O'ZBEKISTON RESPUBLIKASI OLIY VA O'RTA MAXSUS, KASB-HUNAR TA'LIMI VAZIRLIGI
O'RTA MAXSUS, KASB-HUNAR TA'LIMI MARKAZI
BUXORO VILOYATI O'RTA MAXSUS, KASB-HUNAR TA'LIMI BOSHQARMASI
BUXORO TURIZM KOLLEJI

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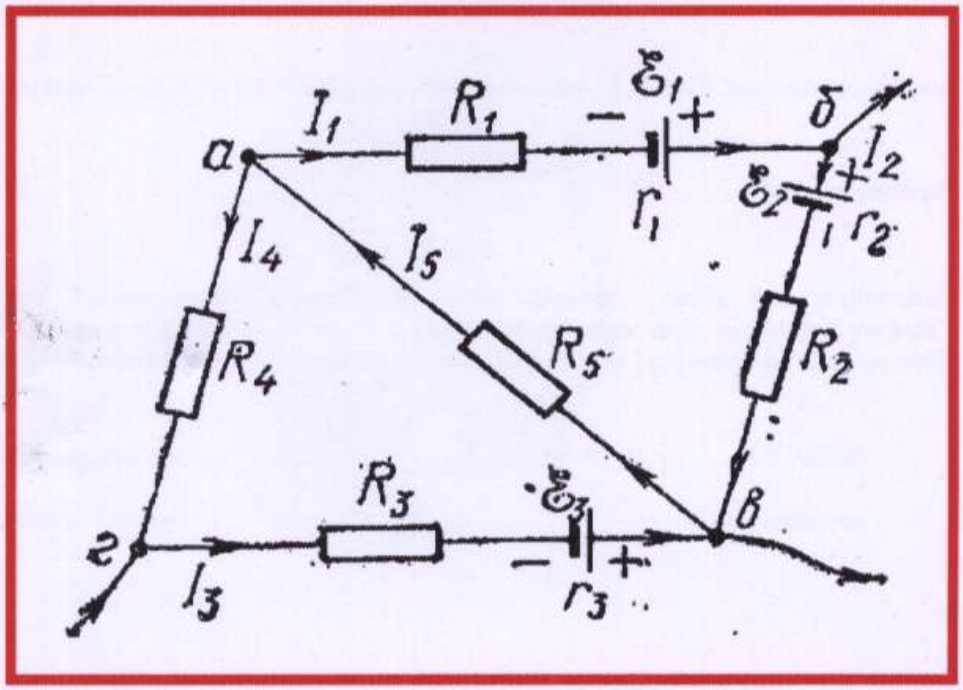
KIRXGOF QOIDALARIGA DOIR MASALALAR YECHISH

USLUBIY ISHLANMA



Buxoro -2017 "Iste'dod"

Kirish

Ushbu uslubiy qo’llanma II qismdan iborat bo’lib, akademik – litsey va kasb-hunar kollejlari hamda umum ta’lim maktab o’quvchi va o’qituvchilari uchun mo’ljallangan.

Mazkur uslubiy qo’llanmada DTM “Axborotnoma” sining 1999-2003 yillardagi sonlarida e’lon qilingan test topshiriqlari va turli xil masalalar yechish kitoblaridan ko’pgina sxemali masalalar tanlab olingan.

Uslubiy qo’llanmada masalalarning to’liq yechimlari keltirilgan bo’lib, masalalarni yechishda har xil usullardan foydalanilgan, ya’ni masalalarni yechishda ularni sxemalarini murakkab ko’rinishdan oddiy ko’rinishga aylantirib, masalalar yechilgan.

Uslubiy qo’llanma yordamida o’quvchilar o’tkazgichlarni ketma-ket va paralel ulash usullarini hamda turli xil sxemalarni ulashni o’rganishlari mumkin.

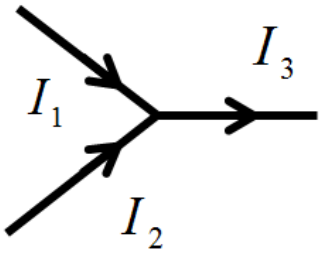
Ushbu uslubiy qo’llanmaning II-qismida nazariy usul bilan bir qatorda amaliy(laboratoriya)usulida yechib ko’rilgan masalalar ham joy olgan.

Ushbu uslubiy qo’llanmadan o’rta talim maktablari o’qituvchilari, ‘Bilimlar bellashuvi’, ‘Olimpiada’ hamda akademik litsey va kollejlar uchun olimpiadalarga tayyorlanayotgan o’quvchilar hamda oliy o’quv yurtlariga kiruvchilar foydalanishlari mumkin.

Tarmoqlangan eleklr zanjiri uchun Kirxgof qoidalari

Kirxgofning birinchi qoidasi:

Tarmoqlanish tugunida uchrashuvchi toklarning algebraik yig'indisi nolga teng.



$$\sum I_k = 0 \qquad (1)$$

$$I_1 + I_2 - I_3 = 0 \qquad (1{,}1)$$

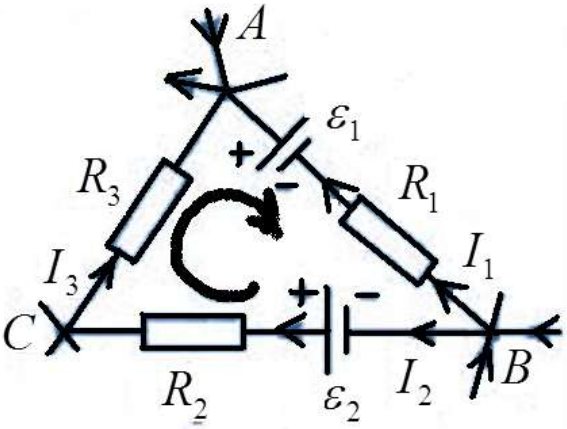
Kiruvchi toklar (+) ishorada(I_1;I_2), chiquvchi toklar (–) ishorada(I_3) olinadi.

Kirxgofning ikkinchi qoidasi: Tarmoqlangan zanjirning berk konturida uning qismlaridan oqayotgan tok kuchlarining tegishli qismlar qarshiliklariga ko'paytmasining algebraik yig'indisi konturdagi tok manbalari elektr yurituvchi kuchlarining algebraic yig'indisiga teng bo'ladi.

$$\sum I_k R_k = \sum \varepsilon_k \qquad (2)$$

Kirxgofning ikkinchi qoidasini tatbiq qilish shartlari

1. Elektr zanjiri qismlaridagi yo'nalish aylanish yo'nalishi bilan mos tushgan toklar musbat, teskari yo'nalgan toklar manfiy.
2. Elektr zanjiridagi tok manbalarining manfiy qutbidan musbat qutbiga tomon yo'nalishi konturning aylanishi bilan mos tushsa, manbaning EYK musbat, aks holda manfiy ishora bilan olinad



$$I_2 + I_3 - I_1 = 0$$

$$\varepsilon = \varepsilon_2 - \varepsilon_1$$

Kirxgofning ikkinchi qoidasi:

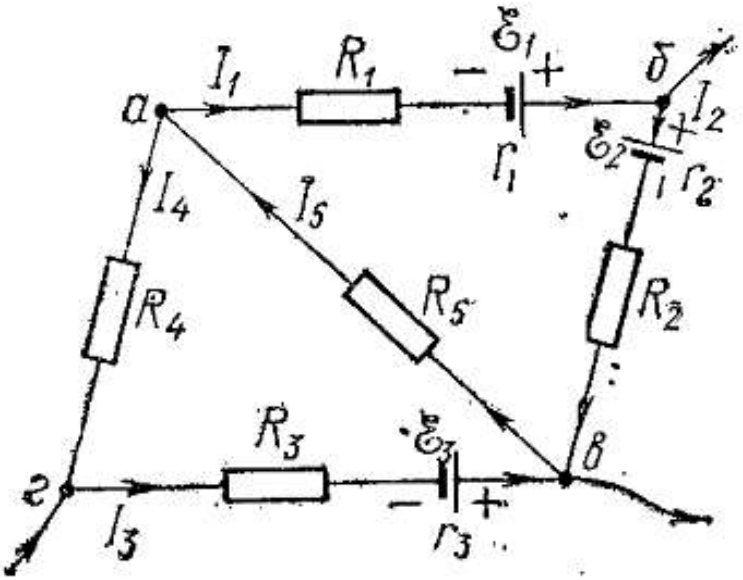
Murakkab elektr zanjirdagi istalgan yopiq konturni aylanib chiqqanda barcha qarshiliklardagi (manbaning ichki qarshiligiham kiradi) kuchlanish tushishlarining algebraik yig'indisi shu kontur E.Yu.K larning algebraic yig'indisiga teng, ya'ni

$$I_1R_1 + I_2R_2 + ... + I_nR_n = \varepsilon_1 + \varepsilon_2 + ... + \varepsilon_n \qquad (3)$$

Har bir konturni aylanib chiqish yo'nalishi (soat strelkasining harakat yo'nalishi bo'yicha yoki unga teskari) ixtiyoriy tanlanadi. Agar ikki tugun orasidagi uchastkada oldindan tanlangan tok yo'nalishi konturni aylanib chiqish yo'nalishi bilan mos tushsa, u holda kuchlanish tushishi musbat hisoblanadi, agar tok yo'nalishi aylanib chiqish yo'nalishiga teskari bo'lsa, kuchlanish manfiy bo'ladi.

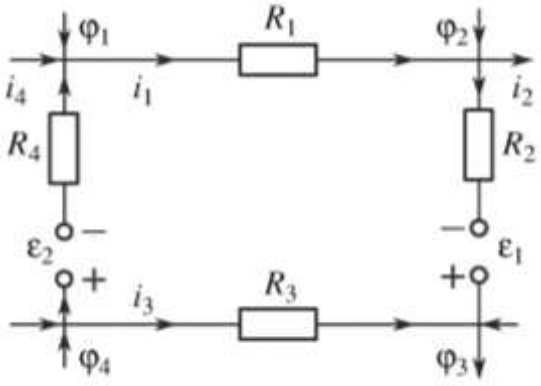
Agar kontur bo'yicha aylanib chiqishda tok manbaini manfiy qutbidan musbat qutbiga tomon o'tilsa, u holda E.Yu.K musbat hisoblanadi, aks holda E.Yu.K manfiy hisoblanadi.

Rasmda ko'rsatilgan **абвг** kontur uchun soat strelkasining harakat yo'nalishi bo'yicha aylanishda 3-formula quyidagi ko'rinishda yoziladi:



$$I_1(R_1 + r_1) + I_2(R_2 + r_2) - I_3(R_3 + r_3) - I_4R_4 = \varepsilon_1 - \varepsilon_2 - \varepsilon_3 \qquad (4)$$

Kirxgofning ikkinchi qoidasi quyidagi sxema misolida

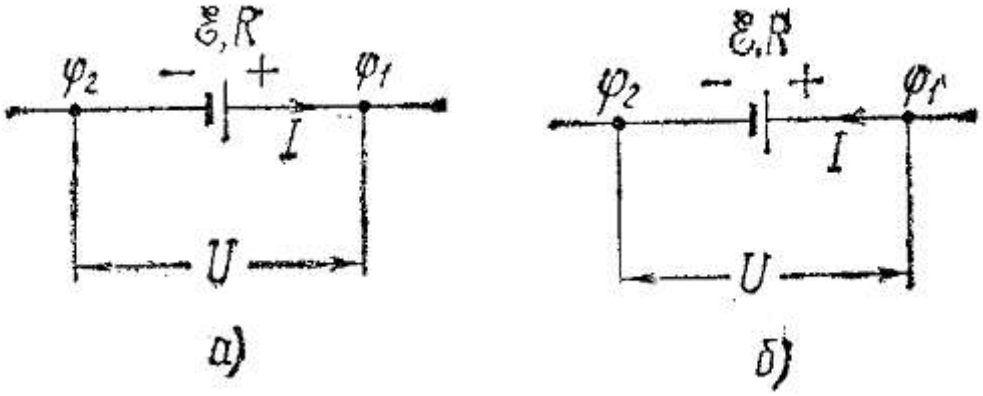


$$i_1R_1 + i_2R_2 - i_3R_3 + i_4R_4 = \varepsilon_1 - \varepsilon_2$$

Har bir uchastkadagi potensiallar farqi quyidagicha

$$i_1R_1 = \varphi_1 - \varphi_2, \qquad i_2R_2 = \varphi_2 - \varphi_3 + \varepsilon_1,$$
$$-i_3R_3 = \varphi_3 - \varphi_4, \qquad i_4R_4 = \varphi_4 - \varphi_1 - \varepsilon_2,$$

Manbaga kiruvchi va undan chiquvchi toklar uchun tenglamalar



Zanjirning ε E.Yu.K va R qarshilik (manbaning ichki qarshiligi ham shunga kiradi) ishtirok etgan qismdagi kuchlanish a rasm uchun

(Manba razryadlanmoqda ya'ni tok bermoqda)

$$U = \varphi_1 - \varphi_2 = \varepsilon - IR \qquad (1)$$

Bunda φ_1 va φ_2 - shu qism boshi va oxiridagi potensiallar. Bu erda qism boshi deganda manbaning musbat qutbi tomoni, oxiri deganda manfiy qutb tomoni tushuniladi va I tok manba ichida manfiy qutbdan musbat qutb tomon oqadi.

Agar zanjirning boshqa qismlari ham E.Yu.K manbaiga ega bo'lsa, u holda bu qismdagi manba ichida qarama-qarshi yo'nalgan tok mavjud bo'lishi mumkin (б-rasm).

Bu holda (Manba zaryadlanmoqda)

$$U = \varepsilon + IR \qquad (2)$$

To'liq zanjir uchun Om qonuni

$$I = \frac{\varepsilon}{R + r}$$

n ta manba ketma-ket ulangan bo'lsa

$$I = \frac{n\varepsilon}{R + nr}$$

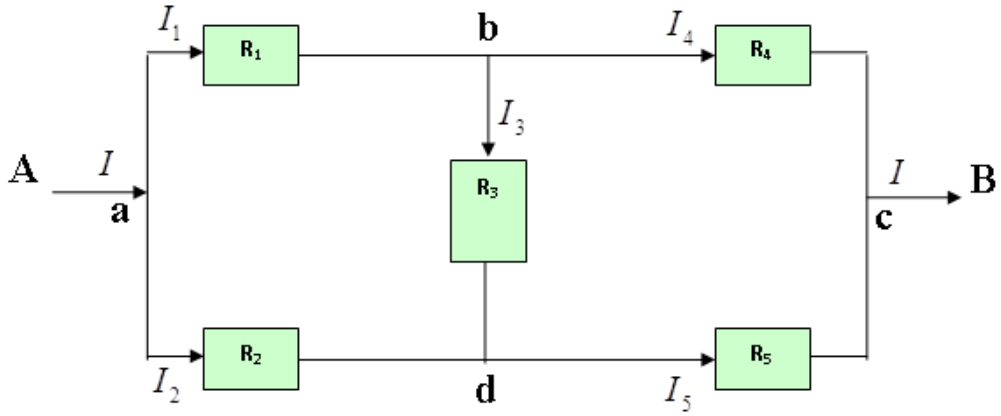
n ta manba parallel ulangan bo'lsa

$$I = \frac{\varepsilon}{R + \frac{r}{n}}$$

ε -manbaning Elektr Yurutuvchi Kuchi R -Tashqi qarshiligi r -ichki qarshilik

MURAKKAB TUZILISHGA EGA BO'LGAN ZANJIR ELEMENTLARIDAGI TOK KUCHI, KUCHLANISH VA UMUMIY QARSHILIKNI HISOBLASH

Buni masalani yechish uchun Krixgofning I-II-qoidasidan foydalanib masalani umumiy holda ko'rib chiqamiz.



Berilgan: $R_1, R_2, R_3, R_4, R_5, I$

$I_1, I_2, I_3, I_4, I_5, R_{AB} - ?$

Kirxkofning 1-2 qonunlaridan foydalanib, quyidagi tenglamalar sistemasini hosil qilamiz.

$$\begin{cases} I = I_1 + I_2 \\ I_1 = I_3 + I_4 \\ I_5 = I_2 + I_3 \\ I_1R_1 + I_3R_3 = I_2R_2 \\ I_5R_5 + I_3R_3 = I_4R_4 \end{cases} \qquad (1)$$

Bu sistemani yechish uchun quyidagilarni topib o'rniga qo'yamiz.

$$\begin{cases} I_2 = I - I_1 \\ I_5 = I - I_1 + I_3 \\ I_4 = I_1 - I_3 \end{cases} \qquad \begin{cases} I_1(R_1 + R_2) + I_3R_3 = IR_2 \\ IR_5 - I_1R_5 + I_3(R_3 + R_5) = I_4R_4 \end{cases} \qquad \begin{cases} I_1(R_1 + R_2) + I_3R_3 = IR_2 \\ IR_5 - I_1R_5 + I_3(R_3 + R_5) = I_1R_4 - I_3R_4 \end{cases}$$

Olingan natijalarni ixchamlab quyidagi sistemani hosil qilamiz. Bu sistemani yechish uchun

2- formuladan foydalanib 3-tenglamani hosil qilamiz.

$$\begin{cases} I_1(R_1 + R_2) + I_3R_3 = IR_2 \\ I_1(R_4 + R_5) - I_3(R_3 + R_4 + R_5) = IR_5 \end{cases}$$

$$I_3 = \frac{IR_2 - I_1(R_1 + R_2)}{R_3} \qquad (2)$$

$$I_1(R_4 + R_5) - \frac{IR_2 - I_1(R_1 + R_2)}{R_3} \cdot (R_3 + R_4 + R_5) = IR_5 \qquad (3)$$

Tenglamani ishlab chiqamiz

$$I_1(R_4 + R_5) - \frac{IR_2}{R_3} \cdot (R_3 + R_4 + R_5) + I_1 \frac{(R_1 + R_2)}{R_3}(R_3 + R_\$ + R_5) = IR_5$$

$$I_1(R_4 + R_5) + I_1 \frac{R_1 + R_2}{R_3}(R_3 + R_4 + R_5) = IR_5 + I\frac{R_2}{R_3}(R_3 + R_4 + R_5)$$

$$I_1 \frac{(R_4 + R_5)R_3 + (R_1 + R_2)(R_3 + R_4 + R_5)}{R_3} = I\frac{R_3R_5 + R_2(R_3 + R_4 + R_5)}{R_3}$$

3-tenglamadan quyidagi natijani olamiz

$$I_1 = \frac{R_3R_5 + R_2(R_3 + R_4 + R_5)}{(R_4 + R_5)R_3 + (R_1 + R_2)(R_3 + R_4 + R_5)} I \qquad (4) \qquad U_1 = I_1 \cdot R_1$$

1-formuladan 1-tenglamani olib, 4-tenglamaga qo'yib natijani olamiz

$$I_2 = I - I_1 = I\left(1 - \frac{R_3R_5 + R_2(R_3 + R_4 + R_5)}{(R_4 = R_5)R_3 + (R_1 + R_2)(R_3 + R_4 + R_5)}\right)$$

$$I_2 = I\frac{(R_4 + R_5)R_3 + (R_1 + R_2)(R_3 + R_4 + R_5) - R_3R_5 - R_2(R_3 + R_4 + R_5)}{(R_5 = R_5)R_3 = (R_1 + R_2)(R_3 + R_4 + R_5)}$$

$$I_2 = I\frac{R_3R_4 + R_3R_5 + R_1(R_3 + R_4 + R_5) - R_3R_5}{(R_4 + R_5)R_3 + (R_1 + R_2)(R_3 + R_4 + R_5)}$$

$$I_2 = \frac{R_3R_4 + R_1(R_3 + R_4 + R_5)}{(R_4 + R_5)R_3 + (R_1 + R_2)(R_3 + R_4 + R_5)} I \qquad (5) \qquad U_2 = I_2 \cdot R_2$$

4-formulani 2-formula yordamida hisoblaymiz quyidagi 6-formula hosil bo'ladi.

$$I_3 = \frac{IR_2 - I_1(R_1 + R_2)}{R_3} = \frac{R_2}{I_3} I - \frac{R_1 + R_2}{R_3} I_1$$

$$I_3 = \frac{R_2}{R_3} \cdot I - \frac{R_1 + R_2}{R_3} \cdot \frac{R_3R_5 + R_2(R_3 + R_4 + R_5)}{(R_4 + R_5)R_3 + (R_1 + R_2) \cdot (R_3 + R_4 + R_5)} \cdot I$$

$$I_3 = \left(\frac{R_2}{R_3} - \frac{R_1 + R_2}{R_3} \cdot \frac{R_3R_5 + R_2(R_3 + R_4 + R_5)}{(R_4 + R_5)R_3 + (R_1 + R_2) \cdot (R_3 + R_4 + R_5)}\right) \cdot I$$

$$I_3 = \left(\frac{R_3(R_2R_4 - R_1R_5)}{(R_4 + R_5)R_3 + (R_1 + R_2) \cdot (R_3 + R_4 + R_5)}\right) \cdot \frac{I}{R_3} \qquad (6) \qquad U_3 = I_3 \cdot R_3$$

4va 6 tenglamalar yordamida 7-formulani keltirib chiqaramiz

$$I_4 = I_1 - I_3 = \frac{R_3R_5 + R_2(R_3 + R_4 + R_5)}{(R_4 + R_5)R_3 + (R_1 + R_2)(R_3 + R_4 + R_5)} I - I_3$$

$$I_4 = \frac{R_3R_5 + R_2(R_3 + R_4 + R_5)}{(R_4 + R_5)R_3 + (R_1 + R_2)(R_3 + R_4 + R_5)} I - \left(\frac{R_3(R_2R_4 - R_1R_5)}{(R_4 + R_5)R_3 + (R_1 + R_2)\cdot(R_3 + R_4 + R_5)} \right) \cdot \frac{I}{R_3}$$

$$I_4 = \frac{R_3^2(R_2 + R_5) + R_3R_5(R_1 + R_2)}{(R_4 + R_5)R_3 + (R_1 + R_2)(R_3 + R_4 + R_5)} \cdot \frac{I}{R_3} \qquad (7) \quad U_4 = I_4 \cdot R_4$$

5-6 formulalardan foydalanib 8-natijani hosil qilamiz

$$I_5 = I_2 + I_3$$

$$I_5 = \frac{R_3R_4 + R_1(R_3 + R_4 + R_5)}{(R_4 + R_5)R_3 + (R_1 + R_2)(R_3 + R_4 + R_5)} I + \left(\frac{R_3(R_2R_4 - R_1R_5)}{(R_4 + R_5)R_3 + (R_1 + R_2)\cdot(R_3 + R_4 + R_5)} \right) \cdot \frac{I}{R_3}$$

$$I_5 = \frac{R_3^2(R_4 + R_1) + R_3R_4(R_1 + R_2)}{(R_4 + R_5)R_3 + (R_1 + R_2)(R_3 + R_4 + R_5)} \cdot \frac{I}{R_3} \qquad (8) \quad U_5 = I_5 \cdot R_5$$

1-sistemani ishlab kerak bo'lgan 4-5-6-7-8 tenglama natijalarini hosil qildik.

Murakkab ko'rinishdagi zanjir elementlaridagi tok kuchi va kuchlanishlarni topdik.Endi zanjirning umumiy qarshiligini hisoblaymiz.

Elektr zaryadi q A nuqtadan B nuqtaga 4-xil yo'l orqali harakatlanadi.

Ya'ni (abc,adc,abdc va adbc).Zaryadning umumiy bajargan ishi har-bir rezistordagi ishlar yig'indisiga teng

abc kontur uchun

$$\begin{aligned} &A = A_1 + A_4; \ \Rightarrow \ qU = qU_1 + qU_4; \Rightarrow U = U_1 + U_4; \\ &I \cdot R_{AB} = I_1 \cdot R_1 + I_4 \cdot R_4 \end{aligned} \qquad (9)$$

adc kontur uchun

$$\begin{aligned} &A = A_2 + A_5; \ \Rightarrow \ qU = qU_2 + qU_5; \Rightarrow U = U_2 + U_5; \\ &I \cdot R_{AB} = I_2 \cdot R_2 + I_5 \cdot R_5 \end{aligned} \qquad (10)$$

abdc kontur uchun

$$\begin{aligned} &A = A_1 + A_3 + A_5; \ \Rightarrow qU = qU_1 + qU_3 + qU_5; \Rightarrow U = U_1 + U_3 + U_5; \\ &I \cdot R_{AB} = I_1 \cdot R_1 + I_3 \cdot R_3 + I_5 \cdot R_5 \end{aligned} \qquad (11)$$

adbc kontur uchun

$$\begin{aligned} &A = A_2 + A_3 + A_4; \Rightarrow \ qU = qU_2 + qU_3 + qU_4; \Rightarrow U = U_2 + U_3 + U_4; \\ &I \cdot R_{AB} = I_2 \cdot R_2 - I_3 \cdot R_3 + I_4 \cdot R_4 \end{aligned} \qquad (12)$$

Ushbu chiqarilgan natijalarning ixtiyoriy biriga yuqorida topilgan tok kuchilarini etib qo'ysak umumiy qarshilik kelib chiqadi.

Masalan (9) formuladagi I_1 va I_4 tok kuchilar o'rniga (4) va (7) natijalarni keltirib qo'yamiz

$$I \cdot R_{AB} = I_1 \cdot R_1 + I_4 \cdot R_4$$

$$I \cdot R_{AB} = \frac{R_3R_5 + R_2(R_3 + R_4 + R_5)}{(R_4 + R_5)R_3 + (R_1 + R_2)(R_3 + R_4 + R_5)} I \cdot R_1 +$$

$$+ \frac{R_3^2(R_2 + R_5) + R_3R_5(R_1 + R_2)}{(R_4 + R_5)R_3 + (R_1 + R_2)(R_3 + R_4 + R_5)} \cdot \frac{I}{R_3} \cdot R_4$$

Tenglikni ikkala qismidan I larni qisqartiramiz. Yuqoridagi aralash tibdagi qarshiliklar sistemasi uchun umumiy formulani hosil qildik

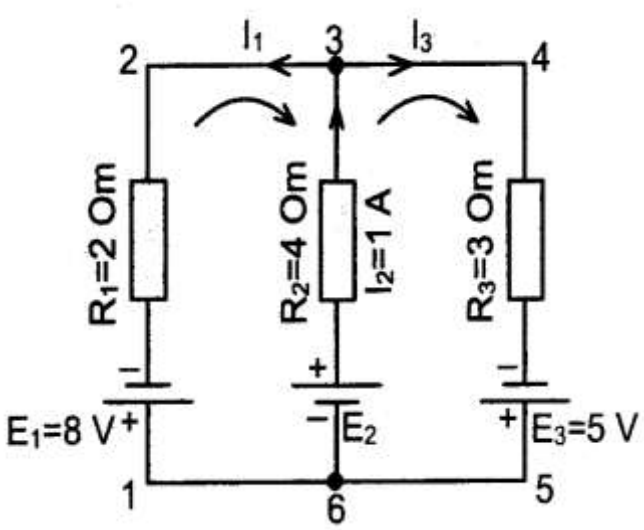
$$R_{AB} = \frac{R_3R_5 + R_2(R_3 + R_4 + R_5)}{(R_4 + R_5)R_3 + (R_1 + R_2)(R_3 + R_4 + R_5)} \cdot R_1 +$$

$$+ \frac{R_3^2(R_2 + R_5) + R_3R_5(R_1 + R_2)}{(R_4 + R_5)R_3 + (R_1 + R_2)(R_3 + R_4 + R_5)} \cdot \frac{R_4}{R_3}$$

Bu formulani yuqoridagi sxemaga o'xshagan masalalarni yechish uchun foydalansak bo'ladi.

KIRXGOF QOIDALARIGA DOIR MASALALAR

1.Quyidagi zanjirdagi noma’lum kattaliklarni aniqlang



Quyidagi zanjir uchun uchta tenglama tuzish mumkin:

1) 1-2-3-6-1 kontur uchun;
2) 3-4-5-6-3 kontur uchun;
3) 1-2-3-4-5-6-1 kontur uchun.

Oxirgi kontur birinchi ikkitasining qo'shilishidan hosil bo'ladi. Shuning uchun mustaqil tenglamalar sifatida uchala tenglamadan ixtiyoriy ikkitasini olish mumkin.

Tok va EYuK orqali Kirxgofning ikkinchi qoidasi tenglamalarini tuzishda tanlab olingan yo'nalishning ishorasi ko'rsatilishi kerak. I_1 tok tanlab olingan harakat yo'nalishiga teskari tomonga oqqanligi uchun uni manfiy deb hisoblash lozim.

E_1 uchun ham "-" ishorasi qo'yilishi kerak, chunki u ham harakat yo'nalishiga qarshi tomonga qarab ta'sir etadi.

3-tugun uchun Kirxgofning birinchi qoidasi,

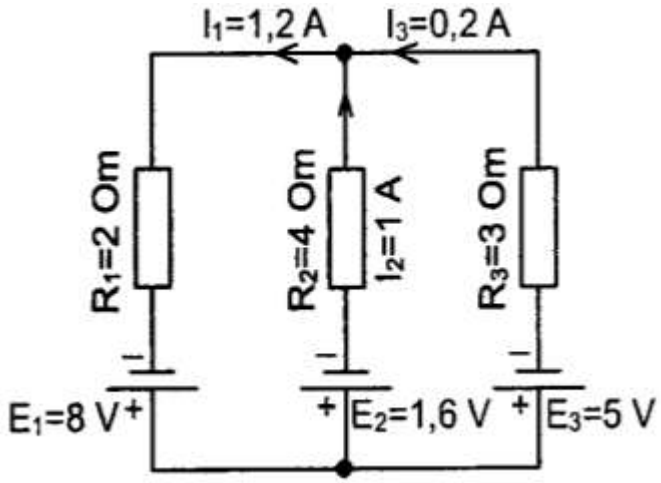
1-2-3-6-1 va 3-4-5-6-3 konturlar uchun Kirxgofning ikkinchi qonunlarini yozib olamiz.

$$\begin{cases} I_2 - I_1 - I_3 = 0 \\ -I_1R_1 - I_2R_2 = -\varepsilon_1 - \varepsilon_2 \\ I_2R_2 + I_3R_3 = \varepsilon_2 + \varepsilon_3 \end{cases} \xrightarrow{\text{Berilganlarni o’rniga qo’ysak}} \begin{cases} 1 = I_1 + I_3 \\ -2I_1 - 1\cdot 4 = -8 - \varepsilon_2 \\ 1\cdot 4 + 3I_3 = 5 + \varepsilon_2 \end{cases}$$

Tenglamalrsistemasini ishlaganimizdan keyin I_1=1,2 A, I_3=-0,2 A, E_2=-1,6 V kabi natijalarga ega bo'lishimiz mumkin.

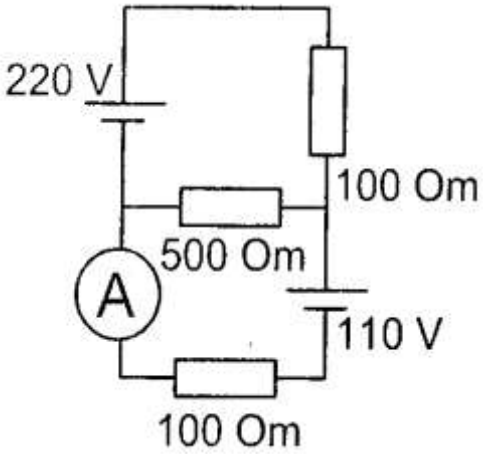
Biz E_2 uchun manfiy qiymatga ega bo'ldik. Bu esa E_2 ning yo'nalishi hisob vaqtida qabul qilingan, ya'ni rasmda ko'rsatilgan yo'nalishga nisbatan qarama-qarshi bo'lishi kerakligini ko'rsatadi. Shuningdek, I_3 tok rasmda ko'rsatilganidek, 3-4 yo'nalish bo'yicha emas, balki unga qarama-qarshi yo’nalishda oqadi. I_1 tok musbat bo'lgani uchun rasmda ko'rsatilgan yo'nalishda oqadi.

Natijalardan kelib chiqib masala shartidagi rasmni quyidagi ko’rinishda ifodalasak bo’ladi:



(I.V.Savel'ev "Umumiy fizika kursi" dan foydalanilgan)

2. Rasmda berilgan ma'lumotlardan foydalanib, ampermetrning ko'rsatishini toping.

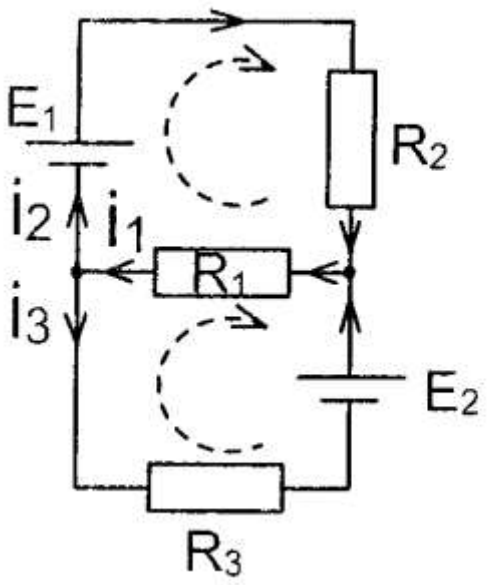


Ishlanishi.

Bu misol Kirxgof qonunlariga asoslanib ishlanadi. Buning uchun zanjirda mavjud tugunlardagi toklarning yo'nalishlarini o'zimiz ixtiyoriy yo'nalishda tanlab olamiz, muhimi, tugunga kirayotgan va tugundan chiqayotgan toklar bo'lishi lozim.

Aytmoqchi bo'lganimiz, hamma tok tugunga yoki hamma tok tugundan tashqariga yo'nalgan bo'lmasligi kerak.

Keyingi qilinadigan ish ikkita konturda toklarning umumiy aylanish yo'nalishlarini tanlab olamiz.



Eslatma: tenglamalar sistemasi tuzib, uning yechimlari topilganidan keyin, agar biror tokning qiymati manfiy ishorali son chiqsa, demak, rasmda dastavval o'zimiz ixtiyoriy ravishda tanlab olgan o'sha tokning yo'nalishi qarama-qarshisiga bo'ladi.
Kirxgofning birinchi qonuniga ko'ra, tugunga kirayotgan va undan chiqayotgan toklar uchun quyidagi tenglamani yozib olamiz:

$$I_1 = I_2 + I_3 \qquad (1)$$

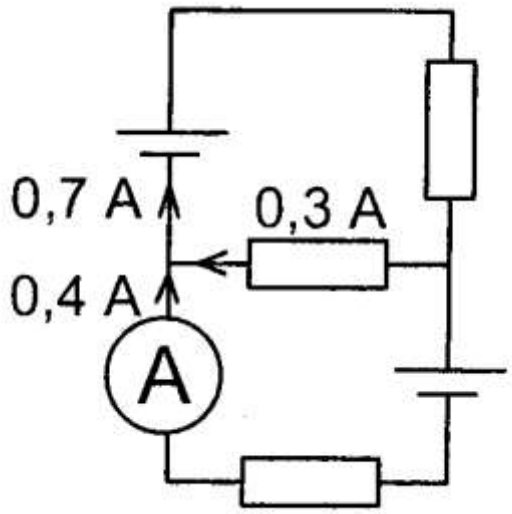
Kirxgofning ikkinchi qonuniga ko'ra, ya'ni har bir konturdagi toklarning mos qarshiliklarga ko'paytmalari algebraic yig'indisi shu konturdagi EYuK larning algebraik yig'indisiga tengligini bilgan holda, 2 ta kontur uchun tenglamalar sistemasi tuzib olamiz. Eslatma: agar konturdagi tokning va EYuKlarning
yo'nalishlari konturdagi biz tanlab olgan aylanish yo'nalishimizga teskari bo'lsa, yoniga minus ishorasini qo'yib yozamiz.

$$\begin{cases} I_2R_2 + I_1R_1 = \varepsilon_1 \\ -I_1R_1 - I_3R_3 = -\varepsilon_2 \end{cases} \qquad \begin{cases} I_2R_2 + I_1R_1 = \varepsilon_1 \\ I_1R_1 + I_3R_3 = \varepsilon_2 \end{cases}$$

Misolda ampermetrdan o'tayotgan tok kuchini topish so'ralgan. Bu I_3 tok kuchiga mos keladi. (1) formulaga asosan tenglamalar sistemasidagi barcha I_1 larning o'rniga I_2+I_3 ifodani qo'yib
chiqamiz.

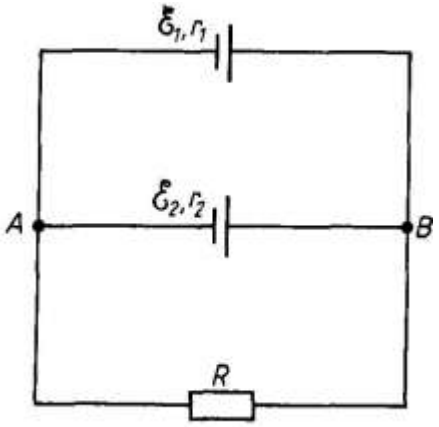
$$\begin{cases} I_2R_2 + (I_2 + I_3)R_1 = \varepsilon_1 \\ (I_2 + I_3)R_1 + I_3R_3 = \varepsilon_2 \end{cases}$$

Tenglamalar sistemasini ishlab va (1) formuladan foydalanib quyidagi natijalarga ega bo’lamiz: I_1=0,3A; I_2=0,7A; I_3=-0,4A
Zanjirda I_3 tokni pastga yo'naltirgan edik. Natija manfiy son chiqdi. Demak I_3 tok kuchi yuqoriga yo'nalgan ekan, ya'ni u tugunga kiradi.

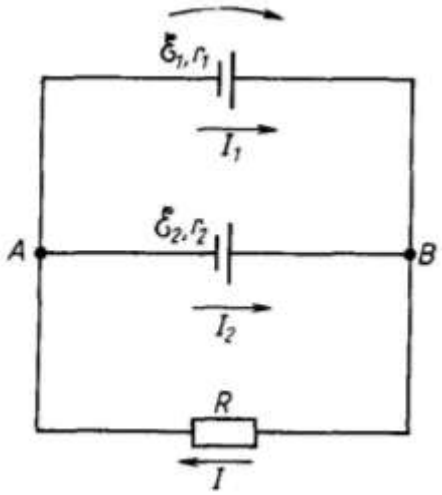


Ampermetrning ko'rsatishi 0,4 A bo'ladi.

3. EYuK lari 1,25 V va 1,5 V, ichki qarshiliklari 0,4Ω dan bo'lgan 2 ta element rasmda ko'rsatilgandek parallel ulangan bo'lib ularga qarshiligi 10 Ω tashqi qarshilik ulangan.
Har bir elementdan o'tadigan tok kuchini va tashqi qarshilikdan o'tadigan tok kuchini aniqlang?



Manbalardan o'tadigan tokning yo'nalishini belgilab chiqamiz va tokning yo'nalishini soat strelkasi bo'yicha olamiz



A tugun uchun Kirxgofning birinchi qoidasini qo'llab quyidagi tenglamani yozamiz

$$I - I_1 - I_2 = 0 \qquad (1)$$

Kirxgofning ikkinchi qoidasidan foydalanib $A\varepsilon_1BRA$ va $A\varepsilon_1B\ \varepsilon_2A$ konturlar uchun tegishli tenglama tuzamiz

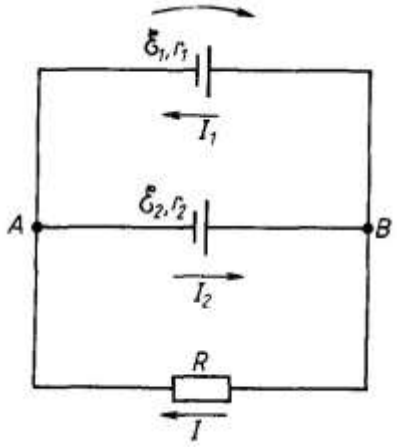
$$I_1 r_1 + IR = \varepsilon_1, \quad I_1 r_1 - I_2 r_2 = \varepsilon_1 - \varepsilon_2 \qquad (2)$$

Masala shartiga berilgan kattaliklarni 1-va2- tenglamalarga keltirib qo'yib nomalum kattaliklarni tenglamalar sistemasi tuzib topamiz.

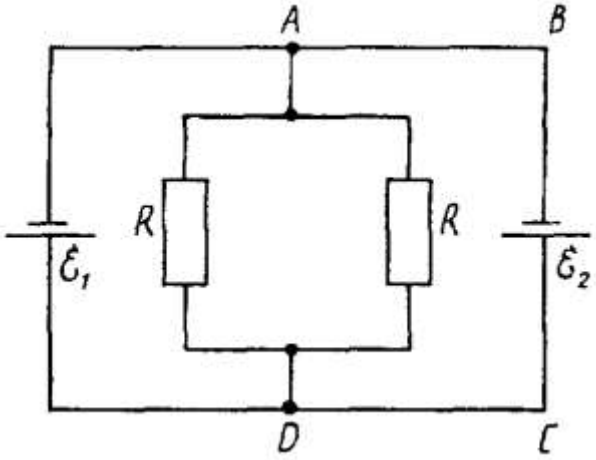
$$\begin{cases} I - I_1 - I_2 = 0 \\ 0{,}4I_1 + 10I = 1{,}25 \\ 0{,}4I_1 - 0{,}4I_2 = -0{,}25 \end{cases} \qquad (3)$$

$$I \approx 0{,}135\,A, \quad I_1 \approx -0{,}245\,A, \quad I_2 \approx 0{,}38\,A$$

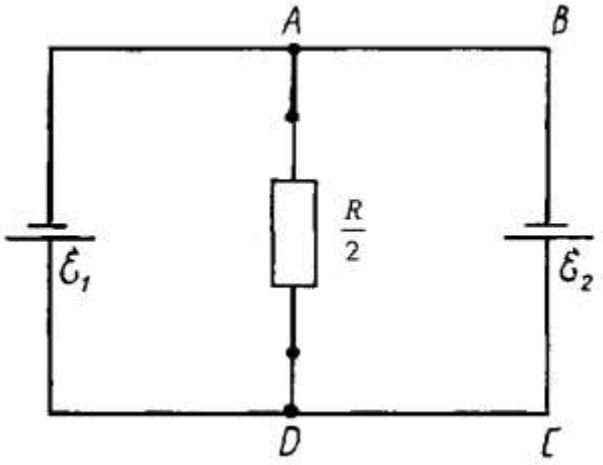
I_1 tok manfiy chiqdi demak u biz tanlagan yo'nalishga teskari yo'nalishda oqar ekan ya'ni quyidagicha($\varepsilon_2 > \varepsilon_1$ 2-manba 1-manbani zaryadlaydi)



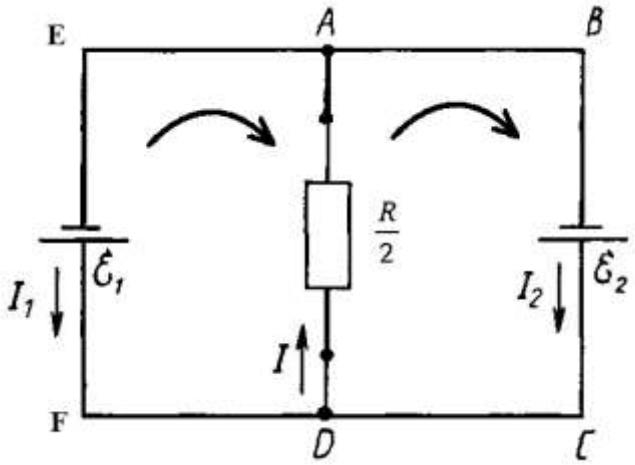
4. Tok manbalarining EYuK lari ε_1=12 V va ε_2=6 V, ichki qarshiliklari $r_1=r_2$=0,5 Ω dan bo'lgan manbalarga 2 ta R qarshilik rasmda ko'rsatilgandek ulandan. R qarshilikning qanday qiymatida ABCD konturdan tok oqmaydi.



Tashqi qarshiliklar o'zaro parallel ulangan bo'lib ularning umumiysi R/2 ga tengligidan sxemani quyidagicha o'zgartiramiz



Kirxgofning birinch va ikkinchi qoidasidan foydalanib tenglamalar tuzishimiz uchun manbadan chiqadigan toklarning yo'nalishini va umumiy aylanish yo'nalishini tanlab olishimiz kerak



D tugun uchun Kirxgofning birinchi qoidasini qo'llab quyidagi tenglamani yozamiz

$$I - I_1 - I_2 = 0 \qquad (1)$$

Kirxgofning ikkinchi qoidasidan foydalanib EFDAE va BCDAB konturlar uchun tegishli tenglama tuzamiz

$$-I_1 r_1 - I\frac{R}{2} = -\varepsilon_1, \qquad (2)$$

$$I_2 r_2 + I\frac{R}{2} = \varepsilon_2 \qquad (3)$$

(2) tenglamalarning har birining oldiga minus qo'yilishiga sabab tanlab olingan aylanish yo'nalishiga teskari.

1- tenglamadan I ni topib 2 va 3- tenglamalarga keltirib qo'yib quyidagicha soddalashtiramiz .

$$\begin{cases} I_1 r_1 + (I_1 + I_2)\dfrac{R}{2} = \varepsilon_1 \\ I_2 r_2 + (I_1 + I_2)\dfrac{R}{2} = \varepsilon_2 \end{cases} \qquad (4)$$

Masala shartida ABCD konturdan tok oqmasligi kerak edi bu degani $I_2=0$ bo'ladi. (4) tenglamaga $I_2=0$ ni etib qo'yib R ni topamiz

$$-\begin{cases} I_1 r_1 + I_1 \dfrac{R}{2} = \varepsilon_1 \\ I_1 \dfrac{R}{2} = \varepsilon_2 \end{cases}$$

$$I_1 r_1 = \varepsilon_1 - \varepsilon_2 \qquad \rightarrow I_1 = \frac{\varepsilon_1 - \varepsilon_2}{r_1}$$

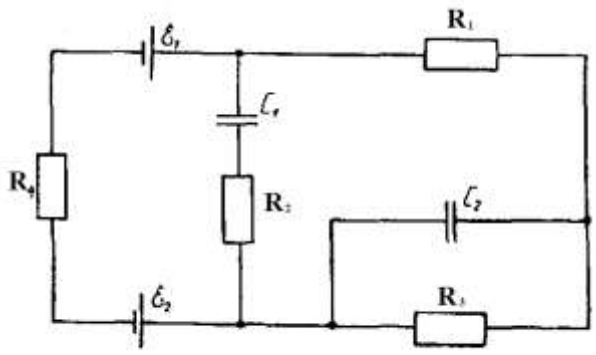
$$+\begin{cases} I_1 r_1 + I_1 \dfrac{R}{2} = \varepsilon_1 \\ I_1 \dfrac{R}{2} = \varepsilon_2 \end{cases}$$

$$I_1 r_1 + I_1 R = \varepsilon_1 + \varepsilon_2 \qquad \rightarrow R = \frac{\varepsilon_1 + \varepsilon_2 - I_1 r_1}{I_1}$$

$$R = \frac{\varepsilon_1 + \varepsilon_2 - I_1 r_1}{I_1} = \frac{\varepsilon_1 + \varepsilon_2 - (\dfrac{\varepsilon_1 - \varepsilon_2}{r_1}) r_1}{\dfrac{\varepsilon_1 - \varepsilon_2}{r_1}} = \frac{2\varepsilon_2 r_1}{\varepsilon_1 - \varepsilon_2}$$

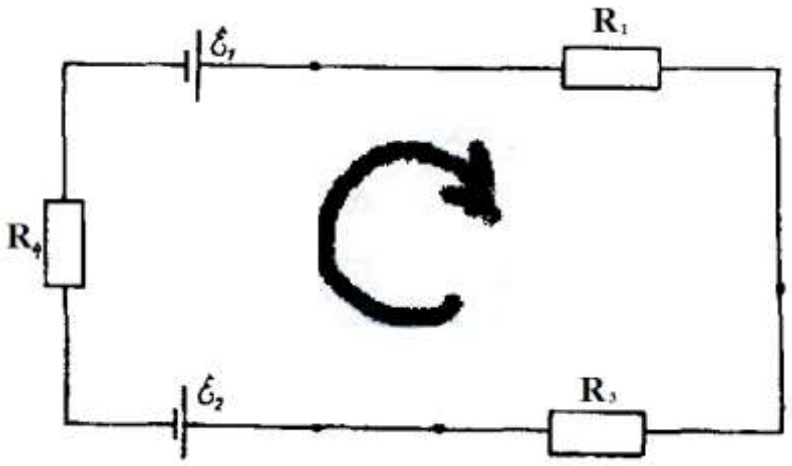
$$R = \frac{2\varepsilon_2 r_1}{\varepsilon_1 - \varepsilon_2} = \frac{2 \cdot 6 \cdot 0{,}5}{12 - 6} = \frac{6}{6} = 1\Omega$$

5. Sxemada berilganlardan foydalanib kondensatorlarda to'planadigan zaryadni aniqlang?



1-rasm

Sxemaga ulangan kondensatorlardan o’zgarmas tok o’tmaydi ular faqat o’ziga parallel ulangan qarshilikning kuchlanishicha kuchlanish bilan zaryadlanadi.
Demak kondensatorlardan tok o’tmagani uchun sxemadan ularni vaqtincha olib tashlaymiz, R_2 qarshilik kondensatorga ketma-ket ulangani uchun undan ham tok o’tmaydi ya’ni uning qarshiligini kattaligi bizga aloqasi yo’q.



Sxemani quyidagicha soddalashtirib aylanish yo’nalishini soat strelkasining yo’nalishi bilan bir-xil oldik. Bundan kelib chiqadiki aylanish yo’nalishidagi EYuK vat ok kuchilarni “+” unda qarama-qarshi yo’nalganlarni “-” ishora bilan olamiz.
Endi Kirxgofning 2-qoidasidan foydalanib quyidagi tenglamani tuzamiz
(Sxemada ikkala manba va qarshiliklar ketma-ket ulanganligi uchun barcha joydan o’tadigan tok kuchi bir-xil I ga teng)

$$\varepsilon_1 - \varepsilon_2 = IR_1 + IR_3 + IR_4$$

$$I = \frac{\varepsilon_1 - \varepsilon_2}{R_1 + R_3 + R_4} \qquad (1)$$

1-rasmdan ko’rinib turibdiki C_2 kondensator R_3 ga parallel ulangan R_3 dagi kuchlanish esa

$$U_3 = IR_3 = \frac{\varepsilon_1 - \varepsilon_2}{R_1 + R_3 + R_4} \cdot R_3 \qquad (2)$$

Endi C_2 kondensatorning zaryadini topamiz

$$q_2 = C_2 \cdot U_3 = C_2 \cdot \frac{\varepsilon_1 - \varepsilon_2}{R_1 + R_3 + R_4} \cdot R_3 \qquad (3)$$

1-rasmdan ko’rinib turibdiki C_1 kondensator R_1 va R_3 ga parallel ulangan R_1 va R_3 dagi kuchlanish esa

$$U_{1-3} = U_1 + U_3 = IR_1 + IR_3 = I(R_1 + R_3) = \frac{\varepsilon_1 - \varepsilon_2}{R_1 + R_3 + R_4} \cdot (R_1 + R_3) \qquad (4)$$

Endi C_1 kondensatorning zaryadini topamiz

$$q_1 = C_1 \cdot U_{1-3} = C_1 \cdot \frac{\varepsilon_1 - \varepsilon_2}{R_1 + R_3 + R_4} \cdot (R_1 + R_3) \qquad (5)$$

6. Rasmda tasvirlangan zanjirdagi galvanometer orqali qancha tok o'tadi.

$$\varepsilon = 2V,\ R_1 = 60\Omega,\ R_2 = 40\Omega,\ R_3 = R_4 = 20\Omega,\ R_G = 100\Omega$$

Kirxgofning birinchi va ikkinchi qoidasini qo'llab quyidagi tenglamalarni yozamiz

$$\begin{cases} I = I_1 + I_3 \\ I_1 = I_2 + I_G \\ I_2 + I_4 = I \\ I_3 + I_G = I_4 \end{cases}; \qquad \begin{cases} I_1R_1 + I_2R_2 = \varepsilon \\ I_3R_3 + I_4R_4 = \varepsilon \\ I_1R_1 + I_GR_G + I_4R_4 = \varepsilon \end{cases}$$

$$\begin{cases} 6I_1 + 4I_2 = 0{,}2 \\ 2I_3 + 2I_4 = 0{,}2 \\ 6I_1 + 10I_G + 2I_4 = 0{,}2 \end{cases} \Rightarrow \begin{cases} 6I_1 + 4(I_1 - I_G) = 0{,}2 \\ 2(I_4 - I_G) + 2I_4 = 0{,}2 \\ 6I_1 + 10I_G + 2I_4 = 0{,}2 \end{cases}$$

$$10I_1 - 4I_G = 0{,}2 \Rightarrow I_1 = \frac{0{,}2 + 4I_G}{10}, \quad 4I_4 - 2I_G = 0{,}2 \Rightarrow I_4 = \frac{0{,}2 + 2I_G}{4}$$

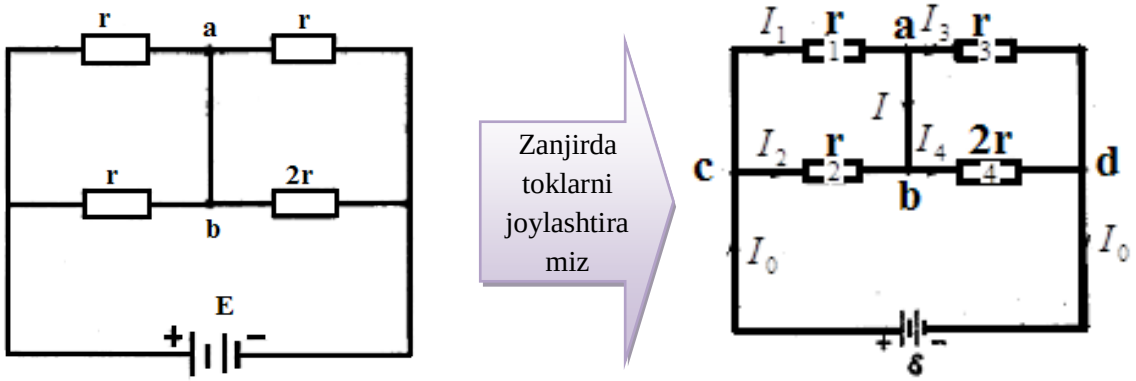
$$6I_1 + 10I_G + 2I_4 = 0{,}2, \quad 6\left(\frac{0{,}2 + 4I_G}{10}\right) + 10I_G + 2\left(\frac{0{,}2 + 2I_G}{4}\right) = 0{,}2$$

$$1{,}2 + 24I_G + 100I_G + 1 + 10I_G = 2, \quad 134I_G = -0{,}2, \quad I_G = -1{,}49 \cdot 10^{-3}\ A$$

Demak galvonametr orqali 1,49 mA o'tar ekan

(yuqoridagi hisoblashga chiqarilgan natija manfiy chiqdi, demak biz tanlagan yo'nalishga qarama-qarshi harakatlanar ekan)

7. Rasmda tasvirlangan sxemada ab ulagich (peremichka) orqali o'tgan tokni toping. Ulagichning, ulovchi simlarning qarshiligi va batareyaning ichki qarshiligini juda kichik deb hisoblang.



1,2,3,4 qarshiliklar orqali I_1, I_2, I_3, I_4, ulash simi (peremichka) orqali I, batareya orqali I_o tok harakatlanadi deb belgilaymiz. Batareyaning ichki qarshiligini hisobga olmay, manba zanjiridagi tokni aniqlaymiz:

$$I_0 = \frac{\varepsilon}{R} \qquad (1)$$

Bunda R, c va d nuqtalar orasidagi umumiy qarshilik.

$$R = \frac{r}{2} + \frac{2}{3}r = \frac{7}{6}r \qquad (2)$$

a tugunda (Kirxgofning 1-qoidasiga ko'ra)

$$I_1 = I_3 + I \qquad (3)$$

1 va 2 qarshiliklarda kuchlanishlar teng (chunki ular parallel ulangan)

$$U_1 = U_2 \quad \Rightarrow \quad rI_1 = rI_2$$

c tugunda (Kirxgofning 1-qoidasiga ko'ra)

$$I_0 = I_1 + I_2 \qquad \text{bundan}$$

$$I_1 = I_2 = \frac{I_0}{2} \qquad (4)$$

3 va 4 qarshiliklarda kuchlanishlar teng (chunki ular parallel ulangan)

$$U_3 = U_4 \quad \Rightarrow \quad rI_3 = 2rI_4$$

ni beradi, lekin d tugunda

$$I_0 = I_3 + I_4 \qquad \text{bundan}$$

$$I_4 = \frac{I_0}{3}, \quad I_3 = \frac{2I_0}{3}, \qquad (5)$$

(4) va (5) dan foydalanib (3) tenglamadan

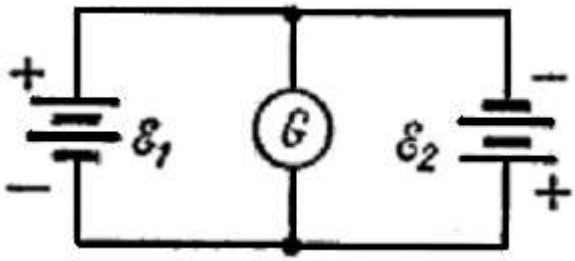
$$I = I_1 - I_3 = \frac{1}{6}I_0$$

Natijaga erishamiz. (1) va (2) tenglamalarni hisobga olib, quyidagi natijaga erishamiz

Demak ulagich orqali o'tadigan tok quyidagiga teng

$$I = \frac{\varepsilon}{7r}$$

8. E.Yu.K lari ε_1 va ε_2 bo'lgan ikkita batareya rasmdagidek ulangan. Batareyalarning ichki qarshiliklari nisbati qanday bo'lganda gal'vanometr orqali tok o'tmaydi? Ulovchi simlarning qarshiligini hisobga olmang.



Kirxgofning 2-qoidasidan foydalanib quyidagi tenglamalarni tuzamiz

$$\varepsilon_1 = U + Ir_1 \qquad (1)$$

$$\varepsilon_1 + \varepsilon_2 = I(r_1 + r_2) \qquad (2)$$

Masala shartiga ko'ra gal'vonometr orqali tok o'tmasa undagi kuchlanish tushuvi nol bo'ladi va (1) tenglama quyidagi ko'rinishga keladi

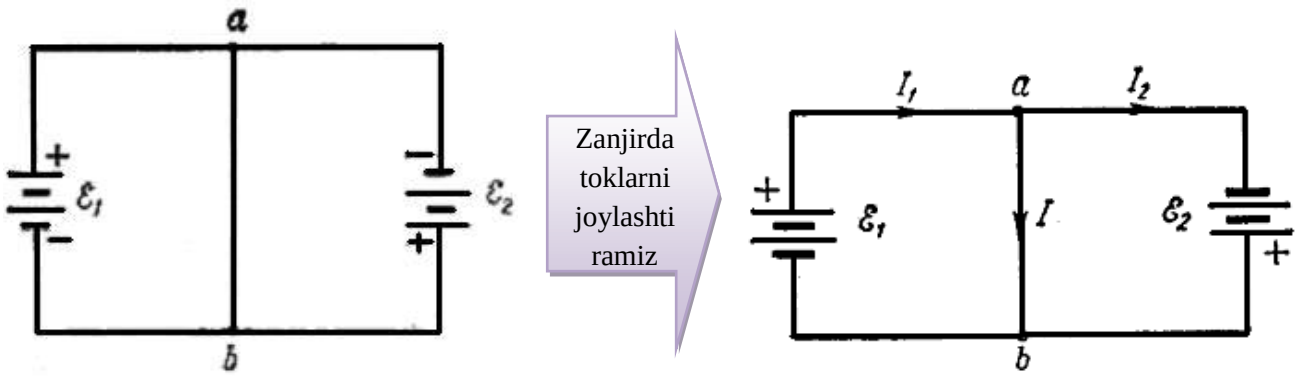
$$U = \varepsilon_1 - Ir_1 = 0 \qquad (3)$$

Bu yerda *I* batareyalar zanjiridagi tok (masala shartiga ko'ra gal'vanometr orqali o'tadigan tok 0 ga teng), *U*-gal'vanometrda kuchlanish tushuvi, r_1 va r_2 –mos ravishda ε_1 va ε_2 batareyalarning ichki qarshiliklari. Bu tenglamalardan *I* ni yo'qotib, quyidagi natijani olamiz.

$$\frac{r_2}{r_1} = \frac{\varepsilon_2}{\varepsilon_1}$$

Yuqoridagi shatr bajarilsa gal'vanometr orqali tok o'tmaydi

9. E.Yu.K lari ε_1 va ε_2 ichki qarshiliklari r_1 va r_2 bo'lgan ikkita batareya rasmdagidek ulangan. Ulovchi simlarning qarshiligini hisobga olmay, ab ulagich orqali o'tgan tokni toping. Ulagich qarshiligi nolga teng deb hisoblang.



Birinchi batareya zanjiridagi tok I_1, ikkinchi batareya zanjiridagi tok I_2 bo'lsin. Ravshanki, perimechka orqali o'tuvchi tok quyidagiga teng:

$$I = I_1 - I_2 \qquad (1)$$

Bundan I_1 - batareya ε_1 ning qisqa tutashuv toki

$$I_1 = \frac{\varepsilon_1}{r_1}$$

I_2 - batareya ε_2 ning qisqa tutashuv toki

$$I_2 = \frac{\varepsilon_2}{r_2}$$

Bu natijalarni (1)- formulaga etib qo'ysak quyidagi natijaga erishamiz

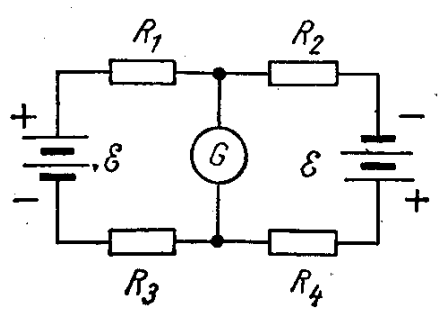
$$I = \frac{\varepsilon_1 \cdot r_2 - \varepsilon_2 \cdot r_1}{r_1 \cdot r_2}$$

Shuni eslatib o'tamizki, bu echim perimechka qarshiligini hisobga olmasa bo'ladi, deb taxmin qilinganda olingan. Agar bunday taxmin qilinmasa, unda *I* uchun yozilgan ifoda peremichkaning qarshiligiga bog'liq bo'ladi, biroq tok bo'lmaslik sharti

$$\varepsilon_1 \cdot r_2 = \varepsilon_2 \cdot r$$

Ifodaga teng

10. Rasmda ko'rsatilgan zanjirda $R_2 > R_1$. Gal'vanometr orqali o'tuvchi tok nolga teng bo'lishi uchun R_3 , R_4 ni qanday tanlash mumkin? Batareyalarning E.Yu.K birday. Batareyalarning ichki qarshiliklarini hisobga olmang.



Gal'vanometr orqali $\boldsymbol{I_G}$ tok nolga tengligini hisobga olib, batareyalar zanjiridagi tok uchun quyidagi ifodani yozamiz:

$$I = \frac{2\varepsilon}{R_1 + R_2 + R_3 + R_4} \qquad (1)$$

Gal'vanometrdagi U kuchlanish ham nolga teng. Kirxgofning 2-qoidasiga ko'ra quyidagi tenglamani tuzamiz:

$$\varepsilon = U + IR_2 + IR_4 \;\Rightarrow\; U = \varepsilon - I(R_2 + R_4) = 0 \qquad (2)$$

(1) formulani (2) formulaga keltirib qo'yamiz va quyidagi natijaga erishamiz

$$\varepsilon - \frac{2\varepsilon(R_2 + R_4)}{R_1 + R_2 + R_3 + R_4} = 0 \qquad (3)$$

Bundan

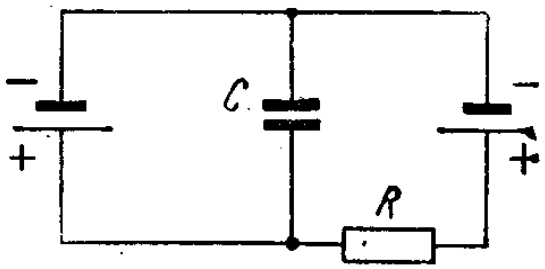
$$R_1 + R_2 + R_3 + R_4 = 2R_2 + 2R_4 \qquad (4)$$

Yoki

$$R_4 = R_3 - R_2 + R_1 \qquad (5)$$

$R_2 > R_1$ bo'lgani tufayli quyidagi shart bajarilishi lozim ($R_4 > 0$) $R_3 \geq R_2 - R_1$

11. Rasmda tasvirlangan sxemada batareyalarning E.Yu.K kattaliklari ε_1 va ε_2, ularning ichki qarshiliklari r_1 va r_2, qarshilik R va sig'im C berilgan. Kondensator zaryadini aniqlang.



Kondensator U kuchlanish bilan zaryadlangandan keyin u orqali tok o'tishi to'xtaydi. Kirxgofning 2-qoidasidan foydalanib chap tomondagi yopiq kontur uchun quyidagi tenglamalarni tuzamiz

$$\varepsilon_1 = I \cdot r_1 + U \qquad (1)$$

To'liq zanjir uchun Om qonunidan zanjirdan aylanadigan *I* tok kuchini topamiz

$$I = \frac{\varepsilon_1 - \varepsilon_2}{R + r_1 + r_2} \qquad (2)$$

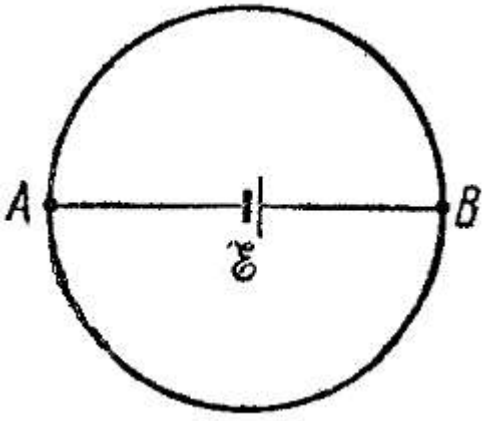
(1) formuladagi I ning o'rniga (2) formulani etib qo'yib U ni topamiz

$$\varepsilon_1 = I \cdot r_1 + U \quad \Rightarrow \quad U = \varepsilon_1 - I \cdot r_1 = \varepsilon_1 - \frac{\varepsilon_1 - \varepsilon_2}{R + r_1 + r_2} \cdot r_1 = \frac{\varepsilon_1 (r_2 + R) + \varepsilon_2 r_1}{R + r_1 + r_2} \qquad (3)$$

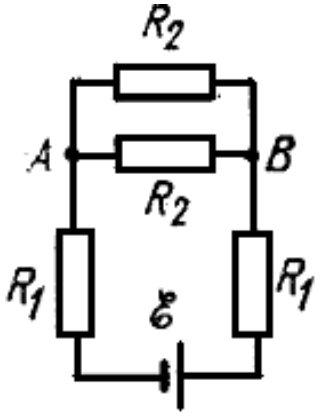
Endi kondensatordagi zaryadni topamiz

$$q = C \cdot U = C \cdot \frac{\varepsilon_1 (r_2 + R) + \varepsilon_2 r_1}{R + r_1 + r_2}$$

12. Rasmda ko'rsatilgan nixrom sim $a = 1m$ radiusli halqa shaklida bukilgan. Halqa markaziga Grene gal'vanik elementi joylashtirilgan bo'lib, u xuddi shunday nixrom sim bilan halqaning diametri bo'yicha A va B nuqtalarga ulangan. Gal'vanik elementning E.Yu.K $\varepsilon = 2V$ va ichki qarshiligi $r = 1{,}5\Omega$. A va B nuqtalar orasidagi kuchlanishni aniqlang. Nixromning solishtirma qarshiligi $\rho = 1{,}1 \cdot 10^{-6}\,\Omega \cdot m$, simning kesim yuzi $S = 1mm^2$. AB simning uzunligi halqaning diametriga teng deb hisoblang.



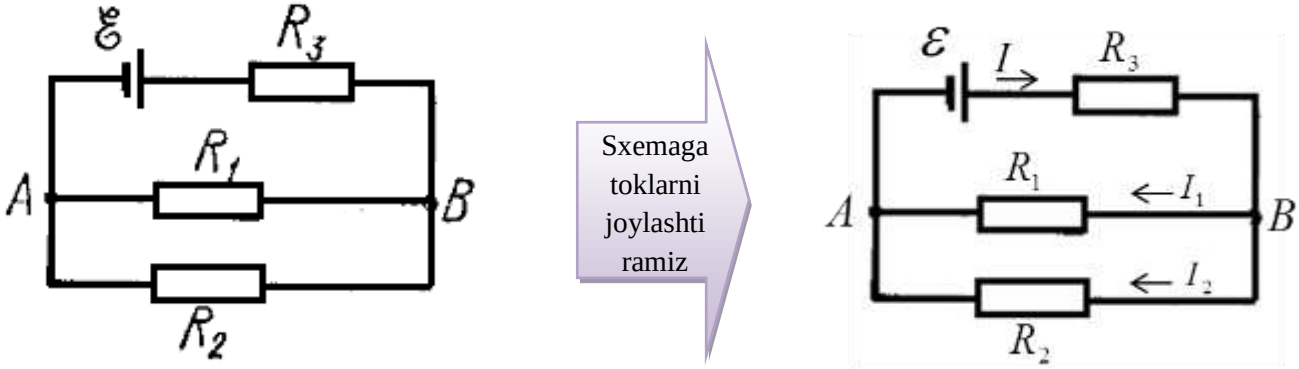
Sxemani quyidagicha o'zgartirami



Sxemani yuqorida ko’rsatilgan ekvivalent sxemasi ko’rsatilgan, bunda R_1 qarshilik elementni halqa bilan tutashtiruvchi simlarning qarshiligiga mos keladi; R_2 qarshilik esa halqaning ikki yarmining qarshiligiga mos keladi. Tashqi zanjirning umumiy qarshiligi $R = 2R_1 + \frac{R_2}{2}$, bunda $R_1 = \rho\frac{a}{S}$, va $R_2 = \rho\frac{\pi \cdot a}{S}$. Umumiy zanjirdagi tok $I = \frac{\varepsilon}{R+r}$. A va B nuqtalar orasidagi kuchlanish

$$U = I \cdot \frac{R_2}{2} = \frac{\varepsilon \cdot R_2}{4R_1 + R_2 + 2r} = \frac{\varepsilon \cdot \pi}{4 + \pi + \frac{2rS}{\rho a}} = 0{,}64V$$

13. Elektr zanjir rasmda tasvirlangan sxema bo’yicha ulangan E.Yu.K manbai va $R_1 = 3\Omega$, $R_2 = 2\Omega$ va $R_3 = 18{,}8\Omega$ qarshiliklardan iborat. R_1 va R_2 qarshiliklar orqali o’tuvchi toklarni aniqlang.Manbaning E.Yu.K $\varepsilon = 100V$ va uning ichki qarshiligi $r = 0{,}2\Omega$



B tugun uchun Kirxgofning birinchi qoidasini qo’llab quyidagi tenglamani yozamiz

$$I = I_1 + I_2 \qquad (1)$$

Tashqi zanjirning umumiy qarshiligi $R_{Um} = R_3 + \frac{R_1 \cdot R_2}{R_1 + R_2} = 20\Omega$.

Umumiy zanjirdagi tokni

$$I = \frac{\varepsilon}{R_{Um} + r} = \frac{\varepsilon}{R_3 + \frac{R_1 \cdot R_2}{R_1 + R_2} + r} = \frac{\varepsilon \cdot (R_1 + R_2)}{(R_3 + r)(R_1 + R_2) + R_1 \cdot R_2} = 4{,}95\,A$$

R_1 va R_2 qarshiliklar paralelligidan tok kuchilarni munosabatini topamiz

$$U_1 = U_2 \quad \rightarrow \quad I_1 \cdot R_1 = I_2 R_2 \quad \rightarrow \quad I_2 = \frac{I_1 \cdot R_1}{R_2}$$

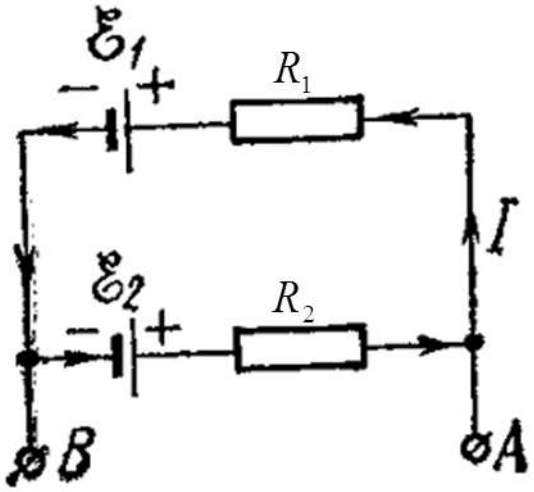
Hosil bo’lgan bu munosabatni (1) formulaga etib qo’ysak

$$I = I_1 + \frac{I_1 R_1}{R_2} \qquad I_1 = I \cdot \frac{R_2}{R_1 + R_2}; \quad I_2 = I \cdot \frac{R_2}{R_1 + R_2} \cdot \frac{R_1}{R_2} = I \cdot \frac{R_1}{R_1 + R_2};$$

$$I_1 = \frac{\varepsilon \cdot (R_1 + R_2)}{(R_3 + r)(R_1 + R_2) + R_1 \cdot R_2} \cdot \frac{R_2}{R_1 + R_2} = \frac{\varepsilon \cdot R_2}{(R_3 + r)(R_1 + R_2) + R_1 \cdot R_2} = 1{,}98\,A$$

$$I_2 = \frac{\varepsilon \cdot (R_1 + R_2)}{(R_3 + r)(R_1 + R_2) + R_1 \cdot R_2} \cdot \frac{R_1}{R_1 + R_2} \cdot = \frac{\varepsilon \cdot R_1}{(R_3 + r)(R_1 + R_2) + R_1 \cdot R_2} = 2{,}97\,A$$

14. Rasmdagi A va B nuqtalar orasidagi potensiallar farqi qanday? Manbaning E.Yu.K $\varepsilon_1 = 1V$ va $\varepsilon_2 = 1{,}3V$, zanjirdagi qarshiliklar esa $R_1 = 10\Omega$ va $R_2 = 5\Omega$ ga teng. Manbalarning ichki qarshiligini hisobga olmang.



$\varepsilon_2 > \varepsilon_1$ shuning uchun I tok rasmda ko'rsatilgan yo'nalish bo'ylab harakatlanadi, AB nuqtalar orasidagi potensiallar farqi har ikkala manba uchun tashqi kuchlanish hisoblanadi. Har ikkala manba uchun Kirxgofning 2-qoidasini yozamiz

Zanjirning ε_1 E.Yu.K va R_1 qarshilik ishtirok etgan qismdagi tashqi kuchlanish (Manba zaryadlanmoqda ya'ni tok olmoqda U kuchlanish ostida)

$$U = \varepsilon_1 + IR_1 \qquad (1)$$

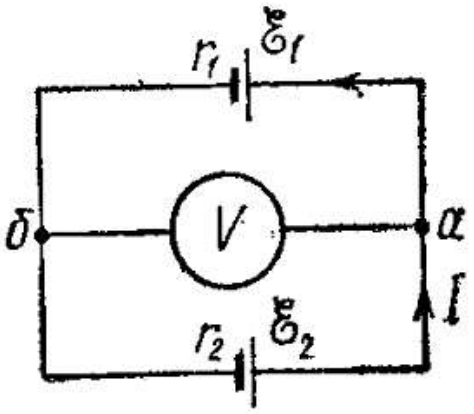
Zanjirning ε_2 E.Yu.K va R_2 qarshilik ishtirok etgan qismdagi tashqi kuchlanish Bu holda (Manba razryadlanmoqda ya'ni tok bermoqda U kuchlanishli)

$$\varepsilon_2 = U + IR_2 \qquad (2)$$

(1) va (2) formulalarni soddalashtirsak quyidagi natijaga ega bo'lamiz

$$U = \frac{\varepsilon_2 \cdot R_1 + \varepsilon_1 \cdot R_2}{R_1 + R_2} = 1{,}2V$$

15. Ikkita element rasmda ko'rsatilgan sxema bo'yicha ulangan. Birinchi elementning E.Yu.K $\varepsilon_1 = 1{,}5V$ va ichki qarshiligi $r_1 = 0{,}6\Omega$, ikkinchi elementning E.Yu.K $\varepsilon_2 = 2V$ va ichki qarshiligi $r_2 = 0{,}4\Omega$. Elementlarning klemmelariga (a va б nuqtalarga) ulangan vol'tmetr qanday *U* kuchlanishni ko'rsatadi? Vol'tmetrning qarshiligi elementlarning ichki qarshiligidan ancha katta.



$\varepsilon_2 > \varepsilon_1$ bo'lgani uchun *I* tok yo'nalishini rasmda ko'rsatilgandek tanlaymiz. Vol'tmetrning qarshiligi elementlarning ichki qarshiliklaridan ko'p marta katta bo'lgani sababli vol'tmetr orqali o'tuvchi tokni hisobga olmaymiz. Elementlarning ichki qarshiliklaridagi kuchlanish tushishlari elementlar E.Yu.K larining ayirmasiga teng bo'lishi kerak, chunki ular qarshi (bir xil qutblari bilan) ulangan:

$$Ir_1 + Ir_2 = \varepsilon_2 - \varepsilon_1 \quad \rightarrow I = \frac{\varepsilon_2 - \varepsilon_1}{r_1 + r_2} \qquad (1)$$

a va b nuqtalar orasidagi potentsiallar farqi (vol'tmetrlarning ko'rsatishi):

Zanjirning ε_1 E.Yu.K va r_1 qarshilik ishtirok etgan qismdagi tashqi kuchlanish (Manba zaryadlanmoqda ya'ni tok olmoqda U kuchlanish ostida)

$$U = \varepsilon_1 + Ir_1 \qquad (2)$$

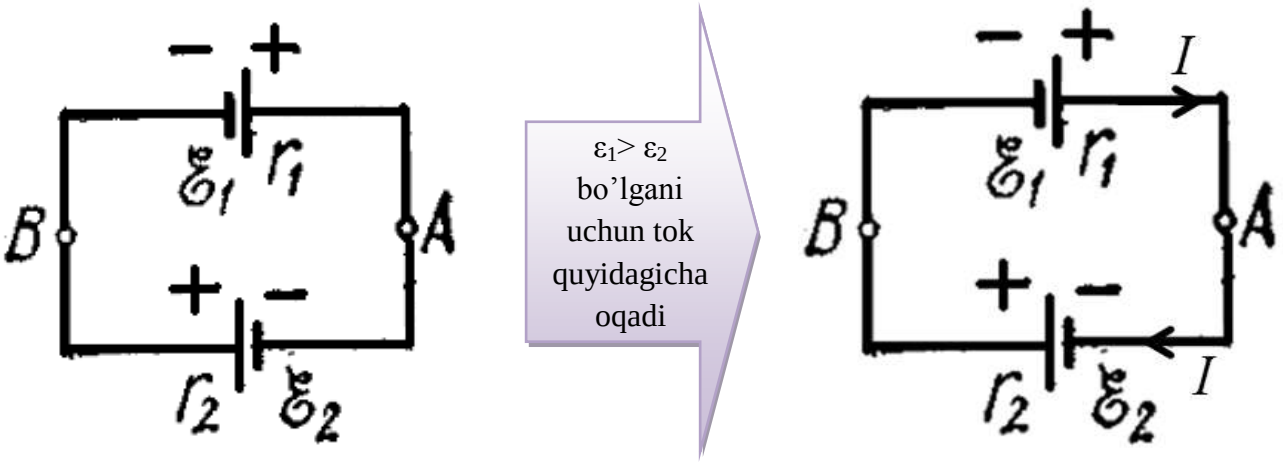
Zanjirning ε_2 E.Yu.K va r_2 qarshilik ishtirok etgan qismdagi tashqi kuchlanish Bu holda (Manba razryadlanmoqda ya'ni tok bermoqda U kuchlanishli)

$$\varepsilon_2 = U + IR_2 \qquad (3)$$

(2) yoki (3) formulaga (1) formulani keltirib qo'ysak quyidagi natijaga ega bo'lamiz

$$U = \frac{\varepsilon_2 \cdot R_1 + \varepsilon_1 \cdot R_2}{R_1 + R_2} = 1{,}8V$$

16. E.Yu.K. $\varepsilon_1 = 1{,}4V$ **va** $\varepsilon_2 = 1{,}1V$ **va ichki qarshiliklari mos ravishda** $r_1 = 0{,}3\Omega$ **va** $r_2 = 0{,}2\Omega$ **bo'lgan ikki element turli ismli qutblari bilan o'zaro tutashtirilgan. Elementlarning klemmalaridagi kuchlanishni aniqlang. Qanday sharoitda B va A nuqtalar orasidagi potentsiallar farqi nolga teng bo'lishini aniqlang**



$\varepsilon_1 > \varepsilon_2$ bo'lgani uchun *I* tok yo'nalishini rasmda ko'rsatilgandek tanlaymiz. Elementlarning ichki qarshiliklaridagi kuchlanish tushishlari elementlar E.Yu.K larining yig'indisiga teng bo'lishi kerak, chunki ular bir tomonga yo'nalgan (har xil qutblari bilan) ulangan:

$$Ir_1 + Ir_2 = \varepsilon_2 + \varepsilon_1 \quad \rightarrow I = \frac{\varepsilon_2 + \varepsilon_1}{r_1 + r_2} \qquad (1)$$

B va A nuqtalar orasidagi potentsiallar farqi:

Zanjirning ε_1 E.Yu.K va r_1 qarshilik ishtirok etgan qismdagi tashqi kuchlanish (Manba razryadlanmoqda ya'ni tok bermoqda U kuchlanishli)

$$\varepsilon_1 = U + Ir_1 \qquad U = \varepsilon_1 - Ir_1 = \varepsilon_1 - \frac{\varepsilon_2 + \varepsilon_1}{r_1 + r_2} \cdot r_1 = \frac{\varepsilon_1 r_2 - \varepsilon_2 r_1}{r_1 + r_2}$$

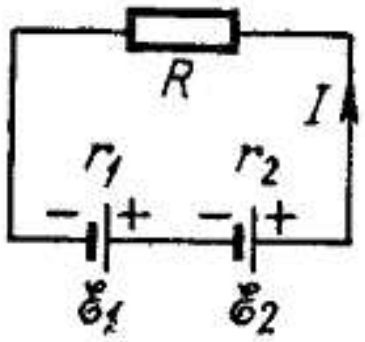
Natijalarni o'rniga keltirib qo'ysak

$$U = \frac{\varepsilon_1 r_2 - \varepsilon_2 r_1}{r_1 + r_2} = -0{,}1V$$

Potensiallar farqi nolga teng bo'lish sharti

$$U = 0 \qquad \rightarrow \qquad \varepsilon_1 r_2 = \varepsilon_2 r$$

17. E.Yu.K. lari $\varepsilon_1 = \varepsilon_2 = 2V$ dan va ichki karshiliklari $r_1 = 0{,}4\Omega$ va $r_2 = 0{,}2\Omega$ bo'lgan ikkita tok manbai ketma-ket ulangan. Tashqi qarshilik qanday bo'lganda manbalardan birining klemmalaridagi kuchlanish nolga teng bo'ladi?



Zanjirdagi umumiy tok quyidagicha topiladi

$$I = \frac{\varepsilon_{Um}}{R_{Um} + r_{Um}} = \frac{\varepsilon_1 + \varepsilon_2}{R + r_1 + r_2} \qquad (1)$$

Har bir manba klemalaridagi kuchlanish quyidagiga teng

$$U_1 = \varepsilon_1 - Ir_1 \quad \text{va} \quad U_2 = \varepsilon_2 - Ir_2 \qquad (2)$$

(2) formuladan masala shartiga binoan U_1 ni nolga tenglashtiramiz
(sababi manbalarning E.Yu.K teng birinchi manbaning ichki qarshiligi katta undan tok chiqmasligi mumkin ya'ni E.Yu.K chi uning ichki kuchlanishiga sarf bo'ladi)

I-yo'l

Rasmdan ko'rinib turibdiki manbalar beradigan kuchlanishlar $U=I\cdot R$ tashqi kuchlanishga sarf bo'ladi.

$$U_1 = \varepsilon_1 - Ir_1 = 0 \;\rightarrow\; I = \frac{\varepsilon_1}{r_1} = 5A$$

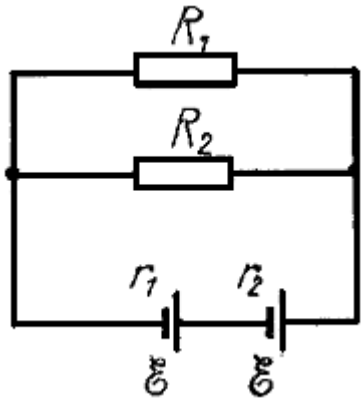
$$U_1 + U_2 = I \cdot R \quad \rightarrow \quad 0 + \varepsilon_2 - Ir_2 = IR \qquad R = \frac{\varepsilon_2 - Ir_2}{I} = 0{,}2\Omega$$

II-yo'l

$U_1 = \varepsilon_1 - Ir_1 = 0 \;\rightarrow\; I = \frac{\varepsilon_1}{r_1} = 5A$ chiqqan natijani (1) formulaga etib qo'yamiz

$$\frac{\varepsilon_1}{r_1} = \frac{\varepsilon_1 + \varepsilon_2}{R + r_1 + r_2} \qquad \rightarrow \qquad R = \frac{\varepsilon_2 r_1 - \varepsilon_1 r_2}{\varepsilon_1} = 0{,}2\Omega$$

18. Agar rasmda ko'rsatilga sxemada r_1 elementning klemmalaridagi potensiallar farqi nolga teng bo'lsa, uning ichki qarshiligi qanday. Sxemadagi $R_1 = 3\Omega$, $R_2 = 6\Omega$, $r_2 = 0{,}4\Omega$. Elementlarning E.Yu.K lari bir xil.



Umumiy zanjirdagi tok

$$I = \frac{2\varepsilon}{R + r_1 + r_2} \qquad (1)$$

Tashqi zanjirdagi umumiy qarshiligi

$$R = \frac{R_1 R_2}{R_1 + R_2} \qquad (2)$$

(1) va (2) formulalarni umumlashtirsak

$$I = \frac{2\varepsilon}{\frac{R_1 R_2}{R_1 + R_2} + r_1 + r_2} = \frac{2\varepsilon(R_1 + R_2)}{R_1 R_2 + (R_1 + R_2)(r_1 + r_2)} \qquad (3)$$

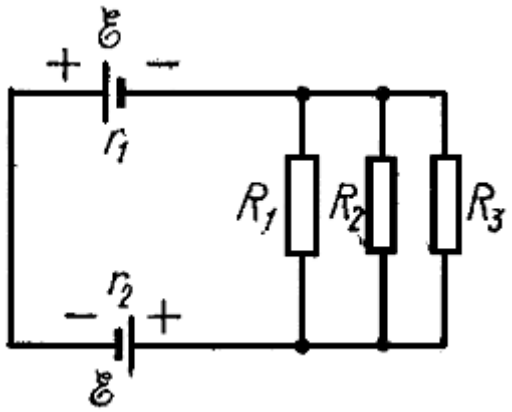
Masala shartiga ko'ra birinchi element klemmalaridagi kuchlanish

$$U = \varepsilon - Ir_1 = 0 \;\rightarrow\; I = \frac{\varepsilon}{r_1}$$

chiqqan natijani (3) formulaga etib qo'yamiz

$$\frac{\varepsilon}{r_1} = \frac{2\varepsilon(R_1 + R_2)}{R_1 R_2 + (R_1 + R_2)(r_1 + r_2)} \;\Rightarrow\; r_1 = \frac{R_1 R_2 + r_2(R_1 + R_2)}{R_1 + R_2} = 2{,}4\Omega$$

19. Rasmdagi sxemada R_1, R_2, R_3, r_1, r_2 qarshiliklar qanday munosabatda bo'lganda, elementlardan birining klemmalaridagi potensiallar farqi nolga teng bo'ladi. Manbalarbibg E.Yu.K. lari bir xil.



Umumiy zanjirdagi tok

$$I = \frac{2\varepsilon}{R + r_1 + r_2} \qquad (1)$$

R tashqi zanjirdagi umumiy qarshiligi

$$R = \frac{R_1 R_2 R_3}{R_2 R_3 + R_1 R_3 + R_1 R_2} \qquad (2)$$

Masala shartiga ko'ra elementlardan birining klemmalaridagi kuchlanish nolga teng bo'lishi kerak

$$U_1 = \varepsilon - Ir_1 = 0 \;\rightarrow\; I = \frac{\varepsilon}{r_1}$$

$$U_2 = \varepsilon - Ir_2 = 0 \;\rightarrow\; I = \frac{\varepsilon}{r_2}$$

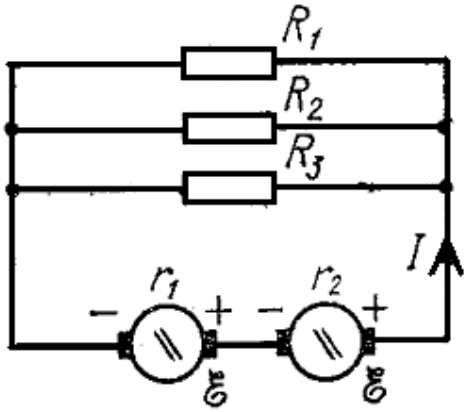
chiqqan natijani (1) formulaga etib qo'yamiz

$$\frac{\varepsilon}{r_1} = \frac{2\varepsilon}{R + r_1 + r_2} \;\Rightarrow\; R = r_1 - r_2$$

$$\frac{\varepsilon}{r_2} = \frac{2\varepsilon}{R + r_1 + r_2} \;\Rightarrow\; R = r_2 - r_1$$

Qaysi birining ichki qarshiligi katta bo'lsa o'sha manbaning klemmalaridagi potensiallar farqi nolga teng bo'ladi.

20. Rasmda tasvirlangan sxema bo'yicha generatorlarning klemmalaridagi U_1 va U_2 potensiallar farqini aniqlang. Generatorlarning E.Yu.K lari birday va $\varepsilon = 6V$ ga teng, ularning ichki qarshiliklari $r_1 = 0{,}5\Omega$ va $r_2 = 0{,}38\Omega$. Tashqi zanjir qarshiliklari $R_1 = 2\Omega, R_2 = 4\Omega$ va $R_3 = 7\Omega$.



Umumiy zanjirdagi tok

$$I = \frac{2\varepsilon}{R + r_1 + r_2} \qquad (1)$$

R tashqi zanjirdagi umumiy qarshiligi

$$R = \frac{R_1 R_2 R_3}{R_2 R_3 + R_1 R_3 + R_1 R_2} \qquad (2)$$

(2) formuladan chiqqan natijani (1) formulaga eltib qo'yamiz

$$I = \frac{2\varepsilon}{\frac{R_1 R_2 R_3}{R_2 R_3 + R_1 R_3 + R_1 R_2} + r_1 + r_2} = \frac{2\varepsilon\left(R_2 R_3 + R_1 R_3 + R_1 R_2\right)}{R_1 R_2 R_3 + (r_1 + r_2)(R_2 R_3 + R_1 R_3 + R_1 R_2)} \qquad (3)$$

Birinchi va ikkinchi generatorlardagi kuchlanish tushishlari:

$$U_1 = \varepsilon - Ir_1 = \frac{\varepsilon\left[R_1 R_2 R_3 + \left(r_2 - r_1\right)\left(R_2 R_3 + R_1 R_3 + R_1 R_2\right)\right]}{R_1 R_2 R_3 + (r_1 + r_2)(R_2 R_3 + R_1 R_3 + R_1 R_2)} = 3V$$

$$U_2 = \varepsilon - Ir_2 = \frac{\varepsilon\left[R_1 R_2 R_3 + \left(r_1 - r_2\right)\left(R_2 R_3 + R_1 R_3 + R_1 R_2\right)\right]}{R_1 R_2 R_3 + (r_1 + r_2)(R_2 R_3 + R_1 R_3 + R_1 R_2)} = 3{,}72V$$

21. E.Yu.K lari $\varepsilon_1 = 2{,}2V$, $\varepsilon_2 = 1{,}1V$, $\varepsilon_3 = 0{,}9V$ **ichki qarshiliklari mos ravishda** $r_1 = 0{,}2\Omega$, $r_2 = 0{,}4\Omega$, $r_3 = 0{,}5\Omega$ **bo'lgan uchta gal'vanik element zanjirga ketma-ket ulangan. Tashqi zanjir qarshiligi** $R = 1\Omega$**. Har bir element klemmalaridagi kuchlanishni aniqlang.**

Butun zanjir uchun Om qonuniga ko'ra undagi tok

$$I = \frac{\varepsilon}{R + r} \qquad (1)$$

Bu yerda ε va r quyidagiga teng

$$\varepsilon = \varepsilon_1 + \varepsilon_2 + \varepsilon_3 \text{ va } r = r_1 + r_2 + r_3 \qquad (2)$$

(2) formuladan chiqqan natijalarni (1) formulaga etib qo'yamiz

$$I = \frac{\varepsilon_1 + \varepsilon_2 + \varepsilon_3}{R + r_1 + r_2 + r_3} \qquad (3)$$

Har bir elementdagi kuchlanish E.Yu.K va elementning ichki qarshiligidagi kuchlanish tushishi orasidagi farqqa teng:

$$U_1 = \varepsilon_1 - Ir_1 = \frac{\varepsilon_1(R + r_2 + r_3) - (\varepsilon_2 + \varepsilon_3)r_1}{R + r_1 + r_2 + r_3} = 1{,}8V$$

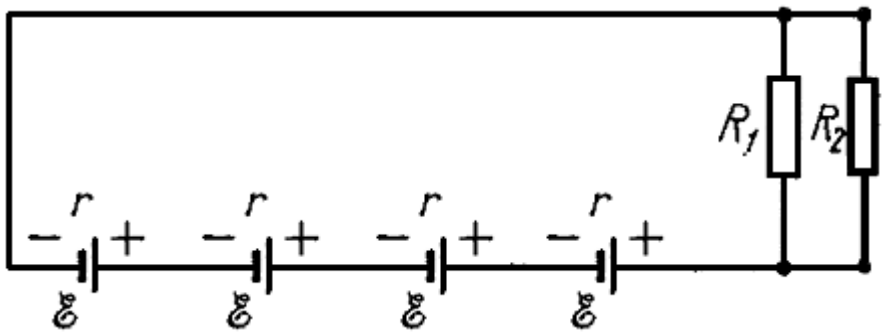
$$U_2 = \varepsilon_2 - Ir_2 = \frac{\varepsilon_2(R + r_1 + r_3) - (\varepsilon_1 + \varepsilon_3)r_2}{R + r_1 + r_2 + r_3} = 0{,}3V$$

$$U_3 = \varepsilon_3 - Ir_3 = \frac{\varepsilon_3(R + r_1 + r_2) - (\varepsilon_1 + \varepsilon_2)r_3}{R + r_1 + r_2 + r_3} = -0{,}1V$$

Batareya klemmalaridagi kuchlanish tashqi zanjirdagi kuchlanish tushishiga teng: $U = U_1 + U_2 + U_3 = 2V$. Uchinchi element klemmalaridagi kuchlanish manfiy bo'lib chiqdi, chunki tok zanjirdagi hamma qarshilik va yig'indi E.Yu.K ga bog'liq, r_3 qarshilikdagi kuchlanish tushishi esa ε_3 ga qaraganda katta.

22. E.Yu.K. lari $\varepsilon = 1{,}25V$ **dan, ichki karshiliklari** $r = 0{,}1\Omega$ **dan bo'lgan ketma-ket ulangan to'rtta elementdan iborat batareya parallel ulangan** $R_1 = 50\Omega$, $R_2 = 200\Omega$ **qarshilikli ikki o'tkazgichni tok bilan ta'minlaydi. Batareya klemmalaridagi kuchlanishni aniqlang.**

Ushbu masalani yechish uchun quyidagi sxemani chizamiz



Butun zanjir uchun Om qonuniga ko’ra undagi tok

$$I = \frac{\varepsilon_{Um}}{R_{Um} + r_{Um}} \qquad (1)$$

Bu yerda ε_{Um} ,R_{Um} va r_{Um} quyidagiga teng

$$\varepsilon_{Um} = \varepsilon + \varepsilon + \varepsilon + \varepsilon = 4\varepsilon\,,\ r_{Um} = r + r + r + r = 4r\,,\ R_{Um} = \frac{R_1 R_2}{R_1 + R_2} \qquad (2)$$

(2) formuladan chiqqan natijalarni (1) formulaga etib qo’yamiz

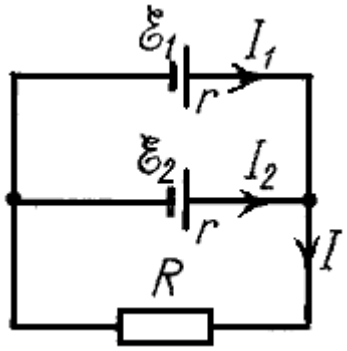
$$I = \frac{4\varepsilon}{\frac{R_1 R_2}{R_1 + R_2} + 4r} = \frac{4\varepsilon(R_1 + R_2)}{R_1 R_2 + 4r(R_1 + R_2)} \qquad (3)$$

Har bir elementdagi kuchlanish E.Yu.K va elementning ichki qarshiligidagi kuchlanish tushishi orasidagi farqqa teng:

$$U_1 = U_2 = U_3 = U_4 = \varepsilon - Ir = \varepsilon - \frac{4\varepsilon(R_1 + R_2)}{R_1 R_2 + 4r(R_1 + R_2)} \cdot r = \frac{\varepsilon R_1 R_2}{R_1 R_2 + 4r(R_1 + R_2)}$$

$$U = U_1 + U_2 + U_3 + U_4 = \frac{4\varepsilon R_1 R_2}{R_1 R_2 + 4r(R_1 + R_2)} = 4{,}95V$$

23. Rasmda tasvirlangan sxemaning E.Yu.K lari $\varepsilon_1 = 1{,}25V$, $\varepsilon_2 = 1{,}5V$, ichki qarshiliklari birday va $r = 0{,}4\Omega$ ga teng bo’lgan ikki element parallel ulangan. Tashqi zanjirning qarshiligi $R = 10\Omega$ ga teng. Tashqi zanjirdan va har bir elementdan o’tuvchi toklarni aniqlang.



Kirxgofning birinchi qoidasini qo’llab quyidagi tenglamani yozamiz

$$I = I_1 + I_2 \qquad (1)$$

Kirxgofning ikkinchi qoidasidan foydalanib berk konturlar uchun tegishli tenglama tuzamiz

$$I_1 r + IR = \varepsilon_1, \qquad I_2 r + IR = \varepsilon_2 \qquad (2)$$

1-tenglamadan *I* ni 2-tenglamaga keltirib qo’ysak

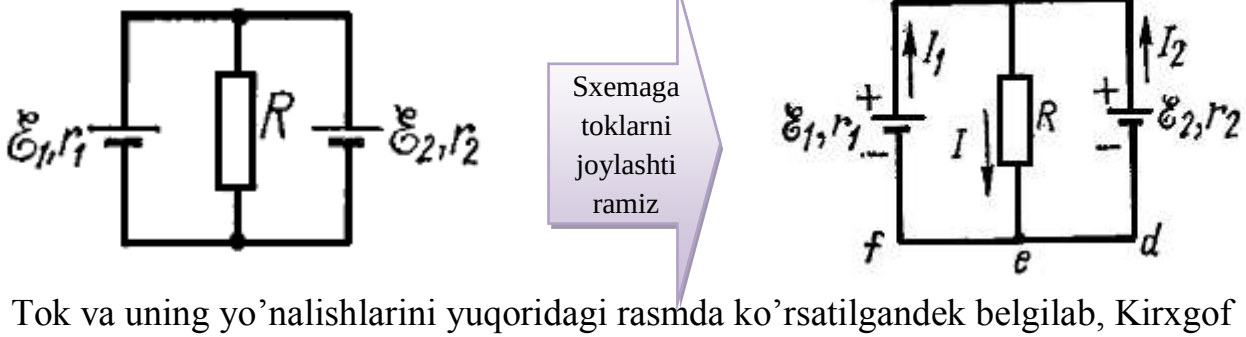
$$\begin{cases} I_1 r + (I_1 + I_2)R = \varepsilon_1 \\ I_2 r + (I_1 + I_2)R = \varepsilon_2 \end{cases} \rightarrow \begin{cases} I_1 r + I_1 R + I_2 R = \varepsilon_1 \\ I_2 r + I_1 R + I_2 R = \varepsilon_2 \end{cases}$$

$$\begin{cases} 0{,}4I_1 + 10I_1 + 10I_2 = 1{,}25 \\ 0{,}4I_2 + 10I_1 + 10I_2 = 1{,}5 \end{cases} \rightarrow \begin{cases} 10{,}4I_1 + 10I_2 = 1{,}25 \\ 10{,}4I_2 + 10I_1 = 1{,}5 \end{cases}$$

$$I_1 = -0{,}25\,A \quad I_2 = 0{,}35\,A \quad I = I_1 + I_2 = 0{,}1\,A$$

I_1 tok manfiy chiqdi demak I_1 tok yo'nalishi biz tanlagan yo'nalishga qarama-qarshi harakatlanar ekan.

24. Rasmda tasvirlangan $R = 10\Omega$ qarshilikdan o'tuvchi tokni aniqlang. Tok manbalarining E.Yu.K lari $\varepsilon_1 = 6V$, $\varepsilon_2 = 5V$, ichki qarshiliklari $r_1 = 1\Omega$, $r_2 = 2\Omega$.



Tok va uning yo'nalishlarini yuqoridagi rasmda ko'rsatilgandek belgilab, Kirxgof tenglamasini tuzamiz, *b* tugun uchun

$$I = I_1 + I_2$$

abef kontur uchun(soat strelkasi yo'nalishi bo'yicha aylaniladi)

$$I_1 r_1 + IR = \varepsilon_1$$

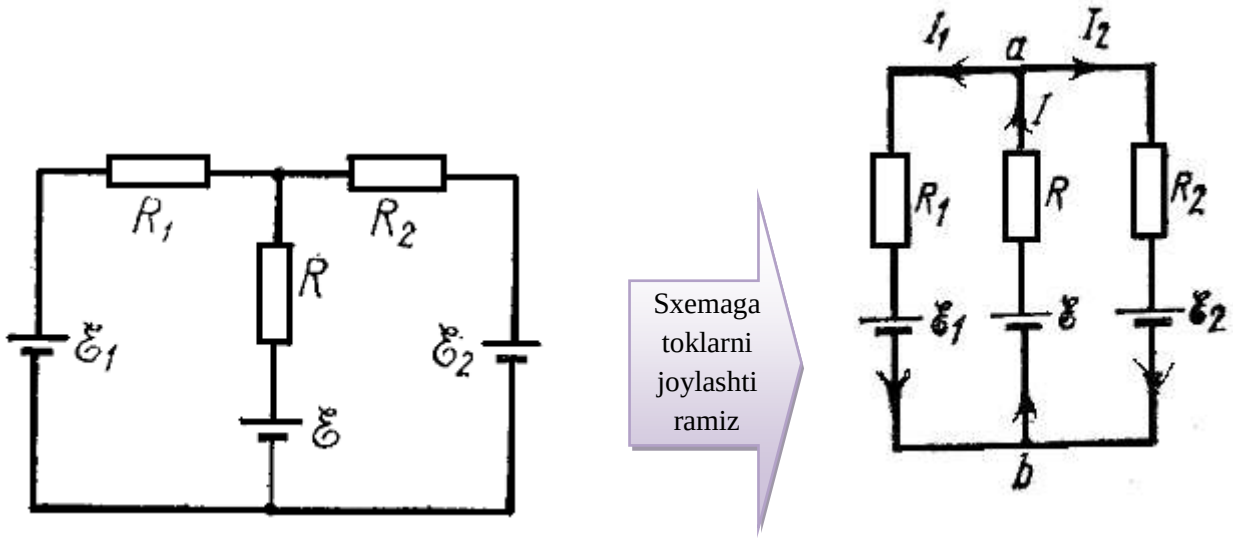
Bcde kontur uchun (soat strelkasiga teskari yo'nalishda aylanadi)

$$I_2 r_2 + IR = \varepsilon_2$$

Yuqoridagi tenglamalarda quyidagi natija kelib chiqadi

$$I = \frac{\varepsilon_1 r_2 + \varepsilon_2 r_1}{R(r_1 + r_2) + r_1 r_2} = 0{,}53\,A$$

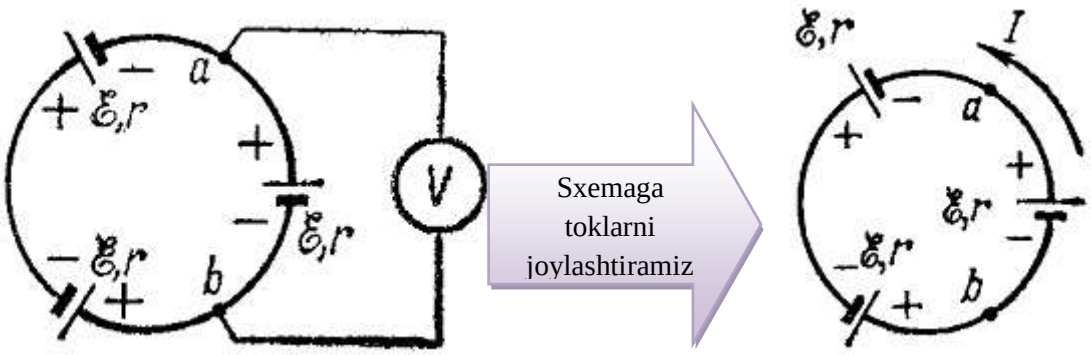
25. Rasmda tasvirlangan sxemada R_1, R_2 qarshiliklar hamda manbalarning E.Yu.K lari $\varepsilon_1, \varepsilon_2$ ma'lum . Uchichi elementning E.Yu.K qanday bo'lganda R qarshilikdan tok o'tmaydi?



R_1, R_2 va R qarshiliklar orqali o'tuvchi I_1, I_2, I toklar yuqoridagi rasmda ko'rsatilgan. U holda $I_1 + I_2 = I$ a va b nuqtalar orasidagi kuchlanish tushishi $\varepsilon_1 + I_1 R_1 = \varepsilon - IR = \varepsilon_2 + I_2 R_2$ bo'ladi. Agar masala shartiga ko'ra *I=0* bo'lsa, u holda $I_1 = -I_2$, $\varepsilon_1 + I_1 R_1 = \varepsilon = \varepsilon_2 - I_1 R_2$. Bundan I_1 ni yo'qotsak, quyidagini olamiz:

$$\varepsilon = \frac{\varepsilon_1 R_2 + \varepsilon_2 R_1}{R_1 + R_2}$$

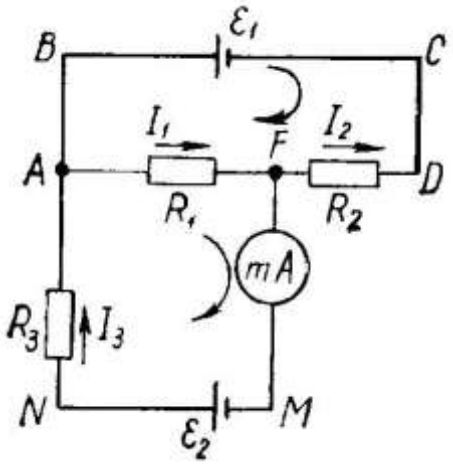
26. Ketma-ket ulangan uchta bir xil elementdan tuzilgan zanjir qisqa tutashtirilgan. Har bir elementning E.Yu.K ε ga va ichki qarshiligi r ga teng. Elementlardan birining qutblariga ulangan vol'tmetr qanday kuchlanishni ko'rsatadi? Ulovchi similar qarshiligini xisobga olmang.



Xuddi o'sha sxemani vol'tmetrsiz qaraymiz. Butun zanjir uchun Om qonunidan undagi tokni topamiz: $I = \frac{3\varepsilon}{3r} = \frac{\varepsilon}{r}$. Zanjirning bir qismi uchun Om qonunidan zanjirning *a* va *b* nuqtalar orasidagi qismi uchun $U_{ab} = \varepsilon - Ir$ tok kuchining o'rniga yuqoridagi natijani keltirib qo'ysak $U_{ab} = \varepsilon - Ir = \varepsilon - \frac{\varepsilon}{r} \cdot r = 0$. Potensiallar farqi nolga teng bo'lgan ikki

nuqtaga har qanday vol'tmetrning ulanishi zanjirda hech nimani o'zgartira olmaydi. Shuning uchun vol'tmetr nol kuchlanishni ko'rsatadi.

27. Rasmda sxemasi berilgan elektr zanjirga uchta rezistor: $R_1 = 100\,\Omega, R_2 = 50\,\Omega,$ $R_3 = 20\,\Omega;$ E.Yu.K $\varepsilon_1 = 2V$ **va** ε_2 **bo'lgan gal'vanik elementlar ulangan. Ampermetr 50 mA tok kuchini ko'rsatadi. Rezistorlardagi tok kuchini va ikkinchi elementning E.Yu.K ni aniqlang. Ampermetr va elementning ichki qarshiligini hisobga olmang.**



Tokning yo'nalishini ixtiyoriy tanlaymiz va uni zanjir sxemasida ko'rsatamiz.Tugunga keluvchi va undan ketuvchi tok kuchlarining algebraik yig'indisi nolga tengligini hisobga olib (Kirxgofning birinchi qoidasidan)

$$I_1 - I_2 - I_3 = 0 \Rightarrow I_3 = I_1 - I_2 \qquad (1)$$

Ampermetr ko'rsatayotgan tok kuchi: $I_A = I_3$ .Konturni soat strelkasi bo'yicha aylanib o'tishini kelishib olamiz va buni sxemada ko'rsatamiz. Berk konturda kuchlanish tushishining algebraic yig'indisi E.Yu.K ning algebraic yig'indisiga tengligidan (Kirxgofning ikkinchi qoidasi) quyidagilarni yozamiz:

ABCDFA kontur uchun:

$$-I_1R_1 - I_2R_2 = -\varepsilon_1 \Rightarrow I_1R_1 + I_2R_2 = \varepsilon_1 \qquad (2)$$

AFMNA kontur uchun:

$$I_1R_1 + I_3R_3 = \varepsilon_2 \qquad (3)$$

(1) tenglamadan I_1 ni aniqlab, (2) tenglamaga qo'yamiz:

$I_1 = I_2 + I_3;\quad (I_3 + I_2)R_1 + I_2R_2 = \varepsilon_2$ bundan

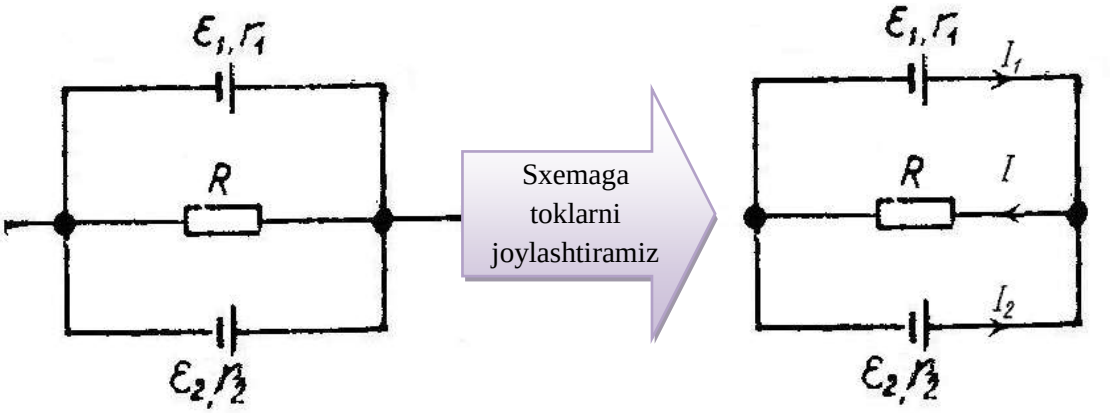
$$I_2 = \frac{\varepsilon_1 - I_3R_1}{R_1 + R_2} = -0{,}02\,A$$

Minus ishora tok kuchi I_2 sxemada shartli ko'rsatilgan yo'nalishga qarama-qarshi ekanini bildiradi.

Tok kuchi $I_1 = I_2 + I_3 = -0{,}02 + 0{,}05 = 0{,}03A$

I_1 ni (3) tenglamaga qo'yib, ε_2 ni topamiz: $\varepsilon_2 = 4V$

28. Zanjirga rasmdagidek ulangan $R = 2\Omega$ qarshilikdan o'tuvchi tok kuchini aniqlang. Berilganlar $\varepsilon_1 = 2V$, $r_1 = 0{,}5\Omega$, $\varepsilon_2 = 4V$, $r_2 = 0{,}7\Omega$.



Tok va uning yo'nalishlarini yuqoridagi rasmda ko'rsatilgandek belgilab, Kirxgof 1-qoidasidan quyidagi tenglamani tuzamiz

$$I = I_1 + I_2$$

yuqoridagi kontur uchun Kirxgofning 2-qoidasini qo'llaymiz

$$I_1 r_1 + IR = \varepsilon_1$$

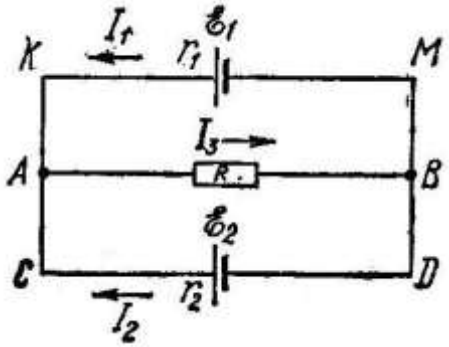
Pastki kontur uchun Kirxgofning 2-qoidasini qo'llaymiz

$$I_2 r_2 + IR = \varepsilon_2$$

Yuqoridagi tenglamalarda quyidagi natija kelib chiqadi

$$I = \frac{\varepsilon_1 r_2 + \varepsilon_2 r_1}{R(r_1 + r_2) + r_1 r_2} = 1{,}24\,A$$

29. Rasmda tasvirlangan elektr zanjiri E.Yu.K lari $\varepsilon_1 = 1{,}6V$ va $\varepsilon_2 = 1{,}3V$ ichki qarshiligi mos ravishda $r_1 = 1\Omega$ va $r_2 = 0{,}5\Omega$ bo'lgan ikki element rasmdagidek ulangan. Hamma tarmoqlardagi toklarni hisoblang. Ulovchi simlarning qarshiligini hisobga olmang.



I-Usul

Kirxgof qonunidan foydalanib va toklarning shartli tanlangan yo'nalishini hisobga olgan holda zanjirning turli qismlari uchun tenglamalar tuzamiz.

A tugun uchun:

$$I_1 + I_2 = I_3$$

KCDM yopiq kontur uchun:

$$\varepsilon_1 - \varepsilon_2 = I_1 r_1 - I_2 r_2$$

KABM yopiq kontur uchun:

$$\varepsilon_1 = I_1 r_1 + I_3 R$$

Oxirgi tenglamadan I_3 ni yo'qotib va tenglamalar sistemasini I_1 va I_2 ga nisbatan echib, quyidagini olamiz:

$$I_1 = \frac{\varepsilon_1 r_2 + (\varepsilon_1 - \varepsilon_2)R}{r_1 R + r_1 r_2 + R r_2} = 0{,}7\,A,\ I_2 = \frac{I_1 r_1 + \varepsilon_2 - \varepsilon_1}{r_2} = 0{,}8\,A$$

$$I_3 = 1{,}5\,A$$

II-Usul

Masalani tugunlar potensiali usulidan foydalanib echamiz. A tugun potensialini φ_A deb belgilab, Btugun potensialini nolga teng deb qabul qilamiz. U holda $\varphi_A - \varphi_B = U_{AB}$ bo'ladi.E.Yu.K bo'lgan va E.Yu.K bo'lmagan zanjirning bir qismi uchun Om qonuni bo'yicha toklar ifodasini yozamiz.

$$I_1 = \frac{\varepsilon_1 - U_{AB}}{r_1},\ I_2 = \frac{\varepsilon_2 - U_{AB}}{r_2},\ I_3 = \frac{U_{AB}}{R}$$

Bundan $I_1 + I_2 = I_3$ bo'lgani uchun

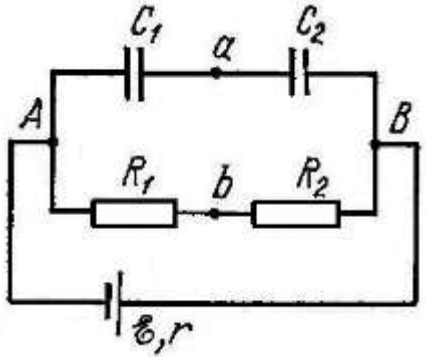
$$\frac{\varepsilon_1 - U_{AB}}{r_1} + \frac{\varepsilon_2 - U_{AB}}{r_2} = \frac{U_{AB}}{R}$$ ni olamiz

Kattaliklarni son qiymatini qo'yib, U_{AB} ni topamiz $U_{AB} = 0{,}9V$

Endi toklarni hisoblaymiz:

$$I_1 = 0{,}7\,A \quad I_2 = 0{,}8\,A \quad I_3 = 1{,}5\,A$$

30. Rasmda tasvirlangan elektr zanjiri E.Yu.K $\varepsilon = 12V$ va ichki qarshiligi $r = 1Om$ li elektr energiya manbaidan $R_1 = 3Om$ va $R_2 = 6Om$ li ikki qarshilik hamda $C_1 = 1\mu F$ va $C_2 = 2\,\mu F$ sig'imli ikki kondensatordan tuzilgan. Zanjirning a va b nuqtalari orasidagi potentsiallar farqini va har bir kondensatorda to'plangan zaryad miqdorini aniqlang.



A nuqtaning potensiali nolga teng, *a* va *b* nuqtalarning potensiallarini φ_a va φ_b ga teng deb olishni shartlashib olamiz; u holda $\Delta\varphi = \varphi_a - \varphi_b$. Masala φ_a va φ_b ni topishga keltiriladi.

Zanjirdagi tokni topamiz:

$$I = \frac{\varepsilon}{R_1 + R_2 + r}$$

b nuqtaning potensiali noldan R_1 qarshilikdagi kuchlanish tushuvi qadar yuqori bo'ladi

$$\varphi_b = IR_1 = \frac{\varepsilon R_1}{R_1 + R_2 + r}$$

AB qismdagi kuchlanish tushuvi:

$$U_{AB} = \varepsilon - Ir = \frac{\varepsilon(R_1 + R_2)}{R_1 + R_2 + r}$$

Ketma-ket ulangan ikki kondensatordagi potensiallar farqi ham U_{AB} ga teng. Kondensatorlarning ulanish usulini hisobga olib, ulardagi zaryad birday va

$$q = C_{Um} \cdot U_{AB} = \frac{C_1 \cdot C_2}{C_1 + C_2} \cdot U_{AB} = \frac{\varepsilon(R_1 + R_2)}{R_1 + R_2 + r} \cdot \frac{C_1 \cdot C_2}{C_1 + C_2} = 7{,}2 \cdot 10^{-6} Kl$$

ga tengligini ko'ramiz.

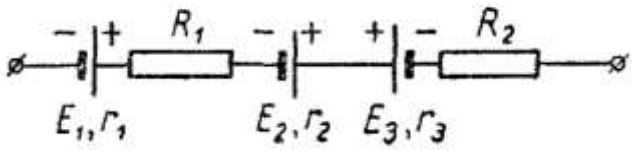
Birinchi kondensator zaryadi va sig'imini bilgan holda uning qoplamalaridagi potensiallar farqini aniqlash mumkin, demak, φ_a ni ham aniqlash mumkin

$\Delta\varphi$ ning ifodasini yozamiz va uning son qiymatlarini topamiz:

$$\Delta\varphi = \frac{\varepsilon(R_1 + R_2)C_2}{(R_1 + R_2 + r)(C_1 + C_2)} - \frac{\varepsilon R_1}{R_1 + R_2 + r} = \varepsilon \frac{R_2C_2 - R_1C_1}{(R_1 + R_2 + r)(C_1 + C_2)} = 3{,}6V$$

Kondensatordagi elektr zaryadni topamiz:

31.Rasmda tasvirlangan batareyaning umumiy E.Yu.K ni va umumiy qarshiligini toping. $\varepsilon_1 = 10V, r_1 = 1\Omega, \varepsilon_2 = 8V, r_2 = 2\Omega, \varepsilon_3 = 15V, r_3 = 3\Omega, R_1 = 5\Omega, R_2 = 10\Omega.$



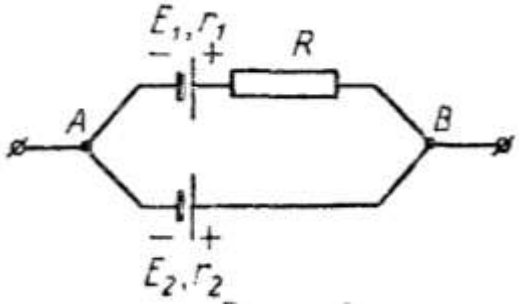
Batareyalar ketme-ket ulanganligi uchun umumiy E.Yu.K va umumiy qarshiligi quyidagiga teng.

$$\varepsilon = \varepsilon_1 + \varepsilon_2 - \varepsilon_3 = 3V, \qquad R = r_1 + r_2 + r_3 + R_1 + R_2 = 21\Omega$$

Uchinchi manba birinchi va ikkinchi manbalarga teskari ulanganligi uchun manfiy ishora bilan olindi.

32. Rasmda tasvirlangan sxemaning umumiy E.Yu.K va Qarshiligini hisoblang.

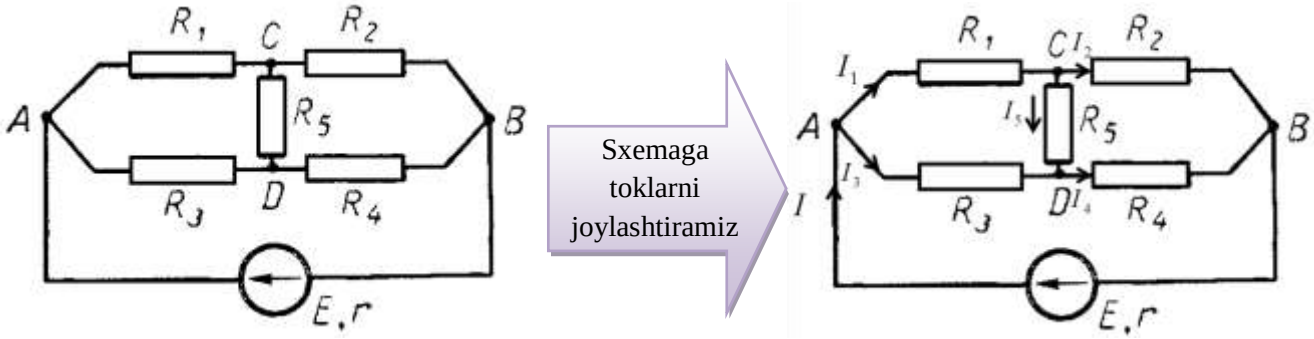
$\varepsilon_1 = 12V$, $r_1 = 1\Omega$, $\varepsilon_2 = 30V$, $r_2 = 3\Omega$, $R = 5\Omega$.



$$R_1 = r_1 + R = 6\Omega, \quad R_2 = r_2 = 3\Omega, \quad R_{Um} = \frac{R_1 \cdot R_2}{R_1 + R_2} = 2\Omega.$$

$$\frac{\varepsilon_{Um}}{R_{Um}} = \frac{\varepsilon_1}{R_1} + \frac{\varepsilon_2}{R_2}, \qquad \frac{\varepsilon_{Um}}{2} = \frac{12}{6} + \frac{30}{3}, \quad \varepsilon_{Um} = 24V$$

32. Rasmdagi sxemada $\varepsilon = 22V, r = 0, R_1 = 1\Omega$, qolgan qarshiliklarning har biri 2 Ω dan. Zanjirdagi toklarni toping.



Yuqoridagi rasmdagidek toklarni joylashtirib chiqamiz. B nuqtadagi potensialni nolga ($\varphi_B = 0$)teng desak A nuqtadagi potensial ($r=0$) $\varphi_A = \varepsilon = 22V$ ga teng bo'ladi.

Endi toklarni quyidagicha topib chiqamiz.

$$I_1 = \frac{\varphi_A - \varphi_C}{R_1}, \; I_2 = \frac{\varphi_C - \varphi_B}{R_2} = \frac{\varphi_C}{R_2}, \; I_3 = \frac{\varphi_A - \varphi_D}{R_3}, \; I_4 = \frac{\varphi_D - \varphi_B}{R_4} = \frac{\varphi_D}{R_4}, \; I_5 = \frac{\varphi_C - \varphi_D}{R_5}. \qquad (1)$$

Kirxgofning birinchi qoidasiga ko'ra quyidagi tenglamani tuzamiz

$$I = I_1 + I_3 \qquad I_1 = I_2 + I_5 \qquad I_4 = I_3 + I_5 \qquad (2)$$

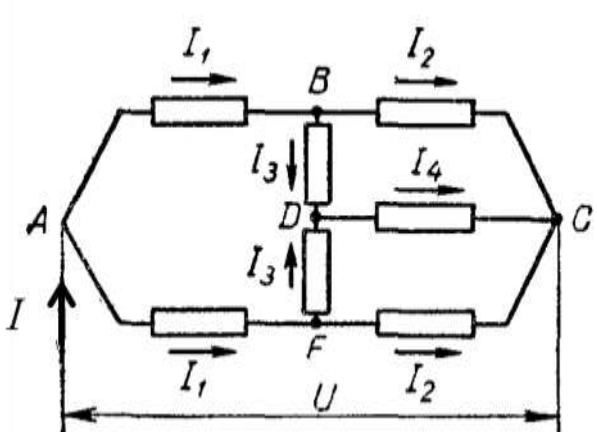
(1) va (2) tenglamalarni soddalashtirsak

$$\begin{cases} \dfrac{22 - \varphi_C}{1} = \dfrac{\varphi_C}{2} + \dfrac{\varphi_C - \varphi_D}{2} \\ \dfrac{22 - \varphi_D}{2} + \dfrac{\varphi_C - \varphi_D}{2} = \dfrac{\varphi_D}{2} \end{cases} \qquad (3)$$

(3) tenglamani yechsak $\varphi_C = 14V, \; \varphi_D = 12V$ natijaga erishamiz ularni yuqoridagi (1) formulaga etib qo'ysak

$$I = 13A, \; I_1 = 8A, \; I_2 = 7A, \; I_3 = 5A, \; I_4 = 6A, \; I_5 = 1A.$$

33. Rasmda tasvirlangan sxemada $U=14V$, barcha qarshilik 1Ω dan. Zanjirdagi toklarni toping.



Yuqoridagi rasmdagidek toklarni joylashtirib chiqamiz. C nuqtadagi potensialni nolga ($\varphi_C=0$)teng desak A nuqtadagi potensial $\varphi_A=U=14V$ ga teng bo'ladi.

Endi toklarni quyidagicha topib chiqamiz.

$$I_1=\frac{14-\varphi_B}{1},\ I_2=\frac{\varphi_B-\varphi_C}{1}=\frac{\varphi_B}{1},\ I_3=\frac{\varphi_B-\varphi_D}{1},\ I_4=\frac{\varphi_D-\varphi_C}{1}=\frac{\varphi_D}{1}. \qquad (1)$$

Kirxgofning birinchi qoidasiga ko'ra quyidagi tenglamani tuzamiz

$$I=I_1+I_1 \qquad I_1=I_2+I_3 \qquad I_4=I_3+I_3 \qquad (2)$$

(1) va (2) tenglamalarni soddalashtirsak

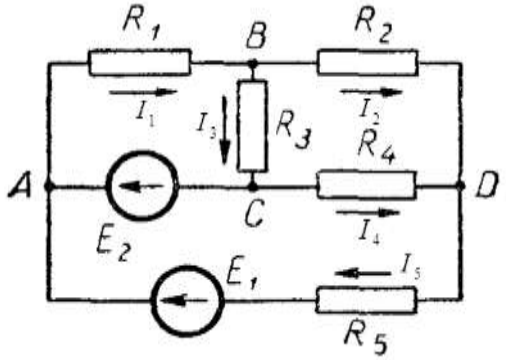
$$\begin{cases}14-\varphi_B=\varphi_B+(\varphi_B-\varphi_D)\\2(\varphi_B-\varphi_D)=\varphi_D\end{cases} \qquad (3)$$

(3) tenglamani yechsak $\varphi_B=6V,\ \ \varphi_D=4V$ natijaga erishamiz ularni yuqoridagi (1) formulaga etib qo'ysak

$$I=16A,\ I_1=8A,\ I_2=6A,\ I_3=2A,\ I_4=4A,$$

34. Rasmda ko'rsatilga sxemada berilganlaridan foydalanib barcha toklarni toping.Ichki qarshilikni hisobga olmang.

$\varepsilon_1=65V, \varepsilon_2=39V, R_1=20\Omega, R_2=R_3=R_4=R_5=10\Omega.$



Yuqoridagi rasmdagidek toklarni joylashtirib chiqamiz. C nuqtadagi potensialni nolga ($\varphi_C=0$)teng desak A nuqtadagi potensial $\varphi_A=\varepsilon_2=39V$ ga teng bo'ladi.

Endi toklarni quyidagicha topib chiqamiz.

$$I_1 = \frac{39-\varphi_B}{20},\ I_2 = \frac{\varphi_B-\varphi_D}{10},\ I_3 = \frac{\varphi_B-\varphi_C}{10} = \frac{\varphi_B}{10},$$

$$I_4 = \frac{\varphi_C-\varphi_D}{10} = -\frac{\varphi_D}{10}.\ I_5 = \frac{65+\varphi_D-39}{10} \qquad (1)$$

Kirxgofning birinchi qoidasiga ko'ra quyidagi tenglamani tuzamiz

$$I_1 = I_2 + I_3 \qquad I_2 + I_4 = I_5 \qquad (2)$$

(1) va (2) tenglamalarni soddalashtirsak

$$\begin{cases} \frac{39-\varphi_B}{20} = \frac{\varphi_B-\varphi_D}{10} + \frac{\varphi_B}{10} \\ \frac{\varphi_B-\varphi_D}{10} - \frac{\varphi_D}{10} = \frac{26+\varphi_D}{10} \end{cases} \qquad (3)$$

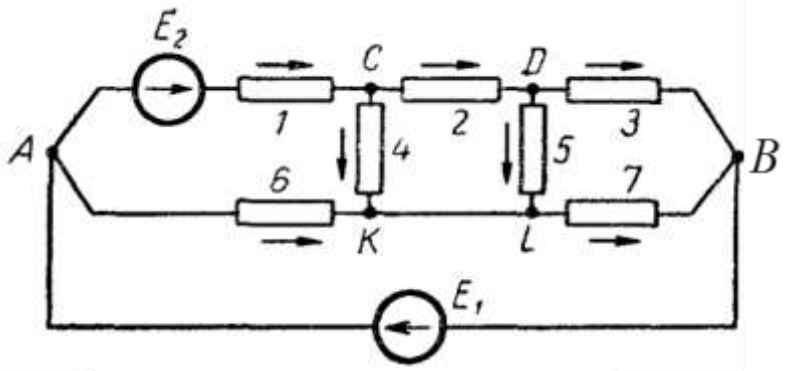
(3) tenglamani yechsak $\varphi_B = 5V,\ \ \varphi_D = -7V$ natijaga erishamiz ularni yuqoridagi (1) formulaga etib qo'ysak

$$I_1 = 1{,}7\,A,\ I_2 = 1{,}2\,A,\ I_3 = 0{,}5\,A,\ I_4 = 0{,}7\,A,\ I_5 = 1{,}9\,A$$

E_2 manba orqali o'tadigan tok kuchi $I_{E_2} = I_4 - I_3 = 0{,}2\,A$ (A dan C ga yo'nalgan)

E_1 manba orqali o'tadigan tok kuchi $I_{E_1} = I_5 = I_{E_2} + I_1 = 1{,}9\,A$ (I_5 yo'nalishida)

35. Rasmda tasvirlangan sxemada E.Yu.K lari $\varepsilon_1 = 10V, \varepsilon_2 = 30V$, barcha qarshiliklar $R_1 = R_2 = R_3 = R_4 = R_5 = R_6 = R_7 = 1\Omega$ dan bo'lsa barcha toklarni toping. Manbaning ichki qarshiligini hisobga olmang



Yuqoridagi rasmdagidek toklarni joylashtirib chiqamiz. B nuqtadagi potensialni nolga ($\varphi_B = 0$) teng desak A nuqtadagi potensial $\varphi_A = \varepsilon_1 = 10V$ ga teng bo'ladi.

Qolgan potensiallarni quyidagicha belgilaymiz. $\varphi_C = x,\ \ \varphi_D = y,\ \ \varphi_K = \varphi_L = z.$

Endi toklarni quyidagicha topib chiqamiz.

$$I_1=\frac{\varepsilon_1+\varepsilon_2-\varphi_C}{R_1}=\frac{30+10-x}{1}=30+10-x,\quad I_2=\frac{\varphi_C-\varphi_D}{R_2}=\frac{x-y}{1}=x-y,$$

$$I_3=\frac{\varphi_D-\varphi_B}{R_3}=\frac{y}{1}=y,\quad I_4=\frac{\varphi_C-\varphi_K}{R_4}=\frac{x-z}{1}=x-z.\quad I_5=\frac{\varphi_D-\varphi_L}{R_5}=\frac{y-z}{1}=y-z \qquad (1)$$

$$I_6=\frac{\varphi_A-\varphi_K}{R_6}=\frac{10-z}{1}=10-z,\quad I_7=\frac{\varphi_L-\varphi_B}{R_7}=\frac{z-0}{1}=z$$

Kirxgofning birinchi qoidasiga ko'ra quyidagi tenglamalarni tuzamiz

$$I_1=I_2+I_4 \qquad I_3+I_5=I_2 \qquad I_4+I_6=I_5+I_7 \qquad (2)$$

(1) va (2) tenglamalarni soddalashtirsak

$$\begin{cases}40-x=x-y+x-z\\ x-y=y+y-z\\ x-z+10-z=y-z+z\end{cases} \qquad (3)$$

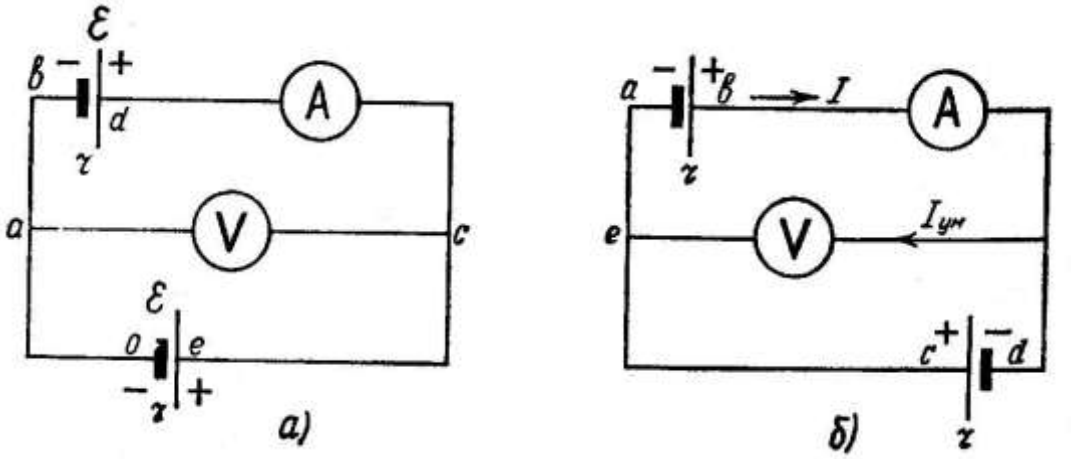
(3) tenglamani yechsak $x=20V,\ y=10V,\ z=10V$ natijaga erishamiz ularni yuqoridagi (1) formulaga etib qo'ysak

$I_1=20A,\ I_2=I_3=I_4=I_7=10A,\ I_5=I_6=0$ natijalarga ega bo'lamiz.

E_2 manba orqali o'tadigan tok kuchi $I_{E_2}=I_1=20\,A$ (A dan C ga yo'nalgan)

E_1 manba orqali o'tadigan tok kuchi $I_{E_1}=I_3+I_7=20\,A$ (B dan A ga yo'nalgan)

36. a va b rasmlardagi vol'tmetr va ampermetrlar nimani ko'rsatadi? ε va r berilgan deb faraz qiling. Ulovchi simlarning qarshiligini hisobga olmang.



(a-rasm uchun) Elektr energiya manbalarini parallel ulash deb, manbalarning musbat qutblari bir o'tkazgichga, manfiy qutblari boshqa o'tkazgichga ulanishiga aytiladi. Bunday ulashda bir manbaning toki boshqasi orqali o'tmaydi. Shuning uchun har bir zaryad bitta manbadan energiya oladi. Bundan parallel ulanganda batareyaning E.Yu.K bitta manbaning E.Yu.K ga teng bo'lishi kelib chiqadi.

Har bir manba orqali zaryadlarning bir qismi o'tadi, shuning uchun batareyaning qarshiligi bitta manbaning qarshiligidan ikki marta kichik bo'ladi, u holda Om qonuni quyidagicha yoziladi:

$$I = \frac{\varepsilon}{R + \frac{r}{2}} \qquad (1)$$

Masalaning shartiga ko'ra (a rasm) $R = \infty$ bo'lgani uchun $I = 0$.

Sxemaga ulangan vol'tmetr bitta elementning kuchlanishiga teng kuchlanishni ko'rsatadi,ya'ni $U = \varepsilon$

(b-rasm uchun) Batareya zanjiridagi tok *I* ga teng bo'lsin. Vol'tmetr orqali o'tuvchi tok

$$I_{Um} = I - I = 0$$

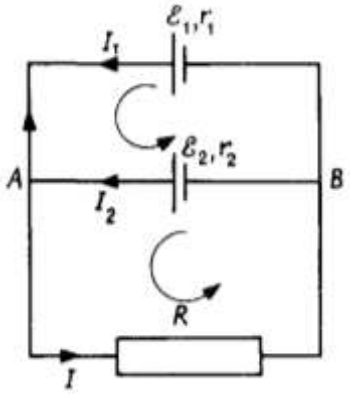
Bo'ladi. Tok $I = \frac{\varepsilon}{r}$, zanjirning ichki qismdagi kuchlanish tushuvi $U = Ir$, chunki tashqi qism qarshiligi nolga teng, ya'ni vol'tmetr nolni ko'rsatadi.

(a rasmdagi) shartga ko'ra $U = \varepsilon$, bundan batareya klemmalaridan uzoqlashgan sari potensial ortadi

(b-rasm uchun) holda batareya klemmalaridan uzoqlashilgan sari potensial kamayadi, bundan batareya klemmasidan eng katta uzoqlashishi.

37. Rasmda tasvirlangan sxemadagi barcha toklarni toping.

$\varepsilon_1 = 2V, \varepsilon_2 = 4V,\ r_1 = r_2 = 2\Omega, R = 9\Omega.$



Kirxgofning birinchi qoidasini qo'llab A tugun uchun quyidagi tenglamani yozamiz

$$I = I_1 + I_2 \qquad (1)$$

Kirxgofning ikkinchi qoidasidan foydalanib berk konturlar uchun tegishli tenglama tuzamiz

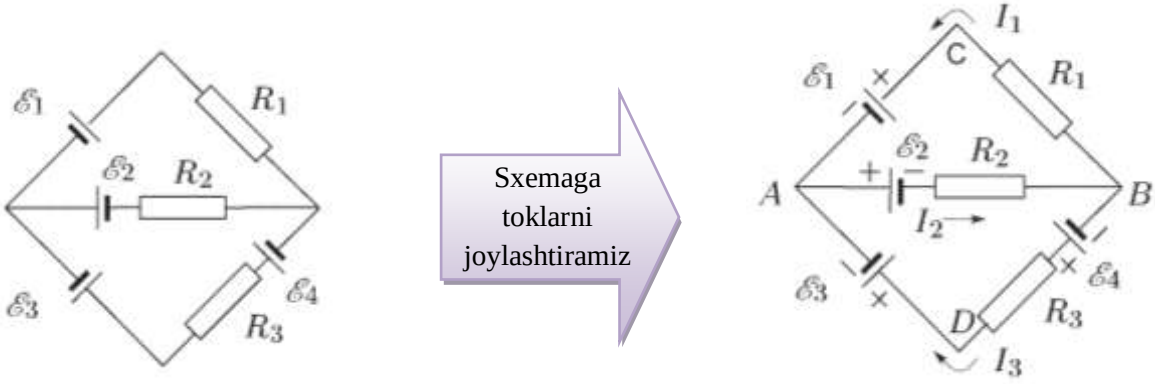
$$I_1 r_1 + IR = \varepsilon_1, \quad I_2 r_2 + IR = \varepsilon_2 \qquad (2)$$

(1)va (2) tenglamalarni soddalashtirib quyidagi natijalarga erishamiz

$$I_1 = \frac{\varepsilon_1 - IR}{r_1}; \quad I_2 = \frac{\varepsilon_2 - IR}{r_2}; \quad I = \frac{\varepsilon_1 r_2 + \varepsilon_2 r_1}{r_1 \cdot r_2 + R(r_1 + r_2)},$$

$$I = 0{,}3A, \quad I_1 = -0{,}35A, \quad I_2 = 0{,}65A.$$

38. Rasmda ko’rsatildan sxemadan foydalanib har bir qarshilikdan o’tuvchi tok kuchini toping. $\varepsilon_1 = 15V, \varepsilon_2 = 5V,\ \varepsilon_3 = 10V, \varepsilon_4 = 35V,\ R_1 = 2\Omega, R_2 = 5\Omega, R_3 = 10\Omega.$



Kirxgofning birinchi qoidasini qo’llab A tugun uchun quyidagi tenglamani yozamiz

$$I_2 = I_1 + I_3 \qquad (a)$$

Kirxgofning ikkinchi qoidasidan foydalanib berk konturlar uchun tegishli tenglama tuzamiz

ACB kontur uchun $\varepsilon_1 + \varepsilon_2 = -I_1R_1 - I_2R_2 \qquad (b)$

ABD kontur uchun $-\varepsilon_2 + \varepsilon_4 - \varepsilon_3 = I_2R_2 + I_3R_3 \qquad (v)$

ACBD kontur uchun $\varepsilon_1 + \varepsilon_4 - \varepsilon_3 = -I_1R_1 + I_3R_3 \qquad (g)$

Yuqoridagi formulalardagi minus ishoralar biz tanlab olgan yo’nalishga teskari ekanligini bildiradi

Endi yuqoridagi formulalardan I_1 va I_3 ni topamiz (*b* va *v* dan):

$$I_1 = \frac{-\varepsilon_1 - \varepsilon_2 - I_2R_2}{R_1};\ I_3 = \frac{-\varepsilon_2 + \varepsilon_4 - \varepsilon_3 - I_2R_2}{R_3};$$

Bu formulalarni (a) formulaga eltib qo’ysak

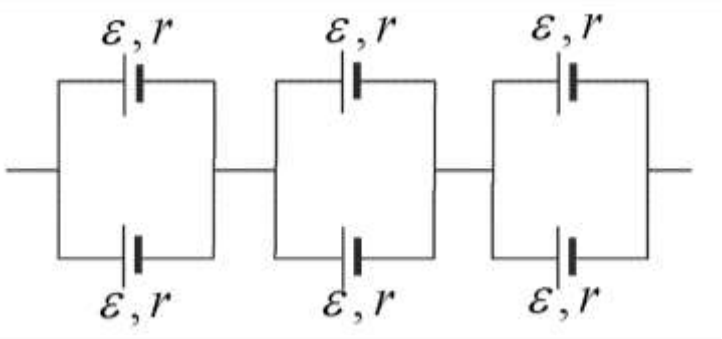
$$I_2 = \frac{-(\varepsilon_1 + \varepsilon_2)R_3 + (-\varepsilon_2 + \varepsilon_4 - \varepsilon_3)R_1}{R_1R_2 + R_1R_3 + R_2R_3}$$

Yuqorida topilgan formulalarga masala shartida berilgan kattaliklarni son qiymatini keltirib qo’ysak quyidagi javoblar kelib chiqadi.

$$I_2 = -2A,\quad I_1 = -5A,\quad I_3 = 3A,$$

Toklarning oldidagi minus ishora biz tanlagan yo’nalishdan teskari yo’nalishda oqishidan dalolat beradi.

39. Rasmda tasvirlangan sxemining umumiy E.Yu.K ni va umumiy qarshiligini aniqlang. Har bir manbaning E.Yu.K $\varepsilon = 1{,}8V$, ichki qarshiliklari $r = 0{,}6\Omega$ dan.



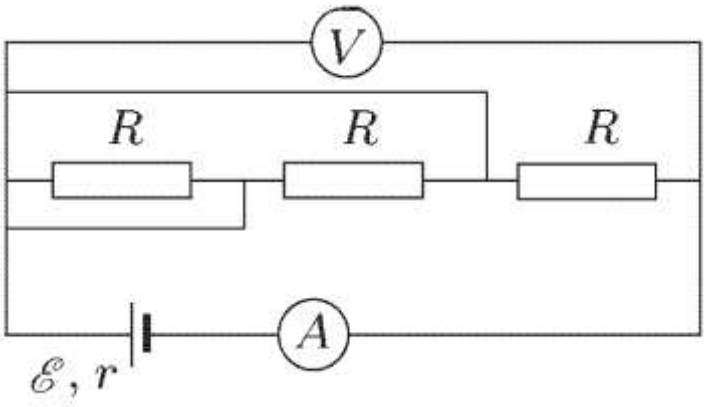
Har ikkita manba o'zaro parallae ulangan bo'lib uch juft manba ketma-ket ulangan parallel ulashda E.Yu.K umumiysi har birining o'ziga teng, ketme-ket ulashda esa umumiy E.Yu.K har bir juftning yig'indisiga teng

$$\varepsilon_{Um} = \varepsilon_{12} + \varepsilon_{34} + \varepsilon_{56} = \varepsilon + \varepsilon + \varepsilon = 3\varepsilon = 5{,}4V$$

Har ikkita manba o'zaro parallae ulangan bo'lib uch juft manba ketma-ket ulangan parallel ulashda ichki qarshilik $r_{12} = \dfrac{r_1 \cdot r_2}{r_1 + r_2} = \dfrac{r}{2}$. ketme-ket ulashda esa umumiy ichki qarshilik har bir juftning yig'indisiga teng

$$r_{Um} = r_{12} + r_{34} + r_{56} = \frac{r}{2} + \frac{r}{2} + \frac{r}{2} = \frac{3r}{2} = 0{,}9\Omega$$

40. Rasmda tasvirlangan sxemaning E.Yu.K $\varepsilon = 4V$, har bir qarshiliklari $R = 45\Omega$ dan, manbaning ichki qarshiligi $r = 1\Omega$ bo'lsa. Vol'tmetr va Ampermetrning ko'rsatgichini aniqlang. Voltimetrning qarshiligi juda katta, Ampermetrning qarshiligi juda kichik. Ulovchi simlarning qarshiligini hisobga olmang.



Rasmda ko'rinib turibdiki barcha tashqi qarshiliklar parallel ulangan

$$\frac{1}{R_{Um}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} \Rightarrow R_{Um} = 15\Omega$$

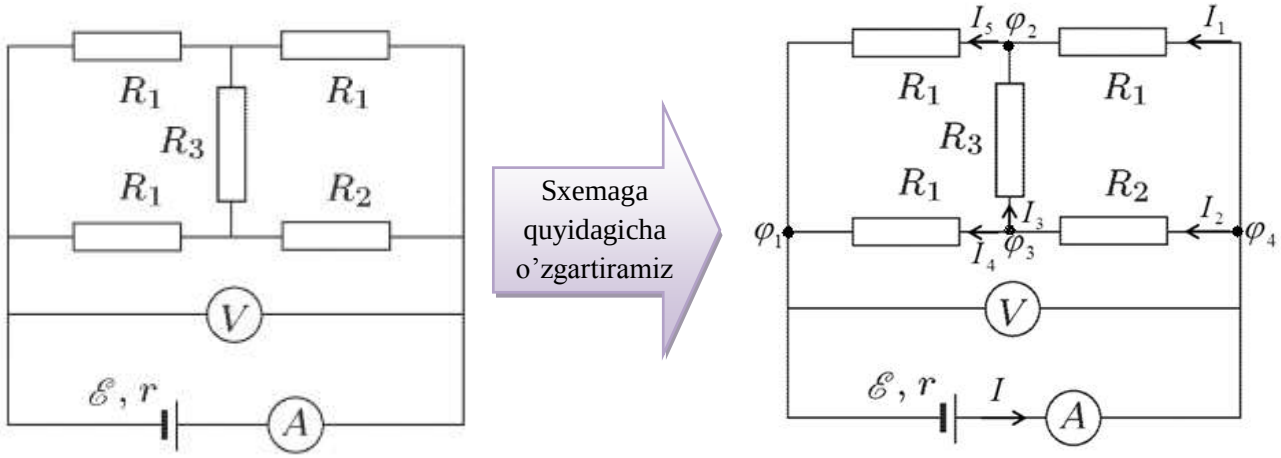
To'liq zanjir uchun Om qonunidan umumiy tokni ya'ni ampermetrdan o'tadigan tokni topamiz

$$I = \frac{\varepsilon}{R_{Um} + r} = \frac{4}{15+1} = 0{,}25\,A$$

Vol'tmetr uchta qarshilikdagi kuchlanish tushuvini ko'rsatadi

$$U = IR_{Um} = 0{,}25 \cdot 15 = 3{,}75V$$

41. Rasmda tasvirlangan sxemadan ampermetr va vol'tmetr ko'rsatishini va har bir qarshilikdan o'tadigan toklarni aniqlang. Tashqi zanjirdagi qarshiliklar $R_1 = 1\Omega, R_2 = 3\Omega, R_3 = 4\Omega$, manbaning E.Yu.K $\varepsilon = 3{,}3V$ va ichki qarshiligi $r = 0{,}2\Omega$. Vol'metrning qarshiligi juda katta, ampermetrning qarshiligi juda kichik. Ulovchi simlarning qarshiligini hisobga olmang.



Yuqoridagi rasmdagidek toklarni joylashtirib chiqamiz. $\varphi_1 = 0$ teng desak

$\varphi_4 - \varphi_1 = \varphi_4 = U = \varepsilon - Ir = 3{,}3 - 0{,}2I$ ga teng bo'ladi.

Endi toklarni quyidagicha topib chiqamiz.

$$I_1 = \frac{\varphi_4 - \varphi_2}{R_1}, \quad I_2 = \frac{\varphi_4 - \varphi_3}{R_2},$$

$$I_3 = \frac{\varphi_3 - \varphi_2}{R_3}, \quad I_4 = \frac{\varphi_3 - \varphi_1}{R_1}. \quad I_5 = \frac{\varphi_2 - \varphi_1}{R_1} \qquad (1)$$

Endi Kirxgofning birinchi qoidasiga ko'ra quyidagi tenglamani tuzamiz

$$I = I_1 + I_2, \qquad I_2 = I_3 + I_4 \qquad I_1 + I_3 = I_5 \qquad (2)$$

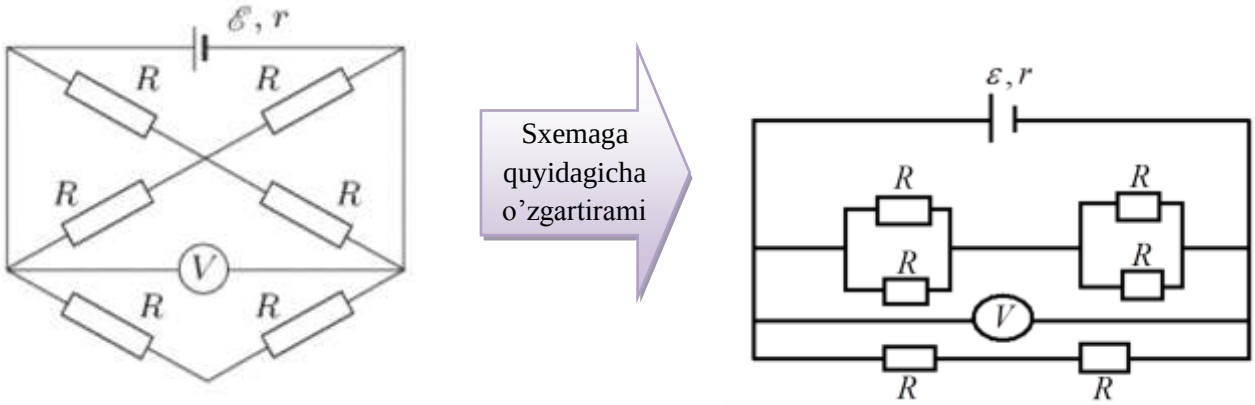
(1) va (2) tenglamalarni soddalashtirsak quyidagi natijaga erishamiz

$$I_1 = 1{,}5\,A, \quad I_2 = 0{,}7\,A, \quad I_3 = -0{,}14\,A, \quad I_4 = 0{,}8\,A, \quad I_5 = 1{,}36\,A$$

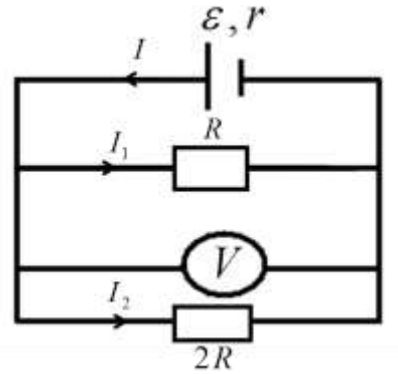
Vol'tmetr ko'rsatgichi $U = \varepsilon - Ir = 3{,}3 - 0{,}2I = 2{,}86V$

Ampermetr ko'rsatgichi $I = I_1 + I_2 = 2{,}2\,A$

42. Rasmda tasvirlangan sxemadan Vol'tmetrning ko'rsatgichini aniqlang.
$\varepsilon = 6V,\ r = 2/3\Omega,\ R = 2\Omega.$



Sxemani yanaham soddalashtiramiz ya'ni qarshiliklarni ketma-ket va paralel ulab toklarni joylashtirib chiqamiz



To'liq zanjir uchun Om qonunidan umumiy tok kuchini topamiz

$$I = \frac{\varepsilon}{R_{Um} + r} = \frac{6}{\frac{4}{3} + \frac{2}{3}} = 3A$$

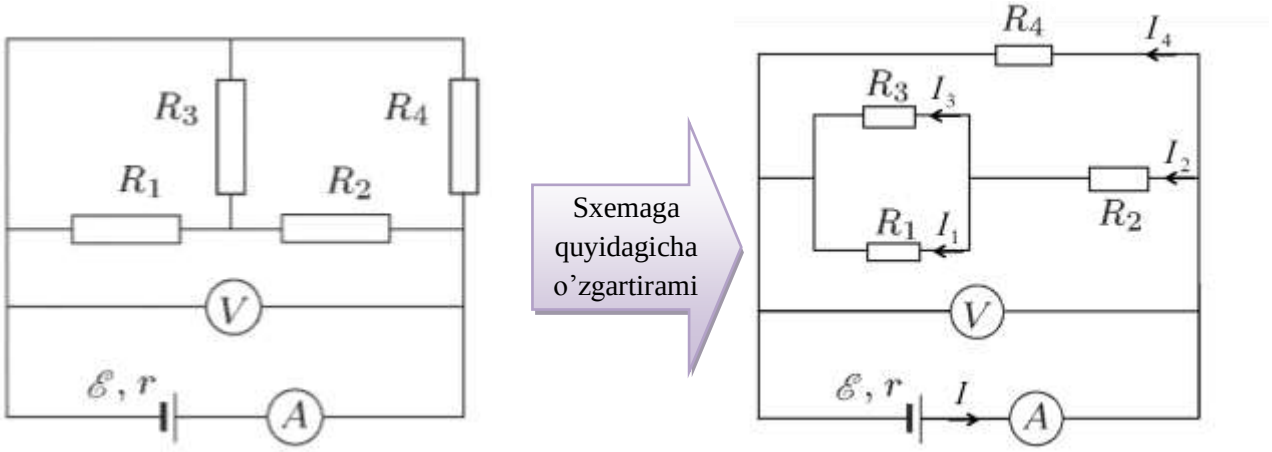
Kixgofning birinchi qonuni va qarshiliklarni paralelligidan quyidagi tenglamalarni tuzamiz

$$I = I_1 + I_2$$

$$U_{Vol} = U_1 = U_2 \ \rightarrow \ I_1 R = I_2 2R \ \rightarrow I_1 = 2I_2$$

Ushbu tenglamalardan $I_1 = 2\,A,\ I_2 = 1A,\ U_{Vol} = 4V$ natijalarga erishamiz.

43. Rasmda tasvirlangan sxemadan ampermetr va vol'tmetr ko'rsatishini va har bir qarshilikdan o'tadigan toklarni aniqlang. Tashqi zanjirdagi qarshiliklar $R_1 = 4\Omega, R_2 = 3\Omega, R_3 = 12\Omega,\ R_4 = 6\Omega$**, manbaning E.Yu.K** $\varepsilon = 21V$ **va ichki qarshiligi** $r = 1\Omega$**. Vol'metrning qarshiligi juda katta, ampermetrning qarshiligi juda kichik. Ulovchi simlarning qarshiligini hisobga olmang.**



Zanjirning umumiy tashqi qarshiligini topamiz

$$R_{13} = \frac{R_1 \cdot R_3}{R_1 + R_3} = 3\Omega, \quad R_{123} = R_{13} + R_2 = 6\Omega, \quad R_{Um} = \frac{R_{123} \cdot R_4}{R_{123} + R_4} = 3\Omega$$

To'liq zanjir uchun Om qonunidan umumiy tok kuchini topamiz

$$I = \frac{\varepsilon}{R_{Um} + r} = \frac{21}{3+1} = \frac{21}{4} A$$

Kixgofning birinchi qonuni va qarshiliklarni paralelligidan quyidagi tenglamalarni tuzamiz

$$I = I_2 + I_4, \quad I_2 = I_1 + I_3, U_{Vol} = U_4,$$

$$U_1 = U_3 \ \Rightarrow \ I_1 R_1 = I_3 R_3 \ \Rightarrow \ I_1 \cdot 4 = I_3 \cdot 12 \quad I_1 = 3I_3$$

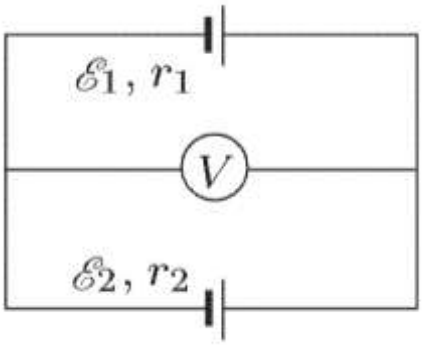
$$U_{123} = U_4 \ \rightarrow \ I_2 R_{123} = I_4 R_4 \ \rightarrow I_2 \cdot 6 = I_4 \cdot 6 \quad I_2 = I_4$$

Yuqoridagi tenglamalarni soddalashtirsak quyidagi natijaga ega bo'lamiz

$$I_2 = I_4 = \frac{I}{2} = \frac{21}{8} A, \qquad I_1 = \frac{3I}{8} = \frac{63}{32}, \quad I_3 = \frac{I}{8} = \frac{21}{32} A$$

$$U_{Vol} = U_4 = I_4 R_4 = 15{,}75V, \qquad U_{Vol} = \varepsilon - Ir = 15{,}75$$

44. Rasmda tasvirlangan sxemadagi voltmetrning ko'rsatgichini aniqlang.
$\varepsilon_1 = 1{,}8V, \varepsilon_2 = 2V, r_1 = 0{,}6\Omega,\ r_2 = 0{,}4\Omega,$



$\varepsilon_2 > \varepsilon_1$ bo'lganligi uchun birinchi manba zaryadlanadi, ikkinchi manba razryadlanadi(zaryadsizlanadi).
Zanjirda tarmoqlanish yo'qligi uchun toklar bir xil bo'ladi
To'liq zanjir uchun Om qonunini ikkita hol uchun quyidagicha yozamiz

I-hol razryadlanish uchun

$$\varepsilon_2 = U + I \cdot r_2 \qquad (1)$$

II-hol zaryadlanish uchun

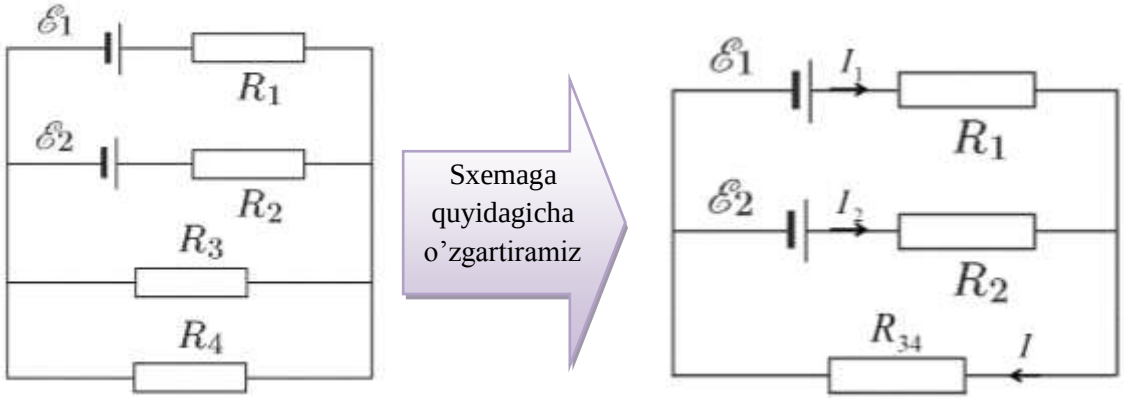
$$U = \varepsilon_1 + I \cdot r_1 \qquad (2)$$

Bu ikkita formulani soddalashtiramiz

$$\begin{cases} \varepsilon_2 = U + I \cdot r_2 \\ U = \varepsilon_1 + I \cdot r_1 \end{cases} \rightarrow \begin{cases} I \cdot r_2 = \varepsilon_2 - U \\ I \cdot r_1 = U - \varepsilon_1 \end{cases}$$

$$\frac{I \cdot r_2}{I \cdot r_1} = \frac{\varepsilon_2 - U}{U - \varepsilon_1} \rightarrow \frac{r_2}{r_1} = \frac{\varepsilon_2 - U}{U - \varepsilon_1} \rightarrow U = \frac{r_1 \cdot \varepsilon_2 + r_2 \cdot \varepsilon_1}{r_1 + r_2} = 1{,}92V$$

45. Rasmda tasvirlangan sxemadagi har-bir qarshilikdan o'tadigan tok kuchini toping. $\varepsilon_1 = 10V, \varepsilon_2 = 4V, R_1 = R_4 = 2\Omega,\ R_2 = R_3 = 4\Omega, r_1 = r_2 = 0$



Kirxgofning birinchi qoidasini qo'llab A tugun uchun quyidagi tenglamani yozamiz

$$I = I_1 + I_2 = I_3 + I_4 \qquad (1)$$

Kirxgofning ikkinchi qoidasidan foydalanib berk konturlar uchun tegishli tenglama tuzamiz

$$I_1R_1 + IR_{34} = \varepsilon_1, \quad I_2R_2 + IR_{34} = \varepsilon_2 \qquad (2)$$

(1) va (2) tenglamalarni soddalashtirib quyidagi natijalarga erishamiz

$$I_1 = 3A; \quad I_2 = 0; \quad I = 3A,$$

Uchinchi va to’rtinchi qarshiliklar paralelligidan quyidagi tenglamalarni tuzamiz

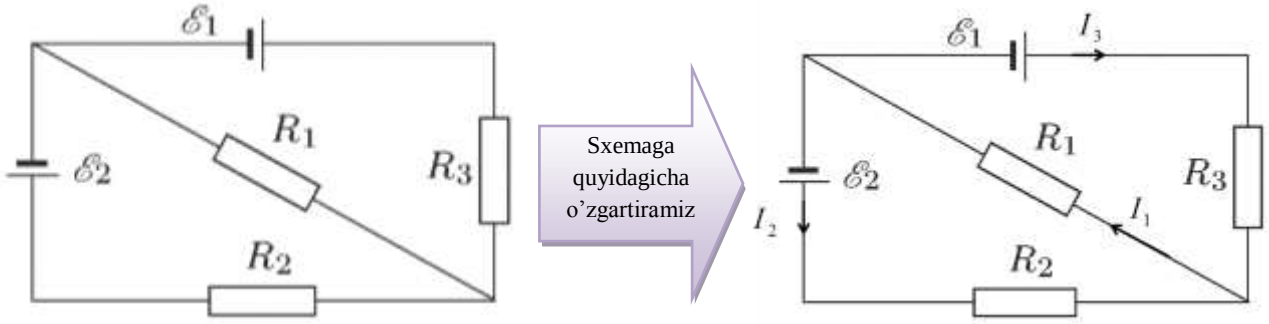
$$U_3 = U_4 \quad \rightarrow \quad I_3R_3 = I_4R_4 \quad \rightarrow \quad I_4 = 2I_3$$

Ushbu natijani (1) tenglamaga eltib qo’ysak tok kuchilarning son qiymati kelib chiqadi

$$I_4 = 2\,A \quad I_3 = 1A$$

46. Rasmda tasvirlangan sxemaning har bir qarshilikdan o’tadigan toklarni toping

$\varepsilon_1 = 2{,}1V, \varepsilon_2 = 1{,}9V, R_1 = 45\Omega, \quad R_2 = R_3 = 10\Omega, r_1 = r_2 = r_3 = 0$



Kirxgofning birinchi qoidasini qo’llab quyidagi tenglamani yozamiz

$$I_1 = I_2 + I_3 \qquad (1)$$

Kirxgofning ikkinchi qoidasidan foydalanib berk konturlar uchun tegishli tenglama tuzamiz

$$I_3R_3 + I_1R_1 = \varepsilon_1, \quad I_2R_2 + I_1R_1 = \varepsilon_2 \qquad (2)$$

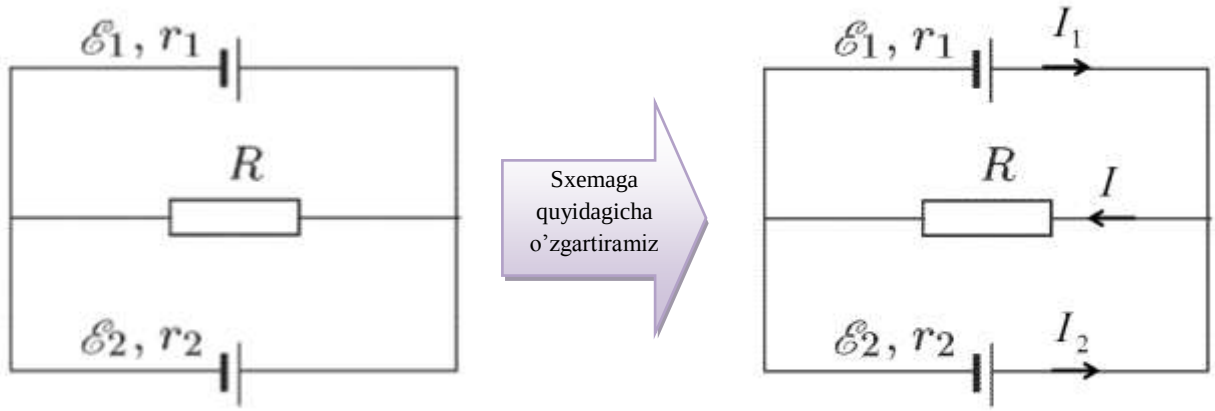
(1) va (2) tenglamalarni soddalashtirib quyidagi natijalarga erishamiz

$$\begin{cases} I_3R_3 + (I_2 + I_3)R_1 = \varepsilon_1 \\ I_2R_2 + (I_2 + I_3)R_1 = \varepsilon_2 \end{cases} \rightarrow \begin{cases} I_3 \cdot 10 + (I_2 + I_3) \cdot 45 = 2{,}1 \\ I_2 \cdot 10 + (I_2 + I_3) \cdot 45 = 1{,}9 \end{cases}$$

$$\begin{cases} 55I_3 + 45I_2 = 2{,}1 \\ 55I_2 + 45I_3 = 1{,}9 \end{cases} \rightarrow I_3 = 0{,}03\,A, \; I_2 = 0{,}01\,A, \; I_1 = I_2 + I_3 = 0{,}04\,A$$

46. Rasmda tasvirlangan sxemadagi toklarni toping

$\varepsilon_1 = 1{,}6V,\ \ \varepsilon_2 = 1{,}3\ \ V, r_1 = 1\Omega,\ \ r_2 = 0{,}5\Omega\ \ \ R = 0{,}6\Omega$



Kirxgofning birinchi qoidasini qo'llab quyidagi tenglamani yozamiz

$$I = I_1 + I_2 \qquad (1)$$

Kirxgofning ikkinchi qoidasidan foydalanib berk konturlar uchun tegishli tenglama tuzamiz

$$I_1 r_1 + IR = \varepsilon_1, \quad I_2 r_2 + IR = \varepsilon_2 \qquad (2)$$

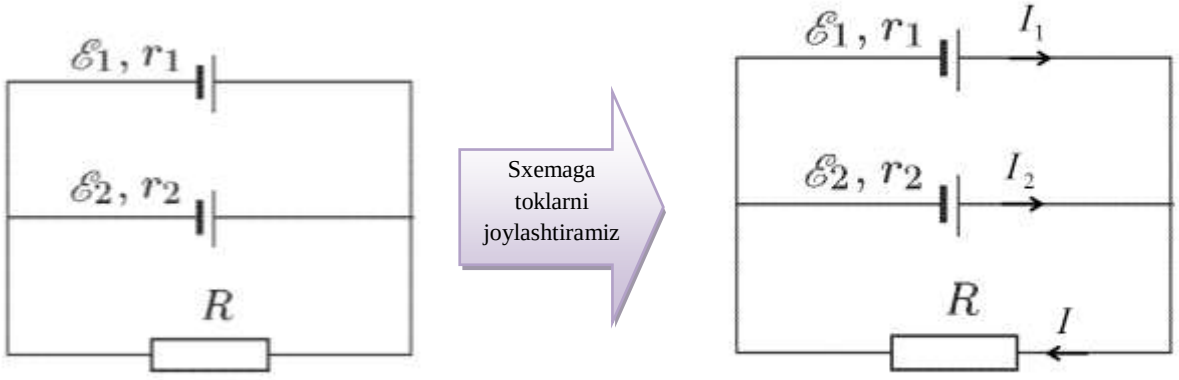
(1) va (2) tenglamalarni soddalashtirib quyidagi natijalarga erishamiz

$$\begin{cases} I_1 r_1 + (I_1 + I_2)R = \varepsilon_1 \\ I_2 r_2 + (I_1 + I_2)R = \varepsilon_2 \end{cases} \rightarrow \begin{cases} I_1 \cdot 1 + (I_1 + I_2)\cdot 0{,}6 = 1{,}6 \\ I_2 \cdot 0{,}5 + (I_1 + I_2)\cdot 0{,}6 = 1{,}3 \end{cases}$$

$$\begin{cases} 1{,}6I_1 + 0{,}6I_2 = 1{,}6 \\ 0{,}6I_1 + 1{,}1I_2 = 1{,}3 \end{cases} \rightarrow I_1 = 0{,}7\,A,\ I_2 = 0{,}8\,A,\ I = I_1 + I_2 = 1{,}5\,A$$

47. Rasmda tasvirlangan sxemada rezistor orqali o'tadigan tokni toping

$\varepsilon_1 = 1{,}9V,\ \ \varepsilon_2 = 1{,}1\ \ V, r_1 = 0{,}8\Omega,\ \ r_2 = 0{,}1\Omega\ \ \ R = 10\Omega$



Kirxgofning birinchi qoidasini qo'llab quyidagi tenglamani yozamiz

$$I = I_1 + I_2 \qquad (1)$$

Kirxgofning ikkinchi qoidasidan foydalanib berk konturlar uchun tegishli tenglama tuzamiz

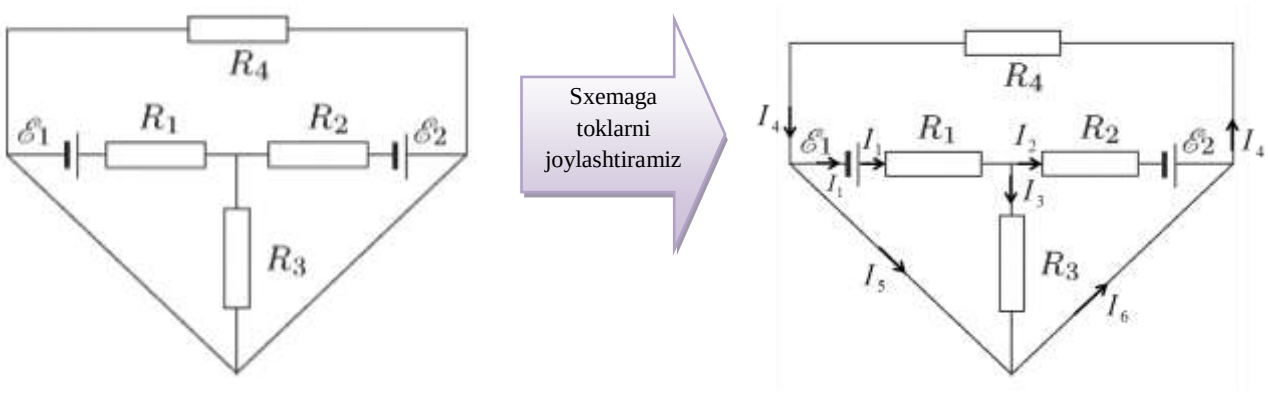
$$I_1 r_1 + IR = \varepsilon_1, \quad I_2 r_2 + IR = \varepsilon_2 \qquad (2)$$

(1) va (2) tenglamalarni soddalashtirib quyidagi natijalarga erishamiz

$$\begin{cases} I_1 r_1 + (I_1 + I_2)R = \varepsilon_1 \\ I_2 r_2 + (I_1 + I_2)R = \varepsilon_2 \end{cases} \rightarrow \begin{cases} I_1 \cdot 0{,}8 + (I_1 + I_2)\cdot 10 = 1{,}9 \\ I_2 \cdot 0{,}1 + (I_1 + I_2)\cdot 10 = 1{,}1 \end{cases}$$

$$\begin{cases} 10{,}8I_1 + 10I_2 = 1{,}9 \\ 10{,}1I_2 + 10I_1 = 1{,}1 \end{cases} \rightarrow I_1 = 0{,}92\,A,\ I_2 = -0{,}8\,A,\ I = I_1 + I_2 = 1{,}2\,A$$

48. Rasmda tasvirlangan sxemadagi barcha qarshiliklardan o'tuvchi toklarni toping. $\varepsilon_1 = 1{,}5V,\ \varepsilon_2 = 1{,}8\ \ V, R_1 = R_2 = R_3 = R_4 = 1k\Omega,\ r_1 = 0, r_2 = 0$



Kirxgofning birinchi qoidasini qo'llab quyidagi tenglamani yozamiz

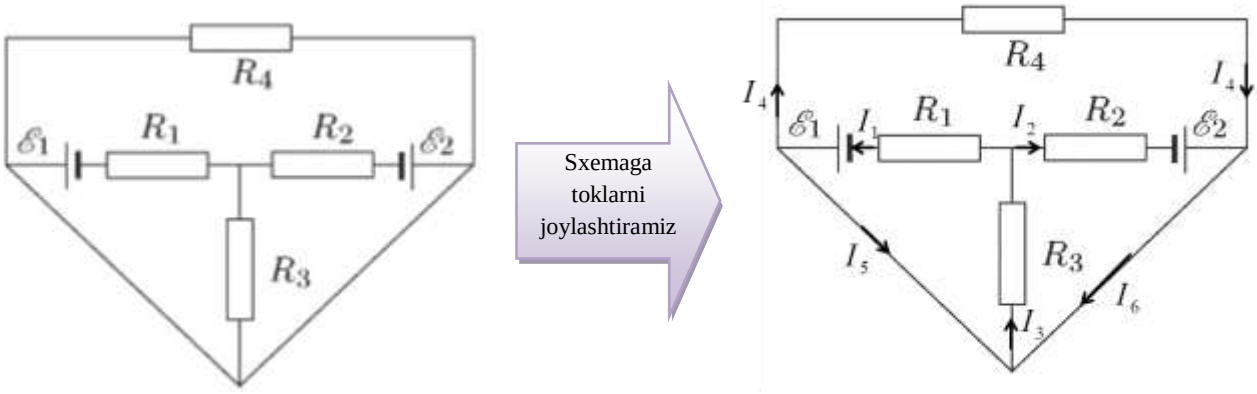
$$\begin{aligned} I_1 &= I_2 + I_3 \\ I_6 &= I_3 + I_5 \\ I_4 &= I_1 + I_5 \\ I_4 &= I_2 + I_6 \end{aligned} \qquad (1)$$

Kirxgofning ikkinchi qoidasidan foydalanib berk konturlar uchun tegishli tenglama tuzamiz

$$\begin{aligned} I_1R_1 + I_3R_3 &= \varepsilon_1 \\ I_2R_2 - I_3R_3 &= \varepsilon_2 \\ I_1R_1 + I_2R_2 + I_4R_4 &= \varepsilon_1 + \varepsilon_2 \end{aligned} \qquad (2)$$

(1) va (2) tenglamalarni soddalashtirib quyidagi natijalarga erishamiz

49. Rasmda tasvirlangan sxemadagi barcha qarshiliklardan o'tuvchi toklarni toping. $\varepsilon_1 = 4V,\ \varepsilon_2 = 8\ V, R_1 = R_2 = 2k\Omega, R_3 = 1k\Omega,\ R_4 = 5k\Omega,\ r_1 = 0, r_2 = 0$



Kirxgofning birinchi qoidasini qo'llab quyidagi tenglamani yozamiz

$$I_1 = I_4 + I_5$$
$$I_3 = I_1 + I_2$$
$$I_6 = I_2 + I_4 \qquad (1)$$
$$I_3 = I_5 + I_6$$

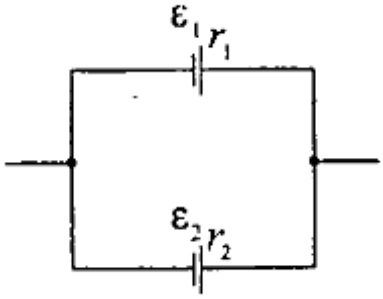
Kirxgofning ikkinchi qoidasidan foydalanib berk konturlar uchun tegishli tenglama tuzamiz

$$I_1R_1 + I_3R_3 = \varepsilon_1$$
$$I_2R_2 + I_3R_3 = \varepsilon_2 \qquad (2)$$
$$I_1R_1 - I_2R_2 + I_4R_4 = \varepsilon_1 - \varepsilon_2$$

(1) va (2) tenglamalarni soddalashtirib quyidagi natijalarga erishamiz

$$I_1 = 0{,}5mA,\ I_2 = 2{,}5mA,\ I_3 = 3mA,\ \ I_4 = 0$$

50. E.Yu.K. lari ε_1=1,4 *V* va ε_2=1,2 *V* hamda ichki qarshiliklari r_1= 0,6 *Om* va r_2=0,4 *Om* bo'lgan ikkita element o'zaro parallel ulangan. Elementlarning qisqichlaridagi potensiallar ayirmasi topilsin.



$\varepsilon_1 > \varepsilon_2$ bo'lganligi uchun birinchi manba razryadlanadi, ikkinchi manba zaryadlanadi.
Zanjirda tarmoqlanish yo'qligi uchun toklar bir xil bo'ladi
To'liq zanjir uchun Om qonunini ikkita hol uchun quyidagicha yozamiz

I-hol razryadlanish uchun

$$\varepsilon_1 = U + I \cdot r_1 \qquad (1)$$

II-hol zaryadlanish uchun

$$U = \varepsilon_2 + I \cdot r_2 \qquad (2)$$

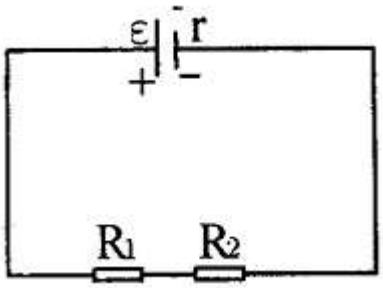
Bu ikkita formulani soddalashtiramiz

$$\begin{cases} \varepsilon_1 = U + I \cdot r_1 \\ U = \varepsilon_2 + I \cdot r_2 \end{cases} \rightarrow \begin{cases} I \cdot r_1 = \varepsilon_1 - U \\ I \cdot r_2 = U - \varepsilon_2 \end{cases}$$

$$\frac{I \cdot r_1}{I \cdot r_2} = \frac{\varepsilon_1 - U}{U - \varepsilon_2} \rightarrow \frac{r_1}{r_2} = \frac{\varepsilon_1 - U}{U - \varepsilon_2} \rightarrow U = \frac{r_1 \cdot \varepsilon_2 + r_2 \cdot \varepsilon_1}{r_1 + r_2} = 1{,}28V$$

ABUTURIYENT GAZETASIDAN OLINGAN MASALALAR

1. Zanjirning ichki qarshiligi 1 Ω, EYuKi 18 V bo'lgan tok manbaidan va qarshiliklari R_1=3 Ω; R_2=5 Ω o'tkazgichlardan tashkil topgan. R_2 o'tkazkichdagi kuchlanish nimaga teng.

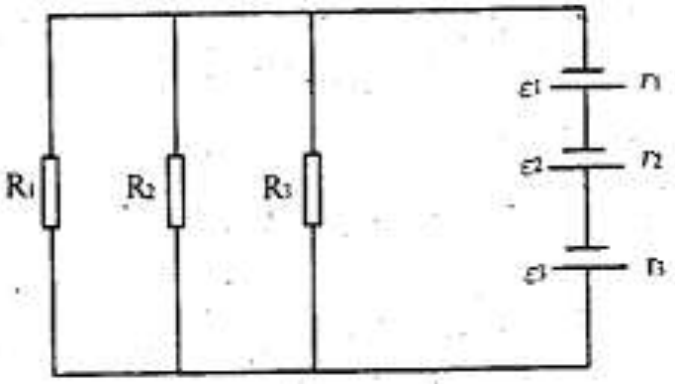


To'liq zanjir uchun Om qonuni formulasidan foydalanamiz

$$I = \frac{\varepsilon}{R_{12} + r} = \frac{\varepsilon}{R_1 + R_2 + r} = \frac{18}{8+1} = 2A$$

$$U_2 = I \cdot R_2 = 2 \cdot 5 = 10V$$

2. Agar EYuKlari mos ravishda 3 V, 4 V, 8 V . Ichki qarshiliklari 1Ω dan, tashqi qarshiliklari mos ravishda 4 Ω, 2 Ω, 4 Ω bo'lsa, tok kuchini toping.



To'liq zanjir uchun Om qonuni formulasidan foydalanamiz

$$I = \frac{\varepsilon}{R + r}$$

Ushbu formulani masala shartiga moslaymiz

$$I = \frac{\varepsilon_{Um}}{R_{Um} + r_{Um}} \qquad (1)$$

$$\varepsilon_{Um} = \varepsilon_1 + \varepsilon_2 + \varepsilon_3 = 15V$$

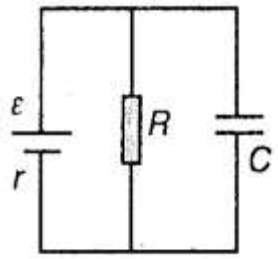
$$\frac{1}{R_{Um}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}; \quad R_{Um} = 1\Omega$$

$$r_{Um} = r_1 + r_2 + r_3 = 3\Omega$$

Natijalarni 1-formulaga etib qo’ysak zang’irdagi umumiy tok kuchi kelib chiqadi

$$I = \frac{15}{1+3} = 3{,}75\,A$$

3. Rasmda keltirilgan zanjirdagi kondensatorning zaryadi nimaga teng?



Kondensator zaryadini quyidagi formula bilan topamiz

$$q = C \cdot U \qquad (1)$$

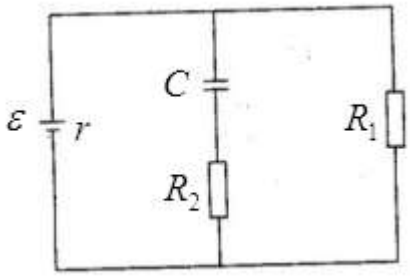
Kondensator tashqi qarshilikka parallel ulanganligi uchun tashqi qarshilikdagi kuchlanish bilan kondensator kuchlanishi bir-xil bo’ladi.

$$U = I \cdot R = \frac{\varepsilon}{R+r} \cdot R \qquad (2)$$

Ikkinchi formulani birinchi formulaga etib qo’ysak quyidagi natijaga ega bo’lamiz.

$$q = \frac{C \cdot \varepsilon \cdot R}{R+r} \qquad (3)$$

4. Rasmda ko’rsatilgan manbaning EYuKi va ichki qarshiligi mos ravishda ε=12 V va r=2 Ω ga teng. R_1=10 Ω va R_2=15 Ω ga teng. Kondensatorning sig’imi 1μF ga teng. Kondensatorda to’plangan zaryadni toping.



Kondensator zaryadini quyidagi formula bilan topamiz

$$q = C \cdot U \qquad (1)$$

Kondensator R_1 qarshilikka parallel ulanganligi uchun R_1 qarshilikdagi kuchlanish bilan kondensator kuchlanishi bir-xil bo’ladi.

$$U = I \cdot R_1 = \frac{\varepsilon}{R_1 + r} \cdot R_1 \qquad (2)$$

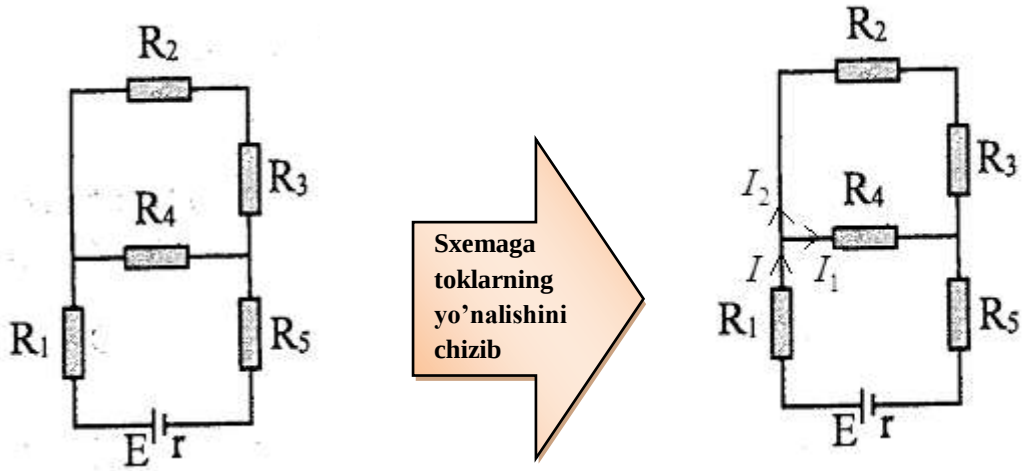
2-formuladan ko'rinadiki R_2 qarshilikni inobatga olmadik chunki R_2 qarshilik kondensatorga ketma-ket ulangan, zanjirning shu qismidan tok o'tmaydi ya'ni kondensator o'zgarmas tokka ulanganda juda qisqa vaqtda zaryadlanadi va zanjirning shu qismini uzib qo'yadi.

Ikkinchi formulani birinchi formulaga etib qo'ysak quyidagi natijaga ega bo'lamiz.

$$q = \frac{C \cdot \varepsilon \cdot R_1}{R_1 + r} = \frac{10^{-6} \cdot 12 \cdot 10}{10 + 2} = 10^{-5} C = 10 \mu C$$

5. R_4 qarshilikdagi kuchlanishni toping.

$E = 26V,\ R_1 = 4\Omega,\ R_2 = 2\Omega,\ R_3 = 4\Omega,\ R_4 = 6\Omega,\ R_5 = r = 3\Omega,$



R_4 qarshilikdagi kuchlanish quyidagi formula bilan topiladi

$$U_4 = I_1 \cdot R_4 \qquad (1)$$

Bu yerdagi I_1 tarmoqlangan qismdagi tok kuchi I_1 ni topish uchun umumiy tok kuchi I ni to'liq zanjir uchun Om qonunidan foydalanib topamiz

$$I = \frac{E}{R_{Um} + r} \qquad (2)$$

R_{Um} Zanjirning umumiy qarshiligi bo'lib uni quyidagicha hisoblaymiz

$$R_{23} = R_2 + R_3 = 6\Omega; \quad R_{234} = \frac{R_{23} \cdot R_4}{R_{23} + R_4} = \frac{6 \cdot 6}{6 + 6} = 3\Omega$$

$$R_{Um} = R_1 + R_{234} + R_5 = 4 + 3 + 3 = 10\Omega$$

Umumiy qarshilikni 2-formulaga eltib qo'ysak I=2 A tok kuchi kelib chiqadi

Endi Krixgofning 1-qoidasidan va R_{23} bilan R_4 paralellik shartidan foydalanib I_1 tok kuchini topamiz

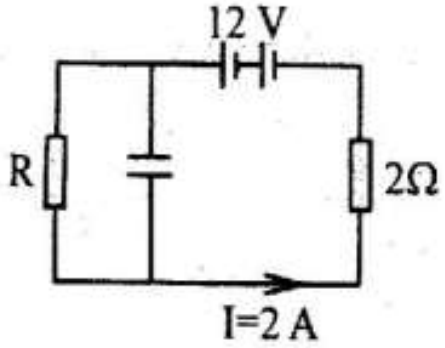
$$I = I_1 + I_2 = 2A$$

$$U_{23} = U_4 \rightarrow I_2(R_2 + R_3) = I_1 R_4 \rightarrow I_2 \cdot 6 = I_1 \cdot 6 \rightarrow I_1 = I_2 = 1A$$

Chiqqan natijani 1-formulaga eltib qo'yamiz

$$U_4 = I_1 \cdot R_4 = 1 \cdot 6 = 6V$$

6. Rasmda berilganlarga ko'ra, kondensatorning quyi qoplamasida 10^{14} ta electron to'plangan bo'lsa, kondensatorning sig'imini toping.



Kondensator sig'imini quyidagi formula bilan topamiz

$$C = \frac{q}{U} \qquad (1)$$

Masala shartida kondensator zaryadi berilgan ya'ni elektronlar sonini bilsak $q=Ne=10^{14} \cdot 1{,}6 \cdot 10^{-19} = 16 \cdot 10^{-6}$ C zaryadni topa olamiz.

Kondensator R qarshilikka parallel ulanganligi uchun R qarshilikdagi kuchlanish bilan kondensator kuchlanishi bir-xil bo'ladi.

$$U = I \cdot R \qquad (2)$$

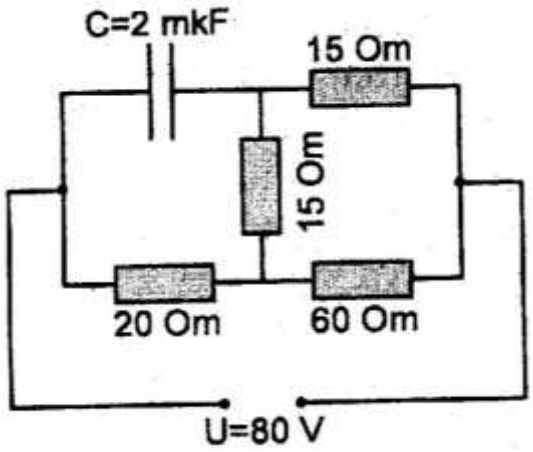
Bizga tok kuchi berilga lekin R qarshilik berilmaga, uni to'liq zanjir uchun Om qonuni formulasidan topib olamiz, ichqi qarshilik berilmaganligi uchun r=o deb hisoblaymiz

$$I = \frac{E}{R_{Um}} = \frac{E}{R+2} \rightarrow R = 4\Omega \qquad (3)$$

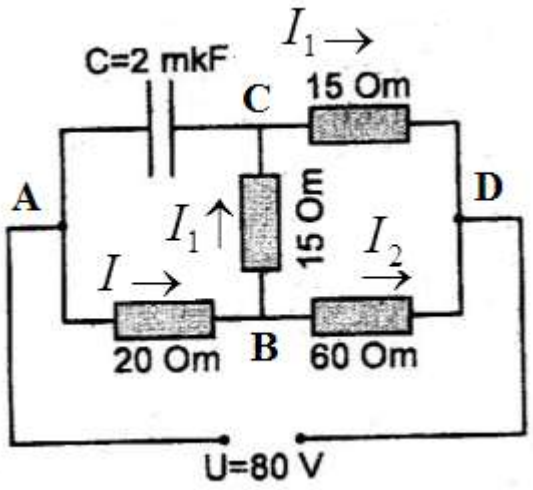
3- va 2- formulalardan U=8 V kelib chiqadi. Chiqqan natijalarni 1-formulaga eltib qo'ysak quyidagi natijaga ega bo'lamiz

$$C = \frac{q}{U} = \frac{16 \cdot 10^{-6}}{8} = 2 \cdot 10^{-6} = 2\,\mu F$$

7. Rasmda ko'rsatilgan sxemadagi kondensator zaryadini toping.



Sxemaga toklarning yo'nalishini chizib chiqamiz



Kondensator zaryadini toppish uchun uning qoplamalari orasidagi potensiallar farqini aniqlash kerak.

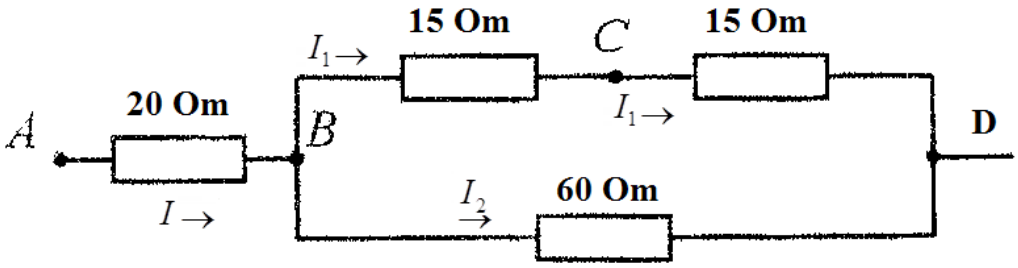
Sxemaga binoan bir tomondan bu potensiallar farqi A va C nuqtalar orasidagi U_{AC} potensiallar farqiga teng. Ikkinchi tomondan u 20 Om va 15 Om qarshiliklardagi U_1 va U_2 kuchlanishlar yig'indisiga teng. Shunday qilib, kondensatorning zaryadi

$$q = C \cdot U_{AC} \qquad (1)$$

$$U_{AC} = U_1 + U_2 \qquad (2)$$

$$U_1 = I \cdot 20, \quad U_2 = I_1 \cdot 15$$

Qarshiliklarni ketma-ket va parallel ulanishidan foydalanish uchun sxemani quyidagi ekvivalent sxema bilan almashtirish mumkin



Bunday zanjirning to'la qarshiligi

$R_{Um} = 20 + \dfrac{(15+15)\cdot 60}{(15+15)+60} = 40\,Om$ ga teng bo'ladi

Berk zanjir uchun Om qonunidan foydalanib umumiy tokni topamiz.

$$I = \frac{U}{R_{Um}} = \frac{80}{40} = 2\,A$$

Endi Krixgofning 1-qoidasidan va qarshiliklarning paralellik shartidan foydalanib I_1 tok kuchini topamiz

$$I = I_1 + I_2 = 2\,A$$

$$U_{23} = U_4 \;\rightarrow\; I_1(15+15) = I_2 \cdot 60 \rightarrow I_1 \cdot 30 = I_2 \cdot 60 \;\rightarrow I_1 = 2I_2$$

$$I_1 + \frac{I_1}{2} = 2\,A \rightarrow I_1 = \frac{4}{3}\,A$$

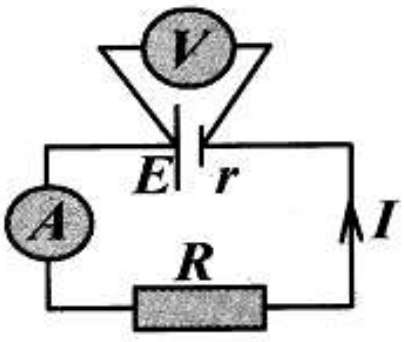
Natijalarni 2- formulaga etib qo'ysak

$$U_1 = I \cdot 20 = 2 \cdot 20 = 40V\,, \quad U_2 = I_1 \cdot 15 = \frac{4}{3} \cdot 15 = 20V$$

$$U_{AC} = U_1 + U_2 = 40 + 20 = 60V$$

$$q = C \cdot U_{AC} = 2 \cdot 10^{-6} \cdot 60 = 120 \cdot 10^{-6}\,C = 120\,\mu C$$

8. E=40 V, I=4 A va voltimetrning ko'rsatishi 30 V bo'lsa, manbaning ichki qarshiligini toping.



Manbaga ulangan voltimetr tashqi qarshilikdagi kuchlanish tushuvini o'lchaydi Zanjirning bir qismi uchun va to'liq zanjir uchun Om qonunidan foydalanib quyidagi formulalarni yozamiz.

$$I = \frac{U}{R} \qquad (1)$$

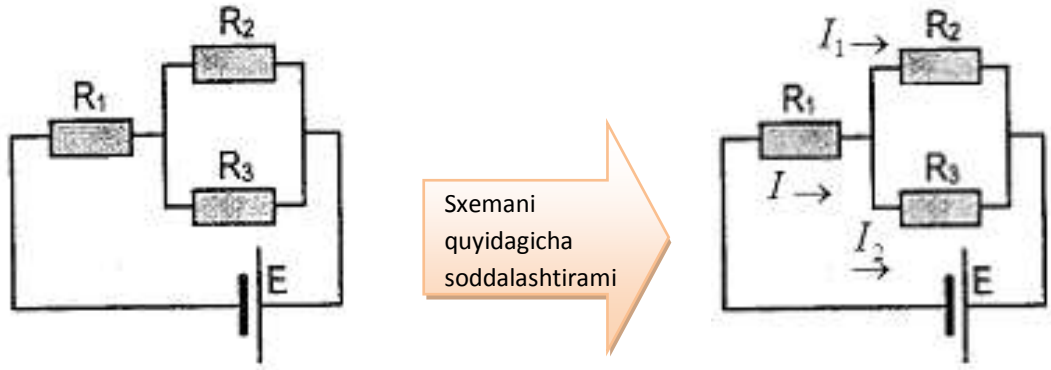
$$I = \frac{E}{R+r} \qquad (2)$$

1-formuladan R ni topib 2-tenglamaga keltirib qo'yamiz

$$I = \frac{U}{R}; \qquad R = \frac{U}{I} = \frac{30}{4} = 7{,}5\Omega$$

$$I = \frac{E}{R+r}, \quad \rightarrow \quad 4 = \frac{40}{7{,}5+r} \rightarrow r = 2{,}5\Omega$$

9. Zanjirda $R_1 = 18\Omega, R_2 = 18\Omega, R_3 = 6\Omega,\ E = 7{,}5V$ **, manbaning ichki qarshiligi nolga teng. R_3 qarshilikdan o'tayotgan tok kuchini toping.**



To'liq zanjir uchun Om qonuni formulasidan umumiy tok kuchini topamiz

$$I = \frac{E}{R_{Um} + r} \qquad (1)$$

$$R_{Um} = \frac{R_2 \cdot R_3}{R_2 + R_3} + R_1 = 22{,}5\Omega; \qquad I = \frac{E}{R_{Um} + r} = \frac{7{,}5}{22{,}5} = \frac{1}{3}A$$

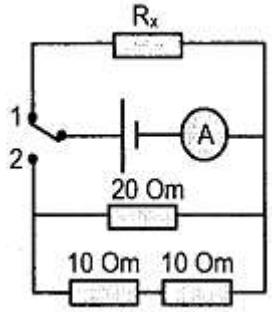
Endi Krixgofning 1-qoidasidan va R_2,R_3 qarshiliklarning paralellik shartidan foydalanib I_2 tok kuchini topamiz

$$I = I_1 + I_2 = \frac{1}{3}A$$

$$U_2 = U_3 \ \rightarrow \ I_1 \cdot R_2 = I_2 \cdot R_3 \rightarrow I_1 \cdot 18 = I_2 \cdot 6 \ \rightarrow 3I_1 = I_2$$

$$I_1 + 3I_1 = \frac{1}{3}A \rightarrow I_1 = \frac{1}{12}A; \qquad I_2 = 3 \cdot \frac{1}{12} = \frac{1}{4}A$$

10. Zanjirdagi kalit 2-holatga o'tkazilganida ideal ampermetrning ko'rsatishi 2 marta kamaydi. R_x ning qiymatini toping.



Ampermetr zanjirning tarmoqlanmagan qismiga ulanganligi uchun u umumiy tok kuchini ko'rsatadi. Har bir hol uchun tenglama tuzamiz

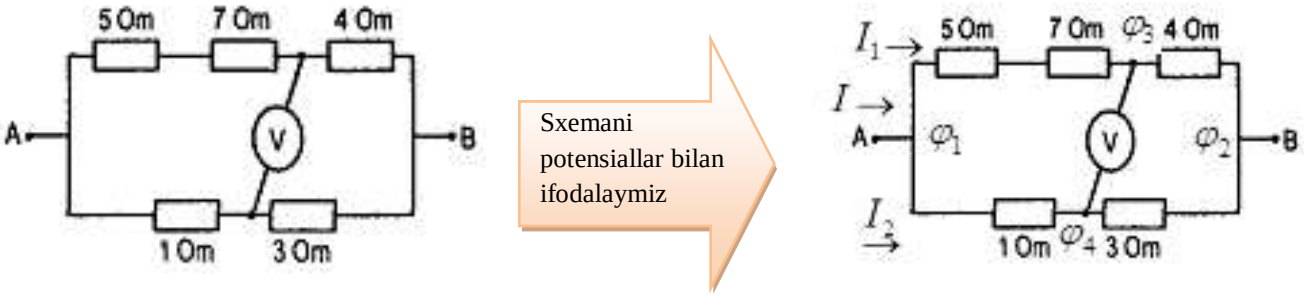
$$1-hol; \quad I_1 = \frac{E}{R_x}$$

$$2-hol; \quad I_2 = \frac{E}{R_{Um}}; \quad R_{Um} = \frac{20 \cdot 20}{20+20} = 10\,Om$$

Masala shartiga ko'ra $I_1/I_2=2$ tok kuchilarni keltirib o'rniga qo'ysak

$$\frac{I_1}{I_2} = \frac{R_{Um}}{R_x} = 2, \rightarrow \quad R_x = \frac{R_{Um}}{2} = 5\,Om$$

11. A va B nuqtalar orasidagi kuchlanish 32 V. Voltimetrning ko'rsatishini toping.



Zanjirning umumiy tok kuchini va har ikkala tarmoqdagi tok kuchini topamiz.

$$I = \frac{U}{R_{Um}} = \frac{32}{3{,}2} = 10\,A$$

$$I = I_1 + I_2 = 10\,A$$

$$U_1 = U_2 \rightarrow I_1(5+7+4) = I_2 \cdot (1+3) \rightarrow I_1 \cdot 16 = I_2 \cdot 4 \rightarrow 4I_1 = I_2$$

$$I_1 + 4I_1 = 10\,A \rightarrow I_1 = 2\,A; \quad I_2 = 8\,A$$

Kuchlanish tushuvlarini potensiallar ayirmasi bilan ifodalaymiz

$\varphi_1 - \varphi_2 = U = 32V$ (1)

$\varphi_1 - \varphi_3 = I_1 \cdot (5+7) = 24V$ (2)

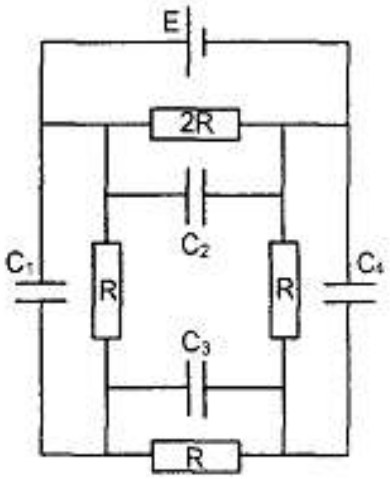
$\varphi_1 - \varphi_4 = I_2 \cdot 1 = 8V$ (3)

$\varphi_3 - \varphi_2 = I_1 \cdot 4 = 8V$ (4)

$\varphi_4 - \varphi_2 = I_2 \cdot 3 = 24V$ (5)

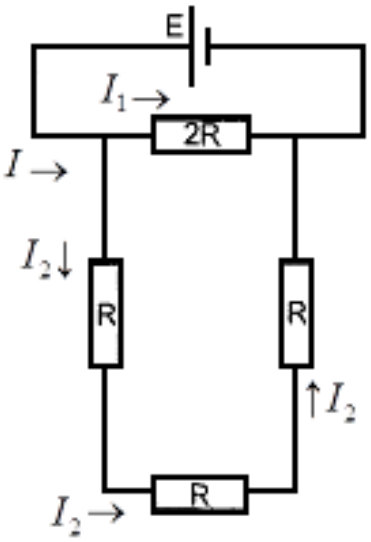
Voltimetrning ko'rsatishi $U_V = \varphi_4 - \varphi_3$ yuqoridagi 4-5-formulalarni soddalashtirsak $U_V = \varphi_4 - \varphi_3 = 16V$ natija kelib chiqadi

12. Rasmda ko'rsatilgan sxemada C_1=12mkF va barcha kondensatorlar zaryadi bir xil. C_2, C_3 va C_4 larning qiymati mkF larda topib, $C_2(C_3 \cdot C_4)^{0,5}$ ifodaning son qiymatini toping.



1-rasm

O'zgarmas tok manbayiga kondensatorlar ulansa ular jada tez zaryadlanadilar va manbadan uziladilar, kondensator ulangan tarmoqdan tok o'tmaydi faqatgina kondensator o'ziga parallel ulangan qarshilik kuchlanishicha kuchlanish bilan zaryadlanadi.Shuning uchun umumiy tok kuchini va har-bir qarshilikka to'g'ri keladigan kuchlanishni topish uchun sxemadan kondensatorlarni vaqtincha olib tashlaymiz va toklarning yo'nalishini qo'yib chiqamiz.



$$I = \frac{E}{R_{Um} + r} \qquad (1)$$

$$r = 0; \qquad R_{Um} = \frac{2R \cdot 3R}{2R + 3R} = \frac{6R}{5}; \rightarrow I = \frac{E}{\frac{6}{5}R +} = \frac{5E}{6R}$$

Endi Krixgofning 1-qoidasidan va qarshiliklarning paralellik shartidan foydalanib tok kuchlarini topamiz

$$I = I_1 + I_2$$

$$U_2 = U_3 \ \rightarrow \ I_1 \cdot 2R = I_2 \cdot 3R \rightarrow 2I_1 = 3I_2 \ \rightarrow I_1 = 1{,}5I_2$$

$$1{,}5I_2 + I_2 = I \rightarrow I_2 = \frac{I}{2{,}5}; \quad I_1 = 1{,}5 \cdot \frac{I}{2{,}5} = \frac{3I}{5}$$

1-rasmdan ko’rinib turibdiki C_1 kondensator R qarshilikka parallel ulangan shuning uchun

$$q_1 = C_1 \cdot U_1 = C_1 \cdot (I_2 \cdot R) = C_1 \cdot \frac{I}{2{,}5} \cdot R$$

C_2 kondensator 2R qarshilikka parallel ulangan shuning uchun

$$q_2 = C_2 \cdot U_2 = C_2 \cdot (I_1 \cdot 2R) = C_2 \cdot \frac{3I}{5} \cdot 2R = C_2 \cdot \frac{6I}{5} \cdot R$$

C_3 va C_4 kondensator R qarshilikka parallel ulangan shuning uchun

$$q_3 = C_3 \cdot U_3 = C_3 \cdot (I_2 \cdot R) = C_3 \cdot \frac{I}{2{,}5} \cdot R$$

$$q_4 = C_4 \cdot U_4 = C_4 \cdot (I_2 \cdot R) = C_4 \cdot \frac{I}{2{,}5} \cdot R$$

Masala shartiga binoan barcha kondensatorlardagi zaryad tengligidan quyidagi natijalar kelib chiqadi.

$$q_1 = q_2$$

$$C_1 \cdot \frac{I}{2{,}5} \cdot R = C_2 \cdot \frac{6I}{5} \cdot R \rightarrow C_2 = \frac{C_1}{3} = \frac{12}{3} = 4\,mkF$$

$$q_1 = q_3$$

$$C_1 \cdot \frac{I}{2{,}5} \cdot R = C_3 \cdot \frac{I}{2{,}5} \cdot R \rightarrow C_2 = C_3 = 12\,mkF$$

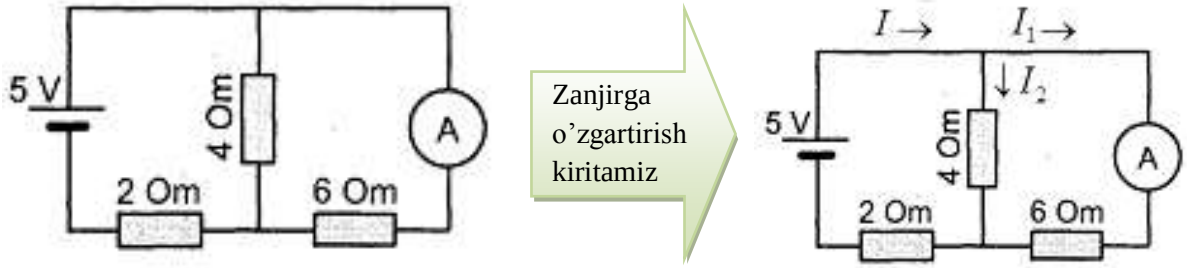
$$q_1 = q_4$$

$$C_1 \cdot \frac{I}{2{,}5} \cdot R = C_4 \cdot \frac{I}{2{,}5} \cdot R \rightarrow C_2 = C_4 = 12\,mkF$$

Barcha kondensatorlar sig'imi aniqlandi endi masala shartida aytilgan ifodani son qiymatini topamiz.

$$C_2(C_3 \cdot C_4)^{0,5} = 4 \cdot (12 \cdot 12)^{0,5} = 4 \cdot 12 = 48$$

13. Rasmda ko'rsatilgan zanjirda ampermtr bilan manbaning o'rni almashtirilsa, ampermetrning ko'rsatishi qanday o'zgaradi.



Rasmdan ko'rinib turibdiki ampermetr tarmoqlangan tok kuchini I_1 ni o'lchaydi. Zanjirning umumiy tok kuchini va har ikkala tarmoqdagi tok kuchini topamiz.

$$R_{12} = \frac{4 \cdot 6}{4+6} = 2{,}4\Omega; \quad R_{Um} = R_{12} + R_3 = 4{,}4\Omega; \quad r = 0 \quad I = \frac{\varepsilon}{R_{Um} + r} = \frac{5}{4{,}4}A$$

$$I = I_1 + I_2 = \frac{5}{4{,}4}A; \quad U_1 = U_2 \rightarrow I_1 \cdot 6 = I_2 \cdot 4 \rightarrow 1{,}5I_1 = I_2$$

$$I_1 + 1{,}5I_1 = \frac{5}{4{,}4}A \rightarrow I_1 = \frac{2}{4{,}4}A;$$

I-holda zanjirdagi ampermetr I_1 tokni ko'rsatadi.

Endi ampermetr va manbaning joyini almashtiramiz

Rasmdan ko'rinib turibdiki ampermetr I_1 tok kuchini o'lchaydi.

Zanjirning umumiy tok kuchini va har ikkala tarmoqdagi tok kuchini topamiz.

$$R_{12}=\frac{4\cdot 2}{4+2}=\frac{8}{6}\Omega;\quad R_{Um}=R_{12}+R_3=\frac{8}{6}+6=\frac{44}{6}\Omega;\quad r=0\quad I=\frac{\varepsilon}{R_{Um}+r}=\frac{5}{\frac{44}{6}}=\frac{30}{44}=\frac{3}{4{,}4}A$$

$$I=I_1+I_2=\frac{3}{4{,}4}A;\qquad U_1=U_2\ \rightarrow\ I_1\cdot 2=I_2\cdot 4\rightarrow I_1=2I_2$$

$$I_1+0{,}5I_1=\frac{3}{4{,}4}A\rightarrow I_1=\frac{2}{4{,}4}A;$$

II-holda ham zanjirdagi ampermetr ko'rsatgichi o'zgarmadi.

14. Ampermetr qanday tok kuchini ko'rsatadi?

$\varepsilon_1=10V;\ r_1=1\Omega;\ \varepsilon_2=3V;\ r_2=1\Omega;\ R_1=3\Omega;\ R_2=4\Omega;$

Kirxgofning birinchi qoidasini qo'llab quyidagi tenglamani yozamiz

$$I=I_1+I_2 \qquad (1)$$

Kirxgofning ikkinchi qoidasidan foydalanib konturlar uchun tegishli tenglama tuzamiz

$$I_1r_1+IR_1+I_1R_2=\varepsilon_1,\quad I_2r_2+IR_1=\varepsilon_2 \qquad (2)$$

1-tenglamadan I ni 2-tenglamaga keltirib qo'ysak

$$\begin{cases} I_1 r_1 + (I_1 + I_2)R_1 + I_1 R_2 = \varepsilon_1 \\ I_2 r_2 + (I_1 + I_2)R_1 = \varepsilon_2 \end{cases}$$

$$\begin{cases} I_1 \cdot 1 + (I_1 + I_2)\cdot 3 + I_1 \cdot 4 = 10 \\ I_2 \cdot 1 + (I_1 + I_2)\cdot 3 = 3 \end{cases}$$

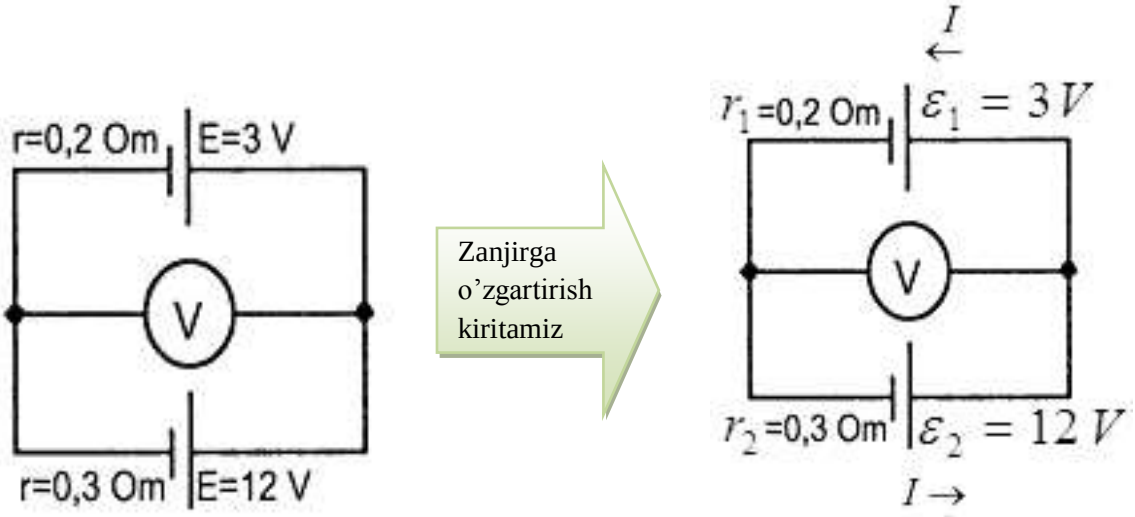
$$\begin{cases} 8I_1 + 3I_2 = 10 \\ 4I_2 + 3I_1 = 3 \end{cases}$$

$$I_1 = \frac{31}{23}; \qquad I_2 = -\frac{6}{23}; \quad I = I_1 + I_2 = 1{,}086\,A$$

Zanjirdagi ampermetr I tok kuchini ko'rsatadi. I_2 tok kuchi manfiy chiqishiga sabab biz tanlagan yo'nalish (Soat sitrelkasining yo'nalishi)ga qarama-qarshi yo'nalishda harakatlanar ekan.

15. Zanjirda berilgan ma'lumotlardan foydalanib, voltimetrning ko'rsatishini toping.

I-yo'l



$\varepsilon_2 > \varepsilon_1$ bo'lganligi uchun birinchi manba zaryadlanadi, ikkinchi manba razryadlanadi(zaryadsizlanadi).

Zanjirda tarmoqlanish yo'qligi uchun toklar birxil bo'ladi

To'liq zanjir uchun Om qonunini ikkita hol uchun quyidagicha yozamiz

I-hol razryadlanish uchun

$$\varepsilon_2 = U + I \cdot r_2 \qquad (1)$$

II-hol zaryadlanish uchun

$$U = \varepsilon_1 + I \cdot r_1 \qquad (2)$$

Bu ikkita formulani soddalashtiramiz

$$\begin{cases}\varepsilon_2 = U + I\cdot r_2 \\ U = \varepsilon_1 + I\cdot r_1\end{cases} \rightarrow \begin{cases}I\cdot r_2 = \varepsilon_2 - U \\ I\cdot r_1 = U - \varepsilon_1\end{cases}$$

$$\frac{I\cdot r_2}{I\cdot r_1} = \frac{\varepsilon_2 - U}{U - \varepsilon_1} \rightarrow \frac{r_2}{r_1} = \frac{\varepsilon_2 - U}{U - \varepsilon_1} \rightarrow U = \frac{r_1\cdot\varepsilon_2 + r_2\cdot\varepsilon_1}{r_1 + r_2} = 6{,}6V$$

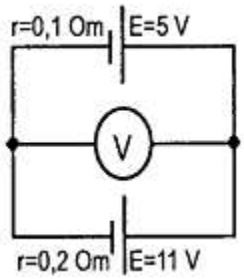
II-yo'l

Manbalarning mos qutblari ulanganligidan ularni parallel desak umumiy tok kuchi(qisqa tutashuv toklari) quyidagicha bo'ladi

$$I_{Um} = I_1 + I_2$$

$$\frac{\varepsilon_{Um}}{r_{Um}} = \frac{\varepsilon_1}{r_1} + \frac{\varepsilon_2}{r_2};\quad r_{Um} = \frac{r_1\cdot r_2}{r_1 + r_2}\qquad \varepsilon_{Um} = \frac{r_1\cdot\varepsilon_2 + r_2\cdot\varepsilon_1}{r_1 + r_2} = 6{,}6V$$

16. Zanjirda berilgan ma'lumotlardan foydalanib, voltimetrning ko'rsatishini toping. $r_1 = 0{,}1\Omega$, $\varepsilon_1 = 5V$, $r_2 = 0{,}2\Omega$, $\varepsilon_2 = 11V$,



I-yo'l

$\varepsilon_2 > \varepsilon_1$ bo'lganligi uchun birinchi manba zaryadlanadi, ikkinchi manba razryadlanadi (zaryadsizlanadi).Zanjirda tarmoqlanish yo'qligi uchun toklar bir xil bo'ladi

To'liq zanjir uchun Om qonunini ikkita hol uchun quyidagicha yozamiz

I-hol razryadlanish uchun

$$\varepsilon_2 = U + I\cdot r_2 \qquad (1)$$

II-hol zaryadlanish uchun

$$U = \varepsilon_1 + I\cdot r_1 \qquad (2)$$

Bu ikkita formulani soddalashtiramiz

$$\begin{cases}\varepsilon_2 = U + I\cdot r_2 \\ U = \varepsilon_1 + I\cdot r_1\end{cases} \rightarrow \begin{cases}I\cdot r_2 = \varepsilon_2 - U \\ I\cdot r_1 = U - \varepsilon_1\end{cases}$$

$$\frac{I\cdot r_2}{I\cdot r_1} = \frac{\varepsilon_2 - U}{U - \varepsilon_1} \rightarrow \frac{r_2}{r_1} = \frac{\varepsilon_2 - U}{U - \varepsilon_1} \rightarrow U = \frac{r_1\cdot\varepsilon_2 + r_2\cdot\varepsilon_1}{r_1 + r_2} = 7V$$

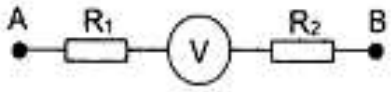
II-yo'l

Manbalarning mos qutblari ulanganligidan ularni parallel desak umumiy tok kuchi(qisqa tutashuv toklari) quyidagicha bo'ladi

$$I_{Um} = I_1 + I_2$$

$$\frac{\varepsilon_{Um}}{r_{Um}} = \frac{\varepsilon_1}{r_1} + \frac{\varepsilon_2}{r_2}; \quad r_{Um} = \frac{r_1 \cdot r_2}{r_1 + r_2} \qquad \varepsilon_{Um} = \frac{r_1 \cdot \varepsilon_2 + r_2 \cdot \varepsilon_1}{r_1 + r_2} = 7V$$

17. Zanjirning AB qismidagi kuchlanish 24 V, R_1=4 Ω va R_2=46 Ω . Ularning orasiga qarshiligi 110 Ω bo'lgan voltimetr ulangan. Uning ko'rsatishini toping.



Sxemada 3 ta qarshilik ketma-ket ulanganda umumiy kuchlanish,qarshilik vat ok kuchilar quyidagiga tengligidan voltimetr ko'rsatgichini aniqlaymiz.

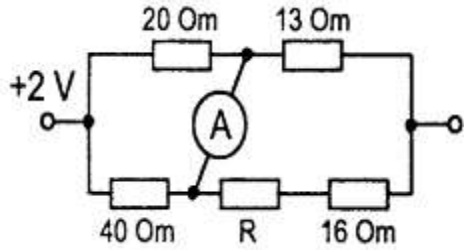
$$U_{AB} = U_1 + U_{Vol} + U_3 = 24V$$

$$R_{Um} = R_1 + R_{Vol} + R_3 = 160\,\Omega$$

$$I_{Um} = I_1 = I_{Vol} = I_3 = \frac{U_{AB}}{R_{Um}} = \frac{24}{160} = 0{,}15\,A$$

$$U_{Vol} = I_{Vol} \cdot R_{Vol} = 0{,}15 \cdot 110 = 16{,}5V$$

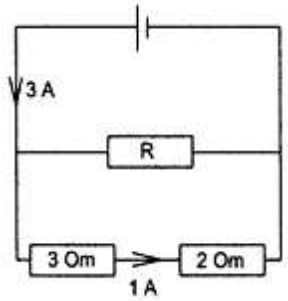
18. Rasmda ko'rsatilgan sxemada ampermetrning ko'rsatishi nol bo'lishi uchun R qarshilik qanday bo'lishi kerak



Ampermetr ulangan nuqtalardagi potensiallar farqi nolga teng bo'lsa ampermetr ulangan simdan tok o'tmaydi buning uchun quyidagi tenglik o'rtinli bo'lishi kerak

$$\frac{R_1}{R_2} = \frac{R_3}{R_4} \quad \rightarrow \quad \frac{20}{40} = \frac{13}{R+16} \quad \rightarrow R = 10\,om$$

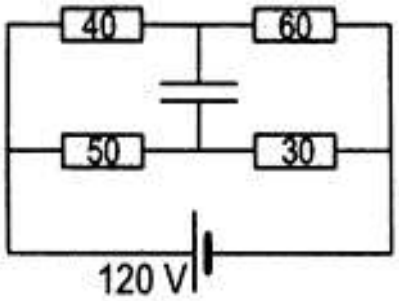
19. Rasmda berilgan ma'lumotlardan foydalanib, R rezistorning qarshiligini toping.



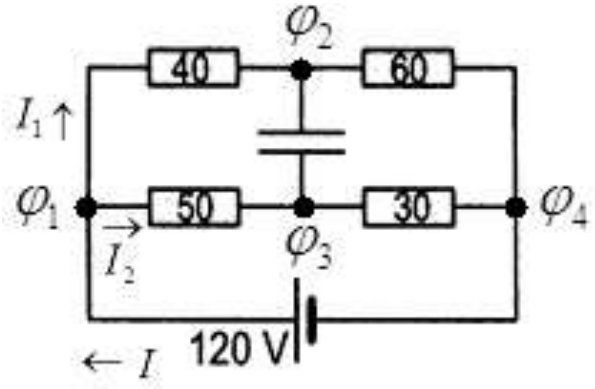
Krixgofning I-qoidasi va qarshiliklar paralelligidan quyidagi formulalarni yozamiz

$$3 = I + 1 \;\rightarrow\; I = 2\,A$$
$$U_1 = U_2 \;\rightarrow\; I \cdot R = 1 \cdot (3+2) \rightarrow 2 \cdot R = 1 \cdot 5 \;\rightarrow R = 2{,}5\,om$$

20. Agar rasmda tasvirlangan elektr zanjirdagi kondensatorning qoplamalar orasidagi masofa 3 mm bo'lsa, qoplamalar orasidagi elektr maydon kuchlanganligini toping.



Elektr maydon kuchlanganligini topish uchun bizga kondensator qoplamalar orasidagi potensiallar farqini bilishimiz kerak(φ_2- φ_3), buning uchun sxemani quyidagi ko'rinishda ifodalaymiz.



Endi Krixgofning 1-qoidasidan va qarshiliklarning paralellik shartidan(R_{12}//R_{34}) foydalanib tok kuchlarini topamiz

$$I = I_1 + I_2 \qquad R_{Um} = \frac{R_{12} \cdot R_{34}}{R_{12} + R_{34}} = \frac{100 \cdot 80}{100 + 80} = \frac{8000}{180} = \frac{400}{9}\,\Omega$$

$$I = \frac{U}{R_{Um}} = \frac{120}{\frac{400}{9}} = \frac{120 \cdot 9}{400} = \frac{1080}{400} = 2{,}7\,A$$

$$U_{12} = U_{34} \;\rightarrow\; U_1 + U_2 = U_3 + U_4$$
$$I_1 \cdot 40 + I_1 \cdot 60 = I_2 \cdot 50 + I_2 \cdot 30 \rightarrow\; 100 I_1 = 80 I_2 \;\rightarrow I_1 = 0{,}8 I_2$$
$$0{,}8 I_2 + I_2 = 2{,}7\,A \rightarrow I_2 = 1{,}5\,A; \quad I_1 = 1{,}2\,A$$

Yuqoridagi natijalardan foydalanib har-bir qarshilikdagi kuchlanish tushuvlarini topamiz.

$$U_1 = I_1 \cdot 40 = 48V \qquad U_2 = I_1 \cdot 60 = 72V$$
$$U_3 = I_2 \cdot 50 = 75V \qquad U_4 = I_4 \cdot 30 = 45V$$

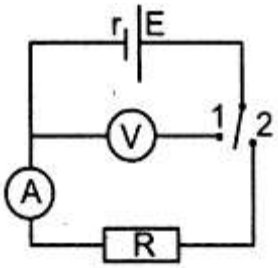
Kuchlanish tushuvlarini potensiallar farqi bilan ifodalaymiz

$$\begin{cases} \varphi_1 - \varphi_2 = U_1 = 48V \\ \varphi_2 - \varphi_4 = U_2 = 72V \\ \varphi_1 - \varphi_3 = U_3 = 75V \\ \varphi_3 - \varphi_4 = U_4 = 45V \end{cases}$$ Sistemani soddalashtirib $\varphi_2 - \varphi_3 = 27\,V$ kelib chiqadi

Kondensatorning elektr maydon kuchlanganligini quyidagicha topamiz

$$E = \frac{U}{d} = \frac{\varphi_2 - \varphi_3}{d} = \frac{27}{3 \cdot 10^{-3}} = 9 \cdot 10^3 V/m = 9kV/m$$

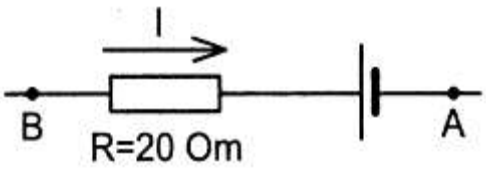
21. Ulagichlar birinchi holatida voltimetr 2 V ni ko'rsatadi, ikkinchi holatida esa ampermetr 0,8 A ni ko'rsatadi. Agar R=2 Om bo'lsa, manbaning ichki qarshiligini toping.



Birinchi holatda manbaga tashqi qarshilik ulanmagani uchun voltimetr manbaning EYuK ni ko'rsatadi. Ikkinchi holatda ampermetr umumiy tok kuchini ko'rsatadi

$$I = \frac{\varepsilon}{R+r}; \qquad 0{,}8 = \frac{2}{2+r} \rightarrow r = 0{,}5\,Om$$

22. Rasmda ko'rsatilgan zanjirning bir qismadagi EYuK i 8 V ga teng (r=0) va $\Delta\varphi_{AB} = 18V$ bo'lsa , 5 minut ichida rezistordan qancha issiqlik ajrab chiqadi?



Rasmdan ko'rinib turibdiki manba AB potensiallar farqi bilan zaryadlanmoqda To'liq zanjir uchun Om qonunini zaryadlanish uchun quyidagicha yoziladi

$$\Delta\varphi_{AB} = \varepsilon + I \cdot (R+r)$$

Bu tenglamadan I ni topamiz

$$18 = 8 + I \cdot (20+0) \rightarrow \; I = 0{,}5\,A$$

Topilgan natijalarni Jou-Lens qonuniga etib qo'yamiz

$$Q = I^2 \cdot R \cdot t = (0{,}5)^2 \cdot 20 \cdot 300 = 1500\,J$$

23. Rasmda ko'rsatilgan elektr zanjirda E_1=57 V va E_2=32 V. Agar r_1/r_2=1,5 bo'lsa, A va B nuqtalar orasidagi potensiallar farqini toping.

I-yo'l

$\varepsilon_2 < \varepsilon_1$ bo'lganligi uchun ikkinchi manba zaryadlanadi, birinchi manba razryadlanadi(zaryadsizlanadi).

Zanjirda tarmoqlanish yo'qligi uchun toklar bir-xil bo'ladi

To'liq zanjir uchun Om qonunini ikkita hol uchun quyidagicha yozamiz

I-hol razryadlanish uchun

$$\varepsilon_1 = U + I \cdot r_1 \qquad (1)$$

II-hol zaryadlanish uchun

$$U = \varepsilon_2 + I \cdot r_2 \qquad (2)$$

Bu ikkita formulani soddalashtiramiz

$$\begin{cases} \varepsilon_1 = U + I \cdot r_1 \\ U = \varepsilon_2 + I \cdot r_2 \end{cases} \rightarrow \begin{cases} I \cdot r_1 = \varepsilon_1 - U \\ I \cdot r_2 = U - \varepsilon_2 \end{cases}$$

$$\frac{I \cdot r_1}{I \cdot r_2} = \frac{\varepsilon_1 - U}{U - \varepsilon_2} \rightarrow \frac{r_1}{r_2} = \frac{\varepsilon_1 - U}{U - \varepsilon_2} \rightarrow U = \frac{r_1 \cdot \varepsilon_2 + r_2 \cdot \varepsilon_1}{r_1 + r_2} = 42V$$

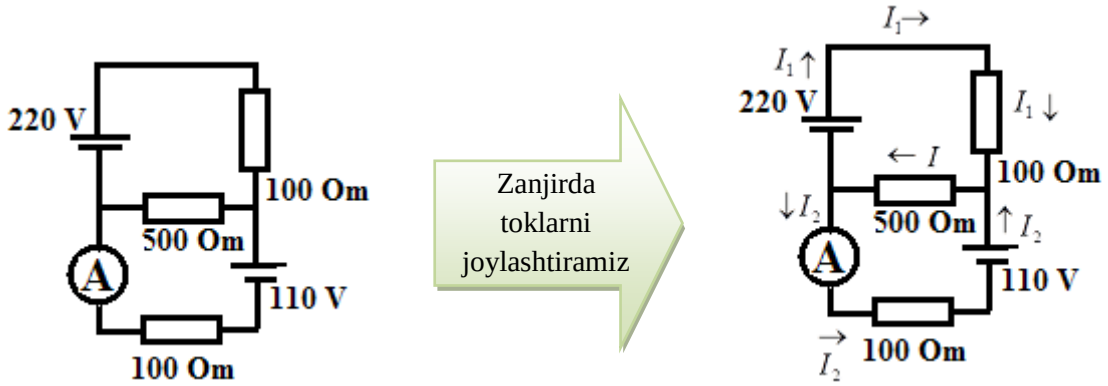
II-yo'l

Manbalarning mos qutblari ulanganligidan ularni parallel desak umumiy tok kuchi(qisqa tutashuv toklari) quyidagicha bo'ladi

$$I_{Um} = I_1 + I_2$$

$$\frac{\varepsilon_{Um}}{r_{Um}} = \frac{\varepsilon_1}{r_1} + \frac{\varepsilon_2}{r_2}; \quad r_{Um} = \frac{r_1 \cdot r_2}{r_1 + r_2} \quad \varepsilon_{Um} = \frac{r_1 \cdot \varepsilon_2 + r_2 \cdot \varepsilon_1}{r_1 + r_2} = 42V$$

24. Rasmda berilgan ma'lumotlardan foydalanib, ampermetrning ko'rsatishini toping. $\varepsilon_1 = 220V, \varepsilon_2 = 110V,\ R_1 = 100\,Om, R_2 = 100\,Om, R_3 = 500\,Om, r_1 = r_2 = 0$



Kirxgofning birinchi qoidasini qo'llab quyidagi tenglamani yozamiz

$$I = I_1 + I_2 \qquad (1)$$

Kirxgofning ikkinchi qoidasidan foydalanib berk konturlar uchun tegishli tenglama tuzamiz

$$I_1 r_1 + I_1 R_1 + I R_3 = \varepsilon_1, \quad I_2 r_2 + I R_3 + I_2 R_2 = \varepsilon_2 \qquad (2)$$

1-tenglamadan I ni 2-tenglamaga keltirib qo'ysak

$$\begin{cases} I_1 r_1 + I_1 R_1 + (I_1 + I_2) R_3 = \varepsilon_1 \\ I_2 r_2 + (I_1 + I_2) R_3 + I_2 R_2 = \varepsilon_2 \end{cases} \rightarrow \begin{cases} I_1 \cdot 100 + (I_1 + I_2) \cdot 500 = 220 \\ (I_1 + I_2) \cdot 500 + I_2 \cdot 100 = 110 \end{cases}$$

$$\begin{cases} 600 I_1 + 500 I_2 = 220 \\ 500 I_1 + 600 I_2 = 110 \end{cases} \rightarrow \quad I_1 = 0{,}7\,A, \quad I_2 = -0{,}4\,A$$

I_2 tok manfiy chiqishiga sabab I_2 tok yo'nalishi biz tanlagan yo'nalishga teskari harakatlanar ekan, lekin baribir Ampermter I_2 tokni o'lchaydi.

25. Rasmda berilgan ma’lumotlardan foydalanib, 1 minut ichida rezistordan ajraladigan issiqlik energiyasini hisoblang.

$$\varepsilon_1 = 10V, \varepsilon_2 = 6V,\ R = 10Om,\ r_1 = 5Om,\ r_2 = 2\ Om,\quad t = 60s$$

Kirxgofning birinchi qoidasini qo’llab quyidagi tenglamani yozamiz

$$I = I_1 - I_2 \qquad (1)$$

Kirxgofning ikkinchi qoidasidan foydalanib berk konturlar uchun tegishli tenglama tuzamiz

$$I_1 r_1 + IR = \varepsilon_1, \quad I_2 r_2 + IR = \varepsilon_2 \qquad (2)$$

1-tenglamadan I ni 2-tenglamaga keltirib qo’ysak

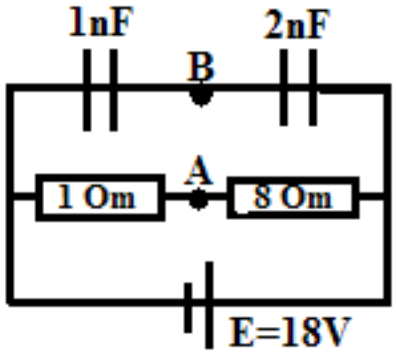
$$\begin{cases} I_1 r_1 + (I_1 - I_2)R = \varepsilon_1 \\ I_2 r_2 + (I_1 - I_2)R = \varepsilon_2 \end{cases} \rightarrow \begin{cases} I_1 \cdot 5 + (I_1 - I_2)\cdot 10 = 10 \\ I_2 \cdot 2 + (I_1 - I_2)\cdot 10 = 6 \end{cases}$$

$$\begin{cases} 15I_1 - 10I_2 = 10 \\ 10I_1 - 8I_2 = 6 \end{cases} \rightarrow I_1 = 1A,\ I_2 = 0{,}5\,A,\ I = I_1 - I_2 = 0{,}5\,A$$

Rezistordan ajralib chiqadigan issiqlik miqdorini Jou-Lens qonunidan topamiz

$$Q = I^2 \cdot R \cdot t = 0{,}5^2 \cdot 10 \cdot 60 = 150\,J$$

26. Rasmda ko’rsatilgan zanjirdagi A va B nuqtalar orasidagi potensiallar farqini toping.



Rasmda ko'rsatilgani kabi zanjir 2 ta o’zaro parallel tarmoqdan iborat: pastki tarmoq o'zaro ketma-ket ulangan 1 Om va 8 Om qarshilikka ega bo'lgan rezistorlardan, yuqoridagi tarmoq o'zaro ketma-ket ulangan 1 nF va 2 nF sig'imli kondensatorlardan iborat. Har ikkala tarmoqdagi kuchlanishlar bir xil va 18 V ga teng.

Om qonuniga ko'ra, har ikkala rezistordan o'tayotgan tok kuchi teng, shuning uchun ulardagi kuchlanish tushuvlari ularning qarshiliklariga to'g'ri proporsional ravishda bo'ladi:

$x+8x=18$ V $9x=18$ V $x=2$ V

Shunda. 1 Om lik rezistordagi kuchlanish tushuvi $x=2$ V ga, 8 Om lik rezistordagi kuchlanish tushuvi $8x=16$ V ga teng bo'ladi.

Kondensatorlar ketma-ket ulangani uchun ulardagi zaryadlar teng bo'ladi. $q=CU$ formulaga ko'ra, ketma-ket ulangan kondensatorlardagi kuchlanish tushuvlari ularning sig’imlariga teskari proporsional bo’ladi:

$2y+y=18$ V $3y=18$ V $y=6$ V

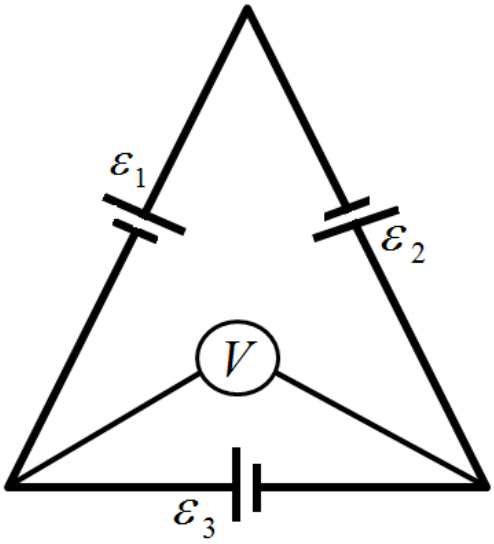
Shunda, 1 nF sig’imli kondensatordagi kuchlanish $2y=12$ V ga, 2 nF sig'imli kondensatordagi kuchlanish $y=6$ Vga teng bo’ladi.

Har bir elementdagi kuchlanish tushuvlarini bilgan hoida, A va B nuqtalardagi potensiallarni aniqlaymiz:

A nuqtaning potensiali 2 V, B nuqtaning potensiali 12 V. Demak bu ikki nuqta orasidagi potensiallar farqi (kuchlanish) 10 V ekan. Agar A va B nuqtalarga voltmetr ulaganimizda u 10 V ni ko'rsatgan bo’lar edi.

27. Rasmda keltirilgan ma’lumotlardan foydalanib, voltmetrning ko’rsatishini toping.

$$\varepsilon_1 = 1V,\ \varepsilon_2 = 2V,\ \varepsilon_3 = 3V,\ r_1 = 3\Omega,\ r_2 = 2\Omega,\ r_3 = 1\Omega,$$



Uchta manba ketma-ket ulangan ulardan o’tadigan umumiy tok kuchi

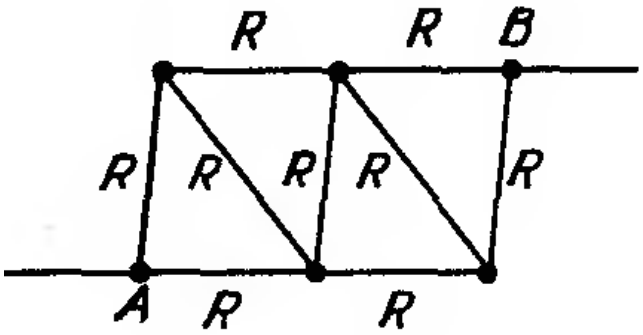
$$I = \frac{\varepsilon_1 + \varepsilon_2 + \varepsilon_1}{r_1 + r_2 + r_3} = \frac{1+2+3}{3+2+1} = 1A$$

Kirxgofning 2-qoidasini qo’llab quyidagi tenglamani tuzamiz

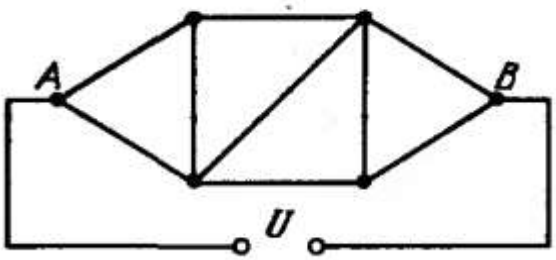
$$I \cdot r_3 + U = \varepsilon_3 \quad \rightarrow \quad U = \varepsilon_3 - I \cdot r_3 = 3 - 1 \cdot 1 = 2V$$

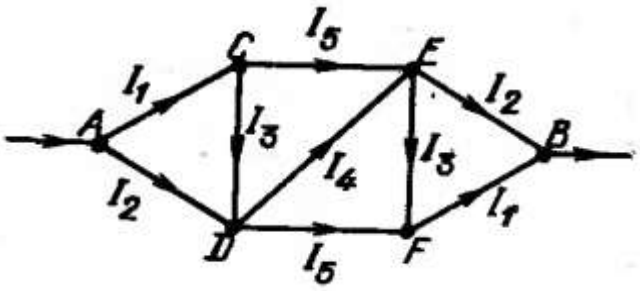
Qo’shimcha adabiyotlardan olingan masalalar

1. AB nuqta orasidagi umumiy qarshilikni toping?



Sxemaning umumiy qarshiligini toppish uchun uning A va B nuqtalari potensiallar farqini U bilian belgilaymiz(1-rasm), 2-rasmda esa sxemadagi rezistorlardagi toklarning harakat yo’nalishlari ko’rsatilgan.





Sxemadan ko’rinib turibdiki CE va DF parallel ulanganligi uchun va qarshiliklari bir-xil bo’lganligi uchun ularda harakatlanadigan toklar teng,bu fikrni CD va EF nuqtalar orasidagi toklar uchun ham shunday deyish mumkin.

Kirxgofning 1-qoidasiga ko’ra

$$I = I_1 + I_2; \qquad I_2 + I_3 = I_4 + I_5;$$

Kirxgofning 2-qoidasiga ko’ra

$$(I_2 + I_5 + I_1)R = U; \quad (I_3 + I_4)R = I_5 R; \quad (I_1 + I_3)R = I_2 R$$

Kirxgofning 1-2-qoidalaridan chiqqan natijalardan

$$I_2 = \frac{6}{5} I_1, \quad I_3 = \frac{I_1}{5}, \qquad I_4 = \frac{3}{5} I_1, \qquad I_5 = \frac{4}{5} I_1. \textit{ Bulardan}$$

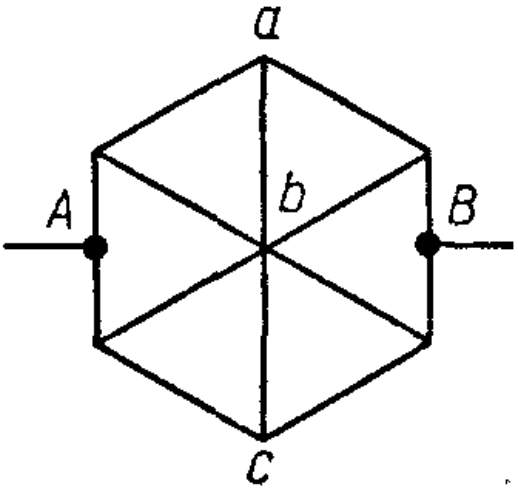
$$U = (I_1 + \frac{4}{5} I_1 + \frac{6}{5} I_1)R. \qquad \frac{U}{I_1} = 3R.$$

$$R_{AB} = \frac{U}{I} = \frac{U}{I_1 + I_2} = \frac{U}{I_1 + \frac{6}{5} I_1} = \frac{5}{11} \cdot \frac{U}{I_1} = \frac{5}{11} \cdot \frac{3 \cdot R \cdot I_1}{I_1} = \frac{15}{11} R,$$

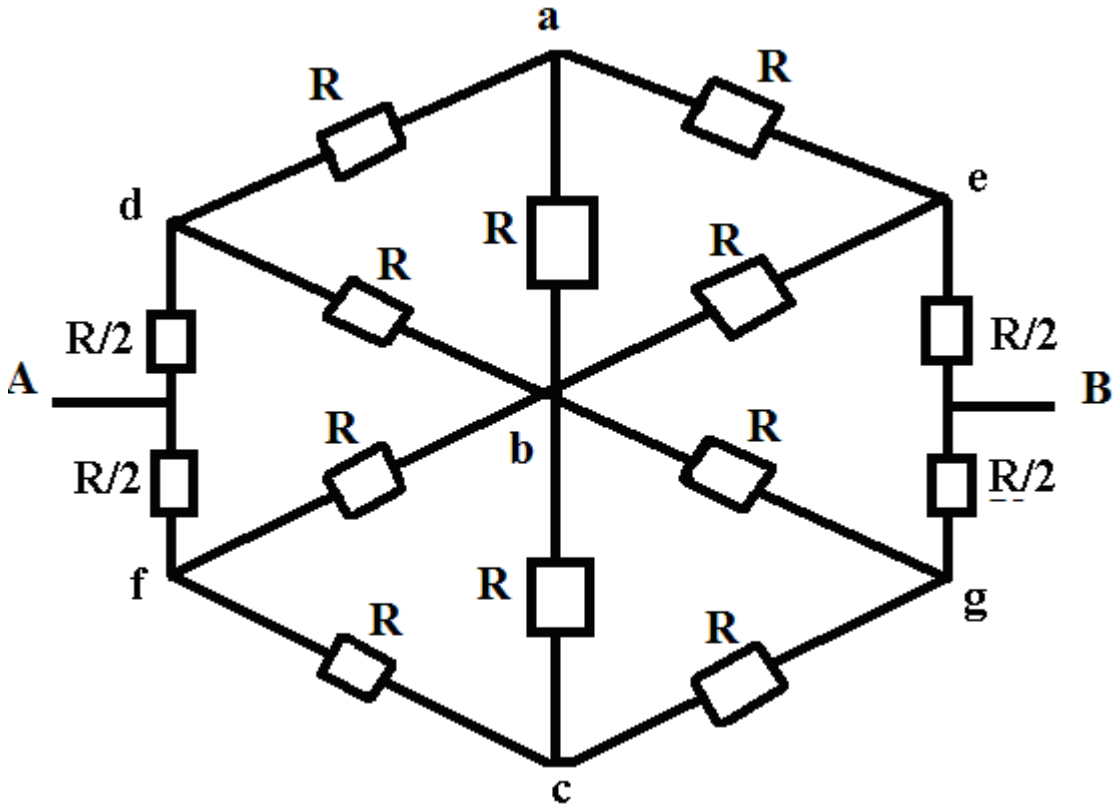
Umumiy qarshilik

$$R_{AB} = \frac{15}{11} R$$

2. Rasmda tasvirlangan sxemaning har bir qismining qarshiligi R bo'lgan qarshilikdan tuzilgan zanjir qismining umumiy qarshiligini hisoblab toping?



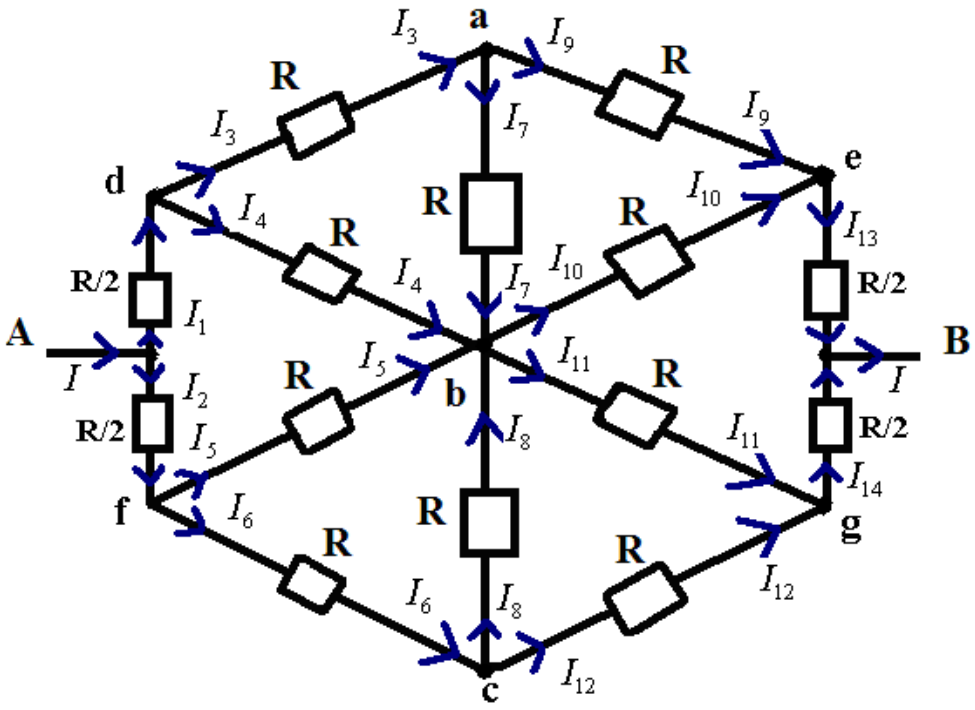
Sxemadagi qarshiliklarni tushunarli bo'lishi uchun uni quyidagicha tasvirlaymiz



Sxemaning qarshiliklari bir-xil bo'lganligi uchun a ,b,c nuqtalarda potensial bir xil $\varphi_a = \varphi_b = \varphi_c$ bo'lganligi uchun potensiallar farqi $\varphi_a - \varphi_b = \varphi_c - \varphi_b = 0$ ga teng bo'ladi va abva bc qismdan tok o'tmaydi .

ISBOT

Har bir qarshilikdan oqayotgan toklarni taqsimlab chiqamiz



Kirxgofning 1-qoidasiga ko’ra tugunlarga kiruvchi va chiquvchi toklar tengligidan quyidagi natijaga ega bo’lamiz.

$$I = I_1 + I_2 \qquad I_3 = I_7 + I_9$$

$$I_1 = I_3 + I_4 \qquad I_6 = I_8 + I_{12}$$

$$I_2 = I_5 + I_6 \qquad I_{13} = I_{10} + I_9$$

$$I_4 + I_5 + I_7 + I_8 = I_{10} + I_{11} \qquad I_{14} = I_{11} + I_{12}$$

Bu natijalardan foydalanib rezistorlarni parallel ulangan qismlaridagi toklar tengligidan quyidagilarni hisoblaymiz.

Ad va Af rezistorlar paralelligidan $U_1 = U_2$ va Kirxgof 1-qoidasidan chiqqan natijalardan toklarni topamiz

$$U_1 = U_2$$

$$I_1 \cdot \frac{R}{2} = I_2 \cdot \frac{R}{2}$$

$$I_1 = I_2 = \frac{I}{2}$$

Be va Bg rezistorlar paralelligidan $U_{13} = U_{14}$ va Kirxgof 1-qoidasidan chiqqan natijalardan toklarni topamiz

$$U_{13} = U_{14}$$

$$I_{13} \cdot \frac{R}{2} = I_{14} \cdot \frac{R}{2}$$

$$\underline{I_{13} = I_{14} = \frac{I}{2}}$$

da va db rezistorlar paralelligidan $\underline{U_3 = U_4}$ va Kirxgof 1-qoidasidan chiqqan natijalardan toklarni topamiz

$$U_3 = U_4$$

$$I_3 \cdot R = I_4 \cdot R$$

$$\underline{I_3 = I_4 = \frac{I_1}{2} = \frac{I}{4}}$$

fb va fc rezistorlar paralelligidan $\underline{U_5 = U_6}$ va Kirxgof 1-qoidasidan chiqqan natijalardan toklarni topamiz

$$U_5 = U_6$$

$$I_5 \cdot R = I_6 \cdot R$$

$$\underline{I_5 = I_6 = \frac{I_2}{2} = \frac{I}{4}}$$

ae va be rezistorlar paralelligidan $\underline{U_9 = U_{10}}$ va Kirxgof 1-qoidasidan chiqqan natijalardan toklarni topamiz

$$U_9 = U_{10}$$

$$I_9 \cdot R = I_{10} \cdot R$$

$$\underline{I_9 = I_{10} = \frac{I_{13}}{2} = \frac{I}{4}}$$

gb va gc rezistorlar paralelligidan $\underline{U_{11} = U_{12}}$ va Kirxgof 1-qoidasidan chiqqan natijalardan toklarni topamiz

$$U_{11} = U_{12}$$

$$I_{11} \cdot R = I_{12} \cdot R$$

$$\underline{I_{11} = I_{12} = \frac{I_{14}}{2} = \frac{I}{4}}$$

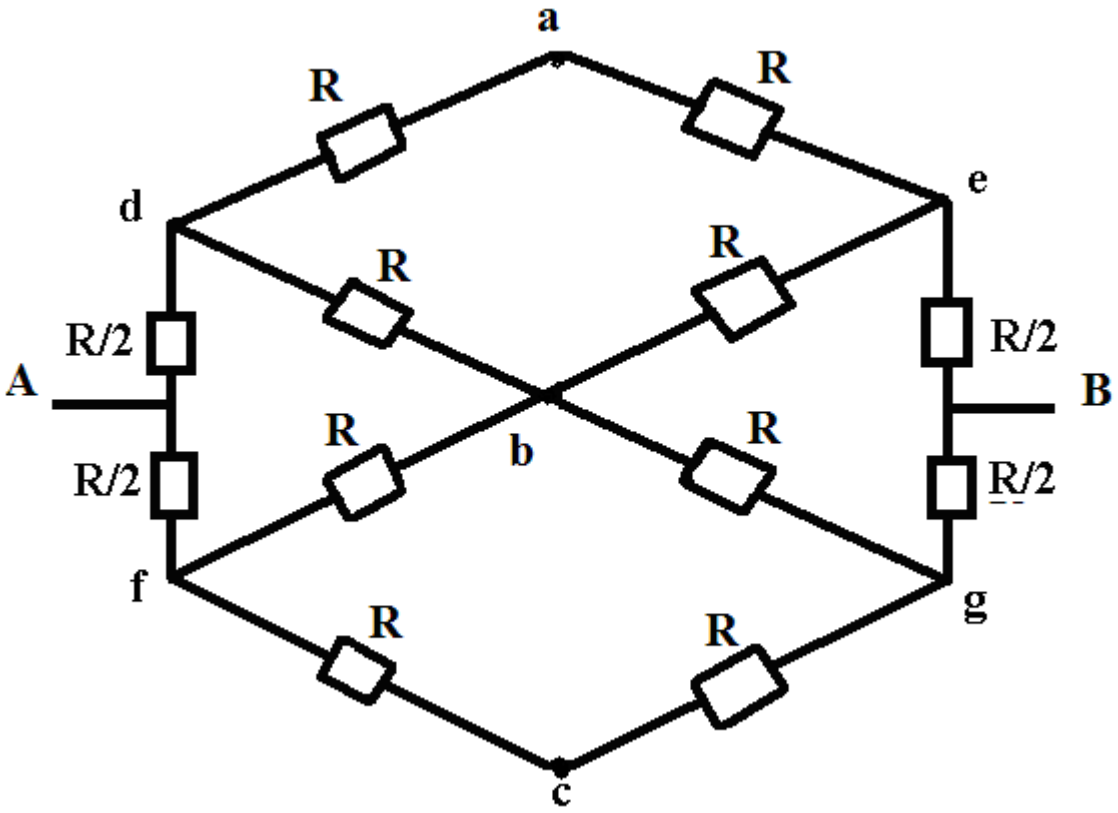
Kirxgofning 1-qoidasidan chiqqan oxirgi natijadan

$$I_4 + I_5 + I_7 + I_8 = I_{10} + I_{11}$$

$$\frac{I}{4} + \frac{I}{4} + I_7 + I_8 = \frac{I}{4} + \frac{I}{4}$$

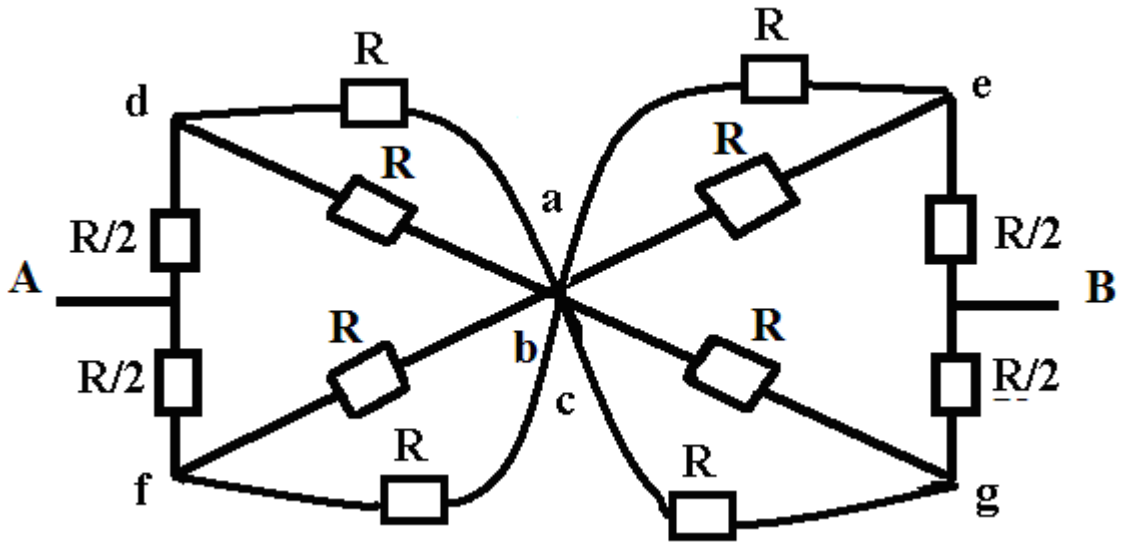
$$I_7 + I_8 = 0; \qquad I_7 = 0; \;\; I_8 = 0$$

natijaga ega bo'lamiz.Demak 7 chi va 8 chi rezistorlardan tok o'tmaydi. Shuning uchun ab va bc qarshiliklarni olib tashlaymiz va sxema quyudagi ko'rinishga ega bo'ladi.



Bu sxema 2-xil usulda bajariladi

1-Usul: abc nuqtalarni tutashtiramiz



abc birlashgan nuqtani o’z xolicha qoldirib hisoblaymiz.
Buning uchun Ab va bB qismlardagi qarshiliklarni hisoblaymiz.

$$\frac{1}{R_{da}}=\frac{1}{R}+\frac{1}{R};\quad R_{da}=\frac{R}{2}$$

$$\frac{1}{R_{ea}}=\frac{1}{R}+\frac{1}{R};\quad R_{ea}=\frac{R}{2}$$

$$R_{Aa}=\frac{R}{2}+R_{da}=\frac{R}{2}+\frac{R}{2}=R$$

$$R_{Ba}=\frac{R}{2}+R_{ea}=\frac{R}{2}+\frac{R}{2}=R$$

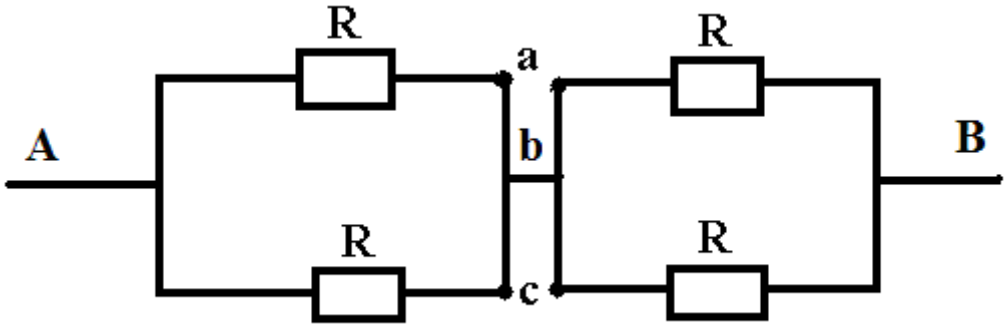
$$\frac{1}{R_{fc}}=\frac{1}{R}+\frac{1}{R};\quad R_{fc}=\frac{R}{2}$$

$$\frac{1}{R_{gc}}=\frac{1}{R}+\frac{1}{R};\quad R_{gc}=\frac{R}{2}$$

$$R_{Ac}=\frac{R}{2}+R_{dc}=\frac{R}{2}+\frac{R}{2}=R$$

$$R_{Bc}=\frac{R}{2}+R_{gc}=\frac{R}{2}+\frac{R}{2}=R$$

Ushbu hisoblashdan so’ng sxema quyidagicha sodda holga keladi.



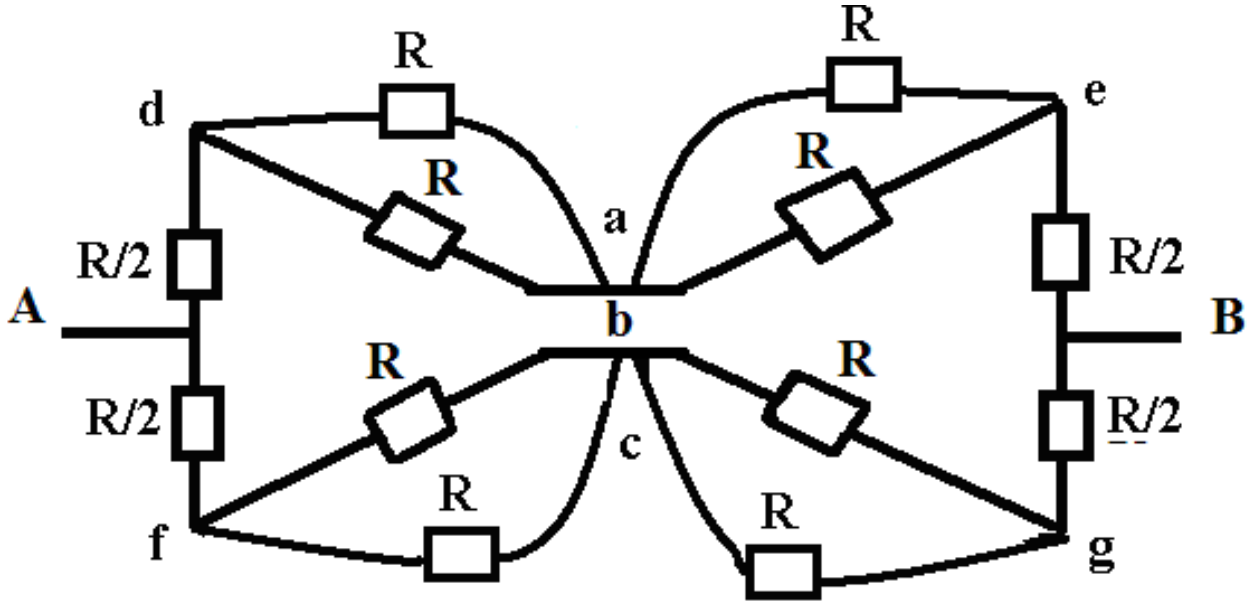
$$\frac{1}{R_{Ab}}=\frac{1}{R}+\frac{1}{R};\qquad R_{Ab}=\frac{R}{2}$$

$$\frac{1}{R_{bB}}=\frac{1}{R}+\frac{1}{R};\qquad R_{bB}=\frac{R}{2}$$

$$R_{AB}=R_{Ab}+R_{bB}=\frac{R}{2}+\frac{R}{2}=R$$

$$Javob: R_{AB}=R$$

2-Usul sxemani b nuqtadan kesamiz va sxema quyidagi holga keladi



$$\frac{1}{R_{da}}=\frac{1}{R}+\frac{1}{R};\quad R_{da}=\frac{R}{2}$$

$$\frac{1}{R_{ea}}=\frac{1}{R}+\frac{1}{R};\quad R_{ea}=\frac{R}{2}$$

$$R_{Aa}=\frac{R}{2}+R_{da}=\frac{R}{2}+\frac{R}{2}=R$$

$$R_{Ba}=\frac{R}{2}+R_{ea}=\frac{R}{2}+\frac{R}{2}=R$$

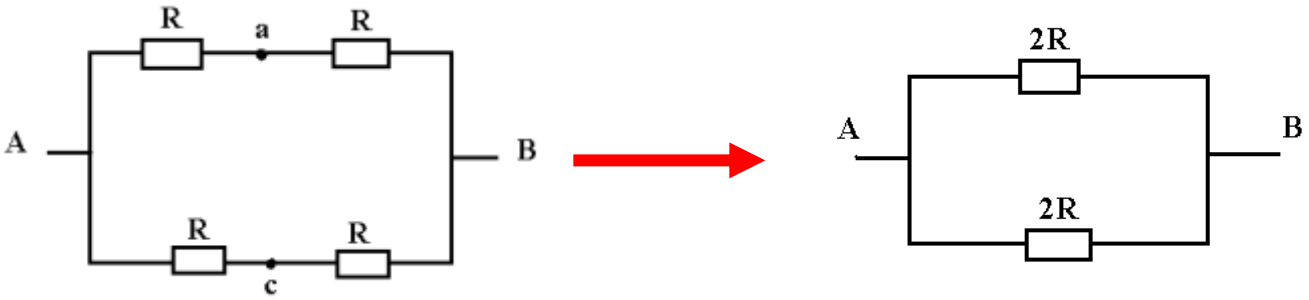
$$\frac{1}{R_{fc}}=\frac{1}{R}+\frac{1}{R};\quad R_{fc}=\frac{R}{2}$$

$$\frac{1}{R_{gc}}=\frac{1}{R}+\frac{1}{R};\quad R_{gc}=\frac{R}{2}$$

$$R_{Ac}=\frac{R}{2}+R_{dc}=\frac{R}{2}+\frac{R}{2}=R$$

$$R_{Bc}=\frac{R}{2}+R_{gc}=\frac{R}{2}+\frac{R}{2}=R$$

Ushbu hisoblashdan so'ng sxema quyidagicha sodda holga keladi.



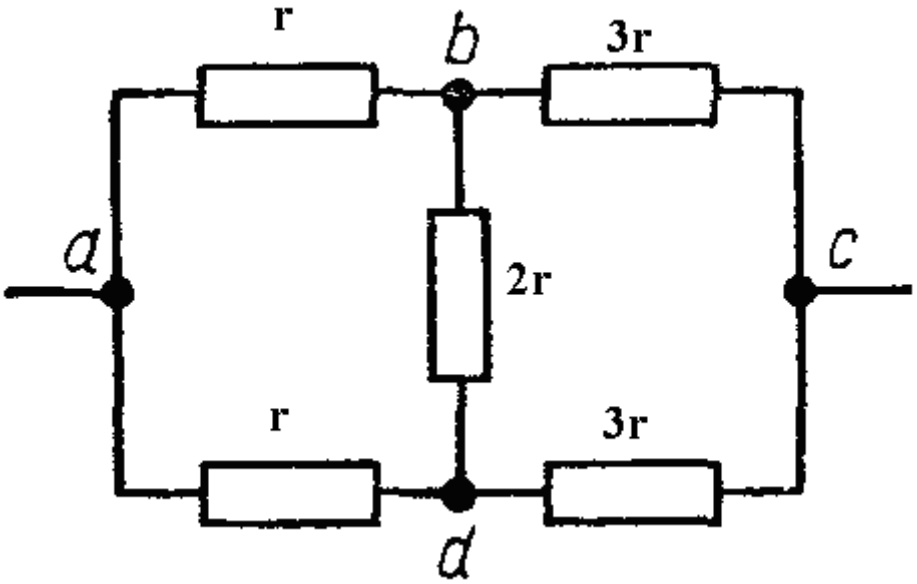
$$\frac{1}{R_{AB}}=\frac{1}{2R}+\frac{1}{2R};$$

$$R_{AB}=R$$

$$Javob: R_{AB}=R$$

3. Rasmdagi sxemaning ac nuqta orasidagi umumiy qarshilikni toping

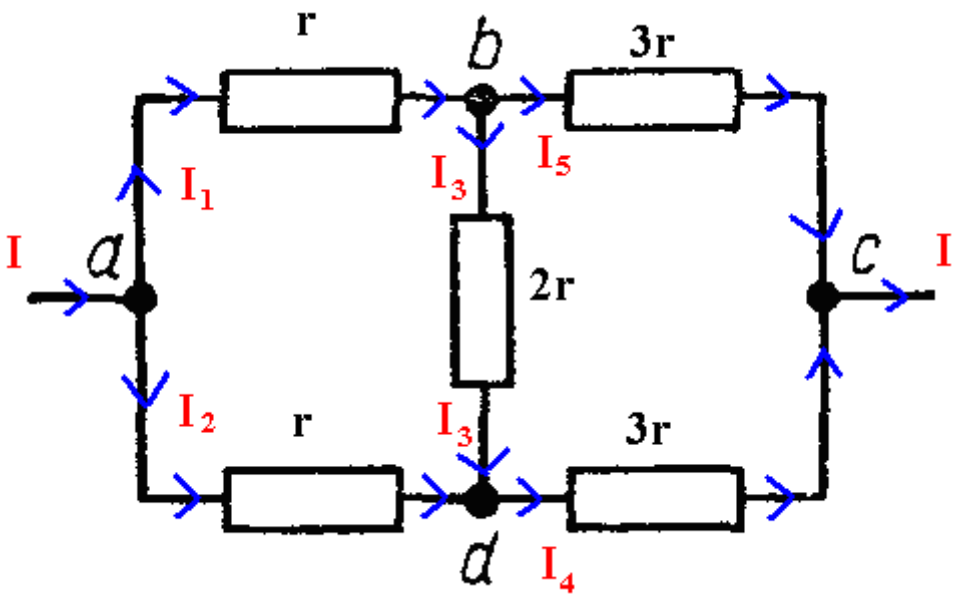
(Bu masalani yechish uchun kitobning boshlanishida shunga o'xshash masalalar uchun umumiy holda topilgan formulaga eltib qo'ysak ham javob chiqadi yoki quyidagicha yechamiz)



b va d nuqtalarda potensiallari bir xil $\varphi_b = \varphi_d$ bo'lganligi uchun bd nuqtalar orasidagi potensiallar farqi $U_{bd} = \varphi_b - \varphi_d = 0$ ga teng ya'ni bd yo'nalishda tok o'tmaydi

ISBOT

Tok o'tmasligini isbotlash uchun sxemaga tok kuchini joylashtirib chiqamiz yo'nalishi bilan



Kirxgofning 1-qoidasiga ko'ra tugunlarga kiruvchi va chiquvchi toklar tengligidan quyidagi natijaga ega bo'lamiz.

$$I = I_1 + I_2$$

$$I_4 + I_5 = I$$

$$I_3 + I_5 = I_1$$

$$I_3 + I_2 = I_4$$

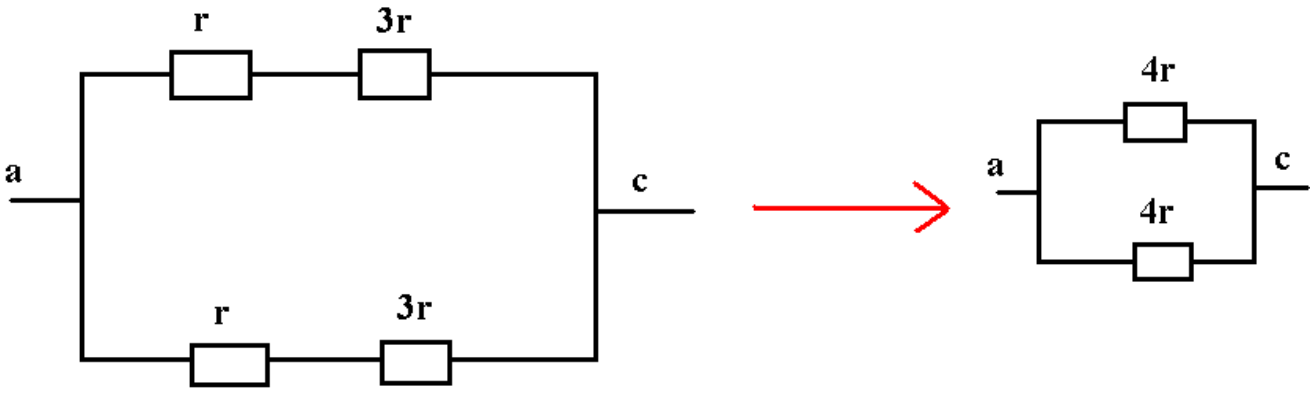
ab,ad rezistorlar va bc, dc rezistorlar o'zaro parallel ulanganligi uchun bu yo'nalishlardagi kuchlanishlari teng bo'ladi

$$U_1 = U_2$$
$$I_1 \cdot r = I_2 \cdot r$$
$$I_1 = I_2$$
$$U_5 = U_4$$
$$I_5 \cdot 3r = I_4 \cdot 3r$$
$$I_5 = I_4$$

Bu natijalarni Kirxgofning 1-qoidasidan chiqqan natijalarga etib qo'ysak

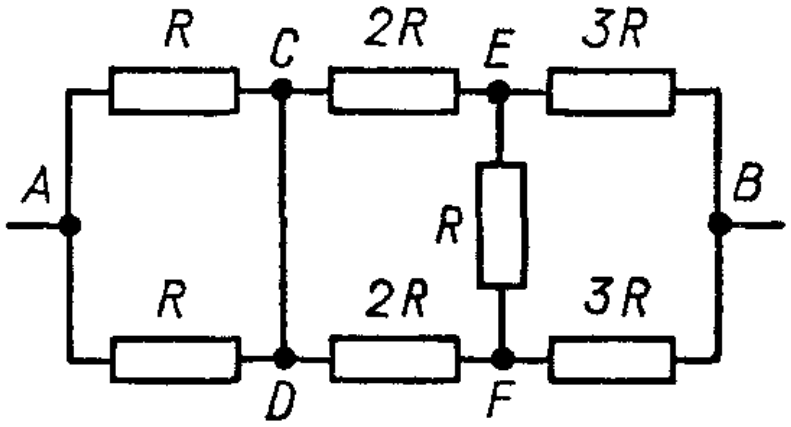
$$I_1 = I_2 = \frac{I}{2}$$
$$I_4 = I_5 = \frac{I}{2}$$
$$I_3 + I_5 = I_1 \Rightarrow I_3 + \frac{I}{2} = \frac{I}{2} \Rightarrow I_3 = 0$$
$$I_3 + I_2 = I_4 \Rightarrow I_3 + \frac{I}{2} = \frac{I}{2} \Rightarrow I_3 = 0$$

Bu natijalardan ko'rinadiki 3-rezistordan tok o'tmas ekan.
Shuning uchun bd rezistorni olib tashlaymiz va sxemamiz quyidagi soda holga keladi



$$\frac{1}{R_{ab}} = \frac{1}{4r} + \frac{1}{4r};$$
$$R_{ab} = 2r$$

4. Zanjirning AB; CD va EF nuqtalar orasidagi umumiy qarshilikni toping.

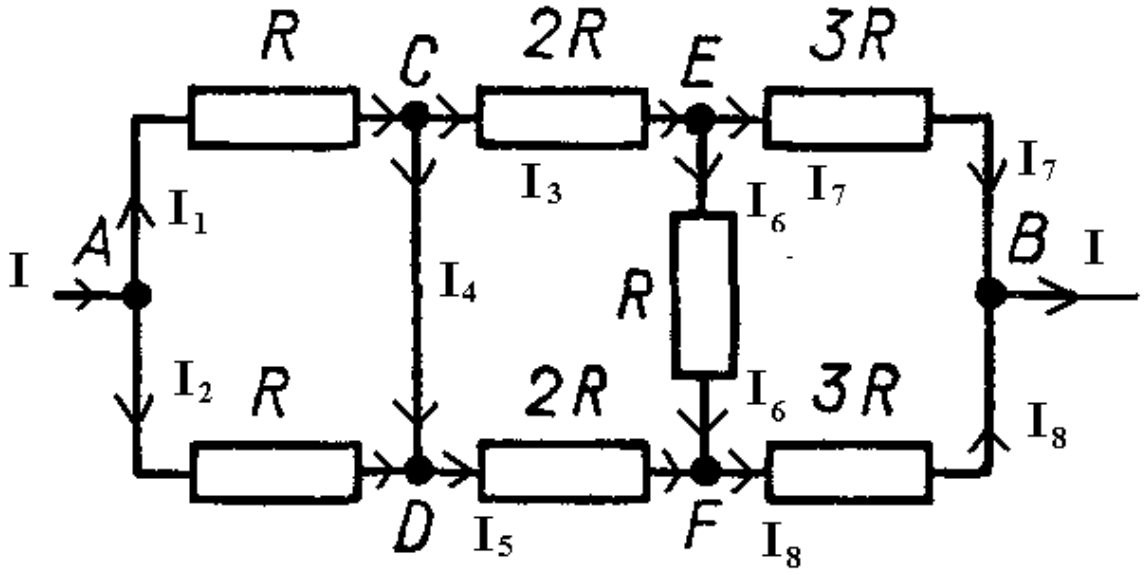


1-HOL($R_{AB} = ?$)

Zanjirning AB qismidagi umumiy qarshilikni topish uchun sxemaning CD va EF qismini olib tashlaymiz sababi bu yo'nalishda tok oqmaydi.CD va EF nuqtalarda potensiallar bir xil,potensiallar farqi o ga teng

Sxemaning CD va EF qismidan tok o'tmasligini quyidagicha tushuntiramiz

Buning uchun sxemada tok kuchilarni quyidagicha joylashtiramiz



Kirxgofning 1-qoidasiga ko'ra tugunlarga kiruvchi va chiquvchi toklar tengligidan quyidagi natijaga ega bo'lamiz.

$$I = I_1 + I_2$$
$$I_1 = I_3 + I_4$$
$$I_2 + I_4 = I_5$$
$$I_5 + I_6 = I_8$$
$$I_6 + I_7 = I_3$$
$$I_7 + I_8 = I$$

AC;AD rezistorlar CE;DF va EB;FB rezistorlar o'zaro parallel ulanganligi uchun bu yo'nalishlardagi kuchlanishlari teng bo'ladi

$$U_1 = U_2$$
$$I_1 \cdot R = I_2 \cdot R$$
$$I_1 = I_2$$
$$U_3 = U_5$$
$$I_3 \cdot 2R = I_5 \cdot 2R$$
$$I_3 = I_5$$
$$U_7 = U_8$$
$$I_7 \cdot 3R = I_8 \cdot 3R$$
$$I_7 = I_8$$

Bu natijalarni Kirxgofning 1-qoidasidan chiqqan natijalarga etib qo'ysak

$$I_1 = I_2 = \frac{I}{2}$$
$$I_7 = I_8 = \frac{I}{2}$$

$$+\begin{cases} I_1 = I_3 + I_4 \\ I_2 + I_4 = I_5 \end{cases}$$

$$I_1 + I_2 + I_4 = I_3 + I_4 + I_5$$

$$I_1 + I_2 = I_3 + I_5$$

$$I = I_3 + I_5$$

$$I_3 = I_5 = \frac{I}{2}$$

$$+\begin{cases} I_5 + I_6 = I_8 \\ I_6 + I_7 = I_3 \end{cases}$$

$$I_5 + 2I_6 + I_7 = I_8 + I_3$$

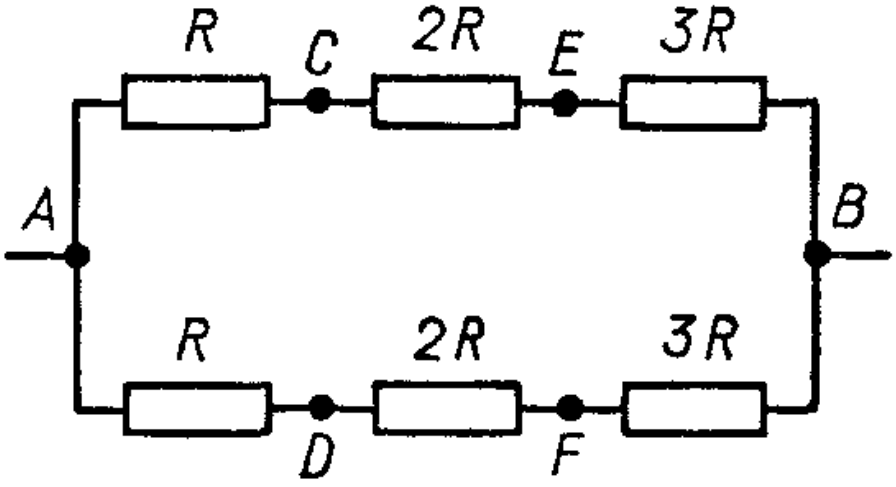
$I_3 = I_5;\ I_7 = I_8;$ *Tengligi uchun qisqarib ketadi*

$$2I_6 = 0;\ I_6 = 0$$

$$I_2 + I_4 = I_5$$

$$\frac{I}{2} + I_4 = \frac{I}{2};\ I_4 = 0$$

Bu natijalardan shuni aniqladikki CD va EF nuqtalar orqali tok o'tmaydi shuning uchun sxemadan ularni olib tashlaymiz.



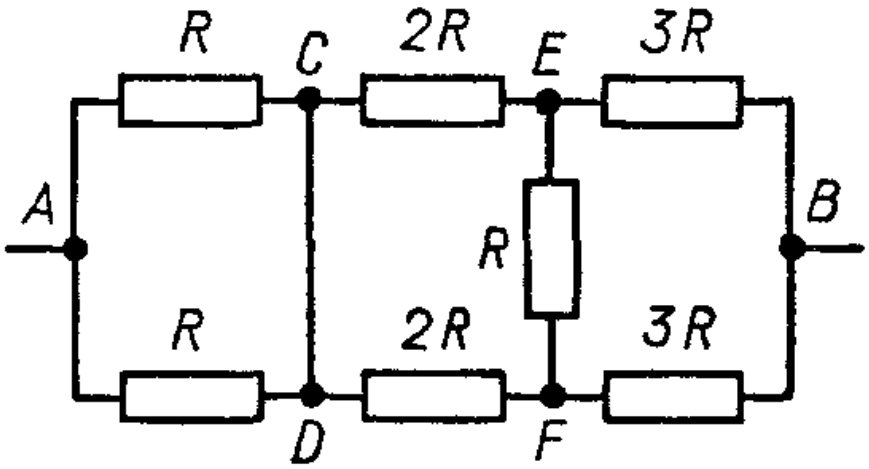
$$R_{ACEB} = R + 2R + 3R = 6R$$

$$R_{ADFB} = R + 2R + 3R = 6R$$

$$\frac{1}{R_{Umum}} = \frac{1}{6R} + \frac{1}{6R} = \frac{2}{6R};$$

$$R_{Umum} = 3R$$

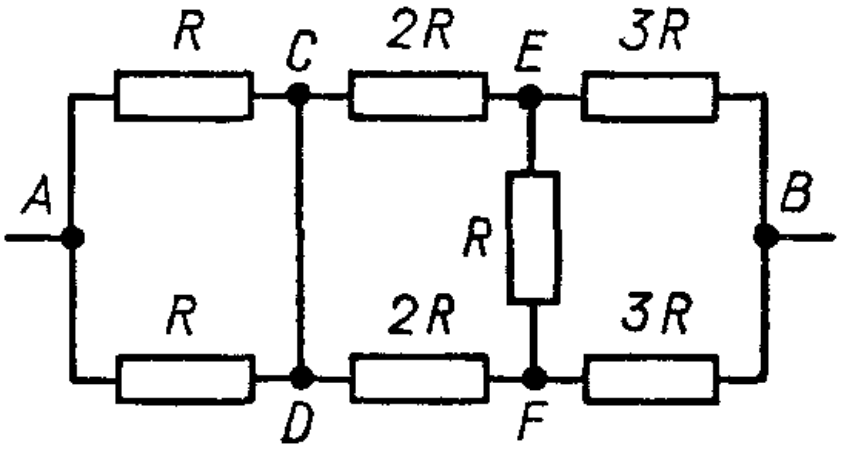
2-HOL($R_{CD} = ?$)



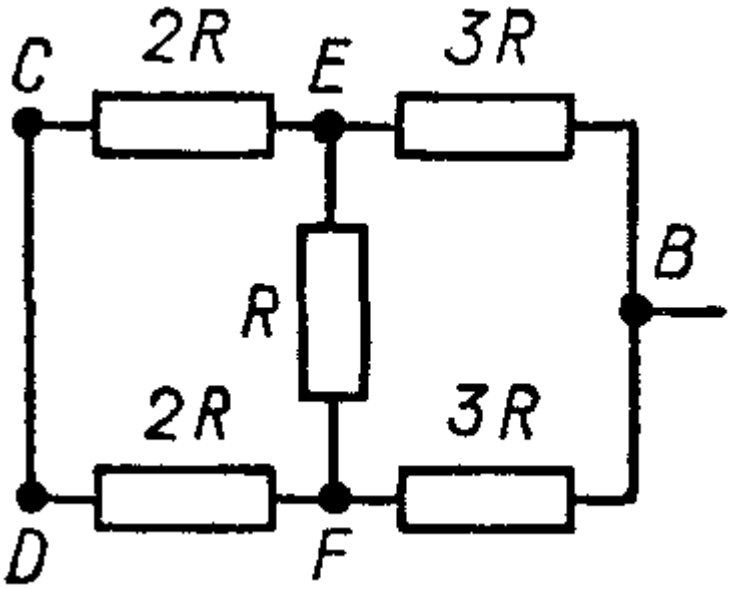
Cxemaning CD nuqtalar orasida qarshilik yo'qligi uchun

$R_{CD} = 0$ ga teng.

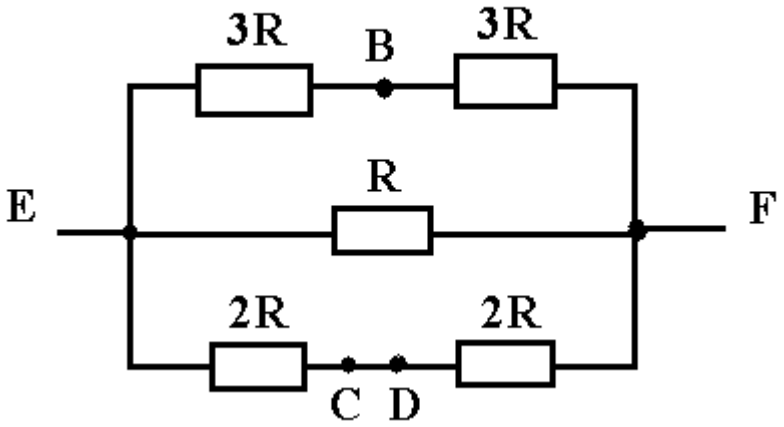
3-HOL($R_{EF} = ?$)



Sxemaning CA va AD qarshiliklari orqali tok o'tmaydi shuning uchun ularni sxemadan olib tashlaymiz va sxemamiz quyidagi ko'rinishga kelada



Sxemaning EC va DF qarshiliklari ketma-ket ulanganligi uchun va CD nuqta orasida qarshilik yo’qligi uchun sxemani quyidagi sodda holga keltiramiz



$$R_{EBF} = 3R + 3R = 6R$$

$$R_{ECDF} = 2R + 2R = 4R$$

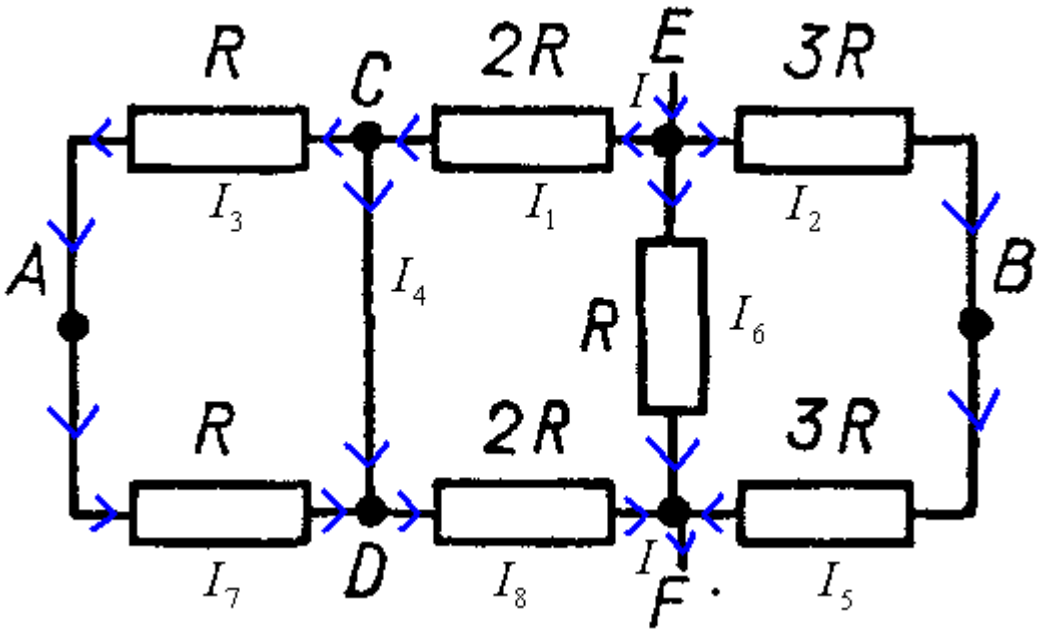
$$\frac{1}{R_{EF}} = \frac{1}{R_{EBF}} + \frac{1}{R} + \frac{1}{R_{ECDF}} = \frac{1}{6R} + \frac{1}{R} + \frac{1}{4R} = \frac{2}{6R} + \frac{12}{12R} + \frac{3}{12R}$$

$$R_{EF} = \frac{12}{17}R$$

Yuqorida sxemaning CA va AD qarshiliklari orqali tok o’tmaydi deyilgan edi endi shuni quyidagicha

ISBOTLAYMIZ

Buning uchun sxemadagi toklarning yo'nalishini qo'yib chiqamiz .Bizga EF nuqtalar orasidagi umumiy qarshilikni toping deyilgani uchun E nuqtadan I tok kuchi kirib F nuqtadan chiqadi deb faraz qilib ishlaymiz va sxema quyidagi ko'rinishga ega bo'ladi.



Kirxgofning 1-qoidasiga ko'ra tugunlarga kiruvchi va chiquvchi toklar tengligidan quyidagi natijaga ega bo'lamiz.

$$I = I_1 + I_2 + I_6$$

$$I = I_6 + I_5 + I_8$$

$$I_1 = I_3 + I_4$$

$$I_8 = I_4 + I_7$$

EC;EF; EB rezistorlar paralel ulanganligidan

$$U_1 = U_2 = U_6$$

$$I_1 \cdot 2R = I_2 \cdot 3R = I_6 \cdot R$$

$$2I_1 = 3I_2 = I_6$$

Bu natijani Kirxgof 1-qoidasidan chiqqan natijalarga etib qo'ysak quyidagi natija kelib chiqadi

$$I_1 = \frac{3}{11} I; \qquad I_2 = \frac{2}{11} I; \qquad I_6 = \frac{6}{11} I$$

FB;FE vaFD rezistorlar o'zaro parallel ulanganligi uchun

$$U_8 = U_5 = U_6$$

$$I_8 \cdot 2R = I_5 \cdot 3R = I_6 \cdot R$$

$$2I_1 = 3I_2 = I_6$$

Bu natijani Kirxgof 1-qoidasidan chiqqan natijalarga etib qo'ysak quyidagi natija kelib chiqadi

$$I_8 = \frac{3}{11} I; \qquad I_5 = \frac{2}{11} I; \qquad I_6 = \frac{6}{11} I$$

CA;AD va EC;CD;DF vaEB;BF rezistorlar o'zaro ketma-ket ulanganligidan quyidagi natijalar kelib chiqadi

$$I_3 = I_7$$

$$I_1 = I_4 = I_8 = \frac{3}{11} I$$

$$I_2 = I_5 = \frac{2}{11} I$$

Bu natijani Kirxgof 1-qoidasidan chiqqan oxirgi natijalarga etib qo'ysak quyidagi natija kelib chiqadi

$$I_1 = I_3 + I_4$$

$$\frac{3}{11} I = I_3 + \frac{3}{11} I$$

$$I_3 = 0$$

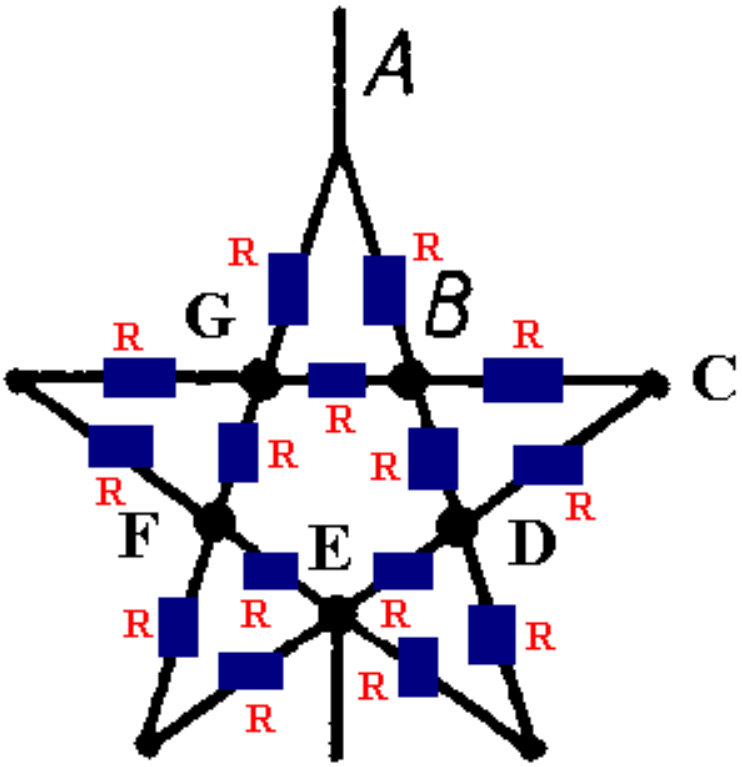
$$I_8 = I_4 + I_7$$

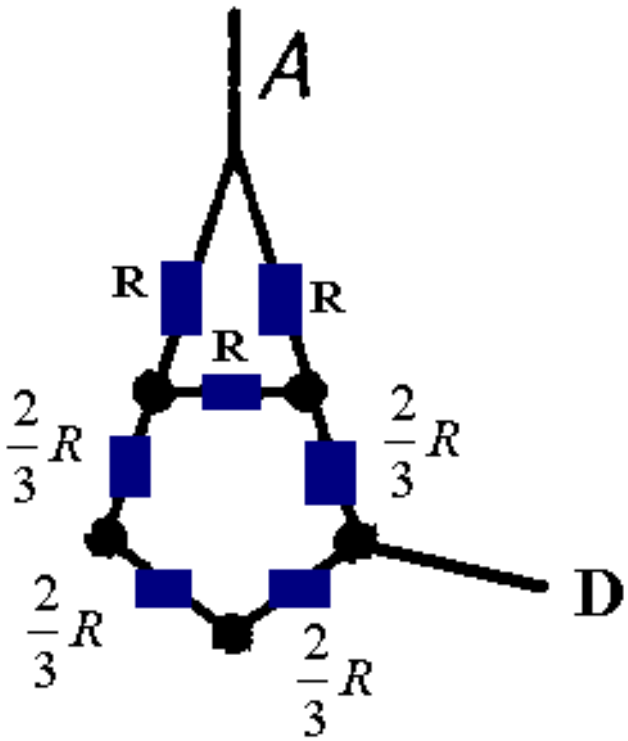
$$\frac{3}{11} I = \frac{3}{11} I + I_7$$

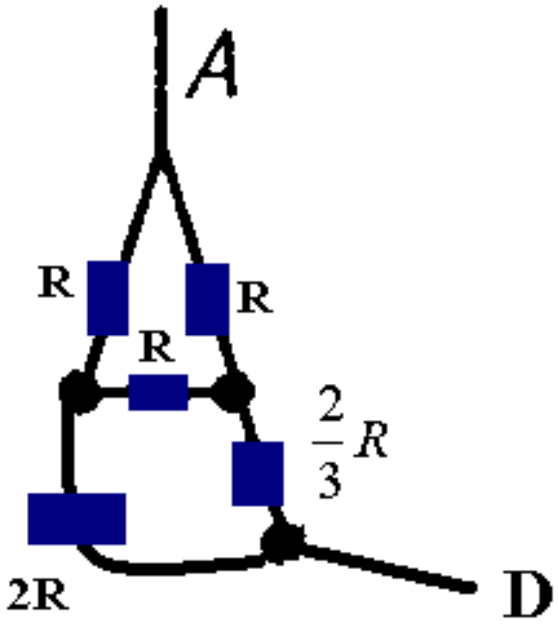
$$I_7 = 0$$

Oxirgi natijaga ko'ra $I_3 = 0; I_7 = 0$ Sxemaning CA va AD qarshiliklari orqali tok o'tmasligini isbotladik.

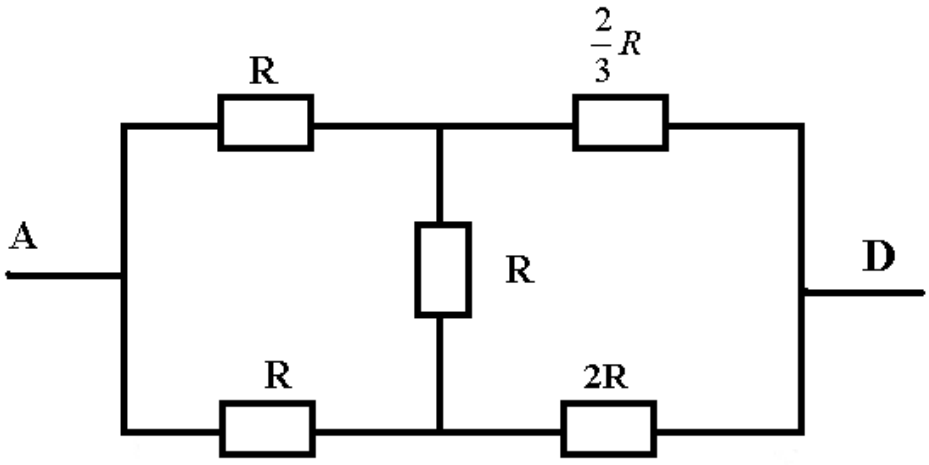
5. AD nuqta orasidagi qarshilikni topamiz.



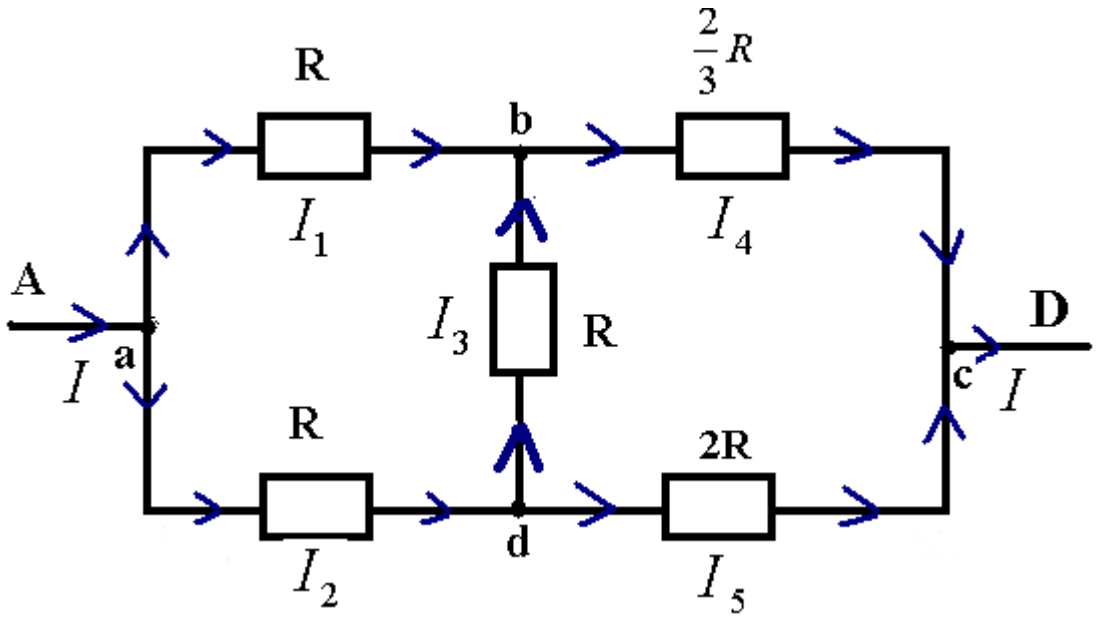




Sxemani quyidagi sodda ko’rinishda ifodalaymiz



Sxemaning umumiy qarshiligini toppish uchun rezistorlarda toklarni harakat yo’nalishini yozib chiqamiz.



Krixgovning 1-qoidasidan quyidagi natijaga ega bo'lamiz

$$I = I_1 + I_2; \qquad (a)$$

$$I_4 = I_1 + I_3; \qquad (b)$$

$$I_2 = I_3 + I_5; \qquad (c)$$

$$I = I_4 + I_5; \qquad (d)$$

Elektr zaryadi A nuqtadan D nuqtaga 4-xil yo'l orqali harakatlanadi. Ya'ni (abc,adc,adbc va abdc).Zaryadning umumiy bajargan ishi har-bir rezistordagi ishlar yig'indisiga teng

abc kontur uchun

$$A = A_1 + A_4; \qquad qU = qU_1 + qU_4;\ U = U_1 + U_4;$$

$$I \cdot R_{AB} = I_1 \cdot R + I_4 \cdot \frac{2}{3}R \qquad (1)$$

adc kontur uchun

$$A = A_2 + A_5; \qquad qU = qU_2 + qU_5;\ U = U_2 + U_5;$$

$$I \cdot R_{AB} = I_2 \cdot R + I_5 \cdot 2R \qquad (2)$$

adbc kontur uchun

$$A = A_2 + A_3 + A_4; \qquad qU = qU_2 + qU_3 + qU_4;\ U = U_2 + U_3 + U_4;$$

$$I \cdot R_{AB} = I_2 \cdot R + I_3 \cdot R + I_4 \cdot \frac{2}{3}R \qquad (3)$$

abdc kontur uchun

$$A = A_1 + A_3 + A_5; \qquad qU = qU_1 + qU_3 + qU_5;\ U = U_1 + U_3 + U_5;$$

$$I \cdot R_{AB} = I_1 \cdot R - I_3 \cdot R + I_2 \cdot 2R \qquad (4)$$

1 va 2 natijalarni tenglashtiramiz

$$I_1 + \frac{2}{3} I_4 = I_2 + 2I_5$$
$$I_3 + \frac{2}{3} I_4 = 2I_5 \qquad (4.1)$$

1 va 4 natijalarni tenglashtiramiz

$$I_1 + \frac{2}{3} I_4 = I_1 - I_3 + 2I_5$$
$$I_3 + \frac{2}{3} I_4 = 2I_5 \qquad (4.2)$$

4.1 va 4.2 tenglamalarni sistema qilamiz

$$\begin{cases} I_1 + \frac{2}{3} I_4 = I_2 + 2I_5 \\ I_3 + \frac{2}{3} I_4 = 2I_5 \end{cases} \quad \textit{sistemani ayirsak}$$

$$I_1 - I_3 = I_2; \quad I_1 = I_2 + I_3$$

(b) natijaga etib qo'yamiz

$$I_4 = I_1 + I_3; \qquad (b)$$
$$I_4 = I_2 + I_3 + I_3 = I_2 + 2I_3; \qquad (I_2 = I_3 + I_5 \ \ (c))$$
$$I_4 = I_3 + I_5 + 2I_3 = 3I_3 + I_5; \qquad (4.3)$$

4.2 va 4.3 natijalarni sistema qilib oddalashtirsak quyidagi natijaga ega bo'lamiz

$$\begin{cases} I_3 + \frac{2}{3} I_4 = 2I_5 \\ I_4 = 3I_3 + I_5; \end{cases}$$
$$- \begin{cases} I_3 + \frac{2}{3} I_4 = 2I_5 \\ 2I_4 - 6I_3 = 2I_5; \end{cases}$$
$$7I_3 - \frac{4}{3} I_4 = 0; \quad I_3 = \frac{4}{21} I_4; \quad I_4 = \frac{21}{4} I_3 \qquad (4.4)$$

$$I_3 + \frac{2}{3} I_4 = 2I_5; \qquad (4.2)\ dan$$

$$\frac{4}{21} I_4 + \frac{2}{3} I_4 = 2I_5; \quad I_5 = \frac{3}{7} I_4;$$

$$I_2 = I_3 + I_5 \quad (c)\, dan \quad I_2 = \frac{4}{21} I_4 + \frac{3}{7} I_4; \quad I_2 = \frac{13}{21} I_4$$

$$I_4 = I_1 + I_3 \quad (b)\, dan \quad I_1 = I_4 - I_3 = I_4 - \frac{4}{21} I_4 = \frac{17}{21} I_4$$

$$I_1 = \frac{17}{21} I_4;$$

$$I = I_4 + I_5 \quad (d)\ dan \quad I = I_4 + \frac{3}{7} I_4 = \frac{10}{7} I_4$$

Bu natijalarni 1-formulaga etib qo'ysak

$$I \cdot R_{AB} = I_1 \cdot R + I_4 \cdot \frac{2}{3} R$$

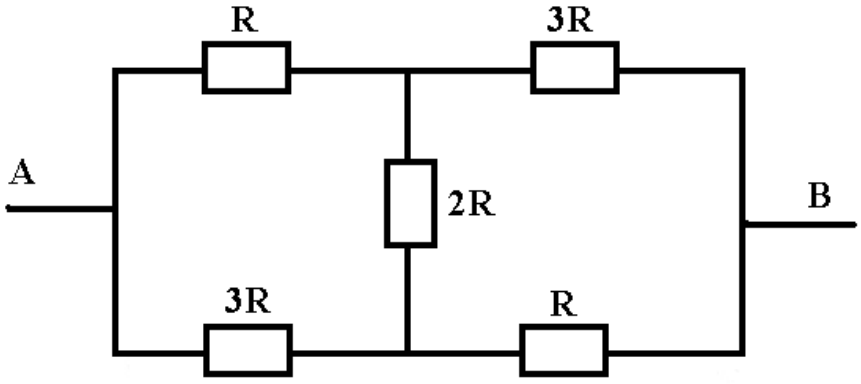
$$\frac{10}{7} I_4 \cdot R_{AB} = \frac{17}{21} I_4 \cdot R + I_4 \cdot \frac{2}{3} R$$

$$\frac{10}{7} R_{AB} = \frac{17}{21} R + \frac{14}{21} R = \frac{31}{21} R$$

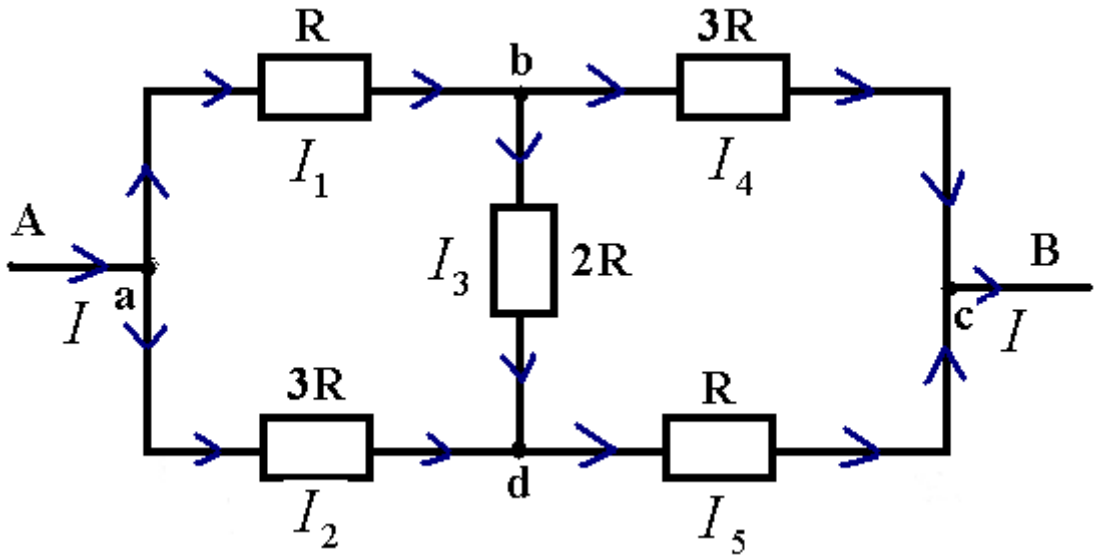
$$Javob: R_{AB} = \frac{31}{30} R;$$

6. AB nuqta orasidagi umumiy qarshilikni toping ?

(Bu masalani yechish uchun kitobning boshlanishida shunga o'xshash masalalar uchun umumiy holda topilgan formulaga eltib qo'ysak ham javob chiqadi yoki quyidagicha yechamiz)



Sxemaning umumiy qarshiligini toppish uchun rezistorlarda toklarni harakat yo'nalishini yozib chiqamiz.



Krixgovning 1-qoidasidan quyidagi natijaga ega bo'lamiz

$$I = I_1 + I_2; \qquad (a)$$

$$I_1 = I_3 + I_4; \qquad (b)$$

$$I_5 = I_2 + I_3; \qquad (c)$$

$$I = I_4 + I_5; \qquad (d)$$

Elektr zaryadi q A nuqtadan B nuqtaga 4-xil yo'l orqali harakatlanadi. Ya'ni (abc,adc,abdc va adbc).Zaryadning umumiy bajargan ishi har-bir rezistordagi ishlar yig'indisiga teng

abc kontur uchun

$$A = A_1 + A_4; \quad qU = qU_1 + qU_4; \; U = U_1 + U_4;$$
$$I \cdot R_{AB} = I_1 \cdot R + I_4 \cdot 3R \qquad (1)$$

adc kontur uchun

$$A = A_2 + A_5; \quad qU = qU_2 + qU_5; \; U = U_2 + U_5;$$
$$I \cdot R_{AB} = I_2 \cdot 3R + I_5 \cdot R \qquad (2)$$

abdc kontur uchun

$$A = A_1 + A_3 + A_5; \quad qU = qU_1 + qU_3 + qU_5; \; U = U_1 + U_3 + U_5;$$
$$I \cdot R_{AB} = I_1 \cdot R + I_3 \cdot 2R + I_5 \cdot R \qquad (3)$$

adbc kontur uchun

$$A = A_2 + A_3 + A_4; \quad qU = qU_2 + qU_3 + qU_4; \; U = U_2 + U_3 + U_4;$$
$$I \cdot R_{AB} = I_2 \cdot 3R - I_3 \cdot 2R + I_4 \cdot 3R \qquad (4)$$

1 va 2 formulalarni tenglashtiramiz

$$I_1 \cdot R + I_4 \cdot 3R = I_2 \cdot 3R + I_5 \cdot R$$
$$I_1 + 3I_4 = 3I_2 + I_5 \qquad (4.1)$$

3 va 4 formulalarni tenglashtiramiz

$$I_1 + 4I_3 + I_5 = 3I_2 + 3I_4 \qquad (4.1)$$

4.1 va 4.2 formulalarni sistema qilib soddalashtiramiz

$$\begin{cases} I_1 + 3I_4 = 3I_2 + I_5 \\ I_1 + 4I_3 + I_5 = 3I_2 + 3I_4 \end{cases}$$

I_1 o'rniga (b) formulani keltirib qo'yamiz

$$\begin{cases} I_3 + I_4 + 3I_4 = 3I_2 + I_5 \\ I_3 + I_4 + 4I_3 + I_5 = 3I_2 + 3I_4 \end{cases}$$

Sistemani ayiramiz

$$-4I_3 + 3I_4 - I_5 = I_5 - 3I_4$$
$$6I_4 = 2I_5 + 4I_3$$
$$3I_4 = I_5 + 2I_3$$

Oxirgi natijaga (c) natijani etib qo'yamiz

$$3I_4 = I_2 + I_3 + 2I_3$$
$$3I_4 = I_2 + 3I_3 \qquad (6)$$

1 va 4 formulalarni tenglashtiramiz

$$I_1 + 3I_4 = 3I_2 - 2I_3 + 3I_4$$
$$I_1 = 3I_2 - 2I_3$$

Oxirgi natijaga (b) natijani etib qo'yamiz

$$I_3 + I_4 = 3I_2 - 2I_3$$
$$3I_3 + I_4 = 3I_2 \qquad (6.5)$$

6 va 6.5 natijalarni sistema qilib soddalashtiramiz

$$\begin{cases} 3I_3 + I_4 = 3I_2 \\ 3I_4 - 3I_3 = I_2 \end{cases}$$

Sistemani qo'shmiz $4I_4 = 4I_2; \quad I_4 = I_2$

b va c natijalarni sistema qilib oxirgi natijani etib qo'ysak

$$-\begin{cases} I_1 = I_3 + I_4 \\ I_5 = I_2 + I_3 \end{cases}$$
$$I_1 - I_5 = I_4 - I_3; \quad (I_4 = I_2)\, dan$$
$$I_1 = I_5 \ \ natija \ \ kelib \ \ chiqadi$$

6-formulaga ushbu natijalarni etib qo'ysak

$$3I_4 = I_2 + 3I_3$$
$$3I_4 - I_2 = 3I_3; \quad (I_4 = I_2 \ dan)$$
$$2I_4 = 3I_3$$
$$I_3 = \frac{2}{3} I_4$$

Ushbu natijalarni 4.1 formulaga etib qo'yamiz

$$I_1 + 4I_3 + I_5 = 3I_2 + 3I_4$$
$$(I_1 = I_5) \ va \ (I_2 = I_4) \ \ dan$$
$$2I_1 + 4I_3 = 6I_4; \qquad (I_3 = \frac{2}{3} I_4)$$
$$.2I_1 + 4 \cdot \frac{2}{3} I_4 = 6I_4$$
$$I_1 = \frac{5}{3} I_4; \quad I_4 = \frac{3}{5} I_1$$

a Formulaga oxirgi natijani etib qo'yamiz

$$I = I_1 + I_2; \qquad (a)$$

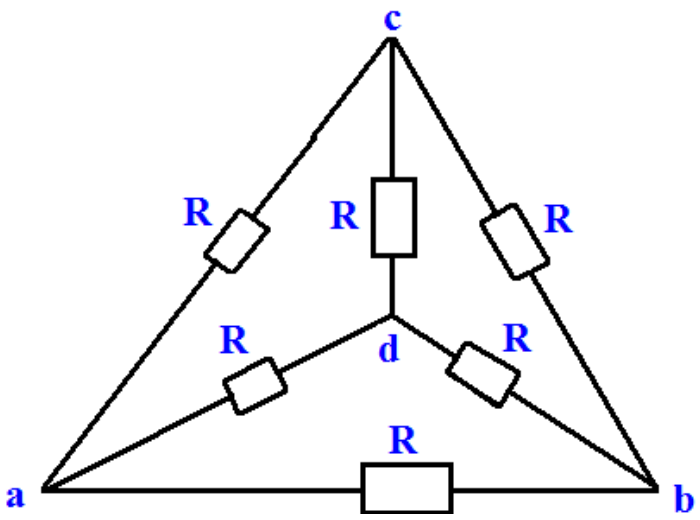
$$I = I_1 + I_2 \ ; (I_2 = I_4) \ dan \ I = I_1 + I_4 \Rightarrow I = I_1 + \frac{3}{5} I_1 = \frac{8}{5} I_1 \Rightarrow I_1 = \frac{5}{8} I;$$

$$I_4 = \frac{3}{5} I_1 \Rightarrow I_4 = \frac{3}{5} \cdot \frac{5}{8} I = \frac{3}{8} I$$

$$I \cdot R_{AB} = I_1 \cdot R + I_4 \cdot 3R; \ \ I \cdot R_{AB} = \frac{5}{8} I \cdot R + \frac{3}{8} I \cdot 3R$$

1-formula $R_{AB} = \frac{5}{8} \cdot R + \frac{9}{8} \cdot R; \quad R_{AB} = \frac{14}{8} R = \frac{7}{4} R; \quad javob: R_{AB} = \frac{7}{4} R$

7. Uchburchakli piramidaning barcha tomonlarining qarshiligi R ga teng sxemaning ab;ad va ac nuqtalar orasidagi umumiy qarshiligini toping?

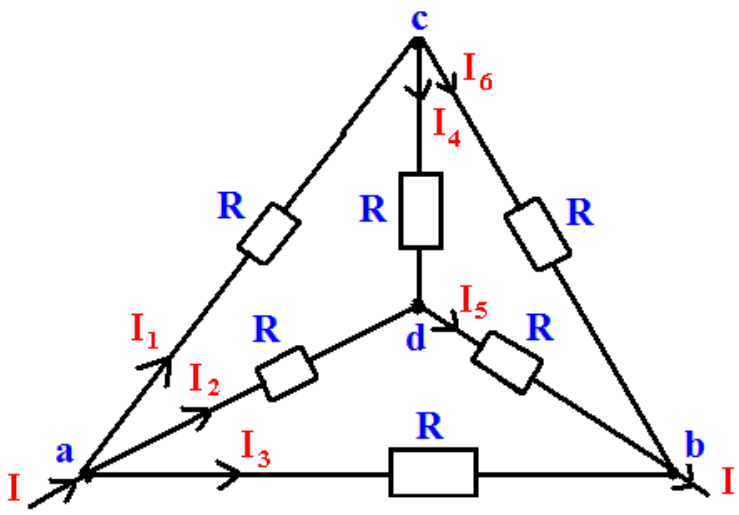


1-HOL $(R_{ab} = ?)$

Sxemaning qarshiliklari bir-xil bo'lganligi uchun va c va d nuqtalarga potensiallar tengligi uchun,potensiallar farqi cd rezistorda 0 ga teng shuning uchun cd rezistordan tok o'tmaydi.

ISBOT

ab nuqtalar orasidagi umumiy qarshilikni hisoblash uchun biz avval har bir rezistor orqali o'tadigan toklarni topib chiqamiz. Demak a va b nuqta orasidagi qarshilikni toping deyilgani uchun a nuqtadan I tok kirib b nuqtadan chiqib ketadi deb faraz qilib masalani ishlaymiz.Va sxemada tok kuchlarini quyidagicha joylashtirib chiqamiz.



Kirxgofning 1-qoidasiga ko'ra tugunlarga kiruvchi va chiquvchi toklar tengligidan quyidagi natijaga ega bo'lamiz.

$$I = I_1 + I_2 + I_3$$

$$I_6 + I_5 + I_3 = I$$

$$I_4 + I_2 = I_5$$

ac;ad;ab rezistorlar va cb;db;ab rezistorlar o'zaro parallel ulanganligi uchun bu yo'nalishlardagi kuchlanishlar teng bo'ladi

$$U_1 = U_2 = U_3$$

$$I_1 \cdot R = I_2 \cdot R = I_3 \cdot R$$

$$I_1 = I_2 = I_3$$

$$U_3 = U_5 = U_6$$

$$I_3 \cdot R = I_5 \cdot R = I_6 \cdot R$$

$$I_3 = I_5 = I_6$$

Bu natijalarni Kirxgofning 1-qoidasidan chiqqan natijalarga etib qo'ysak

$$I_1 = I_2 = I_3 = \frac{I}{3}$$

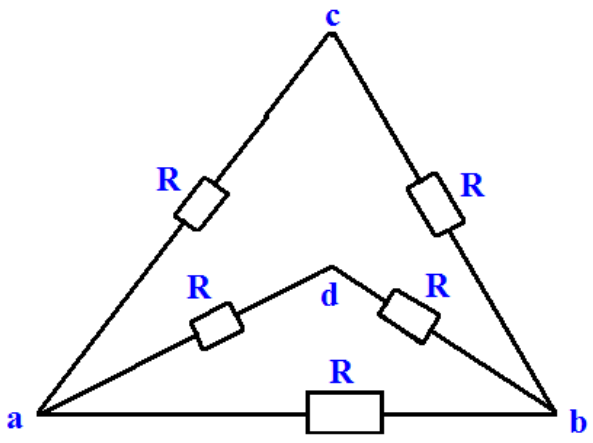
$$I_3 = I_5 = I_6 = \frac{I}{3}$$

$$I_4 + I_2 = I_5 \Rightarrow I_4 + \frac{I}{3} = \frac{I}{3} \Rightarrow I_4 = 0$$

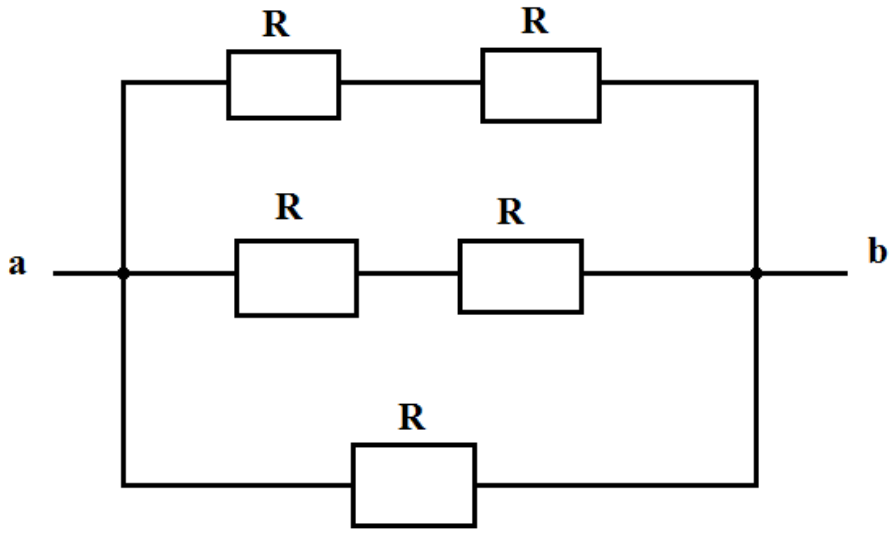
Bulardan cd rezistordagi tok kuchi $I_4 = 0$ ga teng bo'lib chiqdi.

Demak cd yo'nalishda tok harakatlanmaydi potensiallar farqi $\varphi_c - \varphi_d = U_{cd} = 0$ bo'ladi

Shuning uchun cd rezistorni sxemadan olib tashlaymiz va sxemamiz quyidagi ko'rinishga keladi.

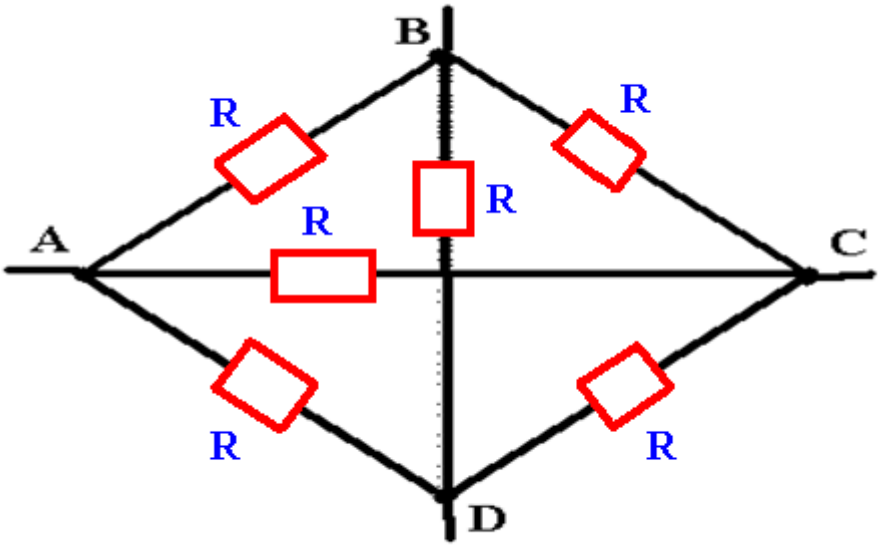


Buni sxemani quyidagi soda ko’rinishda yozamiz



$$\frac{1}{R_{ab}}=\frac{1}{2R}+\frac{1}{2R}+\frac{1}{R};\qquad R_{ab}=0{,}5R$$

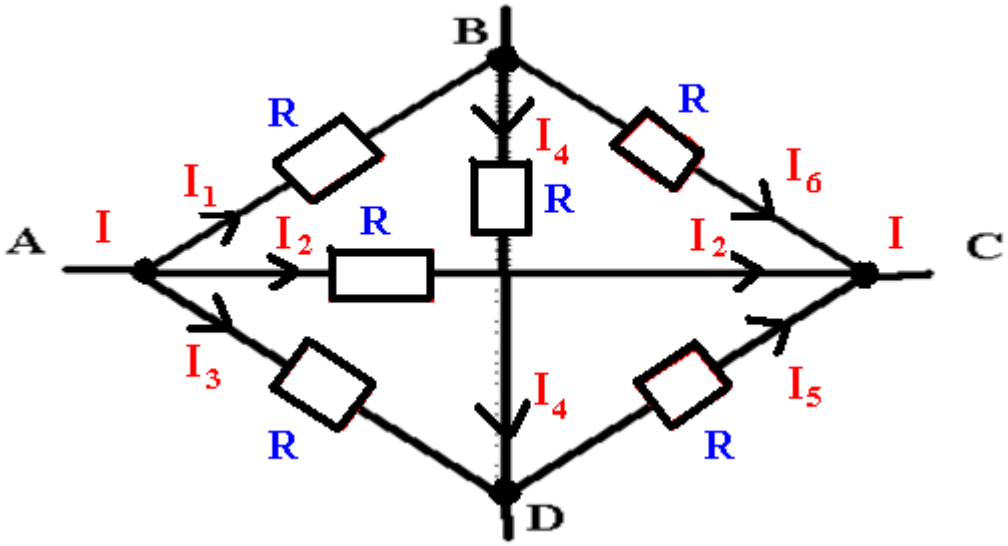
8. Simdan yasalgan ABCD rombning AC nuqtalari orasidagi qarshilikni toping.Rombning tomonlari va diagonallarining qarshiligi R ga teng.(AC va BD diaganallar kesishmagan)



B va D nuqtalarda potensiallari teng $\varphi_B=\varphi_D$ Potensiallar farqi $\varphi_B-\varphi_D=U_{BD}=0$ bo’lganligi uchun BD nuqta orqali tok o’tmaydi.

ISBOT:

AC nuqtalar orasidagi umumiy qarshilikni hisoblash uchun biz avval har bir rezistor orqali o’tadigan toklarni topib chiqamiz. Demak A va C nuqta orasidagi qarshilikni toping deyilgani uchun A nuqtadan I tok kirib C nuqtadan chiqib ketadi deb faraz qilib masalani ishlaymiz.Va sxemada tok kuchlarini quyidagicha joylashtirib chiqamiz.



Kirxgofning 1-qoidasiga ko’ra tugunlarga kiruvchi va chiquvchi toklar tengligidan quyidagi natijaga ega bo’lamiz.

$$I = I_1 + I_2 + I_3$$

$$I_2 + I_5 + I_6 = I$$

$$I_4 + I_6 = I_1$$

$$I_3 + I_4 = I_5$$

AB;AC;AD rezistorlar va BC;AC;DC rezistorlar o’zaro parallel ulanganligi uchun bu yo’nalishlardagi kuchlanishlari teng bo’ladi

$$U_1 = U_2 = U_3$$

$$I_1 \cdot R = I_2 \cdot R = I_3 \cdot R$$

$$I_1 = I_2 = I_3$$

$$U_2 = U_5 = U_6$$

$$I_2 \cdot R = I_5 \cdot R = I_6 \cdot R$$

$$I_2 = I_5 = I_6$$

Bu natijalarni Kirxgofning 1-qoidasidan chiqqan natijalarga etib qo’ysak

$$I_1 = I_2 = I_3 = \frac{I}{3}$$

$$I_2 = I_5 = I_6 = \frac{I}{3}$$

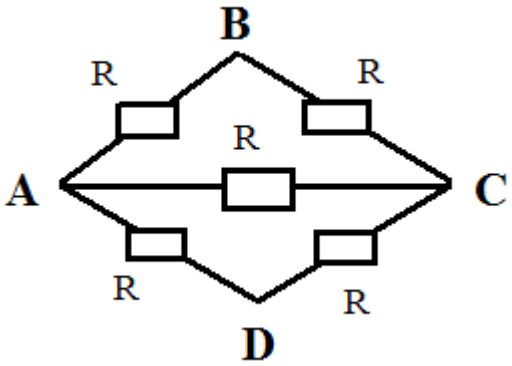
$$I_4 + I_6 = I_1 \quad \Rightarrow I_4 + \frac{I}{3} = \frac{I}{3} \quad \Rightarrow I_4 = 0$$

$$I_3 + I_4 = I_5 \quad \Rightarrow \frac{I}{3} + I_4 = \frac{I}{3} \quad \Rightarrow I_4 = 0$$

Bulardan BD rezistordagi tok kuchi $I_4 = 0$ ga teng bo'lib chiqdi.
shuning uchun BD diagonalni olib tashlaymiz va quyidagi 2-usulda ishlaymiz

1-Usul

Bu sxemani tushunarliroq bo'lishi uchun quyidagicha soddalashtiramiz



$$R_{ABC} = R + R = 2R$$

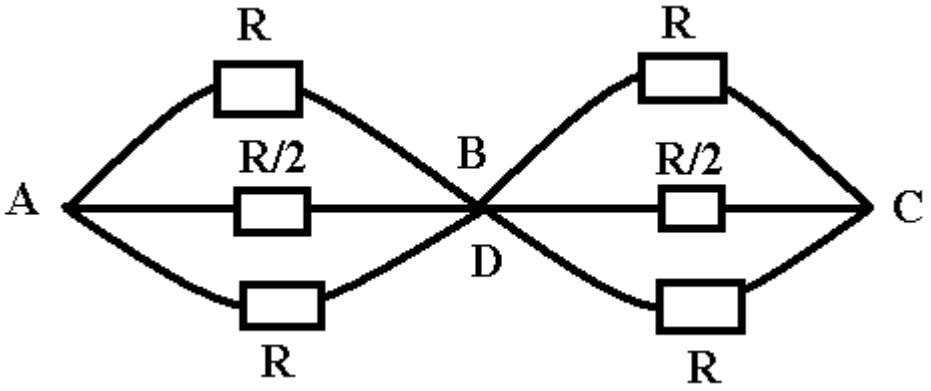
$$R_{ADC} = R + R = 2R$$

$$\frac{1}{R_{AC}} = \frac{1}{R_{ABC}} + \frac{1}{R} + \frac{1}{R_{ADC}} = \frac{1}{2R} + \frac{1}{R} + \frac{1}{2R} = \frac{4}{2R}$$

$$Javob: R_{AC} = \frac{2R}{4} = \frac{R}{2}$$

2-Usul

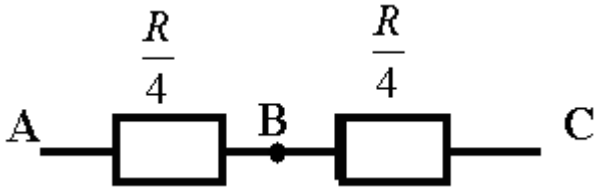
B va D nuqtalarda potensiallar farqi o bo'lganligi uchun BD nuqta orqali tok o'tmaydi shuning uchun BD nuqtalarni birlashtiramiz va u quyidagi holga keladi



$$\frac{1}{R_{AB}} = \frac{1}{R} + \frac{1}{\frac{R}{2}} + \frac{1}{R} = \frac{1}{R} + \frac{2}{R} + \frac{1}{R} = \frac{4}{R}; \qquad R_{AB} = \frac{R}{4}$$

$$\frac{1}{R_{BC}} = \frac{1}{R} + \frac{1}{\frac{R}{2}} + \frac{1}{R} = \frac{1}{R} + \frac{2}{R} + \frac{1}{R} = \frac{4}{R}; \qquad R_{BC} = \frac{R}{4}$$

Ushbu hisoblashlardan so'ng sxemamiz oddiy holga kelib qoladi



$$R_{AC} = \frac{R}{4} + \frac{R}{4} = \frac{R}{2}$$

FOYDALANILGAN ADABIYOTLAR

1. M.S.Sedrik “Umumiy fizika kursidan masalalar to’plami” .

2 .A.P Rimkiyevich “Fizikadan masalalar to’plami.”

3.G.A.Bendrikov, B.B.Buxovsev “Fizikadan masalalar”oliy o’quv yurtlariga kiruvchilar uchun

4.O.I.Ahmadjonov, Sh.O.Ahmadjonov “Fizikadan testlar”namunalari va izohlari.

5.L.P.Bakanina, B.E.Belonuchkin. “Fizikadan masalalar to’plami”

6.Н.Парфентьева, М.Фомина “Решение задач по физике” часть 2

7. Трубецкова С.В. “Физика.Вопросқ-ответы.Задачи-решения”

8. V.S.Volkenshteyn «umumiy fizika kursidan masalalar to'plami »

9. Бендриков Г.А, Буховцев Б.Б «Задачи по физике для поступающих в вузы:»

10.А.П.Рымкевича «Сборник задач по физике»

11.Б.Ю.Коган «Задачи по физике»Пособие для учителей

12. В.И.Васюков, С.Н.Дмитриев «Сборник задач для поступающих в вузы»

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24.Л.В.Тарасов, А.Н.Тарасова «Вопросы и задачи по физике»

25.В.А.Балаш «Задачи по физике и методы их решения»

26. Fizikadan testlar to’plami (1996-2003)

27. Abituriyent gazetasi

MUNDARIJA: