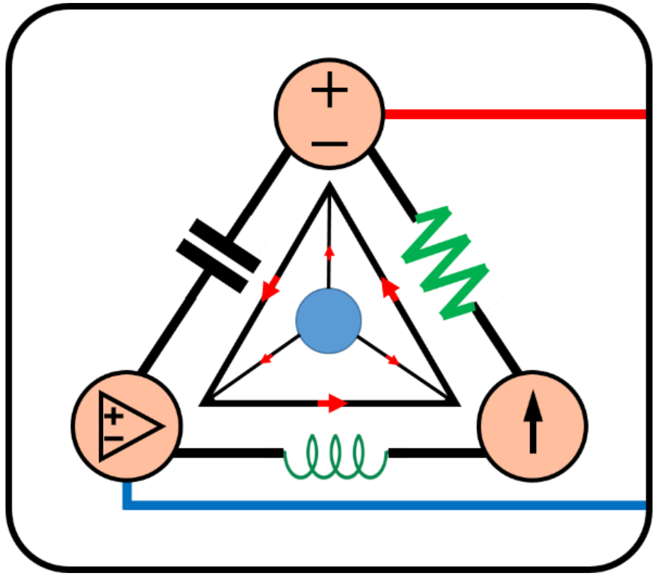
3-Mavzu: Zanjirlarni tahlil qilish usullari.

(Lecture-3: Methods of Analysis)

3-Mavzuning 3-qismi

(Part 3 of the Lecture-3)



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(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.

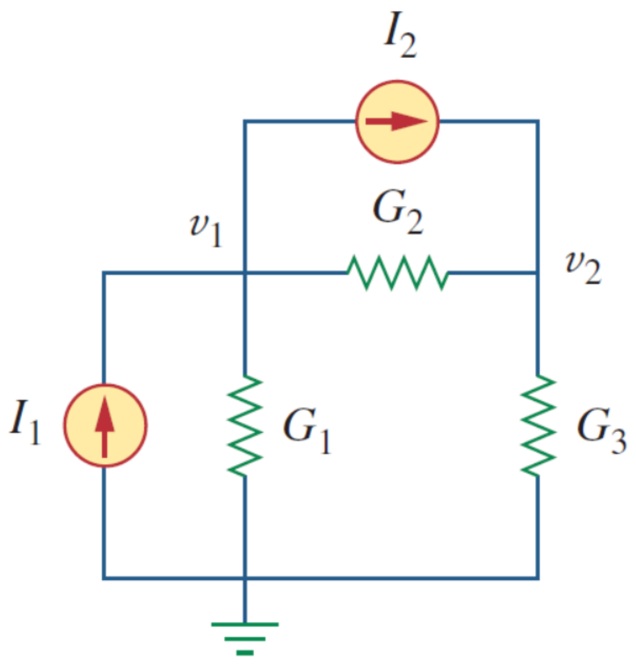
3.4. Tok kuchi manbalari bilan tarmoqni tahlil qilish.

3.5. Tekshiruv yo‘li bilan tugun va mesh tahlillari.

3.6. Qo‘llanilishi.

3.5. Tekshiruv yo‘li bilan tugun va mesh tahlillari.

Ushbu bo‘lim tugun yoki mesh tahlilining umumlashtirilgan tartibini o‘rganishimiz mumkin. Bu elektr zanjirini tekshirishga asoslangan qisqa yondashuvdir.



a)

3.12-rasm.

a) 3.3-rasmni qayta chiqilgan zanjiri.

Elektr zanjiridagi barcha manbalar mustaqil tok kuchi manbalari bo‘lsa, tugun kuchlanish tenglamalarini olish uchun har bir tugun uchun KCL qo‘llashimiz shart bo‘lmaydi.

Biz tenglamalarni shunchaki zanjirni tekshirish orqali ham olishimiz mumkin.

$$\begin{bmatrix} G_1 + G_2 & -G_2 \\ -G_2 & G_2 + G_3 \end{bmatrix} \begin{bmatrix} u_1 \\ u_2 \end{bmatrix} = \begin{bmatrix} I_1 - I_2 \\ I_2 \end{bmatrix} \qquad (3.21)$$

E’tibor bering, diagonal hadlarning har biri to‘g‘ridan-to‘g‘ri 1 yoki 2-tugunga ulangan o‘tkazuvchanliklarning yig‘indisidir.

Diagonaldan tashqari hadlar esa tugunlar orasiga bog‘langan o‘tkazuvchanliklarning salbiylari deb tushunamiz.

Shuningdek, (3.21) tenglamaning o‘ng tomonidagi har bir shart tugunga kiradigan tok kuchlarining algebraik yig‘indisidir.

Umuman olganda, agar mustaqil tok kuchi manbalari bo‘lgan zanjirlarda N ta noaniq tugun bo‘lsa, tugun-kuchlanish tenglamalari o‘tkazuvchanlik nuqtai nazaridan yozilishi mumkin:

$$\begin{bmatrix} G_{11} & G_{12} & \dots & G_{1N} \\ G_{21} & G_{22} & \dots & G_{2N} \\ \dots & \dots & \dots & \dots \\ G_{N1} & G_{N2} & \dots & G_{NN} \end{bmatrix} \begin{bmatrix} u_1 \\ u_2 \\ \dots \\ u_N \end{bmatrix} = \begin{bmatrix} i_1 \\ i_2 \\ \dots \\ i_N \end{bmatrix} \qquad (3.22)$$

$$Gu = i \qquad (3.23)$$

G_{kk} - k tuguniga ulangan o‘tkazgichlar yig‘indisi;

$G_{kj} = G_{jk} -$ k va j, $k \neq j$ tugunlarini to‘g‘ridan-to‘g‘ri bog‘lovchi o‘tkazgichlar yig‘indisining salbiysi;

$u_k - k$ tugunidagi noma’lum kuchlanish;

$i_k - k$ tuguniga bevosita ulangan barcha mustaqil tok kuchi manbalarining yig‘indisi, tugunga kiradigan tok kuchlari ijobiy deb hisoblanadi;

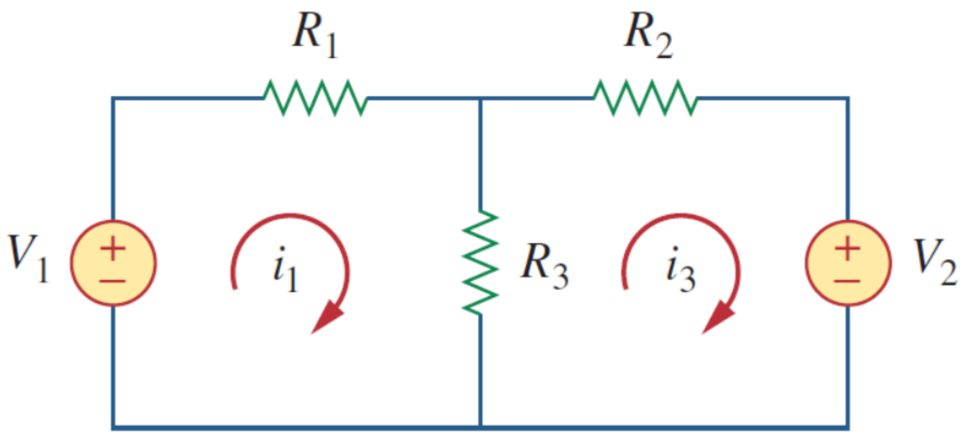
G - o‘tkazuvchanlik matritsasi deb ataladi;

u - chiqish vektori;

i - kirish vektori.

Noma'lum tugun kuchlanishlarini aniqlash uchun (3.22) tenglama yechilishi mumkin.

Demak, bu faqat mustaqil tok kuchi manbalari va chiziqli qarshiliklarga ega bo'lgan zanjirlar uchun amal qiladi.



b)

3.12-rasm.

b) 3.9-rasmni qayta chizilgan zanjiri.

Xuddi shunday, chiziqli qarshilik zanjirida faqat mustaqil kuchlanish manbalari mavjud bo'lganda, tekshirish orqali mesh-tok kuchi tenglamalari olinadi.

Zanjir ikkita yo‘naltiruvchiga ega bo‘lmagan tugunlar va tugun tenglamalarini quyidagicha ifodalashimiz mumkin.

$$\begin{bmatrix} R_1+R_3 & -R_3 \\ -R_3 & R_2+R_3 \end{bmatrix} \begin{bmatrix} i_1 \\ i_2 \end{bmatrix} = \begin{bmatrix} u_1 \\ -u_2 \end{bmatrix} \qquad (3.24)$$

Biz diagonal hadlarning har biri tegishli tarmoqdagi qarshiliklar yig‘indisi ekanligini, diagonaldan tashqaridagi har bir had esa 1 va 2 meshlar uchun umumiy qarshilikning manfiy ekanligini ko‘ramiz.

(3.24) tenglama tegishli tarmoqdagi barcha mustaqil kuchlanish manbalarining soat yo‘nalishi bo‘yicha olingan algebraik yig‘indisini ifodalaydi.

Umuman olganda, agar zanjirda N ta meshlar bo‘lsa, mesh-tok kuchi tenglamalari qarshiliklar bilan ifodalanishi mumkin:

$$\begin{bmatrix} R_{11} & R_{12} & \dots & R_{1N} \\ R_{21} & R_{22} & \dots & R_{2N} \\ \dots & \dots & \dots & \dots \\ R_{N1} & R_{N2} & \dots & R_{NN} \end{bmatrix} \begin{bmatrix} i_1 \\ i_2 \\ \dots \\ i_N \end{bmatrix} = \begin{bmatrix} u_1 \\ u_2 \\ \dots \\ u_N \end{bmatrix} \quad (3.25)$$

R_{kk} - k tuguniga ulangan rezistorlar yig‘indisi;

$R_{kj} = R_{jk} - k$ va j, $k \neq j$ tugunlarini to‘g‘ridan-to‘g‘ri bog‘lovchi rezistorlar yig‘indisining salbiysi;

$i_k - k$ mesh uchun soat mili yo‘nalishi bo‘yicha noma’lum mesh toki kuchi;

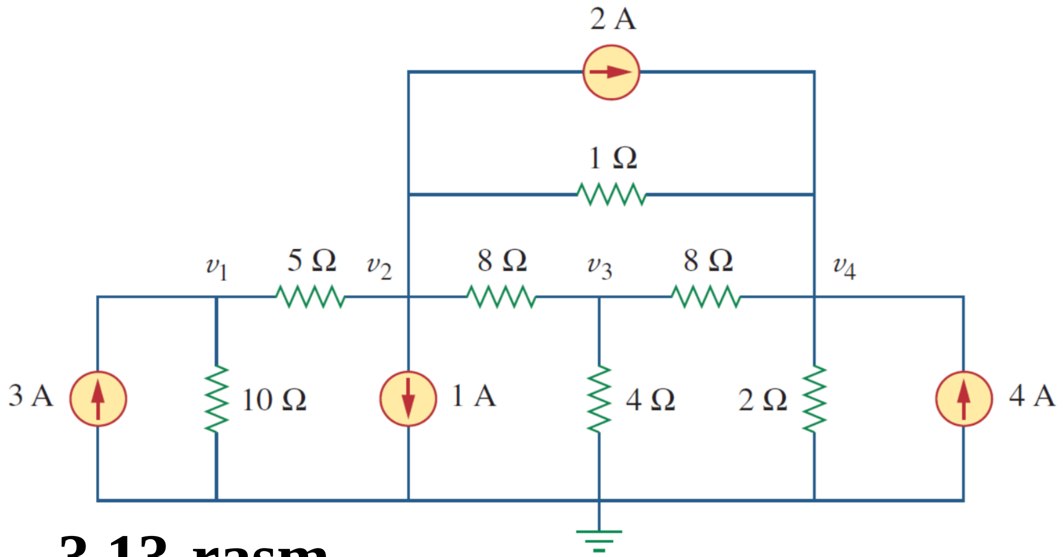
$u_k - k$ mesh to‘rdagi barcha mustaqil kuchlanish manbalarining soat yo‘nalishi bo‘yicha yig‘indisi, kuchlanishning ko‘tarilishi ijobiy deb hisoblanadi;

$$Ri = u \quad (3.26)$$

R - rezistor matritsasi deb ataladi;
i - chiqish vektori;
u - kirish vektori.

Noma’lum mesh toklarini aniqlash uchun (3.25) tenglamani yechish mumkin.

3.5.1-masala: Tekshiruv yo‘li bilan 3.13-rasmdagi zanjir uchun tugun-kuchlanish matritsa tenglamalarini yozing.



3.13-rasm.

Yechish: Siemensdagi G diagonal hadlari quyidagicha aniqlanadi.

$$G_{11} = \frac{1}{5} + \frac{1}{10} = 0{,}3, \qquad G_{22} = \frac{1}{5} + \frac{1}{8} + \frac{1}{1} = 1{,}325,$$

$$G_{33} = \frac{1}{8} + \frac{1}{8} + \frac{1}{4} = 0{,}5, \qquad G_{44} = \frac{1}{8} + \frac{1}{2} + \frac{1}{1} = 1{,}625.$$

Diagonaldan tashqari hadlar

$$G_{12} = -\frac{1}{5} = -0{,}2, \qquad G_{13} = G_{14} = 0,$$

$$G_{21} = -0{,}2, \qquad G_{23} = -\frac{1}{8} = -0{,}125, \qquad G_{24} = -\frac{1}{1} = -1,$$

$$G_{31} = 0, \qquad G_{32} = -0{,}125, \qquad G_{34} = -\frac{1}{8} = -0{,}125,$$

$$G_{41} = 0, G_{42} = -1, \qquad G_{44} = -0{,}125$$

Kirish tok kuchi vektori *i* amperda quyidagi hadlarga ega:

$$i_1 = 3, \quad i_2 = -1 - 2 = -3, \quad i_3 = 0, \quad i_4 = 2 + 4 = 6$$

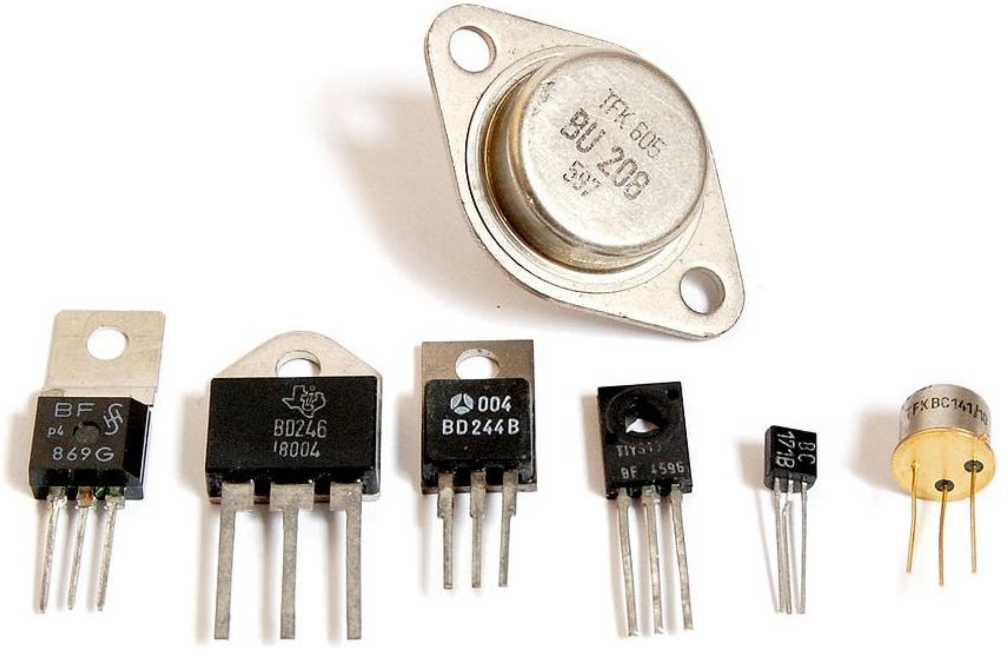
Shunday qilib, tugun-kuchlanish tenglamalari quyidagi matritsa ko‘rinishida yoziladi.

$$\begin{bmatrix} 0{,}3 & -0{,}2 & 0 & 0 \\ -0{,}2 & 1{,}325 & -0{,}125 & -1 \\ 0 & -0{,}125 & 0{,}5 & -0{,}125 \\ 0 & -1 & -0{,}125 & 1{,}625 \end{bmatrix} \begin{bmatrix} u_1 \\ u_2 \\ u_3 \\ u_4 \end{bmatrix} = \begin{bmatrix} 3 \\ -3 \\ 0 \\ 6 \end{bmatrix}$$

u_1, u_2, u_3 va u_4 tugun kuchlanishlarini aniqlash uchun *MATLAB* yordamida hisoblash mumkin.

3.6. Qo‘llanilishi.

Ushbu elektronika va kompyuterlarda joylashgan integral mikrosxemalar uchun asosiy komponent tranzistor deb nomlanuvchi faol, uch terminalli qurilma hisoblanadi.



Muhandis elektron zanjirni loyihalashni boshlashdan oldin tranzistorni tushunish juda muhimdir.

3.14-rasm. Tranzistorlar.

Photo source: [18] - https://info.endaq.com/hubfs/Blog-Images/Electronic-Components/Transistors-white.jpg

Transistorlarning ikkita asosiy turi mavjud: bipolyar o‘tish tranzistorlari (*bipolar junction transistors - BJT*) va maydon effektli tranzistorlar (*field-effect transistors - FET*).

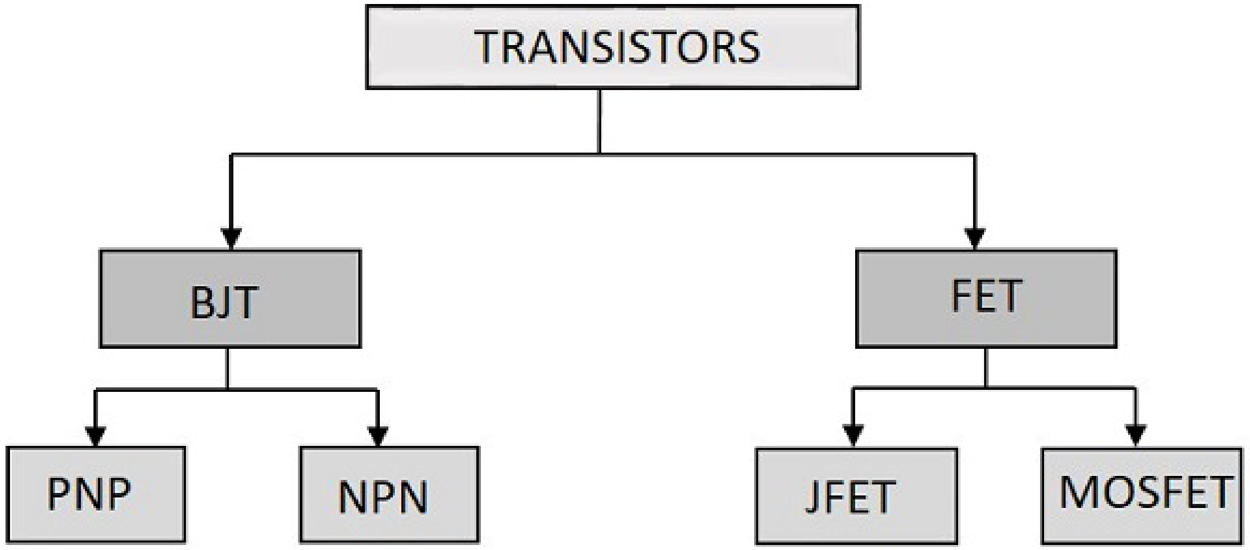
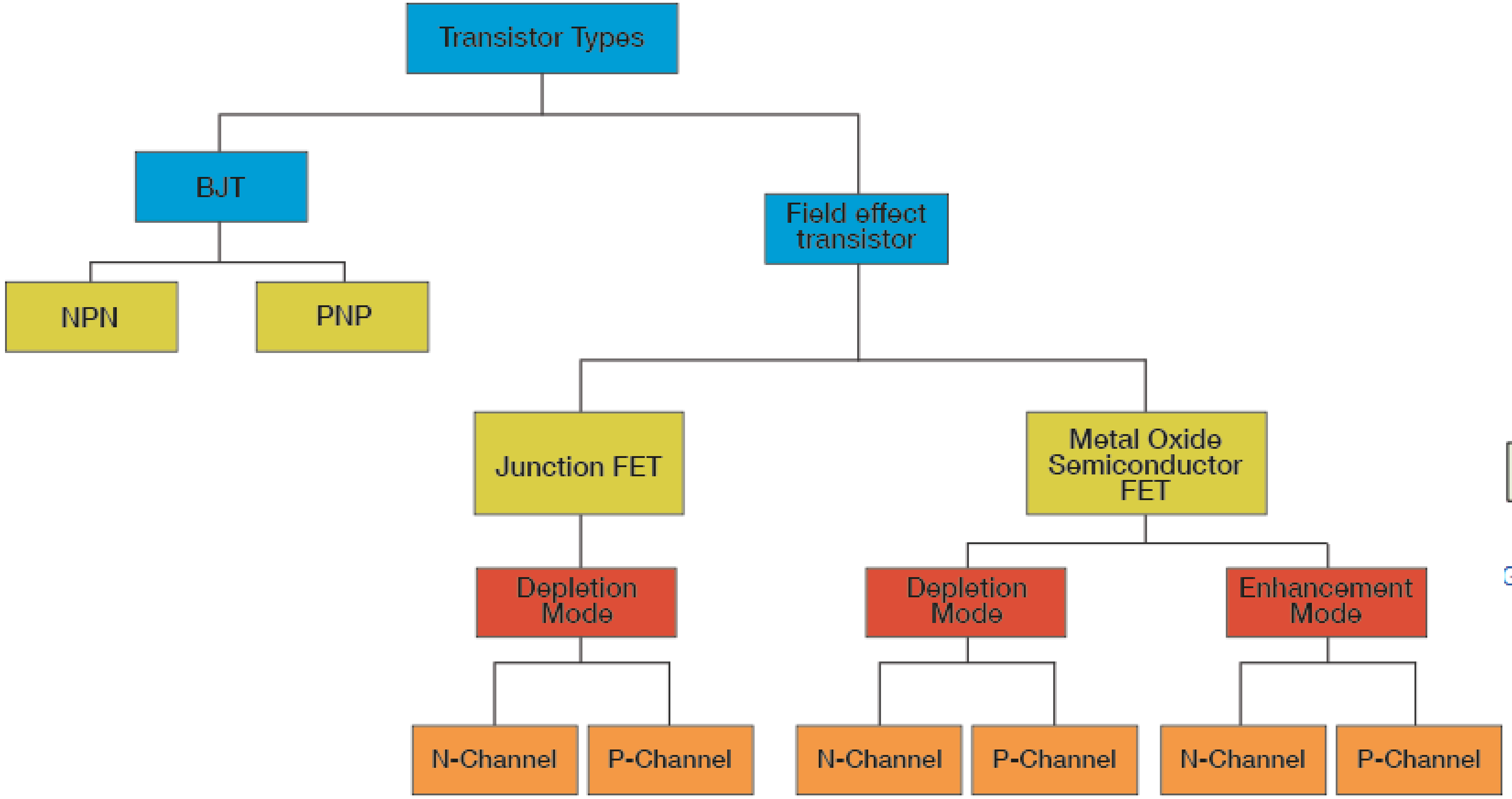


Photo source: [19] - https://www.tutorialspoint.com/basic_electronics/images/transistor_types.jpg

Bu yerda biz faqat BJT larni ko‘rib chiqamiz, ular ikkalasining birinchisi bo‘lgan va bugungi kunda ham qo‘llaniladi.

Bizning maqsadimiz BJT haqida yetarli ma‘lumotni taqdim etishdir, bu bizga ushbu bobda ishlab chiqilgan usullarni o‘zgarmas tok tranzistorli zanjirlarini tahlil qilish uchun qo‘llash imkonini beradi.

Transistorlarning asosiy turlari



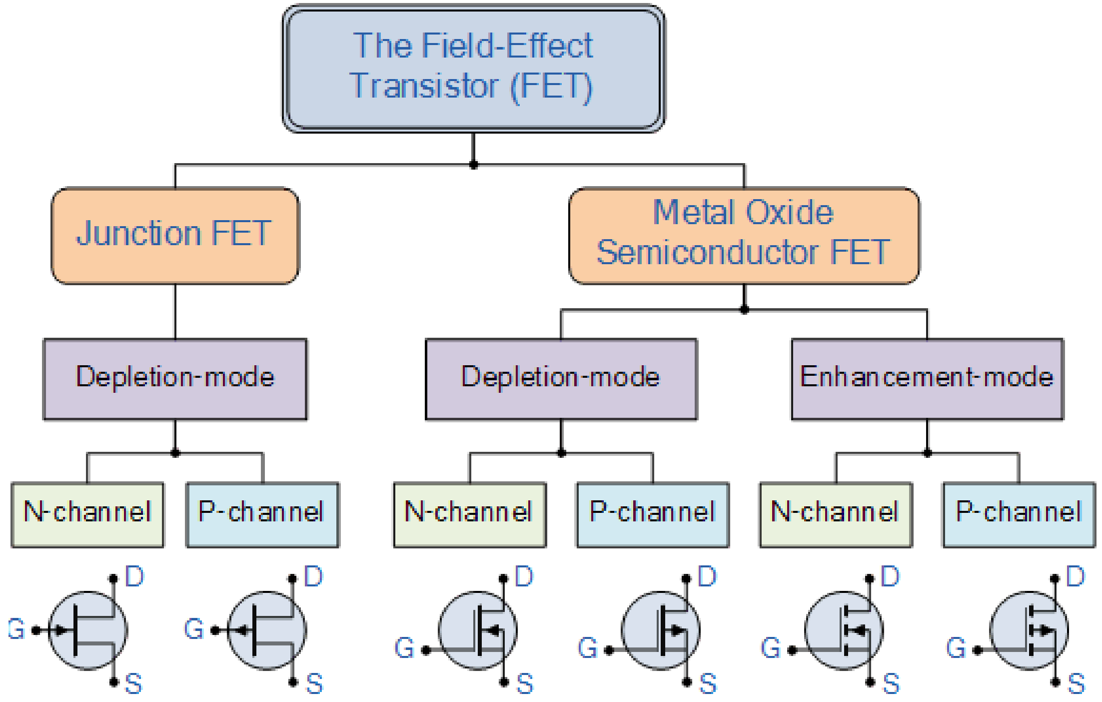
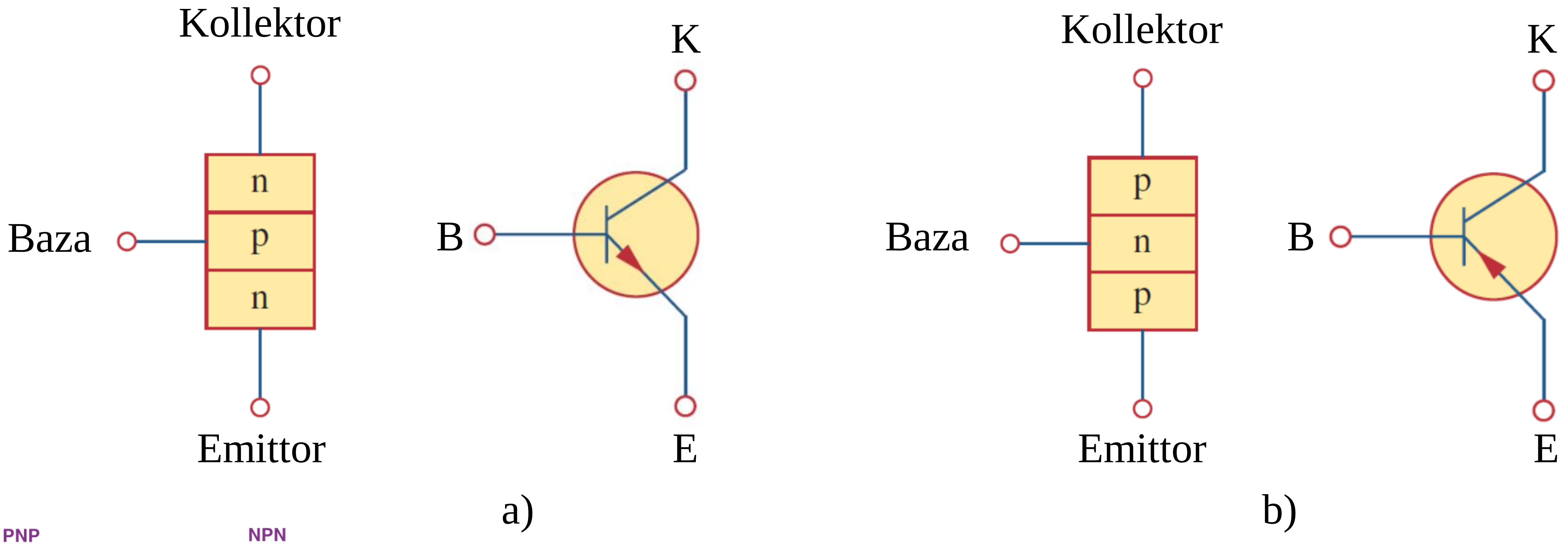
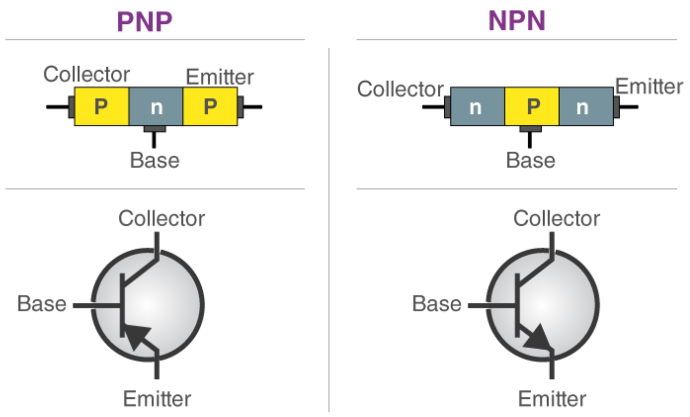


Photo source: [21] - https://www.electronics-tutorials.ws/wp-content/uploads/2018/05/transistor-tran22.gif

Photo source: [20] - https://in.element14.com/wcsstore/ExtendedSitesCatalogAssetStore/cms/asset/images/common/campaign/internet_of_things/trans-2.png

BJT ning ikki turi mavjud: *npn* va *pnp*, ularning sxema belgilari 3.15-rasmda ko‘rsatilgan.



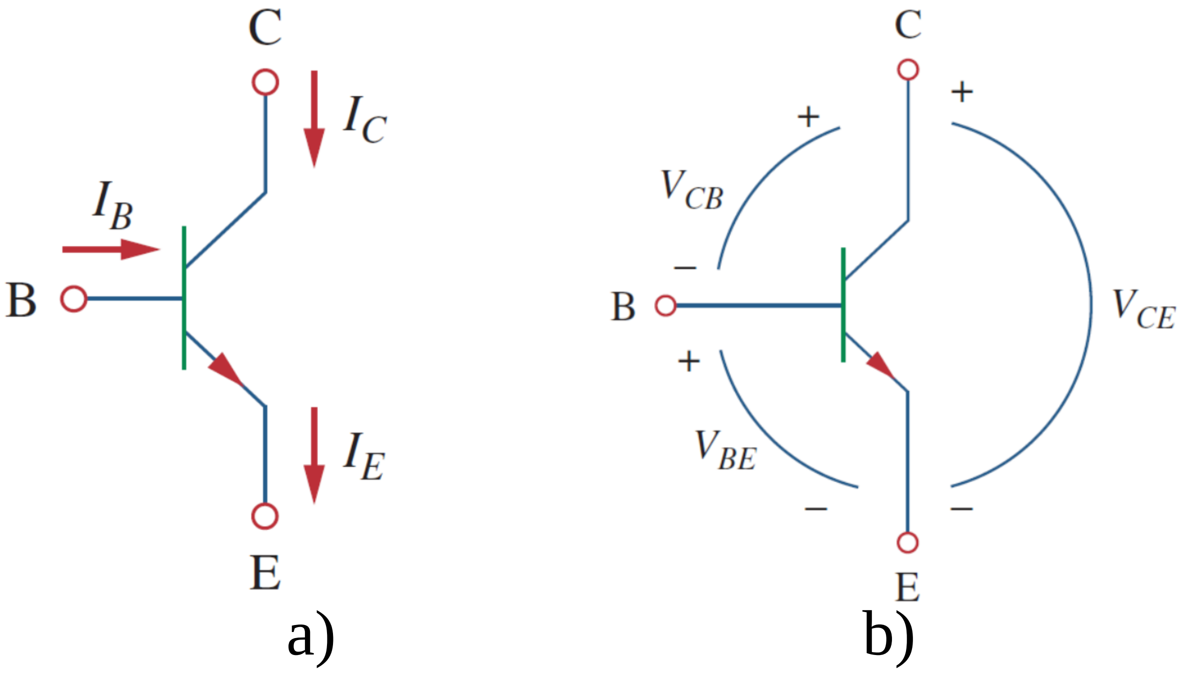


3.15-rasm. Ikki turdagi BJT va ularning sxema belgilari:

a) *npn*; b) *pnp*.

Photo source: [22] - https://cdn1.byjus.com/wp-content/uploads/2020/02/Transistor-2.png

Har bir turda emittor (E), baza (B) va kollektor (K) sifatida belgilangan uchta terminal mavjud. *Npn* tranzistori uchun tranzistorning tok kuchlari va kuchlanishlari 3.16-rasmda ko‘rsatilgan.



3.16-rasm. *Npn* tranzistorining terminal o‘zgaruvchilari:

a) tok kuchlar, b) kuchlanishlar.

3.16-rasm, *a* ga KCL qo‘llash imokini beradi.

$$I_E = I_B + I_K \qquad (3.27)$$

bu yerda: I_E, I_K va I_B mos ravishda emittor, kollektor va baza tok kuchlari.

Xuddi shunday, 3.16-rasm, *b* ga KVLni qo‘llaymiz.

$$U_{KE} + U_{EB} + U_{BK} = 0 \qquad (3.28)$$

bu yerda: U_{KE}, U_{EB} va U_{BK} kollektor-emittor, emitent-baza va baza-kollektor kuchlanishlari.

BJT uchta rejimdan birida ishlashi mumkin: faol, o‘chik va to‘yinganlik. Transistorlar faol rejimda ishlaganda, odatda $U_{BE} \cong 0{,}7\ V$.

$$I_K = \alpha I_E \tag{3.29}$$

bu yerda: α umumiy baza tokning kuchayishi deb ataladi. (3.29) tenglamada α kollektor tomonidan to‘plangan emittor tomonidan yuborilgan elektronlarning ulushini bildiradi.

Shuningdek,

$$I_K = \beta I_B \tag{3.30}$$

bu yerda: β umumiy emittor tok kuchining kuchayishi sifatida tanilgan.

α va β ma'lum tranzistorning xarakterli xususiyatlari bo‘lib, ushbu tranzistor uchun doimiy qiymatlarni qabul qiladi.

Odatda, α 0,98 dan 0,999 gacha bo‘lgan qiymatlarni oladi, β esa 50 dan 1000 gacha bo‘lgan qiymatlarni oladi.

$$I_E = I_B + I_K \qquad (3.27)$$

$$I_K = \beta I_B \qquad (3.30)$$

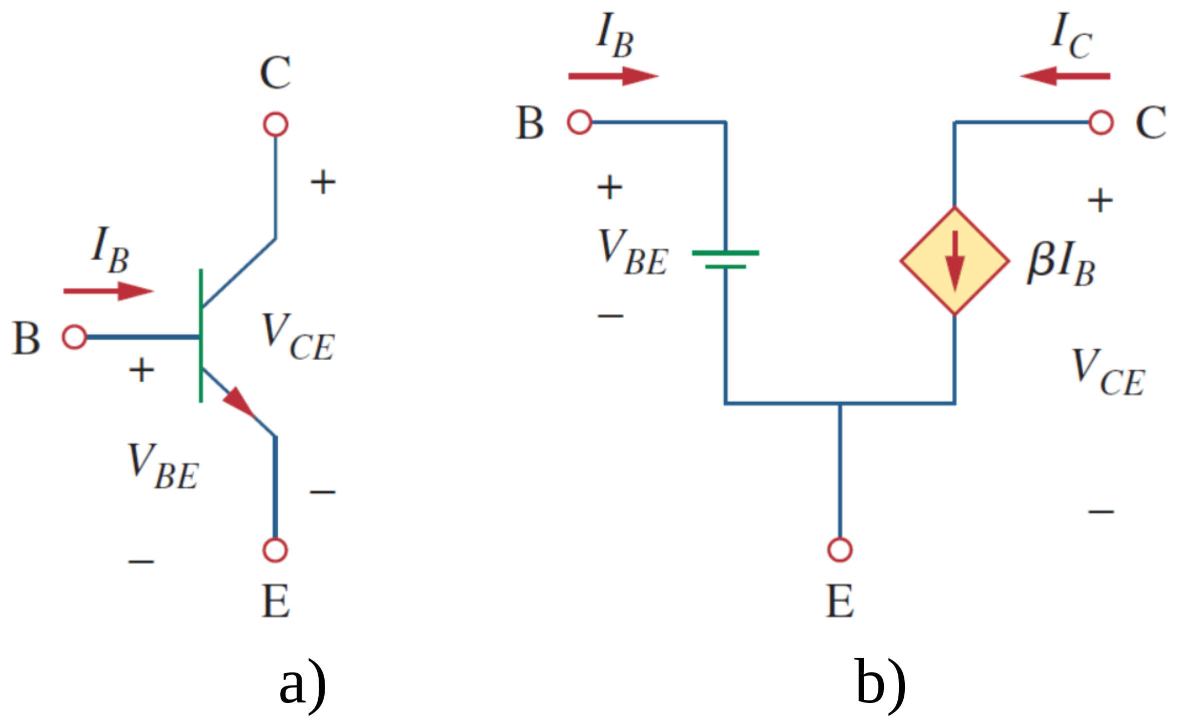
va

$$I_E = (1+\beta)I_B \qquad (3.31)$$

$$\beta = \frac{\alpha}{1-\alpha} \qquad (3.32)$$

Ushbu tenglamalar shuni ko‘rsatadiki, faol rejimda BJT bo‘g‘liq tok kuchi bilan boshqariladigan tok kuchi manbai sifatida modellashtirilishi mumkin.

Shunday qilib, zanjirni tahlil qilishda 3.17-rasm, *a* dagi *npn* tranzistorini almashtirish uchun shakl 3.17-rasm, *b* dagi o'zgarmas tok ekvivalenti modelidan foydalanish mumkin.



3.17-rasm.
a) *npn* tranzistori,
b) uning o'zgarmas tok uchun ekvivalent modeli.

$$\beta = \frac{\alpha}{1-\alpha} \qquad (3.32)$$

(3.32) tenglamadagi β katta bo'lgani uchun, kichik baza tok kuchi chiqish pallasida katta tok kuchlarni boshqaradi.

Binobarin, bipolyar tranzistor kuchaytirgich bo'lib xizmat qilishi mumkin, bu ham tokni kuchayishini, ham kuchlanishni keltirib chiqaradi.

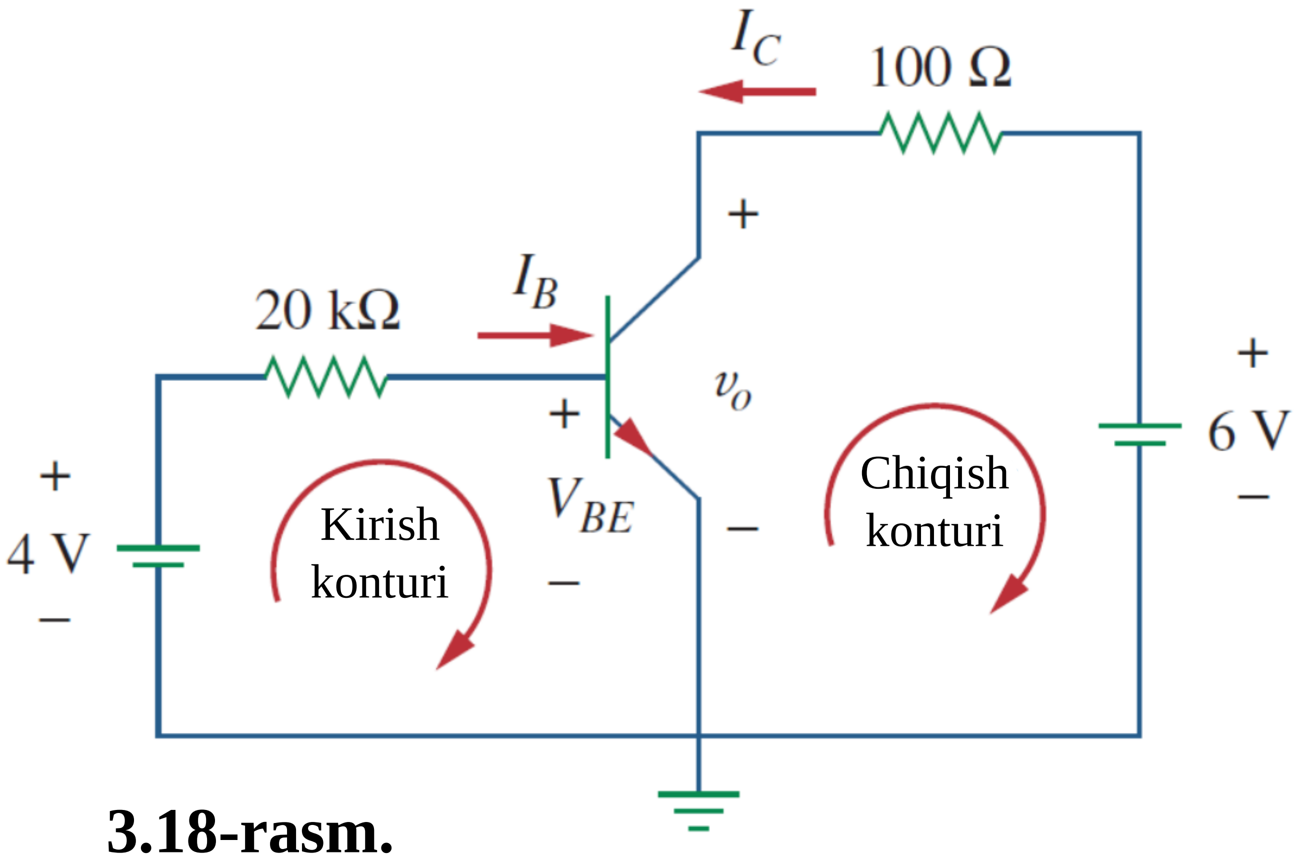
Bunday kuchaytirgichlar dinamiklar yoki ovoz kuchaytirgichlar kabi transduserlarga katta miqdorda quvvat berish uchun ishlatilishi mumkin.

Quyidagi misollarda tranzistorning terminallari orasidagi potensial farq tufayli tugun tahlili yordamida tranzistor davrlarini bevosita tahlil qilib bo‘lmasligini kuzatish kerak.

Faqat tranzistor uning ekvivalent modeli bilan almashtirilganda, biz tugun tahlilini qo‘llashimiz mumkin.

3.6.1-masala: 3.18-rasmdagi tranzistor zanjirida I_B, I_K va u_o ni toping.

Faraz qilaylik, tranzistor faol rejimda ishlaydi va $\beta = 50$.



3.18-rasm.

Yechish:

Kirish konturi uchun KVL ni qo‘llaymiz.

$$-4 + I_B(20 \cdot 10^3) + U_{BE} = 0$$

$$U_{BE} = 0{,}7\ V$$

$$I_B = \frac{4 - 0{,}7}{(20 \cdot 10^3)} = 165\ \mu A$$

Lekin,

$$I_K = \beta I_B = 50 \cdot 165\ \mu A = 8{,}25\ mA$$

Chiqish konturi uchun KVL ni qo‘llaymiz.

$$-u_0 - 100 I_C + 6 = 0$$

yoki,

$$u_0 = 6 - 100 I_C = 6 - 0{,}825 = 5{,}175\ V$$

Bu holda $u_0 = U_{KE}$ ekanligini unutmang.

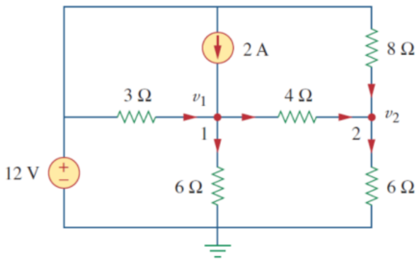
Photo source: [23] - Fundamentals of Electric Circuits, Charles K. Alexander and Matthew N. O. Sadiku / 5th edition, the McGraw-Hill Companies, Inc., -2013. – p 110.

FOYDALANILGAN MANBALAR:

18. https://info.endaq.com/hubfs/Blog-Images/Electronic-Components/Transistors-white.jpg
19. https://www.tutorialspoint.com/basic_electronics/images/transistor_types.jpg
20. https://in.element14.com/wcsstore/ExtendedSitesCatalogAssetStore/cms/asset/images/common/campaign/internet_of_things/trans-2.png
21. https://www.electronics-tutorials.ws/wp-content/uploads/2018/05/transistor-tran22.gif
22. https://cdn1.byjus.com/wp-content/uploads/2020/02/Transistor-2.png
23. Fundamentals of Electric Circuits, Charles K. Alexander and Matthew N. O. Sadiku / 5th edition, the McGraw-Hill Companies, Inc., -2013. – p 110.

TEKSHIRISH UCHUN SAVOLLAR!

3.1. 3.19-rasmdagi zanjirning 1-tugunida KCLni qo‘llash quyidagilarni beradi:



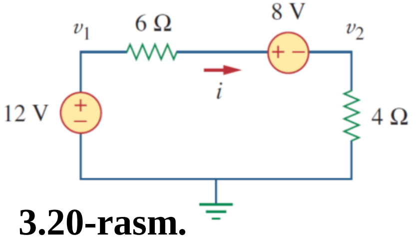
A) $2 + \frac{12-u_1}{3} = \frac{u_1}{6} + \frac{u_1-u_2}{4}$.
B) $2 + \frac{u_1-12}{3} = \frac{u_1}{6} + \frac{u_2-u_1}{4}$.
C) $2 + \frac{12-u_1}{3} = \frac{0-u_1}{6} + \frac{u_1-u_2}{4}$.
D) $2 + \frac{u_1-12}{3} = \frac{0-u_1}{6} + \frac{u_2-u_1}{4}$.

3.19-rasm.

3.2. 3.19-rasmdagi zanjirning 2-tugunida KCLni qo‘llash quyidagilarni beradi:

A) $\frac{u_2-u_1}{4} + \frac{u_2}{8} = \frac{u_2}{6}$.
B) $\frac{u_1-u_2}{4} + \frac{u_2}{8} = \frac{u_2}{6}$.
C) $\frac{u_1-u_2}{4} + \frac{12-u_2}{8} = \frac{u_2}{6}$.
D) $\frac{u_2-u_1}{4} + \frac{u_2-12}{8} = \frac{u_2}{6}$.

3.3. 3.20-rasmdagi zanjir uchun u_1 va u_2 quyidagicha bog‘langan:

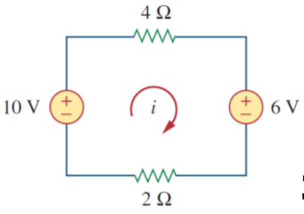


A) $u_1 = 6i + 8 + u_2$.
B) $u_1 = 6i - 8 + u_2$.
C) $u_1 = -6i + 8 + u_2$.
D) $u_1 = -6i - 8 + u_2$.

3.20-rasm.

3.4. 3.20-rasmdagi zanjir uchun u_2 quyidagiga teng:
A) -8 V. B) -1,6 V. C) 1,6 V. D) 8 V.

3.5. 3.21-rasmdagi zanjir uchun i tok kuchi quyidagiga teng:

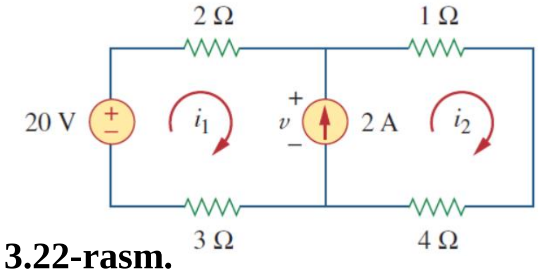


3.21-rasm.

A) $-2{,}667\ A$.
B) $-0{,}667\ A$.
C) $0{,}667\ A$.
D) $2{,}667\ A$.

3.6. 3.21-rasmdagi zanjir uchun kontur (*loop*) tenglamasi:
A) $-10 + 4i + 6 + 2i = 0$. B) $10 + 4i + 6 + 2i = 0$.
C) $10 + 4i - 6 + 2i = 0$. D) $-10 + 4i - 6 + 2i = 0$.

3.7. 3.22-rasmdagi zanjir uchun i_1 tok kuchi quyidagiga teng:



A) 4 A.
B) 3 A.
C) 2 A.
D) 1 A.

3.22-rasm.

3.8. 3.22-rasm zanjiridagi tok kuchi manbaini kesib o‘tuvchi kuchlanish u quyidagiga teng:
A) 20 V. B) 15 V. C) 10 V. D) 5 V.

3.9. Tok kuchi bilan boshqariladigan kuchlanish manbai uchun *PSpice* qism nomi:
A) EX. B) FX. C) HX. D) GX.

3.10. Quyidagi gaplardan qaysi biri IPROBE psevdo-komponentiga tegishli emas:
A) U ketma-ket ulanishi kerak.
B) U shaxobcha tok kuchini yo‘naltiradi.
C) U ulangan shaxobcha orqali tok kuchini ko‘rsatadi.
D) U kuchlanishni parallel ulash orqali ko‘rsatish uchun ishlatilishi mumkin.
E) U faqat o‘zgarmas tok tahlili uchun ishlatiladi.
F) U muayyan zanjir elementiga mos kelmaydi.

E'TIBORINGIZ UCHUN RAHMAT!!!