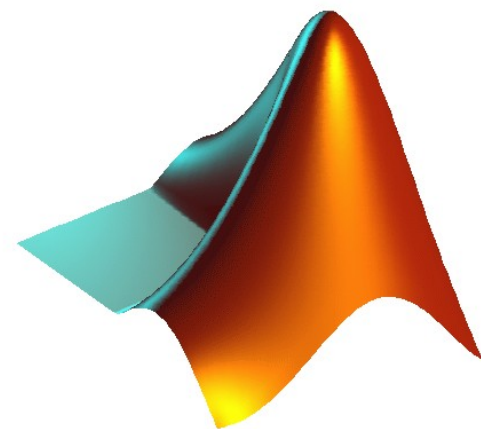
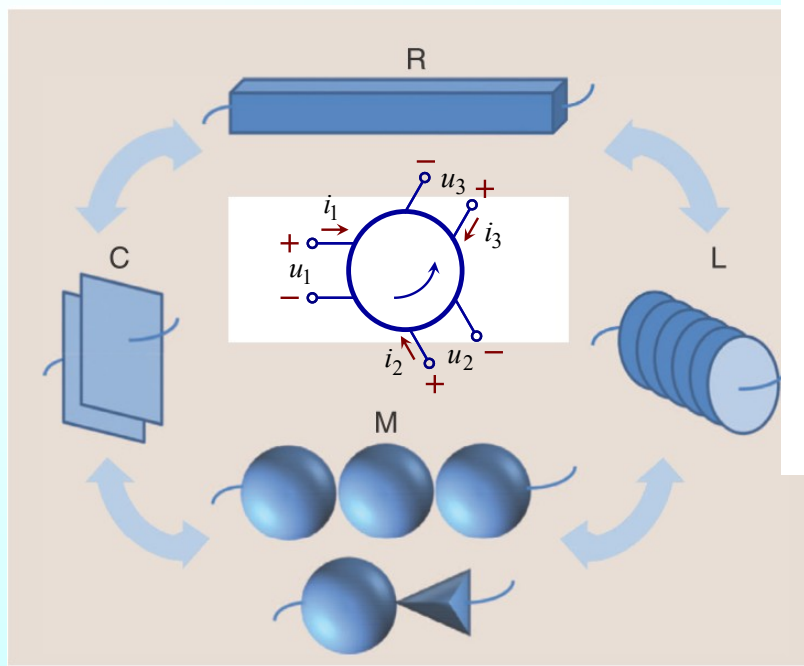


Практикум из рачунарске анализе кола

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

Начин полагања

- **ПРЕДИСПИТНЕ ОБАВЕЗЕ (40%) + ИСПИТ (60%) = УКУПНО (100%)**
- **Предиспитне обавезе (40%)** реализују се полагањем тестова у рачунарској учионици или код куће у онлајн окружењу, у задатом временском интервалу. Предиспитне обавезе се могу надокнадити ванредним тестовима и домаћим задацима са задатим временским роком.
- **Испитни део** се полаже израдом два домаћа задатка са усменом одбраном (**30+30=60%**). Одбрана домаћих задатака може се реализовати у свим испитним роковима.
- Поени са свих активности се сабирају простом сумом.
- За заинтересоване студенте постоји могућност полагања у предроку.
- *Напомена: Домаћи задаци 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

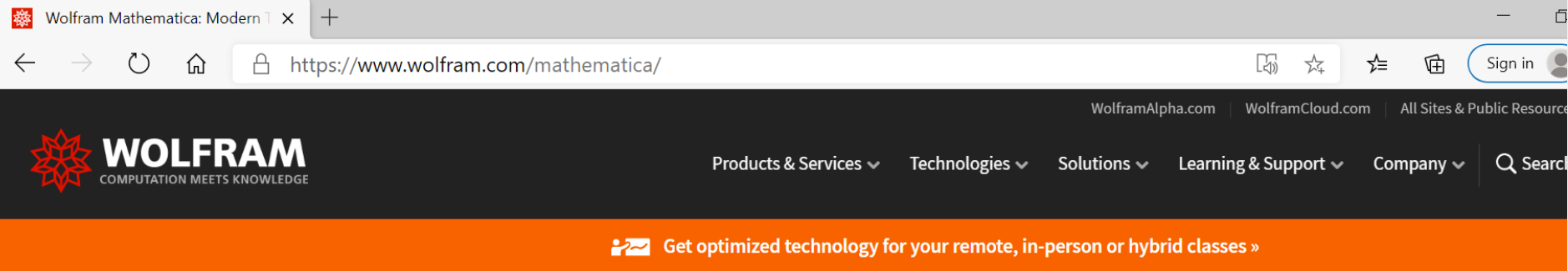
Free/Libre Open Source Software (FLOSS)

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...

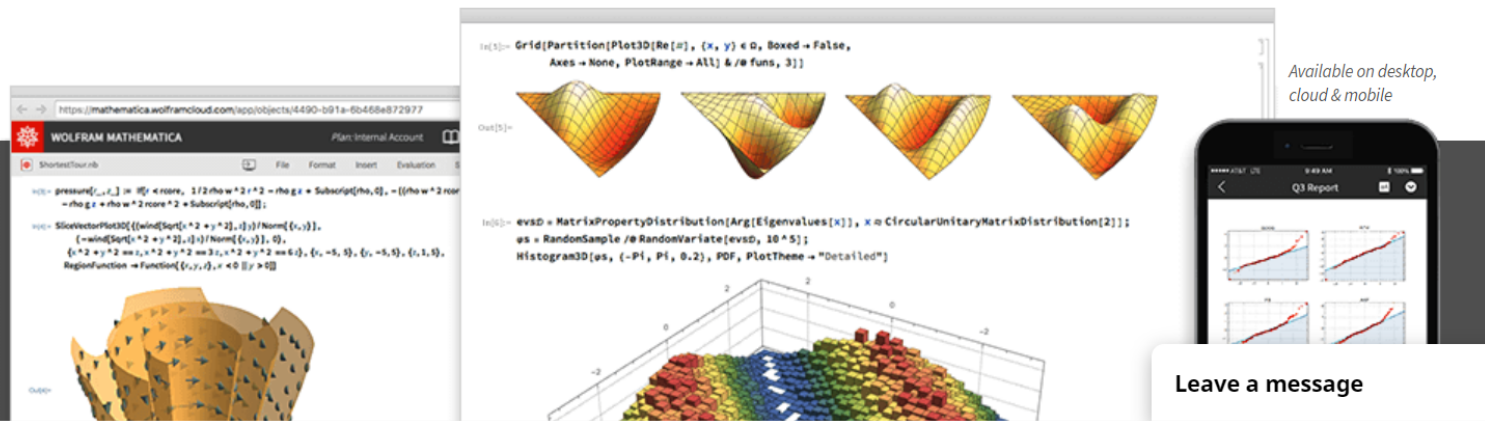
Mathematica

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



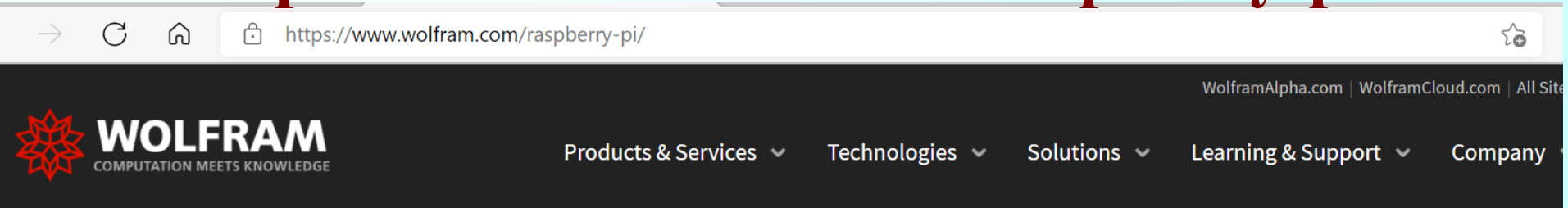
WOLFRAM MATHEMATICA

The world's definitive system for modern technical computing

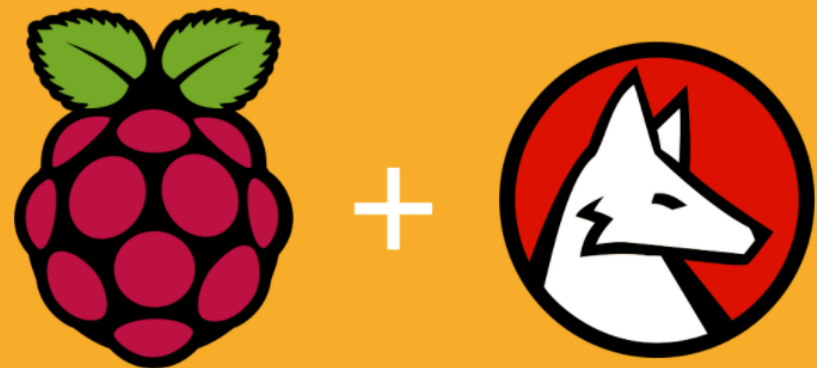


Mathematica free on every Raspberry Pi!

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



Wolfram Language &
Mathematica free on
every Raspberry Pi!



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:

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

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

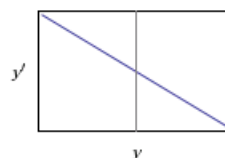
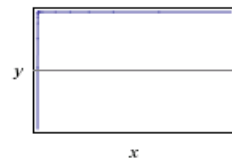
Differential equation solution:

[Approximate form](#)

[Step-by-step solution](#)

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

Plots of the solution:



New to
Wolfram|Alpha?



[Take the Tour >>](#)

New!
Wolfram Problem
Generator

Need a hint? 8

Maxima

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

The screenshot shows a web browser window with the URL <http://maxima.sourceforge.net/>. The page features a navigation bar with links to Downloads, Documentation, Project, and Page Top. The main content area displays a Maxima session snippet: `(%i3) integrate ( 1 / (1 + x^4), x);` followed by a complex mathematical expression for the integral of $1/(1+x^4)$. Below the expression are navigation arrows and a status bar with language options. The footer contains a section titled 'Maxima, a Computer Algebra System' with a description of the software and its capabilities, and a 'Recent Releases' section listing versions 5.44.0 through 5.42.2.

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

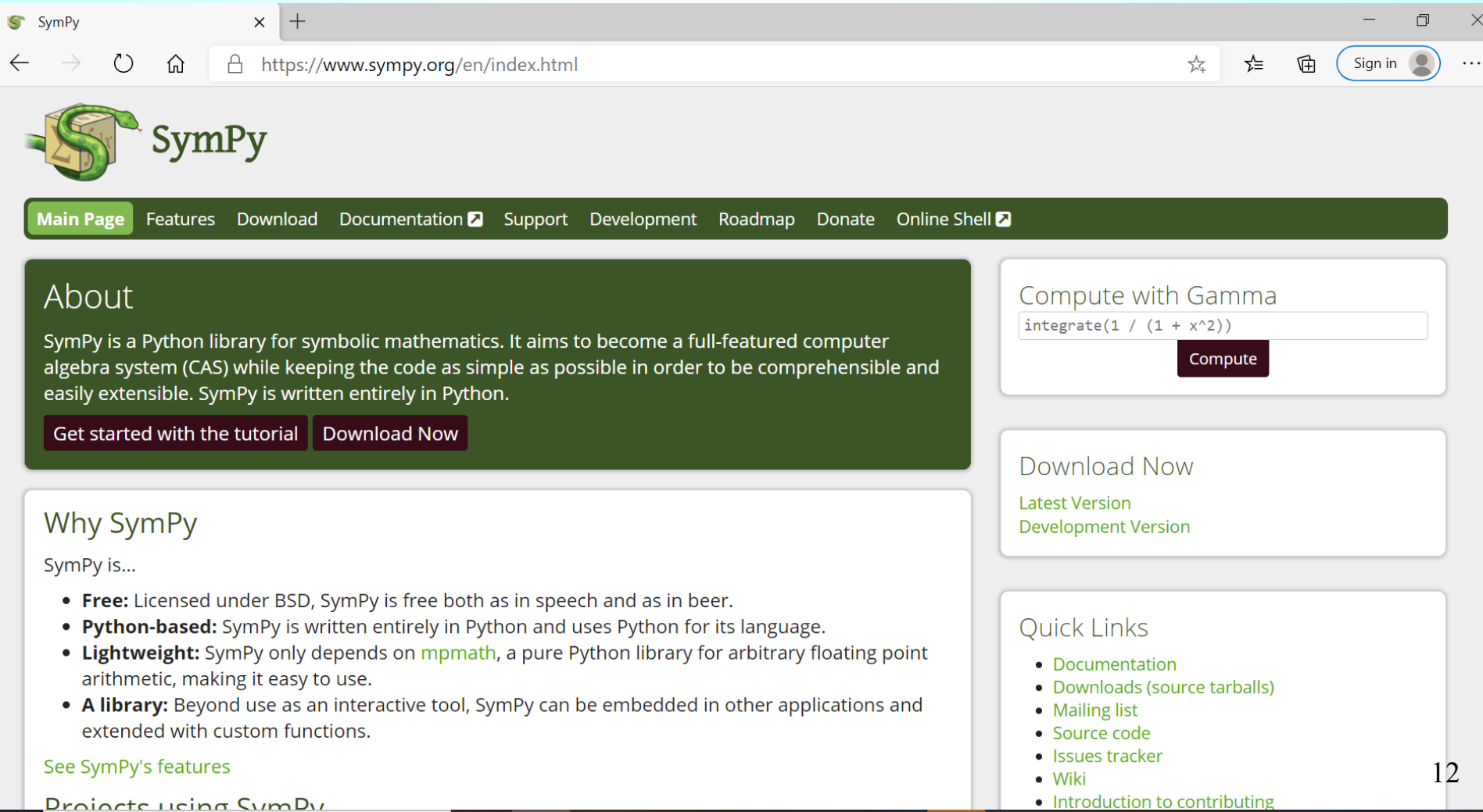
Maxima on Android

https://play.google.com/store/apps/details?id=jp.yhonda&hl=en_US&gl=US

The screenshot shows the Google Play Store interface. At the top, the URL https://play.google.com/store/apps/details?id=jp.yhonda&hl=en_US&gl=US is visible in the address bar. The Google Play logo and a search bar are at the top. A left sidebar contains navigation options: Apps, My apps, Shop, Games, Kids, Editors' Choice, Account, Payment methods, Play Points, My subscriptions, Redeem, Buy gift card, My wishlist, My Play activity, and Parent Guide. The main content area displays the app 'Maxima on Android' by Yasuaki Honda, categorized under Education. It has a rating of 4.5 stars from 2,100 reviews and is suitable for 'Everyone'. A message states 'You don't have any devices' and there is an 'Add to Wishlist' button. A green 'Install' button is present. Below the app title, three preview images are shown: 1. A screenshot of the app's text-based interface showing version 1.1, its development date (Aug 11, 2012), and its reliance on MathJax 2.0 for rendering. 2. A screenshot of a 3D surface plot of the function $2^{*(v^2-u^2)}$. 3. A screenshot of the 'Maxima 5.28.0 Manual' page, which includes a brief history of the system and its development at MIT.

SymPy

www.sympy.org/



The screenshot shows the SymPy website homepage. At the top, there's 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's 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 that 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's a 'Compute with Gamma' section with a text input field containing the expression $\int \frac{1}{1+x^2} dx$ and a 'Compute' button. Below that is a 'Download Now' section with links for 'Latest Version' and 'Development Version'. At the bottom right, there's a 'Quick Links' section with links to Documentation, Downloads (source tarballs), Mailing list, Source code, Issues tracker, Wiki, and Introduction to contributing.

SymPy

https://www.sympy.org/en/index.html

Sign in

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](#)

Compute with Gamma

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

[Compute](#)

Download Now

[Latest Version](#)
[Development Version](#)

Quick Links

- [Documentation](#)
- [Downloads \(source tarballs\)](#)
- [Mailing list](#)
- [Source code](#)
- [Issues tracker](#)
- [Wiki](#)
- [Introduction to contributing](#)

SymPy live

live.sympy.org

live.sympy.org



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

These commands were executed:

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

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

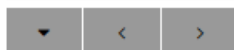
```
>>> diffeq = Eq(f(x).diff(x) + 1000*f(x), 10000)
>>> diffeq
```

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

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

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

```
>>>
```



Evaluate

Clear

Fullscreen

Log In

About this page

SymPy Live is SymPy running on the SymPy Engine.

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

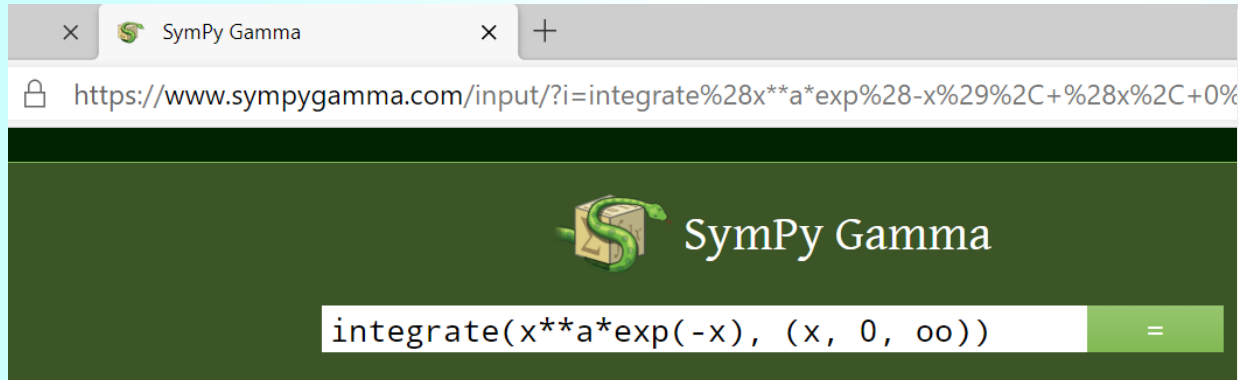
```
>>> from __future__ import division
>>> from sympy import *
>>> x, y, z, t = symbols('x y z t')
>>> k, m, n = symbols('k m n', integer=True)
>>> f, g, h = symbols('f g h', cls=Function)
```

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

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

SymPy Gamma

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



SymPy:

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

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

Antiderivative forms:

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

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

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

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

Examples

Random Example

Arithmetic

Algebra

Trigonometry

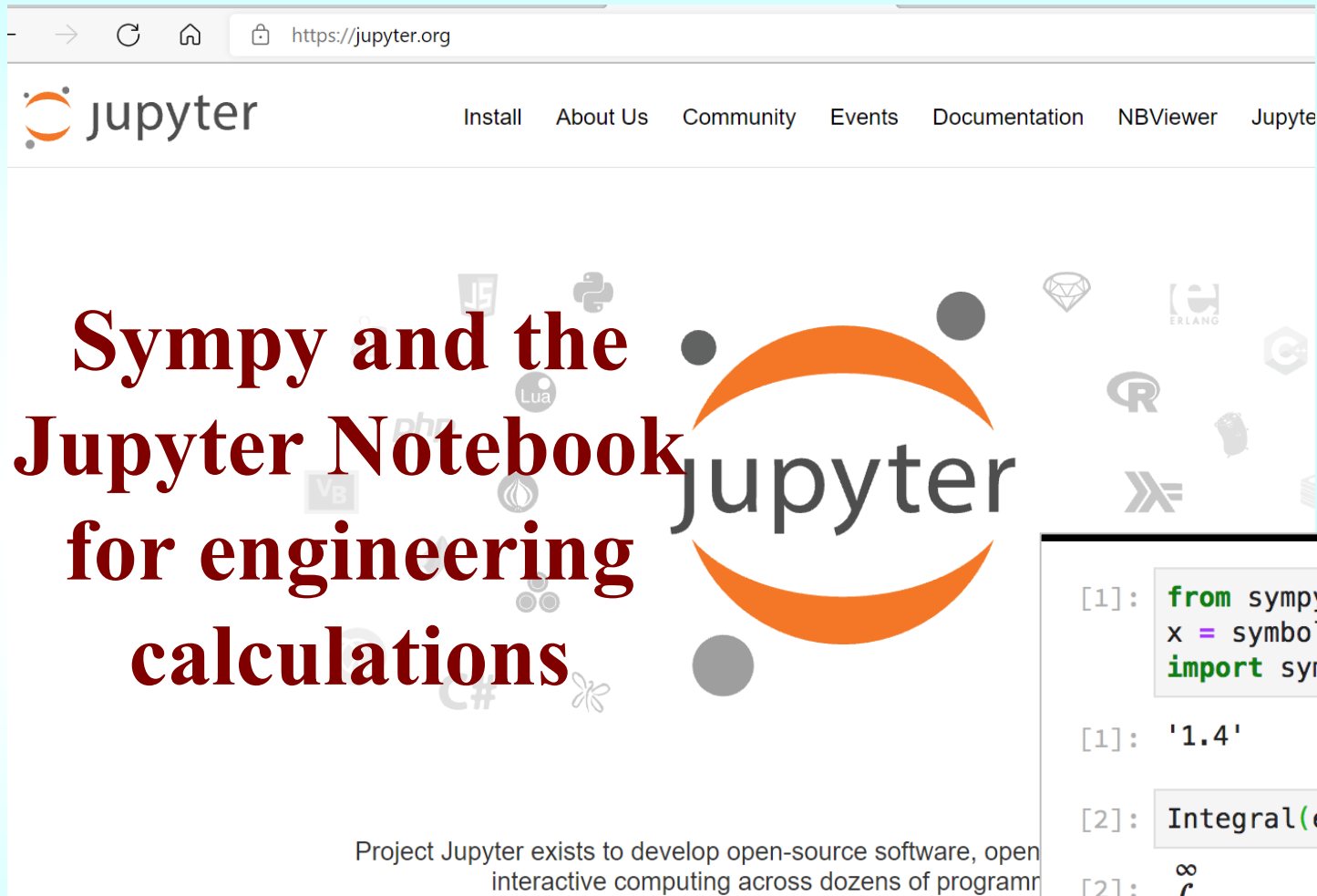
Calculus

Number Theory

Discrete Mathematics

Plotting

Miscellaneous



The image shows the Jupyter website (https://jupyter.org) with a large, semi-transparent text overlay in the center. The text reads: "SymPy and the Jupyter Notebook for engineering calculations". The Jupyter logo is visible in the background of the text. Below the main text, there is a smaller line of text: "Project Jupyter exists to develop open-source software, open interactive computing across dozens of programs".

Sympy and the Jupyter Notebook for engineering calculations

Project Jupyter exists to develop open-source software, open interactive computing across dozens of programs

```
[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

Google

$x \cdot \sin(x)$

Све

Слика

Видео

Мапе

Вести

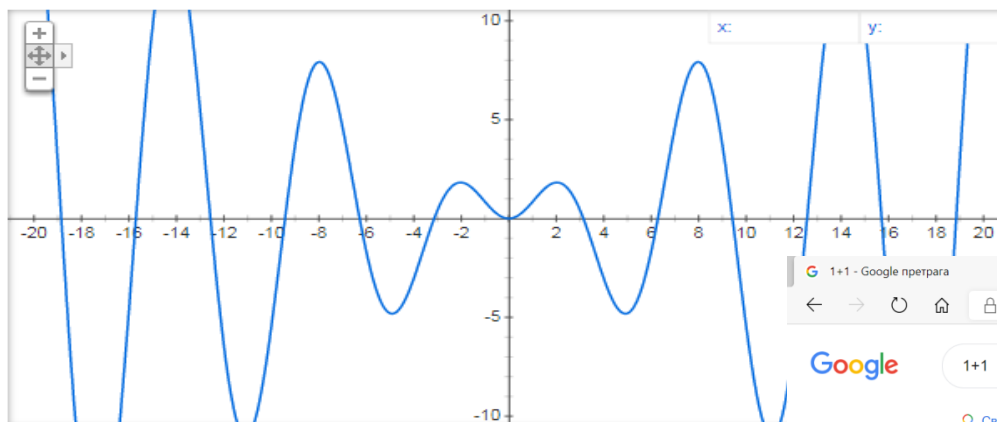
Још

Подешавања

Алатке

Око 3.640.000.000 резултата (0,57 секунде/и)

Графикон за $x \cdot \sin(x)$



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, $\int x \sin x dx$ | Algebraic Trigonometric V
 $g(x) dx = f(x) \int 1 \cdot g(x) dx$...

1+1 - Google претпара

← → ↻ 🏠 https://www.google.com/search?sxsrf=ALeKk02IKn_jfXOK71wFXl_IAsmEQLIWvg%3A16018

Google

1+1

Све Слика Мапе Видео Вести Још Подешавања Алатке

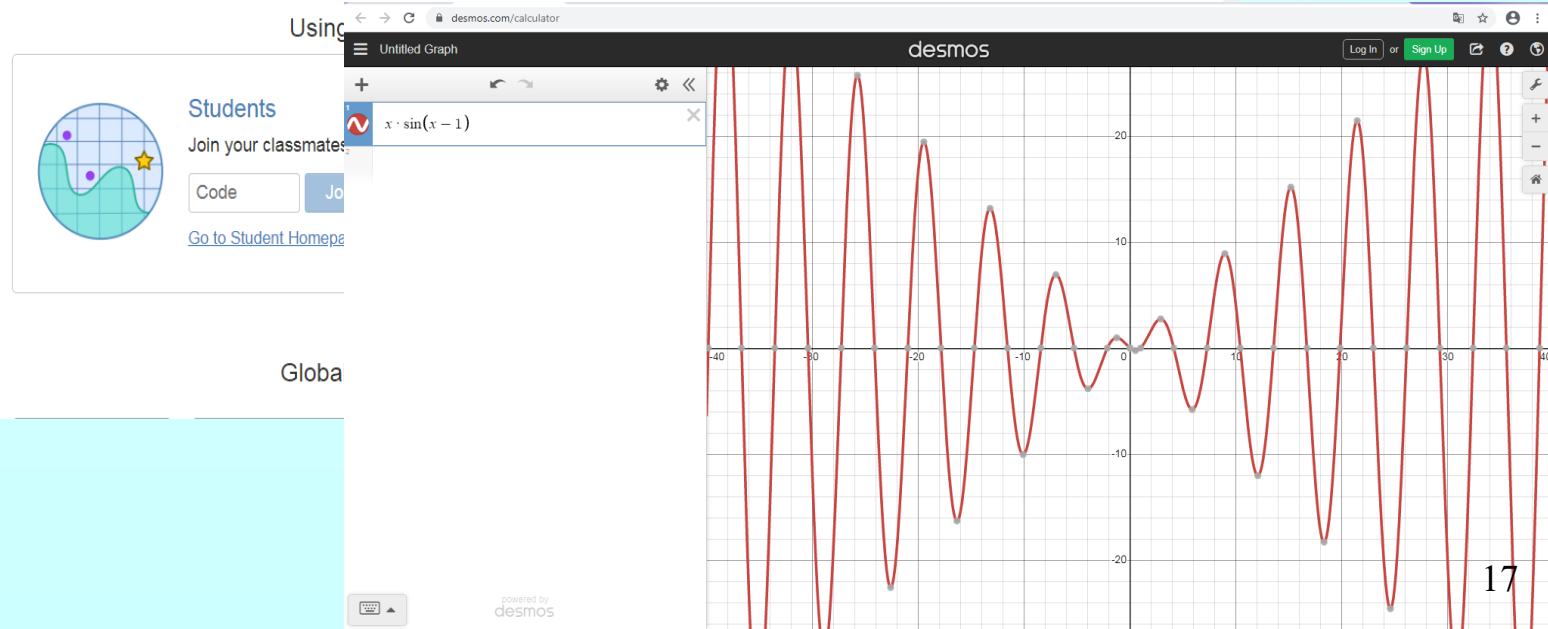
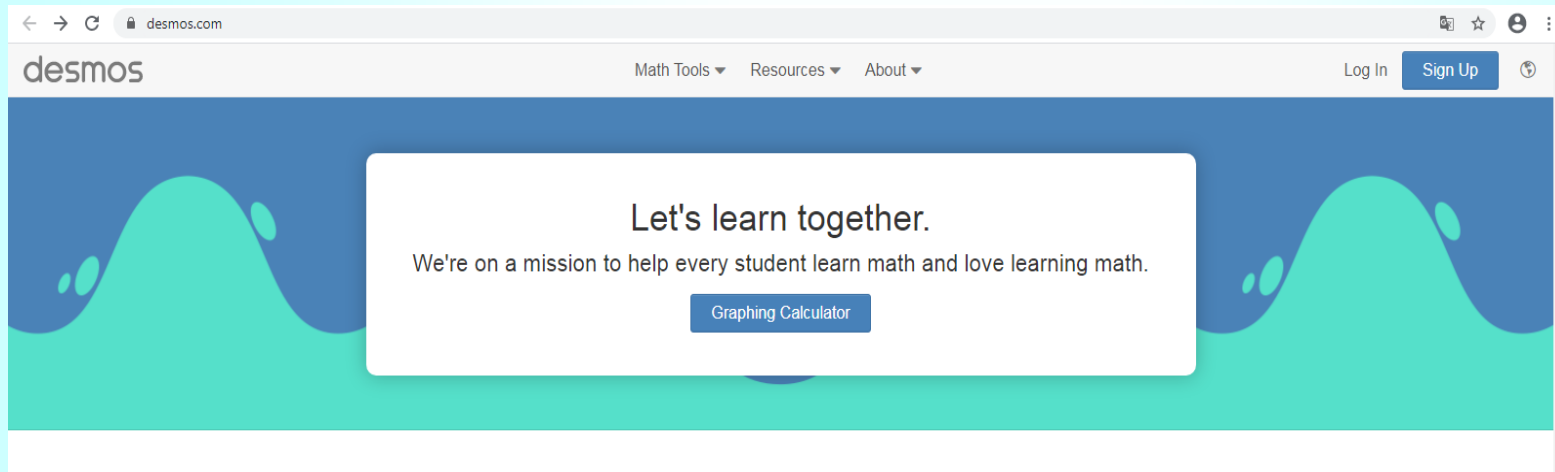
Око 25.270.000.000 резултата (0,72 секунде/и)

1 + 1 = 2

Rad	Deg	x!	(	)	%	AC
Inv	sin	ln	7	8	9	+
π	cos	log	4	5	6	×
e	tan	√	1	2	3	-
Ans	EXP	x'	0	.	=	+

Graphing Calculator – Desmos

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



Symbolab Math Solver - Step by Step calculator

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

Symbolab Math Solver interface showing the main navigation bar, a search bar, and a grid of mathematical symbols and operators. The interface also includes a 'Most Used Actions' section and a 'Step-by-Step Calculator' section.

Solution steps for the integral $\int_0^T x \sin(x) dx$:

Solution

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

Steps

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

Apply Integration By Parts: $u = x, v' = \sin(x)$

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

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

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

Simplify

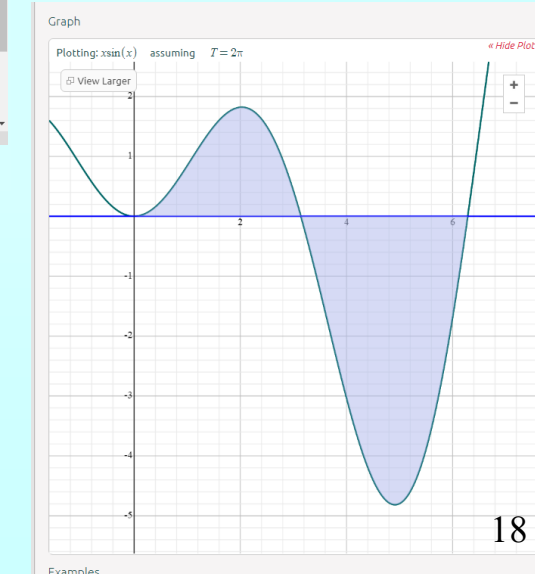
$= [-x \cos(x) + \sin(x)]_0^T$

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

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

Got a different answer? Check if it's correct

Verify



SciLab

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

The image is a composite showing the SciLab website and its software interface. The top part is a screenshot of the website <https://www.scilab.org/> in a web browser. The website has a dark blue header with the SciLab logo and navigation links: Download, Software, Tutorials, Applications, Services, Cloud, and About. Below the header, there's a large blue section with the text "Download Scilab 6.1.0" and "Windows, Linux and Mac OS X". To the right of this text is a 3D surface plot. Below the main text, there's a "Toolboxes" section with a list of categories: Numerical Analysis, Data visualization, Algorithm development, and Application development. The bottom part of the image shows a screenshot of the SciLab 6.1.0 software interface. It features a file browser on the left, a central workspace with a 3D surface plot, and a control panel on the right. The interface is dark-themed and includes various toolbars and windows.

Home Page | www.scilab.org

https://www.scilab.org

Search

Download Software Tutorials Applications Services Cloud About

Download Scilab 6.1.0

Windows, Linux and Mac OS X

Open source software for numerical computation

Toolboxes

- Numerical Analysis
- Data visualization
- Algorithm development
- Application development

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

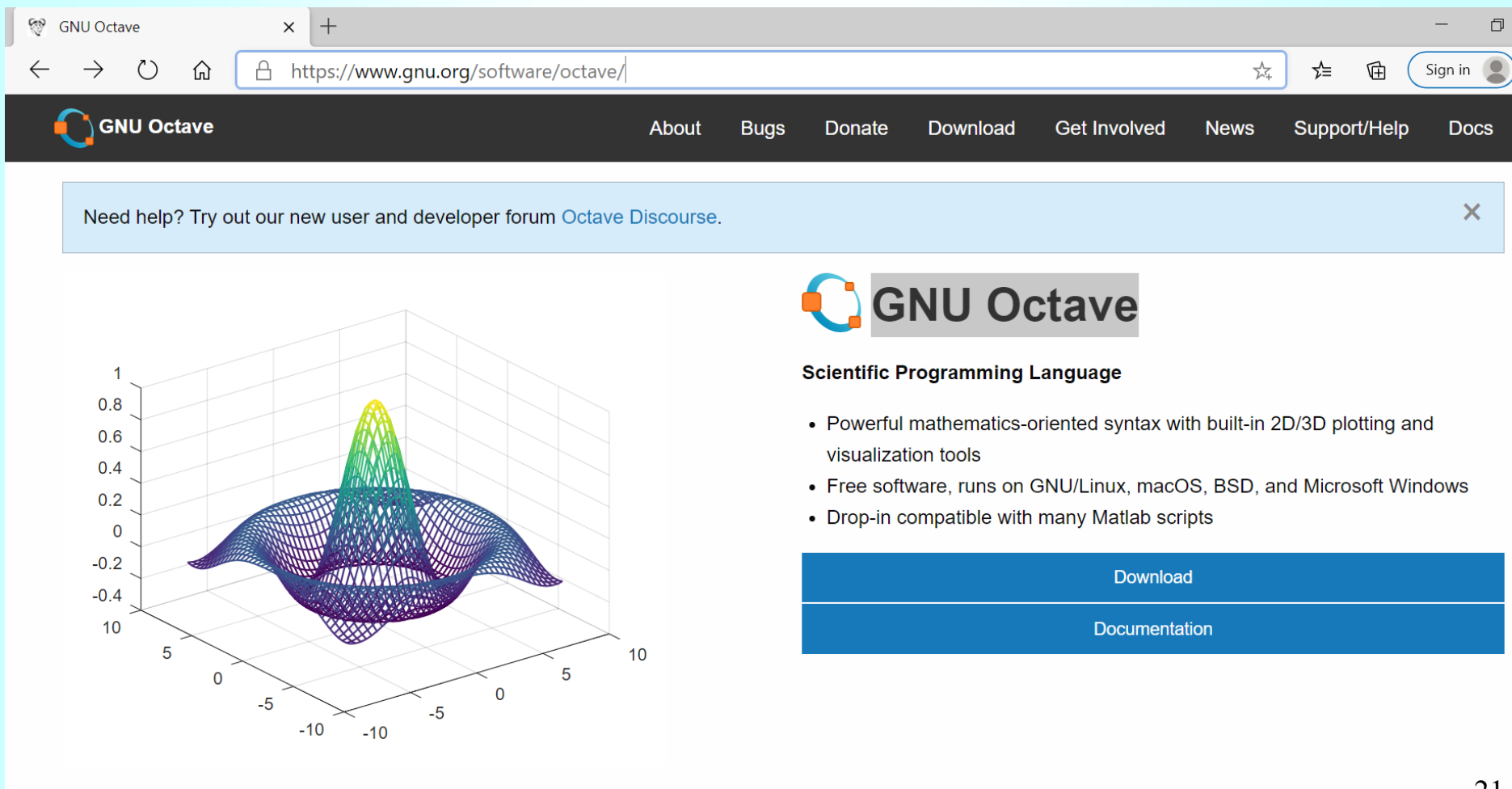
<https://www.scilab.org/software/xcos>

The screenshot displays the Xcos website interface. At the top, the Scilab logo is visible on the left, and a navigation menu includes links for Download, Software, 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 a large, white font on a blue background. Underneath this, four example diagrams are shown, each representing a different application area:

- Signal Processing:** A diagram showing three "Signal Builder" blocks connected to a central processing block. A note below states: "blocks can also emit continuous or discrete activation signals".
- Control Systems:** A diagram illustrating a "Water-Tank System" with a "Controller" and a "Robot-Tank System". It includes a summing junction (Σ) and a feedback loop.
- Mechanics/Thermodynamics:** A diagram showing a series of interconnected blocks representing a mechanical or thermodynamic system, with multiple feedback loops.
- Electronics:** A diagram showing a circuit-like structure with various blocks, including a "MUX" (Multiplexer) and a "MIN" (Minimizer) block.

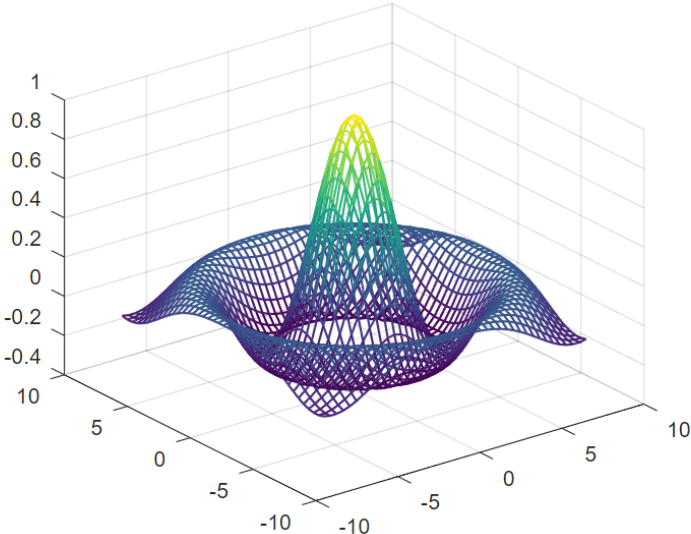
GNU Octave

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



GNU Octave

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>

The screenshot displays the Spectrum Software website's Micro-Cap 12 download page. The browser's address bar shows the URL <http://www.spectrum-soft.com/index.shtml>. The website header includes the Spectrum Software logo and a navigation menu with links to Home, Products, Download, Newsletters, Support, and Contact Us. A banner for "Industrial Strength Simulation" is visible. On the left, a sidebar lists navigation options: MC12 Revision History, Product Information, Features Tour, and New MC12 Features. The main content area features a circuit diagram with various components labeled (e.g., VCC, 15V, V2, QPL, Q2, Q10, R18, 10, 1K, R17, Q21, Q16, Q11, Q1, 40K, R10, Q4, Q5, R16, 1K, C3, 30PF, R1, 1K, %B). A prominent red banner across the circuit diagram states: "MC10, MC11, and MC12 are now free and need no key." In the center of the circuit is a large, circular gold coin with the text "SPECTRUM SOFTWARE" around the top edge and "MICRO-CAP TWELVE" around the bottom edge. The number "12" is prominently displayed in the center of the coin. On the right side, there are two informational boxes: "About Spectrum" and "Help". The "About Spectrum" box contains text about the company's founding in February 1980 and its initial focus on providing software for personal computers. The "Help" box contains text about searching newsletter issues for application notes and frequently asked questions.

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](#).

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...

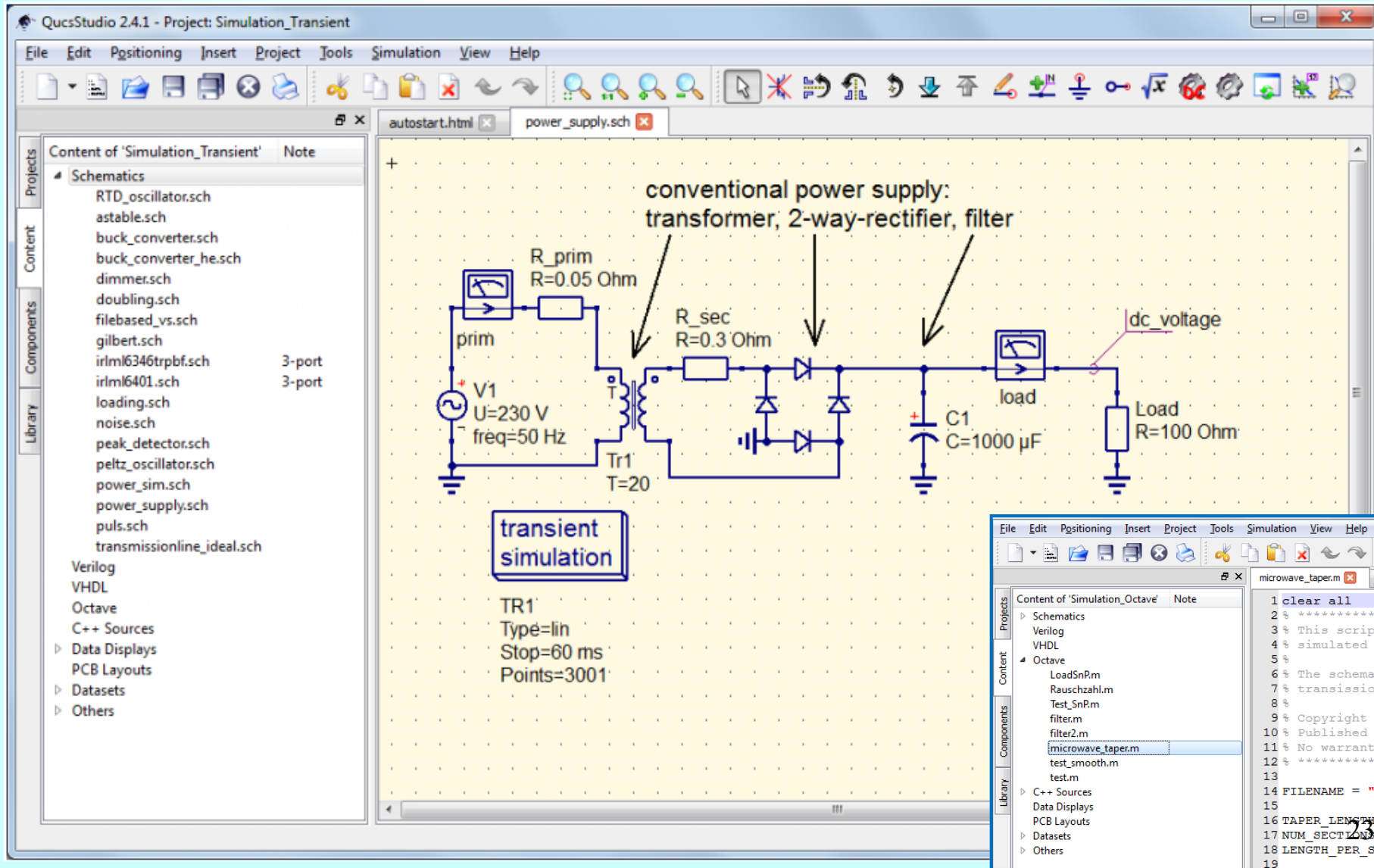
Help

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!*



CircuitLab

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

The image shows a screenshot of the CircuitLab website. The top navigation bar includes the CircuitLab logo, a search bar, and user information for 'milka.potrebic'. The main heading reads 'Circuit simulation and schematics.' Below this, a sub-heading says 'Build and simulate circuits right in your browser.' followed by a list of features: '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 labeled 'Launch CircuitLab' is present, along with a link to 'or watch a quick demo video →'. To the right, a video player titled 'Getting Started with CircuitLab' shows a circuit diagram with a sine wave source (V1, 1 kHz), two resistors (R1, R2, both 100 Ω), and a capacitor (C1, 1 μF). The video player has a play button and a progress bar at 148%.

CircuitLab

Search

milka.potrebic
inbox (0) · settings · log out

Circuit simulation and schematics.

Build and simulate circuits right in your browser.

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

Launch CircuitLab

[or watch a quick demo video →](#)

Getting Started with CircuitLab

Гледајте К... Дели

V1 sine 1 KHz

R2 100 Ω

R1 100 Ω

C1 1 μF

In

out

1-minute Tutorial

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

extbook **NEW!**

ectronic systems with CircuitLab's free,
ik.

[al Circuit Design and Analysis](#)

Powered by CircuitLab > to learn about the full version, please visit www.circuitlab.com/

148%

DoCircuits Circuit Simulator

Do Circuits

Blog Learn Download Login



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



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

25

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

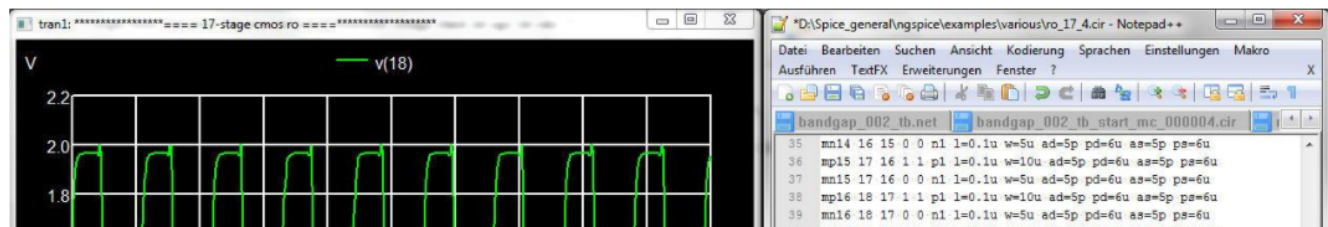
ngspice - open source spice simulator

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.



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



Products Applications Design resources

Home / Design resources

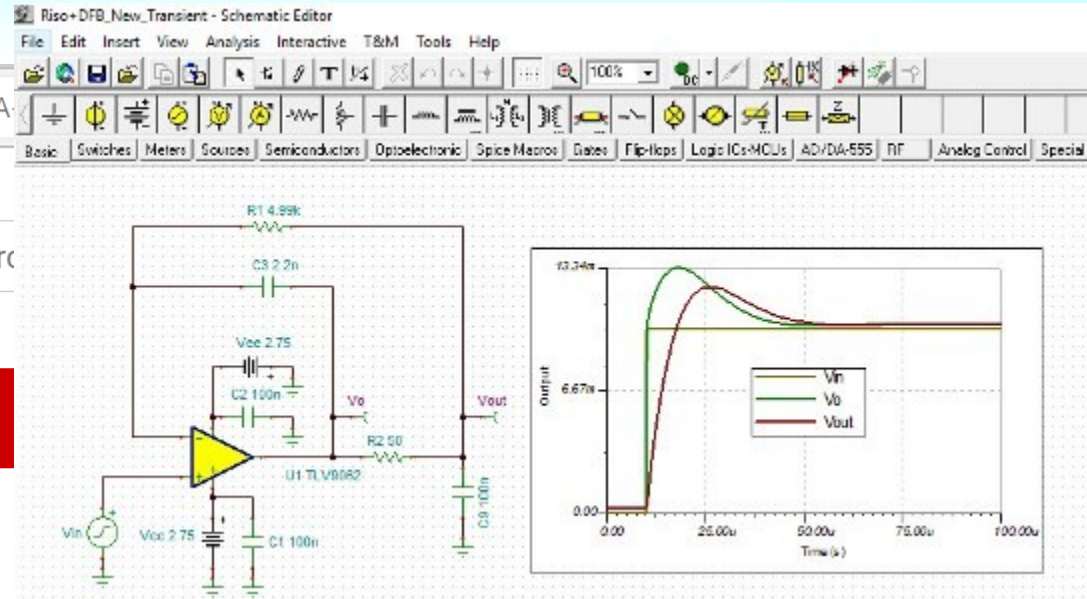
TINA-TI

SPICE-based analog simulation program

Overview Downloads Technical documentation Support & training

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



TINA-TI

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

Electric Circuit Studio

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



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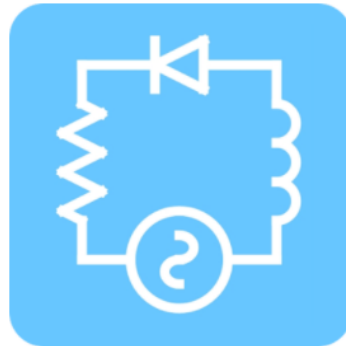
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Parent Guide



Electric Circuit Studio

ECStudio Systems Education

★★★★★ 2,709

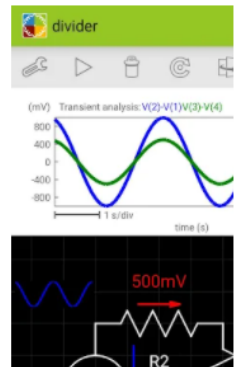
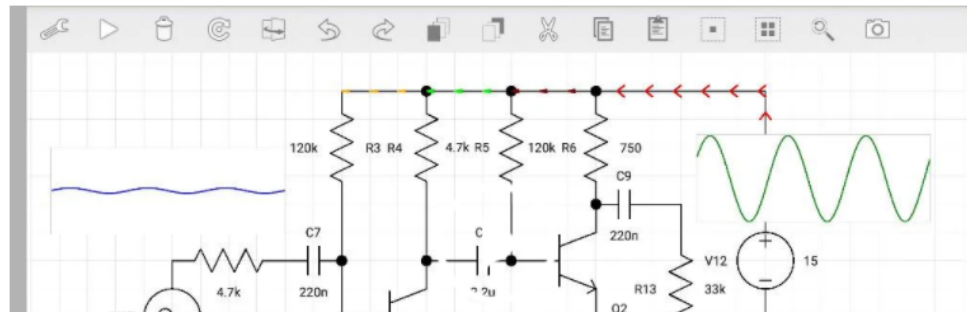
Everyone

Contains Ads

⚠ You don't have any devices

🔖 Add to Wishlist

Install



CircuitSafari SPICE Simulator

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



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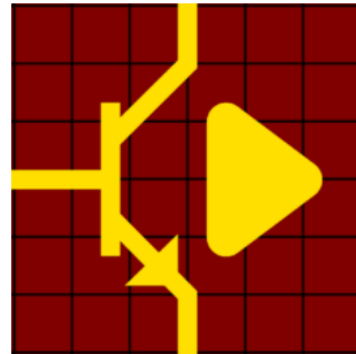
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Buy gift card

My wishlist

My Play activity

Parent Guide



CircuitSafari SPICE Simulator (Early Access)

Logipipe, LLC Productivity

E Everyone

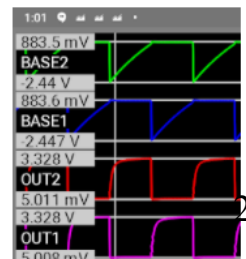
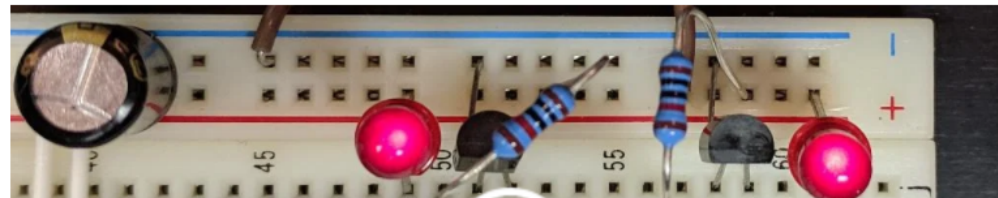
Offers in-app purchases

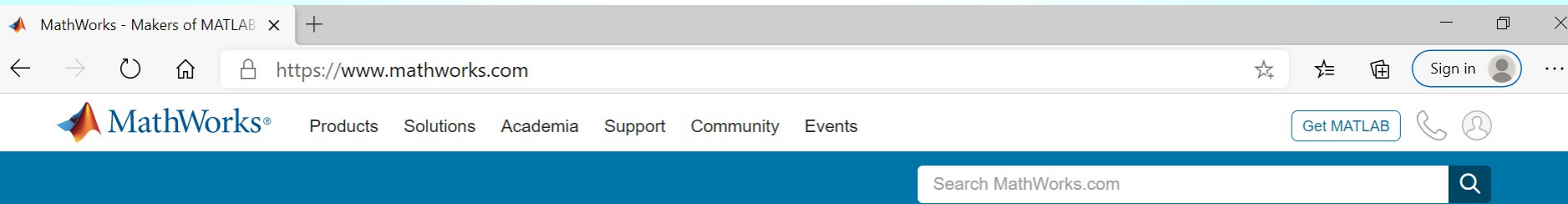
ⓘ This app is in development. It may be unstable.

⚠ You don't have any devices

🔖 Add to Wishlist

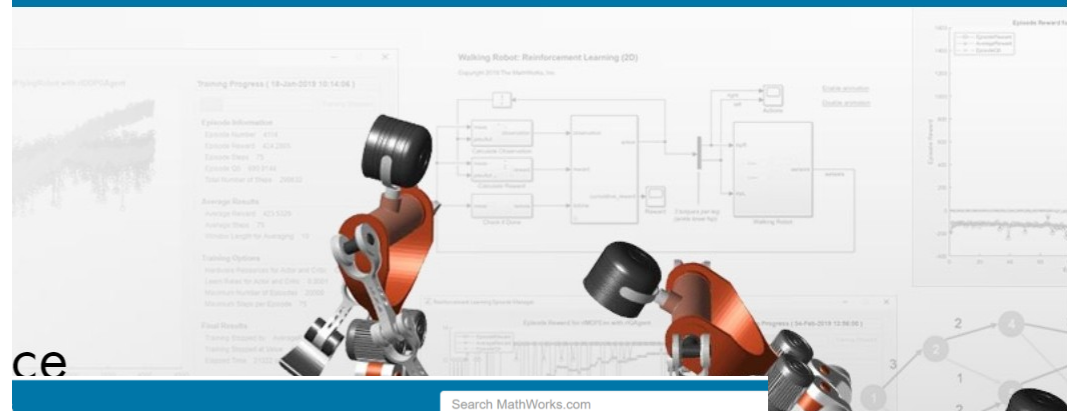
Install



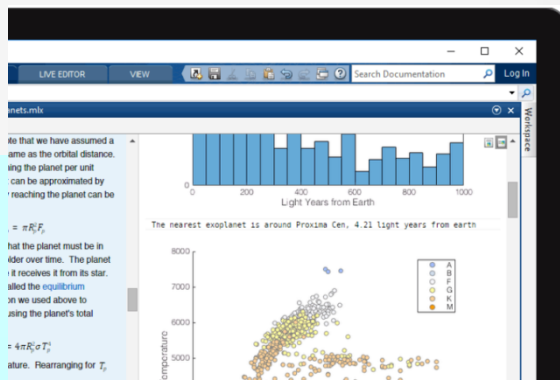


Millions of Engineers and Scientists Trust MATLAB

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



Design AI models and AI-driven systems



Products by Category Alphabetical

Trial software

MATLAB® PRODUCT FAMILY

MATLAB

Parallel Computing

Parallel Computing Toolbox
MATLAB Parallel Server

Math and Optimization

Curve Fitting Toolbox
Optimization Toolbox
Global Optimization Toolbox
Symbolic Math Toolbox
Mapping Toolbox

SIMULINK® PRODUCT FAMILY

Simulink

System Composer

Event-Based Modeling

Stateflow
SimEvents

Physical Modeling

Simscape
Simscape Driveline
Simscape Electrical
Simscape Fluids

SERVICES

Software Maintenance
Training
Consulting

LICENSE TYPES

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



MATLAB

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

MATLAB R2019a

HOME PLOTS APPS

New Script New Live Script New Open Find Files Import Data Save Workspace New Variable Open Variable Clear Workspace Analyze Code Run and Time Favorites Clear Commands Simulink Layout Preferences Set Path Add-Ons Help Community Request Support Learn MATLAB

FILE VARIABLE CODE ENVIRONMENT RESOURCES

Current Folder: C:\Program Files\Polyspace\R2019a\bin

Command Window: New to MATLAB? See resources for [Getting Started.](#)

Workspace: Name Value

System target file browser: Simulink2DSHplus

System target file: Description: asap2.tlc ASAM-ASAP2 Data Definition Target dsh.tlc Borland C++ DSHplus Real-Time Target with dsh.tlc Visual C/C++ DSHplus Real-Time Target with ert.tlc RTW Embedded Coder (no auto configuration) ert.tlc RTW Embedded Coder (auto configures for C) ert.tlc C++ Project Makefile only for the real-time target ert.tlc C++ Project Makefile only for the real-time target

Full name: Template makefile Make compiler

Cancel Help Apply

Simulink2D SHplus

MathWorks

MATLAB®

Professional License

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

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MathWorks® R2019a

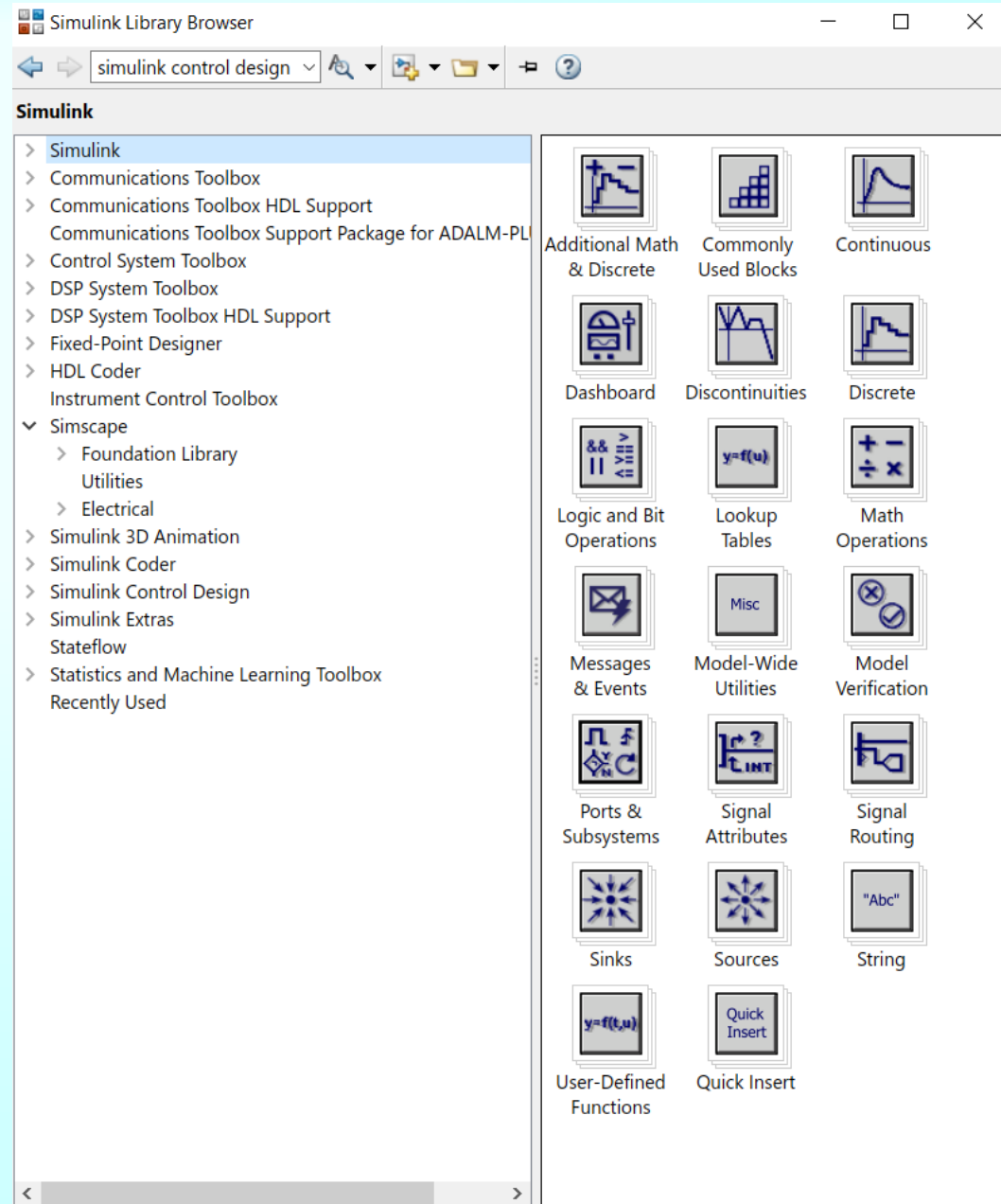
Ready

Toolboxes...

MATLAB

Simulink

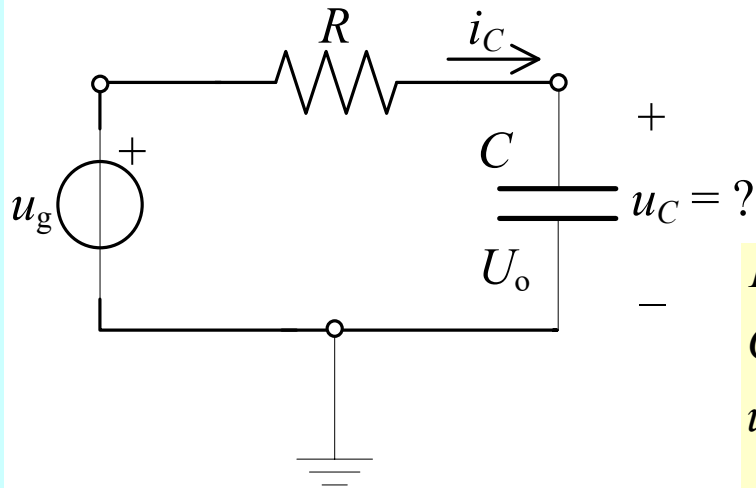
- Алатка за нумеричку анализу математичких модела
- Систем се дефинише графички, уметањем блокова и њиховим повезивањем у мрежу



Simulink > Simscape

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

коло је образовано у тренутку $t_0 = 0$

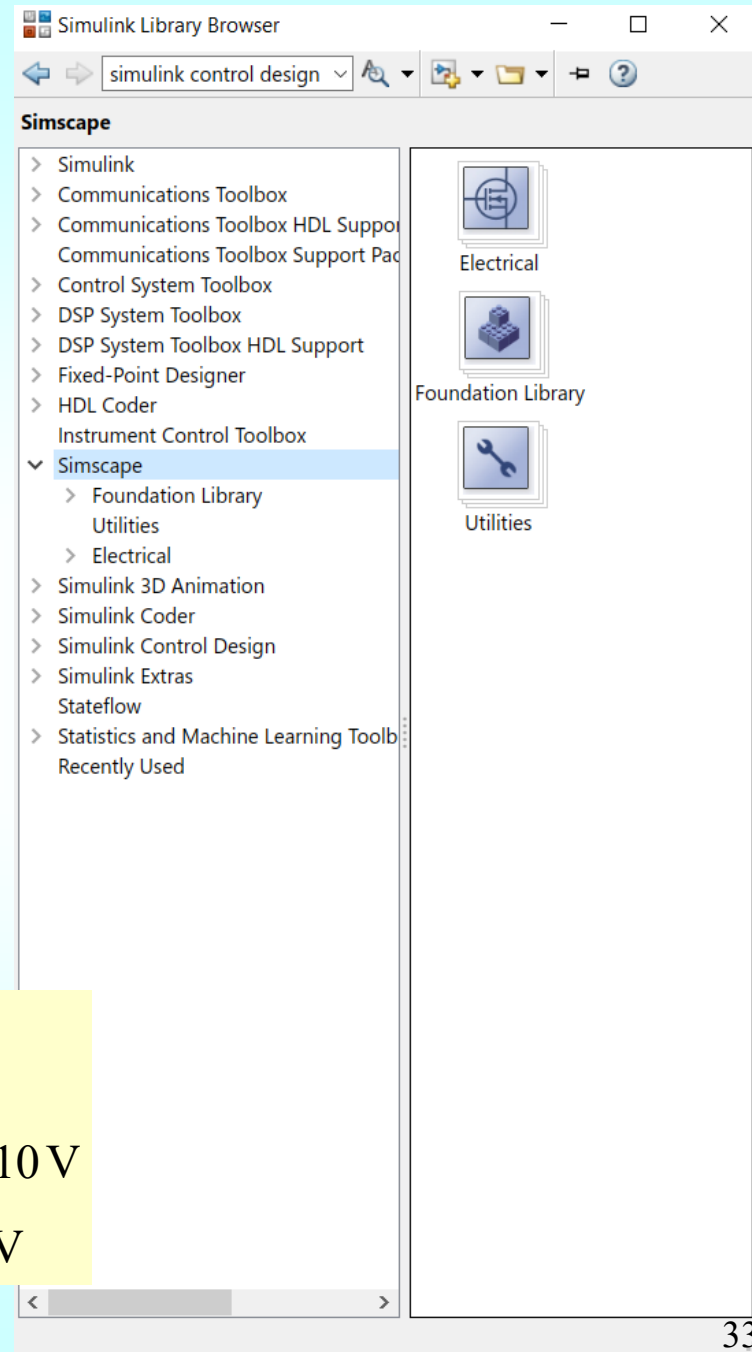


$$R = 1 \text{ k}\Omega$$

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

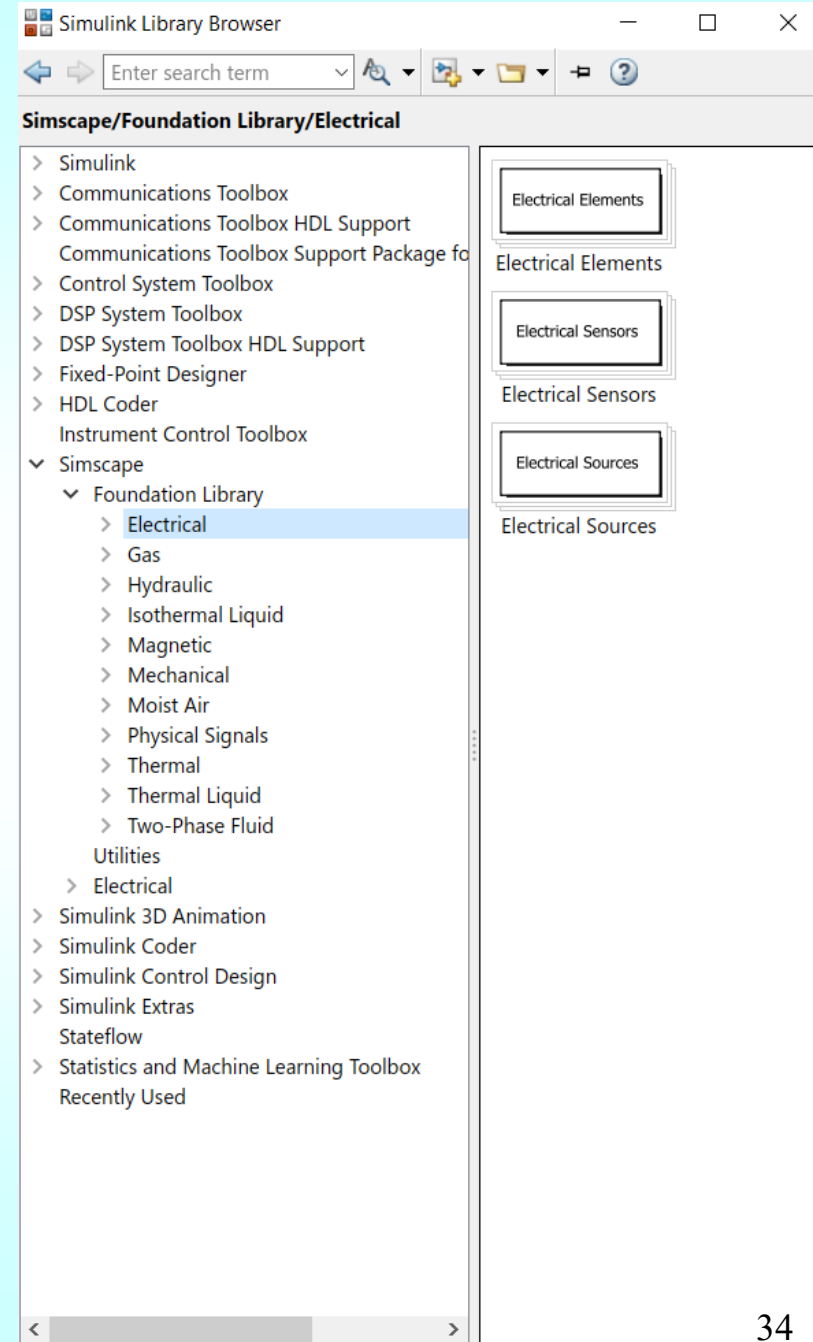
$$u_g(t) = U h(t), U = 10 \text{ V}$$

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



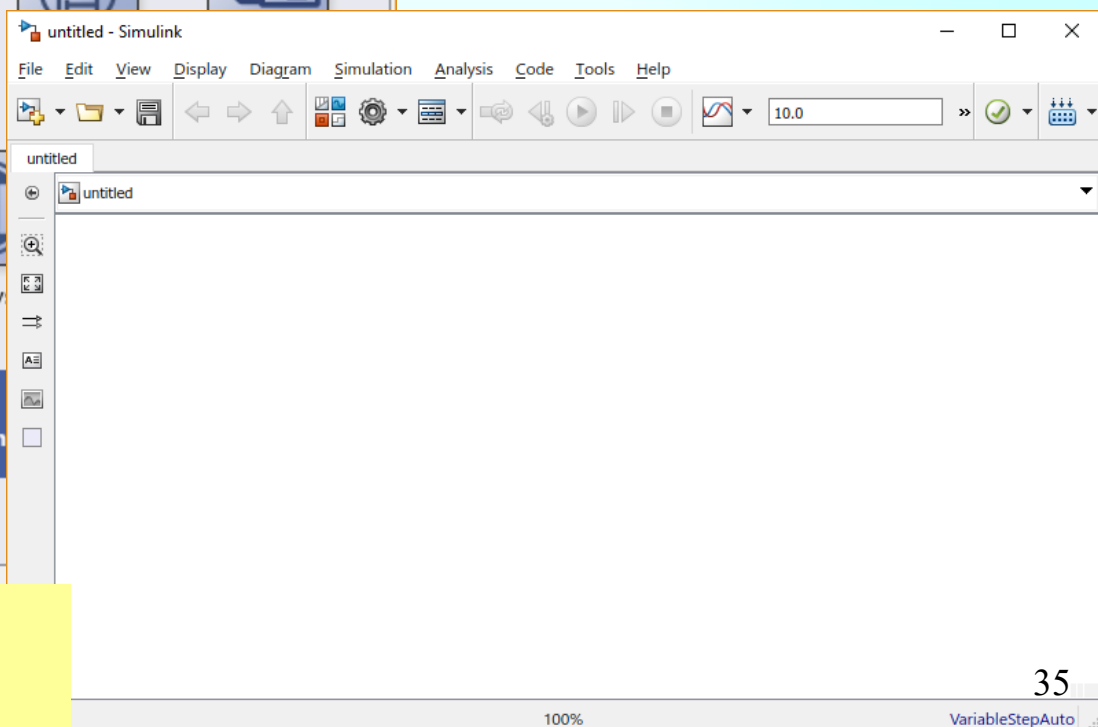
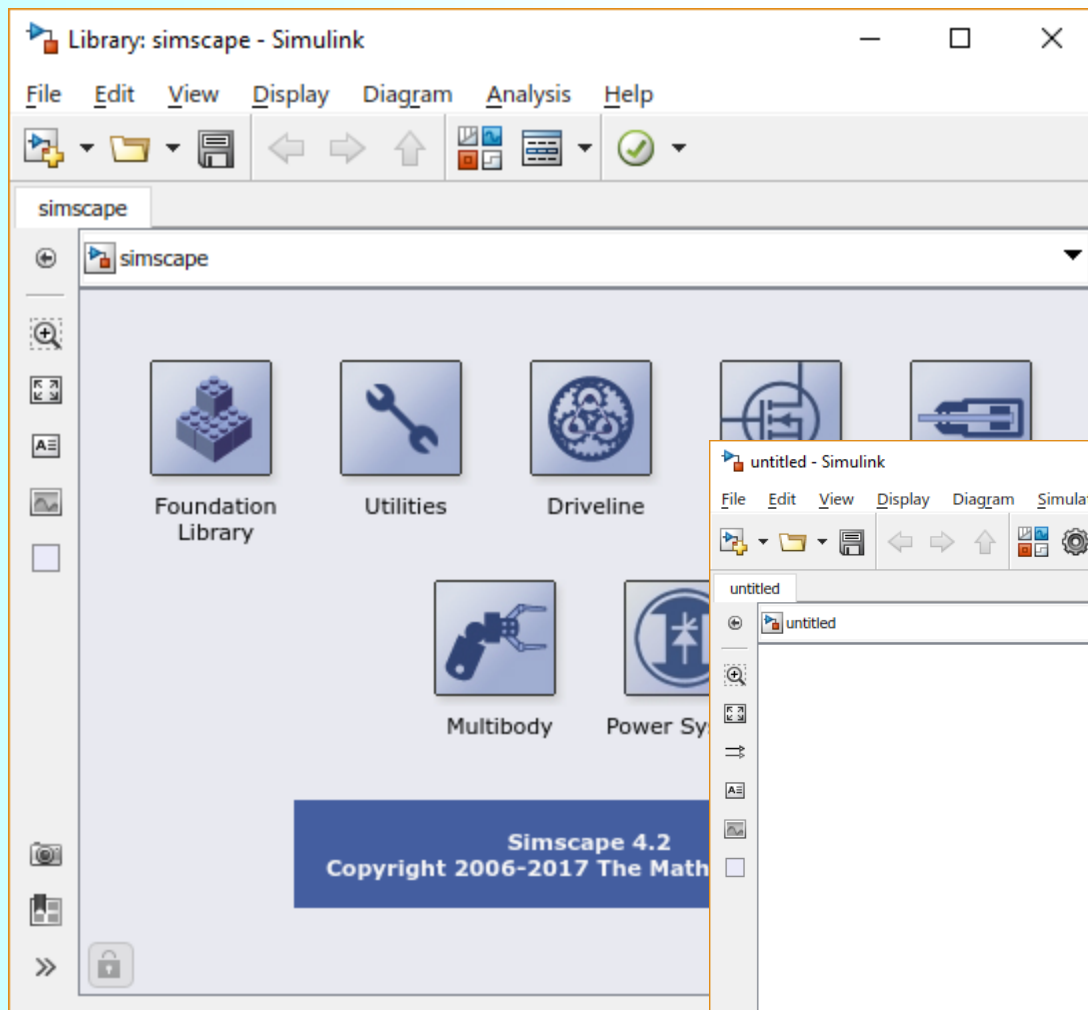
Simulink > Simscape > Foundation Library > Electrical

- Симулација линеарних и нелинеарних електричних кола

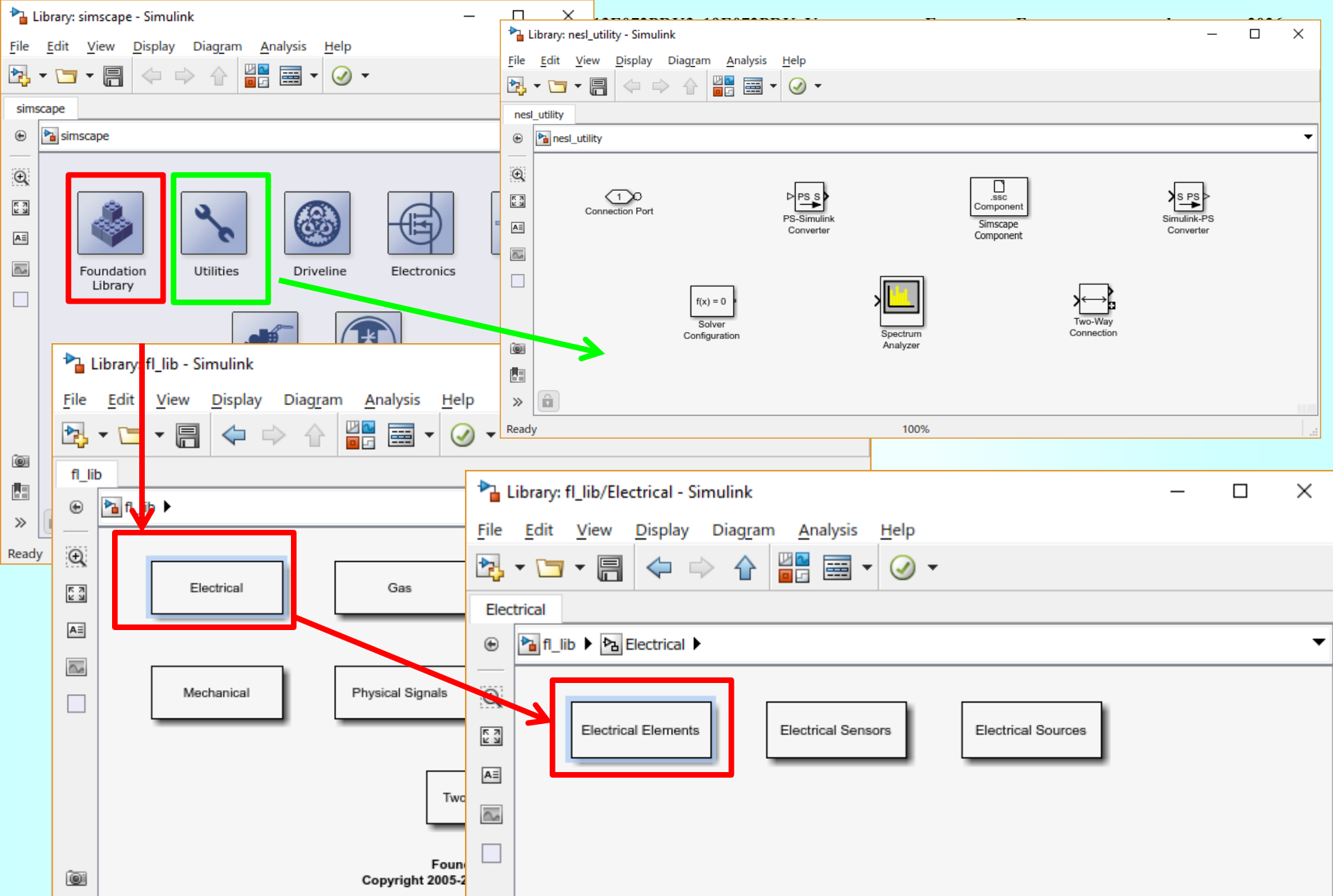


**MATLAB > Simscape >
Foundation Library, Utilities**

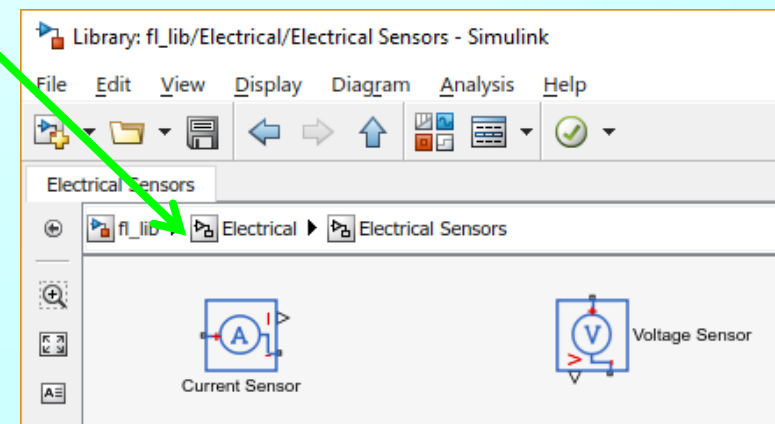
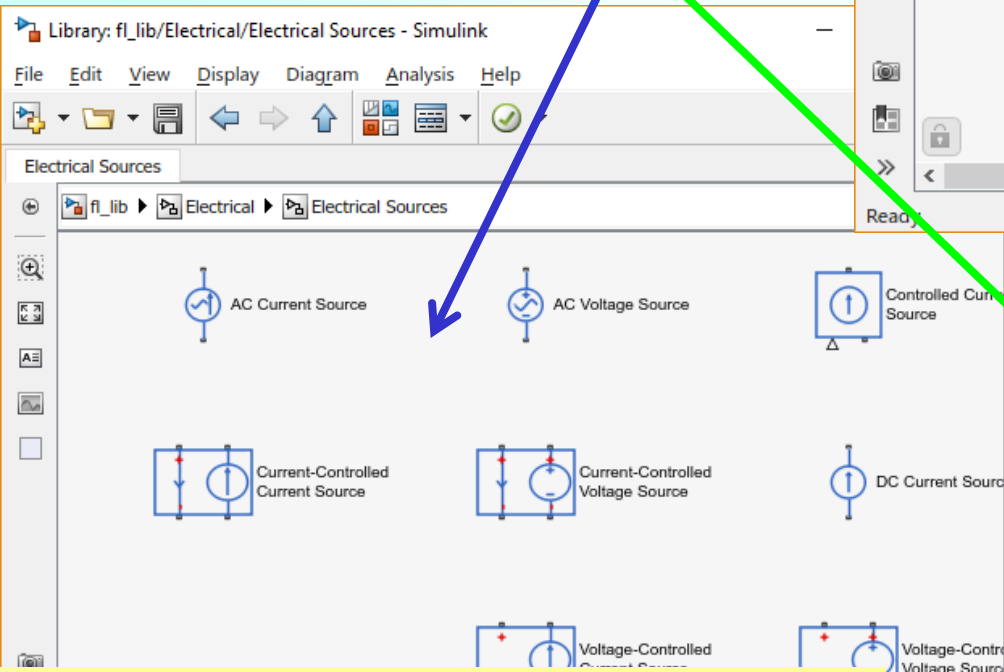
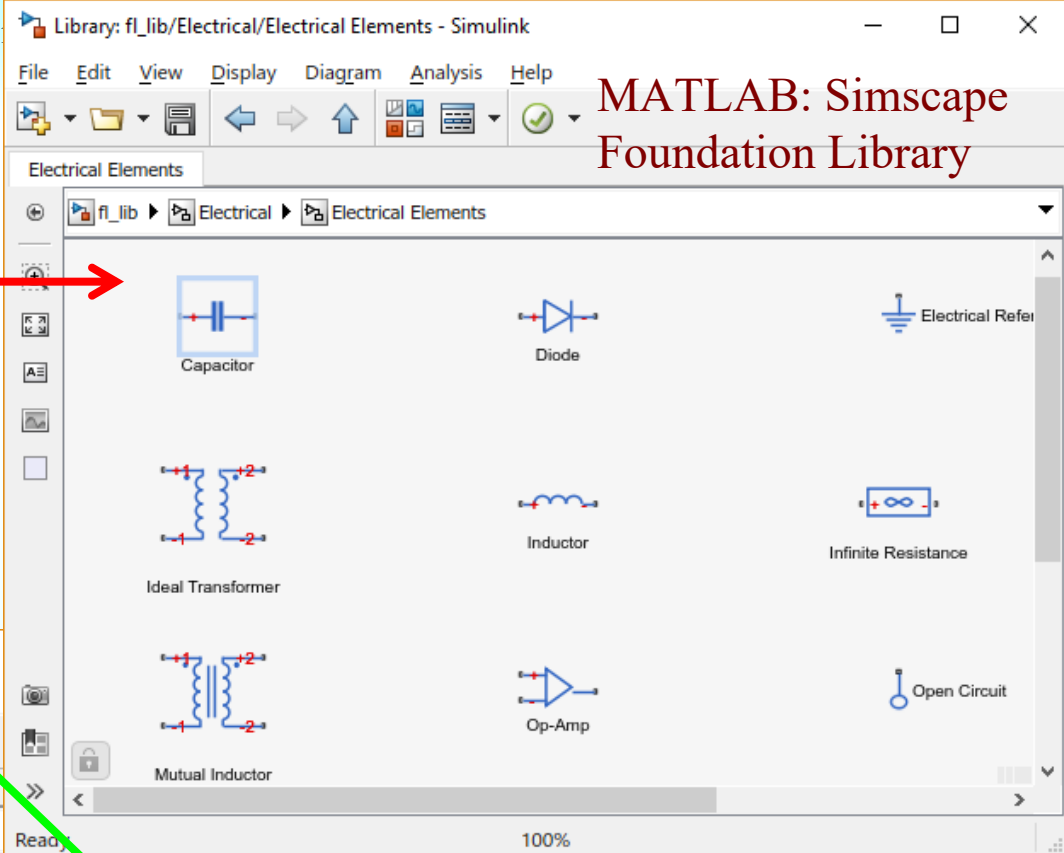
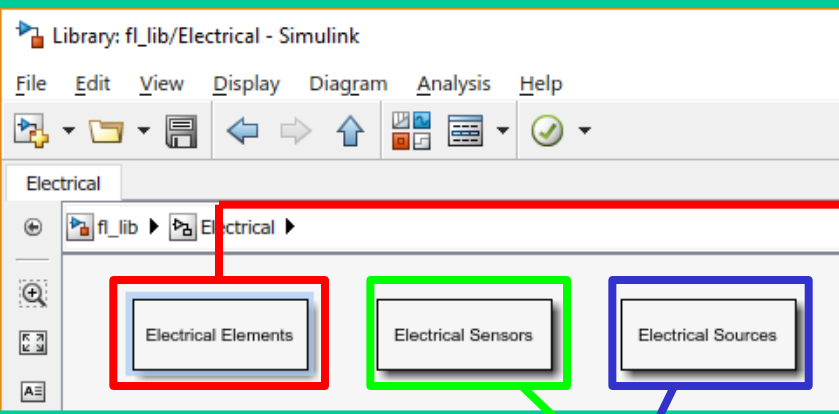
Симулација електричног кола коришћењем **Simscape > Foundation Library** библиотеке



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

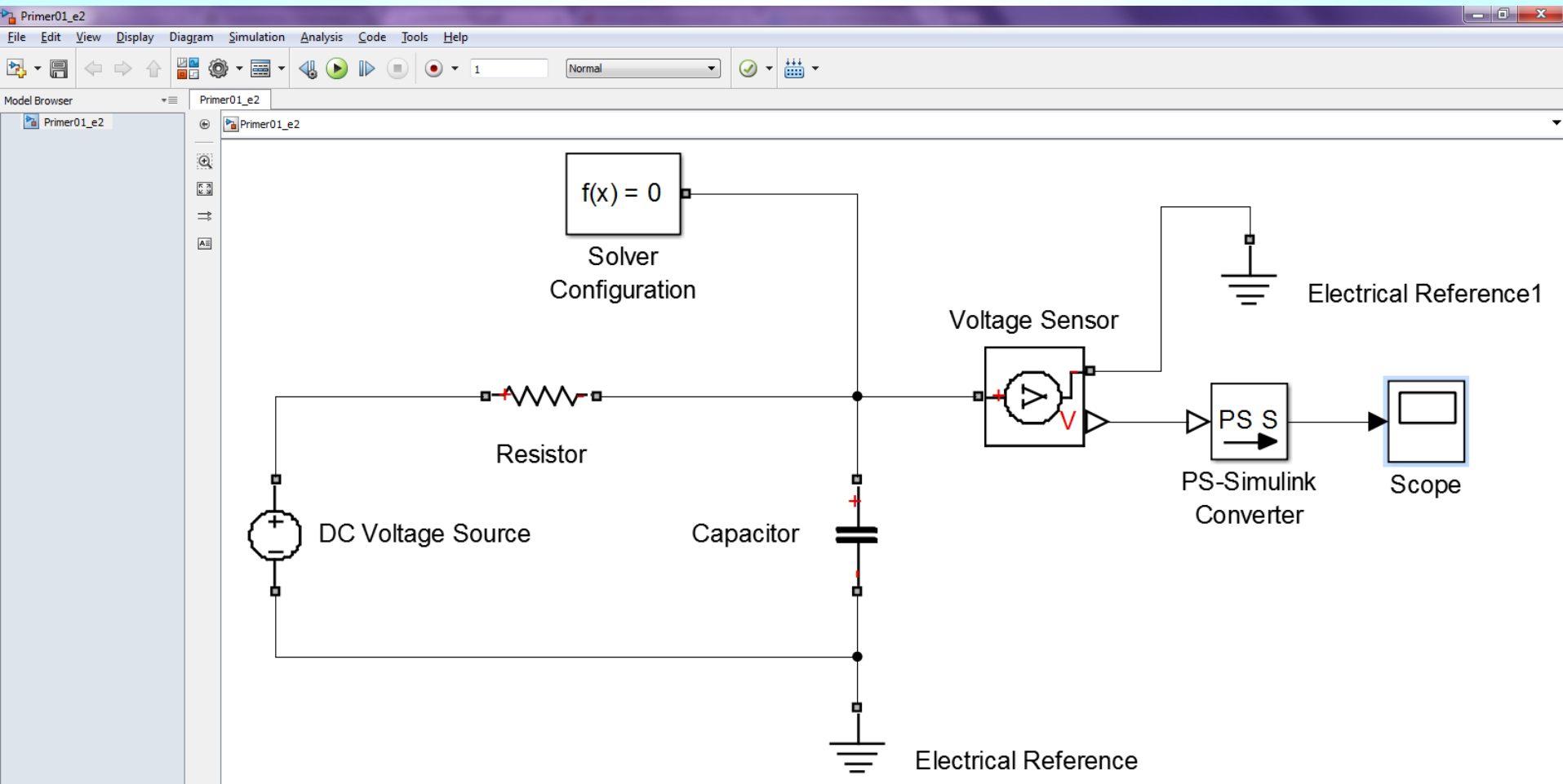


**MATLAB > Simscape >
Foundation Library, Utilities**



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

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



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

Block Parameters: Solver Configuration

Solver Configuration
Defines solver settings to use for simulation.

Parameters

☐ Start simulation from steady state

Consistency tolerance

☐ Use local solver

Solver type

Sample time

☐ Use fixed-cost runtime consistency iterations

Nonlinear iterations

Mode iterations

Linear Algebra

Delay memory budget [kB]

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

Filtering time constant

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:

Block Parameters: Resistor

Resistor

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

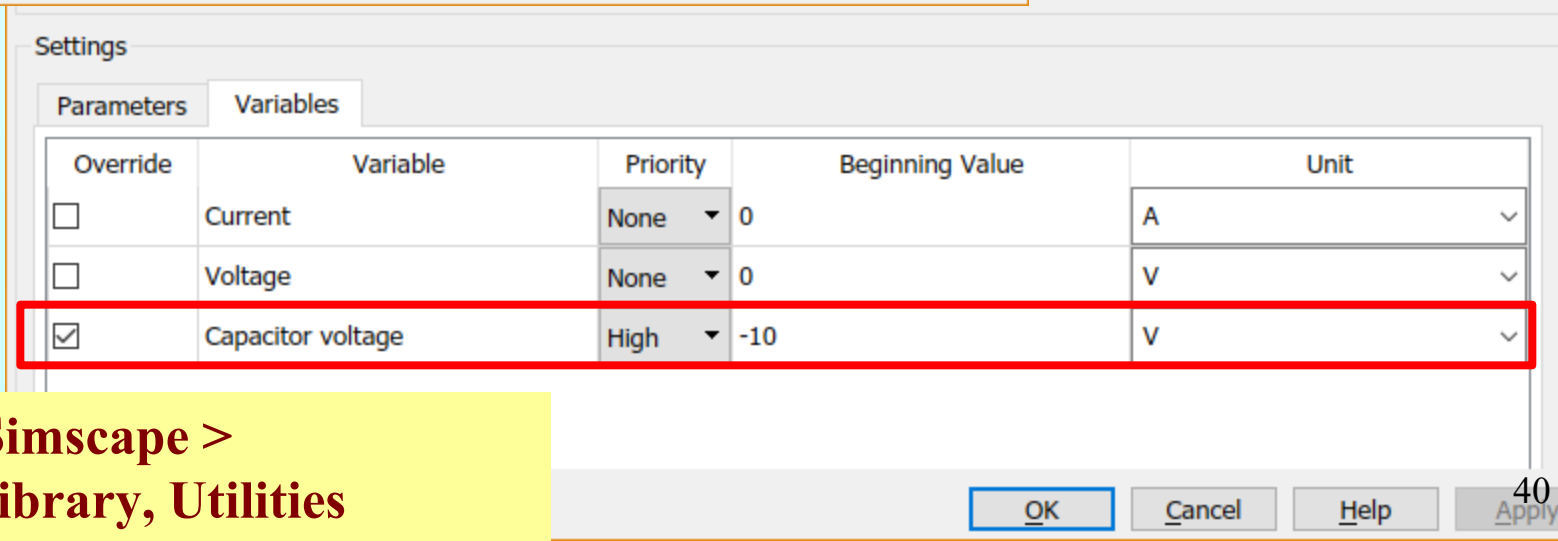
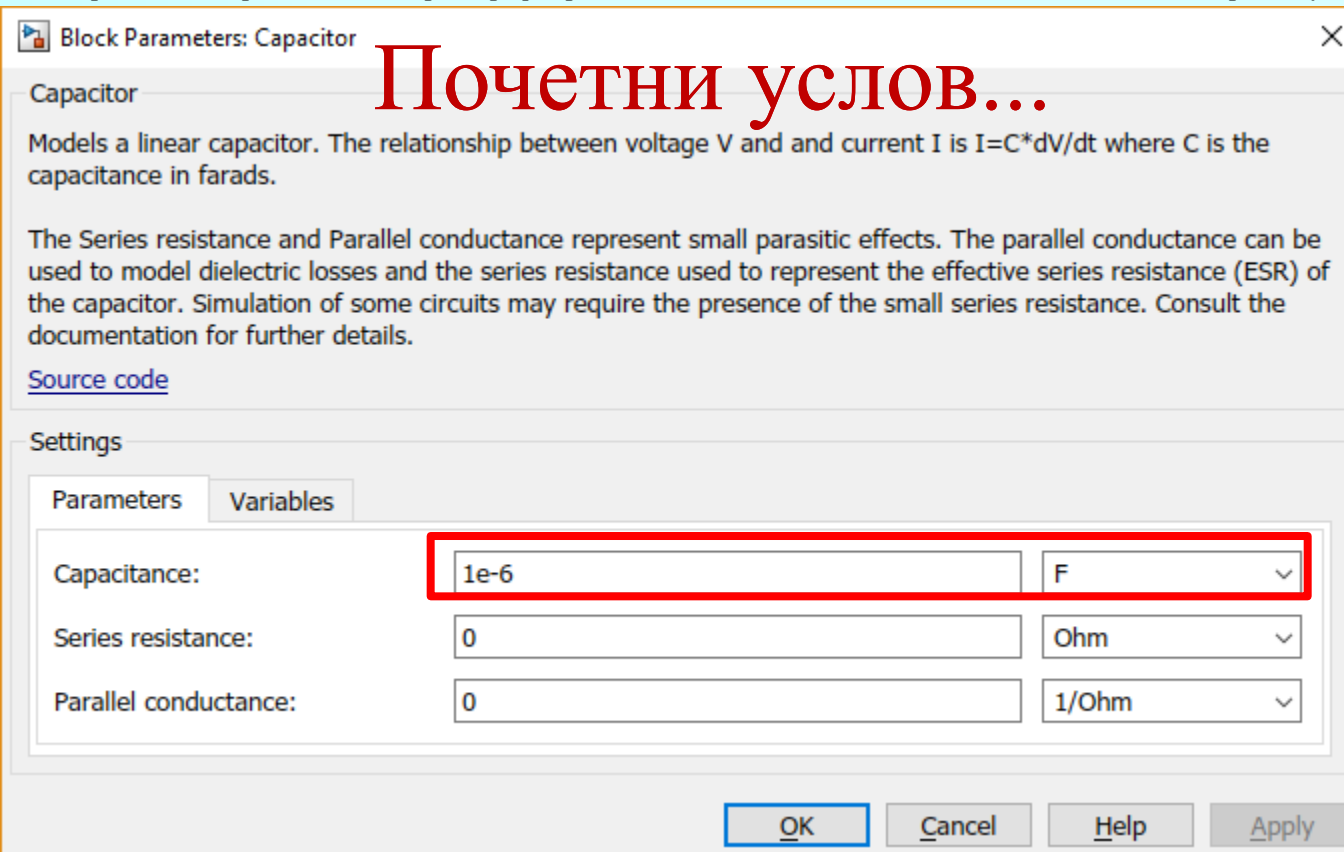
The positive and negative terminals of the resistor are denoted by the + and - signs respectively. By convention, the voltage across the resistor is given by $V(+)-V(-)$, and the sign of the current is positive when flowing through the device from the positive to the negative terminal. This convention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

[Source code](#)

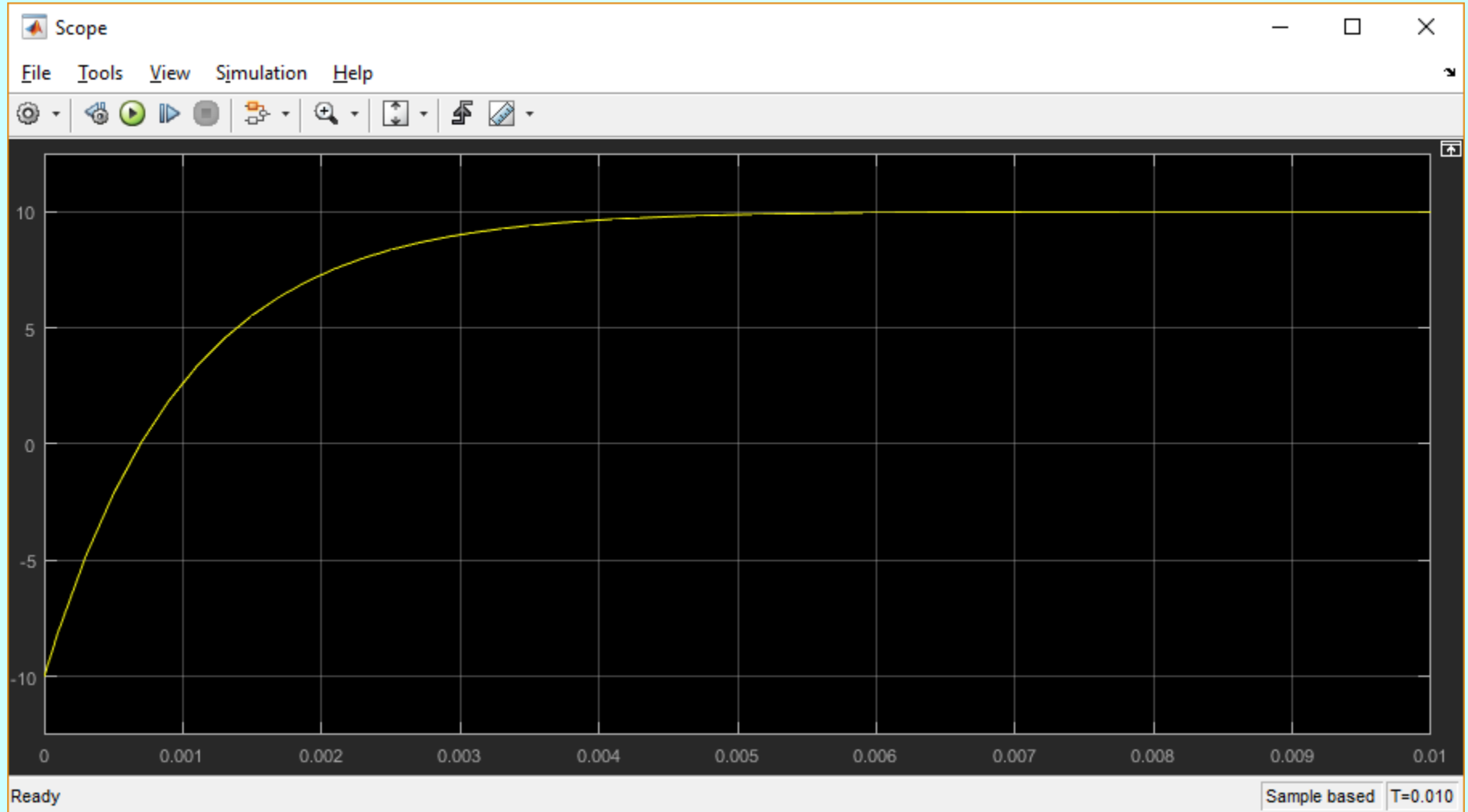
Settings

Parameters Variables

Resistance:

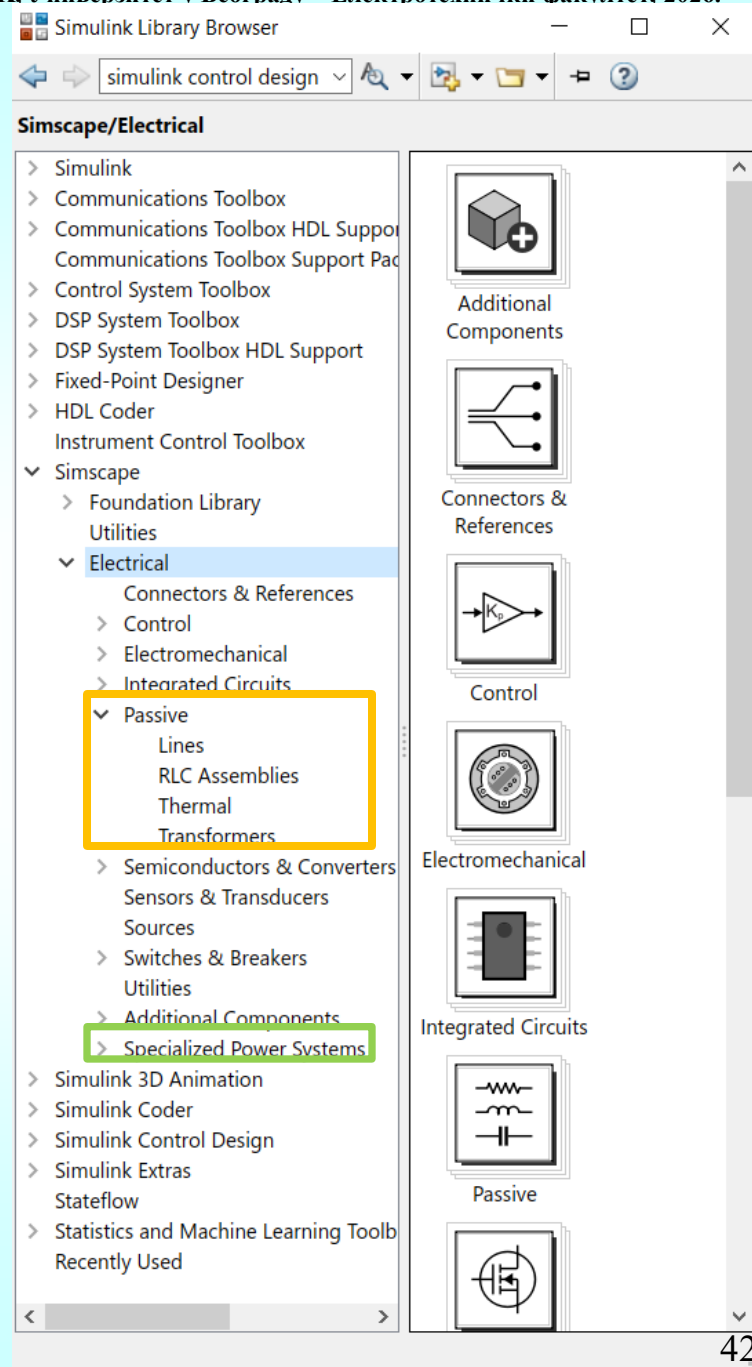


Одређивање одзива...



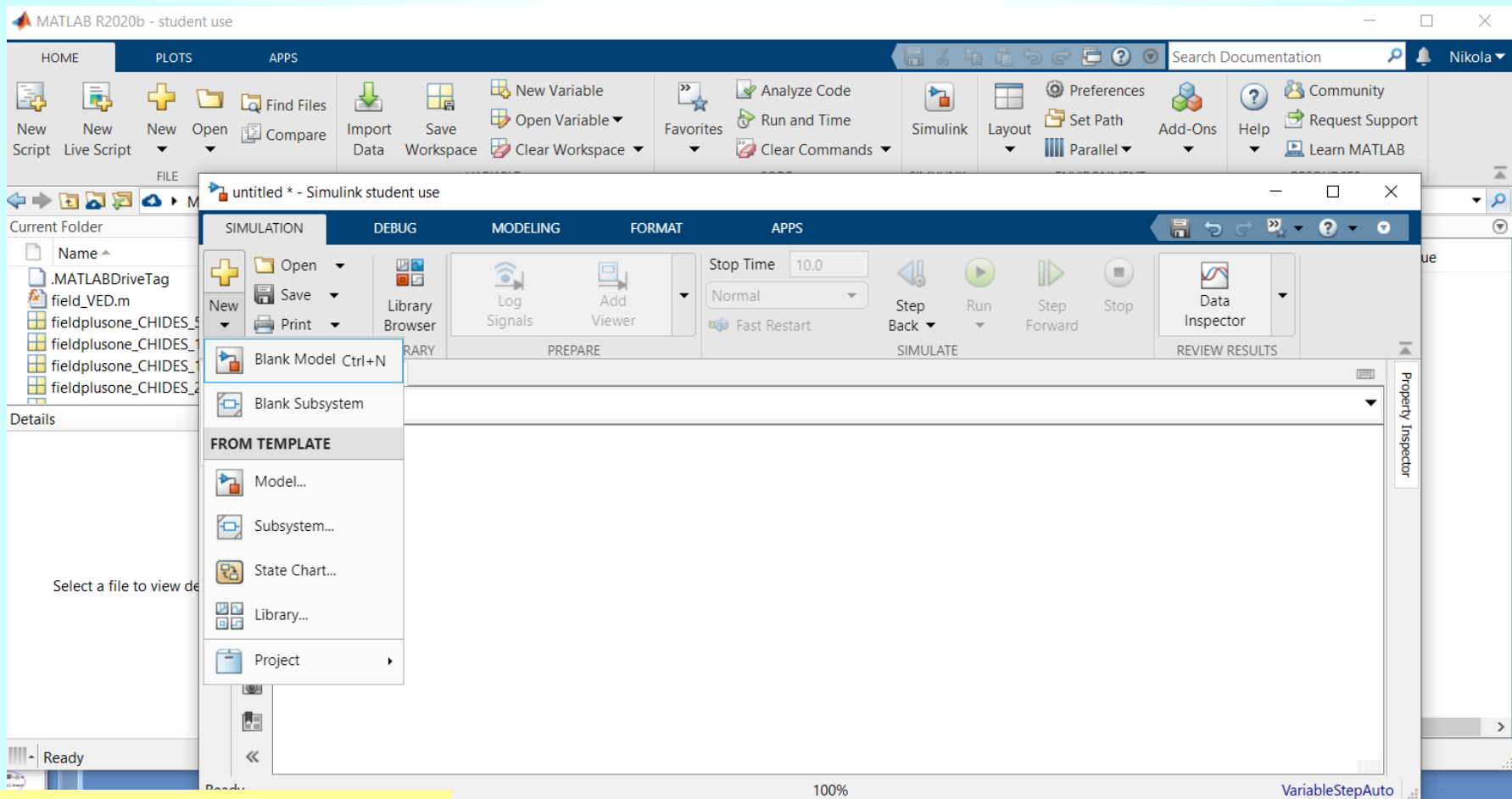
Simulink > Simscape > Electrical

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

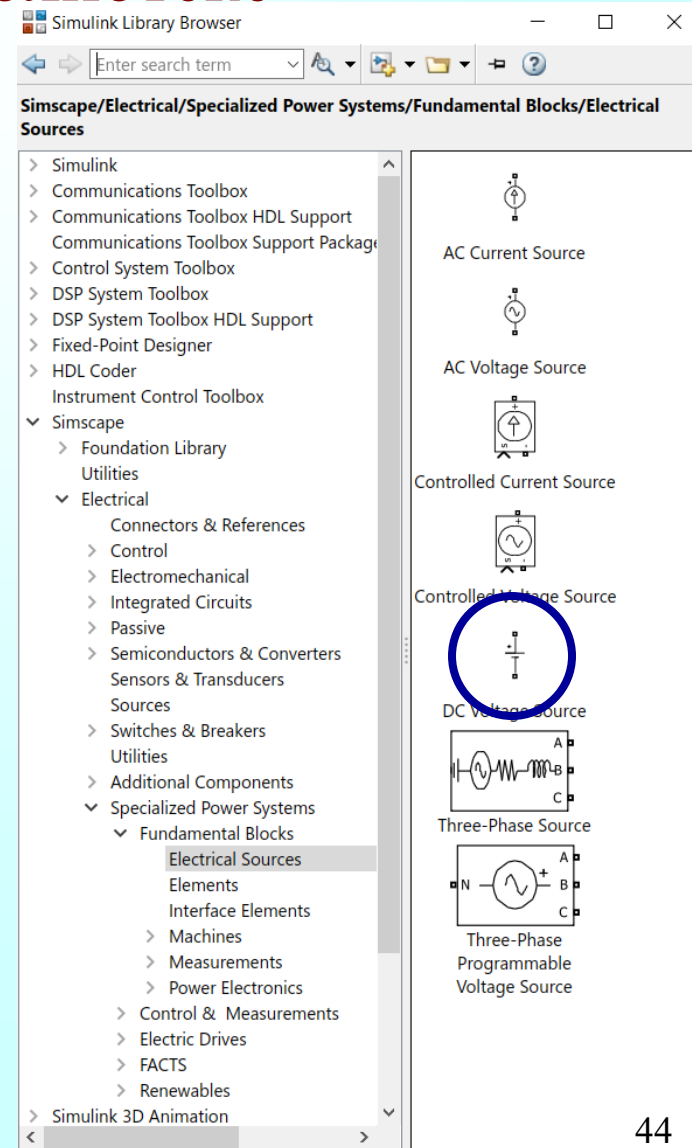
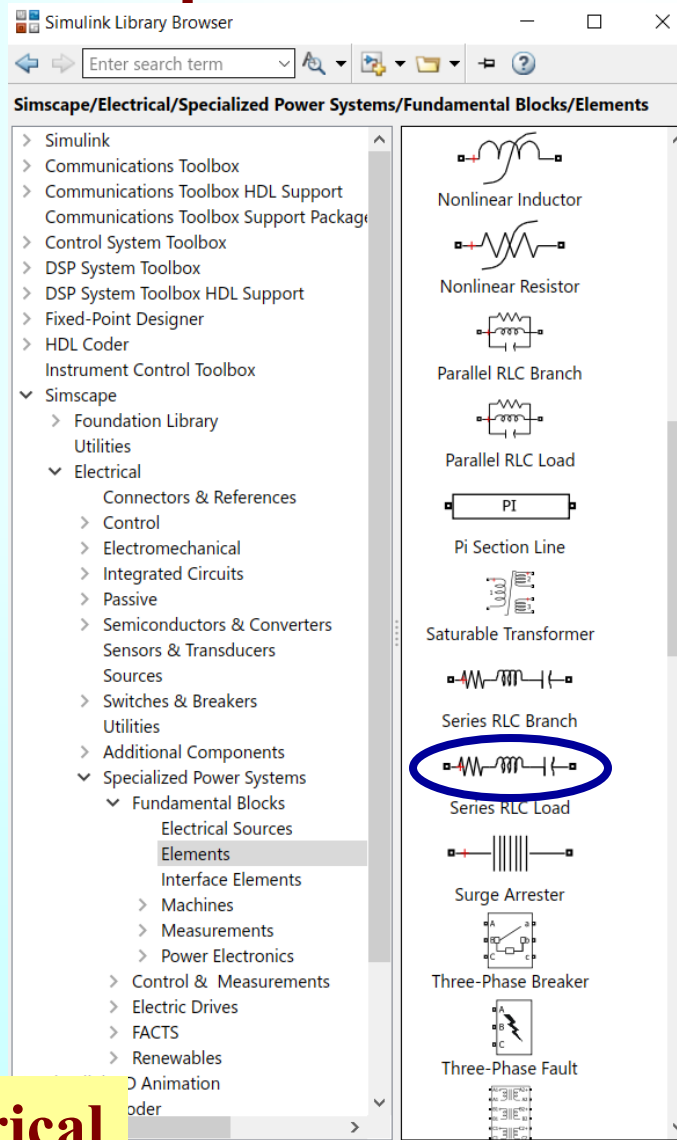


Simscape > Electrical

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

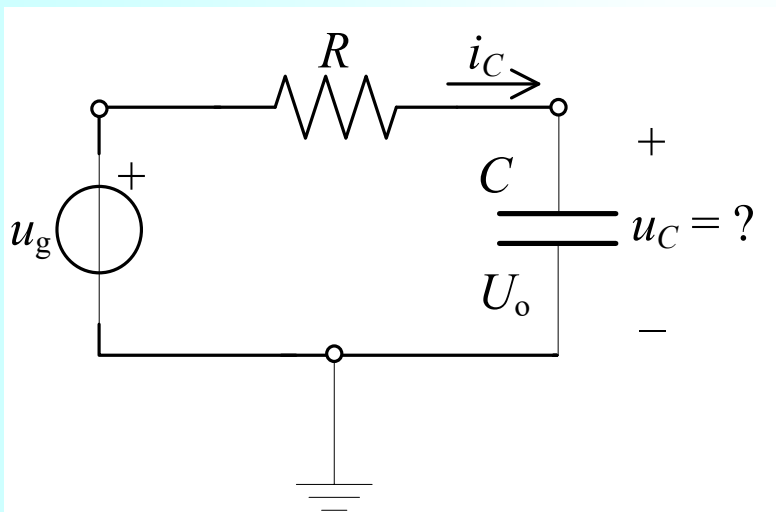


Симулација електричног кола коришћењем **Simscape>Electrical** библиотеке



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

коло је образовано у тренутку $t_0 = 0$

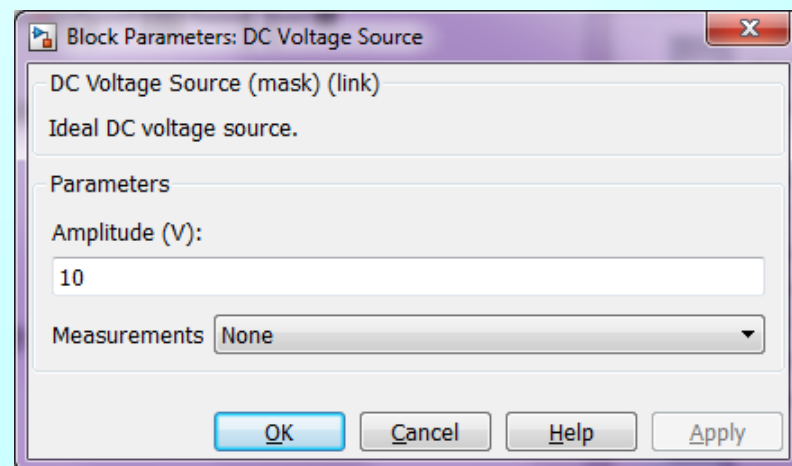
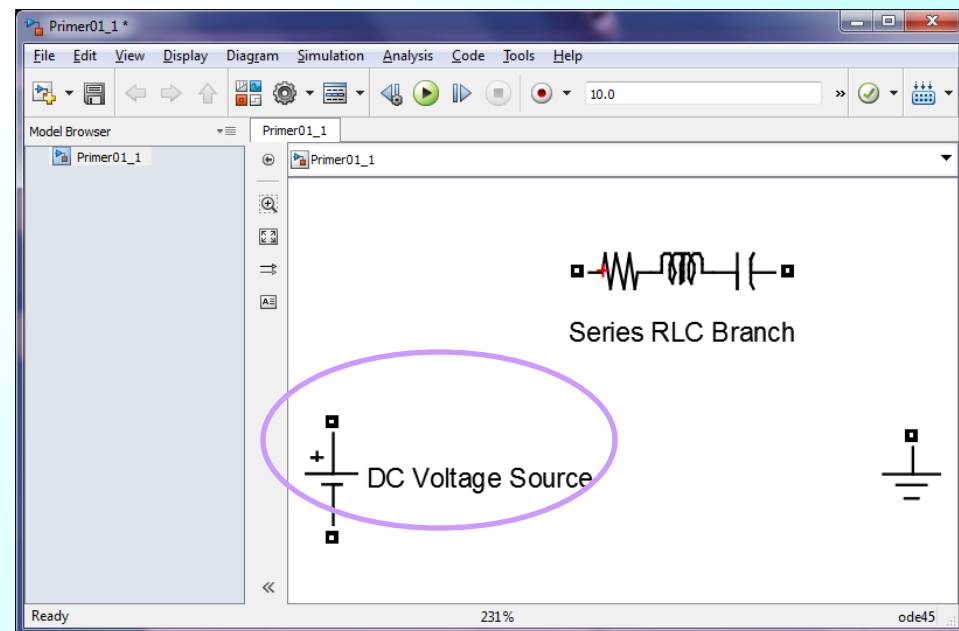


$$R = 1 \text{ k}\Omega$$

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

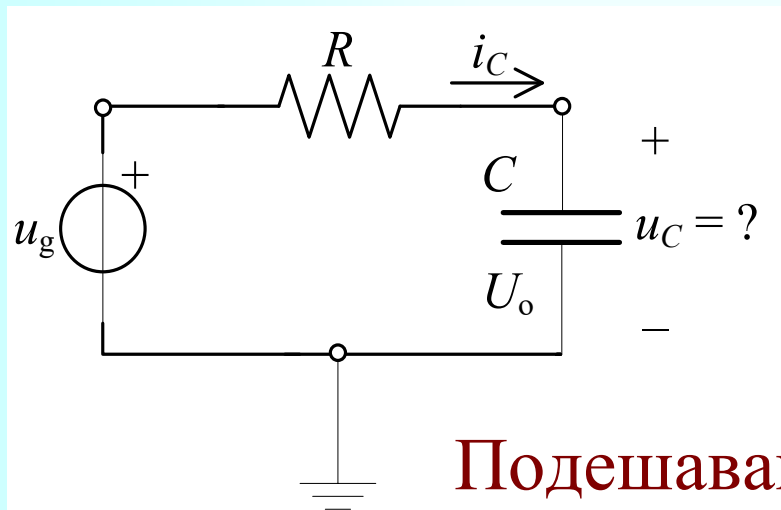
$$u_g(t) = U h(t), U = 10 \text{ V}$$

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



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

коло је образовано у тренутку $t_0 = 0$



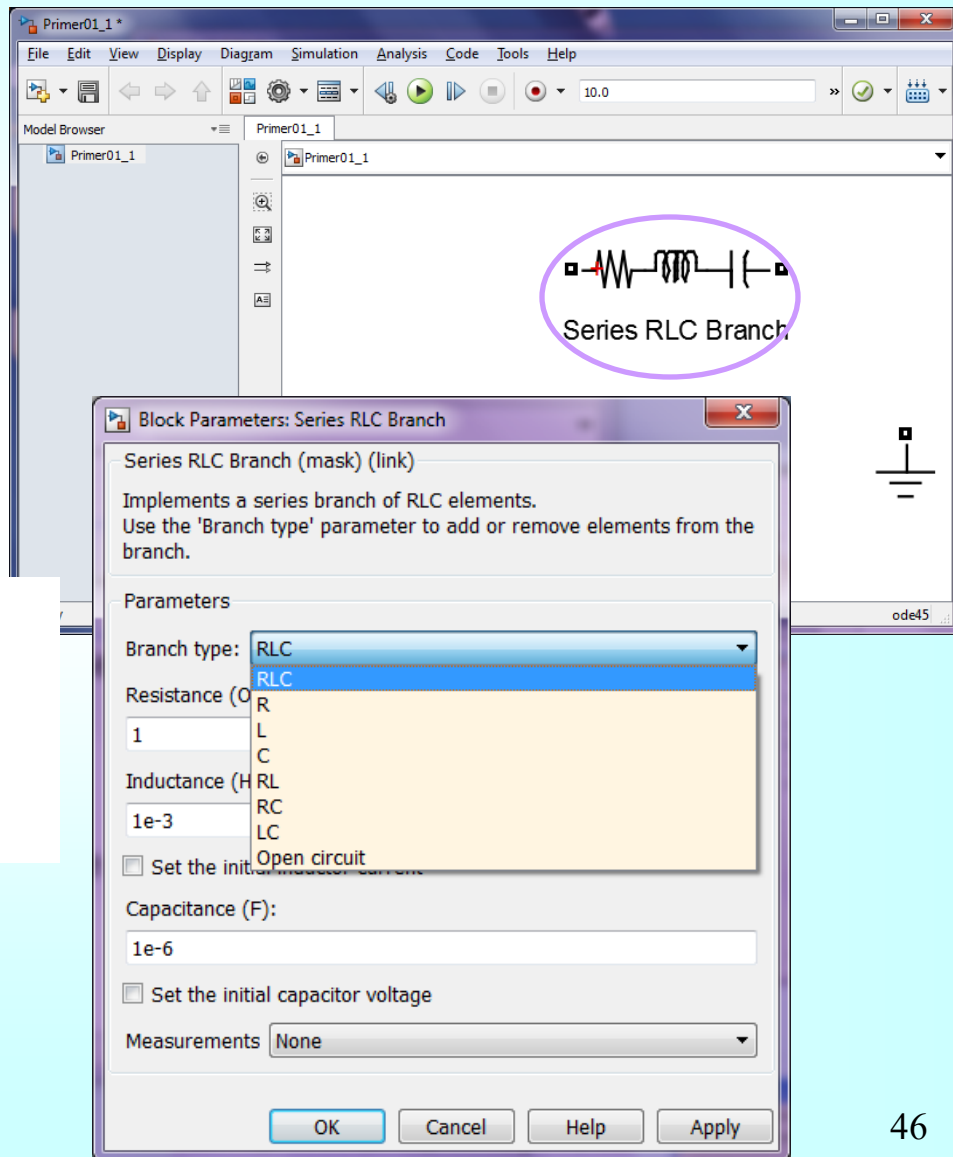
$$R = 1 \text{ k}\Omega$$

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

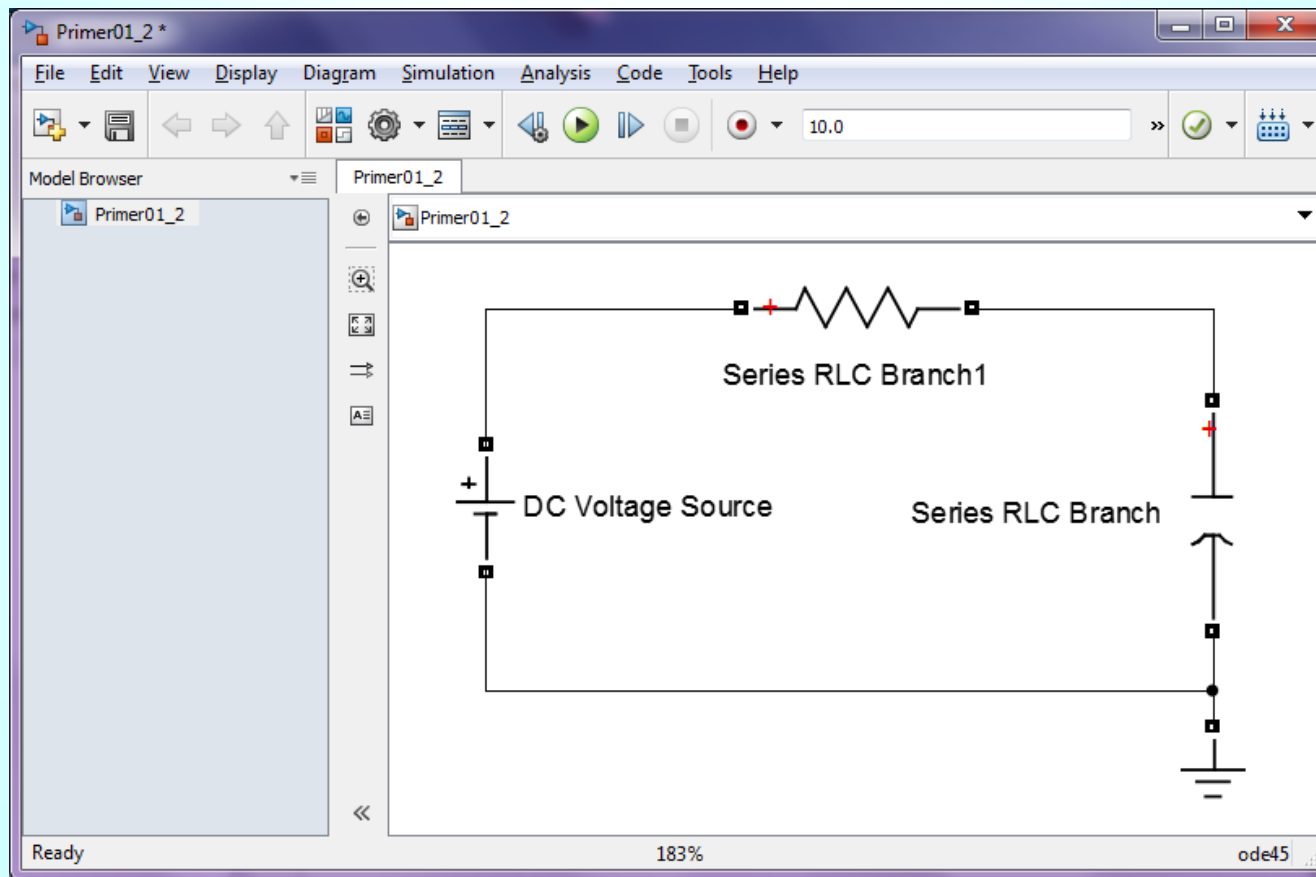
$$u_g(t) = U h(t), U = 10 \text{ V}$$

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

Подешавање
параметара
симулације

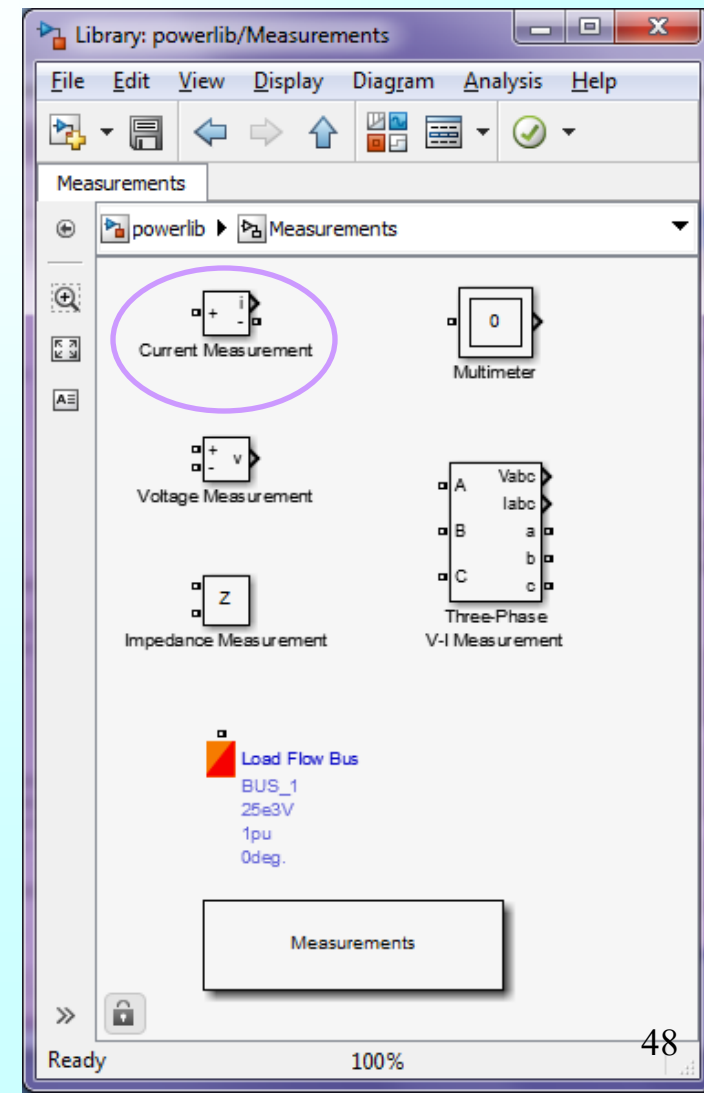
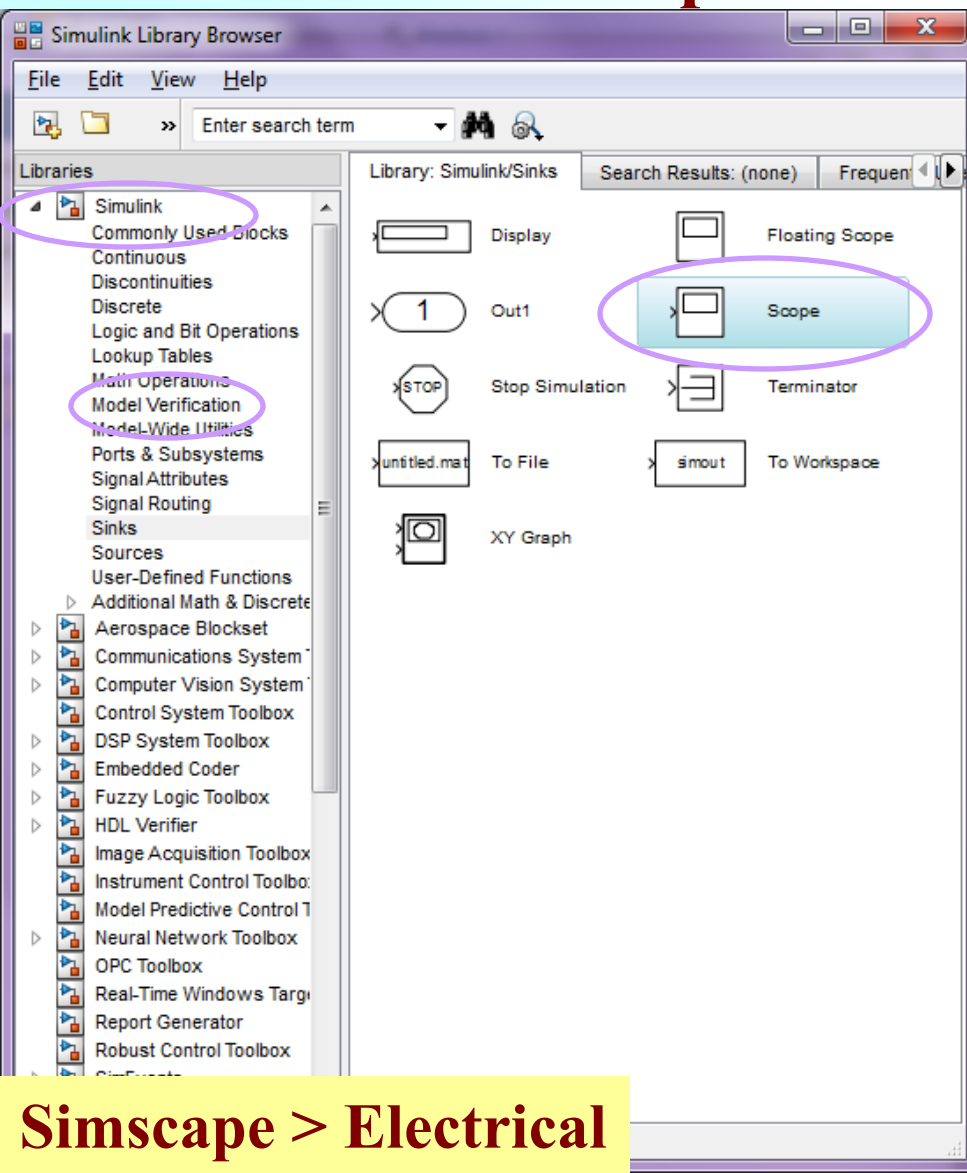


Симулација електричног кола коришћењем **Simscape>Electrical** библиотеке



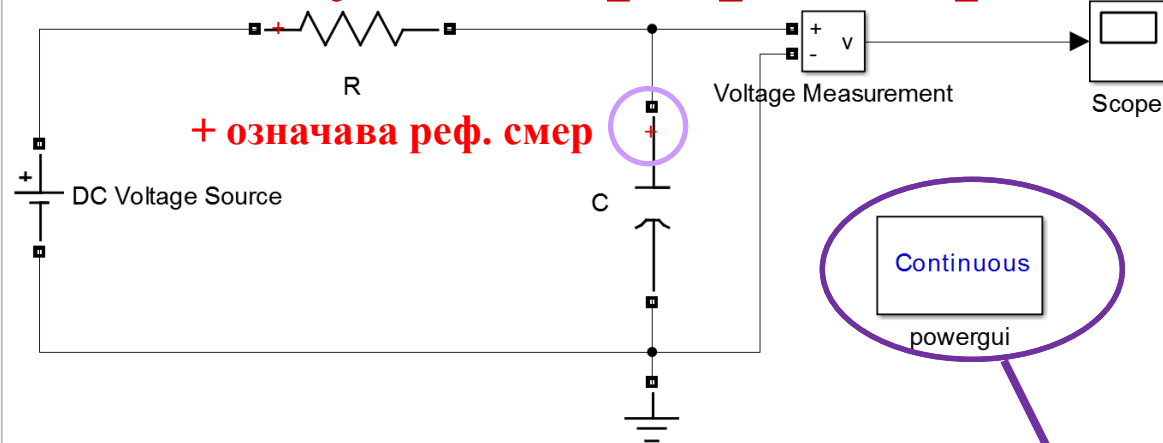
Како се мери напон?

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



Почетни услов, реф. смер...

+ означава реф. смер



Block Parameters: C

Series RLC Branch (mask) (link)

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

Parameters

Branch type: C

Capacitance (F): 1e-6

☒ Set the initial capacitor voltage

Capacitor initial voltage (V): -10

Measurements: None

OK **Cancel** **Help**

Плоче кондензатора се разликују!!!

Block Parameters: powergui

PSB option menu block (mask)

Set simulation type, simulation parameters, and preferences.

Solver **Tools** **Preferences**

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

► Load flow settings

OK **Cancel** **Help** **Apply**

Powergui Initial States Setting Tool. model: untitled

Initial electrical state values for simulation:

1	'Uc' C =	-10 V

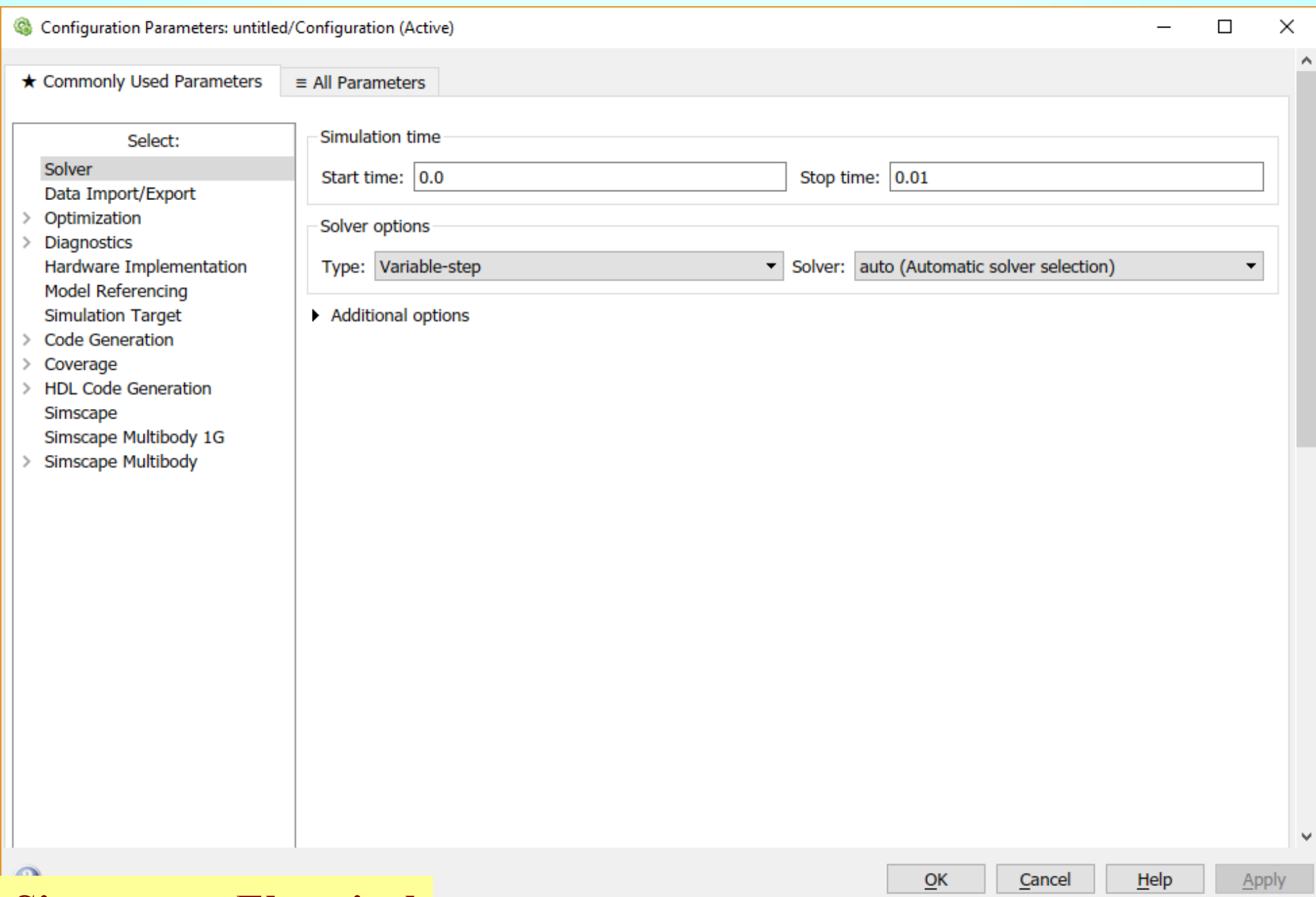
Set selected electrical state values:

-10

Force initial electrical state:

☐ To Steady State ☐ To Zero

Simscape > Electrical



Configuration Parameters: untitled/Configuration (Active)

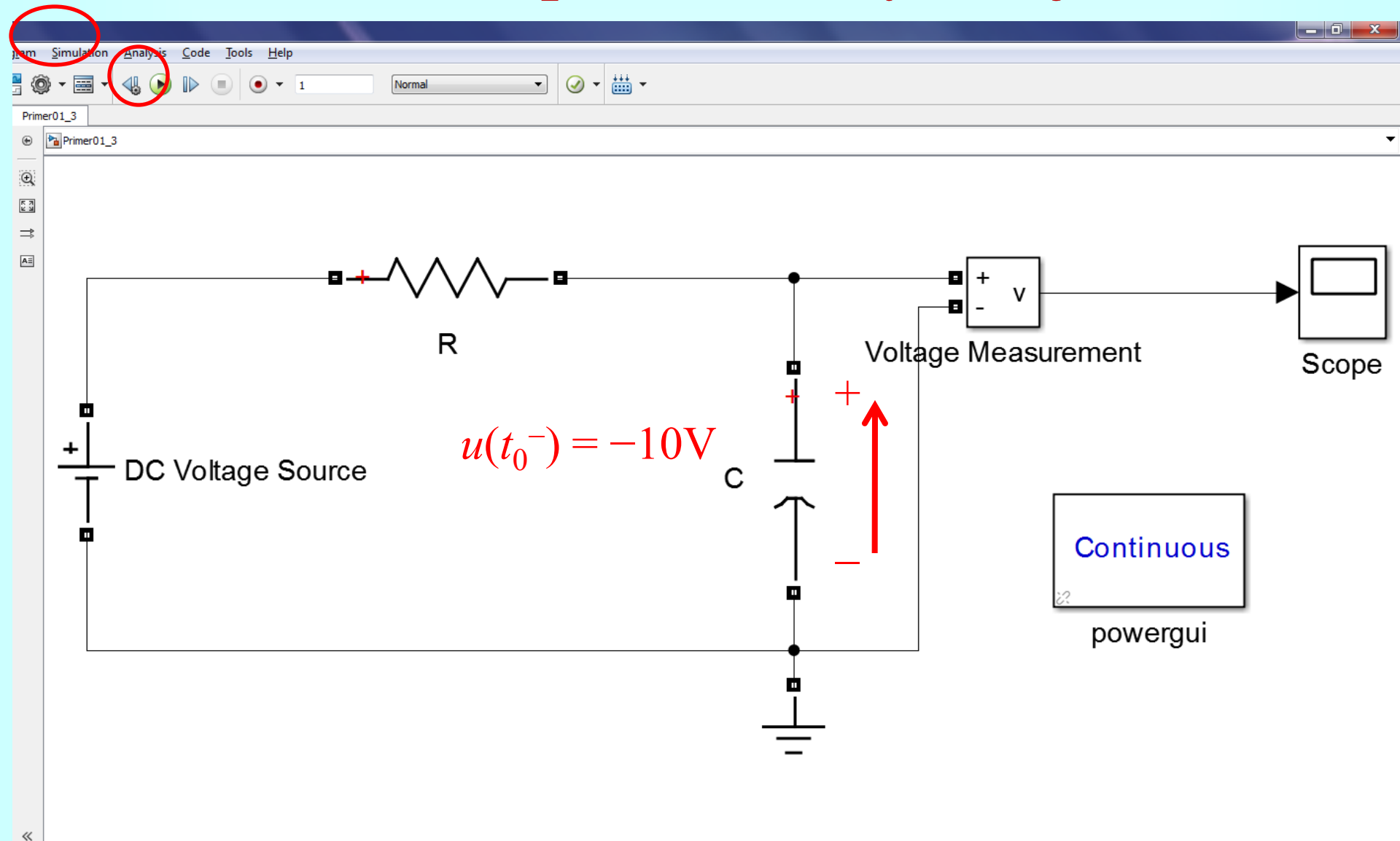
★ Commonly Used Parameters ≡ All Parameters

Category:

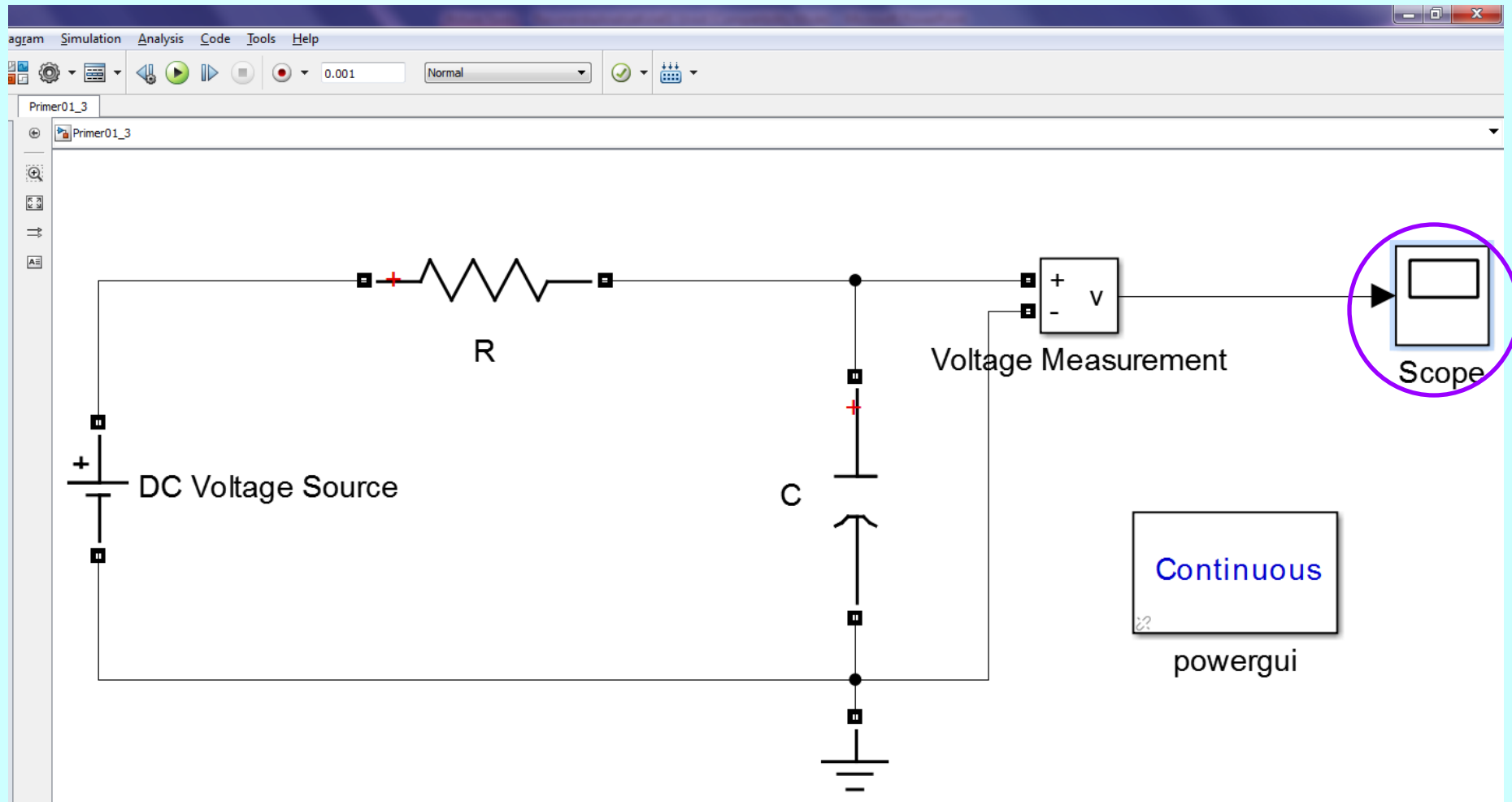
Parameter	Value	Command-Line Name
Solver ▶ Simulation time		
> Start time Simulation start time. Note that the values that you specify as block i...	0.0	StartTime
> Stop time Simulation stop time.	0.01	StopTime
Solver ▶ Solver options		
> Type Choose a variable or fixed-step solver.	Variable-step	SolverType
> 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

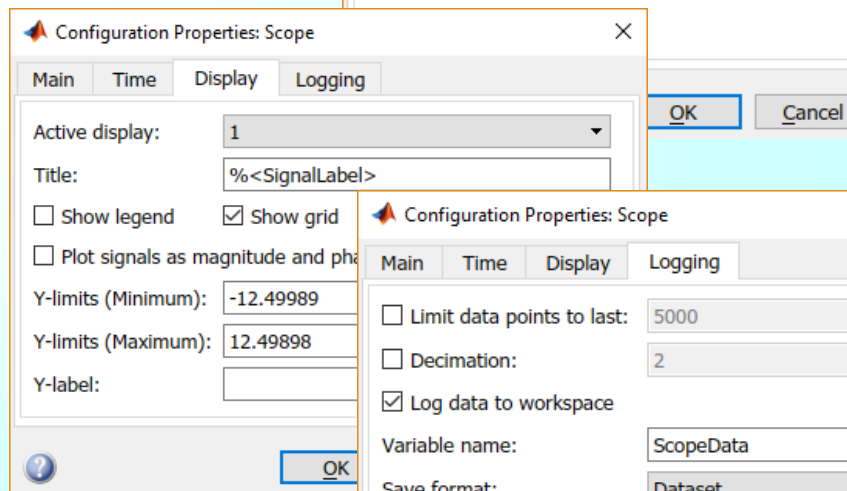
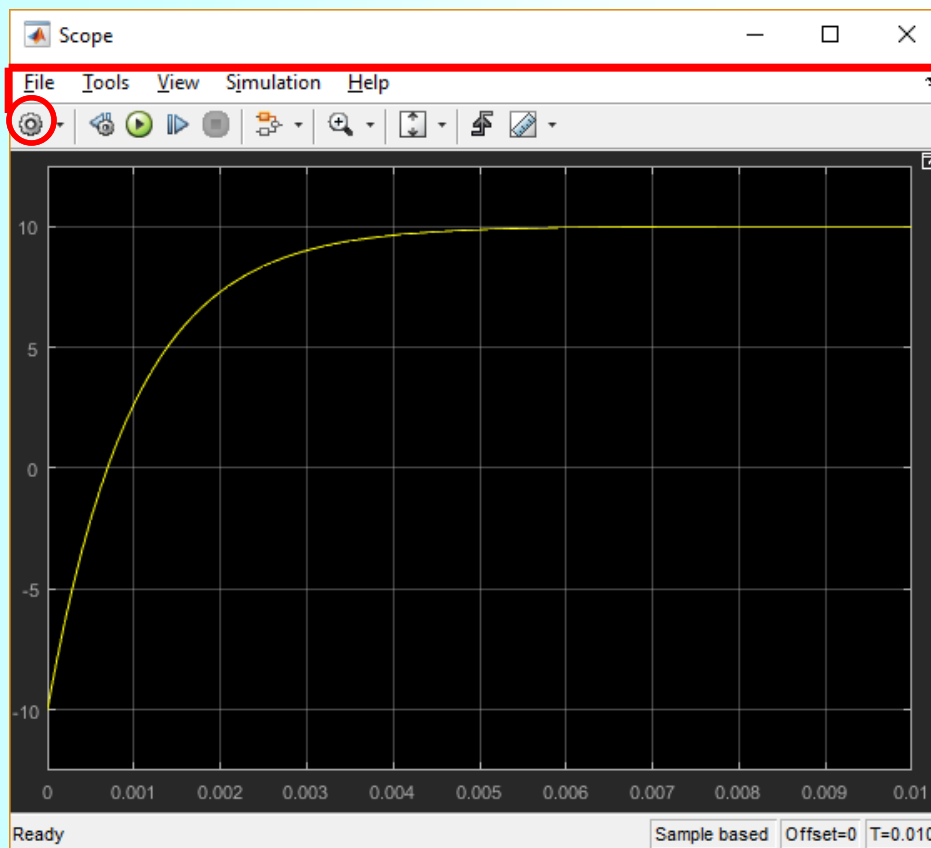
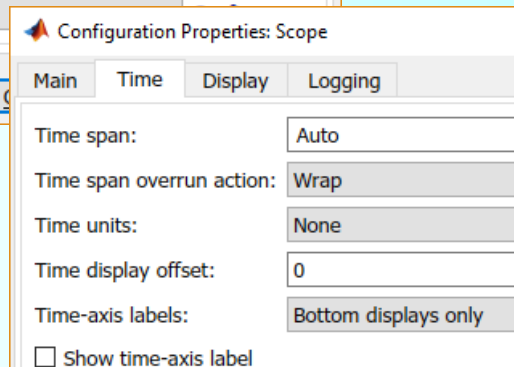
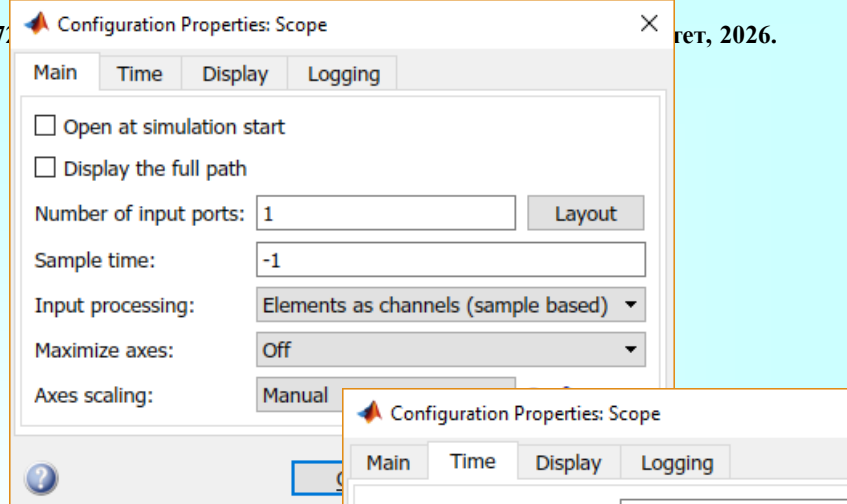
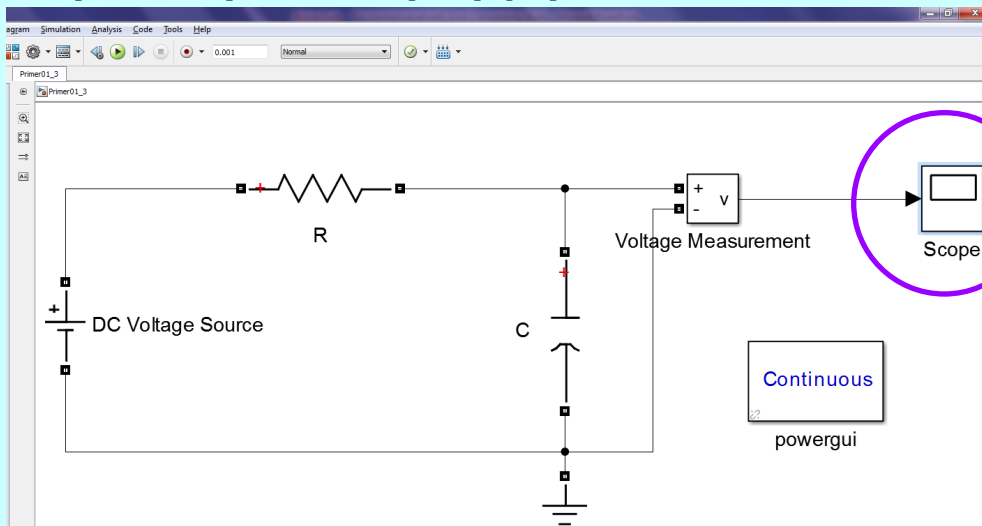
OK Cancel Help Apply

Покретање симулације



Одређивање одзива... Осцилоскоп





Simscape > Electrical

Configuration Parameters: untitled/Configuration (Active)

★ Commonly Used Parameters ≡ All Parameters

Category: All

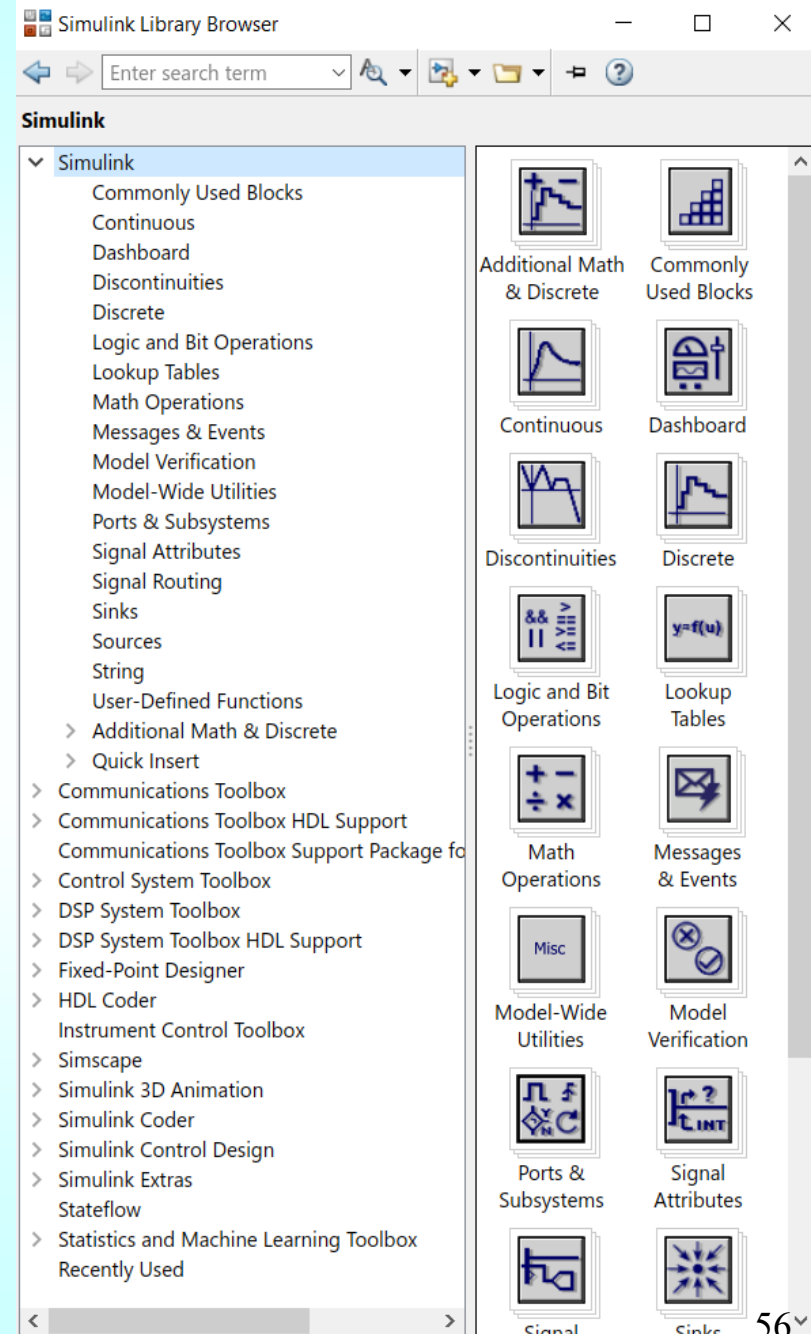
Parameter	Value	Command-Line Name
Solver ▶ Simulation time		
> Start time Simulation start time. Note that the values that you specify as block i...	0.0	StartTime
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> Shape preservation Improve the integration accuracy by preserving the shape of states b...	Disable All	ShapePreserveControl

$\tau = RC = 1 \text{ ms}$
 $\tau/10 = 0.1 \text{ ms}$

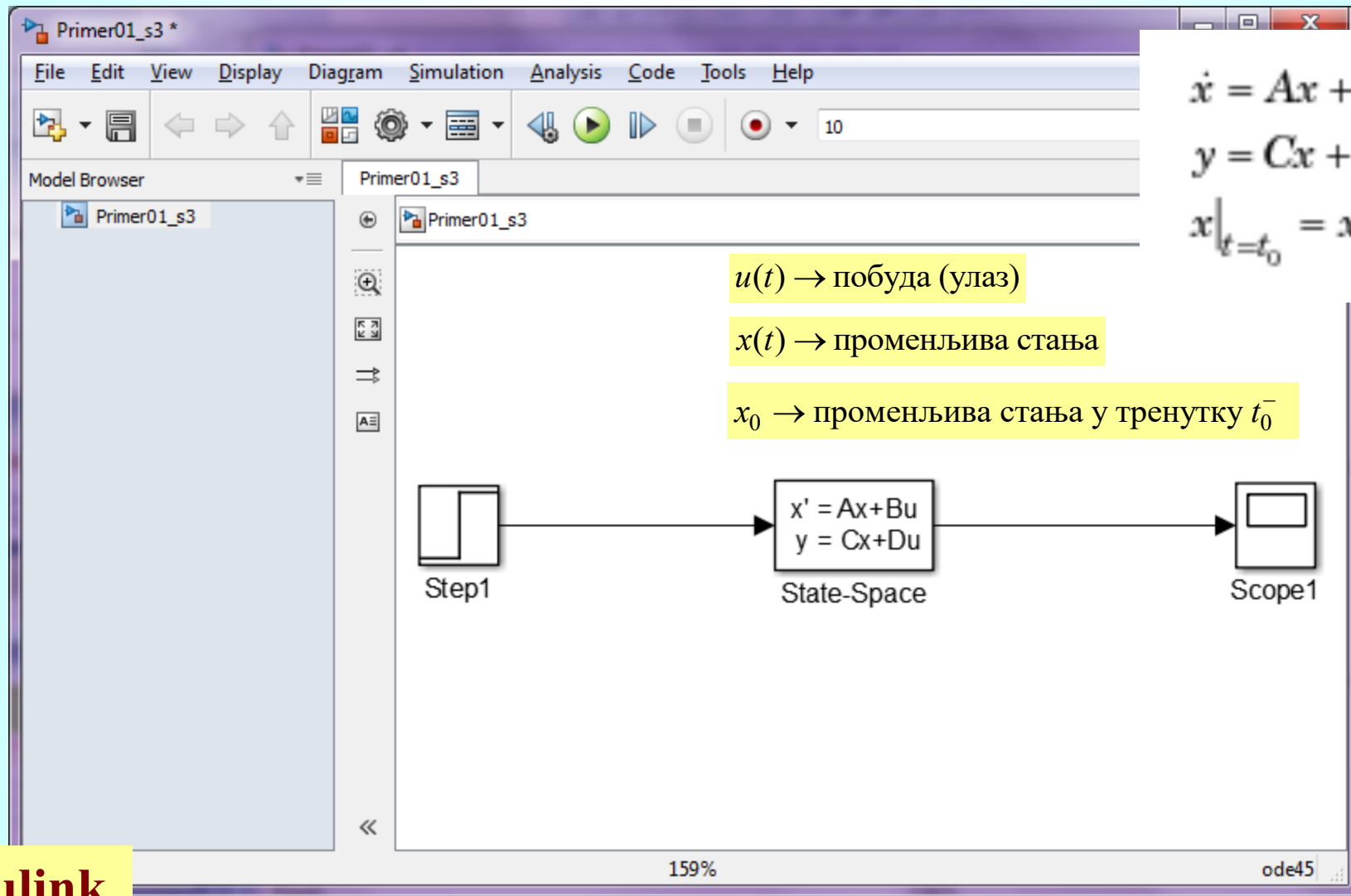
OK Cancel Help Apply

Simulink

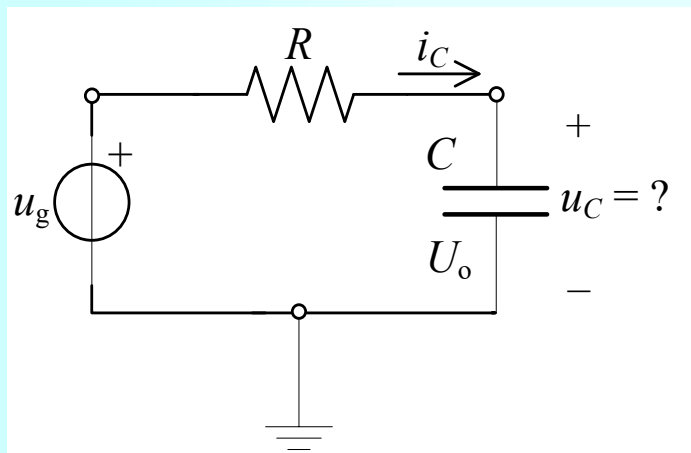
- Решавање кола може се извршити његовим свођењем на систем линеарних диференцијалних једначина
- Дати систем може се представити једноставним блоком са више улаза и излаза



Симулација електричног кола као уопштеног система коришћењем Simulinka



Симулација електричног кола као уопштеног система коришћењем Simulinka



$u = u_g(t) \rightarrow$ 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 $t_0 = 0$

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

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

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

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

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

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

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

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

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

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

аста, доцент, 13E072PRK3, 19E072PRK, Ун

Симулација електричног кола као уопштеног система коришћењем Simulinka

Function Block Parameters: State-Space

State Space

State-space model:

$$\frac{dx}{dt} = Ax + Bu$$

$$y = Cx + Du$$

Parameters

A:

B:

C:

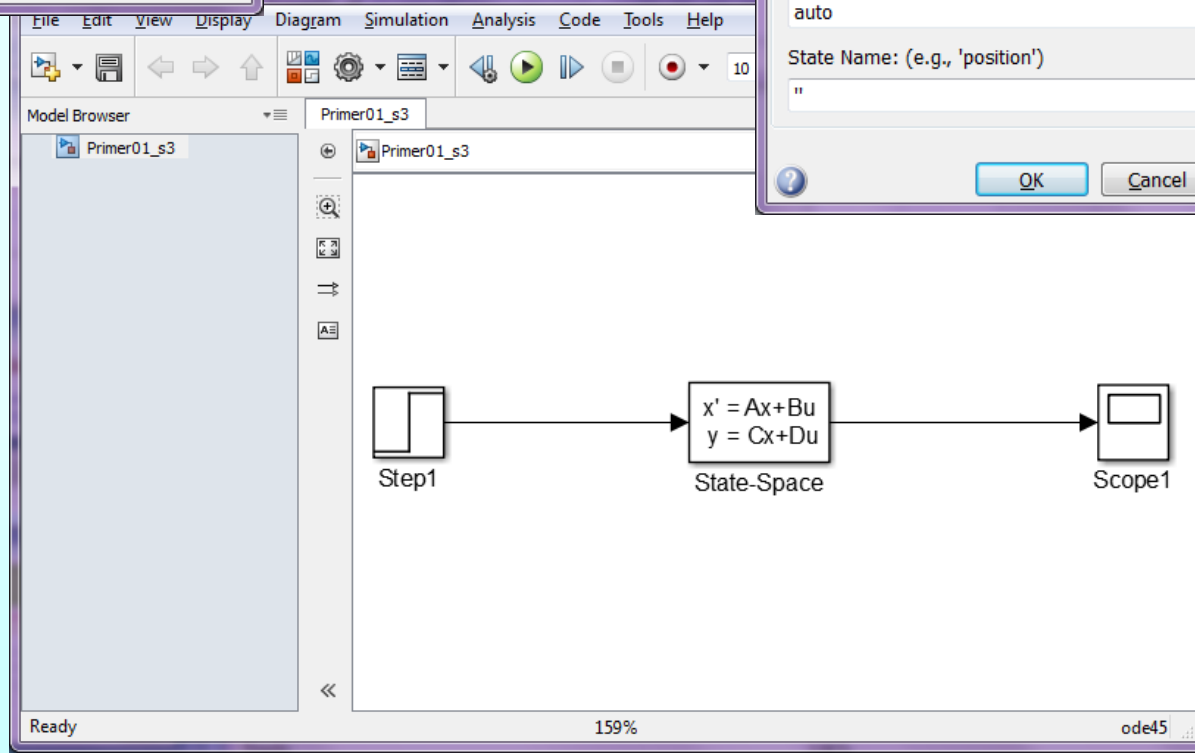
D:

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

Система, доцент, 13E072PRK3, 19E072PRK, Унив

Симулација електричног кола као уопштеног система коришћењем Simulinka

Source Block Parameters: Step1

Step

Output a step.

Parameters

Step time:

Initial value:

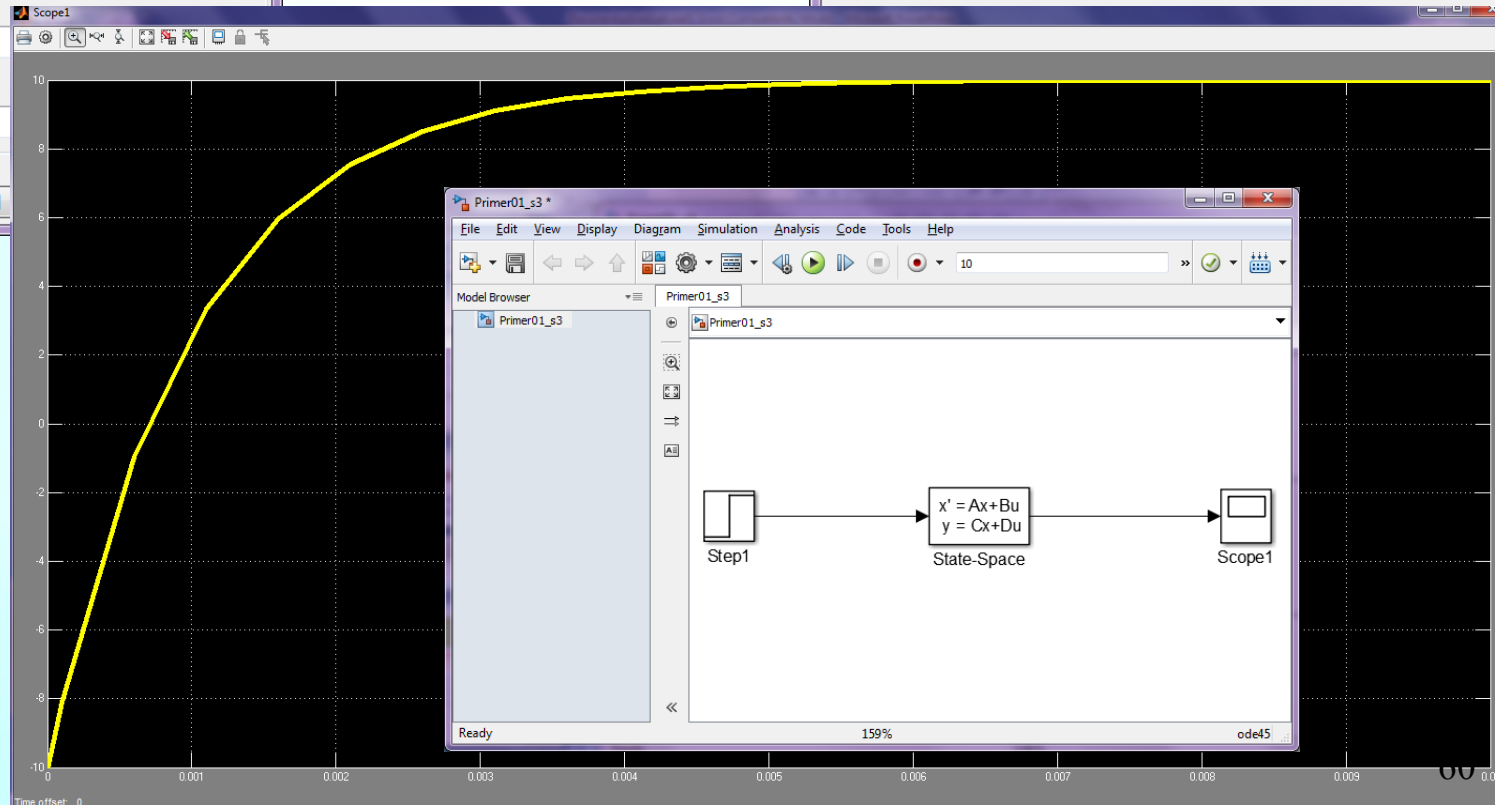
Final value:

Sample time:

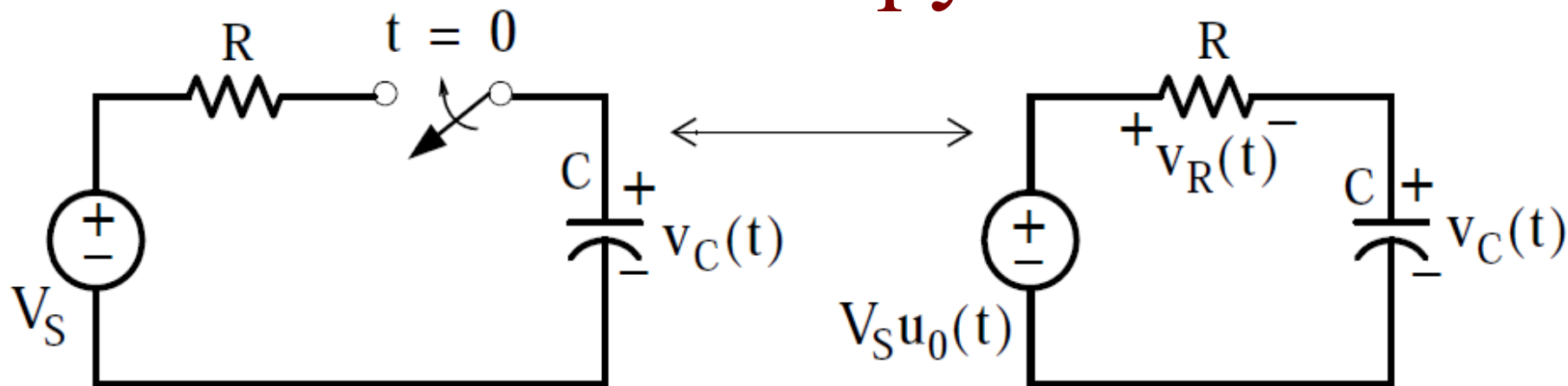
☒ Interpret vector parameters as 1-D

☒ Enable zero-crossing detection

Simulink



Решимо “ручно”



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

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

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

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

$$t > 0$$

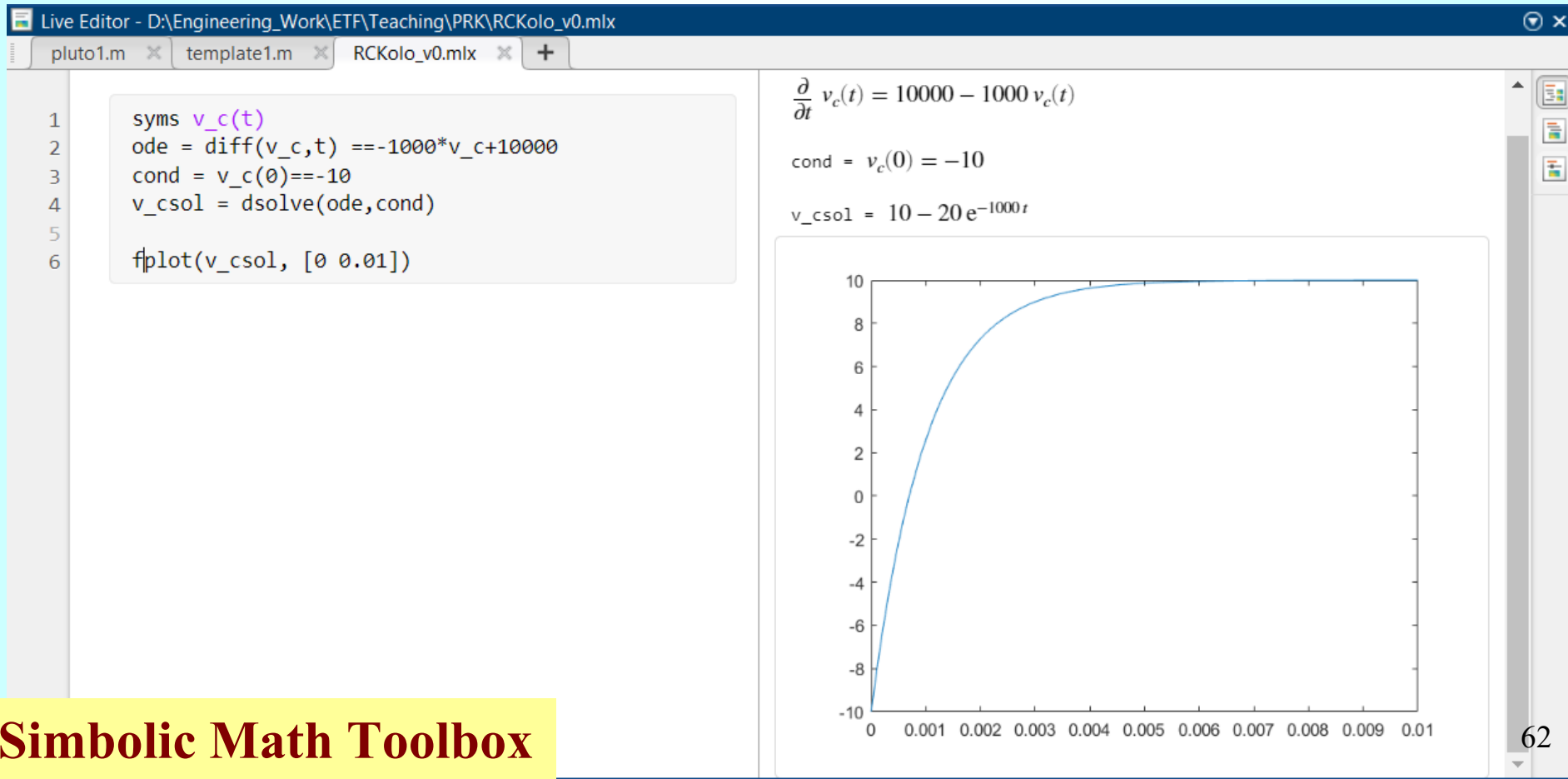
$$RC \frac{dv_C}{dt} + v_C = V_S$$

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

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

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) 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)$
```

