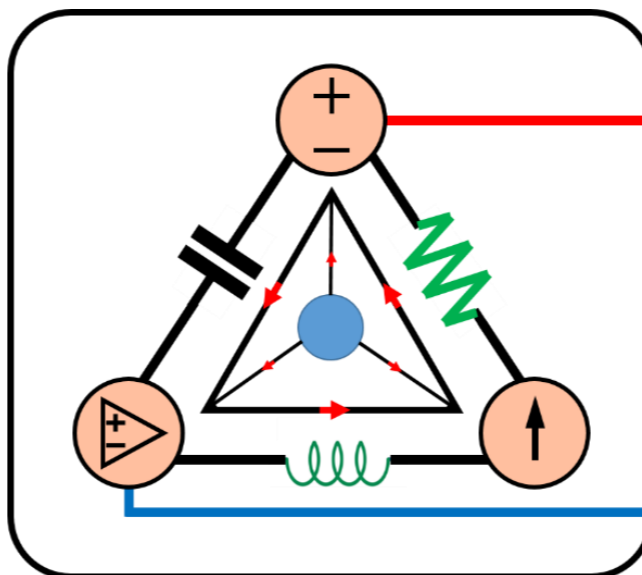


3-Mavzu: Zanjirlarni tahlil qilish usullari.

(Lecture-3: Methods of Analysis)

3-Mavzuning 2-qismi

(Part 2 of the Lecture-3)



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Toshkent shahri, Usmon Nosir, 156-uy.*



3-Mavzu: Zanjirlarni tahlil qilish usullari.

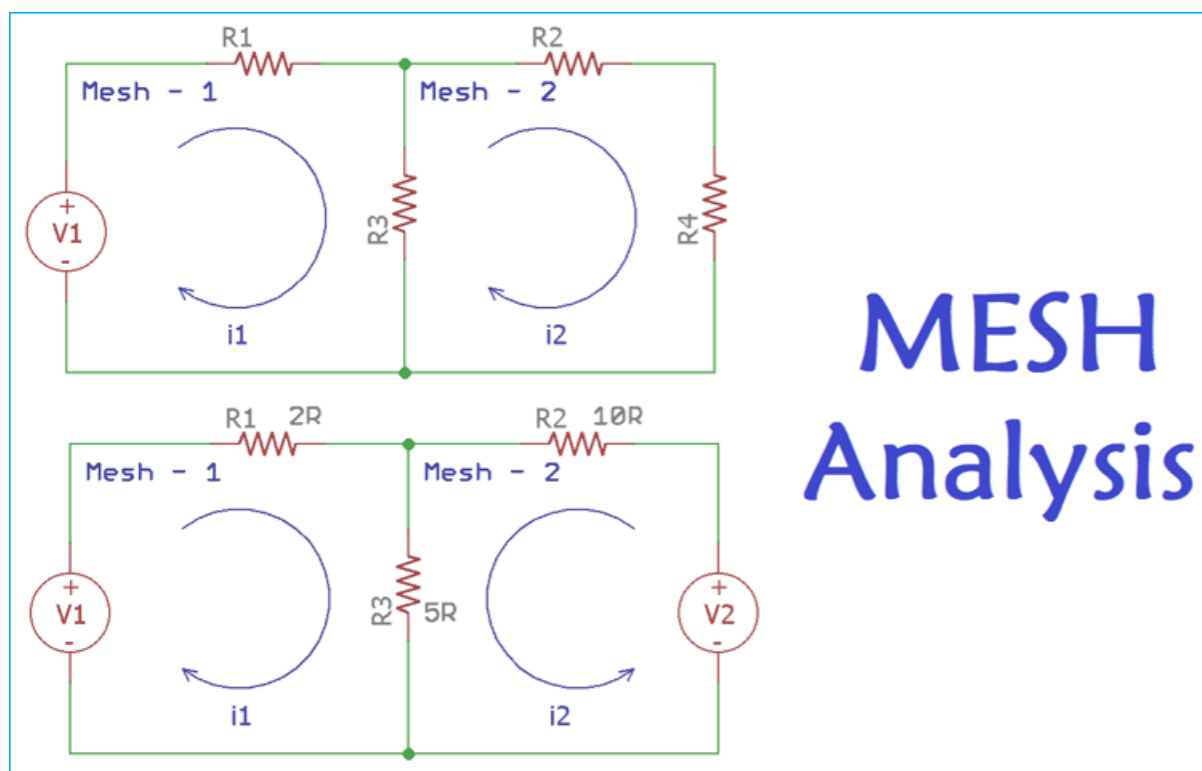
(Lecture-3: Methods of Analysis)

O'quv rejasi:

- 3.1. Tugun tahlili.
- 3.2. Kuchlanish manbalari bilan tugunlarni tahlil qilish.
- 3.3. Mesh (tarmoq) tahlili.**
- 3.4. Tok kuchi manbalari bilan tarmoqni tahlil qilish.**
- 3.5. Tekshiruv yo'li bilan tugun va mesh tahlillari.
- 3.6. Qo'llanilishi.

3.3. Mesh (tarmoq) tahlili.

Mesh tahlili zanjir o‘zgaruvchilari sifatida tarmoqli toklardan foydalangan holda zanjirlarni tahlil qilishning yana bir umumiy tartibini taqdim etadi.



O‘zgaruvchilar sifatida element toklari o‘rniga tarmoqli toklardan foydalanish qulay va bir vaqtning o‘zida hal qilinishi kerak bo‘lgan tenglamalar sonini kamaytiradi.

Mesh (tarmoq, to‘r) - bu ichida boshqa hech qanday halqa bo‘lmagan halqadir.

Photo source: [11] -

https://circuitdigest.com/sites/default/files/projectimage_tut/Mesh-Current-Analysis.png

Ma'lumki, halqa (*loop*) bu zanjirdagi har qanday yopiq yo'l (*closed path*)dir. U biror tugundan boshlanib, boshqa tugunlar to'plamidan faqat bir marta o'tadigan yopiq zanjirga aytiladi.

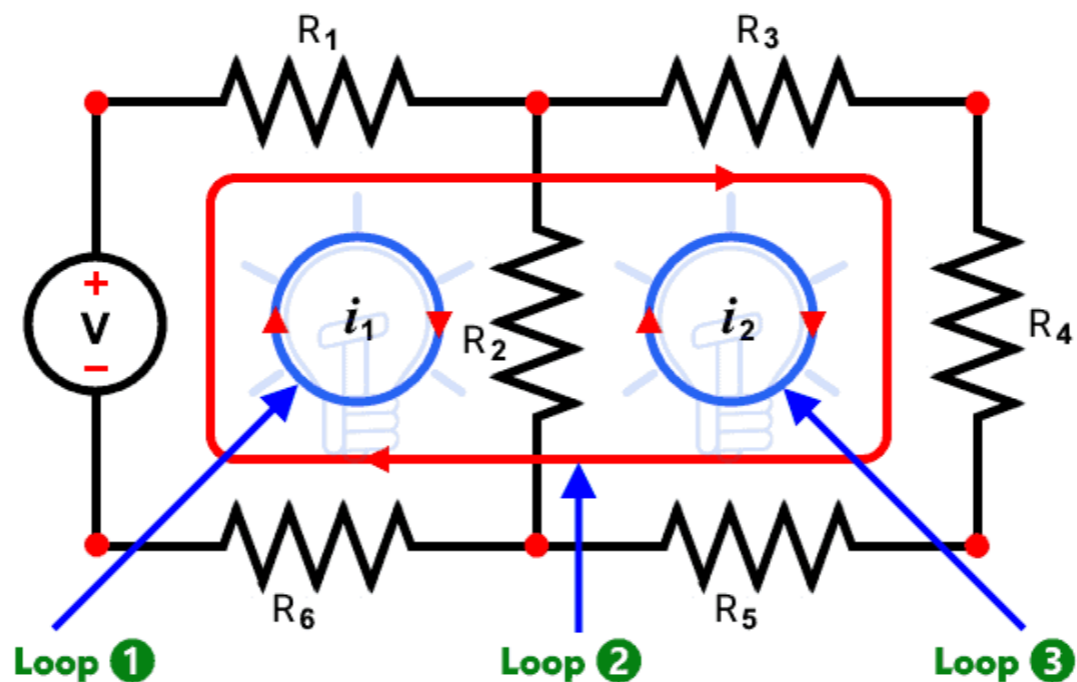


Photo source: [12] - <https://www.electricaltechnology.org/wp-content/uploads/2013/12/How-to-Find-the-Number-of-Loops-in-an-Electric-Circuit.png>

Mesh tahlili, shuningdek, halqa tahlili (*loop analysis*) yoki mesh-tok (*mesh-current*) usuli sifatida ham tanilgan.

Mesh tahlilida zanjirdagi noma'lum tok kuchlarni topish uchun KVL qo'llaniladi.

Mesh Analysis

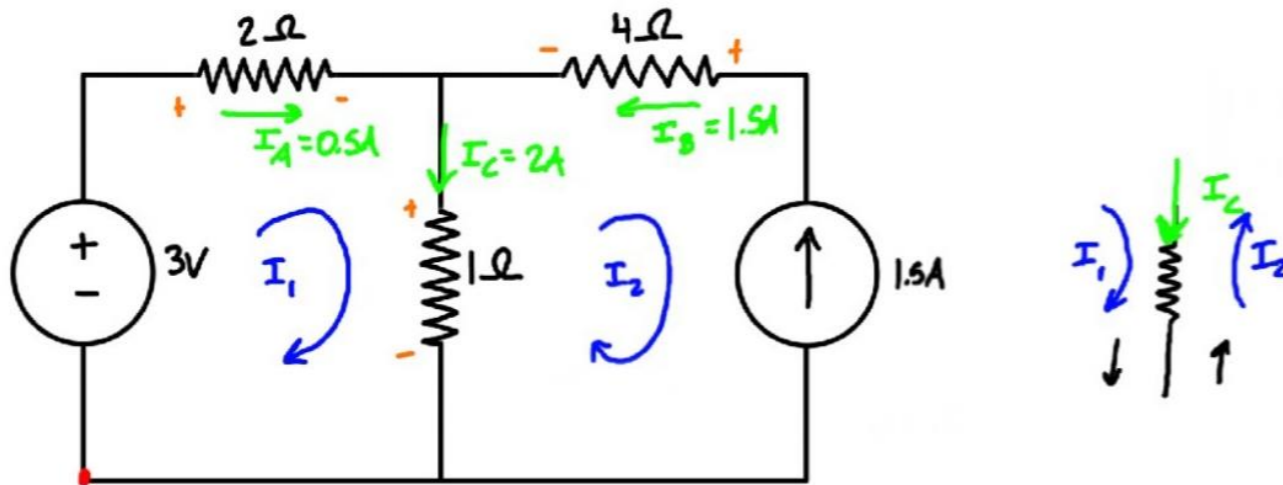
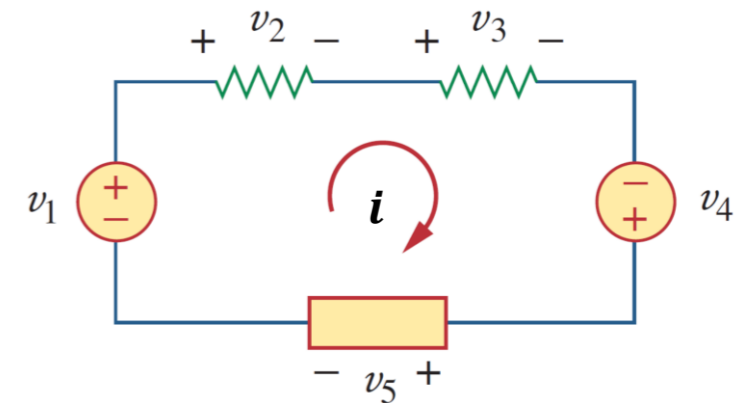


Photo source: [13] -

<https://i.ytimg.com/vi/eQpc2QRFv7Y/maxresdefault.jpg>

Meshga KVL qo'llaniladi

$$\sum U = 0$$

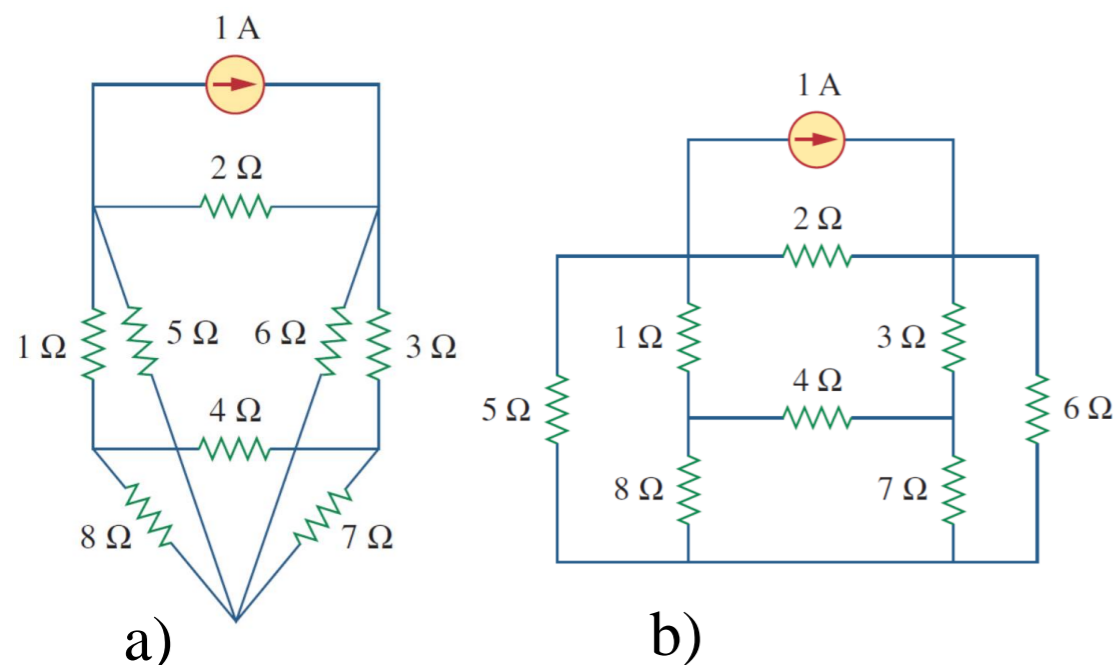


$$-u_1 + u_2 + u_3 - u_4 + u_5 = 0$$

$$u_2 + u_3 + u_5 = u_1 + u_4$$

Photo source: [14] - Fundamentals of Electric Circuits, Charles K. Alexander and Matthew N. O. Sadiku / 5th edition, the McGraw-Hill Companies, Inc., -2013. – p 39.

Zanjir tarmog'ini tahlil qilish tugun tahlili kabi umumiy emas, chunki u faqat tekis (*planar*) bo'lgan zanjir uchun qo'llaniladi.



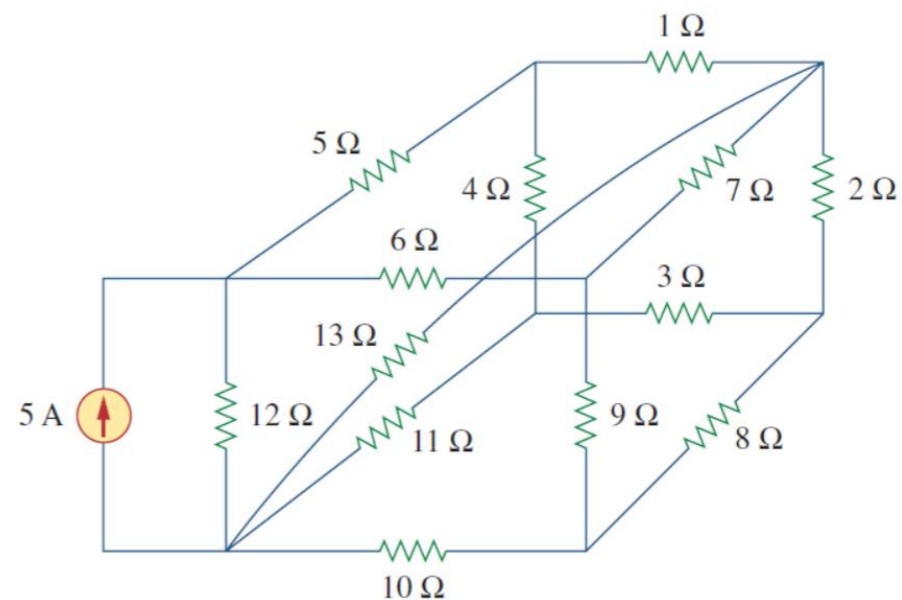
3.8-rasm.

a) kesishgan shaxobchalari bo'lgan tekis zanjir;

b) kesishuvchi shaxobchalarisiz bir xil zanjirning qayta chizilgan holati.

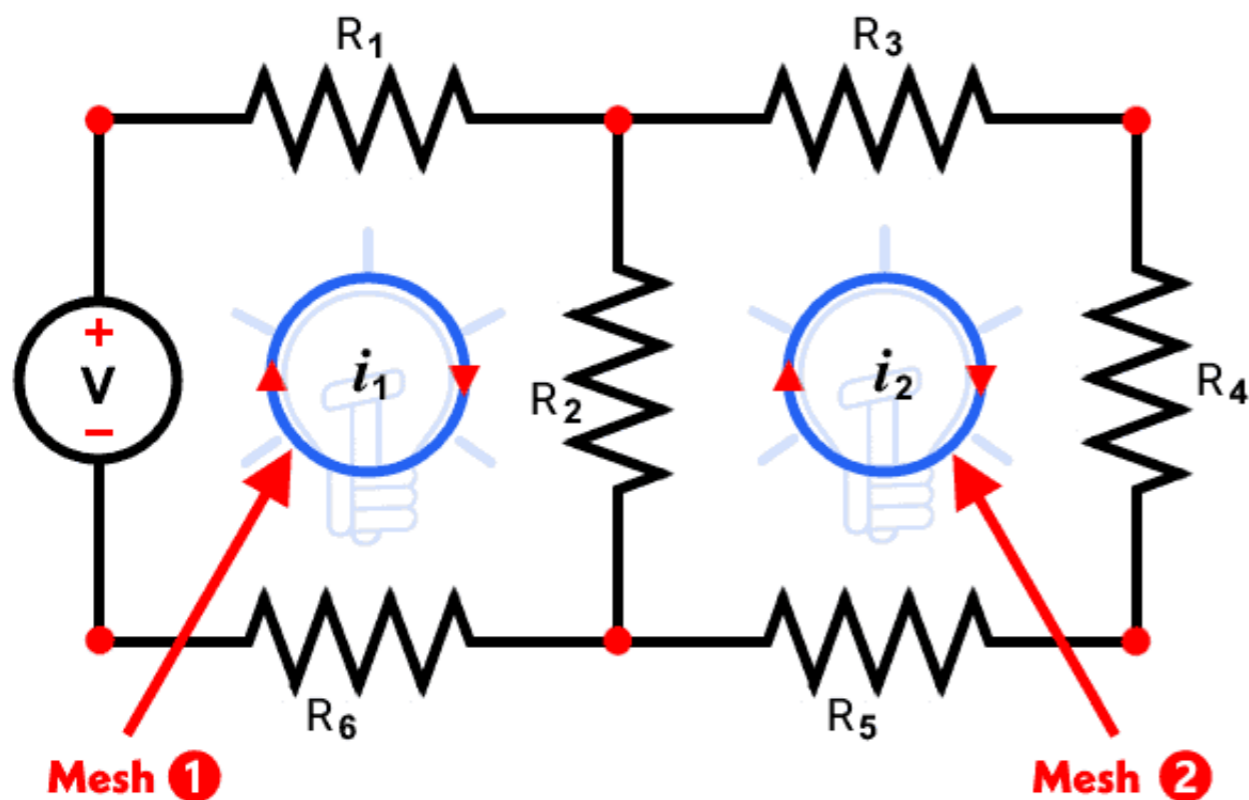
Planar zanjir shaxobchalari bir-birini kesib o'tmagan tekis chizilgan bo'ladi.

Aks holda u tekis bo'lmagan (*nonplanar*) zanjir bo'ladi.



3.9-rasm.

Zanjir kesishuvchi shaxobchalarga ega bo‘lishi mumkin. Agar uni kesib o‘tuvchi shaxobchalar bo‘lmasa, uni qayta chizish mumkin bo‘lsa ham tekis zanjir bo‘ladi.



Mesh tahlilini tushunish uchun biz avval mesh deganda nimani nazarda tutilayotganini bilishimiz kerak.

Mesh - bu ichida boshqa konturlar bo‘lmagan halqadir.

Photo source: [15] - <https://www.electricaltechnology.org/wp-content/uploads/2013/12/How-to-Find-the-Number-of-Meshes-in-an-Electric-Circuit.png>

abefa

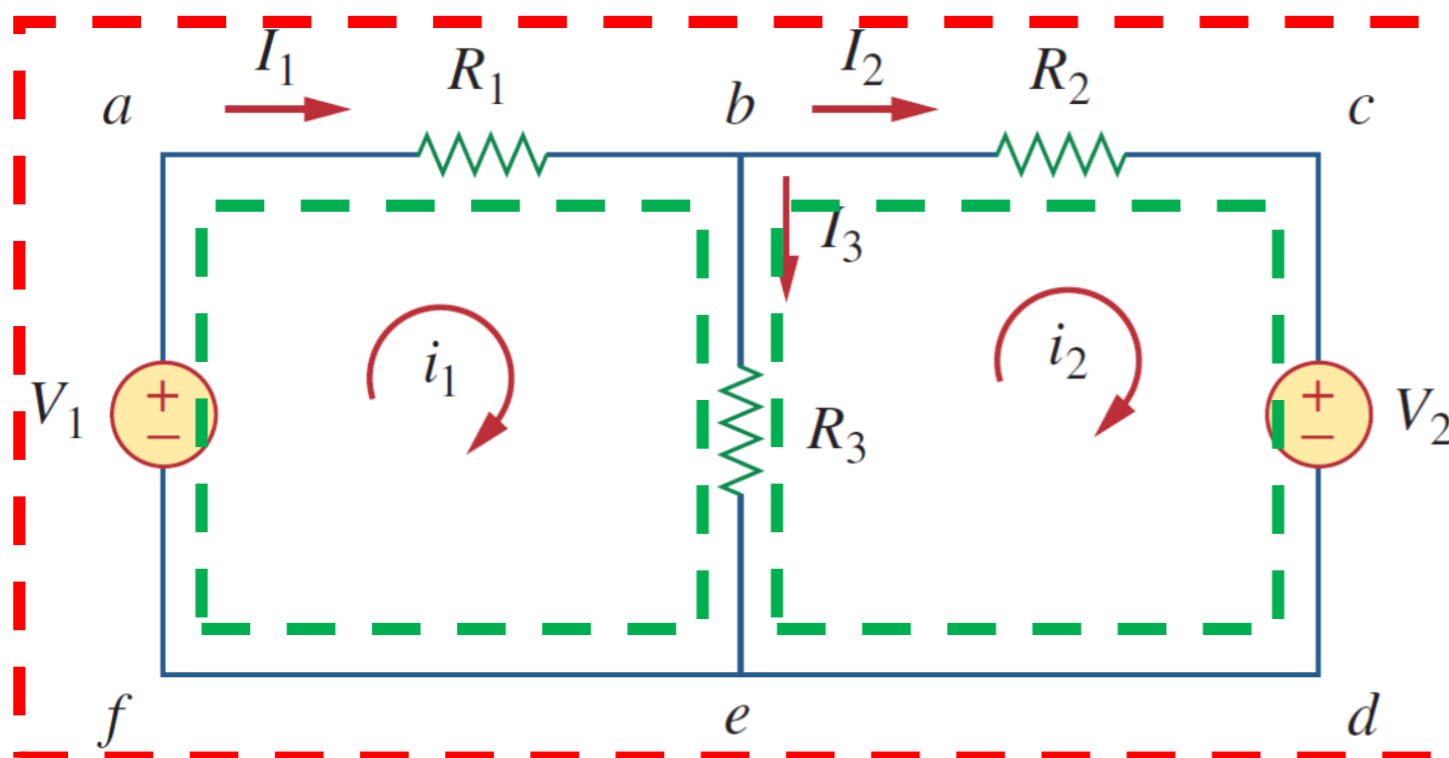
bcdeb

yo'llari meshdir



abcdefa

yo'li mesh emas



Mesh orqali o'tadigan tok kuchi tarmoq tok kuchi (*mesh current*) deb nomlanadi.

Mesh tahlilida biz ma'lum bir zanjirdagi tarmoq tok kuchlarini topish uchun KVLdan foydalaniladi.

3.7-rasm. Ikki mesh (to'r, tarmoq, halqa)li zanjir.

Photo source: [16] -

https://t3.ftcdn.net/jpg/03/23/72/36/360_F_323723637_QqVgHZFSzbbDJ7kQ5dGpwUn7bIJ48HMP.jpg

Meshdagi tok kuchlarni aniqlash bosqichlari:

1. n ta meshga i_1, i_2, \dots, i_n tarmoqlar soni va tok kuchining yoʻnalish belgilanadi;
2. KVL ni har bir n meshga qoʻllaniladi. Om qonunidan foydalanib, kuchlanishlarni mesh toklari bilan ifodalanadi;
3. Meshdagi tok kuchlarini olish uchun bir vaqtning oʻzida hosil boʻlgan n tenglama yechiladi.

Meshdagi tok kuchining yoʻnalishi soat mili yoʻnalishi boʻyicha yoki soat mili yoʻnalishiga teskari (*clockwise or counterclockwise*) joylashtirilsa, yechim qiymatiga taʼsir qilmaydi.

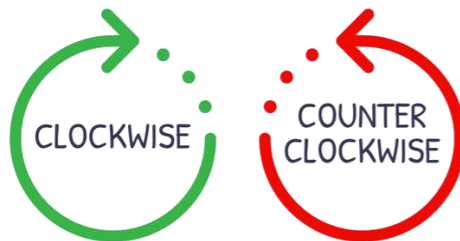


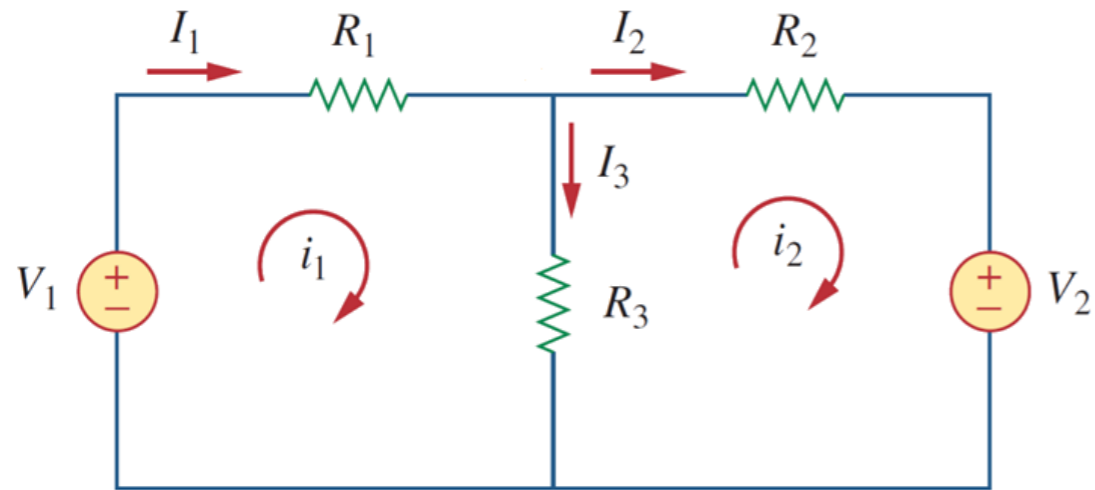
Photo source: [17] -

https://t3.ftcdn.net/jpg/04/54/75/24/360_F_454752453_LNgqzGTNAO0HwKGUZ2x5MbGIECHynyFq.jpg

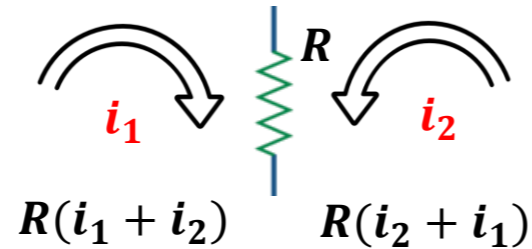
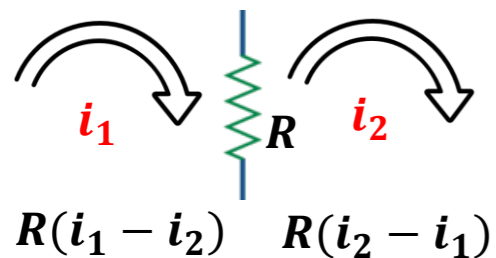
Birinchi bosqich -

i_1 va i_2 mesh tok kuchlarining yoʻnalishlarini 1 va 2-meshlarga belgilanishini talab qiladi.

Mesh tok kuchi har bir meshga ixtiyoriy yoʻnalishda belgilanishi mumkin boʻlsa-da, har bir mesh tok kuchi soat yoʻnalishi boʻyicha oqadi deb taxmin qilinadi.



3.7-rasm. Ikki mesh (toʻr, tarmoq, halqa)li zanjir.



Ikkinchi bosqich -

KVLni 1-meshga qoʻllaymiz.

$$-u_1 + R_1 i_1 + R_3 (i_1 - i_2) = 0$$

$$(R_1 + R_3) i_1 - R_3 i_2 = u_1 \quad (3.13)$$

KVLni 2-meshga qoʻllaymiz.

$$R_2 i_2 + u_2 + R_3 (i_2 - i_1) = 0$$

$$-R_3 i_1 + (R_2 + R_3) i_2 = -u_2 \quad (3.14)$$



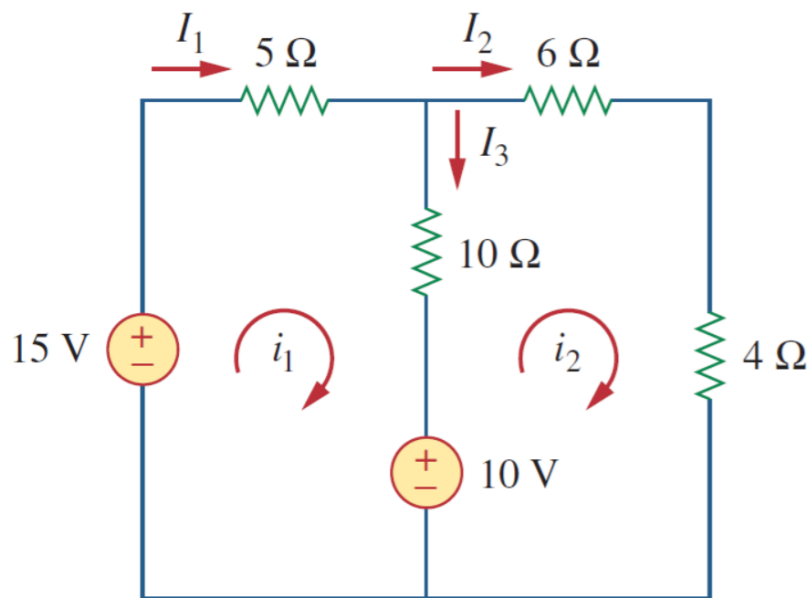
(3.13) va (3.14) tenglamalarni matritsaga qo'yish meshdagi i_1 va i_2 tok kuchlarini olish uchun yechilishi mumkin bo'lgan xadlarni hosil qiladi.

$$\begin{bmatrix} R_1 + R_3 & -R_3 \\ -R_3 & R_2 + R_3 \end{bmatrix} \begin{bmatrix} i_1 \\ i_2 \end{bmatrix} = \begin{bmatrix} u_1 \\ -u_2 \end{bmatrix} \quad (3.15)$$

$$\begin{aligned} I_1 &= i_1, \\ I_2 &= i_2, \\ I_3 &= i_1 - i_2 \end{aligned} \quad (3.16)$$

3.3.1-masala: 3.8-rasmdagi zanjir uchun mesh tahlilidan foydalanib,

shaxobchalardagi tok kuchlari I_1 , I_2 va I_3 larini toping.



3.8-rasm.

1-usul: (3.3.2) \rightarrow (3.3.1)

$$3(2i_2 - 1) - 2i_2 = 1$$

$$6i_2 - 3 - 2i_2 = 1$$

$i_2 = 1 A$; $i_1 = 2i_2 - 1 = 2 - 1 = 1 A$. Demak, $I_1 = i_1 = 1 A$, $I_2 = i_2 = 1 A$, $I_3 = i_1 - i_2 = 1 - 1 = 0$.

Yechish:

1-mesh uchun,

$$-15 + 5i_1 + 10(i_1 - i_2) + 10 = 0 \rightarrow 3i_1 - 2i_2 = 1 \quad (3.3.1)$$

2-mesh uchun,

$$6i_2 + 4i_2 + 10(i_2 - i_1) - 10 = 0 \rightarrow i_1 = 2i_2 - 1 \quad (3.3.2)$$

2-usul:

$$\begin{bmatrix} 3 & -2 \\ -1 & 2 \end{bmatrix} \begin{bmatrix} i_1 \\ i_2 \end{bmatrix} = \begin{bmatrix} 1 \\ 1 \end{bmatrix}$$

$$\Delta = \begin{vmatrix} 3 & -2 \\ -1 & 2 \end{vmatrix} = 6 - 2 = 4$$

$$\Delta_1 = \begin{vmatrix} 1 & -2 \\ 1 & 2 \end{vmatrix} = 2 + 2 = 4$$

$$i_1 = \frac{\Delta_1}{\Delta} = 1 A$$

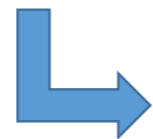
$$\Delta_2 = \begin{vmatrix} 3 & 1 \\ -1 & 1 \end{vmatrix} = 3 + 1 = 4$$

$$i_2 = \frac{\Delta_2}{\Delta} = 1 A$$

3.4. Tok kuchi manbalari bilan tarmoqni tahlil qilish.

Tarmoqli tahlilni tok kuchi manbalari (*bog'liq bo'lgan yoki mustaqil*) ni o'z ichiga olgan zanjirlarda qo'llash murakkab tuyulishi mumkin.

Ammo bu oldingi boblarda duch kelgan muammolardan ancha oson.



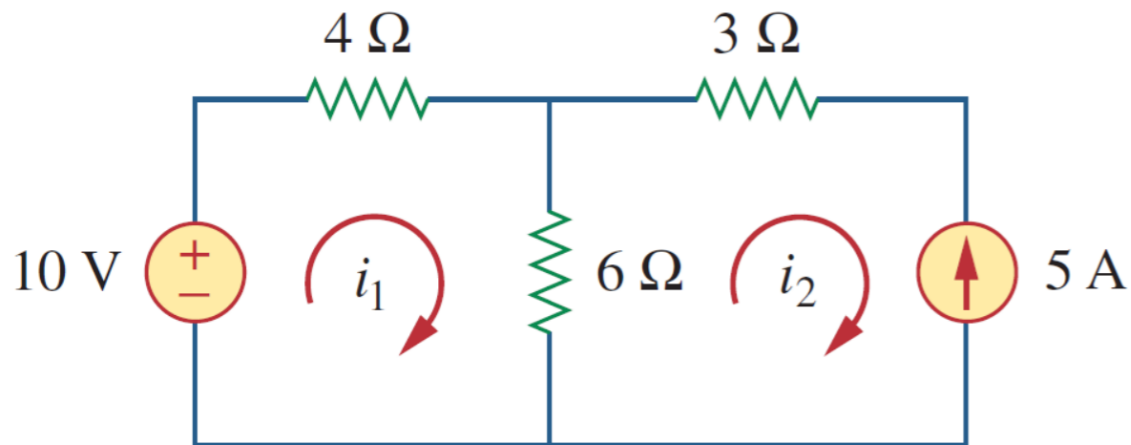
Chunki, tok kuchi manbalarning qo'llanilishi tenglamalar sonini kamaytiradi.

Quyidagi ikkita mumkin bo'lgan holatni ko'rib chiqamiz.

1-holat:

Meshdagi tok kuchlarini aniqlashda har bir mesh uchun tok kuchining harakat yoʻnalishini belgilab olish talab etiladi.

Agar tok kuchi manbai faqat bitta meshda mavjud boʻlsa, 2-meshdagi 5 A tok kuchi i_2 ning yoʻnalishiga qarama qarshi boʻlganligi uchun uning qiymatini $i_2 = -5 A$ ni qabul qilamiz.



3.9-rasm. Tok kuchi manbali zanjir.

1-mesh uchun KVL ni qoʻllaymiz.

$$-10 + 4i_1 + 6(i_1 - i_2) = 0$$

$$10i_1 - 6i_2 = 10$$

$$10i_1 - 6(-5) = 10$$

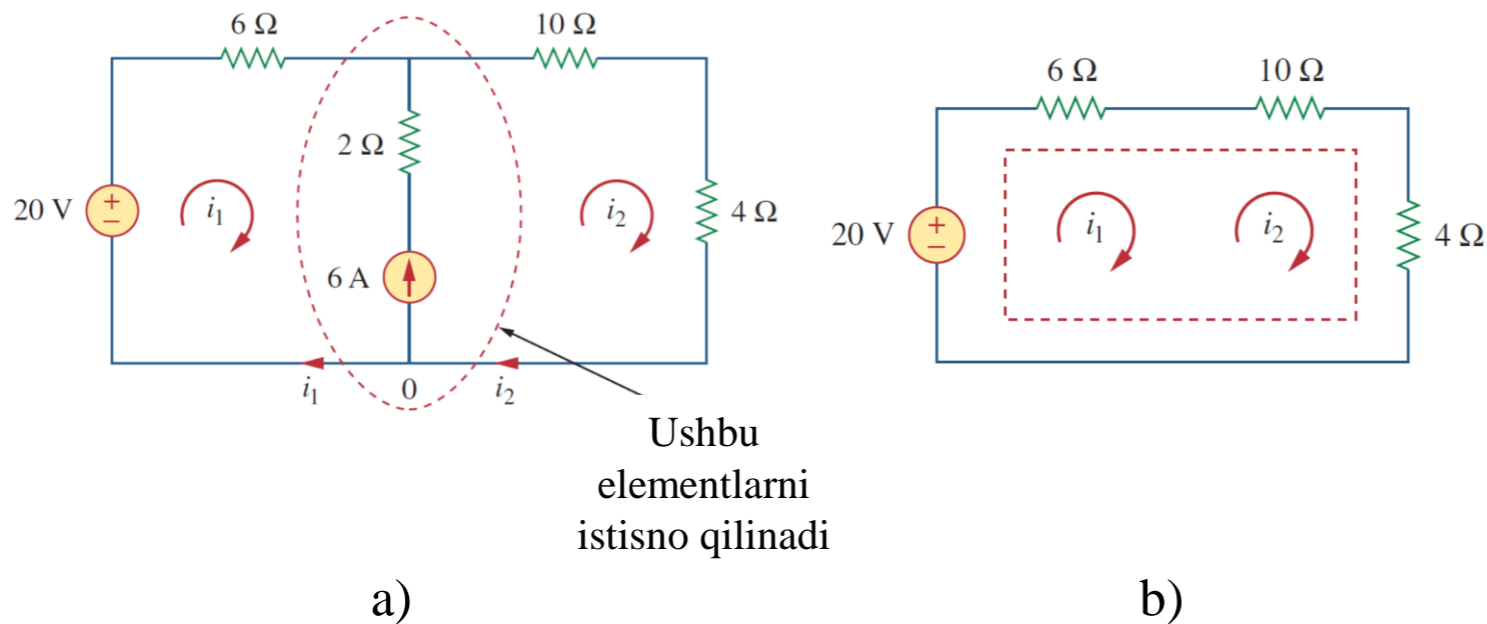
$$10i_1 = -20$$

$$i_1 = -2$$

2-holat:

Ikki tarmoq orasida tok kuchi manbai mavjud bo‘lgan holatni ko‘rib chiqaylik (3.10-rasm, *a*).

3.10-rasm, *b* da ko‘rsatilganidek, biz tok kuchi manbaini va u bilan ketma-ket bog‘langan har qanday elementlarni chiqarib, super meshni hosil qilamiz.



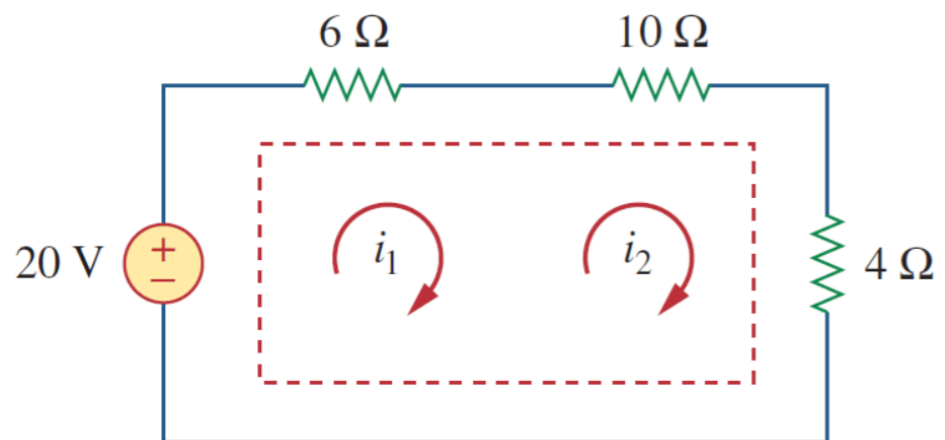
3.10-rasm.

a) umumiy tok kuchi manbaiga ega bo‘lgan ikkita mesh (*tarmoq*);

b) tok kuchi manbaini hisobga olmaganda yaratilgan super mesh.

Supermesh ikkita mesh umumiy (*bog‘liq bo‘lgan yoki mustaqil*) tok kuchi manbaiga ega bo‘lganda paydo bo‘ladi.

3.10-rasm, *b* da ikkita meshning atrofi (*periferiyasi*) da super meshni hosil qilamiz.

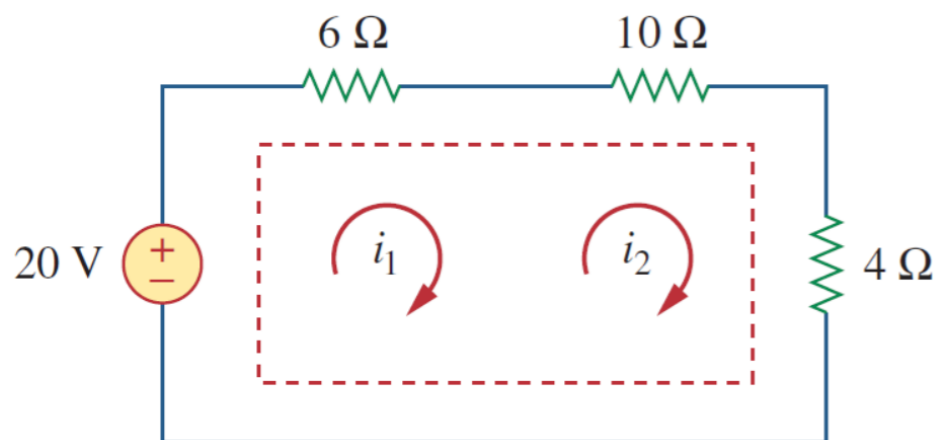


Agar zanjirda ikki yoki undan ortiq super meshlar bo'lsa, ular kattaroq super mesh hosil qilish uchun birlashtirilishi kerak.

Nima uchun super meshga boshqacha munosabatda bo'lish kerak?

Mesh tahlilida KVL qo'llanilganligi sababli, har bir tarmoqdagi kuchlanishni bilishimizni talab qiladi va tok kuchi manbaidagi kuchlanishni oldindan bilmaymiz.

Biroq, super mesh boshqa har qanday mesh kabi KVL ni qanoatlantirishi kerak.



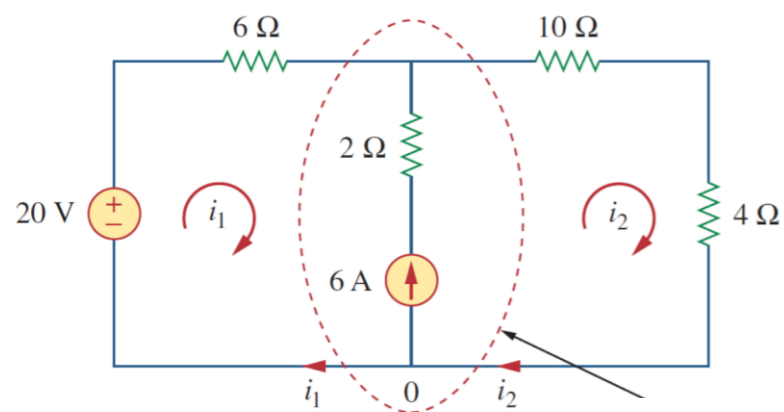
Super meshga KVL ni qo‘llash imkonini beradi.

$$-20 + 6i_1 + 10i_2 + 4i_2 = 0$$

$$6i_1 + 14i_2 = 20 \quad (3.18)$$

Biz KCLni ikkita mesh kesishgan shaxobchadagi tugunga qo‘llaymiz.

$$i_2 = i_1 + 6 \quad (3.19)$$



Ushbu
elementlarni
istisno qilinadi

(3.18) va (3.19) tenglamalarni yechib, quyidagi qiymatlarni topamiz.

$$6i_1 + 14(i_1 + 6) = 20$$

$$20i_1 = -64$$

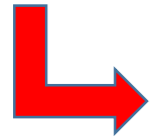
$$i_1 = -3,2 \text{ A}$$

$$i_2 = -3,2 + 6 = 2,8 \text{ A}$$

Super meshning quyidagi xususiyatlariga e'tibor bering:



1. Super meshdagi tok kuchi manbai mesh tok kuchlarini aniqlashda zarur bo'lgan cheklash tenglamasini beradi.



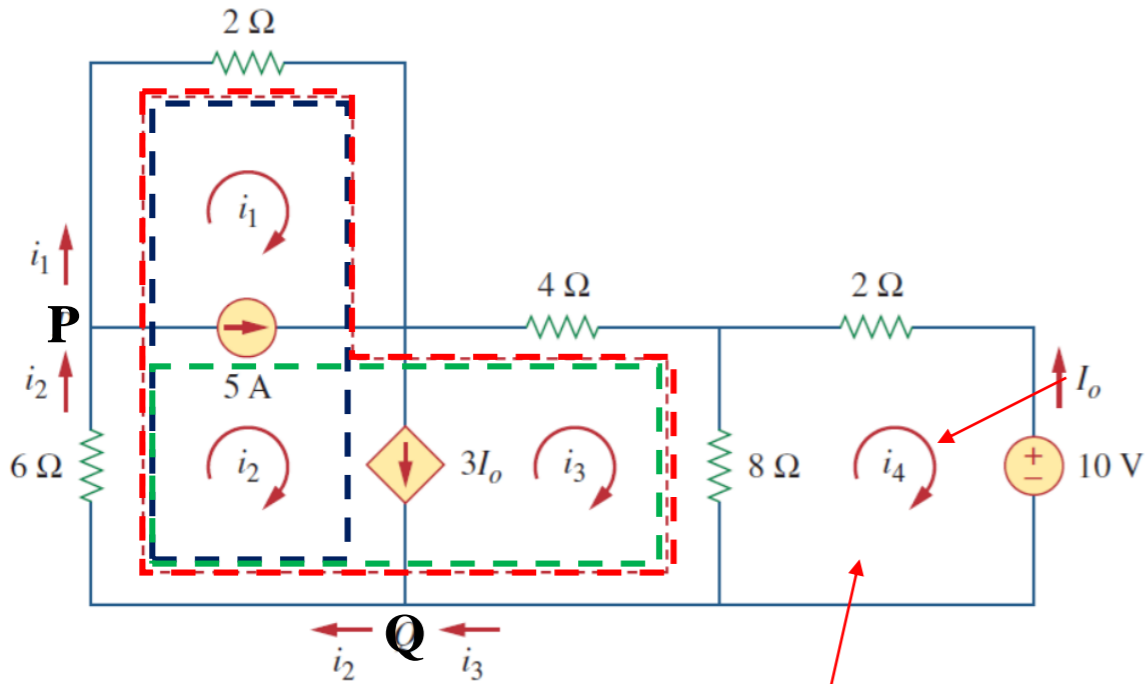
2. Super meshning o'ziga xos tok kuchi yo'q.



3. Super mesh ham KVL, ham KCL qo'llanilishini talab qiladi.

3.4.1-masala: 3.11-rasmdagi zanjir uchun mesh tahlildan foydalanib,

i_1 dan i_4 tok kuchlarini toping.



3.11-rasm.

4-meshga KVL ni qo'llaymiz,

$$2i_4 + 8(i_4 - i_3) + 10 = 0$$

$$5i_4 - 4i_3 = -5 \quad (3.4.4)$$

Yechish:

1 va 2-meshlar super mesh chunki, mustaqil tok kuchi manbai mavjud.

2 va 3-meshlar boshqa super mesh, chunki bog'liq bo'lgan tok kuchi manbaiga ega.

KVL ni kattaroq super meshga qo'llaymiz:

$$2i_1 + 4i_3 + 8(i_3 - i_4) + 6i_2 = 0$$

$$i_1 + 3i_2 + 6i_3 - 4i_4 = 0 \quad (3.4.1)$$

KCL ni P tugunga nisbatan qo'llaymiz:

$$i_2 = i_1 + 5 \quad (3.4.2)$$

KCL ni Q tugunga nisbatan qo'llaymiz:

$$i_2 = i_3 + 3I_o \rightarrow I_o = -i_4 \rightarrow i_2 = i_3 - 3i_4 \quad (3.4.3)$$

$$(3.4.1)$$

$$(3.4.2)$$

$$(3.4.3)$$

$$(3.4.4)$$

$$i_1 = -7,5 \text{ A},$$

$$i_3 = 3,93 \text{ A},$$

$$i_2 = -2,5 \text{ A},$$

$$i_4 = 2,143 \text{ A}.$$

FOYDALANILGAN MANBALAR:

11. https://circuitdigest.com/sites/default/files/projectimage_tut/Mesh-Current-Analysis.png
12. <https://www.electricaltechnology.org/wp-content/uploads/2013/12/How-to-Find-the-Number-of-Loops-in-an-Electric-Circuit.png>
13. <https://i.ytimg.com/vi/eQpc2QRFv7Y/maxresdefault.jpg>
14. Fundamentals of Electric Circuits, Charles K. Alexander and Matthew N. O. Sadiku / 5th edition, the McGraw-Hill Companies, Inc., -2013. – p 39.
15. <https://www.electricaltechnology.org/wp-content/uploads/2013/12/How-to-Find-the-Number-of-Meshes-in-an-Electric-Circuit.png>
16. https://t3.ftcdn.net/jpg/03/23/72/36/360_F_323723637_QqVgHZFSzbbDJ7kQ5dGpwUn7bIJ48HMP.jpg
17. https://t3.ftcdn.net/jpg/04/54/75/24/360_F_454752453_LNgqzGTNAO0HwKGUZ2x5MbGIECHynyFq.jpg



*E'TIBORINGIZ
UCHUN
RAHMAT!!!*