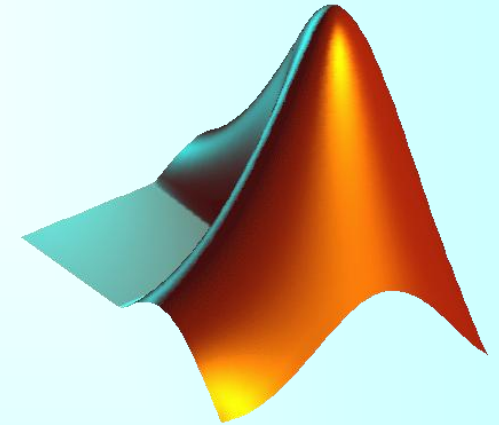
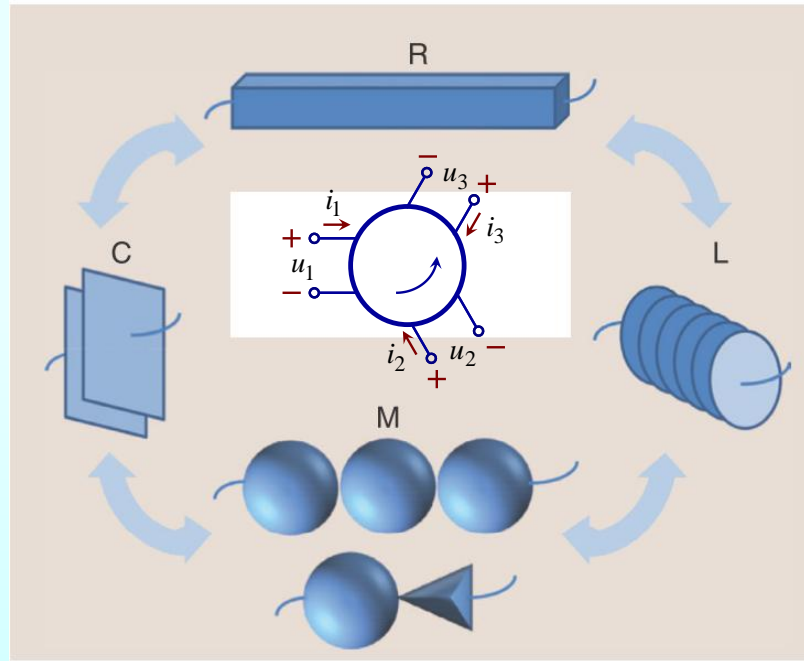


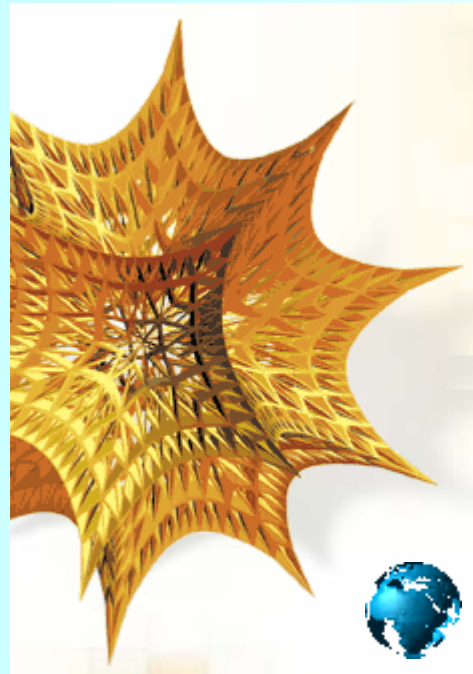
Практикум из рачунарске анализе трофазних кола

1. Увод



Милка Потребих Иваниш

Никола Баста



Практикум из рачунарске анализе трофазних кола 19E072ПРТК

- **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): **Енергетика**
- **Циљ.** Излагање основних концепата анализе помоћу рачунара који се користе у софтверским пакетима за симулацију трофазних електричних кола са гледишта инжењера и истраживача електроенергетике. Увођење основа за анализу модела електроенергетских система и направа за нумеричку и симболичку анализу у временском и фреквенцијском домену. Изградња основних знања из теорије и примене симетричних компоненти.
- **Исход.** Разумевање основних концепата анализе трофазних електричних кола помоћу рачунара и одговарајућих математичких алгоритама. Решавање линеарних трофазних електричних кола у временском и фреквенцијском домену помоћу система компјутерске алгебре.
- **Садржај.** Основни концепти рачунарске симулације трофазних електричних кола. Симболичко и нумеричко израчунавање симетричних компоненти. Моделовање и симулација електроенергетских водова, компоненти и система помоћу савремених софтверских алата.
- **Наставници:** Др **Милка Потребих Иваниш**, редовни професор, соба 64 (milka_potrebic@etf.rs); Др **Никола Баста**, доцент, соба 63 (nbasta@etf.rs).
- **Асистент:** **Ања Ковачевић**, мс. инж.
- Белешке са предавања и лаб. вежби, примери испитних задатака и питања, <http://tek.etf.rs>
- **Додатни материјали и консултације биће организовани преко канала на MS Teams платформи** (линкови за канале су на адреси <http://tek.etf.rs>)
- **Начин одржавања наставе.** Рачунски центар.
- **Начин полагања испита.** 1) Решавање задатака на рачунару у пару (или самостално) у РЦ, или алтернативно
2) издрада два домаћа задатка у пару (или самостално) са пратећим извештајем у виду презентецајује која се усмено брани.
Испит се може полагати у сваком испитном року.
Усмена одбрана домаћих задатака се заказује са предметним наставницима.
За издрату домаћих задатака јавити се е-поштом Милки Потребих Иваниш.
- **Пратити** званично представљање предмета и објављивање општих службених порука на адреси <http://tek.etf.rs/>

Рачунарски (софтверски) алати

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

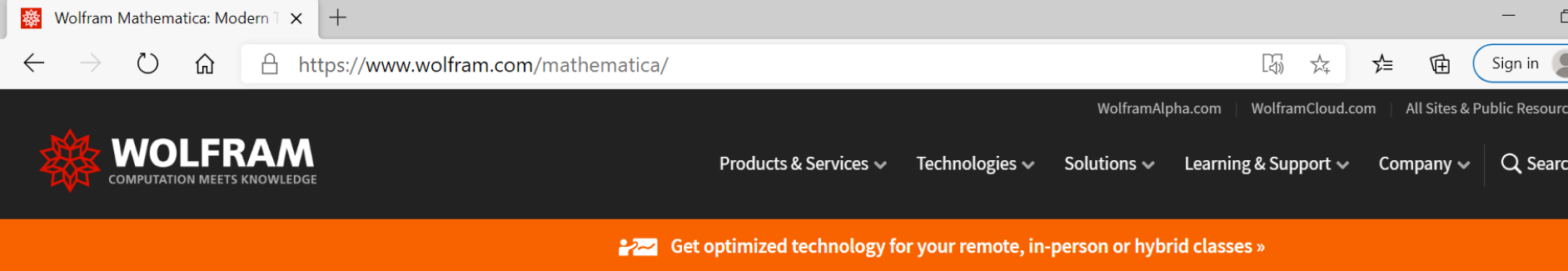
Free/Libre Open Source Software (FLOSS)

Моделовање електричних кола

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

Mathematica

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



WOLFRAM MATHEMATICA

The world's definitive system for modern technical computing

A collage of Mathematica interface elements. On the left, a snippet of code is shown:

```
pressure[..._t_] := If[... < rho, 1/2 rho w^2 + 2 - rho g x + Subscript[rho, 0], -(rho w^2 rho - rho g x + rho w^2 rho + 2 - Subscript[rho, 0])];
```

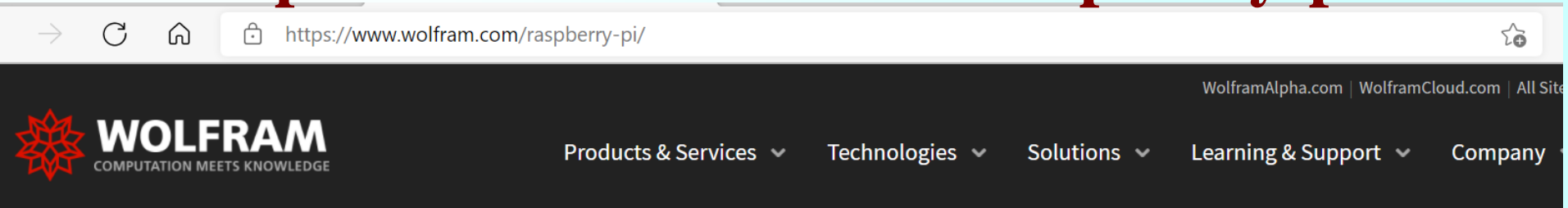
 Below the code is a 3D plot of a surface. In the center, there are four smaller 3D surface plots. To the right, another code snippet is shown:

```
evsd = MatrixPropertyDistribution[Arg[Eigenvalues[x]], x < CircularUnitaryMatrixDistribution[2]]; us = RandomSample[# RandomVariate[evsd, 10^5]]; Histogram3D[us, {-Pi, Pi, 0.2}, PDF, PlotTheme -> "Detailed"]
```

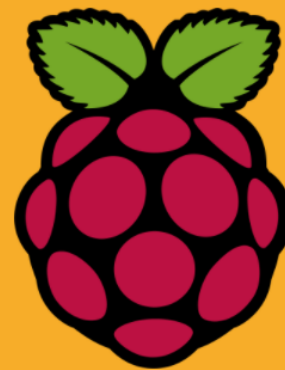
 Below this code is a 3D histogram plot. On the far right, a smartphone displays a "Q3 Report" with several line graphs. The text "Available on desktop, cloud & mobile" is written above the phone. At the bottom right of the collage is a "Leave a message" button.

Mathematica free on every Raspberry Pi!

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



Wolfram Language &
Mathematica free on
every Raspberry Pi!



+



Give your brain a quick workout with Wolfram Problem Generator.



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



[Examples](#) [Random](#)

Input:

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

ODE classification:

first-order linear ordinary differential equation

Alternate forms:

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

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

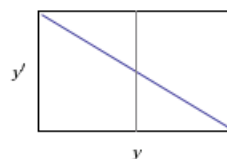
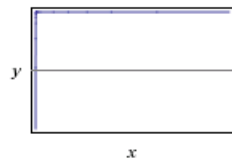
Differential equation solution:

[Approximate form](#)

[Step-by-step solution](#)

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

Plots of the solution:



New to
Wolfram|Alpha?



[Take the Tour >>](#)

New!
Wolfram Problem
Generator

[Need a hint?](#)

Maxima

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

The screenshot shows a web browser window displaying the Maxima website. The browser's address bar shows the URL `maxima.sourceforge.net`. The website's navigation menu includes links for `Downloads`, `Documentation`, `Project`, and `Page Top`. The main content area features a code editor with the following input and output:


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

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

Below the code editor, there are language selection options: `In other languages: عربي • Deutsch • Español • Italiano • Nederlands • Português • Русский • Türkçe • 中文`. The main heading is `Maxima, a Computer Algebra System`. The introductory text states: "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." It also mentions that the source code is available on SourceForge and that Maxima is a descendant of Macsyma from MIT. A sidebar on the right titled "Recent Releases" lists versions 5.44.0 (June 8, 2020), 5.43.2 (Jan 27, 2020), 5.43.1 (Jan 20, 2020), 5.43.0 (May 31, 2019), and 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));
```

Clc

Clear

[AVISO LEGAL](#)

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

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

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

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

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

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

Maxima on Android

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

The screenshot shows the Google Play Store interface for the app "Maxima on Android". The page includes a navigation menu on the left with options like "My apps", "Shop", "Games", "Kids", and "Editors' Choice". The main content area displays the app's logo (a green Android robot with a blue and red "M" symbol), the title "Maxima on Android", the developer "Yasuaki Honda", and the category "Education". The app is rated "Everyone" and has a 2.100-star rating. A warning message states "You don't have any devices". There is an "Install" button and an "Add to Wishlist" button. Below the main content, there are three preview images: the first shows the app's version information (1.1, Aug 11, 2012), the second shows a 3D surface plot of the function $2^{*(v^2-u^2)}$, and the third shows the "Maxima 5.28.0 Manual" page.

SymPy

www.sympy.org/

The screenshot shows the SymPy website homepage. At the top, there is a navigation bar with links for Main Page, Features, Download, Documentation, Support, Development, Roadmap, Donate, and Online Shell. The main content area is divided into several sections: 'About' (describing SymPy as a Python library for symbolic mathematics), 'Why SymPy' (listing features like being free, Python-based, lightweight, and a library), and 'Compute with Gamma' (a calculator interface). The 'Compute with Gamma' section shows the input `integrate(1 / (1 + x^2))` and a 'Compute' button. The 'Download Now' section offers links for the latest and development versions. The 'Quick Links' section provides a list of useful resources like documentation, source code, and a mailing list.

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

Projects using SymPy

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/>.

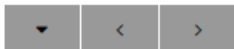
```
>>> diffeq = Eq(f(x).diff(x) + 1000*f(x), 10000)
>>> diffeq
```

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

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

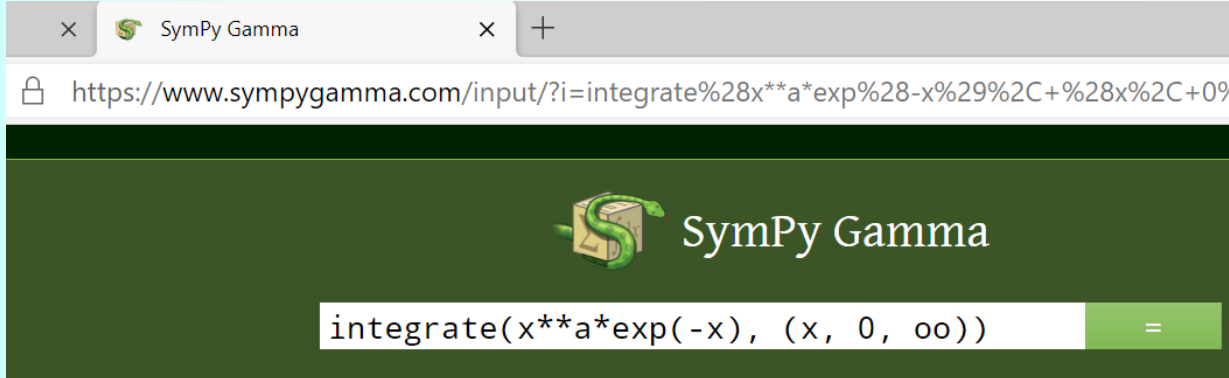
```
>>> from __future__ import division
>>> from sympy import *
>>> x, y, z, t = symbols('x y z t')
>>> k, m, n = symbols('k m n', integer=True)
>>> f, g, h = symbols('f g h', cls=Function)
```

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

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

SymPy Gamma

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



SymPy:

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

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

Antiderivative forms:

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

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

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

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

Examples

Random Example

Arithmetic

Algebra

Trigonometry

Calculus

Number Theory

Discrete Mathematics

Plotting

Miscellaneous



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

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

[1]: '1.4'

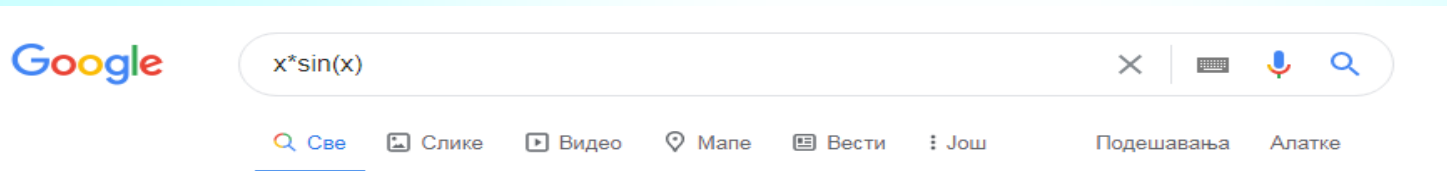
```
[2]: Integral(exp(-x**2), (x, -oo, oo))
```

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

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

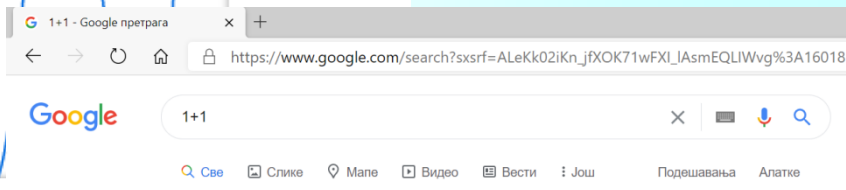
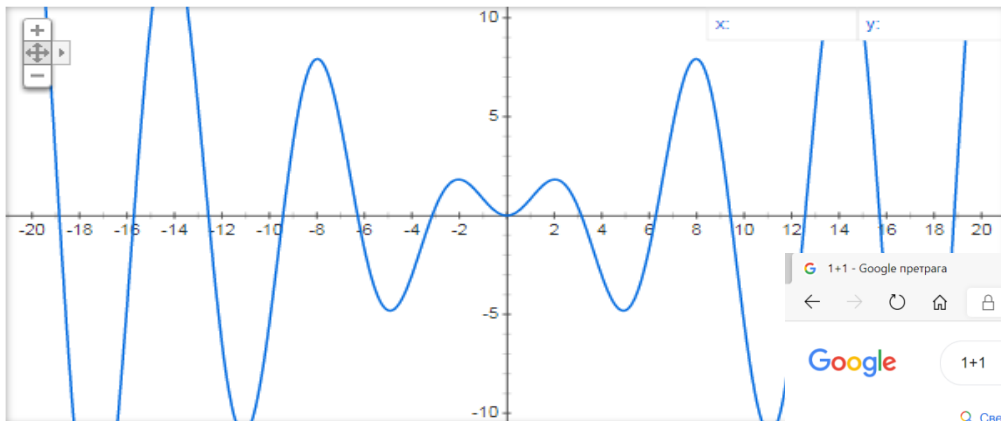
[3]: $\sqrt{\pi}$

Google калкулатор



Око 3.640.000.000 резултата (0,57 секунде/и)

Графикон за $x \sin(x)$



Око 25.270.000.000 резултата (0,72 секунде/и)

www.mytutor.co.uk > Maths ▾ Преведи ову страницу

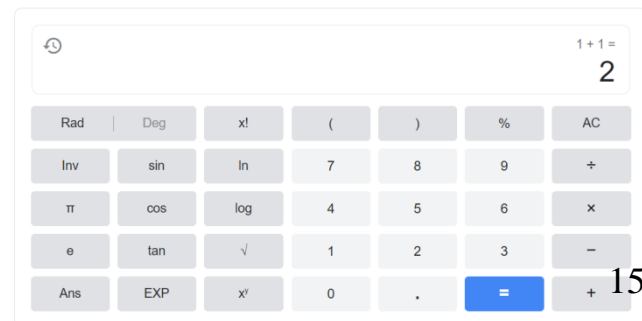
What is the integral of $x \sin(x) dx$? | MyTutor

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

www.teachoo.com > category ▾ Преведи ову страницу

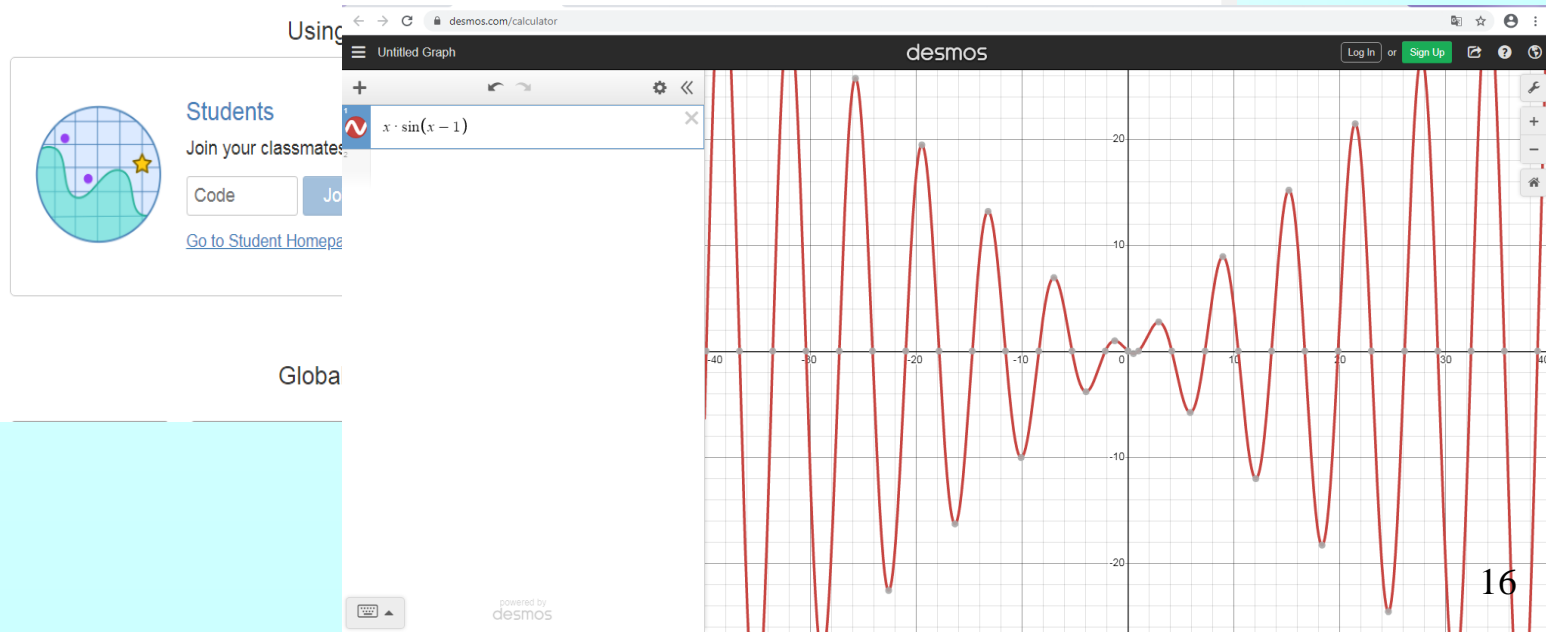
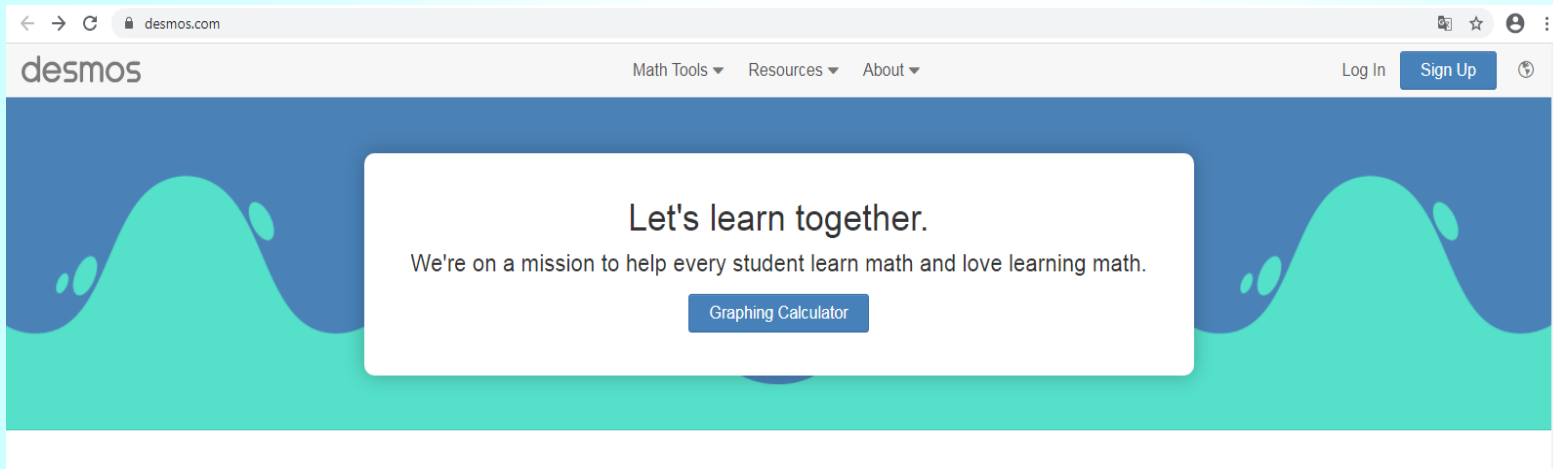
Ex 7.6, 1 - Find integration of $x \sin x$ - Chapter 7 Clas

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



Graphing Calculator – Desmos

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



Symbolab Math Solver - Step by Step calculator

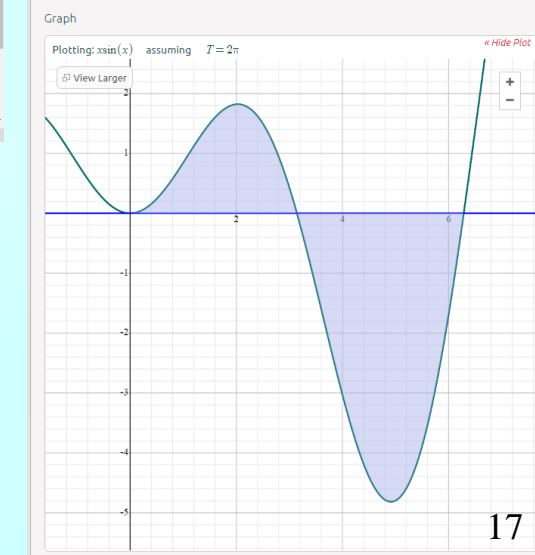
<https://www.symbolab.com/>

The screenshot shows the Symbolab website interface. At the top, there is a navigation menu with options: SOLUTIONS, GRAPHING, PRACTICE, GEOMETRY beta, NOTEBOOK, GROUPS, CHEAT SHEETS, and a language selector set to EN. Below the menu is a search bar and a button that says "Try our new Geometry solver! Got it". The main content area features a large keypad with mathematical symbols and functions, including x^2 , x^\square , $\sqrt{\square}$, $\sqrt[\square]{\square}$, \log_\square , π , θ , ∞ , \int , $\frac{d}{dx}$, \geq , \leq , \cdot , \div , x° , (\square) , $|\square|$, $(f \circ g)$, $f(x)$, \ln , e^\square , $(\square)'$, $\frac{\partial}{\partial x}$, \int_\square , \lim , \sum , \sin , \cos , \tan , \cot , \csc , and \sec . Below the keypad are "Most Used Actions" buttons: simplify, solve for, inverse, tangent, line, and a "See All" dropdown. A sidebar on the left lists subject categories: Pre Algebra, Algebra, Pre Calculus, Calculus, Functions, Matrices & Vectors, Geometry, Trigonometry, Statistics, and Physics. The page title is "Step-by-Step Calculator" and the subtitle is "Solve problems from Pre Algebra to Calculus step-by-step".

The screenshot shows the "Solution" panel for the integral $\int_0^T x \sin(x) dx = \sin(T) - T \cos(T)$. The steps are as follows:
1. **Apply Integration By Parts:** $u = x, v' = \sin(x)$.
$$= [-x \cos(x) - \int -\cos(x) dx]_0^T$$

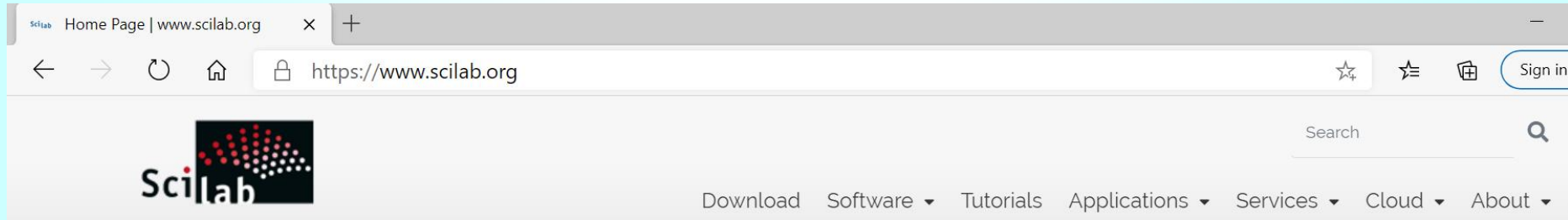
2. **Simplify:**
$$= [-x \cos(x) + \sin(x)]_0^T$$

3. **Compute the boundaries:** $[-x \cos(x) + \sin(x)]_0^T = \sin(T) - T \cos(T)$
The final result is $\sin(T) - T \cos(T)$. There are "Show Steps" buttons for each step and a "Verify" button at the bottom.



SciLab

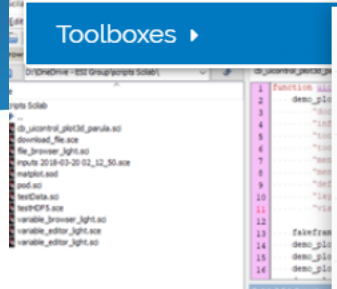
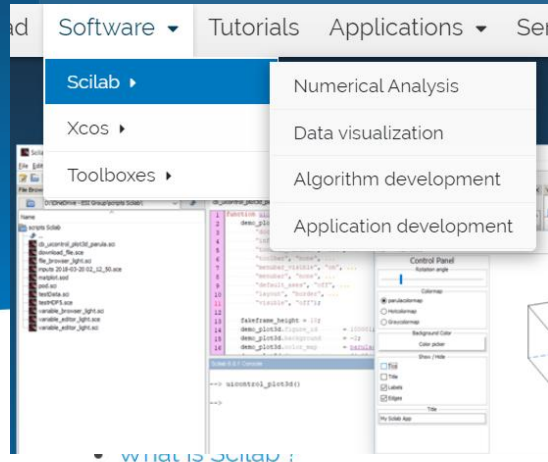
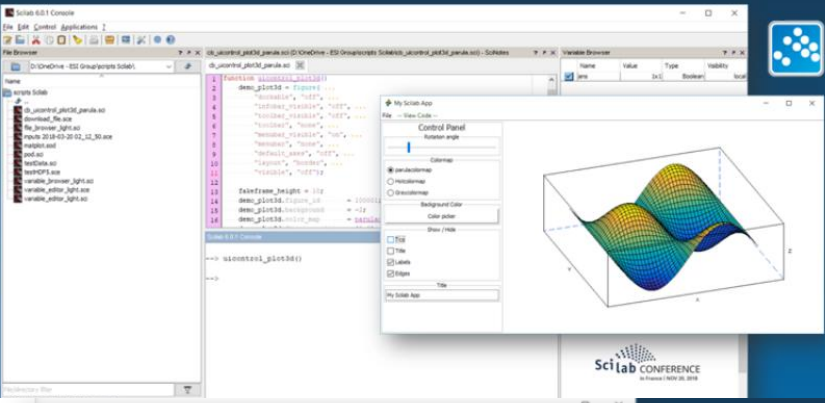
<https://www.scilab.org/>



Download Scilab 6.1.0

Windows, Linux and Mac OS X

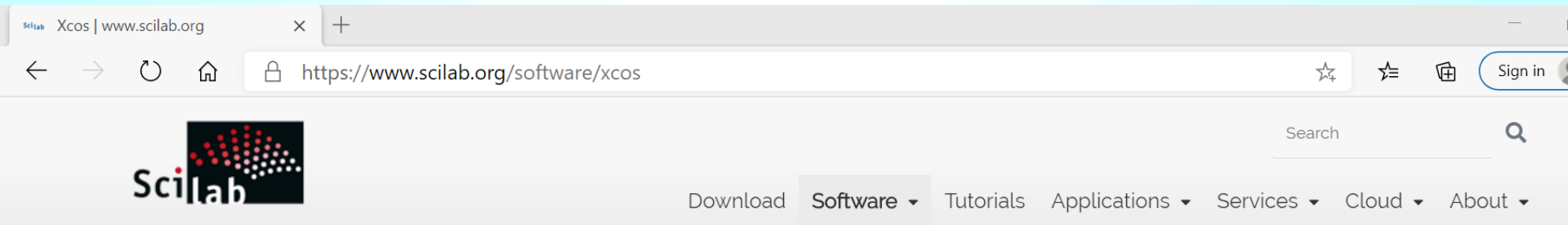
Open source software for numerical computation



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

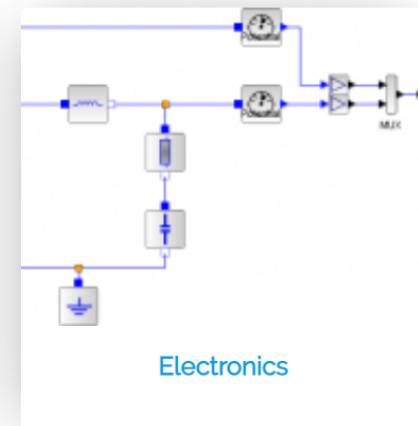
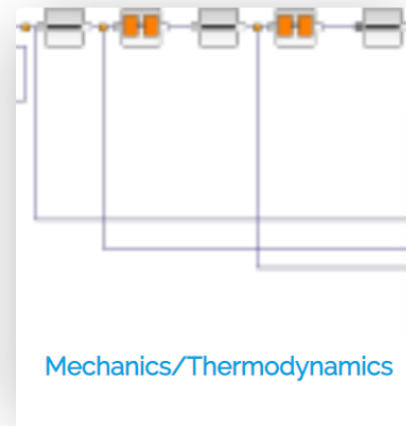
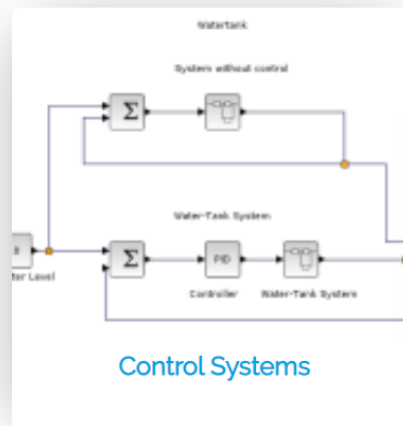
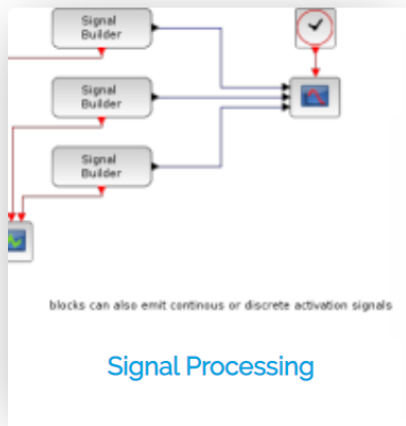
Xcos

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



Home > Software

Xcos



GNU Octave

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

GNU Octave

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

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Micro-Cap

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



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Industrial Strength Simulation

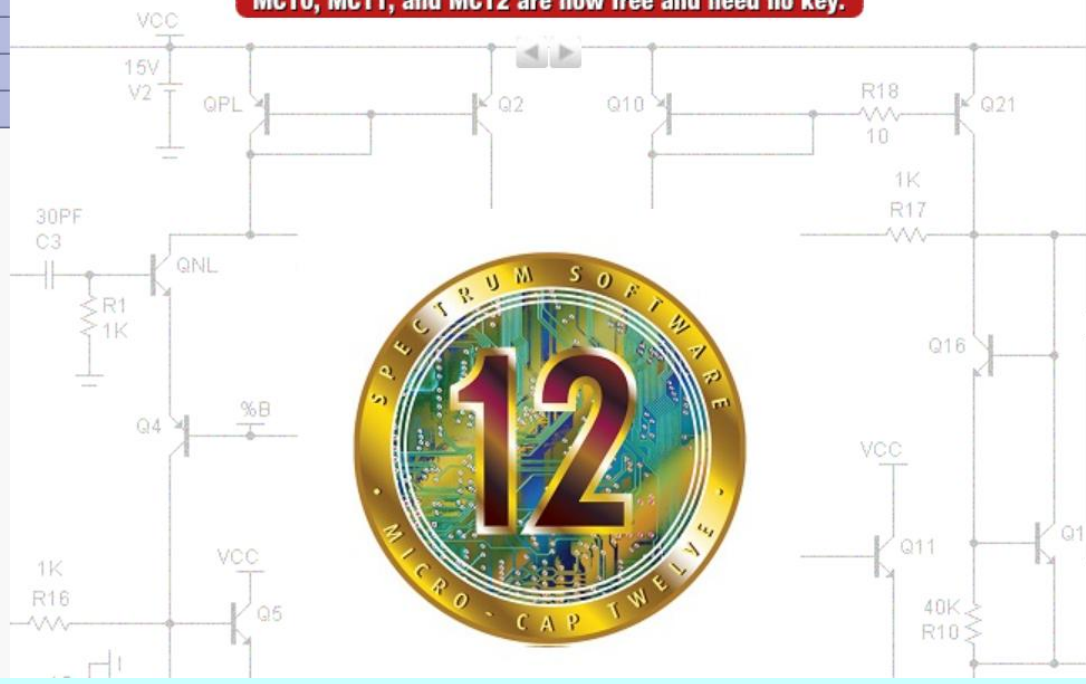
- Select :
- MC12 Revision History
 - Product Information
 - Features Tour
 - New MC12 Features

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

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

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

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



About Spectrum

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

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

Help

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

QucsStudio

<http://qucsstudio.de>

*Octave engine
inside!*

The screenshot displays the QucsStudio 2.4.1 interface. The main window shows a schematic diagram of a power supply circuit. The circuit includes an AC voltage source V1 (230 V, 50 Hz) connected to a primary winding of a transformer Tr1 (T=20). A resistor R_prim (R=0.05 Ohm) is in series with the primary. The secondary winding is connected to a resistor R_sec (R=0.3 Ohm), followed by a 2-way rectifier (four diodes), a filter capacitor C1 (C=1000 μF), and a load resistor Load (R=100 Ohm). A DC voltage source is also shown in series with the load. A 'transient simulation' box is overlaid on the schematic, with parameters: TR1 Type=lin, Stop=60 ms, Points=3001. The left sidebar shows a project tree with 'Simulation_Transient' and a list of schematics. The bottom right shows a simulation console window with a list of files and a script listing simulation steps.

QucsStudio 2.4.1 - Project: Simulation_Transient

File Edit Positioning Insert Project Tools Simulation View Help

Content of 'Simulation_Transient' Note

- Schematics
 - RTD_oscillator.sch
 - astable.sch
 - buck_converter.sch
 - buck_converter_he.sch
 - dimmer.sch
 - doubling.sch
 - filebased_vs.sch
 - gilbert.sch
 - irlm16346trpbf.sch
 - irlm16401.sch
 - loading.sch
 - noise.sch
 - peak_detector.sch
 - peltz_oscillator.sch
 - power_sim.sch
 - power_supply.sch
 - puls.sch
 - transmissionline_ideal.sch
- Verilog
- VHDL
- Octave
- C++ Sources
- Data Displays
- PCB Layouts
- Datasets
- Others

conventional power supply:
transformer, 2-way-rectifier, filter

prim R_prim R=0.05 Ohm

V1 U=230 V freq=50 Hz

Tr1 T=20

R_sec R=0.3 Ohm

load

C1 C=1000 μF

Load R=100 Ohm

dc voltage

transient simulation

TR1 Type=lin Stop=60 ms Points=3001

Content of 'Simulation_Octave' Note

- Schematics
- Verilog
- VHDL
- Octave
 - LoadSnP.m
 - Rauschzahl.m
 - Test_SnP.m
 - filter.m
 - filter2.m
 - microwave_taper.m
 - test_smooth.m
 - test.m
- C++ Sources
- Data Displays
- PCB Layouts
- Datasets
- Others

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

CircuitLab

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

CIRCUIT LAB

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Circuit simulation and schematics.

Build and simulate circuits right in your browser.

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▶ Launch CircuitLab

[or watch a quick demo video ->](#)

Getting Started with CircuitLab

Гледајте К... Дели

CIRCUIT LAB

File Edit Run Help

Press 'F' to search

Essentials

DC Sources

Passive Elements

Voltage Signal Sources

Current Signal Sources

Operational Amplifiers

Diodes

V1 square 1 kHz

R1 100 Ω

C1 10 μF

1-minute Tutorial

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

Powered by CircuitLab - to learn about the full version, please visit www.CircuitLab.com

Textbook **NEW!**

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[Full Circuit Design and Analysis](#)

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Select required signal such as sine, square

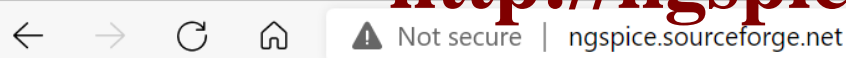
Get started with some sample circuits !

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

Fig. 1: DoCircuits - Home

ngSpice

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



MIXED MODE - MIXED LEVEL
CIRCUIT SIMULATOR

NGSPICE SUMMARY

BASED ON BERKELEY'S SPICE3F5

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

Ngspice Home

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

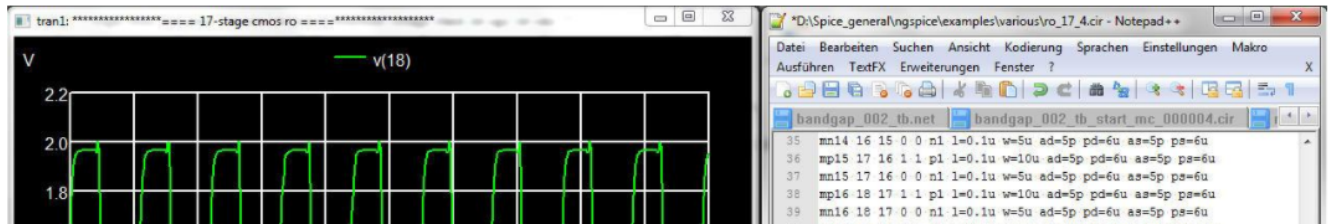
ngspice - open source spice simulator

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

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

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

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



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



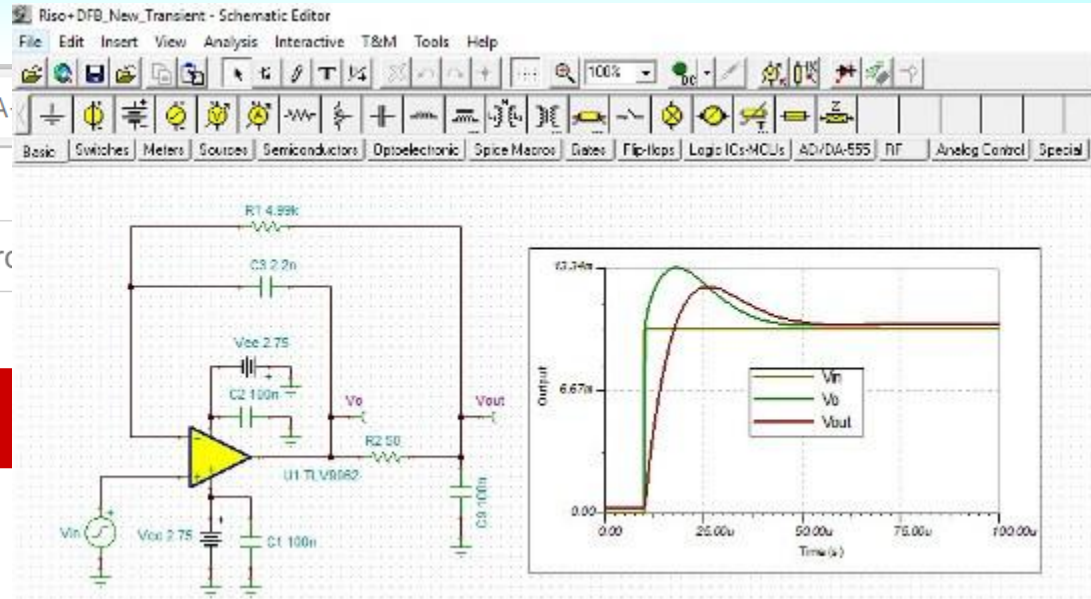
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TINA-TI

SPICE-based analog simulation program

Overview

Downloads

Technical documentation

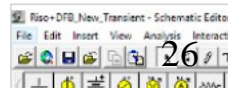
Support & training

TINA-TI

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

Overview

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



Electric Circuit Studio

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



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ECStudio Systems Education

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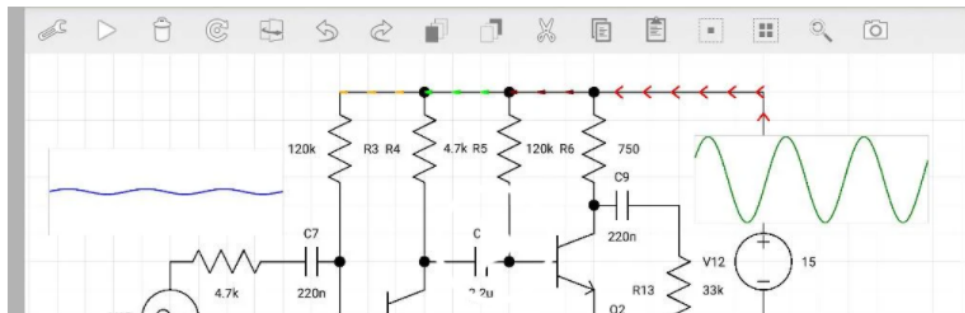
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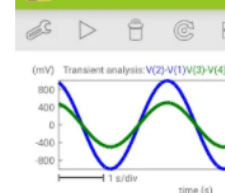
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CircuitSafari SPICE Simulator

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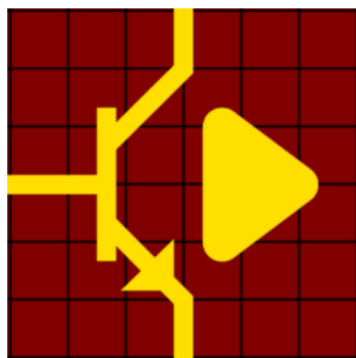
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CircuitSafari SPICE Simulator (Early Access)

Logipipe, LLC Productivity

E Everyone

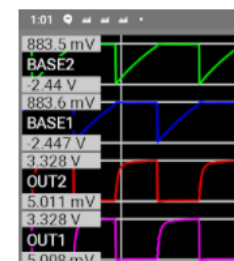
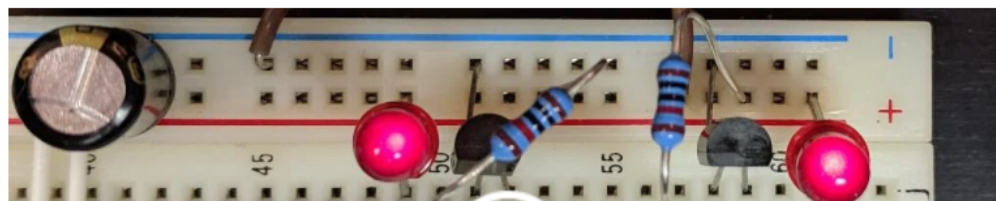
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Julia Programming Language



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44,131



The Julia Programming Language

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Julia in a Nutshell

Fast

Julia was designed for [high performance](#). Julia programs automatically compile to efficient native code via LLVM, and support [multiple platforms](#).

Dynamic

Julia is [dynamically typed](#), feels like a scripting language, and has good support for [interactive use](#), but can also optionally be separately compiled.

Reproducible

[Reproducible environments](#) make it possible to recreate the same Julia environment every time, across platforms, with [pre-built binaries](#).

Composable

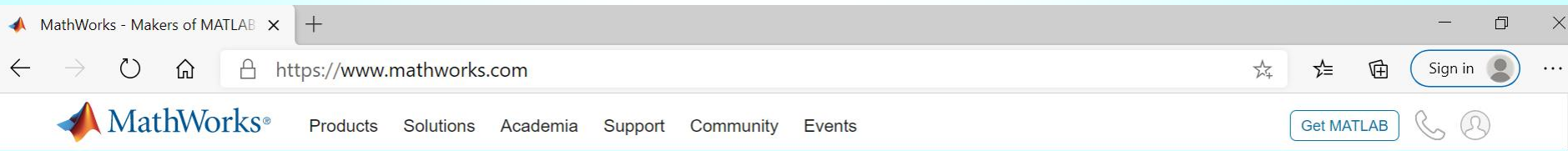
Julia uses [multiple dispatch](#) as a paradigm, making it easy to express many object-oriented and [functional](#) programming patterns. The talk on the [Unreasonable Effectiveness of Multiple Dispatch](#) explains why it works so well.

General

Julia provides [asynchronous I/O](#), [metaprogramming](#), [debugging](#), [logging](#), [profiling](#), a [package manager](#), and more. One can build entire [Applications and Microservices](#) in Julia.

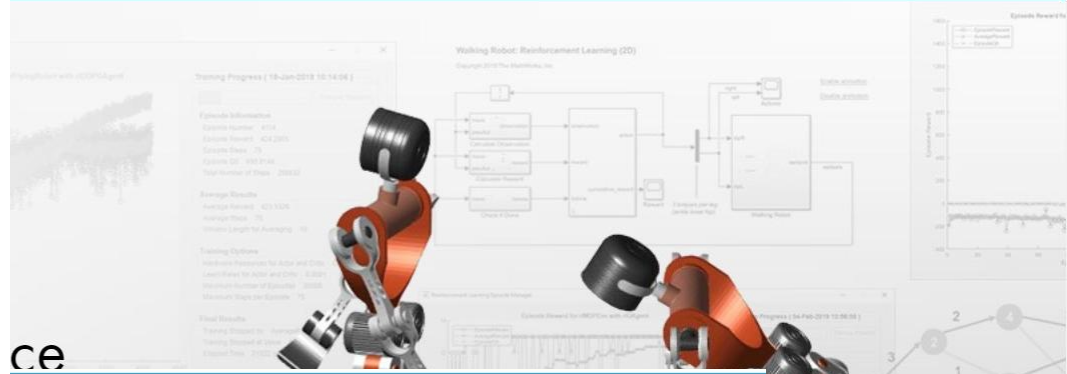
Open source

Julia is an open source project with over 1,000 contributors. It is made available under the [MIT license](#). The [source code](#) is available on GitHub.

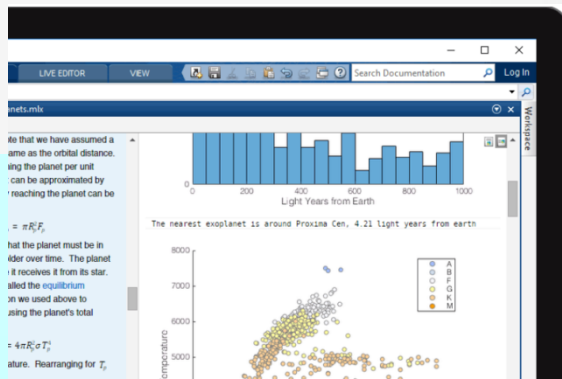


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MATLAB[®] combines a desktop environment tuned for iterative analysis and design processes with a programming language that expresses matrix and array mathematics directly. It includes the [Live Editor](#) for creating scripts that combine code, output,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



Design AI models and AI-driven systems



Products by Category | Alphabetical

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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

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



MATLAB

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

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FILE VARIABLE CODE ENVIRONMENT RESOURCES

Simulink

System target file browser: Simulink2DSHplus

System target file:	Description:
asap2.tlc	ASAM-ASAP2 Data Definition Target
dsb.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)
ext.tlc	RTW Embedded Coder (auto configures for c
ext.tlc	Code (auto configures for c
ext.tlc	C++ Project Makefile only for th
grt.tlc	Real-Time Target
grt.tlc	C++ Project Makefile only for t

Simulink 2D SHplus

MathWorks

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

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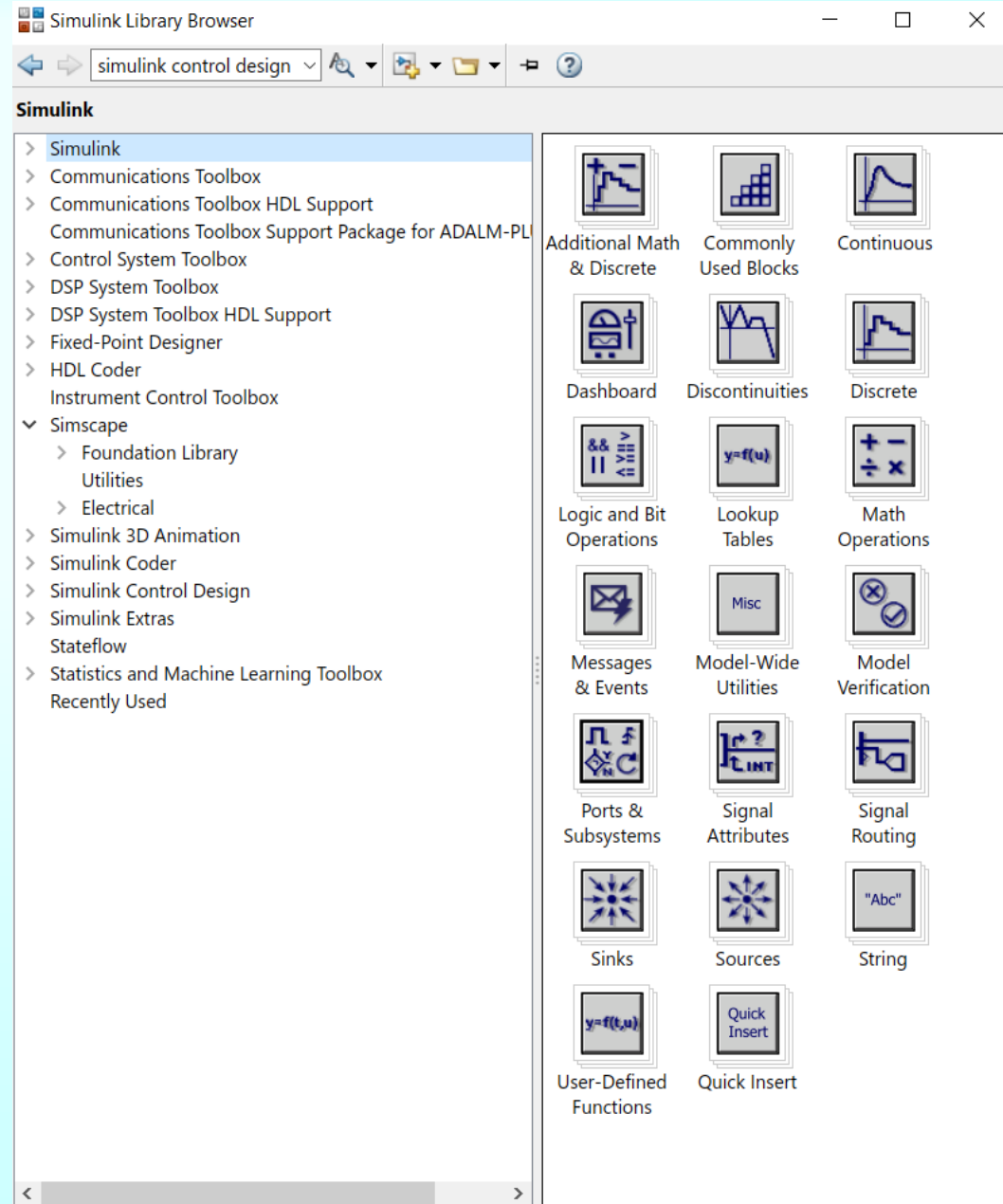
MathWorks R2019a

Toolboxes...

MATLAB

Simulink

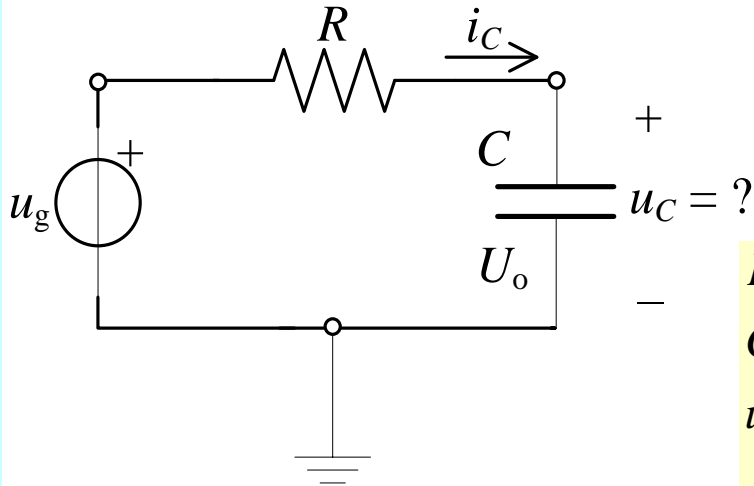
- Алатка за нумеричку анализу математичких модела
- Систем се дефинише графички, уметањем блокова и њиховим повезивањем у мрежу



Simulink > Simscape

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

коло је образовано у тренутку $t_0 = 0$

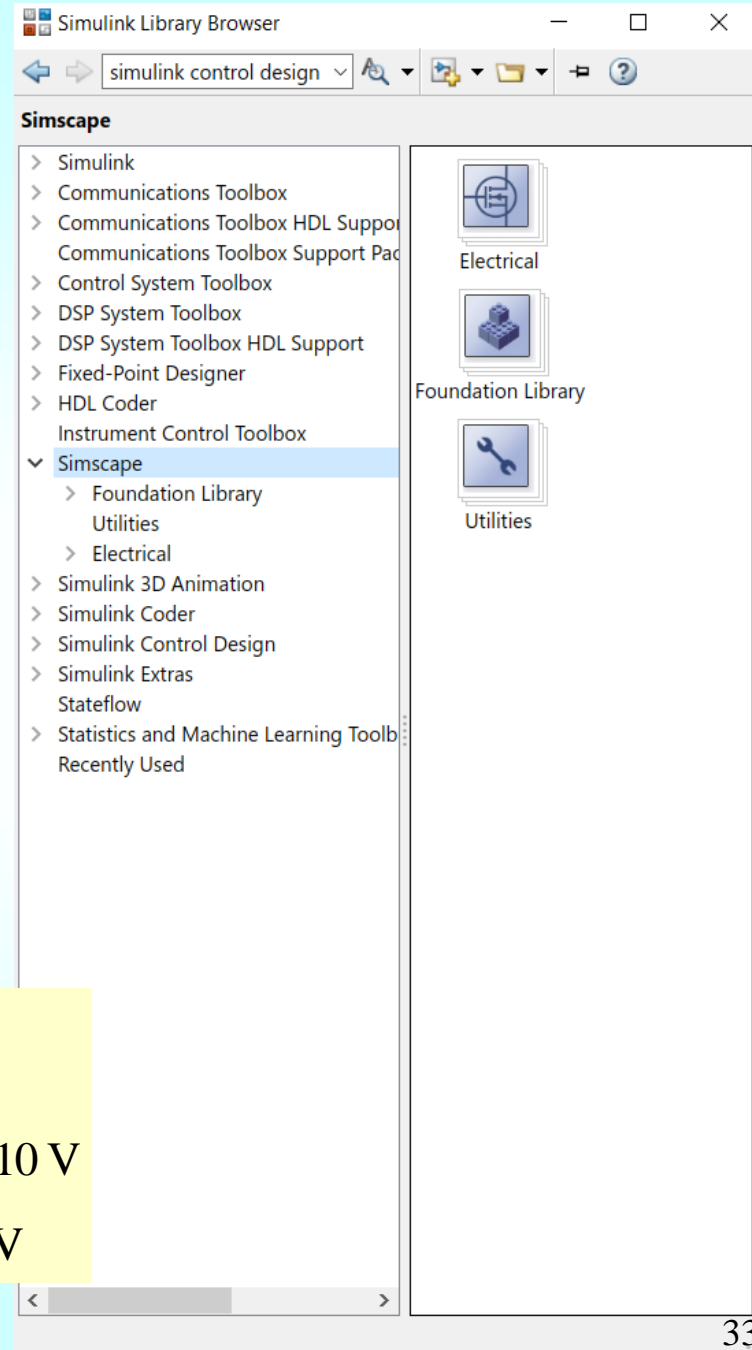


$$R = 1 \text{ k}\Omega$$

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

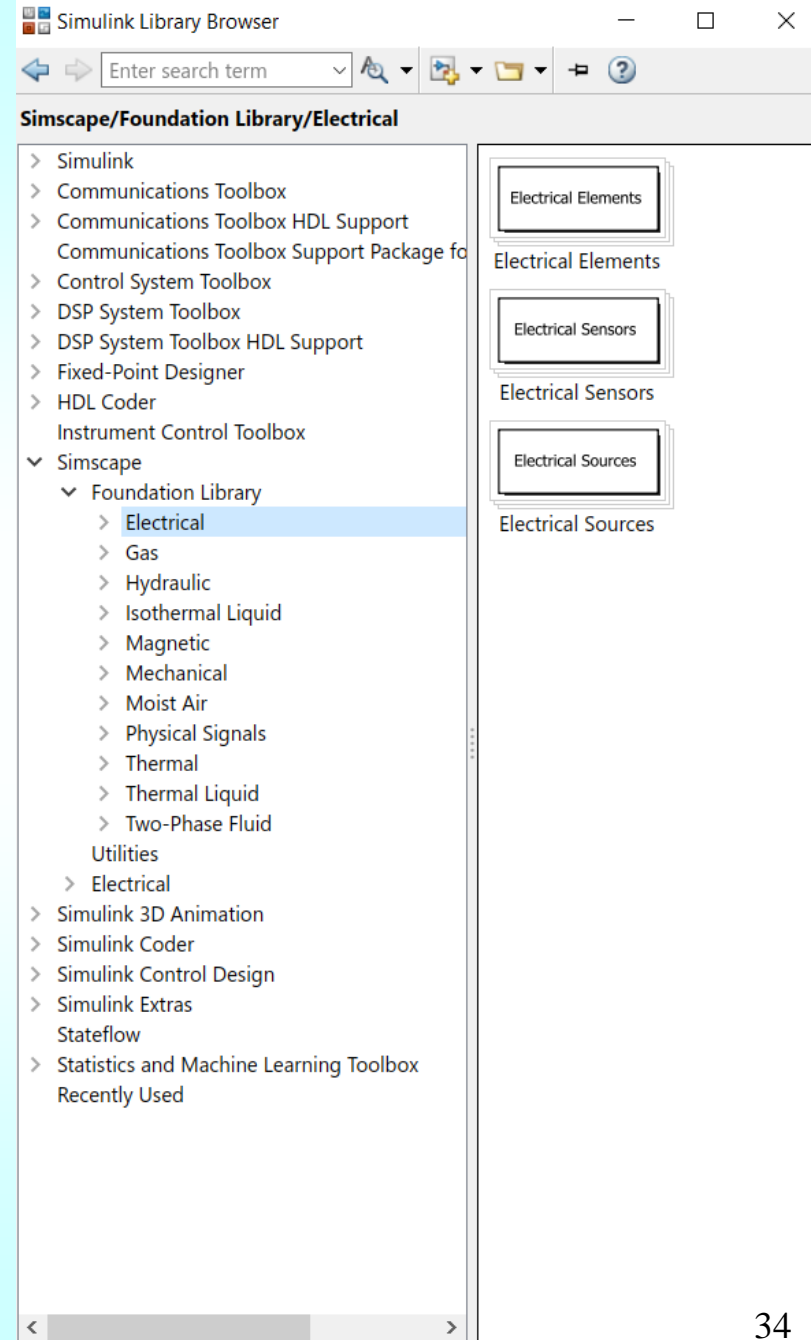
$$u_g(t) = U h(t), U = 10 \text{ V}$$

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



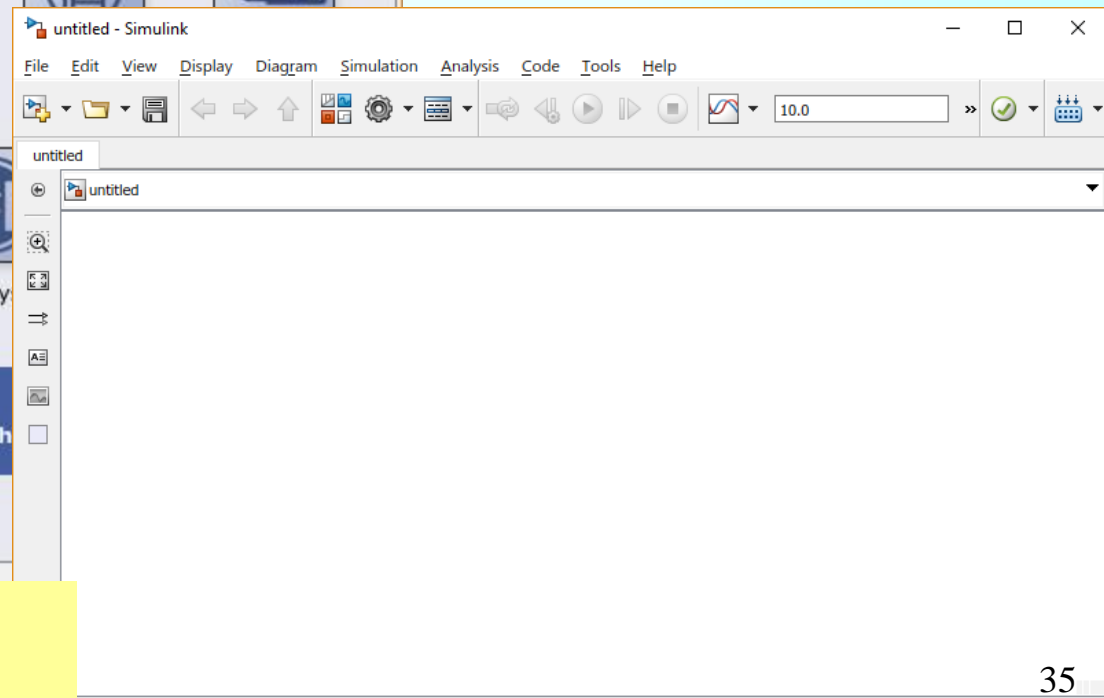
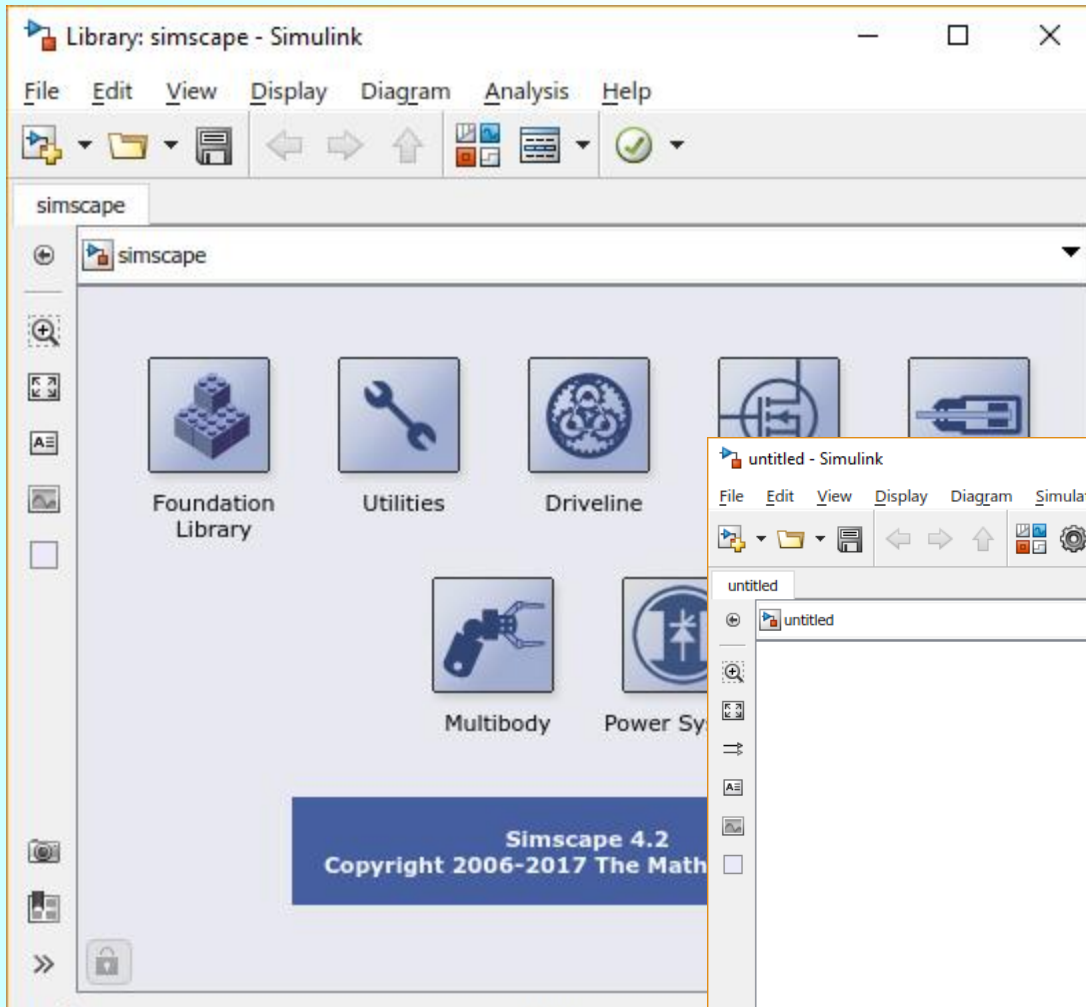
Simulink > Simscape > Foundation Library > Electrical

- Симулација линеарних и нелинеарних електричних кола

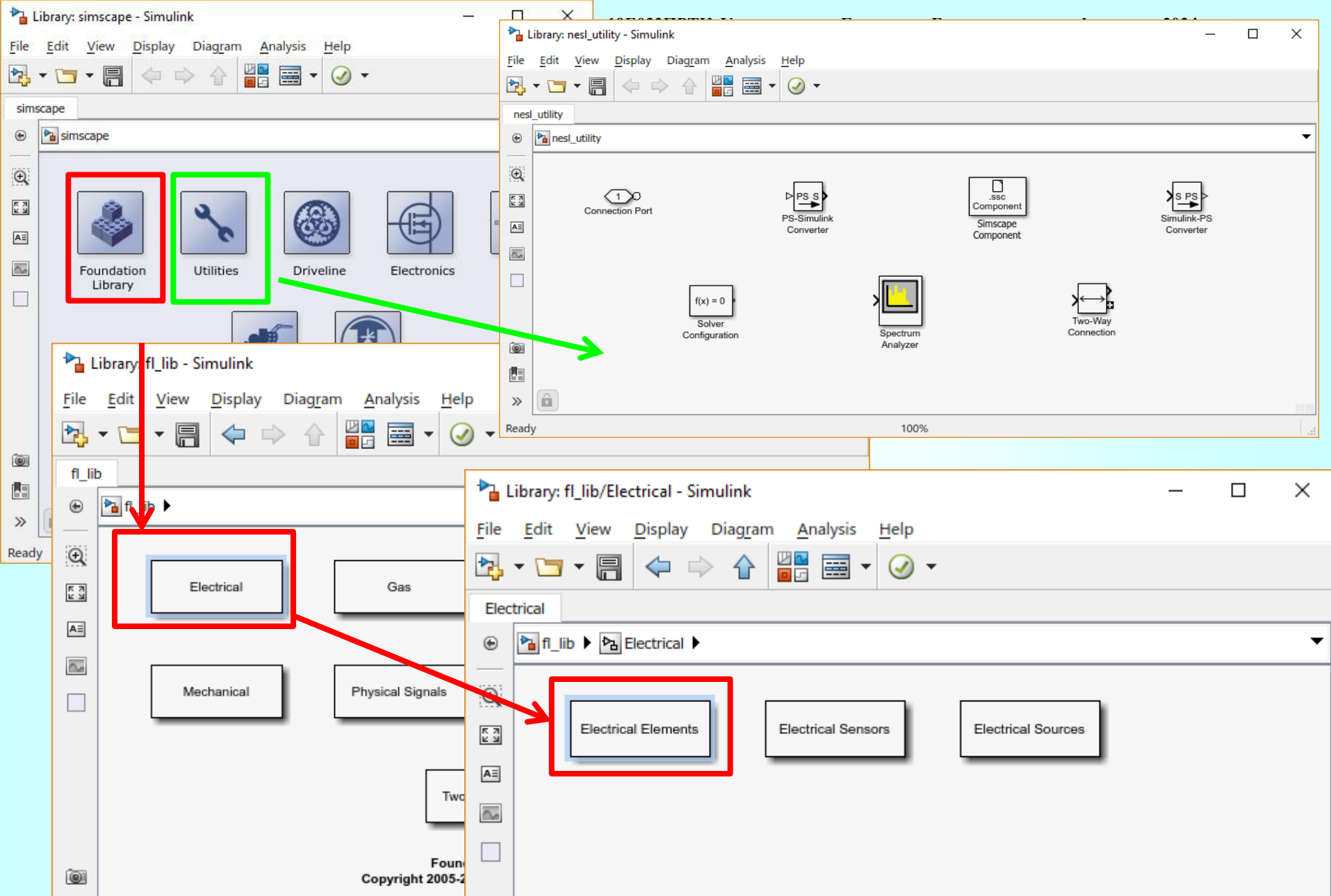


**MATLAB > Simscape >
Foundation Library, Utilities**

Симулација електричног кола коришћењем Simscape > Foundation Library библиотеке

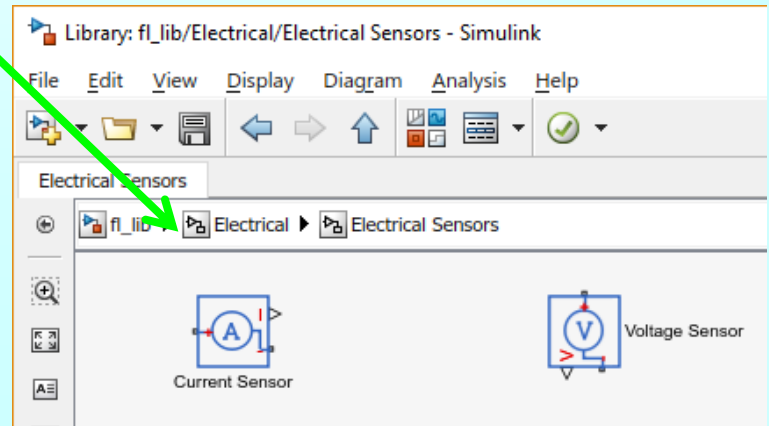
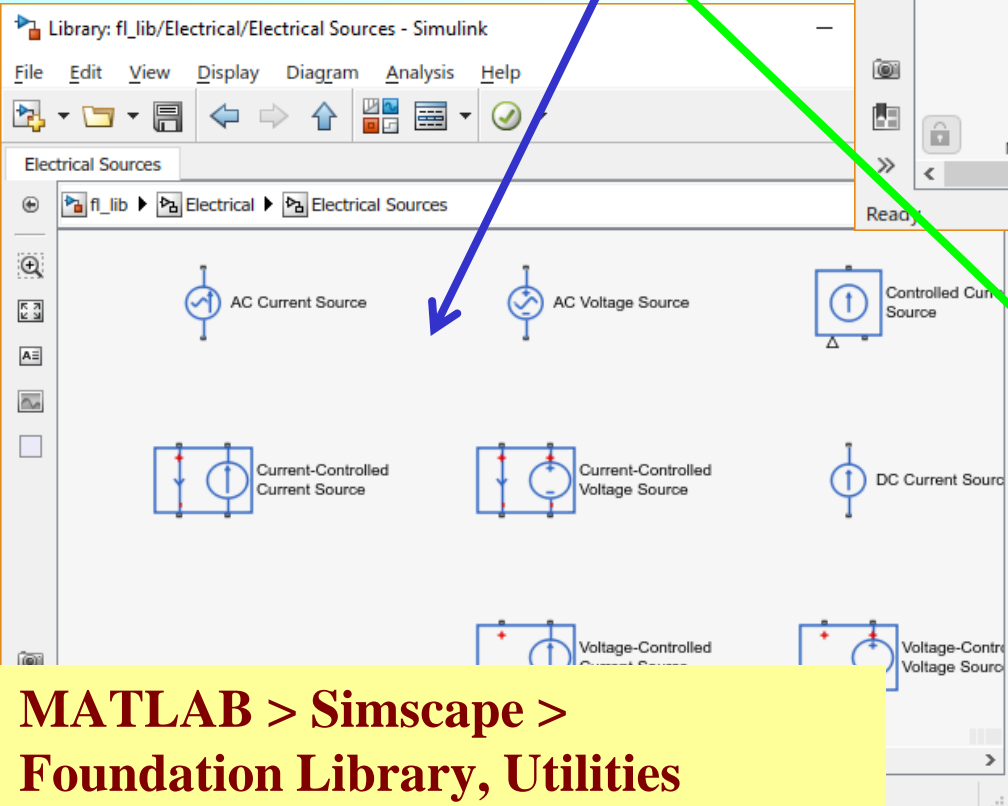
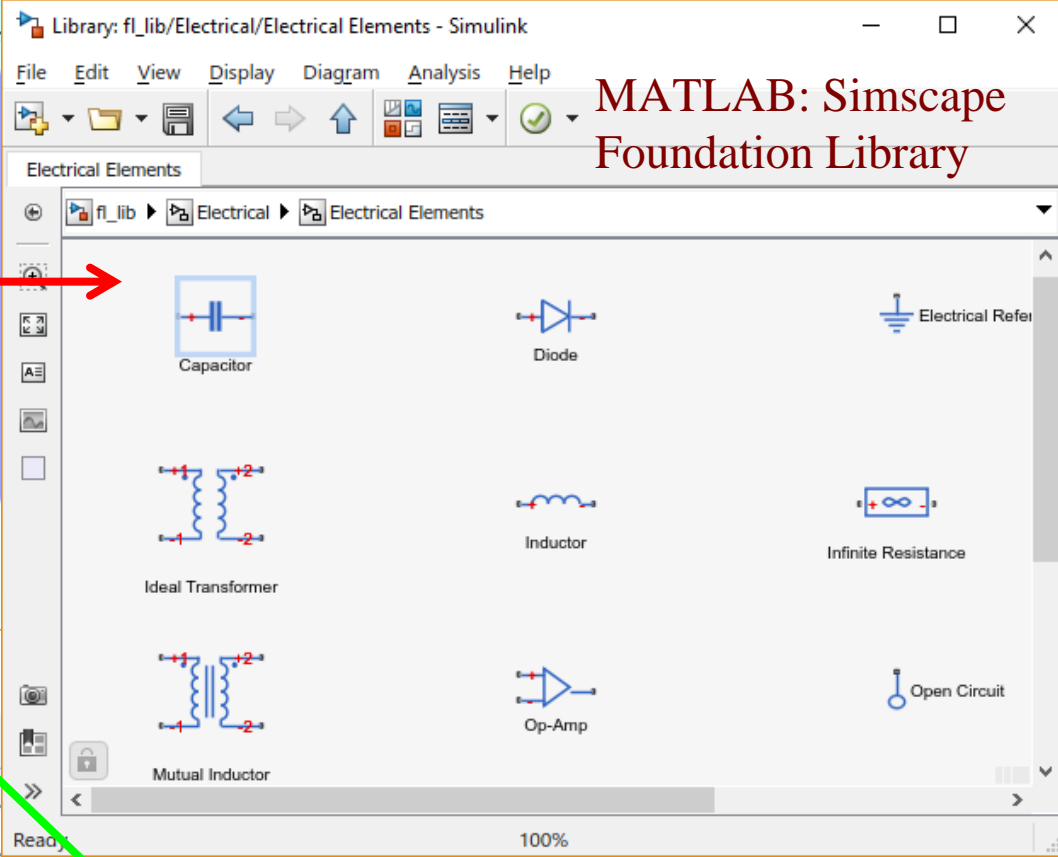
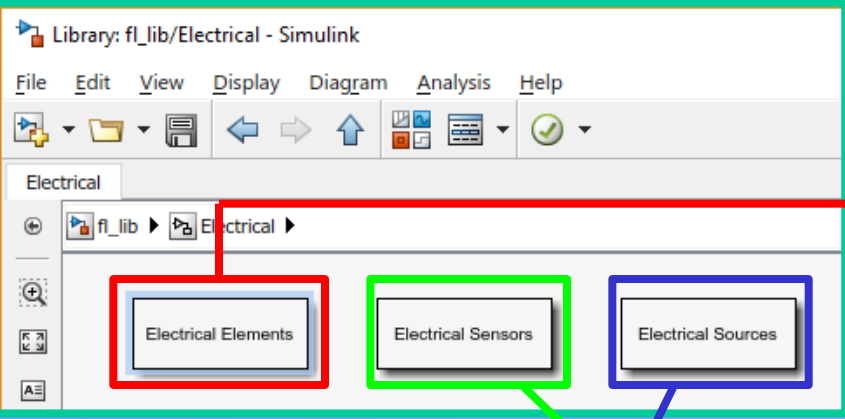


**MATLAB > Simscape >
Foundation Library, Utilities**



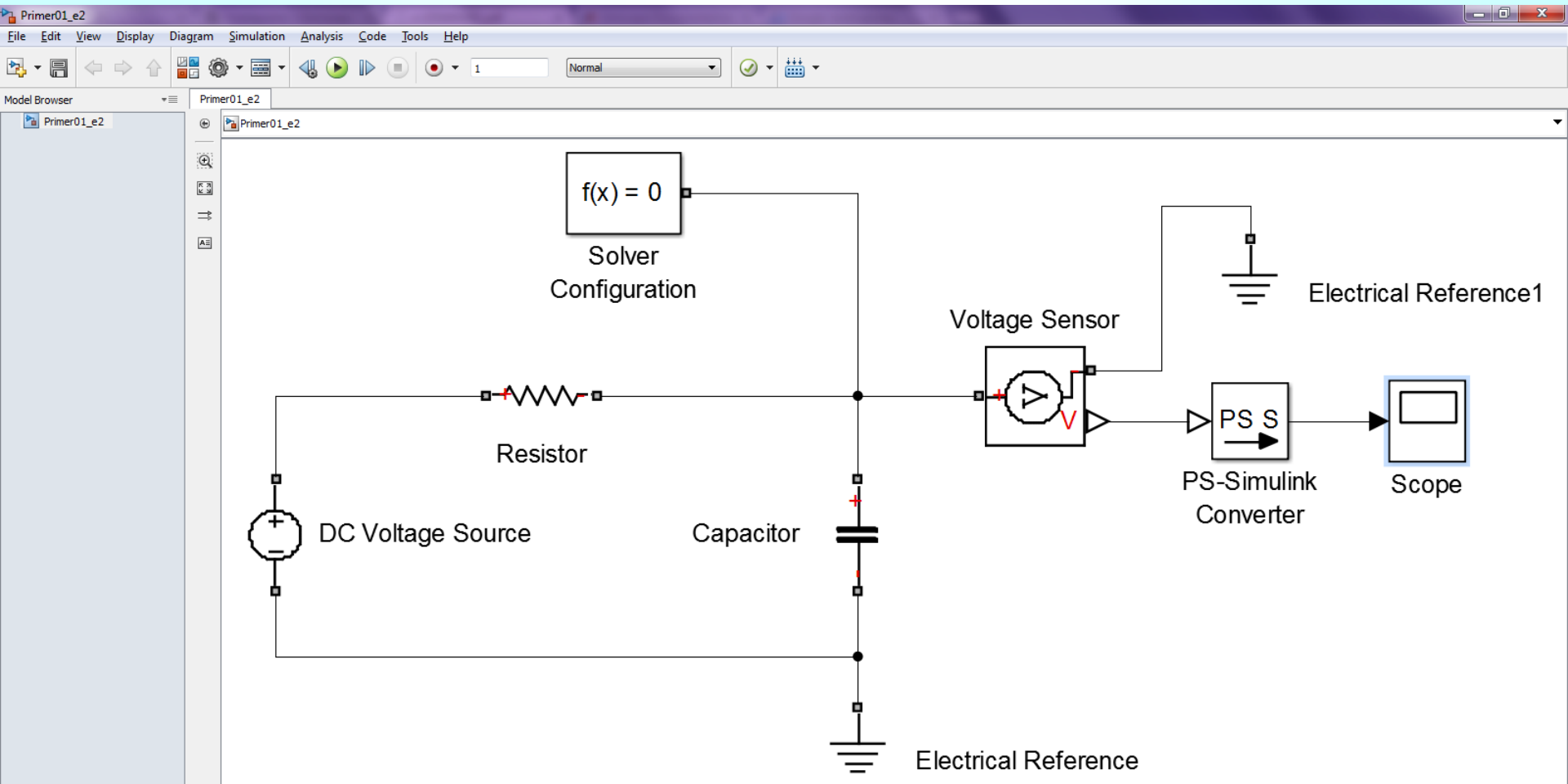
MATLAB > Simscape > Foundation Library, Utilities

MATLAB: Simscape Foundation Library



MATLAB > Simscape > Foundation Library, Utilities

Симулација електричног кола коришћењем Simscape > Foundation Library библиотеке



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

Block Parameters: Solver Configuration

Solver Configuration
Defines solver settings to use for simulation.

Parameters

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

OK Cancel Help Apply

Block Parameters: DC Voltage Source

DC Voltage Source

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

[Source code](#)

Settings

Parameters

Constant voltage: 10 V

OK Cancel Help Apply

Block Parameters: Resistor

Resistor

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

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

[Source code](#)

Settings

Parameters Variables

Resistance: 1000 Ohm

OK Cancel Help Apply

Block Parameters: Capacitor

Почетни услов...

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

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

[Source code](#)

Settings

Parameters Variables

Capacitance:

Series resistance:

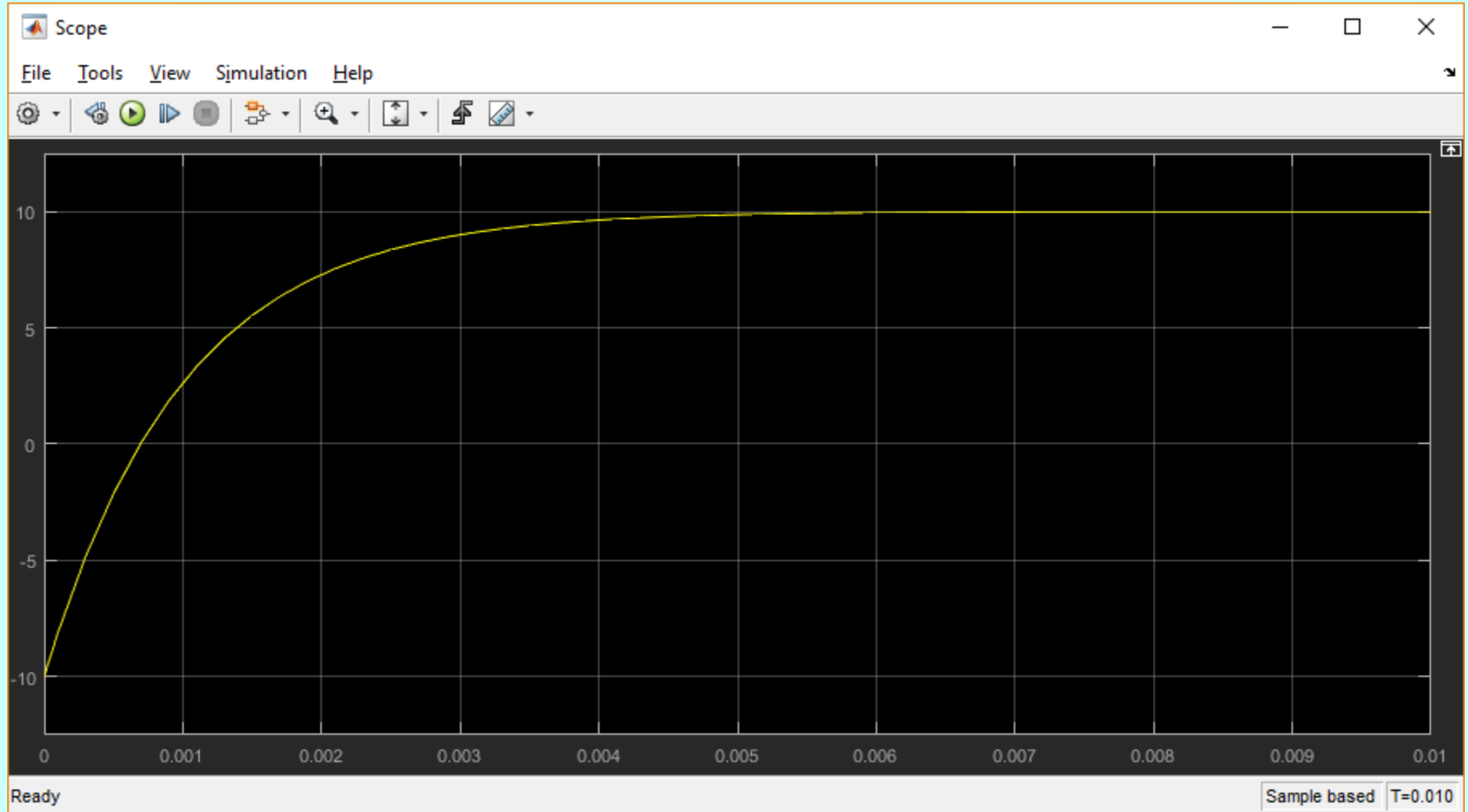
Parallel conductance:

Settings

Parameters Variables

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

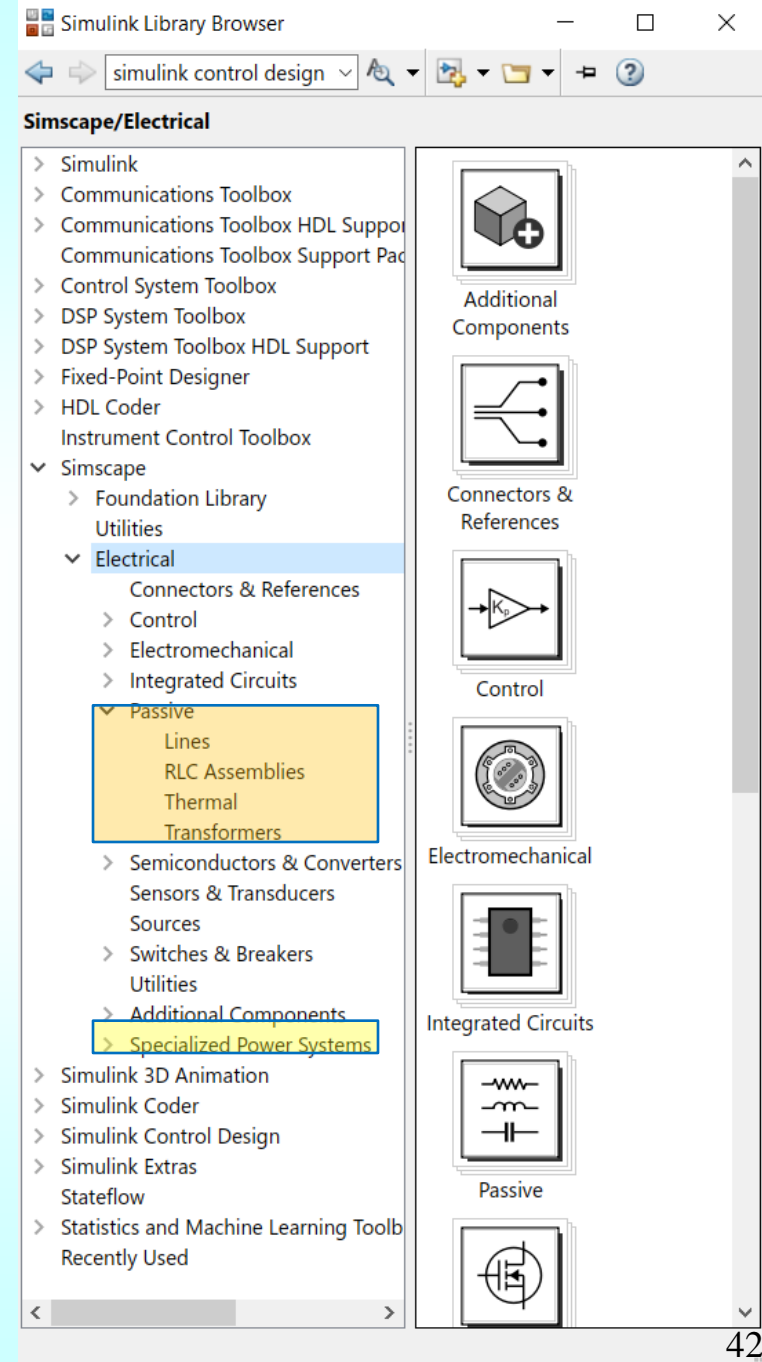
Одређивање одзива...



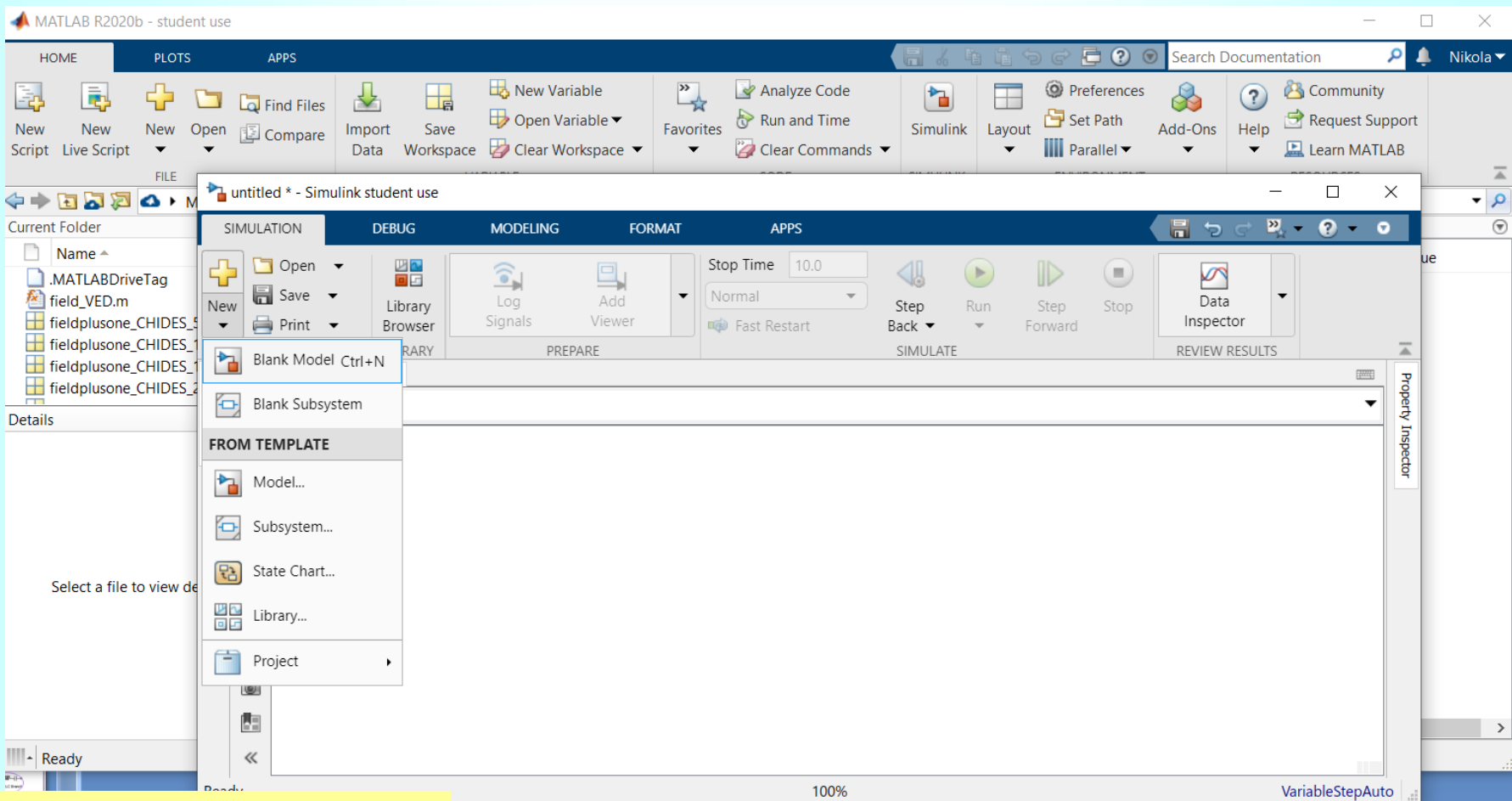
**MATLAB > Simscape >
Foundation Library, Utilities**

Simulink > Simscape > Electrical

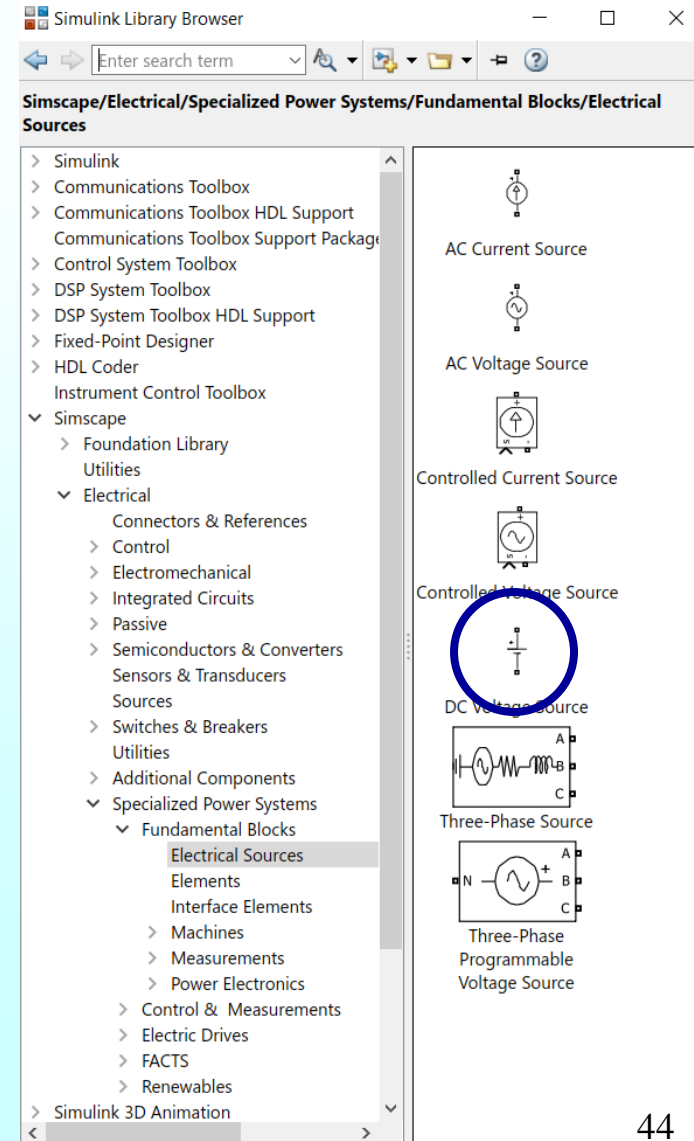
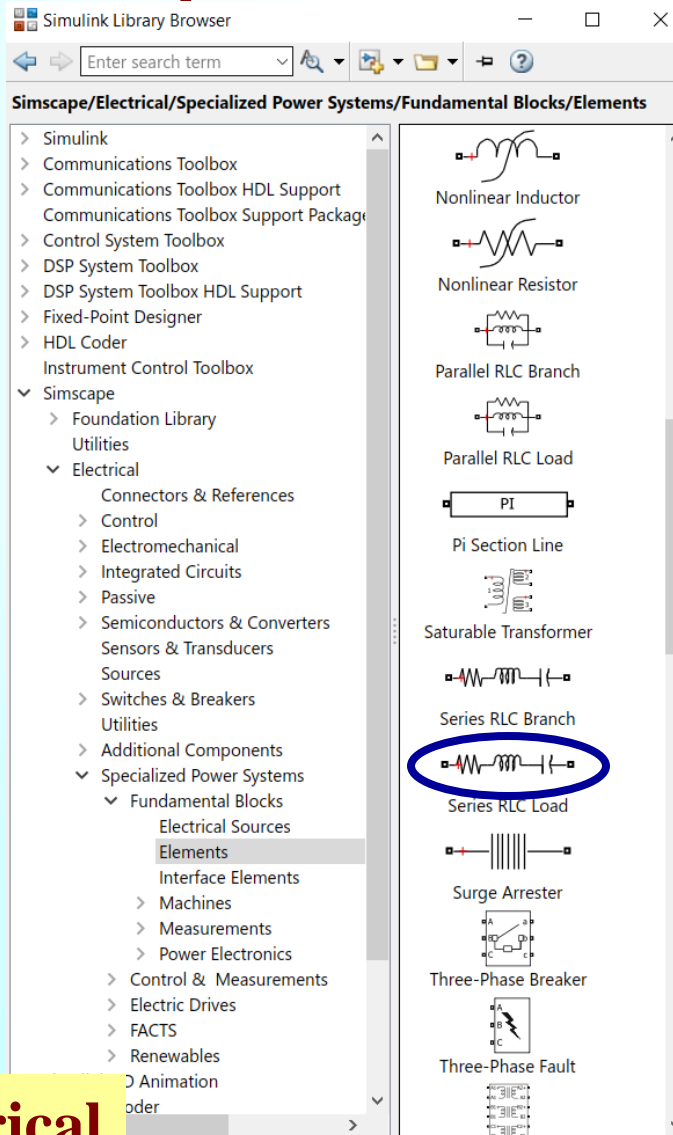
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- Трофазни извори, водови, трансформатори, потрошачи
- Термална анализа



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

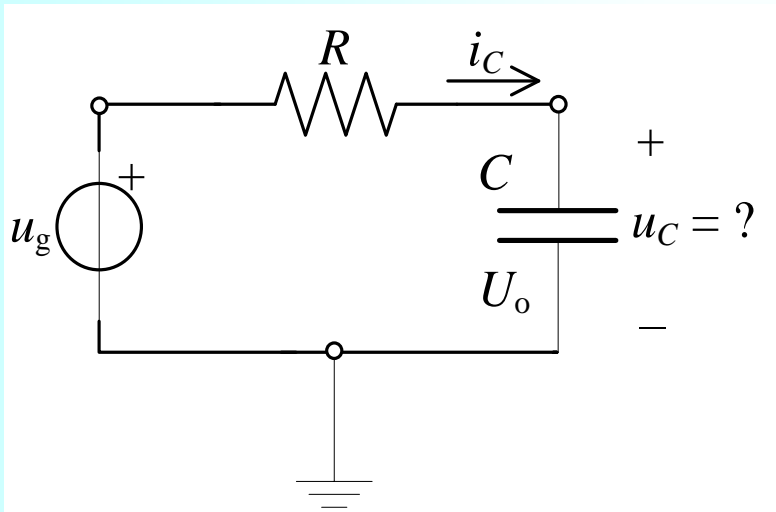


Симулација електричног кола коришћењем Simscape>Electrical библиотеке



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

коло је образовано у тренутку $t_0 = 0$

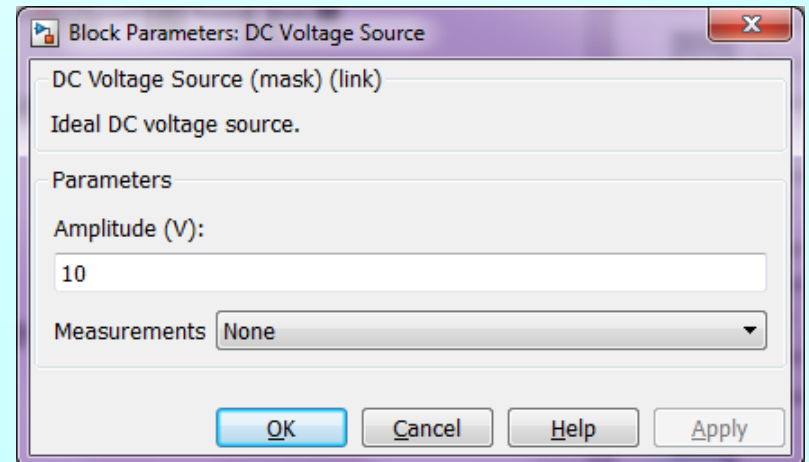
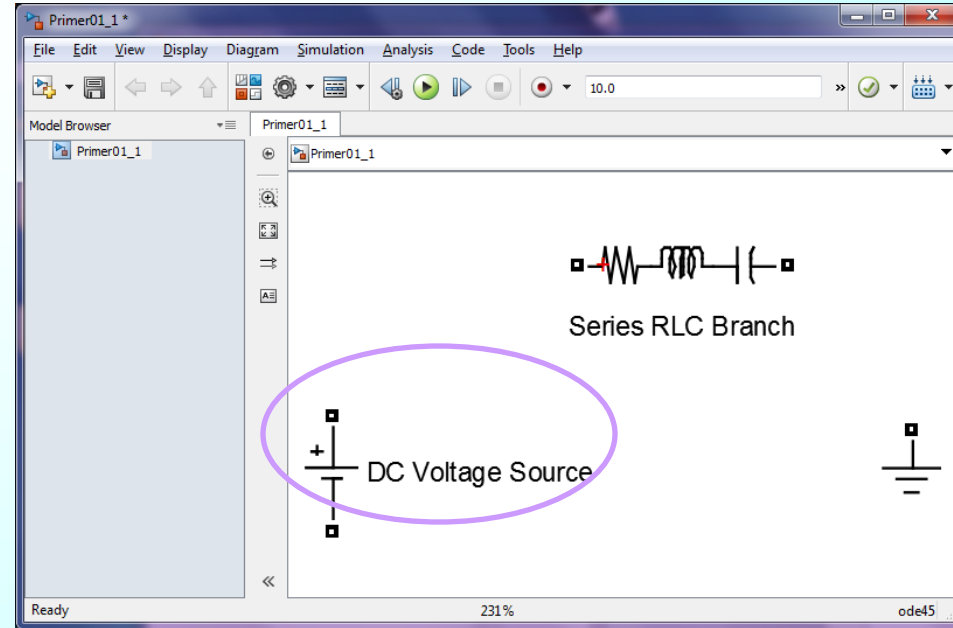


$$R = 1 \text{ k}\Omega$$

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

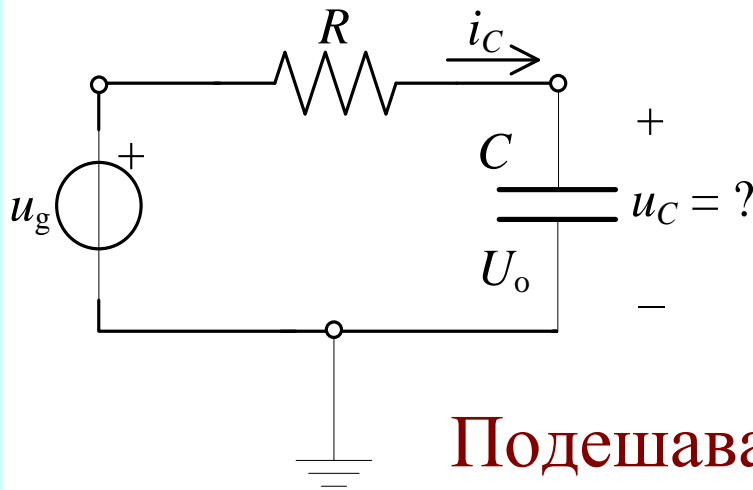
$$u_g(t) = U h(t), U = 10 \text{ V}$$

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



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

коло је образовано у тренутку $t_0 = 0$



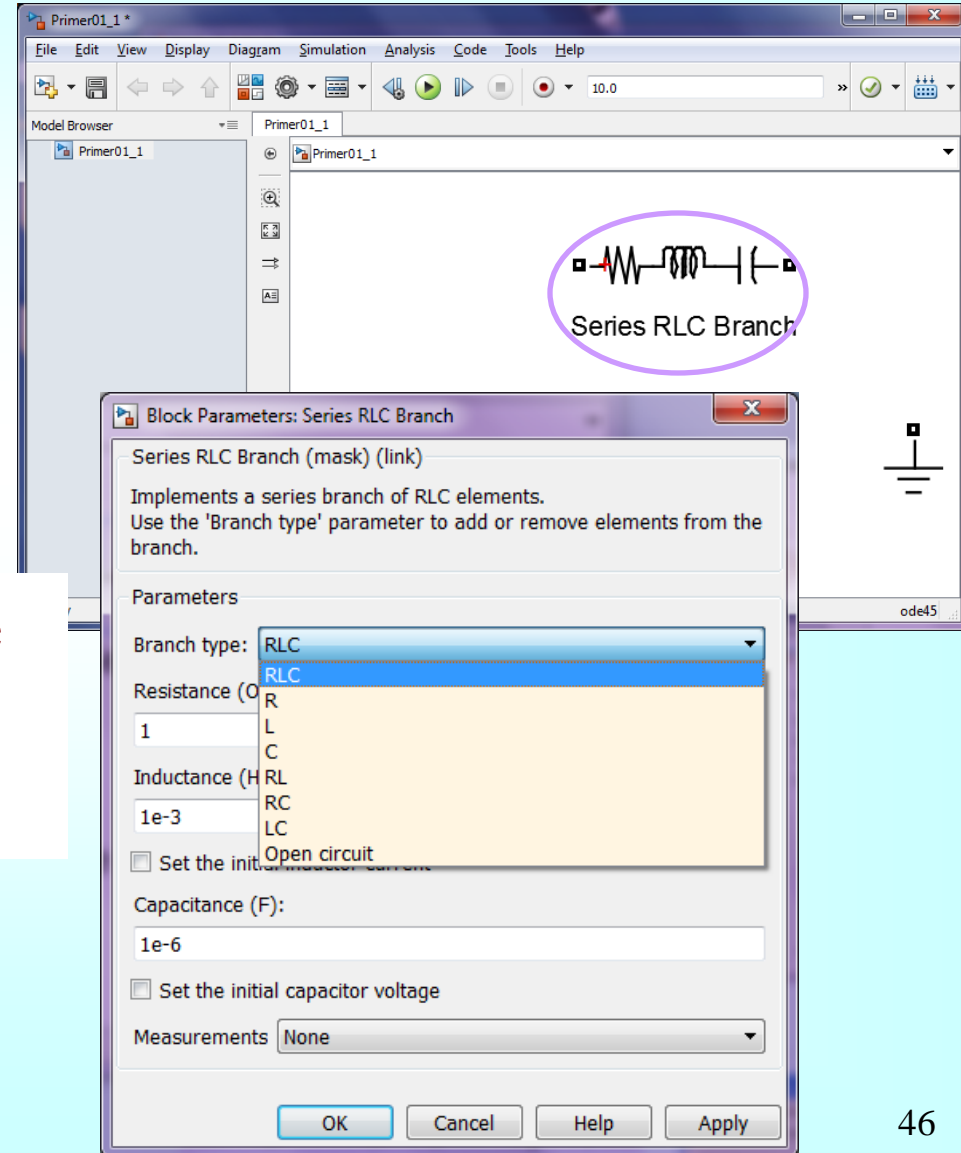
Подешавање
параметара
симулације

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

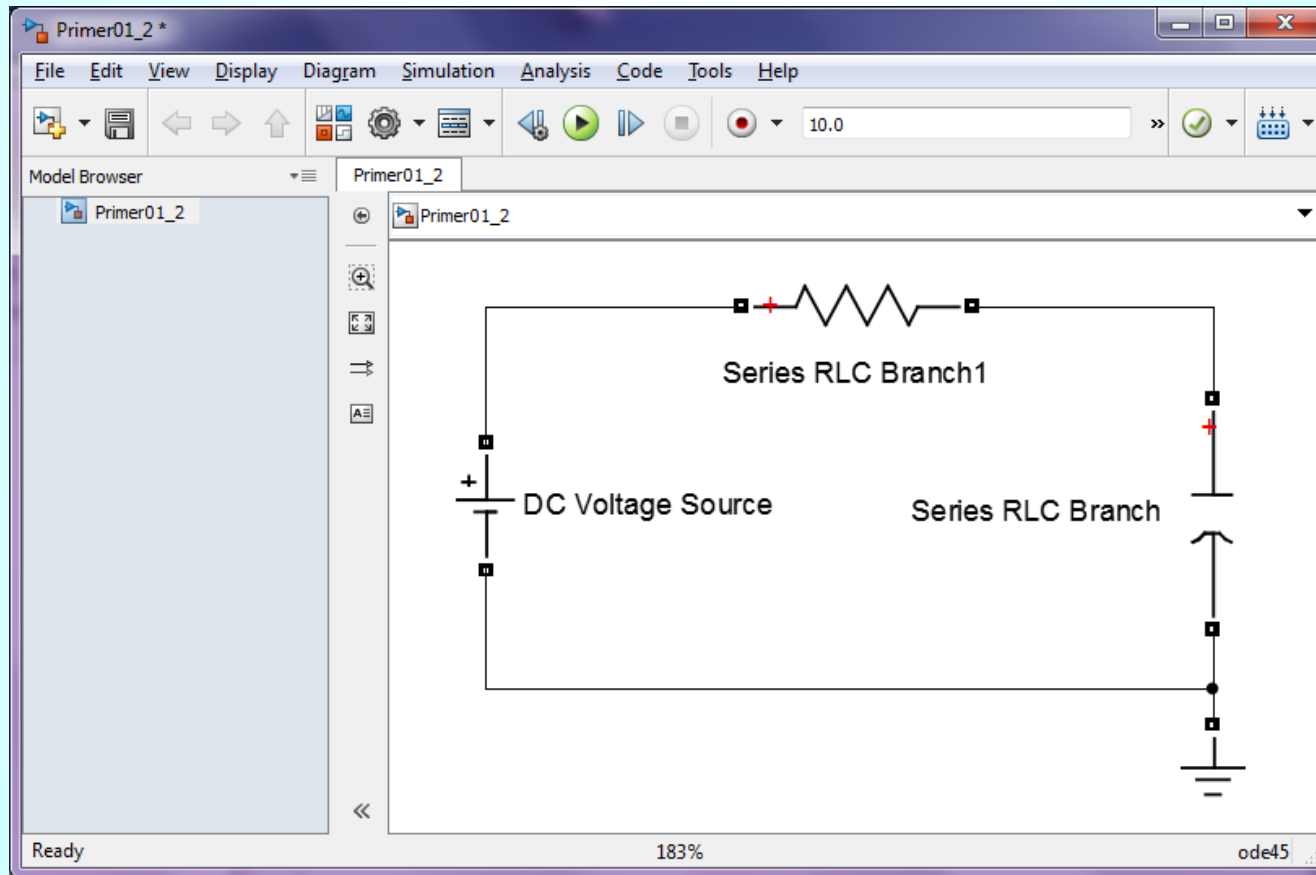
$$C = 1 \mu\text{F}$$

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

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

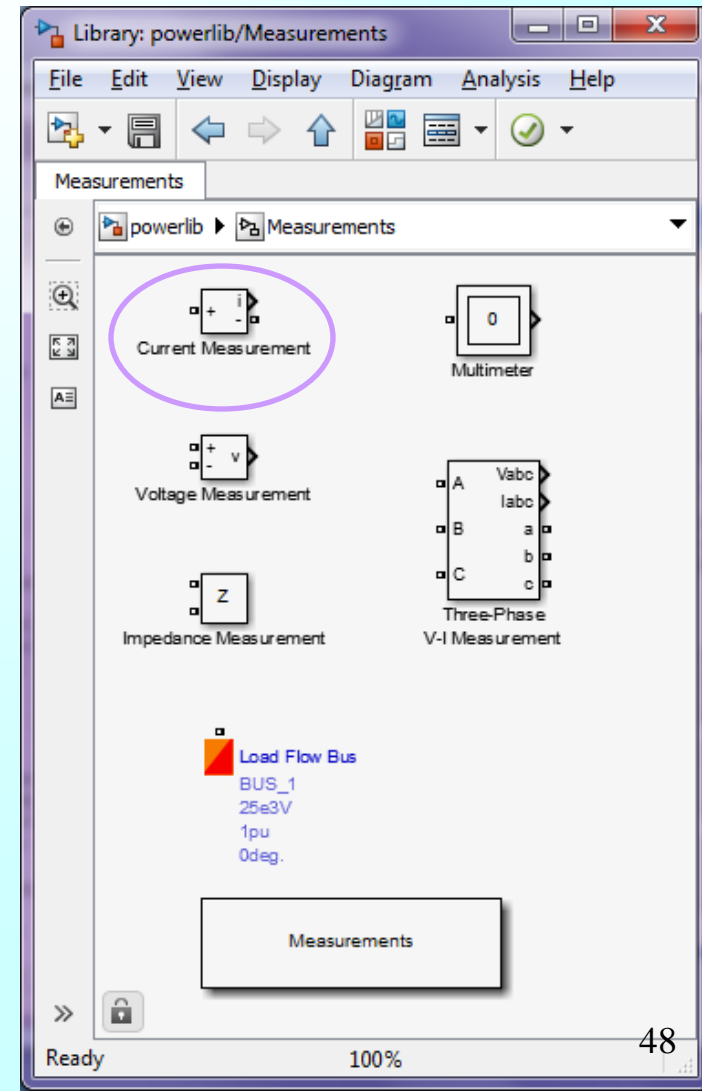
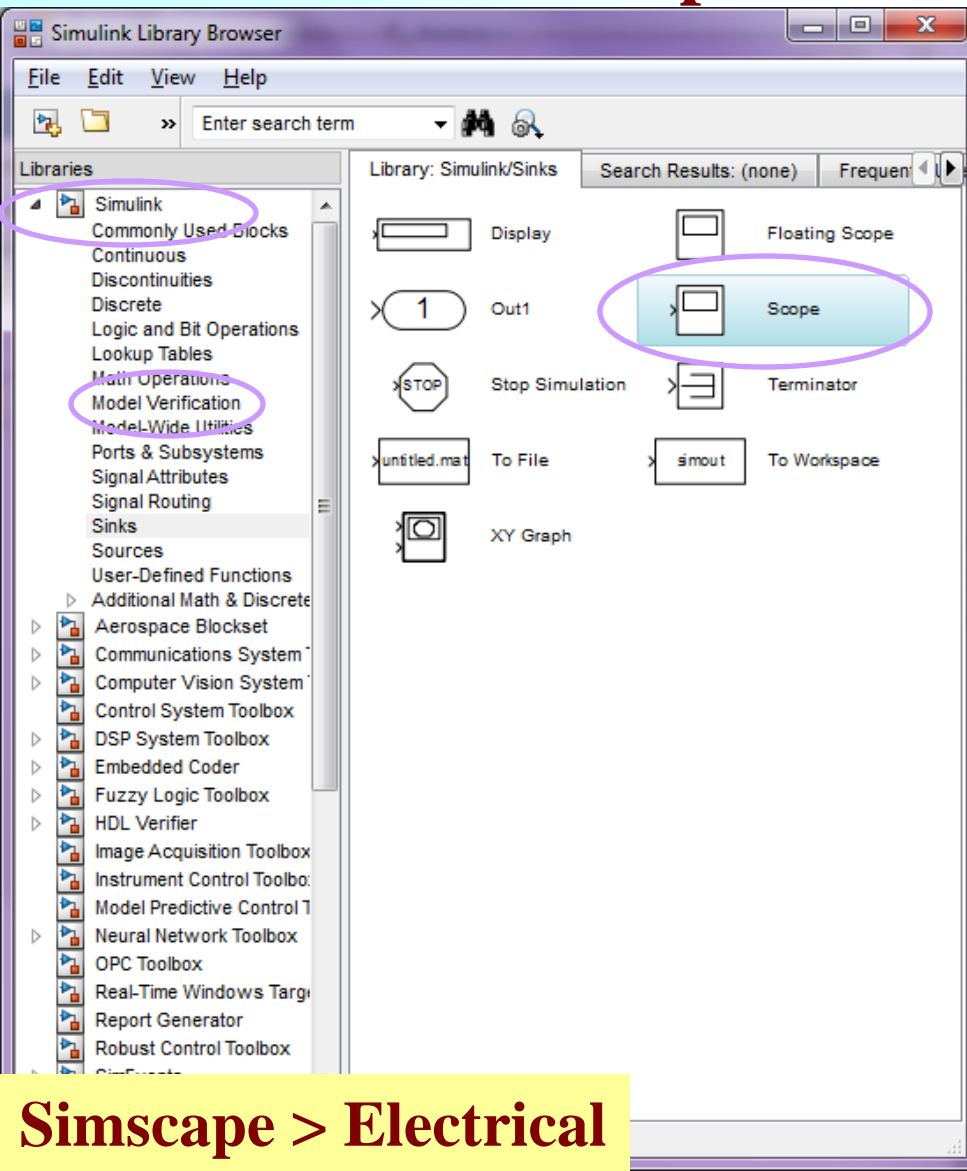


Симулација електричног кола коришћењем **Simscape>Electrical** библиотеке



Како се мери напон?

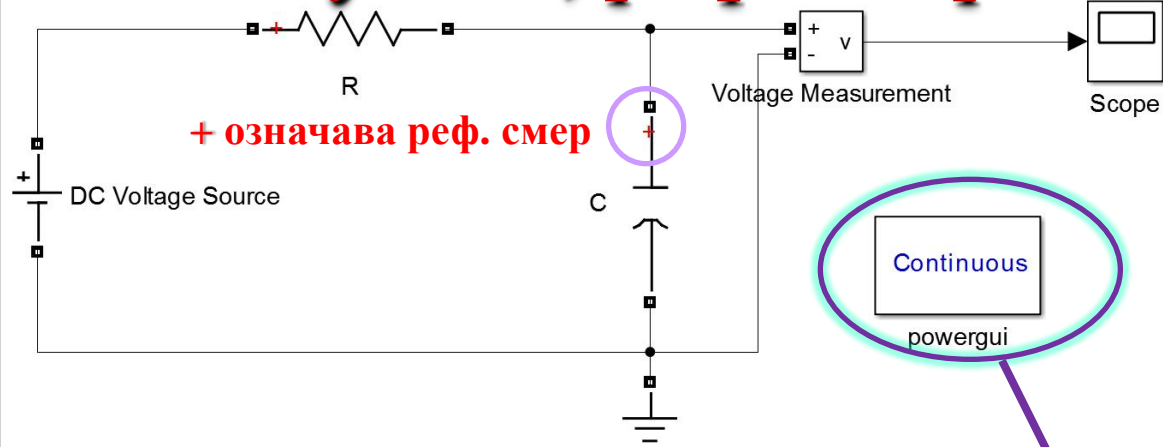
Симулација електричног кола коришћењем **Simscape>Electrical** библиотеке



Simscape > Electrical

Почетни услов, реф. смер...

+ означава реф. смер



Block Parameters: C

Series RLC Branch (mask) (link)

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

Parameters

Branch type: C

Capacitance (F): 1e-6

Set the initial capacitor voltage

Capacitor initial voltage (V): -10

Measurements: None

OK Cancel Help

Плоче кондензатора се разликују!!!

Simscape > Electrical

Block Parameters: powergui

PSB option menu block (mask)

Set simulation type, simulation parameters, and preferences.

Solver Tools Preferences

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

OK Cancel Help

Powergui Initial States Setting Tool. model: untitled

Initial electrical state values for simulation:

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

Set selected electrical state value: -10

Force initial electrical state:

To Steady State

To Zero

The image shows a screenshot of the 'Configuration Parameters' dialog box in Simulink. The window title is 'Configuration Parameters: untitled/Configuration (Active)'. There are two tabs: '★ Commonly Used Parameters' (selected) and '≡ All Parameters'. On the left, a 'Select:' list contains various categories, with 'Solver' highlighted. The main area is divided into sections: 'Simulation time' with 'Start time: 0.0' and 'Stop time: 0.01'; 'Solver options' with 'Type: Variable-step' and 'Solver: auto (Automatic solver selection)'; and 'Additional options' which is currently collapsed. At the bottom right, there are buttons for 'OK', 'Cancel', 'Help', and 'Apply'.

Configuration Parameters: untitled/Configuration (Active)

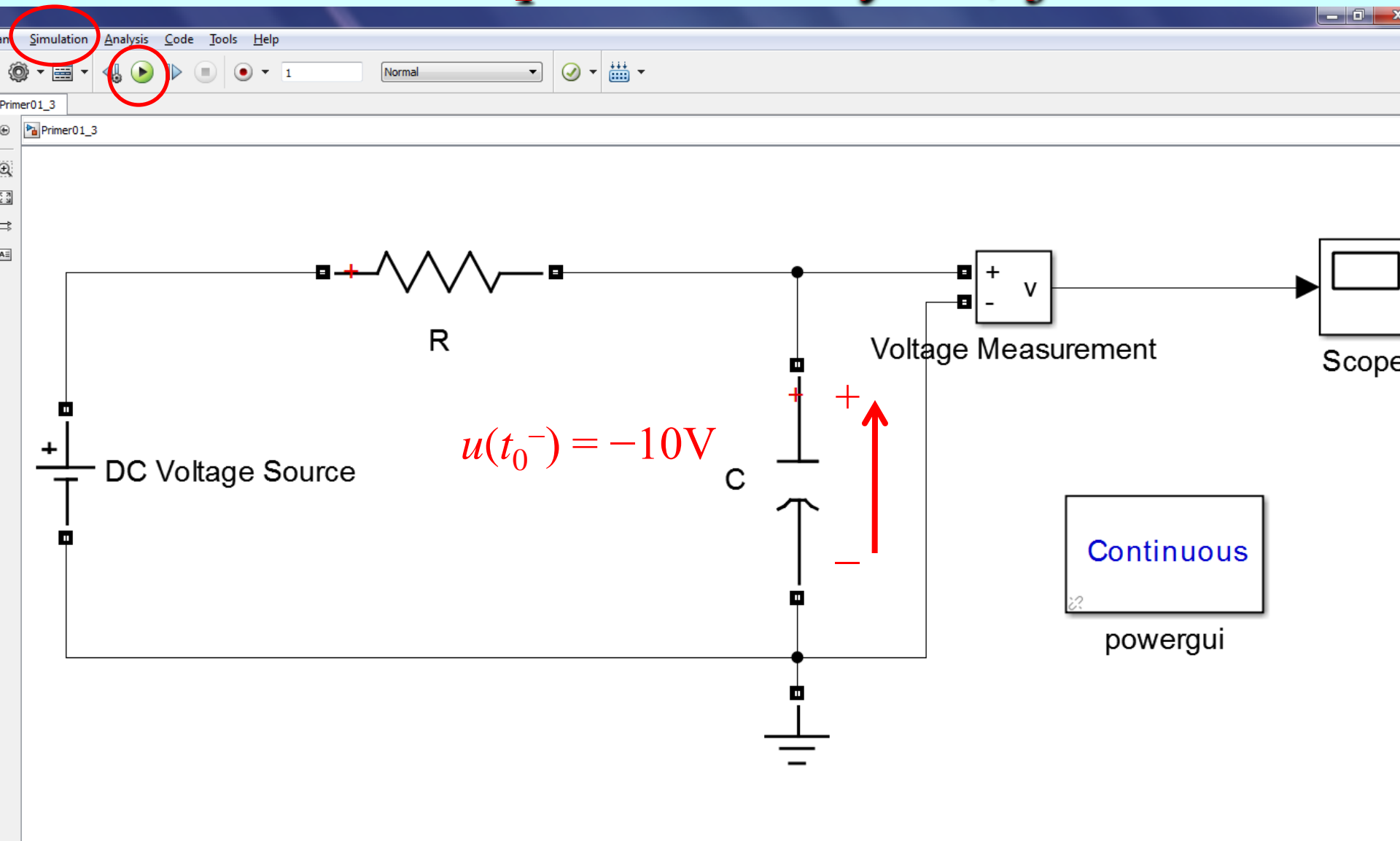
★ Commonly Used Parameters ≡ All Parameters

Category: All Search selected category

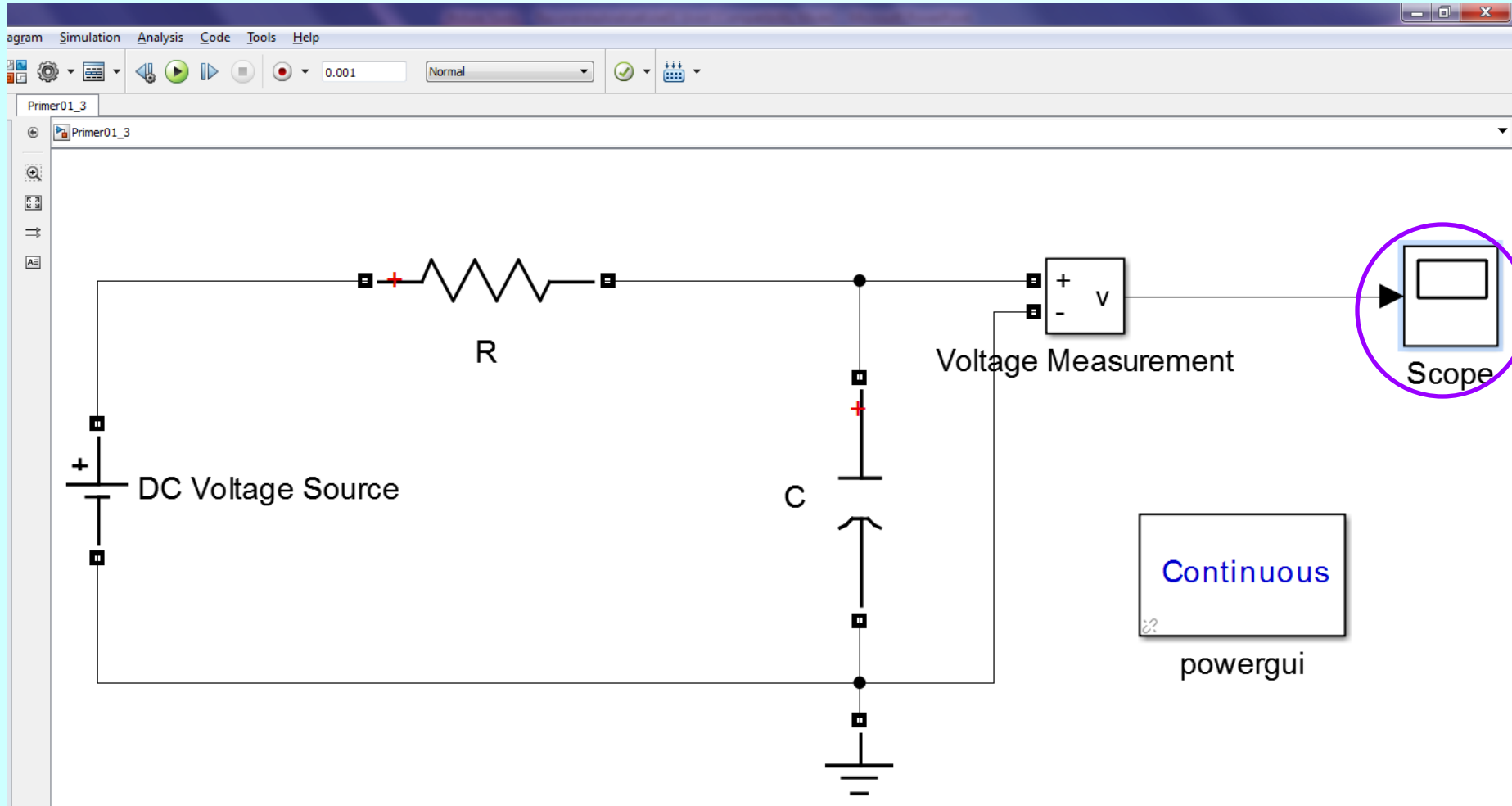
Parameter	Value	Command-Line Name
Solver ▶ Simulation time		
> Start time Simulation start time. Note that the values that you specify as block i...	0.0	StartTime
> Stop time Simulation stop time.	0.01	StopTime
Solver ▶ Solver options		
> Type Choose a variable or fixed-step solver.	Variable-step	SolverType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

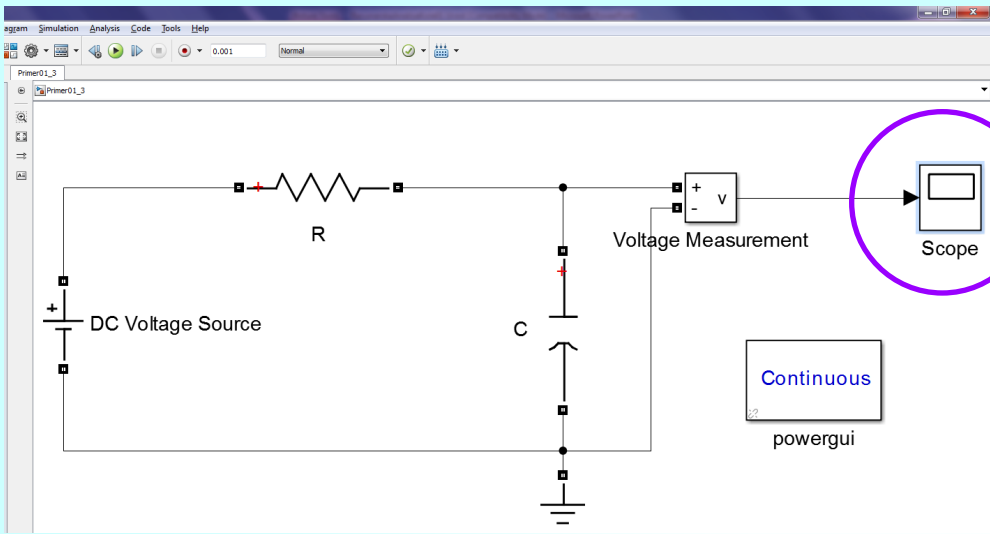
OK Cancel Help Apply

Покретање симулације...



Налажење одзива... Осцилоскоп





Configuration Properties: Scope

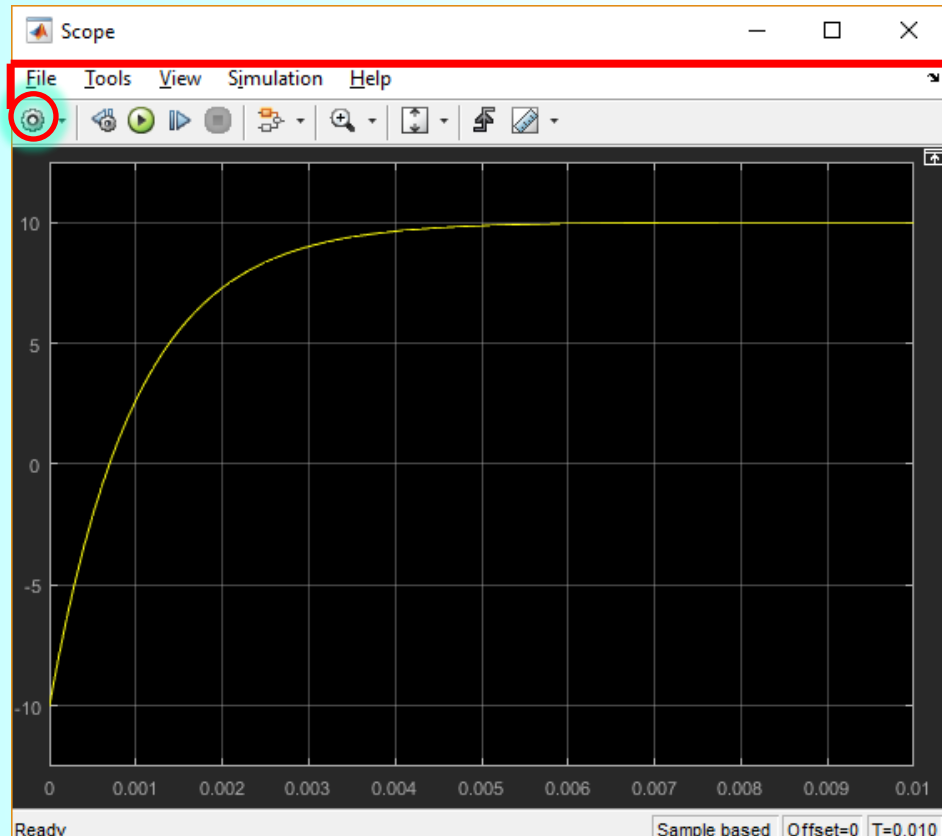
Main Time Display Logging

- 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:

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

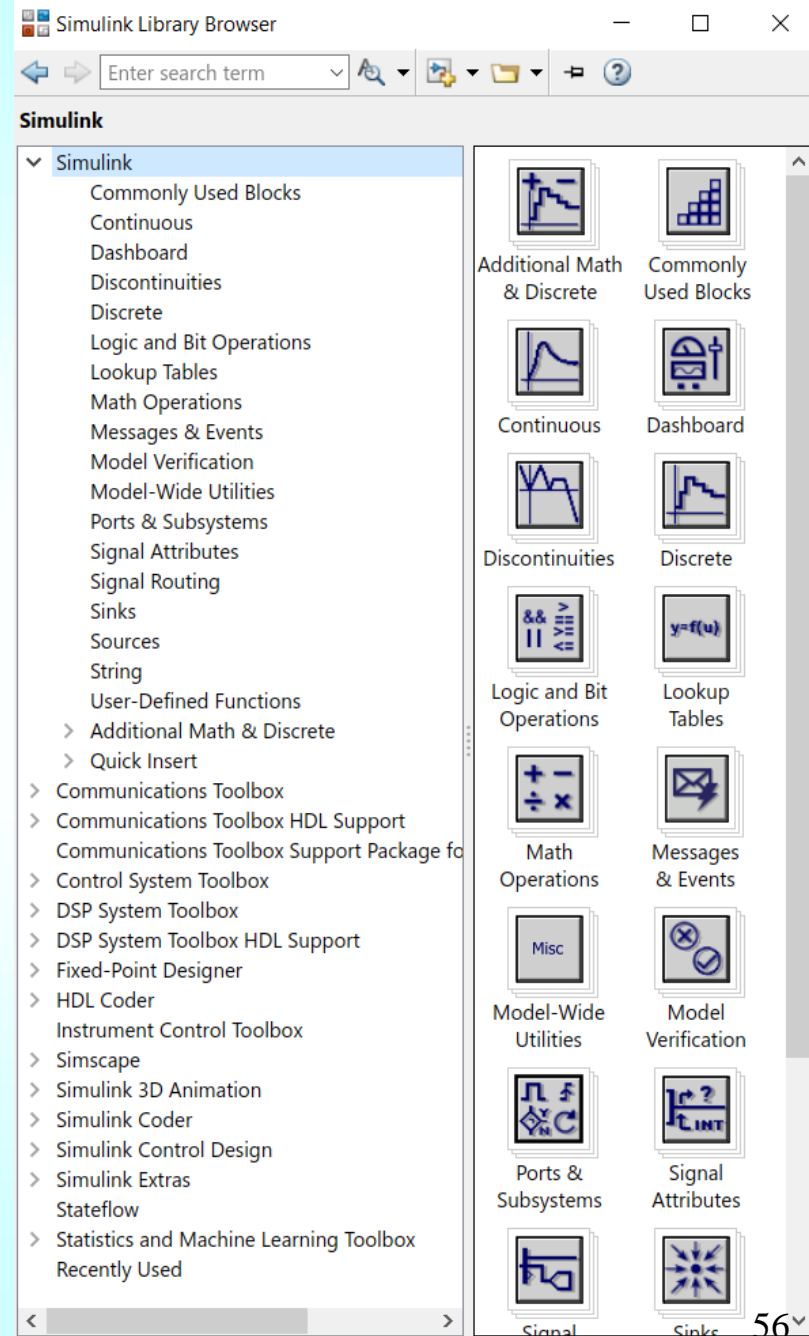
$\tau = RC = 1 \text{ ms}$

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

OK Cancel Help Apply

Simulink

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



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

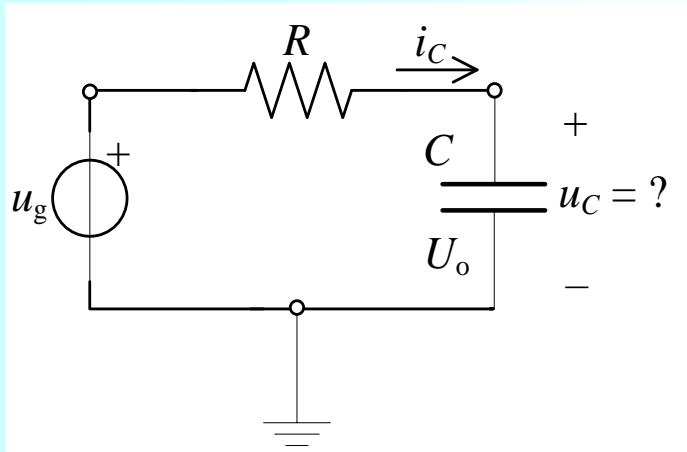
$\dot{x} = Ax + Bu$
 $y = Cx + Du$
 $x|_{t=t_0} = x_0,$

$u(t) \rightarrow$ побуда (улаз)
 $x(t) \rightarrow$ променљива стања
 $x_0 \rightarrow$ променљива стања у тренутку t_0^-

Step1 → State-Space → Scope1

159% ode45

Симулација електричног кола као уопштеног система коришћењем Simulink-а



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

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

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

коло је образовано у тренутку $t_0 = 0$

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

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

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

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

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

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

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

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

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

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

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

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

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

Баста, доцент, 19Е032ПРТК, Универзитет

Симулација електричног кола као уопштеног система коришћењем Simulink-а

Source Block Parameters: Step1

Step

Output a step.

Parameters

Step time:
0

Initial value:
0

Final value:
10

Sample time:
0

Interpret vector parameters as 1-D

Enable zero-crossing detection

OK Cancel Help Apply

Function Block Parameters: State-Space

State Space

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

Parameters

A:
-1000

B:
1000

C:
1

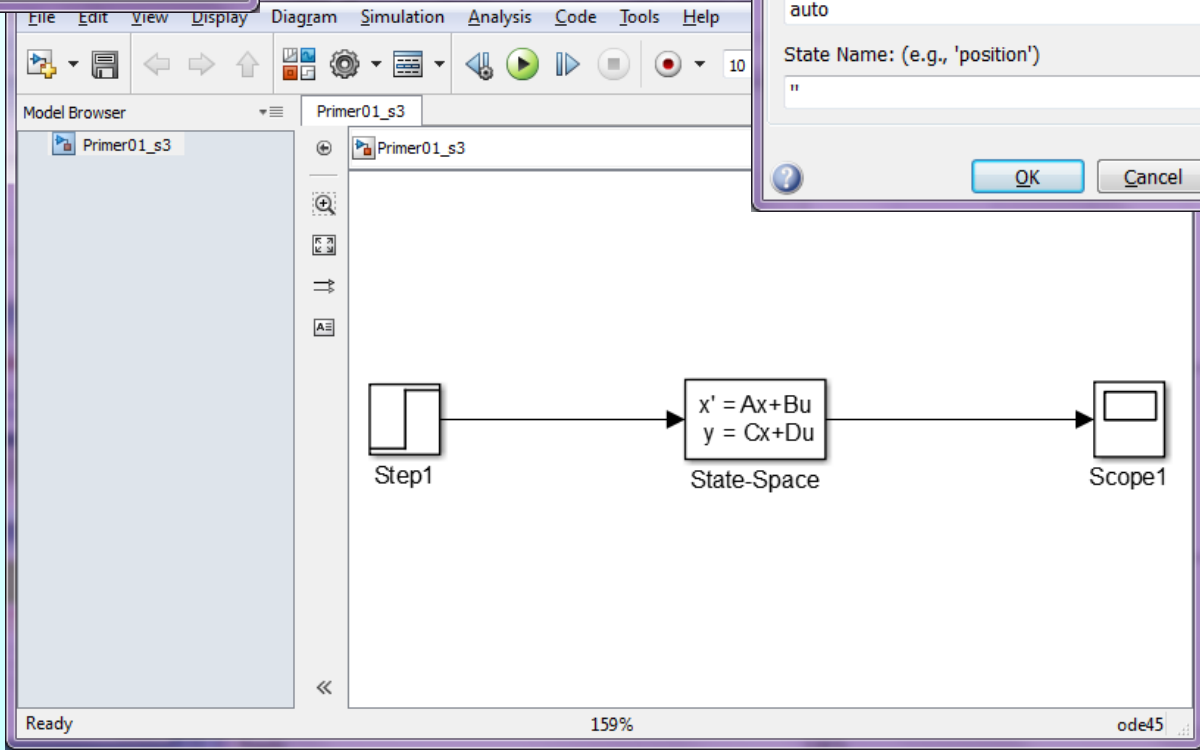
D:
0

Initial conditions:
-10

Absolute tolerance:
auto

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

OK Cancel Help Apply



Баста, доцент, 19E032ПРТК, Универзитет у И

Симулација електричног кола као уопштеног система коришћењем Simulink-а

Function Block Parameters: State-Space

State Space

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

Parameters

A:
-1000

B:
1000

C:
1

D:
0

Initial conditions:
-10

Absolute tolerance:
auto

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

OK Cancel

Source Block Parameters: Step1

Step

Output a step.

Parameters

Step time:
0

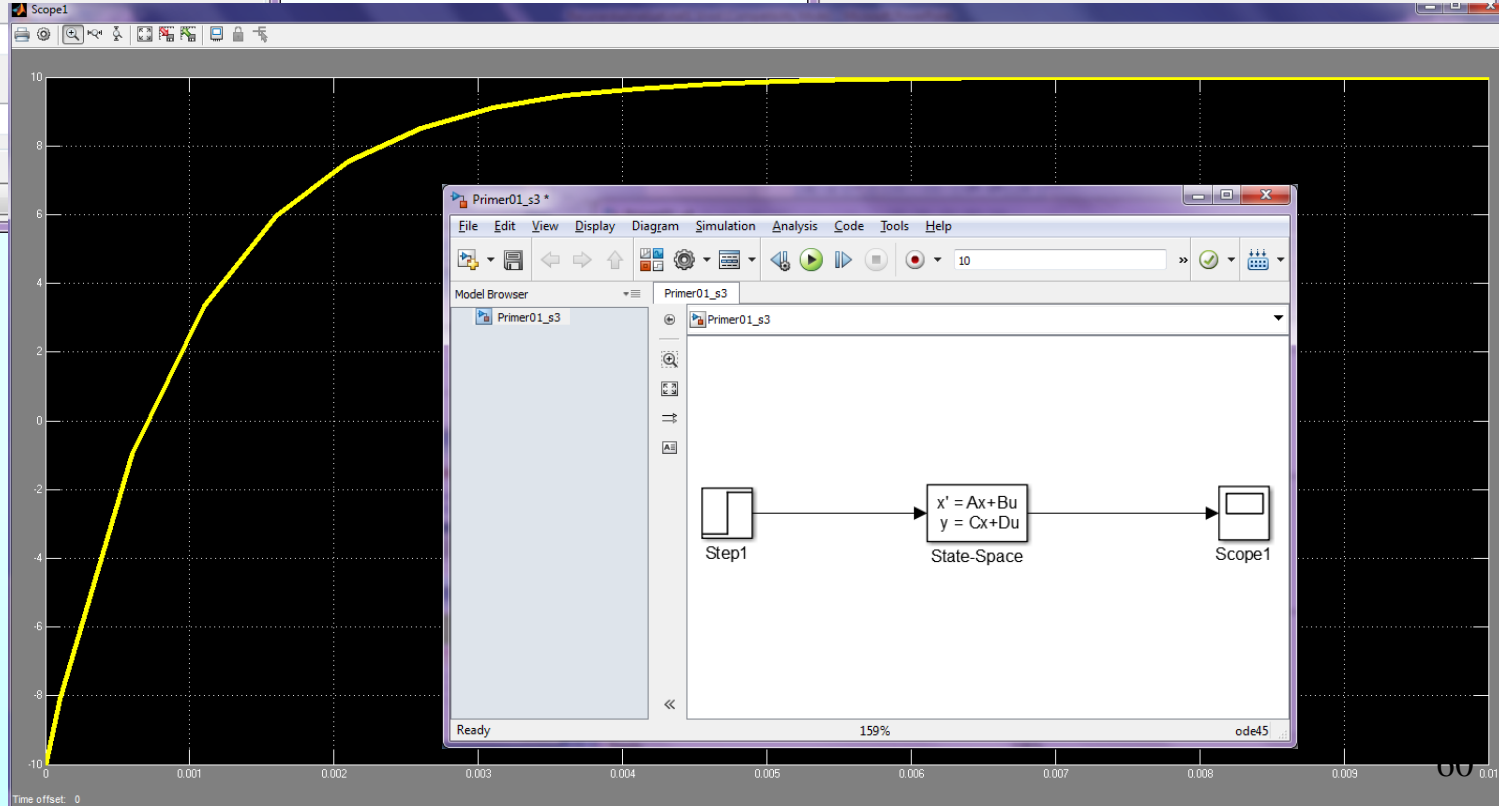
Initial value:
0

Final value:
10

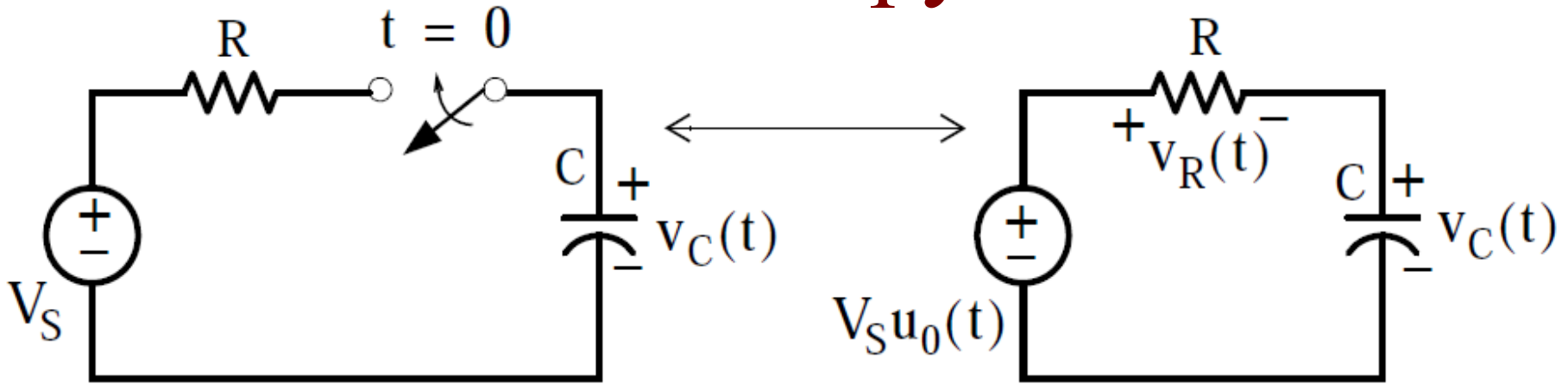
Sample time:
0

Interpret vector parameters as 1-D

Enable zero-crossing detection



Решимо “ручно”



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

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

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

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

$t > 0$

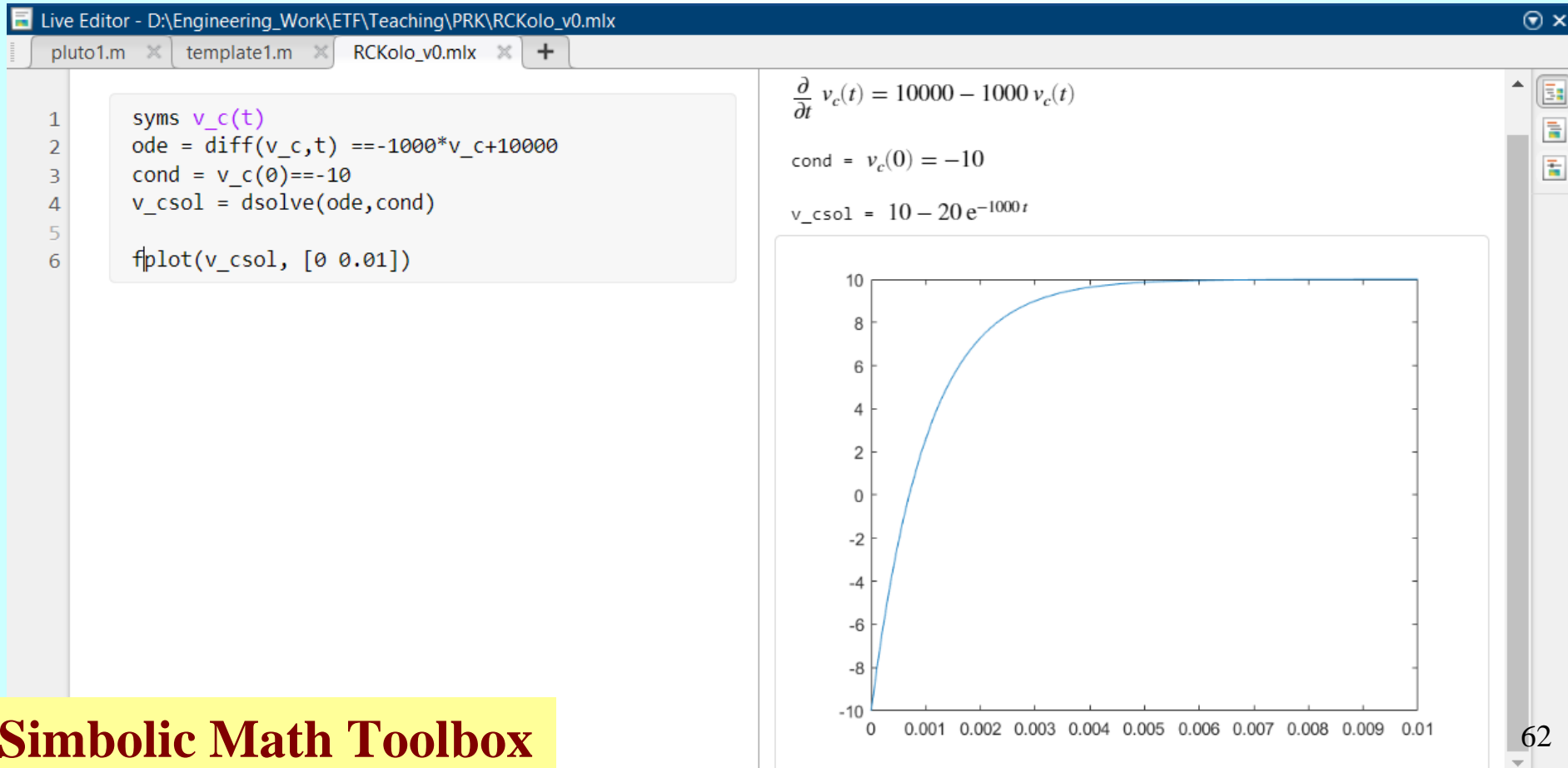
$$RC \frac{dv_C}{dt} + v_C = V_S$$

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

MATLAB

Symbolic Math Toolbox (Live Script)

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



The screenshot displays the MATLAB Live Editor interface. The top window title is "Live Editor - D:\Engineering_Work\ETF\Teaching\PRK\RCKolo_v0.mlx". The editor shows a script with the following code:

```
1 syms v_c(t)
2 ode = diff(v_c,t) == -1000*v_c+10000
3 cond = v_c(0) == -10
4 v_csol = dsolve(ode,cond)
5
6 fplot(v_csol, [0 0.01])
```

The right side of the editor displays the symbolic solution and its plot:

$$\frac{\partial}{\partial t} v_c(t) = 10000 - 1000 v_c(t)$$
$$\text{cond} = v_c(0) = -10$$
$$v_csol = 10 - 20 e^{-1000t}$$

The plot shows the function $v_c(t) = 10 - 20e^{-1000t}$ over the interval $t \in [0, 0.01]$. The x-axis ranges from 0 to 0.01 with major ticks every 0.001. The y-axis ranges from -10 to 10 with major ticks every 2 units. The curve starts at $(0, -10)$ and asymptotically approaches $y = 10$ as t increases.

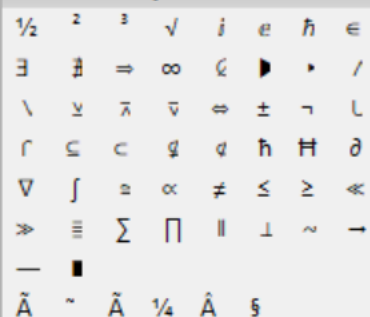
wxMaxima

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) jednacine: [ug=R·iC+uC, iC=C·'diff(uC,t)];
```

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

```
(%i2) jednacineDuC: jednacine, 'diff(uC,t)=DuC;
```

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

```
(%i3) JednacineIzvoda: eliminate(jednacineDuC, [iC]);
```

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

```
(%i4) jednacineStanja: linsolve(JednacineIzvoda, DuC);
```

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

```
(%i5) jednacineDiff: jednacineStanja, DuC='diff(uC, t);
```

```
(%o5) [d/dt uC = (ug - uC) / (C R)]
```

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

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

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

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

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

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

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

