

OSNOVI ELEKTRONIKE (13S041OE)

Predavanja (2 časa sedmično):

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Termini za konsultacije:

- po dogovoru putem mail-a
- grupne konsultacije - nekoliko dana pre kolokvijuma i nekoliko dana pre ispita u januarskom ispitnom roku

Predispitne obaveze:

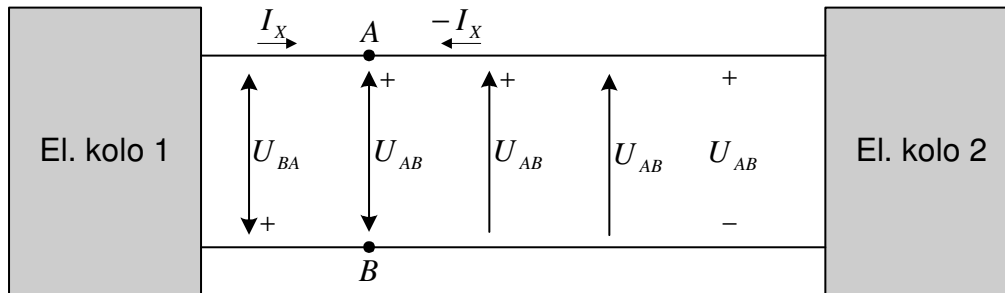
- laboratorijske vežbe (ukupno 3 vežbe) - obavezne, uslov za izlazak na ispit; rade se u parovima prema rasporedu koji će biti blagovremeno objavljen; dozvoljena je zamena termina između studenata (nije je potrebno unapred najavljivati, već je dovoljno u samoj laboratoriji pred početak laboratorijske vežbe o tome obavestiti dežurnog asistenta); uputstva i prateći materijali za laboratorijske vežbe se mogu preuzeti sa sajta predmeta; odštampana uputstva za laboratorijske vežbe je potrebno doneti na same vežbe, kako bi se u njih upisali rezultati dobijeni merenjima i simulacijama (što ujedno predstavlja i izveštaj sa laboratorijskih vežbi koji svaki od parova predaje po završetku istih)
- kolokvijumi - nisu obavezni, izgubljeni poeni se mogu nadoknaditi na ispitu
- domaći zadaci - nisu obavezni, ali se izgubljeni poeni ne mogu nadoknaditi na ispitu

Priprema ispita:

- časovi predavanja i računskih vežbi
- materijali za predavanja i računске vežbe sa sajta predmeta (<http://tnt.etf.bg.ac.rs/~si1oe/>)
- prof. dr Miodrag Popović, prof. dr Milan Ponjavić, "Osnovi analogne elektronike za studente računarskih usmerenja", Beograd, 2020.
- Goran Savić, Milan Ponjavić, "Zbirka rešenih ispitnih zadataka iz Osnova elektronike - za studente Odseka za Softversko inženjerstvo", Beograd, 2022.
- zadaci za samostalni rad sa sajta predmeta (<http://tnt.etf.bg.ac.rs/~si1oe/>)
- zadaci sa dosadašnjih ispita i kolokvijuma (<http://tnt.etf.bg.ac.rs/~si1oe/>)

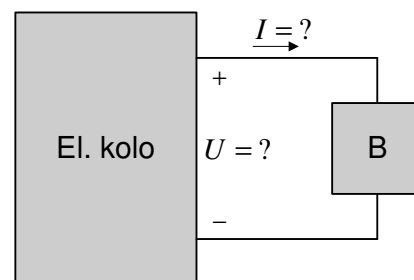
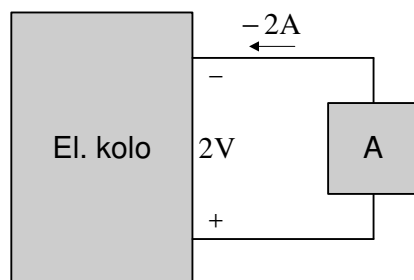
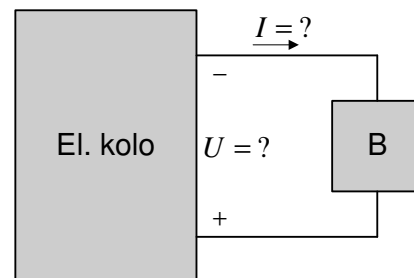
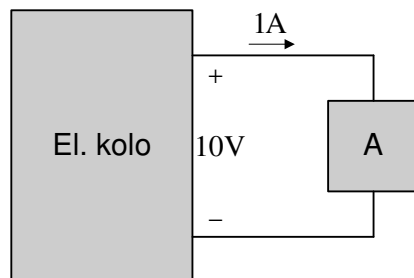
Referentni smer i algebarska vrednost napona i struje

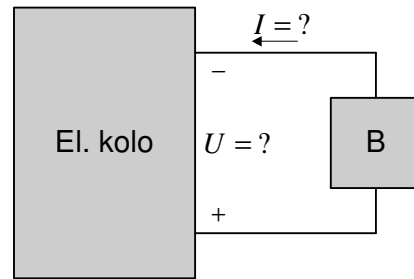
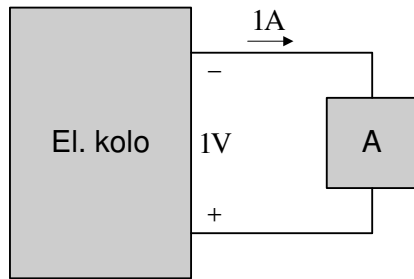
- i struja i napon se definišu preko referentnog smera i algebarske vrednosti



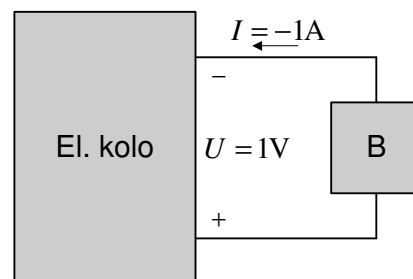
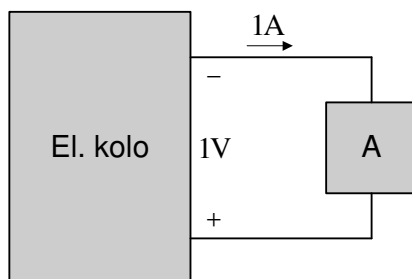
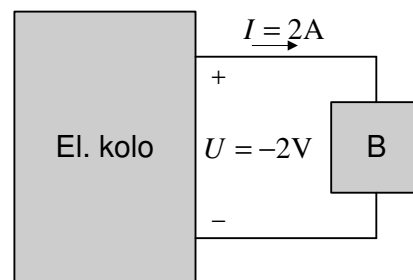
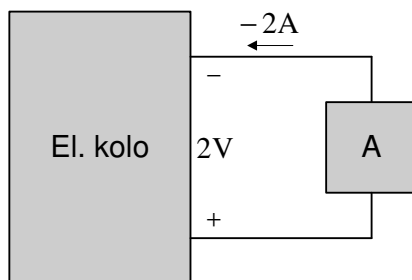
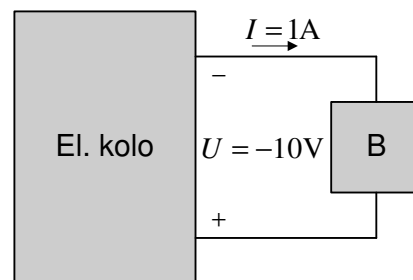
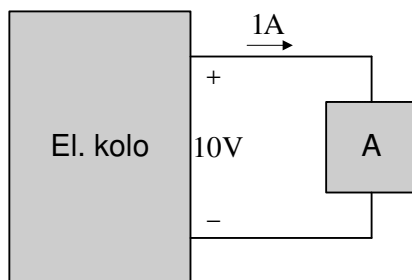
- potencijal tačke A je V_A ; potencijal tačke B je V_B
- napon između tačaka A i B je razlika potencijala $U_{AB} = V_A - V_B$
- $U_{BA} = V_B - V_A = -U_{AB}$

1. Odrediti algebarske vrednosti napona U i struje I za date referentne smerove, tako da element B bude ekvivalentan elementu A.

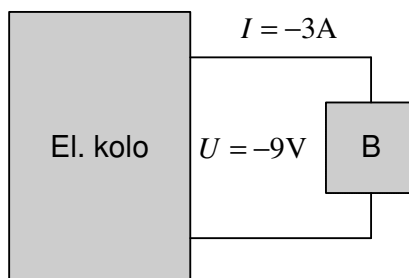
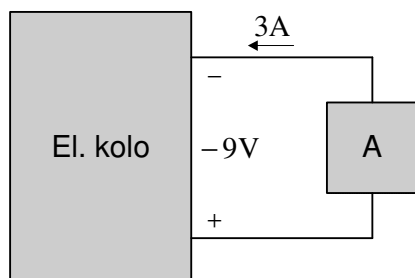
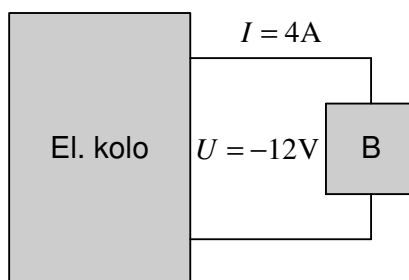
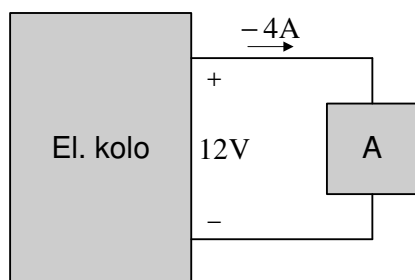
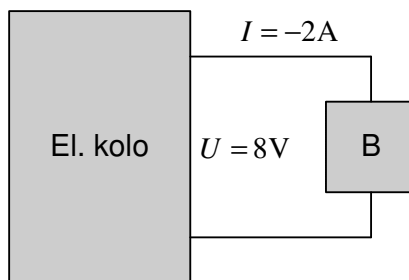
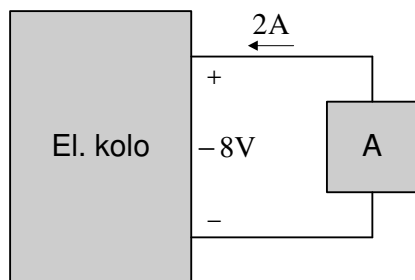




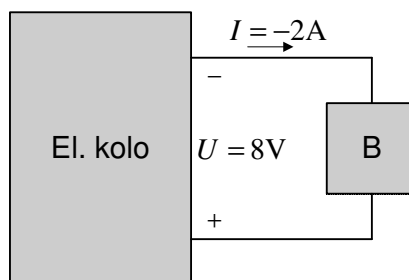
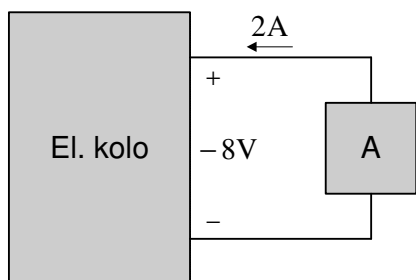
Rešenje:

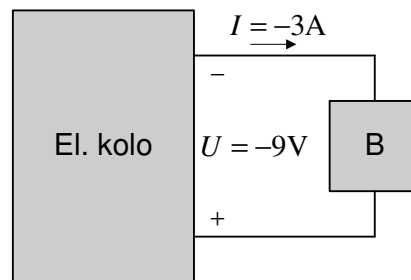
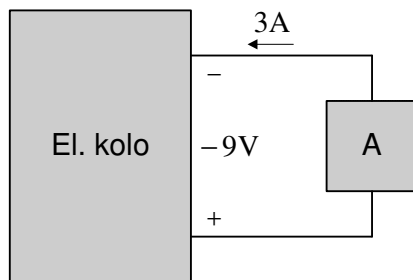
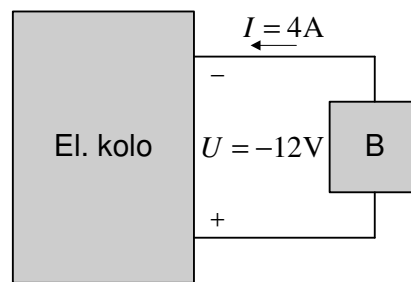
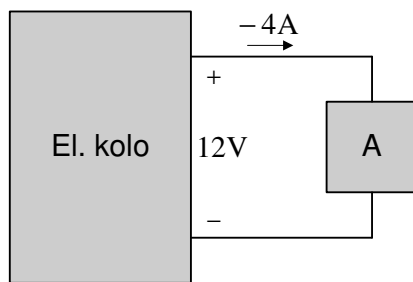


2. Odrediti referentne smerove napona U i struje I za date algebarske vrednosti, tako da elemenat B bude ekvivalentan elementu A.

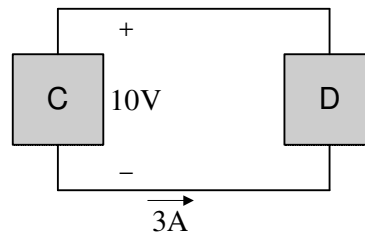
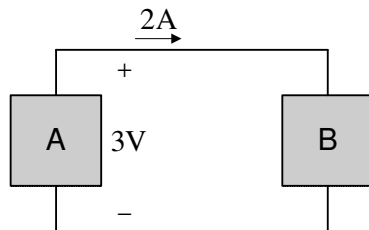


Rešenje:

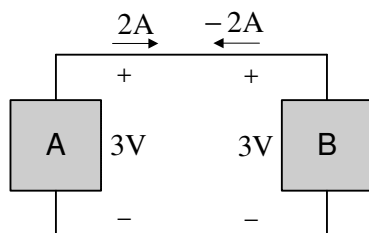




3. Za svaki od elemenata A, B, C i D odrediti snagu koju predaje.

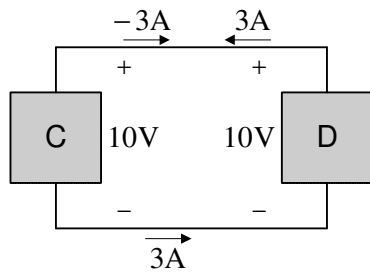


Rešenje:



$P_A = 3V \cdot 2A = 6W$ (element A predaje snagu od 6W, tj. prima snagu od -6W).

$P_B = 3V \cdot (-2A) = -6W$ (element B predaje snagu od -6W, tj. prima snagu od 6W).

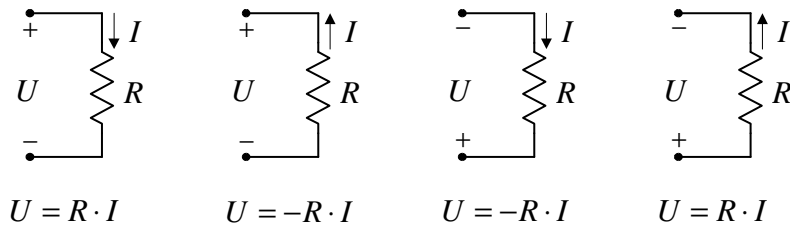


$P_C = 10V \cdot (-3A) = -30W$ (element C predaje snagu od $-30W$, tj. prima snagu od $30W$).

$P_D = 10V \cdot 3A = 30W$ (element D predaje snagu od $30W$, tj. prima snagu od $-30W$).

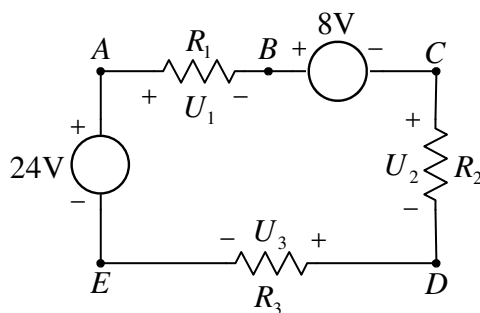
Omov zakon, Kirhofov zakon za struje i Kirhofov zakon za napone

➤ Omov zakon:

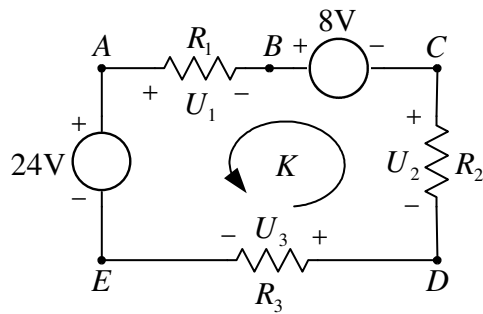


- Kirhofov zakon za struje (prvi Kirhofov zakon): Algebarska suma struja koje utiču u bilo koji čvor kola jednaka je nuli.
- Kirhofov zakon za napone (drugi Kirhofov zakon): Algebarska suma napona u bilo kojoj konturi kola jednaka je nuli.

4. Za kolo sa slike je poznato $U_1 = 9V$ i $U_2 = 5V$. Izračunati napone U_3 , U_{BE} i U_{DB} .



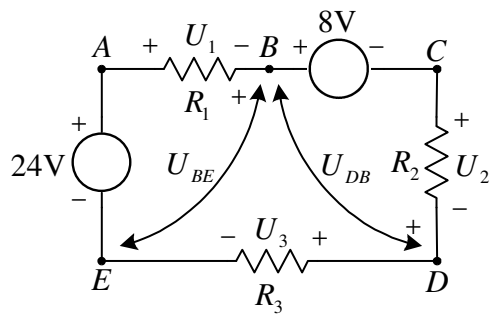
Rešenje:



$$\text{Kontura } K: U_3 + U_2 + 8\text{V} + U_1 - 24\text{V} = 0$$

$$U_3 = 24\text{V} - 8\text{V} - U_2 - U_1$$

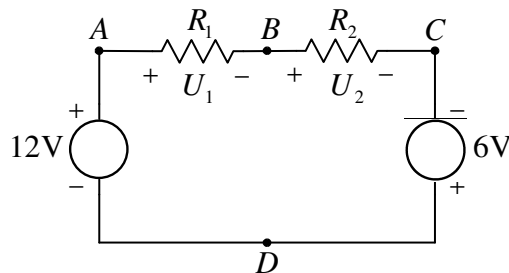
$$\boxed{U_3 = 2\text{V}}$$



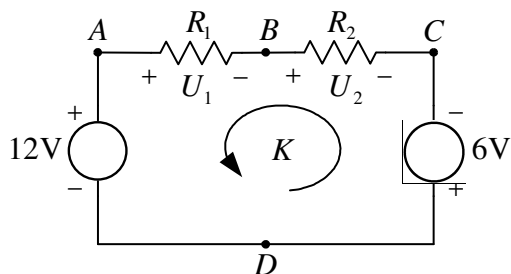
$$U_{BE} = 24\text{V} - U_1 \Rightarrow \boxed{U_{BE} = 15\text{V}}$$

$$U_{DB} = -8\text{V} - U_2 \Rightarrow \boxed{U_{DB} = -13\text{V}}$$

5. Za kolo sa slike je poznato $U_1 = 4\text{V}$. Izračunati napone U_2 i U_{BD} .



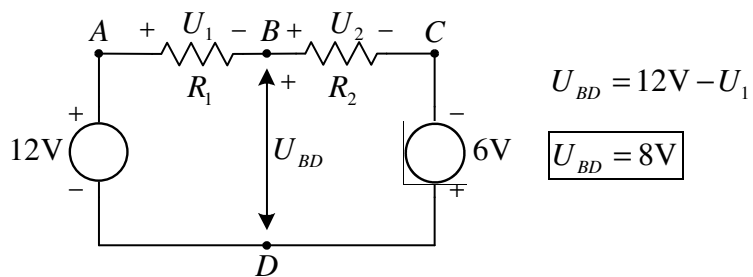
Rešenje:



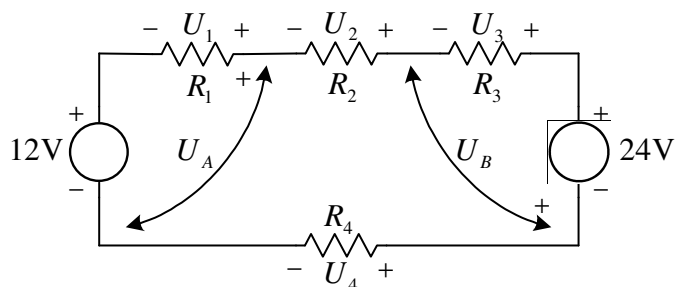
$$\text{Kontura } K: -6\text{V} + U_2 + U_1 - 12\text{V} = 0$$

$$U_2 = 12\text{V} + 6\text{V} - U_1$$

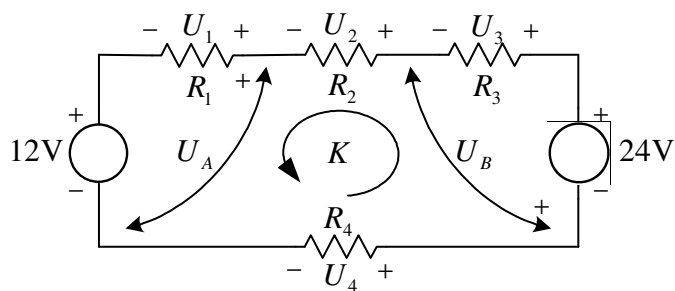
$$\boxed{U_2 = 14\text{V}}$$



6. Za kolo sa slike je poznato $U_1 = 1\text{V}$, $U_2 = 4\text{V}$ i $U_3 = 2\text{V}$. Izračunati napone U_4 , U_A i U_B .



Rešenje:



Kontura K :

$$U_4 + 24\text{V} - U_3 - U_2 - U_1 - 12\text{V} = 0$$

$$U_4 = -24\text{V} + U_3 + U_2 + U_1 + 12\text{V}$$

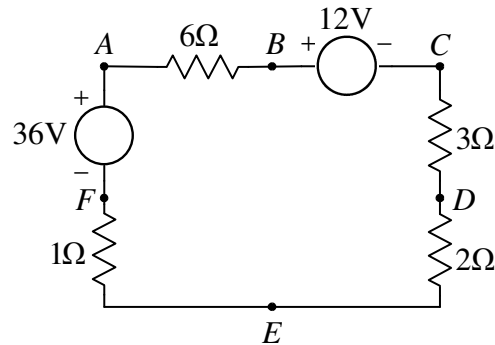
$$U_4 = -5\text{V}$$

$$U_A = 12\text{V} + U_1 \Rightarrow U_A = 13\text{V}$$

$$U_B = U_3 - 24\text{V} \Rightarrow U_B = -22\text{V}$$

7. a) Za kolo sa slike izračunati struju I , napone U_{BE} i U_{FD} , snagu koju predaje idealni naponski generator od 36V i snagu koja se disipira na otporniku otpornosti 3Ω .

b) (Zadatak za vežbu) Ponoviti prethodnu tačku ako se idealni naponski generator od 12V zameni idealnim naponskim generatorom od 72V.



Rešenje:

a) Kontura K :

$$I \cdot 2\Omega + I \cdot 3\Omega + 12V + I \cdot 6\Omega - 36V + I \cdot 1\Omega = 0$$

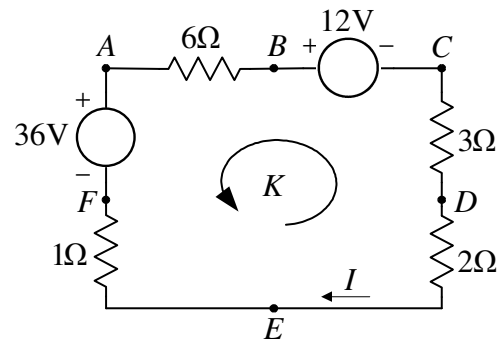
$$I \cdot 12\Omega = 24V \Rightarrow \boxed{I = 2A}$$

$$U_{BE} = -I \cdot 1\Omega + 36V - I \cdot 6\Omega \Rightarrow \boxed{U_{BE} = 22V}$$

$$U_{FD} = -I \cdot 2\Omega - I \cdot 1\Omega \Rightarrow \boxed{U_{FD} = -6V}$$

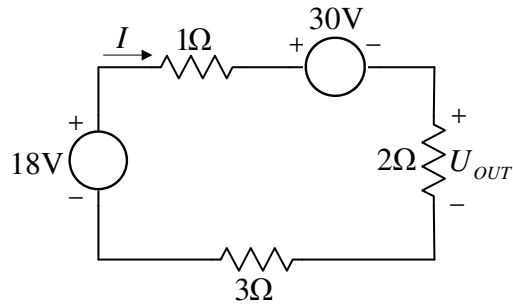
$$P_{36V} = 36V \cdot I = 36V \cdot 2A \Rightarrow \boxed{P_{36V} = 72W}$$

$$P_{3\Omega} = 3\Omega \cdot I^2 = 3\Omega \cdot (2A)^2 \Rightarrow \boxed{P_{3\Omega} = 12W}$$

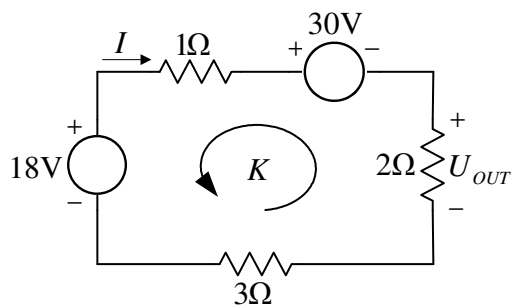


b) $\boxed{I = -3A}$ $\boxed{U_{BE} = 57V}$ $\boxed{U_{FD} = 9V}$ $\boxed{P_{36V} = -108W}$ $\boxed{P_{3\Omega} = 27W}$

8. Za kolo sa slike izračunati struju I , napon U_{OUT} , kao i snagu koju predaje idealni naponski generator od 30V.



Rešenje:



Kontura K :

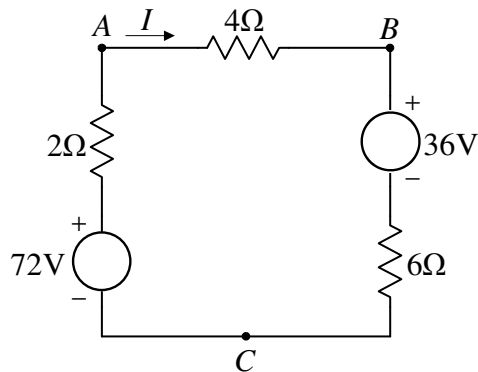
$$I \cdot 3\Omega + I \cdot 2\Omega + 30V + I \cdot 1\Omega - 18V = 0$$

$$I \cdot 6\Omega = -12V \Rightarrow \boxed{I = -2A}$$

$$U_{OUT} = I \cdot 2\Omega \Rightarrow \boxed{U_{OUT} = -4V}$$

$$P_{30V} = -I \cdot 30V \Rightarrow \boxed{P_{30V} = 60W}$$

9. Za kolo sa slike izračunati struju I , napone U_{AC} i U_{CB} , snagu koja se disipira na otporniku otpornosti 6Ω i snagu koju predaje idealni naponski generator od 36V.



Rešenje:Kontura K :

$$I \cdot 6\Omega + 36V + I \cdot 4\Omega + I \cdot 2\Omega - 72V = 0$$

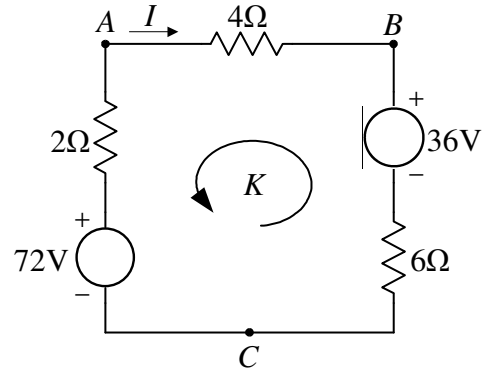
$$I \cdot 12\Omega = 36V \Rightarrow \boxed{I = 3A}$$

$$U_{AC} = 72V - I \cdot 2\Omega \Rightarrow \boxed{U_{AC} = 66V}$$

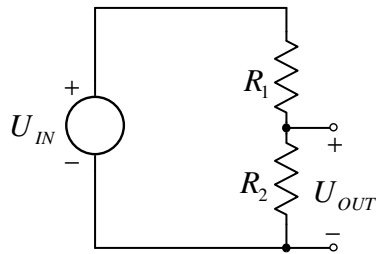
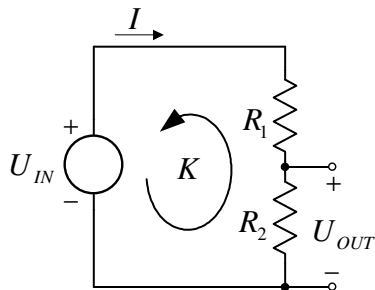
$$U_{CB} = -I \cdot 6\Omega - 36V \Rightarrow \boxed{U_{CB} = -54V}$$

$$P_{6\Omega} = 6\Omega \cdot I^2 = 6\Omega \cdot (3A)^2 \Rightarrow \boxed{P_{6\Omega} = 54W}$$

$$P_{36V} = 36V \cdot (-I) = 36V \cdot (-3A) \Rightarrow \boxed{P_{36V} = -108W}$$



10. Za kolo sa slike (razdelnik napona) je poznat napon U_{IN} i otpornosti R_1 i R_2 . Odrediti napon U_{OUT} .

**Rešenje:**Kontura K :

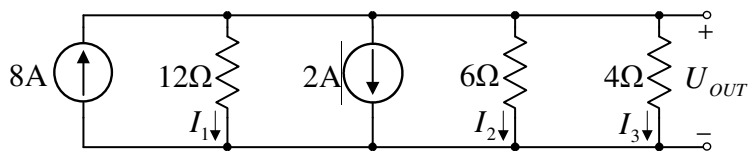
$$I \cdot R_2 + I \cdot R_1 - U_{IN} = 0$$

$$U_{OUT} = I \cdot R_2 \Rightarrow I = \frac{U_{OUT}}{R_2}$$

$$\Rightarrow \boxed{U_{OUT} = \frac{R_2}{R_1 + R_2} \cdot U_{IN}}$$

11. a) Za kolo sa slike izračunati napon U_{OUT} , struje I_1 , I_2 i I_3 , snagu koju predaje idealni strujni generator od 2A i snagu koja se disipira na otporniku otpornosti 4Ω .

b) (Zadatak za vežbu) Ponoviti prethodnu tačku ako se idealni strujni generator od 2A zameni idealnim strujnim generatorom od 20A.



Rešenje:

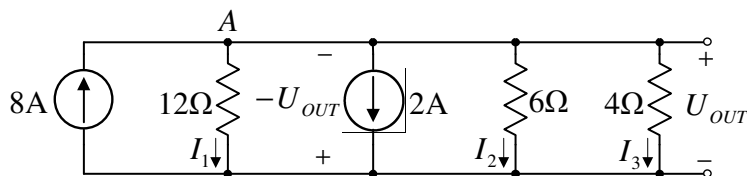
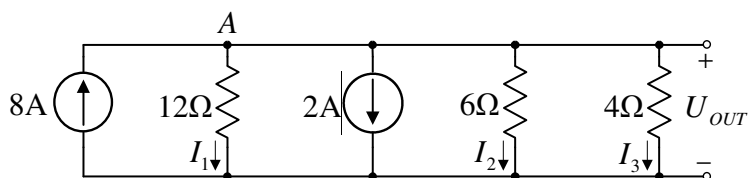
a) Čvor A :

$$8A - I_1 - 2A - I_2 - I_3 = 0$$

$$I_1 = \frac{U_{OUT}}{12\Omega}, I_2 = \frac{U_{OUT}}{6\Omega}, I_3 = \frac{U_{OUT}}{4\Omega}$$

$$8A - \frac{U_{OUT}}{12\Omega} - 2A - \frac{U_{OUT}}{6\Omega} - \frac{U_{OUT}}{4\Omega} = 0$$

$$6A = \frac{6 \cdot U_{OUT}}{12\Omega} \Rightarrow \boxed{U_{OUT} = 12V}, \boxed{I_1 = 1A}, \boxed{I_2 = 2A}, \boxed{I_3 = 3A}$$

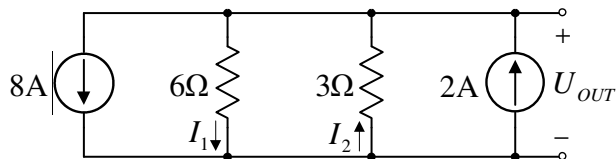


$$P_{2A} = (-U_{OUT}) \cdot 2A = (-12V) \cdot 2A \Rightarrow \boxed{P_{2A} = -24W}$$

$$P_{4\Omega} = 4\Omega \cdot I_3^2 = 4\Omega \cdot (3A)^2 \Rightarrow \boxed{P_{4\Omega} = 36W}$$

b) $\boxed{U_{OUT} = -24V}, \boxed{I_1 = -2A}, \boxed{I_2 = -4A}, \boxed{I_3 = -6A}, \boxed{P_{20A} = 480W}, \boxed{P_{4\Omega} = 144W}$

12. Za kolo sa slike izračunati napon U_{OUT} , struje I_1 i I_2 i snagu koja se disipira na otporniku otpornosti 6Ω .



Rešenje:

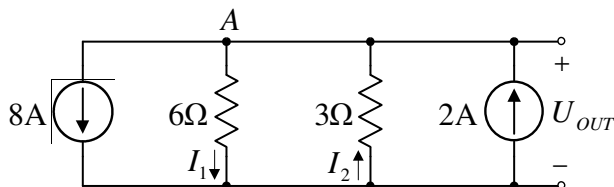
Čvor A: $-8A - I_1 + I_2 + 2A = 0$

$$I_1 = \frac{U_{OUT}}{6\Omega}, I_2 = -\frac{U_{OUT}}{3\Omega}$$

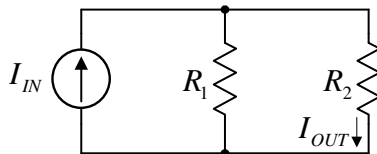
$$-8A - \frac{U_{OUT}}{6\Omega} - \frac{U_{OUT}}{3\Omega} + 2A = 0$$

$$-6A = \frac{U_{OUT}}{2\Omega} \Rightarrow \boxed{U_{OUT} = -12V}, \boxed{I_1 = -2A}, \boxed{I_2 = 4A}$$

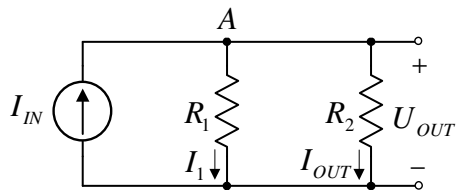
$$P_{6\Omega} = 6\Omega \cdot I_1^2 = 6\Omega \cdot (-2A)^2 \Rightarrow \boxed{P_{6\Omega} = 24W}$$



13. Za kolo sa slike (strujni razdelnik) je poznata struja I_{IN} i otpornosti R_1 i R_2 . Odrediti struju I_{OUT} .



Rešenje:



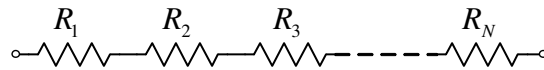
Čvor A:

$$\left. \begin{aligned} I_{IN} - I_1 - I_{OUT} &= 0 \\ I_1 &= \frac{U_{OUT}}{R_1} \\ U_{OUT} &= I_{OUT} \cdot R_2 \end{aligned} \right\} \Rightarrow I_{IN} - \frac{I_{OUT} \cdot R_2}{R_1} - I_{OUT} = 0$$

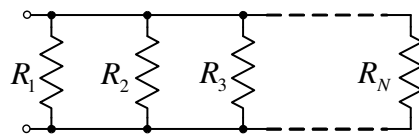
$$\boxed{I_{OUT} = \frac{R_1}{R_1 + R_2} \cdot I_{IN}}$$

Računanje ekvivalentne otpornosti

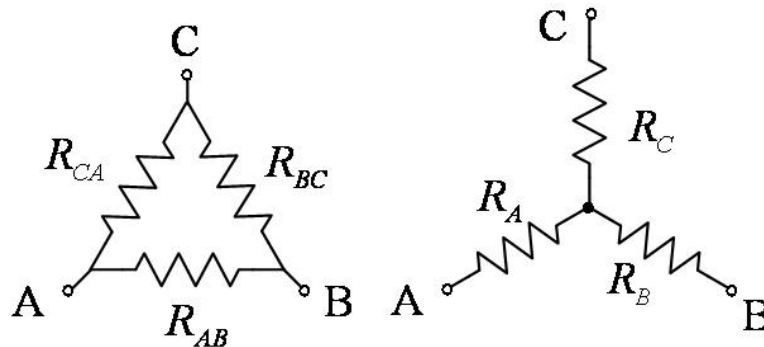
- Redna (serijska veza otpornika): $R_{EKV} = R_1 + R_2 + R_3 + \dots + R_N$



- Paralelna veza otpornika: $\frac{1}{R_{EKV}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \dots + \frac{1}{R_N}$



- Transformacija zvezda-trougao:



$$R_{AB} = R_A + R_B + \frac{R_A R_B}{R_C}$$

$$R_{BC} = R_B + R_C + \frac{R_B R_C}{R_A}$$

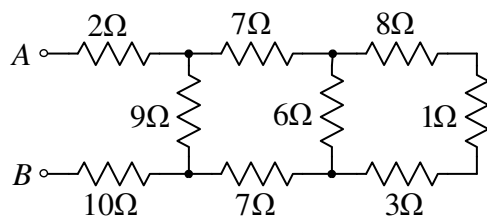
$$R_{CA} = R_C + R_A + \frac{R_C R_A}{R_B}$$

$$R_A = \frac{R_{AB} R_{CA}}{R_{AB} + R_{BC} + R_{CA}}$$

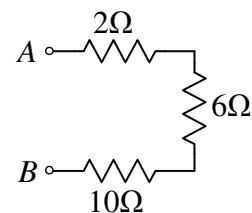
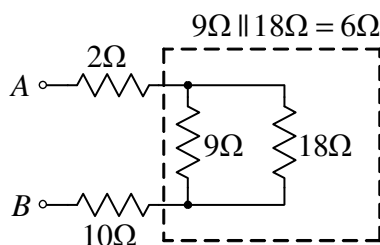
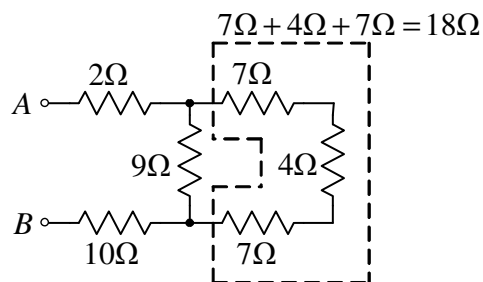
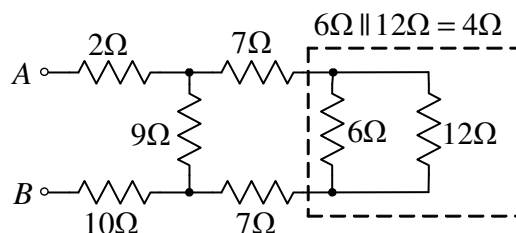
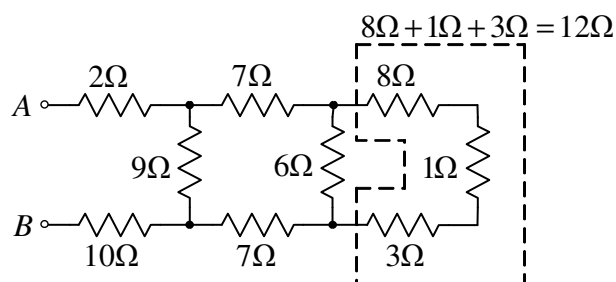
$$R_B = \frac{R_{AB} R_{BC}}{R_{AB} + R_{BC} + R_{CA}}$$

$$R_C = \frac{R_{BC} R_{CA}}{R_{AB} + R_{BC} + R_{CA}}$$

14. Za kolo sa slike odrediti ekvivalentnu otpornost između tačaka A i B .



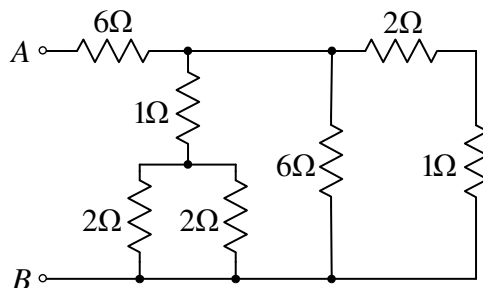
Rešenje:



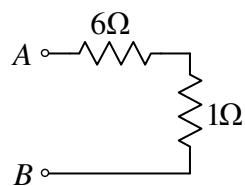
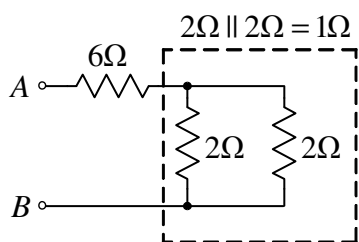
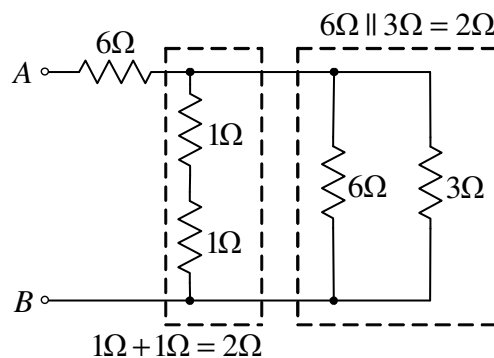
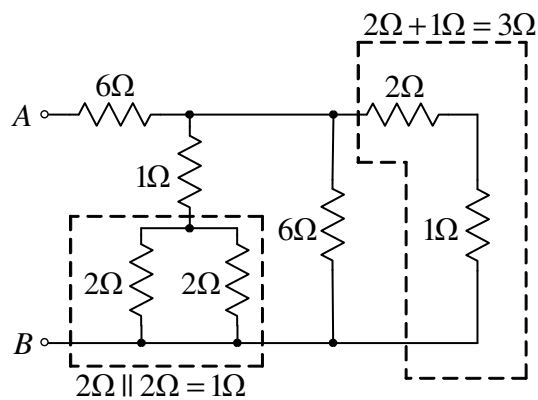
$$R_{EKV} = 2\Omega + 6\Omega + 10\Omega$$

$$R_{EKV} = 18\Omega$$

15. Za kolo sa slike odrediti ekvivalentnu otpornost između tačaka A i B .

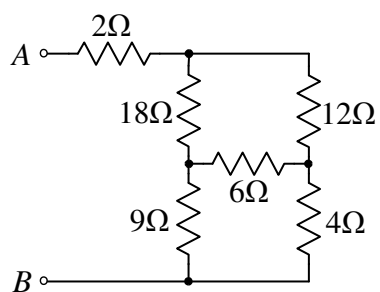


Rešenje:

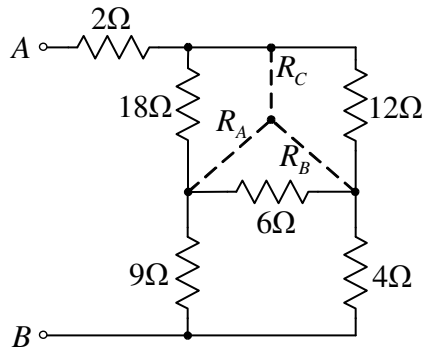


$$R_{EKV} = 6\Omega + 1\Omega \Rightarrow \boxed{R_{EKV} = 7\Omega}$$

16. Za kolo sa slike odrediti ekvivalentnu otpornost između tačaka A i B .



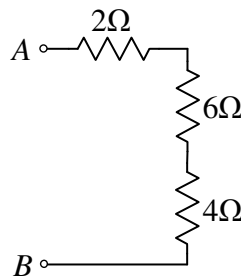
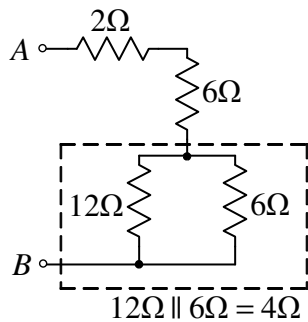
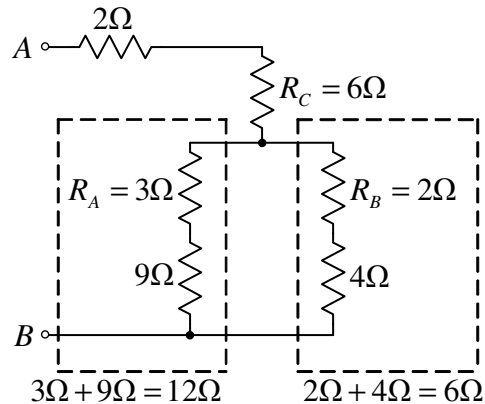
Rešenje:



$$R_A = \frac{6\Omega \cdot 18\Omega}{6\Omega + 12\Omega + 18\Omega} = 3\Omega$$

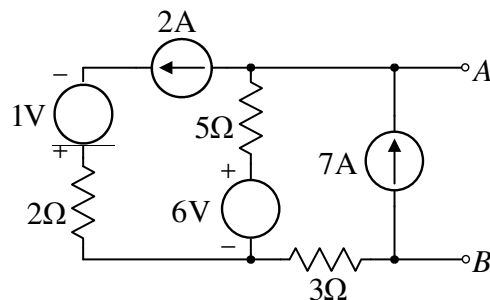
$$R_B = \frac{6\Omega \cdot 12\Omega}{6\Omega + 12\Omega + 18\Omega} = 2\Omega$$

$$R_C = \frac{12\Omega \cdot 18\Omega}{6\Omega + 12\Omega + 18\Omega} = 6\Omega$$



$$R_{EKV} = 2\Omega + 6\Omega + 4\Omega \Rightarrow \boxed{R_{EKV} = 12\Omega}$$

17. Za kolo sa slike odrediti ekvivalentnu otpornost između tačaka A i B.

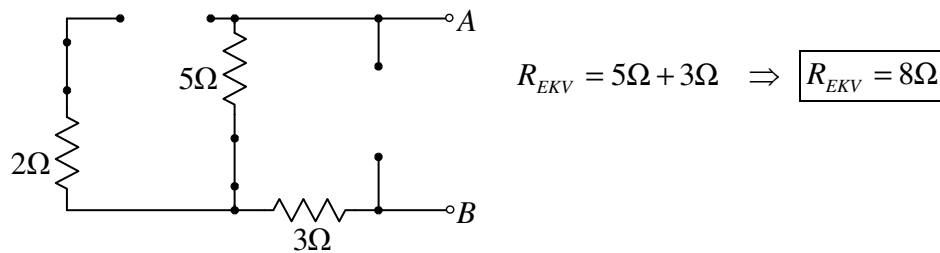


Rešenje:

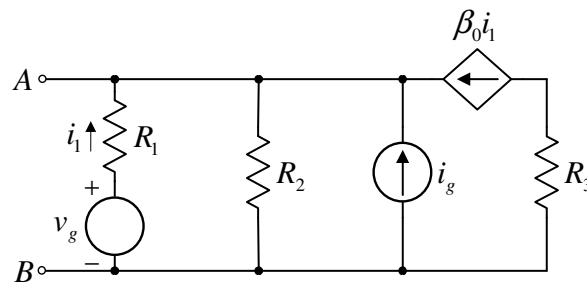
- ukidanje svih nezavisnih generatora u kolu:



- računanje ekvivalentne otpornosti preostalih otpornika.

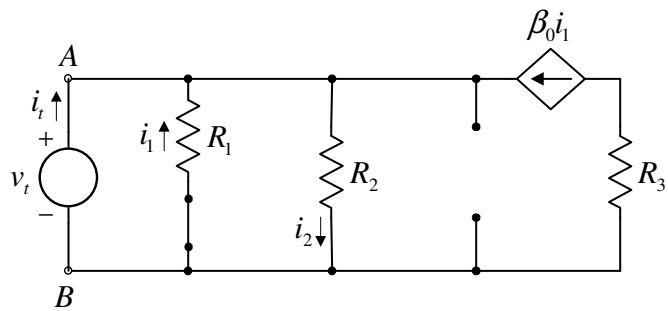


18. Za kolo sa slike su poznati parametri v_g , i_g , β_0 , R_1 , R_2 i R_3 . Odrediti ekvivalentnu otpornost između tačaka A i B .



Rešenje:

- ukidanje svih nezavisnih generatora u kolu;
- povezivanje test generatora v_t između tačaka A i B i označavanje struje i_t koja izlazi iz test generatora;
- računanje ekvivalentne otpornosti kao $R_{EKV} = \frac{v_t}{i_t}$.



$$i_t + i_1 + \beta_0 i_1 - i_2 = 0$$

$$i_1 = -\frac{v_t}{R_1}, \quad i_2 = \frac{v_t}{R_2}$$

$$i_t - \frac{v_t}{R_1} - \beta_0 \frac{v_t}{R_1} - \frac{v_t}{R_2} = 0$$

$$R_{EKV} = \frac{v_t}{i_t} = \frac{1}{\frac{\beta_0 + 1}{R_1} + \frac{1}{R_2}} \Rightarrow R_{EKV} = \frac{1}{\frac{\beta_0 + 1}{R_1} + \frac{1}{R_2}}$$