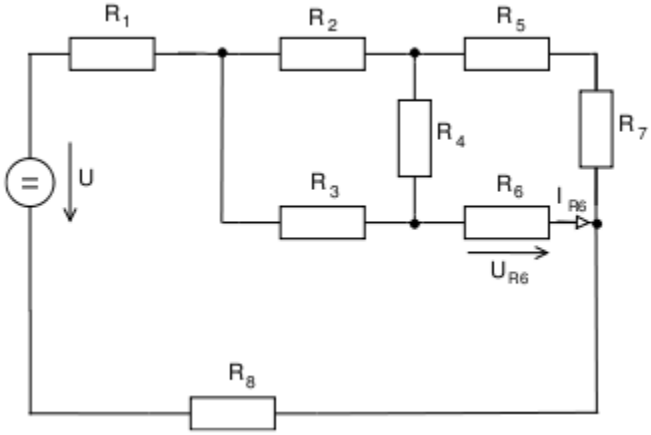
Teorie obvodů
2009/2010

Semestrální projekt

Autor: Kateřina Zaklová, xzaklo00@stud.fit.vutbr.cz
2. 1. 2011

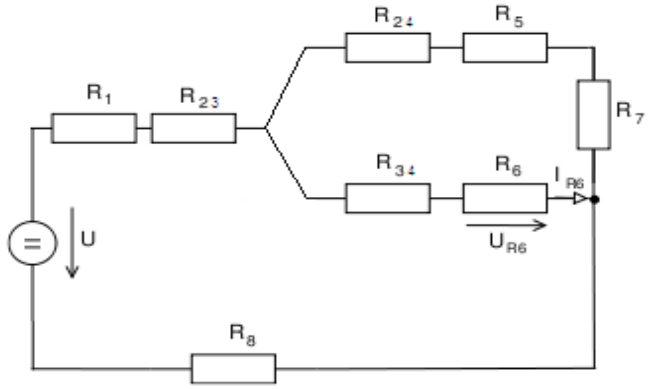
Příklad 1

Stanovte napětí U_{R6} a proud I_{R6}. Použijte metodu postupného zjednodušování obvodu.

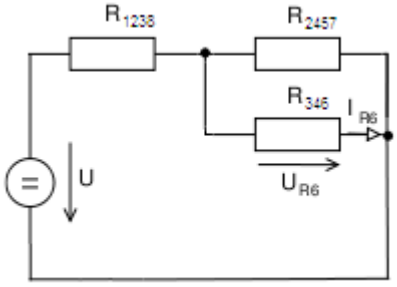


U = 95V, R_1 = 650Ω, R_2 = 730Ω, R_3 = 340Ω, R_4 = 330Ω, R_5 = 410Ω, R_6 = 830Ω, R_7 = 340Ω, R_8 = 220Ω

$$R_{23}=\frac{R_2*R_3}{R_2+R_3+R_4} \qquad R_{24}=\frac{R_2*R_4}{R_2+R_3+R_4} \qquad R_{34}=\frac{R_3*R_4}{R_2+R_3+R_4}$$



$$R_{1238}=R_1+R_{23}+R_8$$
$$R_{2457}=R_{24}+R_5+R_7$$
$$R_{346}=R_{34}+R_6$$



$$R_{2457346}=\frac{R_{2457}*R_{346}}{R_{2457}+R_{346}}$$

$$R_{ekv} = R1 + \frac{R2 * R3}{R2 + R3 + R4} + \frac{((\frac{R2 * R4}{R2 + R3 + R4}) + R5 + R7) * ((\frac{R3 * R4}{R2 + R3 + R4}) + R6)}{((\frac{R2 * R4}{R2 + R3 + R4}) + R5 + R7) + ((\frac{R3 * R4}{R2 + R3 + R4}) + R6)} + R8 = 1505.3199\,\Omega$$

$$I = \frac{U}{R} = 0.0631\,A$$

$$U - R_{1238} * I_1 - R_{346} * I_2 = 0$$

$$I_2 = \frac{U - I_1 * R_{1238}}{R_{346}}$$

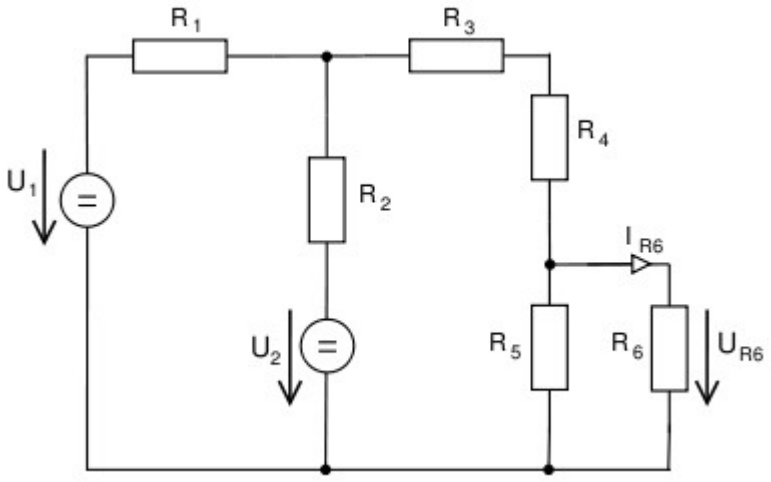
$$I_2 = 0.0318\,A$$

$$I_2 = I_{R6}$$

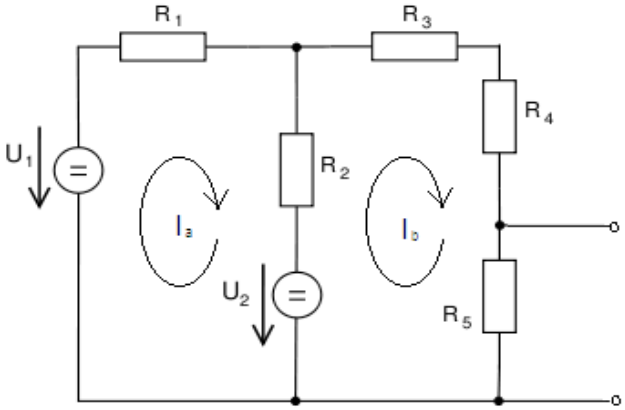
$$U_{R6} = R_6 * I_{R6} = 26.3691\,V$$

Příklad 2

Stanovte napětí U_{R6} a proud I_{R6}. Použijte metodu Theveninovy věty.



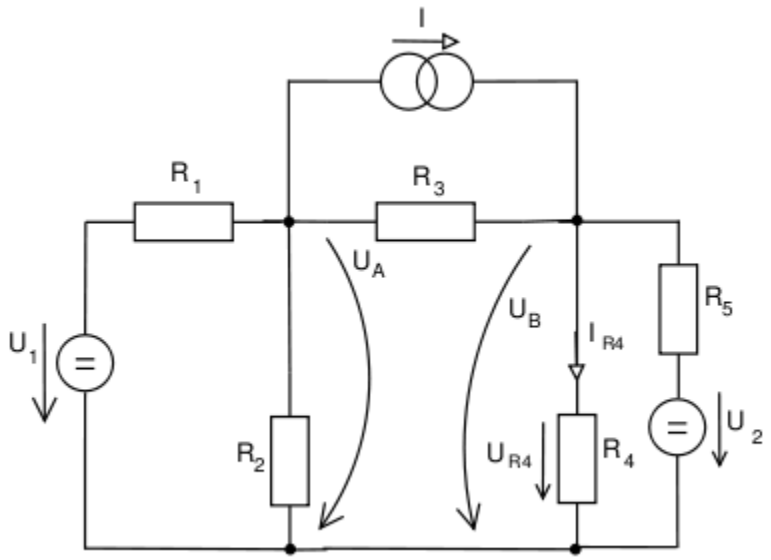
U_1 = 150V, U_2 = 180V, R_1 = 315Ω, R_2 = 615Ω, R_3 = 180Ω, R_4 = 380Ω, R_5 = 370Ω, R_6 = 300Ω



$$R_1 * I_a + R_2 * (I_a - I_b) = U_1 - U_2$$
$$R_2 * (I_b - I_a) + R_3 * I_b + R_4 * I_b + R_5 * I_b = U_2$$
$$I_a = 0.0608\ A$$
$$I_b = 0.1407\ A$$
$$U_i = R_5 * I_b = 52.0594\ V$$
$$R_i = \frac{((\frac{R_1 * R_2}{R_1 + R_2}) + R_3 + R_4) * R_5}{(\frac{R_1 * R_2}{R_1 + R_2}) + R_3 + R_4 + R_5} = 249.7336\ \Omega$$
$$I_{R6} = \frac{U_i}{R_i + R_6} = 94.6993\ mA$$
$$U_{R6} = R_6 * I_{R6} = 28.4098\ V$$

Příklad 3

Stanovte napětí U_{R4} a proud I_{R4}. Použijte metodu uzlových napětí (U_A, U_B).



U_1 = 135V, U_2 = 140V, I = 0,65A, R_1 = 520Ω, R_2 = 420Ω, R_3 = 520Ω, R_4 = 420Ω, R_5 = 215Ω

$$I_1 + I_3 = I + I_2$$
$$I = I_3 + I_4 + I_5$$
$$I_1 = \frac{U_1 - U_A}{R_1} \qquad I_2 = \frac{U_A}{R_2}$$
$$I_3 = \frac{U_B - U_A}{R_3} \qquad I_4 = \frac{U_B}{R_4}$$

$$I_5 = \frac{U_B - U_2}{R_5}$$

$$\frac{U_1 - U_A}{R_1} + \frac{U_B - U_A}{R_3} - \frac{U_A}{R_2} - I = 0$$

$$I - \frac{U_B - U_A}{R_3} - \frac{U_B}{R_4} - \frac{U_B - U_2}{R_5} = 0$$

$$U_A = -19.0858\,V$$

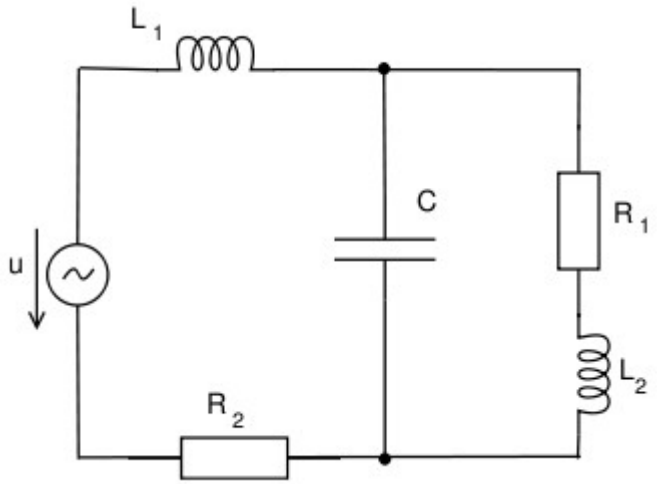
$$U_B = 141.1985\,V$$

$$I_{R4} = \frac{U_B}{R_4} = 0.3362\,A$$

$$U_{R4} = R_4 * I_4 = 141.1985\,V$$

Příklad 4

Pro napájecí napětí platí: $u = U \sin(2\pi ft)$. Ve vztahu pro napětí na kondenzátoru: $u_C = U_C \sin(2\pi ft + \varphi_C)$ určete $|U_C|$ a φ_C. Použijte metodu zjednodušování obvodu.



U = 35V, R_1 = 160Ω, R_2 = 220Ω, L_1 = 270mH, L_2 = 480mH, C = 440µF, f = 85Hz

$$\omega = 2\pi * f = 170\pi$$

$$X_{L1} = j * \omega * L_1 = 0 + 144.1991\text{j}$$

$$X_{L2} = j * \omega * L_2 = 0 + 256.3540\text{j}$$

$$X_C = -j\frac{1}{\omega * C} = 0 - 4.2554\text{j}$$

$$Z_1 = R_1 + X_{L2}$$

$$Z_2 = \frac{Z_1 * X_C}{Z_1 + X_C} = 0.0325 - 4.3066\text{j}$$

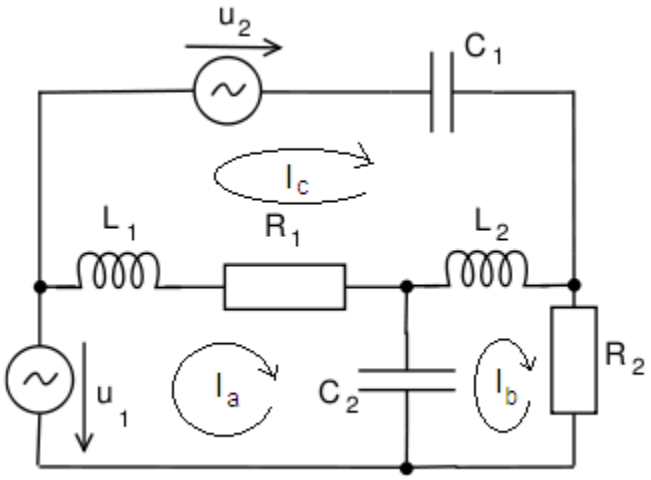
$$Z = R_2 + X_{L1} + Z_2 = 220.0325 + 139.8925\text{j}$$

$$I = \frac{U}{Z} = 0.1133 - 0.0720\text{j}$$

$$U_C = I * Z_2 = -0.3064 - 0.4903\text{j}$$
$$|U_C| = 0.5781\,V$$
$$\varphi_C = \arctan\frac{-0.4903}{-0.3064} = 1.0123\,rad = 238°$$

Příklad 5

Pro napájecí napětí platí: $u_1 = U_1 \sin(2\pi ft)$,$u_2 = U_2 \sin(2\pi ft)$. Ve vztahu pro napětí na cívce: $u_{L2} = U_{L2} \sin(2\pi ft+\varphi_{L2})$ určete $|U_{L2}|$ a φ_{L2}. Použijte metodu smyčkových proudů.



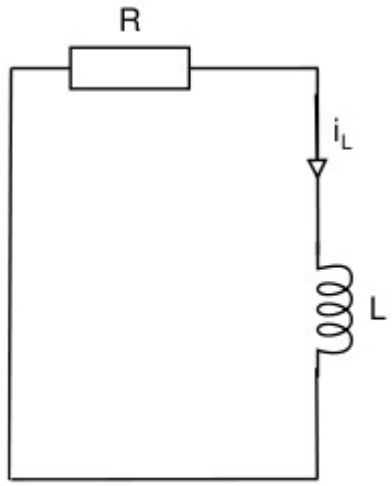
U_1 = 55V, U_2 = 50V, R_1 = 130Ω, R_2 = 125Ω, L_1 = 140mH, L_2 = 60mH, C_1 = 160μF, C_2 = 80μF, f = 60Hz

$$\omega = 2\pi * f = 120\pi$$
$$X_{L1} = j * \omega * L_1 = 0 + 52.7788\text{j}$$
$$X_{L2} = j * \omega * L_2 = 0 + 22.6195\text{j}$$
$$X_{C1} = -j\frac{1}{\omega * C} = 0 - 16.5786\text{j}$$
$$X_{C2} = -j\frac{1}{\omega * C} = 0 - 33.1573\text{j}$$
$$X_{L1} * (I_a - I_c) + R_1 * (I_a - I_c) + X_{C2} * (I_a - I_b) = U_1$$
$$R_2 * I_b + X_{C2} * (I_b - I_a) + X_{L2} * (I_b - I_c) = 0$$
$$X_{C1} * I_c + X_{L2} * (I_c - I_b) + R_1 * (I_c - I_a) + X_{L1} * (I_c - I_a) = -U_2$$
$$I_a = 0.1599 + 0.2035\text{j}$$
$$I_b = -0.1126 + 0.0036\text{j}$$
$$I_c = -0.1622 + 0.3222\text{j}$$
$$U_{L2} = (I_b - I_c) * X_{L2} = 8.7219 + 8.3346\text{j}$$
$$|U_{L2}| = 12.0639\,V$$
$$\varphi_{L2} = \arctan\frac{8.3346}{8.7219} = 0.7627\,rad = 43.7°$$

Příklad 6

Sestavte diferenciální rovnici popisující chování obvodu na obrázku, dále ji upravte dosazením hodnot

parametrů. Vypočítejte analytické řešení $i_L = f(t)$. Proveďte kontrolu výpočtu dosazením do sestavené diferenciální rovnice.



L = 30H, R = 45Ω, $i_L(0)$ = 6A

$$u_R + u_L = 0$$

$$R * i_L + L * \frac{di_L}{dt} = 0$$

$$R * i_L + L * i_L' = 0$$

Charakteristická rovnice:

$$i_L' + \frac{3}{2} i_L = 0$$

$$\lambda + \frac{3}{2} = 0$$

$$\lambda = -\frac{3}{2}$$

Očekávané řešení:

$$i_L(t) = K(t) * e^{\lambda t} = K(t) * e^{-\frac{3}{2}t}$$

$$i_L(t)' = K(t)' * e^{-\frac{3}{2}t} + K(t) * -\frac{3}{2} * e^{-\frac{3}{2}t}$$

$$K(t)' * e^{-\frac{3}{2}t} + K(t) * -\frac{3}{2} * e^{-\frac{3}{2}t} + \frac{3}{2}(K(t) * e^{-\frac{3}{2}t}) = 0$$

$$K(t)' * e^{-\frac{3}{2}t} = 0$$

$$\int K(t)' = \frac{0}{e^{\lambda t}} = \frac{0}{e^{-\frac{3}{2}t}} = 0 * e^{-\frac{3}{2}t} = 0$$

$$K(t) = c$$

$$i_L(t)=c*e^{-\frac{3}{2}t}$$

$$i_L(0)=6$$

$$6=c*e^{-\frac{3}{2}*0}$$

$$c=6$$

$$i_L=6*e^{-\frac{3}{2}t}$$

Zkouška:

$$i_L'+\frac{3}{2}i_L=0$$

$$\frac{-3}{2}6*e^{-\frac{3}{2}t}+\frac{3}{2}*6*e^{-\frac{3}{2}t}=0$$

$$0=0$$

Výsledky

Příklad	Skupina	Řešení
1	B	U_{R6}=26.3691 V I_{R6}=0.0318 A
2	G	U_{R6}=28.4098 V I_{R6}=94.6993 mA
3	E	U_{R4}=141.1985 V I_{R4}=0.3362 A
4	B	$\|U_C\|$=0.5781 V φ_C=238°
5	G	$\|U_{L2}\|$=12.0639 V φ_{L2}=43.7°
6	E	dif.rce: $i_L'+3/2i_L=0$ $i_L=6*e^{-3/2\,t}$