Vysoké Učeni Technické v Brně

Fakulta informačních technologií

Elektronika pre informačne technológie

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Semestrálny projekt

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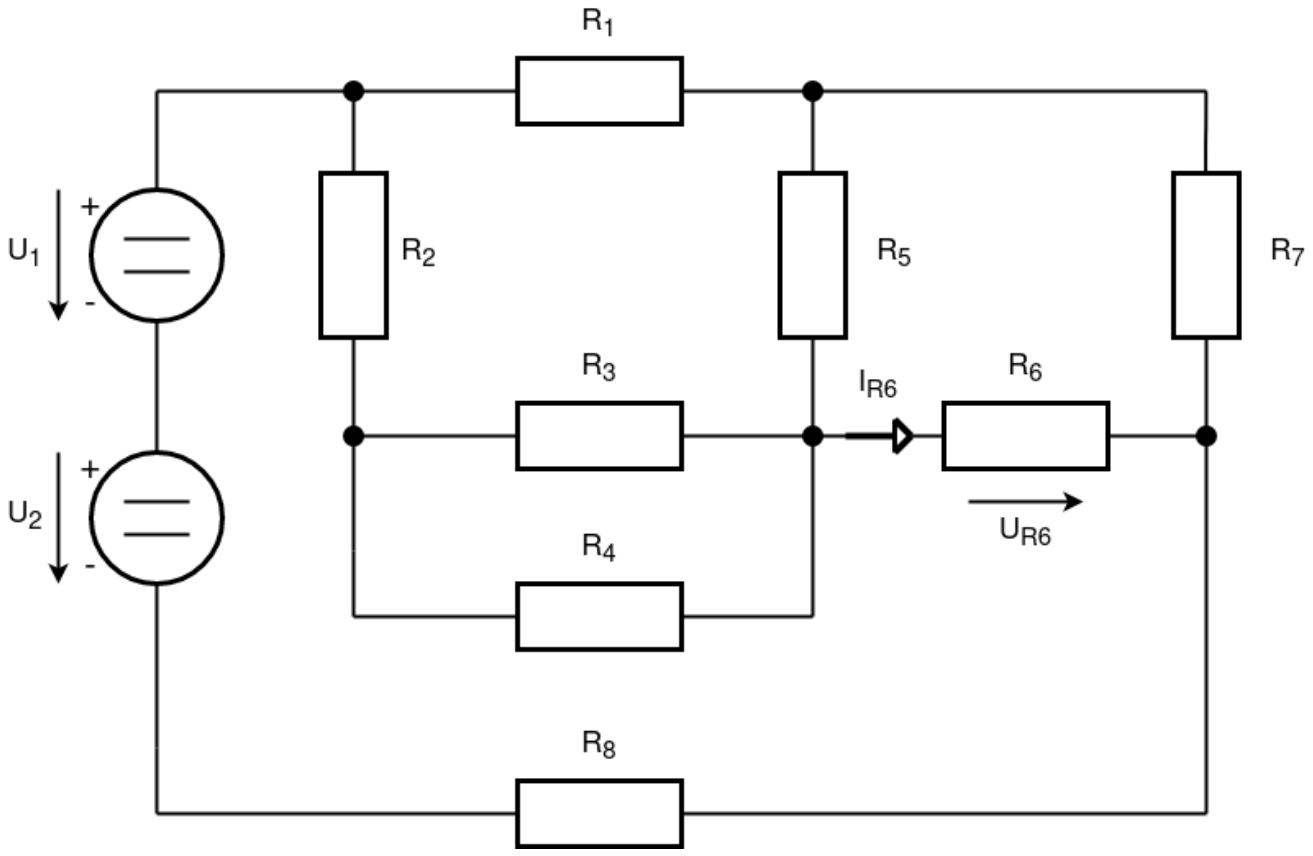
1. Príklad

Zadanie :

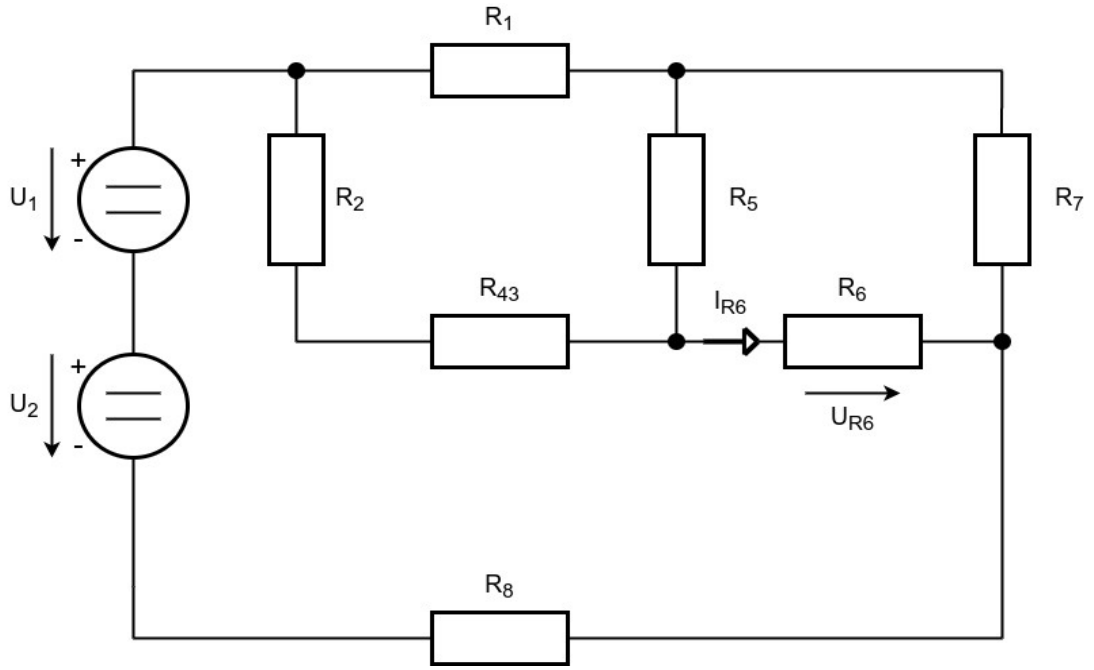
sk.	U_1 [V]	U_2 [V]	R_1 [Ω]	R_2 [Ω]	R_3 [Ω]	R_4 [Ω]	R_5 [Ω]	R_6 [Ω]	R_7 [Ω]	R_8 [Ω]
D	105	85	420	980	330	280	310	710	240	200

$U_{R6} = ?, I_{R6} = ?$



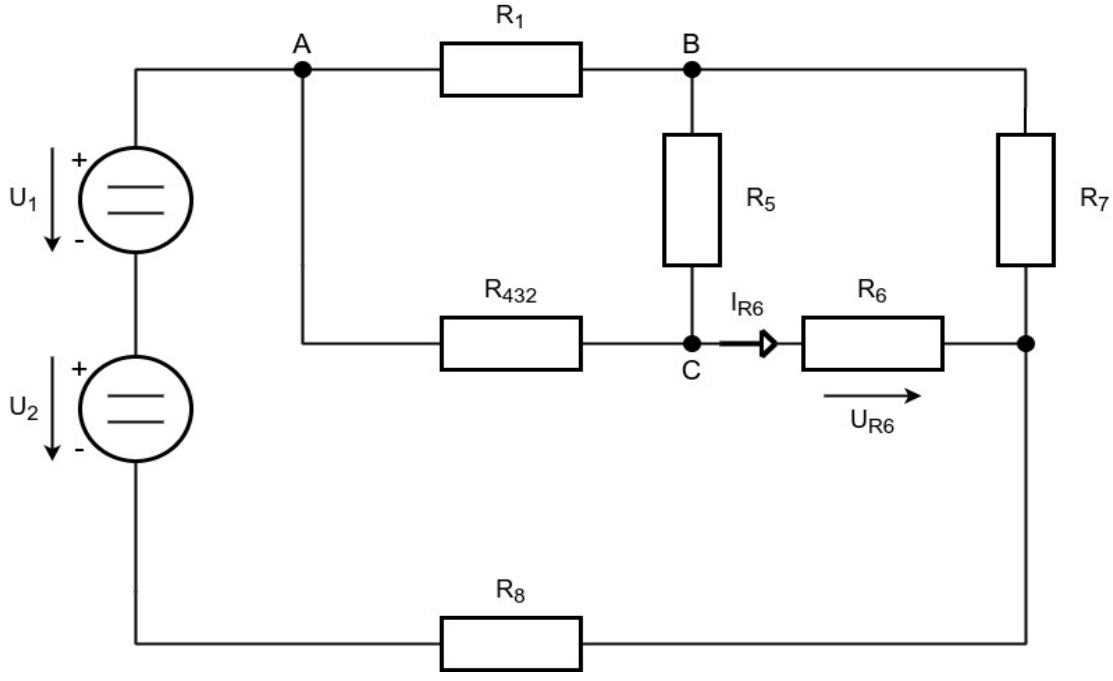
Riešenie : metóda postupného zjednodušovania

R4 a R3 sú zapojené paralelne



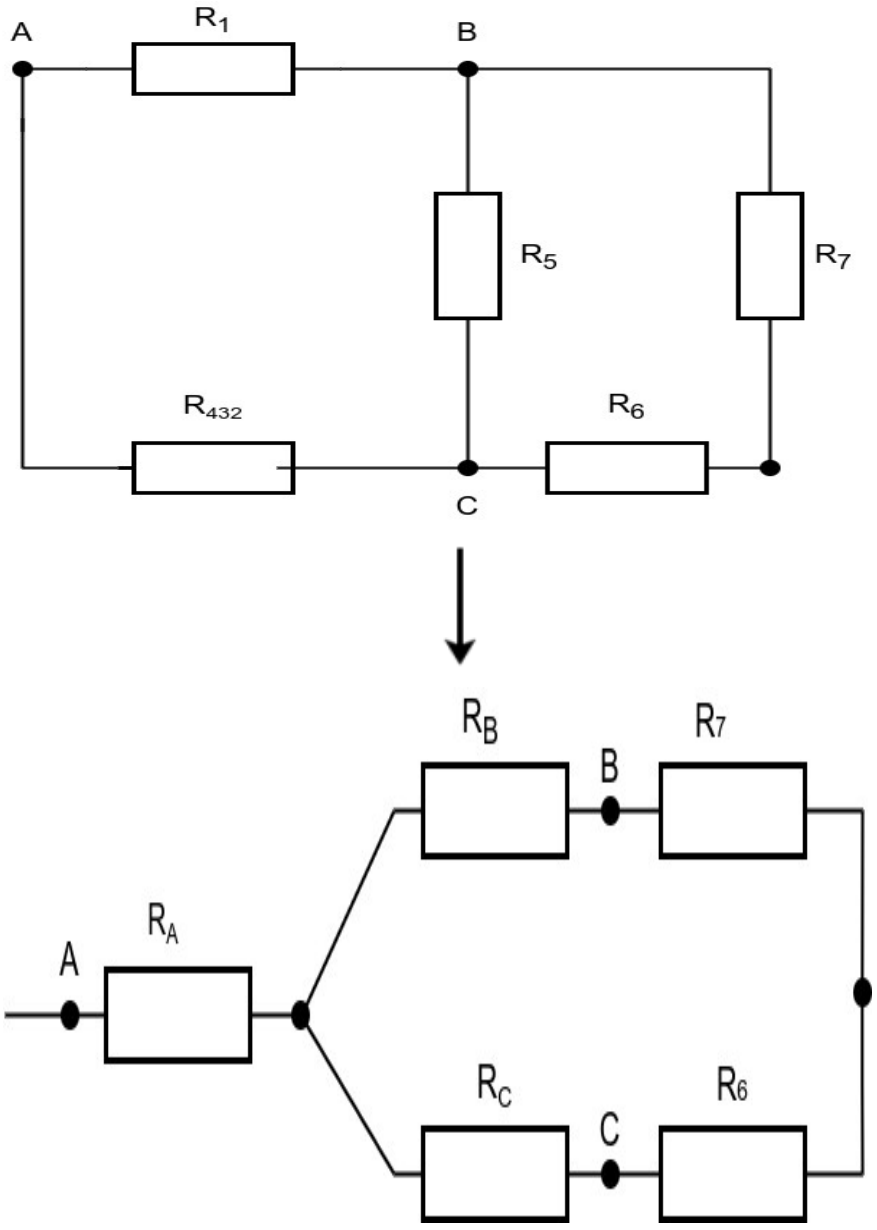
$$R_{43} = \frac{R_4 R_3}{R_4 + R_3} = \frac{280 * 330}{280 + 330} = 151.4754\,\Omega$$

R2 a R43 sú zapojené sériovo



$$R_{432} = R_{43} + R_2 = 151.45754 + 980 = 1131.4754$$

Úprava na trojholnikový tvar

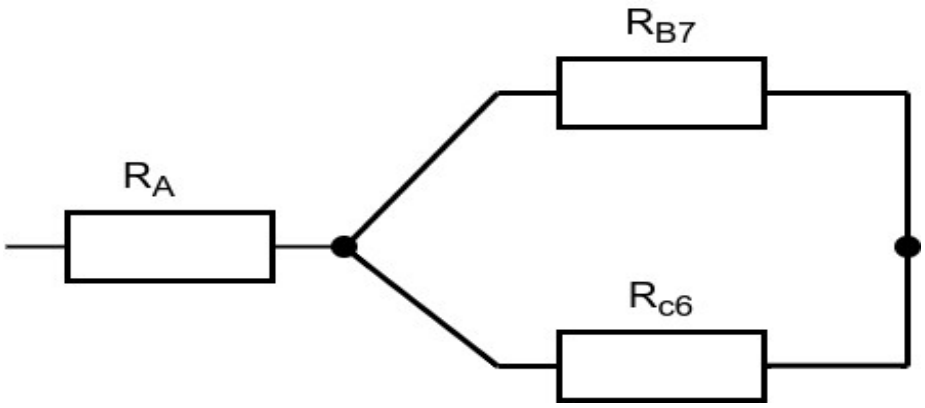


$$R_A = \frac{R_1 * R_{432}}{R_1 + R_{432} + R_5} = \frac{420 * 1131.4754}{420 + 1131.4754 + 310} = 255.2919\,\Omega$$

$$R_B = \frac{R_1 * R_5}{R_1 + R_{432} + R_5} = \frac{420 * 310}{420 + 1131.47541 + 310} = 69.94452\,\Omega$$

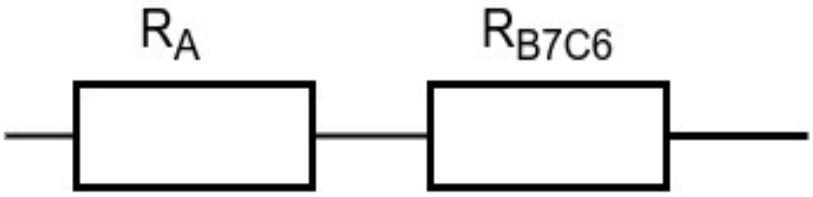
$$R_C = \frac{R_{432} * R_5}{R_1 + R_{432} + R_5} = \frac{1131.4754 * 310}{420 + 1131.4754 + 310} = 188.4298\,\Omega$$

R_B a R_7 a aj R_C a R_6 sú zapojené sériovo

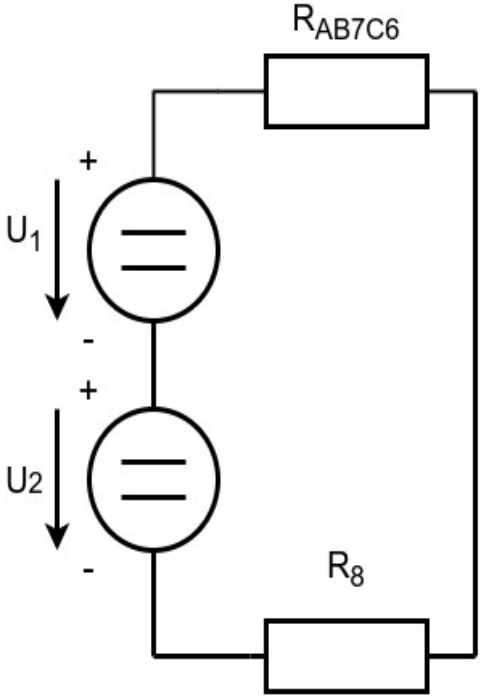


$$R_{B7} = R_B + R_7 = 69.9445 + 240 = 309.9445\,\Omega$$
$$R_{C6} = R_C + R_6 = 188.4298 + 710 = 898.4297\,\Omega$$

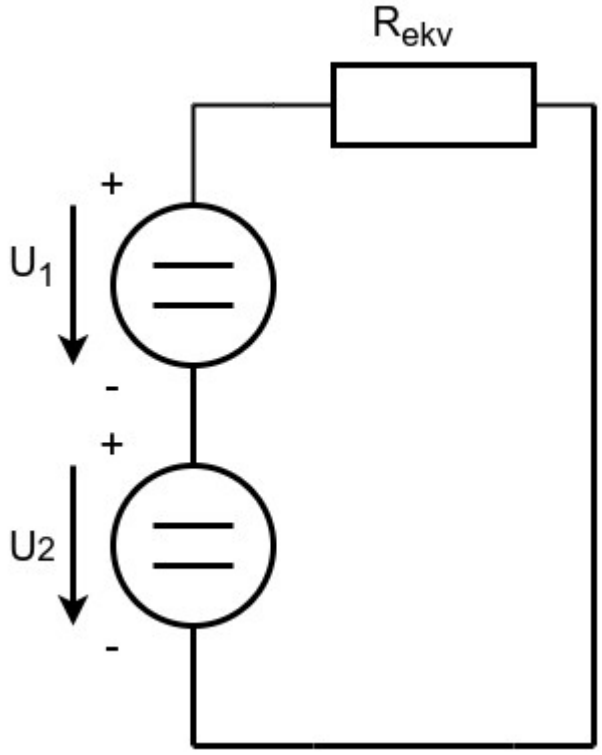
RB7 a RC6 sú zapojené paralelne



$$R_{B7C6} = \frac{R_{B7} * R_{C6}}{R_{B7} + R_{C6}} = \frac{309.9445 * 898.4298}{309.9445 + 898.4298} = 230.4446\,\Omega$$



$$R_{AB7C6} = R_{B7C6} + R_A = 230.4446 + 255.2919 = 485.7366\,\Omega$$



$$R_{REKV} = R_{AB7C6} + R_8 = 485.7365 + 200 = 685.7366\,\Omega$$

Celkový prúd I :

$$I = \frac{U}{R_{EKV}} = \frac{105+85}{685.7366} = 0.2771\ A$$

$U_{R6,}$ I_{R6} :

$$U_{RB7C6} = I * R_{B7C6} = 0.27707 * 230.4446 = 63{,}8502\ V$$

$$\boldsymbol{I_{R6}} = \frac{U_{RB7C6}}{R_{C6}} = \frac{63{,}8502}{898.4298} = 0.0711\ A$$

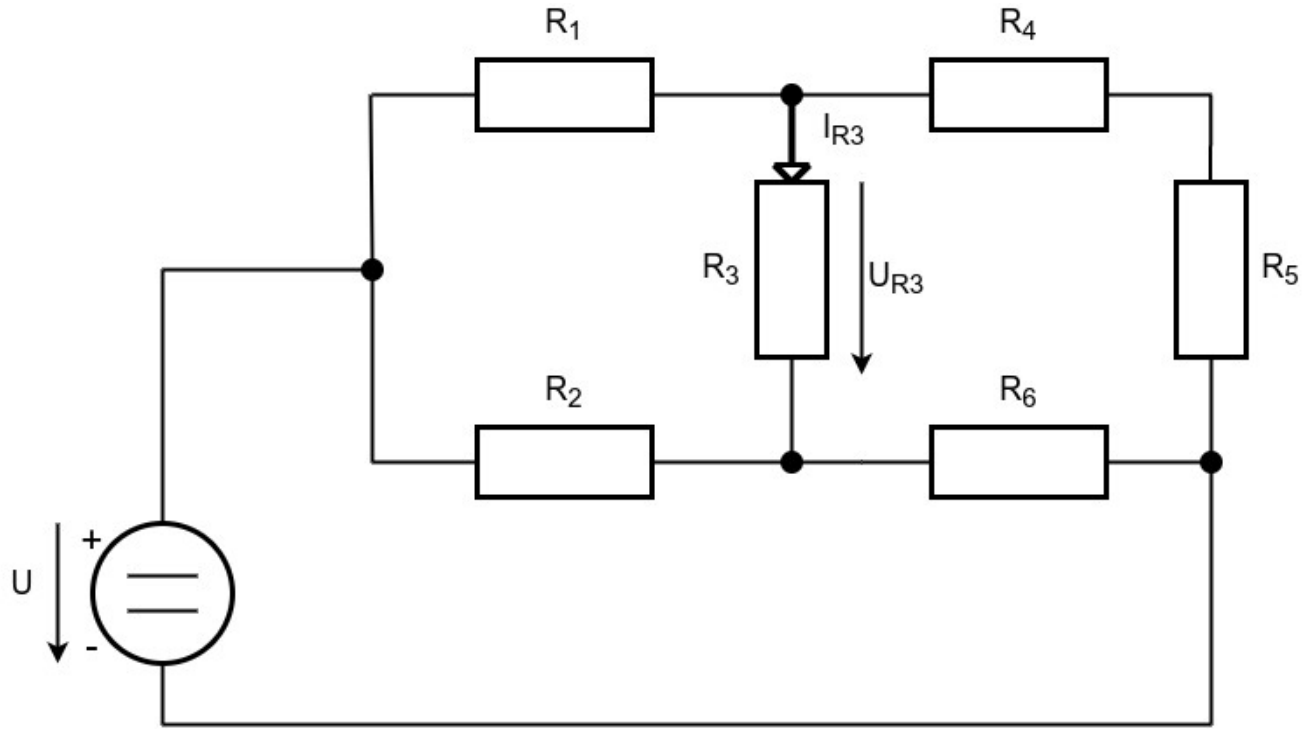
$$\boldsymbol{U_{R6}} = I_{R6} * R_6 = 0.07107 * 710 = 50.4597\ V$$

2. Príklad

Zadanie :

sk.	U [V]	R_1 [Ω]	R_2 [Ω]	R_3 [Ω]	R_4 [Ω]	R_5 [Ω]	R_6 [Ω]
C	200	70	220	630	240	450	300

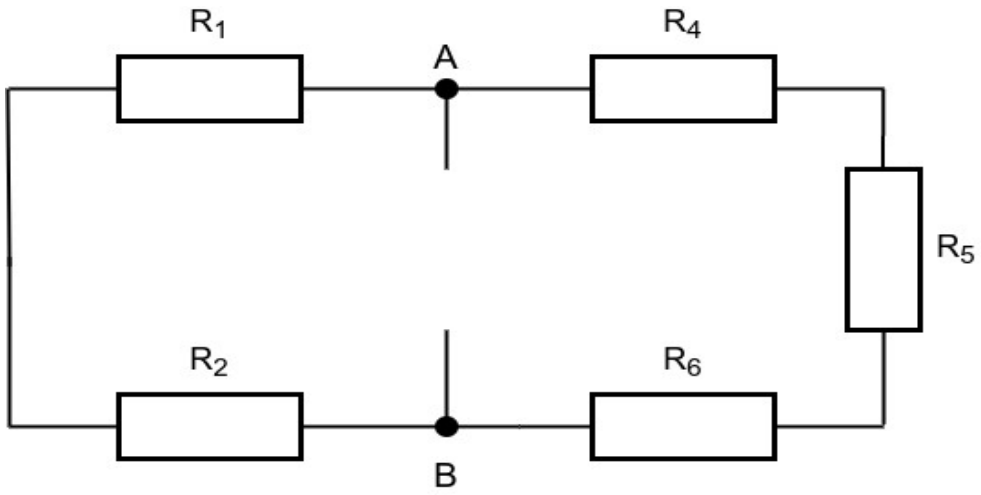
$U_{R3} = ?, I_{R3} = ?$



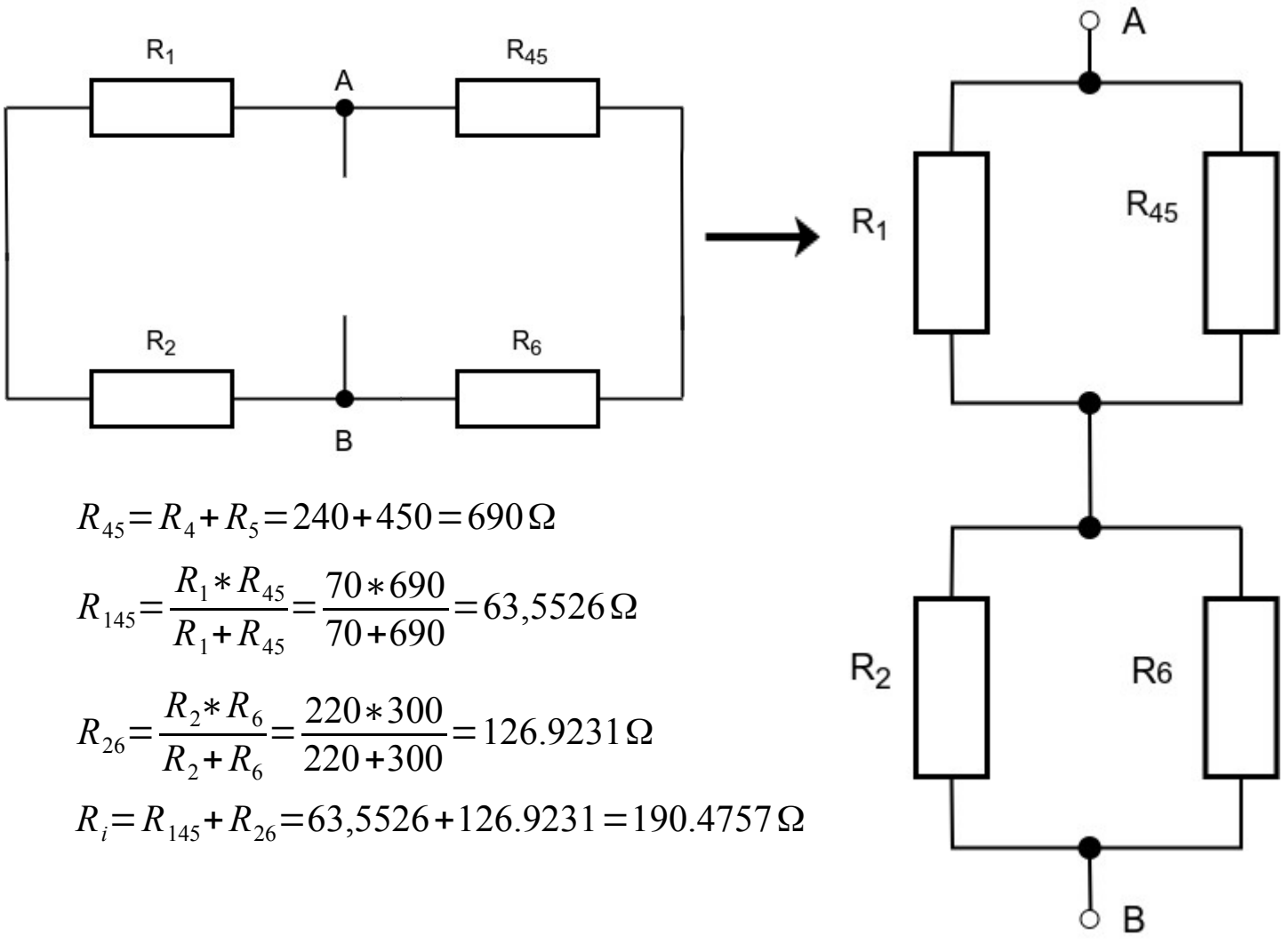
Riešenie pomocou Théninovej vety

Výpočet R_i:

Skratujeme napäťový zdroj odobratím R3



Obvod postupným zjednodušovaním upravujeme



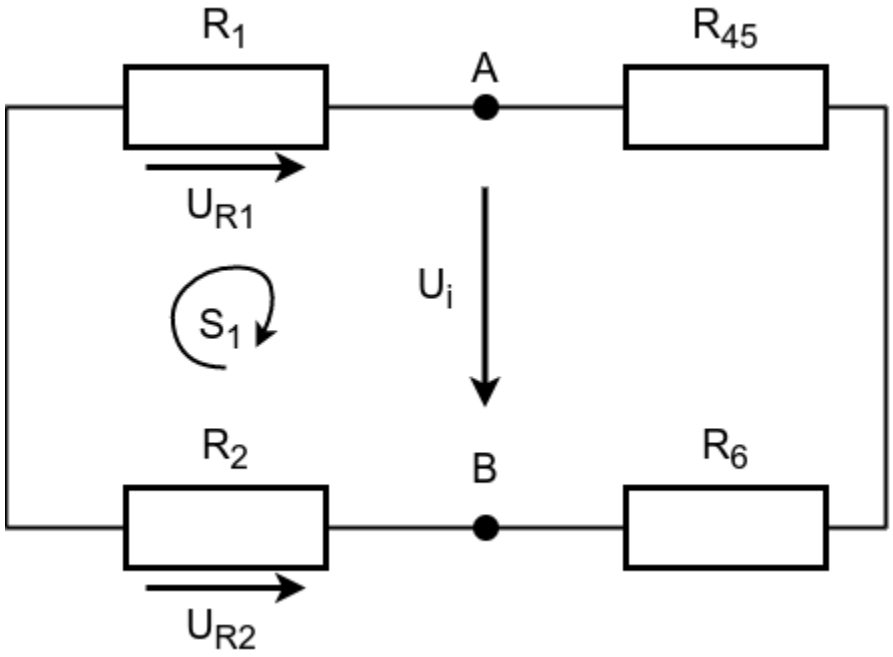
$$R_{45} = R_4 + R_5 = 240 + 450 = 690\,\Omega$$

$$R_{145} = \frac{R_1 * R_{45}}{R_1 + R_{45}} = \frac{70 * 690}{70 + 690} = 63{,}5526\,\Omega$$

$$R_{26} = \frac{R_2 * R_6}{R_2 + R_6} = \frac{220 * 300}{220 + 300} = 126.9231\,\Omega$$

$$R_i = R_{145} + R_{26} = 63{,}5526 + 126.9231 = 190.4757\,\Omega$$

Výpočet U_i:



Pomocou rovnice deliča napätia vypočítame napätie na U_{R1} a U_{R2}:

$$U_{R1} = U * \frac{R_1}{R_1 + R_{45}} = 200 * \frac{70}{70 + 690} = 18.4211\,\Omega$$

$$U_{R2} = U * \frac{R_2}{R_2 + R_6} = 200 * \frac{220}{220 + 300} = 84.6154\,\Omega$$

Pomocou II. Kirchoffového zákonu dopočítame U_i:

$$U_{R1} + U_i - U_{R3} = 0$$

$$U_i = U_{R3} - U_{R1} = 84.6154 - 18.4211 = 66.1943$$

Dopočítame I_{R3} a U_{R3}:

$$\boldsymbol{I_{R3}} = \frac{U_i}{R_i + R_3} = \frac{66.1943}{190.4757 + 630} = 0.0807\,A$$

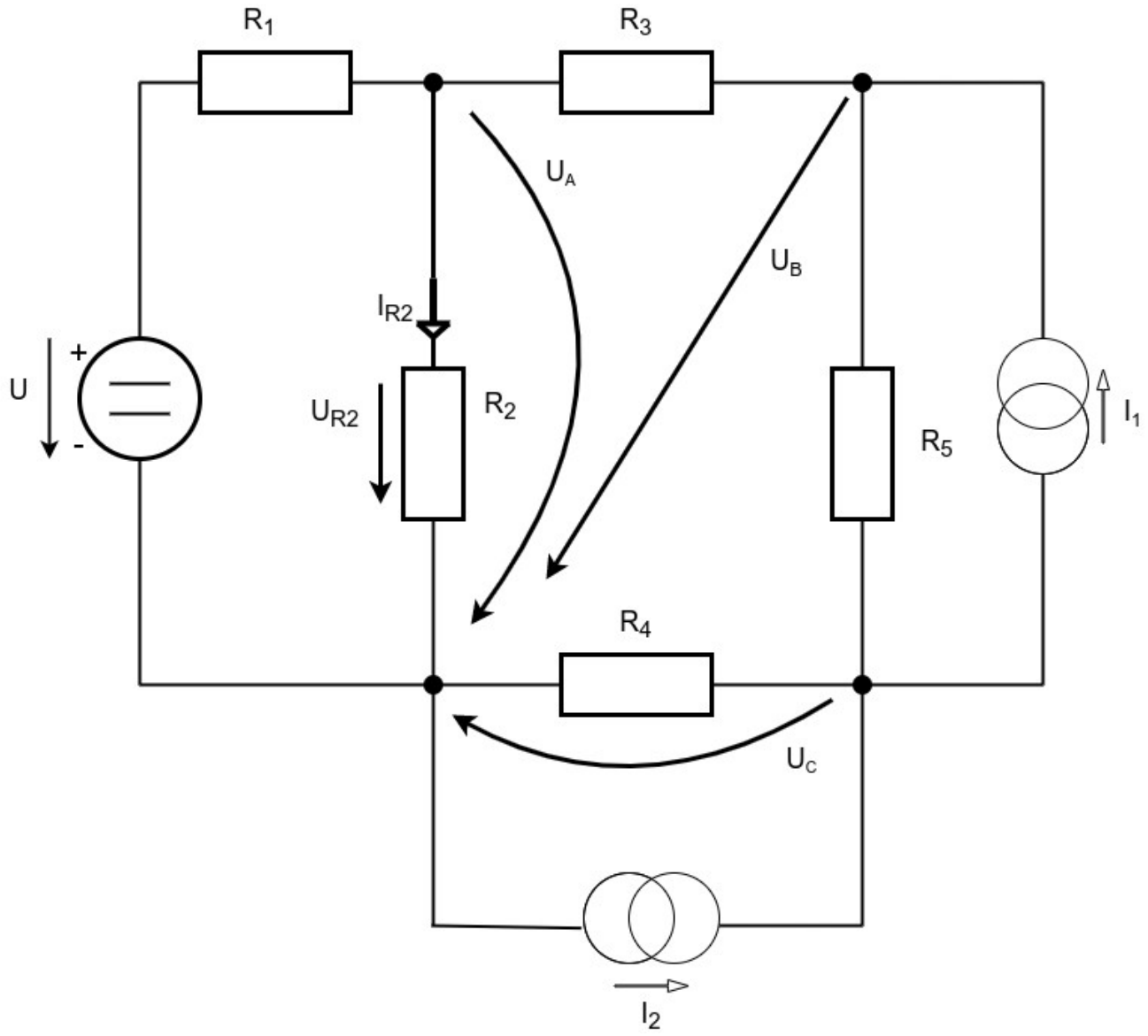
$$\boldsymbol{U_{R3}} = I_{R3} * R_3 = 0.0800678 * 630 = 50.8271\,V$$

3. Príklad

Zadanie:

sk.	U [V]	I_1 [A]	I_2 [A]	R_1 [Ω]	R_2 [Ω]	R_3 [Ω]	R_4 [Ω]	R_5 [Ω]
E	135	0.55	0.65	52	42	52	42	21

U_{R2} = ?, I_{R2} = ?



Riešenie : metóda uzlových napätí

Prevedieme si odpory na vodivosť.

$$G_1=\frac{1}{R_1}=\frac{1}{52}S \quad G_2=\frac{1}{R_2}=\frac{1}{42}S \quad G_3=\frac{1}{R_3}=\frac{1}{52}S \quad G_4=\frac{1}{R_4}=\frac{1}{42}S \quad G_5=\frac{1}{R_5}=\frac{1}{21}S$$

Napäťový zdroj U prevedieme na prúdový zdroj I_3 :

$$I_3=\frac{U}{R_1}=\frac{135}{52}=2.5961\ A$$

Zostavíme rovnice pre nezávisle uzly :

$$A\ :\ -I_3+G_1U_A+G_2U_A+G_3(U_A-U_B)=0$$

$$B\ :\ -I_1+G_3(U_B-U_A)+G_5(U_B-U_C)=0$$

$$C\ :\ -I_2+G_4U_C+G_5(U_C-U_B)+I_1=0$$

Rovnice upravíme :

$$A\ :\ U_A(G_1+G_2+G_3)+U_B(-G_3)=I_3$$

$$B\ :\ U_A(-G_3)+U_B(+G_3+G_5)+U_C(-G_5)=I_1$$

$$C\ :\ U_B(-G_5)+U_C(G_4+G_5)=I_2-I_1$$

Prepíšeme rovnice do maticového tvaru :

$$\begin{pmatrix} G_1+G_2+G_3 & -G_3 & 0 \\ -G_3 & G_3+G_5 & -G_5 \\ 0 & -G_5 & G_4+G_5 \end{pmatrix} * \begin{pmatrix} U_A \\ U_B \\ U_C \end{pmatrix} = \begin{pmatrix} I_3 \\ I_1 \\ I_2-I_1 \end{pmatrix}$$

$$\begin{pmatrix} \frac{17}{273} & -\frac{1}{52} & 0 \\ -\frac{1}{52} & \frac{73}{1092} & -\frac{1}{21} \\ 0 & \frac{1}{21} & \frac{1}{14} \end{pmatrix} * \begin{pmatrix} U_A \\ U_B \\ U_C \end{pmatrix} = \begin{pmatrix} \frac{135}{52} \\ \frac{11}{20} \\ \frac{1}{10} \end{pmatrix}$$

Vypočítame determinanty Sarrusovým pravidlom

$$[D]=\begin{vmatrix} \frac{17}{273} & -\frac{1}{52} & 0 \\ -\frac{1}{52} & \frac{73}{1092} & -\frac{1}{21} \\ 0 & \frac{1}{21} & \frac{1}{14} \end{vmatrix} = (\frac{17}{273}*\frac{73}{1092}*\frac{1}{14})-((-\frac{1}{21})*(\frac{-1}{21})*\frac{17}{273}) -(\frac{1}{14})*(-\frac{1}{52})*(-\frac{1}{52})=\frac{6497}{50083488}=1.2972*10^{-4}$$

$$[D_{UA}]=\begin{vmatrix} \frac{135}{52} & -\frac{1}{52} & 0 \\ \frac{11}{20} & \frac{73}{1092} & -\frac{1}{21} \\ \frac{1}{10} & \frac{1}{21} & \frac{1}{14} \end{vmatrix} = (\frac{135}{52}*\frac{73}{1092}*\frac{1}{14})-((-\frac{1}{21})*(-\frac{1}{21})*\frac{135}{52}) -(\frac{1}{14}*(-\frac{1}{52})*\frac{11}{20})=\frac{4813}{662480}=7.3567*10^{-4}$$

Pomocou Crammerovho pravidla vypočítame U_{R2} a I_{R2} :

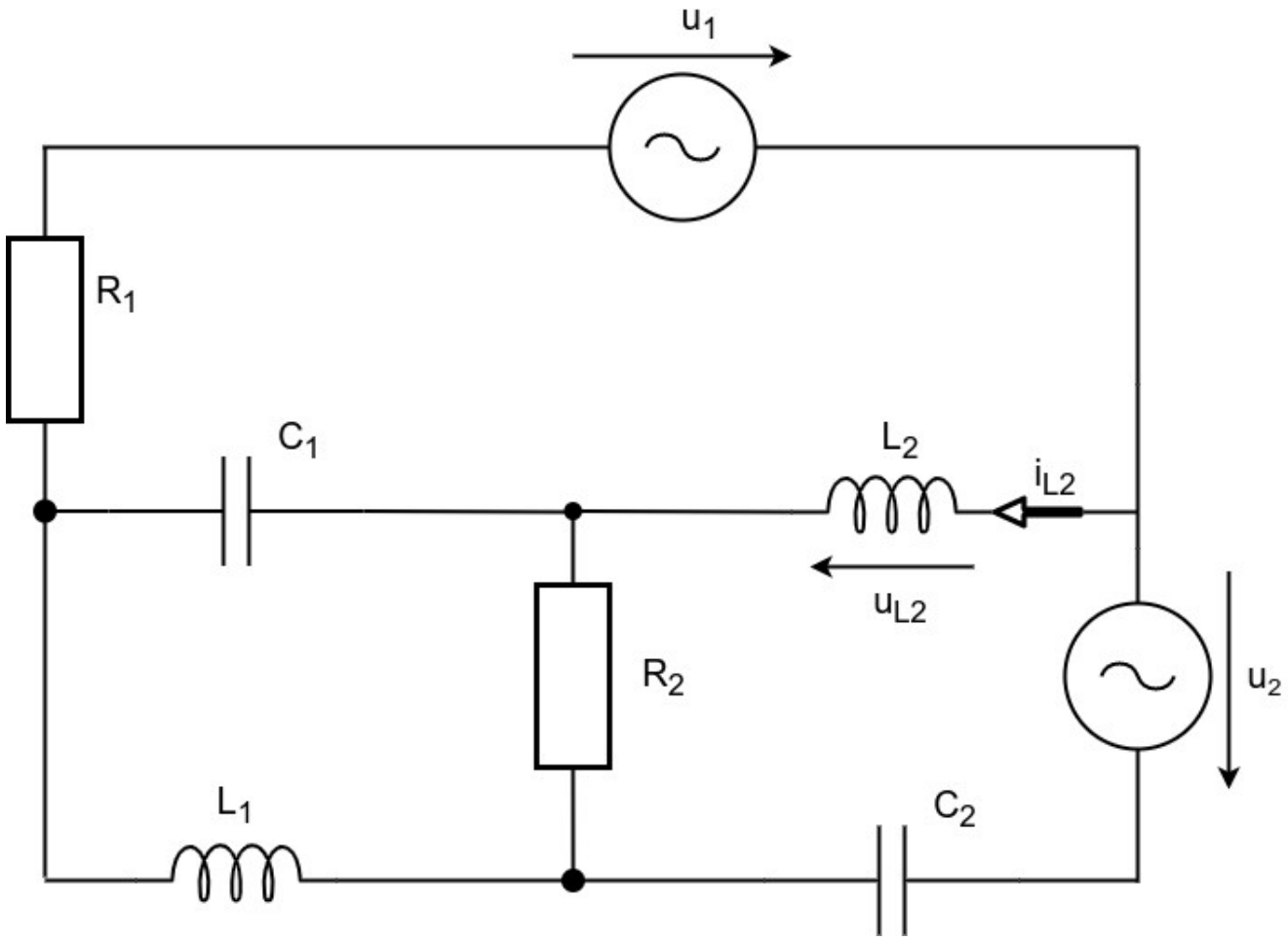
$$U_A=\boldsymbol{U}_{\boldsymbol{R2}}=\frac{[D_{UA}]}{[D]}=\frac{7.3567*10^{-4}}{1.2972*10^{-4}}=56.7107\,V$$

$$\boldsymbol{I}_{\boldsymbol{R2}}=\frac{U_{R2}}{R_2}=1.3502\,A$$

4. Príklad

Zadanie:

sk.	U_1 [V]	U_2 [V]	R_1 [Ω]	R_2 [Ω]	L_1 [mH]	L_2 [mH]	C_1 [μF]	C_1 [μF]	f [Hz]
D	45	50	13	15	180	90	210	75	85



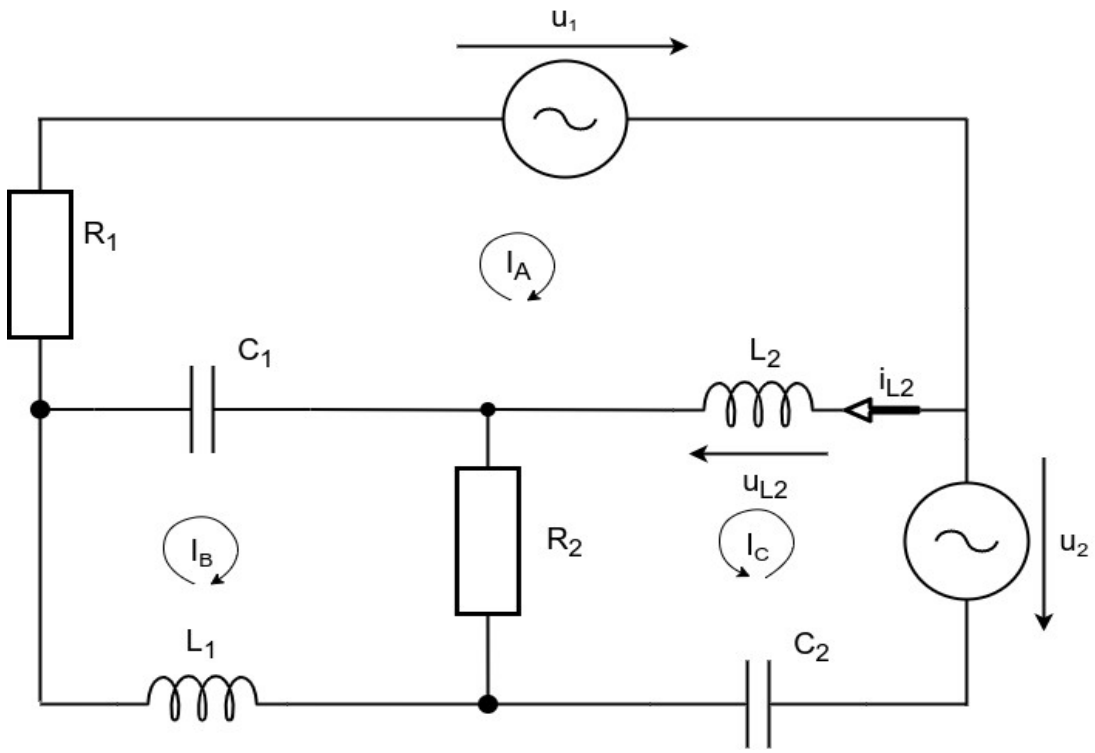
Riešenie : metóda slučkových prúdov

Vyjadríme si impedancie a uhlovú frekvenciu

$$\omega = 2\pi f = 2\pi 85$$

$$Z_{L1} = j\,\omega * L_1 = 96.1327\,j\,\Omega \qquad Z_{C2} = j * -\frac{1}{\omega * C_2} = -24.9655\,\Omega$$

$$Z_{L2} = j\,\omega * L_2 = 48.0664\,j\,\Omega \qquad Z_{C1} = j * -\frac{1}{\omega * C_1} = -8.9162\,\Omega$$



Zostavíme si rovnicu pre slúčkové prúdy:

$$I_A:\ I_A(R_1 + Z_{L2} + Z_{C1}) + I_B(-Z_{C1}) + I_C(Z_{L2}) = -45$$

$$I_B:\ I_A(-Z_{C1}) + I_B(Z_{L1} + Z_{C1} + R_2) + I_C(R_2) = 0$$

$$I_C:\ I_A(Z_{L2}) + I_B(R_2) + I_C(R_2 + Z_{C2} + Z_{L2}) = 50$$

Dosadíme do matice:

$$\begin{pmatrix} R_1+ZL_2+Z_{C1} & -Z_{C1} & Z_{L2} \\ -Z_{C1} & Z_{L1}+Z_{C1}+R_2 & R_2 \\ Z_{L2} & R_2 & R2+Z_{C2}+Z_{L2} \end{pmatrix} * \begin{pmatrix} I_A \\ I_B \\ I_C \end{pmatrix} = \begin{pmatrix} -U_1 \\ 0 \\ U_2 \end{pmatrix}$$

Z týchto rovníc pomocou Crameroveho a Sarussoveho pravidla zistíme hodnoty Ia a Ic.

$$I_A = \frac{300274.01993 - 1038236.8235\,j}{-67985.22 + 145972.4387\,j} = -1.3718 - 1.4182\,j\,A$$

$$I_C = \frac{-345649.9533 + 112479.6468\,j}{-67985.22 + 145972.4387\,j} = 1.5395 + 1.6509\,j\,A$$

Zistime si napätie na L_2 pomocou Ohmovho zákona:

$$U_{L2} = ZL2 * (I_A + I_C) = -11.1878 + 8.0598\,j$$

Vyjadríme zo vzorca [U_{L2}] a φ_{L2}

$$[\boldsymbol{U_{L2}}] = \sqrt{Re(u_{L2})^2 + Im(u_{L2})^2} = 13.7886\,V$$

$$\boldsymbol{\varphi} L_2 = \arctan\frac{-11.1878}{8.0598} = 2.4215\,rad$$

Príklad	Skupina	Výsledky	
1	D	$U_{R6} = 50.4597V$	$I_{R6} = 0.0711$
2	C	$U_{R3} = 50.8271V$	$I_{R3} = 0.0807A$
3	E	$U_{R2} = 56.7107V$	$I_{R2}=1.3502A$
4	D	$[U_{L2}] = 13.7886$	$\varphi_{L2} = 2.4215$ rad