Teória obvodov

2013/2014

Semestrálny projekt - Riešenie zadaných obvodov

Marek Marušic (xmarus05)   Brno, 20. 12.2013

Obsah

Príklad 1 - Zadanie F

Určte napätie UR7 a prúd IR7. Použite metódu postupného zjednodušovania obvodu.

U = 125V

R1 = 510Ω   R5 = 300Ω

R2 = 500Ω   R6 = 800Ω
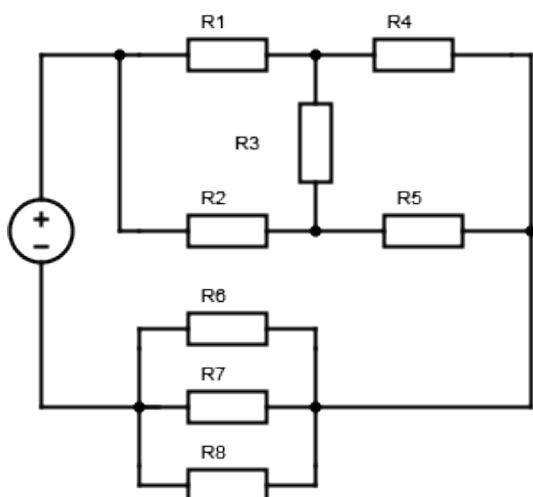
R3 = 550Ω   R7 = 330Ω

R4 = 250Ω   R8 = 250Ω
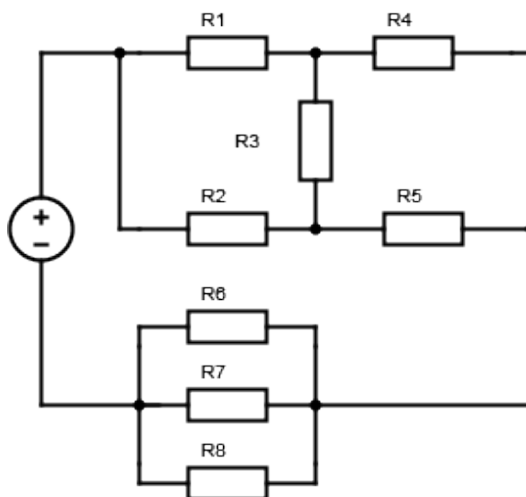
Zjednodušenie obvodu:

Urobím transfiguráciu a prekreslím obvod.
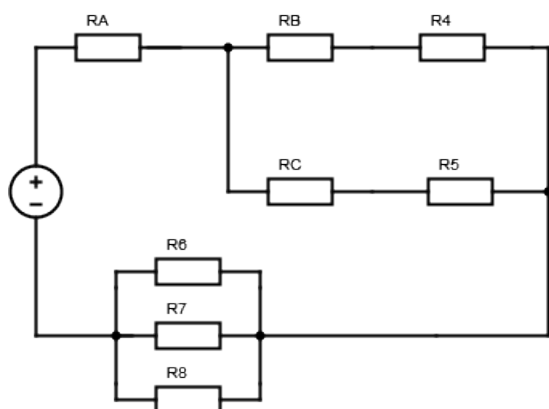
$R_A = R_1 R_2 /(R_1+R_2+R_3)$ =

= 510*500/(510+500+550) =

= 163,4615 Ω

$R_B = R_1 R_3 /(R_1+R_2+R_3)$ =

= 510*550/(510+500+550) =

= 179,8077 Ω

$R_C = R_2 R_3 /(R_1+R_2+R_3)$

= 500*550/(510+500+550) =

= 176,2821 Ω

Po transfigurácii sa dá obvod ešte zjednodušiť ďalej.
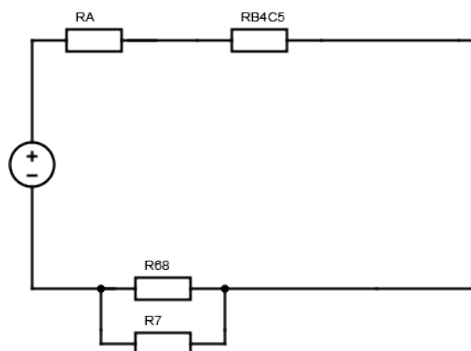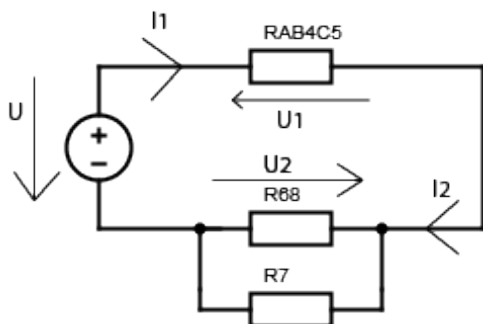

$R_{B4C5} = (R_B + R_4) * (R_C + R_5)/[(R_B + R_4) + (R_C + R_5)]$

$= (179,8077 + 250)*(176,2821+300)/(179,8077 + 250 + 176,2821+300) = 225,9265 \ \Omega$

$R_{68} = R_6 * R_8/(R_6 * R_8) =$

$= 800*250/(1050)=190,4672 \Omega$

Po ďalšom zjednodušovaní obvod vyzerá nasledovne :

$R_{AB4C5} = R_A + R_{B4C5} = 163,4615+225,9165 = 389,388$

$R_{678} = R_{68} * R_7/(R_{68} + R_7) =$

$= 190,4672*330/(190,4672+330) = 120,7649 \ \Omega$

$R = R_{AB4C5} + R_{678} = 389,388 + 120,7649 = 510,1565 \ \Omega$

$I = U/R = 125/510,1565 = 0,245A$

U sa rozdelí medzi U2 a U1 v pomere $R_{678} : R_{AB4C5}$.

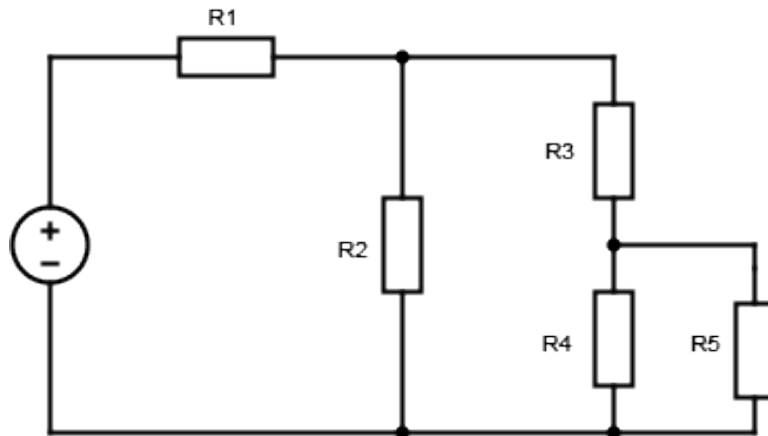$U_2/U_1 = 120,7649/389,388 => U_2 = 29,5910 \ \Omega$

$U_2 = U_{R7} = 29,5910 \ \Omega$

I sa rozdelí medzi I2 a I1 v opačnom pomere $R_{68} : R_7$.
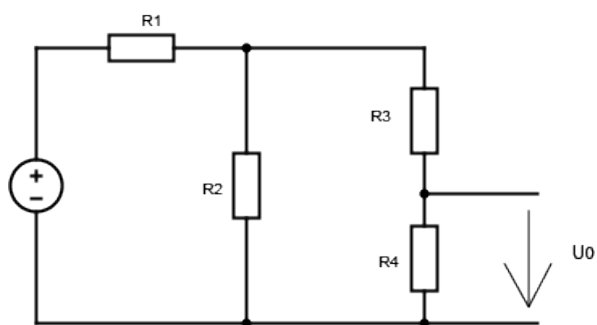
$I_{R7}/I_{R68} = R_{68} / R_7 => I_{R7} = 0,0899A$

Príklad 2 - Zadanie F

Určte napätie UR5 a prúd IR5. Použite metódu Theveninovej vety.

U=130V ,R1= 350 Ω,R2= 600 Ω, R3= 195 Ω,R4= 320 Ω,R5= 280 Ω

Odpojím R5 pre výpočet ideálneho zdroja napätia U_0.

U_0 = U * R_2 *R_4 /(R1*R2+R1*R3+R1*R4+R2*R3+R2*R4)

U_0 = 35,6954 Ω

Zdroj napätia skratujeme pre výpočet vnútorného odporu R_i.
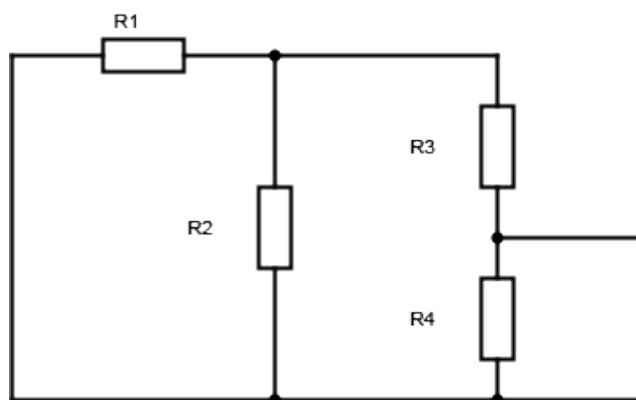
Postupne zjednoduším obvod a dostanem R_i.
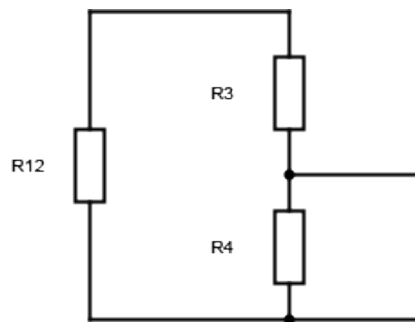
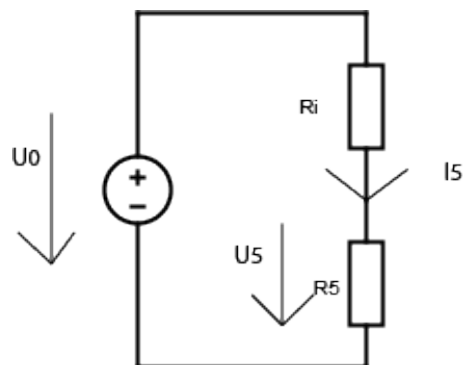$R_{12}= R_1*R_2/(R_1+R_2) = 350*600/950 = 221,0526\ \Omega$

$R_{123}= R_{12}+ R_3 = 221,0526 +195 = 416,0526\ \Omega$

$R_i = R_{123} *R_4 /(R_{123} +R_4)= 416,0526*320/(416,0526+320)$

$= 180,8795\ \Omega$

Zo získaných parametrov vytvoríme náhradné schéma deliča napetia.

$U_z = U_0 * R_5/(R_i+R_5) = 35,6954 * 280/(180,8795+280) = 21,6862\ V$

$I_{R5} = U_0/(R_i+R_5) = 35,6954/(180,8795+280) = 0,0775\ A$

Príklad 3 - Zadanie D

Určte napätie UR4 a prúd IR4. Použite metódu uzlových napätí (UA, UB,UC).

U=115V,I1=60A,I2=0.9A,R1= 500 Ω, R2= 380 Ω, R3= 480 Ω, R4= 370 Ω,R5= 285 Ω
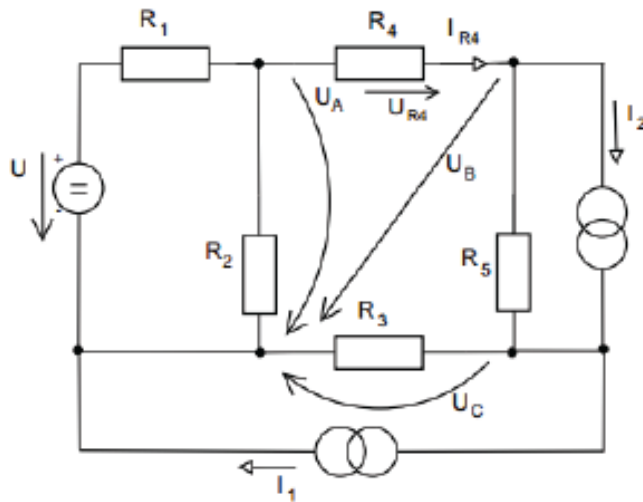
Pre každý uhol vytvoríme rovnice podľa I. Kirchhoffovho zákona.

A: $I_{R1} - I_{R2} - I_{R4} = 0$

B: $I_{R4} - I_{R5} - I_2 = 0$

C: $I_{R5} + I_2 - I_1 - I_{R3} = 0$

Vytvoríme rovnice prúdov v obvode.

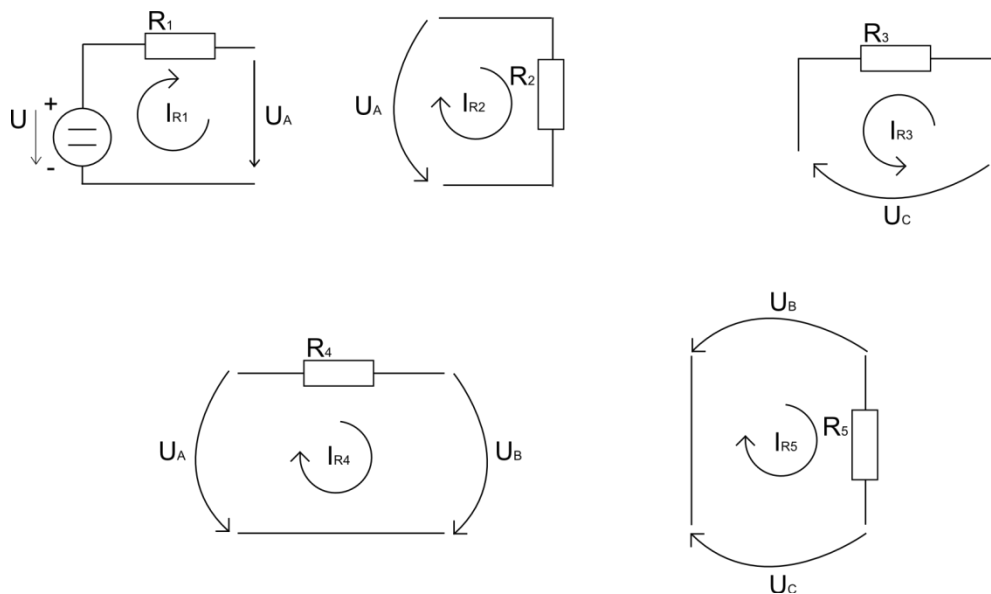$R_1*I_{R1}+U_a-U = 0 => I_{R1} = (U-U_a)/R_1$
$R_2*I_{R2} - U_a = 0 => I_{R2} = U_a/R_2$
$R_3*I_{R3}-U_c = 0 => I_{R3} = U_c/R_3$
$R_4*I_{R4}+U_b-U_a = 0 => I_{R4} = (U_a-U_b)/R_4$
$R_5*I_{R5}+U_c-U_b = 0 => I_{R5} = (U_b-U_c)/R_5$

Dosadíme:

$(U-U_a)/R_1- U_a/R_2-(U_a-U_b)/R_4=0$
$(U_a-U_b)/R_4-(U_b-U_c)/R_5-I_2 =0$
$(U_b-U_c)/R_5+I_2-I_1- U_c/R_3 =0$

$(115-U_a)/500 - U_a/380 - (U_a-U_b)/370 = 0$

$(U_a-U_b)/370 - (U_b-U_c)/285 -0.9 = 0$

$(U_b-U_c)/285 +0.9 -60 - U_c/480 =0$

U_a = -4602,2 V

U_b = -12574 V

U_c = - 18458 V

I_{R4} = $(U_a-U_b)/R_4$ = (-4602,2+12574)/370 = 21,5454 A

U_{R4} = (U_a-U_b) = -4602,2+12574 = 7971.8 V

Príklad 4 - Zadanie F

U = 75 V	R3 = 380 Ω	C1 = 310 µF
R1 = 165 Ω	L1 = 430 mH	C2 = 235 µF
R2 = 150 Ω	L2 = 320 mH	f = 95 Hz
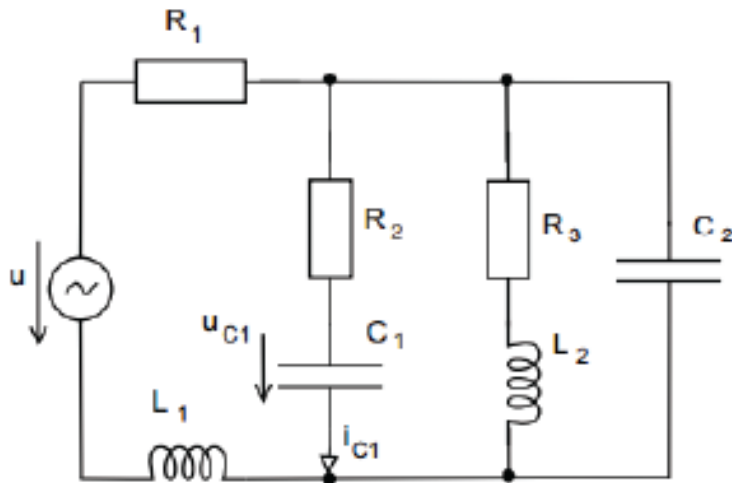
ω = 2*π*95 = 596.9026 rad/s

Z1 = R1 = 165 Ω
Z2 =R2-j1/(ωC1)= 150-j/(596.9026*310*10^{-6})=(150-j5,4042) Ω
Z3=R3+jωL2=380+j596,9026*0, 320=(270+j191.0088) Ω
Z4=-j/(ωC2)=-j/596.9026 *235* 10^{-6}=-j7.1290 Ω
Z5=jωL1=j*596.9026* 0, 430=256.6681j Ω

Odstránime paralelné zapojenie.
1/Z234=1/Z2+1/Z3+1/Z4
1/Z234= 1/(150-j5,4042)+ 1/(270+j191.0088) + 1/(- j7.1290) = 0.00912638+0.138766 j
=>Z234= 0.471909 - 7.17534j Ω

Z = Z1 + Z234 + Z5 = 165 + (0.471909 - 7.17534j) + 256.6681j = 165.4719 +249.4928 j Ω

I= U/Z = 75/(165.4719 +249.4928 j) = 0.1384662 -0.2087745 j A

UZ234=Z234 * I= (0.471909 - 7.17534j) * (0.1384662 -0.2087745 j) = -1.43268 -1.09206j V

IZ2 = UZ234/Z2 = (-1.43268 -1.09206j) / (150-j5,4042) = -0.00927686 -0.00761463 j A

UC1 = -j*1/(ωC1)*IZ2 = 1/[596.9026 * 310*10^{-6} *(-0.00927686 -0.00761463 j)]= -5.4042j * (-0.00927686 -0.00761463 j) = -0.0411510 +0.0501340 j

$$|UC1| = \sqrt{0.0411510^2 + 0.0501340^2} = 0.0649 \text{ V}$$

$$\varphi C1 = \arctan\left(\frac{0.0501340}{-0.0411510}\right) = -50.62°$$

Príklad 5 - zadanie F

Príklad 6 - zadanie D

Zostavte diferenciálnu rovnicu popisujúcu chovanie obvodu na obrázku, dalej ju upravte dosadením hodnôt parametrov. Vypočítajte analitické riešenie uc= f(t). Urobte kontrolu výpočtu dosadením do zostavenej dif. rovnice.

C=25 R=30 uc= 5

$750U´c(t) + uc(t) = 0$ $\qquad$ $uc(0) = 5$ V

$750\lambda+1=0$

$\qquad \lambda = -1/750$

$uc(t) = c(t) * e^{\lambda t}$

$uc(t) = c(t) \cdot e^{(-1/750\,t)}$

$$u´c = c´(t) \cdot e^{-\frac{1}{750}t} + c(t) \cdot e^{-\frac{1}{750}t} \cdot (-\frac{1}{750})$$

$$750 \cdot (c´(t) \cdot e^{-\frac{1}{750}t} + c(t) \cdot e^{-\frac{1}{750}t} \cdot (-\frac{1}{750})) + c(t) \cdot e^{-\frac{1}{750}t} = 0$$

$$750 c´(t) \cdot e^{-\frac{1}{750}t} = 0$$

$$\int c(t)dt = 0 => \square(\square) = \square$$

$$uc(t) = c(t) \cdot e^{-\frac{1}{750}t}$$

$$uc(t) = K \cdot e^{-\frac{1}{750}t}$$

$$5 = K \cdot e^{-\frac{1}{750} \cdot 0}$$

$$5 = K \cdot 1$$

$$K = 5$$

$$uc(t) = 5 \cdot e^{-\frac{1}{750}t}$$

Skúška:

$$u'c(t) = 5 \cdot e^{-\frac{1}{750}t} \cdot (-\frac{1}{750})$$

$$750 \cdot uc´(t) + uc(t) = 0$$

$$750 \cdot \left(5 \cdot e^{-\frac{1}{750}t} \cdot \left(-\frac{1}{750}\right)\right) + 5 \cdot e^{-\frac{1}{750}t} = 0$$

$$-5 \cdot e^{-\frac{1}{750}t} + 5 \cdot e^{-\frac{1}{750}t} = 0$$

$$0 = 0$$