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# Řešení přechodných dějů na transformátoru v nástroji MathWorks MATLAB R2021b

## Cvičení PJS

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FAKULTA ELEKTROTECHNICKÁ  
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# Výpočet přechodného děje na transformátoru

Pro výpočet přechodného děje zapnutí do stavu nakrátko využít simulační nástroj MathWorks MATLAB:

<https://www.mathworks.com/products/matlab.html>

**Math. Graphics. Programming.**

MATLAB is a programming and numeric computing platform used by millions of engineers and scientists to analyze data, develop algorithms, and create models.

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**Inference with the trained network**

```
Let's see how we can infer the network outputs on new data.
imgTestSet = augmentDataAugmentation(Layers(1), InputData, testSetLabels);
predictedLabels = classify(imgTestSet, netTestSet);
accuracy = mean(predictedLabels == testSetLabels);

figure
imshow(imgTestSet{1}, 'Title', 'Predicted Labels');
hold on;
imshow(testSetLabels{1}, 'Title', 'Actual Labels');
title('Accuracy: ' + accuracy);

Let's take a look at a few example images.
idx = 1;
img = imread(imgTestSet{idx});
img = reshape(img, [rows imgTestSet{idx}]);
predicted = imgTestSet{idx};
[prob, labels] = predict(img, net);
[img, scores, predicted, testSetLabels, SDC];
```

**What is MATLAB?** 1:37

**Designed for the way you think  
and the work you do.**

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.

## Professionally Built

MATLAB toolboxes are professionally developed, rigorously tested, and fully documented.

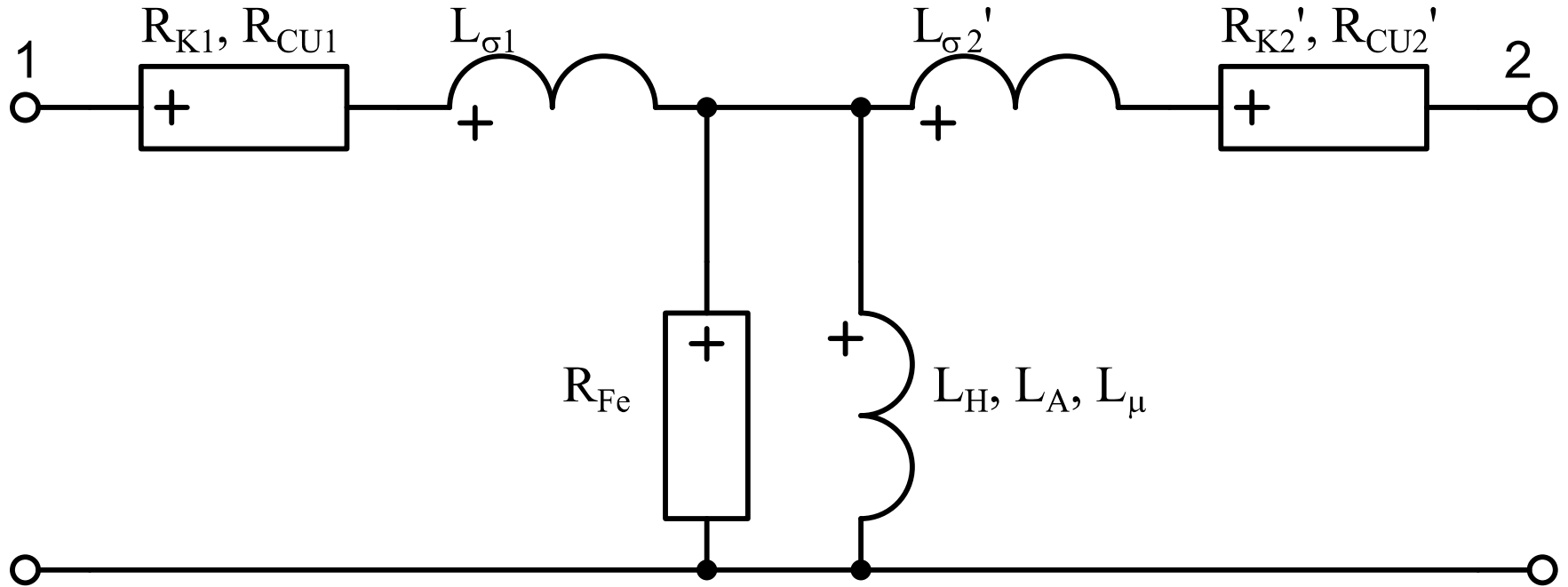
## With Interactive Apps

MATLAB apps let you see how different algorithms work with your data. Iterate until you've got the results you want, then automatically generate a MATLAB program to reproduce or automate your work.

## And the Ability to Scale

Scale your analyses to run on clusters, GPUs, and clouds with only minor code changes. There's no need to rewrite your code or learn big data programming and out-of-memory techniques.

# Náhradní schéma transformátoru



# Parametry transformátoru

$$u_K = 10 \%$$

$$i_0 = 1 \%$$

$$U_{N1} = 110 \text{ kV}$$

$$U_{N2} = 22 \text{ kV}$$

$$S_{NT} = 10 \text{ MVA}$$

$$\Delta P_0 = 0.3 \%$$

$$\Delta P_K = 1.0 \%$$

$$U_{kp} = 10 ;$$

$$I_0p = 1 ;$$

$$U_{n1} = 110 ;$$

$$U_{n2} = 22 ;$$

$$S_{nt} = 10 ;$$

$$dP_0p = 0.3 ;$$

$$dP_{kp} = 1 ;$$

# Parametry transformátoru

$$\omega = 2 \cdot \pi \cdot f$$

$$R_K = r_K Z_{NT} = \frac{\Delta p_{K\%}}{100} \cdot \frac{U_{N1}^2}{S_{NT}}$$

$$R_{K1} = \frac{R_K}{2}$$

$$Z_K = z_K Z_{NT} = \frac{u_{K\%}}{100} \cdot \frac{U_{N1}^2}{S_{NT}}$$

$$X_\sigma = \sqrt{Z_K^2 - R_K^2}$$

$$L_\sigma = \frac{X_\sigma}{\omega} \quad L_{\sigma 1} = \frac{L_\sigma}{2}$$

$$G_{Fe} = g_{Fe} Y_{NT} = \frac{\Delta p_{0\%}}{100} \cdot \frac{S_{NT}}{U_{N1}^2}$$

$$R_{Fe} = G_{Fe}^{-1}$$

$$Y_0 = y_0 Y_{NT} = \frac{i_{0\%}}{100} \cdot \frac{S_{NT}}{U_{N1}^2}$$

$$X_H = \left( \sqrt{Y_0^2 - G_{Fe}^2} \right)^{-1} \quad L_H = \frac{X_H}{\omega}$$

**frekv=50;**

**omega=2\*pi\*frekv;**

**Rk= (dPkp/100) \* (Un1^2/Snt) ;**

**Rk1=Rk/2 ;**

**Zk= (Ukp/100) \* (Un1^2/Snt) ;**

**Xs=sqrt (Zk^2-Rk^2) ;**

**Ls=Xs/omega ;**

**Ls1=Ls/2 ;**

**Gfe= (dP0p/100) \* (Snt/Un1^2) ;**

**Rfe=1/Gfe ;**

**Y0= (I0p/100) \* (Snt/Un1^2) ;**

**Xh=1/sqrt (Y0^2-Gfe^2) ;**

**Lh=Xh/omega ;**

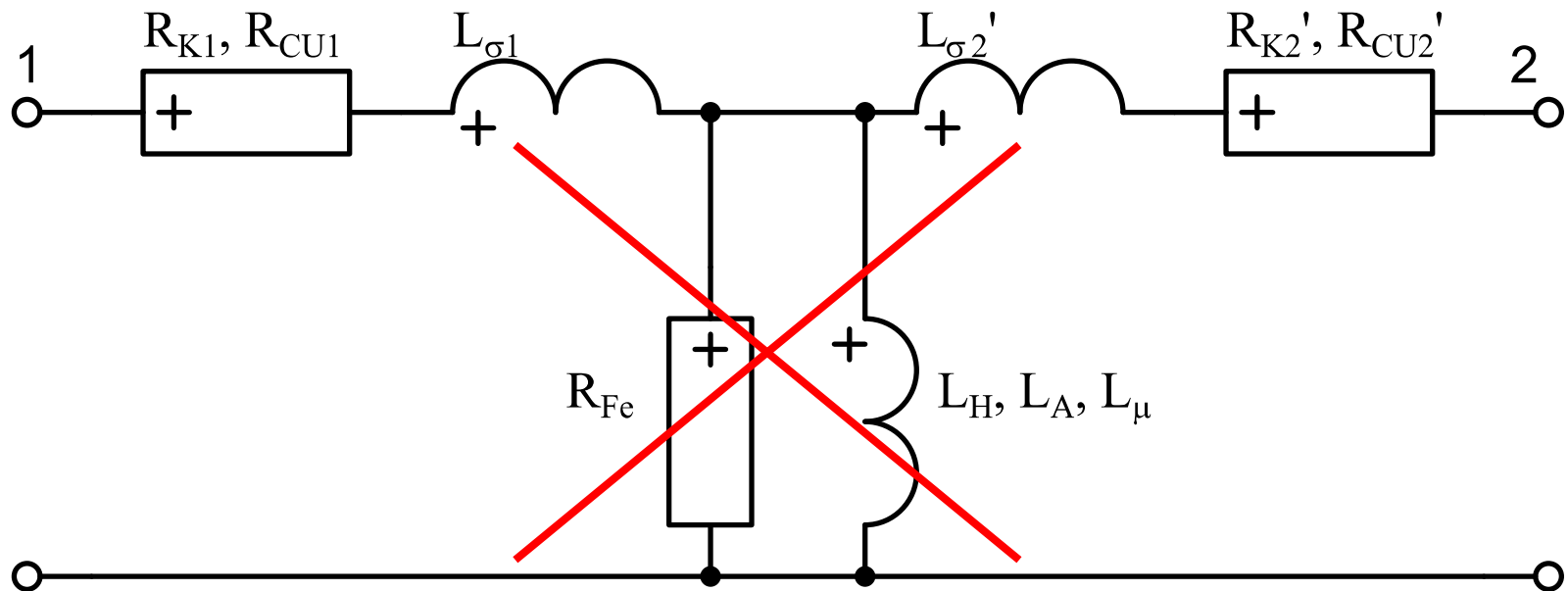
# Transformátor nakrátko

Řešení numerickou metodou se zanedbáním příčné části:

$$L_{\sigma} \frac{di_K}{dt} + i_K \cdot R_K = \frac{u_K [\%]}{100} U_m \sin(\omega \cdot t) \quad U_m = \frac{U_n}{\sqrt{3}} \sqrt{2}$$




$$\frac{di_K}{dt} = \frac{\frac{u_K [\%]}{100} U_m \sin(\omega \cdot t) - i_K \cdot R_K}{L_{\sigma}}$$



# Transformátor nakrátko

Řešení numerickou metodou se zanedbáním příčné části:

$$L_{\sigma} \frac{di_K}{dt} + i_K \cdot R_K = \frac{u_K [\%]}{100} U_m \sin(\omega \cdot t) \quad U_m = \frac{U_n}{\sqrt{3}} \sqrt{2}$$


$$\frac{di_K}{dt} = \frac{\frac{u_K [\%]}{100} U_m \sin(\omega \cdot t) - i_K \cdot R_K}{L_{\sigma}}$$

```
% Reseni prubehu proudu nakratko numerickou metodou
```

```
f1kcc = @(t,y) [(Un1/sqrt(3)*sqrt(2)*Ukp/100*sin(omega*t) - y*Rk) / Ls];
```

```
tspan = 0 : 0.0001 : 0.1;
```

```
y0 = 0;
```

```
[t,y] = ode23(f1kcc, tspan, y0, []);
```

```
plot(t,y);
```

```
grid on;
```

Zpracování pomocí integrační metody pro ODE

# Transformátor nakrátko

The image shows the MATLAB R2021b environment. The Command Window contains the following code:

```
>> Ukp=10;
I0p=1;
Un1=110;
Un2=22;
Snt=10;
>> dP0p=0.3;
dPkp=1;
>> frekv=50;
omega=2*pi*frekv;

Rk=(dPkp/100)*(Un1^2/Snt);
Rk1=Rk/2;
Zk=(Ukp/100)*(Un1^2/Snt);
Xs=sqrt(Zk^2-Rk^2);
Ls=Xs/omega;
Ls1=Ls/2;
>> Gfe=(dP0p/100)*(Snt/Un1^2);
Rfe=1/Gfe;
Y0=(I0p/100)*(Snt/Un1^2);
Xh=1/sqrt(Y0^2-Gfe^2);
Lh=Xh/omega;
>> % Reseni prubehu proudu nakratko
f1kcc = @(t,y) [(Un1/sqrt(3))*sqrt(2)
tspan = 0 : 0.0001 : 0.1;
y0 = 0;
[t,y] = ode23(f1kcc, tspan, y0, []);
>> plot(t,y);
grid on;
fx >>
```

The Workspace window shows the following variables:

Name	Value
C0	7.0808e-04
Ck	0.0739
Deltak	6.6804e-05
dP0p	0.3000
dPcup	1
dPFep	0.3000
dPkp	1
f1kcc	@(t,y)[(Un1/sqrt(3))*s...
frekv	50
Gfe	2.4793e-06
I0c	2.3881e-08 - 5.0069e-...
I0m	7.0808e-04
I0m2	7.0808e-04
I0m3	7.4227e-04
I0p	1
I0t	101x1 double
Ikc	0.0052 - 0.0522i

The Figure 1 window displays a plot of the current  $i_k(t)$  over time  $t$ . The x-axis ranges from 0 to 0.1 seconds, and the y-axis ranges from -0.1 to 0.15. The plot shows a periodic waveform with a period of approximately 0.02 seconds, starting at 0 and reaching a peak of about 0.13 at  $t \approx 0.01$  s.

Zpracování pomocí integrační metody pro ODE

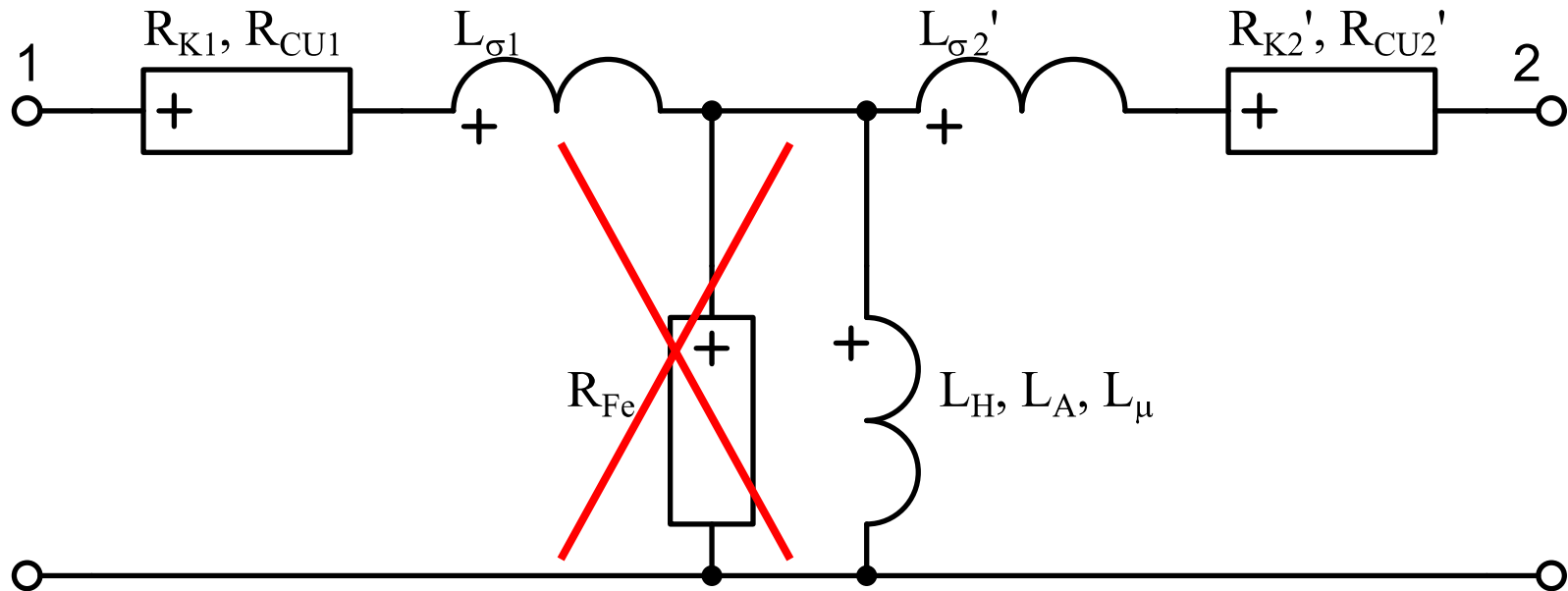


# Transformátor nakrátko

Řešení numerickou metodou bez zanedbání  $L_H$ :

$$\frac{L_\sigma}{2} \frac{di_1}{dt} + i_1 \cdot \frac{R_K}{2} + L_h \frac{di_1}{dt} - L_h \frac{di_2}{dt} = \frac{u_K [\%]}{100} U_m \sin(\omega \cdot t)$$

$$-L_h \frac{di_1}{dt} + L_h \frac{di_2}{dt} + \frac{L_\sigma}{2} \frac{di_2}{dt} + i_2 \cdot \frac{R_K}{2} = 0 \quad \rightarrow$$



# Transformátor nakrátko

Řešení numerickou metodou bez zanedbání  $L_H$ :

$$\frac{L_\sigma}{2} \frac{di_1}{dt} + i_1 \cdot \frac{R_K}{2} + L_h \frac{di_1}{dt} - L_h \frac{di_2}{dt} = \frac{u_K [\%]}{100} U_m \sin(\omega \cdot t)$$
$$- L_h \frac{di_1}{dt} + L_h \frac{di_2}{dt} + \frac{L_\sigma}{2} \frac{di_2}{dt} + i_2 \cdot \frac{R_K}{2} = 0 \quad \rightarrow$$

---

$$P_1 = \frac{L_\sigma}{2} + L_h \quad P_2 = \frac{L_\sigma}{2} + L_h - \frac{L_h^2}{P_1}$$

$$\frac{di_1}{dt} = \frac{\frac{u_K [\%]}{100} U_m \sin(\omega \cdot t) - i_1 \cdot \frac{R_K}{2} - L_h \cdot i_2 \cdot \frac{R_K}{2} \cdot \frac{1}{P_1}}{P_2}$$

$$\frac{di_2}{dt} = \frac{\frac{L_h \cdot \frac{u_K [\%]}{100} U_m \sin(\omega \cdot t)}{P_1} - \frac{L_h \cdot i_1 \cdot \frac{R_K}{2}}{P_1} - i_2 \cdot \frac{R_K}{2}}{P_2}$$

# Transformátor nakrátko

$$P_1 = \frac{L_\sigma}{2} + L_h$$

$$P_2 = \frac{L_\sigma}{2} + L_h - \frac{L_h^2}{P_1}$$

$$\frac{di_1}{dt} = \frac{\frac{u_K[\%]}{100} U_m \sin(\omega \cdot t) - i_1 \cdot \frac{R_K}{2} - L_h \cdot i_2 \frac{R_K}{2} \cdot \frac{1}{P_1}}{P_2}$$

$$\frac{di_2}{dt} = \frac{\frac{L_h \cdot u_K[\%]}{100} U_m \sin(\omega \cdot t) - \frac{L_h \cdot i_1 \cdot \frac{R_K}{2}}{P_1} - i_2 \frac{R_K}{2}}{P_2}$$



```
function ydot = f2(t,y)
```

```
Un1=110;
```

```
Ukp=10;
```

```
Um=Un1/sqrt(3)*sqrt(2);
```

```
omega=314.16;
```

```
Rk = 12.100;
```

```
Ls = 0.38322;
```

```
Lh = 403.75;
```

```
pom1=Ls/2+Lh;
```

```
pom2=Ls/2+Lh-Lh^2/pom1;
```

```
ydot=zeros(2,1);
```

```
ydot(1)=(Ukp/100*Um*sin(omega*t)-y(1)*Rk/2-Lh*y(2)*Rk/2/pom1)/pom2;
```

```
ydot(2)=(Lh*Ukp/100*Um*sin(omega*t)/pom1-Lh*y(1)*Rk/2/pom1-y(2)*Rk/2)/pom2;
```

```
tspan = 0 : 0.0001 : 0.1;
```

```
y0 = [0; 0];
```

```
[t,y] = ode23(@f2, tspan, y0, []);
```

```
plot(t,y(:,1),t,y(:,2));
```

```
grid on;
```

Zpracování pomocí integrační metody pro ODE

# Transformátor nakrátko

The image shows the MATLAB R2021b environment. The Command Window contains the following code:

```
>> tspan = 0 : 0.0001 : 0.1;  
>> y0 = [0; 0];  
[t,y] = ode23(@f2, tspan, y0, []);  
  
plot(t,y(:,1),t,y(:,2));  
grid on;  
>>
```

The Figure window displays a plot of the solution. The x-axis represents time  $t$  from 0 to 0.1, and the y-axis represents the state variables from -0.1 to 0.15. The plot shows a damped sinusoidal signal with a peak amplitude of approximately 0.13 and a period of about 0.02 seconds.

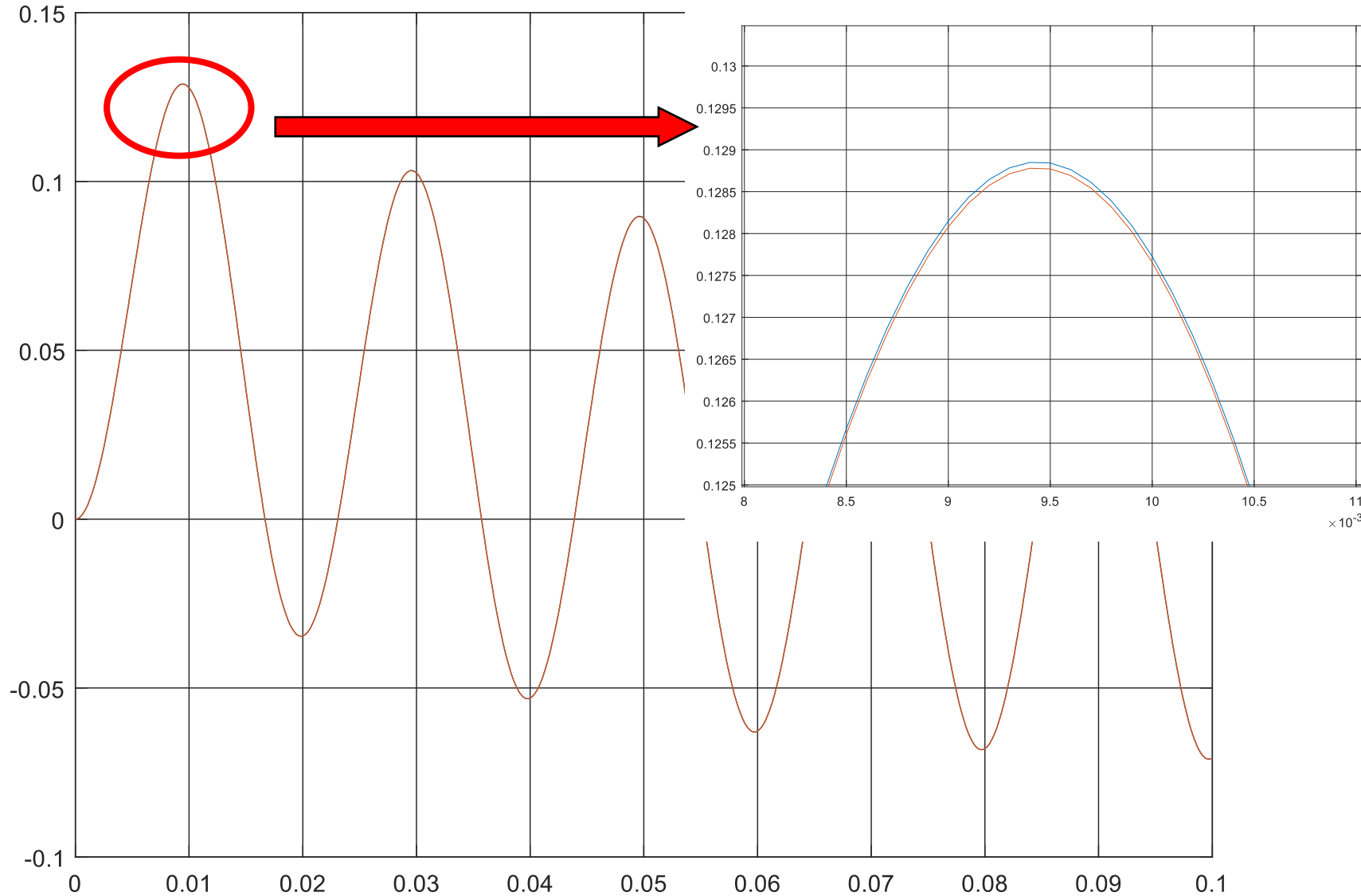
The Workspace window shows the following variables:

Name	Value
C0	7.0808e-04
Ck	0.0739
DeltaIk	6.6804e-05
dP0p	0.3000
dPcup	1
dPfep	0.3000
dPkp	1
f1kcc	@(t,y)[(Un1/sqrt(3))*s...
frekv	50
Gfe	2.4793e-06
I0c	2.3881e-08 - 5.0069e-...
I0m	7.0808e-04
I0m2	7.0808e-04
I0m3	7.4227e-04
I0p	1
I0t	101x1 double
Ikcc	0.0052 - 0.0522i

Zpracování pomocí integrační metody pro ODE

# Transformátor nakrátko

Řešení numerickou metodou bez zanedbání  $L_H$ :



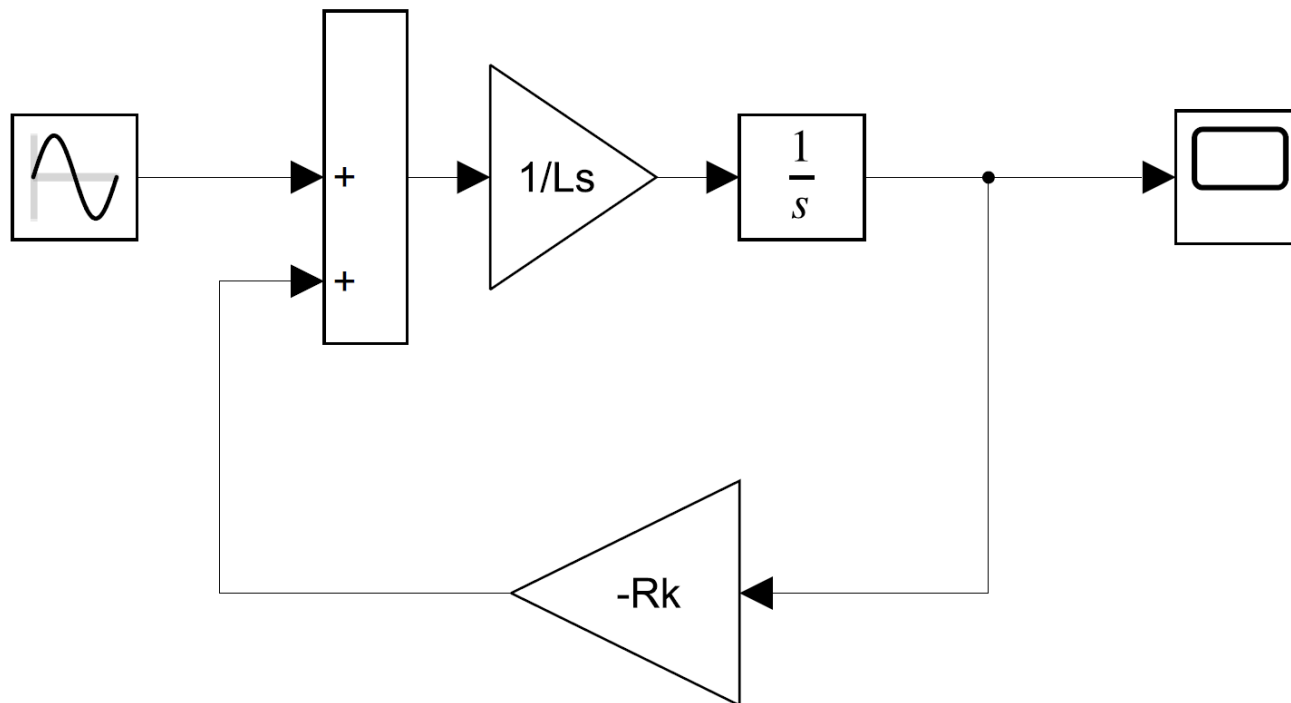
Zpracování pomocí integrační metody pro ODE

# Transformátor nakrátko

$$L_{\sigma} \frac{di_K}{dt} + i_K \cdot R_K = \frac{u_K [\%]}{100} U_m \sin(\omega \cdot t)$$

$$U_m = \frac{U_n}{\sqrt{3}} \sqrt{2}$$

➔ 
$$\frac{di_K}{dt} = \frac{\frac{u_K [\%]}{100} U_m \sin(\omega \cdot t) - i_K \cdot R_K}{L_{\sigma}}$$



Zpracování pomocí bloků nástroje Simulink

# Transformátor nakrátko

The image shows the MATLAB Simulink environment. The main workspace contains a Simulink model for a transformer. The model consists of the following blocks and connections:

- An input sine wave block.
- A summing junction (+) that adds the input signal to a feedback signal.
- A  $1/Ls$  block representing the primary winding inductance.
- A  $1/s$  block representing the primary winding flux.
- A feedback loop containing a  $-Rk$  block (representing the secondary winding resistance) and a summing junction (+) that subtracts the secondary current from the primary current.
- A scope block connected to the output of the  $1/s$  block.

The Scope window displays the output signal, which is a yellow sine wave. The x-axis represents time from 0 to 0.1 seconds, and the y-axis represents the signal amplitude from -0.05 to 0.15. A red arrow points from the scope block in the Simulink model to the Scope window.

The MATLAB Command Window at the bottom left shows the following variables:

Variable	Value
dPkp	1
f1kcc	@(t,y)[(Un1/sqrt(3))*s...
frekv	50
Gfe	2.4793e-06
I0c	2.3881e-08 - 5.0069e-...
I0m	7.0808e-04
I0m2	7.0808e-04
I0m3	7.4227e-04
I0p	1
I0t	101x1 double
Ikc	0.0052 - 0.0522i

Zpracování pomocí bloků nástroje Simulink

# Transformátor nakrátko

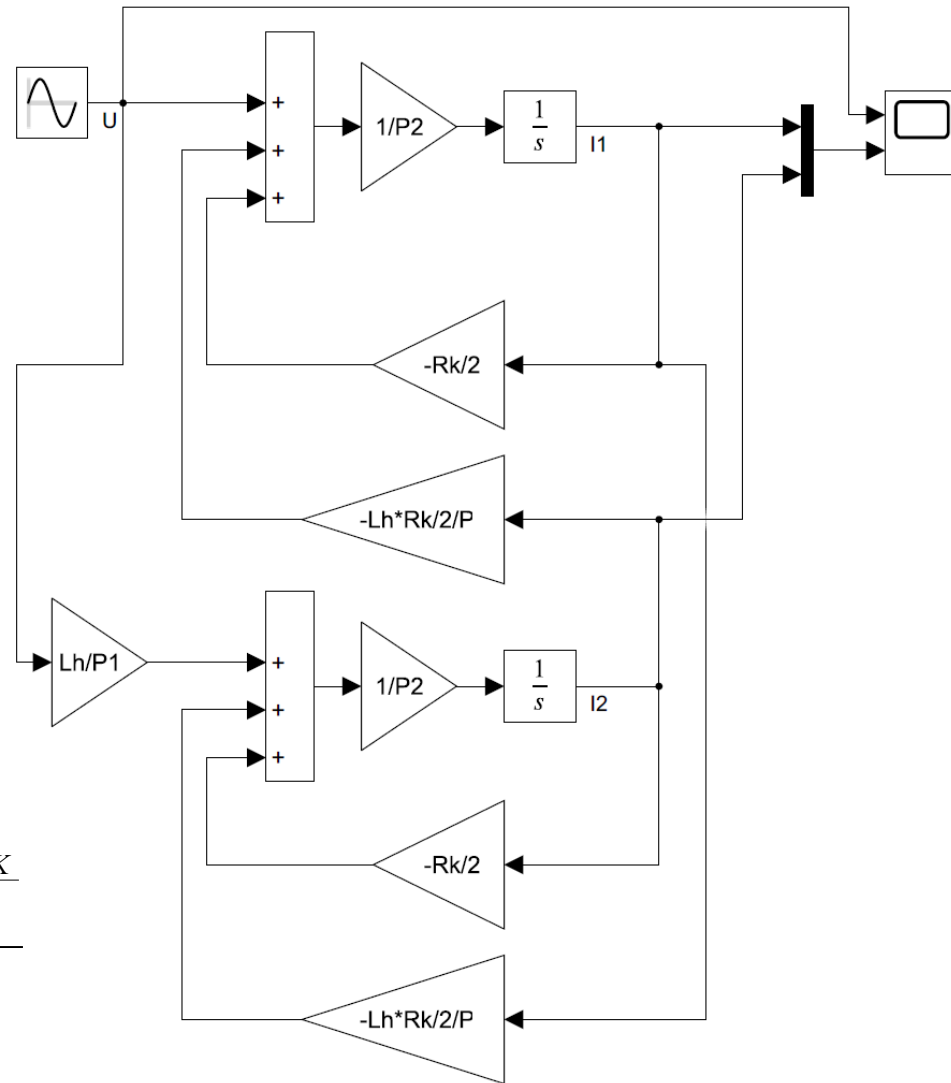
Řešení numerickou metodou bez zanedbání  $L_H$ :

$$P_1 = \frac{L_\sigma}{2} + L_h$$

$$P_2 = \frac{L_\sigma}{2} + L_h - \frac{L_h^2}{P_1}$$

$$\frac{di_1}{dt} = \frac{\frac{u_K [\%]}{100} U_m \sin(\omega \cdot t) - i_1 \cdot \frac{R_K}{2} - L_h \cdot i_2 \frac{R_K}{2} \cdot \frac{1}{P_1}}{P_2}$$

$$\frac{di_2}{dt} = \frac{\frac{L_h \cdot u_K [\%]}{100} U_m \sin(\omega \cdot t) - \frac{L_h \cdot i_1 \cdot \frac{R_K}{2}}{P_1} - i_2 \frac{R_K}{2}}{P_2}$$



Zpracování pomocí bloků nástroje Simulink



# Transformátor nakrátko

The image displays the MATLAB R2021b Simulink environment. The main window shows a Simulink model titled "Nakratko2" (Short Circuit). The model consists of two parallel branches, each representing a transformer winding. Each branch starts with an input voltage source  $U$  connected to a summing junction. The summing junction also receives feedback signals from the secondary side of the transformer. The feedback signals are:  $-Rk/2$  (resistance drop) and  $-Lh \cdot Rk/2/P1$  (leakage inductance drop). The summing junction output is multiplied by  $1/P2$  and then integrated ( $1/s$ ) to produce the primary current  $I1$ . The secondary current  $I2$  is also produced by a similar branch, with a primary current feedback signal  $Lh/P1$  added to the summing junction. The primary current  $I1$  and secondary current  $I2$  are measured and displayed on a Scope block.

The Command Window shows the following MATLAB code:

```
>> P1=Ls/2+Lh;  
>> P2=Ls/2+Lh-Lh^2/P1;  
>>
```

The Scope window displays two plots. The top plot shows the primary current  $I1$  (yellow line) over time, which is a sinusoidal wave with an amplitude of approximately 9. The bottom plot shows the secondary current  $I2$  (blue line) over time, which is a sinusoidal wave with an amplitude of approximately 0.13. The x-axis for both plots is time in seconds, ranging from 0 to 0.1. The simulation is sample-based with a time step  $T=0.100$ .

Zpracování pomocí bloků nástroje Simulink

# Transformátor nakrátko

Řešení implicitní numerickou metodou bez zanedbání  $L_H$ :

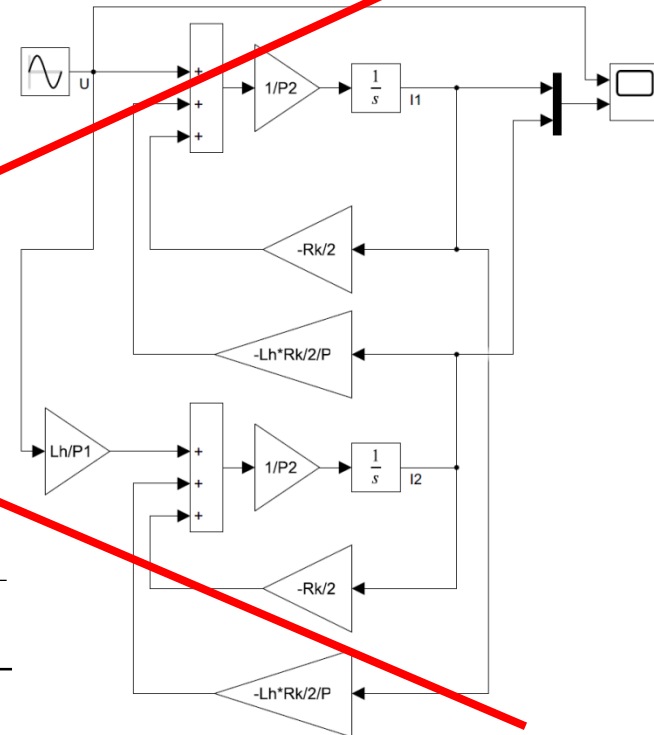
$$\frac{L_\sigma}{2} \frac{di_1}{dt} + i_1 \cdot \frac{R_K}{2} + L_h \frac{di_1}{dt} - L_h \frac{di_2}{dt} = \frac{u_K [\%]}{100} U_m \sin(\omega \cdot t)$$

$$-L_h \frac{di_1}{dt} + L_h \frac{di_2}{dt} + \frac{L_\sigma}{2} \frac{di_2}{dt} + i_2 \cdot \frac{R_K}{2} = 0 \quad \rightarrow$$

$$P_1 = \frac{L_\sigma}{2} + L_h \qquad P_2 = \frac{L_\sigma}{2} + L_h - \frac{L_h^2}{P_1}$$

$$\frac{di_1}{dt} = \frac{\frac{u_K [\%]}{100} U_m \sin(\omega \cdot t) - i_1 \cdot \frac{R_K}{2} - L_h \cdot i_2 \cdot \frac{R_K}{2} \cdot \frac{1}{P_1}}{P_2}$$

$$\frac{di_2}{dt} = \frac{L_h \cdot \frac{u_K [\%]}{100} U_m \sin(\omega \cdot t)}{P_1} - \frac{L_h \cdot i_1 \cdot \frac{R_K}{2}}{P_1} - i_2 \cdot \frac{R_K}{2}$$



# Transformátor nakrátko

Řešení implicitní numerickou metodou bez zanedbání  $L_H$ :

$$L_{\sigma 1} \frac{di_1}{dt} + i_1 \cdot R_{K1} + L_h \frac{di_1}{dt} - L_h \frac{di_2}{dt} = U_{km} \sin(\omega \cdot t)$$

$$U_{km} = \frac{u_K [\%]}{100} U_m$$

$$-L_h \frac{di_1}{dt} + L_h \frac{di_2}{dt} + L_{\sigma 1} \frac{di_2}{dt} + i_2 \cdot R_{K1} = 0 \quad \rightarrow$$

---

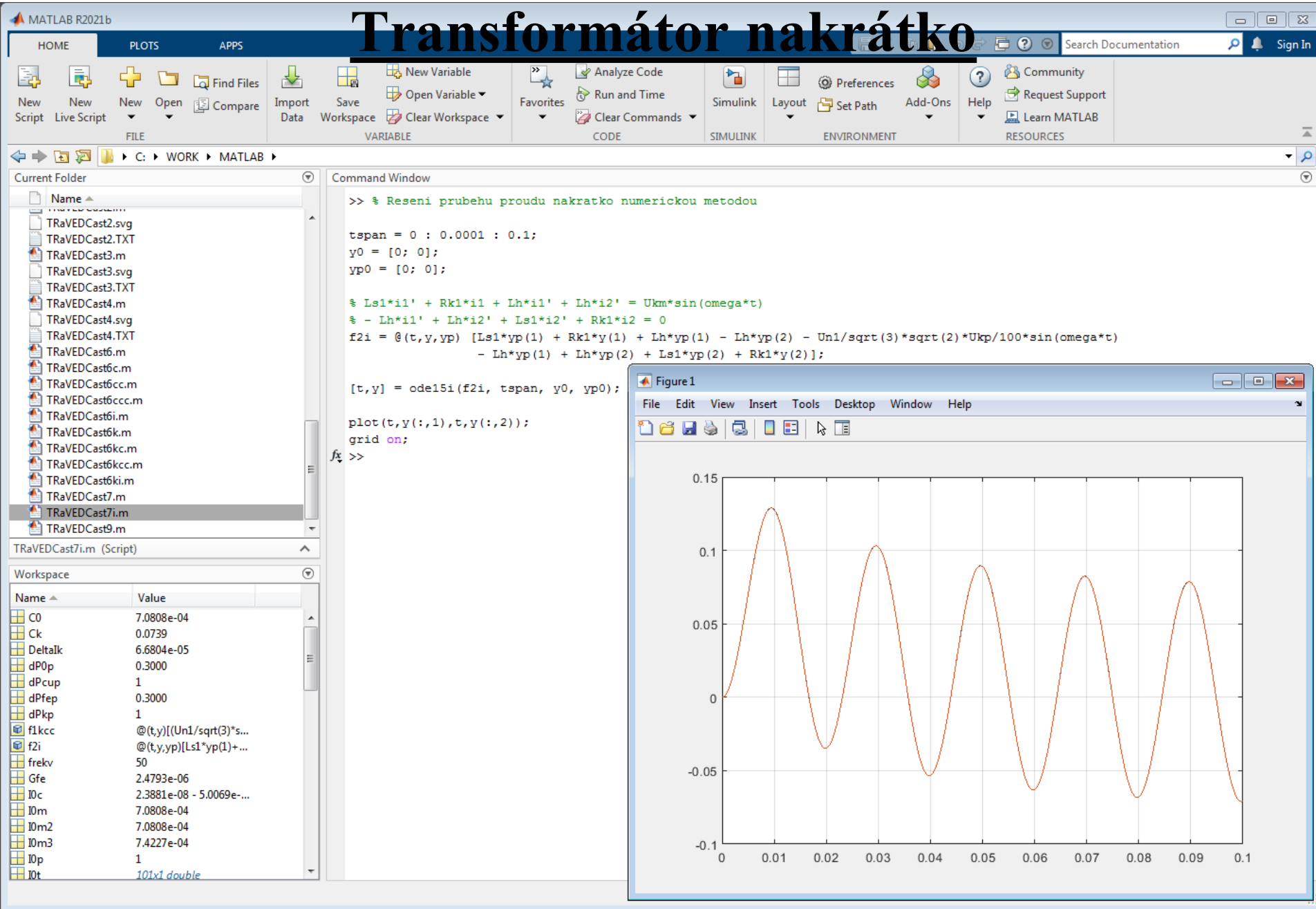
```
Ukm=Ukp/100*Un1/sqrt(3)*sqrt(2);
tspan = 0 : 0.0001 : 0.1;
y0 = [0; 0];
yp0 = [0; 0];

% Ls1*i1' + Rk1*i1 + Lh*i1' + Lh*i2' = Ukm*sin(omega*t)
% - Lh*i1' + Lh*i2' + Ls1*i2' + Rk1*i2 = 0
f2i = @(t,y,yp) [Ls1*yp(1) + Rk1*y(1) + Lh*yp(1) - Lh*yp(2) - Ukm*sin(omega*t)
                - Lh*yp(1) + Lh*yp(2) + Ls1*yp(2) + Rk1*y(2)];
[t,y] = ode15i(f2i, tspan, y0, yp0);

plot(t,y(:,1),t,y(:,2));
grid on;
```

Zpracování pomocí soustavy implicitních diferenciálních rovnic

# Transformátor nakrátko



The image displays the MATLAB R2021b environment. The Command Window contains the following code:

```
>> % Reseni prubehu proudu nakratko numerickou metodou

tspan = 0 : 0.0001 : 0.1;
y0 = [0; 0];
yp0 = [0; 0];

% Ls1*i1' + Rk1*i1 + Lh*i1' + Lh*i2' = Ukm*sin(omega*t)
% - Lh*i1' + Lh*i2' + Ls1*i2' + Rk1*i2 = 0
f2i = @(t,y,yp) [Ls1*yp(1) + Rk1*y(1) + Lh*yp(1) - Lh*yp(2) - Un1/sqrt(3)*sqrt(2)*Ukp/100*sin(omega*t)
                - Lh*yp(1) + Lh*yp(2) + Ls1*yp(2) + Rk1*y(2)];

[t,y] = ode15i(f2i, tspan, y0, yp0);

plot(t,y(:,1),t,y(:,2));
grid on;
>>
```

The Workspace window shows the following variables:

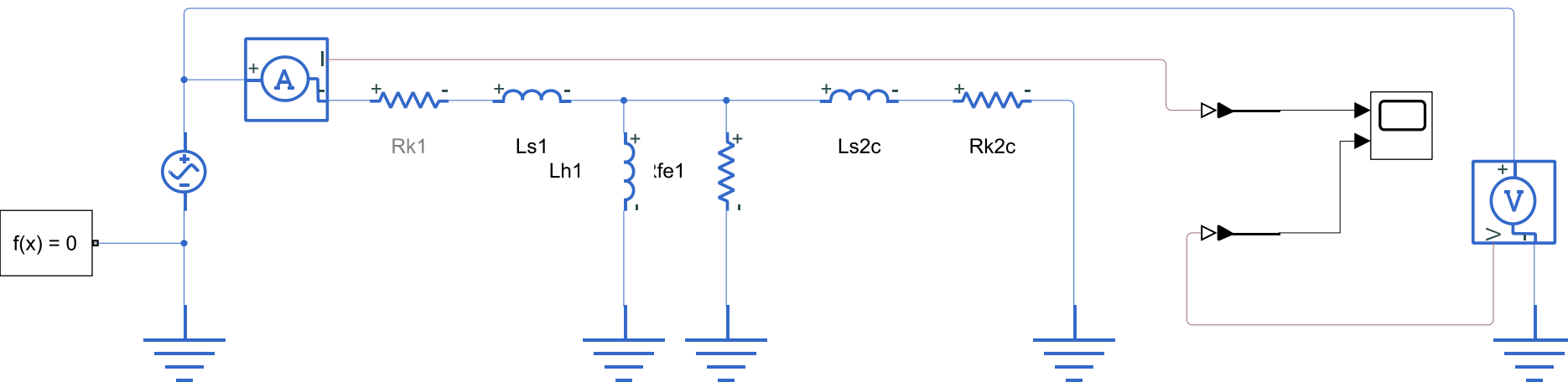
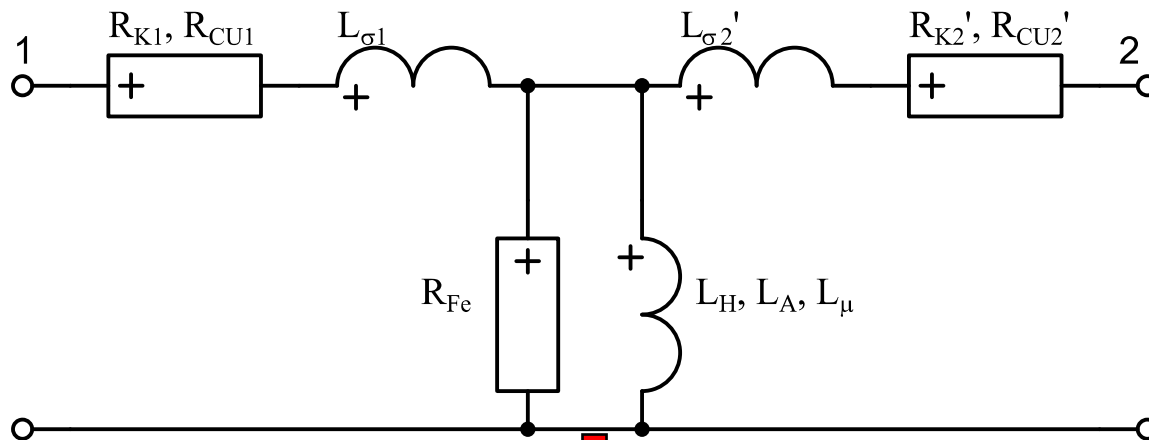
Name	Value
C0	7.0808e-04
Ck	0.0739
DeltaIk	6.6804e-05
dP0p	0.3000
dPcup	1
dPfep	0.3000
dPkp	1
f1kcc	@(t,y)[(Un1/sqrt(3))*s...
f2i	@(t,y,yp)[Ls1*yp(1)+...
frekv	50
Gfe	2.4793e-06
I0c	2.3881e-08 - 5.0069e-...
I0m	7.0808e-04
I0m2	7.0808e-04
I0m3	7.4227e-04
I0p	1
I0t	101x1 double

The Figure1 window displays a plot of the current waveforms. The x-axis represents time (t) from 0 to 0.1 seconds, and the y-axis represents current (y) from -0.1 to 0.15. The plot shows two oscillating waveforms: a primary current (y(:,1)) and a secondary current (y(:,2)). The primary current has a peak amplitude of approximately 0.13 A, and the secondary current has a peak amplitude of approximately 0.10 A. Both waveforms are sinusoidal and in phase.

Zpracování pomocí soustavy implicitních diferenciálních rovnic

# Transformátor nakrátko

Řešení numerickou metodou s kompletní topologií:



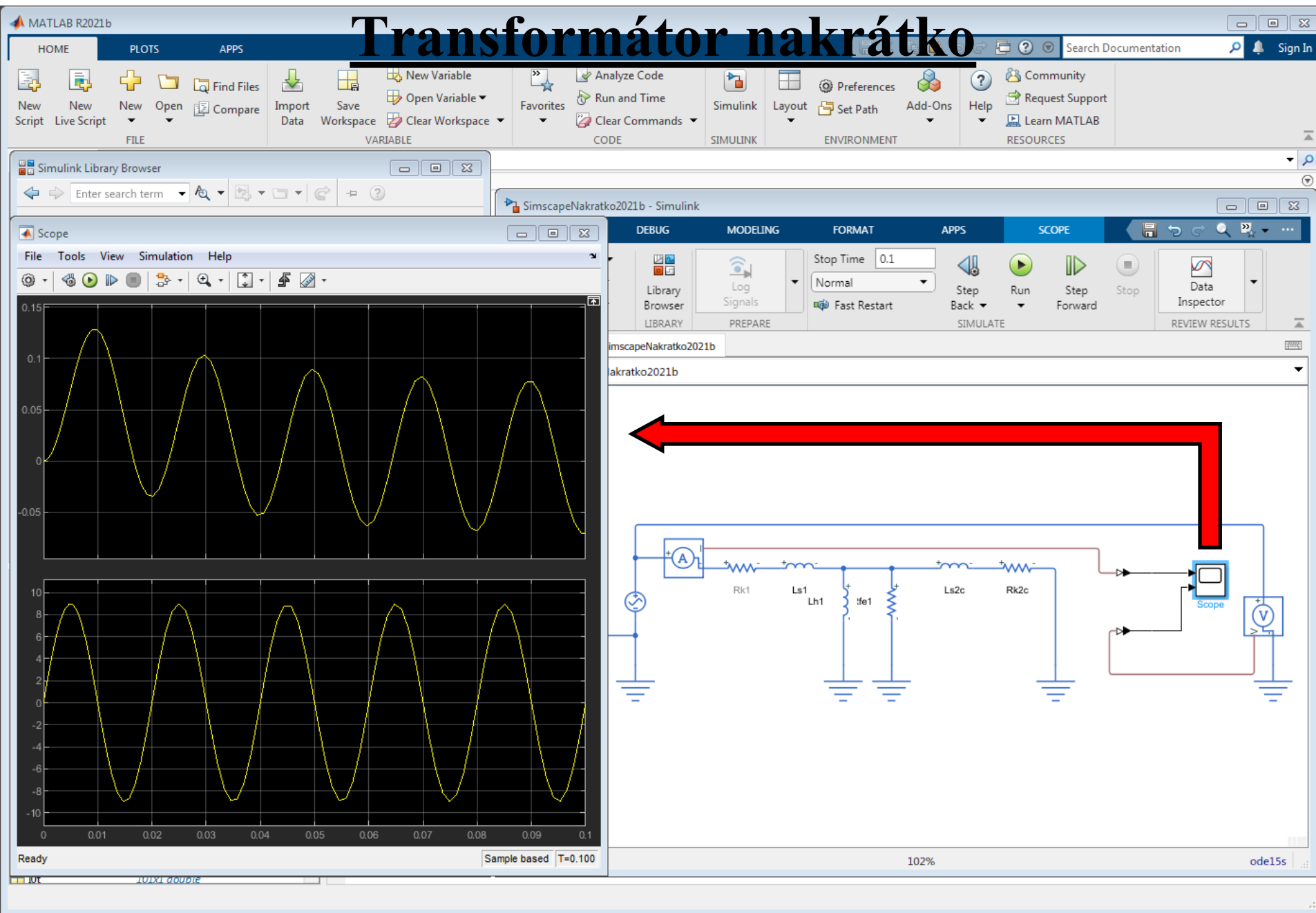
Zpracování pomocí obvodového schéma nástroje Simscape

# Transformátor nakrátko

The image displays the MATLAB R2021b Simulink environment. The main window, titled "SimscapeNakratko - Simulink", shows a circuit diagram of a transformer short-circuit model. The circuit includes an AC voltage source, an ammeter (A), a resistor  $R_{k1}$ , an inductor  $L_{s1}$  in series with an inductor  $L_{h1}$  in parallel, a transformer core model  $tf_{e1}$ , another inductor  $L_{s2}$  in series with a resistor  $R_{k2}$  in parallel, and a voltmeter (V) connected across the secondary terminals. The simulation toolbar is visible at the top, and the Simulink Library Browser is open on the left, showing the "Electrical Elements" category.

Zpracování pomocí obvodového schéma nástroje Simscape

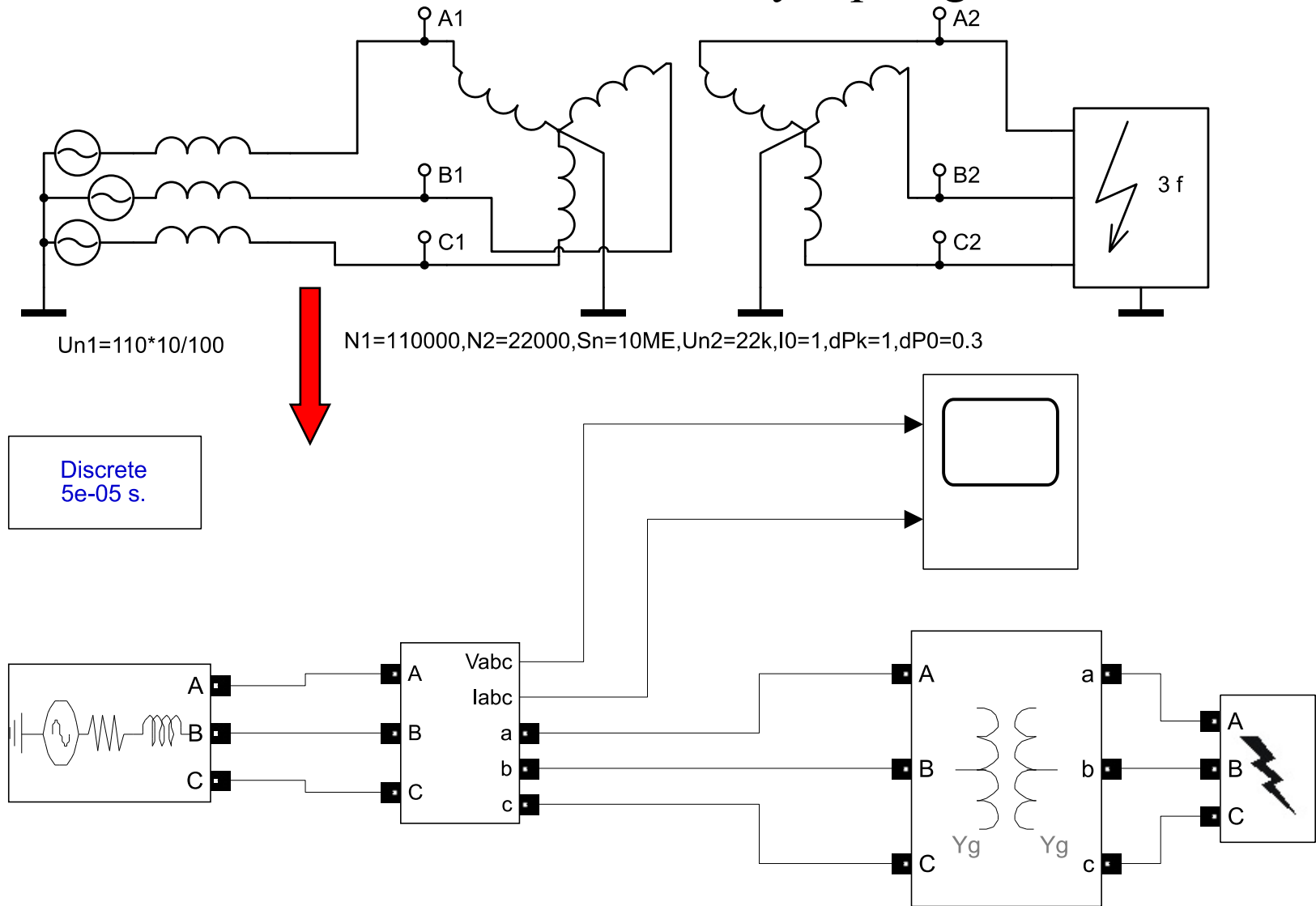
# Transformátor nakrátko



Zpracování pomocí obvodového schéma nástroje Simscape

# Transformátor nakrátko

Řešení numerickou metodou 3f varianty topologie:



Zpracování pomocí nástroje Simscape a knihovny SimPowerSystems



# Transformátor nakrátko

Block Parameters: Three-Phase Transformer (Two Windings)

Three-Phase Transformer (Two Windings) (mask) (link)

This block implements a three-phase transformer by using three single-phase transformers. Set the winding connection to 'Yn' when you want to access the neutral point of the Wye.

Click the Apply or the OK button after a change to the Units popup to confirm the conversion of parameters.

Configuration Parameters Advanced

Units pu

Nominal power and frequency [ Pn(VA), fn(Hz) ] [ Snt\*1e6, frekv ]

Winding 1 parameters [ V1 Ph-Ph(Vrms), R1(pu), L1(pu) ] [ Un1\*1e3, Rk1/Znt, Xs1/Znt ]

Winding 2 parameters [ V2 Ph-Ph(Vrms), R2(pu), L2(pu) ] [ Un2\*1e3, Rk1/Znt, Xs1/Znt ]

Magnetization resistance Rm (pu) Rfe/Znt

Magnetization inductance Lm (pu) Xh/Znt

Saturation characteristic [ i1, phi1 ; i2, phi2 ; ... ] (pu) [ 0,0 ; 0.0024,1.2 ; 1.0,1.52 ]

OK Cancel Help Apply

Discrete 5e-05 s.

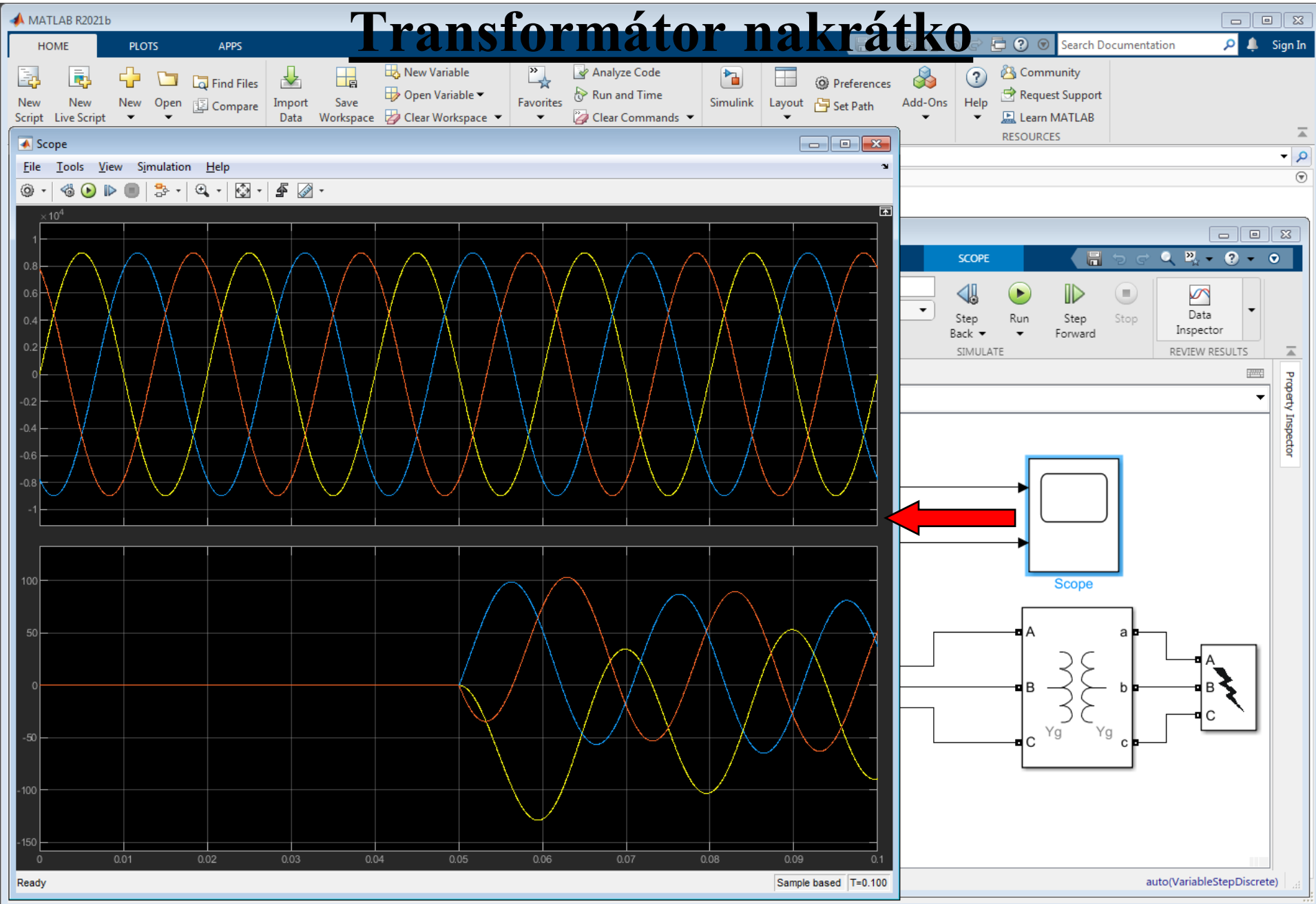
Vabc labc

Three-Phase Transformer (Two Windings)

$Z_{nt} = U_{n1}^2 / S_{nt}$

Zpracování pomocí nástroje Simscape a knihovny SimPowerSystems

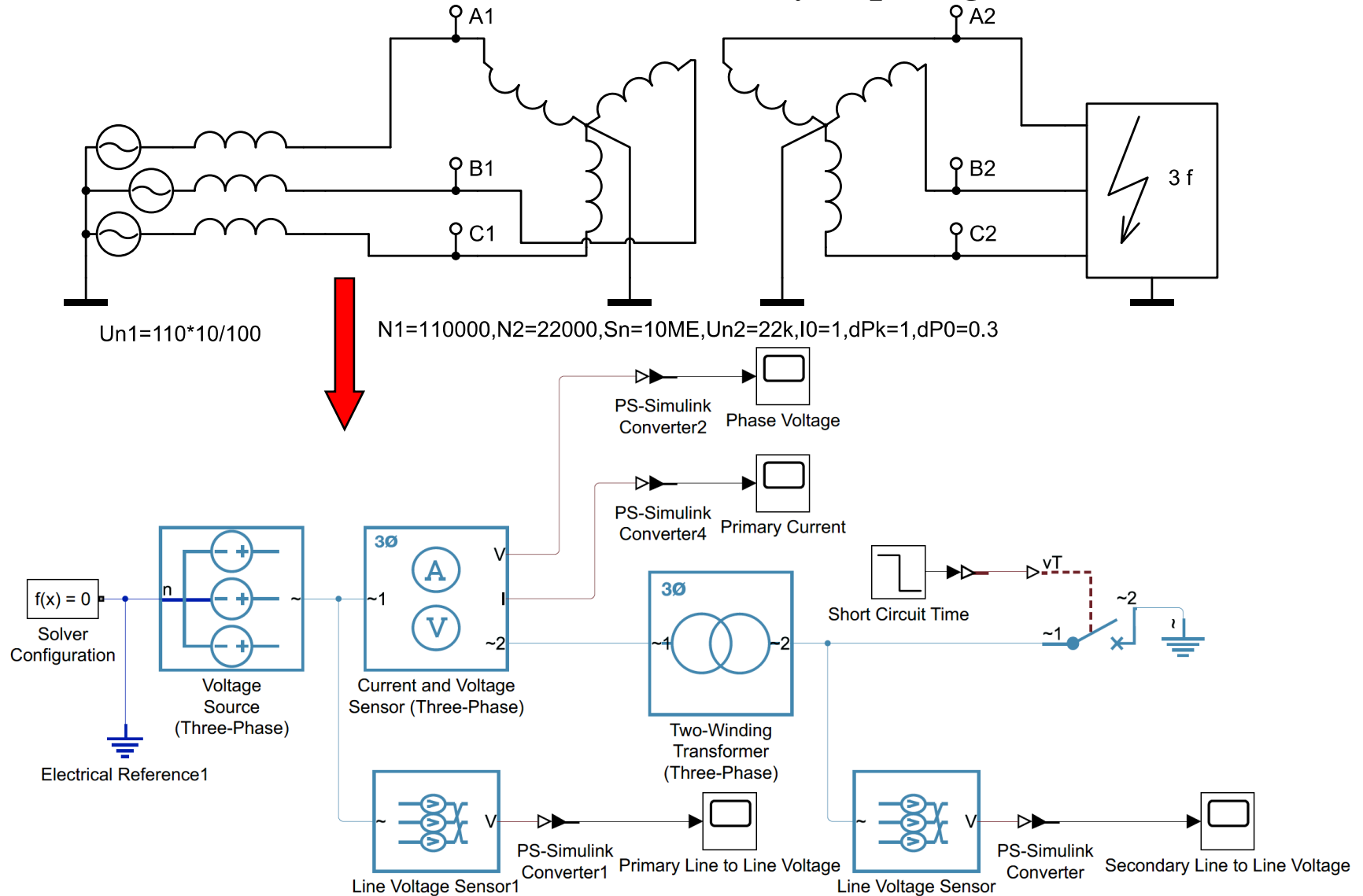
# Transformátor nakrátko



Zpracování pomocí nástroje Simscape a knihovny SimPowerSystems

# Transformátor nakrátko

Řešení numerickou metodou 3f varianty topologie:



Zpracování pomocí nástroje Simscape Electrical verze R2021b

# Transformátor nakrátko

The image displays the MATLAB R2021b Simulink environment. On the left, the Simulink Library Browser shows the 'Transformers' block in the 'Simscape/Electrical/Passive' category. The main workspace shows a Simulink model of a transformer circuit. A 'Block Parameters: Two-Winding Transformer (Three-Phase)' dialog box is open, showing the following settings:

- Rated apparent power:  $S_{nt} * 1E6$  (A\*V)
- Rated electrical frequency:  $freqv$  (Hz)
- Winding 1 connection type: Wye with grounded neutral
- Primary rated voltage:  $Un1$  (kV)
- Winding 2 connection type: Wye with grounded neutral
- Secondary rated voltage:  $Un2$  (kV)
- Core type: Three-phase three-limb

A red arrow points to the 'OK' button in the dialog box. The background model includes components like 'PS-Simulink Converter2', 'PS-Simulink Converter4', 'Line Voltage Sensor1', and 'Line Voltage Sensor'. A 'Short Circuit Time' block is also visible, connected to the transformer's secondary side.

Zpracování pomocí nástroje Simulink Electrical verze R2021b

# Transformátor nakrátko

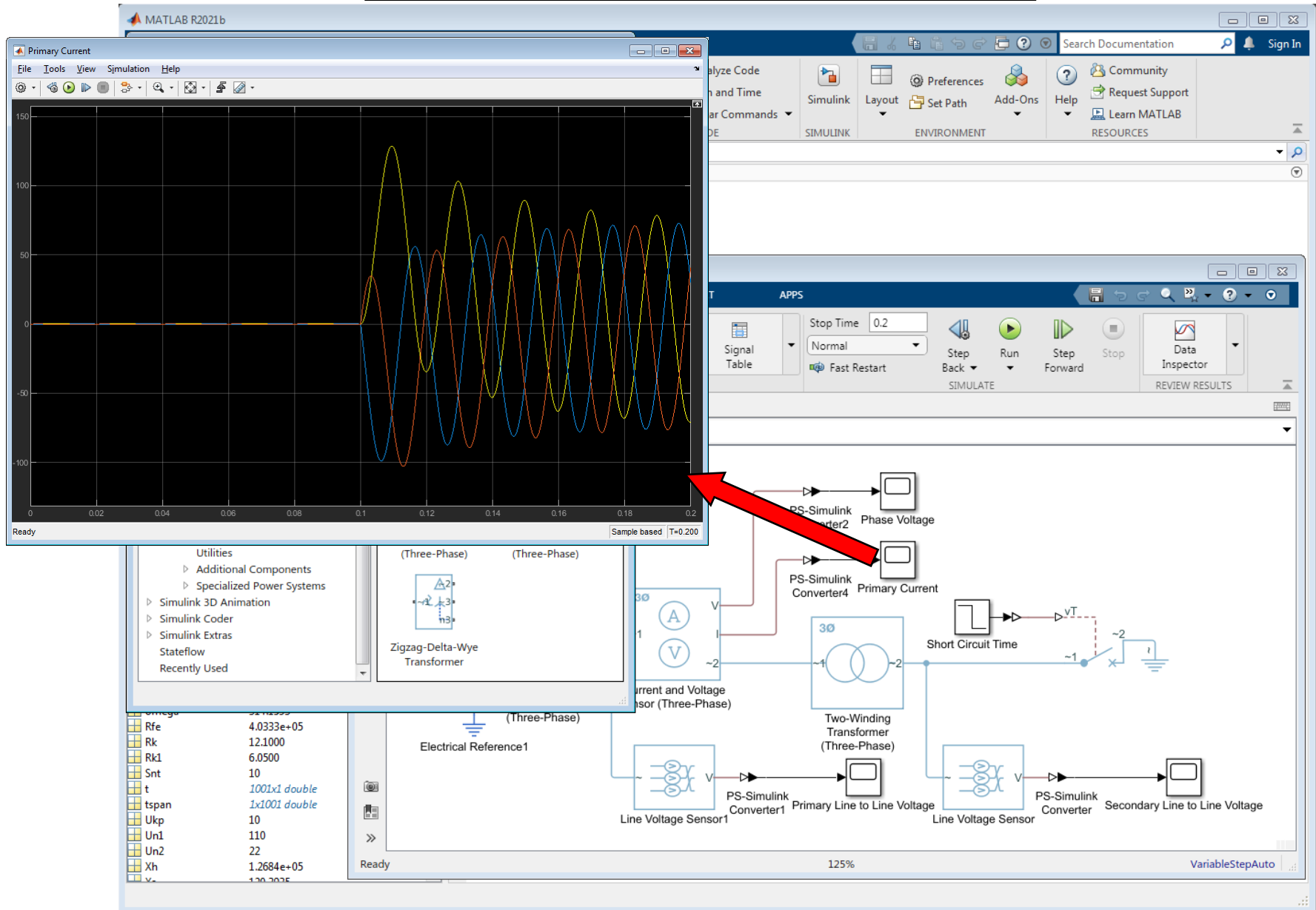
The image displays the MATLAB R2021b Simulink environment. The Simulink Library Browser is open, showing the 'Simscape/Electrical/Passive/Transformers' section. The 'Block Parameters: Two-Winding Transformer (Three-Phase)' dialog box is open, showing the 'Variables' tab. The 'Settings' section is visible, with the following parameters:

Parameter	Value
Primary winding resistance (pu):	$dPkp/100/2$
Primary leakage reactance (pu):	$\sqrt{((Ukp/100)^2 - (dPkp/100)^2)}/2$
Secondary winding resistance (pu):	$dPkp/100/2$
Secondary leakage reactance (pu):	$\sqrt{((Ukp/100)^2 - (dPkp/100)^2)}/2$
Shunt magnetizing resistance (pu):	$1/(dP0p/100)$
Magnetic saturation representation:	None
Shunt magnetizing reactance (pu):	$1/\sqrt{((I0p/100)^2 - (dP0p/100)^2)}$
Zero sequence reactance (pu):	$\sqrt{((Ukp/100)^2 - (dPkp/100)^2)}/2$

The background shows a Simulink model of a transformer circuit. The circuit includes a 'Two-Winding Transformer (Three-Phase)' block, a 'Line Voltage Sensor', and several measurement blocks: 'PS-Simulink Converter2' for Phase Voltage, 'PS-Simulink Converter4' for Primary Current, 'PS-Simulink Converter' for Secondary Line to Line Voltage, and 'Simulink Inverter1' for Primary Line to Line Voltage. A 'Short Circuit Time' block is also present, connected to the transformer's secondary terminals. A red arrow points from the 'Variables' tab in the dialog box to the transformer block in the circuit diagram.

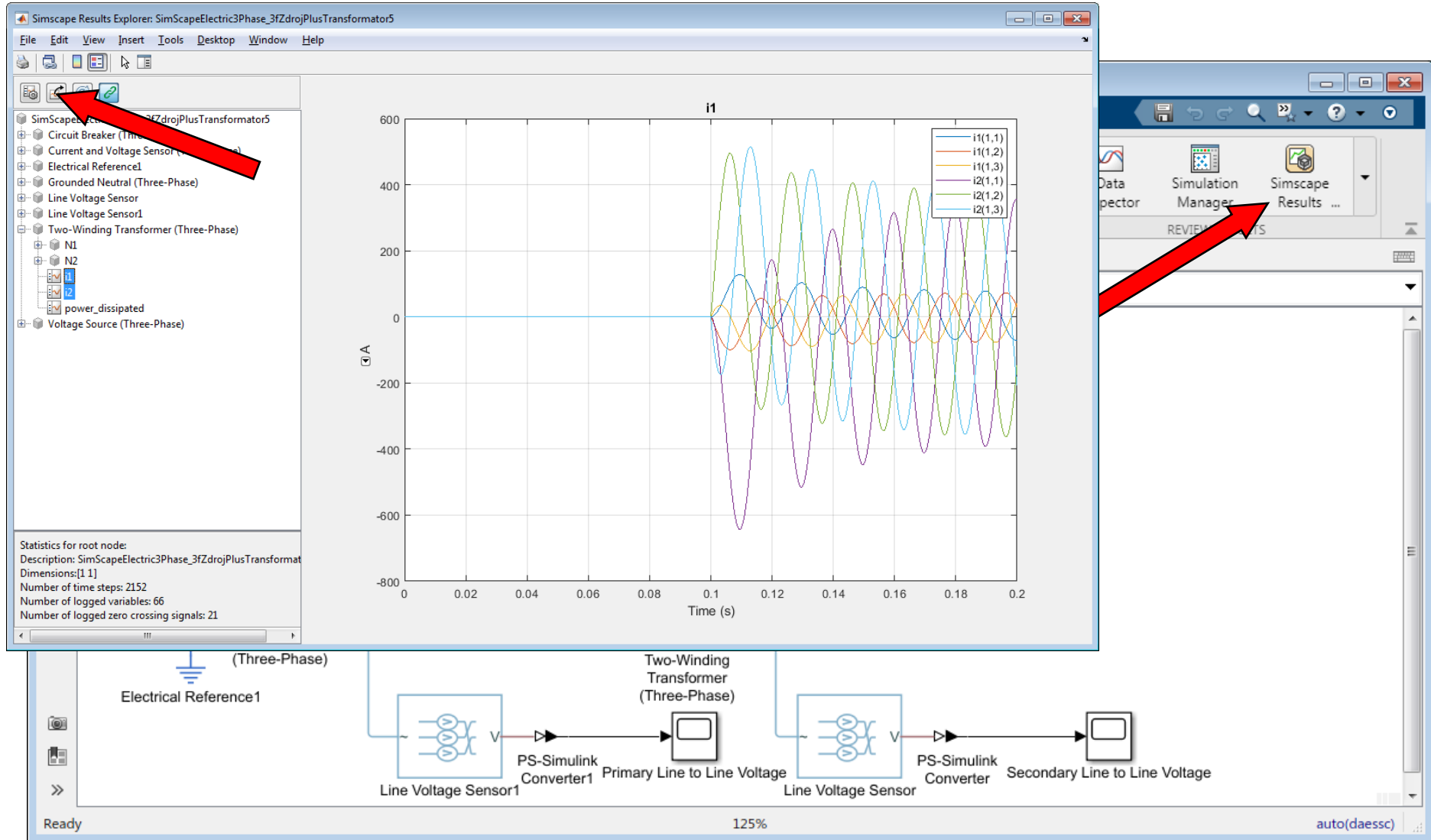
Zpracování pomocí nástroje Simscape Electrical verze R2021b

# Transformátor nakrátko



Zpracování pomocí nástroje Simscape Electrical verze R2021b

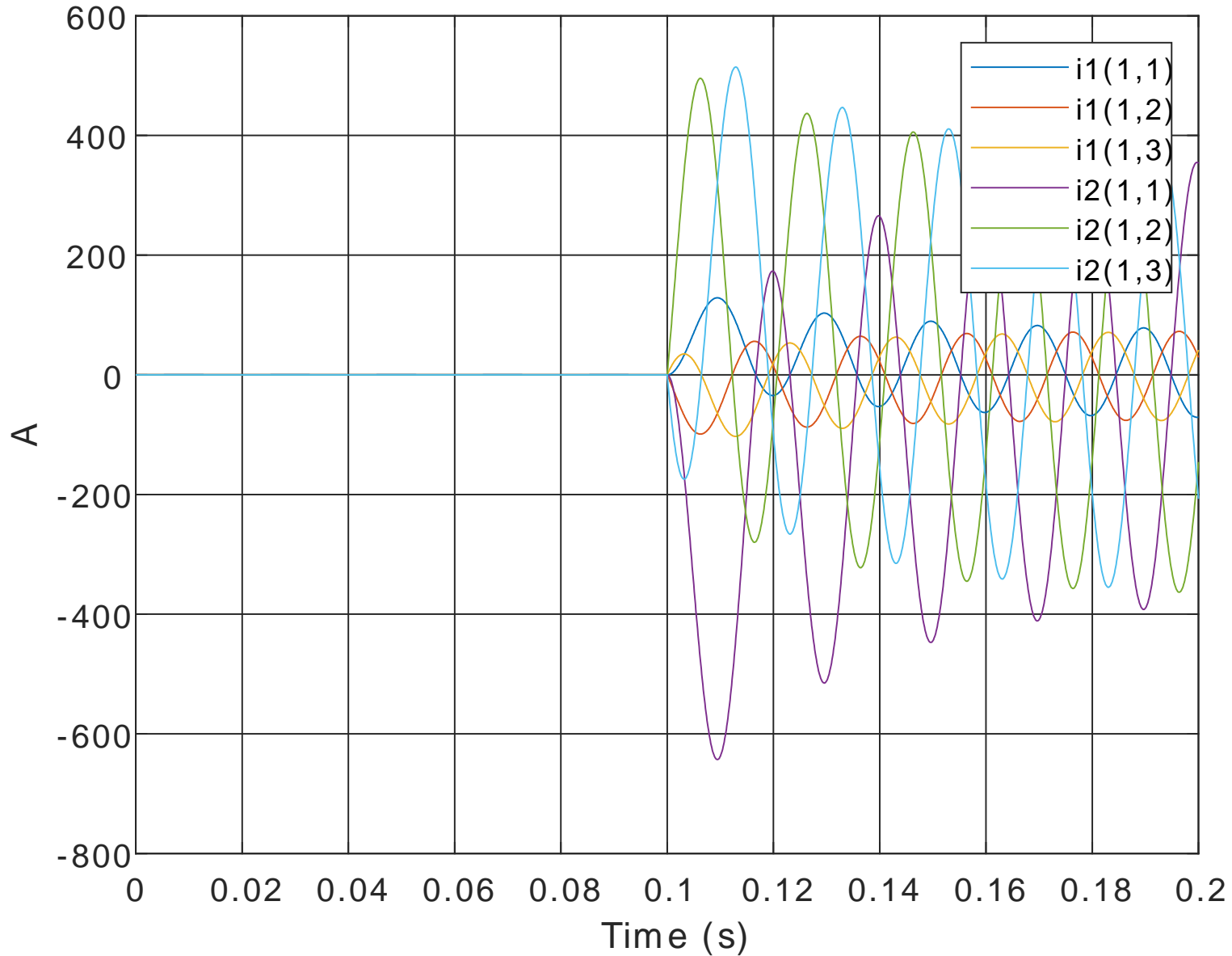
# Transformátor nakrátko



Zpracování pomocí nástroje Simscape Electrical verze R2021b

# Transformátor nakrátko

i1



Zpracování pomocí nástroje Simscape Electrical verze R2021b