

## 7-ma`ruza. Oddiy elektr zanjirlarni hisoblash.

Reja:

1. Ketma–ket ulangan zanjirlarni hisoblash.
2. Parallel ulangan zanjirlarni hisoblash.
3. Aralash ulangan zanjirlarni hisoblash.

### 1. Ketma –ket ulangan zanjirlarni hisoblash.

Amaliyotda elektr zanjirlari asosan  $r$  qarshilikli,  $L$  induktiv cho`lg`amli va  $S$  sig`imli uchastkalarini bir–biriga ulanishi orqali hosilqilinadi. Oxirgi ikki kattalik  $X$  reaktiv qarshilikni beradi. Zanjir uchastkalarini ketma–ket ulashda (7.1–rasm) butun zanjir zanjimlaridagi kuchlanish harbir alohida uchastkalaridagi kuchlanishlar pasayishlarining yig`indisiga teng bo`ladi:

$$U = \sum_{k=1}^n U_K \quad (7.1)$$

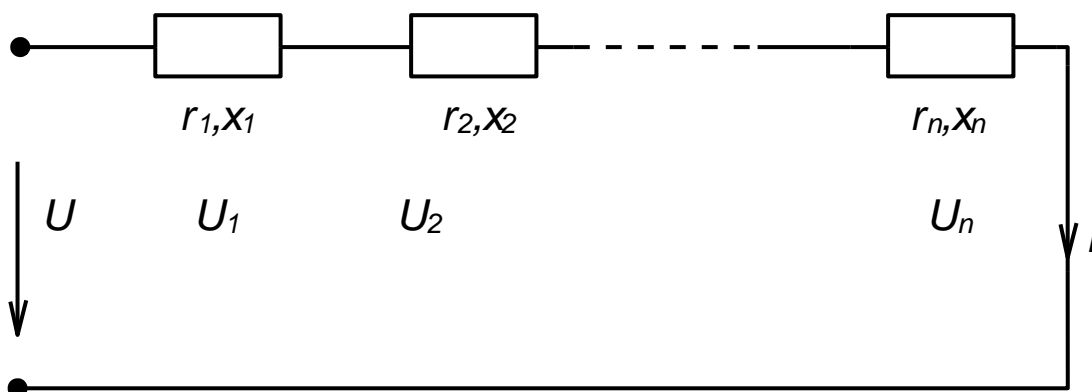
Sinusoidal jarayonlarda, kompleks uslubdan foydalanib va tok zanjirining barcha uchastkalarida bir xil ekanligi uchun yozish mumkin:

$$\dot{U} = \sum_{k=1}^n \dot{U}_K = \sum_{k=1}^n \dot{I}_K \cdot Z_K = \dot{I} \sum_{k=1}^n Z_K = \dot{I} Z \quad (7.2)$$

bu yerda:

$$Z_k = r_k + j X_k \quad (7.3)$$

(7.3) formula  $k$  - uchastkaning kompleks qarshiligini aniqlash formulasi deb ataladi. Ketma–ket ulanishda butun zanjirning kompleks qarshiligi harbir uchastka kompleks qarshiliklarining algebraik yig`indisiga teng:



7.1–rasm.

$$Z = \sum_{k=1}^n Z_K = \sum_{k=1}^n r_K + j \sum_{k=1}^n X_K = r + jX \quad (7.4)$$

$Z$  ni bila turib berilgan kompleks  $\dot{U}$  kuchlanishdagi kompleks  $\dot{I}$  tokni aniqlash mumkin.

7.1 –rasmda qarshilik o`zining ikkita tashkil etuvchisiga ega: aktiv va reaktiv qo`yidagi tengliklardan:

$$r = \sum_{k=1}^n r_K \quad \text{va} \quad X = \sum_{k=1}^n X_K \quad (7.5)$$

kelib chiqadiki, ketma-ket ulangan alohida uchastkalarining ham aktiv, ham reaktiv qarshiliklarining algebraik yig'indilari hisoblanib chiqishi lozim.

Aktiv R va reaktiv Q quvvatlarni hisoblash uchun qo'yidagi formulalardan foydalanamiz:

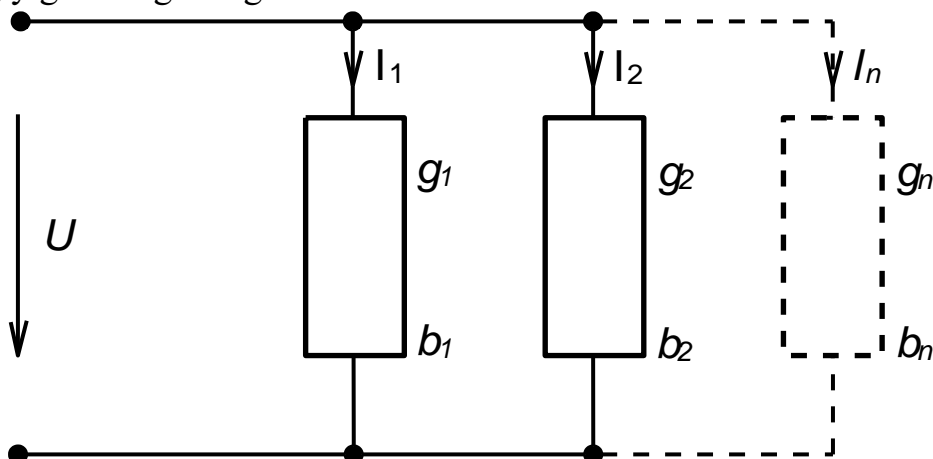
$$P = I^2 \cdot r = I^2 \sum_{k=1}^n r_K = \sum_{k=1}^n I^2 \cdot r_K = \sum_{k=1}^n P_K \quad (7.6)$$

$$Q = I^2 \cdot X = I^2 \sum_{k=1}^n X_K = \sum_{k=1}^n I^2 X_K = \sum_{k=1}^n Q_K \quad (7.7)$$

Ta'rif: Butun zanjirlarning aktiv va reaktiv quvvatlari zanjirning barcha alohida uchastkalarining aktiv va reaktiv quvvatlarining algebraik yig'indisiga tengdir.

## 2. Parallel ulangan zanjirlarni hisoblash.

7.2-rasmda uchastkalari parallel ulangan zanjir sxemasi keltirilgan. Ushbu holatda zanjirga kirish nuqtasidagi umumiy tok qiymati alohida uchastkalardagi toklarning yig'indisiga tengdir:



7.2 –rasm.

Kompleks uslubdan foydalanib va barcha uchastkalardagi kuchlanishlarning bir xil ekanligini nazarda tutib yozamiz:

$$I = \sum_{k=1}^n I_K = \sum_{k=1}^n \dot{U} \cdot Y_K = \dot{U} \sum_{k=1}^n Y_K = U \cdot Y \quad (7.8)$$

bu yerda:

$$U_k = g_k - j b_k \quad (7.9)$$

(7.9) formula uchastkalari parallel ulangan zanjir k – uchastkasining kompleks o'tkazuvchanligi formulasi hisoblanadi.

Parallel ulanishda butun zanjirning kompleks o'tkazuvchanligi zanjir alohida uchastkalari kompleks o'tkazuvchanliklarining algebraik yig'indisiga teng:

$$Y = \sum_{k=1}^n Y_K = \sum_{k=1}^n g_K - j \sum_{k=1}^n b_K = g - j b \quad (7.10)$$

U ni bila turib, berilgan kuchlanish  $\dot{U}$  uchun  $I$  tokning kompleks qiymatini aniqlash mumkin. Qo'yidagi

$$g = \sum_{k=1}^n g_k \quad \text{ea} \quad b = \sum_{k=1}^n b_k \quad (7.11)$$

tenglilardan uchastkalari parallel ulangan zanjirlar uchun alohida uchastkalar aktiv va reaktiv o'tkazuvchanliklarining algebraik yig'indilari alohida hisoblanishi lozimligi kelib chiqadi.

Aktiv va reaktiv Q quvvatlarni hisoblash uchun qo'yidagi formulalardan foydalanamiz:

$$P = U^2 g = U^2 \sum_{k=1}^n g_k = \sum_{k=1}^n U^2 g_k = \sum_{k=1}^n P_k \quad (7.12)$$

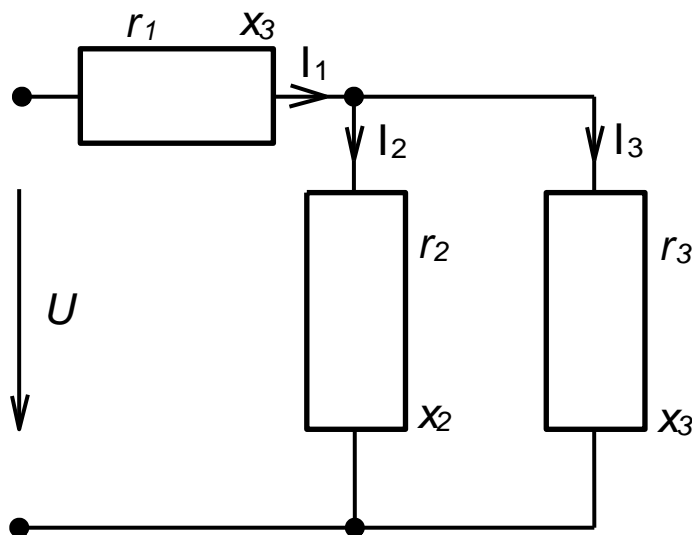
$$Q = U^2 b = U^2 \sum_{k=1}^n b_k = \sum_{k=1}^n U^2 b_k = \sum_{k=1}^n Q_k \quad (7.13)$$

Ta'rif: Butun zanjirning aktiv va reaktiv quvvati ushbu zanjir parallel ulangan alohida uchastkalarining aktiv va reaktiv quvvatlarining algebraik yig'indisiga tengdir.

### 3. Aralash ulangan zanjirlarni hisoblash.

7.3-rasmda uchastkalar aralash ulangan zanjir keltirilgan, unda ketma-ket ulangan ham, parallel ulangan ham uchastkalar ham mavjud. Shuning uchun ana shu kabi zanjirlarni hisoblashda mazkur ma'ruza rejasining avvalgi savollarida keltirilgan hisoblash formulalarini keltirish mumkin.

Zanjir zanjimlaridagi U kuchlanish berilgan bo'lsin. Ko'rsatilgan sxemaning barcha toklarini aniqlash lozim bo'lsin. Bu yerda 2 va 3-uchastkalar parallel ulangan, shu sababli  $U_{23}$  kompleks o'tkazuvchanlikni aniqlash uchun  $U_2$  va  $U_3$  kompleks o'tkazuvchanliklarni qo'shish zarur:



7.3-rasm.

$$U_{23} = U_2 + U_3 = (g_2 - j b_2) + (g_3 - j b_3) = (g_2 + g_3) - j (b_2 + b_3) \quad (7.14)$$

$$U_2 = 1/Z_2 = 1/(r_2 + j x_2); \quad U_3 = 1/z_3 = 1/(r_3 + j x_3) \quad (7.15)$$

(7.15) formuladagi mahrajdagi mavhumlikdan qutulish uchun uning suratini ham mahrajini ham mahrajga turlangan kompleks miqdorga ko'paytirish zarur:

$$U_2 = (r_2 - j x_2)/(r_2 + j x_2) \quad (r_2 - j x_2) = r_2/(r_2^2 + x_2^2) - j x_2/(r_2^2 + x_2^2) = g_2 - j b_2 \quad (7.16)$$

$$U_3 = (r_3 - j x_3)/(r_3 + j x_3) \quad (r_3 - j x_3) = r_3/(r_3^2 + x_3^2) - j x_3/(r_3^2 + x_3^2) = g_3 - j b_3 \quad (7.17)$$

Kompleks uslubdan foydalana turib, zanjirdagi yoki uning uchastkasidagi ekvivalent o'tkazuvchanliklar  $g$  va  $b$  o'rtasidagi hamda ekvivalent qarshiliklar  $r$  va  $x$  o'rtasidagi bog'liqliklarni osongina topa olamiz.

7.3–rasmdagi birinchi uchastka birgalikda olingan ikkinchi va uchinchi uchastkalar bilan ketma–ket ulangan.

U holdabuton zanjirning kompleks qarshiligi:

$$Z = Z_1 + Z_{23} \quad (7.18)$$

$$Z_1 = r_1 + jx_1;$$

$$Z_{23} = 1/Y_{23} = 1/(g_{23} - jb_{23}) = g_{23}/(g_{23}^2 + b_{23}^2) + jb_{23}/(g_{23}^2 + b_{23}^2) \quad (7.19)$$

Zanjirning birinchi qismidagi kompleks tok:

$$I_1 = \dot{U} / Z \quad (7.20)$$

Ikkinchi va uchinchi uchastkalardagi kompleks kuchlanishni qo'yidagi tengliklardan topamiz:

$$\dot{U}_{23} = \dot{U} - I_1 \cdot Z_1 \quad \text{ëku} \quad \dot{U}_{23} = I_1 \cdot Z_{23} \quad (7.21)$$

(7.21) dan ko'rib chiqilayotgan uchastkalardagi kompleks toklar osonlik bilan topiladi:

$$I_2 = \dot{U}_{23} \cdot Y_2; \quad I_3 = \dot{U}_{23} \cdot Y_3 \quad (7.22)$$

Butun zanjir uchun  $Z = r + jx$  ni bila turib, kuchlanish va tok oralig'idagi faza siljishi  $\varphi$  ni qo'yidagi formuladan aniqlaymiz:

$$\varphi = \arctg x/r \quad (7.23)$$

Ta'rif: Aralash ulanishda butun zanjirning aktiv qarshiligi uning alohida uchastkalarida sarflanayotgan aktiv qarshiliklar yig'indisiga teng, reaktiv qarshiligi esa mos holdagi reaktiv qarshiliklarning algebraik yig'indisiga tengdir.

Nazorat savollari:

1. Ketma–ket ulangan zanjirni chizing va hisoblash formulalarini keltiring.
2. Ketma–ket ulangan zanjirda aktiv quvvatlar nimaga teng?
3. Parallel ulangan zanjirni chizib bering va hisoblash formulalarini keltiring.
4. Sxemaning parallel ulangan qismlari uchun o'tkazuvchanlikning formulasini yozing.
5. Aralash ulanganda barcha zanjirning aktiv quvvati nimaga teng bo'ladi?