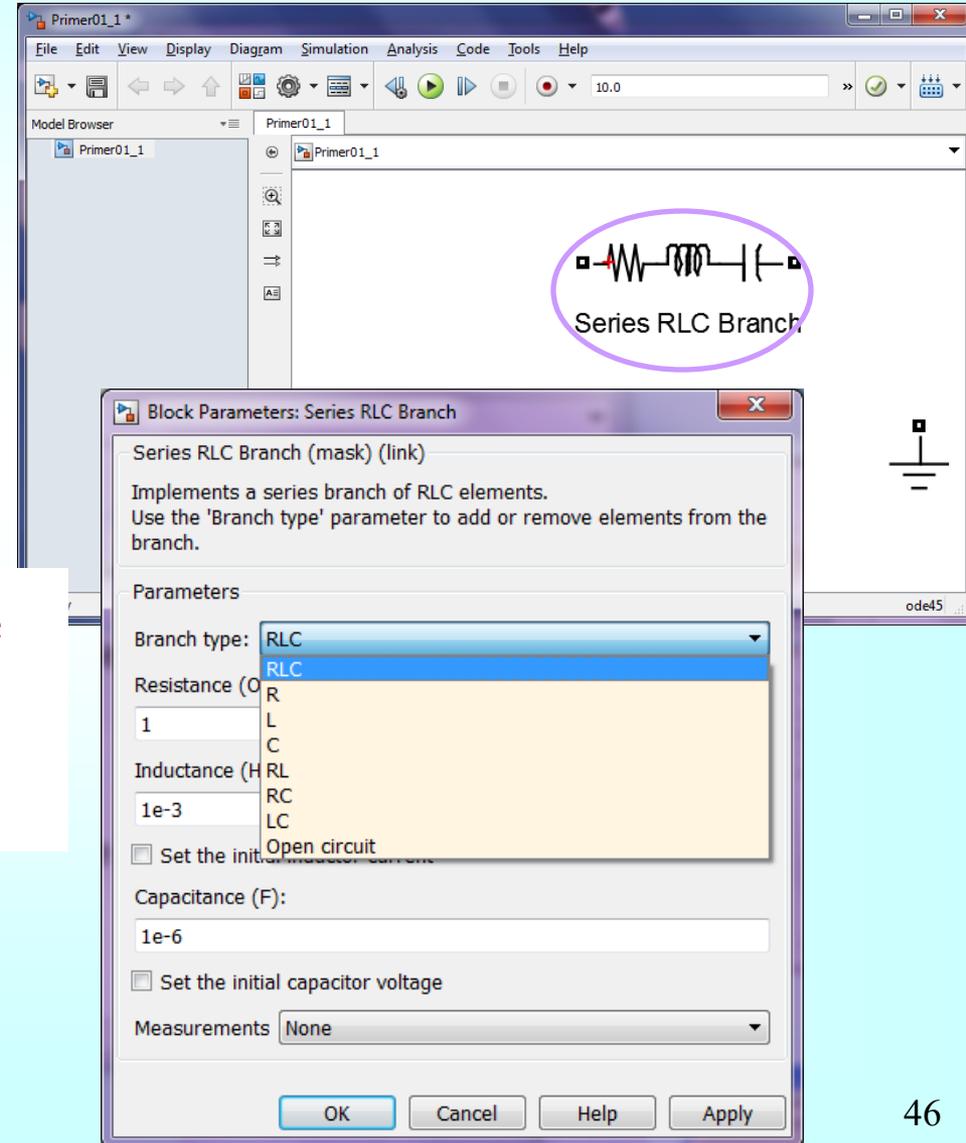
Подешавање
параметара
симулације

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

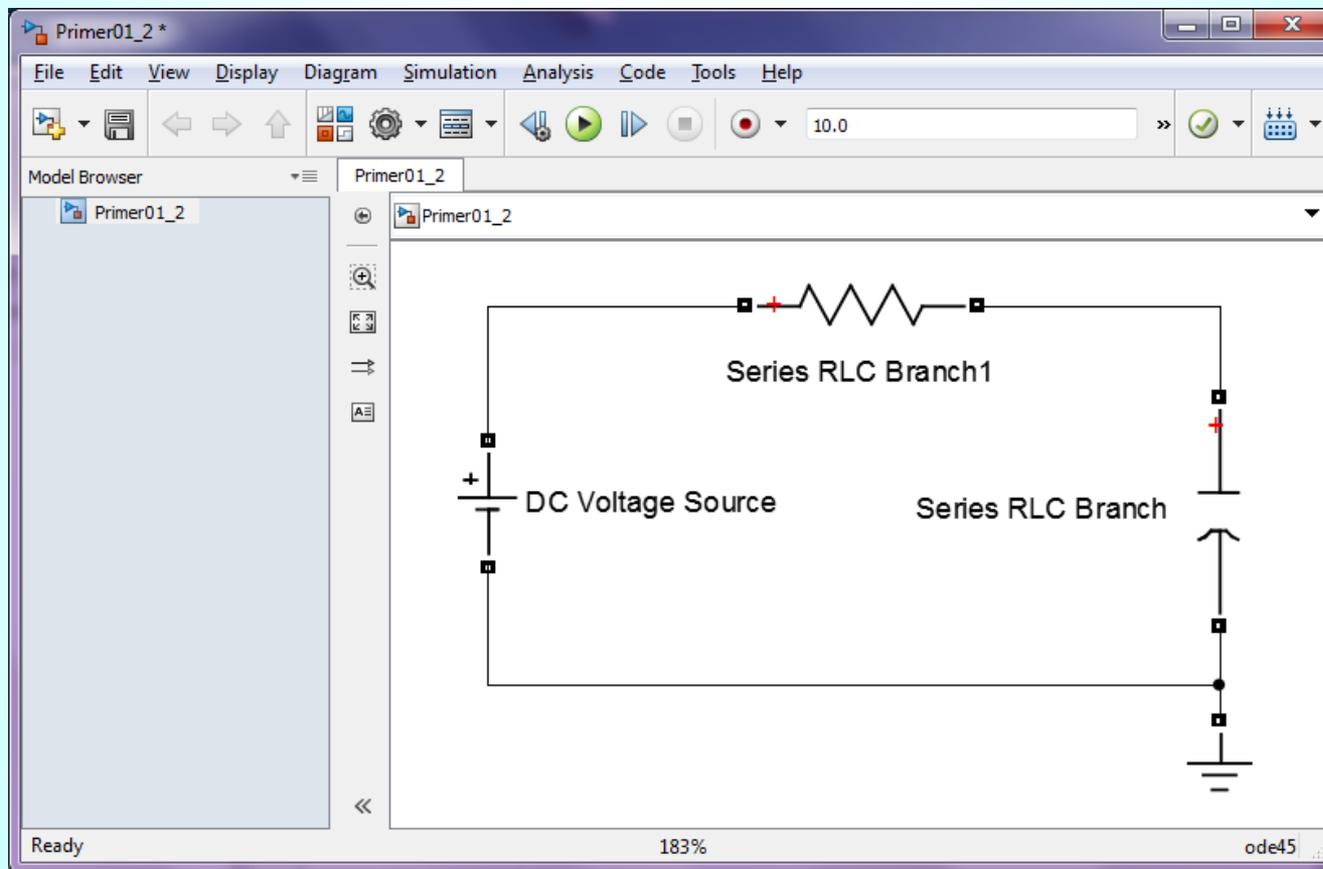
$$C = 1 \mu\text{F}$$

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

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

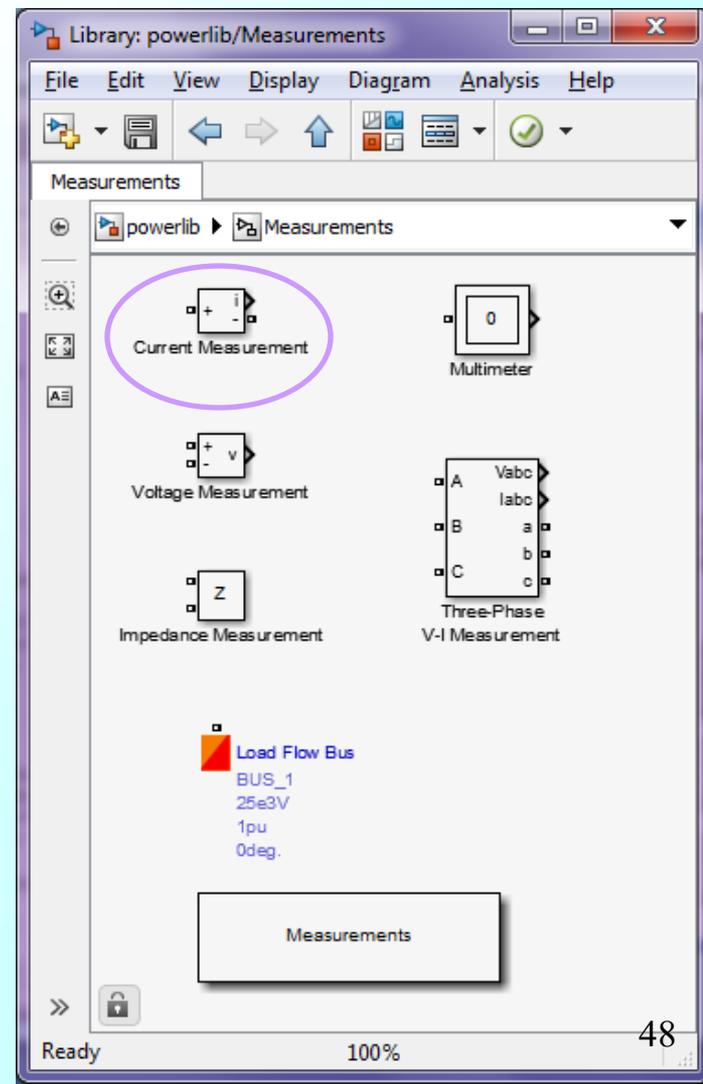
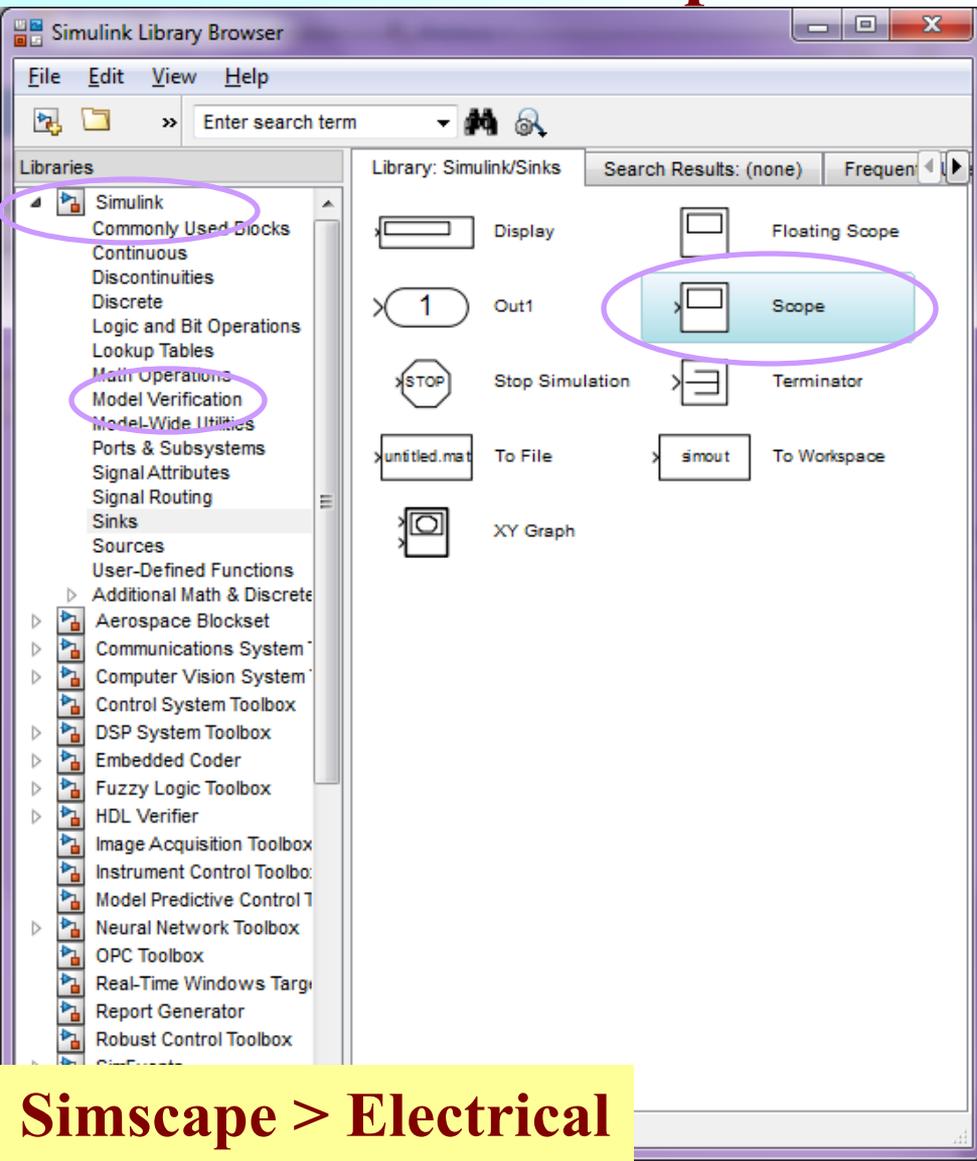


Симулација електричног кола коришћењем **Simscape>Electrical** библиотеке



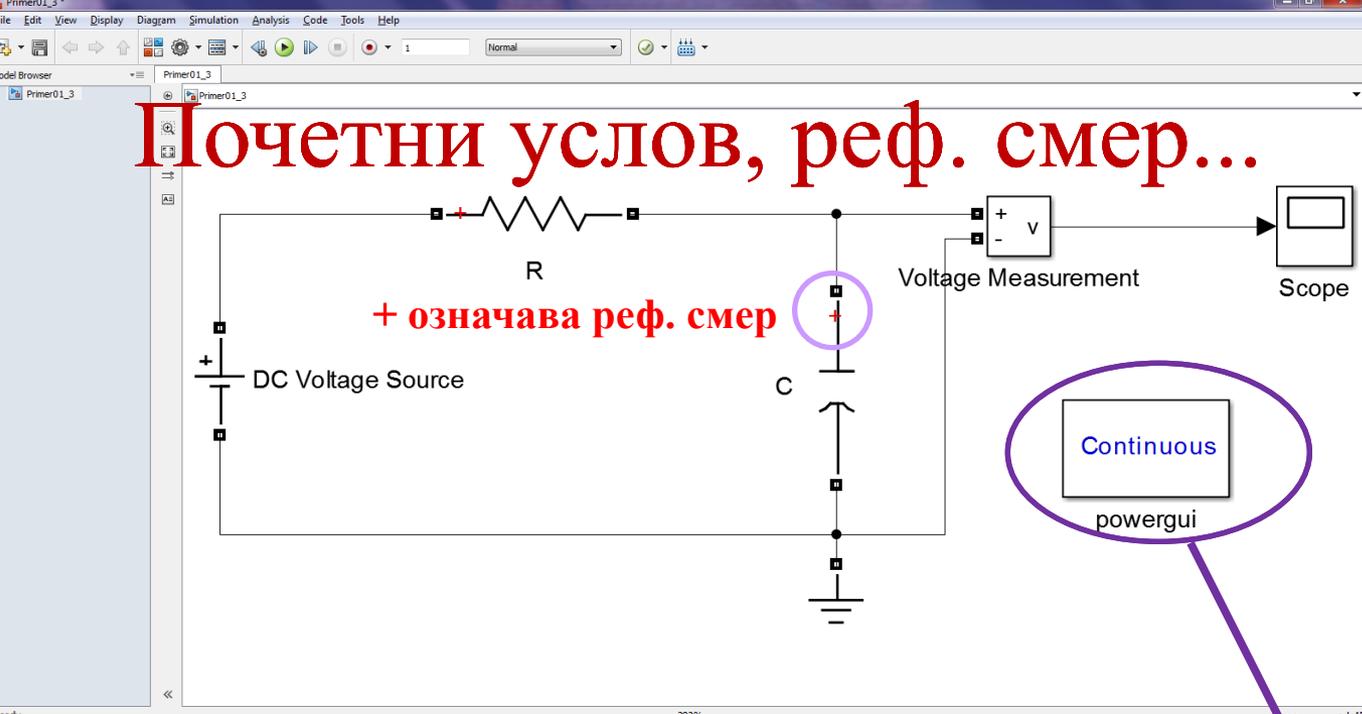
Како се мери напон?

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



Simscape > Electrical

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 Apply

Powergui Initial States Setting Tool. model: untitled

Initial electrical state values for simulation:

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

Set selected electrical state to:

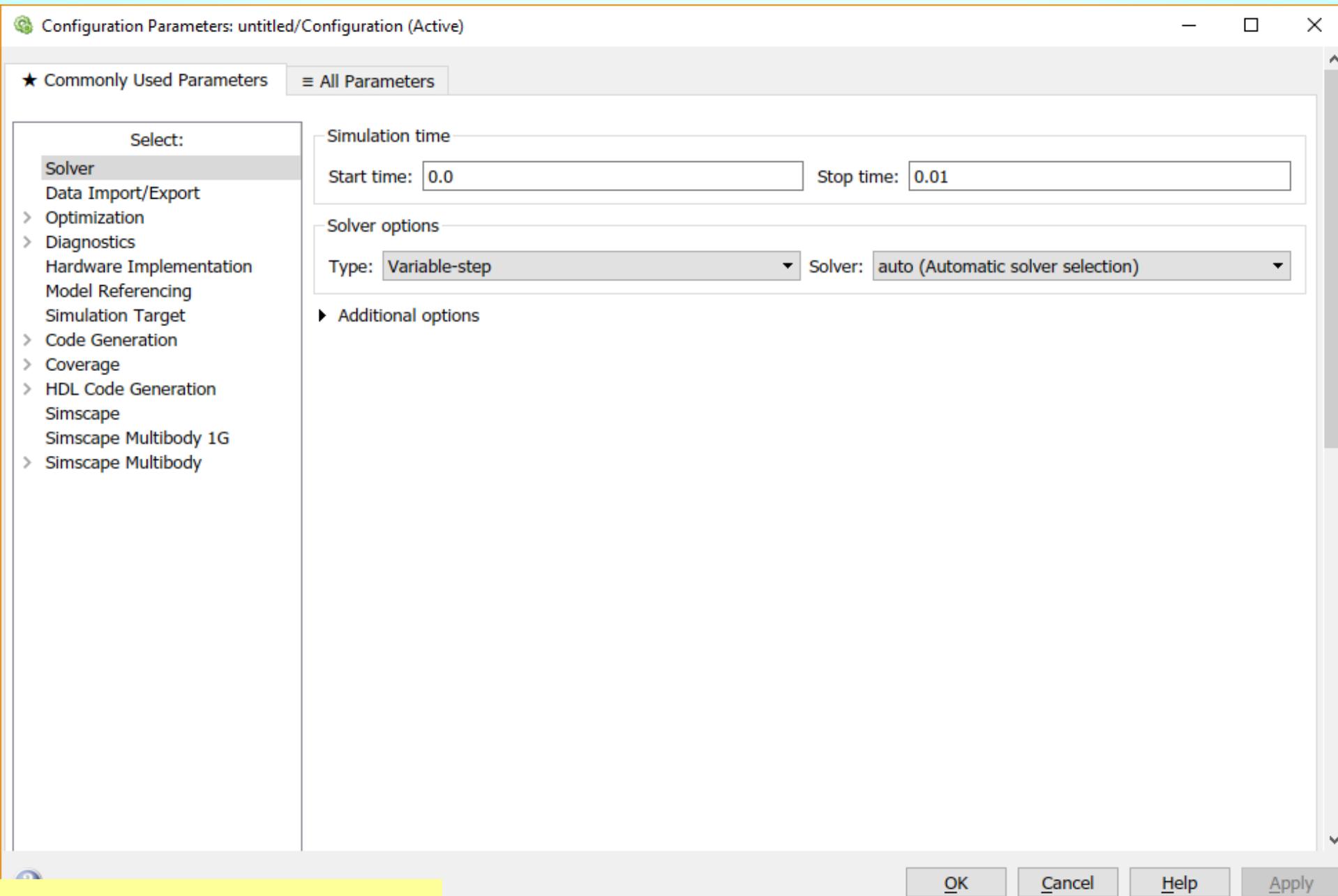
-10

Force initial electrical state:

To Steady State

To Zero

Simscape > Electrical



Configuration Parameters: untitled/Configuration (Active)

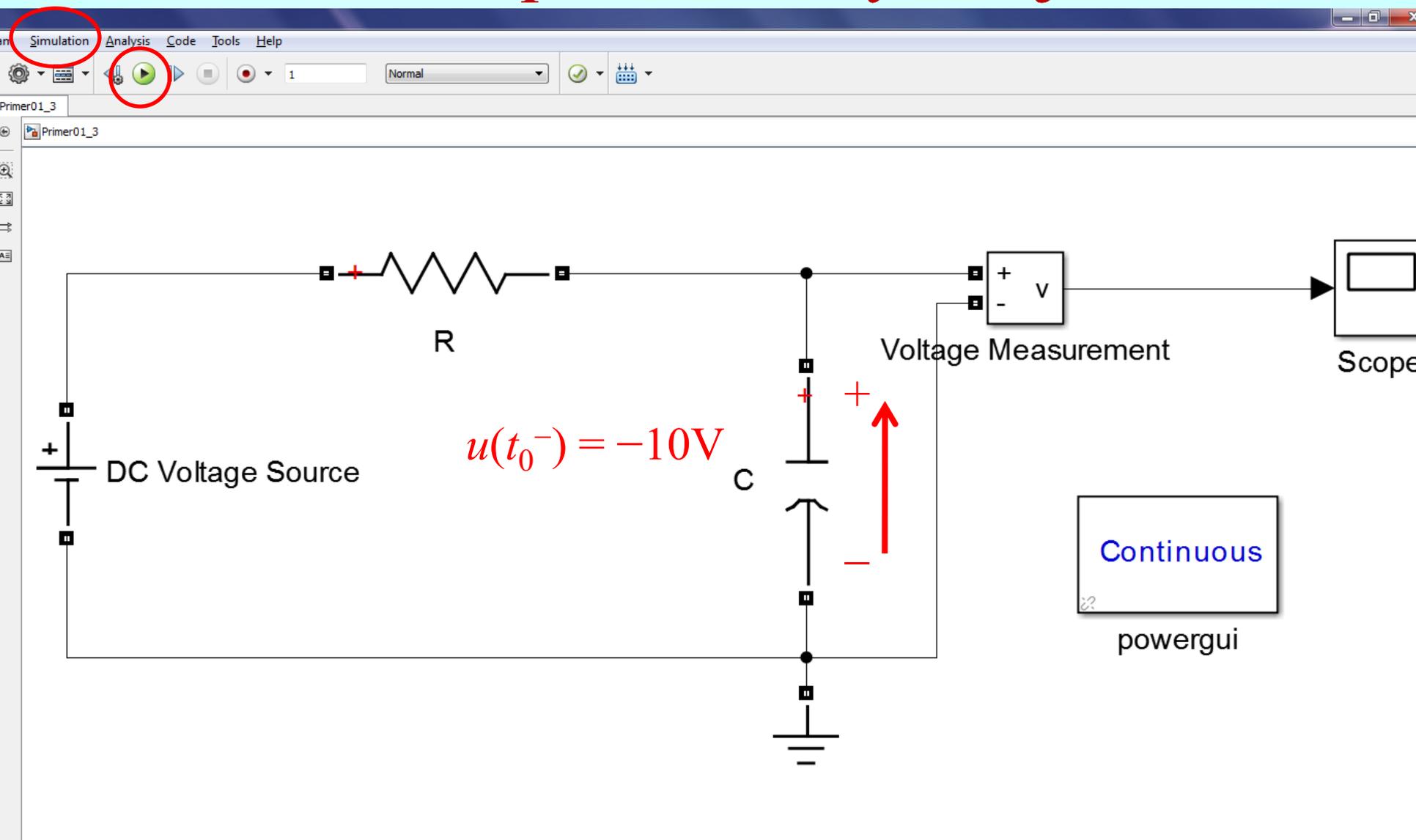
★ Commonly Used Parameters ≡ All Parameters

Category: All Search selected category

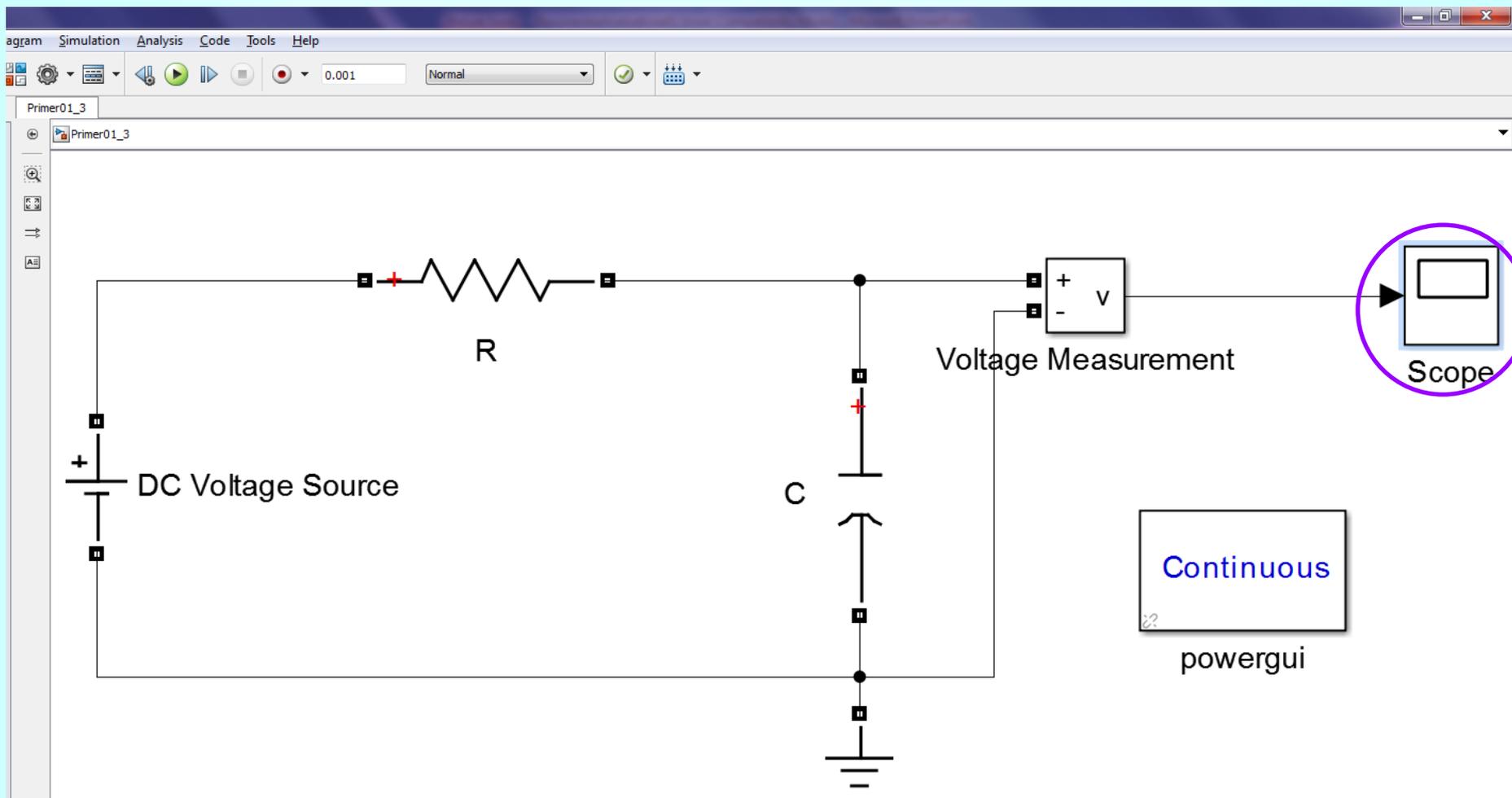
Parameter	Value	Command-Line Name
Solver ▶ Simulation time		
> Start time Simulation start time. Note that the values that you specify as block i...	0.0	StartTime
> Stop time Simulation stop time.	0.01	StopTime
Solver ▶ Solver options		
> Type Choose a variable or fixed-step solver.	Variable-step	SolverType
> Solver Choose a solver. If disabled, enable in "Additional options" by changi...	auto (Automatic solver selection)	Solver
Solver ▶ Additional options		
> 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

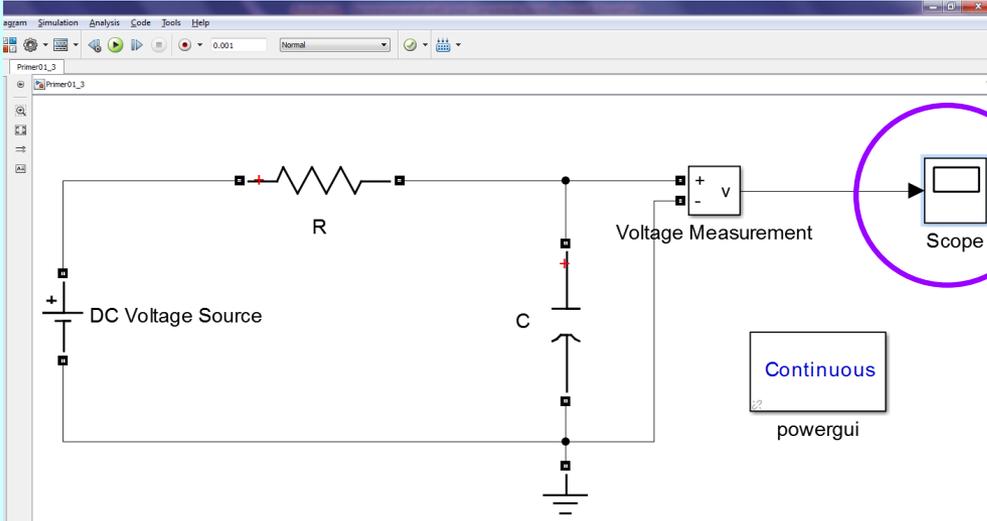
OK Cancel Help Apply

Покретање симулације...



Налажење одзива... Осцилоскоп





Configuration Properties: Scope

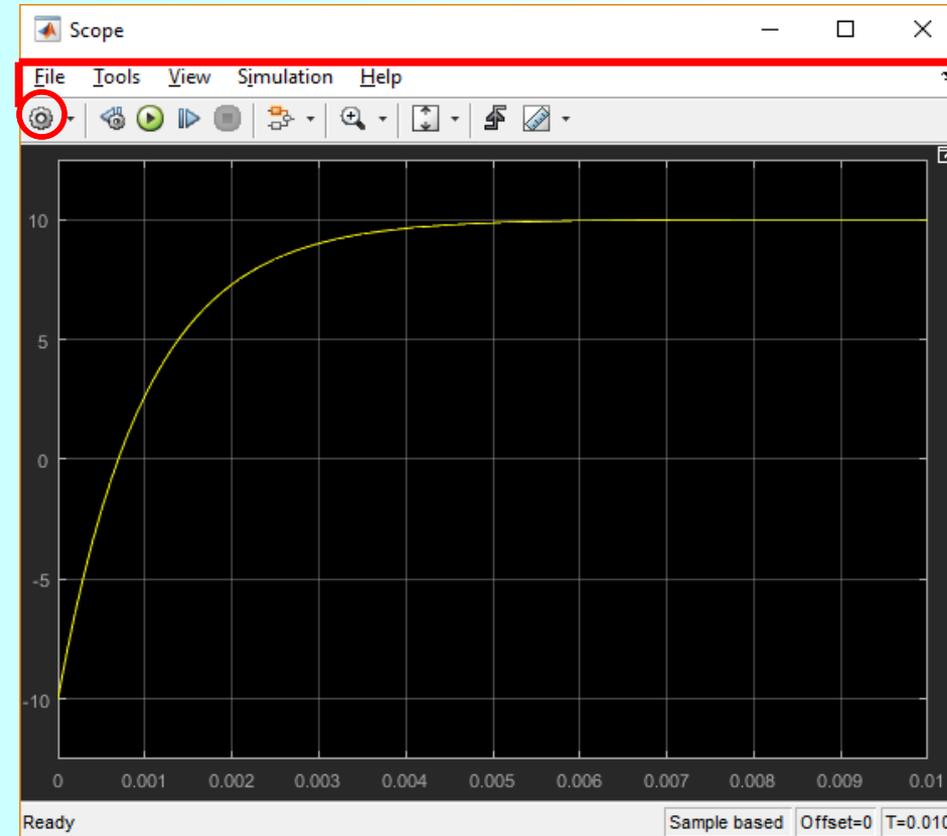
Main | Time | Display | Logging

- 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
Solver ▶ Simulation time		
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
Solver ▶ Solver options		
Type Choose a variable or fixed-step solver.	Variable-step	SolverType
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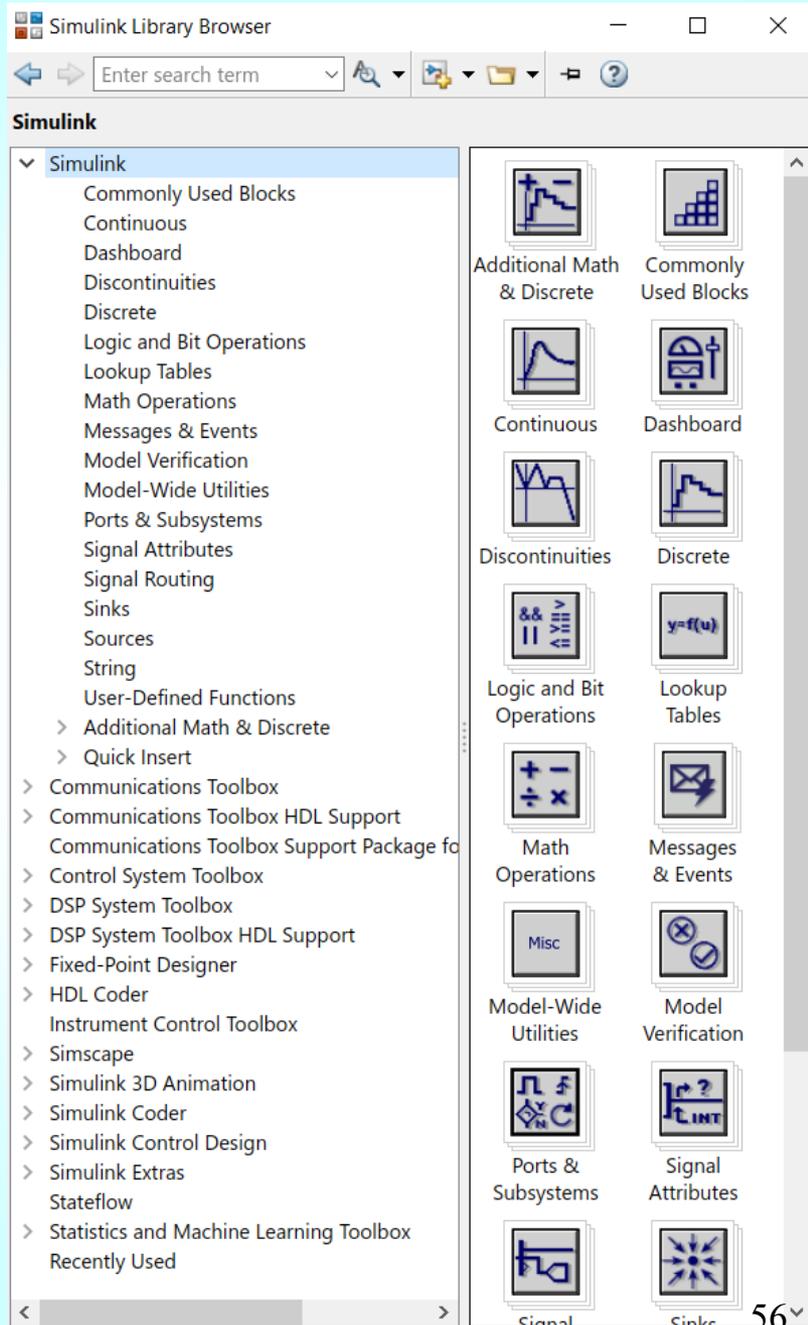
$\tau = RC = 1 \text{ ms}$

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

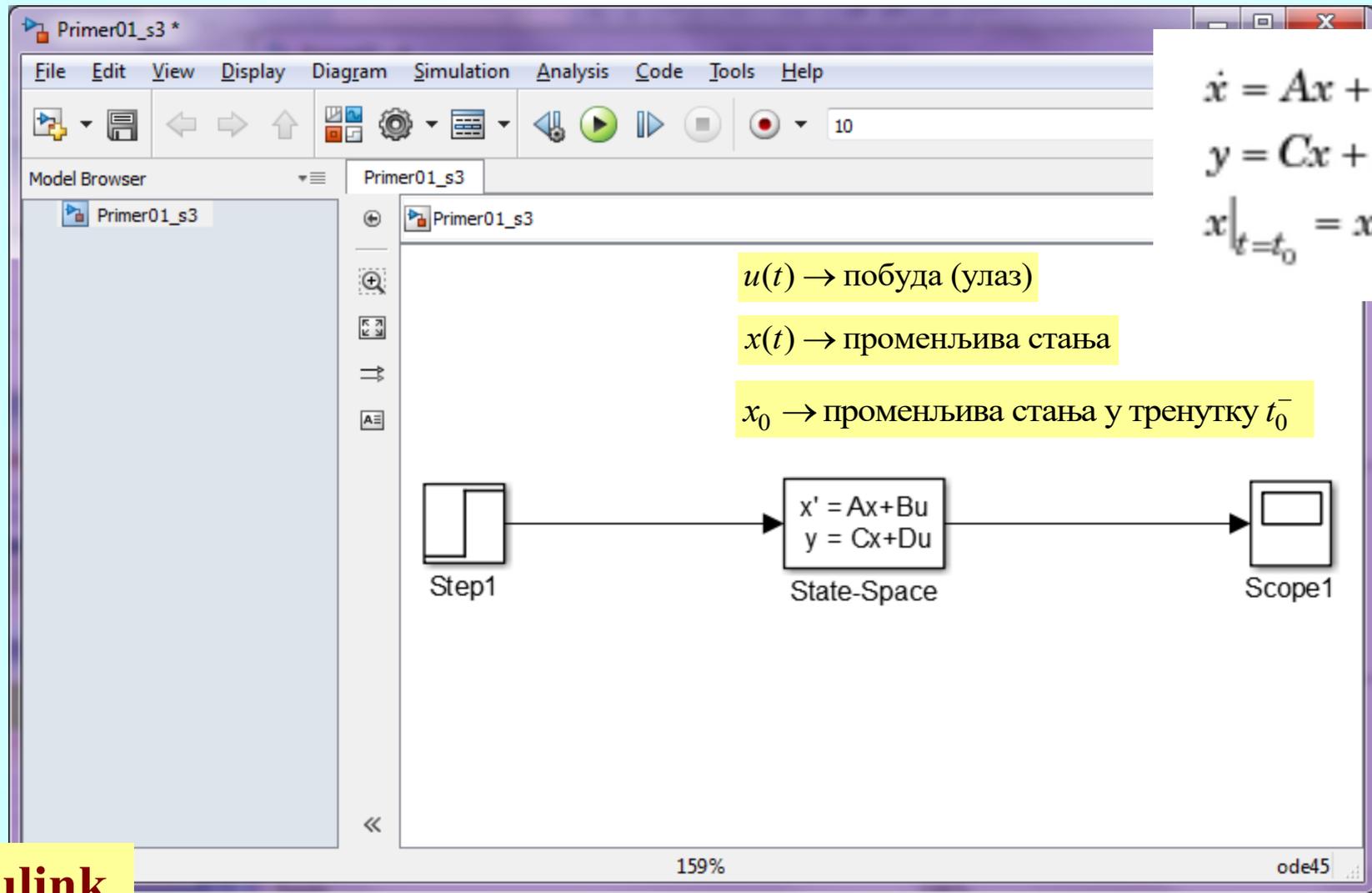
OK Cancel Help Apply

Simulink

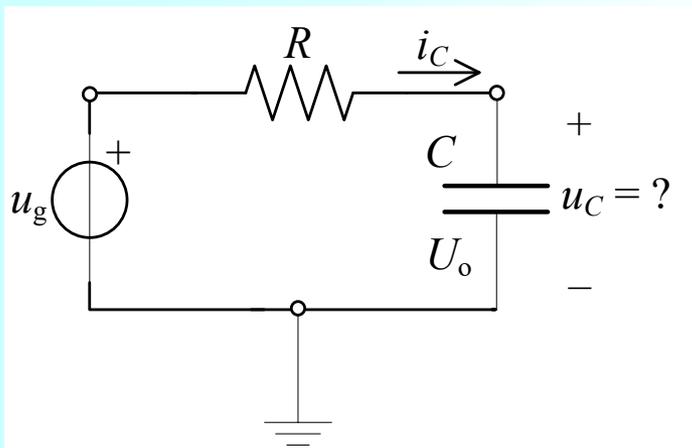
- Решавање кола може се извршити његовим свођењем на систем линеарних диференцијалних једначина
- Дати систем може се представити једноставним блоком са више улаза и излаза



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^-

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

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

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

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

коло је образовано у тренутку $t_0 = 0$

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

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

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

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

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

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

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

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

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

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

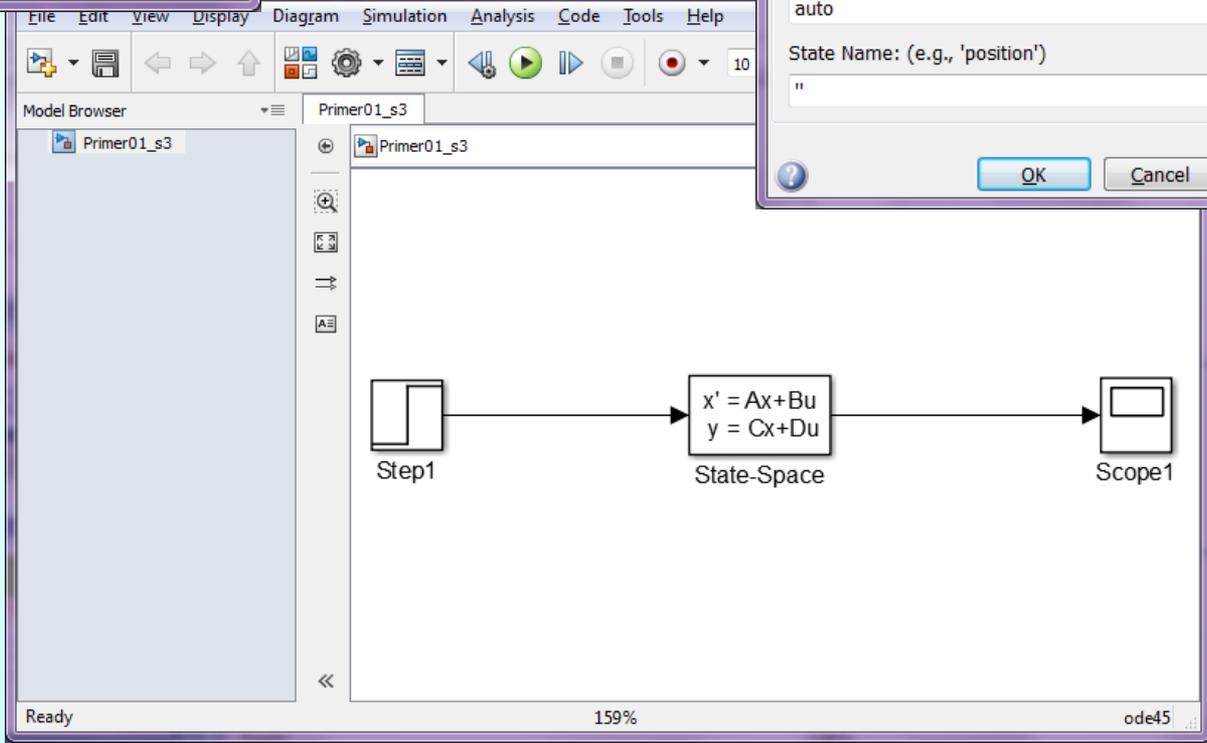
D:
0

Initial conditions:
-10

Absolute tolerance:
auto

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

OK Cancel Help Apply



Баста, доцент, 13Е072РРК3, 19Е072РРК, Унив

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

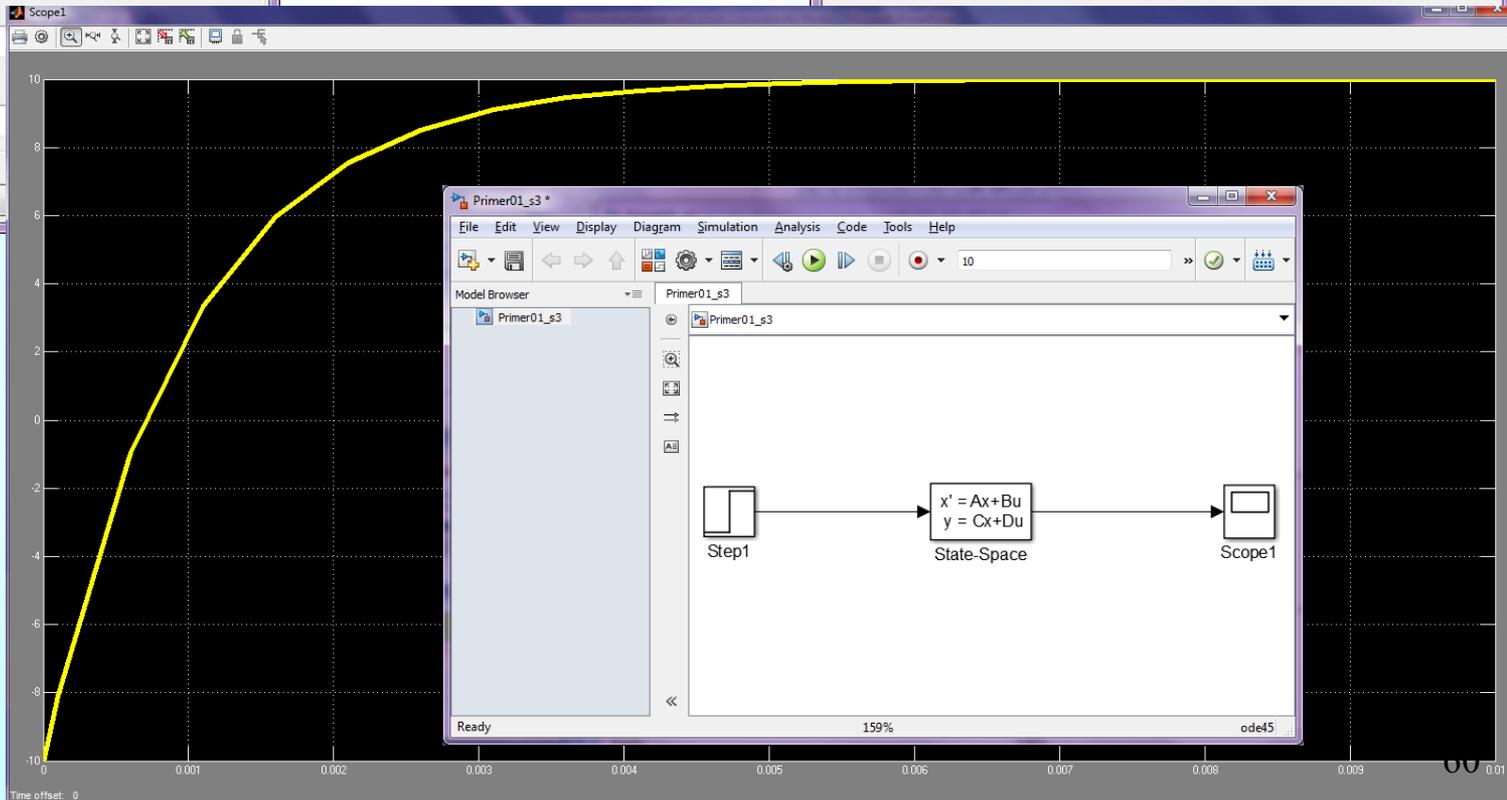
Initial value:
0

Final value:
10

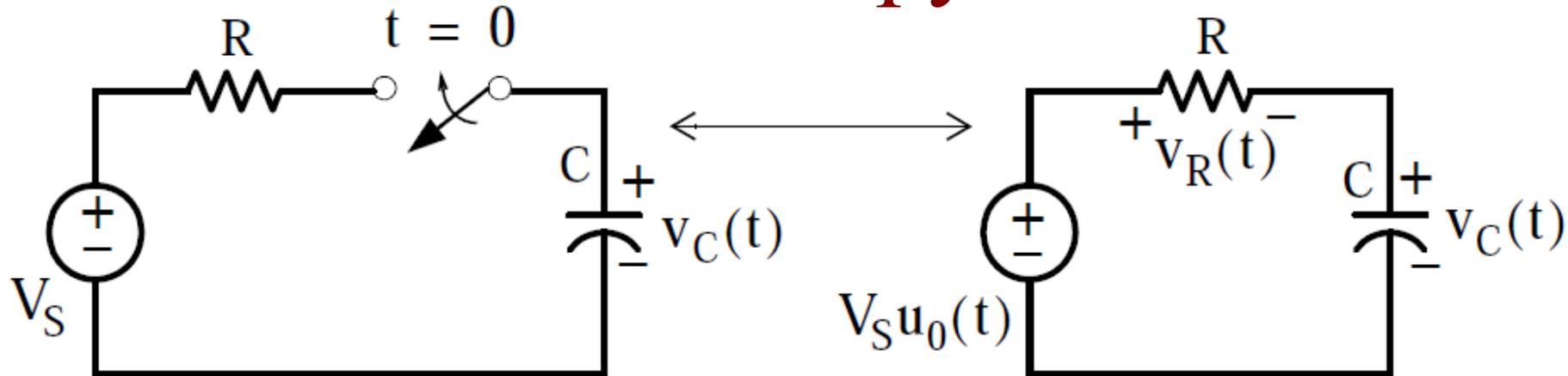
Sample time:
0

Interpret vector parameters as 1-D

Enable zero-crossing detection



Решимо “ручно”



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

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

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

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

$t > 0$

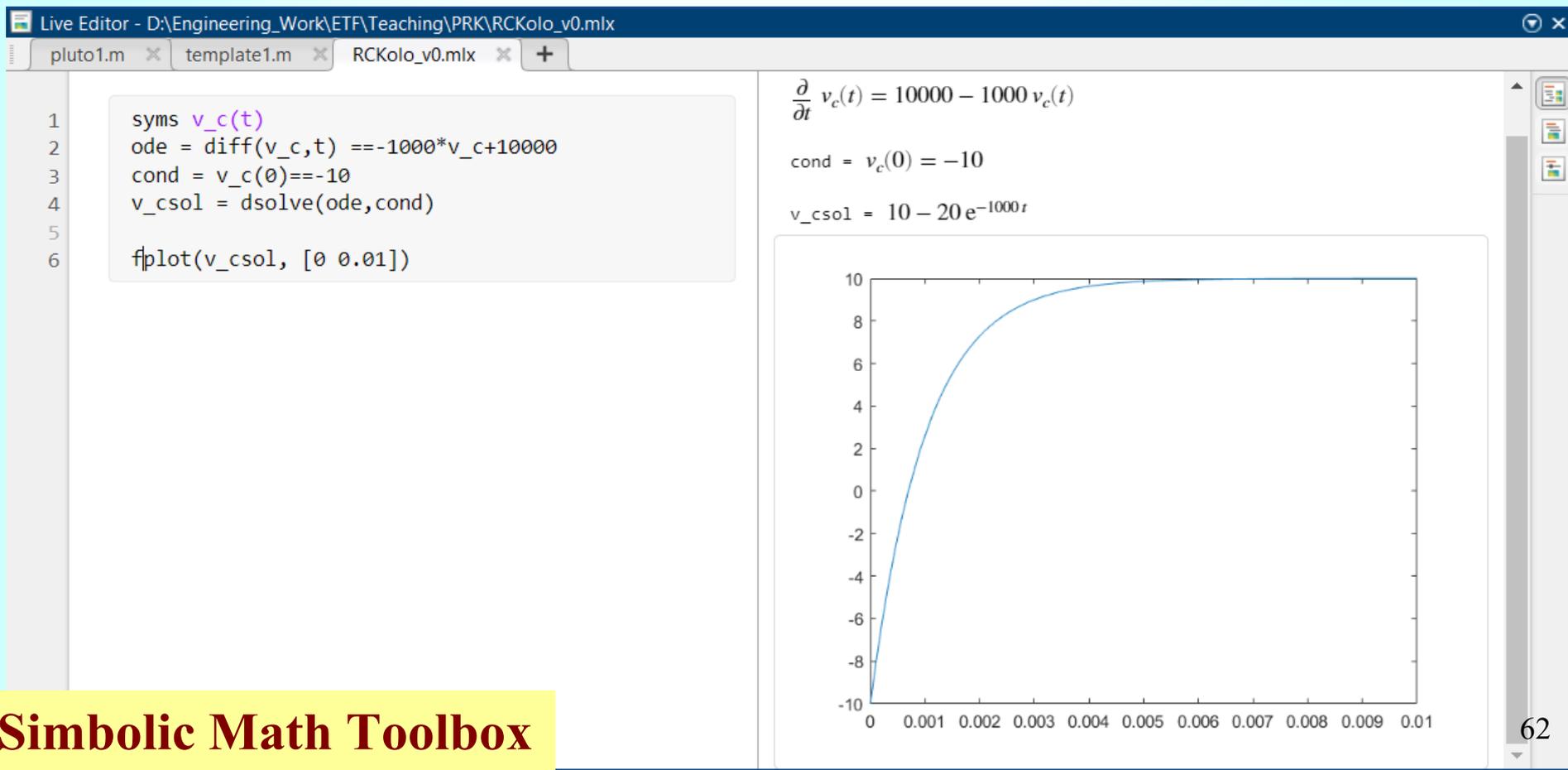
$$RC \frac{dv_C}{dt} + v_C = V_S$$

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

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)$
```

