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"Elektroenergetika" kafedrasi

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# Kasbiy ta’lim fakultetining «Elektroenergetika» yo’nalishidagi talabalar uchun " Elektrotexnikaning nazariy asoslari" fanidan Amaliy ishlarni bajarish uchun USLUBIY KO’RSATMA

Buxoro - 2008 yil

Takrizchi: «Elektroenergetika» kafedrasi
dotstnti. Turdiev M. T.

Ushbu uslubiy kursatma 8 - iyul 2005 yilda «Elektroenergetika» kafedrasida muxokama qilindi (bayonnoma № 17) va Bux.OO va ESTI ning uslubiy kengashi muxokamasiga tavsiya etildi.

Bux.OO va ESTI uslubiy kengashining_____2005 yilgi yigilishida muxokama kilindi va tasdiklandi. Bayonnoma N_____

# Annotatsiya

Ushbu uslubiy kursatma «Elektrotexnikaning nazariy asoslari» fanidan mustaqil ishlarni bajarish uchun uslubiy ko’rsatmalar keltirilgan. Xar bir masalaning echilish namunasi bajarib kursatilgan. Masalalar ENA fanining 1-qismi bo’yicha tanlangan.

# MUSTAQIL ISHLARNI BAJARISH BO'YICHA USLUBIY KO'RSATMALAR.

## 1-MASALA. O'ZGARMAS TOK ZANJIRLARI.

O'zgarmas tok zanjirlari shoxalaridagi toklar bir necha usullar bilan aniklanadi. Jumladan, Kontur toklari usuli, tugun potentsiallari usuli, ustma-ustlash (superpozitsiya) usuli va boshka usullar mavjud. Amalietda sxemani kurinishiga karab ma'lum usul tanlanadi. Masalan, tugunlar soni kam, konturlar soni kup bulsa tugun potentsiallari usuli, aksincha bulsa kontur toklari usuli kullaniladi. Mashinaviy xisoblash usullariga kulay bulgani uchun masalani kontur toklari usulida xisoblaymiz.

Kontur toklari usulida sxemadagi xar bir berk konturdan mustakil kontur toklari okadi deb olinadi. Bu kontur toklari 4 – sxemada kursatilgan.

Boshka konturlarni ta'siri toklarni yunalishiga karab ishoralari belgilanadi. Kontur toklarini yunalishi ixtieriy olinadi. Agar toklar yunalishi notugri olingan bulsa natija teskari ishora bilan chikadi. Biz barcha kontur toklari yunalishini bir xil, ya'ni soat strelkasi yunalishida olamiz (4-rasm.).

Kontur toklari usulida tenglamalar kuyidagicha tuziladi. Kurilaetgan konturning (masalan 1-konturning) toki ($I_{11}$) shu konturning xususiy karshiligi ( $R_{11}$ ) bilan kupaytma shaklida yoziladi. Konturning xususiy karshiligi deb shu konturga bevosita alokador bulgan kashiliklar yigindisi tushuniladi. Masalan, 1-kontur uchun $R_{11}=R_1+R_4+R_6$. Boshka konturlarni ta'siri uzaro umumiy bulgan karshiliklarda utaetgan tok yunalishiga karab aniklanadi. Masalan, $R_4$ va $R_6$ karshilikdan va toklar karama-karshi tomonga o'tadi. SHuning uchun $I_{22}$ va $I_{33}$ kontur manfiy ishorada buladi. Tenglamaning ung tomonida kurilaetgan konturdagi EYUKlarning yigindisi yoziladi. SHunday kilib kontur toklari usulida tuzilga tenglamalar sistemasi kuyidagi kurinishda buladi.

$$I_{11}\cdot(R_1+R_6+R_4)-I_{22}\cdot R_4-I_{33}\cdot R_4=E_1;$$
$$-I_{11}\cdot R_4+I_{22}\cdot(R_2+R_4+R_5)-I_{33}\cdot R_5=E_2; \qquad (1.1.)$$

$$-I_{11}\cdot R_6-I_{22}\cdot R_5-I_{33}\cdot(R_3+R_5+R_6)=E_3;$$

Kuyidagi almashtirishlarni bajaramiz.

$$R_1+R_4+R_6=R_{11};$$

$$R_2+R_4+R_5=R_{22};$$

$$R_3+R_5+R_6=R_{33};$$

$$R_{12}=R_{21}=R_4; \qquad E_{11}=E_1;$$

$$R_{23}=R_{32}=R_5; \qquad E_{22}=E_2;$$

$$R_{31}=R_{31}=R_6; \qquad E_{33}=E_3.$$

Almashtirishlardan sung (1.1) ifoda kuyidagi kurinishni oladi:

$$\begin{aligned} &I_{11}\cdot R_{11}-I_{22}\cdot R_{12}-I_{33}\cdot R_{13}=E_{11};\\ &-I_{11}\cdot R_{21}+I_{22}\cdot R_{22}-I_{33}\cdot R_{23}=E_{22};\\ &-I_{11}\cdot R_{31}-I_{22}\cdot R_{32}-I_{33}\cdot R_{33}=E_{33}; \end{aligned} \qquad (1.2.)$$

(1.2) ifodani standart matritsa kurinishida yozamiz:

$$\begin{vmatrix} I_{11}\\ I_{22}\\ I_{33} \end{vmatrix} \text{X} \begin{vmatrix} R_{11} & -R_{12} & -R_{13}\\ R_{21} & R_{22} & -R_{23}\\ R_{31} & -R_{32} & -R_{33} \end{vmatrix} = \begin{vmatrix} E_{11};\\ E_{22};\\ E_{33}; \end{vmatrix} \qquad (1.3.)$$

SHunday kilib uch o’zgaruvchili tenglamalar sistemasini xosil kildik. Tenglamalar sistemasini echib kontur toklarini kiymatini xisoblaymiz. Tenglamani urniga ko’yish, o’zgaruvchilarni birin-ketin yo’kotish (Gauss usuli) yoki Kramer (aniklovchilar) usulida xisoblash mumkin. Mashinaviy xisobash uchun eng kulay bo’lgani uchun Kramer usulidan foydalanamiz. Buning uchun asosiy va yordamchi aniklovchilarni xisoblaymiz.

Asosiy aniklovchi koeffitsientlar matritsasidan xisoblanadi:

$$\Delta = \begin{vmatrix} R_{11} & -R_{12} & -R_{13}\\ R_{21} & R_{22} & -R_{23}\\ R_{31} & -R_{32} & -R_{33} \end{vmatrix} = R_{11}\cdot R_{22}\cdot R_{33}+R_{21}\cdot R_{32}\cdot R_{13}+R_{12}\cdot R_{23}\cdot R_{31}-$$

$$-R_{13}\cdot R_{22}\cdot R_{31}-R_{12}\cdot R_{21}\cdot R_{33}-R_{11}\cdot R_{23}\cdot R_{32};$$

$$\Delta_1 = \begin{vmatrix} E_{11} & -R_{12} & -R_{13} \\ E_{22} & R_{22} & -R_{23} \\ E_{33} & -R_{32} & -R_{33} \end{vmatrix} = E_{11}\cdot R_{22}\cdot R_{33}+E_{22}\cdot R_{32}\cdot R_{13}+R_{12}\cdot R_{23}\cdot E_{33}- -R_{13}\cdot R_{22}\cdot E_{33}-R_{12}\cdot E_{22}\cdot R_{33}-E_{11}\cdot R_{23}\cdot R_{32};$$

$$\Delta_2 = \begin{vmatrix} R_{11} & E_{11} & R_{13} \\ R_{21} & E_{22} & -R_{23} \\ R_{31} & E_{33} & -R_{33} \end{vmatrix} = R_{11}\cdot E_{22}\cdot R_{33}+R_{21}\cdot E_{33}\cdot R_{13}+R_{12}\cdot R_{23}\cdot E_{33}- -R_{13}\cdot R_{22}\cdot E_{33}-R_{12}\cdot E_{22}\cdot R_{33}-E_{11}\cdot R_{23}\cdot R_{32};$$

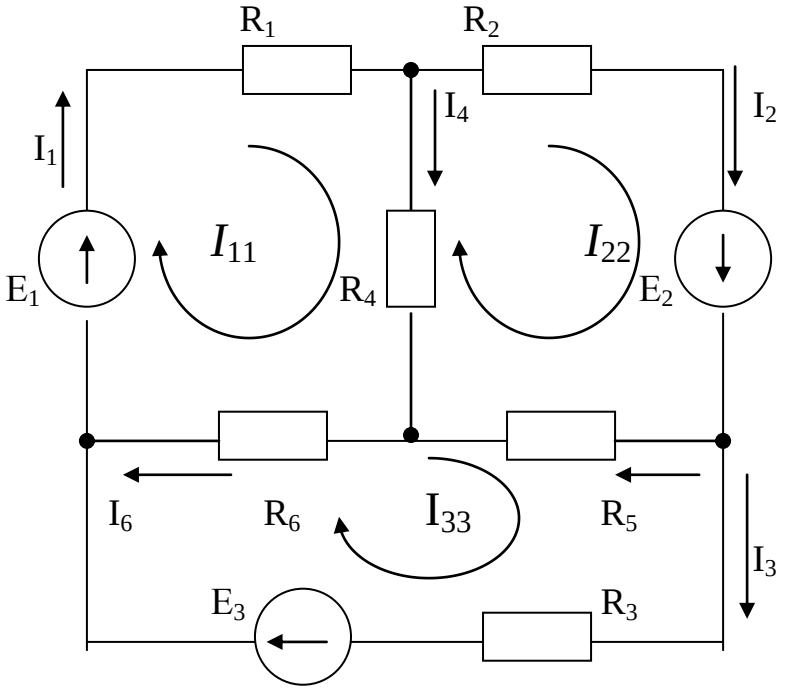
$$\Delta_3 = \begin{vmatrix} R_{11} & -R_{12} & E_{11} \\ R_{21} & R_{22} & E_{22} \\ R_{31} & -R_{32} & E_{33} \end{vmatrix} = R_{11}\cdot R_{22}\cdot E_{33}+R_{21}\cdot R_{32}\cdot E_{12}+E_{11}\cdot R_{23}\cdot R_{31}- -E_{11}\cdot R_{22}\cdot R_{31}-R_{12}\cdot R_{21}\cdot E_{33}-R_{11}\cdot E_{22}\cdot R_{32};$$

Kontur toklari kuyidagi ifodalardan topiladi:

$$I_{11} = \frac{\Delta_1}{\Delta}; \qquad I_{22} = \frac{\Delta_2}{\Delta}; \qquad I_{33} = \frac{\Delta_3}{\Delta};$$

Kontur toklari orkali xakikiy toklarni aniklaymiz:

$I_1=I_{11}$; $I_2=I_{22}$; $I_3=I_{33}$; $I_4=I_{11}-I_{22}$; $I_5=I_{22}-I_{33}$; $I_6=I_{11}-I_{33}$.



4-rasm.. Uzgarmas tok zanjiri sxemasi.

Xisoblangan toklar Kirxgofning I va II-konunlariga tekshirilib ko'riladi.

Misol tarikasida kuyidagi variantni xisoblaymiz.

| Vari-Ant | $E_1$, V | $E_2$ V | $E_3$ V | $R_1$ om | $R_2$ om | $R_3$ o | $R_4$ om | $R_5$ om | $R_6$ om |
|---|---|---|---|---|---|---|---|---|---|
| 27 | 4 | 24 | 6 | 9 | 8 | 1 | 6 | 10 | 4 |

Tenglama koeffitsientlarini aniklaymiz.

$R_{11}= R_1+R_4+R_6= 9+6+4=19;$

$R_{22}=R_2+R_4+R_5=8+6+10=24$

$R_{33}= R_3+R_5+R_6=1+10+4=15;$

$R_{12}=R_{21}=R_4=6;$ $E_{11}=E_1=4;$

$R_{23}=R_{32}=R_5=10;$ $E_{22}=E_2=24;$

$R_{31}=R_{31}=R_6=4;$ $E_{33}=E_3=6.$

Tenglamani matritsa ko'rinishida yozamiz:

$$\begin{vmatrix} I_{11} \\ I_{22} \\ I_{33} \end{vmatrix} \begin{vmatrix} X \end{vmatrix} \begin{vmatrix} 19 & -6 & -4 \\ -6 & 24 & -10 \\ -4 & -10 & 15 \end{vmatrix} = \begin{vmatrix} 4 \\ 24 \\ 6 \end{vmatrix}$$

Asosiy aniklovchini xisoblaymiz:

$$\Delta = \begin{vmatrix} 19 & -6 & -4 \\ -6 & 24 & -10 \\ -4 & -10 & 15 \end{vmatrix} = 19\cdot24\cdot15+24\cdot(-10)\cdot(-4)+(-6)\cdot(-10)\cdot(-4)-$$
$$-(-4)\cdot24\cdot6-(-6)\cdot24\cdot15+19\cdot(-10)\cdot(-10)=3536;$$

YOrdamchi aniklovchilarni xisoblaymiz:

$$\Delta_1 = \begin{vmatrix} 4 & -6 & -4 \\ 24 & 24 & -10 \\ 6 & -10 & 15 \end{vmatrix} = 4\cdot24\cdot15+24\cdot(-10)\cdot(-4)+(-6)\cdot(-10)\cdot6-$$
$$-(-4)\cdot24\cdot6-(-6)\cdot24\cdot15+4\cdot(-10)\cdot(-10)=5096;$$

$$\Delta_2 = \begin{vmatrix} 19 & 4 & -4 \\ -6 & 24 & -10 \\ -4 & 6 & 15 \end{vmatrix} = 19\cdot24\cdot15+(-6)\cdot(-10)\cdot(-4)+(-6)\cdot(-10)\cdot6-$$
$$-(-4)\cdot24\cdot(-4)-4\cdot(-6)\cdot15+19\cdot(-10)\cdot6=8260;$$

$$\Delta_3 = \begin{vmatrix} 19 & -6 & 4 \\ -6 & 24 & 24 \\ -4 & -10 & 6 \end{vmatrix} = 19\cdot24\cdot6+(-6)\cdot(-10)\cdot4+(-6)\cdot24\cdot(-4)-$$
$$-(-4)\cdot24\cdot(-4)-(-6)\cdot(-6)\cdot6+19\cdot24\cdot(-10)=8280;$$

Kontur toklarini xisoblaymiz:

$$I_{11} = \frac{\Delta_1}{\Delta} = \frac{5096}{3536} = 1{,}44;$$

$$I_{22} = \frac{\Delta_2}{\Delta} = \frac{8260}{3536} = 2{,}34;$$

$$I_{33} = \frac{\Delta_3}{\Delta} = \frac{8280}{3536} = 2{,}34;$$

Kontur toklari orkali xakikiy toklarni aniklaymiz:

$I_1=I_{11}=1{,}44$ A;

$I_2=I_{22}=2{,}34$ A;

$I_3=I_{33}=2{,}34$ A;

$I_4=I_{11}-I_{22}=1{,}44-2{,}34=-0{,}89$ A;

$I_5=I_{22}-I_{33}=2{,}34-2{,}34=0$ A;

$I_6=I_{11}-I_{33}=1{,}44-2{,}34=-0{,}9$ A.

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## 2-MASALA. BIR FAZALI SINUSOIDAL TOK ZANJIRLARI.

Bu mavzuda talabalar elektr zanjir va aktiv, induktiv va sigim karshiliklarning,bu turli zanjirlarning kullanishining bilishi lozim.SHu zanjirlarda Om va Kirxgof konunlarining kullanilishi va uzgaruvchan tok zanjirlarining xisoblash usullarida kompleks sonlarning kullashning uzlashtirishlari kerak.

Berilgan ketma - ket va paralel boglangan elektr zanjirning toklarining xisoblang va vektor diagrammasini kuring.

Masalani echish tartibi.

Dastlab zanjir shoxalaridagi karshiliklarni xisoblaymiz:

shoxaning to'la karshiligi:

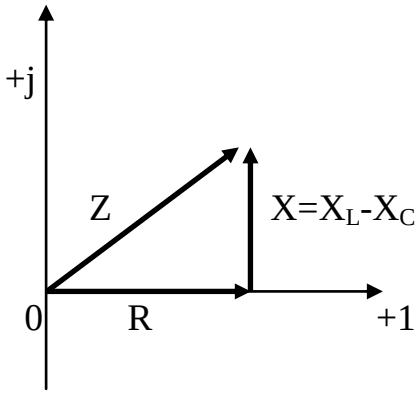
$$Z_1 = \sqrt{R_1^2 + j(X_{l1} - X_{c1})^2};$$

bu erda: $X_L$-induktiv karshilik:

$$X_L = \omega \cdot L = 2\pi \cdot f;$$

$X_S$-sigim karshilik

$$X_C = \frac{1}{\omega \cdot C} = \frac{1}{2\pi \cdot C};$$




Karshiliklar uchburchagidagi faza burchagi:

$$\varphi_0 = arctg(\frac{X_L - X_C}{R});$$

Bu karshilikning kursatgichli kurinishda yozamiz:

$$Z = R + jX = Z \cdot e^{j\varphi};$$

Berilgan zanjirning paralel kismining ekvivalent karshiligini xisoblaymiz:

$$Z_{экв} = \frac{Z_1 \cdot Z_2}{Z_1 + Z_2} = \frac{Z_1 e^{j\varphi_1} \cdot Z_2 e^{j\varphi_2}}{(R_1 + R_2) + J(X_1 + X_2)};$$

Zanjirning umumiy karshiligi.

$$Z_{УМ} = Z_1 + Z_{ЭКВ} = (R_1 + R_{ЭКВ}) + J(X_1 + X_{ЭКВ}) = R_{УМ} + jX_{УМ};$$

Zanjirning umumiy shoxadagi toki.

$$I_1 = \frac{Ue^{j\varphi}}{Z_{ум} e^{j\varphi}};$$

Ikkinchi shoxadagi karshilik

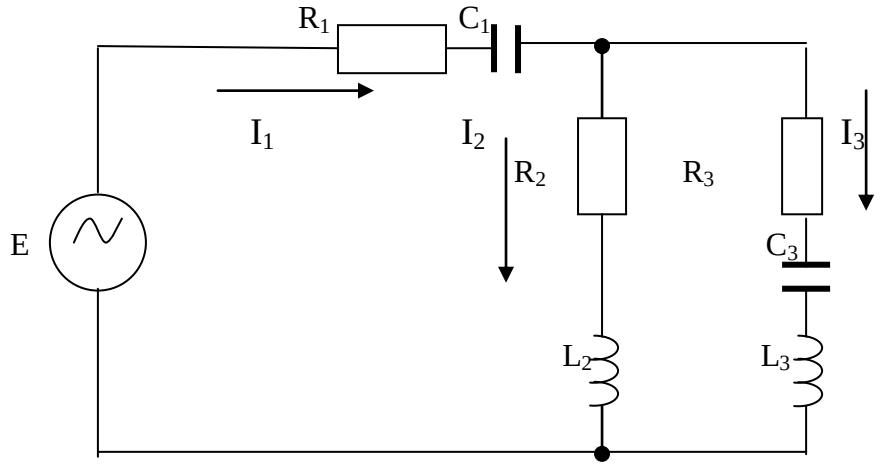
Zanjirning shoxalangan kismidagi toklar.

$$I_2 = I_1 \cdot \frac{Z_3}{Z_2 + Z_3};$$

$$I_3 = I_1 \cdot \frac{Z_2}{Z_2 + Z_3};$$

Kuyidagi masalani namuna sifatida xisoblaymiz.

| Vari-Ant | E, V | $R_1$, Om | $R_2$, om | $R_3$, om | $L_1$, mGn | $L_2$, mGn | $L_3$, mGn | $C_1$, mkF | $C_2$, mkF | $C_3$, mkF |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 220 | 5 | 10 | 8 | 0 | 15,9 | 6,37 | 637 | 0 | 4 |




5-rasm. Bir fazali sinsoidal tok zanjiri.

YUkorida keltirilgan ifodalar asosida karshiliklarni xisoblaymiz:

Birinchi shoxaning sigim karshiligi:

$$X_{C1} = \frac{1}{\omega \cdot C} = \frac{1}{2\pi \cdot C} = \frac{1}{314 \cdot 637 \cdot 10^{-6}} = 5 \ \ ом;$$

Birinchi shoxaning to'la karshiligi :

$$Z_1 = \sqrt{R_1^2 - jX_{C1})^2} = \sqrt{5^2 - j5^2} = 7{,}1e^{-j45^0};$$

Birinchi shoxadagi tok va kuchlanish orasidagi faza siljishi:

$$\varphi_{01} = arctg(\frac{-jX_C}{R}) = arctg(-1) = -45^0;$$

Ikkinchi shoxaning to'la karshiligini xisoblaymiz:

$$X_{L2} = \omega \cdot L_2 = 2\pi \cdot f = 2 \cdot 3{,}14 \cdot 50 \cdot 15{,}9 \cdot 10^{-3} = 5 \ \ ом;$$

$$Z_2 = \sqrt{R_2^2 + j(X_{L2} - X_{C2})^2} = \sqrt{10^2 + j5^2} = 11{,}2e^{j27^0};$$

SHu tartibda uchinchi shoxadagi karshilikni xisoblaymiz:

$$Z_3 = \sqrt{R_3^2 + j(X_{L3} - X_{C3})^2} = \sqrt{8^2 + j2^2} = 8{,}2e^{j14^0};$$

bu erda,

$$X_{L3} = \omega \cdot L_2 = 314 \cdot 6{,}37 \cdot 10^{-3} = 2 \ \ ом;$$

Berilgan zanjirning paralel kismining ekvivalent karshiligini xisoblaymiz:

$$Z_{экв} = \frac{Z_1 \cdot Z_2}{Z_1 + Z_2} = \frac{Z_1 e^{j\varphi_1} \cdot Z_2 e^{j\varphi_2}}{(R_1 + R_2) + J(X_1 + X_2)} =$$

$$= \frac{7{,}1e^{j27^0} \cdot 11{,}2e^{j14^0}}{(10+8) + j(5+2)} = 19{,}3e^{j21^0};$$

Zanjirning umumiy karshiligi.

$$Z_{УМ} = Z_1 + Z_{ЭКВ} = (R_1 + R_{ЭКВ}) + J(X_1 + X_{ЭКВ}) =$$

$$= (5 + 4{,}5) + j(2-5) = 10 - j3 = 10{,}1e^{-j20^0}$$

Bu erda,

$$R_{экв} = Z_{экв} \cdot COS \ \ 21^0 = 4{,}8 \cdot 0{,}94 = 4{,}5 \ \ ом;$$

$$Q_{экв} = Z_{экв} \cdot SIN \ \ 21^0 = 4{,}8 \cdot 0{,}33 = 1{,}6 \ \ ом;$$

Zanjirning umumiy shoxadagi toki.

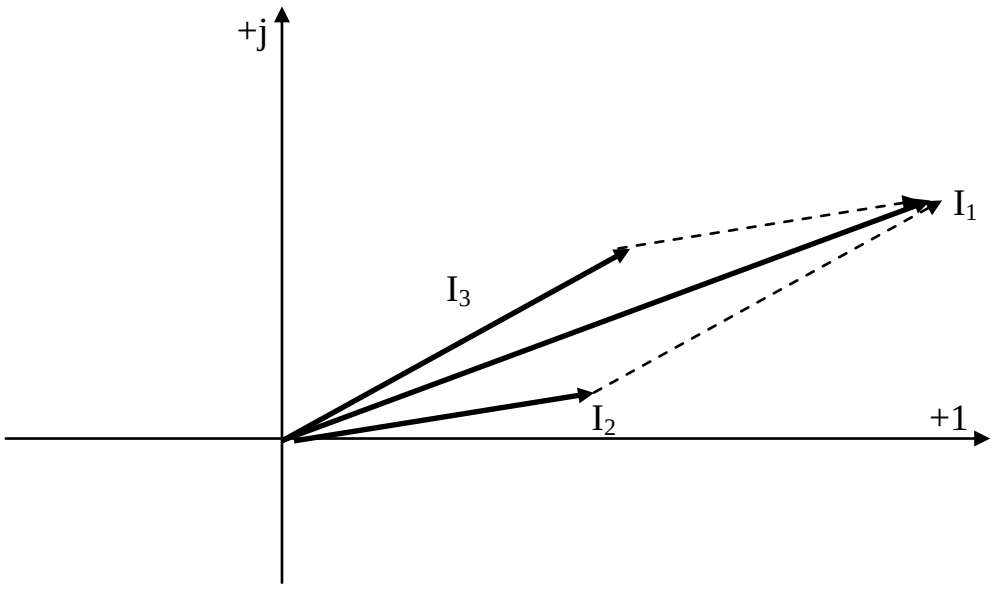
$$I_1 = \frac{Ue^{j\varphi}}{Z_{ум}e^{j\varphi}} = \frac{220e^{j0^0}}{10{,}1e^{-j20^0}} = 21{,}8e^{j20^0};$$

Zanjirning shoxalangan kismidagi toklar.

$$I_2 = I_1 \cdot \frac{Z_3}{Z_2 + Z_3} = 21{,}8e^{j20^0} \cdot \frac{8{,}2e^{j14^0}}{11{,}2e^{j27^0} + 8{,}2e^{j14^0}} = 9{,}3e^{j13^0};$$

$$I_3 = I_1 \cdot \frac{Z_2}{Z_2 + Z_3} = 21{,}8e^{j20^0} \cdot \frac{11{,}2e^{j27^0}}{11{,}2e^{j27^0} + 8{,}2e^{j14^0}} = 12{,}6e^{j25^0};$$

toklar vektor diagrammasi




6-rasm. Tok va kuchlanishlar diagrammasi.

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3-MASALA. UCH FAZALI O'ZGARUVCHAN TOK ZANJIRLARI.

Misol sifatida kuyidagi masalani echamiz.

| Vari-Ant | $U_L$, V | $R_A$, Om | $R_B$, om | $R_C$, om | $X_{LA}$, Om | $X_{LB}$, om | $X_{LC}$, om | $X_{CA}$, om | $X_{BC}$, om | $X_C$, om |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 220 | 13 | 24 | 35 | 10 | 35 | 7 | 3 | 5 | 6 |

A-fazaning karshiligini xisoblaymiz:

$$Z_A = \sqrt{R_A^2 + j(X_{LA} - X_{CA})^2} = \sqrt{13^2 + j(10-3)^2} = 14{,}8e^{j28^0};$$

A-fazaning tok va kuchlanish orasidagi faza siljishi

$$\varphi_0 = arctg(\frac{X_L - X_C}{R});$$

SHu tartibda kolgan fazalardagi to'la karshiliklarni xisoblaymiz:

$$Z_B = \sqrt{R_B^2 + j(X_{LB} - X_{CB})^2} = \sqrt{24^2 + j(35-5)^2} = 38{,}4e^{j51^0};$$

$$Z_C = \sqrt{R_C^2 + j(X_{LC} - X_{CC})^2} = \sqrt{35^2 + j(7-6)^2} = 35e^{j2^0};$$

. Uch fazali zanjirning faza toklarini xisoblaymiz:

Uch fazali istemolchilar «yulduzcha» ulanganda faza kuchlanishi kuyidagicha aniklanadi:

$$U_\phi = \frac{U_л}{\sqrt{3}} = \frac{380}{\sqrt{3}} = 220 \ \ B;$$

A-fazaning faza toki:

$$I_A = \frac{U_{\phi A} e^{j\varphi}}{Z_A e^{j\varphi}} = \frac{220e^{j0^0}}{14{,}8e^{j28^0}} = 14{,}9e^{-j28^0};$$

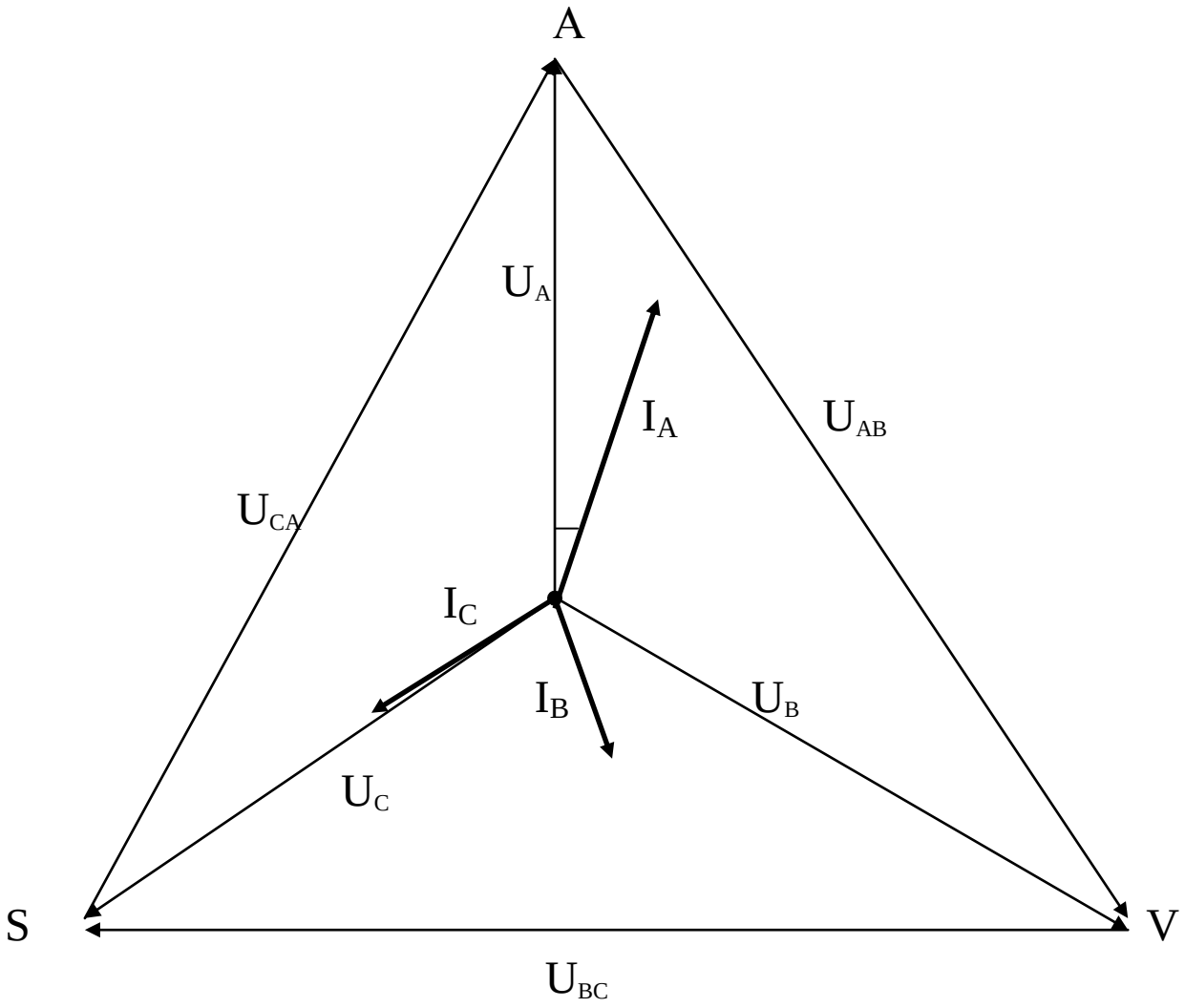
V-fazaning faza toki:

$$I_B = \frac{Ue^{j\varphi}}{Z_{ум} e^{j\varphi}} = \frac{220e^{-j120^0}}{38{,}4e^{j51^0}} = 5{,}7e^{-j171^0};$$

S-fazaning faza toki:

$$I_C = \frac{Ue^{j\varphi}}{Z_{ум}e^{j\varphi}} = \frac{220e^{j120^0}}{35e^{j2^0}} = 7{,}1e^{j118^0};$$

Toklar va kuchlanishlar vektor diagrammasini kuramiz.




7-rasm. Uch fazali zanjirning kuchlanish va tok diagrammalari

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