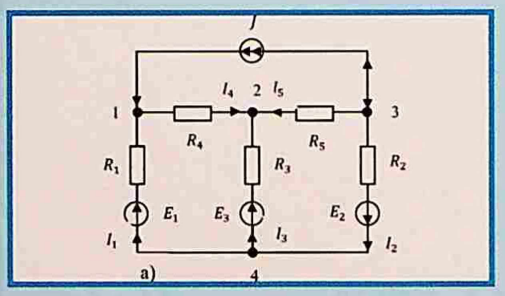
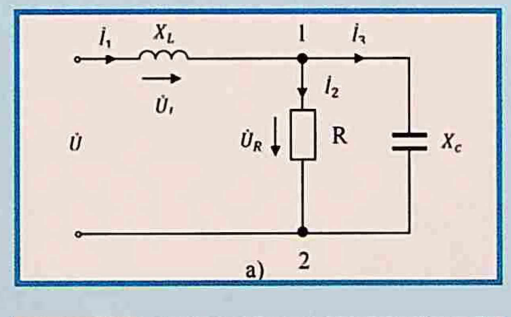
M. IBADULLAYEV, A. TOVBOEV, A. YESENBEKOV

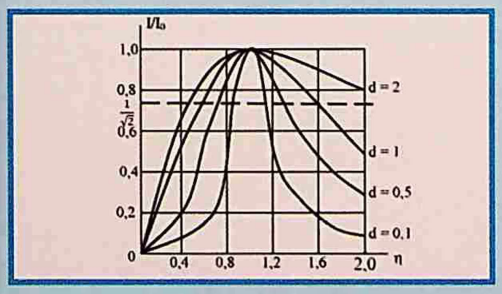
NAZARIY ELEKTROTEXNIKA

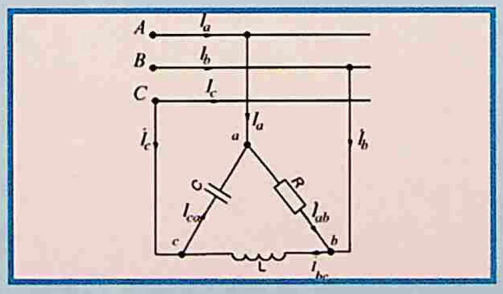
MASALA VA MASHQLAR TO'PLAMI

I - QISM









O‘ZBEKISTON RESPUBLIKASI
OLIY VA O‘RTA MAXSUS TA’LIM VAZIRLIGI

M. IBADULLAYEV, A. TOVBOEV, A. YESENBEKOV

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MASALA VA MASHQLAR TO‘PLAMI

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Oliy va o‘rta maxsus ta'lim vazirligi tomonidan Oliy o‘quv yurtlarining elektroenergetika, elektrotexnika, radiotexnika va boshqa yo‘nalish talabalari uchun o‘quv qo‘llanma sifatida tavsiya etilgan.

«O‘zbekiston xalqaro islom akademiyasi»
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Ushbu o'quv qo'llanma oliy o'quv yurtlarining elektroenergetika, elektrotexnika, elektromexanika, avtomatika, radiotexnika va boshqa yo'nalishlarida ta'lim olayotgan bakalavr talabalar uchun tavsiya etilib, shuningdek magistr, doktorant va soha mutaxassislari ham foydalanishlari mumkin.

O'quv qo'llanma O'zbekiston Respublikasi Oliy va o'rta maxsus ta'lim vazirligining 2020-yil 30-iyundagi 359-sonli buyrug'iga asosan nashr etishga ruxsat berilgan.

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Fanni o'rganishda qoidaga qaraganda misollar foydaliroq bo'ladi.

Isaak Nyuton.

Muqaddima

Mamlakatimiz sanoatining salohiyatini rivojlanishida elektro-energetika sohasining ahamiyati beqiyos bo'lib, uning ilmiy-nazariy asosi bo'lmish nazariy elektrotexnikasiz tasavvur qilib bo'lmaydi.

Umuman olganda, elektrotexnika hamma zamonaviy elektrotexnik soha yo'nalishlari (energetika, avtomatika, elektronika, radiotexnika, aloqa, telekommunikatsiya, informatika va hokazo) uchun fundamental fan tarmog'i hisoblanadi.

O'zbekiston Respublikasi oliy va o'rta maxsus ta'lim vazirligi tomonidan tasdiqlangan o'quv dasturiga asosan «Nazariy elektrotexnika» fanidan ma'ruza amalyot darsi va labarotoriya ishlari rejalashtirilgan bo'lib, talabalar nazarya qismidan olgan bilimlarini chuqurroq o'zlashtirish uchun amaliyot darsida mustaqil masala yecha bilish, hisob grafik ishlarini bajarish va test savollarini yechish natijasida amaliy ko'nikmalarga ega bo'lishadi.

Ushbu o'quv qo'llanma «Nazariy elektrotexnika» fani dasturi asosida tuzilgan bo'lib, chiziqli elektr zanjir qismiga doir talabalar mustaqil yechish uchun misol va masalalar berilib na'muna sifatida yechimlari ko'rsatilgan hamda nazariy bilimlarini sinab ko;rish uchun savollar ham berilgan.

Har bir bobga oid fanning nazariy qismidan elektr zanjirni hisoblash uchun zarur bo'lgan qonun-qoidalar, atamalar, formulalar, tenglamalar, analitik, grafik, kompleks usullar, vektor ifodalari va hisoblash usullari bo'yicha qisqacha asosiy tushunchalar o'z ifodasini topgan.

O'quv qo'llanma elektroenergetika, elektrotexnika, elektro-mexanika, elektrotexnologiya, avtomatika, radioelektronika, telekom-munikatsiya va axborot texnologiya soha yo'nalishlari bo'yicha ta'lim olayotgan bakalavr talabalarga mo'ljallangan bo'lib, undan soha mutaxassislari, magistr va doktorantlar ham foydalanishlari mumkin.

O'quv qo'llanma talabalarga amaliy mashg'ulot darsini o'zlashtirishda mustaqil masalalar yechish, hisob-grafik ishini bajarish, test savollarini yechish va nazariy bilimlarini amalda sinab ko'rishlarida yordam bo'ladi degan umiddamiz. Mualliflar o'quv qo'llanmani nashga tayyorlashda yordam bergan bakalavr talabasi S. K. Matkarimovga samimiy minatdorchiligini bildiradi.

1. O'ZGARMAS TOK ELEKTR ZANJIR

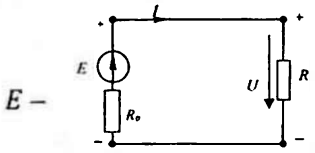
1.1. Umumiy tushunchalar

1. **O'zgarmas tok** – vaqt bo'yicha o'zgarmas bo'lib

$$I = \frac{q}{t}\ (\frac{Kulon}{sek} = A)$$

O'zgarmas tok manbalari: o'zgarmas tok generatori, akkumulator, galvanik elementlar, foto-elementlar, termopara, pyezodatchik va hokazolar elektr yurituvchi kuch (EYK) manbai hisoblanadi.

Amalda mexanik, kimyoviy, issiqlik, shamol, yorug'lik va boshqa xildagi energiyani elektr energiyasiga aylantirish bilan **elektr manbai** hosil qilinadi. Hosil qilingan elektr energiyasini iste'molchilarga uzatish liniyasi, kabel simlari va elektromagnit to'lqin orqali yetkaziladi. Bunday bog'lanishni elektrotexnikada **berk elektr zanjir** deyilib, quyidagi sxema ko'rinishida ifodalash mumkin.



E – manba EYK

I – tok

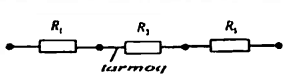
U – istemolchi kuchlanishi

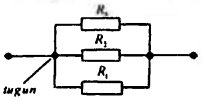
R – iste'molchi qarshiligi.

R_0 – manba ichki qarshiligi

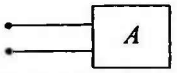
Iste'molchilarda elektr energiyasi boshqa xildagi energiyaga o'zgartiriladi (mexanik, issiqlik, yorug'lik, kimyoviy va hakozolar).

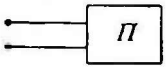
Elektr zanjirlar tarmoqlangan va tarmoqlanmagan bo'lib, iste'molchilarni birlashtiruvchi simlar **tarmoq** (shoxobcha) va uchtadan ko'p shoxobchani birlashtiruvchi nuqtalar – **tugun** deb ataladi.





Ikki qutbli elektr zanjir ***aktiv*** yoki aksincha, ***passiv*** bo'lishi mumkin.





Elektr zanjirni hisoblashdan asosiy maqsad, iste'molchilar foydalanyotgan tok, kuchlanish va sarf bo'ladigan elektr energiyasi quvvatini hisoblab topishdan iborat bo'lib, Om va Kirxgof qonunidan foydalaniladi.

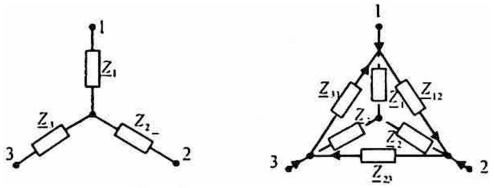
Passiv elektr zanjir parametrlari o'zaro ketma-ket, parallel, aralash yoki murakkab sxemalar ko'rinishida ulanishi mumkin:

Masalan: a) zanjirning R qarshiligi sxemada ketma-ket ulangan bo'lsa, (ekvivalent) umumiy qarshiligi: $R_{ekv} = \sum_{n=1}^{n=\infty} R_n$ –ya'ni **qarshiliklari qo'shiladi**:

b) parallel ulangan holda ekvivalent qarshilik $G_{ekv} = \frac{1}{R_{ekv}} = \sum_{n=1}^{n=\infty} G_n$ bo'lib, **o'tkazuvchanliklari qo'shiladi**:

c) qarshiliklar o`zaro uchburchak (rasm) yoki yulduzcha shaklidagi sxemalarda ulangan yoki aksincha bo'lsa ekvivalent qarshiliklarini topishda quyidagi formulalardan foydalanish mumkin. Yulduzcha va uchburchak tarzida ulangan tarmoqlarni o'zaro almashtirish (ekvivalent parametrlar):

a) uchburchak shaklida ulangan qarshiliklarni yulduzcha shaklida almashtirish tenglamalari:



$$Z_1 = \frac{Z_{31} \cdot Z_{12}}{Z_{12}+Z_{31}+Z_{23}};\quad Z_2 = \frac{Z_{12} \cdot Z_{23}}{Z_{12}+Z_{23}+Z_{31}};\quad Z_3 = \frac{Z_{23} \cdot Z_{31}}{Z_{12}+Z_{23}+Z_{31}};$$

b) yulduzcha shaklidan uchburchak shakliga almashtirish tenglamalari:

$$Z_{12} = Z_1 + Z_2 + \frac{Z_1 \cdot Z_2}{Z_3};\quad Z_{23} = Z_2 + Z_3 + \frac{Z_2 \cdot Z_3}{Z_1};$$

$$Z_{31} = Z_3 + Z_1 + \frac{Z_1 \cdot Z_3}{Z_2};$$

d) Murakkab sxemalardagi ekvivalent qarshiliklarni hisoblashda ketma-ket soddalashtirish usulidan foydalaniladi.

2. Elektr kuchlanish yoki **potensiallar farqi** deb, elektr maydon E (manba) ta'sirida biror musbat q zaryadning l masofaga ko'chirilishida bajarilgan ishga aytiladi va ***Volt*** da o'lchanadi.

$$U_{ab} = \frac{A}{q} = \int_a^b E dl = \varphi_a - \varphi_b \ (V) \qquad (1.1)$$

Masalan: R – qarshilikdagi kuchlanish potensiallar ayirmasiga yoki manba kuchlanishiga teng:

Bunda:

$\varphi_a - \varphi_b = U_{ab} = IR$; yoki $\varphi_b - \varphi_a = U_{ba} = E$; $U_{ba} = -U_{ab}$

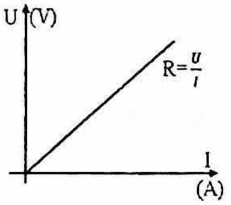
3. Elektr zanjir uchun Om qonuni.

Aktiv R qarshiligi bo'lgan zanjirning bir qismi uchun Om qonuni:

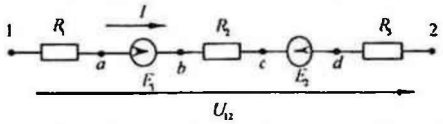
$$U_{ba} = U = RI\ (V) \text{ yoki } I = \frac{U}{R}\ (\text{A}) \qquad (1.2)$$

Bundan:

$$R = \frac{U}{I}(\text{Om}) \text{ yoki } g = \frac{1}{R} = \frac{I}{U}\left(\frac{1}{Om} - \text{ Simens}\right) \qquad (1.3)$$



U holda qarshilik $\boldsymbol{volt - amper}$ xarakteristikasi $I = f(U)$ chiziqli o'zgaradi.



Elektr zanjirga manba ulangan holda butun zanjir uchun Om qonuni quyidagicha tenglama bilan ifodalanadi. Potensiallar tenglamasiga asosan:

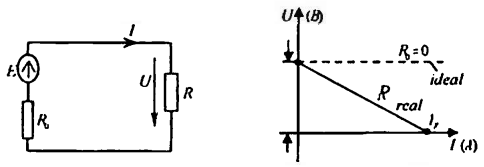
$$\varphi_d = \varphi_2 + R_3 I\ ,\ \varphi_C = \varphi_d + E_2, \varphi_v = \varphi_C + R_2 I, \varphi_a = \varphi_v - E_1, \varphi_1 = \varphi_a - R_1 I$$

yoki: $$\varphi_1 = \varphi_2 + R_1 I + E_1 + R_2 I - E_2 + R_3 I, \varphi_1 - \varphi_2 = U_{12}$$
$$U_{12} = (R_1 + R_2 + R_3)I + E_1 - E_2$$

Bundan: $$I = \frac{E_1 - E_2 + U_{12}}{R_1 + R_2 + R_3} = \frac{E_1 - E_2 + U_{12}}{\sum R_{um}} \qquad (1.4)$$

4. Elektr manbalar ekvivalent o'xshashlik sxemalari.

Amalda elektr zanjir tashqi *Volt-Amper* xarakteristikasi $U(I)$ quyidagicha ifodalaniladi:



Ushbu zanjirdan o'tuvchi tok: $I = \frac{E}{R_0+R}$ yoki: $U = RI$

Kirxgof 2-qonuniga asosan:

$$R_0 I + RI = E \quad \text{yoki} \quad U = E - R_0 I \tag{1.5}$$

$Volt - Amper$ xarakteristikasidan, ya'ni (1.5) tenglamadan: $E = const$ va $R_0 = const$ xarakteristikasi to'g'ri chiziqli bo'lib, kuchlanish manbai tashqi xarakteristikasini $U(I)$ ifodalaydi:

a) salt holatda: $R = \infty, I = 0$ bo'lib: $U = U_0 = E$ (1.6)

b) qisqa tutashtirilganda: $R = 0, U = 0$ bo'lib: $I = I_K = \frac{E}{R_0}$ (1.7)

$R_0 = 0$ bo'lganda esa ideal kuchlanish manbai bo'lib:

$U = E = const$

Ushbu sxemani iste'molchi qarshiligiga nisbatan boshqa ko'rinishga keltirish mumkin. Buning uchun (1.5) tenglamadan manba ichki qarshiligi R_0 ga bo'lib yuborilsa:

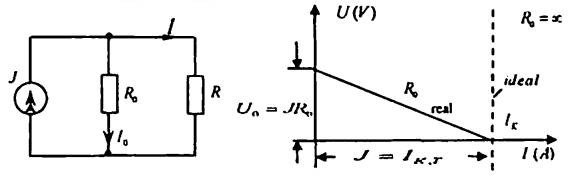
$$\frac{U}{R_0} = \frac{E}{R_0} - I \tag{1.8}$$

(1.7) tenglamaga asosan:

$$I_K = \frac{U}{R_0} = J \ va \ \frac{U}{R_0} = I_0 \quad \text{yoki} \quad I_0 = J - I \tag{1.9}$$

Bundan: $J = I_0 + I$ **tok manbai** bo'ladi, yoki: $I = J - \frac{U}{R_0}$ (1.10)

(1.10) tenglamaga asosan tok manbai (energiya) ekvivalent sxemasi va tashqi xarakteristikasi quyidagicha ifodalanadi:



Tok manbai tashqi xarakteristikasi:

a) salt holatda: $R = \infty, I = 0$ yoki $\dot{J} = I_K = \frac{U}{R_0}$;

$$U = U_0 = I_K R_0 = E$$

b) qisqa tutashuvda: $R = 0;\ U = 0$ yoki $I = I_K = \dot{J} = \frac{U}{R_0}$.

Agar $R_0 = \infty, (g_0 = 0)$ bo'lsa, ideal tok manbai bo'ladi: $\dot{J} = I = const$.

Natijada elektr zanjirni hisoblashda ideal EYK manbaini ekvivalent tok manbaiga almashtirish yoki aksincha amalga oshirish mumkin bo'ladi.

Masalan: berilgan sxemada EYK manbai $E = 12\ V$ ichki qarshiligi $R_0 = 2\ Om$. Tok manbaining ekvivalent sxemasi tuzilsin:

Yechish. Om qonuniga asosan tok manbai qiymatini aniqlaymiz:

$$\dot{J} = \frac{E}{R_0} = \frac{12}{2} = 6\ A$$

Ekvivalent sxemasi quyidagicha ifodalanadi:

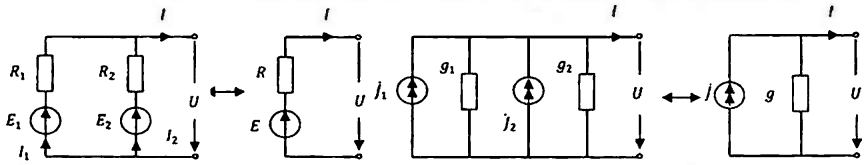
Bunda EYK manbai E bilan tok manbai $\dot{J}$ yo'nalishi bir xil bo'ladi hamda ekvivalent sxemaga almashtirilganda tashqi qarshilik qiymati o'zgarmaydi. Ammo quvvat har xil bo'lishi mumkin.

Masalan. Elektr sxemada tok manbai $J = 10A$, ichki qarshilik $R_0 = 3\ Om$ bo'lganda ekvivalent EYK manbai sxemasi tuzilsin.

Yechish. EYK manba kuchlanishi $E = J R_0 = 10 \cdot 3 = 30\ V$

Eslatma: Keyinchalik ekvivalent sxemaga o'tishda manba ichki qarshiligi yoki o'tkazuvchanligini iste'molchilar tashqi qarshiligi yoki o'tkazuvchanligi bilan hisobga olamiz ($R_0 = 0,\ g = 0$). EYK manba bilan tok manbaini yoki aksincha almashtirilganda tashqi qarshilikga ta'siri bo'lmaydi, lekin manbadan chiquvchi elektr quvvat turlicha bo'lishi mumkin.

Masalan: Ikkita *EYUK* bo'lgan parallel zanjirni, yoki tok manbaidan iborat zanjirlarni ekvivalent sxema bilan almashtiramiz:



a) $E = \frac{E_1 y_1 + E_2 y_2}{y_1 + y_2}$; $z = 1 : y_1 + y_2$ b) $J = J_1 + J_2 \quad g = g_1 + g_2$

Bunda: $I = \frac{E}{R} = \frac{E_1 + E_2}{\sum R}$ $yoki\, I = I_1 + I_2 = E_1 g_1 + E_2 g_2 = \sum Eg$

$g = \frac{1}{R} - o'tkazuvchanlik.$ Demak *EYUK* manba bilan tok manbai bo'lgan sxemalarning ekvivalent o'xshashlik tenglamasi:

$$E = \frac{J}{g} = \frac{J_1 + J_2}{g_1 + g_2} = \frac{E_1 g_1 + E_2 g_2}{g_1 + g_2} = \frac{\sum_{k=1}^{n} E_k g_k}{\sum_{k=1}^{n} g_k}; \qquad (1.11)$$

qarshilik $R_{um} = \frac{1}{g_1 + g_2}$

5. Elektr zanjirni hisoblashda Kirxgof qonuni.

Kirxgof qonun elektr zanjirni hisoblashda asosiy qonun bo'lib, barcha hisoblash usullarining negizi hisoblanadi.

Kirxgof qonuniga asosan p-tarmoq q-tugundan tashkil topgan elektr zanjirni hisoblab, tarmoqdagi tok uchun $K = p - (q - 1)$ tuzilgan tenglamani yechish bilan bajariladi.

Kirxgof I-qonuni: $\sum_{k=1}^{n} I_k = 0$ – tarmoqdagi toklar algebraik yig'indisi nolga teng.

Kirxgof II-qonuni: $\sum_{k=1}^{n} E_k = \sum_{k=1}^{n} R_k I_k$– kontur EYK algebraik yig'indisi shu konturga kiruvchi qarshilikdagi kuchlanishlarning algebraik yig'indisiga teng.

6. Elektr zanjirlarida quvvat muvozanat tenglamasi.

Elektr zanjirda energiya muvozanatlanishi qonuniga asosan: manba elektr quvvati iste'molchilarda sarf bo'ladigan elektr quvvatga teng bo'ladi.

$$\sum_{k=1}^{n} P_{GEN} = \sum_{k=1}^{n} P_{Manb} \qquad (1.12)$$

yoki $\sum_{k=1}^{m} E_m I_m + \sum_{k=1}^{n} J_n U_n = \sum_{k=1}^{n} I_K^2 R_K = U_k^2 G_k$

Bunda: m – EYK manbalar soni, n – tok manbalari soni k – iste'molchilar soni, U, I – bir xil yo'nalishdagi tok va kuchlanish.

7. Murakkab elektr zanjirlarni matritsa usulida hisoblash.

Murakkab tok zanjirlari uchun Kirxgof va Om qonunlariga asosan tuzilgan tenglamalarni yechishda algebraik matritsa usulini qo'llash hisoblash jarayonini ancha soddalashtiradi, ayniqsa, elektron hisoblash mashinalaridan foydalanilsa oson kechadi.

Masalan: n – konturdan iborat zanjir tenglamasi:

$R_{11}I_1 + R_{12}I_2 + \ldots\ldots\ldots + R_{1n}I_n = E_{11}$

$R_{k1}I_1 + R_{k2}I_2 + \ldots\ldots\ldots + R_{kn}I_n = E_{kk}$

$\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots$

$R_{n1}I_1 + R_{n2}I_2 + \ldots\ldots\ldots + R_{nn}I_n = E_{nn}$

yoki qisqacha: $\sum_{i=1}^{n} R_{ki}I_i = E_{kk}(k = 1 \div n)$

Bunda: I_i-kontur toklar qiymatlari E_i - EYUK qiymatlari

$R_{ki} - parametrlar\ qiymatlari\ \ n - tenglamalar\ soni$

Ixtiyoriy son qiymatlardan iborat (berilgan yoki noma'lum bo'lgan) guruhni matritsaviy ustunli tenglama ko'rinishida ifodalaymiz:

$$I = \begin{bmatrix} I_1 \\ \vdots \\ I_n \end{bmatrix} \quad va \quad E = \begin{bmatrix} E_1 \\ \vdots \\ E_n \end{bmatrix} \quad yoki$$

$$Z = \begin{bmatrix} z_{11} - & z_{12} & \ldots\ldots & z_{1n} \\ -z_{21} + & z_{22} & \ldots\ldots & z_{2n} \\ \ldots & \ldots & \ldots & \ldots \\ -z_{n1} - & z_{n2} & \ldots\ldots & z_{nn} \end{bmatrix}$$

Z –kvadratli matritsa determinant tenglamaga o'xshash bo'lib, zanjir elementlaridan tarkib topgan.

Ushbu kvadrat matritsa Z ni I tok ustuniga ko'paytirsak:

$$Z \cdot I = \begin{bmatrix} Z_{11}I_1 - & Z_{12}I_2 \ldots\ldots & Z_{1n}I_n \\ -Z_{21}I_1 + & Z_{22}I_2 \ldots\ldots & Z_{2n}I_n \\ \ldots\ldots & \ldots\ldots & \ldots\ldots \\ -Z_{n1}I_1 - & Z_{n2}I_2 \ldots\ldots & Z_{nn}I_n \end{bmatrix} = \begin{bmatrix} E_1 \\ E_2 \\ \vdots \\ E_n \end{bmatrix} \quad yoki \quad Z \cdot I = E$$

Tenglamani yechish uchun o'ng va chap tomonini teskari matritsa Z^{-1} ga ko'paytirish natijasida $Z \cdot Z^{-1} = Z^{-1} \cdot Z = 1 - birlamchi\ matritsa\ \Delta$ tenglama hosil qilamiz:

$$Z^{-1} = \frac{1}{\Delta}\begin{bmatrix} \Delta_{11} & \Delta_{21} \dots\dots & \Delta_{n1} \\ \Delta_{21} & \Delta_{22} \dots\dots & \Delta_{n2} \\ \dots\dots & \dots\dots & \dots\dots \\ \Delta_{1n} & \Delta_{2n} \dots\dots & \Delta_{nn} \end{bmatrix}$$

Bu oldingi matritsaning determinant Δ - tenglamasi bo'lib, buning Δ_{ik} –algebraik to'ldiruvchisi : $Z^{-1} \cdot ZI = 1I = I = \frac{E}{Z} = E \cdot Z^{-1}$

Demak tok matritsasini hosil qilish uchun $Z^{-1}ni$ E ustuniga ko'paytirish kifoya qiladi:

$$\begin{bmatrix} I_1 \\ I_2 \\ \vdots \\ I_n \end{bmatrix} = \frac{1}{\Delta}\begin{bmatrix} \Delta_{11}E_1 + & \Delta_{21}E_2 \dots\dots & + \Delta_{n1}E_n \\ \Delta_{21}E_1 + & \Delta_{22}E_2 \dots\dots & + \Delta_{n2}E_n \\ \dots\dots & \dots\dots & \dots\dots \\ \Delta_{1n}E_1 + & \Delta_{2n}E_2 \dots\dots & + \Delta_{nn}E_n \end{bmatrix}$$

Bundan kontur tok qiymatlari ustun qatorlariga mos ravishda:

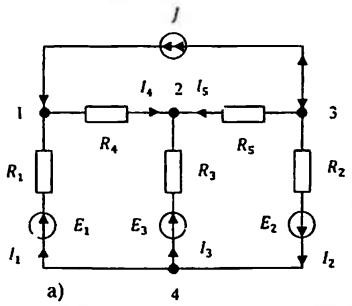
$$I_1 = \frac{1}{\Delta}(\Delta_{11}E_1 + \Delta_{21}E_2 \dots\dots + \Delta_{n1}E_n)$$

Tugun kuchlanish usuliga asosan tuzilgan tenglamalari huddi shu ko'rinishdagi matritsaviy usulda yechish bilan tarmoq toklarini topish mumkin.

$g \cdot U = I$ Kirxgof qonunlariga asosan tuzilgan tenglamalarni yechishda ham matritsa usulidan foydalanish mumkin. Bunda kvadrat matritsa I-qatori Kirxgof qonuniga asosan toklar ustuniga mos elementlar 0,+1 yoki -1 deb olinadi. Keyingi ustunlari Kirxgofning II qonuni asosida tuzilgan tenglama mos tarmoq qarshiliklar koeffitsientini ifoda qiladi.

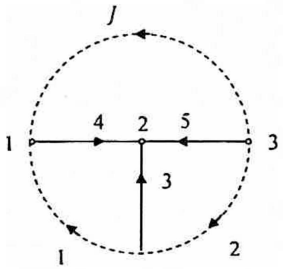
Misol: 5-tarmoq 4-tugun 2-konturdan iborat elektr zanjiri Kirxgof qonunlariga asosan tenglamasini tuzib, matritsa ko'rinishida ifodasini yozing.

Kirxgof qonunlariga asosan tenglama tuzamiz:



1) $-I_1 + I_4 - J = 0$
2) $-I_3 - I_4 - I_6 = 0$
3) $I_2 + I_5 + J = 0$
4) $I_1R_1 + I_4R_4 - I_3R_3 = E_1 - E_3$
5) $I_3R_3 - I_5R_5 + I_2R_2 = E_2 + E_3$

Matritsa ko'rinishidagi ifodasi:



b) Zanjir topologik sxemasi

$$\begin{bmatrix} -1 & 0 & 0 & 1 & 0 \\ 0 & 0 & -1 & -1 & -1 \\ 0 & 1 & 0 & 0 & 1 \\ R_1 & 0 & -R_3 & R_4 & 0 \\ 0 & R_2 & R_3 & 0 & R_5 \end{bmatrix} \cdot \begin{bmatrix} I_1 \\ I_2 \\ I_3 \\ I_4 \\ I_5 \end{bmatrix} = \begin{bmatrix} J \\ 0 \\ -J \\ E_1 - E_3 \\ E_2 + E_3 \end{bmatrix}$$

1.2. Masalalar yechish va uslubiy ko'rsatmalar

1.1-Masala. Aktiv quvvati $P = 400\ Wt$ va kuchlanish $U = 220\ V$ elektr dazmolga uzunligi $l = 10\ m$ teng po'lat sim sarflangan. Po'lat simning kesim yuzasi S va tok zichligi J topilsin. Bunda simning solishtirma qarshiligi $\rho = 0.2 \cdot 10^{-6} om \cdot m$

Yechish: Tok qiymati : $I = \frac{P}{U} = \frac{400}{220} = 1.82\ A$

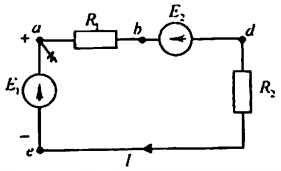
Aktiv qarshiligi : $R = \frac{U}{I} = \frac{U^2}{P} = \frac{220^2}{400} = 121\ om$

Po'lat simning kesim yuzasi : $S = \frac{\rho l}{R} = \frac{0.2 \cdot 10^{-6} \cdot 10}{121 \cdot 10^{-6}} = 0.0165\ mm^2$

Tok zichligi : $J = \frac{I}{S} = \frac{1.82}{0.0165} = 110 A/mm^2$

1.2-Masala. Ketma-ket ulangan elektr zanjirda EYK $E_1 = 4\ V$, $E_2 = 2\ V$, qarshiligi $R_1 = 4\ Om$, $R_3 = 6\ Om$. Tok qiymati va potensiali aniqlanib, diagrammasi tuzilsin.

Yechish. Om qonuniga asosan tokni topamiz:



$$I = \frac{E_1 - E_2}{R_{um}} \frac{4-2}{R_1 + R_2} = \frac{2}{10} = 0{,}2\ A$$

Bunda: $E_1 > E_2$ bo'lganligi uchun tok soat strelkasiga mos yo'nalgan bo'ladi.

Potensiallar farqini aniqlash uchun $\varphi_a = 0$ deb olamiz.

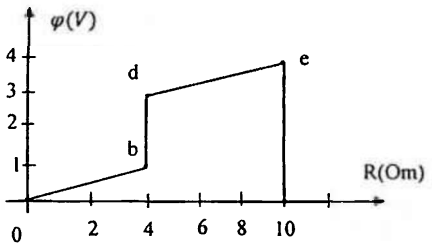
Bunda: $\varphi_b - \varphi_a = R_1 I$ yoki $\varphi_b = \varphi_a + IR_1 = 0 + 0{,}2 \cdot 4 = 0{,}8\ (V)$

φ_d – potensiali: $\varphi_d - \varphi_b = E_2$ *yoki* $\varphi_d = \varphi_b + E_2 = 2{,}8\ (V)$

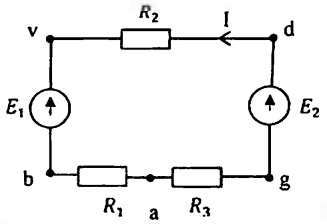
φ_e – potensiali: $\varphi_e - \varphi_d = IR_2$ *yoki* $\varphi_e = IR_2 + \varphi_d = 0{,}2 \cdot 6 - 2{,}8 = 4\ (V)$

$\varphi_a - \varphi_e = -E_1$ yoki: $\varphi_a = -E_1 + \varphi_e = 4 - 4 = 0$

Potensial diagramma chizamiz.



1.3-Masala. Berilagam sxema parametrlari: $E_1 = 10V$; $E_2 = 30V$; $R_1 = 5\ om$; $R_2 = 3om$; $R_3 = 12om$ bo'lganda potensial diagramma tuzulsin.



Yechish: Tok qiymati Om qonuniga asosan:

$$I = \frac{E_2 - E_1}{R_{1+}R_2 + R_3} = \frac{30 - 10}{20} = 1A$$

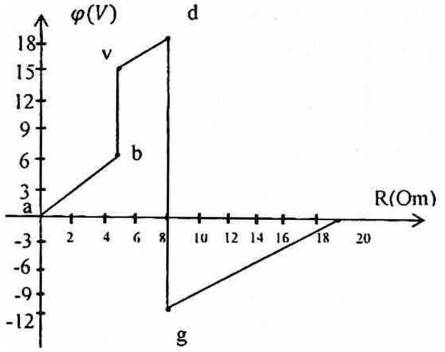
$\varphi_{a=0}$ bo'lganda:

$$\varphi_b - \varphi_a = IR_1;\ \varphi_b = \varphi_a + IR_1 = 0 + 1 * 5 = 5V$$
$$\varphi_v - \varphi_b = E_1;\ \varphi_v = \varphi_b + E_1 = 5 + 10 = 15V$$
$$\varphi_g - \varphi_v = IR_2;\ \varphi_g = \varphi_v + IR_2 = 15 + 1 * 3 = 18V$$
$$\varphi_d - \varphi_g = -E_2;\ \varphi_d = \varphi_g - E_2 = 18 - 30 = -12V$$
$$\varphi_a - \varphi_g = IR_3;\ \varphi_a = \varphi_g + IR_3 = -12 + 1 * 12 = 0$$

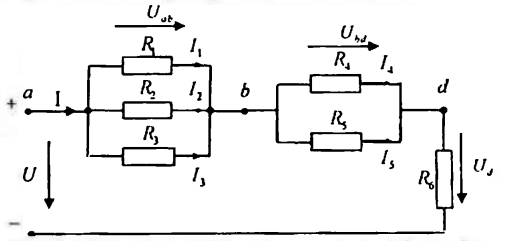
Eslatma: Tugunlardagi kuchlanish manba kuchlanishiga teng.

$$U = \varphi_+ - \varphi_- = E \pm IR_{vm}$$

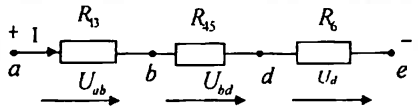
Bu yerda: minus (-) ishora istemolchi ekanligini bildiradi. Plyus(+) ishora generator ekanligini bildiradi .



1.4-Masala. Tarmoqlangan elektr zanjir parametri $R_1 = 40\ Om$, $R_2 = 120\ Om, R_3 = 60\ Om, R_4 = 90\ Om, R_5 = 10\ Om, R_6 = 10\ Om$ bo'lib, $U = 120\ V$ o'zgarmas kuchlanishga ulangan. Ekvivalent qarshilik hamda tarmoqdagi tokni aniqlang.



Yechish. Ekvivalent qarshilik sxemasini chizamiz:



Zanjirning ekvivalent yoki umumiy qarshiligini topamiz.

Buning uchun R_{13} va R_{45} qarshilikni parallel holda qo'shamiz:

$$\frac{1}{R_{13}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} = \frac{1}{40} + \frac{1}{120} + \frac{1}{60} = \frac{6}{120}$$

Bundan: $$R_{13} = \frac{120}{6} = 20\ Om$$

$$R_{45} = \frac{R_4 \cdot R_5}{R_4 + R_5} = \frac{90 \cdot 10}{10 + 90} = 9\ Om$$

Umumiy ekvivalent qarshilik:

$$R = R_{13} + R_{45} + R_6 = 20 + 9 + 11 = 40\ Om$$

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