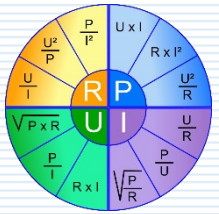
“TIQXMMI” MTU

Elektotexnika va elektronika asoslari

“E va M” kafedrasi
(Elektrotexnika va mexatronika kafedrasi)
O‘qituvchi: **Cho‘lliyev Ya’qubjon Ergashovich**
PhD. Katta o‘qituvchi,



DARS FAOLIYATI:

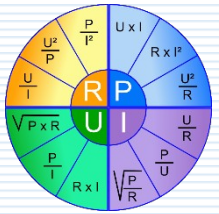
Ma’ruzalar – 15 dona (30-soat), tajriba ishi- 0 dona,

Amaliy mashqlar-15 (30-soat) dona

hisob grafik ishlari bo‘yicha maslahatlar – semestr davomida

MUSTAQIL ISHI:

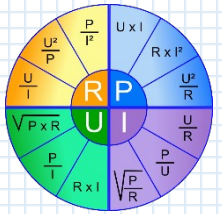
1. Hisob grafik ishi.
2. Tajriba ishlarini amalga oshirish va himoya qilishga tayyorgarlik.
3. O‘z-o‘zini tekshirish va mustaqil kursning alohida bo‘limlarini o‘rganish.



4.1. Kalendar reja

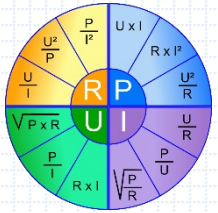
Fan bo‘yicha umumiy 150 soat (5 kredit)
ma’ruza: 30 soat
Amaliyot: 30 soat
Tajriba ishi _ soat

O‘QUV FANIDAN TALABALARNI BAHOLASH QOIDALARI KREDIT MODULLI TIZIMIDA



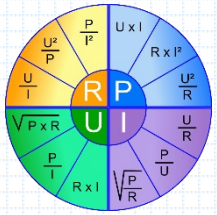
- **1. Mashg‘ulotlar turi.**
- Universitetda fanlar bo‘yicha quyidagicha shkala mavjud:
- Akademik semestr 2 ta akademik moduldan iborat bo‘lib, yozma yoki test sinovlari orqali baholanadi va oraliq bahoga ega bo‘ladi. Birinchi modulni davomiyligi: 1-8, ikkinchisi:8-10 hafta. O‘quv mashg‘ulotlari yakuniy imtihonlar og‘zaki yoki yozma ravishda yakunlanadi.
- **2. baholash mezonlari.**
- OB mezobi: 0-35 ballar – “qoniqarsiz”, 36-42 ballar – “qoniqarli”,41-53 ballar “yaxshi”, 54-60 ballar “a’lo”
- YaN: 0-23 ballar – “qoniqarsiz”, 24-27 ballar – “qoniqarli”, 28-36 ball – “yaxshi”, 36-40 ball – “a’lo”
- Umumiy ballar: 60-69.9 ball – “qoniqarli” , 70-89.9 ball – “yaxshi”, 90 -100ball – “a’lo”.
- **3. Semestr bo‘yicha har bir fan bo‘yicha ballarni taqsimlash.**
- Oraliq baholash – 60 ball. Talaba imtihonda kamida 36 ball olgan bo‘lsa, oraliq baholashdan o‘tadi. Oraliq nazorat bali taqsimlanadi ya’niy 30 balldan. Ma’ruzada mustaqil ishlari uchun 15 ball test sinovlariga 15 ball beriladi. Qolgan 30-ball tajriba va amaliy ishlarini o‘z vaqtida muvaffaqiyatli topshirganlarga amaliyotchi o‘qituvchi tamonidan baholab beriladi.
- Qolgan 40 ballni 10- haftadan keyin yakuniy baholashda oladi.
- Bitta tajriba ishi uchun 2 ball ajratilgan. Ulardan 1 ball o‘z vaqtida topshirganligi uchun, yana 1 ball nazariy qism va ishning tugallangan hisobotini o‘z vaqtida topshirganligi uchun beriladi.
- Darsni uzrli sababsiz o‘tkazib yuborish semestr oxirida 0 ball bilan va 1 ball bilan belgilanadi.
- Imtihon (test, yozma yoki og‘zaki) savollari har bir savolga necha ball qo‘yilishi o‘qituvchi tamonidan belgilanadi.
- Talabalar sababsiz oraliq nazorat topshirmagan bo‘lsa nol ball bilan baholanadi.

ADABIYOTLAR RO‘YXATI



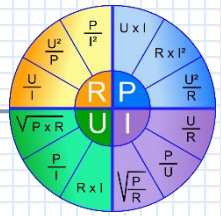
1. А.И.Хонбобоев, Н.А.Халилов. Умумий электротехника ва электроника асослари. -Т.: Ўзбекистон, 2000.- 448 б.
2. Бердиев У.Т. ва Пирматов Н.Б. Электромеханика. Тошкент, “Shams ASA” босмахонаси, 2014 й. -385 б.
3. Иванов И.И., Г.И.Соловьев, В.Я.Фролов. Электротехника и основы электроники. М.: “Лань”, 2012. – 736 с.
4. Основы электротехники и электроники. Под ред. Рекус Г.Г.- М.: Высшая школа, 2005.-287 с.
5. Погодин Д.В., Насырова Р.Г., Краев В.В., Куншина Н.Б.. Электроника: Учебное пособие по дисциплине «Электротехника и электроника». Казань, Изд-во Казан. гос. техн. ун-та, 2010. 254с. - 0.9 экз. на студента
6. Allan R.Hambley. Electrical Engineering. Principles and applications. Fifth edition. Prentise Hall, USA. 2011 – 893 hages.

DARS REJASI



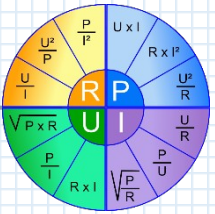
- *1.1. ELEKTROTEXNIKA FANI VA UNING MAQSADI.*
- *1.2. ELEKTR ZANJIRI VA UNING ELEMENTLARI. ENERGIYA MANBALARI.*
- *1.3. OM VA KIRXGOF QONUNLARI.*
- *1.4. ELEKTR ZANJIRLARINI HISOBLASH USULLARI.*

SI sistemasidagi asosiy birliklar



Kattalik		Birlik			
Nomlanishi	O‘lcham belgisi	Nomlanishi		Belgilanishi	
		O‘zbekcha	fransuzcha/inglizcha	o‘zbekcha	xalqaro
Uzunlik	L	metr	mètre/metre	m	
Massa	M	kilogramm[1]	kilogramme/kilogram	kg	
Vaqt	T	soniya	seconde/second	s	
Tok kuchi	I	amper	ampère/ampere	A	
Termodinamik harorat	Θ	kelvin	kelvin	K	
Modda miqdori	N	mol	mole	mol	
Yorug‘lik kuchi	J	kandela	candela	kd	cd

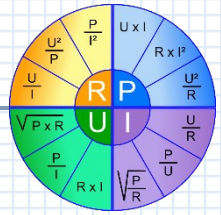
FANNING MAQSADI



Elektrotexnika – Fan va texnikada energiyani o‘zgartirish, materiallar ishlab chiqarish hamda ularga ishlov berish, axborotlarni uzatish va boshqa masalalarni amalga oshirishda elektr va magnit hodisalardan foydalanish bilan shug‘ullanuvchi sohasi hisoblanadi.

Bo'lajak mutaxassislarni elektrotexnika va elektronikadan nazariy va amaliy jihatdan puxta tayyorlab, ishlab chiqarishdagi elektrotexnik jihozlarni oqilona ishlatish, ulardagi avtomatlashtirilgan qurilmalarni malakali ishlata olishga o'rgatishdir. Bu maqsadda elektr zanjirlarni, ulardagi jarayonlarni, zanjirlarni hisoblash usullarini, zanjirlarni yig’ib ishlata bilish, asosiy va yordamchi elektrotexnik qurilmalarning tuzilishi va ishlashini o'rgatishdan iborat.

Elektrotexnika fani

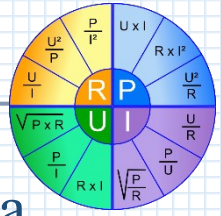


Elektrotexnika fani deb – elektr energiyasi hosil qilib, uni amaliy maqsadlar uchun foydalanish yo‘nalishlarini o‘rganadigan fanga aytiladi. Hozirgi paytda elektr energiyasi ma'lum bo‘lgan barcha energiyalardan farqli o‘laroq sanoatda, transportda, qishloq xo‘jaligida, maishiy xizmatda va xalq xo‘jaligini barcha sohalarida alohida tengi yo‘q o‘rin egallaydi. Bu energiyani ustunlik tomonlari shundaki:

a) uni xohlagan energiya turiga aylantirish mumkin, yoki xohlagan energiyani elektr energiyasiga aylantirish mumkin;

b) eng sodda va arzon moslamalar yordamida elektr energiyasini juda katta tezlik bilan istalgancha miqdorda va xohlagancha uzoq masofalarga uzatish mumkin;

Davomi



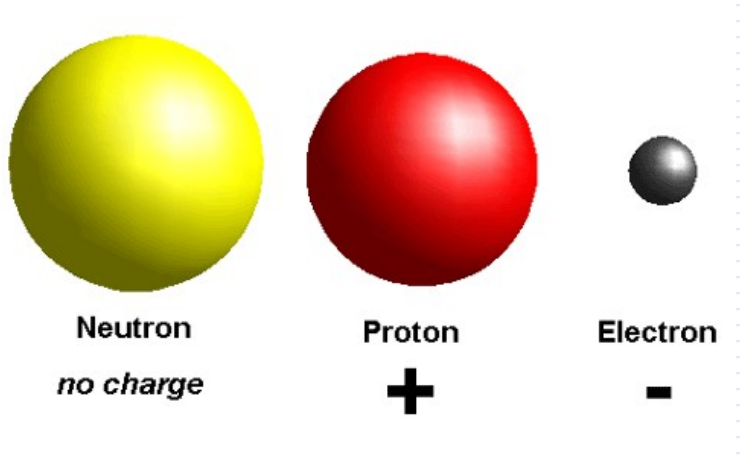
Hozirgi vaqtda sanoatda, transportda va xalq xo’jaligini barcha tarmoqlarida boshqa energiyalar bilan bir qatorda elektr energiyasidan keng ko‘lamda foydalanilmoqda.

Insoniyat bir necha yuz yillar mobaynida har-xil hodisalarni o‘rgana borib, bizni atrofimizni o‘rab turgan bizdan tashqari muhitdan shunday xulosalarni o‘zlariga oldilarki, bizni o‘rab turgan bizdan tashqari barcha narsalar ko‘rinishi, tuzulishi qanday bo‘lishligidan qatiy nazar ular eng sodda elementlardan – atomlardan tuzilgan bo‘ladi. Bir necha atomlar birlashib esa molekulalarni tashkil qiladi. Bir necha molekulalar birlashib esa o‘z navbatida siz va bizga ko‘rinib – ko‘rinmay turgan qattiq, suyuq va gaz holatidagi jismlarni tashkil qiladi.

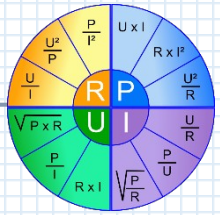
Davomi

Xo‘p shunday ekan, bizdan tashqi muhitdagi narsalar hammasi atomlardan, ya'ni proton va neytronlardan, bitta musbat va bitta manfiy zarrachalardan iborat ekan.

Bir necha protonlar birlashib atom yadrosini, bir necha neytronlar birlashib moddalar elektronlarini tashkil qiladi. Yadro va elektron bu bir butun atom demakdir.



1.2. Elektr zanjiri va uning elementlari. energiya manbalari.



Har qanday elektr qurilmaning tarkibiy qismini **Elektr zanjirlar** tashkil qiladi.

Elektr zanjiri - deb elektr manbai, elektr iste'molchilari va ularni o‘zaro tutashtirib elektr toki uchun yo‘l hosil qiluvchi simlar majmuasiga aytiladi.

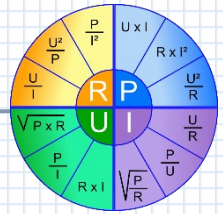
Elektr zanjir tushunchasi elektrotexnika fanining tayanch tushunchasidir.

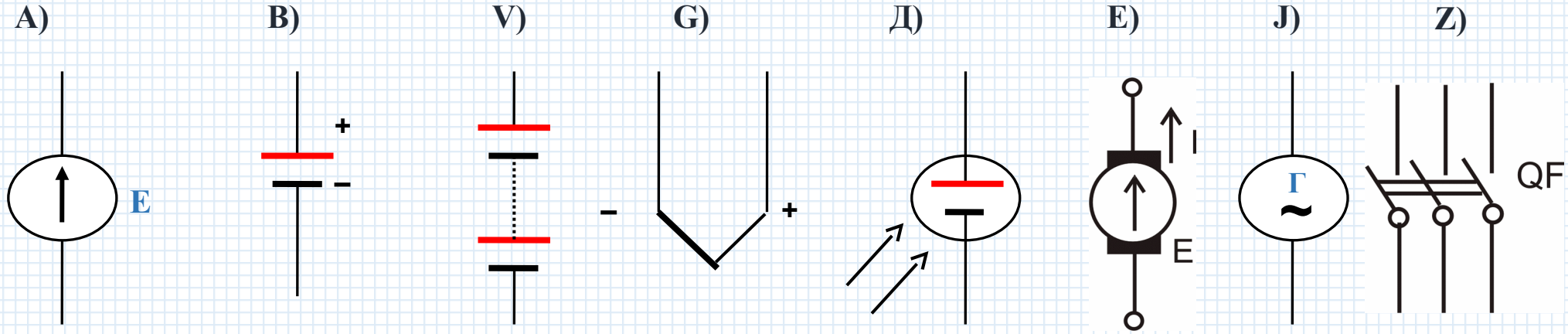
Elektr energiya manbai, iste'molchi va ularni o‘zaro birlashtiruvchi o‘tkazgichlar elektr zanjirning **asosiy** elementlari, o‘lchash asboblari, ulab-uzgichlar va himoyalash qurilmalari esa uning yordamchi elementlari hisoblanadi. Demak, elektr zanjir elementi bu elektr zanjir tarkibiga kiruvchi alohida qurilma bo‘lib, u zanjirda aniq funksiyani bajaradi.

Elektr manbalari 2 turga bo‘linadi:

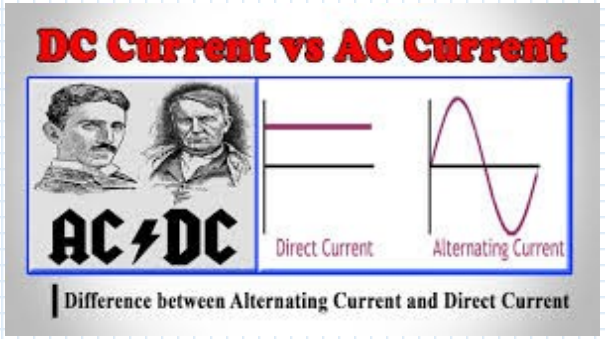
- EYUK manbai;
- Tok manbai.

Elektr energiyasini hosil qiluvchi turli manbalarning shartli belgilanishi.

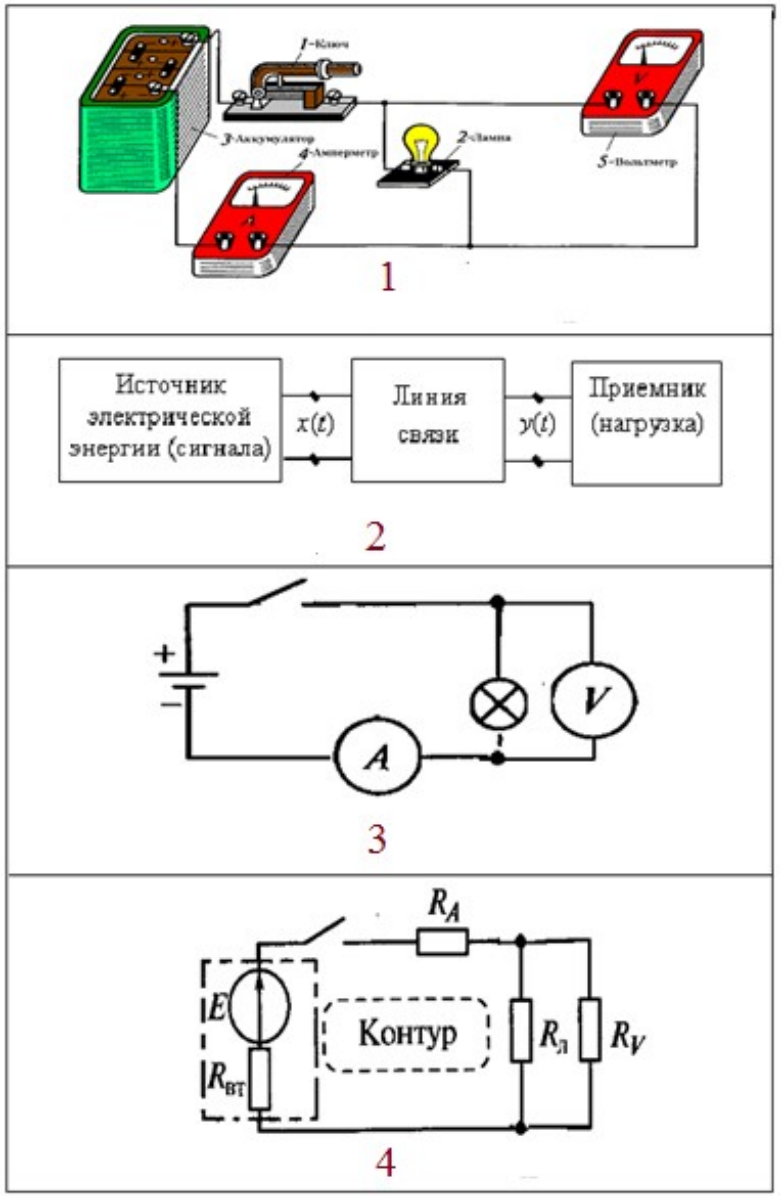




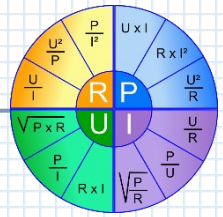
a) – Elektr yurituvchi kuch (EYuK);
b) v) – galvanik elementlar yoki akkumlyator batareyalari;
g)- termoelementlar;
d)- fotoelementlar;
e)- o‘zgarmas tokning elektr mashina generatori;
j)- o‘zgaruvchan tokning elektr mashina generatori
z) – uch fazali ulab - uzgich



Elektr zanjir sxemalari.



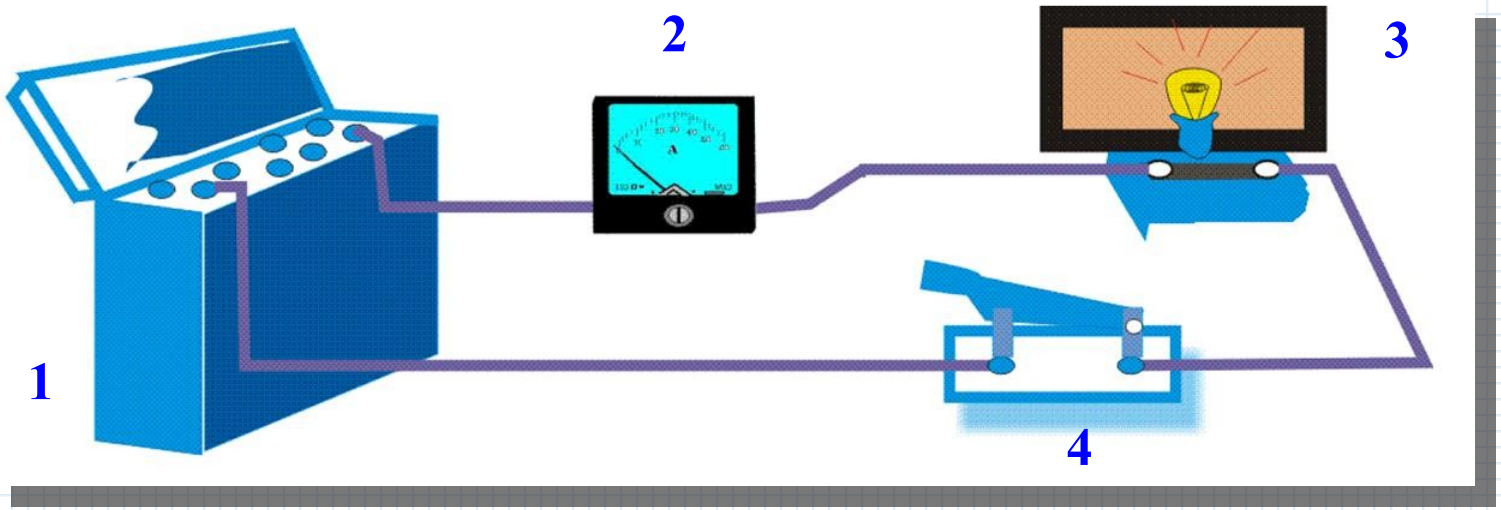
1.Elekt zanjiri
2.Strukturaviy sxemasi
3.Prinsipial sxemasi
4.Almashtirish sxemasi



EYUK manbai – iste'molchi toki o'zgarishi bilan **EYUK** yoki uning qismlari orasidagi kuchlanish o'zgarmaydigan manbadir.

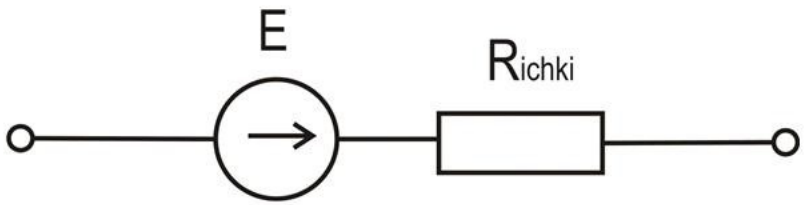
$$R_{ichki} = 0$$

- **Elektr zanjiri**



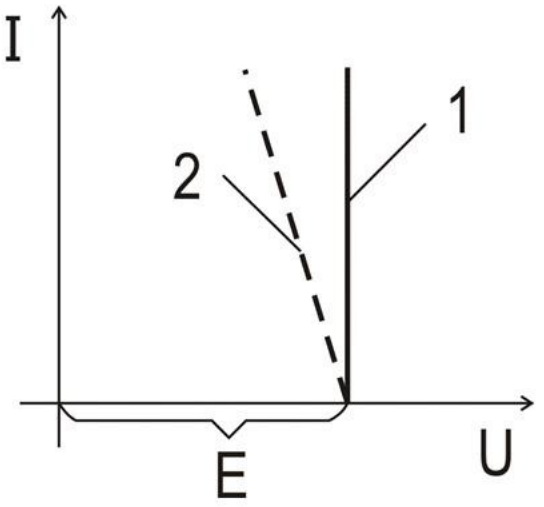
1 - EYUK manbai;
2 - ampermetr;
3 - iste'molchi;
4 - ulab-uzgich (kalit).

EYUK manbai :



1. $R_{ichki} = 0$ **1-rasm.**

2. $R_{ichki} \neq 0$ **real manbalarda.**

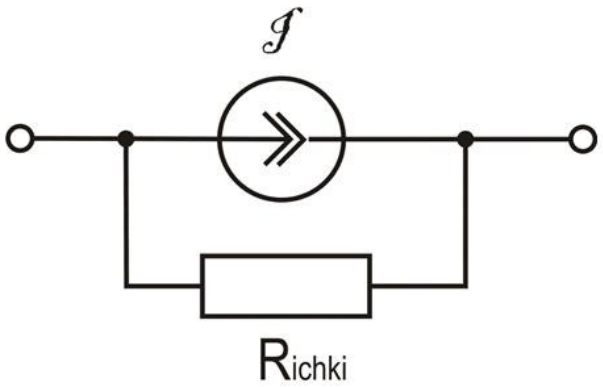


2-rasm.

Tok manbai: Iste'molchi qarshiligi o'zgarishi bilan undan o'tayotgan tok qiymati o'zgarmas bo'ladigan manba tok manbai deyiladi.

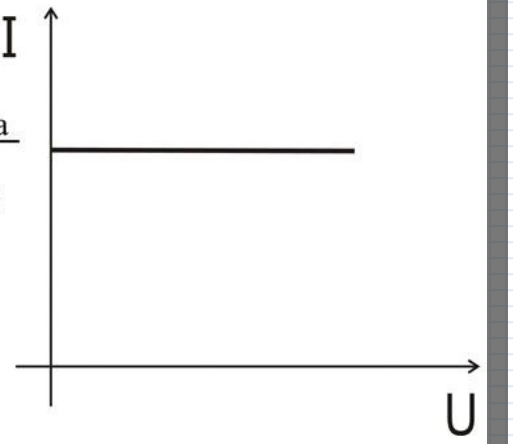
Tok manbaining ichki qarshiligi $R_{ichki} = \infty$

Tok manbai :



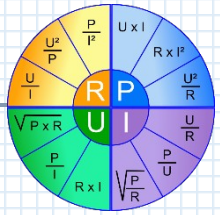
3-rasm.

$$I_{manba} = \frac{E_{manba}}{R_{ichki}}$$



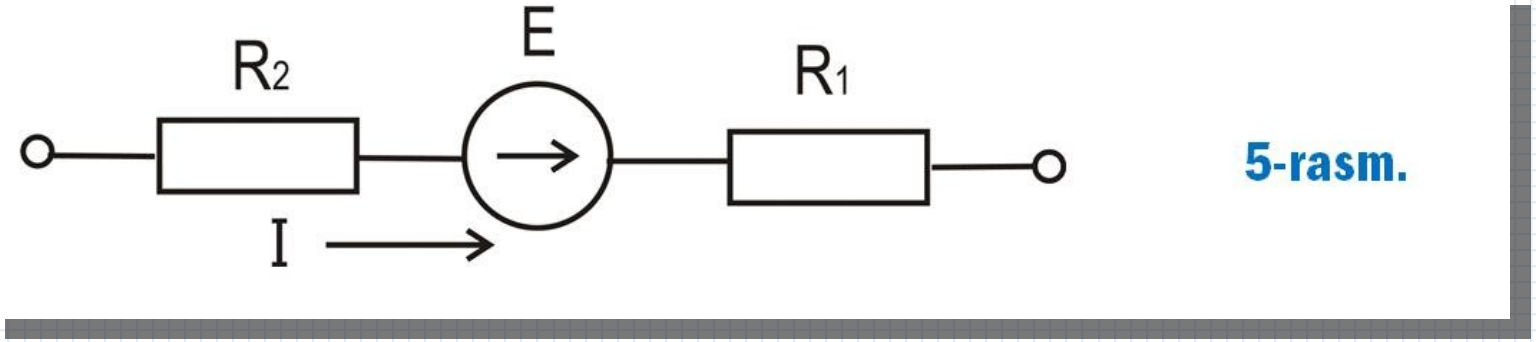
4-rasm.

$$R_{ichki} = \infty$$



•**Elektr zanjiri va uning elementlari:** Elektr zanjirlarini hisoblashda uning ba'zi – bir elementlarini bilish va ularni bir – biridan farqlash zarur.

Tarmoq – bu elektr zanjirlarining bitta yoki bir nechta elementlari ulangan qismi bo'lib ulardan faqat bittayu bitta tok o'tadi.

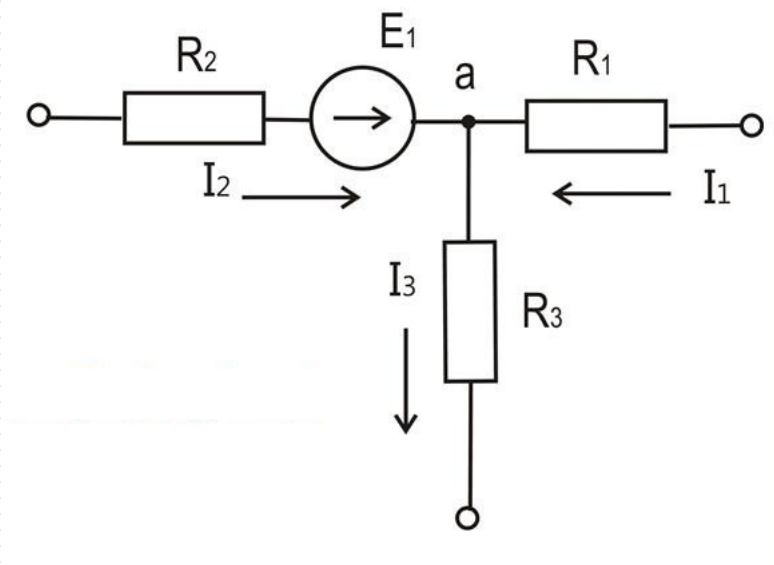


5-rasm.

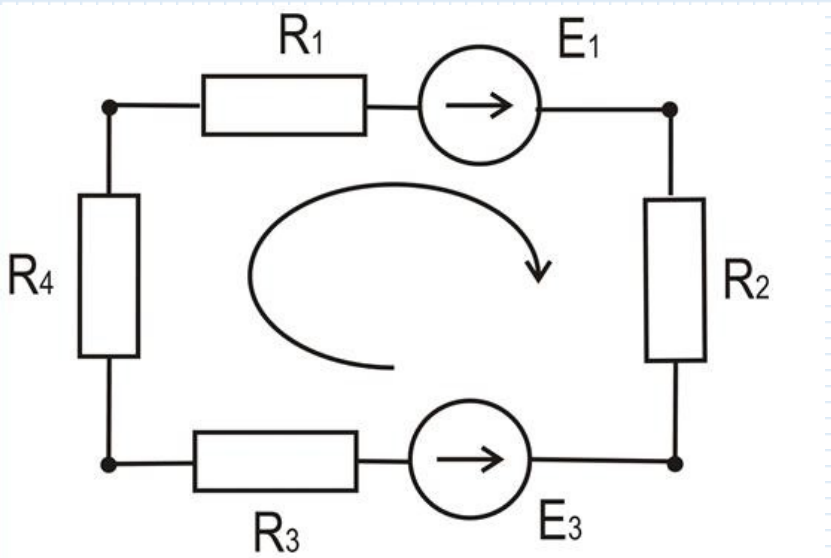
Tugun – bu elektr zanjirlarining uchta yoki undan ortiq tarmoqlari ulangan qismi hisoblanadi.

•**Tugun:** - bir nechta tarmoqlarning birlashgan qismi.

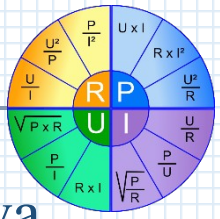
Kontur - elektr zanjirning tarmoqlaridan hosil bo'lgan berk yo'l.



6-rasm.



7-rasm.



•Elektr zanjirlarini hisoblashda ko‘p hollarda zanjir qismlaridagi qarshiliklar va EYUK beriladi va tarmoqlardagi toklarni, zanjirning alohida qismlaridagi kuchlanishlarni hamda quvvatni topish talab etiladi.

•Elektr zanjirlarini hisoblash esa Elektrotexnikaning asosiy qonunlari Om va Kirxgof qonunlariga asoslanadi.

•**Om qonuni:** Berk elektr zanjiridan o‘tayotgan elektr toki EYUK ga to‘g‘ri va zanjirning qarshiligiga teskari proporsionaldir.

$$I = \frac{E}{R + r_и} \qquad (2.1)$$

Bu erda: **I** – tok kuchi (A), **E** – **EYUK** (V), **R** – zanjirning qarshiligi (Om), $\mathbf{r_и}$ – manbaning ichki qarshiligi (Om).

1787-1854

Georg Simon Om

- Nemis fizigi Georg Om 1787-yil tug'ulgan.

U 1826 yilda elektr zanjirlarining asosiy qununini kashf qildi.

- Ammo, dastlab bu qonun bir qator olimlar tomonidan tan olinmadi.

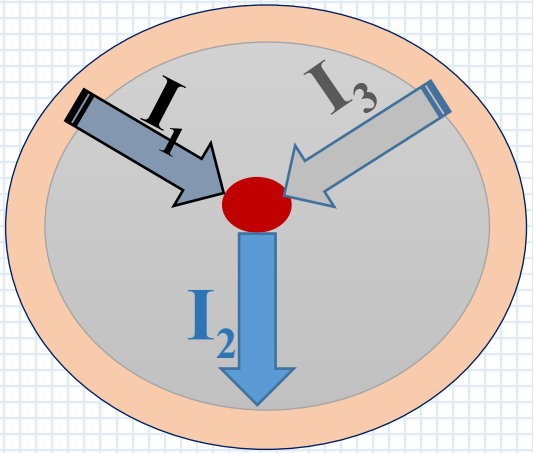
E.X.Lens, B.S.Yakobi, K.Gauss, G.Kirxgof va boshqa olimlarning o'z ilmiy ishlarida Om qonunlarini asos qilib olishganlaridan keyingina bu qonun tan olindi.

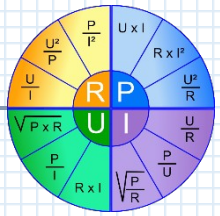
- 1827- yilda tajriba usuli bilan zanjirda EYUK va tok kuchi orasidagi bog'lanishni topdi.
- Elektr qarshiligi sifati Simonning sharafiga Om qabul qilindi

1824-1887

Robert Gustav Kirxgof

- Nemis fizigi Kirxgof 1824 – yilda tavallud topgan.
- U fizikaning elektr, elektrostatika, mexanika, matematik fizika, gidrodinamika, optika bo'limlarida o'z ishlarini amalga oshirib fizika faniga ulkan hissa qo'shgan.
- 1869-yilda ideal suyuqlikdagi qattiq jism harakati to'g'risidagi teoremani kashf qildi.
- Umumiy tok harakatlarining teoremasini kashf etdi.





•**Om qonuni:** Ushbu qonunning fizik mohiyati shundan iboratki, EYUK qancha katta bo'lsa zaryad tashuvchilar energiyasi shuncha ko'p va zaryadlarning tartibli harakat tezligi shuncha katta hamda zanjirdagi tok kuchi shuncha katta demakdir.

•Agar elektr zanjirining qarshiligi orttirilsa zaryad tashuvchilarning harakatiga qarshi harakat ortadi va tok qiymati kamayadi.

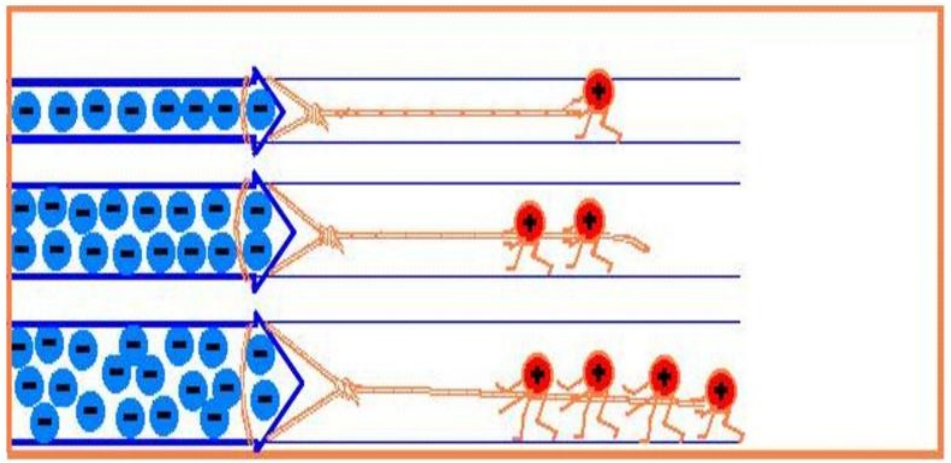
•Om qonunining asosiy ifodasidan quyidagilar kelib chiqadi:

•1. EYUK tok kuchi va qarshilikning ko'paytmasiga teng:

$$E = I(R + r_и) \qquad (2.2)$$

2. Zanjirning barcha qarshiligi EYUK va tok kuchining nisbatiga teng:

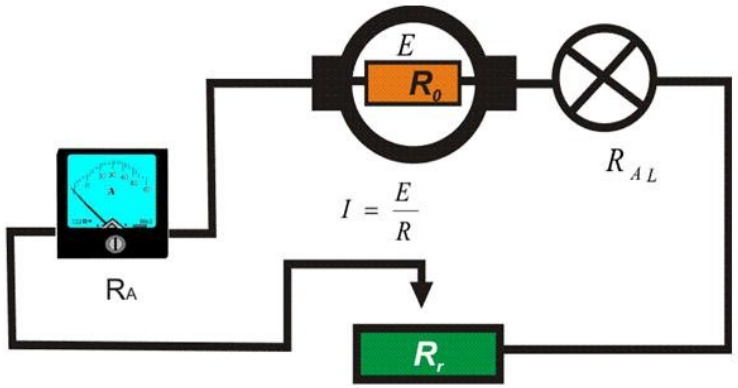
$$R + r_и = \frac{E}{I} \qquad (2.3)$$



8-rasm.

9-rasm.

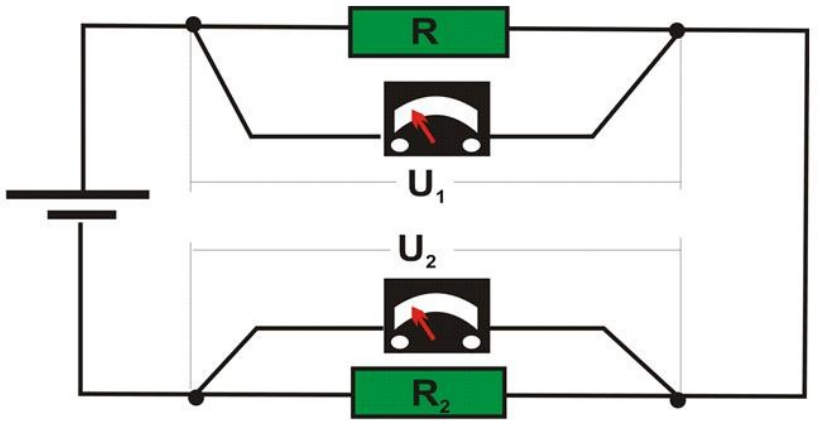
•Agarda uchburchakdagi zanjir qismidagi **U** kuchlanish o’rniga EYUK **(E)** qo’ysak, unda qarshilikni zanjirning to’la qarshiligi **R** deb tushunish kerak.



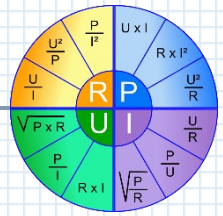
10-rasm.

Butun zanjir uchun Om qonuni

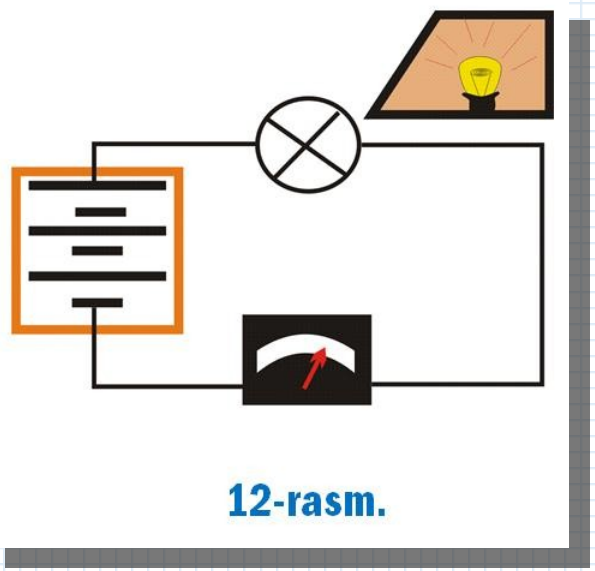
Zanjirning bir qismi uchun Om qonuni



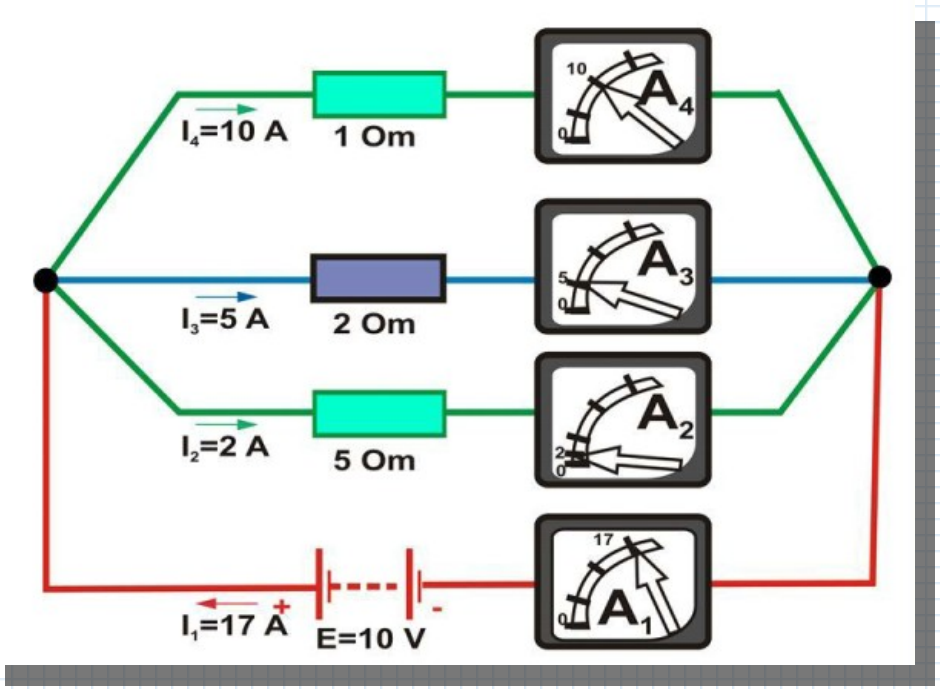
11-rasm.



- **Kirxgof qonunlari:**
- **Gustav Robert Kirxgof** (1824-1887) Germaniyalik nemis olimi. U oddiy elektr zanjirida elektr zaryadlar harakatini, ya'ni manbadan elektr lampagacha va elektr lampadan manbagacha bo'lgan masofada zaryadlar harakatini kuzatdi.

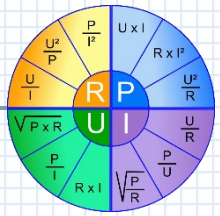


12-rasm.



Kirxgofning 1- qonuni (Toklar qonuni):

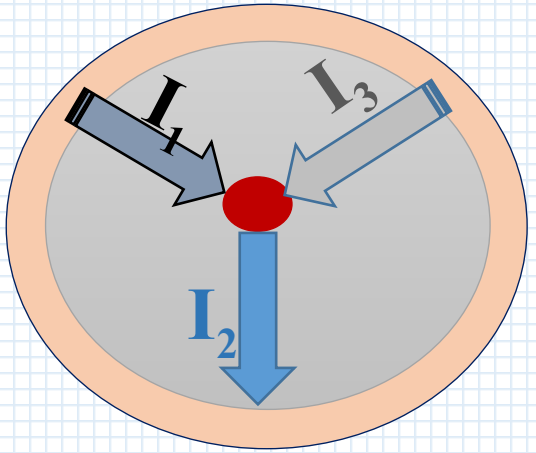
Kirxgofning 1-qonuni tugunga kelayotgan va tugundan chiqib ketayotgan toklarning munosabatlarini belgilaydi. Shunga asosan Kirxgofning 1-qonunining ikkita ta'rifi mavjud. Bu ta'riflar bilan keyingi slaydda tanishamiz.



- **Kirxgofning 1-qonuni:**

- **1-ta’rif:** Tugunga kelayotgan toklar yig’indisi tugundan chiqib ketayotgan toklar yig’indisiga teng:

$$\sum_{i=1}^{m} I_i = \sum_{j=1}^{q} I_j . \qquad (2.4)$$

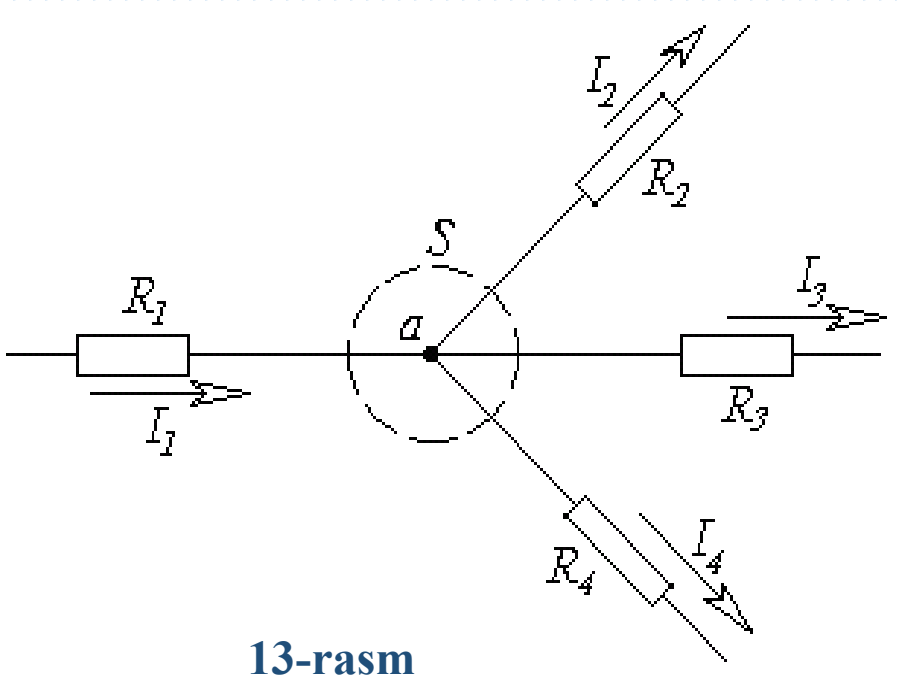


2-ta’rif: Tugundagi toklarning algebraik yig’indisi nolga teng:

$$\sum_{k=1}^{m} I_k = 0 \qquad (2.5)$$

Misol:

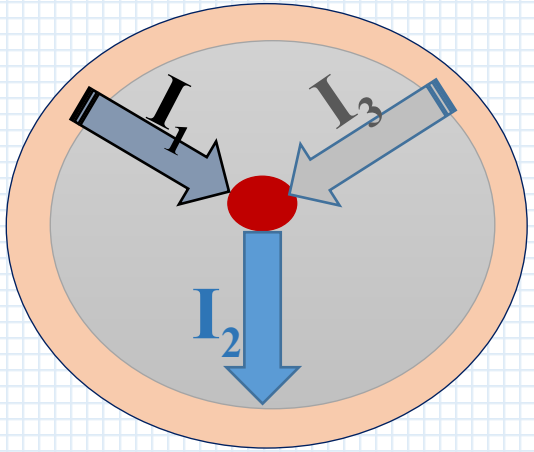
•Quyidagi rasmda elektr zanjirning ***a*** tuguni ko'rsatilgan. Agar ***a*** tugunga kiruvchi toklar musbat ishora bilan olinsa, tugundan chiquvchi toklar ishorasi manfiy olinadi (yoki aksincha).



13-rasm

1-ta'rifga asosan:

$$I_1 = I_2 + I_3 + I_4$$

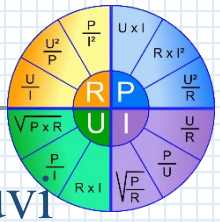


2-ta'rifga asosan:

$$I_1 - I_2 - I_3 - I_4 = 0$$

Izoh: Kirxgof 1-qonunining fizik ma'nosi shundan iboratki elektr zanjirining tugunida zaryadlarning harakati uzluksizdir va unda zaryadlar to'planib qolmaydi.

Kirxgofning 2-qonuni (Kuchlanishlar qonuni):



•Kirxgofning 2-qonuni EYUK va zanjirning barcha qarshiliklarida kuchlanishlar tushuvi o’rtasida bog’liqlikni belgilaydi.

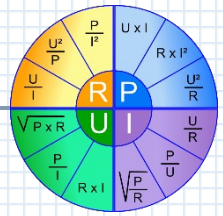
•**Ta’rif:** Zanjirdagi barcha EYUK larning algebraik yig’indisi shu konturdagi qarshiliklarda kuchlanishlar tushuvining algebraik yig’indisiga teng.

$$\sum_{i=1}^{m} E_i = \sum_{k=1}^{n} R_k I_k \qquad (2.6)$$

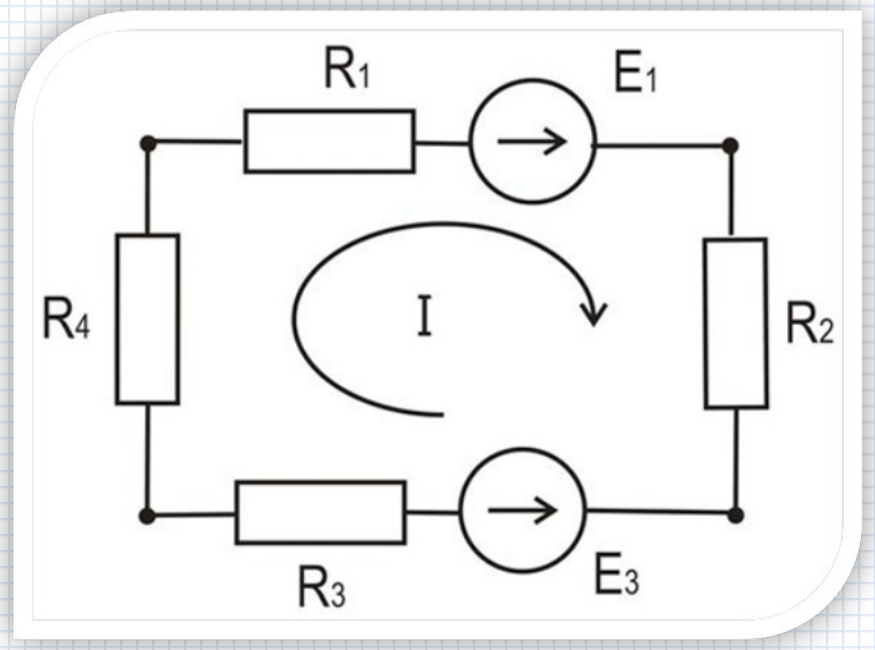
Agar konturni aylanib chiqish yo'nalishi bilan tok yoki **EYUK** yo'nalishi bir xil bo'lsa, u holda yig'indiga tegishli tashkil etuvchilar "**musbat**" ishora bilan, aks holda esa "**manfiy**" ishora bilan kiradi.

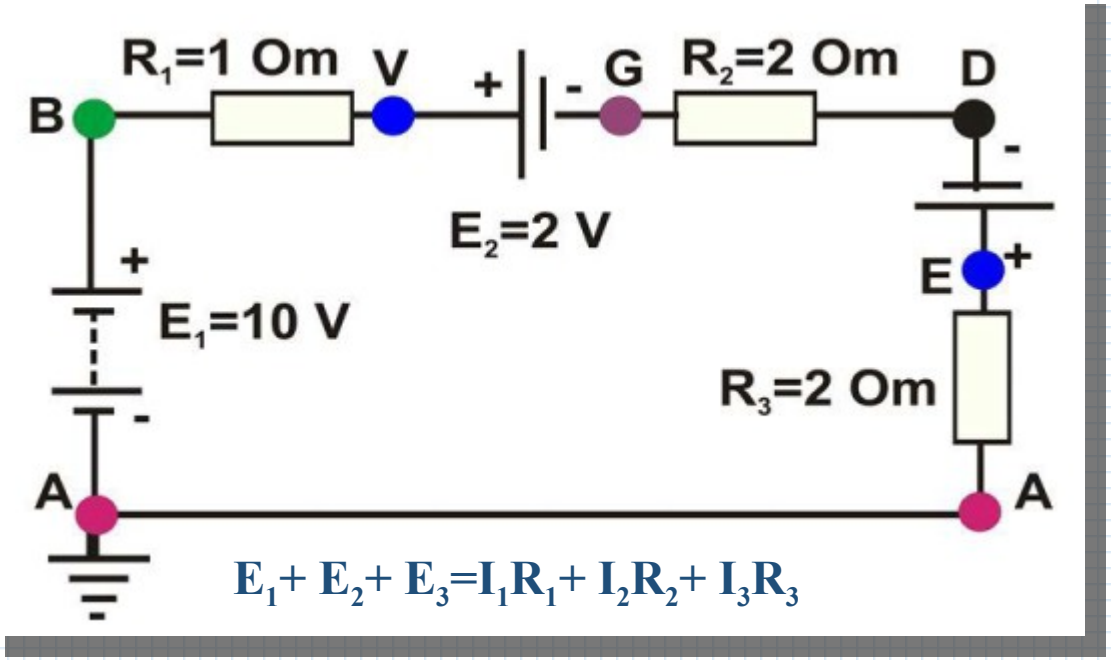
Kirxgofning 2-qonunini boshqa ko'rinishda yozish ham mumkin: zanjirning ixtiyoriy konturida kuchlanishlarning algebraik yig'indisi nolga teng:

$$\sum_{k=1}^{n} U_k = 0. \qquad (2.7)$$



•**Misol:** Quyidagi berilgan zanjir uchun tokni hisoblash ifodasini yozing.



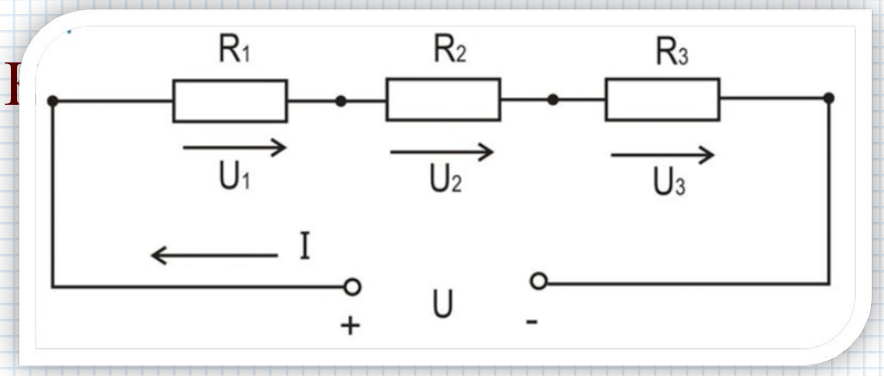


$$I \cdot R_1 + I \cdot R_2 + I \cdot R_3 + I \cdot R_4 = E_1 - E_3$$

$$I = \frac{E1 - E3}{R1 + R2 + R3 + R4}$$

1.4.1. Qarshiliklari ketma-ket ulangan zanjir.

Agar hamma elementlardan bir xil tok (bir xil qiymatga ega) o’tsa bunday zanjirlar ketma-ket ulangan deyiladi (14-rasm).

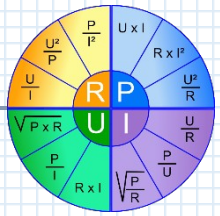


14-rasm

$$U = U_1 + U_2 + U_3$$

$$IR_{ekv} = IR_1 + IR_2 + IR_3$$

Ushbu ifodaning chap va o’ng tomonlarini **I** ga qisqartirsak ketma – ket ulangan elektr zanjirining ekvivalent (umumiy) qarshiligini topish mumkin.



- Om qonuniga asosan elektr zanjiridan o'tayotgan tok:

$$I = \frac{E}{(R_1 + R_2 + R_3)} \qquad \textbf{(2.8)}$$

Yuqorida keltirilgan **(2.8)** ifodaning chap va o'ng tomonlarini **I** ga ko'paytirsak quyidagiga ega bo'lamiz:

yoki

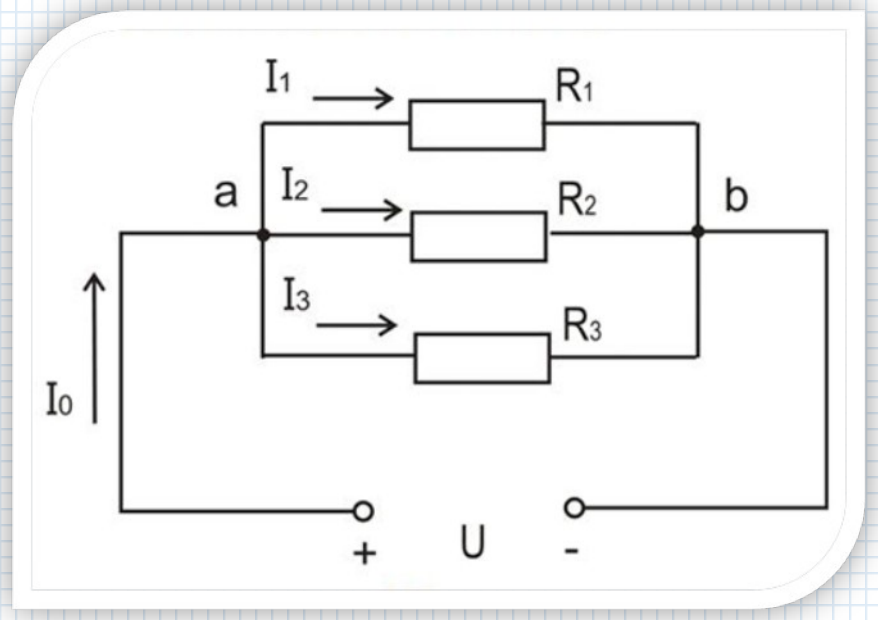
$$IU = IU_1 + IU_2 + IU_3$$

$$P = P_1 + P_2 + P_3 \qquad \textbf{(2.9)}$$

(2.9) ifoda zanjirning **umumiy quvvatini** hisoblash ifodasidir hamda bu ifoda **energiyaning saqlanish qonunini** ifoda etadi.

1.4.2. Qarshiliklari parallel ulangan zanjir.

Agar barcha elementlarining qismlarida bir xil kuchlanish bo'lsa bunday ulangan zanjir parallel ulangan zanjir deyiladi:



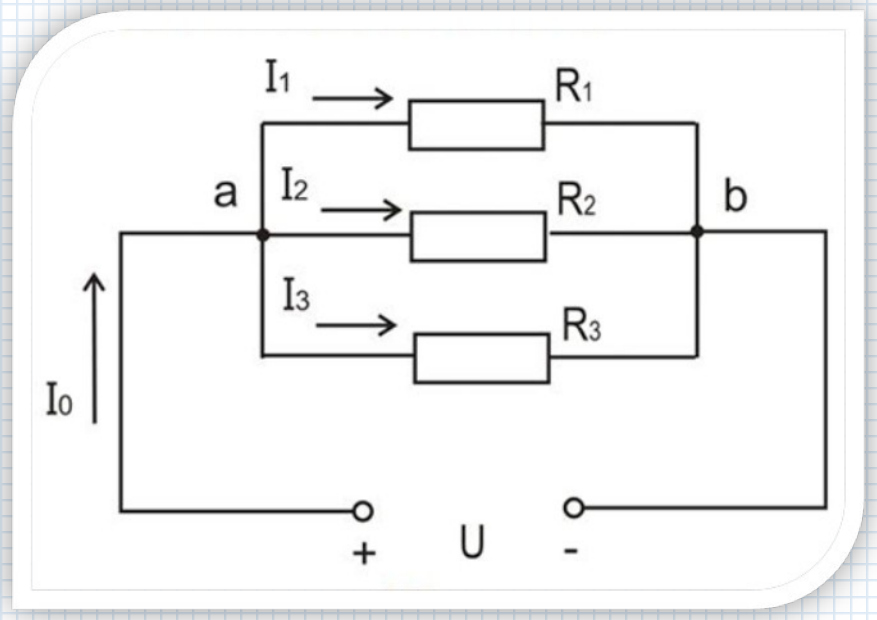
15-rasm

15-rasmda parallel ulangan zanjir keltirilgan. Kirxgofning 1-qonuniga binoan:

$$I_0 = I_1 + I_2 + I_3 \qquad (2.10)$$

yoki **Om** qonuniga asosan:

$$I_1 = \frac{U}{R_1}; \quad I_2 = \frac{U}{R_2}; \quad I_3 = \frac{U}{R_3}$$

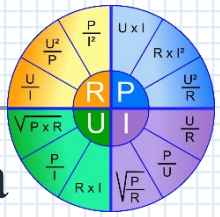


15-rasm

Umumiy tokni esa quyidagi ko'rinishda yozish mumkin:

$$I_0 = \frac{U}{R_{ekv}}$$

$$\frac{U}{R_{ekv}} = \frac{U}{R_1} + \frac{U}{R_2} + \frac{U}{R_3} \quad \text{yoki} \quad \frac{1}{R_{ekv}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} \qquad (2.11)$$



•Yoki qarshilikka teskari bo'lgan kattalik o'tkazuvchanlik deyiladi va quyidagicha yoziladi:

$$G_{ekv} = G_1 + G_2 + G_3 \qquad (2.12)$$

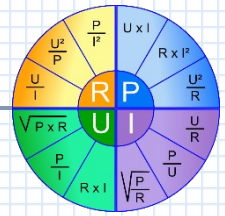
1.4.3. Qarshiliklari aralash ulangan zanjir.

Agar elektr zanjir ketma-ket va parallel ulangan qismlardan iborat bo'lsa bunday zanjirlar **aralash** ulangan deyiladi:

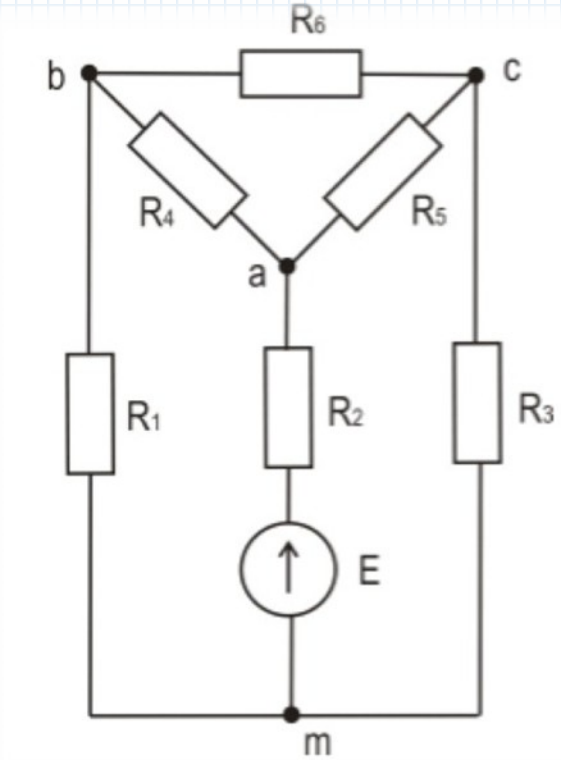
Elektr zanjirida bunday kombinatsiyalar juda ko'p uchraydi. Shuning uchun ekvivalent qarshilikni topishning umumiy shakli yo'q. Bunday zanjirlarni hisoblashda elektr zanjiri **ketma-ket va parallel** qismlarga ajratiladi hamda oldingi bo'limlardagi formulalardan foydalaniladi.

Agar elektr zanjirida bitta energiya manbai bo'lsa bunday zanjir oddiy elektr zanjiri deb ataladi. Bunday zanjirlarda iste'molchilar ketma-ket yoki parallel ulangan hamda bir nechta bo'lishi mumkin. Agar generatorning **EYUK** ichki qarshiligi $\mathbf{r_i}$ va iste'molchilar qarshiliklari ma'lum bo'lsa zanjirning barcha qismlaridagi toklarni **elektr zanjirini o'zgartirish** yoki **proporsional kattaliklar** usullari yordamida hisoblash mumkin.

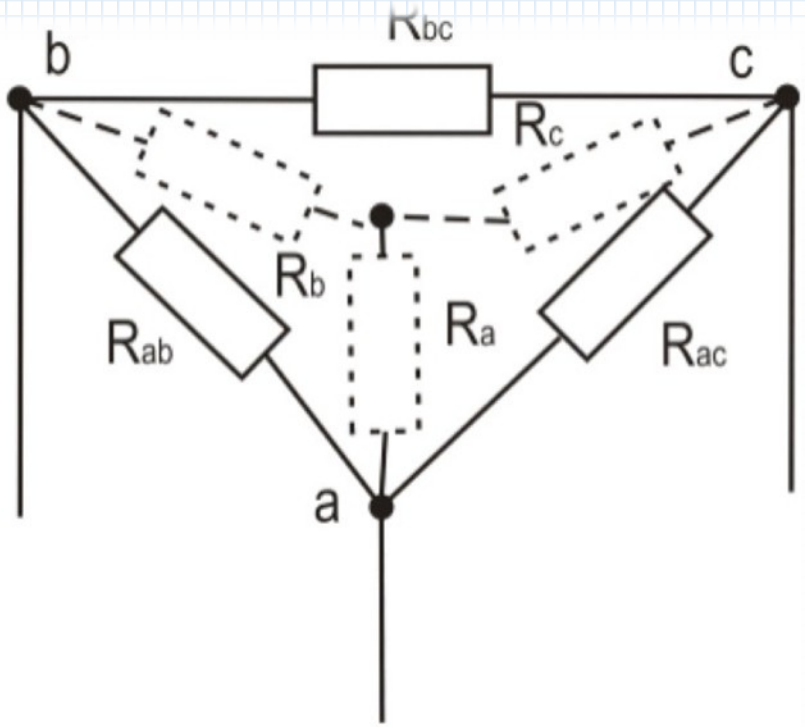
Misol.



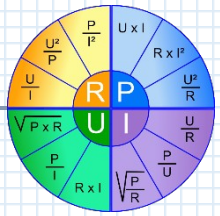
•**Elektr zanjirini o’zgartirish usuli:** Bu usulning mohiyati shundan iboratki ketma-ket yoki parallel ulangan qarshiliklar ekvivalent qarshiliklarga $\mathbf{R_{ekv}}$ almashtiriladi.



16-rasm



17-rasm



•1.4.3. Qarshiliklari aralash ulangan zanjirlar (davomi):

•16-rasmda R_4, R_5, R_6 qarshiliklar o'zaro uchburchak (Δ) sxemada ulangan yoki R_2, R_4 va R_5 lar esa yulduz (Y) sxemasida ulangan. Agar ushbu sxemada **Δ** dan **Y** sxemasig o'zgartirilsa sxema juda soddalashadi.

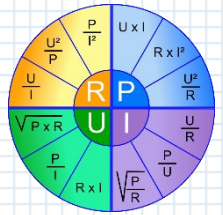
•Uchburchakni (**Δ**) yulduzga (**Y**) o'zgartirish formulalari:

$$R_a = \frac{R_{ab} \cdot R_{ac}}{R_{ab} + R_{bc} + R_{ca}}$$

$$R_b = \frac{R_{ab} \cdot R_{bc}}{R_{ab} + R_{bc} + R_{ca}}$$

$$R_c = \frac{R_{ac} \cdot R_{cb}}{R_{ab} + R_{bc} + R_{ca}}$$

(2.13)



•1.4.3. Qarshiliklari aralash ulangan zanjirlar (davomi):

•Yulduzdan (**Y**) uchburchakka (**Δ**) o’zgartirish formulalari:

$$R_{ab} = R_a + R_b + \frac{R_a \cdot R_b}{R_c}$$

$$R_{bc} = R_c + R_b + \frac{R_c \cdot R_b}{R_a} \qquad (2.14)$$

$$R_{ca} = R_a + R_c + \frac{R_a \cdot R_c}{R_b}$$

Proporsional kattaliklar usuli:

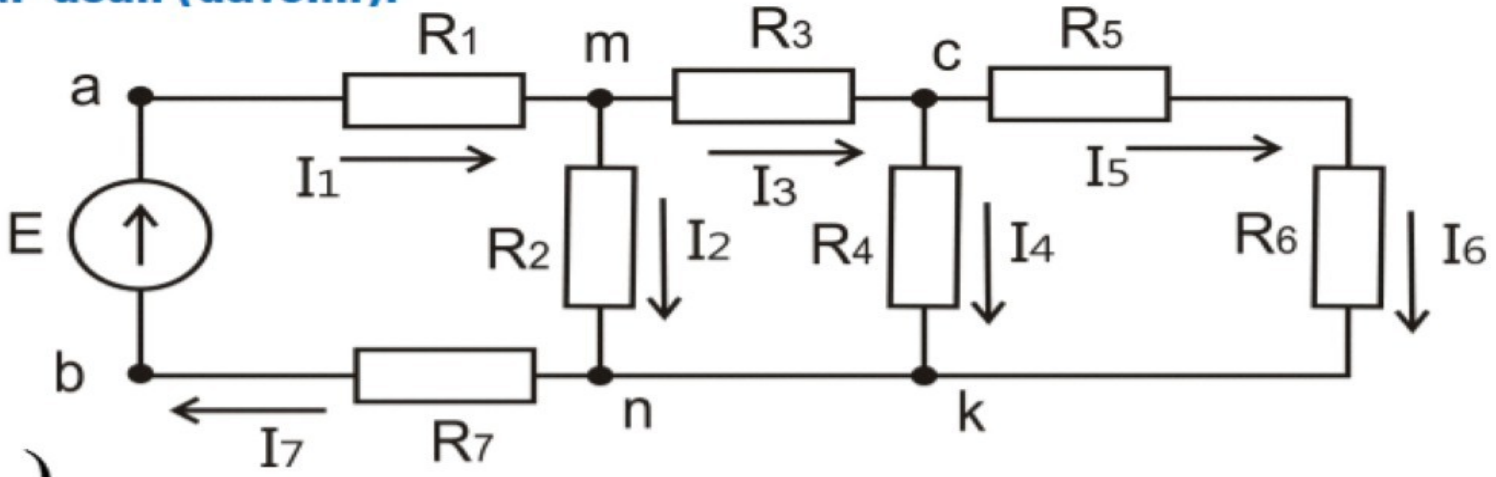
Bu uslning mohiyati shundan iboratki, EYUK manbaidan eng uzoqda joylashgan tarmoqlardan biridagi tok ixtiyoriy ravishda tanlanadi. Keyin esa barcha tarmoqdagi toklar topiladi va shu toklar asosida EYUK ning qiymati **E**□ hisoblanadi. EYUK ning haqiqiy qiymati **E** va hisoblangan qiymati asosida proporsionallik koeffisienti hisoblanadi.

Misol.

Quyidagi elektr zanjiri proporsional kattaliklar usulidan foydalanib hisoblang.

Proporsional kattaliklar usuli (davomi):

21-rasm.



$$I_5 = I_6 = 1A$$

$$U_{ck} = I_5(R_5 + R_6)$$

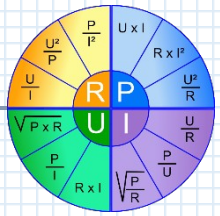
$$I_4 = U_{ck}/R_4 \qquad I_2 = U_{mn}/R_2 \qquad k = E/E`$$

$$I_3 = I_4 + I_5 \qquad I_1 = I_2 + I_3 \qquad I_{1haqiqiy} = k \cdot I_1$$

$$U_{mc} = I_3 \cdot R_3 \qquad I_1 = I_7$$

$$U_{mn} = U_{mc} + U_{ck} \qquad E` = I_1 \cdot R_1 + I_2 \cdot R_2 + I_7 \cdot R_7$$

1.4.4. Murakkab tok zanjirlari va ularni hisoblash usullari



Murakkab elektr zanjiri deb ikkita yoki undan ortiq elektr manbaidan iborat tarmoqlangan elektr zanjiriga aytiladi.

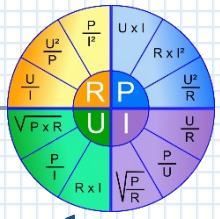
Kirxgof qonunlari yordamida har qanday murakkab zanjirlarni hisoblash mumkin. Buning uchun esa quyidagi tartibga rioya qilish zarur:

1. Berilgan zanjirda tarmoq, tugun va konturlar sonini aniqlash zarur.

2. Barcha tarmoqlardagi toklarga ixtiyoriy yo'nalish beriladi hamda konturlar aylanish yo'nalishi ham tanlanadi (soat mili yo'nalishida yoki unga teskari).

3. Kirxgofning 1-qonuni bo'yicha **n-1** ta tenglamalar tuziladi. Bu erda **n** tugunlar soni. Har qanday tugunga tenglama tuzish mumkin. Ammo shunga e'tibor berish zarurki Kirxgofning 1-qonuni bo'yicha tuzilgan tenglamalar soni tugunlar sonidan 1 ta kam bo'lishi kerak. Haqiqatan har bir tarmoq 2 ta tugunni bog'laydi. Shuning uchun tokning qiymati bitta tugunga + ishora bilan kirsa ikkinchi tugunga – ishora bilan kiradi.

1.4.4. Murakkab tok zanjirlari va ularni hisoblash usullari



4. Zanjirdagi konturlar soni aniqlanadi. Keyin esa **Kirxgofning 2-qonuni** asosida shu konturlarga tenglamalar tuziladi. **Kirxgofning 2-qonuni** asosida tuzilgan tenglamalar soni konturlar soniga teng bo'lishi kerak.

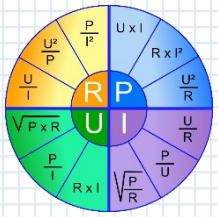
5. Hosil qilingan zanjirning muvozanat tenglamalar sistemasiga son qiymatlar kiritiladi va noma'lumlar har qanday qulay usul bilan topiladi.

6. Musbat ishora bilan topilgan toklar toklarning haqiqiy yo'nalishini belgilaydi. Manfiy ishora bilan topilgan toklar esa ularning haqiqiy yo'nalishiga teskaridir. Bu toklarning haqiqiy yo'nalishi sxemaga kiritilishi lozim.

7. Topilgan natijalar tekshiriladi. Bunda **Kirxgofning 1 va 2- qonunlari** hamda zanjirning quvvatlar balansi tenglamasi tekshiriladi.

Energiyaning saqlanish qonuniga asosan manba quvvatining algebraik yig'indisi iste'molchilardagi quvvatlarning algebraik yig'indisiga teng.

Quvvatlar balansi tenglamasi:



$$\sum_{i=1}^{n} E_i I_i = \sum_{j=1}^{m} I_j^2 R_j \qquad (2.15)$$

Bu ifodada **EYUK** yo‘nalishi va tok yo‘nalishi mos kelsa tenglamadagi quvvat “**musbat**” ishora bilan (generator rejimi – zanjirga energiya beradi), aks holda esa “**manfiy**” ishora bilan (energiya iste’mol qiladi) olinadi.

Agarda elektr zanjirida tarmoqlar soni **3** tadan ortsa tugun va konturlarga tuzilgan tenglamalar sistemasini yechish qiyinlashadi. Bunda elektr zanjirini soddalashtirish asosan 2 ta usulda amalga oshiriladi. Bular **ustma-ustlash** (**superpozitsiya**) va **yordamchi noma’lumlar kiritish** usullaridir.

Ustma-ustlash (**superpozitsiya**) usulida murakkab elektr zanjiri sodda zanjirga o‘zgartiriladi.

Yordamchi noma’lumlar kiritish bu **kontur toklar** va **tugun potensiallar** usulidir. Bu usullarda tarmoqlar sonidan kam bo‘lgan noma’lumlar kiritiladi.

Savollar