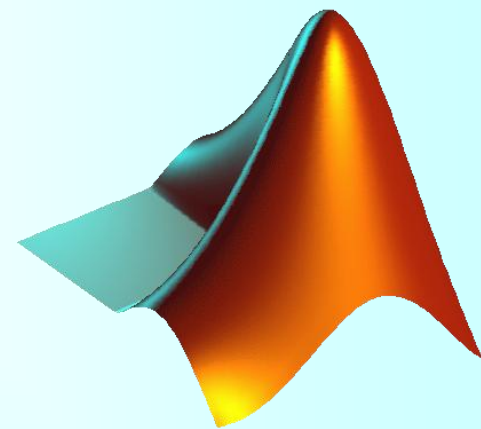
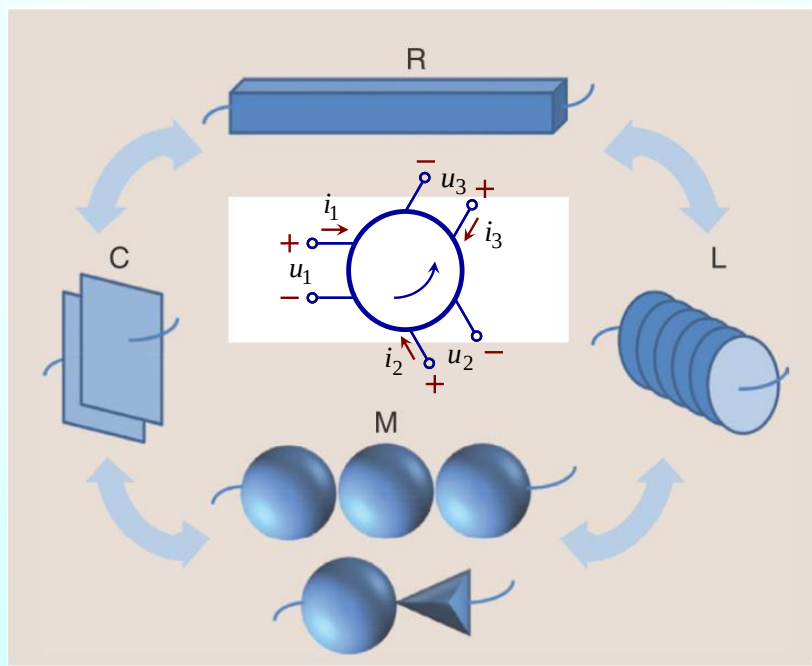


Практикум из рачунарске анализе кола



Милка Потребих Иваниш
Никола Баста



Практикум из рачунарске анализе кола

13E072ПРК3, 19E072ПРК

- **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. Бодеови дијаграми. Трофазна кола. Симболичко решавање електричних кола. Водови.
- **Наставници.** Др **Милка Потребих Иваниш**, редовни професор, соба 64 (milka_potrebic@etf.rs); Др **Никола Баста**, доцент, соба 63 (nbasta@etf.rs).
- **Демонстратори.** Ања Ковачевић, дипл. инж., Филип Нешковић, дипл. 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) израда 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 израду 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/>



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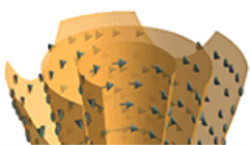
ShortestTour.nb

File Format Insert Evaluation

```
In[1]:= pressure[c_,t_] := If[c < none, 1/2 rho w^2 + rho g x + Subscript[rho, 0], -(rho w^2 rho
-> rho g x + rho w^2 rho + Subscript[rho, 0])];

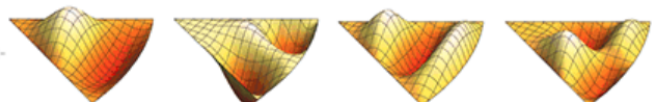
In[2]:= SliceVectorPlot3D[{{wind[Subscript[c, 2] + y^2], (y)} / Norm[{c, y}],
{-wind[Subscript[c, 2] + y^2], (y)} / Norm[{c, y}], 0},
{c^2 + y^2 == 1, c^2 + y^2 == 3}, {c, -5, 5}, {y, -5, 5}, {t, 1, 5},
RegionFunction -> Function[{c, y, t}, c < 0 || y > 0]]]

Out[2]=
```



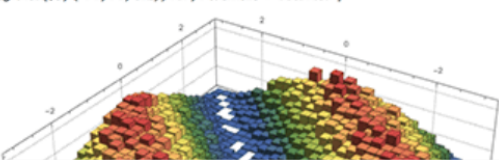
```
In[3]:= Grid[Partition[Plot3D[Re[#], {x, y} <= 0, Boxed -> False,
Axes -> None, PlotRange -> All] & /@ funs, 3]]]

Out[3]=
```



```
In[4]:= evsd = MatrixPropertyDistribution[Arg[Eigenvalues[x]], x <= CircularUnitaryMatrixDistribution[2]];
qs = RandomSample /@ RandomVariate[evsd, 10^5];
Histogram3D[qs, {-Pi, Pi, 0.2}, PDF, PlotTheme -> "Detailed"]

Out[4]=
```



Available on desktop, cloud & mobile



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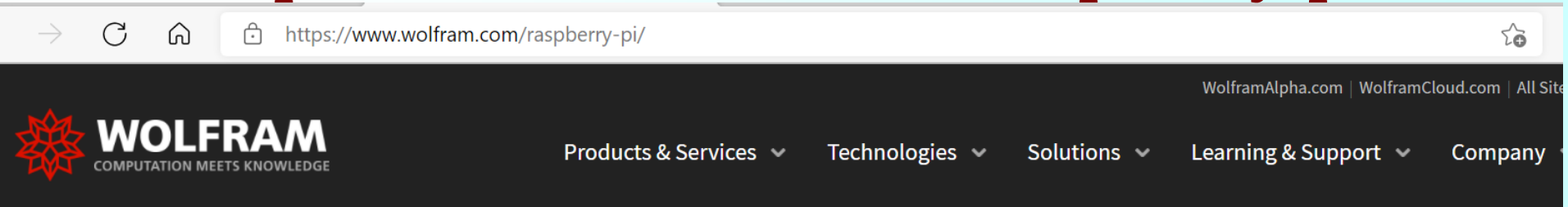
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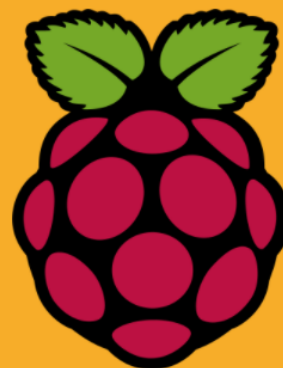
ENG 12:53 AM
SRL 10/5/2022

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



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+



www.wolframalpha.com

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:

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

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

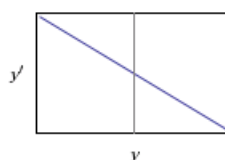
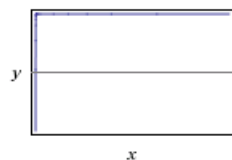
Differential equation solution:

[Approximate form](#)

[Step-by-step solution](#)

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

Plots of the solution:



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

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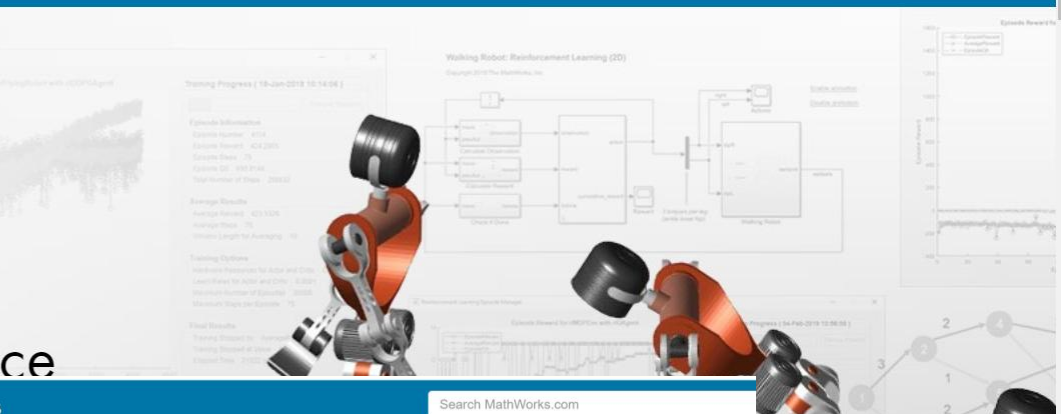
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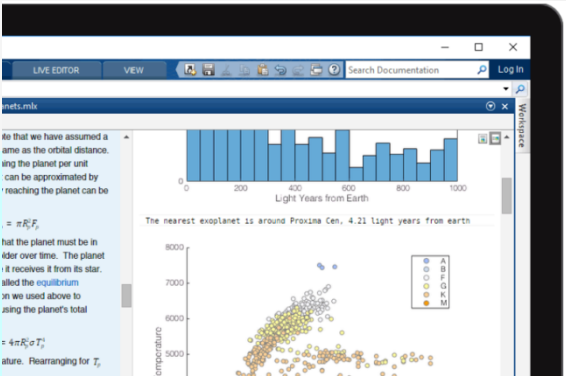
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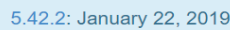
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Maxima on line

<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(explicit(x^2+y^2,x,-1,1,y,-1,1));
```

Clic

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

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MaximaOnAndroid

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

MaximaOnAndroid

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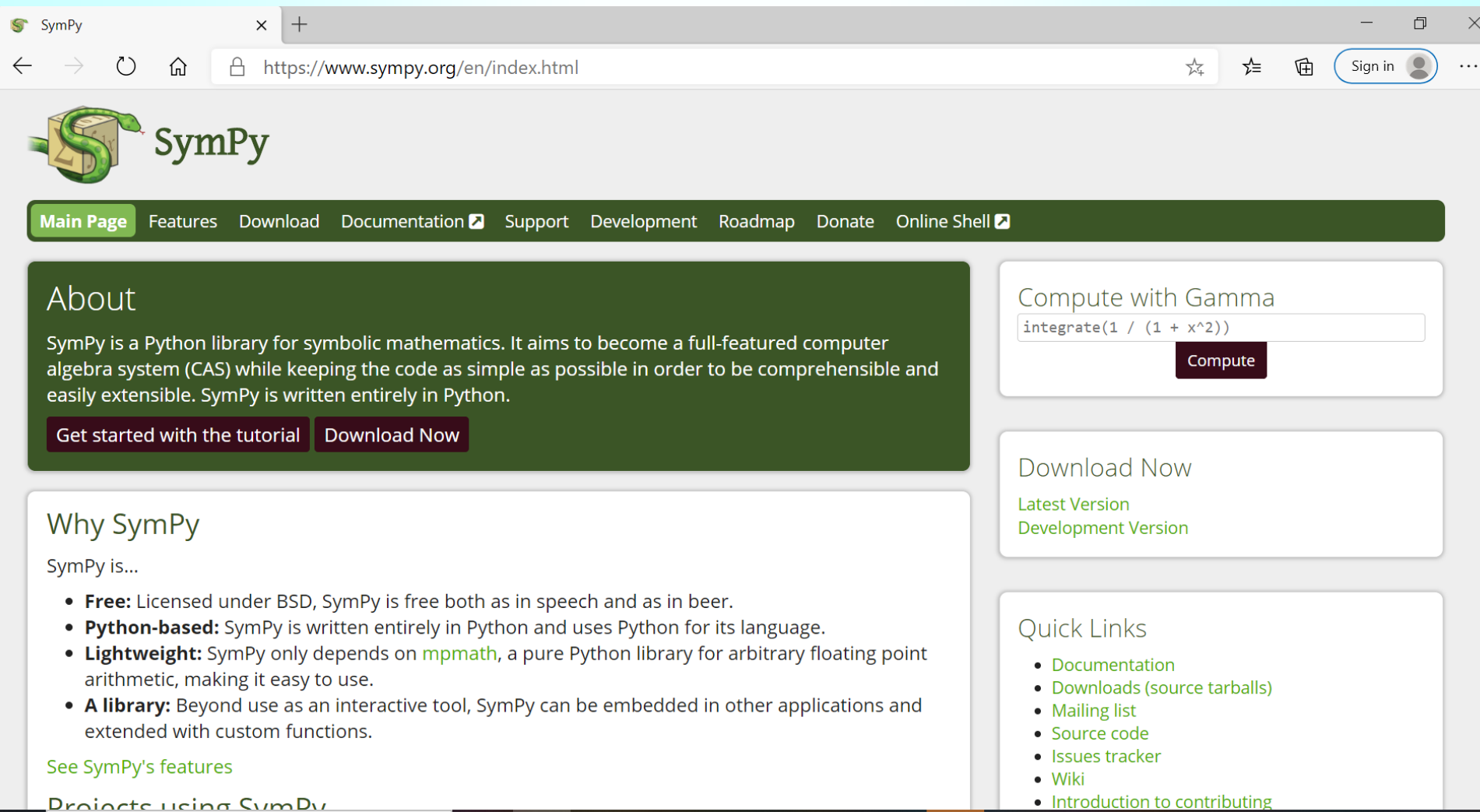
Maxima 5.28.0 Manual

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 1998, 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. On the left, there is an 'About' section with a description of SymPy as a Python library for symbolic mathematics, followed by 'Get started with the tutorial' and 'Download Now' buttons. Below this is a 'Why SymPy' section with a list of features: Free (BSD license), Python-based (written in Python), Lightweight (depends on mpmath), and A library (can be embedded in other applications). On the right, there is a 'Compute with Gamma' section with a text input field containing the expression `integrate(1 / (1 + x^2))` and a 'Compute' button. Below this is a 'Download Now' section with links for 'Latest Version' and 'Development Version'. At the bottom right, there is a 'Quick Links' section with a list of links: Documentation, Downloads (source tarballs), Mailing list, Source code, Issues tracker, Wiki, and Introduction to contributing.

SymPy

[Main Page](#) [Features](#) [Download](#) [Documentation](#) [Support](#) [Development](#) [Roadmap](#) [Donate](#) [Online Shell](#)

About

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.

[Get started with the tutorial](#) [Download Now](#)

Why SymPy

SymPy is...

- **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.

[See SymPy's features](#)

Projects using SymPy

Compute with Gamma

`integrate(1 / (1 + x^2))`

[Compute](#)

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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/>.

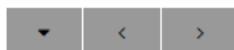
```
>>> diffeq = Eq(f(x).diff(x) + 1000*f(x), 10000)
>>> diffeq
```

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

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

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

```
>>>
```



Evaluate

Clear

Fullscreen

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About this page

SymPy Live is SymPy running on the SymPy Engine.

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

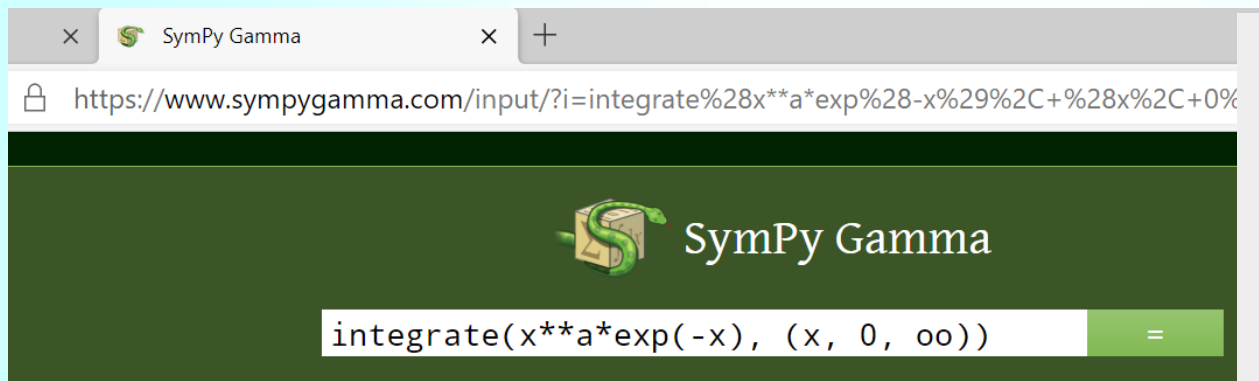
```
>>> from __future__ import division
>>> from sympy import *
>>> x, y, z, t = symbols('x y z t')
>>> k, m, n = symbols('k m n', integer=True)
>>> f, g, h = symbols('f g h', cls=Function)
```

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.

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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

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Algebra

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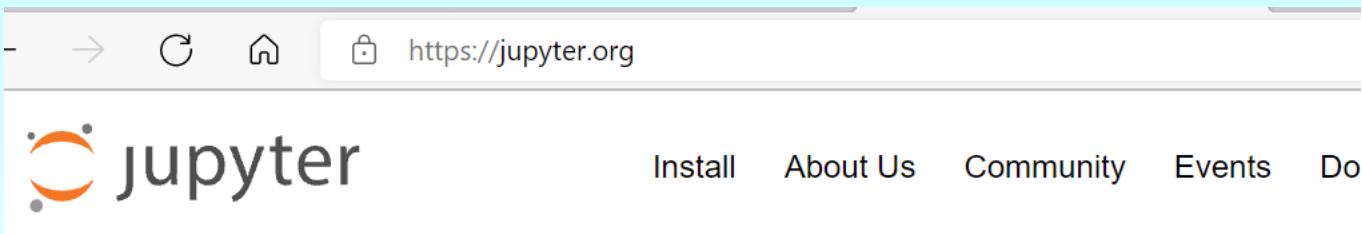
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Miscellaneous



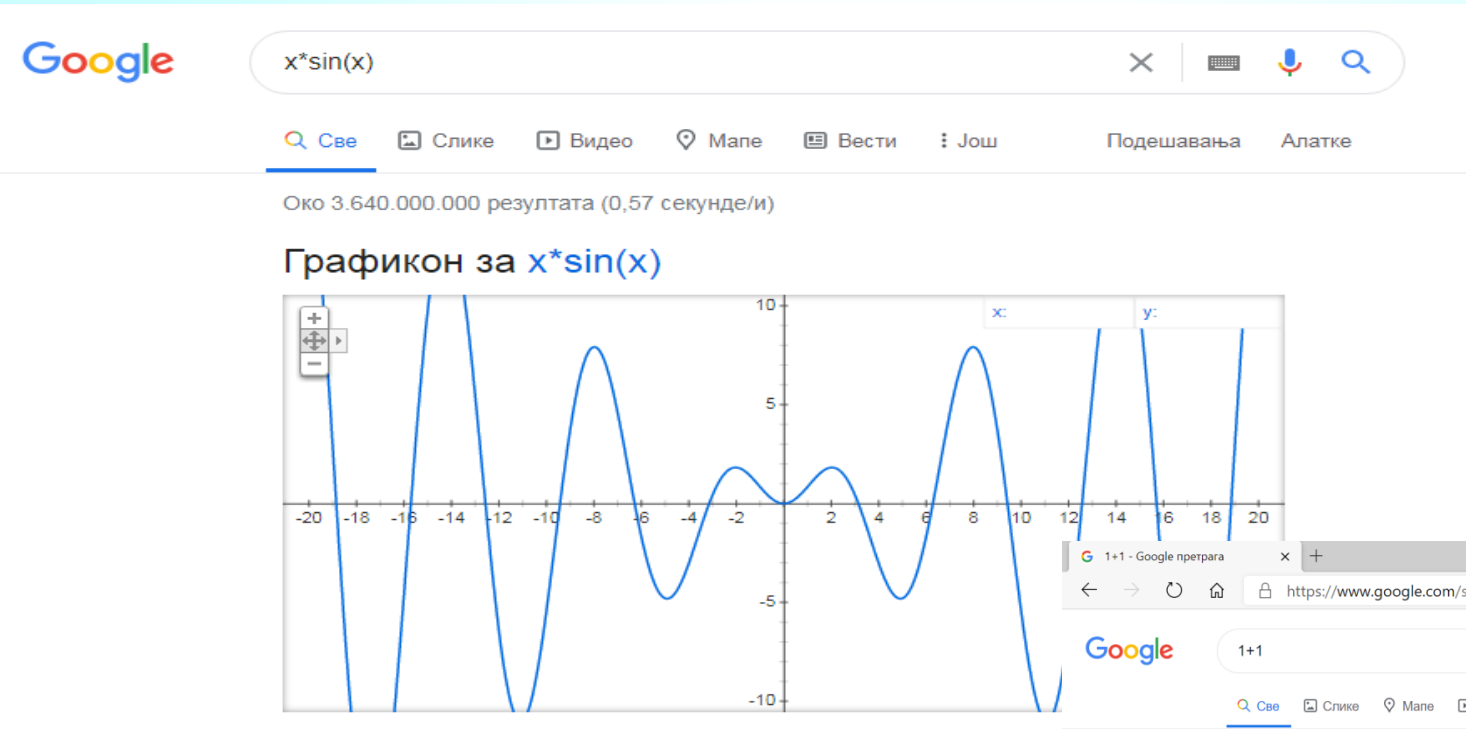
Sympy and the Jupyter Notebook for engineering calculations

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



Project Jupyter exists to develop open-source software, open-standards, and services
interactive computing across dozens of programming languages.

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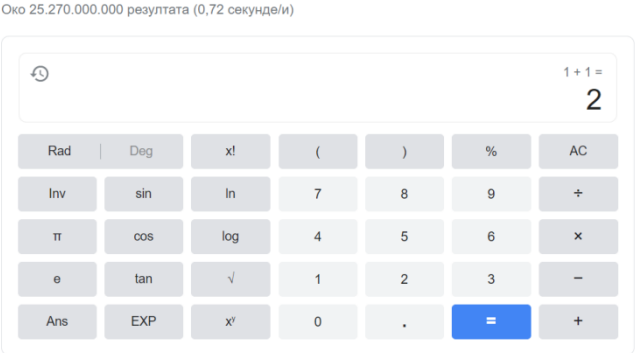
What is the integral of $x \sin(x) dx$? | MyTutor

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...

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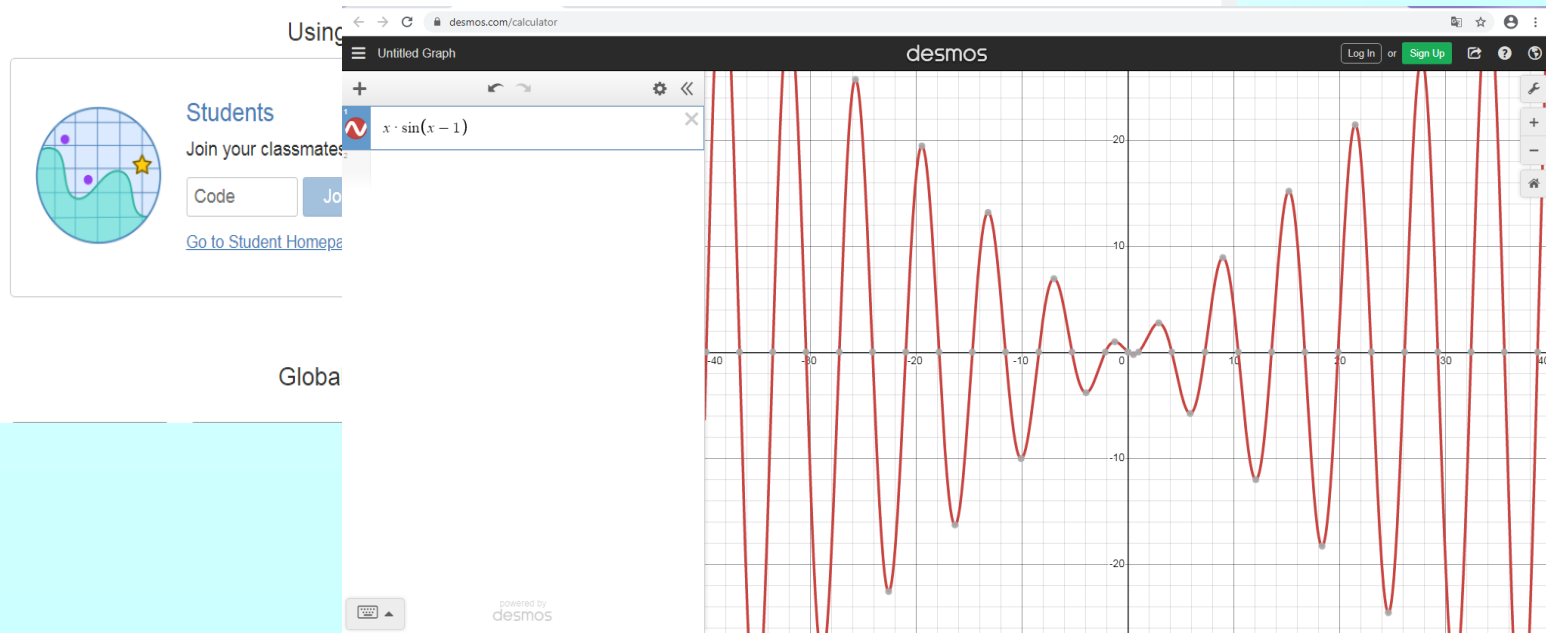
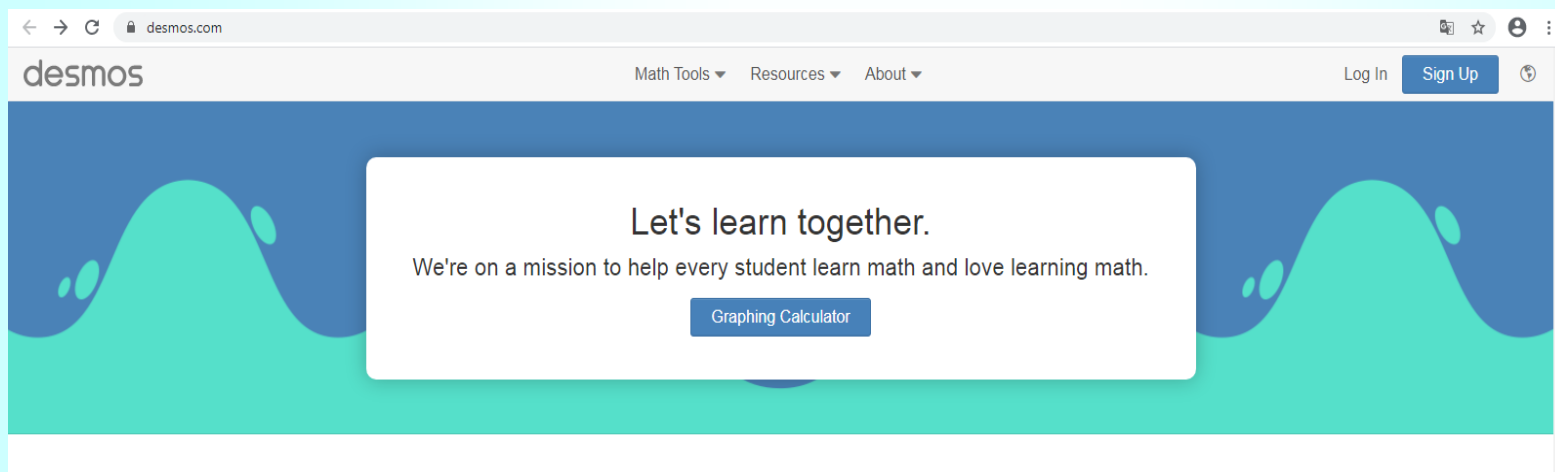
Ex 7.6, 1 - Find integration of $x \sin x$ - Chapter 7 Clas

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/>

Symbolab Math Solver - Step by Step calculator

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

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

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

Pre Algebra Algebra Pre Calculus Calculus Functions Matrices & Vectors Geometry Trigonometry Statistics Physics

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

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

Show Steps

$\int -\cos(x) dx = -\sin(x)$

Show Steps

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

Simplify

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

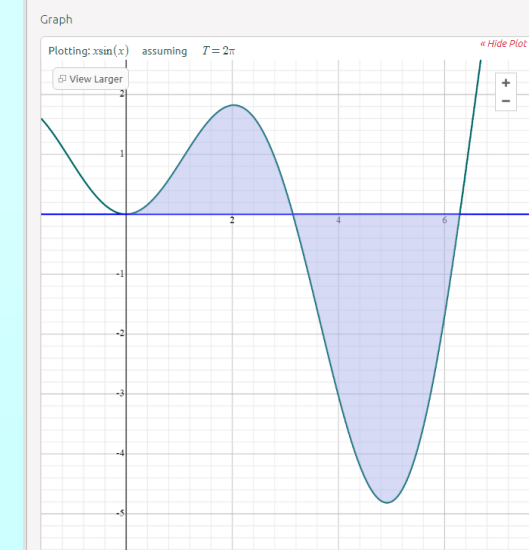
Compute the boundaries: $[-x \cos(x) + \sin(x)]_0^T = \sin(T) - T \cos(T)$

Show Steps

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

Got a different answer? Check if it's correct

Verify



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SciLab CONFERENCE

Xcos

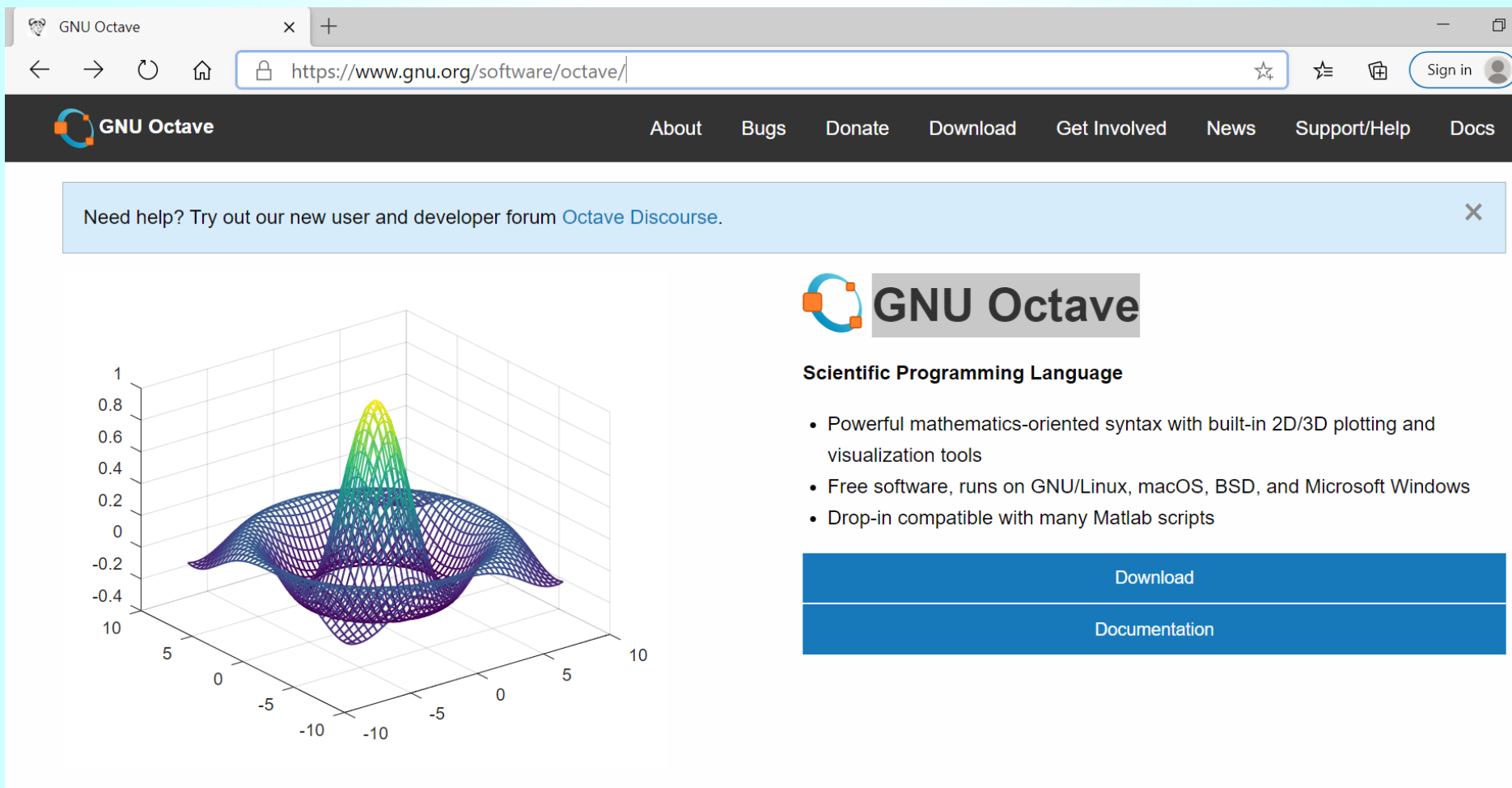
<https://www.scilab.org/software/xcos>

The screenshot displays the Xcos website interface. At the top, the Scilab logo is on the left, and a navigation menu includes 'Download', 'Software' (selected), 'Tutorials', 'Applications', 'Services', 'Cloud', and 'About'. A search bar is located on the right. Below the navigation bar, the word 'Xcos' is prominently displayed in white on a blue background. Underneath, four example diagrams are shown, each with a title at the bottom:

- Signal Processing:** A diagram showing three 'Signal Builder' blocks connected to a 'Scope' block. A note states: 'blocks can also emit continuous or discrete activation signals'.
- Control Systems:** A diagram titled 'Water-Tank System' showing a feedback control loop with a 'Controller' block and a 'Robot-Tank System' block.
- Mechanics/Thermodynamics:** A diagram showing a series of interconnected mechanical or thermal components, including tanks and pipes.
- Electronics:** A diagram showing an electronic circuit with various components like resistors, capacitors, and a 'MUX' block.

GNU Octave

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



The screenshot shows the GNU Octave website homepage. At the top, there is a browser window with the address bar showing <https://www.gnu.org/software/octave/>. Below the browser window is a dark navigation bar with the GNU Octave logo on the left and links for About, Bugs, Donate, Download, Get Involved, News, Support/Help, and Docs on the right. A light blue banner below the navigation bar contains the text "Need help? Try out our new user and developer forum [Octave Discourse](#)." with a close button. The main content area features a 3D wireframe plot of a mathematical function on the left, which is a bell-shaped curve with a central peak and surrounding ripples. To the right of the plot is the GNU Octave logo and the text "Scientific Programming Language". Below this, there is a list of bullet points describing the language's features. At the bottom right, there are two blue buttons: "Download" and "Documentation".

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

CircuitLab

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

The image shows a screenshot of the CircuitLab website and a tutorial video. The website header includes the CircuitLab logo, a search bar, and navigation links: "My Workbench", "Electronics Q&A", and "Textbook". The user profile "milka.potrebic" is shown with "inbox (0)", "settings", and "log out" options. The main heading reads "Circuit simulation and schematics." followed by the subheading "Build and simulate circuits right in your browser." A list of features includes: "Design with our easy-to-use schematic editor.", "Analog & digital circuit simulations in seconds.", "Professional schematic PDFs, wiring diagrams, and plots.", and "No installation required! Launch it instantly with [one click](#)." A green button says "Launch CircuitLab" and a link says "or watch a quick demo video →".

The tutorial video, titled "Getting Started with CircuitLab", shows a circuit diagram with a sine wave source V1 (1 KHz), a resistor R1 (100 Ω), a resistor R2 (100 Ω), and a capacitor C1 (1 μ F). The video includes a play button and a progress bar.

Below the video, a "1-minute Tutorial" is provided with the following steps:

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.

The bottom part of the image shows a screenshot of the CircuitLab editor interface. It includes a toolbar with various components like DC Sources, Passive Elements, Voltage Signal Sources, Current Signal Sources, Operational Amplifiers, and Diodes. The main workspace displays a circuit diagram with a square wave source V1 (1 kHz), a resistor R1 (100 Ω), and a capacitor C1 (10 μ F). The circuit is labeled with "In" and "out" nodes.

At the bottom right, there is a link to the "Textbook" section, which is highlighted with a "NEW!" badge. The text "Electronic systems with CircuitLab's free, ..." is partially visible.

DoCircuits Circuit Simulator

Do Circuits

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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

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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 through 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 shaper. The wave will be shifted to a positive or negative level.

Fig. 1: DoCircuits - Home

Micro-Cap

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

← → ↻ 🏠 ⚠ Not secure | www.spectrum-soft.com/index.shtml

🔊 ☆ ☆

spectrum Spectrum Software

Home Products Download Newsletters Support Contact Us

Industrial Strength Simulation

Select :

MC12 Revision History

Product Information

Features Tour

New MC12 Features

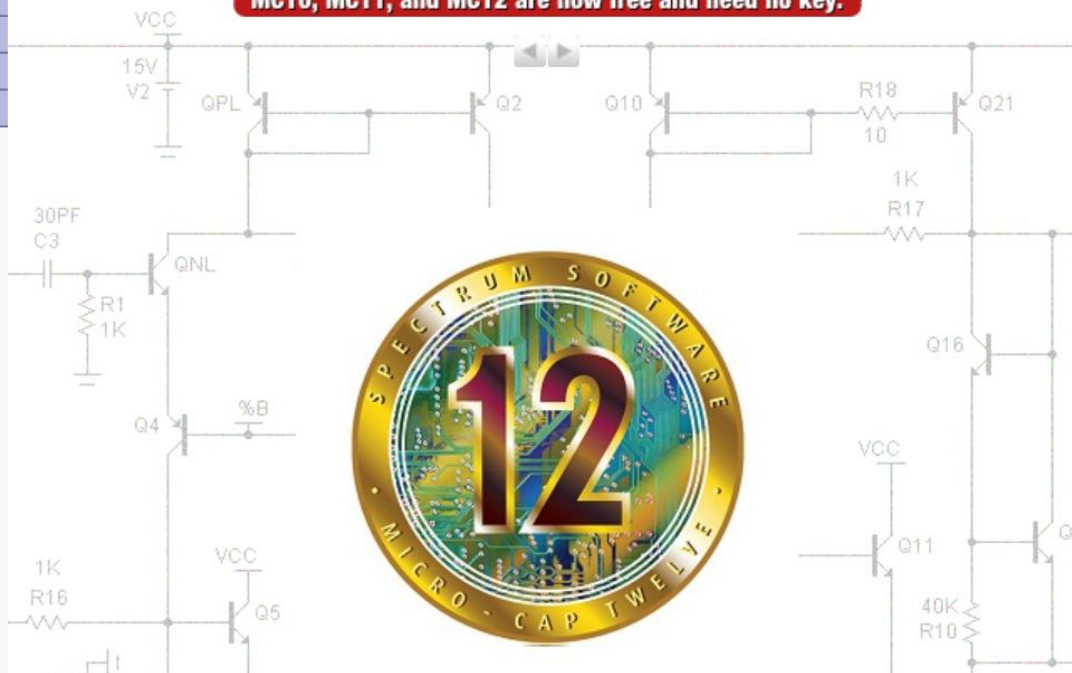
News:

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](mailto:support@spectrum-soft.com).

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.

ngSpice

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

← → ↻ 🏠 ⚠ Not secure | 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

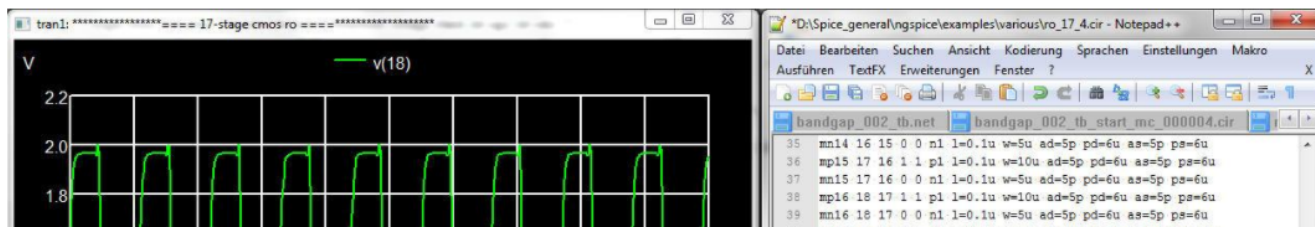
ngspice - open source spice simulator

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.



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https://www.ti.com/tool/TINA

 **TEXAS INSTRUMENTS**

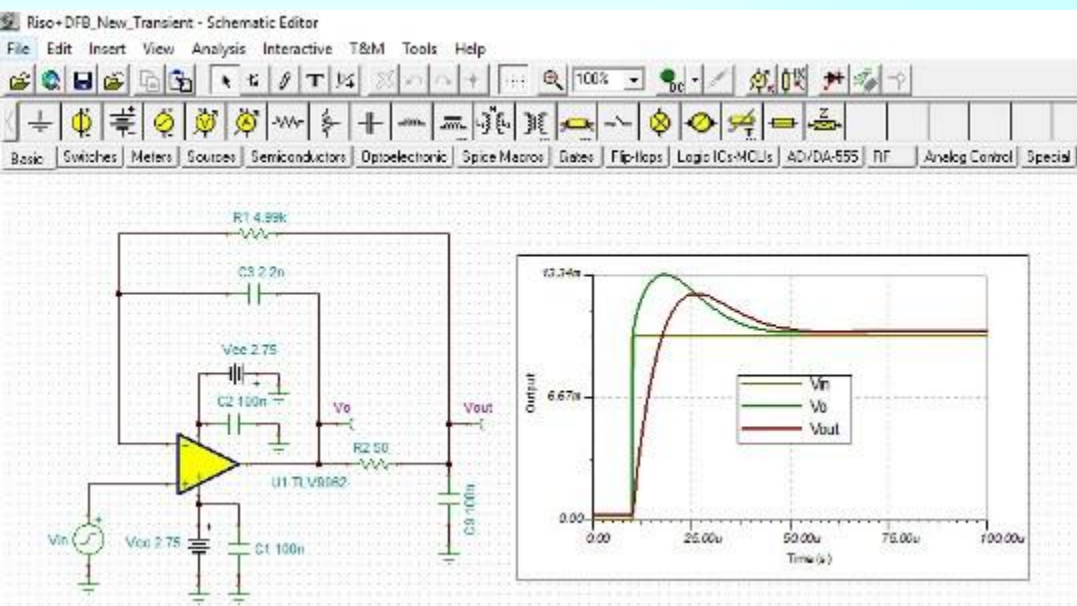
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TINA-TI

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

←

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🏠

🔒 https://play.google.com/store/apps/details?id=com.ecstudiosystems.electriccircuitstudio&hl=en_US&gl=US

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divider

CircuitSafari SPICE Simulator

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

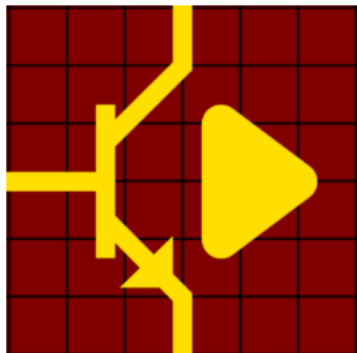


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CircuitSafari SPICE Simulator (Early Access)

Logipipe, LLC Productivity

E Everyone

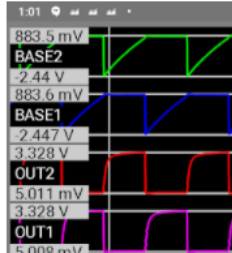
Offers in-app purchases

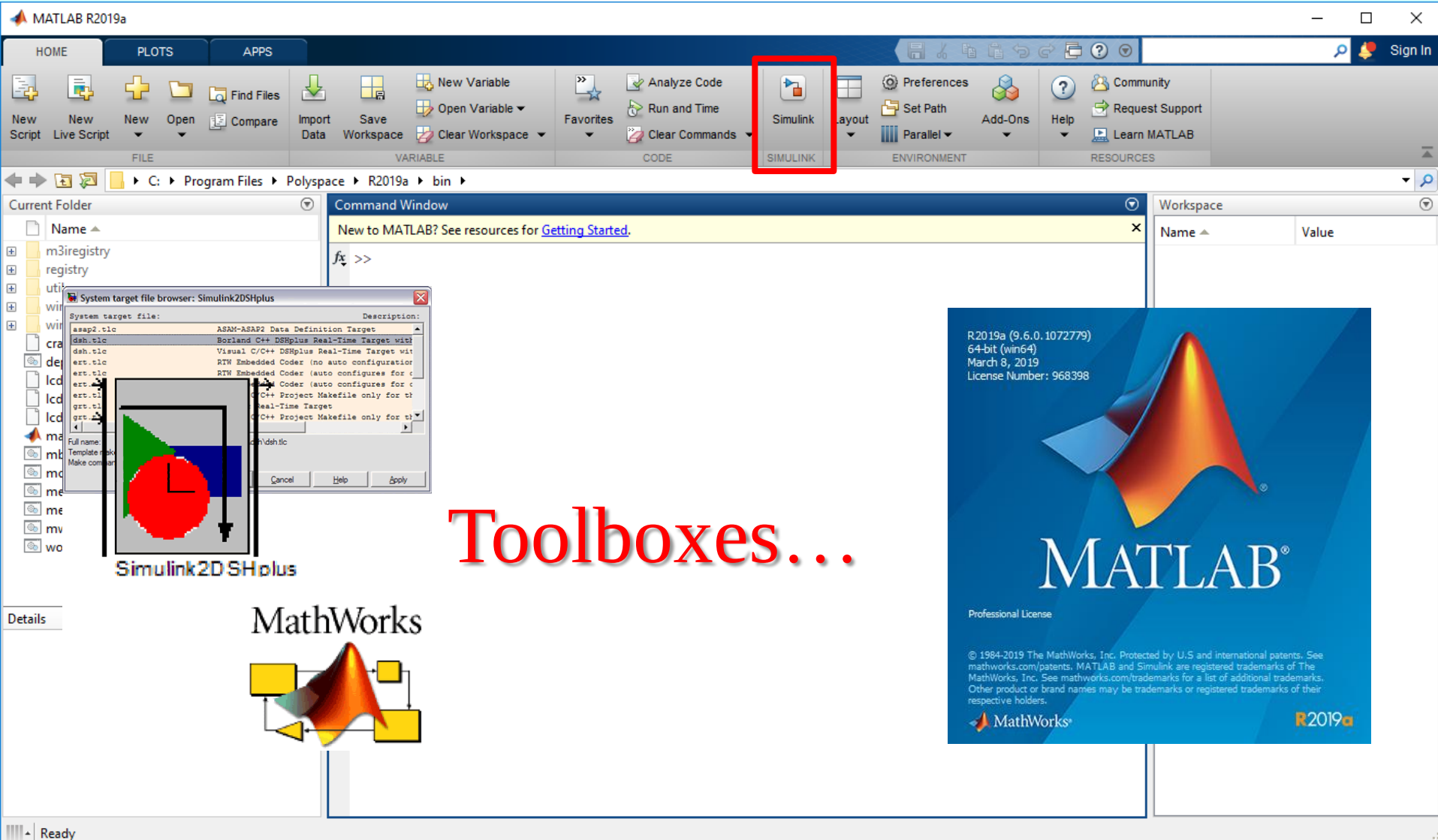
- 📌 This app is in development. It may be unstable.
- ⚠️ You don't have any devices

🔖 Add to Wishlist

Install

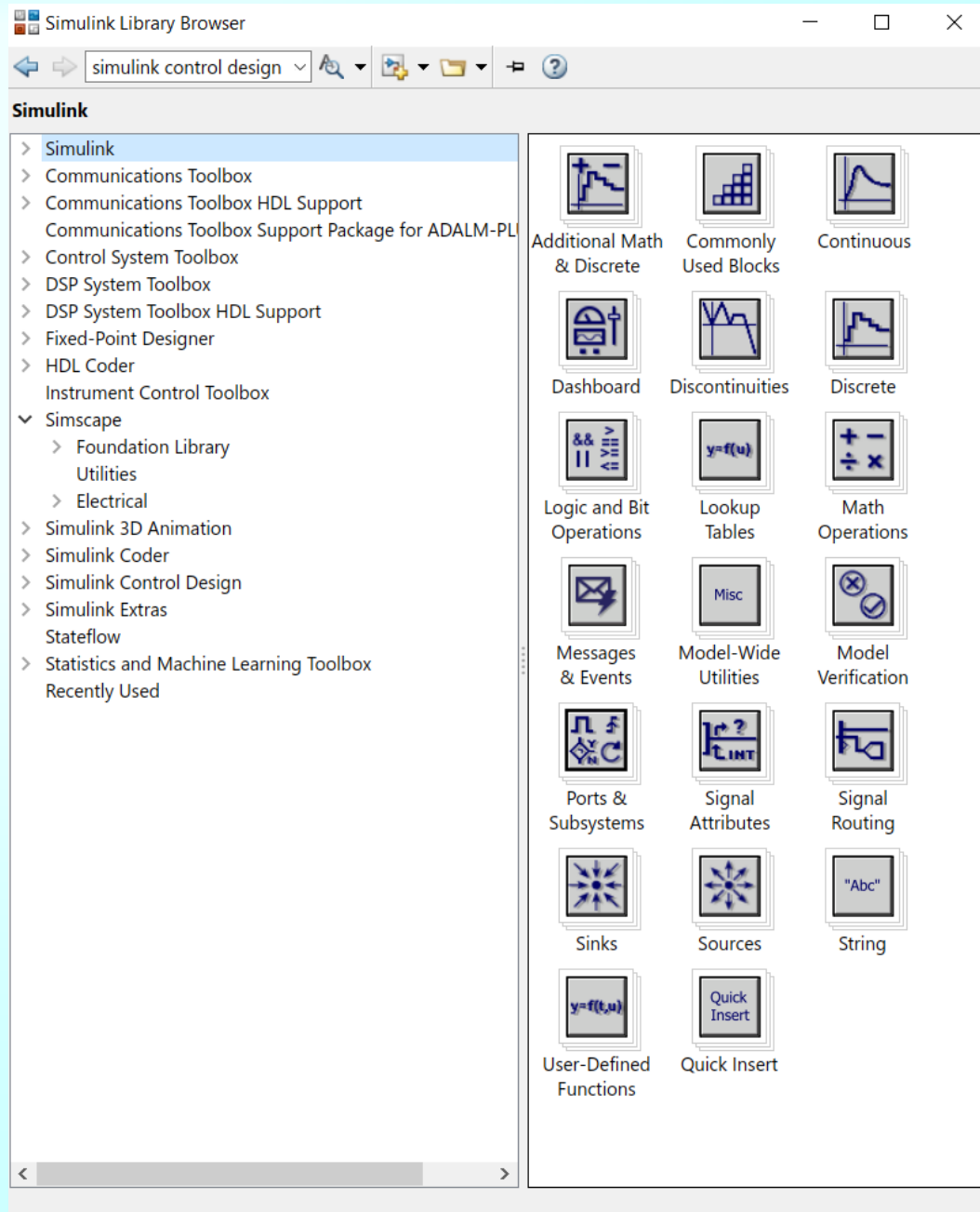
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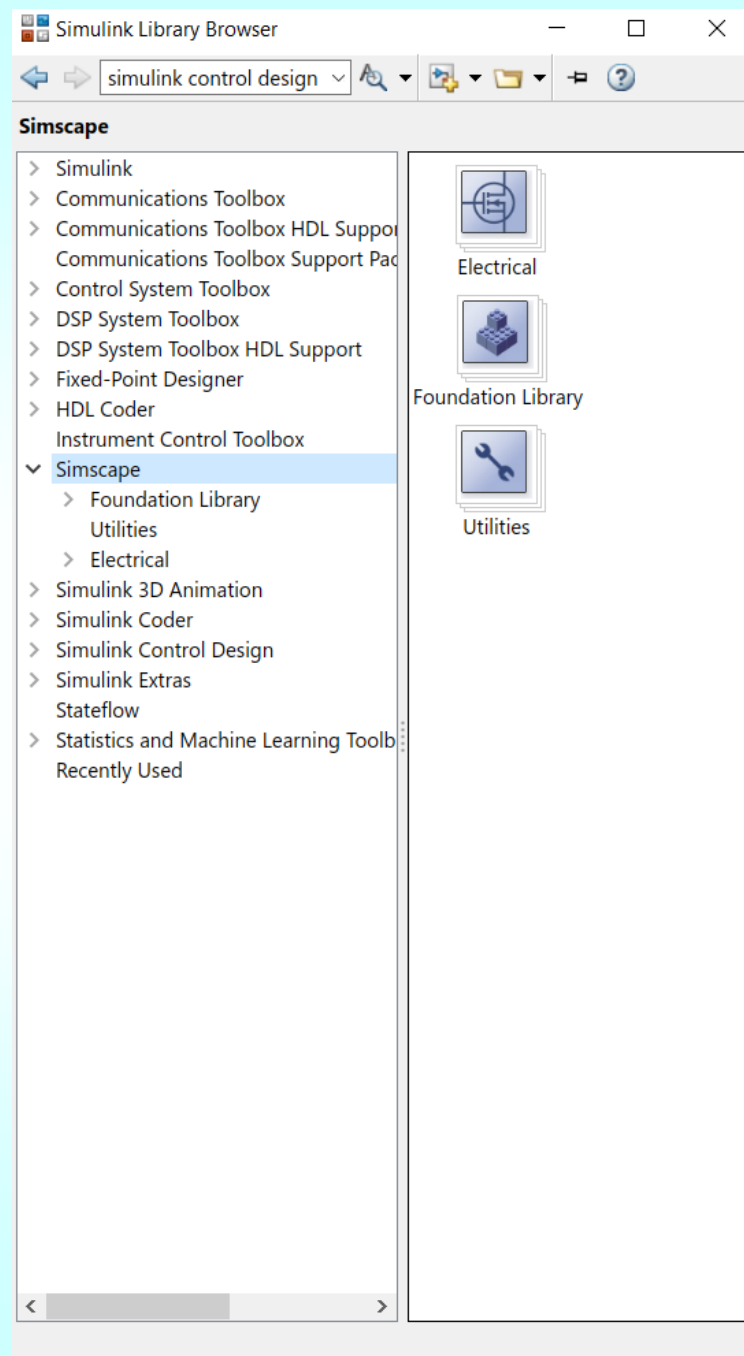
MATLAB Simulink

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



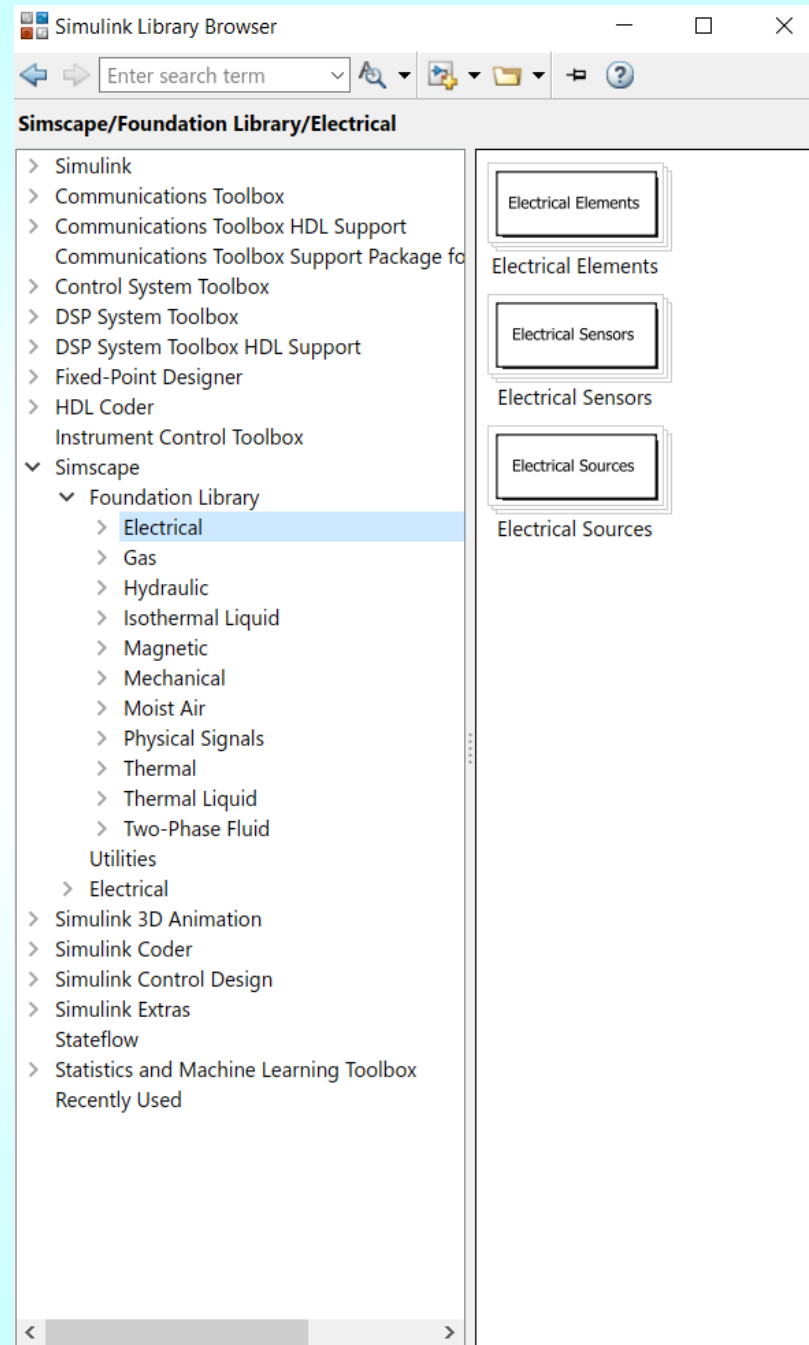
Simulink > Simscape

- Библиотека за симулацију и нумеричку анализу мултидоменских проблема (механика, електродинамика, оптика)



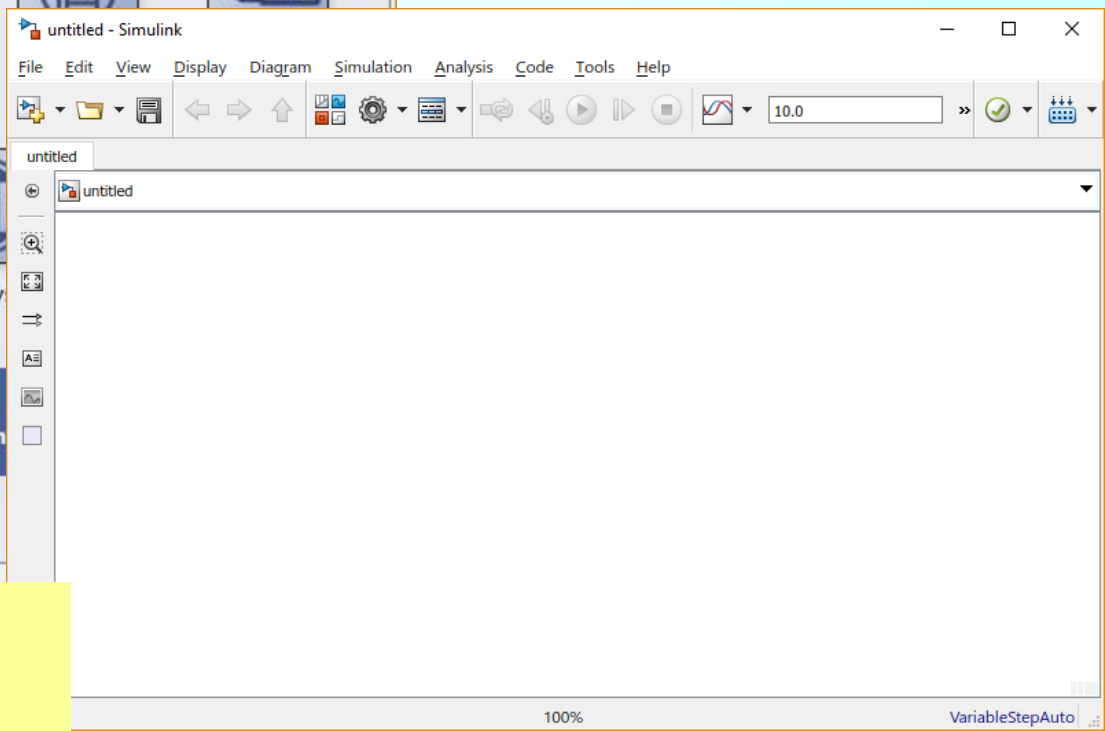
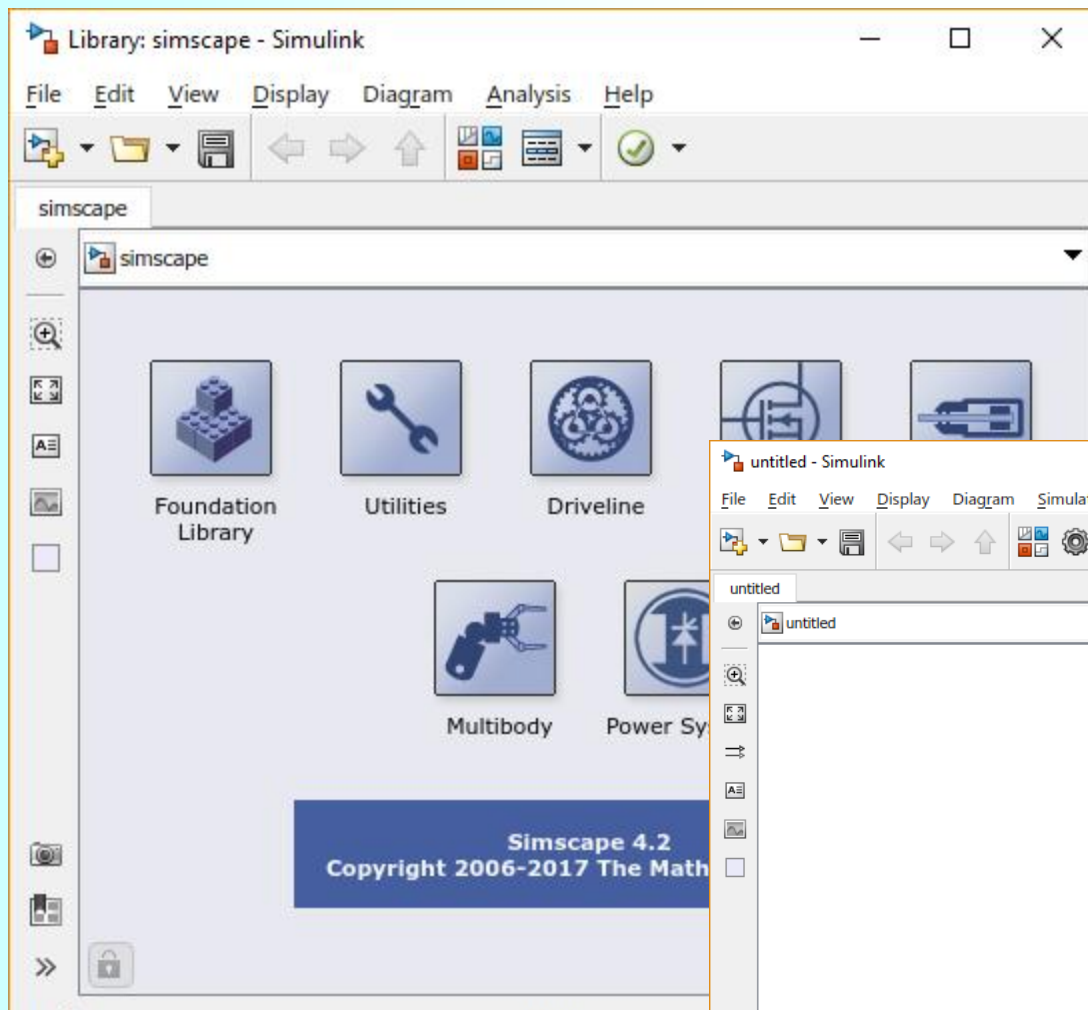
Simulink > Simscape > Foundation Library > Electrical

- Симулација линеарних и нелинеарних електричних кола

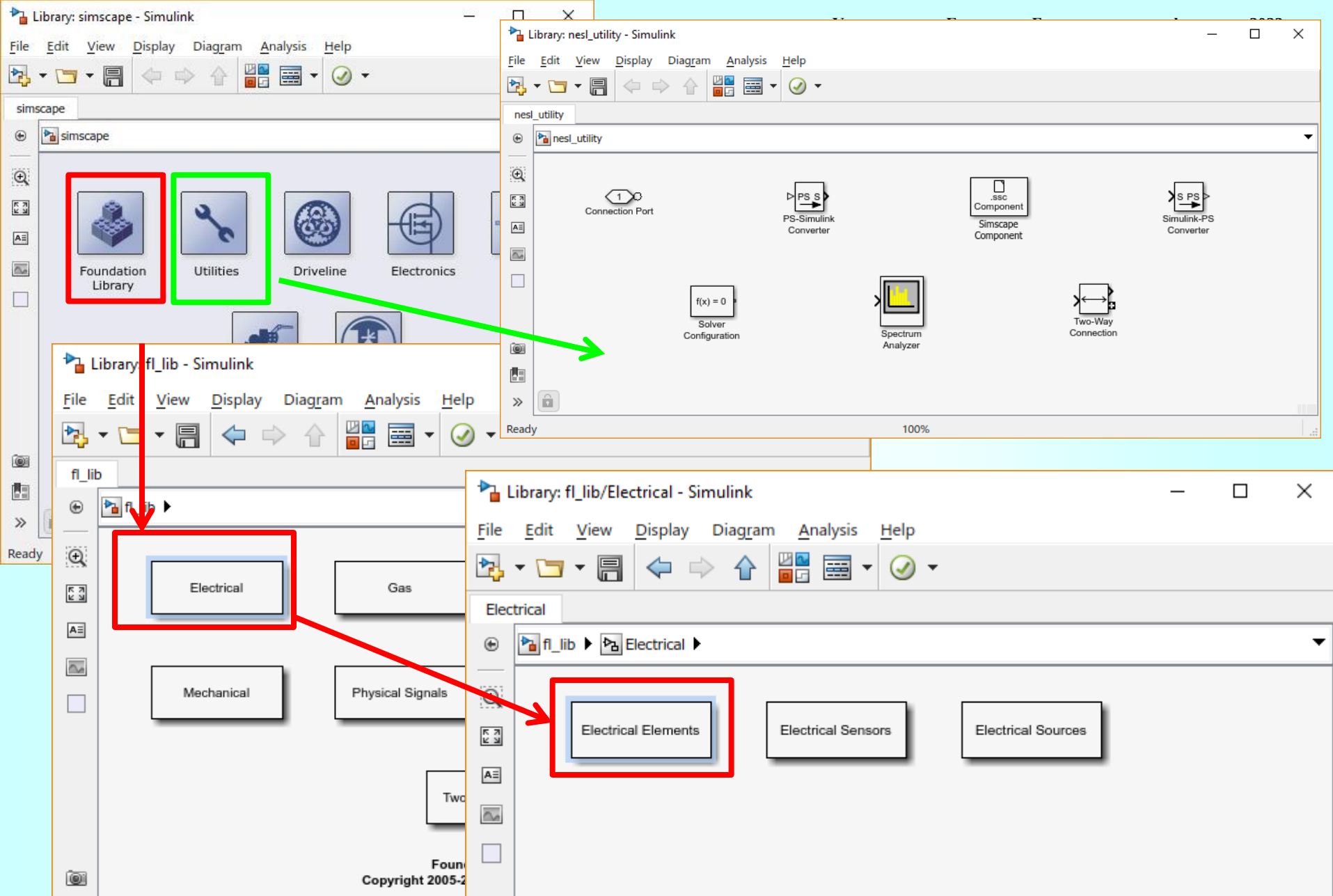


**MATLAB > Simscape >
Foundation Library, Utilities**

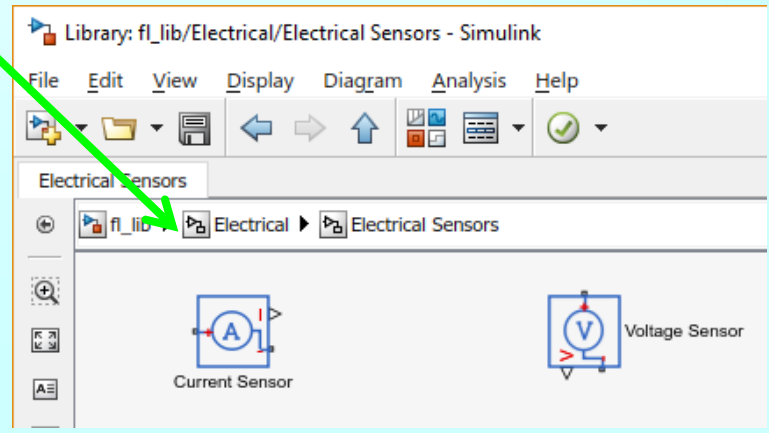
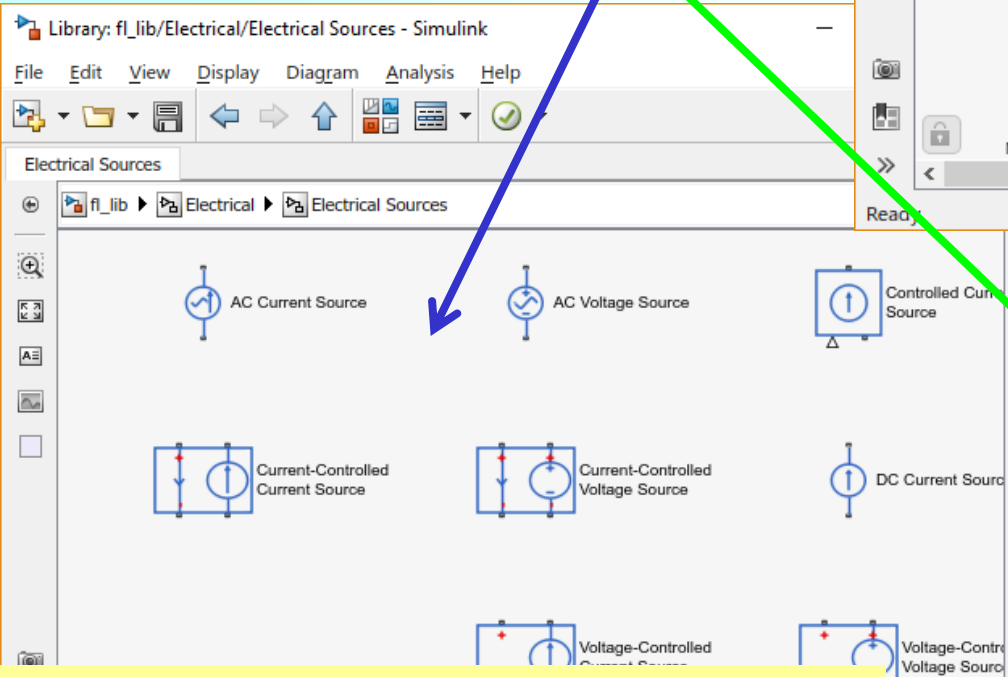
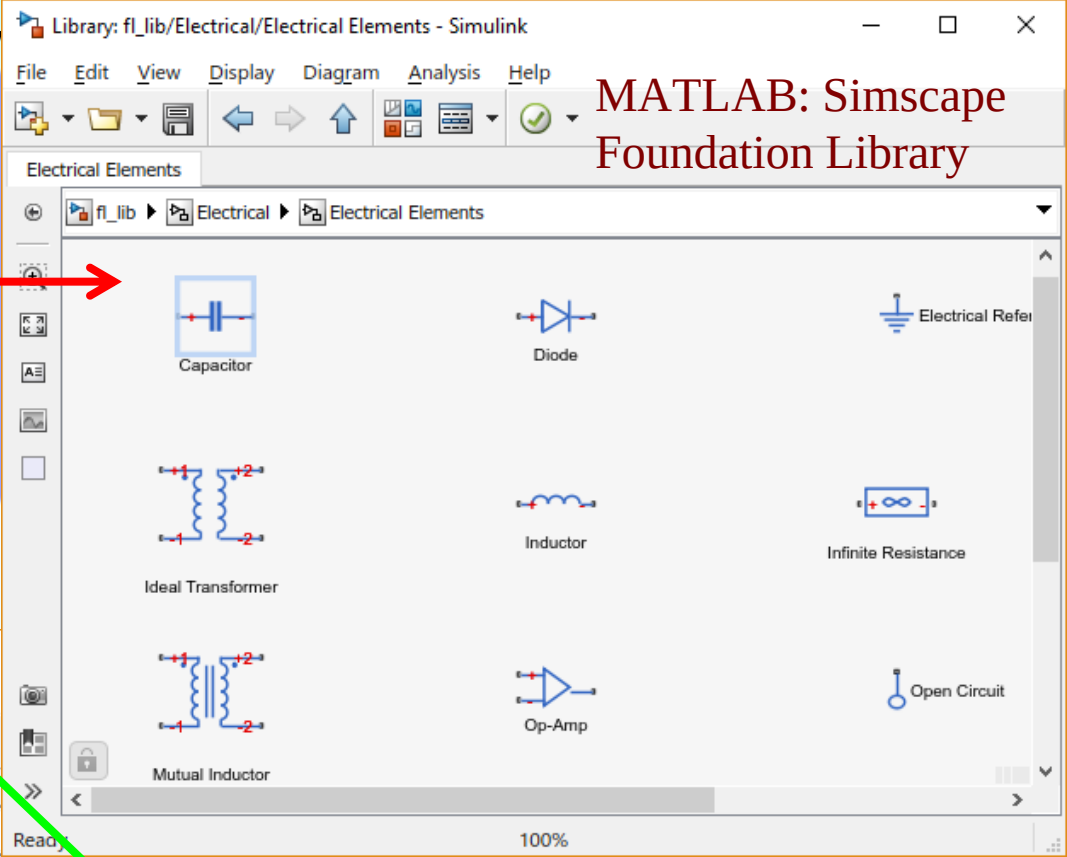
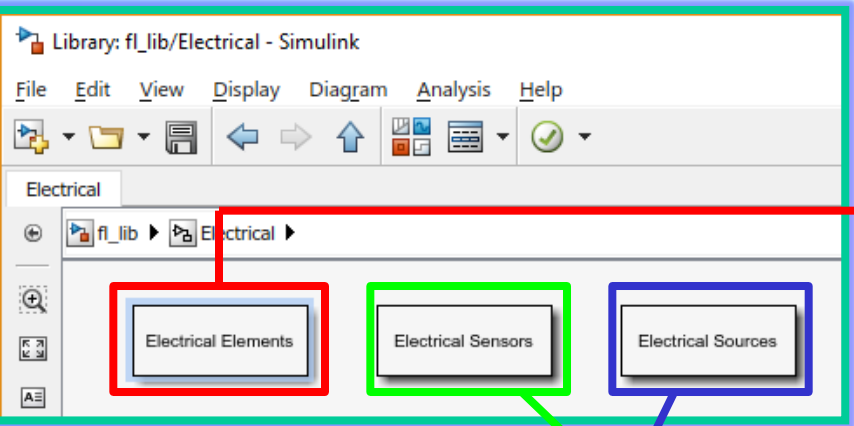
Симулација електричног кола коришћењем **Simscape > Foundation Library** библиотеке



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

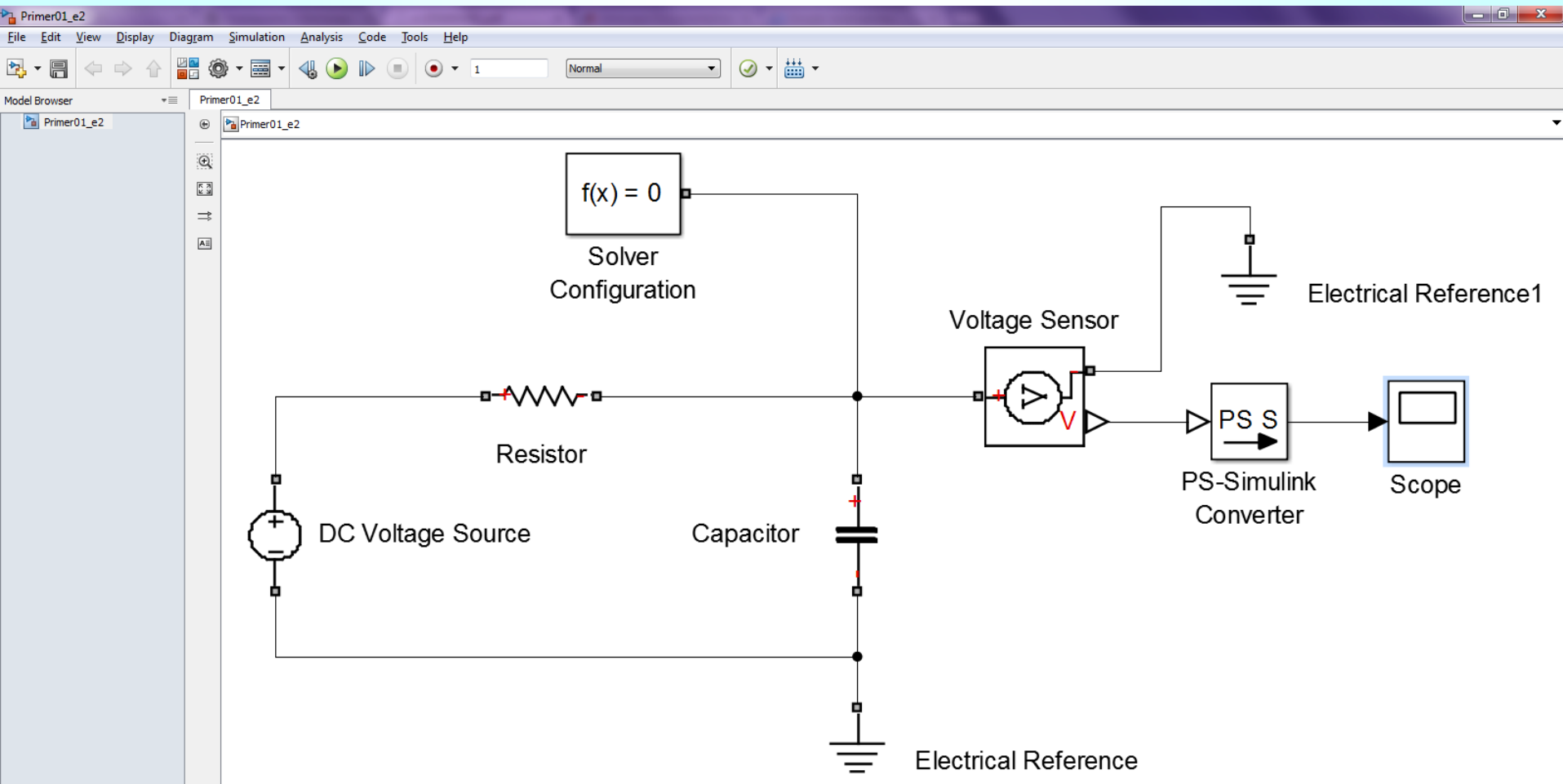


**MATLAB > Simscape >
Foundation Library, Utilities**



MATLAB > Simscape > Foundation Library, 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 tolerance1e-09

☐ Use local solver

Solver typeBackward Euler

Sample time0.001

☐ Use fixed-cost runtime consistency iterations

Nonlinear iterations3

Mode iterations2

Linear AlgebraSparse

Delay memory budget [kB]1024

☒ Apply filtering at 1-D/3-D connections when needed

Filtering time constant0.001

OKCancelHelpApply

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:10V

OKCancelHelpApply

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

ParametersVariables

Resistance:1000Ohm

OKCancelHelpApply

Block Parameters: Capacitor

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:

1e-6

F

Series resistance:

0

Ohm

Parallel conductance:

0

1/Ohm

OK

Cancel

Help

Apply

Почетни услов...

Settings

Parameters

Variables

Override	Variable	Priority	Beginning Value	Unit
☐	Current	None	0	A
☐	Voltage	None	0	V
☒	Capacitor voltage	High	-10	V

OK

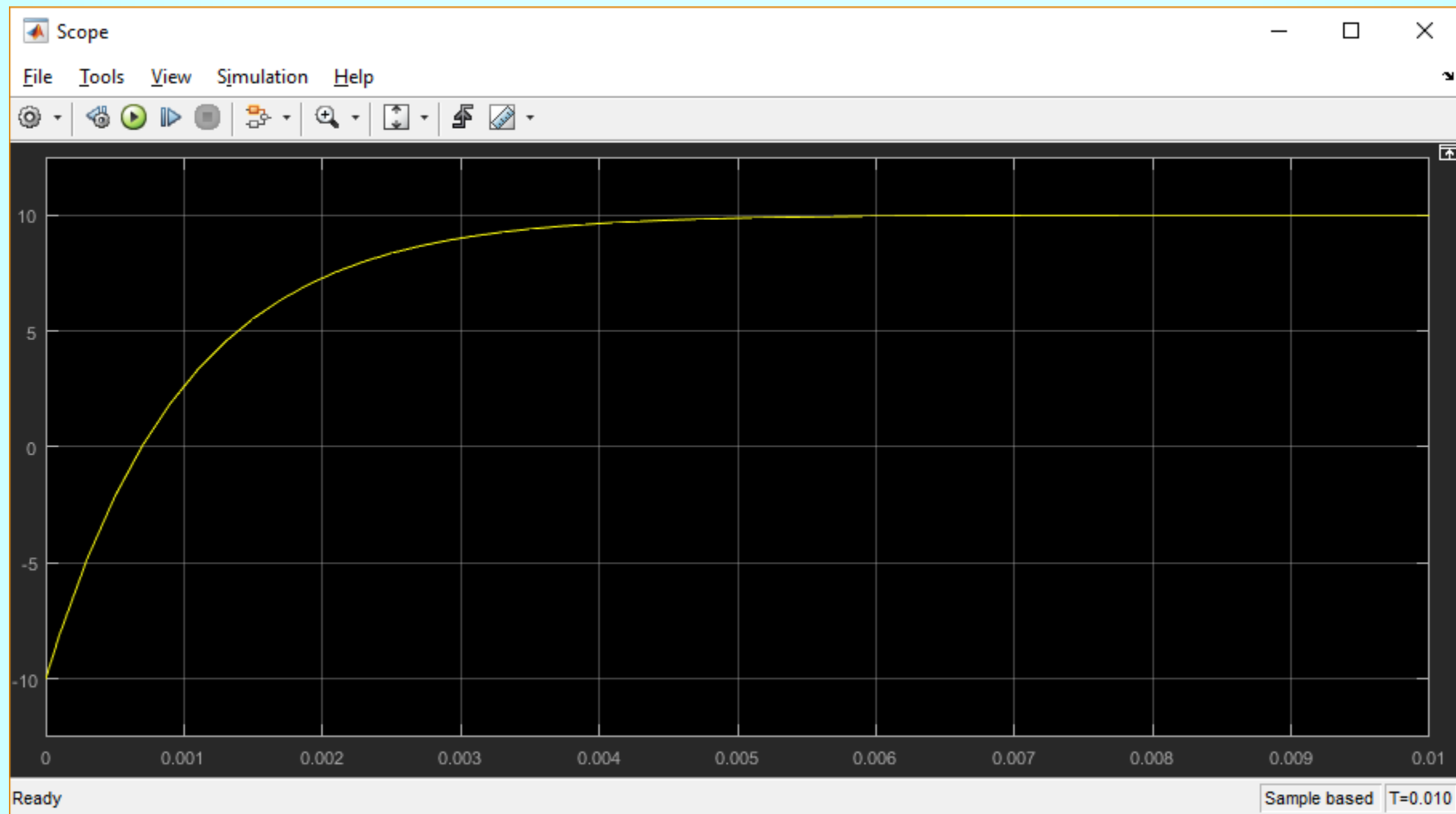
Cancel

Help

Apply

MATLAB > Simscape >
Foundation Library, Utilities

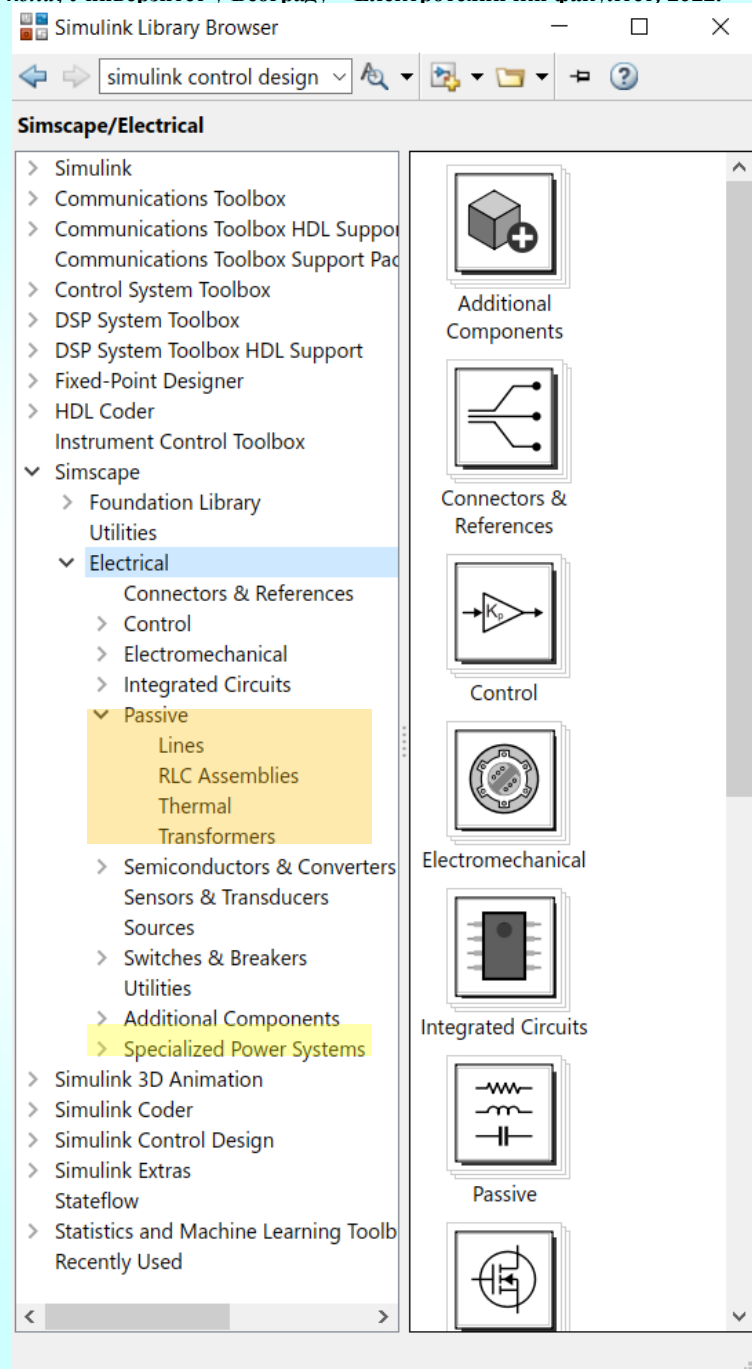
Налажење одзива...



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

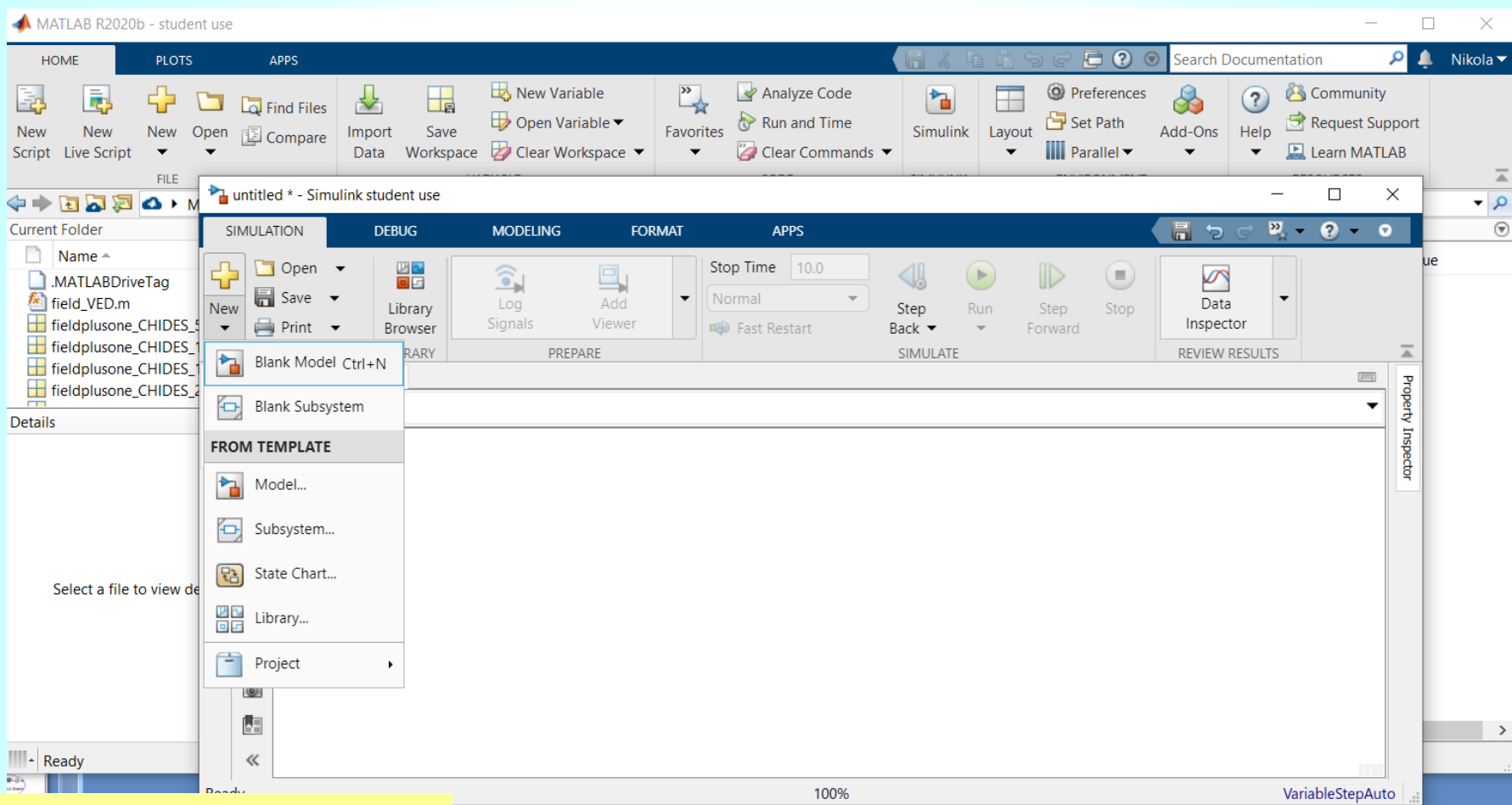
Simulink > Simscape > Electrical

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



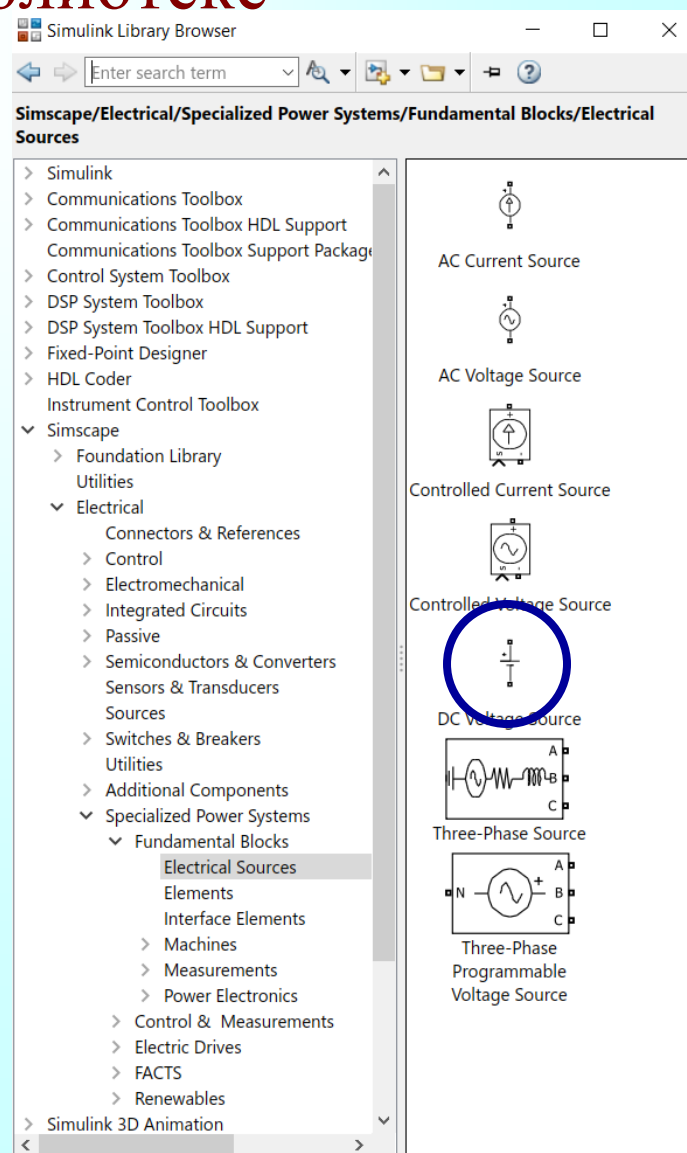
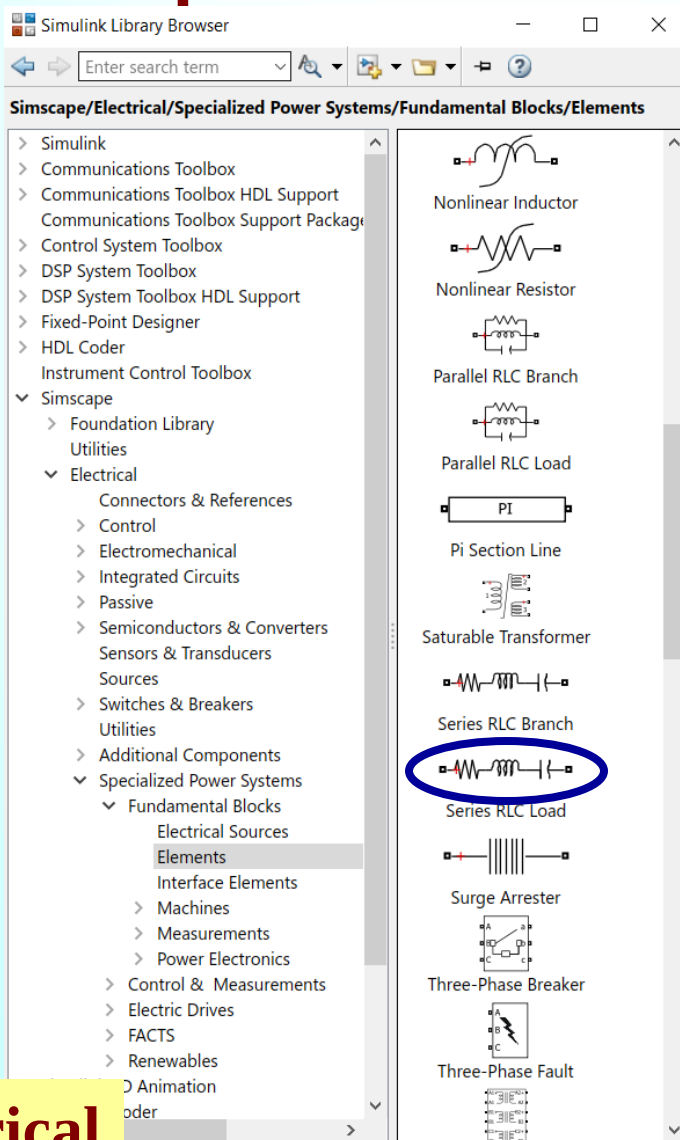
Simscape > Electrical

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



Simscape > Electrical

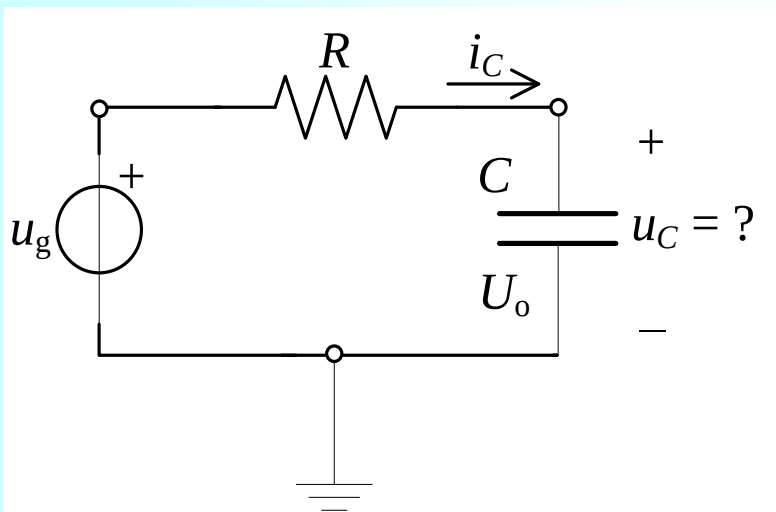
Симулација електричног кола коришћењем **Simscape>Electrical** библиотеке



Simscape > Electrical

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

коло је образовано у тренутку $t_0 = 0$

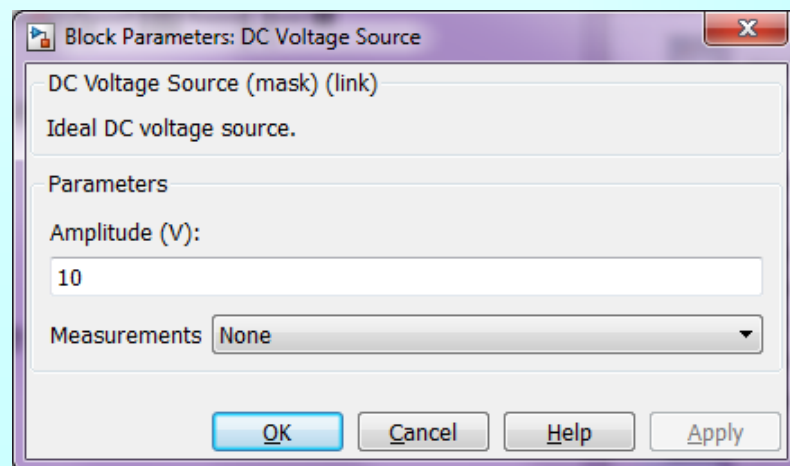
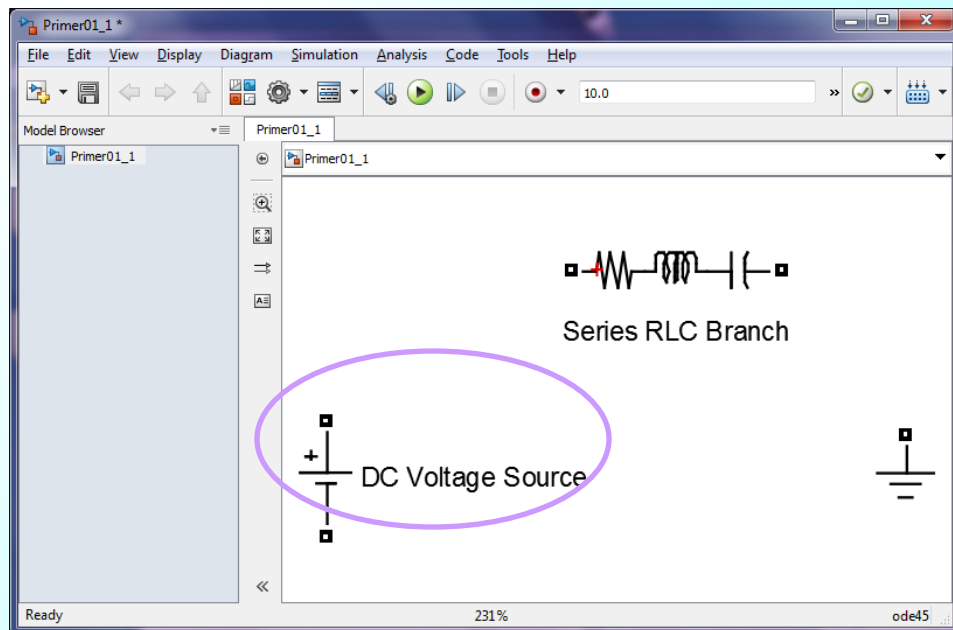


$$R = 1\text{ k}\Omega$$

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

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

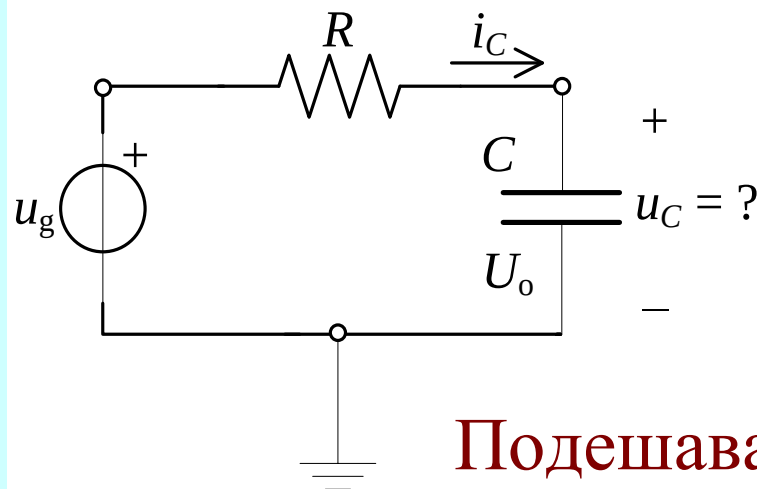
$$u(t_0^-) = U_0 = -10\text{ V}$$



Simscape > Electrical

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

коло је образовано у тренутку $t_0 = 0$



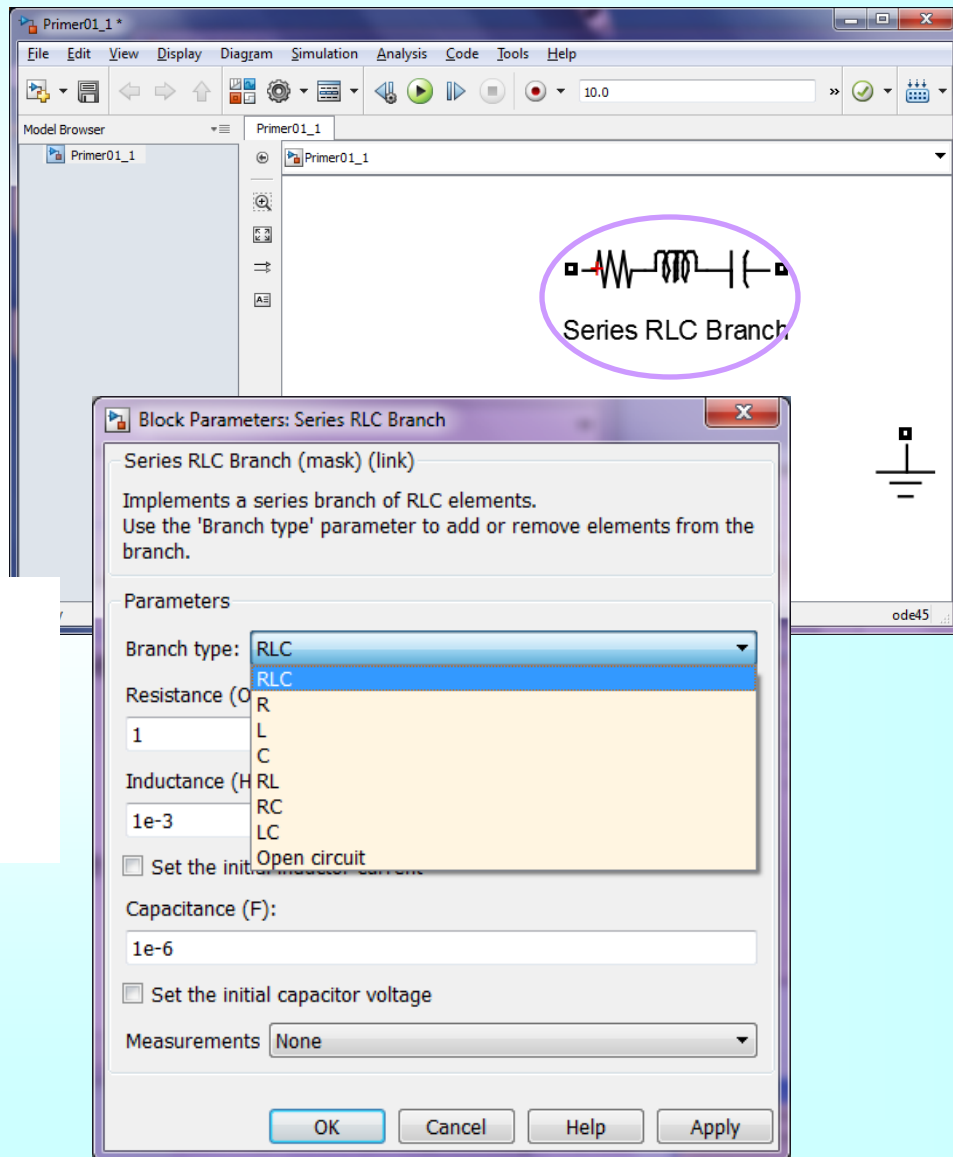
$$R = 1\text{k}\Omega$$

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

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

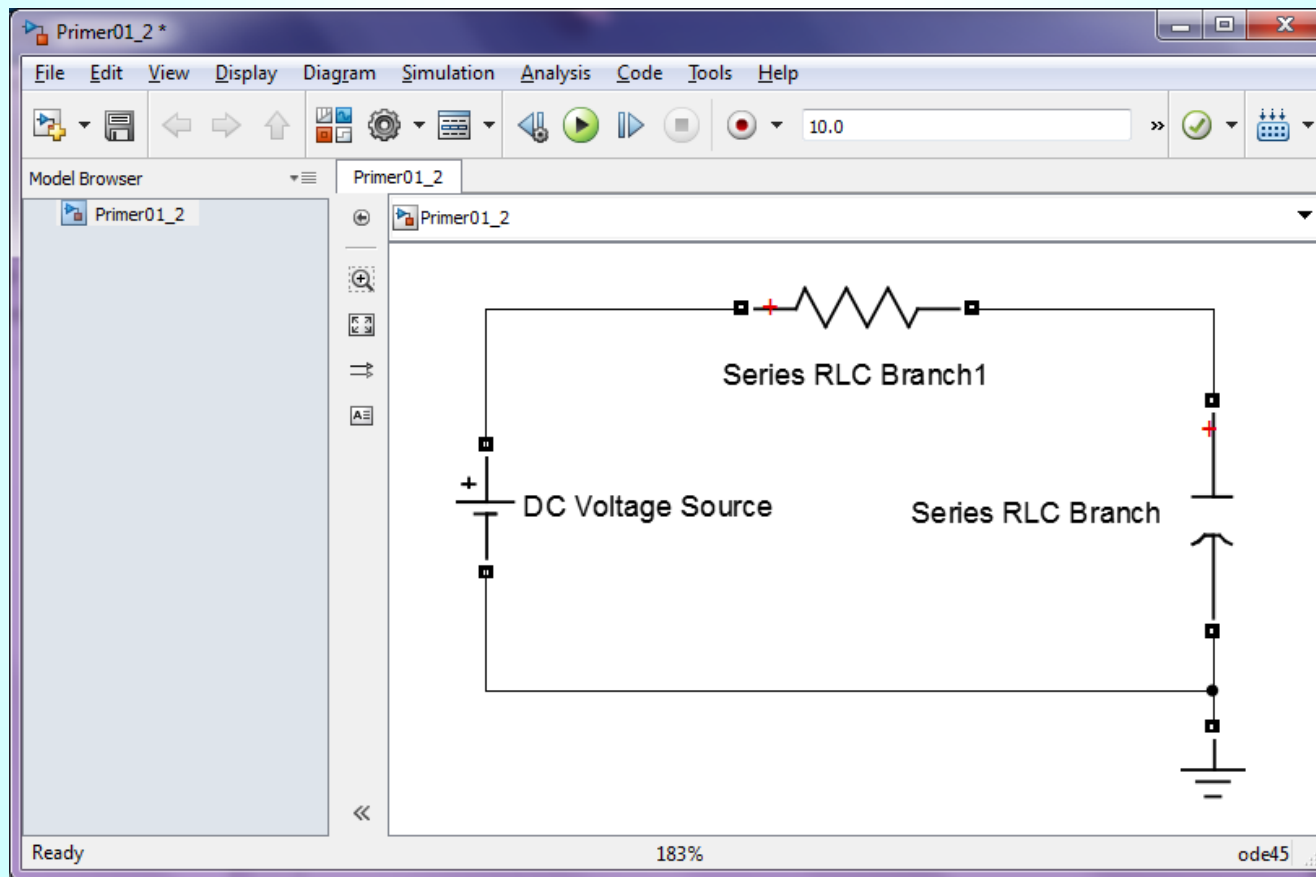
$$u(t_0^-) = U_0 = -10\text{ V}$$

Подешавање
параметара
симулације



Simscape > Electrical

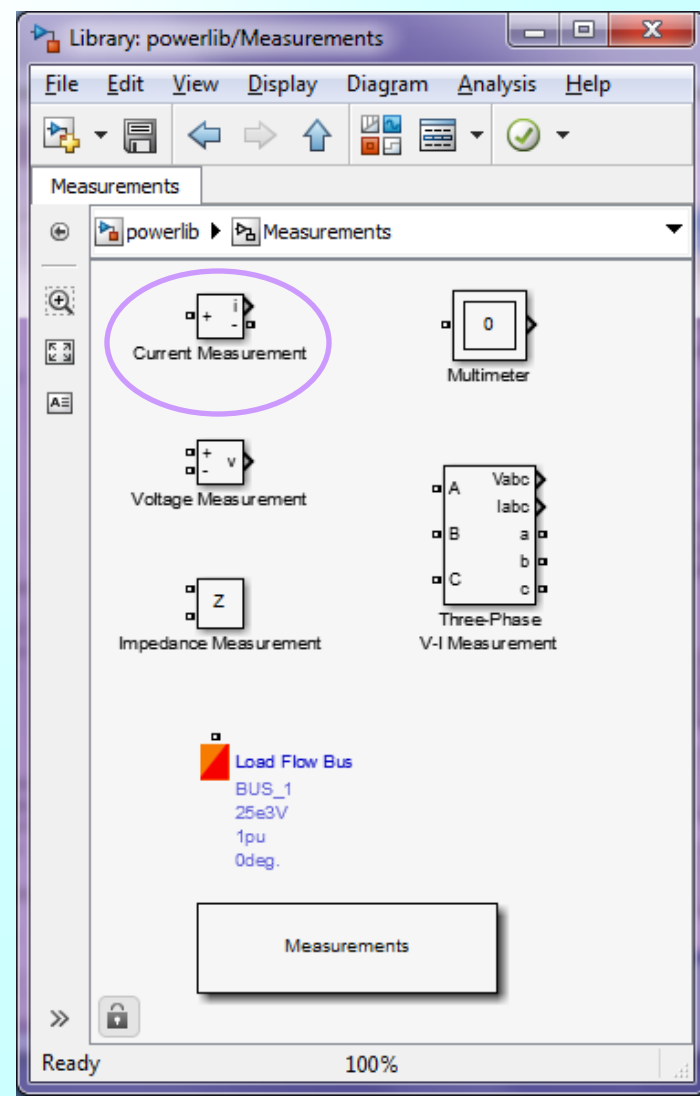
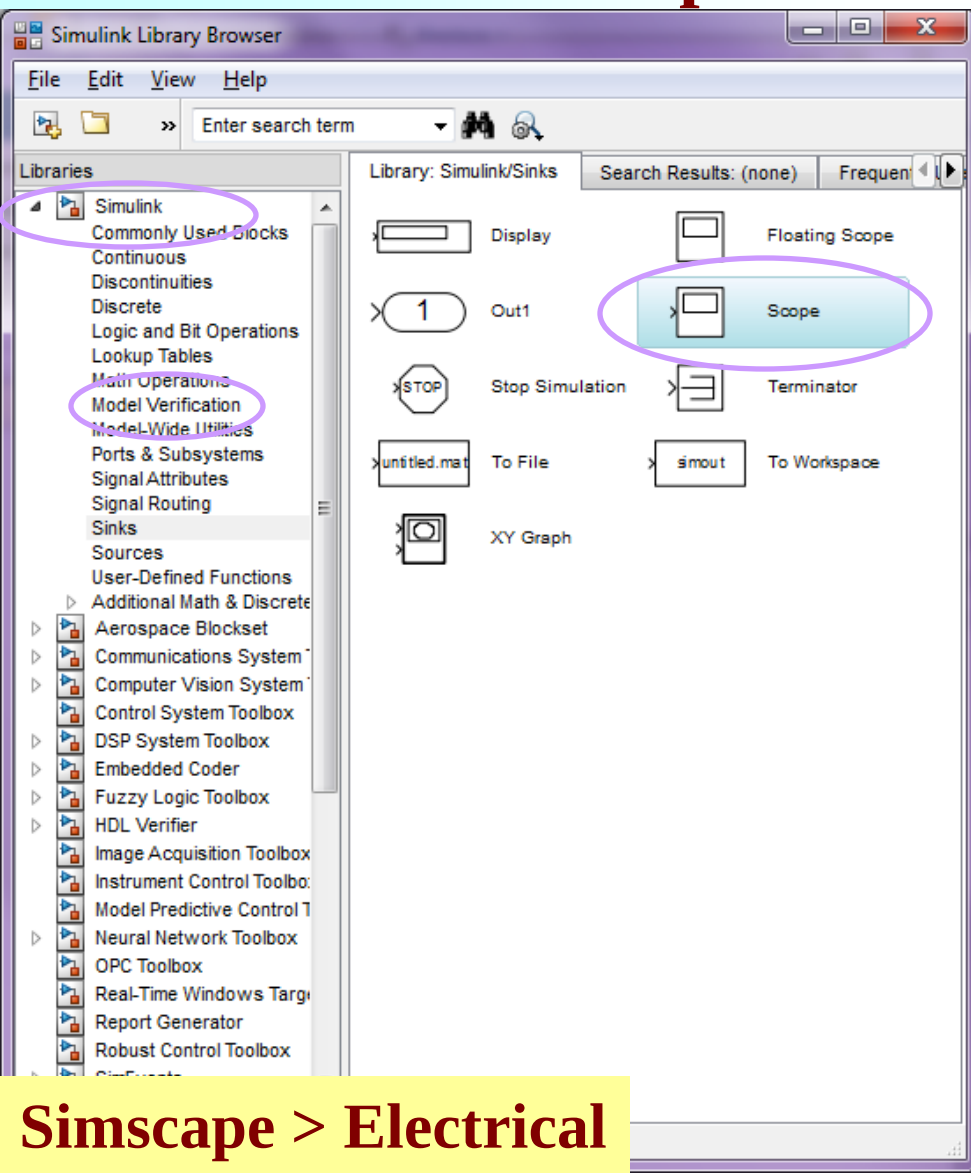
Симулација електричног кола коришћењем **Simscape>Electrical** библиотеке



Како се мери напон???

Simscape > Electrical

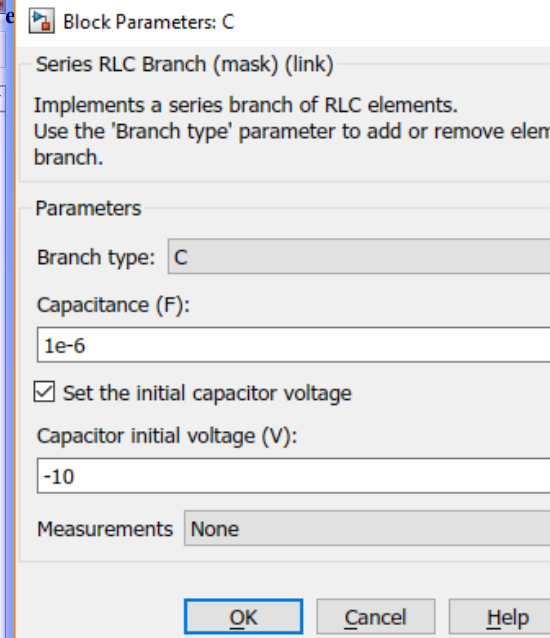
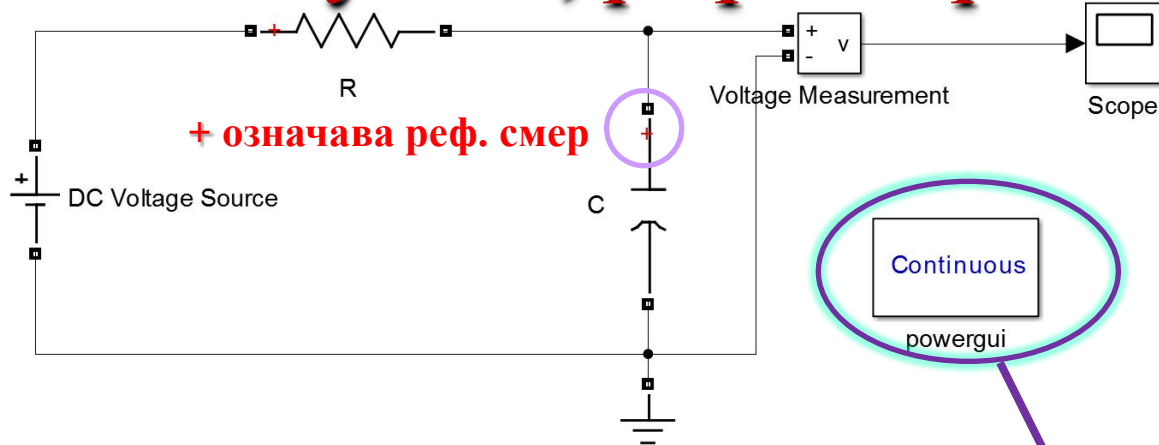
Симулација електричног кола коришћењем **Simscape>Electrical** библиотеке



Simscape > Electrical

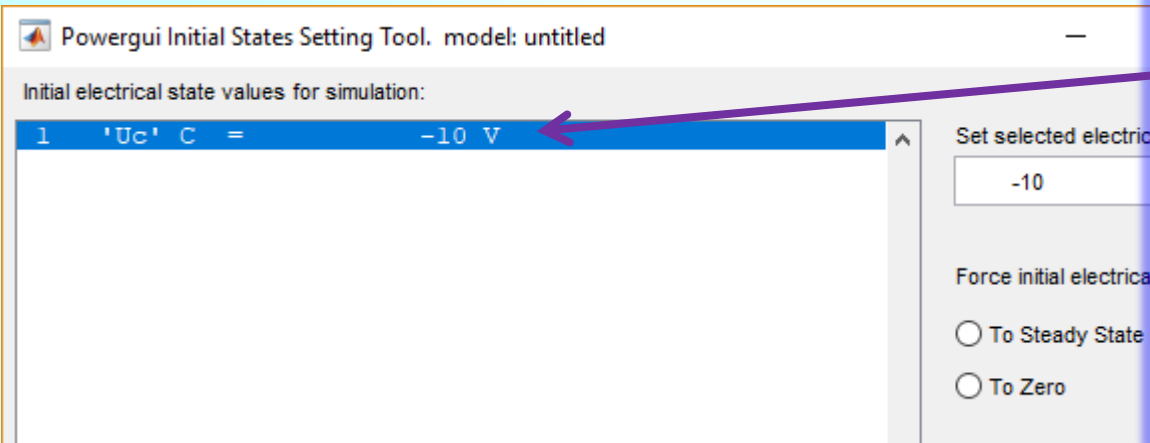
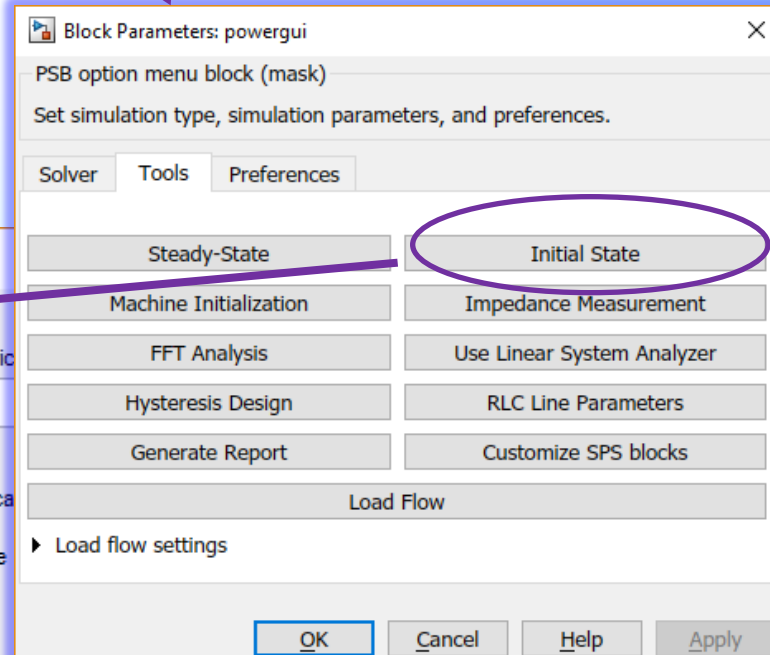
Почетни услов, реф. смер...

+ означава реф. смер



Плоче кондензатора се разликују!!!

Simscape > Electrical



Configuration Parameters: untitled/Configuration (Active)

★ Commonly Used Parameters

All Parameters

Select:

Solver

Data Import/Export

> Optimization

> Diagnostics

Hardware Implementation

Model Referencing

Simulation Target

> Code Generation

> Coverage

> HDL Code Generation

Simscape

Simscape Multibody 1G

> Simscape Multibody

Simulation time

Start time: 0.0Stop time: 0.01

Solver options

Type: Variable-stepSolver: auto (Automatic solver selection)

▶ Additional options

OK

Cancel

Help

Apply

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

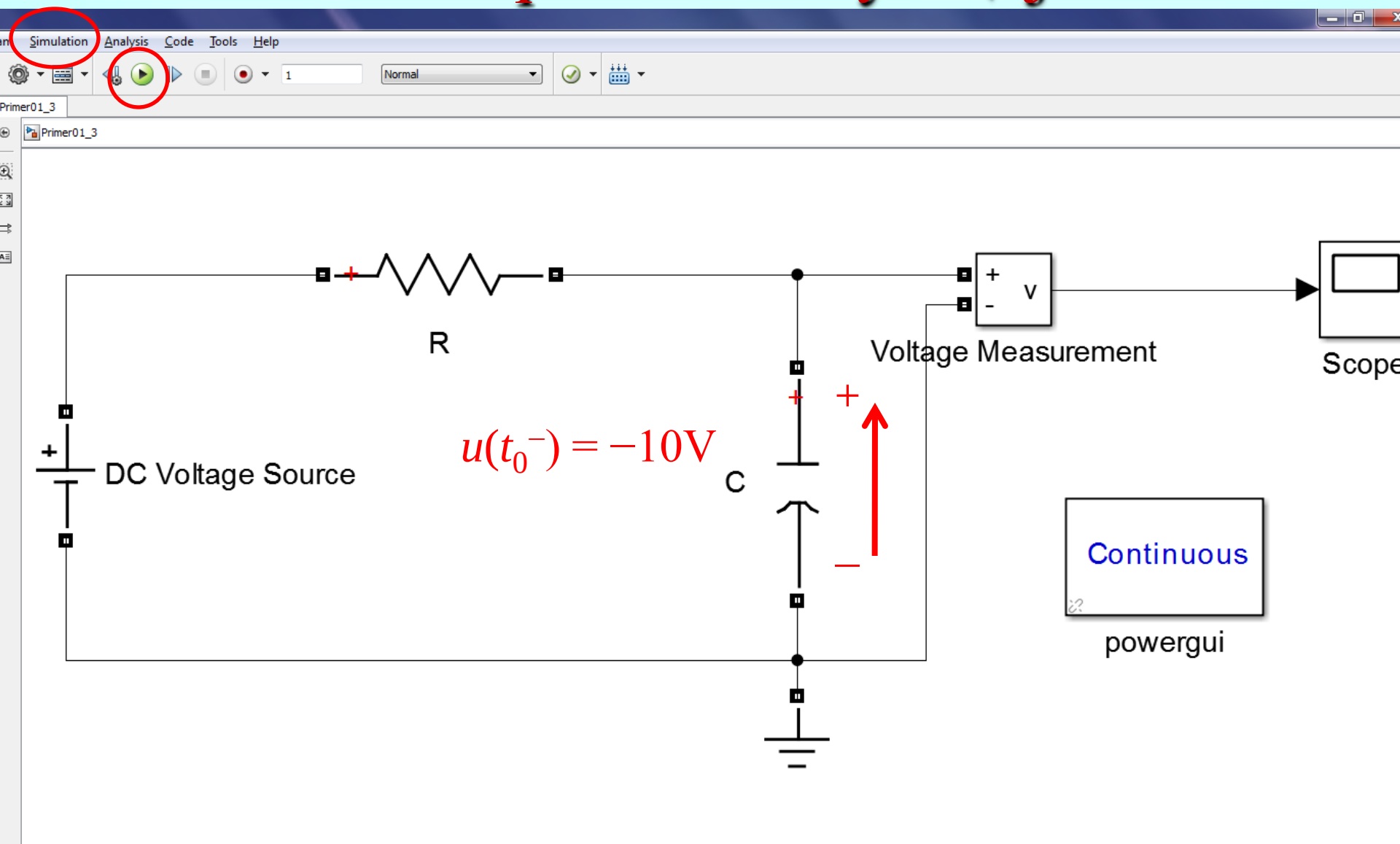
OK

Cancel

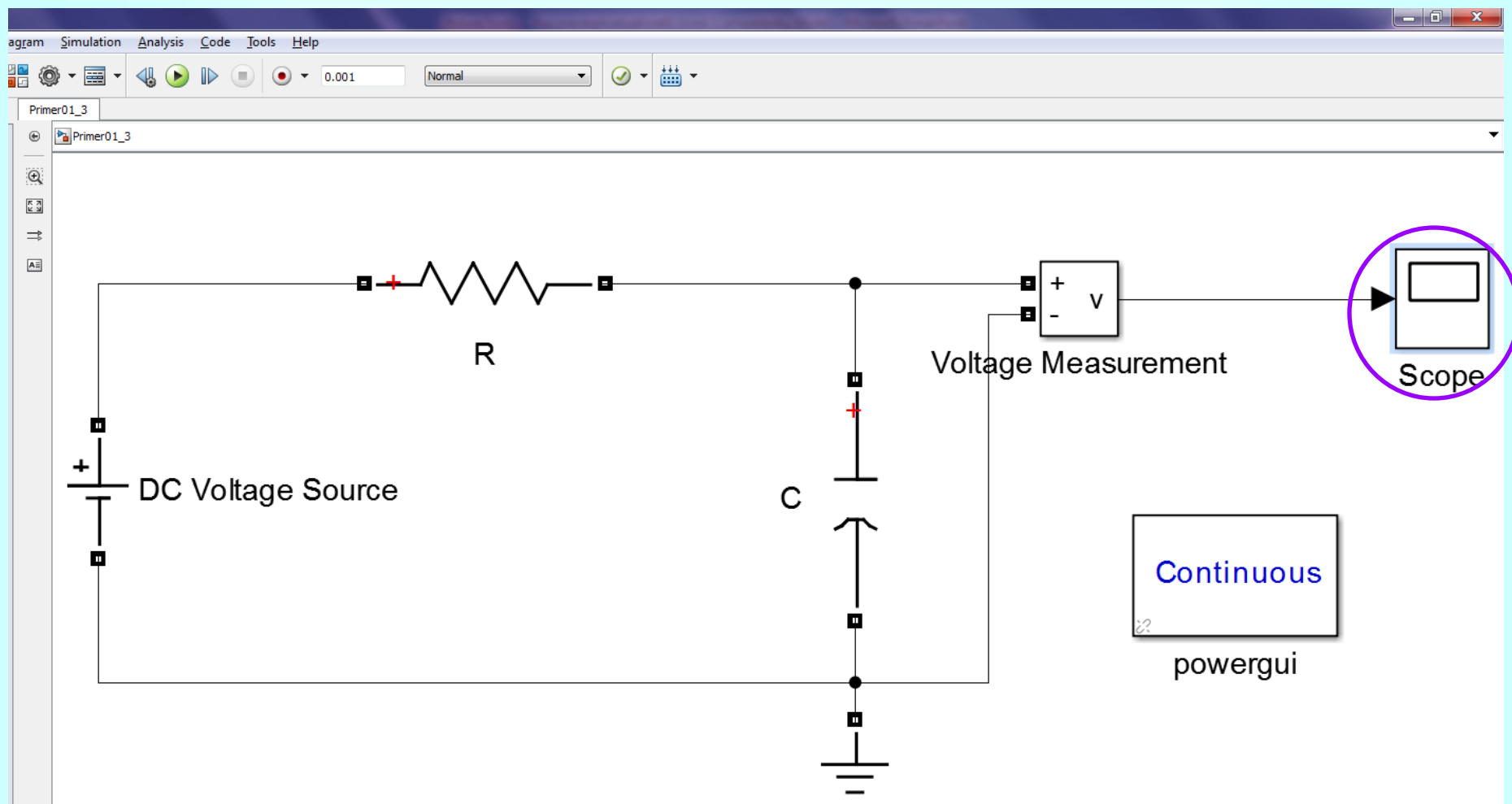
Help

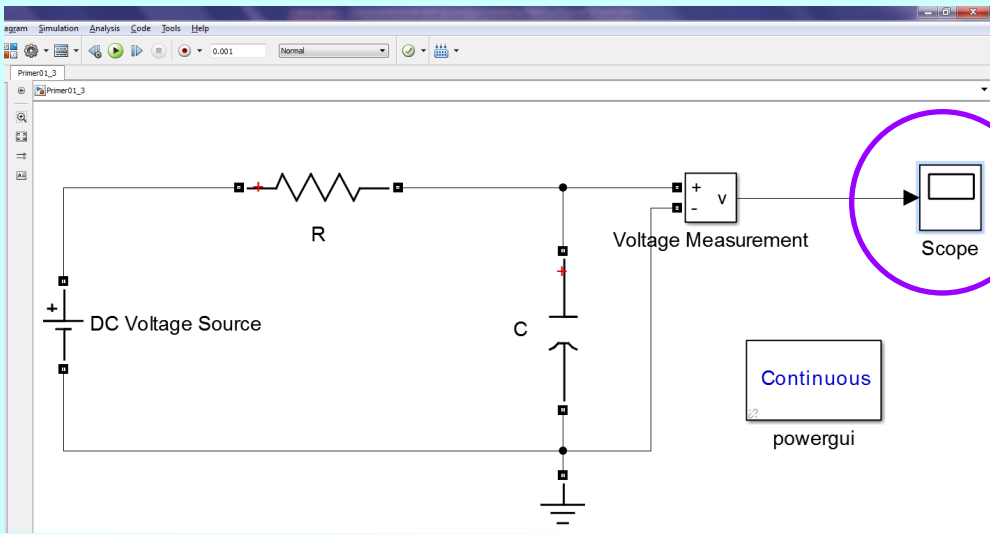
Apply

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

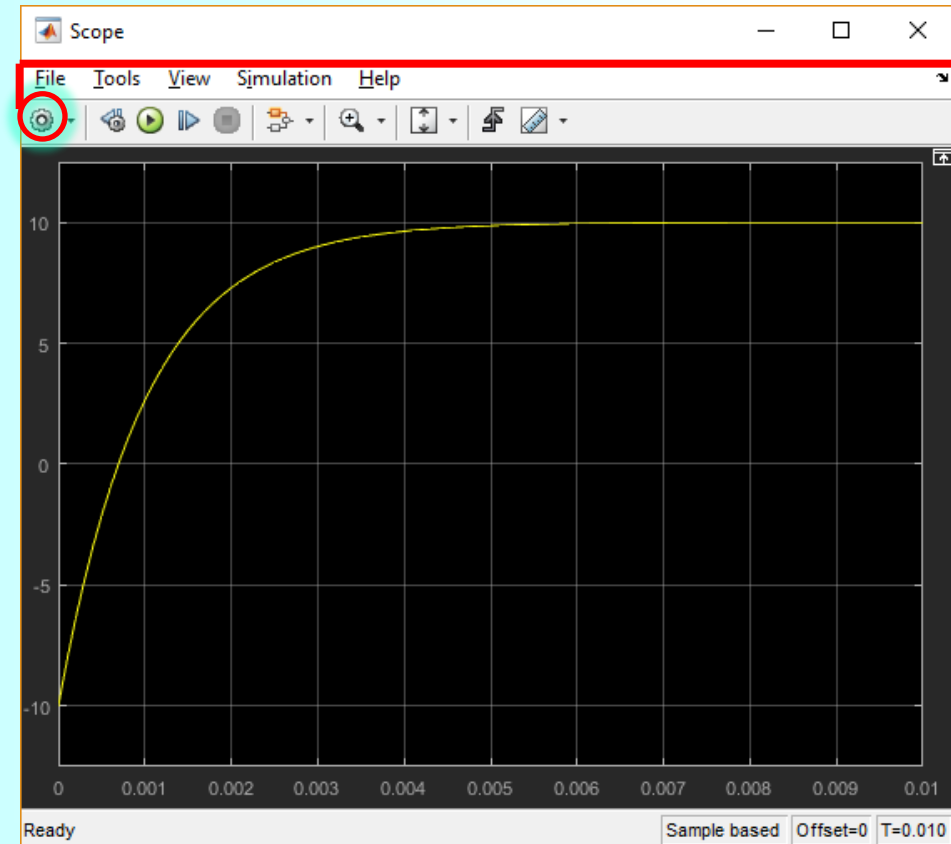
Time span overrun action: Wrap

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): 12.49989

Y-label:

OK

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
> 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

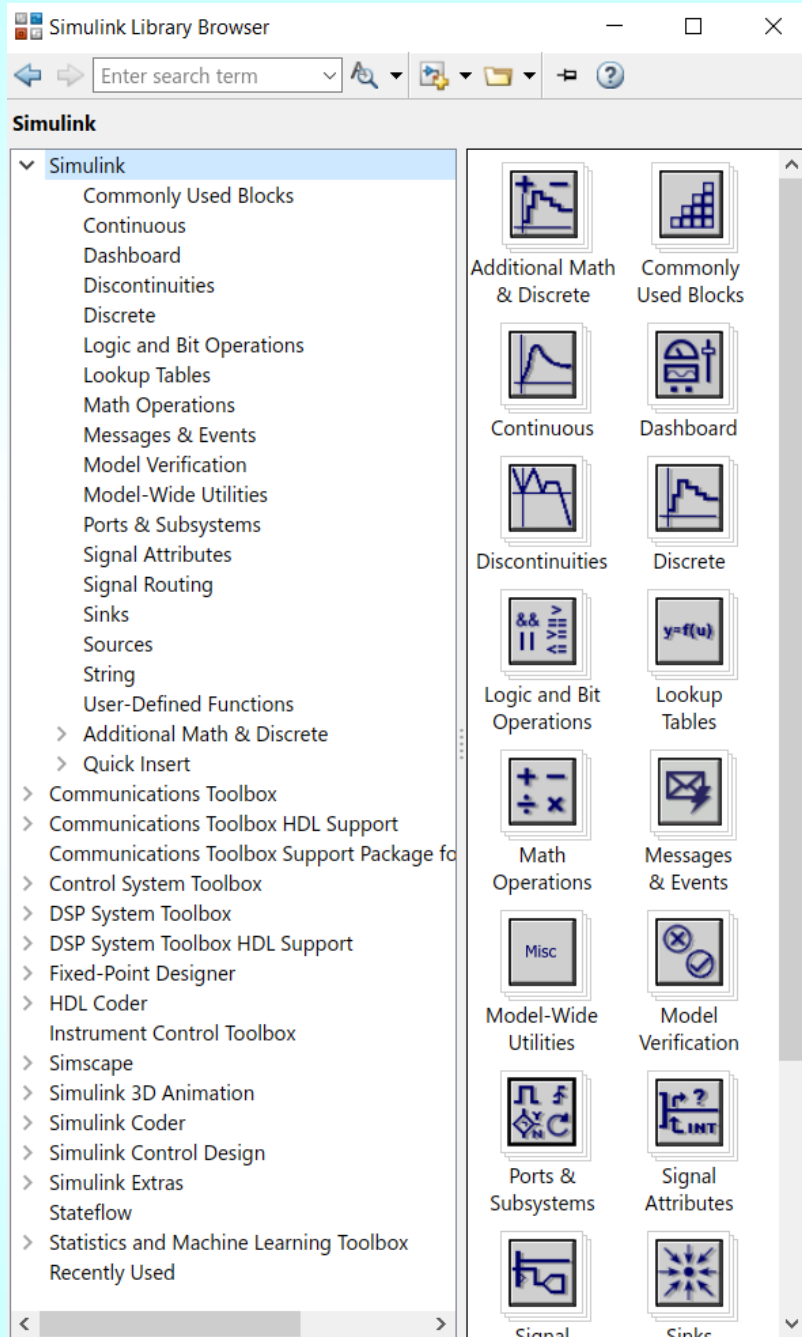
$\tau = RC = 1\text{ms}$

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

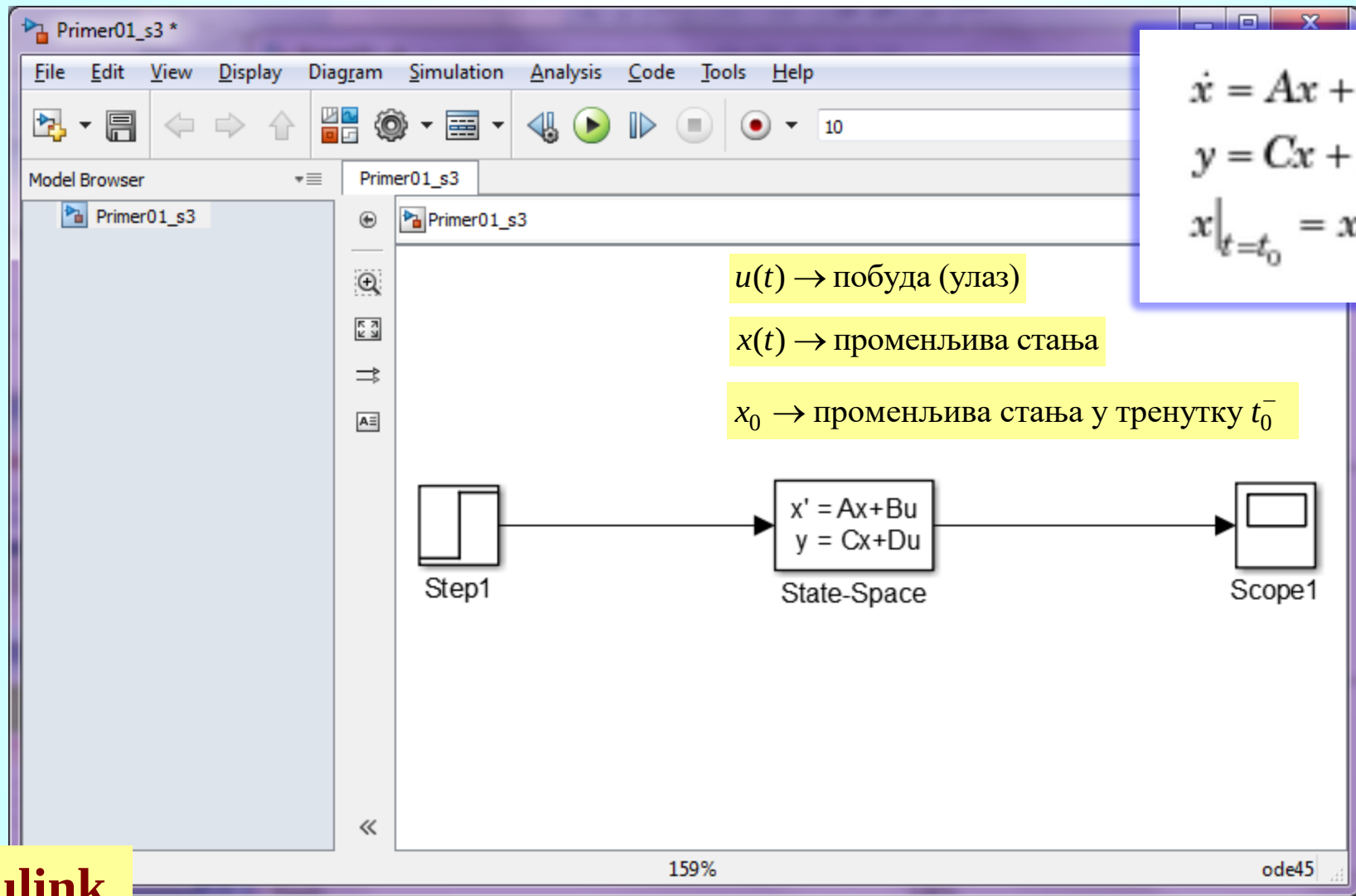
Simscape > Electrical

Simulink

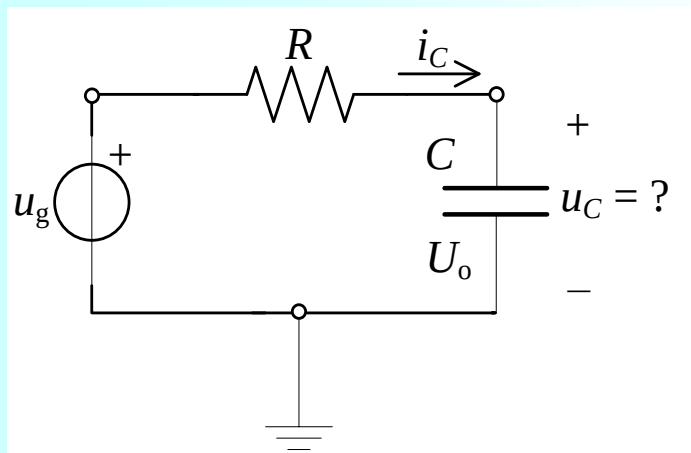
- Решавање кола може се извршити његовим свођењем на систем линеарних диференцијалних једначина
- Дати систем може се представити једноставним блоком са више улаза и излаза



Симулација електричног кола као уопштеног система коришћењем **Simulink**-а



Симулација електричног кола као уопштеног система коришћењем **Simulink**-а



коло је образовано у тренутку $t_0 = 0$

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

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

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

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

$$u = u_g(t) \rightarrow \text{побуда (улаз)}$$

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

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

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

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

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

$$\dot{x} = Ax + Bu$$

$$y = Cx + Du$$

$$x|_{t=t_0^-} = x_0,$$

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

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

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

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

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

Simulink

Source Block Parameters: Step1

Step

Output a step.

Parameters

Step time:

Initial value:

Final value:

Sample time:

☒ Interpret vector parameters as 1-D

☒ Enable zero-crossing detection

OK Cancel Help Apply

Симулација
електричног
кола као
уопштеног
система
коришћењем
Simulink-а

Function Block Parameters: State-Space

State Space

State-space model:

$$\begin{aligned} \dot{x}/dt &= Ax + Bu \\ y &= Cx + Du \end{aligned}$$

Parameters

A:

B:

C:

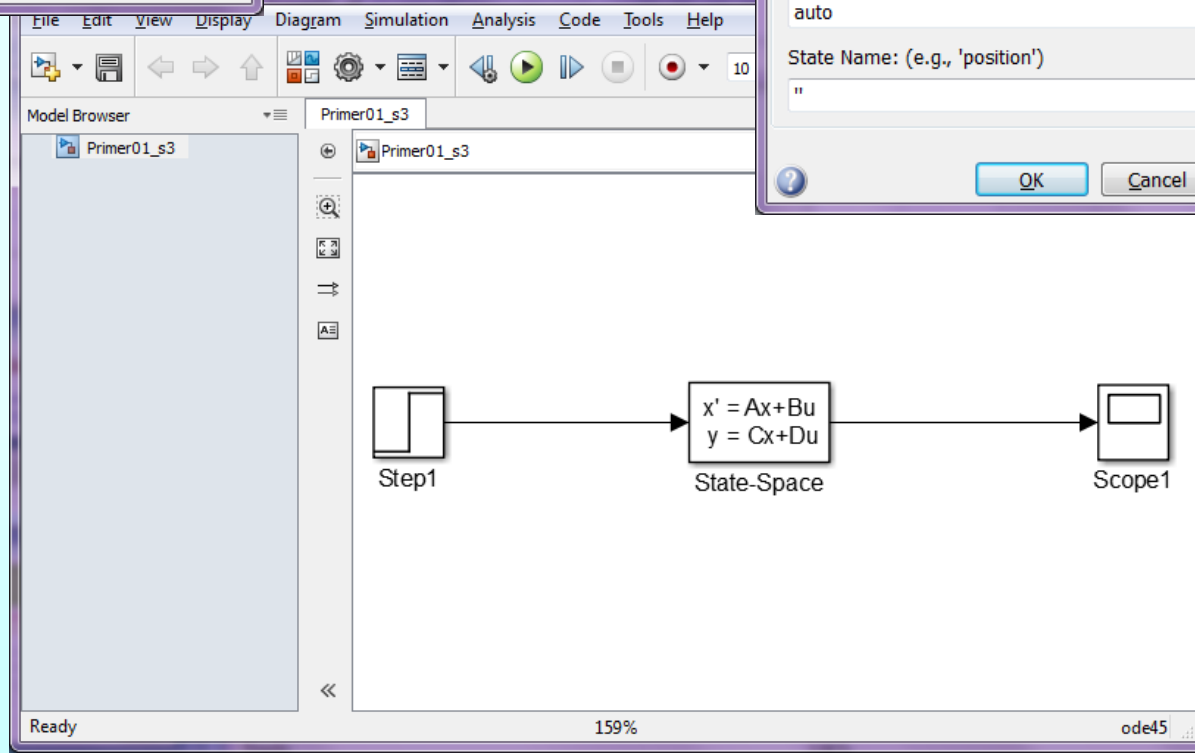
D:

Initial conditions:

Absolute tolerance:

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

OK Cancel Help Apply



Function Block Parameters: State-Space

State Space

State-space model:
 $\dot{x}/dt = Ax + Bu$
 $y = Cx + Du$

Parameters

A:

B:

C:

D:

Initial conditions:

Absolute tolerance:

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

OK Cancel

цент, Практикум из рачунарске анализе кола, У

Симулација електричног кола као уопштеног система коришћењем Simulink-a

Source Block Parameters: Step1

Step

Output a step.

Parameters

Step time:

Initial value:

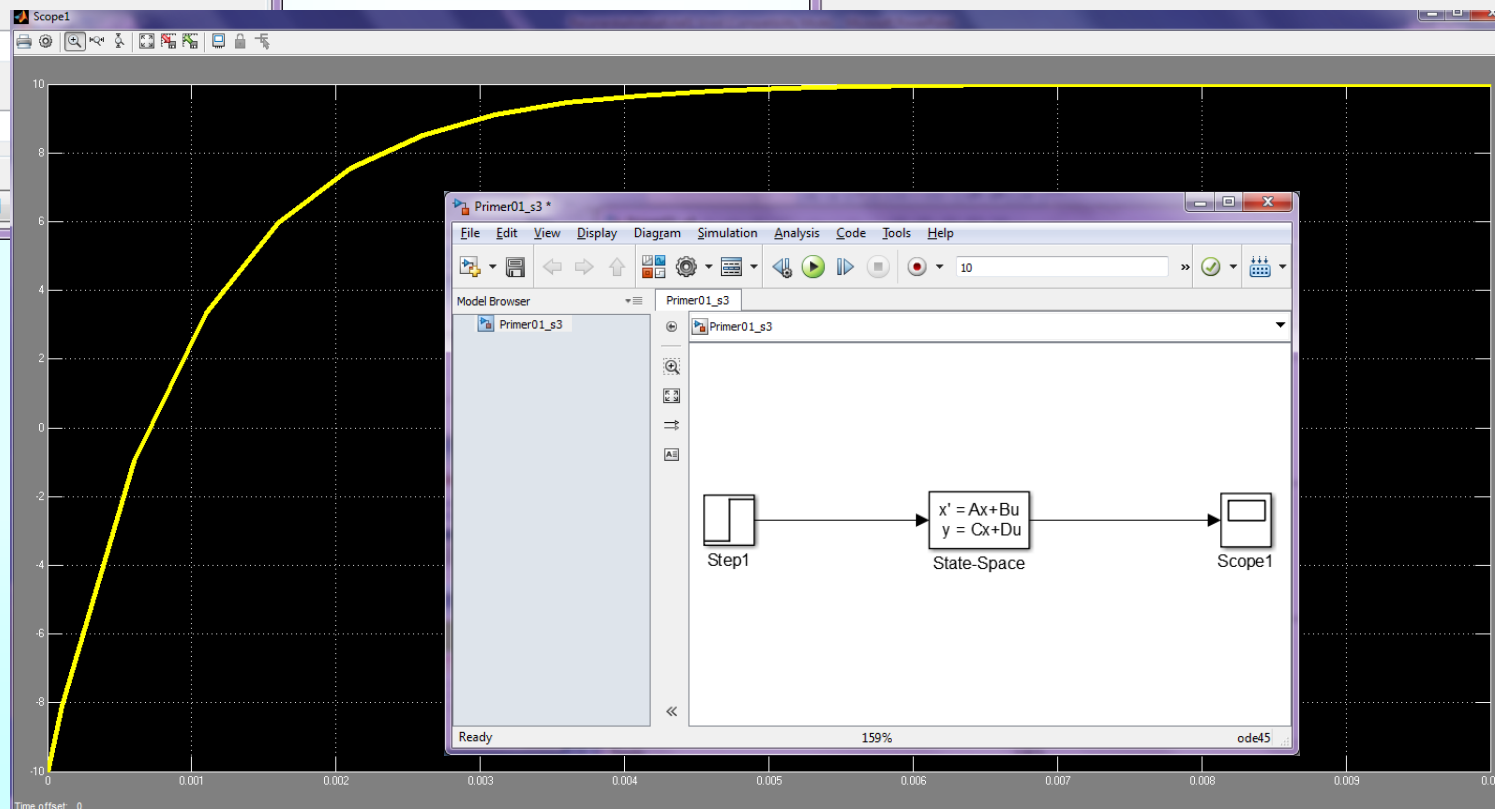
Final value:

Sample time:

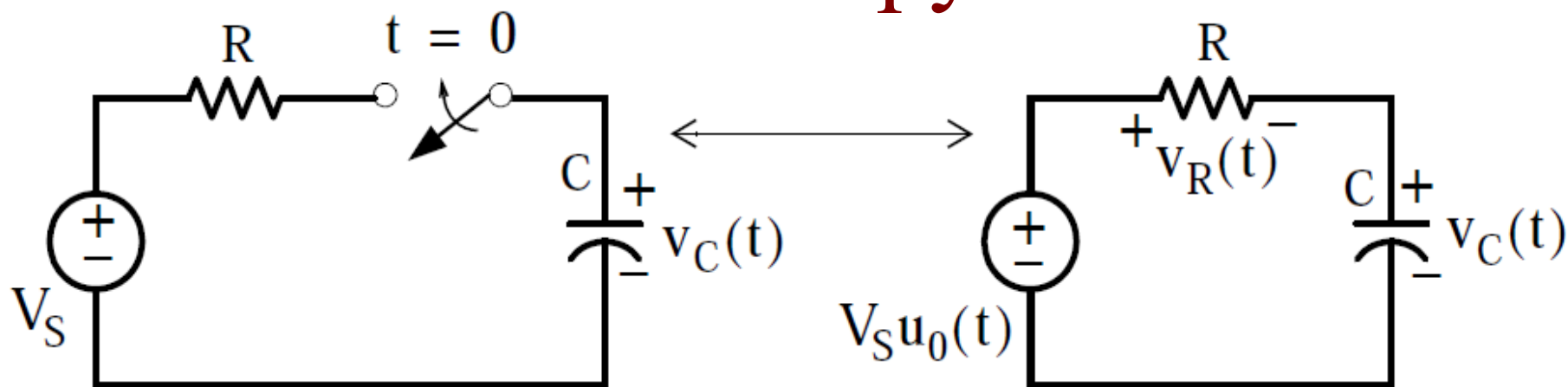
☒ Interpret vector parameters as 1-D

☒ Enable zero-crossing detection

Simulink



Решимо “ручно”



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

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

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

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

$$t > 0$$

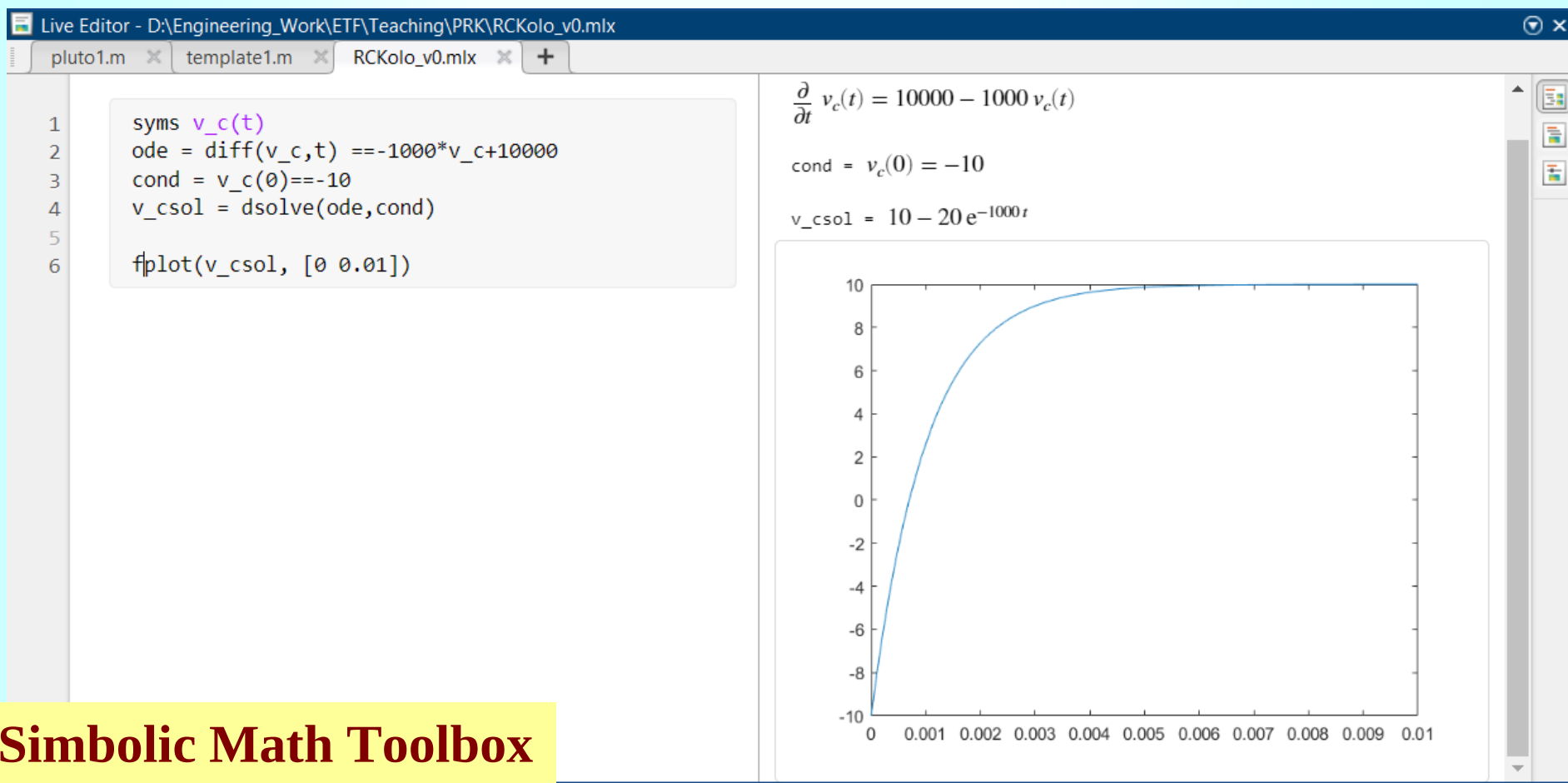
$$RC \frac{dv_C}{dt} + v_C = V_S$$

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

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

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) jednachine: [ug=R*iC+uC, iC=C*'diff(uC,t)];

(%o1) [ug=uC+R iC, iC=C (d/dt uC)]

(%i2) jednachineDuC: jednachine, 'diff(uC,t)=DuC;

(%o2) [ug=uC+R iC, iC=C DuC]

(%i3) JednachineIzvoda: eliminate(jednachineDuC, [iC]);

(%o3) [-ug+uC+C DuC R]

(%i4) jednachineStanja: linsolve(JednachineIzvoda, DuC);

(%o4) [DuC=(ug-uC)/(C R)]

(%i5) jednachineDiff: jednachineStanja, 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) [ $\frac{d}{dt} uC = \frac{U - uC}{C R}$ ]

(%i9) ode2(JednacineDiffZamena, uC, t);

(%o9)  $uC = e^{-\frac{t}{C R}} \left( U e^{\frac{t}{C R}} + c \right)$ 

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

(%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)$
```

