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Řešení přechodných dějů na transformátoru v nástroji SolveElec

Cvičení PJS

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FAKULTA ELEKTROTECHNICKÁ
ZÁPADOČESKÉ UNIVERZITY
V PLZNI

KATEDRA
ELEKTROENERGETIKY

Výpočet přechodného děje na transformátoru

Pro výpočet ustáleného harmonického stavu nakrátko využít simulační nástroj SolveElec:

<http://www.physicsbox.com/indexsolveelec2en.html>



Version 2.5 for Mac and Windows

With Solve Elec you can :

- draw and analyze electrical circuits functioning in direct or alternating current
- get literal formulas and values for current intensities and voltages defined in the circuit.
- verify circuit related equations.
- draw graphs.
- get the equivalent circuit of displayed circuit
- browse an integrated documentation
- edit, save and print reports made of various elements displayed in main window

[Demo](#)

New in version 2.5 :

- analysis of circuits in AC
- oscilloscope
- filter analysis
- formulas and values of transfer functions
- frequency response graphs

Download :

- [Solve Elec 2.5 for MacOS X \(Universal Binary\) 10,5 Mo](#)
- [Solve Elec 2.5 for Windows 3,2 Mo](#)
- [Circuits examples](#)

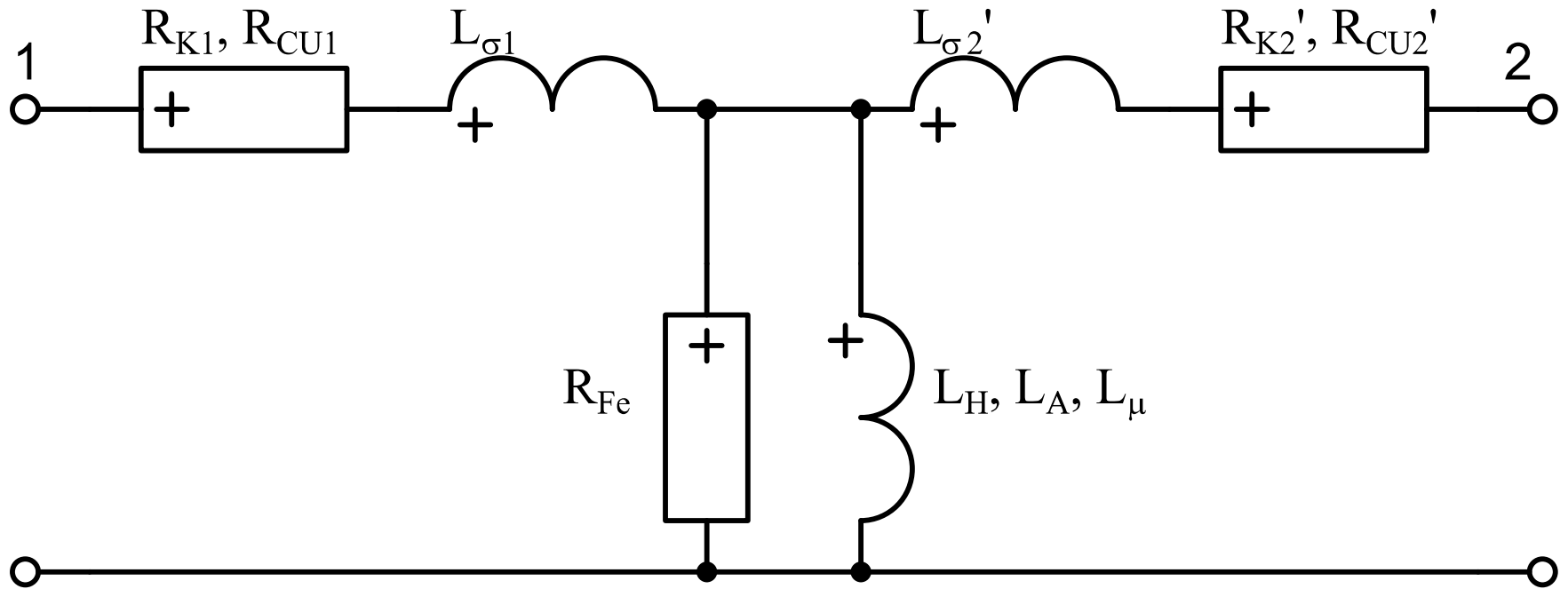
Solve Elec licence :

The version 2.5 of Solve Elec is free.
If you think Solve Elec is worth using, you may like to donate to help continue development..



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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 ;

Parametry transformátoru

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

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

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

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

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

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

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

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

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

$$\text{frekv} = 50$$

$$\text{omega} = 314.16$$

$$\text{Rk} = 12.100$$

$$\text{Rk1} = 6.0500$$

$$\text{Zk} = 121$$

$$\text{Xs} = 120.39$$

$$\text{Ls} = 0.38322$$

$$\text{Ls1} = 0.19161$$

$$\text{Gfe} = 0.0000024793$$

$$\text{Rfe} = 403333.33333$$

$$\text{Y0} = 0.0000082645$$

$$\text{Xh} = 126842.46524$$

$$\text{Lh} = 403.75$$

Transformátor nakrátko

Řešení s kompletní topologií:

$$U_K = U_{N1} \frac{u_K}{100} \cdot \frac{1}{\sqrt{3}}$$

$$I_N = \frac{S_{NT}}{\sqrt{3} \cdot U_{N1}}$$

$$\Psi_K = \arctan \left(\frac{X_\sigma}{R_K} \right)$$

$$\Psi_{K \text{ rad}} = -\frac{\Psi_K}{\pi} 180$$

$$U_k = U_{n1} * U_{kp} / 100 / \text{sqrt}(3)$$

$$U_k = 6.3509$$

$$I_n = S_{nt} / U_{n1} / \text{sqrt}(3)$$

$$I_n = 0.052486$$

$$\Psi_k = \text{atan}(X_s / R_k)$$

$$\Psi_k = 1.4706$$

$$\Psi_{k \text{ rad}} = -\Psi_k / \pi * 180$$

$$\Psi_{k \text{ rad}} = -84.261$$

Transformátor nakrátko

Řešení ustáleného stavu nakrátko s kompletní topologií:

The screenshot displays a circuit simulation software interface for a transformer short-circuit test. The circuit diagram shows an AC voltage source E_1 connected to a primary winding with resistance R_1 and inductance L_1 . The secondary winding, with resistance R_2 and inductance L_2 , is short-circuited through a series combination of resistance R_3 and inductance L_3 . Currents I_1 and I_2 are measured at the primary and secondary terminals, respectively, and voltage U_1 is measured across the primary winding.

Solution Results:

- Circuit solved
- $I_{1\text{rms}} = 52.5 \text{ A}$
- $\text{Phi}i_1 = -84.3^\circ$
- $I_2 = \frac{L_3 R_3 E_1}{-w^2 L_1 L_2 L_3 + L_1 R_2 R_3 + L_2 R_1 R_3 + L_3 R_1 R_2 + L_3 R_1 R_3 + L_3 R_2 R_3 + j \left(w L_1 L_2 R_3 + w L_1 L_3 R_2 + w L_1 L_3 R_3 + w L_2 L_3 R_1 + w L_2 L_3 R_3 - \frac{R_1 R_2}{w} \right)}$
- $I_{2\text{rms}} = \frac{L_3 R_3 E_{1\text{rms}}}{\sqrt{\left(-w^2 L_1 L_2 L_3 + L_1 R_2 R_3 + L_2 R_1 R_3 + L_3 R_1 R_2 + L_3 R_1 R_3 + L_3 R_2 R_3 \right)^2 + \left(w L_1 L_2 R_3 + w L_1 L_3 R_2 + w L_1 L_3 R_3 + w L_2 L_3 R_1 + w L_2 L_3 R_3 \right)^2}}$
- $I_{2\text{rms}} = 52.5 \text{ A}$
- $\text{Phi}i_2 = -84.3^\circ$
- $U_1 = E_1$
- $U_{1\text{rms}} = E_{1\text{rms}}$
- $U_{1\text{rms}} = 6.35 \text{ kV}$
- $\text{Phi}U_1 = 0^\circ$

Circuit properties:

Phase reference	E_1	f	50.0	Hz		
Frequency	$f / 10$	$f \times 10$				
R_1	6.05	Ohm				
R_2	6.05	Ohm				
R_3	403	kOhm				
L_1	192	mH				
L_2	192	mH				
L_3	404	H				
E_1	$E_{1\text{rms}}$	6.35	kV	$\text{Phi}E_1$	0	°
U_1	$U_{1\text{rms}}$	$\text{Phi}U_1$				
I_1	$I_{1\text{rms}}$	$\text{Phi}i_1$				
I_2	$I_{2\text{rms}}$	$\text{Phi}i_2$				

Oscilloscope:

The oscilloscope displays two waveforms: $e_1(t)$ (voltage in kV, green) and $i_1(t)$ (current in A, pink). The voltage waveform is a sine wave with a peak of approximately 15 kV. The current waveform is a sine wave with a peak of approximately 60 A, lagging behind the voltage waveform. The time axis is labeled t (ms) and ranges from 0 to 30 ms.

Zpracování pomocí obvodového schéma