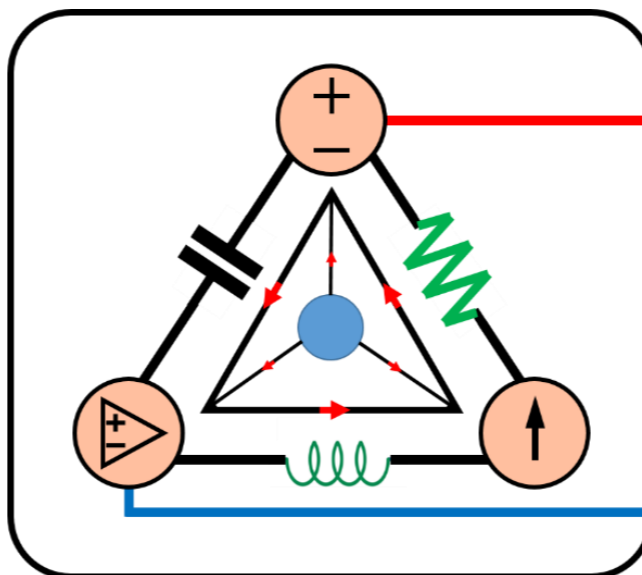


6-Mavzu: Kondensator va induktiv g'altak.

(Lecture-6: Capacitors and Inductors)

6-Mavzuning 2-qismi

(Part 2 of the Lecture-6)



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6-Mavzu: Kondensator va induktiv g'altak.

(Lecture-6: Capacitors and Inductors)

O'quv rejasi:

6.1. Kondensatorlar.

6.2. Ketma-ket va parallel ulangan kondensatorlar.

6.3. Induktiv g'altaklar (Induktorlar).

6.4. Ketma-ket va parallel ulangan induktorlar.

6.5. Kondensator va induktiv g'altaklarda tok kuchi va kuchlanishni bo'linish qoidasi.

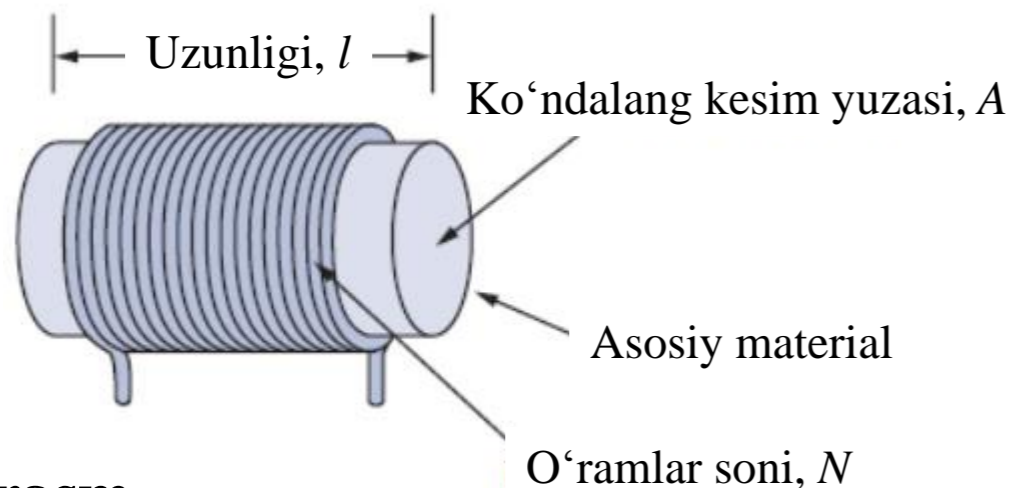
6.6. Kondensator va induktiv g'altaklarning qo'llanilishi.

6.3. Induktiv g'altaklar (Induktorlar).

Induktor - bu o'zining magnit maydonida energiyani saqlash uchun mo'ljallangan passiv element bo'lib, ular elektron va quvvat tizimlarida ishlatiladi.

Elektr tokining har qanday o'tkazgichi induktiv xususiyatlarga ega va induktor sifatida qaralishi mumkin.

Ammo induktiv ta'sirni kuchaytirish uchun induktiv g'altak silindrsimon magnitlangan o'zakka o'tkazuvchi sim o'ralib hosil qilinadi.



6.13-rasm.

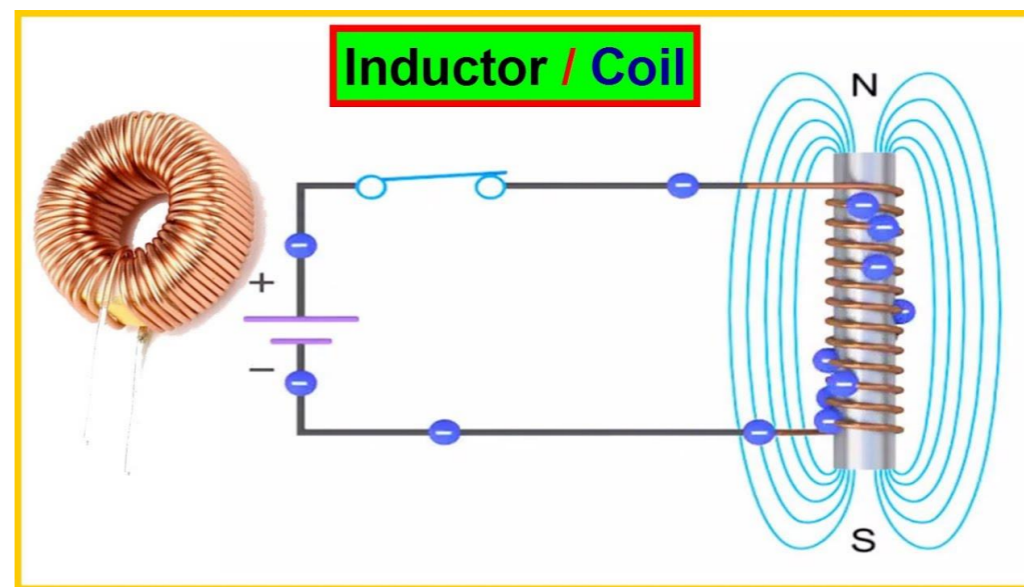


Photo source: [12] - <https://i.ytimg.com/vi/7XlgiEr1NUc/maxresdefault.jpg>

Induktor o‘tkazgich simining magnitlangan o‘zak qismidan iborat. Uning vazifasi elektr energiyasini elektr maydon energiyasiga aylantirib beradi.

Agar induktordan tok o‘tishi mumkin bo‘lsa, induktordagi kuchlanish tok kuchining vaqt o‘zgarishi tezligiga to‘g‘ridan-to‘g‘ri proporsional ekanligi aniqlanadi. Passiv belgi konvensiyasidan foydalanib,

$$u = L \frac{di}{dt} \quad (6.19)$$

bu yerda: L - induktorning induktivligi deb ataladigan proporsionallik doimiysi.

Induktivlik birligi amerikalik ixtirochi Jozef Genri (1797-1878) sharafiga nomlangan Genri (H).

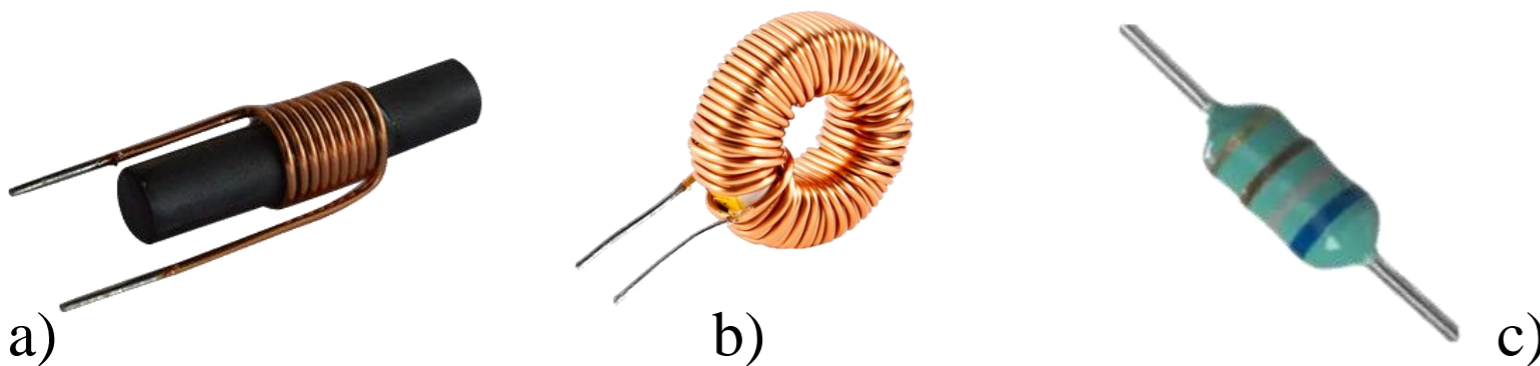
(6.19) tenglama bo‘yicha:

$$\text{Agar, } u = 1 \text{ V va } \frac{di}{dt} = \frac{1\text{A}}{\text{s}} \rightarrow L = \frac{1\text{V}}{\frac{1\text{A}}{\text{s}}} = 1 \text{ H ga teng.}$$

Induktivlik (lotincha *inductio* - ta'sirlash, uyg'otish) - o'tkazgichdan yasalgan konturdan bir amper tok kuchi o'tayotganda shu konturni kesib o'tuvchi magnet maydon induksiya oqimini vujudga keltirish xususiyatidir. U genry (H) bilan o'lchanadi.

Induktorning induktivligi uning fizik o'lchamiga va tuzilishiga bog'liq.

Turli shakldagi induktorlarning induktivligini hisoblash uchun formulalar elektromagnit nazariyadan olingan bo'lib, ularni standart elektrotexnika qo'llanmalaridan topish mumkin.



6.14-rasm. Induktiv g'altaklarning turlari.

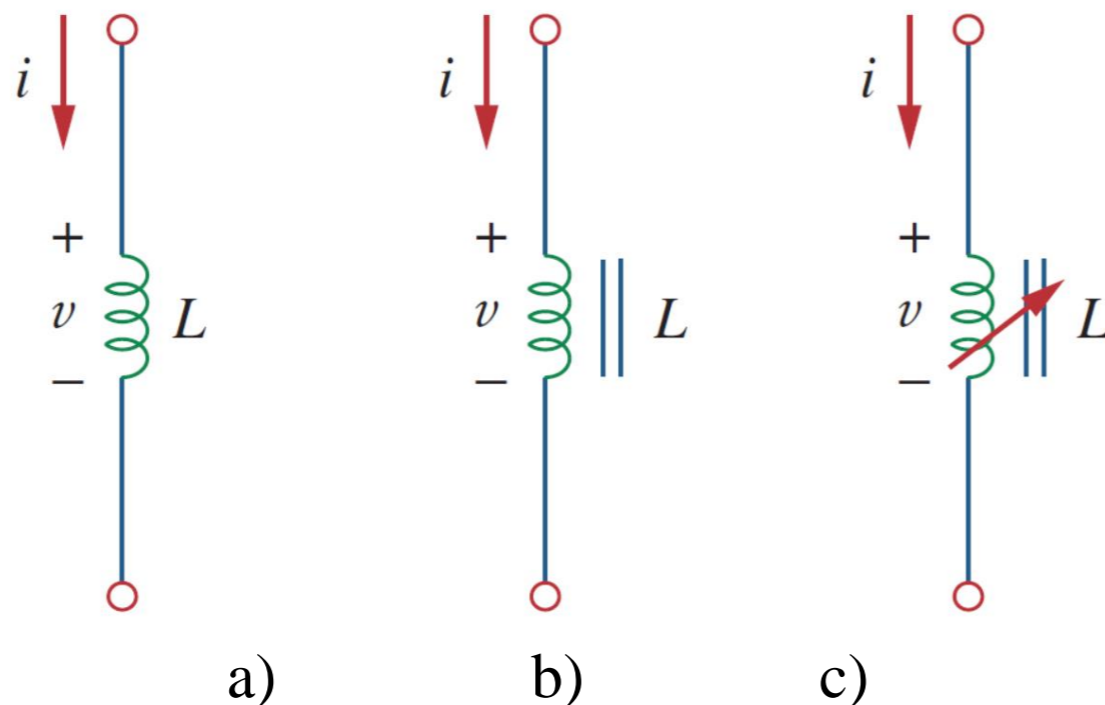
a) solenoidal induktori; b) toroidal induktor; c) chip induktori.

a) - Photo source: [13] -
<https://p.globalsources.com/IMAGES/PDT/B1132530142/Rod-ferrite-core-inductors.jpg>

b) - Photo source: [14] -
<https://qph.cf2.quoracdn.net/main-qimg-fd4f7cef1d90ec6cd93ef961ce23b8c1-lq>

c) - Photo source: [15] -
<https://i0.wp.com/www.electronicandyou.com/wp-content/uploads/2019/07/different-types-of-inductors.jpg?fit=1200%2C675&ssl=1>

Induktorlar aloqa tizimlarida bo‘lgani kabi bir necha mikrogenri (μH) dan quvvat tizimlaridagi kabi o‘nlab genri (H) gacha bo‘lgan qiymatlarga ega. Induktorlar doimiy yoki o‘zgaruvchan bo‘ladi.



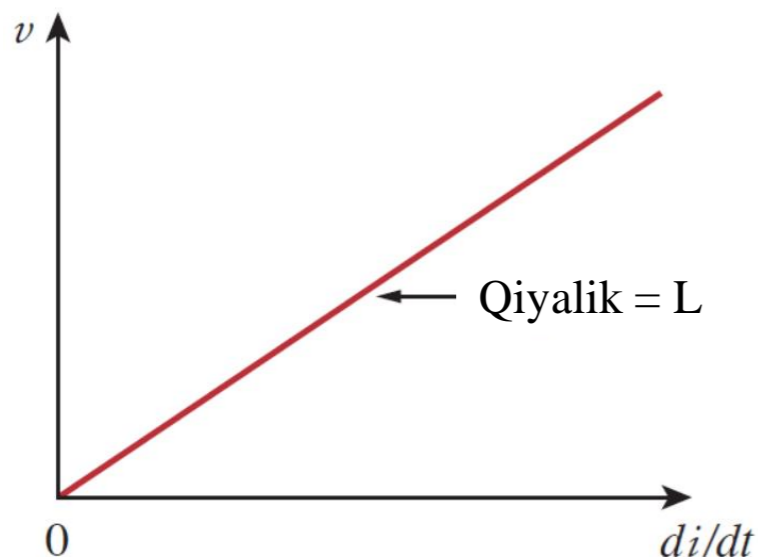
Ular temir asosli, po‘lat, plastmassadan tayyorlanishi mumkin.

6.15-rasm. Induktiv g‘altaklarning zanjirdagi shartli belgilari.

- a) oddiy asosli induktiv g‘altak, b) temir asosli induktiv g‘altak,
- c) o‘zgaruvchan temir asosli induktiv g‘altak.

$$u = L \frac{di}{dt}$$

tenglama bo'yicha induktor uchun tok kuchi va kuchlanish munosabati 6.16-rasmda induktivligi tokdan mustaqil bo'lgan induktor uchun bu bog'liqlik grafigi ko'rsatilgan.



6.16-rasm. Induktorning kuchlanish va tok kuchi bog'liqligi.

Chiziqli bo'lmagan induktor uchun tenglama grafigi (6.19) tenglama to'g'ri chiziq bo'lmaydi, chunki uning induktivligi tok kuchi bilan o'zgaradi.

$$u = L \frac{di}{dt}$$

$$\downarrow$$

$$di = \frac{1}{L} U dt$$

Integralash orqali quyidagini olamiz,

$$i = \frac{1}{L} \int_{-\infty}^t U(\tau) d\tau \quad (6.21)$$

yoki,

$$i = \frac{1}{L} \int_{-\infty}^t U(\tau) d\tau + i(t_0) \quad (6.22)$$

bu yerda: $i(t_0)$ $-\infty < t < t_0$ va $i(-\infty) = 0$ uchun umumiy tok kuchi.

Induktor o‘zining magnit maydonida energiyani saqlash uchun mo‘ljallangan.

Saqlangan energiyani (6.19) tenglamadan olish mumkin.

Induktorga yetkazib beriladigan quvvat:

$$p = ui = \left(L \frac{di}{dt} \right) i \quad (6.23)$$

Saqlangan energiya:

$$W = \int_{-\infty}^t p(\tau) d\tau = L \int_{-\infty}^t \frac{di}{d\tau} i d\tau = L \int_{-\infty}^t i di = \frac{1}{2} Li^2(t) - \frac{1}{2} Li^2(-\infty) \quad (6.24)$$

$i(-\infty) = 0$ ekanligini inobatga olsak,

$$W = \frac{1}{2} Li^2 \quad (6.25)$$

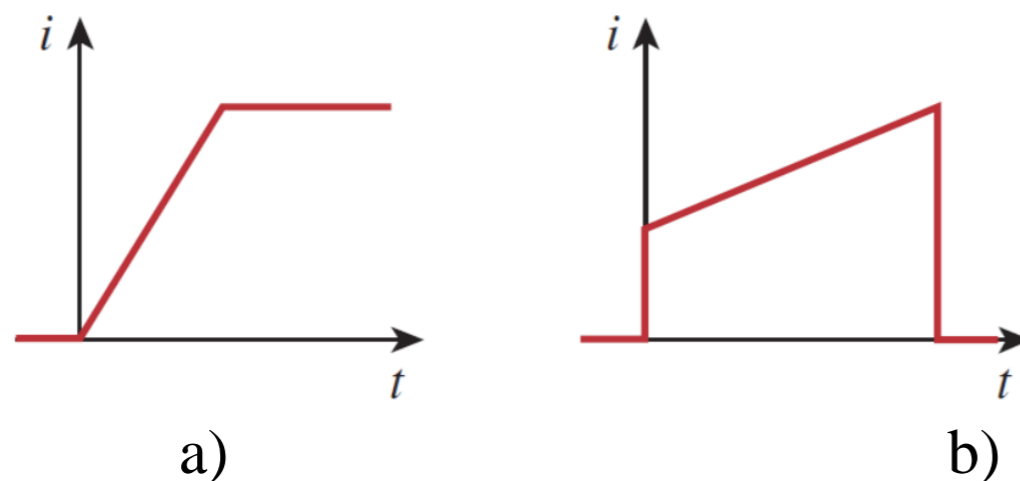
Induktorning quyidagi muhim xususiyatlarini ta'kidlashimiz kerak:

1. $u = L \frac{di}{dt}$ tenglamadan tok kuchi doimiy bo'lganda induktordagi kuchlanish nolga teng bo'ladi.

Shunday qilib, Induktor doimiy tok kuchiga berk zanjir kabi ishlaydi.

2. Induktorning muhim xususiyati uning ichidan o'tadigan tok kuchining o'zgarishiga qarshiligidir.

Ya'ni, induktor orqali o'tayotgan tok kuchi bir zumda o'zgarmaydi.



6.17-rasm. Induktordan tok kuchini o'tishi.

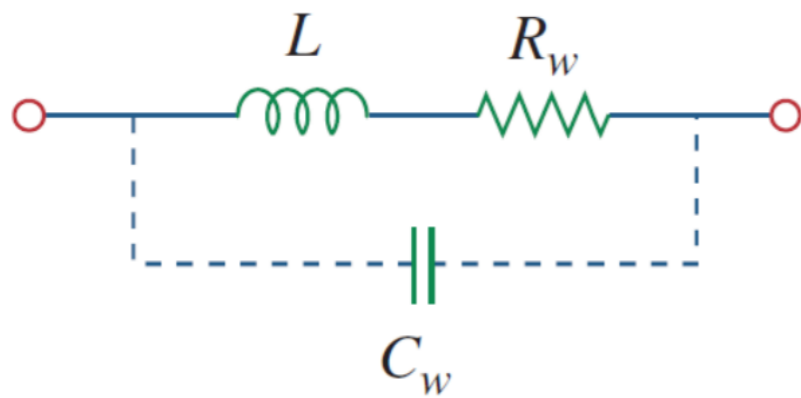
a) ruxsat etilgan, b) ruxsat etilmaydi, keskin o'zgarish mumkin emas.

(6.19) tenglama bo'yicha induktor orqali tok kuchining uzluksiz o'zgarishi cheksiz kuchlanishni talab qiladi, bu fizik jihatdan mumkin emas. Shunday qilib, induktor u orqali tok kuchining keskin o'zgarishiga qarshi turadi.

3. Ideal kondensator kabi ideal induktor energiyani yo‘qotmaydi. Unda saqlangan energiyani keyinroq olish mumkin. Energiyani saqlash vaqtida induktor elektr zanjiridan va ilgari saqlangan energiyani qaytarishda elektr zanjiriga quvvat beradi.

4. Amalda ideal bo‘lmagan induktor 6.18-rasmda ko‘rsatilganidek, muhim qarshilik komponentiga ega.

Buning sababi, induktorning mis kabi o‘tkazuvchi materialdan yasalganligi, u bir oz qarshilikka ega.



Bu qarshilik chulg‘am qarshiligi R_w deyiladi.

R_w ning mavjudligi uni energiyani saqlash qurilmasi va energiyani yo‘qotish qurilmasi qiladi.

Ideal bo‘lmagan induktor, o‘tkazgichlar orasidagi sig‘imli birikma tufayli chulg‘am sig‘imi C_w ga ega.

6.18-rasm. Induktor uchun elektr zanjir modeli.

6.3.1-masala: 0,1 H induktordan o‘tadigan tok kuchi $i(t) = 10te^{-5t}$ A ga teng.

Induktordagi kuchlanish va unda saqlanadigan energiyani toping.

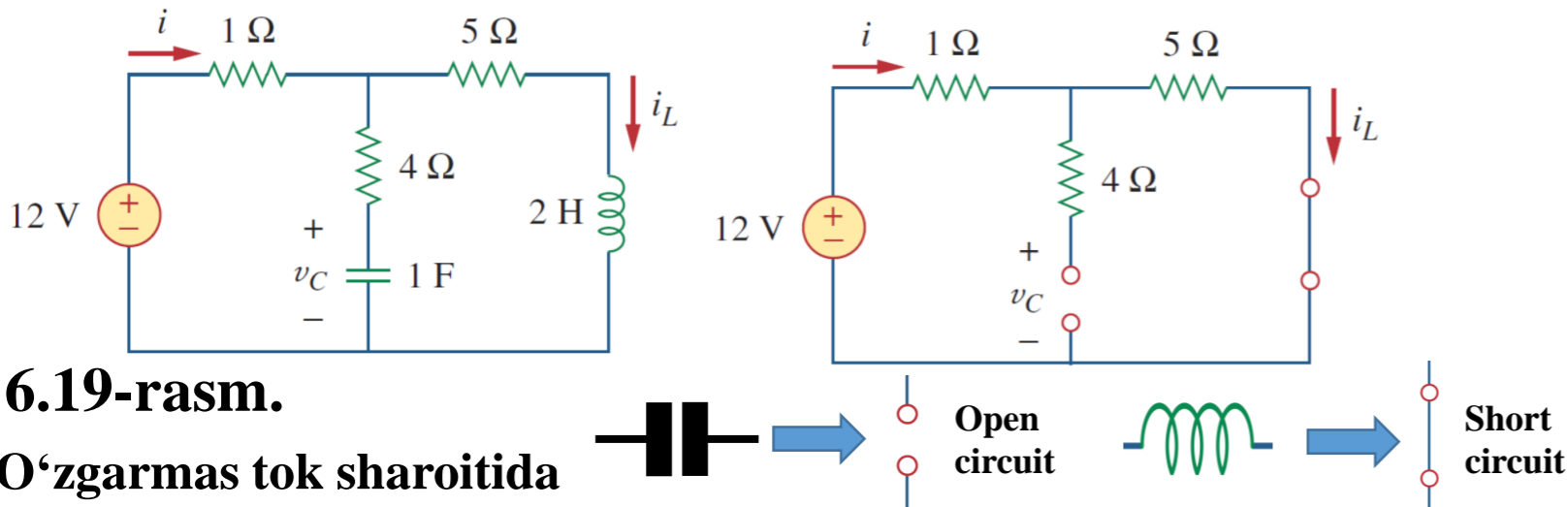
Yechish:

$$U = L \frac{di}{dt}$$

$$L = 0,1 \text{ H} \quad U = 0,1 \frac{d}{dt} (10te^{-5t}) = 0,1(10e^{-5t} + 10t(-5)e^{-5t}) = \\ = e^{-5t} + 5te^{-5t} = e^{-5t}(1 - 5t) \text{ V}$$

Energiyani saqlanishi bo‘yicha, $W = \frac{1}{2} Li^2 = \frac{1}{2} (0,1) 100t^2 e^{-10t} = 5t^2 e^{-10t} \text{ J}$

6.3.2-masala: 6.19-rasm, *a* dagi zanjirni ko‘rib chiqing. O‘zgarmas tok sharoitida: a) i , (u_c) va i_L ni; b) kondensator va induktorda saqlanadigan energiyani toping.



6.19-rasm.

O‘zgarmas tok sharoitida

$$i = i_L = \frac{12}{1 + 5} = 2 \text{ A} \quad u_c = 5i = 10 \text{ V}$$

$$W_C = \frac{1}{2} C u_C^2 = \frac{1}{2} \cdot 1 \cdot 10^2 = 50 \text{ J}$$

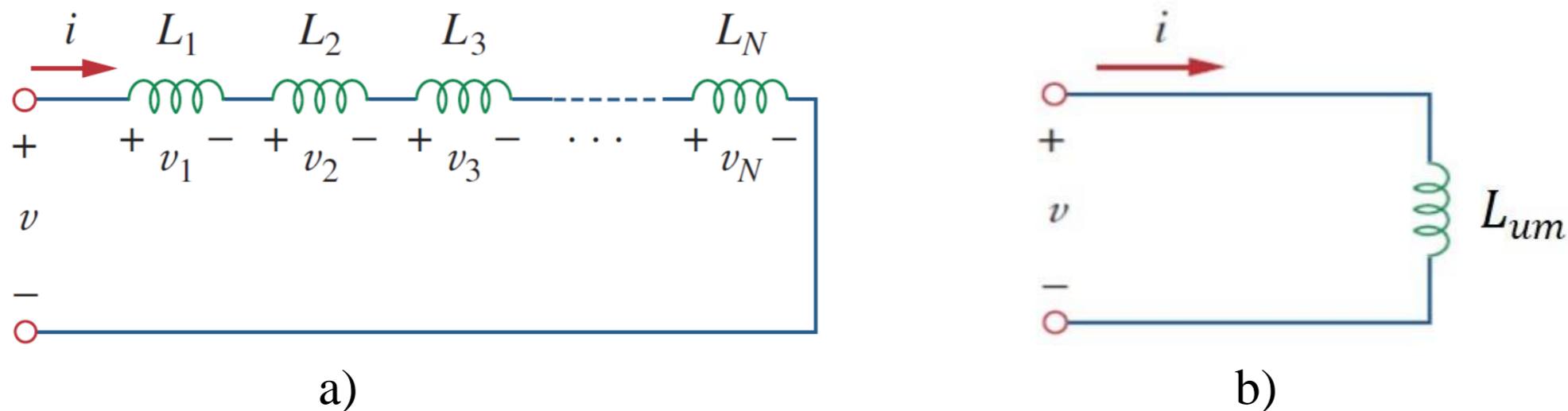
$$W_L = \frac{1}{2} L i_L^2 = \frac{1}{2} \cdot 2 \cdot 2^2 = 4 \text{ J}$$

6.4. Ketma-ket va parallel ulangan induktorlar.

Induktorlarni zanjirlarda ketma-ket va parallel ulanishi ularning zanjirdagi ta'sirini oshiradi.

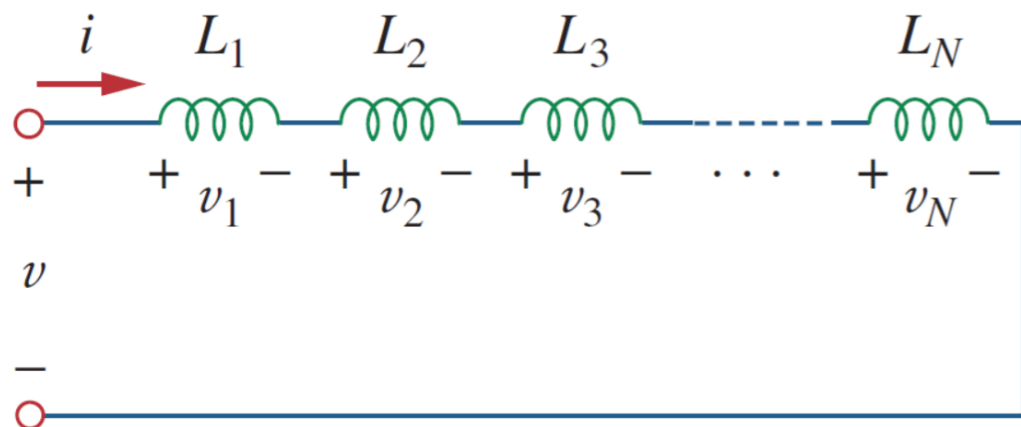
Elektr zanjirlarida ketma-ket yoki parallel ulangan induktorlar to'plamining ekvivalent induktivligini aniqlashimiz kerak. Chunki, uni aniqlash orqali zanjirni tahlil qilishni osonlashtiradi.

Zanjirda ketma-ket ulangan N ta induktorlar orqali bir xil tok kuchi oqib o'tadi.



6.20-rasm.

a) N ta induktorlarning ketma-ket ulanishi; b) ketma-ket ulangan induktorlar uchun ekvivalent zanjiri.



KVL ni qo‘llaymiz:

$$U = U_1 + U_2 + U_3 + \dots + U_N \quad (6.26)$$

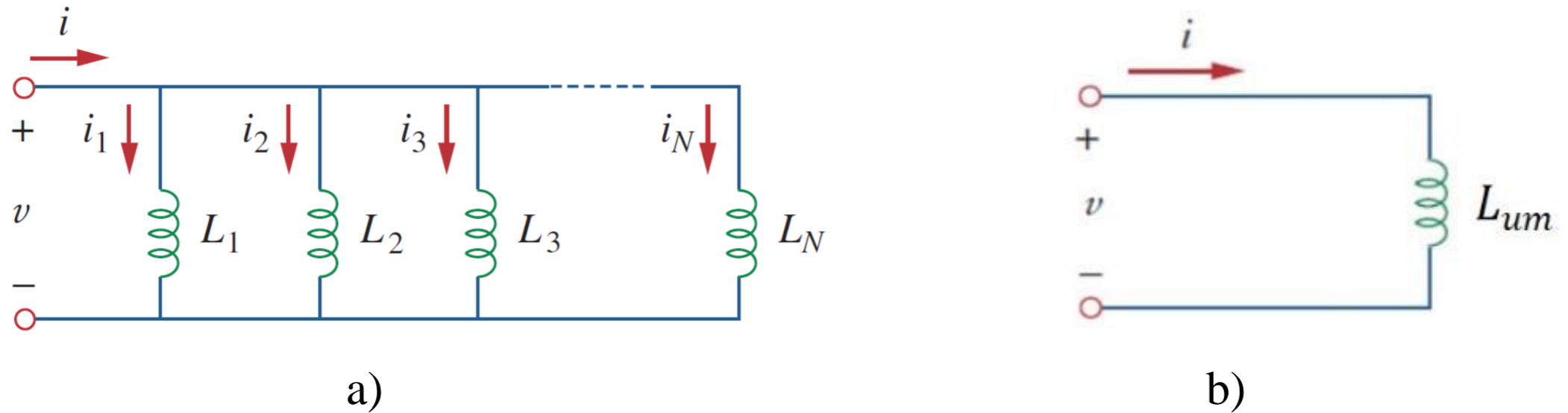
$$U_k = L_k \frac{di}{dt}$$

$$U = L_1 \frac{di}{dt} + L_2 \frac{di}{dt} + L_3 \frac{di}{dt} + \dots + L_N \frac{di}{dt} =$$

$$= (L_1 + L_2 + L_3 + \dots + L_N) \frac{di}{dt} = \left(\sum_{k=1}^N L_k \right) \frac{di}{dt} = L_{um} \frac{di}{dt} \quad (6.27)$$

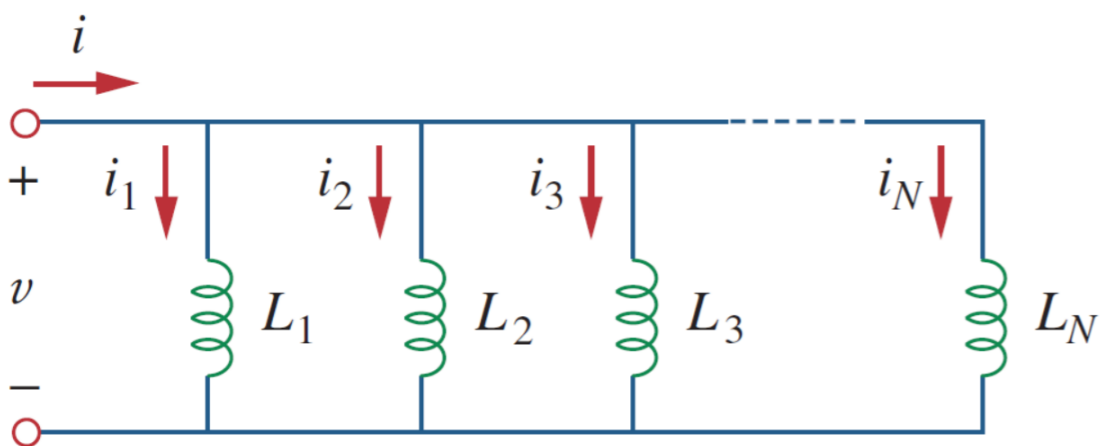
$$L_{um} = L_1 + L_2 + L_3 + \dots + L_N \quad (6.28)$$

Zanjirda parallel ulangan N ta induktorlarning qutblarida har birida bir xil kuchlanish bo‘ladi.



6.21-rasm.

- a) N ta induktorlarning parallel ulanishi,
 b) parallel ulangan induktorlar uchun ekvivalent zanjiri.



KCL dan foydalanamiz:

$$i = i_1 + i_2 + i_3 + \dots + i_N \quad (6.29)$$

$$i_k = \frac{1}{L_k} \int_{t_0}^t U dt + i_k(t_0).$$

$$\begin{aligned} i &= \frac{1}{L_1} \int_{t_0}^t U dt + i_1(t_0) + \frac{1}{L_2} \int_{t_0}^t U dt + i_2(t_0) + \dots + \frac{1}{L_N} \int_{t_0}^t U dt + i_N(t_0) = \\ &= \left(\frac{1}{L_1} + \frac{1}{L_2} + \dots + \frac{1}{L_N} \right) \int_{t_0}^t U dt + i_1(t_0) + i_2(t_0) + \dots + i_N(t_0) = \\ &= \left(\sum_{k=1}^N \frac{1}{L_k} \int_{t_0}^t U dt + \sum_{k=1}^N i_k(t_0) \right) = \frac{1}{L_{um}} \int_{t_0}^t U dt + i(t_0) \end{aligned} \quad (6.30)$$

$$\frac{1}{L_{um}} = \frac{1}{L_1} + \frac{1}{L_2} + \frac{1}{L_3} + \dots + \frac{1}{L_N}$$

(6.31)



$$\frac{1}{L_{um}} = \frac{1}{L_1} + \frac{1}{L_2}$$

$$L_{um} = \frac{L_1 L_2}{L_1 + L_2}$$

Ushbu nuqtada biz o‘rgangan uchta asosiy elektron elementning eng muhim xususiyatlarini umumlashtirish maqsadga muvofiqdir. Xulosa o‘rnida 6.2-jadvalda keltirilgan.

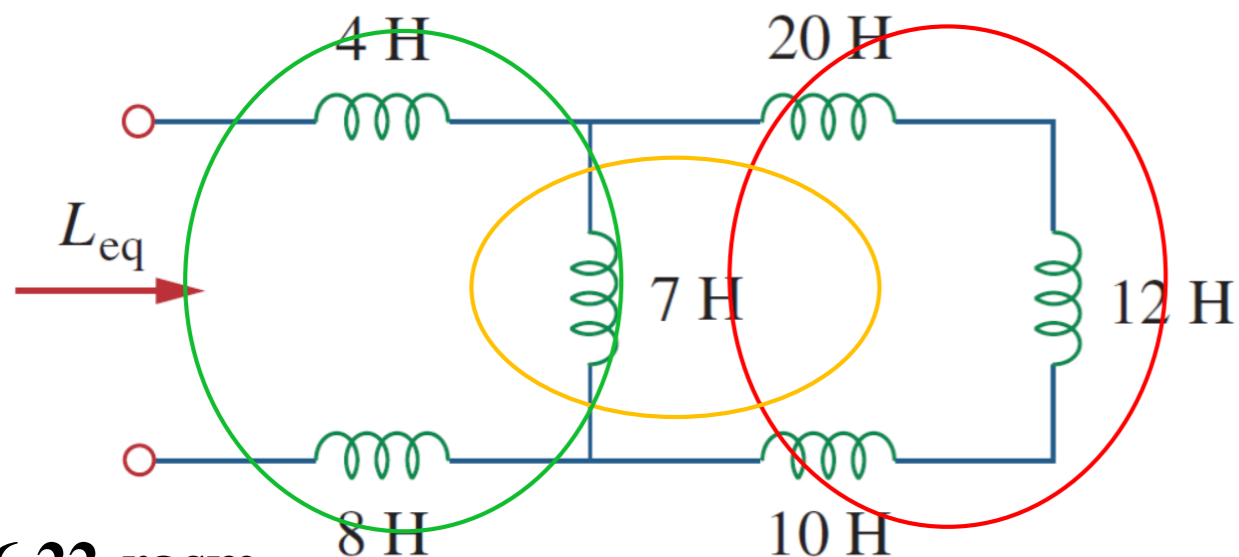
Asosiy elementlarning muhim xususiyatlari

6.2-jadval

Bog‘liqlik	Rezistor (R)	Kondebsator (C)	Induktor (L)
$U-I$:	$U = iR$	$U = \frac{1}{C} \int_{t_0}^t i(\tau) d\tau + U(t_0)$	$U = L \frac{di}{dt}$
$I-U$:	$i = \frac{U}{R}$	$i = C \frac{du}{dt}$	$i = \frac{1}{L} \int_{t_0}^t U(\tau) d\tau + i(t_0)$
P yoki W :	$p = i^2 R = \frac{U^2}{R}$	$W = \frac{1}{2} CU^2$	$W = \frac{1}{2} Li^2$
Ketma-ket:	$R_{um} = R_1 + R_2$	$C_{um} = \frac{C_1 C_2}{C_1 + C_2}$	$L_{um} = L_1 + L_2$
Parallel:	$R_{um} = \frac{R_1 R_2}{R_1 + R_2}$	$C_{um} = C_1 + C_2$	$L_{um} = \frac{L_1 L_2}{L_1 + L_2}$
Doimiy tok manbaida (At DC)	Bir xil	Ochiq zanjir 	Yopiq zanjir 

Text source: [16] - Fundamentals of Electric Circuits, Charles K. Alexander and Matthew N. O. Sadiku / 5th edition, the McGraw-Hill Companies, Inc., - 2013. – p 232.

6.4.1-masala: 6.22-rasmdagi zanjirning ekvivalent induktivligini toping.



6.22-rasm.

$$20 + 12 + 10 = 42 \text{ H}$$

$$\frac{7 \cdot 42}{7 + 42} = 6 \text{ H}$$

$$L_{um} = 4 + 6 + 8 = \mathbf{18 \text{ H}}$$

Ketma-ket ulangan induktorlar:

$$L_{um} = L_1 + L_2 + L_3 + \dots + L_N$$

Parallel ulangan induktorlar:

$$\frac{1}{L_{um}} = \frac{1}{L_1} + \frac{1}{L_2} \text{ yoki, } L_{um} = \frac{L_1 L_2}{L_1 + L_2}$$

FOYDALANILGAN MANBALAR:

12. <https://i.ytimg.com/vi/7XlgiEr1NUc/maxresdefault.jpg>
13. <https://p.globalsources.com/IMAGES/PDT/B1132530142/Rod-ferrite-core-inductors.jpg>
14. <https://qph.cf2.quoracdn.net/main-qimg-fd4f7cef1d90ec6cd93ef961ce23b8c1-lq>
15. <https://i0.wp.com/www.electronicandyou.com/wp-content/uploads/2019/07/different-types-of-inductors.jpg?fit=1200%2C675&ssl=1>
16. Fundamentals of Electric Circuits, Charles K. Alexander and Matthew N. O. Sadiku / 5th edition, the McGraw-Hill Companies, Inc., -2013. – p 232.



*E'TIBORINGIZ
UCHUN
RAHMAT!!!*