



TOSHKENT IRRIGATSIYA VA QISHLOQ  
XO'JALIGINI MEXANIZATSIYALASH  
MUHANDISLARI INSTITUTI



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ТЕМА

09

СОЛИШТИРМА  
КАТТАЛИКЛАРНИ  
ТАХМИНИЙ ҲИСОБЛАШ



БАБАЕВ АЗИЗ  
ГАЛИБОВИЧ



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# Adabiyotlar:

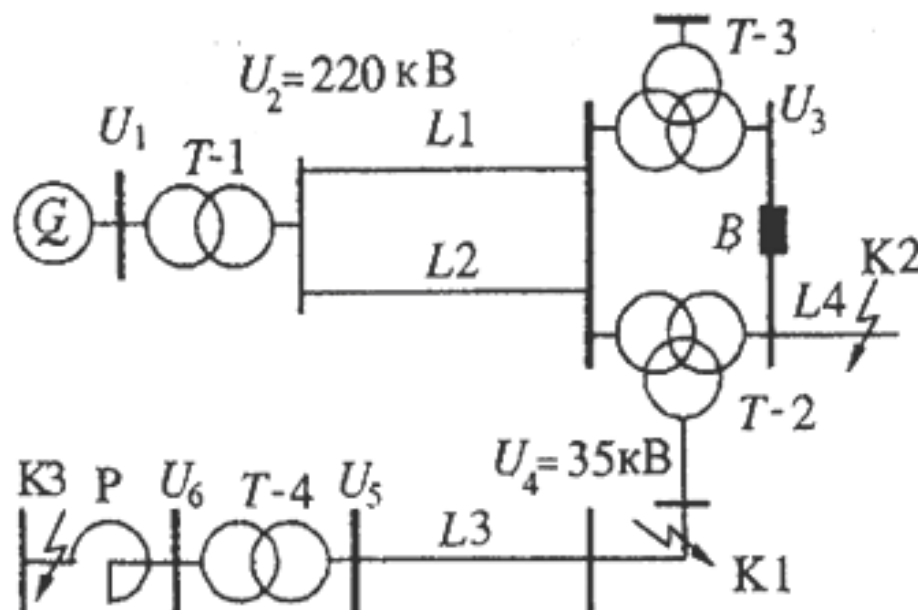
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2. Ульянов С.А. Электромагнитные переходные процессы в электрических системах. - М: Энергия, 1970. - 520 с.
3. Методические указания по определению устойчивости энергосистем. Ч. 1-М.: СПО Союзтехэнерго, 1979. -184 с.
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# SOLISHTIRMA KATTALIKLARDA TAXMINIY IFODALASH

## Qisqa tutashuv toklar hisobi.

**Masala.** Berilgan energosistema sxemasi uchun (5.1rasm) nisbiy va nomli birliklarda aniq va taxminiy keltirishlarni amalga oshiring.

Generator dastlab nominal kuchlanishda salt ishlab turgan deb hisoblab uch fazali qisqa tutashuvdagi o'ta o'tkinchi tokni hisoblang.



5.1-rasm. ES ning sxemasi (5.1 masala uchun)

### **Sxema elementlarining parametrlari :**

Generator G:  $S_{nom}=176,5$  MVA,  $U_{nom}=15,75$  kV,  $x''_d=0,5$ .

Transformator T-1:  $S_{nom}=180$  MVA,  $242/15,5$  kV,  $U_K=12$  %. Transformatorlar

T-2, T-3:  $S_{nom}=90$  MVA,  $220/38,5/11$  kV,  $U_{VS}=12$  %,

$U_{vn}=20$ %,  $U_{sn}=8$ %.

Transformator T-4:  $S_{nom}=60$  MVA,  $35/6,6$  kV,  $U_K=10,5$  %.

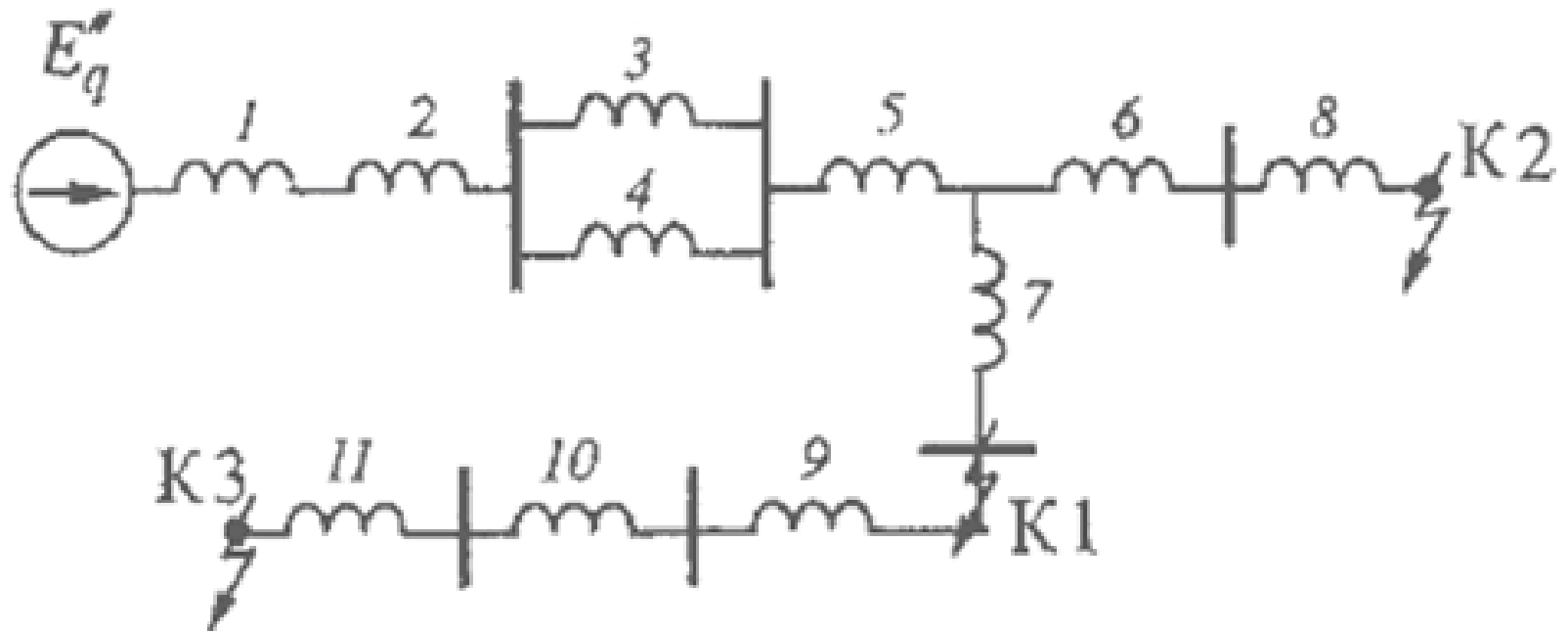
Liniya L1, L2:  $l=110$  km,  $x_o=0,4$  Ohm/km.

Liniya L3:  $l=30$  km,  $x_o=0,4$  Ohm/km.

Liniya L4 (kabel):  $l=2,5$  km,  $x_o=0,08$  Ohm/km.

Reaktor:  $U_{nom}=6$  kV,  $I_{nom}=500$  A,  $x=5$  %.

### Hisoblash sxemasi .



5.2.rasm . 5.1. masalasini echish uchun xisobiy almashtirish sxemasi .

## Nomli birliklarda aniq keltirish

T-1 transformatorning yuqori kuchlanishli shinasi kuchlanishining asosiy pog'onasi  $U_{osn}=220$  kV qabul qilamiz. Transformatorning haqiqiy transformatsiyasi koeffitsientini hisobga olib reaktiv qarshiliklarning keltirilgan qiymatlari uchun quyidagiga ega bo'lamiz:

$$\underline{x_1} = x''_d (U_{nom}^2 / S_{nom}) (k_{r1})^2 = 0.15 (15.75 / 176.5) (242 / 15.75)^2 = 49.8 \text{ Om},$$

$$\underline{x_2} = (U_K \% / 100) (U_{nom}^2 / S_{nom}) = (12 / 100) (242^2 / 180) = 39 \text{ Om},$$

$$\underline{x_3} = x_4 = x_{o1} = 0.4 \cdot 110 = 44 \text{ Om},$$

$$\underline{x_5} = (U_{Kv} / 100) (U_{nom}^2 / S_{nom}) = (12 / 100) (220^2 / 90) = 64.5 \text{ Om},$$

bu erda  $U_{Kv} = 0.5 (U_{Kv-s} + U_{Kv-n} - U_{Ks-n}) = 0.5 (12 + 20 - 8) = 12\%$ ,

$$\underline{x_6} = (U_{Kn} / 100) (U_{nom}^2 / S_{nom}) = (8 / 100) (220^2 / 90) = 43 \text{ Om},$$

bu erda  $U_{Kn} = 0.5 (U_{Kv-n} + U_{Ks-n} - U_{Kv-s}) = 0.5 (20 + 8 - 12) = 8\%$ ,

$$\underline{x_7} = (U_{Ks} / 100) (U_{nom}^2 / S_{nom}) = 0,$$

bu erda  $U_{Ks} = 0$ ,

$$\underline{x}_8 = x_0 / 4 (k_{r2})^2 = 0.08 \cdot 2.5 (220/11)^2 = 80 \text{ Om},$$

$$\underline{x}_9 = x_0 / 3 (k_{r2})^2 = 0.4 \cdot 30 (220/38.5)^2 = 392 \text{ Om},$$

$$\underline{x}_{10} = (U_K \% / 100) (U_{\text{nom}}^2 / S_{\text{nom}}) (k_{r2})^2 = (10.5 / 100) (35^2 / 60) (220/38.5)^2 = 70 \text{ Om},$$

$$\begin{aligned} \underline{x}_{11} &= (x_P \% / 100) (U_{\text{nom}} / 3^{0.5} I_{\text{nom}}) (k_{r4} k_{r2}) = \\ &= (5 / 100) (6 / 3^{0.5} \cdot 0.5) [(35/6.6) (220/38.5)]^2 = 318 \text{ Om}. \end{aligned}$$

Generator EYUK ning faza qiymati :

$$E''_q = U_{\text{nom}} k_{r1} = 15.75 (242 / 3^{0.5} \cdot 15.75) = 242 / 3^{0.5} = 139.8 \text{ kV}.$$

K1 nuqtada boshlangich o'ta o'tkinchi tok:

$$I''_{K1} = E''_q / x_{1\Sigma} = 139.8 / 175.3 = 0.79 \text{ kA},$$

bu erda  $x_{1\Sigma} = x_1 + x_2 + x_3 // x_4 + x_5 + x_7 = 175.3 \text{ Om}$ .

KZ pog'onasiga (38,5 kV) keltirilgan tok:

$$\bar{I}''_{K1} = I''_{K1} (1/k'_{r2}) = 0.79 (220/38.5) = 4.5 \text{ kA},$$

K2 uchun:

$$I''_{K2} = E''_q / x_{2\Sigma} = 139.8 / 298.3 = 0.47 \text{ kA},$$

bu erda  $x_{2\Sigma} = x_1 + x_2 + x_3 // x_4 + x_5 + x_6 + x_8 = 298.3 \text{ Om}$ .

KZ pogʻonasiga (11 kV) keltirilgan tok:

$$\bar{I}''_{K2} = I''_{K2} (1/k'_{r2}) = 0.47 (220/11) = 9.4 \text{ kA},$$

K3 uchun:

$$I''_{K3} = E''_q / x_{3\Sigma} = 139.8 / 955.3 = 0.146 \text{ kA},$$

bu erda  $x_{3\Sigma} = x_1 + x_2 + x_3 // x_4 + x_5 + x_7 + x_9 + x_{10} + x_{11} = 955.3 \text{ Om}$ .

KZ pogʻonasiga (6,6 kV) keltirilgan tok:

$$\bar{I}''_{K3} = I''_{K3} (1/k''_{r2}) (1/k'_{r4}) = 0.146 (220/38.5) (35/6.6) = 4.4 \text{ kA},$$

### Nomli birliklarda taxminiy keltirish

O'rnatilgan shkala bo'yicha transformatsiyalash pog'onalari nominal kuchlanishning o'rtacha miqdori:

$$U_1=15,75 \text{ kV}, U_2=230 \text{ kV}, U_3=10..5 \text{ kV}, U_4=37 \text{ kV}, U_6=6.3 \text{ kV}.$$

230 kV kuchlanish pog'onasiga keltirish qarshilikning quyidagi qiymatlarini beradi:

$$\underline{x_1}=0,15(230^2/176.5)=45 \text{ Om}, \quad \underline{x_2}=(12/100)(230^2/180)=35.4 \text{ Om},$$

$$\underline{x_3}=x_4=0.4 \cdot 100=44 \text{ Om},$$

$$\underline{x_5}=(12/100)(230^2/90)=70.7 \text{ Om}, \quad \underline{x_6}=(8/100)(230^2/90)=47.1 \text{ Om},$$

$$\underline{x_7}=0, \quad \underline{x_8}=0.08 \cdot 2.5(230^2/90)=96 \text{ Om},$$

$$\underline{x_9}=0.4 \cdot 30(230^2/37)=463 \text{ Om}, \quad \underline{x_{10}}=(10.5/100)(37^2/60)(230/37)^2=92.6 \text{ Om},$$

$$\underline{x_{11}}=(5/100)(6/3^{0.5} \cdot 0.5)(230/6.3)^2=464 \text{ Om}.$$

Generator EYUK ining faza qiymati :

$$E''_q = 15.75(230/3^{0.5} \cdot 15.75) = 132.5 \text{ kV.}$$

K1 nuqtada boshlang'ich tok;

$$I''_{K1} = 132.5/173.1 = 0.76 \text{ kA,}$$

bu erda  $x_{\Sigma 1} = 45 + 35.4 + (44/2) + 70.7 = 173.1 \text{ Om.}$

KZ (37 kV) pog'onasiga keltirilgan tok :

$$\bar{I}''_{K1} = 0.76(230/37) = 4.72 \text{ kA,}$$

K2 nuqtada

$$\bar{I}''_{K2} = 132.5/316.2 = 0.42 \text{ kA,}$$

bu erda  $x_{\Sigma 2} = 45 + 35.4 + (44/2) + 70.7 + 47.1 + 96 = 316.2 \text{ Om.}$

KZ (10,5 kV) pog'onasiga keltirilgan tok:

$$\bar{I}''_{K2} = 0.42(230/10.5) = 9.18 \text{ kA,}$$

KZ nuqtada

$$\bar{I}''_{K3} = 132.5/1192.7 = 0.11 \text{ kA,}$$

bu erda  $x_{\Sigma 3} = 45 + 35.4 + (44/2) + 70.7 + 463 + 92.6 + 464 = 1192.7 \text{ Om.}$

KZ (6,3 kV) pog'onasiga keltirilgan tok:

$$\bar{I}''_{K3} = 0.11(230/6.3) = 4.06 \text{ kA.}$$

### Nisbiy birliklarda aniq keltirish .

Bazis quvvat sifatida  $S_6 = 1000 \text{ MVA}$ , bazis kuchlanishi sifatida  $U_{61} = 220 \text{ kV}$ .  
qabul qilamiz: Kuchlanishning boshqa pog'onalarida bazis kuchlanish quyidagidek bo'ladi ;

$$U_{62} = U_{61}/k_{r1} = 220(15.75/242) = 14.3 \text{ kV},$$

$$U_{63} = U_{61}/k_{r2S} = 220(38.5/220) = 38.5 \text{ kV},$$

$$U_{64} = U_{61}/k_{r2N} = 220/11/220 = 11 \text{ kV},$$

$$U_{65} = U_{61}/k_{r1}k_{r3} = 220(38.5/220)(6.6/35) = 7.26 \text{ kV}.$$

KZ pog'onasidagi bazis toklar miqdori :

$$I_{63} = S_6/3^{0.5}U_{63} = 1000/3^{0.5} \cdot 38.5 = 15 \text{ kA},$$

$$I_{64} = S_6/3^{0.5}U_{64} = 1000/3^{0.5} \cdot 11 = 52.5 \text{ kA},$$

$$I_{65} = S_6/3^{0.5}U_{65} = 1000/3^{0.5} \cdot 7.26 = 79.5 \text{ kA},$$

Reaktiv qarshiliklarning nisbiy kattaliklari :

$$x_1 = x''_d(S_6/S_{\text{nom}})(U_{\text{nom}}/U_{62})^2 = 0.15(1000/176.5)(15.75/14.3)^2 = 1.03,$$

$$x_2 = (U_K\%/100)(S_6/S_{\text{nom}})(U_n/U_{61})^2 = 0.81,$$

$$x_3 = x_4 = x_0 l_1 (S_6/U_{61}^2) = 0.4 \cdot 110(1000/220^2) = 0.91,$$

$$x_5 = (U_{Kv}\%/100)(S_6/S_{\text{nom}})(U_{\text{nom}}/U_{61})^2 = (12/100)(1000/90) = 1.33,$$

$$x_6 = (U_{Kn}\%/100)(S_6/S_{\text{nom}})(U_{\text{nom}}/U_{61})^2 = (8/100)(1000/90) = 0.89,$$

$$x_7 = 0, \quad x_8 = x_0 l_4 (S_6/U_{64}^2) = 0.08 \cdot 2.5(1000/11^2) = 1.65,$$

$$x_9 = x_0 l_3 (S_6/U_{63}^2) = 0.4 \cdot 30(1000/38.5^2) = 8.1,$$

$$x_{10} = (U_K\%/100)(S_6/S_{\text{nom}})(U_{\text{nom}}/U_{63})^2 = (10.5/100)(1000/60) = 1.45,$$

$$x_{11} = (x_r\%/100)(I_{65}/I_{\text{nom}})(U_n/U_{65}) = (5/100)(79.5/0.5)(6/7.26) = 6.56.$$

EYUK nisbiy kattaligi :

$$E''_q = 15.75 / 14.3 = 1.1.$$

K1 nuqtada boshlangich o'tkinchi tok;

$$I''_{K1} = E''_q / x_{\Sigma 1} = 1.1 / 3.62 = 0.3,$$

$$\text{bu erda } x_{\Sigma 1} = 1.03 + 0.81 + (0.1/2) + 1.33 = 3.62.$$

KZ dagi nomli tok miqdori;

$$I''_{K1} = I''_{K1} I_{63} = 0.3 \cdot 15 = 4.5 \text{ kA},$$

K2 uchun

$$I''_{K2} = E''_q / x_{\Sigma 2} = 1.1 / 6.16 = 0.18,$$

$$\text{Bu erda } x_{\Sigma 2} = 1.03 + 0.81 + (0.91/2) + 1.33 + 0.89 + 1.65 = 6.16.$$

Nomli birliklarda tok miqdori:

$$I''_{K2} = I''_{K2} I_{64} = 0.18 \cdot 52.5 = \underline{9.4 \text{ kA}},$$

KZ nuqtadagi tokning nomli birliklardagi miqdori:

$$I''_{KZ} = E''_q / x_{\Sigma 3} = 1.1 / 19.73 = 0.056,$$

$$\text{bu erda } x_{\Sigma 3} = 1.03 + 0.81 + (0.91/2) + 1.33 + 8.1 + 1.45 + 6.56 = 19.73.$$

KZ nuqtadagi tokning nomli miqdori;

$$I''_{KZ} = I''_{KZ} I_{65} = 0.056 \cdot 79.5 = \underline{4.4 \text{ kA}}.$$

### Nisbiy birliklarda tarkibiy keltirish .

Tarqribiy keltirishda har bir kuchlanish o'sha bosqichning nominal kuchlanishlarning o'rtacha qiymatiga teng bo'ladi:

$U_{61}=230 \text{ kV}$ ,  $U_{62}=15.75 \text{ kV}$ ,  $U_{63}=37 \text{ kV}$ ,  $U_{64}=10.5 \text{ kV}$ ,  $U_{65}=6.3 \text{ kV}$ .

$S_6=1000 \text{ MVA}$  bo'lganida KZ pog'onalaridagi bazis toklar qiymatlari quyidagiga hisoblanadi:

$$I_{63}=1000/3^{0.5} \cdot 37=15.6 \text{ kA}, \quad I_{64}=1000/3^{0.5} \cdot 10.5=55 \text{ kA},$$

$$I_{65}=1000/3^{0.5} \cdot 6.3=91.5 \text{ kA}.$$

Bu xolda qarshiliklarni hisobi ancha soddalashadi:

$$x_1=x''_d(S_6/S_n)=0.15(1000/176.5)=0.85, \quad x_2=(12/100)(1000/180)=0.67,$$

$$x_3=x_4=0.4 \cdot 110(1000/230^2), \quad x_5=(12/100)(1000/90)=1.33,$$

$$x_6=(8/100)(1000/90)=0.89, \quad x_7=0, \quad x_8=0.08 \cdot 2.5(1000/10.5)=1.82,$$

$$x_9=0.4 \cdot 30(1000/37^2)=8.8, \quad x_{10}=(10.5/100)(1000/60)=1.75,$$

$$x_{11}=(5/100)(91.5/0.5)(6/6.3)=8.7.$$

EYUK ning nisbiy kattaligi :

$$E''_q = 15.75 / 15.75 = 1.$$

K1 o'tkinchi boshlangich tok:

$$I''_{K1} = 1 / 3.26 = 0.3,$$

Bu erda  $x_{\Sigma 1} = 0.85 + 0.67 + 0.415 + 1.33 = 3.26$ .

Tokning nomli kattaliklaridagi qiymati :

$$I''_{K1} = 0.3 \cdot 15.6 = 4.8 \text{ kA, v to'chke K2 } I''_{K2} = 1 / 5.97 = 0.167,$$

bu erda  $x_{\Sigma 2} = 0.85 + 0.67 + 0.415 + 1.33 + 0.89 + 1.82 = 5.97$ ;  $I''_{K2} = 0.167 \cdot 55 = 9.2 \text{ kA}$ ,

$$\text{K3 nuqtada } I''_{K3} = 1 / 22.5 = 0.044,$$

bu erda  $x_{\Sigma 3} = 0.85 + 0.67 + 0.415 + 1.33 + 8.8 + 1.75 + 8.7 = 22.5$ ;

$$I''_{KZ} = 0.044 \cdot 91.5 = 4.1 \text{ kA}.$$

Elektr tok tarmog'ining KZ (kA) nuqtada parametrlarni keltirib hisoblangan qisqa tutashuv toklarning, nomli va nisbiy birliklarda hisoblangan kattaliklari jadvalda keltirilgan.

| Keltirilgan | K1   |      | K2   |      | K3   |      |
|-------------|------|------|------|------|------|------|
| Aniq        | 4.50 | 4.50 | 9.40 | 9.40 | 4.40 | 4.40 |
| Taxminiy    | 4.72 | 4.80 | 9.12 | 9.20 | 4.06 | 4.1  |



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# E'TIBORINGIZ UCHUN RAHMAT!



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